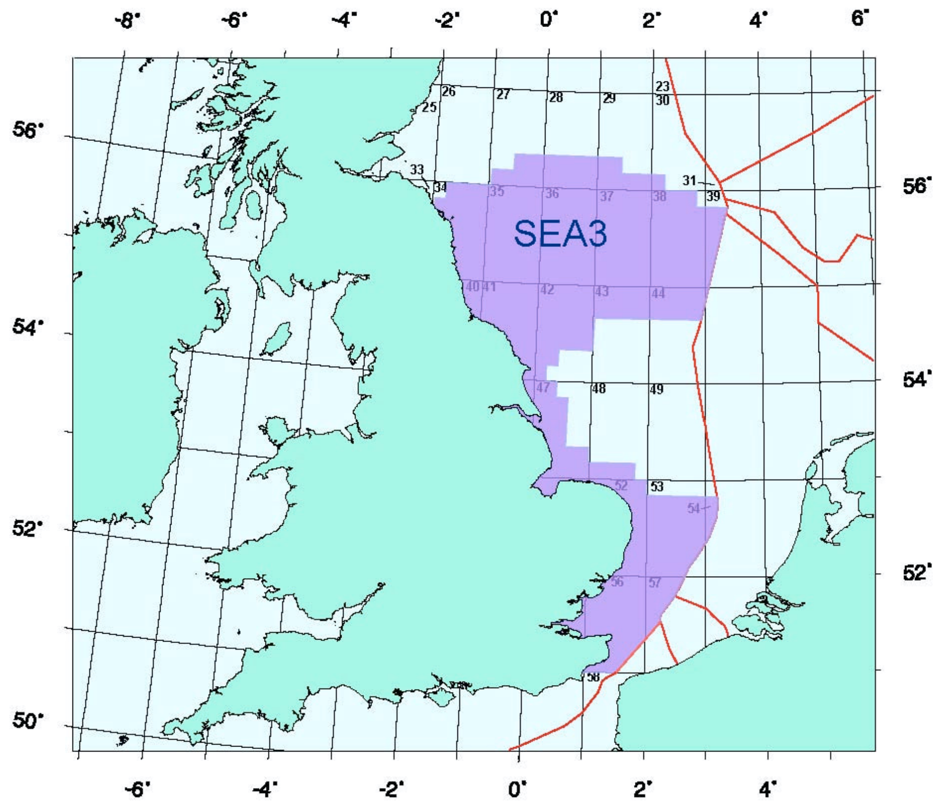
Department of Trade and Industry

Report to the
Department of Trade and Industry

Strategic Environmental Assessment of Parts of the Central & Southern North Sea SEA 3



Consultation Document
August 2002

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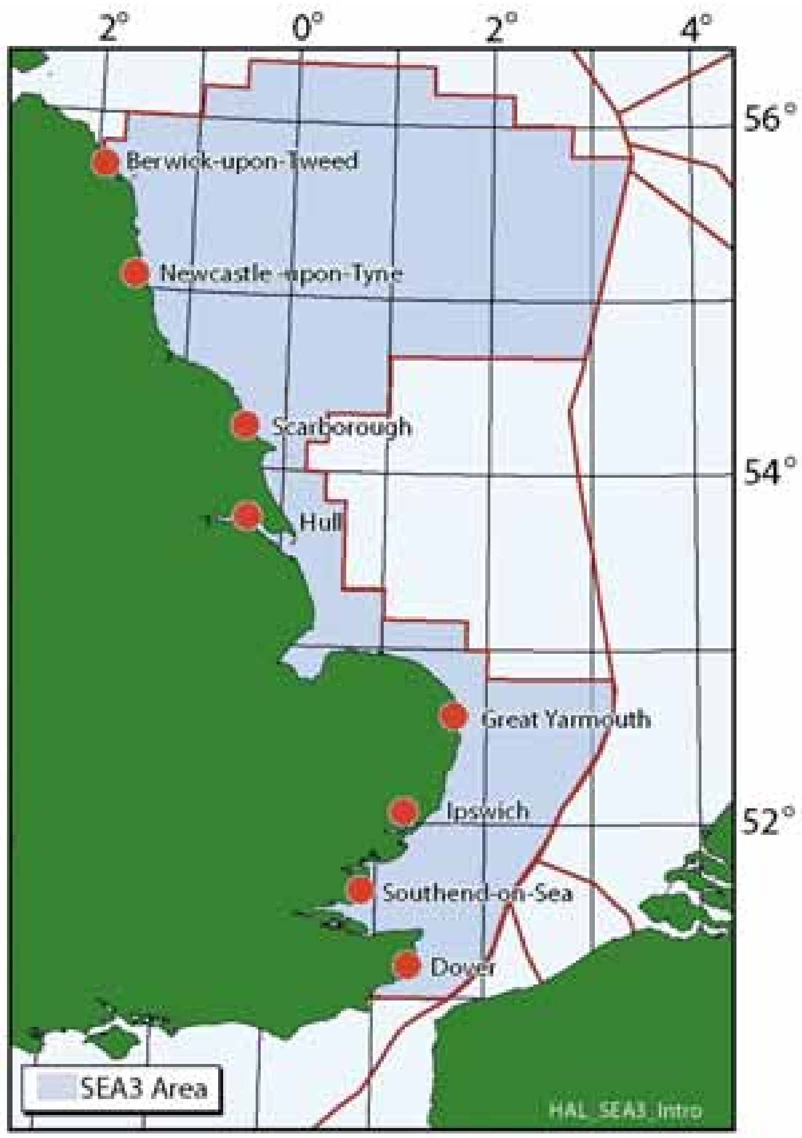
NON-TECHNICAL SUMMARY

Background

The UK Department of Trade and Industry (DTI) is conducting a sectoral Strategic Environmental Assessment (SEA) of the implications of licensing parts of the central and southern North Sea for oil and gas exploration and production (see Figure 1).

Figure 1 - SEA 3



This SEA (SEA 3) is the third in a series planned by the DTI, which will in stages, address the whole of UK waters. The first DTI SEA was conducted in 2000 prior to a 19th Round of offshore licensing and covered areas to the northwest of Scotland. SEA 2 was completed in 2001 and considered the main areas of oil and gas production in the North Sea. SEA 3 (as SEA 2) has been undertaken in line with the recently adopted European SEA Directive (2001/42/EC) with the aim of considering environmental protection and sustainable development objectives in decisions relating to oil and gas licensing in the North Sea. For the purposes of oil and gas licensing, UK waters are divided into quadrants (1° of latitude by 1° of longitude) with each quadrant further divided into 30 blocks.

The SEA 3 area includes the remaining parts of the central and southern North Sea and comprises 362 blocks of which 30 are currently wholly or in part under licence, 205 which have been licensed but are now wholly relinquished, and 127 which have not previously been licensed. Several of the blocks included in the blue shaded SEA 3 area are currently under licence.

The proposed action considered by this SEA is the offer of Production Licences for blocks in part(s) of the UK sector of the North Sea through a 21st Round of offshore licensing. The alternatives to the proposed licensing are not to offer any blocks, or to license a restricted area, or stagger the timing of activity in the area. SEA 3 was selected as the next in the DTI series because the geology of the area is prospective for gas and various projections show the UK having a growing shortfall in gas supplies. Barring rapid and revolutionary developments in photovoltaics or other renewable energy technologies, this shortfall will need to be filled by new UK production or imports.

A required part of an SEA under the SEA Directive is consultation with the public, environmental authorities and other bodies, together with such neighbouring states as may be potentially affected. To facilitate consultation, this assessment document is available in a number of different formats and media. For details see the SEA website (www.habitats-directive.org) or contact the SEA Coordinator (Ms Christine Weare, DTI Oil and Gas Directorate, 86-88 Atholl House, Guild Street, Aberdeen, AB11 6AR). The formal public consultation phase extends for ninety days from the date of publication.

The process used to conduct this SEA draws on earlier UK, European and American examples and in addition, the experience gained and lessons learned from the first two DTI SEAs have been used to refine the process. Improvements made have included involving stakeholders in the scoping stage of the SEA and the establishment of a Steering Group drawn from a range of stakeholders, to provide technical and general advice to facilitate the DTI SEA process. The Steering Group and authors of technical reports also participated in a workshop to identify which oil and gas industry activities might potentially result in significant effects. The DTI commissioned a number of desk-top studies covering a range of topics together with field surveys of specific seabed features of potential conservation interest. The reviews and reports have been used in the preparation of this document. A stakeholder dialogue meeting was held in York on 6 August 2002, facilitated by the independent Environment Council on behalf of the DTI. A wide variety of potential stakeholders, drawn from UK and other regulators, government advisers, local authorities, other industry representatives, academics and NGOs were invited to the session.

The potential occurrence of hydrocarbon reserves is assessed through seismic survey. However, the location of commercial hydrocarbon reserves can only be confirmed by drilling a well, and for the North Sea the success ratio is about 1 in 5 (that is five wells drilled to discover one field). Consequently, there is uncertainty in predicting the scale and precise location of hydrocarbon related activities which could follow the proposed licensing. In order to conduct the SEA, possible development and activity scenarios have been prepared for consultation purposes by the DTI based on the geology and results of past exploration. These involve up to 15 exploration wells and the development of up to seven new producing fields, most probably subsea wells tied back to adjacent, existing gas fields. Only large finds could justify development by stand alone facilities. This activity would represent a small proportion of total gas exploration and production in the UK, which for existing licensed areas in the North Sea, is projected to involve around 200 to 500 exploration/appraisal wells and up to 90 field developments over the next 10 years. The actual scale of activity is dependant on a variety of factors and in particular, oil/gas prices and tax regime. The most likely location of exploration and production activities is in the blocks which surround the SEA 2 area which contains the bulk of the UK's existing offshore gas fields.

The North Sea Environment

Water depths and seafloor

The North Sea is a large shallow sea with a surface area of around 750,000km^2. Water depths gradually deepen from south to north and the main topographic feature of relevance to SEA 3 is the Dogger Bank, which marks a division between the southern and central North Sea.

Tides and currents

The main inflow to the North Sea occurs along the western slopes of the Norwegian Trench, with minor inflows from the English Channel and Baltic. These inflows are balanced by outflow mainly along the Norwegian coast. Water circulation in the North Sea is anticlockwise. The water column of the southern North Sea and coastal fringe remains well-mixed throughout the year while the waters of the central North Sea become layered (stratified) in summer, effectively isolating surface and near bottom waters until autumn gales break down the stratification.

Seabed sediments

Seabed sediments over the majority of the North Sea are composed of either sand or mud, or a mixture of the two. Typically, sandier sediments are found in the south and in coastal waters, and there are also areas which contain gravel. Large sandbanks are present in both coastal and offshore waters, predominantly in the southern part of the SEA 3 area. Rocky outcrops and platforms are associated with discrete sections of the coast, primarily in the northern part of the SEA 3 area.

Seabed animals

The seabed fauna of the North Sea varies mainly according to sediment type and water temperature range. Within the SEA 3 area, a number of coastal habitats including rocky shores, coastal reefs and estuaries support a diverse range of species, a number of which are of conservation interest. Further offshore, a recent DTI survey of the SEA 2 and adjacent areas further highlighted the species richness of certain types of sandbank. Sandbanks are defined by the EU Habitats Directive and offshore examples of this habitat may be designated as conservation sites in the future.

Food web

The North Sea is a very productive area with a "food web„ linking the plankton (the source of much of the initial productivity) with fish, birds, marine mammals, other water column animals and the fauna of the seabed.

Fish and fisheries

Many different types of fish are found in the North Sea with diversity highest in the central and northern North Sea and in inshore waters. The North Sea is one of the world's most important fishing grounds and supports a range of coastal and offshore fisheries. Within coastal waters of the SEA 3 area, there are fisheries for crab, lobster, whelk, and cockles as well as netting for a number of fish species, including salmon, cod, herring and sole. Further offshore, a mixed demersal fishery primarily targets cod and whiting, and plaice and sole are fished for in the southern part of the area. Herring are taken from northwest of the Dogger Bank and in the coastal waters of eastern England. An industrial sandeel fishery targets the Dogger Bank as well as coastal and offshore areas of the northern part of the SEA 3 area.

Birds

A number of internationally important seabird colonies are found along the east coast of England and large numbers of breeding seabirds are associated with these in spring and early summer. Offshore areas of SEA 3 contain peak numbers of seabirds following the breeding season and throughout the winter. Many of the estuaries along the English east coast also support important populations of migratory and wintering wildfowl and waders, as well as breeding birds.

Marine mammals

The waters of the North Sea support a wide variety of marine mammals, with internationally important numbers of grey and common seals. Within the SEA 3 area, the Farne Islands, the Humber Estuary and the Wash support important seal breeding colonies. The most common cetaceans sighted in the North Sea are harbour porpoise, minke whale and white-beaked dolphin. Offshore areas of the

North Sea which are identified as being of importance to marine mammals for foraging and/or breeding and may be protected in the future through implementation of the EU Habitats Directive.

Conservation

The SEA 3 area plays host to a variety of important habitats and species as well as bird areas which are protected under international, national and local designations. Internationally important habitats and species are protected by the EU Habitats Directive whilst the Birds Directive protects important breeding, migratory and wintering bird populations. At present there are no conservation sites within the UK offshore area (outwith 12 nautical miles). However, initiatives at both national and European level are in the process of identifying potential sites which may warrant protection.

Marine archaeology

Prehistoric sites discovered within the SEA 3 area are important but limited. Important coastal sites have been discovered along the coasts of Cleveland, Yorkshire, Norfolk, Essex and Kent. Important offshore archaeological discoveries have been made on the Dogger Bank, the Leman and Ower Banks and the Brown Ridge in the southern North Sea. There are also a number of historic wrecks and protected monuments in coastal waters of the southern SEA 3 area.

Contamination

The North Sea is predominantly surrounded by densely populated land with extensive industry and agriculture. River runoff, atmospheric fallout and past dumping of wastes at sea have resulted in widespread contamination of the marine system with a wide range of chemicals and nutrients. These contamination levels are typically very low but in some (usually) coastal areas concentrations can be high enough to result in marked biological effects. The main contaminants associated with the oil and gas industry come from produced water and oil-based drill cuttings. Discharges of such cuttings have now ceased and cuttings piles have generally not formed in the SEA 3 area due to dispersion.

Other users

In addition to the oil and gas industry and commercial fisheries, the SEA 3 area provides an important resource for a number of other users. Much of the English east coast is rural in nature and attracts a large number of tourists to its unspoilt scenery. Many of the estuaries provide important locations for commercial shellfish cultivation. The coastal margin is also home to many of the UK's major ports and harbours as well as major industrial and population centres. These areas form the focus for shipping and trade and particular regions of SEA 3 experience heavy shipping pressures. The presence of extensive sand and gravel deposits in coastal waters provides an important source of marine aggregates and, within the same area there are a number of marine disposal sites for spoil from dredging operations. A network of subsea communication cables linking the UK with Europe also traverses the SEA 3 region.

Coastal initiatives

Given the large number of users of the SEA 3 environment, there are particular areas of the coast such as major estuaries, where there is the potential for conflict between industries and the environment. Within the SEA 3 area, a number of voluntary coastal groups have been formed to deal with many of these potential issues. There are also European and national initiatives aimed at managing the changing nature of the SEA 3 coastline in terms of future development and conservation.

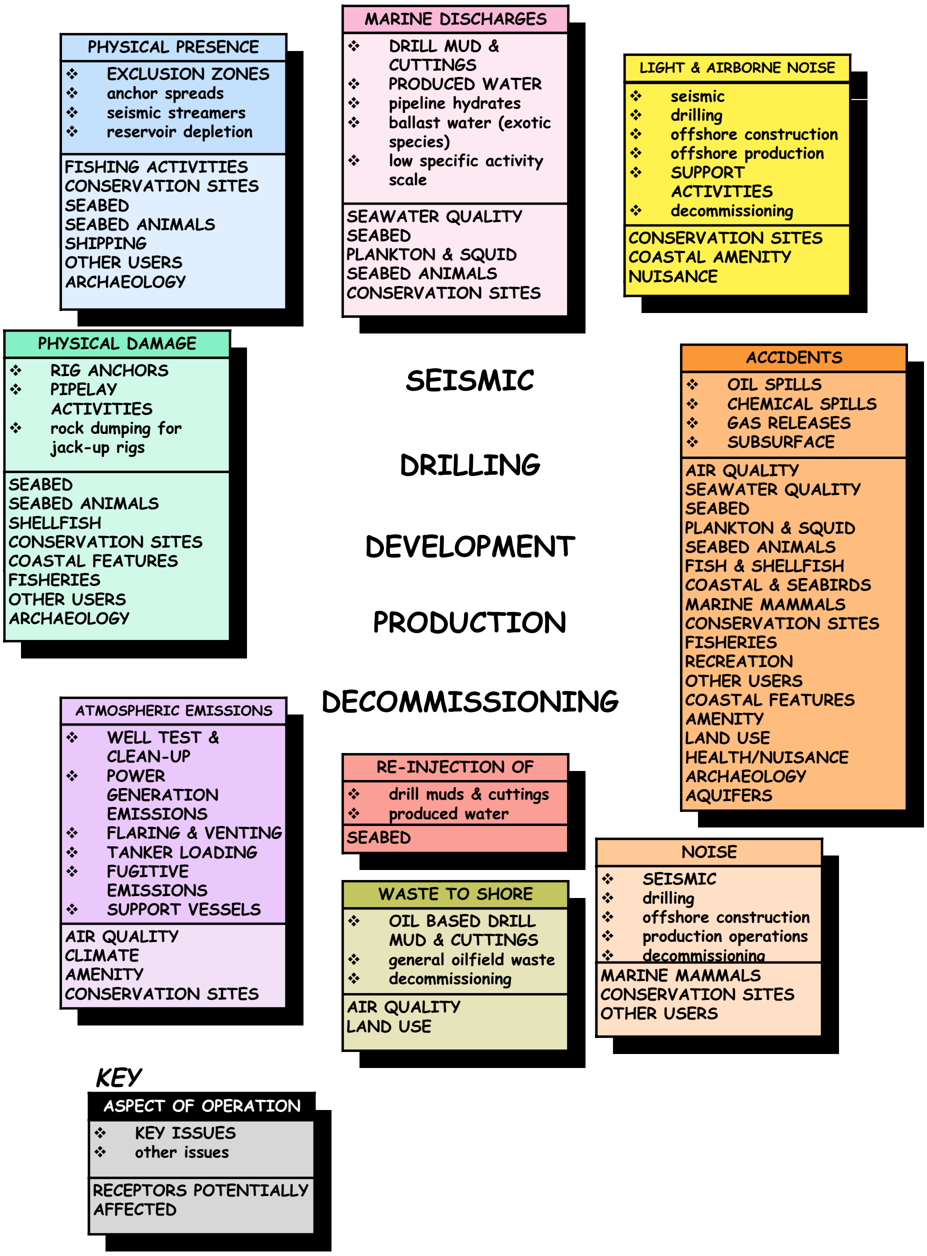
Surrounding coasts

The North Sea coastline has many sites of conservation, economic and human interest. In those countries of relevance to SEA 3, there are a total of 111 sites designated for their bird life. Large stretches of the coastline are popular tourist destinations due to their coastal landscape, cultural heritage, wildlife and opportunities for water-based activities. There are no offshore (beyond 12 nautical miles from shore) conservation sites designated at present, although a process is underway to identify potential sites under the EU Habitats Directive and the OSPAR marine protected areas programme.

Assessment

An assessment of the possible implications of oil and gas activity in the SEA 3 areas was conducted and the findings are discussed in detail in Section 10 of the main report. A summary of the key oilfield activities and associated potential sources of effect is shown in Figure 2. While all sources of emissions, discharges and disturbance could potentially contribute to local, regional and global effects, the following were identified as key issues requiring further consideration in the SEA.

Figure 2 – Summary of key oilfield activities and associated potential sources of environmental effect



Noise

While seismic surveys could potentially affect whales, dolphins, porpoise and seals, it is considered unlikely that physical damage or significant behavioural disturbance of marine mammals will result from activities following the 21st Round licensing or those in existing licensed areas.

Physical damage

The predicted scale of physical disturbance of the seabed, resulting from activity scenarios for potential SEA 3 licensed areas, is very small in comparison with the total area of the North Sea. Recovery of affected seabed is expected to be rapid and it is concluded that the potential incremental and cumulative effects of physical disturbance are not likely to be significant.

Physical presence

Exclusion from large areas of sea by the presence of rigs or installations could result in effects on commercial fishing, as could the presence of snagging hazards associated with pipelines or debris. However, the small scale of such effects from SEA 3 licensing indicates that the number of exclusion zones that may be established is unlikely to cause significant economic impacts. The oil industry and UK fishing industry consultation, liaison and compensation mechanisms, should serve to mitigate any conflicts.

Discharges

Concerns over produced water discharges include the cumulative effects of oil and the possible biological effects of residual chemicals. However, incremental contributions from newly licensed SEA 3 blocks would be negligible from produced water since gas fields tend to produce little or no water. In addition, for new developments there is a presumption against discharge of produced water.

Discharges of water based muds and cuttings in the North Sea have been shown to disperse rapidly with minimal ecological effects. Dispersion mechanisms could, in theory, lead to localised accumulation for example in sandbank areas in the southern North Sea, although this is considered unlikely to be detectable.

Atmospheric Emissions

Potential environmental effects of acid gas and greenhouse emissions are, respectively, regional and global in nature. Local environmental effects of atmospheric emissions are not expected to be significant in view of the high atmospheric dispersion associated with offshore locations. Incremental contribution to regional and global effects will not be significant.

Significant combustion emissions from oil or gas flaring are not expected from potential developments in the SEA 3 licence areas, in view of regulatory controls and commercial considerations. Similarly, combustion emissions from power generation would only be a minor contribution to oil industry, other industry or national totals.

Wastes to shore

Oil based muds are needed to drill through some of the rock types found in the SEA 3 area. Rock cuttings contaminated with oil based mud are no longer discharged to sea and either reinjected into underground rock formations or shipped to land to undergo treatment prior to onshore disposal. The environmental management of treatment and disposal of such cuttings, both onshore and offshore, is strictly controlled. The incremental volumes of cuttings associated with 21st licensing round activities will be small in the context of overall waste disposals from offshore.

Accidental events

The incremental risk of oil spills associated with exploration and development in the SEA 3 area is low, particularly in the southern gas fields. Seabirds offshore are vulnerable to even small spills, particularly in late summer and autumn when many auks are flightless. In the event of a large spill of persistent oil, coastal oiling could occur. However, risk assessments have been carried out for existing activities in the SEA 3 area and contingency measures put in place which mitigate risks to tolerable levels.

The persistence and biological effects of most chemicals used in the oil and gas industry are equivalent to or lower than those of oil, and similar risk assessment conclusions will therefore apply to chemical spills.

The environmental and safety consequences of accidental gas releases depend both on scale, and on whether released gas ignites. The major constituent of natural gas is the greenhouse gas methane, and gas releases on all scales will therefore contribute to global climatic effects. Any foreseeable contribution of methane, including a sustained gas blowout, to global emissions will be negligible.

Cumulative effects

Cumulative effects from activities resulting from the proposed 21st Round licensing, have the potential to act additively with those from other oil and gas activity including both existing activities and new activities in existing licensed areas, or to act additively with those of other human activities (e.g. offshore wind energy, fishing and crude oil transport). Synergistic effects are considered to be potential effects of E&P activities where the joint result of two or more effects is greater than the sum of individual effects. Cumulative effects in the sense of overlapping "footprints,, of detectable contamination or biological effect were considered to be either limited (physical presence, noise, physical damage, emissions, discharges), or unlikely (accidental events). No synergistic effects were identified that were considered to be potentially significant.

Transboundary effects

The SEA 3 area adjoins the continental shelf areas under the jurisdiction of Germany, the Netherlands, Belgium, and France. Prevailing winds and the residual water circulation of the North Sea will result in the transboundary transport of discharges to water (including particulates) and atmospheric emissions.

The environmental effects of underwater noise, produced water, drilling discharges, atmospheric emissions and oil spills may be able to be detected physically or chemically in the marine environments of adjacent states, particularly from activities undertaken in SEA 3 areas close to international boundaries. The scale and consequences of environmental effects in adjacent state territories will be comparable to those in UK territorial waters.

Socio-economic effects

Economic modelling indicates that if oil and gas prices remain at their current levels then between 2.5 and 2.7 million m^3 of oil and between 18.7 and 25.9 billion m^3 of gas may be extracted (depending on oil and gas price scenarios) as a result of 21st round licensing.

Forecast tax revenues range widely, with a maximum of £65-80 million in 2007 period. However, if oil prices drop substantially, under the current fiscal regime, Government revenues from 21st Round are likely to be negative when tax relief for exploration and appraisal activities is given.

The forecast activity could result in a peak of 6,900 total extra jobs in the UK in 2007, of which 80 to 100 are estimated to be direct.

Wider policy objectives

No significant effect of activities following the proposed 21st licence Round are predicted on UK Government or other wider policy and commitments.

Conclusions

Synergistic effects of exploration and production activities with those of other activities in the area are not predicted. A number of potential sources of effects could conceivably be detectable across national boundaries with other European states; however, only oil spills are regarded as having the potential to result in significant negative environmental effects.

The DTI as licensing authority and offshore environmental regulator has at its disposal a range of powerful permit based legislation and other environmental control mechanisms, which provide a sound basis for the regulation of future oil and gas activities in the North Sea. Project-specific permitting allows due attention to be given to the protection of environmental sensitivities (e.g. seasonal seabird vulnerability, and actual or potential conservation sites), other users of the sea and other marine resources. These permits can and do where necessary specify timing, spatial and activity constraints relevant to the sensitivities of the area. No specific additional controls were identified as being essential. A number of gaps in information and understanding relevant to potential environmental sensitivities have also been identified, and may be addressed most efficiently through continuation of ongoing co-operative industry and government programmes including broad scale environmental monitoring.

The overall conclusion of the SEA is that there are no overriding reasons to preclude the consideration of further oil and gas licensing within the SEA 3 area.

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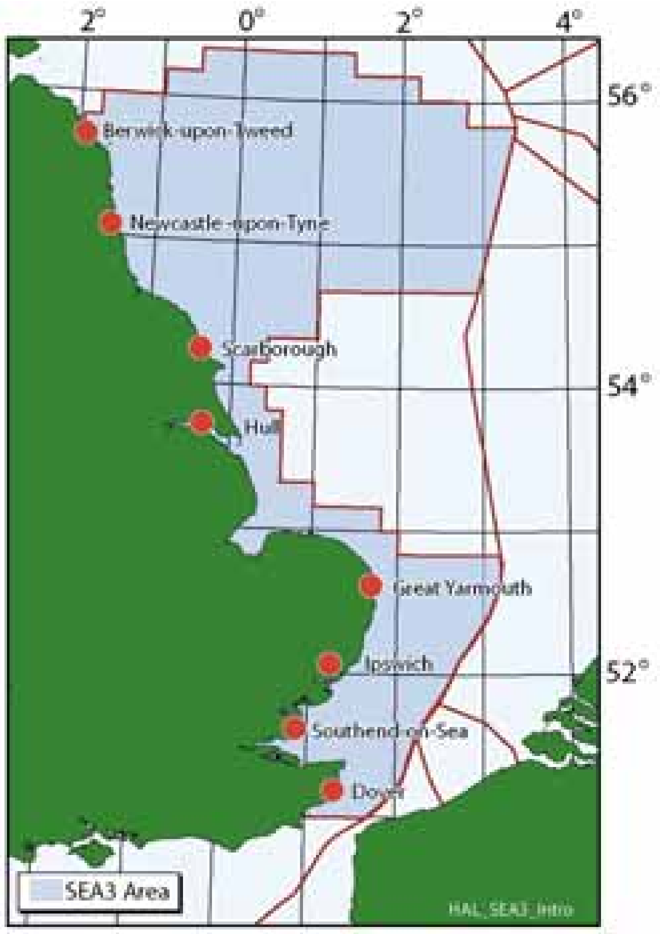
1 INTRODUCTION AND BACKGROUND

1.1 Introduction

The UK Department of Trade and Industry (DTI) is the principal regulator of the offshore oil and gas industry and has taken a proactive stance on the use of SEA as a means of striking a balance between promoting economic development of the UK's offshore oil and gas resources and effective environmental protection.

Strategic Environmental Assessment (SEA) is a process of appraisal through which environmental protection and sustainable development may be considered, and factored into national and local decisions regarding government (and other) plans and programmes.

Figure 1.1 – DTI SEA 3 area



This document reports on an assessment of the environmental implications of licensing for oil and gas exploration and production the parts of the central and southern North Sea (see Figure 1.1 which shows the area within which unlicensed Blocks will be considered for licensing) as part of a Strategic Environmental Assessment process. This is the DTI's 3rd SEA and is hereafter referred to as SEA 3.

1.2 Regulatory context to SEA

Directive 2001/42/EC of the European Parliament and of the Council of 27 June 2001 on the assessment of the effects of certain plans and programmes on the environment (hereafter called the SEA Directive) entered into force on July 21 2001. The United Kingdom, as a Member State, is required to comply with the Directive before 21 July 2004.

The Directive's stated objective is *"to provide for a high level of protection of the environment and to contribute to the integration of environmental considerations into the preparation and adoption of plans and programmes with a view to promoting sustainable development, by ensuring that, in accordance with this Directive, an environmental assessment is carried out of certain plans and programmes which are likely to have significant effects on the environment."*

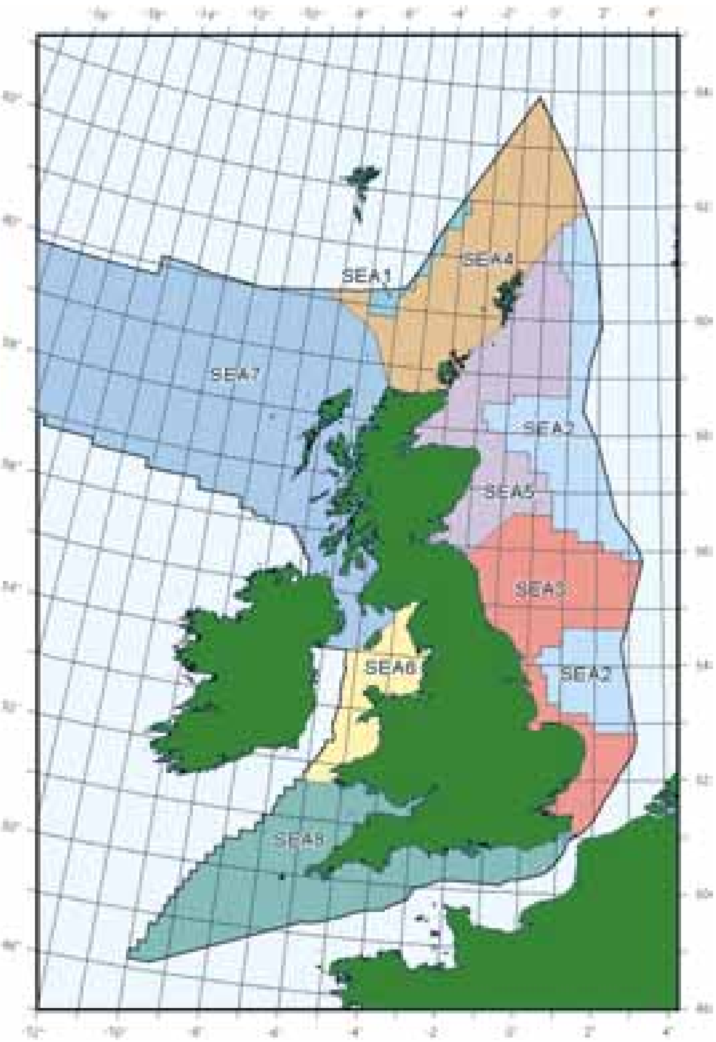
The United Kingdom is also a signatory to the *"UN/ECE Convention on access to information, public participation in decision-making and access to justice in environmental matters"* (hereafter called the Aarhus Convention).

Article 1 of the Aarhus Convention states that *“In order to contribute to the protection of the right of every person of present and future generations to live in an environment adequate to his or her health and well-being, each Party shall guarantee the rights of access to information, public participation in decision-making, and access to justice”.*

A required part of SEA is consultation with the public, environmental authorities and other bodies, together with such neighbouring states as may be potentially affected. To this end SEA 3 has included a stakeholder consultation process involving a scoping step and a dialogue meeting. To facilitate public consultation SEA 3 is documented in this report which is available on-line and in a variety of media together with a range of commissioned studies and reports which support the SEA – see Section 1.7.

1.3 History of the DTI SEA process

Figure 1.2 – DTI Offshore SEAs



In 1999, the Department of Trade and Industry (DTI) began a sequence of sectoral SEAs considering the implications of further licensing of the UK Continental Shelf (UKCS) for oil and gas exploration and production – see Figure 1.2. The SEAs were in line with the UK’s "Greening Government" initiative, which included implementing the intent of the then draft European Council Directive on Strategic Environmental Assessment Directive (see above) - Government Departments would conduct Environmental Appraisals of their major plans and programmes – for the DTI this included oil and gas licensing.

The DTI completed the 1st UK offshore Strategic Environmental Assessment (SEA 1) in 2000, in preparation for the 19th Licensing Round. This SEA covered parts of the formerly disputed area between UK and Faroese waters (an area which was known as the “White Zone,,).

The 2nd Strategic Environmental Assessment (SEA 2) completed during 2001, addressed the implications of licensing for oil and gas exploration and production, some unlicensed parts of the offshore North Sea.

The process for the current SEA, SEA 3 was commenced in the Autumn of 2001. SEA is an evolving process and SEA 3 builds on the lessons learned in conducting the 1st and 2nd SEAs together with input from stakeholders during the scoping and dialogue processes. The DTI oil and gas licensing

SEA process is underpinned by the requirements of the SEA Directive together with those of the Aarhus Convention on public participation and is further described in Section 2.

1.4 Licensing context

Oil and gas exploration and production in the UK is regulated primarily through a licensing system – see Section 3 for more information. Production Licences grant exclusive rights to the holders to "search and bore for, and get, petroleum„ in specific areas. The first offshore (seaward) UKCS Licensing Round took place in 1964 and seaward licensing rounds have been held roughly every one to two years since. In January 2000, there were 109 oil fields, 87 gas fields and 16 condensate fields in production offshore on the UKCS.

The licensing system is managed by the DTI Oil and Gas Directorate's Licensing, Exploration and Development Branch. In 1999, prior to the adoption of the SEA Directive, the Department of Trade and Industry (DTI) had taken a policy decision to implement the intent of the SEA Directive for future UKCS oil and gas licensing.

For the purpose of licensing, the UKCS is divided into quadrants of 1° of latitude by 1° of longitude (except where the coastline, "bay closing line„ or a boundary line intervenes). Each quadrant is then further subdivided into 30 blocks each of 10 x 12 minutes each with an average size of $250km^2$. Production licenses may be issued for single or groups of Blocks and may be offered again following relinquishment. For assessment purposes, SEA 3 considers the environment within bay closing lines (e.g. the Wash and the Humber) although these areas are licensed under a different regime and would not be included in an offshore licensing round.

A number of blocks within the SEA 3 area were first offered for licensing in 1964. The area comprises 362 Blocks of which 30 are currently wholly or in part under licence, 205 which have been licensed but are now wholly relinquished, and 127 which have not previously been licensed – see schematic representation in Section 4. Except to the east, the SEA 3 area surrounds the Southern North Sea gas basin which contains the majority of existing UK gas producing installations and was considered in SEA 2.

The SEA 3 area was selected by the DTI as the next to be considered for licensing on account of its prospectivity for gas (i.e. the potential to contain gas reserves in economic quantities).

The requirement for additional gas supplies to meet UK demand has been highlighted by a number of recent reports including the DTI's Energy Paper 68 "Energy Projections for the UK" of November 2000 and the Transco report "Transporting Britain's Energy 2002: Development of Investment Scenarios of July 2002".

1.5 Scope and purpose of the SEA

The proposed action is to offer Production Licences covering part of the UK sector of the North Sea through a 21st Round of offshore licensing. The purpose of this SEA is to consider the environmental implications of this action and its alternatives, and of the potential exploration, development and production activities which could result.

The SEA aimed to consider the following:

- The environmental protection objectives, standards etc established for the area relevant to the approval and subsequent implementation of the proposed action

- Any existing environmental problems in the area which may be affected by the proposed action
- Potential activities in the area
- The main mitigatory measures and alternatives investigated
- An assessment of the likely significant environmental consequences of the proposed action and its alternatives including the potential for cumulative, synergistic and transboundary effects
- Proposed arrangements for monitoring the environmental effects of the proposed action and post decision analysis of its environmental consequences
- Difficulties encountered in compiling the information and a discussion of uncertainty of impact predictions

The assessment considers the potential environmental effects of opening the area to oil and gas exploration and production activity in terms of continued or future non-oil and gas uses, environmental contamination, biodiversity and conservation of the area. The wider policy issues of continued oil and gas production from the UKCS and sustainable development of the overall national hydrocarbon reserves are not considered since these are subjects for a different appraisal forum.

This consultation document was prepared by independent consultants Hartley Anderson Limited on behalf of the DTI. Contributions to the assessment and the public consultation document have been received from the SEA Steering Group, the DTI and Geotek Limited together with the authors of the underpinning studies summarised in the subsequent sections of this document, participants in the Assessment Workshop and the Stakeholder Dialogue meeting.

1.6 Organisation of the consultation document

The consultation document comprises 12 Sections with a glossary and a non-technical summary. Figures and tables are interspersed throughout the document.

The **non-technical summary** is intended as a comprehensive stand alone summary of the SEA, its findings and conclusions.

Section 1 Introduction and Background provides both a context and guide to the main body of the report.

Section 2 Strategic Environmental Assessment Process provides an overview of the various stages and activities leading up to this public consultation phase.

Section 3 Regulatory Context summarises the requirements of the SEA Directive, the oil and gas licensing process together with an overview of environmental legislation and controls in relation to the oil and gas industry offshore.

Section 4 Activities describes the alternatives to the proposed action and the activities arising (and more fully described in a supporting document, SD_002, available on the SEA website).

Section 5 Physical and Chemical Environment describes the geology, sediments, climatic conditions and oceanography of the area, together with a consideration of the existing levels of contamination and their sources.

Section 6 Ecology addresses the biological features of the area together with their ecological importance and sensitivity to oil and gas activity.

Section 7 Coastal and Offshore Conservation Sites specifically considers habitats of relevance in the context of *The Offshore Petroleum Activities (Conservation of Habitats) Regulations, 2001* which recently entered into force.

Section 8 Users of the SEA 3 Marine and Coastal Environment describes the commercial and other human interests and activities in the offshore area.

Section 9 European Coastal Resources of Potential Relevance to SEA 3 summarises coastal resources and conservation interests in these areas.

Section 10 Consideration of the Effects of Licensing describes the method used to screen potential effects together with a more detailed consideration of those environmental interactions with the potential to cause significant effects and including cumulative, synergistic and transboundary effects. Mitigation measures are also considered.

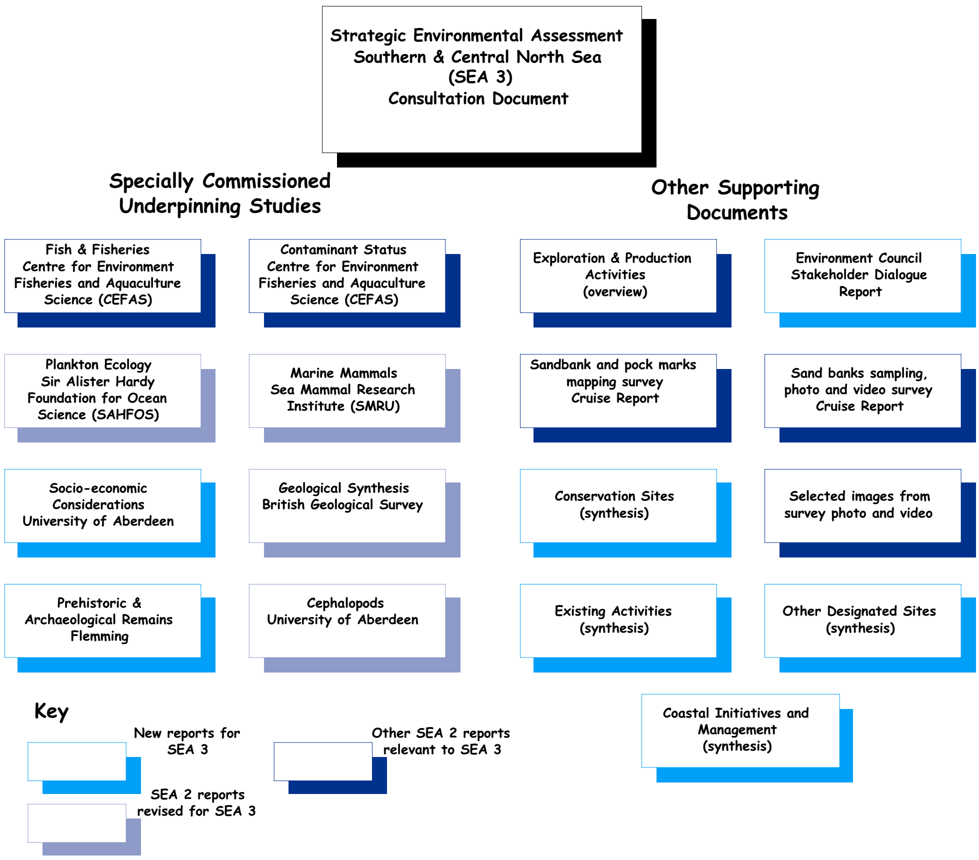
Section 11 Conclusions provides an overall conclusion regarding the likely implications of the proposed licensing and alternatives, together with recommendations for mitigation and monitoring and gaps in understanding relevant to the process.

Section 12 References lists the data sources used in the conduct of the SEA 3 and referenced in the report.

1.7 Supporting studies and documents

As part of the SEA 3 process a series of seabed surveys, independent studies and syntheses were commissioned. These reports underpin the assessment documented in this report and are available for review from the DTI's SEA website (www.habitats-directive.org) – see Figure 1.3 below.

Figure 1.3 – SEA Consultation Document, Supporting Studies and Surveys



Links to additional information sources of potential interest or use in considering the SEA 3 consultation document are included on the SEA website.

2 SEA PROCESS

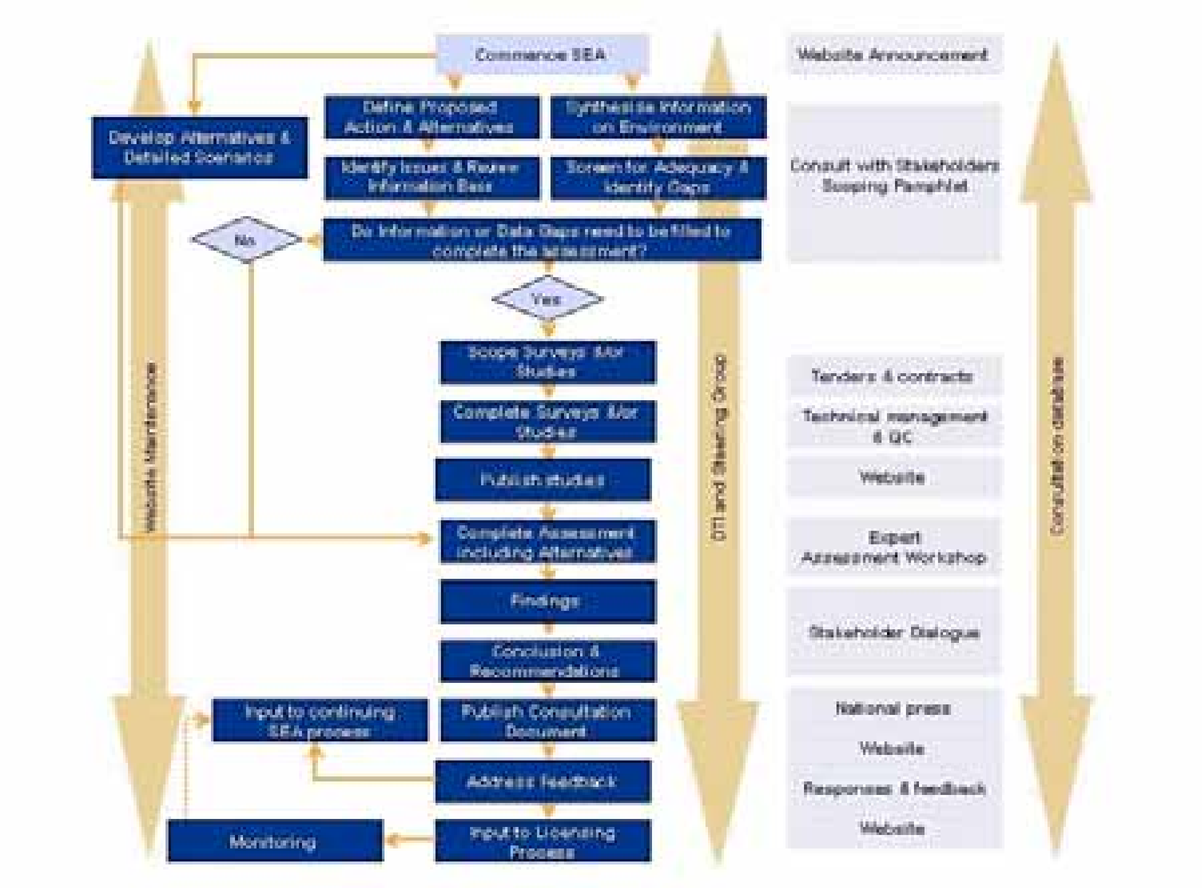
2.1 Introduction

The DTI oil and gas licensing SEA process is underpinned by the requirements of the SEA Directive together with those of the Aarhus Convention. As stated in Section 1, it is recognised that SEA form and practice will continue to develop as the DTI continues to actively seek improvement opportunities in SEA efficiency and effectiveness. Ideas and opportunities for SEA process improvements are identified through review of experience with past SEAs, consultation feedback, input from the Steering Group and DTI, active monitoring of developments in environmental assessment practice worldwide, and communication technology. The process used for SEA 3 builds on those used for SEAs 1 and 2.

2.2 Overview of the SEA process

A summary of the SEA process used for SEA 3 is given below in Figure 2.1.

Figure 2.1 – Overview of the SEA process



The SEA process aims to help inform Ministerial licensing decisions through consideration of the following:

- The environmental protection objectives, standards etc established for the area relevant to the approval and subsequent implementation of the proposed action
- Any existing environmental problems in the area which may be affected by the proposed action
- Potential activities in the area
- The main mitigatory measures and alternatives normally and potentially applied
- An assessment of the likely significant environmental consequences of the proposed action and its alternatives including the potential for cumulative, synergistic and transboundary effects
- Proposed arrangements for monitoring the environmental effects of the proposed action and post decision analysis of its environmental consequences
- Difficulties encountered in compiling the information and a discussion of uncertainty of impact predictions

In November 2000, the Cabinet Office published a code of practice on written consultation (Cabinet Office 2000) which provides criteria (which have been applied to SEA 3) for consultations involving documents in written or electronic form – see below.

Consultation criteria:

- Timing of consultation should be built into the planning process for a policy (including legislation) or service from the start, so that it has the best prospect of improving the proposals concerned, and so that sufficient time is left for it at each stage.
- It should be clear who is being consulted, about what questions, in what timescale and for what purpose.
- A consultation document should be as simple and concise as possible.
- It should include a summary, in two pages at most, of the main questions it seeks views on. It should make it as easy as possible for readers to respond, make contact or complain.
- Documents should be made widely available, with the fullest use of electronic means (though not to the exclusion of others), and effectively drawn to the attention of all interested groups and individuals.
- Sufficient time should be allowed for considered responses from all groups with an interest. Twelve weeks should be the standard minimum period for a consultation.
- Responses should be carefully and open-mindedly analysed, and the results made widely available, with an account of the views expressed, and reasons for decisions finally taken.
- Departments should monitor and evaluate consultations, designating a consultation co-ordinator who will ensure the lessons are disseminated.

Extract from Code of Practice on Written Consultation Nov 2000

Since SEA 1, the DTI oil and gas licensing SEA process has evolved and the following process improvements have been implemented:

- Establishment of a SEA Steering Group with wide representation from a range of stakeholders (established in early 2001)

- A formal scoping step with wide stakeholder involvement
- Integrated management of survey, consultation and assessment processes
- Facilitation of public consultation through dedicated website
- Publication of reports on website, CD as well as hard copy where requested
- Widespread dissemination of data and information
- Development of modular documents applicable to more than one SEA
- Syntheses of data to facilitate access
- Commissioning of expert underpinning studies
- Involvement of authors of expert underpinning studies in an assessment workshop
- Stakeholder dialogue meetings
- A streamlined public consultation document
- Continuing development of the methods for the consideration of cumulative and synergistic effects

Responsibility for the publication of the assessment document rests with the DTI. Members of the steering group, as individuals and through their organisations, may comment on the proposed licensing and the consultation materials (including this document) during the consultation phase, and are encouraging others to do likewise.

2.3 Scoping the SEA

The objective of scoping is to identify key issues of concern at an early stage so that they can be considered in appropriate detail in the SEA. Scoping also aids in the identification of information sources and data gaps that may require to be filled by studies or surveys to underpin the assessment.

The SEA 3 process included a formal scoping step the principal purposes of which were to:

- Promote stakeholder awareness of the SEA initiative
- Ensure access to all relevant environmental information
- Identify opportunities for potential collaboration and the avoidance of duplication of effort
- Identify information gaps so these can be evaluated and filled if necessary
- Identify stakeholder issues and concerns which should be considered in the SEA

Scoping involves consultation with a wide range of stakeholders and to facilitate this a scoping pamphlet is prepared which gives an overview of the:

- Proposed licensing
- The Strategic Environmental Assessment process
- Draft contents list for the public consultation assessment document
- Key information sources on the environment
- Further consultation to be conducted as part of the SEA process

For SEA 3 there were two stages to scoping; initial scoping consultation with a range of academics and conservation organisations was carried out in late 2001 focussed on ascertaining seabed survey needs. This is because of the timescale needed to organise, collect and analyse offshore seabed samples. The conclusion of that consultation was that there was sufficient existing information on seabed habitats and fauna for SEA purposes.

A broader scoping consultation exercise for SEA 3 was undertaken in Spring 2002 involving over 230 stakeholders. The scoping exercise was carried out electronically, (through circulation of a scoping pamphlet). In addition, hard copies were available for those without ready access to e-mail and internet facilities. As well as electronic communication, scoping involved meetings with key stakeholders and follow-up and clarifications with others on points and issues raised. Scoping responses and replies could be divided into 3 types:

1. No comments but would like to be kept informed especially about the stakeholder dialogue meeting
2. Provision of information or pointers to information sources
3. Raising issues to be considered in the SEA

Responses often combined types 2 and 3.

The outputs from the scoping exercise are summarised below. Issues, information sources and gaps identified during scoping fed directly into the scoping of underpinning studies, the SEA document structure and content and further consultation plans. The issues raised during scoping for consideration or more detailed consideration in SEA 3 were:

- Alternatives
- Mitigation measures
- Environmental protection objectives
- Sustainable development
- Cumulative and indirect effects
- Socio-economic effects
- Onshore developments
- Marine archaeology
- Coastal defences
- Shipping routes
- Port approaches and future development plans
- Submarine cables
- Aircraft weapons ranges
- Wind farms
- Protected landscapes
- Coastal fish and fisheries
- Adequacy of offshore seabird data
- *Sabellaria* reefs

2.4 Assessment workshop

An expert assessment workshop was held over two days in July 2002. The workshop brought the expertise of the SEA Steering Group, the authors of the SEA 2 and 3 underpinning technical reports and the SEA team to bear on the assessment process for SEA 3 – see Appendix 2 for more information on the Assessment Workshop.

The objectives of the assessment workshop were to:

- Ensure identification of all potential environmental interactions arising from activities that could follow further licensing in the SEA 3 area
- Screen the potential environmental interactions to identify those which could result in significant effects so that these can be considered further in the Public Consultation Document
- Review areas, sites and features of the SEA 3 region to identify any requiring additional protection over and above that available through existing mechanisms
- Identify gaps in information and understanding, and assess their influence on the confidence with which the SEA 3 assessment of likely effects and necessary mitigation can be made

2.5 Stakeholder dialogue meeting

A stakeholder dialogue meeting was held in York on 6 August 2002, facilitated by the independent Environment Council on behalf of the DTI. A wide variety of potential stakeholders, drawn from UK and other regulators, government advisers, local authorities, other industry representatives, academics and NGOs were invited to the session.

The dialogue session aimed to fulfil a variety of functions including to:
- inform stakeholders of the progress on SEA 3
- canvass reaction and opinion to the initial conclusions resulting from the expert assessment
- seek suggestions on ways to further improve future DTI SEAs of other areas of the UK Continental Shelf (UKCS) prior to decisions on further large scale licensing.

The meeting was attended by some fifty stakeholders and included presentations on the UK & international regulatory context, SEA 3 process, oil and gas activities that could follow further licensing, and the natural environment and human uses of the SEA 3 area. Four stations were established (covering the SEA process, the SEA 3 environment, oil & gas activities, effects and controls, and the outcome of the expert assessment workshop) each with a number of posters, which formed the basis for facilitated discussion, the outcome of which was captured on flip charts. A flip chart report of the meeting was produced by the Environment Council and is included on the SEA website as supporting document SD_003 and a summary of the issues raised in the meeting is given in Appendix 3.

2.6 Studies and surveys

Preliminary review, with input from the SEA Steering Group, of the availability of information to support preparation of the environment description for this assessment (Sections 5 – 9) concluded that a number of commissioned studies were required. These studies were commissioned either to provide expert reviews or data syntheses in areas for which synoptic overviews were not published or readily available. Scoping had concluded that additional field surveys were not required for SEA 3 although information from the SEA 2 shallow sandbanks survey in 2001 was used where relevant.

2.6.1 Studies

In addition to the studies commissioned for SEA 3, authors of the existing SEA 2 underpinning studies applicable to the wider North Sea and including the SEA 3 area were asked if the reports remained current or if new information had become available that should be incorporated into a revised report. Revised reports retain the SEA 2 report number but with a Rev 1 suffix. Applicable SEA 2, SEA 2 revised and SEA 3 reports (all available on the SEA website) are listed below:

Contaminant Status of the North Sea (TR_003) **-** This report draws on a wide range of data sources to provide an overview of the chemicals used in the offshore oil and gas industry, of the chemicals already in the environment and of those released into the environment from other sources. The report was prepared by scientists from the Centre for Environment, Fisheries and Aquaculture Science (CEFAS), with additional data supplied by the Fisheries Research Services Marine Laboratory in Aberdeen.

North Sea Fish and Fisheries (TR_004) **–** This report reviews the nature and scale of fisheries in the North Sea and impact of human activity on fish and fisheries. The report was prepared by scientists from the Centre for Environment, Fisheries and Aquaculture Science (CEFAS) Lowestoft Laboratory with additional data supplied by the Fisheries Research Services Marine Laboratory in Aberdeen.

Overview of plankton ecology in the North Sea (TR_005 Rev 1) **-** This revised SEA 2 report gives an overview of the phytoplankton and zooplankton community composition in the North Sea and how this has fluctuated through the latter half of the 20th century in response to environmental change. The study is based on a unique long-term dataset of plankton abundance in the North Atlantic and the North Sea acquired by the Continuous Plankton Recorder (CPR). The report was prepared and updated by scientists from the Sir Alister Hardy Foundation for Ocean Science (SAHFOS), which specialises in the study of plankton in the North Atlantic and the North Sea.

Marine mammals in the North Sea (TR_006 Rev 1) **-** This revised SEA 2 report describes distribution and abundance of marine mammals in the North Sea, their ecological importance, sensitivity to disturbance contaminations and disease, bycatch and other non-oil related management issues, and conservation framework. The report was prepared and updated by scientists from the Sea Mammal Research Unit, Gatty Marine Laboratory, University of St Andrews.

North Sea Geology (TR_008 Rev 1) **-** This report presents a review of (1) the evolution of deeply-buried sediments with reference to petroleum geology and production-related seabed subsidence (2) the evolution of shallow and seabed sediments with reference to present sediment distributions and seabed features (3) the evidence for possible hydrogeological exchange across selected onshore/offshore areas and (4) the history of earthquakes and the hazard that they may pose. The report was prepared by scientists from the British Geological Survey (BGS) and updated with the inclusion of maps covering SEA 3 area.

Overview of Cephalopods relevant to the SEA 2 and SEA 3 Areas (TR_009 Rev 1) **-** This report provides an overview of cephalopods – squid, octopus, cuttlefish – in the North Sea including the SEA 3 area. The report was originally prepared by Iain Young and updated by Graham Pierce and Jianjun Wang of the Department of Zoology, University of Aberdeen, where a group specialises in cephalopod research.

Conservation Sites in the SEA 3 Area (TR_010) – The wide variety of local, national, European and international designations and sites occurring in the SEA 3 area are summarised in this report. The designations addressed include those conferring statutory protection as well as those of an advisory nature. The report was produced by the SEA Team.

Other Designated Sites in the SEA 3 Area (TR_011) – The SEA 3 area includes a large number of other sites designated for a variety of other interests including archaeology, heritage, geology, bathing water quality, bivalve shellfish production etc. An overview of these designations and sites is provided by this report which was produced by the SEA Team.

Coastal Initiatives and Management Plans in the SEA 3 Area (TR_012) – This report provides an overview of the various management plans which have been developed for the coastal zone, coastal defence, estuaries, biodiversity and coastal habitats covering the SEA 3 area. The report was produced by the SEA Team.

The Potential Socio-Economic Implications of Licensing the SEA 3 Area (TR_013) - This study provides forecast information on probable activity levels, capital expenditure, tax revenues and employment resulting from exploration and production in the proposed 21st Round areas. The report was prepared by Linda Stephen and Alex Kemp of the Department of Economics, University of Aberdeen.

The scope of Strategic Environmental Assessment of North Sea areas SEA3 and SEA2 in regard to prehistoric archaeological remains (TR_014) – This report documents the known and likely occurrence of prehistoric submarine archaeological remains across the North Sea including the SEA 3 area, and makes suggestions on how to enhance the finding and reporting of such artefacts. The document has been prepared by independent scientist Nic Flemming, an authority on submarine archaology.

Human activities in the Sea 3 Area (TR_015) **-** This report is a synthesis of information on human activities in the SEA 3 area which might have an impact on, or themselves be affected by, further oil and gas developments in the SEA 3 areas. The activities include shipping, energy (both existing oil and gas developments and renewable energy), telecommunications, military activities, waste disposal, dredging and aggregate extraction, marine archaeological sites and wrecks. The report was produced by the SEA Team.

The commissioned studies listed above, are available for download as pdf files from the SEA website or in CD or paper copy from the SEA Coordinator (Ms Christine Weare), DTI Oil and Gas Directorate, 86-88 Atholl House, Guild Street, Aberdeen, AB11 6AR.

2.6.2 SEA 2 Sandbank surveys

Information from the SEA 2 shallow sandbanks survey in 2001 was used for SEA 3 where relevant. This survey specifically addressed specific seabed features such as offshore shallow (< 20m) sand areas including linear sandbanks and the shallow parts of the Dogger Bank. The survey was carried out between April and June 2001 and comprised a geophysical leg and biological sampling leg from *S/V Kommandor Jack* and a sampling leg over crests of the Norfolk Banks using the shallow draught vessel *R/V Vigilance.* Following high resolution swathe bathymetry and shallow profiling during the geophysical leg, seabed sampling was carried out using a Van Veen grab in the sandbank and Dogger Bank areas. Video and stills photographs were also obtained in all three survey areas.

2.7 Further consultation process

Key elements of public and stakeholder consultation and input to the SEA 3 process are:

- Scoping consultation (winter 2001, and spring 2002)
- Stakeholder dialogue meeting at the draft assessment stage (summer 2002)
- A 3 month public consultation period following publication of the SEA 3 documents on the website (autumn 2002)
- Post consultation report (winter 2002/3)

The SEA 3 consultation document and supporting documents are available for review and public comment for a period of 90 days from the middle of September 2002. The documents are being made available from the SEA website or on CD or printed copy. Comments and feedback may be made via the website or by fax or letter to the contact in Section 2.6.1 above.

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3 REGULATORY CONTEXT

3.1 SEA Directive

The Treaty establishing the European Community, *"provides that Community policy on the environment is to contribute to,* inter alia*, the preservation, protection and improvement of the quality of the environment, the protection of human health and the prudent and rational utilisation of natural resources and that it is to be based on the precautionary principle."*

The Treaty also provides *"that environmental protection requirements are to be integrated into the definition of Community policies and activities, in particular with a view to promoting sustainable development."*

Directive 2001/42/EC of the European Parliament and of the Council of 27 June 2001 on the assessment of the effects of certain plans and programmes on the environment came into force on 21 July 2001. Member States have several years to put in place the mechanisms necessary to comply with the Directive's requirements. In future, for a number of sectors all plans and programmes which set a framework for future development consent of projects listed in Annexes I and II to *Council Directive 85/337/EEC* (the EIA Directive), and all plans and programmes which have been determined to require assessment pursuant to Council *Directive 92/43/EEC* (the Habitats Directive), are likely to have significant effects on the environment, and should as a rule be made subject to systematic environmental assessment. When they determine the use of small areas at local level or are minor modifications to the above plans or programmes, they should be assessed only where Member States determine that they are likely to have significant effects on the environment.

Strategic environmental assessment is an important tool for integrating environmental considerations into programmes and plans because it ensures that such effects of implementing plans and programmes are taken into account during their preparation and before their adoption.

The SEA Directive sets out the information to be included in the report of the Strategic Environmental Assessment:

- An outline of the contents, main objectives of the plan or programme and relationship with other relevant plans and programmes
- The relevant aspects of the current state of the environment and the likely evolution thereof without implementation of the plan or programme
- The environmental characteristics of areas likely to be significantly affected
- Any existing environmental problems which are relevant to the plan or programme including, in particular, those relating to any areas of a particular environmental importance, such as areas designated pursuant to Directives 79/409/EEC and 92/43/EEC (the Birds and Habitats Directives)
- The environmental protection objectives, established at international, Community or Member State level, which are relevant to the plan or programme and the way those objectives and any environmental considerations have been taken into account during its preparation
- The likely significant effects on the environment, including on issues such as biodiversity, population, human health, fauna, flora, soil, water, air, climatic factors, material assets, cultural heritage including architectural and archaeological heritage, landscape and the interrelationship between the above factors
- The measures envisaged to prevent, reduce and as fully as possible offset any significant adverse effects on the environment of implementing the plan or programme

- An outline of the reasons for selecting the alternatives dealt with, and a description of how the assessment was undertaken including any difficulties (such as technical deficiencies or lack of know-how) encountered in compiling the required information
- A description of the measures envisaged concerning monitoring
- A non-technical summary of the information provided under the above headings

These effects should include secondary, cumulative, synergistic, short, medium and long-term permanent and temporary, positive and negative effects.

ANNEX II of the SEA Directive sets out the criteria for determining the likely significance of effects. These are listed below:

- The characteristics of plans and programmes, having regard, in particular, to:
  - the degree to which the plan or programme sets a framework for projects and other activities, either with regard to the location, nature, size and operating conditions or by allocating resources
  - the degree to which the plan or programme influences other plans and programmes including those in a hierarchy
  - the relevance of the plan or programme for the integration of environmental considerations in particular with a view to promoting sustainable development
  - environmental problems relevant to the plan or programme
  - the relevance of the plan or programme for the implementation of Community legislation on the environment (e.g. plans and programmes linked to waste-management or water protection)

- Characteristics of the effects and of the area likely to be affected, having regard, in particular, to:
  - the probability, duration, frequency and reversibility of the effects
  - the cumulative nature of the effects
  - the transboundary nature of the effects
  - the risks to human health or the environment (e.g. due to accidents)
  - the magnitude and spatial extent of the effects (geographical area and size of the population likely to be affected)
  - the value and vulnerability of the area likely to be affected due to:
    - special natural characteristics or cultural heritage,
    - exceeded environmental quality standards or limit values
    - intensive land-use
    - the effects on areas or landscapes which have a recognised national, Community or international protection status

3.2 Licensing

Exploration and production in the oil and gas industry is regulated primarily through a licensing system managed by the DTI Oil and Gas Directorate's Exploration and Licensing Branch. A brief overview of the offshore or "Seaward" licensing process is given below, more detail can be found on the DTI's website at www.og.dti.gov.uk/upstream/licensing.

The various Orders made under the *Continental Shelf Act 1964* which designated areas of the UK continental shelf for hydrocarbon and mineral exploration were consolidated by the *Continental Shelf (Designation of Areas) (Consolidation) Order 2000 SI 2000 No. 3062*.

The *Petroleum Act 1998*, entered into force in 1999 and consolidated a number of provisions previously contained in five earlier pieces of primary legislation. The Act vests ownership of oil and gas within Great Britain and its territorial sea in the Crown, and gives Government rights to grant licences to explore for and exploit these resources and those on the UK Continental Shelf (UKCS). Regulations set out how applications for licences may be made, and specify the Model Clauses to be incorporated into the licences.

There are two types of Seaward Licences:

- **Exploration Licences** which are non-exclusive, permit the holder to conduct non-intrusive surveys, such as seismic or gravity and magnetic data acquisition, over any part of the UKCS not held under a Production Licence. Wells may be drilled under these licences, but must not exceed 350 metres in depth without the approval of the Secretary of State. These licences may be applied for at any time and are granted to applicants who have the technical and financial resources to undertake such work. Each licence is valid for three years, renewable at the Secretary of State's discretion for one further term of three years. Exploration licence holders may be commercial geophysical survey contractors or Production Licence Operators. A commercial contractor acquiring data over unlicensed acreage may market such data.

- **Production Licences** grant exclusive rights to holders "to search and bore for, and get, petroleum", in the area of the licence covering a specified block or blocks. For licensing purposes the UKCS is divided into quadrants of 1° of latitude by 1° of longitude (except where the coastline, "bay closing line" or a boundary line intervenes). Each quadrant is further partitioned into 30 blocks each of 10 x 12 minutes. The average block size is about 250 square km (roughly 100 square miles). Relinquishment requirements on successive licences have created blocks subdivided into as many as six part blocks. Production Licences are usually issued in periodic "Licensing Rounds", when the Secretary of State for Trade and Industry invites applications in respect of a number of specified blocks or other areas.

Activities carried out under an Exploration or Production Licence require the consent of the Secretary of State and compliance with other legislative provisions and specific conditions attached to the consent – see below.

3.3 Control of operations

There is a wide range of International, European Union, UK and industry measures aimed at protecting the marine environment. A wide range of international agreements, conventions and legislation apply to offshore activities including:

- MARPOL 73/78 is the International Convention for the Prevention of Pollution from Ships 1973 as modified by the Protocol of 1978. MARPOL contains six annexes covering pollution by oil, noxious liquids carried in bulk, harmful substances in packaged form, sewage, garbage and air pollution. MARPOL applies to shipping of various types and in part to oil rigs and production installations

- OSPAR is the Convention for the Protection of the Marine Environment of the North East Atlantic 1992 which entered into force in March 1998. OSPAR amalgamates the principles of the 1972 Oslo and 1974 Paris Conventions and requires the application of:

    - the precautionary principle
    - the polluter pays principle

- best available techniques (BAT) and best environmental practice (BEP), including clean technology

There are currently five annexes to the convention in force:

- Annex I: Prevention and elimination of pollution from land-based sources
- Annex II: Prevention and elimination of pollution by dumping or incineration
- Annex III: Prevention and elimination of pollution from offshore sources
- Annex IV: Assessment of the quality of the marine environment
- Annex V: Protection and conservation of the ecosystem and biological diversity of the maritime area

- Under the 1987 United Nations Agreement on substances that deplete the ozone layer, the Montreal Protocol, governments agreed to phase out production and use of chlorofluorocarbons, halons and other chemicals that destroy ozone in the stratosphere. The Protocol has been periodically reviewed and strengthened in the light of new scientific evidence. The EC implemented the revised Protocol through Regulation 3093/94. The UK has been able to meet the requirements of the Protocols through voluntary co-operation with industry and consumers.

- The Convention on Environmental Impact Assessment in a Transboundary Context was signed in 1991 (the Espoo Convention). This applies to various major activities with the potential to cause transboundary effects and includes offshore hydrocarbon production and large diameter oil & gas pipelines. Projects need to be screened for the potential transboundary effects and an Environmental Impact Assessment and international consultation conducted if necessary.

- The United Nations Framework Convention on Climate Change was signed in 1997 (the Kyoto Protocol) and forms a basis for reductions of greenhouse gas emissions. Six priority gases were identified including carbon dioxide, methane and nitrous oxide. The measures to be taken are to be decided by individual nations.

- The United Nations Convention on Biodiversity (the Rio Convention) was opened for signature at the Rio Earth Summit (1992) and aims to promote the conservation of biological diversity, the sustainable use of its components and the sharing of the benefits of genetic resources. Specific programmes are required for the identification of important components of biodiversity and their understanding and protection (see also OSPAR Annex five). The UK has published a biodiversity action plan (and various subsidiary plans) as part of its implementation of the Convention.

- The International Convention on Oil Pollution Preparedness, Response and Co-operation (OPRC), 1990 entered into force in 1995 and provides a framework for international co-operation in combating major incidents or threats of marine pollution. The UK has established Regulations to implement the convention – see below.

- The UK is party to the Convention on the Conservation of Migratory Species of Wild Animals (also known as CMS or the Bonn Convention) which aims to conserve terrestrial, marine and avian migratory species throughout their range through international cooperation. The UK is party to several agreements which have been concluded to date under the auspices of CMS e.g. the Agreement on the Conservation of Small Cetaceans of the Baltic and North Seas (ASCOBANS).

- The UK is a party to the Convention on Wetlands which was adopted in Ramsar in 1971, and came into force in 1975.

There are numerous pieces of legislation applicable to UK offshore oil and gas activities and a summary of the main environmental controls is given below. As the majority of international and EU measures require UK legislation for implementation, the list below focuses primarily on UK legislation with reference to relevant European or International legislation where this aids clarity. Copies of recent source legislation may be reviewed at www.hmso.gov.uk .

Note - Any development within nearshore waters will be subject to controls additional to those described below, for example, discharges to controlled waters would also come under the remit of the Environment Agency through the Water Resources Act 1991 as amended by the Environment Act 1995 and associated regulations.

Aspect or Activity	Notes
Approvals/Consents for Developments and Wells	The *Petroleum Act, 1998* provides the basis for granting licences to explore for and produce oil and gas. Production licences grant exclusive rights to the holders to "search and bore for, and get, petroleum" in specific blocks. Many of the detailed regulatory provisions are laid down in conditions attached to Licences. These conditions ("Model Clauses") are published in secondary legislation. In the past, they have been incorporated into each Licence by means of a single short paragraph, but with the 20th round they were set out in full in each Licence. A number of different sets of Model Clauses were gathered together in the *Petroleum (Current Model Clauses) Order 1999 (No 160).* It is the Licensee's responsibility to ensure that relevant conditions are not breached. Under the terms of a Production Licence, Licensees require the authorisation of the Secretary of State before installing facilities or producing hydrocarbons. Approval for development programmes and consent for wells, extended well tests, incremental projects and production consents are contingent on complying with the requirements of the *Offshore Petroleum Production and Pipe-lines (Assessment of Environmental Effects) Regulations 1999* The *Offshore Petroleum Production and Pipe-lines (Assessment of Environmental Effects) Regulations 1999* implement the 1985 and 1997 EC Directives on the "Assessment of the effects of certain public and private projects on the environment" with regard to the offshore oil and gas industry. The regulations require an environmental impact assessment and a public consultation document, an Environmental Statement (ES) to be submitted for certain projects including new developments with expected production >500 tonnes of oil/day or 500,000 cubic metres of gas/day. A number of projects (very small developments below the thresholds above, the drilling of wells, extended well tests, modifications to existing developments and small to medium-sized pipelines) may not need an ES to be prepared if a preliminary assessment demonstrates to the satisfaction of the Secretary of State that the project is unlikely to cause a significant adverse environmental impact. In such circumstances a direction from the Secretary of State may be sought that an ES is not required using the appropriate *Petroleum Operations Notice* (PON15). The PON15 must, as far as possible, be a stand alone document and contain sufficient information about the proposed project, its expected location and an environmental assessment to provide a basis for a determination to be made. The *Coast Protection Act (CPA) 1949 (as extended by the Continental Shelf Act 1964),* provides that where obstruction or danger to navigation is caused or is likely to result, the prior written consent of the Secretary of State for the DTLR (now Department for Transport) is required for the siting of the offshore installation - whether mobile or permanent - in any part of the UK designated areas of the Continental Shelf. In practice, this means that consent must be obtained for each drilling operation and for all offshore production facilities. Offshore safety zones (500m in radius) are automatically established for fixed and floating installations. Safety zones for subsea installations and wells to minimise potential damage from third party activities (anchoring, fishing) are established by Order following an application from an Operator.
Approvals/Consents for	The *Petroleum Act, 1998* requires an authorisation (Pipeline Works

Pipelines

Authorisation) from the DTI for the use of or works for the construction of a submarine pipeline. The application process includes a formal consultation process. The authorisation may include conditions for the design, route, construction and subsequent operation of the pipeline. The Pipeline Works Authorisation process has been streamlined and also includes consenting for the placement of concrete mattresses and rock dumping (DEPCON).

The *Offshore Petroleum Production and Pipe-lines (Assessment of Environmental Effects) Regulations 1999* require an environmental impact assessment and an ES to be submitted for certain projects including new pipelines with expected production >40km in length and 800mm in diameter.

Small to medium-sized pipelines may not need an ES to be prepared if a preliminary assessment demonstrates to the satisfaction of the Secretary of State that the project is unlikely to cause a significant adverse environmental impact. In such circumstances a direction from the Secretary of State may be sought that an ES is not required using the appropriate PON15. The PON15 must, as far as possible, be a stand alone document and contain sufficient information about the proposed project, its expected location and an environmental assessment to provide a basis for a determination to be made.

Approval of the Pipeline Works Authorisation is contingent on complying with the above requirements.

Activities which may Potentially Affect SACs, SPAs or other Protected Conservation Interests

The *Offshore Petroleum Activities (Conservation of Habitats) Regulations, 2001* implement European Directives for the protection of habitats and species namely, Council Directive 92/43 on the conservation of natural habitats and of wild fauna and flora and Council Directive 79/409 on the conservation of wild birds in relation to oil and gas activities carried out in whole or in part on the UKCS. The DTI's Oil and Gas Directorate is the Competent Authority. The Secretary of State will, where it is considered that an activity completed under a project consent may have a significant effect on a Special Area of Conservation (SAC) or Special Protection Area (SPA), conduct an Appropriate Assessment (AA) prior to granting the consent. In territorial waters (12 nm) above Directives are implemented by the *Conservation (Natural Habitats, &c.) Regulations 1994*., birds, marine mammals and other wildlife also receive protection under the *Wildlife and Country Side Act 1981* (as amended) and the Countryside and Rights of Way Act 2000 which updates Wildlife and Countryside Act.

Consents for Seismic Surveys

The *Offshore Petroleum Activities (Conservation of Habitats) Regulations, 2001* require prior consent in writing from the DTI for the conduct of geological surveys outside territorial waters – this includes seismic surveys, rig site surveys and pipeline route surveys. Application for consent is made using *Petroleum Operations Notice No 14* (PON14) supported by an Environmental Narrative to enable an accurate assessment of the environmental effects of the survey. Consultations with Government Departments and other interested parties is conducted prior to issuing consent.

Surveys in territorial waters (i.e. from the low water mark up to 12 nautical miles offshore) are covered by the *Conservation (Natural Habitats & c) Regulations 1994 (as amended*). For surveys wholly or partially in territorial waters a PON14b is used to notify the DTI with an accompanying environmental narrative and consultations as above.

The *JNCC Guidelines for Minimising acoustic disturbance to marine mammals from seismic surveys (JNCC Guidelines* www.jncc.gov.uk *)* must be followed at all times for all seismic surveys.

At the end of each survey the operator is required to submit a report of the survey and the marine mammal observations to the JNCC.

Discharge of Drill Muds and Cuttings

OSPAR Decision 2000/3 on the Use of Organic-Phase Drilling Fluids (OPF) and the Discharge of OPF-Contaminated Cuttings came into force in January 2001. It applies to the use and discharge of all organic phase drilling fluids that is both oil based *and* synthetic based drilling fluids. No such fluids may be used without prior authorisation (normally through the PON15/ Environmental Statement process), and discharge of cuttings to sea with a concentration >1% by weight of oil based fluids on dry cuttings is prohibited. The discharge to sea of cuttings contaminated with synthetic fluids will only be authorised in exceptional circumstances. For water based muds control see also chemical use and discharge section below.

Chemical Use and Discharge

The Offshore Chemical Notification Scheme has been superseded by new chemical regulations, the *Offshore Chemicals Regulations 2002*, which implement the recently adopted OSPAR Decision (2000/2) and Recommendations (2000/4 and 2000/5) introducing a Harmonised Mandatory Control System for the use and reduction of the discharge of offshore chemicals. The regulations have introduced a permit system for the use and discharge of chemicals offshore which includes a requirement for site specific risk assessment. A new database ranks chemicals by hazard, based on a PEC:PNEC (Predicted Effect Concentration : Predicted No Effect Concentration) approach. Separate permits are required for drilling, production and pipeline chemicals.

Produced Water

The *Prevention of Oil Pollution Act, 1971 (POPA) (as amended)* and associated Regulations prohibit the discharge of oil or oily mixtures to sea from any offshore installation or pipeline. The Act provides for exemptions to be obtained to allow lawful discharge of treated produced water, sand and other operational discharges. The current standard for produced water discharges is maximum monthly average of 40mg/kg oil-in-water.

OSPAR Recommendation 2000/1 for the Management of Produced Water from Offshore Installations came into force in June 2001. It provides for a reduction in the discharge of oil in produced water by 15% over a five year period and a lowering of the discharge concentration from each installation to 30mg/l over the same period. and applies to the use and discharge of all organic phase drilling. The recommendation also includes a presumption against the discharge to sea of produced water from new developments.

Drainage

The *Merchant Shipping (Prevention of Oil Pollution) Regulations, 1996 (as amended)* give effect to Annex I of MARPOL 73/78 (prevention of oil pollution) in UK waters. They address oily drainage from machinery spaces on vessels and installations. The North Sea is designated a "Special Area", within which the limit for oil in discharged water from these sources is 15ppm. Vessels and installations are required to hold a valid UKOPP (UK Oil Pollution Prevention) or IOPP (International Oil Pollution Prevention) Certificate.

Deposits to Sea

The *Food and Environment Protection Act 1985 (as amended)* is a mechanism through which deposits in the sea are regulated. The *Deposits in the Sea Exemptions Order 1985* exempts a range of non-oil operational discharges, including drilling cuttings, associated with the exploration and production of oil and gas from the licensing requirements of the Act. However, these discharges (for example where chemicals are concerned) are also controlled by various mechanisms as described elsewhere in this section.

Flaring and Venting

A consent to flare or vent gas is also required from the DTI under the terms of the Model Clauses incorporated into Production Licences (see also the *Gas Act 1986*, as amended for venting).

Other combustion emissions

The *Offshore Combustion Installations (Prevention and Control of Pollution) Regulations, 2001* introduced Integrated Pollution Prevention and Control (IPPC) to offshore oil and gas combustion installations with a combined total rated thermal input exceeding 50 MW. Under the Regulations an IPPC Permit will be required in order to operate a qualifying offshore installation. The permit will be granted with conditions that will include provisions based on best available techniques, emission limits, and monitoring requirements. Existing installations must comply by October 2007.

Waste

The *Merchant Shipping (Prevention of Pollution by Garbage) Regulations, 1998* implement Annex IV of MARPOL 73/78 and apply to all fixed and floating offshore installations (including rigs) and their support vessels operating on the UKCS. All domestic and operational wastes, except ground food waste must be stored and taken to shore for disposal.

Food ground to particles 25mm or less may be discharged overboard but only if 12 nautical miles or more offshore. Installations and vessels are required to have a Garbage Management Plan or equivalent.

The *Environmental Protection Act 1990* and associated regulations introduced a *"Duty of Care"* for all controlled wastes. Waste producers are required to ensure that wastes are identified, described and labelled accurately, kept securely and safely during storage, transferred only to authorised persons and that records of transfers (waste transfer notes) are maintained for a minimum of two years. Carriers and waste handling sites require licensing. Although the Act does not apply to offshore installations, it requires operators to ensure that offshore waste is handled and disposed onshore in accordance with the *Duty of Care* introduced by the Act.

Additional controls are applied to more hazardous (special) types of controlled waste by the *Special Waste Regulations 1996 (as amended)*. These Regulations require controlled wastes that are also considered to be special wastes because of their potentially harmful properties, to be correctly documented, recorded and disposed at an appropriately licensed site. Records of transfers (special waste consignment notes) are to be maintained for a minimum of three years.

Oil spill response and reporting

The *Merchant Shipping (Oil Pollution Preparedness, Response and Co-operation Convention) Regulations, 1998* came into force in May 1998 and require all existing offshore installations including drilling from rigs and oil handling facilities (e.g. pipelines) to have an approved oil spill contingency plan. Oil spill plans must be submitted to the DTI for approval at least two months in advance of commencement of operations. Oil Spill Contingency Plans are required to follow a defined format and to include spill risk assessment.

Under the *Merchant Shipping (Prevention of Oil Pollution) Regulations, 1996 (as amended)* vessels and drilling rigs are also required to hold a current, approved Shipboard Oil Pollution Emergency Plan (SOPEP) in accordance with guidelines issued by the Marine Environment Protection Committee of the International Maritime Organisation.

All oil spills are required to be reported as soon as possible, regardless of size to the Coastguard, DTI and other relevant authorities according to the instructions and format included with *Petroleum Operations Notice 1* (PON 1).

The *Offshore Installations (Emergency Pollution Control) Regulations 2002* entered into force in July 2002 and implement the recommendations from Lord Donaldson's review insofar as they relate to the oil and gas industry. The Regulations give the Government powers to intervene in the event of an incident involving an offshore installation where there is, or may be a risk of, significant pollution, or where an operator is failing or has failed to implement effective control and preventative operations.

Use of radioactive sources

Under the *Radioactive Substances Act 1993* a registration certificate from the Environment Agency or Scottish Environment Protection Agency is required to keep and use radioactive sources offshore. The certificate contains details of source type, activity and purpose.

Low specific activity material

Onshore and offshore storage and disposal of naturally occurring radioactive materials (NORM) is regulated under the *Radioactive Substances Act 1993* and operators are required to hold, for each relevant installation, an authorisation to store and dispose of radioactive waste such as low specific activity scale (LSA) which may be deposited in vessels and pipework. The Authorisation specifies the route and method of disposal. Records of disposals are required.

Decommissioning

The UK's international obligations on decommissioning are governed principally by the OSPAR Convention. Agreement on the regime to be applied to the decommissioning of offshore installations in the Convention area was reached at a meeting of the OSPAR Commission in July 1998. Under the *Petroleum Act 1998,* operators proposing to decommission an installation must submit a Decommissioning Programme with supporting Environmental Impact Statement to the DTI for approval prior to any works being commenced. Consultation is a required element of the process

DTI guidance indicates a presumption that all offshore installations will be re-used, recycled or disposed of on land and that any exceptions to that general rule will be assessed individually in accordance with the provisions of OSPAR Decision 98/3.

4 ACTIVITIES

4.1 Introduction

The possible scale of exploration and development activity which could result from a 21st Round of UKCS licensing covering parts of the central and southern North Sea (SEA 3 area) are summarised below. The proposed licensing round would offer Production Licences for marine areas, excluding areas within bay closure lines since these fall under a separate licensing regime see Section 1.4. Much of the SEA 3 area has been previously licensed – see Section 4.2.1.

4.2 Alternatives

SEA 3 is the third of a series of DTI Strategic Environmental Assessments which will, over time, address the entire UK Continental Shelf (UKCS) prior to decisions on further large scale licensing. The DTI has divided the UKCS into a number of areas with the SEA 3 area being selected as the next to consider for licensing, based on knowledge of the geological conditions together with availability of existing oil and gas infrastructure. Alternatives proposed for the development of the oil and gas resources within the proposed 21st Round area have been identified as:

1. Not to offer any blocks for Production Licence award
2. To proceed with the licensing programme as proposed
3. To restrict the area licensed temporally or spatially

The implications of the alternatives are considered in Sections 10 (Consideration of the Effects of Licensing) and 11 (Conclusions). In order to complete the assessment, estimates of the level of activity that might follow from licensing in the SEA 3 area have been developed (see Section 4.2.3) based on the expected prospectivity of the area (see Section 4.2.2).

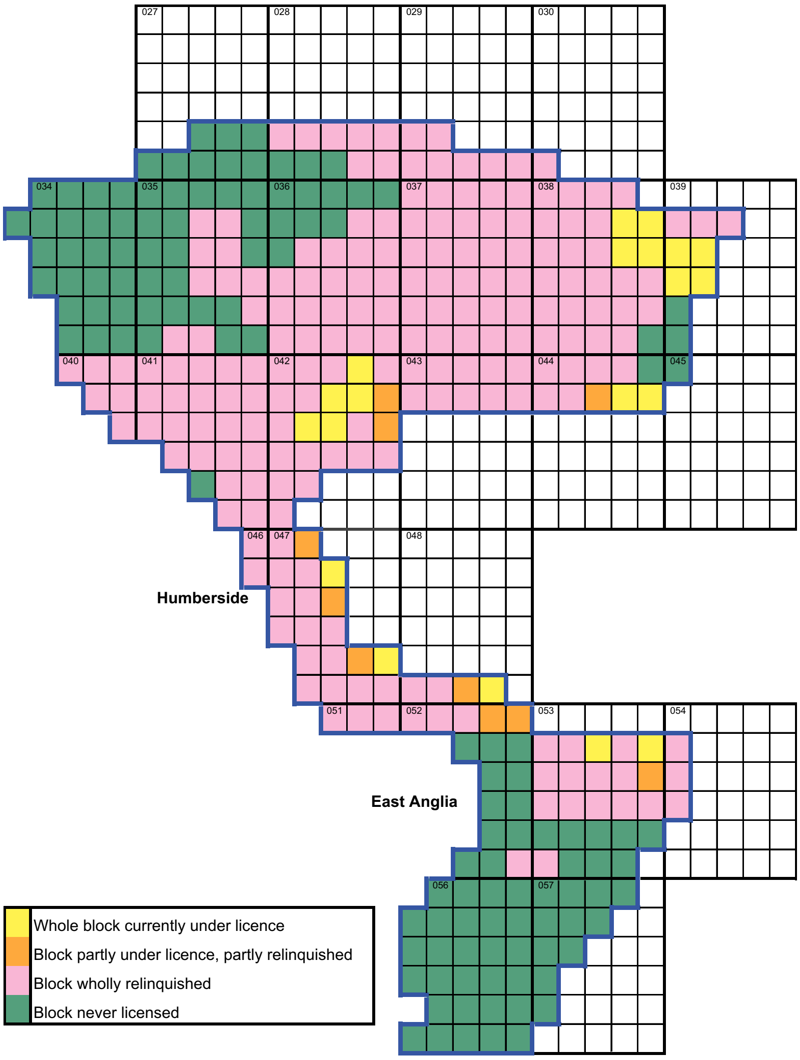
These activity estimates include seismic, exploration drilling and production phases and must only be considered as indicative.

4.2.1 Licensing history

Blocks within the SEA 3 area were first offered for licensing in 1964. The area comprises 362 blocks of which 30 are currently wholly or in part under licence, 205 which have been licensed but are now wholly relinquished, and 127 which have not previously been licensed – see schematic representation in Figure 4.1.

Some of the 21st Round blocks, have been split, with a proportion of the block relinquished and the remainder still licensed - often with a developed field or undeveloped discovery within the retained portion.

Figure 4.1 – Schematic of blocks in the quadrants within the SEA 3 area, either currently licensed or potentially available for licensing



(Source: DTI 2001)

4.2.2 Prospectivity

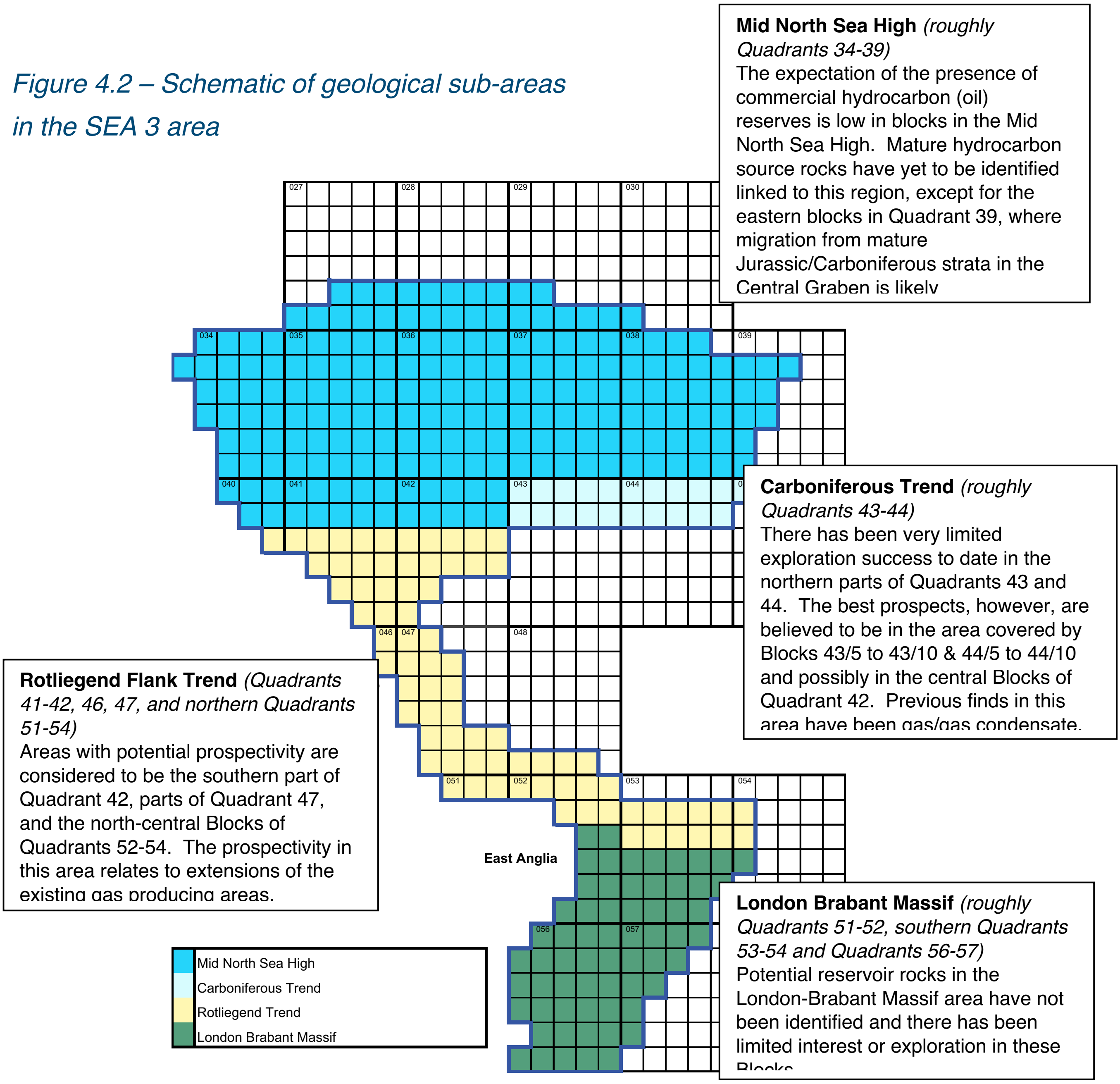
For commercial hydrocarbon resources to occur, a number of factors and features have to coincide. These include:

- The presence of source rocks, with an appreciable organic matter content
- Adequate depth of burial to allow the conversion of the organic matter to oil or gas through the action of temperature and pressure
- The presence of rocks with sufficient porosity to allow the accumulation of oil or gas
- Cap or seal rocks to prevent the oil or gas from escaping from the reservoir rocks
- Migration pathways to permit oil and gas formed from the source rocks to move to reservoir formations

The gas fields of across the southern North Sea are formed from Carboniferous source rocks and trapped in Rotliegend sandstones (reservoir rocks) by Zechstein salts (rock salt) which form an impervious seal.

The SEA 3 area can be divided into 4 sub-areas based on geological characteristics and potential for finding hydrocarbon reserves – see Figure 4.2:

Figure 4.2 – Schematic of geological sub-areas in the SEA 3 area



4.2.3 Estimates of potential activity

Both exploration and development activity levels and timing would depend on a range of factors including the number of blocks licensed, work programme commitments made by licensees, exploration success, economic and commercial factors and Government approval of project development plans.

These forecasts of potential activity were developed by the DTI Licensing Branch. They are not based on detailed mapping, but on a broad understanding of the geology of the areas involved, anticipated applications for the blocks, currently known but undeveloped reserves which are in unlicensed blocks, and the likely exploration success rates. Predicted numbers are therefore indicative only.

However, it should be noted that since much of the area has limited potential for commercial oil and gas reserves and uptake of the Blocks offered is expected to be low at around 10%.

Estimated Scale of Seismic Data Collection:

Mid North Sea High	50-100 km 2D seismic and less than 250 km^2 3D seismic
Carboniferous Trend	250-1250 km^2 3D seismic
Rotliegend Flank Trend	50-100 km 2D seismic, 250-1250 km^2 3D seismic
London Brabant Massif	none
TOTAL	100-200 km 2D seismic, 500- 2500 km^2 3D seismic

Estimated Number of Exploration Wells (drilled within the primary 4 year term of licences awarded)

Mid North Sea High	less than 5 wells
Carboniferous Trend	3-5 wells
Rotliegend Flank Trend	3-5 wells
London Brabant Massif	none
TOTAL	6-15 wells

Estimated Number of Developments

Subsea tieback	1-5 developments tied to existing infrastructure
Stand alone	up to 2 platforms tied to existing infrastructure

The low estimated number of developments which might result from licensing the SEA 3 area reflects the limited prospectivity of the area – see Figure 4.2. In addition to new discoveries, there is the potential for decommissioned fields to be re-examined in light of changes in technology and geological interpretation. The only decommissioned field in the SEA 3 area is the Forbes gas field in Block 43/8 where production ceased in early 1993. There is potential for re-developing this field and since the licence for the block was relinquished, it is potentially available for re-licensing subject to the outcome of SEA 3 and Ministerial consideration.

4.3 Stages of activity

The main stages and activities associated with the licensing process and subsequent exploration, development and production of offshore oil and gas resources are described in Supporting Document *An overview of offshore oil and gas exploration and production activities* (SD_002). This is available as a pdf file on the SEA website, and the key stages in the lifecycle are shown in Figure 4.3 overleaf.

Figure 4.3 – Oil and Gas Exploration and Production Lifecycle

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5 PHYSICAL CHEMICAL ENVIRONMENT

5.1 North Sea overview

The SEA 3 area comprises two contiguous parts: the central North Sea north of the Dogger Bank and south of Devils Hole; and the coastal margin of eastern England.

The Greater North Sea, as defined by the OSPAR Quality Status Report produced in 2000, is situated on the continental shelf of north-west Europe. It opens into the Atlantic Ocean to the north and via the Channel to the south-west, and into the Baltic Sea to the east, and is divided into a number of loosely defined areas. The North Sea is often divided into the relatively shallow southern North Sea (including e.g. the Southern Bight and the German Bight), the central North Sea, the northern North Sea, the Norwegian Trench and the Skagerrak. The shallow Kattegat is seen as a transition zone between the Baltic and the North Sea. The Greater North Sea (including its estuaries and fjords) has a surface area of about 750,000km^2 and a volume of about 94,000km^3. Bathymetry of the North Sea is shown in Figure 5.1.

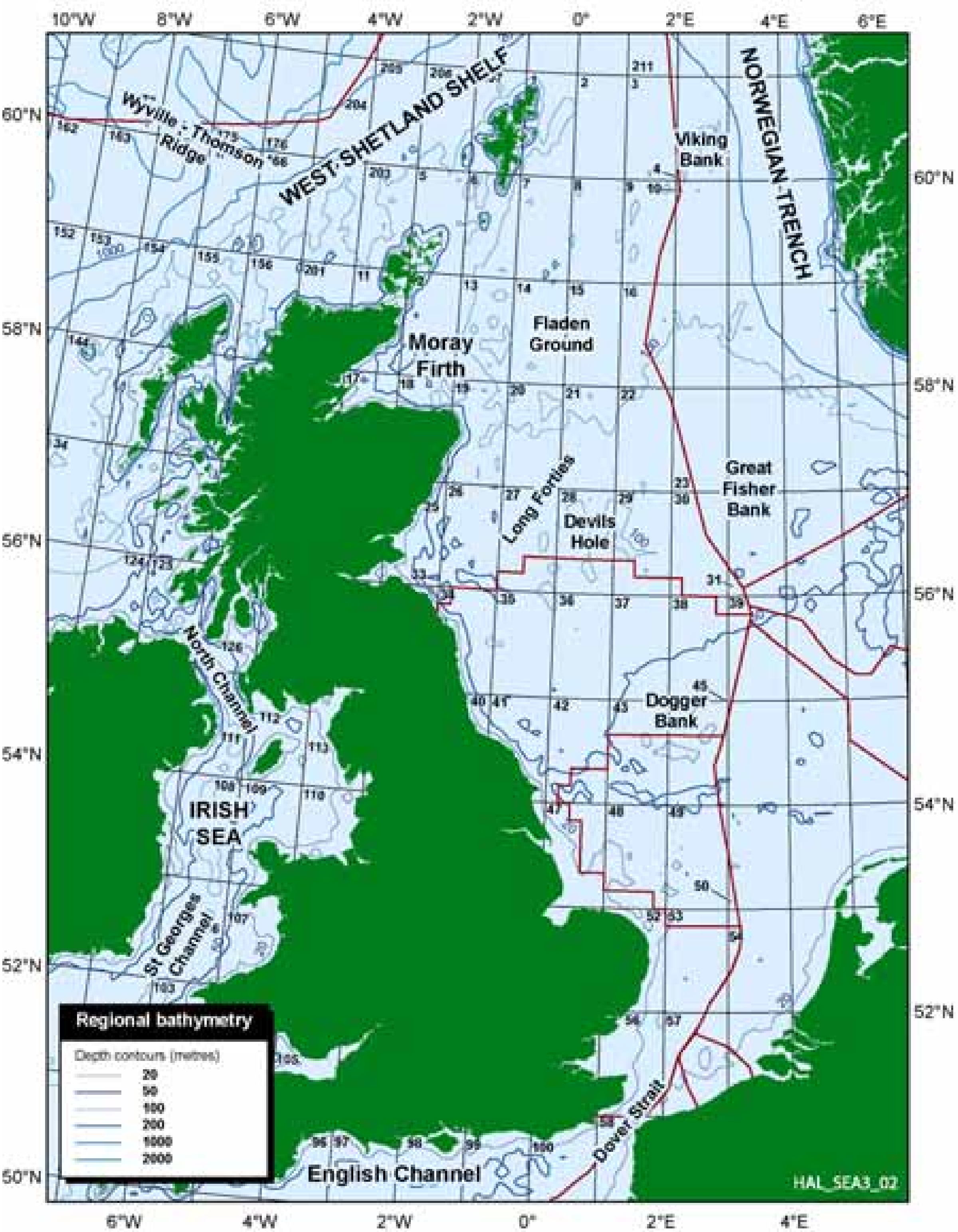
The coastal margin of eastern England north of Flamborough Head is characterised by predominantly rocky shores interspersed by several large estuaries; and south of Flamborough Head by shallow-water, sedimentary conditions, with numerous estuaries, the substantial Wash embayment, and sandbanks.

The modern topography of the North Sea has originated from the influences of deep geological structure on the patterns of basin subsidence, uplift and climate on sediment input. The smaller-scale seabed geomorphology of the continental shelf is a relict of several glacial periods when large volumes of material were eroded from the adjacent mainlands and from the continental shelf itself. This material was then re-deposited on the shelf or in the deeper waters on the adjacent continental slope. The modern sedimentary environment of the North Sea continental shelf is now dominated by low sediment input and the reworking of the seabed by near-bottom currents. Much of what is now the southern North Sea was dry land prior to deglaciation and inundation via the Dover Strait around 9,000 BP (Jelgersma 1979) and the Flandrian transgression around 6,000 BP.

Oil and gas reserves are widely distributed under the North Sea, in several geologically distinct provinces. Around 85% of all gas production in the southern North Sea gas province has been from pre-Zechstein Permian (Rotliegend Group) aeolian dune sandstones, and 13% from Triassic fluvial sandstones. Much of the remaining production has been from Carboniferous fluvial sandstones.

Brief synopses of physical characteristics and resources of the North Sea, with specific reference to the SEA 3 areas, are provided on following page. These reference previous published reviews where available, in addition to a series of scientific and technical reviews commissioned for SEA 2 and SEA 3 which are available from the SEA website (www.habitats-directive.org). Commissioned reviews contain comprehensive references to published data sources.

Figure 5.1 Bathymetry and major features of the North Sea



Source: GEBCO Database

5.2 Geology and substrates

5.2.1 Overview and perspective

To support the SEA process, British Geological Survey (BGS) were commissioned to produce a summary of published geological data and their interpretation from the UK North Sea to the east and north of the British Isles (report updated for SEA 3). The basis for this review is the premise that the modern environment is a synthesis of past environmental conditions. The purpose was to review (1) the evolution of the deeply-buried sediments with reference to the petroleum geology and production-related seabed subsidence, (2) the evolution of the shallow and seabed sediments with reference to present sediment distributions and seabed features, (3) the evidence for possible hydrogeological exchange across selected onshore/offshore areas, and (4) the history of earthquakes and the hazard that they may pose. It is intended that the review will provide a basis for a better understanding of the impacts of possible future changes in the natural environment.

A precursor to the submarine evolution of the North Sea occurred more than 375 million years ago with the deposition of marine limestones. Subsequently, subsidence and burial under thick accumulations of basin sediments has generated gas from coal source rocks, possibly commencing prior to approximately 140 million years ago. Oil and gas has been generated from deeply-buried mudstone source rocks from approximately 65 million years ago to the present day. Commercial petroleum reservoirs occur in almost every sedimentary succession ranging in age from approximately 410-36 million years. Exceptionally, the extraction of oil and gas has lead to production-related seabed subsidence, the effects of which are locally felt. This process appears to be restricted to a few types of reservoir and (to date) does not appear to have had major environmental impact.

Extreme changes from arctic to temperate climates have been the dominant control on sediment type and the overall rate of sediment input into the North Sea from approximately 800,000 years ago to the present day. The overall effect of the repeated glaciations during the cold periods has been to keep the North Sea basin filled with sediments during a time when there was very rapid basin subsidence.

5.2.2 Sediments

Broadscale seabed sediment distribution is shown in Figure 5.2. The bulk of modern seabed sediments comprises substrates that are more than 10,000 years old and have been reworked from strata by currents that have been generated by tides and sea waves.

5.2.2.1 Sandbanks

Both active sandbanks, maintained by the modern tidal current regime, and moribund sandbanks, formed at periods of lower sea level, are found in the SEA 3 area (Belderson 1986, Collins *et al.* 1995). Five major groups of sandbanks are represented in the area (Figure 5.3):

- The East Bank Ridges are a group of sub-parallel ridges in relatively deep water to the north west of the Dogger Bank. These banks are considered to be 'moribund', and are composed of very fine to fine sand which contrasts with the fine to coarse sand composition of other banks in shallower water within the area. Their surface is smooth and lacks the cover of mobile sandwaves seen on other sandbanks in the area.

- The Sand Hills are a group of parallel ridges to the south west of the Dogger Bank. Some of these banks are seen to be covered by sandwaves so may in part be presently 'active'.

- The Norfolk Banks are the best known group of sandbanks and lie off the coast of north east Norfolk, mainly within the SEA 2 area although the southern part of Smith's Knoll extends into the SEA 3 area.

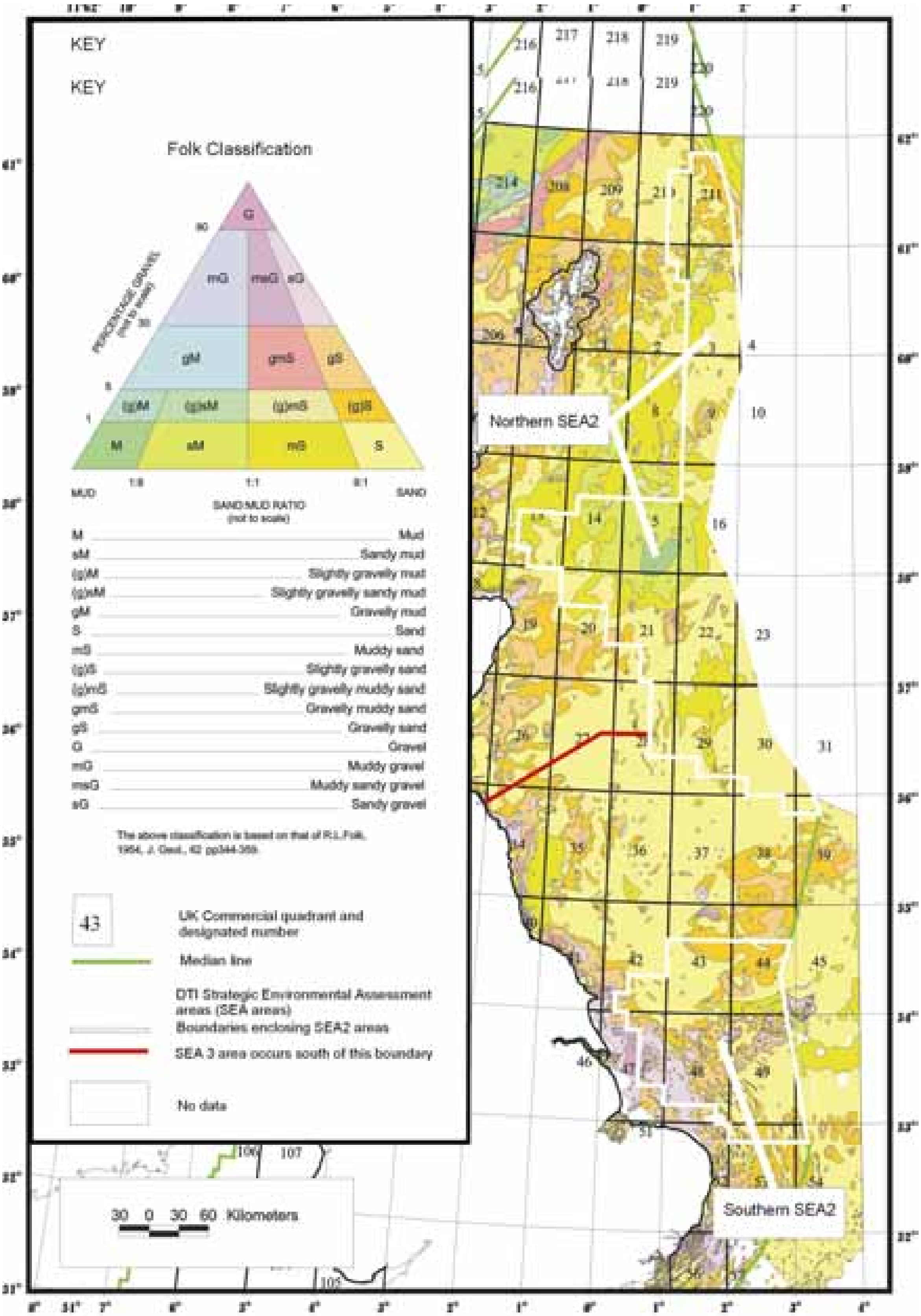
- The Wash contains extensive intertidal flats around its margins and a number of large sandbanks within it. These banks are aligned parallel to the sides of the embayment and to the dominant tidal current directions in and out of the embayment. Most of these banks are partially exposed at low tide.

- The sandbanks or sandwaves in the Thames Estuary area form a complex array aligned approximately parallel to the coast, most of the intervening sea-floor being covered by winnowed 'lag' deposits. In the mouth of the estuary, large sandbanks are exposed at low tide, separated by narrow scoured channels. Narrower, linear banks oriented approximately north-south occur in deeper water north of the Dover Straits.

Linear sandbanks in the southern North Sea have been studied since the early days of hydrographic surveying, with significant early echosounder observations made by Van Veen (1935, 1936). Detailed investigations commenced in connection with offshore oil and gas E&P activities in the late 1960s and early 1970s (Caston 1969, 1972). To support the SEA process, sandbanks within the SEA 2 area were investigated by a survey programme, commissioned by DTI in June-July 2001, which included high-resolution multibeam bathymetry (Figure 5.3), photography of sediment features and epifauna and seabed sampling.

Models for sandbank development include spiral water circulation with convergence over the crestline (Houbolt 1968, Caston 1972); lateral migration; and stratigraphic evolution associated with submergence of coastal sand bodies. Detailed hydrography and sediment transport have been studied on Leman and Well Banks (Caston & Stride 1970, Caston 1972) and Broken Bank (Collins *et al.* 1995). From analysis of historic bathymetric charts, Caston (1972) found that some of the more offshore Norfolk Banks had elongated towards the north west, the direction of net regional sand transport. The evidence for bank migration perpendicular to their long axis is, however, more equivocal. These offshore banks are markedly asymmetrical in cross-section with their steeper flanks oriented towards the north east suggestive of migration in that direction. It has been suggested (Caston 1972) that opposing movement of sand streams may magnify localised irregularities into a complex "S" shaped bank surrounding a pair of ebb and flow channels (as in banks of the Haisborough Tail – Winterton Ridge system), with subsequent erosion of the bank apices leaving a line of *en echelon* banks. The internal structure within some of the offshore banks is evidence of north eastward migration although it is uncertain whether migration still occurs at the present time.

Figure 5.2 – Seabed sediment granulometric classes



Source: BGS © NERC 2002 (all rights reserved)

Figure 5.3 Sandbank features of the North Sea

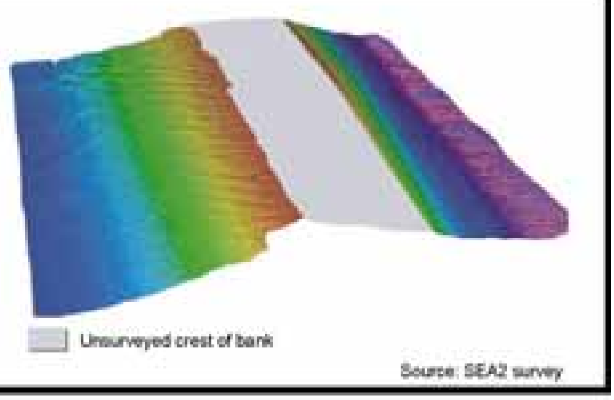
Offshore sandbanks

The East Bank Ridges are a group of sub-parallel ridges in relatively deep water to the north west of the Dogger Bank. These banks were believed by Stride et al (1982) to be features which initially formed early in the Holocene transgression and are now in water depths too great and with tidal currents too weak for their active maintenance and were therefore considered to be 'moribund'. They are composed of very fine to fine sand which contrasts with the fine to coarse sand composition of other banks in shallower water within the area. Their surface is smooth and lacks the cover of mobile sandwaves seen on other sandbanks in the area.

The Sand Hills are a group of parallel ridges to the south west of the Dogger Bank. Some of these banks are seen to be covered by sandwaves so may in part be presently 'active'.

The Norfolk Banks are the best known group of sandbanks and lie off the coast of north east Norfolk. The banks are sub-parallel to the modern coastline and at the southern end of the group sandbanks may be shore-connected.

Smith's Knoll



Sandbank stability

From analysis of historic bathymetric charts, Caston (1972) found that some of the more offshore Norfolk Banks had elongated towards the north west, the direction of net regional sand transport. The evidence for bank migration perpendicular to their long axis is, however, more equivocal. These offshore banks are markedly asymmetrical in cross-section with their steeper flanks oriented towards the north east suggestive of migration in that direction. The internal structure within some of the offshore banks is evidence of north eastward migration although it is uncertain whether migration still occurs at the present time.

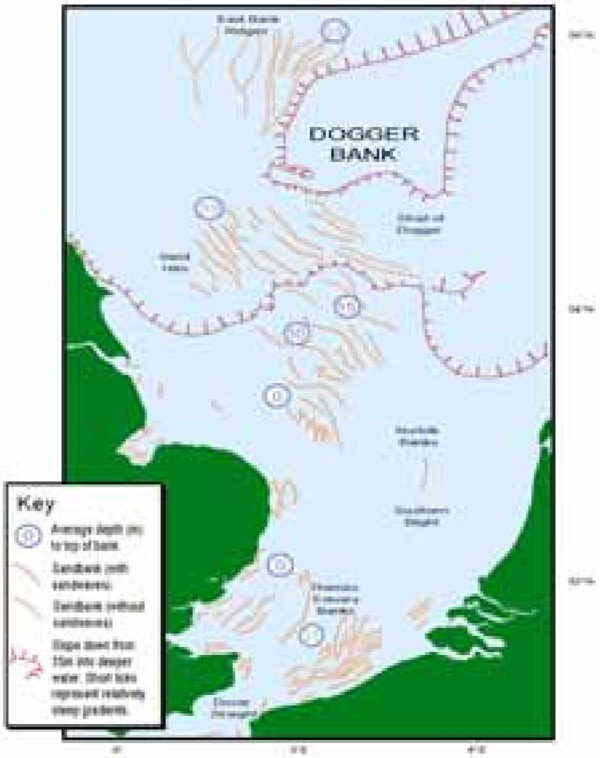
The surfaces of many of the Norfolk Banks are covered in active sandwaves which reflect the pattern of modern sand transport around these banks. The sandwaves have their crests aligned more or less at right angles to the bank crest with their steep faces in opposing directions on either side of the sandbank reflecting the dominance of a clockwise circulation of sand around the bank (see multibeam images).

Wash sandbanks

The Wash is a large coastal embayment on the east coast of England which has extensive intertidal flats around its margins and a number of large sandbanks within it. These banks are aligned parallel to the sides of the embayment and to the dominant tidal current directions in and out of the embayment. Most of these banks are partially exposed at low tide.

Thames estuary sandbanks

The Thames Estuary is a region of strong tidal currents, which have moulded the mobile sea-bed sediments into large sandbanks aligned approximately parallel to the coast, most of the intervening sea-floor being covered by winnowed 'lag' deposits. The sandbanks or sandwaves in the Thames Estuary area form a complex array and vary in size: sandwaves may reach 16 m in height, with wavelengths varying from 50 m to 500 m. In the mouth of the estuary large sandbanks are exposed at low tide, separated by narrow scoured channels. Narrower, linear banks oriented approximately north-south occur in deeper water north of the Dover Straits.



HAL_SEA3_03

Sandbank formation

Both active sandbanks, maintained actively by modern tidal current regime, and moribund sandbanks, formed at periods of lower sea level, are found in the SEA2 area (Belderson 1986, Collins *et al.* 1995). Models for sandbank development include spiral water circulation with convergence over the crestline; lateral migration; and stratigraphic evolution associated with submergence of coastal sand bodies. Detailed hydrography and sediment transport have been studied on Well Bank (Caston and Stride 1970, Caston 1972) and Broken Bank (Collins *et al.* 1995).

Source: BGS commissioned report, DTI 2001 survey data

5.2.2.2 Hard substrates

The three main types of hard substrate occurring at or near seabed comprise unconsolidated gravel spreads, hard cohesive sediments which were formed during the glaciations, and rock outcrops. All three commonly occur together in the nearshore western margins of the North Sea. The distribution patterns of rock, gravel spreads and the hard cohesive gravelly Quaternary sediments are quite well known and have been mapped by regional surveys.

Rock outcrops occur within the SEA 3 area mainly in the north, along the Northumberland coastal margin where extensive areas of Carboniferous strata crop out at the sea bed in a belt that extends approximately parallel with the coast. In the offshore area as far south as the Farne Islands, the Carboniferous strata are Dinantian (Lower Carboniferous) in age, comprising rhythmic sequences of limestones as well as shales, sandstones and coals of various thicknesses. Around the Farne Islands, bedrock comprising sandstones, limestones, mudstones and basic igneous intrusions is partly covered by a patchy veneer of gravel.

From near the Tees Estuary to north of Filey Brigg, Jurassic strata crop out at the sea bed and in the rock platforms seaward of the cliffline. The strata range in age from Rhaetian (Upper Triassic) to Kimmeridgian (Upper Jurassic) and comprise interbedded sandstones, mudstones and limestones deposited in a variety of shallow marine and marginal environments.

Chalk bedrock is the dominant characteristic of the coast around Flamborough Head, and at Thanet in Kent. The exposure at Flamborough Head represents nearly 9% of Europe's coastal chalk and is the most northerly outcrop of coastal chalk in the British Isles. The area is also exceptional in the distance that the chalk is found offshore - at least 3-4 km from the headland.

South of the Humber, isolated outcrops of hard substrate are formed mainly of glacial tills. However, isolated stretches of chalk bedrock also extend into the sublittoral at various locations in North Norfolk, mainly between Sheringham and West Runton but also at East Runton and Cromer, representing the only appreciable area of natural hard substrate on the coast of East Anglia.

5.2.2.3 Soft sediments

Unconsolidated sediment distribution in the SEA 3 area is complex, and reflects both sediment sources and ongoing redistribution by hydrographic processes.

Gravels with carbonate content less than 25% dominate the sea-bed sediments around the Farne Islands. Between the Tyne and the Tees estuaries the shell content is generally less than 60%, decreasing off the coast north of Newcastle. A discontinuous belt of sand occurs in a narrow inshore zone extending from the Tees Estuary to Flamborough Head. Beyond this inshore sand belt, a broader belt of mud-rich, often gravelly sediments runs parallel to the coast. The composition of this gravel varies across the region. Offshore from North Yorkshire, south of Saltburn, the shell content of gravels may exceed 80%. Muddy sediments have accumulated in the Tyne and Tees estuaries, and offshore. Along the Durham and Northumberland coasts some sediments consist mainly of dumped colliery waste. A broad belt of muddy sand extends north-eastwards from Newcastle to the Farne Deeps, with muddy sand also found extensively in the offshore central North Sea.

Between Flamborough Head and Norfolk, sea-bed sediment distribution is complex with Holocene sediments generally forming a veneer less than 1m thick. Exceptionally, the sand-rich sediments comprising the Norfolk Banks attain a maximum thickness of about 40m, but the intervening gravelly sand substrate remains thin. Extensive sheets of gravel and sandy gravel occur off the coasts of Lincolnshire and Humberside. The gravels off the Humber estuary have a varied composition: Carboniferous sandstone and limestones are particularly common, but chalk, Jurassic mudstone, flint and igneous and metamorphic rock types are also found. The gravels are believed to be derived by marine winnowing of glacial moraines and outwash fans deposited during the Devensian glaciation.

Sea-bed sediments in the southern SEA 3 area are mostly relict. Carbonate gravels, which occur in the north-east part of the region, were probably reworked from Pliocene Crag deposits similar to those that outcrop onshore in north-east Essex and Suffolk. In the Thames Estuary the sea-bed sediments were derived by the erosion of beach gravels and fluvial terrace deposits (which mark the ancient courses of the Rivers Thames and Medway) or else from the erosion of underlying Tertiary deposits.

5.2.2.4 Aquifers

Few data are available with which to assess the possible effects of development operations on onshore and offshore aquifers. What data there is indicates that saline water ingresses inland locally on parts of the East Anglian coast whilst the predominant movement elsewhere is that of freshwater flowing offshore. There is a potential local risk of groundwater contamination if developments are superimposed on areas with aquifers and if normal aquifer measures are not followed. There is a negligible risk of contamination of onshore supplies of freshwater from the mature areas of the oil and gas development provinces in the central and northern North Sea. Overall, the risk of onshore aquifer contamination decreases with increasing distance from the offshore to developments.

5.2.2.5 Seismic activity

The regional distribution patterns of earthquakes occurring under the North Sea are related to the deep geological structure. Expectations of earthquakes with magnitude of 4 or higher may require special structural design and are therefore also of environmental concern. In the North Sea as a whole, the expectations for a magnitude 4 natural seismic event is approximately every 2 years and a magnitude 5 natural seismic event every 14 years.

5.2.3 Implications for Strategic Environmental Assessment

The key geological issue for the SEA process is clearly the location and prospectivity of hydrocarbon reserves, which are relatively well-known given the maturity of exploration and development of most of the SEA 3 area. The distribution of seabed substrates, with associated benthic communities, is also relatively well understood throughout most of the SEA 3 area.

5.3 Climate and meteorology

5.3.1 Overview

The central North Sea is situated in temperate latitudes with a climate that is strongly influenced by the inflow of oceanic water from the Atlantic Ocean and by the large scale westerly air circulation which frequently contains low pressure systems (OSPAR 2000). This influence is variable and long-term changes in the strength and persistence of westerly winds are influenced by the winter North Atlantic Oscillation (NAO – a pressure gradient between Iceland and the Azores). Atmospheric circulation has intensified over the last decades (OSPAR 2000), with the most extreme decadal change since the 1860s taking place from about 1960 (very weak westerly winds) to the early 1990s (very strong westerly winds). However, long-term wind data suggests a comparable period in the early 20th Century, and proxy data over several thousand years (from winter tree growth) indicate several occasions when similar increases have occurred.

Metocean conditions in the North Sea have been intensively monitored, especially since commencement of offshore oil and gas production in the 1960s. Reliable data is therefore available for engineering design and operational planning purposes, and in general the North Sea is no longer considered to be an “extreme” province in terms of metocean conditions.

Meteorological Office wind data for the central and southern areas of the North Sea from the period 1854-1994 show the occurrence of winds from all directions, although dominated by winds from south-south-west and south. Predominant wind speeds throughout the year represent moderate to strong breezes (6-13m/s), with the highest frequency of gales (>17.5m/s) during winter months (November-March). Percentage frequency of winds of Beaufort force 7 and above in January is <20% south of 55ºN (Pilot 1997).

Mean annual rainfall, estimated from Nimbus-7 passive microwave imagery, is relatively low in the central and southern North Sea (in comparison to the Atlantic seaboard and to Norwegian coastal waters to the east), in the range 200-400mm (OSPAR 2000).

Fog in the offshore North Sea is not especially common (Pilot 1997), with maximum frequencies (3-4%) in the extreme south during winter. In contrast, coastal fog ("haar") is common during spring and summer along the east coast of Britain north of the Humber, with up to 14 days per month recorded in exceptional years.

5.3.2 Implications for Strategic Environmental Assessment

In conclusion, meteorological conditions within the SEA 3 area are well documented, based on an extensive historical dataset, and are not considered to be a significant issue in terms of the Strategic Environmental Assessment process. Climate issues, in terms of the potential effects of oil and gas combustion, are outside the scope of this assessment.

5.4 Oceanography and hydrography

5.4.1 Sources and studies

The history of broadscale studies of North Sea circulation and hydrographic patterns (e.g. temperature and salinity distribution) was briefly reviewed in SEA 2, with early drifter experiments followed by extensive national and international programmes e.g. the JONSDAP '71, JONSDAP '73 and JONSDAP '76 series. Long-term datasets available for the North Sea have been listed by Clark *et al*. (2001) and include the MAFF Sea Surface Temperature and Salinity Data Set (ship routes to and from the UK, 1963 to 1990); the Institut für Meereskunde (Hamburg) Climatological Atlas of Salinity and Temperature for the North Sea (1968 to 1985); and the Netherlands Institute for Sea Research (NIOZ) Marsdiep Sea Surface Temperature and Salinity Time Series (1860 to present).

The British Oceanographic Data Centre (BODC) hold data from a large number of individual current meter deployments and approximately 10,000 profiles of CTD data from the UKCS and adjacent oceanic waters.

The United Nations Atlas of the Oceans is an " *information system designed for use by policy makers who need to become familiar with ocean issues and by scientists, students and resource managers who need access to underlying data bases and approaches to sustainability*". The website for the Atlas, http://www.oceansatlas.org, is under development.

The NERC North Sea Project, conducted between May 1988 and June 1991, consisted of sixteen cruises along a 1200 nautical mile track, pursued three intermediate objectives in parallel .

- Production of a 3 dimensional transport model for any conservative passive constituent, incorporating improved representations of the necessary physics - hydrodynamics and dispersion

- Identifying and quantifying non-conservative processes - sources and sinks determining the cycling and fate of individual constituents
- Defining a complete seasonal cycle as a data base for all the observational studies needed to formulate, drive and test models

In relation to the SEA 3 area, the NERC North Sea Project included studies of the Flamborough Head frontal system, Humber and Thames plumes and resuspension processes, and detailed study of the southern North Sea sandwave system.

The NERC Land Ocean Interaction Study (LOIS) was a 6 year project (1992-1998) involving over 360 scientists from 11 institutes and 27 universities, aiming to quantify and simulate the fluxes and transformations of materials (sediments, nutrients, contaminants) into and out of the coastal zone. The main study area, embracing river catchments, estuaries and coastal seas, was the UK East Coast from Berwick upon Tweed to Great Yarmouth, concentrating on the Humber and its catchment, and to a lesser extent the River Tweed.

LOIS comprised seven components studying riverine, atmospheric, estuarine, coastal and shelf processes, including a major geological study of the sedimentary record in a traverse of the coastal zone to determine how sediment fluxes have influenced sea level, climate and land use. A LOIS study aimed to establish and maintain a network of flow and water monitoring stations on the Yorkshire Ouse, and the other principal Humber rivers and on the Tweed and Tyne, to provide comparative data on water discharges and on fluxes of sediment, nutrient, metals and organic microcontaminants. The study also included seasonal investigations of the entire north-east coastal strip.

Within the LOIS project, emphasis was given to providing data in a numerical form that can be used by modellers to improve understanding of dynamical processes and the accuracy of simulations in the coastal zone. NORMS is the component responsible for meeting the major simulation modelling objectives of LOIS, although each of the other components had the development of models amongst their objectives. One major advance was the further development of a North Sea CRP water quality model extended to cover the north-west European Shelf and having appropriate boundary conditions both with the open ocean and with coastlines and estuaries. Other specific contributions relevant to SEA 3 included ecosystem models for the Humber plume and a coastal strip model for the area off north-east England.

LOIS output is contained on a series of CD-ROMS available from http://www.pml.ac.uk/lois/ This website also contains a bibliography of 826 LOIS publications (as at 20 June 2001).

The Flamborough front has been intensively studied (Prandle & Matthews 1990, Lwiza *et al*. 1991, Gmitrowicz & Brown 1993) including a collaborative experiment in 1988 by MAFF, POL and UCNW which involved Ocean Surface Current Radar (OSCR), ship-borne Acoustic Doppler Current Profiler (ADCP), Lagrangian drifters and moored current meters. Later work using towed undulating CTD and satellite-tracked drifting buoys established the existence of a strong and persistent jet-like circulation associated with seasonal bottom fronts at the central North Sea cold pool margin (Brown *et al*. 1999).

Seasonal density-driven circulation along the north-east coast of England has also been studied in relation to the transport of algae responsible for paralytic shellfish poisoning (Joint *et al*. 1997, Brown *et al*. 2001), confirming a persistent southward near-coastal flow.

Major littoral drift cells i.e. areas of coastline with continuous longshore sediment transport, separated either by drift divides or sediment sinks, have been identified for the coast of England and Wales by Motyka & Brampton (1993), together with smaller "sub-cells". Although it is important to note that longshore transport is primarily wave-driven and that coastal cell boundaries are identified on the basis of material which will normally settle out on the beach face (i.e. not fines), the identified accretion areas are likely to be representative of sinks for contaminants discharged via fluvial sources or directly to coastal waters.

The National Monitoring Plan (now called the National Marine Monitoring Programme) was initiated in the late 1980s to co-ordinate marine monitoring in the United Kingdom between a number of organisations. The initial phases of the NMMP were to establish the spatial distribution of contaminants in UK marine waters and to define their biological status. This has involved long-term surveys at estuarine, intermediate and offshore sites to determine the distribution of contaminants in a range of matrices.

Phase 2 of the NMMP (see also section 5.5) includes a temporal trend monitoring survey using automated *in situ* instrumentation, capable of deployment at a mooring, for monitoring a range of physico-chemical and environmental variables. The CEFAS-developed SmartBuoy is currently configured to meet the needs of the NMMP through monitoring plant nutrient concentrations and the response of the ecosystem in terms of phytoplankton growth and species composition. Additional physical measurements are also made to ensure that a full interpretation of the time-series data set is possible. Summary data are returned in near real-time (sub-hourly) via satellite telemetry with full data sets recovered during servicing of the buoy. Data are published on the internet to give rapid access to other collaborators and the public.

The NMMP programme is currently being provided data from two deployment groups, each involving a series of linked deployments. The Gabbard Group is located at a site in the southern North Sea in approximately 45m water depth to observe the dynamics of plant nutrients and the growth of phytoplankton. The Warp Anchorage site is located at a site in the outer Thames estuary in approximately 15m water depth, to measure the same parameters. In addition, with joint funding from the UK (DEFRA) and Netherlands governments, CEFAS and the Netherlands Rijkswaterstaat (RWS) and its laboratory the National Institute for Coastal and Marine Management (RIKZ) are jointly operating SmartBuoy deployments in Dutch coastal waters.

5.4.2 Circulation and structure

Sources and circulation of water in the North Sea as a whole were summarised by SEA 2, which identified (after Turrell 1992, see Figure 5.4) the major water masses in the North Sea as Atlantic water, Scottish coastal water, north North Sea water, Norwegian coastal water, central North Sea water, south North Sea water, Jutland coastal water and Channel water. The main inflow to the North Sea occurs along the western slopes of the Norwegian Trench, with minor inflows from the Channel and Baltic. These inflows are balanced by outflow mainly along the Norwegian coast, with most of the water probably passing through the Skagerrak.

The generalised pattern of water movement in the North Sea may be strongly influenced by short-medium term weather conditions, resulting in considerable seasonal and interannual variability. Drastic differences in Atlantic water inflow from year to year, caused by atmospheric forcing, explain some of the observed large scale differences in salinity between years (OSPAR Commission 2000). Storms may also generate nearbed, wave-induced currents sufficient to cause sediment mobilisation.

Density stratification is well developed in the summer months of most years in the central and northern North Sea, with the relative strength of the thermocline determined by solar heat input and turbulence generated by wind and tides. The shallow parts of the southern North Sea remain well mixed throughout the year due to tidal action (QSR 2000). Density stratification in the central and northern North Sea breaks down after September due to increasing frequency and severity of storms and seasonal cooling at the surface.

Fronts or frontal zones mark boundaries between water masses, including tidally-mixed and stratified areas, and are numerous in the North Sea (Figure 5.5). Satellite imagery shows that the central North Sea from Flamborough Head to the Frisian Islands, south-west of Norway and the northern German Bight are frequently characterised by thermal fronts marking transition zones between mixed and stratified water in the North Sea (Pingree and Griffiths 1978, Becker 1990). The SEA 3 area may therefore be divided into the offshore central North Sea area, which is thermally stratified in summer, and the coastal fringe, which is well-mixed throughout the year.

Numerical modelling by Pingree and Griffiths (1978) of the balance between tidal mixing and surface thermal insulation shows that much of the coastal area north of Flamborough Head is stratified in summer, with relatively little coastal mixed water inshore. Although there is considerable inter-year variability, a decrease in surface to bottom temperature gradients towards the coast leads to cross-shore horizontal density gradients (Gmitrowicz & Brown 1993) which, in combination with wind stress, will drive residual flow. Intensive measurement in 1988 of currents in the coastal area off the Tees suggest that cross-frontal density gradients are the dominant factor in forcing a persistent southeastward along-shore mean flow (Gmitrowicz & Brown 1993).

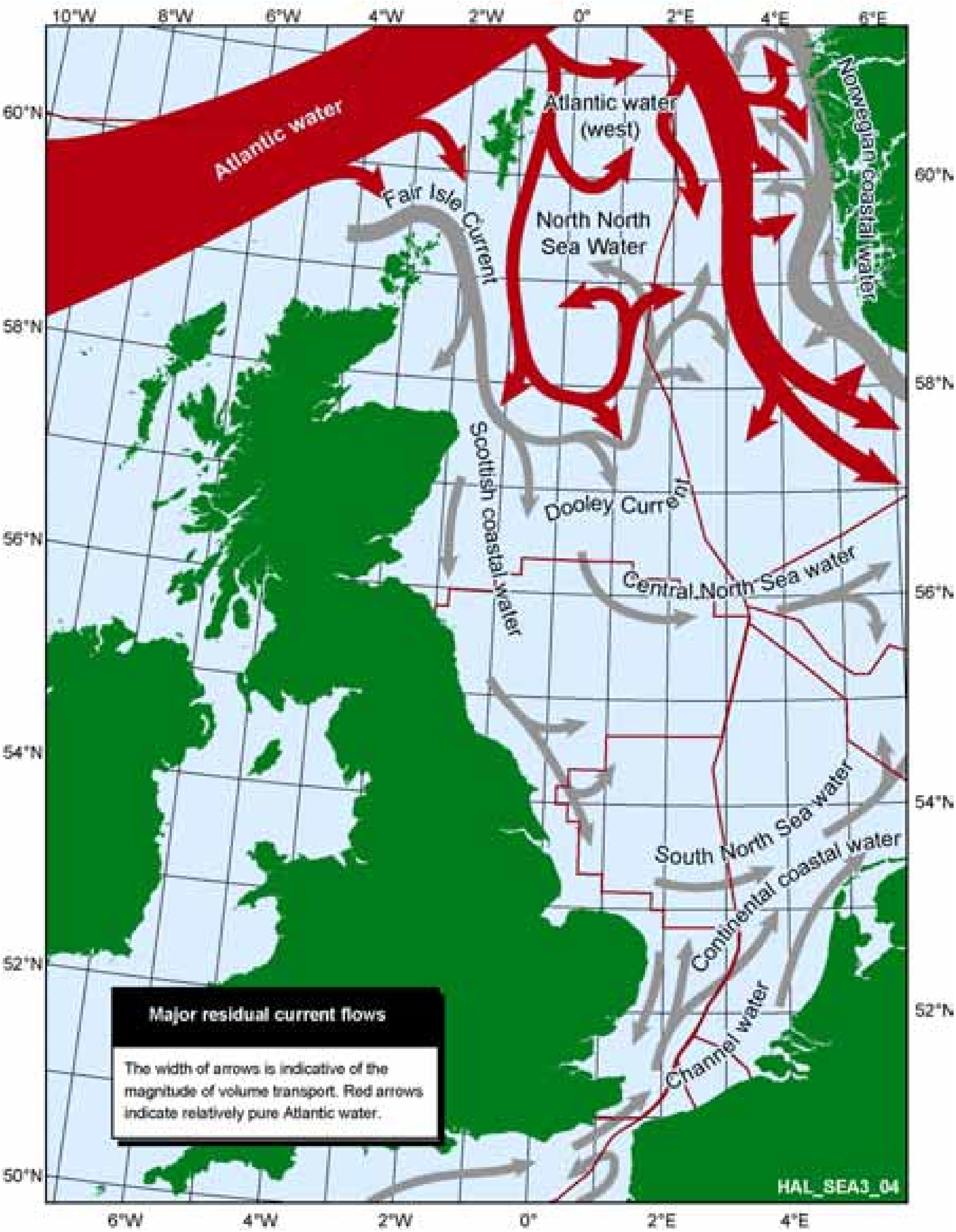
Further offshore, observations of the physical structure of the region between the Northumberland coast and north Dogger Bank were made in 1996, to test for the presence of a summer cold pool system and associated jet circulation in this area (Brown *et al*. 1999). A more detailed survey of the coast from the Forth to Flamborough Head was also carried out in 1997 (Brown *et al*. 2001). Strong bottom fronts were observed to bound a cold pool isolated beneath the thermocline, extending continuously for 500km along the 40m contour, from the Firth of Forth to the eastern end of the Dogger Bank. Persistent and narrow (10-15km) cores of cyclonic near-surface flow were also observed with velocities in excess of 0.1m/s.

Maximum tidal current velocities in the coastal strip are mapped by the JNCC Coastal Directory series (Barne *et al*. 1995a, 1995b, 1998 after Sager & Sammler 1968). In general, maximum velocities are below 1.0m/s except in the vicinity of major headlands (Flamborough Head, Spurn Point and South Foreland) where peak velocities may reach 2.0m/s.

The direction of longshore littoral sediment transport along the east coast of England is generally southerly (Motyka & Brampton 1993, Figure 5.6). Sediment sinks occur at the Tees, off Grimsby, the Wash and Thames, with drift divides at Donna Nook and Sheringham. Accretion areas, which may be potential locations for contaminant accumulation, include (from north to south):

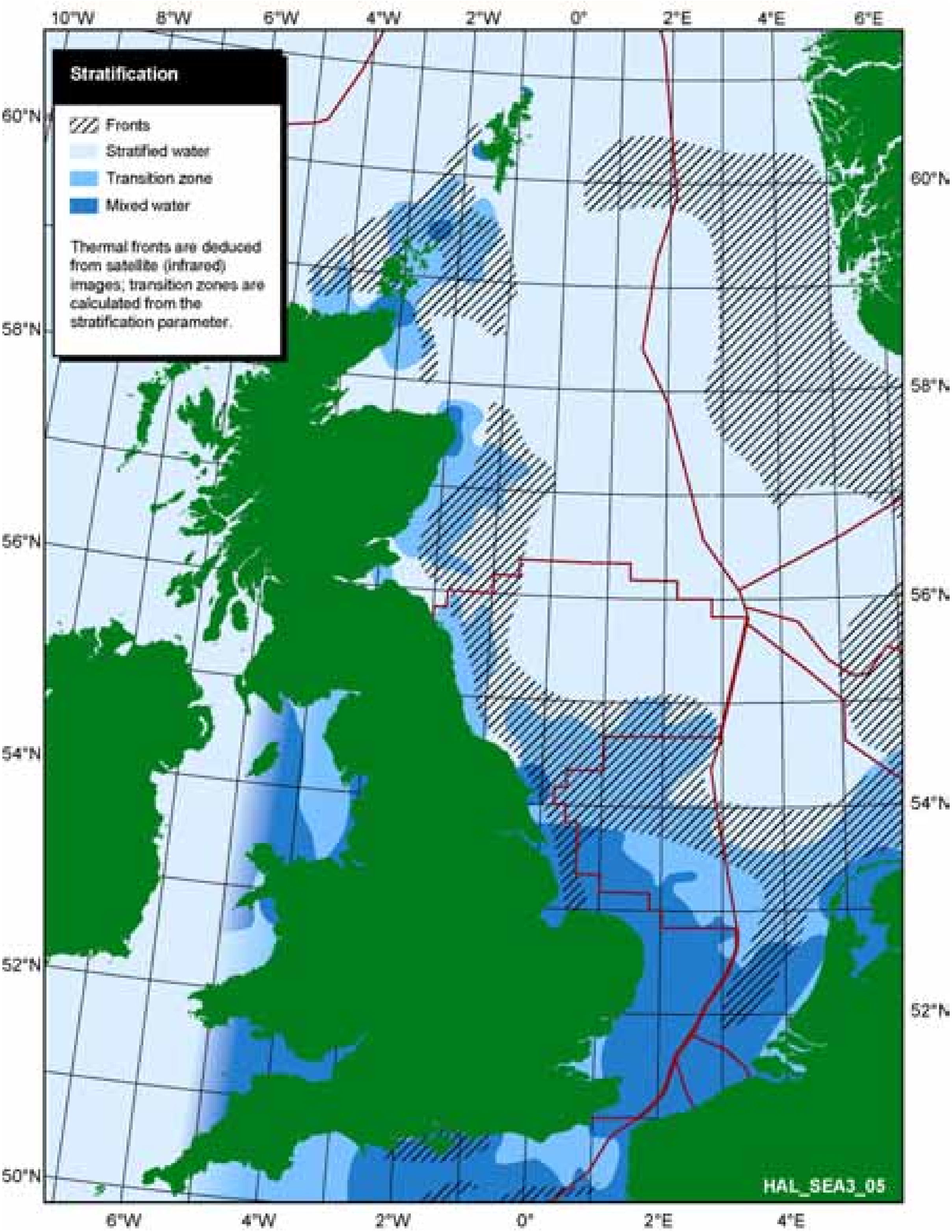
- Sand/silt accretion at Holy Island
- Accretion of cliff derived pebbles between Sunderland and Seaham
- Sand accretion at the mouth of the Tees
- Salt marsh accretion on the north shore of the Humber
- Extensive sand accretion and salt marshes at Donna Nook
- Seaward extension of sand beach and dune build up south of Skegness
- Siltation and alluvial deposition in the Wash
- Generally accretionary coastline between Hunstanton and Blakeney
- Local accretion at nesses along East Anglian coast
- Maplin Sands and other intertidal banks are probably accreting.

Figure 5.4 Residual circulation of the North Sea



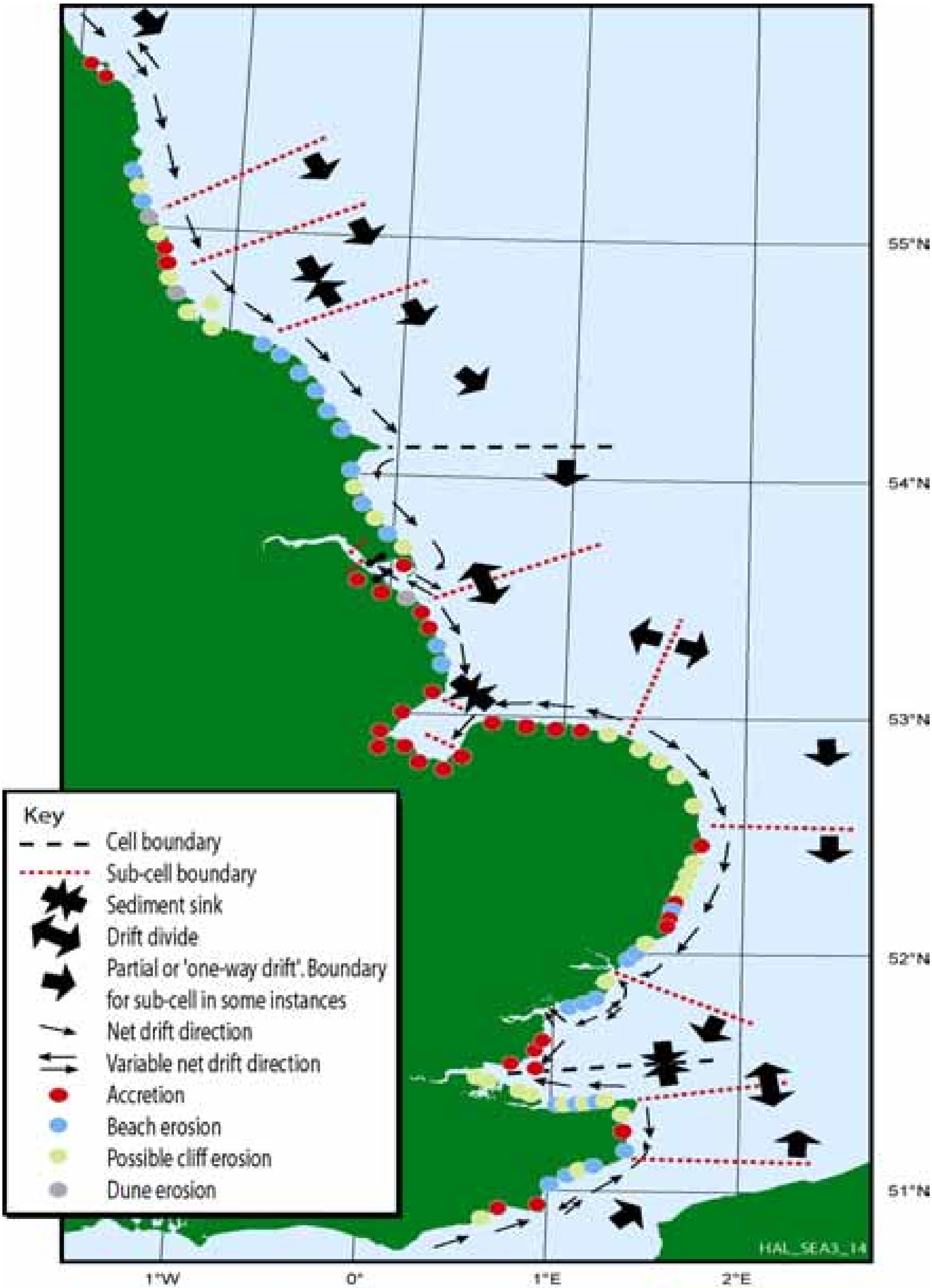
Source: after Turrell et al. 1992

Figure 5.5 Frontal zones and stratification of the North Sea



Source: OSPAR 2001 (after Becker 1990)

Figure 5.6 Littoral drift cells off the English coast



Source: Motyka and Brampton 1993

5.4.3 Local hydrography around sandbanks

Significant local variations in patterns of semi-diurnal tidal and residual circulation occur in the vicinity of sandbanks. Bedforms and current meter measurements around the Leman and Well Banks, Smith's Knoll and Hewett Ridges have demonstrated residual near-bed currents to be strongest towards the bank crestline and in opposing directions on either side of the bank (Caston & Stride 1970, Caston 1972, Huthnance 1973). Current records on each side of Well Bank also demonstrated a clockwise near-bed residual circulation around the bank (Howarth & Huthnance 1984, Collins *et al.* 1995), with maximum semi-diurnal amplitude around 0.75m/s. This residual circulation pattern is considered to be important in the formation and maintenance of linear sandbanks and will also influence the dispersion of soluble and particulate contaminants.

Episodic currents, induced by wave action and storm surges, also influence sandbank development. Numerical model predictions of maximum storm surge currents are described by Flather (1987). The effects of a storm event on the morphology and surficial grain size distribution of the Middelkerke Bank (off the Belgian coast) included lowering of the crest by up to 1.2m, removal of sandwave topography on the bank, and accretion on the lower flank of material removed from the crest (Houthuys *et al.* 1994).

5.4.4 Implications for Strategic Environmental Assessment

The hydrography of the North Sea is relatively well described, although long-term variability in circulation patterns and physical processes remain the subject of long-term investigations. Hydrographic conditions in the North Sea are sufficiently well known that they are no longer considered to represent a significant challenge to exploration and production activities. For the purposes of dispersion and trajectory modelling, large-scale (i.e. hydrographic) physical forcing processes are well parameterised, although there remain some difficulties in modelling small-scale dispersion processes.

5.5 Contamination of water and sediments

5.5.1 Introduction and sources

To support SEA 2, CEFAS in collaboration with FRS were commissioned to review the extent of existing chemical contamination of the North Sea, in the context of "background" levels and trends. The review was based on a number of previous collations and publications, including CEFAS Aquatic Environmental Monitoring Reports (AEMRs), reports from UKOOA including the recent review of seabed monitoring studies (Harries *et al.* 2001), and OSPAR reports including the Quality Status Report (QSR) 2000 (OSPAR 2000) which presents an assessment of marine environmental conditions and temporal changes observed in the Greater North Sea since 1993. The commissioned review also draws on monitoring data acquired through the National Monitoring Programme's first phase (NMP, see below) and second phase (NMMP2).

In 1987/88 the Marine Pollution Monitoring Management Group (MPMMG) reviewed the monitoring carried out in UK estuaries and coastal waters (MPMMG 1998) and concluded that there would be considerable merit in the regular sampling of a network of coastal monitoring stations. This recommendation was accepted by UK Government, and the initial phase of the NMP was established with monitoring by statutory marine monitoring authorities, primarily aimed at producing a co-ordinated and reliable data set on nationally significant contaminants and biological effects in inshore and coastal waters (NMP Green Book 2001). The second phase, NMMP2 is ongoing and has the following main drivers:

- To meet temporal trend monitoring requirements of the OSPAR international agreement (contributing to UK commitments under the OSPAR Joint Assessment and Monitoring Programme, JAMP)
- For compliance with EC Directives (water quality monitoring for metals and organic compounds to meet requirements of the EC Dangerous Substances Directive 76/464/EEC; and shellfish monitoring to meet requirements of the Shellfish Waters Directive 79/923/EEC, Shellfish Hygeine Directive 91/492/EEC and Fisheries Products Directive 91/493/EEC)
- To meet research and development needs
- For local monitoring

NMMP2 seeks to integrate national and international monitoring programmes across UK agencies, and to ensure consistent standards, comparability of measurements and data exchange. In addition to monitoring of known impacted estuaries and offshore sites (the focus of NMP), some monitoring effort in NMMP2 is directed at less impacted estuaries in considering temporal trends and spatial variability.

Within the SEA 3 area coastal fringe (up to 12 miles offshore) together with adjacent estuary and river systems, the Environment Agency (EA) conducts water quality, sediment and shellfish monitoring, largely to meet requirements under EC Directives as listed above. Data from monitoring programmes is co-ordinated by the EA's National Centre for Environmental Data and Surveillance. The Pollution Inventory (PI, www.environment-agency.gov.uk) is an annual record of pollution in England and Wales from activities regulated by the EA. It records pollution that is released into the air, discharged into rivers or the sewerage network, or disposed of as waste on land. The PI now includes three years of data from major industrial sites and is being gradually extended to cover sewage treatment works and sites licensed to work with radioactive substances.

OSPAR publishes a variety of compilations of data provided by contracting parties under JAMP and other agreed programmes, including periodic Quality Status Reviews (OSPAR 2000); annual reports (OSPAR 2002); Assessment and Monitoring Series reports (e.g. concerning eutrophication, OSPAR 2001); Best Available Technique (BAT) and Best Environmental Practice (BEP) Series reports (e.g. concerning reinjection of cuttings and produced water, OSPAR 2001b); and OSPAR Priority Substances Series reports (e.g. concerning PAHs, OSPAR 2001c).

As noted above (Section 5.4.1), the LOIS components provided comparative data on water discharges and on fluxes of sediment, nutrient, metals and organic microcontaminants together with seasonal investigations of the entire north-east coastal strip.

5.5.2 Levels of contamination

5.5.2.1 Water

Water samples with the highest levels of chemical contamination are found at inshore estuary and coastal sites subject to high industrial usage - see Table 5.1. Where, for example, concentrations of total hydrocarbons (THCs) are found to be high offshore, these are in the immediate vicinity of installations with concentrations generally falling to background levels within a very short distance from discharge.

Table 5.1 - Summary of contaminant levels typically found in surface waters of the North Sea

Location	THC (µg/l)	PAH (µg/l)	PCB (ng/l)	Ni (µg/l)	Cu (µg/l)	Zn (µg/l)	Cd (ng/l)	Hg (ng/l)
Waters adjacent to Oil & Gas Installations	1–30[1]	-	-	-	-	-	-	-
Estuaries	12-15[2,3]	>1	30[2]	-	-	-	-	-
Coast	2	0.02–0.1	$1 – 10^4$	0.2-0.9[2,3]	0.3-0.7	0.5-2.2	10-32	0.25-41
Offshore	0.5-0.7[2,3]	Below det.	-	0.2-0.6	0.3-0.6	0.5-1.4	10-51	1.6-69

(Sources: [1] Law & Hudson, 1986, [2] OSPAR Commission, 2000, [3] Law et al. 1994, [4] SOAEFD, 1996)

Spatial patterns in water quality, including dissolved oxygen, nutrients, metal and organic contaminants have been described from NMP data (MPMMG 1998), which includes estuarine and offshore sampling locations within the SEA 3 area.

Adequate dissolved oxygen concentrations are essential in estuaries if appropriate ecosystems are to be maintained, and the return of salmon in recent years to the Thames and Tyne has been linked to restored oxygen concentrations (Wood, 1980; Anon 1997). The only statutory standards for dissolved oxygen in saline waters relate to areas designated under the EC Shellfish Growing Waters Directive (79/323/EEC). This Directive specifies a mandatory standard for shellfish waters of 70% saturation as an average value, and no individual value can be lower than 60% saturation.

The lowest median concentrations recorded by the NMP were recorded in the Thames estuary. The median ranged from 4.2mg/l in the upper estuary to 5.7mg/l in the outer estuary in the summer months. The Thames estuary receives direct discharges from sewage treatment works, serving a population exceeding seven million people, that contributes to the reduced oxygen concentrations in this estuary.

Median concentrations of dissolved oxygen exceeded 11mg/l in the summer in the inner Tees (11.4mg/l), inner and middle Wear (11mg/l), off the Tyne (12.5mg/l), and off the Tees (12.8mg/l). This suggests that these sites could be relatively free from oxygen consuming loads of anthropogenic origin, or alternatively that active photosynthesis during daylight hours maintains oxygen concentrations.

Nutrient concentrations vary seasonally owing to variability in input loads from discharges and rivers, variability in dilutions flows from rivers, seasonal variability in the growth of phytoplankton and rates of remineralisation. In certain forms ammonia is toxic to fish, but there are no environmental quality standards applicable to saline waters. Eighty per cent of estuarine sites sampled by the NMP in the summer had medians below 30µM. The offshore sites, only sampled in the winter, generally had concentrations below 3µM, and many are below the limits of detection. Notable exceptions were the Tees, Tyne, and Wear estuaries. All these estuaries receive inputs of treated sewage effluent and industrial discharges, which are the main source of ammonia. The Tees, for example, receives 87% of its ammonia load from industrial sources, whereas the Thames receives 78% of its ammonia load from treated sewage effluent (Anon 1996).

Nitrite is relatively unstable and readily combines with oxygen to form nitrate. The main source of nitrite is from the oxidation of ammonia. Median concentrations tend to be less in the winter than the summer, reflecting the pattern for ammonia. Median concentrations reported by the NMP were all less than 17µM in the summer and 9µM in the winter (excluding an outlier in the outer Tyne based on two samples). There was a general tendency for median concentrations to decrease with increasing salinity, which would be expected as the nitrite is transformed into nitrate.

Highest winter nitrate concentrations recorded by the NMP were found in the Thames and Tyne estuaries. High loadings to the Humber estuary are also reported.

Phosphorus is present in the aquatic environment in both inorganic and organic forms. However, the organic forms contribute only a small proportion of the total and have not been considered in the NMP. The highest concentrations occur in the Thames estuary reflecting the large population density of the catchment and direct sewage effluent discharges. Reports to PARCOM (Paris Commission) 1996 show that the total orthophosphate load to the Thames estuary exceeds 6000 tonnes/year, of which 58% is from direct sewage discharges to the estuary (NRA, 1995b; Anon, 1996). The balance comes from riverine inputs, but even in these 90% load is accounted for by sewage works (Kinniburgh *et al.* 1997). These PARCOM reports also show high input to the Humber. Orthophosphate concentrations in the Humber estuary were not, however, exceptional (1–10µM) and this may be attributable to uptake onto particles in this particularly turbid estuary (Sanders *et al.* 1997).

Metals concentrations in estuaries were higher than at intermediate and offshore sites. This is interpreted as a direct consequence of the proximity of estuarine sites to inputs e.g. rivers. Within estuaries there was also a general tendency for metal concentrations to decrease with increasing salinity. Where information is available, concentrations tended to be higher in those estuaries that receive inputs from industrial and/or domestic sources. Examples are lead (Tyne, Tees and Thames) and zinc (Tyne and Wear). In the Thames estuary, the North Sea Project reported lead concentrations of 2-4µg/l (Althaus, 1992). There are some examples of major estuaries where either the survey is incomplete or application of QA procedures has resulted in the rejection of a considerable volume of data. This problem is evident for several metals in the Humber/ Ouse (Cu, Pb, Ni, Cr) and Thames (Cu, Zn, Cr).

The concentrations of mercury reported by the NMP were essentially all below the detection limit, typically tens of ng/l. That no real positive signals were observed is consistent with the results of published work using specialised techniques (Coquery & Cossa 1995). These workers reported total dissolved mercury concentrations of about 0.4ng/l for offshore waters of the open North Sea increasing to about 1ng/l at the mouths of estuaries such as the Humber. Even in what would be perceived as contaminated estuaries such as the Scheldt (between Belgium and The Netherlands) concentrations did not exceed 4ng/l.

Many of the metals included in the survey show higher concentrations in the southern North Sea than in the northern North Sea. This is attributed to the generally lower salinity in the southern North Sea, a consequence of the greater fresh water input from major rivers. (A similar effect is evident for parts of the Irish Sea, where apparently high concentrations of metals can be attributed to the lower salinity of this area (CEFAS, 1997)). Some metals are extremely particle-reactive, tending to be adsorbed onto suspended particles, with a consequent reduction in the dissolved phase concentration. Relatively high dissolved lead concentrations in the vicinity of Dogger Bank, observed here and in other studies (Laslett, 1995), are attributed to the relatively clear waters of this area, where there is little removal onto particles.

γ-HCH (lindane) is an organochlorine insecticide and is still commonly used in agriculture and as a timber preservative. Median concentrations of γ-HCH were below the EQS concentration of 20ng/l at all NMP sites except the Thames at Woolwich. Individual results above EQS were also found on the Ouse and Thames. Generally concentrations were lower offshore, although concentrations in the outer Thames estuary and off the East Anglian coast are higher than in the English Channel. This may be due to transport of γ-HCH on suspended particulate material.

The highest median concentrations recorded by the NMP of the triazine herbicides atrazine and simazine were found in the Humber and Ouse estuaries, respectively, with elevated concentrations also found in the Thames. The highest individual concentration of the widely used solvent trichloroethylene was found in the Wear estuary, which receives inputs from both river and point sources discharges. Positive results for the dry cleaning solvent Tetrachloroethylene (at most one tenth of the EQS concentration of 10µg/l) were found in the Wear and Humber estuaries.

Polycyclic aromatic hydrocarbons (PAH) are ubiquitous environmental contaminants. Although they can be formed naturally (e.g. in forest fires), their predominant source is anthropogenic emissions, and the highest concentrations of PAH are generally found around urban centres. Their widespread occurrence results largely from formation and release during the incomplete combustion of coal, oil, petrol and wood, but they are also components of petroleum and its products. PAH reach the marine environment via sewage discharges, surface run-off, industrial discharges, oil spillages and deposition from the atmosphere. The lower molecular weight PAH can be acutely toxic to aquatic organisms, but the major concern is that some PAH form carcinogenically-active metabolites (benzo[*a*]pyrene is the prime example) and PAH concentrations in sediments have been linked with liver neoplasms and other abnormalities in bottom-dwelling fish. Elevated PAH concentrations may therefore present a risk to aquatic organisms and potentially also to human consumers of fish and shellfish.

The highest PAH concentrations generally occur in major estuaries, particularly those of the Humber, Great Ouse, Thames and Tees. PAH concentrations at offshore sites were generally low or undetectable. Of the 39 NMP samples taken at offshore locations around the UK (10 miles or more from the coast), only one (NMP station 245 off the River Tyne sampled in 1993) showed a significant concentration of PAH, and this was only for naphthalene (263ng/l). Apart from this sample PAH were generally not detected in offshore waters. Higher concentrations were found in coastal and estuarine samples (although not in all), with total PAH concentrations ranging from none detected to 8.5µg/l. Total PAH concentrations greater than 1µg/l were found at 14 sites, in the estuaries of the Rivers Tees, Humber, Great Ouse, and Thames. Of these 14 sites, 10 were in the lower reaches of the River Tees estuary, and particularly high concentrations were observed in the vicinity of Redcar Jetty. The PAH profile observed in the five samples collected off Redcar Jetty was dominated by two-and-three-ring PAH, probably derived from an adjacent steel plant. The other data probably reflect inputs from a wide range of combustion processes involving both industrial and domestic sources.

The Environment Agency checks estuary water quality along nearly 120 kilometres in Yorkshire and the Humber. The estuary water quality classification scheme was developed during the 1970s, with consistent results available since 1985. The scheme provides a broad indication of water, biological and aesthetic quality - mainly related to sewage pollution.

The estuaries of Yorkshire and the Humber remained at the same quality between 1985 and 1995. The length of estuary classed as "good" quality has remained at 49.5 kilometres, the length classed as "fair" remained at 51.4 kilometres and the length classed as "poor" remained at 18.1 kilometres. There are no estuaries classed as "bad".

The Humber estuary is affected by flows from many different rivers including the Aire, Ouse, Don and Trent. The large number of releases carried by the rivers into the estuary are difficult to target for improving overall water quality. The whole of the Esk estuary, on the coast at Whitby, is classified as "good" quality.

River quality in the Anglian region is also improving, in 2000 in the East of England 92% of river lengths were fair to good chemical quality, an improvement over the past five years as in 1995, 88% were fair to good quality.

The quality of water in river estuaries within the Thames area is consistently (97%) good or fair. However, there are still significant intermittent water quality problems particularly at times of low flow during the summer months.

The riverine discharges to the landward ends of estuaries and direct discharges to estuaries and coastal waters are monitored by OSPAR (the *Comprehensive Study on Riverine Inputs and Direct Discharges)* to give estimates of the gross input of each substance to the maritime area. The reported riverine loads represent the loads coming from the whole of the river catchment areas, with no attempt to identify the sources of these loads or whether these loads are of natural or anthropogenic origins.

Reported discharges from the east coast of the UK (which will be dominated by discharges from the major estuary systems and industrial areas of the SEA 3 area) are given, as a proportion of total discharges to the greater North Sea, in Table 5.2.

Table 5.2 - Summary of riverine inputs and direct discharges from the UK east coast to the North Sea, as a percentage of North Sea totals

	Cd	Hg	Cu	Pb	Zn	g-HCH	PCBs	NH4-N	N03-N	PO4-P	Total N	Total P	SPM
Lower estimate UK E coast %	18.4	31.3	21.9	31.9	18.5	7.4	0.2	7.4	21.1	30.3	17.7	20.4	9.3
Upper estimate UK E coast %	30.0	30.6	21.5	31.9	17.3	13.1	31.3	7.3	21.0	30.3	17.4	19.6	9.4

The data suggests that riverine and direct inputs from the SEA 3 area are substantial sources of contaminants to the North Sea (consistent with the land area drained by rivers draining to the SEA 3 coast, and with the industrialised nature of eastern England).

5.5.2.2 Sediments

Trends in the concentration and distribution of contaminants in sediments, particularly hydrocarbons (HCs), are similar to those described for surface water contamination - see Table 5.3. There are, however, some notable exceptions. For example, the levels of certain metals appear higher in the southern North Sea compared to the northern North Sea (Pb, V, Cu and Fe). Recent work on seasonal current circulation patterns within the southern North Sea suggests that this may be due to coastal contamination transported offshore without being widely dispersed (CEFAS 2001).

Table 5.3 - Summary of contaminant levels typically found in surface sediments from the North Sea

Location	THC (µg/g)	PAH (µg/g)	PCB (µg/kg)	Ni (µg/kg)	Cu (µg/kg)	Zn (µg/kg)	Cd (ng/kg)	Hg (ng/kg)
Oil & Gas Installations	10-450[1]	0.02-74.7[2]	1,917[6]	17.79[7]	17.45	129.74	0.85	0.36
Estuaries	-	0.2-28[5]	6.8-19.1	-	-	-	-	-
Coast	-	-	2	-	-	-	-	-
Offshore	17-120[2]	0.2-2.7[3,4]	<1[4]	9.5	3.96	20.87	0.43	0.16

(Sources : [1] Daan et al. 1992, [2] Law & Fileman 1985, [3] Klamer & Fomsgaard 1993, [4] OSPAR Commission 2000, [5] CEFAS 1998, [6] Wells et al. 1988, [7] Harries et al. 2001)

Spatial patterns in sediment metal and organic contaminants have been described from NMP data, which includes estuarine and offshore sampling locations within the SEA 3 area. Concentrations of all metals at offshore sites were relatively low compared with those in estuaries. Between estuaries, however, there were differences, with a tendency for higher concentrations to be observed in those estuaries with either current or historical industrial inputs of metals.

In some industrialised estuaries, such as the Tees, concentrations of all metals were relatively high. Other estuaries, however, tended to have high concentrations of a smaller number of metals e.g. Tyne (lead and zinc).

A difficulty in assessing these data is establishing the extent to which concentrations are determined by anthropogenic inputs or local geological sources. For example, the mineralised parts of the Pennines are likely to contribute to the relatively high lead concentrations observed in the estuaries of the Tyne and Tees.

The observations show relatively high metal concentrations in estuaries compared with offshore. However, these differences may be related primarily to sediment type, since estuarine sediments frequently contain more fine clay minerals, constituting the majority of binding sites for metals within sediments. Sediments with a high clay content therefore contain, quite naturally, higher metal concentrations than sandier sediments. Variations in clay mineral content can be compensated for by reference to aluminium content, as aluminium oxides are major components of clay minerals, and consequently aluminium concentrations tend to be high in sediments rich in these minerals. Aluminium concentrations in sediments are believed to be unaffected by geochemical processes and can therefore be used as a surrogate for clay minerals.

Relatively high lead concentrations in some estuaries (e.g. Tyne and Tees) cannot be entirely accounted for by the abundance of clay minerals. The NMP results suggest that the sediments of these estuaries are contaminated by lead. Relatively high residual chromium values are also present in the Tees.

The NMP organic determinands were 11 individual polychlorinated biphenyl congeners, dieldrin, aldrin and endrin, three DDT group compounds (pp-DDT, pp-TDE and pp-DDE) and hexachlorobenzene (HCB). Organic contaminants are lipophilic and therefore have low water solubilities. They preferentially adsorb onto sediments particularly where these are fine grained and/or contain a high proportion of organic carbon. Concentrations would, therefore, be expected to be inherently higher in areas with fine-grained organic-rich sediments than in areas dominated by coarse sandy sediments.

The non-systemic insecticide dieldrin was commonly found at concentrations of 0.2–5µg/kg at estuarine and intermediate sites and these values represent typically background concentrations.

Although use of the insecticide DDT has ceased, its persistence means that it still occurs widely in the environment. In general, environmental levels of the parent compound are less than its metabolities (ppTDE and pp-DDE). pp-DDT was rarely found, but pp-DDE and pp-TDE were more ubiquitous in their occurrence although concentrations of compounds were low and often undetectable at most intermediate and offshore sites.

Total PAH concentrations ranged from not detected at some offshore sites with a sandy substrate (Smith's Knoll (NMP station 395), to 35400µg/kg dry weight in mud from the River Tyne at Hebburn (NMP station 225). All of the highest concentrations (total PAH >10000µg/kg dry weight) were found in the highly industrialised estuaries of north-east England, particularly in muddy sediments from the Rivers Tyne and Wear (NMP stations 225 and 265). Total PAH concentrations between 1000 and 10000µg/kg were found at sites in the Rivers Thames (NMP station 455) and also at two offshore sites (NMP station 245 off the Tyne, and NMP station 295 off the Tees). Additional sediment samples taken at non-NMP sites indicated that fine sediments from the Rivers Blyth and Tees also yield total PAH concentrations above 10000µg/kg dry weight, as did samples from a further site in the River Tyne at Tyne Bridge.

The highest concentration of benzo[*e*]pyrene was found in the River Wear at Queen Alexandra Bridge (NMP station 265), and of all the other PAH at Hebburn in the River Tyne (NMP station 225).

5.5.3 Sources of contamination from the oil and gas industry

The main contaminants associated with the oil and gas industry in the North Sea come from produced water and drill cuttings. Produced water from oilfields is now the major ongoing source of hydrocarbons, with hydrocarbon input from drill cuttings dramatically reduced due to replacement of oil based mud (OBM) discharges with alternative mud systems and disposal methods. There remains a "legacy" of contamination resulting from historic cuttings discharges in the form of cuttings piles in the central and northern North Sea (UKOOA 2002), although cuttings piles have generally not formed in the southern North Sea including the SEA 3 area due to hydrographic dispersion.

5.5.3.1 Produced water

Produced water is derived from formation water in oil/gas reservoirs and from seawater injected to maintain reservoir pressure and enhance extraction efficiency. Produced water may have a complex composition, including dispersed oil, metals and organic compounds including organic acids and phenols. Produced water composition varies between specific installations, and generally differs considerably between oil and gas reservoirs. Trends in produced water discharges have been assessed by UKOOA and are forecast to decrease despite large increases in water production, due to technical developments including re-injection (considered in more detail in Section 10). In general, produced water volumes will be low from the gas and condensate reservoirs likely to occur in the SEA 3 area, although the concentrations of organic compounds may be higher in comparison to oilfield produced water.

Oilfield produced water discharges are also responsible for significant discharges of production chemicals used offshore, where these partition into the aqueous phase. Higher quantities of corrosion inhibitors, gas treatment products and scale inhibitors are discharged into the North Sea than chemicals of any other functional group. Reported discharges of the major process chemical categories are tabulated below (Table 5.4).

Table 5.4 - Peak annual values (in tonnes) of chemicals discharged by functional type between 1992 and 1998 (Value in parenthesis is year observed).

Chemical function	Central North Sea	Southern North Sea
Biocides	98 (1995)	55 (1993)
Corrosion inhibitors	215 (1997)	74 (1996)
Gas treatment	1810 (1997)	2437 (1994)
Scale inhibitors	3030 (1997)	-

Source: CEFAS (2001)

The selection of production chemicals for use offshore is regulated under the Harmonised Mandatory Control System for the Use and Reduction of the Discharge of Offshore Chemicals (see below), which encourages the avoidance of toxic and bio-accumulating chemicals. However, specific concerns remain associated with the widespread use of synthetic polymers in demulsifiers and stimulation fluids (CEFAS 2001). These materials are generally of low toxicity, but may be persistent in the environment due to their inert nature.

5.5.3.2 Drill cuttings

Metals in cuttings discharges are derived mainly from formation minerals, and from mud additives (principally barite and bentonite). The mud component of current and future discharges of cuttings to the North Sea comprise exclusively water-based mud (WBM), which generally results in wide dispersion of discharged cuttings in comparison to previous discharges of OBM, and little accumulation of contaminants in sediments and biota (Cranmer 1988, Neff *et al.* 1989, Hyland *et al.* 1994, Daan & Mulder 1996). Organic-phase drilling fluid (OPF), using biodegradeable synthetic base fluids, may also be used under some circumstances (e.g. in highly deviated or unstable well sections), but will be contained and returned to shore for treatment, re-use and/or disposal.

5.5.3.3 Trends in offshore discharges

Discharges from offshore oil and gas industry activities are monitored by OSPAR and reported in the Annual Report on Discharges, Waste Handling and Air Emissions from Offshore Installations. These data provide an indication of recent trends across the OSPAR area, associated mainly with production levels, increasing maturity of North Sea reservoirs, technical developments and regulatory controls.

Main conclusions from the 2000-2001 annual report (OSPAR 2002) are reproduced below (note that the reported data include returns from Norway, Denmark, Germany and the Netherlands, where different regulatory systems apply):

Offshore Discharges 2000-2001

Total production of hydrocarbons remained at the same level in 1997 and 1998 and increased by 5% in 1999.

The total quantity of oil discharged into the OSPAR maritime area, excluding synthetic-based drilling fluids (now called organic-phase drilling fluid (OPF)), was 9,519 tonnes in 1997, 8,868 tonnes in 1998 and 9,053 tonnes in 1999. This represents a decrease of 7% between 1997 and 1998, and an increase of 2% between 1998 and 1999.

The 1997/1998 decrease followed an exceptional spillage in 1997, while the slight 1998/1999 increase was due to an increase in the discharge of produced water.

If reported discharges of OPF are taken into account, a continuous decrease is seen in the total discharge of hydrocarbons into the maritime area: discharges of 16,753 tonnes of oil and OPF were reported in 1997, 13,873 tonnes in 1998 and 13,642 tonnes in 1999.

Four sources of oil discharges are identified. These are produced water, drill cuttings, spills and flaring operations. Produced water and cuttings are the source of 98% of the total oil and OPF discharged. Spillage is a minor contributor and flaring contributes even less.

The evolution of total discharges including OPF between 1998 and 1999 is due to a slight increase in the discharges of produced water, and a slight reduction in the discharges of reported OPF;

The quality of the water discharged (expressed in terms of the content of oil in the water discharged) shows a continuing slight improvement; it averaged 23,2mg/l in 1999, even better than in 1994 (24,0mg/l), although the quantity of water discharged has doubled since then.

Overall, the number of installations which exceeded the 40mg/l target standard for oil has significantly decreased (down 16%) since 1997. This overall decrease reflects a significant increase in 1998 (up 20%), followed by a more dramatic decrease in 1999 (down 31%).

Offshore Discharges 2000-2001 (continued)

More importantly, the average quantity of hydrocarbons discharged by those installations which exceeded the 40mg/l target standard has significantly and continuously decreased (down 47%). This demonstrates that, in 1998 and 1999, a real effort has been made by those installations with the worst records, including in some cases stopping discharges to the sea by reinjecting the produced water or bringing it to shore for treatment.

Since 1997, the oil discharged via cuttings relates only to the use and discharge of synthetic-base drilling fluids (non-OBM OPF). There is no more discharge of oil-based drillings fluids and cuttings, except by accidental spillage. As OSPAR was not regulating OPF until 2000, not all Contracting Parties have reported their use and discharge of OPF. For those reporting, the hydrocarbons discharged through the use of OPF decreased by 30% in 1998 and by 8% in 1999.

Spillage: the total quantity of oil spilled is fairly stable: the 303 tonnes in 1998 and 283 tonnes in 1999 are in line with quantities spilt in 1994-1996 (1997 was an exceptional year, with a large spill).

Flaring: flaring makes a very minor contribution to the total discharge of oil. There is a reported decrease between 1998 and 1999. However, one of the Contracting Parties involved in flaring is not reporting any data (flaring is not presently regulated by OSPAR).

Source: OSPAR (2002)

5.5.4 Implications for Strategic Environmental Assessment

Key implications for SEA 3, following from the review of contamination of water and sediments above, include:

- The major estuaries of the SEA 3 coastline are generally among the most contaminated locations in the UK, with significant concentrations of metals and organic contaminants
- The coastal and offshore environment, including the vicinity of developed gas fields, is characterised by low levels of contaminants
- There is little evidence for offshore hydrocarbon production representing a significant source of contamination

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6 ECOLOGY

6.1 North Sea overview

The North Sea is a complex and productive ecosystem which supports important populations of fish, seabirds and marine mammals. Offshore pelagic and benthic communities are interlinked in more or less tightly coupled food webs which, together with the abiotic environment, make up marine ecosystems. For much of the SEA 3 area, further ecological interactions occur between marine communities and those of the intertidal, riverine and terrestrial systems.

In a holistic and integrated summary of the status of the entire OSPAR maritime area (OSPAR 2000), marine ecological processes were summarised as follows:

Microscopic phytoplankton constitute the 'grass' of the sea and the basis for production at higher tropic levels. Phytoplankton is grazed by zooplankton, which again forms the food for plankton-feeding fish (e.g. anchovies, herring, mackerel) and whales. Benthic animals living in or on the seabed feed on plankton and dead organic material sinking out from the upper layer. Fish, squid, sea mammals and seabirds feed on smaller fish or benthic animals. Kelp and other macroalgae grow as plants in the lighted zone in shallow waters. Microorganisms contribute to decomposition of organic material and recycling of nutrients.

For much of the SEA 3 area, detritus-based secondary production depends largely on the export of organic material from land, via river run-off, and on highly productive estuarine marshes (the latter being of particular significance for wintering bird populations).

Productivity and biogeographic importance of the North Sea is probably most evident in terms of seabird and migrant waterfowl populations (Section 6.7). Although the major breeding areas are located to the north of the SEA 3 area, the central and southern North Sea and adjacent coastlines are of great importance for wintering birds, and for passage migrants en route to wintering grounds further south.

Conversely, the central and southern North Sea is of less overall importance to cetaceans, although some areas are important for harbour porpoise and white-beaked dolphin. The North Sea supports about half the North-East Atlantic population of grey seals and a similar proportion of the eastern Atlantic harbour seal subspecies (Section 6.8).

The planktonic, benthic and fish populations which support these top predators are reviewed in the following sections. While discernible spatial patterns are present in pelagic community distributions, regional and local heterogeneity is much more obvious in benthic community structure, where characteristic species assemblages are associated with particular seabed habitats – these range from chalk cliffs to muds in estuaries and some deeper water parts of the northern SEA 3 area. Benthic habitats and communities also reflect the recent geological history of the North Sea, and can be considered to be in a process of continuous change in response to climatic and other factors (Section 6.3).

Planktonic communities also reflect temporal variability in response to climatic and hydrographic processes, with significant changes observed over decadal or shorter timescales (Section 6.2).

The intensity and ecological consequences of direct human exploitation of the marine ecosystem have steadily increased, to the present situation where removal of target species impacts the whole North Sea ecosystem and catch levels for many fish stocks are almost certainly not sustainable (CEFAS, this document). A variety of other human pressures on the North Sea environment were reviewed by OSPAR (2000), the most significant of which were inputs of trace organic contaminants from land, seabed disturbance by fisheries, inputs of nutrients from land, effects of discards and mortality of non-target species by fisheries, and input of TBT and other antifouling substances by shipping. In the context of estuarine and coastal areas, direct habitat destruction (e.g. by land reclamation) and disturbance due to industrial and recreational activities are of prime importance to conservation of natural heritage.

6.2 Plankton

6.2.1 Introduction

To support the SEA process, SAHFOS was commissioned to review plankton ecology in the North Sea. The report describes the plankton community structure and how this has changed over the past few decades. The report produced for SEA 2 has been revised for SEA 3 to incorporate new and area specific information.

Plankton in the North Atlantic and North Sea has been monitored for almost 70 years using the Continuous Plankton Recorder (CPR). From this data, changes in abundance and long term trends can be distinguished. Planktonic organisms constitute a major food resource for many commercial fish species and changes in their populations are therefore important in economic terms.

6.2.2 Planktonic communities in the North Sea

Plankton can be divided into phytoplankton (plants) and zooplankton (animals).

The most common phytoplankton groups are the diatoms, dinoflagellates and the smaller flagellates. The latter are often referred to as pico or nano plankton but, because of their small size, they are difficult to study and consequently under researched. Much of this group consists of bacteria, in addition to blue-green algae, and at times may make up 15 to 33% of the total plankton biomass.

The phytoplankton community in the central and southern North Sea is dominated by the dinoflagellate genus *Ceratium*, although there are also high numbers of the diatoms, *Chaetoceros (*subgenera *Hyalochaete* and *Phaeoceros.* Phytoplankton biomass has increased over the last four decades throughout the majority of the North Sea.

The zooplankton communities of the central and southern North Sea regions are dominated in terms of biomass and productivity by copepods, particularly *Calanus* species. In the southern North Sea meroplanktonic echinoderm larvae are the second most abundant group recorded. The larger zooplankton, known as megaplankton, includes euphausiids (krill), thaliacea (salps and doliolids), siphonophores and medusae (jellyfish). The gelatinous taxa are poorly sampled as their bodies disintegrate on contact with the CPR although they are known to be more abundant in late summer and autumn.

Salps and doliolids are known to produce huge swarms, peaking in late summer to October. This can lead to depleted food sources for other herbivorous plankton with subsequent effects to the higher trophic levels. Siphonophores (colonial hydrozoa) can also reach large densities in the North Sea.

Krill is very abundant throughout the North Sea and is a primary food source for fish and whales. During times of increased flow of colder water from the Norwegian Sea, euphausiid numbers increase in the central North Sea.

Meroplankton are the larval stages of benthic organisms that spend a short period of their lifecycle in the pelagic stage before settling on the benthos. Important groups within this category include the larvae of starfish and sea urchins (echinoderms), crabs and lobsters (decapods) and some fish.

The northern North Sea has seen an increase in decapod larvae since the late 1980s, with a dramatic rise in 1998, tied in with a large Atlantic inflow. The southern North Sea has also shown a general increase in abundance, though no pronounced increase in 1998. Echinoderm larvae also increased in the northern North Sea in the late 1990s, although the southern North Sea population shows no change.

6.2.3 Plankton blooms in the North Sea

In the North Sea a phytoplankton bloom occurs every spring, often followed by a smaller peak in the autumn. In spring, as the day length increases and the water column becomes stratified, there is a bloom of diatoms. As little mixing of the water occurs, nutrients essential for the diatoms become depleted and other groups bloom, such as flagellates, followed later by dinoflagellates. As nutrients become further depleted, primary production slows down. Autumn introduces stronger winds which mix the water, introducing nutrients back to the photic zone, initiating a secondary bloom of dinoflagellates. As light levels reduce through the latter part of the year, primary production is again limited. With little primary production during the winter months, nutrients rise to levels to support the spring bloom.

Analysis of detailed time series of bio-optical and temperature data from the central North Sea (Van Haren *et al*. 1999) supports the view that a minimum level of turbulence is a prerequisite for the onset and maintenance of the phytoplankton spring bloom. The progress of the spring bloom, primarily diatoms, is predominantly dependent upon episodic turbulence input following short periods of stratification, which allow the resuspension of a fast sinking (50-200m/day^{-1}) phytoplankton community from the bottom mixing layer. Throughout the spring bloom, algal biomass is either equally distributed through the water column or concentrated in the bottom mixing layer. Growth can only be sustained in the near-surface layer during periods of substantial turbulence input. The establishment of semi-permanent seasonal stratification causes an almost complete reduction in near-surface biomass and a concomitant increase in biomass in the bottom mixing layer which subsequently acts as a source for occasional increased near-surface biomass until early summer.

The winter distribution of phytoplankton and zooplankton around three sandbanks off the Belgian coast was investigated by M'harzi *et al.* (1998), who found significant differences in phytoplankton taxa between the banks. This was attributed to salinity, temperature and turbidity differences and suggests that spatial heterogeneity in plankton communities during late winter may influence "starting positions" (in terms of community composition) for the spring bloom.

CPR results show exceptional phytoplankton blooms in the late 1980s. This was connected with very mild atmospheric conditions together with a large oceanic inflow into the North Sea.

Under certain conditions (e.g. rapid reproduction, reduced grazing pressures, favourable environmental factors) blooms can occur at other times of the year. Many of these blooms involve nuisance or noxious species and are described as Harmful Algal Blooms (HABs). Examples include those connected with paralytic shellfish poisoning (PSP), such as the event in May 1968 when a bloom of the dinoflagellate *Alexandrium tamarense* on the north-east coast of England resulted in hospitalisation of 78 people and large-scale deaths of seabirds and sandeels (Ayres & Callum 1978, Adams *et al*. 1968, Coulson *et al.* 1968). In 1990, PSP toxin was widespread in shellfish samples taken from Berwick to Whitby, and transport modelling indicated that there was no single source of the bloom (Joint *et al*. 1997). HABs may be related to water surface temperatures in spring, as early seasonal stratification may favour phytoplankton growth in the water column (Joint *et al*. 1997). Recent observations of seasonal circulation along the north-east coast of England suggest that dinoflagellates originating from the high concentrations of *Alexandrium tamarense* cysts in the sediment of the Firth of Forth act to maintain a dinoflagellate population in the coastal region south to Flamborough Head, thereby maintaining the risk of PSP outbreaks (Brown *et al*. 2001).

6.2.4 The influence of hydro-climatic changes in the North Sea

A key influence of the North Atlantic weather patterns is the North Atlantic Oscillation (NAO; see also Section 5.4). During certain conditions, westerly winds increase over the North Sea which introduce warmer air and increase the North Sea surface temperatures. In addition, the increase in wind reduces stratification of the surface waters, delaying the onset, or altering the community structure of the spring bloom. These conditions have been more predominant in the last few decades and there is a suggestion that this may be an effect of global warming.

The plankton community in the North Sea has changed over the last few decades with the population composition of *Calanus* changing markedly over the last 10 years. There has also been a considerable increase in phytoplankton colour over the last decade in most areas of the North Sea. These changes have coincided with an increase in sea surface temperature, linked to the state of the NAO. In the eastern North Atlantic Ocean and European shelf seas, strong biogeographical shifts in all copepod assemblages have occurred with a northward extension of more than 10° latitude of warm-water species associated with a decrease in the number of colder-water species (Beaugrand *et al*. 2002). These biogeographical shifts are in agreement with recent changes in the spatial distribution and phenology detected for many taxonomic groups in terrestrial European ecosystems and are related to both the increasing trend in Northern Hemisphere temperature and the North Atlantic Oscillation.

In addition to the general trend in increasing sea surface temperature, there have been times when water of differing salinity and/or temperature has entered the North Sea and changed the local ecosystem. In the late 1970s a pulse of cold, low salinity water entered the North Sea which delayed and lowered the primary production of the spring bloom. Conversely, in the late 1980s and again in the late 1990s, warm, more saline oceanic water entered the North Sea.

Recent research has suggested that inflow into the North Sea is becoming more persistent, rather than episodic. This is notable in the phytoplankton community, with diatoms decreasing and dinoflagellates increasing over the last decade. This could have important ramifications, as many dinoflagellate (and flagellate) species are noxious to other organisms.

It is therefore apparent that hydro-climatic events are important in altering the ecosystem of the North Sea. Current research suggests that these events have a greater impact on the biota of the North Sea than the anthropogenic factors.

6.2.5 Sensitivity to disturbance/contamination

Ship traffic is high in the North Sea, resulting in a relatively high risk of oil spills. Effects on plankton have not been studied extensively although the effects from relatively recent oil spills from tankers e.g. *Torrey Canyon*, *Braer* and *Sea Empress* have been assessed.

Work after the *Sea Empress* spill failed to find any significant effects on the plankton although other studies have shown lowered fecundity and offspring mortality. There is a strong suggestion that dispersant treated oil has a more pronounced effect. Any long-term genetic changes are difficult to assess.

6.2.6 Ballast water and invasive species

Ballast water in ships has been recognised as a source for the introduction of non-indigenous and potentially harmful organisms. A number of planktonic organisms have been identified in the North Sea. There is a growing concern considering the risk of alien species and the importance of protecting native biodiversity. With raised awareness, there are a variety of operational and technical innovations being introduced to reduce the risk of organism transfer via ballast water.

6.3 Benthos

6.3.1 Introduction

The benthic environment can be conveniently considered in terms of three divisions, offshore, nearshore (to approximately 5km) from shore, and intertidal (littoral). These distinctions also correspond broadly to differences in survey methods and the coverage of both individual studies and regional programmes. The inter-relationship of benthic communities and habitat (i.e. substrate type) is well-known and communities are therefore often described in terms of their characteristic substrate.

The offshore benthos of the central and southern North Sea was considered in SEA 2, and much of the information contained therein is equally relevant to SEA 3.

Littoral and nearshore seabed habitats and communities at individual sites have been reviewed comprehensively by MNCR publications (see below) and the JNCC Coastal Directories (Irving 1995a, b, 1998). The following description of individual habitats, communities and species is therefore limited to a synopsis of geographical distribution, with broad patterns considered in a regional context.

While the North Sea has a long geological history dating back to the Permian (about 275 million years ago), events over the last 11,000 years are the prime influences on modern day seabed fauna distributions. During the last glacial period which ended about 11,000 years ago, sea levels were around 100m below present and much of the North Sea was dry land or covered by ice. The present status in the North Sea was achieved about 6,000 years ago when the Flandrian transgression occurred, flooding the shallow land south of the Dogger Bank. Thus the seabed fauna of the North Sea has colonised and developed over the last 6,000 to 11,000 years, in the process being subject to a change from Arctic to more temperate Boreal conditions. While conditions are comparatively stable, they are not static, with long term climatic/hydrographic cycles (OSPAR 2000) and short term extreme events occurring (e.g. the harsh winter of 1962/3, Crisp *et al*. 1964) which result in progressive or sharp ecological changes. Overlain on natural changes are the effects of man's activities which occur at a local and ecosystem level (see Section 6.3.8).

6.3.2 Sources and studies

The history of offshore benthic studies ranges from the classic studies of Petersen (1918) to recent compilations of industry-funded monitoring surveys (Harries *et al*. 2001). Important regional studies and data sources are listed in Table 6.1:

Table 6.1 – Regional surveys

Reference	North Sea area covered	Notes
Govaere *et al.* 1980	Belgian and southern Dutch offshore waters	Sampled infauna. Coverage stopped just south of the SEA 2 area
Dyer *et al*. 1982, 1983	The North Sea between 52° 45' and 61° 39'N	Epifauna sampled by otter trawl since 1978
Creutzberg *et al.* 1984	Majority of Dutch waters	Sampled infauna.
Frauenheim *et al*. 1989	The North Sea between 51° 45' and 60°N	Epifauna sampled by beam trawl
Duineveld *et al.* 1990	The Dutch exclusive economic zone	Sampled infauna. Data also incorporated into the ICES survey of the North Sea (Künitzer *et al*. 1992)
Künitzer *et al*. 1992	The North Sea between 51° and 61°N	Addressed infauna. Several of the contributory studies are also published separately
Kröncke 1992	The Dogger Bank and some immediately adjacent areas	Infaunal surveys carried out in 1985-1987 which revisited many of Ursin's 1950 stations
Duineveld 1992, Holtmann *et al.* 1998	The Dutch exclusive economic zone	A series of infaunal surveys from 1992 to 1997 with results published and compared annually
Jennings *et al*. 1999	The North Sea between 51° 40'and 61° 11'N	Epifauna sampled by beam trawl in 1996
Rees *et al*. 1999	The North Sea between 51° 30'and 58° N (for epifauna) and 51° 30'and 55°N	Infauna sampled by Day grab 1993-1994, epifauna sampled by beam trawl between 1992 and 1996
Zühlke 2001	The entire continental shelf of the North Sea	Epifauna and demersal fish sampled by beam trawl in 1999 and 2000

Nearshore and intertidal studies within the SEA 3 area have been carried out for academic purposes (often reflecting the presence of field stations, such as the Robin Hood's Bay laboratory of the University of Leeds, and the Burnham-on-Crouch laboratory of CEFAS, formerly MAFF); in relation to nuclear power stations at Sizewell and Bradwell (e.g. Bamber & Batten 1989, IECS 1991); to assess the effects of sewage and sewage sludge disposal, and other industrial activities (e.g. construction of the Channel Tunnel, George & Fincham 1989) and to support early conservation assessments (Irving 1995a, b, 1998). Particular studies of relevance to SEA 3 include long-term studies of benthic communities in the Northumberland Deep by JB Buchanan and co-workers (e.g. Buchanan & Moore 1986); recent studies in relation to aggregate dredging off the Suffolk coast (Seiderer & Newell 1999) and in relation to proposed port development in the Thames estuary (Newell *et al*. 2001).

The Marine Conservation Review of Great Britain (the MNCR) commenced in 1987 with the main objectives of identifying sites and species of nature conservation importance, and extending knowledge of benthic marine habitats, communities and species in Great Britain, particularly through description of their characteristics, distribution and extent. The data collected also provide information to support more general measures required to minimize adverse effects of development and pollution, particularly on sites and for species of nature conservation importance.

At the start of the MNCR, survey methods had been developed by contractors to NCC (Nature Conservancy Council) and were aimed at supplying information to inform the identification of conservation importance of sites. These methods provided the basis for the development of MNCR survey techniques, including biotope classification (see box). Survey methods reflected the objectives of the MNCR which were:

- Extending our knowledge of benthic marine habitats, communities and species in Great Britain, particularly through description of their characteristics, distribution and extent

- Identifying sites and species of nature conservation importance

Subsequent to the Environmental Protection Act 1990, the MNCR was undertaken by the JNCC on behalf of the country agencies, including English Nature (EN). Access to MNCR data is provided through MERMAID (see table 6.2).

An overview of the results of MNCR surveys is provided by Hiscock (1998), with more comprehensive review in a regional report series of areas within each of the MNCR coastal sectors. Regional reports relevant to SEA 3 include reviews of inlets in eastern England (Hill *et al*. 1996) and south-east Scotland and north-east England area summaries (Brazier *et al.* 1998).

Table 6.2 – MERMAID and MNCR biotope classification

MERMAID
JNCC's Marine Environmental Resource Mapping and Information Database (MERMAID) database has been developed to provide wider access to information on marine sites, habitats and species around Britain and Ireland, collected as part of the Marine Nature Conservation Review and originally held on the MNCR database. Internet technology enables rapid access to the most up to date information held in JNCC's central data system, including map based searches. The development of MERMAID also links closely with the National Biodiversity Network and is being used as a demonstation project showing that delivery of database information over the internet is both technically possible and advantageous.

MNCR Biotope classification
Over 360 biotopes have been distinguished by the MNCR classification, divided between littoral and sublittoral divisions. The classification allows access via either habitat attributes through a series of habitat matrices or the biological community through a hierarchical classification of biotopes and higher types. The main habitat division is between rock and sediment, sub-divided into phytosociological zones from littoral to circalittoral. These in turn are arranged along an energy gradient with tide and/or wave exposed biotopes at one end of the scale and sheltered, still water biotopes at the other. There are five levels in the hierarchical approach to the classification: major habitats; habitat complexes; biotope complexes; biotopes and sub-biotopes. Each level is related to the degree of biological distinction, to the ability to discriminate types by various methods of remote and in situ sampling, to the ease of recognition by workers with differing skill levels and to the end use of the classification for conservation management at various scales.

6.3.3 Broad patterns of community distribution and types

Recent work on the biogeographical zones (Provinces) of the OSPAR area indicates the SEA 3 area is within the Boreal Province which covers the North and Irish Seas. For the SEA 3 area this accords with the Eastern Atlantic Boreal Region of Briggs (1995).

- Boreal Province including the North and Irish Seas (and SEA 3 area)
- Lusitanian-Boreal Province comprising the Celtic Sea and west coasts of Ireland and Scotland

- Norwegian Coast Province, extending from the Skagerrak to beyond Lofoten
- Arctic Deep-Sea Province, a deep water zone centred on the Norwegian Sea but extending into the Faroe Shetland and Faroe Bank Channels
- Atlantic Deep-Sea Province, a deep water zone to the west of northeast Europe

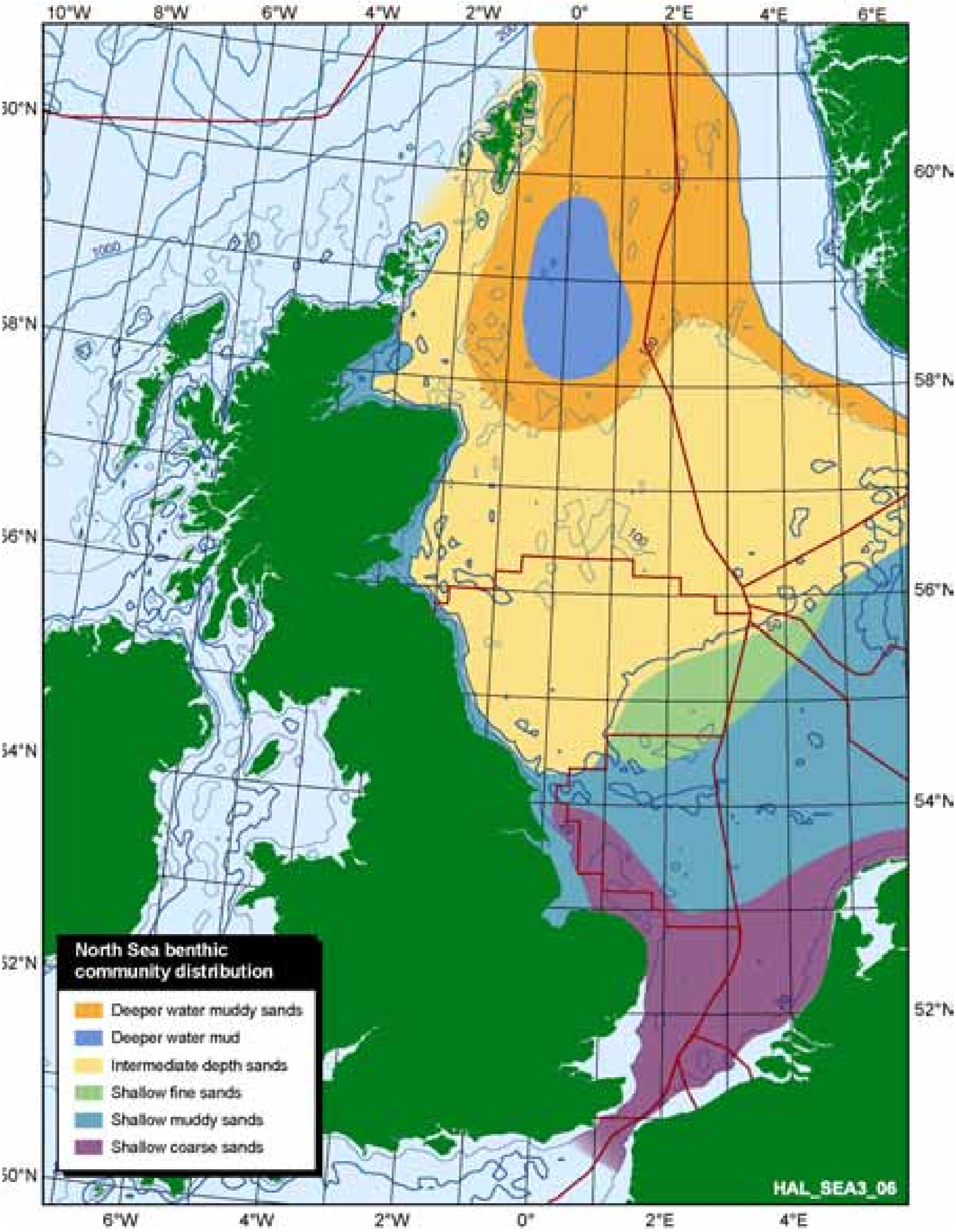
Within a biogeographical province the area can be further subdivided according to physical and biological features. Various authors have noted that the faunal distributions at the offshore seabed in the North Sea appeared to reflect hydrographic patterns and Glémarec (1973) developed this and proposed three subdivisions of the area on the basis of thermal stability over time:

- The northern North Sea where the water mass stratifies strongly in summer, effectively insulating the bottom water and seabed fauna from the large scale temperature changes that occur in the upper water column. The annual temperature range at the seabed is only 1-2°C. This area is to the north of 58°N and approximately bounded by the 100m depth contour
- The central North Sea (between the 100m depth contour and the Dogger Bank) where the annual temperature variation is 7 or 8°C
- The southern North Sea (south of the Dogger Bank) where the water column remains mixed year round and tidal, daily and seasonal variations in temperature occur and the variation over the year is in excess of 10°C

Within each subdivision of the North Sea, Glémarec was able to distinguish a series of faunal communities inhabiting specific sediment types, which accorded well with previous community descriptions. Subsequent studies, including a series of surveys combined to give North Sea wide coverage coordinated by ICES (Künitzer *et al.* 1992), have supported the broad divisions identified by Glémarec. In many cases however, the community groupings distinguished are dependant on the scale of the survey, with smaller scale surveys revealing more localised community types usually reflecting local sediment distribution patterns. It should be noted that such small scale features and localised communities may be of conservation interest on account of their local or wider rarity. The broad scale patterns of offshore seabed faunal community distribution are illustrated in Figure 6.1, developed from Glémarec (1973), Basford *et al.* (1990), Duineveld *et al.* (1990), Künitzer *et al.* (1992), Jennings *et al.* (1999) and Zühlke *et al.* (2001).

In contrast to the macrofauna, the smaller seabed fauna (meiofauna) of the North Sea has been poorly studied with large numbers of species yet to be named in the scientific literature (Heip & Craeymeersch 1995). This basic information is required before different community types can be distinguished and mapped and the full biodiversity of the seabed can be assessed.

Figure 6.1 - Benthic community distributions in the North Sea



Sources: After Glémarec 1973, Basford et al. 1990, Duineveld et al. 1990, Künitzer et al. 1992, Jennings et al. 1999

6.3.4 Offshore southern North Sea - regional context

The seabed of the southern North Sea was the subject of early studies by Petersen (1914 and 1915) and Davis of the Dogger Bank (1923) and southern North Sea (1925). The Danish surveys continued between 1932 and 1955 culminating in a series of papers describing the species composition and distribution of various groups of seabed animals (Ursin 1960, Kirkegaard 1969, and Petersen 1977). The Danish sampling was centred on the Dogger Bank and adjacent areas, reflecting the importance of the area for fisheries. Results of sampling on the central and western Dogger Bank between 1952 and 1954 by Birkett remained largely unpublished until included in a paper by Kröncke (1991), although an important finding regarding the persistence of dense populations of the bivalve *Spisula* was published by Birkett (1953).

More recently, numerous smaller spatial scale investigations of the seabed have been carried out in the southern North Sea. These have primarily been environmental monitoring of various industrial activities (e.g. oil and gas developments (Harries *et al.* 2001), aggregate extraction (Resource Consultants Cambridge Ltd 1993), and sewage sludge dumping (Talbot *et al.* 1982)

The infaunal communities identified by various authors show consistency at a high level. However, depending on the intensity and spatial extent of sampling, localised community types or more subtle variations are distinguished. In terms of broad community distribution, the ICES survey reported by Künitzer *et al*. (1992) provides a good picture. In the southern North Sea four main communities were found in:

- fine sands in 50-70m with a fauna typified by the polychaetes *Ophelia borealis* and *Nephtys longosetosa*
- muddy fine sands in 30-50m with the bivalve *Nucula nitidosa*, the shrimp *Callianassa subterranea* and the cumacean crustacean *Eudorella truncatula*
- coarse sediments mainly in less than 30m (1) with the polychaete *Nephtys cirrosa*, the sea urchin *Echinocardium cordatum* and the amphipod crustacean *Urothoe poseidonis*
- coarse sediments mainly in less than 30m (2) with the polychaetes *Aonides paucibranchiata* and *Pisione remota* and the amphipod crustacean *Phoxocephalus holbolli*

All these major community types are represented within the SEA 3 area.

Dyer *et al*. (1983) conducted cluster analyses of trawled (primarily epi-) fauna from MAFF groundfish surveys over the whole North Sea, showing the area could be divided into 4 northern and 3 southern groups. The southern groups corresponded to the northern slopes of the Dogger Bank (S3), the shallowest part of the Dogger Bank and other shallow stations on the western side of the North Sea (S2), and the broad area of muddy fine sands off the Dutch coast forming group S1.

The cluster analysis performed by Jennings *et al*. (1999) indicated that the epifauna of the whole North Sea south of the Dogger Bank was similar and formed a single cluster. In contrast, Rees *et al*. (1999) concluded that the area could be divided into 6 groupings based on sediment type and epifauna. Those included within the SEA 3 area were northwestern North Sea gravel, Stony, east Channel and east coast of England gravel, nearshore muddy sand/Dogger Bank, and southern North Sea sand, with the latter 2 being most extensive.

6.3.5 Offshore sandbanks

From the work of Vanosmael *et al.* (1982) on the Kwinte Bank of Belgium, the fauna of offshore linear sandbanks appears distinctive in a number of features, in particular the very high densities of interstitial (that is living in the interstices between sediment grains) polychaetes present. These species show very high variability between sampling stations which either reflects patchiness of distribution or very tightly defined habitat requirements, so that a small alteration in location of samples results in a large difference in the fauna recorded.

Similar sandbanks occur in parts of the SEA 2 and SEA 3 areas although there appears to be no published quantitative information on the fauna present. Since some sandbanks in waters of 20m or less may be considered for inclusion in UK Natura 2000 sites (potential SACs), the DTI commissioned detailed surveys of these habitats within the SEA 2 and adjacent areas.

It is clear that there are major sediment and faunal differences between the offshore linear sandbanks (the Norfolk Banks) and the banks in the approaches to the Wash. The Wash approach banks (Galahad field, Dudgeon Shoal, Cromer Knoll and the western end of the Haddock Bank) have a stony and coarse shell sediment with extensive epifauna and infauna. In contrast, the offshore linear banks were sandier with a fauna typified by the sea urchin *Echinocardium cordatum* and the bivalve *Fabulina fabula* with sandeels (two species) common.

The DTI samples of the Dogger Bank indicate a richer (more and larger animals of a range of species) fauna than that found on the sandbanks to the south. At the 5mm material level, no major differences can be discerned between the various stations sampled across the Dogger Bank. Predominant species were *Echinocardium cordatum, Fabulina fabula* and a range of worms including the sand mason *Lanice conchilega* and *Owenia fusiformis.*

The fauna recorded during the DTI survey of the southern SEA 2 sandbanks accords closely in terms of species distribution with previous surveys of the area. Banks within the SEA 3 area off the south Norfolk, Suffolk and Essex coasts are likely to support similar faunal communities.

6.3.6 Nearshore benthic habitats and communities

A substantial amount of information is available concerning nearshore benthic habitats and communities of the east coast of England – this has been reviewed by MNCR coastal sector reports and JNCC Coastal Directories (Irving 1995a, b, 1998), and is summarised in Appendix 4.

The range of nearshore benthic habitats includes sand plains, rocky outcrops and reefs, deep water muds and gravels; each with a characteristic species assemblage. Habitats of conservation interest include particularly the limestone exposures around Flamborough Head and Thanet.

6.3.7 Sediment shores

Soft sediment shorelines are present throughout the SEA3 coastline, but are particularly well developed south of the Humber. A range of shore types are represented (see Appendix 4), including exposed sandy shores and sheltered estuarine mudflats.

6.3.8 Rocky shores

Rocky shores are particularly prevalent north of the Humber (Appendix 4), although examples are present in the southern part of the SEA3 area, including artificial sea defence structures. Rocky shores have characteristically zonation of animal and plant populations, which varies with location and degree of exposure.

6.3.9 Species and communities of conservation interest

Sanderson (1995a, b, 1998) lists rare and scarce marine benthic species that have been recorded in the JNCC Coastal Directory regions within the SEA 3 area, together with their known areas of occurrence. 'Nationally rare' marine benthic species are those native organisms known to occur in eight or fewer of the 10 x 10km squares (of the Ordnance Survey national grid) containing sea within the three-mile territorial limit for Great Britain. 'Nationally scarce' are those known to occur in 55 or fewer. Species at the limit of their global distribution (e.g. 'southern' or 'northern' species) may be rare within Great Britain's territorial seas but occur more commonly towards the centre of their biogeographic range. Species described here as 'nationally rare' or 'nationally scarce' are therefore not necessarily endangered globally and, although they are of national interest, their conservation importance needs to be carefully considered.

Sanderson (1995a, b, 1998) lists three species of hydroid, two polychaete worms, three bryozoans, one ascidian sea squirt, one anemone, two amphipods, two molluscs and one red alga. Of these, three species are protected under the Wildlife & Countryside Act 1981 of which two have individual species action plans under the UK Biodiversity Action Plan (www.ukbap.org.uk/):

The starlet sea anemone *Nematostella vectensis* occurs in only a few coastal lagoons in the Isle of Wight, Sussex, Hampshire, and in Dorset and along the East Anglian coast. It may also occur in some brackish ponds and ditches. The species is listed as *Vulnerable* by IUCN/WCMC and *Rare* on the GB Red List

- The lagoon sand shrimp (the amphipod crustacean *Gammarus insensibilis*) is also a lagoonal specialist species which is always associated with macrophytes, and in particular with drifting mats of the green alga *Chaetomorpha linum.* Within the UK, the amphipod is fairly widely distributed in lagoons along the south and east coasts of England, between Dorset and Lincolnshire. The species is listed as *Rare* in the British Red Data Book. The species is regarded as *Nationally Scarce* in a recent review of benthic marine species.

(No species plan for the tentacled lagoon worm *Alkmaria romijni*, which is protected under the WCA 1981, is listed under the UK BAP.)

In addition to species listed by Sanderson (1995a, b, 1998), three further species with distributions within the SEA 3 area are recognised under the UK Biodiversity Action Plan:

- The lagoon seaslug *Tenellia adspersa* is a very small nudibranch, growing to a maximum length of less than 10mm, with a pale yellow or pale brown body marked with tiny black spots of varying density. The species favours a range of sheltered brackish water habitats including saline lagoons, brackish ditches, estuaries and harbours, with recent records from Portishead (Bristol Channel), the Fleet (Dorset) and St. Osyth (Essex). The species was listed as *Insufficiently known* but at least *Rare* in the British Red Data Book and classified as *Nationally rare* in a recent review of benthic marine species.

- The native or flat oyster (*Ostrea edulis* L.) is a sessile, filter-feeding, bivalve mollusc, associated with highly productive estuarine and shallow coastal water habitats with sediments ranging from mud to gravel. *Ostrea edulis* is widely distributed around the British Isles, the North Sea, Mediterranean and Black Sea. In the 18th and 19th centuries, there were large offshore oyster grounds in the southern North Sea and the Channel producing up to 100 times more than today's 100-200 tonnes. During the 20th century its abundance declined significantly in European waters. The main UK stocks are now located in the rivers and flats bordering the Thames Estuary, The Solent, River Fal, the west coast of Scotland and Lough Foyle. Native oyster fisheries are subject primarily to UK shellfisheries conservation legislation; the species is not named in any national or international nature conservation legislation or conventions.

- *Sabellaria spinulosa* reefs, JNCC Marine Nature Conservation Review (MNCR) biotope code CMX.SspiMx, comprise dense subtidal aggregations of this small, tube-building polychaete worm.

Sabellaria spinulosa colonies can act to stabilise cobble, pebble and gravel habitats, providing a consolidated habitat for epibenthic species. They are solid (albeit fragile), massive structures at least several centimetres thick, raised above the surrounding seabed, and can persist for many years. As such, they provide a biogenic habitat that allows many other associated species to become established. The *S. spinulosa* reef habitats of greatest nature conservation significance are those which occur on predominantly sediment or mixed sediment areas. These enable a range of epibenthic species with their associated fauna and a specialised 'crevice' infauna, which would not otherwise be found in the area, to become established.

S. spinulosa is naturally common around the British Isles. It is found in the subtidal and lower intertidal/sublittoral fringe with a wide distribution throughout the north-east Atlantic, especially in areas of turbid seawater with a high sediment load. Recent research in the Wash using remote video, identified very extensive areas of reef rising up to 60cm above the seabed and almost continuously covering a linear extent of 300m. However, in most parts of its geographical range *S. spinulosa* does not form reefs, but is solitary or in small groups encrusting pebbles, shell, kelp holdfasts and bedrock. It is often cryptic and easily overlooked in these habitats. Where conditions are favourable, much more extensive thin crusts can be formed, sometimes covering extensive areas of seabed. However, these crusts may be only seasonal features, being broken up during winter storms and quickly reforming through new settlement the following spring. There are extensive examples of this form of colony in the Berwickshire and North Northumberland Coast cSAC. These crusts are not considered to constitute true *S. spinulosa* reef habitats because of their ephemeral nature, which does not provide a stable biogenic habitat enabling associated species to become established in areas where they are otherwise absent.

6.3.10 Non-native species

Several non-native species are present in the sheltered waters of the region's inlets and have become part of the British marine fauna. Some of these are associated with the importing of oyster stock and were first recorded in Britain in the locality, while others have spread from adjacent parts of the coast. Examples include the slipper limpet *Crepidula fornicata* and the oyster drill *Urosalpinx cinerea* (both from the eastern USA), the barnacle *Elminius modestus* (Australasia) and the stalked sea squirt *Styela clava* (west Pacific). These species can dominate the indigenous fauna in some locations; for example, on the lower shore off Shotley Point, close to where the Orwell joins with the Stour, there is a rich community featuring *Styela clava*, with chains of *Crepidula fornicata* covered by *Elminius modestus*., (Hill *et al.* 1996). Recently a number of offshore species (e.g. the razor shell *Ensis directus/americanus*) appear to have colonised the southern North Sea.

6.3.11 Anthropogenic effects on the North Sea benthos

6.3.11.1 Fishing

The North Sea has been fished for millennia but it is only since the introduction of the combustion engine that offshore areas have been subjected to intensive demersal fishing. In recent years, the extent and nature of changes at the seabed resulting from fishing activity have become apparent and is the subject of reviews including de Groot and Lindeboom (1994) and Jennings and Kaiser (1998). Effects at the species level may be positive or negative for example, physical damage of large, long lived and fragile species can lead to mortality and potentially local extinction, while other species such as hermit crabs which survive trawling may increase in number, finding a rich supply of food in the discards of fish and killed or damaged benthic organisms. At the ecosystem level, a shift towards a seabed community where shorter generation, more opportunistic species predominate has been proposed and for which evidence is beginning to accumulate e.g. Frid and Hall (1999).

All parts of the SEA 2 area are or have been fished intensively (see Sections 8.2) and the types of seabed effects noted above are to be expected in the area.

6.3.11.2 Aggregate extraction

In a number of discrete, licensed areas in the southern North Sea sand and gravel is removed by dredger (see Section 8.6). Such extraction removes the habitat and kills or disperses the seabed fauna. The effects of this localised activity have been reviewed by Newell *et al*. (1998) and appear similar to the effects of major storms where extensive sediment redistribution occurs followed by recolonisation and an ecological succession. The resulting benthic community may be different from that which existed previously as the sediment type may be different (e.g. muddy sand as opposed to clean sand as a result of the changed seabed topography).

6.3.11.3 Dumping

With the exception of maintenance dredging from harbours and shipping channels no wastes are now dumped in the North Sea. Previously, dredged material, industrial wastes and sewage sludge were dumped at defined licensed sites resulting in a range of effects at the seabed related to the nature of the site and the type and volume of wastes. These effects included physical smothering, alteration of sediment type, chemical contamination and organic enrichment with ecological effects ranging from none detectable to substantial alteration of community type (OSPAR 2000).

There are no dumping grounds within SEA 2 area but in the southern North Sea there are a number just to the west of the boundary, although all are now disused.

6.3.11.4 General contamination of the North Sea

The North Sea, and especially the southern part, is surrounded by large centres of population, agriculture and industry and serviced by some of the busiest shipping lanes in the world. These have resulted in substantial diffuse inputs of nutrients, contaminants and sediments either directly or from atmospheric fallout, which have resulted in a wide range of ecological effects. These effects range from sublethal changes to individuals (e.g. the endocrine disruption caused by tributyltin antifouling paints (Ten Hallers-Tjabbes *et al.* 1994) and bioenergetic changes (McDowell *et al.* 1999), through enrichment of the seabed by enhanced phytoplankton productivity (Pearson *et al*. 1985) to the annihilation of benthic animals by low concentrations of oxygen in following intense phytoplankton blooms (Rachor 1990).

These effects are well summarised in QSR (1993) and OSPAR (2000) (and their component reports) and in general are viewed as declining in intensity as control measure take effect. Such effects are also not regarded as significantly affecting the seabed fauna of offshore waters although Krönke (1992) suggests that the faunal changes noted on the Dogger Bank might be due to eutrophication (although system changes resulting from fisheries interaction is an alternative explanation).

6.3.11.5 Wrecks and artificial substrates

The deliberate and accidental placement of hard substrates in the North Sea where the seabed is predominantly sand and mud will allow the development of "island" hard substrate communities. Such "islands" occur naturally, for example on glacial dropstones and moraines but the substantial expansion of the number of hard surfaces has a number of potential implications for seabed fauna. Firstly, the additional surfaces can provide "stepping stones" allowing species with short lived larvae to spread to areas where previously they were effectively excluded. Examples of deliberately placed structures include facilities for producing offshore oil and gas and those for exploiting offshore wind energy. The rapid colonisation of new oil and gas platforms has been documented a number of times (e.g. Forteath *et al.* 1982) and such colonising species can have very rapid growth rates (e.g. the horse mussel *Modiolus modiolus*, Anwar *et al*. 1990), and cause slight enrichment at the seabed through dislodged animals and settlement of the wastes produced (Myers & Southgate 1979). In the context of the SEA 3 area, such effects from existing facilities are only minor.

6.3.11.6 Exotic species introductions

The deliberate or accidental introduction of animal, plant and microbial species to the North Sea (and adjacent areas) can have major effects at the seabed through disease, direct competition or indirect exclusion. The majority of the seabed species introductions (see above) have occurred through transport with ships ballast or ballast water or associated with commercial shellfish.

6.4 Cephalopods

6.4.1 Data source

To support the SEA process, the University of Aberdeen was commissioned to provide a review of cephalopods in the North Sea. The report discusses their biology, fisheries, sensitivity to metal contamination and other conservation considerations.

6.4.2 Cephalopods in the North Sea

Knowledge of squid distribution in North Sea waters is mainly based on information from commercial whitefish vessels that take squid as a bycatch.

The main cephalopod species recorded from commercial fisheries in the northeast Atlantic are the lolinigid squids *Loligo forbesi* and *Loligo vulgari*s, the ommastrephid squids *Todarodes sagittatus, Todaropsis eblanae* and *Illex coindetii*, the cuttlefish *Sepia officinalis* and the octopuses *Octopus vulgaris* and *Eledone cirrhosa* (Pierce & Guerra 1994). The two common lolinigid squids are pelagic species with ranges which overlap extensively. *L. vulgaris* is less abundant than *L. forbesi* in the northern part of its range but increasingly replaces *L. forbesi* with decreasing latitude and, in the southern part of the range, *L. vulgaris* dominates (Pierce *et al*. 1994b; Pierce *et al*. 1994c).

A total of 24 cephalopod species have been recorded from the North Sea (Seaward 1982). In addition to species listed above, frequently recorded species are *Alloteuthis subulata*, *Sepiola atlantica* and *Rossia macrosoma*. A number of oceanic species may occasionally occur in the North Sea (e.g. *Mastigoteuthis*, *Octopoteuthis*, *Heliocranchia*).

An influx of the squid *Todarodes sagittatus* to the North Sea during 1937 was accompanied by an influx of common dolphins that same year, and it was assumed that the common dolphins were feeding on these squid (Fraser 1946).

Eledone cirrhosa is a benthic octopod that has a life-span thought to be between 18 and 24 months (Boyle 1983). *E. cirrhosa* has a wide distribution over shelf regions from the Mediterranean in the south to the Norwegian Lofoten Islands in the north. The animal generally occurs in depths between 50 and 300 metres and can be found on a wide variety of sea-bed types from soft mud to rocky bottom (Boyle 1983). Cuttlefish of the genera *Sepia*, *Sepiola* and *Rossia* are generally inshore species associated with sandy substrates (often among eel-grass beds).

Cephalopods are short-lived, carnivorous animals that have rapid growth rates. Cephalopods play an important part in marine food webs, feeding on fish, crustaceans and other cephalopods. In turn, cephalopods are prey themselves to whales, dolphins, seals, birds, and some large fish species.

6.4.3 Cephalopods and metals

Cephalopods naturally accumulate high levels of some trace metals. Copper content in some cephalopod species' livers has been found to be 100 times higher than the mean vertebrate level and 100,000 times higher than seawater. Studies in California have revealed cephalopod levels to be three orders of magnitude higher than concentrations found in scallops, oysters and mussels. Studies of pilot whales off the Faroe Islands (where there is little or no anthropogenic pollution) have revealed high levels of cadmium. This is thought to be accumulated through their primary diet of squid suggesting the potential for bioaccumulation up the food web.

6.5 Fish and commercially exploited shellfish

6.5.1 Data sources

CEFAS, working in collaboration with FRS, was commissioned to review fish and fisheries information from the North Sea of relevance to the SEA process. The report describes the fish resources of the region (i.e. spawning grounds, nursery areas), and also the intensity and distribution of commercial fishing activity. It describes those fisheries management measures which recommend seasonal closures of parts of the North Sea to protect spawning or juvenile fish, and regions where these may have consequences for oil and gas exploration and production. The report also summarises the most important consequences of oil and gas exploration for fish populations and commercial fisheries, such as the use of seismic surveys and the placement of structures on the sea bed.

Information on the seasonal distribution of commercially important fish and shellfish is available from several sources. The most reliable of these are the routine research vessel surveys undertaken by European Research Laboratories. These annual surveys, often co-ordinated by the International Council for the Exploration of the Sea (ICES), target major commercial species but also record information on the distribution and abundance of the non-target components of the fish and shellfish catch. In addition, information on distribution of commercial species can be obtained from landings data obtained from local and regional fish markets by DEFRA (formerly MAFF) and SEERAD. Only for cod and sandeel fisheries were the total international landings by ICES rectangle available; for other species the UK landings have been used.

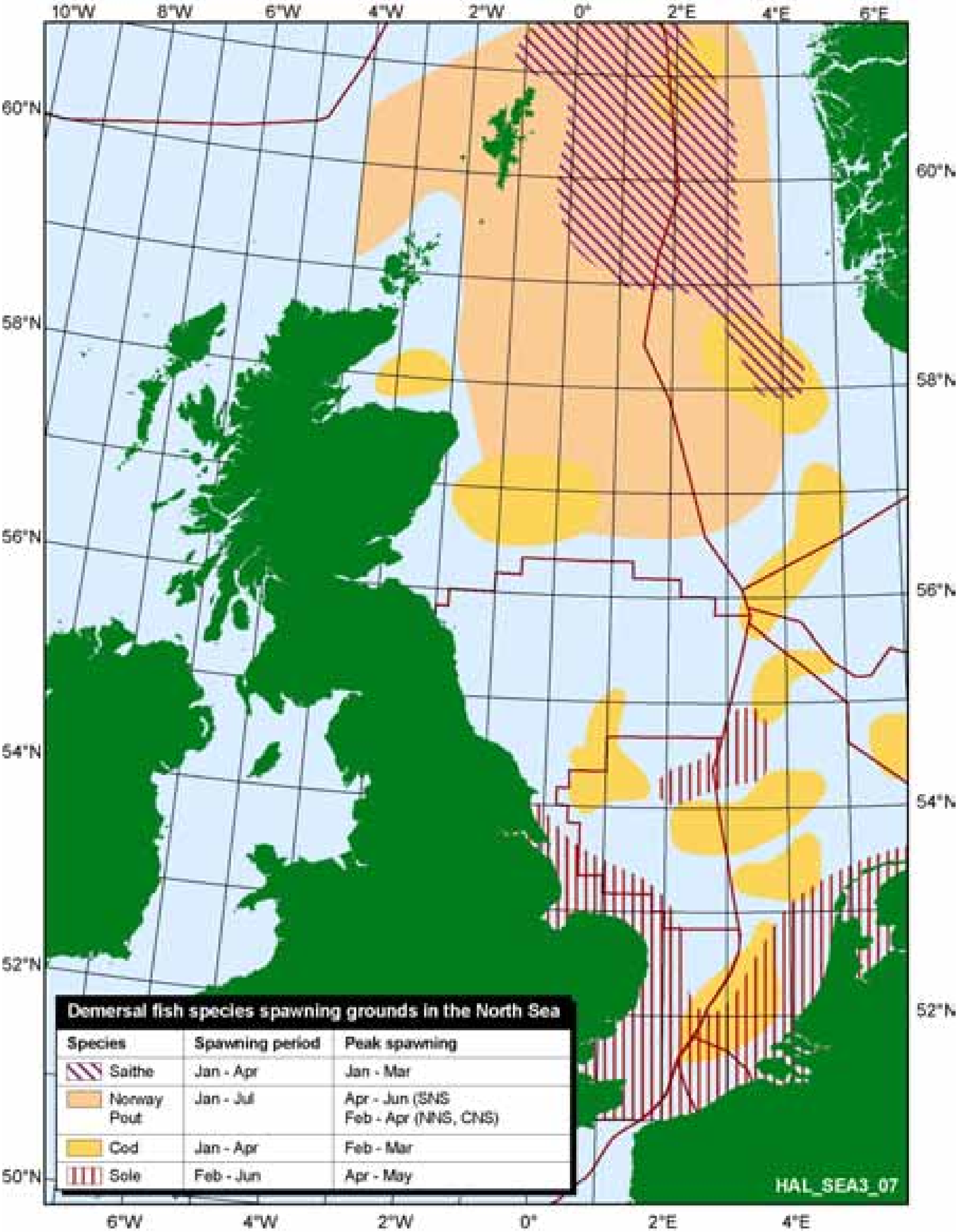
Sea Fisheries Committees were formed in the 1890s in order to protect inshore fishing interests. In 1994 the seaward limit of fisheries committees was extended to 6 nautical miles, and the committees now encompass a range of fisheries monitoring and environmental responsibilities. Sea Fisheries Committees within the SEA 3 area are the Northumberland Sea Fisheries Committee, the North Eastern Sea Fisheries Committee, the Eastern Sea Fisheries Joint Committee and the Kent and Essex Sea Fisheries Committee.

It is important to realise that fisheries-independent survey data describe a snapshot of the distribution of a species in a region at a particular time. Spawning areas and nursery grounds are dynamic features of fish life history and are rarely fixed in one location from year to year. While some fish species exhibit the same broad patterns of distribution from one year or season to the next, others show a large degree of variability.

6.5.2 Fish and commercial shellfish ecology

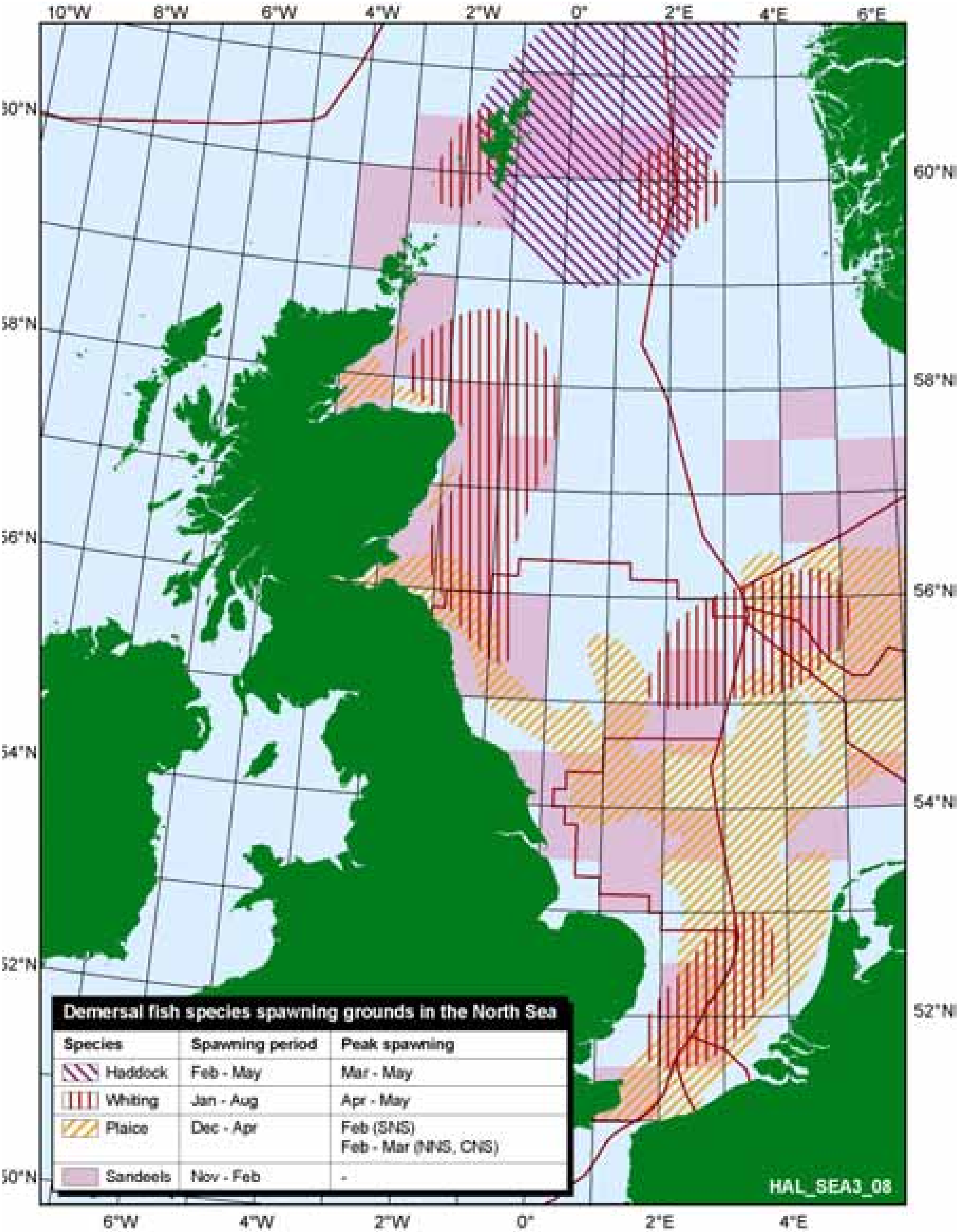
Most of the commercially important fish species spawn in the spring (Figures 6.2 to 6.5), between January and June, although sandeel and herring are exceptions which spawn outside this period. Shrimp, edible crab and lobster tend to be winter spawners, but the period of egg brooding is protracted. Spawning areas and nursery grounds for most fish species are dynamic features of life history and are rarely fixed in one location from year to year. Thus, while some species have similar patterns of distribution from one season to the next, others show greater variability. The combined distribution of spring-spawning fish species showed that over much of the central North Sea spawning activity is sporadic (in comparison to northern parts of the North Sea), and some areas have low sensitivity. In the SEA 3 area the greatest spawning activity occurs in coastal waters and in the most easterly part.

Figure 6.2 - Demersal fish spawning areas in the North Sea (saithe, Norway pout, cod and sole)



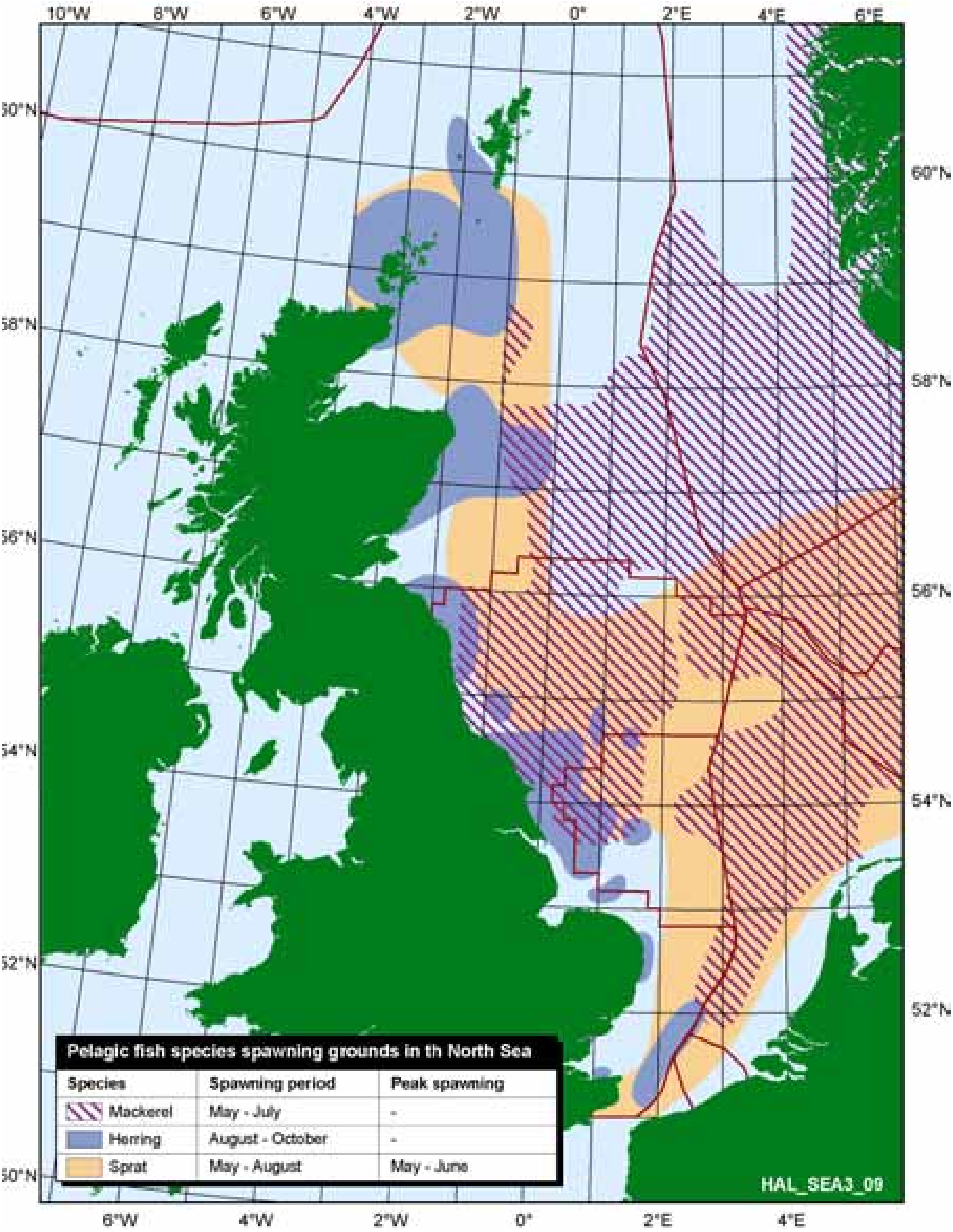
Source: CEFAS commissioned study for SEA 2

Figure 6.3 - Demersal fish spawning areas in the North Sea (haddock, whiting, plaice and sandeels)



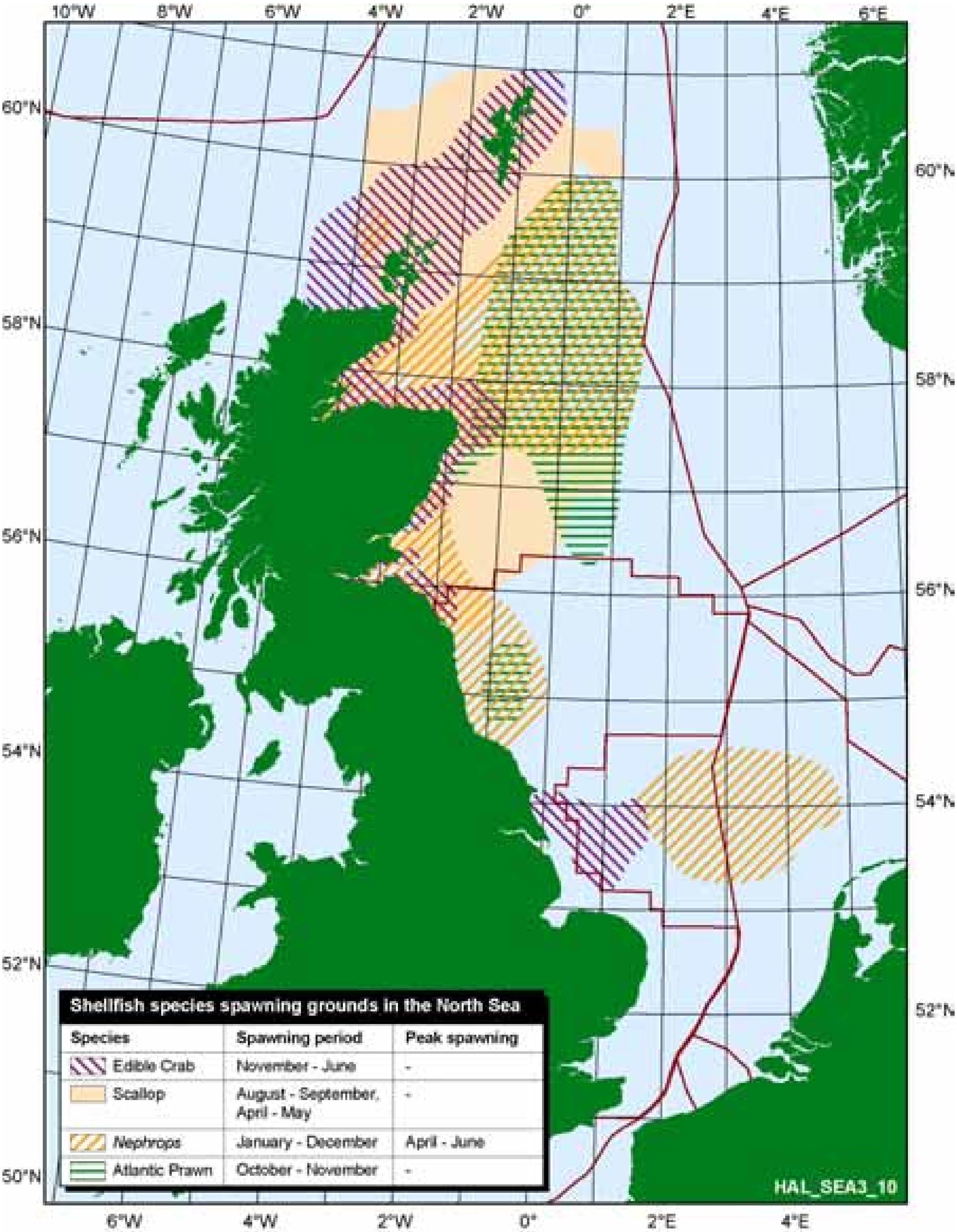
Source: CEFAS commissioned study for SEA 2

Figure 6.4 - Pelagic fish spawning areas in the North Sea (mackerel, herring and sprat)



Source: CEFAS commissioned study for SEA 2

Figure 6.5 - Shellfish spawning areas in the North Sea (edible crab, scallop, Nephrops and Atlantic prawn)



Shellfish species spawning grounds in the North Sea		
Species	Spawning period	Peak spawning
Edible Crab	November - June	-
Scallop	August - September, April - May	-
Nephrops	January - December	April - June
Atlantic Prawn	October - November	-

Source: CEFAS commissioned study for SEA 2 & additional CEFAS information
See also Figure 8.3 for crab distribution

Recent research has suggested that there have been substantial changes in the fish communities of the North Sea during the 20th Century. These communities consist of species that have complex interactions with one another and the natural environment, either acting as predators at higher trophic levels, providing prey items for larger predators, or consuming a wide range of benthic invertebrates. Fish species in these communities will undergo natural variation in population size, largely as a result of variation in year to year success in recruitment. Broad scale patterns of climate change, and the impact of human exploitation, will also contribute to these population trends.

6.5.3 Commercial Fish Species

Whiting is one of the most numerous and widespread species found in the North Sea. The recaptures of tagged whiting, and the use of a number of fish parasites as markers, show that the populations to the north and south of the Dogger Bank form almost separate populations. It is also possible that the whiting in the northern North Sea may contain both inshore and offshore populations (Hislop & MacKenzie 1976).

The main spawning areas for whiting are in the Southern Bight, in the central North Sea north of the Dogger Bank, and off the east coast of Scotland (Figure 6.3). The spawning season is long, and extends from January in the Southern Bight through to late August or early September in the North, but the majority of spawning takes place in April-May. The spatial distribution of 0-group whiting in the pelagic phase (3-5cm in length) is extensive, and during summer juveniles can be found throughout much of the North Sea, but particularly to the north-east and east of Scotland, off north-eastern England and in the German Bight (Gordon 1977).

Haddock occur throughout the northern North Sea, although in the Norwegian Deep adult haddock are not regularly encountered below 250m and the highest catch rates occur between 80m and 200m (Albert 1994). Although the haddock has a northerly distribution, they can occasionally be caught south of the Dogger Bank during the summer. Haddock are generally regarded as benthic fish but they can also be found in midwater, and this is confirmed by their adult diet, which includes sandeel, Norway pout, long rough dab, gobies, sprat and herring (Cranmer 1986).

In the North Sea haddock spawn between February and May, with peak spawning activity between mid-March and early April. The main spawning area is in the central northern North Sea between the Shetland Islands and the Norwegian Deep, and southwards towards the Fladen Ground (Figure 6.3). After spawning, adult haddock disperse and migrate westward toward the Orkney and Shetland Islands and into the central part of the North Sea to feed.

Saithe is also a northern species, with main spawning areas in the northern North Sea east of the Shetland Islands and along the edge of the Norwegian Deep (Figure 6.2). Norway pout are typically found in the northern and central areas of the North Sea and in the Skagerrak and Kattegat, with the centre of distribution lying midway between the Shetland Islands and the Norwegian coast (Knijn *et al*. 1993).

Plaice are typically a coastal species, and can be found at highest abundance in the Southern part of the North Sea, along the east coast of the UK, and in the eastern Channel, Skagerrak and Kattegat. Plaice are flatfish which live on mixed substrates at depths of between a few metres to around 200m, with older individuals generally occurring in deeper water.

Plaice spawn throughout the shallower parts of the southern North Sea and off the eastern coast of Britain, from Flamborough Head to the Moray Firth. Centres of high egg production occur in the Southern Bight, whilst egg production around the Dogger Bank and in the German Bight is more diffuse (Figure 6.3). Peak spawning occurs in early January in the eastern part of the English Channel, and during February in the Southern Bight, German Bight and off Flamborough Head. The duration of the planktonic developmental stages, two to three months, is long compared with that of many fish species. This prolonged period results in long exposure to residual currents, leading to the young plaice settling in nursery areas some distance from where they were spawned. Part of the North Sea plaice population spawns in the English Channel and returns to its feeding grounds in the North Sea after spawning. The offspring of this spawning population are thought to enter the North Sea by passive drift on the prevailing currents. Many shallow, sandy bays and estuaries on the North Sea coasts of England and continental Europe act as important nursery areas for plaice, especially the Dutch Wadden Sea (Kuipers 1977). Such shallow coastal waters support the majority of 1 year old plaice, and juveniles gradually disperse further offshore away from these nursery areas as they mature.

The sole is a southern species that is close to the northern limits of its distribution in the North Sea. It is confined to those parts of the southern North Sea where winter temperatures do not fall below 5^0C for prolonged periods, and seasonal movements are generally governed by the local temperature regime. During extremely cold winters, dense aggregations of sole occur in deeper and warmer waters of the North Sea such as the Silver Pit.

Sole spawn in shallow inshore areas and close to sandbanks less than 30m deep during April and May. Spawning occurs earlier in the southern part of the North Sea and later in populations off the northeast coast of England and in the German Bight. Major southern North Sea spawning grounds include the Belgian coast, the Thames Estuary, the Norfolk Banks, the Wadden Sea, and the German Bight (Figure 6.2). Whilst sole larvae are pelagic at first, during a period of approximately one month they metamorphose into the demersal phase. This relatively brief period in the water column prevents the offspring from moving large distances away from spawning grounds. It is therefore likely that local abundances of 0-group sole reflects the spawning success of local spawning aggregations. Nursery grounds are situated in shallow waters along the English and continental European coasts at depths between 5 and 10m.

The lemon sole does not belong to the sole family. The centre of distribution of mature lemon sole is in the coastal waters of northern Scotland and the Orkney and Shetland Islands, but they are also found off the north-eastern coast of England and throughout the central and northern North Sea. There do not appear to be seasonal differences in distribution, and the species as a whole probably does not undertake extensive migrations. Little is known about the spawning habits of lemon sole, and it is thought to spawn everywhere it is found. The spawning season is long, and off the Scottish East coast extends from April to September.

In UK waters there are two species of monkfish, also called anglerfish, the black bellied monkfish *Lophius budegassa*, and the white monkfish, *Lophius piscatorius*. The latter predominates north of latitude 55^oN in the North Sea and West of Scotland. The basic biology of the two species is very similar, although in the waters surrounding the UK and Ireland, black bellied monkfish are found predominantly in the deeper waters of the continental shelf and slope. Monkfish are found in an unusually wide range of depths, extending from the very shallow inshore waters down to around 1,100m. Juvenile monkfish (mainly white monkfish) can be found over most of the northern North Sea to depths of about 150m, while spawning adults are found at all depths but are generally scarce in coastal waters.

Spawning takes place during January to June in relatively deep water, and although monkfish have a long spawning season, each female probably produces only one batch of eggs. After hatching, young fish spend three or four months in mid-water before they settle on the seabed (Hislop *et al*. 2001).

Atlantic herring are found throughout the shelf waters of north-western Europe from the northern Bay of Biscay to Greenland, and east into the Barents Sea. During daytime, herring shoals remain close to the sea bottom or in deep water to a depth of 200m. At dusk they move towards the surface and disperse over a wide area. These diurnal vertical movements may be related to the availability of prey items, or to the stage in their maturation cycle.

Although most fish species have a single spawning season in the North Sea, herring is an exception. Sub-populations of North Sea herring spawn at different times and localised groups of herring can be found spawning in almost any month. At present there are three major populations of herring in the North Sea, which can be identified by differences in their spawning time and area. These 'races' are mixed for the majority of the year, but separate during the breeding season when each race migrates to its own spawning grounds (Daan *et al*. 1990). The races are:

- Buchan/Shetland herring, which spawns off the northeast Scottish coast and Shetland coasts during August to September
- Banks or Dogger herring, which spawns in the central North Sea off the northeast English coast during August to October
- Southern Bight/Downs herring, which spawns in the English Channel and Southern Bight of the North Sea during November to January

Spawning normally takes place in relatively shallow water, at depths of approximately 15-40m (Figure 6.4). Herring deposit their sticky eggs on coarse sand, gravel, shells and small stones, and shoals congregate on traditional spawning grounds where all members of the shoal spawn more or less simultaneously. The result of such spawning activity is an 'egg carpet', which may be 4 to 9 layers thick and cover an area of one hectare (Blaxter & Hunter 1982). Each female will produce a single batch of eggs every year, but there are pronounced differences in the number, sizes and weights of the eggs produced by each of the different spawning 'races' in the North Sea. Incubation of herring eggs takes one to three weeks depending on water temperature, and when the eggs hatch the larvae become pelagic and are transported by the prevailing water currents. Most autumn spawned herring larvae drift in an easterly direction from the western North Sea towards important nursery grounds in the eastern North Sea and to the Skagerrak and the Kattegat. Larvae from the west of Scotland are thought to drift into the Moray Firth, and the Firth of Forth also provides a nursery area for herring of more uncertain origin.

The dependency of herring on specific substrates makes the species particularly susceptible to impacts resulting from oil and gas exploration and production.

There are five species of sandeel in the North Sea, though the majority of commercial landings are of *Ammodytes marinus*. Sandeels are a shoaling species which lie buried in the sand during the night, and hunt for prey in mid-water during daylight hours (Winslade 1974).

Spawning of *A. marinus* usually takes place between November and February. Spawning activity occurs throughout much of the southern and central North Sea, but especially near sandy sediments off the coasts of Denmark, northeastern England, eastern Scotland, and the Orkney Islands (Figure 6.3). Sandeel eggs are demersal, and are laid in sticky clumps on sandy substrates. On hatching, the larvae become planktonic, resulting in a potentially wide distribution, and the larvae of *A. marinus* are the most abundant of the sandeel larvae in the North Sea. Sandeels adopt a demersal habit by around 2-5 months after hatching (Wright & Bailey 1996) and are believed to over-winter buried in the sand. Tagging experiments have shown that there is little movement between spawning and feeding grounds, indicating that fishing and spawning grounds may coincide (Kunzlik *et al*. 1986). Sandeels are an important food item for mackerel, whiting, cod, salmon, other economically important fish species, and sea birds.

Mackerel are fast swimming pelagic fish that are widespread in North Atlantic shelf waters. Two main stocks occur in the northeast Atlantic, the western stock and the North Sea stock, and this separation is based on differences in the timing and the areas used for spawning. The North Sea stock has been at a very low level for many years due to high fishing pressure and poor recruitment.

North Sea mackerel overwinter in the deep water to the east and north of the Shetland Islands, and on the edge of the Norwegian Deeps. In spring, they migrate south to spawn in the North Sea between May and July, but they may also spawn along the southern coast of Norway and in the Skagerrak (Lockwood 1988; Dawson 1991) (Figure 6.4). The pelagic eggs can be found in the central North Sea at depths to 60m below the surface, but the majority are found in the upper mixed layer above 26m (Coombs *et al.* 1981).

Sprat are most abundant in the relatively shallow waters of the southern North Sea and Skagerrak, and are found in the UK coastal waters as far north as the east coast of Scotland and the Orkney Islands. Most sprat spawn for the first time at an age of about two years, and important spawning areas in the North Sea are centred on the inner German Bight, the area off the north-western coast of Jutland, and the English East coast (Figure 6.4). Spawning in the vicinity of the southern SEA 3 region is from May to August and peaks during May and June.

6.5.4 Salmonids

Salmon migrate close to the coast as they return to spawn in their home rivers on the east coast of Scotland and the north-east coast of England; they are believed to enter the North Sea from the north. Salmon and sea trout are known to occur in the Aln, Coquet, Tyne, Wear, Tees, Esk, Yorkshire Ouse, Humber and Trent. A small number of salmon and sea trout are also caught from the River Thames, where the Thames Water Authority began a programme to restore a salmon population to the River Thames in 1978 (Thames Estuary Project 1996). Significant numbers of returning salmon were first reported in 1983 and subsequently the maximum reported in any one year has been 330 individuals.

6.5.5 Commercial Shellfish Species

Commercially exploited mollusc and crustacean species within the SEA 3 area include mussels (*Mytilus edulis*), cockles (*Cerastoderma edule*), norway lobster (*Nephrops norvegicus*), edible crab (*Cancer pagurus*), lobster (*Homarus gammarus*), pink prawn (*Pandalus montagui*) and brown shrimp (*Crangon crangon*). Scallop (*Pecten maximus*) and queen scallop (*Aequipecten opercularis*) are fished in the northern SEA 3 area, around Lindisfarne and the North Yorkshire and Humberside coasts; while whelks (*Buccinum undatum*) are caught in pots off the Holderness and north Norfolk coasts. Whiteweed (the hydroid *Sertularia cupressina*) is also exploited in the Thames estuary for decorative use, although market demand is currently low.

Mussels occur in suitable intertidal and subtidal habitats throughout the SEA 3 coastal fringe, although the main exploited stocks occur in public and private lay holdings in the Wash and adjacent areas. Sandy sediments in the Wash and Thames estuary support by far the largest proportion of UK cockle landings. Cockle relaying trials are in progress in the Wash, together with studies into cockle breakage during fishing (ESFJC 2001).

Native oyster beds have been exploited off Suffolk, Essex and the north Kent coast for many centuries, and in the first half of the century a large natural fishery was coupled with a thriving fishery based on re-laying. A combination of overfishing and the cold winter in 1963 then greatly reduced stocks, and up to 1980 the fishery was increasingly dependent on harvesting cultivated native oysters, purchased from Cornwall and The Solent and relaid in the region for ongrowing. The practice was severely disrupted in the 1980s with the introduction of *Bonamia ostreae* (a parasite that infects the blood cells of native oysters), which caused extensive mortality of the native oysters. In recent years controlled relaying of native oysters for only a limited period of time has revived this fishery and the industry persists.

Nephrops are found in deeper water, on muddy and sandy mud substrates in the SEA 3 area, principally off Northumberland and in the Silver Pit off the Humber (Figure 6.5). They do not migrate, and spend their life in the area in which they settle as larvae. *Nephrops* population characteristics appear to vary considerably with sediment type, although it is probably due to factors related to the sediment (water currents, prey animals in the sediment), rather than the sediment itself. In all areas, females mature at about 3 years old and, from then on, carry eggs each year from September to April or May. After hatching, the larval stage lasts 6 to 8 weeks, before settlement to the seabed. While carrying eggs, females come out of their burrows very infrequently, and are naturally protected from trawlers. Male *Nephrops* therefore dominate trawl catches for most of the year, and are more heavily exploited than females.

Edible crab are widespread on mixed substrates of sand, gravel and rock around the coasts of eastern England, and support substantial fisheries throughout the SEA 3 region. Edible crabs feed mainly on living food, including marine worms, virtually all types of shellfish and even fish. Dispersion is mainly by larval drift, but adult females are known to migrate considerable distances, and can often follow consistent migration routes from year to year.

Crabs grow by moulting their hard outer shell at regular intervals. The main moult occurs between July and October. The females moult first, followed by the males a month or so later. Mature female crabs mate just after the moult when still in a soft condition, spawn in November or December, and the eggs are carried for about seven months before they hatch. In English waters, the distribution of crab spawning grounds have been described from surveys of early stage zoea, and suggests that crab spawning activity is most intense off the east coast of England, north-east of the Humber (Fig. 6.5). Recent CEFAS work (Eaton D 2001) has indicated the probability of distinct spawning stocks north and south of the Flamborough Front. The larvae live in the plankton for about one month before settling on the seabed and assuming adult form at about 3mm in size.

Lobsters are distributed throughout the coastal region wherever there is suitable habitat, such as rocky reefs with crevices for protection. This occurs mainly along the Northumberland, Yorkshire and Holderness coasts and offshore from The Wash and the north Norfolk coast. The largest catches of lobster occur in July and August, as stocks move inshore to feed on moulting edible crabs.

6.5.6 Species of conservation significance

There are six fish species that require the designation of SAC in UK waters under Annex II and IV of the Directive (Potts & Swaby 1993). Only the European sturgeon *Acipenser sturio* and the whitefish *Coregonus lavaretus* require strict protection within SAC under Annex IV.

Of these, the European sturgeon is relatively rare and there are only sporadic catches of adults around the North Sea coasts. The species is at its northerly limit here, as it occurs in greater abundance on the French west coast in rivers such as the Gironde. The sturgeon occurred regularly in the Thames up to the early nineteenth century, but has declined since then (Wheeler 1958) and is now rarely recorded. Some sturgeon were landed at North and South Shields early this century, but this fish was already considered rare by the 1940s. A few specimens of sturgeon were recorded off Flamborough Head in 1970; one was landed at Bridlington in 1970, three at Grimsby (in 1872, 1953 and 1986) and three from the Great Ouse (in 1924, 1968 and 1987).

The basking shark, tope and porbeagle are likely to occur in small numbers throughout the North Sea at times of peak zooplankton distribution and abundance. The common skate can be found at low density throughout the northern part of the North Sea, but is rare in, or absent from, the southern North Sea. The angel shark is rarely seen in the North Sea.

The majority of the remaining fish species of conservation importance are coastal and occur in greatest abundance in relatively shallow coastal water. The shad species, allis shad and twaite shad, and the lampreys (*Lampetra fluviatilis and Petromyzon marinus*) are migratory, making spawning migrations into the tidal and freshwater reaches of rivers and occupying estuarine and inshore waters to feed.

The lampern *Lampetra fluviatilis* has been recorded only singly between 1832 and 1982, from the Tweed, Tyne, Tees, Blyth and Humber. The lampern fishery in the Thames was once substantial, but declined until only a single lampern was recorded there in 1899. The only recent records are from the Blyth in 1982 and from West Thurrock power station in 1964 and 1967 (Wheeler 1969).

The sea lamprey *Petromyzon marinus* was once considered 'not uncommon' in north-east England, but since the early 19th century it has mostly been recorded singly from Redcar, Tees, Tyne, Aln, Cullercoats, Tweed, New Water Haugh, Tynemouth Pier, Bamburgh, Newburn, Blyth, South Shields and the North Sea (Davis 1983). The sea lamprey has never been common in the Thames and was never exploited, although at times it was recorded as abundant (Murie 1903). A record exists of a sea lamprey in the River Blyth in 1984 and they have been recorded from the rivers Coquet and Tees by recent NRA fish surveys.

Twaite shad were recorded at the turn of the century ascending rivers and were occasionally captured, but there are no records of viable populations. However, the allis shad is regularly captured in the River Tweed (Campbell pers. comm.) and frequents the estuaries of most of the north-east's rivers in the autumn months (Davis 1983). In 1836, shad were reported to be abundant in the Greenwich area and were fished commercially. The twaite shad was more common in the lower Thames than the allis shad. Twaite shad were reported as abundant in the Thames by Murie (1903), but were later reported to be in decline. However, they were still caught further down the estuary, possibly breeding in creeks in Southend (Wheeler 1958, 1969). There have been occasional records of one or two twaite shad from the West Thurrock intake screens since the 1960s, and a single specimen was caught off Blackwell Point in 1976 (Wheeler 1969; Andrews & Wheeler 1985; Thomas pers. comm. 1992). It was recorded as 'occasionally caught on rod and line' in the Marine Fauna of Whitstable (Newell 1954) but is now often caught within the Thames Estuary (Kent and Essex Sea Fisheries Committee pers. comm.). Allis shad were recorded singly from West Thurrock, Blackwell Point and Richmond in the 1970s (Andrews & Wheeler 1985).

6.6 Marine reptiles

Leatherback turtles *Dermochelys coriacea* are occasionally recorded off eastern coasts of the UK from Shetland coast to Norfolk, mostly in summer and most commonly in northern areas. The leatherback turtle is now thought to be resident in Scottish waters at certain times of the year (Brongersma 1972; Langton *et al.* 1996; Godley *et al.* 1998); previously, they were considered to be vagrants. Four other species of turtle have been recorded more rarely, from south and west coasts of Britain and Ireland.

Bycatch and strandings data for turtles are held in the database TURTLE (Pierpoint & Penrose 1999), and bycatch data have been analysed by Pierpoint (2000) in relation to Biodiversity Action Plan and Habitats Directive obligations of the UK.

Records of turtles since 1970 were collated by MJS Swan in the JNCC Coastal Directory series (Swan 1995a, b, 1998), and included two leatherback turtle (both dead) stranded on the North Yorkshire coast and one leatherback turtle (also dead) from the Norfolk coast.

Sightings records listed by Pierpoint (2000) from SE Scotland, E and SE England total 15 sightings of live animals, more than 75% of which occurred in November. The timing of sightings throughout UK waters imply that leatherbacks move into British and Irish waters from the south and west, and pass northwards up western coasts and the Irish Sea. Some leatherbacks enter the central North Sea in autumn. A paucity of sightings in the southern North Sea earlier in the year suggests that it is unlikely that many turtles enter the North Sea via the English Channel (Pierpoint 2000). A total of 11 records of dead leatherbacks are recorded by Pierpoint (2000) from the SEA 3 area.

Data from marine mammal and fisheries monitoring programmes suggest that turtle bycatch in pelagic and demersal trawls, and in set gill nets in UK and Irish waters is uncommon (and by implication, extremely rare in the SEA 3 area where turtle numbers are very low). Bycatch of leatherback and loggerhead turtles is reported from pelagic drift net fisheries to the south and west of Britain, however.

6.7 Seabirds and coastal waterbirds

6.7.1 Data sources

Systematic seabird monitoring programmes around the UK, Netherlands, Belgium, Germany, Denmark, Sweden and Norway, and international collaboration between organisations throughout north-west Europe has resulted in one common database for the waters of this area, the European Seabirds at Sea (ESAS) database (Stone *et al.* 1995). ESAS contains over one million records of birds sightings, consisting of processed data from strip transect observations from ships and aircraft. Resulting publications include an atlas of bird concentrations vulnerable to oil and other surface pollutants in the North Sea (Carter *et al.* 1993), a distribution atlas of seabirds in north-west Europe (Stone *et al*. 1995), and an electronic atlas of seabird distribution and vulnerability (BODC 1998). A review of the relative importance of areas within the North Sea was produced by Skov *et al*. (1995).

Count data for seabird breeding colonies is collated by the Seabird Colony Register, including the "Operation Seafarer" survey in 1969-70 and a repeat survey of the whole coast of Britain and Ireland in 1985-87 (Lloyd *et al*. 1991). Seabird colony counts of the "Seabird 2000" programme, have largely been completed, although data compilation and interpretation is still in progress.

The breeding distributions of coastal waterbirds were surveyed as part of fieldwork for the *88-91 Atlas of Breeding Birds in Britain and Ireland* (Gibbons *et al.* 1993), using intensive effort by a large number of volunteers. Abundance and distribution maps were produced from count data on a 10km interpolation grid.

The Wetland Bird Survey (WeBS) aims to monitor all non-breeding waterbirds (i.e. wildfowl and waterfowl including divers, grebes, herons, swans, ducks, geese, waders gulls and terns) in the UK to provide the principal data on which the conservation of their populations and wetland habitats is based (Musgrove *et al.* (2001). WeBS is a partnership scheme of the British Trust for Ornithology (BTO), The Wildfowl & Wetlands Trust (WWT), Royal Society for the Protection of Birds (RSPB) and the Joint Nature Conservation Committee (JNCC). WeBS monitoring continues two long-running count schemes; synchronised Core Counts conducted once per month at a wide variety of coastal and wetland sites, primarily from September to October; and Low Tide Counts on selected estuaries with the aim of identifying key areas used during the low tide period, principally by feeding birds.

Monitoring data for migrant and wintering waterfowl throughout the UK distinguishes between estuarine locations, most of which are monitored by WeBS counts and reported annually (see above) and were also reviewed by Davidson *et al*. (1991), and non-estuarine coasts which are less frequently monitored, e.g. by the Winter Shorebird Counts of 1984/85 and 1995/96 (Moser & Summers 1987). More detailed studies of individual estuaries and coastal locations are listed by Stroud & Craddock (1995a, b) and May & Law (1998).

In addition, counts of breeding and non-breeding birds are made on a systematic basis at many bird reserves, notably those managed by the RSPB. General biology of individual waterfowl species (see below) has been summarised mainly from Cramp (1977 - 1993).

6.7.2 Central North Sea and coastal margin overview

Of the seabird species which breed regularly in Britain and Ireland, fulmar, cormorant, shag, gannet, three species of auk, six species of gull and five species of tern breed around mainland North Sea coasts within the SEA 3 area. Although the major colonies in terms of biogeographic populations are located north of the SEA 3 area (in Shetland and along the Atlantic seaboard), auk and kittiwake colonies at the Farne and Coquet Islands, Marsden Bay and at Bempton Cliffs support internationally important populations (the kittiwake colony at Bempton Cliffs, at 75,000 pairs in 1987, is of world stature) (Tasker 1995a, b). Cormorants also breed in internationally important numbers at the Farne Islands.

Table 6.3 - Internationally important seabird breeding colonies

Species	Colony	Count 87-93 (from Tasker 1995 a, b)	Seabird 2000
Cormorant	Farne Islands	268 (93)	196 (01)
	Marsden Bay	225 (93)	248 (99)
Shag	Farne Islands	1,948 (93)	1,373 (01)
Kittiwake	Farne Islands	5,889 (93)	5,781 (01)
	Marsden Bay	7,700 (86)	2,031 (99)
	Filey North Cliffs	5,666 (90)	5,120 (02)
	Bempton Cliffs	75,000 (87)	24,870 (00)
	North Cliff, Flamborough	8,368 (87)	17,707 (00)
Sandwich tern	Farne Islands	3,445 (89)	2,364 (01)
	Coquet Island	2,131 (92)	1,190 (01)
	Blakeney Point	4,000 (92)	100 (00)
Arctic tern	Farne Islands	3,710 (89)	1,526 (00)
Common tern	Coquet Island	842 (92)	1,033 (00)
Roseate tern	Coquet Island	29 (92)	42 (01)
Little tern	Blakeney Point	160 (93)	100 (00)
	Great Yarmouth	277 (91)	220 (00)
Guillemot	Farne Islands	25,309 (93)	35,436 (01)
	Bempton Cliffs	29,300 (87)	32,860 (00)
Puffin	Farne Islands	34,710 (93)	No count
	Coquet Island	13,273 (93)	17,208 (01)
Razorbill	Bempton Cliffs	7,350 (87)	5,710 (00)

Note:
1 The numbers on brackets relate to the year of colony survey
2 There are various definitions of population numbers of importance at the Britain & Ireland, European and biogeographical scales. This, coupled with changes in the population sizes at individual colonies over time, results in changes in the relative importance of certain colonies. However, for completeness colonies which are or have been of importance are listed above.

Table 6.4 – Nationally important seabird breeding colonies

Species	Colony	Count 87-93 (from Tasker 1995 a, b, 1998)	Seabird 2000
Black-headed gull	Coquet Island	3,996 (93)	2,218 (01)
	Frampton Marsh	1,858 (90)	0*
	Holkham	2,314 (92)	855 (01) *
	Hamford Water	>6,000 (90)	11,000 (00)
	Flanders Mere	4,000 (94)	3,155 (00)
Sandwich tern	Havergate	250 (94)	1 (01) *
	Foulness / Maplin	330 (95)	0*
Arctic tern	Coquet Island	672 (93)	833 (00)
Common tern	Farne Islands	313 (89)	150 (00)
	Terrington outer trial	150 (90)	0*
	bank	130 (90)	99 (00) *
	Snettisham	159 (89)	300 (00)
	Scolt Head	154 (91)	78 (00) *
	Holkham	250 (92)	50 (00) *
	Blakeney Point	143 (93)	199 (00)
	Breydon Water	143 (93)	0*
	Maplin Bank	150 (95)	1 (00) *
	Dungeness		
Little tern	Holy Island	42 (89)	25 (00)
	Long Nanny	51 (92)	43 (00)
	South Gare	45 (93)	10 (00) *
	Easington Lagoons	62 (93)	49 (00)
	Tetney	85 (89)	4 (00) *
	Gibralter Point	50 (91)	32 (00)
	Holme	32 (91)	0*
	Titchwell – Thornham	27 (89)	5 (00) *
	Scolt Head	63 (89)	87 (00)
	Holkham	89 (93)	86 (00)
	Minsmere	26 (95)	4 (00) *
	Orford Beach	25 (95)	70 (00)
	Horsey Island	35-40	12-20 (00) *
Puffin	Bempton Cliffs	6,050 (87)	1,951 (00) *

Note:

1. *The numbers on brackets relate to the year of colony survey*
2. *There are various definitions of population numbers of importance at the Britain & Ireland, European and biogeographical scales. This, coupled with changes in the population sizes at individual colonies over time, results in changes in the relative importance of certain colonies. However, for completeness colonies which are or have been of importance are listed above. Based on National pop estimates (in Stroud et al. 2001) figures\sites asterisked* would no longer be of National importance.*

Sandwich tern populations centred on the Farne Islands, Coquet Island and Blakeney Point are of international importance, with internationally important colonies of Arctic tern at the Farnes, Common and Roseate terns at Coquet Island and Little terns at Blakeney Point and Great Yarmouth. South of Yarmouth, the only seabird colonies of international importance are an inland colony of cormorants at Abberton Reservoir (which feed at nearby estuaries) and the lesser black-backed gull colony at Orfordness (Tasker 1998).

Eiders and shellduck are the principal wildfowl species which breed on North Sea coasts, with numbers of eider, both those breeding on the Farne Islands and Coquet Island and those wintering off the coasts, being of particular national significance (Tasker 1995a). Breeding waders include lapwing, redshank, oystercatchers, ringed plover, avocets and snipe. Most waders breed on estuarine shingle structures and beaches, sand dunes and salt marshes, with two important areas within the SEA 3 area (the Wash and north Norfolk coast) (Doody *et al*. 1993).

Generalised distribution patterns and movements of seabirds in the North Sea are summarised in Figures 6.6 and 6.7. In general, offshore areas of the central North Sea including the offshore SEA 3 area contain peak numbers of seabirds following the breeding season and through winter, with birds tending to forage closer to coastal breeding colonies in spring and early summer.

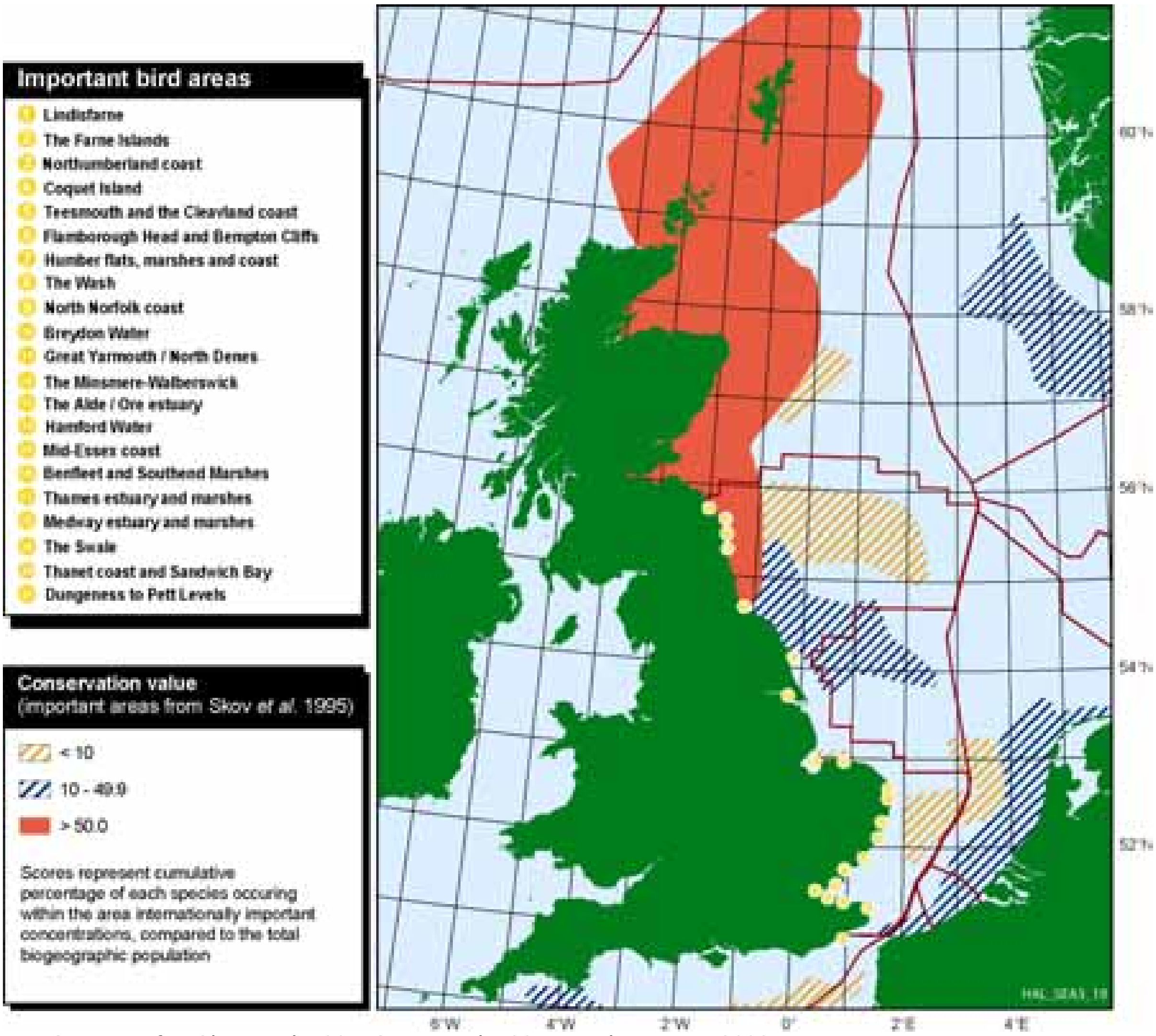
Internationally important numbers of many waterbird populations that breed in western and eastern Europe, and above the Arctic Circle from Canada to central Siberia, migrate to overwinter in the UK (see figure 6.7). In particular, the UK supports over 25% of the East Atlantic flyway population of nine species of waders. Approximately 60% of the waders which overwinter on the coast of Britain use the North Sea coastal margin (including the Channel) (Doody *et al*. 1993), representing some 40% of the waders wintering along the Atlantic shores of Europe (Moser & Prys Jones 1990).

6.7.3 Species accounts – seabirds

Synopses were given in SEA2 of the population, distribution and general biology of individual seabird species regularly recorded in the North Sea (fulmar *Fulmarus glacialis*, sooty shearwater *Puffinus griseus*, Manx shearwater *Puffinus puffinus*, storm petrel *Hydrobates pelagicus*, Leach's petrel *Oceanodroma leucorhoa*, Gannet *Sula bassana*, cormorant *Phalacrocorax carbo*, shag *Phalacrocorax aristotelis*, pomarine skua *Stercorarius pomarinus*, arctic skua *Stercorarius parasiticus*, long-tailed skua *Stercorarius longicaudus*, great skua *Stercorarius skua*, little gull *Larus minutus*, black-headed gull *Larus ridibundus*, common gull *Larus canus*, lesser black-backed gull *Larus fuscus*, herring gull *Larus argentatus*, Iceland gull *Larus glaucoides*, glaucous gull *Larus hyperboreus*, great blackbacked gull *Larus marinus*, kittiwake *Rissa tridactyla*, sandwich tern *Sterna sandvicensis*, common tern *Sterna hirundo*, arctic tern *Sterna paradisea*, guillemot *Uria aalge*, razorbills *Alca torda*, puffins *Fratercula arctica* and little auk *Alle alle*).

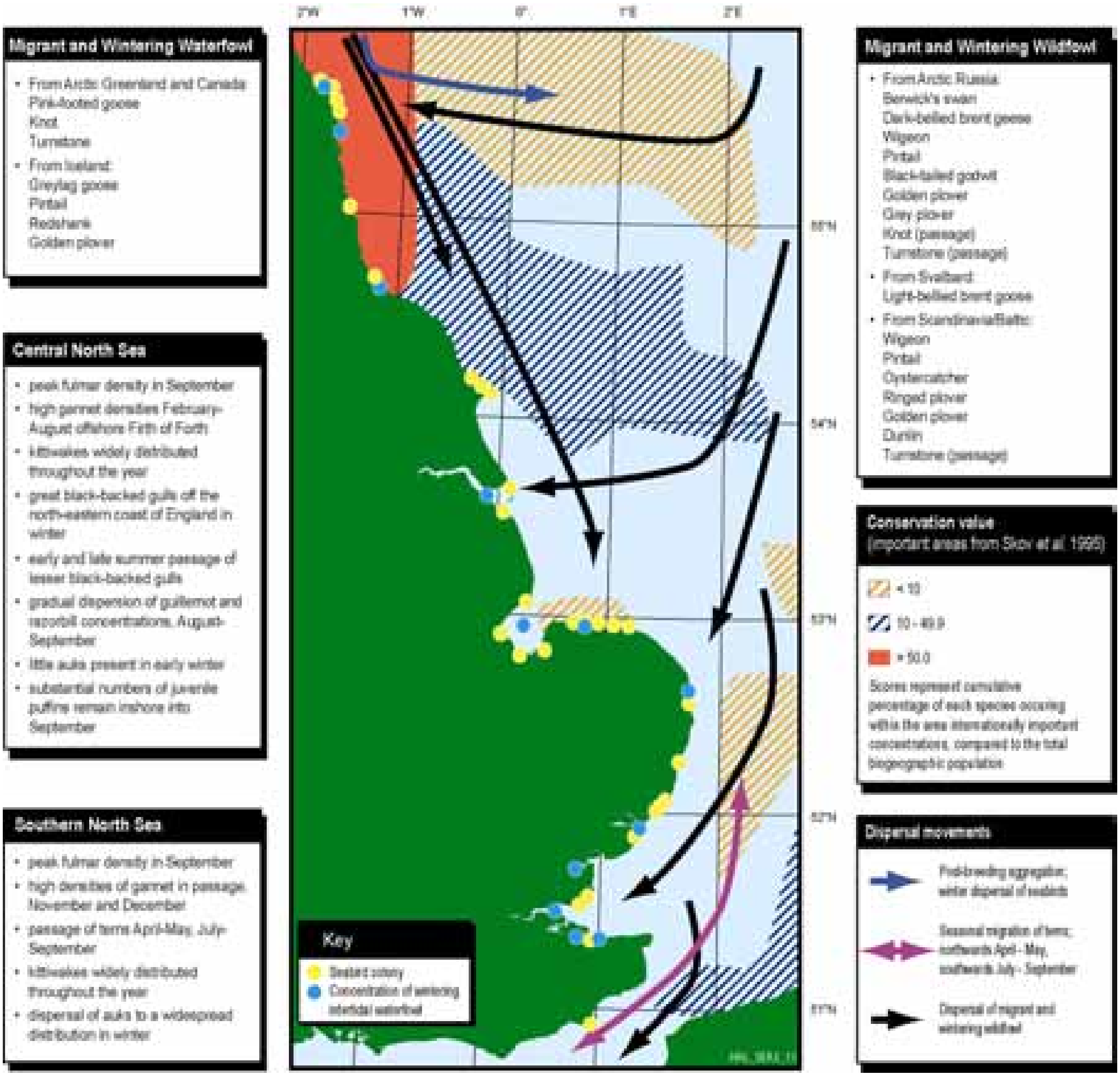
For the most abundant species, these synopses are further summarised, in relation to the SEA3 area, in Appendix 5.

Figure 6.6 – Broadscale distribution of important areas for birds in the North Sea and SEA 3 area



Source: after Skov et al. 1995, Stone et al. 1995, Heath & Evans 2000

Figure 6.7 – Seasonal distribution and movements of seabirds and waterbirds in the SEA 3 area



Source: after Skov et al. 1990, Stone et al. 1995, Heath & Evans 2000, Gibbons et al. 1993

6.7.4 Species accounts – coastal waterbirds

Although many are primarily associated with freshwater, wet grassland and moorland habitats, rather than strictly coastal locations, breeding species of waterbirds (herons, wildfowl, gallinules and waders) recorded along the coastal margin of eastern England include bittern *Botauris stellaris*, grey heron *Ardea cinerea*, mute swan *Cygnus olor*, greylag goose *Anser anser*, Canada goose *Branta canadensis*, shelduck *Tadorna tadorna*, wigeon *Anas penelope*, gadwall *Anas strepera*, teal *Anas crecca*, mallard *Anas platyrhynchos*, pintail *Anas acuta*, garganey *Anas querquedula*, shoveler *Anas clypeata*, pochard *Aythya ferina*, eider *Somateria mollissima*, common scoter *Melanitta nigra*, goldeneye *Bucephala clangula*, ruddy duck *Oxyura jamaicensis*, water rail *Rallus aquaticus*, moorhen *Gallinula chloropus*, coot *Fulica atra*, oystercatcher *Haematopus ostralegus*, avocet *Recurvirostra* *avosetta*, little ringed plover *Charadrius dubius*, ringed plover *Charadrius hiaticula*, lapwing *Vanellus vanellus*, dunlin *Calidris alpina*, ruff *Philomachus pugnax*, snipe *Gallinago gallinago*, black tailed godwit *Limosa limosa*, curlew *Numenius arquata*, redshank *Tringa totanus* and common sandpiper *Actitis hypoleucos* (Gibbons *et al*. 1993, Stroud & Craddock 1995a, b, May & Law 1998). (In addition, the Norfolk coast also supports many pairs of breeding marsh harriers *Circus aeruginosus*, as well as bearded tits *Panurus biarmicus* and most of Britain's breeding Montagu's harriers *Circus pygargus*, Stroud & Craddock 1995b) Of the above, it is most likely that shelduck, eider, oystercatcher, avocet, ringed plover and redshank will breed (or feed during the breeding season) on littoral beaches and adjacent saltmarshes within the SEA3 area.

In addition to coastal breeding species, internationally important numbers of migrant and wintering waterfowl use the SEA3 area coastline. In mid-winter, the coastal area between Berwick and Dungeness holds over 800,000 waterfowl (about half the English total), the majority on estuaries south of the Humber (Stroud & Craddock 1995a, b; May & Law 1998). In addition, the region lies on the major migratory flyway of the east Atlantic, and many birds moving between arctic breeding grounds and wintering areas on African, Mediterranean and south-west European coasts stage in the area. Species which have internationally important wintering populations at coastal sites in the SEA3 area include Bewick's swan, light-bellied brent goose, dark-bellied brent goose, greylag goose, pinkfooted goose, pintail, wigeon, oystercatcher, curlew, knot, redshank, turnstone, purple sandpiper, golden plover, lapwing, grey plover, shelduck, black-tailed godwit, bar-tailed godwit, dunlin, ringed plover, avocet and cormorant (several of which are also resident breeders, see above).

Individual species accounts for important coastal waterbird species are given in Appendix 5.

6.7.5 Importance of individual coastal areas

There are 149 Important Bird Areas (IBAs) in the UK which regularly support over 20,000 wintering or passage water birds, or more than 1% of the biogeographic or flyway population of a waterbird species; 46 IBAs for breeding seabirds; and 20 sites for breeding waterbirds (including gulls and terns) (Heath & Evans 2000). Of these, 21 are located on the SEA 3 area coastline (see figure 6.6); with the Wash, Mid-Essex coast and Humber flats, marshes and coasts representing three of the five most important sites for wintering waterbirds. Flamborough Head and Bempton Cliffs are among the five most important sites for breeding waterbirds (see also chapter 7 for other conservation designation).

IBAs within the SEA 3 area, identified by Heath and Evans (2000) are as follows (from north to south):

- **Lindisfarne** supports breeding terns and attracts large numbers of wintering waterbirds (regularly holding 41,500 birds) including the majority of the Svalbard breeding population of light-bellied Brent goose. The area is also important for passage ringed plover, grey plover, sanderling and redshank and for summer moulting assemblages of eider.
- The **Farne Islands** support large numbers of breeding seabirds, especially terns and auks, with 54,200 breeding seabirds and 14,200 breeding waterbirds. The IBA is nationally important for breeding cormorants, eiders, kittiwakes and guillemots.
- The **Northumberland coast** IBA covers much of the coastline between the Scottish border and the Tyne estuary, and is important for breeding terns and wintering waders.
- **Coquet Island** is internationally important for breeding seabirds (12,800 pairs), notably terns.
- **Teesmouth and the Cleveland coast** are important for breeding terns and wintering waterbirds (20,500), and is nationally important for wintering cormorant, shelduck, sanderling and purple sandpiper; and for passage ringed plover, sanderling, knot, purple sandpiper, redshank and greenshank.

- **Flamborough Head and Bempton Cliffs** hold 46,100 pairs of breeding seabirds and 76,000 pairs of breeding waterbirds on a regular basis. Important species include kittiwake, guillemot, razorbill and puffin.
- **Humber flats, marshes and coast** include an elongated shingle spit (Spurn Point), intertidal habitats (especially mudflats), saline lagoons and reedbeds. The IBA is important for breeding raptors and waders, wintering wildfowl and waders (160,700 birds) and passage waterbirds (69,100 birds). It is nationally important for breeding shelduck, pochard, ringed plover and bearded tit; and for wintering dark-bellied brent geese, wigeon, teal, pintail, pochard, oystercatcher, ringed plover, grey plover, lapwing and sanderling.
- **The Wash** comprises one of the most important areas of estuarine mudflats, sandbanks and saltmarsh in Europe. The IBA holds 336,700 wintering and 264,400 passage waterbirds on a regular basis, and is also nationally important for breeding black-headed gulls.
- **North Norfolk coast** IBA extends for over 40km and includes extensive intertidal sand and mudflats and saltmarsh. The IBA regularly holds 779,500 wintering waterbirds, and is nationally important for breeding oystercatcher and black-headed gulls.
- **Breydon Water** is a tidal estuary which regularly supports 41,000 wintering waterbirds.
- **Great Yarmouth / North Denes**, an accreting sand dune, shingle beach and separate fore-dune ridge system provides breeding sites for little terns.
- The **Minsmere-Walberswick** IBA, which includes the tidal Blyth estuary is noted for breeding avocets, gadwall, pochard, water rail; and for wintering gadwall and black-tailed godwit.
- The **Alde / Ore estuary** holds 12,200 breeding waterbirds and 23,100 wintering waterbirds on a regular basis, and is nationally important as a breeding area for herring gull; and for wintering shelduck, wigeon, teal and black-tailed godwit.
- **Hamford Water**, a shallow estuarine basin regularly holds 38,500 wintering waterbirds. This IBA is nationally important for breeding black-headed gulls, and for wintering shelduck and redshank.
- The **Mid-Essex coast** comprises a large complex of estuaries and sand-silt flats, providing habitat for wintering and passage waders and wildfowl, and for breeding terns. The IBA regularly holds 230,400 wintering, and 81,300 passage waterbirds and is nationally important for wintering little grebe, great crested grebe, cormorant, wigeon, gadwall, pintail, shoveler, goldeneye, red-breasted merganser, lapwing, sanderling, redshank, greenshank and green sandpiper.
- **Benfleet and Southend Marshes** are an extensive area of mudflats and saltmarsh holding up to 34,700 wintering geese and waders. The IBA is of national importance for wintering ringed plover, and passage grey plover.
- The **Thames estuary and marshes**, about 15km of the south coast of the Thames has extensive grazing-marshes, saltmarsh and mudflats which attract a wide range of wintering estuarine and wetland birds (regularly 36,000 in winter). The IBA is of national importance for breeding grey heron, and for wintering little grebe, cormorant, white-fronted goose, dark-bellied brent geese, shelduck, gadwall, teal, pintail, shoveler, ringed plover, grey plover, ruff and black-tailed godwit.
- **Medway estuary and marshes** includes tidal channels draining saltmarsh and grazing-marsh – important for wintering and passage wildfowl, with 69,200 wintering, and 35,200 passage birds. The IBA is of national importance for little grebe, cormorant, wigeon, teal, shoveler, black-tailed godwit, green sandpiper and greenshank.
- **The Swale** IBA includes mudflats and saltmarshes bordering the Swale, regularly holding 67,400 wintering waterbirds. The IBA is of national importance for breeding shoveler, pochard, black-headed gull; and for wintering little grebe, cormorant, white-fronted geese, dark-bellied brent geese, shelduck, wigeon, gadwall, teal and green sandpiper.
- **Thanet coast and Sandwich Bay** IBA has a wide variety of habitats including rocky coastline, mudflats and shingle beaches. They support wintering and passage waders and are of national importance for wintering great crested grebe, grey plover and sanderling.

- **Dungeness to Pett Levels** IBA includes two shingle beaches with breeding terns and wintering wildfowl, with 33,200 wintering waterbirds regularly counted. The IBA is of national importance for breeding gadwall, and for wintering great crested grebe, cormorant, white-fronted geese, wigeon, gadwall, teal, common scoter and sanderling.

6.7.6 Sensitivities and vulnerability - seabirds

Overall status of breeding seabirds in Britain and Ireland is reviewed by Lloyd *et al.* (1991), and summarised by SEA 2, with the conclusion that probably the most important factor currently affecting seabird numbers is the quality and abundance of their food.

Table 6.5 – UK population trends in seabird species

Species	Trend
Fulmar	↑
Gannet	↑
Great skua	↑
Black-headed gull	↑
Lesser black-backed gull	↑
Great black-backed gull	↑
Kittiwake	↑
Sandwich tern	↑
Little tern	↑
Guillemot	↑
Black guillemot	↑
Arctic skua	↑
Storm petrel	=
Common tern	=
Manx shearwater	?
Cormorant	?
Shag	?
Common gull	?
Razorbill	?
Herring gull	↓
Roseate tern	↓
Arctic tern	↓

Commercial fishing has resulted in major, but complex changes in seabird food stocks (Furness 1987) including removal of food source (especially herring), reduction in competition (by removal of predatory fish), and availability of fishing discards. In addition, entanglement in nets may be a major cause of seabird mortality, for example in coastal waters of north-west Ireland where salmon drift-netting has resulted in heavy mortality of puffins and other seabirds. Using evidence from ringing recoveries, Mead (1989) considered that modern fishing techniques, particularly the use of monofilament nets, are now the main cause of unnatural death among auks, especially in the seas around Britain and off Iberia.

Pollution of the sea by oil, predominantly from merchant shipping, can also be a major cause of seabird mortality. Although locally important numbers of birds have been killed on the UKCS directly by oil spills from tankers, for example common scoter off Milford Haven following the Sea Empress spill in 1996, population recovery has generally been rapid in contrast to post-spill trends (1989-1998) of marine bird populations in Prince William Sound following the Exxon Valdez oil spill. Lance *et al*. (2001) evaluated recovery of injured taxa using regression models of population trends, and comparison of population trends of injured taxa in the oiled area relative to the unoiled area using homogeneity of the slopes tests. Most taxa for which injury was previously demonstrated were not recovering and some taxa showed evidence of increasing effects nine years after the oil spill, with evidence of slow recovery, lack of recovery, and divergent population trends in many taxa which utilize shoreline and nearshore habitats where oil is likely to persist.

Little or no direct mortality of seabirds has been attributed to exploration and production activities on the UKCS. However, Wiese *et al*. (2001) claim that mortality has been documented due to impact on the structure, oiling and incineration by the flare, of seabirds aggregated around oil drilling platforms and rigs in above average numbers due to night lighting, flaring, food and other visual cues. These sources of mortality it was conjectured could, following offshore hydrocarbon development in the North-west Atlantic (i.e. the Grand Banks), affect both regional and global breeding populations. However, based on North Sea seabird colony performance this scale of effect seems unfeasible.

Chronic pollution resulting from illegal dumping or tank washing probably has a greater impact on seabirds than accidental spills from shipping casualties (e.g. Andrews & Standring 1979). Beached bird surveys around the UK (Stowe & Underwood 1983), and elsewhere in Europe (e.g. Vauk 1984), provide useful data on the risks to seabirds of oil pollution in the North Sea.

Seys *et al*. (2002) evaluated various approaches of beached bird collection at the Belgian coast during seven winters (1993-1999). Data collected through Belgian rehabilitation centres concern injured, living birds collected in a non-systematical way. Oil rates derived from these centres appear to be strongly biased to oiled auks and inshore bird species, and are hence of little use in assessing the extent of oil pollution at sea. The major asset of rehabilitation centres in terms of data collection seems to be their continuous warning function for events of mass mortality. Weekly surveys on a representative and large enough section rendered reliable data on oil rates, estimates of total number of bird victims, representation of various taxonomic groups and species-richness and were most sensitive in detecting events quickly (wrecks, oil-slicks, severe winter mortality, etc.). Monthly surveys gave comparable results, although they overlooked some important beaching events and demonstrated slightly higher oil rates, probably due to the higher chance to miss short-lasting wrecks of auks.

Although a high proportion of seabirds and coastal birds recovered dead from beaches show signs of oiling (e.g. up to 64% of divers, Stowe 1982 cited in Pollock *et al.* 2000), most of the oil samples taken from bird plumage suggest that bunker oils from shipping discharges were predominantly involved (Cormack 1984). It is also likely that a proportion of oiled bird carcasses were dead prior to coming in contact with oil.

The vulnerability of seabird species to oil pollution at sea is dependant on a number of factors and varies considerably throughout the year. The Offshore Vulnerability Index (OVI) developed by JNCC and used to assess the vulnerability of bird species to surface pollution considers four factors:

- the amount of time spent on the water
- total biogeographical population
- reliance on the marine environment
- potential rate of population recovery (Williams *et al.* 1994)

Vulnerability scores for offshore areas are determined by combining the density of each species of bird present with its vulnerability index score (see Table 6.6). Of the species commonly present offshore in the North Sea (see above), gannet, skuas and auk species may be considered to be most vulnerable to oil pollution due a combination of heavy reliance on the marine environment, low breeding output with a long period of immaturity before breeding, and the regional presence of a large percentage of the biogeographic population. In contrast, the aerial habits of the fulmar and gulls, together with large populations and widespread distribution, reduce vulnerability of these species.

Table 6.6 – Individual species vulnerability index scores

Red-throated diver	29*	Arctic skua	-24
Black-throated diver	29*	Great skua	-25
Great northern diver	29*	Little gull	-24
Great crested grebe	23*	Black-headed gull	-11
Red-necked grebe	26*	Common gull	-13
Fulmar	-18	Lesser black-backed gull	-19
Sooty shearwater	19*	Herring gull	-15
Manx shearwater	23*	Great black-backed gull	-21
Storm petrel	-18	Kittiwake	-17
Gannet	-22	Sandwich tern	-20
Cormorant	-20	Common tern	-20
Shag	24*	Arctic tern	-16
Scaup	20*	Little tern	-19
Eider	16*	Guillemot	22*
Long-tailed duck	17*	Razorbill	24*
Common scoter	19*	Black guillemot	29*
Velvet scoter	21*	Little auk	22*
Goldeneye	16*	Puffin	21*
Red-breasted merganser	21*		

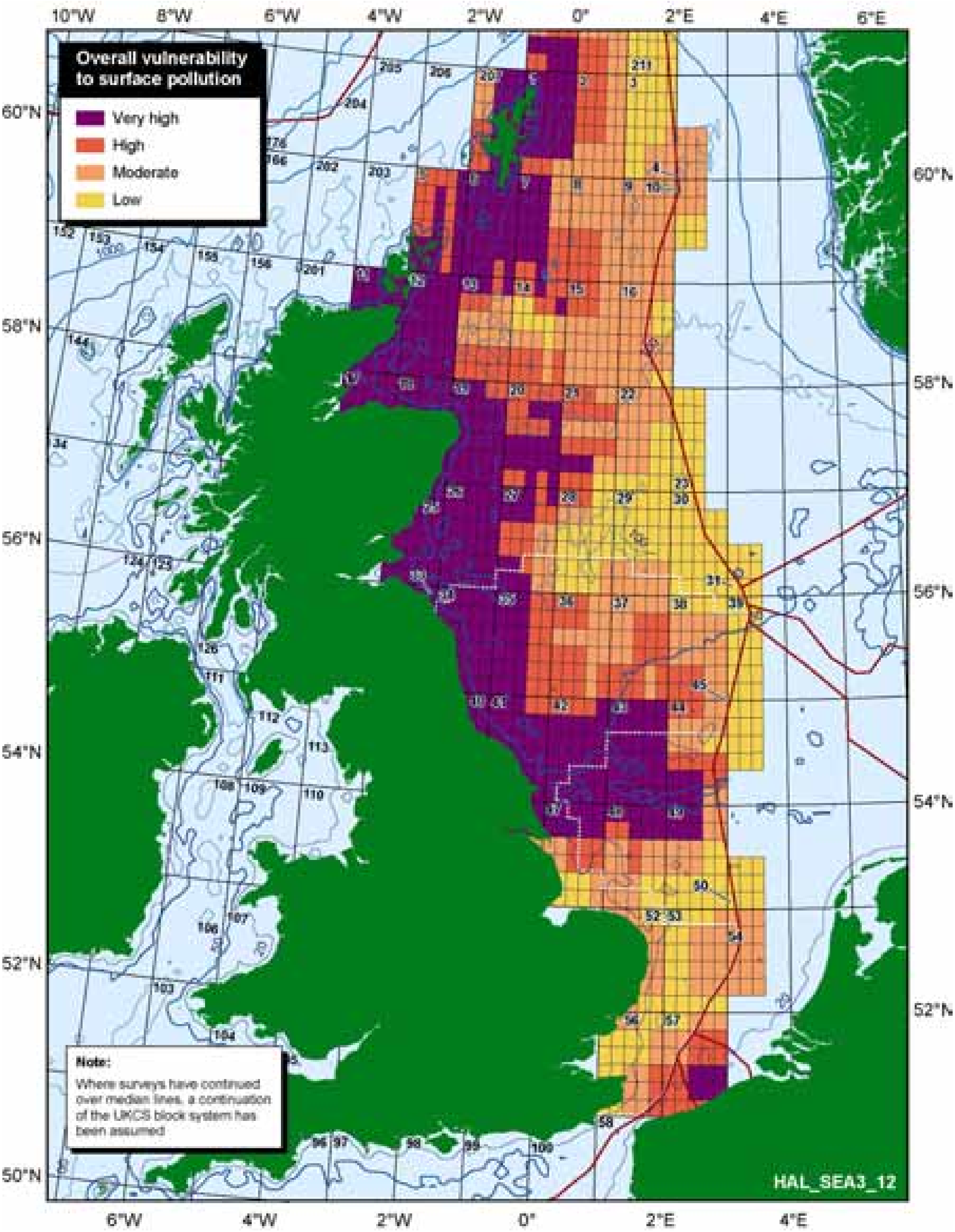
* *large proportion of time spent on the surface of the sea and therefore individuals of this species are at high risk from surface pollutants*

Source: BODC 1998

Vulnerability scores for individual UKCS licence blocks have been calculated by JNCC, and smoothed seabird vulnerability maps are published by BODC (1998). Overall vulnerability to surface pollutants (taking seasonal variability into account); seasonality (expressed as number of months in which very high vulnerability occurs) and data gaps (defined as blocks for which two or more consecutive months are unsurveyed) are shown in Figures 6.8 and 6.9.

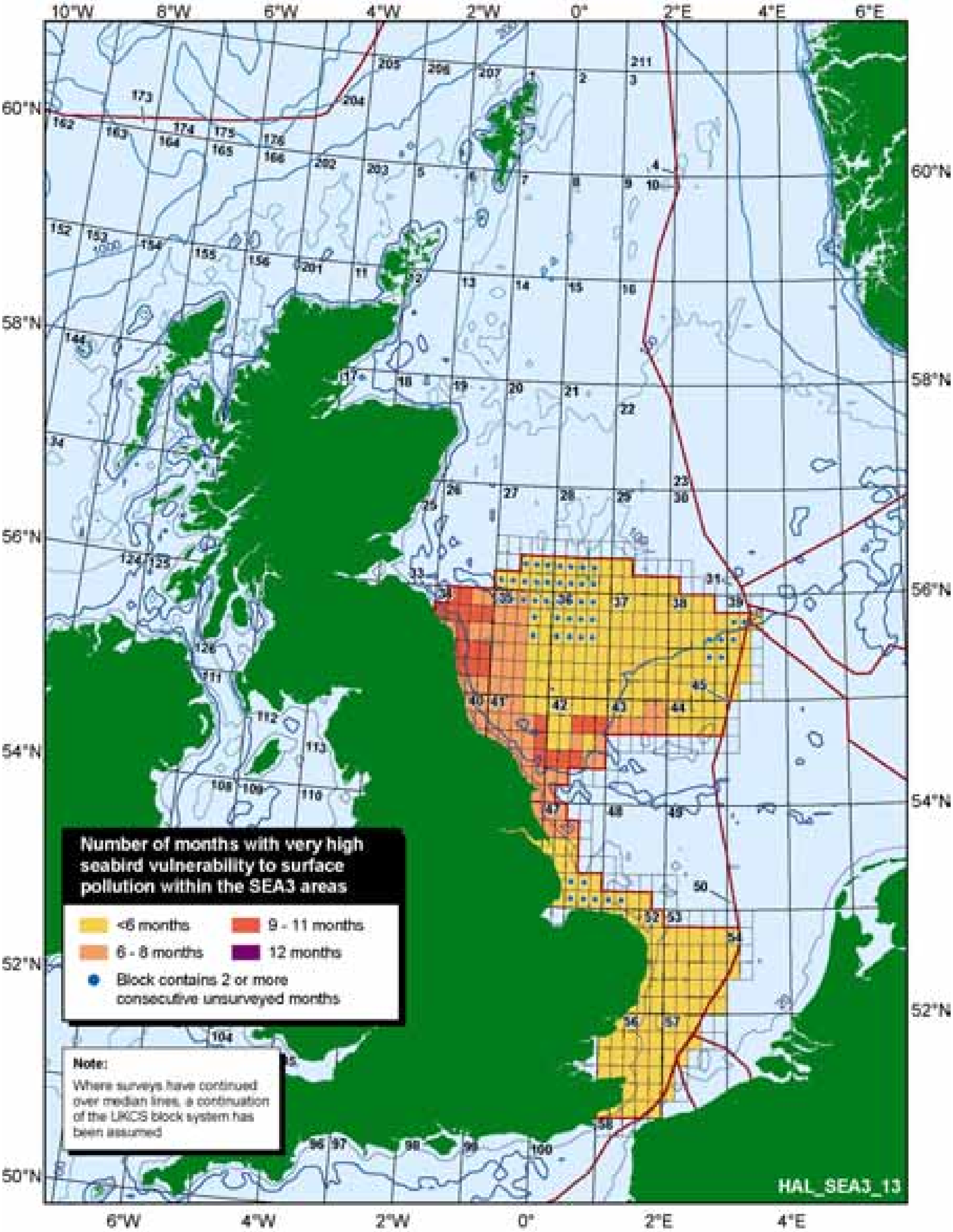
Overall seabird vulnerability of seabirds to surface pollution is very high in parts of Quadrants 27, 34, 35, 40, 41, 42, 43 and 47; corresponding to SEA 3 areas within the central North Sea south-east of the Forth, inshore along the Northumberland coast and east of Flamborough Head to Spurn Point (west of the Dogger Bank). As was the case for SEA 2 areas, much of the seabird vulnerability is associated with proximity of breeding colonies and post-breeding dispersal of auks and is therefore seasonal. Vulnerability is very high for between 6 and 8 months of the year in parts of Quadrants 34, 35, 40, 41, 42, 43, 46 and 47; and for between 9 and 11 months in parts of Quadrants 34, 41 and 42 (corresponding to areas off the Northumberland coast, which are adjacent to the Farne colonies and hold birds all year). Remaining blocks within the SEA 3 area are highly vulnerable for less than six months; i.e. had operational windows within which vulnerability is lower.

Figure 6.8 – Overall vulnerability of seabirds to surface pollution



Source: JNCC Block vulnerability data

Figure 6.9 – Seasonal vulnerability of seabirds to surface pollution (expressed as number of months in which very high vulnerability is present, data gaps for seabird vulnerability are also shown)



Source: JNCC Block vulnerability data

Vulnerability data are adequate for most of the SEA 3 area, although data gaps are present for two or more consecutive months in parts of Quadrants 27, 28, 35, 36, 38 and 39 in the central North Sea and also Quadrants 47 and 48 of the North Norfolk coast. Much of the available information dates from SAST work in the early 1980s (principally SAST 2 between 1983 and 1986) and it is possible that significant ecological change has occurred since then, as is known for plankton distribution (Beaugrand *et al*. 2002).

6.7.7 Sensitivities and vulnerability - coastal waterbirds

Trends in wintering waterbird populations have been summarised from WeBS data (Musgrove *et al*. 2001), analysed using the "Underhill index" (Underhill 1989) which allows between-year comparison of numbers, even if the true population size is unknown. Musgrove *et al*. (2001) present annual indices on a log scale, over the period 68/69 to 99/00 for most species, from which the trend in recent years (five to ten years) has been qualitatively assessed.

Table 6.7 – UK population trends in wintering wildfowl and wader species

Species	Trend (UK)
Bewick's swan	↑
Light-bellied brent goose (Svalbard)	= (UK ↓)
Dark-bellied brent goose	↑
Greylag goose (Icelandic)	↑
Greylag goose (re-established)	↑↑
Pink-footed goose	↑
Shelduck	↓
Eider	=
Pintail	=
Wigeon	=
Oystercatcher	=
Avocet	↑↑
Ringed plover	↓
Golden plover	↑
Grey plover	↑
Lapwing	↑
Knot	↓↓
Purple sandpiper	? ↑
Dunlin	↓
Black-tailed godwit	↑↑
Bar-tailed godwit	=
Curlew	↑
Redshank	↑
Turnstone	↓

As the major breeding areas for most wildfowl and wader species are outside the UK (in the high arctic for many species), population dynamics are largely controlled by factors outwith the scope of SEA 3 – including breeding success (largely related to short-term climate fluctuations, but also habitat loss and degradation) and migration losses. Other significant factors include lemming abundance on arctic breeding grounds (e.g. white-fronted goose). Variability in movements of wintering birds, associated with winter weather conditions in continental Europe, can also have a major influence on annual trends in UK numbers, as can variability in the staging stops of passage migrants. However, there has been continued loss of wintering habitat in the UK over the last century, due largely to land reclamation of saltmarsh and intertidal estuarine habitats; offset in part by recent designation of conservation sites and associated management measures.

Several species, including shelduck, pintail, ringed plover, dunlin and turnstone increased consistently in numbers during the late 1970s and 1980s, then decreased during the 1990s. Reasons for this probably vary between species, since breeding areas used by these species are different.

With the exception of the knot (which declined severely in the early 1970s due to a run of unusually cold springs and summers on their Greenland breeding grounds), the numbers of most waders which overwinter predominantly on UK estuaries have either been stable or have increased over the last 30 years. However, over the period 1984-85 to 1997-98 the non-estuarine populations of many waders have declined (Gregory *et al*. 2001): ringed plover by 13%, sanderling by 18%, purple sandpiper by 15% and turnstone by 20%. The decrease in numbers of all four species has been greatest in the south, but also in the west of UK for ringed plover and turnstone. The northward shift of these species broadly coincides with a decrease in very cold winter days over the last decade. The wintering distributions of seven of the twelve commonest species of wader are shifting from southwest England and south Wales to south and south-east England, including the southern SEA 3 area. The tendency towards milder winters over the last 20 years may be allowing waders to make increased use of food-rich estuaries in south-east Britain where previously they had been vulnerable to the effects of cold weather. The three non-governmental organisations (NGOs) most closely involved in bird monitoring in the UK, the Royal Society for the Protection of Birds (RSPB), the British Trust for Ornithology (BTO) and The Wildfowl & Wetlands Trust (WWT) have therefore suggested that climate change may already be affecting bird populations and will raise difficult questions for site and species conservation in coming decades (Gregory *et al*. 2001).

6.8 Marine mammals

Eight marine mammal species occur regularly over large parts of the North Sea: grey seal, harbour seal, harbour porpoise, bottlenose dolphin, white-beaked dolphin, Atlantic white-sided dolphin, killer whale and minke whale.

6.8.1 Data sources

A review of marine mammal distribution, ecological importance and sensitivity to disturbance and contamination in the SEA 2 area was carried out by the Sea Mammal Research Unit (SMRU), which has been revised and updated for the SEA 3 process.

There is extensive information on the distribution and abundance of grey seals around Britain from annual aerial surveys of breeding colonies and from over 100 animals fitted with satellite-relayed data loggers. Information on harbour seals is drawn from a variety of sources; the most detailed information is from aerial surveys conducted during the moult by SMRU (SMRU unpublished data). Very new information on harbour seal distribution at sea has also been made available by SMRU. There is also extensive information on distribution in the North Sea from a number of summer sightings surveys (SCANS-94, NASS-89 and NILS-95). Estimates of abundance are available from these surveys for some species. There are also many records from year-round surveys by the European Seabirds at Sea Consortium (ESAS) since 1979, from cetacean observations made during seismic surveys in 1996-98, and sightings by voluntary observers compiled by the Sea Watch Foundation.

6.8.2 Cetacean distribution and abundance

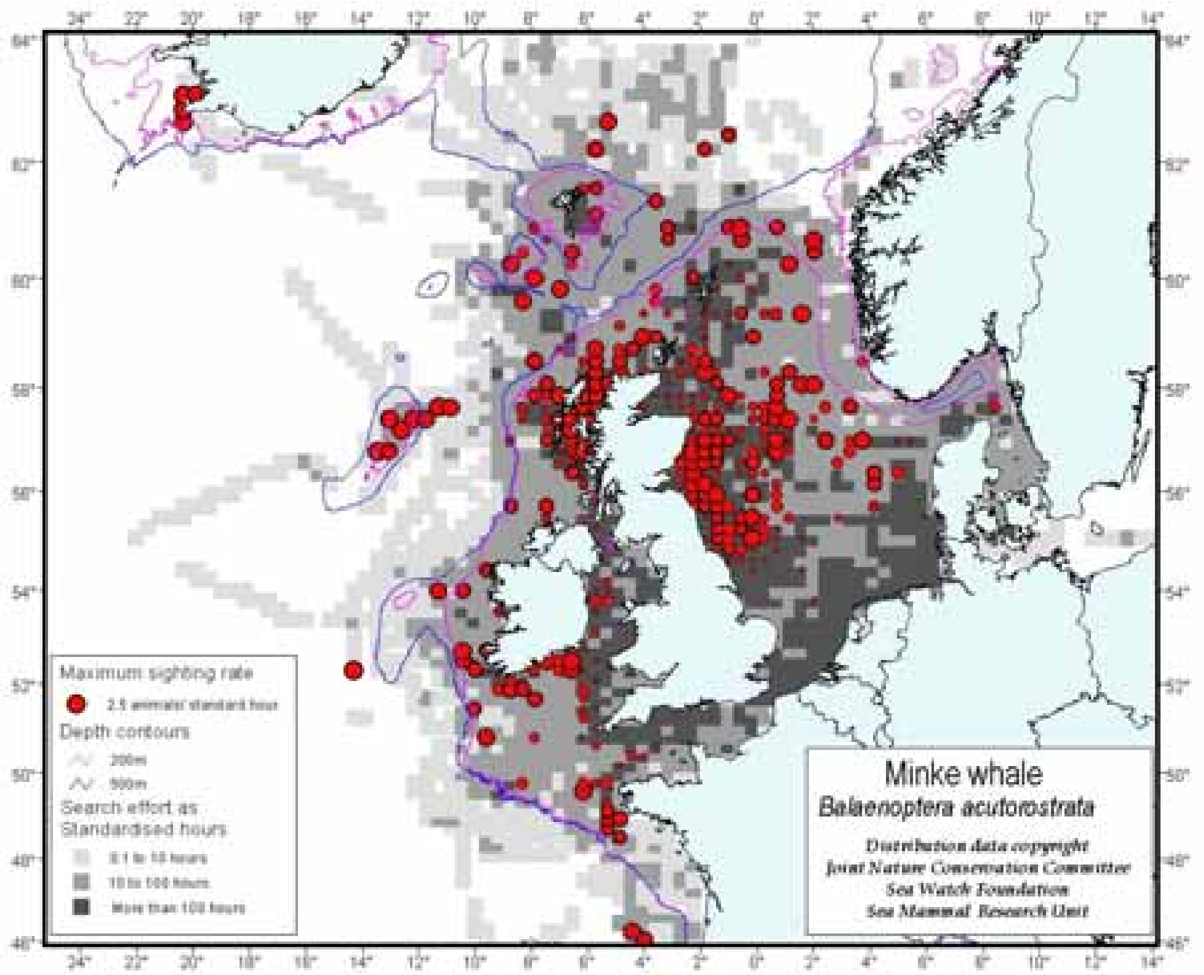
Minke whales occur throughout the central and northern North Sea in summer particularly in the west. Highest densities appear to be in the northwest North Sea, particularly off the mainland coast of Scotland and into the western part of the central SEA 2 area, and through much of the SEA 3 area, at least as far south as Flamborough Head. The estimated summer abundance of minke whales in North Sea survey blocks of the SCANS survey was 7,200 (approximate 95% confidence interval 4,700 – 11,000). This estimate includes shelf waters to the west of Shetland and Orkney. Figure 6.10 (from Reid *et al.* in press) shows crude sightings rates (numbers of animals per hour), corrected for different probabilities of detecting minke whales in different sea states, from a wide variety of sightings platforms throughout the area over a 20 year period. This makes clear the fact that minke whales are also widely distributed, at least during summer months, in much of the SEA 3 block.
The **harbour porpoise** is the commonest cetacean in the North Sea. Figure 6.11 (from Reid *et al.* in press) shows sightings rates of harbour porpoises (numbers sighted per hour), corrected for probability of detection under different sea states, for the area around the UK. These data represent several thousand sightings made on hundreds of different platforms over a 20 year period. Highest overall sightings rates are found in the northern central North Sea, in the SEA 2 block and northern parts of the SEA 3 block, but harbour porpoises are clearly abundant throughout both blocks except in the south-eastern fringes of the SEA 3 block.

Figure 6.12 shows the distribution of porpoise density (in schools km^{-2}) calculated from sightings made from ships during the SCANS surveys (Burt *et al.* 1999). Highest densities were observed north of 56ºN, mostly in a north-south band between 1ºE and 3°E. These areas of high density fall mostly within the northern and central SEA 2 blocks. The density of porpoises in inshore areas around Shetland, and the North Sea coasts of Norway, Sweden, Denmark, Germany and the Netherlands are shown blank in Figure 6.12 only because these areas were surveyed from the air and the data could not be modelled in the same way as the shipboard sightings.

The estimated summer abundance of harbour porpoises in North Sea survey blocks of the SCANS survey was 268,452 (approximate 95% confidence interval 210,000-340,000). This estimate includes shelf waters to the west of Shetland and Orkney. The total SCANS estimate for the North Sea, Celtic Sea, Channel, Skagerrak and Kattegat was 341,366 (95% confidence interval 260,000-449,000). Bjørge and Øien (1995) estimated that there were 82,600 porpoises in the North Sea north of 56ºN. This estimate is known to be biased downwards because the probability of detection on the transect line was assumed to be one. There are no other harbour porpoise abundance estimates for the north-eastern North Atlantic.

The density of harbour porpoises predicted from the spatial modelling does not exactly mimic the sightings distribution from the SCANS survey. This is to be expected because the model predicted density based on latitude, longitude, sea depth and distance from the coast as covariates, as well a two interaction terms. The predicted density in unsurveyed areas is determined by the relationship between observed density and these covariates in surveyed areas, and represents the best prediction of density at this time of year (July) from the available data. Although subject to a number of possible biases, the cetacean atlas data (Figure 6.11) provide a synoptic overview, integrated over a longer time period and all seasons, but which is broadly in agreement with the modelled results in Figure 6.12, showing highest densities in central and northern areas of the North Sea.

Figure 6.10 – Sightings rates (numbers per standard hour) of minke whales



Source: Reid et al. (in press)

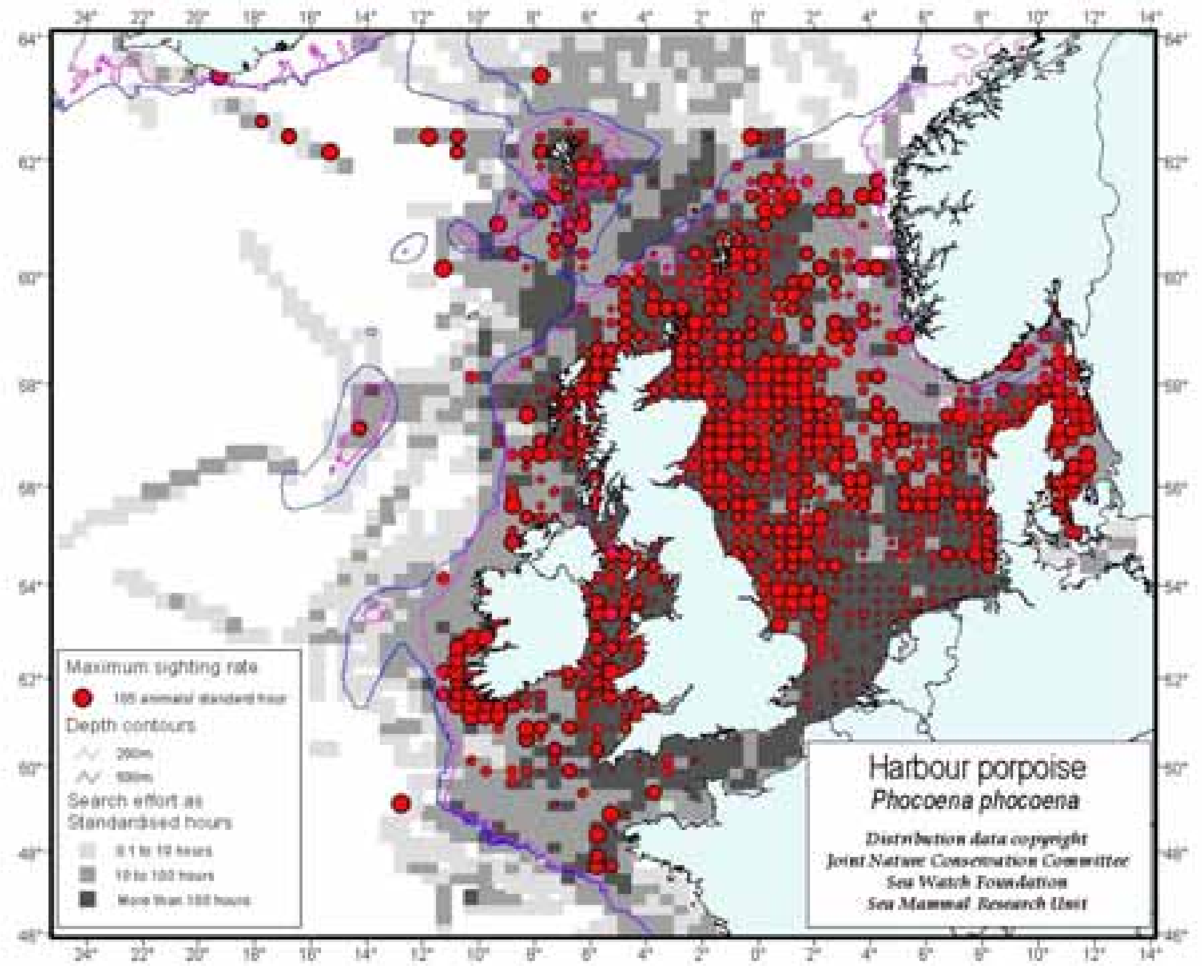
SAST data from 1979 to 1991 show the highest rate of porpoise sightings in April to June (the calving season), and July to September. These changes may be the result of porpoises moving into the northern North Sea from Norwegian waters (Northridge *et al.* 1995).

Summarising all available information, it is clear that the northern part of SEA 3 and the coastal strip of SEA 3 as far south as around 53°30' are important areas for porpoises, especially in summer.

In the North Sea **bottlenose dolphins** are rarely sighted outside coastal waters of northeastern Scotland. Seismic surveys (Stone 1998, 2001) and SCANS also show sporadic sightings in the coastal strip of SEA 3.

White-beaked dolphins are most commonly sighted in the central part of the North Sea between 54˚N and 59˚N. Their distribution includes the northern part of the SEA 3 block, with some sightings as far south as about 54°N. White-beaked dolphins are present year round in the North Sea, with some suggestion of a seasonal aggregation around the Northeast English coast during April-June (Northridge *et al.* 1997).

Figure 6.11 – Sightings rates (numbers per standard hours) of harbour porpoises



Source: Reid et al. (in press)

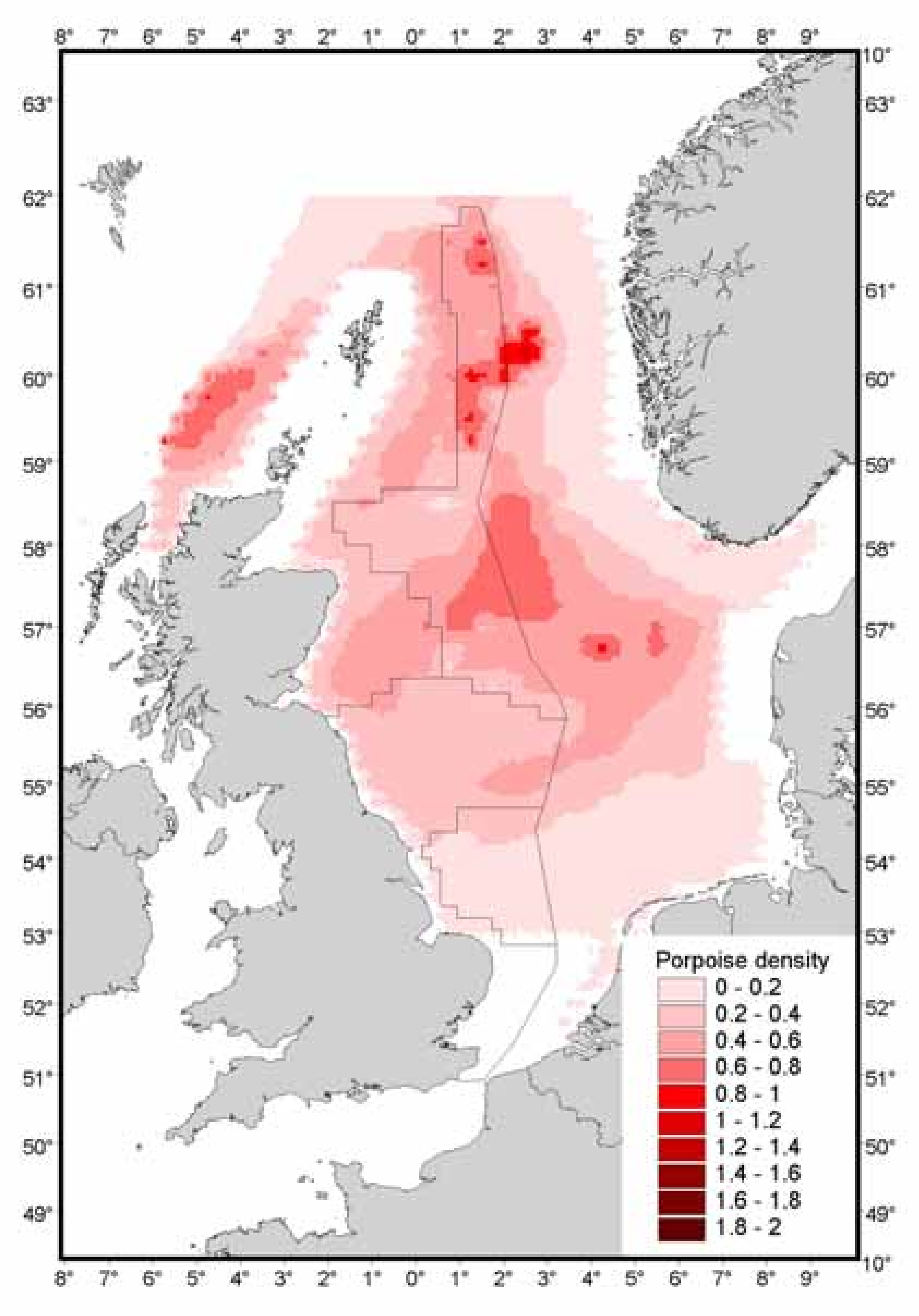
In the North Sea, **Atlantic white-sided dolphins** have been recorded during a number of surveys. They appear to be most common in the northwestern parts of the North Sea, particularly to the west of the central SEA 2 area and the northern part of the SEA 3 area. Reid *et al.* (in press) also show scattered sightings down the Yorkshire coast as far as Flamborough Head in the SEA 3 area. Their presence is seasonal, with the bulk of sightings occurring between May and September (Northridge *et al.* 1997).

The SCANS survey estimated 11,760 *Lagenorhynchus* dolphins (white-beaked plus white-sided) in the North Sea (95% confidence interval 5,900-18,800). This estimate includes shelf waters to the west of Shetland and Orkney.

Killer whales have been observed throughout the north-western North Sea in all months except October. Most records are from the northern part of the northern SEA 2 block and in the northeastern part of the central SEA 2 block, with very few sightings indeed in the SEA 3 area. Association of killer whales with oil platforms has been reported.

Other cetacean species are not common in the North Sea.

Figure 6.12 – Harbour porpoise density (schools.km^{-2}) predicted from spatial modelling of the SCANS data



Source: Burt et al. 1999 and Hammond et al. 1995 & 2002

6.8.3 Seal distribution and abundance

Harbour seals are one of the most widespread pinniped species and have a practically circumpolar distribution in the Northern Hemisphere. In the North Sea, harbour seals haul out on tidally exposed areas of rock, sandbanks or mud. Pupping occurs on land from June to July. The moult is centred around August and extends into September. Thus from June to September harbour seals are ashore more often than at other times of the year.

There are four sub-species. Only the eastern Atlantic harbour seal, *Phoca vitulina vitulina,* occurs in the North Sea. A minimum estimate of population size for this sub-species based on counts at haul-out sites is around 70,000 individuals. However, counts of seals hauled out on land during the moulting season (August) represent only about 60-70% of the total population. Approximately 54% of this subspecies breeds in the North Sea. Table 6.8 shows the minimum estimates of population size for areas in the North Sea based on aerial surveys of animals hauled out on land during the moult or the pupping season.

Table 6.8 – Counts of harbour seals in the North Sea

Area	Count (year)	
UK - English East coast	3,700	(1999)
UK - Scottish East coast	1,500	(1996-97)
UK – Shetland	6,000	(1996-97)
UK – Orkney	8,500	(1996-97)
Denmark	2,100	(2000)
Germany	11,500	(2000)
The Netherlands	3,300	(2000)
Norway, south of 62ºN	1,200	(1996-98)

Harbour seal distribution at sea is constrained by the need to return periodically to land. Until recently, the available data showed that harbour seals were unlikely to be found more than 60km from shore, although recent studies have shown that harbour seals from Scotland, Denmark and the Netherlands are distributed widely across the North Sea.

Figure 6.13 shows the distribution of harbour seals in the North Sea, extended from Reijnders *et al.* (1997) to take into account additional known haul-out sites in the south-western North Sea. At-sea sightings from Pollock *et al.* (2000) are also shown.

Until recently, direct information on foraging movements and the distribution at sea of harbour seals in the North Sea was limited to studies in the Moray Firth; the results are summarised by Thompson *et al.* (1996). They showed that harbour seals moved only to alternative haul-out sites within a range of 75km and that all harbour seals foraged within 60km of their haul-out sites.

Hall *et al.* (1998) proposed that harbour seals from the south-western North Sea that haul out in The Wash forage coastally, based on the dominance of two coastal species, gobies and dragonet, and the lack of sandeels, that are distributed primarily offshore, in the diet.

Based on this information, it would appear that harbour seals would forage only in the coastal area of the SEA 3 block. However, recent studies of harbour seal foraging distribution have revealed that this species forages much further offshore that previously thought. Figure 6.14 shows areas where harbour seals have been tracked using satellite-link telemetry from Scotland (SMRU, University of St Andrews) and Denmark (Fisheries Museum, Esbjerg and ELSAM, Denmark); another recent study in the Netherlands has found similar results (data not available). These studies clearly show that harbour seals forage over wide areas of the North Sea and it is to be expected that the population inhabiting the east coast of England, of which The Wash is the largest concentration, behaves similarly. Harbour seals are therefore likely to be distributed over much of the central and southern North Sea including the SEA 3 area.

Grey seals are restricted to the North Atlantic; total abundance is approximately 300,000 animals. The population in the northeast Atlantic has been increasing at around 6% annually since the 1960s; its current size is estimated at around 130,000-140,000 individuals, of which approximately 70,000 are associated with breeding colonies in the North Sea. The major grey seal colony in the SEA 3 area is located at the Farne Islands (around 3,600 individuals). Successful breeding was first recorded in the Wadden Sea in the Netherlands (at Terschelling) in the 1980s. Pup numbers there have increased from just two in 1985 to more than 100 in 2000. Along the Norwegian west coast up to 62ºN, tagging of 21 pups in 2000 confirmed that grey seals still breed in this area.

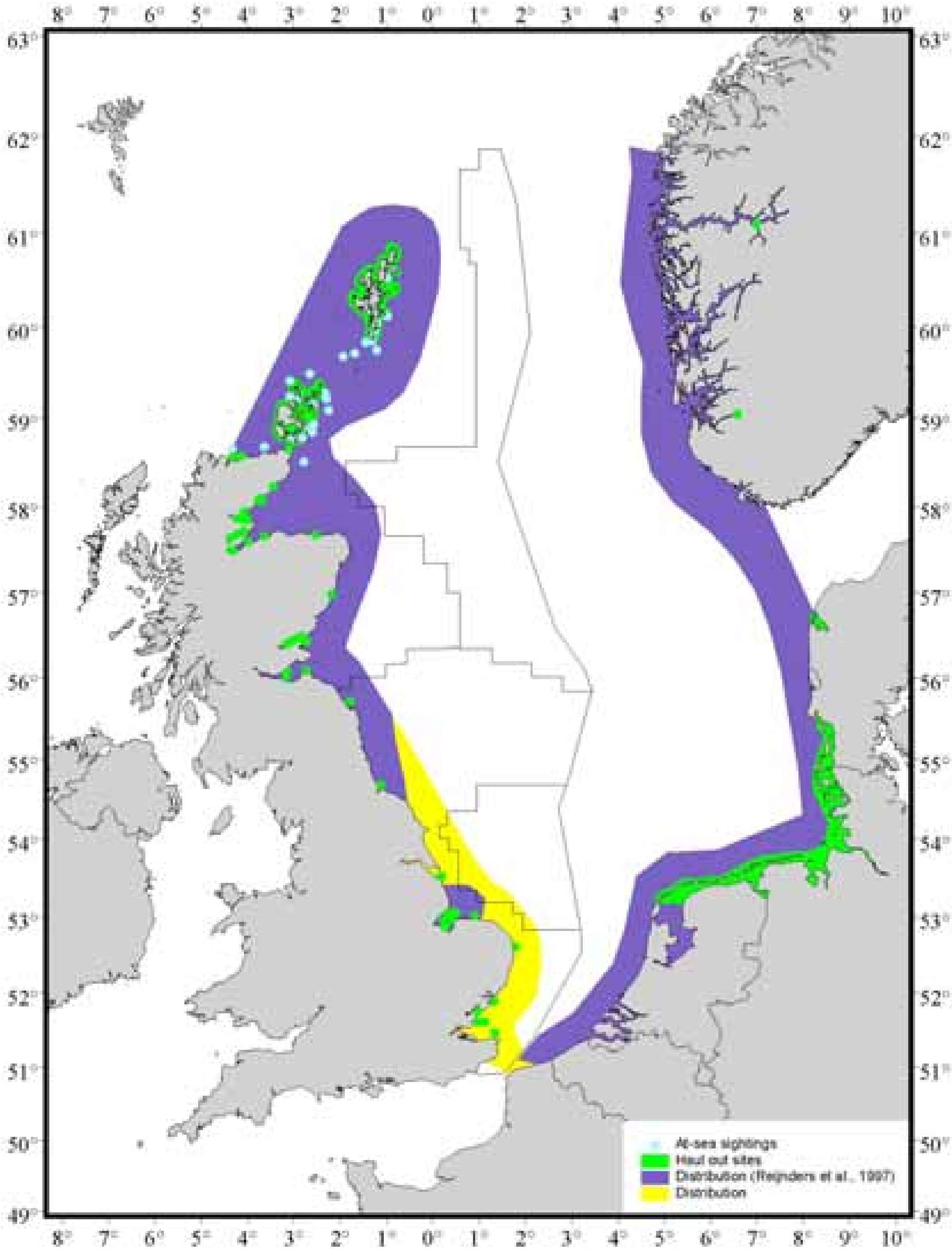
Most of the grey seal population will be on land for several weeks from October to December, and again in February and March during the moult. Densities at sea are likely to be lower during this period than at other times of the year. Further information on distribution and movements of grey seals comes from using numbered tags attached to the flippers of pups. These indicate that young seals disperse widely in the first few months of life. Pups marked in the UK have, for example, been recaptured or recovered along the North Sea coasts of Norway, France and The Netherlands, mostly during their first year (Wiig 1986).

Extensive information on the distribution of British grey seals at sea is available from studies of animals fitted with satellite-relay data loggers. Figure 6.15 shows the tracks of 108 grey seals recorded over a period of about 10 years (see McConnell *et al.* 1999 for details).

It is clear from Figure 6.15 that grey seals that haul out along the western shores of the North Sea are distributed mainly to the west of 0° longitude. There are tracks in the northern, central and southern SEA 2 area and in the northern parts of the SEA 3 area, but these do not appear to be major areas for grey seals. This is confirmed by recent work at the SMRU in which a mathematical and statistical modelling framework has been developed that uses satellite-linked telemetry and other data to generate predicted distributions of where grey seals spend their time foraging around the British Isles (Matthiopoulos *et al.* in preparation). Figure 6.14 shows such a distribution overlaid on the SEA 2 and SEA 3 areas. Although the model predicts that grey seals do spend some time in these areas, it is a small percentage of total time at sea. The model estimates that grey seals spend 1.5% of their time in the northern and central SEA 2 areas, only 0.2% of their time in the southern SEA 2 area, and 3.0% of their time in the SEA 3 area. Activity in the SEA 3 area is concentrated in the north off the Farne Islands, a particularly important area for grey seals (McConnell *et al.* 1999).

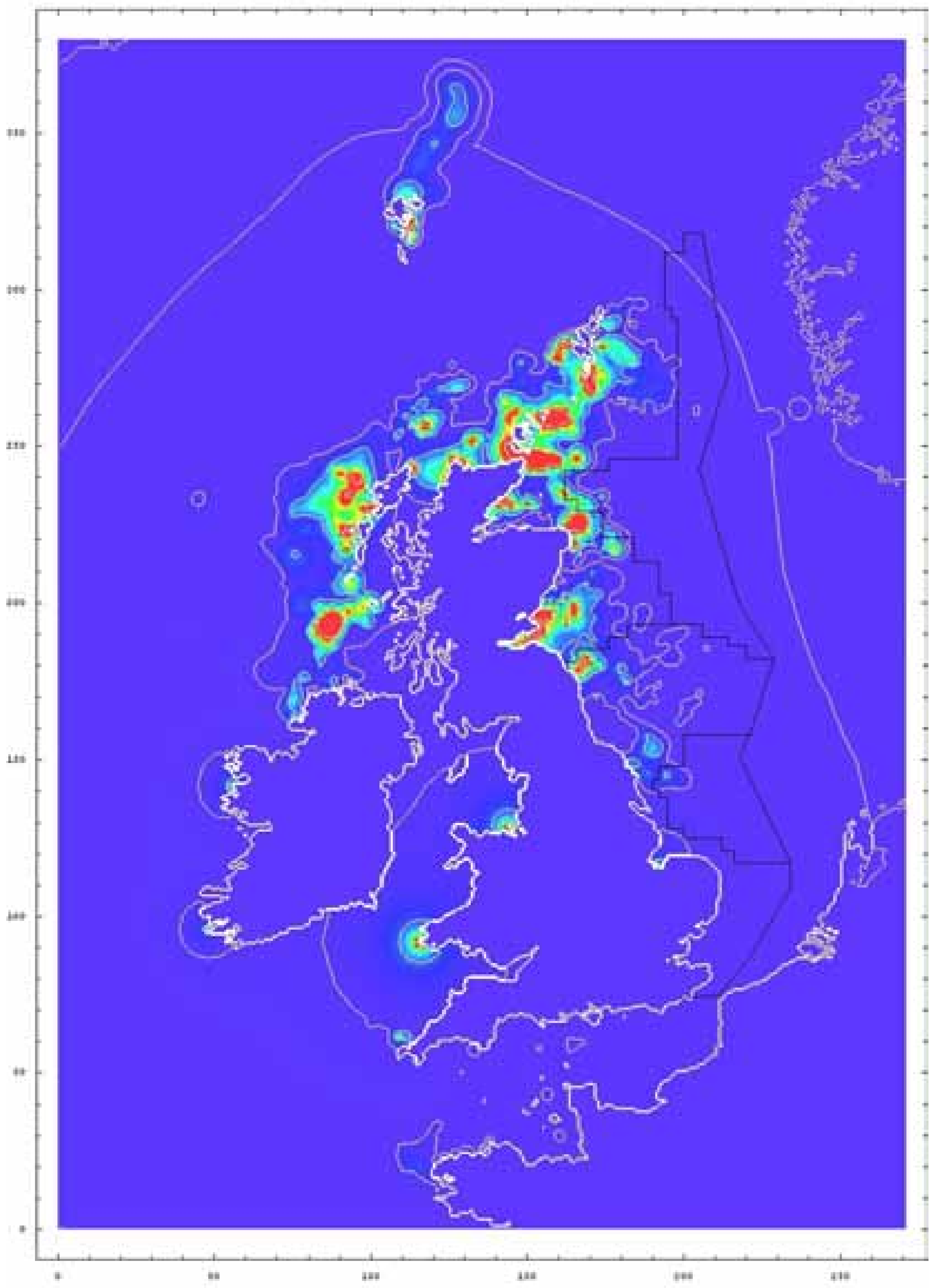
Model output is only as good as the input, and the telemetry data for the southern North Sea are few. Additional information for the southern SEA 2 area and SEA 3 area comes from the grey seal diet study in this area (Prime & Hammond 1990). The diet of animals that haul out to the south of the Humber Estuary (Donna Nook) includes the greater sandeel (*Hyperoplus lanceolatus*), a species with an offshore distribution. Prime and Hammond (1990) also calculated that prey represented at the haul out site could have come from a distance of up to about 135km away. The inference is that grey seals that haul out at the Humber may spend more time foraging in the southern SEA 2 area and the SEA 3 area than the model currently predicts.

Figure 6.13 – Harbour seal distribution around the North Sea



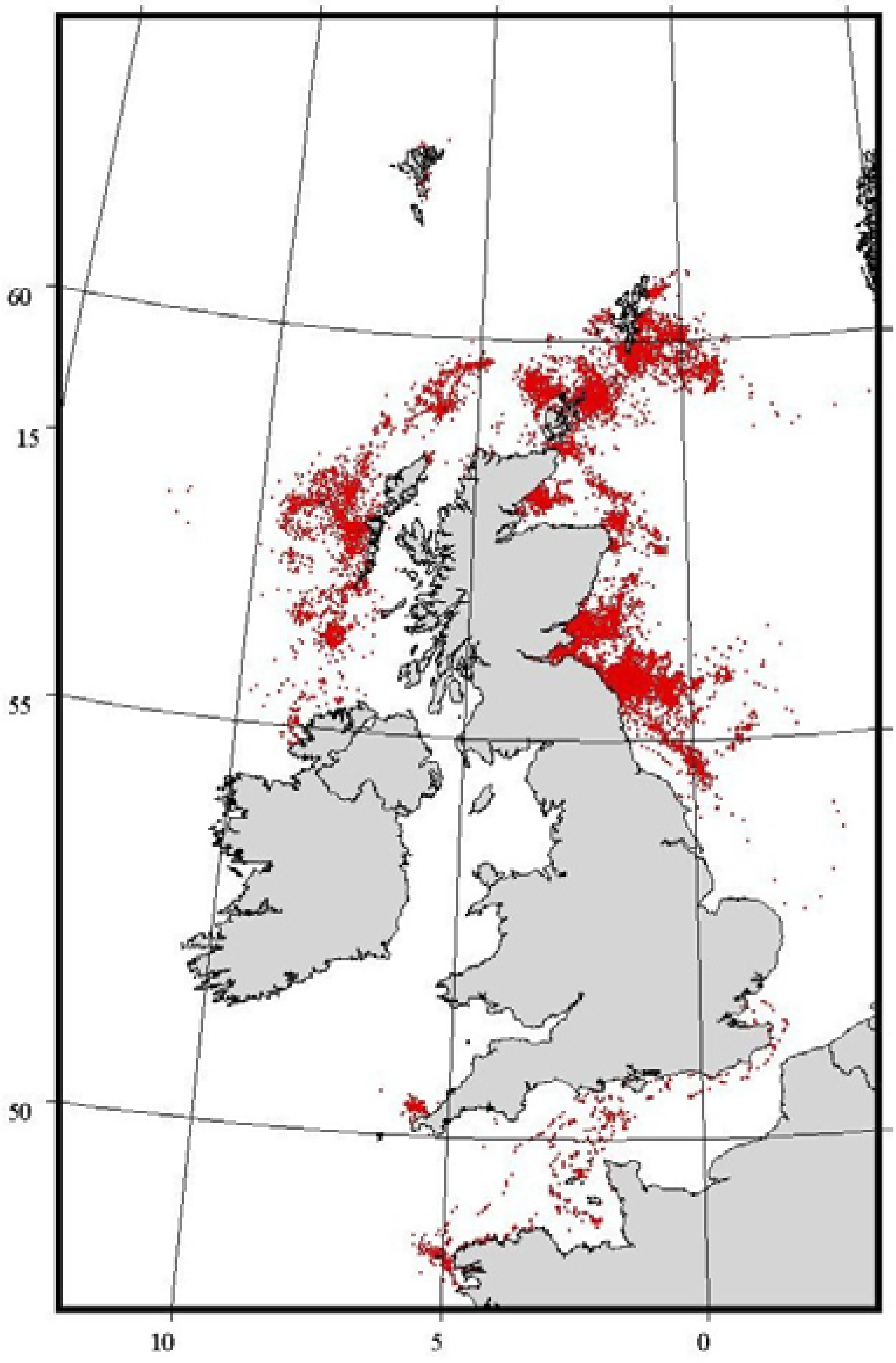
Sources: Reijnders et al. 1997, Pollock et al. 2000, SMRU unpublished data and Bjørge 1991

Figure 6.14 – Distribution of grey seals foraging around the British Isles (predicted by a spatial model using the satellite-linked telemetry data from figure 15 and other SMRU unpublished data)



Source: Matthiopoulos et al. (in preparation)

Figure 6.15 – Locations of 108 grey seals fitted with satellite-relay data loggers over a period of about 10 years



Source: McConnell et al. 1999

6.8.4 Ecological importance

Grey seals are important marine predators in the North Sea. Their diet comprises primarily sandeels, whitefish and flatfish, in that order of importance, but varies seasonally and from region to region. A current estimate of annual prey consumption in the North Sea is approximately 130,000 tonnes, of which almost 50% is sandeels. Grey seal foraging movements are on two geographical scales: long and distant trips from one haul-out site to another; and local repeated trips to discrete offshore areas. The large distances travelled indicate that grey seals in the North Sea are not ecologically isolated and can thus be considered as coming from a single ecological population. Foraging destinations at sea are typically localized areas characterized by a gravel/sand seabed sediment; the preferred burrowing habitat of sandeels, an important component of grey seal diet. The limited distance from a haul-out site of a typical foraging trips indicates that the ecological impact of seal predation may be greater coastally, rather than further offshore. Recent and ongoing mathematical modelling has generated predicted distributions of where grey seals spend their time foraging around the British Isles. Although the model predicts that grey seals do spend some time foraging in the SEA 2 blocks, it is a small percentage of total time at sea. Additional information indicates that the southern SEA 2 block may be more important for grey seals that the modelling currently predicts.

The harbour seal is the smaller of the two species of pinniped that breed in Britain but is also an important predator in the North Sea. The diet is composed of a wide variety of prey including sandeels, whitefish, herring and sprat, flatfish, octopus and squid. Diet varies seasonally and from region to region. A very approximate estimate of annual consumption of prey by harbour seals in the North Sea is 65,000-90,000 tonnes. Direct information on foraging movements and the distribution at sea of harbour seals in the North Sea is limited to studies in the Moray Firth, where harbour seals forage within 60km of their haul-out sites. It is highly unlikely, therefore, that harbour seals forage in the central and northern SEA 2 blocks. However, if foraging ranges in the south-western North Sea are similar, harbour seals are likely to forage in the south-western part of the southern SEA 2 block.

There is relatively little information on the ecology of cetaceans in the North Sea. Harbour porpoises in the North Sea seem to feed mainly on fish found on or near to the seabed. The main fish species consumed by porpoises (identified in samples recovered mainly from fishing nets) from the Scottish east coast during the 1960s were herring, sprats, whiting, sandeels, cod, Norway pout and other gadoids, while decapod shrimps were also present (Rae 1965, 1973). Between 1989 and 1994, animals sampled from throughout the UK North Sea were found to have been eating mainly small gadoid fish such as whiting, poor cod, Norway pout and pollack, as well as herring, sprats, sandeels and gobies. Greater Argentines were also recovered from at least 6 animals around Shetland (Martin 1995). Samples collected from Scottish waters between 1992 and 1994 yielded mainly small gadoids and sandeels (Santos *et al.* 1994). Samples from 50 animals stranded or bycaught in the North Sea between 1995 and 2002 showed the diet to comprise 90% whiting, and small amounts of herring, sandeel, sprat and cod (SMRU/IoZ unpublished data).

For most of the past 40 years, the contents of North Sea porpoise stomachs have been dominated by much the same range of species, namely small gadoids, clupeids and sandeels. However, there is some evidence that the diet has changed during this period from one composed mainly of herring to the current diet dominated by whiting. Harbour porpoises are the most numerous marine mammals in the areas under consideration, with a total North Sea population of around a quarter of a million animals. Total fish consumption per annum is likely to run into hundreds of thousands of tonnes for the North Sea as a whole. The significance of this species' predation from an ecological perspective has not been assessed, nor is the importance of the areas under consideration with respect to the entire North Sea.

Relatively little information is available for other cetacean species. Minke whales feed on a variety of fish, including herring, cod, haddock, sandeels. White-beaked dolphins take whiting and other cod-like fish, sandeels, herring and octopus. Killer whales are known to feed on herring, mackerel and seals around haul-out sites.

The abundance and availability of fish, especially those species mentioned above, is clearly of prime importance in determining the reproductive success or failure of marine mammals in this area, as elsewhere. Changes in the availability of principal forage fish may therefore be expected to result in population level changes of marine mammals. It is currently not possible to predict how any particular change in fish abundance would be likely to affect any of these marine mammal populations.

6.8.5 Bycatch and other non-oil related management issues

The accidental capture of marine mammals in fishing gear is an issue of some current concern throughout EU waters, and beyond. Work by the SMRU since 1993 has been targeted at determining accidental catch ('bycatch') rates of marine mammals in several fisheries in UK waters.

North Sea waters are exploited by fishing vessels from several EU and other states, and there is a lack of detailed information on the activities of these vessels that hinders any assessment of the overall scale of bycatches in this area.

The primary gear types that have been associated with marine mammal bycatch elsewhere are gill and tangle nets and certain specific types of trawling. Trawling for pelagic species, in particular, has been linked to marine mammal bycatch in some parts of the world. An ongoing study of cetacean bycatch in pelagic trawling in the North Sea has not so far revealed any potentially significant conservation issues (SMRU unpublished).

The only other current significant threat to marine mammals from fishing gear appears to stem from the use of static nets, notably bottom set gill and tangle nets. These nets ensnare bottom feeding seals and cetaceans almost wherever they are used, and are probably the primary cause of more marine mammal mortalities in the North Sea and elsewhere than any other human induced source.

(Hall *et al.* 2001) used the SMRU seal tagging database to estimate the minimum level of seal mortality from tags returned from seals found in fishing gear. They estimated that a minimum of around 2% of all seals tagged were subsequently killed in fishing gear, and it is thought that most such mortality is in gill and tangle nets.

Harbour porpoises are also taken in bottom set gill and tangle nets. This species is predominantly bottom feeding, and appears to be particularly vulnerable to accidental entanglement in such nets. Typical bycatch rates are between 6 and 36 porpoises per 10,000 net km.hours. Typical fleets of nets may be 1km long and are soaked for 24 hours, so that an average kill rate per haul is about one porpoise in every 70-420 net hauls, depending on the type of fishery. Highest bycatch rates (animals per net km.hour) are observed in the short nets that are set around wrecks in the central North Sea (Northridge & Hammond 1999; Vinther 1999).

The major fishing fleets involved in bottom set gillnetting and tangle netting in the North Sea are from Denmark, the UK and Norway. The current estimate of the average number of porpoises killed annually in the Danish gill and tangle net fisheries of the North Sea is in excess of 5,000 animals (Vinther & Larsen 2002). The much smaller UK fleet is estimated to take around 530 porpoises per year currently (CEC 2002). The total estimated kill of around 5,500 porpoises per year in the North Sea is thought to exceed sustainable levels. In addition, there is Norwegian gillnetting in the northern

North Sea, and small amounts of German and Dutch netting that have not been adequately documented.

Danish gill and tangle net effort is heaviest in the Danish sector of the North Sea, but historically some fishing effort has extended into the UK sector and would have occurred, and may still do to a small extent, in the southern and central SEA 2 areas as well as the northern part of the SEA 3 area. Norwegian gillnetting probably occurs in the northern SEA 2 area, although this has not been quantified.

UK gillnet and tangle net fisheries operate predominantly in coastal waters, in the central southern North Sea and to the west of Shetland. There is very little UK gill/tangle net effort in the northern and central SEA 2 areas. Most UK gillnet fishing activity in the North Sea in concentrated in the SEA 3 area and in the southern SEA 2 area. Most observed bycatch in these areas has been in the coastal strip of the SEA 3 area, along the Yorkshire coast, and further offshore in the northeastern section of the SEA 3 area. Relatively lower bycatch rates have been observed in the southern SEA 2 area, possibly because of lower porpoise densities in this area.

Although the bycatch of the UK gillnet and tangle net fleets in the North Sea has been estimated at around 530 animals per year, it is not possible to say what the total bycatch in either SEA 2 or SEA 3 areas are, in part because the bycatches have not been analysed on this geographical stratification, and in part because it is not clear how much non-UK gill and tangle net fishing effort is likely to occur in these areas.

Bycatches of other small cetacean species in the North Sea have been recorded very rarely, and present information suggests that bycatch rates are unsustainable only for harbour porpoises in the North Sea.

6.8.6 Conservation frameworks

Marine mammals are included in a wide range of conservation legislation. All species are listed on Annex IV (Animal and Plant Species of Community Interest in Need of Strict Protection) of the European Commission's Habitats Directive. Under Annex IV, the keeping, sale or exchange of such species is banned as well as deliberate capture, killing or disturbance. The harbour porpoise, bottlenose dolphin, grey seal and harbour seal are also listed in Annex II of the Habitats Directive. Member countries of the EU are required to consider the establishment of Special Areas of Conservation (SACs) for Annex II species. Candidate SACs have been established for the bottlenose dolphin in the Moray Firth and in Cardigan Bay. No candidate SACs have yet been established for the harbour porpoise. A number of terrestrial candidate SACs have been established for grey and harbour seals around the coast of the UK; there are currently no marine candidate SACs for seals.

Under the Agreement on the Conservation of Small Cetaceans of the Baltic and North Seas (ASCOBANS) provision is made for protection of specific areas, monitoring, research, information exchange, pollution control and heightening public awareness. Measures cover the monitoring of fisheries interactions and disturbance, resolutions for the reduction of bycatches in fishing operations, and recommendations for the establishment of specific protected areas for cetaceans.

In UK waters, all species of cetacean are protected under the Wildlife and Countryside Act 1981 and the Wildlife (Northern Ireland) Order 1985. Whaling is illegal under the Fisheries Act 1981. Guidelines to minimise the effects of acoustic disturbance from seismic surveys, agreed with the oil and gas industry, were published by the then Department of the Environment in 1995 and revised in 1998. In 1999, the then Department of the Environment, Transport and the Regions produced two sets of guidelines aimed at minimising disturbance to cetaceans. Grey and harbour seals in the vicinity of fishing nets can be killed to prevent damage to the nets or to fish in the nets under the

Conservation of Seals Act 1970. Both species are protected during the breeding season; however, licences to kill seals may be granted for any time of the year for specific listed purposes.

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7 COASTAL AND OFFSHORE CONSERVATION SITES

7.1 Overview

The SEA 3 area displays a wide variety of habitat types, from those of a coastal nature, such as estuarine mudflats and sandflats, saltmarsh, sea cliffs and reef habitats, to those associated with the offshore environment. Some of these habitats are rare in a national and/or international context, and many support important numbers of birds, and other animals and plants. The English east coast, which borders the SEA 3 area, supports a large number of conservation sites protected by a range of international, national and local designations.

As well as containing important sites for nature conservation, the SEA 3 area also boasts sites of archaeological importance. Discoveries have been made in both the coastal and offshore environments and there are areas of SEA 3 deemed to be of considerable archaeological potential.

7.2 Existing coastal conservation sites

This section identifies those coastal sites protected by international, national and local conservation designations. The coastal zone of SEA 3 has been split into two sections - Scottish Borders to Humber Estuary and Lincolnshire to Kent - to aid accessibility of information.

7.2.1 Scottish Borders to Humber Estuary

7.2.1.1 Overview

This coastal region takes in the impressive cliffs of the Berwickshire coast and runs down to, and includes the intertidal expanse of the Humber Estuary.

The Scottish Borders coastline is almost entirely cliffed as far as the English border, reaching heights of nearly 200m between Fast Castle Head and St. Abb's Head. These headlands support important seabird breeding colonies and the coastal waters support a rich variety of benthic flora and fauna.

Stretches of the Northumberland coast support a very extensive range of intertidal mudflats and sandflats, ranging from wave-exposed beaches to sheltered muddy flats with rich infaunal communities. Lindisfarne, situated off the Northumberland coast, comprises a variety of coastal habitats, including rocky shore, sand dunes, saltmarsh and intertidal sand and mudflats with extensive beds of eelgrass *Zostera* spp., an important source of food for wintering birds. The Farne Islands provide an important breeding site for grey seals *Halichoerus grypus*, with some 1,000 seal pups produced on the islands each year.

Further south, the sheer chalk cliffs of Flamborough Head, an important seabird breeding colony, form one of the outstanding landforms of the Yorkshire coast. At the southern end of this stretch of coast, Spurn Head forms a shingle spit 5km long at the mouth of the Humber Estuary. The estuary is one of the largest in Britain and presents an expanse of intertidal habitat which provides internationally important wintering and breeding grounds for wader and wildfowl populations (Heath & Evans 2000).

7.2.1.2 Nature and landscape conservation

The area plays host to a variety of important marine habitats and species as well as bird areas which are protected under international, national and local designations (Table 7.1; see also SEA 3 Conservation Report).

Table 7.1 - Numbers of coastal protected sites in the Scottish Borders to Humber Estuary region	
International	
Candidate Special Areas of Conservation (cSAC)	7
Special Protection Areas (SPA)	8
Ramsar	4
Important Bird Areas (IBA)	8
National and local	
Voluntary Marine Reserve (VMR)	1
Preferred Conservation Zone (PCZ)	1
Regional Landscape Designation	1
Marine Consultation Area	1
National Park	1
Areas of Outstanding Natural Beauty (AONB)	1
Heritage Coasts	6
National Nature Reserves (NNR)	6
Sites Of Special Scientific Interest (SSSI)	25
Local Nature Reserve (LNR)	7
Others	
National Trust for Scotland Properties and Sites	1
National Trust Properties and Sites	31
RSPB Reserves	2
Wildlife Trust Reserves	12

The principal European designations are SPAs established under the 1979 EC Directive on the Conservation of Wild Birds, and SACs under the 1992 EC Habitats and Species Directive. Ramsar sites are designated mainly for their important waterfowl populations but also rare or endangered plant and animal species. Current coastal SPAs and Ramsar sites between the Scottish Borders and Humber Estuary are listed in Table 7.2.

Table 7.2 - Sites of international importance for birds in the Scottish Borders to Humber Estuary region

Site	Status	Conservation interest
St. Abb's Head to Fast Castle	SPA	Breeding seabirds
Northumbria Coast	SPA and Ramsar	Breeding terns and wintering waders
Lindisfarne	SPA and Ramsar	Breeding terns and wintering wildfowl
Farne Islands	SPA	Breeding seabirds and waterbirds
Coquet Island	SPA	Breeding seabirds
Teesmouth and Cleveland Coast	SPA and Ramsar	Breeding terns and wintering wildfowl
Flamborough Head and Bempton Cliffs	SPA	Breeding seabirds and waterbirds
Humber Flats, Marshes and Coast (Phase 1 and 2)	SPA and Ramsar	Breeding raptors and waders, and wintering wildfowl and waders

SACs are a more recent initiative, hence their status as candidate sites at the present time. Nevertheless, UK Government policy is that they should be treated as designated sites once the details are registered with the European Commission. The reasons for designation are being reviewed as part of a moderation process undertaken by the European Commission and the list may therefore be amended. Sites such as the Humber estuary have been proposed as part of this process and there remains the possibility that further sites will be added to the list. The marine and coastal cSACs along this section of coast are listed in Table 7.3.

Table 7.3 - cSACs in the Scottish Borders to Humber Estuary region		
Site	**Area (ha)**	**Conservation interest**
St. Abb’s Head to Fast Castle	128	Vegetated sea cliffs
Berwickshire and North Northumberland Coast	65,335	Grey seal, mudflats and sandflats, reefs, sea caves
Tweed Estuary	156	Estuaries, river lamprey, mudflats and sandflats
North Northumberland Dunes	1,148	Shifting dunes, mature dunes, fixed dunes
Durham Coast	394	Vegetated sea cliffs
Beast Cliff - Whitby (Robin Hood`s Bay)	260	Vegetated sea cliffs
Flamborough Head	6,312	Vegetated sea cliffs, reefs, caves

National conservation designations provide the underpinning protection for most of the European sites, as well as safeguarding sites of national importance. These sites are National Nature Reserves (which extend to Mean Low Water Springs) or Sites of Special Scientific Interest (SSSIs) that have been designated for geological, botanical, entomological, ornithological and/or marine biological interest. In addition to managing some of these nationally important sites, NGOs including the National Trust, RSPB and various Wildlife Trusts, also protect a range of coastal sites.

The nature conservation importance of coastal waters around Scotland have been recognised by the identification of Marine Consultation Areas. These are sites “considered to be of particular distinction in respect of the quality and sensitivity of their marine environment”. Whilst not a statutory designation, Scottish Natural Heritage wish to be consulted over proposals for developments at these sites one of which is located on the Berwickshire coast. The St. Abb's Head and Eyemouth Voluntary Marine Reserve set up in 1984 highlights the importance of the region's marine biodiversity.

Landscape conservation is recognised at a European level by the identification of Environmentally Sensitive Areas (ESAs) which have the restoration of traditional landscapes as one of its objectives. National recognition in Scotland is given through the definition of Regional Landscape Designations (RLD). The Berwickshire coast has been designated as an RLD. The coastal landscape of the region is also protected through Heritage Coast, National Park and AONB designations.

7.2.2 Lincolnshire to Kent

7.2.2.1 Overview

This coastal region includes the extensive Lincolnshire sand dunes and runs down to the white chalk cliffs of Kent and shingle expanse of Dungeness.

The Lincolnshire coast is a dynamic environment dominated by sand dune systems and saltmarsh communities. Further south, the estuarine expanse of the Wash presents an array of important marine and coastal habitats, including extensive intertidal flats and sand banks which provide important habitat and refuge for a huge number of waterbirds and other animals. The intertidal flats here and on the North Norfolk Coast provide ideal conditions for common seal *Phoca vitulina* breeding and hauling-out and hold the largest colony of common seals in the UK, with some 7% of the total UK population.

The low-lying barrier coast of North Norfolk supports intertidal sand and mudflats, together with areas of freshwater grazing marsh, saltmarsh and reedbed. On the east coast of Norfolk, the mosaic of wetland habitats of the Broads forms one of the finest marshland complexes in the UK. Much of the

Suffolk coast contains large areas of marsh and extensive reedbeds. Lagoons are a prominent feature and support a range of floral and faunal communities from brackish through to freshwater. The dynamic shingle structures of Orfordness and Benacre Ness provide examples of the constantly changing nature of much of the Suffolk coast.

The ecological significance of much of the Essex coast lies in the large number of estuaries present in the area. These display a wide variety of estuarine habitats which include tidal creeks and islands, intertidal mud and sandflats, grazing marsh and saltmarsh. The invertebrate fauna and the sheltered nature of many of the estuaries attract internationally important numbers of waterbirds during the migration and winter periods. In Kent, the Thanet Coast is the longest continuous stretch of coastal chalk in the UK and further along the coast, Dungeness contains the largest shingle expanse in Europe (Barnes *et al*. 1995).

7.2.2.2 Nature and landscape conservation

The nature conservation importance of this section of coast is acknowledged through the designation of international, European and nationally recognised conservation areas (Table 7.4; see SEA 3 Conservation Report). The coastline has numerous Special Protection Areas (SPAs) and candidate Special Areas of Conservation (cSACs) (Tables 7.5 and 7.6).

Table 7.4 – Numbers of coastal protected sites in the Lincolnshire to Kent region

International	
Candidate Special Areas of Conservation (cSAC)	14
Special Protection Areas (SPA)	23
Ramsar	20
Important Bird Areas (IBA)	18
Biosphere Reserve	1
Environmentally Sensitive Areas (ESA)	4
National and local	
National Parks	1
Areas of Outstanding Natural Beauty (AONB)	3
Heritage Coasts	4
National Nature Reserves (NNR)	21
Sites Of Special Scientific Interest (SSSI)	60
Local Nature Reserves (LNR)	20
Others	
RSPB Reserves	13
National Trust Sites and Properties	32
Wildlife Trust Reserves	53

Current coastal SPAs and Ramsar sites between Lincolnshire and Kent are listed in Table 7.5.

Table 7.5 - Sites of international importance for birds in the Lincolnshire to Kent region

Site	Status	Conservation interest
Gibraltar Point	SPA and Ramsar	Breeding terns and wintering waterfowl
The Wash	SPA and Ramsar	Passage and wintering waders and wildfowl
North Norfolk Coast	SPA and Ramsar	Breeding species, wintering wildfowl and migrating waders
Great Yarmouth North Denes	SPA	Breeding Little Tern

Table 7.5 - Sites of international importance for birds in the Lincolnshire to Kent region		
Broadland	SPA and Ramsar	Breeding raptors and wintering waterfowl
Breydon Water	SPA and Ramsar	Wintering and passage wildfowl and waders
Benacre to Easton Bavents	SPA	Diverse assemblage of breeding and wintering species
Minsmere - Walberswick	SPA and Ramsar	Breeding, wintering and passage species
Alde-Ore Estuary	SPA and Ramsar	Breeding and wintering waterbirds
Deben Estuary	SPA and Ramsar	Breeding raptors and wintering waterfowl
Stour and Orwell Estuaries	SPA and Ramsar	Wintering waders and wildfowl
Hamford Water	SPA and Ramsar	Wintering waders and wildfowl, and breeding tern
Colne Estuary (Mid-Essex Coast Phase 2)	SPA and Ramsar	Wintering waders and wildfowl, and breeding tern
Blackwater Estuary (Mid-Essex Coast Phase 4)	SPA and Ramsar	Wintering and passage waders and wildfowl, and breeding tern
Dengie (Mid-Essex Coast Phase 1)	SPA and Ramsar	Wintering and passage waders and wildfowl
Crouch and Roach Estuaries (Mid-Essex Coast Phase 3)	SPA and Ramsar	Wintering waterbirds
Foulness (Mid-Essex Coast Phase 5)	SPA and Ramsar	Wintering and passage waders and wildfowl, and breeding tern
Benfleet and Southend Marshes	SPA and Ramsar	Wintering geese and waders
Thames Estuary and Marshes	SPA and Ramsar	Wintering and passage waders and wildfowl
Medway Estuary and Marshes	SPA and Ramsar	Wintering and passage waders and wildfowl, and breeding tern
The Swale	SPA and Ramsar	Wintering and passage waders and wildfowl, and breeding Mediterranean gull
Thanet Coast and Sandwich Bay	SPA and Ramsar	Wintering and passage waders
Dungeness to Pett Level	SPA	Breeding tern, Mediterranean gull and Aquatic warbler, wintering geese and passage wildfowl

The marine and coastal cSACs along this section of coast are listed in Table 7.6.

Table 7.6 - cSACs in the Lincolnshire to Kent region		
Site	**Area (ha)**	**Conservation interest**
Saltfleetby-Theddlethorpe Dunes and Gibraltar Point	960	Shifting dunes, fixed dunes
The Wash and North Norfolk Coast	107,802	Mudflats and sandbanks, shallow inlets and bays, Atlantic salt meadow, Common seal
North Norfolk Coast	3,454	Fixed dunes, shifting dunes, lagoons
Overstrand Cliffs	30	Vegetated sea cliffs
Winterton-Horsey Dunes	426	Shifting dunes, fixed dunes
The Broads	5,866	Various fen types, residual alluvial forest

Table 7.6 - cSACs in the Lincolnshire to Kent region		
Site	**Area (ha)**	**Conservation interest**
Benacre to Easton Bavents Lagoons	367	Lagoons
Minsmere to Walberswick Heaths and Marshes	1,266	Drift line vegetation
Alde, Ore and Butley Estuaries	1,562	Estuaries, mudflats and sandflats, Atlantic salt meadow
Orfordness-Shingle Street	1,358	Lagoons, drift line vegetation
Essex Estuaries	47,218	Estuaries, mudflats and sandflats, Atlantic salt meadow
Thanet Coast	2,808	Reefs, sea caves
Sandwich Bay	1,138	Fixed dunes, shifting dunes
Dungeness	3,224	Drift line vegetation

Biosphere Reserves are terrestrial and coastal ecosystems which are internationally recognised within the framework of UNESCO’s Man and the Biosphere (MAB, 1971) Programme. The designation of the Norfolk Coast as a Biosphere Reserve emphasises the importance of this area for conservation, education and research.

National conservation designations provide the underpinning protection for most of the European sites, as well as safeguarding sites of national importance. These sites are National Nature Reserves (which extend to Mean Low Water Springs) and Sites of Special Scientific Interest (SSSIs) that have been designated for geological, botanical, entomological, ornithological and/or marine biological interest. A number of these sites are managed by a variety of NGOs including the National Trust, RSPB and local Wildlife Trusts.

Landscape conservation is recognised at a European level by the identification of Environmentally Sensitive Areas (ESAs) which have the restoration of traditional landscapes as one of its objectives. The coastal landscape of this region contains four ESAs - The Broads, Suffolk River Valleys, Essex Coast and North Kent Marshes. Numerous regions of the coastal landscape are also protected through Heritage Coast, National Park and AONB designations.

7.3 Potential for additional coastal and offshore sites

This section describes coastal and offshore areas of SEA 3 which contain habitats and/or species some of which may be afforded protection in the future through the implementation of the Habitats Directive and Birds Directive in UK offshore waters.

At present, the UK has not fulfilled its quota of EC sites and there is a perceived gap in the coverage of potential sites between 3-12nm from the coast. English Nature is keen to initiate a programme to identify sites within this region which could form part of the Natura 2000 network. Developments within UK territorial waters ought to take account of the likely prospect of EC sites being designated between 3-12nm in the future (pers. comm. P Gilliland, English Nature).

7.3.1 Overview

The Offshore Petroleum Activities (Conservation of Habitats) Regulations 2001 came into force on 31 May 2001, and regulate UKCS offshore oil and gas activities with respect to the European Council Directive on the conservation of natural habitats and of wild fauna and flora (the Habitats Directive), and the European Council Directive on the conservation of wild birds (the Birds Directive).

At present there are no designated conservation sites within the UK offshore area. However, the UK and other European Member States are in the process of reviewing selection criteria and identifying potential sites which may warrant protection under the Habitats and Birds Directive, and also under. OSPAR's Marine Protected Areas programme.

7.3.2 Offshore Natura 2000 project

The UK Government is currently taking steps to implement the Habitats Directive and the Birds Directive in offshore waters and enabling legislation is due late 2002. Selection of SACs and SPAs in the UK has so far been confined to terrestrial sites and within UK territorial waters. The UK offshore area refers to the area from the 12 nautical mile territorial seas limit out to the UK Continental Shelf designated area limits, up to a limit of 200nm.

The JNCC have recently reviewed site selection criteria and identified relevant habitats and species to be considered for selection of Natura 2000 sites in UK offshore waters - *Natura 2000 in UK Offshore Waters: Advice to support the implementation of the EC Habitats and Birds Directive in UK offshore waters.* JNCC Report 325 (Johnston *et al.* 2002). JNCC and UK Government are now in the process of identifying possible SACs in UK offshore waters and marine SPAs.

7.3.3 OSPAR marine protected areas

At Sintra, Portugal, in 1998 the OSPAR Commission adopted a new Annex V *'On the Protection and Conservation of the Ecosystems and Biological Diversity of the Maritime Area'*. The objective of this Annex is to take the necessary measures to protect and conserve the ecosystems and the biological diversity of the maritime area which are, or could be, affected as a result of human activities, and to restore, where practicable, marine areas which have been adversely affected (OSPAR 2002).

The establishment of MPAs will also contribute to and take account of Contracting Party's obligations under other international Conventions and Directives, including EC Directives (and in particular the Council Directive 92/43/EEC on the conservation of natural habitats and wild flora and fauna and the Council Directive 79/409/EEC on the conservation of birds).

7.3.4 Potential conservation sites

7.3.4.1 Annex I habitats

Three habitat types listed on Annex I of the Habitats Directive are known to, or potentially occur in UK offshore waters:

Sandbanks which are slightly covered by sea water all the time - described 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 *Cymbodoceion nodosae*." (Interpretation Manual of European Union Habitats, Eur 15/2 1999).

Reefs - described as "Submarine or exposed at low tide, rocky substrates and biogenic concretions, which arise from the sea floor 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." (Interpretation Manual of European Union Habitats, Eur 15/2 1999).

Submarine structures made by leaking gases – described as "Spectacular submarine complex structures, consisting of rocks, pavements and pillars up to 4m high. These formations are due to the aggregation of sandstone by a carbonate cement resulting from microbial oxidation of gas emissions, mainly methane. The methane most likely originated from microbial decomposition of fossil plant materials. The formations are interspersed with gas vents that intermittently release gas. These formations shelter a highly diversified ecosystem with brightly coloured species." (Interpretation Manual of European Union Habitats, Eur 15/2 1999). Within the SEA 3 area, the Annex I habitat *"Submarine structures made by leaking gases"* is unlikely to be present.

The location and extent of areas of possible Annex I habitat in UK offshore waters have been mapped by BGS for JNCC. Limitations on using existing geological map interpretations to map the location and extent of Annex I habitats in UK offshore waters were encountered, principally because the Folk classification category of 'gravel' used in the geological maps does not match the Habitats Directive definition of 'reef' (Johnston *et al.* 2002).

Sandbanks which are slightly covered by sea water all the time

The main location of offshore sandbanks in the SEA 3 area occur around the north and north-east coast of Norfolk, in the outer Thames Estuary and off the south-east coast of Kent. These may include areas of the Dogger Bank, the Norfolk Banks and sandbanks found in the outer Thames Estuary and eastern English Channel (see Figure 7.1).

The Annex I sandbank habitat may form the summits of more extensive structures which extend into water deeper than 20m. The actual area considered for protection may therefore need to be increased to incorporate complete sandbank flanks, associated sandy habitats and/or channels between banks, to maintain the structure and functions of a sandbank.

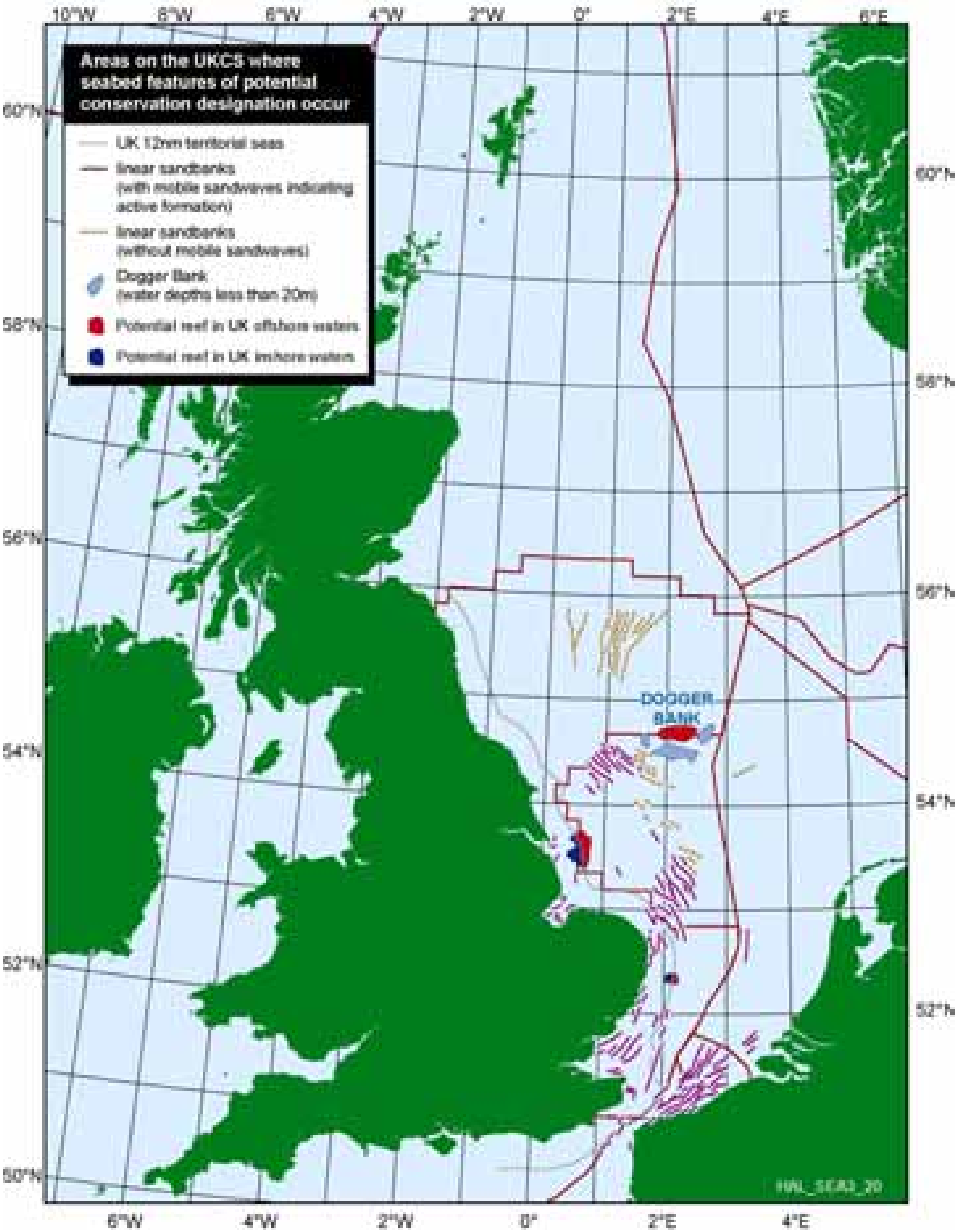
Reefs

Potential bedrock and stony/rocky reef habitats are much more common in western UK offshore waters, and are virtually absent from UK offshore waters in the North Sea. Information regarding the location of biogenic reefs is limited (Figure 7.1).

Recent research in the Wash using remote video identified extensive areas of *S. spinulosa* reef rising up to 60cm above the seabed and almost continually covering a linear extent of 300m. However, whilst *S. spinulosa* is very common around the British Isles and does form reefs, "in most parts of its geographical range *S. spinulosa* does not form reefs, but is solitary or in small groups encrusting pebbles, shell, kelp holdfasts and bedrock" (*Sabellaria spinulosa* reefs Habitat Action Plan, UK Biodiversity website). Where conditions are favourable, much more extensive thin crusts can be formed, sometimes covering extensive areas of the seabed. However, these crusts may be only seasonal features, being broken up during winter storms (Jones 2002, English Nature Natural Area Profile Draft).

Given the insufficient information on location of potential reef habitat, a degree of caution must be exercised in identifying potential locations of reef habitat in SEA 3 as more detailed survey information is required.

Figure 7.1 – Main locations of offshore sandbank and reef habitats



7.3.4.2 Habitats Directive Annex II species

There are four species listed on Annex II of the Habitats Directive that are known to occur in UK offshore waters for which selection of SACs will be considered (Johnston *et al.* 2002):

- Grey seal *Halichoerus grypus*
- Common seal *Phoca vitulina*
- Bottlenose dolphin *Tursiops truncatus*
- Harbour porpoise *Phocoena phocoena*

For the two seal species, coastal SACs within SEA 3 have already been proposed to protect their selected breeding colonies and moulting and haul-out sites - the Berwickshire and North Northumberland cSAC (grey seal breeding site) and The Wash and North Norfolk cSAC (common seal breeding site). Three nearshore SACs have been proposed for bottlenose dolphin, none of which are within the SEA 3 area and there are as yet no proposed nearshore SACs for harbour porpoise in UK waters.

The above Annex II species are typically wide ranging, thus making it difficult to identify specific areas which may be deemed essential to their life and reproduction, and therefore, considered for proposal as SACs.

Relevant information on the distribution of Annex II species in UK offshore waters is limited. Further analysis of data and further survey in some cases, will be required to identify areas in UK offshore waters which may qualify as SACs for these species.

ASCOBANS

Conservation of the bottlenose dolphin, harbour porpoise and other small cetaceans within the North Sea also forms part of the ASCOBANS agreement.

The Agreement on the Conservation of Small Cetaceans of the Baltic and North Seas (ASCOBANS) was concluded in 1991 under the auspices of the Convention on Migratory Species (UNEP/CMS or Bonn Convention) and entered into force in 1994.

ASCOBANS co-ordinates and implements conservation measures for dolphins, porpoises and other toothed whales *(Odontoceti)* in the Baltic and North Seas. Since migrating cetaceans regularly cross national boundaries, ASCOBANS promotes their effective protection by international cooperation. Currently eight European countries - Belgium, Denmark, Finland, Germany, the Netherlands, Poland, Sweden and the United Kingdom - are Parties to the Agreement.

A Conservation and Management Plan forming part of the Agreement obliges Parties to engage in habitat conservation and management, surveys and research, pollution mitigation and public information (ASCOBANS website).

7.3.4.3 Birds Directive Annex I and migratory species

Marine SPAs are being considered for 56 bird species which are either on Annex I of the Birds Directive or are migratory species which regularly occur in UK waters (Johnston *et al.* 2002).

The list of Birds Directive Annex I and regularly occurring migratory species to be considered for marine SPAs consists of a number of different bird species with very different dispersion patterns, some of which breed in the UK and some that are only found in UK Waters at certain times of the year.

Three types of marine Special Protection Areas (SPAs) are being considered in the UK (for both inshore and offshore waters):

- Extensions to SPA breeding colonies
- Inshore areas used by birds in the non-breeding seasons (divers, grebes and seaduck)
- Marine feeding areas (and potential moulting areas)

Work is proceeding on identifying areas that may qualify for these three types of marine SPA. For feeding and moulting areas, the European Seabirds at Sea (ESAS) database is likely to be the primary source of data for identification of such areas for those species for which there is adequate information in the database.

7.3.4.4 OSPAR marine protected areas

OSPAR envisage that MPAs 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).

No sites have formally been proposed for the OSPAR MPA network by Contacting Parties. The WWF have proposed a number of potential sites for consideration by the OSPAR Contracting Parties and one of these, the Dogger Bank is of relevance to the SEA 3 area.

At the 4th OSPAR workshop on Marine Protected Areas in Roscoff, July 2002, it was anticipated that Contracting Parties within OSPAR should propose their first set of MPAs for Territorial Seas, offshore areas where they exhibit sovereignty and/or jurisdiction, and High Seas by 2006. 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.

7.4 Marine and coastal archaeological resources and sites

7.4.1 Overview

The modern-day SEA 3 environment has been extensively shaped by Ice Age glacial movement and natural coastal processes. These processes have profoundly affected the patterns of human settlement and activity in the region. Although far from complete, the archaeological record provides invaluable information on historical settlements and activities within the central and southern North Sea area.

The dependence on maritime trade, and the often treacherous waters that surround the UK have resulted in a huge number of ship wrecks in UK coastal and offshore waters. The locations of most of these wrecks are known although there is no legal protection of the sites. However, there are a number of wreck sites which have been given legal protection as they are deemed particularly important historically.

The most valuable form of protection for archaeological sites in England is scheduling which gives legal protection to nationally important archaeological sites in England. Archaeological sites which are not scheduled monuments are protected by the planning process.

Much of the information regarding coastal and marine archaeological sites comes from the SEA 3 Technical Report - *The scope of Strategic Environmental Assessment of North Sea areas SEA 3 and SEA 2 in regard to prehistoric archaeological remains* (Flemming 2002). Information regarding the location of wreck sites and historic wrecks comes from the UK Hydrographic Office and the Royal Commission on the Historical Monuments of England (RCHME), respectively. English Heritage provided information on relevant scheduled monuments.

7.4.2 Marine and coastal archaeological sites in SEA 3

Prehistoric submarine archaeological remains back to a date of the order of 100,000 years can occur over almost the whole floor of the North Sea. Artefacts dating from the last 10,000-12,000 years have been found in sites scattered throughout the present coastal and offshore North Sea environment. Mammal bones from 500,000 years BP have been found on the floor of the southern North Sea.

Prehistoric sites discovered within the SEA 3 area are important but limited. Important coastal sites have been discovered along the coasts of Cleveland, Yorkshire, Norfolk, Essex and Kent. Important offshore archaeological discoveries have been made on the Dogger Bank, the Leman and Ower Banks and the Brown Ridge in the southern North Sea.

The survival or destruction of an archaeological deposit, whether originally inland or on the coast, depends upon the local topography of the site, low net sediment accumulation so that the artefacts are not buried too deeply and favourable oceanographic conditions so that the site is gently eroded to expose artefacts.

Areas of archaeological potential in the North Sea include "fossil" estuaries and river valleys; flanks of banks and ridges with peat layers; valleys, depressions or basins with wetland or marsh deposits; nearshore creeks, mudflats and peat deposits; "fossil" areas where sites would have been sheltered by low-lying islands as the sea level rose, and in present day coastal wetlands, mudflats and estuaries.

As mentioned, important archaeological discoveries have been made in the coastal and marine environment of SEA 3.

Coastal discoveries

Storms and tidal currents have recently exposed a prehistoric wattle screen or panel on the beach at Seaton Carew, just south of Hartlepool, Cleveland. The wattle was embedded in peat and drowned forest materials which are extensive in the region. ^{14}C dating of the peat gives an age of 4,200-5,000 years BP.

Coastal erosion is both revealing settlements as well as destroying known sites. Twenty five villages on the Yorkshire coast between Flamborough Head and Spurn Head have been eroded into the sea in the last 1,000 years. Numerous prehistoric artefacts were washed out of the cliffs during the late 19th century, including Neolithic axes and remains of mammoth and rhinoceros.

In early 1999 a circle of 56 wooden posts surrounding an up-turned oak tree stump was exposed by beach erosion at Holme-next-the-Sea, Norfolk. Carbon dating and dendrochronology showed the wood to be 4,100 years old. The posts are thought to have been 3m tall originally and were shaped with bronze axes.

The marshlands, creeks and tidal mudflats of the Essex coast have provided numerous Mesolithic and Neolithic sites dating from 7,600-3,500 years BP. Finds include wooden structures and many stone artefacts. The extensive remains of the mediaeval town of Dunwich, which collapsed into coastal waters because of the erosion of the soft cliffs, has been subject to repeated survey.

Two Bronze Age dugout canoes have been salvaged at Dover and indicate an active cross-Channel trade with substantial cargoes of bronze artefacts. The materials are about 3,300 years old.

Offshore discoveries

Human artefacts, worked flints, spear-heads and mammal remains have been dredged from locations reported as the Dogger Bank. The known Pleistocene fauna reported to have been trawled from Dogger Bank consist of mammoth and rhinoceros teeth. Flemming (2002) suggests that a richer environment for the origin and preservation of archaeological materials would be the vast lagoon which existed to the south of Dogger Bank from 8,000-7,000 years BP. The discoverability of such artefacts depends upon modern marine sediment thickness - Holocene sediments 5-20m thick on the SE flank of Dogger Bank have been described, while 1m thick Holocene deposits cover most of the surface of the Bank.

Evidence that the submerged peat landscape, probably of Mesolithic age, was occupied by humans was confirmed by the discovery in 1931 of a barbed pointed weapon trawled up in a lump of "moorlog", the fishermens' name for peat from the seabed. It was dredged from between the Leman and Ower banks from a depth of about 36m. ^{14}C dating of the peat gave a date of 8,500 years BP, while the tool itself has been dated to 11,740 +/- 150 years BP. The implement is made of bone or antler, and carved with numerous notches and some decorations.

Since 1964, Dutch fishermen working in the southern North Sea have dredged up thousands of fossil mammal bones, some of which have been worked or carved to make human artefacts. According to the fishermen the bones are dredged up in the gullies around the Brown Ridge, on the border of UK and Dutch territorial waters.

7.4.2.1 Scheduled monuments in the SEA 3 area

'Scheduling' is the process through which nationally important sites and monuments are given legal protection by being placed on a list, or 'schedule'. Scheduled monuments are protected by the Ancient Monuments and Archaeological Areas Act 1979, and scheduling is the only legal protection specifically for archaeological sites. Only deliberately created structures, features and remains can be scheduled.

The schedule now has about 18,300 entries (about 31,400 sites) of which a number are of relevance to SEA 3 as they are found below the high water mark (Figure 7.2). These include several Saxon coastal fish weirs in Essex as well as coastal artillery defences on the Isle of Grain (pers. comm. Oliver Frankham, English Heritage).

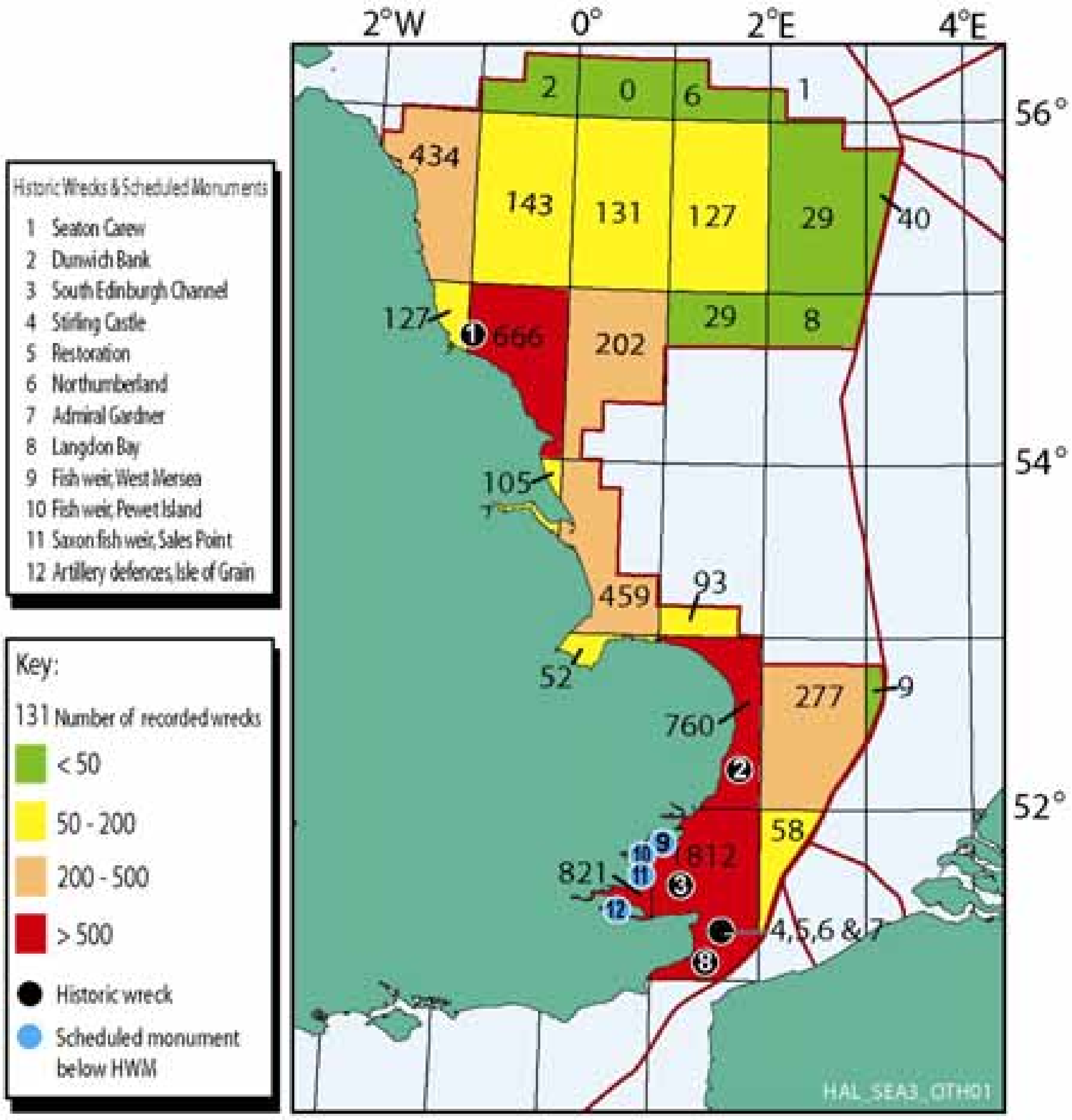
7.4.2.2 Wrecks and historic wrecks in the SEA 3 area

There are a large number of wrecks within the SEA 3 areas although only a proportion of these are charted. Records from the UK Hydrographic Office reveal 6,391 confirmed wrecks within the SEA 3 area, of which 63% were chartered. The majority of the wrecks were found in coastal waters and in particular, the outer Thames Estuary where 1,812 wrecks were identified (Figure 7.2).

Important historic wrecks in UK waters are designated under the Protection of Wrecks Act 1973. Wrecks or wreck sites may be considered to merit designation if they contribute to the understanding of the past on the account of their historical, archaeological, or artistic importance. Restricted areas may include an area of surrounding seabed deemed necessary to secure protection of the wreck.

There are 8 historic wrecks within the SEA 3 area, of which 6 are located in the Thames Estuary and coastal waters off Kent (Figure 7.2; pers. comm. Steve Waring, RCHME).

Figure 7.2 – Wrecks, historic wrecks and scheduled monuments in the SEA 3 area



7.5 Implications for Strategic Environmental Assessment

Information regarding the large number of coastal conservation sites within SEA 3 is available and has been compiled in the SEA 3 Conservation Report. Of considerable importance to SEA 3 are the on-going programmes to identify conservation sites within 3-12nm and also further offshore.

There are a variety of initiatives at different stages of development for offshore industries to report and record archaeological artefacts found as part of their activities. Given the difficulty in terms of cost and logistics of surveying large areas of the North Sea for archaeological remains, these offshore industries currently offer the best means of finding archaeological sites away from the coast.

Potential interactions between both coastal and offshore conservation and archaeology sites, and exploration and production activities are considered in Section 10

8 USERS OF THE SEA 3 MARINE AND COASTAL ENVIRONMENT

8.1 Introduction

The SEA 3 marine environment provides an important resource for a wide variety of different users. The extensive natural gas reservoirs of the southern North Sea have attracted significant infrastructure development and a number of oil and gas pipelines traverse the SEA 3 area. Major UK and international fishing fleets operate in the central and southern North Sea. The presence of offshore sand and gravel deposits in coastal waters provides an important source of marine aggregates and, within the same area there are a number of marine disposal sites for spoil from dredging operations. A network of subsea communication cables linking the UK with Europe also traverses the SEA 3 region.

A variety of other human pressures on the North Sea environment were reviewed by OSPAR (2000), the most significant of which were inputs of trace organic contaminants from land, seabed disturbance by fisheries, inputs of nutrients from land, effects of discards and mortality of non-target species by fisheries, and input of TBT and other antifouling substances by shipping. The effects of the offshore oil and gas industry, including input of oil and physical disturbance, were considered to be relatively lower.

8.2 Oil and Gas

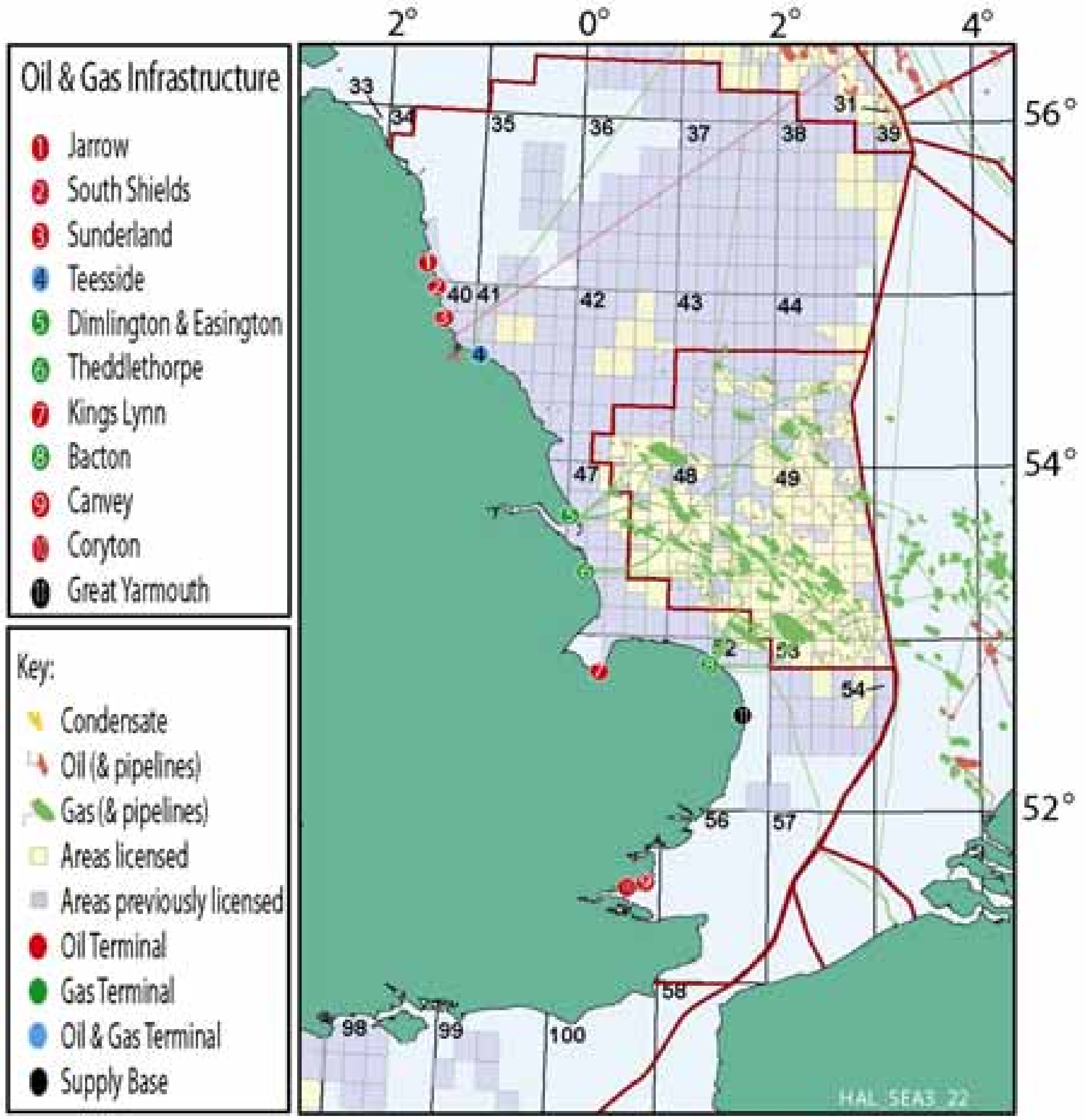
8.2.1 Overview

The oil and gas industry in the North Sea has grown into a major economic industry since the late 1960s. The year 2001 saw record levels of production maintained in the UKCS with 107 million tonnes of oil and natural gas liquids (NGLs) and 112 billion cubic metres of gas (DTI Oil and Gas Directorate website).

Offshore activity in the North Sea has primarily centred on the oil and gas fields of the northern and central North Sea and the gas fields of the southern North Sea (Figure 8.1). Numerous oil and gas pipelines traverse the SEA 3 area. The CATS and SEAL gas pipelines and the Norpipe oil pipeline carry oil and gas into the terminals at Teesside. Dimilington, Easington and Theddlethorpe terminals receive gas from the central and southern North Sea fields. Bacton is the UK's largest gas terminal receiving gas from the fields of the southern North Sea. Great Yarmouth is the main supply base for the Southern North Sea gas fields.

Some areas of the SEA 3 area have never been licensed although the majority have historically been licensed but are now relinquished with the result that to date little exploration has taken place.

Figure 8.1 – SEA 3 Oil and Gas Activity



Source: SEA 3 Users Report

8.3 Fisheries

8.3.1 Introduction

The Centre for Environment Fisheries and Aquaculture Science (CEFAS), working in collaboration with the Fisheries Research Services (FRS), was commissioned to review fisheries information for the previous SEA 2 area (Rogers & Stocks 2001). Given that this review also included areas of relevance to SEA 3, CEFAS/FRS deemed their findings applicable to the current SEA 3 process.

The report describes the fish resources of the region and the intensity and distribution of commercial fishing activity. It describes those fisheries management measures which recommend seasonal closures of parts of the North Sea to protect spawning or juvenile fish. The report also summarises the most important consequences of oil and gas exploration for fish populations and commercial fisheries, such as the use of seismic surveys and the placement of structures on the seabed (Rogers & Stocks 2001).

Specific information regarding coastal fisheries has come from the relevant sea fisheries committees (see SEA 3 Users Report).

8.3.2 Coastal and offshore fisheries

The North Sea is one of the world's most important fishing grounds. Major UK and international fishing fleets operate in the southern, central and northern North Sea and target both pelagic and demersal fish and shellfish stocks. Fishing activity in the North Sea is shown in Figures 8.2 and 8.3.

Figure 8.2 - Fishing activity in the North Sea. Stock management areas are also shown.

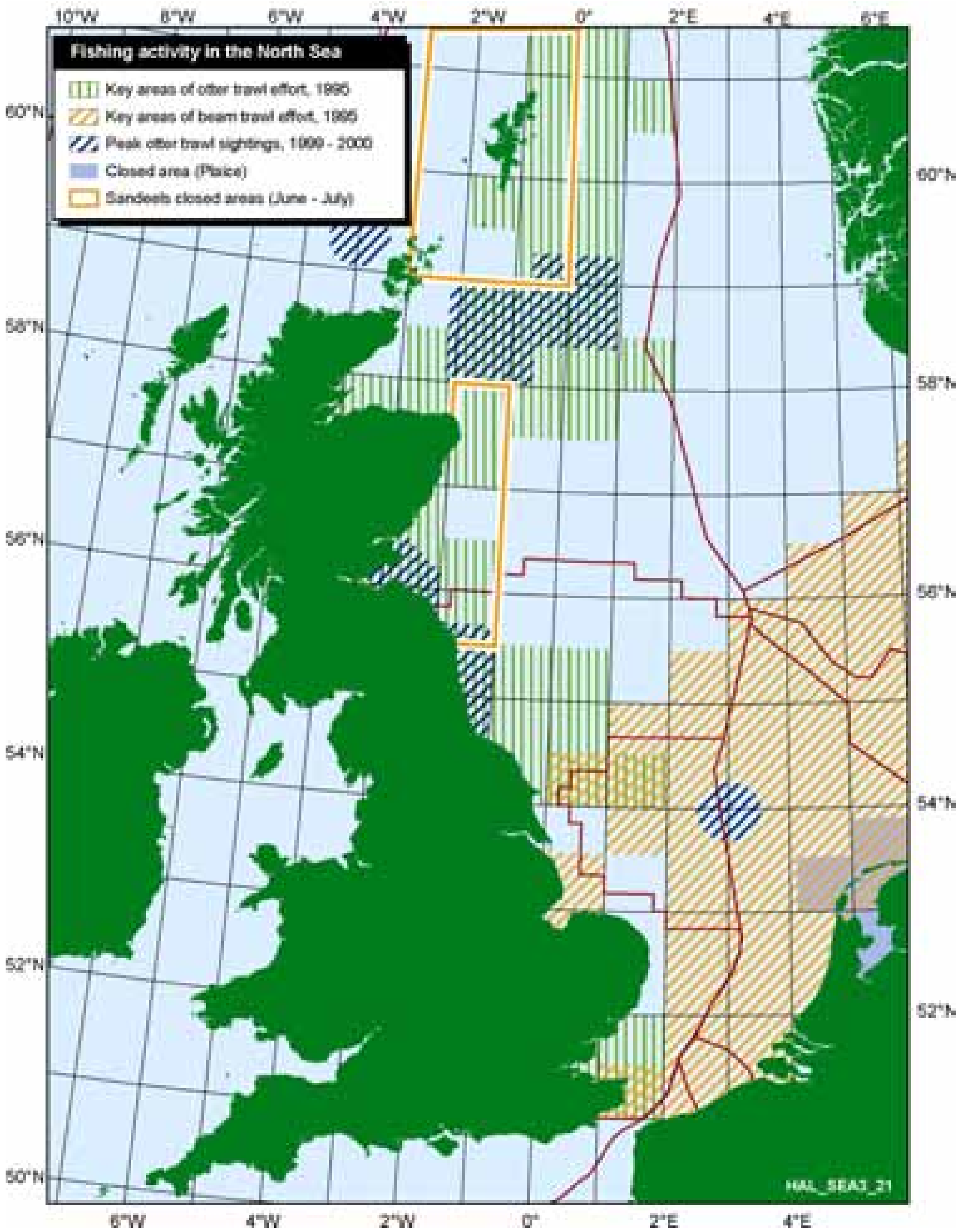
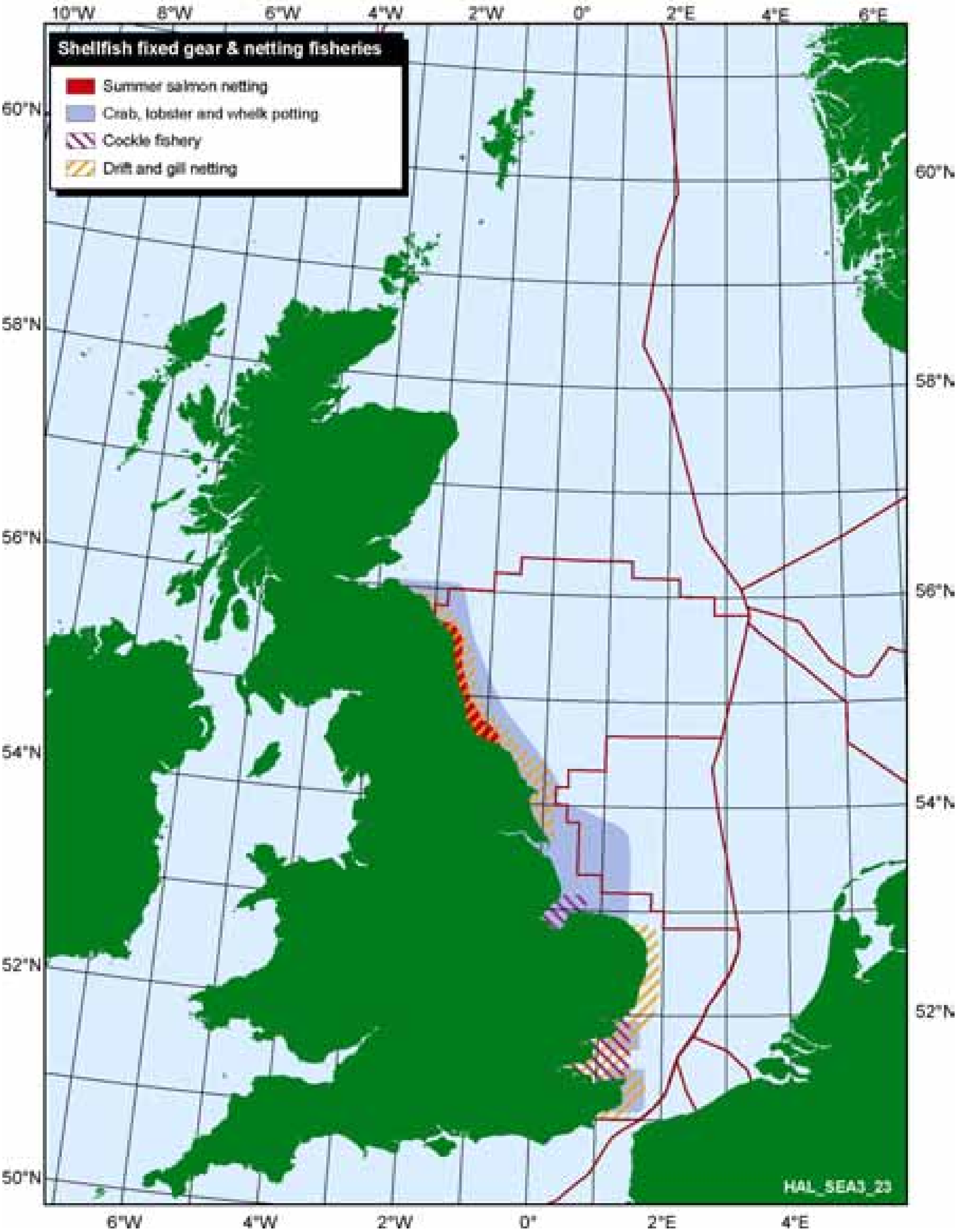


Figure 8.3 – Shellfish, fixed gear and net fisheries



Note: Additional data provided by D Bevan of N.F.F.O. Services Limited

8.3.2.1 Coastal fisheries

Within SEA 3, coastal fisheries (within 6nm of the coast) form an important source of income for many communities. The fixed gear fishery using pots and creels for crabs, lobsters and whelks is extensive, particularly off the Northumberland and Yorkshire coasts. Salmon are caught in the summer between Holy Island and Whitby using fixed nets. Other vessels trawl for finfish and shrimp and there are also vessels utilizing drift nets and lines (Figure 8.3).

There are a number of ports within SEA 3 which support important coastal fisheries. In the northern region of SEA 3 the ports of North Shields, Blyth, Amble, Hartlepool, Whitby, Scarborough, and Grimsby are home to sizable crab and lobster potting vessels as well as trawlers and netting vessels. Further south, fishing ports along the North Norfolk coast exploit the crab and lobster fishery within the Wash and off the North Norfolk coast. Great Yarmouth and Lowestoft are the largest fishing ports in the southern part of SEA 3 and the coastal fishery here targets a variety of species including cod, plaice, bass, shrimp, skate, herring and sole by netting, trawling and long-lining. A variety of coastal fisheries exist within the Essex and Kent region, the most profitable being the cockle fishery in Essex and netting for sole in Kent.

8.3.2.2 Offshore fisheries

Mixed demersal fisheries

One of the most important fisheries in the North Sea is the mixed demersal fishery that targets cod, haddock and whiting in the central and northern parts of the region. Usually, otter trawl and seine net vessels catch cod as part of a mixed fishery in which haddock and whiting form an important component of the catch. Cod also forms an important bycatch in the beam trawl fisheries targeting plaice and sole.

Recent overflight data (1990-2000) for English waters showed that most otter trawl effort was concentrated in the 1st and 4th quarters of the year on the northeast coast of England in the vicinity of the Farn Deep (off Northumberland), and during the spring and summer months further offshore south and west of the Dogger Bank, and near the Silver Pit. There was relatively little otter trawl effort in the southern SEA 3 area.

International landings of cod by ICES rectangle for 1999 showed that, in the 1st and 2nd quarters of the year, the highest catches were taken in offshore areas of the southern part of SEA 3 including around the coast of Kent. In the second half of the year a similar fishing pattern remained, but cod were also landed from offshore waters of the northern part of SEA 3 although in lower numbers.

Landings of haddock are concentrated in the northwestern North Sea, and although haddock are largely absent from the southern North Sea, they do occur there during years of strong recruitment.

Whiting are caught throughout the year over a wide area, but especially in the northern North Sea and off the north east coast of England.

Plaice and sole fisheries

North Sea plaice and sole are taken in a mixed flatfish fishery by beam trawlers in the southern and southeastern North Sea. There are also directed fisheries for plaice carried out with seine and gill nets and by beam trawlers in the central North Sea. Beam trawl activity is low/moderate throughout much of the SEA 3 area although there are areas off the Lincolnshire and Kent coasts which support greater fishing effort.

Herring and mackerel fisheries

Fishing for herring offshore is mainly undertaken with purse seines and trawls and to a very minor extent by fixed nets in coastal waters. While North Sea stocks are fished throughout the year, landings are greatest in the third quarter of the year, predominantly from northwest of the Dogger Bank and in coastal waters of eastern England. Mackerel are primarily targeted by pelagic trawlers in the northern North Sea.

Industrial fisheries

Trawlers using fine-meshed gears take sandeel. Fishing for sandeels takes place mainly during the summer months, especially throughout May, June and July, and is focussed on the Dogger Bank, and within both offshore and coastal areas of the northern part of SEA 3. Danish and Norwegian fleets accounted for 95% of the international landings of sandeel from the central North Sea in 1999.

Crustacean fisheries

Crustacean fisheries are generally of high value and target specific grounds at different times of the year. A range of gears, such as bottom trawls, prawn trawls, seines and pots are used in these fisheries, as well as scallop dredges.

Norway lobster (*Nephrops norvegicus*) are landed from discrete areas to the north and west of the Dogger Bank, along the northeast coast of England, the eastern coast of Scotland, and on the Fladen ground in the northern North Sea. Whilst there are no strict fishing seasons for Norway lobster effort in the Farn Deeps and Firth of Forth fisheries is concentrated in the autumn and winter.

The edible crab fishery is an important source of income to UK shellfishers. The traditional fishery is seasonal with peak catches in May and June, but many fishermen, supplying both the live continental market and the home processing market, now prosecute the fishery throughout the year. Two distinct types of vessels are involved in the crab fishery: smaller inshore vessels working a mix of crab and lobster pots; and larger Vivier crabbers (boats equipped to carry their catches live for extended periods) which work the offshore grounds. Crabs are captured in traps, called pots or creels, which are baited with fresh fish. The traps are shot in fleets of 20 or more depending on vessel size and are usually hauled once every 24 hours. Some of the larger vessels will work up to 1000 traps.

Crab fisheries off the English coast are prosecuted by vessels from Bridlington, Grimsby and ports along the north Norfolk coast. Although crab grounds in this region are mainly inshore, they also extend eastwards into the gas fields beyond the Silver Pit.

8.3.3 Fisheries management

The effects of these fish and shellfish fisheries are widespread and ecologically important, and the removal of target and non-target species impacts the whole North Sea ecosystem. There is concern about the stocks of herring, cod, haddock, whiting, saithe, plaice and sole which are close to or outside Safe Biological Limits. Catch levels for many fish stocks are almost certainly not sustainable (OSPAR 2000, CEFAS website).

To ensure the sustainability and recovery of these fisheries, a range of fisheries management measures have been implemented by the European Commission, including area and seasonal closures that restrict access to specific fleets in order to offer protection to juveniles and spawning adults and encourage stock recovery (Figure 8.2). For example, during spring 2001, a large closed area was implemented in the southern North Sea and throughout much of Danish and Norwegian waters, which restricted access to cod fisheries. The closure covered the main spawning area and season for mature cod (14 February-30 April 2001). However, the closure has been lifted for 2002 (pers. comm. J Dann, CEFAS) and is unlikely to be repeated. Along the Dutch, German and Danish North Sea coasts, a permanently protected area (the plaice box) has been established to reduce the mortality of juvenile plaice in the beam trawl fishery (Figure 8.2).

Sandeel fisheries off the east coast of Scotland are also closed seasonally. Both the cod closure and plaice box have caused the displacement of fishing activity away from traditional grounds and towards the oil and gas fields of the North Sea. For the otter trawl fleet this represents an increase in existing levels of local effort in regions where the two industries already co-exist. There is some evidence of a slight increase in beam trawl activity in the central and Southern North Sea, since the gear was first used in the southern North Sea during the 1960s. This may have implications for the safety of both the fishing vessels and underwater structures associated with the hydrocarbon industry when they come into contact.

8.3.3.1 Implications for Strategic Environmental Assessment

In conclusion, considerable information is available concerning the intensity and economic importance of fisheries within the SEA 3 area of the North Sea. The accuracy of the reported landings of commercial species is a source of considerable debate in the UK and Europe, and is governed by a number of complex and interrelated factors. Firstly, the catches of species that are controlled by quota management may be under-reported or mis-reported by area so that a fishery does not exceed its quota in a particular year. Secondly, those species which are not controlled by quotas may be underreported because there is no legal requirement to record landings, or several species may be grouped together as historically there was little interest in collecting data by species. However, these concerns apply principally to the reliability of stock assessments and are not considered to represent a data gap in terms of assessment of the potential effects of licensing.

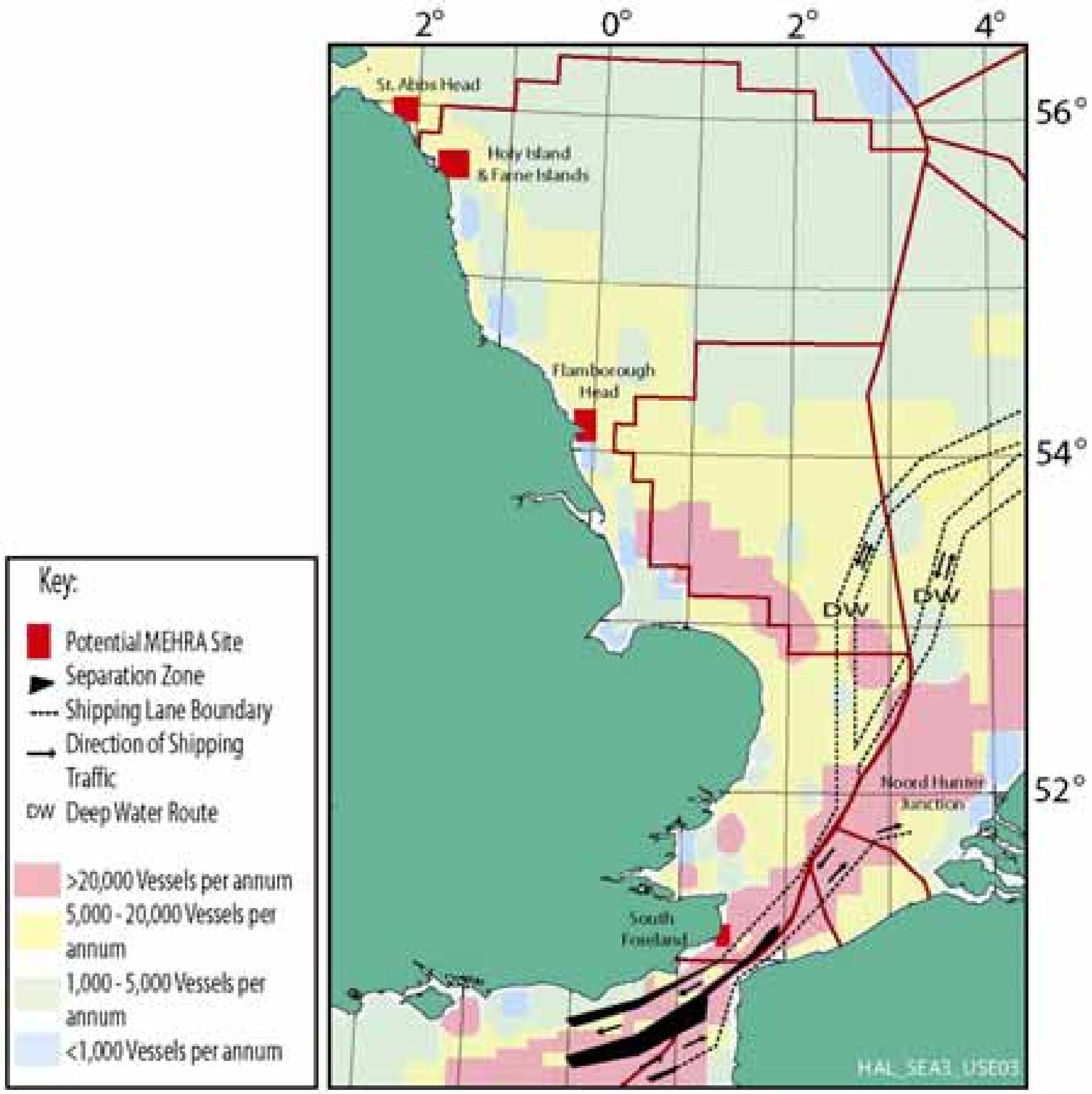
Potential interactions between fisheries and exploration and production activities are considered in Section 10.

8.4 Shipping

Shipping and maritime trade are key to the UK economy and 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 Tees and Hartlepool, Grimsby and Immingham, and London. These ports form the focus for many of the major shipping routes throughout the North Sea.

Coastal and offshore areas of the southern North Sea experience very heavy shipping pressures (>20,000 ships per annum), in particular southern shipping routes from the Humber and the eastern entrance to the English Channel (Figure 8.4). Within the SEA 3 area there are a number of potential Marine Environment High Risk Areas (MEHRAs) designed to protect marine areas of high environmental sensitivity at risk from shipping (DETR 1999).

Figure 8.4 – Shipping in SEA 3



Source: *SEA 3 Users Report*

8.5 Military activity

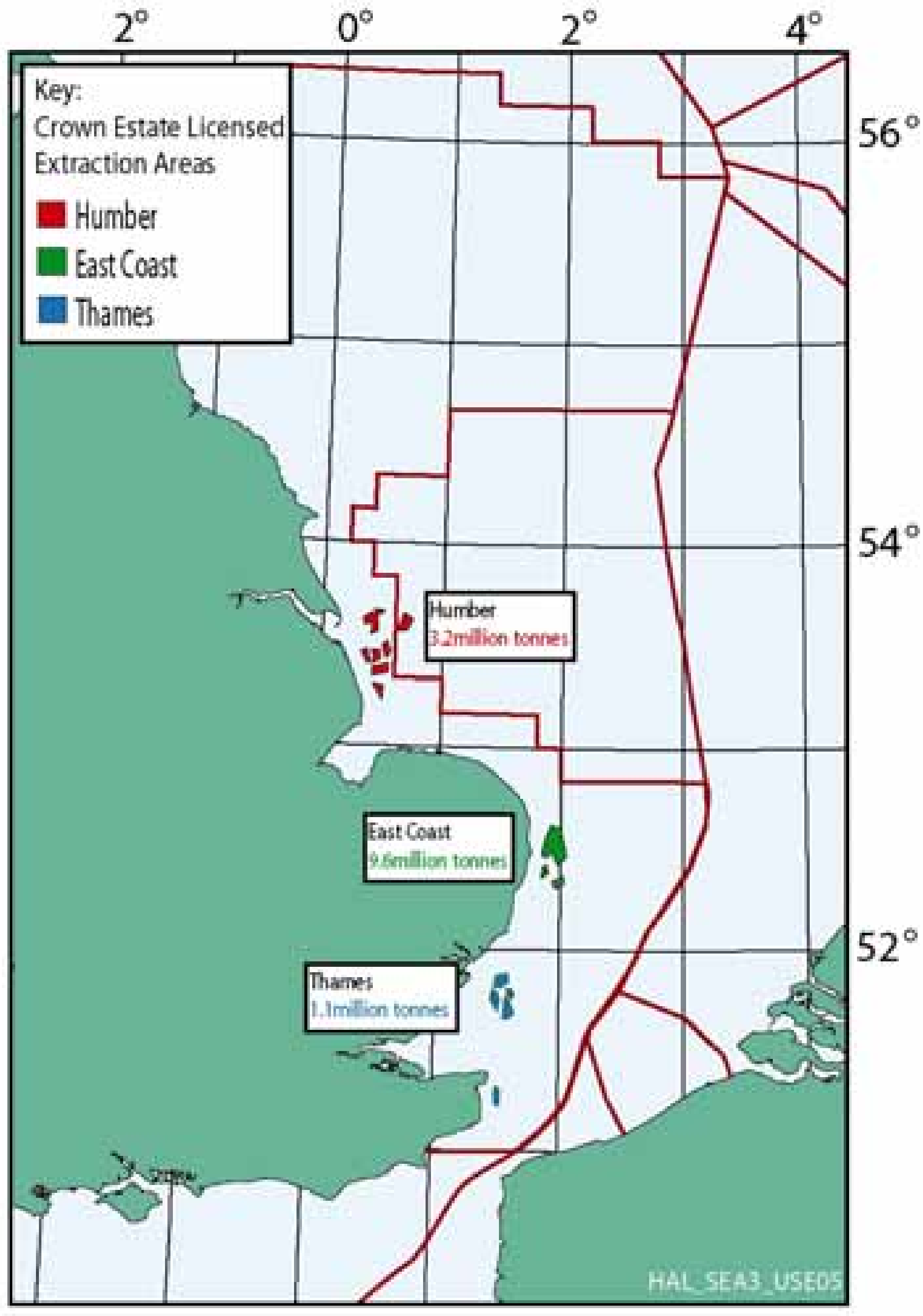
There are a number of military practice and exercise areas within the SEA 3 area. Those of particular relevance include the Flamborough Head submarine practice area and the extensive exercise areas for mine-laying, sweeping and disposal off the Essex and Kent coast (PEXA Charts Q6405and Q6401).

8.6 Aggregate extraction

Marine sand and gravel are important sources of industrial aggregates for concrete production for road and buildings construction, and for beach replenishment. The presence of extensive offshore sand and gravel deposits has led to a concentration of dredging licences in areas such as the Humber, off Great Yarmouth and the Outer Thames Estuary (The Crown Estate website).

Marine aggregate extraction in SEA 3 totalled almost 14 million tonnes in 2001, accounting for 61% of the UK marine aggregate total (Figure 8.5).

Figure 8.5 - Marine aggregate extraction in the SEA 3 area



8.7 Marine disposal sites

The dumping of most forms of industrial waste at sea has been prohibited since 1994 and the disposal of sewage sludge from the UK was phased out at the end of 1998. The bulk of the material eligible for sea disposal now comes from dredging operations, an essential activity for ports and navigation channels as well as coastal engineering projects.

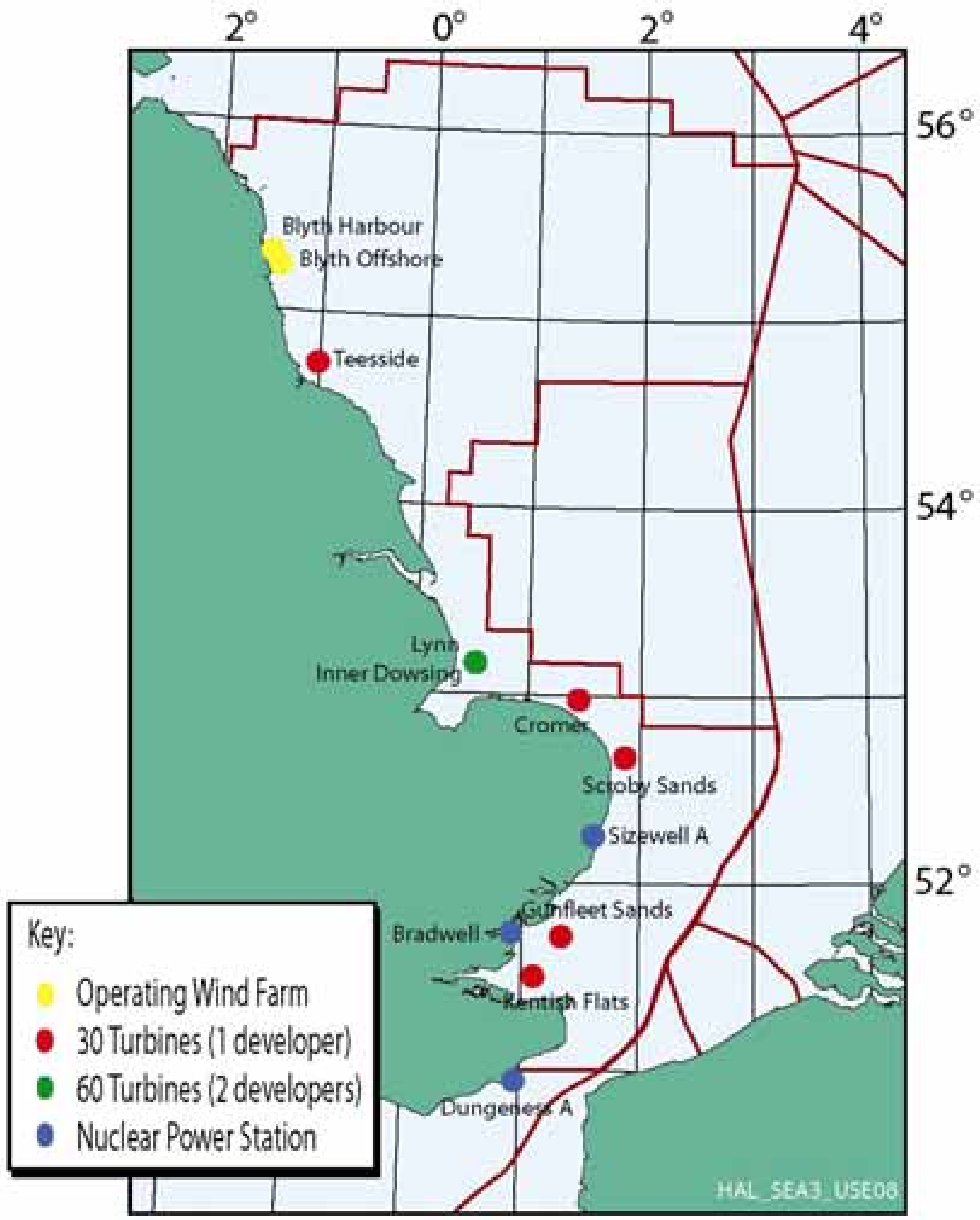
Of the 9.2 million tonnes of dredge spoil disposed of in the SEA 3 area in 2000, approximately 80% was dumped in the coastal waters around the Humber and Thames Estuaries, the result of extensive port and navigation channel maintenance in these areas (see SEA 3 Users Report).

8.8 Other energy sources

It is widely acknowledged that the UK has the greatest scope for developing offshore wind energy in Europe. In April 2001 the Crown Estate announced the names of wind farm developers who had successfully pre-qualified to obtain a lease of seabed for the development of offshore wind farms. Options have been submitted for 13 locations around the coastline of England and Wales, seven of which would lie off the east coast of England (Figure 8.6). These potential wind farm sites are located between 1.5 to 8km offshore and some aim to be in production by 2003 (The Crown Estate website).

Nuclear power is currently an important source of electricity generation accounting for almost 23% of the total electricity produced in the UK in 2000. There are a number of coastal nuclear power stations within the SEA 3 area (Figure 8.6; BNFL website).

Figure 8.6 - SEA 3 other energy sources

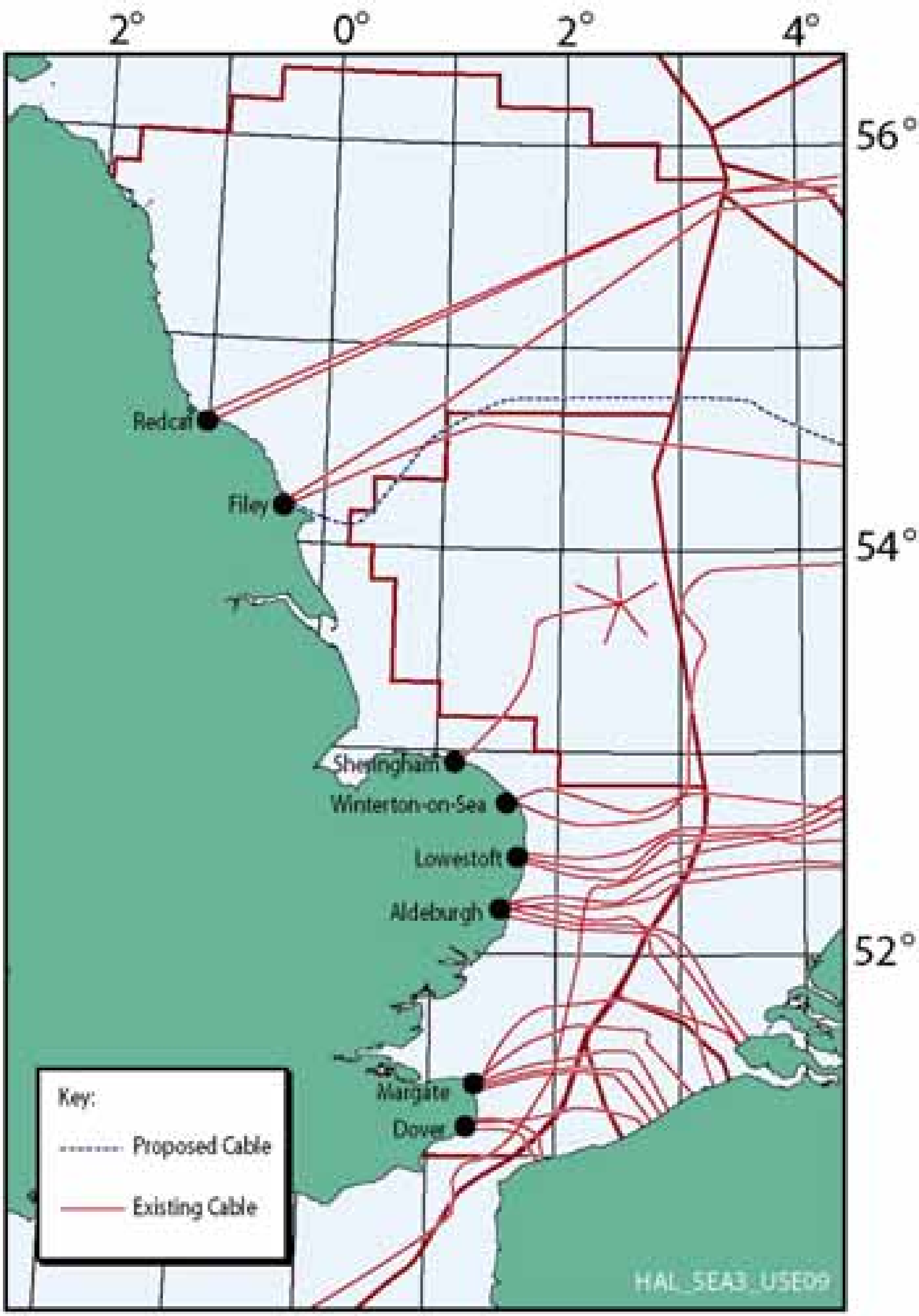


8.9 Telecommunication cables

The growth in Internet use and the development of e-commerce has seen a 500% increase in global electronic data transmission over the past 3 years. Cable numbers are increasing as a result of this increased traffic with many now traversing the North Sea to link the UK with mainland Europe.

There are 26 operational telecommunication cables which cross the SEA 3 area, the majority of which connect the south east of England with Europe (Figure 8.7; Kingfisher Cable Awareness Charts). In general, most of the cables are trenched to a depth of 40-90cm with rock-dumping used to anchor cables as a last resort. However, older redundant cables are more likely not to be trenched.

Figure 8.7 - SEA 3 telecommunication cables

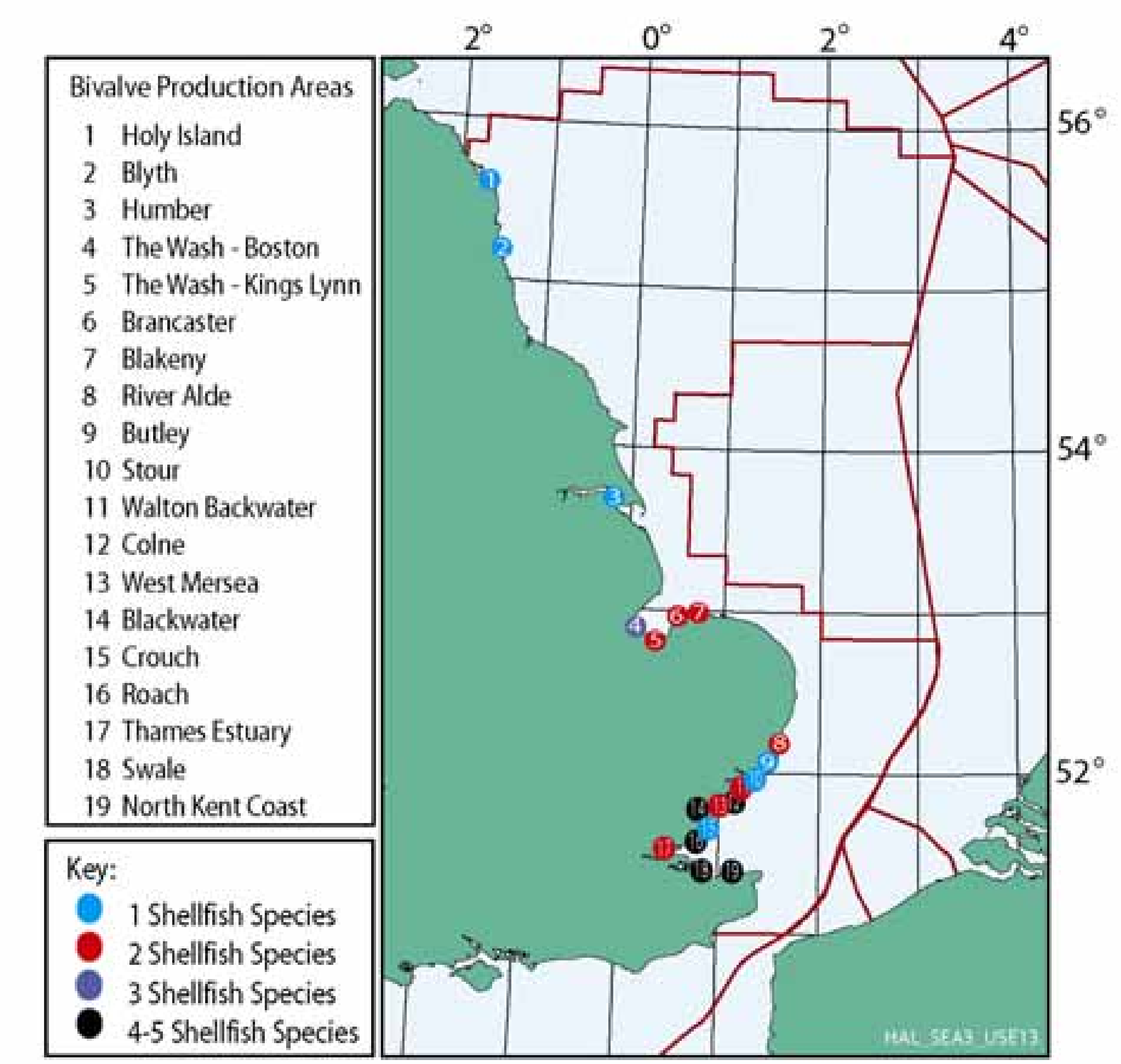


8.10 Mariculture

Mariculture is the cultivation of marine species within coastal waters and includes shellfish farming, finfish farming and algae cultivation. Shellfish farming is the only form of mariculture in the SEA 3 area.

In the UK, shellfish for human consumption must be harvested from designated production areas, those of relevance to SEA 3 are highlighted on Figure 8.8 (Food Standards Agency website).

Figure 8.8 – SEA 3 designated bivalve production areas



Within the SEA 3 area shellfish mariculture is primarily focused on mussel cultivation in the Wash and the cultivation of native and Pacific oysters in the estuaries of Essex and Kent, with the Blackwater estuary supporting high intensity cultivation of both species (see SEA 3 Users Report).

8.11 Other coastal resources and users

8.11.1 Coastal settlements

The coastal region of the northern part of SEA 3 is predominantly rural along much of its length although there are areas, focussed around the Rivers Tyne, Tees and Humber, of intense industrialisation and dense population. The major population centres include Newcastle-upon-Tyne, Gateshead, Sunderland and Hull.

Lincolnshire is predominantly rural, with a small coastal population. Norfolk also has a largely undeveloped, rural coastline, industry being centred on King's Lynn and Great Yarmouth. Suffolk has little residential development, with the exception of Lowestoft and Felixstowe and along the open coast of north Essex, the port of Harwich and coastal holiday resorts of Frinton-on-Sea and Clacton-on-Sea are major settlements. To the south, the region contains some of the most heavily populated parts of the UK, notably the Thames Estuary and the Medway towns of north Kent (Barnes *et al*. 1995).

8.11.2 Tourism and leisure

The wild and unspoilt natural scenery of much of the North East attracts many tourists in pursuit of open-air leisure activities including walking, bird watching, wildfowling and golf. Fortresses line much of the coastline such as Tynemouth, Dunstanburgh and Bamburgh Castles. The Christian seat of learning once found at Lindisfarne and the seal colony on the Farne Islands also attract further tourists to the area (British Tourist Authority website).

In Yorkshire, traditional coastal resorts include Scarborough (acclaimed as Britain's first seaside holiday resort), Whitby, Filey, Bridlington, Cleethorpes, Hornsea and Withernsea.

The stretch of coast from the Scottish Borders to the Humber Estuary contains 61 designated bathing waters of which 24 have been awarded an ENCAMS Seaside Award for 2002 (ENCAMS Seaside Awards website).

Further south, many of this region's coastal towns have had a long association with the tourism industry, most notably Mablethorpe, Skegness in Lincolnshire and Great Yarmouth in Norfolk. The Norfolk Coast Path National Trail, in addition to many other coastal footpaths and the region's rich wildlife popular for birdwatching and wildfowling alike, attract further visitors. The North Norfolk coast is also a popular destination for dinghy sailors and windsurfers.

Suffolk's tourism industry is oriented around its small towns and villages with Lowestoft being the major seaside resort in the county. There is a busy leisure boating industry which links up with the Broads. Wildfowling, birdwatching and walking are important leisure pursuits (Barnes *et al*. 1995).

Coastal areas of Essex and Kent are major areas for tourism with a number of highly developed traditional seaside resorts, particularly Southend-on-Sea, Clacton-on-Sea, Margate and Ramsgate. This region has seen a dramatic increase in water-based activities in the last 20 years and boating is now a significant industry in some areas, most notably within the Essex estuaries e.g. Blackwater and the Crouch, along the Thames Estuary and off popular beaches. Windsurfing, sea angling and wildfowling are also popular activities (Barnes *et al*. 1995).

The southern coast of the SEA 3 area, from Lincolnshire to Kent contains 78 designated bathing waters of which 36 have been awarded an ENCAMS Seaside Award for 2002 (ENCAMS Seaside Awards website) and 8, a Blue Flag award (Blue Flag Campaign website).

8.11.3 Ports

On Teesside, the port of Tees and Hartlepool handled over 51 million tones of traffic in 2000 and was responsible for handling almost 12% of the UK's oil and gas traffic and 7% of the UK's non-oil traffic. On the southern flank of the Humber Estuary, Grimsby and Immingham the largest port in the UK, handled over 52 million tones of cargo, including almost 10% of the UK's oil and gas traffic and 9% of the non-oil traffic (DTLR 2000).

Felixstowe, in Suffolk is the largest container port in the UK, handling over 40% of the UK's container traffic in 2000. The Port of London comprises the tidal Thames between Teddington Lock in West London and the North Sea, a distance of 150 kilometres and is the third largest port in the

UK, handling 47.9 million tonnes of traffic in 2000. In the same year London was responsible for handling the greatest amount of non-oil traffic in the UK (10.8% of the UK total, 30.1 million tonnes). The future development of the ports of London, Tilbury, Sheerness and Thamesport is an integral part of the Thames Gateway London Partnership regeneration initiative (Thames Gateway London Partnership website).

Dover on the Kent coast is the UK's principal international ferry port and the biggest ferry port in Europe. In 2000, over 16 million ferry passengers passed through the port, the Dover to Calais route being by far the most popular with almost 15 million passengers.

8.11.4 Coastal issues and management initiatives

The main risk of flooding in the northern part of the SEA 3 region lies within the Tees and Humber Estuaries, where much of the industrial development has taken place on claimed land within the confines of the old estuaries. Artificial sea defences protect much of the coast of these estuaries, and the beaches of cliffed sections elsewhere have been built up by colliery waste dumping, particularly along the Durham coast and at Lynemouth in Northumberland. This has to some extent protected the cliffs from erosion but has caused pollution and impoverishment of the marine and shoreline environment. 'Turning the Tide', a coastal initiative in Co. Durham is currently tackling this issue and removing much of the colliery waste in an attempt to improve the coastal environment ('Turning the Tide' website).

Along the coast of East Anglia, Essex and Kent, relative sea level is rising at a more rapid rate than anywhere else in the UK; this fact, the ongoing erosion of coastal habitats and the threat of flooding by tidal surges are major considerations for coastal zone management and have resulted in the construction of extensive sea defence and coast protection works.

South Essex and North Kent are some of the most heavily populated parts of the UK with the major industries of the region being mostly situated around the Thames Estuary. The Thames Barrier and its associated tidal defences comprise the most expensive and significant sea defence project in the region, designed to protect London even from storms of a severity that is expected only once every 1,000 years.

In 1995, the former Ministry of Agriculture, Fisheries and Food (MAFF) published guidance on the preparation of Shoreline Management Plans (SMPs) for discrete lengths of coastline. These set out a strategy for long-term (next 50 years) sustainable coastal defence within coastal sediment cells, taking account of natural coastal processes and human and other environmental influences and needs (DEFRA 2001).

The first tranche of SMPs have adopted management strategies which advocate a policy of 'doing nothing' or 'holding the line' with regard coastal defences in the northern part of the SEA 3 area. SMPs for the southern part of SEA 3, advocate 'holding the existing line' or some form of 'managed realignment' for much of the coast.

The coastal region of SEA 3 area has formed the subject of a pilot scheme intended to provide a framework for managing European and Ramsar sites that are located on or adjacent to dynamic coastlines. Coastal Habitat Management Plans (CHaMPs) will apply where the conservation of all the existing interests of the conservation site in situ is not possible due to natural or quasi-natural changes to shorelines. Six of the seven pilot CHaMPS were for sites in the southern part of the SEA 3 area and the results of the project are expected soon ('Living with the Sea' website).

8.12 Implications for Strategic Environmental Assessment

In conclusion, available information concerning other users of the marine environment within the SEA 3 area is adequate to support assessment of the potential effects of licensing. Potential interactions between other users and exploration and production activities are considered in Section 10.

9 EUROPEAN COASTAL RESOURCES OF POTENTIAL RELEVANCE TO SEA 3

9.1 Introduction

The SEA 3 area borders the waters of Norway, Denmark, Germany, the Low Countries (the Netherlands and Belgium) and France. This section presents a high level summary of the coastal resources of these countries. A brief overview of coastal conservation within each of the countries is given, as well as a complete listing of internationally important conservation sites.

9.2 Norway, Denmark, Germany, the Low Countries and France

9.2.1 Overview

Much of the information presented in this summary of coastal resources of European countries of relevance to SEA 3 comes from the OSPAR Commission Quality Status Report 2000 for Region II – Greater North Sea (OSPAR Commission 2000). Information regarding conservation sites is based upon research undertaken for the previous SEA 2 process together with subsequent data gathering.

9.2.2 Coastal resources

The coastal resources of other North Sea states of relevance to SEA 3 are briefly described below. These resources include fisheries and aquaculture, ports and shipping, coastal industries, energy producing industries, and tourism and leisure. Coastal nature conservation in these countries is also briefly described.

9.2.2.1 Fisheries and mariculture

Fishing activities vary in importance in the countries bordering the North Sea. In 1997, Denmark (45%) and Norway (22%) had by far the greatest percentage of landings of fish and shellfish from the Greater North Sea, with Germany (5%), the Netherlands (7%), Belgium (1%) and France (4%). The combined landings of different species in 1995 amounted to 3.5 million tonnes.

The gear types used in the North Sea fisheries are demersal active gear (otter and beam trawl, demersal seines), pelagic active gear (purse seines, pelagic trawl) and passive gear (nets, traps, lines).

The major commercial crustacean fishery in the North Sea is for Norway lobster with landings between 12,000 and 20,000 tonnes/year. Crab, lobster and shrimp fishing activities are concentrated in the coastal zones and estuaries. The brown shrimp is caught mainly in the coastal zones in and around the Wadden Sea, along the coasts from Denmark to Belgium. Fishing activities for mussel, cockle, clam species, whelk and winkle are concentrated along the French Channel coast and the Wadden Sea.

Mariculture is undertaken by many of the North Sea states. The cultivation of salmon is the main product of Norwegian mariculture and in 1996, 120,000 tonnes of salmon was produced. Other less important species cultivated in Norway are rainbow trout, halibut, cod, turbot and eel. Mussels are cultured in coastal waters of Denmark, in the Dutch and German Wadden Sea and along the coast of Brittany. Oysters are cultured in the south-west of the Netherlands, along the coasts of Normandy and Brittany, in Norway and in Germany.

Kelp, *Laminaria hyperborea*, is also harvested for the chemical industry in southern Norway and the annual harvest is around 160,000 tonnes.

9.2.2.2 Ports and shipping

Most of Europe's largest ports are situated on North Sea coasts and rivers, these include Hamburg, Bremen, Rotterdam, and Le Harve. Of these ports, Rotterdam is by far the largest handling 322 million tonnes of cargo in 2000. The throughputs of the other major ports in 2000 were Hamburg (85 million tonnes), Le Harve (67 million tonnes) and Bremen (45 million tonnes) (European Sea Ports Organisation website). The shipping lanes of Hamburg and Bremerhaven are connected with Traffic Separation Schemes to Rotterdam and the English Channel.

Approximately half of the shipping activity in the Greater North Sea consists of ferries and roll-on/roll-off vessels on fixed routes. The ports of Dover, Harwich, Hull and the Tyne form the focus for many of these ferry routes.

9.2.2.3 Coastal industries

Along the south and west coast of Norway, most industries are situated in the innermost part of the fjords, often in connection with larger cities (Oslo, Bergen). Some oil refineries are located in the coastal zones. In Denmark, industrial production is on the east coast of Jutland, and near Esbjerg. German coastal industries are concentrated near the banks of the rivers Elbe, Weser, Ems and Jade. In the Netherlands, industries are situated in the Scheldt estuary, in the Rotterdam area, and near Amsterdam and Ijmuiden. The Belgian coastal industry is mainly situated in the Antwerp area and on the French coast, various industrial developments are focussed on the Calais-Dunkerque coast and Seine estuary.

9.2.2.4 Energy industries

The offshore oil industry has been important to the Norwegian economy since the early 1970s. In 1999 Norwegian oil exports amounted to NOK 168 billion and the petroleum industry generated around 14.6% of Norway's state revenues. The oil and gas is brought ashore through pipelines or by tankers before onward distribution to refineries.

There are a number of offshore wind farm projects currently in the coastal waters of Denmark and the Netherlands, although these are relatively small scale and in shallow waters. However, larger offshore wind farm projects are planned in a number of countries. In Denmark, planned projects include Horns Rev (150MW), Laeso (150MW), Omo Stalgrunde (150MW) and Gedser Rev (15MW). In the Netherlands, projects are planned at the mouth of the Scheldt River (100MW), and at Ijmuiden (100MW) (British Wind Energy Association website).

9.2.2.5 Tourism and leisure

Tourism and recreation in North Sea coastal areas is an important social and economic activity. The numbers of overnight stays and number of berths in marinas has increased over the last decade. In the North Sea area of Denmark 25 million overnight stays were counted in 1996, 13 million for Belgium, over 21 million for Germany and 13.5 million for the Netherlands. No information was available for France and Norway.

Outdoor recreation is central to leisure activities in Norway - walking, cycling, swimming, sailing, mountaineering, skiing, white-water canoeing, and fishing are all popular. Sailing and other water-based sports are also popular activities for the other countries bordering the central and southern North Sea.

9.2.2.6 Nature conservation

A programme of work on Marine Protected Areas carried out in 1996 identified a number of sites of marine biological value that are examples of areas worthy of protection in a Nordic context. Twelve of these sites were in Norway, four of which are on the south-west coast (Framvaren, Lindespollene, Utvær/Indrevær and Skorpo/Nerlandsøy). At the present time, the only area in Norway that is protected specifically because of its marine life are the Froan Skerries.

Further south, the Wadden Sea is the main feature of conservation interest. It comprises an extensive area of shallow seas and low-relief coastline stretching from Den Helder in the western Netherlands to Esbjerg in western Denmark.

Protection at a national level and cooperation between the three Wadden Sea countries on the protection of the Wadden Sea has developed in parallel. The first comprehensive protection schemes were introduced in 1979-1980 in all three countries. The trilateral Wadden Sea Cooperation has developed to constitute as the overall framework for the protection of the Wadden Sea as one entire, shared ecosystem.

The trilateral Wadden Sea conservation area consists of:

- In The Netherlands, the areas under the Wadden Sea Memorandum including the Dollard
- In Germany, the Wadden Sea national parks and protected areas under the existing Nature Conservation Act seaward of the main dyke and the brackish water limit including the Dollard
- In Denmark, the Nature and Wildlife Reserve Wadden Sea

The majority of the Wadden Sea will be included in Natura 2000 sites network (as both SACs and SPAs), in addition, parts of the area are designated as Ramsar sites or Biosphere Reserves and the area has been proposed as a World Heritage Site.

Germany has identified a number of areas for inclusion within the Natura 2000 network or as part of the OSPAR marine protected areas programme. These include parts of the Dogger Bank, and the sandbanks of Borkum-Riffgrund and Amrum-Aussengrund. The Netherlands have also identified areas of the Dogger Bank for further research prior to putting forward for protection (pers. comm. C Turnbull, JNCC).

9.3 Listing of protected sites

A complete listing of internationally important conservation sites for birds around the North Sea margins is tabulated below (Table 9.1; Heath & Evans 2000).

Table 9.1 - Listing of Special Protection Areas and Ramsar Sites along the North Sea Coastline

*IBA No.	Site No.	Site Name	SPA	Ramsar
NORWAY				
32	1	Froan		
38	2	Havmyran		
39	3	Smola archipelago		
	4	Sandblast/Gaustadvagen		
	5	Haroya Wetlands System		
	6	Giske Wetlands System		
40	7	Runde		
43	8	Kjorholmane seabird reserve		
44	9	Jaeren wetland system		
45	10	Lista wetland system		

Table 9.1 - Listing of Special Protection Areas and Ramsar Sites along the North Sea Coastline				
***IBA No.**	**Site No.**	**Site Name**	**SPA**	**Ramsar**
46	11	Skjernoy, South Skerries	■	
DENMARK				
22	12	Hanstholm Reservatet	■	
18	13	Vangsa Hede	■	
17	14	Alvand Klithede & Forby So	■	
23	15	Agger Tange & Kirk Vig	■	■
28	16	Nissum Bredning	■	
39	17	Harboore Tange, Plet Enge & Gjeller So	■	■
38	18	Nissum Fjord	■	■
41	19	Stadil Fjord & Veststadil Fjord	■	■
43	20	Ringkobing Fjord	■	■
56	21	Fjilso	■	■
50	22	Kallesmaersk Hede, Graerup Langso & area	■	
53	23	Fano	■	■
55	24	Skallingen & Langli	■	
51	25	Ribe Holme & meadows	■	■
52	26	Mando	■	■
57	27	Vadehavet	■	■
65	28	Romo	■	■
67	29	Ballum og Husum Enge, Kamper strandenge		■
60	30	Tonderrmarsken, Magisterkog & Rudbol So	■	
23	31	Agger Tange & Krik Vig	■	■
GERMANY				
2	32	Schleswig-Holstein		■
1	33	Heligoland island	■	
34	34	Neuwerker & Scharhorner Watt (Hamburgisches Wattenmeer)	■	■
107	35	Elbmarsch from Stade to Otterndorf (Niederelbe, Barnkrug-Ottendorf)	■	■
65	36	Lower Weser	■	
90	37	Wattenmeer, Jadebusen		■
58	38	Wattenmeer Elbe-Weser-Dreieck	■	■
63	39	Ems valley from Leer to Emden	■	
NETHERLANDS				
17	40	Dollard	■	■
12	41	Rottumeroog	■	■
11	42	Rottumerplaat	■	■
10	43	Schiermonnikoog	■	

Table 9.1 - Listing of Special Protection Areas and Ramsar Sites along the North Sea Coastline				
***IBA No.**	**Site No.**	**Site Name**	**SPA**	**Ramsar**
9	44	Engelsmanplaat	■	■
8	45	Ameland:Duinen-Oerd	■	■
7	46	Terschelling: Dunes & Noordvaarder	■	■
6	47	Terschelling: De Boschplaat	■	■
1	48	Wadden Sea	■	■
5	49	Griend	■	■
4	50	Vlieland	■	■
2	51	Texel: Schorren & Zeeburg	■	■
3	52	Texel: Dunes & Hors	■	■
18	53	N.Sea north of Waddensea	■	■
13	54	Balgzand	■	■
19	55	Zwanenwater	■	■
92	56	Dunes of Schoorl	■	
21	57	Westplaat	■	■
24	58	Haringvliet	■	■
25	59	Hollands Diep	■	■
23	60	Kwade Hoek	■	
27	61	Grevelingen	■	■
20	62	Voordelta	■	■
26	63	Lake Volkerak	■	■
28	64	Oosterschelde	■	■
29	65	Zoommeer	■	■
30	66	Markiezaat	■	■
32	67	Westerschelde & Saeftinghe	■	■
33	68	Zwin (Dutch part)	■	
16	69	Groningen Wadden Sea coast	■	■
15	70	Lauwersmeer	■	■
14	71	Frisian Wadden Sea coast	■	■
35	72	Makkumer and Kooiwaard	■	■
36	73	Workumerwaard	■	■
37	74	Steile Bank & Mokkebank	■	■
34	75	Lake Ijsselmeer	■	■
38	76	Lake Markermeer	■	■
66	77	Oostvaardersplassen	■	■
67	78	Lepelaarplassen	■	
69	79	Polder Zeevang	■	
BELGIUM				
1	80	Vlaamse Banken		■
2	81	Westkust	■	

Table 9.1 - Listing of Special Protection Areas and Ramsar Sites along the North Sea Coastline				
***IBA No.**	**Site No.**	**Site Name**	**SPA**	**Ramsar**
FRANCE				
64	82	Cap Gris-Nez		
62	83	Estuaire de la Canche		
60	84	Estuaires picards: bais de Somme et d'Authie		

*Note: *IBA (Important Bird Area) number which identifies the site in Heath & Evans 2000*

10 CONSIDERATION OF THE EFFECTS OF LICENSING

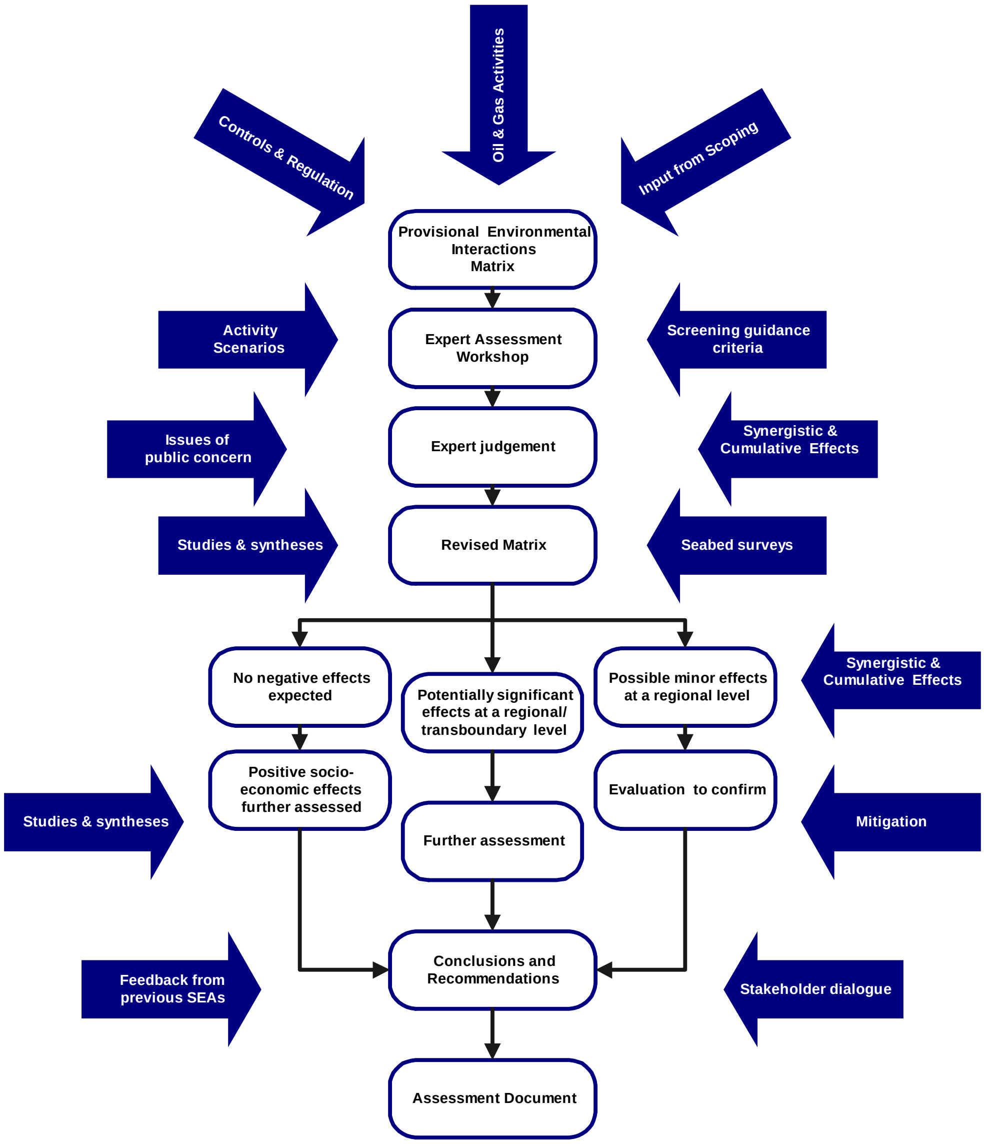
10.1 Introduction

The overall process adopted for this strategic environmental assessment is described in Section 2. The approach and methods used to identify the potential effects that could follow from SEA 3 licensing, and to assess them for significance are outlined below. The base case for the assessment what Alternative 2 in Section 4.2 (i.e. to offer the area for licensing) since this was judged to represent the greatest scale of potential interactions and effects.

10.2 Approach

The assessment for this SEA was a staged process which has incorporated inputs from a variety of sources (outlined below) and shown in Figure 10.1.

Figure 10.1 – SEA 3 assessment process



The initial stage was the identification of interactions between the activities that might follow from licensing of the SEA 3 areas and receptors within the environment (both the natural environment and human uses of the area). The interactions and implications considered include positive, negative, direct, indirect, cumulative, synergistic and transboundary effects. This initial step drew on input from scoping, published descriptions of the effects of oil and gas activities, the first two DTI SEAs and the EU SEA Directive.

The next stage was review of the range of potential interactions to identify those which might potentially have effects of a scale which should be considered further in the SEA. This was achieved through an expert assessment workshop held in July 2002 (see Appendix 2) . The process followed is illustrated in Figure 10.1 which includes the input information and outputs. Prior to the workshop, a provisional environmental interactions matrix was developed and circulated along with a summary of generic oil and gas activities (see SD-002 on the SEA website), and scale of potential activity in the SEA 3 area (see Section 4.2.3).

The provisional interactions matrix was reviewed in detail at the workshop using indicative criteria (both revised at the workshop and taking into account the criteria for determining the likely significance of effects included as Annex 2 to the SEA Directive). Expert judgement was used to identify those interactions which should be considered further in the SEA – see Appendix 2. The criteria used in the consideration included the scale, severity and duration of effects on the environment, human health and socio-economics, together with issues of public concern. In this way the review attempted to ensure balanced consideration of scientific and perception issues.

The conclusions from the assessment workshop were presented and discussed at a stakeholder dialogue meeting held in York in August 2002 – see Appendix 3 and Report No. SD_003.

The final stage was detailed consideration of the interactions agreed at the workshop and the input from the stakeholder meeting using the assessment criteria given in Appendix 2. This stage is documented in Sections 10.3-10.6 and included quantification of the scale and magnitude of the potential activities and interactions, consideration of the sensitivity and ability to recover of the receptor(s), existing controls and agreements in place (see Section 3.3), information gaps, and a conclusion regarding the potential effect of further licensing in the SEA 3 area.

Issues considered to be of negligible or minor importance in terms of a Strategic Assessment were not considered further.

10.3 Consideration of effects

10.3.1 Noise

Potential effects of offshore exploration and production on marine mammals result in large part from acoustic disturbance (e.g. McCauley 1994, Richardson *et al*. 1995, Evans & Nice 1996, Moscrop 1997, Gordon *et al*. 1998, Stone 1998), with seismic sources generally regarded as the most significant. The SEA 3 Effects Assessment Workshop identified the effects of seismic and drilling noise on marine mammals, particularly harbour seals, as a potentially significant issue.

10.3.1.1 Sources

Sources of underwater noise associated with E&P include seismic exploration, other geophysical surveys, drilling, construction, production, and explosive cutting if used in decommissioning.

Predicted activity scenarios for potential licensed blocks suggest a total of 100-200km 2D seismic and 500-2500 km^2 3D seismic in the potential SEA 3 licence area. In addition, up to 25-30 site surveys may be required for exploration, appraisal and development locations. As context, the distribution of previous 2D seismic surveys within the SEA 3 area, listed by the DEAL (Digital Energy Atlas and Library, http://www.ukdeal.co.uk/), is shown in Figure 10.2. Although the highest density of previous seismic survey (with corresponding acoustic disturbance) is concentrated outside the SEA 3 area, it is clear that all of the SEA 3 area has previously been covered by 2D seismic, and that the predicted additional requirement for 2D seismic represents a minor increment. Similarly, a substantial coverage of 3D seismic has previously been acquired in developed areas of the southern North Sea, with predicted limited additional 3D seismic required in SEA 3 areas

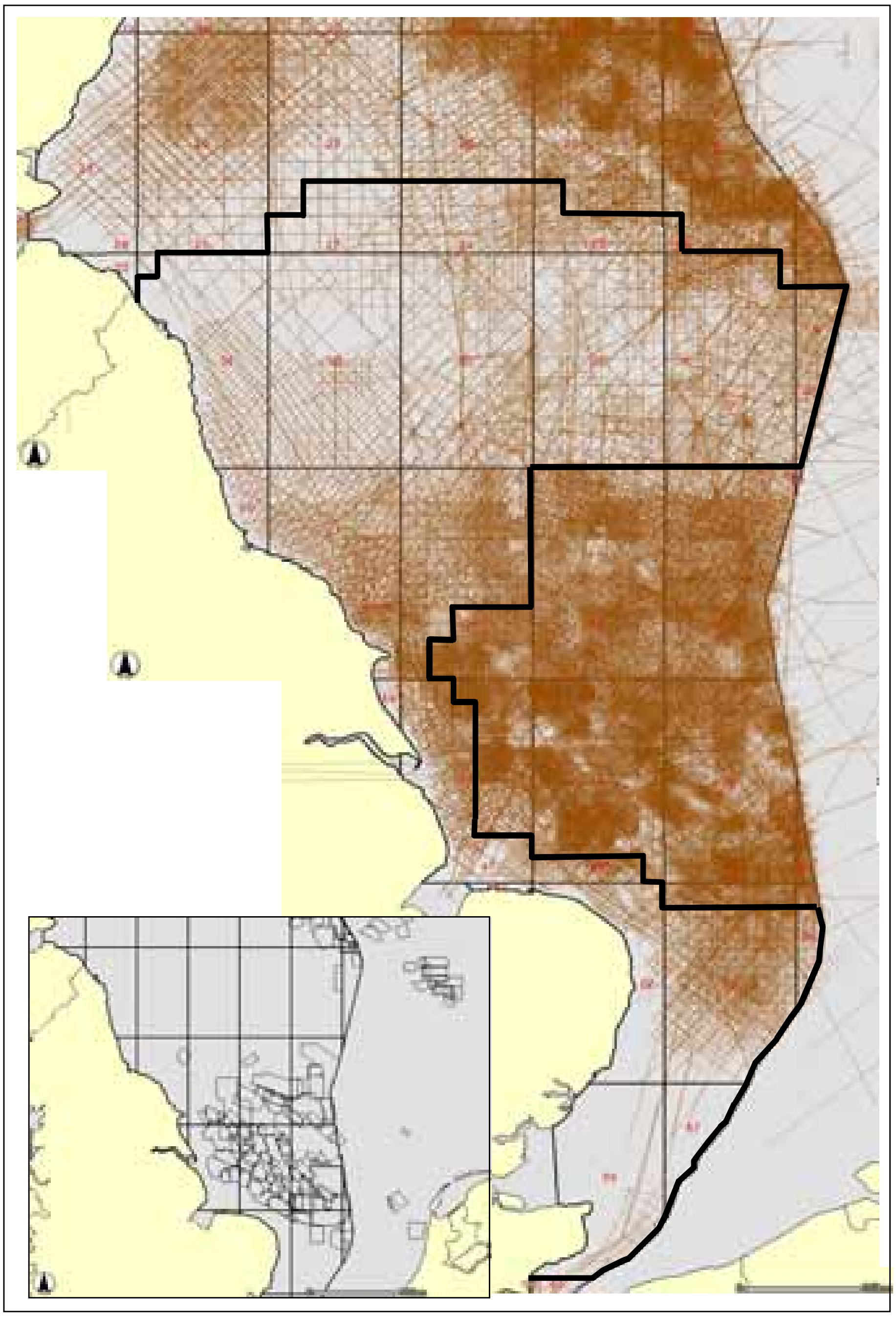
Sound pressure in water is usually defined in logarithmic units (dB) against a reference pressure (e.g. p_{ref} = 1µPa). In addition to relative sound pressure, the frequency distribution of propagated noise has a major influence on transmission and effects on receptors. Spectrum level is the level in dB re 1µPa^2/Hz.

Source levels associated with seismic airguns, vessels, drilling and explosives have been reviewed in the context of marine mammal disturbance by SMRU (TR_006 Rev 1). Airgun arrays are the commonest high energy source; by 1985 more than 97% of marine seismic surveys used airguns (Turnpenny & Nedwell, 1994). Airgun arrays are towed behind purpose built survey vessels, with guns suspended at depths of 1 to 10 m and fired at intervals of a few seconds.

With the exception of explosives, airgun arrays are the highest energy man made sound sources in the sea; broadband source levels of 248-259 dB re 1µPa .m are typical of large arrays (Richardson *et al*. 1995). Apparent source level of a surface-towed airgun source is dependent on the relative position of the receptor; for example a receiver to the side of an array will receive a signal of longer duration but lower maximum amplitude (Gordon *et al*. 1998). Received bandwidth and apparent source level are also strongly dependent on deployment depth, due to destructive interference from the reflected "ghost" array effect. Most of the energy produced by airguns is below 200 Hz. Barger & Hamblen (1980) reported a bandwidth of 40Hz centred about 120 Hz. The peak spectral level occurred between 35 and 50 Hz, and decreased monotonically with increasing frequency; spectral level at 200Hz was 48dB down on the peak at 40Hz. Source levels at higher frequencies are low relative to that at the peak frequency but are still loud in absolute terms and relative to background levels. Goold & Fish (1998) recorded 8 kHz sounds above background levels at a range of 8km from the source, even in a high noise environment.

Drilling noise is generally low frequency, with highest levels being recorded from drill ships. Conventional drill platforms produce very low frequency noise, with strongest signals at around 5 Hz whereas drill ships produce noise with tonal elements up to 600 Hz (Richardson *et al*. 1995, Greene, 1987). There have been no detailed studies published of drilling, development and production noise around North Sea installations, although the loudest sounds are likely to result from pile driving during jacket and template installation. Pile driving source levels can be high, levels of 131-135 dB re 1 µPa. were measured 1km from a hammer used for pipe installation (Richardson *et al*. 1995). Operational noise associated with drilling rigs and the Foinaven and Schiehallion FPSO facilities has recently been monitored using pop-up hydrophone monitoring (Swift & Thompson 2001) (it should be noted that noise emission characteristics of FPSOs may be significantly different from those of steel jacket platforms). Data from three recovered pop-ups at Foinaven and Schiehallion were characterised by high and variable levels of noise in three noise bands "Low" (1-10Hz), "Whale" (10-30Hz) and "High" (30-100Hz). Mean received spectrum levels (105-120 dB re 1 µPa^2 / Hz) exceeded the predicted upper limit of prevailing ambient ocean noise in all noise bands, except in the "Low"-band where received levels were close to the predicted upper limit of ambient ocean noise.

Figure 10.2 - Distribution of 2D seismic surveys (inset: distribution of 3D seismic surveys)



(source: Digital Energy Atlas and Library, http://www.ukdeal.co.uk/)

10.3.1.2 Ambient noise

Few published data are available regarding ambient (background) noise in the central and southern North Sea, although the MoD have modelled, and made extensive measurements of ambient noise (Amanda Gallagher, QinetiQ, written comment to SEA 3 Stakeholder Dialogue Session).

it is likely that similar sources dominate natural sound pressure levels in most marine environments; specifically wind, breaking waves and precipitation, with transient noise also associated with earthquake and glacial-related events in some parts of the world. Wind generated noise results from various mechanisms, with oscillating bubbles in breaking waves representing the main source of noise above 200Hz (Banner & Cato 1988]). At low and moderate wind speeds, the greatest sound energy is generated in the range 200-1000 Hz. Wind noise varies with wind strength, and with other factors including water temperature and density stratification. Typical noise levels are 66 ± 6 dB re $1\mu Pa^2/Hz$ at 100Hz for wind speeds 3.4-5.4m/s, increasing to 78 ± 6 dB re $1\mu Pa^2/Hz$ at 100Hz for wind speeds of 13.9-17.1 m/s. Extreme levels of wind noise up to 85-95 dB re $1\mu Pa^2/Hz$ at 141Hz are predicted during storm events (McCauley 1994).

Anthropogenic sources of noise include shipping, other marine operations such as dredging and aggregate extraction, military activities including sonar and live firing exercises, recreational activities and scientific research.

The noise produced by ships represents one of the most pervasive forms of man-made noise in the ocean (McCauley 1994), and in areas of high shipping density (such as the central and southern North Sea) produces a non-descript low frequency noise (< 500 Hz). This low frequency noise propagates extremely well in deep water (see below), with higher frequencies more limited in propagation range; propagation will also be reduced in shallow water. Broadband source levels of ships between 55 and 85m in length are around 170-180 dB re 1 µPa (Richardson *et al*. 1995), with most energy below 1 kHz. Scrimger & Heitmeyer (1991) give source levels for 50 different merchant ships which range over 140-170 dB re $1\mu Pa^2/Hz$ between 100-700 Hz. Use of bow thrusters increases broadband sound levels, in one case by 11 dB and includes higher frequency tonal components up to 1 kHz (Richardson *et al*. 1995).

Ambient noise levels in the central and southern North Sea are therefore likely to be correlated with shipping density, which is highest in the approaches to ports and around the south-eastern perimeter of the SEA 3 area (see Figure 8.4) and with areas which experience increased frequency of breaking waves, such as shallow offshore banks. During periods of strong winds, local variability in ambient noise will be swamped by wider-scale increases in wind-generated noise. In general, the combination of natural and anthropogenic sources will produce a relatively high ambient noise environment within the SEA 3 area.

10.3.1.3 Propagation

Most environmental assessments of noise disturbance use simple spherical propagation models of the form **SPL = SL – 20log(R)**, where SL = source level, R = source-receiver range, to predict sound pressure levels (SPL) at varying distances from source. However, several workers have measured or modelled additional signal modification and attenuation due to a combination of reflection from sub-surface geological boundaries, with sub-surface transmission loss due to frictional dissipation and heat; and scattering within the water column and sub-surface due to reflection, refraction and diffraction in the propagating medium (Etter 1991, Rogers 1981, Gausland 1998, VerWest & Bremner 1998, Ward *et al*. 1998). In shallow water, reflection of high frequency signals from the seabed results in approximately cylindrical propagation and therefore higher received spectrum levels than for spherically propagated low frequency signals (which penetrate the seabed). However, the sub-surface attenuation of signal with distance is frequency dependent, with stronger attenuation of higher frequencies with increasing distance from the source. Frequency dependence due to destructive interference also forms an important part of this weakening of a noise signal. Simple models of geometric transmission loss may therefore be unreliable in relatively shallow water; in areas of complex seabed topography and acoustic reflectivity; where vertical density stratification is present in deep water; and where the noise does not originate from a point source. The first two of these factors will apply particularly in the sandbank areas considered by SEA 3, generally reducing propagation of low and medium frequency noise.

10.3.1.4 Potential effects on marine mammals

In view of the distribution of marine mammals in the SEA 3 area (and adjacent North Sea), seismic and other E&P-related noise are most likely to affect harbour porpoise and harbour seal. Potential effects of E&P activities, in terms of acoustic disturbance, were considered by SMRU in report TR_006 Rev 1.

Richardson *et al*. (1995) defined a series of zones of noise influence, also used by the SMRU commissioned report. Four zones are recognised which will generally occur at increasing sound level: (1) the zone of audibility (2) zone of responsiveness (3) zone of masking (4) zone of hearing loss, discomfort or injury. Gordon *et al*. (1998) reviewed potential acute effects in terms of physical damage, noise-induced hearing loss (temporary and permanent threshold shifts) and short-term behavioural responses; with chronic effects (see below) including long term behavioural responses, exclusion, and indirect effects. The most likely physical/physiological effects were considered to be shifts in hearing thresholds and auditory damage.

Acute physical effects, and behavioural and chronic effects are assessed separately in the following section.

10.3.1.5 Acute physical effects

In terrestrial mammals, exposure to loud sounds can lead to temporary threshold shifts (TTS), permanent threshold shifts (PTS) and non-auditory tissue damage, which may be fatal. For continuous sound sources, the intensity of the signal relative to the hearing threshold at that frequency, and the duration of the exposure can both affect the timing of the onset of TTS and PTS. As a general rule, if a sound can cause a TTS, a prolonged exposure to it will lead to a PTS. For impulsive sounds, the intensity, pulse duration, pulse repetition rate and duration of exposure can all affect the timing and extent of TTS and PTS (Richardson *et al*. 1995). In the case of extremely loud sounds there may be an instant PTS and even damage to non auditory organs.

Only recently have experiments to induce threshold shifts been conducted on captive marine mammals. TTSs have been measured directly in a bottlenose dolphin exposed to single 1-second pulses of narrow band sound underwater (Ridgeway *et al*. 1997). TTS became evident at received levels of 194-201 dB re 1µPa at 3kHz, 193-196 dB at 20 kHz and 192-194 dB at 75kHz. TTS has been induced, experimentally, in three pinniped species, harbour seal, northern elephant seal and Californian sea lions (Kastak & Schusterman 1996 and Kastak *et al*. 1999). All three species showed a similar TTS of 4.6-4.9 dB, after 20-22 minutes of exposure at 65-70 dB above sensation level in the frequency range 0.1-2 kHz.

With the absence of reliable information on the levels of sound likely to cause hearing damage in most marine mammal species, it has been common practice to transfer human Damage Risk Criteria (DRC) to other mammals (Richardson *et al*. 1995). Humans exposed, in air, to continuous sound levels 80dB above their absolute hearing thresholds are likely to suffer TTS and eventual PTS. If this DRC can be applied to marine mammals we would predict that at low frequencies (<500 Hz) TTS would occur at around 165-180 dB re 1µPa@1m in phocids and at around 180-210 dB re 1µPa@1m in small odontocetes.

These represent the DRC estimates for exposure to continuous noise. For impulsive, intermittent sounds, e.g. airgun blasts, the sound levels may be significantly higher, and will depend on the length and number of pulses received. Richardson *et al*. (1995) estimated the DRC for 100 pulses to be 138 dB above absolute hearing threshold. This would be approximately 208 dB for a harbour seal and would be higher for small odontocetes. Such levels could be encountered directly below or within 100m horizontal distance from a large commercial airgun array.

It must be emphasised that the validity of applying DRC estimates from human studies to seals and odontocetes is unproven, though the recent TTS studies mentioned above suggest that this is not an unduly conservative assumption. Given the lack of information on threshold levels for large cetaceans it is not possible to suggest reliable DRCs for this group.

With the exception of explosives, airgun arrays are the highest energy man made sound sources in the sea. The peak levels of sound pulses are much greater than the RMS levels from continuous sources such as ship noise or other industrial sources (Richardson *et al.*1995). However, because the sound pulses are short relative to the inter-pulse intervals, the total energy transmitted to the water may be lower than from some continuous sources. Direct comparisons between different types of sources are therefore difficult to interpret. Their ability to cause hearing damage will of course depend on the characteristics of the receiver (marine mammal ears) which in many cases are poorly known (SMRU TR_006 Rev 1).

Very intense pressure waves, e.g. blast waves from explosions, 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 & Young 1948, Trasky 1976).

Blast damage in marine mammals has been investigated using both submerged terrestrial mammals (Goertner 1982; Richmond, Yelverton *et al*. 1973; Yelverton, Richmond *et al*. 1973) and dolphin cadavers (Myrick, Cassano *et al*. 1990). Goetner (1982) estimated distance at which slight lung and intestinal injuries would occur in various marine mammals. Marine mammals are at greatest risk of injury when they are at the same depth as, or slightly above, the explosion. Risks drop off quite sharply above and below this depth. For example, a harbour porpoise within 750m of an explosion of a 545kg charge at 38m is likely to suffer injury if it is at the same depth. But 30m above, or 43m below it, only animals within 500m are likely to be injured. "Safe" distances for larger animals will be substantially less (Richardson *et al*. 1995). Young (1991) estimated safe ranges for marine mammals of three different sizes and for human divers. However, the "safe" distances for humans are substantially larger than those for an equivalent sized marine mammal. Richardson *et al*. (1995) have suggested that a precautionary approach would be to use the human value for all marine mammals. This would give a safe distance of 600m for a 1kg explosion, 900m for a 10kg explosion and 2km for a 100kg explosion.

10.3.1.6 Behavioural and chronic effects on marine mammals

The zone of audibility is defined by the range at which an animal can just detect the sound. For a sound to be detected it must be both above the absolute hearing threshold for that frequency and be detectable against the background noise level in that frequency band.

Both conditioned behavioural responses to sound playback and electrophysiological measurements have been used to measure hearing sensitivities for a number of marine mammal species (see Richardson *et al.* 1995). Underwater audiograms have been derived for a range of phocid 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 85 dB re 1 µPa. Sensitivity decreases rapidly at higher frequencies, but in the one animal tested at low frequency, the threshold at 0.1 kHz was 96 dB re 1 µPa indicating good low frequency hearing.

No behavioural audiograms are available for grey seals, but electro-physiological audiograms (based on auditory evoked potentials) showed a similar pattern over the range of frequencies tested (Ridgeway & Joyce 1975). The fact that grey seals make low frequency calls suggests that they also have good low frequency hearing.

Behavioural audiograms have been reported for some odontocete species, 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.

Small odontocetes are therefore considered to be more sensitive to high frequencies than are phocid seals (SMRU TR_006 Rev 1). At their best frequencies, odontocetes are around 20-30 dB re 1µPa@1m more sensitive than phocids. However, below about 2 kHz phocids become relatively more sensitive than small odontocetes, e.g. At 2kHz harbour porpoises and juvenile bottlenose dolphins had estimated hearing thresholds of 50-70 dB re 1µPa@1m, similar to estimates for a range of phocid seal species. At 100Hz, dolphin hearing thresholds had risen to 130 dB re 1µPa@1m. At 100Hz, harbour seal threshold was estimated to be 95dB re 1µPa@1m, approximately 35dB better than the dolphin.

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.

The level of background noise will often determine whether a sound is detectable or not, especially at frequencies where the hearing is highly sensitive. As a rule of thumb, Richardson *et al.* (1995) suggest that a mammal can barely detect a sound signal if its received spectrum level is equal to the level of noise in the 1/3 octave band in which it lies.

Critical ratios, i.e. the ratio of sound level to background level at which detection is masked, have been estimated for a range of species. These have so far involved high frequency or continuous tone sound sources (Southall *et al.* 2000, Richardson *et al.* 1995). For harbour seals, Turnbull &Terhune (1993) showed that increasing repetition rate decreased hearing threshold for pulsed sounds above 2kHz irrespective of the level of masking, i.e. faster repetition decreased the critical ratio. This implies that critical ratios for irregular short pulses will be higher than for continuous tones. To date there are no useful data on the masking effects of background noise on ability to detect low frequency pulsed sounds (SMRU TR_006 Rev 1).

Actual behavioural responses to seismic noise have proved difficult to monitor, although Goold (1996) presented evidence which he interpreted as 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 on and off within a survey block. In a later paper (Goold, 1998), seasonal changes in the distribution of dolphins in the same area at the same time were revealed that may explain some, or all, of the larger scale changes previously attributed to seismic surveys. If nothing else, this shows the difficulty of interpreting correlational studies made from platforms of opportunity.

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. 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 airguns but returned to forage in the same areas on subsequent days.

10.3.1.7 Control and mitigation

Seismic surveys must be carried out under the terms of an exploration or production licence, and proposed surveys notified to Government through submission of a PON14. Where required, JNCC or country agencies must be consulted and an effects assessment submitted.

In British waters, all species of cetacean are protected under the *Wildlife and Countryside Act 1981* as amended and updated by the *Countryside Rights of Way Act 2000* and the *Wildlife (Northern Ireland) Order 1985*. Guidelines to minimise the effects of acoustic disturbance from seismic surveys, agreed with the oil and gas industry, were published by the then Department of the Environment in 1995 and revised and issued by the JNCC in 1998. Member companies of the UK Offshore Operators Association (UKOOA) have indicated that they will comply with these Guidelines in all areas of the UK Continental Shelf. Under the Guidelines there is a requirement for visual and acoustic surveys of the area prior to seismic testing to determine if cetaceans are in the vicinity, and a slow and progressive build-up of sound to enable animals to move away from the source.

The harbour porpoise, bottlenose dolphin, harbour seal and grey seal are listed in Annex II of the Habitats Directive. Member countries of the EU are required to consider the establishment of Special Areas of Conservation (SACs) for Annex II species. Candidate SACs have been established for the bottlenose dolphin in the Moray Firth and in Cardigan Bay (outside the SEA 3 area). No candidate SACs have yet been established for the harbour porpoise. A number of terrestrial candidate SACs have been established for grey and harbour seals in the SEA 3 area including the Berwickshire and North Northumberland cSAC (grey seal breeding site) and The Wash and North Norfolk cSAC (common seal breeding site).

The most abundant marine mammals in the SEA 3 area all show distinct seasonal patterns in distribution, with harbour porpoises and minke whales most frequent offshore in summer; harbour seals largely onshore (pupping) in June-July, followed by moulting until September; and grey seals in the Farnes pupping in autumn and moulting in February and March. Seals are likely to forage widely in the offshore SEA 3 area in autumn and winter (Section 6.8.3). Overall, therefore, there are no clearly identifiable periods which should be preferred for seismic activities.

Drilling noise has been considered in Environmental Statements for exploration wells, although noise from production facilities has received comparatively little attention. Recent observations suggest that significant production noise intensities may occur, and this issue is likely to be assessed in more detail in future Environmental Statements. Project assessments will, however, continue to be limited by the uncertainties noted above until new information becomes available.

10.3.1.8 Conclusions

SMRU conclusions indicate that seismic activities in the SEA 3 area could potentially affect minke whale, harbour porpoise, grey seals and harbour seals, although only harbour porpoise and harbour seals occur in significant numbers throughout most of the area. Existing control and mitigation methods for E&P activities are generally regarded as effective in preventing physical damage. There is no evident seasonality to overall sensitivity of marine mammals in offshore areas.

Environmental assessment of individual projects on the UKCS is considered to be relatively robust, although concerns exist over the reliability of sound propagation models and the availability of sound intensity criteria for marine mammals.

In view of the limited incremental extent of noise resulting from predicted activity levels, in relation to previous activity and oil and gas activities in existing licensed acreage; together with existing control and mitigation methods; it is considered unlikely that physical damage or significant behavioural disturbance of marine mammals will result from the activity scenarios associated with proposed licensing. However, there are legitimate grounds for concern, in particular due to uncertainty about the relationship between observable responses and population consequences.

Recommendations have been made by SMRU for research required to address information gaps and assist in the implementation of reasonable management measures (to avoid unnecessary constraints on E&P activity). These include:

- **Dose Response**. Research, often in the form of controlled exposure experiments, to address key uncertainties about marine mammal acoustics, sensitivities and effects of sound
    - Initially undertaken in locations where conditions are optimal (good weather, adequate populations, long term studies, good logistics).
    - Assessment of accumulated impacts on populations that range widely and may migrate to other areas.
- **Exposure Risk.** Targeted surveys together with telemetry based studies of movements and behaviour of selected species should be linked with oceanography and monitoring of other components of the ecosystem to identify important habitats and explore why they are important and improve our ability to predict marine mammal distributions at sea, year round.
- Assessing **medium** or **long term consequences** of particular activities will require long term monitoring of status and distribution of populations of interest. There are currently no monitoring schemes for any offshore cetacean populations in UK waters that would be capable of detecting even large changes in population levels. Achieving this cost effectively will require the development of new methods, passive acoustic techniques are one promising possibility. Even with such programs, establishing direct cause and effect will be difficult and necessarily retrospective.
- **Development of effective mitigation**. Current mitigation practice is largely based on “common sense” measures and it is difficult establish whether they work and/or could be made more effective. (The effectiveness of seismic guidelines has been reviewed by Stone 1997, 1998, 2000; resulting in strengthening of monitoring and reporting requirements.) It will always be prudent to utilise effective mitigation measures, if they are easy to apply, even when harmful effects of noise have not been proven.

10.3.2 Light and airborne noise

The Assessment Workshop identified light and airborne noise as potential sources of significant effect on a number of receptors that should be assessed further. Such considerations only apply to activities very close to shore and for short term activities such as seismic and drilling can be mitigated to acceptable levels through technological measures, operational control including restrictions on the timing of activities and importantly through public and stakeholder consultation. Such activities have previously been successfully undertaken in onshore and nearshore areas by a number of small and large operators e.g. along the central English Channel coast (see for example Brocklehurst *et al.* 1989 and Hartley, 1990).

In addition, to additional mitigatory measures available to operators, activities in nearshore waters are subject to a range of additional statutory controls (see Section 3). These additional controls would apply to other stages of oil and gas activity and are regarded as adequate to ensure that these are designed and managed to a standard that would not result in significant effects. Consequently, light and airborne noise are not considered further in this SEA.

10.3.3 Physical disruption

10.3.3.1 Archaeology

The subject of prehistoric marine archaeological remains has received little attention in the planning or assessment of oil and gas activities. It was not addressed in SEA 2 and this gap was recognised by the SEA team, and was subsequently raised during scoping. A review of the topic was commissioned for SEA 3 (TR_014) covering the North Sea, which has emphasised the extensive nature and temporal span of such remains in the area.

Prehistoric submarine archaeological remains up to around 100,000 years old can occur over almost the whole floor of the North Sea and south of 52° 30' human artefacts as old as 500,000-700,000 years BP could survive on the sea floor. In practice, artefacts dating from the last 10,000-12,000 years have been found at sites across the southern North Sea, primarily recovered by commercial trawling. Most artefacts are scattered and isolated but the potential exists for important sites to be found, for example along the courses of former, now submerged river valleys. The report provides an overview of known and likely areas with prehistoric and archaeological remains but no submarine sites were identified as of such importance as to suggest exclusion of the area from licensing.

Oil and gas activities have the potential to damage such artefacts and sites, in particular through the trenching of pipeline into the seabed and through rig anchoring. However, oil and gas activity was also recognised to present the opportunity to provide beneficial new archaeological data, for example through rig site or pipeline route mapping and sediment coring. The report includes a summary of existing practices regarding the reporting, investigation and protection of prehistoric and archaeological remains.

The recognition of the importance of prehistoric submarine archaeological remains has led to a number of recent initiatives. Draft guidance has been produced for the British Marine Aggregate Producers Association and the Royal Commission on the Historical Monuments of England. This guidance aims to provide best practice and practical advice regarding the archaeological impacts of marine aggregate dredging. The SEA 3 report on marine archaeology includes some initial suggestions for discussion of protocols and a reporting regime relevant to the oil and gas industry.

In conclusion, while prehistoric marine archaeological remains will occur in the SEA 3 area, the benefits of new information that may flow from oil and gas activity in the area were judged to outweigh the potential damage to such remains. It is proposed that the subject of a reporting regime and access to suitable technical support and advice are followed with UKOOA and others as a mitigation measure for existing and potential future oil and gas activity in the North Sea.

10.3.3.2 Physical damage to biotopes and other seabed sensitive features

A number of receptors were identified in Appendix 2 as potentially susceptible to physical damage from SEA 3 oil and gas activities. However, with the exception of archaeological remains and remarkable benthic species or colonies, it is believed that the effects of the range of potential SEA 3 activities would be mitigated to acceptable levels by existing controls. In the case of archaeological remains and benthic fauna, there is a theoretical risk of serious damage from a range of human activities affecting the seabed. However, in the case of oil and gas activities pre-activity assessment and survey can be expected to identify the presence of exceptional features and to thus allow for either further investigation and/or alterations to planned activities so that such features are not damaged of unacceptable affected.

10.3.4 Physical presence

10.3.4.1 Fishery interactions

Mobile exploration activities (seismic and drilling) and the physical presence of offshore infrastructure required for production can both have significant direct effects on fishing activities within the affected area, in terms of:

- Loss of access due to exclusion zones and obstructions
- Safety risks associated with “fastening” of fishing gear to obstructions.

The SEA 3 Effects Assessment Workshop identified potential effects on inshore and offshore fishing as a significant issue. Offshore fishing activities and concerns were reviewed by CEFAS in a commissioned study for SEA 2, and the National Federation of Fishermen’s Organisations provided additional information on nearshore shellfisheries.

Exclusion from installation safety zones

The *Petroleum Act 1987* allowed for the creation of safety zones at all offshore surface installations and subsea structures, excluding pipelines. Under this legislation, a zone of 500m radius (an area of approximately 78 hectares) is created when surface structures such as platforms become operational, and when mobile drilling rigs are on-location. It is normal practice to apply for a safety zone around subsea developments, but these may not be marked with surface buoys. Without such visible markers, the offshore oil and gas industry is dependent on fishing vessels maintaining a safe distance from all seabed structures.

To ensure that the risk of fishery interactions is reduced, pipeline route and locations of subsea structures are notified to fishermen and other mariners through direct liaison with representative organisations and established publications such as Admiralty charts, Kingfisher charts and FishSafe computer systems. Support vessels normally patrol exclusion zones around manned platforms, and the proximity of other vessels can be monitored from the installations themselves.

In the early 1980's, it was estimated that the loss of fishing area in the North Sea caused by these zones was ~0.25% of the total area of the North Sea. Although this has increased over the last decade, the maximum loss of fishing area over the whole North Sea is less than 1%. Safety zones are listed by DEAL (Digital Energy Atlas and Library, http://www.ukdeal.co.uk/), and the extent of exclusion zones in the southern gas province of the North Sea is relatively low. Predicted activity levels in the SEA 3 area involve a total of 6-16 exploration wells, which will typically require a temporary (30-60 day) exclusion zone; 1-5 subsea tiebacks which may require exclusion zones; and 2 stand-alone developments requiring permanent exclusion zones.

The exclusion of fishing activity from these zones does not adversely affect fish catch rates, as fishing effort is simply diverted to other regions (CEFAS commissioned report). The loss of area does not result in a proportional loss of catch, and the individual zones themselves are so small that they do not completely obscure any one fishing ground.

Conversely, it has been thought that these safety zones may act as closed areas, protecting populations and individuals from capture by fishing gears and thereby enhancing the stock. There is little evidence to support this assertion.

Trawling interactions

The safety of all users of the sea must be of primary concern during the design and construction of sub-sea structures, particularly to ensure that if over-trawled, gears do not become snagged. Where possible, vulnerable structures such as templates, wellheads, subsea valve assemblies and manifolds are placed within a safety zone and provided with further protection such as a composite structure with a steel framework, designed with sloping sides to deflect trawls. Pipelines may be protected by the addition of a protective coating or by burial. In all cases these extra measures are expensive and the offshore industry has recently revised its guidelines to take account of recent advances in technology and the changing requirements of the industry (DNV 1997). For structures designed and built 10 or more years ago, the loads determined at the time may no longer be applicable to the heavier gears used by the more powerful fleets now operating in the North Sea. The potential for increased impact loads is considered during revisions to the Safety Case for a facility.

The decision as to whether a pipeline is trenched or placed on the sea bed is complex, taking into account the need for pipeline protection, the reduction of obstruction to fishing gears, seafloor conditions etc. Although pipelines can cause accidental interference, it has been reported that they are used by some trawlers as tows, presumably on the assumption that pipelines aggregate fish and so provide greater catch rates that similar tows nearby. A recent Norwegian study involving experimental trawling of pipelines with gill nets and otter trawls concluded that they had only limited ability to aggregate fish (Valdemarsen 1993, Soldal 1997). Since the loss of the trawler *Westhaven*, however, there have been a number of initiatives to ensure that pipeline spans and sub-sea structures do not pose a threat to fishing vessels.

Traditionally, pipelines of diameter less than 16 inches were buried for their own protection, while larger diameter pipelines were left on the seabed and were unlikely to be seriously damaged. Although there is evidence that pipelines up to a diameter of 40 inches cause only minimal gear damage, they can affect the gear geometry and efficiency once past the obstruction (Valdemarsen 1993). Even surface laid pipelines which are protected by rock dumping can also present a hazard to towed fishing gears (Soldal 1997).

Debris outside exclusion zones, such as containers lost from supply vessels in transit is also of concern to fishermen. All reasonable measures are taken by the industry to prevent losses and to recover debris where possible.

Interactions of fixed gear and E&P (seismic and pipelay)

Edible crab fisheries off the English coast are prosecuted primarily by vessels from Bridlington, Grimsby and ports along the north Norfolk coast. Although crab grounds in this region are mainly inshore, they can extend eastwards into the gas fields beyond the Silver Pit. Smaller inshore vessels may work a mix of crab and lobster pots, generally within a few miles of the coast.

Crabs are captured in traps (pots or creels), which are baited with fresh fish. The traps are shot in fleets of 20 or more depending on vessel size and are usually hauled once every 24 hours. Some of the larger vessels will work up to 1000 traps. The traditional crab fishery is seasonal with peak catches in May and June, although the peak value is typically in late summer. The fishery is now prosecuted throughout the year by many fishermen, supplying both the live continental market and the home processing market.

The major interaction of fixed gear fisheries and E&P results from seismic survey and (to a lesser extent) site survey and pipelay operations, since these vessels have restricted manoeuvrability and it is usually necessary to remove fishing gear for the duration of the operation. Installation exclusion zones, as discussed above, may also cause disruption to fixed gear fisheries.

In advance of exploration or development activities, particularly within important fishing areas (i.e. much of the inshore SEA 3 areas), established fisheries liaison mechanisms are used to minimise conflicts (through a combination of route selection, timing and operational procedures), and to agree management and control methods such as the use of seismic guard vessels (in many cases these are chartered fishing vessels). Where appropriate, financial compensation is normally agreed for temporary loss of access to fishing grounds.

Fisheries liaison is conducted in accordance with guidelines established by UKOOA.

Physical disturbance and discharge effects on commercial species

Indirect ecological effects on commercially targeted species (which could obviously result in economic impacts on fisheries) may result from impacts on benthic or pelagic prey species and predators, but are particularly of concern in relation to two species:

- **Herring**, which are demersal spawners and dependant on localised areas of suitable substrate (Section 6.5.3)

- **Edible crabs**, which support locally important fisheries, and (in comparison to most commercial fish species) are relatively sedentary (although they undertake seasonal migrations on- and offshore)

In general, effects on benthic populations and communities may result from smothering which can be direct (from physical disturbance or discharges of particulate material) or indirect (from winnowing of disturbed material). Effects on continental shelf infauna are normally short lived and similar to those from severe storms and dredge spoil disposal where recovery is normally well underway within a year (Rees *et al*. 1977, SOAEFD 1996). Habitat recovery from the processes of anchor scarring, anchor mounds and cable scrape will depend primarily on re-mobilisation of sediments by current shear. Bedforms in much of the southern SEA 3 area indicate active sediment erosion and transport, particularly in the vicinity of sandbanks (Section 6.3.5), and smothering effects are therefore unlikely to be significant at benthic population and community levels in the SEA 3 area.

However, herring eggs are believed to be particularly susceptible to smothering, and there has therefore been a requirement for many years that potential herring spawning areas are identified (by sidescan sonar and seabed sampling) in advance of drilling and development; and that appropriate mitigation such as timing and/or avoidance of specific areas is undertaken with the prior approval of regulatory agencies.

In addition to the potential effects of smothering, sediment plumes in the water column and settling to the seabed from construction activities and pipeline trenching activities can potentially result in effects on pelagic and benthic biota through clogging of feeding mechanisms, temporarily altering the nature of the seabed sediments or in near surface waters, reduction of light for photosynthesis (Newell et *al*. 1998). The extent of effects will vary according to the frequency of occurrence and the tolerance of the species involved, itself a function of the average and extreme natural levels of sediment transportation/deposition experienced in an area. Near-bed concentrations of suspended particulate material (SPM) in the coastal and southern SEA 3 areas are high, and the effects of anthropogenic sediment plumes are unlikely to be significant or long-term.

Control and mitigation

The principal control and mitigation measures in place to minimise effects on fisheries are the statutory consultation required under *The Offshore Petroleum Production and Pipe-lines (Assessment of Environmental Effects) Regulations 1999*, which includes regulatory agencies and advisers (SEERAD and CEFAS), national fisheries representative bodies and regional fisheries committees in

England. Local fisheries associations, which are usually sector-specific, will also be consulted where relevant (usually for inshore areas).

Guidelines have been established for fisheries liaison, and compensation mechanisms for gear damage are implemented through UKOOA.

Advance notice of exploration and production operations (and other marine activities) in UK national waters are provided through Coastguard broadcasts on VHF radio, and through published Notices to Mariners. To ensure that the risk of fishery interactions is reduced, pipeline routes and locations of surface installations and subsea structures will be notified to fishermen and other mariners through direct liaison at national and local levels and the established mechanisms:

- Admiralty charts
- Kingfisher charts
- FishSafe computer systems

Conclusions

Although exclusion can represent a significant conflict between fishing and production in intensively developed areas within established fishing grounds, the spatial extent of predicted temporary and permanent exclusion zones is unlikely to cause significant economic impacts. Additional in-field and export pipelines will be few in number, and designed to minimise risks of interactions with trawl gear. Short-term disruption to inshore and offshore fixed gear fisheries (mainly crab potting) may be necessary during seismic surveys, although the extent of this will be limited in view of the predicted level of activity.

The oil industry and UK fishing industry maintain consultation, liaison and compensation mechanisms, which should serve to mitigate and resolve any conflicts.

10.3.5 Marine discharges

10.3.5.1 Introduction

The SEA 3 Assessment Workshop identified a number of marine discharges from E&P operations as potential sources of significant environmental effect. These related primarily to produced water and drilling discharges.

10.3.5.2 Sources – produced water and other aqueous discharges

Marine discharges from exploration and production activities include produced water, sewage, cooling water, drainage and surplus WBM, which in turn may contain a range of hydrocarbons in dissolved and suspended droplet form, various production and utility chemicals, metal ions or salts (including Low Specific Activity (LSA) radionuclides). In addition to these mainly platform-derived discharges, a range of discharges are associated with operation of subsea developments (hydraulic fluids), pipeline testing and commissioning (treated seawater), and support vessels (sewage, cooling and drainage waters). The effects of the majority of these are judged to be negligible and are not considered further here.

Produced water is derived from reservoir (“fossil”) water and through condensation. The majority of produced water discharge volume to the North Sea is associated with oil production and produced water volumes from gas fields are extremely small in comparison.

Chemical composition and effects of produced water discharges have been reviewed previously (e.g. Middleditch 1981, 1984, Davies *et al*. 1987, Ray & Engelhardt 1992, E&P Forum 1994, Reed &

Johnsen 1996, OLF 1998). Chemical composition is strongly field-dependent, with generally little correlation between the oil-in-water content (which is used as the standard for environmental regulation) and the aromatic content (principally responsible for toxicity). Studies of acute and chronic toxicity of produced water in Norway (OLF 1998) concluded that Polycyclic Aromatic Hydrocarbons (PAH) and alkylated phenols were the major contributors, with immunotoxic, carcinogenic and teratogenic effects in the former, and possible oestrogenic effects in the latter case.

Other components of produced water include organic compounds (mainly volatile fatty acids), metals and residual process chemicals. None of these are considered likely to have significant effects (OLF 1998).

10.3.5.3 Sources – drilling wastes and other solid discharges

Drilling wastes are a major component of the total waste streams from offshore exploration and production, with typically around 1,000 tonnes of cuttings resulting from an exploration or development well. Cuttings are discharged at, or relatively close to sea surface during "closed drilling", whereas surface hole cuttings will be discharged at seabed during "open-hole" drilling

Levels of drilling activity identified for exploration and development of SEA 3 licence areas are a total of between 6 and 15 exploration and appraisal wells, together with between one and 5 subsea developments and up to 2 possible platform developments (Section 4.2). On the assumption that these developments will comprise one additional well each up to 7 development wells are forecast. Cuttings discharges from these activities would therefore total a maximum of around 22,000 tonnes, assuming the use of water-based muds. (Use of oil-based mud systems, for example in highly deviated sections or in halite sections, would require the onshore disposal or reinjection of a proportion of this material.)

Predicted drilling activity in blocks already licensed in the southern, central and northern North Sea, from DTI forecasts, suggests between 45 and 60 wells per year during the period 2002 – 2005 (i.e. annual cuttings discharges of around 50,000 tonnes). Forecast drilling discharges resulting from SEA 3 licence areas over the same period represent an annual increment of up to 10% on predicted North Sea discharges. It should be noted that the DTI forecast of drilling activity in existing licensed blocks is conservative (1999 and 2000 drilling activities were 261 and 249 wells respectively, DTI 2001) – the actual increment resulting from SEA 3 may therefore be less than 5%.

In 1999, 157,253 tonnes of water-based drilling chemicals and additives (including some 54,000 tonnes of barite and other weighting agents) were reported as being discharged to the UKCS (CEFAS commissioned study). These discharges resulted from 36 exploration/appraisal and 225 development wells (DTI 2001) together with workovers, giving an average WBM chemicals discharge of 603 tonnes per well. The predicted incremental annual discharge of WBM chemicals from SEA 3 related drilling represents a minor increase on 1999 values.

The contaminant composition of drilling wastes has changed significantly over the last few decades, in response to technical and regulatory developments. Previous widespread and substantial discharges of oil-based muds, and later synthetic muds, have been superseded by alternative disposal methods (either containment and onshore treatment, or reinjection) or by use of water-based muds.

Mud systems used in surface hole drilling for exploration wells are usually simple (seawater with occasional viscous gel sweeps) and would not result in significant contamination of sediments. However, the composition of closed drilling discharges likely to result from exploration, appraisal and development drilling (and to a lesser extent from well maintenance activities) is more complex, and will include cuttings (i.e. formation solids, in varying degrees of consolidation and in a range of particle sizes), barite, salts (sodium and potassium chloride), bentonite and a range of mud additives in much smaller quantities. Water-based mud additives perform a number of functions, but are predominantly polymeric organic substances and inorganic salts with low toxicity and bioaccumulation potential. In addition to mud on cuttings, surplus water-based mud may be discharged at the sea surface during or following drilling operations. Due to its density, a proportion of the particulate component of the mud (including barite) may settle in the immediate vicinity of the discharge.

A major insoluble component of water-based mud discharges, which will accumulate in sediments, is barite (barium sulphate). Barite has been widely shown to accumulate in sediments following drilling (reviewed by Hartley 1996). Barium sulphate is of low bioavailability and toxicity to benthic organisms (eg Starczak *et al*. 1992). Other metals, present mainly as salts, in drilling wastes may originate from formation cuttings, from impurities in barite and other mud components or from other sources such as pipe dopes. Although a variety of metals (especially chromium) are widely recorded to accumulate in the vicinity of drilling operations (e.g. Engelhardt *et al*. 1989, Kröncke *et al*. 1992), the toxicity of settled drill cuttings appears to be related primarily to hydrocarbon content, even in WBM discharges (e.g. ERTSL 2001).

10.3.5.4 Potential effects of produced water

Potential effects of produced water discharges include direct toxicity, organic enrichment, contaminant bioaccumulation and dissolution of particulates and precipitates. Some slight elevation in the sea temperature may occur in the immediate vicinity of the discharge. These effects may be of significance in terms of:

- Chronic accumulation of persistent contaminants in the marine environment
- Acute or chronic effects on biota, including effects on productivity, within the human foodchain (ie indirect effects on human health and commercial interests)
- Acute or chronic effects on other biota (i.e. indirect effects on biodiversity)

The toxic effects of produced water are influenced by bulk dispersion and dilution processes following discharge, and potentially by bioaccumulation and biomagnification of individual contaminants. Direct measurement of dispersion and dilution of gas platform produced water discharges is difficult given the low volumes of discharged water.

The studies of produced water toxicity and dispersion (see E&P Forum 1994, and OLF 1998), concluded that the necessary dilution to achieve a No Effect Concentration (NEC) would be reached at 10 to 100m and certainly less than 500m from the discharge point.

Dispersion of discharged effluents in the SEA 3 areas will be influenced by the hydrographic regime, in the southern area primarily by tidal currents. Wave-induced turbulence will be a significant dispersion mechanism in the North Sea under typical weather conditions, particularly with respect to vertical mixing. In practice, noting the dilution ranges necessary to achieve NECs for individual produced water components, regional hydrographic considerations will be of minor relevance as extremely low contaminant concentrations are achieved through turbulent dispersion in close proximity to the discharge.

The eventual fates of produced water discharges are poorly known. Although it might be expected that volatile hydrocarbon fractions will evaporate to atmosphere or be metabolised by marine organisms in the water column, surface adsorption onto particulates and subsequent incorporation into sediments is a more likely fate for persistent organic compounds and metals. At present, however, quantitative understanding of these processes is lacking.

The environmental effects of produced water discharges can be mitigated through volume reduction, improved treatment prior to discharge, and alternative disposal methods (e.g. reinjection). There is an OSPAR presumption against discharging produced water from new developments.

10.3.5.5 Potential effects of drilling discharges

The past discharge to sea of drill cuttings contaminated with oil based drill mud resulted in well documented acute and chronic effects at the seabed (e.g. Davies *et al*. 1989, Olsgard & Gray 1995, Daan & Mulder 1996). However, through OSPAR and other actions, the discharge of oil based and other organic phase fluid contaminated material is now effectively banned and the effects of such discharges are not considered relevant to the SEA 3 process.

In contrast to oil based mud discharges, effects on seabed fauna of the discharge of cuttings drilled with WBM and of the excess and spent mud itself are subtle or undetectable, although the presence of drilling material at the seabed is often detectable chemically (e.g. Cranmer 1988, Neff *et al*. 1989, Hyland *et al*. 1994, Daan & Mulder 1996). Considerable data has been gathered from the North Sea and other production areas, indicating that physical disturbance is the dominant mechanism of ecological disturbance where water-based mud and cuttings are discharged.

Water based muds are of low inherent toxicity (see Ray *et al*. 1989, ERTSL 2001) and toxicological studies of the major individual constituents have reported limited or no effects (e.g. Tagatz & Tobia 1978, Starczak *et al*. 1992).

Surface hole cuttings (surficial and shallow formation sediments with small quantities of gel sweep additives) are normally discharged at the seabed. Subsequent discharges of WBM cuttings from closed drilling are dispersed more widely in the water column, and deposition is often detectable only through chemical analysis of characteristic tracer components (e.g. barium). Quantities of cement may also be discharged directly to seabed during installation of casing.

Surface hole cuttings piles in the SEA 3 area will be dispersed, typically over a time scale of 1-5 years, mainly through re-suspension and bedload transport due to tidal and wave-induced currents.

Near-bed current velocities and sediment mobility in the southern North Sea are generally sufficient to prevent detectable local accumulation of cuttings. Significant topographic depressions (e.g. "Pits" present north of the Norfolk Sandbanks) could act as depositional sinks, although the majority of these features appear to be tidally scoured, with little evidence of recent deposition. Circulatory residual currents around sandbanks result in accretion over bank crests and a proportion of WBM cuttings discharges in southern North Sea areas may be deposited over such features.

Reported accumulation of barium in depositional areas of the Skagerrak (OSPAR 2000) may also be linked to wide area dispersion of cuttings from the North Sea, including southern areas from where sediment transport processes may move particulate contaminants over considerable distances.

In contrast to the general picture of limited effects of WBM discharges, Cranford & Gordon (1992) reported low tolerance of dilute bentonite clay suspensions in sea scallops (*Placopecten magellanicus*). Cranford *et al*. (1999) found that used water based mud and its major constituents, bentonite and barite caused effects on the growth, reproductive success and survival of sea scallops, which were attributed to chronic toxicity and physical disturbance. It may be that *Placopecten* is especially sensitive to drill muds (or fine sediments in general) or that in the field, water based drilling discharges very rapidly disperse to below effective concentrations.

Studies of the effects of water based mud discharges from 3 production platforms in 130-210m off California found significant reductions at some stations in the mean abundance of 4 of 22 hard bottom taxa investigated using photographic quadrats (Hyland *et al*. 1994). Hyland *et al*. (1994) concluded that these reductions reflected possible negative responses to drilling discharges, attributed to the physical effects of particulate loading, namely disruption of feeding or respiration, or the burial of settled larvae. It is unlikely that drilling over hard seabed substrates would occur in the SEA 3 areas.

10.3.5.6 Control and Mitigation

Produced water discharges are regulated under the *Prevention of Oil Pollution Act 1971* with limits set for the proportion of oil in water (currently 40 mg/litre) and the daily flow which may be discharged. Through OSPAR, the UK is committed to a 15% reduction in total discharged volume of oil in produced water by 2006 and there is a presumption against discharge from new developments. Chemical use has been monitored through the OCNS which has been superseded by the new chemical regulations (*Offshore Chemicals (Pollution Prevention and Control) Regulations 2002*). These regulations introduce a new permit system for the use and discharge of chemicals offshore and include a requirement for site specific risk assessment.

The management of produced water and chemical discharges will continue to be a key issue addressed through the environmental assessment process for planned developments (under *The Offshore Petroleum Production and Pipe-lines (Assessment of Environmental Effects) Regulations 1999*).

Solid and aqueous waste discharges from exploration and production operations are also regulated under the *Prevention of Oil Pollution Act 1971*, and are exempted (at the point of production) from the *Food and Environment Protection Act 1985*. Discharges associated with specific exploration drilling or development projects in the licensed areas require to be assessed under the *Offshore Petroleum Production and Pipe-lines (Assessment of Environmental Effects) Regulations 1999*.

Alternative disposal methods for cuttings, including onshore treatment and reinjection as currently implemented for oil and synthetic-based muds, may also be feasible for drilling with water-based mud (for example, if particular benthic biotope sensitivities were identified).

10.3.5.7 Conservation sites

Any potential offshore conservation sites and additional sites in territorial waters in the SEA 3 area, would be designated primarily with regard to seabed features (sandbanks and reefs), and associated benthic communities (see Section 7). Given the small volumes of gas field discharges and their dispersion by tidal and other currents, effects on the benthos of designated offshore conservation sites are unlikely.

Cuttings discharges could, if a well location was sufficiently close to a designated site, disperse over or accumulate in it, with potential effects on benthos. This is probably unlikely in view of the small number of wells forecast, and the locations of potential features of designation. However, potential effects from specific projects would require to be evaluated (through the Appropriate Assessment mechanism) and mitigation measures adopted.

10.3.5.8 Conclusions

The environmental effects of produced water discharges are limited primarily by dispersion, below NEC.

Discharges of WBM cuttings in the North Sea have been shown to disperse rapidly and to have minimal ecological effects. Dispersion mechanisms could, in theory, lead to localised accumulation in relation to topographic features (sandbank crests) although this is considered unlikely to be detectable.

10.3.5.9 Ballast water exotics

There have been a number of deliberate and accidental introductions of marine animals and plants to the North Sea and UKCS. The actual or potential introduction of exotic species through vessel ballast water discharges has been an issue for a number of years and was a specific part of the remit of the review conducted for SEA 2 by the Sir Alister Hardy Foundation for Ocean Science (see TR_005 Section 14). The report summarises changes in plankton communities of the North Sea and adjacent areas due to either natural changes in distribution attributed to climatic shifts, and accidental introductions of non-native species.

Introduced, non-native species can have a number of negative effects from disease to damaging native bio-diversity. In response to this a number of technical and procedural measures have been proposed (such as the use of ultraviolet radiation to treat ballast water) or introduced such as a mid-ocean exchange of ballast water (the most common form of preventing invasion by non-native species). In addition, the International Maritime Organisation (IMO) proposed voluntary guidelines for the control and management of ships' ballast water in Agenda 21 at the United Nations Conference on Environment and Development (UNCED) in 1992. This was adopted in Resolution A.868 (20) Agenda item 11, in 1997.

The potential for oil and gas activities involving ballast water discharge that might follow SEA 3 licensing is seen as remote. This is because the majority of ballast water is carried by ships and gas production from the area would be exported by pipeline, and in view of the limited number of wells anticipated the likelihood of the use of a rig which has just transatlantic (or wider) transfer is very low.

As an additional mitigation, the current IMO voluntary guidelines on ballast water management should be followed for SEA 3 and wider North Sea oil and gas activities.

10.3.6 Subsurface discharges

A range of subsurface discharges may be made as a result of oil and gas activities. Of prime relevance to the SEA 3 area would be drill muds and cuttings which may be ground and reinjected to rock formations rather than discharged to sea or returned to land. The target formation(s) for reinjection of such materials is selected on the basis of geological understanding from previous drilling in the area, with performance monitored over time. Any release to sea or to other unintended rock strata is regarded as an accident and considered later in Section 10.

10.3.7 Atmospheric emissions

10.3.7.1 Introduction

Atmospheric emissions from offshore exploration and production of oil and gas contribute to reduction of local air quality, and to atmospheric concentrations of greenhouse and acid gases on a global scale. Following consideration of the predicted scale of emissions associated with potential activity in the SEA 3 areas, the Assessment Workshop concluded that potential effects of emissions on local air quality may require further consideration.

The SEA 3 assessment considers the potential environmental effects of further licensing to oil and gas exploration and production activity in terms of continued or future non-oil and gas uses, environmental contamination, biodiversity and conservation of the area. The wider policy issues of continued oil and gas production from the UKCS and sustainable development of the overall national hydrocarbon reserves, specifically with regard to greenhouse gas emissions and UK commitments under the Kyoto Protocol, are not considered since these are subjects for a different appraisal forum.

10.3.7.2 Sources

The major sources of emissions to atmosphere are internal combustion for power generation by installations, terminals, vessels and aircraft, flaring for pressure relief and gas disposal, cold venting and fugitive emissions.

Power requirements for the offshore industry are dominated by oil production installations (typically >50MW per platform), with smaller contributions from gas platforms and mobile drilling units (typically 10MW per unit) and support vessels. The major energy requirement for production is compression for injection and export, with power generated by gas or dual-fuel turbine. Fuel gas accounted for 59.5% of total CO_2 emissions from the UKCS in 1998 (UKOOA 1999).

Short-term trends in emissions from exploration and production are variable – from 1996-1998, CO_2 emissions increased slightly (by 5%), methane emissions decreased by more than 10%, and NOx emissions have increased by 14% (UKOOA 1999).

Flaring from existing UKCS installations has been substantially reduced relative to past levels, largely through continuing development of export infrastructure and markets, together with gas cycling and reinjection technologies. Total flaring (excluding terminals) on the UKCS averaged 4.76 million m^3/d in 2000, compared to 6.48 million m^3/d in 1991 (DTI 2001).

New developments will generally flare in substantial quantities only for pressure relief, with “zero routine flaring” now considered a realistic design target for planned developments. Other than start-up flaring, subsea tie-back developments, which are predicted to account for the majority of production from proposed licence areas, will generally have little effect on host platform flaring.

10.3.7.3 Potential effects

Gaseous emissions from the combustion of hydrocarbons and other releases of hydrocarbon gases contribute to atmospheric concentrations of greenhouse gases, acid gases and reduction in local air quality.

Atmospheric greenhouse gases include carbon dioxide (CO_2), methane (CH_4), and oxides of nitrogen (NO_X). Man-made emissions of greenhouses gases (particularly CO_2) are implicated in amplifying the natural greenhouse effect resulting in global warming and potential climate change (IPCC 1995). The potential effects of emissions of greenhouse gases are therefore global in scale.

Atmospheric acid gases include sulphur dioxide (SO_2) and oxides of nitrogen (NO_X). These gases react with water vapour forming acids, and increasing the acidity of clouds and rain which can result in vegetation damage, acidification of surface waters and land, and damage to buildings and infrastructure. In addition these gases can transfer directly to terrestrial surfaces through dry deposition (close to the source) causing similar damage to acid rain (UKTERG 1988). The potential effects of emissions of acid gases are considered to be most important at a regional scale.

Reduction in local air quality through inputs of contaminants such as oxides of nitrogen (NO_X), volatile organic compounds (VOCs) and particulates, which contribute to the formation of local tropospheric ozone and photochemical smogs, which in turn can result in human health effects (EPAQS 1996).

10.3.7.4 Conclusions

Potential environmental effects of acid gas and greenhouse emissions are, respectively, regional and global in nature. Local environmental effects of atmospheric emissions are not expected to be significant, in view of the high atmospheric dispersion associated with offshore locations.

Significant combustion emissions from flaring are not expected from potential development in the possible SEA 3 licence areas, in view of regulatory controls and commercial considerations, and combustion emissions from power generation are unlikely to represent a major contribution to industry or national totals.

10.3.8 Wastes to shore

Environmental receptor interactions with wastes to shore, in particular air quality, onshore land use and cumulative effects were identified in Appendix 2 as having potentially serious effects. The return of drill muds and cuttings to shore for treatment and disposal was classed as having potentially major effects. Given the limited number of wells projected to flow from licensing in the SEA 3 area (up to 22 over four years), that many or most would be drilled with water based drill fluids, and that interfield transfer of oily cuttings for reinjection is shortly expected to be permitting in UK waters, it is unlikely that major effects would result.

Similarly, air quality and cumulative effects were classed as having potentially moderate effects. In view of the very limited volumes of material (drilling wastes and general oilfield waste) likely from drilling or operations together with the stringent control of waste disposal activities under IPPC and the Landfill Directive it is believed that any effects on land will be negligible.

A number of subsea tiebacks and up to 2 small platforms are projected to be the likely scale of field development in the SEA 3 area. At the end of field life these facilities would be either removed for reuse or for recycling. The bulk of any returned material for recycling would be steel, for which there is a ready market and consequently significant cumulative or air quality effects are not viewed as likely.

10.3.9 Accidental events

10.3.9.1 Oil spill – nearshore diesel spills

Introduction

Oil spills are probably the issue of greatest public concern in relation to the offshore oil and gas industry. A major feature of oil and gas production on the UKCS is the distinction between oil (and condensate) fields in the central and northern North Sea, and gas fields in the southern North Sea including the SEA 3 area. Large oil spills resulting from E&P are potentially associated with export (pipeline and tanker loading sources), with the additional potential for uncontrolled oil blowout, and significant spill risks are therefore limited to central and northern North Sea areas. The largest inventories of persistent oil associated with E&P in southern gas field areas, including the SEA 3 area, are of drilling rig or support vessel fuel oil and oil based drilling fluids.

Environmental risk is generally considered as the product of probability (or frequency) and consequence. The environmental consequences of oil spills are associated primarily with seabirds, marine mammals, fisheries and coastal sensitivities; and are considered in Section 6. The sources, frequency and scale of hydrocarbons spills are considered below.

Spill scenarios and frequency analysis

Hydrocarbon spills have been reported from exploration and production facilities on the UKCS since 1974 under PON1 (formerly under CSON7), with annual summaries published in the "Brown Book" series (now superseded by on-line data available from the DTI website www.og.dti.gov.uk). This data – the DTI PON1 database – has been widely used for risk assessment in the preparation of the previous SEAs, project Environmental Statements and Oil Spill Contingency Plans for exploration wells and developments in licensed areas of the UKCS.

A geographically wider database, collated by SINTEF, includes reported well control incidents (i.e. "blowouts" involving uncontrolled flow of fluids from a wellbore or wellhead) from the North Sea and Gulf of Mexico from 1957 (Holand 1996).

Since 1986 the UK has carried out unannounced surveillance flights over offshore installations in accordance with international obligations under the Bonn Agreement. The Scottish Fisheries Protection Agency, DEFRA and the Maritime and Coastguard Agency also undertake routine overflights of the UK waters. The DTI works closely with these agencies to ensure that any oil spill emanating from an offshore installation is reported, so the effective level of surveillance is significantly greater than the 300 hours currently funded. In particular, the Maritime and Coastguard Agency routinely survey the gas platforms in the Southern North Sea.

In 2000, 300 hours were flown on 55 ‘dedicated’ oil rig patrols i.e. those funded solely by the DTI. In total, 2,219 surveys of installations were undertaken during which the total amount of oil observed from unreported spills was just over 1 tonne from 32 separate detections (DTI 2001).

The Department uses a computer link to the aerial surveillance aircraft which transmits photographic images of pollution incidents and enables the Department to investigate oil spill incidents as they happen. The Department is currently upgrading the computer link to include the transmission of video imagery.

Blowouts, which may involve liquids or only gas (with no concomitant risk of oil spill to sea), are extremely rare in modern drilling, with a range of historical frequencies quoted by previous Environmental Statements (reviewed in SEA 1). Recommended blowout frequencies as input basis data for risk analysis of North Sea installations are provided by Holand (1996, Table 12.2), based on the SINTEF database. These vary from 0.0049 shallow gas blowouts/well for exploration drilling, to 0.00005 blowouts per production well-year (equivalent to 0.00075 assuming a typical 15 year well life). The recommended frequencies do not distinguish between gas and oil, which makes application to spill risk assessment difficult.

The UK Health and Safety Executive’s Offshore Safety Division records well kicks, involving an unexpected but controlled flow of formation fluids into the wellbore, including “serious” kicks defined as those that posed a safety hazard to personnel on the installation or had the potential to cause a significant safety hazard (Hinton 1999). Between 1988 and 1998, 52 serious kicks were recorded from 3,668 UKCS wells (an occurrence rate of 1.4%), none of which resulted in pollution (most kicks involved gas). The only significant blowouts on the UKCS to date have been from *West Vanguard* (1985) and *Ocean Odyssey* (1988), both involving gas.

In summary, it can be concluded that there is negligible risk of significant oil spill to water resulting from blowouts or well control problems in the southern gas sector (including the SEA 3 area). There is a very small probability that catastrophic damage to a drilling rig or production gas platform, resulting from a gas blowout, could result in loss of relatively small quantities of fuel and other oil inventories held on the installation.

Similarly, there is no risk of oil spill from infield flowlines, risers and topsides processing resulting from gas production (DTI PON1 data indicates that these sources are the most frequent sources of spills from oil production operations in the central and northern North Sea, with most spills being <1 tonne).

The major types of spill from mobile drilling rigs during exploration and development drilling have been organic phase drilling fluids (and base oil), diesel and crude oil. There has been a correlation between the number of reported spills and number of wells drilled, but no consistent trend in the volume of hydrocarbons spills from mobile rigs since 1984 (a marked increase between 1986-1993, with a subsequent decrease to <100 tonnes/year). The proportion of total oil spilled from mobile rigs and fixed installations, due to oil-based mud, has dramatically reduced from 64.7% in 1993 to 0.6% in 2000.

For the UKCS as a whole, the total amount of oil spilled during 2000 was 78 tonnes which continues the downward trend of recent years (DTI 2001). The number of reports made to the DTI increased from 372 in 1999 to 423 in 2000. It is clearly evident that the trend for reporting even the smallest of spills continues, with 405 reports for spills of less than 1 tonne; these represent 96% of reports.

Spill fate

The fate of oil spills to the sea surface is relatively well understood and the eight main oil weathering processes listed below, were summarised in SEA 2 (Section 10.4.7.3):

- Evaporation
- Dispersion
- Emulsification
- Dissolution
- Oxidation
- Sedimentation/Sinking
- Biodegradation
- Combined processes

Spill trajectory

Oil spill trajectory modelling can be carried out deterministically (i.e. with defined arbitrary weather conditions, usually "worst case") or stochastically (i.e. using statistical distributions for wind and current regimes). Quantitative spill trajectory modelling has not been carried out as part of the SEA process, since the results of numerous modelling exercises are available in Environmental Statements and Oil Spill Contingency Plans prepared for exploration wells and developments the southern North Sea.

For illustrative purposes, deterministic calculations have been carried out to estimate the time to beach from the most prospective areas within the SEA 3 region, where exploration and production activities are most likely; to either the closest landfalls or to adjacent significant coastal sensitivities (Figure 10.3). These calculations have assumed a constant 30 knot wind speed (consistent with "Essential Elements" criteria for oil spill response measures used in UKCS licence conditions) and that a slick front will move at 3% of wind speed. Time to beach has also been calculated for summer and winter average wind speeds recorded from the area (derived from the North Sea Pilot).

The shortest distances to land are from the SEA 3 Rotliegend Flank Trend prospects; north-central blocks of Quadrants 52-54 to the Norfolk coast, and from blocks close to the north coast of East Anglia in Quadrant 47. For the purposes of this assessment, a distance to shore of 22km has been taken as representative, with a corresponding "Essential Elements" time to beach of 10 hours. A time to beach of 24h is calculated from Quadrant 52 to the Wash.

The Mid North Sea High and Carboniferous Trend prospective areas in the northern SEA 3 area are considerably further offshore, with "Essential Elements" time to beach in excess of 100h, indicating that beaching of a diesel or low persistence spill is very unlikely.

Throughout most of the SEA 3 area, with the exception of inshore parts of the southern area, tidal current velocities are relatively low and oil spill trajectory will be most influenced by wind. Most frequent wind directions vary seasonally and throughout the SEA 3 area, but are generally offshore (i.e. away from adjacent UK coastline) with the exception of the southern SEA 3 area in summer, when east or southeast winds are most frequently recorded. Estimated "Essential Elements" time to beach at various points in Belgium, the Netherlands and Denmark range from 105 to 180 hours.

It should be noted, however, that dominance by winds from any direction is low and wind (and therefore wind-driven oil spill track) may occur in any direction throughout the year.

Figure 10.3 – Distances and beaching times to land from most prospective SEA 3 areas

Ⓐ Mid North Sea High - Denmark, trajectory distance 300km (approx)

Time for oil to beach (assuming an onshore wind)

wind strength (knots)	time (hrs)	most frequent wind direction
30	180	–
12 (winter average)	450	SW (Winter)
10 (summer average)	540	NW / W (Summer)

Ⓑ Carboniferous Trend (Q43-44) - Flamborough Head, trajectory distance 190km (approx)

Time for oil to beach (assuming an onshore wind)

wind strength (knots)	time (hrs)	most frequent wind direction
30	114	–
12 (winter average)	285	SW (Winter)
10 (summer average)	342	NW / W (Summer)

Ⓒ Carboniferous Trend (Q43-44) - Friesian Islands, trajectory distance 240km (approx)

Time for oil to beach (assuming an onshore wind)

wind strength (knots)	time (hrs)	most frequent wind direction
30	144	–
12 (winter average)	360	SW (Winter)
10 (summer average)	432	NW / W (Summer)

Ⓓ Rotliegend Flank Trend (Q47) - Wash, trajectory distance 40km (approx)

Time for oil to beach (assuming an onshore wind)

wind strength (knots)	time (hrs)	most frequent wind direction
30	24	–
12 (winter average)	60	SW (Winter)
10 (summer average)	72	SW / W (Summer)

Ⓔ Rotliegend Flank Trend (Q52-54) - Norfolk Coast, trajectory distance 22km (approx)

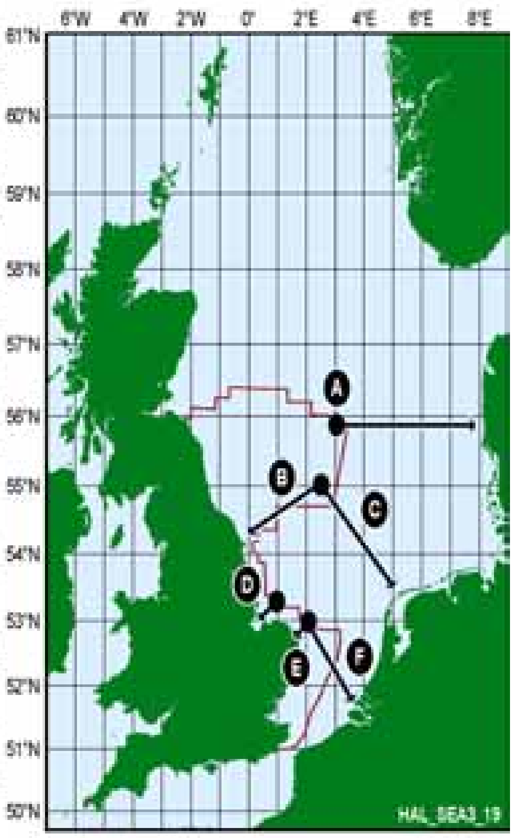
Time for oil to beach (assuming an onshore wind)

wind strength (knots)	time (hrs)	most frequent wind direction
30	13	–
12 (winter average)	33	SW (Winter)
10 (summer average)	38	SW / W (Summer)

Ⓕ Rotlielegend Flank Trend (Q52-54) - Scheldt Estuary, trajectory distance 175km (approx)

Time for oil to beach (assuming an onshore wind)

wind strength (knots)	time (hrs)	most frequent wind direction
30	105	–
12 (winter average)	262	SW (Winter)
10 (summer average)	315	SW / W (Summer)



Offshore ecological effects – seabirds and marine mammals

Offshore seabird and sea mammal sensitivities were reviewed in Section 6.

Overall seabird vulnerability to surface pollution is very high in parts of Quadrants 27, 34, 35, 40, 41, 42, 43 and 47 within the SEA 3 area (Figure 6.8). Much of the seabird vulnerability is associated with proximity of breeding colonies and post-breeding dispersal of auks and is therefore seasonal. A proportion of coastal blocks between Flamborough Head and the Farne Islands are highly vulnerable for 6-8 months but even here there are periods within which vulnerability is lower which could form operational windows for certain oil and gas operations.

Direct mortality of seabirds from an oil spill is an issue of major public concern, although exploration and production to date in the North Sea has resulted in very few attributable impacts. Nevertheless, spills affecting waters with high vulnerability could have catastrophic results at a local and population level (Tasker 1997). Seabirds are affected by oil pollution in several ways, including oiling of plumage and loss of insulating properties, and ingestion of oil during preening causing liver and kidney damage (Furness & Monaghan 1987).

The areas with consistently high seabird vulnerability are generally at distances of >100km (60h under "Essential Elements" conditions) from prospective areas of the Carboniferous Trend and Rotliegand Flank Trend. Given the low persistence of potential spills from gas exploration and developments, seabirds are not considered to be exposed to a significant incremental risk as a result of SEA 3 licensing.

There is relatively little information concerning the effects of oil spills on marine mammals (SMRU TR_006 Rev 1). Direct mortality from oil exposure has rarely been reported, and has usually been associated with major oil spills such as the *Exxon Valdez* in Alaska. High concentrations of phenanthrene and naphthalene were reported in the bile of oiled harbour seals (*Phoca vitulina*) collected following the spill (up to 23 times higher than in control seals) and high concentrations of PAHs in the blubber (up to 400 ppb) (Frost & Lowry 1993). Due to the condition of many of the carcasses examined it was difficult to attribute cause of death to oil toxicity, but many animals exposed to oil did develop pathological conditions. Additional pup mortality was also reported in areas of heavy oil contamination compared to unoiled areas.

More generally, marine mammals rely on their blubber for insulation and are thus less vulnerable than seabirds to fouling by oil (Geraci & St Aubin 1990). However, they are at risk from hydrocarbons and other chemicals that may evaporate from the surface of an oil slick at sea within the first few days. Seals often barely raise their nostrils above the surface of the water when they breathe, so a seal surfacing in a fresh slick is likely to inhale vapours. Cetaceans also typically inhale close to the surface. Symptoms from acute exposure to volatile hydrocarbons include irritation to the eyes and lungs, lethargy, poor coordination and difficulty with breathing. In severe cases, individuals may drown as a result of these symptoms.

Coastal ecological effects

Seabirds in the vicinity of major breeding colonies are highly vulnerable to oil spills, particularly those species which spend most of their time on the water (e.g. auks). However, the large cliff-based breeding colonies are all north of Flamborough Head, and are distant from prospective SEA 3 areas. Seabird colonies south of the Humber are predominantly gull and tern sites, and these species have relatively low vulnerability to oil spills.

The vulnerability of coastal waterbirds (including ducks, geese and waders) has not been quantified with a methodology comparable to the seabird OVI. In general, the following considerations are relevant:

- The seasonality of vulnerability, in most cases, is high with particular exposure of important biogeographical populations during migration periods

- The local distribution of most waterbird species does not expose them to a high risk of contact with oil spilled at sea – many species rely on saltmarsh and estuarine sites. However, it is noted that persistent oil in embayments (such as the Wash) and estuaries may be very difficult to deal with, as use of dispersants is unlikely to be appropriate. Oil deposited on intertidal flats may be slow to degrade (Gundlach & Hayes 1978) and large numbers of waterbirds may be at risk

- The Wash and North Norfolk are important areas for waterbirds, particularly in autumn and winter, and are relatively close to the Rotliegend Flank Trend prospects; north-central blocks of Quadrants 52-54 to the Norfolk coast, and from blocks close to the north coast of East Anglia in Quadrant 47. Even though these are gas prospects and spill risks are low, block-specific licence conditions may be appropriate to manage spill risks associated with bunkering and bulk transfers to mobile drilling units.

Grey and harbour seals come ashore regularly throughout the year between foraging trips and additionally spend significantly more time ashore during the moulting period (February-April in grey seals; August in harbour seals) and when pupping (October-December in grey seals; June-July in harbour seals). Animals most at risk from oil coming ashore are young pups. These animals are born without blubber and rely on their prenatal fur and high metabolic activity for thermal balance. They are therefore more susceptible than adults to external oil contamination (Ekker *et al*. 1992). Grey seals remain on the breeding colonies until they are weaned and unlike adults or juveniles, would be unable to leave the contaminated area. Females may also abandon contaminated pups during an oil spill, leading to starvation and premature death. The Wash population of harbour seals is probably most at risk from spills originating from the Rotliegand Flank Trend prospective areas, although the increase in overall level of risk resulting from SEA 3 licensing is regarded as low. Grey seal breeding populations on the Farne Islands are a considerable distance from prospective SEA 3 areas and oil spill impacts resulting from SEA 3 licensing are unlikely.

Coastal, intertidal and maritime habitats are also at risk from oil spills, either through direct contact with surface slicks, or through wind-blown oil (or dispersant). The major risks of persistent oil spills throughout the SEA 3 coastline are associated with shipping and particularly tanker traffic (Lord Donaldson 1994), to which SEA 3 related activities represent very little incremental risk. There are high levels of tanker traffic within the recognised lanes leading to and from the Channel, ports on the east coast of England, and Rotterdam (Section 8.4). In many cases these routes are close to shore and limited time is available for mounting spill response measures.

Fishery effects

All hydrocarbon spills have the potential to affect fish and shellfish populations by tainting, caused by ingestion of hydrocarbon residues in the water column and on the seabed. If large-scale releases of heavy oil were to reach the seabed then there is potential for smothering of features that are used by fish either as spawning, feeding or nursery grounds.

In the event of a substantial oil spill from an offshore installation, the *Food and Environment Protection Act 1985* (FEPA) enables Ministers to establish temporary fishing exclusion zones which prevent fishing for a fixed period of time. As a recent example, such fisheries exclusion zones were established in the aftermath of the *Braer* and *Sea Empress* oil spill incidents (which were related to transport of crude oil rather than to the exploration and production of hydrocarbons). The *Braer* spill had particularly severe effects on the fish farming industry in the Shetland Islands, while commercial fishing activities were only affected in a small area of the Burra Haaf.

The exclusion of commercial fishing activity would only be lifted when monitoring studies showed that fish and shellfish in potentially contaminated areas were of a suitable standard for human consumption.

Experience (e.g. the *Braer* spill) also indicates that irrespective of actual contamination levels and closures, spills may result in significant loss of public confidence in seafood quality from the perceived affected area, and therefore in sales revenue. Either perceived or actual contamination of target species with hydrocarbons or other chemicals may therefore result in economic damage to the inshore fishing industry, aquaculture and associated processing and support industries.

As discussed above, the incremental risk associated with SEA 3-related activities is considered to be very small.

Control and mitigation

Spill prevention measures and mitigation proposed for all phases of offshore exploration and production include spill prevention and containment measures, risk assessment and contingency planning. Minimum beaching times from some parts of the possible licence area with sustained 30 knot winds, are very short and may not provide sufficient time for full spill response mobilisation. Tiered response resources, available through Government and industry contingency arrangements, include facility for large-scale aerial application of dispersants within a few hours, if consultation with regulatory agencies judges this to be appropriate. Coastal oil spill risks would be a key issue in assessment and risk management of proposed developments, under *The Offshore Petroleum Production and Pipe-lines (Assessment of Environmental Effects) Regulations 1999* and *The Merchant Shipping (Oil Pollution Preparedness, Response and Co-operation) Regulations 1998*.

Coastal oil spill contingency response arrangements are currently the responsibility of local authorities. Following previous licence Rounds, Operators of nearshore blocks have consulted and co-operated with local authorities on contingency planning, and in some cases have developed Coastal Protection Plans; and trained local authority personnel and provided response equipment.

The use of dispersants is a key aspect of UK oil spill response strategy for areas where there are no ecological or fisheries conflicts. However, for oils that rapidly disperse and evaporate naturally such as diesel, dispersants are unlikely to be applied, particularly as DEFRA is unlikely to grant approval in shallow coastal waters. For more background see
http://www.defra.gov.uk/environment/marine/oilspill/oil-gas.pdf .

Seabird vulnerability data gaps are present for relatively few of the SEA 3 area blocks, only blocks in Quadrants 27 and 28 having two or more months unsurveyed for seabird distribution, although there are some sensitive areas in Quadrants 35 (offshore Northumberland) and 47-48 (offshore from the Wash) for which vulnerability data for individual months are lacking. Contingency planning for activities close to these areas would need to take note of these gaps, particularly with regard to the consequent difficulty in deciding whether application of chemical dispersants is appropriate.

Conclusions

Overall, incremental risk of oil spills associated with exploration and development is very low in the SEA 3 area, where production can be expected to involve gas. In the event of a spill of persistent oil from SEA 3 area activities, and without an effective response, oiling of adjacent coasts is possible, although the volumes of such materials potentially spilled or beaching would be small. However, specific risk assessments of proposed activities are mandated together with the implementation of contingency measures to mitigate risks.

Cumulative effects are considered here as identified effects from E&P activities resulting from the proposed 21st Round licensing, which have potential to act additively with those from other oil and gas activity (including both existing activities and new activities in existing licensed areas). Synergistic effects are considered to be potential effects of E&P activities which act additively with those of other human activities (eg fishing and crude oil transport).

To some extent, all potential **sources** of effect (i.e. disturbance, emissions and discharges) resulting from oil and gas activity within the southern North Sea are cumulative, in so far as they are incremental to previously existing sources. Sources have therefore been quantified, based on predicted activity scenarios, and placed in the context of existing activities so far as possible throughout the assessment. However, **effects** are considered cumulative only if the "footprint" of a particular project overlaps with that of adjacent activities or if transient effects are produced sequentially.

10.4 Cumulative and synergistic effects

As noted above, the SEA Directive requires *inter alia* that cumulative and synergistic effects should be considered. Stakeholder consultation has confirmed the importance of cumulative effects within the overall process (SEA 2 Post Public Consultation Report). The approach adopted for assessment of cumulative effects within the DTI SEA process reflects guidance from a range of sources within the UK, EU and internationally. Guidelines on the range of techniques for assessing cumulative impacts (and indirect impacts & impact interactions) has been prepared on behalf of the EU, although this was primarily targeted at Environmental Impacts Assessments and Integrated Pollution Prevention and Control. Other background literature utilised included best practice guidelines from other countries and industries and published work including Bain *et al*. 1986, Canter & Kamath 1995, Irwin & Rodes 1992, Lane & Wallace 1998, Vestal *et al*. 1995, Cumulative Effects Assessment under the U.S. National Environmental Policy Act (NEPA website), and Canadian Environmental Assessment Act (Canadian Environmental Assessment Agency website).

Incremental effects have been considered within the SEA process as effects from licensing E&P activities, which have the potential to act additively with those from other oil and gas activity, including:

- forecast activity in newly licensed areas,
- new exploration and production activities in existing licensed areas,
- existing production activities
- forecast decommissioning activities
- “legacy” effects of previous E&P activities, post-decommissioning (e.g. unrecovered debris and cuttings material)

Cumulative effects are considered in a broader context, to be potential effects of E&P activities which act additively or in combination with those of other human activities (past, present and future), notably:

- fishing
- shipping, including crude oil transport
- military activities, including exercises (principally in relation to noise)

Synergistic effects – synergy occurs where the joint effect of two or more processes is greater than the sum of individual effects – in this context, synergistic effects may result from physiological interactions (for example, through inhibition of immune response systems) or through the interaction of different physiological and ecological processes (for example through a combination of contaminant toxicity and habitat disturbance).

To some extent, all potential sources of effect (i.e. disturbance, emissions and discharges) resulting from oil and gas activity within a mature province such as the North Sea are cumulative, in so far as they are incremental to previously existing sources (although the net trend of overall source level may be a reduction, due to improved environmental management and/or declining production levels).

Therefore, effects are considered incremental, cumulative or synergistic only if:

- the physical or contamination “footprint” of a predicted project overlaps with that of adjacent activities

- the effects of multiple sources clearly act on a single receptor or resource (for example a fish stock or seabird population)
- if transient effects are produced sequentially.

Those potentially significant effects considered to be cumulative are assessed below.

Underwater Noise

Although the range of seismic noise propagation makes incremental exposure to noise from sequential surveys in potential 21st Round acreage and noise from seismic surveys in previously-licensed areas possible, the extent of this is dependent on exploration activity level, operational and timing factors and is impossible to predict. However, simultaneous seismic surveys cause acoustic interference and are therefore managed on a cooperative basis ("timeshared"). This has the effect of substantially mitigating the probability of a single receptor receiving disturbance from two or more sources concurrently, but can increase the duration of continuous disturbance.

The total duration of seismic associated with SEA 3 exploration will be limited (100-200km 2D seismic and 500-2500 km^2 3D seismic). Offshore, marine mammals are not generally confined to localised areas and it is unlikely that individuals would be exposed to the full duration of a survey. No marine mammal species are known to follow regular migration pathways in the North Sea, which could be "blocked" by cumulative seismic disturbance.

Overall, the likelihood of incremental noise effects from seismic surveys will depend on the timing and location of seismic, but is considered to be low both in terms of simultaneous surveys, and also in terms of sequential surveys affecting the same receptors (marine mammals). There is no evidence that substantial E&P activity in the North Sea to date has resulted in direct mortality or acute trauma to marine mammals.

Incremental Simultaneous and sequential surveys in 20th Round and previously licensed areas. Seismic and operational noise (e.g. drilling, thruster and pipeline manifold noise).

Cumulative Seismic survey noise and broadband impulse noise, for example military sonars; and continuous sources e.g. shipping

Synergistic None known

Physical damage to biotopes

Potential sources of physical disturbance to the seabed, and damage to biotopes, were identified as rig and laybarge anchoring, wellheads and templates, jacket footings, pipelay activities including trenching, rock-dumping and jack-up rig spud cans; of these, rig anchoring and pipelay accounted for most spatial extent. Given the forecast exploration and production scenarios for SEA 3 areas, it is likely that there would be considerable spatial separation between disturbance "footprints", and a low probability of incremental overlap of affected areas. Recovery of affected seabed through sediment mobility, and faunal recovery and re-colonisation, is expected to be rapid where the source of effects is transient (e.g. anchoring); less than five years in most cases.

Existing control and mitigation measures are provided through the Offshore Petroleum Production and Pipe-lines (Assessment of Environmental Effects) Regulations, 1999 or (in the vicinity of an SAC) from The Offshore Petroleum Activities (Conservation of Habitats) Regulations, 2001. The required consenting procedure for specific projects ensures that biotopes of particular conservation or ecological value are identified and provided appropriate protection.

Incremental Physical footprint incremental to existing oil and gas activity – increment of one eight-millionth of North Sea area

Cumulative Cumulative effects dominated by trawling. Overall effect of oil and gas development likely to be positive, through fishing exclusion.

Synergistic None known

Physical presence

The physical presence of offshore infrastructure required for exploration and production can have significant direct effects on other users of the affected areas (notably the fishing industry). In the early 1980's, it was estimated that the loss of fishing area in the North Sea caused by these zones was ~0.25% of the total area of the North Sea. The predicted incremental effect of exploration and development of SEA 3 licence areas amounts to 23 exclusion zones (although not all would be concurrent), an increment of less than 0.5% of existing excluded area.

Incremental Small increment to existing exclusion zones and obstructions

Cumulative Exclusion and fastening risks are cumulative to those resulting from natural obstructions, shipwrecks and other debris. Extent of cumulative effect associated with 20th Round is negligible.

Synergistic None known

Marine Discharges

Total produced water discharge from UKCS oil production was 244 million tonnes in 2000, with an average oil in water content of 21.5 mg/kg (DTI 2001), in comparison with which the potential discharge from SEA 3 developments (which are predominantly gas with low water volumes) will be negligible. It should also be noted that through OSPAR, the UK is committed to a 15% reduction in total discharged volume of oil in produced water by 2006 and consequently there is a presumption against discharge from new developments.

Environmental effects of produced water discharges are limited primarily by dispersion, to below No Observed Effect Concentrations (NOECs). Although synergistic interactions between individual components, particularly PAHs, specific process chemicals (particularly those which are surface-active, including demulsifiers), and other organic components are possible, and require further investigation, "whole effluent" exposure studies are a more relevant approach to assessing environmental risk of discharges. In general, studies of "whole" produced water effects at environmentally meaningful concentrations have not demonstrated significant toxicity or other physiological effect (including endocrine disruption). There are also no known indications that incremental or cumulative effects of produced water discharges have or will exceed threshold concentrations for significant environmental effect, or exceed environmental "carrying capacity".

On a UKCS scale, produced water discharges are, and will continue to be dominated by previous oil developments in the central and northern North Sea. Key concerns over produced water discharges relate to potential incremental and cumulative effects of oil and possible biological effects of residual process chemicals. To a very large extent, these will be mitigated by a presumption against consenting of new discharges, in favour of Produced Water Re-Injection (PWRI). This control can be effectively implemented through existing legislative mechanisms.

Discharges of WBM cuttings in the SEA 3 area of the North Sea have been shown to disperse rapidly and to have minimal ecological effects. Dispersion mechanisms could, in theory, lead to localised accumulation in relation to topographic features (the bottoms of pockmark and sandbank crests, in the central and southern North Sea respectively) although on the basis of previous drilling with OBM and WBM, resulting contamination is considered very unlikely to be detectable and to have negligible incremental or cumulative ecological effect. Periodic re-suspension of seabed sediments due to wave and tidal currents occurs throughout the North Sea (with reduced frequency in deeper water), and any contamination associated with WBM cuttings will be dispersed over a period of a few years.

Incremental Produced water – incremental contribution of PW is dependent on extent of PWRI (given presumption against new PW discharges) and forecast increase in PW volume from existing fields, but will be negligible in view of the predicted discharge volumes from SEA 3 developments. WBM drilling discharges generally disperse widely and significant accumulations do not occur. It is therefore possible that discharge footprints will overlap, although the ecological effects will be undetectable. Potential "sinks" include sandbank crest accretion zones, which are subject to periodic (frequency dependent on water depth) remobilisation of sediments due to storm events.

Cumulative Principal cumulative sources of major contaminants, including hydrocarbons and metals, are riverine and atmospheric inputs. Cumulative sources of particulate contaminants include dredge spoil disposal and coastal discharges, although these are negligible in the context of natural suspended particulate loads.

Synergistic Synergistic effects of chemical contaminants in PW and drilling discharges are frequently postulated, although substantive data is almost entirely lacking and it is considered unlikely that significant synergistic effects would result from chemicals used in gas processing and WBM.

ATMOSPHERIC EMISSIONS

Atmospheric emissions from offshore oil and gas exploration and production activities may contribute to reduction of local air quality. Greenhouse and acid gas emissions effectively contribute to a mixed regional or global "pool" and can therefore be considered cumulative.

It should be noted that implications of the ultimate use of oil and gas production from UKCS the with regard to greenhouse gas emissions and UK commitments under the Kyoto Protocol, were not considered here since these are subjects for a different appraisal forum.

Flaring from existing UKCS installations has been substantially reduced relative to past levels, largely through continuing development of export infrastructure and markets, together with gas cycling and reinjection technologies. New developments will generally flare in substantial quantities only for pressure relief, with "zero routine flaring" now considered a realistic design target for new developments. Other than start-up flaring, subsea tie-back developments, which are predicted to account for the majority of production from proposed SEA 3 licence areas, will generally have little effect on host platform flaring.

Incremental Incremental emissions resulting from internal combustion for power generation by installations, terminals, vessels and aircraft, flaring for pressure relief and gas disposal, cold venting fugitive emissions

Cumulative Greenhouse and acid gas emissions effectively contribute to a mixed regional or global "pool" and can therefore considered to be cumulative. However, on a global scale, cumulative effects of emissions resulting from SEA 3 developments will be negligible in comparison to the influence of onshore sources.

Synergistic None known

WASTES TO LAND

In view of the relatively small number of wells predicted in SEA 3 licensed areas, and likely removal of the current prohibition on interfield cuttings reinjection, it considered unlikely that major incremental or cumulative landfill requirement will result from SEA 3.

Incremental Incremental return of general oilfield wastes insignificant; incremental return of drilling wastes also unlikely to represent a significant contribution to onshore waste disposal requirements.

Cumulative Not quantified

Synergistic None known

Oil Spills

The incremental risk of oil spills associated with exploration and development in the SEA 3 area is low, since production will almost certainly involve gas. In the event of a spill of persistent oil, and in the absence of an effective response, there are possible effects of coastal oiling around much of the North Sea coastline. Offshore seabirds are also vulnerable, particularly in late summer and autumn. However, a considerable amount of risk assessment work has been carried out for previous exploration and production activities in the area, and understanding of the likely incremental risk is well-developed. Established risk-reduction and mitigation measures, including operational timing, and spill response contingency measures have been developed which will minimise incremental risks.

In terms of cumulative risk, there is little doubt that due to scale and consequence, the major risk of significant oil spills is associated with tanker transport of crude oil, and refined products. Although some control and response measures have been implemented, for example following the Donaldson enquiry into the Braer incident, the residual risk remains relatively high (in comparison to other oil spill sources including E&P). The SEA 3 area is located close to major terminal and refinery centres, including Immingham and Rotterdam. In 1997, 374 million tonnes of crude oil were either imported or exported to north-west Europe (QSR 2000), the majority of which will pass through or in close proximity to the SEA 3 area. To date, there have been no major tanker spills within or close to the SEA 3 area, although other shipping activity can also result in significant pollution incidents. For example, in 1998 the cargo vessel Pallas ran aground and spilled 250 m^3 of oil in the Wadden Sea, resulting in 16,000 dead seabirds (QSR 2000).

Other cumulative sources of anthropogenic hydrocarbon input to the North Sea include rivers and land run-off (combined 16,000-76,000 tonnes/year), coastal sewage/sewage sludge (1000-10,000 tonnes/year), dredge spoils (2000-10,000 tonnes/year), operational shipping discharges (1000-5000 tonnes/year) and atmospheric deposition (7000-15,000 tonnes/year). Although cumulative hydrocarbon inputs are often summed for comparative purposes, it is important to note that the environmental effects and fate of individual oil types and sources may be very different. Simple comparison of cumulative inputs may therefore be misleading, in terms of effects assessment. Nevertheless, it can be observed that the majority of oil spills most likely to result from E&P operations will make an insignificant contribution to overall North Sea inputs.

It is also reasonable to observe that overall, although the acute effects of oil spills can clearly be severe at a local scale, the cumulative effects of around a century of oil spills from shipping to the North Sea – and thirty years of oil and gas development – do not appear to have resulted in wide-scale or chronic ecological effects. It is therefore concluded that the limited incremental effects of SEA 3-related activity, assuming that effective risk management practices continue to be implemented, will be minimal.

Incremental Hydrocarbons from oil spills will be incremental to produced water discharges and other (minor) offshore E&P sources; however, it is considered very unlikely that oil spill footprints will overlap given the predicted spill frequency associated with SEA 3 activities.

Cumulative There are a range of cumulative sources of hydrocarbons to the North Sea. Accidental spills represent a minor contribution to overall North Sea inputs.

Synergistic None known

10.5 Transboundary effects

It is a requirement for Strategic Environmental Assessment that transboundary effects are identified, under *European SEA Directive (2001/41/EC)* and the *Espoo Convention*; and this requirement also applies to project environmental assessments conducted under the *Offshore Petroleum Production and Pipe-lines (Assessment of Environmental Effects) Regulations 1999*.

Consideration of transboundary effects is intended to promote adequate consideration of, and consultation between the relevant governments, on transboundary effects where a plan or programme in one state may have significant effects on the environment of another.

The Convention on Environmental Impact Assessment in a Transboundary Context was signed in 1991, (the *Espoo Convention)*. This applies to various major activities with the potential to cause transboundary effects and includes offshore hydrocarbon production and large diameter oil & gas pipelines. Projects need to be screened for the potential transboundary effects and an Environmental Impact Assessment and international consultation by government conducted if necessary.

Clearly, offshore activities have a high likelihood of transboundary effects, both because of location adjacent to international boundaries and due to the unbounded nature of the marine and atmospheric environment.

The SEA 3 areas are contiguous with continental shelf areas under the jurisdiction of Germany, the Netherlands, Belgium and France as defined by UNCLOS. All states bounding the North Sea are members of OSPAR. Prevailing wind and residual water circulation of the North Sea will result in the transboundary transport of discharges to water (including particulates) and atmospheric emissions.

Sources of potentially significant environmental effects, with the additional potential for transboundary effects, are:

- Underwater noise
- Marine discharges – drilling discharges

- Atmospheric emissions
- Accidental events – oil spills

All of the above aspects may be able to be detected physically or chemically in adjacent state territories, particularly from activities undertaken in SEA 3 areas close to the international boundary. The scale and consequences of environmental effects in adjacent state territories will be comparable to those in UK territorial waters. There are no identified transboundary effects in which environmental consequences in a neighbouring state are overwhelmingly due to activities resulting from the proposed 21st Round licensing.

10.6 Socio-economic effects

10.6.1 Introduction

The potential socio-economic implications of licensing the SEA 3 area have been assessed by the Department of Economics, Aberdeen University (Professor Alex Kemp and Linda Stephen). The following section summarises the findings of their research.

In formulating assumptions regarding probable number and timing of exploration and appraisal wells, discoveries and developments, the views of the relevant experts in the DTI were taken fully into account. The size and cost of developments, operation and decommissioning in the SEA 3 area were estimated through employment of the Monte Carlo technique, which has provided the following optimistic and pessimistic estimates for the SEA 3 area:

- Under both optimistic and pessimistic conditions a 8.72Mboe (1.39 million m^3) field was discovered in the Carboniferous Trend of the SNS, which would be developed in 2005 at a cost of $3.18/barrel.

- In the Rotliegend Flank Trend of the Southern North Sea (SNS) two fields were discovered under pessimistic conditions, the largest of which is a 78.3Mboe (12.45 million m^3) field forecast to be developed in 2004 with associated costs of $4.01/barrel. The optimistic scenario for this area predicted the discovery of 5 fields the largest of which was again a 78.3Mboe (12.45 million m3) field which would be developed in 2004 at a cost of $4.01/barrel. A further two significantly sized fields are predicted to be discovered under optimistic conditions. These include a 24.3Mboe (3.86 million m^3) field which would be developed in 2005 at a cost of $2.51/barrel and a 26.2Mboe (4.16 million m^3) discovery which would be developed in 2006 at a cost of $5.90/barrel.

- A 15.71Mboe (2.5 million m^3) field discovered in the Mid North Sea High (CNS). This single field is predicted to be discovered under both optimistic and pessimistic conditions and would be developed in 2006 at a cost of $5.24/barrel.

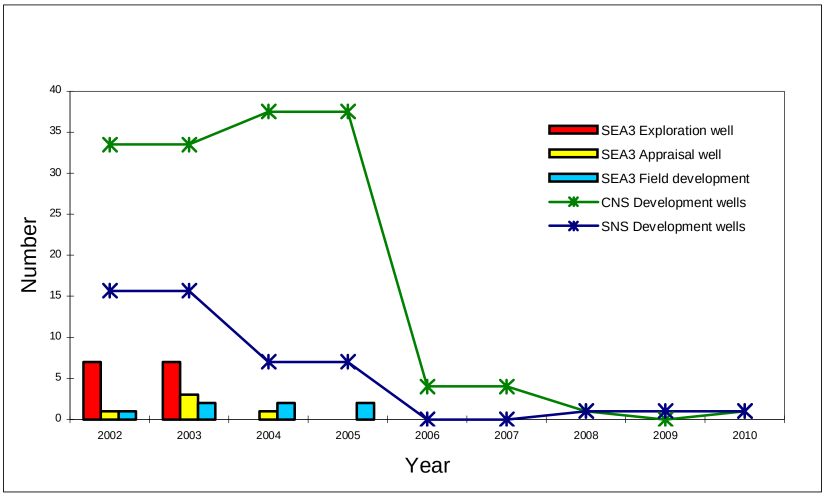
10.6.2 Existing field life and infrastructure

Effects of projected developments on field life of existing installations, and capacity of the existing oil and gas export infrastructure of the SEA 3 area (including onshore reception facilities) were also assessed on an individual quadrant basis. The SNS is a mature area with a proliferation of existing infrastructure. In a few cases the SEA 3 blocks or part blocks to be re-licensed are close to a number of existing installations, but in most cases they are relatively remote. Existing infrastructure in the CNS is somewhat limited. The only infrastructure accessible within this section of the SEA 3 area is from Block 26 which may allow access to the Auk and Fulmar fields. In general, there is little scope for the further utilisation of the existing oil and gas infrastructure in all parts of the SEA 3 area from the development of new discoveries and technical reserves in Blocks being made available in the 21st round. The precise location of any new discoveries is not known and therefore the specific offshore infrastructure which may be utilised cannot be specified at this time.

10.6.3 Activity

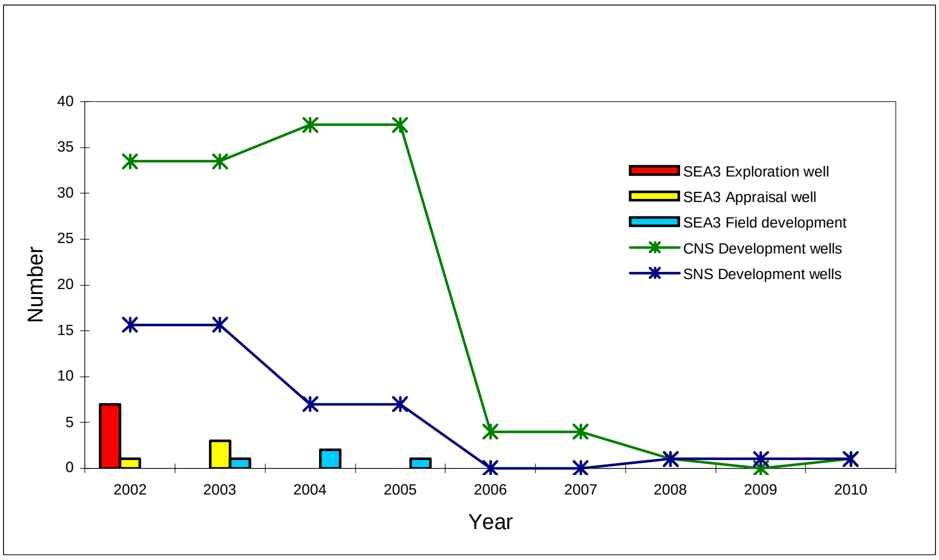
Projected drilling activity in the SEA 3 area are shown under both optimistic and pessimistic conditions in Figures 10.4 and 10.5.

Figure 10.4 - Projected number of SEA 3 exploration, appraisal and development wells under optimistic conditions.



DTI 2001 Brown Book estimate for maximum new development wells also shown.

Figure 10.5 - Projected number of SEA 3 exploration, appraisal and development wells under pessimistic conditions.



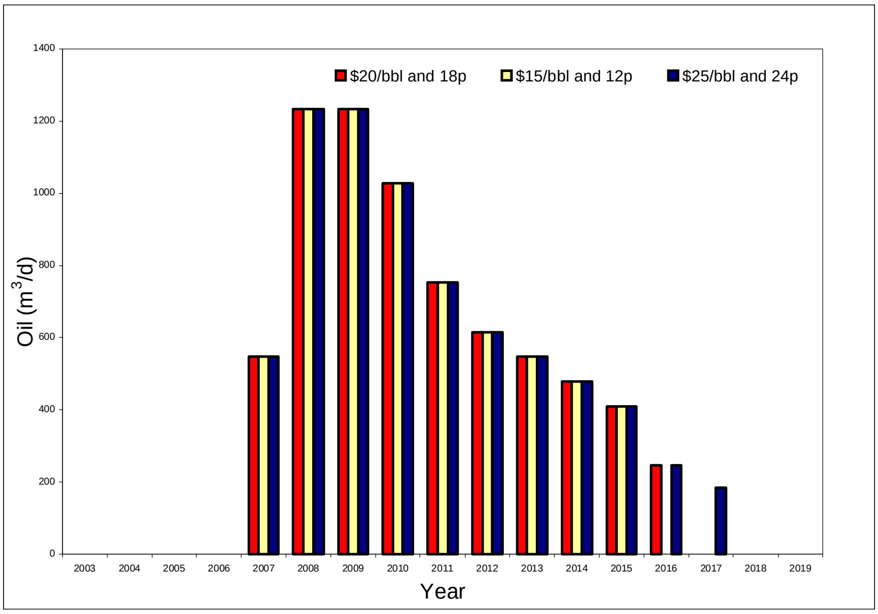
DTI 2001 Brown Book estimate for maximum new development wells also shown.

10.6.4 Production

Contribution of predicted SEA 3 activities and production are shown in Figures 10.6 to 10.7 (assuming a \$20/barrel and 18p/therm, \$15/barrel and 12p/therm and \$25/barrel and 24p/therm price).

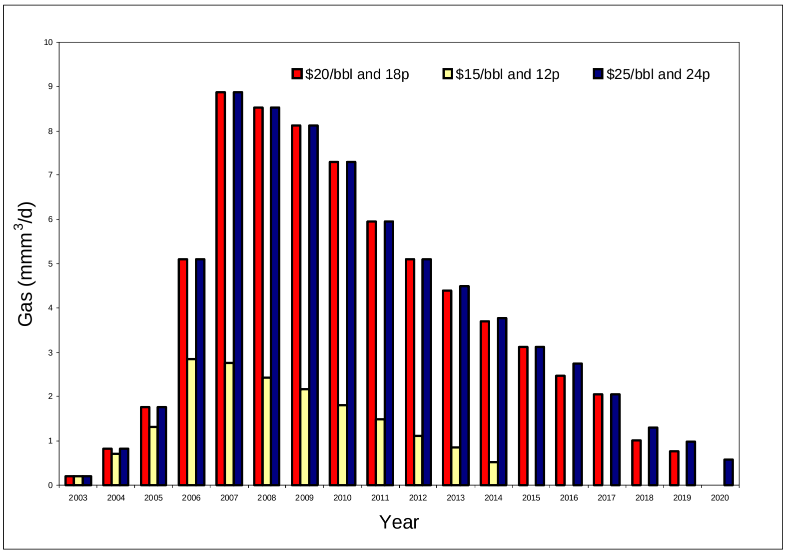
Should exploration and development occur at the levels identified in the Aberdeen University study projected oil extraction from the CNS could be 2.59 million m^3 at a price of \$20/barrel and 18p/therm, 2.49 million m^3 at a price of \$15/barrel and 12p/therm and 2.65 million m^3 at a price of \$25/barrel and 24p/therm. Peak production of 1232 m^3/d would be expected to be reached during 2008 and 2009 for all three price scenarios (see Figure 10.6).

Figure 10.6 - Projected oil production profile for additional SEA 3 developments.



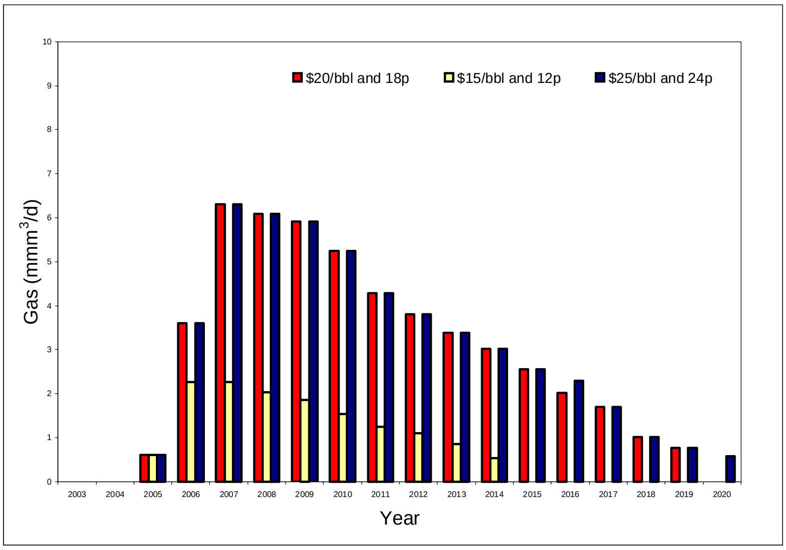
Projected gas production for all three price scenarios have again been assessed under optimistic and pessimistic conditions. Under optimistic conditions re-licensing of the SEA 3 area could provide the following volumes of gas 25285 million m^3 at 18p/therm, 6634 million m^3 at 12p/therm and 25850 million m^3 at 24p/therm. Peak production under optimistic conditions would be expected to be reached between 2006 and 2007 for all price scenarios (see Figure 10.7).

Figure 10.7 - Projected gas production profile for additional SEA 3 developments (optimistic scenario).



Under pessimistic conditions re-licensing of the SEA 3 area could provide volumes of gas as follows, 1835 million m^3 at 18p/therm, 5209 million m^3 at 12p/therm and 18664 million m^3 at 24p/therm. Peak production under these conditions would again be expected to be reached between 2006 and 2007 for all scenarios (see Figure 10.8).

Figure 10.8 - Projected gas production profile for additional SEA 3 developments (pessimistic scenario).



10.6.5 Employment

Within the petroleum industry, the number of skilled employees is declining. Re-licensing of the SEA 3 area could lead to some increase in direct, indirect and induced employment within this industry, contributing to a slowing down of the decline in the UK workforce.

If an oil price of $25/bbl is realised, SEA 3 activities within the UKCS could result in the number of extra jobs rising from between 1700 (80 of which are direct - see Figure 10.9) and 1900 (100 of which are direct - see Figure 10.10) in 2003 to a peak of between 4700 (400 direct) and 6900 (650 direct) in 2007. Additional employment is expected to decline sharply over subsequent years to approximately 1000 (80 direct) by 2021.

Figure 10.9 - No. of jobs resulting from SEA 3 activities assuming a $25/barrel and 24p/therm price (pessimistic scenario).

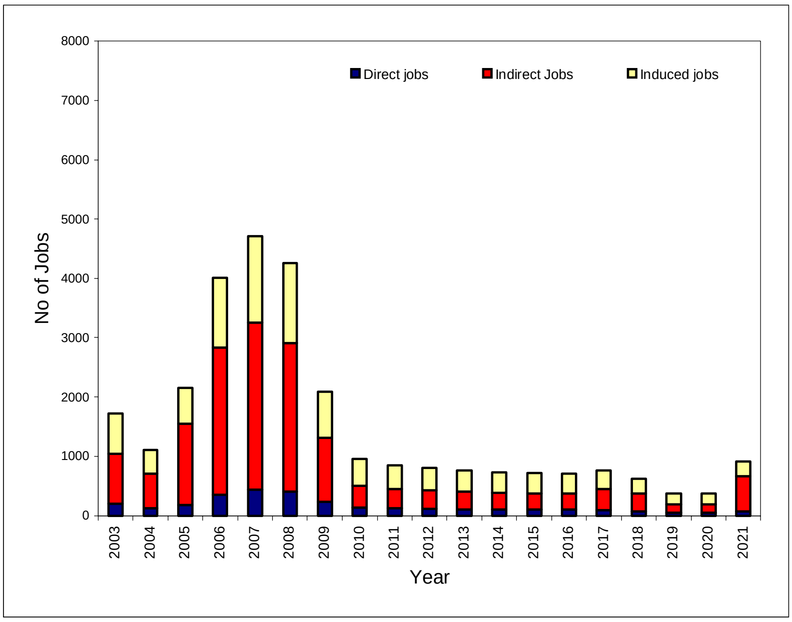
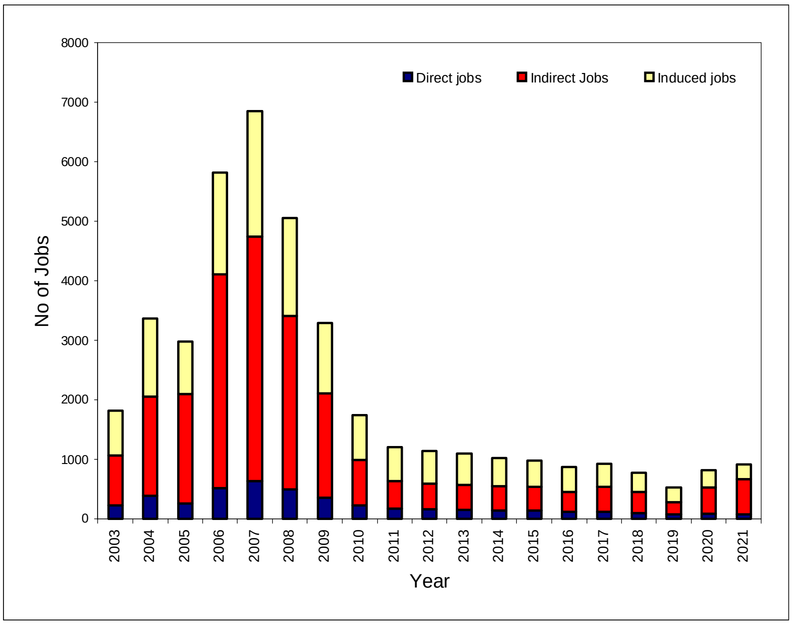


Figure 10.10 - No. of jobs resulting from SEA 3 activities assuming a $25/barrel and 24p/therm price (optimistic scenario).



At an oil price of $20/bbl, the estimated extra jobs in the UK could range from 1500 (220 direct - see Figure 10.11) to 1800 (250 direct - see Figure 10.12) in 2003 and reach a peak of 4700 – 6750 in 2007. The projected increase in employment is then expected to decline sharply over subsequent years until 2010 where the numbers would fluctuate around 1000 (80-100 direct) until 2020.

Figure 10.11 - No. of jobs resulting from SEA 3 activities assuming a $20/barrel and 18p/therm price (pessimistic scenario).

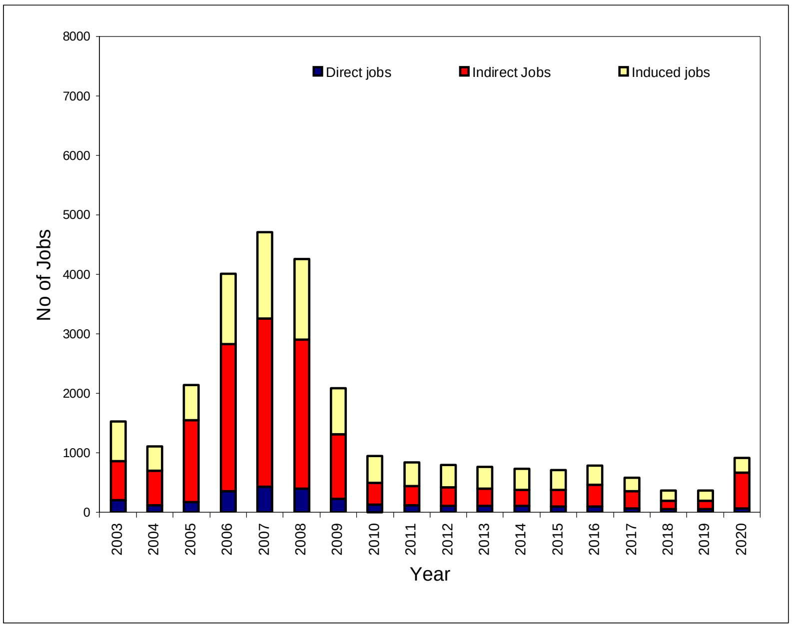
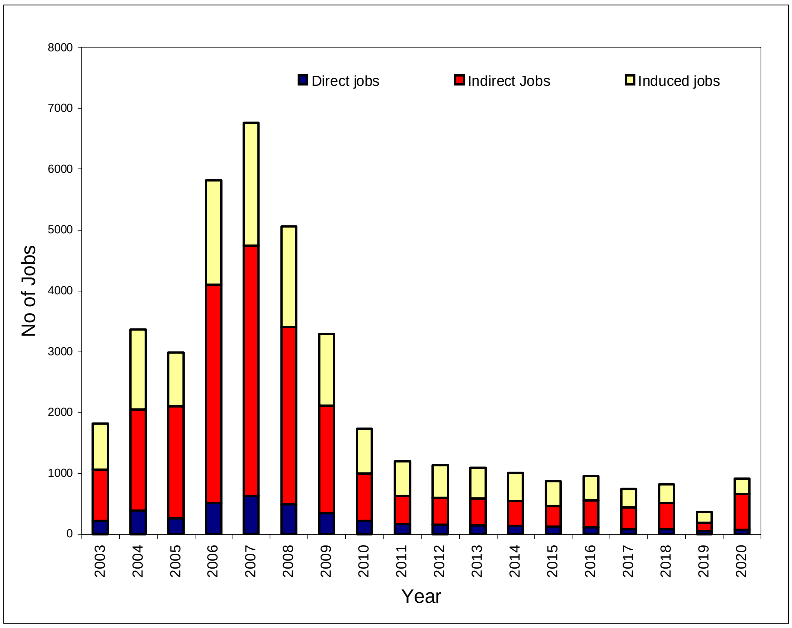


Figure 10.12 - No. of jobs resulting from SEA 3 activities assuming a $20/barrel and 18p/therm price (optimistic scenario).



With an oil price of $15/bbl, the extra jobs created in the UK in 2003 are estimated to reach between 1550 (220 direct see - Figure 10.13) and 1800 (250 direct - see Figure 10.14), with possible peaks of 2750 (400 direct) and 1750 (250 direct) in 2004 and 2006 respectively. Extra employment is expected to fluctuate around 1500 (230 direct) until 2009, when a sharp decline is forecast to approximately 250 (10 direct) by 2016.

Figure 10.13 - No. of jobs resulting from SEA 3 activities assuming a $15/barrel and 12p/therm price (pessimistic scenario).

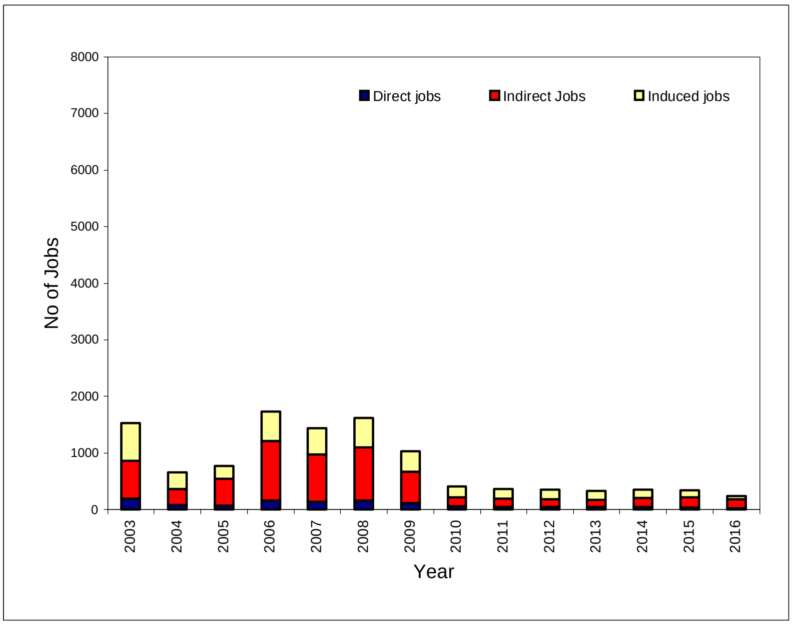
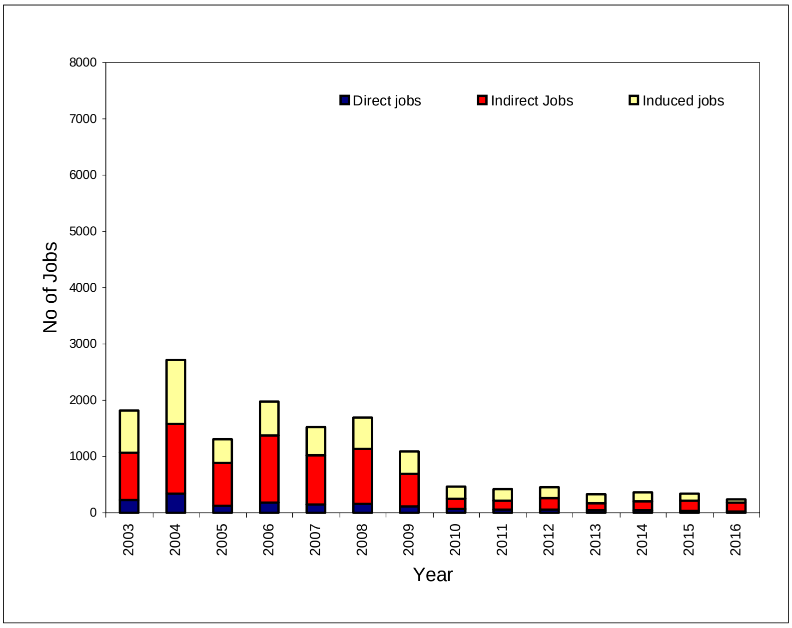


Figure 10.14 - No. of jobs resulting from SEA 3 activities assuming a $15/barrel and 12p/therm price (optimistic scenario).



For these three oil price scenarios the greatest number of extra oil jobs are expected to occur during the initial four years of development (2004-2007), with all prices forecasting sharp declines in extra employment in subsequent years. However, SEA 3 activities could reverse the decline in skilled employees entering the petroleum industry and sustain competitive employment levels.

10.6.6 Tax revenues

Tax revenue from the petroleum industry is intrinsically linked to the world market price of oil and gas. High market prices can drive tax revenues up, whereas a fall in oil prices leads to a decrease in tax revenue for the UK Treasury.

Government tax revenues, resulting from 21st Round-related activity, for the first two years (2003-2004) at an oil price of $25/barrel are expected to be negative, ranging from -£24 million to -£37 million (Figures 10.15 and 10.16). Positive tax revenue is expected to peak in 2007 at between £65 million - £80 million. Approximately £14 million - £15 million will be generated from the Central North Sea (CNS), with the remainder (£51 million - £65 million) generated from the Southern North Sea (SNS). Tax revenue is expected to decline steadily between 2008 and 2012, with a negative tax revenue in the range £7 million - £8 million forecast by 2013.

Figure 10.15 - Potential tax revenue @ $25/barrel and 24p/therm price (optimistic scenario).

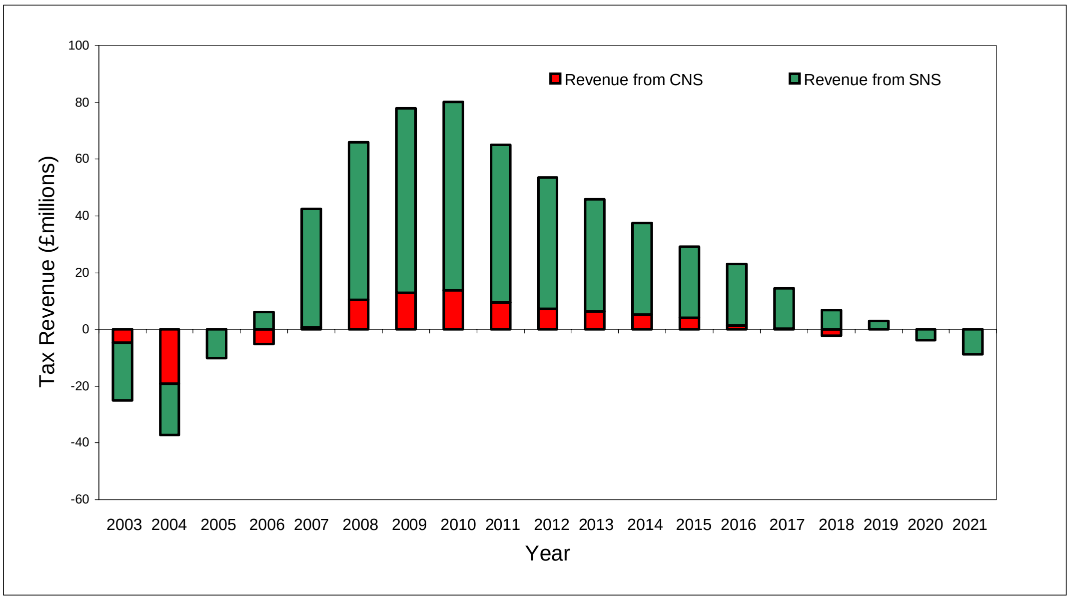
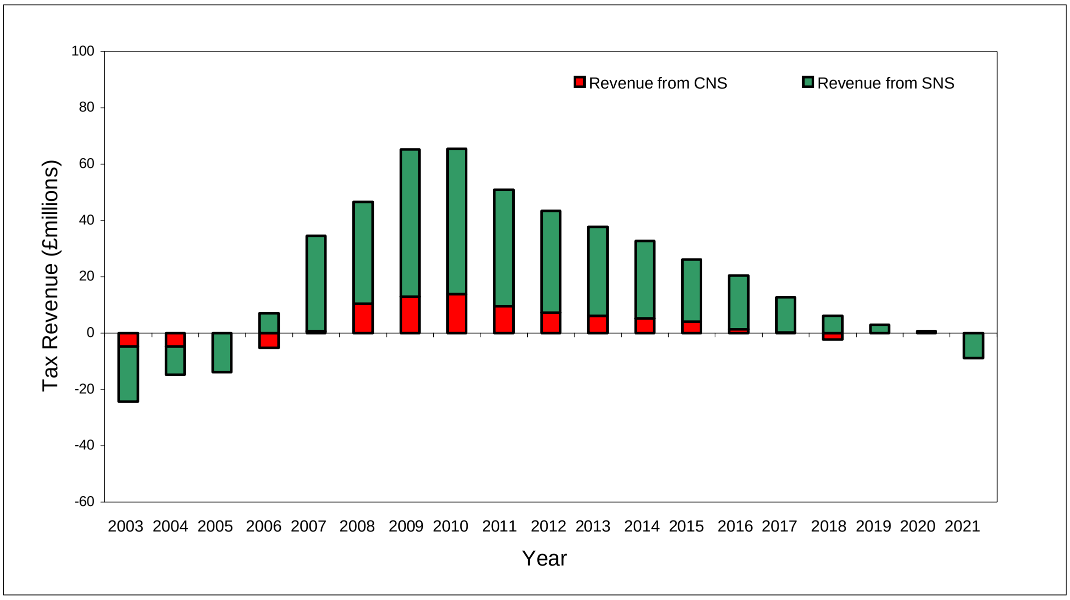


Figure 10.16 - Potential tax revenue @ $25/barrel and 24p/therm price (pessimistic scenario).



Similar negative tax revenues are expected for the first three years for $20/barrel and $15/barrel. The $20/barrel price is expected to give a moderate return ranging from £45 million - £55 million by 2007 with a steady decline in revenue forecast over subsequent years until 2013 when a negative tax revenue of between £9 million - £10 million is expected (Figures 10.17 and 10.18).

Figure 10.17 - Potential tax revenue @ $20/barrel and 18p/therm price (optimistic scenario).

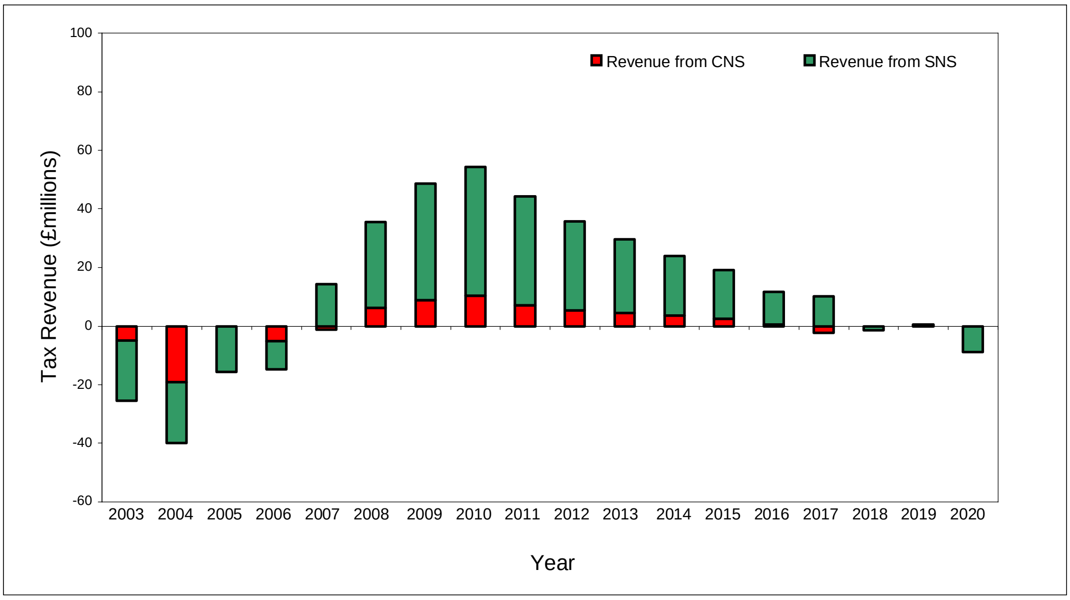
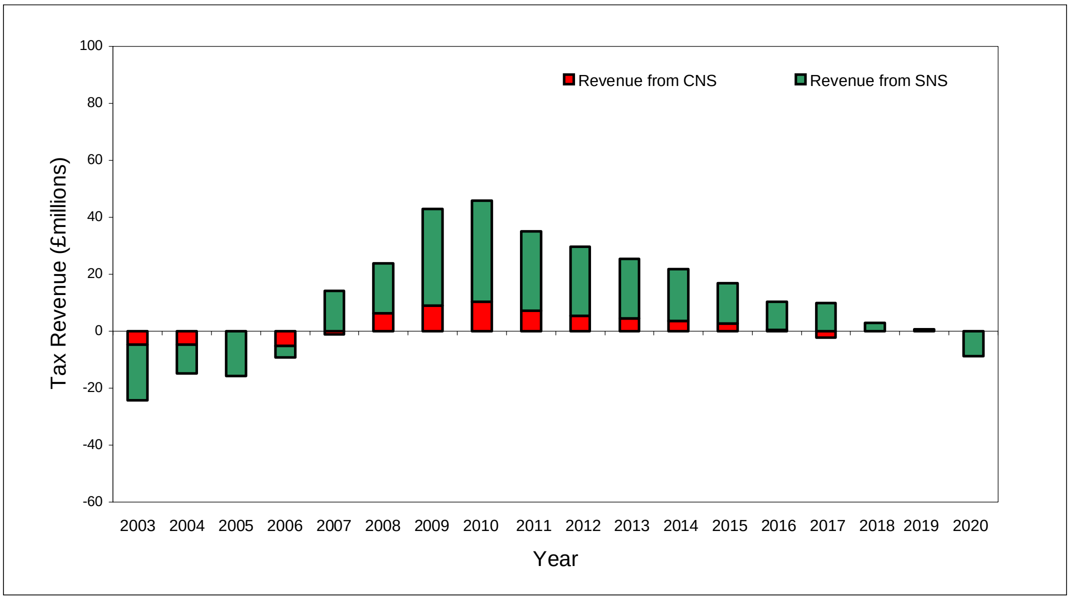


Figure 10.18 - Potential tax revenue @ $20/barrel and 18p/therm price (pessimistic scenario).



At $15/barrel, after an initial negative tax revenue of between -£20 million - -£39 million, the positive tax revenue is expected to peak in 2009 at £11 million -£16 million, almost four times less than the peak tax revenue forecast for $25/barrel. Tax revenue is expected to decline over subsequent years with a negative revenue expected by 2013 (Figures 10.19 and 10.20).

Figure 10.19 - Potential tax revenue @ $15/barrel and 12p/therm price (optimistic scenario).

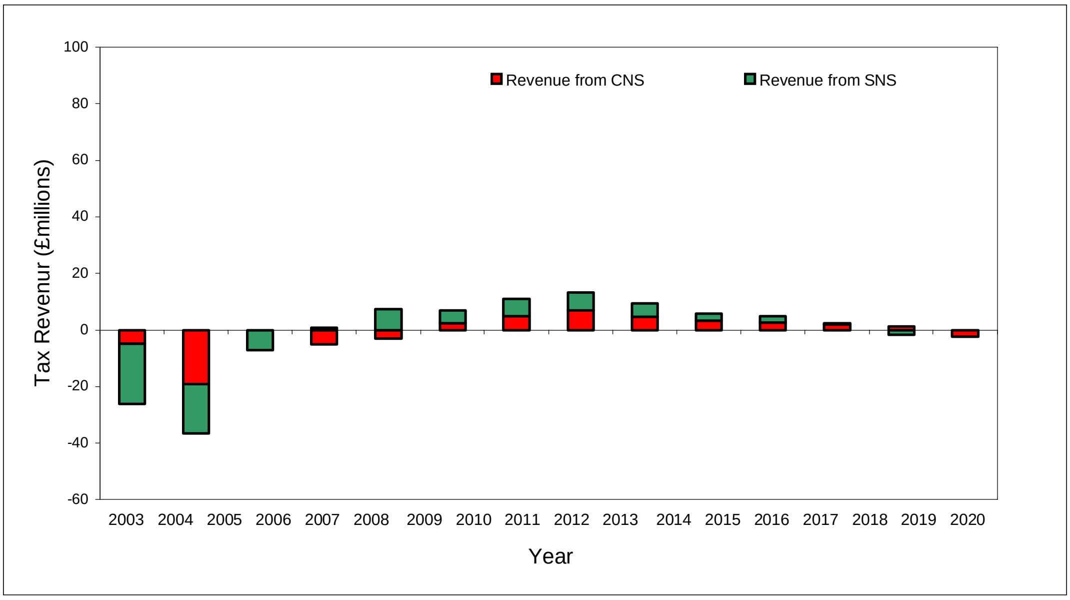
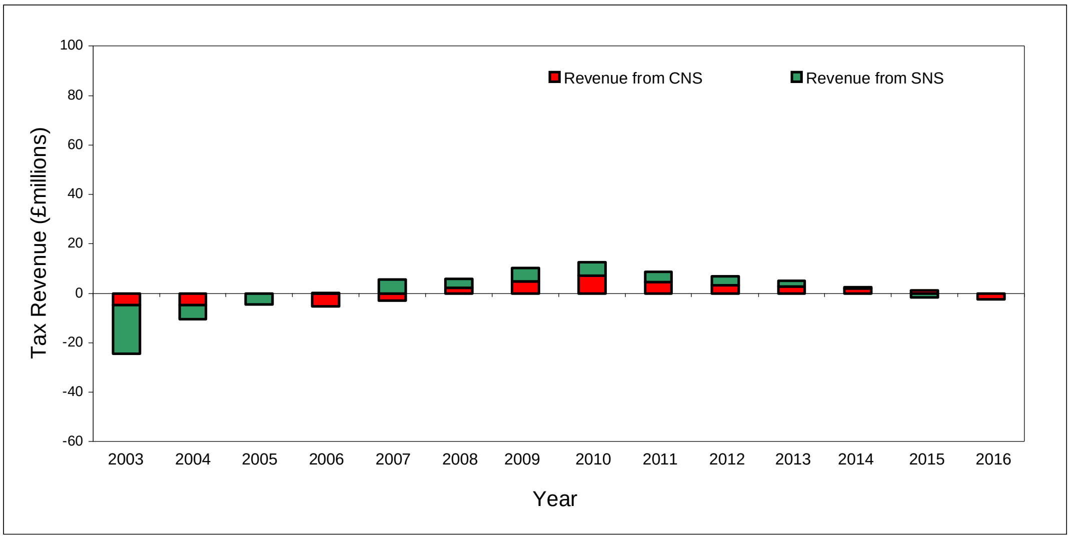


Figure 10.20 - Potential tax revenue @ $15/barrel and 12p/therm price (pessimistic scenario).



A high tax revenue for the UK Treasury is expected to be generated by an oil price of $25/barrel, with a low tax revenue generated by $15/barrel. A price of $20/barrel, while not generating the high revenue expected for $25/barrel, will produce moderate tax revenue forecasts considerably higher than those generated for $15/barrel.

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11 CONCLUSIONS

11.1 Conclusions

Conclusions from the consideration of potential effects of licensing the SEA 3 area in Section 10, are summarised below:

Noise - Seismic activities in the SEA 3 blocks could potentially affect regionally important numbers of harbour porpoise and harbour seals although existing control and mitigation methods are generally regarded as effective in preventing physical damage. In view of the limited incremental extent of noise resulting from predicted low levels of activity, and in relation to previous activity and activities in existing licensed acreage, together with existing control and mitigation methods, it is considered unlikely that physical damage or significant behavioural disturbance of marine mammals will result from the activity scenarios associated with proposed licensing.

Physical damage at the seabed - The predicted spatial scale of physical disturbance of the seabed, resulting from activity scenarios for the potentially licensed area, is very small in comparison with the total area of the North Sea. In terms of area, the major source of physical disturbance from SEA 3 E&P activities is predicted to be pipelaying. Recovery of affected seabed through sediment redistribution and faunal re-colonisation are expected to be rapid where the source of effects is transient, less than five years in most cases. Prehistoric marine archaeological remains may be affected by pipelaying or other activities but it has been proposed (as a mitigation measure and as a way to obtain new information) to promote the awareness and reporting of archaeological finds during oil industry activities in the North Sea. It is therefore concluded that the potential incremental and cumulative effects of physical disturbance are not likely to be significant.

Physical presence - Although exclusion can represent a significant conflict between fishing and production in intensively developed areas within established fishing grounds, including much of the SEA 3 area, the spatial extent of exclusion zones is unlikely to cause significant negative economic impacts. The oil industry and UK fishing industry maintain consultation, liaison and compensation mechanisms, which should serve to mitigate and resolve any conflicts.

Discharges - The environmental effects of produced water discharges from gas fields are limited, primarily by dispersion, and below No Effect Concentrations (NECs). OSPAR recommendation 2001/1 will result in reductions in both concentrations and the total amount of oil discharged from offshore installations. For new developments (including those stemming from 21st Round licensing) there will be a presumption against produced water discharge to sea.

Discharges of WBM cuttings in the North Sea have been shown to disperse rapidly and to have minimal ecological effects. Dispersion mechanisms could, in theory, lead to localised accumulation in relation to topographic features (including southern North Sea sandbanks) although this is considered unlikely to be detectable.

Emissions - Potential environmental effects of acid gas and greenhouse emissions are, respectively, regional and global in nature. Local environmental effects of atmospheric emissions are not expected to be significant, in view of the high atmospheric dispersion associated with offshore locations.

Significant combustion emissions from flaring are not expected from potential development in the possible SEA 3 licence area. In view of regulatory controls and commercial considerations, combustion emissions from power generation are not predicted to represent a major contribution to industry or national totals.

Wastes to shore - Sustainable and commercially viable options for onshore disposal of OBM cuttings remains a significant challenge for the industry, although permitted transfer between installations for reinjection should now ease the situation.

However, the associated environmental effects of onshore treatment and long-term storage of processed OBM cuttings are not considered to represent significant environmental effects of E&P activities in SEA 3 area, in the context of overall emissions and waste disposal to land.

Accidental events - Overall, incremental risk of oil spills associated with exploration and development in the SEA 3 area is low, particularly in the southern area where production will almost certainly involve gas. In the event of a spill of persistent oil, and in the absence of an effective response, there are possible effects of coastal oiling. Offshore seabirds are also vulnerable, particularly in late summer and autumn. However, risk assessments of current activities have been carried out and established contingency measures are in place which mitigate risks.

In general, the fate and consequence processes which affect chemicals in the environment are comparable with those for hydrocarbon components, and are dependent on the partitioning of individual compounds between dissolved and particulate phases in the water column. Persistence and biological effects of most chemicals used in the oil and gas industry are equivalent or lower than those of oil, and similar risk assessment conclusions will therefore apply.

Environmental and safety consequences of gas releases will depend both on scale, and whether released gas ignites. The major constituent of natural gas is the greenhouse gas methane, and gas releases on all scales will therefore contribute to global climatic effects. The significance of any foreseeable contribution, including a sustained gas blowout, to global methane concentraions (which include very large fluxes through natural processes) will be negligible.

Cumulative effects - Cumulative effects are considered here as identified effects from E&P activities resulting from the proposed 21st Round licensing, which have potential to act additively with those from other oil and gas activity including both existing activities and new activities in existing licensed areas, or to act additively with those of other human activities (e.g. fishing and crude oil transport). Synergistic effects are considered to be potential effects of E&P activities where the joint result of two or more effects is greater than the sum of individual effects, for example through physiological interactions or the interaction of different physiological and ecological processes.

Although there is potential for sources to be additive in some cases, (for example through mixing of sea water masses containing dispersed discharges) cumulative effects in the sense of overlapping "footprint" of detectable contamination or biological effect are considered to be limited (physical presence, noise, physical damage, emissions, discharges), or unlikely (accidental events). Synergistic effects were insignificant, either because of the scale of other sources is minimal (noise, physical presence); because effects are insignificant in the context of natural processes (cuttings discharges) or because the contribution resulting from proposed licensing is negligible in the context of other activities (physical damage, emissions, oil spills).

Transboundary effects – The SEA 3 area is contiguous with continental shelf areas under the jurisdiction of Germany the Netherlands, Belgium and France. All states bounding the North Sea are members of OSPAR. Prevailing wind and residual water circulation of the North Sea will result in the transboundary transport of discharges to water (including particulates) and atmospheric emissions.

The environmental effects of underwater noise, drilling discharges, atmospheric emissions and oil spills may be able to be detected physically or chemically in adjacent state territories, particularly from activities undertaken in SEA 3 area close to international boundaries. The scale and consequences of environmental effects in adjacent state territories will be comparable to those in UK territorial waters. There are no identified transboundary effects in which environmental consequences in a neighbouring state are overwhelmingly due to activities resulting from the proposed 21st Round licensing.

Socio-economic effects - Economic modelling indicates that if oil and gas prices remain at their current levels then between 2.5 and 2.7 million m^3 of oil and between 18.7 and 25.9 billion m^3 of gas may be extracted (depending on oil and gas price scenarios).

Forecast tax revenues range widely, with a maximum of £65-80 million in 2007 period. However, if oil prices drop substantially, under the current fiscal regime, Government revenues from 21st Round are likely to be negative when tax relief for exploration and appraisal activities is given.

The forecast activity could result in a peak of 6,900 total extra jobs in the UK in 2007, of which 80 to 100 are estimated to be direct. The number of employees in the petroleum industry is declining and has been for some time, although there also appear to be skill shortages at the moment. The UKCS may be a mature province but the skills and expertise acquired are exportable assets. Regular and wide ranging licensing rounds could help maintain expenditure in the industry which in turn may help sustain employment levels and reverse the trend towards skills shortages by giving some security to those employed in the industry. Petroleum companies are primarily international and therefore the UK competes for funding and skilled staff with other petroleum producing provinces. If the skills base is not maintained, any competitive advantage which the UK has acquired, may be lost.

Wider policy objectives - Based on the review of potential effects, no significant effect of activities following the proposed 21st Licence Round is predicted in relation to wider UK Government policy and commitments.

At a wider scale of assessment, it is clear that the major environmental pressures on the North Sea are not associated directly with hydrocarbon exploration and production, but with trace organic contaminants from land, seabed disturbance by fisheries, inputs of nutrients from land, effects of discards and mortality of non-target species by fisheries, and input of TBT and other antifouling substances by shipping (OSPAR 2000). Fishing mortality (of both target species and bycatch), and trawling disturbance effects are probably the most significant direct anthropogenic effects on the ecology of the North Sea. In this context, the combined effects predicted as a result of routine E&P activities which may arise from 21st Round licensing are minimal. Provision of gas from UK resources will contribute to security of national supply.

The SEA Directive requires that, in considering the likely significance of effects, the degree to which the plan or programme influences other plans and programmes should be addressed, together with the promotion of sustainable development (Section 3.1).

11.2 Information gaps

Current understanding of North Sea habitats and ecosystems are reviewed in Sections 5 and 6, with reference to the SEA 3 area. The North Sea is a relatively well studied area, and holistic assessments of its status have been undertaken in 1993 and 2000 (OSPAR 2000). International and multi-disciplinary cooperation is also a feature of North Sea science, for example through JAMP, ESAS, SCANS programmes; and of North Sea environmental protection for example through OSPAR, Natura 2000 and ASCOBANS (see glossary for acronyms).

The DTI sponsored a seminar (June 2001) on offshore oil and gas environmental research, with the aim of identifying priorities for future work aimed at improving protection of the environment in relation to offshore activities. Four core topics were considered: marine discharges (produced water, chemicals and drilling fluids); atmospheric emissions (flaring and other atmospheric discharges); protection of species and habitats (noise and other impacts); and monitoring (compliance and effects).

A DTI call for research proposals has recently closed and these will be reviewed by the R&D Steering Group prior to selecting and commissioning projects.

Significant gaps identified during the SEA 3 assessment (some of which were also identified during SEA 2), are summarised as follows:

- Long-term variability and trends in hydrographic characteristics, in relation to natural phenomena (eg the NAO) and climate change and the implications for North Sea ecology e.g. the effects on distribution of changes fronts and food distribution in the North Sea
- Wide area and regular monitoring of benthic community structure, with regard to long term trends. Further development of the taxonomy of several important macrofaunal groups is also required for reliable assessment of historic and future data
- Wide area and regular monitoring of chemical contaminants with regard to long term trends. Consistent methodologies are required or intercalibration exercises to be undertaken as new techniques are adopted to ensure comparability with historic data
- Cephalopod spawning areas in the North Sea
- Seasonal data gaps and update of seabird distribution data
- Distribution of marine mammals (update of SCANS data) and seal distribution and movements – specifically Wash/Blakeney Point for harbour seals and (to a lesser extent) Humber (Donna Nook) for grey seals
- Sound propagation and effects of noise on marine mammals (see SMRU commissioned report Section 3.1.3)
- Fate and biological effects of organic contaminants, including residual process chemicals including the role of assimilation and accumulation of contaminants
- Physical dispersion and accumulation of particulates and associated contaminants with specific reference to sink areas including sandbanks and other offshore conservation sites
- Prehistoric and archaeological remains - palaeo-topography of shorelines and wetlands during the last 100,000 years including the sequence and influence of the Flandrian transgression

As noted in SEA 2, a scientific perspective on future priorities for North Sea research (with a strong emphasis on southern North Sea seabed issues) was presented by Gerlach (1995), who suggested seven key areas: the phenomenon of rare species; meiofauna in suboxic sediment layers; dormancy of animals and bacteria in sediment; lateral advection of organic flux to the benthos; selection of representative monitoring sites; and importance of viruses, bacteria and other parasites.

11.3 Recommendations

In SEA 2 recommendations were made in the following five areas:

- **Scientific understanding**
- **Environmental effects monitoring**
- **Activity scenarios**
- **SEA process evaluation - cumulative effects**
- **Integrated management**

These recommendations remain valid and applicable to SEA 3. However, it should be noted that in all areas progress has been made, for example through the DTI R&D Steering Group, the publication of *Safeguarding our Seas* in May 2002 and the SEA process improvements introduced for SEA 3.

Recommendations arising from the Strategic Environmental Review process undertaken in relation to the proposed 21st Licensing Round are:

1. At the Stakeholder Meeting a number of recommendations for process improvements for future SEAs were made. These should be evaluated with the SEA Steering Group and taken forward as appropriate.
2. It is clear that co-ordination on SEA is required at several levels at an interdepartmental level, within departments to ensure the sharing of information and experience, the avoidance of duplication of effort and stakeholder confusion and fatigue.
3. Feedback mechanisms should be explored to allow stakeholders access to information on the accuracy of predictions made in environmental statements, for example, through publicly available post activity reviews.
4. The subject of a reporting regime for prehistoric marine archaeological remains and access to suitable technical support and advice should be followed up with industry bodies and others as a mitigation measure for existing and potential future oil and gas activity in the North Sea.
5. Further to the integrated management recommendation made in SEA 2 the merits of an SEA at a cross sectoral level should be explored. This would support but not replace sectoral SEAs.
6. A number of the information gaps identified above are relevant in a wider context than oil and gas activity, in addition to the DTI R&D initiative other mechanisms for the coordination of research priorities (ideas clearing house) and funding should be reviewed.

11.4 Overall Conclusion

Alternatives proposed for the development of the oil and gas resources within the proposed 21st Round area were identified as:

1. Not to offer any blocks for Production Licence award
2. To proceed with the licensing programme as proposed
3. To restrict the area licensed temporally or spatially

The overall benefits and disadvantages of these alternatives are summarised below:

Key source / effect	Not to offer any blocks	To proceed as proposed	To restrict the area temporally or spatially
Noise Physical damage at the seabed Physical presence Discharges Emissions Wastes to shore Accidental events Cumulative effects Transboundary effects		*No major effects are predicted, given existing regulatory controls and mitigation*	*No clearly identifiable/ justified seasonal or spatial restrictions were identified*
Socio-economic effects			
Wider policy objectives			

Key
Strong benefit
Some benefit
No benefit or disadvantage
Potential, but minor environmental effect or socio-economic disadvantage
Potential significant environmental effect or socio-economic disadvantage

After consideration of the nature of the area and the potential effects and benefits of 21st Round licensing, both in isolation and in the context of existing activities in the adjacent area (considered in SEA 2), it is recommended that the DTI proceed with licensing (Alternative 2). However this recommendation is predicated on the projections of the likely scale and location of activities that could follow licensing.

If geological interpretations change dramatically, for example if the London Brabant Massif is re-evaluated as a highly prospective area, then future licensing decisions will need to review changes in environmental aspects and understanding, including human uses of the area.

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APPENDIX 1: GLOSSARY AND ABBREVIATIONS

Term	Definition
µg	Micrograms
µPa	Micropascal (unit of pressure)
2D	2 Dimensional (of seismic)
3D	3 Dimensional (of seismic)
4D	4 Dimensional (of seismic, includes temporal parameter)
Acute	Of relatively short duration
Amphipods	Marine crustaceans (“sandhoppers”)
Anaerobic	Used of an environment in which oxygen is deficient or absent
Anchor mound	The disturbance to the seabed caused by the movement of the anchors
Annulus	The space between the drill string and well bore
Anode	Metal fitting, commonly of zinc or aluminium alloy, that provides corrosion (cathodic) protection
Anthropogenic	Resulting from human activity
AONB	Area of Outstanding Natural Beauty
Appraisal well	Well drilled to determine the physical extent, reserves and likely production rate of a field
Aqueous discharges	Watery discharges to the sea
Artificial Lift	A method of increasing oil production rate from a well, for example by gas injection at the wellhead or electrically powered submersible pumps within the well
ASCOBANS	Agreement on the Conservation of Small Cetaceans of the Baltic and North Seas (United Nations)
Barite	Barium sulphate – a naturally occurring heavy mineral added to drilling mud as a weighting agent to increase its specific gravity and thus the hydrostatic head of the mud column
Base fluid	The liquid component of drilling mud
Bathymetry	Measurement and study of ocean depth and floor
bbl	Barrel (= $0.1589m^3$)
Benthic	Relating to organisms living in or on the seabed
Benthos	Organisms living in or on the seabed
Bentonite	Naturally occurring clay mineral; used in drilling fluids to increase viscosity
BGS	British Geological Survey
Bioaccumulation	The uptake of elements or compounds within organisms
Biocide	A chemical toxic or lethal to living organisms, used to inhibit microbial growth and fouling within pipelines and other equipment
Biocoenoses	Association of organisms forming a closely integrated community
Biodiversity	Diversity of species
Biogenic	Produced by the action of living organisms
Biogeographic	Relating to the geographical area characterised by distinctive flora and fauna
Biomagnification	The transfer of increasing concentrations of elements or compounds up the trophic levels in the food web
Biomass	Living material; eg the total mass of a species or of all living organisms present in a habitat; usually excluding shell mass
Biosphere Reserves	Sites designated for the long-term study of ecosystems and the monitoring of environmental change
Biota	The total flora and fauna of a given area
Biotope	A physical habitat and its associated biological community

Term	Definition
Block	Sub-division of sea for the purpose of licensing to a company or group of companies for exploration and production rights. A Block is approximately 200-250 square kilometres
Bloom	Rapid increase in concentration of phytoplankton, often dominated by one species; may be seasonal (spring bloom); natural or anthropogenic
Blow-out	The uncontrolled release of oil, gas or water from a well
Blow-out preventor	Hydraulically operated device used to prevent uncontrolled releases of oil or gas from a well
BOD	Biochemical (Biological) Oxygen Demand - The amount of oxygen required to degrade the organic material and to oxidise reduced substances in a water sample; used as an index of water pollution
BOP	Blow Out Preventor
BP	Before Present
Bunkering	Transfer of fuel from supply vessel to rig or platform
Carcinogenic	Compounds inducing cancer
Casing	Steel lining used to prevent caving of the sides of a well, to exclude unwanted fluids and to provide a means of the control of well pressures and oil and gas production
CATS	Central Area Transmission System
CEFAS	Centre for Environment, Fisheries and Aquaculture Science
Cephalopods	Marine molluscs including squid, cuttlefish and octopus
Cetaceans	Aquatic mammals including whales, dolphins and porpoises
ChaMP (Coastal Habitat Management Plan)	A document that provides a framework for managing European and Ramsar sites that are located on or adjacent to dynamic coastlines
Christmas tree (xmas tree)	Valve assembly at the top of a well used to control flow of oil or gas
Chronic	Of relatively long duration
Clupeid	Family of fish including herring, sprat and anchovy
cm	Centimetres
COAST	Computer Assisted Shipping Traffic - vessel movement database, developed by Safetec on behalf of UKOOA, DETR and HSE
Combustion emissions	Emissions of gases from the burning of fossil fuels such as oil or gas including carbon, nitrogen and sulphur oxides, and may include particulates and unburned hydrocarbons
Completion	See Well Completion
Condensate	Liquid hydrocarbons, sometimes produced along with natural gas
Contaminants	Substances which may cause impurity or pollution
Copepod	Small crustaceans, usually planktonic
Corrosion Inhibitor	Chemical formulation used to minimise corrosion; a variety of formulations use different chemical properties
Corrosion protection	Use of chemicals or sacrificial anodes to protect a structure from progressive breakdown by chemical attack (or rusting)
cSAC	Candidate Special Area of Conservation - conservation site proposed for designation by national government under the EU Habitat & Species Directive
CSON	Continental Shelf Operations Notice
Cuttings pile	Pile of mainly rock chips deposited on the seabed as a result of drilling
dB	Decibel
DDT	Dichlorodiphenyltrichloroethane (a pesticide)
DEFRA	Department for Environment, Food and Rural Affairs
Dehydration	The process of removing water from a pipeline (during pre-commissioning); removal of water from gas as part of the production process
Demersal	Living at or near the bottom of the sea

Term	Definition
DEPCON	Deposit Consent (included in Pipeline Works Authorisation)
DETR	Department of Environment, Transport and the Regions (functions now split between the Department for Environment Food and Rural Affairs (DEFRA), the Department for Transport and the Office of the Deputy Prime Minister (the last two formerly the Department for Transport, Local Government and the Regions (DTLR))
Development well	Well drilled in order to produce hydrocarbons from a proven field
Downhole injection	Injection of gas, water or slurrified solids to a porous receiving rock formation
DP	Dynamic Positioning – active positioning of a stationary vessel or rig by thrusters (as compared to anchoring)
Drill bit	A drilling tool used to cut through rock
Drill casing	Steel pipe cemented into a well to prevent cave-in and stop fluids from leaking from surrounding rock into the hole or vice versa
Drill cuttings	Rock chips produced as a result of drilling
Drill string	Lengths of steel tubing roughly 10m long screwed together to form a pipe connecting the drill bit to the drilling rig. It is rotated to drill the hole and delivers drilling fluids to the bit
Drilling mud	Mixture of clays, water and chemicals used to cool and lubricate the drill bit, return rock cuttings to the surface and to exert hydrostatic pressure to maintain well control
DSV	Dive Support Vessel
DTI	Department of Trade and Industry
DTLR	Department for Transport, Local Government and the Regions (now replaced by the Department for Transport and the Office of the Deputy Prime Minister)
Dynamic Positioning	Use of thrusters instead of anchors to maintain the position of a vessel
E&P	Exploration and Production
EA	Environmental Assessment - systematic assessment of the environmental effects a proposed project may have on its surrounding environment
EC	European Community
EEC	European Economic Community
EMAS	Eco Management and Audit Scheme
EMS	Environmental Management System
ENCAMS	Environmental Campaigns – operating company for Tidy Britain Group and Going for Green environmental charities
Endocrine disrupting compounds	Compounds which have an effect on the hormonal systems of organisms
Environmental Aspect	An activity that causes an environmental effect
Environmental Effect	Any change to the environment or its use
Environmental Impact Assessment	Systematic review of the environmental effects a proposed project may have on the surrounding environment
Environmental Management System	System established to manage an organisation's processes and resultant environmental impacts
Environmental Statement	Formal document presenting the findings of an EIA process for a proposed project. Issued for public consultation in accordance with *The Offshore Petroleum Production and Pipe-lines (Assessment of Environmental Effects) Regulations, 1999*
EPAQS	Expert Panel on Air Quality Standards (See References)
Epifauna	Organisms living on the surface of the seabed
Epipelagic	Relating to towards the surface of the water column
ES	Environmental Statement

Term	Definition
ESA	Environmentally Sensitive Area
ESAS	European Seabirds At Sea
ESDV	Emergency Shut Down Valve
EU	European Union
Exploration well	Well drilled to determine whether hydrocarbons are present in a particular area
FEED	Front End Engineering Design
Flare	Controlled burning of gas for pressure relief (or during well testing for disposal of excess gas)
Fluorescein	Yellow-green fluorescent dye used for leak detection
Formation	An assemblage of rocks or strata
FPS	Floating Production System
FPSO	Floating, Production, Storage and Offloading Facility
FPV	Floating Production Vessel
Freespan	An unsupported section of pipeline on the seabed, usually resulting from seabed erosion
Front	Boundary region between different water masses; eg between stratified and vertically-mixed waters; often associated with high biological productivity
FRS	Fisheries Research Services
Fugitive emissions	Very small chronic escape of gas and liquids from equipment and pipework
g	Grams
Gadoid	Fish of the cod family
Geology	Physical structure and substance of the earth
Geomorphology	The study of the underlying form, and weathering processes, of rocks
Giga	Billion (10^9)
Glacigenic	Relating to glacial activity
GOR	Gas Oil Ratio
Greenhouse effect	Rise in the earth's temperature due to infra-red radiation being trapped in the atmosphere by water vapour, carbon dioxide and other gases
Greenhouse Gas	Gas which contributes to the greenhouse effect. Includes gases such as carbon dioxide and methane.
Guar Gum	Natural organic additive used to increase viscosity in drilling fluids
Ha	hectacre
HOCNF	Harmonised Offshore Chemical Notification Format
Holocene	Geological period since latest glaciation; from about 10,000 years ago to present
HSE	Health and Safety Executive
Hydrocarbon	Compounds containing only the elements carbon and hydrogen, including oil and natural gas
Hydrography	In this context, the study of sea water masses, currents and tides
Hydrotest	Pressure test using water
Hz	Hertz (unit of frequency)
IBA	Important Bird Area
ICES	International Council for the Exploration of the Sea
Immunotoxic	Having a toxic effect on the immune system
IMO	International Maritime Organisation
Imposex	Chemical interference with the sexual development of organisms

Term	Definition
Injection well	Well into which gas or water is pumped to maintain reservoir pressure
IPCC	Intergovernmental Panel on Climate Change (See References)
IPPC	Integrated Pollution Prevention and Control
ISO 14001	International standard for environmental management systems
Isobath	Depth contour
JAMP	Joint Assessment Monitoring Programme
JNCC	Joint Nature Conservation Committee
Jumper	Short joining section of pipeline (often flexible) or umbilical
km	Kilometres
Licence block	Area of the sea which has been sub-divided and licensed to a company or group of companies for exploration and production of hydrocarbons
Licensing round	An allocation of licences made to oil companies
Liner	Small diameter casing placed within a well to carry hydrocarbons back to the surface
LNR	Local Nature Reserve
Lost circulation	Uncontrolled loss of drilling fluid to porous rock formation; may be controlled by addition of a "pill" of a Loss Control Material
LSA (Low Specific Activity)	Low dose, naturally occurring radiation
m	Metres
MAB	UNESCO's Man and the Biosphere Programme
Macrofauna	Larger benthic organisms, defined as >0.5mm or 1.0mm in size
Macrozooplankton	Larger free-floating microscopic animals
Manifold	A piping arrangement which allows one stream of liquid or gas to be divided into two or more streams, or which allows several streams to be collected into one
MARPOL	International Marine Pollution Convention
Mattresses	Concrete structures used to protect pipelines or other subsea structures
MCA	Marine Consultation Area
MEHRA	Marine Environment High Risk Area – area of high environmental sensitivity at risk from shipping
Mesolithic	10,000-4,000 BP. Middle Stone Age
Meso-pelagic	Relating to the middle section of the water column
mg	Milligrams
Micro-zooplankton	Smaller free-floating microscopic animals
MLWS	Mean Low Water Springs (of tides)
Mud	See Drilling Mud
MW	Megawatt
NATO	North Atlantic Treaty Organisation
Natura 2000	Sites of conservation value designated under the EU Habitats Directive
NEC (No Effect Concentration)	Concentration at which no detrimental effects are expected to occur
Neolithic	4,000-2,500 BP. Period of human history characterised by the use of polished stone tools. Early Stone Age
NERC	UK Natural Environment Research Council
NGLs	Natural Gas Liquids
NGO	Non Governmental Organisation
NNR	National Nature Reserve
NSA	National Scenic Area
OCNS	Offshore Chemicals Notification Scheme
Odontocetes	Toothed whales
Oestrogen	Female hormone
Oestrogenic	Acting as an oestrogen

Term	Definition
OILMAP	Computer model used to predict oil spill trajectories
OLF	The Norwegian Oil Industry Association
Ontogenetic	Relating to the development of an individual organism
OPRC	International Convention on Oil Pollution Preparedness, Response and Co-operation
Organic compounds	Materials containing carbon combined with hydrogen, often with other elements
Organotins	Organic compounds of tin, used as antifouling and wood preservative; Dibutyl tin (DBT) or Tributyl tin (TBT). Cause imposex in gastropod molluscs
OSD	Offshore Safety Division
OSIS	Oil Spill Information System (Computer model used to predict oil spill trajectories)
OSPAR	Oslo and Paris Commission
OVI	Offshore Vulnerability Index – measure of seabird vulnerability to surface pollution including oil spills
Oxygen Scavenger	Chemical used to remove oxygen
Ozone	A gas formed naturally in the atmosphere containing three atoms of oxygen
PAH	Polycyclic (Polynuclear) Aromatic Hydrocarbons - group of organic chemicals produced naturally and by anthropogenic processes, e.g. combustion. May be carcinogenic and toxic
PCB	Poly Chlorinated Biphenyls – synthetic organic chemicals previously (until 2000) used as specialist lubricants and electrical insulating fluids. Bioaccumulate and cause arrange of effects in animals
PCZ	Preferred Conservation Zone
PEC (Predicted Environmental Concentration)	Concentration of a chemical predicted to occur in the environment
Pelagic	Organisms living in the water column of the sea
Permeability	Degree to which a solid allows the passage of fluid through it
Petrogenic	Derived from mineral hydrocarbons
PEXA	Practice and Exercise Areas for the military
Photochemical smog	Aerosol produced by an extremely complex interaction of ultraviolet radiation, nitrogen oxides (NO and NO_2), oxygen, ozone and Volatile Organic Compounds (VOCs); may cause respiratory, eye, nose and throat irritation
Photosynthesis	Process by which plants convert carbon dioxide into organic compounds using the energy of light absorbed by chlorophyll
Phytodetrital deposition	Particulate material derived from dead phytoplankton which settles to the seabed
Phytoplankton	Free floating microscopic plants (algae); including diatoms and dinoflagellates
Pig	Piece of equipment inserted into a pipeline and carried along by the flow of oil and gas; used to clean or monitor the internal condition of the pipeline
Plankton	Free-floating microscopic organisms
PLONOR	Posing Little or No Risk to the Environment
PNEC	Predicted No Effect Concentration
PON	Petroleum Operations Notice
Porosity	Ratio of volume of pore space to total volume (of for example rock)
PPC	Pollution, Prevention and Control
ppm	Parts per million
ppmv	Parts per million by volume
Produced water	Water removed from the reservoir along with oil and natural gas

Term	Definition
Quadrant	Subdivision of sea area for purposes of awarding licences for hydrocarbon exploration and exploitation. A whole quadrant in contains thirty blocks, and is approximately 7,500 sq km.
Quaternary	Geological period from 1.6 million years ago to present; comprising the Pleistocene and the Holocene
Radionuclide	Natural or artificial radioactive isotope
Ramsar Sites	Areas designated by the UK under the Ramsar Convention (Convention on Wetlands of International Importance especially as waterfowl habitat)
RCHME	Royal Commission on the Historical Monuments of England
Residual current	Time-averaged current, over many tidal cycles (usually expressed as a residual vector)
Rheological	Relating to flow or current
Riser	A pipe which connects a rig or platform to a subsea wellhead or pipeline during drilling or production operations
Riserless	Drilling without the installation of a riser; involves the direct discharge of cuttings to the seabed
RLD	Regional Landscape Designation
ROV	Remotely Operated Vehicle
RSPB	Royal Society for the Protection of Birds
SAC	Special Area of Conservation - conservation site designated by national government under the EU Habitat & Species Directive
Sacrificial anodes	Metal plates placed on underwater structures to prevent corrosion
SAST	Seabirds at Sea Team (of the JNCC)
Satellite altimetry	Measurement of height (eg wave height) by radar from satellite
Satellite well	Well with subsea wellhead connected via pipelines to the main development
SBM	Synthetic oil-Based Mud
Scale Inhibitor	Chemical formulation used to minimise the formation of metal carbonate scales in pipework and equipment
SCANS	Small Cetaceans Across the North Sea (survey programme)
SEA	Strategic Environmental Assessment or Appraisal
SEAL	Shearwater-Elgin Area Line
Sediments	Loose material, such as sand and mud, laid down at the bottom of the sea, river or lake
SEERAD	Scottish Executive Environment and Rural Affairs Department
Seismic	Survey technique used to determine the structure of underlying rocks by passing acoustic shock waves into the strata and detecting and measuring the reflected signals. Depending on the spacing of survey lines, data processing method and temporal elements, the seismic is referred to as either 2-D, 3-D or 4-D.
Shale	Mud or claystone rocks
Shallow gas	Gas accumulation present near the surface of the seabed
Shoreline Management Plan	A document that sets out a strategy for coastal defence for a specified length of coast, taking account of natural coastal processes and human and environmental influences and needs
Sidescan Sonar	Side-looking sonar system used to map seabed features
Sidetrack	Creation of new section of the wellbore for the purpose of detouring around an obstruction in the main borehole, or of reaching a different target.
SINTEF	The Foundation for Scientific and Industrial Research at the Norwegian Institute of Technology
SMP	Shoreline Management Plan
SOAEFD	Scottish Office Agriculture, Environment and Fisheries Department

Term	Definition
SOPEP	Shipboard Oil Pollution Emergency Plan
SPA	Special Protection Area - conservation site designated by national government under the EU Wild Birds Directive
Spanning	See freespan.
Special Area of Conservation	Areas designated as European Sites (Natura 2000) under the Habitats and Species Directive
Special Protection Areas	Areas designated as European Sites under the Wild Birds Directive
Spoolpiece or spool	Short section of pipe; e.g. used to join longer lengths of pipeline to riser or manifold
Spud	Installation of conductor; the date of commencement of a drilling operation
SSIV	Subsea Isolation Valve
SSSI	Site of Special Scientific Interest
Strategic Environmental Assessment (or Appraisal)	An appraisal process through which environmental protection and sustainable development is considered in decisions on policy, plans and programmes
Stratification	Development of a stable layered density structure in the water column; may be as a result of temperature gradients (thermal stratification) or salinity gradients. Often seasonal
Stuck Pipe	Drill pipe, collars, casing or tubing that is stuck downhole; may be controlled by mud additives or “spot” fluid
Sweep	Addition of a batch of additive to a drilling fluid; typically of a viscous additive to clear the hole of cuttings
Tank washings	Effluent as a result of cleaning tanks on rigs or vessels
Target location	Position within a reservoir which is the target at the start of drilling the well
Tee	A joint in a pipeline to allow another pipeline to be fed into it
Teratogenic	Causing abnormal foetal development
THC	Total Hydrocarbons
Thermocline	Stable boundary between two layers of water of different temperature
TLP	Tension Leg Platform
Topsides	Section of an offshore facility above the water level
Trenching	Excavation of a trench into the seabed for a pipeline or umbilical
Troposphere	The layer of the atmosphere below the stratosphere extending from ground level to 10-15km above the Earth’s surface
UK	United Kingdom
UKCS	United Kingdom Continental Shelf
UKDMAP	United Kingdom Digital Map (software based compilation of environmental information)
UKOOA	United Kingdom Offshore Operators Association
UKOPP	United Kingdom Oil Pollution Prevention
UKTERG	United Kingdom Terrestrial Effects Review Group (See References)
Umbilical	Narrow, reinforced, flexible pipeline containing several different cores, which are used to carry electrical power, chemicals and control fluids to the wellhead or other subsea equipment
UNECE	United Nations Economic Commission for Europe
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organisation
Venting	Release of gas to atmosphere for operational or emergency reasons
Viscosifier	Component of drilling fluids used to increase viscosity; usually an organic polymer or bentonite
VMR	Voluntary Marine Reserve

Term	Definition
VOC (Volatile organic compounds)	Organic compounds such as ethylene and benzene which evaporate readily and contribute to air pollution directly or indirectly
VSP	Vertical Seismic Profile
Vulnerability	Seabird vulnerability to surface pollution; quantitative index combining several factors
WBM	Water-based mud - drilling fluid using water as the carrier phase (cf. oil-based or synthetic mud)
Well Completion	The process by which a finished well is prepared for use by fitting a wellhead, liner and downhole equipment
Well Kill	The filling of the well bore with drilling fluid of a suitable density to stop the flow of the well
Wellhead	Control equipment fitted at the top of a well
White Zone	The formerly disputed area of sea between the UK and the Faroes
Workover	Re-entry into a completed well for modification or repair work
WWF	World Wildlife Fund
Xmas tree	Assembly of valves and fittings located at the head of a well to control the flow of oil and gas
Zooplankton	Free floating animals (often microscopic)

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APPENDIX 2: SUMMARY OF ASSESSMENT WORKSHOP

Overview

The expert assessment workshop was held over two days in July 2002 and brought the expertise of the SEA Steering Group, the authors of the SEA 2 and 3 underpinning technical reports and the SEA team to bear on the assessment process for SEA 3.

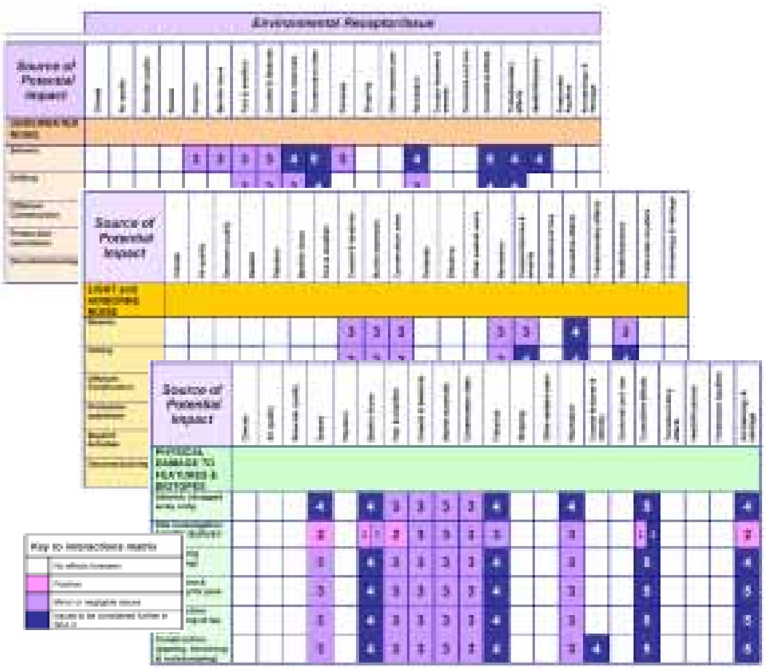
The objectives of the workshop were to:

- Ensure identification of all potential environmental interactions arising from activities that could follow further licensing in the SEA 3 area
- Screen the potential environmental interactions to identify those which could result in significant effects so that these can be considered further in the Public Consultation Document
- Review areas, sites and features of the SEA 3 region to identify any requiring additional protection over and above that available through existing mechanisms
- Identify any gaps in information and understanding, and assess their influence on the confidence with which the SEA 3 assessment of likely effects and necessary mitigation can be made

Workshop preparation materials included an overview of oil and gas activities and sources of effects, potential scale of activity that might follow from licensing of the SEA 3 areas, a preliminary activities/receptors interactions matrix and indicative criteria for use in screening effects. Participants received an update on issues arising from scoping, and a series of presentations by the topic experts.

These materials were used during the workshop to facilitate the generation of a revised interactions matrix and to identify those issues of strategic importance which should be examined in detail in the SEA 3 assessment. Issues were not only identified on scientific evidence of effects and implications for other users but also took account of issues of public concern (see revised criteria overleaf).

Figure A1 – Example working interaction matrices



The consideration of effects assumes compliance with all relevant legislation and controls and the application of current standard operational controls and mitigation – see Section 3.

Example interactions matrix work sheets from the assessment workshop are given in Figure A1 left.

The matrices have been collated in tabular form. The tables are colour coded to distinguish those interactions which members of the group felt required further consideration within the SEA 3 consultation document – see Matrices Section in this Appendix.

Revised Assessment Screening Criteria

Effects	Consequences
1 **None foreseen**	No detectable effects
2 **Positive**	Activity may contribute to recovery of habitats Positive benefits to local, regional or national economy May generate information useful for understanding or management
3 **Negligible**	Change is within scope of existing variability but potentially detectable
4 **Moderate**	Disturbance of populations of species in areas of importance for their breeding, feeding or other parts of the life cycle with expectation of good recovery[1] Damage to an offshore area 100 hectares or more, or 2 hectares or more of a benthic fish spawning ground or coastal habitat with expectation of good recovery Low potential to cause change[2] to internationally or nationally protected populations, habitats or sites Possible but unlikely effect on human health Possible transboundary effects Possible contribution to cumulative effects Issue of limited public concern May cause nuisance Damage to a building or site with historic, architectural or archaeological value, possibly reducing its importance Possible short term minor loss to business, communities or public finance
5 **Major**	Disturbance of populations of species in areas of importance for their breeding, feeding or other parts of the life cycle with expectation of moderate recovery[1] Damage to an offshore area 100 hectares or more, or 2 hectares or more of a benthic fish spawning ground or coastal habitat with expectation of moderate recovery Moderate potential to cause change[2] to an internationally or nationally protected populations, habitats or sites Transboundary effects expected Moderate contribution to cumulative effects Issue of public concern Possible effect on human health Damage to a building or site with historic, architectural or archaeological value, reducing its importance Possible medium term loss to loss to business, communities or public finance
6 **Severe**	Disturbance of populations of species in areas of importance for their breeding, feeding or other parts of the life cycle with expectation of poor recovery[1] Damage to an offshore area 100 hectares or more, or 2 hectares or more of a benthic fish spawning ground or coastal habitat with expectation of poor recovery High potential to cause change[2] to an internationally or nationally protected populations, habitats or sites Major transboundary effects expected Major contribution to cumulative effects Issue of acute public concern Likely effect on human health Destruction of a building or site with historic, architectural or archaeological value Long term, substantial loss to business, communities or public finance

Notes:

1. *Assessed using expert judgement, consistent with the following general principles;*
   - *Potentially affected area is > 10% biogeographic population (where quantification practicable)*
   - *Recovery to pre-licensing status within:*
     1 year = good
     5 years (or 2 generations for long lived species) = moderate
     10 years (or 5 generations for long lived species) = poor
2. *Change - an effect contrary to the objectives of management plans for national or international sites or species*

Matrices

These matrices summarise the output of the screening of issues conducted at the assessment workshop in terms of the potential, relative magnitude of effects, indicative of those subjects which should be considered further in the public consultation document. The matrices form part of the assessment process and as such are not an endpoint or conclusion. The SEA 3 area adjoins the coast and although the prospective areas generally lie offshore the ranking substantially erred on the side of precaution. Note the numbers 2-6 relate to the Assessment Screening Criteria.

Source of Potential Impact	2	3	4	5	6
UNDERWATER NOISE					
Seismic		Plankton Benthic fauna Fish & shellfish Coastal and seabirds Fisheries	Marine mammals Recreation Transboundary Health/Nuisance	Conservation sites Cumulative	
Drilling		Fish & shellfish Coastal and seabirds Marine mammals Recreation	Conservation sites Transboundary Cumulative		
Offshore Construction		Fish & shellfish Coastal and seabirds Marine mammals	Conservation sites Transboundary Cumulative Recreation		
Production operations		Fish & shellfish Coastal and seabirds Marine mammals Recreation	Conservation sites Transboundary Cumulative		
Decommissioning		Coastal and seabirds	Fish & shellfish Recreation Transboundary Cumulative Health/Nuisance	Marine mammals Conservation sites	

Source of Potential Impact	2	3	4	5	6
LIGHT and AIRBORNE NOISE					
Seismic		Coastal and seabirds Marine mammals Conservation sites Recreation Coastal features/amenity Health/Nuisance	Cumulative		
Drilling		Coastal and seabirds Marine mammals Conservation sites Recreation	Coastal features/amenity Cumulative Health/Nuisance		
Offshore Construction		Coastal and seabirds Marine mammals Conservation sites Recreation	Coastal features/amenity Health/Nuisance		
Production operations		Marine mammals Conservation sites Recreation	Coastal and seabirds Coastal features/amenity Cumulative Health/Nuisance		
Support Activities		Coastal and seabirds Marine mammals Recreation Coastal features/amenity	Conservation sites Cumulative Health/Nuisance		
Decommissioning		Coastal and seabirds Marine mammals Conservation sites Recreation Coastal features/amenity	Health/Nuisance		

Key to interactions matrix	
(white)	No effects foreseen
(pink)	Positive
(lilac)	Minor or negligible issues
(dark blue)	Issues to be considered further in SEA 3

Source of Potential Impact	2	3	4	5	6
PHYSICAL DAMAGE TO BIOTOPES					
Seismic (dragged array only)		Fish & shellfish Coastal & seabirds Marine mammals Conservation sites	Seabed Benthic fauna Fisheries Recreation Archaeology	Cumulative	
Site investigation Environmental survey	Seabed Benthic fauna Fish & shellfish Cumulative effects Archaeology & heritage	Coastal & seabirds Benthic fauna Marine mammals Conservation sites Fisheries Recreation	Cumulative effects		
Drilling (rig anchoring)		Seabed Fish & shellfish Coastal & seabirds Marine mammals Conservation sites Recreation	Benthic fauna Fisheries Archaeology	Cumulative effects	
Drilling (rock dumping for jack-ups)		Seabed Fish & shellfish Coastal & seabirds Marine mammals Conservation sites Recreation	Fisheries Benthic fauna	Cumulative effects Archaeology & heritage	
Construction (anchoring of lay barge)		Seabed Fish & shellfish Coastal & seabirds Marine mammals Conservation sites Recreation	Benthic fauna Fisheries	Cumulative Archaeology & heritage	
Construction (pipelay, trenching & rockdumping)		Seabed Fish & shellfish Coastal & seabirds Marine mammals Conservation sites Recreation	Benthic fauna Fisheries Coastal features/amenity	Cumulative Archaeology & heritage	

Source of Potential Impact	2	3	4	5	6
PHYSICAL PRESENCE					
Seismic survey (towed streamers)		Marine mammals Conservation sites Coastal features/amenity Cumulative effects	Fisheries Shipping Recreation		
Drilling (rig & anchors)		Benthic fauna Fish & shellfish Coastal & seabirds Marine mammals Conservation sites Fisheries Shipping	Other seabed users* Recreation Coastal features/amenity Cumulative effects Archaeology & heritage		
Production (installations and pipelines		Benthic fauna Fish & shellfish Coastal & seabirds Marine mammals Conservation sites Shipping	Fisheries Recreation	Other seabed users Coastal & seabirds Onshore/Land use Cumulative Archaeology & heritage	
Depletion of reservoir (seabed subsidence)		Seabed Benthic fauna Fish & shellfish Conservation sites			

Key to interactions matrix	
	No effects foreseen
(pink)	Positive
(purple)	Minor or negligible issues
(dark blue)	Issues to be considered further in SEA 3

Source of Potential Impact	2	3	4	5	6
MARINE DISCHARGES					
Drilling (muds and cuttings)		Plankton Fish & shellfish Coastal & seabirds Marine mammals Conservation sites Fisheries Other seabed users	Seawater quality Benthic fauna Recreation Cumulative Transboundary Health/Nuisance Archaeology & heritage	Seabed	
Construction (hydrotest and pipeline drying)		Seabed Plankton Benthic fauna Fish & shellfish Coastal & seabirds	Seawater quality Recreation		
Production (produced water) NB Gas		Seabed Plankton Benthic fauna Coastal & seabirds Marine mammals Conservation sites Fisheries	Seawater quality Fish & shellfish Recreation Cumulative Transboundary Health/Nuisance		
Other discharges NNM platform	Coastal & seabirds	Plankton Benthic fauna Conservations sites	Coastal & seabirds Cumulative Transboundary		
Ballast water (exotics & PSP etc)		Fisheries		Plankton Benthic fauna Fish & shellfish Conservation sites Cumulative effects Transboundary Health/Nuisance	
Low specific activity scale					

Source of Potential Impact	2	3	4	5	6
SUBSURFACE DISCHARGES					
Drilling (muds and cuttings injection)	Onshore/Land use		Seabed		
Production (produced water injection)					

Key to interactions matrix	
	No effects foreseen
(pink)	Positive
(lilac)	Minor or negligible issues
(dark blue)	Issues to be considered further in SEA 3

Source of Potential Impact	2	3	4	5	6
ATMOSPHERIC EMISSIONS					
Drilling (well test/clean-up)		Coastal & seabirds Conservation sites Recreation Health/Nuisance	Coastal features/Amenity	Climate Air quality Cumulative Transboundary	
Production (power generation)		Coastal features/Amenity	Climate* Air quality Cumulative Transboundary		
Production (flaring/venting)		Coastal & seabirds Conservation sites Health/Nuisance	Climate Air quality	Coastal features/Amenity Cumulative Transboundary	
Production (tanker loading - VOCs)		Coastal features/Amenity Health/Nuisance	Climate Air quality Cumulative Transboundary		
Production operations (Fugitives emissions)		Coastal features & Amenity	Climate Air quality Cumulative Transboundary		
Support vessels			Climate Air quality Conservation sites* Cumulative Transboundary		

Source of Potential Impact	2	3	4	5	6
WASTES TO SHORE					
Drilling (muds and cuttings)		Climate	Air quality	Onshore/Land Use Cumulative effects	
Low specific activity scale					
General oil field waste		Onshore/Land use	Air quality Cumulative effects		
Decommissioning		Climate Onshore/Land use	Air quality Cumulative effects		

Key to interactions matrix	
(white)	No effects foreseen
(pink)	Positive
(lilac)	Minor or negligible issues
(dark blue)	Issues to be considered further in SEA 3

Source of Potential Impact	2	3	4	5	6
ACCIDENTS					
Oil spills		Seabed Shipping Onshore/Land use	Seawater quality Plankton Benthic fauna Other users of the seabed Transboundary effects Archaeology & Heritage	Air quality Fish & shellfish Marine mammals Fisheries Coastal & Seabirds Recreation Cumulative effects Health/Nuisance	Conservation sites Coastal features/amenity
Chemical spills		Shipping Onshore/Land use	Air quality Seawater quality Seabed Plankton Benthic fauna Fish & shellfish Coastal & Seabirds Marine mammals Other users of the seabed Transboundary effects Archaeology & Heritage	Fisheries Recreation Coastal features/amenity Cumulative effects Health/Nuisance	Conservation sites
Gas releases		Fisheries Shipping Recreation	Seabed Benthic fauna	Climate Air quality Coastal features/amenity Cumulative effects Transboundary effects	Health/Nuisance
Injection accidents		Seabed Benthic fauna Fish & shellfish		Freshwater Aquifers	
Drilling accidents				Freshwater Aquifers	

Key to interactions matrix	
(white)	No effects foreseen
(pink)	Positive
(lilac)	Minor or negligible issues
(dark blue)	Issues to be considered further in SEA 3

Considerations for the assessment and potential information gaps

Considerations for the assessment identified during the workshop:

- Conservation sites
  - Implementation of the Habitats & Species Directive offshore and OSPAR Marine Protected Areas
- Contaminant Status
  - Effects of local geology and sediment type on contaminant concentrations
- Prehistoric & Archaeological Remains
  - Prospecting, high resolution shallow acoustics, coring and grab sampling have a very high potential to provide key information. Logging of data, inspection of cores and reporting finds on palaeo-environments is essential
- Marine Mammals
  - Marine mammals are important components of North Sea ecosystem
  - Noise is a potentially serious threat and needs to be managed (seismic practice OK, decommissioning not)
  - Need to take effects on seals seriously (in particular, harbour seals may have important foraging areas in SEA 3)
  - Harbour porpoise densities are lower in Southern North Sea but effects are potentially cumulative with fisheries bycatch
  - ASCOBANS and Habitat Directive responsibilities
- Birds
  - Implementation of the Birds Directive offshore
- Benthos
  - Distribution, ecology and conservation significance of Sabellaria colonies
- Fish & Fisheries
  - Inshore sites important for herring and edible crab
- Plankton
  - Introduction of exotics with ballast water
- Geological Context
  - Rock platforms occur off the Humber
  - Sandbanks include both active and relict features

Potential information gaps identified during the workshop:

- Contaminant Status
  - Long-term monitoring of contamination spread from existing installations
- Prehistoric & Archaeological Remains
  - Palaeo-topography of shorelines and wetlands during the last 100,000 years
- Marine Mammals
  - Seal distribution and movements – specifically Wash/Blakeney Point for harbour seals and seals (to a lesser extent) Humber (Donna Nook) for grey seals
- Birds
  - Effects on distribution of changes fronts and food distribution in North Sea
- Benthos
  - Long term trends in community composition (offshore)
  - Interactions with fish populations depleted by fishing
- Fish & Fisheries
  - High resolution spatial data for commercial fleets – especially in coastal waters off Lincolnshire and in Thames
- Plankton
  - In situ studies of the effect of production activities on plankton

    - Assimilation / accumulation of contaminants in plankton
- Cephalopods
    - Spawning areas in North Sea
- Geological Context
    - Sequence and influence of the Flandrian transgression

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APPENDIX 3: SUMMARY OF STAKEHOLDER MEETING

A stakeholder dialogue meeting was held in York on 6 August 2002, facilitated by the independent Environment Council on behalf of the DTI. A wide variety of potential stakeholders, drawn from UK and other regulators, government advisers, local authorities, other industry representatives, academics and NGOs were invited to the session.

The dialogue session aimed to fulfil various functions including to:
- Inform stakeholders of the progress on SEA 3
- Canvass reaction and opinion to the initial conclusions resulting from the expert assessment
- Seek suggestions on ways to further improve future DTI SEAs of other areas of the UK Continental Shelf (UKCS) prior to decisions on further large scale licensing.

The meeting was attended by some fifty stakeholders and included presentations on the UK & international regulatory context, SEA 3 process, oil and gas activities that could follow further licensing, and the natural environment and human uses of the SEA 3 area. Four stations were established (covering the SEA process, the SEA 3 environment, oil & gas activities, effects and controls, and the outcome of the expert assessment workshop) each with a number of posters, which formed the basis for facilitated discussion, the outcome of which was captured on flip charts. A transcript of the meeting was produced by the Environment Council and is included on the SEA website as supporting document SD_003.

Some selected issues raised at the Stakeholder Dialogue Meeting

- Shellfisheries off the Humber
- Are the DTI SEA results available, and will they be on a GIS
- Can existing gas pipeline be used to transport CO_2 for sequestration in the future
- Are learnings from previous SEAs applied retrospectively
- SEA 6 could complement the Irish Sea Pilot Study
- How should SEAs take account of technology advances
- Is there sufficient information on habitats between 3 and 12nm from the coast
- The Royal Navy have measurements and models for ambient noise levels in the North Sea and elsewhere
- SEA presents the opportunity for coordination of interests and impacts between land and sea allowing planning in the widest sense
- Potential impacts on marine mammals during decommissioning
- SEAs should aim to identify research needs and prioritise them
- Need to evaluate the effectiveness of the SEA process
- If the workshop was earlier or later in the process it would be less useful
- Need for an integrated UK SEA

APPENDIX 4 – NEARSHORE AND COASTAL BENTHOS

Nearshore benthic habitats and communities

A substantial amount of information is available concerning nearshore benthic habitats and communities of the east coast of England – this has been reviewed by MNCR coastal sector reports and JNCC Coastal Directories (Irving 1995a, b, 1998), from which the following is largely drawn.

Off much of the Northumberland coast, between 40-60m depth, there is a plain of fine sand being divided by a band of medium sand and gravel running parallel to the shore (Buchanan 1963, 1965). Deeper than 60m, the sediments consist of very fine sand with varying proportions of silt. Three principal communities have been identified, though these were found to be poorly correlated with sediment type: (1) a burrowing brittlestar *Amphiura filiformis-Amphiura chiajei* community; (2) an amphipod *Haploops tubicola* community; and (3) a bivalve *Chamelea gallina* community. Long-term monitoring of benthic communities off Blyth has shown periods of stability interspersed with periods of change caused by fluctuating winter temperatures and the flux of phytoplankton to the bottom (Buchanan & Moore 1986).

Mainland Northumberland headlands are often associated with subtidal tilted limestone reefs, which form extensive areas of bedrock terraces, with surge gullies and tunnels. Several northern species, (e.g. the bottlebrush hydroid *Thuiaria thuja* and the anemone *Bolocera tuediae*) are near their known southern limits of distribution here.

Tide-swept gravels and pebbles, offshore south of the Farnes, support a community of high nature conservation importance including hydroids, bryozoans and crustaceans. Further south, off the Durham coast, the sea bed is also predominantly sedimentary. Evidence of smothering of the sea bed by colliery waste and dredge spoil was apparent inshore, with low species diversity (Loretto 1992).

Further offshore from Northumberland, the sea bed is muddy, with boulders and mixed sediments, hard substrata being dominated by the soft coral *Alcyonium digitatum*, hydroids and bryozoans. The water in these areas is turbid and a dark, fine silt covered all sites investigated.

Sublittoral fine sand is present at many locations, including St Mary's Island where sandstone reefs are also present. At this site, *Echinocardium cordatum* is present within a brittlestar *Amphiura filiformis* community to a depth of 60m.

On the southern side of Flamborough Head, a well developed kelp forest of *Laminaria hyperborea* extends down to a depth of 4m. This species does not recur further south until the Dover Strait. A wide range of hydroids and bryozoans are dominant in areas of strong tidal streams and sand scour, along with the soft coral *Alcyonium digitatum* and colonial tunicates (sea squirts). Species able to bore into the chalk include the sponge *Cliona celata*, the polychaete *Polydora ciliata* and the bivalves *Hiatella arctica* and *Zirfaea crispata*. Interestingly, there are few sponge species present, and wrasse *Labridae* spp., which are normally plentiful around inshore rocks, are also uncommon.

The sublittoral macrobenthos between Flamborough Head and the Humber is typical of Jones' (1950) 'boreal offshore gravel association', with horse mussels *Modiolus modiolus*, brittlestars *Ophiothrix fragilis* and the bryozoan *Flustra foliacea* characterising the fauna. In the Humber estuary the ragworm *Hediste diversicolor*, the bivalve *Macoma balthica*, the amphipod *Corophium volutator* and oligochaetes were found to be the most abundant and widespread littoral species, with species diversity increasing seawards from west (7 species per station) to east (40 species per station) (Hinton-Clifton 1964; Jones 1973).

Off the mouth of the Humber the sea-bed substrate is composed largely of gravels and is characterised by species of genera such as bryozoans *Flustra*, whelks *Buccinum*, mussels *Modiolus* and polychaete worms *Sabellaria* (Murray *et al.* 1980). Further to the south, off Mablethorpe, the sediment is muddier. A total of 164 species were described by Resource Consultants Cambridge Ltd. (1993) in grab samples taken offshore about 100km east of the mouth of the Humber. Polychaetes (91 species) were dominant, but other annelids were represented, along with eleven other phyla. Both numbers and abundance of species varied widely from place to place.

Rees *et al*. (1982) describe five main community types in the Humber estuary:

1. Impoverished marine sand, in the central channel from Immingham to the mouth, influenced by tidal action and characterised by *Nephtys* spp., Mysidae, *Spio filicornis* and *Spiophanes bombyx*.
2. 'Transitional' muddy sand, mostly from Barton to Immingham on the south side, influenced by tidal current action, with *Capitella capitata*, *Polydora* sp., Mysidae, Gammaridae and *Nephtys* spp.
3. Impoverished estuarine muddy sand, from the upper estuary to Paull Roads on the north side, influenced by tidal current action. Sparse fauna, distinguished from transitional muddy sand by the absence of polychaetes.
4. Marine sand, at the southern mouth, containing a rich fauna in areas which were presumed to be less exposed than those of impoverished marine sand in the main channel. Characteristic species include *Spiophanes bombyx* and *Spio filicornis.*
5. Nearshore mud, off Immingham and Grimsby, with a rich mud fauna including *Polydora* sp. and *Pygospio elegans*.

The Wash is a large (66,000ha) sea inlet, about half of it exposed at low water in the form of sand and mudflats, an area comparable in Britain only to Morecambe Bay. In the outer reaches there are deep channels between the sandbanks, the greatest depth (47m) being recorded from the Lynn Deeps, midway between Hunstanton and the Friskney shore. The intertidal flats, amounting to around 40% of the total area of the Wash, consist mainly of fine sands supporting a community characterised by the lugworm *Arenicola marina*, with cockle *Cerastoderma edule*, Baltic tellin *Macoma balthica,* mussel *Mytilus edulis,* the gastropod *Hydrobia ulvae*, the crustacean *Corophium volutator* and the polychaete worm *Nephtys hombergii* (English Nature 1994).

Dipper *et al.* (1989) recorded five main sublittoral community types:

1. A brittlestar *Ophiura albida* community on fine sand and silt, particularly throughout the southern part of the Wash, with densities up to 1,500/m^2. Also with the brittlestar *Ophiura texturata*, the starfishes *Asterias rubens* and *Crossaster papposus*, the urchin *Psammechinus miliaris*, the anemone *Sagartia troglodytes*, the shrimps *Crangon crangon* and *Pandalus montagui* and the sandmason worm *Lanice conchilega*.
2. A fanworm *Sabella pavonina* community on fine sand overlying sticky clay mud, present at just two sites, NE of the Boston Deep and NE of Sunk Sand. The *Sabella* tubes provided a substratum for thick growths of the hydroid *Obelia dichotoma* and the bryozoan *Flustra foliacea*. The anemone *Sagartia troglodytes* is abundant in the mud between the *Sabella* tubes.
3. Muddy sand with shell gravel and pebbles characterised by hydroids, the bryozoan *Flustra foliacea* and the soft coral *Alcyonium digitatum*. Other prominent species included the anemone *Sagartia troglodytes*, the sandmason worm *Lanice conchilega* and the occasional brittlestar *Ophiura albida.*
4. Rippled sand with occasional empty shells and virtually no epifauna.
5. Soft mud with lugworm *Arenicola* casts.

In parts of the Wash the polychaete *Sabellaria spinulosa* has an important influence on the composition of sediment communities (see also below). This worm can build reef-like structures from coarse sands, creating niches for other invertebrate species, which in turn provide an important food source for commercial species such as shrimps and flatfish. Sites where *S. spinulosa* was found in 1991, mostly to the north and north-east, had over twice the number of species recorded from them compared with sites where it was absent (NRA 1994).

Much of the near-shore sea bed in the Sizewell area is of coarse sand and fine muddy sand with some clay deposits (IECS 1991). The dominant community features the bivalves *Nucula* spp. and *Macoma balthica,* together with the polychaete worm *Spiophanes bombyx* and the heart urchin *Echinocardium cordatum*. Amphipod crustaceans are also common, reflecting the high energy conditions of these sites. A deep subtidal trench runs parallel to the coast from Sizewell northwards and contains a distinctive community associated with the fine, organically rich sediments that have accumulated there. The less stable offshore Sizewell-Dunwich sandbank system supports a more species-poor community characterised by amphipods (Bamber & Batten 1989).

Major river estuary channels, e.g. the Tyne, Tees, Humber and Thames, where tidal scour may be considerable, generally consist of mixed mud, muddy sand and gravel, with a fauna comprised predominantly of capitellids, oligochaetes, nematodes and the polychaete *Polydora* sp. The diversity and quantity of species present is related primarily to salinity and water quality (i.e. organic pollution loading).

The sea bed of much of the Thames estuary consists of gravel, pebbles, clay or chalk, with silt and mud occurring in areas of deposition. Within the estuary, Andrews *et al*. (1982) lists all of the invertebrates and fish that were recorded between 1975-1981 from shore collecting, trawling and power station intake screens. The list includes 40 species of polychaete worm (the most frequently recorded being ragworm *Hediste diversicolor*); 11 species of oligochaete worm (mostly in the upper reaches); the barnacles *Balanus improvisus* (being the most widespread) and *Elminius modestus* (having an upriver penetration to Greenhithe); the brown shrimp *Crangon crangon* (fished commercially in the outer reaches) and the prawns *Palaemon longirostris* and *Pandalus montagui*; the shore crab *Carcinus maenas*; winkles *Littorina littorea* (the most abundant snail in the estuary and commercially fished in the outer estuary); several echinoderms including the starfish *Asterias rubens,* the sea urchin *Psammechinus miliaris*; and the ascidian *Molgula manhattensis*.

A 1972 study by MAFF of the sea bed around the sewage sludge disposal sites in the outer Thames Estuary was described by Talbot *et al.* (1982), who identified nine faunal and sediment associations, the most common ones being dominated by the polychaete worms *Nephtys* spp., *Spio* spp. and *Spiophanes* spp., bivalves *Tellina* spp. and amphipods. Further offshore, Frauenheim *et al.* (1989) sampled the larger benthic fauna such as crustaceans, echinoderms and molluscs as part of a study of the whole North Sea. The most common species included the echinoderms *Asterias rubens* and heart urchin *Echinocardium cordatum* and the polychaete worm *Aphrodite aculeata.*

A survey of 218 sites between Gravesend Reach and the Black Deep approach channel to the outer Thames estuary was carried out in 2001, together with a trawl survey and assessment of the age structure and commercial significance of cockle (*Cerastoderma edule*) populations, as part of environmental assessment of the proposed London Gateway Port project (Newell *et al.* 2001). In general, the communities were found to be rich in species (for this type of habitat), with high biomass values especially in the intertidal mudflats of the upper estuary. Epifauna was dominated by the swimming crab *Liocarcinus holsatus*, prawn *Pandalus montagui* and brown shrimp *Crangon crangon* with colonial bryozoan *Alcyonidium diaphanum* and hydroid *Sertularia cupressina*. Multivariate analysis of macrofaunal community structure distinguished at least five communities, corresponding to variation in sediment, water depth, salinity and current velocity.

Owing to the high turbidity of the waters around the Thanet coast, little light penetrates to the sea bed, limiting the depth to which algae can grow. The sublittoral fringe kelp zone is compressed into an extremely narrow band around chart datum, with no kelp below this depth (Northen in prep.). A low diversity of red algal species, including *Phyllophora pseudoceranoides, Plocamium cartlagineum* and *Griffithsia flosculosa*, extends to a maximum depth of only 4m, with many plants being heavily encrusted by the bryozoan *Electra pilosa*.

Thanet chalk substrates within the kelp zone are also characterised by a well developed crevice fauna. As a result of the softness of the chalk and sand scouring, few animals are able to colonise this bedrock, other than those able to bore into it, such as piddocks *Barnea candida* and *B. parva* and the spionid worm *Polydora ciliata*. The subtidal zone at Fulsam Rock, Margate had many piddocks, *Pholas dactylus* and *Hiatella arctica*, present in the chalk platform in 1986, their old burrows being colonised by the anemone *Sagartia elegans* or the honeycomb worm *Sabellaria alveolata* (Tittley *et al*. 1986). However no evidence of piddocks was found here during a survey in 1995.

Sediment shores

Sandy beaches are found throughout the SEA 3 coastline, for example in the Northumberland area from Cheswick south to Seahouses, Beadnell Bay, Embleton Bay, Alnmouth Bay, between the Tyne and Hartlepool where they are backed by high (up to 45m) limestone cliffs and from Redcar to Saltburn-by-the-Sea, backed by sand dunes. Between the Wansbeck estuary and Blyth (Northumberland), the 3km stretch of sand and shingle shore is speckled with coal dust. These exposed sandy beaches generally have low productivity, and a sparse fauna due to a combination of low organic content, physical disturbance by wave action, and dessication due to draining of pore water. Characteristic species include burrowing amphipods along the strandline, and the sandmason worm *Lanice conchilega* on the lower shore, with lugworms *Arenicola marina* on less exposed beaches where organic content is slightly higher.

A near-shore reef at Newton Haven (Northumberland) protects a sand community, including an unusual littoral population of the burrowing urchin *Echinocardium cordatum*, and razor shells *Ensis ensis* and *Ensis arcuatus.*

Sandy beaches are also widespread in the south of the SEA 3 area, for example at Pegwell Bay in the Thanet area (Kent). Much of the open coast of north Norfolk between Brancaster Bay and Blakeney is composed of mobile sands and some shingle, backed by extensive sand dune systems, with spits and offshore islands sheltering intertidal flats. Wave-exposed sandy beaches occur on the open Norfolk coast and are largely devoid of infauna, particularly on the well drained area of the upper shore. Towards the low water mark, where the sand is noticeably wetter, dense aggregations of lugworms and *Lanice conchilega* are common.

Along the shingle coastline around Orford Ness, the mobility of the rounded stones means that the intertidal zone is largely devoid of marine life, with the exception of amphipods feeding on strandline debris. Indeed, Bamber & Batten (1989) report the beach at Sizewell, representative of much of this coastline, as being effectively lifeless.

The intertidal flats at Maplin Sands (Essex) are of marine biological interest because of their extensive beds of dwarf eelgrass *Zostera noltii* (240ha) and eelgrass *Zostera marina* (58ha) (Wyer *et al*. 1977). Maplin Sands also support unusually lush growths of fern-like hydroids *Sertulia argentea* and *S. cupressina* (known locally as ‘whiteweed’), which also grow further up the Thames. Whiteweed is commercially exploited in this area, and is dried for decorative use.

Increasing mud composition in intertidal sediments, usually indicative of shelter, is generally associated with higher biological productivity. Intertidal flats composed of muddy sand at

Lindisfarne and Budle Bay, supports large populations of lugworm *Arenicola marina*. One shore site on the north side of the Wansbeck estuary (Northumberland) was surveyed by Brazier & Murray (1994), revealing communities typical of sheltered muddy sand.

Soft estuarine mudflats are widely distributed in estuaries throughout the area and are generally highly productive, although species diversity is often limited by low and variable salinity. Within the Tees estuary the softest muds of Seal Sands support only fifteen species but numbers of individuals are high, particularly of the polychaete *Manayunkia aestuarina*. The sandier Bran Sands supports a wider variety of less abundant polychates. Around the estuary mouth Seaton, North Gare and Coatham Sands are mostly well-graded sand exposed to wave action. Here there is a sparse fauna of amphipods, isopods and the polychaete *Scolelepis squamata* (Davidson & Evans 1981). Much of the intertidal zone of the River Deben, a typical East Anglian estuary, consists of muddy substrata. In the upper and mid Deben estuary, sandy mud is dominated by the bivalve *Macoma balthica*, the polychaete worm *Manayunkia aestuarina* and the oligochaete worm *Tubifex costatus* (Hill *et al*. 1996). Areas of well-sorted mud throughout the estuary are characterised by the polychaete worms *Nephtys hombergii* and *Caulleriella killariensis,* with ragworm *Hediste diversicolor* and the oligochaete worm *Tubificoides* spp.

The shore habitats of the Blackwater Estuary include saltmarsh, mud, sandy mud and mixed substrata. Of particular note are two extensive areas of intertidal clay, at Rolls Farm south of Tollesbury and at the east end of West Mersea. This rare habitat is extensively bored by the piddocks *Barnea candida* and *Petricola pholadiformis* (Hill *et al*. 1996). Dense beds of mussels *Mytilus edulis*, covered by barnacles, are present on areas of mixed substrata, a particularly extensive example being found in St Lawrence Bay. Rich lowshore communities influenced by tidal movement occur off Stansgate Abbey Farm (on the south shore) and off Rolls Farm (on the north shore). These feature sponges, particularly *Halichondria panicea* and *Halisarca dujardini*, with anemones *Sagartia* spp., the peacock worm *Sabella pavonina* and abundant quantities of the red alga *Griffithsia flosculosa.* In the sublittoral, the richest areas appear to be associated with mixed muddy substrata in the mid to low estuary, with a range of polychaetes, crustacea and ascidians. Polychaete species included *Exogone* spp., *Cirriformia tentaculata*, *Mediomastus fragilis* and *Tharyx marioni* and the tube-building *Sabellaria spinulosa*. Brittlestars *Amphipholis squamata* and *Ophiura* spp. are also present, together with the ascidians *Ascidiella aspersa*, *Ascidiella scabra* and *Dendrodoa grossularia* attached to larger pebbles (Hill *et al*. 1996).

The most widespread habitats in the Orwell Estuary are mud and sandy mud, supporting high abundances of the bivalves baltic tellin *Macoma balthica*, cockles *Cerastoderma edule* and *Mya arenaria*.

Dense beds of eelgrass *Zostera noltii* and *Z. angustifolia* are present at several locations, for example, on Fenham Flats (Northumberland). The tidal flats at Warkworth Harbour (at the mouth of the River Coquet) have dense growths of the green alga *Enteromorpha* spp., with small amounts of seagrass *Zostera* spp., both fed on by wildfowl (Brazier & Murray 1994).

The north-west half of The Swale, a tidal channel separating the Isle of Sheppey from the Kent mainland, is relatively deep, with a shoreline of exposed clay where tidal scour is strongest. Deposits of soft mud are present in the middle reaches, becoming increasingly more sandy towards the eastern end. Near Whitstable, firm clay is also present on the mid and lower shore. In these mid-shore areas, dense mussel *Mytilus edulis* beds support barnacles, the brown wrack *Fucus vesiculosus* and a variety of red algae (Hill *et al*. 1996). Lower down the shore, the clay is bored by the piddock *Pholas dactylus*.

Of interest at Hunstanton (east of the Wash) are the discrete exposures of intertidal peat. The sandflats at Hunstanton are characterised by lugworms, but exposures of Greensand rock at extreme low water mark support hard substratum communities, with a range of sponges, hydroids, molluscs and echinoderms (sea urchins).

Rocky shores

Two important shore habitats present along much of the Northumberland and North Yorkshire coasts are the intertidal rock platforms and boulders (Foster-Smith 1988). The biological communities of the bedrock platforms vary according to degree of exposure to wave action; they can be dominated by mussels *Mytilus edulis*, barnacles or fucoid seaweeds. Boulder beaches provide overhangs, and in deeper channels between boulders where sand and silt accumulates the tube-worm *Sabellaria spinulosa* is commonly found.

The Farne Islands have extensive littoral and sublittoral rock, the latter supporting extensive kelp beds, grazed by sea urchin *Echinus esculentus*, with *Pomatoceros triqueter* on vertical faces and soft coral *Alcyonium digitatum* on tide-swept areas.

Chalk bedrock is the dominant characteristic of the coast around Flamborough Head. The exposure here represents nearly 9% of Europe's coastal chalk and is the most northerly outcrop of coastal chalk in the British Isles. The area is also exceptional in the distance that the chalk is found offshore - at least 3-4km from the headland. The Head also acts as a biogeographic boundary, with certain marine species reaching their southern or northern distributional limits here. The north-facing shore has been identified as being of international importance for its algal communities, particularly in the splash zone on the cliffs (extending 15-20m above mean high water) and in caves.

At various locations in North Norfolk, mainly between Sheringham and West Runton but also at East Runton and Cromer, lie isolated stretches of chalk bedrock, which extend from the shore into the sublittoral. These represent the only appreciable area of natural hard substrate on the coast of East Anglia and are especially important because of the limited exposure of chalk bedrock in the European marine environment (Covey 1995, English Nature 1994).

On Thanet there are chalk cliffs on the shore and in the subtidal zone. The Thanet cliffs are considered to be of international nature conservation importance as the best chalk cliffs and associated algal communities in Britain and possibly Europe (Fowler & Tittley 1993). The unusual algal communities are best developed within Epple Bay and Pegwell Bay, where they show a distinctive vertical zonation. In places the bare chalk rock is tinged blue by chalk-boring blue-green algae. Within caves, unusual algal communities are well represented in Botany Bay, Kingsgate Bay and, in particular, Pegwell Bay (Tittley 1985). Some caves are large, extending over 30m into the cliffs and reaching 6-10m in height.

A number of wrecks (ships, aircraft and other solid material) and other artificial structures, are present throughout the SEA 3 area. These objects offer hard substrata in areas which may be largely sedimentary, thus providing discrete new habitats for opportunistic colonising species that otherwise would not be present.

Two littoral sites in the Brancaster area (North Norfolk), surveyed by an MNCR team in 1993, contain extensive outcrops of a fossilised forest, which support a mat of algae and dense growths of sandmason worms and are intensively bored by piddocks (a bivalve). Also, just south of Hartlepool, an area of the foreshore is notified as SSSI on account of exposures of a submerged forest.

APPENDIX 5 – SPECIES ACCOUNTS OF SEABIRDS AND COASTAL WATERBIRDS

Species accounts - seabirds

Synopses were given in SEA 2 of the population, distribution and general biology of individual seabird species regularly recorded in the North Sea (fulmar *Fulmarus glacialis*, sooty shearwater *Puffinus griseus*, Manx shearwater *Puffinus puffinus*, storm petrel *Hydrobates pelagicus*, Leach's petrel *Oceanodroma leucorhoa*, Gannet *Sula bassana*, cormorant *Phalacrocorax carbo*, shag *Phalacrocorax aristotelis*, pomarine skua *Stercorarius pomarinus*, arctic skua *Stercorarius parasiticus*, long-tailed skua *Stercorarius longicaudus*, great skua *Stercorarius skua*, little gull *Larus minutus*, black-headed gull *Larus ridibundus*, common gull *Larus canus*, lesser black-backed gull *Larus fuscus*, herring gull *Larus argentatus*, Iceland gull *Larus glaucoides*, glaucous gull *Larus hyperboreus*, great black-backed gull *Larus marinus*, kittiwake *Rissa tridactyla*, sandwich tern *Sterna sandvicensis*, common tern *Sterna hirundo*, arctic tern *Sterna paradisea*, guillemot *Uria aalge*, razorbills *Alca torda*, puffins *Fratercula arctica* and little auk *Alle alle*).

For the most abundant species, these synopses are further summarised, in relation to the SEA 3 area, below:

Fulmars are the most numerous seabird breeding in Britain and Ireland (571,000 pairs, Lloyd *et al*. 1991) although the major colonies are north of the SEA 3 area. Fulmars are generally the species recorded in highest numbers offshore throughout the UKCS. This species has undergone a remarkable population and range expansion in western Europe, for reasons that are still unclear but may include a combination of food availability from whaling offal and fishing discards; genetic factors, and climate change (reviewed by Lloyd *et al*. 1991).

Wintering densities are relatively low throughout the North Sea (except for the most northern areas), probably due to widespread dispersion of young birds in the north Atlantic and Arctic, and periodic colony attendance by breeding adults. During March and April, breeding birds undergo an exodus from the colonies, while at the same time fourth year and older pre-breeding birds return to the vicinity of their natal colonies. Overall fulmar densities are therefore high at this time, inshore off eastern Britain. Distribution during early and late breeding season is more widespread, with increasing numbers in the southern and central North Sea leading to a peak density in September. It is probable that moulting fulmars, particularly immature and non-breeding birds, move southwards and eastwards in the North Sea with peak numbers of moulting birds from May to September. Strong correlation has been observed between the presence of trawlers and high densities of fulmars, although this influence is variable and other factors obviously affect distribution (Tasker *et al*. 1987).

The **gannet** colony at Bempton is the most southerly on the UK North Sea coast, and although relatively small at around 780 occupied sites in 1987, has increased from previous count of 18 in 1968-70.

The southern North Sea holds relatively high gannet densities in November and December, when dispersion from large breeding colonies (e.g. 20,000 pairs at the Bass Rock) is at a maximum. High densities in the southern North Sea probably represent passage of breeding adults. During the pre-breeding and breeding seasons (February - August), gannets are concentrated inshore and offshore around the major breeding colonies in Shetland and the Firth of Forth.

Cormorants and **shags** are essentially coastal species which are rarely recorded offshore. Coastal colonies of both species are restricted to north of Flamborough Head, with significant colonies at the Farne Islands. Outside the breeding season, the majority of cormorants breeding in Britain and

Ireland move only locally and are exclusively coastal, although shags disperse more widely, with some ringed British birds crossing to the Norwegian coast (Galbraith *et al*. 1986).

No **skuas** breed within the SEA 3 area, although arctic skuas are present in the North Sea from April to December, while great skua show similar seasonality although a few birds are also recorded in late winter. Pomarine and long-tailed skuas are occasional passage migrants, breeding in the high arctic.

Little gulls are concentrated mainly in inshore and southern areas during spring and autumn. Very few **black-headed gulls** are recorded offshore, despite large coastal breeding populations (in excess of 129,000 pairs around the North Sea; 14.6% of the GB population breeding within the SEA 3 area, Tasker 1995a, b 1998). Peak abundance of **common gulls** in the North Sea is in winter, and distribution is predominantly southern and inshore although a summer concentration occurs around the Dogger Bank. **Lesser black-backed gulls** are principally summer visitors to the North Sea, with numbers offshore evidencing passage of birds to breeding colonies around the North Sea, mainly in the Skagerrak, south-west Norway and the Helgoland Bight. **Great black-backed gulls** breed around the northern coasts of the North Sea, and highest densities are recorded at sea between September and April. At all times of the year, numbers of great black-backed gulls are highest in the western North Sea, and the area off the north-eastern coast of England is most important during the winter period.

Herring gulls breed on virtually all natural habitats of all North Sea coastal areas with the exception of the Wash. Herring gulls from North Sea breeding populations are relatively sedentary, generally remaining throughout the year within 100km of their natal colony. Wintering populations are supplemented by migratory birds from northern Scandinavia and arctic Russia. Herring gull densities in offshore central areas of the North Sea are highest from November to March, and very low from April to October.

Kittiwakes have a circumpolar distribution, with over 400,000 breeding pairs around the North Sea coast of Britain and lower numbers in the low countries and Scandinavia. Approximately 24% of the GB population breeds within the SEA 3 area, primarily at the large colony at Bempton Cliffs. Kittiwakes from colonies in eastern Britain disperse throughout the North Sea and Bay of Biscay in winter, with increasing densities inshore around breeding colonies during spring and summer. However, substantial numbers of kittiwakes remain offshore during the breeding season, possibly due to movement of non-breeding birds into the North Sea from the Atlantic.

All terns are summer visitors to the North Sea, normally recorded between April and October. **Sandwich terns** breed around the southern and eastern North Sea with substantial colonies at the Farne and Coquet Islands and at Blakeney Point (around 9,500 pairs at these three sites, 60% of the GB population within the SEA 3 area). **Common terns** nest on all coasts of the North Sea and **arctic tern** have colonies mainly in northern areas although small numbers breed on all coasts of the North Sea, including East Anglia (23.7% and around 10% of the GB population respectively, within the SEA 3 area). **Little terns** breed in relatively small numbers at scattered colonies throughout the SEA 3 area coast, although cumulatively these account for 38.1% of the GB population. Substantial numbers of terns migrate northwards through the offshore North Sea in April and May, with return passage from July to September.

A total of about 62,503 **guillemots**, 8,012 **razorbills**, and 103,051 **puffins** have been counted in the breeding season at colonies within the SEA 3 area (Tasker 1995a, b, 1998), accounting for 6.0%, about 6% and about 11% of GB populations respectively. All three species breed in colonies on cliffs at the Farne Islands, Coquet Island and Bempton Cliffs.

Between March and June, most guillemots are found within 30km of their colonies, with a massive movement of birds into the offshore North Sea in July. Large concentrations of guillemots occur in the central northern North Sea at this time, with a gradual southward movement in concentration to off eastern Scotland and north-east England through August and September, and dispersal to a more widespread distribution in the southern North Sea in winter. During the post-breeding movement of birds away from colonies, guillemots moult and are flightless, and therefore are highly vulnerable to surface pollution.

Razorbills follow a broadly similar seasonal distribution pattern to guillemots, although razorbills from more southerly colonies are relatively sedentary.

Outwith the breeding season, the life history of puffins is much less understood than those of other auk species. Ring recoveries are rare and no clear description of puffin winter distribution is available from ringing recovery information. Sightings data indicate that departure from breeding colonies commences in July with movement south and east from the northerly colonies. Adults from colonies in eastern England move north to the Firth of Forth and central North Sea, with rapid offshore dispersal of juveniles, except for the most southerly breeding areas (Flamborough Head), where substantial numbers of juvenile puffins remain inshore into September. Winter puffin distribution in the North Sea is widespread with low densities.

Little auks are arctic breeders and regular winter visitors to the Norwegian coast and North Sea. Distribution records suggest a net movement from the western North Sea in November and December towards southern Norway during late winter, with migration northwards between February and May. Total numbers present in the North Sea are relatively insignificant in terms of overall little auk breeding population (Tasker *et al*. 1987).

Species account - coastal waterbirds

Although many are primarily associated with freshwater, wet grassland and moorland habitats, rather than strictly coastal locations, breeding species of waterbirds (herons, wildfowl, gallinules and waders) recorded along the coastal margin of eastern England include bittern *Botauris stellaris*, grey heron *Ardea cinerea*, mute swan *Cygnus olor*, greylag goose *Anser anser*, Canada goose *Branta canadensis*, shelduck *Tadorna tadorna*, wigeon *Anas penelope*, gadwall *Anas strepera*, teal *Anas crecca*, mallard *Anas platyrhynchos*, pintail *Anas acuta*, garganey *Anas querquedula*, shoveler *Anas clypeata*, pochard *Aythya ferina*, eider *Somateria mollissima*, common scoter *Melanitta nigra*, goldeneye *Bucephala clangula*, ruddy duck *Oxyura jamaicensis*, water rail *Rallus aquaticus*, moorhen *Gallinula chloropus*, coot *Fulica atra*, oystercatcher *Haematopus ostralegus*, avocet *Recurvirostra avosetta*, little ringed plover *Charadrius dubius*, ringed plover *Charadrius hiaticula*, lapwing *Vanellus vanellus*, dunlin *Calidris alpina*, ruff *Philomachus pugnax*, snipe *Gallinago gallinago*, black tailed godwit *Limosa limosa*, curlew *Numenius arquata*, redshank *Tringa totanus* and common sandpiper *Actitis hypoleucos* (Gibbons *et al*. 1993, Stroud & Craddock 1995a, b, May & Law 1998). (In addition, the Norfolk coast also supports many pairs of breeding marsh harriers *Circus aeruginosus*, as well as bearded tits *Panurus biarmicus* and most of Britain's breeding Montagu's harriers *Circus pygargus*, Stroud & Craddock 1995b) Of the above, it is most likely that shelduck, eider, oystercatcher, avocet, ringed plover and redshank will breed (or feed during the breeding season) on littoral beaches and adjacent saltmarshes within the SEA 3 area.

Shelduck are characteristic estuary birds, feeding on muddy and sandy shores and breeding in rabbit burrows, tree cavities or similar holes. Most British birds migrate in July to moult in company with the rest of the NW European population in the Heligoland Bight, although some birds remain to moult in the Wash (Bryant 1981). On return from their moult, shelduck are widely distributed with main concentrations in the SEA 3 area around the Humber and southeast coast from the Wash to the Thames estuary. Throughout Europe, shelduck numbers have increased steadily during the previous century with a steady increase in the British population since 1975 to a 1988-91 estimate of 44,200 birds; 10,600 breeding pairs (Gibbons *et al*. 1993). Of these, at least 14,000 birds (5,000 breeding pairs) have been recorded from SEA 3 areas, with additional numbers breeding along much of the Northumberland coast (Stroud & Craddock 1995a, b, May & Law 1998).

The SEA 3 area is at the southern limit of the breeding range of **eider**, which are principally an Arctic species, with Coquet Island the most southerly breeding site on the east coast (Gibbons *et al*. 1993). A few non-breeders were also recorded in 1988-91 along the Northumberland coast, at Flamborough, around the Wash and south to the Thames estuary. Eider distribution is probably determined by food availability, with extensive estuarine mussel beds being favoured feeding areas. Most British eiders move only short distances between breeding and wintering, although Northumberland birds are known to winter in the Firths of Forth and Tay.

Oystercatchers breed widely along shingle beaches, dunes, salt marshes and rocky shores within the SEA 3 area, particularly in East Anglia, and are expanding the breeding range into diverse inland nesting habitats, although the SEA 3 area holds a relatively low proportion, <20%, of the British population (33,000-43,000 pairs in the mid 1980a, Piersma 1986). British oystercatchers winter predominantly around UK coasts, although many juveniles may winter in western France and Iberia.

Avocet in the UK are confined to breeding around shallow, brackish lagoons in East Anglia and the Thames estuary (mainly on designated reserves), having recolonised England after a 100-year absence, in the early 1940s. The breeding population has since increased to 400-500 pairs (Gibbons *et al*. 1993) – Minsmere, Havergate Island (the stronghold), Trimley Marshes on the Orwell and Elmley on the Swale have the main breeding concentrations. The avocet is not a threatened species in world or European terms, and the English population represents only 2% of the western European population of 19,600 pairs (Piersma 1986). However, the species is likely to remain very local in Britain and Ireland (due to habitat specialisation) and being widely recognised through its adoption as a logo by the RSPB, must be regarded as a particularly sensitive species in the context of SEA 3.

Sandy and shingle beaches are the favoured breeding habitat of **ringed plover**, with a distribution scattered around the low-lying coasts of Britain and Ireland. In England the extensive beaches around the Greater Thames and up to Humberside hold the majority of the population (Gibbons *et al*. 1993), although ringed plover are sensitive to disturbance and about 70% of breeding pairs in SE England were on nature reserves or other well-protected sites. The population within the SEA 3 area (Berwick to Dungeness) accounted for 19.8% of territoral (presumed breeding) pairs in Great Britain in 1984 (Prater 1989). In winter, birds are distributed all around the coast although a return to breeding sites may start as early as mid-February. The British and Irish breeding population of ringed plover (around 10,000 pairs) represents almost 80% of the temperate breeding population of the nominate race of ringed plovers.

Breeding **redshanks** are found on wet grasslands inland and coastal saltmarsh, where they occasionally reach densities of over 100 pairs per km^2 (Cadbury *et al*. 1987). Inland breeding populations have declined, although a 1985 RSPB/NCC survey of breeding waders on saltmarsh showed high densities of redshank including those at sites in NW England and East Anglia.

In addition to coastal breeding species, internationally important numbers of migrant and wintering waterfowl use the SEA 3 area coastline. In mid-winter, the coastal area between Berwick and Dungeness holds over 800,000 waterfowl (about half the English total), the majority on estuaries south of the Humber (Stroud & Craddock 1995a, b; May & Law 1998). In addition, the region lies on the major migratory flyway of the east Atlantic, and many birds moving between arctic breeding grounds and wintering areas on African, Mediterranean and south-west European coasts stage in the area. Species which have internationally important wintering populations at coastal sites in the SEA 3 area include Bewick's swan, light-bellied brent goose, dark-bellied brent goose, greylag goose, pink-footed goose, pintail, wigeon, oystercatcher, curlew, knot, redshank, turnstone, purple sandpiper, golden plover, lapwing, grey plover, shelduck, black-tailed godwit, bar-tailed godwit, dunlin, ringed plover, avocet and cormorant (several of which are also resident breeders, see above).

Bewick's swan *Cygnus columbianus* winter in western Europe following a narrow-front migration from breeding grounds in arctic Russia. The inland Ouse and Nene Washes are the most important sites numerically for Bewick's swan in northwest Europe, although internationally important numbers (132 in 99/00) are also recorded at the coastal Breydon Water. Birds arrive typically in November, and leave in March.

Pink-footed goose *Anser brachyrhynchus* are listed as wintering in internationally important numbers at the North Norfolk marshes and the Wash (Stroud & Craddock 1995b), although the 1999/2000 WeBS counts do not list these sites, but record an increase at Breydon Water and Berney Marshes from 1 in 1995/96 to 6,600 in 99/00. Pinkfeet arrive in Britain, usually in early October, from breeding grounds in Iceland and east Greenland, with return passage in April. In severe winters, a few pinkfeet from the Spitsbergen breeding population (which winter in Denmark, Germany and the Low Countries) reach east Britain.

Three distinct populations of **greylag goose** winter in the UK, derived from breeding populations in Iceland, north-west Scotland, and a naturalised re-established population in England and Wales. Large numbers of birds (1,837 in 99/00) from the latter breeding population winter along the North Norfolk coast, with additional birds at the Wash and several estuary sites. Internationally important numbers from the Icelandic population also winter at Lindisfarne.

Dark-bellied brent goose *Branta bernicla bernicla* winter in internationally important numbers at several sites in south-east England, with the Wash supporting almost one third of the UK wintering population (peak count 99/00 28,811). Birds arrive from arctic Russia in November-December, with subsequent movement between and within the Netherlands, south-east England and west France influenced by food supply and weather.

Wintering populations of **light-bellied brent goose** *Branta bernicla hrota* at Lindisfarne are derived from the Svalbard breeding population, with about 30% of the international population (1,767 birds) wintering at this site in 99/00 (Musgrove *et al*. 2001). (Much larger numbers, ca. 15,000 birds, from the Canadian population winter at Strangford Lough and Lough Foyle in Northern Ireland.)

Winter counts of **wigeon** at Breydon Water and Berney Marshes, and at the Blackwater estuary, have trebled and doubled respectively during the five years to 99/00 (Musgrove *et al*. 2001) with about 14,500 birds counted at these two sites (representing nationally important numbers). Internationally important numbers are recorded at the Ouse Washes (24,540 in 99/00) Swale estuary (11,725) and North Norfolk coast (18,950). These birds are predominantly from breeding populations in Fenno-Scandia and north-east Russia.

Wintering **pintail** numbers on the North Norfolk coast have remained relatively steady in recent years (1,235 in 99/00), representing internationally important numbers; with 2,000-3,800 birds at Ouse Washes and more variable numbers (264-1,688) at Nene Washes. These include breeders from Iceland, north Russia, Fenno-Scandia and the Baltic although large numbers of the north European breeding population are also thought to winter in west Africa.

Local breeding populations of **oystercatcher**, **redshank**, **curlew** and **ringed plover** along the east coast of England are supplemented by wintering birds from Europe; particularly oystercatchers from Norway, ringed plover from Scandinavia and the Baltic and redshank from Iceland and the Faroes. **Lapwing** numbers are also at their highest in winter, although a post-breeding dispersal in late May and June brings many lapwing from central and eastern Europe to the Low Countries and eastern Britain.

Ringed plover are described (Taylor 1980) as "leap-frog" migrants (i.e. northernmost breeding populations winter farthest south), thus a substantial passage of birds down the North Sea coasts involves breeders from arctic Europe moving to and from the Mediterranean basin and Atlantic coasts. To a lesser extent, similar movement patterns have been noted in the three Palearctic subspecies of redshank, with birds from northern Fenno-Scandia migrating to West Africa while Icelandic birds move only to the North Sea.

Curlew numbers have remained relatively constant over the least thirty years, with a maximum count in Great Britain for 99/00 (nearly 100,000 in February) the highest ever recorded by WeBS. Wintering sites of international importance include the Wash, with the Humber, Thames, Blackwater, Medway, Swale and Stour estuaries together with the North Norfolk coast and Lindisfarne also of national importance in Great Britain.

The summer breeding population of **black-tailed godwit** (around 60 pairs in the 1970s decreasing to around 40 pairs in the late '80s) is substantially augmented by wintering birds from arctic Europe and Asiatic Russia to a recorded Great Britain maximum in 99/00 of 16,556 birds. The WeBS annual index shows a continued increase in numbers of this species over thirty years, with only minor fluctuations. Several sites within the SEA 3 area are of international importance (>700 birds) including the Wash, Stour estuary, Ouse Washes, Swale and Blackwater estuaries.

Bar-tailed godwit *Limosa lapponica* wintering numbers in Britain have fluctuated since the late 1960s, with a peak in 99/00 of 48,704 birds. Sites within the SEA 3 area of international importance (>1000 birds) include the Wash, Thames estuary, Lindisfarne, Humber estuary and North Norfolk coast.

Golden plover *Pluvialis apricaria* and **grey plover** *Pluvialis squatarola* are characteristic wintering birds of the coastline of eastern England, with substantially increasing counts of golden plover recorded at the Wash, Blackwater estuary and Breydon Water in recent years (Musgrove *et al*. 2001). Grey plover numbers have remained relatively constant at a number of east coast sites which hold internationally important winter populations (>1,500) – the Wash, Hamford Water, Dengie Flats, North Norfolk coast, Lindisfarne and estuaries of the Thames, Blackwater, Swale, Stour, Medway and Humber. Golden plover breed widely in tundra and upland habitats of Iceland, northern Britain, Fenno-Scandia and arctic Russia, with mixing of migrant populations in winter. Grey plover breed in the high arctic of northern Siberia, Alaska and Canada with peak numbers in Britain occurring during the autumn passage of Siberian birds to west Africa. The Dutch Waddenzee and the Wash in particular are important staging posts in this extended migration, with a proportion of adults arriving in arrested moult and completing moult at these sites. Juvenile passage birds arrive about six weeks later than adults, leaving North Sea staging areas in late October and early November. Spring migration from the Wash occurs fairly late (April to late May).

Knot *Calidrus canutus* make very long non-stop migrations between estuarine staging areas, with breeding birds from Canadian high-arctic islands and northern Greenland wintering in wester Europe, whereas birds from north-central Siberia migrating through Europe to winter in west Africa. The Wash held a peak of 60,711 birds in 99/00, the Thames estuary 21,942 and Humber estuary 25,719, with lower but still internationally important numbers (>3,500) counted at Dengie Flats, North Norfolk coast, Lindisfarne and the Stour and Swale estuaries. Overall, knot numbers in Great Britain in 99/00 were the lowest for over a decade.

Dunlin have a Holarctic breeding distribution, including uplands in Scotland, northern England and Ireland, and winter on most ice-free coasts of the northern hemisphere. Dunlin occur on passage through eastern Britain in August and September, with return migration in late May having a more westerly emphasis. Maximum dunlin counts in Great Britain were at their lowest for eleven years in 99/00, with only the peak winter count at Dengie Flats significantly higher than normal. The peak count at the Wash was also increased following several years of successive decline, although it is likely that these were passage rather than wintering birds. Sites of international importance in the SEA 3 area include the Wash (peak 99/00 count 41,503), and the Thames, Blackwater, Humber, Medway and Stour estuaries.

Purple sandpiper *Calidris maritima* are almost exclusively birds of rocky shores, and are therefore not effectively monitored by WeBS and other (mainly estuarine) counts. The breeding range is further south than that of knot (and Sanderling), and includes Siberia, Norway, Iceland, Greenland and northern Canada; although the winter distribution is further north than other *Calidris*, with most over-wintering in Iceland and wester Norway and the SEA 3 area close to the southern limit of winter distribution. Relatively low numbers (max 360) were recorded by WeBS counts between 95/96 and 99/00, although the Farne Islands, Seahouses to Budle Point, Tees estuary, Durham coast and Cambus to Newbiggin (all north of Flamborough) were considered to be sites of national importance.

Turnstone *Arenaria interpres* are also predominantly rocky shore birds, although not as exclusively as purple sandpiper. Turnstones have a Holarctic breeding range with breeding birds from the north-western population (north-east Canada and Greenland) wintering in western Europe, while birds from the Fenno-Scandian and west Russian population migrate through the Baltic and western Europe to winter in Morocco and west Africa. Wintering turnstone numbers in Great Britain have declined steadily from highs in the mid to late 1980s, with Thanet and the Wash considered to be sites of international importance in 99/00.