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ENVIRONMENTAL MANAGEMENT CONSULTANTS

CORDAH

Offshore Wind Energy Generation: Phase 1 Proposals and Environmental Report

For consideration by the Department of Trade and Industry

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1 Non-technical summary

Rationale

In the report *'Future Offshore'* (DTI, 2002), it was proposed that an announcement of a second competition for site leases (second licensing round), for offshore windfarms, would be made in Spring, 2003. This competition will focus on three Strategic Areas. These have been identified and defined borders that, in certain localities, cross the boundary of UK territorial waters (Figure 1, Annex 2). To assist decision-making on the design and terms of the competition the Department of Trade and Industry (DTI) has commissioned a Strategic Environmental Assessment (SEA) in line with the requirements of the 'SEA' Directive[1]. The SEA has resulted in preparation of this *Environmental Report* on the proposals

The need for the development of renewable energy generation in the UK, including wind energy, mainly arises from the requirement to reduce emissions of greenhouse gases. The United Nations "Earth Summit" in 1992, established the need to control greenhouse gases, recognising the growing concerns of rising levels of global warming and pollution. In February 2003, the Government released an energy white paper promoting the reduction of the UK's carbon dioxide emissions - the main contributor to global warming - by some 60% by about 2050 with expectations of real progress by 2020.

The proposed development

For each Strategic Area an estimate was made of likely outputs (MW) for two development scenarios for a series of dates. It was decided to base the SEA on the 'most likely' and 'maximum credible' development scenarios plus the 'no development' scenario. For each development scenario, for each strategic area, and for the years 2010 and 2020 the likely number of turbines (based on the MW outputs) is shown in the following two tables (Tables 4 and 5). The current Round One offshore windfarm developments (as shown in Figure 11, Annex 2) are included in these scenarios.

[1] *Directive 2001/42/EC on the Assessment of the Effects of Certain Plans and Programmes on the Environment* (27 June 2001). Although this Directive is not in effect, DTI aims to follow its requirements in this exercise.

The scenarios are summarised as follows (for translation into turbine numbers see Section 6):

Scenario	Liverpool Bay (MW)	Greater Wash (MW)	Thames Estuary (MW)	Total
Likely (2010)	800	1,600	1,200	4,000
Maximum credible (2010)	1,500	2,500	2,000	7,500
Likely (2020)	1,500	5,000	1,700	10,200
Maximum credible (2020)	3,000	7,000	5,000	17,500

Note; total allows for some development development outside of the Strategic Areas.

On current assumptions, an array occupying an area of 13km x 13km could generate 1000MW. Turbines may be located in depths of up to 50m and technological advance may allow development in deeper waters. Turbines are likely to range from 3 to 5MW and with a maximum, top tip, height from sea level of 150m to 160m.

Description of the environmental situation

The three Strategic Areas are dominated by complex mosaics of soft sediments (Figure 4, Annex 2) in shallow (less than 50m) water (Figure 3, Annex 2). Large areas of the coastline of each Strategic Area are sedimentary in character and a substantial amount of the UK total estuarine and intertidal area is present.

Existing chemical contamination of the sediments in each Strategic Area is localised and in some cases significant. Highest levels of metal, hydrocarbon and other contaminants including, in the Liverpool Bay Area, radioactive waste are associated with muds in estuaries and other sediment sinks, particularly in the vicinity of heavily industrialised localities.

Each Strategic Area is important in terms of its marine wildlife, particularly waterfowl, seabirds, harbour porpoise, seals and commercial fish species spawning and/or nursery areas. Large tracts of the coastline and inshore areas have been or are proposed to be designated under the Habitats Directive for their intertidal areas (which in turn often support large populations of birdlife), seal haul out locations, shallow subtidal sandbanks and biogenic reefs (Figures 2, 5 and 6, Annex 2). Offshore areas of potential reef and shallow subtidal sandbank occur in all three Strategic Areas, particularly in the Greater Wash. English Nature is deliberating, also, on potential sites for conservation designation within the 12nm limit of territorial waters. Similarly, coastal areas have also been designated, as Special Protection Areas under the Birds Directive, because of their bird interests and potential future offshore areas are currently being considered for designation as well. Cetaceans, sharks and rays are known to be, or believed to be, present in each of the Strategic Areas. Along the coast of each Strategic Area are a number of Special Protection Areas (Birds Directive)

Economically, each Strategic Area is significant because of the presence of large ports and the associated shipping, including fishing, activity (Figures 8 and 10, Annex 2). Commercial fisheries include several whitefish species as well as shellfish (molluscs and crustaceans). Fishing activities range from nearshore fishing for crab and lobster to large-scale offshore, commercial operations.

Aggregate extraction is a significant activity, particularly in the Greater Wash and to a lesser extent the Thames Estuary. Only two sites are located in Liverpool Bay (Figure 11, Annex 2). Disposal sites have a small seabed take in each of the three Strategic Areas, with the greatest amount being located in the southern part of the Liverpool Bay Strategic Area (Figure 11, Annex 2). Ministry of Defence activities, both coastal and offshore, are present in the Greater Wash and Thames Estuary Areas (Figure 16, Annex 2).

There are differences in seascape character and value between the three Areas. Liverpool Bay has the most diverse range of seascapes. The seascapes within each of the Greater Wash and Thames Estuary Areas are relatively uniform. In the Greater Wash they are predominantly rural, but lack sufficient 'character' elements to warrant landscape designations. Many of the seascapes in the Thames estuary are characterised by industrial and high-density settlement features and, also, insufficient 'character' elements warranting landscape designations. Seascape sensitivity has been mapped (Figure 18, Annex 2). Recreational activities are substantial in each Strategic Area, particularly the Thames Estuary where recreational navigation is most intense.

Summary of potential significant impacts

The medium and significant risks of environmental impact on the various environmental factors have been tabulated in Section 9.16. A single, low likelihood but high impact, catastrophic event was also identified, whereby collision by cargo (particularly oil tanker) vessel or passenger ferry could result in a significant impact through a loss of inventory (including fuel oil) or loss of life (Section 9.15).

A risk based analysis has shown that (first table in Section 9.16) the main concerns for offshore windfarm development are the potential effects on:

- sediment transport processes;
- conservation sites, biodiversity habitats and species;
- collision risk, displacement, disturbance and barrier effects on birds;
- collision and subsequent loss of inventory from cargo vessels; and
- collision and loss of life from passenger ferries.

Positive impacts are:

- potential fisheries and biodiversity recovery areas should they offer refugia from other activities;
- job creation during construction and operational phases;
- contribution to reduction in greenhouse gas and other atmospheric emissions;
- improved balance of payments; and
- increased energy security.

In addition, a separate analysis of seascape issues suggests that developments less than a certain distance from the coast (within 8 to 13km) will probably have significant visual impact. The distance will vary according to the nature of the seascape in the range of 8km to 13km.

Further, for a number of the assessments discussed in Section 9.16, a degree of uncertainty remains as a consequence of either a lack of data or understanding of effects on a scale larger than previously assessed. These data gaps and research needs have been identified and listed in Section 12.4. The main uncertainties are:

- physical processes associated with large and multiple site development;
- large scale (cumulative) impacts on the benthic environment from major development;
- extent of impacts on birds;
- underwater operational noise on marine mammals;
- electric field effects on marine mammals, migratory fish and elasmobranchs (sharks, skates and rays); and
- impacts on recreation and tourism income.

Summary of potential cumulative impacts

The assessments of the potential risk of significant cumulative impact have been summarised and tabulated in Section 10.3 and the main points highlighted below.

There is a potential risk of cumulative impacts on:

- macro-scale effects on physical processes including sediment transport;
- seascape if development concentrates within medium or high areas of visual sensitivity;
- exclusion of marine mammals due to noise disturbance from seismic and operational activities
- specific bird species such as common scoters, red-throated divers and terns; and
- elasmobranchs remain unknown because of lack of data on how these receptors react to physical and environmental changes induced by windfarms.

These statements hold for all Strategic Areas.

Comparative analysis of development scenarios

Liverpool Bay

With respect to the variety of mappable constraints, Liverpool Bay is the most homogenous of the three Strategic Areas (Figure 21, Annex 2). In comparison with the other Strategic Areas, there are fewer areas of either a high or a low level of constraint. Consequently, it is less easy for developers to identify sites of relatively low constraint in the Strategic Area. For Liverpool Bay the magnitude of the difference between the 'most likely' and the 'maximum credible' scenarios is the least among the Strategic Areas by the year 2010. A substantial increase by 2020 is, however, suggested in these scenarios, representing a maximum potential for 6.2% of the area taken by windfarm development (see below and Figures 22 and 23, Annex 2):

Scenario	Total area (km^2)	Year 2010 (km^2)	Year 2020 (km^2)
Most likely	8,130	135 (1.7%)	254 (3.1%)
Maximum credible	8,130	254 (3.1%)	507 (6.2%)

Overall, the greater amount of constraint and sensitivities occur in the southern part of the Strategic Area, particularly the presence of bird interests, marine habitats of conservation interest, seascape, fisheries and marine traffic (Figure 21, Annex 2). Seascape constraints in the north of the area are significant as a consequence of topography and amount of surrounding coastline including the Isle of Man (Figure 18, Annex 2). Conversely, industrialisation and population density is greater in the south, which in isolation would be thought to offer good siting potential, and a local market (Figure 17, Annex 2).

It is therefore considered appropriate for the greater proportion of future windfarm development to concentrate in the offshore portion of the Strategic Area, most likely with a focus on fewer large windfarms. Locating offshore would limit concerns about visual impacts and birds. Some development, probably of smaller windfarms, could be accommodated within the remainder of the Strategic Area but would be subject to greater levels of constraint and hence potential opposition from one or more interested party, statutory or otherwise.

In terms of capacity to accommodate the two development scenarios, Liverpool Bay Strategic Area is considered capable of supporting each, given that the maximum credible scenario, in 2020 represents a maximum of 6.2% of the total area of the Strategic Area (Figures 22 and 23, Annex 2). However, uncertainties relating to a number of potential impacts (Sections 9 and 10) would need to be addressed to determine whether the 2020 forecasts are achievable without major risk of impact, particularly with respect to physical processes, impacts elasmobranchs and impacts on birds. It is anticipated that in progressing toward the 2010 scenario, these uncertainties would be progressively resolved and the likelihood determined of being able to match the 2020 forecast.

Greater Wash

The Greater Wash has the largest area of low constraint in comparison with the other Strategic Areas (Figure 21, Annex 2). This low constraint area is located in the north east of the Strategic Area outside the 12nm limit. In terms of surface area the amounts occupied for the two scenarios are as follows:

Scenario	Total area (km^2)	Year 2010 (km^2)	Year 2020 (km^2)
Most likely	13,100	270 (2.1%)	845 (6.5%)
Maximum credible	13,100	423 (3.2%)	1183 (9.0%)

The Greater Wash Strategic Area is the largest of the three under consideration and offers the greatest potential capacity for windfarm development (Figure 1, Annex 2). Inshore areas, particularly along the southern part of the area from the Wash and along the north Norfolk Coast, carry the greatest amount of constraint and sensitivity, particularly with respect to visual, marine mammals, inshore fisheries, birds and offshore SAC/SPA habitats (Figure 21).

Areas of offshore aggregate extraction, should they become exhausted in an appropriate timeframe might offer preferable, ‘brownfield’, sites for development (Figure 11, Annex 2). The presence of an extensive oil and gas operation (Figure 12, Annex 2) might present cumulative impact issues such as frequency and scale of seismic surveys, benthic impacts and exclusion of fisheries particularly if, as is likely, development this far offshore is on a large scale.

In terms of the carrying capacity, the ability to achieve the 2020 scale of development for either scenario would be subject to resolving existing uncertainties, particularly those associated with:

- cabling and elasmobranchs;
- physical processes, including sediment transport;
- bird distribution and sensitivity to barrier effects; and
- cetacean distribution and sensitivity to noise.

It is possible that the size of development forecast in the maximum credible, 2020, scenario may not be achievable without resolving (and mitigating) these issues. Both of the scenarios forecast for 2010 are considered achievable and can be readily accommodated.

Thames Estuary

Like the Greater Wash, the Thames Estuary has areas of low constraint on the eastern boundary of the Strategic Area (Figure 21, Annex 2). In terms of surface area the amounts occupied for the two scenarios are as follows:

Scenario	Total area (km^2)	Year 2010 (km^2)	Year 2020 (km^2)
Most likely	5,901	202 (3.4%)	287 (4.9%)
Maximum credible	5,901	338 (5.7%)	845 (14.3%)

This Strategic Area has fewer environmental constraints than the other Strategic Areas (Figure 21, Annex 2), though coastally, several estuaries and marshes are important bird habitats (Figure 6, Annex 2). Seagrass beds are also present along the Essex coast at Maplin Sands. Commercial activities and recreational navigation are other main constraint (Figures 8, 10, 11 and 15, Annex 2). Though of these, aggregate extraction sites may offer 'brownfield' development sites should they become exhausted at an appropriate time (Figure 11, Annex 2). In general, avoidance of coastal sensitivities, including conservation interests and visual impacts, favours offshore development. However, the presence of large amounts of commercial and recreational vessel movements, in the smallest Strategic Area, means that conflict with large scale developments are more likely than in the other areas, even they too support large amounts of ship traffic. In addition, a number of MoD PEXAs might also represent constraints to development, both offshore and nearshore (Figure 16, Annex 2). It is therefore likely that a few large to very large developments might be the most appropriate means of meeting the development scenario forecasts. However these potential conflicts may not ultimately be avoidable should development approach the scale of development forecast for 2020 in the maximum credible scenario.

As noted above, the main uncertainties about windfarm development would require addressing to facilitate extensive development without resulting in significant and unacceptable impacts.

Greenhouse gas emissions

Over the course of the life-cycle of a windfarm (from construction to decommissioning and eventual disposal) the emissions of CO_2 and other emissions are significantly lower than other electricity generating technologies (see table below).

Technology	Emissions (g/kWh)		
	CO_2	SO_2	NO_x
Landfill gas	49	0.34	2.6
Onshore wind	9	0.006	0.02
Offshore wind*	9	0.087	0.036
Coal (best practice)	955	11.8	4.3
Oil (best Practice)	818	14.2	4.0
Gas (CCGT)	466	0.0	0.05

* from Eyre 1995. Based on 400kW turbine with 20 year lifespan.

A very rough calculation indicates that the following reductions would be achieved for the two windfarm development scenarios by the year 2010 and 2020.

Scenario	Year	TWh generated (per annum)	CO_2 reduction (millon tonnes)
Most likely	2010	14	8.4
Maximum credible	2010	36	21.6
Most likely	2020	26	15.6
Maximum credible	2020	60	36

At present, UK overall CO_2 emissions are ~160 million tonnes *per annum* and the government target is to emit ~130 million tonnes *per annum* by 2010. The most likely and maximum credible scenarios for offshore windfarm development would make a 28% and 72% contribution respectively to achieving this target.

From these calculations, it is evident that windfarm development in the offshore environment is to be strongly supported because of its positive contribution to reducing greenhouse gas emissions and thereby meeting Government obligations and more widely a sustainable approach to energy production.

Conclusions of the Environmental Report

This SEA has been carried out, voluntarily in accordance, where practicable, with the SEA Directive[2]. It was undertaken for the proposed development of offshore windfarms in the three Strategic Areas (Figure 1, Annex 2) as part of Government strategy to reduce greenhouse gas emissions. The timescale under assessment is from the present (2003) until 2020 (Section 6). Two development scenarios have been considered (Section 6, Figures 22 and 23, Annex 2) and their potential impacts assessed (Sections 9 and 10). This *Environmental Report* details the potential environmental impacts, both positive and negative, identified during the SEA process and describes their varying degree of significance (Sections 9 and 10). It has not been possible to assess a number of potential impacts, to assess with any certainty in the absence of baseline information or understanding of the relevant processes and environmental responses (Sections 9 and 10). Suggested studies to address these gaps, not already underway, have been identified (Section 12.4).

Section 11, the comparative analysis of the development scenarios, has endeavoured to assess the potential impacts and draw conclusions with respect to:

[2] *Directive 2001/42/EC on the Assessment of the Effects of Certain Plans and Programmes on the Environment* (27 June 2001). Although this Directive is not in effect, DTI aims to follow its requirements in this exercise.

- the overall capacity of the three Strategic Areas to accommodate the draft programme, assessed as two development scenarios and the comparative implications of a strategy favouring particular scales of windfarm developments (i.e. large windfarms vs. small windfarms); and
- Strategic Area capacity to accommodate the development scenarios and how best to achieve them with respect to particular scales of windfarm development.

It has been concluded that the potential constraints on achieving the aims of the draft programme, for the two development scenarios are not sufficient to prejudice its success, subject to the following observations:

- the likely development scenario, to 2010, is achievable for each Strategic Area without coming into significant conflict with the main significant impact risks, namely areas of high sensitivity to visual impact, concentrations of sensitive seabirds, designated and potentially designated conservation sites, MoD Practice and Exercise Areas (PEXAs) and main marine traffic areas;
- the 2020 likely development scenario would only be achievable subject to resolving the uncertainties concerning impacts on: physical processes, birds, elasmobranchs and cetaceans;
- based on our present state of knowledge, fewer large windfarms, of around 1GW or more generating capacity, located offshore are generally preferred against several small-scale developments (comparable to Round One sites), though the latter would be preferable for development closer to the coast;
- the maximum credible scenario for 2010 is achievable subject to resolving the uncertainties concerning impacts on physical processes, birds, elasmobranchs and cetaceans;
- the maximum credible scenario for all Strategic Areas, particularly the Greater Wash and Thames Estuary, for 2020, may be compromised by constraints, particularly cumulative impacts and conflict with marine traffic (commercial and recreational navigation); and
- large scale development could exclude fisheries from significant areas of fishing grounds, particularly if it were to coincide with severance areas associated with other offshore activities.

In order to assist windfarm development with minimal environmental disturbance, it is suggested that the following strategic approach is adopted:

- in all Strategic Areas, avoid the majority of development within the nearshore zone of high visual sensitivity (Figure 19, Annex 2);

- where development might occur in nearshore areas, preferentially select low constraint areas and consider small scale development;

- avoid development in shallow water where common scoter and red throated diver and other species (including marine mammals) are known to congregate (particularly in Liverpool Bay and Greater Wash), pending the outcome of monitoring studies;

- address the uncertainties of large scale impacts at a strategic level, particularly cumulative and those impacts that apply equally to developments irrespective of their location.

Consideration of the potential for adverse environmental impacts of offshore wind energy to compromise development efforts should take into account the economic benefits and more importantly, the indisputable environmental benefit of generating energy using the renewable resource of offshore wind.

2 Introduction and objectives of the SEA

In the report *'Future Offshore'* (DTI, 2002), it was proposed that an announcement of a second competition for site leases (second licensing round), for offshore windfarms, would be made in Spring, 2003. This competition will focus on three Strategic Areas. These have been identified and defined borders that, in certain localities, cross the boundary of UK territorial waters (Figure 1, Annex 2). These Areas were selected on the basis of analysis of the *Windbase* database and provisional indications from the industry (submitted to the Department by the British Wind Energy Association) of areas of most interest in terms of offshore wind development. Key features governing the identification of the three Areas include proximity to grid connections serving important markets and offshore siting criteria conducive to cost-effective construction, operation and maintenance of windfarms. The three Areas are the North-West (hereinafter referred to as Liverpool Bay), Thames Estuary and the Greater Wash (Figure 1, Annex 2).

To assist decision-making on the design and terms of the competition the Department of Trade and Industry (DTI) has commissioned a Strategic Environmental Assessment (SEA) in line with the requirements of the 'SEA' Directive[3]. The SEA has resulted in preparation of this *Environmental Report* on the proposals set out in Section 4. The structure and contents of this *Environmental Report* are considered to be consistent with the Directive. Section 6 outlines the draft programme (as required under Article 6 of the SEA Directive) which is based on a limited number of potential development scenarios. It is against this draft programme for the development of offshore wind that this SEA is making its analysis.

This SEA is known as the Phase 1 SEA as there will be 'follow on', directly-linked SEA work once development activity begins in the three Areas. This work will focus on implementing the recommendations contained in this *Environmental Report.* This Phase 1 SEA was guided by a Steering Group of specialists in coastal/marine environmental issues, wind energy development and SEA (a list of members is presented at Annex 1).

It is expected that there will be additional SEAs undertaken for further competition rounds in other offshore areas. These SEAs will be followed by the Environmental Impact Assessments (EIAs) required under existing legislation for individual consent applications to develop windfarms.

The *Environmental Report* provides information and advice pertaining to*:*

[3] *Directive 2001/42/EC on the Assessment of the Effects of Certain Plans and Programmes on the Environment* (27 June 2001). Although this Directive is not in effect, DTI aims to follow its requirements in this exercise.

- the nature and extent of constraints that would seem to preclude windfarm development, for example, pipeline routes and their safeguarding zones and areas of aggregate extraction (possible 'maximum' constraints);
- the nature and extent of certain environmental and socio-economic features that may be affected by windfarm development and the subsequent levels of constraint, for the offshore wind industry, should they wish to develop in specific localities within the three Strategic Areas ('relative' constraints);
- identification of locations within the three Areas exhibiting the lowest levels of constraint;
- the significance of environmental and socio-economic impacts arising from different realistic scales of windfarm development in areas with lowest levels of constraint; and
- recommendations concerning an environmental management framework for managing the impacts of windfarm development in the three Areas.

This *Environmental Report* is subject to a 28 day period of public consultation. Once this period has been completed a summary of all comments will be prepared. The Environmental Report will be amended, as appropriate, to take account of the comments and a final version issued with the summary of the consultation comments. Both these documents will be a significant input to government decision-making on the nature of the second licensing round.

2.1 Orientation

This Environmental Report has been structured in the following manner:

A summary of findings and salient features for quick reference:

- Non technical Summary (Section 1, above).

Introductory and scene -setting sections that include: the reasons for carrying out the SEA, the focus of the SEA, the approach and method taken for the analysis, the development scenarios that represent the draft programme and a review of other planned developments and trends in activities by other sectors present in the study areas:

- Introduction and objectives of the SEA (this section);
- Legal, policy and regulatory framework (Section 3);
- Scoping and SEA design (Section 4);
- Approach and method (Section 5);
- Development scenarios (Section 6); and
- Relation to other plans (Section 7).

The environment of the study area and the potential impacts from the draft programme:

- Description of the environmental situation (Section 8);
- Prediction and evaluation of impacts (Section 9);
- Prediction and evaluation of cumulative impacts (Section 10); and
- Comparative analysis of development scenarios (Section 11).

Conclusions and recommendations are provided in the following sections:

- Environmental management framework (Section 12); and
- Conclusions of the environmental report (Section 13).

Of the supporting information, there are the reference sources, figures and other data. The latter two are presented in Annexes as follows:

- References (Section 14).
- Steering Group members (Annex 1).
- Figures (Annex 2) as follows:
  - Figure 1: Location
  - Figure 2: offshore habitats of conservation interest
  - Figures 3 and 4: bathymetry and sediments
  - Figures 5 and 6: conservation designations
  - Figures 7 to 18: environmental and economic resources and usage
  - Figures 19 to 23: spatial analyses and representation of scenarios.
- Results of seascape assessment (Annex 3)
- Lists of rare or threatened marine species (Annex 4).

In order to assist the reader in navigating around this lengthy and complex document, each section is numbered individually in the footer and a reference to the section title in the header of each page.

3 Legal, policy and regulatory framework

This section outlines the policy and regulatory framework surrounding the development of offshore wind farms in the UK. It explains the rationale and need for such developments by reference to international, European and UK energy and environmental policy. Then it provides an overview of key UK legislation controlling developmental activities during the construction, operation and decommissioning phases of a typical offshore wind farm development.

3.1 Renewable energy policy framework

3.1.1 International policy context

The need for the development of renewable energy generation in the UK, including wind energy, mainly arises from the requirement to reduce emissions of greenhouse gases. The United Nations "Earth Summit" in 1992, established the need to control greenhouse gases, recognising the growing concerns of rising levels of global warming and pollution.

The Kyoto Protocol, drawn up in 1997, aimed to reduce the emissions of greenhouse gases by developed countries, and led to widespread policy support and encouragement for the generation of electricity from renewable resources. The result has been rapid development of renewable technology, particularly wind.

3.1.2 European policy context

In response to the Kyoto Protocol, the European Community agreed to work towards reducing emissions and to increasing the contribution to energy supplies from renewable sources. In August 2001, the EU published Directive (2002/358/CE) which continued to commit member states to set levels and targets for reducing emissions and increasing renewable energy supply. This Directive also requires the Commission to assess progress towards these national targets and, if necessary, submit proposals for mandatory targets should progress not be sufficient.

3.1.3 National policy context

It is apparent that current and future policies will be largely driven by the UK's global commitments with regard to climate change and the need to reduce harmful gaseous emissions. Ultimately, this means the development of a low-carbon economy, reducing the reliance on fossil fuels and developing alternative, sustainable, low-carbon solutions. In February 2003, the Government released an energy white paper promoting the reduction of the UK's carbon dioxide emissions - the main contributor to global warming -

by some 60% by about 2050 with expectations of real progress by 2020. In January 2000, the UK Government committed itself to supplying 10% of UK electricity needs from renewable sources by 2010. The white paper confirms this target and sets an ambition of 20% of electricity from renewables by 2020.

The key policy instrument for achievement of the current targets is the Renewables Obligation (RO). Launched on 1 April 2002, the RO requires electricity providers to supply a specified and growing proportion of their sales from renewables. The percentage rises from 3.0% in 2002/03, the first year of the RO, to 10.4% by 2010/11, and currently remains at 10.4% in all subsequent years. The RO will remain in place until 2027, and it is estimated that achieving the 2010 target could result in a saving of around 2.5 million tonnes of carbon emissions. Increasing use of renewables to meet the UK Government's 2020 aspirations could mean an annual reduction of 3 to 5 million tonnes of carbon emissions by 2020. Offshore wind energy is seen as a major contributor towards this target and the UK's other international commitments.

The RO is also the main mechanism for stimulating growth and investment in the offshore wind industry, with an associated system of capital grants designed to promote its further development. Other measures include exemption from Climate Change Levy payments for renewable energy users and regional targets for generation.

In Scotland under the devolution arrangements, the responsibilities of the Scottish Executive extend to adjacent waters as far as the 12nm limit. The Executive has devolved responsibility for the promotion of renewables in Scotland as well as the consents required under Section 36 of the Electricity Act to construct and operate generating stations. The Executive is committed to raising the overall proportion of electricity generated from renewable sources to 18% by 2010 (including existing large hydro). The Executive has consulted, recently, on the potential to generate as much as 40% of Scotland's electricity from renewable sources by 2020. Developers, however, are currently more interested in windfarms onshore or on offshore islands rather than offshore projects.

In Wales, the Welsh Assembly Government and relevant agencies are pursuing, strongly, an increasingly active clean energy/energy-conservation strategy (Welsh Assembly Economic Development Committee, 2003). In doing this they recognise that Wales has a higher preponderance of industrial activity than the UK average and the most energy intensive industries are often concentrated in the more deprived areas. As such Wales' energy intensive industries face potentially serious consequences if carbon reduction targets are over ambitious. Wales produces around 12 mega-tonnes of carbon through carbon dioxide emissions in a year and has set an overall target of reducing that by about 20% or 2.5 mega-tonnes of carbon by 2020. The Economic Development Committee of the Welsh Assembly has undertaken a review of energy policy in Wales, the final report of which was published in January 2003. A series of conclusions were drawn from a wide public consultation and recommendations have been made to the Assembly covering future strategic policy, planning procedure and targets for production of energy from renewable sources. Offshore wind is likely to feature strongly in the Assembly Government's future energy policy (probably a third of the target) though the coastline offers potential locations for other offshore energy generation technologies such as tidal stream, wave and tidal barrage.

3.2 Marine environmental policy

3.2.1 International and European policy context

The need for international action for the conservation of biodiversity was recognised at the United Nations "Earth Summit" in 1992. The "Convention on Biological Diversity" was signed there by 159 governments and has subsequently been a driving force behind national and international environmental policy during the subsequent years, with much of this work focused on the marine environment. Ten years later, the 'follow on' summit to Rio, the World Summit on Sustainable Development (WSSD) held in Johannesburg, affirmed a number of commitments, targets and timetables aimed at the achievement of a more sustainable marine environment.

In the European Union and wider European context there are a number of elements to marine environmental policy, with particular focus on nature conservation and sustainability. In 1979, the "Convention on the conservation of European wildlife and natural habitats", otherwise known as the Bern Convention, was signed by the Council of Europe. The aim of the Convention was to ensure the conservation of European wildlife and natural habitats by means of co-operation between states. In the same year, the EC 'Directive on the conservation of wild birds', the 'Birds Directive' was adopted. The Directive allowed for the creation of Special Protected Areas (SPAs) to protect habitats supporting a number of listed bird species, and in addition, places an obligation upon Member States to avoid pollution or deterioration of habitats also used by species listed in the Directive.

In part to fulfil the requirements of both the Bern Convention and the 1979 Birds Directive, but also to begin to fulfil the commitments made during the 1992 Rio "Earth Summit", the European Commission adopted the 1992 Directive on the Conservation of Natural Habitats and of Wild Fauna and Flora, generally known as the 'Habitats Directive'. This Directive aims to protect biodiversity through the conservation of natural habitats and of wild fauna and flora in the European 'territory' and to maintain or restore, at a favourable conservation status, natural habitats and species of wild fauna and flora. The main mechanism for achieving these aims is the creation of network of conservation sites called the Natura 2000 network of sites, which includes SPAs allowed for under the Birds

Directive, as well as Special Areas of Conservation (SACs) designated for habitats and species listed in the Habitats Directive.

In 1992, the Oslo and Paris Convention for the Protection of the Marine Environment of the North-East Atlantic (the "OSPAR Convention") replaced the earlier Oslo and Paris Conventions which were adopted in the 1970s. Of particular relevance is Annex V of the Convention which deals with issues such as protection and conservation of marine ecosystems, biological diversity and nature conservation. This Annex is supported by a strategy that will be implemented, through an established Biodiversity Committee within OSPAR, by advocacy of the establishment of a network of marine protected areas throughout the OSPAR region.

The Bergen Declaration, arose from the fifth International Conference on Protection of the North Sea, was signed by ministers of states bordering the North Sea in 2002. This declaration proposed a number of elements that should be included in future marine policy to be pursued by signatory countries. These included *inter alia*, the development of ecosystem approaches to marine management, the conservation and restoration of species, the need for achievable sustainable fisheries, and the promotion of renewable energy in the marine environment. .

3.2.2 National policy context

The UK responded to the 1992 Convention on Biodiversity, by producing "Biodiversity: The UK Action Plan (BAP)" in 1994. This plan set out a strategy for conserving and enhancing wild species and wildlife habitats in the UK. The plan is well underway with Habitat Action Plans (HAPs) written for various (including marine) habitats, Species Action Plans written for a number of species (including marine species), at a national level. In addition, a network of Local Biodiversity Action Plans (LBAPs) has been created, with a focus on achieving biodiversity targets at the local (generally local authority) level.

In the Defra document, *Working with the Grain of Nature. A Biodiversity Strategy for England*[4], reference is made to sustainable development of the offshore energy sector through the further incorporation of biodiversity considerations into the environmental assessments (SEAs and EIAs) relating to offshore renewable energy and other activities

The *1994, Conservation (Natural Habitats, &c.) Regulations* transposed into UK law the 1992 EC Habitats Directive, setting out the requirements that the Directive places upon UK authorities. The regulations detail the processes involved in the designation of SACs and SPAs, and they allow for the development of "Schemes of management" to facilitate the management of marine SACs in order to achieve conservation objectives for the site.

[4] [www.defra.gov.uk/wildlife-countryside/ewd/biostrat/index.htm],

The designation of marine SACs in the UK has been limited to sites within the 12 nautical mile (12nm) territorial limit, and it is important to note that this is the extent of the Conservation Regulations. However, the UK Government has been advised that the Habitats Directive applies to the full extent of the UK continental shelf and adjacent waters to a limit of 200 nautical miles from the baseline from which the territorial sea is measured. Consequently, the UK Government, through the Joint Nature Conservation Committee, is in the process of identifying offshore (beyond 12nm) areas for designation as SACs and SPAs. The UK Government is committed to bringing in regulations to implement the Habitats Dirvective beyond 12nm.

In 2002 the UK government outlined it's strategy for conservation and sustainable development in the marine environment within the Marine Stewardship Report (MSR) – "Safeguarding our Seas" sets out the UK government's vision for clean, healthy, safe, productive and biologically diverse oceans and seas. It commits the UK government to a framework of initiatives to enhance marine nature conservation, conserve biodiversity, improve management of marine resources and develop scientific research to help inform future policy decisions.

The MSR was built upon in November 2002 by the production of "Seas of Change" - the government's consultation paper to help deliver its vision for the marine environment (DEFRA, 2002b). "Seas of Change" fulfils the commitment made in the MSR to consult on arrangements for stakeholder involvement in future marine stewardship reports. In addition, it is designed to gather views on the principles that could underpin a future ecosystem approach to marine environmental management and invites comment on a number of strategic goals for the marine environment.

3.3 Legal and regulatory framework

The legal and regulatory basis under which development rights for offshore wind energy are allocated is defined clearly only within UK territorial waters, that is within the 12 nautical mile limit. At present the Government is carrying out a review of the regulatory framework for development in marine waters[5]. The need to develop legislation to allow development to take place beyond territorial waters will naturally be affected by this process.

The development of an offshore windfarm, within territorial waters, falls under Section 3 of the Crown Estate Act 1961 that provides the right to use Crown Estate land. Statutory

[5] *Regulatory Review of Development in Coastal and Marine Waters*. (co-ordinated by DFT). http://www.shipping.dft.gov.uk/marine/.

consent is provided in the form of a lease granting rights of occupation for the placing of structures or cables on the seabed.

The construction of an offshore windfarm requires a range of consents involving several separate Government departments. There are two consent routes currently available in England and Wales for developers to proceed with an offshore windfarm and all offshore cabling applications. These are:

- Section 36 of the Electricity Act 1989 and Section 34 of the Coast Protection Act (CPA) 1949; and
- Transport and Works Act (TWA).

Both routes require an application under Section 5 of the Food and Environmental Protection Act (FEPA) 1985, for deposits in the sea or within the seabed covering the installation of the turbine foundations and scour protection material. A FEPA licence may also be required to cover any deposits entering the water column during installation, from drilling or pile driving.

Other consents will also be required depending on the nature of the site and the related onshore development proposals. These may include permits, licences and consents under the Town and Country Planning Act, 1990 (for onshore substations and cables); Electricity Act 1989 (for onshore overhead lines); the Water Resources Act, 1991 (if erecting structures in a water course); The Conservation (Natural Habitats, &c) Regulations, 1994 (if works are within or adjacent to a designated conservation site), and relevant Harbour Licences (if placing works within navigable waters). The figure below demonstrates the geographical extent of the principal legislative controls. Further information and can be found at www.mceu.gov.uk.

Environmental Impact Assessment

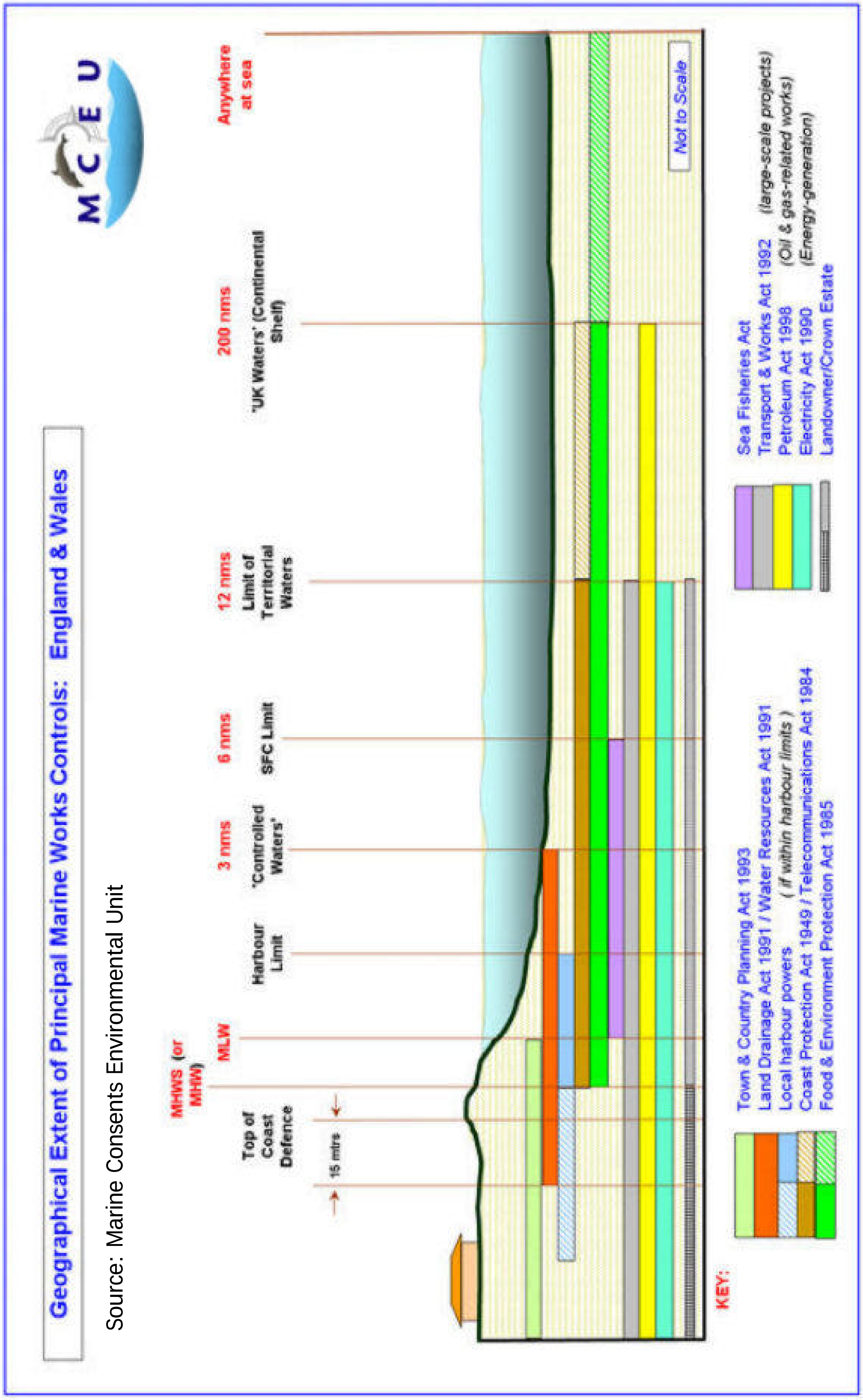
The Environmental Impact Assessment Directive (85/337/EC and as subsequently amended by 97/11/EC) requires an EIA to be carried out in support of applications for development consent for wind farms where they are likely to have significant environmental effects. Where various consents impose a requirement for more than one EIA, a single Environmental Statement covering all relevant environmental issues will normally be sufficient.

Appropriate Assessment

The principal aim of the Habitats Directive 92/43/EEC, on the conservation of natural habitats and of wild fauna and flora, is to sustain biodiversity through the conservation of natural habitats and wild fauna and flora in the territory of Member States. These targets are principally being met through the establishment of Special Areas of Conservation (SACs), which form part of a network of sites known as the Natura 2000 network.

The purpose of the Birds Directive is to protect the eggs and nests of a series of listed bird species within Member States. This is achieved by the protection of the birds' potential habitats, through the preservation, maintenance or restoration of a sufficient diversity and area of habitat essential to the conservation of listed bird species. These targets are principally being met through the establishment of SPAs. For species that it is not thought possible to establish designated areas, such as highly mobile ones, for example harbour porpoise, management measures need to be developed to implement the directive for such species.

Developments that may have an effect on Ramsar sites are also subject to the requirement for an appropriate assessment.


Geographical Extent of Principal Marine Works Controls: England & Wales
Source: Marine Consents Environmental Unit
MCEU
MHWS (or MHW)
MLW
3 nms
6 nms
12 nms
200 nms
Anywhere at sea
Top of Coast Defence
15 mtrs
Harbour Limit
'Controlled Waters'
SFC Limit
Limit of Territorial Waters
'UK Waters' (Continental Shelf)
Not to Scale
KEY:
Town & Country Planning Act 1993
Land Drainage Act 1991 / Water Resources Act 1991
Local harbour powers (if within harbour limits)
Coast Protection Act 1949 / Telecommunications Act 1984
Food & Environment Protection Act 1985
Sea Fisheries Act
Transport & Works Act 1992 (large-scale projects)
Petroleum Act 1998 (Oil & gas-related works)
Electricity Act 1990 (Energy-generation)
Landowner/Crown Estate

Together SACs and SPAs form a network of sites known as 'Natura 2000' sites. The Habitat Directive requires that any activities, plans, or projects whether inside or outside a 'Natura 2000' Site, that are likely to have a significant effect on the conservation status of the site's features shall be subject to an assessment. The assessment must be appropriate to determine the implications of the proposed plan or project with respect to the conservation objectives of the Natura 2000 site, which may be affected. Therefore, where a proposed offshore windfarm site is located within, or would be likely to significantly affect, a designated, proposed, or candidate 'Natura 2000' site, consenting authorities must ensure an Appropriate Assessment is carried out.

Where a proposed project does not fall within the boundaries of a 'Natura 2000' site, an appropriate assessment would only be required if it is considered (and fully justified) that a significant effect on the site is likely. It is the responsibility of the competent authority, with advice from the statutory conservation agencies, to determine whether a proposed project is likely to have a significant effect on a European Site. In the case of projects outside 12nm, the UK Department of Transport and Industry (DTI) or other, as appropriate, competent authority would undertake the assessment of significance.

Generally, a project may only proceed once it has been ascertained that it will not significantly adversely affect the integrity of a site's features. In the event that the development of a windfarm might result in adverse impact on a European site, the scheme would only be granted consent if the Secretary of State is satisfied that there were:

- appropriate grounds of imperative overriding public interest;
- no alternative solutions available; and
- suitable compensating habitat for the loss to that site.

4 Scoping and SEA design

Consistent with 'good' SEA practice scoping consultations, involving key stakeholders, were undertaken to determine the work to be done in implementing the SEA and preparing the *Environmental. Report.* Actions undertaken included *inter alia*:

- providing information about the expected windfarm development activity, to be subject to SEA as a consequence of the 'second round', and the main alternatives (levels of activity and spatial distribution);
- identifying the main specific development actions arising from construction, operation and maintenance, and decommissioning phases of offshore windfarm development;
- determining the main likely significant impacts/issues to be examined for each development alternative, by phase and associated main actions, and the key receptors; and
- preparing a Scoping Report.

In addition to focusing on the development alternatives and the main likely significant impacts/issues, the Scoping Report (BMT Cordah, 2003) identified potentially beneficial opportunities arising from windfarm development. Also, it presented brief discussions of data availability issues, the consultation process and the choice of impact assessment methods that were to be used to guide the SEA and present the results.

The Scoping Report was based on the following consultation and other inputs:

- scoping workshop held in London on 25 November 2002;
- written scoping views submitted post-workshop by specific workshop attendees;
- perusal of previous Environmental Statements for individual offshore windfarms and specific advice such as the Environment Agency's '*Scoping the environmental impacts of windfarms (on-shore and off-shore)*' (May, 2002) and the results of other related studies undertaken by English Nature, Countryside Council for Wales and Scottish Natural Heritage;
- comments received, from members of the SEA Steering Group, on drafts of the Scoping Report; and
- the requirements of the 'SEA' Directive.

This Scoping Report was published on the SEA website where interested parties could ascertain the focus of the SEA and the nature of the work to be undertaken.

The Scoping Report was the foundation for the SEA work. However, as SEA work progresses new information may be obtained, some assumptions may be unfounded and data availability and other practicalities may mean that the approach and method need to be changed. During the SEA work changes to the approach and methods did occur, primarily because of data-related difficulties. The Steering Group advised on the acceptability of changes, to the SEA work programme, including amendments to the approach/methods to be used, subsequent to the preparation of the Scoping Report.

Scoping consultations indicated that impacts should be considered for the following development phases:

- exploration (in particular seismic surveys);
- construction (site preparation and erection of turbines and laying of cables);
- operation and maintenance (infrastructure and transport requirements);and
- decommissioning (including removal and after-use options).

Also, it was recommended that the SEA should include onshore coastal activities directly related to windfarm development such as transmission line connections and reinforcement.

Finally, it was considered important to predict and evaluate a range of impacts under three broad categories:

- physical environment;
- biological environment; and the
- human environment.

The range of impacts to be examined under the 'Human environment' category goes beyond a strict interpretation of the SEA Directive. They are included in this SEA as they have been identified as being important by a number of consultees. Also, inclusion of such impacts in this SEA is consistent with government policy on sustainable development and the thrust of ODPM[6] draft guidance on implementing the SEA Directive in England.

In addition, the Scoping Report makes it clear that most consultees consider it to be vital that the SEA focuses explicitly on the cumulative impacts. This aspect is seen as one of the key features distinguishing the SEA from individual EIAs for consent applications. It was stressed that it is important to identify key receptors (e. g. birds and fish in terms of habitat change and disturbance, and people with respect to visual and other socio-economic impacts) for consideration of cumulative impacts.

[6] Office of the Deputy Prime Minister (2002) *Draft Guidance on the Strategic Environmental. Assessment Directive.* London: Office of the Deputy Prime Minister.
It should be noted, however, that this guidance is primarily focussed on land use planning and not the marine environment.

Thus, consideration of cumulative impacts focuses on the combined, incremental effects of:

- windfarm development in the three strategic focus areas with other past (including 'first round' windfarms), present or reasonably foreseeable development actions. These actions are likely to include non-windfarm development actions (such as aggregate extraction) if they are present or deemed likely to occur with a reasonable degree of certainty;
- the range of impacts, from windfarm development only, with respect to the three Strategic Areas; and
- development-related changes, over time, within the wind-farm lifecycle (based on assumptions regarding pace and direction of technological change).

In all of the above situations and for the key receptors it is necessary to consider long-term chronic effects as well as short-term acute effects. To the extent possible, the implications of all of these types of cumulative impacts are taken into account in the SEA.

Finally, the SEA attempts to predict and evaluate cumulative impact on 'global' issues such as biodiversity, greenhouse gas production (in terms of UK contribution) and global warming. These issues can only be tackled in very broad, general terms.

5 Approach and method

Since a SEA focuses on a strategic rather than a site- or project-specific level of analysis, the level of detail that can be analysed and presented can vary from a typical site-specific EIA. Basically, it can be difficult for an SEA to provide the level of detail and quantification of impacts that can be achieved in EIAs. This SEA is no exception; thus, the overall approach focuses more on assessing constraints, sensitivities and risks instead of detailed analysis of the characteristics of specific impacts. Such an approach is believed to be consistent with 'good international practice' in SEA and the requirements of the SEA Directive.

The methods used in this SEA are consistent with this overall approach. A two stage process has been used; first, a GIS-based spatial analysis was undertaken, thereafter followed by risk-based analysis of likely effects (including cumulative implications) of the selected development scenarios**. It is important to note that the GIS mapping and analysis only pertains to factors that could be mapped.** All other factors are described, assessed, using a risk-based approach and conclusions drawn as to the potential environmental risk posed to them in Sections 8, 9 and 10).

It should be noted that, following Steering Group discussion, the methodology described below differs from that proposed and outlined in the Scoping Report. The use of GIS has been restricted to mapping *inter alia* existing structures and activity areas, selected socio-economic and environmental (including seascape) factors using simple scoring systems (see Tables 1 and 2). Remaining factors have been described in Section 8 and the potential impacts on them (along with those mapped) in Section 9.

5.1 Stage 1: Spatial analysis

The spatial analysis is based on electronic overlays (layers) of data and maps to integrate and present data to assist with the description of the existing environment and economic activity and to facilitate identification of areas of high/low constraints. The process progresses through two steps:

1) Identification of maximum constraints – areas of serious constraints to windfarm development, for example, pipelines and the accompanying safeguarding zones; and
2) Mapping of other factors such as shipping lanes and potentially designated marine habitats of conservation interest– to identify areas of lesser or greater degrees of constraint ('relative' constraints).

5.1.1 Step 1 – maximum constraints

Certain factors are maximum constraints on development. A composite map showing the distribution of these factors has been produced (see Figure 19, Annex 2) and described in Section 8. Included in this map are:

- existing and planned licensed areas for aggregate extraction, waste disposal and military operations;
- oil and gas structures and safety zones;
- cultural heritage sites (mostly wrecks and other seabed obstructions);
- cables;
- existing shipping/navigation lanes and Traffic Separation Areas; and
- proposed windfarm developments from the first licensing round.

5.1.2 Step 2 – 'relative' constraints

Selected socio-economic, visual (seascape) and ecological factors were mapped (Figures 2, 5, 6, 8, 9, 15, and 18, Annex 2). Each factor was layered on the basemap to facilitate a spatial analysis and a visualisation of those areas with greatest potential, and fewest constraints, for development. To assess these factors, their characteristics were allocated a rating score from 0-3, as shown in Tables 1 and 2. Once each rated layer was mapped, the spatial analysis process then interpolated them all to generate the constraints map (Figures 19 and 20, Annex 2). This map highlights locations that are subject to several constraints (a high total score) and those with fewer constraints (a low total score). Socio-economic and ecological factors are presented separately in Figures 19 and 20 (Annex 2) as noted in the legend of these and as listed in Tables 1 and 2, prior to their combination (Figure 22, Annex 2), to maximise clarity and understanding. The visual (seascape) factor is included in Table 2 with the ecological factors.

During the development of this approach, due consideration has been given to comparable methodologies such as those followed for assessments of MEHRAs (Marine Environmental High Risk Areas), those pertaining to application of Regulation 33 of the *Conservation (Natural Habitats &c.) Regulations,* 1994 and the work of Oakwood Environmental Ltd (2002).

Table 1: Spatial analysis scoring for each socio-economic factor

Factor	Score	Criteria
Shipping	0	Absent
	1	Low intensity (1-2500 hours *per annum*)
	2	Medium intensity (2500-7500 *per annum*)
	3	High intensity (7500-20000 *per annum*)
Fishing effort	0	None
	1	Low (1-500 hours in 2002)
	2	Medium (500-5000 hours in 2002)
	3	High (5000-15000 hours in 2002)
Shellfishery areas	0	Absent
	1	Unlicensed and unexploited beds [future resource]
	2	Licensed, but unexploited beds
	3	Licensed natural and farmed beds

At the outset of this SEA, the intention of the spatial analysis approach was to map the majority of ecological data (for example species distributions and migration routes) and so offer a robust and objective appreciation of the spatial patterns of ecological resources and their complex interplay. However, the availability, extent, format, resolution and quality characteristics of existing datasets have meant that, for the greater part, this has not been feasible or practicable. Factors that could not be mapped are considered in the risk-based impact analysis described below.

Table 2: Spatial analysis scoring for each environmental factor

Factor	Score	Criteria
Designated habitats	0	Absent
	1	-
	2	Nationally important undesignated potential interest feature, proposed designation and designated site
	3	Internationally important undesignated potential interest feature, proposed designation and designated site
fish spawning areas (all selected commercial species)	0	Absent
	1	-
	2	Species spawning in water column
	3	Species spawning in sediment
Fish nursery areas (all selected commercial species)	0	Absent
	1	-
	2	Pelagic species
	3	Demersal and benthic species
Seascape	0	No sensitivity
	1	Low sensitivity
	2	Medium sensitivity
	3	High sensitivity

Notes:

Commercial fish species spawning on the seabed included here are; sand eel, herring and sprat. Other species are water column spawners.

Commercial fish species with pelagic juveniles included here are; herring and sprat. All others are demersal or benthic.

There are two main outcomes of the spatial analysis. First, there is a series of maps showing, for each Strategic Area, the constraints based on the score of individual factors. These maps are presented in Annex 2. The second main output results from interrogating the GIS data to show localities, within each Strategic Area, that show different levels of constraint (based on the combined scores of each mapped factor). These maps show a gradation of localities from those showing low levels of constraint to those characterised by higher levels.

These maps (Figures 19 to 21, Annex 2) show respectively the following:

- constraints caused by existing structures and socio-economic activities (some characterised by legal exclusions);
- constraints caused by ecological and visual (seascape) factors; and
- all constraints and showing existing windfarm proposals within the Strategic Areas.

However, the maps only show those factors that could be incorporated into the GIS framework. These 'constraint' maps are the basis of the impact assessment stage of the work. Localities showing low constraint levels are assumed to be those likely to be favoured by developers on the assumption that operating in such localities is commercially viable. Thus, it is useful to consider the likely impact of different development scenarios in terms of these localities. This work allows factors (and impacts on these factors), that could not be incorporated into the GIS, to be considered.

5.2 Risk-based impact analysis

For each Strategic Area, the generic impacts applicable to the two main development alternatives (the 'most likely' and the 'maximum credible' scenarios – see Section 6) were assessed using a risk-based approach. The analysis focused on both factors that could be mapped and specific receptors such as certain birds and fish species that could not be incorporated into the GIS database. As the basic difference between the two scenarios is one of scale in terms of size and extent of construction and support-related activities the impacts are similar; only the magnitude (and perhaps significance) of the impacts vary. The impacts of both scenarios are compared in the Section 10.

To the extent possible, impacts were quantified (e.g. seabed 'take') and other impacts were described qualitatively using the professional judgement of the SEA 'team' based on an extensive literature review. All impacts were evaluated in terms of their significance using a risk–based approach that has been used previously to assess impacts in the marine environment. BMT Cordah used a variant on this approach to assess impacts from decommissioning the Brent Spar oil production platform in Norwegian inshore waters to construct a harbour extension. This approach focuses on an analysis of the likelihood of an impact occurring and the expected consequences. Particular attention was paid to identifying and isolating key areas of uncertainty, e.g. baseline data gaps or lack of knowledge about impacts that make prediction difficult. Details showing how the risk-based approach is applied to impacts are shown in Section 9.

5.2.1 Seascape

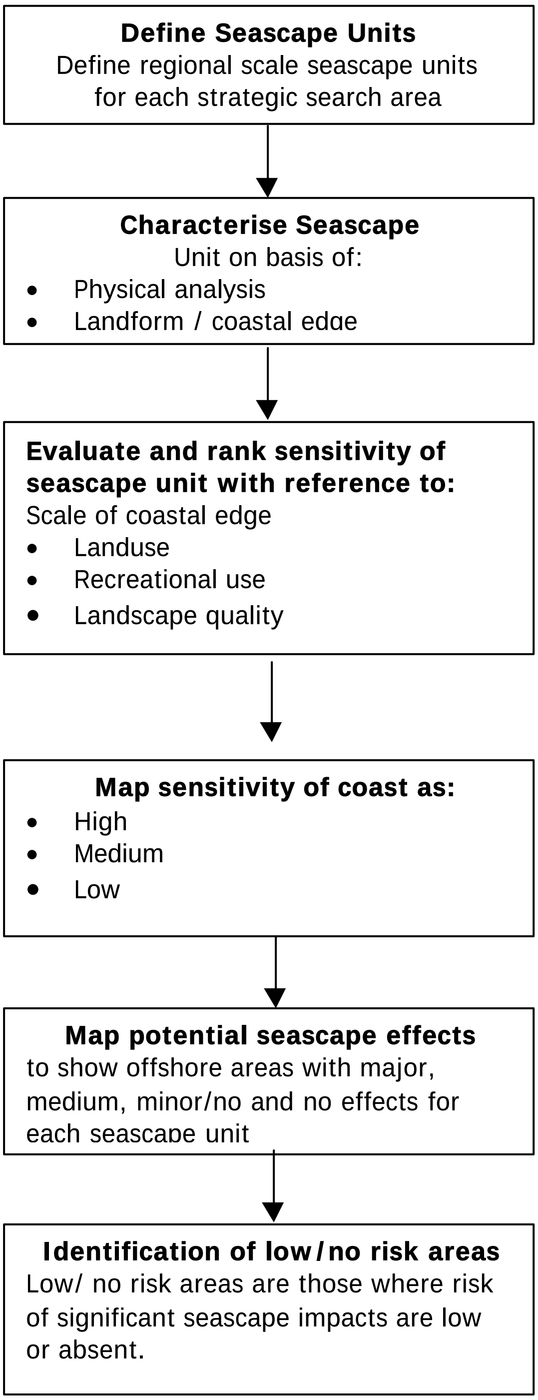
The issue of visual impact is an emotive and ultimately subjective issue. As a consequence it is challenging to address, more so for a strategic environmental assessment when as it considers general, rather than site specific, plans (Section 6). Consequently, for the purpose of this SEA, a seascape assessment was carried out as a specific study, with a methodology of its own. The results of the work, however, have been included in the constraints map described above (Section 5.3.1).

Seascape assessment is considered to be an extension of landscape character assessment. Accordingly the principles of landscape character assessment are applicable, acknowledging the particular features such as the coast which differentiates seascape from landscape. Wherever seascape is mentioned in this report, it should be understood to encompass seascape, landscape and visual amenity.

The methodology used has drawn on key elements of the CCW Guidance (2001) and applied them within the constraints of undertaking a strategic, desk-based study using available baseline data. Also, the approach has been designed to be compatible with the GIS method used in the SEA. Accordingly the methodology has followed the process illustrated in the flow chart below.

This assessment is constrained by the availability of data and the need to develop a methodology based on quantifiable criteria. For example, the assessment has not taken into consideration potential effects on onshore historic landscapes. The assessment has not taken account of the various ancillary components of offshore wind farms. However, it is considered that in relation to the strategic nature of the study, the mapped outputs provide a useful input to the SEA in respect of potential seascape, landscape and visual effects.

Seascape assessment methodology flowchart



It is acknowledged that offshore wind farms will consist of several components with the potential to cause seascape effects during construction, operational and decommissioning phases. These will comprise various construction stage activities and the different operational phase components including onshore or offshore substations, grid connections, storage yards and docking facilities. However, the detail of any proposed development will not be known until individual proposals are made. Accordingly, this strategic assessment is based on the potential seascape effects arising from the turbines. It is envisaged that the offshore turbines will be a minimum of 100m height to blade tip and a maximum of 160m to blade tip. The potential effects arising from the minimum and maximum turbine heights are assessed below.

Lighting

Implementation of a lighting regime will result in the navigational lighting associated with an offshore wind farm having a visual effect extending at least 8km (equivalent to 5 nautical miles) from the wind farm boundary. Depending on the location of any offshore windfarm this lighting may be visible from the shore, and detailed impact assessment would be needed.

Seascape units

Countryside Council for Wales (CCW) guidance (CCW, 2001) was used to assist describing the seascape baseline. It recommends a hierarchical approach to defining seascape units to produce national, regional and local seascape units. With respect to the three Strategic Areas the national units are:

- *Liverpool Bay* is encompassed by National Unit 11 (Great Orme to Solway Firth);
- *The Greater Wash* is bisected by National Units 2 and 3 (Flamborough Head to the Wash and the Wash to the Thames); and
- *The Thames Estuary* is made up of 2 units: National Units 3 and 4 (the Wash to the Thames and the Thames to Selsey Bill respectively).

The Guidance recommends that regional units will be the normal working level for seascape assessment.

Regional seascape units have been defined, for this SEA, on the basis of 'view sheds', coastal geometry and orientation. Therefore, principally, they are from headland to headland with a maximum linear extent of approximately 15km of coastline. The derivation and analysis of seascape units is presented in Section 9.12 and illustrated in Figure 18 (Annex 2).

Sensitivity ranking

The seascape units were analysed to determine their sensitivity to change of the type associated with offshore windfarms. This was achieved by identifying the presence of the following key elements for each unit and scoring the different characteristics of each element as detailed in the table below.

Scale: Seascape scale is determined by the scale of the topographic features in each seascape unit e.g. bays, cliffs, beaches or headlands. Small scale seascape/landscape is considered to be more sensitive to change of the nature associated with offshore wind farm development, whereas a large scale seascape/landscape is considered to have more capacity to accommodate this type of development.

Landuse: This has categorised into three broad categories of use in order to provide a measure of development on the coastal edge and within the hinterland component of each seascape unit. Where industry is identifiable on the 1:50,000 scale OS maps, it is likely to be large scale and the area is considered to be less sensitive to change of the nature associated with offshore wind farm development. Where there is existing settlement, the seascape unit is considered to be more sensitive to offshore wind farm development and where landuse is predominantly rural indicating limited built development, the seascape unit is considered to be of most sensitivity to offshore wind farm development.

Recreational use: It is considered that resort towns have the most intense usage and are therefore ranked as major recreational use, with marinas and visitor centre locations ranking as moderate usage and camping and caravan sites as minor use. It is recognised that intensity of recreational use is not the only measure of sensitivity to change. Less developed stretches of the coastline which are valued for recreational use may be considered to be more sensitive to offshore wind development than intensively developed coastal resorts. However, by ranking quality as defined by various designations and landuse as defined by type of use with rural uses ranking the highest, account has been taken of the sensitivity of non-developed coastline, particularly where this occurs in or adjacent to a designated landscape.

Seascape quality: This has been assessed in relation to formal recognition of quality by landscape designation, as well as by the presence of recognised coastal footpaths which have generally been established along sections of the coast where the quality of the coastal interface is appreciated by walkers. It has also been assessed in relation to the presence of Blue Flag beaches. It is noted that this definition of quality differs from the CCW Guidance definition which is "*the condition of the seascape components or features that comprise a seascape*".

Table 3 Sensitivity ranking for seascape parameters.

Rank	Scale			Landuse			Recreational use				Quality			
	large	medium	small	industrial	settlement	rural	major	moderate	Minor	none	National park	AONB	Heritage coast / coastal footpath	Blue flag beach
3														
2														
1														
-1														
-2														

Final Ranking System

Scores for each Strategic Area have been calculated as follows:

1. No sensitivity coastal unit – score of zero or less than zero;
2. Low sensitivity coastal unit – lower third of scores;
3. Medium sensitivity coastal unit – middle third of scores; and
4. High sensitivity coastal unit – upper third of scores.

It has been assumed that development visible from locations assessed as having no sensitivity and low sensitivity will have no effect or minor effect (i.e. not significant) upon seascape, landscape or visual amenity of that coast. Maps have been produced showing low or no sensitivity seascape units, medium sensitivity seascape units and high sensitivity seascape units in respect of potential seascape, landscape and visual effects.

Method of Mapping Potential Effects

Having ranked the coastal units within each Strategic Area in relation to their sensitivity to change arising from offshore wind development, the next step has been to assess the potential effects on seascape, landscape and visual amenity for the adjacent offshore areas.

Minimum recommended offshore threshold distances are highest for high sensitivity seascape units and decrease for medium and low/no sensitivity seascape units. In practice this means that the area of major effect for a high sensitivity coastal unit will be closer to the shore (0-8km offshore) than the area of medium effect for medium sensitivity seascape unit which is 8-13km (See Table 21, Section 9.12). In this way minimum offshore thresholds have been plotted to reflect the sensitivity of each coastal seascape unit. This method returns the maximum areas of low or no effect whilst establishing appropriate minimum distances for offshore development.

Minimum offshore limits for wind farm development for each seascape unit have been set, with reference to CCW Guidance and in response to consultation during the study period, at 8km, 13km, and 24km respectively for high, medium and low sensitivity seascape units.

Zones with sequentially greater seascape effects towards the shore will be identified as areas located between the distance of no significant effect and the shoreline using the criteria below (see Table 21, Section 9.12).

Visual Overlap

View cones from more sensitive areas of coast overlap with those of less sensitive areas, therefore areas of sea immediately off shore from preferred coast may be visible from more sensitive coastlines. These areas of visual overlap have been assessed according to the most sensitive area from where they are visible. For the purpose of assessment the visibility criteria listed in Table 3 will be applied to the areas of overlapping visibility. This will be taken into account in the next phase of the assessment.

The results of the seascape assessment are discussed in Section 9.12.

5.3 Outputs

Once this risk-based analysis was completed, a number of outputs resulted (see Sections 9 and 10). For example, it was possible to identify and describe:

- special studies needed to obtain baseline data and/or information on the nature of expected impacts to reduce the risks. The recommended studies will focus on particular receptors, the type of studies needed and the relative priority for implementation (discussed in greater detail in Section 12.4);

- mitigation measures to reduce risks, related to specific aspects of the development phases of windfarms (Section 12.2);

- monitoring programmes to track the nature and scale of expected actual impacts that exhibit levels of uncertainty that may be considered acceptable, but require evidence to justify this assumption (Section 12.3); and

Also, at this stage, opportunities were identified and measures that could be implemented to maximise the benefits from these opportunities were described (see Section 12.1).

6 Development scenarios

It is essential that the SEA considers the impacts of a reasonable number of alternatives to comply with both the 'SEA' Directive and draft ODPM Guidance on application of the 'SEA' Directive. This will enable the proposed framework for management of offshore wind generation to be based on the environmental implications of credible alternative courses of action. This information will enable the DTI to inform the public, when the framework is adopted, on how the *Environmental Report* and consultations,

"*......have been taken into account in accordance with Article 8 [requiring consideration of an Environmental Report and the results of consultations in decision-making prior to adoption of an intended plan or programme] and the reasons for choosing the plan or programme, as adopted, in the light of other reasonable alternatives".*

There are two distinct aspects to devising credible alternatives. First, it is necessary to consider the likely scale of development scenarios in terms of Megawatt (MW) output by a specific date (2010 and 2020 were selected). Secondly, based on these 'output' scenarios it is important to determine the likely alternative options with respect to of the layout configuration of windfarms. A no development option has also been considered and used to compare the environmental risks of the other development scenarios (see Section 8.6).

6.1 Description of development scenarios

The scenarios were developed taking into account current knowledge and reasonable expectations regarding key factors such as:

- Government policy evolution;
- Technical innovation;
- Grid connections and need for reinforcement; and
- Capacity for constructing windfarms (e. g. barge availability) (OXERA, 2003).

For each Strategic Area an estimate wa made of likely outputs (MW) for two development scenarios for a series of dates. It was decided to base the SEA on the 'most likely' and 'maximum credible' development scenarios plus the 'no development' scenario. For each development scenario, for each strategic area, and for the years 2010 and 2020 the likely number of turbines (based on the MW outputs) is shown in the following two tables (Tables 4 and 5). The current Round One offshore windfarm developments (as shown in Figure 11, Annex 2) are included in these scenario's.

Table 4: Most Likely scenario, MW and turbines installed

	2010 (MW)	Turbine numbers 3MW	5MW	2020 (MW)	Turbine numbers 3MW	5MW
Within territorial waters						
Greater Wash	800	267	160	1500	500	300
Thames Estuary	1000	333	200	1500	500	300
Liverpool Bay	800	267	160	1500	500	300
other	400	133	80	1000	333	200
sub-total	*3000*	*1000*	*600*	*5500*	*1833*	*1100*
Beyond territorial waters						
Greater Wash	800	267	160	3500	1167	700
Thames Estuary	200	67	40	200	67	40
Liverpool Bay	0	0	0	0	0	0
other	0	0	0	1000	333	200
sub-total	*1000*	*333*	*200*	*4700*	*1567*	*940*
Total MW installed	**4000**	**1333**	**800**	**10200**	**3400**	**2040**
Proportion of UK electricity supply	**4.0%**			**10.2%**		

Table 5: Maximum credible scenario, MW and turbines installed

	2010 (MW)	Turbine numbers 3MW	5MW	2020 (MW)	Turbine numbers 3MW	5MW
Within territorial waters						
Greater Wash	1500	500	300	2000	667	400
Thames Estuary	1000	333	200	2000	667	400
Liverpool Bay	1000	333	200	2000	667	400
other	1000	333	200	1500	500	300
sub-total	*4500*	*1500*	*900*	*7500*	*2500*	*1500*
Beyond territorial waters						
Greater Wash	1000	333	200	5000	1667	1000
Thames Estuary	1000	333	200	3000	1000	600
Liverpool Bay	500	167	100	1000	333	200
other	500	167	100	1000	333	200
sub-total	*3000*	*1000*	*600*	*10000*	*3333*	*2000*
Total MW installed	**7500**	**2500**	**1500**	**17500**	**5833**	**3500**
Proportion of UK electricity supply	**7.5%**			**17.5%**		

It is extremely difficult to predict the number, scale and location of windfarms between 2003 – 2020 because of the large uncertainties. Figures 21 and 22 (Annex 2) show the overall area that windfarms would take to realise these scenario's and values for the overall area of take has been calculated and presented in Section 11. It is not possible to map these development scenarios in terms of likely number, size and distribution of windfarms. Though the following likely site development strategies are thought to be reasonably accurate.

Small windfarms are likely to be built near the coast to reduce costs. Their location will be driven, partly, by the need to transmit electricity for the shortest possible distance (to reduce losses) and to connect with the grid at the nearest location. Windfarms under 300MW are likely to seek connection with the regional distribution network. The operators of this network take power from National Grid substations and distribute it locally. The connection is likely to be at a facility that needs the minimum reinforcement work to be able to accept the electricity. Therefore, it is not so easy to predict preferred locations because of the uncertainty concerning the location of windfarms, but also the range of connection options open to windfarm operators. On the basis of the scenario analysis above, the number of cables and connections to the regional distribution network may be highest in the Liverpool Bay area.

Larger windfarms are not so constrained by these factors, for example, larger cables lose less energy. Cabling costs are less significant in terms of overall capital costs and, thus, more options are available to connect with the grid. However, operators will want to connect to the National Grid as economically as possible. Figure 1 (Annex 2) shows those National Grid coastal connection facilities capable of accepting power from large-scale windfarms. These will all need some reinforcement if the maximum credible scenario is realised.

On current assumptions, an array occupying an area of 13km x 13km could generate 1000MW. Turbines may be located in depths of up to 50m and technological advance may allow development in deeper waters. Turbines are likely to range from 3 to 5MW and with a maximum, top tip, height from sea level of 150m to 160m.

The most efficient layout for an array of turbines is not a rectilinear grid, but an array based on equilateral triangles (DTI, 1999). On current assumptions, an array occupying an area of 12km x 12km could generate 1000MW (turbines may have a rotor arm diameter of ~100m with a spacing distance of ~1km). In practice, the array will be based on lines and columns following nominal seabed contours. Turbines may be located in depths in the range 10-50m and technological advance may allow development in deeper waters.

7 Relation to other plans

To assist understanding of the way the environment will change without offshore windfarm development in the strategic areas (the 'no windfarm development' scenario), it is necessary to consider the objectives and scope of other plans, programmes or major development initiatives likely to affect the three Strategic Areas. Then, the impacts of windfarm development can be compared with the environmental baseline as it is expected to be in the same timeframe as the windfarm developments rather with the environmental baseline as it is now.

7.1 Shipping

The key development to take place, within all three Strategic Areas, will be the revision of current traffic management in order that the UK government complies with EU legislation. This has some potential implications for offshore development, such as:

- alteration of shipping lanes which will affect the location of wind farms; and
- the use of Automotive Identification Systems (AIS).

Presently, the development of a traffic management plan that requires community-wide vessel monitoring and tracking is underway. Though this is due to be implemented by the end of 2004, no specific information on the likely outcome and implications is presently available.

7.1.1 Thames Gateway

It is proposed to improve the import and export capacity of the Thames Estuary area, through development of a lower Thames Crossing, further enhancement of existing links to Europe, particularly passenger and goods terminals and cruise liner facilities, as well as port development at Shell Haven. Port development associated with this project could have an impact on the physical conditions and processes of the area. Also, capital and maintenance dredging and disposal may occur within the Thames Strategic Area. It is difficult to predict the location and significance of the likely impacts. They may be widespread rather than localised. They may also impact on nationally or internationally important habitats and species. Therefore it is not possible to determine, at this stage, the extent to which there may be a change in the key baseline features of the Strategic Area, and its significance.

Additionally, the flood defence network for the Thames Estuary is currently being assessed with a view for substantial improvement or modification. Though falling outside of the Strategic Area boundary, there is the potential for changes in shipping activity as a consequence of flood defence scheme construction work.

7.2 Aggregates

Aggregate extraction currently takes place in all three Strategic Areas, but with varying degrees of intensity. The following trends have been identified:

- the tonnage extracted and the seabed area subject to extraction in the Thames Estuary is declining;
- the aggregate industry in the Greater Wash is progressively operating further offshore; and
- in Liverpool Bay, one licence application is currently being considered, but there are no others expected in the short term.

Additionally, the aggregates sector has recently completed a Regional Environmental Assessment of the east English Channel (Posford Haskoning, 2003). There is a possibility that the industry as a whole may concentrate a significant proportion of future activity in this region.

These trends, if combined, might have ramifications for future aggregate extraction activity in one or more of the Strategic Areas. Overall, the possible movement of extraction offshore in the Greater Wash area and a general movement of extraction activities to the east English Channel have most implications for the Greater Wash and Thames Estuary Areas:

Greater Wash – a move further offshore may be neutral or even detrimental in terms of baseline changes. The outcome depends on the scale of the movement and growth in the aggregate sector. In the short term, and assuming some growth in output, the impact may be detrimental in terms of benthos, benthically oriented fish and their predators as new areas are exploited and depleted areas begin the recovery process.

Thames Estuary – a move of extraction activities to the east English Channel would benefit the environment of this Strategic Area if it results in recommencement of the decline in production from the area. If no movement occurs and there is continued growth, then the impact is likely to be detrimental to the benthos, benthically oriented fish and their predators,.

Liverpool Bay – only limited growth is expected with a limited detrimental effect on the benthos.

Overall, a continuation of growth with no general movement to the east English Channel will have a small and limited detrimental effect. If, however, a general movement to the east English Channel occurs then the overall environmental impact will be beneficial in terms of the Strategic Areas. In such an eventuality abandoned sites may help 'free up' existing aggregate areas for windfarms and offer 'brownfield' opportunities for development. Future expansion of the aggregates industry is entirely reliant on the areas put forward to which the Crown Estates accepts applications for licences. (BMAPA *pers. comm*.; Crown Estates *pers. comm.*).

7.3 Oil and gas exploration

Exploration within the North Sea depends on block licensing, exploration success, and the economic and commercial benefits of the development. The oil and gas sector is currently subject to a SEA programme and two SEA Reports that are relevant to The Greater Wash and Thames Estuary Strategic Areas (DTI 2001 and 2002) have been completed. Estimates of likely future exploratory activity, for both of their SEA areas (SEA 2 and SEA 3), are low resulting from licensing in both areas reflecting the limited prospects for oil and gas production. The most likely situation is a possible expansion of production from existing, or limited increase in number, of offshore facilities. A similar SEA has yet to be carried out that would encompass the Liverpool Bay Strategic Area though it is understood (CCW, *pers. comm*.) that a similar situation exists.

On the 5th February, 2003, the DTI announced the 21st seaward licensing round that offered blocks in both the Greater Wash and the Thames Estuary Strategic Areas (www.og.dti.gov.uk). Along with the announcement, support information was provided that made reference to significant discoveries that were on offer, none of which were in or near the Strategic Areas. No blocks in or near the Liverpool Bay Strategic Area were included in the announcement.

The SEA programme, ever-improving regulatory control and technological innovation are likely to reduce the impacts from current and expected oil and gas activity in the future. Within the next 10 years it is possible that activity may decline thus reducing the impact of this industry in the Strategic Areas. Beyond this time horizon there is too much uncertainty to make any prediction of the likely future of the industry and, thus, of the effect on the environmental baseline of the Strategic Areas. Overall, in the near term, the overall effect is expected to be, at best, positive and, at worst, neutral.

7.4 Nature conservation designations

There already exists a network of Special Areas of Conservation (SAC) and Special Protection Areas (SPA) around Britain collectively known as Natura 2000. However, the UK Government is currently taking steps to implement the Habitats Directive in waters beyond 12nm and complete the network of SPAs by including marine sites both inshore and beyond 12nm. This will result in further sites being designated or existing designations extended. The three main types of marine SPA are currently envisaged as:

- seaward extensions of breeding colony SPAs beyond low water mark;
- inshore areas used by birds in the non-breeding seasons e.g. seaduck and divers; and
- marine feeding areas.

There already exists a network of Special Areas of Conservation (SAC) and Special Protection Areas (SPA) around Britain collectively known as Natura 2000 however, the UK Government is currently taking steps to implement the Habitats and Birds Directives in waters further offshore. This will result in further sites being designated and existing designations extended.

Special Protection Areas (SPA)

The three main types of marine SPA are currently envisaged as:

1. Seaward extensions of breeding colony SPAs beyond low water mark
2. Inshore areas used by non-breeding birds, (e.g. seaduck and divers)
3. Aggregations of seabirds away from the coast, probably for feeding but possibly for other reasons.

The process is being informed by data collected using boat based, aerial and land based surveys. Guidance is currently being developed by JNCC for the identification and boundary definition of these marine SPAs. Guidance has been produced for seaward extensions of breeding colony SPAs or four species (Atlantic puffin *Fratercula arctica*, common guillemot *Uria aalge*, razorbill *Alca torda,* and northern gannet *Morus bassanus*). Any guidance will be subject to review with the SPA scientific working group that includes representatives from the statutory conservation and countryside agencies and RSPB.

Special Areas of Conservation (SAC)

The marine SAC's are currently envisaged as:

- sandbanks which are slightly covered by seawater all the time;

- reefs (which include bedrock reefs, stony reefs and biogenic reefs);
- submarine structures made by leaking gas; and
- submerged or partially submerged sea caves (although sea-caves are not currently known to occur in UK offshore waters).

Marine SAC's may also be designated for species. In UK Waters, these are likely to include:

- grey and common seals;
- bottlenose dolphins; and
- harbour porpoises.

Further information on the designation of Marine SACs and SPAs can be found in Natura 2000 in UK Offshore Waters, Johnston et al, JNCC 2002 (http://www.jncc.gov.uk/publications/jncc325/intro325.htm).

7.5 Fishing

It is envisaged that fishing activity will remain in all three Strategic Areas, but the effort may change as a consequence of Common Fisheries Policy developments with respect to catch quotas and other changes. Further, it has been indicated CEFAS (*pers. comm.)* that stock management areas may be implemented in the future, in order to control declining fish reserves. Existing fisheries management schemes encompass parts of the Thames Estuary and Greater Wash Strategic Areas (DTI 2001, 2002) and include requirements that restrict access by specified fleets in order to offer protection to the fish resource. Overall, the environmental baseline in the Strategic Areas (especially, in the Thames Estuary and Greater Wash) may improve with developments in fishery management and a more sustainable approach, to fisheries, in the future.

7.6 Military exercise

The MoD assesses proposals for wind farms on a case by case basis as part of the planning process. To assist developers a procedure has been put in place whereby prior to the formal planning process Defence Estates at MoD will advise a developer whether or not they will object to a particular project.

7.7 Civil aviation

Currently under review is the potential development of a new airport on the south bank of the river Thames at Cliffe, North Kent. It is proposed to build four new runways with a capacity of 312 million passengers. It is difficult to predict the likelihood of this development occurring; however, if it were to occur it is unlikely to affect the environmental conditions of the Strategic Areas except for the visual, noise, air pollutant and, perhaps, bird characteristics of the Thames Estuary. It is likely that this airport would add a significant, localised 'maximum' constraint, to windfarm locations, as it would require safeguarding areas of 18 to 30km as well as take off and landing corridors of 8.5km. The Civil Aviation Authority (CAA) are also required to be notified during the planning stages of a windfarm development, at which time they assess each proposal for existing and future aircraft usage and physical and electromagnetic obstruction (CAA, *pers. comm.*).

7.8 Cables

The rights of the cable industry (including telecommunications, power and interconnector cables) to develop in international waters are protected under United Nations Convention on the Law of the Sea (UNCLOS), and any future developments should be checked against existing and proposed cables. There are several cross-Atlantic cables currently proposed that would landfall in the Thames Estuary and Greater Wash Strategic Areas. The UK Cable Protection Committee (UKCPC) is currently preparing a response to the '*Future Offshore'* document and has requested that it be consulted during the consent process (UKCPC, *pers. comm*.). Minimum exclusion zones between cables, and telecommunications cable interactions with power cables, are currently being researched. The Crown Estate licence cables in Territorial Waters.

7.9 Microwave transmission

Locations of microwave links cannot be released, however, they are considered during assessment of windfarm development proposals by he Home Office. At present, the Home Office has no objection to any of the existing proposals for offshore windfarm development. Further, it does not foresee any future conflicts for windfarm developments offshore with respect to microwave links. Though at present it is a legal requirement to consult on this matter, the Home Office has suggested that they are removed from the consultation list for offshore developments. However, some microwave communication links do exist in inshore areas within the Strategic Areas (Home Office *pers. comm.*).

8 Description of the environmental situation

This section summarises our present understanding of the environmental conditions and trends in each of the three Strategic Areas: Liverpool Bay, Greater Wash and Thames Estuary. The baseline description concentrates on factors that are relevant to the assessment process as a whole and does not attempt to present a comprehensive and broader presentation of all aspects of the baseline. Determination of the physical, biological and socio-economic factors relevant to the assessment has been made by the scoping process as presented in the Scoping Report (BMT Cordah, 2003).

The following sections describe, first, the physical environment, then the biological and, finally, the socio-economic aspects for each Strategic Area. In many instances the proximity of the Greater Wash and Thames Estuary has allowed for description of these two areas in combination. Wherever practicable the data have been presented graphically and/or in tables to help convey the salient features as clearly and succinctly as possible.

8.1 Physical environment – processes

8.1.1 Liverpool Bay

Physical environment

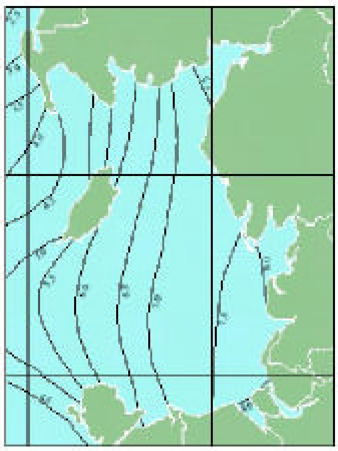
Within the Liverpool Bay Strategic Area the majority of the coastal reaches are low-lying, including a series of 14 estuaries that represent nearly 25% of the total UK estuarine area and all except one exceeds 5,000ha in area (DEFRA, 2000, Barne *et al.,* 1998). The largest of these are the macro-tidal estuaries of the Solway Firth and Morecambe Bay (BGS, 2002) and the latter represents the second largest area of intertidal mud and sand in the UK, after the Wash. The importance of these estuarine areas in the context of this SEA is with respect, primarily, to the associated bird interest. From the Solway Firth to the western boundary of the Strategic Area, the character changes to one dominated by a rocky coastline, giving the region two distinct areas.

Generally, the benthic environment is characterised by sand and muddy sand, with only localised areas of both muddier and coarser sediments (Figure 4, Annex 2). A small area of hard ground and patches of shallow subtidal sand (Figure 5, Annex 2) are notable due to their conservation value offshore (Section 8.4). The existing levels of contamination and ecological and economic attributes of these sediments are described in subsequent sections. A small number of subtidal rock outcrops and gravel areas are present (Figure 2, Annex 2).

Geology

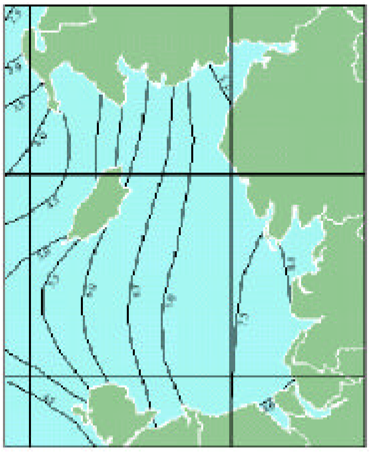
During the last glaciation, the Liverpool Bay region was one of extensive deposition, as an ice sheet flowed down the western Irish Sea and spilt over eastwards into the shallower, eastern part, depositing a complex sequence of sediments across coastal fringes of the region (British Geological Survey, 1978, 1980 and 1987). Much of the north-eastern Irish Sea is underlain by till (boulder clay), which may be over 100m thick in the over-deepened valleys off the Cumbrian coast. Off the coast of Lancashire and Cumbria, muds of variable thickness formed during the melting of the ice sheet overlie the till. Thick muds from glacial melt also overlie till to the west of the Isle of Man and Anglesey. The north-eastern Irish Sea is the site of the East Irish Sea and the Solway Firth Basins, which are separated by a narrow ridge of older sedimentary rocks stretching between the Lake District and the Isle of Man. The East Irish Sea basin is made up of eight or more faulted basins, filled with up to 4.5m of sediments.

Oceanography



Liverpool Bay current speeds (Lee and Ramster, 1981)

The wider physical hydrography of the Irish Sea, including Liverpool Bay, have been described in some detail in other reports (Bowden, 1980, DEFRA 2000, OSPAR 2000a, Weighall *et al.,* 2000). The salient information from these, and related, documents are described here.



Liverpool Bay tidal range (Lee and Ramster, 1981)

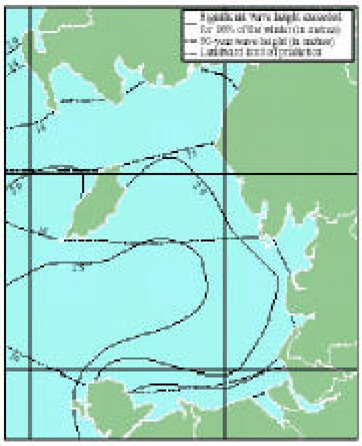
Liverpool Bay and Irish Sea circulation is moved by the action of tides, winds and differences in density between adjacent water masses (Bowden, 1980). The twice daily flooding and ebbing of the tides provides the most obvious movement of water. However, the strength of the tidal currents varies across the region and this determines many of the processes and distributions within the sea (mixing, fronts, sediment transport, sediment distribution and, indirectly, elements of the long period, density-driven circulation). The cumulative effect of individual wind events contributes to the overall long-term (>2 months) mean circulation of the region. In general, the weakest flows are in response to water density differences between the saline oceanic inflows and freshwater input by river discharge.

However, such currents are persistent and produce a major contribution to the residual flow, especially in the eastern Irish Sea.

More notable, are strong, persistent, circulations associated with summer heating and stratification of the water column, particularly in the deep basin of the western Irish Sea.

The tide propagates into both north and south entrances of the Irish Sea from the Atlantic Ocean (Robinson, 1979). The tidal waves from both directions meet to the south west of the Isle of Man, generating an area of very weak tidal currents ($<35cm.s^{-2}$). The majority of the tidal energy flux into the Irish Sea is through the southern entrance. This flux largely dissipates off Anglesey and the Mull of Galloway, to the west of the southern and northern extremities of the Strategic Area, where tidal currents are strong and peak flows exceed 120cm s^{-1}.

The maximum tidal range occurs on the Lancashire and Cumbrian coasts where the mean spring range is 8m. Toward the eastern boundary of the Strategic Area, the tidal range is approximately 6.5m (see figure, above right). In shallow water, sudden changes in bathymetry and/or topography may generate locally high current velocities near headlands, islands and estuaries (see figure, above left), the strongest of which are associated with the upper half of the area.

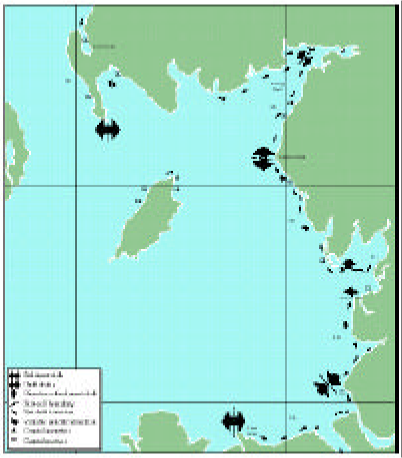


Liverpool bay wave heights based on 10% winter and spring heights. Draper 1982

Given the sheltered nature of the Irish Sea, surface waves are typically locally generated, of a short period and comparatively steep. The 50-year return value of the significant wave height ranges from 2m coastally to 1.5m at the western boundary of the Strategic Area (see figure, left). Storm surge waves, caused by the combined action of both wind forcing water and sea height variations due to atmospheric pressure, have been predicted to reach maximum levels of 2m along the Lancashire and Cumbrian coasts and lower offshore (Flather, 1987).

The long-term mean circulation through the Irish Sea is characterised as weakly northwards, typically travelling at a velocity of between 1 to $3cm.s^{-1}$. Within Liverpool Bay, the freshwater discharges from the Rivers Dee, Mersey, Lune and Ribble cause complex horizontal and vertical water density changes that control mean flow. It is believed (Ramster and Hill, 1969, DEFRA, 2000) that there is a mean near bed landward flow of the order of $3cm.s^{-1}$ and an offshore, northerly surface flow of some $4cm.s^{-1}$. The latter is also highlighted by radionuclide transport patterns from the Sellafield discharge (DEFRA, 2000). The northerly (clockwise) surface flow is reported to be density driven though a southerly (anticlockwise) flow may also occur as a consequence of wind (Norton, *et al.,* 1984).

Sediment transport


Liverpool Bay littorine transport cells (Motyka and Brampton, 1993)

Along the south of the Liverpool Bay Strategic Area, up to the River Mersey, there is a high easterly transport of sand with some lower shingle transport. This is partially controlled by groynes and defences, but as the area predominantly consists of wide sand flats, this transport is difficult to control. To the west of the Dee and up to the Mersey the movement is significantly reduced. To the north of the River Mersey there is significant wave induced transport along the coast up to the River Ribble. From there the rate drops significantly up to the River Wye where there are dune systems supplying the beaches along the tourist areas of Blackpool and Fleetwood. However, in recent years urbanisation and coastal squeeze have significantly reduced the size of these areas. This factor, coupled with natural (and engineered) changes to the morphology of the Mersey area means that existing patterns of coastal sediment transport may differ from previously published data (Motyka and Brampton, 1993 and Irish Sea Study Group, 1990).

From Morecambe Bay northward there is weak drift in multiple directions, with sediment supply coming from the number of estuaries along this stretch. The controlling factor is wind driven, causing dune development where conditions are favourable and maintaining the wide sand flats with pebble and cobble back faces along the rest of the area. Once north of St. Bees Head, however, the drift becomes north-easterly towards the Solway Firth. Tidal action changes the patterns of siltation and erosion and sinks have historically trapped quantities of coal particles along the beaches just north of St. Bees Head (Motyka and Brampton, 1993 and Irish Sea Study Group, 1990).

The far north of the Strategic Area is dominated by moderate westerly drift along the coastline to the west of the Solway Firth (Irish Sea Study Group, 1990). In the Solway Firth and Morecambe Bay areas, significant periodical morphological changes occur because of being open to wave action and the impact of storm surges, both of which can generate significant sediment resuspension and redistribution.

8.1.2 Greater Wash and Thames Estuary

Physical environment

The bathymetry of these two Strategic Areas is illustrated in Figure 3 (Annex 2). It is apparent that the water depth is consistently less than 50m and in many locations less than 10m. A large proportion of the coastal margins of these Strategic Areas is low-lying, sedimentary and interspersed with intertidal areas and estuaries. The Wash itself, of which the eastern portion falls within the Greater Wash Strategic Area, (see Figure 1, Annex 2) is the largest UK intertidal area (DEFRA 2000).

The seabed of the Greater Wash in particular, but also the Thames Estuary, is dominated by sand and gravels, with only limited areas of finer particles (Figure 4, Annex 2). These sediments are of interest not least because of their conservation (Section 8.4), fisheries (Section 8.5.2), and economic (Section 8.5) value. The existing levels of contamination and ecological attributes of these sediments are described in subsequent sections.

Geology

The Thames and Greater Wash Strategic Areas are part of the North Sea basin. Although much of the rest of the North Sea Basin and its sub-basins tended to subside and extend during the Mesozoic and Tertiary periods, filling with sediments, the extreme southern end of the North Sea formed by the Anglo-Brabant Massif remained emergent throughout most of this period. Also in the northern part of this area these sediments generally form a veneer of less than 1m. Bedrock or glacial deposits are often exposed locally. Exceptionally, the sand-rich sediments comprising the Norfolk Banks in the south east of this region attain a maximum thickness of about 40m, but the overlying gravely sand substrate remains thin (British Geological Survey, 1985, 1986 and 1991).

The distribution of seabed sediment reflects this history and the interaction of erosion, transportation and deposition, related both to hydrodynamic conditions at the sea floor and the supply of sediment. Large concentrations of sediments with high gravel content occur on bathymetric highs in areas of extensive rock outcrop, and in areas of strong current in the English Channel and offshore in the Humber Estuary.

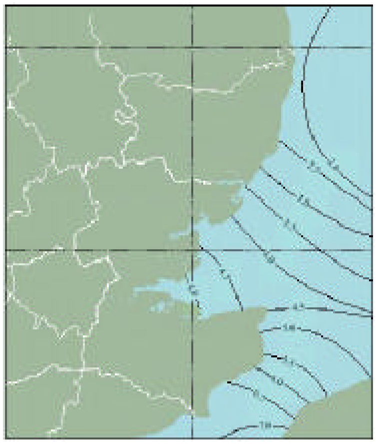
Sands are widespread, very largely mobile and tend to accumulate in areas of moderate to strong tidal currents. Tidal sand ridges up to 50km in length and 40m in height are also common, particularly off the East Anglian coast and in the Straits of Dover.

The Wash has extensive deposits of till which is a stiff, reddish to greyish brown clay containing patches of sand and silt. Much of it is less than 5m thick but thickens to as much as 25-20m toward the Lincolnshire coast. Its component particles of chalk, red sandstone and grey mudstone are derived from the sedimentary rocks of eastern England.

To the north-east of Norfolk the sediments consist of lacustrine sands and muds, and deltaic sediments (lagoonal clays, sands with plant remains, worn shells and pebbles of the Yarmouth Roads Formation). Further to the south-east, offshore from east Norfolk, deposits comprise shelly grey marine sands with silt parings (Red Crag Formation), grey marine clays and fine-grained sands (Westkapelle Ground Formation), and fluviatile or estuarine sands with clay laminae and flint pebbles (Yarmouth Roads Formation). There is also the Brown Bank Formation, comprising silty clays and fine sands, deposited in estuarine or fluviatile environments. The Thames region has areas of Red Crag and Westkapelle Ground Formation in the northern extents of the area (British Geological Survey 1986 and 1991). Sediments are laminated silty clays and fine sands, deposited in estuarine or fluviatile environments towards the south.

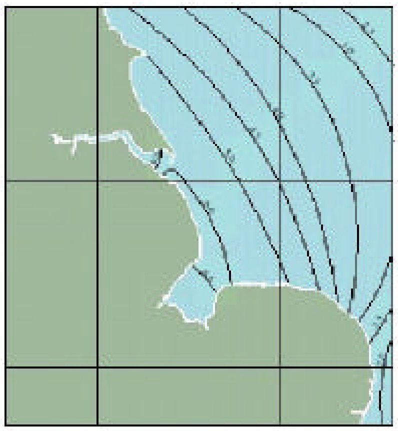
The course of the River Thames was located north of the present estuary, resulting in terrace sands and gravels being deposited across southern and eastern Essex. During the Anglian glaciation, the route of this ancient river was blocked by ice, and diverted southwards and followed several different courses over time as a result of convergence with the early courses of the Rivers Medway and Stour.

Oceanography



Thames max tidal ranges (Lee and Ramster, 1981)

The general residual circulation pattern of the North Sea has been reported or summarised in a number of publications (for example Hill, 1973; Turrell, 1992; Stone *et al.,* 1995; DTI 2002). In essence, these reports indicate that, in the inshore locations for these Strategic Areas, there is a southward movement of Scottish Coastal Water that is then deflected offshore in the vicinity of the Wash (the South North Sea Water). English Channel water passes through the eastern portion of the Thames Estuary. The southern North Sea is not generally subject to stratification at any time of the year, with the water column remaining well-mixed (OSPAR 2000b).



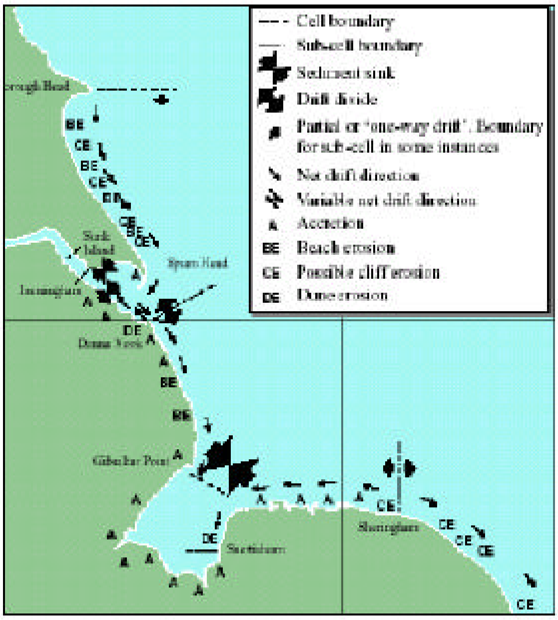
Max spring tidal ranges in the Wash (Lee and Ramster, 1981)

The maximum tidal range for the Greater Wash increases from north-east to east from 3m to peak heights of 6.5m in the mouth of the Wash (see Figure, right). For the Thames Estuary the range, from east to west, is 3 to 5m (see Figure, above). Wave heights for both areas (recorded as height exceeded 10% of the time) are generally between 0.5m and 2.5m. Higher values are recorded offshore and the Greater Wash has marginally higher values than the more sheltered Thames Estuary (Barne *et al.,* 1995, 1998).

In both the Greater Wash and Thames Estuary Strategic Areas, tidally-generated currents in the nearshore environment generally have maximum velocities that do not exceed 1.25 $m.s^{-1}$ except at the southern boundary of the Thames Estuary toward the Straits of Dover (Barne *et al.,* 1998).

Sediment transport

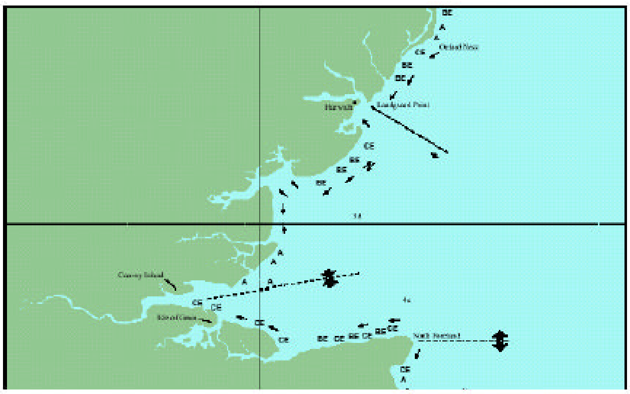
Longshore littoral sediment transport is southerly (Motyka and Brampton, 1993) with sediment sinks present in both Strategic Areas, off the Wash and Thames Estuary as identified by coastal cell boundaries (see figures, left). Within the Greater Wash Strategic Area, sediment accretion occurs within the mouth of the Humber, throughout the Wash and along the North Norfolk Coast. In the Thames Estuary Strategic Area, accreting locations are limited to Maplin Sands (Motyka and Brampton, 1993).



Littorine transport cells for the Wash area
Source: Motyka and Brampton, 1993

To the North of the Greater Wash Strategic Area, south of Flamborough Head there are thin sand and pebble beaches on clay. There is high coastal drift along the open coastal areas, but little at the northern Humber where areas of accretion with salt marsh are present. Sediment transported from this area feeds the Lincolnshire coast. (Motyka and Brampton, 1993).

To the south of the Humber there are several wide beaches most with clay underlay. There is a moderate southward drift of sand with some input believed to be coming from flood dominated currents over the Dogger Bank area offshore. The areas near Skegness accrete this sand into dune structures. Tidal flows at the Humber and Wash modify the currents and sediments in this region (Motyka and Brampton, 1993; D'Olier *et. al.*, 2002).


Thames littorine transport cells (Motyka and Brampton, 1993)

The southern part of the Strategic Area is predominantly accreting the material from the north. Dune systems and salt marshes are common along the coastal areas. Sand and silt are supplied from the north offshore and from the riverine sediments from the Humber and Wash, whereas heavier pebble material comes from the eastern areas (Motyka and Brampton, 1993).

The northern part of the Thames Strategic Area has some thin veneer sand beaches with southward drift slowing towards the Thames. There is little beach building material from erosion of northern areas with storm events being dispersed seaward. The southern region erodes westerly towards the Thames especially of shingle. At the Westerly tip near Margate and just to the south there is little coastal drift. Sand flats at this location, which attract significant levels of tourism, are nourished by offshore sands (Motyka and Brampton, 1993).

8.2 Chemical environment

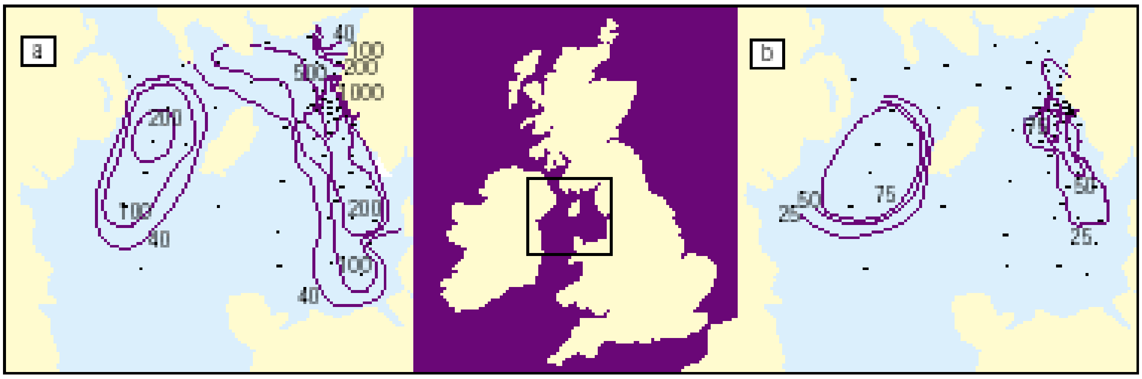
Chemical burdens in sediments are strongly correlated with sediment character. Both hydrocarbon and metals preferentially bind with the finest particle sizes and hence contaminant loads are consistently found to be higher in muds than clean sands. Example data, summarised from DEFRA 2002, DTI 2000 and, OSPAR 2000a/b, for sediment contaminant loads are summarised in Table 6. Site specific examples from data collected in the three Strategic Areas are also included. Contaminants are significantly higher in estuaries, particularly industrialised locations such as the Mersey, not only because they are both source of contaminants but also as they act as sinks with predominately fine sediments offering a substantial holding capacity (see Figure 4.7 in OSPAR, 2000b).

Contamination of dredge spoil at licensed disposal sites is monitored under FEPA licensing arrangements and in general concerns are focussed on potential loads of organotin (TBT), heavy metals and organic compounds such as polychlorinated biphenyls and polyaromatic hydrocarbons (CEFAS 2001a and b).

Chemical waste disposal sites have not been in use since 1994 (liquid industrial chemical waste) or 1995 (solid industrial waste). They are no longer considered a major contaminant source (for example OSPAR 2000a and b).

BMT Cordah has not found evidence of the existence of munition dumps based on information from the Irish Sea Pilot Project (JNCC *pers. comm.*) and Crown Estates, and hence potential chemical contamination from such dumps, in any of the three Strategic Areas.

In Liverpool Bay, the presence of Sellafield is noteworthy as a source of (authorised) radionuclide contamination. Though other minor sources are present (OSPAR 2000b), Sellafield represents the dominant source. The distribution of the least soluble radionuclides; caesium-137, plutonium and americium-241 has been identified as corresponding with the muddy sediments in the north eastern portion of the Strategic Area, with greatest concentrations close to the Sellafield outfall as illustrated by the distribution of caesium (see figure, below).



Caesium-137 concentrations (Bq/kg dw) and silt distributions (% <63µm)in surface sediments of the Irish Sea. Source: MacCarthey *et al.*, 1994.

Elevations of thorium-234 and protactinium-234 in the Ribble Estuary represent discharges from the fuel fabrication plant at Springfields. Radionuclides in North Sea sediments are present at low concentrations (OSPAR 2000a) except in the vicinity of source outlets.

Table 6: Sediment contaminant loads – general and site specific

Location	THC (µg/g)	PAH (µg/g)	PCB (µg/kg)	Pb (mg/kg)	Cu (mg/kg)	Zn (mg/kg)	Cd (mg/kg)	Hg (mg/kg)	TBT (µg/kg)
Estuaries		0.2-45	6.8-19.1	22	17-80	84	0.1-1	0.5-56	0 –12.93
Offshore	17-120	0-2.7	<1	13	4.0-9.2	21-58	0.43 – 0.6	0.16 - 30	-
Burbo, Liverpool Bay	0.08-0.74	-	-	7-20	2.7-11.6	49-115	<0.1-0.5	0.01-0.30	-
Kentish Flats, Thames Estuary	<7 – 33.4	-	<20	5.7-12	<2-18	14-42	<0.2	<0.06-0.09	-

Sources: various reports summarised from DEFRA 2000, DTI 2002,OSPAR 2000a/b, SeaScape Energy Ltd (2002) and EMU 2002

8.3 Biological environment

This section contains a description of general features, but focuses, where possible, on the spatial and temporal distribution of species and species groups thought to represent those most likely to be the subject of impact from windfarm development. Particular emphasis has been placed on conservation-motivated designation, the views of the SEA Steering Group and the result of consultation during the scoping study, as summarised in the scoping report (BMT Cordah 2003). To describe these habitats and fauna, this section is organised into three main parts:

- designated sites with their occurrence and main relevant features;
- potentially-impacted, but non-designated habitats; and
- potentially sensitive species (or species groups) focussing on designated species, those of concern to conservation interests and those that may potentially be impacted by windfarm developments. These include marine mammals, sharks and rays, birds and macrobenthic fauna.

8.4 Protected habitats: Natura 2000 and other designated areas

The coastal elements of the Strategic Areas have a number of sites designated under the EC Habitats Directive (Directive 92/43/EEC) and the EC Birds Directive (Directive 79/409/EEC), as Special Areas of Conservation (SACs) and Special Protected Areas (SPAs). Together, these form the Natura 2000 series of sites. In addition, a number of further statutory and non-statutory designations also exist, including sites designated as wetlands of international importance under the Ramsar Covention of 1971, Sites of Special Scientific Interest (SSSIs), National Nature Reserves (NNRs), Marine Nature Reserves (MNRs) and Local Nature Reserves (LNRs).

Additionally, OSPAR envisage the development of Marine Protected Areas (MPAs) that should not only protect marine species and habitats under immediate threat or subject to rapid decline, but also aim to protect or conserve additional features, such as representativity, productivity and high natural biodiversity. Areas important for migratory species might also be identified and included in the system of MPAs (OSPAR 2002). Some of these are likely to be existing or proposed marine Natura 2000 sites but will not be restricted to them. A well-managed, ecologically coherent network of OSPAR MPAs is envisaged by 2010.

Figure 6 shows the locations and extent of designated SAC and SSSI sites and Figure 7 shows SPA and Ramsar sites. The numbers of internationally recognised designations in each Strategic Area are summarised in Table 7 and the designation features for each of the SACs are detailed in Table 8.

Table 7:Summary of international designations for each strategic area with a marine component.

Area	Number of coastal SACs	Number of SPAs and Ramsar sites
England and Wales	66 (inc. 26 with marine component)	100 (including 93 classified and 7 proposed SPAs)
Liverpool Bay	7	9 coastal sites
Greater Wash	4	5 coastal sites
Thames Estuary	5	12 coastal sites

The bulk of the designated, or potentially designated, Natura 2000 sites listed are as a consequence of their intertidal sediment areas (and associated bird populations). In addition, two Annex 1 habitat types (as included in the Habitats Directive) are known to occur actually, or potentially, offshore in the three Strategic Areas (Johnston *et al*., 2002), and these are detailed below:

1. Sandbanks which are slightly covered by seawater all the time, defined as:

"sublittoral sandbanks, permanently submerged. Water depth is seldom more than 20m below chart datum. Non vegetated sandbanks or sandbanks with vegetation belonging to the Zosteretum marinae *and* Cymodoceion nodosae*."*

Within the study areas a number of potential sandbank areas have been identified (Johnston *et al.*, 2002). These have been noted based upon the distribution of sandy sediments (including sands, muddy sands, gravelly sands and some sandy gravels) forming "sandbank" structures such as sandy mounds, open shelf ridge sandbanks, estuary mouth sandbanks, and headland associated banks.

Areas of sand in less than 20m of water which are part of a bank topographically distinct from surrounding sediments represent areas of Annex 1 sandbank habitat (JNCC, *pers. comm*.). However, it is important to realise that in reality, such sandbank structures may extend beyond this depth limit and, consequentially, depth alone should not be used to indicate the potential boundaries of potential sites. We are content that we have identified the location of sandbanks but it is the data available to characterise them which is insufficient and may inhibit the site selection process.

2. Reefs, defined as:

" submarine or exposed at low tide, rocky substrata and biogenic concretions, which arise from the seafloor in the sublittoral zone but may extend into 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."

Within the study areas these reefs may consist of bedrock outcrops, aggregations of boulders and cobbles, or biogenic structures created by the Ross worm *Sabellaria spinulosa* or horse mussel *Modiolus modiolus*.

The JNCC Mermaid database contains a number of records for *S. spinulosa*, with a number of records in The Wash area of the Greater Wash study area. It is thought that extensive stable beds of biogenic reefs constructed by *S. spinulosa* in the mouth of The Wash, represents one of only a few currently known examples of well developed and persistent reef in the UK (CEFAS, 2001). Others have been noted in, for example, the English Channel. The presence of this commonly occurring species as the cornerstone of a biogenic reef should not be confused with either patchy distribution on gravels and mixed sandy sediments or as thin crusts, even when covering extensive areas (such as off the Berwickshire and north Northumberland coast). Neither of these types of occurrence qualifies under Habitats Directive. Further, reefs and encrustations of *Sabellaria alveolata*, which are generally intertidal, should also not be confused though these are of interest as a BAP habitat (see Section 8.4.1)

Modiolus reefs tend to be present at a depth of 5m to 70m and true beds are not known south of the Wash or the Severn Estuary. There are records of *M. modiolus* reefs from The Wash and Humber areas of the Greater Wash strategic Area, and also from the Harwich, Virley Channel, and Medway parts of the Thames area. There are no records for the Liverpool Bay Strategic Area though they are present nearby, to the west at locations north and south of the Isle of Man and to the south off Angelsey and the Lleyn Peninsula.

It is important to remember that the data for distribution of both *S. spinulosa*, and *M. modiolus* is incomplete, and becomes more so, the greater the distance offshore, of the location being considered. It should be noted that neither of these species qualify as Annex I species unless they are present in reef formation.

Figure 2 (Annex 2) shows the locations of potential reef habitat (bedrock and gravel (Folk classification) seabed types) and sandy sediment in less than 20 m in the three Strategic Areas. Where these meet the substratum and topographical criteria they fit the description for Annex I habitats reef and sandbank. Variable amounts of both sandbanks and reefs occur in the Strategic Areas both within and beyond the 12nm territorial seas limit. Of particular note is the extent of the sandbanks in the Greater Wash area, including The Wash and North Norfolk coast SAC and the offshore North Norfolk Banks. Much of the nearshore sandy sediment indicated in Figure 2 (Annex 2) is not part of distinct bank structures and, therefore, is unlikely to qualify as Annex I sandbank habitat. Small scattered areas of bedrock and gravel are present in the Liverpool Bay and Thames Estuary areas and a large expanse of gravel is present in the north of the Greater Wash Strategic Area.

There are a number of coastal habitats within each of the study areas of conservation importance, and included within SAC designations (see Table 8). These include a number of habitats, including salt marsh, sand dune, terrestrial vegetation, and cliff related habitats, as well as a number of terrestrial and coastal species of interest. Additional information regarding the distribution of coastal habitats and species is contained within the JNCC Coastal Directories.

Table 8: Marine features for SAC designations

SAC	Estuary / large inlet	intertidal mud and sand	subtidal sand-banks	reef	sea caves	common seal	otter	lamprey	others
Liverpool Bay									
Solway Firth	1^o	1^o	1^o	2^o	-	-	-	2^o	1^o: S. 2^o: V, D.
Drigg Coast	1^o	2^o	-	-	-	-	-	-	1^o : D 2^o: S, D
Morecambe Bay	1^o	1^o	2^o	2^o	-	-	-	-	1^o: V, S, D, Sp. 2^o: L, D.
Sefton Coast	-	-	-	-	-	-	-	-	1^o: D, Sp 2^o: D. Sp
Menai Strait and Conwy Bay	2^o	1^o	1^o	1^o	2^o	-	-	-	-
Great Orme's Head	-	-	-	-	-	-	-	-	1^o: H, G. 2^o :Cl
Dee Estuary	2^o	1^o						2^o	2^o: S, D, Sp
Greater Wash									
North Norfolk Coast	-	-	-	-	-	-	2^o	-	1^o: L, V, D, 2^o: Sp
Overstrand Cliffs	-	-	-	-	-	-	-	-	1^o: Cl
Saltfleetby/Theddlethorpe Dunes and Gibraltar Point	-	-	-	-	-	-	-	-	1^o: D, 2^o: D,
The Wash and North Norfolk Coast	1^o	1^o	1^o	1^o	-	1^o	2^o	-	1^o: S, V, 2^o: L,
Thames Estuary									
Alde, Ore & Butley Estuaries	1^o	2^o	-	-	-	-	-	-	1^o: S
Essex Estuaries	1^o	1^o	2^o	-	-	-	-	-	1^o: S, V
Orfordness/Shingle Street	-	-	-	-	-	-	-	-	1^o: L, V
Thanet Coast	-	-	-	1^o	1^o	-	-	-	-
Sandwich Bay	-	-	-	-	-	-	-	-	1^o: D 2^o: D

Note 1^o refers to those features for which the SAC is primarily designated. 2^o refers to features of secondary importance in the designation of the site.

Other features are categorised as follows: S – saltmarsh, salt meadow and their associated vegetation; D – dunes and dune slacks; V – vegetation; L – lagoons; Sp – named species of interest; H – heaths; G – grassland; Cl – Cliffs. Source: www.jncc.gov.uk/ProtectedSites/SACselection/UK_SAC_map.htm

Special Protection Areas

The Birds Directive requires conservation measures to be put in place to protect Annex 1 and regularly occurring migratory species. To achieve this, a network of Special Protected Areas (SPAs) has been established in the UK, including several located along the coastal boundary of each of the three Strategic Areas (see Figure 6, Annex 2). The qualifying species of these SPAs are listed in Tables 9, 10 and 11 (Annex 2). Long-term monitoring data are available for a network of important coastal sites, held in the WeBS database, (BTO, 2001) which includes detail on population size, trends and locality for each species. Of particular note from this table are the following features:

Liverpool Bay:

- overwintering waders (particularly redshank *Tringa totanus* and turnstone *Arenaria interpres*) on Mersey Narrows and North Wirral Foreshore SPA;
- overwintering and passage waders (particularly dunlin *Calidris alpina alpina*, knot *Calidris canutus*, bartailed godwit *Limosa lapponica*) and ducks (wigeon *Anas penelope*) on the Ribble and Alt Estuary SPA; and
- overwintering geese (pink footed goose *Anser brachyrhynchus*) on Martin Mere SPA and the Ribble and Alt Estuary SPA.
- overwintering and passage waders (particularly bar-tailed godwit *Limosa lapponica*, redshank *Tringa totanus*, black-tailed godwit *Limosa limosa islandica*, curlew *Numenius arquata*, dunlin *Calidris alpina alpina*, grey plover, knot *Calidris canutus*, oystercatcher *Haematopus ostralegus* and redshank *Tringa totanus*) and passage terns on Dee Estuary SPA;

Greater Wash:

- the Wash supports the largest population of over-wintering waterfowl in the UK, with an average of 310,000 birds (1993-1998);
- breeding tern populations (in particular sandwich tern *Sterna sandvicensis*, common tern *Sterna hirundo* and little tern *Sterna albifrons*) on the North Norfolk Coast SPA;
- overwintering waders (in particular knot *Calidris canutus*, golden plover *Pluvialis apricaria* and dunlin *Calidris alpina alpina*) on the Humber SPA and (in particular oystercatcher *Haematopus ostralegus*, grey plover *Pluvialis squatarola*, golden plover *Pluvialis apricaria*, lapwing *Vanellus vanellus*, knot *Calidris canutus*, dunlin *Calidris alpina alpina*, bar-tailed godwit *Limosa lapponica*, black-tailed godwit *Limosa limosa islandica*, curlew *Numenius arquata*, redshank *Tringa totanus* and turnstone *Arenaria interpres* – all present in numbers exceeding international thresholds) on The Wash SPA;

- overwintering ducks and swans (particularly shelduck *Tadorna tadorna* and whooper swan *Cygnus cygnus*) in The Wash SPA; and
- geese (pink footed goose *Anser brachyrhynchus* and dark bellied brent goose *Branta bernicla bernicla*) on The Wash and North Norfolk Coast SPAs.

Thames Estuary:

- substantial breeding gull population (lesser black-backed gull *Larus fuscus*) on the Alde Ore Estuary SPA;
- substantial overwintering ducks (teal *Anas crecca*, shoveler *Anas clypeata* and gadwall *Anas strepera*) on the Aberton SPA; and
- overwintering waders (dunlin *Calidris alpina alpina*) on the Medway and the Stour and Orwell SPAs.

Trends in designation

The process for identifying SPAs fully detached from the coast is currently being developed by JNCC and the country conservation agencies and entails the agreeing of methodology for the identification of seabird aggregations and the refining of JNCC's selection guidelines (JNCC, *pers. comm.*). Aggregations of seabirds which satisfy the guidelines for SPA selection may be proposed for designation by country conservation agencies or the JNCC depending on their location. The JNCC has issued guidance on the appropriate seaward extension to breeding colonies for Atlantic puffin (*Fratercula arctica*), common guillemot (*Uria aalge*), razorbill (*Alca torda*) (1km extension) and northern gannet (*Morus bassanus*) (2km extension) and will continue to issue guidance once appropriate analysis of data has been undertaken. These extensions are intended to protect the birds engaged in preening, washing and resting on the water adjacent to breeding colonies. As most seabird species range a considerable distance from the coast to forage (Table 12), SPAs for feeding will be identified separately and will vary in distance from shore, depending on the species engaged in the activity.

Table 9: Qualifying bird species for SPAs in Liverpool Bay

Species	Duddon Estuary	Leighton Moss	Martin Mere	Mersey Estuary, New Ferry	Mersey Narrows and North Wirral Foreshore	Ribble and Alt Estuary	The Dee Estuary	Traeth Lafan / Lavan Sands, Conway Bay	Ynys Seiriol / Puffin Island	Morcambe Bay
Terns and gulls										
Sandwich Tern *Sterna sandvicensis*	B						P			B
Common Tern *Sterna hirundo*						B	B			
Little Tern *Sterna albifrons*							B			B
Herring Gull *Larus argentatus*										B
Lesser Black-backed Gull *Larus fuscus*										B
Ducks, geese and swans										
Pintail *Anas acuta*	O		O	O			O			O
Shelduck *Tadorna tadorna*				O			O			O
Teal *Anas crecca*				O			O			
Pink-footed Goose *Anser brachyrhynchus*			O							O
Bewick's Swan *Cygnus columbianus bewickii*			O			O				
Whooper Swan *Cygnus cygnus*			O			O				
Other seabirds										
Cormorant *Phalacrocorax carbo*									B	
Waders										
Bittern *Botaurus stellaris*		B, O								
Ringed Plover *Charadrius hiaticula*	P			P						P

Species	Duddon Estuary	Leighton Moss	Martin Mere	Mersey Estuary, New Ferry	Mersey Narrows and North Wirral Foreshore	Ribble and Alt Estuary	The Dee Estuary	Traeth Lafan / Lavan Sands, Conway Bay	Ynys Seiriol / Puffin Island	Morcambe Bay
Sanderling *Calidris alba*	P									P
Knot *Calidris canutus*							O			O
Redshank *Tringa totanus*	O			P, O	O		P, O			O
Golden Plover *Pluvialis apricaria*				O		O				O
Dunlin *Calidris alpina alpina*				O			O			O
Turnstone *Arenaria interpres*					O					O
Ruff *Philomachus pugnax*						B				
Bar-tailed Godwit *Limosa lapponica*						O	O			O
Ringed Plover *Charadrius hiaticula*										
Black-tailed Godwit *Limosa limosa islandica*							O			
Curlew *Numenius arquata*							O			O
Grey Plover *Pluvialis squatarola*							O			O
Oystercatcher *Haematopus ostralegus*							O	O		O
Raptors										
Marsh Harrier *Circus aeruginosus*		B								

Source: http://www.jncc.gov.uk/UKSPA/sites/spalistP-Z.htm (O = Over winter, B = Breeding, P = on passage)

Table 10: Qualifying bird species for SPAs in the Greater Wash

Species	Breydon Water, Halvergate Marshes	Broadland	Great Yarmouth – North Denes	Gibraltar Point	Humber, Flats,Marshes and Coasts	North Norfolk Coast	The Wash
Terns and gulls							
Sandwich Tern *Sterna sandvicensis*						B	
Common Tern *Sterna hirundo*	B					B	B
Little Tern *Sterna albifrons*			B	B	B	B	B
Roseate Tern *Sterna dougallii*						B	
Mediterranean Gull *Larus melanocephalus*						B	
Ducks, geese and swans							
Pintail *Anas acuta*						O	O
Shoveler *Anas clypeata*		O					
Teal *Anas crecca*							
Wigeon *Anas penelope*							
Gadwall *Anas strepera*		O					
Shelduck *Tadorna tadorna*					O		O
Pink-footed Goose *Anser brachyrhynchus*		O				O	O
Dark-bellied Brent Goose *Branta bernicla bernicla*						O	O
Bewick's Swan *Cygnus columbianus bewickii*	O						
Whooper Swan *Cygnus cygnus*		O					O
Waders							
Turnstone *Arenaria interpres*							O
Bittern *Botaurus stellaris*		B, O				B, O	

Species	Breydon Water, Halvergate Marshes	Broadland	Great Yarmouth – North Denes	Gibraltar Point	Humber, Flats,Marshes and Coasts	North Norfolk Coast	The Wash
Sanderling *Calidris alba*					P		P
Dunlin *Calidris alpina alpina*					O		
Knot *Calidris canutus*				O	O	O	O
Ringed Plover *Charadrius hiaticula*							P
Oystercatcher *Haematopus ostralegus*							O
Bar-tailed Godwit *Limosa lapponica*				O	O	O	O
Black-tailed Godwit *Limosa limosa islandica*							O
Curlew *Numenius arquata*							O
Ruff *Philomachus pugnax*		O				O	
Golden Plover *Pluvialis apricaria*	O				O	O	O
Grey Plover *Pluvialis squatarola*				O			O
Avocet *Recurvirostra avosetta*	O					B, O	O
Redshank *Tringa totanus*					P, O	O	O
Raptors							
Marsh Harrier *Circus aeruginosus*		B			B	B	B
Hen Harrier *Circus cyaneus*	O				O	O	

Source: http://www.jncc.gov.uk/UKSPA/sites/spalistP-Z.htm (O = Over winter, B = Breeding, P = on passage)

Table 11: Qualifying bird species for SPAs in the Thames Estuary

Species	Abberton Reservoir	Alde Ore Estuary	Benfleet and southend Marshes	The Swale	Colne Estuary	Crouch and Roach Estuary	Dengie Estuary	Deben Estuary	Hamford Water	Medway Estuary and Marshes	Stour and Orwell Estuary	Thanet coast and Sandwich Bay	Blackwater estuary	Foulness and Thames estuary and marshes
Terns and gulls														
Sandwich Tern *Sterna sandvicensis*		B												B
Common Tern *Sterna hirundo*														B
Little Tern *Sterna albifrons*		B			B				B	B			O	B
Roseate Tern *Sterna dougallii*														
Lesser Black-backed Gull *Larus fuscus*		B												
Mediterranean Gull *Larus melanocephalus*				B										
Ducks, geese and swans														
Pintail *Anas acuta*										O	O			
Shelduck *Tadorna tadorna*										O	O		O	
Teal *Anas crecca*									O					
Gadwall *Anas strepera*	O													
Shoveler *Anas clypeata*	O			O										
Wigeon *Anas penelope*														
Pink-footed Goose *Anser brachyrhynchus*														

Species	Abberton Reservoir	Alde Ore Estuary	Benfleet and southend Marshes	The Swale	Colne Estuary	Crouch and Roach Estuary	Dengie Estuary	Deben Estuary	Hamford Water	Medway Estuary and Marshes	Stour and Orwell Estuary	Thanet coast and Sandwich Bay	Blackwater estuary	Foulness and Thames estuary and marshes
Dark-bellied Brent Goose *Branta bernicla bernicla*			O		O	O			O	O			O	O
Bewick's Swan *Cygnus columbianus bewickii*														
Whooper Swan *Cygnus cygnus*														
Other seabirds														
Cormorant *Phalacrocorax carbo*	B													
Waders														
Bittern *Botaurus stellaris*														
Marsh Harrier *Circus aeruginosus*		B		B										
Ringed Plover *Charadrius hiaticula*			P							O			P, O	
Sanderling *Calidris alba*														
Knot *Calidris canutus*			O	O			O							O
Redshank *Tringa totanus*		O		O	O					O	O		O	P
Golden Plover *Pluvialis apricaria*	O													
Dunlin *Calidris alpina alpina*														
Turnstone *Arenaria interpres*											O	O		
Ruff *Philomachus pugnax*									O				O	

Species	Abberton Reservoir	Alde Ore Estuary	Benfleet and southend Marshes	The Swale	Colne Estuary	Crouch and Roach Estuary	Dengie Estuary	Deben Estuary	Hamford Water	Medway Estuary and Marshes	Stour and Orwell Estuary	Thanet coast and Sandwich Bay	Blackwater estuary	Foulness and Thames estuary and marshes
Bar-tailed Godwit *Limosa lapponica*				O			O							O
Golden Plover *Pluvialis apricaria*				O	O				O				O	O
Ringed Plover *Charadrius hiaticula*				P					P	P	O			
Black-tailed Godwit *Limosa limosa islandica*				O					O	O	O		O	
Dunlin *Calidris alpina alpina*										O	O		O	
Curlew *Numenius arquata*														
Grey Plover *Pluvialis squatarola*			O	O			O		O	O	O		O	O
Oystercatcher *Haematopus ostralegus*														O
Avocet *Recurvirostra avosetta*		B, O		B, O	O			O	O	B, O			O	B, O
Raptor														
Hen Harrier *Circus cyaneus*				O	O		O				O		O	O

Source: http://www.jncc.gov.uk/UKSPA/sites/spalistP-Z.htm (O = Over winter, B = Breeding, P = on passage)

Table 12: Predicted bird foraging radii of breeding seabirds (from BirdLife International 2002)

Species group	Foraging range (km)			
	1's	Low 10's	Mid 10's	100's
Gulls and terns	little tern	terns, black-headed and common gulls		
Shearwaters and petrels				
Skuas	arctic		great	
Auks	black guillemot		other auks	
Others		cormorant and shag		gannet

8.4.1 Other habitats

The benthic environment in the three Strategic Areas is dominated by soft sediments (Figure 4, Annex 2), with only localised areas of bedrock and gravel (Folk classification) (Figure 2, Annex 2). As a consequence of their potential conservation interest under the EC Habitats Directive potential reef and shallow sandbank habitats have been described above. This section consequently concentrates on those habitats not covered by this legislation.

A number of sublittoral BAP habitats should be noted (www.ukbap.org.uk) as being present, or potentially present, in one or more of the Strategic Areas:

- littoral and sublittoral chalk;
- *Modiolus modiolus* beds (see Section 8.4);
- mud habitats in deep water;
- *Sabellaria spinulosa* reefs (see Section 8.4);
- *Sabellaria alveolata* reefs (but usually intertidal);
- seagrass beds; and
- sheltered muddy gravels.

Their likely occurrence in one or more of the Strategic Areas is noted in the following subsections. An additional number of BAP habitats, for coastal and intertidal areas are considered to potentially be present in the Strategic Areas. These would require consideration with respect to landfall site selection (see Section 9.8). These include:

- coastal and floodplain grazing marsh
- coastal saltmarsh;

- coastal; sandune;
- coastal vegetated shingle;
- littoral and sublittoral chalk;
- maritime cliffs and slopes;
- mudflats; and
- tidal rapids.

The North and Irish Seas have been the subject of a number of studies aimed at establishing and systematically reporting the faunal distribution and assemblages in the seabed. This approach was pioneered by Petersen (1915) whilst Jones, (1950) provided the most widely accepted terminology and Connor *et al.* (1997) defined the MNCR biotope classification scheme that is now in general use, though it is currently undergoing extensive revision. Other work concerned with the systematic assessment of faunal communities includes, for example, Thorson (1957), Glemarec (1973), Kingston and Rachor (1982), Dyer *et al.* (1983), Mackie (1990), Basford, Eleftheriou and Rafaelli (1990), Kunitzer *et al.* (1992) and Hiscock (1998). The consensus view, albeit with differences of opinion with respect to detail, are that the faunal assemblages within the UK seas can be rationalised into a relatively small number of communities, characterised by one or a few species. Further, these communities closely correspond to seabed sediment type.

These faunal communities have been summarised in Table 13 which correlates those reported to occur in the three Strategic Areas and links them to their associated sediment type. The table provides the MNCR biotope classification codes along with other terminology and some of the characterising species. This table has been further developed based on site-specific reports as follows:

- Eagle, 1973 (muddy sand and clean sand);
- Norton *et al.,* 1984 (muddy sand, mixed sand and gravel, clean sand);
- Jones, 1951, (coarse sand, fine sand, muddy sand and mud);
- Econet Ltd, 2001 and EMU, 2002 (both clean sands and gravelly sand); and
- Rees and May, 1987; and NWP Offshore Ltd. 2002 (both muddy sand).

8.4.1.1 Liverpool Bay

In Liverpool Bay, the mapped sediment patterns (Figure 4, Annex 2) show a reasonable similarity with respect to biotope distribution patterns shown below (Mackie, 1990).

Work by Eagle (1973) for the south east of Liverpool Bay sampled both muddy sand and clean sand and identified the muddy sand to be characterised by the polychaete *Lagis* *koreni* and the bivalve *Abra alba* and the clean sand by the polychaetes *Magelona mirabilis* and *Nephtys cirrosa.* These findings are consistent with those of Mackie (1990) and as reported in Hiscock (1997) and correspond to the biotopes of CMS.AbrNucCor and IGS.FabMag respectively. Hughes and Atkinson (1997) looked at the deep-water mud habitat off the Sellafield coast and identified a rich community characterised by large burrowing crustaceans (for *example Callianassa subterranea* and *Jaxea nocturna*). Their findings correspond to the biotope CMU.SpMeg.

With the exception of the last one, these biotopes are widespread throughout the UK, and further afield, and as such are not sensitive to disturbance from a conservation value perspective. The deep water mud biotope, CMU.SpMeg, occurs in a low energy environment, supports large and long lived speceis that are considered to be sensitive to impacts and the faunal community characterising this biotope would take an extended period to recover from significant, and particularly habitat-wide. impact. The possibility of species of conservation interest being present in this Strategic Area is discussed in Section 8.4.2.

The following BAP habitats of particular note (www.ukbap.org.uk) are:

- small pockets of mud in deep water west of Sellafield (Figure 4, Annex 2);
- *Sabellaria alveolata* reefs subtidally in Walney Channel, Morecambe Bay; and
- sublittoral sands and gravels (a category that includes 17 MNCR biotopes (Version 97.06) which are extensive and varied in this Strategic Area (Figure 4, Annex 2).

These biotopes are widespread throughout the UK, and further afield, and as such are not sensitive to disturbance from a conservation value perspective. The possibility of species of conservation interest being present is discussed below.

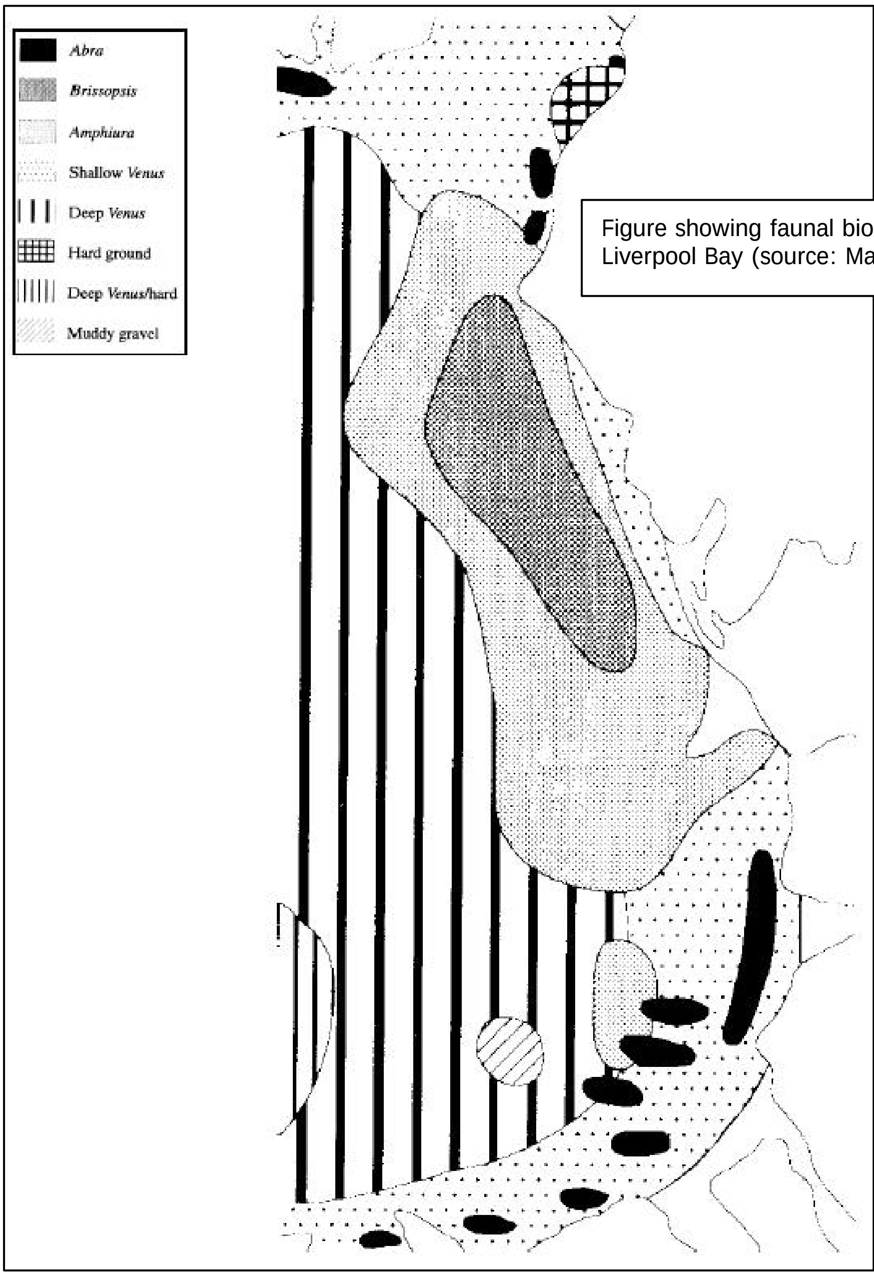


Figure showing faunal biotopes in Liverpool Bay (source: Mackie, 1990)

8.4.1.2 The Greater Wash and Thames Estuary

Hiscock (1998), referencing the work of Murray *et al.* (1980), describes the sublittoral environment off the Humber as typical of the "offshore gravel association" and the horse mussel *Modiolus modiolus* (the CMX.ModMx of MNCR biotope classification). Offshore gravel and sand sediments predominate and consequently support similar fauna, including patches of *M.modiolus*, the brittlestar *Ophiura* spp. and a range of epifaunal species, including the seasquirt *Dendrodoa grossularia, the bryozoans Alcyonidium* spp. and *Flustra foliosa* and the barnacle *Balanus* spp. (Kenny and Rees, 1996). The biotopes, CGS.Ven and ECR.PomByC encompass such fauna. Further offshore, the linear sandbanks of the Norfolk Banks have been shown to be demonstrably different from these gravel and sand sediments. The sediment is predominantly sand rather than gravelly and as such does not support a diverse epifaunal community. Samples from the Norfolk Banks (DTI, 2002) have determined that the fauna of these sandbanks is characterised by the sea urchin *Echinocardium cordatum* and the bivalve *Fabulina fabula*. This biotope probably corresponds to IGS.FabMag, though the validity of this biotope requires further consideration (Connor *et al.,* 1997). Sandeels (*Ammodytes* spp.) were also noted to be present.

In the Wash itself, the sandier sediments support elements of the offshore sand (IGS.Sell and IGS.FabMag biotopes) and muddy sand associations (CGS.AfilEcor biotope) including the brittlestar *Ophiura* spp., the polychaetes *Lanice conchilega, Spiophanes* spp.*, Spio* spp. and the sea urchin *Psammechinus miliaris.* Inshore muds and sandy muds are characterised by the polychaetes *Arenicola* spp. and *Sabella* spp. (Hiscock 1998) and correspond to the IMS.MacAbr biotope.

The few samples taken within the Greater Wash and Thames Estuary Strategic Areas that were reported in Kunitzer *et al.* (1992), identified faunal assemblages characterised by the polychaete *Nephtys* spp., *Echinocardium* spp. and the amphipod *Urothoe* spp. for coarse sand. These findings concur with the “offshore sand”/”shallow *Venus*” communities and IGS.Sell and IGS.FabMag biotopes of Table 13.

All of these biotopes are widely distributed around the UK and other North East Atlantic areas and as such do not represent particular conservation sensitivity. The possibility of species of conservation interest being present is discussed below.

Table 13: Faunal assemblages in soft sediments

	MNCR biotopes	Community classifications			Characterising fauna			
Sediment type		**Jones (1950)**	**Petersen (1915)**	**Mackie (1990)**	**Molluscs**	**Echinoderms**	**Polychaetes**	**Others**
Mud (M) and Sandy mud (sM)	IMS.MacAbr	Shallow mud	*Macoma*	*Macoma*	*Macoma, Abra*	-	*Arenicola, Sabella*	-
	CMU.BriAchi	Offshore mud	*Brissopsis-chiajei*	*Brissopsis* (15-100m)	-	*Brissopsis, Amphiura chaijei*	*Lumbrineris, Levinsenia*	-
	CMU.SpMeg				*Abra alba*	*Amphiura* spp.		*Virgularia mirabilis, Callianassa*
Mud (M) and Sandy mud (sM)	IMS.MacAbr	Shallow mud	*Macoma*	*Macoma*	*Macoma, Abra*	-	*Arenicola, Sabella*	-
	CMU.BriAchi	Offshore mud	*Brissopsis-chiajei*	*Brissopsis* (15-100m)	-	*Brissopsis, Amphiura chaijei*	*Lumbrineris, Levinsenia*	-
Sand (S)	IGS.Sell and IGS.FabMag	Offshore Sand	*Venus*	Shallow *Venus* (nearshore, 5-40m)	*Chamelea, Fabulina, Dosinia, Spisula, Gari*	*Echinocardium, Acrocnida,*	*Magelona, Nephtys, Aonides, Spio, Owenia*	*Bathyporeia Urothoe*
Muddy Sand (mS) "	CGS.AfilEcor	Offshore muddy sand	*Echinocardium-Amphiura*	*Amphiura* (offshore 15-100m)	*Abra, Nucula, Dosinia, Corbula, Mysella, Thyasira, Phaxas*	*Echinocardium, Amphiura, Ophiura, Labidoplax ,*	*Myriochele, Spiophanes, Scololepis,*	*Phoronis*
	CMS.AbrNucCor	-	-	*Abra* (inshore 5-30m)	*Abra, Thyasira*	-	*Lanice, Lagis*	-
Gravelly Sand (gS)	LGS.Lcon	-	-	-	-	-	*Lanice. Owenia*	*Crangon, Electra*
Gravel (G)	CGS.Ven	Offshore gravel	-	Deep *Venus*	*Glycymeris,* Venerids, *Astarte,.*	*Echinocyamus, Spatangus,*	-	-
	CMX.ModMx	-	-	*Modiolus*	*Modiolus*	*Ophiothrix*	-	-
Sandy Gravel	ECR.PomByC	-	-	-	-	-	*Pomatoceros*	*Flustra, Balanus*

8.4.2 Potentially sensitive species

A number of marine species are either designated under current conservation legislation or considered in need of some form of non-statutory conservation management such as BAPs (biodiversity action plans). Those species known to occur, thought to potentially occur within any of the Strategic Areas, or highlighted during consultation are described below. A full account of species considered to be threatened, vulnerable or highlighted for other reasons of conservation interests, including those lists drafted by OSPAR's Biodiversity Committee and the Review of Marine Nature Conservation's (RMNC) Irish Sea Pilot Study, are appended (Annex 4). Species of particular relevance (BAP species) are discussed further below. Distribution data have primarily been sourced from national databases (www.jncc.gov.uk/mermaid and www.marlin.ac.uk) and UK BAP (www.ukbap.org.uk), with additional specific references provided below as appropriate. For most, if not all of the species listed in Annex 4 but not described in this section, insufficient knowledge of their ecological requirements and lack of distribution data prevent an accurate mapping of their occurrence. Consequently, consideration of the possibility of these species occurring in a specific development location would be required on a case by case basis, for example in individual EIAs implemented for windfarm licence applications.

8.4.2.1 Marine mammals

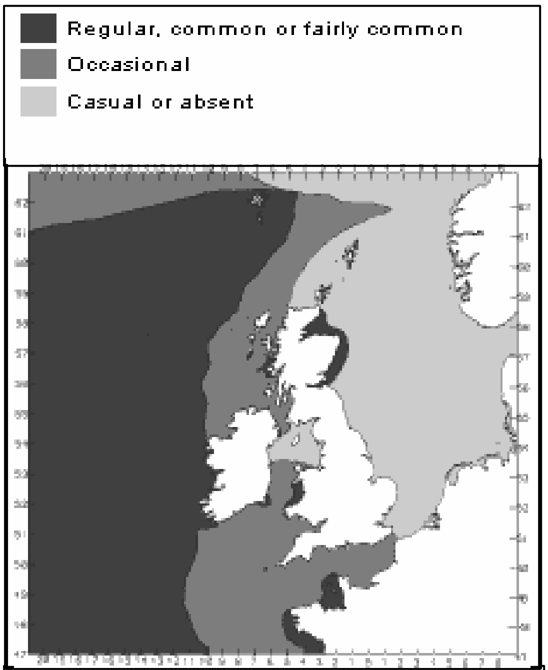
Historically 24 species of cetacean have been reorded in UK waters (Evans, 1989). The following species have been recorded in UK waters (Stone, 1997, 1998, 1999, 2000, 2001, Richardson *et al.,* 1985, Pollock *et al.,* 1997, Camphyusen and Reijnders, 1993, www.ukbap.org.uk):

- harbour porpoise;
- bottlenose, common, Risso's, white-beaked, striped and Atlantic white-sided dolphins;
- sperm, pygmy sperm, long-finned pilot, narwhal, beluga, northern bottlenose, killer (orca), false killer and Sowerby's, Cuvier's and True's beaked whales, ; and
- minke, sei, humpback, blue, northern right and fin whales.

Of these species, existing knowledge and recent sightings highlight those that are more likely to occur in one or all of the Strategic Areas:

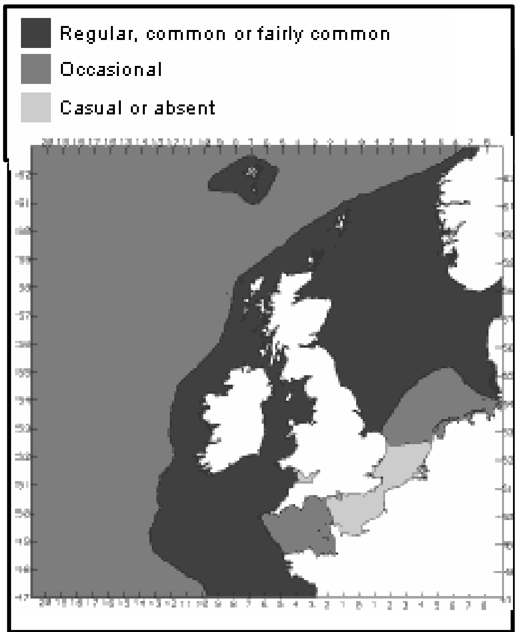
- harbour porpoise, all dolphin species and long-finned pilot whale (JNCC, 2002; SeaWatch Foundation, 2002; Hammond *et al.,* 1995; Whale and Dolphin Conservation Society, *pers. comm.*);
- white-beaked dolphin (Hammond *et al.,* 1995) in the Greater Wash and Thames Estuary areas;

- Risso's dolphin in Isle of Man Area (Powergen Renewables Ltd, 2002);
- Minke whale (Seawatch Foundation, 2002);
- Cuvier's beaked whale (Whale and Dolphin Conservation Society, *pers. comm.*)



Bottlenose dolphin distribution (Source: Seawatch Foundation, 2002)

Two cetacean species found in UK waters, bottlenose dolphin (*Tursiops truncatus*) and harbour porpoise (*Phocoena phocoena*) are listed on Annex II of the Habitats Directive (92/43/EC) and sites which are essential to their life and reproduction may be designated as SACs. JNCC will be examining data to see if SACs for feeding areas for these species can be identified. Consequently, habitats supporting populations of either of these species could be considered for SAC designation (Johnston *et al.,* 2002). The current population estimate for the bottlenose dolphin is uncertain (Seawatch Foundation, 2002) though the Moray Firth population is in the order of 120 and Cardigan Bay supports a population in the range of 150 - 350 (www.ukbap.org.uk). The current understanding of their distribution indicates that they could be present in the southernmost reaches of Liverpool Bay (JNCC, 2002 and see figure, above) but only sporadically in the other Strategic Areas. For example, several sightings were made of individual dolphins between 24th June and 6th July 2001 in the Thames Estuary (Seawatch Foundation, 2002). Those observed in Liverpool Bay are presumed to be non-resident individuals from southern, Celtic Shelf populations (Hammond *et al.,* 1995). On the other hand, harbour porpoises have been observed throughout all Strategic Areas (see figure, right). Their UK population is uncertain (JNCC, 2002, Camphuysen, 1994). Further, the number of porpoises in any one

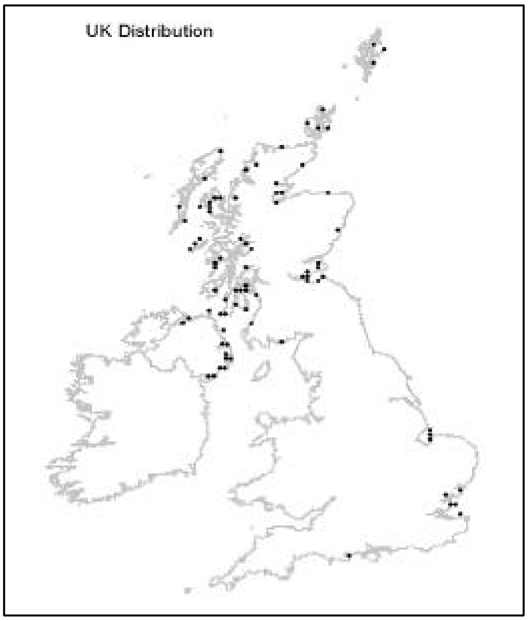


Harbour porpoise distribution (Source: Seawatch Foundation ,2002) location is unclear as is the general pattern of movements and the proportion of the population represented by individuals and groups passing through UK waters (JNCC, 2002).

Both of the UK seal species, the grey seal (*Halichoerus gypus*) and the common (or harbour) seal (*Phoca vitulina*) are listed on Annex II of the Habitats Directive and sites which are essential to their life and reproduction may be designated as SACs. Grey and common seal distributions, when occupying haul out and breeding sites (peaking in winter months), suggest that both are present in all three Strategic Areas. However, the tendency for the former species to be distributed in open coast means that they are not generally present in significant numbers in either the Thames Estuary or Liverpool Bay (see figure left).

Grey seal distribution (JNCC, 2002)

With respect to the Greater Wash, grey seals are known to haul out at a number of locations in the Wash and North Norfolk Coast SAC and also in the Humber Estuary (Hammond *et al.,* 2002). The Wash is a significant population centre for common seals, supporting some 7% to 9% of the UK population of 33,400 or more individuals (JNCC, 2002; CEFAS, 2000). A number of common seal haul outs are located in the Thames Estuary and a single one in Liverpool Bay (see figure, below). Grey seals are also present in Liverpool Bay, including haul outs in the Dee Estuary and a number of breeding sites are known, albeit outside of the Strategic Area, on the east coast of Anglesey (Westcott, 2002).



Common seal distribution (Source: JNCC 2002)

When grey and common seals are away from breeding and haul-out sites, their distribution is not well understood (Johnston *et al.,* 2002). Hall *et al.,* (1998) made the observation, from stomach content evidence, that the common seal population in the Wash foraged locally.

More recent studies, cited in Hammond *et al.,* (2002), are accumulating data that suggest they may be wider ranging. The implication from these studies is that these seals will undoubtedly be foraging in the Greater Wash area. Grey seal foraging movements are believed to be focused on gravel/sand sediments within 40km of haul out sites where they predominantly feed on sandeels (Hammond *et al.*, 2002).

8.4.2.2 Sharks and rays

Current knowledge of distribution of elasmobranchs around the UK is recognised as being very limited. What is known is primarily based on catch and by-catch data (Gill *et al.,* 2001). In general, dogfish, smoothhounds, skates and rays are benthic feeders, eating organisms such as small fish, molluscs, crustaceans and worms (Dipper, 1989) whereas the basking shark is planktivorous and; tope, spurdog, bullhuss, and porbeagle are piscivores. The basking shark is protected under the Wildlife and Countryside Act 1981 and is a BAP species. It should be noted that JNCC have recently advised DEFRA that the basking shark should be added to Schedule 5 of the Wildlife and Countryside Act and afforded full protection. Additionally the basking shark appears on Appendix 2 of CITES and Annex B of the EC CITES regulation. Apart from tope and basking sharks, UK sharks are mostly demersal. Many species have inshore habitat specific requirements often during the juvenile phase of life.

Porbeagle (*Lamna nasus*) and spurdog *(Squalus acanthias)*, skates and rays are a highly valued catch for commercial and recreational fishermen. The largest species are the most valuable, though often uncommon, and consequently vulnerable to commercial extinction whilst smaller and more fecund species appear to be increasing in abundance. However, there is a lack of species-specific data recording and a lack of catch per unit effort data.

The most common sharks in British waters are the lesser spotted dogfish (*Scyliorhinus canicula)* and spurdog. The large-spotted dogfish (*Scyliorhinus stellaris)* is less common, but can be found in the English Channel, the Irish Sea, (including Liverpool Bay) and occasionally off the west coast of Scotland (Vas, 1991). The same author reported that the angel shark (*Squatina squatina)* was most common off the west coasts of Scotland, Ireland, England and Wales but is rare in the North Sea (Vas, 1991). Recent information (CCW, *pers comm.*) indicates that they are only rarely caught in Liverpool Bay. This formerly common species has declined significantly and is now on the IUCN Red List assessment. Further, JNCC have recently advised DEFRA that it should be afforded formal protection by its addition to Schedules 5 and 8 of the Wildlife and Countryside Act 1981 during the forthcoming quinquennial review (English Nature, *pers. comm.).*

The smoothhound (*Mustelus mustelus*) is not as common off the British Isles as the stellate smoothound (*Mustelus asterias)* but can be found in shallow water in the English Channel, the Irish Sea (including Liverpool Bay) though very rarely in the North Sea (Vas, 1991). Tope (*Galeorhinus gal.eus*) uses inshore areas for pupping and nursery grounds and is a UK BAP species of concern. The porbeagle is commercially valuable and listed as an important UK species (Vas, 1991). Basking shark (*Cetorhinus maximus*) can be found in the surface waters off all coasts of the British Isles in the summer months, but is especially prevalent in the Irish Sea and off the Cornish coast (Vas, 1991). The basking shark is legally protected and has an IUCN Red List status as a vulnerable fishery species. There may be important nursery grounds in the Bristol Channel.

Of the skates and rays, the thornback ray (*Raja clavata)* is one of the most common in all British waters, for most of the year, but its population is in serious decline off the Welsh coast due to overfishing (Dipper, 1987). It inhabits inshore muddy, sandy and gravel bottoms around 10-16m particularly spring and summer when females aggregate to spawn (for example, on Constable Bank, Liverpool Bay. CCW, *pers. comm*.). Most ray species inhabits similar habitats to a depth of up to 250m with a preference for gravel or sandy areas. The common skate (*Dipturus batis*) has been seriously overfished in UK and is now was being found only occasionally in Scotland and Ireland (Gill *et al.,* 2001). It is a BAP species and classified as globally endangered by the IUCN. It is possible that this species is extinct in the Irish Sea (www.ukbap.org.uk). JNCC have recently advised DEFRA that the common skate should be added to Schedule 5 of the Wildlife and Countryside Act and afforded full protection.

Of the other species of skate and ray recorded in the UK, none are currently on the IUCN list and most are currently believed to be distributed throughout UK waters. However, the JNCC have recently advised DEFRA to add the common, black, long-nose and white skate to schedules 5 of the Wildlife and Countryside Act, 1981, during its recent (quinquennial) review (English Nature, *pers comm*.).

Some species, such as tope, smoothhound and nursehound, are known to favour rough ground for nursery areas (CCW, *pers. comm*.)

8.4.2.3 Seabirds

The location of SPAs, designated because of their importance to bird populations, have been outlined above in Section 8.4. For offshore waters, Johnston *et al.,* (2002) lists 56 species of birds for which marine SPAs are being considered.

Stone *et al.,* (1995) and Webb *et al.,* (1990) mapped the distribution of these species and from these data the relevant species for each Strategic Area have been summarised in Table 14. Seasonality of occurrence is also indicated in this table. These data however, were limited in their scale and temporal detail. Mapping the data was not possible. The lack of recent and detailed distribution data, including nearshore reaches, is considered to be a data gap. The following features, supplemented where appropriate by information from recent additional studies, are noteworthy:

All strategic areas:

- Support localised over-wintering populations of common scoter. In addition to protection as a migratory species under the Birds Directive, common scoter is also a UK BAP priority species, and specially protected under Schedule 1 of the Wildlife and Countryside Act 1981.

Liverpool Bay:

- Over-wintering populations of cormorants are high;
- Gulls, in general, are at least widespread and abundant. Sabine's gull is present;
- terns present during spring and summer; and
- Populations of red throated diver, terns and over-wintering and moulting common scoter.

Greater Wash:

- Guillemot and razorbill populations are widespread during spring through to autumn and are relatively abundant;
- Substantial localised, over-wintering eider duck populations are apparent;
- Kittiwake populations are generally sizeable;
- Little auk and little tern populations are localised or small; and
- Populations of red throated diver and other tern species.

Thames Estuary:

- The red-throated diver is widespread throughout the area in the winter; and
- Species with a northern or open sea distribution are generally absent (such as eider, skuas and shag).

Tasker *et al.,* (1990) refer to 24 species of marine birds that regularly breed in UK waters, which are now being surveyed in a systematic manner at breeding colonies (Seabird 2000, see http://www.jncc.org/marine).

General information regarding the distribution and ecology of the species identified above is detailed below.

Common scoter

The distribution of common scoters in the Strategic Areas is likely to be related directly to feeding areas, and there is evidence to support this from Liverpool Bay (Seascape Energy Ltd., 2002). Studies by the Lancashire Wildlife Trust (CCW, *pers. comm.*) show that birds can undertake early morning movements to feeding areas, after drifting away during the night.

Common scoter prefer shallow bays and soft sediment areas where their food is located (Percival, 2001; Kirchhoff, 1979, cited in Brager *et al.,* 1995, and Durnick *et al.,* 1993). Their food is infaunal molluscs, particularly bivalves, such as mussels, cockles, and clams, as well as various gastropods (Alerstam, 1990; Cramp *et al.* 1977 *et seq.*; Brager *et al.,* 1995 and, Kirby *et al.*, 1993). The birds are believed to feed in inshore waters (to 2km, Percival, 2001) that is generally less than 10m depth. However, recent studies by CCW (in prep.) suggest that further investigation of their feeding habits in water to the 20m contour should be undertaken.

Within Liverpool Bay CCW (in prep) have identified key wintering sites: Red Wharf Bay, Conwy Bay/Lavan Sands; Colwyn Bay; west of Formby Point; and Shell Flat (west of Blackpool) (Figure 7, Annex 2). For other study areas, Stone *et al.,* (1995) provides some distributional data, and predictive distributions can be indicated, based upon our understanding of their ecology. Percival (2001) also notes the Wash, North Norfolk Coast and the Thames Estuary as important areas for common scoter.

Eider ducks

Eiders are gregarious birds and are generally recorded close to shore throughout the year, where they favour sheltered areas of coast. Their distribution is related to their main food source, the blue mussel *Mytilus edulis*.

Cormorant

Cormorants move inland during the winter, and Stone *et al.,* (1995) indicates that cormorants are present in low numbers from the northern western Liverpool Bay area between March and April, and not present within the other study areas. In May to February, high numbers are recorded in southern Liverpool Bay, with low numbers still present in the northeast. Also, low numbers are present in the eastern side of the Thames study area between October and March.

Cormorants generally feed inshore in waters of depths of one to three metres, and this is believed to be a major factor in their inshore distribution. They can travel large distances to feed, with records from Northern Ireland of journeys of up to 60km inland for breeding animal.

Red throated divers

The red throated diver is generally found within five kilometres of land although they can be recorded from further offshore (Seascape Energy Ltd., 2002). It feeds on bottom dwelling fish as well as those actually in the water column, diving to depths between 2 and 9m. However, the extent to which depth is a factor in the feeding area distribution of this species is not known.

The distribution of this species generally follows that of the common scoter, although the divers are more dispersed. Stone *et al.,* (1995) indicate that no red throated divers are found in the Strategic Areas from April to May, but present in internationally important numbers in southern Liverpool Bay from June to September, central Liverpool Bay October to November, and within all study areas in December to March. However, as the surveys published by Stone *et al.* (1995) were largely offshore, it is likely to have understated the presence of this species, particularly in coastal waters. The EIA at Gunfleet Sands (GE Gunfleet Ltd, 2002) in the Thames Estuary Strategic Area, reinforced the work of Stone *et al.* (1995) in locating red throated diver in low numbers during winter months.

Guillemots and razorbills

These species are recorded by Stone *et al.,* (1995) from the Liverpool Bay area throughout the year, with particularly high numbers of guillemots from July to February. Razorbills are absent from the Thames study area, and are only recorded from the Wash in February and March. No information is available regarding their preferred feeding areas though, as noted in Table 12, they forage widely.

Table 14: Seabird distribution in the Strategic Areas (modified from Stone *et al.*, 1995)

Area	Liverpool Bay				Greater Wash				Thames Estuary			
Months	04-05	06-09	10-11	12-03	04-05	06-09	10-11	12-03	04-05	06-09	10-11	12-03
Bird species												
Red-throated diver	0	L	L	L	L	L	L	W	0	0	L	W
Black-throated diver	0	0	0	0	L	0	0	L	0	0	0	L
Great northern diver	0	0	0	0	0	0	0	0	0	0	0	0
Great crested grebe	0	0	L	L	0	0	0	0	0	0	0	0
Red-necked grebe	0	0	0	0	0	0	0	0	0	0	0	0
Fulmar	W	W	T	W	L	L	W	W	L	L	L	L
Manx shearwater	0	L		0	0	0	L	0	0	0	0	0
Storm petrel	0	L	L	0	0	0	0	0	0	0	0	0
Leach's petrel	0	L	L	0	0	0	0	0	0	L	L	0
Gannet	W	T	T	L	0	W	T	L	L	L	L	L
Cormorant	L	L	L	L	0	0	0	0	0	0	L	L
Shag	L	L	L	L	0	0	0	0	0	0	0	0
Eider	L	L	L	L	L	0	L	L	0	0	0	0
Common scoter	L	L	L	L	L	0	L	L	L	L	L	L
Velvet scoter	0	0	0	0	L	0	0	L	0	0	0	0
Pomarine skua	Sp	0	0	Sp	0	Sp	Sp	0	0	0	0	0
Arctic skua	L	L	L	0	0	L	L	0	0	0	0	0
Great skua	0	L	L	0	0	L	L	0	0	0	0	0
Little gull	0	L	L	L	0	L	L	L	0	0	0	L
Sabine's gull	0	Sp	Sp	Sp	0	0	0	0	0	0	0	0
Black-headed gull	L	L	L	L	0	0	L	L	L	L	L	L
Common gull	W	L	W	W	L	L	T	T	L	L	T	T
Lr black-backed gull	W	W	W	W	L	L	L	L	L	L	W	W
Herring gull	W	T	T	T	L	L	W	W	L	L	W	W
Glaucous gull	0	0	0	0	0	0	Sp	Sp	0	0	0	0
Great black-backed gull	W	W	W	W	0	L	L	W	L	L	L	W

Kittiwake	T	T	T	T	W	T	T	T	L	L	W	W
Sandwich tern	L	L	L	L	L	L	0	L	L	0	0	L
Common/arctic tern	L	W	0	0	0	0	0	0	L	L	0	0
Little tern	0	0	0	0	Sp	Sp	Sp	0	0	0	0	0
Guillemot	W	W	T	T	L	W	T	T	L	L	T	T
Razorbill	W	W	W	W	0	L	W	W	0	0	W	W
Little auk	0	0	0	0	0	0	L	L	0	0	0	0
Puffin	L	L	0	0	0	L	0	L	0	0	0	L

Notes: density of birds (birds.km^{-2}) ranked by shading based on most populous record cell (in Stone *et al.*, 1995).

Key: Sp – individual sightings. L – locally distributed. W – widely distributed. T – throughout area

8.4.2.4 Waders and wildfowl

Population trends in wildfowl and waders in the UK (Cranswick *et al.,* 1999) suggest the following:

- divers, grebes, herons, geese populations, rails, some waders (for example. oystercatcher, knot, sanderling, dunlin, godwits) remained stable;
- coot, some waders (e g. avocet, lapwing, golden plover, curlew, redshank, turnstone), passage migrants, terns except arctic had declined;
- cormorant populations had declined (but in Ireland they had increased)
- mute swan, gulls, arctic tern populations were increasing
- some duck populations were increasing (gadwall, teal, ruddy duck, red-breasted merganser) whilst others declined (widgeon, mallard, smew, goosander, scaup) and still others remained stable (sea ducks except scaup)

The UK is relatively mild for its latitude, hence its general international importance for non-breeding waterbirds, but especially along its coasts and within its estuaries. Some of the cause for these changes were evidently a consequence of the relative severity of winter – whereas the 1998 winter was mild, the preceding two were severe, thus some bird species favouring cold winters, such as wigeon and goosander were less abundant as a consequence of the 1998 winter. The UK is also a cold weather refuge, seeing increases in several species when cold weather forces movement from continental NW Europe. Therefore, in very severe winters, we get more wigeon, as they tend to move west and south in search of relatively milder locations. Other trends were more long term (over 10 years or more).

8.4.2.5 Benthic fauna

A number of species of conservation interest are listed in Annex 4 and include a number of epifaunal and infaunal benthic invertebrates. Of the infaunal species, only two molluscs are BAP species. A third species outlined below is included in the OSPAR Biodiversity Committee draft list of threatened or declining species (Annex 4).

) and mentioned here because of its habitat preferences and hence potential to occur in offshore sediments in the Strategic Areas. These lists draw attention to a number of other infaunal and also epifaunal invertebrate species that could potentially be present in the soft sediments in the Strategic Areas. Analysis of occurrence would be determined during EIAs for specific future windfarm licence applications.

Fan mussel, *Atrina fragilis*

This bivalve mollusc lives partially buried in a wide range of soft sediments (Tebble, 1966). At present there are few records of its occurrence in UK waters. MarLIN (www.marlin.ac.uk) presents a map of locations (including potential sites) though all are outside of the Strategic Areas. Seaward (1990) reports a pre-1951 record of its occurrence in the Liverpool Bay Strategic Area, but it has not been reported since. Never present in large aggregations, ascertaining its presence in any one location would be resource intensive.

Flat Oyster, *Ostrea edulis*

Once widely distributed around the UK on a range of intertidal and shallow subtidal unconsolidated substrates (to a maximum depth of 80m, Tebble, 1966), this species has been subject to unsustainable exploitation, particularly in the 18th and 19th Century, and further impacted by tributyl tin (TBT) pollution. Population strongholds include the estuaries and flats of the Thames Estuary Strategic Area. Additional distribution data, identify locations particularly along the north of the Liverpool Bay Strategic Area. The Thames Estuary supports substantial amounts of licensed farm bed areas (Figure 8, Annex 2).

Arctic Quahog, *Arctica islandica*

In the UK, this robust bivalve mollusc is mainly found in Scottish Waters. Its population is said to be declining and as such OSPAR have included it in its listing of threatened or declining species for the North Sea (OSPAR region II, Annex 4). Found in firm sand and muddy sand from shallow water to considerable depths (Tebble, 1966), location data on the JNCC database (www.jncc.gov.uk/mermaid) show few records in the three Strategic Areas, though both Tebble (1966) and Seaward (1990) refer its distribution to extend throughout the UK.

8.5 Socio-economic environment

8.5.1 Seascape

The character of the landscapes and coasts of England are described in Countryside Character volumes published by the Countryside Agency. Character areas closely relate to Natural Areas described by English Nature, but these character descriptions provide a benchmark against which the visual effect of development and change on the coast should be assessed (see, www.countryside.gov.uk).

Aea's of Outstanding Natural Beauty (AONBs) are equivalent to National Park for planning purposes, and both designations represent our finest landscapes and coastlines of national importance. Landscape Assessments have been published by the Countryside

Agency for all AONBs affected by the current exercise. It should also be noted that National Trails, as designated by the Countryside Agency, and provide popular access to particular coastlines require consideration during visual impact assessment. During the Seascape assessment these designations along with features described below (Sections 8.5.9, 8.5.11 and 8.5.12).

For the three Strategic Areas, the following landscape features and character are of particular note.

8.5.1.1 Liverpool Bay

Within the English part of the area the following protected landscapes and coasts occur:

Solway Coast AONB. Low lying coast with views across the Solway Firth to the Scottish coast : development would be seen against the Scottish mountains, which rise to Criffel, 569m

St Bees Head Heritage Coast. High coastal cliffs (up to 141m) with clear view across the northern part of the area. The Isle of Man is plainly visible in clear weather from St Bees Head.

Lake District National Park. Internationally recognised National Park with a low coast stretching from Ravenglass to Silecroft, backed by high mountains. Clear views across the area from popular mountain summits up to 600m near the coast, including the Isle of Man, Morecambe Bay and in exceptional conditions, to North Wales.

Arnside a Silverdale AONB. With high coast of hills and bays facing the mudflats and sands of the Kent Estuary and Morecambe Bay, with extensive seaward views across the central part of the area. There are extensive and popular seaward views from the highest point, Arnside Knott, 169m.

8.5.1.2 Thames Estuary

Within the Thames Estuary Strategic Area, several protected landscapes occur which may be affected by offshore wind energy development, particularly any development near shore, as follows:

The Broads. This is equivalent to a National Park. Approaching the coastline at Hornsey, Ormesby and Great Yarmouth, the Broads are the low-lying marshes and water bodies. Offshore development and on-shore related infrastructure could be visible from the Broads and intrude on the quiet rural character of the area.

Suffolk Coasts and Heaths AONB. A low lying coast of sand spits, estuaries and low cliffs backed by heaths between north of Southwold and Deben Estuary near Felixstowe, and the Orwell Estuary.

Suffolk Heritage Coast. This is located coincident with the AONB between Southwold and the Deben.

Kent Downs AONB. This is and inland, high downland area affording views across the Thames Estuary. Highest viewpoints are around 180m, falling towards the coast. The North Downs Way National Trail provides access to some of these high vantage points.

8.5.1.3 Greater Wash

The protected landscapes and coasts are:

Spurn Head Heritage Coast. A low-lying sandspit projecting into the mouth of the Humber and some distance west of the projected eastern boundary of the Greater Wash area.

North Norfolk AONB. Consisting of mainly low lying coast from Hunstanton to Cromer, but with viewpoints from low hills and cliffs up to 100m, and heaths and marshy coast facing the inner Wash near Kings Lynn.

North Norfolk Heritage Coast. This is coincident with the central section of the North Norfolk AONB.

The North Norfolk Coast Path National Trail. This provides access to many viewpoints along the AONB.

8.5.2 Fish and fisheries

A number of commercially important fish species have spawning and nursery grounds that are known to overlap at least one of the three Strategic Areas (Figure 9, Annex 2)). Although these spawning and nursery areas have been described, specific spawning activity in any one year is variable (CEFAS, 2001). Consequently, the following description can only be viewed as broadscale and indicative. It should also be noted that only sandeel, herring and sprat spawn in the sediment, all other species including benthic and demersal species release their eggs into the water column.

Liverpool Bay supports widespread cod, whiting, sole, lemon sole, sprat, herring and *Nephrops* spawning areas. The area also provides haddock, whiting, sole, lemon sole, plaice, herring, sandeel and *Nephrops* nursery areas.

The inshore, sandy habitats of Liverpool Bay is a recognised nursery ground for plaice and sole (NWP Offshore Ltd., 2002). Investigations by National Wind Power to support an Environmental Statement for an offshore wind farm development at North Hoyle show that dab and whiting spawn across a large part of the Strategic Area. Cod, flounder and sole spawning areas are more localised in extent in the north of the Strategic Area towards the Solway Forth. Cod, whiting, ling and mackerel do not have specific nursery areas within Liverpool Bay, whereas flatfish species are more commonly located in inshore areas (CEFAS, 1999; NWP Offshore Ltd., 2002).

The Greater Wash supports significant sole spawning areas and lemon sole spawning and nursery areas across the entire Strategic Area. Plaice spawning areas lie farther out to sea within the eastern buffer of the search area. Farther offshore is a large expanse of sandeel spawning grounds and whiting nursery grounds. The inshore areas of the Greater Wash supports cod nursery areas and herring spawning grounds. Herring nursery areas are located farther offshore in the centre and north of the Strategic Area. The buffer zone supports the southern and western extent of sprat spawning and nursery grounds.

The Thames Estuary supports sole spawning areas, lemon sole and sprat spawning and nursery areas, with plaice spawning areas in the eastern extent of the Strategic Area. The inshore region also supports herring nursery grounds whilst cod nursery areas and sandeel spawning grounds are located farther offshore.

The seasonality of spawning varies between species and this information is summarised in Table 15. From this it is apparent that spawning activity is highly variable between species, but overall is largely concentrated to the first half of each year. Sandeels are distinct from this generalisation, spawning during winter months.

Migratory fish of commercial importance, such as European eel (A*nguilla anguilla*), Atlantic salmon (*Salmo salar*) and sea trout (*Salmo trutta*) will pass through each of the three Strategic Areas to and from their spawning and feeding grounds. Given that all spawning, nursery, the greater part of feeding and much of the fisheries (excepting salmon netsmen in the estuaries of salmon rivers) will take place away from the three Strategic Areas, these species will not be considered further in this Environmental Report.

Table 15: Spawning periods for commercial species (from Coull *et al.*, 1998)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Cod												
Whiting												
Haddock												
Plaice												
Lemon Sole												
Sole												
Sprat												
Herring												
Mackerel												
Sandeels												
Nephrops												

To help describe the status of fisheries, annual fishing hours within ICES grid squares for the area of Liverpool Bay from 1999 to 2002 are provided on Figure 8 (Annex 2). Beam trawl fishing intensity is presented in Figure 10 (Annex 2). The greatest concentration of fishing hours is present in the in the area around and to the east of the Isle of Man. An overall declining trend is observed in the ICES data (DTI *pers. comm.)* with the annual hours fishing in the Liverpool Bay Strategic Area, particularly in the vicinity of the Isle of Man and the region between the island and the mainland.

The Greater Wash and the Thames Estuary do not demonstrate as great a concentration of fishing hours although the Strategic Area is extended over a greater area. The largest concentration of fishing hours is observed in the area located off The Wolds and the mouth of the Thames. According to ICES data (DTI *pers.comm*.), a reduction in the number of fishing hours has also occurred in these areas over the period from 1999 to 2002.

8.5.3 Shellfisheries

Data available from CEFAS (1999) and Coull *et al.,* (1998), for Liverpool Bay, indicate that localised natural shellfish beds (mussels, oysters and cockles) are present within inshore areas of Morecambe Bay, the Ribble Estuary, along the Crosby and Wallasey coasts and in the River Dee (see Figure 9). Licensed production areas are also present in these locations, except the Dee, but are substantially less in extent. Offshore scallop fisheries are widespread in the Strategic Area (Bannister, 1999) covering an area that is essentially the entire area west of a line from Great Ormes Head to Wigtown Bay that follows the 12 nautical mile territorial limit. Norwegian lobster *Nephrops norvegicus,* are fished in the area between the Isle of Man and the mainland and inshore edible crab and lobster fisheries exist in the vicinity of Whitehaven. Brown Shrimp are fished in the Solway Firth, Morecambe Bay, the North Wales coast and in the Ribble Estuary.

Beam trawl-fishing intensity within inshore areas of Liverpool Bay, near to the coastline and farther offshore is low (Figure 10, Annex 2). A large area of medium beam trawl intensity is present within the centre of the Strategic Area.

The inner region of The Wash supports a large number of both natural shellfish beds and bivalve mollusc production areas (mussels and cockles). Beam trawl intensity is also high in this area. The North Norfolk coastline, east from the Wash, also supports natural beds and production areas (including oyster) although these are relatively small and isolated. Beam trawl intensity in the outer reaches of the Greater Wash Strategic Area decreases to medium and eventually to low farther offshore (Figure 10, Annex 2). Edible crab and lobster are fished commercially offshore of the Wash and inshore in the vicinity of Cromer. Whelks (*Buccinum undatam*) are fished in both the Greater Wash and Morecambe Bay. Brown shrimp are fished in the Humber Estuary and The Wash and pink shrimp are fished in the Wash and Morecambe Bay.

The Thames Estuary supports extensive areas of natural beds east of the Isle of Sheppey and along coastal and inshore areas north from Southend-on-Sea, Foulness Island, the Blackwater Estuary and Mersea Island. The outer estuary also supports natural beds although these are less extensive. The Thames Estuary also supports a large area of licensed bivalve mollusc production (Figure 8, Annex 2). Whelk fisheries are present in a number of inshore areas, adjacent to the Blackwater estuary, Harwich and Margate. Beam trawl intensity within the Thames Estuary is generally low, although the area of coastline north and east of Margate has a medium beam trawl intensity. Pink and brown shrimp are fished in the mouth of the Thames Estuary, between the Isle of Sheppey and the Blackwater Estuary, and lobster are caught in inshore waters of the coast between Clacton and Southwold.

Unlike the commercially exploited fish species, *Nephrops* breeds and inhabits the same locality and thus do not possess distinctive spawning and nursery areas. Further, there is not a clearly defined breeding season, though the peak in spawning activity is in the spring (Table 15). Detailed information about seasonal distribution of the other crustacean species was not available.

8.5.4 Cephalopods and cephalopod fishery

Cephalopods are short-lived, but fast-growing carnivorous invertebrates that play an important role in oceanic and coastal food webs. The significance of cephalopod stocks to international commercial fisheries is of relatively recent, but growing, importance (Boyle, 1990; Boyle and Pierce, 1994).

Though the UK cephalopod fauna extends to at least 48 species (Stephen, 1944), the main cephalopod species of economic importance in the northeast Atlantic are restricted to the following:

- long finned (loliginid) squids, *Loligo forbesi* and *Loligo vulgaris* (Augustyn, 1990);
- short-finned (ommastrephid) squids, *Todarodes sagittatus, Todaropsis eblanae* and *Illex coindetii;*
- the cuttlefish *Sepia officinalis;* and
- octopus species, *Octopus vulgaris* and *Eledone cirrhosa* (Pierce *et al*., 1994).

There is very little information concerning all aspects of cephalopod natural history including general distribution patterns, location of spawning areas and spawning behaviour (DTI, 2001):

- cuttlefish catch data show use of inshore areas for spawning in the English Channel, which may extent towards the Thames;
- octopi are generally thought to occur in depths between 50 and 300 metres, and are found on a wide variety of sea-bed types from soft mud to rocky bottom (Boyle, 1990); and
- squid distribution, based on by-catch data from 1980 to 1990 suggest that the main *Loligo* species, *L. forbesi* was widely distributed. Limited information suggest that *Loligo* spp. move into the central North Sea regions from the West coast of Scotland to spawn (Lum-Long *et al.,* 1992), but little further information is known.

Since 1995, annual UK landings of loliginid squid have ranged between 1600 and 3200 tonnes, making the UK the second most important fishery nation for loliginid squid within the ICES region after France. Over the same period UK cuttlefish landings have ranged between 2300 and 4600 tonnes, with the UK again taking second place to France (ICES, 2002). The cephalopod catch is mainly within the English Channel and northern North Sea though a limited catch is taken in the Irish Sea.

8.5.5 Aggregate extraction

The British marine aggregates industry has operated in each of the Strategic Areas for over 30 years and is considered to have long-term interests in each (BMAPA, *pers. comm.*). All of the three Strategic Areas have currently licensed aggregate extraction and depositional activity within them (see Figure 11, Annex 2). Within each, current aggregate extraction sites are generally located close to the 12 nautical mile limit. Commercially viable resources of sand and gravel are present over a limited spatial distribution as reflected by the current and proposed application locations. The total amount of sand and gravel within the Strategic Areas can be seen from the BGS seabed sediment information (Figure 4, Annex 2) though only a small percentage is currently considered commercially viable. Extraction is limited to areas that the Crown Estate makes available for application during licence rounds. (BMAPA, *pers. comm.*).

The greatest concentration of current extraction sites is located in the east coast Strategic Areas, with 40% of UK marine aggregate extraction taking place in the Greater Wash Strategic Area and only two sites currently in operation in Liverpool Bay.

Within the Strategic Areas there are additional localities subject to applications for future extraction licences (Crown Estate Commissioners, 2000). Though it should be noted that the Office of the Deputy Prime Minister (ODPM) is currently working on new regulations for the industry that are due to be released shortly. Notwithstanding the ODPM work, which may facilitate a shorter development timetable, currently application can take up to 10 years to progress through the consents process. In addition, future proposed areas for extraction already surveyed by prospective aggregate extraction companies may extend further across the Strategic Areas.

The Crown Estate also issues prospecting licences for site investigation for a period of 18 months to allow developers to investigate the potential resource of an investigation site. Many of the prospecting licences have been associated with near-shore locations, however, there is a move towards investigation of potential resources further offshore.

As aggregate sites become depleted, they offer the potential to windfarm development as "brownfield" sites. Over the timescale that this SEA is addressing (i.e. to 2020), a number of sites are almost certain to become available, perhaps within as little as five to ten years (Crown Estate, *pers. comm*.).

8.5.6 Dredged materials and disposal of other wastes

Disposal areas for dredged materials are present in all three Strategic Areas (see Figure 11, Annex 2). These are localised in the Wash, but extensive in Liverpool Bay, consisting predominantly of sand and silt. (Rees *et al.,* 1992) and will vary on an annual basis depending on the extent of development in near shore areas (NWP Offshore Ltd., 2002 with reference to Liverpool Bay).

Figure 11 (Annex 2) shows the current licensed disposal sites (harbour and approach maintenance shown on HO charts) within the SEA area. Historically, there were a number of disposal sites within the Strategic Areas for sewage sludge or industrial liquid waste, but these are no longer used (CEFAS *pers comm.*, 2002). Sites that had a history of industrial liquid waste disposal may require additional checks at the EIA level; however, CEFAS is confident that these areas should not be pose an environmental risk as there should be little residual waste remaining at the sites.

There is a great number of aqueous discharge points in the Strategic Areas. However, there are only three significant long sea outfalls that are listed in the OPL pipeline data as they are included as subsea obstructions. The longest is to the east of Rhyl in the Liverpool Bay Strategic Area and there are two smaller outfalls in the Greater Wash Area. It is likely that a more detailed evaluation of outfalls would be required when assessing possible cable landfall locations during EIAs.

8.5.7 Oil and gas

Several oil and gas-related structures are operated within the Strategic Areas (see Figure 12, Annex 2). Within Liverpool Bay a number of offshore oil and gas fields are present (NWP Offshore Ltd., 2002) and the Liverpool Bay Asset accounts for around 2% of the total UK hydrocarbon production yield. The total facility comprises offshore installations and a number of both offshore and onshore facilities for extraction, processing and transport of hydrocarbons.

The outer reaches of the Greater Wash Strategic Area supports a significant amount of offshore platforms and associated infrastructure. Several major pipelines follow two routes from the offshore installations to come onshore at the northeast Norfolk coast, the Wolds coast and north of the Humber. (see Figure 13, Annex 2).

There are no oil and gas exploration and/or production facilities within the Thames Estuary Strategic Area.

8.5.8 Other seabed structures

Gas pipelines operate between the offshore fields in Liverpool Bay to the Point of Ayr (see Figure 13, Annex 2) and from Morecambe Bay to Walney (NWP Offshore Ltd., 2002). Telephone service cables also operate across Morecambe Bay for Blackpool and between Haverigg Point and the Isle of Man. Cables that are not in service also run between the Isle of Man and Anglesey and Colwyn Bay and between Colwyn Bay and Morecambe Bay.

Within the southern region of the Thames Estuary Area, a number of fibre optic, telegraph and ‘out of service’ cables extend north and eastwards from North Foreland and Broadstairs (GREP UK Marine Ltd., 2002). There are a significant number of cables in the south of the area with seven reaching landfall between Margate and Ramsgate (Figure 13, Annex 2). Within the Greater Wash Area there is a number of existing cables and, also, several proposed connections. Smaller scale cable and pipeline crossings are also likely to be present within estuaries and river mouths in the Strategic Areas, but these have not been mapped for this SEA.

Known sites of cultural heritage interest were obtained from *inter alia* English Heritage (National Monuments Record), Cadw: Welsh Historic Monuments and the Clwyd-Powys Archaeological Trust (1998). These data allowed for these features to be mapped as point locations (Figure 14, Annex 2). In order to allow for some spatial consideration These an arbitrary 100m diameter area was incorporated into the GIS. A few areas have been present as block as a consequence of multiple features being present.

8.5.9 Boats, ships and navigation

It is estimated that around 95% of the UK's international trade by volume is transported by sea. Many of the largest ports in the UK are located along the east coast of England and these include Felixstowe, Tees and Hartlepool, Grimsby and Immingham, and London (DTI 2001, 2002). These ports form the focus for many of the major shipping routes throughout the North Sea. Consequently, the shipping activity in the three Strategic Areas has been investigated and described below with reference to the following data sources:

- quantitative shipping movement data derived from the COAST database of shipping movements (Figure 15, Annex 2);
- fishing intensity data supplied by ICES, based on total fishing hours and number of vessels, at a resolution of 30km x 30km (Figure 8, Annex 2);
- consultation with the Royal Yachting Association (RYA) with respect to recreational navigation; and
- designated navigation channels mapped on Admiralty charts.

In general, the following comments can be made:

- the Strategic Areas do not currently include any IMO traffic separation schemes, except at the mouth of the Humber and the conjunction of the English Channel with the North Sea. These areas are generally considered to be exclusion zones with respect to other activities. There are also several entry channels to main ports within the Areas though these are typically restricted to within a few kilometres of the mouth of the inlet or estuary (Figure 15, Annex 2);
- inshore traffic is under-represented in the COAST data; and
- much of the shipping movement follows relatively clearly defined routes.

In addition to these general observations, the following observation can be made for each of the Strategic Areas.

Liverpool Bay

The density plot shows that the vast majority of the vessels sail to and from Morecambe Bay and the River Mersey. The volume of traffic passing between existing offshore installations is relatively low. The vessels trafficking in Morecambe Bay are mainly travelling to/from Douglas Bay in Isle of Man and the North Channel. Other high intensity traffic routes are mainly vessels sailing to and from the Skerries Traffic Separation Scheme (TSS) and vessels travelling south of the Isle of Man to and from the North Channel.

Greater Wash

The density plot clearly illustrates that the most heavily trafficked area is the Humber approach. Most of the vessels are travelling to and from the Thames Estuary and Rotterdam, though there is a lower, but nonetheless observable volume of vessels travelling towards the Wash. The other heavily trafficked route is identified as northbound towards various east coast UK ports. The volume of vessels travelling between the Baltic and the Humber is considered to be moderate.

Thames

The area is very heavily trafficked with the density of traffic being approximately 31,860 vessels *per annum* recorded as passing through the Thames Estuary and approximately 26,769 vessels *per annum* entering the Harwich Channel. The number of vessels travelling towards the Dover Strait is approximately 33,891 vessels *per annum*.

The majority of the traffic entering the Thames Estuary originates from Zeebrugge, Oostende, Dover Strait and various Baltic ports. For the Harwich Channel, the vast majority of the traffic is vessels sailing to/from the Dover Strait, Rotterdam, and Hamburg. Another very heavily trafficked area consists of vessels travelling towards the Dover Strait and these vessels have been identified to be travelling from various North Sea and Baltic ports.

In their response to the Future Offshore consultation paper, the RYA indicated that the Thames Estuary Strategic Area is perhaps the most intensively used of the three for recreational navigation. It should be noted that there will inevitably be a number of particularly heavily used routes for recreational craft travelling from one port to another, including overseas, and that these may not necessarily shadow the commercial shipping routes shown in Figure 15 (Annex 2).

8.5.10 Military

Figure 16 (Annex 2) shows the PEXAs (Practice and Exercise Areas) marked on the HO charts. In addition, to these the Defence Estates also have a number of facilities and other sites such as ranges and test ranges that are not marked on the maps. Information has been received from the Crown Estate on munitions deposition grounds, however it appears that there are no significant deposits within the Strategic Areas.

8.5.11 Recreation

Use of the maritime resource includes a range of recreational activities including those described individually below. Though extensive use is made of the UK coastline as well as its inshore and offshore waters, quantitative data is limited. This section describes leisure activities in general terms and it can generally be assumed that the intensity of activity reflects population density and distribution of amenity such as bathing beaches (Figure 17, Annex 2).

Bathing beaches

Figure 17 (Annex 2) shows the locations of beaches listed in the UK Good Beach Guide, which includes Blue Flag and locally important beaches around the UK.

The Liverpool Bay Strategic Area has three Blue Flag beaches designated under the EC Bathing Water Directive (76/160/EC). One is located at Hoylake on the Wirral and a further two are located on the coastline north of Blackpool. Two further Blue Flag beaches lie within the buffer zone. A beach at Red Wharf Bay in Anglesey lies in the southwest of the buffer zone, whilst a second is located at Siloth in the northern buffer zone.

In the Greater Wash Strategic Area, six Blue Flag beaches are located along the coastline at Skegness and Mablethorpe. One of the beaches lies within the western buffer zone of the area. A further Blue Flag beach is located on the North Norfolk coast.

Thirteen Blue Flag beaches are located in the Thames Estuary Strategic Area at Margate, Whitstable, Sheerness, St. Mary's Marshes, Southend-On-Sea, Mersea Island, Brightlingsea and Clacton-On-Sea.

Other recreational activities

The coastline around the UK provides a significant recreational resource for walking and cycling, whether it be for short stretches along local beaches or on regional or national trails such as the North Wales Path (See Section 8.5.1 and NWP Offshore Ltd., 2002). Of course, there is an enormous range of recreational activities occurring in the Strategic Areas including *inter alia* sea angling, jet skiing, sand-yachting, parakarting and scuba diving.

8.5.12 Coastal development

The southern part of the Liverpool Bay Strategic Area has been subject to extensive industrialisation to the extent that it represents one of the most intensely developed stretches of coast in Great Britain (DEFRA, 2000). Major population centres are concentrated around Liverpool, Birkenhead and Chester (see Figure 17, Annex 2). Smaller, more localised population centres concentrated round Blackpool, Morecambe, Whitehaven , Kendal, Rhyl and Colwyn Bay are associated mainly with tourism.

In the Greater Wash Strategic Area, the majority of coastal population centres are associated with tourism, with the exception of Cleethorpes which is mainly a centre of industrial activity (Figure 18). Industrial population centres are located within the south-west portion of the Thames Estuary Strategic Area. However, some coastal towns such as Felixstowe, Clacton-On-Sea and Margate are mainly associated with tourism (Figure 17, Annex 2).

8.5.13 Summary of baseline description

The three Strategic Areas are dominated by complex mosaics of soft sediments (Figure 4, Annex 2) in shallow (less than 50m) water (Figure 3, Annex 2) that are the result of geological and oceanographic processes. Large areas of the coastline of each Area are sedimentary in character and a substantial amount of the UK total estuarine and intertidal area is present.

Existing chemical contamination of the sediments in each Strategic Area is localised and in some cases significant. Highest levels of metal, hydrocarbon and other contaminants including, in the Liverpool Bay Area, radioactive waste are associated with muds in estuaries and other sediment sinks, particularly in the vicinity of heavily industrialised localities.

Each Strategic Area is important in terms of its marine wildlife, particularly waterfowl, seabirds, harbour porpoise, seals and commercial fish species spawning and/or nursery areas. Large tracts of the coastline and inshore areas have been or are proposed to be designated under the Habitats Directive for their intertidal areas (which in turn often support large populations of birdlife), seal haul out locations, shallow subtidal sandbanks and biogenic reefs (Figures 2 and 4, Annex 2). JNCC has recently identified the location of potential Annex I habitat in UK waters beyond the territorial seas limit. Offshore areas of potential reef and sandbank occur in all three Strategic Areas, particularly in the Greater Wash. For the three Strategic Areas, both reef and shallow subtidal sandbanks are included in this proposal, particularly in the Greater Wash Strategic Area. English

Nature is deliberating, also, on potential sites for conservation designation within the 12nm limit of territorial waters. Cetaceans, sharks and rays are known to be, or believed to be, present in each of the Strategic Areas.

Economically, each Strategic Area is significant because of the presence of large ports and the associated shipping, including fishing, activity (Figure 8, Annex 2). Commercial fisheries include several whitefish species as well as shellfish (molluscs and crustaceans). Fishing activities range from nearshore fishing for crab and lobster to large-scale offshore, commercial operations.

Aggregate extraction is a significant activity, particularly in the Greater Wash and to a lesser extent the Thames Estuary. Only two sites are located in Liverpool Bay (Figure 11, Annex 2). Disposal sites have a small seabed take in each of the three Strategic Areas, with the greatest amount being located in the southern part of the Liverpool Bay Strategic Area (Figure 11, Annex 2). Ministry of Defence activity, both coastal and offshore, is present in the Greater Wash and Thames Estuary Areas (Figure 16, Annex 2).

There are differences in seascape character and value between the three Areas. Liverpool Bay has the most diverse range of seascapes. The seascapes within each of the Greater Wash and Thames Estuary Areas are relatively uniform. In the Greater Wash they are predominantly rural, but lack sufficient 'character' elements to warrant landscape designations. Many of the seascapes in the Thames estuary are characterised by industrial and high-density settlement features and, also, insufficient 'character' elements warranting landscape designations. Recreational activities are substantial in each Strategic Area, particularly the Thames Estuary where recreational navigation is most intense.

8.6 Trends and summary of 'no windfarm development' scenario

To provide a broad overview summary of a complex trend situation in each Strategic Area is difficult, but must be attempted for the purposes of informing the SEA and characterizing the 'no development' scenario. The discussion on key strategic trends applies to all Strategic Areas; individual Areas are only discussed when there are important differences.

Section 7 outlines the socio-economic and trends, derived from a survey of development intent, covering a range of activities. Also, and where data allows, environmental trends have been described throughout Section 8. In the absence of windfarm development, a variety of environmental changes may take occur over time.

Commercial and recreational navigation is likely to increase, but slowly. The localities/routes used have the capacity to absorb increasing usage. The regulatory framework, for controlling navigation/environmental interactions, is strengthening in effectiveness and it is expected that the net pollution effect from navigation is not likely to increase. The net inflow of pollutants from rivers is expected to decrease as the current programme of wastewater treatment station construction and implementation of the Water Framework Directive takes effect.

Development pressure from other sea uses will vary. Production of aggregates is likely to increase, but the pattern of sources will vary. There is likely to be less activity in the Thames and a movement offshore elsewhere. Some of the expected increase in aggregate extraction may move outside the Liverpool Bay and Greater Wash Areas. The net effect in the Thames is likely to be an improvement as old workings recover (albeit not to the same situation as prior to extraction). The situation in the other Areas is possibly slightly detrimental or neutral.

In the Thames Estuary Strategic Area, the Thames gateway project may alter sediment characteristics, generate substantial volumes of dredged materials and possibly locally alter sediment transport processes. In addition, the project will generate increased shipping and coastal engineering activity. All of these could result perhaps widespread and significant changes in the faunal composition of the Area. These activities will boost local economic activities and generate increased employment opportunities and enhance incomes.

Oil and gas exploratory activity is expected to decline over the next few years to negligible levels (DTI, 2001), though production will continue at significant levels. Oil and gas activity is expected to be limited to expansion of existing activities. There may be a small, but insignificant, adverse localised environmental impact. In the longer term, decommissioning of structures on depleted reservoirs is likely to take place that may result in seabed recovery and reopening of areas to fishing and other commercial activities.

No information is available on changes in military-related activities.

Fishing intensities, especially for finfish, is expected to decline. Certain current practices remain unsustainable and it seems likely that future policy implementation may cause a decrease in fishing activities. This may allow both recovery of some (or all) fish stocks and also other fauna that may have historically been impacted by fishing activities.

There may be concurrent increase in pressure on the shellfish resource. These two impacts will be most apparent in the Greater Wash and Thames Estuary Areas. The overall effect may be environmentally beneficial if the shellfisheries are managed in a sustainable manner as finfish populations my increase as a result of reduced fishing effort and provide a better resource for the future.

Conservation designations in offshore areas are likely to offer formal protection for some habitat features. This applies to both SAC (habitats and species) and SPA (birds) features

(Johnston *et al.,* 2002). This could potentially restrict economic activities in and possibly adjacent to designated areas but could potentially enhance biological quality of the designated sites. The extension of conservation designations is likely to benefit benthic communities and birds with some possible benefits for cetaceans and elasmobranchs.

Finally, there is the issue of climate change. It has been predicted that the sea level may rise by up to 23cm by 2050. Such a rise would affect coastal resources adversely. There may be a demand for improved and extended coastal defence measures that may result in adverse environmental impacts in the coastal interface between the land and the sea.

The impacts of climate change could have a number of other ramifications for the environment. For example, there is the potential for changes in the distribution of species, possibly to the exclusion in the Strategic Areas of those species at, for example, the southern limit of their range or the loss of suitable breeding conditions and habitat and competition from incoming species. Substantial effort is being expended in developing predictive models and monitoring programmes to assess the potential impacts of global warming and a review of these are beyond the scope of this SEA. There will be certain localised areas where there will be adverse impacts, but not sufficient to detract from this overall conclusion.

These broad developmental projections are not expected to have an adverse impact on landscape/seascape character and value. Also, the net effect on socio-economic issues is minimal, except for a likely decline in income to fishing communities and a localised boost to jobs and economic growth in the southern portion of the Thames estuary.

To summarise, the environmental conditions are expected to improve, slightly and slowly, in the 'no windfarm development' scenario except, perhaps in the southern Thames estuary where the Thames Gateway project(s) may have significant adverse consequences. Overall, the development of windfarms will occur within this context of general, but gradual environmental improvement.

9 Prediction and evaluation of impacts

9.1 Risk-based approach

As stated in Section 5, the overall SEA approach is based on mapping key factors in a GIS format complemented by a risk-based approach to evaluate the significance of impacts on important receptors. The aim is to provide a consistent method of evaluating impact significance (impact 'risk') based on a clear set of criteria. In a risk-based approach two aspects are important:

- **consequence**: characteristics of an impact (interaction occurring between an activity and a receptor); and
- **likelihood**: the probability that an impact will occur.

The impact significance or 'risk' is expressed as the product of the consequence and likelihood of expressed as follows: ***Risk = Consequence x Likelihood***

There are different levels of consequences and likelihoods and thus it is necessary to use a simple scoring system, based on common scales, to allocate both specific consequence and likelihood levels to particular impacts.

To assign a level of consequence to each interaction, criteria were defined for different characteristics of environmental and socio-economic impacts. The consequence categories and their scores are presented in Table 16 below. If an impact were to meet one of the criteria, that is assigned a particular score, then it would be assigned the score applicable to that criterion.

It should be noted that the table does not include seascape impacts as the seascape approach used to determine areas of high to low significance already incorporates its own specific criteria (Section 5.3).

Table 16[7]: Consequence definitions, categories and scoring

Consequence Category	Scoring	Definition
Serious	5	• Impact with the following characteristics: - irreversible or long-term adverse change to key physical and/or ecological processes; - irreversible or long-term reduction in habitat and species diversity; and/or - direct loss of rare and endangered habitat or species and/or their continued persistence and viability (i.e. availability of necessary resources to support characteristics of habitat or population of species) if the expected change will have importance at the national or international level. • Natural habitat restoration time long-term and requiring innovative intervention techniques bearing substantial financial costs. • Significant medium - long term financial loss to owners of businesses. • Change that prejudices the likely success of existing policies and plans or integrity of designated areas of nature conservation. • Increased hazard exposure to commercial and recreational navigators. • Substantial job losses in small communities.
Moderate	3	• Impact resulting in: - medium-term (between 5 and 20 years) adverse change to physical and ecological processes; - direct loss of some habitat (5 – 20%) crucial for listed species' continued persistence and viability in the project area and/or some mortality of species of conservation significance; - introduction of fauna or flora, not typical of the region, and invasive species replacing resident 'natural communities' within the project area; or - environmental stress lowering reproductive rates of species within the project area if the expected change will have importance beyond the local level (i.e. the strategic areas plus the buffer zone and within a landward coastal strip of 5kmabove the high water mark), but not at national or international level. • Natural restoration time of between 2 to 5 years and requiring substantial intervention, but using established techniques.

[7] Based on table included in Azerbaijan International Operating Company (2002) *Azeri, Chirag & Gunashli Full Field Development Phase 1: Environmental and Socio-Economic Impact Assessment*. Baku: BP (see also website: www.caspiandevelopmentandexport.com). Additional sensitivity information from Percival, 2001.

		• Medium-term financial loss to owners of businesses.
Minor	1	• Impact resulting in: - short-term adverse change to physical and ecological processes; - short-term decrease in species diversity in selected biotopes/areas within the project area; and/or - increased mortality of species due to direct impact from project activities and/or direct loss of a small amount habitat. - temporary disturbance of species, resulting in their cessation of normal behaviour and/or commencement of avoidance behaviour if the expected change has importance only at the local level (i.e. the strategic areas plus the buffer zone and within a landward coastal strip of 10 km above the low water mark). • Natural restoration within 2 years requiring minimal or no intervention. • Short term financial loss to owners of businesses.
None	0	• Impact absorbed by local natural environment (i.e. the strategic areas plus the buffer zone and within a landward coastal strip of 1 or 2km above the high water mark) with no discernible effects. • No restoration or intervention required. • No increase in hazard exposure. • No job losses. • No financial loss.
Positive	+	• Activity has net positive and beneficial affect resulting in environmental improvement for example: - greater likelihood of maintenance of ecosystem integrity; - improvement of habitat for rare and endangered species of fauna and flora as well as for those species known to naturally occur in the area; - enhanced natural biodiversity; and - growth of 'naturally occurring' populations of flora and fauna. • Reduced hazard exposure. • Potential financial gains to owners of businesses. • Job gains and increase in *per capita* incomes.

To the extent possible scientific evidence and inferences, based on observation of previous similar developments, have been used to assign a consequence category and score to an Impact. Where it has not been possible to quantify an impact, qualitative judgement has been used.

To assign a likelihood score to impacts three criteria were defined and ranked. The criteria for likelihood are shown in Table 17. A score of '5' (certain) represents the highest likelihood that the activity will occur.

Table 17: Likelihood categories and scores[8]

Category	Score	Definition
Certain	5	The impact will occur.
Likely	3	The impact is likely to occur at some time during windfarm life cycle.
Unlikely	1	The impact is unlikely to but may occur at some time during windfarm life cycle.

Risk /impact significance scores are categorised as shown in Tables 18 and 19.

Table 18: Consequence-likelihood product results[9]

LIKELIHOOD \ CONSEQUENCE	1	3	5
5	5	15	25
3	3	9	15
1	1	3	5

Table 19: Risk scores[10]

[8] Based on table in Azerbaijan International Operating Company (2002)
[9] Based on table in Azerbaijan International Operating Company (2002)

Impact significance or risk category	Risk scores (range)
Low	**0-8**
Medium	**9-14**
Significant	**15-25**

These tables do not cover the situation when there is insufficient data to characterise an impact. A risk-averse approach has been taken insofar as a lack of knowledge and/or data about the characteristics of an impact is shown by use of the term 'unknown' in the tables used to evaluate the impact risk (see below). Such impacts are candidates for the further research and additional studies that are recommended in Section 12.

9.2 Windfarm development activities and environmental impact

It was noted in the Scoping Report (BMT Cordah, 2003) that the life cycle of an offshore windfarm can be divided into four phases:

- pre-construction – including geotechnical and geophysical data acquisition;
- construction – driven, vibrated or drilled foundations and above seabed component construction from a jack-up barge and support vessels. Possibly grouted and with scour protection. Also use of sacrificial anodes. Cable laying using barge, 1 to 3m burial depth of one or more cables in parallel by ploughing or ROV mounted water jetting;
- operation - during wind speeds of 5 to 25ms^{-1}. Monthly maintenance visits, biannual service visits; and
- decommissioning – Two basic options available. First, dismantling and removal from site of above seabed structures; removal or subsurface cutting of foundation. Second, possible alteration and re-use of structures

Potential significant impacts from these phases have been identified during the scoping stage of the SEA and these have been assessed in the following sections. When data allow they have been quantified in terms of magnitude.

9.3 Coastal and offshore processes

There is a range of important effects on coastal processes that may occur locally or remotely as a result of the development of offshore windfarms (ABPmer, 2002). Other than sediment plumes generated during the construction phase, these are restricted to the operational phase of the windfarm lifecycle and are as follows:

[10] Based on table in Azerbaijan International Operating Company (2002)

- sandbank mobility;
- sediment redistribution (and contaminants);
- changes to seabed morphology;
- scouring of sediments at the base of a turbine tower;
- changes to flow regime and wave climate; and
- changes to coastal sediment budgets.

9.3.1 Sandbank mobility

Sediment sinks causing large scale deposits or sand wave formations are maintained by a highly mobile surface layer, generally with an ebb flow dominated and a flood flow dominated edge maintaining the overall area. (ABPmer, 2002). The sediment may also be lost from one end of the sand area and form the pathway for the maintenance of another area or beach system (e.g. the Margate area described in Section 8.1). The construction of a windfarm could potentially reduce the supply of sediment to adjacent areas. Locally there may be scouring and altering of the equilibrium that maintains the sandy area. From the Round One windfarm EIAs, however, modelling results consistently predicted that non-mobile sediments, sandbanks (and gravels) would not be impacted beyond the localised effects around each turbine structure (GE Gunfleet Ltd, 2002; Offshore Wind Power Ltd, 2002; Norfolk Offshore Wind, 2002, Powergen Renewables, 2002). From theoretical studies, however, worst case would be the situation where altering the local wave climate or cumulative local scour could destabilise the accretion/deposition balance that otherwise maintains the sandbank, causing permanent substrate changes (ABPmer, 2002).

Remotely, the sand may be part of larger pathways supplying coastal beaches or offshore sand areas. Disruption of these pathways can cause alteration of the coastal environment, loss of beaches or altering the seabed morphology.

Though the modelling results of the 30 turbine, Round One windfarm sites suggest no significant impact on sandbank mobility, the effect of larger sized windfarms cannot be assumed to be the same. Also, the modelling results require ground-truthing and a programme of study has been planned at the Scroby Sands site (CEFAS, *pers. comm.)*. As the studies reported in ABPmer, 2002, describe the theoretical possibility of significant impacts, it is concluded that uncertainty remains as to the potential significance of windfarm development might have on sandbank mobility.

9.3.2 Sediment redistribution and contaminants

During the construction phase, pile driving, dredging and cable laying will all cause sediment disturbance and redistribution due to the action of these activities on the seabed. In addition, during operation there will be local scour action on the seabed, which in absolute, if not relative, terms could collectively redistribute a large amount of sediment, (as outlined in Section 8.1). Sediment suspension and subsequent redistribution from cable laying in particular could be appreciable. At the Inner Dowsing site (Greater Wash Strategic Area), for example, it has been predicted that 90% of resuspended sediments from cable laying settled out within 1km of the construction corridor (Offshore Wind Power Ltd., 2002). In this document, it was also noted that the quantity of suspended material was not significant in comparison with baseline conditions. With respect to the potential for smothering by the resettlement of redistributed sediment, it should be noted that many species of benthic fauna, including sessile epifauna are to some extent tolerant to such events. This is self-evident given that they are, after all living in dynamic environments which will be subject to periodic disturbance events that include redistribution of sediment material. At the level of the faunal community, the tolerance is greater as community integrity will remain even were such disturbance events to result in the localised mortality of some of its component species. The relative impacts of sediment distribution will be controlled by the amount of redistribution (the thickness of the layer of resettled material), its variance from the existing material (introduction of mud onto a sand sediment will have a more substantial effect than mud settling on mud) and the sensitivity of the species/community (communities found in turbid environments will be less sensitive to those present in areas of low particulate loading).

Should these sediments have historically been used for industrial, sewage or ammunition disposal, or have acted as a natural sink for oil or chemical contamination, there is potential for these substances, and the accumulated contaminants, to become redistributed due to the construction and operation of offshore wind farms. According to information received from the Crown Estates and JNCC there does not appear to be any ammunition disposal areas within the SEAs, however, these should be checked with the MoD in the planning phase. There are several sites within the areas that have previously been used for dredging and sewage sludge disposal. CEFAS outlined several that are no longer used within the areas, but stated that these should not be considered as at risk of sediment contamination (CEFAS *pers. comm.*). Sediments that are redistributed would initially be expected to travel on normal sediment pathways, especially during construction. Therefore, based on the results of sediment analysis prior to construction, a risk assessment of this material should be carried out, especially if the likely deposition of the material is on public beaches or environmentally sensitive areas. The production of sediment plumes during the construction phase is dependent on the current and sediment properties at the site at the time of the construction. It should be examined and modelled during the planning phase of a development.

During decommissioning there is some potential for sediment redistribution, dependent on the extent and methods used for removal. There is a possibility for some plume creation during the physical removal of the support structures for the turbines, however, this should be lower than the disruption during the construction and operational phases. At decommissioning the potential effects are considered to be comparable with construction but that this assessment could be refined as a consequence of developing a greater understanding of the particular site obtained from construction and operation phases.

9.3.3 Changes to seabed morphology

Construction and cable laying can potentially cause the alteration of seabed morphology, either as a direct impact of scouring, or by the interference on sediment transport pathways and local wave regimes (ABPmer, 2002). Cumulative sediment movements or alteration of the wave flow regime can cause changes in local and coastal morphology if the erosion/deposition balance is altered.

Sandbanks and reef structures provide physical barriers to the coastal areas and can dramatically reduce the energy of waves reaching the coast e.g. Scroby Sands is responsible for reducing height of a 50 year return wave by over 75% (Posford Duvivier, 1997)

Consequently, within proposed wind farms, local seabed morphology is likely to change with a minor consequence. On a broader scale modelling predicts no change. For larger windfarms and groups of windfarms, the effects are not known at present. On both a broader and larger scale, there remains the possibility of significant impacts occurring, a potential significance of windfarm development that cannot be currently predicted.

9.3.4 Scouring of sediments

Local effects can consist of local scour around the base of the wind turbine support structure and the cumulative effect of multiple structures and the effects on the local wave climate and its influence on sediment mobility.

The turbine support structures and any development placed in the marine environment has the potential to modify local processes, predominantly by creating wake associated with existing currents. Even where local existing currents maybe below the threshold for sediment transport, the localized wake vortices can amplify the shear stress on the sediments adjacent to the structure causing scouring. (Breusers, 1972; ABPmer, 2000).

This is particularly likely should turbines or cables be placed in areas of high sediment motility, which can result in excessive local scour and altering of downstream areas.

The existing information on scour is based on small-scale models of monopile support structures. These studies have determined that there is a direct relationship between the diameter of the tower (4-5m) and the extent of scouring (ABPmer, 2002). Present estimations of the extent of scour indicate it to be in the order of 6-10 times the tower diameter, which equates to between 24 to 50m. Variation in the extent of scouring is a consequence of differences in sediment characteristics and current regime. This impact can be reduced, appreciably, by the addition of heavy gravel (2.5 to 30cm diameter particles) scour protection at the base of the tower. Typically, scour protection materials are placed around a tower having a radius of 25m.

From these figures and assuming (for simplicity) that the impacted area is circular, the following areas of impact can be calculated (total area $=\Pi \times r^2$).

No scour protection: $3.14 \times 25^2 = 1{,}965\text{m}^2$

This figure also corresponds to the scour protection area.

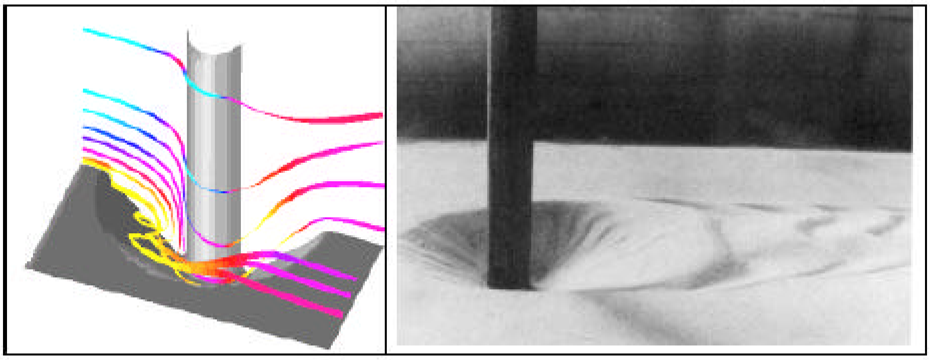
Based on the present layout strategy of arranging turbines at intervals of 700 - 1000m in the direction of the prevailing wind (BWEA, *pers. comm*.) and 350m apart perpendicular to the wind (National Wind Power Ltd, 2002), the total area associated with each turbine is:

Area associated with each turbine (1000m x 350m) = 3,500,000 m^2
Percentage area scoured at 1000m spacing (1965/3,500,000 x 100) = 0.056%

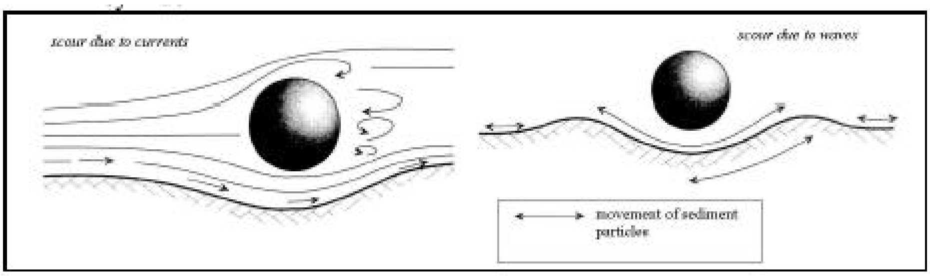
Area associated with each turbine (700m x 350m) = 245,000 m^2
Percentage area scoured at 700m spacing (1965/245,000 x 100) = 0.080%

Consequently, the footprint on the seabed of each turbine is in the order of 0.056 to 0.080% of the total area occupied by the turbine and, hence, of the windfarm.

Cables on the surface of the seabed can also cause scour. The diagrams below from the ABPmer modeling investigation, shows the scour and other effects of a monopile structure and of a cable laid on the seabed.



Flow structure interaction and scour development based on a monopile development (ABPmer, 2000).



Flow structure interactions for a marine cable laid on the seabed and the effects of continual current and wave/tidal flow effects (ABPmer, 2000).

The impacts of scour, which are certain to occur, are localised and as such the consequence is low. Associated impacts of scouring on, for example, fauna are discussed in the following sections.

9.3.5 Changes to flow regime and wave climate

Remote or far-field effects can include:

- changes to the flow regime; and
- changes to the wave climate caused by defraction, focusing effects or sheltering.

Both of these changes can be precursors to indirect impacts on sediment pathways and sediment transport system. These remote effects can affect the area immediately around the site and include the adjacent coastlines, or influence large-scale currents and systems within the Strategic Areas.

These issues should be investigated in greater detail in the site evaluation phase of development, however, no large scale windfarms yet exist and the ABPMER report points out that large-scale effects maybe difficult to evaluate from modeling alone.

Modelling for Round One sites have generally come to the same conclusions as typified by studies for the Cromer site (Norfolk Offshore Wind, 2002) where wave heights within the site are predicted to decline by 0.5m and in the immediate vicinity of the site by 0.1m. At any distance from the windfarm, no changes were identified through modelling.

It is presently not possible to draw firm conclusions from these studies unless only considering small scale windfarms, similar to those of the Round One sites. For larger sites the potential effects are unknown.

9.3.6 Changes to coastal sediment budgets

Coastal areas being nourished from offshore sediment sources have been described above (Section 8.1) where it has been noted that Dogger Bank feeds the coast south of the Humber (Greater Wash) and the beaches in the area of Margate receive offshore sediments. Consequently, the potential for windfarm developments to interrupt the sediment transport from these sources, which present knowledge is unable to predict, would require specific assessment during project specific EIAs or a broader and larger scale separate study.

Were sediment budgets to be affected by windfarm development, this could have severe consequences to coastal areas, either with respect to sea defence, coastal erosion or economic impacts regarding to beach replenishment programmes. From existing modeling studies, coastal processes are unlikely to be affected by small developments. It is not known, however, whether larger sites could have an impact.

9.3.7 Coastal and offshore processes – conclusions

For the majority of the Round One, windfarms, modelling has been carried out on coastal processes. The general conclusions of these studies, which have been discussed below, are that local effects on processes occur but the models do not predict any effects beyond the immediate vicinity of the proposed developments. It should be noted, however, that these studies, like the others referenced here, were for small (30 - 90 turbine) developments, and therefore the extrapolation of these findings to larger developments cannot be considered anything other than tentative.

Impact	Likelihood	Consequence	Risk
Sandbank mobility	3	3	9. Medium. Uncertain about this risk
Sediment redistribution	5	1 or 3	5 or 15. Low or significant. Latter if local contaminated areas of greater consequence
Seabed morphology – small sites	3	1	Low
Seabed morphology – large sites	3	Unknown	Unknown
Scouring	5	1	5. Low, effected area small
Flow regime and wave climate – local effects	5	1	5. Low, only occurs within and near site
Flow regime and wave climate – far field effects	Unknown	Unknown	Unknown
Coastal sediment budgets – small sites	1	5	5. Low
Coastal sediment budgets – large sites	Unknown	Unknown	Unknown

9.4 Benthic environment

With the exception of a very few localised areas where hard substrata and biogenic reefs may be present (Figures 2 and 4, Annex 2), it is currently understood that the seabed in each of the Strategic Areas consists of various types of soft sediment (Figure 4, Annex 2). Each sediment type, from mud to gravel, and their particular benthic invertebrate fauna, cover sizeable areas in the Strategic Areas, albeit in variable proportions as a consequence of geology and current regimes. The impact on these habitats from windfarm development and its significance are discussed below. These impacts are considered to be:

- disturbance and redistribution of sediments during installation of turbines on-site and cable laying;
- scouring of sediments in the immediate locality of each turbine and/or piling of scour protection and cable crossing material on the seabed;
- disturbance and redistribution of chemical contaminants during construction and from subsequent scouring of sediments;
- larger scale changes to seabed sediment and near bottom conditions; and
- loss of food resources for faunal groups.

9.4.1 Disturbance and redistribution of sediments

Sediment disturbance during construction and cable laying will come from vessels such as jack-up barges coming into contact with the seabed, penetration of the surface sediment by foundations and sediment ploughing (or water jetting) for cable laying. For each activity, sediment disturbance will be localised and of short duration. The extent of this disturbance will be influenced by the characteristics of the sediment being disturbed (the finer the material and the stronger the prevailing current, the more widely it will be redistributed). The effects on benthic fauna will be limited to localised mortality or displacement, where objects come into contact with the sediment and smothering by resettled sediment occurs. Different fauna are variably tolerant to such disturbance, but as the activities will be localised and disturbance will be short-lived, the impact can be regarded as low, even for long lengths (10s of km's) of cabling. Where mortality might occur, recruitment from adjacent unimpacted areas would ensure rapid recovery.

9.4.2 Scouring of sediments

It is accepted that localised scouring will occur around the base of each tower and accompanying cables. The area effected by the monopile design has been estimated in the preceding section. The effects on the benthic environment are substantial in the footprint of the turbine. With sediment erosion, the existing benthic faunal communities, including both invertebrates and fish, will inevitably be eliminated. However, the dynamics of change of physico-chemical conditions and associated fauna are more complex to predict. There is the possibility that the scour zone will, at least initially, become azoic as conditions become too harsh (where coarse and current agitated sediment particles predominate) to support benthic fauna.

Over time, the sediment conditions are likely to stabilise as currents sort the sediment particles and those that remain become too large to be readily agitated. This stability will allow recolonisation by benthic invertebrates, albeit by species that were probably absent in the pre-turbine sediment. This recolonisation itself may then, over time, increase sediment stability through its consolidation and allow colonisation to continue with recruitment of additional species. However, increased encrustation and colonisation by invertebrate fauna and flora will lead to a build up of biomass that might increase friction with currents and ultimately result in breakdown of areas of the consolidated sediment. This will increase local sediment instability and the process starts repeating itself. At some point an equilibrium will be achieved between faunal community and sediment stability, though at no time is it likely that the pre-turbine faunal community will be reinstated, in its entirety, whilst the tower is in place and local currents have been modified.

If scour protection is incorporated into the design of each structure, this also represents a substantial change in sediment character as coarse gravel and rocks cover the pre-existing sediment. As with changes to the soft sediment, the scour protection is likely to be colonised by fauna and flora (if light conditions allow). In the case of scour protection, the difference of the fauna between before and after construction will be greater than without such protection.

It was noted in the previous section that the proportion of the seabed area affected by scouring or scour protection, within the boundary of each windfarm, is likely to be in the order of 0.056 to 0.08%. From the scenarios presented for 3MW turbines in Tables 3 and 4 (Section 6) the total amount of area potentially subject to scouring or placement of scour protection, in km^2 and percentage of the total area, of each Strategic Area has been calculated. The calculation is based on the maximum area of scour of 1,965m^2, as calculated in Section 9.3.4. As with the calculations for area of scouring, the figures below are based on worse case scenarios. For example, it is highly unlikely that 3MW turbines will be more frequently deployed than 5MW ones. The results of the calculations are shown in the table below.

Scenario	Year 2010		Year 2020	
	Number of 3MW turbines	Total scour area (km^2)	Number of 3MW turbines	Total scour area (km^2)
Liverpool Bay (Total area 8,130 km2)				
Most likely	267	0.53 (0.006%)	500	0.98 (012%)
Maximum credible	500	0.98 (0.012%)	1000	1.96 (0.24%)
Greater Wash (Total area 13,100km2)				
Most likely	534	1.05 (0.008%)	1667	3.28 (0.025%)
Maximum credible	833	1.64 (0.012%)	2334	4.59 (0.035%)
Thames Estuary (Total area 5,901km2)				
Most likely	400	0.79 (0.013%)	567	1.11 (0.019%)
Maximum credible	666	1.31 (0.022%)	1667	3.28 (0.056%)

It is very evident from this table that even in the Thames Estuary Strategic Area, where the highest proportional values are seen, the total area of seabed take is a very small proportion of each soft sediment type. Further, these figures will only represent the maximum total take from a specific habitat (and particular biotope) if development were to occur on a single biotope. This scenario is considered to be a very unlikely outcome. Consequently, the impact on the benthic flora and fauna from scouring on the larger scale can be considered to be low.

Of the benthic invertebrate species of soft sediments that are of conservation interest (see Section 8.4.2), the likelihood of them being present in the sediment impacted by the scour zone is low because of both the proportionally small area in question and also the species scarcity. This judgement notwithstanding, it is necessary for project-specific EIAs to be alert to the potential for populations of these species to be present. In the case of the Fan mussel *Atrina fragilis*, however, its particularly sparse distribution (at least in UK waters) renders categorical determination of its presence or absence in any one location immensely difficult. The spatial distribution of these areas of scouring means that there would be a low risk of the ecological integrity of any one species or habitat being compromised, but a high consequence should it occur. In exceptional circumstances, where even a very small loss of habitat or individuals of a population might trigger a regional extinction, then the risk of significant impact is considered greater (see table in Section 9.4.6 below).

Scouring impacts with respect to biogenic reefs, such as consolidated aggregations of *Sabellaria* worms, and horse mussel (*Modiolus modiolus*) beds, should be considered to be a significant. Not only are these habitats of conservation interest (see Section 8.4), but should their integrity be disrupted by scouring or smothering by scour protection, then they are likely to be lost to that area. For the most part *Sabellaria* and *Modiolus* are both widely but sparsely distributed on coarse sediments but rarely in aggregations that warrant description as a reef.

9.4.3 Disturbance and redistribution of chemical contaminants

The chemical contaminant burden of the sediments has been described above (Section 9.2). It was noted that the muddier sediments bear the greatest contaminant load and in particular those closest to the source of the contamination (industrial discharges and waste disposal sites). In Liverpool Bay, radioactive contamination from Sellafield was also noted. The character of the sediments in the Strategic Areas means that the potential impacts on the environment associated with the resuspension of contaminated sediments would only pose a potential environmental risk in estuaries and muds. The possibility of disturbing appreciably contaminated sediments would most likely be as a consequence of routing cables through such areas. Given the small scale of cable trenching (20cm diameter by 1-3m depth), the amount of resuspended material would likely to only have a localised impact which would be addressed at the EIA stage of a proposed development.

9.4.4 Larger scale changes to seabed sediment and near bottom conditions

Wider scale changes to sediment transport and current patterns might have a modifying effect on the benthic fauna. However, such changes, unless substantial and causing a conspicuous change in conditions are unlikely to be detectable above the natural spatial and temporal variation characteristic of benthic fauna or long-term changes associated with other drivers (for example climate change). The potential for such changes to occur and the scale of the change should it occur have yet to be predicted (see previous section) and as a consequence the implications on the benthic fauna is unknown (see Section 12.

9.4.5 Loss of food resources for faunal groups

The final impact on the benthic environment concerns the feeding opportunities for fish, birds and marine mammals. For the same reasons that the impacts on the benthic fauna *per se* have been concluded to be of minor significance, the impacts on those animals feeding on the benthic resource is similarly considered to be low. However, should the proportion of limited and specific resources lost reach an ecologically significant extent then the risk of significant impact could be greater. The likelihood of this is considered to be low as the limited resource, such as biogenic reefs, is safeguarded by conservation interests against substantial amounts of loss. Even so, the consequence of such substantial losses would be high. This potential impact does not include the potential displacement effect as a consequence of other impacts, such as noise disturbance and avoidance behaviour of the above-water components.

Work has been commissioned by COWRIE to assess displacement from feeding grounds on common scoter (www.crownestate.co.uk/estates/marine/windfarms/cowrie.shtml).

9.4.6 Benthic impacts - conclusions

In conclusion, the potential impacts on the benthic environment are considered to be low with the exception of the following:

- damage to rare, endangered or threatened benthic species that are very localised in occurrence and with low population densities;
- resuspension of contaminated sediments in localised, sediment 'sink', areas such as estuaries. The relative significance of this impact would require consideration during project specific EIAs; and
- scouring or smothering by scour protection of biogenic reefs is considered to be a serious risk because of their conservation interest and low capacity for regeneration.

The scale and likelihood for cumulative effects to increase the significance of these potential impacts will be further assessed in Section 11.

Impact	Likelihood	Consequence	Risk
Sites and species without conservation importance	5	1	5. Low
Conservationally important sites and species	3	3 - 5	9 – 15. Medium to significant
Scouring and scour protection	5	1 - 5	5 – 25. Low to significant localised effect – significant on biogenic reefs
Scouring and scour protection – rare benthic species	1	5	5. Low. Unless potential for regional extinction then significant.
Redistribution of contaminants	1 - 3	3	3 – 9. Low to medium. Localised and mostly applicable to cabling
Large-scale changes to sedimentation and near-bottom conditions	Unknown	Unknown	Unknown. Effects of large developments need to be assessed.
Loss of food resources for other fauna – general	5	1	5. Low. Small areas of loss of food resources

Loss of food resources for other fauna – limited sources	1	5	5. Low. Other protective mechanisms keep likelihood low.

9.5 Potential environmental impacts to fisheries resources

The potential impact on the commercial fisheries resource from windfarm development and its significance is discussed below. This section does not make reference to economic impacts that are covered separately. T he potential environmental impacts are considered to be:

- seismic-mediated mortality and physical damage of planktonic eggs, larvae and adults;
- disturbance and redistribution of sediments during installation of turbines on-site and cable laying;
- scouring of sediments in the immediate locality of each turbine and/or piling of scour protection and cable crossing material on the seabed;
- physical presence in water column;
- interruption of migration routes;
- physical loss of shellfish beds; and
- loss of food resources for faunal groups.

9.5.1 Seismic-mediated mortality

Pre-construction activity that potentially impacts the fisheries resource is restricted to potential mortality of planktonic eggs, larvae and pelagic fish species, associated with the firing of airguns during seismic surveys. Research indicates that this impact is highly localised, within a few metres, or less, of the airgun (for eggs and larvae: see for example Holliday *et al.*, 1987; Kostyvchenko, 1973 and for adult fish: see for example, La Bella *et al.,* 1996; Turnpenny and Nedwell, 1994). This potential impact is therefore considered to be negligible.

9.5.2 Disturbance and redistribution of sediment

Disturbance to commercially important fish and shellfish species as a consequence of sediment disturbance would potentially impact, for example, spawning grounds of herring, sprat and sandeels, all of which lay their eggs in or on the substrate, and natural and commercial beds of cockles, clams, oysters and mussels. It could also potentially interfere with the burrowing behaviour of sandeels, normal activities of the flatfish species (sole, plaice etc) and also the benthic feeding activities of demersal species (such as cod, whiting, haddock). However, the potential impact on these species is considered to be in general low, a conclusion that is based on the relatively small predicted area of impact on sediments, as discussed in Section 9.2. The temporal variability of the focus of spawning activity each year (as noted in Section 8.5.2) indicates that a small loss of potential spawning area would not be critical to reproductive success given that all available spawning resource are not utilised each year.

Sediment redistribution, particularly during construction and decommissioning, might have a smothering effect on eggs, shellfish and, if sedimentation were severe, buried sandeels. The likelihood of this being a significant impact is low, not least because of the small size of windfarm structures (such as monopiles with a diameter of 5m or less and the small trench width required for cable laying. However, local concentrations of, for example herring spawn may be sensitive to sediments from construction activities. If egglaying and incubation periods are not avoided in the vicinity of such spawning beds then the consequence could be greater. Sediments from the cable burying process at Gunfleet Sands have been modelled and it was concluded that 90% of resuspended sediment would settle out of the water column within 1km of the site of disturbance. (GE Gunfleet Ltd, 2002).

9.5.3 Scouring of sediments and piling of scour protection

Scour, or the presence of scour protection, around the base of each structure has been described in Sections 9.2 and its effects on the benthic fauna in Section 9.3. The same arguments apply to the potential effects on fish. The minimal impact of the loss of a small part of the potential resource as a consequence of the turbine footprint, is further supported by the knowledge that all commercial fish stocks are currently subject to overfishing. Consequently the existing population size is below the potential, unfished population size and as such is not resource constrained. Even a loss of 0.056 to 0.080% area of seabed (Section 9.2) would not result in a reduction in population size.

9.5.4 Physical presence in water column

For juvenile and adult fish, the presence of turbines is not thought to represent a significant impact on their viability. Each structure is no more than 5m in diameter and they will be widely spaced (see Section 9.2). The capacity for fouling growth on the towers to attract fish is though to be limited, given the small size, however observations of the turbine structures at Blyth, indicate that they appear to have attracted fish (Econet Ltd. 2002), in particular flatfish were noted to congregate in the scoured depression. This impact is considered be of low significance.

9.5.5 Interruption of migration routes

Eels and salmonids undertake large scale migrations to/from spawning areas. There are also thought to be smaller scale, such as shrimp, crab and lobster that are thought to take place at least in some localities (CEFAS, *pers. comm.*). Such movements will take place in each of the three Strategic Areas. It is not anticipated that a windfarm would present any form of interference to mass movements and migration with the possible exception of sediment resuspension and noise generation during construction and decommissioning. This potential impact would be seasonal; restricted locally to where construction would be taking place within a development site; and only occurring during a limited part of the windfarm life cycle. Consequently, but subject to as much mitigation through timing of activities as is practicable, determined by project specific EIA work, the potential impacts to migration is considered to be low or medium.

9.5.6 Physical loss of shellfish beds

Existing farmed shellfish beds are mapped (Figure 8, Annex 2) and as such, appropriate project planning would avoid impacting these resources. Where construction in or cable laying through natural beds is unavoidable, the extent of loss would be expected to be relatively small for the reasons described in previous sections (Section 9.3). Such an assessment, however, would need to be qualified by the potential smothering effects and contaminant loads of settlement of sediments disturbed by construction and decommissioning. The potential impact on the shellfisheries resources of the three Strategic Areas is concluded to be minimal assuming appropriate levels of consideration are applied.

9.5.7 Fisheries resource impacts – conclusions

Pre-construction, construction, operation and decommissioning of windfarms have the potential impacts on fisheries resources as outlined in the table. These have been determined to represent a low risk of being significant, with the exception of impacts associated with changes to sediment character by, for example disturbance and redistribution.

Impact	Likelihood	Consequence	Risk
Seismic-mediated mortality	3	1	3. Low
Disturbance and redistribution of sediments	5	1 – 3	5 – 15. Low to medium. Risk subject to timing and locality
Scouring and scour protection	5	1	5. Low. Small area of scouring
Physical presence in water column	5	1	5. Low. Potential to have positive effect.

Interruption of migration routes	1 - 3	3	3 – 9. Low to medium. Only potential for construction effects
Physical loss of shellfish beds	1	3 - 5	3 – 5. Low. Assuming avoiding beds if practicable

9.6 Noise and vibration impacts

Noise and vibration generated by the operation of the wind turbines may disturb fish and sea mammals in the area. Research on the effects of noise transmitted through water on receptors, is currently very limited in the UK and has generally concentrated on seismic-propagated sound and marine mammal receptors.

Studies of the effects of noise on fish at the small windfarm site at Vindeby, Denmark, and oil and gas platforms in the UK sector, have concluded that they appear undisturbed by the background noise climate. Further, as noted elsewhere, fish may actually accumulate in the area of the turbines and foundations as occurs at other offshore structures. (ETSU, 2001).

Marine mammals rely on sound to communicate, find prey, and determine the environment around them (Richardson *et al.*, 1987). Therefore, there is the potential for marine mammals, such as cetaceans, to be affected by noise from wind turbines, but studies at the Vindeby site were not able to demonstrate any noticeable change in behaviour or numbers of animals present during its operation. Also, the study did not it look at long-term effects.

There are four main sources of impacts:

- seismic surveys during the pre-construction phase;
- noise – generating activities during construction and decommissioning;
- vessel movement during all phases;
- turbine-generated noise during operations; and
- potential use of explosives during decommissioning.

There are seasonality issues with respect to noise generation and also the presence of receptors. For example, there will be survey and construction/decommissioning windows when prevailing conditions would favour operations.

9.6.1 Seismic surveys

Seisimc surveys will be carried out during the preconstruction stage of windfarm development. Stone (1997, 1998, 2000) summarised reports from seismic vessels operating around the British Isles in which white-beaked and white-sided dolphins were seen less often during periods of seismic array activity. Conversely, more pilot whales were seen during periods of activity. This may indicate different avoidance strategies for deep diving animals like pilot whales and may expose them to greater effect. Both harbour and grey seals showed short-term avoidance behaviour during controlled exposure experiments with small airguns (Thompson *et al.,* 1998). In both cases seals abandoned foraging sites and swam away from load sounds such as airguns, but returned to forage in the same areas on subsequent days.

Studies of the grey whale and bottlenose dolphins in the US provide some indication of avoidance thresholds. Tests on grey whales were performed as the whales migrated past Big Sur, California. Whales were exposed once to a single airgun (source level=226 dB) and several continuous (source levels 151–163 dB) stimuli associated with offshore oil industry (Tryak, 1993). Airguns used in seismic surveys are likely to produce intermittent and brief sounds with frequencies between 1.8-500Hz dependent on the equipment used.

Observation of 3,500 migrating grey whales showed significant responses. Whales slowed down and altered course at ranges of 1–3 km. Half of the whales avoided exposure to continuous stimuli at levels 117–123 dB and to airgun pulses at 170 dB. Due to the fact that little is known of whale behaviour and it is difficult to establish baselines for detecting disturbance, this study provides one of the few examples where avoidance of noise by whales can be ascertained. This study, and oil and gas operational observations, indicates that baleen whales may exhibit avoidance behaviour if present nearby (SMRU, 2001; Trayak, 1993). Bottlenose dolphins, *Tursiops truncatus*, exposed to continuous noise levels near 120dB showed no such avoidance response. Behavioural audiograms have been reported for some toothed whales, including harbour porpoise (Richardson *et al.*, 1995). Toothed whales such as porpoises are most sensitive to sounds above about 10 kHz and below this sensitivity declines. In contrast, high frequency hearing is good; upper limits of sensitive hearing range from about 65 kHz to well above 100 kHz in most species. This is related to the use by these species of high frequency sound pulses for echolocation and moderately high frequency calls for communication (Tyack, 1993). Table 15 shows the hearing thresholds for selected marine mammals.

Goold (1996) presented evidence showing large-scale, long-term changes in abundance and distribution of common dolphins during a survey and shorter-term changes in behaviour between periods when guns were being fired within a survey block.

It is now considered good practice to initiate seismic surveys with a build up, from a low noise intensity, to operational sound levels in order to allow marine mammals and other fauna to move away from the survey area without the risk of harm. Assuming this practice is typical it is anticipated that the consequence of the impact is minor as avoidance behaviour will occur only for the duration of the operation.

Table 20: Hearing thresholds of marine mammals

Species	Frequency Range (Hz)	Reference
Odontocetes	40 to 200,000	Richardson *et al*., 1995
Harbour porpoise	1,000 to 150,000	Richardson *et al*., 1995
Bottlenose dolphin	40 to 150,000	Richardson *et al*., 1995 Ketten, 1998
Comment: No odontocete has been shown to have acute hearing (<80dB re 1µPa) below 500Hz. Odontocetes commonly have functional hearing between 200Hz and 100,000Hz, although may have functional ultrasonic hearing to nearly 200,000Hz		
Pinnipeds	30 to 180,000	Richardson *et al*., 1995 Ketten, 1998
Harbour (common seals)	1,000 to 180,000	Richardson *et al*., 1995
Comment: Most pinnipeds species are sensitive in the frequency range from 1,000 to 20,000Hz.		
Baleen Whales	15 to 30,000	Richardson *et al*., 1995 Ketten, 1998
Comment: Hearing in baleen whales is not well studied. They are known to be sensitive to frequencies below 1000Hz, but can hear sounds considerably higher but to unknown frequencies. Upper functional range predicted to extend to 20,000 to 30,000Hz.		

9.6.2 Construction-and decommissioning-generated noise

The loudest noise and vibration from offshore windfarms will be during construction; during piling, drilling and cable laying. Additionally, boat noise is likely to be significantly higher in the construction phase. Piling work has been recorded to generate intermittent high intensity sound that is detectable up to 20km away, with a sound power output of 225dB at 315Hz at the source (ERM, 2002). However, it is likely that, subject to specific conditions, detectable, and potentially impacting levels of sound, could extend beyond this range. Cable laying and dredging are estimated to have a much lower sound emission threshold, but with short periods of continuous noise, also detectable up to 20km away (ERM, 2002). Gastrup *et al.* (2000) assessed the noise impacts from the first four offshore windfarms in Denmark, and suggested that the response of marine life is one of short term avoidance, with no long-term effect directly linked to the construction phase. Consequently, the significance of this impact, because it is temporary, is minor.

Very intense pressure waves, e.g. blast waves from explosions, which may take place during decommissioning, also have the potential to cause damage to body tissues. Damage is most likely to occur where substantial impedance differences occur, e.g. across air/tissue interfaces in the middle ear, sinuses, lungs and intestines. Five of eleven Weddell seals sampled in the vicinity of blasting sites showed signs of inner ear damage (Bohne *et al*., 1985,1986) and various seals have been observed to be killed directly by explosives (Fitch and Young, 1948; Trasky, 1976).

Notwithstanding the above comments, the current understanding of noise impacts, including those from activities such as rock dumping for scour protection, is limited and as such research work is currently ongoing, including work funded by the DTI and COWRIE.

9.6.3 Operational noise

Current estimations for the surface sound power output of a single turbine is a sound power output 90-100dB and a sound pressure level of 50-60dB(A) immediately adjacent (scale used for determining human response). The modelling carried out for the Kentish Flats Wind Farm EIA (EMU, 2002) predicted that the 'in field' above the surface sound would be 50dB(A) dropping to 35dB(A) at 2.5km with a frequency estimated at between 20-150kHz. The subsurface sound has not been measured for any of the current windfarm EIAs and there is concern that the vibration potentially caused by the mechanical operation of turbines could cause infrasound vibration in the water. However, work cited in OSPAR (2003b) suggests that underwater noise in the frequency range above approximately 1kHz is not higher than ambient, though noise below this frequency is greater than ambient. The effects of such frequencies on marine organisms have not yet been researched, however, infrasound has been linked to sensitivities in seals (Richardson *et al.*, 1995). There is presently ongoing COWRIE funded research into the effects that noise and vibration has on marine mammals, (www.crownestate.co.uk/estates/marine/windfarms/cowrie.shtml).

Underwater audiograms have been derived for a range of seal species and all show a similar pattern over the range of frequencies tested (Richardson *et al.*, 1995). The audiograms for harbour seals are typical, indicating a fairly flat frequency response between 0.1 and about 40kHz, with hearing thresholds between 60 and 85dB. Sensitivity decreases rapidly at higher frequencies, but in the one animal tested at low frequency, the threshold at 0.1kHz was 96dB indicating good low frequency hearing. No behavioural audiograms are available for grey seals, but electro-physiological audiograms showed a similar pattern over the range of frequencies tested (Ridgeway and Joyce, 1975). The fact that grey seals make low frequency calls suggests that they also have good low frequency hearing. The potential impacts of windfarms, in the low or infrasound frequencies, are dependent on the equipment used for the turbines and propagation of vibrations into the water and sediments. These infrasounds could potentially increase over the turbines lifecycle due to wearing of the gear mechanism or minor increase up to the 6 monthly service. Small toothed whales are considered to be more sensitive to high frequencies than seals (Hamond *et al.*, 2002).

The zone of responsiveness is defined as the area around a source within which a marine mammal shows an observable response (Richardson *et al.*, 1995). Behavioural responses are always difficult to predict. Whereas the physical process of detecting or being damaged by a sound can be predicted from combinations of empirical studies and acoustic models, this is not the case for behavioural reactions to sound. The reactions of an intelligent marine mammal to a particular stimulus may be effected by several factors, e.g. nutritional state (hungry or satiated), behavioural state (foraging, resting, migrating etc.), reproductive state (pregnant, lactating, juvenile, mature), location and previous exposure history. Actual behavioural responses to seismic noise have proved difficult to monitor.

A Danish summary paper (Gastrup *et al.*, 2000) on the first four offshore windfarms in Denmark, speculates that the effects of noise on marine life is short term avoidance, with no long-term effect directly linked to the construction phase. The key impact for marine mammals is the operational noise, and the attraction/repulsion affects of the noise versus the potential attraction of fish aggregation.

9.6.4 Noise impacts - conclusions

A great deal of uncertainty remains with respect to both the amount of sub-surface noise generated by windfarms and also the effect that this might have on receptors.

Impact	Likelihood	Consequence	Risk
Seismic noise	5	5	25. Significant
Construction noise	5	1	5. Low
Operational noise	5	Unknown	Unknown. Depends on type of noise and species
Decommissioning noise	3-5	1 or 5	3 – 25. Low or significant. Potential use of explosives would be significant

9.7 Electric field disturbance to marine life from cables

Cables transmitting power to the mainland and between turbines have the potential to disturb marine animals that are sensitive to electric and magnetic fields. It has been suggested that there may be a risk that marine mammals and migratory fish species may be subject to disturbance of small and large scale disorientation (OSPAR, 2003a). However, the greatest focus of study on electric field related impacts has been concentrated on the elasmobranchs (sharks skates and rays), fish that are particularly electro-sensitive (Gill and Taylor, 1991). The limited understanding of the interaction between electric fields generated by transmission cabling and sharks and rays, though tentatively suggesting the effect might not be significant (see below), has led to COWRIE commissioning a study to investigate the effects of electromagnetic fields on them (www.crownestate.co.uk/estates/marine/windfarms/cowrie.shtml).

The potential impacts of electric power cables, including electric fields, were recently discussed by the OSPAR Biodiversity Committee (OSPAR, 2003b). The following salient points were made, on the basis that cables were buried to a sediment depth of at least 1m:

- medium and high voltage power cables with alternating current have no negative effect on the marine environment during operation;
- high voltage power cables with direct current develop significant electromagnetic fields that may be six times greater than background field strength; and
- high voltage bipolar direct current cables have a magnetic field strength that is minimal and typically substantially less than background readings.

These observations concur with those made in at least one Round One EIA (Offshore Wind Power Ltd, 2002), where alternating current cables are proposed, with burial (1 to 3m depth) and with shielding in place.

9.7.1 Impacts on elasmobranchs

All the shark, skate and ray species frequenting British waters, including the Strategic Areas, are electro-sensitive species (Gill *et al.*, 2001). Evidence of the use of electro-reception for prey detection or navigation may be lacking in certain species, but all species possess electro-receptors and, therefore, have the potential to be affected by changes in electric fields (Dawson *et al.,* 1980, von der Emde, 1999).

Preliminary research commissioned by CCW has demonstrated that the lesser spotted dogfish, *Scyliorhinus canicula,* avoids electric fields at 1000µV/m (or 10µV/cm) which are the maximum predicted to be emitted from 3-core undersea 150kV, 600A cables (Gill *et al.,* 2001).

The avoidance response by the lesser spotted dogfish was highly variable amongst individuals. However, changes in behaviour from the bottom to the water column and to the surface within the test tanks, points to a potential direct aversion to cables. Due to the limitations of this study it is difficult to estimate a field strength that could provide a physical barrier to electromagnetically sensitive species. The tests on *Scyliorhinus canicula* were based on surface laid cables, and both cable burial and shielding would undoubtedly significantly reduce the field strength to which elasmobranch species might be exposed.

It is likely that there will be an impact from electromagnetic fields, but its scale is unknown. The number of cables would appear to be a critical factor. A few larger cables may be preferable to a larger number of smaller cables. The latter option might create a series of 'lines' from offshore to onshore that create barriers to elasmobranch movements. Areas bounded by cables may become *de facto* 'reserves' trapping the fish within the confines of the cables. If this assumption were correct then, again, larger windfarms with fewer cables than a series of smaller cables may be preferable in terms of minimising impacts on elasmobranchs.

9.7.2 Electric field impacts – Conclusions

There is substantial uncertainty concerning the potential risk of impact on marine fauna from electric fields (see table below). Consequently it is not possible to conclude whether the risk of impact is low or more significant. This lack of information has been recognised and as such studies have been commissioned to investigate this, particularly with respect to elasmobranchs.

Impact	Likelihood	Consequence	Risk
Impacts on marine mammals	5	1 - Unknown	5 - ?? Low to unknown – probably low if a/c., buried and shielded
Impacts on migratory fish	5	1 - Unknown	5 - ?? Low to unknown – probably low if a/c, buried and shielded
Impacts on elasmobranchs	5	1 - Unknown	5 - ?? Low to unknown Depends on strength, location and number of cables and species

9.8 Landfall impacts

These impacts will depend on the number of:

- cable landfalls;
- grid connections;
- type and extent of grid reinforcement actions needed; and
- locations of the landfalls and connections.

These issues have been discussed, briefly, in Section 6.

Activities associated with landfalls will occur periodically over the next 10-15 years. They will be associated with the construction phases of some, but perhaps not all, of the individual windfarm developments as there may be sharing of facilities by the developers.

Potential impacts at the point of landfall could be manifold but all could be mitigated through appropriate site selection to avoid:

- designated and sensitive habitats and species;
- cultural heritage interests;
- sensitive landscapes;

- contaminated sediments (and land);
- interruption of coastal processes; and
- damage to other economic interests.

It is thought at a strategic level, the risk of significant impacts as a consequence of landfall construction and operation is low. Each Strategic Area offers a number of routes to the existing potential grid connections, by way of avoiding sensitive areas (see Figure 1, Annex 2), that pose only a low environmental risk. This conclusion assumes that through both the developers own environmental policies and the influence of the EIA process, that any proposed development would map out a low sensitivity route for cabling, substation location (and in the case of landscape, sympathetic design) and connection to the National Grid.

9.8.1 Landfall impacts – conclusions

This aspect of windfarm development has been considered to be of low risk of a significant impact, assuming that there would be appropriate sight selection to avoid sensitive features.

Impact	Likelihood	Consequence	Risk
Landfall receptors damaged	1	5	5 – Low Assuming selection of low risk routing during EIA.

9.9 Foraging and migrating birds

BirdLife International (BirdLife International, 2002) has identified a number of bird species groups which it considers to be potentially sensitive to windfarm developments. The groups include divers (including red-throated diver), cormorants and shags, swans, geese, some species of wading birds, seaducks (such as eider and common scoter), terns and auks such as guillemots. Three main types of impact have been identified:

- bird strike;
- exclusion; and
- habitat loss.

Each of these impacts has been assessed individually for each of the bird species and groups, as appropriate, for the three Strategic Areas.

9.9.1 Bird strikes

It should be noted that for long lived, slow maturing species, even low rates of collision mortality may be significant. Similarly, where population sizes are small, even low collision mortality may be significant. The impact, upon all species, of bird strike with turbines, will be largely limited to the operational phase of the life-cycle of a wind farm. The rate of bird strike will be subject to a number of variables, not least:

The majority of studies to date have demonstrated low rates of collision mortality per turbine (Percival, 2001; BirdLife International, 2002). However, as most studies are based on terrestrial windfarms and only relatively few small offshore windfarms, considerable care is needed in extrapolating the results to larger offshore windfarms. It should be noted that for long lived, slow maturing species, even low rates of collision mortality may be significant. This would be the case if additive to other sources of mortality or if, as a result of large numbers of turbines, the total numbers of birds killed is relatively high, although the collision rate per turbine is low. The impact, upon all species, of bird strike with turbines, will be largely limited to the operational phase of the life-cycle of a wind farm. The rate of bird strike will be subject to a number of variables, not least:

- individual species sensitivity to strikes;
- prevailing weather and visibility conditions;
- population of birds adjacent to windfarm;
- normal flight behaviour (height above sea level etc.);
- migration and local inter-site routes;
- feeding habitats; and
- seasonal variability in flight capability (as affected by, for example, moulting).

The key variable amongst those listed above might be considered to be the population size of any one species in the vicinity of a windfarm. Birds tend to congregate about a limited resource. For many seabirds this is most conspicuous when considering breeding colonies, where the limited resource is nesting sites. However, food resources for some species, such as sea ducks, also lead to aggregations of individuals. Flights between locations also lead to aggregation if routes are well defined. In the case of migration it is widely accepted that birds do not generally follow narrowly limited migration paths (Alerstam, 1990), with the occasional exception (such as the narrow straits in the mouth of the Mediterranean and other seas). In contrast, mass movements between, for example, estuarine feeding sites tend to generate large flocks of birds (Percival, 2001). Given that the potential risk of bird strike increases with the number of individuals coming into contact with a windfarm site, particularly for species of conservation importance, it is clear that the location of breeding sites and feeding distribution require consideration in assessing potential risk. The risk to birds during migration might be considered to be lower, subject to specific information suggesting the contrary and hence the need for additional study (see Section 12.4). The possible impacts on specific species are assessed below.

Common scoter

Field studies of the internationally important population of common scoter undertaken in Liverpool Bay indicate that, in normal circumstances, flight is below minimum blade tip height (which is typically in excess of 20m above sea level). However, the presence of vessels (including those undertaking the surveys) caused them to increase the height of their flight to within turbine height (NWP Offshore Ltd, 2002b and Seascape Energy Limited, 2002). The presence of vessels during maintenance could therefore lead to an increased risk of collision at certain times of the year.

Cramp *et al.* (1977 *et seq.*) indicate that common scoters generally fly low over the water surface, but higher over land, and potentially up to several hundred metres. Alerstam (1990) reports details of common scoters travelling at 100m to 250m during migratory flight above the sea, but at night, increasing their altitude to between 100 and 4,200m, averaging 1,000m. . Prevailing wind conditions are an essential factor in modifying flight behaviour (for all birds, not just common scoter). For example, headwinds tend to force birds to fly lower, whilst in tailwinds flight height increases, notably on longer flights. This effect relates to flight efficiency and the altitude of different wind speeds.

If undisturbed, the potential for collision with turbine blades during movement between roosting and feeding areas by common scoters is therefore considered to be relatively low. However disturbance, to which they are known to be sensitive, and general local and migratory movements may lead to increased likelihood of collision given the greater heights at which the birds will fly, particularly during poor weather conditions. As this species of sea duck is of considerable conservation interest in the three Strategic Areas, the potential for significant risk from bird strike is considered to be high. This risk is relevant to the known areas where numbers are greatest, such as southern Liverpool Bay, Morecambe Bay, Solway Firth, Thames Estuary and the Wash and North Norfolk coast (Section 8.4.2.3). Outside of these localities, the potential risk is likely to be moderate. However, data on their distribution remains incomplete and as such the EIA process for individual developments should anticipate the requirement to ascertain additional distribution data to confirm or modify these preliminary, strategic evaluations as deemed appropriate.

Percival (2001) reviewed research carried out in Denmark that suggested common scoter were able to avoid windfarms, even in darkness when they substantially extended the distance between turbines and flight path. These observations are considered to reinforce the conclusions drawn above. Local birds are likely to develop a familiarity with fixed structures, such that generally they will accommodate them in their movements.

However, in conditions that hamper their normal flight behaviour, they are likely to take greater avoidance action. Therefore the potential barrier effect, if turbine spacing is sufficiently close, birds might fly around the whole windfarm site which, if large, may involve a lengthy extension to flights into feeding areas (Dirksen *et al.* 1998, Spaans *et al.* 1998, cited in BirdLife International 2002). The issue of optimum spacing between turbines, in terms of both efficiency of the wind farm and to minimise or remove problems for birds is one that merits further discussion between the industry, conservationists and researchers.

Eider ducks

Painter *et al.* (1999) reported that eiders were initially prone to collision with wind turbines at Blyth Harbour, however, the incidence of bird strike appeared to decrease with time, with no strikes recorded in the second phase of study (years 3-6) at the site. It is possible that this decrease was due to habituation of the local populations of eiders to the presence of the turbines. It should also be noted that the methodology used is considered by the authors as likely to underestimate the estimated mortality. Danish studies reported in Percival (2001) indicate that eider were capable of avoiding turbines even during darkness.

Eiders undertaking longer distance movement and migration, have been recorded flying at high altitudes (Alerstam, 1990), however, breeding pairs in the British Isles are thought to show relatively small amounts of movement, with distances travelled rarely less than 200km (Cramp *et al.,* 1977 *et seq*). Lincoln *et al.* (1998) report sightings of seaducks flying at heights barely above wave height. The preferred habitat of eider, in nearshore waters (Section 8.4.2.3), suggests that increased distance between the shore and a windfarm reduces the likelihood of collision, as in the case of the common scoter. Though the probability of a bird strike in an offshore locations low, in comparison with (for example) Blyth Harbour, it still remains likely that it might occur. The consequence of such a risk is sensitive to the relative importance placed on the population in question. The eider population in the Greater Wash Strategic Area has been noted in SPA designations (Section 8.4.2.3). Its presence in the Liverpool Bay Strategic Area is more limited (and not noteworthy) and in the Thames Estuary it may not be present at all (Section 8.4.2.3). It is thought, therefore, that risk of bird strike on eider duck is low except in the Greater Wash where it is considered to be moderate.

Cormorants

Painter *et al.* (1999) observed that cormorants passing below turbines that straddled a roost area, generally flew lower than the level of turbine blades, with a subset of around 10% of those observed, flying at the height of the blades. Studies in the Netherlands by Dirkesen *et al.* (1998) provide some evidence that cormorants may actively avoid turbines when flying between roosts and feeding areas, with both cormorants and black terns observed avoiding installations by between 50 and 100m, and by greater distances in the dark. Observational data on the average flying heights of cormorants is limited, however, it is thought that this species generally has a low likelihood of strike. Cormorants have only been noted to be of conservation interest, as a consequence of population size, in Liverpool Bay (Section 8.4.2.3). As such, the risk of bird strike is considered to be moderate in this Strategic Area.

Red throated divers

Populations of this species of seabird are present in internationally important numbers in the Liverpool Bay and Greater Wash Strategic Areas (Section 8.4.2.3). It is also found in the Thames Estuary Strategic Area in winter months. At the proposed Burbo Flats windfarm site (Seascape Energy Ltd., 2002), 3.2% of the divers were encountered as flying at or above the height of the proposed turbines. Though generally thought to spend a greater amount of time in nearshore waters (less than 5km from the coast. See Section 8.4.2.3), these sightings appeared to be of individuals undertaking longer flights to and from inshore waters. This indicates that a small proportion of the diver population passing through any proposed offshore site may be at risk from collision with turbine blades.

Alerstam (1990) reports details of radar tracking of red throated divers undertaking longer migration flights, following the coast. In this case the divers travelled at 300m above sea level, increasing to 600m when the animals passed over land. Cramp *et al.* (1977 *et seq.*) report that red throated divers frequently fly at altitudes up to 200m and exceptionally to 700m.

Though these observations suggest that the frequency of bird strike might be low there is the possibility that it could occur. The conservation importance placed on the species consequently suggests that the risk is high as it could potentially have at least a national scale impact on population size.

Guillemot and razorbill

Present throughout each of the three Strategic Areas, these species are thought to generally fly below turbine blade levels. However on occasion they are likely to fly higher, particularly when arriving and exiting breeding cliffs and in conditions of tail wind (A. Webb, *pers. comm*.). Their flight is swift and direct but is not powerful (Cramp, 1974).

It is considered that the likelihood of strike will be infrequent, but likely to occur on occasion, for example, in strong wind conditions. There is insufficient information regarding average flight heights, distribution and avoidance behaviour for these species to allow a fully informed assessment of risk to be made. Such uncertainty suggests that the potential risk posed to auk species should be assessed from a precautionary perspective. Although the populations in the three Strategic Areas are of no particular conservation importance, the potential risk of significant impact is concluded to be moderate due to lack of information to make a determination of low risk.

Windfarm location several kilometers or more distant from breeding colonies should substantially reduce likelihood of collision and hence also consequence of bird strike on the population as a whole (Percival, 2001, cites recommendations that advocate distances as much as 20km).

Terns (sandwich, common, roseate and little)

Records of tern flight from recent EIA studies show a preference for flying between 5 and 10m above sea level (Seascape Energy, 2002; PowerGen, 2002). This finding is in line with published studies such as Perrins (1998) and Cramp *et al.* (1977 *et seq.*) who gave heights of 3 to 7m and exceptionally 12m. Studies from Belgium (Everaert *et al.,* 2002, reported in BirdLife International, 2002) reported the presence of little and common terns among bird strikes from a wind farm. However, there is some evidence from studies in the Netherlands (Dirksen *et al.,* 1998) that tern species may actively avoid turbines when travelling between roosts and feeding areas. It was reported that black terns avoided turbines by between 50 and 100m with this distance increasing in the dark, or when foraging parties were larger.

The flight height characteristic of terns, and evidence of avoidance behaviour, means that terns will fly, generally, either below the minimum height of the turbine blades or around them. Nevertheless, some collisions, if not many, will occur. This estimation suggests that the potential risk is high because of the conservation importance of some tern populations. Avoiding proximity to breeding colonies and generally keeping a distance of several kilometres from the coast (the preferred foraging localities of terns) would mitigate against a high risk (Table 12, Section 8.4). Terns are a good example of the influence of factors such as age of bird and season in potential collisions. Adults feeding chicks were observed to fly very close to overhead powerlines, between their feeding and nesting areas, that they otherwise gave greater avoidance to; also recently fledged youngsters were less manoeuvrable than adults as they were perfecting their flying skills (Henderson *et al.* 1996, cited in BirdLife International 2002).

Lesser black-backed gulls

There is some evidence to suggest that lesser black-backed gulls may be vulnerable to collision. Studies at a windfarm in Belgium (Everaert *et al.,* 2002 reported in BirdLife International, 2002) recorded black backed gulls as one of the main casualty species. Painter *et al.* (1999) recorded strikes of great black backed and herring gulls from the Blyth Harbour site, and noted that activity at turbine height was limited to larger gull species such as greater black-backed and herring gulls, although many of their flights (40%) were still below the rotors. If it is assumed that lesser black backed gulls fall into the category of larger gull when considering behaviour, then it should be assumed that they are certain to be subject to bird strike. Populations of this gull are noteworthy in the Thames Estuary Strategic Area because of the breeding populations in the Alde-Ore Estuary SPA. The consequence of bird strike on this species then is considered to be moderate in the Thames Estuary Strategic Area but low elsewhere.

Geese and swan species

No specific migratory routes have been identified for geese and swan species through the study areas, however, it is known that these animals have good eyesight and can avoid obvious structures in their path during conditions of good visibility. Goose and swan flight generally occurs in conditions of good visibility (Alerstam, 1990) and it is thought that these birds will generally be able to detect the presence of turbines and avoid them. Observed disruption of brent geese flock formation by wind turbines in Germany (Koop, 1997 reported in BirdLife International, 2002) indicates that this species was able to observe the turbines and alter its behaviour accordingly.

These species are known to generally fly above turbine height during longer distance or migratory journeys, and reports exist from the North Sea of Bewick swans flying at heights from 65m to 2000m above sea level (PowerGen, 2001). For example, goose species tend to fly at greater height while travelling longer distances, only dropping to lower altitudes as they approach their feeding, roosting and breeding sites (Percival for PowerGen 2001), or in poor weather conditions. In addition, there is evidence to suggest that a number of bird species, including geese, may use the coastline as a major geographic feature, by which to navigate during migration (Alerstam, 1990), and may fly at lower altitudes while doing so, but few data on preferred altitudes exist.

Local movement of swans and geese between different feeding areas will tend to be at lower altitudes than longer distance flights, and may fall within potential turbine collision heights. There is no information regarding local routes in the Strategic Areas, however they would not be expected to move any significant distance from the shore or estuary during these flights.

Consequently, if the locations of windfarms avoid routes used for shorter distance movement (for example, between roost and feeding areas) and inshore areas where lower level migratory movement may occur, the likelihood of strike is low. The consequence would be moderate or high for species of conservation interest. Given that it is thought unlikely for bird strike to occur, the potential risk to geese and swans is low.

Wading birds

Wading birds are known to fly, on occasion, at heights which put them at risk of collision with wind turbines (Seascape Energy Ltd, 2002; Painter *et al*, 1999). Radar studies of wading bird movements from the Netherlands (van der Winden *et al.*) recorded substantial movement of waders between roosting and feeding areas. Birds were recorded travelling at heights generally below 75 metres, within a height range placing them at risk of collision with turbine blades.

In a study, undertaken at a 20-turbine site in Kreekrat, Netherlands (Musters *et al.,* 1995, 1996) some indirect information on collision was collected through the search for corpses. These data showed low rates of collision, with wading birds, with estimated mortality of 0.41 – 0.53 % of the waterfowl population passing through a 20-turbine site. Further, studies at Blyth (reviewed by Percival, 2001) indicated that bird strike frequency was twice as high for overhead powerlines as it was for the turbines.

The placement of turbines along flight paths used by these species would potentially risk an incidence of bird strike, particularly close to shore and in areas where birds cross estuaries to pass between habitat areas used for feeding and breeding (Percival, 2001). Outside of these short distance movements, it is thought that migration generally takes place across a broad front and without identifiable and predictable routes (Percival, 2001, Alestram, 1990). As a consequence, there are unlikely to be high concentrations of migrating birds passing through a proposed windfarm site beyond nearshore (1 or 2km from the coast, Percival 2001) waters.

These data and observations suggest that bird strikes are likely to occur though the frequency would be low for offshore windfarm locations. The consequences are not serious and hence an overall risk is low.

9.9.1.1 Bird strikes – conclusions

The potential risk of bird strike being a significant environmental impact has been assessed for each of the key species and species groups, as previously discussed in Section 8.4. From the table below it is apparent that the potential for significant impact exists for common scoter, red throated diver, terns and lesser black-backed gulls. Medium risk of a significant impact also exists for eider, guillemot and razorbill.

Impact	Likelihood	Consequence	Risk
Common scoter	3 – 5	5	15 – 25. Significant
Eider	3	3	9. Medium
Cormorant	1	1 – 3	1 – 3 Low
Red throated diver	3	5	15. Significant
Guillemot and razorbill	3	3	9. Medium as a precaution to limited data
Tern species	3	5	15. Significant
Lesser black-backed gull	5	1 - 3	5 – 15. Low or significant. Latter in Thames only
Swans and geese	1	1 - 5	1 – 5. Low
Waders	3	1	3. Low

9.9.2 Exclusion by disturbance, habitat change, and barrier effects.

In the offshore marine environment, exclusion of birds can potentially occur as a consequence of the following:

- displacement from a location by pre-construction, construction, operation and decommissioning activities;
- loss of feeding habitat because of the footprint of the turbine foundations, scouring (or scour protection), power cables and zones of avoidance about each turbine;
- sedimentation of habitat from construction plumes; and
- barrier effects, preventing birds from moving in a chosen direction.

These potential impacts are discussed and assessed generically below followed by additional observation for individual species where relevant.

Displacement as a result of disturbance

Generally speaking, birds will be sensitive to disturbance from activities on the water during all phases of the windfarm life-cycle. Birds will depart from the area of influence to avoid the source of disturbance and consequently be excluded from that location for the duration of the disturbance. The risk of a potentially significant impact from displacement is dependent on the following:

- availability of alternative localities, such as other feeding areas;
- scale of the disturbance (spatially and magnitude) including the distance from the disturbance within which the bird reacts to the disturbance;
- frequency and duration of the disturbance;
- sensitivity to the disturbance; and
- habituation to the disturbance.

The distribution of bird species of particular interest, and their feeding ecology, have been used to assess the potential risk of significant impact from disturbance and displacement.

Loss of and changes to feeding habitats

Though the loss of feeding habitat through the physical loss of seabed habitat is certain to occur, the maximum total area of loss, including scour and/or scour protection, would be no more than 0.8% of a windfarm site (Section 9.3.4). Should a proposed site include only small areas of suitable feeding habitat for particular species of interest, such as mussel beds for eider, then appropriate siting of turbine foundations would be necessary to ensure low levels of physical loss. In both of these scenarios, the consequence is considered to be minor and therefore the risk of a potential significant impact is also low.

From existing studies, notably the 'Round One' EIAs and other studies (ABPmer, 2002), changes to sediment character and physical processes are of small scale and restricted to the windfarm site (Section 9.3). Consequently the potential risk of a significant impact is low, because of the limited spatial extent.

In addition to physical loss of habitat there is also a potential 'exclusion' zone around turbines and farms where foraging birds are displaced. For some species at least, the likelihood of this effect occurring is probably high. However, research carried out in Denmark, albeit of small windfarm developments, and reviewed by Percival (2001) noted that both eider and common scoter were more abundant in the windfarm area immediately after construction was completed. It was concluded that their distribution was more strongly mediated by food availability than any turbine avoidance behaviour. This suggests that exclusion may not be an absolute effect, over all bird species, with at least some species and individuals foraging amongst turbines.

The consequence would be dependent on the amount of exclusion and the availability of alternative habitat and is thought to vary from minor to serious. A serious consequence would apply where cumulative exclusion of an extensive area of habitat, or from a restricted habitat with few alternatives, by a series of windfarm developments might occur (see Section 10). The concern relating to loss and or change to habitat is that of cumulative impacts in particular potentially affecting limited habitats such as shallow sandbanks that are important feeding areas, notably in combination with displacement.

There is a possibility that offshore windfarm areas may attract a range of seabird and seaduck prey species. The structures might become encrusted with shellfish such as mussels, and attract duck such as eider and common scoter, although surface area for colonisation is limited. Reduced fishing effort in and around the turbines and reef effect may also lead to increased abundance of fish species around the structures, potentially attracting divers, auks, terns and gulls. Both the likelihood and consequence of this is uncertain but is thought to be low on the basis that the increase in food availability would be small. This would be perceived to be positive, assuming that such attraction would not increase the risk of bird strike.

Barrier effects

There is some indication that wind turbines may act as offshore barriers to bird movement (BirdLife International, 2002; Percival, 2001; OSPAR 2003b), with birds flying around turbine groups rather than through them. A study of the effects of a Swedish offshore windfarm (Larson, 1990) upon migrant birds travelling along adjacent coastline recorded a reduction in the number of birds in the coastal area adjacent to the windfarm after its construction. The potential for, and significance of, any such effects will depend upon the siting and arrangement of the turbines, and generally, the closer inshore turbines are sited, the greater the potential for interception of bird movement for feeding, roosting, breeding, feeding and migration. Locally collected, site-specific knowledge will be essential when determining the potential for a proposed site to lead to bird strike or act as a barrier to movement.

The extent to which birds avoid turbines have variously been estimated as ranging from 100m to 1500m, with a typical range of 400-800m (Percival, 2001, Guillemette *et al.*, 1998, Painter *et al.*, 1999). In general birds are considered to avoid passing through windfarms, even when the total number of turbines is only 20 or 30 (Percival, 2001). The suggestion is that the likelihood of barrier effects occurring to be high, though the fact that bird strikes occur indicates that this is not a certainty. The consequence of such a response by birds is likely to range from low to high, dependent on the species in question, its physical condition and the deviation in movement that the wind farm causes. Issues of spacing between individual turbines and between clusters of turbines may be important and may offer the potential for mitigation (see Section 12.2).

Uncertainty remains about this potential impact with respect to individual species and in relation to the size of the windfarm. The Crown Estates have commissioned a study through its COWRIE programme of research to investigate this issue, with respect to common scoter (www.crownestate.co.uk/estates/marine/windfarms/cowrie.shtml).

Species-specific assessments

Below the effects for different species are assessed.

Common scoter

The common scoter is hunted along much of its migration route and this may make them sensitive to the presence of boats. Studies in Denmark have indicated that they will avoid suitable feeding areas if there is boat activity (Seascape Energy Limited, 2002), or fly at greater heights, making them more vulnerable to bird strike. Vessel movement during construction and maintenance could therefore cause disturbance, and this is likely to be most significant between July and September when the birds are moulting. At this time the distress is likely to be at its highest as birds will find it more difficult to avoid the vessels, owing to a period of flightlessness. Further, if moulting has only been partially completed, the impaired flying capability of these birds would make them more susceptible to striking rotating turbine blades. The likelihood of this occurring is therefore concluded to be high, the consequence moderate and hence the risk also high.

Common scoters prefer areas of soft sediment, primarily sand and gravel, in a water depth generally 20m or less (RSPB, *pers. comm*., CCW, *pers. comm*,) supporting preferred molluscan prey species. Alerstam (1990) and Cramp *et al*. (1977 *et seq.*) report their key foods as *Mytilus, Macoma baltica, Cerastoderma (Cardium), Spisula* and a number of other bivalve species. Existing distribution data for the south part of Liverpool Bay Strategic Area is presented in Figure 7 (Annex 2). Consequently, development within shallow water, over suitable feeding habitats such as sandbanks, could lead to both direct and indirect (through disturbance) habitat loss. Consequently, the potential risk to common scoter in prime common scoter habitat is the same as described in the previous paragraph.

If feeding habitat is avoided during siting, the likelihood of exclusion will be low and limited largely to disturbance by boat activity which occurs during all stages of the windfarm life-cycle i.e. during pre-construction, construction, operation and decommissioning. The relative frequency of boat activity and the timing of its occurrence therefore influence greatly the impact risk. It is anticipated that the likelihood of disturbance during each of these phases is certain, but only with a moderate consequence during operation but high during construction and decommissioning. The risk of a potential significant impact therefore ranges between low and high. Whilst it may be possible to carry out some mitigation by sensitive timetabling routine maintenance visits, unplanned breakdowns may occur at any time and so timing of maintenance vessels within the windfarms cannot be fully controlled.

Eiders

Painter *et al.* (1999) reporting on effects of onshore wind turbines at Blyth Harbour, found no evidence of displacement from habitat for eiders, or a range of other species, including seabirds and wading species. Studies undertaken by Guillemette *et al.* (1998) at an offshore site in Denmark were not able to show any effects on eider populations or behaviour due to the turbines, beyond the ducks' avoidance of flying and landing within 100m of the turbines. It is possible that this initial displacement may have been due to disturbance of the food supply during construction, rather than the general presence of the turbines. Further studies at the same site (Tulp, *et al.,* 1999, reported in BirdLife International, 2002), showed that the eiders were active at night and that activity was reduced, with an effect up to 1500m away from the nearest turbine.

Eiders are known to prefer inshore feeding areas supporting blue mussels, their main prey species. In addition, they generally feed at depths of less than 10m, though they may feed in up to 30m of water (Alerstam, 1990; Cramp *et al.* (1977 *et seq.*). The risk of conflict between eiders and offshore windfarm sites would be limited to overlap between sites and location of shellfish beds at a suitable depth (more usually to 10m, but potentially to 20m). There may be potential for some localised disturbance within roosting areas as a result of turbine avoidance behaviour while flying and landing.

If feeding habitat is avoided during siting, the risk of exclusion will be low, as it is unlikely to occur and the consequence is minor.

Cormorant

Cormorants feed on fish in coastal waters, generally to 3m depth or shallower and exclusively during the day. It is thought unlikely that any offshore windfarm will impact upon cormorant through disturbance and loss of feeding areas except as a result of nearshore construction. This would be of minor consequence because of the localised nature of the activity and the widely foraging habitat. There would potentially be a greater likelihood of disturbance and loss of foraging, in the vicinity of the Ribble and Alt Estuary SPA, where important numbers of breeding cormorant are present (Section 8.4) and if activities were to coincide with their breeding season. In this locality it is likely that there would be an impact and the consequence would be moderate. However the impact risk is thought to be low.

Red throated divers

Red throated divers feed in inshore waters, diving to depths of up to 9m metres to catch their prey of various fish species, including sand eels, herring and sprats (Cramp, *et al.,* 1977 *et seq.*), but also crabs, shrimp and mussels. The birds are reported (Cramp *et al*., 1974) to be generally tolerant of human presence and limited disturbance. Occasional passage of servicing vessels may not disturb them significantly from their feeding habitat, however, they would potentially be affected by loss of habitat due to construction on feeding habitat, or changes to hydrodynamics or sediment regime that altered feeding habitat.

Given their broad diet, the certain small amount of habitat loss (Section 9.4.2) and potential impacts on fish (Section 9.5) is of minor consequence. Their relative tolerance to disturbance suggests that they would be unlikely to be greatly displaced, perhaps with the exception of periods of construction and decommissioning. The consequence of this impact would be minor, perhaps with the exception of construction and decommissioning. Overall, the potential risk to red-throated diver is low to significant.

Guillemot and razorbill

These species forage widely, feeding in particular on small fish such as sandeels. As a result, though they are likely to be affected by habitat loss and disturbance, the consequences will be minor and the subsequent risk of potential significant impact will be low. However, it should be noted that there are no data concerning their avoidance behaviour with respect to windfarms so at present it is not possible to assess the potential significance of barrier effects.

Terns (sandwich, arctic, common, roseate and little)

Tern species rely on nearshore food sources of herring, sprat and sand eels particularly during the breeding season, as well as some crustaceans and cephalopods (Alerstam, 1990; Powergen Renewables, 2001). The suitability of feeding areas is strongly influenced by prevalent sea conditions, with areas that are neither too rough nor too calm, known to be preferred. In addition, Cramp *et al.,* (1977 *et seq*.) indicate that little terns prefer to fish in shallow water (less than 10m). Tern feeding areas are generally within 10 km of breeding sites, and in the case of little terns, within 1km (BirdLife International, 2002; Percival, 2001; see Section 8.4). Tern colonies are present at two SPAs in Liverpool Bay, six in the Greater Wash and four in the Thames Estuary Strategic Areas (Tables 9 to 11, Section 8.4). The likelihood and consequence of a significant impact on tern feeding habitat would only result in a potentially significant risk if windfarms are located within these foraging ranges of the tern colonies. With respect to construction of cable routes, an impact would only be likely and the consequence moderate (because of localised nature of the operation) if it were to occur during the breeding season between May and July.

There is limited evidence of the potential for windfarm developments to affect the movement of terns. However, studies from Germany (Koop, 1997, reported in BirdLife International, 2002) do report some effect on behaviour between 200 – 500m from turbines. It is possible that turbines placed along routes used by tern species for longer distance movements, particularly migration, could cause some disruption to journeys undertaken. These data suggest, though without any degree of certainty, that terns would be less subject to barrier effects than some other species.

Lesser black backed gulls

The lesser black backed gull is less of a scavenger and more of a piscivore than other similarly sized gulls. Though widely distributed (Table 14, Section 8.4.2.3), only the large numbers of breeding birds at the Alde Ore Estuary SPA (Section 8.4 and 8.4.2.3) are of conservation interest in the three Strategic Areas. Given that this species forages widely, the likely loss of some feeding habitat and disturbance is of minor consequence. Sites in close proximity to the Alde Ore Estuary, taking into account the increase in the number of foraging birds, suggest that the impact consequence would be moderate.

Geese and swan species

There is limited potential for disruption to feeding habitat for geese and swan species within the Strategic Areas, given the likely distances between offshore windfarms and feeding habitat. Some localized and temporary disturbance may occur if cables were to be laid directly in a prime feeding or breeding area at certain times of the years.

Therefore, it is considered unlikley that feeding habitat and disturbance would occur or have anything other than minor consequence.

It is possible that offshore windfarms may have the potential to disrupt longer distance movement. There is some evidence of changed flying behaviour associated with turbines for brent geese, with studies from Germany (Koop, 1997, reported in BirdLife International, 2002) reporting that turbines disrupted flock formation, when within 200 to 500m of turbines. However, as discussed in the previous section, it is considered likely that that most movement in offshore areas will be at altitudes above turbine height (except in the onset of weather conditions that brings birds to lower altitude). Consequently, it is unlikely that barrier effects will occur. Were movements between feeding locations interrupted by the presence of wind turbines, the consequence is probably minor as the birds are unlikely to be under physiological stress compared to being on long-distance migration. The likelihood of exclusion is thought to be low.

Wading birds

Wading birds feed in localities outside of the areas likely to be subject to wind farm development. A number of studies have been unable to find before and after evidence of significant, long-term displacement of shore birds (including waders) from nearby habitat by wind turbines (Painter *et al.,* 1998; Still *et al.,* 1996; Winkelman, 1989 and Munsters *et al.,* 1995; 1996). As such the potential risk of a significant impact by displacement (disturbance) or loss of habitat is concluded as low (unlikely and of low consequence).

With respect to barrier effects, wading birds have shown to alter flight behaviour in the vicinity of wind turbines, reacting within 200 – 500m from turbine groups and flying over or around them (Koop, 1997, reported in BirdLife International, 2002). As wading birds are generally small birds, the long distances over which they migrate undoubtedly place them under considerable physiological stress. As such, the need to deviate during flight around or over a windfarm could potentially pose appreciable consequences. It is unknown, however, if there are any clearly defined migration paths that waders follow. Indeed, Alerstam (1990) suggests there are none. With respect to migrating waders, the conclusion is reached that windfarms may represent at least a partial barrier, given that avoidance of turbines by 200-500m, but that the consequence may not be in excess of moderate unless in a definable migration corridor.

9.9.3 Exclusion of birds – conclusions

The risk represented by the three types of exclusion have been discussed both generically and species by species. The risk-based impact assessment made in the preceding paragraphs is summarised in the following table. The key points of interest are:

- potential significant risk of impact through loss of feeding habitat for common scoter;
- potential, but variable, risk of barrier effects on any bird species;
- medium risk of significant impact through displacement to common scoter, cormorant (in Liverpool Bay) and terns; and
- medium risk of significant impact through loss of feeding habitat and barrier effects to terns.

Impact	Likelihood	Consequence	Risk
Displacement			
Common scoter	3	3 - 5	9 -15. Medium or significant. Latter in main habitats
Eider	1	1	1. Low
Cormorant	1 - 3	3	3 – 9. Low to medium (latter near SPA)
Red throated diver	3	1 - 3	3 - 9. Low to medium (latter for population concentrations)
Guillemot and razorbill	3	1	3. Low
Tern species	3	3	9. Medium when within feeding range of breeding colonies
Lesser black backed gulls	1	1 - 3	1 – 3. Low, even near SPA
Geese and swans	1	1	1. Low
Waders	1	1	1. Low
Loss of feeding habitat			
Common scoter	3	3 or 5	9 or 25. Medium or significant. Latter if substantial prime habitat damaged
Eider	1	1	1. Low
Cormorant	1	1	1. Low
Red throated diver	3	1	3. Low
Guillemot and razorbill	3	1	3. Low
Tern species	3	3	9. Medium when within feeding range of breeding colonies
Lesser black backed gulls	1	1 - 3	1 - 3. Low
Geese and swans	1	1	1. Low
Waders	1	1	1. Low

Barrier effects			
All bird species	3 or 5	1 - 5	3 – 25. Low to significant
Common scoter	3-5	1-5	3 – 25 Medium to significant
Tern species	3	3	9. Medium but few data (i.e. uncertain)
Geese and swans	3	1	3. Low
Waders	3	3	9. Low

9.9.4 Regional, national, and international scale impacts.

A number of birds found in the three Strategic Areas are of regional, national or international importance. The project related impacts have been related in the preceding sections (9.9.1 and 9.9.2). The impacts on populations

9.10 Conservation

A number of conservation designations, national, international, statutory and non-statutory exist within the Strategic Areas. Future windfarm development has the potential to affect such designations, whether directly, or indirectly. The main issues of concern are:

Structure and function

Windfarms have the potential to significantly affect a variety of biological and physical features, including species composition and assemblages, and the physical shape of the environment. The ways in which biological and physical features interact over time, and their requirements in order to function are important factors. Examples include:

- Direct or indirect removal, destruction, or modification. This would apply particularly to habitats, but might also apply to species.

- Creation of barriers for features such as migratory species, which use the conservation site for part of their life cycle.

Integrity and quality

The potential to significantly affect the coherence of a conservation site's ecological structure and the way it functions across its whole area must be considered, as must effects upon individual habitats, or species for which the site is designated. Potential effects upon characteristics of the site, such as water quality and species richness of individual habitats should be included during assessment.

For example:

- The isolation, removal or damage to components of a site by one or more development, leading to a decrease in the overall conservation value of that site.

Ecological coherence of site network

Interference with the way a designated sites (particularly international designations) functions as part of a network of areas supporting the life cycle of wide ranging species (for example, the use by migratory birds of the network of SPAs across Europe), or safeguards the biological distribution of non migratory species within or across bio-geographic areas.

A number of interest features, however, may not be designated but conservation agencies would still be likely to seek avoidance of these habitats. The consequence of developing on a site would probably be considered high, unless an Appropriate Assessment or EIA was able to robustly demonstrate to the contrary. The likelihood of development proceeding on a designated site, or one with interest features is probably low, but if it were to occur, an impact on them would be likely. Windfarm developers are consequently alerted to the need to recognise the potential risk associated with pursuing an interst in such a site ands the need for additional or more detailed work for the Appropriate Assessment.

9.10.1 Impacts on conservation designations – conclusions

There exists the potential for significant impacts to occur on designated, and potentially designated sites with respect to the three characteristics listed in the table below and discussed in the preceding paragraphs.

Impact	Likelihood	Consequence	Risk
Structure and function	3	5	15. Significant
Integrity and quality	3	5	15. Significant
Site network coherence	3	5	15. Significant

9.11 Cultural heritage

Known sites of cultural heritage interest were obtained from *inter alia* English Heritage (National Monuments Record), Cadw: Welsh Historic Monuments and the Clwyd-Powys Archaeological Trust (1998). Many of the sites have been mapped (Figure 14, Annex 2) and included in the spatial analysis. However, some coastal sites were mapped only if they were located on the coastal edge. Other sites could not be mapped, because of the type of data made available. The assessment of cultural heritage has not included cultural associations and this is acknowledged to represent a data gap in this report.

The mapped sites have not been categorised by nature of the cultural heritage interest. Most are believed to be wrecks, but other types of sites are included. The mapping has included a 100m diameter 'buffer' zone for each site. This was done to enable the site to be included in the map. Given that these sites are widely dispersed throughout the three Strategic Areas, albeit with higher densities in certain areas, such as the approaches to the Mersey Estuary, it is impracticable to assume that windfarm developments would not encompass one or more sites, given the large spacing between each turbine. It will be incumbent on specific project EIAs to take the location of a cultural heritage site into account, were it to be present in a proposed area of development, and make an assessment accordingly.

Cultural heritage features located on the coast have not been mapped directly. Most coastal cultural heritage sites will not be affected, directly or indirectly, by offshore windfarms. Individual project EIAs will consider the implications for coastal sites when examining the possible impacts of onshore facilities related to offshore windfarm development.

Impact	Likelihood	Consequence	Risk
Seabed sites	3	1	3. Low
Coastal sites	1	1	1. Low

9.12 Seascape, landscape and visual amenity

The main objective of seascape study was to identify levels of sensitivity, of seascape units, to offshore development of windfarms within the three Strategic Areas. This has been carried out by a process of ranking seascape units, based on a series of factors such as land use and presence/absence of areas possessing designations for landscape (Section 5.2.1).

Characterisation of the seascape units has been carried out by a desk-based survey of GIS information and by reference to 1:50,000 Ordnance Survey (OS) Landranger Series Maps. This has been primarily based on landform and coastal morphology in order to define the respective seascape units illustrated in Figure 19.

These seascape units are characterised as being of No/Low, Medium and High sensitivity to change of the nature associated with the proposed offshore windfarms. Minimum offshore distances have been established for each of these seascape units, based on CCW guidance, within which offshore windfarm development of the scale envisaged is predicted to result in Major, Medium and Minor or No seascape, landscape or visual effects. Figure 18 (Annex 2) shows low or no sensitivity seascape units, medium sensitivity seascape units and high sensitivity seascape units in respect of potential seascape, landscape and visual effects.[11] In order to take account of the "overlap" of visibility between different seascape units, a viewshed of 180^{o} around each headland separating the seascape units has been defined and this viewshed has been assigned the sensitivity rating of the most sensitive adjacent seascape unit.

The table below shows the results of the analysis in terms of the sensitivity of the seascape unit with the distance-based effects thresholds for 160m turbines, which is illustrated in Figure 18 (Annex 2).

[11] It should be noted that the 'bands' used to determine overall seascape sensitivity refer specifically to each Strategic Area. They cannot be used for the other Areas.

Table 21: Effects of proposed development for different seascape unit sensitivities

Seascape unit sensitivity	Significance of effect		
	Possible minor or no effect – Preferred Areas	Possible medium effects threshold	Possible major effects threshold
Low/no sensitivity	8km+ offshore	N/A*.	<8km offshore
Medium sensitivity	8km+ offshore	8-13km offshore	<8km offshore
High sensitivity	24km+ offshore	13-24km offshore	<13km offshore

It should be noted that the distance thresholds are not prescriptive but rather indicative of the distance at which possible effects may occur and would therefore need to be considered within the scope of any environmental impact assessment.

The mapped output shown in Figure 18 (Annex 2) for each of the three Strategic Areas show relative sensitivities of coastal areas in relation to potential seascape, landscape and visual effects arising from the minimum and maximum size of anticipated turbines for the next phase of offshore wind farm development. The maps also show areas of possible moderate and significant effects.

Liverpool Bay

The mapped output shows a fairly complex pattern of potential seascape effects, reflecting the more complex nature of this coast and related sensitivities (Figure 18, Annex 2). There is a band of major effect adjacent to the coast that runs along the north coast of Wales, then northwards across the mouths of the Rivers Dee and Mersey, adjacent to Blackpool, and across the outer edge of Morecambe Bay. Then, it proceeds around the Cumbrian coast, across the Solway Firth to the Dumfries and Galloway coast. Potential areas of medium effect are fragmented and most extensive adjacent to the Cumbrian coast. There is a fairly broad band of minor or no effect beyond which there is an extensive triangular area along the western edge of the Strategic Area, in which it is anticipated that there would be no seascape, landscape and visual effects from the coast.

The Greater Wash

The mapped output for the Wash shows a very simple pattern of diminishing potential effects with distance from the coast and a very extensive part of the Strategic Area with no effects from the coast (Figure 18, Annex 2).

The Thames Estuary

The mapped output for the Thames shows a margin of major effect running round the coastal edge, with a varying band of medium effect and a broad band of minor or no effect, beyond which there is an extensive outer area of no seascape effect (see Figure 18, Annex 2).

It should be noted that with greater refinement, locations may be identified within low sensitivity areas that may be unsuitable for windfarm development due to local circumstances. Conversely development in locations within higher sensitivity areas may have acceptable seascape, landscape or visual effects. Use of EIA on a case-by-case basis will still be necessary for any individual proposed development consent application.

Windfarm layout considerations

In the outer reaches of the Strategic Areas within which it is considered that there will be no effect on seascape, landscape or visual amenity, larger blocks of turbines may be more acceptable than closer to land. In broad terms a more complex coastline may be better suited to smaller groups of turbines which relate to the scale of the coastline, whilst broad sweeps of coastline may be better suited to accommodate single rows or series of rows in a linear pattern.

9.13 Impacts on other users

In this section the impacts affecting commercial (including fisheries) and recreational navigation interests are considered together. The inclusion of recreational navigation reflects the view of the Royal Yacht Association that the interests of its members are best served by a joint consideration of the two main types of navigational interest in EIA/SEAs (Response to *Future Offshore* by the Royal Yachting Association, 2003).

The main potential impacts relate to:

- safety;
- severance (impact on access); and
- loss of areas for activities.

9.13.1 Construction phase

During construction there will be considerable movement of vessels between nearby ports and the windfarm locations. Also, there will be a 'moving' area of construction within the windfarm location.

In the worst case situation, the construction vessel movements are additional to existing movements, with no accompanying diminution of existing commercial or recreational navigation traffic in the area. Also, it needs to be assumed the construction vessel would not be working elsewhere, but tied up in port. Even in such a situation there will only be a small increase in the risk of collision[12] in the vicinity of the main routes used to service the windfarms.

Similarly, the risk of having to deviate from well-established routes to avoid construction traffic/activities is small. Such deviation can have cost implications to shipping companies and fishermen as well as representing a 'nuisance' to sea users. There is very little risk of the instances where deviation is necessary resulting in fishermen and recreational sailors being exposed to increased danger due to having to spend more time at sea during worsening weather conditions.

For fisheries, the adverse impact on the catch/effort ratio will be negligible as the area to be avoided will be small at any one point in time.

Impact	Likelihood	Consequence	Risk
Commercial and recreational navigation	3	1	3. Low
Fisheries	3	1	3. Low

[12] References to the term 'collision' should be interpreted as including 'allision' (intentional collision of a ship with a stationary object)

9.13.2 Operational phase

9.13.2.1 Safety

There is an increased probability of collision for all vessels with an increase in fixed offshore structures. The consequences depend on many factors. Generally, the larger vessels will probably survive a collision and severe damage will occur to a turbine tower. With smaller vessels there is a greater likelihood that vessels will suffer more damage than the turbine towers. There is a medium scale risk associated with increased likelihood of collisions. Some collisions may cause death and injury and environmental harm through spillage or leakage of harmful materials.

In general, large cargo vessels and passenger ships are unlikely to be at risk, as they will avoid windfarms unless there is an onboard event such as an engine failure, or extremely bad weather. Then they may drift, or be forced, toward a windfarm and collisions ensue. Such a collision could have a catastrophic outcome if loss of inventory or, in the case of passenger ship, loss of life were to occur (see Section 9.15). Smaller vessels such as fishing boats or yachts may enter and/or traverse a windfarm. In such situations there may be a greater risk of a collision.

In terms of windfarm size, some navigational interests (particularly the recreational sector) would appear to favour smaller dispersed blocks rather than a large, concentrated block. Basically, it is considered that there is more risk to boats and crews when trying to travel round a large impediment in worsening weather compared to avoiding a larger number of smaller blocks. There are fewer options for 'escape' should conditions deteriorate significantly. Similar considerations may apply to small coastal commercial vessels, but not to large cargo vessels whose size and equipment are such that the risk is not increased.

Another key safety issue for recreational navigational interests concerns clearance between the lowest tip of turbine blades and masts. The RYA is concerned that there is a significant risk to boats which may venture too close to turbines that the blades may damage the mast structure with serious consequences for the crew and the boat. The risk depends on the clearance factor built into turbine design (see Section 12) and to some extent whether navigation exclusion zones are established at windfarm sites.

During the operational phase there will be a need for operations and maintenance works to keep windfarms generating efficiently for as long as possible. Repairs will be a regular occurrence. Operations and maintenance works will require some shipping traffic to transport equipment and workers. These will be additional to normal traffic, but will be so small in magnitude that the safety impact on other users will be negligible. As technology advances it may be possible to replace most of the ship traffic with helicopters, thus reducing the safety risks to other users.

The rotating blades of wind turbines can scatter electromagnetic signals causing interference in a range of communication systems. The signals can be reflected from turbine blades, so that nearby receivers pick up both a direct and reflected signal (Eyre, 1995). Signals that can be affected include:

- television broadcasts;
- microwave links, which are used by a range of large organisations for communications;
- VHF Omni-directional Ranging (VOR) used for aircraft navigation;
- instrument Landing System (ILS) used by aircraft on approach to landing;
- radar;
- safety of Life at Sea (SOLAS) transmissions;
- LORAN - a long range navigational system which uses low frequency;
- cellular radio for portable telephones; and
- satellite communications.

Interference with television reception tends to be highly localised. It is unlikely to be a major concern as mitigation measures can be put in place. The impact of a particular wind farm on microwave links should be assessed at an early stage in the project planning process. Rotating turbine blades can have a serious impact on civil and military aviation radar; their effect on ships' radar is not likely to be highly problematic. A detailed assessment of the effect of a planned wind farm on aviation radar systems local to the development will be made by the Civil Aviation Authority or the Ministry of Defence as appropriate on a case by case basis. An assessment of the potential impact on VOR and ILS will be made at the same time. Because of their height wind turbines in the vicinity of aerodromes will also be assessed as vertical obstructions much like any other tall structure such as a building to ensure that the safety of aviation operations is not compromised. The DTI advises developers to ensure that the sensitivity of potential wind farm sites to concerns from the aviation community is assessed early in the planning process. Guidance for developers on aviation issues is available from the DTI (ETSU, 2002).

Interference with communications systems in the final four categories is unlikely to be problematic

Approach funnels for aerodromes are usually considered as obstacle free zones and extend around 8.5km for commercial airports. (CAA, 2001) In addition, aerodromes can apply for safeguard zones in which all factors affecting aircraft are considered and regulated over an 18km or 30km radius from the aerodrome. (ABPmer, 2002). Should turbines be built within this radius they would need to be considered by the CAA. Under the obstruction regulations (CAA, 2001) towers will need to be coloured in a special pattern and specific lighting requirements would apply. The regulations require expert interpretation and are therefore only considered on a site by site basis by the CAA at the planning stage.

Impact	Likelihood	Consequence	Risk
Safety	3	3 or 5	9 or 15. Medium or significant, depending on ship size and weather conditions and flight path requirements

9.13.2.2 Severance

Severance occurs when traditional access routes are 'closed' or made more difficult to use.

Many of the possible impacts of windfarms depend on location. For example, windfarms that impede, seriously, shipping routes from existing or proposed ports and harbours might endanger their economic viability.

Also, windfarms can affect sediment movements in their vicinity. There is a small risk that sediment movements, caused by windfarms, might affect existing channels used for navigation hindering navigation. He situation is complex as such channels may alter course historically through natural processes. However, individual site selection by windfarm developers, based on the information in this *Environmental Report*, can help prevent such impacts occurring. Implementing EIAs for individual site consents will act as a type of 'assurance check' that site selection criteria and assumptions are valid and that no such impacts are expected to occur.

There is considerable recreation navigational 'coastal hopping' occurring in some of the close inshore localities of the Strategic Areas. This is common in the locale of the eastern rivers in the north of the Thames estuary and occurs when boats move along the coast stopping periodically. Such movements are close inshore and are at risk should windfarms be located close to the shore. The need to detour offshore increases safety risk and may lead to certain localities experiencing less recreational navigation because of severance. Such an eventuality would cause a decline in the income and potential viability of businesses that depend, to a greater or lesser extent on providing services to the boats and the crews. Such recreational navigation is less common in the Liverpool Bay and Greater Wash areas. In general, this impact is low risk because of the expected trend to locate windfarms at increasing distances from the shore. The east coast rivers possess the second largest concentration of recreational sailors in the UK, especially in the vicinity of the proposed Gunfleet windfarm. Thus, the location of windfarm developments very near the shore would increase the scale of the impacts in the north-eastern corner of the Thames estuary compared to other localities in this Strategic Area.

Another specific activity in relation to recreational navigation is competitive racing. There are three main types:

- 'close' inshore racing using craft such as dinghies. This occurs widely;
- yacht racing, occurring relatively close inshore, but widespread although with a preponderance in the Solent; and
- offshore racing such as the 'Fastnet' race.

Offshore racing is probably most at risk from windfarm development due to the expected increase of windfarms likely to be located at greater distances from the shore. Most offshore racing occurs outside the strategic areas, but there is at least one significant race in the Liverpool Bay Strategic Area, for example, the Dee to Isle of Man event. The 'nearshore' racing might be threatened by windfarm development, but this is considered to be less likely.

Impact	Likelihood	Consequence	Risk
Commercial shipping	5	1	5. Low
Fisheries (with and without exclusion zones)	5	1 - 3	5 or 15. Low or significant. Latter if exclusion zones promulgated.
Recreational navigation (with and without exclusion zones)	5	1 - 3	5 or 15. Low, but locally could be significant (Liverpool Bay, East Rivers in Thames estuary)

9.13.2.3 Loss of areas

Generally, windfarms, will effectively sterilise areas in terms of certain future other uses e.g. most Ministry of Defence Practice and Exercise Areas (PEXAs) or oil and gas exploration and production. No information is available on the Ministry's intention regarding changes in PEXAs so an assessment of impacts is not possible. In the latter case it is not expected that there will be major new oil and gas activities in the Strategic Areas although there may be continued development adjacent to existing fields. As indicated in Section 7, especially for the Greater Wash, aggregate extraction is likely to move further offshore. Therefore, there may be a loss of resource available to the aggregate industry from windfarms.

An issue that has arisen from the first licensing round relates to possible 'exclusion' zones (sometimes referred to as 'exclusion' zones). Basically, some developers may wish to declare an enforceable zone banning entry to boats both into the vicinity of a windfarm (defined boundary round the windfarm) and into the windfarm area itself. Currently, legislation powers are relatively weak in terms of setting and enforcing such zones. At the same time the question of establishing safety zones around windfarms to protect both structure and shipping is under discussion.

Depending on their extent, these zones could force boats to detour round the windfarms and, depending on the size of the windfarms, this may result in increased safety risks (see above). To counterbalance this effect it is plausible that such zones may reduce the potential risk of increased collisions from boats travelling into or through windfarms. At present, the RYA opposes such zones in nearshore waters – it has no policy yet regarding offshore waters. It is argued that there are established mechanisms and protocols to warn sailors of obstacles and that these procedures work well. Nevertheless, should safety zones be implemented then the severance effect of windfarm development will increase. The effect of the zone proposed for each wind farm will be assessed during the consents process.

It is likely that, irrespective of size of blocks, that some commercial vessels will need to deviate to avoid the blocks and journey distances and times will increase. This is an added cost. However, given that a 1000MW windfarm will occupy an area of 12km x 12km the extent of any deviation from the optimum route is likely, in most cases, to be small relative to the overall length of the route. There may be some exceptions to this case, for example, aggregate-related shipping, when the route is short and windfarms are located near to each other. In those cases the cost may be significant and competitiveness may suffer. The extent to which this may be a significant impact for individual operations cannot be gauged, however, as it will depend on the ability of the operator to pass on the extra costs in price increases or to absorb them through internal cost-reduction measures.

For the fisheries sector, the extent of the impact on catch/effort ratios will depend, in the main, on the existence of safety zones. Reduced ratios mean less income with indirect impacts in the economies of the fishing communities. Should such zones be promulgated, and depending on their location, then there is a small risk of an adverse impact on fishermen, their families and communities. Even if no zones exist then there may still be an adverse impact because certain types of fishing techniques may not be allowed or may be restricted to defined areas e.g. scallop dredging could damage cables. Trawling, purse seining, static, gill or drift netting and long line fishing could occur, but perhaps on a small scale or with limitations. Potting is possible without restrictions. Another source of potential adverse impact would arise from the need to deviate to avoid windfarms at certain times e.g. during adverse weather.

Those who could potentially be affected by the establishment of a safety zone around a wind farm will be consulted during the consents process.

Windfarms may act to increase fish biomass resulting from the presence of turbines. This outcome has been observed in the oil and gas sector. However, there is no evidence whether it will occur for windfarms. The scour protection materials may expand, also, suitable habitats for crustacaea and the biomass of certain commercially valuable species may increase. Should safety zones not be implemented and fish and shellfish biomass increase then catch/effort ratios, also, may increase. The longevity of this impact will depend on the sustainability of the fishery regime.

Overall, the net effect on fisheries is very difficult to predict. On balance, it is likely to be negative with a small increase in catch/effort especially in the period immediately following completion of construction. This may be reversed due to increased fish and shellfish catches, but such an eventuality is likely only to occur after a number of years of windfarm operation.

Impact	Likelihood	Consequence	Risk
Commercial and recreational navigation	5	1	5. Low
Fisheries	5	1 - 5	5 - 25. Low or significant. Latter if exclusion zones promulgated

9.13.3 Decommissioning phase

Theoretically, decommissioning can take two main forms:

- Removal of all or most structures; and
- Retention of all/most structures for re-use.

The option of abandonment is not considered likely and is not considered in this *Environmental Report.* Of course, by the time decommissioning is needed there may be options that have not yet been identified.

Removal is, in a sense, the reverse of the construction phase and similar impacts are likely to occur. Retention and re-use will require some construction actions to transform the structures into a state for the intended re-use.

If some structures are retained then care will be needed to ensure that they are marked to avoid collisions. They would then add to the already large list of structures that are a hazard to navigation. The impacts of the intended after-use would still require assessment to determine if significant and unintended impacts were likely to occur even if the after-use was designed to achieve beneficial objectives.

Impact	Likelihood	Consequence	Risk
Commercial and	3	1	3. Low

recreational navigation			
Fisheries	3	1	3. Low

9.14 Economic impact

A range of offshore impacts may have some economic consequences. These have been mentioned, as appropriate, in the discussion of the key direct impacts. The impacts of the different life-cycle phases are considered below. Both of these will result in socio-economic impacts. Another important issue is the impact on revenue generation from recreation and tourism for coastal communities.

9.14.1 Construction phase

The development of offshore windfarms will require fabrication or assembly of structures. Fabrication of the towers, turbines and blades is a relatively undeveloped industry in the UK. However, there will be a significant opportunity for the offshore construction industry to extend or adapt existing skills to take advantage of this new market.

The ideal situation is for the components to be fabricated and assembled in the UK in existing yards/factories near or within the Strategic Areas. This would be of especial benefit to Liverpool Bay as it is comparatively depressed economically compared to the other two Areas. This activity maximises job creation and income injection into local economies through the income and employment multipliers. Basically, the fabrication and assembly work represents new income (or at minimum replaces lost income if industry has declined locally). This income is spent locally, e.g. by employees in shops and then by the shopkeepers. There are successive ‘rounds’ of spending with some money disappearing from the local economy to buy goods and services not available locally. This increased money flow creates indirect jobs as employers take on additional staff to deal with increased demand for goods and services.

Depending on the needs of the industry and the suitability/availability of existing facilities it may be necessary to create special fabrication yards within/near the Strategic Areas (a situation that occurred during the early period of North Sea oil and gas exploration and production). It has not been possible to investigate the likelihood of such yards being required. Such yards would create jobs, but their existence would be characterised by peaks and troughs of activity and, overall, they are not likely to be a permanent source of employment. Depending on their location, duration and intensity of activity there may be a propensity for mini ‘boom and bust’ events in the nearest communities.

Assembly of components is less beneficial as there is no fabrication work. However, it still creates income generation and jobs.

The creation of new skills and experience in/near the Strategic Areas may assist the UK gain a comparative advantage, over other countries, in some of the activities around the design, manufacture, operation and maintenance of windfarms. If this occurred then the economic benefits will be consolidated in the long-term, and perhaps even be enhanced.

Impact	Likelihood	Consequence	Risk
Recreation and tourism income generation	Unknown	5	Unknown. May be locally serious for businesses and communities.
Job creation	5	3 or 5	15 or 25. Significant benefit

9.14.2 Operational phase

In this phase, onshore provision of infrastructure and services will be needed. Income and jobs will be generated by a range of activities such as:

- Construction of the windfarms offshore;
- Grid connection facility upgrading and reinforcement; and
- Operation and maintenance of the windfarms.

The number of jobs is likely to be less than in construction and the type will be different with less demand for unskilled and semi-skilled labour.

One major economic concern for certain coastal communities is the perceived adverse effect on seascape resulting in decreasing levels of recreation and tourism activities. People may alter visiting patterns and visit communities that have ‘intact’ seascapes.

The income from recreation and tourism is the mainstay of many small businesses and underpins the economic and social viability of some communities. Small communities are more likely to be more dependent on recreation and tourism income than larger communities as the latter are more likely to have a more diverse economic base.

It is possible that, initially, some communities may experience an increase in visitor numbers because of a windfarm. This is considered unlikely, and if it were to occur would probably be short-lived.

The impact on tourism revenues is difficult to predict. The evidence from land-based windfarms is mixed and may not be applicable to offshore windfarms. Should there be an adverse effect then there are likely to be ‘winners’ and ‘losers’ in terms of individual communities. From a regional or national perspective, there is no net effect as displaced tourism income is likely to be spent elsewhere. However, the impact could be significant for individual communities whose recreation and tourism income declines. It is possible that such an impact may be limited in duration as people become 'habituated'. Again, there is so little evidence that this possible effect, probably, should be discounted until experience is gained on the timing and scale of such an impact.

Impact	Likelihood	Consequence	Risk
Recreation and tourism income generation	Unknown	5	Unknown. May be locally serious for businesses and communities.
Job creation	5	3	15. Significant benefit

9.14.3 Decommissioning phase

The impacts of this phase will be similar to those occurring during construction.

9.15 Catastrophic events

Very low likelihood but high consequence events are not adequately accounted for in the risk assessment methodology applied in this SEA. Consequently catastrophic events that might take place, as a consequence of wind farm development, are considered in this section and outside of the risk based analysis carried out for the other potential impacts discussed above.

Unlike oil and gas, for example, windfarm developments do not carry with them substantial amounts of hazardous material or require large numbers of personnel on site with the exception of construction and decommissioning. Consequently catastrophic events are considered to be restricted to the potential risk from ship collision involving loss of large quantities of cargo (particularly oil or other chemicals) or large numbers of passengers.

With respect to cargo vessel collision and the loss of the ship's inventory to the environment, the amount of material discharged and its fate as controlled by the meteorological and oceanographic conditions prevailing at the time of the incident, determine the magnitude of the impact. Similarly, where passenger ferries are involved in collision then the potential loss of life is similarly incident specific. These observations apply more or less equally to each of the three Strategic Areas, though it is a scenario that is more likely to be played out where marine traffic is most intense. Figure 16 shows the main shipping routes which emphasises the relative importance of traffic associated with:

- the Mersey and Morecambe Bay in Liverpool Bay Strategic Area;
- the Humber Estuary and Wash in the Greater Wash Strategic Area; and
- the Thames and Harwich in the Thames Estuary Strategic Area.

Key environmental sensitivities in the vicinity of these shipping routes include nearby designated sites (mainly estuaries such as Morecambe Bay, the Wash, the Swale and Medway).

It should also be noted that establishing safety zones around wind farms would limit the potential for such an event to occur as much as practicable.

9.16 Summary of potential significant impacts

The medium and significant risks of environmental impact on the various environmental factors have been identified in the preceding sections have been reiterated in the table below. It is noteworthy that a number of these assessments, particularly those with a medium risk of significant impact, range from a low assessment. Variation in the assessment has been as a consequence of site specific or development phase specific differences in risk. Also included in the table is the single catastrophic event described in Section 9.15 which doesn't have a score but has been identified as a significant potential environmental impact. A second table follows that draws together all of those potential impacts that, for various reasons, have not been determined.

A risk based analysis has shown that the main concerns for offshore windfarm development are the potential effects on:

- sediment transport processes;
- conservation sites, biodiversity habitats and species;
- collision risk, displacement, disturbance and barrier effects on birds;
- collision and subsequent loss of inventory from cargo vessels; and
- collision and loss of life from passenger ferries.

Positive impacts are:

- potential fisheries and biodiversity recovery areas should they offer refugia from other activities;
- job creation during construction and operational phases;
- contribution to reduction in greenhouse gas and other atmospheric emissions (as introduced in Section 3, Section 8.6 and elaborated in Section 11.2.4).;
- improved balance of payments; and
- increased energy security.

In addition, a separate analysis of seascape issues suggests that developments less than a certain distance from the coast (within 8 to 13km) will probably have significant visual impact. The distance will vary according to the nature of the seascape in the range of 8km to 13km.

Impact	Likelihood	Consequence	Risk
Physical processes			

Sandbank mobility	3	3	9. Medium. Tentative conclusion.
Sediment redistribution	5	1 or 3	5 or 15. Low or significant. Latter if local contaminated areas of greater consequence
Benthic Environment			
Conservationally important sites and species	3	3 - 5	9 – 15. Medium to significant
Scouring and scour protection	5	1 - 5	5 – 25. Low to significant localised effect – significant on biogenic reefs
Scouring and scour protection – rare benthic species	1	5	5. Low. Unless potential for regional extinction then significant.
Redistribution of contaminants	1 - 3	3	3 – 9. Low to medium. Localised and mostly applicable to cabling
Disturbance and redistribution of sediments	5	1 – 3	5 – 15. Low to medium. Risk subject to timing and locality
Fisheries resources			
Interruption of fisheries resource migration routes	1 - 3	3	3 – 9. Low to medium. Only potential for construction effects
Noise			
Seismic noise	5	3	15. Significant
Decommissioning noise	3-5	1 or 5	3 – 25. Low or significant. Potential use of explosives would be significant
Birds - collision			
common scoter	3 – 5	5	15 – 25. Significant
eider	3	3	9. Medium
red throated diver	3	5	15. Significant
guillemot and razorbill	3	3	9. Medium
tern species	3	5	15. Significant
lesser black-backed gull	5	1 - 3	5 – 15. Low or significant Latter in Thames only
Birds - displacement			
Common scoter	3	3 - 5	9 -15. Medium or significant. Latter in main habitats
Cormorant	1 - 3	3	3 – 9. Low to medium (latter near SPA)
Red throated diver	3	1 - 3	3 - 9. Low to medium (latter for population concentrations)
Tern species	3	3	9. Medium when within feeding range of breeding colonies
Birds – loss of feeding grounds			
Common scoter	3	3 or 5	9 or 25. Medium or significant.

			Latter if substantial prime habitat damaged
Tern species	3	3	9. Medium when within feeding range of breeding colonies
Birds – barrier effects			
All species	3 or 5	1 - 5	3 – 25. Low to significant
Tern species	3	3	9. Medium when within feeding range of breeding colonies
Conservation designations			
Structure and function	3	5	15. Significant
Integrity and quality	3	5	15. Significant
Site network coherence	3	5	15. Significant
Impact on other users			
Safety during operation	3	3 or 5	9 or 15. Medium or significant, depending on ship size and weather conditions and flight path requirements
Severence on fisheries (with and without safety zones)	5	1 - 3	5 or 15. Low or significant. Latter if exclusion zones promulgated.
Severence on recreational navigation (with and without safety zones)	5	1 - 3	5 or 15. Low, but locally could be significant (Liverpool Bay, East Rivers in Thames estuary)
Loss of areas by fisheries	5	1 - 5	5 - 25. Low or significant. Latter if exclusion zones promulgated
Economic impacts			
Job creation	5	3 or 5	15 or 25. Significant benefit
Catastrophic events			
Cargo and passenger vessel collision	Very unlikely	Very high	Catastrophic event – major significance.

For a number of potential impacts, it has not been possible to formulate a view on the potential risk of an impact on the environment. This has been the case for the potential impacts listed in the table below either because the likelihood of occurrence has not been resolved, the consequence of the impact occurring, or both. The main uncertainties are:

- large-scale development effects on physical processes;
- disturbance to marine mammals; and
- disturbance to elasmobranchs.

In addition, for a number of the assessments discussed previously n Section 9, a degree of uncertainty remains as a consequence of either a lack of data or understanding of effects on a scale larger than previously assessed. These data gaps and research needs have been identified and listed in Section 12.4

Impact	Likelihood	Consequence	Risk
Physical processes			
Sandbank mobility	3	3	9. Medium. Uncertain about this risk
Seabed morphology – large sites	3	Unknown	Unknown
Flow regime and wave climate – far field effects	Unknown	Unknown	Unknown
Coastal sediment budgets – large sites	Unknown	Unknown	Unknown
Benthic Environment			
Large-scale changes to sedimentation and near-bottom conditions	Unknown	Unknown	Unknown. Effects of large developments need to be assessed.
Operational noise impacts (on marine mammals)	5	Unknown	Unknown. Depends on type of noise and species
Electric field impacts			
Impacts on marine mammals	5	1 - Unknown	5 - ?? Low to unknown – probably low if a/c., buried and shielded
Impacts on migratory fish	5	1 - Unknown	5 - ?? Low to unknown – probably low if a/c, buried and shielded
Impacts on elasmobranchs	5	1 - Unknown	5 - ?? Low to unknown Depends on strength, location and number of cables and species
Economic impacts			
Recreation and tourism income generation	Unknown	5	Unknown. May be locally serious for businesses and communities.

10 Prediction and evaluation of cumulative impacts

The prediction and evaluation of cumulative[13] impacts is complex because of the difficulty of disentangling these impacts in the context of changes already underway and expected in the future. Describing the nature and direction of these changes is subject to considerable uncertainty due to external pressures such as global warming.

Cumulative impacts are considered in terms of:

- interactions between impacts of windfarms and other current or planned developments and other initiatives; and
- incremental, combined effects of different, specific impacts from windfarms.

Originally, it was the intention to consider the incremental, combined effects of different impacts (in time and space) accompanying technological change within the windfarm life-cycle. This has not proved possible because of the range and scale of the attendant uncertainties.

A general feature of windfarm development in the three Strategic Areas should be noted. There is not a well-defined construction phase for development of windfarms over the next 10-15 years. Windfarms may be constructed, periodically, throughout this period. The first windfarms may be operating while the others are in construction. However, it may be expected that the bulk of windfarm construction will take place during the period 2003-2015 with operation and maintenance dominating thereafter. This sequence has implications for the evolution of cumulative impacts.

10.1 Cumulative impacts from windfarms and other activities

There may be some windfarms sited relatively close to shore, close to each other and to other activities. Further, there is the potential for cumulative impacts with respect to other marine activities. The interactions are likely to occur between windfarms and the activities described in preceding sections (such as Sections 7 and 8). The main likely cumulative impacts are expected to focus on *inter alia*:

- seascape/landscape issues;
- flow regime, wave climate and sediment transport processes;
- benthos;
- cetaceans and seals;

[13] defined as increasing by one addition after another. Source: Cambridge International Dictionary of English.

- elasmobranchs;
- birds;
- fisheries (including shellfish);
- conservation designations;
- socio-economic issues;
- navigation; and
- Government environmental objectives.

Overall, the type of cumulative impacts and their significance will depend on two main factors:

- scale and 'density' of windfarms and other developments or activities; and
- location.

Basically, there is a gradation of impact as number and density of windfarms increase. For example, the types of cumulative impacts of the 'most likely' scenario are the same as would be expected from the maximum credible scenario. However, the level of significance may alter substantially as more windfarms are constructed and begin operation. Due to the uncertainty concerning the extent of windfarm development and the location of individual windfarms it is not possible to provide a precise assessment of cumulative impacts. Rather, in most instances professional judgement, with reference to supporting evidence and expert opinion, has been carefully applied to draw conclusions. These issues are presented below. A summary account of the situation pertaining to each Strategic Area can be found in Section 11 entitled, '*Comparative Analysis of Alternatives*'.

10.1.1 Flow regime, wave climate and sediment transport processes

Very little is known about the cumulative impact of many windfarms on these environmental factors. As indicated earlier in Section 9 entitled *'Prediction and Evaluation of Impacts'* most modelling work has focused on individual windfarms. Assessing the combined effect of a number of windfarms remains largely, at best, in the realms of expert judgement. Depending on location, large-scale changes in all or some of these factors could affect the area immediately around the site and may include the adjacent coastlines; or influence large-scale currents and systems within the wider Strategic Areas.

It is not anticipated that other activities taking place away from the coast in the Strategic Areas have anything other than a minor impact on these processes. Only coastal infrastructure and flood defence works might have more significant effects in coastal processes. Consequently away from the coast there is no scope for cumulative effects when considering them alongside windfarm development. Windfarm related landfall work would not have a significant effect on the coastal processes and therefore significant impacts would not occur.

10.1.2 Benthos

Wider-scale changes to sediment transport and current patterns might have a modifying effect on the benthic fauna. However, such changes, unless substantial and causing a conspicuous change in conditions are unlikely to be detectable above the natural spatial and temporal variation characteristic of benthic fauna. In the 'worst case' prognosis, however, such changes could cause a significant cumulative impact on benthic fauna by way of a modification to sediment character as a consequence of both scouring and the redistribution of sediments during construction, operation (through changes in flow regime) and decommissioning. Subsequent shifts in benthic faunal community structure may or may not be considered a significant impact, a conclusion that would be dependent on whether species (or habitats) of conservation interest were at risk, the biodiversity was compromised and/or those species that depended upon the benthos for food were effected. The potential for a cumulative impact from windfarm development, and other activities that disturb the sediment, depends on timing. Should one disturbance event occur at the same time as another, or where recent activities have left an adjacent area of seabed undergoing recovery, then the individual minor impact may result in a cumulative effect that is more significant. Similarly, this cumulative effect process applies to species that require certain seabed conditions for spawning and nursery areas are potentially at risk. Of particular note would be sediment characteristic changes that might change the suitability of a habitat for, for example, herring spawning, sandeel burial or Ross worm (*Sabellaria spinulosa)* reef formation. Such impacts are unlikely to affect all seabed habitats, in all Strategic Areas, as they are likely to be localised. Only if the summation of these localised changes equate to a significant proportion of the relevant seabed type, would a significant cumulative impact be said to have occurred. Should they occur in specific localities then fisheries might also be at risk.

Faunal impacts will be associated with the other activities as follows:

- aggregate extraction impacting the benthos by sediment removal and redistribution;
- waste and dredge spoil disposal impacting the sediment by smothering and/or contamination;
- oil and gas operations impacting the benthos by smothering and/or contamination;
- trawling impacting the benthos by physical disturbance;
- cable laying impacting the benthos by physical disturbance and sediment redistribution; and

- waste disposal impacting the benthos by sediment contamination including enrichment.

With the exception of fishing (trawling), which is wide ranging in its activity (Figure 10, Annex 2), each of these activities will have a localised footprint of impact, the extent of which will be site specific. For each activity, the footprint will likely have a central area where the impact is severe and additionally outer zones of decreasing impact as the magnitude of the source of the impact (for example contaminant concentration and redistributed sediment concentration) decreases. The addition to the combined impact on the seabed of all activities that the potential windfarm development represents is negligible (see Section 9.4). Given its wide-ranging nature, the greatest existing impact on the seabed is from trawling. The impacts from windfarms are further marginalised, in consideration of cumulative impacts, given that there are no discharges, unlike, for example, oil and gas and waste disposal. Consequently it is concluded that windfarms will not likely to significantly increase the cumulative effect on the benthic fauna, unless sensitive or rare habitats or species were subject to cumulative effects.

However, should windfarms result in areas of, for example, reduced fishing activity then beyond there own footprint (from scouring), there may be a positive cumulative impact on the benthos.

10.1.3 Fisheries (including shellfish)

Again, the siting and operation of windfarms will determine the extent of cumulative impacts on fisheries. These can result from two ‘pathways’ by:

- windfarms affecting the fish/shellfish resource; and
- Affecting the economic output of fisheries.

There is a risk of cumulative impact on commercially valuable fish/shellfish species being moderate (due to possible macro-scale changes in flow regime and sediment transport). Thus, the potentially available catch (not considering policy-related restrictions that may be applied by central government) may be threatened. The species most likely to be subject to cumulative impacts would be those that spawn on the seabed, such as herring, or live there, such as flatfish.

A more significant potential impact is the possible ‘restrictions’ on access to fishing grounds. Depending on location, a windfarm, or group of windfarms, may both impede access and add to fishing costs if boats have to travel further to the grounds. In the maximum credible scenario this cumulative interaction will be at its greatest. Considering these two pathways, there is risk of a significant impact on the viability of certain fisheries with indirect significant socio-economic impacts in terms of families and small communities with a high dependency on fisheries. There is also the risk of increased fishing pressure, and hence cumulative impact caused by offset of fishing activity, on other accessible areas. These may, additionally, be more (or conversely less) sensitive to the effects of fishing activity. Alternatively, increased habitat for commercially important crustaceans (lobster and crab) and some fish species, benefiting from refugia effects (see Section 9.5), may provide incremental gains that may prove economically beneficial, particularly for smaller fishing vessels.

10.1.4 Noise impacts on cetaceans and seals

Cetaceans are sensitive to noise and are also impacted by fisheries (as by-catch and competition for food), pollution and disturbance. An increase in the number of windfarms in a Strategic Area may result in larger areas being avoided by cetaceans as a consequence of both construction and possible operational noise. However, our understanding of cetacean sensitivity and response patterns to underwater noise is very limited. Consequently it is not possible to make more than tentative observations as follows.

As they are generally free-ranging over large areas, it is thought that cetaceans will pursue an avoidance strategy. However, the cumulative impact may be considered to be moderate as there will be an increase in distress and disturbance levels and avoidance may affect the survival ability of certain individuals, particularly if already stressed by, for example, high body burdens of accumulated pollutants. In addition, if noise levels are similarly increasing in alternative areas of occupancy, for example from simultaneous expansion of offshore windfarms in other parts of the North East Atlantic, then the cumulative squeeze on available habitat may reach a point in the future where this becomes a significant impact. It is unclear at present as to the scale of development from windfarm and other noise generating activities that would produce such an effect. However, the probable restriction of windfarm development in the three Strategic Areas discussed in this document would suggest that this particular cumulative impact would not be tangible within the next few years, and probably not within the 20 year timescale of this SEA.

Further, should exclusion be a significant effect on cetaceans, depending on the extent of avoidance and the spatial arrangement of windfarms and other noise sources, there remains the possibility of the accumulation of ‘no-go areas’ that could amount to significant barrier effects.

With an increase in the number of windfarm development areas that cetaceans might seek to avoid, the relative importance of other noise sources increases. Noise generated by shipping, oil and gas drilling and production activities, cable and pipeline laying and aggregate extraction may already be excluding cetaceans from areas of the sea. Noise levels from oil platform operations and exploratory drilling may have the effect of excluding cetaceans from their locality, though at present insufficient understanding of the effects on cetaceans do not allow for a more rigorous assessment. Similarly, aggregate extraction, cable laying and noise levels from areas of intense shipping traffic could also be considered likely to restrict movements of cetaceans. In consideration of the area covered by each of these activities as illustrated in Figures 12 (aggregate and disposal); 13 (oil and gas); and 16 (shipping), it is evident that apart from the main shipping movement routes, the total area represents a small proportion of each Strategic Area. The spatial extent of the credible potential for windfarm development represents a sizeable increase in the area of possible exclusion (or disturbance). Consequently, the potential for significant cumulative effect when considering all marine activities is not considered to be substantially greater than for the individual effect of a substantial development of windfarms. As such, the effect is considered to be moderate.

The pre-construction phase of windfarm development includes a period of seismic survey work. The sound generated and propagated by these surveys is known to result in avoidance behaviour in cetaceans (Section 9.6.1). Other sectors, primarily oil and gas, but also the aggregate industry also carry out seismic surveys. As such, the greatest scope for cumulative impact is present in Liverpool Bay and the Greater Wash Strategic Areas. Given that the impact of individual seismic surveys is temporary (to a matter of a few days or weeks); restricted in extent of effect (though this is difficult to predict); and that they do not occur simultaneously in close proximity (to avoid sound wave interference), it is considered that cumulative effects will in general not be significant. However, it is acknowledged that the overall increase in seismic survey work has the potential, just as a general increase in ambient noise from windfarm operation, to have a wider effect on cetacean distribution. There may be the potential for cetaceans to occur less frequently in areas with higher incidence of seismic survey activity. This could extend to areas beyond UK territorial waters. Should this impact occur, then the potential subsequently exists for significant cumulative impact assuming alternative areas are also subject to frequent seismic surveys.

Seals can also be subject to noise-induced stress and as they require haul out and breeding sites on land, can be considered as, at least periodically, to be constrained in their movements more so than the majority of cetaceans. Again, they are expected to avoid areas subject to noise levels above tolerance thresholds. Seals are considered to be subject to the same kinds of impacts as cetaceans that arise from the need to avoid specific areas. However, a very dense congregation of windfarms may make avoidance difficult and in fact might have the potential to collectively act as a barrier to movement to and from such sites. This type of cumulative impact has greatest scope to occur in the Greater Wash Strategic Area. Food supplies may be affected by macro-scale changes in flow regime and sediment transport (particularly grey seals preying primarily on sandeels, Section 8.4.2.1) compounding the problems, resulting from noise-avoidance behaviour for seal populations, perhaps even threatening the viability of certain local populations. A further threat may come from increased competition from fisheries for remaining fish stocks (especially if inshore fishery activity is restricted by the presence of windfarms). Thus, the cumulative impact, for certain local populations of seals, is likely to be significant.

It is less clear as to the potential and level of significance for the cumulative impact potential of seismic survey related activities on seals. It is considered unlikely that a sufficient number of surveys would occur, and for a sufficiently protracted period of time, to restrict seal movements. However, as discussed above for cetaceans, the possibility of increased disturbance may result in shifts in the character of population distribution. Whether this might manifest itself in a significant cumulative impact is uncertain.

10.1.5 Electromagnetic fields on elasmobranchs

For elasmobranchs, the main impact relates to the incremental increase in the number of electromagnetic fields and subsequent possible restrictions to movements. The number and location of cables, coupled with the potential electromagnetic field strengths, including those already present in the marine environment, will determine the extent and significance of the impacts on elasmobranchs. A few larger cables may be preferable to a larger number of smaller cables. The latter option might create a series of ‘lines’ from offshore to onshore that create partial or absolute barriers to elasmobranch movements. Areas bounded by cables may become *de facto* ‘reserves’ trapping the fish within the confines of the cables. Should this be accompanied by changes in prey abundance and composition due to macro-scale changes in flow regime and sediment transport, in addition to fishing pressures, then the cumulative impact on these species will be increased. Overall, using ‘worst case’ assumptions, the cumulative impact is considered to be significant. However, it is probable that burial, shielding and tranmission using alternating current represents a more likely ‘case’ and therefore the cumulative impact would be minor.

10.1.6 Birds

Birds will be subject to a variety of possible cumulative impacts arising from:

- deaths and injury due to collisions;
- disturbance and stress from the need to avoid windfarms (increases as number and density of windfarms increase);

- reduced access due to presence of windfarms to feeding areas and other important locations for specific activities e g. moulting; and
- alterations in abundance and composition of prey species and food supplies (due to possible macro-scale changes in flow regime and sediment transport).

The cumulative impact is expected to be significant in terms of those species that are of international, European and national importance (e g. common scoters, red-throated divers, terns and, at least in the Thames Estuary Strategic Area, lesser black backed gulls).

There is limited scope for cumulative effects on birds due to collisions and barrier effects with respect to other sectoral activities. However, cumulative effects by exclusion, and disturbance may occur with, for example, high levels of marine traffic. The significance of this would be moderate, or greater if it were to result in exclusion from a particular, spatially limited, resource. This may occur in a restricted number of localities and with respect to particular species. Greater significance of impact would occur if impacts in more than one Strategic Area were to compound the effect of displacement. The following species and localities are considered to fall within this analysis:

- common scoter in the southern part of Liverpool Bay and/or off the north Norfolk Coast (Greater Wash) in shallow water (less than 20m);
- eider in Liverpool Bay and/or Greater Wash, in shallow water (less than 20m);
- cormorant in Liverpool Bay, in the vicinity of Ynys Seiriol/Puffin Island SPA; and
- terns in the vicinity of primary population concentrations (including Ribble, Dee, the Wash, North Norfolk Coast and Foulness and Thames Estuary and marshes SPAs).

This may also occur on an international scale where comparable levels of windfarm or other activities are excluding the above species from their preferred habitats in other parts of their range.

10.1.7 Conservation designations

The amount of designated conservation area is increase within the time period covered by the SEA, by designation of SACs and SPAs fully detached from the coast and the extension of seabird breeding colony SPAs away from the coast. Should some windfarms be sited within, or in the vicinity of, designated or potentially designated areas then there is a risk that their ability to achieve their objectives is compromised. The cumulative impact on birds *per se* is dealt with separately above. The cumulative impact on designations is dependent on the likely impact on the key bird species.

The potential for cumulative effects on SACs is dependent on the distribution of developments coinciding with interest features. Should there be extensive development or other activity (such as aggregate extraction or trawling) on such potential sites, then cumulative effects, manifest in the degradation of the integrity of the site network (including on a European scale) might pose a significant risk of an impact. This has been previously discussed in Section 9.10.

Potential cumulative impacts on designated species such as marine mammals have been discussed elsewhere in this Section.

10.1.8 Seascape / landscape issues

Various turbine configurations may be envisaged relative to the shape size and location of the overall areas where sensitivity to windfarms is rated as medium or low. Tables 4 and 5 (Section 6) provide indications of possible turbine numbers and configurations for 2010 and 2020 in respect of the likely and maximum development scenarios. Whilst these tables may be used in conjunction with the constraint maps to give a general idea of potential cumulative effects arising from offshore windfarm development, it is not possible to predict the actual outcome of future licensing rounds for further development.

From an appreciation of current developer interest (Crown Estate *pers. comm*.; BWEA, *pers. comm*.; various developers *pers.comm*.), it is considered likely that there would be interest in developing several large-scale windfarms in The Greater Wash. Additional aspirations include some larger scale developments in the outer parts of the Thames Estuary and mainly medium to smaller scale developments in Liverpool Bay. Again, at a strategic level, this would appear to respond to seascape sensitivities and potential effects. It is considered that larger groups of turbines may be more appropriate further offshore, because being at a greater distance from the shore, they would be less visible and occupy a smaller horizontal angle. Where smaller groups of turbines are proposed closer to shore, intervisibility between individual groups will need to be considered relative to the varying sensitivity of the relevant seascape units. Beyond the 24km limit from the coastline and passenger shipping channels, potential cumulative seascape effects are not likely to be significant.

At distances of less than 24km from the coastline and passenger shipping channels, cumulative seascape effects would need to be considered on a case-by-case basis in respect of the following:

- other existing and proposed offshore developments;
- other existing or proposed offshore wind farm developments; and
- other existing or proposed large scale, high visibility onshore structures.

The siting and operation of windfarms will determine the extent of cumulative seascape impacts. If there were to be a number of small, inshore windfarms located near to each other then there would be a significant risk to seascape character, quality and the perceptions of local people and visitors. Separate windfarms may appear to present a continual 'line' of turbines from certain offshore and onshore viewpoints (the 'picket fence' effect).

In terms of development on land, the need for overhead power lines and construction/fabrication sites may result in some localised impacts. It is unlikely, however, that there will be a significant cumulative impact within the Strategic Areas, with the possible exception of overhead power lines. The construction/fabrication sites or yards are likely to be dispersed and/or located in industrialised areas where the effect on landscape character will be low. Offshore, cumulative impacts are of minor significance due to the relatively low number of receptors.

Visual impacts in association with other activities would be restricted to oil and gas structures. These are only present in Liverpool Bay and the Greater Wash Strategic Areas. In the latter they are all located some distance offshore (Figure 12, Annex 2) beyond any likely significant visual impact from coastal receptors. In Liverpool Bay Strategic Area, the Lennox platform is located within the 12nm territorial limits and hence the combination of visual impact may become moderately significant in this case. A higher value of significance is not thought likely given that the platforms are located beyond the boundary of high visual sensitivity for windfarms (Figure 18, Annex 2).

10.1.9 Socio-economic issues

Due to uncertainties of construction and operational timings it is not easy to predict the number and pattern of jobs. At any one time there may be jobs linked to construction and operational phases in the Strategic Areas. Generally, the number employed in construction of a windfarm is likely to be more than those employed in operation and maintenance. Also, the type of jobs will be different. It is expected that construction work will be periodic and not continual (with specialist companies hiring staff to meet peaks in demand). Operation and maintenance jobs will be more permanent with less need for unskilled and semi-skilled labour.

In forecasting employment creation it is important to note that during the early years of wind farm installation manufacturing demands will be critically dependent on 'new build'. However. when turbines reach ages in excess of 10 years they will begin to be 're-powered' (replaced) by newer, more efficient and/or larger machines. If it may be assumed that most windfarms in the Strategic Areas begin operation in the period 2005-2015 then after an initial 10 year period the level of employment in the industry is liable to become much more stable although at a lower level.

There are some empirical data from different countries that relate MW installed capacity to jobs, but in the main these relate to onshore windfarms. Also, there are projections for EIA studies for individual offshore windfarms in the UK. It is not possible to be definitive about job creation not only because offshore windfarms are so new, but also because the data from onshore wind generation may not be directly relevant to offshore wind and the data are presented in different formats. Also, data from countries with a 'mature' wind industry cannot be used as a direct guide to the expected number of jobs in countries, such as the UK, with a fledgling industry. The former countries are probably net exporters and thus are not just servicing the domestic market. Therefore, two estimates are presented below showing possible minimum and maximum job creation:

- The minimum estimate is based on 1 – 2 full time equivalent jobs being created by 1MW of installed capacity (see for example, NWP Offshore Ltd., 2002 [EIA for proposed North Hoyle windfarm] and Greenpeace 2000 [in the latter case the estimate is ~2.2 jobs/MW installed]); and
- The maximum estimate is based on 3-4 full time equivalent jobs being created by 1MW of installed capacity (see for example, Border Wind and Greenpeace, 1998 [estimating 4.5/MW installed] and data for Germany in a report entitled *'New Energy'*).

The estimated job creation[14] for each scenario, for the years 2010 and 2020, is shown in the following two tables:

Scenario (2010)	Year (MW)	Jobs-minimum	Jobs-maximum
Most likely	2010 (4000)	4000 - 8000	12000 - 16000
Maximum credible	2010 (7500)	7500 - 15000	22500 - 30000

Scenario (2020)	Year (MW)	Jobs-minimum	Jobs-maximum
Most likely	2020 (10200)	10200 - 20400	30600 – 40800
Maximum credible	2020 (17000)	7500 - 15000	51000 - 68000

It is unlikely that the demand for labour will be of such a scale as to cause problems for the viability of companies not involved in the offshore windfarm sector. They are not expected to lose labour, for example, due to competing higher wages, and not be able to replace workers. The size of the population base, and diversity of the economic sectors in the Strategic Areas, is such that labour shortages are unlikely to occur.

Decommissioning work will not be occurring during the period of maximum construction and operational activities. Decommissioning is unlikely to occur until after 2020. Then,

[14] These job creation projections focus on wind energy generated jobs only. They do not take account of jobs foregone in other energy generation sectors because of wind energy development.

the work will overlap with the operational phase of some windfarms constructed by the period 2015-2020 and windfarms constructed thereafter. Such cumulative impacts are outside the scope of this SEA as the likely development of the offshore wind industry beyond 2020 is unknown.

There may be implications for the UK balance of payments position arising from windfarm development. It is expected that the UK may become a net importer of natural gas in the near future. At present, the UK generates approximately 35% of its electricity from natural gas. If the UK had 4-7GW of installed offshore wind capacity by 2010 then there would be less need to import natural gas thus producing a saving on the balance of payments. This could be equivalent to £85 to 145 million annually (BWEA, *pers. comm.*).

10.1.10 Navigation

The main shipping lanes are well known and careful siting of windfarms will avoid any significant cumulative impact. However, apart from rather broadscale information, the routes used by recreational sailors are not well known. Most sailing is located in inshore coastal waters and thus, there is the potential to disrupt and displace (assuming suitable waters are available) recreational sailors if there were to be a number of windfarms in coastal waters. It is likely that any such impacts will be most significant in the Thames Estuary because of the amount of recreational sailing in this Strategic Area.

10.2 Government environmental objectives

A rapid increase in offshore windfarms will play a major role in assisting the UK achieve its objectives in terms of its Kyoto Protocol commitments and possibly, the more ambitious goal recommended by the Royal Commission on Environmental Pollution (a 60% cut in the UK's CO_2 emissions by 2050). Indeed, depending on the speed of development, and the scale of wind electricity generation replacing power generated by greenhouse gas producing combustion processes, the UK may be able to exceed its stated targets and enable it to revise its targets upwards.

In terms of stated government objectives for the marine environment, a rapid expansion of windfarms may compromise these objectives in certain localities. These are not likely to be of such a scale so as to detract significantly from continued progress toward these objectives in the overall UK context.

10.3 Summary overview of cumulative impacts

The discussion above outlines the potential cumulative impacts associated with development of offshore windfarms both in respect of multiple windfarms and also in combination with other activities. The assessments of the potential risk of significant cumulative impact have been described above. These are now reiterated and summarised here in the table below.

A good deal of uncertainty remains with respect to concluding the potential risk of cumulative impacts on:

- macro-scale effects on physical processes including sediment transport;
- seascape if development occurs within medium or high areas of visual sensitivity;
- exclusion of marine mammals due to noise disturbance from seismic and operational activities
- specific bird species such as common scoters, red-throated divers and terns; and
- elasmobranchs remain unknown because of lack of data on how these receptors react to environmental changes induced by windfarms.

These statements hold for all Strategic Areas.

All the Strategic Areas are considered to be subject to a trend of improvement in environmental quality. The development of windfarms will reduce the magnitude of this trend. It is not possible to estimate the extent of this net effect, for each Area because different environmental factors will be affected in different ways and due to the uncertainties in prediction.

Impact	Strategic Area	Risk
Seascape – between windfarms	All but particularly Greater Wash	Higher for nearshore and numerous small developments
Seascape – with other structures	Only south parts of Liverpool Bay, and Greater Wash	Moderate risk – most platforms offshore or outwith high windfarm visibility sensitivity.
Seabed – between windfarms	All	Negligible (windfarm have small footprint)
Seabed – with other activities	All	Negligible. Moderate if relating to sensitive or rare species or habitat (windfarm footprint small compared with other activities).
Effects on cetaceans – between windfarms and other activities	All, though less frequent in Thames Estuary	Moderate. From noise (operational and seismic) as wide ranging species. Also future international impact could be moderate.
Noise effects on seals – between windfarms	All, particularly Greater Wash	Moderate. May be greater in localised areas
Loss of feeding opportunities for	All, particularly Greater Wash	Moderate. Displacement may lead to greater competition with fishing. But

seals		restricted fisheries access might result in improvement to food resources
Exclusion of birds by windfarms/other activities	Liverpool Bay	Locally significant for common scoter, eider, and terns. Possible inter area and international significance also
Exclusion of birds by windfarms/other activities	Greater Wash	Locally significant for common scoter, eider, and terns. Possible inter area and international significance also
Exclusion of birds by windfarms/other activities	Thames Estuary	Locally significant for terns. Possible inter area and international significance also
Fisheries resources impacted by windfarms	All	Moderate. Changes to habitat particularly with respect to herring, sand eel and flatfish. But restricted access might result in improvement to resources (refugia)
Fisheries activities restricted by windfarms	All	High. Should developments reach scale of maximum credible scenario and restrictions to movement in place.
Conservation designations – from all activities	All	Possibly significant. Integrity of network of sites compromised
Socio-economic - from windfarms	All	Significant. Positive job and wealth creation

11 Comparative analysis of scenarios

In this section comments are made on the three development scenarios and on options for windfarm configuration and layout. Again, the discussion is focused on issues rather than impacts. The impact of the scenarios on CO_2 reductions and UK government targets are presented separately. Conclusions are made where possible and that are as site specific as information and understanding allows.

11.1 'No development' scenario

Section 8.6 indicates the expected overall direction of change in the baseline situation for all Strategic Areas. There are some differences between them, but not sufficient to change the overall conclusion. The 'no development' scenario is equivalent to the expected state of the baseline at the time that the windfarms will be implemented. The SEA is focusing on a seventeen year period of development (2003-2020). Thus, it is not possible to accurately describe the condition of the environment in the Strategic Areas at a single point in time, or provide details of the expected direction and degree of change over the entire time period. It is only possible to provide an indication of the direction of key trends.

To summarise, based on the data and analyses presented in preceding sections, the environmental conditions are expected to improve, slightly and slowly, in the 'no development' scenario. It is possible that the effects of global warming could have an impact on patterns of faunal distribution, as a consequence of changes in, for example, seawater temperature, in addition to changes in oceanographic parameters which would also manifest changes in ecological characteristics. There will be certain localised areas where there will be adverse impacts from expected non-windfarm projects, but not sufficient to detract from this overall conclusion. The trend of improvement is an estimation of a general nature and there will be considerable variation both between and within the Strategic Areas. The status of some specific environmental features may not change and may even decline. Overall, however, a gradual improvement is expected.

11.2 Development scenarios

In this section, an attempt is made to consider the implications of the two development scenarios for each Strategic Area. For each Strategic Area, the scenario outputs (Tables 4 and 5, Section 6) have been converted into the area of seabed occupied on the basis that a 1GW (1,000MW) windfarm would occupy an area of 13km x 13km (BWEA, *pers. comm.*).

11.2.1 Liverpool Bay

Liverpool Bay

With respect to the variety of mappable constraints, Liverpool Bay is the most homogenous of the three Strategic Areas (Figure 21, Annex 2). In comparison with the other Strategic Areas, there are fewer areas of either a high or a low level of constraint. Consequently, it is less easy for developers to identify sites of relatively low constraint in the Strategic Area. For Liverpool Bay the magnitude of the difference between the 'most likely' and the 'maximum credible' scenarios is the least among the Strategic Areas by the year 2010. A substantial increase by 2020 is, however, suggested in these scenarios, representing a maximum potential for 6.2% of the area taken by windfarm development (see below and Figures 22 and 23, Annex 2):

Scenario	Total area (km^2)	Year 2010 (km^2)	Year 2020 (km^2)
Most likely	8,130	135 (1.7%)	254 (3.1%)
Maximum credible	8,130	254 (3.1%)	507 (6.2%)

It is expected that there may be a focus on increasing the number of relatively small windfarms (up to 500MW), particularly for the most likely scenario where no development has been predicted to occur beyond the 12nm limit. These may result in a number of cables to the regional power network. More cables/connections results in an increase in impacts especially affecting benthic fauna, elasmobranchs and the local population centres and environments in the vicinity of the landfall and connection sites. The increase in development toward the maximum credible scenario (2020) will incrementally increase the extent of potential impacts, including cumulative issues (Section 10).

The number of windfarms within the 12nm limit will result in limited 'additive' adverse impacts on sea users, particularly commercial and recreational navigation and fisheries.

In terms of seascape impacts, there is likely to be a 'build-up' of windfarms. An observer traveling along the cost is likely to see a series of windfams, but at irregular intervals. A 'picket fence' effect is not expected to result. Further, large scale developments, which are thought to be the main focus for developers, will likely be located sufficiently distant from the coast to minimise large-scale and significant visual impact.

Compared to the other Strategic Areas, overall Liverpool Bay will be the least at risk of significant adverse impacts that will detract from the overall improvement in environmental conditions that is expected to occur in the future. However, the risk of a cumulative impact on certain bird species is expected to be significant, particularly in the southern part of the Strategic Area where common scoter are present in internationally significant numbers.

The salient features of the non-mapped constraints that might influence site location strategies, in conjunction with the constraints maps, are listed below. It can be noted that the majority of these indicate greater potential constraint for nearshore, shallow water development:

- radioactive contaminants from Sellafield are concentrated in shallow muddy sediments along the north east coast;
- the muddy sediment areas off the Cumbrian coast is a BAP habitat that is considered sensitive to disturbance;
- bottlenose dolphins are occasionally sighted in the south of the Strategic Area and may be sporadic elsewhere;
- harbour porpoise are commonly sighted throughout the Strategic Area;
- common and grey seal haul-out and breeding sites are located along the southern coast, from the Dee estuary eastwards. Common seals forage locally, but grey seals travel up to 40km to feed;
- a number of elasmobranch species pup and have nursery areas inshore, often over rough ground (e.g. tope, smoothhound and nursehound); the angel shark is present but only rarely encountered; the area is a stronghold for basking shark; thornback ray, a species in serious decline, favours shallow inshore soft sediment habitats and females aggregate over Constable Banks, for spawning;
- the common scoter and red throated diver are present, particularly in the southern parts of the Strategic Area, in shallow inshore areas; and
- the flat oyster is noted to be present in areas along the coast in the northern half of the Strategic Area.

Overall, the greater amount of constraint and sensitivities occur in the southern part of the Strategic Area, particularly the presence of bird interests, marine habitats of conservation interest, seascape, fisheries and marine traffic (Figure 21, Annex 2). Seascape constraints in the north of the area are significant as a consequence of topography and amount of surrounding coastline including the Isle of Man (Figure 18, Annex 2). Conversely, industrialisation and population density is greater in the south, which in isolation would be thought to offer good siting potential, and a local market (Figure 17, Annex 2).

It is therefore considered appropriate for the greater proportion of future windfarm development to concentrate in the offshore portion of the Strategic Area, most likely with a focus on fewer large windfarms. Locating offshore would limit concerns about visual impacts and birds. Some development, probably of smaller windfarms, could be accommodated within the remainder of the Strategic Area but would be subject to greater levels of constraint and hence potential opposition from one or more interested party, statutory or otherwise.

In terms of capacity to accommodate the two development scenarios, Liverpool Bay Strategic Area is considered capable of supporting each, given that the maximum credible scenario, in 2020 represents a maximum of 6.2% of the total area of the Strategic Area (Figures 22 and 23, Annex 2). However, uncertainties relating to a number of potential impacts (Sections 9 and 10) would need to be addressed to determine whether the 2020 forecasts are achievable without major risk of impact, particularly with respect to physical processes, impacts elasmobranchs and impacts on birds. It is anticipated that in progressing toward the 2010 scenario, these uncertainties would be progressively resolved and the likelihood determined of being able to match the 2020 forecast.

11.2.2 Greater Wash

The Greater Wash has the largest area of low constraint in comparison with the other Strategic Areas. This low constraint area is located in the north east of the Strategic Area outside the 12nm limit. In terms of surface area the amounts occupied for the two scenarios are as follows:

Scenario	Total area (km^2)	Year 2010 (km^2)	Year 2020 (km^2)
Most likely	13,100	270 (2.1%)	845 (6.5%)
Maximum credible	13,100	423 (3.2%)	1183 (9.0%)

Assuming that developers are attracted to the areas with least constraints (on the basis that other factors are 'neutral' with regard to siting decisions) then it may be expected that there will be a concentration of windfarms in the north east of the Strategic Area. Also, there may be another possible concentration within the 12nm limit and in the area between the mouth of the Wash and the major north-west to south-east shipping lane.

Such a distribution will limit the cumulative seascape impacts in terms of onshore views. There will be a concomitant increase in seascape impact for viewers on boats and ships (ferry passengers and recreational sailors). Large concentrations of windfarms may cause significant impacts for fisheries, birds and cetaceans.

The salient features of the non-mapped constraints that might influence site location strategies, in conjunction with the constraints maps, are listed below. Bird and elasmobranch interests are concentrated in nearshore waters, whereas the remainder apply equally across the whole of the Strategic Area. It can be noted that the majority of these indicate greater potential constraint for nearshore, shallow water development:

- bottlenose dolphin may only be sporadically sighted;
- harbour porpoise are commonly sighted;

- common seal populations are high in the Wash and along the north Norfolk coast. Grey seals are also present in these locations and also the Humber Estuary. Common seals forage locally, but grey seals travel up to 40km to feed
- substantial bird interests are present in this Strategic Area. For example: the Wash supports the largest UK population of overwintering waterfowl; common scoter, red throated diver and terns are important along the north Norfolk coast and there is a substantial overwintering population of eider;
- a number of elasmobranch species pup and have nursery areas inshore, often over rough ground (e.g. tope, smoothhound and nursehound); the angel shark is present but only rarely encountered; thornback ray, a species in serious decline, favours shallow inshore soft sediment;
- *Sabellaria* reefs in the mouth of the Wash, and potentially elsewhere, represent important benthic habitats; and
- an economically important crab fishery exists in the area.

The Greater Wash Strategic Area is the largest of the three under consideration and offers the greatest potential capacity for windfarm development (Figure 1, Annex 2). Inshore areas, particularly along the southern part of the area from the Wash and along the north Norfolk Coast, carry the greatest amount of constraint and sensitivity, particularly with respect to visual, marine mammals, inshore fisheries, birds and offshore SAC/SPA habitats (Figure 21, Annex 2).

Areas of offshore aggregate extraction, should they become exhausted in an appropriate timeframe might offer preferable, 'brownfield', sites for development (Figure 11, Annex 2). The presence of an extensive oil and gas operation (Figure 12, Annex 2) might present cumulative impact issues such as frequency and scale of seismic surveys, benthic impacts and exclusion of fisheries particularly if, as is likely, development this far offshore is on a large scale.

In terms of the carrying capacity, the ability to achieve the 2020 scale of development for either scenario would be subject to resolving existing uncertainties, particularly those associated with:

- cabling and elasmobranchs;
- physical processes, including sediment transport;
- bird distribution and sensitivity to barrier effects; and
- cetacean distribution and sensitivity to noise.

It is possible that the size of development forecast in the maximum credible, 2020, scenario may not be achievable without resolving (and mitigating) these issues. Both of the scenarios forecast for 2010 are considered achievable and can be readily accommodated.

11.2.3 Thames Estuary

Like the Greater Wash, the Thames Estuary has areas of low constraint on the eastern boundary of the Strategic Area. In terms of surface area the amounts occupied for the two scenarios are as follows:

Scenario	Total area (km^2)	Year 2010 (km^2)	Year 2020 (km^2)
Most likely	5,901	202 (3.4%)	287 (4.9%)
Maximum credible	5,901	338 (5.7%)	845 (14.3%)

The distribution and nature of the cumulative impacts are similar to those highlighted for the Wash. Of course, the Thames Gateway project may interact in a significant way with windfarm development. Depending on implementation schedules, the Thames Gateway project may act as a constraint on windfarm development or the opposite situation may occur.

The salient features of the non-mapped constraints that might influence site location strategies, in conjunction with the constraints maps, are listed below. Bird and elasmobranch interests are concentrated in nearshore waters, whereas the remainder apply equally across the whole of the Strategic Area. It can be noted that the majority of these indicate greater potential constraint for nearshore, shallow water development:

- neither bottlenose dolphin or harbour porpoise are thought to occur more than sporadically;
- seagrass beds on Maplin Sands are a BAP habitat and considered sensitive to disturbance;
- common seal haul-out sites are present but few grey seals are found in this Strategic Area; commons seals forage locally to haul out sites;
- a number of elasmobranch species species pup and have nursery areas inshore, often over rough ground (e.g. tope, smoothhound and nursehound); the angel shark is present but only rarely encountered; thornback ray, a species in serious decline, favours shallow inshore soft sediment;
- other than lesser black backed gulls, and the occurrence of red throated diver and common scoter, there are fewer bird concerns than in the other Strategic Areas; and
- recreational navigation is widespread in the Strategic Area.

This Strategic Area has fewer environmental constraints than the other Strategic Areas (Figure 21, Annex 2), though coastally, several estuaries and marshes are important bird habitats (Figure 6, Annex 2). Seagrass beds are also present along the Essex coast at

Maplin Sands. Commercial activities and recreational navigation are other main constraint (Figures 8, 10, 11 and 15, Annex 2). Though of these, aggregate extraction sites may offer 'brownfield' development sites should they become exhausted at an appropriate time (Figure 11, Annex 2). In general, avoidance of coastal sensitivities, including conservation interests and visual impacts, favours offshore development. However, the presence of large amounts of commercial and recreational vessel movements, in the smallest Strategic Area, means that conflict with large scale developments are more likely than in the other areas, even they too support large amounts of ship traffic. In addition, a number of MoD PEXAs might also represent constraints to development, both offshore and nearshore (Figure 16, Annex 2). It is therefore likely that a few large to very large developments might be the most appropriate means of meeting the development scenario forecasts. However these potential conflicts may not ultimately be avoidable should development approach the scale of development forecast for 2020 in the maximum credible scenario.

As noted above, the main uncertainties about windfarm development would require addressing to facilitate extensive development without resulting in significant and unacceptable impacts.

Greenhouse gas emissions

11.2.4 Greenhouse gas emissions

Renewable energy and specifically wind turbines can significantly reduce the greenhouse gas emissions, especially when compared to traditional fossil fuels. In direct comparison, each unit (kWh) of energy from a coal-fired power station produces 860g of carbon dioxide (CO_2), 10g of SO_2 and 3g of NO_x (BWEA, 2000; Eyre, 1995; http://www.bwea.com/edu/calcs.html) however the operation of wind turbines produce almost zero CO_2 emissions. CO_2 is the key 'indicator' greenhouse gas since, in global terms, it contributes more than 80% of the potential global warming effect of man-made emissions of greenhouse gases (DTI, 2002).

Over the course of the life-cycle of a windfarm (from construction to decommissioning and eventual disposal) the emissions of CO_2 and other emissions are significantly lower than other electricity generating technologies (see table below).

Technology	Emissions (g/kWh)		
	CO_2	SO_2	NO_x
Landfill gas	49	0.34	2.6
Onshore wind	9	0.006	0.02
Offshore wind*	9	0.087	0.036
Coal (best practice)	955	11.8	4.3
Oil (best Practice)	818	14.2	4.0

Gas (CCGT)	466	0.0	0.05

* from Eyre 1995. Based on 400kW turbine with 20 year lifespan.

A very rough calculation indicates that the following reductions would be achieved for the two windfarm development scenarios by the year 2010 and 2020.

In addition to this 'saving' in greenhouse gas emissions, it has been calculated that 1 GWh of electricity generated from renewable sources, rather than from fossil fuel, reduces CO_2 emissions by 600 tonnes (Greenpeace and European Wind Energy Association, 2001 and based on certain assumptions of the existing fuel mix in generating electricity). A very rough calculation indicates that the following reductions would be achieved for the two windfarm development scenarios by the year, 2010 and 2020.

Scenario	Year	TWh generated (per annum)	CO_2 reduction (millon tonnes)
Most likely	2010	14	8.4
Maximum credible	2010	36	21.6

Scenario	Year	TWh generated (per annum)	CO_2 reduction (million tonnes)
Most likely	2020	26	15.6
Maximum credible	2020	60	36

At present, UK overall CO_2 emissions are ~160 million tonnes *per annum* and the government target is to emit ~130 million tonnes *per annum* by 2010. The most likely and maximum credible scenarios for offshore windfarm development would make a 28% and 72% contribution respectively to achieving this target.

From these calculations, it is evident that windfarm development in the offshore environment is to be strongly supported because of its positive contribution to reducing greenhouse gas emissions and thereby meeting Government obligations and more widely a sustainable approach to energy production.

12 Environmental management framework

This section presents a framework to assist management of windfarm development in the Strategic Areas. It is hoped that the information and advice presented here will be useful to government, the regulatory bodies and the offshore windfarm industry.

The prevention or control of impacts depends on the implementation of mitigation and monitoring measures at the correct time in the correct way and at the correct place. The process of impact management needs an environmental management plan and has three basic phases:

- implementation of mitigation measures;
- monitoring/evaluation; and
- revision of the plan (via use of results from the previous monitoring and evaluation phase).

This process may be in operation for a considerable period of time, but with varying emphases and intensity of application and revision. In certain cases it has been found useful to initiate liaison arrangements with national and local government bodies, NGOs and representatives of local communities. Such an institutional mechanism serves as a means of ensuring that impact management takes account of the continuing concerns of key stakeholders and that both the management processes, and decisions taken on the basis of the results from mitigation and monitoring studies, are transparent.

This section is subdivided into the following topics:

- opportunities;
- mitigation measures;
- monitoring; and
- additional studies.

12.1 Opportunities

Opportunities are defined as being situations with the potential to realise a benefit through human intervention. The main opportunities identified, through consultation as part of the SEA, are:

- artificial reef creation/Creation of refugia (depending on government policy, the context and other related actions such as possible exclusion of fishing for specified time periods). Adoption of windfarm sites as protected areas for benefit of marine management or maintenance or recovery of marine biodiversity;

- shared operation and maintenance activity;
- shared infrastructure (e. g. cabling and onshore facilities);
- utilisation of co-located sites (promoting/encouraging use of sites previously affected by other activities);
- co-generation projects (e. g. wind, wave, gas);
- site re-use ;
- tourism benefits;
- siting of monitoring equipment for environmental research; and
- local economic diversification e. g. through supply chain benefits associated with greater certainty of potential developments.

Some of these opportunities will be the responsibility of the industry operators, for example, sharing facilities such as cables. Others will require leadership by operators, but working in partnership with other stakeholders, for example, tourism benefits. Others are likely to require a lead government role, for example, the promotion of supply chain benefits.

These opportunities need careful review to determine the likely benefits and possible costs. A priority listing of opportunities in terms of cost-effectiveness would be a useful starting point for action. Action with regard to some opportunities may need mechanisms such as joint working groups to map out ‘action’ plans to ensure that the benefits from opportunities are captured as quickly and as efficiently as possible.

12.2 Mitigation

Mitigation measures can be divided, broadly, into the following main types:

- preventing or minimising impacts before they occur by limiting the extent or timing of an action and its implementation;
- eliminating or reducing an actual impact over time by maintenance or contingency planning operations during the life of the project;
- rectifying an impact by repairing, rehabilitating or restoring the affected environment;
- compensating for an impact by replacing or providing substitute resources or environments; and
- maximising beneficial impacts through specific additional actions.

In the situation of the likely development of the three Strategic Areas the most effective form of mitigation is expected to be through 'preventing or minimising' impacts. The DTI might consider introducing interim location criteria into its decision on the nature of the second round. This would be justified by use of the precautionary principle in the sense that it is important to know, with credible positive evidence, that expected impacts, from an increase in windfarm numbers, pose a low additional risk of significant cumulative impacts. As shown earlier, there is considerable uncertainty and a concomitant significant risk of adverse impacts on certain bird species, fisheries, cetaceans and elasmobranchs. Also, the reaction of the public to extensive changes in seacapes, and possible indirect impact on the economies of coastal communities dependent on tourism and recreation as a result of possible concentrations of windfarms, is another important 'unknown' warranting caution.

There are two main options for achieving this aim:

- limiting the total number of windfarms within the Strategic Areas, but with no restriction on location; and
- identifying specific locations, within the Strategic Areas, where windfarms may be operated or where there is a presumption in favour of windfarms.

Both these options could be time bound. Since there is considerable uncertainty regarding certain impacts, efforts are needed to reduce or manage it so that future decisions can be made on a more informed basis. This will require special studies and monitoring programmes (see below). Thus, the key implications of this overall management approach are:

- selection of locational (and possibly time boundaries) for the ‘second round’;
- using windfarms receiving consent as vehicles for monitoring to ascertain actual impacts;
- review of results; and
- decisions on future locational and time boundaries for subsequent licensing ’rounds’;

The knowledge and experience gained will assist selection of other Strategic Areas and individual consent decisions on applications within and without any such designated areas.

In addition, the DTI might consider issuing a 'best practice' *Guide* for the industry on mitigation practices (perhaps in conjunction with an industry body). This document would review international and UK experience and have, as one of its primary aims, information and advice on how location decisions made by an operator can prevent and minimise likely adverse impacts prior to proceeding for consent. This would help avoid the situation, which has been prevalent to some extent, of 'retrofitting' mitigation during (or indeed after) EIA reports have been prepared and consent applications submitted. Such an application of mitigating measures can be useful, but may not mean that the aim of preventing or minimising adverse impacts, to the maximum extent possible, will be achieved in every case. Indeed, there can be significant 'transaction' costs for operators and society when key interested parties need to agree on mitigation measures at a late stage in the authorisation process that is characterised by substantial local opposition to a windfarm.

Also, this *Guide* could provide advice on preparing and implementing environmental management plans, for operators, covering such issues as *inter alia:*

- description of the mitigation action(s);
- time/place for implementation;
- determination of expected results;
- responsibility for implementation (named individual(s));
- site decommissioning and restoration plans;
- monitoring strategy needed to check on implementation and level of performance success; and
- reporting procedures to regulators, within the industry and to a community liaison committee (if formed).

The SEA work indicates, on balance, that the larger the concentration of windfarms (in relation to a given level,or target, of MW installed) then the cumulative impact on most receptors is less than when compared with a larger number of smaller windfarms. There are three exceptions to this finding. First, there is the likely increased exposure of recreational and commercial navigation to hazards in situations of bad weather and/or when there is damage to a vessel. Secondly, there is the seascape impact of a horizon being 'full' of turbines from particular viewpoints. Finally, there may be an adverse effect on certain bird species.

To some extent these difficulties can be overcome by careful siting of large concentrations of windfarms. In terms of birds, there is insufficient data to identify preferred locations so it may be necessary to limit the number of large concentrations, until research can determine areas to be avoided because of the presence of birds. An option might be to allow a limited number of large concentrations with regularly spaced 'flyway' corridors, of for example, 3 - 5km width and to monitor the effect on birds.

It is not the function of this SEA to provide detailed advice to the industry on mitigation measures. These can only be determined by the characteristics of the proposed development and the site and its surroundings. Arising for the SEA work, some general suggestions can be presented.

It is clear that the siting of windfarms is a critical factor in determining the impacts from individual windfarms and the cumulative impacts.

Noise

It is now considered good practice to initiate seismic surveys with a gradual progression from a low to higher noise intensity (the operational level) to allow marine mammals and other fauna to move away from the survey area without the risk of harm.

Noise caused by pile driving or other construction activities can be treated in the same manner, and where sustained or acute noise is produced, bubble curtains can be used to baffle the sound, and especially any resulting shock wave, to protect marine fauna.

Operational noise can be dramatically reduced by the regular maintenance of turbines and continual monitoring for vibration. This must, however, be set against the noise, disturbance and visual impacts of maintenance vessels on marine fauna. Careful modelling of layout and orientation to minimise wind and wave effects on the turbine support structures also aids the mitigation of noise effects from these factors.

Guidance on mitigating the effects of explosives use of on marine mammals is already available from JNCC.

Electric field effects on elasmobranchs

Seek to operate transmission cabling on an alternating current system and have cabling buried, armoured and shielded to result in negligible field strengths that are not substantially in excess of background measurements. Burying the cables greatly increases the mitigation to marine species.

If cables are abandoned, or left buried at the end of operation, it should be recorded due to the fact that unconnected cables can create weak electromagnetic fields. Additionally any adjacent future developments laid in parallel could cause electric fields in unconnected cabling. (UKCPC, *pers. comm.*)

Electro-magnetic interference with communications and military activities

Where test ranges or exercise areas are located nearby, and at specific sites where aircraft manoeuvres are carried out, a safeguarding distance must be allowed to ensure no obstruction from the turbines, and to prevent interference with radar and communications. Though the major radar and LiDAR sites can be seen on the maps in the CAA guidance (CAA, 2002) there are possible windfarm locations that could interfere with permanent or mobile monitoring stations and microwave communication links. Such an impact would be of great concern to the MoD because of the increased hazard.

As a result of these and related considerations, a series of meetings were arranged between the MoD and DTI in February 2003 to formulate guidelines. In the meantime the MoD, CAA and Home Office consider individual windfarm proposals at the consent stage on a case-by-case basis.

Navigational safety

Sea users need to be notified of construction activities with sufficient notice to be able to plan their activities and journeys accordingly. This is normal practice and sea users are accustomed to managing changes in traffic patterns. It is important that users are kept up to date promptly with any changes to construction activities, schedules and routing.

Windfarms in large blocks are considered to pose more of a hazard to small boats and yachts than a larger number of smaller blocks. Smaller blocks might be considered appropriate for inshore areas with significant recreational navigation and other small boat traffic. However, there are implications for seascape.

Seascape

Experience of assessing potential seascape effects arising from offshore wind farms has confirmed that the design layout of the turbines is important. There is clearly an opportunity, in appropriate locations, to create offshore wind farm designs that contribute positively to the seascape areas in which they are located. Matters to be taken into account include:

- coherence and balance from the maximum number of sensitive receptors;
- relationship of layout and array to foreground and background to the view;
- perception and legibility of pattern;
- compactness; and
- relationship to any other offshore structures.

Whilst it is acknowledged that seascape will be one constraint in the context of several others affecting offshore windfarm design, it is considered that attention to the visual appearance aspects of design may play a significant role in acceptability or otherwise of any windfarm development. This is an area where further research is recommended in order to establish the key parameters affecting windfarm layout from a seascape, landscape and visual amenity perspective.

Mitigation measures to limit the direction and range of any lighting may be implemented to minimise any potential effects on visual amenity. The colouring of turbines may help to mitigate the visual impacts as suggested by Environmental statements from several of the existing UK windfarms (EMU, 2002; NWP,2002).

Fisheries

Managed access for fisheries will allow certain fisheries to continue with concurrent socio-economic benefits. Exclusion zones should be avoided in areas known to be fished commercially, unless there is an over-riding safety case justifying such zones.

Sediment transport and water quality

The key issues regarding sediment transport are scour at the base of turbine support structures and dredging or redistribution of sediments during construction and decommissioning. Scour is likely to occur at the base of most support structures, though mainly localised and not significant unless the construction alters the wave and wind currents to alter the flow rates and patterns.

These effects can be minimised by the addition of scour protection at the base of each support structure and where necessary, minimising any washings and fine sediment overspill from barges used to carry any spoil. Additionally, seasonal and tidal timing of the work to periods of low current activity can reduce the turbidity and sediment plume that could be caused by construction or decommissioning work. In extreme circumstances it maybe possible to erect surface or sub-surface sediment booms to contain potential sediment plumes.

During decommissioning, in some cases, buried cables are abandoned, minimising the effects on the sediment and fauna.

Related to the redistribution of sediments is the effect on water quality by creating turbidity, or the increase in concentration of contaminants, such as hydrocarbons, into the water column. Minimising the extent of sediment disturbance can significantly reduce this, as well as analysis of sediments prior to construction to avoid areas where levels would pose a significant risk.

Additionally, the effective protection of structures against corrosion, and examination of biofouling paints and coatings and their potential impacts on the immediate marine environment should be carried out.

Benthic communities.

Minimising the impacts of construction on benthic communities can be achieved by limiting the amount of sediment scour through use of anti-scour materials (though this in itself results in a substantial change to faunal composition) and by managing the amount of sediment disturbed and redistributed as described previously. By appropriate site selection, noted sensitive habitats (designated or otherwise) could be avoided.

During decommissioning, leaving the anti-scour material in position is likely to be the preferred option, as removal can cause more significant seabed and faunal disturbance.

Decommissioning and restoration

To ensure acceptable decommissioning and restoration the Government and the Crown Estate might consider that the use of bonds or substantial financial deposits will be necessary. The Scottish Executive has concluded that no work should commence on the Robin Rigg site, in the Solway Firth, until a bond has been put in place. The bond will cover all works and measures to restore the site in accordance with the site restoration plan to be agreed with the Scottish Ministers (RYA, *pers. comm.*).

The precise design of financial instruments of this kind cannot be discussed here, but it is desirable that the size of the bond or deposit should reflect the likely cost of the decommissioning process should the need arise at any stage of the project's intended life-cycle. There is a political choice to be made in terms of allocation of the financial risk. The key issue relates to the choice as to whether the risk (cost) should fall on the pioneers of the industry, or be spread more widely in recognition of the wider benefits of renewable energy.

12.3 Monitoring programmes

There is, up to now, no experience of operating entire wind farms, or groups of wind farms, in UK waters, and fairly limited experience offshore elsewhere. The assumptions and methodology used when assessing the impacts will need to be checked against the accumulating experience of the first years' of operation. Also, to the extent consistent within the time frames of second and subsequent rounds, it is important that the results of monitoring studies should be incorporated into the strategic planning of future developments and the location, construction and operational decisions made by industry operators. Thus, there should be a strategy providing for monitoring, mitigation and control of individual and cumulative impacts. It is critical that the data, analyses and experience acquired during these first year's of operation and study are disseminated widely.

There are two main types of monitoring which can be undertaken:

- mitigation 'monitoring' as part of supervision or consent compliance (whether mitigation actions have been implemented in accordance with an agreed schedule and are working as expected); and
- impact monitoring (scale and extent of actual impacts).

In trying to learn from the implementation of windfarm developments both kinds of monitoring are important.

Monitoring studies to determine actual impacts and the consequences for the offshore energy generation industry must not be seen as a technical exercise of gathering data. It requires an institutional framework to manage the work and to undertake the following activities:

- determine the need for specific monitoring studies;
- determine the objectives of the monitoring studies;
- approve the monitoring protocols;
- select the contractors hired to undertake the monitoring (a 'quality control' function);
- review and results and evaluate the implications in terms of the objectives;
- consider whether a monitoring study should cease or be continued; and
- oversee a forum or other mechanism for ensuring that the results are disseminated widely to key interested parties.
- implement necessary measures at sites as relevant and apply outcomes of monitoring and research to future developments.

The Dutch Government has established a mechanism to manage the advancement of their understanding of the environmental issues associated with development of offshore wind (Anon, 2001). The Crown Estate currently manage a programme of research that is specifically designed to look at site-specific issues. As an alternative, an adaptation of the NSW-MEP model might be appropriate for the monitoring work to be done in the early phase of the offshore wind energy industry.

Impact monitoring is of particular importance if there is considerable uncertainty concerning the scale and significance of one or more adverse impacts. Interpretation of the monitoring data can function as an 'early-warning' system indicating if an impact is occurring and allowing action to be taken to remedy the situation if data show existence of a trend likely to result in an unacceptable impact in the near future.

Careful and well-considered thought is needed before monitoring recommendations are formulated. Monitoring can be expensive, particularly in relation to ecological impacts. Therefore, it is important that consultations take place between the licensing authorities, the industry, conservation agencies and NGOs to discuss necessary impact monitoring. Important issues to be considered include:

- identification of impacts to be monitored in priority order;
- design of an appropriate monitoring programme for each identified impact;
- likely duration of the individual monitoring programmes;
- the institutional system by which monitoring data will be collected, collated, analysed, interpreted and action taken, if necessary, to prevent or reduce unwanted impacts; and
- cost of overall monitoring recommendations.

12.4 Additional studies

There are a number of studies about to be initiated, or already underway, that will provide valuable information for further SEA work, though the results were not available for this SEA (see, for example, the list in *Future Offshore,* and Crown Estate website: (www.crownestate.co.uk/estates/marine/windfarms/cowrie.shtml).

Additional suggested studies can be categorised into two types, those that address baseline data gaps and those that look to develop our understanding of actual impacts on key species and processes. The lists that follow include those identified by scoping respondents but not those already being carried out as part of the DTI's and Crown Estate's commitment to windfarm related research.

Baseline data gaps

- distribution and main flight paths of seabirds including migratory, feeding/roosting patterns (being addressed partly by RSPB/JNCC study funded by DTI) and their behavioural response to windfarms;
- distribution of marine mammals and their behavioural response to windfarms;
- location of areas of significance for shark, skate and ray populations;
- location of areas of significance for squid populations;
- landscape/seascape assessment methodology and baseline data acquisition (visibility, character, quality, value and capacity to accommodate change); and
- characteristics of inshore/nearshore fisheries and distributions of fished species.

Impact studies

- macro-scale impacts on tidal regime, wave climate and sediment processes of large concentrations of turbines and windfarms in offshore situations;

- modelling study of changes to coastal sediment budgets from individual and several large windfarms;
- ground-truthing tidal, wave and sediment transport models;
- variability of key bird species' sensitivity to windfarm impacts during different weather conditions and times of year.

12.5 Conclusion

Data from mitigation implementation analyses, monitoring of impacts and additional studies will play an important role by informing (and improving the predictive power) of future SEAs and individual EIAs undertaken for consent applications. Also, these data can be used also to inform technological development of windfarm design and the management of existing windfarms during construction, operation and decommissioning or abandonment.

Thus, through allowing limited offshore windfarm development (with in-built safeguards based on current knowledge and assumptions) and a rigorous programme of 'research' and other studies, a flexible process of experimental and adaptive management can be set in motion to achieve the benefits of offshore wind generation industry. At the same time, uncertainties can be reduced and the likelihood of significant adverse impacts minimised.

13 Conclusions of the Environmental Report

This SEA has been carried out, voluntarily in accordance, where practicable, with the SEA Directive[15]. It was undertaken for the proposed development of offshore windfarms in the three Strategic Areas (Figure 1, Annex 2) as part of Government strategy to reduce greenhouse gas emissions. The timescale under assessment is from the present (2003) until 2020 (Section 6). Two development scenarios have been considered (Section 6, Figures 22 and 23, Annex 2) and their potential impacts assessed (Sections 9 and 10). This *Environmental Report* details the potential environmental impacts, both positive and negative, identified during the SEA process and describes their varying degree of significance (Sections 9 and 10). It has not been possible to assess a number of potential impacts, to assess with any certainty in the absence of baseline information or understanding of the relevant processes and environmental responses (Sections 9 and 10). Suggested studies to address these gaps, not already underway, have been identified (Section 12.4).

Section 11, the comparative analysis of the development scenarios, has endeavoured to assess the potential impacts and draw conclusions with respect to:

- the overall capacity of the three Strategic Areas to accommodate the draft programme, assessed as two development scenarios and the comparative implications of a strategy favouring particular scales of windfarm developments (i.e. large windfarms vs. small windfarms); and
- Strategic Area capacity to accommodate the development scenarios and how best to achieve them with respect to particular scales of windfarm development.

It has been concluded that the potential constraints on achieving the aims of the draft programme, for the two development scenarios are not sufficient to prejudice its success, subject to the following observations:

- the likely development scenario, to 2010, is achievable for each Strategic Area without coming into significant conflict with the main significant impact risks, namely areas of high sensitivity to visual impact, concentrations of sensitive seabirds, designated and potentially designated conservation sites, MoD Practice and Exercise Areas (PEXAs) and main marine traffic areas;
- the 2020 likely development scenario would only be achievable subject to resolving the uncertainties concerning impacts on: physical processes, birds, elasmobranchs and cetaceans;

[15] *Directive 2001/42/EC on the Assessment of the Effects of Certain Plans and Programmes on the Environment* (27 June 2001). Although this Directive is not in effect, DTI aims to follow its requirements in this exercise.

- based on our present state of knowledge, fewer large windfarms, of around 1GW or more generating capacity, located offshore are generally preferred against several small-scale developments (comparable to Round One sites), though the latter would be preferable for development closer to the coast;
- the maximum credible scenario for 2010 is achievable subject to resolving the uncertainties concerning impacts on physical processes, birds, elasmobranchs and cetaceans;
- the maximum credible scenario for all Strategic Areas, particularly the Greater Wash and Thames Estuary, for 2020, may be compromised by constraints, particularly cumulative impacts and conflict with marine traffic (commercial and recreational navigation); and
- large scale development could exclude fisheries from significant areas of fishing grounds, particularly if it were to coincide with severance areas associated with other offshore activities.

In order to assist windfarm development with minimal environmental disturbance, it is suggested that the following strategic approach is adopted:

- in all Strategic Areas, avoid the majority of development within the nearshore zone of high visual sensitivity (Figure 19, Annex 2);
- where development might occur in nearshore areas, preferentially select low constraint areas and consider small scale development;
- avoid development in shallow water where common scoter and red throated diver and other species (including marine mammals) are known to congregate (particularly in Liverpool Bay and Greater Wash), pending the outcome of monitoring studies;
- address the uncertainties of large scale impacts at a strategic level, particularly cumulative and those impacts that apply equally to developments irrespective of their location.

Consideration of the potential for adverse environmental impacts of offshore wind energy to compromise development efforts should take into account the economic benefits and more importantly, the indisputable environmental benefit of generating energy using the renewable resource of offshore wind.

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[16] NB This draft report is subject to review by the relevant Bern Standing Committees during the December 2003 meeting, and is cited here on that understanding.

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15 Annexes

Annex 1

Steering Group Members

Annex 2

Figures

Annex 3

Annex 4

Seascape results