DONG energy

Gunfleet Sands
Offshore Wind Farm

Gunfleet Sands 2 Offshore Wind Farm Environmental Statement

June 2007

Preface

This Environmental Statement has been prepared by the RPS Group Plc on behalf of DONG Energy in support of the following applications for an offshore wind farm in the outer Thames estuary:

Application	Lead Authority
Section 36 and Section 36A of the Electricity Act 1989	The Department of Trade and Industry (DTI)
Section 95 of the Energy Act 2004	The Department of Trade and Industry (DTI)
Section 5 of the Food and Environmental Protection Act 1985 Part II	The Marine and Fisheries Agency
Section 34 of the Coast Protection Act 1949	The Marine and Fisheries Agency
Port of London Act 1968, River Works Licence	Port of London Authority

Requests for additional copies of this Environmental Statement, priced at £250 for hardcopy and free on CD, or the Non-Technical Summary (free) should be made to:

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A downloadable version of the Non Technical Summary is also available from the Gunfleet Sands Offshore Wind Farm website: **www.gunfleetsands.co.uk**

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1. INTRODUCTION

1.1 Background to the Development

The Gunfleet Sands project, which is located approximately 8.5km south-east of Clacton-on-Sea, Essex, consists of the already consented Gunfleet Sands 1 project[1], which has consent to construct up to 30 turbines, each of a maximum capacity of 3.6MW, thus yielding a total capacity of 108MW, and a proposed extension, Gunfleet Sands 2 (GS2) – see Figure 1.1.

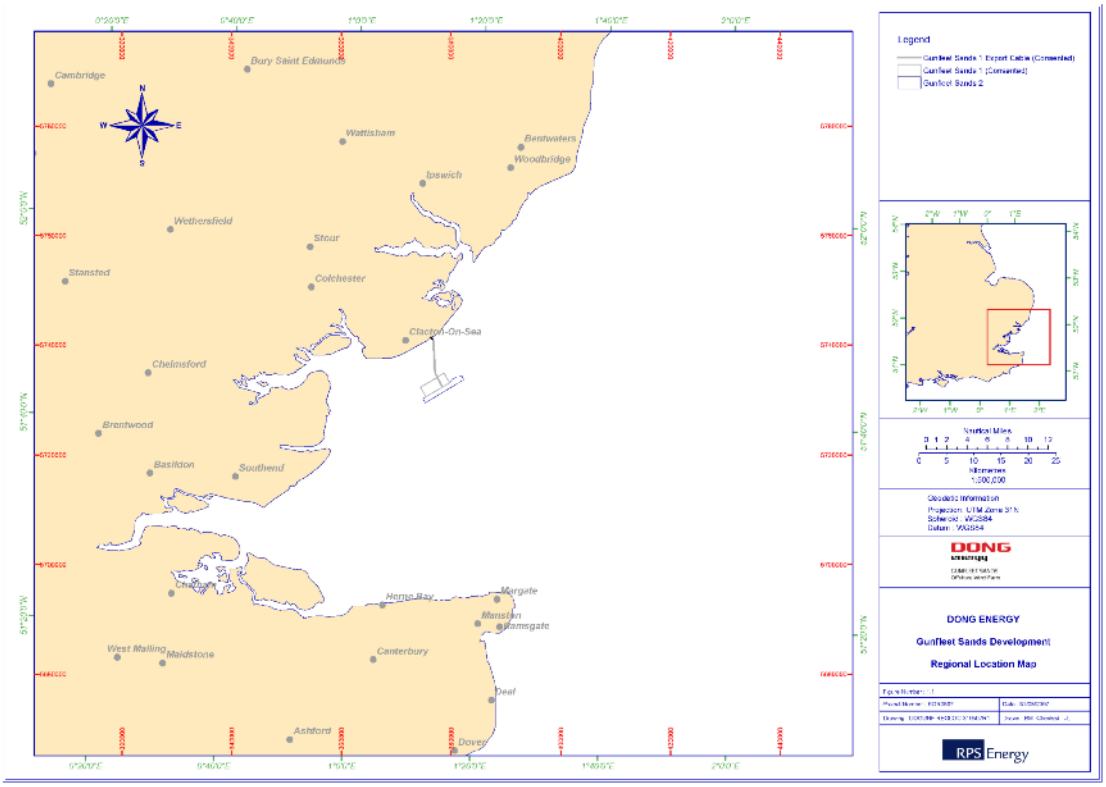


Figure 1.1 Gunfleet Sands Development - Regional Location Map

The GS1 project has obtained the following consents necessary for its construction and operation:

[1] For the purpose of this ES the terminology Gunfleet Sands 1 will be used for the already consented part of the project otherwise referred to as just Gunfleet Sands. Gunfleet Sands 2 will be used for the extension dealt with in the present report. The phases are abbreviated GS1 and GS2, respectively.

Consent	Licence Number	Issue Date
Transport and Works Act (TWA) order (The Gunfleet Sands Offshore Wind Farm Order, 2004).	2004 No. 933	April 2004
Food and Environment Protection Act (FEPA) licence (for construction of the turbines)	Original – 31919/03/0 Revision -31919/06/02	November 2003
Food and Environment Protection Act (FEPA) licence (for construction of met mast and radar mast)	32765/05/02	December 2005
Coast Protection Act, Section 34 (for met-mast and radar mast)	32765/05/02	September 2005
Town and Country Planning Act (for all onshore cabling works)	03/00011/FUL	March 2003
Water Resources Act 1991, Sections 109 and 210 (for onshore cabling works)	AE/2003/00030	March 2003
Town and Country Planning Act (for modification to cable route crossing and directional drilling under Holland Brook)	06/000445/FUL	May 2006
Water Resources Act 1991, Sections 109 and 210 (for modification to cable route crossing and directional drilling under Holland Brook)	AE/2006/00095	April 2006
Town and Country Planning Act (for installation of fibre optic cable from consented cable jointing pit to PLA radar compound	03/00011/FUL	October 2006

Table 1.1 Consents awarded to the GS1 project

The proposed extension, (GS2) was awarded a lease option agreement by Crown Estate in December 2003 and includes up to 22 turbines with a maximum total capacity of 64MW. The development comprises the turbines, inter turbine cabling, an offshore substation, an optional met mast and radar mast.

The development will utilise the existing onshore electricity connection consented under the GS1 Town and Country Planning and Water Resources Act permissions and the offshore export cable route consented under Transport and Works and FEPA to Mean High Water Springs (MHWS).

1.2 The Applicant

In December 2006, DONG Energy (DONG) acquired the GS1 and GS2 offshore wind farm projects from GE Wind Energy. DONG is one of the leading energy groups in the Nordic region. The company pioneered the offshore wind farm industry in Denmark with projects constructed in the 1990's. In 2002 and 2003 DONG constructed the world's two largest offshore wind farms; Horns Rev and Nysted.

DONG is involved in a number of Round 1 and Round 2 offshore wind projects in the UK. In 2006 the Barrow offshore wind project went into operation and currently the Burbo Bank project is under construction, which will be completed during 2007.

1.3 Project Consultants

The Environmental Impact Assessment (EIA) process for the GS1 project was undertaken by Hydrosearch Associates Ltd. In 2003, Hydrosearch was acquired by the RPS Group, becoming RPS Energy. RPS Energy (RPS) has continued to provide consultancy support to the Gunfleet Sands project between 2002 to date and have been commissioned by DONG to manage the EIA process for the GS2 development.

RPS has extensive experience in providing consultancy services for the offshore renewables sector. In summary, RPS has been, or is currently involved in, the following offshore wind projects:

- Burbo Bank
- Humber & Westernmost Rough
- Arklow Bank
- Gunfleet I *
- London Array *
- Scroby Sands
- Blyth Offshore
- West of Duddon
- Docking Shoal
- Long Island, US
- Cromer
- Solway Firth
- Scarweather Sands
- Walney**
- Sheringham Shoal**
- Shell Flats
- Rhyl Flats
- Kentish Flats
- Lynn
- Inner Dowsing
- Lincs *

* Lead consultants responsible for overall EIA process.
** Peer review of Environmental Statements

The Environmental Statement for this project has been prepared by the following consultants.

Organisation	Scope of Works
RPS	Overall EIA co-ordination Marine Ecology and Marine Mammals Nature Conservation Commercial Fisheries and Fisheries Ecology Archaeology Ornithology Unexploded Ordnance Water Quality Specification and QC of Geophysical Survey
ABPmer	Coastal Processes
Marico Marine	Navigation Risk Assessment
Landscape Design Associates	Offshore Photomontages Seascape and Visual Impact Assessment
Osiris Projects	Geophysical Survey and Benthic Grab Survey
Legal Advice	Hammonds

Table 1.2 List of contributors to GS2 EIA

1.4 Policy Context and the Strategic Need for Wind Power

The following section of the ES presents a brief summary of key global, European and UK policy and legislation related to renewable energy, in particular wind. This section is intended to provide the context for the proposed GS2 development.

1.4.1 Global Policy

In 1988 the United Nations Environment Programme (UNEP) established the Intergovernmental Panel on Climate Change (IPCC), in order to provide regular assessments of the state of knowledge on climate change.

The IPCC's initial Assessment Report in 1990 contributed to the development of The Kyoto Protocol to the United Nations Framework Convention on Climate Change (UNFCCC). This was adopted in 1992 and entered into force in 1994. The IPCC's second Assessment Report provided vital input to the process which ultimately led to the adoption of the UNFCCC in 1997.

Under the Kyoto Protocol, participating countries have agreed to limit or reduce their emission of greenhouse gases and have been assigned targets stipulating the maximum amount which they can emit per year over the Commitment Period (2008–12). Following Russia's ratification on 18 November 2004, the Kyoto Protocol entered into force on 16 February 2005.

1.4.2 European Policy

The European Council (2001) Directive 2001/77/EC relates to the promotion of electricity produced from renewable energy sources. Issued in September 2001, it commits Member States to setting national targets from renewable sources in terms of a proportion of total electricity consumption.

In 2005, the European Union set an initial target of generating 22 per cent of its electricity from renewable sources by 2010. This target will only be reached with a significant contribution from wind, which has the potential to meet up to 50 per cent of the target. More recently, on March 9th 2007, European Union leaders agreed to adopt a binding target on the use of renewable energy, including wind, within all 27 EU states. This target was set at 20% by 2020. During the same summit in Brussels, EU leaders also agreed to cut carbon dioxide emissions by 20% by the same date.

1.4.3 European Wind Capacity

With respect to the capacity within EU states for electricity generation from wind, in 2006 the cumulative wind power capacity operating in the EU increased by 19% and now exceeds 48,000 MW. In an average wind year this will produce approximately 100 TWh of electricity, equal to 3.3% of total EU electricity consumption.

For the seventh consecutive year, wind power is second only to gas-fired capacity (approximately 8,500 MW in 2006) in terms of new electricity generating installations.

The top five European countries contributing to cumulative wind power capacity at the end of 2006[2] were:

1. Germany (20,622 MW);
2. Spain (11,615 MW);
3. Denmark (3,136 MW);
4. Italy (2,123 MW);
5. UK (1,963 MW)[3]

Figure 1.2 below shows the amount of new wind installation (in MW) within the EU in 2006.

1.4.4 National (UK) Policy

As its contribution to the EU commitment to the Framework Convention on Climate Change, the UK is committed to greenhouse gas emission reductions of 12.5 per cent from 1990 emission levels by a date in the period 2008–12. However, the UK Government has set itself a domestic target for reduction of CO_2 emissions beyond this commitment to the EU. The domestic target is to reduce CO_2 emissions by 20% below 1990 levels by 2010.

[2]Figures courtesy of the European Wind Energy Association

[3] 2,000MW level exceeded in UK in February 2007.

In November 2000, the Government published the UK Climate Change Programme, which outlined the target areas and policies through which it intended to achieve these targets.

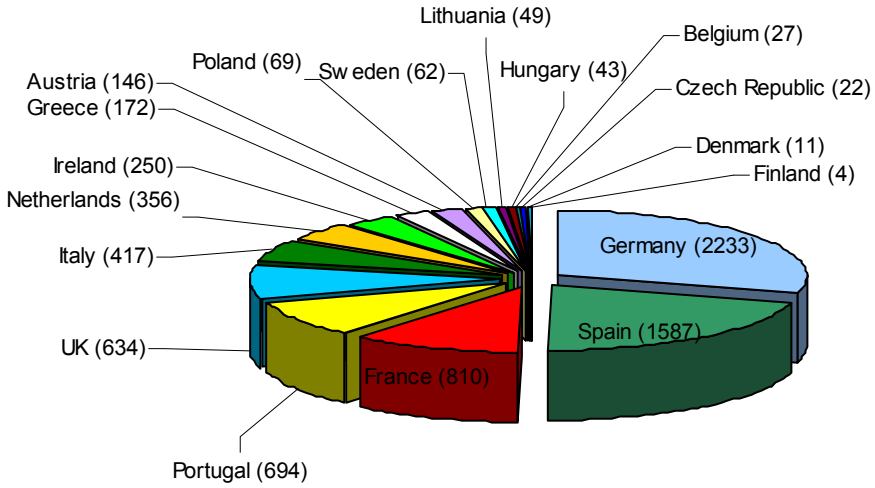


Figure 1.2 New wind installation (MW) in EU member states, 2006

The Climate Change Programme further states that its main objective in the energy sector is to work towards the target of obtaining 10 per cent of the UK's electricity supply from renewable sources by 2010, with an extension of this target to 15 per cent by 2015.

In February 2003, the Government also published an Energy White Paper, sub-titled, "*Our Energy Future – creating a low carbon economy".* This white paper identified three key challenges to UK energy supply; environmental; decline in indigenous supplies; and a need to update existing infrastructure. To address these challenges, four key goals were proposed, the first of which was to put the UK on a path to cut CO_2 emissions by some 60% by about 2050, with real progress by 2020.

More recently, in March 2007, the Government published a draft Climate Change Bill that sets out a series of measures intended to cut emissions of CO_2 by 60% by 2050. The draft Bill also includes proposals to make these carbon reduction targets legally binding.

The development of renewable energy is vital to the Government's CO_2 reduction targets, and provides benefits to the UK economy in terms of security of energy supply and economic development.

With respect to specific planning documents and policy, Planning Policy Statement 22 – Renewable Energy (PPS22), sets out the UK Government's policies for renewable energy. Local Planning Authorities should have regard for this document when preparing local development documents and when taking planning decisions.

1.4.5 UK Wind Capacity

Renewable energy sources in the UK now provide just over 5% of the total electricity supply, of which about half comes from wind (DTI, 2006). On the 9th February 2007, the Braes of Doune Onshore Wind Farm was officially opened by the Secretary of State for Trade and Industry, Alistair Darling. The commissioning of this facility took the UK over the 2 gigawatt level of installed wind capacity, in turn becoming only the seventh country worldwide to achieve this milestone.

The recently completed Energy Review (DTI 2006) reaffirms the UK Government's commitment to renewable energy and the Renewables Obligation (RO). The RO is the Government's main policy instrument for encouraging the development of renewable energy generating capacity. It has provided an impetus to meet the UK's target of achieving 10% of electricity production from renewable energy sources by 2010 and 15% by 2015. The Energy Review expresses the Government's aspiration to strengthen the RO to give longer-term certainty, including extending obligation levels to 20%. The Review gives particular support to offshore wind.

The development of offshore wind power is regulated through a series of Development Rounds administered by the Crown Estate, as landowner of the seabed to the territorial limit (12 nautical miles) and administrator beyond that limit.

Eleven Round 1 projects have been consented, totalling 1 GW of capacity. Of these, four are operational and three are being constructed. In December 2003 it was announced that 15 projects would be awarded Round 2 licences, with a combined potential capacity of 7.2 GW.

As of May 2007, three Round 2 projects have been awarded consents for at least the marine elements of the scheme. These are London Array, Greater Gabbard and Thanet, all in the Thames Estuary.

1.4.6 The Stern Review

2006 saw the publication of the Stern Review 'The Economics of Climate Change', an independent review to assess the evidence and build understanding of the economics of climate change. This was an independent review commissioned by the Chancellor of the Exchequer, reporting to both the Chancellor and the Prime Minister.

The review concluded that the scientific evidence for climate change is now overwhelming, climate change presents very serious global risks, and it now demands an urgent global response. The economic costs of doing nothing about climate change will be equivalent to losing up to 20 per cent of global GDP each year. All countries will be affected, but the poorest countries will suffer earliest and most. The benefits of strong, early action will considerably outweigh the costs.

The report states that policy to reduce emissions should be based on three essential elements: carbon pricing, removal of barriers to behavioural change and, of most relevance to this project, supporting the development of a range of low-carbon and high-efficiency technologies on an urgent timescale.

1.4.7 Regional Policy

Emerging regional guidance for the East of England region is set out in the East of England Plan – Draft revision to the Regional Spatial Strategy (RSS) for the East of England. The RSS sets out a strategy to guide planning and development in the East of England to the year 2021. Within the draft document, policy ENV8 – Renewable energy and energy efficiency set out planning advice related to renewable energy projects.

Following a review of the draft document by Government, changes were proposed to this policy, with policy ENV8 replaced by two separate policies (ENG1 – Carbon Dioxide Emissions and Energy Performance and ENG2 – Renewable Energy Targets).

Public consultation on the Government's Proposed Changes to this plan ended on 9th March 2007. Following consideration of responses to this consultation stage, the Secretary of State is expected to publish the finalised East of England Plan in mid 2007.

Details of Policy ENG2 are provided below.

Policy ENG2 – Renewable Energy Targets	The development of new facilities for renewable power generation will be supported, with the aim of meeting the following regional targets. **By 2010** – at least 1192 Megawatts of installed capacity for renewable energy. **By 2020** – at least 4250 Megawatts of installed capacity.

The targets outlined within Policy ENG2 are based upon a regional study of the capacity for renewable energy within the East of England region that was published in mid-2001[4]. This final report set two possible targets for 2010 – a business as usual target and an elevated target. Using the report's elevated target, it was concluded that renewables would supply 14% of Eastern region's electricity in 2010. This would be acheived mainly through the deployment of onshore and offshore wind and biomass plants.

Table 1.3 summarises renewable energy percentage targets for the East of England, based on the findings of this report[3].

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

Table 1.3 Reviewed renewable energy targets for 2010 and 2020 expressed as the percentage contribution of renewables to total electricity consumption in the East of England

1.4.8 Local Policy

The proposed GS2 development has no landward infrastructure associated with it as it will utilise the power export cable and land-based substation works that are already consented as part of the Gunfleet Sands 1 project. Therefore, no part of the proposed GS2 development is within the jurisdiction of the local planning authority, Tendring District Council. Even so, it is relevant to consider this proposed development in the context of local planning policies.

The Tendring District Local Plan was adopted by the council on 14th April 1998 and covered the period up to 2001. A Replacement Local Plan has now been developed that provides up to date planning policies and proposals to guide development up to 2011. A re-deposit draft of the Local Plan was published in 2005.

Policy EN13a of the re-deposit draft relates to Renewable Energy.

[4] East of England Sustainable Development Round Table: Making Renewable Energy a Reality: Setting a Challenging Target for the Eastern Region.

Policy EN13a – Renewable Energy	Planning permission will be granted for development proposals for renewable energy generation, subject to there being no material adverse impact on the local environment in relation to noise; vibration; smell; visual intrusion; residential amenity; landscape characteristics; biodiversity; cultural heritage; the water environment; the treatment of waste products and highway and access considerations.

At a broader, county level, the principal local planning document is the Essex and Southend-on-Sea Replacement Structure Plan (April, 2001). The following policy is of note within this plan.

EG2 – Renewable Energy Schemes	Proposals for renewable energy schemes will be permitted providing there is no materially adverse impact upon: 1. Existing land-uses by reason of pollution, odour, noise or loss of visual amenity; 2. The local highway network, including the convenience and safety of road users; 3. Telecommunications networks, radar installations and flights paths for aircraft; 4. Areas of Outstanding Natural Beauty, the Coastal Protection Belt, statutorily protected nature conservation sites, landscape character, historic settlements or buildings/areas of architectural importance. In relation to offshore schemes, the visual impact of associated onshore electricity transmission equipment should be minimised, preferably by the undergrounding of cables and servicing for the development should be from local port facilities.

1.4.9 Conclusions on Policy Context

The preceding sections provide a brief overview of various policy and legislative frameworks, on a global to local level, that have been implemented in order to facilitate and support reductions in carbon emissions. Specific reference has been made to the key role that renewable energy projects have to play in achieving these reductions in carbon emissions.

From this overview, it is possible to note that the proposed GS2 project fits well with existing policy and has the potential to play a key role in helping the UK achieve its targets of electricity generation from renewable energy schemes.

2. APPROACH TO THE ENVIRONMENTAL IMPACT ASSESSMENT

2.1 The EIA Process

The EC Directive 85/337/EEC as amended by Directive 97/11/EC (The EIA Directive) requires an EIA to be completed in support of an application for development of certain types of projects. Offshore wind farms are listed in Annex II of the Directive as "installations for the harnessing of wind power for energy production (wind farms)", and these provisions have been transposed into UK legislation.

Table 2.1 (below), lists the requirements of the EIA Directive, together with the location of this information within the ES.

EIA Regulations: Schedule 4, Parts I and II	Location within ES
A description of the development proposed, comprising information about its site and the design, size or scale.	Chapter 3
An outline of the main alternatives studied by the applicant, or appellant, and an indication of the main reasons for their choice, taking into account the environmental effects.	Chapter 3
The data required to identify and assess the main effects that the development is likely to have on the environment.	Chapters 4 - 19
A description of the likely significant effects of the project on human beings, flora, fauna, water, air, climate, material assets, cultural heritage and the interaction between these.	Chapters 4 – 19
A description of the likely significant effects of the development on the environment, which should cover the direct effects and any indirect, secondary, cumulative, short, medium and long term, permanent and temporary, positive and negative effects of the development resulting from: (a) the existence of the development; (b) the use of natural resources; (c) the emission of pollutants, the creation of nuisances and the elimination of waste. A description by the applicant of the forecasting methods used to assess the effects on the environment.	Chapters 4 - 19
A description of the measures envisaged to prevent, reduce and where possible offset any significant adverse effects on the environment.	Chapters 4 - 19
Measures to monitor these effects should the development proceed.	Chapters 4 - 19
An indication of any difficulties (technical deficiencies or lack of knowledge) encountered by the applicant in compiling the required information.	Chapters 4 - 19
A non-technical summary of the above information (this exists as a stand-alone document separate to this ES).	NTS

Table 2.1 Requirement of the EIA Directive (97/11/EC) and location of information within the ES

2.1.1 Electricty Act 1989

The need for an EIA for electricity generation projects requiring consent under Section 36 of the Electricity Act 1989 is provided for in England and Wales by the Electricity Works (Environmental Impact Assessment) (England and Wales) Regulations 2000. These set out the statutory process and minimum requirements for the provision of adequate environmental information to enable the likely significant environmental effects of the development to be assessed. Regulation 7 of the 2000 Regulations enables a written request to be submitted to the Secretary of State (SoS) to state his opinion as to the information to be provided with the ES (the scoping opinion).

2.1.2 Food and Environment Protection Act 1985

No regulations applying the EIA directive have been made under this Act. However, Section 8 of the Act requires applicants to provide the licensing authority with such information as it deems necessary to enable it properly to consider the application. The licensing authority's policy is that this information shall include the equivalent of a formal ES in support of all offshore wind farm projects to inform the process of impact assessment.

2.1.3 Harbour Works (Environmental Impact Assessment) Regulations 1999

An EIA is also required to satisfy the Harbour Works (Environmental Impact Assessment) Regulations 1999 where a scheme is proposed that is to be sited in or partly within a port or harbour.

2.1.4 Town and Country Planning Act 1990

The Town and Country Planning (Environmental Impact Assessment) (England and Wales) Regulations 1999 implement the EIA Directive, so far as it applies to development under the Town and Country Planning Act 1990. However, the proposed GS2 development would utilise landward infrastructure that is already consented via the GS1 project. Therefore, no additional landward consents will be required and an EIA under the Town and Country Planning Regulations will not be required.

2.2 EIA Guidance

Guidance on implementing the UK's EIA Regulations is provided in DETR Circular 02/99 Environmental Impact Assessment and also in the DETR's Environmental Impact Assessment: A Guide to Procedures, 2000.

Specific guidance with respect to EIA for offshore wind farms has been obtained from the following documents;

- Guidance Note for Environmental Impact Assessment in respect of FEPA and CPA requirements (Version 2 – June 2004; Marine Consents Environment Unit);
- Consultation for Offshore Wind Energy Developments: Best Practice Guidelines (BWEA, 2002);
- Guidance on Electricity Works (EIA) Regulations (DTI, 2000);
- Guidance Notes: Offshore Wind Farm Consents Process (updated August 2004; DTI and MCEU).
- Historic Environment Guidance for the Offshore Renewable Energy Sector. Wessex Archaeology, January 2007. Report commissioned by COWRIE Ltd.
- BWEA Recommendations for Fisheries Liaison. August 2004.

2.3 Identification of Likely Significant Impacts

The potential significant impacts associated with this proposed development have been identified through a variety of methods. These are listed below;

- Review of generic EIA guidance for offshore wind farms[5];
- Consultation with key stakeholders via issue of an EIA scoping report (see Section 2.4 below);

[5] CEFAS (2004). Offshore Wind Farms - Guidance note for Environmental Impact Assessment In respect of FEPA and CPA requirements Version 2 - June 2004.

- Meetings with key stakeholders;
- Review of the formal scoping opinion issued by the DTI (February 2007);
- Experience and expertise of the EIA project team.

2.4 Impact Assessment Methodology

In order to assess the potential impacts of the proposed GS2 development, the magnitude of the effect being assessed has been evaluated against the sensitivity of the receptor in question. In determining the magnitude of any given effect, the following have been considered:

- Spatial extent of the effect;
- Duration of the effect; and
- Frequency of the effect.

In terms of the sensitivity of the receptor, the following have been considered;

- Vulnerability of the receptor;
- Recoverability of the receptor; and
- Value/Importance of the receptor.

The significance of an impact has been assessed by combining the evaluations of the magnitude of a potential impact and the sensitivity of the feature affected as indicated in Table 2.2 (below). For example, an impact of low magnitude acting on a feature of high sensitivity is assessed as an impact of **Moderate** significance.

Magnitude of Effect			**Significance**	
	High	*Moderate*	*Moderate/Major*	*Major*
	Medium	*Minor/Moderate*	*Moderate*	*Moderate/Major*
	Low	*Negligible*	*Moderate*	*Moderate*
		Low	**Medium**	**High**
		Value and Sensitivity of Receptor		

Table 2.2 Matrix of magnitude of effect & value/sensitivity of receptor used to derive the significance of effect

Table 2.3 (below) provides definitions of the significance levels shown above.

Significance	Definition
Negligible	Very slight change from baseline condition. Change barely distinguishable, approximating to the "no change" situation.
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 on its scale and duration).
Major Adverse	The impact gives rise to serious concern and is judged unacceptable
Minor Beneficial	The impact is of minor significance but has some environmental benefits.
Moderate Beneficial	The impact provides some gain to the environment.
Major Beneficial	The impact provides a significant positive gain to the environment.

Table 2.3 Definitions of significance used within this ES

For certain discrete sections, including ornithology and marine mammals, slightly different impact assessment methodologies have been used. Where certain parameters use different methodologies these are outlined in the respective sections.

With respect to cumulative impact assessment, the EIA for GS2 has assessed the potential for cumulative impacts to arise;

- On their own, i.e. impacts developing over time associated with GS1.
- Cumulatively with all adjacent wind farm consented and proposed sites (Round 1 and Round 2);
- Cumulatively with any combination of the consented and proposed wind farm sites (Round 1 and Round 2) within the same SEA area and
- Cumulatively with any combination of all the above with other existing or proposed offshore developments.

2.5 Scope of the Environmental Impact Assessment

In order to assist the identification of environmental effects from the proposed GS2 development, a formal scoping exercise was undertaken and an EIA Scoping Report produced. This report was issued to key stakeholders in December 2006.

The objectives of this report were:

- To set out the overall approach to the EIA process;
- To identify the main aspects of the environment likely to be significantly affected by the construction and operation of the proposed GS2 development;
- To identify relevant environmental studies for the competent authorities and statutory consultees to consider;
- To set out a provisional contents list and structure for the ES for GS2; and
- To invite comments on (a) the proposed project and the (b) proposed scope of the EIA, from key stakeholders and consultees.

Details on the organisations that were issued with the Scoping Report are set out below in Table 2.4. Those organisations that responded to the scoping report are highlighted with an asterisk (*). All responses received are included within Appendix B. The Scoping Report was also issued to the DTI who undertook their own consultation process with key stakeholders.

The results of the DTI consultation were used to formulate the formal scoping opinion that was issued to DONG by the DTI in May 2007. The scope of this EIA is largely based upon the formal scoping opinion issued to DONG by the DTI.

2.6 Consultation Process

As part of the formal EIA process undertaken for this project, and in line with best practice for offshore wind farm projects, consultation has been undertaken with a wide range of statutory and non-statutory stakeholders at all stages of the project to date.

A formal scoping report was produced in December 2006 that was issued to the organisations listed below.

Organisation	
CEFAS	Chamber of Shipping *
DEFRA *	East of England Tourist Board
DTI *	English Heritage (HQ) *
DfT	English Heritage (Eastern England)
Natural England *	Essex Police Marine Unit
Environment Agency *	Essex Shellfishermen's Association
Essex County Council	Essex Wildlife Trust
Defence Estates *	Frinton and Walton Town Council
Tendring District Council *	Greater London Authority
Harwich Haven Authority	Harwich Fisherman's Association
JNCC	Holehaven Fishermen's Association
Kent and Essex Sea Fisheries Committee *	Honourable Company of Master Mariners *
Marine Fisheries Agency	Ipswich Borough Council
Maritime and Coastguard Agency *	ITC
National Air Traffic Services *	Leigh and Southern Fishermen's Association
Port of London Authority *	Leigh on Sea Shellfish Merchant's Association
Crouch Harbour Authority	London Port Health Authority
Royal Society for the Protection of Birds *	Maldon District Council
Royal Yachting Association – HQ *	Medway Ports
Royal Yachting Association, Eastern Region *	St Osyth Parish Council
Trinity House *	NTL *
Angling Skippers	Radio Communications Agency
Babergh District Council	RNLI
Blackwater Oystermen's Association	Rochford District Council
Bradwell Marina	St Osyth Parish Council
Crown Castle *	Thames Water
Brightlingsea Harbour Office	Thurrock Council
Brightlingsea Town Council	Walton Fishermen

Table 2.4 Organisations issued GS2 scoping report (* signifies response received)

Organisation	
BT *	West Mersea Fisherman's Association
Warwick Energy Ltd	London Array Ltd
Burnham and District Fishermen	Westminster Gravels Ltd
Cable & Wireless *	Colchester Port
Ofcom	Thames 21
Suffolk Coastal District Council	CSS
Colchester Borough Council	Greater Gabbard Offshore Wind Ltd
Civil Aviation Authority *	London Southend Airport *
Clacton Fishermen	Thurrock Thames Gateway Development Corporation *
T-Mobile *	Clacton Aerodrome
National Grid Wireless	NFFO
Orange *	Kentish Flats Ltd *
BBC – wind farms query tool*	

Table 2.4 (Cont'd)

In addition to written consultation, meetings have been held over the course of the project. These are summarised in Table 2.5.

Organisation	Date	Location
Defra/DTI	23.11.06 & 23.04.07	London
Local commercial fishermen	12.12.06	Clacton
Brightlingsea Harbour/RYA	13.12.06	Brightlingsea
Tendring District Council	13.12.06	Weeley
Kent and Essex Sea Fisheries Committee	22.02.06	Brightlingsea
RSPB	28.02.07	London
Port of London Authority	26.02.07 & 18.04.07	London
Trinity House	05.03.07	London
Natural England/Defra/DTI	21.03.07	London
MCA	22.03.07	Southampton
Local commercial fishermen	12.12.06 & 19.04.07	Clacton
CEFAS	01.02.07	London
RYA/Fishermen/Port of London Authority	12.04.07	London

Table 2.5 Meetings held during EIA process for GS2

All the consultation undertaken as part of the GS2 project has sought to maintain the clear lines of communication between the developer and key stakeholders established during the GS1 project.

2.7 Regulatory Context

2.7.1 Overview

It is important to note that this proposed development will utilise the same export cable as the GS1 project, which has already obtained all the necessary consents (both offshore and onshore). Therefore, the consents being sought for the GS2 development only relate to the construction of up to 22 additional turbines and the related inter-turbine cables, i.e. offshore works only.

It should also be noted that permission is being sought to move the location of the currently consented offshore substation. The reason for moving the substation is to obtain a logical and optimised design of the inter-turbine cable array for both phases 1 and 2.

Permission to relocate the offshore substation is being sought via an amendment to the existing FEPA and CPA consents for this structure.

2.7.2 Offshore Wind Farm Consents Process

It is intended to seek consents for the GS2 development under the following provisions:

- Section 36 Electricity Act 1989 – for the construction and operation of the wind farm. The scope of this consent will include the wind turbines and their foundations;
- Section 36A (I) Electricity Act 1989 (Declaration) – Where a consent is granted by the Secretary of State (SoS) in relation to the construction or operation of an offshore wind farm, he may at the same time make a declaration under Section 36A (I) of the Act as respects rights of navigation;
- Section 5 Food and Environment Protection Act (FEPA) 1985 Part II - consent for the placement of wind turbine foundations in the seabed and laying of cables between the wind turbines;
- Section 34 Coast Protection Act 1934 – consent from the SoS for the construction of the proposed development. The purpose of this consent is to ensure that works do not endanger the safety of navigation;
- River Works Licence from the Port of London Authority – so far as necessary for all parts of the development within the Authority's jurisdiction; and
- Section 95 Energy Act 2004 (Safety Zones) – Where a renewable energy installation is proposed to be constructed, extended, decommissioned or operated, or a renewable energy installation is being constructed, extended, operated or decommissioned, and the SoS considers it appropriate for safety reasons, he may issue a notice declaring that specified areas are to be designated as safety zones. Such zones are intended to secure the safety of the renewable energy installation or other installations in the vicinity during construction, operation, extension or decommissioning. Importantly, the purpose of the safety zone is also to secure the safety of individuals in or around the installation, vessels in the vicinity and individuals on such vessels. This is described further in Section 95 (2) Energy Act 2004.

The SoS may issue a notice either on application to him by any person or, where no such application has been made, on his own initiative – see Section 95 (3) Energy Act 2004.

A notice under Section 95 may provide for the safety zone to vary, specify prohibited activities and/or provide for vessels being permitted to enter the zone.

3. SCHEME DESCRIPTION

3.1 Location and Size of Development

The proposed development site is located on and immediately adjacent to a sand bank, known as Gunfleet Sands, which lies approximately 8.5km south-east of Clacton-on-Sea, Essex. The GS1 project, which is already consented, lies to the immediate north west of the proposed GS2 development. The total area of the GS2 development is 7.5km^2 (compared to 10km^2 for the GS1 development).

The boundary locations of the consented GS1 development and the proposed GS2 development are shown in Figure 3.1. This figure also shows the consented layout of turbines for GS1 and the proposed layout for GS2.

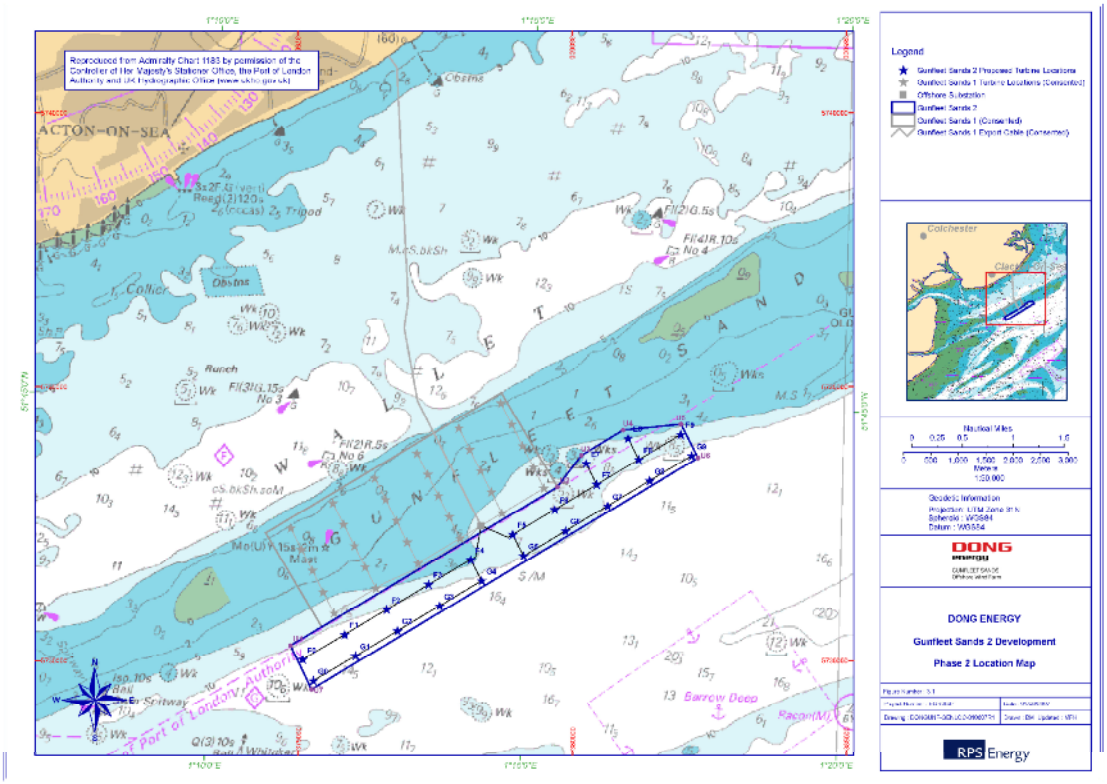


Figure 3.1 Proposed layout of GS2 (and consented layout of GS1)

The co-ordinates of the proposed GS2 turbines are listed in Appendix C.

3.2 Strategic Environmental Assessment (SEA) and Site Selection

In November 2002, the DTI published a consultation document 'Future Offshore' which outlined a proposed strategic approach to the arrangements for site leasing for offshore renewable development.

This report identified three areas, the Thames estuary, the Greater Wash and the North West, where potential for offshore wind development appeared the most promising. The Strategic Environmental Assessment (SEA) of these areas carried out on behalf of the DTI was completed in June 2003.

Crown Estate initiated a tender process for Round 2 in 2003 following the SEA process. One of the project categories covered extension projects adjacent to an existing Round 1 project. A proposal for an extension to the existing GS1 project was put forward by the developer Deltaic, which was subsequently acquired by GE.

One of the criteria in the Crown Estate tender process was that projects could not be located within an exclusion zone near the coast to comply with the findings of the SEA. This exclusion zone has a minimum width of 8km but extends to 13km in areas of particular sensitivity. The exclusion zone was proposed in recognition of the potentially higher sensitivity of shallow coastal waters to wind farm development, in particular the possible disturbance to birds, the visual impact from the shore, the potential impact on inshore fishing and recreational activities. Developers were able to tender for any sites within the boundaries of the Strategic Areas other than those located within this exclusion zone. In order to comply with this criterion, GS2 could only be located to the south of GS1, i.e. outside the 8km visual exclusion zone.

Following issue of preliminary information to stakeholders about the proposed location of the GS2 development, objections to the location of the site were raised by representatives of the local commercial fishing industry. Whilst not objecting to the scheme in principle, local fishermen did object to the proposed location of GS2, requesting that the site be re-located to the top of the Gunfleet Sands feature, as for the GS1 project.

Based on these representations by local commercial fishermen, preliminary investigations were undertaken by the developers to relocate the GS2 development within the SEA exclusion zone, so that the `new` turbines were also sited on the main sandbank. This option was discussed with the Crown Estate and the DTI. However, following these discussions with the Crown Estate, it was confirmed that locating any part of the GS2 development within this exclusion zone would not be permitted as this would conflict with the findings of the SEA process. Therefore, the proposed GS2 site remains in its original, proposed location.

3.3 Environmental Benefits

Once operational, the GS2 offshore wind farm will be able to provide clean, renewable electricity to approximately 45,000 households. Compared to electricity generated from coal fired power plants CO_2 emissions to the atmosphere will be reduced by approx. 180,000 tonnes when GS2 is operational. Likewise, reductions in SO_2 and NO_X will amount to 2000 and 600 tonnes respectively, when wind replaces coal as the energy source[6].

3.4 Site Layout

3.4.1 Site Layout Considerations

The positioning of the turbines for the GS2 project is dependent on the GS1 layout. The turbines will be positioned with the same distances and direction as GS1. The total area of GS1 is 10km^2 and 7.5km^2 for GS2.

[6] The numbers used for the calculations are taken from http://www.bwea.com/edu/calcs.html

The proposed site layout and pattern of the inter-turbine cabling array is presented in Figure 3.1 (above). A Coastal Protection Act (CPA) application was submitted in April 2007 to re-locate the position of the GS1 offshore substation for GS1 to a new location (still within the boundaries of the GS1 project). The rationale behind this application was that re-locating the GS1 offshore substation would enable a more logical inter-turbine layout for the GS1 project and make it possible for the GS1 and GS2 turbines to connect into the same substation.

3.5 Turbines and Foundations

3.5.1 Foundations

The GS1 project has consent for monopiles only, therefore the same foundation concept is proposed for GS2. It is likely that monopiles with diameters up to 5m will be used, with overall lengths of up to 75m and seabed penetration depth of up to 50m. Gravel/rock may be considered for scour protection purposes. Predicted dimensions and material requirements are set out below.

Dimensions	Examples of the steel monopile foundation dimensions are given below: • Outer shaft diameter: 4.5-5m • Shaft wall thickness: 0.06-0.1m • Overall length: 50-75m • Sea bed penetration: up to 50m • Weight (dry): 300-700 tons depending on depth
Material Requirement	Typical amounts per foundation: • Steel: 300-700 tons • Concrete for fixing of transition piece: 25-100 ton • Gravel/Rock for scour protection of monopiles: 150–1000 m^3
Seabed Preparation	Generally, will not be required, although some removal of obstructions may be required.

Table 3.1 Foundation details for proposed GS2 development

3.5.2 Scour Protection

There are two main design options to address above seabed erosion:
ØØ
1. Allow for scour in the design; or
2. Install scour protection such as rock dumping and/or matts.

The amount of local scour around a monopile without scour protection is expected to be less than 3-4 times the monopile diameter i.e. 20m radius of scour protection. Allowance for scour in the design will lead to increases in penetration depths and potentially wall thickness of monopiles, and therefore additional fabrication and handling weights, both leading to increases in the cost.

The use of scour protection of loose rock, rough gravel or mats around the base of the pile to a diameter of 3-4 times the pile is the most likely solution, though the choice of solution can only be made after detailed design of foundation, taking into account a range of aspects including soil data, tidal, depth of water, foundation option, maintenance strategy and cost of options. However, for the purpose of the EIA process, the use of scour protection, as described above, will be considered.

Installation will be undertaken using a specialised rock side dumping vessel. Once the vessel has positioned itself alongside the specified rock dump location the hydraulically operated dozer blades pushes the rock material over the ships side. Alternatively rock is transported to site by barge where it is then grabbed and dropped onto location by excavating bucket (either positioned on same barge or separate installation vessel).

The final option involves matts being transported to site on the installation vessel, whereby they are picked up and lowered onto location around the base of the foundation.

The integrity of the installation will be checked on a regular basis by inspection of scour protection which is likely to be undertaken at a frequency of 1-5 years. Maintenance of scour protection may require periodic installation of additional scour protection material.

3.5.3 Turbines

This section provides details on the actual turbines that are proposed to be installed for the GS2 project. It is proposed that similar turbines to those used for the GS1 development will be used for the GS2 project (see Table 3.2 for proposed turbine dimensions). A contract has been signed with Siemens to supply 3.6MW turbines to for GS1. The intention is to purchase the same turbines for GS2.

The total weight of a typical Gunfleet Sands turbine will be up to 1000 tonnes.

Phase	Turbine Size (MW)	Turbine size base case	Max hub height (above MHWS)	Max hub height (above LAT)	Max rotor diameter	Max height (above MHWS)
GS1 (108MW)	3.6	3.6MW	80	84	107	131
GS2 (64MW)	3.6	3.6MW	80	84	107	135

Table 3.2 Turbine sizes and dimensions for GS1 and GS2

Phase	Number of Turbines	Spacing	Turbine Size Base Case	Total MW
GS1 (108MW)	30	435 x 890m	3.6	108.0
GS2 (64MW)	22	435 x 890m	3.6	64.8 (will be reduced to 64MW to comply with Crown Estate lease agreement

Table 3.3 Turbine numbers and spacing

With respect to blade clearance (airdraft) figures, based upon a 3.6MW turbine with a rotor diameter of 107m, the airdraft at MHWS will be 22 metres. Although the consent for the GS1 project states that the clearance between lowest blade tip and sea level should be 20m at MHWS, the GS2 project will adhere to Royal Yachting Association (RYA) guidance[7] which recommends a minimum of 22 metres at MHWS.

[7] The RYA's Position on Offshore Energy Developments. December 2005.

Turbine	Rotor diameter (meters)	Maximum Hub height –MHWS (meters)	Maximum Tip height – MHWS (metres)	Air draft-MHWS (meters)	Air draft-LAT (meters)	Air draft-HAT (meters)
3.6 MW	107	81.5	135	22	~27	~22

Table 3.4 Airdraft figures for turbines

The wind farm will be designed and constructed to satisfy the requirements of the Civil Aviation Authority (CAA) and the Trinity House Lighthouse Service (THLS) in respect of marking, lighting and fog-horn specifications. THLS recommendations will be followed as described in "Renewable Energy Installation Farms and Fields-Provision and Maintenance of Local Aids to Navigation by Trinity House" and "IALA Recommendation 0-117 on the Marking of Offshore Wind Farms, edition 2, December 2004". CAA recommendations on "Lighting of Wind Turbine Generators in United Kingdom Territorial Waters", September 2004 will also be followed.

The project met with THLS on the 5th March 2007 where the markings, lighting and fog-horn specifications were agreed.

All the wind turbines would be marked with clearly visible unique identification characters which will be visible from all side of the wind turbine generators and will comply with requirements set out in Maritime and Coastguard Agency Marine Guidance Note MGN 275, i.e. they should be visible from at least 150m from the structure and be permanently lit by downlights to minimise light pollution.

The colour scheme of the turbine tower, nacelle and blades is likely to be light grey RAL 7035, white RAL 9010 or equivalent. The same colour scheme will be adopted for GS1 and GS2.

3.6 Electrical Infrastructure and Grid Connection

The only electrical infrastructure associated with the proposed GS2 development is inter-turbine cables. The GS2 project will utilise the marine export cable, which is already consented as part of the GS1 project, to bring electricity from the offshore substation to the onshore substation.

The electricity generated by the individual turbines is 690V, which is stepped up to 33kV for transmission from the turbine. 33kV electrical cables will lead directly through the turbines into the seabed. Small groups of turbines will be linked in series, with a cable leading to the offshore sub-station. This means that if the cabling for a particular turbine needs maintenance work, only a small group of turbines needs to be disabled.

3.7 Cables

The turbines will be connected to the step up transformers located in the offshore substation via a network of array cables that are laid between wind turbines and the offshore substation. The array cables will use a voltage of 33 kV. The total length of array cables for all phases will be approximately 34km. The cable type will most likely be a Sea-armoured 3 core copper XLPE cable.

For the connection from the offshore substation to the onshore substation, it is proposed that a 132 kV Sea-Armoured 3 core copper XLPE cable will be used.

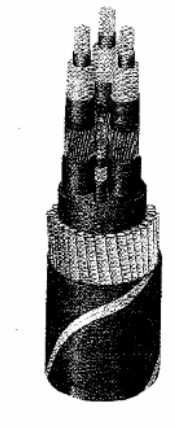


Figure 3.2 33 kV 3 core copper XLPE cable

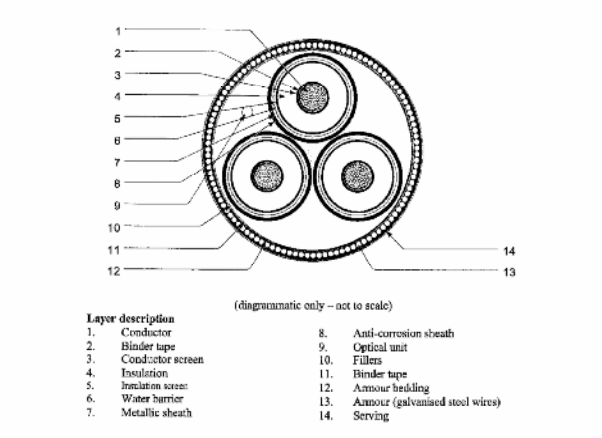


Figure 3.3 Diagram of 132 kV 3 core copper XLPE cable

3.8 Offshore SubStation

One 132/33kV offshore substation would be installed for both the GS1 and GS2 developments. It is proposed that the final substation is located in an alternative position in order to optimise the inter-turbine cable configuration. An application to re-locate the currently consented offshore sub-station was submitted by DONG in April 2007 (see Figure 3.1).

Figure 3.4 Offshore substation at Nysted Offshore Wind Farm (Denmark)

The medium voltage cables will be collected at the offshore substation and the voltage stepped up by transformers for onshore transmission. The proposed offshore substation is likely to comprise the following main components:

- Medium to high voltage transformer;
- Auxiliary transformers;
- Batteries;
- High voltage(33kV/132kV) GIS (Gas isolated) switch gear;
- Diesel generator and tank; and
- Accommodation (emergency, permanent or semi permanent. Subject to O&M strategy and safety case).

The GIS switchgear is isolated with approximately 70 kg SF6 to minimise the overall footprint and size of the substation. Each HV power transformer will contain approximately 80,000 litres of oil whereas the diesel tank will contain approximately 100,000 litres of oil. The equipment containing significant quantities of oil e.g. transformer, diesel generator and tank will be bunded with an open steel bund which can hold more than the complete volume of fluid.

Apart from the main equipment the offshore substation will include electrical panel boards for control and relays, communication, stock and workshop for regular spare parts and smaller reparations and emergency accommodation and safety equipment.

The total weight of the substation is expected to be up to 1200 tonnes. The structure will be marked similarly to the turbines in terms of navigation and aviation lighting.

3.9 Radar

In order to minimise any potential effects on the existing onshore radar mast supporting the Vessel Traffic System (VTS) owned and operated by the Port of London Authority (PLA) at Holland Haven, the project will install radar on the southeastern-most turbine of the proposed GS2 development. The provision of new radar was agreed as a mitigation measure within the GS1 project. Subsequent discussions with the PLA, have resulted in the agreement to mount this radar upon a turbine, therefore removing the need for an additional structure within the site.

3.10 Wind Farm Construction Details

3.10.1 Installation of Foundations

In the UK, the steel monopile is the most common foundation type used for offshore wind turbines mainly due to suitable ground conditions for the monopile option.

In the most frequently used version of the concept, steel monopiles are driven into the seabed from a jack-up barge using a hydraulic hammer which is available in various capacities for either operation above or below the water surface.

An alternative installation method includes drilling to assist piling operations ("drive, drill and drive"). Drilling may be applied where ground conditions make driving impossible or difficult. It is not predicted that the drive, drill, drive technique will be required on the GS2 site.

3.10.2 Installation of Turbines

With respect to the method of construction, installation of the turbines will typically comprise multiple lifting operations whereby the topside modules are lifted into position on an already installed foundation.

The topside modules (whether single or multiple) will be transported to site either on a transport barge where it will be lifted off and installed by crane on a separate installation vessel or will be transported to site on the installation vessel itself.

The installation vessel would either be of a jack up type or anchored floating vessel type.

3.10.3 Installation of Inter-Turbine Cables

The inter-turbine array cables may be installed using one of the three methods; ploughing, trenching or jetting.

1. Ploughing	A forward blade cuts through the seabed laying the cable behind. The blade and the cable are dragged by a cable laying vessel. Ploughing tools can be pulled directly by surface vessel or can be mounted onto self propelled caterpillar tracked vehicles which run along the seabed taking its power from surface vessel. Both methods may also be used in combination. The trench can either be backfilled post cable lay or during cable lay operation. **Note:-** That even if primary method eventually adopted of laying cables i.e. the export cable is ploughing there will still likely be local spots that will require jetting to bury and protect the cable i.e. for any jointing loops, corners areas whereby plough unable to negotiate, cable crossings, exposed cables etc.
2. Trenching	This method consists of three operations. First a trench is excavated while placing the sediment next to the trench. The cable is subsequently laid in the trench and lastly the sediment is returned to the trench. The sediment must not contain larger rocks. Trenching is a difficult, long and expensive method to use compared to other methods listed here however this technique may be required for small sections of cable runs where other methods are not practical.
3. Jetting	Two methods of water jetting are typically available; *Method 1*: The cable is laid on the seabed first and afterwards a jetting sledge is positioned above the cable. Jets on the sledge flush water beneath the cable fluidizing the sand whereby the cable by its own weight is sinking to the depth set by the operator. As the sediment is fluidized a minor amount of sediment spill is expected as compared to trenching. The sledge is moving forward by the force of the jets as they are aligned in backwards direction. *Method 2:* In this method water jets are used to jet out a trench ahead of cable lay. The cable can typically be laid into the trench behind the jetting lance. Jetting tools can be pulled directly by surface vessel or can be mounted onto self propelled caterpillar tracked vehicles which run along the seabed taking its power from surface vessel. Both methods may also be used in combination.

Table 3.5 Potential inter-turbine cable installation methods

3.10.4 Construction Phase Safety Zones

It is expected that a 500m safety zone will be established during construction around any installation where work is taking place. This is in line with DTI's consultation document on Safety Zones, published November 2006.

It is expected that the safety zone will encompass the entire wind farm area during construction. However, an alternative approach which might be used is the use of a rolling safety zone which is located around the area being constructed.

3.10.5 Transport of Equipment to Site

With regard to transportation, all major elements of the offshore scheme, including foundation piles, blades, towers and nacelles will be transported to the site by sea. There will be no requirement to transport any large-scale components of the proposed development by road.

A local port will be used as a construction, operation and maintenance base, with regular traffic to and from the GS2 site to this port.

3.11 Construction Noise

The following section provides details on the predicted noise emissions that will be generated during the construction phase of the proposed GS2 development. For the purposes of the noise assessment, the following key elements have been considered.

- Noise generated from foundation installation (via piling);
- Noise from general construction activity (non-piling);
- Noise produced by construction vessels;
- Noise produced from cabling; and
- Noise from the decommissioning phase.

3.11.1 Installation of Foundations

Steel monopiles will be driven into the seabed from a jack-up barge using a hydraulic hammer, which is available in various capacities for either operation above or below the water surface. For the purposes of this study, the foundation specification set out in Table 3.1 have been used:

The piling operations will generate both airborne and sub-sea noise and vibration. With respect to sub-sea noise, data on the noise generated from piling operations was collected over the period 10th July 2006 to 24th July 2006 from the Burbo Bank offshore wind farm site in Liverpool Bay. Subacoustech Ltd collected the data under instruction from COWRIE. The data collected is of relevance to the GS2 project as the monopile diamater at Burbo Bank was 4.7m, similar to that proposed for GS2.

All underwater sound recordings were undertaken using low noise Bruel & Kjaer hydrophones deployed from the side of the survey vessel. The hydrophone was attached to an anti-heave buoy, which trailed behind the boat. During sound recordings the survey vessel's engines and other equipment which might have interfered with the measurements, were turned off and the boat was allowed to drift

Broadband sound recordings were undertaken at incremental ranges from the construction operation. The first set of measurements was taken on 11th July at ranges from 100m to 15km along a transect line on a bearing of 310^{o}. The water depth along this transect varied from 7m in the immediate vicinity of the pile to a depth of 24m at 15km.

The unweighted peak-to-peak noise level data with range obtained during this construction operation is shown as 'Transect 1' in Figure 3.5. At measurement ranges from 100m to 5km, there was a high level of signal to noise, and the individual pile strikes can clearly be identified in the noise time history records. The data indicates that the unweighted peak-to-peak noise varied from 207 dB re. 1 Pa. at a range of 100m to approximately 143 dB re. 1 Pa, at a range of 5km.

Data was also recorded at ranges of 10km and15 km, but with the high background sea noise level on this night, the pile strikes are difficult to distinguish, and the data may therefore be influenced by the background noise.

The second set of data was obtained in the early hours of 16th July 2006. During this piling operation the sea state was slight with a low swell. Initial measurements were conducted at a range of 20km, along a bearing of 270° (Transect 2) in a water depth of 29m. Distinct pile strikes (good signal to background noise) were recorded at a level of approximately 135 dB re. 1 Pa. The survey vessel therefore moved out to a range 25km from the piling operation. At this range the individual pile strikes were audible on the instrumentation headphones, but were difficult to identify against the sea noise level in the noise time history data.

Figure 3.5 (below) shows the peak-to-peak un-weighted impact piling noise with range measured during construction of the Burbo Bank offshore wind farm (taken from COWRIE, 2006).

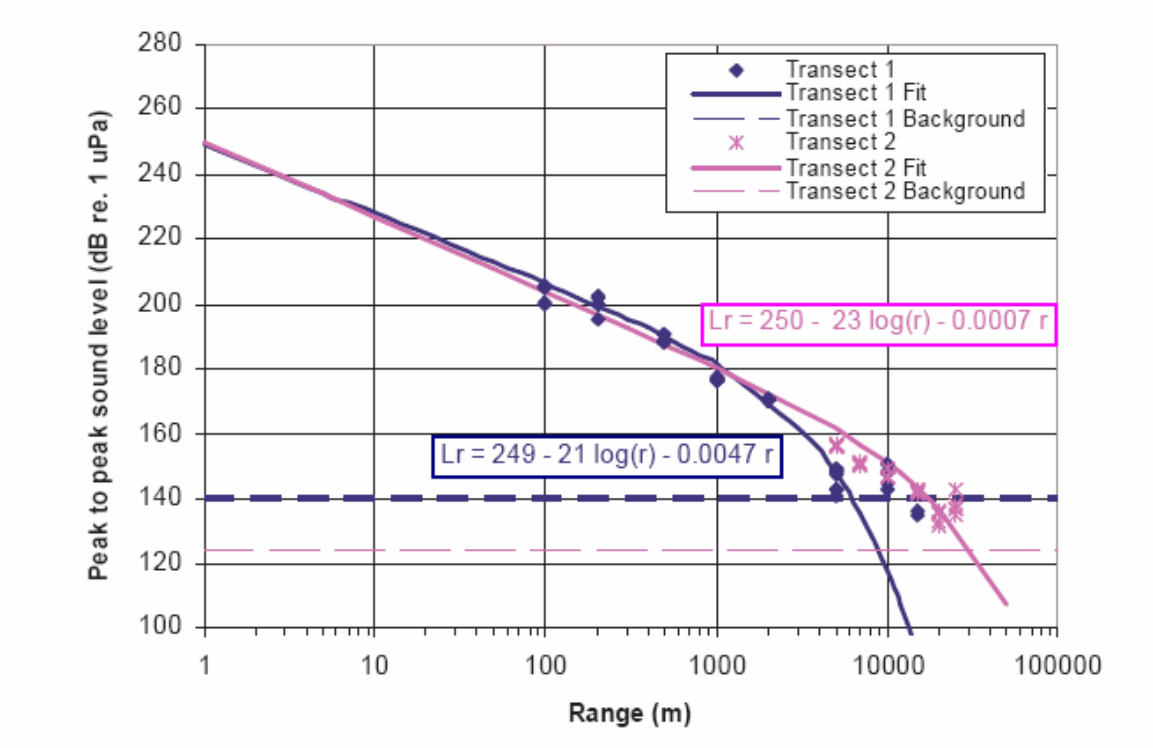


Figure 3.5 ***Peak to peak un-weighted impact piling noise with range measured during construction of the Burbo Bank Offshore Wind Farm (taken from COWRIE, 2006)***

Table 3.6 (below) summarises the measured noise data from the Burbo Bank monitoring survey and compares it with measured noise levels from other offshore wind farms.

Site	Pile Diameter	Measured Noise Data
Burbo Bank	4.7m	249 dB re. 1 _ Pa @ 1 m
Barrow	4.7m	252 dB re. 1 Pa @ 1 m
North Hoyle	4.0m	249 dB re. 1 Pa @ 1 m
Kentish Flats	4.3m	243 dB re. 1 Pa @ 1 m

Table 3.6 ***Measured noise data from UK offshore wind farm sites***

From table 3.6, it is possible to note that measured noise levels at Burbo Bank correlated well with the levels determined from measurements during construction of other wind farm projects.

There is, however, considerable variability in the propagation of this sound with range. The sound propagation data for Burbo Bank resembles that for other very shallow water sites with silt and sand banks, where the sound propagation is probably dominated by interaction with the seabed, resulting in both high geometric and absorption losses.

3.11.2 Noise from General Construction Activity

Based upon the principles and tabulated construction noise levels contained within BS5228 part 1, construction works associated with the turbine installation and cabling works would be approximately 88-91 dB $L_{Aeq,t}$ at 10m. These levels assume that a crane, pneumatic power tools, winching gear and generators are used.

Assuming that the percentage on-time of each item of plant is on average 50% of a working day, then the resultant daily noise level would be in the range 85-88 dB $L_{Aeq,t}$ at 10m. When combined with geometric spreading, the construction noise levels would be approximately 65-68 dB $L_{Aeq,12hr}$ at 100m and 45-48 $L_{Aeq,12hr}$ at 1km.

3.11.3 Noise from Construction Vessels

Construction vessels will be required to access the array site on a regular basis during the construction period. It is considered that the noise impact associated with these vessels is considered to be insignificant due to the already high levels of shipping traffic within the Thames Estuary.

3.11.4 Noise from Cabling

Inter-turbine cables may be installed using ploughing, trenching or jetting techniques. Regardless of the method adopted, the main noise source is predominantly the vessel itself and the on-deck operations. Using similar activities undertaken at Shoreham Harbour, in Sussex, predicted noise levels are in the range 65-75 dB LAmax at a distance of 200m from the cabling works. This noise is considered to be insignificant, compared to the noise of the construction vessels.

3.11.5 Noise from Decommissioning

During the decommissioning phase of the project, noise will be generated from the dismantling of the turbines and foundations. No significant noise sources are expected during this phase, apart from the use of vibrating hammers.

3.12 Operation and Maintenance

3.12.1 Operational Safety Zones

During operation a 50m safety zone may be required around each turbine structure in line with DTI's Safety Zone consultation.

3.12.2 Operational Phase Noise

Noise emissions from wind turbines can be separated into two categories; aerodynamic and mechanical noise. Aerodynamic noise occurs when the wind is passing the blades and mechanical noise is emitted from the engineering components of the turbine such as gearbox and generator. For the purpose of this assessment, it is predicted that the turbines will have a Sound Power Level (SPL) of no greater than 110 dB(A) at hub height measured according to BS EN 61400 111.

3.13 Decommissioning of the Site

DTI issued a consultation document in December 2006 on decommissioning of offshore renewable energy installations under the Energy Act 2004. The decommissioning process (as described in the DTI consultation document) is outlined in Table 3.6 below:

Stage 1	Preliminary discussions with DTI initiated by developer
Stage 2	Issue of a notice by the Secretary of State requiring a decommissioning programme
Stage 3	Detailed discussions; submission and consideration of a draft programme (including proposed financial security measures)
Stage 4	Consultation with interested parties; DTI conducts decommissioning Appropriate Assessment (where appropriate)
Stage 5	Formal submission of a programme and approval under the Energy Act
Stage 6	Reviews and modification of decommissioning programme (and any financial security); review of conduct or decommissioning; Appropriate Assessment (where necessary).
Stage 7	Undertake approved decommissioning programme
Stage 8	Monitoring of site

Table 3.6 Proposed decommissioning process for offshore renewable energy installations

DONG will ensure that the financial security required by DTI will be established for decommissioning of the wind farm.

3.13.1 Decommissioning of Turbines

Preparation before removal from foundation/transition piece will typically include;

- Removal of all loose Items from the structure;
- Disconnection of required electrical control and power cables;
- Removal of liquids such as lube oils / transformer liquids etc;
- Installation/certification of lifting points; and
- Hot bolting key bolts to aid unbolting process.

Once the preparation scope has been completed, it is expected that the tower, blades and Nacelle will be removed by crane in reverse process of their installation. Sections, once removed, will be placed onto a transportation barge that will transport them to shore, where materials will be recycled wherever possible.

3.13.2 Decommissioning of Steel Monopile Foundations and Transition Pieces

Monopile/transition pieces will be removed by cutting the monopile at an appropriate depth such that any pile remains left in the ground are unlikely to be uncovered. It is expected that cutting will be achieved by use of high pressure water/grit jetting from the inside of the monopile, in the following manner;

- The seabed within the monopile is excavated to approximately 1m below required cutting depth. Excavated soil which would be sand and silt through which the pile was originally driven, would be disposed of on the seabed adjacent to the pile. Such material is native soil and therefore uncontaminated;
- A remotely operated High pressure water/grit cutting tool is set up within monopile at appropriate cutting depth;
- Monopile /Transition piece is rigged up onto the decommissioning vessel crane;
- Monopile is internally circumferentially cut at appropriate depth;
- Upper cut section of monopile(including Transition piece) once cut free is lifted out of water and placed onto Jack up vessel deck or floating barge; and
- Batch of recovered monopile/Transition piece sections are transported to shore for recycle.

The material around the monopile may very well be consolidated and (depending on depth of cut) require significant crane capacity to remove. In bad cases, it may be necessary to use vibrating hammers as part of removal process to assist in separating the material from the pile.

Other methods of cutting the monopile, which are also possible, include;

- Wire Cutting - This involves cutting through the monopile with steel cutting wire. The cut would be carried out from the outside of the pile, requiring external excavation to an appropriate cutting depth. The requirement to first remove scour protection from around the base of pile makes this option less attractive; and
- Explosives - Explosive cutting is also a well known method but it is not expected to be first choice.

3.13.3 Decommissioning of Offshore Cables

The intention would be to only remove those offshore cables, sections of offshore cables or cable ends which are uncovered. This will be determined by survey prior to decommissioning of the site. Cables in this category will be removed by lifting cable ends onto the cable retrieval vessel and the cables will be spooled back onto a drum.

A water jetting or similar tool would typically be required to assist the retrieval of buried cables. Any sub-sea trenches left after cable removal will be filled by natural tidal action.

Exposed cable ends where a foundation has been removed will be buried to a suitable depth, if the cable length is expected to remain covered and total cable removal is therefore not required the reburying of cut cable ends is likely to be carried out by remotely operated vehicles. Recovered cable will be stripped and recycled.

3.13.4 Decommissioning of Scour Protection

Seabed scour protection materials would not be removed during decommissioning. By their nature these materials would be difficult to recover and should provide useful marine habitat.

4. COASTAL PROCESSES

4.1 Introduction

This section of the ES provides an overview of the marine physical environment drawing extensively on a wealth of data, surveys and technical studies provided to both the Round 1 and adjacent Round 2 offshore wind farm development proposals. The structure for this section includes a review of:

- Geology;
- Geomorphology;
- Coastal Process; and
- Water Quality.

The majority of the information presented in the following section is derived from the dedicated coastal process assessment produced for this project by ABPmer. The full report is presented in Appendix D.

4.2 Consultation

The project scoping report (DONG Energy, 2006) has facilitated a process of stakeholder consultation and drawn out a range of site specific interests and issues to confirm the requirements for further EIA investigations.

The scoping report outlines the methodology for additional coastal process studies assuming that the project can be regarded as an extension to the Round 1 development that has already gained consent for the major part of the total development. All effects already assessed from the 30 monopiles case can therefore be scaled-up to reflect the moderate increase in turbine numbers. No additional modelling is required as the assessment of effects for the GS2 development are considered to remain as described, being small-scale and localised to each structure, i.e. there is no larger array effect.

On this basis, a three-staged approach has been undertaken for the EIA:

1. The description of the far-field baseline conditions remain as reported for GS1;

2. The description of the near-field baseline is extended to encompass the revised layout and updated to reflect new data and understanding obtained since the publication of the GS1 ES in 2002; and

3. The assessment of the likely significant impacts is drawn on considerations already provided from the original coastal process assessment and has been updated to consider the additional monopiles proposed for GS2. In addition, the further sediment data recorded at for sites within the GS2 boundary provide the basis for determining local scour and describing sediment mobility.

In regards to the marine physical environment key comments received from consultees are summarised below in Table 4.1.

Consultee	Comment
Port of London	Although the Outer Thames channels and banks are considered to be generally historically stable, some of the cross-bank channels have a tendency to migrate over time. The Spitway channel may, as a result of migration, therefore move towards the proposed turbines. This issue should be addressed within the coastal processes study within the EIA. The scoping report makes no reference to any sand waves or other mobile bed forms across or around the bank. Further information should be provided on this issue within the EIA. The scoping report makes no reference to the potential for scour around the turbine foundations. Further information should be provided on this issue within the EIA. We will include a consideration of scour in our studies.
Defra	Cefas would agree that the technical report produced for GS1 and its findings (ABPmer 2002) are directly applicable to GS2, in relation to the hydrodynamic regime and sediment transport. The three-stage approach proposed will be acceptable to address the coastal processes element of the EIA.
Natural England	The scoping report suggests that coastal and sedimentary process will be adequately covered in the EIA, but we welcome the developer's intention to agree the scope and detail of modelling work with CEFAS and the Environment Agency. We would also recommend that the effects of predicted sea level rise should be taken into account when quantifying the existing and projected wave and tidal conditions at and around the wind farm site.

Table 4.1 Stakeholder interests related to physical environment

4.3 Data Sources

The description of the local marine physical environment has been supported by a comprehensive set of contemporary data sets and information which has previously been collated for studies related to GS1. This includes a range of site-specific data sets:

- Broad scale sediment maps (BGS, 1990);
- Surficial sediment sampling (Titan, 2002a);
- Metocean surveys (Thales, 2002);
- Geophysical surveys (Titan, 2002b);
- Geological overview (BGS, 2002); and
- Coastal process investigations (ABPmer, 2002).

In addition, broader scale studies and recent research studies have also been reviewed:

- Contemporary navigation charts (UKHO, 1968, 1992);
- Broad-scale description of sediment transport (HR et al, 2002);
- Potential effects of offshore wind developments on coastal process (ETSU, 2002);
- Sandbanks, sediment transport and offshore wind farms (Kenyon and Cooper, 2004);
- Assessment of potential impact of Round 2 offshore wind developments on sediment transport (ABPmer, 2005a);
- Generic research on seabed morphology and offshore wind farms (CEFAS, 2006); and
- Generic research on wave effects and offshore wind farms (CEFAS, 2007).

4.4 Project-Specific Survey

A suite of new surveys has been completed to address specific gaps in available data across GS2. These new surveys include:

- Additional sediment sampling and analysis (ABPmer, 2005b);
- Geophysical surveys (OSIRIS, 2006); and
- Geotechnical surveys (Seacore, 2004).

The combination of existing data, information and new project specific surveys provides a comprehensive body of evidence to support the EIA.

4.5 Description of Existing Environment

4.5.1 Geology

The understanding of local geology has been gained from an overview produced by BGS (2002), along with the site specific geophysical and geotechnical surveys. For the purposes of the EIA, the geological evidence provides detailed descriptions of the sub-soil conditions into which monopile will be piled.

Gunfleet Sand lies on the northern side of the London Basin Syncline and the solid geology underlying the Quaternary sediments on the bank generally comprises the London Clay Formation. However, due to a small, local, eroded anticlinal flexure trending north-west to south-east, only basal members of the London Clay Formation, such as the Harwich Member and older Palaeocene Woolwich Beds, are likely to be found underlying the sand bank within at least part of the wind farm development site.

Gunfleet Sand is likely to have been formed during the Holocene transgression. With rising sea level there would have been an increasing supply of sand released from the eroding coastline. An initial accumulation of sand, perhaps associated with an obstruction at the sea bed, is likely to have formed sand ribbons, which in turn would have progressed to a smooth or rippled sand sheet. With a further supply of sand, this would have graded to megaripples and elongate trains of small sand waves. With increasing sea level and as more sediment became available for transport, the linear sand bank would have been formed. It is not known at exactly what stage in the Holocene transgression the present tidal system established itself, thus dating the formation of Gunfleet Sand poses a difficult problem.

In broad terms, however, it is thought that although the North Sea had reached its present configuration by about 7,000 years BP, the Thames Estuary had not developed to its present gross configuration until approximately 5,000 years BP.

The interpretation of survey data provides details of the geological succession across the area. These detailed are summarised in Table 4.2, with an example of these sequences shown in Figure 4.1.

Unit	Description	Thickness (m)
I	Top layer of cross-bedded Holocene SANDS, with intermittent layers of soft clay, making up the main features of the Gunfleet Sand area.	10 - 14m across site. No discernible trends.
II	Quaternary (Pleistocene) deposits, comprising mainly soft to firm CLAY with sandy layers, together with intermittent layers of dense SAND and GRAVEL, which generally occur towards the base of this section. Acoustic masking occurs within this unit and is most likely caused by the presence of biogenic gas, created by the decomposition of organic matter within the sediments.	4 - 9m. Thicker along southern boundary and towards west.
III	Stiff to very stiff fissured CLAY of the London Clay Formation (Eocene). These beds are characterised by the presence of small-scale faulting, which can be clearly seen on much of the geophysical data. This material is generally only present to the south and west of a distinctive monocline feature, which traverses the GS1 site from west to east, veering towards the south east to cross the GS2.	3-15m. Significantly thicker to east.
IV	Dense to very dense SAND and GRAVEL (Woolwich Beds - Eocene). These beds include an intermittent uppermost hard layer thought to represent the Harwich Stone Band. These strata may contain coarser grained materials up to boulder size.	Not fully penetrated everywhere, but maximum thickness greater than 30m
V	Stiff to very stiff CLAY of the Thanet Formation (Eocene). These beds are present across the whole area, but are generally shallower in the north and east, due to their uplift during the formation of the monocline feature.	5-12m, but only detected in 4 locations. Could be present only as isolated “lenses”.
VI	The CHALK of Upper Cretaceous age. Chalk was identified in only four of the boreholes and its interface with the overlying Eocene beds is difficult to identify on the geophysical data. The borehole data indicates that the upper surface of the Chalk is covered by a thin layer of flint gravel	Found at BH16, BH22, BH26 and BH28, only, and at depths from 40 to 48m.

Table 4.2 Geotechnical units identified within the Gunfleet Sand development area (RPS, 2004)

The key consideration from the geological review is that the underlying geology appears suitable for direct piling methods and there is no anticipation for drilling and arisings. In addition, the potential for scouring around the monopile foundations remains within Unit I of Holocene sand.

4.5.2 Geomorphology

Geomorphology is considered here as net changes in the arrangement of large-scale coastal features measured over contemporary timescales. The primary geomorphological features are the sandbank itself and its surrounding sandwaves.

Gunfleet Sand extends from the southern end of the Dengie Peninsula for approximately 40km to the ENE, and is between 2.5 and 3.5km wide. At its inshore end it includes Buxey Sand, and its most north-eastern tip is enclosed by Goldmer Gat. At the head and tail of the bank dries at low tides, elsewhere depths are generally >0 to 2m CD. The bank is steeper on the north-westerly facing slope than the south-westerly facing slope.

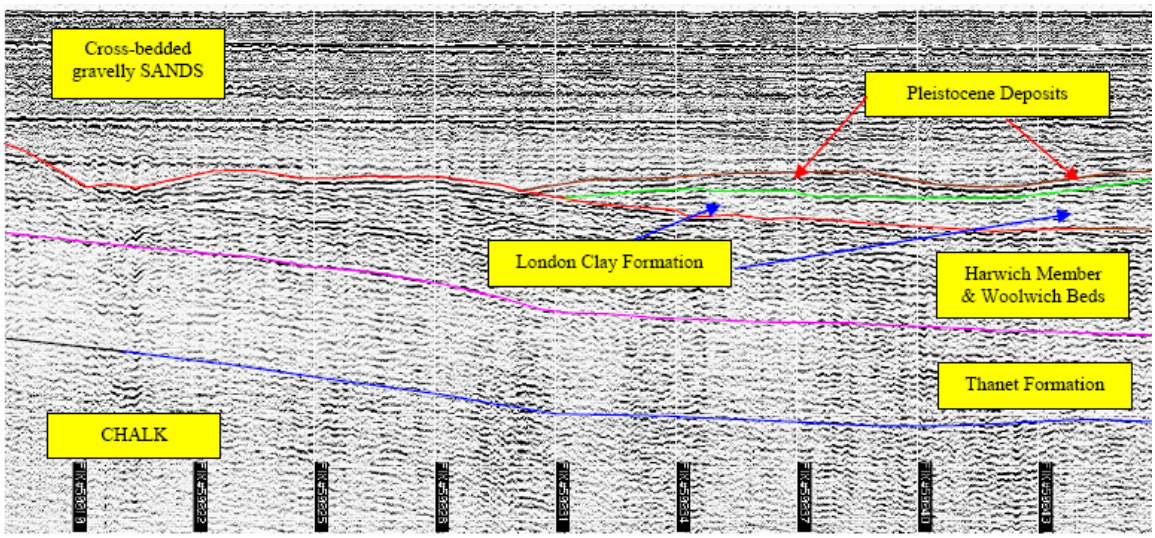


Figure 4.1 Sub-bottom geophysical profile showing variation of geotechnical units (OSIRIS, 2004)

Evidence of contemporary change of Gunfleet Sand can be assessed from sequences of surveys of the seabed. In the present case, the available data is in the form of editions of navigation charts for the local area and detailed site-specific surveys of the wind farm site.

4.5.2.1 Chart comparison

Evidence on changes in the macro form of Gunfleet Sand is limited to two periods of modern survey (single beam echo sounder) undertaken to produce Admiralty Chart 1975: Thames Estuary – Northern Part. The pre-metric chart was produced from surveys up to 1968 and illustrates Gunfleet Sand in much the same position as the later chart which is based on surveys completed between 1985 and 1988.

It is to be noted that the 1968 chart illustrates the bank with extensive drying areas along its entire length, including the position of the old lighthouse where the level of the bank is recorded as 3 feet above CD. In comparison, the more recent chart shows this site to be permanently covered by the tide in an approximate depth of 2.6m below CD of water, a change of depth of around 3.5m. This local reduction is also generally represented across the majority of the length of the bank, with drying areas now limited to 'seaward' and 'landward' ends of the bank. The total drying area has reduced by around 74% of its original plan area over a 20 to 23-year period and by average depths of around 1m. However, the overall position of the bank remains unchanged.

For the area of the wind farm, the following observations are provided:

- In 1968 the top of the bank is represented on the chart as a relatively flat feature with drying heights that cover around 40% of the GS1 site. From the 1985 survey onwards, there are no longer any drying areas within the GS1 site;
- The approximate increase in depth between 1968 and 1985 is around 1m over the length of the bank;
- Towards the 'eastern' end of the development site the depth contours have narrowed on the top of the bank from 1968 to 1985 leading to some apparent 'reshaping' of this part of the bank. In the same part of the bank the gradient on the southern flank has reduced;
- In contrast, the other major sand banks within the Outer Thames Estuary (shown on Chart 1975) indicate far less change in form and loss of drying areas than Gunfleet Sand, although general losses are evident throughout the area; and

- From consideration of the wave and tidal regime, it is possible to identify a mechanism whereby refraction effects of offshore waves moving down East Swin focuses wave energy towards GS1 and GS2. This mechanism would remain active through the majority of the tidal cycle, as it is not fully limited by low water sheltering from adjacent banks.

4.5.2.2 Comparison of local surveys

Two surveys are now available across the area local to GS1 and GS2, although the overlapping coverage remains slightly different between each survey. These surveys span the period 2001 to 2005 and involve high-resolution surveys which are able to map out finer scale bedform features, such as sandwaves (see Figure 4.2). Table 4.3 provides a schedule of these geophysical surveys which includes bathymetry and sidescan data collection.

Date	Coverage	Method	Bathymetric line spacing	Reference
2001	GS1	Single beam	50m	Titan, 2001
2005	GS1 & GS2	Multi-beam	Full coverage	Osiris, 2005
2007	GS1 & GS2	Multi-beam	Full coverage	Osiris, 2007

Table 4.3 Schedule of geophysical surveys

This survey evidence indicates that from the shallow crest, the bank steepens down its north flank into the Wallet in a fairly regular manner. There are signs of ridges on the seabed at this point which are interpreted as well-cemented planar and cross-bedded sands, providing the ability to maintain the steep slope. This relatively firm substrate forms the base upon which there is a surface layer of mobile sands. The dynamic nature of the seabed is evidenced by the transitory arrangement of small sandwaves and ripples.

Observed bedforms are represented as ripples and megaripples with crest orientation in a general north to south alignment. Crest heights vary between 0.2 to 0.9m and wavelengths in the range 9 to 16m. The asymmetry in these features indicated a south-westerly transport direction along the southern flank and north-easterly direction along the northern flank, although certain features are reported as symmetrical, particularly near the crest of the bank. On the central part of the bank, and in the area where mobile sediments are thickest, a sequence of sandwaves was observed during part of the 2001 survey, however, these features were not evident later in the same survey and after a period of bad weather.

It is important to note that the 2001 survey offers a lower resolution than that obtained in 2005, and additional data has been obtained from PLA to provide coverage across GS2 consistent with the 2005 survey.

The following comments can be offered from a comparison between these two surveys:

- The general shape of the bank in this location has remained consistent with a shallow slope from East Swin towards a narrow crest on the northern side of the bank and running down a steeper slope into the Wallet;
- The flattest area of the site is on the western side; and
- Between the two surveys some local changes can be seen in bed levels related to movement of the mobile sands.

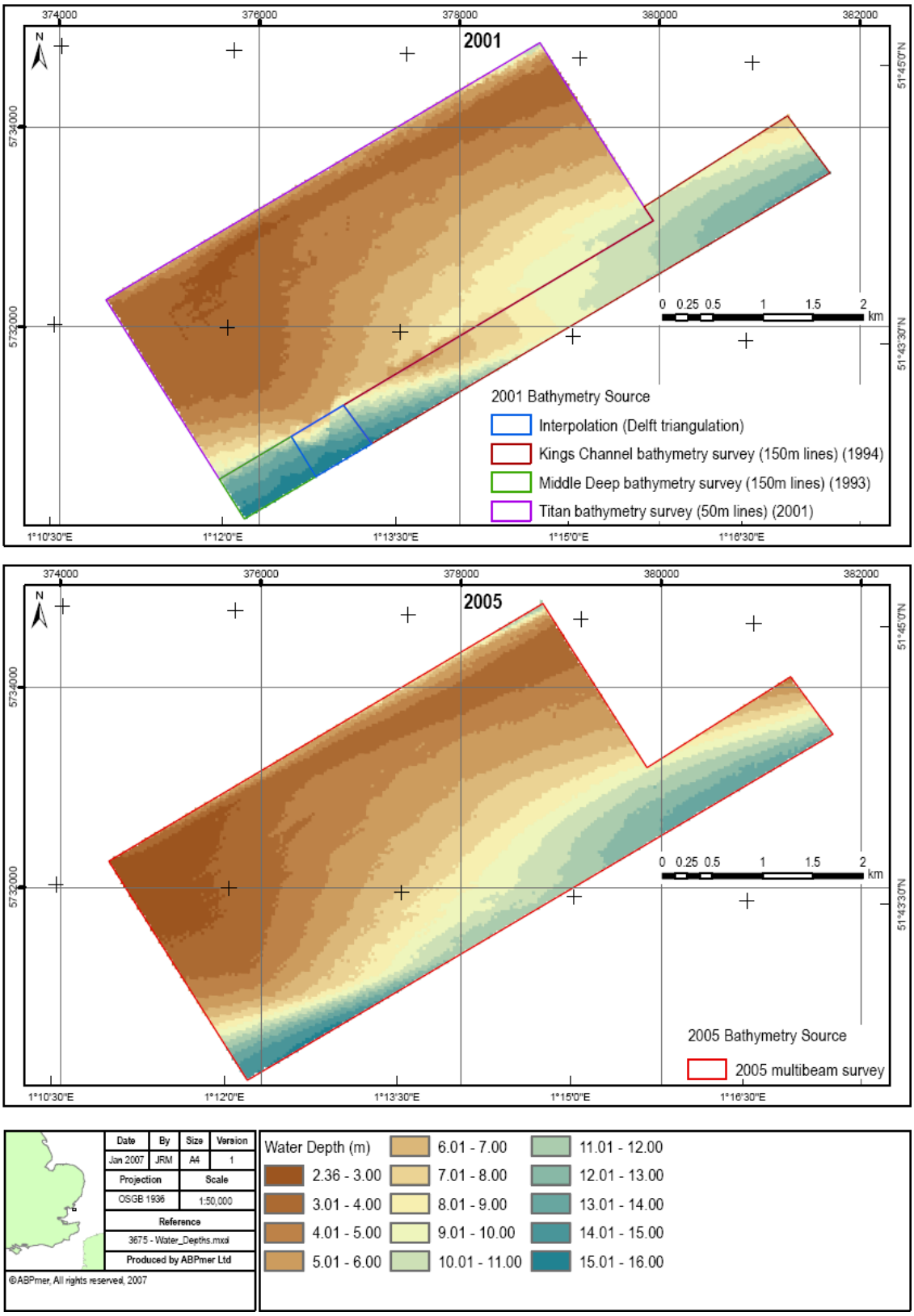


Figure 4.2 Comparison between 2001 and 2005 surveys

Further seabed features can be resolved from the geophysical surveys which includes the identification of several wrecks. In some cases, and especially where prominent structures protrude above the seabed, then local scour can develop. Figure 4.3 shows an example of such scour around a wreck feature which is close to the location of the proposed radar mast within GS2. For this example the shallow scour 'tail' extends around 120m from the structure.

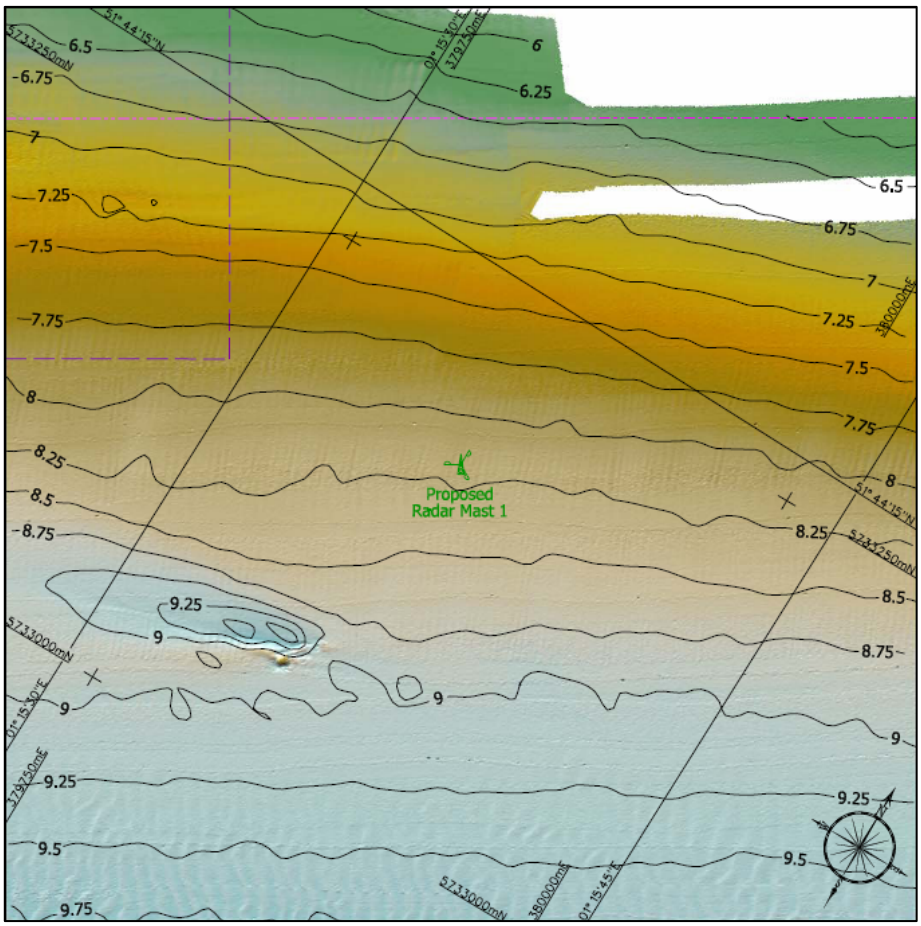


Figure 4.3 Local scour observed around a wreck (OSIRIS, 2005)

4.5.3 Coastal and Marine Processes

4.5.3.1 Tidal Regime

The Outer Thames Estuary is open to tidal influences from both the North Sea and English Channel, with the latter only exerting a moderate influence. The tidal range amplifies slightly as it moves into the Thames, and locally the tidal range on Gunfleet Sand is around 4m on springs and 2m on neaps. It is only on the extreme low waters that localised drying areas are revealed on the banks.

The pattern of tidal flows through the Thames follows the alignment of the various banks and channels. Locally there is a net residual clockwise circulation around Gunfleet Sand, with ebb dominance through the Wallet and flood dominance along East Swin.

A metocean survey provides details of variation in local water levels, currents and waves at four sites over the period January 2002 to February 2003. Figure 4.4 indicates the relative location of each deployment, noting that the most eastern deployment (January to July 2002) resides within GS2.

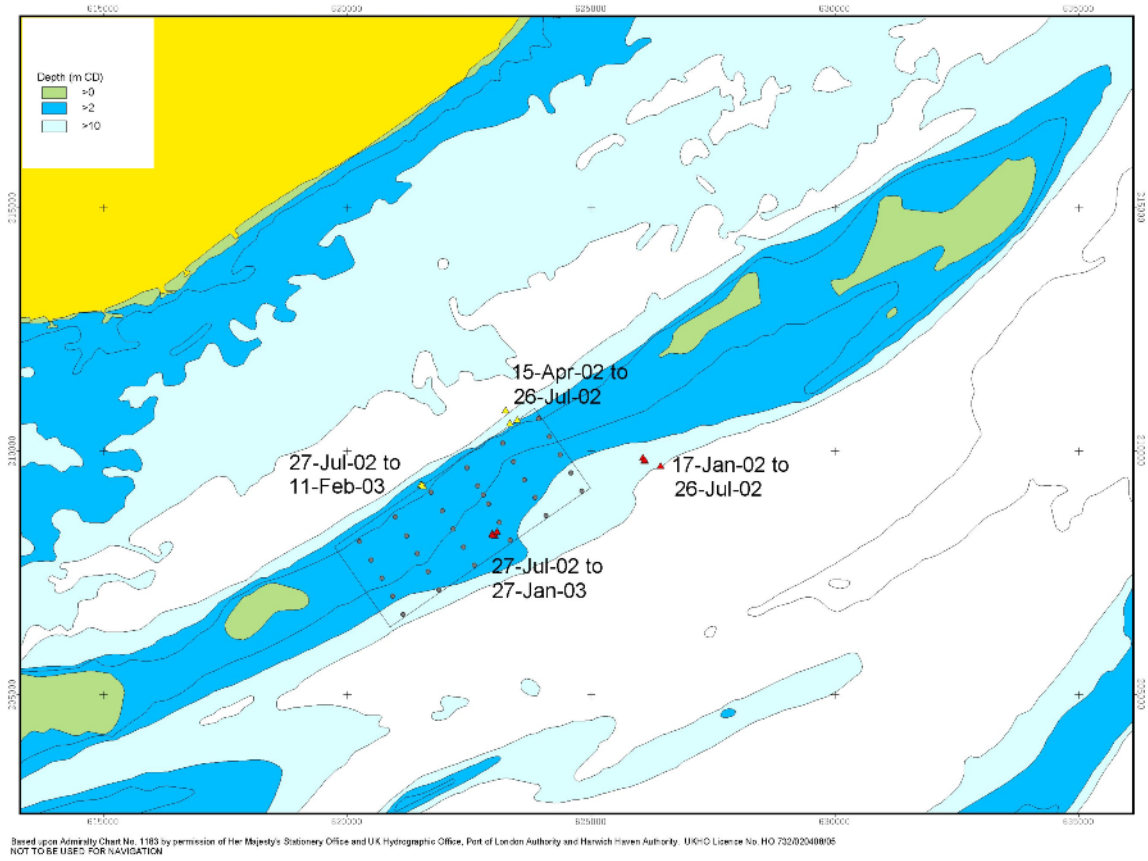


Figure 4.4 Location of metocean deployments

The main observations from the tidal measurements are:

- Stronger currents are observed at the northern sites, with a maximum near bed flow of 0.94m/s; and
- The ebb tide is stronger at the northern sites, and the flood stronger at the southern sites confirming the clockwise circulation around the bank.

4.5.3.2 Surges

Surges are meteorological effects which are superimposed onto tidal movements. The effect of North Sea surges in the Thames Estuary can lead to quite a pronounced variation from the predicted tidal level and with near comparable amplitude.

Previous analysis of surge records demonstrates that surge levels in the North Sea in general are amplified progressively as they propagate southwards with the tide and towards the Thames Estuary (Prandle & Wolf, 1978 and Heaps, 1993). This interaction with the tide generally leads to the peak surge level in the Thames Estuary being in phase with the flood tide.

Evidence for surge influence on local tides is seen in the water level measurements from Walton-on-the-Naze. Data for the period 2000 to 2002 have been provided by PLA and includes analysis of non-tidal effects. These data also demonstrate that, for the period of events considered, the peak surge level is consistently observed on the flood tide. An illustration of the largest positive surge recorded during this period of data is provided in Figure 4 for an event commencing on 29 January 2000 around midday. This event peaked initially on the evening flood tide and then reached a maximum surge level of 1.82m on the following flood tide the next day. The duration of this particular positive surge was over 24 hours, which is not untypical for the North Sea.

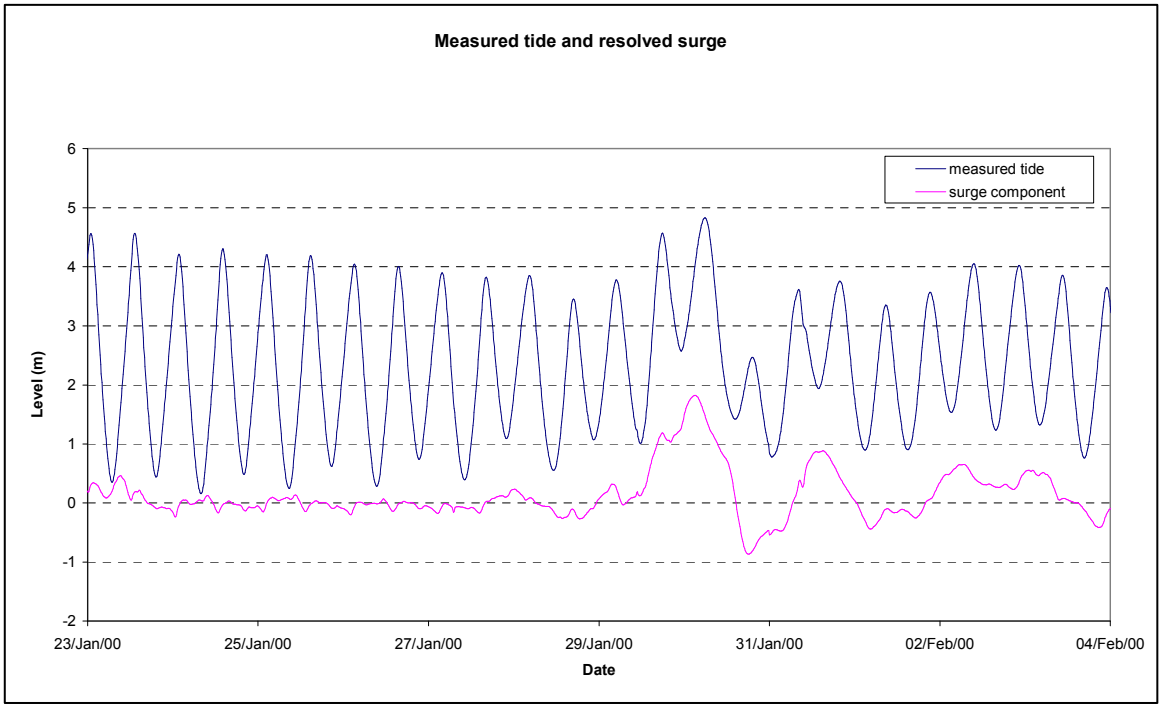


Figure 4.5 Measured surge events at Walton-on-the-Naze

The main consequence of a large positive surge is to elevate water levels over the duration of the surge period, but with minimal effect on the tidal range. Consequently, these type of surges result in little net effect on tidal flows.

4.5.3.3 Wave Regime

The wave regime within the Outer Thames Estuary results from a combination of north-easterly offshore waves from the North Sea and locally generated wind-waves from the south-west, and the interaction of these waves with the large shallow sandbanks and strong flows along the tidal channels.

The metocean survey has recorded the local wave regime for a 12-month period and across four locations around GS1 and GS2. Figure 4.6 presents this data in the form of wave roses.

A review of the measured wave data identifies that:

- Local waves are typically fairly small, with the majority of recorded waves less than 1m (significant wave height, Hs), and with wave periods between 3 and 4s;
- Waves generally approach the bank from east and southerly sectors; and
- Waves at the southern sites are larger than those recorded at the northern sites where additional shoaling will have reduced wave heights due to the shallow water across the sandbank.

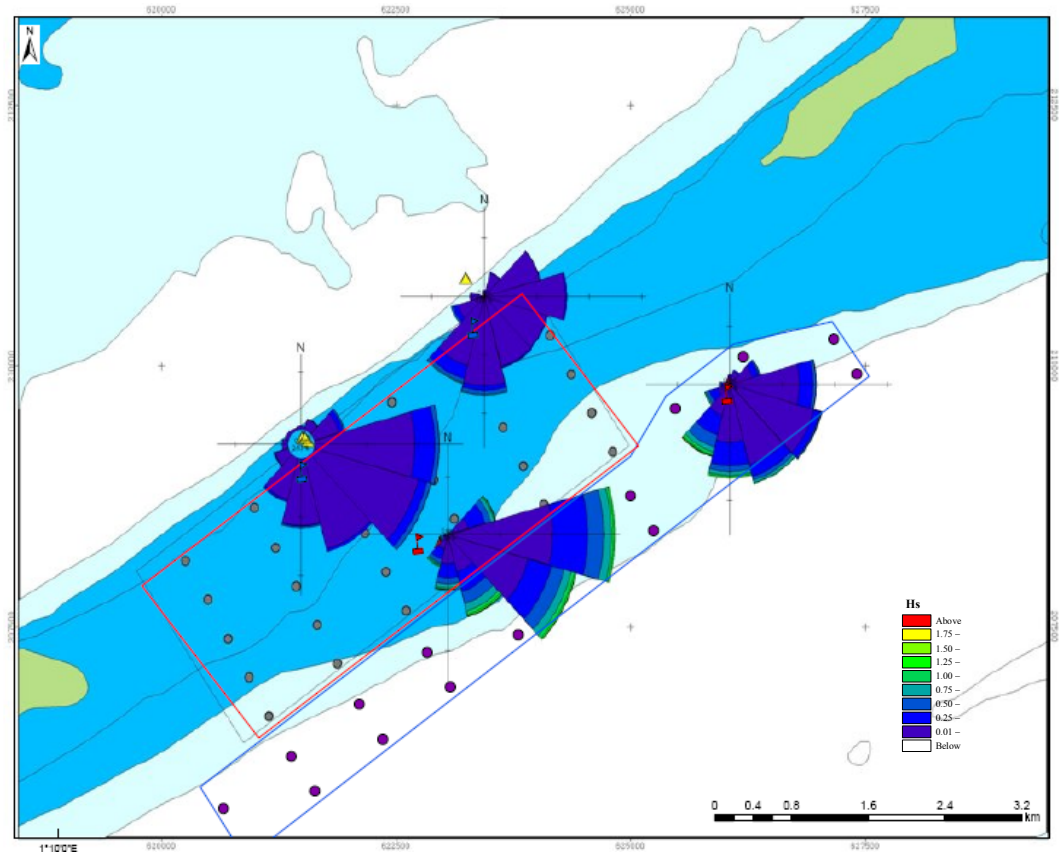


Figure 4.6 Local wave regime

Across a tidal cycle the wave regime also demonstrates strong tidal modulations which are directly attributed to additional sheltering offered by the large shallow tidal banks around the period of low water. Figure 4.7 presents an extract of waves measured at GS2 during spring tides which clearly demonstrates this tidal modulation, with periods around high waters required to accept the largest waves.

Further consideration of the importance of extreme wave conditions has been considered to assist engineering design. This analysis shows that design waves originate from extreme offshore conditions with 1 in 10 year return period waves across GS2 generally less than 3.5m in significant wave height and 6 seconds in wave period (ABPmer, 2007).

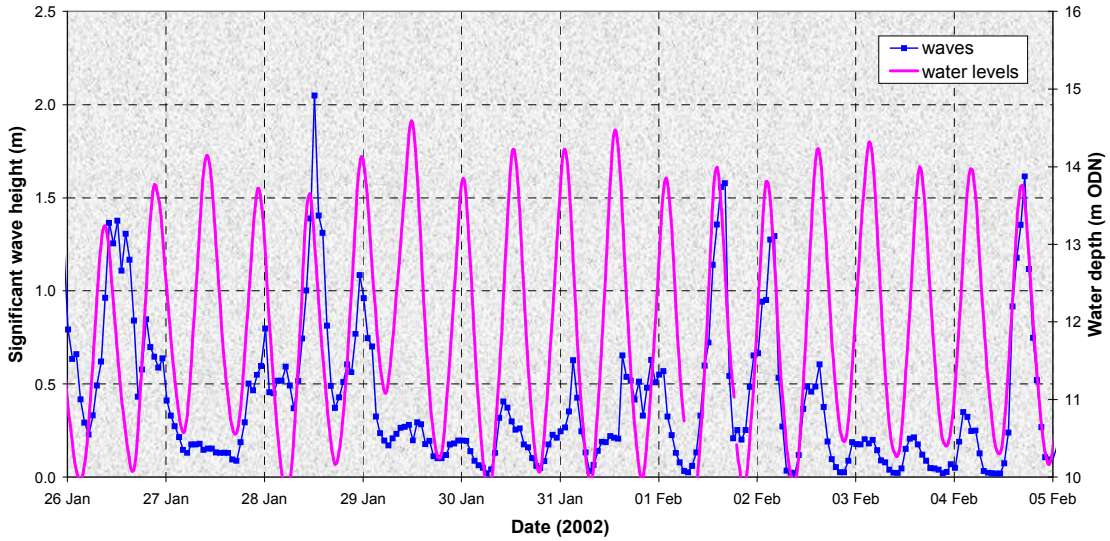


Figure 4.7 Time series of waves measured at GS2

4.5.3.4 Climate Change

Climate change influences at offshore sites remain uncertain and are a subject of major research programmes such as the UK Climate Impacts Programme (UKCIP). The most probable effects relate to sea level rise and increased storminess.

Over short to medium term periods (months to years) the tidal signal in water levels can be regarded as varying relative to a stationary level referred to as mean sea level, however, over longer time periods (decades) mean sea level may vary in response to sea level rise (eustatic changes) and changes in land surface elevation due to glacial rebound (isostatic changes). The recommended value for flood and coastal defence planning for the south-east region of the UK is 4mm/year to 2025 and then 8.5mm/year from 2025 to 2055 (DEFRA, 2006).

Adopting these predicted estimates of net adjustment to mean sea level equates to a net increase in mean sea level of 0.36m over a 50-year lease period of the wind farm (using a start date of 2010).

At the present time the potential for increased storminess is far more uncertain. Present guidance (DEFRA, 2006) suggests an allowance of 5% increase for offshore wind speed and extreme wave heights up to 2055, and a 10% increase thereafter. It has to be borne in mind that these figures represent offshore locations only and such increases remain with high levels of uncertainty and do not consider variations in directions or frequency of events.

For the Outer Thames, the prevailing wind is from the west (from the land) and these wind-waves tend to be fetch limited, more so at low water. An increase in mean sea level and wind speed is likely to result in a moderate increase in wave activity over the longer term, noting that the fetch lengths will remain as present.

The combination of a modified tidal regime and more storms is a likely driver for further coastal change within the Outer Thames Estuary. This is likely to be most evident along the shorelines where much of the wave energy is finally dissipated leading to modified rates of littoral drift. These predicted changes in littoral drift are separate to any issues related to GS1 and/or GS2.

4.5.3.5 Sediment Transport Regime

Gunfleet Sands is one of a series of prominent sandbank features within the Outer Thames and must be regarded as a sink for sandy sediment. Between the various banks, the tidal channels have generally scoured away finer sediments to leave coarser sands and gravels.

Figure 4.8 illustrates an extract from the BGS map (1990) of surficial sediments with inclusion of recent sediment samples taken within GS2 (ABPmer, 2005b). Across Gunfleet Sand sediments are generally grouped as sands and sandy muds, whereas in the tidal channel to the north of the bank known as the Wallet there is a marked change in sediment type to gravely muddy sand and sandy gravely mud.

Summary details of the additional grab samples are provided in Table 4.4. The following comments can be made:

- Sand is the dominant sediment type across GS1 and GS2;
- Sediments recovered from GS1 (samples G11 to G20) contain no gravel, and tend to be either sands (uni-modal) or muddy sands (bi-modal and poorly sorted); and
- Sediments recovered from GS2 contain small amounts of gravel and a higher content of sand, and tend to be moderately well sorted and uni-modal.

These differences are attributed to GS2 being on the southern flank of Gunfleet Sand and within the influence of stronger channel flows moving through East Swin.

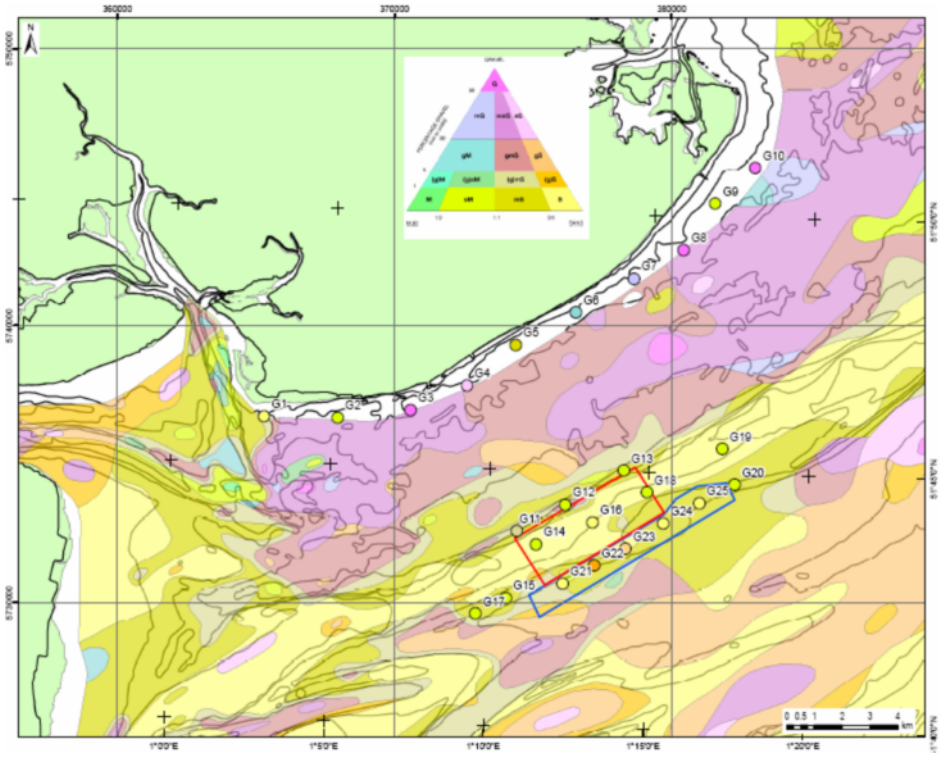


Figure 4.8 Surficial sediment cover across Gunfleet Sands (based on BGS, 1990)

Site	Easting (m)	Northing (m)	Grain Size Distribution			Textural Group (After Folk)	Sorting	Modal Type
			%Mud	%Sand	%Gravel			
G10	627292	221927	3.3	0.8	96.0	Gravel	very well sorted	Unimodal
G11	619860	208200	7.2	92.8	0.0	Sand	Moderately well sorted	Unimodal
G12	621460	209300	82.7	17.3	0.0	sandy Mud	Poorly sorted	Bimodal
G13	623450	210655	31.2	68.8	0.0	muddy Sand	Poorly sorted	Bimodal
G14	620500	207795	0.9	99.1	0.0	Sand	well sorted	Unimodal
G15	619583	205820	80.2	19.8	0.0	sandy Mud	Poorly sorted	Bimodal
G16	622500	208750	0.1	99.3	0.6	Sand	Moderately well sorted	Unimodal
G17	618405	211693	17.2	82.8	0.0	muddy Sand	Poorly sorted	Unimodal
G18	624290	209915	28.3	71.7	0.0	muddy Sand	Poorly sorted	Unimodal
G19	626982	211693	47.0	53.0	0.0	muddy Sand	very poorly sorted	Bimodal
G20	627511	210455	28.8	71.2	0.0	muddy Sand	Poorly sorted	Bimodal
G21	621583	206467	4.6	95.4	0.0	Sand	Moderately well sorted	Unimodal
G22	622561	207165	0.0	98.3	1.7	slightly gravelly Sand	Moderately well sorted	Unimodal
G23	623692	207863	0.5	89.8	9.7	gravelly Sand	Poorly sorted	Unimodal
G24	624977	208813	6.0	93.5	0.5	Sand	Moderately sorted	Unimodal
G25	626220	209693	0.0	100.0	0.0	Sand	Moderately well sorted	Unimodal

Table 4.4 Summary of sediment properties from additional grab samples (ABPmer, 2005b)

An assessment has been made of the mobility of local sediments within GS2 in response to measured wave and tidal conditions. An extract of this analysis is presented in Figure 4.9 and related to thresholds for mobility of muds, sands and gravels.

This analysis indicates that all sediments are potentially mobile at some stage, with gravels only occasionally mobile during peak flows on spring tides. This assessment indicates that the seabed can be considered to be a 'live' sediment regime. This conclusion is important in relation to risks of scour around any structures installed onto the local seabed.

The tidal regime at this site has previously been shown to be flood dominant and consequently the net direction of sediment transport for GS2 will be to the south-west. This pattern is endorsed by existing field evidence of bedform asymmetry and patterns of local scour around wrecks.

Figure 4.10 presents an overall summary for net sediment transport pathways of sands in transport around Gunfleet Sand, with the movement of sediment driven along each pathway by the net tidal residual.

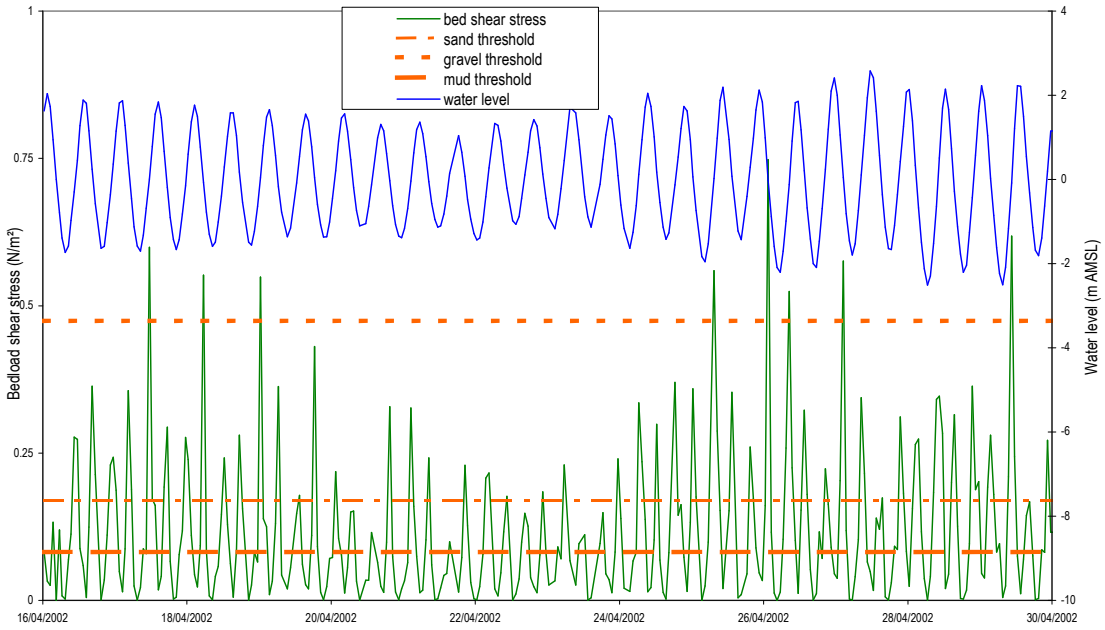


Figure 4.9 Variation of bed shear stress

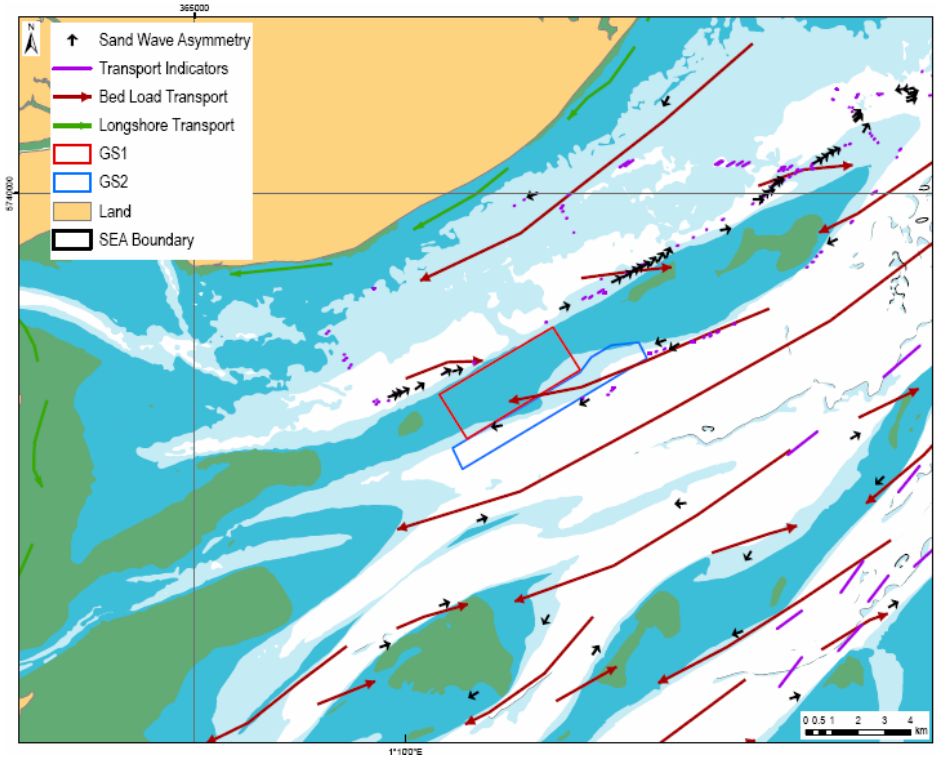


Figure 4.10 Net sediment transport pathways for sands

Along with the sand transport pathways there is a population of finer grain sediments (primarily muds and silts) which move in suspension. At times of peak flows the sand sized material may also move into suspension creating enhanced levels of suspended sediment particularly near the seabed.

Measurements of suspended sediment across the general area suggest that for the region concentrations are typically in the range of 32-64mg/l during 'summer' increasing to 64-128mg/l for 'winter' (HR Wallingford et al., 2002).

Local measurements in the Wallet show sediment loads in the range 12-102mg/l (near-surface) with highest values recorded local to the seaward tip of Gunfleet Sand (HR Wallingford et al., 2002); and from the metocean surveys near-bed concentrations of up to 579mg/l and 838mg/l for northern and south sites, respectively.

It should be noted that surface measurements are likely to report weaker concentrations than near-bed concentrations, as in mixed sediment regimes populations of coarser sand sized sediments will remain 'near-bed'.

4.6 Impact Assessment

4.6.1 Potential Impacts during construction/decommissioning and operational phases

The assessment of the likely significant impacts draws on considerations already provided from the GS1 coastal process assessment (ABPmer, 2002) and updated to consider the additional monopiles proposed for GS2. Where relevant, additional evidence from completed Round 1 projects has been used to further corroborate the general understanding of potential impacts.

Impacts discussed below cover both the construction/decommissioning and operational phases.

Impact Title: Potential impact upon local geology

During the construction phase of the scheme, up to 22 monopiles will be piled into the seabed to a depth of around 50m. Given the overall long-term stability of Gunfleet Sand as a feature within the Outer Thames there is considered to be **No Impact** on the local geology.

Mitigation Measures

None required.

Residual Impact

It is predicted that there will be **No Impact** upon local geology.

Impact Title: Potential impact upon geomorphological processes acting around Gunfleet Sands

The presence of up to 22 small-scale monopile foundations separated by around 890m in the direction of sediment pathways is considered to have **No Impact** on the larger scale geomorphology processes acting around Gunfleet Sand. Locally, wake effects in the flow regime around individual structures will lead to the potential for scour. However, evidence from the Scroby Sands Round 1 offshore wind farm demonstrates that sand waves and other bedform features are able to move past such structures without hindrance.

Mitigation Measures

None required.

Residual Impact

No Impact on larger scale geomorphology but some localised scour and scour wake effects are predicted.

Impact Title: Potential impact upon the tidal regime

The coastal process study undertaken for GS1 (ABPmer, 2002) has previously concluded that:

- The general flow regime remains unaffected at short distances away from the development site; and
- The installation of structures on the sea bed creates obstacles that interfere with local flow patterns creating turbulent flows that may lead to scour development.

The same manner of effect is predicted for GS2. Most effects around small structures are likely to dissipate within around ten diameters of the structure itself, which in the case of a 5m diameter monopile is around 50m in the lee of the structure. The along row separation of 890m is more than adequate to ensure that there is no opportunity for any wake to wake interaction in the direction of the tidal flow.

Therefore, it is concluded that there will be **No Impact** upon the local tidal regime from the proposed GS2 development, although there will be some **negligible**, **localised** disruption to local flow patterns that may result in scour development.

Mitigation Measures

None required.

Residual Impact

No Impact upon the local tidal regime from the proposed GS2 development, although there will be some **negligible**, **localised** disruption to local flow patterns that may result in scour development.

Impact Title: Potential impact upon the wave regime

The coastal process study undertaken for GS1 (ABPmer, 2002) has previously concluded that

- The installation of structures on the sea bed creates local obstacles that have minor effect in altering the passage of local waves;
- The primary effect on waves is refraction and scattering of waves off the structures; and
- The scale of the structure in relation to the incident wave is at a level that diffraction effects are not important. This conclusion is consistent with the subsequent research completed at Scroby Sands (CEFAS, 2007).

The same manner of effect is predicted for GS2. Therefore, it is predicted that there will a **negligible impact** upon local wave regime.

Mitigation Measures

None required.

Residual Impact

It is predicted that there will a **negligible impact** upon local wave regime.

Impact Title: Potential impact upon the sediment transport regime

The probable impacts on the sediment transport regime relate to short-term sediment plumes that may be generated during the cable laying process and scour around structures during the operational phase.

The coastal process study undertaken for GS1 (ABPmer, 2002) has previously concluded that:

- The local modification to tidal flows and waves will create turbulent wakes in the water column around each structure that will result in the potential for scour;
- The impact of the wind farm structures on waves and tides is not at a scale to that will alter any of the far-field regional transport pathways. This conclusion is consistent with the subsequent research completed at Scroby Sands (CEFAS, 2006); and
- Any material locally disturbed by the construction of the wind farm is likely to be rapidly dispersed away from the site and will add to the background suspended sediment concentrations. However, this process will be short-term as the site adjusts.

The baseline assessment for sediment mobility at GS2 has shown that there is a 'live' bed regime, i.e. active in response to local waves and tides and provides a strong indication that scour will occur around the base of each foundation in the absence of any scour protection. Under steady flow conditions, it has been estimated that the equilibrium scour depth for a 5m diameter monopile will be between 3.8m and 6.2m deep (n.b. the geological data suggests these depths would not be impeded by underlying soils). The width of the scour hole is predicted to be approximately 33m for the 3.8m deep scour pits and 48m for the 6.2m deep pits. The spacing between turbines of 890m mitigates any risk of group scour across the array.

The conclusions for GS2 remain consistent to the field evidence reported from the Scroby Sands offshore wind farm (CEFAS, 2006), noting that this site is also related to a sandbank with a 'live' sediment transport regime. Importantly, the spacing of foundations for Scroby Sands is only 375m. The key conclusions from the DEFRA funded research are summarised in Table 4.5 and presented in Figure 4.11.

Length scale (m)	Type of Impact	Significant Impact?
0 to 100	Scour pits	Yes, as predicted by EIA
100 to 1000	Scour wakes	Not significant with respect to total volume change
> 1000	Sandbank morphology	No evidence

Table 4.5 Scale of morphological features observed at Scroby Sands (CEFAS, 2006)

One of the interesting observations from Scroby Sands is the feature referred to in Table 4.5 as a scour wake. These appear as shallow depressions extending away from the main scour hole and generally extending in the down-drift direction of sediment transport.

A similar feature has been noted around the wreck in GS2 which has a scour wake which extends to around 120m from the seabed obstruction. It is anticipated that similar features will form within GS2 and will also be insignificant in relation to the overall (natural) volume changes observed across Gunfleet Sand.

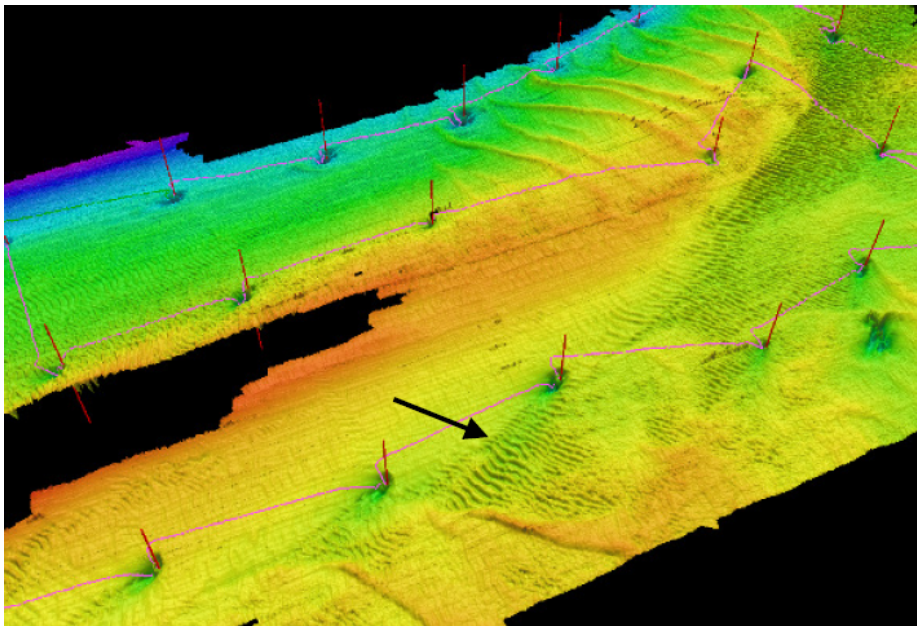


Figure 4.11 Measured scour across Scroby Sands (CEFAS, 2006)

Therefore, with respect to changes in the sediment transport regime, it is concluded that there will be a **negligible impact** upon Gunfleet Sand as a result of the proposed GS2 development. However, it is predicted that a probable residual impact will arise via the formation of secondary scour wakes which may extend from each turbine foundation as a shallow depression and for distances of around 100m in the direction of net sediment transport. This impact is likely to be comparable to the observed effect around the wreck and is judged to be of **minor** significance.

Supplementary studies have also been completed to consider the potential impact of sediment plumes which may arise during the process of cable installation (ABPmer and RPS, 2004). These studies conclude that:

- The small fraction of silts has the potential to remain in suspension for longer periods and become advected away from the trench in the form of a sediment plume. The relative impact of this plume needs to reflect that, in the main, the mud fraction is nominal (<5% content) and hence the actual volume of material released at any time is low; and
- Furthermore, the rapid dispersion of any plume is unlikely to create concentrations that are measurable above ambient conditions and detectable beyond distances of a few hundred metres as the plume is entrained into ambient sediment loads.

All plume effects are expected to be short-lived and not act cumulatively with subsequent cable laying operations. Therefore, it is predicted that there will be a **negligible impact** from increased suspended sediment loads during the construction phase of the project.

Mitigation Measures

In order to reduce the amount of scour around the base of each turbine, it is proposed that gravel/rock/mattresses will be considered for scour protection purposes to mitigate the design risk. The use of scour protection is likely to be favorable to mitigate any sediment losses due to scouring.

Residual Impact

With adequate scour protection introduced at the base of each turbine, it is envisaged that the localised scour around each turbine described above will be reduced, resulting in a **negligible impact**.

4.6.2 Cumulative Impacts

The main consideration made in relation to cumulative impact is in relation to assessing the risk for any greater effect on the physical environment resulting from GS2 in combination with GS1.

The primary rationale offered is that each structure provided in the installation of GS1 and GS2 is considered to create localised changes in waves and tides that result in the potential for local scour. The consistent separation of all structures across the combined array (GS1 and GS2 together) is more than sufficient to conclude that no greater effect will form with GS2 present alongside GS1.

4.6.3 Proposed Monitoring

The present monitoring arrangements agreed for GS1 under FEPA (licence 31919/06/02) provide for monitoring of suspended sediments, seabed morphology and scour. It is recommended that the same monitoring approach is adopted to include for GS2, noting that the improved assessment of sediment grain size has already been completed (ABPmer, 2005b).

The proposed seabed morphology monitoring will ideally extend from present baseline surveys which adopt high-resolution multi-beam sonar. A key feature of interest within further post-construction monitoring is the potential for formation of scour wakes as reported from Scroby Sands.

5. WATER/SEDIMENT QUALITY AND METEROLOGICAL CONDITIONS

5.1 Introduction

The following section of the ES provides information on water/sediment quality in the proposed GS2 study area plus details on meteorological conditions at the site. Potential impacts upon these parameters from the proposed GS2 scheme are discussed.

5.2 Consultation

There has been no specific consultation related to water or sediment quality undertaken as part of the EIA process. However, CEFAS, Natural England and the Environment Agency were all consulted during the scoping phase of the project. No specific comments about water/sediment quality were received in their responses.

5.3 Data Sources

As part of the original GS1 EIA process a number of studies were undertaken to gather data on water/sediment quality and meteorological parameters within the study area. Table 5.1 (below) lists all these studies. Data from these reports have been used to produce this section of the GS2 ES.

Survey/ Study	Date	Undertaken By	Description
Contaminants Study	2002	Hydrosearch Associates Ltd	Assessment of the concentrations of **selected contaminants** in estuarine and marine sediments in the vicinity of Gunfleet Sands offshore wind farm. Contaminants were analysed in sediments from 14 of the 65 benthic sample sites.
Oceanographic Survey	2002	Thales GeoSolutions Ltd	Collection of wave height, direction, ocean currents, **turbidity** and tidal current data from 2 sites around Gunfleet Sands.

Table 5.1 Summary of studies related to water/sediment quality undertaken as part of GS1 EIA

In addition to these studies, further work has been undertaken since the submission of the ES for GS1 (in May 2002) that have collected data suitable for defining water and sediment quality and meterological conditions around the Gunfleet Sands sites (Table 5.2).

Survey/ Study	Date	Undertaken By	Description
GS2 Coastal Processes Technical Study	2007	ABPmer	Study which (1) describes far-field baseline conditions, (2) describes near-field baseline conditions; and (3) assesses likely significant impacts of the phase II development.
Contaminants Study	2002	CMACS	Assessment of the concentrations of **selected contaminants** from the 6 sample locations within and adjacent to the proposed GS2 boundary.
Review of Inter-Turbine Cable Installation Options	2004	ABPmer/RPS	Assessment of the likely **sediment disturbance effects** arising from both jetting and ploughing installation methods for laying inter-turbine cables.
Assessment of the Energy Production of the Proposed Gunfleet Sands Wind Farm	2003	Garrad Hassan and Partners Ltd	Assessment of 18 months of **meteorological data** from the Gunfleet Sands met mast and longer term data from the Walton-on-the-Naze met station.

Table 5.2 Summary of physical studies undertaken since submission of GS1 ES

5.4 Project-Specific Survey

No project-specific surveys related to water/sediment quality or meteorological conditions have been undertaken for the GS2 EIA process.

5.5 Description of Existing Environment

5.5.1 Water Quality

5.5.1.1 Suspended Sediment Concentrations

Measurements of suspended sediment across the general Thames area suggest that for the region, concentrations are typically in the range of 32-64mg/l during 'summer' increasing to 64-128mg/l for 'winter' (HR Wallingford et al., 2002).

Local measurements in the Wallet show sediment loads in the range 12 to 102mg/l (near-surface) with highest values recorded local to the seaward tip of Gunfleet Sands (HR Wallingford et al., 2002); and from the metocean surveys near-bed concentrations of up to 579mg/l and 838mg/l for northern and southern sites, respectively.

It should be noted that surface measurements are likely to report weaker concentrations than near-bed concentrations, as in mixed sediment regimes populations of coarser sand sized sediments will remain 'near-bed'.

5.5.1.2 Chemical Water Quality

No specific chemical water quality data has been collected as part of this project. However, information is available on the chemical status of water quality in the estuary from various sources, including regular monitoring undertaken by the Environment Agency.

As a result of substantial investment in sewage treatment, the construction of new sea outfalls and treatment of industrial discharges, chemical water quality in the Thames has improved significantly since the 1960's.

In 2000, using the NWC estuarine classification scheme, almost 25% of the estuaries within the Thames region were classified as good with the remainder classed as fair. The NWC scheme will soon be replaced by new classifications developed under the EU Water Framework Directive.

5.5.2 Sediment Quality

As part of the EIA for the GS1 project, contaminants were sampled in a total of 14 sites across the wider study area. These sites were chosen based upon the range of sediment types and locations in the survey grid.

Most metal concentrations were significantly correlated with the aluminium content or the organic content, or both. Total petroleum hydrocarbon concentrations were significantly correlated with the organic content of the sediment, but not the aluminium content.

None of the 14 sites sampled showed high concentrations of contaminants, and all maxima were below concentrations that would be of environmental concern. After allowing for the clay and organic content, there was evidence of slightly elevated concentrations of most metals at site 1, near Clacton. These may be due to the nearby sewage discharge.

An additional six sites were sampled in 2007 as part of the benthic survey for the GS2 development. The six sites sampled were analysed for metals and total hydrocarbons (THC) and compared against (a) Canadian Interim Sediment Quality Guidelines (ISQG) which gives the Threshold Effects Levels (TEL) for a range of chemicals, below which adverse biological effects would not be expected and (b) Probable Effects Level (PEL), which indicates the concentrations at which a toxicity effect would likely be evident.

Arsenic was above the TEL for all sites within the GS2 area, however, these concentration were well below the PEL. None of the other metals were above either the TEL or PEL. Within the GS2 area, the following Polyaromatic Hydrocarbons (PAHs) - Naphthalene, Acenaphthylene, Acenaphthene, Fluorene and Phenanthrene exceeded the TEL for some sites. For all sites, all PAHs were well within PEL concentrations.

5.5.3 Meteorological Conditions

An independent assessment of the wind climate at the proposed Gunfleet Sands offshore wind farm was carried out by Garrad Hassan and Partners Ltd, on behalf of GE Wind Energy Ltd, in September 2003 (Garrad Hassan & Partners Ltd, 2003). Eighteen months of data from the 60m tall meteorological mast installed on the site was reviewed as part of this assessment. Boom-mounted anemometers are located at 60, 59.8, 47.5, 47.3, 35 and 34.8m. Data from the met mast were correlated with a longer-term data set from the Walton-on-the Naze meteorological station, located approximately 12km north of the Gunfleet Sands site.

Plate 5.1 ***Met Mast on Gunfleet Sands***

Location	Description of Measurement	Period
Gunfleet Sands 60m site mast	Ten minute records of mean, standard deviation, min and gust wind speed at 34.8m, 35m, 47.3m, 45m, 59.8m and 60m above mean sea level; Mean wind direction and standard deviation at 33.6m, 58.3m and 58.5m above mean sea level.	24/01/02 to 08/07/03
Walton-on-the-Naze Meteorological Station	Hourly mean wind speed and direction at 10m height. Annual frequency distribution of wind speed and wind direction.	01/01/98 to 26/07/02 01/09/00 to 31/12/02

Table 5.3 Summary of measurements made at the 60m met mast and Walton-on-the-Naze meteorological station

Comparisons of 18 months of measured wind speeds at the site met mast (60m above sea level) with the concurrent wind speeds at Walton-on-the-Naze met station were undertaken. Based upon these results of this analysis, the following conclusions were made:

- The long-term wind speed is estimated to be 9.0m/s at a height of 60m above mean sea level at the location of the met mast;
- The long-term wind speed is estimated to be 9.3m/s at hub height (74m above mean sea level);
- The standard error associated with this prediction of long-term wind speed is 0.37m/s at 60m above MSL and 0.39m/s at hub height and
- Mean ambient turbulence intensity at the met mast is 5.1% in the range of wind speeds from 5m/s to 15m/s.

With respect to projected extreme wind speeds at hub height, the following values were obtained.

Return Period	Averaging Period	Extreme Wind Speed at 74m above MSL (upper estimate m/s)
1 Year	10 minute 1 minute 5 second 3 second	30.7 34.9 40.6 41.5
50 Year	10 minute 1 minute 5 second 3 second	43.2 49.2 57.2 58.4

Table 5.4 Predicted extreme wind speeds at Gunfleet Sands met mast

5.6 Impact Assessment

5.6.1 Water Quality

Impact Title: Construction activities, including installing inter-turbine cables will lead to deteriorations in water quality

The process of installing the turbines (via piling) and inter-turbine cables (trenching/jetting) has the potential to lead to short-term, localised changes in water quality in and around the GS2 site.

With respect to suspended sediment concentrations, this area is characterised by high ambient concentrations. Therefore, it is unlikely that any increases in concentrations produced by construction activities will be detectable above these background conditions.

In terms of chemical water quality, previous studies of sediment quality in this area indicated that this area was characterised by low levels of contaminants. Therefore, it is predicted that although sediments will be mobilised during the construction process, in particular during cable-laying operations, there will be no deterioration in local water quality from released contaminants.

One other possible route for impacts upon water quality will be from the accidental discharge of contaminants, such as fuel oil, from construction vessels and plant. All contactors appointed to the GS2 project will be required to demonstrate that they have mechanisms and processes in place to avoid pollution incidents, such as oil spill contingency plans. By adhering to such plans and measures, pollution events will not occur during the construction, or operational phase of this development.

Consequently, it is predicted that there will be a **Negligible Impact** upon water quality from the proposed GS2 development.

Mitigation Measures

None required.

Residual Impact

It is predicted that there will be a **Negligible** impact upon water quality during the construction phase.

5.6.2 Sediment Quality

Impact Title: Construction activities, including installing inter-turbine cables will lead to deteriorations in sediment quality

As long as standard pollution avoidance measures are adhered to, it is predicted that there will be **No Impact** upon sediment quality during either the construction or operational phase of the proposed GS2 development.

Mitigation Measures

None required.

Residual Impact

It is predicted that there will be a **Negligible** impact upon sediment quality during the construction phase.

5.6.3 Conclusions

Water and sediment quality in the GS2 development area is generally good. Potential effects upon water and sediment quality from the proposed project have been assessed. It is concluded that as long as standard pollution contingency plans are developed and adhered to, there will be a negligible impact upon water quality during both the construction and operational phases of the project and no impact upon sediment quality.

6. NATURE CONSERVATION

6.1 Introduction

This section presents information on sites of nature conservation interest that exist in the vicinity of Gunfleet Sands and also assesses the potential impacts upon these sites from the proposed GS2 development. Details are provided on the sites designated under international and national legislation. Information on the Thames Estuary proposed Special Protection Area (pSPA) for red-throated divers is covered in detail in the section on ornithology, due to the obvious link between this proposed designation and birds.

6.2 Consultation

Consultation on issues related to nature conservation has been carried out with a number of key organisations and stakeholders as part of this EIA. The EIA scoping report was issued to Natural England, Defra and RPSB in December 2006 and responses from these organisations were received by DONG in the following months.

The scoping responses from these organisations highlighted certain issues related to nature conservation that they wished the EIA to consider. In order to discuss these issues in more detail, follow-up meetings with these organisations were held in the period February-March 2007. As part of these meetings, the potential impacts of the proposed GS2 development identified via scoping responses were discussed in more detail.

6.3 Data Sources

Information on the spatial distribution of sites of nature conservation interest around the Gunfleet Sands area has been obtained from the following data sources:

- the MAGIC web-site[8];
- the Natural England web-site[9];
- the UK Marine SAC project web-site[10].

6.4 Project-Specific Surveys

Project-specific bird surveys have been undertaken from 2001 to date as part of the on-going ornithological monitoring associated with the GS1 development. These data will provide the basis of the information submitted for the shadow Appropriate Assessment required for the Thames Estuary SPA, which may be designated in the future. Full details of this aspect are provided in Chapter 10.

Benthic surveys have also been undertaken in 2002 and more recently in 2007, as part of the baseline data collection process for this project. Data from these surveys is of relevance to certain aspects of marine nature conservation.

[8] www.magic.gov.uk

[9] www.naturalengland.org.uk

[10] www.ukmarinesac.org.uk

6.5 Description of Existing Environment

6.5.1 Designated Sites of Nature Conservation Importance

The designated sites search area comprised of a 20km radius from the central point of the GS2 location. There are fourteen designated sites of conservation importance within the search and one site which has been identified as a potential site for designation. These sites are summarised in Table 6.1 (below) and shown in Figure 6.1. It should be noted that the proposed development does not lie within any currently designated sites and that the closest designated site (Essex Estuaries cSAC) is some 5.0km away from the proposed site development at its closest point.

Site	Designation	Conservation Interest Features
Little Oakley Channel Deposit	SSSI	Area of inter-glacial sediments yielding abundant flora and fauna remains.
Hamford Water	SPA Ramsar SSSI NNR	The majority of the area is comprised of mudflats and salt marsh. Coastal sand dunes, marsh and improved grassland are found in small quantities. Internationally important populations of: Dark-bellied Brent Goose, Grey Plover, Redshank Nationally important populations of: Shelduck, Teal, Ringed Plover, Bar-tailed Godwit, Avocet Important breeding populations of: Little Tern
Weeleyhall Woods	SSSI	Large ancient woodland with good examples of a number of woodland types.
Riddles Wood	SSSI	Area of woodland with good examples of chestnut coppice.
Holland on Sea Cliffs	SSSI	Area of gravel deposits significant in tracing the diversion of the Thames.
Clacton Cliffs and Foreshore	SSSI	Channel cut into a gravel accumulation forming a sequence of freshwater and estuarine sediments.
Essex Estuaries Marine Site	European Marine SAC	Coastal plain estuarine with associated open coast mudflats, sandbanks, also salt marsh and other important coastal habitats. Comprises the major estuaries of the Colne, Blackwater, Crouch and Roach rivers and is important as an extensive area of contiguous estuarine habitat. Outstanding habitats for a number of plants.
Holland Haven Marshes	SSSI	Reclaimed estuarine salt and freshwater marsh bisected by Holland Brook and its tributaries resulting in a ditch network comprising examples of brackish to freshwater transition. Breeding birds include: Skylark, Meadow Pipit, Yellow Wagtail, Reed Warblers and Ringed Plover. The winter bird populations include: Hen Harrier, Short-eared Owl, Wigeon, Teal, Pintail, Shoveler, Pochard, Snipe, Brent Goose, Twite, Lapland Bunting and Purple Sandpiper. During the migration periods, Spotted Redshank, Black-tailed Godwit, Whimbrel, Green Sandpiper and Common Sandpiper.

Table 6.1 Sites of International, European or National importance for nature conservation within 20km of the GS2

Site	Designation /s	Conservation Interest Features
Colne Estuary	SPA Ramsar SSSI NNR	Variety of habitats including mudflats, salt marsh, grazing marsh, sand and shingle pits, disused gravel pits and reed beds. Forms part of the Essex estuaries. Internationally important populations of: Dark-bellied Brent Goose, Grey Plover Nationally important populations of: Hen Harrier Important breeding populations of: Pochard, Ringed Plover, Little Tern
Blackwater Estuary	SPA Ramsar SSSI NNR	Mudflats fringed by salt marsh with other habitat comprising of humid grassland and water-fringed vegetation. Forms part of the Essex estuaries. Internationally important populations of: Dark-bellied Brent Goose, Dunlin, Balck-tailed Godwit, Nationally important populations of: Ringed Plover, Hen Harrier, Important breeding populations of: Pochard, Ringed Plover, Little Tern
Sandbeach Meadows	SSSI	An area of grassland as a remnant of extensive grazing marshes. Nationally important Dark-bellied Brent Goose Populations of Wigeon and European White-fronted Goose.
Dengie	SPA SSSI Ramsar NNR	Mudflats comprise the majority of the area with small pockets of salt marsh, sand dunes, inland water and improved grassland. Internationally important populations of: Dark-bellied Brent Goose, Knot Nationally important populations of: Grey Plover, Hen Harrier
Crouch and Roach Estuaries	SPA Ramsar SSSI	Tidal mudflats, saltmarsh and improved grassland. Also areas of inland water, freshwater marsh and humid grassland. Internationally important populations of: Dark-bellied Brent Goose, Nationally important populations of: Hen Harrier
Foulness	SPA Ramsar SSSI	Mudflats cover the majority of the area with salt marsh and water fringed vegetation. Internationally important populations of: Dark-bellied Brent Goose, Oystercatcher, Knot, Bar-tailed Godwit, Grey Plover, Redshank Nationally important populations of: Avocet, Hen Harrier Important breeding populations of: Avocet, Ringed Plover, Little Tern, Common Tern, Sandwich Tern
Thames Estuary	Potential SPA[11]	Internationally important population of Red-throated Diver

Table 6.1 (Cont'd)

[11] As of June 2007, the exact status and timescales of this potential SPA were unknown – Figure 10.3 in Chapter 10 displays the extent of this potential SPA.

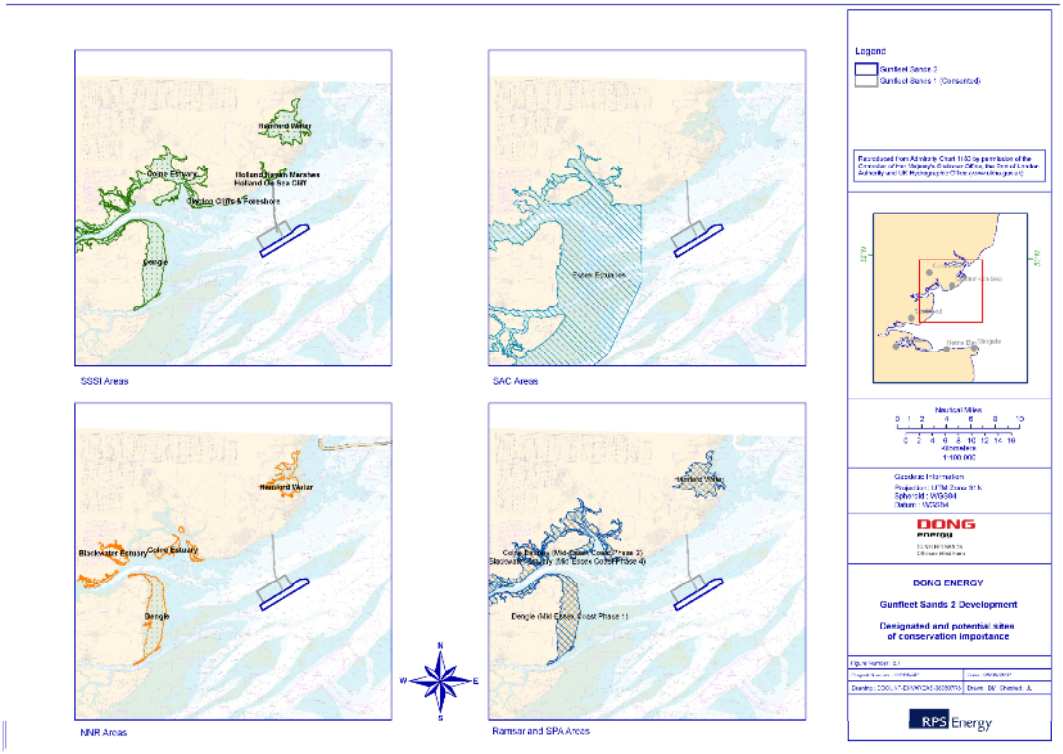


Figure 6.1 Designated and potential sites of conservation importance

Summary information on each site and the reasons for their designated status are given in Appendix E.

6.5.2 Annex I Habitats / Annex II species

The response from Natural England on the GS2 EIA scoping report included the following comment; "sites that support qualifying Annex I habitat (including shallow sandbanks and reefs), or which are of importance for Annex II species, should be treated with care to ensure that they are not damaged or altered in such a way that might frustrate their selection as SAC's. The EIA should thus identify whether any qualifying Annex I habitats or Annex II species are present and assess the impact of the proposed development accordingly".

With respect to Annex I habitats, the habitats mentioned by Natural England were shallow sandbanks and reefs as these are the two Annex I marine habitats thought to occur around the proposed GS2 site. The distribution of these habitats around the proposed GS2 site are summarised below.

6.5.2.1 Subtidal Sandbanks

Subtidal sandbanks consist of sandy sediments that are permanently covered by shallow sea water, typically at depths of less than 20m below chart datum (but sometimes including channels or other areas greater than 20m deep). The habitat comprises distinct banks (i.e. elongated, rounded or irregular 'mound' shapes) which may arise from horizontal or sloping plains of sandy sediment. Where the areas of horizontal or sloping sandy habitat are closely associated with the banks, they are included within the habitat.

Within the UK's inshore waters sandbanks which are permanently covered by shallow sea water can be categorised into four main sub-types

1. Gravelly and clean sands;
2. Muddy sands;
3. Eelgrass *Zostera marina* beds;
4. Maerl beds (composed of free-living *Corallinaceae*).

The latter two sub-types are particularly distinctive and are of high conservation value because of the diversity of species they may support and their general scarcity in UK waters.

In terms of whether Annex I sandbank habitat exists within the study area, in their scoping response of 09.02.07, Natural England (see above) stated the need to identify whether any qualifying Annex I habitats are present in the study area. The proposed GS2 development is situated on part of the Gunfleet Sands sandbank feature. The majority of the Gunfleet Sands sandbank is situated in less than 20m water depth and comprises a mixture of gravelly and clean sands and muddy sands. Therefore, it is concluded that the Gunfleet Sands sandbank could potentially represent suitable habitat for future designation as a marine SAC.

Although it is not currently possible to state one way or the other if the Gunfleet Sands sandbank may eventually become designated as a SAC, the impact of the proposed development upon this feature has been assessed, as per advice from Natural England.

6.5.2.2 Reefs

This Annex I habitat is defined as "submarine, or exposed at low tide, rocky substrates and biogenic concretions, which arise from the seafloor in the sublittoral zone but may extend in to the littoral zone where there is an uninterrupted zonation of plant and animal communities. These reefs generally support a zonation of benthic communities of algae and animal species including concretions, encrustations and corallogenic concretions" (EC, 2003).

The UK has defined the habitat further to include bedrock, boulders and cobbles (generally >64 mm in diameter), including those composed of soft rock, e.g. chalk. Aggregations of species that form a hard substratum (biogenic concretions) which enable an epibiotic community to develop are also considered in this habitat category.

With respect to bedrock, boulders and cobble reefs, none of these habitat types occur within the development site, which is composed predominantly of sands. There is also no evidence that biogenic reefs, in particular *Sabellaria spinulosa* exist within the proposed GS2 site. Site-specific data collected via sidescan sonar and benthic surveys of the GS2 site show no evidence of *Sabellaria spinulosa* within the proposed development area. Therefore, it is concluded that there is no Annex I reef habitat present within the proposed GS2 development area.

In terms of Annex II species, the following are known to occur within the wider Thames Estuary region;

- Sea lamprey;
- River lamprey;
- Allis and twaite shad;
- Atlantic salmon;
- Bottlenose dolphin;
- Harbour porpoise;
- Grey seal;
- Harbour (common) seal.

Potential impacts upon the specific BAP targets for these species are discussed below. More detailed impact assessments for fish and marine mammals are presented in Sections 8 and 9 respectively.

6.5.3 UK BAP Species and Habitats

The UK is a signatory to the 1992 Convention of Biological Diversity, which was signed at the 1992 Rio Earth Summit and provides a legal framework for biodiversity conservation. In 1994, the UK government launched the UK Biodiversity Action Plan (BAP) which currently comprises over 390 species action plans (SAP's) and 45 habitat action plans' (HAP's). Each plan has a set of targeted actions and objectives designed to protect key biodiversity resources.

UK BAP Species/Habitat	Distribution around Gunfleet Sands
Sublittoral sands and gravels;	The majority of the proposed GS2 site comprises sublittoral sands and gravels.
Sabellaria spinulosa (in its reef-building form);	Based on sidescan and benthic grab data, there is no evidence of *S. spinulosa* within the proposed GS2 site.
Certain marine fish species (part of Grouped Plan for commercial marine fish);	Certain species on this plan, in particular cod, herring, sole and plaice, will occur within the study area at certain times of year.
Allis and Twaite Shad;	Both allis and twaite shad are likely to exist within the wider Thames Estuary. However, there is no evidence that the proposed GS2 site provides unique habitat for these species.
Harbour porpoise;	Although harbour porpoises do occur within the Thames Estuary, they are considered uncommon in this region.
Bottlenose dolphin (part of Grouped Plan for small dolphins);	Although bottlenose dolphins do occur within the Thames Estuary, they are considered uncommon in this region.

Table 6.2 UK BAP Habitats and Species that may occur within the GS2 study area

Potential impacts upon these BAP habitats and species are assessed below.

6.6 Impact Assessment

6.6.1 Designated Sites of Nature Conservation Importance

6.6.1.1 Construction/Decommissioning & Operational Phases

Impact Title: The proposed GS2 development may create adverse effects upon existing designated sites

The proposed GS2 development does not lie within or immediately adjacent to any other designated sites, therefore, there is no scope for direct impacts upon such features during either the construction or operational phase of the proposed project.

The closest designated site to the study area is the Essex Estuaries candidate Special Area of Conservation (cSAC), whose boundary is 5km to the west of the proposed development. The qualifying features of this site include sandbanks which are slightly covered by seawater all the time, estuaries and mudflats and sandflats not covered by seawater at low tide.

There is the potential that changes in local hydrodynamic conditions and sediment transport processes from the proposed GS2 development may lead to indirect impacts upon the qualifying features of this cSAC.

However, the coastal processes assessment undertaken by ABPmer (Section 4) concluded that any changes to sediment transport and hydrodynamic processes will be small-scale and localised around the individual turbines. Therefore, it is concluded that there will be **No Impact** upon the Essex Estuaries cSAC as a result of the proposed development.

It is also concluded that there will be **No Impact** upon any other designated sites due to the distance of the GS2 site from any other sites and also the fact that only small-scale, localised impacts are predicted from the GS2 development.

The only site of nature conservation interest within which the proposed GS2 development is located is the proposed Thames Estuary SPA. Potential impacts upon this proposed SPA are discussed in detail in Chapter 10.

Mitigation Measures

As the development will not have a significant effect on any designated site of nature conservation, no mitigation is required.

Residual Impacts

It is predicted that there will be **No Impact** upon any designated sites during either the construction/decommissioning or operational phases.

Proposed Monitoring

As the development will not have a significant effect on any designated site of nature conservation, no monitoring is required.

6.6.2 Potential Annex I Habitats/Annex II Species

Impact Title: The proposed GS2 development may create adverse effects upon potential Annex I habitats and/or Annex II species

As detailed in Section 6.4, the only habitat that may qualify as an Annex I habitat which is known to occur in the proposed development area is subtidal sandbank. Currently, the Gunfleet Sands feature is not designated as a cSAC and it is unknown whether or nor Natural England are considering this feature as part of their on-going work to identify and designate new marine SAC' s in the 0-12nm zone. However, in line with guidance provided by Natural England within their scoping response, this EIA assesses potential effects upon this habitat, to determine whether the development is likely to damage or alter this habitat in such a way that might frustrate its possible selection as an SAC. To make this assessment more robust, the assessment has been carried out with a presumption that the proposed GS2 site lies within an SAC designated for its subtidal sandbank.

In order to assess potential effects upon a SAC, it is essential to consider whether or not the conservation objectives of the features for which the site is designated are compromised as a result of an activity. With respect to conservation objectives of shallow subtidal sandbanks, it is possible to consider the conservation objectives for these features from existing SAC's, in which these features occur.

Typical favourable condition targets for shallow subtidal sandbanks include the following:

- No net decrease in extent from baseline;
- Average PSA parameters (%sand/silt/gravel) used to define sediment type should not deviate significantly from an established baseline;
- Depth distribution of bank should not deviate significantly from baseline;
- Average water temperature/salinity should not deviate significantly from baseline;
- Species composition, diversity and abundance of sand/gravel communities should not deviate significantly from baseline; and
- No significant decline in the number and occurrence of representative biotopes.

Based upon assessments of coastal processes (Section 4) and benthic ecology (Section 7), it is concluded that if Gunfleet Sands were to become designated as an SAC and set favourable condition targets similar to those listed above, there would be no adverse effect on any of these targets, and thus the integrity of the site. Therefore, it is concluded that the proposed GS2 development would have **No Impact** on potential Annex I shallow subtidal sandbank habitat.

With respect to potential impacts upon fish and marine mammal species listed on Annex II of the Habitats Directive, these are assessed in detail in Section 8 (fish and shellfish) and Section 9 (marine mammals).

Mitigation Measures

As the development will not have a significant effect on any designated site of nature conservation, no mitigation is required.

Residual Impact

It is predicted that there will be **No Impact** upon any Annex I habitat during either the construction/decommissioning or operational phases.

Proposed Monitoring

As the development will not have a significant effect on any designated site of nature conservation, no monitoring is required. However, based upon knowledge of monitoring conditions attached to FEPA licenses for other offshore wind farm projects, it is likely that there will be a requirement to undertake regular bathymetric surveys of the site during its operational phase. Data from such surveys will be of use in confirming the predictions made above related to integrity of the sandbank, such as extent and depth distribution.

6.6.3 UK BAP Species and Habitats

Impact Title: The proposed GS2 development may create adverse effects upon the targets and objectives of UK BAP species and/or habitats

Table 6.1 identified that certain UK BAP species and habitats may occur within the proposed GS2 site. These include sublittoral sands and gravels, certain marine fish species, including allis and twaite shad and harbour porpoise and bottlenose dolphins. The Action Plans for each of these species and habitats comprises a set of objectives and targets. In order to identify potential impacts of this proposed project upon these species and habitats, potential conflicts with these targets are assessed below.

Species /Habitat	UK BAP Objective/Targets	Assessment	Further Details in ES
Sublittoral Sands & Gravels	Protect the extent/quality of a representative range of sublittoral sands and gravel habitats and communities.	The proposed project will result in a small loss of sublittoral sands/gravels, through the presence of piles and potential scour protection. However, this loss is predicted to only result in a **Minor Adverse Impact** upon these BAP targets.	Chapter 7
S. spinulosa in its reef-form	Maintain extent, distribution and quality of existing *S. Spinulosa* reefs. Establish and ensure neccessray habitat conditions required for the re-establishment of *S. Spinulosa* reef where formerly found.	Not present within site. Therefore, **No Impact** upon these BAP targets predicted.	Chapter 7
Commercial Marine Fish Species	To bring all stocks identified within the plan within precautionary reference points as defined by the International Council for the Exploration of the Seas (ICES) within 5 years.	Only minor adverse impacts are predicted upon fish resources from the proposed development. Which will not create impacts at broader stock-levels. Therefore, there will be **No Impact** upon this BAP objective.	Chapter 8
Allis and Twaite Shad	Ensure the continued survival of allis and twaite shad stocks.	No impacts upon these species are predicted from the proposed development. Therefore, there will be **No Impact** upon this BAP objective.	Chapter 8
Harbour Porpoise	Maintain the current range and abundance of harbour porpoise (short-term). Ensure that no anthropegenic factors inhibit a return to waters that it previously occupied (longer-term).	The detailed assessment on marine mammals concluded that there will be only Minor Adverse impacts upon these species as a result of this proposed development. Therefore, it is judged that there will be **No Impact** upon these BAP targets due to the GS2 project.	Chapter 9
Bottlenose Dolphin	Maintain the current range and abundance of small dolphins (short-term) and increase the ranges of small dolphin populations (longer-term).		

Table 6.3 Potential impacts upon UK BAP habitats and species targets/objectives

6.6.4 Cumulative Impacts

The proposed GS2 development has the potential to create cumulative impacts on nature conservation with other proposed projects in the Thames Estuary, including other offshore wind farm developments (London Array, Greater Gabbard, GS1, Thanet, Kentish Flats), marine aggregate extraction, commercial fishing activity and major port developments (London Gateway).

The assessment presented above indicates that there will be, at most, a minor adverse impact upon certain features of nature conservation interest (UK BAP sublittoral sands and gravels) as a result of the GS2 development in isolation. However, it is also necessary to consider the potential for more significant impacts to arise upon sites or features from the various projects listed above.

With respect to potential impacts upon existing designated sites, it is predicted that GS1 will not produce cumulative impacts with other offshore wind farm projects due to the spatial separation of this project with other sites (apart from GS1, which it lies adjacent to). In terms of the potential for GS1 and GS2 to produce cumulative impacts upon existing designated sites, both these sites are located some distance from any such sites and, therefore, it is concluded that there will be **No Impact** upon existing designated sites.

The only potential cumulative impact on nature conservation arises as a result of the possible effects of the consented GS1 project and the proposed GS2 project and also the consented London Array project on red throated divers in the Thames. As detailed above, there are proposals being developed to create a SPA within the Thames Estuary, due to large populations of this species that have been identified through surveys associated with previous wind farm developments.

Should this SPA be designated, there is the potential that the GS1, GS2 and London Array projects could all interact to produce adverse effects upon this SPA population.

The potential for this cumulative impact to arise is assessed in detail in the section on ornithology (Chapter 10).

6.7 Conclusions

Based upon the assessments presented above, it is concluded that there is limited scope for the proposed GS2 development to produce adverse impacts either upon existing sites of nature conservation interest or potential Annex I habitats. Potential impacts upon Annex II species, in particular marine mammals, are covered in detail in other sections of the ES.

However, there is the potential for the proposed GS2 development to create cumulative impacts upon red throated diver and the possible SPA for this species. This is assessed in detail in Chapter 10.

7. BENTHIC ECOLOGY

7.1 Introduction

The following section of the ES provides information on benthic ecology in the proposed GS2 study area and assesses the likely significant impacts upon benthic ecology of the proposed development.

7.2 Consultation

Consultation with respect to benthic ecology has been carried out with key stakeholders, including DTI, Defra, CEFAS and Natural England (NE). These organisations were issued the EIA scoping report in December 2006 and follow-up meetings were held on February 1st 2007 (CEFAS) and March 21st 2007 (NE, DTI and Defra). The scope of the 2007 benthic survey was agreed via correspondence with CEFAS.

7.3 Data Sources

A variety of surveys were undertaken as part of the original GS1 project, which included the collection of data on benthic ecology in the study area. Since the submission of the GS1 ES (May 2002) additional studies have been undertaken. Table 7.1 (below) lists all studies undertaken to date that have gathered data relevant to benthic ecology within the study area.

Survey/ Study	Date	Undertaken By	Description
Gunfleet Sands Geophysical Survey	2001	Titan Environmental Surveys Ltd	Bathymetric, sidescan and seismic sub-bottom profiles collected across proposed development site.
Gunfleet Sands Environmental Survey	2002	Titan Environmental Surveys Ltd	Particle size data collected at 65 sites within and around proposed development site.
Gunfleet Sands Geophysical Survey	2005	Osiris	Updated (from 2001) bathymetric, sidescan and seismic sub-bottom profiles collected across proposed development site (including GS2 boundary).

Table 7.1 Summary of previous Gunfleet studies relevant to benthic ecology

7.4 Project-Specific Survey

A benthic survey was undertaken in April 2007 by Osiris Projects Ltd on behalf of DONG. The scope and specification of this survey were developed by RPS and issued to CEFAS and NE for comment and approval. Approval was granted by CEFAS on 20.02.07 and by NE on 22.02.07. The objectives of this survey were two-fold:

1. To provide a pre-construction baseline of benthic communities in and around the GS1 site, as per the GS1 FEPA consent (31919/06/0) – clause 9.5 and Point 4 of Annex A; and
2. To gather information on benthic communities in and around the proposed GS2 development boundary to enable characterisation of the site for EIA purposes[12].

[12] Requirement for additional survey data on GS2 stated by CEFAS during meeting at DONG on Thursday 1st February 2007.

With respect to the GS2 EIA characterisation survey, the survey design comprised the following:

- Six sites for macrofaunal determination/particle size analysis (PSA) and chemical determinants;
- Single samples (0.1m2 Day grab over a 1mm sieve) (total 6 samples); and
- All PSA samples sieved down to 2µm with 1 phi class intervals using sieving and laser diffraction (total 6 samples).

Locations of the survey sites are shown on Figure 7.1. A further 23 sites were sampled as part of the GS1 pre-construction survey. These sites had previously been surveyed as part of the GS1 Environmental Impact Assessment (EIA) in February 2002, which comprise an array of 65 sites of which 12 sites were sampled in replicate (2 samples at each). These data have been used in support of the data collected specifically for GS2 (samples prefixed GFS), in order to spatially contextualise the species composition over the wider area.

Details of the survey methodologies and processing techniques are provided in the stand-alone technical report (Appendix F).

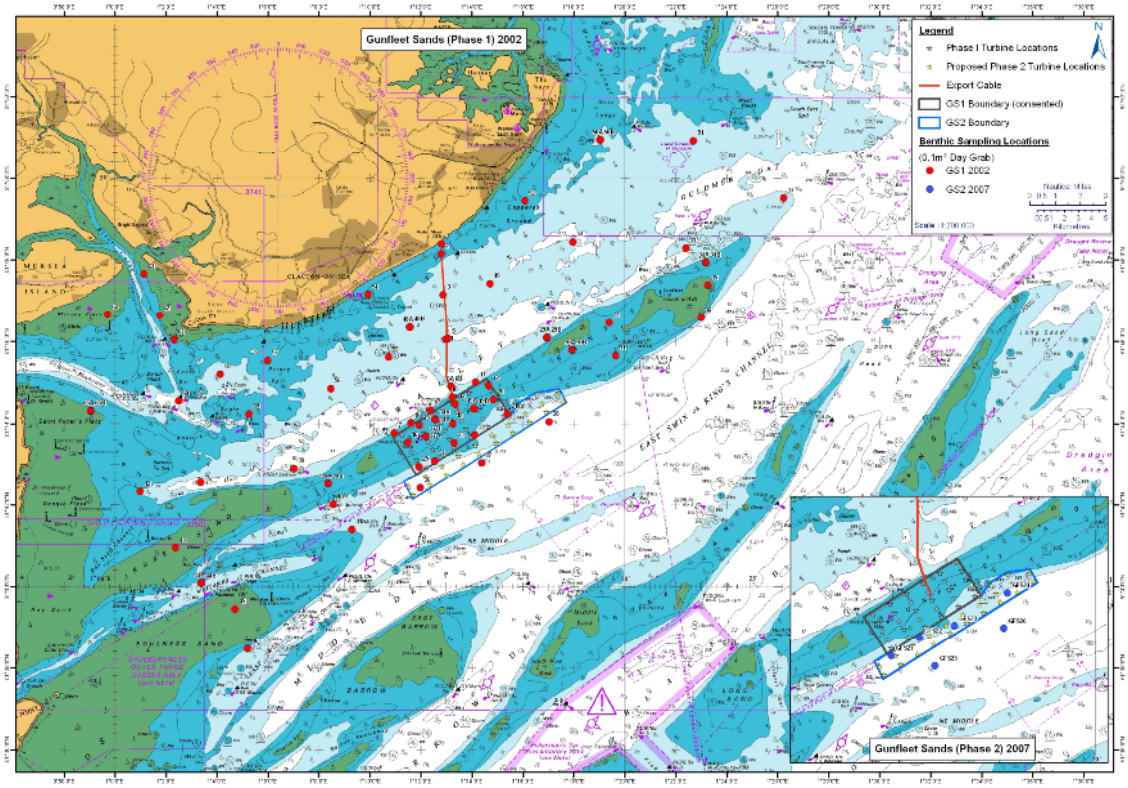


Figure 7.1 ***Locations of benthic survey sites for the consented GS1 wind farm, taken in February 2002 (red; main picture) and the proposed GS2 extension, taken in April 2007 (blue; inset)***

7.5 Description of Existing Environment

7.5.1 Sediment Analysis

7.5.1.1 Particle Size Analysis

Sediments across the entire survey area (GS1 and GS2) were generally comparable with mean ranges of particle size fraction components of 39% silt/mud (>63 um), 11% very fine sand (63-125 um), 14% fine sand (125-250 um), 10% medium sand (250-500 um), 6% coarse sand (0.5-1.0 mm), 4% very coarse sand (1-2 mm) and 16% gravel (<2mm). Percentage contributions of each of these sediment categories across the survey area are geospatially illustrated in Figure 7.2.

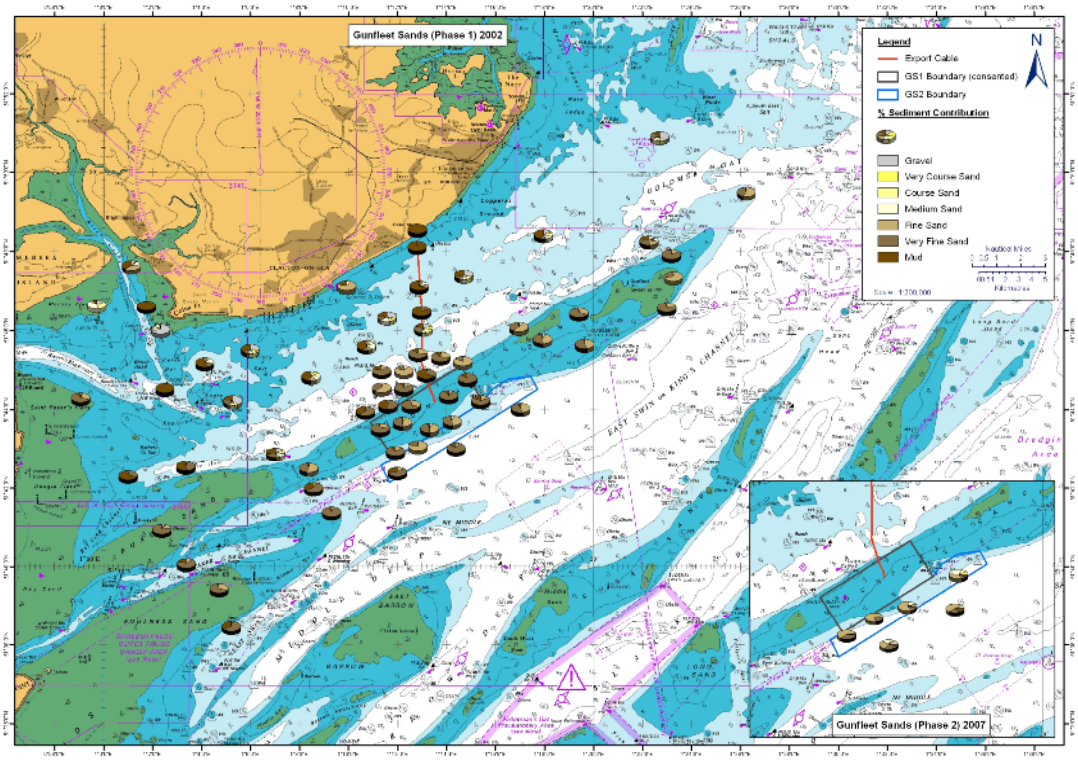


Figure 7.2 ***Percentage contributions of each sediment category for benthic samples taken for consented GS1 wind farm, February 2002 (main picture) and the proposed GS2 extension, April 2007 (inset)***

Generally, the sediments across Gunfleet, Buxey and Foulness Sands were dominated by mud, and fine sand fractions, with higher proportions of gravel at sites inshore of these banks. Multivariate analysis of the sediments gave four sediment groups, statistically distinct at the 5% significance level (SIMPROF). Sites 50 and 52 were hard indurated clay and as such could not be analysed by sieving, hence these samples are labelled 'no PSA'. Site 61 was an outlier (uc – unclassified) due to the comparatively large amount of gravel (77%) in this sample. SIMPER analysis of the resulting sediment groups highlighted the % contribution of sediment categories that contributed to the overall similarity within each group. Full SIMPER outputs are provided in the stand-alone technical report (Appendix F). The summary outputs of the similarity analysis are:

Sediment Group A: Slightly gravelly muddy sand to muddy sand characterised by the following:- mud (43.3% of the similarity), very fine sand (32.1%), fine sand (23.4%), medium sand (0.4%) and gravel (0.8%).

Sediment Group B: Slightly gravelly sand to sand characterised by the following:- mud (7.4%), very fine sand (50.9%), fine sand (38.6%), medium sand (2.9%), coarse sand (0.1%) very coarse sand (0.2%) and gravel (0.1%).

Sediment Group C: Slightly gravelly sandy mud to mud characterised by the following: - mud (54.6%), very fine sand (44.9%), fine sand (0.4%) and medium sand (0.1%).

Sediment Group D: Gravelly muddy sand to gravelly mud characterised by the following: - mud (38.1%), very fine sand (9.7%), fine sand (8.5%), medium sand (11%), coarse sand (0.9%), very coarse sand (0.9%) and gravel (18.8%)

The distribution of these four sediment types across the survey area is shown in Figure 7.3. This shows that the slightly gravelly muddy sand to muddy sand (Sediment Group A) and the slightly gravelly sand to sand (Sediment Group B) were distributed along the sand bank features of Buxey, Foulness and Gunfleet Sands, the latter comprising the locality of the proposed GS2 wind farm. The slightly gravelly sandy muds to mud of Sediment Group C were distributed along the cable route and in the outer part of the Blackwater/Colne Estuary. Sediment Group D (gravelly muddy sand to gravelly mud) occurred in the shallower waters between Gunfleet Sands and the Essex coast.

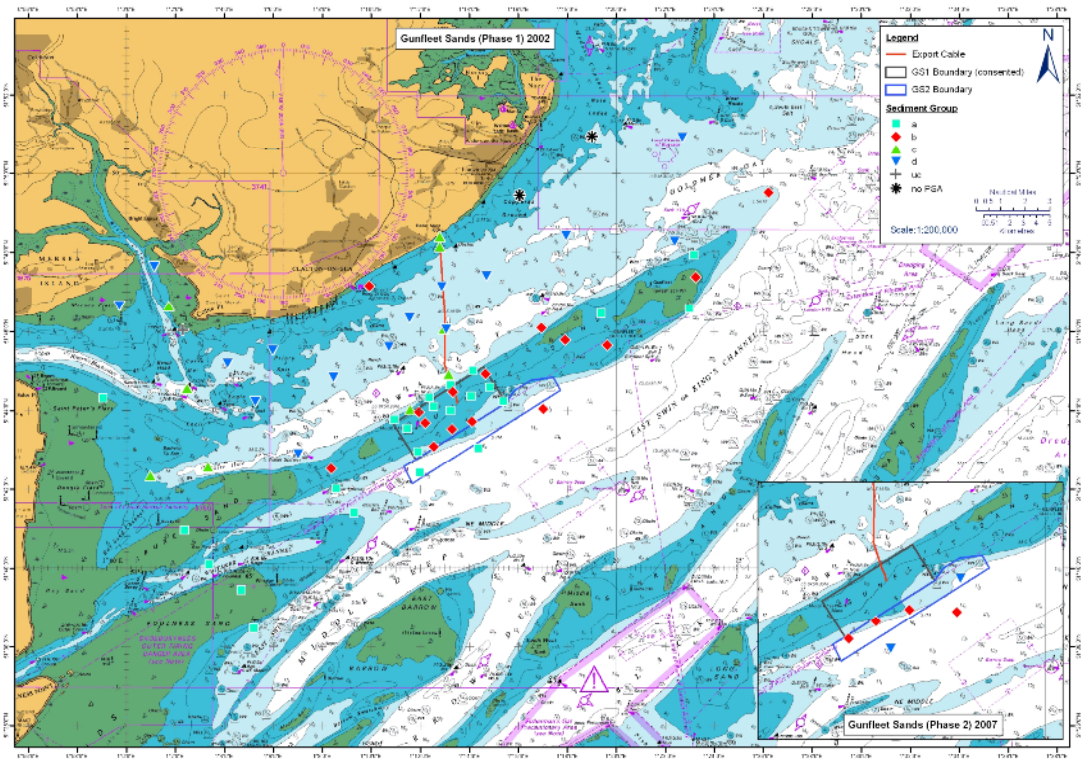


Figure 7.3 ***Locations of sediment groups based on PRIMER analysis of sediment composition for all samples taken for GS1, February 2002 (main picture) and GS2, April 2007 (inset)***

7.5.1.2 Sediment Contaminant Analysis

The 6 sites sampled during the GS2 survey were analysed for metals and total hydrocarbons (THC). These have been compared against the available Canadian Interim Sediment Quality Guidelines (ISQG) which gives the Threshold Effects Levels (TEL) for a range of chemicals, below which adverse biological effects would not be expected. The chemical concentrations have also been compared to the Probable Effects Level (PEL), which indicate the concentrations at which a toxicity effect would likely be evident. Effects may be observed in some sensitive species if exposed to contaminants at the TEL, whereas the PEL is likely to cause adverse effects in a wider range of organisms.

Arsenic was above the TEL for all sites within the GS2 area, however, these concentration were well below the PEL. None of the other metals were above either the TEL or PEL. Within the GS2 extension area, the following Polyaromatic Hydrocarbons (PAHs) - Naphthalene, Acenaphthylene, Acenaphthene, Fluorene and Phenanthrene - exceeded the TEL for some sites. For all sites, all PAHs were well within PEL concentrations.

7.5.2 Faunal Composition Analysis

7.5.2.1 Descriptive Characteristics

In all, a total of 132 taxa (species or higher group) of benthic fauna were recorded across the survey area, comprising 56 annelids, 30 crustaceans, 22 molluscs, 7 echinoderms and 17 in the category 'other'. This latter group include protozoa, hydrozoa, bryozoa, nemertea, nematoda, sipuncula, phoronida and pycnogonida.

A total of 12 species were found during the GS2 survey that were not recorded during the GS1 survey, two species of *Glycera*) and one species of *Nephtys* (all annelid worms), two species of *Bathyporeia* and *Cheirocratus intermedius* (all amphipod crustacea) and five 'other' species were identified.

The occurrence of these additional species could be due to a number of factors; for example; increased spatial distribution of sampling, the time of year (GS1 samples were taken in February and GS2 in April therefore a potentially increase in species abundance and prevalence in the GS2 samples) inter-laboratory differences, i.e. identification of genera to different species levels, (e.g. *Glycera*) although it should be noted that both laboratories follow strict internal/external QA), and the presence of rocks in sample GFS 25, where the 5 additional encrusting species were identified.

On average, taxa in the group Annelida dominated the benthic samples in terms of observed number of species, with an average of 3.5 annelid species per 0.1m^2 Day grab, compared to 1.1 crustaceans, 1.5 molluscs, 0.2 echinoderms, and 0.5 species 'other' species. In terms of abundance, the 'other' taxa dominated the benthic samples across the survey area, with an average 22.9 'other' species counted per 0.1m^2 Day grab, compared to 7.7 annelids, 4.0 crustacean, 16 molluscs and 0.4 echinoderms. Note, 'other' includes colonial organisms being allocated a nominal abundance of '1'.

The percentage contribution across all sites for species and abundance in each major group is shown in Figure 7.4.

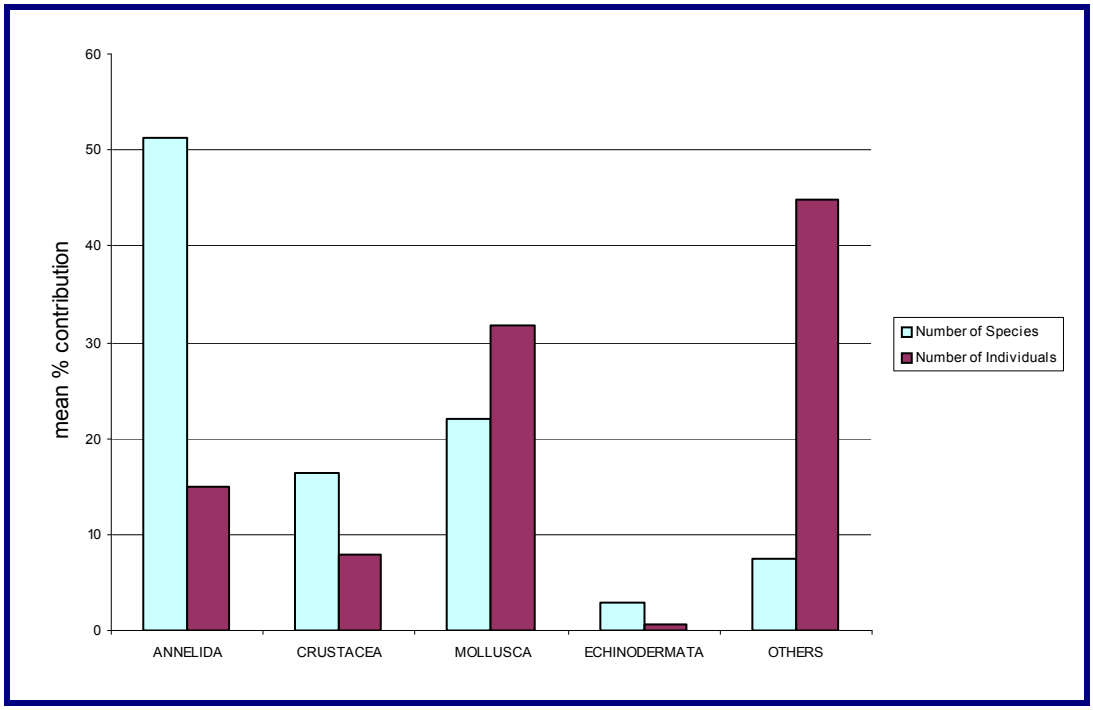


Figure 7.4 ***Mean percentage contribution of abundance and observed number of species of each taxon per site across the study area***

One notable occurrence was the identification of the Ross worm *Sabellaria spinulosa.* This species was recorded at sites 5, 48, 51 and GSF25, all outside the immediate vicinity of the proposed GS2 extension. In any case, abundances were not indicative of either 'reef' or 'crust' formations, with a maximum of 10 individuals in sample GSF25. Additionally, no reef formation was noted in the survey log. 'Sublittoral sands and gravels' is a UK Biodiversity Action Plan (BAP) Habitat and therefore the habitat in and adjacent to the proposed GS2 extension is afforded protection under this national legalisation. It should, however be noted, that none of the species found in this area are afforded any direct scheduled species or statutory protection, and are all species typical of mobile sandy sediment substrata, which is widely distributed around the UK coast.

7.5.2.2 Multivariate Analyses

A multivariate analysis of the GS1 and GS2 faunal data combined was performed using square root transformation of the data to build a similarity matrix. From this matrix, cluster analysis was showed that the level of similarity between sites based on the species composition and abundances of these species is generally low, indicating poor association within the sparse fauna. Four main clusters were identified - A, B, C and D. With the addition of the GS2 data, faunal group slightly altered from that reported for GS1 data alone (Titan Environmental Surveys Ltd, 2002), with subgroup (C1) originally associated with main group C, transposed to main group B (now subgroup B1).

SIMPER analysis of the GS1 and GS2 data combined gives the similarities within each faunal group, and the species that contribute to this similarity. Full SIMPER outputs including similarity within groups and dissimilarities between groups are provided in Appendix F. The output of this similarity analysis (cut off for contribution 90%) are summarised as follows:

Faunal Group A: Characterised by a impoverished species community, with the annelid *Nephtys kersivalensis* (62.9% of the similarity) and phoronid "worm" *Phoronis muelleri* (21.3%)

Faunal Group B: Characterised by the amphipod *Bathyporeia pelagica* (34.9%), annelid *Nephtys cirrosa* (26.9%), bivalve mollusc *Nucula nitidosa* (19.9%), annelid *Magelona mirabilis* (4.6%) and annelid *Nephyts kersivalensis* (4.1%)

Faunal Group B1 (Group C1 in GS1 data only dendrogram): Characterised by the bivalve molluscs *Nucula nucleus* (83.3%) and *Barnea parva* (6.9%).

Faunal Group C: Characterised by a wide range of species including the bivalve mollusc *Abra alba* (19.0%), annelids *Notomastus latericeus* (16.2%), *Nereis longissima* (10.6%), *Glycera alba* (7.8%), *Scoloplos armiger* (6.2%), echinoderm *Lepidonotus squamatus* (5.7%), annelid *Lumbrineris gracilis* (4.6%), mollusc *Nucula nucleus* (4.5%), annelid *Eteone longa* (4.0%), *Chaetozone gibber* (2.7%), amphipod *Ampelisca spinipes* (2.6%), annelids *Sabellaria spinulosa* (2.1%), *Nephtys caeca* (1.8%) and sea anemone *Edwardsia claparedii* (1.1%), amphipod *Dyopedos monacanthus* (1.0%) and echinoderm *Amphiura* sp. (0.9%)

Faunal Group D: Characterised by a small species compliment including the amphipod *Corophium volutator* (36.8%) and annelids *Glycera alba* (30.1%) *Goniada maculata* (6.2%), *Nephtys kersivalensis* (6.1%), bivalve mollusc *Barnea candida* (5.3%), annelid *Notomastus latericeus* (5.3%) and sea anemone *Edwardsia claparedii* (4.1%)

The distribution of faunal groups across the sites is presented in Figure 7.5. Along the Buxey, Foulness and Gunfleet sandbank (where the proposed GS2 extension and consented GS1 wind farm will lie), the species assemblage comprises predominately faunal group B; a sandy community typified by *Bathyporeia pelagica*, *Nephtys spp., Nucula nitidosa and Magelona mirabilis;* and subgroup B1 typified by *Nucula nucleus* and *Barnea parva*.

Faunal group D dominates along the northern flank of the Gunfleet sandbank, away from the proposed GS2 extension. Faunal group C is predominant in the sediments inshore of these sandbank features. Finally, faunal group A is associated with the entrances to the Colne and Blackwater estuaries.

Further statistical analysis showed that the sediment and faunal groups are not closely associated. The best correlation between biotic and abiotic variables was for the gravel, coarse sand and mud fractions, indicating that the biological community composition in the survey area was most strongly associated with the proportion of these fractions. However, it is notable that the correlation value (0.386) shows that the association between biological and sediment datasets is not good, and that other environmental (e.g. current and wave velocities on the seabed, depth, scour) and/or biological variables (predation/prey relationships) are likely to be influencing the biological community composition more strongly than sediment composition alone.

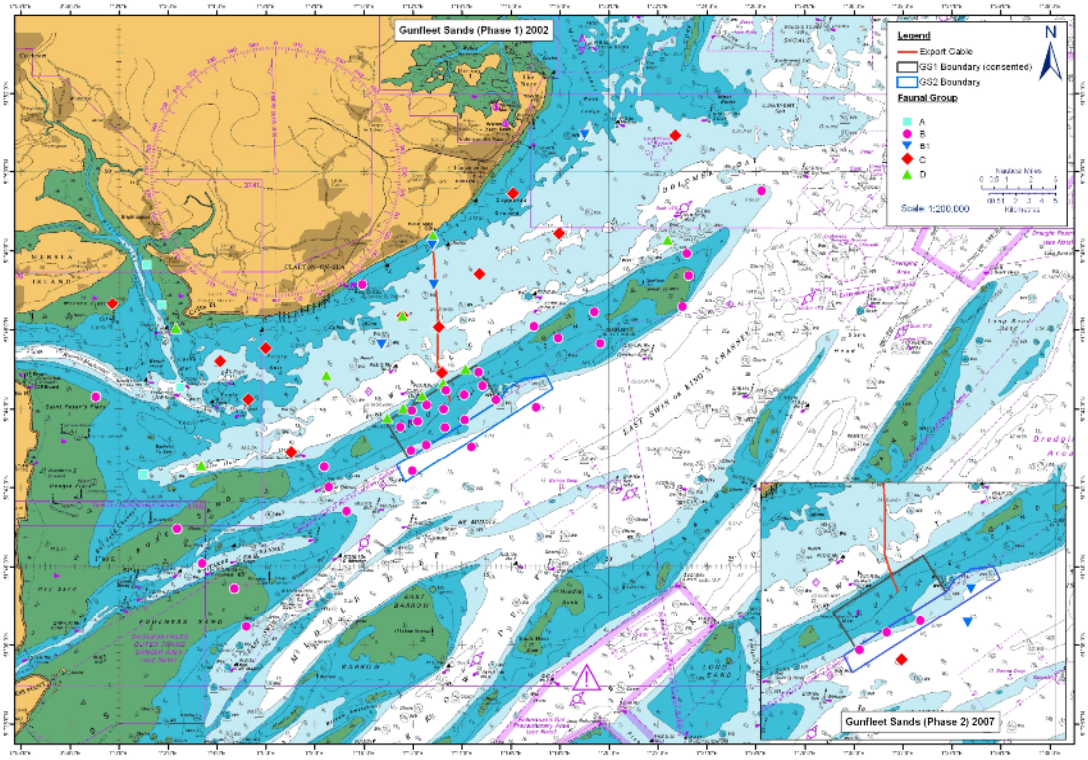


Figure 7.5 ***Locations of faunal groups based on PRIMER analysis of faunal composition for all samples taken for GS1, February 2002 (main picture) and GS2, April 2007 (inset)***

7.6 Impact Assessment

The following section of the ES assesses the likely significant effects of the proposed GS2 development upon benthic communities. The methodology for assessment is the same as that presented in Chapter 2.

The specific nature of the biological communities associated within the sediments in the immediate vicinity of the proposed GS2 wind farm have been identified from the baseline surveys discussed in the baseline section above. The faunal groups that are predominant in this area are faunal group B, a sandy community, typified by the amphipod *Bathyporeia pelagica*, the annelids *Nephtys spp.,* and *Magelona mirabilis* and the bivalve mollusc *Nucula nitidosa;* and subgroup B1, typified by bivalve molluscs *Nucula nucleus* and *Barnea parva*. The MarLIN sensitivity rationale (www.marlin.ac.uk) has been utilised for these typical species where available.

Whilst the nature of sensitivity to an impact is species-specific, the sensitivities of these species are likely to be indicative of the response to impacts of other species within the same family/group. This allows assessment of the overall sensitivity of the benthic biological communities in the area potentially impacted by the proposed GS2 extension.

7.6.1 Construction and Decommissioning Phases

Impact Title: The proposed GS2 scheme will cause a temporary increase in suspended sediment concentrations from trenching and/or piling operations (plume effects)

During construction, suspended sediment concentrations (SSC) may increase as a result of the cable laying and piling activities. Raised levels of suspended sediments can affect benthic communities by clogging respiratory and feeding mechanisms and through light attenuation, which can affect the photosynthetic rates of marine flora. Hence, there is the potential for adverse impact on sensitive species with increased SSC. The coastal process assessment (see Appendix D) evaluated increases in SSC associated with the construction phase as being temporary, and localised to *within a few hundred metres* of each monopile, with SSC entrained to ambient concentrations away from this immediate area.

The impact of increased SSC on the intolerance, recoverability and sensitivity of benthic species typical of the GS2 sediments has been assessed by MarLIN. The amphipod *Bathyporeia pelagica* has a low intolerance, but very high recoverability and is therefore considered to have very low sensitivity to increased SSC. The annelids *Nephtys spp.* and *Magelona mirabilis,* together with the bivalve mollusc *Nucula spp.* have been assessed as being tolerant. Whilst there could be species present that are more sensitive to increased SSC, these species are typical of the mobile sand communities found in this area and are adapted to high background levels of SSC. It is anticipated that any adverse effect on species composition would be limited to the immediate vicinity of the proposed GS2 wind farm; additionally, impacts would be temporary and would, therefore, have a **Negligible Impact**.

Mitigation Measures

As only a negligible impact is predicted upon benthic communities from increased SSC during the construction phase, no mitigation is required.

Residual Impact

A **Negligible Impact** upon benthic communities from increased SSC is predicted.

Impact Title: The proposed GS2 scheme will cause a temporary increase in sediment deposition from plumes

During construction, increased sediment deposition as a result of sediment disturbance from the cable laying and piling activities may occur. Re-deposition of suspended sediments can affect benthic communities by smothering respiratory and feeding mechanisms. As with SSC, smothering effects have the potential to decrease species diversity, abundance and biomass. The coastal process study (see Appendix D) predicts that increased SSC and the resulting redeposition will be localised and temporary, and the sediment would be entrained into background SSC within a *few hundred metres* of the monopiles.

The impact of smothering on the intolerance, recoverability and sensitivity of benthic species typical of the GS2 sediments has been assessed by MarLIN. The amphipod *Bathyporeia pelagica* has an intermediate intolerance, but high recoverability and is therefore consider having low sensitivity to smothering.

Annelids *Nephtys spp.* have been assessed as being tolerant and *Magelona mirabilis* having low intolerance, intermediate recoverability and therefore not sensitive. The bivalve mollusc *Nucula spp.* has also been assessed as having low intolerance, with very high recoverability and therefore very low sensitivity. Whilst there could be species present that are more sensitive to smothering, these species are typical of mobile sand communities, and are therefore naturally adapted to dynamic sediment regime. It is anticipated that any adverse effects on species composition would be limited to the immediate vicinity of the proposed GS2 wind farm; additionally, impacts would be temporary and would therefore have a **Negligible Impact**.

Mitigation Measures

As only a negligible impact is predicted upon benthic communities from increased sediment deposition during the construction phase, no mitigation is required.

Residual Impact

A **Negligible Impact** upon benthic communities from sediment deposition is predicted,

Impact Title: The proposed GS2 scheme will potentially cause the release of contaminants bound in sediments

During construction, there is the potential for contaminants locked up in the sediments to be re-suspended as a result of the cable laying and piling activities. The release of such contaminants may lead to impacts on macrobenthos through toxic effects resulting in a reduction in macrobenthic diversity, abundance and biomass. The sediment chemistry results were compared against Canadian Interim Sediment Quality Guidelines (ISQG). The ranges of concentrations found at the GS2 site are well within, or close to, the range expected sediments with the GTE. Arsenic and some Polyaromatic Hydrocarbons (PAHs) were slightly elevated above Threshold Effects Levels (TEL). All concentrations were within Probable Effects Levels (PEL). These levels are not deemed likely to have a significant adverse effect on associated benthic ecology. During sediment disturbance, low levels of contaminants contained in the sediment would be rapidly diluted and dispersed in the water column. Any potential effect upon macrofaunal assemblages are therefore predicted to be of **Negligible Impact**.

Mitigation Measures

As only a negligible impact is predicted upon benthic communities from the release of contaminants from sediments, no mitigation is required.

Residual Impact

A **Negligible Impact** upon benthic communities from the remobilisation of contaminated sediments is predicted.

Impact Title: The proposed GS2 scheme will potentially cause the release of pollutants from construction plant

There are a range of contaminants that have the potential to be released during the construction phase of the wind farm development, arising directly from construction vessels and activities, including spillages of diesel oil from vessels and/or rig run-off; sewage discharges, antifoulant biocides and leachates from cement and/or grouting compounds. The release of such contaminants may lead to impacts on macrobenthos through toxic effects resulting in a reduction in macrobenthic diversity, abundance and biomass. Where contamination is significant, recovery of areas through recolonisation may be limited.

The area over which such potential discharges of pollutants to the water column could occur will be limited to the sites of each proposed turbine placement location, and as such any associated impact would be anticipated to be similarly limited in extent. Given the limited spatial extent, any potential effects upon macrofaunal assemblages are predicted to be of **Negligible Impact**.

Mitigation Measures

Mitigation measures will be adopted to ensure that the potential for release of any such materials (and therefore any associated impact potential) is minimised. It is proposed that a Marine Pollution Contingency Plan for spills and collision incidents will be developed and implemented. This plan will address all potential contaminant releases (both compounds and pathways). This will include provision of oil drainage traps on rigs, sewage treatment systems (or storage tank provision), and adherence to Harmonised Mandatory Control Systems (HMCS) for chemical releases including grouting and rig wash degreasing and detergent products. In this manner, accidental release of potential contaminants from rigs and supply/service vessels will be strictly controlled, thus providing for protection of marine life during the construction phase of the wind farm development.

The plan will have regard for local estuaries and rivers and other offshore installations. The plan will also include key emergency contact details (Environment Agency, Natural England and MCA).

Residual Impact

Successful implementation of these mitigation measures will result in there being **No Impact** upon benthic communities from release of pollutants during the construction phase.

7.6.2 Operational Phase

Impact Title: The proposed GS2 scheme will cause the loss of seabed habitat through the presence of turbines and foundations

In the immediate footprint of the proposed GS2 scheme, up to 22 turbines are proposed. It is anticipated that a direct loss of habitat as result of the turbines and scour protection would be 33,452m^2 (0.033km^2), i.e. 0.44% of a total proposed GS2 wind farm area of 7.5km^2. As these sediments will be within the direct footprint of the turbines and scour protection, no recovery of this seabed could occur until decommissioning, when the developer is required to return the seabed to its original state.

This habitat is afford national protection under UK BAP Habitat 'sublittoral sands & gravels', however, the low species composition within this area, and the abundance of similar habitat with the Greater Thames Estuary (GTE) and elsewhere off UK coasts lead to the evaluation of the area as being of low value. Although the magnitude of the impact to this area of seabed is high, the comparatively small size and prevalence of similar habitat within the wider areas, lead to an assessment of **Minor Adverse** significance.

Mitigation Measures

There are no mitigation measures available to minimise the loss of benthic habitat from the proposed turbines and foundations.

Residual Impact

A **Minor Adverse Impact** upon benthic communities from habitat loss is predicted.

Impact Title: The proposed GS2 scheme will potentially cause scour and also alter sediment transport processes, leading to change in seabed habitats

Localised scour around each monopile is expected to occur. The coastal processes assessment estimates that the equilibrium scour depth associated with each monopile to be between 3.8m and 6.2m deep, and between 33m and 48m wide. Within the scour pit, there will be a direct impact of substrate loss. Outside the scour pit, within a few hundred metres of the monopile, benthic communities will be affected by increases in sediment deposition and erosion, as scour redistributes the predicted 747m^3 of sediment eroded from the scour pit. This will potentially cause abrasion and disturbance effects to benthic communities, and lead to a reduction in benthic species composition, abundance and biomass.

The impact of abrasion and disturbance on the intolerance, recoverability and sensitivity of benthic species typical of the GS2 sediments has been assessed by MarLIN. The amphipod *Bathyporeia pelagica* is tolerant to abrasion and physical disturbance. The annelid *Nephtys* spp. has been assessed as having intermediate intolerance, very high recoverability and therefore low sensitivity. The annelid *Magelona mirabilis*, and the bivalve mollusc *Nucula* spp. have intermediate intolerance but high recoverability and therefore have low sensitivity. The sensitivity of the habitat in this area to abrasion and disturbance is therefore considered to be low.

Whilst the benthic communities are related to sediment composition to some degree, other abiotic factors are likely to be shaping the benthic community, for example, geological features, scour, water depth and currents. The faunal data indicates that communities are more closely associated with gross morphological features, such as sandbanks (faunal group B). The patchy distribution of sediment groups A and B across this sandbank, relates to different proportions of mud, and very fine and fine sand. These natural alterations in sediment types may affect species abundances and biomass on a local scale. However, in context of the wider sandbank area, the overall benthic community composition remains the same. Therefore, whilst localised changes in scour as a result of the proposed monopiles could cause a potential reduction in abundance and biomass of more sensitive species, the overall community structure (species composition) is likely to be retained. These effects are therefore considered to be **Minor Adverse** in context of the wider GTE area.

Mitigation Measures

It is proposed that scour protection will be used around the base of the GS2 turbines. It is expected that rock, rough gravel or mats around the base of the pile to a diameter of 3 to 4 times the pile is the most likely solution for scour protection.

Residual Impact

The use of scour protection around the base of each turbine will reduce the amount of scour that occurs in this area. Therefore, there will be less of an impact upon benthic communities in this area from abrasion and disturbance than if scour protection were not used. It is predicted that with the use of scour protection, there will be a **Negligible Impact** upon benthic communities from scour effects.

Impact Title: The proposed GS2 scheme will potentially cause the colonisation of turbines and possibly scour protection, leading to increased biodiversity

The turbines and associated scour protection are likely to be colonised by a variety of epifaunal species associated with hard substrate and will not reflect the species complement associated with the soft benthic sediments within the original footprint.

Species that are likely to colonise the turbines and scour protection include barnacle, hydroids, bryozoans, juvenile bivalves, tubiculous amphipod crustaceans and polychaete worms, as well as more mobile epifaunal species such as crustaceans and echinoderms.

However, it should be noted that any increase in biodiversity associated with colonisation of the turbines and scour protection is not regarded as mitigation for the loss of species associated with the soft sediments in the footprint of the turbine and scour protection structures. The effect of the monopile structures are, therefore, not considered to be beneficial, nor are they considered to be adverse, as there will be a replacement of one type of community with another. It is therefore assessed as having a **Neutral Impact**.

Mitigation Measures

No mitigation is required.

Residual Impact

It is predicted that there will be a **Neutral Impact** upon benthic communities from colonisation of the turbines and/or scour protection.

Impact Title: The proposed GS2 scheme will potentially cause toxic effect on benthic communities from sacrificial anodes on foundations

Anodes of zinc or aluminium will be used to provide cathodic protection for the turbines. Dissolved zinc is toxic to marine life at low concentrations, and the Environmental Quality Standard (EQS) is 40µg/l as an annual mean value. However, the small amount of zinc that would be released into the water column will be rapidly diluted and dispersed. Any impacts to benthic assemblages would therefore be **Negligible**.

Mitigation Measures

Aluminium could be used, as it is non-toxic to marine life. Overall, any materials used will be evaluated during the technical design to ensure best practice is adopted.

Residual Impact

It is predicted that there will be a **Negligible Impact** upon benthic communities from potential effects of anodes on the turbines.

7.6.3 Cumulative Impacts

An assessment of potential impacts for the proposed GS2 wind farm development must also take into consideration the potential cumulative and in-combination impacts of other developments, including other wind farms. Table 7.2 gives an overview of known projects and plans which are either consented or planned activities in the GTE. Impacts considered in this section are based on the overall impacts to the 'sublittoral sand and gravel habitats' in the terms of the GTE area, rather than on specific effects to communities and their individual species.

Development	Area of Impact (km^2)	% GTE[13] area affected	No. of turbines	Estimated habitat loss	Estimated area disturbed by scour pit
Gunfleet Sands 2 (GS2)	7.5	0.14%	Up to 22	0.028 km^2	0.043
Gunfleet Sands 1 (GS1)	10	0.19%	30	0.039 km^2	0.059
Kentish Flats	10	0.19%	30	0.039 km^2	0.059
London Array	266.4	5.03%	271	0.35 km^2	0.532
Greater Gabbard	102	1.92%	Up to 140	0.182 km^2	0.275
Thanet	35	0.66%	Up to 100	0.130 km^2	0.196
London Gateway (dredging and reclamation)	19.3	0.36%	NA	NA	
Aggregate Extraction	62.66	1.18%	NA		
Total Area of Impact	**512.86**	**9.67%**		**0.01%**	**0.02%**

Table 7.2 Summary of consented/planned activities in the Greater Thames Estuary (GTE) that may create potential in-combination impacts

Table 7.2 gives estimates of habitat loss as a direct result of the turbine and scour protection. These have been based upon calculations done for GS2, i.e. 22 turbines = loss of 0.03km^2, therefore, one turbine = loss of 0.0013km^2. This figure has been applied to all other Thames wind farm projects. The numbers of turbines per project are those given in most recent documentation related to these schemes.

Although this is a relatively crude methodology, it does give an indication of the anticipated loss of habitat as a result of turbine placement of 0.01% of the GTE area. A potential additional loss of habitat of 1.18% through aggregate dredging could also occur, however this figure is for the entire licence application area, rather than smaller areas that are subjected to active dredging activities, and so it is unlikely that this percentage is subject to direct habitat loss. Given the size of the area impacted by habitat loss, the in-combination impact of sublittoral habitat loss is considered to be Minor Adverse in terms of the GTE area.

The coastal process assessment considered that the separation between monopiles would prevent localised changes in waves and tides around each monopile interacting, thereby preventing any cumulative scour effect. Given that the same turbine separation occurs over the wider Gunfleet Sands area, and that the other wind farms occur in spatially distinct areas of the GTE no in-combination impact is therefore considered feasible. However, in terms of area impacted by scouring, there will be a footprint of scour for each of the monopiles across the GTE. Table 7.2 gives estimates for the area likely to be subjected to scouring effects. This is based on a maximum 50m diameter; each scour pit area (area = πr^2) was multiplied by the number of turbines for each wind farm, to give an overall potential area of effect of 0.02% of the GTE area.

The actual impact within each scour zone is related to the sensitivity of the benthic communities present. In the case of GS2, the habitat has been considered to be of low sensitivity; the habitat present at the other wind farm sites maybe more sensitive to abrasion and disturbance impacts.

[13] Percent area impacted is based on a Greater Thames Estuary (GTE) Area = ~5,300 km^2

However, given the size of the area 0.02% of the GTE, the cumulative effect of these localised scouring incidents will contribute an overall **Minor Adverse Impact** effect on sublittoral habitats in the GTE area.

Other impacts associated with the GS2 wind farm as discussed in previous sections have been assessed as having negligible or no impact. These are largely impacts associated with the construction phase and therefore temporary and localised. It is, therefore, judged to be unlikely that these effects would have a significant in-combination effect on benthic communities with the effects of the other GTE plans and projects

7.6.4 Proposed Monitoring

As part of the conditions attached to the FEPA licence for the GS1 project, a pre-construction benthic survey of the area around Gunfleet Sands was undertaken in April/May 2007. This survey array was approved by both CEFAS and Natural England. This array includes both near-field and far-field sampling stations, within both the GS1 and GS2 boundaries.

Consultation will be undertaken with CEFAS and Natural England to determine the scope of further benthic surveys for the GS1 and GS2 sites.

7.7 Conclusions

The existing benthic communities within and around the proposed GS2 site have been described using data from the original 2002 benthic survey plus data from the recent 2007 survey. This analysis concluded that there are 4 main sediment types across the survey area and also 4 main faunal assemblages.

Across the actual site of the proposed GS2 development, the main faunal group comprised a sandy community, typified by *Bathyporeia pelagica* and *Nephtys* spp. Further analysis of environmental variables concluded that there was no strong correlation between benthic communities and sediment types, and that it was more likely that other environmental factors, (water depth, current speed) are likely to influence biological community composition.

With respect to potential impacts, during the construction phase of the scheme it is predicted that there will be negligible impacts upon localised benthic communities from increased SSC and deposition. During the operational phase, it is predicted that there will be a minor adverse impact upon benthic communities through habitat loss from the turbines and scour protection. There will also be a potential minor adverse impact from localised scour, although if scour protection is used as proposed, this impact will reduce to one of negligible significance

It is likely that some form of colonisation may occur on the turbines and scour protection. However, as any increase in biodiversity from this source in effect is replacing a reduction in biodiversity from habitat loss associated with the turbine placement, it is predicted that this will produce a neutral impact.

There is also scope for in-combination impacts upon benthic communities from other projects in the GTE region. With respect to potential in-combination effects from coastal processes, this is not predicted. There will be a cumulative impact from habitat loss throughout the estuary, however, in the scale of the wider region, this loss is predicted to be only of minor adverse significance.

Overall, it is concluded that although there will be adverse impacts upon benthic communities from the proposed GS2 development, these will be localised and of only minor adverse significance.

8. FISH AND SHELLFISH RESOURCES

8.1 Introduction

The following section of the ES describes the baseline environment for fish and shellfish resources in the proposed GS2 study area and assesses the likely significant effects of the proposed GS2 scheme upon these resources.

8.2 Consultation

Consultation with organisations with interests in fish and shellfish resources has been undertaken via issue of the EIA scoping report in December 2006 and also specific meetings. Meetings have been held with CEFAS, Natural England and Kent and Essex Sea Fisheries Committee, during which, aspects of the scheme in relation to this particular parameter were discussed. Consultation with the local fishing community has also been undertaken via various group meetings and also face-to-face meetings.

8.3 Data Sources

Information on fish and shellfish resources in the area on and around Gunfleet Sands has been gathered from a range of sources, including the following:

- Data from the Gunfleet Sands 1 EIA epibenthic trawl survey (2002);
- Data from Kent and Essex Sea Fisheries Committee Annual Reports;
- Consultation with local commercial fishermen and representatives of the fishing industry;
- Technical reports produced by CEFAS;
- DEFRA landings data for relevant ICES rectangles; and
- ES's published for other Thames Estuary offshore wind farms.

8.4 Project-Specific Surveys

No specific fish/shellfish resource surveys have been undertaken for this study. Epibenthic surveys of the site using a 2m beam trawl were undertaken in February and September 2002, which did provide some information on certain fish species in this area. However, these surveys were not intended to act as fish resource surveys.

8.5 Description of Existing Environment

8.5.1 Overview

In line with recommendations set out in relevant guidance documents[14] this sub-section describes and assesses the presence and relative importance of fish and shellfish resources, including:

- The major species of fish and shellfish in the area that are of significant importance in commercial and recreational fisheries;
- Those species of fish in the area that are of conservation importance;

[14] Offshore Wind Farms. Guidance Note for Environmental Impact Assessment in respect of FEPA and CPA requirements. Version 2. CEFAS. June 2004.

- Elasmobranch fish (which are often also of commercial and recreational importance) which may be susceptible to the effects of electromagnetic fields; and
- Species that have a restricted geographical distribution and are locally abundant in the area.

For these fish and shellfish resources, the following aspects of their ecology have been considered:

- Distribution of spawning, nursery and feeding grounds;
- Distribution of overwintering areas for crustaceans (eg lobster and crab); and
- Any known migration routes.

8.5.2 Overview of Fish and Shellfish Resources of the Strategic Area

The Greater Thames Estuary supports a wide range of finfish species, with up to 112 different species documented by Swaby and Potts (1998). The composition of fish species within this region includes commercially important species, such as sole, bass, herring, thornback rays, sprat, cod and plaice plus non-commercial species, including pogge, lesser spotted dogfish, dragonets, many species of gobies and bib, to name just a few.

The abundance and composition of the fish fauna in this region varies throughout the year. A series of 6 otter trawl surveys were undertaken in 2002 by Marine Ecological Services Ltd as part of the EIA for the London Gateway port development. This set of surveys showed that in the outer-mid estuary and outer estuary, there were significant changes in community composition of the fish populations between late summer, winter and spring (MES, 2002).

With respect to shellfish, the Greater Thames region supports a range of species, including commercially important species such as edible crab (*Cancer pagarus*), lobster (*Hommarus gamarus*), cockles (*Cerastoderma edule*), oysters (*Ostrea edulis*) and whelks (*Buccinum undatum*). Extensive commercial cockle beds exist throughout the estuary, many of which are covered by the Thames Estuary Cockle Regulating Order 1994 and managed by the Kent and Essex Sea Fisheries Committee. At the time of writing, the Thames Estuary cockle fishery is the largest in the UK in terms of landings (up to 25,000 tonnes are landed each year). Further details on the distribution of key cockle beds are provided below.

8.5.3 Data from the 2002 trawl survey

Some limited information on the composition of fish within the immediate Gunfleet Sands area is available from the 2002 trawl surveys, undertaken as part of the EIA work for the GS1 project. The following species were recorded from the February 2002 and September 2002 surveys.

Finfish		Shellfish
Cod	Pollack	Edible crab
Sand goby	Herring	Velvet swimming crab
Plaice	Pogge	Pink shrimp
Flounder	Pout	Brown shrimp
Whiting	Dab	Common mussel
5-bearded rockling	Sole	Common whelk
Sprat		Spider crab

Table 8.1 Fish species recorded during the 2002 epibenthic beam trawl survey

8.5.4 Major species of fish and shellfish in the area that are of significant importance in commercial and recreational fisheries

Analysis of DEFRA landings data from the ICES rectangle within which the proposed GS2 development is located (32F1) enables a picture to be developed of which species are of significant importance to commercial and recreational fisheries in this wider area. Based upon landings data for the period 2002-2006, the top 5 species (ranked by value of landings) from this area were:

1. Sole (£1,509,333)
2. Cockles (£1,445,391)
3. Sprats (£884,405)
4. Crabs (£634,446)
5. Skates and Rays (£572,890)

These figures illustrate the importance of sole to commercial fisheries in this area. Sole will be targeted by netters on top of the bank and trawlers in the deeper water surrounding the main bank feature. Of the other high value species noted above, skates and rays will be targeted on top of the bank by netters and long-liners (see Chapter 11 for more details on the distribution of fishing activity in this area).

In addition to these species, a further 45 species were landed from 32F1 between 2002-2006, illustrating the diversity of fish species within this area.

8.5.5 Species of Conservation Importance

The following species of nature conservation importance are known to occur within the wider Thames Estuary region.

Species	Legislation				
	Wildlife & Countryside Act 1981	EC Habitats Directive	UK BAP	IUCN	CITES
Allis shad (*Alosa alosa*)	Schedule 5	Annex II	Y	-	-
Twaite shad (*Alosa fallax*)	Schedule 5	Annex II	Y	-	-
River lamprey (*Lampetra fluviatilis*)	-	Annex II and V	-	-	-
Sea lamprey (*Petromyzon marinus*)	-	Annex II	-	-	-
European sturgeon (*Acipenser sturio*)	Schedule 5	Annex II and IV	-	-	Appendix 1
Tope (*Galeorhinus galeus*)	-	-	-	Vulnerable	-

Table 8.2 ***Marine fish species afforded protection under national legislation and international conventions which may occur within the wider Thames Estuary region***

It is likely that all these species exist within the wider Thames Estuary at certain times of year. However, there is no evidence that suggests that the proposed GS2 development area provides a unique habitat for any of these species and if these species do occur in this area, it is predicted that their distribution is extremely patchy and seasonal.

8.5.6 Distribution of elasmobranch species

Many species of elasmobranch fish occur within the Greater Thames Estuary region. Skates and ray species are distributed widely throughout this area, with this group of fish representing an important target species for commercial fisheries in this area. Landings are made throughout the year, with a peak in landings from 32F1 in May and November.

Other elasmobranch species that will occur in this area include lesser and greater spotted dogfish, spurdogs, smoothhound and tope. The exact distribution of these species is unclear.

Some information on the movement of rays in this region has been obtained by CEFAS via tagging thornback rays (*Raja clavata*) with Data Storage Tags (DST's). Initial data from these tagging surveys indicate that rays tagged within the Thames Estuary are not restricted to this area but move widely within the southern North Sea region. The fish also exhibit a seasonal pattern of movements, with the period April to October spent within the Estuary and the period November to March outside the estuary (Hunter *et al*, 2005).

8.5.7 Distribution of spawning and nursery grounds

The distribution of spawning and nursery grounds for key species in the Thames Estuary is shown in Figures 8.1 to 8.2.

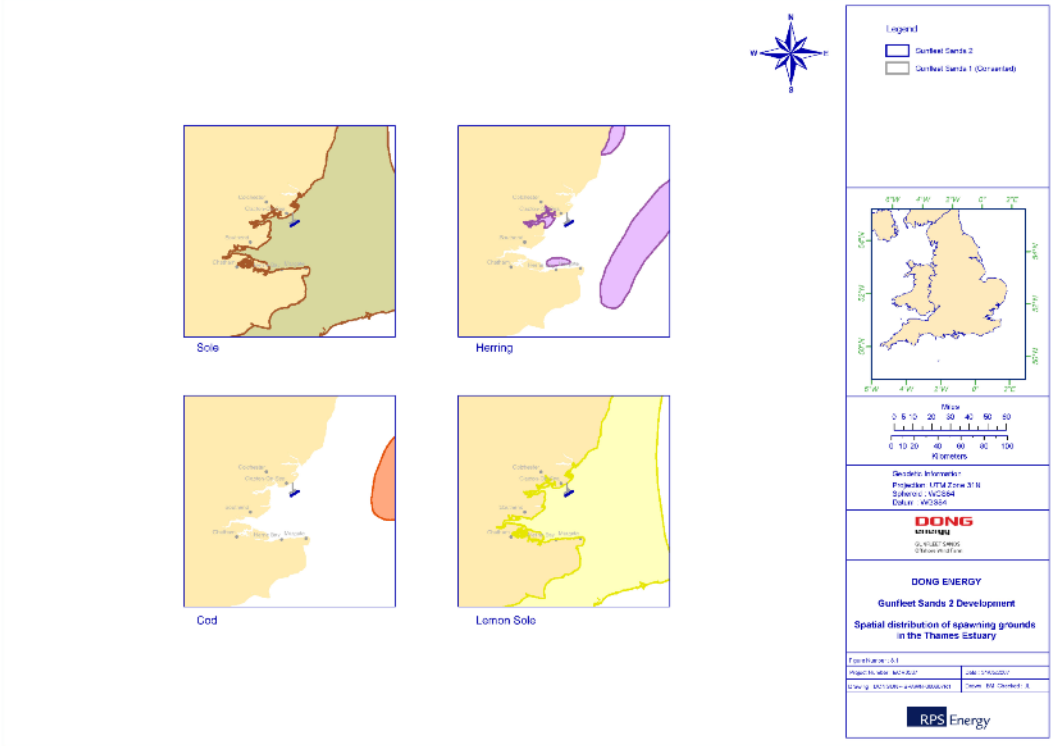


Figure 8.1 Spatial distribution of spawning grounds in the Thames Estuary

Species	Spawning Grounds	Nursery Grounds
Sole		
Herring		
Thornback Rays		
Lemon Sole		
Mackerel		
Whiting		
Plaice		
Sprat		
Brill		
Dab		
Cod		

Table 8.3 Species with spawning and/or nursery grounds within wider Thames Estuary region

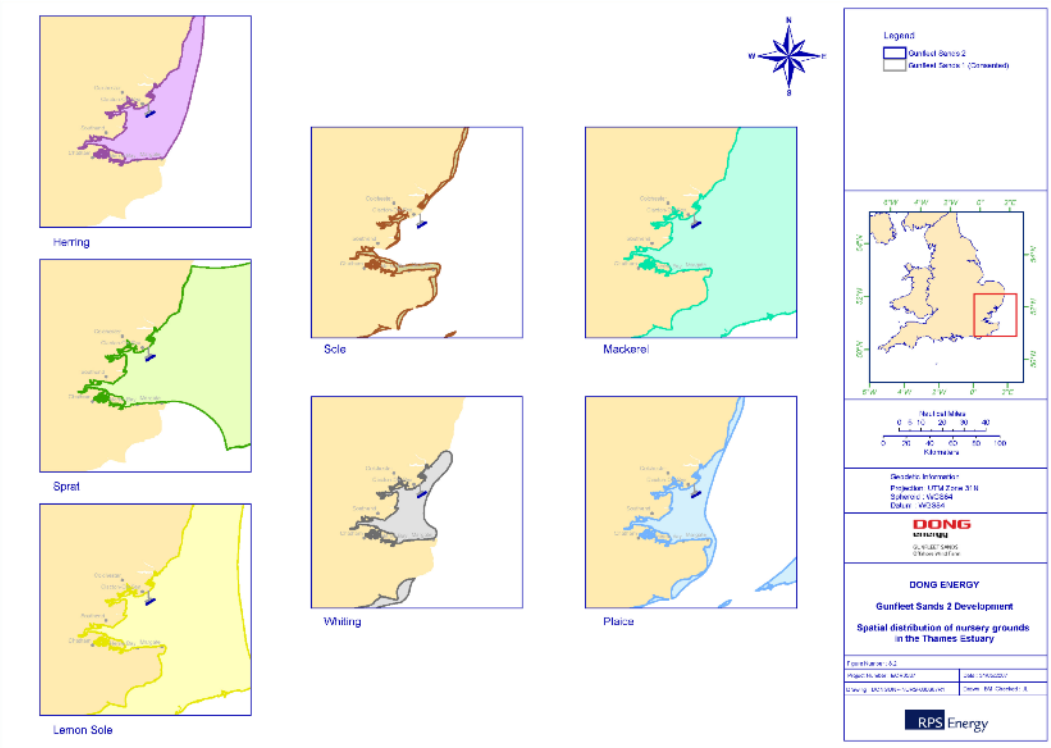


Figure 8.2 Spatial distribution of nursery grounds in the Thames Estuary

The seasonality of spawning events for these key species is shown below in Figure 8.3.

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Sole												
Herring												
Lemon Sole												
Thornback Ray												

Key

	Spawning Period

Figure 8.3 Spawning periods for species within wider Thames Estuary region

In addition to the spawning and nursery grounds of these species of commercial importance, the juveniles of the following species were recorded in this region during the young fish surveys of the south and east coast of England (1981 - 1997) (Rogers *et al*, 1998). The presence of the juveniles of these species indicates that they also utilise this region as spawning/nursery grounds.

- Smelt
- Poor cod
- Bib
- Five-bearded rockling
- Greater pipefish
- Pogge
- Nilsonn's Pipefish
- Bass
- Butterfish
- Gobies spp.
- Dab

8.5.8 Distribution of Overwintering Areas for Crustaceans (eg lobster and crab)

There are no known overwintering grounds for crab or lobster within the immediate vicinity of Gunfleet Sands.

8.5.9 Known migration routes

The composition and abundance of fish populations within the Thames Estuary region are seasonal in nature, with certain species entering and leaving the estuary throughout the year as part of annual spawning/feeding migrations. For example, adult sole enter the Inner Estuary in the period between January and February ahead of the annual spawning period of March to May (linked to a critical water temperature). Similarly, from tagging experiments undertaken by CEFAS, it is known that thornback rays also exhibit seasonal movements from the estuary to the southern North Sea. In practice, many commercial species that exist within the estuary at certain times of the year will, at other times, be found further offshore. Therefore, migration routes in and out of the estuary will exist. However, the exact position of these routes is not clear and will vary significantly between species and between each year.

In terms of fish species that make distinct seasonal migrations through the estuary to freshwater, salmon (*Salmo salar*), sea trout (*Salmo trutta*), smelt (*Osmerus eperlanus*), the European eel (*Anguilla anguilla*) and both species of shad are all known to undertake migrations through the estuary to reach freshwater at certain times of the year.

8.6 Impact Assessment

8.6.1 Construction and Decommissioning Phases

Impact Title: Installation and or decommissioning of the main turbine structures will lead to increased suspended sediment concentrations and sediment deposition in and around the GS2 site that may create adverse effects upon local fish and shellfish resources

During construction, suspended sediment concentrations (SSC) may increase as a result of cable-laying or piling activities. The coastal processes assessment (Appendix D) predicts that these increases will be temporary and localised and that any plume generated will disperse rapidly. This assessment also concluded that any plume generated would be unlikely to create concentrations that are measurable above ambient conditions and detectable beyond distances of a few hundred metres as the plume is entrained into ambient sediment loads.

Due to the high existing background levels of SSC in this area, and the fact that species that are found in this area are already adapted to these high background levels, the predicted increases in SSC that will arise during construction are not expected to create adverse effects upon mobile fish resources in this region.

Therefore, based on the fact that the majority of fish resources likely to be exposed to possible increases in SSC are (a) already adapted to the high background levels of SSC that exist in this area and (b) mobile and can, therefore, move from areas where SSC levels increase to levels that they find uncomfortable, it is judged that there would be a **Minor Adverse Impact** on the majority of mobile fish resources within the GS2 site as a result of increases in SSC produced during the construction phase.

With respect to sedentary species, of particular note in this part of the Thames Estuary are cockles. Extensive cockle beds exist to the west of the GS2 site. However, these beds are too distant from the proposed works to experience any increases in SSC or subsequent sediment deposition that may arise during the construction phase. Therefore, it is predicted that there will be **No Impact** upon sedentary shellfish species.

Mitigation Measures

None required.

Residual Impact

It is predicted that there will be a **Minor Adverse** impact upon finfish as a result of increased SSC and **No Impact** upon sedentary shellfish, due to them not existing in areas where increased SSC is predicted to arise.

Impact Title: Noise from the construction phase of the scheme may disrupt spawning activity of key commercial species

During the construction phase of the scheme, piling works will be required to install the turbines. Noise emissions from these works have the potential to disrupt the spawning behaviour of key commercial species, in particular sole and herring, both of which spawn within the Thames Estuary. With respect to sole, spawning of this species takes place between March and May each year around sandbank features, such as Gunfleet Sands. Herring spawn earlier in the year, between December and February. A discrete herring spawning ground is known to exist on the Eagle Bank in the mouth of the Blackwater Estuary, some 7km to the west of the proposed GS2 site.

The most likely way in which noise could impact upon the spawning of these species would be to produce behavioural avoidance responses within the fish that prevented them reaching their discrete spawning grounds. If this occurred and spawning did not take place, there could be subsequent knock-on effects upon the wider stock.

Without mitigation, there is the potential for noise emissions from piling to create a **moderate-major adverse impact** upon the spawning of certain species, in particular sole and herring.

Mitigation Measures

DONG is committed to not undertaking any piling works in the period from 1st February to 1st June in each construction season (as per the GS1 FEPA licence). This mitigation measure is designed to allow spawning fish to reach their spawning grounds and spawn without any potential adverse impact from piling noise.

Residual Impact

Successful implementation of this mitigation measure will result in **No Impact** upon fish spawning in and around the proposed GS2 site.

Impact Title: Noise from the construction phase of the scheme may cause injury or mortality to fish

Noise generated during the construction process, in particular from piling activities, has the potential to not only disrupt the potential spawning behaviour of certain fish species, but also has the potential to create adverse impacts via direct mortality and/or injury (lethal and sub-lethal effects).

Fish are receptive to noise, with hearing and the detection of vibrations being one of their most developed senses; making use of the good propagation of low frequency sounds which is approximately five times faster than in water than air (Shepherd, *et al*, 2006).

Different species of fish have different hearing abilities and are broadly grouped into hearing specialists (those that possess a gas-filled swim bladder) and non-specialists (those that lack a gas-filled swim bladder). Hearing specialists include herring and cod whilst non-specialists include flatfish such as dab and sole and elasmobranchs, including ray species.

Based on a review of literature presented in Shepherd, *et al*, (2006), it is predicted that any fish within 100m of a pile location will suffer direct mortality upon the commencement of piling if piling is started at the maximum capacity of the equipment. This review also stated that hearing specialists such as herring and bass may suffer physical injury at ranges of 3km (deep water) and 250m (shallow water) and 2km (deep water) and 200m (shallow water) for the respective species (Shepherd, *et al*, 2006).

Since it is not known what amount of damage may occur to fish in the proximity of piling works, nor is it known to what degree such damage might lead to subsequent mortality, there could be adverse effects ranging from **Minor** to possibly **Major** significance for these hearing sensitive species.

Comparable figures for other species, including sole, plaice and bass are in the order of a few tens of metres in shallow water and 50m to 200m in deep waters. Rays are likely to be at the lowest end of the ranges. Impacts on most species are considered likely to be of **Minor** to possibly **Moderate** significance in the absence of suitable mitigation measures (see below),

Mitigation Measures

In order to reduce the potential significance of impacts on fish from piling noise, it is proposed that mechanical "soft-start" methods will be used during the piling activity. This process involves piling commencing at low energy levels and building up slowly to full impact force. The force of the hammer can be adjusted using either the height of the hammer above the pile or amount of energy used to drive the hammer onto the top of the pile.

Although this mitigation measure has been developed with respect to marine mammals, piling noise will be dominated by low frequency sound and thus mechanical soft start is effective for most fish species as it will rapidly remove fish away from the area of likely hearing damage, and ultimately from the zone of disturbance.

Residual Impact

By adopting soft-start procedures during the piling works for GS2, it is predicted that the significance of potential impacts upon fish will be greatly reduced to **Negligible** to **Minor Adverse** impacts.

8.6.2 Operational Phase

Impact Title: Presence of up to 22 turbines will lead to a loss of fisheries habitat

Once operational, the presence of the turbine structures, and potential scour protection, will lead to a loss of habitat that may currently be used as a spawning, nursery or feeding ground for certain fish species. It is estimated that 522.5m^2 of existing habitat will be lost to the turbine footprints when they are installed. In addition to this, it is possible that scour protection will be required around the turbine bases. It is estimated that protection with a 22m radius may be required around the base of each turbine. If scour protection was required, it is calculated that there would be an overall footprint of 33,452m^2 (0.033km^2).

The total area of the proposed GS2 development area is 7.5km^2. Therefore, the largest amount of habitat that could be lost from the proposed GS2 development represents just 0.6% of the development area.

The existing habitats in the areas where the GS2 turbines are proposed comprise a mixture of medium/coarse sands and sandy gravels. It is predicted that these areas provide spawning and feeding habitat for certain fish species. However, it is also judged that this area does not provide any unique habitat type for any species of fish and is not rare in the context of the wider Thames Estuary.

Therefore, because of the fact that the amount of habitat loss is small, and that the habitats that will be lost are relatively common throughout the Thames Estuary region, it is predicted that loss of potential spawning/nursery/feeding habitat will result in a **Minor Adverse Impact** upon fish resources in this region.

Mitigation Measures

None required.

Residual Impact

It is predicted that there will be a **Minor Adverse** impact upon finfish as a result of habitat loss.

Impact Title: The turbines and associated turbine foundations may create new, 'complex' habitat that could provide refuge habitat for many fish species and may also produce some form of aggregation of local fish stocks

During the operational phase, there is the potential that the turbines and associated scour protection may create `new` complex habitat that may attract certain species of fish and shellfish. A recent report produced by PML Applications Ltd in association with the Scottish Association of Marine Sciences (Linley *et al*, 2007), which included a review of scientific literature associated with `artificial reef` effects, concluded that whilst there is likely to be an enhancement effect for finfish and Crustacea, the extent and nature of the effect, is heavily dependant on the nature of the reef created and the characteristics of the indigenous populations at the time of introducing the artificial reef (Linley *et al*, 2007).

The recent report by Linley *et al* identified that within the Thames region, the greatest potential for potentially enhancing effects of turbine `reefs` was related to crab and lobster, with finfish categorised as having a neutral to positive likelihood of enhancement. With respect to GS2, the fact that the site exists on and adjacent to a sandbank means that a distinct fish assemblage exists in this area, with crustaceans such as crab and lobster not as common as further inshore where rocky ledges exist. Therefore, it is predicted that whilst there may be some beneficial impact upon local fish populations as a result of the creation of new, complex `reef` habitat, the significance of this is judged to **Negligible** to **potentially Minor Beneficial.**

Mitigation Measures

None required.

Residual Impact

It is predicted that there will be a **Negligible** to **potential Minor Beneficial** impact upon fish as a result of `reef` effects from the GS2 development.

Impact Title: A reduction in fishing pressure within the GS2 site may create beneficial effects upon local fish and shellfish resources

During the operational phase of the scheme, certain fishing activities may reduce in intensity or frequency due to the presence of the turbine structures and any associated safety zones around them. In particular, the use of drift nets and/or trawling may be affected in some way. If fishing pressures do decrease in this area, there is the potential that this will create beneficial impacts upon local habitats, benthic communities and local fish resources through reducing or removing the adverse environmental effects of fishing.

In reality, if fishing pressure in this site is reduced, or even removed it is judged unlikely that large-scale increases in fish populations will arise. Roberts (1998) concluded that benthic communities in dynamic and highly mobile sand bank areas are unlikely to benefit significantly by restricting fishing. In practice, if fishing activity is reduced within the site, displaced fishermen may target areas that have not previously been targeted using trawls, resulting in potential impacts upon other areas.

Therefore, it is predicted that even if certain fishing activities are reduced or removed as a result of the presence of the turbines, there will be a **Negligible** impact upon local fish resources

Mitigation Measures

None required.

Residual Impact

It is predicted that there will be a **Negligible** impact upon fish and shellfish if fishing pressure were to be reduced as a result of changes in fishing intensity within the GS2 site.

Impact Title: Electromagnetic fields generated by the inter-turbine / site-to-shore cables may potentially create adverse effects upon electro-sensitive fish species

Certain consultees have raised concerns that electromagnetic fields (EMF) from inter-turbine and site-to-shore cables may create adverse effects upon certain electro-sensitive fish species, in particular elasmobranch species including rays, which are a key commercial fish species in this region. Certain species of rays and other elasmobranch species, including spurdogs, are now assessed as having low stock levels and therefore particularly at risk from certain activities, including commercial fishing. The apparent poor state of the stocks of these species is the key reason that a bye-law has recently been implemented via the Common Fisheries Policy (CFP) to limit the by-catch of rays (and spurdogs) to 25% of the total catch in the North Sea.

Research-based studies into this potential impact have been, and are still being undertaken by various research facilities. The key work done to date on this issue has been via COWRIE-funded studies, with the most recent report being the 2005 report (Gill *et a.l,* 2005) – COWRIE 1.5 Electromagnetic Fields Review. Currently, a mesocosm experiment is being set up at a test site at Loch Ceann Traigh, in Scotland. This experiment represents COWRIE Electromagnetic Fields Phase 2 (COWRIE 2.0).

In addition to these reviews and experimental studies, data is also starting to be gathered from wind farm sites that are now operational. The following impact assessment aims to summarise some of the key findings from these various data sources.

The results of the COWRIE Phase 1 work (Gill & Taylor, 2001) demonstrated that EMF emitted by industry standard AC offshore cables were within the range of detection by electro-sensitive species, including dogfish and rays. However, this study concluded that it was not possible, based on the data available at that time, to determine whether any particular impact would arise upon such species.

Potential electromagnetic impacts are associated with the operational phase. These impacts can be categorised as follows;

- **Attraction** to artificial fields with associated potential for animals to waste energy resources searching for absent prey animals or con-specifics;
- **Repulsion**, with potential impacts to the normal movements of animals, exclusion of areas of seabed or water column and possible disruption to migrations through a 'barrier' effect;
- **Interference** with navigation or orientation for species using the Earth's (geomagnetic) field to navigate or induced electrical fields associated with water movement through the geomagnetic field to orientate or time behavioural movements (eg in relation to the tide). If animals perceive a different magnetic field to the Earth's there is potential for them to become disorientated; Depending on the magnitude and persistence of the confounding magnetic field the impact could be a trivial temporary change in swimming direction or a more serious impact on migration; and
- **Physiological effects** on marine organisms (eg potential impacts on cell development).

Based on current empirical data, it is not possible to state whether or not (a) these impacts will arise upon fish on and around Gunfleet Sands and (b) their significance if the impacts do actually occur.

Preliminary data are starting to accumulate from operational wind farms in Denmark and UK waters, although much of these preliminary findings are based upon broader marine ecological studies and not specific EMF-focussed studies. Even so, data from a diving survey of the North Hoyle offshore wind farm (Bunker, 2004) noted juvenile whiting present in dense shoals around turbine foundations (feeding on amphipods dwelling on the monopiles). The wind farm was operational and generating power at the time of survey.

Other surveys, including fisheries surveys of the Horns Rev and Kentish Flats sites, have demonstrated that fish species, including electro-sensitive species such as thornback rays, do occur within the boundaries of operational wind farms, when electrical power is being transmitted along inter-turbine cables.

Based upon the limited evidence available to date, in particular results from monitoring studies of operational wind farms, it is predicted that there will be no more than a **Minor Adverse Impact** upon fish from EMF emitted from inter-turbine and site-to-shore cables.

Mitigation Measures

There is no direct mitigation currently available to offset the potential effects of EMF other than ensuring all cables are buried to a target depth of 1.5m.

Residual Impact

It is predicted that there will be a **Potential Minor Adverse Impact** upon certain fish species as a result of EMF produced by inter-turbine cables.

8.6.3 Cumulative Impacts

Although it is predicted that there will only be minor adverse impacts upon fish and shellfish resources from the proposed GS2 development, it is also important to consider the potential for cumulative impacts to arise upon fish resources from other developments in the Thames region, in particular other offshore wind farms and dredging.

One potential cumulative impact that may arise upon fish resources is the loss of potential spawning/nursery habitats as a result of the presence of these projects. Table 8.4 below presents a summary of other projects in this area, along with an estimate of the area covered by the projects boundaries. It is important to note that the km^2 figures presented do not represent the actual amount of fisheries habitat that would be lost, just the project boundaries. In reality, the area of habitat `lost` as a result of projects will be a lot less than these values and will relate to the actual area lost to turbine foundations.

From table 8.4 it can be noted that even using these figures, which are over-estimates of actual habitat loss, less than 10% of the Greater Thames Estuary (GTE) would be affected if all these schemes were constructed. In practice, it is estimated that less than 1% of habitat within the GTE would be `lost` if all these schemes were constructed. Therefore, it is predicted that there will be a **negligible** cumulative impact upon fish resources in the form of habitat loss through the interaction of all these schemes.

Another potential cumulative impact that may arise is from noise generated during the construction phases, in particular from piling operations. Cumulative impacts from noise would only arise if construction activities were undertaken at the same time. Kentish Flats is already constructed therefore there is no scope for cumulative noise impacts with the GS2 project. Because of the limited availability of turbines and jack-up rigs it is highly unlikely that more than 2 or 3 projects in the Thames Estuary will be constructed at the same time.

Development	Area of Impact (km^2)	% GTE[15] area affected
Offshore Wind Farms		
Gunfleet Sands 2 (GS2)	**7.5**	**0.14%**
Gunfleet Sands 1 (GS1)	10	0.19%
Kentish Flats	10	0.19%
London Array	266.4	5.03%
Greater Gabbard	102	1.92%
Thanet	35	0.66%
Dredging Projects		
London Gateway (dredging and reclamation)	19.3	0.36%
Aggregate Extraction	62.66	1.18%
Total Area of Impact	**512.86**	**9.67%**

Table 8.4 Summary of consented/planned activities in the Greater Thames Estuary (GTE) which may create potential cumulative impacts upon fish resources

Adopting a worst-case realistic scenario, if 3 offshore wind farm developments in the Thames region were to undertake piling operations concurrently, it is likely that a significant area of the GTE would become affected with piling noise intense enough to illicit a response from hearing sensitive fish species, such as herring. Also, if simultaneous piling is occurring at all sites, overlap of sound and pressure waves from different rigs may occur causing zones where the noise levels are high enough to cause either temporary or permanent damage to noise-sensitive species over a wider area.

However, all piling operations associated with wind farms are required to have mitigation for marine mammals, and in particular soft start procedures (see Impact Statement above related to effects on fish species from piling noise). It is unfeasible to monitor for the presence of fish species close to piling operations in the same way that marine mammals are monitored, but building up the intensity of hammer strikes on the pile over a period of twenty minutes would encourage mobile fish species to move away before the intensity of sound becomes injurious and thus reduce mortality and injury around each pile. Whilst it is plausible that sound waves from uo to 3 different piling operations could interact and produce heavily ensonified areas where the sound pressure pulse become additive, it is unlikely to occur unless the hammer strikes are in perfect synchrony given the very short duration of the sound pulse. Therefore fatal effects from piling would not be any more widespread cumulatively than individually.

It is likely that large areas in the GTE would be affected by noise from up to 3 active piling operations at levels that could affect sensitive fish species. The GS2 development is committed to restricting piling so that most spawning periods are avoided. This is considered to be the most sensitive period for fish and would have the most extensive consequences if not implemented.

Outside the spawning season the combined effects of noise from up to 3 different piling operations would affect fish species over a much larger area than individually, and therefore behavioural effects and displacement would potentially be more widespread. However, sound dissipates very quickly in shallow water and the large number of sand banks in the area would have a large bearing on the area of water in which noise would be high enough for an effect to occur. Sandbanks would create areas of “shadow” on the opposite side from where the piling is located. In these areas very little noise would occur and fish would have refuge. This may add to intra-specific competition but the unaffected areas would still be so extensive as to render this effect small. Furthermore the effects would only be temporary and for most fish affected, reversible.

[15] Percent area impacted is based on a Greater Thames Estuary (GTE) Area = ~5,300 km^2

Effects from shipping on fish species as a result of the cumulative effects from more than one wind farm development are unlikely to be greater than effects from individual wind farms, as the area already contains a large number of vessel movements.

In summary, the cumulative effects from simultaneous development of wind farms and dredging in the GTE area are likely to be greater than GS2 in isolation. However, whilst these effects are likely to be more widespread, they are not likely to last longer or be of greater magnitude. Because all wind farm developments in the area would have some seasonal restrictions on piling activity the most sensitive spawning periods would be avoided. Thus the overall impact of simultaneous construction would be **Minor Adverse** and reversible.

8.6.4 Proposed Monitoring

As part of the conditions attached to the FEPA licence for the GS1 project, a pre-construction survey of fish populations in the area around Gunfleet Sands is planned. This survey is scheduled for the period June – September 2007. The scope of this survey will be expanded to include coverage of the proposed GS2 site.

9. MARINE MAMMALS

9.1 Introduction

The following section of the ES provides information on the distribution of marine mammals (whales, dolphins, porpoises [Cetacea] and seals [Pinnipedia]) in the proposed GS2 study area. This section also assesses the potential impacts of the proposed development upon these species. This section is intended to provide an update on the marine mammal baseline described in the GS1 ES. The section also provides background information on the relevant legislation and planning policies.

Further information related to marine mammals is provided in Appendix G.

9.2 Consultation

The EIA scoping report was issued to a number of organisations with interests and expertise in marine mammals, including Natural England, DTI and Defra. In addition to this written consultation, meetings have also been held over the course of the EIA process with representatives of these organisations to discuss particular aspects of the project, including marine mammals. The key guidance on the scope and approach of this assessment has been from Natural England.

9.3 Data Sources

The marine mammal baseline described in the ES for GS1 is no longer current as the data upon which it was based is now more than 4 years old. For this reason, the most up to date data have been acquired, upon which to provide a baseline for this ES. Information regarding the location of statutory and non-statutory designated sites that are designated for marine mammals were obtained from the JNCC website. Information on the distribution of marine mammals was obtained during the desk study from the following sources:

- GS1 ES;
- Records acquired and held by Essex Wildlife Trust;
- Results from Shepherd et al. (2006) which analysed all marine mammal data acquired during the bird surveys for the Thames Wind Farms;
- Atlas of Cetacean Distribution in North-west European Waters. Reid et al. (2003); and
- Distribution and Abundance of the Harbour Porpoise and other Small Cetaceans in the North Sea and Adjacent Waters. Hammond et al. (1995).

The Sea Watch Foundation was also contacted as part of the desk study to obtain recent data held in the National Cetacean Database, but they were unwilling to provide the services requested for reasonable costs. Most data held in the National Cetacean Database for the Essex coast are provided by Essex Wildlife Trust and Biodiversity Records Centre and therefore data from this source adequately provides an update to the original data described in the GS1 ES. Furthermore, data from the aerial and boat-based surveys analysed in Shepherd *et al*. (2006) provides a much more detailed and robust description of the marine mammals in the area.

9.4 Project-Specific Surveys

Although specific surveys have not been conducted solely for GS2, the area was covered during the boat and aerial surveys for birds between January 2002 and December 2005. This systematic survey provides the most complete picture of marine mammal distribution, population and use of the area available.

9.5 Description of Existing Environment

9.5.1 Legislative and Policy Context

Marine mammals are protected under a range of policies and legislation. Key legislation relevant to marine mammals include:

- EU Council Directive (92/43/EEC) on the conservation of natural habitats and of wild fauna and flora (the Habitats Directive);
- 1992 OSPAR Convention;
- Agreement on the Conservation of Small Cetaceans in the Baltic and North Seas (ASCOBANS);
- Natural Environment and Rural Communities (NERC) Act 2006;
- Wildlife and Countryside Act 1981 (as amended);
- Conservation of Seals Act (1970);
- UK Biodiversity Action Plan (1994); and
- Local Biodiversity Action Plan.

A summary of these legislative/policy documents is provided in Appendix G.

9.5.2 Desk Study

Due to the large ranges of most marine mammal species, an area much wider than the immediate area around Gunfleet Sands needs to be considered within any desk study. The study area refers to the southern North Sea (see Figure 9.1).

This area is not known for large numbers of marine mammals but the common seal *Phoca vitulina* is resident, having several small exposed sandbanks off this coastline on which they give birth. The Wash and North Norfolk Coast Special Area of Conservation (SAC) was designated in part for the common seals that haul-out and give birth on the extensive intertidal flats. The Wash and North Norfolk Coast SAC holds at least 7% of the UK population of common seal.

Data collected in the last 25 years have indicated that few cetaceans frequent the area (Northridge *et al.,* 1988; Hammond *et al*., 1995; and Reid *et al*., 2003). Previous desk studies concluded that the southern North Sea was not very important for marine mammals.

However, several species have been regularly recorded in the area including: harbour porpoise (*Phocoena phocoena*), bottlenose dolphin (*Tursiops truncates*), common seal (*Phoca vitulina*) and grey seal (*Halichoerus grypus*). Historic data indicated that other species were recorded in most years including white-beaked dolphin (*Lagenorhynchus albirostris*), minke whale (*Balaenoptera acutorostrata*), pilot whale (*Globicephala melas*) and common dolphin (*Delphinus delphus*). Records also indicated that several other cetacean and pinniped species were rare in the area.

However, aerial and boat-based surveys conducted in the area on behalf of wind farm developers between 2002 and 2005 and reported in Shepherd *et al*. (2006) have shown that porpoises appear resident in moderate numbers in the offshore regions compared with other areas of the UK. Furthermore data from Germany and Holland show that this species frequents the southern North Sea on a more regular basis than data previously indicated (Abt and Siebert, 2006; MacLeod *et al*., 2006 and Santos *et al*., 2006).

Several other species of marine mammal have been recorded in the area including grey seal (*Halichoerus grypus*), white-beaked dolphin (*Lagenorhynchus* albirostri)s, bottlenose dolphin (*Tursiops truncates*), and less frequently minke whales (*Balaenoptera acutorostrata*) and killer whales (*Orcinus orca*) among others. The historical data indicate that the most commonly recorded species across this region are:

- Harbour porpoise;
- Grey seal; and
- Common seal.

All three of these species are possibly present throughout the year and it is considered that the harbour porpoise and small numbers of common seal are resident and use the area for all life stages including mating, birthing, weaning and foraging.

Whilst virtually nothing was reported regarding the breeding behaviour of the harbour porpoise in the region, there are several known haul out sites along the North Kent coast on which common seals give birth. The grey seal breeds mostly in association with known rocky breeding sites (rookeries) either in the north of England, Scotland or the Channel Islands (English Nature, 2004a and 2004b). Several smaller rookeries are present in The Wash.

Several other species have been encountered less frequently in the region and are probably visitors in most years. These include the white-beaked dolphin, pilot whale, minke whale and bottlenose dolphin. Several other cetacean and pinniped species were identified as vagrants and were only rarely recorded. Marine mammal species most likely to be encountered in the southern North Sea are shown in Table 9.1.

	EC Habitats Directive (Annex)	ASCOBANS	Wildlife and Countryside Act	Wild Mammals (Protection) Act	Conservation of Seals Act 1970	UK Biodiversity Action Plan / CRoW Act 2000, list ref in Section 74 / NERC Act 2006 List ref in Section 41
Minke whale	IV		5	●		Baleen whales grouped plan
Atlantic white-sided dolphin	IV	●	5	●		Small dolphins grouped plan
Bottlenose dolphin	II & IV	●	5 & 6	●		
Short-beaked common dolphin	IV	●	5 & 6	●		
White-beaked dolphin	IV	●	5	●		
Killer whale	IV	●	5	●		Toothed whales grouped plan
Long-finned pilot whale	IV	●	5	●		
Harbour porpoise	II & IV	●	5 & 6	●		Priority Species
Common seal	II & V			●	●	
Grey seal	II & V			●	●	

Table 9.1 Legislation and conservation initiatives under which whales, dolphins and seals are protected

Data acquired from Essex Wildlife Trust for 2001 – 2006 are shown in Figure 9.1. These records support conclusions from the above data but also indicate that white-beaked dolphins move into the area in the summer and have used river mouths.

Data acquired during aerial and boat based survey in the greater Thames region between January 2002 and December 2005 indicate that porpoises were the most common marine mammal encountered and that seals were the second most common. Both were present all year round and summaries of the records for these two species groups are given in Table 9.2 together with the sightings indices (SI) for each of the species in the form number of animals per kilometre surveyed. It was clear that numbers of porpoises and seals increase in the winter after records were adjusted for survey effort. Seal numbers drop in the summer and autumn when both species are breeding indicating the low breeding activity in the area. The results from these surveys can be seen in Figures 9.2 to 9.4.

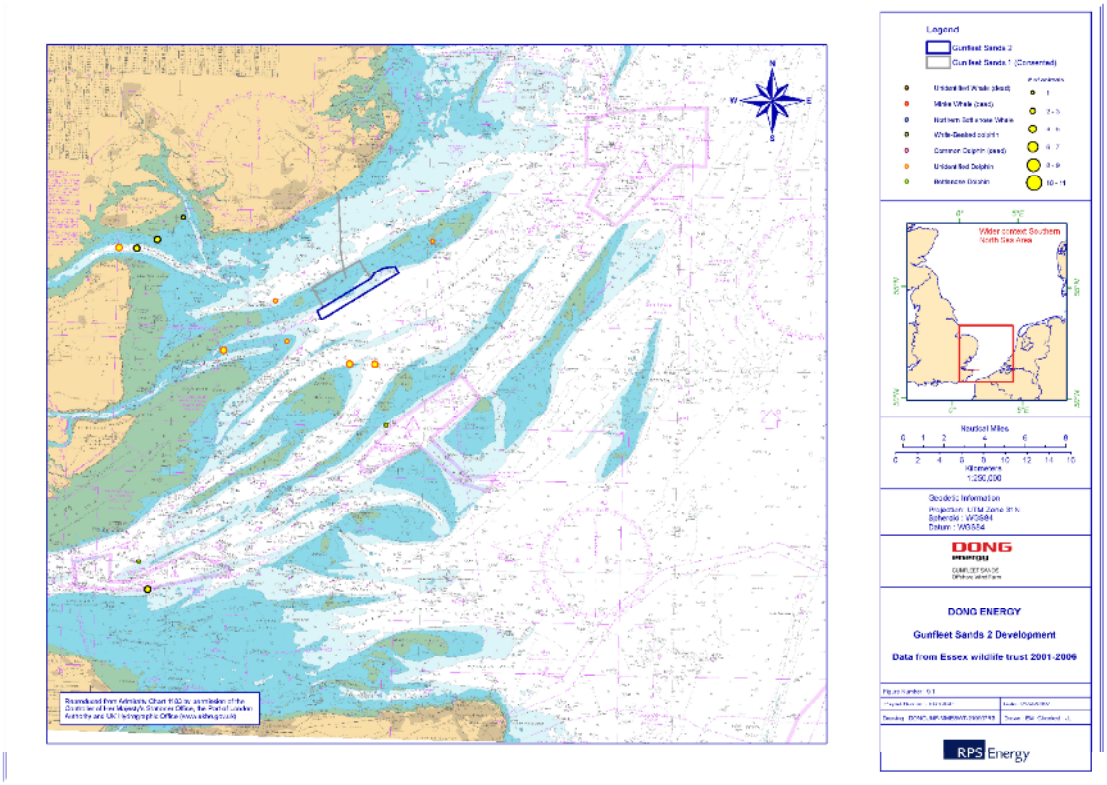


Figure 9.1 Data from Essex Wildlife Trust, 2001-2006

	Distance	Harbour Porpoise	Harbour Porpoise SI	Seal sp.	Seal SI
Winter	15,779	879	0.0557	368	0.0233
Spring	6,008	164	0.0273	73	00122
Summer	3,031	31	0.0102	31	0.0102
Autumn	2,278	47	0.0206	3	0.0013

Table 9.2 Seasonal trends in sightings of harbour porpoises and seal species

9.5.2.1 Seals

Of the sightings that confidently identified seals to species level, the common seal was encountered 12 times over the course of the three years and the grey seal on four occasions. This is clearly low but must be considered along with those that were not identified to species as well. Seals are generally restricted to within 15 km of land (see Figure 9.2). Only one sighting was located close to Gunfleet Sands but several records were acquired on Buxey Sand and near the entrance to the Blackwater Estuary some 15 km west of Gunfleet Sands.

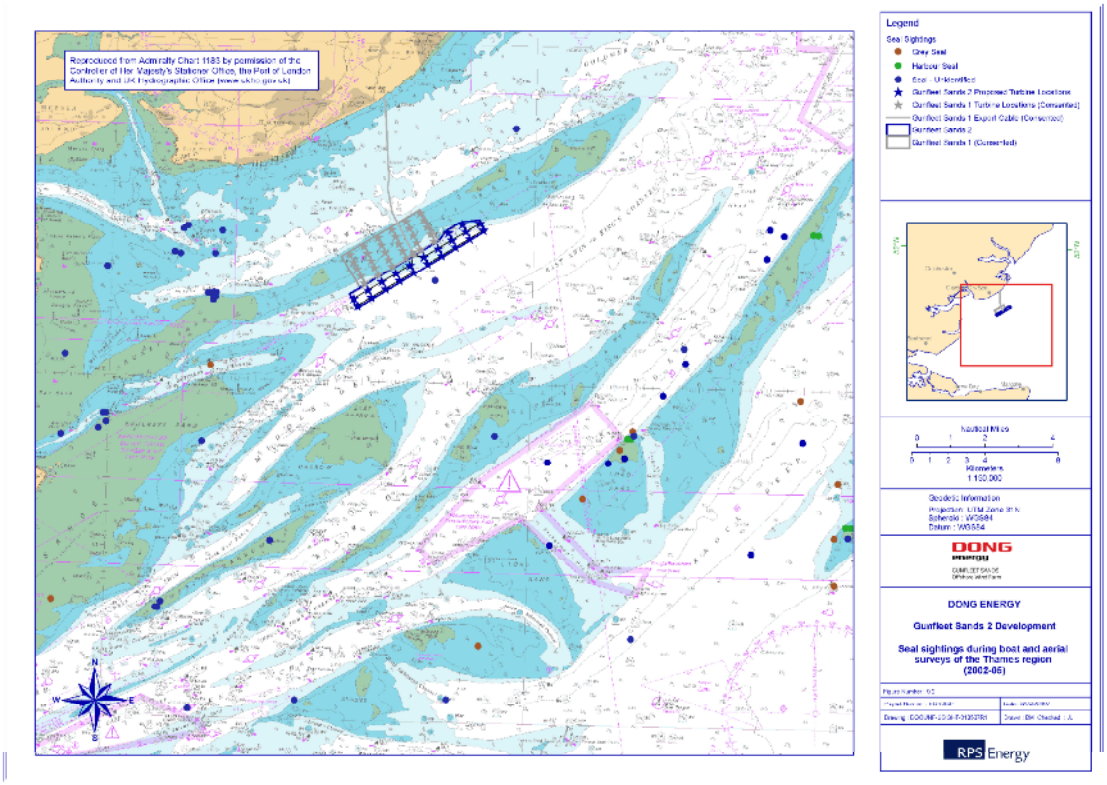


Figure 9.2 Seal sightings during boat and aerial surveys of the Thames Region (2002-2005)

Unidentified seal encounters were moderate with 102 sightings and 475 animals. It is likely that a large proportion of these sightings were common seals. Several large aggregations of common seal were recorded along Kentish Knock and Long Sand (up to 55) and Goodwin Sands (up to 40). Overall sightings indices indicated that most seals were recorded during the winter months with reductions in spring through to the autumn. Records were biased to haul out areas where animals are more easily spotted, but this does not necessarily indicate they were confined to these areas.

Common seals were recorded as individuals and occasionally as large groups of 25 - 55 animals. The largest of these were recorded in March and May. Although it was not specifically noted, these larger groups were probably basking on Long Sands, Kentish Knock and Margate Sands. It is notable that no common seals were recorded in June. However this could be due to the incomplete coverage of the survey area in this month rather than lack of common seals.

9.5.2.2 Cetaceans

The harbour porpoise was by far the most common species recorded with 952 of the sightings (60.4%) over the course of the three years of survey ,and an estimated 1,121 animals (see Figure 9.3). Porpoises were generally seen as individuals or pairs but with occasional groups of between three and nine animals. During the aerial and boat-based survey the only other cetacean identified with confidence to species level was the bottlenose dolphin.

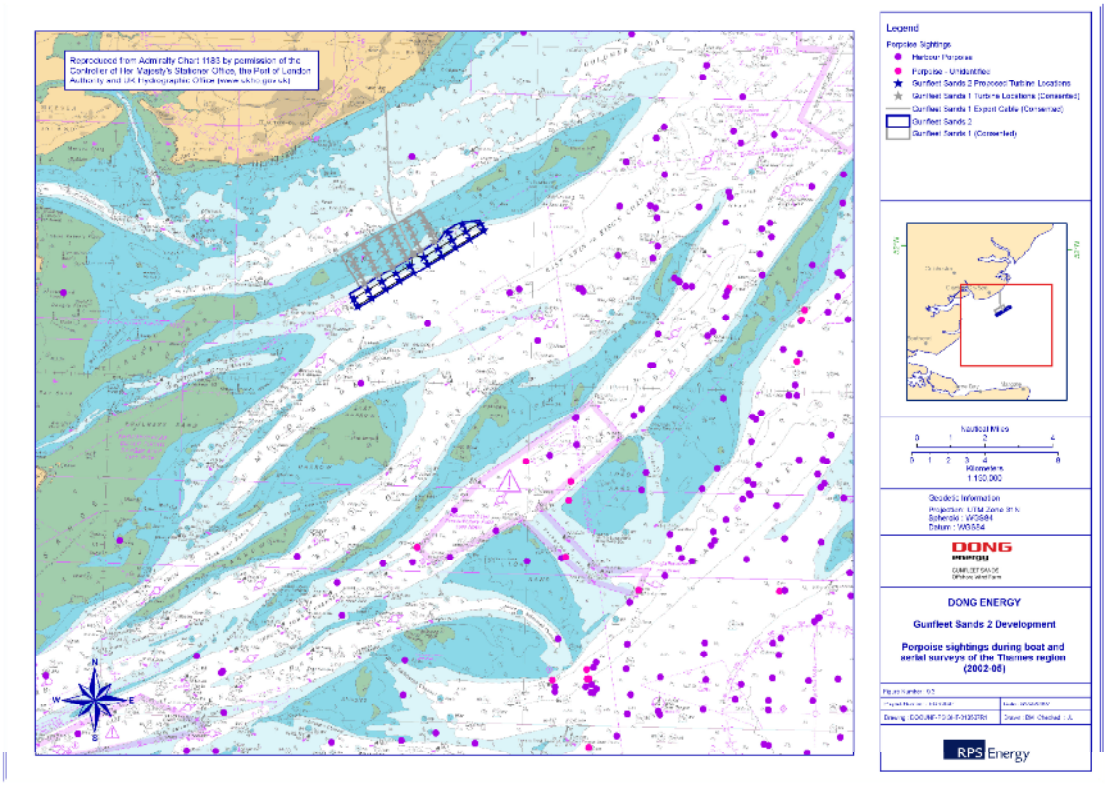


Figure 9.3 Porpoise sightings during boat and aerial surveys of the Thames Region (2002-2005)

Bottlenose dolphins were recorded on four occasions (0.2%) which over the course of three years surveying is clearly low. All bottlenose dolphin sightings were taken during the same survey, two of which were close enough to have been the same animal (see Figure 9.4). There were also 93 unidentified cetacean sightings comprising 115 animals, of which most were probably bottlenose dolphins or white-beaked dolphins.

Cetaceans were recorded across the survey area but numbers increased slightly with increasing distance from the coast. Only three porpoise records were taken between the coast and Gunfleet Sands but around 21 encounters were recorded in the King's Channel, indicating that porpoises frequently use the area east of the proposed wind farm site. Numbers were higher during the winter months and these were generally found in two concentrations off the Norfolk coast and to the east of Long Sands and Kentish Knock.

The concentrations during the winter months probably reflect localised food sources and in particular spawning fish species, especially herring. The data suggest an influx during the winter months rather than redistribution in the region: animals are probably moving in from other areas to take advantage of the prey food species.

Porpoises were generally recorded in higher numbers outside of the main shipping routes. However, a large aggregation of porpoises occurred to the east of "The Sunk Precautionary Ground" where ships lay up in wait, and numbers were highest east of Long Sands, areas particularly intensively used by shipping of all sizes. It is however clear that porpoises move freely across the region regardless of the vessel activity.

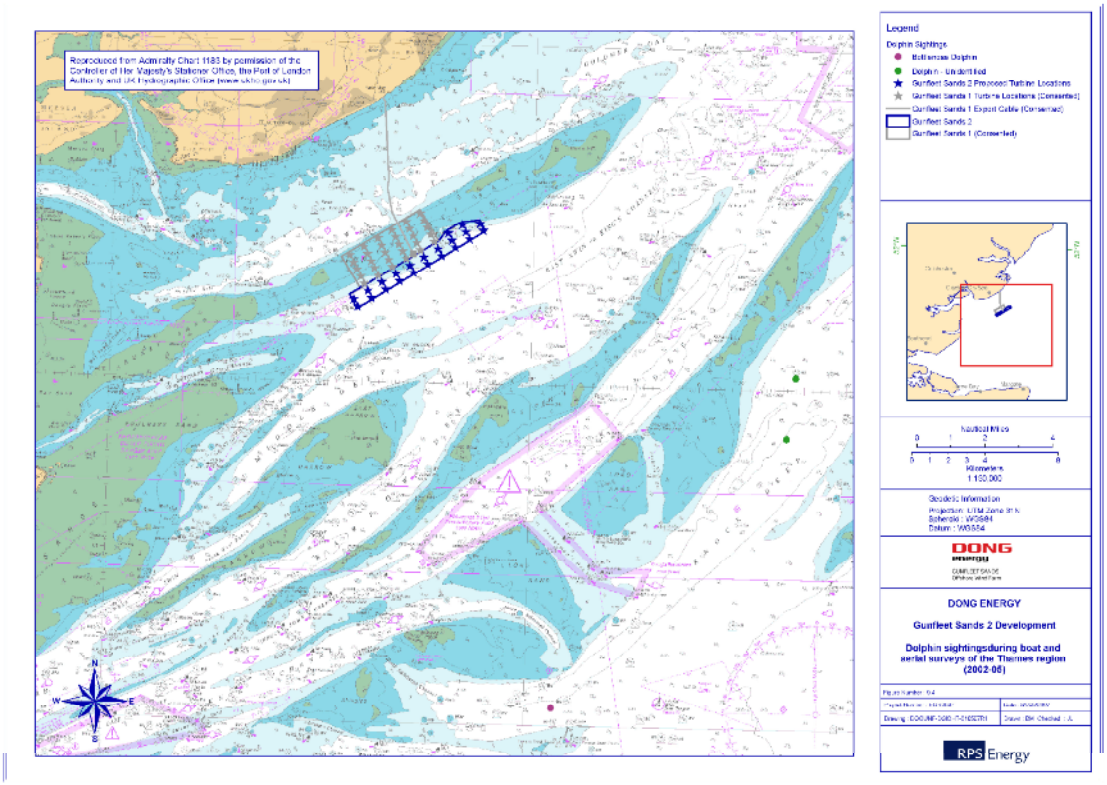


Figure 9.4 ***Dolphin sightings during boat and aerial surveys of the Thames Region (2002-2005)***

9.5.3 Identification of Valued Ecological Receptors (VER's)

The marine mammals listed in Table 9.3 have been identified as VER's. VER's are habitats and species that are valued in some way, and could be affected by the proposed development. The VERs will be considered as seals, dolphins and harbour porpoises due to the similarities of sensitivity of the species in each group (see Appendix G for more details on VER's).

VER	Value	Reason
Common Seal *Phoca vitulina*	Regional level	The importance of the east coast in England for their breeding and tourism that depends on basking seals
Grey Seal *Halichoerus grypus*	District level	Low numbers and few breeding grounds in the area
Harbour Porpoise *Phocoena phocoena*	Regional level	The moderately high numbers encountered for England and resident status
White-Beaked Dolphin *Lagenorhynchus albirostris*	County level	The apparent increasing importance of the area for seasonal food resources but low numbers overall
Bottlenose Dolphin *Tursiops truncatus*	County level	Regular sightings and use of the area for a few individuals

Table 9.3 VER's and their value and justification of valuation

9.6 Impact Assessment

9.6.1 Assessment methodology

The likely significant effects of the proposed GS2 project during construction, operation and decommissioning phases and the potential ecological impacts upon marine mammals arising from them have been identified and characterised taking into consideration the parameters listed in Appendix G.

9.6.2 Assessment of Significance

Magnitude of potential effect	Nature conservation value of sites damaged or improved				
	International	UK/National	Regional	County	District
Major negative	Major adverse	Major adverse	Moderate adverse	Moderate adverse	Minor adverse
Intermediate negative	Moderate adverse	Moderate adverse	Moderate adverse	Moderate adverse	Minor adverse
Minor negative	Minor adverse	Minor adverse	Minor adverse	Minor adverse	Minor adverse
Neutral	Neutral	Neutral	Neutral	Neutral	Neutral
Positive	Major beneficial	Major beneficial	Moderate beneficial	Moderate beneficial	Minor beneficial

Table 9.4 Assessing the significance of effects

9.6.3 Potential Effects upon Marine Mammals

This section of the report provides information on the potential effects of the proposed GS2 offshore wind farm on marine mammals around Gunfleet Sands.

Potential effects during the construction, operational and decommissioning phases are identified, along with mitigation measures where appropriate. The proposed development will involve the following activities during the construction/decommissioning and operation phases:

Construction/Decommissioning Phases	Operational Phase
• Detailed survey across the proposed site; • Laying of cables between turbines, offshore substation; • Piling of turbine and substation bases and installation of turbines and substations; • Construction vessel traffic.	• Operation of the turbines; • Operations vessels across the array including bird and marine mammal monitoring; • Additional vessel movements for tourism to the wind farm.

Table 9.5 Activities related to the GS2 development that may affect marine mammals

The above activities could affect marine mammals in various ways, directly and indirectly, during the construction/decommissioning and operational phases. The potential effects identified for each stage are assessed in detail below.

As outlined above, the VER's identified with respect to marine mammals, have been grouped into seals, dolphins and harbour porpoises due to the similarities of sensitivity of the species in each group. Effects on these three groups of species are considered separately below.

9.6.4 Construction/Decommissioning Phases

One of the key potential effects upon marine mammals during the construction phase is noise generated by the piling process. The potential effects of noise on marine mammals have been extensively studied. Of relevance to the proposed GS2 project is a review of the effects on marine mammals from anthropogenic marine noise sources produced by Shepherd *et al.* (2006). A short summary is given in Appendix G.

9.6.4.1 Seals

Impact Title: Pile driving operations may create adverse impacts upon seals on and around the GS2 site

Pile driving is known to produce very loud underwater sounds that can be fatal or acutely injurious to seals if they are close enough to the sound source. Underwater sound from piling may also travel many kilometres and still cause temporary or permanent injuries although of a much less serious nature. Before assessing the potential for this impact to arise during the construction phase of the GS2 project, it is appropriate to consider some of the key issues related to noise effects on marine mammals.

With respect to potential impacts of noise on seals around Gunfleet Sands, it is important to recognise that in deep water, sound waves can travel considerable distances and could affect animals many kilometres from the source. In contrast, in shallow water the sound is adsorbed by the substrate and dissipates quickly.

Gunfleet Sands is a sand bank and flanked on several sides by other shallow water areas including Buxey Sands to the west, Long Sands to the east and Sunk Sands to the south. Sounds generated at Gunfleet Sands as a result of piling would, therefore, be expected to travel short or moderate distances in certain directions from some of the pile locations.

Based on work undertaken by RPS and Subacoustech on behalf of the Thames Developers Group in 2006 (RPS, 2006; Subacoustech, 2006), it is predicted that potentially damaging sound levels may travel for 10 kilometres or so from source. It is further predicted that most sound would dissipate in the shallows within 15-20 km of the site.

Seals are more susceptible to low frequencies which are transmitted much more efficiently than high frequencies and therefore further. However, few seals have been recorded around Gunfleet Sands and therefore, this potential effect is likely to be low. The seals that are present in the area could be displaced and undergo behavioural changes within several kilometres of each piling operation.

This would potentially make an area of a kilometre or so around each piling operation unsuitable for marine mammals for the duration of the piling, which is expected to be around 4-8 hours. Once completed and the piling stopped, the marine mammals would move back into the area. This would therefore be a short-term, temporary and reversible effect.

It is also predicted that there will be a low level of mortality of fish species in close proximity of the piling, as well as the displacement of larger number of fish away from the area of piling. Whilst this would potentially reduce the amount of fish available as prey for seals, it may also attract seals to the piling for the free food, a.k.a. “the dinner gong” effect. Seals forage across large areas for prey items and the only time at which they may be susceptible to reduced prey within several kilometres of a pile would be after giving birth when pups are being weaned. In the Greater Thames region this would only affect common seals in August and September.

Seals have been known to associate sounds from small-scale piling with food (see note on dinner gong effect). Given the sound levels involved with the proposed piling at GS2, this is unlikely to happen. However, should such an effect be recorded during piling, it would be assumed that the seals suffer no adverse effects in line with the JNCC’s seismic survey mitigation guidelines (JNCC, 2004).

Without the use of any mitigation measures, there is the potential that noise from piling activities may result in a **Moderate Adverse Impact** upon seals in the vicinity of the GS2 site.

Mitigation Measures

In order to mitigate potential impacts from piling operations upon seals, it is proposed that the following mitigation measures are adopted during the construction phase:

- Suitably qualified and experienced Marine Mammal Observer (MMO) or Observers would be appointed and Natural England notified of their identity and credentials before any construction work commences;
- The MMO would maintain a record of any sightings of marine mammals within the mammal monitoring zone and action taken to avoid any disturbance being caused to them;
- Piling activities would not commence until half an hour has elapsed during which marine mammals are not detected in or around the site. The monitoring should be undertaken both visually (by the MMO) and acoustically using appropriate Passive Acoustic Monitoring (PAM) equipment. Both the observers and equipment would be deployed at a reasonable time before piling is due to commence;
- At times of poor visibility (e.g. night-time, foggy conditions, sea state greater than that associated with force 4 winds) enhanced acoustic monitoring of the zone would be carried out prior to commencement of relevant construction activity;
- A reporting methodology would be put in place before works commence to enable efficient communication between the MMO and the skipper of the monitoring vessel; and

- Once the half hour detection period has past, piling would only commence using the soft start procedure. The duration and nature of this procedure must be discussed and agreed prior to commencement of operations with the Marine Mammal Observer.

It is proposed that the piling would start on low power and be increased uniformly over a 20-minute period until full or operational power is reached.

Residual Impacts

Adherence to these mitigation measures will ensure that impacts upon seals during the piling activities will be minimised. Therefore, it is predicted that there would be a **Minor Adverse Impact** upon seals from piling activities.

Proposed Monitoring

Marine mammal records would be collected incidentally as part of the bird monitoring programme. Records would then be used to establish use of the area during construction and operations. The records would be incidental and therefore unsuited to Before, After, Control Impacts (BACI) method. It would however, be a useful reference to inform future wind farm development.

Impact Title: Construction activities, in particular cable-laying, may result in increases in suspended sediment concentrations, which may create adverse impacts upon seals in and around the GS2 site

Sediments would be re-suspended into the water column as a result of the piling and cable laying activities. This could affect species of marine mammals dependent on foraging using visual cues. Whilst seals use eyesight for finding prey and navigating, they can also successfully hunt in turbid and unlit waters. Therefore a slight local increase in turbidity would not affect the foraging ability of seals. Therefore, it is predicted that there will be a **temporary Minor Adverse Impact** upon the foraging behaviour of seals during cable-laying activities.

Mitigation Measures

As any impacts are assessed to be temporary and minor adverse, no mitigation measures related to this impact are proposed.

Residual Impacts

The significance of this impact is judged to be **temporary Minor Adverse**.

Proposed Monitoring

None proposed.

9.6.4.2 Harbour Porpoises

Impact Title: Pile driving operations may create adverse impacts upon harbour porpoises on and around the GS2 site

Porpoises are more sensitive to high frequency sounds than seals but are still vulnerable to the pressure wave of very intense sources such as piling if they are close enough to the source. Sounds created at Gunfleet Sands as a result of piling would be expected to travel short or moderate distances.

Based upon modelling work undertaken for other offshore wind farm projects in the Thames (see Shepherd *et al,* 2006), most sound would dissipate in the shallows within 5-10km of the site, especially the high frequencies that porpoises are most sensitive to. In certain directions from some of the pile locations e.g. where there is deep water, potentially sub-lethal injurious sound levels may travel for several kilometres. In theory, if porpoises were exposed to these levels of sound over a long period of time, injuries could occur. However, if exposed to sub-lethal but intense sound levels porpoises are expected to move away due to discomfort caused by the noise. This would reduce their exposure and their risk of temporary or permanent hearing shift. If they move closer it would be considered that the sounds do not cause discomfort and thus would be less likely to harm them.

Porpoises have been recorded moving back into an area in which piling has occurred only hours after piling has stopped (Tougaard *et al*., 2004). Therefore the short duration but repetitive nature of piling over the course of installing piles for 22 turbines and a substation is unlikely to displace porpoises for significant periods of time. Periods between piling operations would be much longer than the piling activities themselves and therefore the porpoises would have adequate time to recover.

Porpoises use sound to communicate, navigate and detect food and predators or other risks. Sound from other sources may affect communication by masking the sounds on which porpoises rely. The high frequencies that they use to communicate would overlap with some of the higher frequencies generated by piling. It is unlikely that vessel movements associated with construction of the wind farm would mask echolocation to any significant level since porpoises move readily in the area with the current high level of vessel activity. It is probable that their range of communicating is already reduced in the area due to high levels of background noise. Noise from piling has the potential to mask some of the sounds that porpoises depend on within a certain distance from the piling operations.

However, masking would only be partial due to the short duration of each pulse created by the piling hammer, and relatively long period between pulses. Echolocation clicks produced by porpoises are extremely short and the returning signals are received very quickly due to the speed sound travels underwater. Furthermore, porpoises echolocation is only effective for 200-300 m (Richardson *et al*., 1995). Therefore echolocation would still be effective between piling pulses. Whilst this would reduce the overall effectiveness of hearing, and in human terms would be an annoyance, it would not mask hearing to any detrimental degree.

It is also important to note that porpoises do not readily react with vessels or human activities and therefore are unlikely to approach large jack-ups or barge. The harbour porpoise is highly mobile and is expected to move away from the intense sound sources produced during piling.

Porpoise numbers in this area are also lowest during the summer and autumn when most of the piling activity on GS2 is proposed to occur and, therefore, the risk of impacts on this species will be at their lowest.

In terms of significance of impact, without the use of any mitigation measures, there is the potential that noise from piling activities may result in a **Moderate Adverse Impact** upon seals in the vicinity of the GS2 site.

Mitigation Measures

In order to mitigate potential impacts from piling operations upon porpoises, it is proposed that the same mitigation measures set out in relation to seals (see above) are adopted during the construction phase.

Residual Impacts

Adherence to these mitigation measures will ensure that impacts upon porpoises during the piling activities will be minimised. Therefore, it is predicted that there would be a **Minor Adverse Impact** upon porpoises from piling activities.

Proposed Monitoring

See mitigation measures above for details on use of MMO's and PAM during the construction phase.

Impact Title: Construction activities, in particular cable-laying, may result in increases in suspended sediment concentrations, which may create adverse impacts upon porpoises in and around the GS2 site

Sediments would be re-suspended into the water column as a result of the piling and cable laying activities. This could affect species dependent on foraging using vision.

However, porpoises use echolocation regularly when foraging and would not be affected by any increases in turbidity. Therefore, it is predicted that there will be **No Impact** upon porpoises from increased suspended sediment concentrations.

Mitigation Measures

As it is predicted that there will be no impact upon porpoises from increased suspended sediment, no mitigation measures are proposed.

Residual Impacts

It is predicted that there will be **No Impact** upon porpoises from increased suspended generated during the construction process.

Proposed Monitoring

None proposed.

Impact Title: Increased vessel activity during the construction phase may lead to adverse effects upon porpoises on and around the GS2 site

The Thames area carries a great number of vessels and smaller craft would not constitute a significant increase in activity. Data acquired for the Thames wind farms has shown that porpoise numbers are high where vessel traffic is also high. Therefore, porpoises are unlikely to be affected by the relatively small numbers of vessels involved with construction. However, porpoises do not readily interact with vessels and avoid large structures and, therefore, could be visually disturbed by the presence of the large jack-up piling vessel or other large vessels that may be involved with construction. This effect is likely to move them away from the location of the piling activity and aid the soft start which intends to slowly build up the noise intensity and safely encourage marine mammals to move away. It is predicted that a **Minor Adverse Impact** may arise from disturbance from construction activity.

Mitigation Measures

No mitigation measures would be of use to reduce the effects of this activity.

Residual Impacts

It is predicted that there will be a **Minor Adverse Impact** upon porpoises via disturbance during construction.

Proposed Monitoring

Monitoring measures related to reducing noise impacts (see above) will be of relevance to this potential impact.

9.6.4.3 Dolphins

Impact Title: Pile driving operations may create adverse impacts upon dolphins on and around the GS2 site

High volume noise created as a result of piling at GS2 would be capable of causing fatalities or serious injury to dolphins in close proximity to the piling operation. Such intense sounds are expected to travel only several hundred metres depending on the depth of water.

However, the use of soft starts would prevent dolphins from being suddenly exposed to the full intensity of piling noise and the use of MMOs would prevent the soft start if animals were detected within 500m. Dolphin numbers in this area appear to be highest during the summer and autumn when most of the piling activity is proposed to occur. However, the numbers recorded are low and the risks of encountering dolphins are not expected to be high. Dolphins are also highly mobile and are expected to move away from the gradually intensified sound sources produced during the soft start and, therefore, unlikely to occur within an area of high risk.

Based upon modelling work undertaken for other offshore wind farm projects in the Thames (see Shepherd *et al,* 2006), most sound would dissipate in the shallows within 5-10km of the site, especially the high frequencies that dolphins are most sensitive to. In certain directions from some of the pile locations e.g. where there is deep water, potentially sub-lethal injurious[16] sound levels may travel for several kilometres. In theory, if animals were exposed to these levels of sound over a long period of time, chronic injuries could occur such as temporary or permanent hearing loss. However, if exposed to sub-lethal but intense sound levels dolphins are expected to move away due to discomfort caused by the noise. This would reduce their exposure and their risk of temporary or permanent hearing shift. If they move closer it would be considered that the sounds do not cause discomfort and thus would be less likely to harm them.

The short duration but repetitive nature of piling over the course of installing up to 22 turbines is unlikely to displace dolphins for significant periods of time. Periods between piling operations would be much longer than the piling activities themselves and allow dolphins time to recover.

Dolphins use sound to communicate, navigate and detect food and predators or other risks. Sound from other sources may affect communication by masking the sounds on which dolphins rely. It is unlikely that vessel movements associated with construction of the wind farm would mask echolocation to any significant level since dolphins move readily in the area with the current high level of vessel activity. It is probable that their range of communicating is already reduced in the area due to high levels of background noise.

[16] Differentiates between fatalities or serious injury as a result of intense close quarter sounds

Noise from piling has the potential to mask some of the sounds that dolphins depend on within a certain distance from the piling operations. The high frequencies that they use to communicate would overlap with some of the higher frequencies generated by piling.

However, masking would only be partial due to the short duration of each pulse created by the piling hammer, and relatively long period between pulses. Echolocation clicks produced by dolphins are extremely short and the returning signals are received very quickly due to the speed sound travels underwater. Further, dolphin echolocation is only effective for 200-300 m (Richardson *et al*., 1995). Therefore echolocation would still be effective between piling pulses. Whilst this would reduce the overall effectiveness of hearing, and in human terms would be an annoyance, it would not mask hearing to any detrimental degree.

Based upon this assessment, it is concluded that during the construction phase of the scheme, the noise generated by piling operations would result in a **Minor Adverse Impact** upon dolphins.

Mitigation Measures

In order to mitigate potential impacts from piling operations upon dolphins it is proposed that the same mitigation measures set out in relation to seals and porpoises (see above) are adopted during the construction phase, i.e. soft-start, use of MMO's etc.

Residual Impacts

Adherence to these mitigation measures will ensure that impacts upon dolphins during the piling activities will be minimised. However, it is predicted that even with these mitigation measures, a **Minor Adverse Impact** upon dolphins from piling activities will remain.

Proposed Monitoring

See mitigation measures above for details on use of MMO's and PAM during the construction phase.

Impact Title: Increased vessel activity during the construction phase may lead to adverse effects upon dolphins on and around the GS2 site

Pre-construction surveys and additional vessel traffic as a result of the construction phase of the project could disturb dolphins. However, vessel traffic in this area is already very high and the additional movements and activities as a result of the construction are unlikely to be significant. Therefore, it is predicted that a **Minor Adverse Impact** upon dolphins may arise from disturbance from construction activity.

Mitigation Measures

Mitigation measures related to reducing noise impacts (see above) will be of relevance to this potential impact.

Residual Impacts

It is predicted that there will be a **Minor Adverse Impact** upon dolphins via disturbance during construction.

Proposed Monitoring

Monitoring of marine mammals during the construction phase would occur incidentally as part of the bird monitoring.

9.6.5 Operational Phase

9.6.5.1 Seals, Porpoises and Dolphins

Impact Title: Noise and vibration produced by turbines and/or survey/maintenance vessels during the operational phase of the project may result in adverse impacts upon seals, porpoises and dolphins

The levels of noise associated with operational turbines would not be high enough to pose a risk to marine mammals. Seals have been recorded in close proximity to other fixed and noisy features such as oilrigs and platforms, often using such features for foraging. Porpoises have also been recorded within a wind farm array. Therefore, it is not predicted that these species will suffer adverse effects from noise and vibrations emitted from the turbines.

With respect to vessel movements due to maintenance of the wind farm, these additional movements would not represent a significant increase on current activity in this area. This part of the Thames Estuary is already very busy with a wide range of human activities and the small increase in vessel activity associated with the proposed wind farm is unlikely to change any activities of the marine mammals.

Therefore, it is predicted that there will be **No Impact** upon seals, porpoises and dolphins from noise generated in the operational phase of the GS2 project.

Mitigation Measures

None required.

Residual Impacts

No Impact.

Proposed Monitoring

Although it is predicted that there will be no impact upon seals, porpoises and dolphins from noise and vibration generated during the operational phase, the developer is willing to install facilities that will enable sub-sea noise and vibration from the turbines to be assessed and monitored during the operational phase of the wind farm.

These facilities will enable detailed post construction data to be collected on the frequency and magnitude of underwater noise produced by the GS2 offshore wind farm. The choice of sites for installing this monitoring equipment would reflect the different conditions such as sediment type, water depth and pile type.

Impact Title: The presence of turbines and associated scour protection will result in a permanent loss of habitat within the GS2 site for <u>all</u> marine mammals

As a result of the presence of the turbines and associated scour protection, a relatively small area of sandy habitat will be lost. With scour protection, it is calculated that the turbines and associated rock armour would produce an overall footprint of 33,452m^2 (0.033km^2). The total area of the proposed GS2 development area is 7.5km^2. Therefore, the largest amount of habitat that could be lost from the proposed GS2 development represents just 0.6% of the development area.

Overall, the loss of 0.033km^2 of habitat is insignificant compared to the whole of the wider Thames region where seals, porpoises and dolphins occur. Furthermore, the rock scour protection around the turbine bases would eventually become colonised and provide shelter and feeding opportunities for certain marine mammal species. The effects of any habitat loss would, therefore, be temporary.

There are no records of basking seals on Gunfleet Sands, although the water depth is suitable for basking at this location (*pers. comm,* Merchant Navy Captain with local knowledge). Therefore, there would also be no loss of basking areas or pupping areas as a result of the proposals.

The magnitude of effects as a result of changes in habitat would be positive by virtue of the replacement of existing sandy substrates over the short to medium term by alternative but productive habitat features around each turbine. The significance of these effects would, therefore, be **Minor Beneficial.**

Mitigation Measures

None required.

Residual Impacts

Minor Beneficial Impact.

Proposed Monitoring

None required.

9.6.6 Summary of impacts upon marine mammals

Effect	Significance of Impacts		
	Seals	Dolphins	Porpoise
Effects from construction	Minor Adverse	Minor Adverse	Minor Adverse
Effects from operational activities	No Impact	No Impact	No Impact
Permanent habitat change (Operational Phase)	Minor Beneficial	Minor Beneficial	Minor Beneficial

9.6.7 Cumulative Effects

In considering potential cumulative effects upon marine mammals, the following other projects/activities have been considered.

- GS1 Offshore Wind Farm;
- London Array Offshore Wind Farm
- Thanet Offshore Wind Farm;
- Kentish Flats Offshore Wind Farm;
- Greater Gabbard Offshore Wind Farm; and
- Commercial fisheries.

All the wind farms would produce similar effects on marine mammals to those identified above for the GS2 project, with only operational impacts possible at Kentish Flats as construction has already been completed. The five other sites are spread throughout the Greater Thames region from Thanet in the south to Greater Gabbard in the north east and Kentish flats in the west.

GS2 is likely to be constructed concurrently with GS1 and as such, would extend the construction activities and cover a larger area at this location than GS1 alone. The construction process for both these wind farms would be conducted as one, and by combining the construction processes in using the same vessels etc, it would reduce the total amount of activities when compared with entirely separate projects. It would however, extend the overall duration of construction and increase the overall area affected but not by the same degree as if they were entirely separate.

The cumulative effects from the other three sites (London Array, Thanet and Greater Gabbard) need to be considered as totally separate schemes and would have very similar effects as GS2. Potential cumulative effects from habitat loss, the construction phase of the project and also the operational phase are discussed below.

9.6.7.1 Habitat Loss

With respect to habitat loss, GS2 is located on a shallow sandbank which becomes partly exposed at low tide. Although this appears to be suitable for basking seals no records have been made of seals basking or pupping at this location. However, if seals were displaced from other sandbanks affected by one of the other wind farms, they may use Gunfleet Sands on which to bask or, for common seals, even to pup. It is highly unlikely that grey seals would pup on sandbanks.

Basking or pupping occurs only at low tide and seals would only be affected by displacement during the short period in which the sand is exposed. If seals do move to Gunfleet Sands for basking disturbance at low tide forcing them into the water would not be a serious issue. If pupping should occur however, potentially disturbing activities such as moving a piling rig into place should wait until the mother and pup have taken to the water. If not the pup could be forced into the water before it is able to do so. It is a very brief transition for a common seal pup from birth to swimming and therefore construction activities would not be delayed for more than a couple of hours at most.

Most of the permanent habitat loss envisaged as a result of the Round 1 and 2 wind farms would be at the location of the turbine and offshore substation bases. The areas likely to be lost as a result of all proposed wind farms being developed would still be insignificant in terms of the overall areas of the habitats mapped in the region. Furthermore the scour protection provided for the bases would be quickly colonised forming artificial reefs. These areas would provide alternative sources of food for most of the marine mammal VER's identified in the baseline.

The combined effects of habitat loss and fisheries operating in the area would result in a slight increase in the magnitude of effects. However, this would be slight as fishing activity has decreased in recent years and fish stocks appear to be recovering still further.

The cumulative effects of permanent habitat loss with other proposed wind farms in the Greater Thames region would result in a greater area affected than at GS2 alone. The effects would be temporary given that the areas affected would be colonised and provide shelter to many prey items for most of the marine mammals encountered in the area. The overall magnitude of effects would therefore be Minor Negative and the significance of these effects, **Minor Adverse.**

9.6.7.2 Effects from Construction

The worst case scenario for piling would be that all the Thames wind farms would be conducting piling during the same season or seasons and with piling rigs operating simultaneously. Should this be the case, a significant area of the Greater Thames would be affected by piling noise (ensonified). Only a small proportion of this area would be affected by sound levels considered to be physically damaging, but a significant area would be affected by sound levels considered to cause a behavioural response, i.e. marine mammals would move away from the source.

If this were to be the case, marine mammals would be deterred from a significant area within the Greater Thames region for much of the spring, summer and autumn. Between piling activities they would probably attempt to move in and feed but would move away when piling recommences. This would potentially preclude foraging from a large area in which important food stocks would be found. In the late summer these are probably important for building reserves of blubber for the winter. Whilst there are many other areas in which marine mammals could forage they are likely to be less preferential than the areas they currently use or would cause higher densities and thus increase intra- (within species) and inter- (between species) specific competition. This could lead to additional stress and reduced survival. It would be very difficult to quantify such an effect but it is likely to be of Intermediate Negative magnitude and the significance of effect Moderate Adverse for seals and dolphins and Major Adverse for harbour porpoises. The significance of effect on harbour porpoises would be unacceptable but as stated would be the worst-case scenario.

It is very unlikely that piling would occur simultaneously at all five proposed wind farms due to the limited number of piling rigs and hammers capable of driving the large piles needed for the turbines. Furthermore there is also a limited supply of turbines which determines in general the timing of project construction. The most likely scenario is that piling would occur on a maximum of 2 or 3 projects in the Thames Estuary at any one time. Because of the abundance of shallows in the area and the dissipation of sound across shallows, large areas would remain unaffected by piling noise and thus enable most if not all of the marine mammals to forage successfully. Because of the relatively long periods between piling operations conducted by each piling rig, and the quick recovery displayed by marine mammals at other piling (and seismic) operations, they would quickly move back into an area in which operations had ceased. Whilst this would result in an increase of stress levels over the effects from GS2 in isolation, they would still be minor negative in magnitude and **Minor Adverse** in significance.

The mitigation measures proposed to reduce the risk of injury or death of marine mammals in close proximity to the piling i.e. soft start and MMO's are likely to be applied at each wind farm. Therefore the combined effects of the risk of injury or death would be negligible.

Following the above assumptions of two or three piling operations being active at any one time, it is likely that other forms of vessel activity associated with construction would be of a similar level across developments. Because the vessel activity in the Greater Thames region is so high, even three operations conducted simultaneously would not be a significant increase on current activities. The effects of sediment re-suspension would be very localised and unlikely to be an issue across developments.

Except in the case of GS1 the other wind farm developments are located at least 10km from GS2 (London Array). Visual disturbance from vessels operating on GS2 is therefore unlikely to act in combination with those operating on other wind farms. Both seals and cetaceans are known to use very busy areas such as King's Channel and are therefore unlikely to be affected by wind farm construction traffic any more than they are from current activities.

Most of the potential effects identified and used in the in-combination assessment are relatively benign across such a large area and with proposed developments being so far from each other. However the effects of noise from piling at several locations would increase the level of effects if the worst-case scenario were to occur. However, it is unlikely for the worst case to occur given the few number of rigs available that can hammer such large piles. The most likely scenario would be two to three piling activities occurring simultaneously. Whilst this is likely to have a larger overall effect than just one piling operation on GS2 it would leave large areas unaffected by noise and therefore still remain as a minor negative magnitude of effect. The significance of this effect would be **Minor Adverse.**

9.6.7.3 Effects from Operations

Marine mammals do not appear to be affected by turbine noise or vibrations generated by wind turbines. Therefore the cumulative effects of the other wind farms would be **negligible**.

Marine mammals have not been known to show adverse reactions to EMF generated around electricity cables. The cables for all wind farms are likely to be laid to a depth in the substrate that would prevent undue effects on fish at the substrate surface or be covered in rock ballast to reduce these effects. Therefore cumulative effects as a result of the cables would be **negligible**.

Additional vessel traffic for maintenance, monitoring and tourism will again not be a significant addition to the existing vessel activity in the area. The magnitude of effects as a result of the operation of the wind farm would be Neutral. The significance of these effects would also be **Neutral**.

9.7 Conclusions

Five species of marine mammals have been regularly recorded in the area surrounding the proposed GS2 wind farm. The porpoise is the most common species and is considered to be resident. Common and grey seals are also present, the former thought to be resident for most of the year but few breed. Bottlenose dolphin and white-beaked dolphin are present in small numbers but on a more sporadic basis than the other marine mammals recorded.

Potential effects from the proposed GS2 wind farm include visual and acoustic disturbance from vessel traffic, disturbance from cable laying including reduced visibility from resuspended sediments and, in particular the effects of noise as a result of piling operations. Sound levels generated by piling large piles into the seabed have the potential to injure or kill marine mammals in close proximity and to cause less serious injury to a few kilometres.

Mitigation measures proposed are intended to reduce the risks to marine mammals by firstly preventing piling from starting if marine mammals are observed to be too close to the piling operation and then to start piling with hammer blows that would be sub-injurious but uncomfortable, and over a short period of time to build up to full power. In this way they would be encouraged away from the piling and thus risk. By this means the effects on marine mammals from piling would be kept low.

Marine mammals could be displaced from a large area around each piling operation but on a short term and thus temporary but repetitive basis. Fish species could also be affected by injury or displacement and therefore affect marine mammal foraging potential. Marine mammals have been shown to move back into areas previously affected by loud noise soon after the disturbance has halted. Because of this the effects are considered to be short term, temporary and reversible.

Construction of the wind farm would create small areas of artificial reef around each turbine and substation base. These areas would provide some shelter for marine mammals with better foraging potential than the existing habitats provide.

The significance of effects as a result of GS2 is therefore predicted to be no greater than **minor adverse**. Because of the changes in habitat around turbine bases, it is expected that a minor benefit could occur for marine mammals.

Cumulative effects would potentially affect large areas of the region due to simultaneous piling operations and increased vessel traffic. However, because of the limited resources for wind farm construction, it is expected that only two or three could occur at the same time. Although this would affect a much larger area than GS2 on its own, it would only comprise a very small proportion of the region as a whole and the resources it contains.

It is possible that changes in the marine mammal assemblage or individual activities at GS2 could change due to other wind farms. For example Gunfleet Sands could become used for basking or pupping seals whilst currently it is not. Appropriate mitigation measures would be used to ensure that seals would not be significantly affected if this should happen. Therefore the significance of effects acting cumulatively with other wind farms would be no different than GS2 on its own.

10. ORNITHOLOGY

10.1 Introduction

This section describes the results of various investigations, including desk-based reviews of existing information about offshore birds and specific surveys undertaken in relation to the proposed Gunfleet Sands 2 development (GS2).

The information presented describes and evaluates the importance of the proposed wind farm area and adjacent areas for birds, including breeding, migratory and wintering populations. It should be noted that this section addresses only the offshore components of GS2. Onshore components, including the grid connection, are unchanged from the GS1 Environmental Statement (ES). The potential effects of the proposed development are identified and an assessment of their likely significance with respect to ornithological features of importance for nature conservation is made.

10.2 Assessment methodology

To provide a structure to the assessment of impacts, a recognized impact assessment methodology has been used. It follows that developed by Scottish Natural Heritage (SNH) and the British Wind Energy Association (BWEA) (Percival *et al*., 1999). This approach is consistent with the requirements of key legislation and environmental policy including the Environmental Assessment Regulations 1999 and Institute of Environmental Assessment Guidelines (IEA 1995). The assessment involves three stages:

1. Determination of the sensitivity of the feature (in this case bird populations) potentially affected. The sensitivity of a feature is based on an evaluation of the relative importance of the population for nature conservation;
2. Identification of the magnitude of potential effects of the proposed development; and
3. Assessment of the likely significance of potential effects on a scale from Very Low to Very High. Significance is determined by combining the magnitude of an effect with the sensitivity of the feature that it potentially acts upon.

The criteria for categorising the sensitivity of features, the magnitude of potential effects and the likely significance of potential effects are attached at Appendix H.1.

10.3 Consultation

Natural England and the Royal Society for the Protection of Birds (RSPB) were consulted with regard to the scope of the EIA, the data upon which it would rely, the methods of data collection and the method for assessing the significance of potential impacts.

The response of both organisations to the scoping report is included in Appendix H.8. In summary, the key issues highlighted by both organisations in their scoping responses and in subsequent meetings, included:

- The need for sufficient, recent surveys of the site. It was noted that the assessment should be based on at least 2 years of recent survey data for the site;
- The importance of surveying an appropriate area – the survey area should include the proposed development, a buffer of at least 2km around the proposed development as well as an appropriate reference area;
- The need to provide sufficient information to enable an assessment of the impacts of the proposed development on the interest features of the Thames Estuary potential SPA;
- The need for an assessment of potential collision risk; and

- The need for cumulative and in-combination assessment, particularly with regard to the red-throated diver population of the Thames Estuary.

It was agreed with consultees that in-combination displacement effects arising from offshore wind farm construction within the Thames strategic area was the most important potential impact on the diver population of the Thames Estuary potential SPA. It was also agreed that the method used for the assessment of potential impacts of London Array (see RPS, 2005) represented a transparent and consistent method for assessing the magnitude of potential in-combination displacement effects.

In undertaking this assessment, the issues raised by consultees have been fully taken into account.

10.4 Data Sources

Baseline information for the assessment of potential impact on birds has been obtained from a variety of sources including existing literature and site surveys.

The study area for baseline depends on the specific element of the investigation as follows:

- Desk-study area – important populations and sites were identified within a 20km radius from a central point within GS2;
- Boat survey area – boat surveys were undertaken over the area of the wind farm and an adjacent area, totalling approximately 126.7km2;
- Aerial survey area – comprising data taken from the TH1 (1290.5km2), TH2 (1315.7 km2) and TH4 (1168.9 km2) survey areas, a total area of approximately 3775.1km2;
- Assessment area – the wind farm area plus an additional 1km and 2km buffer.

Survey methods are described in more detail in Section 10.4 (below).

10.4.1 Desk Study

The locations of designated conservation sites for their ornithological interest were identified from the MAGIC website and information on the cited interest features was obtained from relevant organisations, including JNCC and Natural England. Information on seabird breading colonies was obtained from Seabird 2000 national seabird survey (Mitchell *et al*., 2004). Wetland Bird Survey (WeBS) and international and national threshold values were obtained from Pollitt *et al*. (2003).

The most sensitive features are those that form the cited interest features of sites of European or National importance, SACs, SPAs, Ramsar sites and SSSIs (see Chapter 6 for more detail on Nature Conservation) and sites where important populations of species occur exceeding published thresholds of international or national importance (usually 1% of the biogeographic or national populations respectively for bird species). A 'biogeographic' population is defined as a population that shares common breeding, migration and wintering grounds. The boundaries of this range, and hence the population size, are determined by the government's advisors on nature conservation.

Other features of importance include species listed on Annex I of the EC Birds Directive, regionally important populations and UK Biodiversity Action Plan (BAP) priority species.

Existing data relating to the proposed wind farm area has also been reviewed. As the GS2 lies immediately adjacent to GS1 there is existing information relating to the environmental impact assessment of that site, as reported in GE Energy & Hydrosearch (2002). Further surveys of the GS1 site and adjacent areas were continued between 2001 and 2002 and these have been collated in an interim report (RPS, 2005) which has also been reviewed.

Details of project specific surveys undertaken at GS2 are summarised below.

10.5 Project-Specific Survey

In order to collect sufficient information to assess the baseline of the proposed development site and its surround, boat based surveys were considered necessary in and around the proposed wind farm site. COWRIE guidance (Camphuysen *et al*., 2004) indicates that the aerial and boat survey methods are complementary and both provide important information about the distribution, abundance and behaviour of birds. Survey areas should cover the proposed wind farm and adjacent areas. Surveys should extend over a calendar year, to enable all populations of potential conservation interest to be assessed, ideally utilising both survey platforms.

The location and extent of aerial and boat survey areas are illustrated in Figure 10.1.

10.5.1 Aerial Surveys

Aerial surveys were flown within the region of the wind farm between March 2005 and August 2006. The standard aerial survey method is described in Komdeur *et al*. (1992). In addition, data from aerial surveys conducted for the GS1 EIA, collected over the period 2002-2003, was also considered within this assessment.

The aerial survey methods undertaken are detailed in Appendix H.3. In summary a high-winged, twin-engine (Partenavia) aircraft was used which enabled two observers to simultaneously record the species, number and distance from the aircraft (within defined distance bands) of birds observed on either side of the aircraft. As with boat surveys, observations were time-logged allowing positions to be inferred subsequently from a GPS track of the flight path.

The data used in this assessment include the results of aerial surveys flown on the dates indicated in Table 10.1.

Year	Aerial Sector		
	TH1	TH2	TH4
2005	6th March 13th March 31st July 13th November 11th December	7th March 15th March 16th November 6th December	11th August
2006	14th January 18th February	13th January 2nd March	4th June 22nd June 11 August

Table 10.1 Dates of aerial surveys in sectors TH1, TH2 and TH4 between March 2005 and June 2006

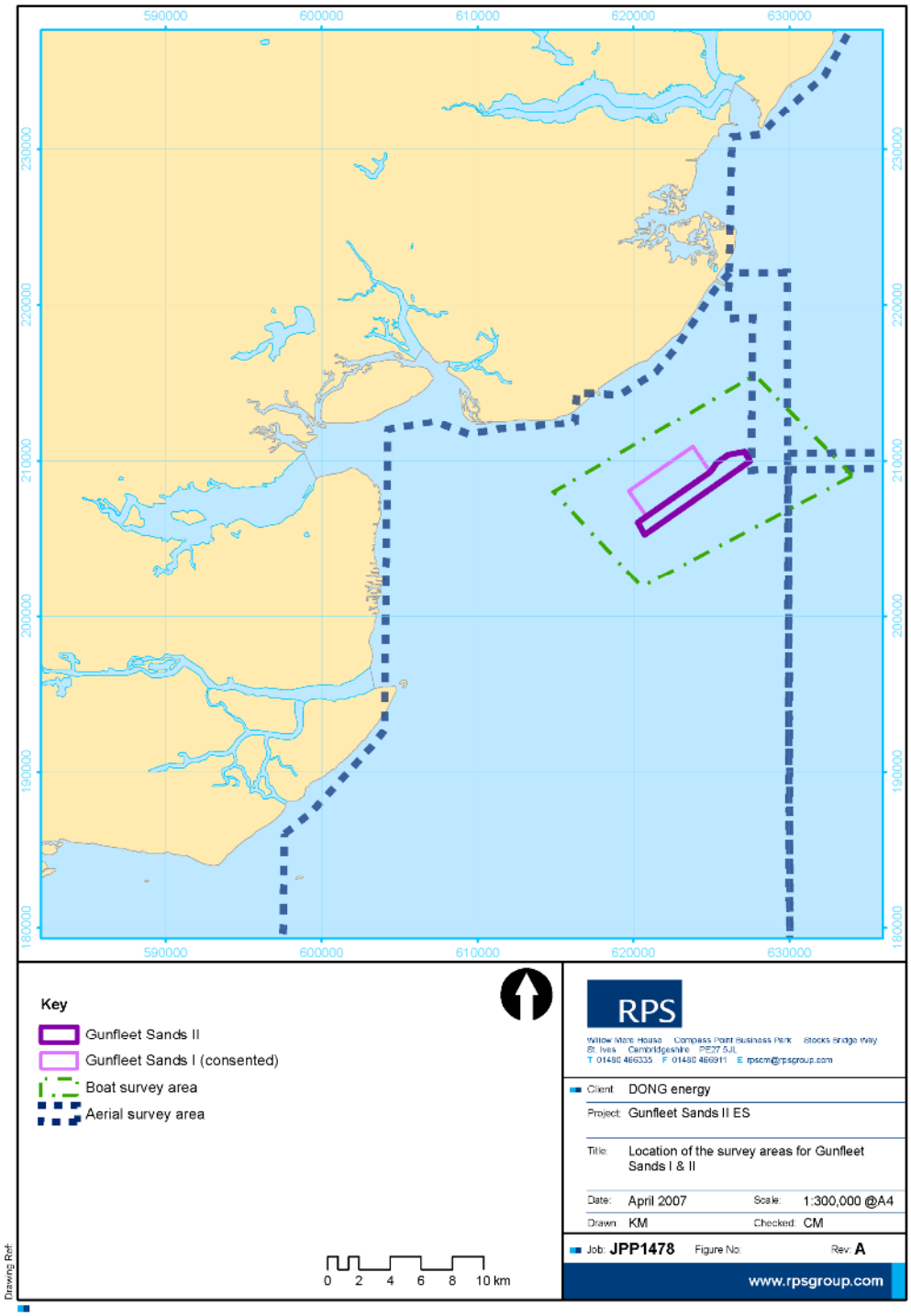


Figure 10.1 Location of survey areas for Gunfleet Sands 1 and 2

10.5.2 Boat Surveys

The GS1 ES (Hydrosearch, 2002) presented data on birds obtained from boat surveys undertaken monthly between October 2001 and July 2002. Boat surveys of the GS1 survey area have continued since the submission of the ES, as it was agreed that surveys would continue following consent in order to establish a baseline against which the effects of wind farm construction and operation can be evaluated. An interim report of the results collected during the period July 2002 – December 2004 was produced in February 2005.

This document presents the results collected during the period January 2005 – February 2007. The dates of boat surveys are indicated in Table 10.2. Since November 2004 monitoring surveys have been undertaken over a revised survey area of approximately 126.7km^2. The revised survey area fully covers GS2 as well as adjacent buffer and reference areas, between 2-4km of the wind farm boundary (Figure 10.2).

The survey methods are described in Appendix H.3. A 12m boat is used for the surveys which follow a standardised pattern of transects that provide coverage for most, if not all, of the survey area. The location of the boat is recorded at regular intervals using handheld GPS. Information on the species, number, age, behaviour, direction and flight height and direction is recorded.

2005	2006	2007
15th & 29th January 11th & 18th February 10th & 29th March 1st November 5th & 13th December	13th & 23rd February 22nd March 1st April 3rd October 5th November 2nd & 9th December	14th January 3rd & 18th February

Table 10.2 Dates of boat surveys undertaken between January 2005 and February 2007

10.6 Description of Existing Environment

10.6.1 Sites of importance for nature conservation

Of the 14 designated sites and 1 potential designated site identified within 20km of the GS2 site (see Chapter 6), 10 are important for their ornithological interest and of these the following are considered to be the most important:

- Hamford Water – Ramsar Site, SPA, NNR, SSSI
- Dengie – Ramsar Site, SPA, NNR, SSSI
- Colne Estuary – Ramsar Site, SPA, NNR, SSSI
- Blackwater Estuary – Ramsar Site, SPA, NNR, SSSI
- Foulness – Ramsar Site, SPA, SSSI
- Crouch and Roach Estuaries – Ramsar Site, SPA, SSSI

The coastal intertidal mudflats, freshwater wetlands, salt marshes, sand dunes, saline lagoons, shingle banks and dock structures within the protected sites detailed above provide ideal conditions for foraging and nesting grounds for a variety of species of conservation interest. Supporting internationally and nationally important numbers of wintering waterfowl and breeding wildfowl and wader and seabird colonies year round, the designated sites also provide a vital resting ground for migrating birds on the spring/autumn passage.

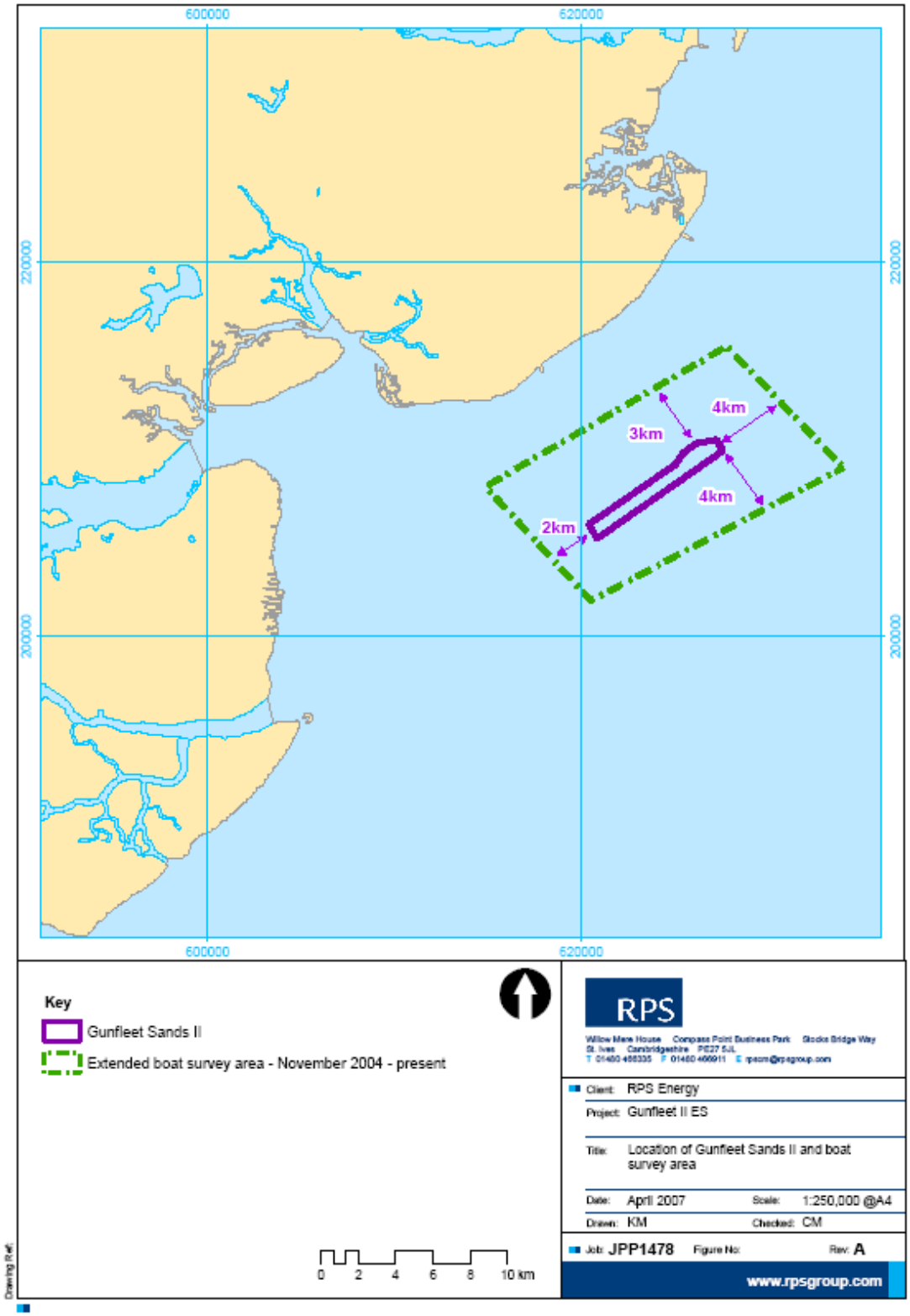


Figure 10.2 Revised Survey Area (since November 2004)

The protected sites with ornithological interest are primarily coastal areas important for wildfowl, waders and seabirds and their associated habitats. The majority of these bird populations are only likely to use offshore areas for commuting between feeding and roosting sites.

In addition aerial surveys undertaken within the Thames Estuary indicate the consistent presence of a wintering population of red-throated diver (a migratory species listed on Annex I of the Council Directive 79/409/EEC on the conservation of wild birds "Bird Directive") that regularly exceeds the published criterion of national importance (50 individuals). Although the current national winter population abundance estimate for red-throated diver is clearly an underestimate, JNCC consider that the Greater Thames Estuary qualifies as a Special Protection Area (SPA) on the basis of the diver population it supports. For the purposes of this assessment, the Thames Estuary has been treated as if it were an SPA.

10.6.2 Findings of GS1 ES and Interim Report

The GS1 ES and subsequent interim report reviewed data collected within the GS2 area (as part of the buffer area of GS1) and its surround. In summary the findings of the ES and interim report identified:

- The GS1 survey area as a whole and the development area itself does not provide habitat of importance to the species of waders and wildfowl cited within the surrounding Essex SPAs and SSSIs;
- A number of waterfowl and waterbird species were recorded in the survey area including, great-crested grebe, mallard and brent goose. In each case there was no evidence to suggest a strong association with the GS1 area;
- The GS1 survey area as a whole and the development area itself does not provide habitat of importance to the summer breeding populations of little tern or sandwich tern cited within the surrounding Essex SPA's and SSSI's;
- Summer surveys identified that the sea around the GS1 area provided a foraging resource for common terns (and/or unidentified common/arctic terns) but the numbers recorded were low and fall well below thresholds for national or regional importance;
- Divers are widespread at Gunfleet but tend to occur in low densities, typically less than 8 accumulated total birds per year per 1km2. There was no apparent relationship with divers and the wind farm area. Divers are most abundant within the Thames Estuary during December to March and the survey data collected for the ES and interim report reflected this. This dramatic decline in numbers reflects a difference in the distribution of divers within the Thames Estuary during 2002/03 and 2003/04. During 2003/04 there were fewer birds within the inner estuary with most observations made in the southern and outer (eastern) part of the estuary. Within the wind farm area the same pattern was observed with all birds being observed during both December 2002 and January 2003. During the winter of 2003/04 no divers were observed within the GS1 area;
- Other species recorded in the survey area included gannet, auks (mainly guillemot,), fulmar, skua species, common scoter, eider, kittiwake and gulls. Apart from a small number of guillemot and common scoter, the only species recorded within the GS1 area in substantial numbers were gulls and kittiwake;
- The most abundant gulls observed in the GS1 area were herring gull and lesser black-backed gull. Although less abundant a relatively high proportion of all black-headed gull observations were made within the wind farm area. kittiwake also occurred in the wind farm area; and
- The GS1 ES noted that land birds occurred in greatest numbers during spring and autumn with major movements recorded during the first and second weeks of November. No data relating to land birds was available for presentation in the interim report.

The data available for this desktop study has been useful in identifying key Species of Conservation Interest, and key areas within the wider area. However, field surveys have been undertaken to quantify offshore bird populations at the wind farm site and to provide comprehensive and accurate baseline measurements.

10.6.3 Results of Project Specific Aerial Surveys

Table 10.3 presents the maximum number of birds recorded (based on the peak monthly count across all areas) within the GS2 area (+1km and + 2km buffers) and TH1 survey area during the aerial surveys undertaken during the period 2005 – 2006. The results of the individual aerial surveys are illustrated in Appendix H.9.

Species Group	Species	GS2	GS2 +1km	GS2 +2km	TH1
Wildfowl	Brent Goose				141
	Common Scoter				254
	Duck spp.				250
	Eider				6
	Goose spp.				254
	Mallard				95
	Shelduck				17
	Teal				40
	Wigeon				18
	Diver spp.		2	3	426
	Great Northern Diver				1
	Red-throated Diver		2	4	156
	Great Crested Grebe				1
	Grebe spp.				4
	Red-Breasted Merganser				7
	Arctic Skua				1
	Great Skua				2
Wader	Curlew				2
	Dunlin				1
	Lapwing				250
	Oystercatcher				1398
	Redshank				1
	Small wader spp.				640
	Wader spp.				2262
Gull	Black-Backed gull spp.			2	54
	Black-Headed Gull			2	1655
	Common Gull		3	5	158
	Great Black-backed Gull		1		72
	Grey Gull spp. (Herring or Common)		2		405
	Gull spp.		3	3	5796
	Herring Gull		3	1	559
	Kittiwake				383
	Large gull spp.	1			71
	Large wader spp.				161
	Lesser Black-Backed Gull				16
	Small gull spp.				66

Table 10.3 ***Peak counts of birds recorded during aerial surveys between 2005 - 2006 for the TH1 survey area and for the GS2 area +1km and + 2km*** *(data have not been corrected for coverage nor distance related detection errors)*

Species Group	Species	GS2	GS2 +1km	GS2 +2km	TH1
Tern	Arctic/Common Tern				13
	Tern spp.				51
Auk	Auk spp.			3	89
Passerine	Passerine spp.				52

Table 10.3 (Cont'd)

The aerial surveys indicate that birds were infrequently recorded within the actual wind farm area and the surrounding 1km and 2km buffer zones. None of the birds recorded occurred in numbers of either international or national importance within either the wind farm or the surrounding buffer zones.

10.6.4 Results of Project Specific Boat Surveys

Maximum counts for all species recorded within the boat survey area during the boat surveys during the period January 2005 to February 2007 are summarised in Table 10.4 with the peak monthly counts tabulated in Appendix H.4. Results of the monthly counts are illustrated in Appendix H.10. Raw boat survey data have been corrected to compensate for coverage and distance related detection errors as described in Appendix H.5.

Bird Type	Species	Peak Count	Month and Year
Wildfowl	Swan sp.	21	Jan 07
	Brent Goose	24	Nov 05
	Dark-Bellied Brent Goose	39	Dec 06
	Shelduck	3	Jan 05
	Eider	6	Mar 05
	Common Scoter	72	Jan05
	Velvet Scoter	15	Feb 07
Divers	Diver spp.	84	Jan 05
	Black-Throated Diver	74	Dec 06
	Red-Throated Diver	447	Dec 05
Waterbird	Great Crested Grebe	27	Jan 05
Seabird	Cormorant	3	Mar / Apr 06
	Gannet	19	Nov 06
	Fulmar	3	Jan/Mar 05/ Feb 07
Waders	Wader spp.	6	Nov 05
	Lapwing	60	Nov 05
	Ringed Plover	3	Feb 05

Table 10.4 ***Peak Counts of Birds Recorded During Boat Surveys within the Boat Survey Area between January 2005 & February 2007*** *(Data has been corrected for Coverage & Distance Related Detection Errors)*

Bird Type	Species	Peak Count	Month & Yr
Waders (cont.)	Knot	9	Nov 05
	Curlew	72	Apr 06
	Common Sandpiper	27	Dec 06
	Redshank	3	Feb 05
	Dunlin	6	Nov 05
	Turnstone	3	Mar 05
Gulls	Gull spp.	1236	Mar 05
	Large Gull spp.	344	Feb 07
	Little Gull	6	Dec 06
	Great Black-Backed Gull	39	Nov 06
	Lesser Black-Backed Gull	546	Mar 05
	Black-Headed Gull	308	Jan 07
	Herring Gull	902	Dec 05
	Common Gull	339	Feb 05
	Kittiwake	833	Jan 05
Terns	Sandwich Tern	9	Oct 06
Auks	Auk spp.	29	Jan 05
	Guillemot	363	Dec 06
	Razorbill	30	Dec 06
Passerines / Raptors	Passerine spp.	57	Apr 06
	Marsh Harrier	3	Apr 06
	Wood Pigeon	120	Apr 06
	Swallow	9	Oct 06
	House Martin	6	Apr 06
	Starling	15	Mar 05
	Redwing	6	Feb 05
	Meadow Pipit	27	Oct 06
	Warbler spp.	9	Apr 06
	Chaffinch	18	Mar 05

Table 10.4 (Cont'd)

Table 10.4 identifies that gulls (including unidentifiable gulls, lesser black-backed gull, herring gull and kittiwake) were by far the most abundant species recorded in the boat survey area. The next most abundant species was red-throated diver, followed by guillemot.

Gulls were recorded regularly throughout the survey period as illustrated in Appendix H.10.

Auks and divers occurred in greatest abundance during December and January, with few birds recorded outside of these months.

Table 10.5 presents the boat survey data based on the locations of the total number of birds recorded during the peak months of the surveys (across all areas). The locations are, within the GS2 area (+1km and + 2km buffers).

Bird Type	Species	Peak Count & Location Recorded		
		GS2	GS2 + 1km	GS2 + 2km
Wildfowl	Brent Goose		3	24
	Eider			6
	Common Scoter	24	24	63
Divers	Diver spp.	9	3	9
	Black-Throated Diver	0	14	21
	Red-Throated Diver	18	122	209
Waterbird	Great Crested Grebe	4	8	11
Seabird	Gannet		13	19
Waders	Lapwing		60	60
	Knot	3	3	3
	Common Sandpiper		18	18
	Redshank			3
Gulls	Gull spp.	3	206	221
	Large Gull spp.		6	140
	Little Gull			3
	Great Black-Backed Gull	3	21	33
	Lesser Black-Backed Gull	12	106	250
	Black-Headed Gull		9	271
	Herring Gull	30	102	912
	Common Gull	18	51	222
	Kittiwake	24	93	244
Terns	Sandwich Tern		3	3
Auks	Auk spp.			8
	Guillemot	12	32	162
Passerines / Raptors	Passerine spp.		3	36
	Swallow			9
	Marsh Harrier		3	3
	Starling			9
	Chaffinch		6	6
	Warbler		9	9

Table 10.5 ***Peak Counts of Birds Recorded During Boat Surveys within the GS2 Area, GS2 + 1km Buffer Area and GS2 + 2 km Buffer Area, between January 2005 & February 2007*** *(Data has been corrected for Coverage & Distance Related Detection Errors)*

Table 10.5 identifies that within the wind farm area relatively small numbers of birds were recorded relative to the peak counts of recorded across the boat survey area (summarised in Table 10.4).

The most abundant species recorded in the wind farm area were common scoter, diver sp. / red-throated diver, gulls, and guillemot. The total numbers of gulls recorded were relatively low when compared to the number recorded within the boat survey as a whole.

Beyond the actual wind farm area within the 1km buffer zone the numbers of diver recorded increased beyond the UK 1% threshold (49) with a peak count of 139 (combined) comprising over ~30% of the total survey area peak count (447). Gull species also increased although numbers were still considerably lower than the peak counts.

Within the 2km buffer zone there was a further increase in the numbers of diver recorded with the peak count of 239 (combined) equating to over 50% of the peak count across the entire survey area. Numbers of gulls increased with the greatest increase observed occurring with

herring gull. The peak count of guillemot recorded (162) in the 2km buffer equated to over 50% of the peak count (363) across the entire survey area however the numbers recorded do not indicate a population of importance for conservation.

10.6.5 Flight Heights

To consider the risks of bird collision with the wind turbines the boat survey data were analysed to identify patterns of flight height for the bird species observed. The results of this analysis are, summarised in Table 10.6.

Bird Type	Species	Flight Height (m)			
		<5	5-15	15-100	>100
Wildfowl	Swan spp.			21	
	Brent Goose	63			
	Dark-Bellied Brent Goose	39			
	Shelduck			3	
	Eider		6		
	Common Scoter	96	36		
	Velvet Scoter	18			
Divers	Diver spp.	84	84		
	Black-Throated Diver	45	36	12	
	Red-Throated Diver	375	261	42	
Waterbird	Great Crested Grebe	6			
Seabird	Cormorant	3	3	3	
	Gannet	39	6		
	Fulmar	9			
Waders	Wader spp.	6			
	Lapwing	60		6	
	Ringed Plover	3			
	Knot	9			
	Curlew	66	6		
	Common Sandpiper	27			
	Redshank	3			
	Dunlin	6			
	Turnstone		3		
Gulls	Gull spp.	9	459	57	3
	Large Gull spp.	27	96	168	12
	Little Gull		6	3	
	Great Black-Backed Gull	42	69	12	

Table 10.6 Total Number of Flying Birds Observed at each Height Category Recorded within the Boat Survey Area between Jan 2005 – Feb 2007

Bird Type	Species	Flight Height (m)			
		<5	5-15	15-100	>100
Gulls	Lesser Black-Backed Gull	681	1380	1530	186
	Black-Headed Gull	30	372	48	
	Herring Gull	1281	2691	1488	21
	Common Gull	441	1035	435	9
	Kittiwake	480	1992	168	
Terns	Sandwich Tern		12		
Auks	Auk spp.	57			
	Guillemot	210			
	Razorbill				
Passerines / Raptors	Passerine spp.	39	36		
	Marsh Harrier	3			
	Wood Pigeon		120		
	Swallow	9			
	House Martin		6		
	Starling		12	6	
	Redwing	6			
	Meadow Pipit	12	15		
	Warbler spp.	9			
	Chaffinch	6	18		

Table 10.6 (Cont'd)

Apart from gulls relatively few birds were observed at rotor height (taken to be heights above 15m), although a total of 52 divers (approximately 5.8% of diver records) and 21 swans (presumably mute swan) were recorded above 15m.

Of the gulls, lesser black-backed gull (45% of all flights recorded) and herring gull (28% of all flights recorded) were the most numerous species recorded above 15m, followed by common gull (23% of all flights recorded). The majority of kittiwake flights (75%) occurred between 5-15m.

As part of the EIA for London Array, surveys were commissioned during February and March 2005 to directly observe the behaviour of divers within the Thames Estuary in response to vessel movements (Norman & Ellis, 2005). The response of divers was observed closely in response to the approach of the survey vessel.

It was found that whilst there were few clear patterns for flocks, it appeared that most individuals fly at approximately 90^{o} to the survey vessel route and then tend to continue to fly in the direction of their initial take-off. The very large majority of birds observed flew below rotor height. The implication of these findings is that disturbed divers will tend to displace away from the source of disturbance through low, direct flight. It is concluded, therefore, that disturbed birds are at low risk of collision with turbines.

10.6.6 Ornithological importance of the study area

The GS2 site will be located approximately 8.5km offshore at its closest point and is unlikely to support significant numbers of waterfowl. The surveys undertaken and subsequently reported for the GS1 application and monitoring, have identified that the GS2 site does not support significant populations of species that are of importance with respect to coastal designated sites. There is also no indication that any of the species from these sites regularly pass through the site.

Project specific surveys have identified a range of seabirds within the proposed wind farm site and adjacent sea areas. The relative importance of these has been evaluated using the following criteria:

1. Population size. Surveyed population size within the boat survey area or TH1 aerial survey area (whichever is the greater) is assessed against published 1% thresholds of National importance. Substantial populations that do not exceed this threshold may be considered to be of regional importance;
2. Conservation status. Populations that form part of a cited interest feature of a site of international (SPA) or national (SSSI) importance within the region; and
3. Protection status. Species listed on Annex I of the EU Birds Directive, Schedule 1 of the Wildlife & Countryside Act (as amended) or priority species identified in the UK Biodiversity Action Plan.

The outcomes of this analysis are summarized in Table 10.7. The last column of this table includes an evaluation of the "sensitivity" of each population based on the criteria contained in the SNH/BWEA guidance for assessing impacts on birds (see Table 1 of Appendix H.1).

Species	Population		Conservation status		Protection status			Sensitivity
	> 1% national population	Regionally important population	SPA	SSSI	Annex I	W&C Sched 1	UK BAP priority species	
Brent Goose / Dark-Bellied Brent Goose			●	●				Very High
Diver spp. / Black-Throated Diver / Red-Throated Diver	●		● (p)		●	●		Very High
Ringed Plover			●					Very High
Knot			●					Very High
Redshank			●					Very High
Dunlin								Very High
Sandwich Tern			●		●			Very High
Shelduck			●					High
Black-Headed Gull			●					High
Common Scoter						●	●	Medium
Velvet Scoter						●		Medium
Little Gull						●		Medium
Lesser Black-Backed Gull		●						Medium
Herring Gull		●						Medium
Kittiwake		●						Medium

Table 10.7 Summary of sensitivity of bird species recorded in the surveyed area

Species	Population		Conservation status		Protection status			Sensitivity
	> 1% national population	Regionally important population	SPA	SSSI	Annex I	W&C Sched 1	UK BAP priority species	
Marsh Harrier					●	●		Medium
Redwing						●		Medium
Eider								Low
Great Crested Grebe								Low
Cormorant								Low
Gannet								Low
Fulmar								Low
Lapwing								Low
Curlew								Low
Common Sandpiper								Low
Turnstone								Low
Great Black-Backed Gull								Low
Common Gull								Low
Guillemot								Low
Razorbill								Low
Swallow								Low
House Martin								Low
Starling								Low
Meadow Pipit								Low
Wood Pigeon								Less than Low
Chaffinch								Less than Low

Table 10.7 (Cont'd)

Note: (p) indicates Thames Estuary *potential* SPA

Divers, including individuals identified as red-throated divers, were recorded within the wind farm. It is expected that the GS2 area will be included within any Thames Estuary potential SPA that may be designated, of whatever size, and the divers occurring within the wind farm will form part of the interest feature of this SPA. In addition to bird populations this chapter also considers the potential impact upon this potential European site and the red-throated diver population that forms its interest feature.

10.7 Impact Assessment

An assessment of likely significant effects arising from the construction, operation and decommissioning of the wind farm is presented. The assessment has been prepared in accordance with relevant guidance for offshore wind farm Environmental Impact Assessments and including Nature Conservation Guidance on Offshore Wind farm Developments – DEFRA, March 2005 (Version R1.9).

Potential impacts arising from the construction/decommissioning and operational phases are assessed, along with potential in-combination impacts through the interaction of GS2 and other offshore wind farms in the Thames Estuary. In addition, this section also includes an assessment of the potential impact of the proposed GS2 development, both in isolation and in-combination with other offshore wind developments, on the Thames Estuary potential SPA.

Following the SNH/BWEA guidance, the magnitude of an effect is evaluated for each potential impact identified. This evaluation is combined with the sensitivity of the feature(s) upon which the effect acts to determine the significance of the impact.

The sensitivity of features is indicated in Table 10.7. The criteria for evaluating the magnitude of impacts are detailed in Table H.2 of Appendix H.1. The matrix for establishing the significance is shown in Table H.3 of Appendix H.1.

10.7.1 Construction / Decommissioning Phase

Impact Title: Noise, vibration and visual impacts during the construction phase of the project may result in disturbance to and potential displacement of bird populations

Construction activities will involve the transportation of components to the wind farm followed by the installation of foundations, erection of turbine towers and assembly of rotor structures followed by cable installation. The construction activities may require the use of various types of vessel and equipment as described in Chapter 3.

Noise and vibration caused by these activities has the potential to disturb bird populations. It is expected that the most sensitive species, including, divers, ducks and seabird species, will be displaced from active construction areas during the construction phase. Other species, including gulls, may remain within the construction area, attracted by enhanced foraging opportunities.

The most sensitive populations identified in the baseline studies in the region of construction are the red-throated diver populations associated with the Thames Estuary potential SPA. Specific potential impacts upon this and other species are discussed in more detail below.

10.7.1.1 Potential effects on diver species

It is anticipated that noise arising from construction activities and the physical presence of construction equipment, vessels and crews will disturb divers displacing them from working areas, a study undertaken in connection with the preparation of the London Array ES (Norman & Ellis 2005) indicated that divers responded to the presence of boats at a variety of distances.

Whilst some allowed the survey vessel to approach to within several hundred metres others took flight at approach distances of up to approximately 1km. These effects are expected to be temporary, occurring only during periods of construction activity and only during the months that divers are present in significant numbers (winter months, particularly November to February).

The maximum number of divers (all species pooled) recorded within the GS2 and adjacent 1km buffer was 139, the mean number present was 12.36.

It is considered that the temporary displacement of these birds will produce an effect of negligible magnitude because:

- The number of individuals affected is relatively small compared to the size of the Thames Estuary population. Surveys undertaken in the Thames since 2002/03 indicate a population of between 6,437 – 11,089 (JNCC 2005);
- There is extensive alternative habitat within the Thames; and
- The effects will be temporary and will only occur when divers are present (i.e. winter). For practical reasons (associated with adverse weather conditions) it is expected, in any event, that construction will be of limited intensity during the winter months.

It is expected that the impacts of decommissioning will be similar to those arising during construction. Therefore, the potential impacts are considered to be of negligible magnitude and therefore of **low significance**.

10.7.1.2 Potential effects on other species

For most other species, numbers are sufficiently low that no impact is predicted as a result of disturbance caused by construction activities. This includes the species that are listed on the citations for coastal sites of nature conservation importance. Whilst gulls occur in higher numbers the potential magnitude of disturbance impacts is not considered to be substantial for these species for the following reasons:

- Disturbance arising from construction is temporary and it is expected that once construction is complete disturbance effects will completely dissipate;
- Gulls are reasonably tolerant of disturbance activities and are known to follow boats. There is potential that the construction activities could provide enhanced foraging opportunities to gull species; and
- There is extensive alternative habitat in the Thames estuary available for gull species. There is no evidence as a result of the studies undertaken to suggest that the wind farm area and its surround is of particular importance for gulls. Changes in density within these alternative habitats caused by temporary displacement of birds from the wind farm are not considered to be significant.

On this basis the magnitude of potential disturbance / displacement impacts caused during the construction period are considered to be negligible magnitude and **very low significance** for all additional species.

10.7.2 Operational Phase

Langston & Pullan (2002) identify a range of potential impacts upon birds arising from wind farm operation. Key amongst these are:

- Habitat loss;
- Disturbance and displacement (resulting from visits for servicing, it is anticipated that the majority of these visits will involve small fast vessels transferring crew to perform minor engineering works. Infrequently, more significant works may be required involving heavier equipment);
- Mortality arising from collision with turbines; and
- Barrier effects.

The magnitude of the potential impacts arising from each of these effects is evaluated below.

Impact Title: Loss of habitat due to the presence of up to 22 turbines

10.7.2.1 Potential effects on all species

The area of habitat loss resulting from the turbines and associated scour protection is typically very small and will represent just 0.033km^2 (approximately 0.4% of the total wind farm area). As such it is considered that the potential impact of habitat loss is of negligible magnitude for all species and of **very low significance**.

Impact Title: Disturbance and displacement from the turbines during the operational phase

10.7.2.2 Potential effects on all species

There is a concern that other bird species may be disturbed by wind farm operation or will avoid entering the matrix of turbines. The Centre for Evidence-Based Conservation (CEBC 2005) concluded that, notwithstanding a general lack of data, wind farm operation can result in a reduction in bird density, particularly amongst ducks and waders. Whilst disturbance (displacement) distances of up to 800m have been reported (e.g. SGS Environment 1996 and Gill *et al.,* 1996) there have been few studies that have systematically examined the magnitude of the effect (Percival, 2000), particularly in offshore environments.

This effect has the potential to cause an impact on a population if it excludes a significant number of birds from high quality foraging habitat. The greatest displacement impacts are potentially, therefore, on highly sensitive species with restricted distributions that are closely linked to food availability. Of the species recorded divers are considered to be the most susceptible to this kind of effect. Potential displacement impacts on this species are considered separately below.

The potential displacement impacts to gulls are likely to be similar to those outlined in relation to the construction effects. There is no evidence as a result of the studies undertaken to suggest that the wind farm area and its surround is of particular importance for gulls.

The wider estuary provides substantial equivalent habitat and changes in density within these alternative habitats caused by any displacement of gulls from the wind farm are not considered to be significant. Therefore the potential effects of displacement and disturbance to gulls are considered to be of negligible magnitude and **very low significance**.

Guillemots, whilst not abundant, were one of the more numerous birds recorded within the boat survey area. Garthe & Hüppop (2004) consider the overall sensitivity of auks to wind farm developments as low, although they are moderately sensitive to disturbance effects of vessels.

There is limited information on the likely response of auks to wind farm operation. Pre- and post-construction monitoring undertaken at Horns Rev indicated a possible avoidance effect, although the results of this monitoring could be confounded by high levels of ongoing construction works at the wind farm site (NERI 2003). NERI (2003) also acknowledges that possible shifts in the distribution of prey species cannot be discounted as a potential cause of changes in the distribution of auks and other seabird species.

More recent monitoring undertaken at North Hoyle, however, suggested little difference between pre and post construction distributions of guillemot (Npower Renewables Ltd 2005). A key finding from this monitoring study is that guillemot, and other auks, continue to forage within the wind farm following construction.

As it is unlikely that the construction of GS2 will result in the permanent loss of significant expanses of auk foraging habitat which may be used by the guillemot population of the Thames estuary it is, therefore concluded that the magnitude of potential displacement and disturbance effects is likely to be **negligible** and of **very low significance.**

All other species recorded during the study occurred in low numbers and/or infrequently within the wind farm area and the buffer zones. On this basis the magnitude of potential disturbance and displacement effects on these species is considered to be **negligible** and of **very low significance.**

10.7.2.3 Potential effects on diver species

It is unknown if divers will habituate to the presence of the wind farm and over what timeframe any habituation might occur. There is evidence from Denmark that common scoter (another species considered to be sensitive to wind farm operation) has started to habituate to the operational Horns Rev wind farm, some 2-3 years after becoming operational (Petersen & Fox, 2007). A similar effect has yet to be observed for divers at Horns Rev so it is assumed, for the purposes of this assessment, that all divers will be displaced from the operational wind farm area. In addition it is assumed that divers will also be displaced from an area of sea adjacent to the wind farm, although the effect in this buffer area is expected to be less intense.

Nevertheless, due to the relatively small area affected (GS2 +1km buffer is approximately 28.8 km^2 in extent) and the relatively low numbers of divers recorded (mean and peak number of divers recorded in this area are 12.36 and 139 respectively), potential disturbance and displacement effects are considered to be of negligible magnitude and therefore of **low significance.**

Even in the absence of any habituation by divers the numbers affected represent a very small proportion of the Greater Thames Estuary population. It is considered that the wider estuary provides substantial equivalent habitat and any changes in density within these alternative habitats caused by the displacement of divers from the wind farm are not considered to be significant.

If birds do habituate to the presence of the wind farm, it is predicted that there will still be disturbance arising from the activities of maintenance vessels within the wind farm area. The area affected by a maintenance vessel at any one time will be localised and temporary and a significant disturbance impact is not anticipated.

It is not anticipated that the access routes for maintenance vessels will cause disturbance, as the routes used will be the same for those proposed and consented for GS1. Due to the small size of GS2 the volume of traffic is not expected to increase significantly.

Impact Title: Potential mortality arising from collision with turbines

10.7.2.4 Potential effects on species other than gulls and divers

Extensive research on the behaviour of seabirds around offshore wind farms (e.g. Larsson 1994, Kahlert *et al*. 2004 and Petterson, 2005), including studies using radar, indicates that birds generally avoid colliding with turbines. In the case of migratory wildfowl this is seen as an evasion of the wind farm area, with birds correcting their flight lines to avoid entering the turbine array up to several kilometres away from the wind farm. For those birds that do enter the wind farm, there is a tendency for flights to follow the corridors between turbine rows.

Those birds that do enter the wind farm area typically show low collision rates either as a consequence of low flight heights (i.e. below the rotor swept area) or due to an innate ability to avoid rotating turbines.

The majority of species recorded at GS2 (with the exception of gulls and divers, considered separately below) were observed to fly below 15m and, therefore, are not considered to be at risk of collision. For most species the potential effects of collision will be of negligible magnitude and **very low significance.**

10.7.2.5 Potential effects on gull species

Studies reporting low collision rates include Still *et al.* (1996) and Painter *et al.* (1999) who discuss the findings of monitoring at Blyth Harbour. At this site, collisions, mainly involving gulls, appeared to decline over time and were not thought to result in a significant population effects on any species. Some studies have indicated that gulls may be susceptible to collision (e.g. Everaert, 2003), however, Garthe & Hüppop (2004) conclude that gulls are amongst the seabirds that are least sensitive to wind farm development, in part, due to their high flight manoeuvrability.

The results of boat surveys (Table 10.5) indicate few gulls within the GS2 wind farm area (or within 1km of the wind farm), although Table 10.6 indicates a relatively large proportion of these were found at rotor height (>15m). In light of the low numbers and likely high rates of collision avoidance it is considered that the potential effects of collision to gull species will be of negligible magnitude and **very low significance.**

10.7.2.6 Potential effects on diver species

In the case of divers, it is assumed that most birds will avoid entering the wind farm (see displacement effects above). It is not known whether divers will habituate to the presence of the wind farm, in the event that they do the risk of collision and the potential increase in mortality of this species have been calculated.

The results of boat surveys have been used to determine the numbers of birds at risk in the following way:

1. As it is difficult to separate diver species during surveys, all records of divers (including those positively identified as black-throated diver) were pooled;
2. The risk zone for collision calculation is taken, on a precautionary basis, as being equivalent to the GS2 wind farm area + 1km, which is approximately 28.7 km2. The mean number of divers observed within this area during boat surveys was determined from GIS data and corrected for coverage and distance related detection errors. The mean number of divers present within the GS2 wind farm area + 1km was 12.36;
3. The proportion of divers in flight was recorded during boat surveys. It is known, however, that divers are sensitive to the presence of the survey vessel and will fly when approached (e.g. Norman & Ellis, 2005). In contrast aerial surveys, during which behaviour is also recorded, provide a more accurate snapshot of the proportion of birds in flight at any time. Aerial surveys of the TH1 sector for the period 2005/06 were analysed to determine the proportion of birds in flight during the surveys. Out of a total of 1,879 divers observed in TH1 in 2005/06, 181 (9.6%) were recorded as “in flight”;
4. Aerial surveys provide no information on flight height, but this is recorded during boat surveys as height categories. For the purpose of this assessment it is assumed that all birds flying above 15m are at risk of collision. This is precautionary as the minimum air draft for the turbines proposed at Gunfleet Sands is 22m. Analysis of the boat survey data indicates that approximately 6% of birds in flight were recorded at heights above 15m;
5. The mean number of divers flying at rotor height within GS2 (+1km) is, therefore, 12.36 x 0.096 x 0.06 = 0.071

Annual collision rates arising from this level of flight activity have been calculated using the Collision Risk Model developed by SNH (2000). Details of these calculations are included at Appendix H.6. In summary, the results of collision risk modelling indicated a low risk of mortality as summarised in Table 10.8.

Avoidance rates for this species have yet to be determined empirically so a range of values are presented, including the precautionary value of 95%. It should be noted though that where avoidance rates have been measured for sea birds, values are typically much higher than 95% and it is considered that in this assessment more weight should be given to collision rates predicted for avoidance rate values of 99% and above.

Area	Avoidance rate			
	95%	99%	99.9%	99.99%
GS2 (22 turbines)	1.69	0.34	0.03	0.003

Table 10.8 Annual collision rates (birds / yr) predicted for GS2. Collision rates are shown for a range of avoidance rates

However, even at the highly precautionary rate of 95% it can be seen that predicted mortality arising from collision is of negligible magnitude and therefore of low significance.

Concerns have been expressed that divers may be at higher risk of collision if disturbed by maintenance vessels as it is known that this species is sensitive to the presence of boats. The results of Norman & Ellis (2005) indicate, however, that whilst divers will avoid a vessel, disturbed birds tend to fly away from the source of disturbance following a low, direct trajectory and are not, therefore, at greater risk of collision.

Impact Title: Potential barrier effects from the GS2 development

GS2 is not located between foraging or roosting areas and there is no indication that it is located on any migratory flight lines. The wind farm is not therefore located in a position that would obstruct regular movements of bird species (including divers) within the Thames Estuary; in fact its location at the northern periphery of the Thames Estuary suggests that it will have a negligible barrier effect of **low/very low significance**.

10.7.3 Cumulative Impacts

The following section of the impact assessment considers the potential cumulative effects of the proposed GS2 scheme and other offshore wind developments in the Thames region

Impact Title: Cumulative impact of habitat loss from GS2 and other offshore wind farms in the Thames Region

Due to the small area of seabed directly affected by wind farm construction and operation, it is considered that the GS2 will make a negligible contribution to habitat loss arising from the installation of turbines and foundations alone or together with other wind farms within the Thames Estuary.

On this basis it is considered that there will be **No Impact** due to cumulative habitat loss.

Impact Title: Cumulative impact of displacement from GS2 and other offshore wind farms in the Thames Region

The potential for a cumulative displacement effect on most bird species is considered to be very low. A significant displacement effect for existing consented projects within the Thames Estuary (including offshore wind farms) has not been identified either individually or collectively. The additional displacement arising from the construction and operation of GS2 is considered to be insignificant due to the low numbers of birds recorded within the wind farm and its small size.

In light of other consented developments within the Thames Estuary, consultees identified cumulative displacement effects on divers as an area requiring specific further consideration.

The potential for a cumulative effect on divers during the construction phase is unlikely to occur as a consequence of the construction of Thanet or Greater Gabbard (should those sites be constructed concurrently with GS2) due to the low number of divers recorded in each of those wind farm areas.

The relatively small magnitude of the predicted displacement effect arising from GS2, Thanet and Greater Gabbard is not considered to be significant. Of the remaining sites within the Thames Estuary yet to be constructed, it is proposed that GS1 and GS2 will be constructed concurrently. The proposed coordinated construction of GS1 and GS2 together is expected to reduce the overall development timeframe compared to that required to construct the two areas separately, implying a slight (beneficial) reduction in disturbance to birds (particularly divers) during the construction phase.

It is possible that the remaining site, London Array, may also be under construction during the construction of GS1 and GS2. The ES for London Array considered displacement effects on divers arising from construction alone and together with other consented (but yet to be constructed) and proposed wind farms in the Thames Estuary. It was concluded that there was no indication of a likely significant effect. The additional disturbance created by the construction of 22 turbines at GS2 is considered to be relatively low, particularly as most construction is likely to take place during the warmer months of the year when weather conditions enable greater site access and divers are absent or present in low numbers.

The assessment of potential cumulative effects on divers arising from the operation of GS2 is considered separately below in relation to the Thames Estuary potential SPA and the population of red-throated diver for which it is expected to qualify (see below).

On this basis it is considered that there will be **No Impact** on divers or any other bird species arising from cumulative displacement during the construction phase. It is also considered that there will be **No Impact on** divers (see below) and other bird species from cumulative displacement during the operational phase.

Impact Title: Cumulative collision mortality from GS2 and other offshore wind farms in the Thames Region

Of activities proposed in the Thames Estuary only wind farms are likely to cause increased mortality through collisions at levels that could potentially lead to adverse effects on bird populations.

Predicted collision rates for all Round 1 and 2 sites in the Thames (all of which have now been consented) have been assessed alone and cumulatively and it has been concluded that there will be **No Impact** from cumulative collision mortality.

The collision rates for divers predicted for consented sites in the Thames Estuary (as indicated in relevant ES and / or materials related to Appropriate Assessment) are summarised in Table 10.9.

Site	Conclusion of EIA
Greater Gabbard	Not significant (no impacts predicted)
Gunfleet Sands	Not significant
Kentish Flats	Not significant (less than 1 collision / year)
London Array	Not significant (no significant effect predicted for avoidance rates of 99.96 – 99.99%)
Thanet	Not significant (approximately 1 collision / year)

Table 10.9 Significance of collision mortality rates on divers for consented Round 1 and 2 wind farms in the Thames Estuary

The additional predicted collision mortality impact arising from GS2 is negligibly low (calculated as <1 collision /year) and a significant effect alone or cumulatively with existing consented wind farms is not predicted.

Impact Title: Cumulative barrier effects from GS2 and other offshore wind farms in the Thames Region

It is predicted that there will be **No Impact** cumulatively from barrier effects from GS2 and other Thames offshore wind farms. GS2 is located on the northern periphery of the Thames Estuary diver population and does not obstruct regular flight lines between foraging or roosting areas, nor does it interfere with migratory pathways. There is no indication that the construction and operation of other consented wind farms with the Thames Estuary would affect or cause flight lines of any bird species to deviate such that GS2 would create a barrier to bird movements. The cumulative effect arising from GS2 is likewise considered to be negligible.

10.7.4 Potential impacts of GS2 upon the Thames Estuary potential SPA

The Thames Estuary is likely to qualify as an SPA on the basis of the wintering red-throated diver population that it supports, although no site has yet been proposed for inclusion in the Natura 2000 network. For the purpose of this assessment a site which has the potential for designation has been used based on RPS (2005) who identified a likely SPA boundary based on advice from JNCC. The Thames Estuary potential SPA identified by RPS (2005) extends over 4,711km^2 and includes much of the Thames Estuary (see Figure 10.3). Appendix H.7 illustrates the location of the potential SPA and summarises its likely conservation objectives.

Impact Title: Habitat loss within the Thames Estuary potential SPA

The area of habitat loss resulting from the GS2 turbines and associated scour protection is typically very small and will represent just 0.033km^2 (approximately 0.4% of the total wind farm area). As such it is considered to be negligibly small in relation to the extent of the potential SPA, whatever its extent might be. The potential impact on the Thames Estuary potential SPA of GS2 alone is considered to be of negligible magnitude and **low significance**.

Impact Title: Displacement of divers from the Thames Estuary potential SPA

It is predicted (see Section 10.7.2.3) that divers will be displaced from the wind farm area temporarily during construction (and decommissioning), and, in the absence of habituation, during the operational lifetime of the wind farm.

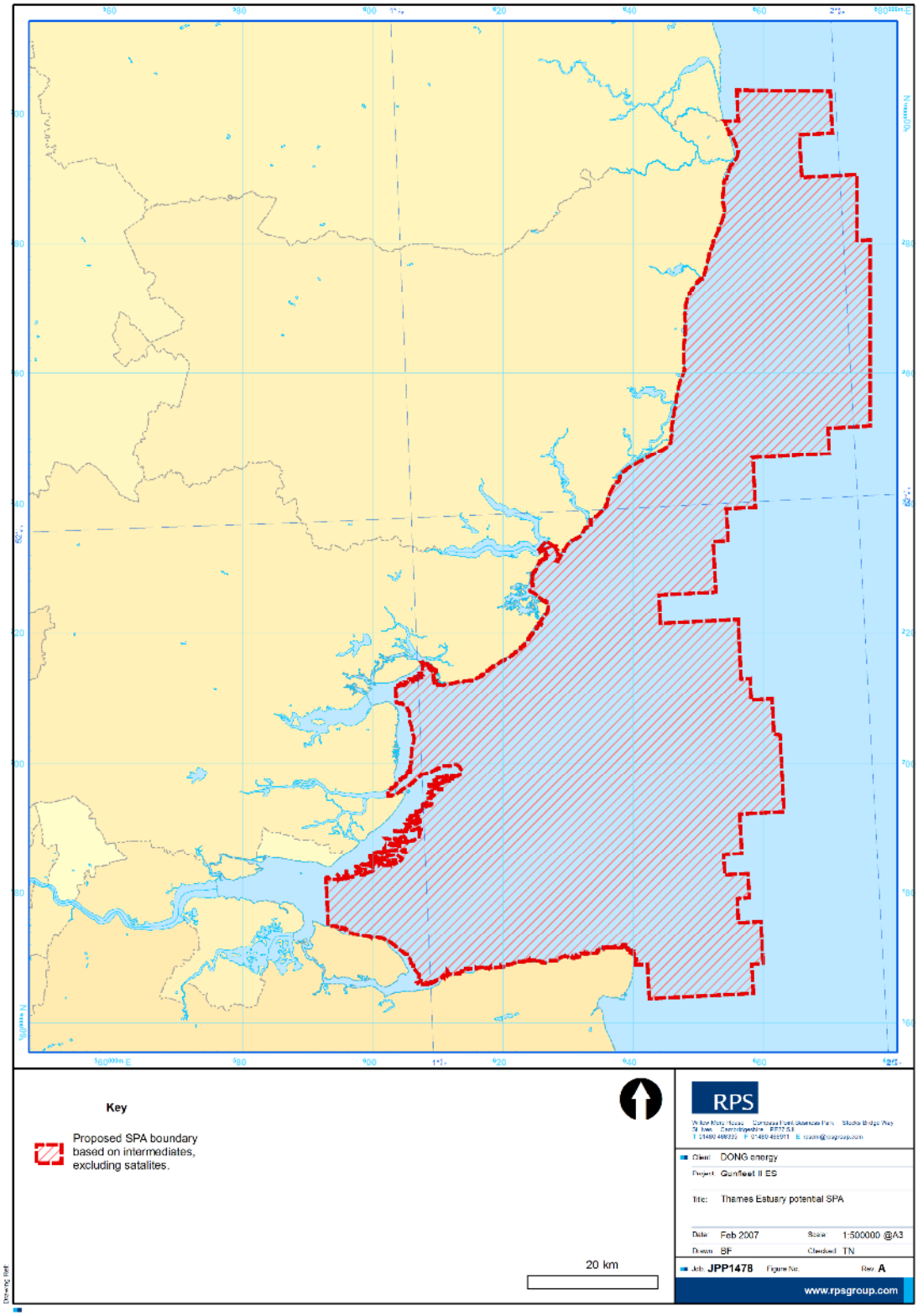


Figure 10.3 Extent of Thames Estuary potential SPA

It was agreed with consultees that an appropriate method for the assessment of displacement effects upon the diver population of the potential SPA was that used in the EIA for London Array (see RPS, 2005). In summary the method employed for that assessment was based on a categorisation of the relative importance of sea areas within the Thames estuary for divers on the basis of aerial survey data. Several years of data were aggregated and interpolated to generate a proportional distribution map of the diver population within the Thames. The SPA area proposed by JNCC is divided into 500m x 500m cells and the proportion of the population (expressed as %) observed within that cell during aerial surveys between 2002 and 2006 determined. As the aerial surveys are flown as transects spaced at 2km the data have been interpolated to achieve the 500m grid indicated below (see Figure 10.4).

The magnitude of the displacement caused by a wind farm is estimated by calculating its "interaction" with the proportional distribution map. The wind farm boundary is overlaid onto the proportional distribution map and the proportion of the population lying within it is calculated using the following rules:

1. 100% displacement within the wind farm. It is assumed that all divers within the wind farm are displaced; and
2. 50% displacement within a 1km buffer around the wind farm. It is assumed (based on RPS 2005) that the maximum extent of disturbance effects will be 1km. Beyond 1km it is assumed that diver abundance will be unaffected by the operation of the wind farm. The magnitude of the displacement effect within this buffer is, therefore, 50% – displacement being 100% (all birds displaced) at the wind farm boundary, declining, linearly, to 0% (no birds displaced) at 1km from the wind farm boundary.

Using this method the proportion of the Thames Estuary potential SPA population displaced by GS2 is 1.18%. The GS2 wind farm will not, however, be constructed in isolation from the already consented GS1 wind farm and a large proportion of the 1km buffer for GS2 will be occupied by that wind farm. Consideration of the displacement effect for GS1 and GS2 in isolation from one another will, therefore, result in a double counting of displacement effects.

On this basis the additional displacement potential caused by GS2 has been determined by calculating the interaction of the combined areas of the Gunfleet Sands (GS1 and GS2) wind farm and then subtracting the previously calculated GS1 component from this value

The combined interaction is 2.34% and the interaction of GS1 was previously calculated as 1.72%. The contribution of GS2 is, therefore, 2.34% – 1.72% = **0.62%**.

To put this figure in to context, boat surveys indicate that the mean number of divers within the wind farm + 1km buffer area was 12.36. This represents a very small proportion of the Greater Thames Estuary population (estimated 6,437 – 11,089 (JNCC 2005), which, for the purposes of this assessment is also assumed to be the SPA population).

On this basis GS2 alone is not expected to cause a significant impact on the Thames Estuary potential SPA as the number of birds affected is very small and form a relatively small proportion of the potential SPA population. It is considered that there is ample alternative habitat available for displaced birds.

The potential impact of GS2 alone is considered to be of negligible magnitude and **low significance** (in-combination effects are dealt with in detail below).

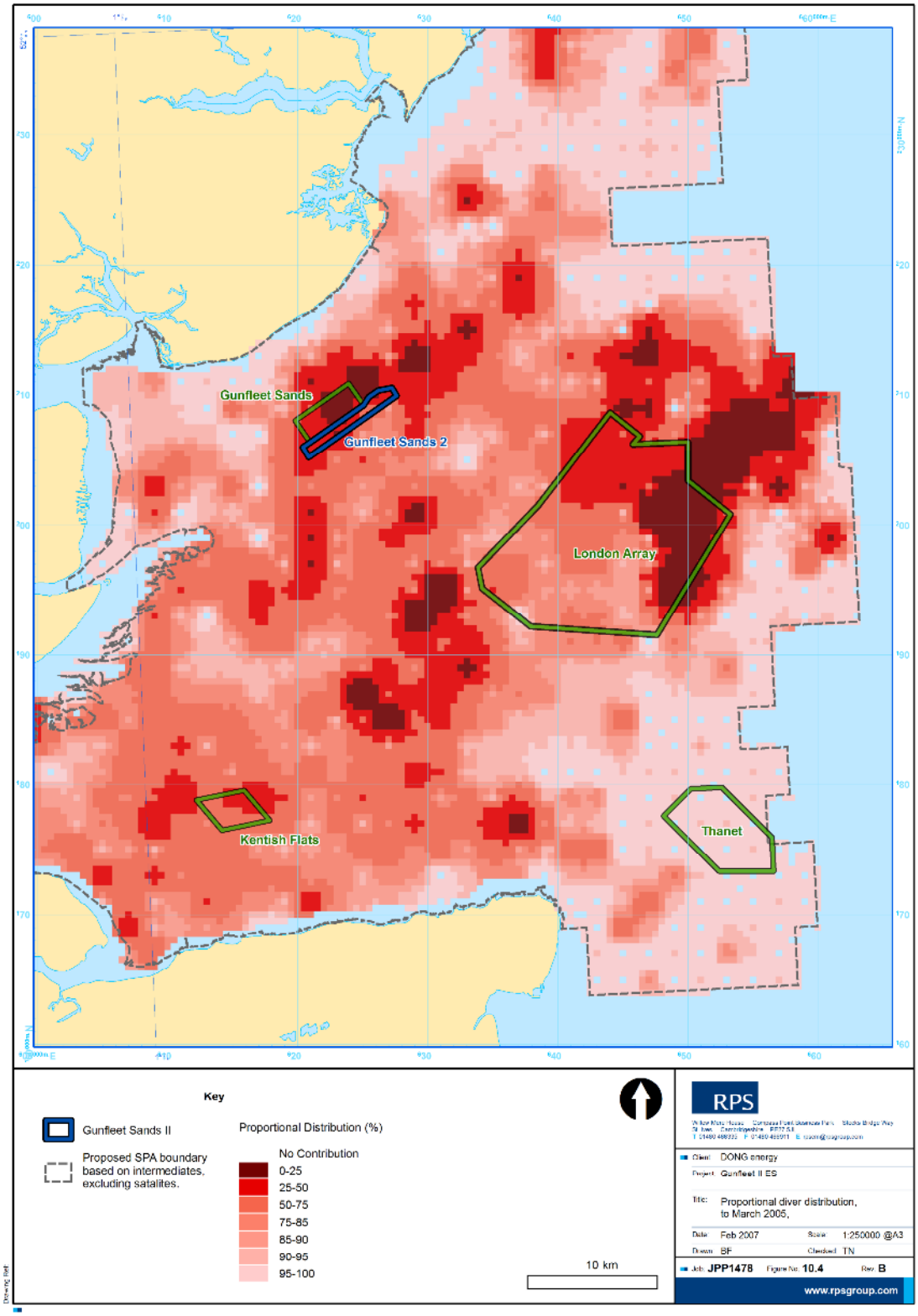


Figure 10.4 Proportional diver distribution to March 2005

Impact Title: Effect of collision mortality on the diver population of the Thames Estuary potential SPA

Collision modelling for divers (see section 10.7.2.6) predicts very low collision rates. Over the lifetime of the wind farm the low rates of collision predicted are not anticipated to cause a significant impact on the potential SPA population.

The potential impact of GS2 alone on the diver population of the potential SPA is considered to be of negligible magnitude and **low significance**.

Impact Title: Barrier effect on the diver population of the Thames Estuary potential SPA

There is no indication that GS2 is located in a position that would obstruct regular movements of divers within the Thames Estuary. Any impact of GS2 alone on the potential SPA population is considered to be of negligible magnitude and **low significance**.

10.7.5 In-combination impacts on the Thames Estuary potential SPA

Impact Title: Habitat loss within the Thames Estuary potential SPA

Potential habitat loss arising from wind farm construction and other activities, such as dredging for example, within the Thames Estuary potential SPA has been assessed for all consented sites. A significant effect alone or in-combination has not been identified.

The additional habitat loss arising from GS2 (the only other offshore wind farm site proposed at this stage within the Thames Estuary) is considered to be negligibly small and there is no indication of a likely significant in-combination effect.

Impact Title: Displacement of divers from the Thames Estuary potential SPA

Using the proportional distribution method, the combined displacement effect arising from the construction and operation of Kentish Flats, Thanet and, the already consented GS1 wind farm was presented in RPS (2005). The combined interaction of these wind farms was approximately 2.52%. Various development options were considered for London Array with an interaction of between 3.1 – 3.4%. The potential in-combination effect of a displacement impact of up to **5.72%** has, therefore, already been assessed and it has been concluded that an impact of this magnitude would not have an adverse effect on the integrity of the Thames Estuary potential SPA.

There are no further offshore wind farms proposed for the Thames Estuary, at this stage, except for GS2 and the predicted displacement effect arising from that proposal is **0.62%** (see section 10.6.5).

The likely in-combination displacement effect arising from the construction and operation of offshore wind farms within the Thames Estuary will be in the range **6.24% – 6.54%**. The additional displacement represented by GS2 is less than 10% of this overall figure.

Although the combined wind farm areas may displace up to 6.54% of divers, it is considered that the effect on the population itself will be of a lesser magnitude than this for the following reasons:

1. The displacement calculations are based on a set of precautionary assumptions, including complete displacement of divers from the wind farm and reduced density outside of the wind farm;
2. No account is taken of any habituation that may occur. Evidence from Horns Rev indicates that common scoter are habituating to the presence of the operational wind farm, although a similar effect has yet to be observed for divers;
3. Potential habitat for this species is extensive within the wider Thames Estuary. It is considered that most, if not all birds displaced from wind farm areas, will find sufficient alternative foraging habitat during the winter months and that mortality arising from displacement will be relatively low; and
4. The magnitude of the impact should be placed in context. The maximum count of divers within the wind farm area (+1km) was 139, the mean number present was 12.36. These numbers are small both in relation to the total population size of the potential Thames Estuary SPA but also the inter-annual variability in diver numbers.

In light of the relatively small additional increase in displacement arising from GS2 and the likelihood that alternative habitat exists for the small number of birds affected a significant in-combination effect is not predicted.

Impact Title: Effect of collision mortality on the diver population of the Thames Estuary potential SPA

The potential impact on divers arising from collisions with consented wind farms within the Thames Estuary has been assessed and it has been concluded, in all cases, that a significant effect, alone or in-combination, is not predicted.

With the exception of GS2 there are no further foreseeable wind farm proposals within the Thames Estuary. For the purposes of this assessment, therefore, the only further source of collision mortality is the proposed GS2 wind farm. The additional predicted collision mortality arising from GS2 has been calculated at <1 collision /year (see Table 10.8) and it is considered that this represents an increase in the combined collision risk to divers of a negligibly small magnitude.

On this basis a significant in-combination effect on divers due to collision mortality arising from wind farm operation in the Thames Estuary is not predicted.

Impact Title: Barrier effect on the diver population of the Thames Estuary potential SPA

The potential impact on divers arising from the barrier effect caused by consented wind farms within the Thames Estuary has been assessed and it has been concluded, in all cases, that a significant effect, alone or in-combination, is not predicted. With the exception of GS2 there are no further foreseeable wind farm proposals within the Thames Estuary. GS2 is located on the northern periphery of the Thames Estuary diver population and does not, together with other wind farms, create an obstruction to any regular flight lines between foraging or roosting areas, nor does it interfere with migratory pathways. There is no indication that the construction and operation of other consented wind farms with the Thames Estuary would affect or deviate flight lines of any bird species such that GS2 would create a barrier to diver movements alone or in-combination with other sites.

On this basis a significant in-combination effect on divers due to barrier effects arising from wind farm operation in the Thames Estuary is not predicted.

10.7.6 Mitigation Measures

To the extent practical, construction works will be undertaken outside the periods when red-throated diver are present in high densities. Lighting of turbines will be required for navigational safety purposes. To the extent that it is consistent with these requirements, lighting that is known to minimise the attraction of birds will be used. Red strobes are typically considered to be the least attractive form of lighting to birds.

10.7.7 Proposed Monitoring

Ornithological monitoring will be undertaken during the pre-construction, construction and post-construction phases of the proposed scheme. The proposed objectives of the monitoring will be:

1. To confirm predictions made in the ES;
2. To assess collision risk prior to construction of the wind farm and any actual collisions during and post-construction; and
3. To provide generic information on bird/wind farm interactions.

The exact specifications for the ornithological monitoring will be determined via consultation with Natural England. However, it is initially proposed that the following monitoring surveys will be undertaken:

(a) Aerial Surveys: 4 surveys in the winter months, of which 2 will be undertaken in the mid-winter period; and
(b) Boat Surveys: 2 surveys per month during the period November to beginning of March covering the winter period for 3 years post-construction.

In addition to these proposed surveys, the findings of the study reviewing state-of-the-art automated recording techniques to measure habitat use, as required under the terms of the FEPA licence for GS1, will also be assessed.

Due to the proximity of the consented GS1 project, it is proposed that efforts will be made to co-ordinate the ornithological monitoring required for GS1 with that proposed here for GS2.

10.8 Conclusions

GS2 is located in an area of relatively low bird density. The populations of most species are small, although species are present that are of conservation importance, including red-throated diver.

A systematic assessment of the potential impacts arising from the proposed construction, operation and decommissioning of the wind farm, alone and in-combination with other developments in the Thames Estuary has been undertaken and it is concluded that in all cases the overall effects are likely to be negligible or low.

When these predictions are combined with sensitivity on a species by species basis (Table 10.10) it is concluded that there will be no impacts of Medium, High or Very High significance.

Species	Sensitivity	Overall magnitude of potential impacts	Significance of impacts
Brent Goose / Dark-Bellied Brent Goose	Very High	Negligible	Low
Diver spp. / Black-Throated Diver / Red-Throated Diver	Very High	Negligible	Low
Ringed Plover	Very High	Negligible	Low
Knot	Very High	Negligible	Low
Redshank	Very High	Negligible	Low
Dunlin	Very High	Negligible	Low
Sandwich Tern	High	Negligible	Very Low
Shelduck	High	Negligible	Very Low
Black-Headed Gull	Medium	Negligible	Very Low
Common Scoter	Medium	Negligible	Very Low
Velvet Scoter	Medium	Negligible	Very Low
Little Gull	Medium	Negligible	Very Low
Lesser Black-backed Gull	Medium	Negligible	Very Low
Herring Gull	Medium	Negligible	Very Low
Kittiwake	Medium	Negligible	Very Low
Marsh Harrier	Medium	Negligible	Very Low
Redwing	Low	Negligible	Very Low
Eider	Low	Negligible	Very Low
Great Crested Grebe	Low	Negligible	Very Low
Cormorant	Low	Negligible	Very Low
Gannet	Low	Negligible	Very Low
Fulmar	Low	Negligible	Very Low
Lapwing	Low	Negligible	Very Low
Curlew	Low	Negligible	Very Low
Common Sandpiper	Low	Negligible	Very Low
Turnstone	Low	Negligible	Very Low
Great Black-Backed Gull	Low	Negligible	Very Low
Common Gull	Low	Negligible	Very Low
Guillemot	Low	Negligible	Very Low
Razorbill	Low	Negligible	Very Low
Swallow	Low	Negligible	Very Low
House Martin	Low	Negligible	Very Low
Starling	Low	Negligible	Very Low
Meadow Pipit	Low	Negligible	Very Low
Wood Pigeon	Less than Low	Negligible	Very Low
Chaffinch	Less than Low	Negligible	Very Low

Table 10.10 Significance of impacts for GS2

In addition this assessment has considered potential impacts on populations associated with sites of importance for nature conservation including coastal SPAs and the Thames Estuary potential SPA.

Where it is thought likely that some or all of the individuals of a species observed within the wind farm survey areas form part of a qualifying population for a SPA then the sensitivity of that species has been considered Highly Sensitive. For some species this is considered to be a highly precautionary approach. In all cases, however, a significant effect on SPA populations, including the Thames Estuary potential SPA, is not predicted for GS2, either alone or in-combination with other developments or activities.

11.0 COMMERCIAL FISHERIES

11.1 Introduction

The following section describes the various site specific and cumulative impacts that commercial fishing could potentially sustain from the installation, operation and decommissioning of the Gunfleet 2 Offshore Wind Farm development (GS2). For the purposes of this assessment, commercial fishing is defined as any form of fishing activity legitimately undertaken and declared for profit.

The description of the existing commercial fisheries environment used as the reference baseline for the following assessments is given in Appendix I.

11.2 Guidance

The aspects of commercial fishing assessed below, are as specified in the CEFAS Guidelines (Version 2 - 2004), namely:

- The introduction of seabed obstacles;
- Impacts on commercially exploited species;
- Increased steaming times to fishing grounds;
- Safety issues;
- Complete loss or restricted access to traditional fishing grounds; and
- Any other concerns raised by local fishermen and their representatives.

The local fishermen who operate in the general area of the Thames Estuary in which the GS2 wind farm is to be located are not affiliated to, and therefore not represented by, the National Federation of Fishermen's Organisations (NFFO). The general concerns expressed by the NFFO during consultation meetings (Brown & May Marine, 2006) and at FLOW meetings, with regards to wind farms in general, are summarised as relating to:

- The ability of fishing vessels, particularly trawlers to operate within wind farms;
- Displacement of fishing vessels into other over-fished areas;
- Increased navigation risks;
- Potential gear hooking risks associated with scouring and cable spans; and
- The impacts of survey and construction vessel movements.

The local fishermen who responded to telephone questionnaires recorded the following concerns:

- Displacement and/or reduced access to the site;
- The difficulties of single handed vessels in maintaining a watch whilst hauling and shooting gear and loss of steerage when coming fast; and
- Dropped or moving scour protection rocks.

Opinions differed amongst the consulted local skippers as to whether they would fish in the wind farm once it was operational.

11.3 Confidence in Predicted Impacts

The CEFAS Guidelines (2004) state that EIA's for offshore wind farms must:

- Assess the potential commercial loss to local fisheries;
- Evaluate the significance of this loss;
- Suggest effective mitigation measures, particularly where exclusion zones are planned; and
- Incorporate cumulative impacts in respect of other wind farms and other human activities.

There are, however, a significant number of factors which constrain quantitative assessment of the economic impacts associated with the construction and operational phases of offshore developments such as wind farms.

The limitations of officially recorded fisheries statistics, the surveillance data and satellite tracking are discussed in Appendix I. Furthermore, the unpredictability of the fisheries legislation and controls, much of which is implemented at short notice without prior consultation, seriously inhibits confident assessment of future patterns and trends over time frame equating to the operational life of the Gunfleet 2 wind farm. Despite more than 30 years of installing offshore oil and gas structures in the North Sea, and a study undertaken into the socio-economic impacts of offshore wind farms undertaken by Seafish and CEFAS (2006), there is no universally recognised or standardised model or methodology for quantifying the potential economic impacts of offshore installations on commercial fishing. The assessments given below are therefore largely qualitative as opposed to quantitative.

11.4 Methodology and Approach

Each of the aspects specified in the CEFAS Guidelines (2004) as requiring evaluation are assessed, where appropriate, for the construction (and decommissioning) and operational phases in terms of the site specific and the cumulative effects. The majority of the concerns expressed by fishermen and fishermen's representatives are covered by the aspects specified in the CEFAS Guidelines (2004). Those that are not are assessed under the heading: 'Additional Concerns Raised by Fishermen and their Representatives.'

As a consequence of the mobility and the diverse nature of the fishing comprising the existing baseline (receiving environment), the following criteria have been adopted for the purpose of evaluating potential impacts:

- The spatial extent of the effect relative to operating area;
- The duration of the effect;
- The probability of the effect occurring;
- The type and number of vessels potentially affected;
- The vulnerability of the individuals involved; and
- Their ability to adapt to and compensate for any effects.

A number of the local trawler skippers consulted have expressed reservations as to whether they will be able to tow their gears within the GS2 site. The draft issue report of a study undertaken by Seafish (2006) questions whether it will be feasible for trawlers to work within operational wind farms.

Whilst the findings of the Seafish (2006) study have not been accepted by the FLOW group or the BWEA, in line with best practice, for the purposes of the following assessments, the worst case scenario is assumed, whereby trawlers and dredgers and vessels using drifting gears will not operate within the GS2 site during both the construction and operational phases. It is however assumed that static (fixed) gear activities could resume within the site once construction activities have been completed.

11.5 Site Specific Impact Assessment

11.5.1 The Introduction of Seabed Objects

Potential Impacts

Offshore construction related debris and accidentally dropped objects have, in the past, been shown to cause damage to fishing gears and loss of catch. If such an incident occurred, a potentially **moderate adverse impact** may arise upon commercial fishing activity.

Mitigation and Monitoring

Pre-construction bottom and side scan sonar survey will be undertaken across the area of development. Local fishermen will be invited to send representatives to be present during the survey. All obstructions found on the seabed will be recorded and plotted on a suitable chart. A post construction survey will repeat the pre construction survey and new obstructions directly attributable to the offshore works will be removed.

Residual Impact

With contractor compliance to the required standards, it is expected that there will be **No Impact**.

11.5.2 Impacts on Commercially Exploited Species

The direct impacts on the main species targeted by vessels operating in the GS2 area during the construction, operational and decommissioning phases are assessed in Chapter 8.

Mitigation Measures

As stated, it is assumed that towed gear activity will not occur within the site during its operational phase. A recently published report of an extensive study commissioned by the DTI to review the reef effects and potential for enhancement and mitigation (Linley, Wilding, Black, & Mangi, 2007) makes the following conclusions:

- Partial closure and the increased habitat provided by scour protection could enhance crab stocks and have a positive impact on crab and lobster fisheries within the Thames Estuary;
- Exclusion of particular fishing gears from wind farms could be used to assist recovery of specific commercially valuable species e.g. cod, bass, whiting at some sites;
- Partial closure offers potential for bass restoration areas in locations such as in the Thames Estuary;
- Closure of offshore wind farms, as part of a wider strategic network of Marine Protected Areas (MPA's) to support fisheries management could have significant enhancement / mitigating potential for local fisheries; and
- The closure of offshore wind farms could extend protection of nursery and spawning areas.

Residual Impact

It is possible, that with the absence of towed gear activity during the operational phase, there will, over time, be a **potential minor beneficial impact** on commercially exploited species.

11.5.3 Increased Steaming Times to Fishing Grounds

Potential Impacts

Vessels having to divert around the site en-route to their fishing grounds will incur increased time and fuel costs.

11.5.3.1 Construction & Decommissioning Phases

The locations of most of the base ports, relative to the main local fishing grounds, as illustrated in Figure 10.1 of Appendix I, associated with the relatively short construction and decommissioning periods, indicate that the residual impact on steaming times for the majority of vessels will be of **negligible** significance. Occasional diversions by certain vessels may however be necessary, giving rise to limited instances of short term **minor adverse** residual impacts.

11.5.3.2 Operational Phase

Adverse impacts during the operational phase will only occur if vessels are unable to steam through the site. A number of factors suggest that, in suitable conditions, it should be feasible for fishing vessels to steam through the operational site. Post construction trawl surveys and maintenance vessel movements within constructed sites confirm that vessels of the size within the local fishing fleet can navigate through operational wind farm sites. The minimum spacing between the turbine lines is also considerably wider than the entrance channels to many ports through which merchant vessels, much larger than fishing vessels, freely steam and manoeuvre (Figure. 11.1). It is also of note that licensed tourists trips are operated into a number of operational Round 1 sites (www.bobleroi.co.uk/BoatTrips_5/BoatTrips_5.html, www.bayblast.co.uk/kentish-flats.htm,). It is therefore expected that there will be a **negligible** residual impact on steaming times during the operational phase of the wind farm.

11.5.4 Safety Issues

The principal safety concerns relevant to fishing vessels are collision risks, which are assessed in Section 13, and gear hooking risks. A number of studies (Drew & Hopper, 1996; De Groot & van de Haak, 1984; Brown & May Marine 2000-2007; MIAB Inquiries, 1998, 2006) have shown that in the majority of incidents, it is either trawl doors or beam trawl shoes which hook under cables, pipelines or umbilicals.

Evidence from the operational Barrow Offshore Wind Farm also indicates that certain static methods such as potting can take place within an operational wind farm (Brown & May Marine survey observations 2006; pers com, T. Watson, BOW-FLO, 2007).

For static gear vessels, the main hooking risks are gears or the retaining anchors fouling on the rock scour protection and the retaining anchors hooking inter-field cables. Gear and anchor fouling on the scour protection material should not however occur, provided that gears are not deployed within 50m safety zones around the turbines.

The seabed penetration depths of the static gear anchors are such that hooking of inter-field cables should not pose a risk. If it transpires, however that there is a potential risk, alternative methods such as chain weights could be used, which have proved effective in both anchoring the gear and preventing hooking.

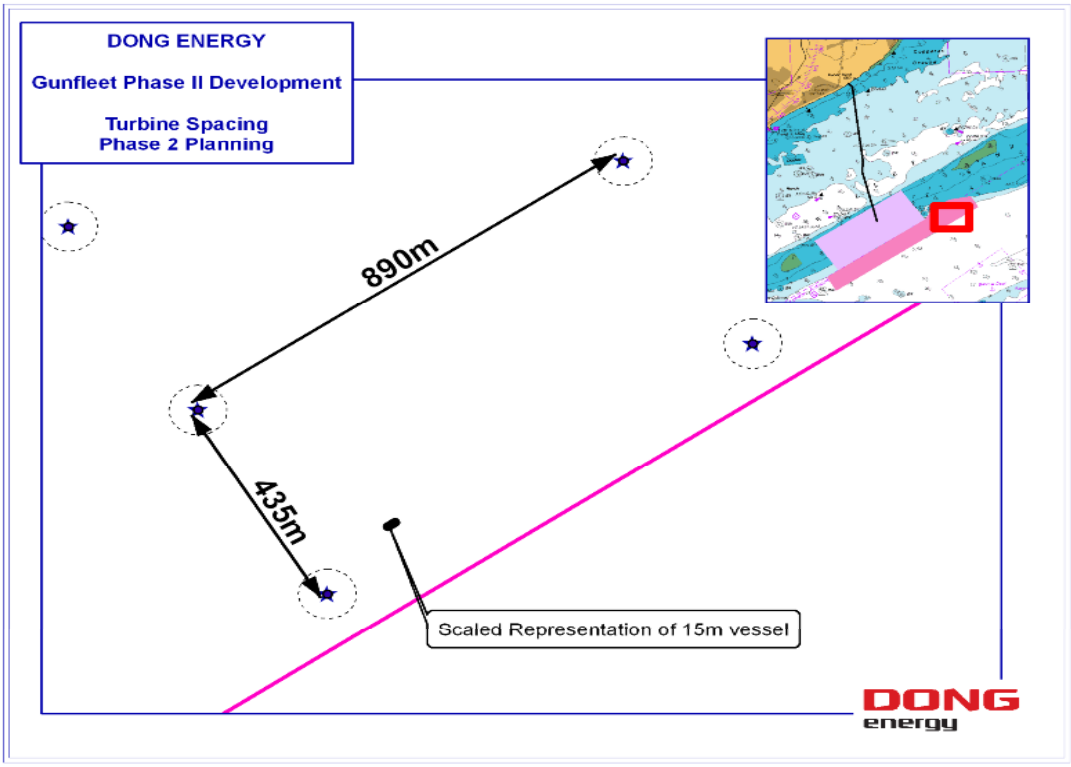


Figure 11.1 Turbine spacing in GS2 Offshore Wind Farm

11.5.5 Complete loss or restricted access to traditional fishing grounds

Potential Impacts

The main concern expressed by fishermen in respect of wind farms is that loss of fishing area will result in loss of earnings. The scale of any such losses will primarily be a function of:

- The levels fishing that have traditionally occurred within a site and the landings values derived from it;
- Whether it is practically feasible to fish other areas; and
- Whether the income and costs associated with fishing other areas would compensate the effects associated with the lost area.

11.5.5.1 Construction & Decommissioning Phases

During the construction phase, all fishing vessels will be excluded from the site. As discussed in Appendix I, the number of vessels that could be potentially affected is relatively small. Ten vessels provided estimates of their fishing effort within the site area. A further 11 vessels, including 4 potters and netters are considered to have the potential to fish the area.

As discussed in Appendix I, due to data limitations, it is not possible to accurately quantify the value to fishing of a small sea area such as that covered by the GS2 site. At 7.5km², the area of exclusion is obviously small, relative to the extent of the fishing grounds within the Thames Estuary as depicted by Figure 10.1 of Appendix I. The satellite tracking data also indicates that there has been minimal recorded activity by over 15m trawlers within the site.

As discussed in Appendix I, shellfish dredging, potting and netting do not occur to any significant degree within the immediate site area.

Mitigation Measures

In view of the extent of the fishing grounds within the Thames Estuary, it is reasonable to assume that the majority of trawlers and particularly the larger vessels should, for the most part, be able to mitigate the loss of area by fishing alternative grounds. This may not be the case, however, for certain smaller vessels with more limited operating ranges.

Residual Impact

In the case of shellfish dredgers and potters, the residual impact is expected to be **negligible** as these vessels do not have a history of operating within the site area.

For the majority of trawlers, and for some netters, with the potential to fish alternative areas, the potential impact is likely to be **minor adverse** For a limited number of vessels with fewer mitigating opportunities there could be a **moderate adverse impact**.

11.5.5.2 Operational Phase

Potential Impacts

For the purpose of this assessment, a worst-case scenario has been adopted whereby it is assumed that trawling will be excluded from the GS2 site during the operational phase. The same loss of area impacts will apply during the operational phase as discussed above for the construction phase, but over a longer time frame.

Mitigation Measures

It is to be expected that a degree of accommodation will occur over time as alternative fishing areas are identified and developed. It is also possible that the exclusion of trawling could have positive stock enhancement effects which could ultimately benefit trawling and potting.

The Linley, Wilding, Black, & Mangi (2007) study referenced above states:

'Evidence suggests that not only will stocks of fish increase within wind farm footprints, but there will be enhancement effects in the area surrounding the closed area'.

'Wind farm structures and their scour protection may extend distribution of some mobile species such as crabs and lobsters due new habitat opportunities thus enhancing the productivity of these species'.

The Horns Rev and Nysted benthic sampling programmes used diver observations and underwater videos around a number of wind turbine bases between 2003 and 2005. The abstract of the paper presented by S. Leonhardt at the 'The Danish Monitoring Programme' conference (November 2006) states:

'Artificially deployed hard bottom substrates are generally considered beneficial to the reproduction and growth of some native mobile species such as crabs by providing shelter and nursery grounds'.

'Eggs and juveniles of different species of crab, bristle worms and sea slugs were found at the turbine foundations during the survey period. The edible crab (Cancer pagurus) colonized the deployed hard substrates as adults and juveniles'.

'A rapid growth of juveniles was found from 2003 to 2005. At both wind farm sites, fish were often found in numbers swimming around the artificial reef structures apparently searching for food and shelter'.

It is therefore possible that the enhancement effects could extend beyond the site boundary to the benefit of trawlers. The possible increase in crab and lobster productivity would also be of obvious benefit to potting both within the site and in adjacent areas.

Residual Impact

Assuming enhancement effects do not occur, the residual impacts would be as given for the construction phase. However, over time, enhancement effects may compensate for the loss of area impacts on trawlers and in the case of potters, may produce a **minor beneficial** effect.

11.5.6 Additional Concerns Raised by Fishermen and their Representatives

11.5.6.1 NFFO concerns

The majority of the concerns expressed by the NFFO have been addressed in the above assessments and in the Navigation and Shipping (Section 13) assessment. The one exception is: displacement of fishing vessels into other over-fished areas.

Whilst there is general concern over the condition of most pressure stocks within the Southern North Sea, there are no official notices identifying specific areas within the Thames Estuary as being over fished.

11.5.6.2 Concerns expressed by local fishermen

The local fishermen's concern regarding reduced or lost access is assessed above.

With regards to single handed vessels maintaining watch whilst shooting and hauling gears, as a worst-case scenario has been adopted, whereby it is assumed that trawling will not occur within the site, this will not be an issue. In the case of static gear vessels, it will be necessary for them to make the appropriate allowances when setting their gear. Generally the positioning of potting line haulers allows forward and aft visibility.

11.6 Cumulative Impacts

11.6.1 Other Offshore Wind Farm Developments

The existing and planned wind farms which could theoretically contribute to cumulative effects are:

- Gunfleet Sands 1 offshore wind farm (consented with construction planned for 2008/09);
- London Array offshore wind farm (consented with construction planned for 2008/09);
- Greater Gabbard[17] offshore wind farm (consented with construction planned for 2008/09);
- Kentish Flats operational site; and
- Thanet offshore wind farm (consented with construction Planned for 2008/09).

Figure 11.2 illustrates the locations of the various developments within the strategic area.

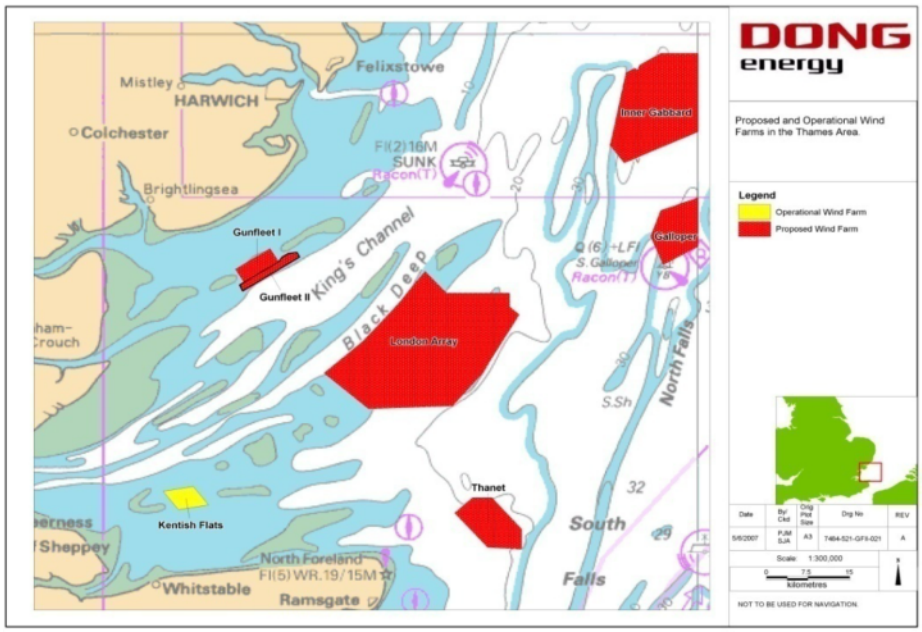


Figure 11.2 Existing and Proposed Wind Farm in the Thames Strategic Area. (Source: Crown Estates)

11.6.2 The Introduction of Seabed Objects

Assuming the contractors for all of the developments comply with the same standards and procedures with respect to construction related debris and accidentally dropped objects, there will be **no cumulative impact**.

[17] Comprising Inner Gabbard and Galloper

11.6.3 Impacts on Commercially Exploited Species

11.6.3.1 Construction Phase

Cumulative impacts relating to construction phases will only occur if the same construction activities at more than site coincide. Whilst all of the Round 2 developers have stated that construction is planned for 2008-9, due to the shortages of installation vessels and projected delays in turbine supplies, it is questionable whether that in reality, simultaneous construction activities will occur.

In addition, there is on-going liaison between the Thames Area developers with the aim of minimising cumulative impacts as far as is practically possible.

It is also considered unlikely that the decommissioning activities of more than one site will coincide. In all probability, it is unlikely that the overall cumulative impacts on commercially exploited species during construction and decommissioning will be of **minor adverse** significance.

11.6.3.2 Operational Phases

In terms of the possible enhancement effects discussed above, it is possible that some degree of cumulative **beneficial** impact may occur.

11.6.4 Increased steaming times to fishing grounds

11.6.4.1 Construction and Decommissioning Phases

If construction or decommissioning exclusion between sites does occur, for the larger, further ranging vessels, there may be some **minor adverse** impacts on steaming times.

11.6.4.2 Operational Phases

Taking that, as is likely, fishing vessels will be able to steam through operational sites, there is little prospect of significant cumulative effects, with the result that the expected cumulative impact will be **negligible**.

11.6.5 Cumulative Loss or Restricted Access to Traditional Fishing Grounds

The local skippers consulted considered that, at certain times of year, they will fish in the areas where other projects are proposed, giving a potential for certain vessels to be impacted. The magnitude of the impact will be relative to the combined areas of the sites, the access policies to be implemented and the degree to which the vessels local to the GS2 site actively fish the areas of other developments.

Table 11.1 summarises the relative areas and access policies of existing and consented wind farms within the Thames Area. This is based upon Table 7.14 in the London Array ES (RPS, 2005) and shows that when all projects in the Greater Thames Estuary are considered, almost 10% of the total area will be covered by developments. It is however unlikely that the loss in the values of landings will be proportional to the loss of area, as some of the sites will be accessible in their operational phases and the relative values of fishing between site locations varies.

The GS2 development has the smallest area of any of the Thames Area developments. From Baseline Description (Appendix I,) it also appear that, the main operating areas of the vessels local to GS2 are to the north and west of the site and do not encroach into other sites. It therefore probable that the GS2 will make only a minor contribution to the potential cumulative loss or restricted access effect.

Development	Area of Impact (km^2)	% GTE area affected	Restrictions placed by development
Offshore Wind Farms			
Gunfleet Sands 2 (GS2)	**7.5**	**0.14%**	50m safety zones around turbines, otherwise no restrictions on fishing [18]
Gunfleet Sands 1 (GS1)	10	0.19%	50m safety zones around turbines, otherwise no restrictions on fishing.
Kentish Flats	10	0.19%	50m safety zones around turbines, otherwise no restrictions on fishing.
London Array	266.4	5.03%	500 m safety zones around turbines prohibit all mobile fishing gear.
Greater Gabbard	102	1.92%	500 m safety zones around turbines prohibit all mobile fishing gear.
Thanet	35	0.66%	50 m safety zones around turbines.
Dredging Projects			
London Gateway (dredging and reclamation)	19.3	0.36%	Permanent loss of $0.93km^2$ due to reclamation. Intermittent access to areas undergoing capital dredging.
Aggregate Extraction	62.66	1.18%	No fishing during dredging. Open access at all other times (temporal constraint).
Total Area of Impact	**512.86**	**9.67%**	

Percent area impacted is based on a Greater Thames Estuary (GTE) Area = ~5,300 km^2

Table 11.1 Areas and Access Restrictions of Existing and Proposed Thames Area Wind Farms

11.6.6 In-Combination Effects

The only other human activity with the potential to have significant in-combination effects is marine aggregate dredging. Figure 11.3 shows the locations of the active licensed aggregate dredging areas within the Thames Area.

[18] Subject to on-going discussions with local commercial fishermen.

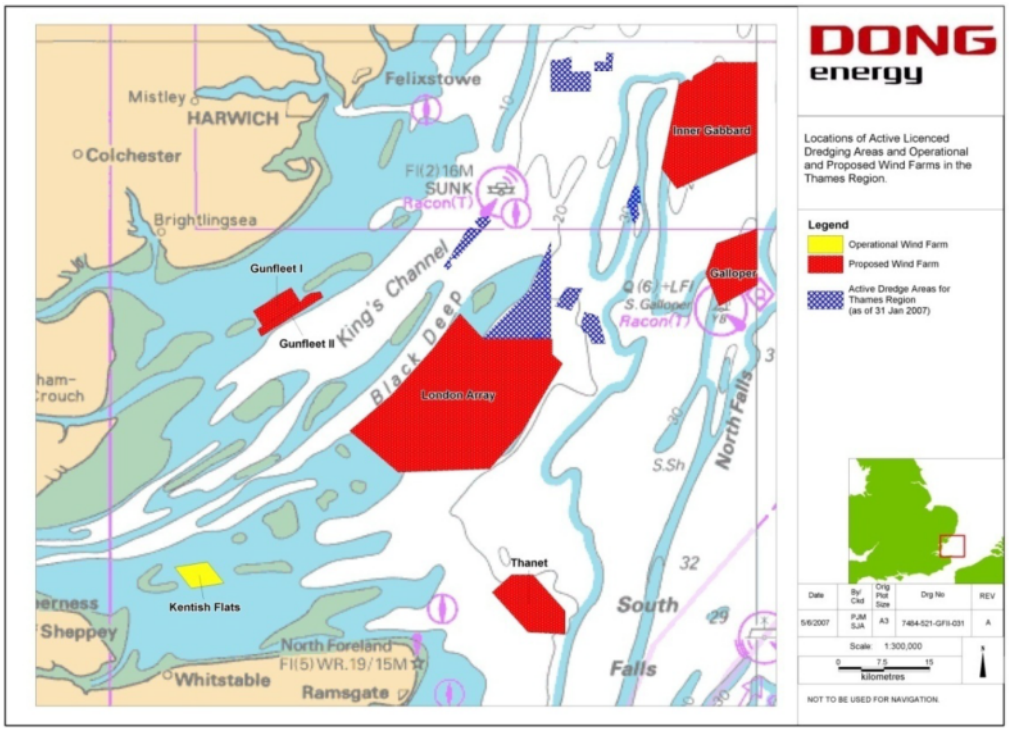


Figure 11.3 Active Licensed Aggregate Dredging Sites &Operational & Consented Wind Farms (Source: Crown Estate)

As detailed in Table 11.1, fishing is excluded during dredging operations, but there is open access at all other times. The other dredging activity of relevance is the capital and maintenance dredging that will occur for the London Gateway development which was given government approval on May 31st 2007.

Volume 1.0 of the Inspectors Report (2005) of the Public Inquiry, states that capital dredging and reclamation works will result in 8.3 million metres³ of material being suspended in the water column, of which approximately 1.0 million metres³ would be carried in suspension for distances of up to 13 km. The report considers that such suspended sediment levels would not adversely affect fisheries or fish resources, the Inspector stating:

'I am not convinced that dredging would interrupt spawning to the detriment of fish stocks, since it would appear to me that fish reaching a physiological state of readiness to spawn, will do so, somewhere in the vicinity, even if noise and turbidity from dredging activity affects their choice of grounds.'

In view of the scale of works associated with the London Gateway development and the Inspectors opinion of the potential impacts, the in-combination effects associated with the GS2 construction activities will be, by comparison, insignificant.

12. SEASCAPE AND VISUAL CHARACTER

12.1 Introduction

This chapter considers the impacts that the proposed Gunfleet Sands 2 (GS2) Offshore Wind Farm will have, with its associated offshore infrastructure, on the existing landscape and seascape environments, their characteristic features and on the people who view it. The purpose of the assessment is to determine the magnitude and significance of any change to the character and value of the seascape as well as the potential impact upon views, visual amenity and receptor groups within the 30km radius Zone of Theoretical Visibility (ZTV).

12.2 Consultation

To cover all the potentially significant seascape and visual impacts a 30km radius study area around the proposed offshore wind farm was agreed with Tendring District Council. The final list of eight representative viewpoints was then also agreed with Tendring District Council.

12.3 Site and Study Area

The proposed GS2 development will include up to 22 turbines. They will be arranged in two rows in a north-easterly to south-westerly direction, at a distance of approximately 8.5km and 10km from the nearest shore at Clacton-on-Sea. The turbines will also form an extension to the existing consented (although not as yet constructed) 30 turbines of the Gunfleet Sands 1 Offshore Wind Farm (GS1), extending from the south-east (seaward) side of GS1, on a continuous grid formation, with the same separation and alignment as GS1. As the consented turbines of GS1 (along with those at London Array) can be viewed from the majority of the study area, they have been identified as part of the existing baseline for the purposes of the assessment of GS2.

It is accepted practice within landscape assessment work that the extent of the study area is broadly defined by the visual envelope or the Zone of Theoretical Visibility (ZTV) arising from the development site (the area within which it may be possible to see any part of the proposed development). Within the ZTV, the extent of visibility of a proposed development depends upon a variety of factors including the scale of development, the nature of the receiving environment, the range and distribution of visual receptor groups and the relationship between the viewpoint and the development itself including orientation, distance and local screening. It will also include the prevailing meteorological and weather conditions available at any one time and the duration (permanency) of the development.

12.4 Data Sources

The methodology follows relevant standards and guidance principally set out in the Maritime Ireland/Wales Interreg 1994 – 1999 Guidance 'Guide to Best Practice in Seascape Assessment' (GSA) published in March 2001[19]. This sets out a clear methodology for undertaking seascape characterisation and for the subsequent evaluation of impacts.

[19] Maritime Ireland/Wales Interreg 1994 – 1999 Guidance 'Guide to Best Practice in Seascape Assessment' (GSA) published in March 2001

The assessment also draws upon the established Countryside Agency methodology (Landscape Character Assessment Guidance, 2002)[20] and other recognised guidelines, in particular the Institute of Environmental Management and Assessment and the Landscape Institute's Guidelines for Landscape and Visual Impact Assessment, second edition (2002)[21]; the Visual Analysis of Wind Farms – Good Practice Guidance SNH (Draft Report, July 2005)[22], the Guidance on the Assessment of the Impact of Offshore Wind Farms – DTI (2005)[23] and the Companion Guide to PPS22 (ODPM, 2004)[24]. For further detailed information on data sources, legislation and guidance and scope of work, refer to Appendix J (Seascape and Visual Assessment Technical Report).

12.5 Description of Existing Environment

12.5.1 Landscape and Seascape Policy Context

As part of establishing the existing baseline environment, the assessment reviewed a range of relevant landscape and seascape policy designations at a national regional and local level, from a number of local planning authorities, namely;

Structure Plans

- Suffolk County Council (Adopted 2001); and
- Essex and Southend-on-Sea Structure Plan (Adopted April 2001).

Local Plans

- Tendring District Council (Adopted 2005);
- Maldon District Council (Adopted Replacement, November 2005);
- Babergh District Council (Adopted 2006);
- Suffolk Coast District Council (Adopted March 2006);
- Rochford District Council (Adopted Replacement, June 2006); and
- Colchester Borough Council (Adopted review, March 2004).

In summary, the national, regional and locally important landscape / seascape designations that fall within the study area comprise the following;

National Designations

- The Suffolk Heritage Coast (Natural England);
- Suffolk Coast Area of Outstanding Natural Beauty; and
- Dedham Vale and Stour Valley Area of Outstanding Natural Beauty.

[20] Landscape Character Assessment Guidance, 2002 – Countryside Agency
[21] Guidelines for Landscape and Visual Impact Assessment (Institute of Environmental Management and Assessment / Landscape Institute 2002)
[22] Visual Analysis of Wind Farms – Good Practice Guidance SNH (Draft Report, July 2005)
[23] Guidance on the Assessment of the Impact of Offshore Wind Farms – DTI (2005
[24] Companion Guide to PPS22 (ODPM, 2004)

National Registers

- Registered Parks and Gardens in England (English Heritage), including Kings Promenade Gardens, Clacton on Sea; St Osyth Pak; Wivenhoe Park; Thorpe Park, Cliff Gardens, Felixstowe; Bawdsey Manor Gardens and Castle Park, Colchester; and
- Scheduled Monuments (English Heritage)

Local Designations

- Special Landscape Area – Suffolk Coastal DC, Babergh DC, Maldon DC, Rochford DC;
- Coastal Protection Belt – Tendring DC. Colchester BC, Maldon DC, Rochford DC;
- Countryside Conservation Area - Colchester BC; and
- Conservation Areas.

The areas of landscape designation identified above, are illustrated on Figure 12.1. They generally cover areas of attractive, mature and undeveloped landscapes / seascapes and are relevant insofar as they cover areas which are valued for either landscape and /or visual amenity reasons, which are of importance in the context of the wider landscape. They are detailed within the baseline landscape environment section and a summary of their baseline quality and sensitivity is provided in the landscape baseline summary table.

12.5.2 Landscape and Seascape Environment

The identified study area embraces a long, varied and notably indented stretch of coastline. It extends from the Deben, Orwell and Stour Estuaries to the north, to the River Crouch and Foulness Island to the south. Between these points the coastline encompasses the Tendring and Maldon Peninsulas and Mersea Island. Whilst considerable areas exhibit a natural undeveloped character, particularly to the south, there are extensive areas of urban development along the Tendring coast (Clacton-on-Sea, Frinton on Sea and Harwich), inland (Colchester and Ipswich) and isolated major industrial features (Bradwell power station and the docks in Harwich / Felixstowe).

12.5.3 Landscape Character

The landscape character context is identified at different levels, with the Countryside Character Initiative (CCI) and English Nature's Natural Areas providing the broader framework to determine the character of the British countryside at a national level.

Within the CCI Character Map, the study area embraces three Landscape Character Areas (LCAs): Area 81: The Greater Thames Estuary; Area 82: Suffolk Coast and Heaths; and Area 111: The Northern Thames Basin. It also encompasses the key Natural Areas, Area 67: Greater Thames Estuary and Area 105: Suffolk Coast.

Further, more detailed tiers of landscape character assessment also exist and include the Suffolk Coast and Heaths Landscape Assessment work, undertaken by the Countryside Agency, the Mid-Essex Coast Landscape Character Assessment, and the Tendring District Landscape Character Assessment. Reference should be made to Appendix J which gives a more detailed summary of key aspects of existing landscape character assessment work.

12.5.4 Seascape Context

Whilst the above landscape assessments provide useful baseline detail, the information is insufficient to appraise the seascape character areas in full. In order to assess the seascape context, three key components have been defined in line with the recognised methodological guidance in the Irish Marine Institute's Guide to Best Practice in Seascape Assessment (GSA) as detailed in Appendix J. These include the marine component, the hinterland component and the coastal component. These assist with identifying regional seascape character units, which straddle segments of the coastline, with their character being defined by both seaward and landward elements.

12.5.5 Regional Seascape Units

At this regional scale five seascape units have been identified within the 30km study area. The approximate extents of these are illustrated on Figure 12.2. These include the Regional Seascape Units at:

- Stour and Orwell Estuaries;
- Tendring Peninsula;
- Mersea Island and Estuaries;
- Maldon Peninsula; and
- North Thames Estuary.

The key characteristics of each of these regional seascape units have been considered within Appendix J. A summary baseline quality and sensitivity of each unit is detailed in Summary Table 12.1.

12.5.6 Historic Environment

A number of historic elements, relevant to the assessment, exist along the coast, as illustrated on Figure 12.1. They include the Conservation Areas, Registered Parks and Gardens and Scheduled Ancient Monuments. In most cases they are generally connected with the settlement pattern and the Heritage Coast (which is located approximately 28kms to the north of the proposed GS2 offshore wind farm development).

The landscape baseline connected with the setting of these features is identified within Appendix J. The quality and sensitivity of these are identified in Summary Table 12.1, below.

12.5.7 Landscape Baseline Summary

The summary table below highlights the relevant baseline landscape and seascape futures and character areas within the study area, as indicated above and summarises their baseline quality and sensitivity to change to the GS2 development.

12.5.8 Meteorological Context

The degree, extent and likelihood of visual impact arising from the proposed offshore wind farm development is an amalgam of a variety of different factors, not least the prevailing weather conditions that occur in the vicinity at any one time. This information was sourced from the Dover Strait Pilot (NP28 -detailed in Appendix J). Collectively, both the climate and the day-to-day weather patterns (identified in the Appendix J) will combine to reduce the number of days upon which views of the proposed offshore wind farm will be available from the coastline and hinterland. Moreover, even where poorer visibility does not wholly obscure views of the proposed wind farm, it will still inhibit views of the development rendering it more visually recessive within the wider seascape.

12.5.9 Visual Environment

The purpose of the Visual Assessment is to determine the Zone of Theoretical Visibility (ZTV) of the development (the area of land / sea within which it may be possible to see any part of the proposed development) and to determine how visible the proposals would be from sensitive viewpoints and assess the impact upon visual receptor groups and visual amenity.

12.5.10 Zone of Theoretical Visibility

The computer generated ZTV's to nacelle and blade tip (Figures 12.3 and 12.4) identify key stretches of the landscape and coastal hinterland, from which the proposed wind farm development may theoretically be visible within the agreed 20km radius from the proposed wind farm. This is in line with the Visual Analysis of Wind Farms Good Practice Guidance (SNH). For full details of the methodology refer to Appendix J.

As illustrated by the ZTV studies, the principal zones of visibility extend along the flat low lying and undeveloped peninsulas, particularly at Maldon, Rochford and along the Blackwater Estuary to the west. The extent of visibility is then more restricted to the north across the coastal plateau areas at Tendring and to the open landscape areas either side of Clacton. The elevated peninsula at the Naze then assists with restricting visibility to the south east facing slopes (to the north) of Hamford Water. Further to the north there is very limited visibility along the Stour and Orwell Valleys and to the north of Felixstowe.

12.5.11 Key Visual Receptors

A range of visual receptors can be expected to be affected by the proposed development. These receptors will include, but not be limited to, local residents, those travelling through the area including pedestrians and motorists, those visiting the area for recreational and amenity purposes and those working outdoors. The extent of the effect upon certain groups will vary according to the nature of the view, intricacies of the surrounding landscape, seascape and their level of sensitivity to the type of development. For ease of presentation the Seascape and Visual Assessment identifies 3 key categories of visual receptors. These are (1) local residents; (2) the travelling public; and (3) visitors to the area. They have been detailed further in the technical report in Appendix J.

12.5.12 Viewpoint Appraisal

To help define the existing visual baseline environment, it is accepted practice to select and agree upon a number of representative viewpoints within the visual envelope of the development. These ideally include a broad range of sensitive viewpoints and visual receptor groups, from which the assessment of both of the existing baseline conditions and effects arising from the proposed development will be assessed. This will determine how visible the proposals will be from specific locations and will help gauge the anticipated effects upon general visual amenity. The representative viewpoint locations are illustrated Figure 12.7. They include:

Regional Seascape Units	Landward Distance from site (min)	Condition (Quality)	Intervisibility with the site	Sensitivity to the development
Stour and Orwell Estuaries	13.5km	Medium - High	Low - Medium	Medium
Tendring Peninsula	8.5km	Medium – Low	Medium - High	Medium - Low
Mersea Island and Estuaries	12km	Medium – High	Medium	Medium - Low
Maldon Peninsula	17.0km	Medium – High	Medium - High	Medium – Low
North Thames Estuary	20km	Not Assessed – This RSU is on the periphery of the study area with very limited public access.		
Designated Landscape				
Suffolk Coast AONB	28km	High	Low	Low
Dedham Vale and Stour Valley AONB	23km	High	Negligible	Low - Negligible
Special Landscape Area – Suffolk Coastal DC	29km	Medium –High	Negligible	Negligible
Special Landscape Area Babergh DC	27km	Medium –High	Negligible	Negligible
Special Landscape Area Maldon DC	17km	Medium –High	Medium	Low - Medium
Special Landscape Area Rochford DC	19km	Medium –High	Medium - High	Low
Coastal Protection Belt – Tendring DC Colchester BC, Maldon DC, Rochford DC	9km	Medium –High	Low - Medium	Low - Medium
Countryside Conservation Area - Colchester BC	16.5km	Medium –High	Medium	Low - Medium
Historic Landscape				
The Suffolk Heritage Coast	28km	High	Low	Low - Medium
Conservation Areas along the coast	8.5km	High	Medium - High	Low - Medium
Registered Parks and Gardens at Clacton	8.5km	High	High	Medium

Summary Table 12.1 Landscape and Seascape Baseline

- Viewpoint 1 - View from the cliff top, The Naze;
- Viewpoint 2 - View from the Greensward, Frinton-on-Sea;
- Viewpoint 3 – View from public footpath at Great Holland;
- Viewpoint 4 – View from radar tower at Holland Haven;
- Viewpoint 5 - View from the seafront promenade, Clacton-on-Sea;
- Viewpoint 6 - View from the coastal sea defences, Seawick;
- Viewpoint 7 View from the beach at West Mersea; and
- Viewpoint 8 - View from Bradwell Bird Observatory, St Peter's Chapel, St Peter's Way.

The summary of baseline quality and sensitivity to change to the GS2 development is detailed below within Summary Table 12.2. For further descriptions of the existing view and a list of the key visual receptors covered, refer to the Seascape and Visual technical report in Appendix J.

12.6 Impact Assessment

12.6.1 Introduction

Judgments on the significance of effects arising from the proposed GS2 development, upon the existing and visual environment, are based on an assessment of the magnitude of the proposed change, in light of the sensitivity of the receptor, to the type of change proposed. This is assessed in line with the LI / IEMA evaluation process, where the magnitude and subsequent significance of effect takes into account the scale, extent and duration of the effect. Effects can be adverse, neutral or beneficial. The assessment methodology is summarised in Appendix J.

12.6.2 Seascape Effects

At a regional scale, a total of 5 seascape units have been identified within the 30km study area, although only 4 of these are relevant to the assessment of effects for the GS2 development. The magnitude and significance of effect of these has been summarised below. A more detailed assessment is then provided in Appendix J.

12.6.2.1 Stour and Orwell Estuaries Regional Seascape Unit

Lying approximately 13.5km to the north of the proposed wind farm site this regional seascape unit is one of the furthest units from the proposed development. The broadly low lying, highly indented coastline is also characterised by large areas of marshland, reclaimed farmland and significant settlement and industrial development along the coast, particularly at the major promontories and provides a variety of contrasting seascape character within an exposed large scale landscape that is generally harmonious and of *Medium* to *High* quality and of *Medium* sensitivity to change.

The proposed GS2 development, which is an extension to the existing consented offshore wind farm at GS1, will not introduce any new features in to this regional seascape unit but will extend the spread of consented turbines at GS1 by a third. Also taking account of the distance to the GS2 Offshore Wind Farm, the limited intervisibility from the majority of the landward element, the open and contrasting character with the presence of industrial dock development, the consented turbines at GS1 and London Array, the magnitude of impact arising from the GS2 development upon the seascape unit is considered to be generally Low to Negligible. Since the sensitivity of the seascape unit to the GS2 development is Medium the significance of effect upon this regional seascape unit is assessed as **Minor- Negligible.**

No.	Viewpoint Location	Grid Ref	Approx. Distance to Nearest Turbine (GS2)	Seascape Unit	Quality of the Baseline View	Sensitivity to the change (receptor group)
1	View from the cliff top, The Naze	626538, 223458	13.0km	Stour and Orwell Estuaries	Medium	Medium - Low
2	View from the Greensward, Frinton-on-Sea	624109, 219827	9.5km	Tendring Peninsula	Medium	Medium - Low
3	View from the public Footpath, Great Holland	622000, 219350	10km	Tendring Peninsula	Medium	Medium - Low
4	View from near the radar tower, Holland Haven	621750, 217150	8.3km	Tendring Peninsula	Medium	Medium - Low
5	View from the seafront promenade, Clacton-on-Sea	617450, 214350	8.9km	Tendring Peninsula	Medium - Low	Low
6	View from atop the sea defence barrier, Seawick	613136, 212712	10.1km	Tendring Peninsula	Low	Low
7	View from the beach at West Mersea	602000, 212400	19.6km	Mersea Island and Estuaries	Medium	Medium – Low
8	View from Bradwell Bird Observatory, near St Peters Chapel, St Peters Way	603167, 208069	17.5km	Maldon Peninsula	Medium to High	Medium

Summary Table 12.2 Visual Baseline

12.6.2.2 Stour and Tendring Peninsula Regional Seascape Unit

This seascape unit forms a well defined elevated and highly developed peninsula between the tributaries of the Stour and Orwell to the north and the Blackwater to the south.

It is also the nearest seascape unit to the proposed wind farm extension with the landward element located approximately 8.5km to the north-west and the seaward element extending to include the consented offshore wind turbines of GS1 within the unit.

The introduction of a further 22 turbines for the GS2 development will represent a minor increase to the extent to which wind turbines are identified as being a defining element of this seascape unit. Although the GS2 turbines will add a number of turbines to the existing composition of wind turbines and will be seen to both add a degree of density and extend the overall spread, in isolated cases on the coast, it will also be seen to join the perceived separation between the consented wind farms at GS1 and London Array.

Given the existing nature of the seascape character with a number of disparate features present, the addition of the turbines will not constitute a substantial change to the character or increase the visual exposure within the area. The resulting magnitude of effect is therefore considered to be generally Low - Medium**.** As the level of sensitivity to change of this seascape unit is Medium – Low the resultant significance of effect of the proposed GS2 turbines on this seascape character area is assessed as **Minor- Moderate.**

12.6.2.3 Mersea Island and Estuaries Regional Seascape Unit

Centred on Mersea Island and the estuaries of the River Blackwater and River Colne, this low lying, undeveloped seascape, is reasonably contained by the elevated Tendring peninsula to the north east and the Maldon peninsula to the south. These positively assist with restricting its general relationship with the open sea, to isolated coastal areas. Even within these views the indented coastline is always apparent and the consented wind turbines of GS1 and London Array and the Bradwell power station form key built influences within the general character. The addition of 22 turbines to the GS2 development will, therefore, typically result in a *Low* magnitude of effect from within this seascape unit. When combined with a *Medium – Low* sensitivity to change the overall significance of effect is assessed as **Minor.**

12.6.2.4 Maldon Peninsula Regional Seascape Unit

This clearly defined low lying, undeveloped and distinctly isolated seascape unit which is characterised by a wide expanse of mud flats, marshland, sea defence bunds and reclaimed fen is more obviously defined by large expanses of flat terrain and sky rather than by the sea itself. As such the sea is generally separated visually, from the land, and even though the landscape is predominantly open from the more elevated settled areas to the west, the view and character is more obviously associated with the estuary areas rather than eastwards towards the sea. Although the extent of potential visual exposure of the GS2 development is widespread within the area, the large open exposed nature of the area combined with existing built influences of Bradwell power station and the consented turbines at GS1 and London Array provide a scale and character to contain the magnitude of effect to *Low*. When combined with *Medium – Low* sensitivity to change the overall significance of effect of the GS2 development is considered to be **Minor**.

12.6.3 Effects on Designated Landscapes

The majority of the coastline within the study area is recognised to a degree for its nature conservation and aesthetic value with a number of overlapping designation present (see Figure 12.1). A number of these areas however, exist beyond the area of theoretical exposure.

The nearest, elevated and most developed coastline at Tendring, will also positively assist with restricting visibility. This is particularly the case for the two identified AONB's (refer to the Landscape and Seascape Effects Summary Table 12.3 for details).

There will, however, be a degree of increased visibility, and consequential magnitude of effect, on the low lying, undeveloped and exposed peninsulas to the south. These areas include the Special Landscape Areas within the Coastal Protection Belt, which physically incorporate extensive intertidal areas as well as the open, exposed adjoining landscape. A combination of distance and scale within the landscape from these areas will limit the magnitude of effect, typically to *Medium to High*. As a result the significance of effect on designated landscapes is assessed to be no more than **Moderate** in isolated areas and more generally **Minor to Negligible**.

12.6.4 Historic Environment

The majority of significant historic features that exist within the study area, are connected with the general settlement pattern. They include the key conservation areas located on the Tendring Coast at Clacton-on-Sea seafront, Frinton, Great Holland and Walton, along with the Registered Park and Garden on the Clacton-on-Sea seafront. All of these have a direct relationship with the coast. Although there will be clear views toward the GS2 development from these areas, the project will only represent a minor increase to the extent to which wind turbines are identified as being a defining element in the area. As a result the Magnitude of effect is considered to be *Low – Medium*. When combined with a *Low –Medium* sensitivity to the change arising from the proposed development, on account of the urbanised edge with a high number of existing features including the consented offshore turbines at GS1 and London Array, the significance of effect is assessed to be **Minor – Moderate**. Elsewhere a combination of distance, orientation, nature and scale of the historic setting will reduce the effect. Refer to Summary Table 12.3 Landscape and Seascape Effects, for details.

12.6.5 Visual Effects

The potential areas of greatest visual effect, arising from the proposed development, are primarily located within 1-2km of the coastline and within the remote coastal margin areas. Further inland visual effects are generally only gained from the more elevated, east and south east facing slopes. The key features of the Tendring Peninsula and Mersea Island ridgelines, positively assist in restricting the visual envelope of the proposed development. From locations inland, views may also be less focussed on the distant horizon and be more complex with other points of interest closer to the receptor that draws the eye. The significant existing disparate built elements sited intermittently along and off the coast, including the consented offshore wind farms at GS1, London Array and Kentish Flats, also assist in restricting the potential visual profile of the proposed development.

The following analysis refers to the eight agreed representative viewpoints referred to in the baseline conditions. Reference should be made to the existing panoramas and wireframes (Figures 12.8-15) and to the photomontages (Figures 12.16–12.23) which illustrate the existing and proposed view for each viewpoint.

Regional Seascape Units	Condition (Quality)	Sensitivity to the development	Magnitude of Operational Effect	Significance of Effect
Stour and Orwell Estuaries	Medium - High	Medium	Low - Negligible	Minor - Negligible
Tendring Peninsula	Medium – Low	Medium - Low	Low - Medium	Minor - Moderate
Mersea Island and Estuaries	Medium – High	Medium - Low	Low	Minor
Maldon Peninsula	Medium -High	Medium – Low	Low	Minor
Designated Landscape				
Suffolk Coast AONB	High	Low	Low	Minor
Dedham Vale and Stour Valley AONB	High	Low	Negligible	Negligible
Special Landscape Area – Suffolk Coastal DC	Medium –High	Low	Negligible	Negligible
Special Landscape Area Babergh DC	Medium –High	Low	Negligible	Negligible
Special Landscape Area Maldon DC	Medium –High	Low - Medium	Medium - High	Moderate
Special Landscape Area Rochford DC	Medium –High	Low	Medium – High	Minor -Moderate
Coastal Protection Belt – Tendring DC Colchester BC, Maldon DC, Rochford DC	Medium –High	Low - Medium	Medium - High	Moderate
Countryside Conservation Area - Colchester BC	Medium –High	Low - Medium	Low - Medium	Minor -Moderate
Historic Landscape				
The Suffolk Heritage Coast	High	Low - Medium	Low	Minor
Conservation Areas along the coast	High	Low - Medium	Low - Medium	Minor - Moderate
Registered Parks and Gardens at Clacton	High	Low - Medium	Low - Medium	Minor - Moderate

Summary Table 12.3 Landscape and Seascape Effects

12.6.5.1 Viewpoint 1 - View from the cliff top, The Naze

From this viewpoint, at a distance of approximately 13km to the north of the nearest turbine of the proposed GS2 development, the turbines will extend the spread of consented offshore turbines at GS1 by approximately 12° to the north across this simple elevated coastline. This will then extend the spread of turbines of the combined GS1 and GS2 to approximately 26° within the open panoramic view. The wireframe and photomontage (see Figures 12.8 and 12.16) indicate that all the turbines of the GS2 development will be visible from this viewpoint and will appear to both extend and overlap with the consented array of offshore turbines at GS1. The layout of the proposed development, when viewed from this viewpoint, will also be fairly regular, both where the turbines overlap with the consented turbines and where they extend to the north, being discernable as individual elements with a regular spacing and alignment. The turbines will, however, not extend to close the visual gap between the consented wind farm at London Array, which will form a separate built influence to the north extending to approximately 45° of the overall view.

The extent and simplicity of this elevated view, which will include the consented turbines at GS1 and London Array, provides a comparable scale which assists with containing the magnitude of impact to *Medium* to *Low*. Since the sensitivity to change of the key visual receptor group of visitors to the Naze is considered to be *Medium* to *Low*, the overall significance of impact is assessed as **Moderate to Minor**

12.6.5.2 Viewpoint 2 - View from the Greensward, Frinton-on-Sea

When viewed from this viewpoint, which is located at a distance of approximately 9.5km to the north of the nearest turbine of the proposed GS2 development, the turbines will extend the spread of consented offshore turbines at GS1 by approximately 15° to the north across an uncomplicated elevated coastline. The GS2 turbines will then extend the spread of turbines of the combined GS1 and GS2 projects to a total of approximately 36°. As the wireframe and photomontages (see Figures 12.9 and 12.17) indicate, all the turbines of the GS2 development will be visible from this viewpoint, as they appear to both extend and overlap with the consented array of offshore turbines at GS1 in a fairly regular alignment of loose clusters where they extend to the north. The turbines will also extend to close the visual gap and overlap with the consented wind farm at London Array, which then extends the built influence to the north by a further 45° of the overall view.

Given the above, the magnitude of effect arising from the proposed development is, therefore, assessed as *Medium - Low*. When combined with a *Medium – Low* sensitivity to change to the type of development, the significance of effect on the key receptor group of visitors to the public open space is assessed to be **Moderate to Minor.**

12.6.5.3 Viewpoint 3 – View from public footpath at Great Holland

This viewpoint is located at a distance of approximately 10km to the north of the nearest turbine of the proposed GS2 development and approximately 1.5km from the Tendring coastline itself.

When viewed from this locally elevated inland viewpoint, the turbines will extend the spread of consented offshore turbines at GS1 by approximately 14° to the north within the seascape which lies beyond the undulating agricultural landscape and between the elevated and settled foreshore at Holland-on-Sea to the south and Frinton-on-Sea to the north. This will then extend the spread of turbines of the combined GS1 and GS2 projects to approximately 38° within the open panoramic view. The wireframe and photomontage (see Figures 12.10 and 12.18) indicate that all the turbines of the GS2 development will generally be visible from this viewpoint. It also indicates that the majority of the extension will sit behind the GS1 development and will not significantly alter the generally regularity of the composition.

Where it does extend to the north, the spacing of the turbines does become wider and the turbines will appear in 3 discernable rows with some separation between them. The turbines will also extend to close the visual gap and overlap with the consented wind farm at London Array, which then extends the built influence to the north by a further 50° of the overall view.

As a result, the anticipated magnitude of effect arising from the proposed development is judged to be *Medium – Low* and when combined with a *Medium - Low* sensitivity to change in the view for visitors using the footpath, the resultant significance of impact is assessed to be **Moderate – Minor.**

12.6.5.4 Viewpoint 4 – View from radar tower at Holland Haven

From this viewpoint at a distance of approximately 8.3km to the north, north-west of the nearest turbine of the proposed GS2 development, the turbines will extend the spread of consented offshore turbines at GS1 by approximately 17° to the north across the elevated and varied foreshore. This will then extend the spread of turbines of the combined GS1 and GS2 projects to approximately 37° within the open panoramic view. The wireframe and photomontage (see Figures 12.11 and 12.19) indicate that all the turbines of the GS2 development will be visible from this viewpoint. They will also appear to sit beyond the consented array of offshore turbines at GS1, for the majority of the scheme, adding some density to the existing composition when viewed from this viewpoint. To the north they will then be clearly discernable as 3 tight clusters with a degree of regular spacing between them. Also, in this part of the layout they will be seen to overlap with the turbines of the consented wind farm at London Array which will form a distant but extensive built influence along the horizon line to the north, extending to approximately 55° of the overall view.

Given the above the magnitude of effect arising from the proposed development is therefore, assessed as *Medium - Low.* When combined with a *Medium - Low* sensitivity to change to the type of development, the significance of effect on the key receptor group of visitors to the public open space is assessed to be **Moderate - Minor.**

12.6.5.5 Viewpoint 5 - View from the seafront promenade, Clacton-on-Sea

When viewed from this viewpoint, which is approximately 8.9km to the north of the nearest turbine of the proposed GS2 development, the turbines will extend the spread of consented offshore turbines at GS1 by approximately 7° to the north and 4° to the south across the active and varied seafront. They will then extend the spread of turbines of the combined GS1 and GS2 projects to a total of approximately 39°.

As the wireframe and photomontage (see Figures 12.12 and 12.20) indicate, all the turbines of the GS2 development will be visible from this viewpoint as they appear to sit beyond the consented array of offshore turbines at GS1, adding more density to the composition but not adding any significant irregularity to the consented GS1 layout as they will follow the general pattern and alignment of the consented turbines.

To the north, the turbines will continue the regular spacing of the GS1 turbines and to the south they will add an additional row of two to the composition. With the exception of the two turbines to the south, however, the GS2 development will not extend the overall spread of turbines within the view as the consented turbines of London Array will stretch along the horizon and extend the composition of turbines to the north by an additional 20°.

From this viewpoint, the magnitude of effect arising from the proposed development is therefore assessed as *Low.* When combined with a *Low* sensitivity to change to the type of development, the significance of effect on the key receptor group of visitors the beach, pier and promenade, is assessed to be **Minor.**

12.6.5.6 Viewpoint 6 - View from the coastal sea defences, Seawick

From this viewpoint, which is approximately 10.1km to the west of the nearest turbine of the proposed GS2 development, the turbines will extend the spread of consented offshore turbines at GS1 by approximately 1° to the north and 5° to the south, within oblique views to the north east across this simple, exposed and low lying foreshore. This will then extend the spread of turbines of the combined GS1 and GS2 projects to approximately 34° within the open panoramic view. The wireframe and photomontage (see Figures 12.13 and 12.21) indicate that all the turbines of the GS2 development will be visible from this viewpoint and will appear to substantially overlap with the consented array of offshore turbines at GS1. When viewed from this viewpoint, the layout will also add density to the arrangement, forming a continuation in the fairly regular layout. Where the turbines do extend the GS1 arrangement to the south they will be seen with a wider spacing to the last row of two turbines. The turbines will not, however, extend the visual spread of the consented turbines at London Array which will form a separate built influence behind GS1 and GS2, extending for a further 9° to the north of the view and provide some connection with the exposed foreshore in the near distance.

Given the above, the magnitude of effect arising from the proposed development is therefore assessed to be *Low*. When combined with a *Low* sensitivity to change to the type of development, the significance of effect on the key receptor group of visitors to the beach and raised promenade is assessed to be **Minor.**

12.6.5.7 Viewpoint 7 - View from the beach at West Mersea

This viewpoint is located at a distance of approximately 19.6km to the west of the nearest turbine of the proposed GS2 development. When viewed from this viewpoint on the beach, the turbines will extend the spread of consented offshore turbines at GS1 by approximately 4° to the south. This will then extend the spread of turbines of the combined GS1 and GS2 projects to approximately 17° within a small oblique section of the open panoramic view.

The wireframe and photomontage (see Figures 12.14 and 12.22) indicate that all the turbines of the GS2 development will generally be visible from this viewpoint. It also indicates that the extension will substantially sit behind the consented turbines at GS1, adding a degree of density. They will not, however, significantly alter the regularity of the composition. Where it does extend to the south the four turbines will be seen with a regular spacing. In addition the turbines will not extend the overall spread of turbines within the view as they will be seen to sit wholly in front (i.e. to the west) of the consented turbines at London Array, which then extends the built influence of turbines to the south by approximately 12° and to the north by approximately 5° to visually connect with the distant Tendring peninsula.

From this viewpoint, with an open flat and varied panorama with a collection of natural and built elements present to enclose the seaward view, including the consented offshore turbines, the magnitude of effect arising from the proposed development is, therefore, assessed to be *Low.* When combined with a *Medium – Low* sensitivity to change to the type of development, the significance of effect on the key receptor group of visitors to the beach is assessed to be **Minor.**

12.6.5.8 Viewpoint 8 - View from Bradwell Bird Observatory, near St Peter's Chapel, St Peter's Way

When viewed from this viewpoint, which is approximately 17.5km to the west of the nearest turbine of the proposed GS2 development, the turbines will extend the spread of consented offshore turbines at GS1 by approximately 5° to the south across the overriding horizontal and exposed character of the Dengie Marshes. They will then extend the spread of turbines of the combined GS1 and GS2 projects to a total of approximately 17°.

As the wireframe and photomontage (see Figures 12.15 and 12.23) indicate, all the turbines of the GS2 development will be visible from this viewpoint as they appear to sit substantially behind the consented array of offshore turbines at GS1, adding density to the composition.

To the south the turbines will then continue the regular arrangement with a slightly wider spacing of turbines. They will not, however, extend the overall spread of turbines within the view as the consented turbines of London Array will stretch along the horizon and extend the composition of turbines to the south by a further 34°.

From this viewpoint, where the proximity of the sea also assumes a low profile in this exposed coastal seascape, the magnitude of effect arising from the proposed development is therefore assessed as *Low.* When combined with a *Medium* sensitivity to change to the type of development, the significance of effect on the key receptor group of travellers on St Peters Way, is assessed to be **Minor - Moderate**.

12.6.6 Visual Effects upon Visual Receptor Groups

It is considered that those who visit the main tourist areas along both coasts and the extensive nature reserves will be most affected. They will include day visitors to the beaches / tourist areas, walkers, cyclists, and ornithologists but the significance of effect is judged to be no more than *Moderate to Minor*. The effect on residential properties and the majority of settlements in the wider study area is generally limited, as the existing coastal influences will typically restrict views.

There will also be further effects on the residential properties that exist within the seafront towns of Walton-on-the-Naze, Frinton-on-Sea, and Clacton-on-Sea, where clear seaward views are available. Again, these will be no more than *Moderate to Minor*. For full details of the effects on receptor groups refer to Appendix J.

12.6.7 Visual effects at Night

The GS2 extension will be marked to be visible by day and by night, with prevailing visibility conditions, and will be lit in accordance with the International Association of Lighthouse Authorities (IALA) standards. For aviation purposes it is proposed that turbines will be lit in accordance with the Civil Aviation Authority (CAA) requirements. Night time visual effects will not be available from the majority of the study area as the lighting only has a visible range of 5nm and should, therefore, not be visible from the landfall at distances beyond 9km. The navigation lights of the nearest turbines will, however, be faintly visible from the Tendring coastline around Clacton-on-Sea. At this distance, it is judged that they will be too faint to create any significant additional glare or night glow, beyond that of the consented turbines at GS1. Any views out to sea will also be compromised within most of this distance by the light spillage around the viewpoint associated with the urban coast. However, marine-based receptors within this distance will be affected at night by the proposed lighting but not to any significant degree.

12.6.8 Duration of Seascape and Visual Effects

Chapter 3 (Scheme Description) identifies the key offshore elements associated with the proposed development. The sources of potential effects arising from these are identified as being the proposed turbines, which will give rise to effects upon the seascape environment. The anticipated nature of these effects is identified below according to the stage of the proposed development

12.6.9 Construction & Decommissioning

During the construction phase the main effect will be increased activity of construction vessels travelling to the site from local ports (and most likely also the Netherlands), the presence of jack-up barges and the progressive construction of the wind turbine. During this phase there will be some minor effects on the Tendring regional seascape character unit. There will also be minor effects on the associated visual receptors and general visual amenity, during construction operations, but there will be no significant effect until the later stages of construction. This will, however, become increasingly significant towards the end of the construction period. The additional effects arising from marine vessel activity associated with cable installation, cargo barges and transportation materials, including land based or harbour construction activity, are also considered to be relatively insignificant as there is an existing baseline of marine activity in the area.

During the decommissioning phase, there will be visual effects associated with decommissioning activity, which will be similar to that of the construction phase and relatively insignificant as there is an existing baseline of marine activity in the area. As the anticipated length of decommissioning will be slightly less than for the construction phase, these impacts will be more temporary than for the construction period.

12.6.10 Operation

Of the three stages, it is the operational phase that will have the most significant impact due to the duration of this stage, i.e. 20 years. The main elements of effect during this operational period will include the visual influence of the turbines on the respective seascape character units, designated landscapes, from visual receptors groups and sensitive viewpoints as well as on general visual amenity.

The magnitude and subsequent significance of any seascape effect arising from the proposed development is directly related to the capacity of the seascape to accommodate change. The ability of the seascape area and individual visual receptors, to accommodate an identified change has been established through a recognised evaluation process as detailed earlier.

12.7 Cumulative Impacts

12.7.1 Introduction

As indicated in the SVIA methodology (Appendix J), the potential cumulative effects of GS2 will be confined to an area where one or more operational or consented wind farms are located within 30km of a coastal receptor, which is also within the GS2 30km study area. This section looks at the additional seascape and visual effects arising from the combination of turbines at GS2, with one, or more of the Round 1 and 2 offshore wind farm developments, identified below.

12.7.2 Round 1 Offshore Projects

As part of the first round of offshore wind farm development around the UK, two wind farms gained planning consent within the GS2 study area. These include the operational Kentish Flats wind farm and the consented GS1 wind farm.

No.	Viewpoint Location	Quality of the Baseline View	Sensitivity to the change (receptor group)	Magnitude of Operational Effect	Significance of Effect
1	View from the cliff top, The Naze	Medium	Medium – Low	Medium to Low	Moderate to Minor
2	View from the Greensward, Frinton-on-Sea	Medium	Medium – Low	Medium to Low	Moderate to Minor
3	View from the public Footpath, Great Holland	Medium	Medium - Low	Medium to Low	Moderate to Minor
4	View from near the radar tower, Holland Haven	Medium	Medium - Low	Medium to Low	Moderate to Minor
5	View from the seafront promenade, Clacton-on-Sea	Medium - Low	Low	Low	Minor
6	View from atop the sea defence barrier, Seawick	Low	Low	Low	Minor
7	View from the beach at West Mersea	Medium	Medium – Low	Low	Minor
8	View from Bradwell Bird Observatory, near St Peters Chapel, St Peters Way	Medium to High	Medium	Low	Minor to Moderate

Summary Table 12.4 Visual Effects

The Kentish Flats development is located between 8.5 - 11km due north of the north Kent coastline at Herne Bay and approximately 26.5km from the nearest turbine of the GS2 development. The consented GS1 development will then be located directly to the north-west side of the GS2 development and will form a continuous grid formation, with the same separation and alignment as GS2. As the GS1 will be built in advance of the GS2 development, it has been included within the baseline assessment for the GS2 development and thus, also forms part of the main assessment of seascape and visual effects.

12.7.3 Round 2 Offshore Projects

In addition to the consented Round 1 offshore wind farm developments that lie within the core of the study area, the 270 turbines of the Round 2 consented (although not as yet constructed) London Array offshore wind farm may potentially add further cumulative / in combination effects. This wind farm lies between 13.5 and 27km due south-east from the proposed GS2 development. Significantly, it will also typically extend to cover a large area to the seaward side of the GS2 development, forming a major focus in the seascape character and an integral part of the view from the majority of the study area. It has, therefore, also been identified as part of the baseline and as such, the judgements on cumulative assessment will be endorsed by the seascape and representative viewpoint analysis that has been carried out specifically for the GS2 development

12.7.4 Cumulative Seascape Effects

The magnitude and significance of cumulative effects on seascape character are a function of the baseline sensitivity of each Regional Seascape Unit (RSU), the number and scale of the proposed wind farms in that character unit, and the overall size and shape of the seascape unit. Effects on the identified RSU's are summarised below.

12.7.5 Seascape Character

In general, the combined zone of theoretical visibility of all cumulative wind farms, (illustrated by the ZTVs Figures 12.5 and 12.6), is fairly extensive along the coastal margins and the low lying estuary areas along the River Blackwater and the River Colne. A more intermittent theoretical coverage is then found inland, primarily within the Tendring Peninsula RSU. However, direct physical effects arising from the offshore wind farms will be limited for a large proportion of the seascape resource. This includes the Stour and Orwell Estuaries RSU and Mersea Island and Estuaries RSU. Within these seascape units a combination of distance, together with the nature and scale of the seascape, will limit the intervisibility and effect on character. When considered further with the elevated Tendring Peninsula RSU, which positively screens visibility, the significance of cumulative effects arising from the GS2 development, in combination with all the Round 1 and 2 developments, will generally be no more than **Minor.**

Within the more open and exposed Maldon Peninsula RSU, to the south, the turbines at GS2 will only provide a slight extension to the small isolated consented turbines of GS1 within a small isolated section of the distant, exposed and simple seascape. They will, therefore, not provide any significant new focus in the seascape resource and only a **Minor** cumulative significance of effect. These two wind farm developments will also be viewed from the majority of the Maldon peninsula, along with the turbines at Kentish flats.

They will also be seen collectively as distinctly separate built elements within the view, with an open exposed flat character of the foreshore dominating the view and providing some capacity to reduce the significance to **Minor - Moderate**. The proposed GS2 site will, however, be located, along with the consented GS1 scheme, within the Tendring Peninsula RSU and will thus, carry more significant effects.

Although most prominent within this unit, where the wind farms will occupy a more central position, the Tendring peninsula RSU also has a good capacity to accommodate change on account of its existing quality, value, existing features and the nature of the components that combine to define its character. The introduction of the GS2 turbines will also represent only a minor increase to the existing extent of turbines at GS1. These all assist with reducing the significance of effect to no more that **Minor - Moderate.**

12.7.6 Additional Round 2 Effects on Seascape Character

In addition, although the turbines of the consented London Array scheme lie beyond the extents of the regional seascape unit, they will add a further significant built influence beyond the combined developments at GS1 and GS2. They will be seen as both a separate and linked development where it overlaps with the developments at GS1 and GS2. They will also typically double the spread of turbines in the seascape resource. The cumulative effect on the Tendring peninsula RSU, arising from the combined GS1 and GS2 developments, together with the London Array development is therefore judged generally to be **Moderate**.

Whilst the effects arising from the developments of GS1, Kentish Flats and London Array may result in a major change inevitably affecting the character of the Essex seascape, cumulative effects arising from these developments in combination with GS2 are no more than **Moderate.** Wind turbines will become a significant characteristic in this seascape regardless of the GS2 development. Whilst the turbines at GS2 will slightly compound the existing effect, they will not lead to a further significant change in the general character of the Essex coast.

12.7.7 Designated Landscapes

As indicated by the cumulative ZTV's and supported by site survey, shared intervisibility between designated landscapes in Essex, the turbines at GS2 and other turbines will be limited to the coastal peripheries of these areas on the Tendring, Maldon, and Rochford peninsulas. This is due, in part, to the distance to the offshore developments from the designated areas, but also because of the intervening vegetation within these areas and the elevated nature of the Tendring peninsula. These will positively assist in containing character and restricting most views towards the coast from the majority of these areas. Intervisibility is particularly limited from the two AONB areas to the north. Cumulative effects arising from the offshore wind farms on designated landscapes within the study area will therefore generally be **Negligible - Minor**.

The effects on the Historic Environment, including the setting of Conservation Areas and Registered Parks and Gardens arising from the GS2 development will be generally be no more than **Minor to Moderate** where a significant built presence along the seafront is already present.

12.7.8 Cumulative Visual Effects

This section of the report summarises the anticipated cumulative visual effects arising from the turbines at GS2 in combination with other identified Round 1 and 2 offshore wind farms. Areas of potential cumulative visibility are illustrated on Figures 12.5 and 12.6 (cumulative ZTV's). The representative wireframes (Figures 12.8– 12.15) and photomontages (Figures 12.16 – 12.23) illustrate the typical anticipated cumulative view for each viewpoint.

The assessment, below, has identified two types of cumulative visual effect, namely effects arising from combined and sequential views. This is in accordance with the Scottish Natural Heritage publication Cumulative Effect of Wind Farms version 2 (April 2005). For full details of the assessment criteria refer to the SVIA Technical Report in Appendix J.

12.7.9 Combined Views

The extent of combined theoretical visual exposure of the GS2 development with the GS1 development (refer to Figures 12.5 and 12.6 - Cumulative ZTV to nacelle and blade tip), broadly covers the same extent within the study area. This is a reflection of the close proximity and integral character of the two adjoined wind farms. The overall effect is that there will be a high visual relationship between the two connected developments, from views along the coast, from the marine component and from intermittent areas inland. In addition, the existing Kentish Flats offshore wind farm, which comprises 30 turbines to 115m blade tip height, will also have a high combined theoretical cumulative visual exposure with the GS1 and GS2 developments.

This coverage is generally limited, however, to the southern half of the study area along Foulness Island, the eastern extents of Maldon peninsula and along the West Mersea and Tendring coastline.

The cumulative magnitude of effect of the Round 1 offshore wind farms with the GS2 development is therefore considered to be *Low*. When combined with a generally *Low - Medium* sensitivity to change to the GS2 development the significance of cumulative effect is considered to be **Minor** with the generally open exposed and remote foreshore areas providing some capacity for change. The cumulative impact is then generally reduced further inland and to the north.

12.7.10 Additional Round 2 Effects on Combined Views

As identified in the visual effects section, a range of further cumulative effects, arising from the addition of the Round 2 development at London Array, will be gained from various locations along the Essex coast and inland. From the nearest representative viewpoint (Figure 11a and b) at Holland Haven, the turbines of GS1 will occupy a 20˚ section of the available 180˚ view and will dominate the central seascape view, with the nearest turbine approximately 6.5km away from the viewpoint. The turbines at GS2 will then sit, for the most part, beyond this development cluster at a minimum distance of 8.3km, with the layout typically being viewed as a continuation of the arrangement in GS1. It will, however, also extend the spread of consented offshore turbines at GS1 by approximately 17° to the north.

In clear weather conditions, when London Array will be visible on the distant horizon, it will introduce a further layer of visual complexity and an extensive built influence to the north overlapping with the prominent cluster created by GS1 and GS2. It will also extend to a total of approximately 55° of the overall view and extend the overall spread of turbines by over 40°. The magnitude of effect arising from the addition of London Array is therefore, assessed as *Medium*. When combined with a *Medium - Low* sensitivity to change to the type of development, the significance of cumulative effect on the key receptor group of visitors to the public open space is assessed to be **Moderate - Minor**.

Although the turbines at Kentish Flats have been illustrated within most wireframe views, at distances in excess of 30km from the Tendring Peninsula and further to the north they will not generally be perceptible. However, to the south they will be visible both in combination views and successional views. The cumulative effect resulting from this development in such locations is therefore more related to the viewer's perception than with actual intervisibility. Whilst the viewer will be aware that other developments are present, they will only view the offshore developments in the same view, infrequently.

12.7.11 Sequential Views

The main vehicular routes inland through Essex include the A120 and the A133, which head towards the coast from Colchester.

From both of these routes the extent of combined theoretical visibility is limited. However, where a degree of combined theoretical visibility is available (along the A120) views will be reasonably continuous and they will only consist of views to either GS1 or GS2 or both. Views will therefore not be interchangeable with the other offshore developments.

Along the Essex coast, within the study area, there are a limited number of vehicular routes, particularly to the south. However, there are two stretches of coastal road along the nearest Tendring peninsula. These include the elevated seafront promenades at Clacton-on-Sea and Frinton-on-Sea. In general, open views of the sea from both of these routes is restricted by the natural and built up elements connected with the two settlements. Where seaward views are available, the turbines at GS2 will be seen in combination with the turbines with both GS1 and London Array. Cumulative sequential effects arising from a combination of GS2 and other wind farm developments in Essex are therefore considered no more than *Low*. Coupled with no more than *Low* receptor sensitivity for travellers on these routes, with mostly perpendicular available views, the overall significance of effect on the Essex coast is overall judged to be **Minor**.

12.7.12 Cumulative Summary

Whilst it is acknowledged that the character of the Greater Thames Estuary would inevitably change should all or the majority of the proposed developments be constructed, GS2 will only contribute typically to a **Minor** cumulative effect on the coastal margins of the Essex and Suffolk, within the 30km study area. Although all the turbines will be visible from the majority of points along the Tendring coast, they will be viewed, at all times, to sit substantially behind the consented turbines of the GS1 project, with only minor extensions to the arrangement depending on the particular location.

The most significant cumulative seascape and visual effects will generally be confined to the nearest landfall along the Tendring peninsula. From these points the turbines will also be seen to sit, for the most part, in front of the horizontal spread of the consented London Array turbines, which will stretch wholly or substantially behind. For the most part, however, the London Array turbines will remain, even in conditions of good visibility, visually recessive along the horizon line and will as such, provide no more than a **Moderate – Minor** level of cumulative significance overall. Elsewhere within the study area the turbines will typically form minor elements within oblique sections of the view with the majority of foreground activity, largely associated with the estuary landscapes, prominent in the view.

12.8 Mitigation Measures

The inherent characteristics of the proposed GS2 development, means that there are very limited opportunities for incorporating mitigation measures within the development. The size and generating capacity of the turbines has to be sufficient to ensure that they remain commercially viable and the actual siting of the turbines is, to a large extent, predetermined by the Crown Estates with only more local adjustments being possible to best suit prevailing seabed conditions. However, it is important to note that the location of the proposed GS2 development has been guided largely by the Strategic Environmental Assessment (SEA) process undertaken for the 2nd round of offshore wind developments.

A key conclusion of this SEA process was that no Round 2 developments should be sited within an 8km visual exclusion zone in order to minimise potential visual impacts upon local receptors. As a result of adhering to this recommendation, and being sited outside this 8km zone, potential visual impacts of the GS2 project have already been mitigated for to a large degree.

Careful consideration has been given to the colour of the structures in order to ensure that they remain relatively visually recessive. However, there is a degree of conflict with existing standard requirements for structures out at sea, which clearly have to remain visible, and identifiable to shipping. Thus, the need to paint the lower sections of the turbine columns yellow, in accordance with Trinity House requirements, is unavoidable. Whilst this assists with improving visibility at sea it should make little difference to visibility from land given that the turbines are to be seen at a minimum distance of 8.5km and substantially to the rear of the consented GS1 scheme. Navigation requirements also necessitate that the turbine locations should be identifiable at night and hence the need for navigation lights, although again at a distance of 8.5km there would be little difference to the visibility from land.

12.9 Conclusions

The assessment process has sought to establish the full extent of the likely seascape landscape, visual and cumulative effects arising from the proposed wind farm development, at all stages of the project. Whilst effects upon the identified regional seascape units will inevitably occur, they will generally be of no more than **Minor** significance from the majority of the study area. More significant isolated effects, will then be limited to the nearest regional seascape unit at Tendring Peninsula where turbines would already be a key component of the seascape character, with the anticipated construction of the consented GS1 and London Array projects. As a result the significance will be limited to **Minor – Moderate**.

The visual effects will be more noticeable than effects upon the character of the seascape resource itself. The proposed GS2 development will represent the addition of a number of significant elements into an exposed visual environment with the consented turbines at GS1 and London Array, once they have been constructed. The GS2 turbines will, in some views, introduce an added density, to the collective arrangement and read as a minor extension to the existing composition of turbines at GS1. There will also be localised areas of **Moderate - Minor** visual effect upon to the nearest eastern urban coastline of Tendring and an isolated area of **Minor - Moderate** effect at the remote coastal edge of the Maldon peninsula. Elsewhere and from the majority of the study area the magnitude and significance of the collective visual effect is however judged to be no more than **Minor.**

The nature of the development, however, with its offshore siting, scale and relative simplicity of the marine components, the focusing, in part, of interest upon the coastal foreshore, and the existence of visually contrasting built elements, all combine to make the proposed development more acceptable in both visual and seascape terms. It is, therefore, considered that the overall nature of the effect will be generally neutral from the majority of seascape units and viewpoints given that the turbines of the consented offshore wind farms will already be there.

The nature of the effect will, however, be slightly adverse from the closest viewpoints on the Tendring coast, i.e. representative viewpoints 2, 4 and 5. From these viewpoints, where the turbines are more prominent in views and discernible as individual elements, the added visual density, complexity and areas of turbine overlap will impart a slightly adverse effect. However, this will often be in the context of the character of the coastal edge which, for much of its length is characterised by visually disparate elements.

13. SHIPPING AND NAVIGATION

13.1 Introduction

This chapter reports on the findings from consultation with navigational stakeholders and from analysis of the vessel traffic surveys, navigation and risk assessment carried out for the proposed Gunfleet Sands 2 (GS2) wind farm development (see full Technical Report in Appendix K). The assessment follows MCA Marine Guidance Note 275(M)[25]. The checklist that accompanies MGN275 is completed and can be found in Appendix K.

13.2 Consultation

Consultation and meetings have been held with representatives of the following stakeholders with interests and responsibilities for navigation in the area.

- The Ministry of Defence;
- Port of London Authority (Pilotage is also subject to Port of London regulations);
- Trinity House Lighthouse Service;
- Maritime & Coastguard Agency;
- Royal Yachting Association;
- Fisherman's Organisations;
- The River Crouch Authority;
- Harwich Haven Authority;
- The Clacton-on-Sea Aero Club and
- Local Diving Club.

13.3 Data Sources

13.3.1 Reference Documents

The following documents have been used and their requirements covered in the Navigational Risk Assessment and the preparation of this report:

Organisation	Reference Document
MCA	MGN 275 (M)
	Draft: "Shipping Route Template"
	Draft Interim Guidance to mariners operating in the vicinity of UK Offshore Wind Farms Wind Farm
RPS Hydrosearch	Summary of Oceanographic Data Acquired Between January 2002 and February 2003 (Report Number 01-306.14)
RYA / CA	Sharing the Wind / Coastal Atlas
BWEA / MARICO Marine	"Investigation of Technical and Operational Effects on Marine Radar Close to Kentish Flats Offshore Wind Farm"
British Marine Aggregate Producers Association (BMAPA	Regional Dredging Charts

Table 13.1 Reference documents used in navigational risk assessment

[25] Proposed UK Offshore Renewable Energy Installations (OREI) - Guidance on Navigational Safety Issues Notice to Other UK Government Departments, Offshore Renewable Energy Developers, Port Authorities, Shipowners, Masters, Ships' Officers, Fishermen and Recreational Sailors.

Organisation	Reference Document
IALA	The Marking of Offshore Wind Farm, Edition 2, Dec 2004
	The Marking of Offshore Wind Farm, Edition 1, Dec 2005
QinetiQ and MCA	Results of the electromagnetic investigations and assessments of marine radar, communications and positioning systems undertaken at the North Hoyle wind farm by Agency- 22 November 2004
MCA / RAF	Offshore Wind Farm Helicopter Search and Rescue Trials Undertaken at the North Hoyle Wind Farm, undertaken March 2005
ETSU	Feasibility of mitigating the effects of windfarms on primary radar W/14/00623/REP DTI PUB URN No. 03/976
BAE Systems	Press Release, 13 June 2005
DTI	Methodology for Assessing the Marine Navigational Safety Risks of Offshore Wind Farms – dated 7th September 2005
UK Government	Energy Act 2004
PLA	Interference to radar imagery from offshore wind farms

Table 13.1 (Cont'd)

13.4 Project-Specific Survey

Two vessel traffic surveys, each of 14 days duration, were conducted using MARICO Marine's radar and AIS[26] tracking and recording system to assist in assessing the impacts that the GS2 project may have on navigational users within the site and the surrounding sea area.

The surveys were carried out by AIS, radar and direct observation by MARICO Marine's watch-keepers, based with the equipment at the Holland Haven radar site, approximately 7km north of the GS2 location.

Operators recorded all vessel types in accordance with MCA guidance note MGN 275(M). Observations were on a 24 hour basis and each continued for 14 days in an area of approximately 8nm around the site. A total of 28 days of combined AIS and radar data was recorded in two periods between 2nd and 16th March 2007 and between 4th and 18th May 2007 to cover seasonal and tidal variations.

13.5 Description of Existing Environment

13.5.1 Vessel Traffic Analysis

After processing, over 49,800 individual records from the first recording period (March 2007) and over 34,370 from the second period (May 2007) were combined within the GIS database. Altogether more than 532 vessel tracks have been plotted from the 14 days of recorded data from March 2007 along with 493 vessel tracks from the survey in May.

Figures 13.1a and 13.1b show an overview of the raw data collected during the 14 day period and includes all radar targets. The proposed wind farm turbine locations are shown as red dots, the GS2 development with a blue border and the consented GS1 development a red border. The 3 possible positions for the substation location are also marked by the yellow circles.

[26] Automatic identification systems (AIS) are designed to be capable of providing information about the ship to other ships and to coastal authorities automatically. The requirements are regulated by the International Maritime Organisation and the regulation requires AIS to be fitted aboard all ships of 300 gross tonnages and upwards engaged on international voyages, cargo ships of 500 gross tonnage and upwards not engaged on international voyages and all passenger ships irrespective of size. The requirement became effective for all ships by 31 December 2004

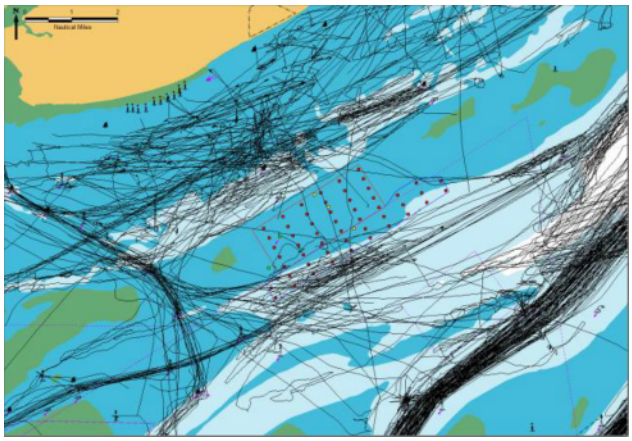


Figure 13.1a: plot of March 2007 traffic

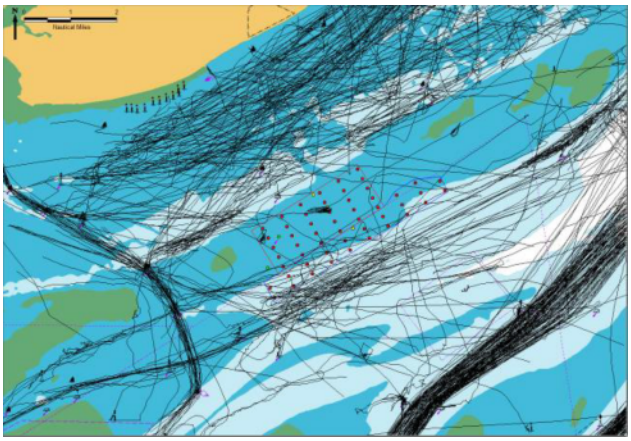


Figure 13.1b: plot of May 2007 traffic

Statistical analysis was carried out from the data collected on vessel type, size and transiting draught to produce overall conclusions on navigation and routeing.

13.5.2 Vessel Traffic Density

An overview of vessel traffic density in the vicinity is illustrated by Figures 13.2a and 13.2b. The area has been divided in to squares with sides of 300 x 300m. The number of vessels passing through each square has then been counted and the resultant numbers colour coded (see key on plot) to give a thematic plot of the density of vessel traffic through each square. Each colored square depicts the total number of vessels that passed through that square during the survey period.

The density of vessel traffic passing through the proposed GS2 wind farm site extension is very low with some activity shown in the south western part of the proposed site.

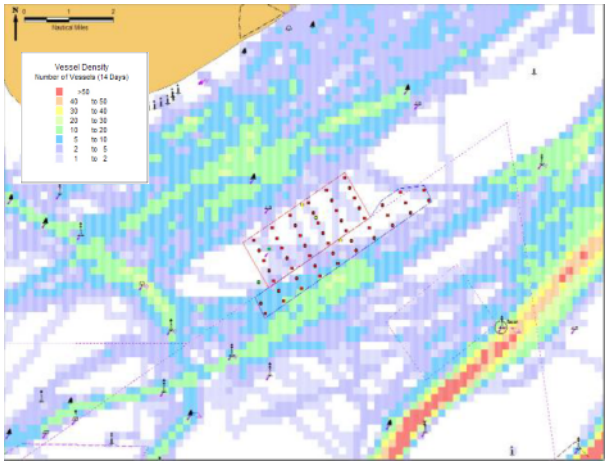


Figure 13.2a: Thematic plot all vessels March 2007

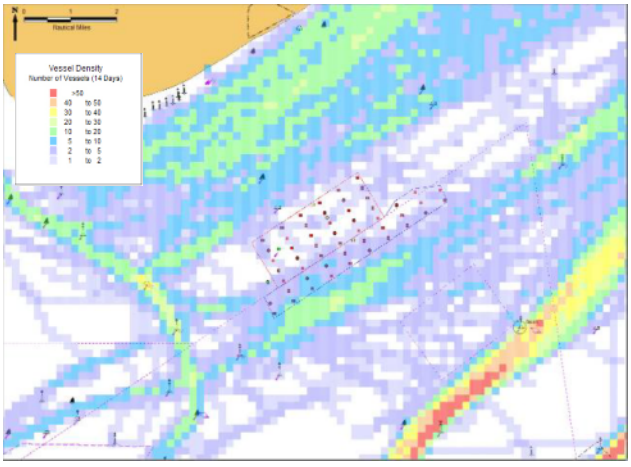


Figure 13.2b: Thematic plot all vessels May 2007

The predominant commercial vessel usage is greater than 3nm from the proposed GS2 site, with vessels using the buoyed channels and avoiding the natural geographic restrictions. The single exception was the lighthouse tender vessel “Alert”.

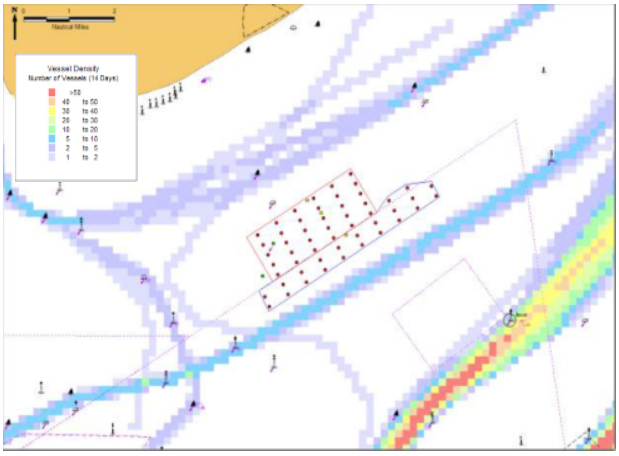


Figure 13.3a: Thematic plot commercial vessels March 2007

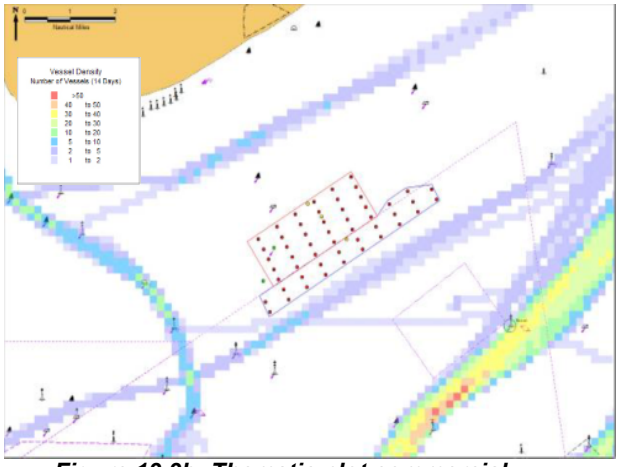


Figure 13.3b: Thematic plot commercial vessels May 2007

Commercial vessel routes of the area remained consistent and the effect of non-transit users of the area such as fishing and yachting in the area can be clearly seen.

13.5.3 Traffic analysis of Base Case by use of Gates

Two Gates[27] were positioned to intersect the main vessel traffic flows. The vessel tracks intersecting the Gates were then analysed.

13.5.3.1 Traffic Analysis through Gate A

The number of targets crossing Gate A at intervals is represented as a bar graph of the number and position of transits in each direction. The highest density in both directions is within the Spitway Channel, approximately 2nm to the west of the site.

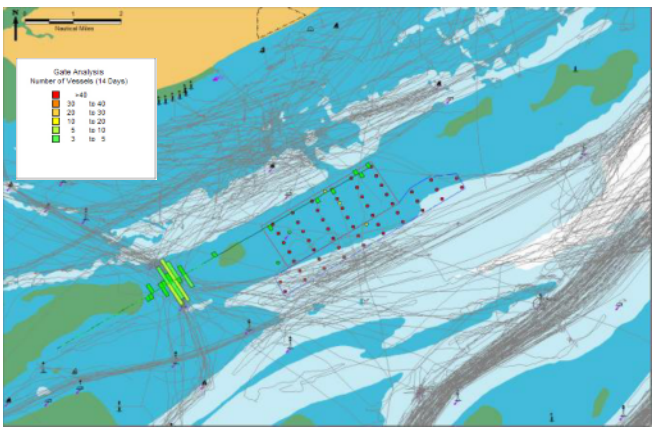


Figure 13.4a: Analysis at Gate A for March 2007

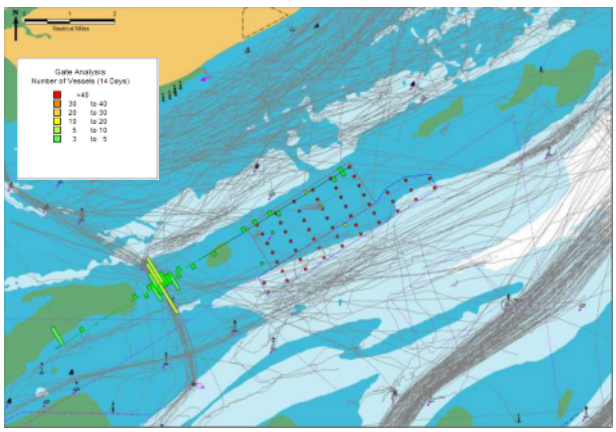


Figure 13.4b: Analysis at Gate A for May 2007

Table 13.2 shows a breakdown by vessel type for the two 14 day survey periods of vessel transits through Gate A.

[27] A "Gate" is an imaginary line between two points used for analysis of a GIS database

Vessel Type	Percentage Of All Vessels (First Period)	Percentage Of All Vessels (Second Period)
Tankers	0%	0%
Dry Cargo	12%	29%
Passenger	0%	0%
Fishing	60%	46%
Yachts	2%	14%
Naval	2%	0%
Others	4%	2%
No Details	20%	9%

Table 13.2 Breakdown of vessels by type passing through Gate A

13.5.3.2 Traffic Analysis through Gate B

Figures 13.5a and 13.5b show the total traffic passing through the analysis 'Gate B'. The flow through the Gate shows that the highest density of traffic in both directions is within the Barrow Deep channel, over 3nm to the south of the GS2 boundary.

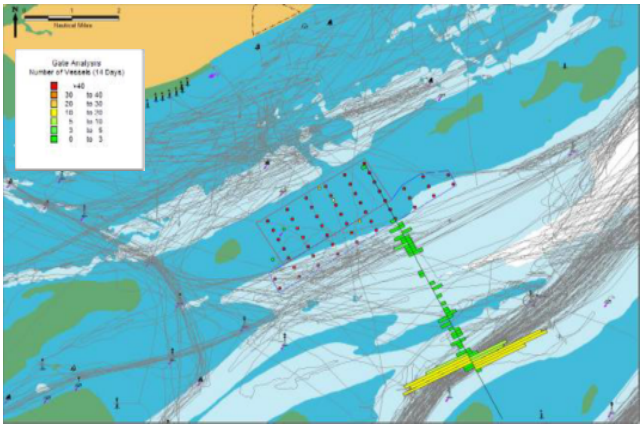


Figure 13.5a: Analysis at Gate B for March 2007

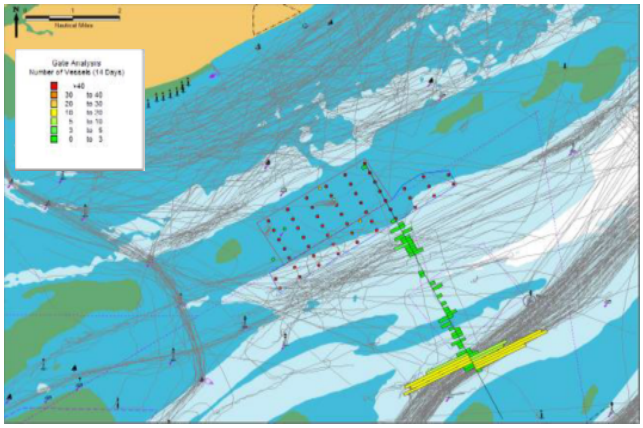


Figure 13.5b: Analysis at Gate B for May 2007

Table 13.3 shows a breakdown by vessel type for the two 14 day survey periods of vessel transits through Gate B.

Vessel Type	Percentage Of All Vessels (First Period)	Percentage Of All Vessels (Second Period)
Tankers	5%	9%
Dry Cargo	33.3%	29%
Passenger	0%	0%
Fishing	19.5%	23%
Yachts	0%	2%
Naval	1%	0%
Others	35.2%	33%
No Details	6%	4%

Table 13.3 Breakdown of vessels by type passing through Gate B

13.5.4 Marine Accident Investigation Board Dataset

The Marine Accident Investigation Branch (MAIB) dataset used to assess incidents in the area covers a period of 10 years from January 1997 to January 2007 and records just 8 incidents that have occurred within the area used in the plots. From the sample recording periods, the overall incident rate on a per movement basis over the 10 years is in the order of **5.988×10^{-5}** incidents or reported near misses per transiting movement; or **8** incidents in **10 years** which equates to an average of **0.8** incidents per annum.

This rate is low, compared to similar results for other areas of the UK east coast.

13.5.5 Royal National Lifeboat Institution (RNLI) Incident Data

The RNLI maintains lifeboats at Harwich, Walton on the Naze, Clacton, West Mersea and Burnham, all of which operate in the area of the development. In the 7 year period from 2000 to 2006, the RNLI lifeboats were called out on a total of 272 occasions to incidents within the area, an average of 45.33 callouts per year.

Of the above incidents, only 1 occurred within the area encompassed by the GS1 site and none at all in the GS2 site. Many incidents occurred over 3nm away from the northern boundary of the GS1 site, along the coastline at Clacton-on-Sea.

It is not expected that the wind farm will adversely affect the number of RNLI incidents and mitigation measures have been identified in the Risk Assessment.

13.6 Impact Assessment

The proposed wind farm is to be marked, lit and provided with navigational aids in accordance with IALA guidelines. The arrangements have been agreed with Trinity House and the impact assessment carried out accordingly.

Impact Title: The proposed GS2 development may lead to changes in vessel routeing

Such is the location of the GS2 project, and with the current vessel tracks through the area already passing already at more than 700m from the closest proposed turbine position, it is unlikely vessels will need to navigate with any change through the area should the proposed site be developed.

It is expected that transiting vessels will continue to use existing buoyage and channel navigation past the proposed site without the need to change, therefore there should be no increase of transiting vessel density due to the GS2 development and thus, **No Impact**.

Mitigation Measures

See Section 13.8 for overview of standard mitigation measures.

Residual Impacts

See Section 13.10.

Impact Title: The proposed GS2 development may lead to changes in navigation incident rates

Overall the GS2 wind farm would be considered to have a **Negligible Impact** on navigation incident rates in the area.

Mitigation Measures

See Section 13.8 for overview of standard mitigation measures.

Residual Impacts

See Section 13.10.

Impact Title: Increases in future traffic levels may create adverse impacts upon the proposed GS2 development

The general indications are that traffic levels in the vicinity of the GS2 site may remain reasonably stable for the foreseeable future with a possible slow increase in ship numbers. There is a possibility of an increase in imports to the River Crouch from vessels delivering materials for construction of the Olympics amenities. However, even a doubling of vessel traffic through the East Swin Channel would only increase the existing flow of 10 ships in 14 days to 20 ships in 14 days, only slightly more than one ship movement per day. After 2012, vessel numbers can be expected to decline slightly as the “Olympic Effect” fades.

Due to the location of the GS2 site well to the north of the main shipping channels, known development projects at terminals in the Thames Estuary are not expected to have a significant effect on traffic flows. While the effect of some of these developments may mean larger ships using the Black Deep (3nm south of the development), activity in proximity to the wind farm is not expected to change.

Therefore, it is unlikely that even a significant increase in vessel traffic would be inconvenienced by the proposed wind farm extension during its lifetime. Overall the GS2 wind farm would be considered to have a **Negligible Impact** to navigation in the area.

Mitigation Measures

See Section 13.8 for overview of standard mitigation measures.

Residual Impacts

See Section 13.10.

13.7 Risk Assessment

The Navigation Risk Assessment (NRA) has been carried out[28] in three parts to cover not only the construction and operation of the wind farm, but also for the eventual decommissioning including the removal of the towers, turbines and other wind farm infrastructure.

13.7.1 Hazard Data Review Process

The hazards identified have been assessed and scored by an expert panel comprising Master Mariners, experienced navigators, construction contractors, wind farm operators, RYA, fishermen, stakeholders[29] and members of the study team. Frequency and consequence data has been assessed for each hazard in terms of a 'most likely' and 'worst credible' scenario.

13.7.2 Hazard Identification Meeting

Hazard identification and scoring meetings were convened, at which the following organisations took part:

- DONG;
- Port of London Authority;
- Representatives of the commercial fishing industry;
- Marico Marine; and
- Royal Yacht Association.

13.7.3 Risk Assessment – Construction Phase

The highest risk number assessed is 5.83, which is within the ALARP (As Low as Reasonably Practicable) range. The top ten hazards identified were as follows:

Rank	Hazard	Most Likely Consequence	Worst Credible Consequence	Risk Number
1	Dropped major item during installation operations	Loss of equipment Delay to construction Injuries	Object hits vessel or a person on vessel Casualties Major delays Major damage or loss of vessel	5.83
2	Helicopter accident	Helicopter ditches Injuries Damage to helicopter	Helicopter crashes Fatalities Damage to vessel Damage to turbines Delay to project	5.69
3	Vessel collides with tower while navigating	Minor damage to vessel Minor damage to tower Injuries	Significant damage to vessel Collapse of Tower Casualties Pollution	4.85
4	Personnel transfers to/from wind turbine towers from service vessels	Minor injury Single major injury	Major injury Rescue services required	4.83

Table 13.4 Top 10 hazards identified for construction phase

[28] In accordance with MCA "Draft Interim Guidance to mariners operating in the vicinity of UK Offshore Wind Farms"

[29] See Sections 12 & 15.4.1

Rank	Hazard	Most Likely Consequence	Worst Credible Consequence	Risk Number
5	Light aircraft accident	Aircraft ditches Injuries Damage to aircraft	Aircraft crashes Fatalities Damage to turbines Delay to project	4.81
6	Construction vessel collides with a fishing or recreational vessel in the vicinity of the wind farm	Minor hull damage Minor delay to construction Injuries	Hulls breached Major delay to construction Loss of vessel & equipment Casualties Minor pollution	4.78
7	Vessel constructing wind farm collides with a fishing or recreational vessel	Minor hull damage Minor delay to construction Delay to fishing vessel	Hulls breached Major delay to construction Loss of vessels & equipment Casualties Pollution	4.78
8	Construction vessel encounters unexploded ordnance	Construction delays due to disposal of ordnance	Explosion Major construction delay Loss of vessel Casualties Pollution	4.59
9	Person in water requires rescue	Minor injury Rescue by own craft or back-up service vessel	Major injury Rescue services required	4.29
10	Personnel injured during transfers between service vessels	Minor injury Service vessel deals with incident	Major injury Rescue services required	4.07

Table 13.4 (Cont'd)

Although the overall risk numbers fall within the ALARP range, there are a small number of individual items that score in the range of 7 to 9 where some consideration for additional mitigation will be beneficial. For example, it was noted that the highest ranked hazard is "Dropped major item during installation operations", as illustrated in the table below.

Here it is clear that the risk to people in the worst credible case is assessed as being 7 and therefore above the ALARP range. Clear work procedures, staff training and close control of the construction phase will be used to mitigate the risk to people and this is acknowledged by DONG.

In each case where the individual assessed risk has scored 7 and above, mitigation must be considered. Additional mitigation will include widely publicising the dangers, issuing notices to local clubs and sailing organisations.

Hazard Detail	Risk By Consequence Category								Risk Overall
	Most Likely				Worst Credible				
	People	Property	Environment	Stakeholders	People	Property	Environment	Stakeholders	
Dropped major item during installation operations	6	6	0	6	7	7	0	7	**5.83**
Helicopter accident	4	7	2	6	6	6	2	6	**5.69**
Personnel transfers to/from wind turbine towers from service vessels	8	0	0	0	6	0	0	6	**4.83**
Vessel makes contact with underwater construction equipment	0	2	0	2	3	6	0	7	**3.81**

Table 13.5 Extract from the construction ranked hazard list

13.7.4 Risk Assessment – Operational Phase

The highest risk number identified is 4.90 which is within the ALARP range. The top ten hazards identified were as follows:

Rank	Hazard	Most Likely Consequence	Worst Credible Consequence	Risk Number
1	Helicopter or aircraft crash	Fatalities Damage to wind farm structure Short term reduction of supply	Significant loss of life Pollution Major damage to wind farm structure Long term reduction of supply	4.90
2	Wind farm maintenance vessel collides with a leisure vessel	Minor hull damage Injuries Delay to wind farm maintenance work	Loss of maintenance vessel and equipment, or leisure vessel Casualties Pollution Minor and partial interruption of supply	4.78
3	In vicinity of wind farm maintenance vessel collides with a fishing vessel	Minor hull damage Injuries	Loss of maintenance vessel and equipment or fishing vessel Casualties Pollution Delay to wind farm maintenance work	4.78

Table 13.6 Top 10 hazards identified for operational phase

Rank	Hazard	Most Likely Consequence	Worst Credible Consequence	Risk Number
4	Deliberate damage to wind farm infrastructure of one or more turbine towers to create hazard to shipping	Damage to navigating vessel(s) Long term partial interruption of supply	Loss of sub-station Damage to navigating vessel(s) Injuries Long term partial interruption of supply	4.50
5	Large navigating vessel fouls export cable	Loss of anchor Drifting vessel Commercial claim Cable damage Short term interruption of supply	Major cable damage Long term major interruption of supply Loss of anchor Commercial claim	4.28
6	Leisure vessels intentionally navigate recklessly through the wind farm	Damage to leisure vessel(s) Injuries SAR required	Loss of leisure vessel(s) Casualties SAR required Short term partial interruption of supply	4.03
7	Wind farm maintenance vessel collides with a fishing vessel within the wind farm	Minor hull damage Injuries Delay to wind farm maintenance work	Loss of maintenance or fishing vessel Casualties Pollution Loss of equipment Minor and partial interruption of supply	4.02
8	Wind farm maintenance vessel collides with a ferry	Minor hull damage Injuries	Loss of maintenance vessel and equipment Casualties Navigating vessel's hull breached Pollution Delay to wind farm maintenance work	3.83
9	Vessel collides with sub-station while navigating	Minor damage to vessel Minor damage to sub-station Injuries	Destruction of sub-station Significant long term interruption of supply Significant damage to vessel Casualties Pollution	3.82
10	Blade failure in vicinity of small navigating vessel	Blade sections miss vessel & land in sea Minor and partial interruption of supply	Damage to vessel Casualties Minor and partial interruption of supply	3.66

Table 13.6 (Cont'd)

There were no individual scores above the ALARP range for the operational phase.

13.7.5 Risk Assessment – Decommissioning Phase

The highest risk number assessed, 5.59 is within the ALARP range. The top ten hazards identified were as follows:

Rank	Hazard	Most Likely Consequence	Worst Credible Consequence	Risk Number
1	Major item dropped during decommissioning operations	Loss of equipment Delay to decommissioning Injuries	Object hits vessel or a person on vessel Casualties Major delay to decommissioning Major damage or loss of vessel	5.59
2	Accident involving leisure craft sightseers	Minor injuries Rescue services required	Casualties Minor pollution Minor decommissioning delays	5.16
3	Member(s) of public involved in accident	Minor injury	Casualties Damage to vessel	5.16
4	Decommissioning vessel encounters existing underwater cables	Damage to existing cable Damage claim	Damage to existing cable Damage claim	5.07
5	Helicopter crash onto decommissioning or service vessel	Helicopter crashes Significant loss of life	Helicopter crashes Loss of all crew and passengers	4.9
6	Decommissioning vessel collides with a fishing or recreational vessel	Minor hull damage Minor delay to decommissioning Injuries	Hull breached Major delay to decommissioning Loss of vessel & equipment Casualties Pollution	4.78
7	Decommissioning vessel collides with a fishing or recreational vessel	Minor hull damage Minor delay to decommissioning Injuries	Hull breached Major delay to decommissioning Loss of vessel & equipment Casualties Pollution	4.78
8	Blade failure	Blade sections land in sea Delay to decommissioning	Loss of vessel Casualties Major delay to decommissioning	4.72
9	Vessel collides with tower while navigating	Minor damage to vessel Minor damage to tower Injuries	Significant damage to vessel Collapse of tower Decommissioning delays Casualties Pollution	4.54
10	Person in water requires rescue	Minor injury Rescue by own craft Rescue by service craft	Major injury Rescue services required	4.29

Table 13.6 Top 10 hazards identified for decommissioning phase

Again there were a small number of individual items that scored in the range of 7 to 9 where some consideration for additional mitigation will be beneficial.

In each case where the individually assessed risk has scored 7 and above, mitigation will be undertaken. The table highlights the risk to people if there was an accident involving leisure craft / sightseers at the construction site.

For decommissioning mitigation, it is assumed that GSL would apply to the Secretary of State for Trade and Industry under section 36A of the Energy Act 2004, to establish Safety Zones of 500m around each offshore structure for the safety of the decommissioning and site clearing process and of the crew of the vessels navigating in the vicinity.

Additional mitigation will include widely publicising the dangers, issuing notices to local clubs and sailing organisations.

Hazard Detail	Risk By Consequence Category								Risk Overall
	Most Likely				Worst Credible				
	People	Property	Environment	Stakeholders	People	Property	Environment	Stakeholders	
Major item dropped during decommissioning operations	6	6	0	3	7	7	0	6	5.59
Accident involving leisure craft sightseers	6	0	0	0	9	0	0	6	5.16
Member(s) of public involved in accident	6	0	0	0	9	0	0	6	5.16
Decommissioning vessel encounters existing underwater cables	0	7	0	3	0	7	0	3	5.07

Table 13.7 Extract from the decommissioning ranked hazard list

13.8 Cumulative and In-Combination Effects

There is only one wind farm currently operating in the wider area; Kentish Flats. However, the GS1, London Array, Thanet and Greater Gabbard wind farms have all been consented and will be developed in the next few years.

The GS2 site adjoins the consented GS1 project and forms an extension to it. Although GS2 will increase the size of the site by adding up to 22 turbines, their location on the Gunfleet Sands is out of the lanes used by commercial traffic and will not increase traffic density in the area. Therefore, we consider the effect in-combination with the GS1 site to be **negligible**.

The closest distance between the GS2 site and London Array is about 8nm and is, therefore, within the 5 to 10nm range that is labelled as 'Tolerable' in the draft 'Wind Farm Shipping Route Template' (MCA, 2005). All other wind farm developments are outside this range and no impacts are expected.

The vessel traffic flows in the vicinity of the London Array are not expected to significantly affect the GS2 project, as the developers are predicting only minor changes in traffic patterns due to the installation of the wind farm (RPS, 2005).

The development at Greater Gabbard and the proposed changes to the routeing in the adjacent Sunk area will not have an effect on the traffic flows passing the GS2 site as the same channels within the Outer Thames Estuary and within the vicinity of the GS2 site will still be used. The other wind farms in the area are not expected to have any significant effect on the GS2 site due to their remote positions. Therefore, the overall in-combination effects of the other wind farms in the area are expected to be of **negligible** significance.

13.9 Mitigation Measures

13.9.1 General

The wind farm will be marked and fitted with navigational aids as required by Trinity House, the MCA and the PLA.

A possible reduction in the coverage by the PLA's Holland Haven radar has been identified and so the developers have agreed to install an additional radar scanner on one of the turbine towers at the south eastern end of the GS2 site to supplement the existing installation and mitigate any effects.

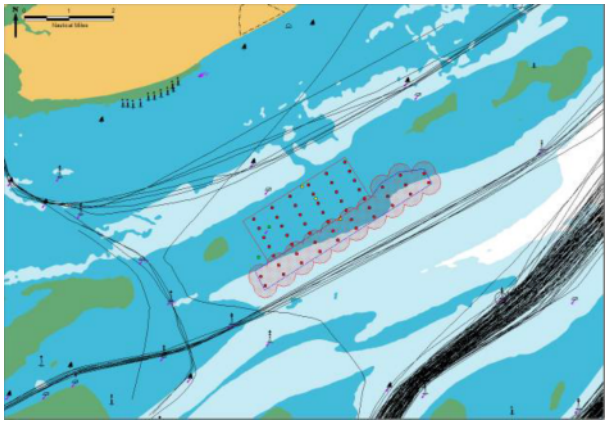
13.9.2 Risk Reduction – Construction and Decommissioning Phases

During construction and eventual decommissioning of the wind farm it is expected that DONG will apply to the Secretary of State for Trade and Industry under section 36A of the Energy Act 2004, to establish Safety Zones of 500m[30] around each offshore structure. This would be on the basis of safety of life and is in line with existing practice.

This distance is also consistent with the MCA's Wind farm 'Shipping Route Template', which suggests that shipping routes should be kept a minimum of 500m distance from wind turbines and that the area should be designated as "Small Craft Only Recommended".

Some recorded traffic uses the area to the south western end of the GS2 site; however this has already been identified as limited to fishing vessel activity.

It can be seen from Figure13.6a and 13.6b that all vessels (except one) passed over 700m from the proposed turbines and therefore 200m beyond the edge of the 500m assessment boundary. The exception vessel, passing at 500m to the proposed tower positions, was a small (60m length) dry cargo vessel. No commercial vessels were recorded passing through the site or boundary areas.



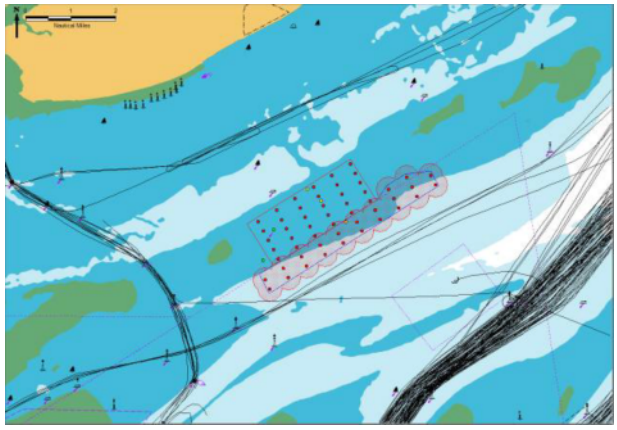


Figure 13.6a: Commercial vessel tracks – March 2007 ***Figure 13.6b: Commercial vessel tracks – May 2007***
(Turbines shown with 500m safety zones)

The following were identified as measures to reduce risk during the construction phase and decommissioning of the wind farm project:

[30] See Wind farm 'Shipping Route Template' – IMO/UNCLOS Safety Zone

General	• Site surveys; • Inaccessibility of most of site to larger vessels due to draft; • 500m safety zone around each tower/substation during construction and decommissioning; • Dissemination of information to ports, yacht clubs, local organisations and fisherman's associations; and • Notices to Mariners, update charts, etc.
Operational	• Use of onshore vessel movement coordinator; • Staff training; and • Boat crew training.
Procedural	• Work procedures; • Emergency response procedures; and • SAR Procedures;
Vessel Movements	• Pilotage and pilotage exemptions for commercial vessels as per existing PLA requirements; • International Regulations for Preventing Collisions (ColRegs); • Positioning of Lights & NavAids for site in accordance with IALA; and • Cover of site by standby craft/rescue boats capable of helicopter transfers.
Aviation	• Clacton-on-Sea Airfield to be kept notified of any pertinent operational matters; • Vertical clearance zones above construction vessels; • Helicopter operation procedures; and • Light aircraft should be kept away using CAA limitations.

Table 13.8 Summary of mitigation measures to reduce risk during construction/decommissioning phases

13.9.3 Risk Reduction – Operational Phases

General	• The site has low vessel traffic density; • Most of wind farm site is inaccessible to medium and large vessels; • Ferries do not operate close to the wind farm; • Dissemination of information to ports, yacht clubs, local organisations and fisherman's associations; • 22m clearance of blades; and • Notices to Mariners, updated charts, etc.
Operational	• Staff training; • Boat crew training; • Exercises with Rescue & Emergency Services; • Turbine blades stopped when iced formed; • Emergency cover by standby craft/rescue boat within farm when on site; • Maintenance vessels should have rescue capability and be capable of helicopter transfers of casualties in clear area for rapid transfer of serious injuries.

Table 13.9 Summary of mitigation measures to reduce risk during operational phase

Procedural	• Work procedures; • Emergency response procedures; and • SAR Procedures.
Vessel Movements	• Pilotage and pilotage exemptions for commercial vessels as per existing PLA requirements; • International Regulations for Preventing Collisions (ColRegs); • Positioning of Lights & NavAids for site in accordance with IALA; and • Drifting vessels can anchor.
Aviation	• Clacton-on-Sea Airfield to be kept notified of any pertinent operational matters; • Helicopter operation procedures; and • Light aircraft should be kept away by CAA limitations.

Table 13.9 (Cont'd)

13.9.4 Search and Rescue Services (SAR)

It is clear from the investigations carried out at the North Hoyle offshore wind farm[31] that, with the exception of helicopter operations, the SAR services could continue to operate as at present. The investigations carried out highlighted that there could be limitations on the use of helicopters in offshore wind farms and further consultative work continues. The helicopters from Wattisham would have a response time of about 25 minutes.

The size and capability of the boats used by the RNLI from the local stations should mean that they would still be able to access the wind farm site without undue problem. The wind farm maintenance and support vessels will add to the coverage in the area and may provide scope for the development of operational co-operation with the helicopter services.

Any increase in need for SAR due to the wind farm will be mitigated by jointly developing procedures with the SAR services and providing co-ordination training for the wind farm service vessels' crew.

DONG has confirmed that they are mindful of this situation and well aware of the importance of maintaining the effectiveness of the SAR services in the area. Therefore, DONG has made a firm commitment to work with the MCA before the offshore construction commences to develop detailed and effective Emergency Response & Co-operation Plan and procedures for the project that cover its construction, operation and decommissioning phases.

13.10 Residual Impacts and Conclusions

From the work carried out it has been concluded that the proposed GS2 wind farm extension is not expected to significantly increase navigational risk for the following reasons:

- Commercial shipping is constrained into buoyed channels by geographic restrictions of water depths, tidal range and sand banks;
- No commercial vessels were observed passing through the site and the predominant vessel type in the area was the fishing vessel;
- The predominant route used by commercial vessels in transit was the Barrow Deep channel, more than 3nm to the south, the ships being restricted to this channel by their draft;

[31] MCA / RAF: Offshore Wind Farm Helicopter Search and Rescue Trials Undertaken at the North Hoyle Wind Farm, undertaken March 2005.

- The proposed site is within the harbour limit of the Port of London Authority who control shipping within the vicinity through an advanced VTS and traffic information system;
- Pilots are available and pilotage is compulsory for most significant vessels;
- A few commercial vessels were observed using the East Swin Channel directly to the south. Here commercial vessels passed mostly 750m away from the closest proposed turbine location, following the buoyed channel;
- Very few commercial vessels were observed in transit using Spitway Channel to the west, those that did followed the buoyed channel, approximately 3000m away from the closest proposed turbine location;
- Few vessels cross the Gunfleet Sands bank, those that do require to be a shallow draught and are therefore, by definition, small vessels;
- The area of the proposed wind farm is not currently used by waiting vessels or as an anchorage;
- No incidents were recorded by MAIB (1997-2007) within the proposed site and the overall rate for the surrounding area at 5.988x10-5 per unit transit, is very low;
- The RNLI already have adequate cover in the area. The majority of incidents to which they responded occurred along the shoreline at Clacton-on-Sea;
- It is unlikely that commercial vessels will need to change routes through the area, leaving the existing traffic density unchanged and the risk profile unaffected;
- The Wattisham Helicopter SAR base is only 25nm from the proposed GS2 site, with an expected reaction time of about 25 minutes;
- It is predicted that the turbines will not significantly increase the visual impairment locally for vessels navigating in the area;
- The installation of an additional radar scanner on one of the turbine towers at the south eastern end of the site for the Port of London Authority will mitigate expected effects at the existing Holland Haven radar site;
- Following recent research work, the wind farm is expected to have only minor significant effects on ship's radar;
- The overall in-combination effects of the other wind farms in the area are expected to be of negligible significance;
- Emergency Response & Co-operation Plans will be developed by detailed consultation with the SAR services;
- The navigation services provided by the PLA will undoubtedly cover the Gunfleet Sands site within their warning systems for vessels navigating in the Thames Estuary;
- Safety Zones of 500m around each offshore structure is expected to be applied for during construction and the eventual decommissioning phase;
- Construction site hazards (items dropped from towers), which features high on the Ranked Hazard List during construction and decommissioning will be mitigated by staff training, work procedures and onshore co-ordination of movements during the construction and decommissioning phases;
- Mechanical failure onboard a large ship, leading to a drifting or loss of control situation, is unlikely to lead to the vessel contacting a turbine tower due to the location of the site largely on the side of a sand bank on which the vessel, if of significant size, is likely to ground first;
- Obstruction heights for the turbines will be placed on aviation charts and the lighting fitted to the turbines in accordance with Civil Aviation Authority requirements;
- Clacton-on-Sea flying club confirm that their aircraft do not fly more than 1 or 2 miles offshore and so will not over fly the area;
- The assessment considered that the likelihood of incidents with sightseers was low, the promulgation of information and the 500 metre safety zones during construction and decommissioning are the best mitigation;
- An accident to wind farm operational staff features in the top ten hazards. Close attention to staff training and tight operational procedures will implemented by the developers;
- Wind farm service vessels will work in pairs to ensure that, should one be needed to deal with an incident, the other will be able to cover remaining personnel obligations on site; and

- The risk assessment identified one possible hazard related to security, namely deliberate damage to wind farm infrastructure, based on the ability of dissident groups causing disruption to power generation systems. The realism of such a consideration is difficult to justify but its inclusion ensures that the possibility is not neglected. Regular updates of the risk assessment will also help to adjust the position of such a hazard to its rightful place in the order of consideration.

13.11 Proposed Monitoring

As the site is within the PLA VTS area, the infrastructure will be in place to allow navigation in the area to be closely monitored.

The wind farm will be monitored 24/7 from a shore based control room with full operational control of the turbines. Communication procedures between the wind farm operational control room, maintenance base, the PLA and the MCA will be put in place before the commencement of construction and will be maintained throughout the life of the project.

It is proposed that the vessel traffic in the area will be reassessed one year after completion of the construction and periodically after that as found necessary in consultation with the PLA and the MCA.

14. MARINE ARCHAEOLOGY

14.1 Introduction

This section presents a summary of the baseline conditions identified in the report prepared by Wessex Archaeology (2002) for the GS1 offshore wind farm and the supplementary report on updated data for the proposed GS2 offshore wind farm, prepared by RPS (2007) – see Appendix L.

14.2 Consultation

In response to the scoping exercise, English Heritage Maritime Archaeology Team made reference to the importance of the archaeological analysis of geotechnical and geophysical survey data that, along with desk-based assessment, would help determine the potential implications of the development on marine archaeology and wrecks. This response also made reference to the preparation of a mitigation strategy in the event that material of archaeological interest was affected by the proposed development, or discovered during the project.

Consultation will continue with English Heritage's Maritime Team and also Essex County Council Historic Buildings and Conservation Group throughout the EIA process to include proposals for mitigation measures.

14.3 Data Sources

Data for the desk-based studies and field surveys was obtained from various sources including:

- Records of wrecks, obstructions and casualties (documented losses) from the National Monuments Record (NMR);
- Records held by the Receiver of Wreck;
- Records held by the UKHO;
- Records of known archaeological sites and finds from the Essex Heritage Conservation Record (EHCR);
- Geophysical surveys including side scan sonar, sub-bottom and magnetometer survey undertaken by Titan Environmental Surveys Ltd in 2001 and Osiris Projects Ltd in 2005 and 2007;
- Documentary sources, including Wessex Archaeology, Essex Record Office and Colchester Museum;
- Ministry of Defence; and
- Local fishermen

The assessment has been prepared with reference to appropriate EIA guidance and "good practice" advice including that presented in:

- Institute of Field Archaeologists (IFA) Standard and Guidance for Archaeological Desk-Based Assessments (IFA, 1999);
- Joint Nautical Archaeology Policy Committee's Code of Practice for Seabed Development (JNAPC, 2006); and
- Historic Environment Guidance for the Offshore Renewable Energy Section (COWRIE, 2007).

14.4 Project-Specific Survey

As part of the site development, a detailed marine geophysical survey was carried out from September to December 2005 by Osiris Projects Ltd to establish subsurface conditions and locate seabed features including those that may represent an archaeological site (RPS, 2006). This survey entailed sidescan sonar and magnetometer survey over an area of approximately 5100m in length and 740m in width at 40m line centres. Further survey work was carried out in 2007 to collect additional geophysical data over parts of the site and also to use a ROV to investigate anomalies identified in the 2005 survey.

14.5 Description of Existing Environment

14.5.1 Designated Sites

14.5.1.1 Protection of Wrecks Act 1973

There are no wrecks or areas subject to designation under the Protection of Wrecks Act that lie within the proposed GS2 site. The nearest wreck designated under the Act lies in the South Edinburgh Channel, *c.* 20 kilometres to the south of the proposed wind farm.

If a wreck of historical, archaeological or artistic importance was discovered in the course of proposed works, then it would be possible for the Secretary of State to designate it at very short notice, irrespective of any inconvenience to development.

14.5.1.2 The Ancient Monuments and Archaeological Areas Act 1979

Statutory protection for archaeology is principally enshrined in the *Ancient Monuments and Archaeological Areas Act* (1979). Nationally important sites are listed in a Schedule of Monuments and are accorded statutory protection. The Act can be used to protect wrecks and other forms of nationally important monuments below mean water level to the limit of the UK Territorial Sea. There are no scheduled monuments that lie within the proposed wind farm. Those in the wider area include the medieval parish church and cemetery at Holland-on- Sea.

14.5.1.3 Protection of Military Remains Act 1986

There are no sites that fall within the terms of the Protection of Military Remains Act within the proposed GS2 site or within the wider MSA. However, there are nine recorded losses of military aircraft that are recorded as having 'ditched off Clacton-on-Sea' whilst in military service, or due to military action. These losses are shown in Table 14.1

ID	Name	Date of Loss
2029	Supermarine Spitfire MK IIA P7383	1941
2030	Hawker Hurricane MK IIB Z3152	1941
2031	Hawker Hurricane MK IIB Z3186	1941
2032	Bristol Blenheim MK IV Z7363	1941
2033	Hawker Hurricane MK IIA Z2513	1941
2034	Supermarine Spitfire MK VB BL337	1942
2035	Supermarine Spitfire MK VB BL720	1942
2036	Supermarine Spitfire MK IX LZ922	1943
2037	Supermarine Spitfire MK VB BM19	1944

Table 14.1 Military losses of aircraft during action

The records for the losses adjacent to the Study Area represent reported points of loss that have not been confirmed by survey. In most cases, records of aircraft lost whilst on military service do not have a recorded location of their place of loss, as this is often unknown. As the given locational qualifier for all aircraft ('off Clacton-on-Sea') is vague, the crash site cannot be predicted with any accuracy.

Given the level of air activity over the Thames Estuary during WWII there is a relatively high potential for further aircraft or related material to be present within the Study Area. By way of an example, the *Second World War ARP Incident Files* held by the ERO cite an aircraft that crashed in the sea off Holland Haven in June 1941. The NMR does not record this aircraft. Any aircraft that have crashed while in military service are automatically protected by the Protection of Military Remains Act 1986. In addition to military aircraft, Table 14.2 lists the vessels that may have sunk in the region while in military service, or due to military action.

ID	Name	Date of Loss	Description
2000	*Resolute*	1943	76 tonne British barge buried under a series of small sandwaves giving a significant localised magnetic anomaly. Wreck dispersed to the seabed in 1950.
2002	*HMS Reed* (possibly)	1940	99 tonne British Drifter struck by a mine in the Thames estuary. This 30.5 m wreck is broken up and sits in a scour 'littered with wreckage'.
2006/2007	*Resolute* (part of)	1943	Considered to be part of British barge, but not located by UKHO since 1986.
2010	*Ability*	1940	293 tonne British motor barge mined in 1940, the vessel is broken up and lying in a trough in an undulating seabed.
2020	*SS Adaptity*	1940	Armed British Cargo Vessel of 372 tonnes, mined in 1940. Not located since 1975
2021/2022	*Tam O Shanter* (part of)	1943	British barge wire swept in 1959, and not located since 1974

Table 14.2 Military losses of vessels whilst in service

Although all of the above vessels might be regarded as 'war graves', this term has no meaning in law. Moreover, none of these wrecks appear to have been designated as a 'protected place' or 'controlled site' hence the site-specific provisions of the Protection of Military Remains Act 1986 do not apply. However, it would be an offence to carry out unauthorised excavations for the purpose of discovering military remains. None of these vessels lie within the proposed wind farm, the nearest is *SS Adaptity* **2020**, which lies within the Study Area.

14.5.2 Prehistoric Archaeological Potential

The scenario for sea level rise in Appendix L suggests that the area of the proposed wind farm has the potential to contain terrestrial sites from the Palaeolithic, Mesolithic and possibly the Neolithic (500,000 BP to 2,400 BC).

For the Lower Palaeolithic there is clear evidence of activity within the region. One of the main 'type sites' for the period is located near Clacton-on Sea. The Clactonian flint assemblage represents occupation along the early Thames/Medway watercourse for about three kilometres, and is associated with faunal remains, palaeo-botanical data and a rare wooden spear. The spear has been used to support the assertion that active hunting was part of the Lower Palaeolithic subsistence economy within the Thames palaeovalley. Mineralised mammal teeth recovered by fishermen off Clacton (R. Jacobs, *pers. comm.*) may relate to the faunal remains element of the Clactonian Thames/Medway assemblage.

Two identifiably Palaeolithic sites are located on the coast and refer to Lower Palaeolithic material found in terrace gravels above the low cliffs between Clacton-on-Sea and Holland-on-Sea. The strata containing these sites are not obviously present within the sub-bottom profiler data, thus any Lower Palaeolithic material is only likely to occur within a re-worked context in sediments below the low water mark.

The Middle Palaeolithic is marked by a general absence of sites and finds within the British archaeological record.

During the Late Upper Palaeolithic the area of the proposed wind farm was on dry land located at the head of one of the late-Devensian Thames-Medway palaeovalley systems, now located *c.* 20 m below OD (Bridgland, 1995). The human occupation of Britain appears to have recommenced at approximately 13,000 BP at a time when the subsistence economy relied on hunting and gathering. Given that river valleys were favoured hunting sites it seems reasonable to suggest that Palaeolithic occupation may be expected within the general area of the proposed wind farm. Such sites are rarely exposed with many probably destroyed or buried by fluvial deposits as sea level rose after the end of the Devensian glaciation.

The presence of an active Mesolithic population within the region is demonstrated by the existence of major sites at Walton, on the Rivers Blackwater and Crouch, and a smaller site at Jaywick (Wilkinson and Murphy, 1995). Typically these sites occur as scatters of stone tools specific to the activity being performed. The Crouch and Blackwater sites were found within a silty-clay layer that overlay London Clay. Similar sequences have been identified within the sub-bottom profiler data along the marine cable route for the Gunfleet Sands 1 Wind Farm.

The presence of Neolithic occupation in the region is suggested by single chance finds and archaeological fieldwork undertaken in 1984 on behalf of Essex County Council on the beach at Jaywick (Wilkinson and Murphy, 1995). At Jaywick, evidence for prehistoric occupation was recorded at intervals along a length of former land surface within the intertidal zone. Underlying the beach deposits at Jaywick there were various circular wooden structures, a small dug out canoe and two broken wooden paddles (Warren, 1936). These features demonstrate occupation on the coastal margins and appear to relate to populations exploiting marine resources. The best exposures of former land surfaces upon the London Clay were found towards the top of the beach where it was overlain by grey marine clays. The possibility of finding Neolithic sites within the proposed wind farm will depend upon the extent to which the marine transgression has removed or sealed the former land surfaces.

Following the Mesolithic and possibly the Neolithic, the archaeological potential of the proposed wind farm is maritime (i.e. wreck) related.

14.5.3 Maritime Archaeological Sites

14.5.3.1 Known and Reported Wrecks

Records of wrecks, obstructions and casualties within the Study Area were collated using information provided by the UK Hydrographic Office (Wrecks Section), the National Monuments Record (NMR) and the Receiver of Wreck. These records were compared with charts of seabed features with the result that 10 separate wreck sites were identified of which three lay within the footprint of the proposed wind farm (**201, 2013** and **2017**). These wrecks are classified in Table 14.3 and illustrated in Figure 14.1. A full list of those identified in the Study Area is presented in Appendix L.

Wreck Status	Wind Farm	Marine Study Area (MSA)
Live Wreck – a reported obstruction or loss found by UKHO survey	3	7
Dead Wreck – a reported obstruction or loss considered not to exist by the UKHO	0	2
Recorded point of loss (position vague)	0	1
Total	**3**	**10**

Table 14.3 Classification of wreck status

The three unidentified wrecks within the footprint of the proposed wind farm are located in the north-east area. Wreck 201 is located 266m SW of turbine F9; Wreck 2013 is located 95m NE of turbine E7; Wreck 2017 (which correlates with a geophysical anomaly 304) is located 327m NNE of turbine F6.

14.5.3.2 Geophysical Anomalies

In addition to the wreck records, marine geophysical data collected by Titan and Osiris Projects Ltd were assessed archaeologically. A total of 28 anomalies were identified from the elements of the data that lay within the Study Area, of which six lay within the footprint of the proposed wind farm. These anomalies are summarised as follows in Table 14.4.

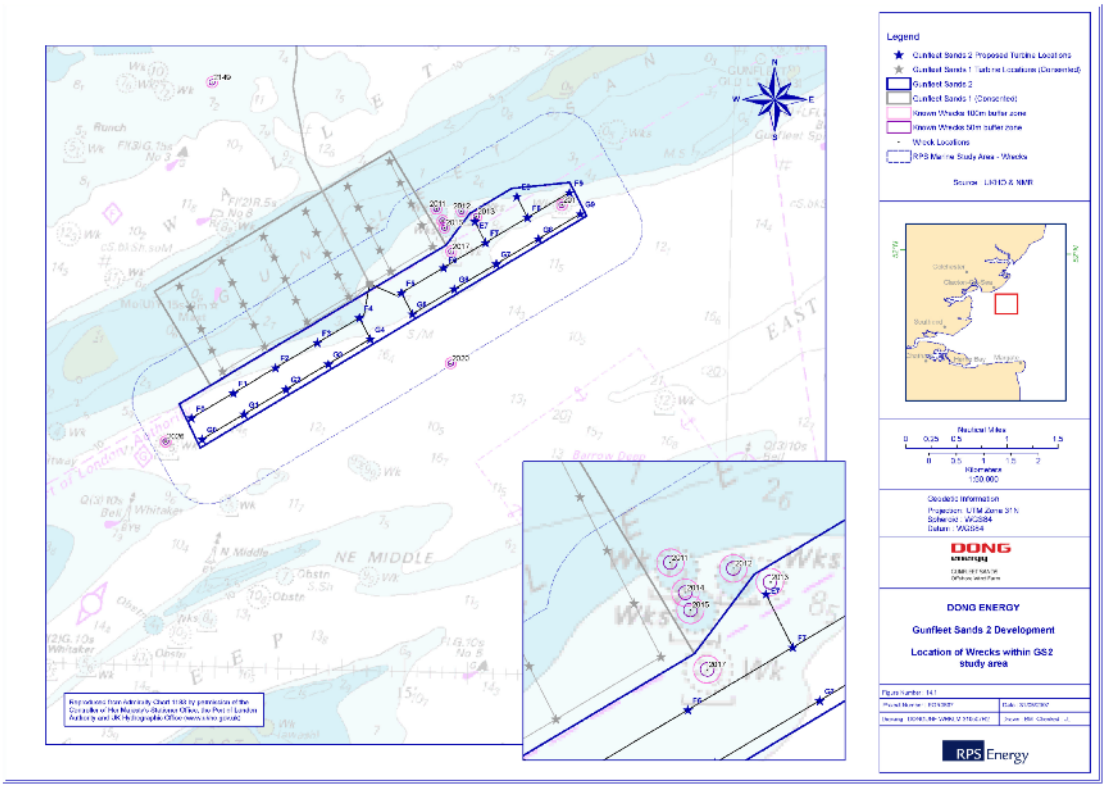


Figure 14.1 Wrecks identified in the proposed wind farm development area

Anomaly Type	Wind Farm	MSA
Anomalies most likely to represent wrecks	1	2
Small side-scan / magnetic anomalies - possibly metal debris	3	9
Side-scan / magnetic anomalies likely to be minor debris	2	10
Magnetic anomaly with no side-scan hit	-	6
Misc	-	1
Total	**6**	**28**

Table 14.4 Anomaly type and occurrence

Of the six anomalies identified within the proposed wind farm only anomaly **304** appears to be a probable wreck. This correlates with the unknown wreck **2017** and lies 327m NNE of turbine F6. Anomaly **303** in the south and anomalies **305** and **306** in the north-east corner are interpreted as 2m long objects and appear to represent possible unexploded ordnance. Anomalies **301** and **302** in the north-east corner appear to represent minor debris.

14.5.3.3 Documented Losses

The NMR locate recorded losses for which there is no confirmed position at certain arbitrary points around the coast – called Named Locations (NLOs). Within the vicinity of the proposed wind farm there are two named locations:

- Off Clacton-on-Sea; and
- On Gunfleet Sands

The 18 documented losses recorded as lost 'Off Clacton-on-Sea' include vessels lost between 1633 and 1943. They comprise both merchant and military vessels and include nine WWII aircraft. It should be noted that some of the located unidentified wrecks and obstructions within the Study Area might relate to a documented loss. Additional research by Wessex Archaeology has demonstrated that at least one further wreck, the *Cygnet* (Richmond, 1868), not recorded by the NMR, was lost on the Gunfleet Sands indicating the possibility for further vessels not yet recorded.

The NLO 'On Gunfleet Sands' is located to the north of the proposed wind farm. However, it records the loss of a further 183 vessels within the Gunfleet Sands region. Where known, the dates of these losses are recorded in Table 14.5.

Date of Loss on Gunfleet Sands		Number of losses
Post-medieval	Up to 1649	1
	1650-1699	10
	1700-1749	0
	1750-1799	45
	1800-1849	69
	1850-1899	40
Modern	1900-1913	7
	WWI	3
	1919-1938	0
	WWII	8
Total		**183**

Table 14.5 Documented losses on Gunfleet Sands

Records held by the Receiver of Wreck note three distinct areas of historic wreckage (i.e. wreck over 100 years old) recovered from the Gunfleet Sands area, 5-8 miles east of Clacton Pier. Colchester Museum has dated the material recovered to between 1780 and 1830, although was

unable to provide any further information on the material, including the exact location of the sites (pers. comm.). The recovered material relates to three individual sites (**2149**):

- A wooden wreck carrying granite building stones. Some of the stones have been raised;
- A buried vessel carrying mill-stones which was dated to c. 1780 by a cannon ball, a sword handle and various stone items recovered from the wreck. The timbers from this vessel are noted to have 'mostly gone'; and
- A wooden wreck possibly carrying a cargo of wine. A bell has been recovered from the wreck bearing a makers stamp. The wreck has been dated to c. 1780 by the bottle collection.

Further material recovered from the seabed by local fishermen includes a collection of seventeenth century German/English Bartmann jugs and a complete Mediterranean storage vessel (**2147**). The finds were trawled from the seabed within the vicinity of the proposed wind farm, although no precise location can be attributed to them.

These finds suggest the presence of two seventeenth century wreck sites within the vicinity of the Gunfleet Sands (although the NMR records only one seventeenth century vessel lost off Clacton-on-Sea: a Dutch cargo vessel, **2038** stranded and abandoned near Little Holland in 1633).

Additionally, 20 to 30 Second World War parachute mines are trawled from the seabed within the general Gunfleet area on an annual basis (Richard Jacobs, pers. comm.). The recorded ordnance is considered in Chapter 16.

14.5.4 Maritime Archaeological Potential

The dated casualties show a strong bias towards the period between the late eighteenth century and the Second Word War. This is principally due to the beginning of the systematic recording of casualties during the eighteenth century (mostly for insurance purposes) and is not indicative of an absence of maritime activity during the preceding centuries.

The potential for wrecks within the vicinity of Clacton-on-Sea and Gunfleet Sands covers all periods, dating as far back as the inundation of the area during the Neolithic. Although the potential for the survival of early prehistoric boats in UK waters is scarce, a Neolithic canoe has been found at Jaywick, near Clacton (Warren 1936). Various Bronze Age boats and cargoes have been found around the coast of England and Wales, notably in Langdon Bay near Dover. To date these discoveries have been made at or close to the shore rather than in open waters, possibly reflecting patterns of ancient seafaring that favoured routes close to the shore. From at least the Iron Age onwards, however, sea-going ships could have traversed out to the Gunfleet and some among them are likely to have foundered, either as a result of collision, war or weather. It is possible that some remains of these vessels and their cargoes may have survived.

Subject to the circumstances of loss and the effects of post-depositional processes, potential wrecks sites may occupy an extended area beyond the confines of any remaining hull. This extended area may contain significant elements of structure, artefacts and stratified deposits that would be an integral part of the wreck site.

In addition to the potential for shipwrecks of many periods, there is also a potential for stray finds of ship-borne debris items lost or thrown overboard.

14.5.5 Previous Maritime Impacts

The baseline data suggests that two types of archaeological site may be present within the proposed wind farm: drowned prehistoric sites and landscapes; and shipwrecks and associated material. Both these site types are likely to have been subject to previous disturbance.

The main processes militating against the survival of prehistoric land-surfaces and any associated sites are the reworking of those deposits during the course of marine transgression. Wave and tidal action are likely to have repeatedly eroded and deposited former terrestrial material, washing out fine sediments, abrading otherwise robust artefacts and exposing organic materials to chemical and biological decay.

The process of wreck formation is itself likely to be the main source of previous disturbance to wrecks within the Study Area, as vessels reaching the seabed are likely to suffer various forms of collapse and decay before stabilising. The main post-depositional processes active in the area are likely to be sand movement and trawling. Sand movement may expose and rebury a wreck, causing periodic instability that leads to physical, biological and chemical decay.

14.6 Impact Assessment

14.6.1 Impact Assessment Methodology

This section assesses the likely effects of the development on this resource in terms of the importance of the identified receptor and the degree of direct and indirect impact by the development. Proposed mitigation measures and the residual effects are also identified.

Details of the impact assessment methodology are included within Appendix L.

Impact Title: The proposed GS2 development may create adverse impacts upon marine archaeology and wrecks

The baseline conditions indicates that there are three unidentified wrecks within the foot print of the proposed wind farm and suggests there is a potential for prehistoric terrestrial sites of Palaeolithic, Mesolithic and possibly Neolithic date, as well as unknown wrecks, cargoes or stray items of ship-borne debris from at least the Iron Age onwards.

14.6.1 Construction Phase

Aspects of the marine construction that may provide a threat to the marine archaeological resource or wreck comprise:

- Installation of foundations for the turbines;
- Installation of scour protection;
- Inter-turbine cabling within the wind farm; and
- Anchoring by construction and maintenance vessels.

Scour protection may be placed around the centre of each foundation prior to its installation. The internal electrical infrastructure will comprise cables running from the turbines to the offshore sub-station. The cables will be buried in sub-sea trenches to a target depth of approximately 2m which provides protection against marine activities and scour.

Various vessels will be used in the construction of the wind farm, including 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 over an extended area.

Any wrecks, prehistoric deposits, land-surfaces and artefacts that are present within the footprint of the various elements of the scheme, at depths reached by construction will be impacted directly by excavation (e.g. trenching of the inter turbine cable trenches) and monopile installation, and indirectly by potential scour triggered by construction activities. Construction will disturb and/or remove both the deposits and any associated artefacts, exposing them to physical, biological and chemical decay.

There are three wreck sites (**201, 2013** and **2017**) that lie within the boundary of the proposed GS2 site. In the absence of mitigation it is possible that these wrecks might be damaged by construction, both directly (by adjacent works) or indirectly (from construction vessel anchors, for example).

Damage might encompass:

- direct damage to the wreck structure and contents in the immediate short term;
- disturbance to relationships between structures, artefacts and their surroundings in the short term;
- destabilisation prompting renewed corrosion and decay in the medium to long term; and
- erosion leading to damage, disturbance and instability in the medium to long term.

The other known wrecks within the MSA are unlikely to be impacted by the proposed development. However, the development may impact hitherto unknown wrecks and prehistoric terrestrial sites within the wind farm as well as discrete items of ship-borne debris. Damage might encompass direct damage, disturbance, destabilisation and/or erosion. It should be noted that repeated discoveries of apparently discrete items from a specific area might indicate the presence of a coherent shipwreck.

14.6.2 Operational Phase

Maintenance operations, to both the wind farm and the buried cables will involve anchored or jack-up vessels being stationed at the required point of maintenance. The turbines, masts and offshore sub-station may affect sediment transport leading to the exposure of previously buried archaeological remains in the medium to long term. These will impact upon any archaeology or wreck, as per during construction.

14.6.3 Decommissioning Phase

The wind farm is likely to be decommissioned by removing the turbine towers and meteorological mast by either lifting the foundations, or cutting them off below seabed level. Cables are typically capped and ballasted to the seabed. The additional disturbance to the seabed, and any archaeological material therein, will be relatively minor.

However, the anchors, cables and jack-up spuds of vessels used in decommissioning may impact archaeological material or wrecks, as during construction.

14.6.4 Significance of Effect

The potential is therefore present for medium to high magnitude effects on low to highly sensitive receptors resulting in impacts of **minor to major adverse impact** significance if mitigation measures are not used.

14.7 Cumulative Impacts

The key source of potential cumulative impacts on archaeology arises from the consented GS1 project which lies immediately adjacent to the proposed GS2 development. The potential for the GS1 development to create adverse impacts upon archaeological features was assessed during the EIA process for this project. Consent has now been awarded for this site, subject to a condition upon the FEPA licence, related directly to archaeology (see mitigation measures below).

Subject to the mitigation measures set out in the FEPA consent for GS1 and those proposed for GS2 (see below), it is considered that there will be no cumulative impacts upon archaeology from the consented GS1 scheme and proposed GS2 project.

14.8 Mitigation Measures

The following measures are designed to mitigate the impact of the development upon known sites, and to establish the presence of unknown sites. It is suggested that all aspects of any further archaeological work be detailed by a Written Scheme of Investigation (WSI).

In view of their potential archaeological significance it is possible that exclusion zones may be placed around the three known wrecks (**201, 2013** and **2017**) within the proposed wind farm. Given the absence of any clear idea as to the nature of these sites, and a definite indication as to the size of the possible construction vessels, the exact dimensions and locations of these potential exclusion zones are unknown at this stage.

All exclusion zone dimensions will be provisional upon the availability of further information concerning the nature and location of all of these sites. In order to further refine the exclusion zones it is suggested that a suitably experienced archaeologist review any further geophysical survey.

It is proposed that all exclusion zones would be marked on the scheme masterplans, including contract documents.

A Protocol for Unexpected Discoveries (to be included within the WSI) 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. The protocol will make provision for the institution of temporary exclusion zones 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 protocol will also provide for the reporting of archaeological discoveries to the EHCR. The protocol 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 (Joint Nautical Archaeology Policy Committee). The protocol will be appended to the WSI for the construction phase referred to above.

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The WSI will also make provision for such 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.

The WSI will be subject to the approval of English Heritage's Maritime Team and Essex County Council Historic Buildings and Conservation Group.

It should be noted that if a wreck of historical, archaeological importance were to be discovered in the course of construction, then it would be possible for it to be designated at very short notice, irrespective of any inconvenience to construction activities.

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Similarly, any military 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.

14.9 Residual Impacts

The adoption of satisfactory mitigation measures would ensure that the overall effect of the development would not be in conflict with historic environment policies and there would be no significant residual adverse impact after their implementation. This would reduce the magnitude effect to negligible/low on low to highly sensitive receptors, so resulting in impacts which have **negligible to minor significance**.

15. OTHER MARINE USERS

15.1 Introduction

The following section of the ES contains information related to a range of other marine users including oil and gas developments, cables and pipelines, waste disposal sites and marine aggregate extraction. Information is also presented with respect to recreational activities, including sailing and recreational angling. The likely significant impacts of the proposed GS2 development upon these activities are assessed.

15.2 Consultation

Organisations that represent some of the activities listed above, e.g. British Marine Producers Association (BMAPA) for marine aggregate extraction and the Royal Yacht Association (RYA), were issued copies of the EIA scoping report in December 2006. The RYA also attended a meeting with DONG and RPS on 13.12.06 and took part in the Hazard Identification Workshop undertaken as part of this project on 12.04.07.

15.3 Data Sources

Information on the distribution and nature of these other marine uses in the vicinity of Gunfleet Sands has been obtained from a variety of sources, including web-sites and previous ES's for projects within the Thames Estuary.

15.4 Project-Specific Survey

No specific surveys related to this parameter have been undertaken as part of this EIA.

15.5 Description of Existing Environment

15.5.1 Pipelines and Cables

Based upon a review of up-to-date charts showing cables and pipelines it is possible to note that no such structures are present within the proposed GS2 site.

15.5.2 Oil and Gas Exploration and Related Activities

There are no existing or planned oil and gas exploration projects within the wider study area.

15.5.3 Marine Aggregate Extraction

There are currently 8 licensed aggregate extraction areas within the wider Thames Region (see Figure 15.1). The licences to extract aggregates from these areas are held by Britannia Aggregates Ltd, British Dredging Ltd, Hanson Aggregates Marine Ltd, CEMEX UK Marine Ltd and United Marine Dredging Ltd.

During 2005, just under 1.6 million tonnes of aggregate were dredged from the Thames region (Crown Estate/BMAPA, 2006). The closest aggregate site to the GS2 site is Area 257 (operated by United Marine Dredging Ltd) which is located approximately 16km to the east of the proposed GS2 site.

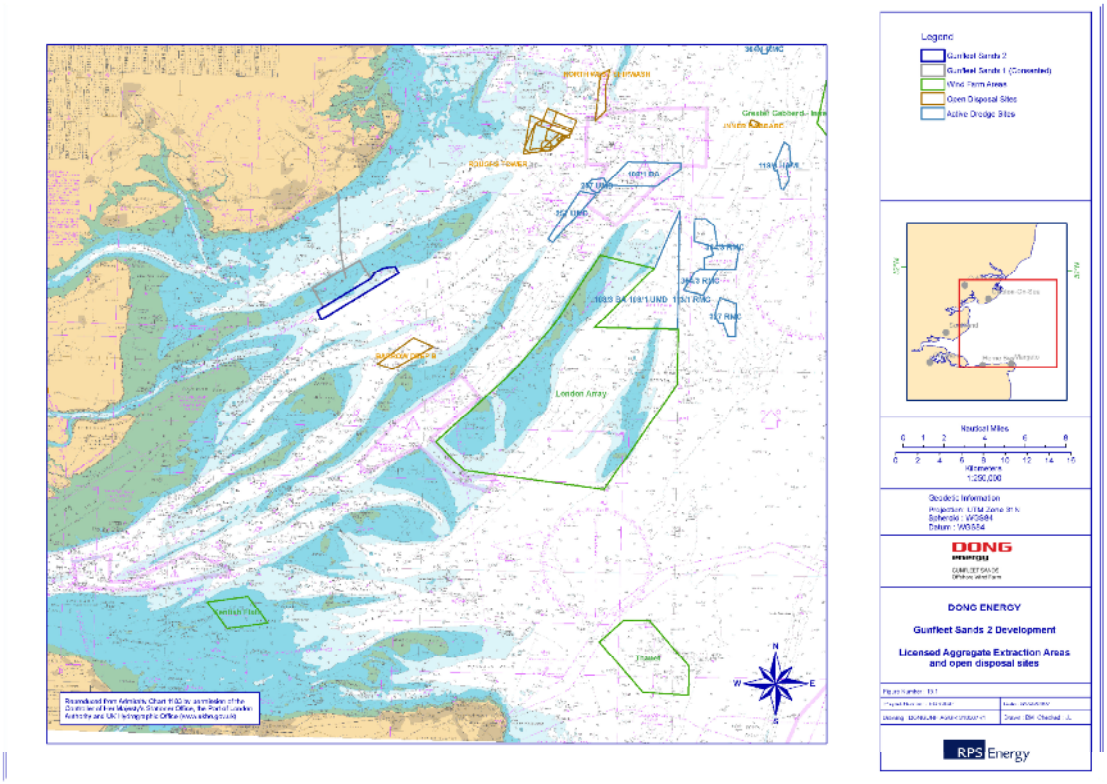

Figure 15.1 Other marine users in the wider Thames Estuary

The British Marine Aggregates Producers Association (BMAPA) have recently commissioned a Regional Scoping Study for the Thames Region, with a view to undertaking a Regional Environmental Assessment in the near future in order to strategically assess the potential for further extraction in this region. If such an exercise is started, it will be essential that close consultation between the aggregates industry and offshore wind industry is maintained.

15.5.4 Military Activity

Shoebury and Foulness military testing range is located immediately south of the proposed development site.

15.5.5 Waste Disposal

There are no waste disposal sites in the immediate vicinity of Gunfleet Sands. The closest open sites are located at Barrow Deep (approximately 10km to the south of Gunfleet Sands) and Roughs Tower (approximately 10km to the north-east of Gunfleet Sands) – see Figure 15.1.

15.5.5 Recreational Activity

The proposed GS2 site is located approximately 8.5km offshore of Clacton-on-Sea. The main recreational activity that takes place in this area is sailing. The proximity of sheltered harbours and marinas in estuaries such as the Crouch, Roach, Blackwater and Colne make this part of the Thames Estuary a popular place for both local and visiting sailors.

Although sailing activity takes place all year round, the main period for sailing is between April and September each year. Specific details on the distribution of recreational vessel activity in this area have been obtained via radar surveys of the area undertaken by Marico Marine as part of the formal navigation assessment for GS2. Data from these surveys relevant to recreational vessels are presented in Chapter 13.

In addition to sailing, the area is also popular for hobby boat fisherman, i.e. small 1-2 man craft which head towards the sandbanks in this area to target species such as bass, sole, rays and cod with rod and line. This activity is widespread and the exact spatial distribution is difficult to plot. However, it is likely that due to the presence of wrecks and the nearby Gunfleet Sands sandbank feature, recreational fishing activity does take place in this area (details on charter angling, which is a commercial venture, are provided in Chapter 11).

15.5.6 Offshore Wind Farm Development

Figure 15.1 shows the position of offshore wind farm developments in the Thames Estuary. As of June 2007, only Kentish Flats has actually been constructed. However, the following developments have gained consents to build:

- Gunfleet Sands 1
- Thanet
- Greater Gabbard
- London Array[32]

15.6 Impact Assessment

15.6.1 Construction, Decommissioning and Operational Phases

Impact Title: The construction and operation of the proposed GS2 project may create adverse impacts upon cables, pipelines, oil and gas facilities, waste disposal sites, marine aggregate sites and military exercise areas

There are no known cables or pipelines, oil or gas exploration facilities, waste disposal sites, licensed marine aggregate sites or military exercise areas in the vicinity of the GS2 boundary. Therefore, it is predicted that there will be **No Impact** upon these features during either the construction, operational or decommissioning phase of this project.

Marine aggregate extraction activities do occur within the Greater Thames Estuary, although the closest active extraction site is approximately 16km distant from Gunfleet Sands. However, there is the potential that during the construction phase of the scheme, increased vessel traffic associated with the proposed wind farm may increase navigation risk between these craft and aggregate dredgers in transit to wharves within the Thames Estuary. The potential for this impact to arise is assessed in detailed in Chapter 13.

[32] Only offshore consents have been issued for London Array. Onshore planning consents were discussed at a Public Inquiry held in April 2007, with a decision due in September 2007.

Mitigation Measures

As there is no predicted impact upon any of the marine uses listed above, no mitigation measures are required.

Residual Impacts

No Impact is predicted upon cables, pipelines, oil and gas facilities, waste disposal sites, marine aggregate sites and military exercise areas.

Cumulative Impacts

As no impacts upon these other marine uses are predicted from the GS2 development, there is no scope for any cumulative impacts with any other planned or consented activities, such as other offshore wind farm projects.

Impact Title: The construction and operation of the proposed GS2 project may create adverse impacts upon recreational activity

Recreational activity in this area is dominated by sailing and, to a lesser degree, hobby angling. During the construction/decommissioning phase of the scheme, there is the potential for disruption to these recreational activities. Potential impacts of the development upon sailing activity, during both the construction and operational phases, have been assessed in detail as part of the navigation risk assessment undertaken for the project by Marico Marine. Please refer to Chapter 13 for further details.

With regard to potential impacts upon recreational fishing activity, during the construction phase, there will be an exclusion zone around the entire site. During this, recreational craft including angling vessels, will not be permitted to enter the site. Therefore, there will be a **Minor Adverse Impact** upon vessels that may fish in this area.

During the operational phase it is expected that vessels undertaking recreational fishing activities in this area will continue to fish within the site. There is also the possibility that the new habitat introduced to the site in the form of scour protection may attract certain species that favour hard substrates. Therefore, there may be an increased range of species available to hobby fishermen in this area.

Mitigation Measures

During the construction phases of the scheme, there is no direct mitigation to offset the loss of potential angling grounds from the proposed exclusion zone. However, the boundaries of the exclusion zone will be clearly marked and all changes will be transmitted via notice to mariners at regular intervals.

Residual Impacts

During the construction phase, it is predicted that there will be a **Minor Adverse Impact** upon recreational angling in this area. During the operational phase there will be **No Impact** upon this activity, and it is possible that there may even be a slight beneficial impact should new fish species move into the area attracted by the introduction of new, hard substrates.

Cumulative Impacts

With respect to recreational sailing, potential cumulative impacts upon this activity from the proposed GS2 development and other developments in the Thames Estuary are assessed in detail in Chapter 13. For recreational angling, there is scope for the GS2 development to interact with other projects in the wider Thames Estuary. However, it is judged that the relatively limited geographical range of a typical 1-2 man recreational fishing craft means that it is unlikely that this activity will interact with other projects. The exception to this is the consented GS1 project.

However, once the GS1 and GS2 developments are operational, **no cumulative impacts** upon recreational angling are envisaged.

16. MUNITIONS AND UNEXPLODED ORDNANCE

16.1 Introduction

The following section of the ES contains information on munitions and unexploded ordnance (UXO) within and around the proposed GS2 site.

16.2 Consultation

There has been no specific consultation with respect to munitions and UXO undertaken as part of this EIA. Information on the presence of munitions on the site has been gathered via informal discussions with local commercial fishermen.

16.3 Data Sources

The key data sources used to identify the presence and location of munitions and UXO in and around the GS2 site have been a series of site-specific surveys undertaken since 2002, including a recent Remote Operated Vehicle (ROV) survey which was begun in April 2007 and is on-going at the time of writing.

16.4 Project-Specific Survey

A detailed geophysical survey was conducted from September to December 2005 by Osiris Projects Ltd to establish subsurface conditions prior to piling and ploughing operations on the GS1 site and the proposed GS2 site. The survey produced a high-resolution magnetic data set that has been of use in detecting unexploded ordnance in this area.

In order to gain more detailed information on some of the targets identified by the 2005 geophysical survey, ahead of a proposed geotechnical survey of the site, Osiris Projects Ltd was commissioned by RPS to investigate up to 40 potential UXO targets within the boundaries of the proposed wind farm sites and export cable route.

These targets were investigated using a ROV and a specialised high resolution sonar system over the period April/June 2007. Only preliminary results of this survey were available at the time of submitting this ES (see Figure 16.1).

16.5 Description of Existing Environment

The GS2 site falls within an area with a known history of military conflict. During the past two World Wars the Thames Estuary was mined and bombed by all parties and the legacy of these conflicts is the continued presence of UXO. The magnetometer and sidescan survey carried out in 2005 identified a total of 105 targets over the GS1 site, the GS2 site and the site-to-shore cable route. Of these 105 targets;

- 72 have been confirmed with side scan sonar and sub bottom profile data;
- 33 targets are buried;
- 48 targets are considered to be high risk, of which 18 lie within 100m of cables and turbine;
- 20 targets are considered to be moderate risk;
- 27 targets are considered to be low risk;
- 10 targets are considered to be of no risk;

- 14 targets cover wrecks; and
- 1 buried target is of a known aircraft crash site.

Only 3 of these 105 targets were located with the boundaries of the GS2 site. These 3 targets were surface high-risk targets, with one of them associated with a ship wreck.

In addition to those targets identified from the 2005 survey, 20 to 30 Second World War Parachute Mines are trawled from the seabed within the general Gunfleet area on an annual basis (R. Jacobs, *pers. comm.*).

Full details of the targets identified in the 2005 survey and investigated in the 2007 follow-up survey are presented in Appendix M.

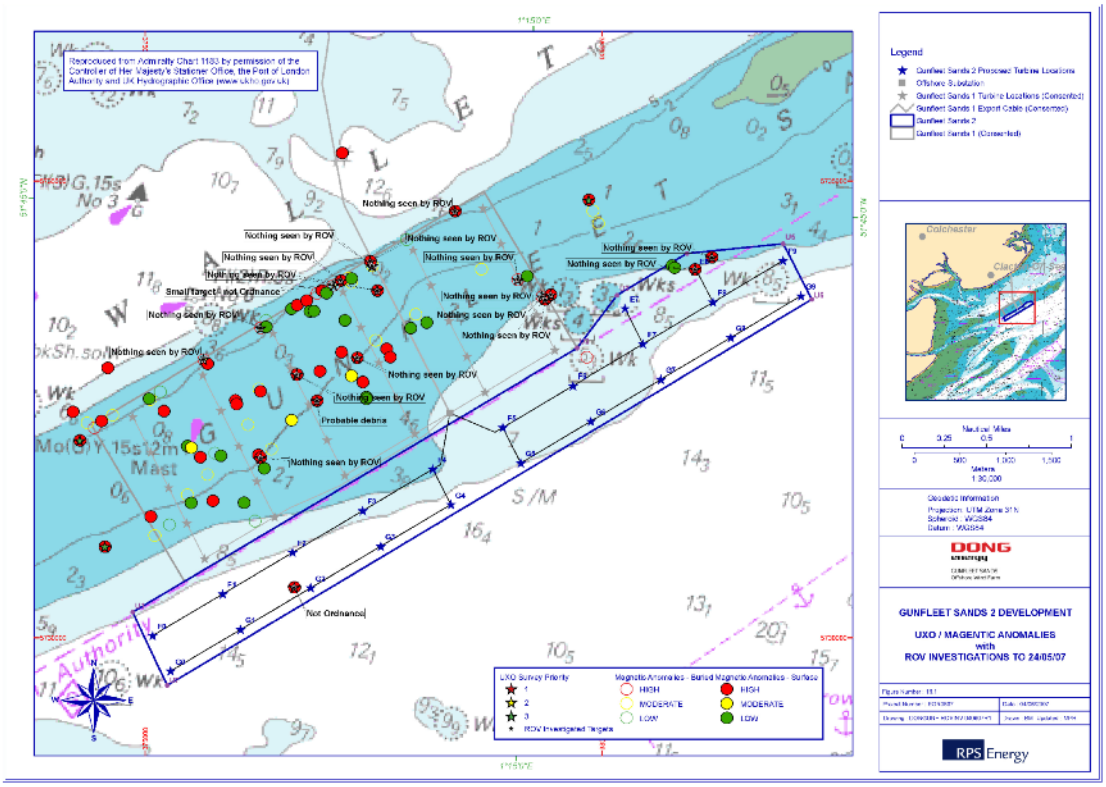

Figure 16.1 UXO / magnetic anomalies investigated by ROV (as of 24th May 2007)

16.6 Impact Assessment

16.6.1 Construction and Decommissioning Phases

Impact Title: Construction and decommissioning works associated with the GS2 development may disturb UXO, resulting in a risk of explosion

During the construction and/or decommissioning phase of the GS2 project, there is the possibility that UXO buried within the proposed construction site may be impacted by installation of turbines and/or cables. Fragmentation from an exploding UXO will penetrate the surface and could be lethal to surface support crews. A detonation of a large aircraft dropped bomb or sea mine will cause significant damage to any subsurface trenching equipment and may also breach the hull of any adjacent surface support vessel.

Based upon the results of the 2005 geophysical survey and the 2007 follow-up ROV survey, it is possible to note that there are only 3 targets within the proposed GS2 boundary and that these targets were assessed as not being potential UXO.

Therefore, it is predicted that there will be **No Impact** upon UXO from the proposed construction and decommissioning works associated with GS2.

Mitigation Measures

One of the key mitigation measures available to reduce potential impacts from UXO's, i.e. a detailed site examination, has been carried out between April – June 2007. This pre-construction survey has enabled potential UXO materials to be differentiated from targets with high metal contamination. As a result of this survey, the proposed construction works for both GS1 and GS2 can be planned with confidence in terms of the potential of encountering UXO's.

Further to this, it is recommended that the following mitigation measures are also adopted during the construction phase of this project.

- A registered Explosives and Ordnance Disposal Specialist (EODS) should be present on geotechnical/installation vessels to identify any suspicious items that may be encountered;
- All personnel conducting intrusive work should attend an Explosive Ordnance Safety and Awareness Briefing; and
- Posters and information of a general nature of the UXO threat should be held in the site office for reference and as a reminder. The safety awareness briefing is an essential part of the Health and Safety Plan so the site conforms to the CDM regulations 1994.

Residual Impacts

If measures detailed in the above section are implemented it is considered that the risks to the project could be managed resulting in **No Impact** from UXO's.

Cumulative Impacts

The ongoing ROV survey is investigating both the GS1 and GS2 sites. Preliminary results state that there is no potential for UXO within the GS2 site. Therefore, it is considered that there will be no cumulative impacts resulting from UXO's.

17. TELECOMMUNICATIONS

17.1 Introduction

The following section of the ES contains information on aspects of telecommunications related to the proposed GS2 site. Likely significant effects of the proposed GS2 project upon telecommunications are assessed. Information on radar, specifically marine radar issues related to the Port of London Authority, is presented in Chapter 13.

17.2 Consultation

The GS2 EIA scoping report was issued to a number of organisations identified from other projects in this area and following this initial consultation exercise, further contact was made with additional companies with telecommunication responsibilities. In total, consultation has been carried out with the following bodies:

- Office of Communications (OFCOM);
- T-Mobile;
- British Telecom;
- Cable and Wireless;
- Radio Communications Agency;
- Crown Castle;
- Arqiva (Spectrum Planning Group); and
- Orange

17.3 Data Sources

The main source of information on potential telecommunication issues has been direct consultation with the key organisations listed above. The BBC on-line wind farm assessment tool [33] was also used to obtain information on the potential for the GS2 project to impact upon telecommunications.

17.4 Project-Specific Survey

No project-specific survey related to telecommunications has been undertaken for this project as there has been no identified need for one and also no request for one by any of the key stakeholders. The co-ordinates of the project have been entered into the BBC web-based assessment tool (see footnote 2).

17.5 Description of Existing Environment

There are no fixed telecommunication cables within the proposed GS2 study area. With respect to radio and television transmitters, the closest such facility to the GS2 site is the civil fixed link operated and owned by the Port of London Authority at Holland Haven.

[33] http://wind farms.kw.bbc.co.uk/cgi-bin/rd/wind farms/wind farm.cgi

17.6 Impact Assessment

17.6.1 Construction and Decommissioning Phases

Due to no fixed telecommunications links existing within the proposed GS2 site, there will be **No Impact** upon fixed links during the construction or decommissioning phases of the proposed project. This has been confirmed through consultation with key telecommunications stakeholders throughout the EIA process.

17.6.2 Operational Phase

Impact Title: Disturbance effects may arise on radio and television signals during the operational phase

There is evidence that wind turbines can sometimes affect domestic television or radio reception when turbines are situated less than 5km from residential properties. The proposed GS2 wind farm is not expected to have any impact on radio or television reception as the site is located approximately 8.5km offshore.

It is judged that it is also unlikely that the proposed project will have any affect on the television transmission network. There are no Rebroadcast links (RBLs) to relay transmitters, crossing the Thames estuary and as a consequence there is no potential for the proposed project to cause interference with the television transmission network.

No objections to the proposed scheme have been received from any of the key organisations consulted as part of the EIA process, including OFCOM. The results of a query submitted to the BBC on-line wind farm assessment tool also concluded that in its proposed location, the GS2 project would not affect any homes or transmitters.

Therefore, it is concluded that there will be **No Impact** upon telecommunications during the operational phase of this project.

Mitigation Measures

None required.

Residual Impacts

It is predicted that there will be **No Impact** upon radio and television signals from the GS2 development.

Cumulative Impacts

Due to the fact that the proposed GS2 development has received no objections from any stakeholders in the telecommunications sector, it is predicted that there will be **no cumulative impacts** on telecommunications with other offshore or onshore wind farm projects in the Thames region.

18. AVIATION

18.1 Introduction

The following section of the ES contains information on aspects of aviation around the proposed GS2 site. Information is presented under the following headings:

18.2 Consultation

The GS2 EIA scoping report was issued in December 2006 to the following organisations with responsibilities for and interests in aviation:

- National Air Traffic Services (NATS);
- Civil Aviation Authority (CAA);
- London Southend Airport;
- Defence Estates;
- Clacton Aerodrome.

Responses on the proposed development have been received from NATS, CAA, Defence Estates and London Southend Airport. Discussions have also been held between the manager of Clacton Aerodrome and members of the project team undertaking the marine navigation risk assessment.

18.3 Data Sources

The key source of data on the possible consequences of the proposed GS2 development upon aviation has come from direct consultation with the key stakeholders listed above.

18.4 Project-Specific Survey

No project-specific survey has been carried out with respect to the proposed GS2 development.

18.5 Description of Existing Environment

The proposed GS development (and the adjacent consented GS1 project), are not in the direct flight path of any major airport. The closest facility is Clacton Aerodrome, which is located approximately 8km to the north of the proposed site. London Southend Airport, which currently handles European passenger and cargo services, is located approximately 40km from the proposed site.

18.6 Impact Assessment

18.6.1 Construction and Decommissioning Phases

No impacts upon either civil or military aviation are predicted during the construction and/or decommissioning phases of the project.

18.6.2 Operational Phase

Impact Title: Adverse impacts may arise upon civil and/or military aviation during the operational phase

Consultation has been carried out with a number of key aviation stakeholders. The responses from CAA, London Southend Airport and NATS are summarised below in Table 18.1.

Consultee	Response
CAA	Continued consultation with aviation stakeholders is strongly recommended. DONG Energy should refer to the DTI/MoD/CAA/BWEA co-sponsored document, Wind Energy and Aviation Interests – Interim Guidelines. This document recommends that developers submit a Pre-Planning Consultation Form to the CAA and MoD to establish any possible aviation-related concerns at an early stage. Contact should be made with London Southend Airport. DONG Energy should be aware that there will be a need to install aviation obstruction lighting to some or all of the associated wind turbines. The CAA is happy to discuss specific aviation lighting requirements at any stage during the development process. There is a requirement in the UK for all structures over 300 feet high to be charted on aviation maps. Should this proposed wind turbine development progress and the 300 feet height be breached, to achieve this charting requirement, developers will need to provide details of the development to the Defence Geographic Centre (AIS Information Centre).
London Southend Airport	London Southend Airport has verbally confirmed that they have no objections to the proposed GS2 development (*pers. comm. Cpt Mark Baker, 10.05.07*). However, a written response is still awaited from this organisation.
NATS	The proposed development has been examined from a technical safeguarding aspect and does not conflict with our safeguarding criteria. Accordingly, NATS (En Route) Public Limited Company (NERL) has no safeguarding objections to the proposal. This letter does not provide an indication of the position of any other party, whether they be an airport, airspace user or otherwise.
Clacton Aerodrome	No formal response in writing but discussions between the manager of the Clacton Aero Club and members of the project team confirmed that their aircraft do not operate more than 1-2 miles off the coast to ensure gliders safe return to their airfield. The compliance of the wind farm structures with the CAA height and lighting requirements reassured them and they did not see any problems with the wind farm extension.

Table 18.1 Summary of aviation stakeholder responses to GS2 proposal

Based upon these comments, it is predicted that there will be **No Impact** upon aviation from the proposed GS2 development.

Mitigation Measures

- Continue consultation with key aviation stakeholders, i.e. CAA and NATS;
- Follow guidance set out in "Wind Energy and Aviation Interests" guidance document; and
- Ensure that aviation lighting is installed in a suitable and appropriate manner.

18.6.3 Cumulative Impacts

Due to the fact that the proposed GS2 development has received no objections from any stakeholders in the aviation sector, it is predicted that there will be **no cumulative impacts** on aviation with other offshore or onshore wind farm projects in the Thames region.

19. SOCIO-ECONOMIC

19.1 Introduction

The following chapter of the ES presents information on socio-economic aspects of the proposed GS2 development not covered in previous chapters (such as commercial fishing, shipping and navigation and other marine users). Topics covered include the local economy, employment, tourism, and education. The likely significant impacts of this proposed development upon these parameters are discussed.

19.2 Consultation

Consultation relating to socio-economic issues has been carried out with a number of key organisations and stakeholders as part of this EIA. The EIA scoping report was issued to the following organisations that have a socio-economic remit:

- Essex County Council.
- East of England Tourist Board.
- Babergh District Council.
- Brightlingsea Town Council.
- Thurrock Thames Gateway Development Corporation.
- Ipswich Borough Council.
- Colchester Borough Council.
- Tendring District Council.
- Frinton and Walton Town Council.
- Maldon District Council.
- Rochford District Council.
- Thurrock Council.
- St Osyth Parish Council in December.

19.3 Data Sources

The following documents have been reviewed in order to obtain information as to the potential socio-economic effects of the proposed GS2 wind farm;

- Essex and Southend-on-Sea Replacement Structure Plan (2001);
- Tendring Tourism Strategy, Tendring District Council Economic Development Services (2001);
- Gunfleet Sands Offshore Wind Farm Environmental Statement (2002);
- Tendring Community Strategy 2005–2011. Tendring Local Strategic Partnership (2005);
- Lincs Offshore Wind Farm Environmental Statement Volume One: Offshore (2006);
- Tendring District Replacement Local Plan. Local Plan Inquiry September 2006. Topic Paper 3: Employment Land (2006); and
- Tendring District Council: Corporate Equalities Policy (2007).

19.4 Project-Specific Survey

There has been no project-specific survey related to socio-economic issues undertaken for this project. A desk-study assessing the anticipated socio-economic and community effects was completed for the Gunfleet Sands 1 (GS1) Offshore Wind Farm ES (Hydrosearch, 2002).

19.5 Description of Existing Environment

When considering the proposed GS2 development, it is important to note that, in terms of the EIA process, the project consists only of up to 22 offshore wind turbines and associated inter-turbine cables, i.e. there is no landward infrastructure associated with the proposed GS2 development. However, although located entirely offshore, the proposed scheme still has the potential to create socio-economic impacts upon local communities.

The coastal communities that are considered most likely to be directly impacted by the offshore development of the GS2 wind farm are the same as those cited in the ES for the consented GS1 wind farm. These coastal communities are Harwich, Dovercourt, Walton-on-Naze, Frinton-on-Sea, Holland-on-Sea, Clacton-on-Sea, Jaywick, St Osyth and Brightlingsea, which are all within the Tendring District, Essex. Where appropriate, a wider regional assessment is made of the socio-economic issues.

19.5.1 The Tendring District

The Tendring District is a peninsular region located in the north-east corner of Essex covering an area of 338 km^2, with a coastline of approximately 70km. The district is predominantly rural with the main population areas located on the coast. The population size of the Tendring district is currently estimated at 141,500 people, with Clacton-on-Sea the principal urban area (Tendring District Council, 2007). In 2001, data from the National Office of Statistics indicated that a large proportion of people within the district were over the age of retirement (~ 33%) which is high compared to the national average of approximately 18%.

However, in recent years it is thought that an increased number of younger people have moved to the district attracted by low house prices (Tendring Local Strategic Partnership, 2005).

19.5.2 Employment

In an economic survey of the Eastern Region in 2003, the Tendring district was shown to have the weakest economic performance and was ranked 5th for deprivation levels (Tendring District Replacement Local Plan, 2006). Only 50% of the population within the district is of working age (between 16–59 years), well below the national average of 78.6%. In addition, average earnings within the district are 13% below the national average, and a considerable proportion of those living in the Tendring district are commuters. The Tendring Community Strategy (2005) suggested that without an increase in employment opportunities, commuting out of the district is expected to increase.

The mainstays of the local economy are health-care, manufacturing, tourism and the maritime industry (Townroe, 2000). However, the Essex and Southend-on-Sea Replacement Structure Plan (2001) identified structural employment problems in the coastal settlements and prioritized Clacton, Walton and Harwich for economic regeneration. The creation of employment is a key priority for these areas and the Plan aims to encourage the local economy through “investment in new employment and enterprise opportunities”. In support of this economic regeneration, the Tendring Community Strategy 2005–2011 was published, which provides a framework for the regeneration of the Tendring district. Some of the main aims of this strategy are to strengthen the local economy, secure more jobs and improve education. Progress towards achieving these aims has been made in recent years by the community partnership. For instance, unemployment was reduced by 1.6% between May 2002 and April 2004 and 21 new jobs were created with the aid of Enterprise grants.

19.5.3 Education

There are a number of initiatives that seek to improve the levels of education in the area and to increase employment related training schemes. However, there are still low levels of adult literacy and numeracy in the deprived neighbourhoods within this District.

19.5.4 Tourism

Tourism is one of the 5 largest industries within the UK, with domestic tourism, in the form of day-trips and short breaks to the coast, contributing a significant part of tourism revenue. For over 100 years the eastern coastal strip, centred around Clacton and Walton, has been promoted to visitors as the Essex Sunshine Coast. The main employment sectors in the local tourist industry are accommodation, catering and recreation facilities.

In 1998, tourism in Tendring was valued at around £185 million, with 69% generated by staying visitors and the remaining 31% from day visitors. Although there has been some investment in recent years in the regeneration of the main resort of Clacton-on-Sea, the Tendring District Community Strategy 2005–2011 highlighted the need for further investment in the Districts' tourism sector in order to remain competitive within the UK industry. The Tendring Tourism Strategy stated that the attraction of new investment and the development of attractions are considered key priorities for improving the local tourist economy.

19.6 Impact Assessment

An assessment of the proposed social and economic impacts resulting from the proposed offshore works has been undertaken. The impacts are considered with respect to the 3 phases of the project; construction, operation and decommissioning.

The project has the potential to generate a range of economic and social impacts. The key issues would be employment opportunities and spend into the local economy. These social impacts can be sub-divided into:

- Direct impacts, such as employment opportunities in the construction, operation and maintenance of the wind farm;
- Indirect impacts, such as additional employment created down the supply chain, that will be initiated by the project; and
- Induced impacts, i.e. second tier employment, supported by spending of wages in the local economy.

It is difficult to establish clear levels of indirect or induced impacts for a project such as this. Therefore, estimates of potential impacts are made by using available data from other offshore or onshore wind farm developments where possible.

19.6.1 Construction, Operational and Decommissioning Phases

19.6.1.1 Local employment and economy

Impact Title: The proposed GS2 development may have an impact on local employment levels

It is currently proposed that construction of the proposed GS2 project would take place at the same time as the consented GS1 project, with offshore works beginning in the spring of 2008 and the two sites (GS1 and GS2) being commissioned by the end of 2009. The wind farm is expected to be operational for at least 20 years. The nature and scale of the local employment impacts associated with all phases of the project would depend on how much of the labour is local. With respect to the number of personnel predicted to be involved in each stage of the project, Table 19.1 sets out the estimates below.

Phase	Activity	Description of Key Tasks	Number of Personnel Required
Construction	Heavy Vessel Transports	Turbine installation	10
		Foundation installation	3-4
		Scour protection	1
		Offshore installation platform	1
		Array cables	3
		Export cables	5
	Sub-Total		**24[34] (48)**
	Commissioning & Support Vessels	Anchor handling and towage	6
		Commissioning personnel transport	24
		Guard vessels / security	3
	Sub-Total		**33[35] (50)**
	Onshore Support	Construction/Commissioning Management	4
		Pre-assembly	4
		Delivery and receipt of manufacturing loads	4
		Site security	3
	Sub-Total		**15[36]**
Operational[37]	O&M Activities	Operations Manager	1
		Maintenance technicians	2
		Secretary	1
	Sub-Total		**4**
TOTAL			**117**

Table 19.1 Estimated numbers of personnel required for the construction and operational phases of the proposed GS2 project

[34] In reality, more than one vessel type will be required and because of 24hr ops, back-up crews will be required. Therefore, the estimate of 24 personnel should be doubled to 48.
[35] Use of back-to-back crews means that in reality, it is estimated that the actual number of personnel required for these activities is 50% greater, i.e. 50.
[36] Exact numbers of personnel required for this aspect is difficult to estimate at this stage.
[37] During the first 5 years of the GS2 project, the turbine supplier will be responsible for the operations and maintenance activities.

With respect to potential local employment it is predicted that personnel required to undertake the construction and operation of this project would be sourced by contractors appointed by DONG. It is not possible to state how many of these positions could be filled by local people.

Although it is not possible to state exactly how many of the employment positions associated with the proposed GS2 development will be taken up by local people, it is estimated that there will be only a **potential Minor Beneficial Impact** upon local employment as a result of the proposed GS2 development.

Mitigation Measures

None required.

Residual Impact

It is predicted that there may be a **potential Minor Beneficial Impact** upon local employment levels from the proposed GS2 development.

Impact Title: The proposed GS2 development may have an impact on the local economy

With respect to expenditure and potential effects upon the local economy, a review of the distribution of expenditure on the Scroby Sands Offshore Wind Farm, off the coast of Great Yarmouth, provides a guide as to how the proposed GS2 project may affect these parameters.

Scroby Sands is a 30-turbine Round 1 offshore wind farm with a maximum output of 60 MW. The project cost £75 million and was commissioned in the autumn of 2004. The value distribution for the various phases of this scheme are summarised in Table 19.2.

Stage	Distribution of Value		
	East of England	Other UK	Non UK
Development	19%	25%	53%
Construction	7%	34%	59%
Operation	75%	8%	17%

Table 19.2 Value distribution by phase and by location for the Scroby Sands Offshore Wind Farm – "operation" takes account of the first five years of the wind farm's operation (Douglas Westwood Ltd and ODE Ltd (2005)

The estimated outlay costs of the GS2 project (development, construction and outlay phases) based on an industry accepted cost of £1.5 million/MW is estimated to be approximately £86.4 million. By using the ratios from Scroby Sands development purely as an estimate for the GS2 project it can be seen in Table 19.3 that approximately £14 million and £27 million would be invested in the local and national economies, respectively. It should be noted however, that the Scroby Sands project involved onshore works, for which the associated expenditure contributed to the costs of the project.

Therefore, the associated expenditure of the GS2 project, which does not have any associated onshore works, is likely to be slightly less than estimated in Table 19.3. However, this comparison does provide an estimation of the positive benefit that would result from the project.

	Estimated total cost (£ million)	Regions (£ million)	Rest of UK (£ million)	Non UK (£ million)
Development	1.7	0.3	0.5	0.9
Construction	76.9	7.7	26.1	43.1
Operation	7.8	5.9	0.6	1.3
Total cost	**86.4**	**13.9**	**27.2**	**45.3**

Table 19.3 Estimated distribution of expenditure by phase and location for the GS2 offshore wind farm development. Ratios of expenditure derived from the value distributions for the Scroby Sands Offshore Wind Farm – Douglas Westwood Ltd and ODE Ltd (2005)

As can be seen in Table 19.3, substantial amounts of money have already been spent in the UK and in the local area, including the carrying out of surveys and data collection necessary for the projects' development, which has brought business to boat operators, surveyors, the hospitality sector etc. in the order of £300,000.

For the construction phase it is widely recognised that specialist expertise can rarely be sourced locally for such a project, which accounts for the high proportion of non-UK expenditure during the construction period. Aside from the contracts directly awarded for the construction of the wind farm, the local community can benefit indirectly through the provision of auxiliary services, such as port use, plant hire, accommodation, monitoring etc.

Therefore, it is concluded that there will be a **Minor Beneficial Impact** on the local economy levels during the development, construction and operation of the project.

Mitigation Measures

None required.

19.6.1.2 Tourism and Education

Impact Title: The proposed GS2 development may have an impact on local education and tourism

The development of wind farms off the East Anglian coast, one of the three strategic areas identified by the Government for such renewables developments, offer an opportunity for links with local education and to attract students and others with an interest in the environment. The presence of wind farms is undoubtedly a useful educational resource, providing real links with elements of the curriculum being taught in schools about climate change and our environment.

Therefore, there is the potential for a **Minor Beneficial Impact** on local education to arise from the proposed GS2 development.

In terms of tourism, the construction activities associated with the offshore development phase of GS2 are temporary and limited in nature. The proposed works will also be located over 8km offshore with the majority of the large components of the project (foundation piles, blades, nacelles, towers etc.), being transported to the site by sea. Therefore, it is predicted that there will be **No Impact** upon local traffic, and thus tourism, during the construction phase of the GS2 project.

During the operational phase, the development will be visible from some viewpoints along the Tendring coastline. Assessment of the visual and seascape impacts is covered wholly in Chapter 12. From experience of other operational offshore wind farms in the UK (Scroby Sands, Kentish Flats, North Hoyle), it is predicted that the development of the proposed GS2 project will generate considerable interest both from the local population and from visitors.

This comment is qualified by results of exhibition days and a public questionnaire issued as part of the GS1 project. The reaction to the development at GS1 from the questionnaire responses was positive with 87% of respondents in favour of the offshore wind farm being built at Gunfleet Sands, although 11% were unsure and 3% were not in favour. The responses for siting the wind farm at Gunfleet Sands included the attraction of people to the local area. The majority (87%) of respondents also indicated that there would be interest from the local population in trips visiting the wind farm.

As both the GS1 and GS2 sites will be visible, but distant from the shore (at approximately 7-8 km), it is likely that organised boat trips to view the wind farm will be a popular attraction. Various local operators consulted during the proposal of GS1 indicated that they might be interested in developing this service. It is also possible that charter fishing trips may increase within the site as the foundation structures may actually encourage fish stocks (as has happened at the Vindeby Wind Farm, Denmark).

There does not appear to be any documented examples of wind farms having a negative effect on tourism, and there is good evidence to suggest that they can have a positive one. Whilst the proposed wind farm is likely to generate significant interest and to present opportunities for tourism and education the towns along the Essex Sunshine Coast, Clacton-on-Sea and Walton-on-Naze in particular, are well placed and well equipped to benefit from any increase in visitor activity. It can also be concluded that any negative impacts relating to this increase in public interest will be negligible, as the numbers involved are likely to be relatively small in relation to current visitor numbers.

Overall, it is anticipated that there will be a **Minor Beneficial Impact** upon tourism during the construction/decommissioning and operational phases of the proposed GS2 project.

Mitigation Measures

No mitigation measures are required. Regular monitoring of the local economy is undertaken by Tendring District Council, therefore close co-operation with Tendring should be maintained to monitor any effect of the wind farm, for employment, tourism and leisure activities.

Residual Impacts

Overall, it is considered that there will be a **Minor Beneficial Impact** upon tourism during the construction/decommissioning and operational phases of the proposed GS2 project.

19.6.2 Cumulative Impacts

To date, 1 offshore wind farm development has been constructed in the Thames region (Kentish Flats), with an additional 4 granted consent (London Array, Thanet, GS1 and Greater Gabbard). As a result of these developments there are potential benefits for increasing employment and input to the local economy across this entire region throughout the construction phases of the wind farms, which would continue into the operation, maintenance and decommissioning phases.

In addition to potentially increasing employment within the region, the various projects are likely to increase the level of environmental education and the number of tourists interested in environmental issues, to the region. Therefore, overall, there is likely to be **Minor Beneficial Impact** on the socio-economic environment of the wider Thames region.

20. SUMMARY OF ENVIRONMENTAL IMPACTS

20.1 Introduction

The following section of the ES provides a summary of all the potential environmental impacts that may arise from the proposed GS2 development. The potential impacts are presented in summary tables under the following headings;

- Impacts upon the Physical Environment;
- Impacts upon the Biological Environment; and
- Impacts upon the Human Environment

Information is presented with respect to the predicted significance of all the impacts identified during the EIA process. Where appropriate, mitigation measures are also summarised. The residual impact, i.e. impact after successful implementation of mitigation measures, is also presented.

Parameter (ES Chapter)	Potential Impact	Significance	Mitigation	Residual Impact
Coastal Processes (Chapter 4)	Potential impact upon local geology due to the presence of up to 22 turbines	**No Impact**	None Required	**No Impact**
	Potential impact upon geomorphological processes around Gunfleet Sands due to the presence of up to 22 turbines	**No Impact** upon wider geomorphological process. Some localised scour and possible secondary wake effects	Scour protection will be used around the base of each turbine which will minimise scour effects	**No Impact** on wider processes Some localised scour
	Potential impact upon tidal regime due to the presence of up to 22 turbines	**No Impact** upon wider tidal regime. Some **negligible, localised** wake effects may lead to scour (see above)	Scour protection will be used around the base of each turbine which will minimise scour effects	**No Impact** on wider tidal regime Some localised wake effects leading to scour
	Potential impact upon wave regime due to the presence of up to 22 turbines	**Negligible**	None Required	**Negligible**
	Potential impact upon sediment transport processes due to the presence of up to 22 turbines	**Negligible Impact** upon wider sediment transport regime around Gunfleet Sand as a result of the proposed GS2 development	Scour protection will be used around the base of each turbine which will minimise scour effects	Formation of secondary scour wakes for distances of around 100m in the direction of net sediment transport is judged to be of **Minor** significance
	Potential impact upon suspended sediment loads during the construction phase of the project	**Negligible**	None Required	**Negligible**
	Potential *cumulative impact* upon physical processes from GS1 and other offshore wind farms in the Thames Region	**No Impact**	None Required	**No Impact**
Water & Sediment Quality (Chapter 5)	Construction activities, including installing inter-turbine cables will lead to deteriorations in water quality	**Negligible Impact**	None Required	**Negligible**
	Construction activities, including installing inter-turbine cables will lead to deteriorations in sediment quality	**No Impact**	None Required	**No Impact**

Table 20.1 Summary of predicted impacts on the physical environment

Parameter (ES Chapter)	Potential Impact	Significance	Mitigation	Residual Impact
Nature Conservation (Chapter 6)	Potential for adverse effects upon existing designated sites during construction and operational phases	**No Impact**	None Required	**No Impact**
	Potential for adverse effects upon potential Annex I habitats during construction and operational phases	**No Impact**	None Required	**No Impact**
	Potential for adverse effects upon the targets and objectives of UK BAP species and/or habitats	**No Impact** upon all UK BAP species/habitats apart from sublittoral sands and gravels. A **Minor Adverse Impact** is predicted on this habitat type	None Required for majority of habitats. None available to mitigate minor adverse impact upon sublittoral sands/gravels	**No Impact** upon all UK BAP species/habitats apart from sublittoral sands and gravels. A **Minor Adverse Impact** is predicted on this habitat type.
	Potential for cumulative effects on nature conservation from GS1 and other offshore wind farms and other activities.	**No Impact**	None Required	**No Impact**
Benthic Ecology (Chapter 7)	Temporary increase in suspended sediment concentrations from trenching and/or piling operations (plume effects)	**Negligible**	None Required	**Negligible**
	Temporary increase in sediment deposition from plumes	**Negligible**	None Required	**Negligible**
	Potential release of contaminants bound in sediments, resulting in adverse effects upon benthic organisms	**Negligible**	None Required	**Negligible**
	Potentially release of pollutants from construction plant resulting in adverse effects upon benthic organisms	**Negligible**	Development and adherence to a project-specific Marine Pollution Contingency Plan	**No Impact**
	Permanent loss of seabed habitat through the presence of turbines and foundations	**Minor Adverse**	None available	**Minor Adverse**
	Potential for scour effects and changes in sediment transport processes to result in changes in seabed habitats and benthic communities	**Minor Adverse**	Scour protection will be used around the base of each turbine which will minimise scour effects	**Negligible**
	Potential colonisation of turbines (and scour protection), leading to increased biodiversity	**Neutral Impact** (assessed as neutral as effect will just be a change from existing mobile sediment community to new, hard substrate community, not any noticeable increase in biodiversity)	None available	**Neutral**

Table 20.2 Summary of predicted impacts on the biological environment

Parameter (ES Chapter)	Potential Impact	Significance	Mitigation	Residual Impact
Benthic Ecology (Chapter 7)	Potential toxic effect on benthic communities from sacrificial anodes on foundations	**Negligible**	None required	**Negligible**
	Cumulative Impact upon benthic communities through loss of habitats from GS1 development and other offshore wind farms and activities	**Minor Adverse**	None available	**Minor Adverse**
Fish & Shellfish (Chapter 8)	Increased sediment concentrations and deposition from construction activity may create adverse effects upon local fish and shellfish resources	**Minor Adverse** (finfish) **No Impact** (sedentary shellfish)	None available	**Minor Adverse** (finfish) **No Impact** (sedentary shellfish)
	Noise from the construction phase of the scheme may disrupt spawning activity of key commercial species	**Moderate-Major Adverse**	DONG is committed to not undertaking any piling works in the period from 1st February to 1st June in each construction season (as per the GS1 FEPA licence). This mitigation measure is designed to allow spawning fish to reach their spawning grounds and spawn without any potential adverse impact from piling noise	**No Impact**
	Noise from the construction phase of the scheme may cause injury and/or death to fish species	**Minor – Major Adverse**	Use of soft-start methods	**Negligible – Minor Adverse**
	Presence of up to 22 turbines will lead to a loss of fisheries habitat	**Minor Adverse**	None available	**Minor Adverse**
	Presence of turbines may result in the creation of new, 'complex' habitat that could provide refuge habitat for many fish species	**Negligible**	None Required	**Negligible**
	Reduction in fishing pressure within the GS2 site may create beneficial effects upon local fish and shellfish resources	**Negligible**	None required	**Negligible**
	Electromagnetic fields generated by the inter-turbine / site-to-shore cables may potentially create adverse effects upon electro-sensitive fish species	**Potential Minor Adverse**	None available	**Potential Minor Adverse**
	Cumulative Impact upon fish resources through loss of spawning/nursery habitats from GS1 development and other offshore wind farms and activities	**Negligible**	None available	**Negligible**

Table 20.2 (Cont'd)

Parameter (ES Chapter)	Potential Impact	Significance	Mitigation	Residual Impact
Fish & Shellfish (Chapter 8)	Cumulative Impact upon fish resources through piling noise generated from multiple projects	**Moderate Adverse**	Use of soft-start methods. DONG is committed to not undertaking any piling works in the period from 1st February to 1st June in each construction season (as per the GS1 FEPA licence). This mitigation measure is designed to allow spawning fish to reach their spawning grounds and spawn without any potential adverse impact from piling noise	**Minor Adverse**
Marine Mammals (Chapter 9)	Pile driving operations may create adverse impacts upon seals on and around the GS2 site	**Moderate Adverse**	Use of Marine Mammals Observers (MMO's) to maintain sightings record of any sightings of marine mammals within the mammal monitoring zone No piling until 30mins has elapsed during which marine mammals are not detected in or around the marine mammal monitoring zone Monitoring using visual and Passive Acoustic Monitoring equipment (PAM) Development of reporting methodology to enable efficient communication between the MMO and the skipper of the monitoring vessel Piling to be undertaken using the soft start procedure	**Minor Adverse**
	Pile driving operations may create adverse impacts upon porpoises on and around the GS2 site	**Moderate Adverse**		**Minor Adverse**
	Pile driving operations may create adverse impacts upon dolphins on and around the GS2 site	**Minor Adverse**		**Minor Adverse**
	Increases in suspended sediment concentrations from cable-laying may create adverse impacts upon seals in and around the GS2 site	**Temporary Minor Adverse**	None required.	**Temporary Minor Adverse**
	Increases in suspended sediment concentrations from cable-laying may create adverse impacts upon porpoises and dolphins in and around the GS2 site	**No Impact**	None required	**No Impact**
	Increased vessel activity during the construction phase may lead to adverse effects upon seals, porpoises and dolphins on and around the GS2 site	**Minor Adverse**	None available	**Minor Adverse**
	Noise and vibration produced by turbines and/or survey/maintenance vessels during the operational phase of the project may result in adverse impacts upon seals, porpoises and dolphins	**No Impact**	None required	**No Impact**

Table 20.2 (Cont'd)

Parameter (ES Chapter)	Potential Impact	Significance [38]	Mitigation	Residual Impact
Marine Mammals (Chapter 9)	The presence of turbines and associated scour protection will result in a permanent loss of habitat within the GS2 site for all marine mammals	**Minor Beneficial**	None required	**Minor Beneficial**
	Cumulative Impact upon marine mammals through piling noise generated from multiple projects	**Minor Adverse**	Use of soft-start; MMO's and PAM monitoring.	**Minor Adverse**
	Cumulative Impact upon marine mammals through habitat loss generated from multiple projects	**Minor Adverse**	None available	**Minor Adverse**
Ornithology (Chapter 10)	Noise, vibration and visual impacts during the construction phase of the project may result in disturbance to and potential displacement of populations of divers	Divers = **Low** Other Species = **Very Low**	None required	Divers = **Low** Other Species = **Very Low**
	Loss of habitat due to the presence of up to 22 turbines	All species = **Very Low**	None required	**Very Low**
	Disturbance and displacement from the turbines during the operational phase	Divers = **Low** Other Species = **Very Low**	None required	Divers = **Low** Other Species = **Very Low**
	Potential mortality arising from collision with turbines	Divers = **Low** Gulls = **Very Low** Other Species = **Very Low**	None required	Divers = **Low** Gulls = **Very Low** Other Species = **Very Low**
	Potential barrier effects from the GS2 development	All species = **Low/Very Low**	None required	All species = **low/very low**
	Cumulative impact of habitat loss from GS2 and other offshore wind farms in the Thames Region	All species = **No Impact**	None required	All species = **No Impact**
	Cumulative impact of displacement from GS2 and other offshore wind farms in the Thames Region	All species = **No Impact**	None required	All species = **No Impact**
	Cumulative collision mortality from GS2 and other offshore wind farms in the Thames Region	All species = **No Impact**	None required	All species = **No Impact**
	Cumulative barrier effects from GS2 and other offshore wind farms in the Thames Region	All species = **No Impact**	None required	All species = **No Impact**
	Habitat loss for divers within the potential Thames Estuary SPA	Divers = **Low**	None required	Divers = **Low**

Table 20.2 (Cont'd)

[38] Significance criteria for ornithology differs from other parameters. Please refer to Appendix H for full details.

Parameter (ES Chapter)	Potential Impact	Significance [39]	Mitigation	Residual Impact
Ornithology (Chapter 10	Displacement of divers from the potential Thames Estuary SPA	Divers = **Low**	None required	Divers = **Low**
	Effect of collision mortality on the diver population of the potential Thames Estuary SPA	Divers = **Low**	None required	Divers = **Low**
	Barrier effect on the diver population of the potential Thames Estuary SPA	Divers = **Low**	None required	Divers = **Low**
	Habitat loss within the potential Thames Estuary SPA loss via in-combination impacts	**No Impact**	None required	**No Impact**
	Displacement of divers from the potential Thames Estuary SPA via in-combination impacts	**No Impact**	None required	**No Impact**
	Collision mortality on the diver population of the potential Thames Estuary SPA via in-combination impacts	**No Impact**	None required	**No Impact**
	Barrier effect on the diver population of the potential Thames Estuary SPA via in-combination impacts	**No Impact**	None required	**No Impact**

Table 20.2 (Cont'd)

[39] Significance criteria for ornithology differs from other parameters. Please refer to Appendix H for full details.

Parameter (ES Chapter)	Potential Impact	Significance	Mitigation	Residual Impact
Commercial Fisheries (Chapter 11)	Introduction of seabed objects	**Moderate Adverse Impact**	Pre-construction bottom and side scan sonar survey will be undertaken across the area of development. Local fishermen will be invited to send representatives to be present during the survey. All obstructions found on the seabed will be recorded and plotted on a suitable chart. A post construction survey will repeat the pre construction survey and new obstructions directly attributable to the offshore works will be removed.	**No Impact**
	Impacts upon commercially exploited species	**Potential minor beneficial impact**	None required	**Potential minor beneficial impact**
	Increased steaming times to fishing grounds	**Short-term minor adverse impacts** (construction) **Negligible Impacts** (operational)	None required.	**Short-term minor adverse impacts** (construction) **Negligible Impacts** (operational)
	Complete loss or restricted access to traditional fishing grounds	Potting and dredging vessels = **No Impact** Majority of trawlers and some netters = **Minor Adverse Impact** Certain trawlers = **Moderate Adverse Impact**	None available	Potting and dredging vessels = **No Impact** Majority of trawlers and some netters = **Minor Adverse Impact** Certain trawlers = **Moderate Adverse Impact**
	Cumulative impacts upon commercial fishing	Minor Adverse Impact	None available	Minor Adverse Impact

Table 20.3 Summary of predicted impacts on the human environment

Parameter (ES Chapter)	Potential Impact	Significance	Mitigation	Residual Impact
Seascape (Chapter 12)	Impact upon regional seascape units	**Minor/Moderate Adverse** (Tendring Peninsula) **Minor Adverse** (all other seascape units)	None available	**Minor/Moderate Adverse** (Tendring Peninsula) **Minor Adverse** (all other seascape units)
	Impact upon designated landscapes	Range **from Minor/Moderate Adverse to Negligible**	None available	Range from **Minor/Moderate Adverse to Negligible**
	Impact upon historic landscapes	**Minor/Moderate Adverse**	None available	Minor/Moderate Adverse
	Visual effects from selected viewpoints	**Moderate/Minor Adverse** (viewpoints 1 to 4) **Minor/Moderate Adverse** (viewpoint 8) **Minor Adverse** (viewpoints 5, 6, 7)	None available	**Moderate/ Minor Adverse** (viewpoints 1 to 4) **Minor/Moderate Adverse** (viewpoint 8) **Minor Adverse** (viewpoints 5, 6, 7)
	Cumulative impact on regional seascape units	**Minor/Moderate Adverse** (Tendring Peninsula) **Minor Adverse** (all other seascape units)	None available	**Minor/Moderate Adverse** (Tendring Peninsula) **Minor Adverse** (all other seascape units)
	Cumulative impact on designated landscapes	Range from **Minor/Moderate Adverse to Negligible**	None available	Range from **Minor/Moderate Adverse to Negligible**
	Cumulative impact on historic landscapes	**Minor/Moderate Adverse**	None available	**Minor/Moderate Adverse**
	Cumulative visual impact from selected viewpoints	Combined views = Range from **Minor to Minor/Moderate Adverse** (public users of open space) Sequential views = **Minor Adverse**	None available	Combined views = Range from **Minor to Minor/Moderate Adverse** (public users of open space) Sequential views = **Minor Adverse**

Table 20.3 (Cont'd)

Parameter (ES Chapter)	Potential Impact	Significance	Mitigation	Residual Impact
Shipping & Navigation (Chapter 13) [40]	The proposed GS2 development may lead to changes in vessel routeing	**No Impact**	A list of mitigation measures have been identified in Chapter 13. The key mitigation measures are summarised below: The wind farm will be marked and fitted with navigational aids as required by Trinity House, MCA and PLA Installation of a radar on the south-eastern end of the site Emergency Response and Co-operation Plans will be developed by detailed consultation with SAR services Safety zones of 500m around each offshore structure during construction/decommissioning Turbines will be marked on aviation charts and aviation lighting will be installed according to Civil Aviation Authority requirements	**No Impact**
	The proposed GS2 development may lead to changes in navigation incident rates	**Negligible**		**Negligible**
	Increases in future traffic levels may create adverse impacts upon the proposed GS2 development	**Negligible**		**Negligible**
	Cumulative impact on navigation of interaction between GS1 and GS2 and other Thames offshore wind farms	**Negligible**		**Negligible**
	Cumulative impact on navigation of interaction between GS2 and other Thames offshore wind farms	**Negligible**		**Negligible**

Table 20.3 (Cont'd)

[40] Assessment of impacts on shipping and navigation includes a formal risk assessment. Please refer to Chapter 13 for further details.

Parameter (ES Chapter)	Potential Impact	Significance	Mitigation	Residual Impact
Marine Archaeology (Chapter 14)	The proposed GS2 development may create adverse impacts upon marine archaeology and wrecks	**Minor to Major Adverse**	Development of Written Scheme of Investigation (WSI). This will include an Archaeological Protocol for Unexpected Discoveries and will be developed through consultation with English Heritage and Essex County Council	**Negligible to Minor Adverse**
Other Marine Users (Chapter 15)	Construction and operation of the proposed GS2 project may create adverse impacts upon cables, pipelines, oil and gas facilities, waste disposal sites, marine aggregate sites and military exercise areas	**No Impact**	None required	**No Impact**
	Construction of the proposed GS2 project may create adverse impacts upon recreational activity	**Minor Adverse** (on recreational angling)	Boundaries of exclusion zones will be clearly marked and all changes will be transmitted via notice to mariners at regular intervals	**Minor Adverse** (on recreational angling)
	Operation of the proposed GS2 project may create adverse impacts upon recreational activity	**No Impact** (on recreational angling)	Boundaries of exclusion zones will be clearly marked and all changes will be transmitted via notice to mariners at regular intervals	**No Impact** (on recreational angling) – possible **Minor Beneficial Impact**
	In-combination impacts on recreational activity (angling) between GS2 and other offshore wind farms	**No Impact** (on recreational angling)	None required	No Impact (on recreational angling) – possible **Minor Beneficial Impact**
Munitions and UXO (Chapter 16)	Construction and decommissioning works associated with the GS2 development may disturb UXO, resulting in a risk of explosion	**No Impact**	All personnel conducting intrusive work should attend an Explosive Ordnance Safety and Awareness Briefing. Posters and information of a general nature of the UXO threat should be held in the site office for reference.	**No Impact**

Table 20.3 (Cont'd)

Parameter (ES Chapter)	Potential Impact	Significance	Mitigation	Residual Impact
Telecommunications (Chapter 17)	Disturbance effects may arise on radio and television signals during the operational phase	**No Impact**	None required.	**No Impact**
	Cumulative impacts upon telecommunications from GS1 and other Thames offshore wind farms	**No Impact**	None required.	**No Impact**
Aviation (Chapter 18)	Adverse impacts may arise upon civil and/or military aviation during the operational phase	**No Impact**	Consultation will be continued with key aviation stakeholders, i.e. CAA and NATS. Aviation lighting will also be installed in a suitable and appropriate manner.	**No Impact**
	Cumulative impacts upon aviation from GS1 and other Thames offshore wind farms	**No Impact**	None required	**No Impact**
Socio-Economics (Chapter 19)	The proposed GS2 development may have an impact on local employment levels	**Potential Minor Beneficial Impact**	None required	**Potential Minor Beneficial Impact**
	The proposed GS2 development may have an impact on the local economy	**Potential Minor Beneficial Impact**	None required	**Potential Minor Beneficial Impact**
	The proposed GS2 development may have an impact on local education and tourism	Education = **Potential Minor Beneficial Impact** Tourism = **No Impact**	None required	Education = **Potential Minor Beneficial Impact** Tourism = **No Impact**
	Potential in-combination impacts upon socio-economic conditions	**Potential Minor Beneficial Impact**	None required	**Potential Minor Beneficial Impact**

Table 20.3 (Cont'd)

21. CONCLUSIONS AND RECOMMENDATIONS

21.1 The Proposed Project

The proposed GS2 extension is a 64MW offshore wind farm comprising up to 22 turbines and associated inter-turbine cables. The total area of the GS2 boundary is 7.5km2 and the site is located immediately adjacent to the consented GS1 project. It is currently proposed that foundation and cable installation for GS1 and GS2 would be undertaken in spring/summer 2008, followed by turbine installation in spring/summer 2009 with completion of the project in December 2009.

21.2 Assessment of Impacts

The potential environmental impacts of the proposed GS2 development have been assessed by undertaking a formal Environmental Impact Assessment (EIA). Potential impacts of the construction and operational phases of the project upon the physical, biological and human environment have been assessed.

To assist in the EIA process, a number of surveys have been undertaken at the site, including marine biological, bird and shipping surveys. In addition, detailed consultation has been undertaken with key stakeholders, including government departments, local authorities, commercial fishermen and navigation bodies.

The key findings of the ES are summarised below:

- Impacts upon the physical environment are predicted to be of minor significance and localised around the base of the turbines. No impacts are predicted upon local coastlines in terms of changes to waves, tides or coastal processes;
- Minor impacts are predicted upon marine habitats, fish and birds;
- It is predicted that there will be no significant impacts upon any sites of nature conservation interest, including the potential Thames Estuary Special Protection Area (SPA);
- It is expected that marine mammals, including seals, dolphins and porpoises, will temporarily stay away from the area during the construction phase due to the noise generated, but will return once the wind farm is operational;
- Over the duration of the construction phase, fishing activity will be disrupted due to the presence of exclusion zones around the site. Discussions are on-going about access arrangements to the site for commercial fishing vessels during the operational phase;
- An assessment of the potential visual impacts of the project has concluded that there will be minor adverse impacts from certain viewpoints along the Tendring coastline, especially when GS2 is considered in-combination with other offshore wind farms in this area;
- With suitable mitigation measures, it is predicted that there will be no impacts upon marine archaeology, other marine activities, telecommunications and aviation; and
- Potential impacts on shipping and navigation have been assessed via a risk assessment which concluded that the proposed GS2 project is not expected to significantly increase navigation risk.

Overall, it is concluded that although the proposed GS2 project will result in some impacts upon the environment, these have been judged to be of minor significance.

21.3 Summary of Monitoring Proposals

The following section provides a summary of the monitoring proposals set out within this ES.

21.3.1 Coastal Processes

The present monitoring arrangements agreed for GS1 under FEPA (licence 31919/06/02) provide for monitoring of suspended sediments, seabed morphology and scour. It is recommended that the same monitoring approach is adopted to include for GS2, noting that the improved assessment of sediment grain size has already been completed (ABPmer, 2005b).

The proposed seabed morphology monitoring will ideally extend from present baseline surveys which adopt high-resolution multi-beam sonar. A key feature of interest within further post-construction monitoring is the potential for formation of scour wakes as reported from Scroby Sands.

21.3.2 Nature Conservation

As the development will not have a significant effect on any designated site of nature conservation, no specific monitoring is required. However, data from regular bathymetric surveys (see above) will be of use in confirming the predictions made above related to integrity of the sandbank, such as extent and depth distribution.

21.3.3 Benthic Ecology

A pre-construction benthic survey of the area around Gunfleet Sands was undertaken in April/May 2007 as part of the FEPA conditions for GS1. This survey included near-field and far-field sampling stations, within both the GS1 and GS2 boundaries. Consultation will be undertaken with CEFAS and Natural England to determine the scope of further benthic surveys for the GS1 and GS2 sites.

21.3.4 Fish and Shellfish Resources

As part of the conditions attached to the FEPA licence for the GS1 project, a pre-construction survey of fish populations in the area around Gunfleet Sands is planned. This survey is scheduled for the period June – September 2007. The scope of this survey has been expanded to include coverage of the proposed GS2 site.

21.3.5 Marine Mammals

Marine mammal records would be collected incidentally as part of the bird monitoring programme. Records would then be used to establish use of the area during construction and operations. MMO's will also be used during the construction phase as part of the mitigation protocol.

21.3.6 Ornithology

Ornithological monitoring will be undertaken during the pre-construction, construction and post-construction phases of the proposed scheme. The exact specifications for the ornithological monitoring will be determined via consultation with Natural England. However, it is initially proposed that the following monitoring surveys will be undertaken:

(a) Aerial Surveys: 4 surveys in the winter months, of which 2 will be undertaken in the mid-winter period;

(b) Boat Surveys: 2 surveys per month during the period November to beginning of March covering the winter period for 3 years post-construction.

Due to the proximity of the consented GS1 project, it is proposed that efforts will be made to co-ordinate the ornithological monitoring required for GS1 with that proposed here for GS2.

21.3.7 Archaeology

An archaeological protocol will be developed through consultation with English Heritage and Local Authorities. This protocol will include measures for monitoring the potential for discovering archaeological resources during the construction phase.

21.4 Concluding Statement

Renewable energy is an integral part of the Government's longer-term aim of reducing CO_2 emissions by 60% by 2050. To help combat climate change, the Government has set a target of 15% of electricity supply from renewable energy by 2015.

The potential environmental impacts of the proposed GS2 scheme have been assessed by a formal EIA process. The EIA process undertaken for this project has identified that although there will be some minor environmental impacts on certain parameters, overall, the proposed GS2 project will not result in any long-term, significant adverse environmental impacts. The offshore wind farm will also potentially generate employment on the local level, especially during the operational phase of the project.

The development of the proposed GS2 project will help meet both regional and national targets for electricity generation from renewable energy schemes and will also reduce carbon emissions and as such, represents a nationally important project. It is estimated that once operational, the offshore wind farm will be able to provide clean, renewable electricity to approximately 45,000 households. Compared to electricity generated from coal fired power plants, CO_2 emissions to the atmosphere will be reduced by approximately 180,000 tonnes by the operation of the GS2 project.

22. REFERENCES

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