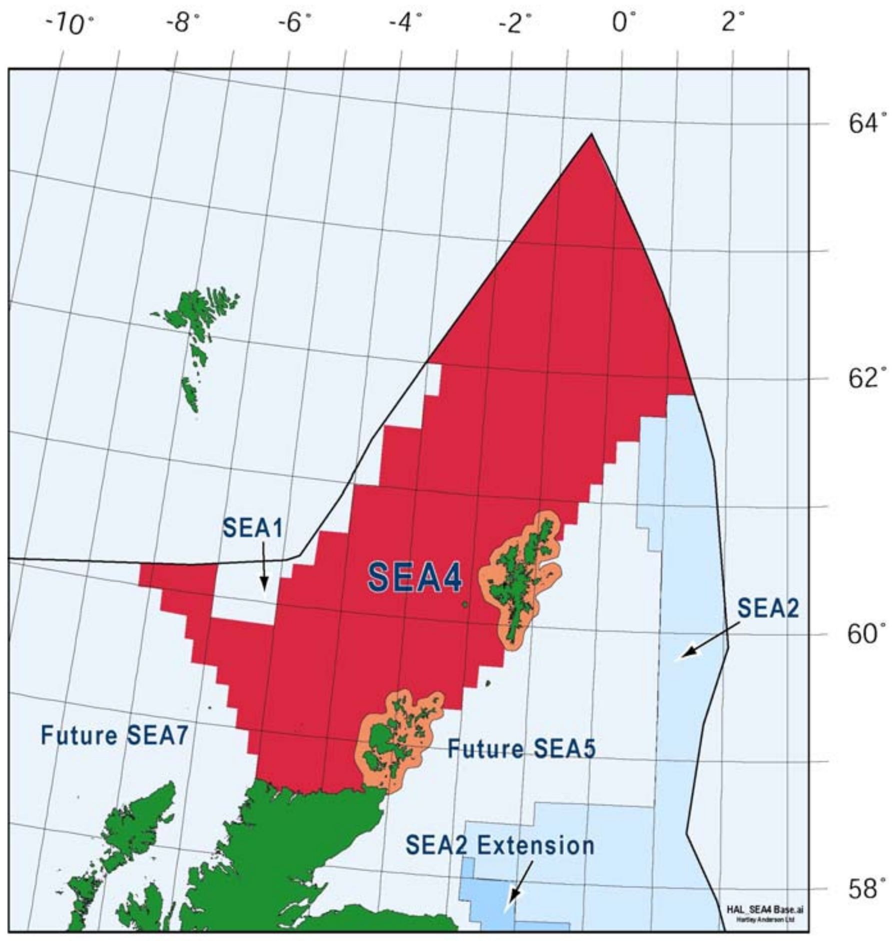
Report to the
Department of Trade and Industry

Strategic Environmental Assessment
Area North and West of Orkney and Shetland



Consultation Document
September 2003

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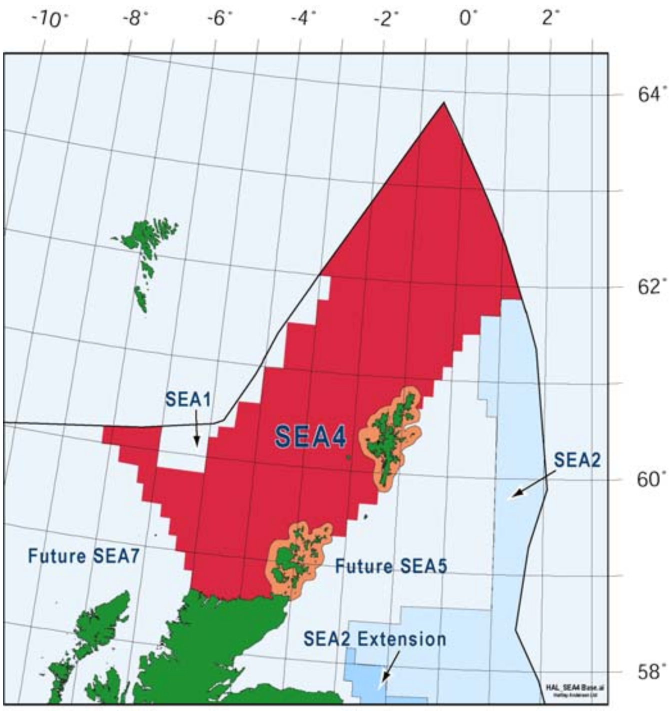
NON-TECHNICAL SUMMARY

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 area north and west of Orkney and Shetland for oil and gas exploration and production (see Figure 1).

Figure 1 – The SEA 4 area



This SEA (SEA 4) is the fourth in a series planned by the DTI, which will in stages, address the whole of UK waters. The first DTI offshore oil and gas SEA was conducted in 1999/2000 prior to a 19th Round of offshore licensing and covered areas along the formerly disputed median line with the Faroes. SEA 2 was completed in 2001 and considered the main areas of oil and gas production in the North Sea. SEA 3 was finished in 2002 and addressed the remaining parts of the southern North Sea. SEA 4 has been undertaken in line with the European SEA Directive (2001/42/EC, which is required to be implemented by July 2004) with the aim of considering environmental protection and sustainable development objectives in decisions relating to oil and gas licensing in the area to the north and west of Orkney and Shetland.

For the purposes of oil and gas licensing, UK waters are divided into quadrants (1º of latitude by 1º longitude) with each quadrant further divided in to 30 blocks, each of approximately 250km^2.

Blocks within the SEA 4 area were first offered for licensing in 1965. The area covered by SEA 4 comprises some 508.5 blocks of which 33.5 are currently wholly under licence, 33 are partly licensed and partly relinquished, 130 have been licensed but are wholly relinquished, and 312 have not previously been licensed.

The proposed action considered by this SEA is the offer of Production Licences for blocks covering parts of the UK continental shelf through a 22nd Round of offshore licensing. SEA 4 was selected as the next in the DTI series based on knowledge of the geology of the area and the availability of existing oil and gas infrastructure. 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.

A requirement 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 (http://www.offshore-sea.org.uk) or contact the SEA Coordinator, 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 North American examples, and the experience gained and lessons learned from the previous DTI SEAs. Improvements made include the formal involvement of stakeholders at several stages of a 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, authors of technical reports and key stakeholder representatives also participated in a workshop to identify which oil and gas industry activities might potentially result in significant effects. To contribute to the SEA the DTI commissioned geological and biological surveys of the seabed together with a number of desk-top studies covering a range of topics. These reviews and reports have been used in the preparation of this document. A stakeholder dialogue meeting was held in Nairn on 1 July 2003, facilitated by independent facilitators People=Positive™ 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. 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 18 exploration wells and the development of up to 4 new producing fields, 2 of which would most probably be through subsea wells tied back to existing facilities with the other 2 developments by means of floating production vessels. The actual scale of activity is dependent on a variety of factors and in particular, oil prices and tax regime. The most likely location of exploration and production activities is expected to be in the blocks close to the existing offshore oilfields.

The SEA 4 Environment

Water depths and seafloor

Water depths gradually deepen out to the continental shelf edge, from where the seabed slopes down into the Faroe-Shetland Channel to the west and the Norwegian Sea to the north where water depths reach 2,400m. The Faroe-Shetland Channel is bounded to the south by the Wyville Thomson Ridge and to the east and west by the continental shelves of the UK and the Faroe Islands. A northwest-southeast oriented branch (the Faroe Ban Channel) leads off the southern end of the Faroe-Shetland Channel and flanks the Wyville Thomson Ridge.

Tides and currents

Water circulation is dominated by the northward flow of surface water from the North Atlantic through the area, a proportion of which enters the North Sea from the west and the north. Colder and deeper water flows in the opposite direction from the Norwegian Sea through the Faroe-Shetland Channel. The hydrography of the area is complex and water currents (from tides, storms and internal waves) are typically moderate to strong, even in the deeper water parts of the Faroe-Shetland Channel.

Seabed sediments

In coastal areas, seabed sediments are highly varied and range from exposed bedrock to mud. The sediments of the continental shelf are tide scoured sands and gravels often with numerous cobbles and boulders. Moving deeper, mixtures of sand and gravel are common, typically with the proportion of mud increasing in depth. Strong bottom currents play an important role in determining the distribution of sediment and the bedforms (e.g. sandwaves).

Seabed animals

The coastal regions of SEA 4 contain common habitats and seabed communities and also those that are national or internationally rare. Coastal and shelf habitats range from bedrock to mud with the biological communities varying according to a number of controlling factors such as exposure to wave action. In deep water areas, the distribution of seabed species is modified by water temperature and bottom-currents although at present information regarding the biology of many of these species is limited. No large reefs or colonies of cold water corals have been found in the area. A group of diapirs (mud volcanoes) are present in the deep water to the north of the area, but the unusual biological communities often associated with such features in other parts of the world have not been found.

Food web

Coastal and surface waters are an area of high productivity 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. An area of enhanced primary productivity occurs along the shelf break but the cold, deep waters of the Faroe-Shetland Channel are much less productive.

Fish and fisheries

The waters of the shelf and upper slope support a rich diversity of fish species similar to those found at similar depths elsewhere on the UKCS. However, the cold deep water within the Faroe-Shetland Channel supports a different fish fauna with comparatively few species. Fisheries are very important in parts of the SEA 4 area. There are several demersal fisheries of which the mixed fishery for cod, haddock and whiting is the most important. The main pelagic fisheries are for herring and mackerel and there are industrial fisheries for sandeel and blue whiting. A number of regulatory measures are in place to preserve over-fished or threatened stocks. Coastal waters support important creel fisheries for various shellfish species.

Birds

A large number of internationally important seabird colonies are found on the cliffs that make up much of the SEA 4 coast and huge numbers of breeding seabirds are associated with these in spring and early summer. Coastal waters support substantial populations of birds throughout much of the year. After the breeding season, species such as fulmar, gannet, kittiwake, guillemot, puffin and razorbill leave coastal waters and disperse offshore to feed. Coastal and sheltered waters also support important populations of migratory and wintering wildfowl and waders, as well as breeding birds.

Marine mammals

The SEA 4 area supports a wide variety of marine mammals, with internationally important numbers of grey and common seals found at coastal breeding colonies. The most common cetaceans sighted in shelf waters are harbour porpoise, minke whale and white-beaked dolphin. Deeper-water species include Atlantic white-sided dolphin, long-finned pilot whale, killer whale, sperm whale and fin whale, some of which are thought to migrate through the area. Several species of beaked whale are thought to inhabit deeper water in the Faroe-Shetland Channel, although there is very little information concerning these species. Hooded seals, which breed in the Arctic, are regularly observed in the deeper waters of the SEA 4 area.

Conservation

The SEA 4 area contains 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, offshore areas of SEA 4 containing important habitats and species have been identified and enabling legislation is currently undergoing public consultation.

Marine archaeology

The coastal region of SEA 4 supports a wealth of prehistoric sites. Due to changes in relative sea level, prehistoric submarine archaeological remains of up to about 9000 years old could occur in the SEA 4 area down to water depths of around 150m. However, despite the potential for sites, marine archaeological discoveries are very rare primarily due to the strong currents and exposed nature of much of the shelf area. There are a large number of identified wrecks throughout the area, some of which are protected.

Contamination

The SEA 4 area is remote from areas of major industrial activity and therefore includes some of the least polluted habitats in the UK. However, there are local sources of contaminants, in particular hydrocarbons, and the atmospheric and hydrographic transport of persistent contaminants into the SEA 4 area has probably resulted in detectable pollution throughout the region.

Other users

In addition to the oil and gas industry and commercial fisheries, the SEA 4 area provides an important resource for a number of other users. Much of the SEA 4 coast is rural in nature and attracts a growing number of tourists to its unspoilt scenery and natural history interest. There are several large coastal ports which form a focus for shipping and trade. The area experiences low to moderate shipping pressures and a proportion of this involves tanker traffic to and from the Sullom Voe and Flotta oil terminals. Sheltered coastal waters support important locations for both finfish and shellfish cultivation.

Coastal initiatives

In general, the different industries which utilise the SEA 4 area have adopted a range of industry-specific management measures to reduce environmental impacts. However, there are also a number of measures which apply across the various industries including coastal planning, water quality, and nature conservation initiatives. A more integrated approach to coastal management is also being promoted by the introduction of a range of Integrated Coastal Zone Management initiatives.

Surrounding coasts

The Faroe Islands and the south west coast of Norway are of potential relevance to the SEA 4 area. Fishing and mariculture are important to both coastal communities, as is tourism. Stretches of the coastline are popular with tourists for their landscape value, cultural heritage, wildlife and opportunities for water-based activities. The adjacent Faroese and Norwegian coasts support 29 sites designated for their bird life. No offshore (beyond 12 nautical miles from shore) conservation sites have been 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 4 areas was conducted and the findings are discussed in detail in Section 10 of the main document. 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.

Noise

The potential effects of seismic noise on whales and dolphins remain a significant area of uncertainty, and cause for concern in relation to offshore exploration activities. The range of potential behavioural effects, and the consequent potential for cumulative effects, indicates that all marine mammal populations in the area are likely to be exposed to biologically significant sound levels. However, the proposed level of activity does not represent a significant change to recent seismic survey effort which in turn does not appear to have resulted in significant changes in sightings frequency or behavioural responses. Mitigation measures already implemented, together with proposed modifications, appear to provide some degree of protection from acute effects and are generally followed by the industry. It is therefore concluded that there is an acceptably low risk of potential effects of underwater noise resulting from SEA 4 activity. The SEA makes a number of recommendations in relation to remaining uncertainties and data gaps.

Physical damage

The predicted scale of physical disturbance of the seabed, resulting from potential activity scenarios for SEA 4 area, is very small in comparison with the total SEA 4 area. Survey work conducted prior to drilling or construction activity can be expected to identify potential sensitive features and habitats, which would then be avoided. Recovery of the affected seabed is expected to be rapid on the continental shelf and slope whilst in the deep water muds of the north of the area physical evidence of activities can be expected to be long lasting. 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 subsea wellheads. However, the small scale of such effects which could follow from SEA 4 licensing indicates that the number of exclusion zones that may be established is unlikely to cause significant economic impacts. The established 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, for new developments there is a presumption against discharge of produced water in favour of reinjection to sub-surface geological formations and existing developments in the area already reinject the vast majority of the water produced. As a consequence of this, produced water discharges are not viewed as a significant consideration for SEA 4 licensing.

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. Discharges of water based muds and cuttings in the SEA 4 area (and elsewhere) have been shown to disperse rapidly with minimal ecological effects. Dispersion of further discharges of mud and cuttings could lead to localised accumulation in areas where reduced current allows the particles to settle on the seabed. However, in view of the scale of the area, the water depths and currents, and projected level of activity in the area, 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 4 area, 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 may be needed to drill through some of the rock types found in the SEA 4 area. Rock cuttings contaminated with oil based mud are no longer discharged to sea and are 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 22nd licensing round activities will be small in the context of overall waste disposals from offshore.

Accidental events

Specific concerns in relation to oil spills in the SEA 4 area include the location of prospective areas upwind from sensitive coastlines, the importance of aquaculture along adjacent coastlines, and the relative remoteness of the area from stockpiles of oil spill response resources. 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, although the consequences of major oil spills in the area may clearly be severe, in both ecological and economic terms, the incremental risk associated with the predicted level of activity is moderate or low. Existing exposure to risk is “high” or “very high” as a result of shipping around the north of Shetland, Fair Isle Channel and western Orkney; and DTI has regulatory mechanisms in place to require Operators to develop effective oil spill mitigation measures, covering organisational aspects and the provision of physical and human resources. Times to beach, under worst case trajectory modelling conditions, are sufficient to allow the deployment of response measures where appropriate.

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.

Cumulative effects

Cumulative effects from activities resulting from the proposed 22nd 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. fishing and crude oil transport). Synergistic effects are considered to be potential effects of exploration and production 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 (noise, physical presence, physical damage, emissions, discharges), or unlikely (accidental events), although further research is recommended into possible cumulative effects of seismic noise on whales and dolphins. No synergistic effects were identified that were considered to be potentially significant.

Transboundary effects

The SEA 4 area adjoins areas under the jurisdiction of the Faroe Islands and Norway. Prevailing winds and the residual water circulation 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 the marine environments of adjacent states, particularly from activities undertaken in SEA 4 areas close to international boundaries. The scale and consequences of environmental effects in adjacent state territories will be comparable to those in UK waters.

Socio-economic effects

The economic impacts of licensing the SEA 4 area are likely to be incremental rather than absolute. Production from fields in the SEA 4 area would serve to slow down declines in overall UKCS production, employment and tax revenues, as well as extending the lives of facilities such as the Sullom Voe and Flotta terminals and assisting in maintaining employment in areas such as Shetland and Orkney. Shetland and Orkney have experienced influences from activity on the UKCS for about 30 years and the oil and gas industry is now a well-established and important part of the two local economies. Any negative socio-economic impacts of SEA 4-related development will therefore not be new to these areas and will be on a relatively small scale compared with what has happened in the past.

Forecasts of UKCS oil production suggest an average decline of 5.0% per year. Under a pessimistic scenario SEA 4 production would slow down that decline, whereas an optimistic SEA 4 scenario predicts that production would actually increase during the five years 2009-13 before the decline resumed.

Also under the pessimistic scenario, SEA 4 expenditure accounts for 22.5% of total UKCS capital expenditure in 2010 and 20.6% in 2011. With the optimistic scenario, the SEA 4 expenditure would account for about 70% of the total in 2010 and 2011. Total capital expenditure under an optimistic scenario is estimated at over £4.4 billion. The implications for employment have also been considered. For the optimistic scenario the overall UK total is 19,830 person years, with a peak of 1970 in 2010. For the pessimistic scenario the overall total is 5,440 person years, with a peak of 695 in 2009.

Wider policy objectives

No significant effect of activities following the proposed 22nd 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 SEA 4 area. 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 4 area.

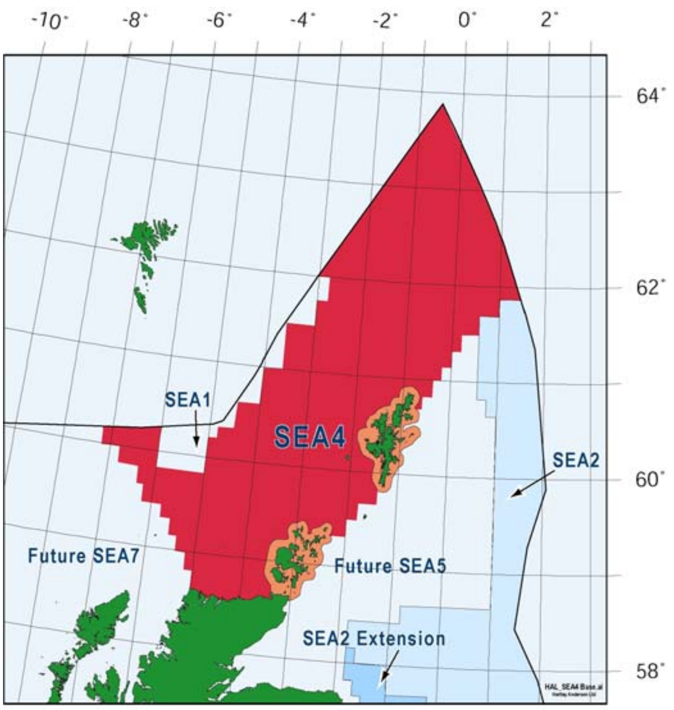
1 INTRODUCTION AND BACKGROUND

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) policies, plans and programmes.

Figure 1.1 – DTI SEA 4 area



This document reports on an assessment of the environmental implications of licensing for oil and gas exploration and production of the parts of an area of the United Kingdom Continental Shelf (UKCS) to the north and west of Orkney and Shetland (see Figure 1.1). The figure shows the area within which unlicensed blocks have been considered for licensing as part of a Strategic Environmental Assessment process. This is the DTI's 4th offshore oil and gas SEA and is hereafter referred to as SEA 4.

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."*

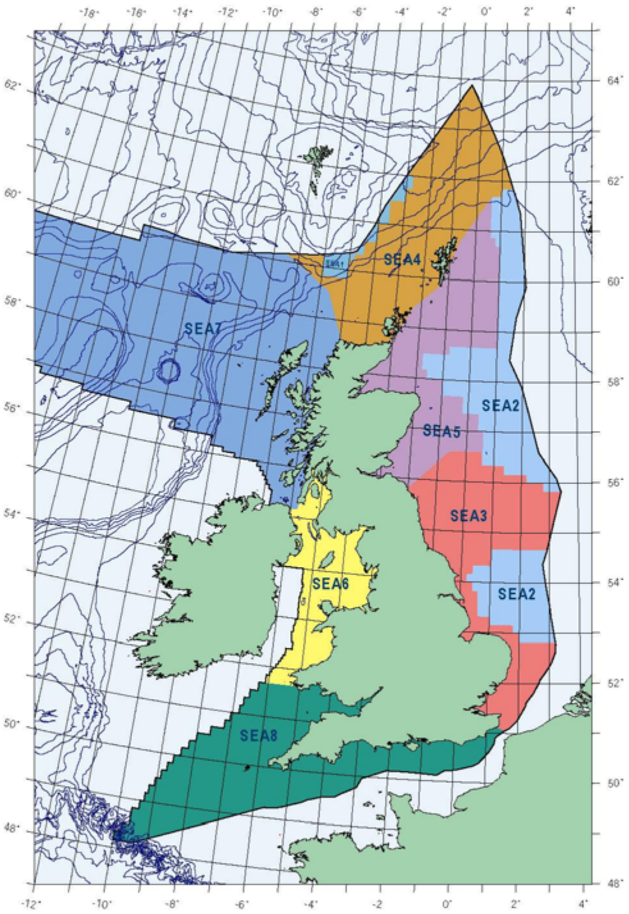
The United Kingdom is also a signatory to the *"UN/ECE Convention on access to information, public participation in decision-making and access to justice in environmental matters"* (hereafter called the Aarhus Convention).

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 4, has included a stakeholder consultation process involving a scoping step and a dialogue meeting. To facilitate public consultation the SEA 4 process is documented in this report which is available on-line and in a variety of media along with a range of commissioned studies and reports which support the SEA process (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 conducted the first UK offshore Strategic Environmental Assessment (SEA 1) in 1999/2000 in preparation for the 19th Licensing Round. This SEA addressed the deep water area along the formerly disputed boundary between UK and Faroese waters (an area which was known as the "White Zone").

Subsequent SEAs have included SEA 2 (2001), which covered the central spine of the North Sea where the majority of existing UK oil and gas fields are located and SEA 3 which assessed the remaining parts of the southern North Sea (2001-2002).

SEA 4 is addressing an area of the UKCS to the north and west of Orkney and Shetland which abuts the SEA 1 area.

The process for SEA 4 commenced in the Autumn of 2002. SEA is an evolving process and SEA 4 builds on the lessons learned in conducting the 1st, 2nd and 3rd SEAs together with input from stakeholders during the scoping and dialogue processes and practice from the UK and elsewhere. The DTI oil and gas licensing SEA process is underpinned by the requirements of the SEA Directive and 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 allowing 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 2002, there were 149 oil fields and 110 gas fields in production offshore on the UKCS (DTI oil and gas website http://www.og.dti.gov.uk/information/fields.htm).

The licensing system is managed by the DTI's Licensing and Consents Unit. 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 of 10 x 12 minutes with an average size of 250km^2. Production licences may be issued for single or groups of blocks and may be offered again following relinquishment. For assessment purposes, SEA 4 considers the environment within bay closing lines (e.g. around Orkney and Shetland) although these areas are licensed under a different regime and would not be included in an offshore licensing round.

Blocks within the SEA 4 area were first offered for licensing in 1965. The area comprises some 508.5 blocks of which 33.5 are currently wholly under licence, 33 are partly licensed and partly relinquished, 130 have been licensed but are now wholly relinquished, and 312 have not previously been licensed (see schematic representation in Figure 4.1 in Section 4).

1.5 Scope and purpose of the SEA

The proposed action is to offer Production Licences covering parts of the UKCS through a 22nd 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 aims 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 specifically considers habitats and species of relevance in the context of *The Offshore Petroleum Activities (Conservation of Habitats) Regulations, 2001*.

Section 8 Users of the Sea and Coastal Environment describes the commercial and other human interests and activities in the coastal and offshore area.

Section 9 Other European Resources of Potential Relevance to SEA 4 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.

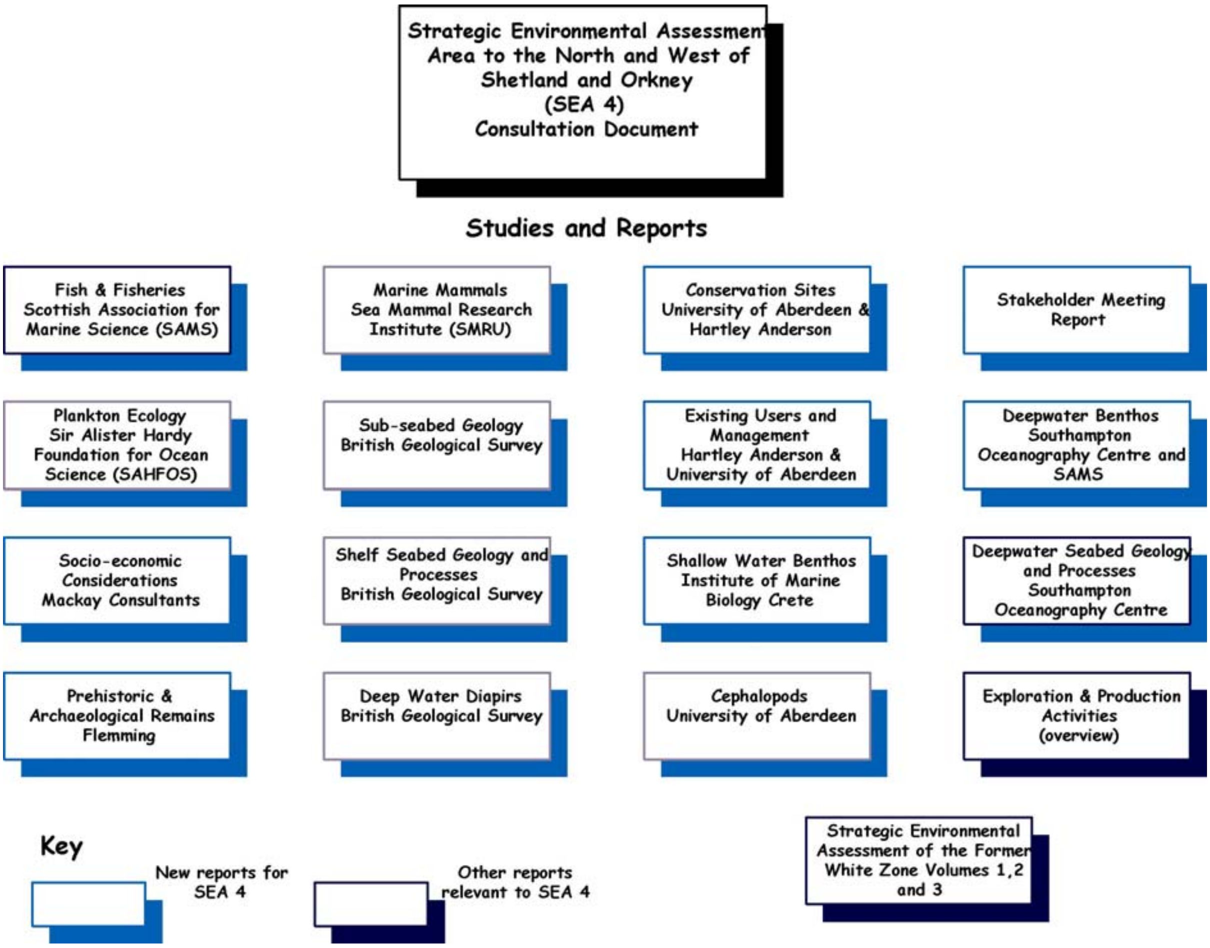
Section 11 Conclusions provides an overall conclusion regarding the likely implications of the proposed licensing and alternatives, together with recommendations for mitigation and monitoring and gaps in understanding relevant to the process.

Section 12 References lists the data sources used in the conduct of the SEA 4 and referenced in the report.

1.7 Supporting studies and documents

As part of the SEA 4 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.offshore-sea.org.uk) – 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 4 consultation document are included on the SEA website.

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2 SEA PROCESS

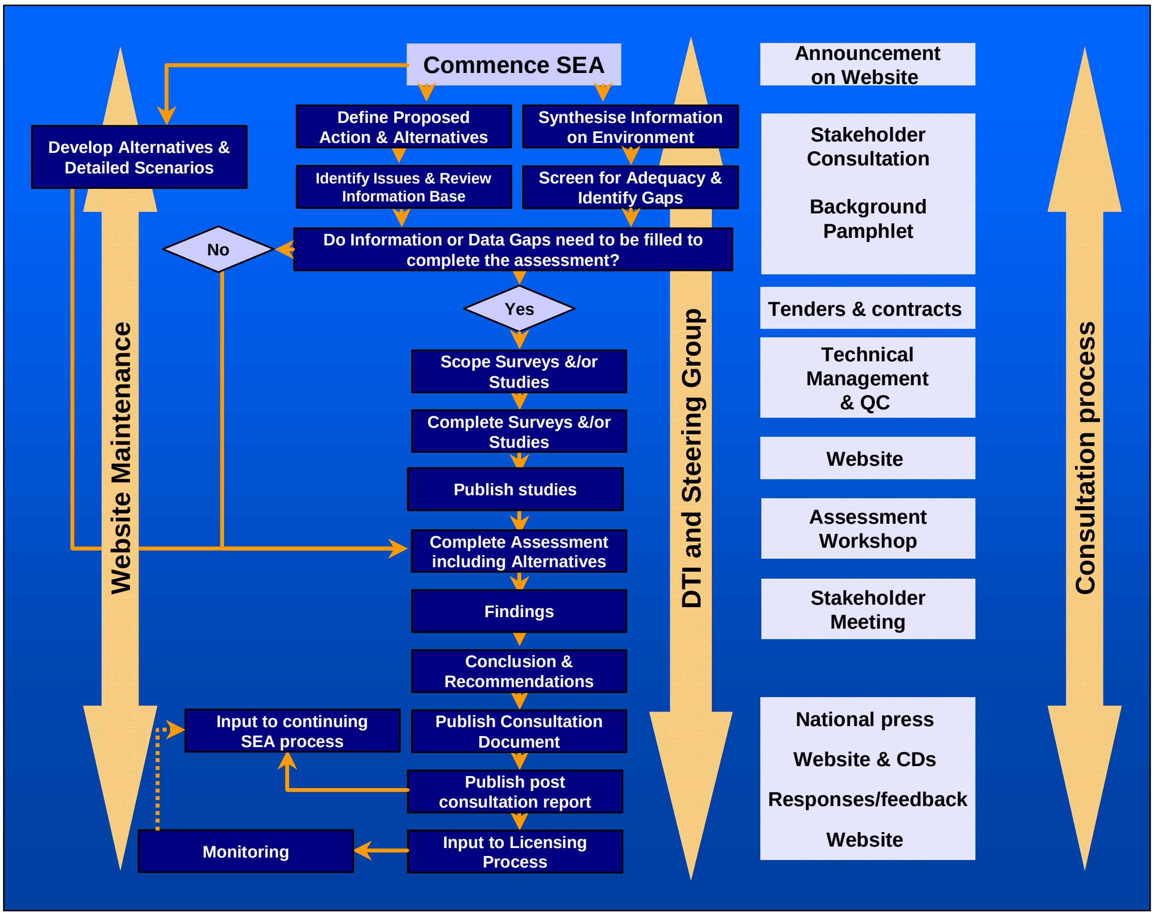
2.1 Introduction

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 4 builds on those used for SEAs 1, 2 and 3.

2.2 Overview of the SEA process

A summary of the SEA process used for SEA 4 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 environmental implications of the proposed action.

In November 2000, the Cabinet Office published a code of practice on written consultation which provides criteria (which have been applied to SEA 4) 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 November 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 and other users in an assessment workshop
- Stakeholder workshop 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 comment.

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 4 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 could 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 was prepared providing an overview of:

- 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 4 there were two stages in the scoping process; initial scoping consultation with a range of academics and conservation organisations was carried out in early 2002, focussed on ascertaining seabed survey needs. This part of scoping was conducted early because of the timescale needed to organise, collect and analyse offshore seabed information and samples. The conclusion of that consultation was that although parts of the area had been surveyed by AFEN (see AFEN 2000 and 2001 for details) and the DTI between 1996 and 2000, additional information on seabed habitats and fauna would be needed for SEA 4 purposes and, as such, a survey of targeted areas of SEA 4 was conducted in the summer of 2002.

A broader scoping consultation exercise for SEA 4 was undertaken in Spring 2003 involving some 135 stakeholders. The scoping exercise was carried out electronically, through the 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 4 were:

- Marine archaeology
- Adequacy of offshore seabird data
- Potential new offshore reef locations
- Tourism
- Mitigation for nearshore operations
- Exclusion of blocks in close proximity to Fair Isle
- Establishment of bay closure lines around offshore islands
- Linkage between the SEA and licensing processes
- Potential impacts of Promote Licences
- Linkage between SEAs for oil & gas and wind
- OSPAR list of threatened and/or declining species and habitats
- Biodiversity Action Plan species
- Effects on designated sites or species
- Maximum activity scenarios
- Orange roughy fish
- Offshore Natura 2000 sites
- Visual intrusion

2.4 Assessment workshop

An expert assessment workshop was held over two days in May 2003. The workshop brought the expertise of the SEA Steering Group, the authors of the SEA 4 underpinning technical reports, other users of the offshore area and the SEA team to bear on the assessment process for SEA 4 – 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 4 area
- Screen potential environmental interactions and identify Strategic Issues so that these could be considered further in this Public Consultation Document
- Review areas, sites and features of the SEA 4 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 4 assessment of likely effects and necessary mitigation can be made

2.5 Stakeholder dialogue meeting

A stakeholder workshop meeting was held in Nairn on 1 July 2003, facilitated by independent facilitators People=Positive™ 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:

- Update stakeholders on SEA 4 progress and issues

- Gather stakeholder input to and comments on the information and analysis on which SEA 4 will be based
- 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 thirty five stakeholders and included presentations on the UK & international regulatory context, SEA 4 process, oil and gas activities that could follow further licensing, and the natural environment and human uses of the SEA 4 area. Four stations were established (covering the SEA process and context, the SEA 4 physical, chemical and ecological environment, human interests in the SEA 4 area and a consideration of effects and controls) each with a number of posters, which formed the basis for facilitated discussion, the outcome of which was noted on flip charts. Stakeholder input was captured and a learning portfolio report of the meeting was produced by People=Positive™ and is included on the SEA website as supporting document SD_004. A summary of the issues raised in the meeting is given in Appendix 3.

2.6 Studies and surveys

A 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 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. In addition, scoping concluded that further field surveys were required for SEA 4.

2.6.1 Studies

SEA 4 commissioned and other applicable SEA reports (all available on the SEA website) are listed below:

The Scope of Strategic Environmental Assessment of Continental Shelf Area SEA 4 in Regard to Prehistoric Archaeological Remains - This report documents the known and likely occurrence of prehistoric coastal and submerged marine archaeological remains in the SEA 4 area, and makes suggestions as to how the finding and reporting of such artefacts could be enhanced. The document has been prepared by independent scientist Nic Flemming, an authority on underwater archaeology.

Synthesis of Information on the Shallow Benthos of the SEA 4 Area – An overview of the seabed habitats and biological communities of the continental shelf part of the SEA 4 area from the early scientific studies to recent oilfield monitoring survey results. The report was prepared by A. Eleftheriou, an authority on northeastern Atlantic seabed biota, formerly with the Marine Laboratory Aberdeen. He is currently at the Institute of Marine Biology, Crete.

An Overview of Benthic Ecology of the Faroe-Shetland Channel - Five large-scale seabed surveys have been undertaken in the SEA 4 area over the last seven years. In the course of these surveys, 366 sites were sampled for benthic macrofauna, sediment type, organic content, heavy metals and hydrocarbons. The various data from these surveys is compiled and analysed in this report to provide a general overview of the benthic ecology of the region. The report was produced by JA Hughes and B Bett from the DEEPSEAS Group, Southampton Oceanography Centre and B Narayanaswamy from the Deep-Sea Benthic Group, Scottish Association for Marine Science, Dunstaffnage Marine Laboratory.

An Overview of Cephalopods Relevant to the SEA 4 Area - This report, prepared by the Department of Zoology, University of Aberdeen, provides an overview of the distribution and ecology of cephalopods (particularly squid and octopus) in the SEA 4 area. Fisheries, environmental contamination and other related conservational issues are also discussed.

Coastal Conservation Sites in the SEA 4 Area - The wide variety of local, national, European and international designations and sites occurring in the SEA 4 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 in association with the Institute of Coastal Science and Management, University of Aberdeen.

Existing Users and Management Initiatives Relevant to SEA 4 - This report is a synthesis of information on human activities in the SEA 4 area which might have an impact on, or themselves be affected by, further oil and gas developments in the SEA 4 area. The activities include shipping, energy (both existing oil and gas developments and renewable energy), telecommunications, military activities, tourism and leisure, aggregate extraction, fishing and marine archaeological sites. The report was produced by the SEA 4 team in association with the Institute of Coastal Science and Management, University of Aberdeen.

Fish and Fisheries in the SEA 4 Area - This report was prepared by Dr John Gordon, an Honorary Fellow of the Scottish Association for Marine Science. The report describes the fish resources of the region (i.e. spawning grounds, nursery areas, communities), and also the intensity and distribution of commercial fishing activity. A review of fisheries management measures in operation in the area is provided, as is an assessment of possible interactions between the fishing and oil and gas industries.

Sub-seabed Geology - A historical description of the sub-seabed geology of SEA 4 and details of existing and potential hydrocarbon discoveries in the area are given in this report. The likelihood and distribution of seismic activity in the area is also included. The report was produced by scientists from the British Geological Survey (BGS).

Continental Shelf Seabed Geology and Processes - This BGS report gives an overview of the geomorphology and near-bottom currents of the SEA 4 area. Seabed geological formations, bedforms and sediment transport (including iceberg ploughmarks, tidal sand banks and sedimentary sinks) are also discussed.

Geological Evolution Pilot Whale Diapirs and Stability of the Seabed Habitat - This BGS report looks in depth at the large field of mud mounds to the north of SEA 4 area known collectively as the Pilot Whale Diapirs.

Background Information on Marine Mammals Relevant to Strategic Assessment 4 - The distribution and abundance of marine mammals in the SEA 4 area, their ecological importance, sensitivity to disturbance, contaminations and disease, by-catch and other non-oil related management issues, and conservation framework are described in this report. The report was prepared by scientists from the Sea Mammal Research Unit, University of St Andrews.

Plankton Report for Strategic Environmental Assessment Area 4 - This report gives an overview of the phytoplankton and zooplankton communities of SEA 4, in particular their composition and sensitivity to disturbance/contamination. 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 by scientists from the Sir Alister Hardy Foundation for Ocean Science (SAHFOS), which specialises in the study of plankton in the North Atlantic.

Seafloor Sediments and Sedimentary Processes on the Outer Continental Shelf, Continental Slope and Basin Floor - This report, prepared by scientists from the Southampton Oceanography Centre, describes the surficial sediments in SEA 4 and the sedimentary processes that are active in the area at the present day. The report is based on sidescan sonar images, multibeam bathymetry, sub-bottom profiles, seabed photographs and sediment samples. The Holocene and late glacial events and processes that contributed to the present day seafloor morphology and sediment distribution are reviewed, as is the present day oceanographic regime.

The Potential Socio-Economic Implications of Licensing the SEA 4 Area - This study, by Mackay Consultants a leading group of economists specialising in the oil industry, provides an assessment of the possible socio-economic implications of licensing the SEA 4 area in relation to oil and gas production/reserves, capital, operating and decommissioning expenditure, employment, tax revenue and existing facilities both on and offshore.

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, DTI Oil and Gas Directorate, 86-88 Atholl House, Guild Street, Aberdeen, AB11 6AR.

2.6.2 SEA 4 Offshore Survey

A survey was carried out in the summer of 2002 from the *MV Kommandor Jack* and comprised geophysical and biological sampling. Photographs were also collected using a towed camera system. Biological material collected during the survey (and supporting data documentation) is deposited in the collection of the National Museums of Scotland, Edinburgh to promote its long term availability for scientific study.

2.7 Further consultation process

Key elements of public and stakeholder consultation and input to the SEA 4 process are:

- Scoping consultation (Spring 2002, and Spring 2003)
- Stakeholder dialogue meeting at the draft assessment stage (Summer 2003)
- A 3 month public consultation period following publication of the SEA 3 documents on the website (Autumn 2003)
- Post consultation report (Winter 2003/4)

The SEA 4 consultation document and supporting documents are available for review and public comment for a period of 90 days from the middle of September 2003. The documents are being made available from the SEA website (www.offshore-sea.org.uk) 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 until July 2004 to put in place the mechanisms necessary to comply with the Directive's requirements. After this, 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 plans and programmes 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/index.htm.

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 up to that point by the

Continental Shelf (Designation of Areas) (Consolidation) Order 2000 SI 2000 No. 3062. This has since been amended by the *Continental Shelf (Designation of Areas) Order 2001*.

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.

  A new type of production licence, the Promote Licence, which was offered first in the 21st Licence Round provides a period of time during which licensees are able to work up potential prospects - primarily using existing data. Full checks as for the Traditional Production Licence are made before any consent for further work is given. Environmental conditions may be part of the Licence.

Offshore 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:

- The International Maritime Organization (IMO) was established by means of a Convention adopted under the auspices of the United Nations and is responsible for measures to improve the safety of international shipping and to prevent marine pollution from ships. The IMO International Convention for the Prevention of Pollution from Ships, 1973, as modified by the Protocol of 1978 (commonly referred to as MARPOL 73/78) 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. In July 2003, the IMO's Marine Environment Protection Committee (MEPC) agreed a finalized draft of a proposed International Convention for the Control and Management of Ships' Ballast Water and Sediments. It is estimated that about 10 billion tonnes of ballast water are transferred globally each year, potentially transferring from one location to another species of marine life that may prove ecologically harmful when released into a non-native environment. A proposal to the IMO MEPC for an area of North Western European waters stretching from the Shetland Isles to Portugal to be designated as a Particularly Sensitive Sea Area (PSSA). A PSSA is an area requiring special protection because of its significance for recognised ecological, socio-economic or scientific reasons and which may be vulnerable to damage by international maritime activities. Specific measures can be used to control the maritime activities in the PSSA, such as vessel routeing, and strict application of MARPOL discharge and equipment requirements for ships.

- 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 (CFCs), 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 largely 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.

- Norway and the UK have developed the Norbrit Agreement (The Norway-United Kingdom Joint Contingency Plan) for joint counter pollution operations in the zone extending 50 miles either side of the median line separating the UK and Norwegian continental shelf. The Norbrit Agreement sets out command and control procedures for pollution incidents likely to affect both parties, as well as channels of communication and resources available.

- 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). Note: the ASCOBANS area was extended in August 2003 to include areas of the Atlantic to 15º West.

- 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 Scottish Environment Protection 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 (EIA) 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 production installations and wells to minimise potential damage from third party activities (anchoring, fishing) may be established by Order following an application from the Operator.

Approvals/Consents for Pipelines

The *Petroleum Act, 1998* requires an authorisation (Pipeline Works 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 >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

A consultation exercise was launched in August 2003 on draft regulations*, the Offshore Marine Conservation (Natural Habitats &c.) Regulations 2003*, which would apply *Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora* and the *Council Directive of 2 April 1979 on the conservation of wild birds (79/409/EEC)* to the UK Continental Shelf and waters beyond 12 nautical miles from the baselines over which the UK exercises sovereignty. The regulations would afford protection to species listed by the directives, primarily cetaceans, turtles, certain fish and birds, as well as requiring Special Areas of Conservation (SACs) and Special Protection Areas (SPAs) to be identified and protected.

The *Offshore Petroleum Activities (Conservation of Habitats) Regulations, 2001* implement the above directives 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 (12nm) the 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

A permit is required in advance for the use of drilling, production, utility and other chemicals offshore (*Offshore Chemicals Regulations 2002*). These regulations implement the 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 permit application process (the PON15B is the mechanism for this) includes a mandatory risk assessment. Any variation in use from permit must have prior approval. Chemical use and discharge must be reported. Chemicals which are used offshore must be registered under the Offshore Chemical Notification Scheme. A database ranks chemicals by hazard, based on a PEC:PNEC (Predicted Effect Concentration : Predicted No Effect Concentration) approach. Separate permits are required for chemicals used in drilling, production, pipelines, workover and decommissioning.

Produced Water and other oil containing discharges

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.

The DTI have recently completed a consultation exercise on the *Offshore Petroleum Activities (Oil Pollution Prevention and Control) Regulations 2003* which will largely replace POPA and introduce a new permitting regime for oily discharges.

OSPAR Recommendation 2001/1 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 stand alone 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. A licence is required for such activities unless specifically exempted under the *Deposits in the Sea Exemptions Order 1985* which 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. The onsite injection of operational wastes is specifically exempted under the above Order. Off-site injection does not qualify for the above exemption, as the deposits will not be made on the site of drilling for, or production of, oil or gas and therefore it is necessary to obtain a FEPA Part II licence.

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 50MW. 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.

A Directive of the European Parliament and of the Council has been rposed which would amend Directive 1999/32/EC with regard to the sulphur content of marine fuels. The aim of the proposal is to reduce the impact of ships' emissions of sulphur dioxide (SO2 or SOx) and particulate matter (PM) on environmental acidification and human health.

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.

The plan must also meet the requirements of the *Offshore Installations (Emergency Pollution Control) Regulations 2002.* In his report of the review of the Government's involvement in salvage and intervention in pollution incidents following the grounding and subsequent salvage of the Sea Empress at Milford Haven, Lord Donaldson of Lymington made a number of recommendations relating to the offshore industry. In particular, he recommended that a single representative should be authorised to act on behalf of the Secretary of State for Trade and Industry i.e. a SOSREP. The SOSREP role is to monitor and if necessary intervene to protect the environment in the event of a threatened or actual pollution incident in connection with an offshore installation.

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).

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.

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4 ACTIVITIES

4.1 Introduction

The possible scale of exploration and development activity which could result from a 22nd Round of UKCS licensing covering the SEA 4 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).

4.2 Alternatives

SEA 4 is the fourth 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 4 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 22nd 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

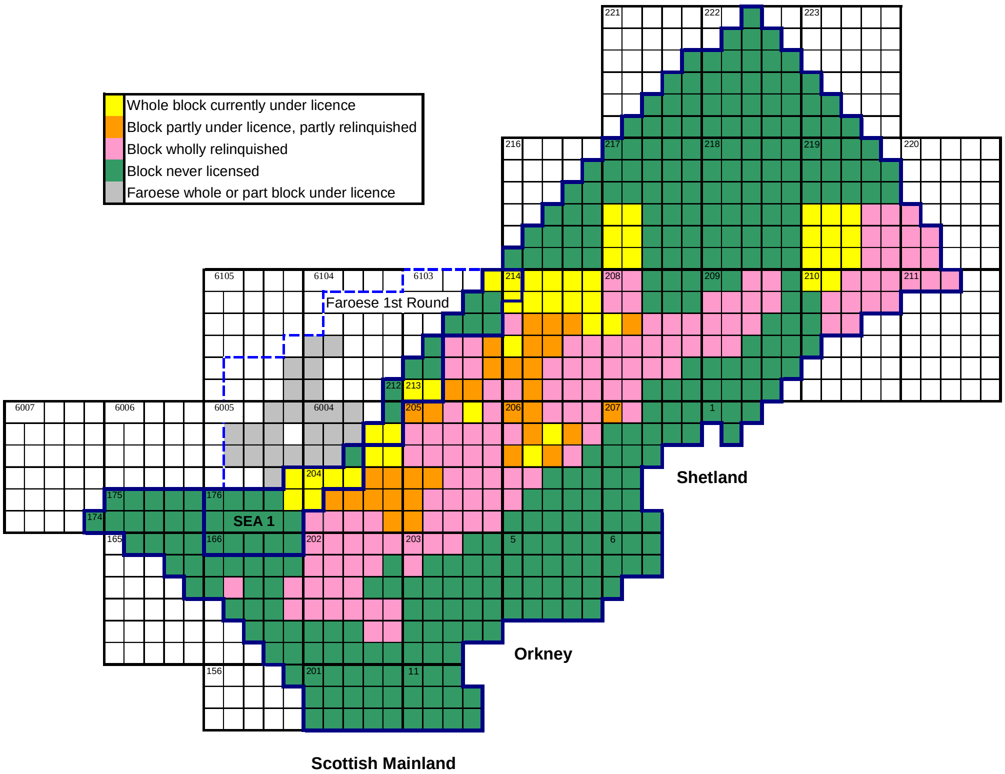
The implications of the alternatives are considered in Sections 10 (Consideration of the Effects of Licensing) and 11 (Conclusions). In order to complete the assessment, estimates of the level of activity that might follow from licensing in the SEA 4 area have been developed (see Section 4.2.3) based 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 4 area were first offered for licensing in 1965. The area comprises some 508.5 blocks of which 33.5 are currently wholly under licence, 33 are partly licensed and partly relinquished, 130 have been licensed but are now wholly relinquished, and 312 have not previously been licensed – see schematic representation overleaf in Figure 4.1.

Figure 4.1 – Schematic of blocks in the quadrants within the SEA 4 area, either currently licensed or potentially available for licensing



(Source: DTI 2002)

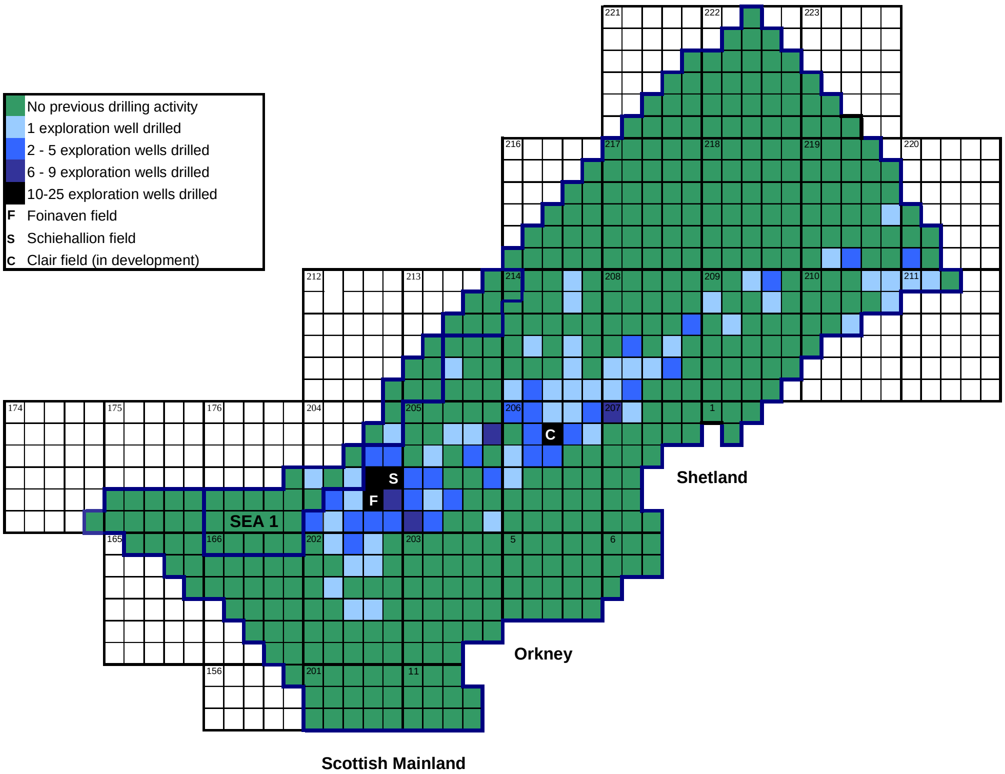
4.2.2 Prospectivity

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

Previous licensing of the SEA 4 area has led to the drilling of a number of exploration wells and subsequent developments. The extent and location of these, as well as information relating to the adjacent SEA 1 area, are highlighted in Figure 4.2. In addition to the fields indicated on Figure 4.2 there are a number of discoveries that have yet to be exploited, generally because the size of field is currently uneconomic to develop. These discoveries are all to the west of Orkney and Shetland (Area 2 as characterised in Section 4.2.3).

Figure 4.2 – Schematic of SEA 4 exploration and development activity



Notes:

1. *Information sourced from www.og.dti.gov.uk*
2. *Area offered for licensing following SEA 1 is also highlighted*

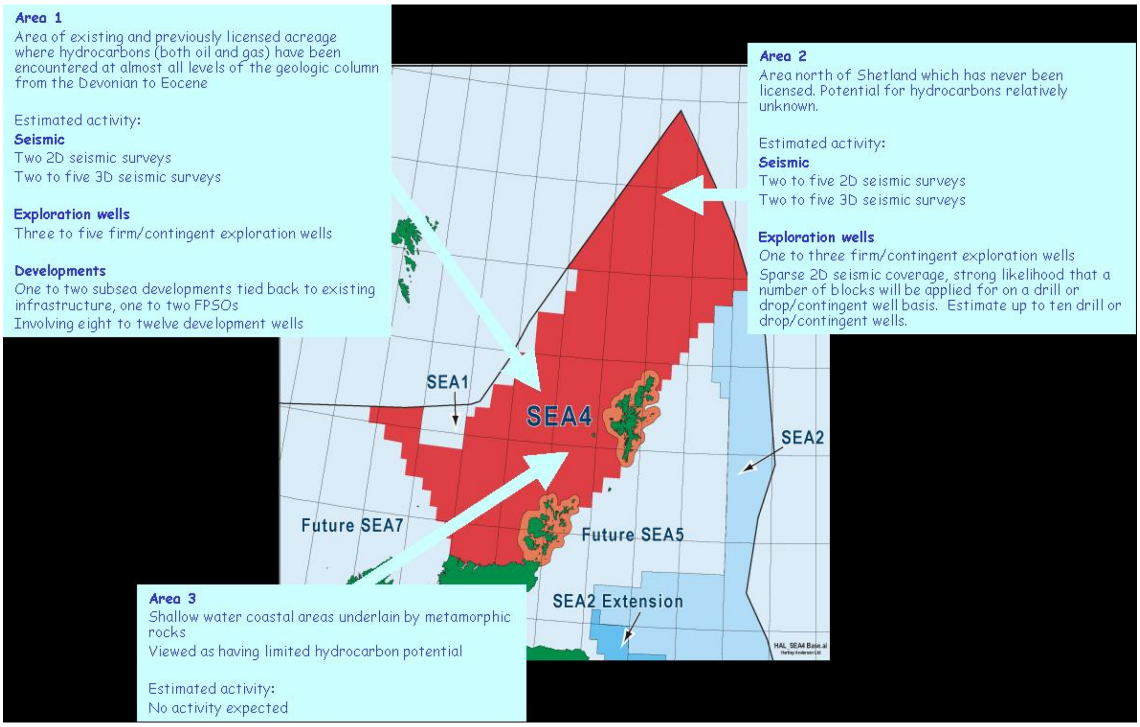
4.2.3 Estimates of potential activity

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 and Consents Unit. They are not based on detailed mapping, but on a broad understanding of the geology of the area 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.

The SEA 4 area can be divided into 3 sub-areas based on current understanding, geological characteristics, and potential for finding hydrocarbon reserves (see Figure 4.3).

Figure 4.3 – Schematic of geological sub-areas in the SEA 4 area



Explanatory note:

1. *A Firm well is a commitment to drill, which is not contingent upon any further evaluation. No waivers will be considered by the DTI for Firm wells.*
2. *A Contingent well is a commitment to drill, contingent upon additional evaluation. These are not firm wells although, the Operator must make a technical case to the DTI for a waiver of the commitment if the Operator no longer feels the drilling of the Contingent well is justified on technical, geological or other grounds.*
3. *D/D or Drill or Drop well is a commitment to drill or relinquish the licence within a specified time frame – again these wells may not be drilled unless geological evaluations prove to be favourable.*

Area 1

Seismic - two 2D seismic surveys (500-1000km length of 2D seismic lines) and two to five 3D seismic surveys (500-2500 km^2 of 3D coverage)
Exploration wells – three to five firm/contingent wells
Developments - one to two subsea developments tied back to existing infrastructure, one to two Floating Production Storage and Offtake vessels (FPSO) involving some eight to twelve development wells

Area 2

Seismic – two to five 2D seismic surveys (1000-4000 km length of 2D seismic lines), two to five 3D seismic surveys (500-2500 km^2 of 3D coverage)
Exploration wells – one to three firm/contingent wells
Note: For area 2 there is only sparse 2D seismic coverage, and there is a strong likelihood that a number of blocks will be applied for on a drill or drop/contingent well basis. An estimate of up to 10 drill or drop/contingent wells could be expected.

Area 3

No activity expected

In addition the DTI estimate that around 10 Promote Licences may be sought within the SEA 4 area.

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

By way of context, 44 whole and part blocks in the SEA 1 area were offered in the 19th Licensing Round. As a result of the Licensing Round production licences covering 12 whole and part blocks were awarded – see Table 4.1. For the SEA 1 area, the operator work commitments agreed at licence award and published included 7 firm wells, 6 contingent wells, and 3 drill or drop wells. All the licences awarded during the 19th Round had existing 3D seismic data, therefore the majority of the work programmes offered reprocessing existing 3D surveys as opposed to collection of new data. Only some blocks had commitments to acquire new 2D and 3D seismic surveys. To date 4 wells have been drilled (204/18-1, 204/17-1, 204/16-1, 204/10-1) and in general the results remain confidential. A new 2002 3D seismic survey has been acquired covering blocks 204/16 and 204/21. Approximately 1,250 kilometres of long offset 2D seismic data has been acquired over block 204/18 and adjacent areas.

Table 4.1 – Comparison of activity predicted in SEA 1 against that resulting from 19th Round Licensing

Blocks[1]	Seismic surveys[2,]		Exploration wells			Developments	
	Predicted	Actual	Predicted	Actual	Drilled[3]	Predicted	Actual
204/18		2 Firm 1 Contingent		3 Firm 1 Contingent	1 (abandoned)		
204/17		1 Contingent 1 Reprocess		1 Firm 1 Contingent	1		
213/5 214/1		1 Firm 1 Reprocess		D/D	0		
213/26 213/27		1 Reprocess		D/D	0		
204/21		1 Firm 1 Contingent		1 Firm 2 Contingent	0		
204/9 204/10		1 Reprocess		1 Firm 1 Contingent	1		
176/20 204/16		1 Firm		D/D	1		
176/25		1 Contingent 1 Reprocess		1 Firm 1 Contingent	0		
Total	**10**	**5 Firm 4 Contingent 5 Reprocess**	**15**	**7 Firm 6 Contingent 3 D/D**	**4**	**5**	**See notes[4]**

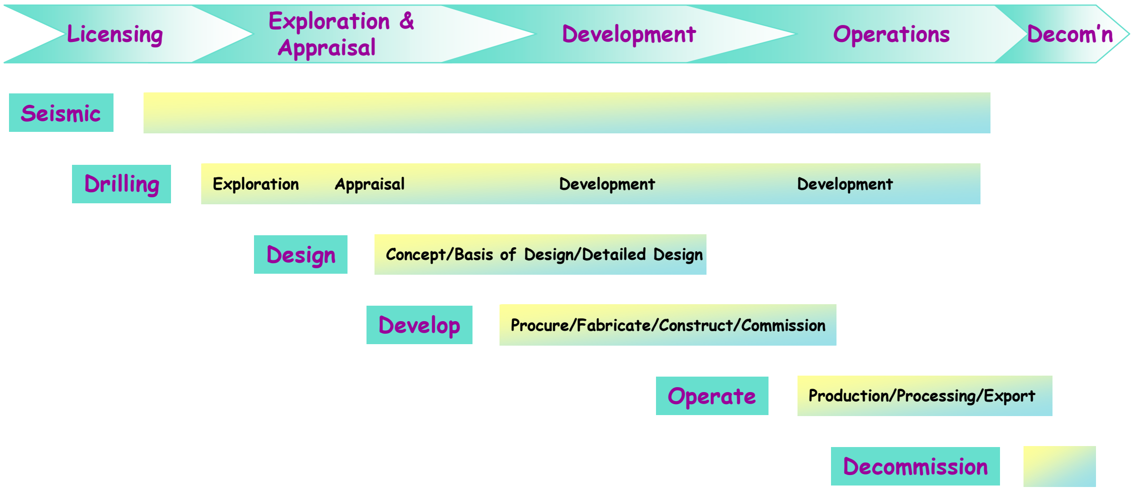
Notes:

1. *Work programmes for licensed blocks are arranged according to Licence number with some licences covering more than one block.*
2. *Where work programmes have indicated, "acquire seismic data" this has been interpreted for comparison purposes as a seismic survey although it may in fact, merely be the purchase of for reprocessing of existing seismic data. Where reprocessing of seismic data has been indicated in the work programmes, these have been highlighted.*
3. *Actual wells drilled since 19th licensing round closed on the 27th February 2001. Information from DTI well data exchange project - http://www.og.dti.gov.uk/pls/wons/wdep0100.qryWell - as on 21st August 2003.*
4. *Development plans for discoveries are dependent on the finding of economically viable reserves as a result of exploration activity and therefore it is not yet possible to fully review this aspect.*

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 4.4 below.

Figure 4.4 – Oil and Gas Exploration and Production Lifecycle



5 PHYSICAL AND CHEMICAL ENVIRONMENT

5.1 Regional overview

The physical and chemical environment of the SEA 4 area includes some of the most extreme environments within UK waters from deep, sub-arctic water masses of the northern Faroe-Shetland Channel to the relatively warm, high energy nearshore continental shelf. The SEA 4 area includes some of the wildest and least influenced by human activities parts of the UK.

The overall topography of the SEA 4 area is dominated by the Faroe-Shetland Channel bounded to the south by the Wyville Thomson Ridge and the east and west by the continental shelves of Shetland, Orkney, the Scottish mainland and the Faroe Islands. To the north, the Faroe-Shetland Channel connects with the southern Norwegian basin and to the south, with the Faroe Bank Channel, which in turn connects with the North Atlantic Basin.

The present-day seafloor morphology of the area is largely the product of the late Pleistocene glaciation, when ice-related processes transported large amounts of sediment to the continental shelf edge, from where it was distributed down slope by gravity-driven processes, such as debris flow. Ice was also responsible for the most prevalent seabed features of the lower continental shelf and upper slope, iceberg ploughmarks resulting from the grounding of floating icebergs and the ‘ploughing’ of a furrow into the seabed by the keel of the iceberg. Ploughmarks are the dominant morphological feature of the continental slope west and north of Shetland from 200-450m water depth.

Other seabed features, on the shelf and in deeper water, are largely the result of reworking of surficial sediments by bottom currents. Rock crop at seabed and just below seabed in the areas of the inner and middle continental shelf occur in areas that had previously undergone repeated strong sub-ice sheet erosion and had subsequently been starved of post-glacial sediment input. The reworked sediments typically consist of large areas of relict seabed gravel on elevated topography, mobile sheet sand deposits on relatively flat seafloor and muddy sands and sandy muds in the sheltered coastal and nearshore areas and in basins on the open continental shelf.

The DTI 2002 programme of new deep-water seabed multibeam and sample data acquisition in support of SEA 4 included a blanket survey over a large field of mud mounds in the southern Norwegian Basin mounds, collectively named the Pilot Whale Diapirs. No evidence for fluid escape (or possible associated biological communities) have been found to date. However, there remains a possibility that localised areas of fluid escape may be active in the mud diapir province.

The hydrography of the whole SEA 4 area may be characterised as being relatively high in energy in terms of near-bed current velocities and wave climate, although there are large differences in the type of current activity and the composition of different water masses. Large scale ocean circulation in the area is dominated by the northward flow of surface and mid-depth North Atlantic Water, from the Rockall Trough over the Wyville Thomson Ridge before entering the North Sea via the Fair Isle current and to the north-east of Shetland. This flow is concentrated along the eastern side of the Faroe-Shetland Channel as a slope current close to the edge of the west Shetland Shelf and is most intense over the 400m contour. Colder and deeper water flows in the opposite direction from the Norwegian Sea, south-westwards along the Faroe-Shetland Channel; through the Faroe Bank Channel and to a lesser extent over the Wyville Thomson Ridge.

Tidal currents are significant only in shelf waters of the SEA 4 area with generally low to moderate velocities although topographic constraints result in higher current speeds in localised areas of the Pentland Firth, Orkney and Shetland.

5.2 Geology, substrates and shoreline types

5.2.1 Overview

To support the SEA 4 process, British Geological Survey (BGS) and the Southampton Oceanography Centre were commissioned to produce summaries of both published geological data and their interpretations of data from the DTI 2002 and earlier seabed survey programmes of the SEA 4 area. It is intended that the review will provide a synopsis of current understanding of conditions in the modern seabed environment.

The Faroe-Shetland and Faroe Bank Channels together form a narrow deep trough separating the Faroe Islands from the west Shetland shelf to the east and the Wyville Thomson Ridge and several isolated banks to the south. To the north, the Faroe-Shetland Channel broadens into the southern Norwegian Sea Basin, reaching a water depth of about 2,400m at the northern limit of the SEA 4 area. The Faroe Bank Channel continues as a narrow trough for about 250km to the southwest and west of the SEA 4 area, finally connecting with the deep Atlantic basin (Figure 5.2.1).

The topography of the SEA 4 region has been shaped by a series of major tectonic events and more recent glacial events. Many of the modern topographical features including the Faroe-Shetland Channel, retain a NE-SW trend, inherited from a series of tectonic events, the Caledonian Orogeny (440-410Ma) being the most influential. Regional NW-SE trending deformation events (<65Ma) have also played an important role in shaping the structure of the major basins. The present day seismicity of the area is regarded as very low.

5.2.2 Geology

The underlying basement rocks of the SEA 4 area can be separated into two major provinces; the Foreland Province and the Orthotectonic Caledonide Province (Kelling *et al.* 1985). The Foreland Province consists predominantly of Lewisian gneiss locally overlain by Torridonian and Cambro-Ordovician sediments while the Orthotectonic Caledonide Province includes Moine, Daladrian and Caledonised Lewisian. The two provinces are separated by the Moine thrust zone and their juxtaposition is a direct result of the late Caledonian collision of the Laurentian-Greenland and Fennoscandian-Russian continental plates. The present surface distribution of the basement rocks is a consequence of geological events since the Caledonian Orogeny (Table 5.1, Stoker *et al.* 1993).

Table 5.1 – Major geological events since the Caledonian Orogeny
Mid-late Devonian (388-362Ma)
Local crustal extension formed basins, notably in the West Orkney Basin. Period of deposition of alluvial, fluvial and lacustrine sediments.
Early Permian (290-256Ma)
Extension and rifting created large and widespread basins. The basins were infilled largely by deposition which continued into the Triassic (245-208Ma).
Late Jurassic (154-135Ma)
Subsidence of basins and rising sea levels led to the widespread deposition of fine-grained sediments. Restricted circulation during the Kimmeridgian to Ryazanian (154-141Ma) allowed anoxic black shales to accumulate – the major hydrocarbon source rocks of the SEA 4 area.
Early Cretaceous (135-124Ma)
Major rifting episode concentrated along the Faroe-Shetland Basin. Sediment shed from uplifted areas into adjacent West Shetland, Faroe-Shetland and Rona Basins. During the Late Cretaceous active rifting largely ceased and sea level rose.
Late Paleocene to early Eocene (57-54Ma)
Massive volcanism resulted in lavas being extruded over much of the north and west of the SEA 4 region. A vigorous bottom current circulation developed in the Late Eocene (35Ma) causing major

Table 5.1 – Major geological events since the Caledonian Orogeny
erosion in the deep water basins.
Mid-Miocene (16-10Ma) to present
Sedimentation in the deep-water basins mostly controlled by bottom-current activity, resulting in sediment drifts. Quaternary ice sheets eroded the shelf areas depositing large amounts of sediment down slope. Since post-glacial, shelf areas have been starved of sediment but fluctuations in bottom-current velocity have resulted in erosion and resedimentation of slope and basin deposits.

Petroleum geology

Drilling in the SEA 4 region began in 1972. Since then, activity has continued at a low level compared to the North Sea due to a combination of factors including, the deep water, complex geology, lack of offshore infrastructure, and short summer weather window.

The organic-rich Kimmeridgian to Ryazanian Kimmeridge Clay Formation (154-136Ma) is the principal source rock of the area. Other Jurassic, Cretaceous and Cenozoic shales generally lack sufficient organic content of the right type or are immature. There is a wide variety of potential hydrocarbon trapping mechanisms and stratigraphic seals. However the timing of source rock maturation, and particularly hydrocarbon maturation, is not well understood.

The main discoveries in the SEA 4 area include the Clair oilfield which was discovered in 1977 and is the largest oilfield under development on the UKCS with possible reserves of up to 4 billion barrels. The principal reservoir comprises Devono-Carboniferous continental clastics but oil also occurs in fractures within the underlying Lewisian metamorphic basement.

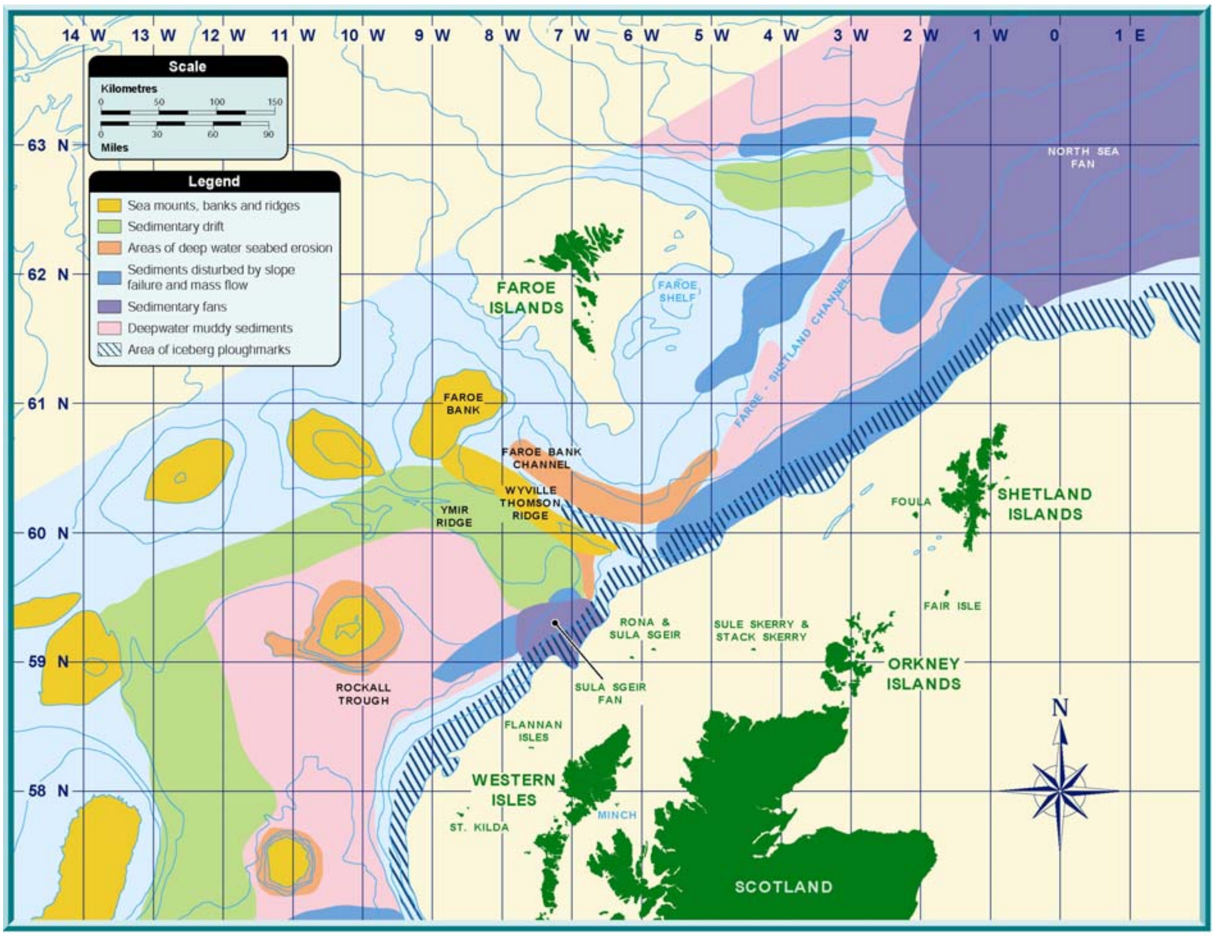
The Foinaven oilfield discovered in 1992 was the first deep-water discovery west of Shetland and the first field from the SEA 4 region to be developed. The reservoir consists of Upper Paleocene sandstones and recoverable reserves are estimated at 200 million barrels. The Schiehallion and Loyal oilfields were also discovered in Upper Paleocene reservoirs in 1993 and 1994, respectively. Recoverable reserves are estimated at 425 million barrels. In addition there are a number of smaller undeveloped hydrocarbon accumulations in the area.

It is unlikely that hydrocarbons will be discovered in the extreme north of the SEA 4 area until techniques are developed to improve seismic resolution beneath the Palaeogene lavas.

5.2.3 Substrates

There is little modern sediment input to the continental shelf and Faroe-Shetland Channel, and the modern seabed environment now largely reflects the effects of reworking by near-bottom currents on the topography and sediments that originated during the former glaciations. The effects of glacial erosion are evident on the outer continental shelf and upper slope but there are also bedforms generated from sediment deposition as the ice sheets advanced and retreated across the continental shelf. Inner shelf and nearshore sediments consist largely of carbonate fragments of post-glacial benthic fauna.

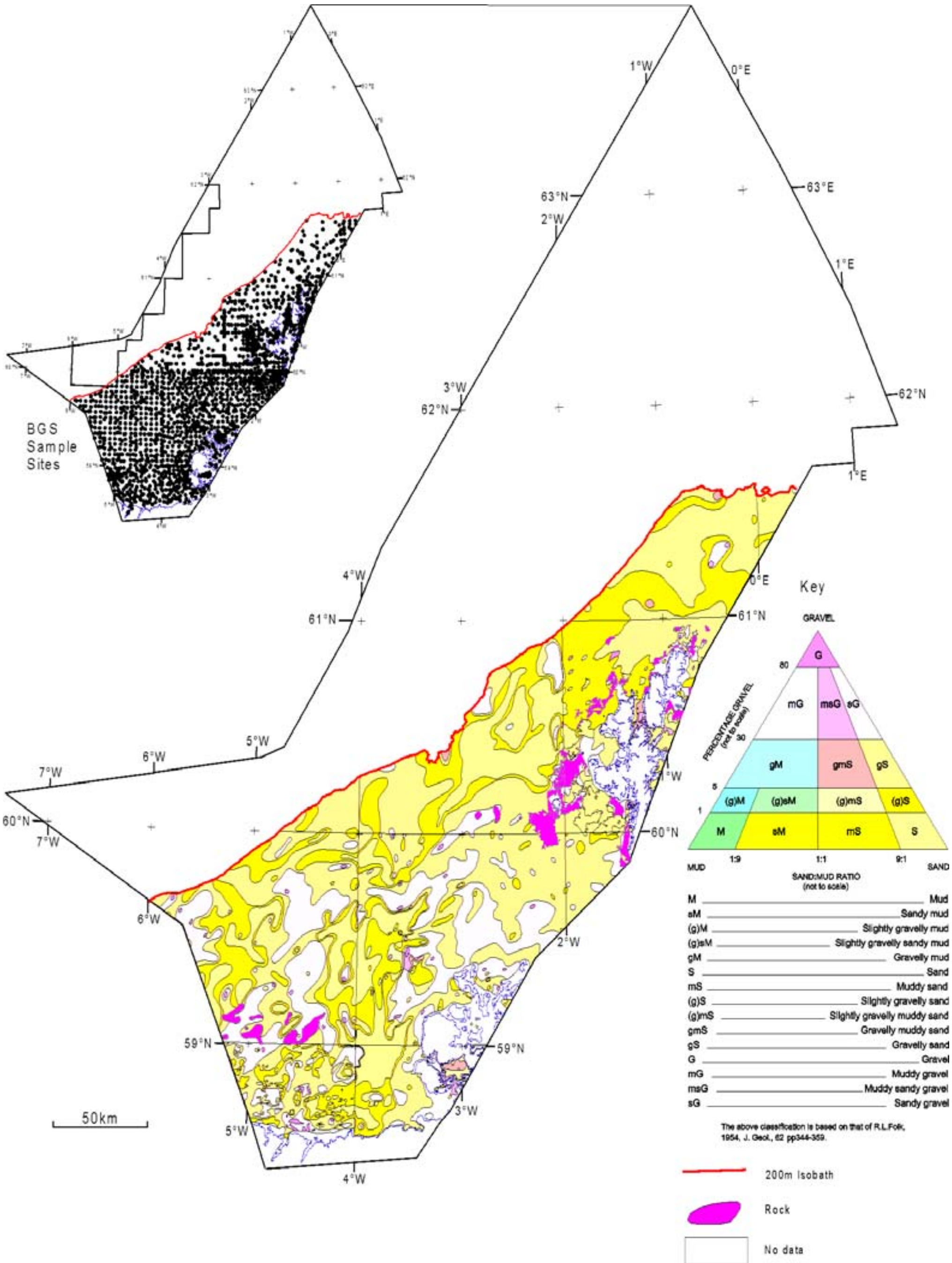
Figure 5.1 – Main topographical features of the SEA 4 area



5.2.3.1 Continental shelf

The composition and distribution of the seabed sediments on the shelf are influenced by the abundances of sediment sources and tidal, wave, wind and residual near-bottom currents. The latter flows as a dominant current towards the NE and parallel to the bathymetric contours on the outer continental shelf and upper slope. Inner shelf bedflows are dominated by tidal currents and wave action. Seabed substrates on the shelf can be divided into areas of rock outcrop and those of unconsolidated sediments (Figure 5.2).

Figure 5.2 – Seabed sediments on the continental shelf (modified after Pantin 1991)



Rock

The submarine rock outcrops on the continental shelf principally consist of strong sedimentary rocks of more than 210Ma age and extremely strong crystalline metamorphic rock of more than 545Ma age. Coastal and mid-shelf areas underlain by these crystalline rocks have resisted repeated glacial erosion and are now mostly swept clean of mobile sediments by very strong near-bottom currents.

Gravel

Gravel is defined by the BGS modified Folk classification as solid particles ranging in size from >2mm to >256mm. This definition represents a range of habitats and according to the Wentworth classification covers granules (>2mm), pebbles (>4mm), cobbles (>64mm) and boulders (>256mm).

The BGS survey of the area was unable to accurately sample boulders and cobbles and therefore gravel mostly refers to areas of grain sizes <64mm.

In many shelf locations, but particularly on topographic highs, gravel fields form lag deposits that are exposed or are covered by thin mobile seabed sediments. For example, extensive fields of seabed gravel occur on regional features such as the Otter, Papa, Stormy and Solan Banks situated to the north and west of Orkney. In contrast, ridges of lag gravel also occur on gravel berms formed by the seabed ploughing processes associated with iceberg scour.

Inner shelf and nearshore areas of seabed rock and gravel support a diverse and prolific calcareous biota which contributes significantly to the proportion of calcium carbonate in nearshore sediments. These sediments represent major high-latitude centres of modern carbonate production (Farrow *et al.* 1984) consisting of bivalve and echinoid fragments, serpulid tubes, barnacle plates and bryozoans, the proportions and ages of which vary with location. Fragments of the cold-water coral *Lophelia pertusa* have been found on positions of elevated seabed on moraines and rockhead to the north west of Shetland.

Sand

West of Shetland, large areas of shelf are characterised by longitudinal sand patches overlying a gravel substrate. Individual sand patches are usually strongly elongate, typically a few tens to two hundred metres wide by hundreds of metres to several km long. The predominant trend of the elongate patches is NE to ENE. On the basis of sidescan sonar data, sand cover varies from <5% to >95%, but is typically in the 10-60% range (Masson *et al*. 2003).

A baseline video survey of the Clair field in 2000 indicated that the seabed was tide scoured and varied from sand, through mixed sand, gravel and pebble, to cobble and boulder pavement. Topographic highs had a greater proportion of cobbles and boulders, although such rocks were ubiquitous over the survey area. The sediment pattern accorded with the BGS description of the area given by Stoker *et al.* (1993), with sediments arranged linearly, parallel to the tidal stream axis, with ribbons of sand alternating with coarser material. Over much of the area the layer of sand was thin and only partially covered the hard clay beneath (Hartley Anderson 2000, ERTSL 2001a).

Tidal sand banks, tidal sand ridges and fields of migrating sandy bedforms typically form in water depths ranging from 20-100m or more and in the areas that are prone to the strongest wave and tide generated near-bottom currents. These bedforms and adjacent nearshore seabed areas locally consist of more than 60% shell fragments that have been derived from the prolific post-glacial benthic biota.

Mud

Muddy sediments are rare on the shelf with the exceptions of sheltered sea lochs and certain mid-shelf enclosed basins where the mud overlies accumulations of Pleistocene and early Holocene sediments. At other sites, thick sequences of sub-seabed mud occur under superficial sands and gravelly sands. Pockmarks are found in areas of fine-grained muds and form following seabed excavation by processes involving fluid or gas escape at the seabed. In the SEA 4 area, an area of pockmarks has been identified in a deeper water area of the mid-shelf.

Other features

In the SEA 4 area, the 80m isobath more or less defines the shoreward limits of thick unconsolidated muddy and gravelly unsorted sediments known as diamictons. Diamictons map over most of the outer continental shelf and extend oceanwards to the slope, some deposited as moraines as the ice retreated (Stoker & Holmes 1991). Their distribution correlates with areas of hard substrate and is commonly associated with positive seabed topography.

Iceberg ploughmarks persist most abundantly at seabed in >120m water depth (see below), with most of those on the shelf buried or otherwise obliterated by strong-near-bottom currents following the late-glacial. The iceberg furrows are partly filled with sediment, usually sand, and are flanked on both sides by ridges typically consisting of gravelly sediment.

5.2.3.2 Continental slope and basin floor

The present day seafloor substrates of the continental slope and deep water basins are largely the product of late Pleistocene sedimentation, when ice-related processes transported large amounts of sediment to the continental shelf edge, from where it was distributed down slope by such processes as debris flows (Stoker *et al.* 1991, Stoker 1995).

Continental slope

Iceberg ploughmarks (Figure 5.3) are the dominant feature of the upper continental slope west and north of Shetland between 200-450m water depth (Masson 2001, Belderson *et al.* 1973). The upper limit of the ploughmark zone originally extended onto the outer continental shelf, but many of these shallow water ploughmarks have been partly erased or buried by post-glacial sediment redistribution. An intense pattern of cross-cutting iceberg ploughmarks, similar to those on the eastern slope of the Faroe-Shetland Channel, covers the crest and upper slopes of the Wyville Thomson Ridge.

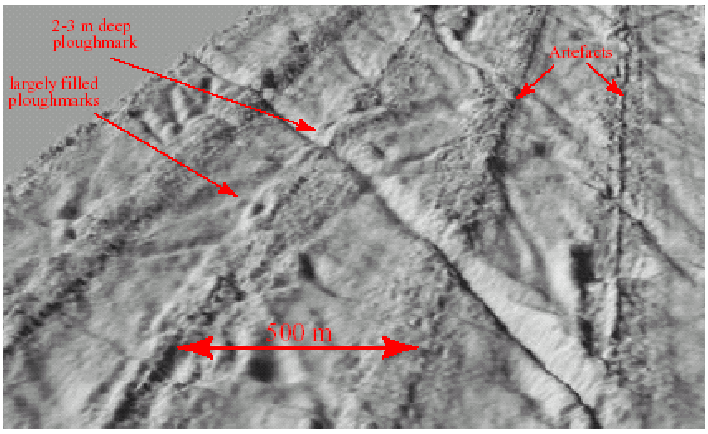


Figure 5.3 – 3D perspective of iceberg ploughmarks on the upper slope north of Shetland. Most of the ploughmarks in this area are largely infilled. The single obvious ploughmark is 2-3m deep (Masson *et al.* 2003).

Sediment bedforms indicate that north-east directed bottom currents are particularly active at water depths <500m, under the NE directed slope current where peak current velocities >0.75ms^{-1} can be expected. In this area, mobile sand bedforms move over a predominantly gravel substrate. Gravel at the seabed and areas of seabed scour in the sill area between the Faroe-Shetland and Faroe Bank Channels indicates local bottom currents >1.0ms^{-1}.

On the lower slope (450 to 1000m water depth), there is a gradual down slope change from a mixed gravel/sand seafloor to muddy sand. The gravel/sand sediments, called "gravel lag contourites" (Stoker *et al.* 1998) result from the reworking and winnowing of Pleistocene glacial sediments by strong Holocene bottom currents. However, the patchy occurrence of sand and the occurrence of bedforms such as barchan-type sand dunes suggest that the supply of sediment to the slope is limited (Stride 1982).

In general, stronger currents (correlating with coarser sediment) occur at greater depths in the relatively narrow southern Faroe-Shetland Channel and Faroe Bank Channel than in the more open Norwegian Basin further north. The presence of barchan sand dunes in the southern Faroe-Shetland Channel at about 1150m water depth suggest a WSW-flowing bottom current of 0.15-0.8ms^{-1} with erosional furrows adjacent to the dunes suggesting that flow velocities can reach >1.0 ms^{-1} (Wynn *et al.* 2002).

Basin floor

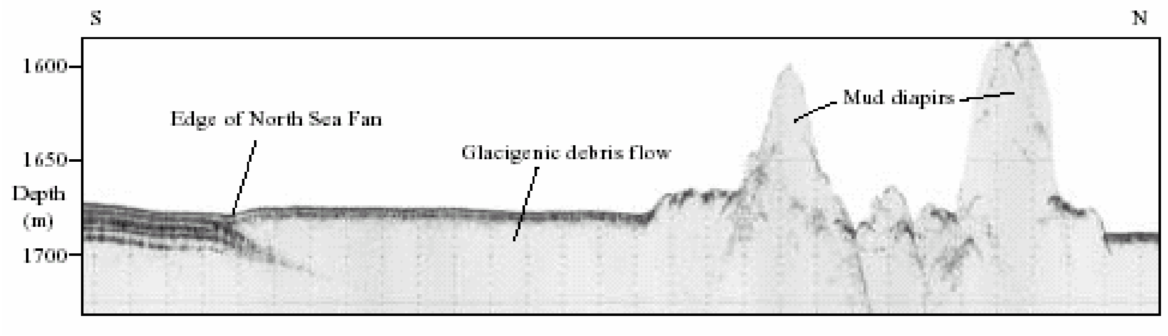
The term 'Basin floor' is used to describe areas of very low slope gradient and essentially includes all areas deeper than 1000m depth within SEA 4. Three distinct provinces, the Faroe Bank Channel, Faroe-Shetland Channel and Norwegian Basin are distinguished.

A veneer of sand or muddy sand covers much of the Faroe Bank Channel floor, deposited by bottom currents during the Holocene. However, much coarser sediments occur along the northern edge of the floor and grain-size generally increases towards and onto the lower slope of the Faroe platform. Large parts of the Faroe Bank Channel floor shows evidence of seafloor erosion (furrows and scours) and sediment transport/deposition under the influence of bottom currents (sediment drifts and contourite sheets).

The floor of the Faroe-Shetland Channel is characterised by relatively featureless mud and muddy sand with some gravel. The boundary between muddy sand and mud at the seafloor gradually moves deeper in the basin as it becomes narrower towards the south, reflecting the increasing importance of bottom currents.

A surface veneer of mud covers the floor of the Norwegian Basin below 1000m water depth and glacigenic debris flow sediments of the North Sea Fan underlie much of the area. A field of mud diapirs resulting from the upward migration of fluid/mud to the surface occurs in the southern Norwegian Basin (Figure 5.4). No evidence for fluid escape (or possible associated biological communities) has yet been found but there remains the possibility that localised areas of fluid escape may be active in the area.

Figure 5.4 – A 3.5kHz profile from the Norwegian Basin floor showing mud diapirs (Masson et al. 2003).



5.2.4 Shoreline types

Geological processes underpin the shape and form of the present-day shoreline of Shetland, Orkney and the north coast of Scotland.

The coastline of Shetland is formed by a variety of metamorphic, igneous and sedimentary rock types, and has a very complex shape. There are extensive stretches of exposed cliffs and rocky shorelines with long, narrow inlets known locally as voes which extend for several kilometres inland (Stoker *et al.* 1993). Sheltered areas display a range of sand spits, tombolos and bars (Flinn 1964, Steers 1973).

The Orkney Islands are generally low-lying with gentle slopes and rounded topography. Spectacular cliff and rock formations characterise much of the western coastline with eastern coasts displaying predominantly rocky shorelines interspersed with sandy and shingle beaches and sand dunes. The islands are mostly composed of Devonian sedimentary rocks (410-360Ma), predominantly Middle and Upper Old Red Sandstone (Barne *et al*. 1997).

High exposed cliffs formed from a variety of metamorphic, sedimentary and igneous rocks dominate much of the north coast of Scotland. Lewisian gneiss typically forms rounded and hummocky slopes, although in the vicinity of Cape Wrath it forms steep cliffs (Steers 1973). In Caithness, Old Red Sandstone forms high cliffs with stacks and geos, whereas the more intricate and indented coastline between Strathy Point and Loch Eriboll is largely formed of Moine rocks (Stoker *et al*. 1993). Loch Eriboll is one of three large sea lochs which cut into the western part of the coast in alignment with geological formations. Prominent headlands provide shelter for a number of beach and dune systems (Barne *et al*. 1996).

5.2.5 Implications for Strategic Environmental Assessment

A small number of oil fields have been discovered to the west and north-west of Shetland. It is unlikely that hydrocarbons will be discovered in the extreme north of the SEA 4 region until techniques are developed to improve seismic resolution beneath the Palaeogene lavas present in the area. The seabed topography and current regime present numerous challenges to oil and gas development in the SEA 4 area.

5.3 Climate and meteorology

The SEA 4 region has a generally mild, maritime climate resulting from prevailing south-westerly winds and the warming influence of the Atlantic Continental Slope Current. The weather is strongly influenced by two semi-permanent weather systems, a low pressure region over Iceland and a high pressure area over the Azores. When these are in place, a stream of secondary depressions pass between the two in a general east or north-east direction. These depressions occur with a similar frequency throughout the year; however, they are most intense in winter months when gales are more common. The area has characteristically changeable weather patterns caused by the variability in positions of warm and cold fronts and development of anticyclones and depressions. Polar depressions from the Norwegian Sea are characterised by a relatively small circulation of intense, squally showers (of snow in winter). The area experiences frequent low cloud with periods of extensive rain and drizzle. Sea fog is more common in the summer and relatively uncommon during the winter months.

Winds in the area can occur from any direction, but predominant winds tend to be from the south-south-west, west-south-west and west. Less predominant, but displaying a more uniform distribution, are winds from the east-north-east and east. During spring (April to June), the area is characterised by a uniform wind distribution, with east-south-east, north-north-west, north and north-north-east winds being predominant. During the rest of the year (from July to March) south-south-west, west-south-west and north winds occur with a percentage frequency of 32%. Marshall (1997) provides wind roses which summarise wind direction and speed data for the UK and Faroes.

There is a significant seasonal variation in wind speed. Annual mean wind speeds tabulated by Marshall (1997) for Lerwick and Tórshavn are between 11 and 15 knots (moderate breeze). In winter (November to March), monthly mean wind speeds are between 12 and 17 knots but are generally less in the summer months ranging from 8 to 13 knots. Gales are common in winter, occurring on 8 days per month in January and December, and calm conditions are rare throughout the year.

5.4 Hydrography

Hydrographic data sources and characteristics of the Faroe-Shetland Channel were comprehensively described in SEA 1, which noted that since the pioneering *Porcupine* and *Lightning* studies of 1868-

1870 (Wyville Thomson 1874), the Faroe-Shetland Channel environs have been one of the most studied oceanic regions of the world. Two hydrographic sections across the Faroe-Shetland Channel have been surveyed by the Aberdeen Marine Laboratory for over a century (Turrell *et al.* 1999a, 1999b).

The whole SEA 4 area may be characterised as relatively high energy, in terms of near-bed current velocities and wave climate although there are large differences in water depths and the structure of the water column. In broad terms, hydrographic characteristics differ between shelf, slope and deep channel/basin components of the SEA 4 area.

5.4.1 Data sources

Relevant hydrographic data have been reviewed and synthesised by Dooley and Meincke (1981); Hansen and Østerhus (1985); Saunders (1990); Turrell (1997); Turrell *et al*. (1999); Hansen (2000).

International and national oceanographic programmes in the area include:

- Overflow '60 (Tait *et al.* 1967, cited in Van Aken and Eisma 1987)
- Overflow '73 (Ellett & Edwards 1978 and Müller *et al.* 1979, cited in Van Aken & Eisma 1987)
- the North Atlantic-Norwegian Sea Exchanges (NANSEN) project (Van Aken & Becker 1996)
- the Nordic WOCE programme (e.g. Hansen *et al.* 1998, Turrell *et al.* 1999b, Østerhus *et al.* 1996a and b, Østerhus *et al.* 1999, Orvik *et al.* 1999)
- the EU-MAST VEINS (Variability of Exchanges in the Northern Sea) programme (Hansen & Østerhus 2000)

The Northwest Approaches Group (NWAG) sponsored a project to develop a high resolution 3D computer model of the currents of the West of Shetland shelf and slope, making use of metocean data collected by oil companies in this area of the North Atlantic (Turrell *et al.* 1999b).

To the north, recordings of hydrographic data in the Norwegian Sea have been undertaken since 1948 from Ocean Weather Station Mike (OWSM) located in the eastern margin of the Norwegian Sea at 66ºN, 2ºE (Østerhus *et al.* 1996b). This series of measurements represents the longest homogeneous time series from the deep ocean and is operated by the Norwegian Meteorological Institute.

5.4.2 Major circulation patterns

Large scale ocean circulation in the area is dominated by the northward flow of surface and mid-depth North Atlantic Water, which flows from the Rockall Trough over the Wyville Thomson Ridge before entering the North Sea via the Fair Isle current and to the north-east of Shetland. The existence of the Fair Isle current was first demonstrated in the late nineteenth century using surface drift bottles and sea-bed drifters (Fulton 1897). Modified North Atlantic Water is also advected into the area from north and south of the Faroes.

Much colder and deeper water flows from the Norwegian Sea, south-westwards along the Faroe-Shetland Channel; through the Faroe Bank Channel and to a lesser extent over the Wyville Thomson Ridge, although some may also be recirculated back into the Norwegian Sea.

Five distinct water masses are therefore recognised in the SEA 4 area:

- **North Atlantic water**
  - from the Rockall Trough, crosses the Wyville Thomson Ridge
  - concentrated along the eastern side of the Faroe-Shetland Channel
  - slope current most intense over the 400m contour

- **Modified North Atlantic Water**
  - dominates the surface flow in the centre and along the western slope of the Faroe-Shetland Channel
  - represents the northern branch of the North Atlantic Current
- **Arctic Intermediate/North Icelandic Water**
  - from north of the Iceland Faroe Ridge
  - occupies water depths of 400-600m on the Faroese side of the Channel; slightly shallower depths at the Scottish side of the Channel
- **Norwegian Sea Intermediate Water**
  - water depths of 600-800m**Faroe-Shetland Channel Bottom Water**
  - depths greater than 800m

5.4.3 Slope, channels and basins

The surface waters of the Faroe-Shetland Channel are characterised by two distinct water masses; North Atlantic and Modified North Atlantic waters. North Atlantic water enters the Faroe-Shetland Channel over the Wyville Thomson Ridge and is concentrated along the eastern side of the Channel, as a slope current close to the edge of the West of Shetland Shelf. It is most intense over the 400m contour (Turrell *et al.* 1999a). This water originates from the Rockall Trough. The Modified North Atlantic Water dominates the surface flow in the centre and along the western slope of the Channel and represents the northern branch of the North Atlantic Current. As this water flows towards the Faroe Islands from the west it splits and flows into the Faroe Bank and Faroe Bank Channel areas and northwards around the Faroe Plateau in clockwise direction entering the Faroe-Shetland Channel from the north-east (Hansen 1985, Saunders 1990). The net flow of these two water masses is to the northeast (Turrell *et al.* 1999a).

Below the Modified North Atlantic Water, Arctic Intermediate/North Icelandic Water originating from north of the Iceland Faroe Ridge occupies water depths of 400-600m on the Faroese side of the Channel (Blindheim 1990). At the Scottish side of the Channel the area occupied by this water is narrow and in slightly shallower depths.

A second intermediate water mass is present on the Faroese side of the Channel in the form of Norwegian Sea Intermediate Water which occupies water depths of 600-800m. This intermediate water is most likely created at the surface in the Arctic domain of the Iceland and Greenland Seas, north of the Arctic front (Blindheim 1990), and is subducted between the more saline surface waters of Atlantic origin and the Norwegian Sea Deep Water below (Blindheim 1990). The boundary between the Norwegian Sea Deep Water and Norwegian Sea Arctic Intermediate Water is usually defined to be where the temperature is -0.5ºC (Müller *et al.* 1979) which is found around (although usually above) the 1,000m contour and appears to be the depth from which the densest overflow into the Faroe-Shetland Channel is drawn (Hansen & Østerhus 2000).

Below these intermediate waters at depths of greater than 800m the Channel is filled by cold water originating from the Norwegian Sea known as Faroe-Shetland Channel Bottom Water. It is believed that most of the transport within this water leaves the Channel through the Faroe Bank Channel and to a lesser extent over the Wyville Thomson Ridge (see above), although some may be recirculated back into the Norwegian Sea (Turrell *et al.* 1999a).

The temperature and salinity characteristics of each of the above identified water masses are defined below in Table 5.2 (adapted from Heath & Jónasdóttir 1999):

Table 5.2 – Water Mass Salinity and Temperature

Water mass	Temperature (ºC)	Salinity ($^{0}/_{00}$)
North Atlantic Water	> 7.5	> 35.3
Modified North Atlantic Water	6.0 - 7.5	35.12 - 35.18
Arctic Intermediate/North Icelandic Water	3.0 - 4.5	34.95 - 35.00
Norwegian Sea Intermediate Water	0.25 - 0.75	< 34.92
Faroe-Shetland Channel Bottom Water	< 0.5	-

The mean velocity of the Scottish shelf edge current is approximately 40cm/s towards the northeast (Saunders 1990). The shelf edge current exhibits a seasonal maximum transport in December/January and a minimum in June/July (Gould *et al.* 1985). Measured near-bottom current velocities indicate peak currents over 75cm/s on the upper continental slope west of Shetland (Graham 1990a, Graham 1990b, Strachan & Stevenson 1990). Sediment bedforms observed on the upper slope, such as small barchan-type sand waves, longitudinal sand patches and comet marks (Werner *et al.* 1980), confirm currents in the range 40 to >75 cm/s (Kenyon 1986). Periodic and episodic peak currents are driven by semi-diurnal tides, internal waves (Sherwin 1991), storm surges (Turrell & Henderson 1990), gyres and eddies (Dooley & Meinke 1981).

There is considerable seasonal variability in the intensity of the flow of the water masses through the Faroe-Shetland Channel (Harmes *et al.* 1999). This variability is apparent in both the surface and underlying water layers, but most apparent at intermediate depths of 400-600m. Current velocities in the north-east flowing waters show a maximum in the winter and currents close to the bottom of the Channel show a maximum in summer.

5.4.4 Shelf currents

Tidal currents are significant only in shelf waters of the SEA 4 area with tidal amplitudes generally low to moderate although topographic constraints result in high current velocities in localised areas of the Pentland Firth, Orkney and Shetland.

Tidal range throughout the area is moderate with a mean spring range of 1.5m in Shetland and up to 3.0m in Orkney. Tidal surges are also less significant than in other areas of the UKCS with tidal surges of between 1.25m and 1.5m occurring in Orkney on average once in every 50 years.

Tides in the area are semi-diurnal. Flood streams are generally from west to east in the offshore areas, through the Pentland Firth and between islands in Orkney and Shetland, with the flood stream deflected southwards along the Shetland coastlines. The maximum tidal current amplitude in nearshore waters is 0.04m/s (BODC 1998), although near Muckle Flugga, in Yell Sound, Linga Sound, Bluemull Sound and near Sumburgh Head in Shetland; through the Pentland Firth; and in Hoy Sound in Orkney; tidal streams reach considerably higher velocities - between 3.5m/s and 4.5m/s.

Residual tidal flows through the Pentland Firth and Fair Isle Channel are very low, so that bedflows are dominated by non-tidal components (Johnson *et al*. 1982). Estimated maximum orbital near-bottom currents, generated from wind-waves or internal waves at the shelf edge and shorewards, may have up to 10 fold or more higher speeds than the tidal currents (Holmes *et al*. 2003). These orbital currents are important energy sources for mobilising sediment grains into the tidal streams.

5.4.5 Wave climate

The wave climate throughout the SEA 4 area, due to the exposed nature of the Atlantic, is more severe than that found in the Northern North Sea. The wave conditions are similar throughout most of the SEA 4 area with a significant wave height of 2.5m exceeded for 50% of the year and 4.0m for

10% of the year (BODC 1998). Estimated 50 year wave heights in the offshore area are approximately 32m and wave periods of greater than 20 seconds (Grant *et al.* 1995).

5.5 Contamination

Anthropogenic contamination of the environment can be defined as the introduction by humans of materials in locations or concentrations in which they do not occur naturally. If present in sufficient concentrations, contaminants have the potential to disturb biological processes through a variety of mechanisms, including increased availability of food and nutrients, toxicity, mutagenicity and interference with reproductive physiology. It is very likely, although unproven, that localised anthropogenic contamination of the SEA 4 area commenced up to 9000 years ago with the disposal of organic wastes associated with hunting and butchery, by pre-historic Mesolithic and Neolithic communities living on the continental shelf areas between the northern mainland coast and out to a present-day water depth of the order of 150m on either side of the Orkney-Shetland Ridge (Flemming 2003).

However, large-scale contamination of the marine environment is principally associated with industrial development, with major sources comprising terrestrial emissions and discharges (transported to the marine environment via rivers and atmospheric transport); shipping; military activities (which have accounted for substantial input of hydrocarbons and other contaminants to the SEA 4 area over the past century); and offshore industries including oil and gas production. In general, riverine and atmospheric transport accounts for the largest inputs of contaminants to the north-east Atlantic and North Sea (OSPAR 2000). The major sources of contaminants associated with offshore oil and gas activities are drill cuttings, produced water and flaring; with relatively minor inputs via drainage and other discharges (Section 10.4).

Contaminants introduced from these sources may also be naturally present in the marine environment, in which case background concentrations may be low, high or variable; or may be synthetic (not naturally occurring) in which case background concentrations should be zero. Once introduced to the marine environment, contaminants may accumulate in the water column – in solution or adsorbed to suspended particulates; sink and accumulate in sediments, or volatilise to the atmosphere (frequently through aerosol production by breaking waves). At any stage, contaminants may be ingested or otherwise taken up by living organisms, which may in turn be consumed, leading to biomagnification of persistent contaminants in the food chain. Biodegradation of contaminants is largely associated with microbial populations in the water column and sediments. The rate of biodegradation varies widely between contaminants with some (e.g. low molecular weight aliphatic hydrocarbons) biodegraded rapidly, and others degraded slowly (e.g. some Polycyclic Aromatic Hydrocarbons (PAHs), chlorinated hydrocarbons such as polychlorinated biphenyls (PCBs), polychlorinated dioxins and dibenzofurans (PCDD/Fs) and organochlorine pesticides) or not at all (e.g. radionuclides).

In general, deep-water marine environments have relatively low contaminant burdens in comparison to coastal waters and especially industrialised estuaries. The SEA 4 area is remote from areas of major industrial activity and therefore includes some of the least polluted habitats in the UK. However, there are local sources of contaminants, in particular hydrocarbons; and long-range transport of persistent contaminants has probably resulted in detectable pollution throughout the region.

5.5.1 Data sources

In comparison to coastal environments and estuaries, relatively few data for contaminant concentrations and effects are available for the offshore SEA 4 area. Much of the available data results from localised surveys in relation to oil and gas developments in previously licensed blocks and from coordinated wide-area surveys conducted in 1996 and 1998 by the Atlantic Frontier

Environmental Network (AFEN) (McDougall 2000 – AFEN CD). AFEN has also commissioned "fingerprint" analysis of oil residues sampled from Shetland and Orkney coastlines, with the aim of identifying the source of beached oil and tars. Additional sampling and analysis was commissioned by DTI for the SEA 4 area in 2002; preliminary results from the analyses of metals and hydrocarbons are available.

Existing contaminant data for the Greater North Sea (including the SEA 4 area) and adjacent arctic areas of the OSPAR region (including the Norwegian and Barents Sea, extending south to the Faroe Bank Channel) were summarised in Quality Status Reviews by OSPAR (2000a and b). The Faroese shelf and Faroe Bank Channel were also included in the Arctic Monitoring and Assessment Programme (AMAP) which produced a second assessment of Arctic pollution issues in 2002 (AMAP 2002), focussed on Persistent Organic Pollutants (POPs) and metals.

5.5.2 Hydrocarbons

Many biogenic hydrocarbons occur naturally in seawater and marine sediments derived mainly from phytoplanton and other marine biota. Petrogenic hydrocarbons also occur naturally, associated with seeps. However, hydrocarbon contamination through anthropogenic inputs are widespread in the marine environment with inputs from the offshore E&P industry, shipping, atmospheric transport and coastal sources. Hydrocarbons discharged to the water column are subject to a range of physical processes and biodegradation (see Section 10.4), and elevated concentrations of most petrogenic hydrocarbons in the North Sea are limited to the vicinity of point source discharges, in areas with intense shipping (especially the Dover Straits and German Bight) and in major estuary systems (notably the Elbe) (OSPAR 2000a).

Analyses of seabed samples from the vicinity of the Foinaven, Vrackie, Schiehallion and Clair Fields, together with samples taken by the AFEN 1996, AFEN 1998, DTI 2000 and DTI 2002 surveys, indicate that hydrocarbon contamination is localised and associated primarily with discharges of oil-based cuttings from exploration, appraisal and development drilling. The Foinaven field survey (ERT 1998) observed concentrations of the synthetic hydrocarbon base fluid XP-07 up to 43µg/g between 200m and 500m from the drilling centres, indicative of limited contamination of sediments. However, these concentrations are low in comparison to those found close to multiwell developments in the North Sea, and indicate that dispersion of cuttings and subsequent biodegradation of organic phase drilling fluids have been rapid.

With the exception of two samples clearly associated with drilling discharges and one sample which contained a large quantity of phytodetritus, total hydrocarbon concentrations in the AFEN 1996 and 1998 samples from west of Shetland were between 0.5 and 11.5µg/g (dry weight sediment, McDougall 2000). Total hydrocarbon concentrations in 64 samples taken in the SEA 4 area on behalf of DTI in 2002 had a very similar range from 0.8 to 11.0µg/g, which is comparable with typical background values for North Sea areas remote from offshore oil activities (0.2-5µg/g; NSTF, 1993). As further comparison, total petroleum hydrocarbon concentrations in marine sediments from open parts of the Barents Sea range from 5 to 60µg/g (Santos *et al.* (1996).

Interpretative statistics, such as the Carbon Preference Index of the n-alkane series, and the ratio of isoprenoid hydrocarbons pristane and phytane, indicate a biogenic rather than petrogenic origin for the majority of aliphatic hydrocarbons in the AFEN and DTI samples. Gas chromatographic profiles (GC) obtained for all the AFEN samples were, in general, very similar across the study areas and depict an homologous series of n-alkanes (albeit at low levels) ranging in carbon number from approximately nC12 to nC36 with evidence of a low level high molecular weight 'hump' of material (commonly referred to as unresolved complex material, UCM), primarily over the region nC20 to nC33 (McDougall 2000). The UCM is composed of a mixture of hydrocarbons, including cycloalkanes, which remain after substantial weathering and biodegradation of petrogenic inputs

(Farrington *et al*. 1977). The presence of this UCM suggests low level contamination of these sediments with heavily weathered mineral oil or its degradation products; most probably from historic and dispersed shipping sources.

Total 2-6 ring Polycyclic Aromatic Hydrocarbons (PAH) in the AFEN 1996 and 1998 were in the range 15-238ng/g (dry weight sediment), which are again broadly typical of uncontaminated sediments (McDougall 2000). Concentrations in 32 samples from the DTI 2002 survey were comparable, in the range 5-519ng/g.

On a worldwide basis, background values for PAH concentrations in sediments appear to fall within the range of a few tens to approximately 500ng/g (dry weight sediment) (Windsor & Hites 1979). In comparison, the DIFFCHEM survey (OSPAR, 1997) analysed PAHs in 22 estuaries in western Europe. Values for the sum of all PAHs were between 218ng/g (Wadden Sea) and 6080ng/g (Scheldt estuary). PAH concentrations in surface sediments from the arctic Russian marine environment are generally lower than 500ng/g (range 4-3400ng/g) (AMAP, 1998); while sediments near Svalbard contained total PAH concentrations of 1600 to 8100ng/g, probably due to contamination by petroleum and petroleum products, as indicated by the predominance of alkylated naphthalenes. Total PAH concentrations in sediments from several locations along the northern Norwegian coast occur over a wide range (4-46000ng/g), with the highest concentrations found in some contaminated harbour areas (Konieczny 1996). Total PAH concentrations in samples from the SEA 4 area are therefore consistent with background or heavily weathered and dispersed levels.

Between 1996 and 2003, AFEN funded analysis to "fingerprint" oiled sea birds and tarballs found on beaches in Orkney, Shetland and the Western Isles in order to improve understanding of the sources of oil pollution and to help target pollution control efforts to priority areas. Analysis of 208 samples supports the conclusion that the majority of resolved petroleum hydrocarbons evident in the beached oils originate from maritime sources, such as fuel and lubricating oils (ERT 2003). Crude oil residues are relatively rare, with most characterised as North Sea or Middle East crudes, probably linked to either local tanker operations or losses from offshore installations.

5.5.3 Metals

"Heavy" metals, including barium, cadmium, copper, iron, lead, mercury, nickel and zinc, are naturally present in seawater and marine sediments, in a range of forms and concentrations. In excessive concentrations, metals can exhibit toxicity and result in significant environmental effects; with cadmium, lead and mercury generally regarded as the elements of greatest concern (OSPAR 2000a, b). Concentrations of metals in seawater and sediments are greatly influenced by adsorption on to clay particulates, and suspended solids loading and sediment particle size distribution therefore have a significant effect on measured concentrations. Similarly, analytical methods usually involve an acid extraction procedure and "total" metal concentration may have little relation with the proportion which is soluble or otherwise bioavailable. Variability in extraction efficiency, and therefore the reliability and interpretation of analytical data, is a particular issue in the case of barium, which is a major constituent of drilling fluids and is therefore used as a "tracer" for oilfield contamination (Hartley 1996).

There are very few measurements of water column metals in the SEA 4 area, or adjacent offshore areas (OSPAR 2000a, b), although data for the northern North Sea from the 1985-1987 ICES Baseline Study of Trace Metals in Coastal and Shelf Sea Waters (ICES 1991) and German ZISCH Project (Circulation and Contaminant Transfer in the North Sea) are reported by OSPAR (1993). These data indicate dissolved trace metal concentrations similar to open ocean water (cadmium 0.004-0.024µg/l, copper 0.11-0.42µg/l, lead 0.036-0.051µg/l, mercury 0.003 – 0.008µg/l, nickel 0.16-0.30µg/l).

Sediment metal concentrations have been measured in samples from wide area AFEN and DTI surveys (Table 5.3) and in field surveys within the SEA 4 area.

*Table 5.3 - Ranges of metal concentrations (µg/g dry weight sediment) recorded in AFEN and DTI surveys, 1996-2002. ND= not detected * excluding sample 53748#2*

	AFEN 96 (206 samples)	AFEN 98 (83 samples)	DTI 2002 (61 samples)
Ba	84 - 546 *	188 - 824	208 – 349
Cd	ND	ND	ND
Cr	11 – 71	21 – 86	10 – 35
Cu	4 – 35	5 – 37	2 – 39
Ni	9 – 45	11 – 41	5 – 34
Pb	2 – 39	3 – 14	3 – 20
Zn	11 - 88	22 - 68	15 – 76
TotalBa	106 - 1282	210 - 825	

As noted above, barium is a major component of drilling fluids and is generally regarded as an indicator of oilfield contamination (Hartley 1996, OSPAR 2000a). For example, recent accumulation of barium in depositional areas of the Skagerrak (Longva & Thorsnes 1997) are considered likely to be associated with drilling discharges in the North Sea. Elevated barium concentrations in the SEA 4 area have been detected only in close proximity to drilling locations. With the exception of a single sample from close to an exploration well site, barium concentrations in AFEN 96 samples (measured using a relatively aggressive perchloric/hydrofluoric acid digest) were 84-546µg/g, with a similar range recorded in DTI 2002 samples. In contrast, barium concentrations measured by the 1998 Foinaven survey using nitric acid extraction within 500m of the drill centres were as high as 1560µg/g, and up to 6560µg/g using a sodium/potassium carbonate fusion procedure. These data indicate a moderate accumulation of drilling wastes, although concentrations are lower than levels typically recorded around well centres in the North Sea.

Other metals are present in SEA 4 sediments at concentrations similar to background levels recorded from uncontaminated offshore areas. Cadmium was below analytical detection limits (<1µg/g) in all AFEN and DTI samples. In deep water Greenland Sea sediments, average cadmium concentrations were 0.12 ± 0.05µg/g (AMAP, 1998). Cadmium concentrations measured at 43 sites in the Barents Sea averaged 0.08 ± 0.08µg/g (OSPAR 2000b). Similar levels were found in Norwegian Sea sediments with cadmium concentrations ranging from 0.08 to 0.19µg/g. Cadmium concentrations in Icelandic sediments average 0.22µg/g (range 0.05-0.74µg/g) (Egilson *et al*. 1999) which is somewhat higher than in the sediments of the Norwegian and Greenland Seas and is probably due to volcanic activity (OSPAR 2000b).

Lead levels in surface sediments in the Norwegian Sea at sites far from point sources ranged from 7 to 22µg/g (AMAP, 1998). A similar concentration range was found in the Barents Sea with concentrations of 5 to 32µg/g. The mean concentration of lead in sediments around Iceland is 11.7µg/g (Egilson *et al*. 1999). Lead in AFEN and DTI samples varied between 2 and 39µg/g.

5.5.4 Persistent contaminants

A range of contaminants are characterised as persistent i.e. are biodegraded or degraded by physical processes (e.g. photo-oxidation) very slowly. Such contaminants may be transported at a global scale and in some cases are highly toxic or contribute to global environmental effects. Persistent contaminants include chlorinated hydrocarbons such as polychlorinated biphenyls (PCBs), chlorofluorocarbons (CFCs), polychlorinated dioxins and dibenzofurans (PCDD/Fs) and organochlorine pesticides; brominated flame retardants; octylphenol and nonylphenol ethoxylates (OPE and NPE); organo-metallic compounds such as tributyl tin (TBT); and radionuclides etc:

- polychlorinated biphenyls (PCBs) have been used in a variety of industrial products, such as transformer and capacitor oils, hydraulic and heat exchange fluids, lubricating and cutting oils, and as a plasticiser in paints, plastics and sealants. There are 209 chlorinated biphenyl congeners with different chlorine substitutions on the biphenyl rings. The number and positioning of the chlorines influences both toxicity and physical properties such as solubility and vapour pressure

- polychlorinated dioxins and dibenzofurans (PCDD/Fs) – the major sources of polychlorinated dibenzodioxines and -furanes (PCDD/Fs) to air are waste incineration, particularly through incomplete combustion, wood burning and other combustion, and metallurgical industries

- organochlorine pesticides such as hexachlorocyclohexanes (HCHs), hexachlorobenzene (HCB), DDTs and chlordanes are now widespread in the marine environment, including relatively pristine areas such as the Arctic and Antarctic

- octylphenol and nonylphenol ethoxylates are cleaning agents with a suspected endocrine disruptive capacity

- organotin compounds, especially TBT, are used as antifouling paints, although application to boats smaller than 25m or to aquaculture cages has been discontinued

- radionuclide contaminants in the marine environment include natural radionuclides (e.g. radium-226, lead-210, polonium-210 arising mainly from ore processing) and artificial radionuclides produced by weapons testing and nuclear reprocessing (e.g. caesium-137).

None of the above are currently discharged by the offshore oil and gas industry, although some PCBs and ethoxylates have been used historically (in transformers, paints and drilling fluids)

No analyses of persistent pollutants in samples from AFEN and DTI surveys have been carried out. However, OSPAR Quality Status Reviews and AMAP indicate the widespread presence, at very low concentrations, of several contaminants in deep water environments adjacent to the SEA 4 area. Temporal monitoring indicates a reduction in accumulation rates of some, but not all persistent pollutants. Consideration of the sources and transport pathways of persistent contaminants implies that comparable concentrations will be present within the SEA 4 area. For example, caesium-137 from discharges at Cap de la Hague and Sellafield can be traced in the Barents Sea with a time lag due to transportation of approximately four to five years. The peak in ^{137}Cs activity of around $50Bq/m^3$ measured in the Barents Sea in the early 1980s is probably the highest activity concentration that has occurred in this sea area (OSPAR 2000b). However, ^{137}Cs is also transported via the Norwegian Coastal Current from the Skagerrak, which continues to receive Chernobyl-derived caesium isotopes in the outflow of water from the Baltic Sea, which received a significant input from the accident in April 1996 (OSPAR 1993).

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6 ECOLOGY

6.1 Regional overview

The ecological functioning of any ecosystem involves a large number of individuals and species interacting with the physical environment and interlinked by a complex arrangement of trophic (feeding) and other biological interactions. For the most part, marine ecosystems are dependent on sunlight as the primary energy source, with carbon fixed by phytoplankton, and to varying degree coastal algae and macrophytes, transferred through the foodweb through direct grazing, predation and detrital pathways.

Ecological processes in the SEA 4 area, in terms of both community structure and functioning, can be broadly distinguished in a pattern which follows the regional topographic distinction between continental shelf and deep basin; with different species assemblages characteristic of specific habitats in the pelagic system and benthic environment at different water depths. Superimposed on these broad patterns, there are local patterns of distribution (particularly of benthic fauna) at a variety of spatial scales, frequently corresponding to substrate features associated with sedimentary erosion and deposition.

The deepwater SEA 4 area has been described (SEA 4 assessment workshop) as being of considerable scientific and conservation interest as a result of the combination of contrasting seabed habitats and communities. Deep water cetacean populations of the SEA 4 area (and the neighbouring region) are clearly of national and international significance. Coastal habitats and communities adjacent to the area are widely recognised as being of high conservation value, associated particularly with breeding seabird colonies.

The extremes of the SEA 4 area are illustrated by comparison of the west Shetland and Orkney shelf, characterised by high temperatures, hydrodynamic energy and primary productivity; with the much colder, less dynamic and dark waters of the deep Faroe-Shetland Channel. The high sediment mobility associated with tidal and wave action results in mobile, and often patchy benthic habitats with the high productivity of benthic and fish species assemblages driven by a highly seasonal input of phytoplankton and detrital carbon. There is also a coupling, to some degree, of the shelf ecosystem to highly productive coastal, intertidal and terrestrial systems through the export of detritus, and through foraging and seasonal migrations of fish, seabirds and marine mammals. High productivity is associated with short lifespan and rapid turnover of primary and intermediate consumers (most invertebrates and fish) and relatively high rates of utilisation by top predators – seabirds, marine mammals and humans. The apparent sensitivity of seabirds to food availability is a cause of concern, in relation to potential effects of changes in hydrographic conditions, and removal of stocks by fishing.

The deep channels and basins of the SEA 4 area are characterised by a lower hydrodynamic energy, although still erosive seabed environment; contrasting with most other areas in comparable water depth which have been studied (which are more quiescent and depositional). There is distinct bathymetric zonation of species assemblages; and less direct pelagic-benthic coupling, although the importance of phytodetrital deposition has been recognised only comparatively recently, and requires further investigation. Vertical transfers of carbon and energy also result from diurnal migrations of zooplankton, cephalopods and fish, and meso-pelagic and bathy-pelagic predation on squid and fish by marine mammals. Near-surface predation on zooplankton, cephalopods and fish by seabirds is probably less intense than in coastal waters, due to distance from breeding colonies.

Although the area is among the least intensively utilised areas of the UKCS for industrial uses, anthropogenic influences are widespread. These influences range from the historic decimation of baleen whale populations; to physical disturbance of the seabed and indirect ecological impacts of fishing activities (e.g. food availability to benthos and seabirds associated with the dumping of bycatch). The long-term ecological effects of many anthropogenic effects, including potential climate change, remain very uncertain.

6.2 Plankton

6.2.1 Introduction

To support the SEA process, SAHFOS was commissioned to review plankton ecology in the SEA 4 area (Plankton Report for Strategic Environmental Assessment Area 4). The report describes the plankton community structure and how this has altered over the past few decades. Data for the SEA 4 report has been provided by the Continuous Plankton Recorder Survey (CPR) and also sourced from outside organisations.

Plankton in the North Atlantic and North Sea has been monitored for almost 70 years using the Continuous Plankton Recorder. 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

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 of the SEA 4 area is dominated by the dinoflagellate genus *Ceratium*, although there are also high numbers of the diatoms, Chaetoceros (subgenera *Hyalochaete* and *Phaeoceros*). Phytoplankton biomass in the SEA 4 area and North Sea in general are very similar with the exception of *Thelassiosira* spp. which are significantly more abundant in the SEA 4 area. Phytoplankton biomass has increased over the last four decades throughout the majority of the SEA 4 area.

The zooplankton community of the SEA 4 area is dominated in terms of biomass and productivity by copepods, particularly *Calanus* species. Zooplankton species found in this region include the Calanoid copepods *Calanus helgolandicus* and *C. finmarchicus* as well as a number of meroplanktonic organisms (Decapoda and Echinodermata larvae). The larger zooplankton, known as megaplankton, including euphausiids (krill), thaliacea (salps and doliolids), siphonophores and medusae (jellyfish) are also present in the SEA 4 area. These 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. Occurances of salps and doliolids are rare both in the SEA 4 area and North Sea.

Euphausids (‘prawn like’ organisms) are not routinely surveyed by the CPR although they are thought to be very abundant throughout the SEA 4 region and are known to be a primary food source for fish and whales. During times of increased flow of colder water from the Norwegian Sea, euphausiid numbers increase. Survey results however show that in the SEA 4 area and North Sea in general their numbers are steadily decreasing.

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 SEA 4 area has seen an increase in echinodermata larvae and decapod larvae since the 1990s, a consequence of increased productivity of the benthos of the North Sea. Echinoderm larvae have shown pronounced periods of abundance during the late 1990s.

6.2.3 Plankton blooms

In the North Atlantic 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 due to surface warming, 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 which support the spring bloom.

Analysis of detailed time series of bio-optical and temperature data (Van Haren *et al*. 1999) supports the view that a minimum level of turbulence is required for the onset and maintenance of the phytoplankton spring bloom. The progress of the spring bloom is primarily dependent upon periodic turbulence input following short periods of stratification, allowing the resuspension of fast-sinking phytoplankton 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. As growth can only be sustained in the near-surface layer during periods of substantial mixing, phytoplankton in the bottom layers act as a source for occasional increases in near-surface biomass until early summer.

The complicated interactions amongst these physical and biological factors results in great natural variability in the abundance of phytoplankton (Tett & Edwards 2002).

CPR data for the SEA 4 area indicates that there is a strong link between algal blooms and hydro-climatic events, such as incursions of oceanic water via the Shelf Edge current.

Under certain conditions (e.g. rapid reproduction, reduced grazing pressures and 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). There are approximately three thousand identified species of marine phytoplankton of which about forty are known to exhibit intrinsically harmful properties. Examples of HABs relevant to the SEA 4 area include those associated with paralytic shellfish poisoning (PSP), such as the discovery of high levels of *Alexandrium tamarense* recorded in shellfish samples in Orkney in 1991. More recently in August 1996 there was a bloom of a dinoflagellate identified as *Gymnodium* cf. *mikimotoi* extending from Orkney to the west coast of Scotland. This outbreak was associated with the death of shellfish, finfish and other invertebrates in the affected area (Kelly & MacDonald 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). Observations of seasonal circulation along the north-east coast of England suggest that dinoflagellates originating from the high concentrations of *A. 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). Data suggests that Orkney forms the present-day centre of distribution for this dinoflagellate in northern waters (Tett & Edwards, 2002).

6.2.4 The influence of hydro-climatic change

The North Atlantic Oscillation (NAO; see also Section 5.4) is a key influence of the North Atlantic weather patterns. During certain conditions, westerly winds increase over the North Sea which introduce warmer air and increase the 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 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 density over the last decade in the SEA 4 area. 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.

The SEA 4 area contains the Faroe-Shetland Channel resulting in zoo-and phytoplankton communities being greatly influenced by the inflow of Atlantic Oceanic water through the Channel into the North Sea. It is thought that this inflow is linked to the NAO (Reid *et al*. 2001). Warm/temperate oceanic species of plankton are introduced into this area by the oceanic water that circulates through the Faroe-Shetland Channel, which also ‘seeds’ the North Sea with copepod species and warm water euphausiids such as *Nyctiphanes couchi*. The Channel is thought to contain the majority of the over wintering population of *C. finmarchicus* which in turn invades the northern North Sea shelf during spring months. These inflow events are no longer thought to be ‘exceptional’ and have in fact increased in frequency, having a massive impact on the plankton ecosystem.

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 East Atlantic and North Sea. Current research suggests that these events have a greater impact on biota than the anthropogenic factors.

6.2.5 Sensitivity to disturbance/contamination

The SEA 4 area contains a large port on Shetland (Sullom Voe) which is used for the storage and offloading of hydrocarbons. In addition the area between Orkney and Shetland is utilised by oil tankers exiting the North Sea. As a result the plankton community in the SEA 4 area is open to disturbance from oil spills, as well as pollutants contained in fresh water run off.

During the period that the oil industry has been active in the SEA 4 area there has only been one “major incident”. This occurred in 1993 when the Braer tanker spilled its cargo of 84,000 tonnes of crude oil off the Shetland coast. This incident has allowed examination of trophic level responses to oil contamination. Planktonic larval stages of lobster were found to be more susceptible, with higher mortality rate and increased amount of premature hatching. Conversely it has been shown that the addition of oil, in conjunction with high nutrient concentration, can benefit certain ciliates.

There is a strong suggestion that dispersant treated oil has a more pronounced effect. Any long-term genetic changes are not obvious and are therefore difficult to assess.

6.2.6 Ballast water and invasive species

Ballast water is a recognised vector for the introduction of non-indigenous and potentially harmful organisms into distant areas. Resting stages of both zoo- and phytoplankton can easily be transported in the fine sediments at the bottom of ballast water tanks offering a means of entry into the SEA 4 area.

There is a growing concern considering the risk of alien species and the importance of protecting native biodiversity. Raised awareness of this problem has resulted in the introduction of a variety of operational and technical innovations to reduce the risk of organism transfer via ballast water.

6.3 Benthos

The first DTI SEA provided a detailed overview (SEA 1 Volume 2 Section 3.1) of the seabed faunal communities and the history of their study for the majority of the SEA 4 area and this is not duplicated here. Since SEA 1 was prepared there have been two further DTI funded surveys conducted over the SEA 4 area, the results of which are summarised in the SEA 4 underpinning reports on deeper water seabed fauna and sediments prepared by Bett, Hughes *et al*. and Masson *et al*. (2003). An overview of the seabed biology of continental shelf depths including coastal regions is provided in the report by Eleftheriou (2003). In addition there have been a number of oil industry commissioned surveys in the area, a good proportion of which have been made available through the SEA scoping process. These latter surveys provide detailed information on relatively limited areas and give valuable insights into how applicable the regional survey results are at a local scale.

Biogeographic zones are inferred from the distribution patterns of a range of species over broad areas, which in turn can be related to major ecological influences such as depth, water temperature etc. Typically, boundaries between biogeographic zones are not sharp since individual species respond differently to ecological factors and therefore have different distributions. The area to the north and west of Scotland is characterised by the interface of five biogeographic zones (illustrated in Figure 11 in Volume 2 of SEA 1) resulting in a high total number of species being present. However, the SEA 4 area is believed to include only 2 biogeographical provinces, the:

- Boreal province, centred on the North Sea and including the continental shelf and upper slope including the Wyville Thomson Ridge
- Arctic deep-sea province, centred on the Norwegian Sea but extending into the Faroe-Shetland and Faroe Bank Channel

Within each province a series of biological communities can be distinguished according to physical and biological characteristics.

The biological communities of the SEA 4 shelf depths (<200m) have a long history of exploration and are in general well characterised as summarised in Hiscock (1998). The Shetland Isles were the subject of a series of eight dredging and collecting cruises (see Jeffreys *et al*. 1869). These cruises were aimed at collecting for subsequent description the wide variety of species present and it is clear from the list of taxa obtained that, in qualitative terms, this early work provided a comprehensive picture of the benthic fauna. The work of Jeffreys *et al*. also provided insights into the relative abundance of species and biogeography of the fauna since their collecting expeditions were not restricted to the British Isles but ranged between the Mediterranean and the Arctic.

Perspectives on the level of understanding of the seabed fauna can alter over time so that Murray and Hjort (1912) stated that "*British investigators have made the plateau round the Shetland Islands to a depth of about 200 metres one of the most familiar*" although by 1995 Kingston *et al*. concluded that "*The offshore benthic fauna around the Shetland Islands is not particularly well known…*". These divergent perspectives are believed to reflect the shift over the last century from qualitative to quantitative sampling in soft bottom benthic ecology. In terms of species composition and broad scale community distribution, the early dredging work provided a picture that remains generally applicable today. It should be noted that dredging is more efficient at collecting larger species from both rocky and soft seabeds (individuals and colonies of which are typically widely spaced), whereas grab and core sampling chiefly targets the smaller species living within sediments. The advent of underwater (and in particular digital) photography from towed systems or remotely operated vehicles provides a non-destructive bridge with the earlier dredging information.

Coastal waters

The seabed communities of the coastal waters of the SEA 4 area are summarised in Eleftheriou (2003) who in turn draws on the syntheses of data provided by for example Hiscock (1998), Bennett & Covey (1998) and Howson (1999). The seabed habitats in the coastal waters range from bedrock to mud with the biological communities varying according to a number of controlling factors such as exposure to wave action. Thus an identical intertidal rockface found on an open coast or in a sheltered voe (inlet) would have entirely different biological communities. The coastal regions of the SEA 4 area contain both common habitats and communities and those that are national or internationally rare. For intertidal areas, habitats and communities of scientific and conservation importance are typically well known and afforded protection of some sort, for example through designation as a Site of Special Scientific Interest (SSSI – see Section 7.2). In coastal subtidal areas the process of identification of candidate Special Areas of Conservation (cSAC) is well advanced and again will afford some degree of protection to the seabed habitats and communities included.

Offshore areas

Dyer *et al.* (1982) reported the patterns of faunal distribution from a series of trawls and videos throughout the North Sea and the west of Shetland continental shelf and subsequently (1983) published a description of the various regions present in the area based on seabed faunal distribution. The west of Shetland continental shelf stations grouped together as region N4, differing from areas in the northern North Sea by the presence of the sea urchins *Cidaris cidaris* and *Echinus tenuispinus.* The slate pencil sea urchin *Cidaris cidaris* is one of the most common animals seen in seabed photos and videos taken as part of oil industry environmental surveys in the area (e.g. Hartley Anderson 2001). Since the work of Dyer *et al.* no new attempts to classify the fauna of the area in terms of community types or assemblages of species have been published.

The broad distribution of the habitats and communities of the SEA 4 continental shelf away from the coasts are summarised in Eleftheriou (2003) and Holmes *et al*. (2003). The general picture over the bulk of the continental shelf is current scoured sands and gravels with a biological community similar to that found in similar conditions in the northern North Sea. There are faunal differences evident in places on the SEA 4 area shelf normally attributable to variation in sediment type – for example the occurrence of the Norway lobster (*Nephrops norvegicus*) in the patch of muddier sediment to the west of Orkney. Local variants of biological communities have been reported, for example the super-abundance of the free living tubeworm *Ditrupa arietina* has been reported in the area by Stephen (1923) and Dyer *et al*. (1982) although such a community type is not unique to the SEA 4 area having also been found elsewhere (e.g. Celtic Sea, Hartley & Dicks 1977).

Surveys associated with the potential construction of new pipelines in the area and the development of the Clair oilfield have provided further amplification on the nature of the offshore habitats and fauna. A predevelopment survey of the Clair field area was conducted in April-May 2000, still photographs and video footage was collected to supplement the seabed samples taken at 59 stations (Hartley Anderson 2000, ERTSL 2001a). In addition, video transects were made at two seabed mounds and in conjunction with five trawl sampling tows.

The sediments of the Clair area are coarse and derive chiefly from glacial material and its redistribution by water currents. Sidescan sonar records from past rig site surveys indicate the seabed is current scoured and comprises ribbons of sand (aligned along the northeast-southwest axis of tidal currents) alternating with gravel and stony material. The depth of sand in these ribbons can be very shallow. The seabed mounds have a greater proportion of cobbles and boulders, although such rocks are ubiquitous over the survey area.

The sand/gravel habitat (as assessed by grab sampling) supports a relatively uniform boreal shelf sand macrofaunal community, dominated by tube making worms e.g. *Galathowenia oculata*, characteristic of more stable sediments; and worms e.g. *Pisione remota* and *Hesionura elongata*, typical of mobile, well sorted sands.

Epifaunal cover of exposed cobble and boulder surfaces is typically extensive, approaching 100% and consisting of hydroid turf, sponge and bryozoan mats. The best developed encrusting fauna is seen in areas with limited sand presence including the seabed mounds. Where cobbles and boulders are part buried in sand, hydroid turf is the predominant epifauna. In addition to encrusting animals, a range of erect sessile species were observed, including the bryozoan *Cellaria* sp., other bryozoans, the anemones *Hormathia digitata*, *Parazoanthus anguicomus* and *Bolocera tuediae*, several sponges and what are believed to be small hard corals (up to 2cm high).

In addition to encrusting and erect sessile fauna, the hard seabed is typified by a range of motile animals, the most common of which are the sea urchins *Cidaris cidaris* and *Echinus esculentus*, starfish *Stichastrella rosea, Asterias rubens* and *Porania pulvillus* (cushion star), brittle stars including *Ophiothrix fragilis*, and squat lobsters *Munida rugosa*. The majority of these species have been reported from earlier surveys in the region e.g. Dyer *et al*. (1982) and Frauenheim *et al*. (1989).

Information gaps

There are still gaps in the basic understanding of marine habitats and the identity and ecology of some species. For example, seabed mapping conducted as part of the evaluation of export pipeline routes for the Clair field development (D Bingham pers. comm.) has found 2 previously uncharted features, a large seabed mound and a nearly circular ridge rising some 70m from the surrounding seabed. The Clair pipeline survey information in these areas is only geophysical with no visual or sample confirmation of the nature of these features. To elucidate these features and their potential scientific or conservation interest, it is proposed to survey them during the field work being undertaken for SEA 5 during the autumn of 2003, with results available in time to be considered in the decisions regarding licensing within the SEA 4 area.

On a smaller scale, the bivalve shellfish *Thyasira gouldi* was believed to be endangered and restricted in distribution to a few west of Scotland sea-lochs and so a UK Biodiversity Action Plan was developed for the species. However, a recent study into the identity of all the species of *Thyasira* found on the UK shelf (Oliver & Killeen 2002) has shown that the species is more common and widespread than previously thought and thus is unlikely to require species specific conservation effort.

Although similar gaps in information and understanding apply to many of the species found in offshore UK waters, for the purposes of strategic assessment the level of information available on shelf depth seabed communities is regarded as adequate.

Deep water areas

The SEA 4 area is one of the cradles of deep sea research, with the early ground breaking studies exemplified by the popular accounts published by Wyville Thomson (1874) and Murray and Hjort (1912). To a large extent, later work has amplified rather than altered the general patterns identified by the earlier exploration. The seafloor of the SEA 4 area has been the subject of 5 major mapping and sampling cruises between 1996 and 2002, funded initially by the Atlantic Frontier Environmental Network (AFEN) and latterly by the DTI as part of its SEA process. In addition, there have been a number of programmes of academic investigation of features identified or subjects highlighted by the AFEN and DTI surveys (see e.g. Grehan & Freiwald 2001).

The AFEN and DTI surveys used a combination of seafloor mapping and physical or photographic sampling which has allowed the broad distribution of habitats and species to be distinguished across the area.

Masson *et al*. (2003) provides a description of the seafloor topography and sediments of the SEA 4 area. The sediments are largely glacial in origin and the band of numerous iceberg ploughmarks or scars along the upper slope between 200 and 450m provides evidence of glacial activity. The sediments follow a general pattern of decrease in grain size from sand and gravel at the shelf break to mud in the deeper waters. The pattern is not uniform across the area since strong water currents occur at depth, resulting in the presence of coarser sediments than might be indicated by the depth. In particular, the occurrence of large areas of gravel substrate on the continental slope and in places on the basin floor is regarded as unusual. A group of mud diapirs (mud “volcanoes”) are present in the north of the SEA 4 area. These are often associated with fluid escape or expulsion and on occasion with specialised seep biological communities, although no evidence of this has been found on these diapirs. No large reefs or colonies of cold water corals were found, which accords with the conclusions of Long *et al*. (1999) and Roberts *et al.* (2003).

AFEN (2000) and Bett (2001 and 2003) have emphasised the biological importance of the hydrographic effects of the physical barrier presented by the Wyville Thomson Ridge, confirming the findings of the early studies described by Wyville Thomson (1874). To the north of the Wyville Thomson Ridge a major faunal division occurs at around 500m reflecting the change from warm north Atlantic water near surface to cold Faroe-Shetland Channel bottom water derived from the Norwegian Sea. Bett (2001) indicates that cold water faunal group can be subdivided into three, reflecting stations below 1200m, and those between 500 and 1200m to the north of Shetland and those between 500 and 1200m to the west of Shetland.

Hughes *et al*. (2003) have drawn the results of the various AFEN and DTI surveys together and carried out multivariate analyses to identify the broad groupings within the biological data. These groupings give an indication of the general patterns of faunal community distribution across the area. The results indicate the presence of 2 main groups in the data corresponding with stations generally in less than 500m of water and those deeper than this. The total number of groups identified was seven although all contained very few stations (outliers) bar a group of stations in the north of the area and in water depths of <650m.

Scoping for SEA 4 has provided access to a number of unpublished reports of oil industry surveys. As with the continental shelf area, these contribute detailed understanding of localised areas and help to gauge the seabed and fauna variability within a small area. In addition, the exploration or development activities with which these surveys are associated normally involve the use of remotely operated vehicles (ROV) which have in some cases been used to collect specimens to aid in the identification of animals seen in seabed photographs. The surveys examined indicate that whilst the seabed of an area may appear to have a fairly sparse fauna (e.g. Gardline 2002), ROV observation often reveals the presence of scattered boulders or groups of boulders colonised with spectacular epifauna (e.g. Hartley Anderson 2002). Such features are vulnerable to physical damage (see Gage *et al*. in press) and potentially to smothering by sediment disturbance or particulate discharges.

Information gaps

The fauna of the area beyond the continental shelf is poorly known and difficult to identify since the literature is scattered and applicable identification guides are few. A substantial proportion of benthic species found are new to science with for example between 20 and 40% of peracarid crustaceans being undescribed. AFEN initiatives to improve the situation are described in AFEN (2001) and there are a number of other projects underway to improve basic understanding of the fauna – although by their nature these projects can take several years to complete. There is a growing literature suggesting that for many purposes (typically environmental monitoring), animals do not have to be identified to the level of species (see e.g. Terlizzi *et al*. 2003). This presents an apparent paradox with the increasing concern and effort regarding biodiversity. However, whilst recognising there are many seabed species that presently cannot be identified, it is believed that the level of understanding of seabed fauna communities of the area is adequate for the purposes of SEA.

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. The report (An Overview of Cephalopods Relevant to the SEA 4 Area) discusses cephalopod biology, fisheries, sensitivity to metal contamination and other conservation considerations.

6.4.2 Cephalopods in the North Sea

Cephalopods are short-lived, carnivorous animals characterised by rapid growth rates. These molluscs are opportunistic predators consuming a variety of crustaceans, fish and other cephalopods. They are an important part of marine food webs providing a source of prey for whales, dolphins, seals, birds and some larger fish species. Cephalopods form an important part of the diet of a number of cetacean species, including white-beaked dolphin, Atlantic white sided dolphin, Risso's dolphin, sperm whale and pilot whale(Hammond *et al.* 2003).

Knowledge of squid distribution and abundance is gathered mainly from fisheries data. Demersal trawl and seine net vessels land cephalopods as a by-catch providing monthly data on species abundance by ICES rectangle.

A significant proportion of total UK landings of loliginid squid, in particular *Loligo forbesi*, come from the SEA 4 area. 320 tonnes of loliginid squid were landed from the SEA 4 area in 1998, equating to 15% of the total UK catch for this group. The proportion of landed catches of loliginid squid from the SEA 4 remains similar in 1999 and 2000, 12.7 % and 15.2% respectively. Peak landings of loliginid squid from this area occur during the winter months. Catches are lower during mid summer as this is the period where old adults are dying off and recruitment has yet to begin. During June the SEA 4 area provides between 25% and 50% of the total UK landings of loliginid squid.

A total of 29 cephalopod species have been recorded as occurring in waters ranging from 150 to 4,850m in the north-east Atlantic (Collins *et al*. 2001). In addition to species listed above, other recorded species include the sepiolids *Sepiola atlantica* and *Rossia macrosoma* and the squids

Todarodes sagittatus and *Todaropsis eblanae*, often landed in catches alongside *L. forbesi*. The deep water octopus *Haliphron atlanticus* has also been reported in the SEA 4 area by Collins *et al.* (1995).

Loliginid or long-finned squid are of major commercial importance to European fisheries. These species live on or near the sea bottom, mainly on the continental shelf and are probably not found at depths below 400m. Catches from the SEA 4 area are dominated by *L. forbesi*, with highest concentrations found in June. The small loliginid squid *Alloteuthis subulata* is often found in trawl hauls with *L. forbesi* and is therefore likely to be present in the SEA 4 area.

Three short-finned squid (Ommastrephidae) have been recorded in the SEA 4 area, *T. sagittatus*, *Todaropsis eblanae* and *Illex coindetii*. These squid live at the sea bottom and also in the pelagic zone, performing vertical migration to the surface at night (Nesis 1987). These ommastrephid squid occur in inshore and offshore waters, migrating over long distances between feeding and breeding grounds however, as these squid are not noted for following predictable migratory paths, their occurrence in the SEA 4 area is probably best described as sporadic.

Various deep water squid are likely to be present in the Faroe-Shetland Channel, the most important being *Gonatus fabricii*. This species has been recorded at depths between 350m and 1200m. Juveniles are caught in surface layers, mature *G. fabricii* move to deeper water at a length of 50-70mm.

There is only one octopus of potential commercial value in the SEA 4 area, *E. cirrhosa*. This octopus is generally found at depths between 50 and 300m on a wide variety of sea bed types. This species is often taken as a by-catch in demersal fishing but rarely landed due to the lack of a domestic market in Scotland.

6.4.3 Cephalopods and metals

Cephalopods are known to naturally accumulate high levels of certain contaminants. It has been suggested by Miramand & Bentley (1992) that the digestive gland of cephalopods constitutes a good potential indicator of heavy metal concentrations in the marine environment. Their research of the octopus *E. cirrhosa* and cuttlefish *Sepia officinalis* shows that the digestive gland (which constitutes 6-10% of the animal by weight) was found to accumulate silver, cadmium, cobalt, copper, iron, lead and zinc. Over 80% of the total body burden of silver, cadmium and cobalt and between 40 and 80% of the other chemicals were found to accumulate in this area. High concentrations of copper, nickel and vanadium accumulate in the branchial hearts and the kidney was found to contain high concentrations of manganese, nickel and lead.

Cephalopods are regarded as being an important link in marine food chains, providing an essential food source for many of the marine environments top predators. Studies of pilot whales off the Faroe Islands (where there is little anthropogenic pollution) have revealed high levels of cadmium, thought to be accumulated through their primary diet of squid. This supports evidence of cephalopods acting as a vector for the transfer of cadmium to top marine predators and also suggests that there is potential for bioaccumulation up the food chain.

6.5 Fish and commercially exploited shellfish

6.5.1 Overview

Dr John Gordon, an Honorary Fellow of the Scottish Association for Marine Science, was commissioned to review fish and fisheries information for the SEA 4 area (Gordon 2003). The report describes the fish resources of the region (i.e. spawning grounds, nursery areas, communities), and also the intensity and distribution of commercial fishing activity. A review of fisheries management measures in operation in the area is provided, as is an assessment of possible interactions between the fishing and oil and gas industries.

The fish communities found on the SEA 4 continental shelf and shelf-edge are similar to those found at similar depths in other areas of the UKCS, the dominant species being saithe, haddock, whiting, blue whiting, cod, and Norway pout. The upper continental slope, above 500m is characterised by Atlantic water and temperatures similar to the west of Scotland upper slope. The fish community of this area is comparable to that of the Atlantic continental slope to the west of the Hebrides and includes rabbit fish, Norway haddock, bluemouth and blue whiting. Moving down the slope into the Faroe-Shetland Channel, the very rapid change in temperature below about 500m means that the deep-water fish communities differ to those found at similar depths in other areas. In the transition zone between the Atlantic and colder Norwegian Basin water, the fish community comprises species that are seldom, if ever, encountered in the warmer Atlantic including Greenland halibut, Arctic skate, roughead grenadier and blue whiting. Below the transition zone, the fish fauna is sparse and of limited commercial interest (Bullough *et al.* 1998) including deep water species of eelpout, Arctic skate, rockling and Greenland halibut.

This section describes fish and shellfish species of commercial importance present in the SEA 4 area.

6.5.2 Data sources

Routine groundfish surveys carried out by Fisheries Research Services (FRS) targeting cod, haddock, whiting, saithe, herring and mackerel as well as scallops and *Nephrops* are used to inform the relevant ICES Working Groups. These surveys target the major commercial species but also record information on the distribution and abundance of the non-target components of the fish and shellfish catch.

Information relating to the latest assessments of fish stocks comes from the ICES Advisory Committee on Fishery Management Reports (ICES 2002, 2003).

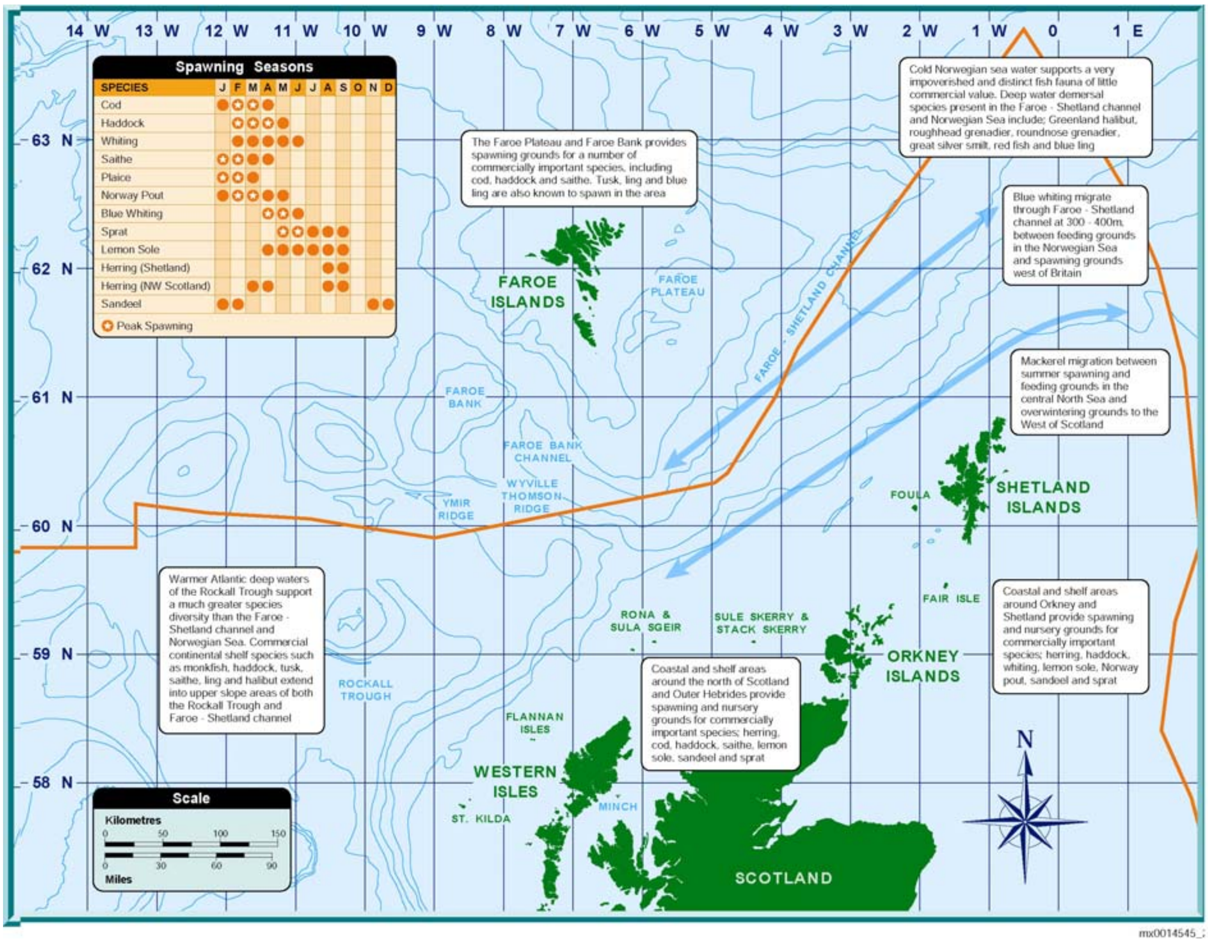
The UKOOA published report *Fisheries Sensitivity Maps in British Waters* (Coull *et al*. 1998), provides information on the known spawning and nursery grounds for the main commercial species around the UK.

Information from academic reviews, surveys of comparable habitats to the west of Scotland and in Norwegian waters, and data provided for previous SEAs have also been utilised.

6.5.3 Fish and shellfish ecology

Most of the commercially important fish species spawn between January and June, although sandeel and herring are exceptions which spawn outside this period (Figure 6.1). 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 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. General spawning and nursery areas for individual fish species in SEA 4 are highlighted in Gordon (2003).

Figure 6.1 – Fish spawning and distribution in the SEA 4 area (Note: Details of individual species spawning and nursery grounds can be found in Gordon (2003)



6.5.4 Commercial fish species

Demersal species

Haddock *(Melanogrammus aeglefinus)*

Haddock spawning takes place between February and May to the north west of Scotland, around Shetland and into the northern North Sea. Currents may transport larvae from the west of Scotland through the SEA 4 area into the North Sea.

Following spawning, some haddock migrate westwards from the northern North Sea to feeding grounds around Orkney and Shetland (Knijn *et al*. 1993), inshore surveys around Shetland indicating a higher proportion of adult haddock (FRS 2002). Nursery grounds are widely distributed mostly in offshore waters of the northern North Sea, around Shetland and off the north west coast of Scotland (Coull *et al*. 1998).

The most recent advice from ICES (2002) indicates that the haddock stocks in ICES divisions VIa (west of Scotland) and IV (North Sea) which incorporate the SEA 4 area, are currently harvested outside safe biological limits (ICES 2002).

Whiting *(Merlangius merlangus)*

Whiting are widely distributed throughout the North Sea (Knijn *et al.* 1993), around Shetland and Orkney and off the north coast of Scotland.

Whiting are batch spawners with a prolonged spawning period from February to June. Important spawning areas include the North Minch extending round to the north coast and an area to the west of Shetland (Coull *et al.* 1998). Nursery grounds tend to be located inshore although evidence suggests that there are no significant grounds around Orkney and Shetland (Coull *et al.* 1998, FRS 2002).

ICES (2002) indicate that whiting stocks in divisions VIa and IV are harvested outside safe biological limits.

Saithe *(Pollachius virens)*

Saithe are thought to spawn along the shelf edge at depths of 100-200m and the main spawning grounds are associated with the Norwegian Deep and the shelf edge north and north east of Shetland (Coull *et al.* 1998). Nursery grounds are located in coastal waters around Scotland, and juveniles remain in these areas for one or two years before moving offshore.

In the Norwegian Deep, saithe are a common species at depths <250m in summer and autumn, moving to slightly deeper waters (>300m) in winter (Bergstad 1990, 1991a, b). Saithe are also caught in the pelagic zone, up to 100m off the bottom.

The saithe stock in the SEA 4 area is currently judged to be within safe biological limits (ICES 2002).

Cod *(Gadus morhua)*

Cod spawning occurs between January and April in localised areas all around the British Isles, one area being off the north west coast of Scotland (Coull *et al.* 1998). Nursery areas tend to be located inshore where the juveniles are associated with rocky shores making accurate bottom trawl survey assessments difficult (FRS 2002).

Juvenile cod are widely distributed throughout the North Sea whereas the adults form regional groupings with limited spawning and feeding migrations (Knijn *et al*. 1993). In the Norwegian Deep, cod are most frequent on the upper and middle slope, predominantly in southern areas where they appear to seasonally migrate up and down the slope (Bergstad 1990a). A similar pattern may exist on the continental slope to the north of Shetland.

ICES indicate that the cod stock in the SEA 4 area is outside safe biological limits. Given the very low stock size, the recent poor recruitments, and continued high fishing mortality despite management efforts to promote stock recovery, ICES have recommended a closure of all fisheries for cod as a targeted species or bycatch (ICES 2002).

Lemon sole *(Microstomus kitt)*

Adult lemon sole are found in the coastal waters of northern Scotland and around Orkney and Shetland (Knijn *et al.* 1993). Spawning takes place between April and September over a wide area (Coull *et al.* 1998). Nursery grounds are thought to have a similar distribution to the spawning areas.

Plaice *(Pleuronectes platessa)*

Plaice are widely distributed throughout the North Sea although they are more abundant as both juveniles and adults in the south. They spawn throughout their adult range and a spawning area to the south of Shetland has been identified (Coull *et al*. 1998). Plaice eggs are pelagic and following metamorphosis, larvae enter the coastal sandy nursery grounds. After a year they gradually disperse offshore.

Others

Tusk *(Brosme brosme)* have a northerly distribution and are found at the shelf edge and on the upper continental slope over rocky ground at depths of 150-450m (Knijn *et al.* 1993). Spawning appears to take place in the northern North Sea and the Skaggerak between April and June (Magnússon *et al.* 1997). It is assumed that the nursery grounds are in deep water.

The anglerfish (monkfish, *Lophius* spp.) is widely distributed around Scotland both on the shelf and on the continental slope to depths of about 1000m. However, a shelf-edge survey (FRS 2002) to the east of the Wyville Thomson Ridge caught no anglerfish in depths greater than 400m where the temperature was below 4ºC. A significant number of small anglerfish were caught on the shelf in the SEA 4 area. An area to the north west of Orkney known as the Noup was found to support a high percentage of juvenile fish.

Anglerfish are subject to significant fishing mortality before attaining full maturity and the stock is particularly vulnerable to depletion of the spawning component. The anglerfish stock in the SEA 4 area is currently judged to be outside of safe biological limits (ICES 2002).

The Greenland halibut *(Reinhardtius hippoglossoides)* is a deep-water flatfish that is widely distributed in cold northern waters. They are exploited around Greenland, Iceland, the Faroes, and Norway, and in recent years a fishery in the Faroe-Shetland Channel has developed. The halibut spawns in deep-water and is an active predator off the bottom, feeding on other fishes and crustaceans.

The orange roughy (*Hoplostethus atlanticus)* is a slow-growing, sedentary fish, inhabiting deep, cold waters over steep continental slopes, ocean ridges and sea-mounts where it feeds on crustaceans and fish. Found in waters between 3-9ºC (Fishbase website – www.fishbase.org), the orange roughy has been targeted to the west of Scotland by a deep-water (1,200-1,700m) French fishery which has since declined (UKBAP website – Grouped plan for deep water fish). In the Faroe-Shetland Channel, the presence of very cold water below about 500m restricts the distribution of orange roughy and none were found in deep-water survey hauls from the SEA 4 area (Gordon 2003).

Pelagic species

Mackerel *(Scomber scombrus)*

There are two main stocks of mackerel based on the timing and area of spawning (Coull *et al.* 1998). The western stock spawns between March and July mainly to the south and west of the British Isles, the nursery grounds extending to the shelf edge, west of Orkney and Shetland. Over the last 20 years there has been a westerly shift of the spawning areas and a northerly shift in the distribution of juveniles (Walsh *et al*. 1995), with relatively high concentrations of juveniles over the shelf to the west of Orkney and Shetland. After spawning the adult fish migrate northwards to feeding grounds in the Norwegian Sea and in the northern North Sea. Estimates of the western spawning stock biomass, derived from egg surveys, indicate a decrease of 14% between 1998 and 2001.

The North Sea stock spawns mainly in the central North Sea and migrates to overwinter in the deep water to the north and east of Shetland, and on the edge of the Norwegian Deep. The North Sea component is considered to be severely depleted and outside safe biological limits. ICES have advised that the combined North East Atlantic stock of mackerel (includes western, southern and North Sea spawning components) is currently outside safe biological limits (ICES 2002).

Blue whiting *(Micromesistius poutassou)*

Blue whiting migrate through the Faroe-Shetland Channel at water depths between 300-400m from spawning grounds to the west of Britain to feeding grounds in the Norwegian Sea. The northerly migration occurs between May and July, with the return migration in December and January. Spawning occurs between April and June each year with the nursery area extending across the whole Faroe-Shetland Channel area (Coull *et al*. 1998).

The populations of blue whiting along the shelf edge of the SEA 4 area are probably analogous to those of the Norwegian Deep where juvenile blue whiting are the dominant species by number and weight during the winter (Bergstad 1990a, 1991a).

The status of the blue whiting is currently assessed as a combined stock covering a large area of the north east Atlantic. Conflicting catch and survey data mean that the current estimate of stock size is uncertain, nevertheless ICES have classified the stock as likely to be harvested outside safe biological limits (ICES 2003).

Norway pout *(Trisopterus esmarkii)*

Spawning occurs throughout offshore waters of SEA 4, with important areas to the north west of Scotland and between Shetland and Norway. In shelf waters, spawning occurs from January to April while in deeper waters spawning is slightly later, taking place between March and May. Nursery grounds are located in the same areas as the spawning grounds (Coull *et al.* 1998).

Bergstad (1990) identified the Norway pout as the numerically dominant species in several of the upper and mid-slope assemblages of the Norwegian Deep. In recent inshore surveys of Shetland, Norway pout was the most abundant species (by number) accounting for 42% of the total catch (FRS 2002).

The Norway pout stock in the North Sea is classified as being within safe biological limits whilst there is no current information on which to evaluate the west of Scotland stock (ICES 2002).

Herring *(Clupea harengus)*

Herring are demersal spawners returning to the same spawning areas to lay their eggs on stones and gravel. Three main races of autumn spawning herring have been identified in the UK waters, the most northerly being the Buchan/Shetland herring which spawns off the north east coast of Scotland and around Orkney and Shetland between August and September. A major spawning area also lies to the west of the Outer Hebrides and extends along the north coast of Scotland.

After hatching, Buchan/Shetland herring larvae drift with the currents to the main nursery grounds in the Skagerrak and Kattegat. The west coast of Scotland and the Moray Firth are also important nursery grounds. Although nursery areas are not indicated in the SEA 4 area (Coull *et al.* 1998), recent inshore surveys around Shetland have shown juvenile herring to be relatively abundant (FRS 2002).

On leaving the nursery grounds herring disperse to feeding grounds over a wide area where the different races become mixed. The main feeding ground of the spring spawning Atlanto-Scandian herring is in the central Norwegian Sea and during their migration to spawning areas on the Norwegian coast, it is likely that some pass through the most northerly part of the SEA 4 area (Napier & Goodlad 1997).

The status of the herring stock to the north west of Scotland is unknown relative to safe biological limits but spawning biomass has been increasing strongly over recent years. The North Sea stock is classified as being within safe biological limits (ICES 2003).

Sandeel (Family Ammodytidae)

There are five species of sandeel that occur in UK waters but 90% of the commercial catch consists of one species, *Ammodytes marinus.* Sandeels are a shoaling species that lie buried in the sand during the night and emerge during the day to feed in midwater (Knijn *et al*. 1993). During the winter they remain in the sediment only emerging to spawn. Spawning takes place from November to February and is widespread over the SEA 4 shelf area (Coull *et al.* 1998). The eggs are laid in sticky clumps on sandy substrates and the pelagic larvae adopt the demersal habit after about 2-5 months. Nursery grounds share a similar distribution to the spawning areas.

Sandeels represent the main food source for a large number of seabirds on Shetland and Orkney. The proximity of the main sandeel fishing grounds to coastal bird colonies and the combined effect of poor sandeel recruitment and fishing on the breeding success of the seabirds has led to a series of closures and restrictions on the sandeel fishery in the area.

The Shetland sandeel population is not a separate stock, but forms part of a larger complex of subpopulations. Estimates of the consumption of sandeel by seabirds and other predators greatly exceed the quantities taken by the fishery in recent years (ICES 2002).

Sprat *(Sprattus sprattus)*

Sprat are a short-lived species which spawn in most of the waters around the UK including the southern part of the SEA 4 area. They spawn between May and August and unlike herring, the eggs are pelagic. There are no identified nursery grounds in the SEA 4 area and sprat were virtually absent from inshore surveys carried out around Shetland in November/December (FRS 2002).

Migratory species

Salmonids

Salmon *(Salmo salar)* are an anadromous species, migrating from the sea to breed in freshwater. Spawning takes place in gravelly areas of rivers and streams and after a period of 1-6 years the young salmon migrate downstream to the sea. A brief description of their life cycle, main threats and management was provided for SEA 3 and much of the information is relevant to SEA 4 (SEA 3 Post Consultation Report).

For the first few months at sea, the salmon are passively transported northward (Jonsson *et al*. 1993, cited in Friedland *et al.* 2000) eventually reaching the main feeding grounds south west of Greenland. Their geographic distribution at sea conforms to the main surface current patterns, in particular with the slope currents north and west of Scotland (Holm *et al*. 2000). Relatively large numbers of salmon were found in June in the Atlantic surface current moving north east along the Faroe-Shetland Channel (Shelton *et al.* 1997).

On the return migration to spawn, salmon are believed to enter UK waters from the north, to move south and then inshore to their home rivers. Salmon are not abundant in Shetland and Orkney as there is a shortage of large rivers where they can spawn. The importance of Scotland's north coast for salmon is reflected in the designation of several rivers as cSACs including the Rivers Thurso, Naver and Mallart.

European eel *(Anguilla anguilla)*

European eels are found in rivers throughout SEA 4 and relevant information regarding their life cycle, main threats and management was provided for SEA 3 (SEA 3 Post Consultation Report). Scottish fisheries for eels are on a small scale compared to those in England and throughout Europe.

Many Scottish eel populations are very slow growing and fishing requires careful management to avoid over-exploitation. Fishing for silver eels is usually carried out in rivers draining extensive, shallow, lowland lochs outside the SEA 4 area (Scottish Executive website).

Fish of conservation interest

There are records of nationally and internationally protected marine and estuarine fish species within the SEA 4 area although these are limited in number. A brief description of the biology of a number of these species including allis and twaite shad, and river and sea lampreys was provided for SEA 3 and much of the information is relevant to the SEA 4 area (SEA 3 Post Consultation Report).

The Shetland region has records of species including allis shad (*Alosa alosa*), twaite shad (*Alosa fallax*), sturgeon (*Acipenser sturio*) and sea lamprey (*Petromyzon marinus*). Orkney has individual records of sea lamprey and sturgeon. Sturgeon have also been recorded off the north coast of Scotland (Barne *et al.* 1996, 1997a, b).

Information relating to the distribution of basking sharks *(Cetorhinus maximus)* in the SEA 4 area is limited. In the late 1940s, basking sharks were targeted by a Norwegian fishery which continued to the west of Shetland right through the 1950s and for some decades beyond that (Fairfax, 1998). Twenty basking sharks were taken by a vessel operating from Scalloway, Shetland in the summer of 1953 (Fairfax 1998).

Although widely distributed in both hemispheres, basking sharks appear to be most regularly recorded in coastal areas of the UK with seasonally persistent tidal fronts (e.g. western Scotland, Clyde area, central Irish Sea and the western approaches to the English Channel). They are mainly recorded in surface waters from April to September, when mostly immature females are seen. In late summer, basking sharks are thought to disperse offshore but their winter distribution and the location of pregnant females year-round remains unknown, but is thought to be in deep water (Species Action Plan for basking shark).

A satellite-tracking study, funded jointly by DEFRA, CEFAS, and the Marine Biological Association of the UK, is currently underway with the aim of providing more information on the life histories of basking sharks in European waters. Findings so far indicate that basking sharks tagged in UK waters in the summer remain on the European continental shelf throughout the winter and do not make trans-oceanic migrations; tagged fish move extensively within continental shelf waters, and there does not appear to be separate sub-populations off Scotland and south west England. More details of the tagging project can be found on the project website (http://www.cefas.co.uk/sharks/default.htm).

Basking sharks are protected under Schedule 5 of the Wildlife and Countryside Act 1981 and have recently been given protection by the Convention on International Trade in Endangered Species (CITES).

6.5.5 Commercial shellfish species

Commercially exploited crustacean species within the SEA 4 area include Norway lobster *(Nephrops norvegicus)*, lobster *(Homarus gammarus)*, edible crab *(Cancer pagurus)*, velvet crab (*Necora puber*) and green crab *(Carcinus maenas).* Molluscan species include scallop *(Pecten maximus)*, cockles *(Cerastoderma edule)*, mussels *(Mytilus edulis)* and periwinkles *(Littorina littorea).*

Nephrops is widely distributed in Scottish waters in areas of suitable muddy substrate at depths between 15 and 800m. Fertilisation and spawning takes place from August to November and the fertilised eggs are carried by the female for about nine months while they develop. Hatching begins in late April and continues until August, and after a relatively short pelagic phase, juveniles settle on the bottom and construct a burrow. Light intensity appears to be the most important determinant of when *Nephrops* emerge from their burrows to feed and therefore become most vulnerable to capture. The main fishing ground in the SEA 4 area is the Noup, to the north west of Orkney.

Lobster, edible crabs and velvet crabs are distributed inshore throughout the SEA 4 area where there is suitable rocky habitat. Juveniles tend to be found inshore and adults further offshore. Recently, stocks of Shetland lobster have been severely depleted and fishing effort has switched to other species such as edible, velvet and green crabs. An important offshore fishery for edible crabs has developed off the north coast of Scotland (FRS website).

Scallops occupy sandy, gravelly mud sediments throughout the region and are found from just below low water mark to depths of beyond 100m. In Scottish waters, scallops spawn in the spring with a later spawning in the autumn. Larvae are free swimming and spend about 3-4 weeks in the water column before settling onto the seabed. There are good scallop grounds around both Orkney and Shetland, especially to the north and west of Shetland. Scallops are also found in a small area off the north coast of Scotland and are widely distributed throughout the Moray Firth. Scallops represent an important nearshore fishery in the area.

Cockles are limited to areas of sheltered intertidal mud and sandflats whilst mussels are common around the SEA 4 coast, from the mid shore to the subtidal zone and in areas exposed to water currents. On exposed rocky shores mussels are generally small; larger, more exploitable mussels being confined to sheltered inlets (Barne *et al.* 1997a, b). Periwinkles are collected on shores around Shetland and 82 tonnes were landed in 2001 (Gordon 2003).

6.6 Marine reptiles

The TURTLE (Pierpoint & Penrose 2002) database holds records of sightings at sea, bycatch and strandings for marine turtles drawn from numerous published and unpublished sources. Bycatch data has been analysed by Pierpoint (2000) in relation to Biodiversity Action Plan and Habitats Directive obligations of the UK. Five species of marine turtle have been recorded in UK waters (Pierpoint 2000). Of these, only one, the leatherback turtle (*Dermochelys coriacea*), is annually reported and now thought to be a regular visitor to Scottish waters (Barne *et al.* 1997).

The leatherback turtle has a distinct seasonal occurrence in Scottish waters. The majority of sightings (75%) are recorded between August and October, while sightings further south are concentrated in July and September. The timing of sightings suggest that leatherbacks enter British waters from the south and west, and travel northwards up the western coasts and the Irish Sea, with some leatherbacks entering the central North Sea in Autumn (Pierpoint 2000). The occurrence of leatherbacks within UK waters are thought to be as a result of deliberate migratory movement (UK Biodiversity Action Plan website: http://www.ukbap.org.uk/).

Leatherback turtles have been sighted all around the UK & Irish coasts. However, records are concentrated to the west and south of Ireland, south west England and the west coast of Scotland, Orkney and Shetland. There are fewer recorded sightings of marine turtles from the North Sea coast of east Scotland. Pierpoint (2000) records a total of 45 sightings of leatherback turtles in the north and north west region of Scotland, with 24 recorded sightings in the north and north east. Pierpoint (2000) also records a total of 11 dead leatherback turtles within the SEA 4 area.

Loggerhead turtles have also been recorded in UK and Irish waters, albeit less frequently than leatherbacks. Loggerheads are most frequently reported as strandings (81%) and have been predominantly found on the west coast of Ireland, south west England and the west coast of Scotland. Unlike leatherbacks, the presence of loggerheads is thought to be as the result of animals having been carried by currents from their normal habitat.

The TURTLE database also contains a record of a green turtle, found dead on the shore of Loch of Stenness, Orkney in 1980. Like the loggerhead, the presence of green turtles are thought to be accidental and they are not considered regular visitors to the area (Pierpoint & Penrose 2002).

6.7 Seabirds and coastal waterbirds

6.7.1 Data sources

The Seabirds at Sea Team (SAST) was established in 1979 by the Nature Conservancy Council after a one year pilot study. Since then, seabird monitoring programmes have studied seabirds in the North Sea, the sea north of Scotland, waters off western Scotland and the Irish Sea, areas in the English Channel and off south-west Britain. Management of SAST passed to the Joint Nature Conservation Committee (JNCC) in 1991 who have continued the work. Systematic seabird monitoring programmes have also been carried out around the Netherlands, Belgium, Germany, Denmark, Sweden and Norway and international collaboration between organisations throughout north west Europe, including the UK, has resulted in one common database for the waters in this area, the European Seabirds at Sea (ESAS) database (Stone *et al.* 1995). ESAS contains over one million records of bird sightings, consisting of processed data from strip transect observations from ship and aircraft. Resulting publications include a distribution atlas of seabirds in north west Europe (Stone *et al.* 1995), and an electronic atlas of seabird distribution and vulnerability (BODC 1998). In addition to this Skov *et al.* (1995) produced a review of the relative importance of areas within the North Sea.

Further data on seabird distribution north and west of Scotland were collected as part of a project to survey waters west of Britain (Webb *et al.* 1990) and later research identified the concentrations of seabirds vulnerable to surface pollution south and west of Britain (Webb *et al.* 1995), and in the North Sea, but with some overlap into the Atlantic Frontier (Carter *et al*. 1993). Survey coverage in the area remained inadequate, however, increasing interest from the oil and gas industry resulted in the commissioning of a two year study of waters between Shetland and the Faroe Islands, which began in 1994 (Bloor *et al.* 1996). Further survey coverage has been obtained since the publication of this study, with the aim of improving both spatial and temporal distribution of coverage. Some of the later data has been made available through the JNCC/ESAS Seabird and Cetacean Distribution Atlas (Stone *et al.* 1994 and BODC 1998), with a final report summarising seabird and cetacean distribution in the Atlantic Frontier (Pollock *et al*. 2000). Surveys have also been conducted around the Faroe Islands between 1979 and 1999, culminating in a published report on the distribution of seabirds and cetaceans in waters surrounding the Islands (Taylor & Reid 2001). The JNCC SAST has not surveyed the area to the North of Shetland to any great extent and the general distribution of seabirds in this area is less well known.

The annual monitoring of seabird numbers and their breeding success through colony counts is carried out by a collaboration from the JNCC, RSPB and SOTEAG (Shetland Oil Terminal Environmental Advisory Group), as part of the JNCC's Seabird Monitoring Programme. The resulting publication summarises breeding success at breeding colonies and compares the results with previous years (Mavor *et al.* 2002).

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. Non-breeding waterbirds in the UK are monitored by the Wetland Bird Survey (WeBS), which provides the principal data on which the conservation of their populations and wetland habitats is based (Pollitt *et al.* 2003).

Detailed studies of breeding, migrant and wintering wildfowl at individual estuaries and coastal locations are listed by Stroud & Craddock (1997), May & Law (1997a & b) and Meek (1997 a & b).

6.7.2 North and west of Scotland and coastal margin overview

Seabirds are a group of birds that depend mainly on the sea, beyond the tide-line for their food. While this group includes species such as the black-headed and common gulls, which often breed and feed inland, the group does not include other species that spend only part of the year at sea such as divers, seaducks and phalaropes (Lloyd *et al.* 1991).

Of the seabirds species which breed regularly in Britain and Ireland, fulmar, gannet, shag, Arctic skua, great skua, great black-backed gull, kittiwake, common and Arctic tern, guillemot, razorbill, black guillemot and puffin all have breeding populations within the SEA 4 area which exceed 1% of their European population. Most of these species have major colonies, in terms of biogeographic populations, located on Shetland, Orkney and the north coast of Scotland. As a consequence, this region is internationally important in terms of seabird numbers and/or the diverse breeding assemblages it hosts and is amongst the most important for offshore seabirds in Europe (Tasker 1997a, b & c, Pollock *et al.* 2000). Table 6.1 summarises coastal seabird colonies which are designated as Special Protection Areas

Table 6.1 Internationally important seabird colonies in the SEA 4 area with protected status.

Colony	Species	Number of birds (pairs)	Colony	Species	Number of birds (pairs)
SHETLAND					
Hermaness & Saxa Vord	Gannet	12,000 (94)	**Fair Isle**	Fulmar	43,320 *
	Great skua	630 (97)		Arctic tern	1,120 (93-97)
	Puffin	25,400 (87)		Guillemot	25,165 (94)
	Shag	540 *		Gannet	1,166 *
	Guillemot	11,363 (91)		Shag	1,099 *
	Kittiwake	1,710 *		Razorbill	2,044 *
	Fulmar	14,890 (86)		Puffin	8,700 *
				Great skua	130 (95)
				Arctic skua	74 *
				Kittiwake	9,660 *
Fetlar	Arctic tern	520 (94-97)	**Foula**	Arctic tern	1,100 (92-96)
	Great skua	512 (92)		Leach's petrel	50 (76)
	Arctic skua	130 *		Great skua	2,170 (92)
	Fulmar	9,800 *		Arctic skua	125 (95)
				Guillemot	25,125 (87)
				Puffin	48,000 (87)
				Shag	2,400 (87)
				Razorbill	6,200 (87)
				Fulmar	46,800 (86)
				Kittiwake	3,840 *
Noss	Gannet	7,310 (94)	**Papa Stour**	Arctic tern	1,000 *
	Great skua	410 (97)			
	Guillemot	30,619 (96)			
	Puffin	2,348 *			
	Kittiwake	4,270 *			
	Fulmar	5,870 (86)			
Mousa	Arctic tern	767 (94)	**Ramna Stacks & Gruney**	Leach's petrel	22 (94)
	Storm petrel	6,760 (96)			
Sumburgh Head	Arctic tern	700 (94)			
	Guillemot	10,752 *			
	Kittiwake	1,366 *			
	Fulmar	2,542 *			

Colony	Species	Number of birds (pairs)	Colony	Species	Number of birds (pairs)
ORKNEY					
Papa Westray (North Hill & Holm)	Arctic tern Arctic skua	1,950 (97) 135 *	**Hoy**	Fulmar Great skua Arctic skua Guillemot Puffin Great black-backed gull Kittiwake	35,000 * 1,900 * 59 * 13,400 * 3,500 * 570 * 3,000 *
Calf of Eday	Fulmar Cormorant Guillemot Great black-backed gull Kittiwake	1,955 * 223 (95) 8,241 * 938 * 1,717 *	**Marwick Head**	Guillemot Kittiwake	24,388 (91) 7,110 *
Auskerry	Arctic tern Storm petrel	780 (92-95) 3,600 (95)	**West Westray**	Fulmar Arctic tern Guillemot Razorbill Kittiwake Arctic skua	1,400 * 1,200 (97) 28,274 (88) 1,307 * 24,000 (88) 77 *
Copinsay	Fulmar Guillemot Great black-backed gull Kittiwake	1,615 * 13,333 * 600 * 3,610 *	**Rousay**	Fulmar Arctic tern Guillemot Kittiwake Arctic skua	1,240 * 1,000 * 7,102 * 4,900 * 180 *
HIGHLAND					
North Caithness Cliffs	Fulmar Guillemot Razorbill Puffin Kittiwake	16,310 * 26,994 (87) 2,212 * 1,750 * 15,650 *	**Cape Wrath/Clo Mor**	Fulmar Puffin Kittiwake	2,300 * 5,900 * 9,660 *
Sule Skerry & Sule Stack	Leach's petrel Storm petrel Gannet Puffin Shag Guillemot	5 (86) 1,000 (86) 4,890 (94) 43,380 (93) 874 * 6,298 *	**North Rona & Sula Sgeir**	Fulmar Leach's petrel Storm petrel Guillemot Gannet Razorbill Puffin Great black-backed gull Kittiwake	11,500 * 2,750 (86-88) 1,000 (86-88) 28,944 * 9,000 * 1,541 * 5,250 * 733 * 5,040 *

Source (Pollock et al. 2000, JNCC website)
*Note: The numbers in brackets relate to the year of colony survey. * indicates no colony survey date available, information from JNCC website SPA species account data from the period 1991/92 – 1995/96*

There are currently no designated offshore Special Protection Areas in the SEA 4 area.

Of particular interest are Ramna Stacks and Gruney and the colonies at North Rona and Sula Sgeir which support important breeding sites for Leach's petrel, two of only seven breeding sites in the EU. In 2001, Mavor *et al.* 2002 recorded 2,263 apparently occupied sites (AOS) (using tape-playback) for Leach's petrel on North Rona, making this the second largest colony in Great Britain, after St Kilda, while on nearby Sula Sgeir an estimated nine AOS were recorded. Tape-playback was also used on North Rona for storm petrel. 147 responses were obtained, equating to 414 AOS, while on nearby Sula Sgeir eight were recorded.

Guillemots also breed on both North Rona and Sula Sgeir, while North Rona has always supported a large colony of great black-backed gull (Benn *et al*. 1986). Manx shearwater are found around North Rona, despite not breeding on either North Rona or Sula Sgeir. These birds are thought to be from the nearest Scottish colonies on Hoy (140km away), St Kilda (210km) and Rhum, Canna and Eigg (230km) or non-breeders (Benn *et al*. 1986).

In addition to these internationally important colonies there are also important seabird colonies on the Pentland Firth Islands which support 1,200 pairs of Arctic terns, while Scapa Flow is of international importance for wintering and breeding shags.

All seabird colonies have recently been re-surveyed and results are expected some time in 2004.

SAST/ESAS surveys have found several species are present over the deep waters of the Atlantic Frontier (in and adjacent to the SEA 4 area) throughout the year. Fulmar are present in nationally important numbers at various colonies including Hermaness & Saxa Vord (2.8% of the national population), Fetlar (1.8%), Fair Isle (8.0%) and Hoy (6.5%). Kittiwakes, which generally nest on steep cliff slopes, often shared with other seabirds species occur in important numbers at Cape Wrath (2.0%), West Westray (4.9%) and Fair Isle (2.0%), while Fair Isle also supports important numbers of guillemot (3.6%), puffin (1.9%) and Arctic skua (2.3%). The islands of Sule Skerry and Sule Stack are also important for a number of bird species including storm petrel (1.2%) and puffin (9.7%) (JNCC website). The great black-backed gull, the least common of the breeding *Larus* species recorded in the SAST/ESAS survey of the Atlantic Frontier and waters north and west of Scotland, is generally a coastal breeder on islands or on tops of rocky stacks. There are important colonies on the Calf of Eday (4.9%), Copinsay (3.2%), Hoy (3.0%) and North Rona and Sula Sgeir (3.9%).

Generalised distribution patterns and movements of seabirds in the SEA 4 area and adjacent waters are summarised in Figure 6.7.1. Coastal Important Bird Areas in the SEA 4 area and adjacent waters, as well as those on the Faroe Islands and the south west coast of Norway, as identified by Heath & Evans (2000), are also shown in Figure 6.2.

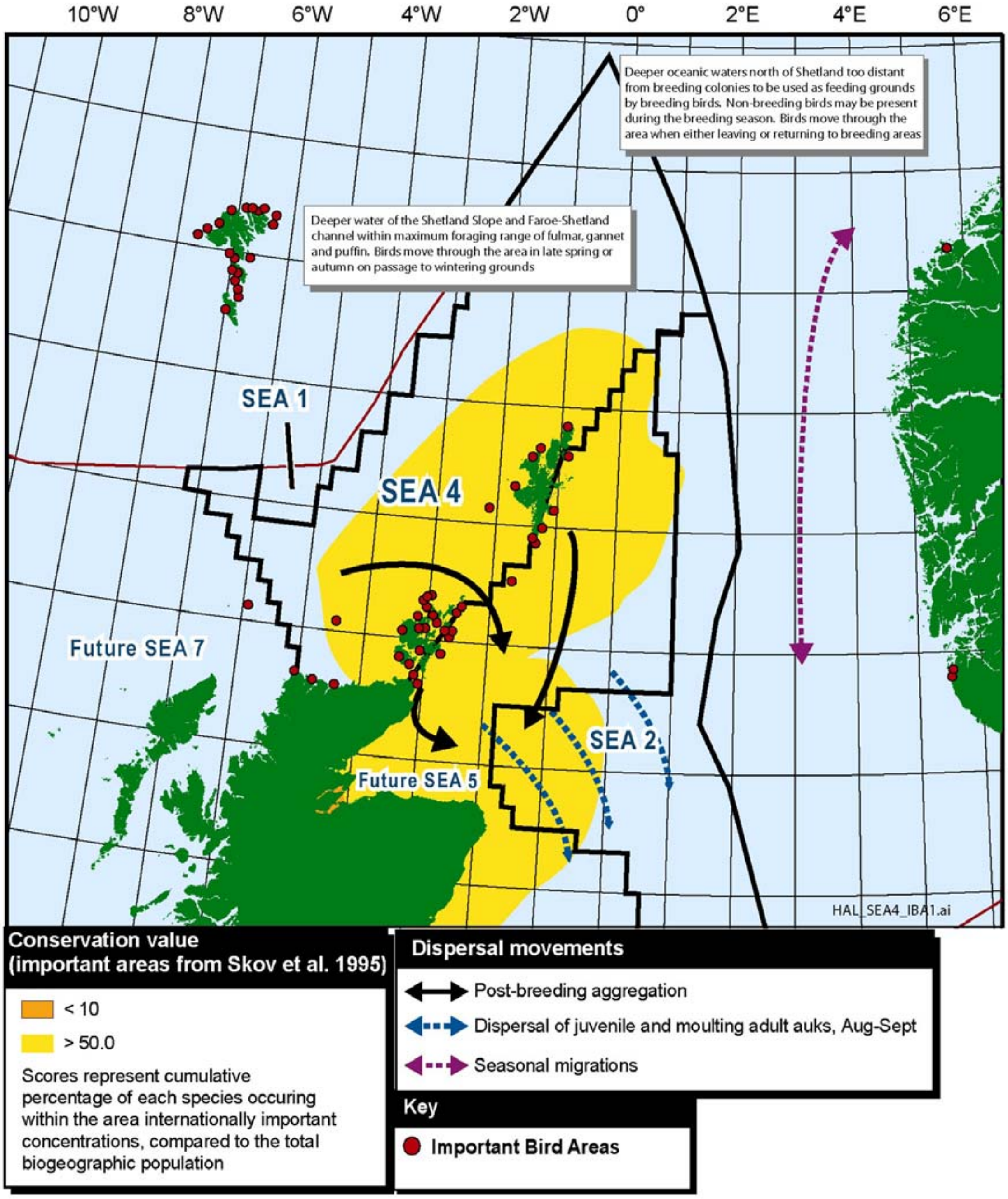
In general, nearshore waters of Shetland, Orkney and the north coast of Scotland hold vulnerable concentrations of birds virtually throughout the year (Stone *et al*. 1995). After the breeding season, species that feed further offshore such as fulmar, gannet, kittiwakes, guillemot, puffin and razorbill leave coastal waters close to the islands.

Waterbirds are a group that include divers and grebes, bitterns and herons, rails, crakes and coots, wildfowl[1] and waders. The two latter groups are further subdivided: wildfowl is a large group which includes ducks, shelducks, geese and swans, while waders include oystercatcher, whimbrel, snipe, avocets, stilts, plovers sandpipers, godwits, curlews, snipe and phalarope (Hulme 2002).

In the SEA 4 region the most notable breeding diver is the red-throated diver, while both the red-throated and great northern diver winter in the region. Nationally important numbers of red-throated diver are present on, among others, Hermaness & Saxa Vord, Foula, and Eday. In addition to these, the Slavonian grebe is also known to winter on Orkney. Although grey heron have a widespread distribution that encompasses Orkney and Shetland, there does not appear to be any breeding or wintering populations within the SEA 4 area of notable interest. The same appears true for moorhen and coot, the former of which appears to have a "healthy" population on Orkney (Gibbons *et al*. 1993).

[1] JNCC refer to this group as waterfowl

Figure 6.2 - General seabird distribution, movement and Important Bird Areas



Sources: after Skov et al. 1990, Stone et al. 1995

Of the breeding coastal wildfowl species that regularly occur in the SEA 4 region, mallard and eider appear to be the most common, particularly in Orkney. The pintail is a rare breeding species in Britain, preferring shallow, unimpeded waters adjacent to grassland and other open habitat. Although pintails are known to breed at several sites on Orkney, including lochs on West Mainland, Shapinsay and Stronsay (22-26 pairs from 1991 survey, Meek 1993b), this species does not occur at sea in the SEA 4 area. A familiar sight on muddy and sandy shores is the shelduck, which breeds wherever there is adequate invertebrate food supplies in close proximity to breeding sites. This species nests in burrows, tree cavities and other similar holes. The main concentration of shelduck is found in Orkney (Gibbons *et al.* 1993).

The breeding waders that utilise shingle, sand dune, open coast and exposed rocky areas on Shetland and Orkney are most notably the oystercatcher, purple sandpiper and ringed plover (May & Law 1997a and Meek 1997a). There are a number of other breeding waders that utilise other habitats: bog and moorland (lapwing, redshank and snipe); moorland and upland mire (dunlin and whimbrel), flooded peat cuttings/shallow pools (red-necked phalarope) and marsh/wet grassland (curlew and Icelandic race of black-tailed godwit), but which may also utilise estuarine and sheltered voes for feeding. Of these waders, oystercatcher, lapwing, redshank, snipe and curlew are the most common, while red-necked phalarope, whimbrel and Icelandic race of black-tailed godwit are nationally rare.

6.7.3 Species accounts – seabirds

Synopses were given in SEA 1 and SEA 2 of the population, distribution and general biology of individual seabird species regularly recorded in waters of the Atlantic Frontier, west and north of Scotland and the North Sea (fulmar *Fulmarus glacialis,* sooty shearwater *Puffinus griseu*s, Manx shearwater *Puffinus puffinu*s, storm petrel *Hydrobates pelagicu*s, Leach's petrel *Oceanodroma leucorhoa,* gannet *Sula bassan*a, cormorant *Phalacrocorax carbo,* shag *Phalacrocorax aristoteli*s, pomarine skua *Stercorarius pomarinu*s, Arctic skua *Stercorarius parasiticu*s, long-tailed skua *Stercorarius longicaudu*s, great skua *Stercorarius sku*a, little gull *Larus minutu*s, black-headed gull *Larus ridibundu*s, common gull *Larus canu*s, lesser black-backed gull *Larus fuscus*, herring gull *Larus argentatu*s, Iceland gull *Larus glaucoide*s, glaucous gull *Larus hyperboreu*s, great black-backed gull *Larus marinus,* kittiwake *Rissa tridactyl*a, sandwich tern *Sterna sandvicensi*s, common tern *Sterna hirundo*, arctic tern *Sterna paradise*a, guillemot *Uria aalg*e, razorbill *Alca tord*a, puffin *Fratercula arctica* and little auk *Alle all*e).

For those species that are present, in relation to the SEA 4 area, throughout the year, or are regular summer/winter visitors or migrants, these synopses are further summarised, in Appendix 5.

The 2001 breeding season saw the complete breeding failure in Shetland of those species that rely heavily on sandeels (*Ammodytes* spp.) to feed their chicks, most notably kittiwakes, Arctic tern and Arctic skuas (Mavor *et al.* 2002). Details of these and other breeding statistics are also summarised in Appendix 5.

6.7.4 Species accounts – waterbirds

Breeding waterbirds in the SEA 4 area

Although many are primarily associated with freshwater, wet grassland and moorland habitats, rather than strictly coastal locations, there are a number of waterbird species that are known to breed in the SEA 4 area Table 6.2

Table 6.2 - Waterbird species known to breed in the SEA 4

Divers	Wildfowl (including ducks, shelduck, geese and swans)	Waders
Red-throated diver (*Gavia stellata*)	Teal (*Anas crecca*)	Whimbrel (*Numenius phaeopus*),
	Mallard (*Anas platyrhynchos*)	Redshank (*Tringa totanus*),
	Pintail (*Anas acuta*)	Lapwing (*Vanellus vanellus*)
	Wigeon (*Anas penelope*)	
	Red-breasted merganser (*Mergus serrator*)	Red-necked phalarope (*Phalaropus lobatus*),
	Shoveler (*Ana clypeata*)	Dunlin (*Calidris alpina*),
	Eider (*Somateria mollissima*),	Black-tailed godwit (Icelandic race) (*Limosa limosa*),
	Tufted duck (*Aythya fuligula*),	Ringed plover (*Charadrius hiaticula*),
		Oystercatcher (*Haematopus ostralegus*),
	Shelduck (*Tadorna tadorna*)	Golden plover (*Pluviallis apricaria*),
	Greylag goose (*Anser anser*)	Greenshank (*Tringa nebulari*),
		Curlew (*Numenius arquata*),
		Common sandpiper (*Actitis hypoleucos*),

The red-throated diver is known to breed at sites on both Shetland and Orkney and travel between hill-top lochan breeding sites and coastal waters to feed. Particularly important are Foula, Hermaness, Saxa Vord & Valla Field, Hoy, Mainland Orkney moors and Ronas Hill – North Roe and Tingon. Orkney also supports outstanding populations of the five most common species of wader, compared to that found elsewhere in the UK (Table 6..3)

Table 6.3 - Breeding densities (pairs/sq.km) of five common species of wader

Site	Lapwing	Snipe	Curlew	Redshank	Oystercatcher
Orkney	8.7	5.0	6.6	2.8	15.8
Shetland	4.9	6.7	3.6	2.7	8.3
Outer Hebrides	22.5	13.4	0.0	11.9	11.4
Scottish farmland	2.3	0.7	1.0	0.1	1.2
Lowland wet grassland (England & Wales)	1.7	1.0	0.2	1.2	0.3

Source: (Whyte et al. 1995, Gill et al. 1994, Dodds et al. 1995, O'Brien 1994, O'Brien & Smith 1992, cited in Meek 1997a)

Orkney also supports nationally important numbers of short-eared owl, *Asio flammeus* (2-7% of the British breeding population), hen harriers, *Circus cyaneus* (8%), peregrine falcon, *Falco peregrinus* (1%), rock pipit, *Anthus petrosus* (2%) and raven, *Corvus corax* (>1%) (Meek 1997).

Wintering and migrant birds

In addition to coastal breeding species, internationally important numbers of migrant and wintering waterfowl use the SEA 4 area coastline, particularly Orkney. Species which have internationally important wintering populations at coastal and maritime sites in the SEA 4 area include great northern diver, whooper swan, greylag goose, barnacle goose, wigeon, pochard, ringed plover, purple sandpiper, curlew, redshank and turnstone (May & Law 1997b), several of which also breed in the area. Orkney is the most important wintering locality for purple sandpiper, while numbers have also risen on Shetland (Meek 1997b, JNCC website). Orkney, in particular the east Sanday coast, also supports nationally important numbers of bar-tailed godwit.

Both the great northern diver and Slavonian grebe winter on the Islands, as well as wintering populations of red-throated diver. Grey herons, which frequent a range of habitats including rocky shores, have a widespread distribution in Britain including, Shetland, Orkney and the north coast of Scotland. In 2000/01 the Great Britain maximum total counted was 4,269 (September) (Pollitt *et al.* 2003). However there appears to be no breeding or wintering numbers of notable interest in the SEA 4 area.

Species accounts for important waterbird species are further summarised 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 waterbirds, 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). Two of the five most important sites for breeding seabirds (including gulls and terns) are in or adjacent to the SEA 4 area: Foula and Caithness Cliffs. Thirty-seven IBAs are located on the SEA 4 area coastline (Figure 6.7.1 of SEA 4 IBAs and those on Faroe and Norway), (see also chapter 7 for other conservation designation), with a further 19 IBAs on the Faroe Islands, and 10 on the south west coast of Norway (see chapter 9 for IBA sites on the Faroe Islands and Norway).

IBAs within the SEA 4 area identified by Heath & Evans (2000) are as follows:

Shetland

- **Sumburgh Head**. The site comprises boulder strewn beaches and cliffs along the east side of Sumburgh Head. The IBA is important for its colonies of breeding seabirds.
- **Lochs of Spiggie & Brow**. Largest "machair-type" lochs in Scotland. Important site for wintering whooper swan (143 individuals, 2.6% of wintering population) and wildfowl.
- **Foula** is the most westerly of the Shetland Islands. The IBA is important for breeding red-throated diver, Arctic skua, Leach's petrel, great skua, guillemot, puffin and shag. Site holds large populations of nesting cliff and moorland seabirds, regularly supporting 127,000 pairs.
- **Papa Stour**. The IBA supports an important assemblage of breeding seabirds and waders. Also important for breeding ringed plover (100 pairs, 1992).
- **North Roe & Tingon**. Site is important for breeding merlin (6 pairs, 0.5% of GB breeding population) and red-throated diver (50 pairs, 5.3% of GB population) in addition to great skua (165 birds, 1992). This IBA also holds important assemblages of breeding moorland birds and is nationally important for breeding whimbrel (31 pairs, 1994) and Arctic skua (140 pairs, 1992).
- **Ramna Stacks & Gruney**. Site is important for breeding Leach's petrel (22 pairs, 0.1% of GB breeding population) and other breeding seabirds.
- **Hermaness, Saxa Vord & Valla Field**. Site is nationally important for breeding red-throated diver (28 pairs, 3.0 % of UK breeding population), fulmar (26,200 pairs 5%), whimbrel (14 pairs, 3%), Arctic skua (115 pairs, 4%) and guillemot (11,400 pairs, 2%). The site is also important for breeding gannet, great skua, puffin as well as black guillemot. On a regular basis the IBA holds 70,600 pairs of breeding seabirds.

- **Fetlar**. Site holds 13,100 breeding seabirds on a regular basis. This is the best site for breeding red-necked phalarope as well as nationally important for breeding fulmar (12,600 pairs, 1986) and whimbrel (70 pairs 1989).
- **Noss**. Site is important for breeding gannet, great skua and guillemot. Noss also has one of the largest seabird colonies in Britain, holding 41,800 breeding pairs, as well as being nationally important for breeding fulmars (5,850 pairs).
- **Mousa**. The IBA is important for breeding Arctic tern (767 pairs, 1.7% of GB breeding population) and storm petrel.
- **Fair Isle**. The IBA supports large colonies of breeding seabirds and is also important as a stop-over for migrating birds. It regularly holds 72,400 breeding seabirds and 21,900 breeding waterbirds. It is nationally important for breeding fulmar (35,200 pairs, 1991), Arctic skua (87 pairs, 1995), kittiwake (19,300 pairs 1988), as well as having an endemic subspecies of wren (*Troglodytes troglodytes*). The site is also important for breeding shag, great skua, Arctic tern, guillemot, razorbill and puffin.

Orkney

- **Pentland Firth Islands**. The IBA is important for breeding Arctic tern and great black-backed gull. These islands are important for large numbers of breeding seabirds, holding 11,600 pairs on a regular basis. The site is also nationally important for breeding guillemot (9,200 pairs).
- **South Walls & Switha**. Site is important for breeding seabirds and waders and wintering geese, with wintering barnacle goose numbering 1,000 individuals (3.7% of GB wintering population).
- **Hoy**. The IBA is important for breeding seabirds (56,000 pairs on a regular basis), raptors and waders. Site nationally important for breeding fulmar (37,000 pairs), Arctic skua (96 pairs), Arctic tern (525 pairs) and guillemot (13,900 pairs). The site is also important for breeding red-throated diver, great skua and great black-backed gull.
- **Marwick Head**. The IBA is important for breeding guillemot and regularly holds 26,000 pairs of breeding seabirds. The site is also nationally important for breeding kittiwake.
- **Rousay**. Site is important for assemblages of breeding moorland birds, as well as breeding Arctic tern.
- **South Westray Coast**. This site is important for wintering waders - sanderling and purple sandpiper.
- **North Westray Coast**. This IBA consists of two sections of coastline on North Westray and is important for breeding seabirds including Arctic tern and black guillemot.
- **West Westray**. IBA holds 45,000 pairs of breeding seabirds and 32,200 pairs of breeding waterbirds. Species include Arctic tern, guillemot and kittiwake. The IBA is also nationally important for breeding Arctic skua (95 pairs) and razorbill (1,180 pairs).
- **Papa Westray (North Hill & Holm)**. The IBA is important for breeding seabirds including Arctic tern and black guillemot. The IBA is also nationally important for breeding Arctic skua (150 pairs).
- **Eday**. The IBA supports notable breeding populations of seabirds (10,700 pairs) and upland species including breeding red-throated diver (10 pairs, 1991-1996), cormorant (225 pairs, 1995), whimbrel (8 pairs, 1995), Arctic skua (110 pairs, 1992), guillemot (8,450 pairs, 1986) and wintering purple sandpiper (250 birds, 1992).
- **East Sanday**. The IBA is nationally important for breeding Arctic tern (9450 pairs), and wintering sanderling (300 birds) and snow bunting (340 birds). The IBA is also important for other wintering species: ringed plover, bar-tailed godwit, purple sandpiper and turnstone, passage species: turnstone and purple sandpiper and breeding species: sandwich tern.
- **North Ronaldsay Coast**. The IBA is important for breeding black guillemot and wintering purple sandpiper. The site is also nationally important for wintering snow bunting (115 birds)
- **Auskerry**. Site supports large numbers of breeding seabirds and is nationally important for breeding Arctic tern (670 pairs, 1993). The site is also important for breeding storm petrel.

- **Copinsay**. The IBA is important for breeding seabirds, holding 16,500 pairs on a regular basis. Site is important during the breeding season for great black-backed gull (695 pairs) and is nationally important for breeding guillemot (220,440 birds).
- **Faray and Holm of Faray**. These small islands are important for breeding seabirds, including great black-backed gull and black guillemot.
- **Rothiesholm Peninsula, Stronsay**. The IBA holds important seabird colonies and is important for breeding great black-backed gull.
- **South-Eastern Stronsay**. The IBA is important for breeding seabirds and wintering waders and wildfowl. Breeding species include black guillemot and corncrake, the latter of which does not meet IBA criteria, but is of global conservation concern.
- **Scapa Flow**. The IBA is important for wintering waterbirds and is nationally important for wintering red-necked grebe (5 birds, 1988-1989), eider (895 birds, 1988-1989), long-tailed duck (1,010 birds, 1988-1989) and red-breasted merganser (425 birds, 1988-1989). The site supports breeding black guillemot and wintering great northern diver, Slavonian grebe, shag and velvet scoter.
- **North Mainland Coast**. The IBA is important for wintering waders and nationally important for wintering long-tailed duck (265 birds, 1993-1994) and snow bunting (110 birds, 1993-1994). The IBA also supports wintering purple sandpiper, curlew, redshank, and turnstone.
- **Sound around Wyre**. A large sea area that comprises the sounds of Eynhallow, Gairsay, Rousay and Wyre. The IBA is important for wintering divers and is of national importance for wintering eider (2,590 birds, 1989-1990) and long-tailed duck (2,160 birds, 1989-1990).
- **Sule Skerry and Sule Stack**. The IBA holds 63,800 pairs of breeding seabirds on a regular basis and is nationally important for breeding guillemot (9,600 pairs, 1993). The IBA also supports breeding storm petrel, gannet, shag and puffin.

North Highlands

- **North Rona and Sula Sgeir**. Islands are of major importance for breeding seabirds, holding 55,200 pairs on a regular basis. The IBA is nationally important for breeding fulmar (9,000 pairs 1985-1986), kittiwake (5,050 pairs, 1986) and puffin (5,250 pairs, 1986). The IBA also supports breeding gannet, Leach's petrel, great black-backed gull, guillemot and razorbill.
- **Cape Wrath**. The IBA holds 17,100 pairs of breeding seabirds and 10,800 pairs of breeding waterbirds. Site is of national importance for breeding kittiwakes (10,300 pairs) and guillemots (9,800 pairs). The site also supports breeding razorbill.
- **Eilean Hoan**. Breeding birds of notable interest include few pairs of Arctic tern and storm petrel. The site also supports wintering barnacle geese from the Greenland breeding population and breeding Leach's petrel.
- **Eilean nan Ron**. The IBA is important for breeding seabirds and wintering barnacle goose from the Greenland breeding population.
- **Caithness Cliffs**. This IBA supports 127,000 pairs of breeding seabirds and 54,000 pairs of breeding waterbirds. The site is nationally important for breeding fulmar (27,100 pairs) and cormorant (250 pairs). The IBA also supports breeding shag, herring gull, great black-backed gull, kittiwake, guillemot, razorbill and black guillemot.

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 in SEA 2, with the conclusion that probably the most important factor currently affecting seabird numbers is the quality and abundance of their food. The population trend of some of the seabird species present in the SEA 4 area have been updated by Mavor *et al.* 2002 and are shown in Table 6.4.

Table 6.4 - UK breeding 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	Probably ↑
Arctic skua	↑
Storm petrel	?
Common tern	↓
Manx shearwater	?
Cormorant	↑
Shag	↑
Razorbill	Probably ↑
Herring gull	↓
Roseate tern	↓
Arctic tern	↓

Source: Mavor et al. 2002
*Note: * Net changes based on comparisons with total recorded during 1969-70 survey*

Commercial fishing has resulted in major, but complex, changes in seabird food stocks (Furness 1987) including removal of food source (especially herring and sand eels), reduction in competition (by removal of predatory fish), and availability of fishing discards. In addition, entanglement in any net set within the feeding range of seabirds, as well as getting caught on lines of baited hooks, carries the risk of unintentional bycatch of seabirds (Tasker *et al* 2000). Monofiliment gillnets are generally the type of fixed fishing gear that results in the largest by catch of birds and mammals. However, studies around Scotland have found no evidence of widespread impact from the use of this fishing gear, with only “hot spots”of by catch detected where nets were set immediately beside colonies (Murray 1993, Murray *et al* 1994, cited in Tasker *et al* 2000). Long-line fishery is one of the world’s major fishing methods and the primary bird by catch from this method is the fulmar. Nevertheless, because the breeding distribution and population size is expanding, long-line mortality is not currently regarded as a serious threat to the species. Lost fishing gear may also be picked up by gannets and cormorants, including netting from the sea surface to use as nesting material instead of seaweed. 92% of 465 gannet nests checked in Shetland were found to contain some visible nylon, while 50% contained virtually nothing else (Camphuysen 1990a). As a result, adults and chicks may become entangled and die from starvation (Montevecchi 1991).

Small sandeel fisheries operate at Shetland and off the west coast of Scotland and are different to the larger North Sea sandeel fishery as they are smaller in scale, restricted to small inshore grounds and are managed nationally (Fisheries Research Services 2003). Sandeels (*Ammodytes marinus*) are important food for many breeding seabirds in the North Sea and North Atlantic (Furness & Tasker 2000). The breeding success of many seabirds that feed on sandeels, including the Arctic tern and kittiwake, declined around Shetland during the mid 1980s. At this time, assessment was also made of the sandeel stock and it was found that there were declining numbers of young fish entering the Shetland fishery. As a result of this, the fishery was closed from 1st July 1989 to the end of December, with seasonal closure also implemented again in 1990. The fishery was closed completely in 1991 (Fisheries Research Services 2003). Monaghan *et al.* (1989), found that Arctic terns in Shetland, during this shortage, had difficulty in finding sandeels of the 4cm-8cm class with which to feed their young and that the adults themselves were in poor condition prior to chicks hatching.

As it was suggested that the local sandeel fishery was the cause of the decline in seabird breeding success, a study was commissioned between 1990 and 1993 to assess the situation. The findings indicated that seabird breeding failures were not directly caused by the sandeel fishery, but by natural factors affecting the early life history of sandeels. Following the study, the Shetland sandeel fishery was reopened in 1998 subject to a new regime that consisted of an annual total allowable catch of 7,000 tonnes and closure during the months of June and July, when seabirds are feeding their chicks. There was also a limit on vessel size to boats of 20 metres or less. In 2001 arrangements were reviewed and it was agreed that they should continue for an additional three years. However, a survey in 2001 indicated that due to poor recruitment, Shetland sandeels were at very low levels again. In July 2003, Martin Heubeck, an ornithologist from Aberdeen University, reported that early indications suggested that the 2003 seabird breeding season is the poorest since monitoring began in the mid 1980s and that seabirds dependent on sandeels, such as puffins, kittiwakes, terns, guillemots and Arctc skua are suffering the most (Shetland Today 2003). The poor breeding success of many Shetland seabirds has since been confirmed (M. Tasker pers.comm.)

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, 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.

In 1993 the *Braer* ran aground at Garth's Ness in Shetland and began leaking Norwegian Gulfaks crude oil from the moment of impact. In total 85,000 tonnes of oil was spilled by the *Braer*. 207 birds were received at the cleaning centre set up to deal with oiled birds, of these 23 were successfully rehabilitated, while an estimated 31 out of 34 seals were successfully rehabilitated. There was difficulty in determining the number of birds that died as a result of the oil as some would never have been found and stormy weather at the time of the spill caused a high mortality of storm victims that became oiled after death. 1538 dead birds were found on the beaches including shag (857), black guillemot (203), kittiwake (133), and long-tailed duck (96), as well as great northern diver (13), eider (70) and great black-backed gull (45). There was a clear excess of females over males found. The main groups of breeding seabirds affected by the spill were locally resident species, while summer visitors would have been out of Shetland waters at the time of the spill. In general the 1993 breeding season was successful for most species that may have been affected by the oil spill, with the exception of shag and black guillemot.

Fortunately, the timing and location of the spill, two of the most important factors that determine the extent of the effect on the fauna and in the case of the *Braer* spill, the stormy weather, resulted in the rapid dispersion of the oil in the water column and within a short period (in terms of oil spills), the effects were rapidly reduced. Long term effects on wildlife have proved to be less than first feared with the most notable impact on breeding populations of resident seabirds closest to the spill (SOTEAG 1993).

Prior to the *Braer* spill, the *Esso Bernicia* spilled 1,200 tonnes of fuel oil into Sullom Voe after the ship collided with the mooring jetty in 1979. Richardson *et al*. (1981) found that numbers of wintering birds were considerably reduced as a result of the spill and 87% of the dead oiled birds found were recovered from the coastline of Sullom Voe and Yell Sound. Strong currents rapidly dispersed the oil around the islands causing heavy mortality of birds like the black guillemot and great northern diver.

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 offshore installations. North Sea studies from the early 1980s found no evidence of flare impact on flocks of birds (Dunnet 1987, Bourne 1979 & Hope Jones 1980). Since these studies, flaring on offshore installations in the UKCS has been reduced to low levels. Offshore installation lights are constantly on and Nederlandse Aardolie Maatschappij b.v. (NAM) have suggested a potential to impact migratory birds. However, the extent of impact depends greatly on the location and timing of the lights. As there is very little passerine migration west of Shetland, offshore installation lights are expected to have little or no impact on bird mortality.

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.

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 (Table 6.5). Of the species commonly present offshore in the SEA 4 area and 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 6.5 Individual species vulnerability index scores

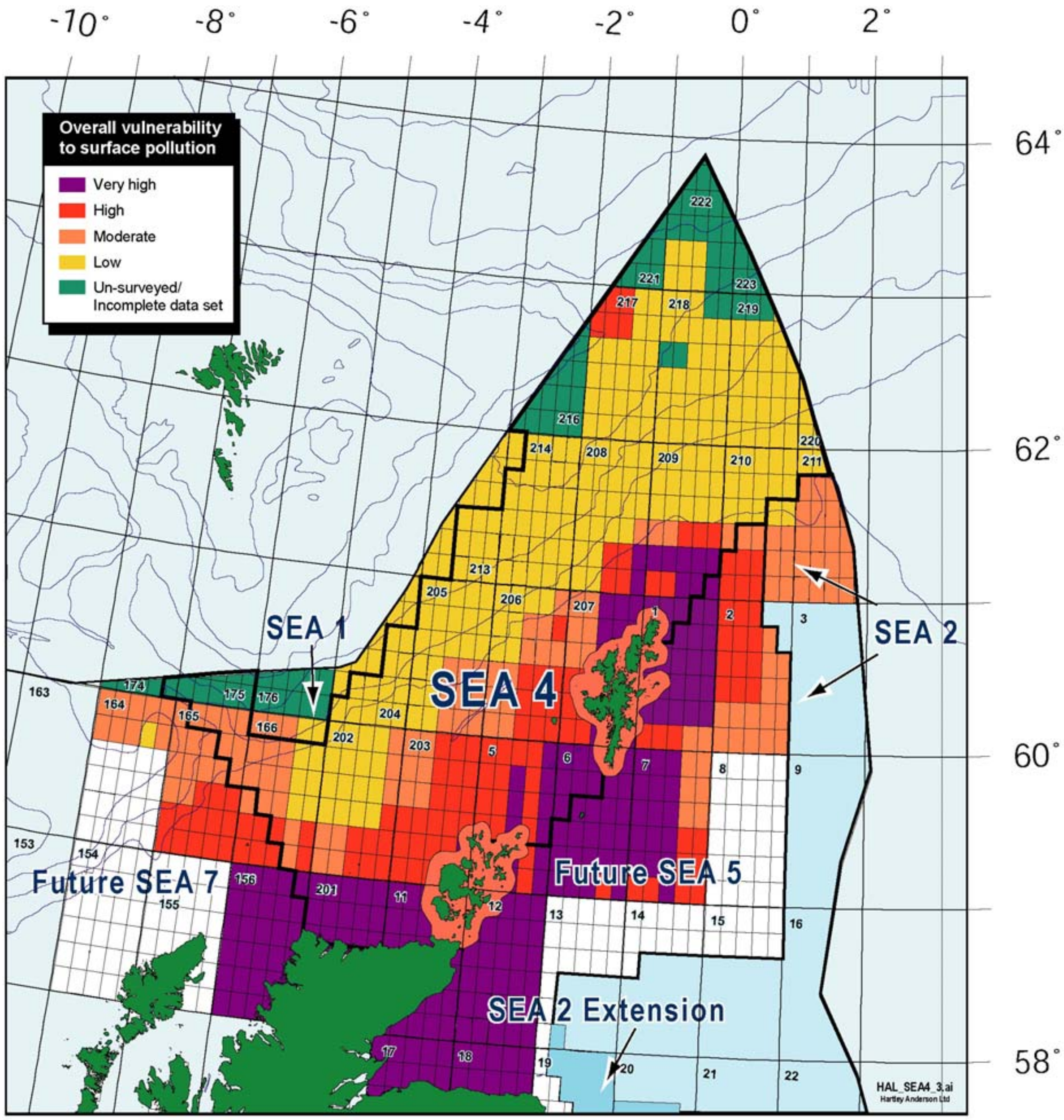
Species	Score	Species	Score
Red-throated diver	29*	Arctic skua	-24
Black-throated diver	29*	Great skua	-25
Great northern diver	29*	Little gull	-24
Great crested grebe	23*	Black-headed gull	-11
Red-necked grebe	26*	Common gull	-13
Fulmar	-18	Lesser black-backed gull	-19

Species	Score	Species	Score
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 6.3 and 6.4

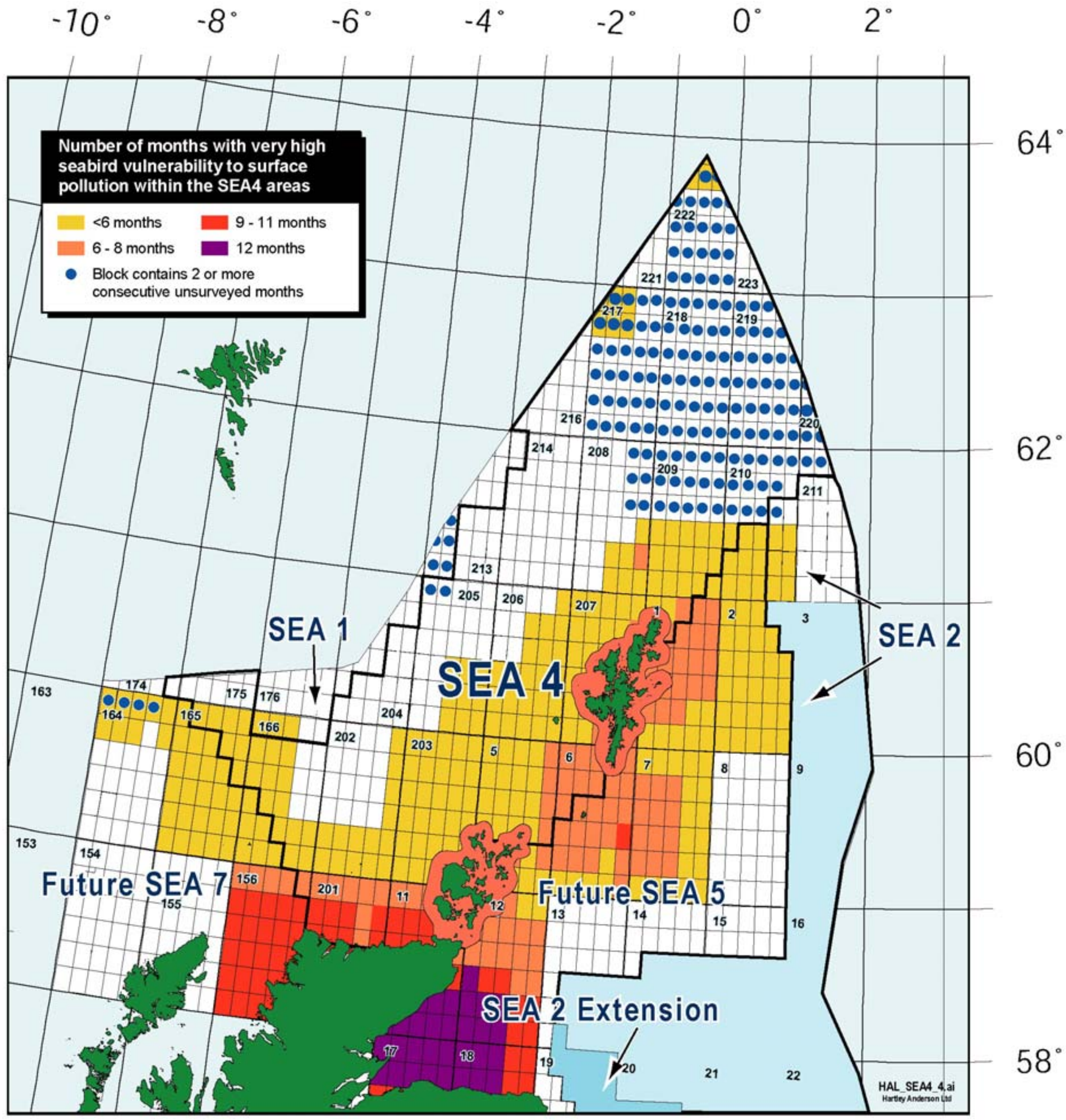
Figure 6.3 – Overall seabird vulnerability in the SEA 4 area and surrounding waters



Source: JNCC block vulnerability data

Overall seabird vulnerability of seabirds to surface pollution is very high in some blocks of Quadrants 5, 6, 11, 156, 201, 203, 207, 208 and 209, corresponding to SEA 4 areas north of the Scottish mainland, in the Fair Isle Channel and nearshore north and west of Shetland. 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 some blocks of Quadrants 5, 6, 11, 156, 201, 207 and 208 and for between 9 and 11 months in some blocks of Quadrants 11 and 201, while remaining blocks within Quadrants in the SEA 4 area are highly vulnerable for less than six months; i.e. had operational windows within which vulnerability is lower.

Figure 6.4 – Seasonal vulnerability in the SEA 4 area and surrounding waters.



Source: JNCC block vulnerability data

Vulnerability data are relatively adequate for most of the SEA 4 area, with the exception of the most northern region. However, data gaps are present for two or more consecutive months in parts of Quadrants 205, 208, 217, 218, 219, 220 and 222. 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). In 1999 JNCC produced a report that aimed to provide a more comprehensive analysis of variability in SAST seabird dispersion data and its consequences. From studies in the Irish Sea they found that many studies reported seabirds associated with fronts and surrounding bodies of water. Fronts are regions of enhanced biological productivity, which occur where tidally mixed waters converge with seasonally stratified waters. Species were found to utilise frontal areas differently with guillemots favouring the surface expression and the warm side of the front, razorbills preferring colder mixed water and Manx shearwater preferring the warm side of the front (O'Brian *et al*. 1999). The relationship between foraging predators and a front remains difficult to detect, however fronts may have major influences on the spatial and temporal variability in seabird densities and require further investigation.

This report concluded that for areas of the North Sea at least, seabird densities for low-density areas can be confidently predicted while predicting densities of high density areas it is necessary to be more cautious, due to the intrinsically greater variability associated with high densities.

6.7.7 Sensitivities and vulnerability – coastal waterbirds

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 4 – 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 (a major competitor for food for white-fronted geese). 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.

Populations of some wintering waders and wildfowl have increased over the last 30 years (Table 6.6). The precise reasons for this increase varies between species and remains unknown for some, however it is believed that the increase coincides with a better recognition of the value and hence the protection of wetlands for wildlife (Gregory *et al.* 2002).

Table 6.6 Long term population trends of wintering waterbirds

Species	*Long-term trend	**Short-term trend
European white-fronted goose	↓	↓
Knot	↓	↑
Mallard	↓	↓
Bar-tailed godwit	↓	↓
Pochard	↓	↓
Ringed plover	↑	↓
Dunlin	↓	↓
Turnstone	↑	↓
Icelandic greylag goose	↑	↓
Shelduck	=	↓
Oystercatcher	↑	↓
Wigeon	↑	↑
Sanderling	↑	↑
Redshank	↑	↑
Tufted duck	↑	↑
Mute swan	↑	↑
Curlew	↑	↑
Goldeneye	↑	↑
Shoveler	↑	↑
Greenland barnacle goose	↑	↑
Goosander	↑	↓

Species	*Long-term trend	**Short-term trend
Whooper swan	↑	↑
Pink-footed goose	↑	↑
Pintail	↑	↓
Dark-bellied brent goose	↑	↓
Bewick's swan	↑	↓
Teal	↑	↑
Red-breasted merganser	↑	↑
Grey plover	↑	↑
Svalbard barnacle goose	↑	↑
Canada goose	↑	↑
Black-tailed godwit	↑	↑
Gadwall	↑	↑
Avocet	↑	↑
Rudy duck	↑	↑
Coot	-	↑
Canadian light-bellied brent goose	-	↑
Great crested grebe	-	↑
Greenland white-fronted goose	-	↑
Little grebe	-	↑

Source: Gregory et al. 2003.
*Note: *Long term trends are % changes between winters 1970/71 and 2000/2001; **Short term trends are % changes between winters 1990/91 and 2000/2001. National monitoring of coot, great crested grebe, little grebe, brent goose and Greenland white-fronted goose started later than for other species and only short term trends are shown.*

The red-throated diver is relatively difficult to record accurately. However there appears to be consistency of numbers both nationally and at individual sites in the UK. In the non-breeding season, the biogeographic population (Europe/Greenland) is estimated to be 75,000 individuals with about 4,850 of these occurring in UK waters. Unfortunately there is little available information on changes to either the British or European wintering numbers due to poor winter monitoring (JNCC website). This issue is being addressed by the planning of enhancements to monitoring provisions at both national and international level. It is thought that the UK's breeding population of Slavonian grebe winters around the coasts of Britain and Ireland, however, there is little evidence to suggest range of dispersal. Wintering Slavonian grebes usually remain at favoured sites for extended periods through the winter. This makes the species particularly susceptible to oil spills - in the 1970s between 8% and 16% of the birds wintering in Shetland died as a result of the *Esso Bernicia* spill (Heubeck & Richardson 1980, cited in Pollitt *et al.* 2003).

With the exception of knot and bar-tailed godwit, the numbers of most waders that over-winter predominantly on UK estuaries have either been stable or have increased over the last 30 years. Full surveys in 1984-85 and 1997-98 of the preferred habitat of wintering ringed plover, sanderlings, purple sandpipers and turnstones have shown declines in their non-estuarine populations of 15%, 20%, 21% and 16% respectively (Gregory *et al.* 2002). Although all four species have decreased, most in the south of the UK, decreases for ringed plover and turnstone have also been recorded in the west of the UK.

Despite any official estimate, the moorhen wintering population is thought to be in the region of 750,000 birds, based on the UK breeding population estimate of 240,000. Despite their distribution extending throughout Orkney and north to Shetland, numbers of breeding and/or wintering birds are unknown. However, their population on Orkney is believed to be "healthy" (Gibbons *et al.* 1993). There is a similar situation for the coot, which utilises the nutrient-rich lochs of Orkney.

6.8 Marine mammals

Hammond *et al* (2003) indicates that twelve species of marine mammal regularly occur in the SEA 4 area: grey seal, harbour seal, hooded seal, harbour porpoise, white-beaked dolphin, Atlantic white-sided dolphin, Risso's dolphin, long-finned pilot whale, killer whale, minke whale, fin whale and sperm whale. In addition to these, other, rarer species such as Sowerby's beaked whale, humpback whale, Sei whale and common dolphin are also known to regularly occur in the area. These are further discussed in section 6.8.2.1.

6.8.1 Data sources

A review of marine mammal distribution, ecological importance and sensitivity to disturbance and contamination in the north of Scotland, with particular reference to the SEA 4 area, was carried out by the Sea Mammal Research Unit (SMRU), St Andrews (Hammond *et al.* 2003). Quantitative information for this area has been provided by a variety of sighting surveys including the Small Cetacean Abundance in the North Sea (SCANS) survey carried out in July 1994 and the North Atlantic Sightings Survey (NASS) in July 1987 and 1989. The general distribution and seasonal patterns of movement by cetacean species have also been determined by a number of acoustic recordings by Cornell University, Aberdeen University and the Joint Nature Conservation Committee's Seabirds at Sea Team (SAST), using the US Navy's SOSUS hydrophone array and low frequency sonobuoys. There are also a number of published reports of cetacean observations made during seismic surveys from 1996 to 2000.

In addition to these surveys, a combined atlas of cetacean distribution around the British Isles has been produced using combined cetacean sightings data from SCANS, the European Seabirds at Sea database (ESAS) and the Seawatch Foundation. Cetacean sightings data from SCANS have also been combined with those from the European Seabirds at Sea database and those of the Seawatch Foundation to produce a combined Atlas of cetacean distribution around the British Isles using sightings per standardised unit of time (Reid *et al.* 2003).

There is extensive information on the abundance and distribution of grey seals around Britain from annual aerial surveys carried out by SMRU and satellite-relayed data loggers attached to over 100 animals in the field; while information on harbour seals is drawn from aerial surveys conducted during the moult by SMRU and ongoing satellite telemetry studies in eastern Scotland. Satellite-telemetry studies also provide information on foraging distributions of hooded seals.

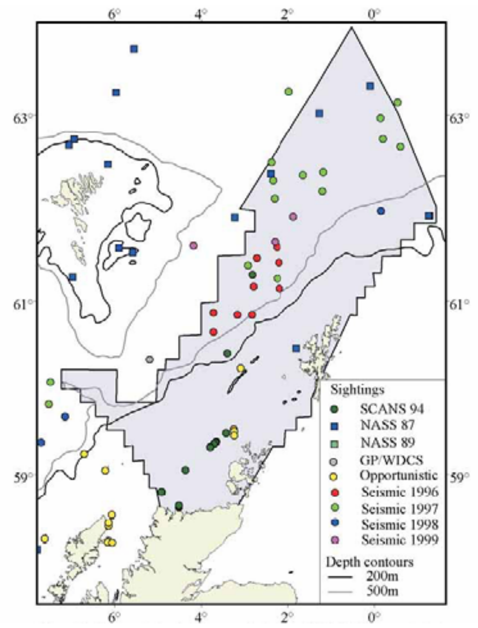
6.8.2 Cetacean distribution and abundance

There is at least nine different species of cetacean regularly sighted in the SEA 4 area (minke whale, *Balaenoptera acutorostrata*; harbour porpoise, *Phocoena phocoena*; white-beaked dolphin, *Lagenorynchus albirostris*; Atlantic white-sided dolphin, *Lagenorhynchus acutus*; long-finned pilot whale, *Globicephala melas*; killer whale, *Orcinus orca*; fin whale, *Balaenoptera physalus*; sperm whale, *Physeter macrocephalus* and Risso's dolphin, *Grampus griseus*), with a further ten species recorded less regularly. As a result, the SEA 4 area is an important area for cetaceans in a regional context. Although little is known about the abundance and seasonal distribution of these species, it is thought that some of the offshore species, in particular sperm whales and fin whales, probably migrate through the area. The area may also be important for some of the less frequently sighted species such as the beaked whales. The area on the shelf is also important for cetaceans, especially for minke whales, porpoises and white-beaked dolphins (Hammnond *et al.* 2003). Figures 6.5 to 6.13 show sightings of nine different species of cetacean regularly sighted in the SEA 4 area from a plethora of surveys. For effort related data see the *Atlas of cetacean distribution in north-west European waters* (Reid *et al* 2003).

In 2000 there were 467 sightings of marine mammals (9,258 individuals) made during seismic surveys in UK waters. Of these the most frequently seen species were white-beaked and white sided dolphins. Sperm whales, fin whales and minke whales were also seen with moderate frequency, with other species seen in lower frequency. Marine mammal sightings peaked in August, with most sightings occurring to the west of Shetland and in the northern North Sea (Stone 2003).

Minke whales are widely distributed throughout the world's oceans and there are three distinct populations: Southern Hemisphere, Northern Pacific and North Atlantic. Of the North Atlantic population, there are three recognised stocks for management purposes: north eastern Atlantic, west Greenland and Canadian east coast. Minke whales within the SEA 4 area belong to the north eastern Atlantic stock.

Figure 6.5 - Minke whale sightings in SEA 4 area (Hammond et al. 2003)

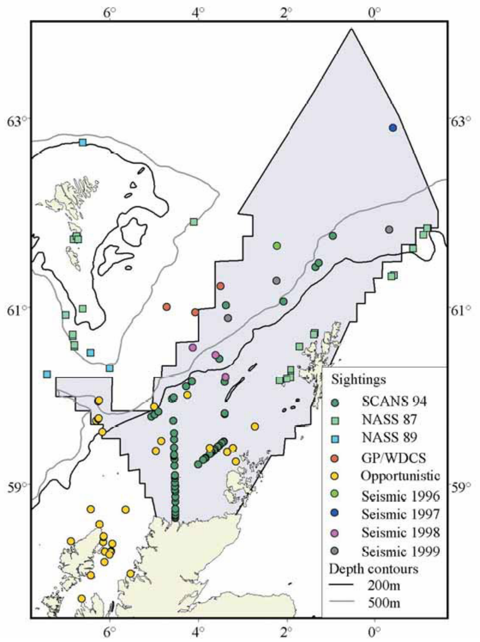


Although there is no direct evidence that minke whales in the Northern Hemisphere migrate they do appear to have seasonal shifts in their latitudinal abundance, as seen in the area north of Britain. This species moves into the area at the beginning of May and feeds throughout the summer until October when they move south to breed (Evans 1980).

Within the SEA 4 area most sightings are within the 200m depth contour with some sightings over deeper water (150m-500m) between north-west Scotland and the Faroes (Figure 6.5). The estimated summer abundance of minke whales in waters around Shetland and Orkney, as determined by the SCANS survey, was 2,920, while the estimate for the North Sea was 7,200 (Hammond *et al.* 2003). Estimates have been generated for the number of minke whales in the North Sea, north of 56ºN at 20,300 for 1995 (Schweder *et al.* 1997, cited in Hammond *et al.* 2003), which is approximately 18% of the north east Atlantic stock of 112,000 whales in 1995.

New abundance estimates have recently been calculated from Norwegian surveys, however the results are currently confidential. Current available information suggests that although minke whales are regularly sighted in the SEA 4 area, the areas to the west and east of Scotland appear to be of greater importance to this species (Reid *et al* 2003)..

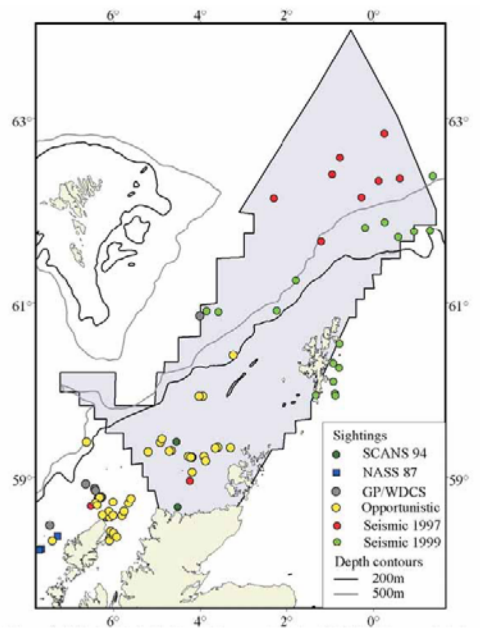
Figure 6.6 - Harbour porpoise sightings in SEA 4 area (Hammond et al. 2003)



The harbour porpoise is the most abundant cetacean species in British waters (including the area under consideration), with a total North Sea population estimated at a quarter of a million animals with densities around Shetland among the highest anywhere in the Northeast Atlantic. Although there are numerous sightings of harbour porpoise within the SEA 4 area, sightings are generally confined to coastal and continental shelf areas along the eastern and southern boarders of the SEA 4 area.(Figure 6.6).

Around Shetland and Orkney, the summer abundance of harbour porpoise from the SCANS survey is estimated at 61,000, with density in waters immediately adjacent to Shetland and Orkney estimated at 0.784 porpoises per square kilometre. This represents one of the highest densities in the whole survey. SAST data from 1979 to 1991 indicates that the highest rate of porpoise sightings in the northern North Sea, including the SEA 4 area, are in April to June, (the calving season) and July to September. This may be as a result of harbour porpoises moving from Norwegian waters into the northern North Sea. The SEA 4 area is therefore an important area for this species, particularly in summer.

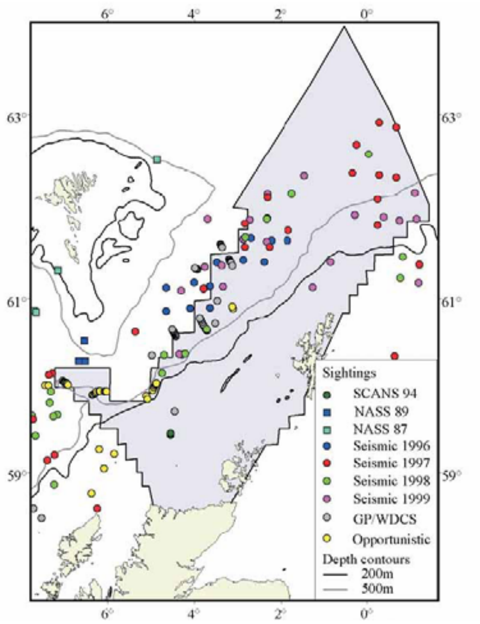
Figure 6.7 - White-beaked dolphin sightings in SEA 4 area (Hammond et al. 2003)



White-beaked dolphins are confined to the North Atlantic (Hammond *et al.* 2003). They are the most commonly recorded species in shelf waters surveyed by SAST/ESAS north and west of Scotland, with distribution almost entirely confined to water depths <200m (Figure 6.7). The SCANS survey estimated the summer abundance of white-beaked dolphins in the shelf waters around Shetland and Orkney at 1,157, while the estimated summer abundance in the North Sea (including the Shetland and Orkney estimate) was 7,856. This species is present in the North Sea and waters around Shetland and Orkney all year round, with increased numbers between May and October.

White-beaked dolphins are commonly seen in the northern North Sea, including shelf waters of the SEA 4 area, suggesting that the SEA 4 area is the extreme of their distribution in the eastern North Atlantic (Hammond *et al.* 2003).

Figure 6.8 - Atlantic white-sided dolphin sightings in the SEA 4 area (Hammond et al. 2003)

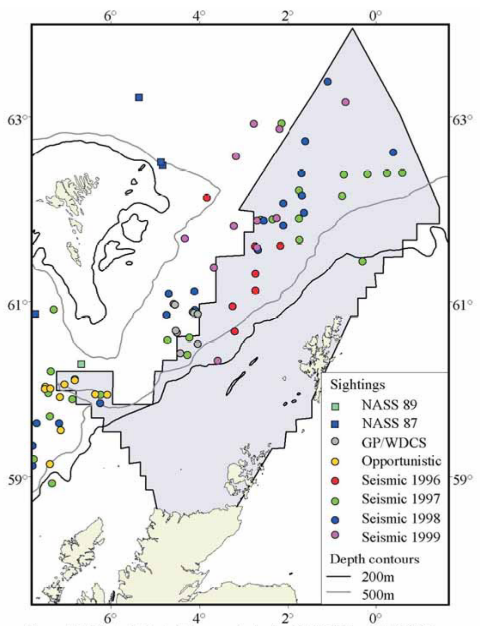


Atlantic white-sided dolphins, like the white-beaked dolphins are confined to the North Atlantic. While they share most of their range with the white-beaked dolphin, their distribution in the eastern North Atlantic is predominantly offshore - along the shelf edge and in water deeper than 1000m. Most sightings in the SEA 4 area are in deep water (Figure 6.8).

The presence of Atlantic white-sided dolphins in the North Sea is seasonal with the bulk of sightings occurring between May and September (Northridge *et al.* 1997, cited in Hammond *et al.* 2003). Atlantic white-sided dolphins are more frequently recorded in shelf waters (<200M), during the summer, particularly in July. Between June and November this species is generally more widespread occurring in high abundance over the Faroe-Shetland Channel and Faroe Bank Channel. SAST data from 1979 to 1991 surveys around the Faroe Islands indicates that this species was the most numerous cetacean recorded in the area, particularly during June and July, with a peak in numbers in August (Taylor & Reid 2001).

SCANS survey results did not distinguish between white-beaked dolphins and Atlantic white-sided dolphins. As a consequence, to the SCANS survey recorded them simply as *Lagenorhynchus spp*. The 1994 SCANS survey estimated 11,760 *Lagenorhynchus* dolphins (white-beaked plus white-sided) in the North Sea, which included the shelf waters around Shetland and Orkney. In the Shetland and Orkney shelf waters alone there was an estimated 1,569 animals.

Figure 6.9 - Sightings of long-finned pilot whales in the SEA 4 area (Hammond et al. 2003)

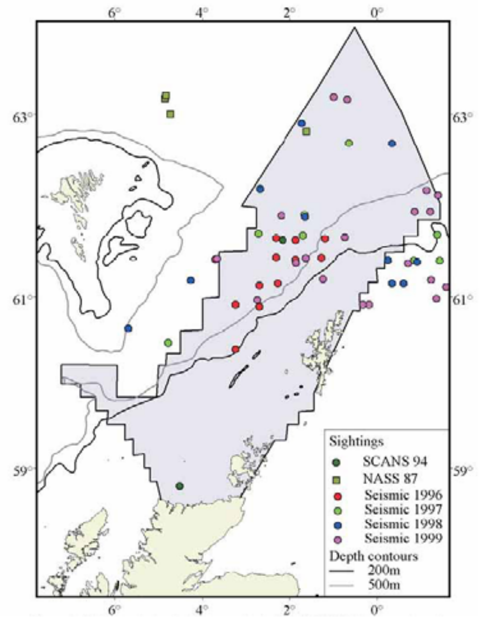


Atlantic white-sided dolphins are regularly associated with long-finned pilot whales, a species which occurs in both hemispheres, and was the second most abundant cetacean species recorded by the SAST/ESAS surveys. . Long-finned pilot whales are commonly seen in deep waters (1000m), north and west of Shetland and Orkney in the SEA 4 area, with sightings in Shetland waters in most months of the year (Figure 6.9).

High abundance is common in the Faroe-Shetland Channel and the Faroe Bank Channel and their occurrence in deep water channels is thought to be related to the distribution of squid, their main food source within the area (Desportes & Mouritsen 1993). Around the Faroe Islands, highest numbers of sightings are during the summer, particularly August. There has been a long-standing catch of pilot whales and other small cetaceans off the Faroe Islands.

This is a gregarious species, with an average group size of 11-24 animals (Taylor & Reid 2001, Pollock *et al.* 2000) although a pod of 400 individuals has been recorded in the Faroe Bank Channel in August 1997. This is also one of the most commonly mass-stranded of the cetacean species, with strandings around the UK North Sea coast increasing since 1947, including a number of mass strandings involving more than 150 animals in total between November 1982 and January 1985 (Martin *et al.* 1987, cited in Hammond *et al.* 2003). The precise cause of these strandings remain unknown.

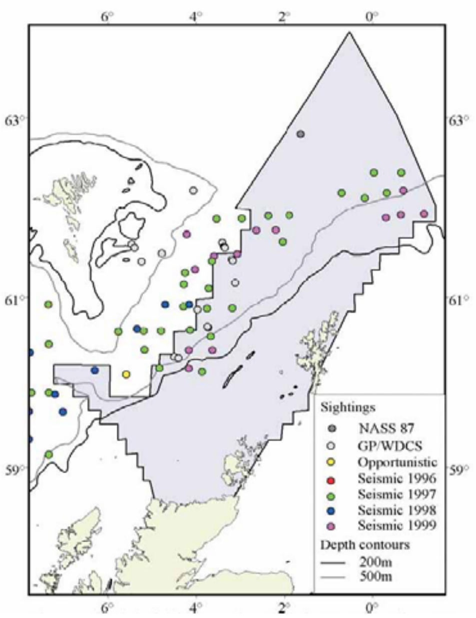
Figure 6.10 - Sightings of killer whales in the SEA 4 area (Hammond et al. 2003)



Killer whales are found in all oceans and most seas. Within the SEA 4 area significant numbers of animals have been found distributed over both the continental shelf and in deep offshore waters, particularly over the slope to the north and north west of Shetland (Pollock *et al.* 2000 Hammond *et al.* 2003). Seismic surveys in 1996, 1997 and 1998 recorded killer whales throughout the Faroe-Shetland Channel and on the shelf north of Shetland (Figure 6.10).

Sightings of killer whales in inshore Shetland waters have also increased in recent years, particularly around Sumburgh Head, Yell, Bluemill and Colgrave sounds, Whalsay and Papa Stour. This behaviour may reflect an expansion in the range of the North Atlantic killer whale in relation to prey distribution (Fisher *et al.* 1999). They are present north of approximately 58ºN in all months except October, with pod size in the SEA 4 area ranging from 1 to 17 animals, (with a mean of 4 in waters north and west of Scotland (Pollock *et al.* 2000) and 6 in waters around the Faroe Islands (Taylor & Reid 2001).

Figure 6.11 - Fin whale sightings in the SEA 4 area (Hammond et al. 2003)

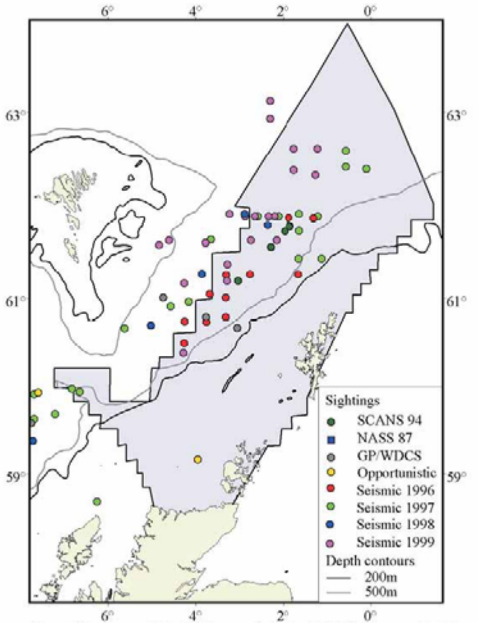


Fin whales are deep water baleen whales. SAST and seismic sightings record fin whale distribution as centred north of 60ºN, with most fin whales found in deep water (>1000m) to the north and west of the SEA 4 area (Figure 6.11).

Acoustic monitoring along the Shelf edge, using SOSUS arrays, has shown that fin whales are present in the area throughout the year, with numbers in the region of 6 to 20 vocalising individuals. Singing activity was found to be lowest in areas around Shetland and the Faroe Islands during the summer (May to September).

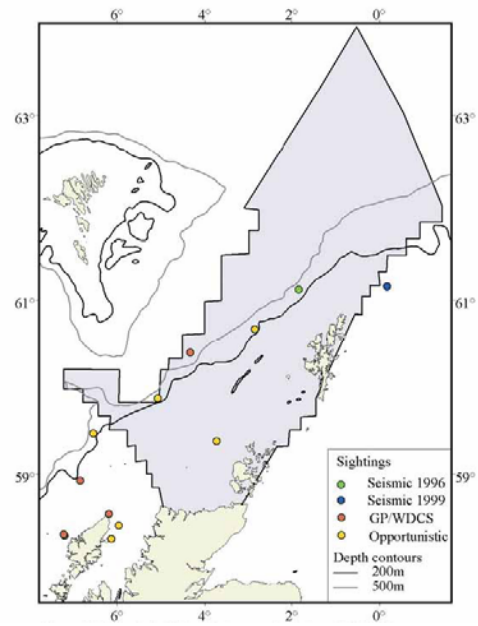
Like fin whales, sperm whales are also regularly sighted in deep water between the Faroe Islands and Shetland. Sperm whales are normally distributed on or beyond the continental shelf break to the west and north of the UK (Figure 6.12), particularly along the Faroe-Shetland Channel. This species predominantly feeds on mesopelagic cephalopods and their distribution is thought to be related to food supply (Waring *et al.* 1993, Jaquet 1996).

Figure 6.12 - Sightings of Sperm whales in the SEA 4 area (source Hammond et al. 2003)



All sperm whales sighted or stranded around northern Britain to date, have been males, as males migrate to high latitudes to feed. Sperm whales have also been recorded fairly regularly in Orkney and Shetland waters, with sightings and strandings reported in most months (Shetland Sea Mammal Group 2001, cited in Hammond *et al.* 2003). SAST surveys in waters north and west of Scotland, found the sperm whale to be the most frequently encountered species of large whale in the study area. As they are regularly recorded in deep waters in the SEA 4 area it is thought that the western edge of SEA 4 covers a migratory route for at least a portion of the north eastern Atlantic sperm whale population (Hammond *et al.* 2003). Acoustic studies by Swift *et al.* (1999) found that sperm whales are numerous in May and October and in deeper water to the north and west of SEA 4.

Figure 6.13 - Sightings of Risso's dolphins in SEA 4 (Hammond et al. 2003)



Risso's dolphin is less abundant than other dolphin species in the SEA 4 area, but is widely distributed throughout the shelf waters of Shetland, Orkney and the north of Scotland (Figure 6.13).They are capable of deep dives and, although elsewhere in their range, they are generally considered to be a deep water species, in Atlantic Frontier waters most sightings occurred in shelf waters shallower than 200m, with records along the shelf edge between July and December.

Although Risso's dolphin is regularly sighted in the SEA 4 area, the areas to the west of Scotland, particularly the waters surrounding the Outer Hebrides, are of greater importance for this species (Reid *et al* 2003). Risso's dolphins appear to be absent from Faroese waters with sightings from SAST surveys in the area occurring in the Scottish side of the Faroe-Shetland Channel (Taylor & Reid 2001).

6.8.2.1 Other species

Several other toothed whale species are present in the area. For some, such as the common dolphins, the area appears to be a marginal part of their habitat, inhabited only during a restricted part of the year (Hammond *et al.* 2003). For other species such as the beaked whales, the area could be an important part of their habitat. However, for species that are rarely seen and are thought to exist in small numbers such as these, the significance of the area is difficult to determine

Below is a brief synopses of cetaceans, which while infrequently seen, are thought to be present in the SEA 4 area.

Blue whales (*Balaenoptera musculus*) are not recorded by SAST/ESAS sighting surveys, although their spring migration route is thought to pass close to the Faroe Islands, with recent sightings including one in April 1990 and two in July 1995 (Bloch 1998). Seismic surveys in the Faroe-Shetland Channel have recorded definite identifications of blue whales in 1996 (two individuals) and 1997 (three individuals) together with a larger number of indeterminate species, identifications which may have included blue whales. The majority of definite blue whale sightings reported from seismic surveys throughout the UKCS were in the Faroe-Shetland Channel. SOSUS monitoring in 1996-97 showed pronounced seasonal variation throughout the Atlantic Frontier with peak detection rates in November and December. Movement patterns did not show any consistent pattern of directional movement. The available information suggests that blue whales are present in waters between Shetland and the Faroe Islands (east of SEA 4, in the waters of SEA 1), throughout the autumn, winter and spring.

Sei whales (*Balaenoptera borealis*) were recorded in deep waters to the south east of the Faroes when SAST began dedicated deep water surveys in the area. Generally considered a pelagic species, sei whales were found to form large groups particularly in the Faroe-Shetland Channel. A migratory species, sei's are thought to reach Scottish waters between April and July, leaving the area during August and September (Pollock *et al.* 2000, Taylor & Reid 2001).

Humpback whales (*Megaptera novaeangliae*) are uncommon in Atlantic Frontier waters, including waters of the SEA 4 area. There have only been four sightings since 1979; two of which were in the Faroe-Shetland Channel. Sightings occurred in summer months between May and September.SOSUS monitoring of six regions north and west of Britain and Ireland in 1996-1997 detected humpback whales between mid November and late March. From November through February groups of humpbacks were tracked moving from the north (approximately 63ºN), travelling on a south-westerly course to around 53ºN. However, no corresponding norhward migration was detected (Clark & Charif 1998). At least three humpback whales returned annually to inshore waters around the Shetland Islands between March and September from 1992 to 1997, although they were not sighted around Shetland in 1998 (Fisher 1999). Individual humpbacks have also been sighted in the Schiehallion area (west of Shetland), in June and July of 1998 (Fisher 1999). Three sightings from seismic vessels have been made in the Faroe-Shetland Channel in 1996, 1997 and 1998, with a further twenty-four observations (totalling 40 animals) recorded in Faroese waters between the months of April and October. Sightings of humpback whales have increased, particularly in the last few years.

The distribution of beaked whales (*Mesoplodon, Ziphius* and *Hyperoodon spp*.) are poorly understood worldwide. They tend to live in areas of deep water with ocean trenches and canyons and have long dive duration. They are generally difficult to identify and their inconspicuous surfacing behaviour may explain the limited number of sightings. SAST/ESAS surveys have recorded a total of 62 unidentified beaked whales from the area north and west of Scotland. These were thought to be *Mesoplodon* species together with one positive identification of Sowerby's beaked whale (*M. bidens*), south of Rosemary Bank (north-east of the Western Isles). Beaked whales were recorded throughout the year, with the exception of February-April and July, with a distinct peak in August. Beaked whale distribution throughout the Atlantic Frontier, north and west of Scotland is similar to that of the sperm whales, with a greater proportion of sightings occurring in water deeper than 1000m (Pollock *et al.* 2000). Sightings of unidentified beaked whales have also been recorded in the Faroe Bank, and Faroe-Shetland Channel. Sightings have mostly been of single animals with fewer observations of larger groups. Information on beaked whale diets and niche separation and distribution is given in MacLeod *et al*. (2003).

Other sightings of beaked whales west of Britain and Ireland, recorded by Evans (1992) include: Cuivier's beaked whale (*Ziphius cavirostris*), east of Orkney (1980), south of Ireland (1984 and

1987), off north west Ireland (1987) and off Skye (1988) and Sowerby's beaked whale in the Minches (1977). There have also been recorded strandings of Cuvier's, Sowerby's and True's (*Mesoplodon mirus*) beaked whales around the British coast (Evans 1992).

Northern bottlenose whales (*Hyperoodon ampullatus*), have been sighted in the Atlantic Frontier, and north and west of Scotland seven times, with a total of 17 animals seen, since 1979 (Pollock *et al.* 2000). These sightings included two sightings recorded by seismic survey in the northern Faroe-Shetland Channel in 1997. All SAST records of this species have occurred over deep water and the distribution in the north Atlantic is known to centre in cold deep waters near or seaward of the 1000m isobath (Reeves *et al.* 1993). This species is thought to migrate northwards from low latitudes in the spring, returning south from polar waters in autumn. However, catches of bottlenose whales in the Faroes have occurred throughout the year, suggesting that some individuals are non-migratory (Bloch 1996).

Bottlenose dolphins (*Tursiops truncatus*) are generally uncommon in the SEA 4 area (Pollock *et al.* 2000). They have been recorded in coastal shelf waters to the north east of the Western Isles, south of Shetland and off the north east Scottish coast between April and August. They have also been recorded in offshore groups along the continental shelf edge close to the 1000m isobath. Although there is a resident population in the Moray Firth, it is likely, but as yet unproven, that bottlenose dolphins in the Atlantic Frontier region are from an offshore population, and not from the resident and semi-resident populations in the Moray Firth and elsewhere around the UK coast.

Common dolphins (*Delphinus delphis*) are occasional summer visitors to the SEA 4 area (Hammond *et al.* 2003). They have been recorded by SAST during the survey of the Atlantic Frontier and the area north and west of Scotland. Only three sightings were recorded north of 60ºN, with the most (approximately 98) sightings concentrated around 59ºN in shelf waters, west of the Western Isles. The majority of sightings were in deep waters over or beyond the 1000m isobath (Pollock *et al.* 2000). SAST surveys of waters around the Faroe Islands recorded one sighting of four dolphins over the eastern side of the Faroe-Shetland Channel in November1997 (Taylor & Reid 2001).

6.8.3 Seal distribution and abundance

Three species of pinniped have been recorded within the SEA 4 area; harbour (or common) seals (*Phoca vitulina*), grey seals (*Halichoerus grypus*) and hooded seals (*Cystophora cristata*).

Harbour seals are one of the most widespread pinniped species, occurring throughout the temperate and subarctic waters of both the North Atlantic and North Pacific (Bigg 1981). The harbour seal is a resident breeder within the SEA 4 area and is distributed around all the coasts of the north west of Scotland and the offshore islands. In the North Sea, this species hauls out on tidally exposed areas of rocks, sand banks or mud.

Pupping occurs on land from June to July, therefore females and pups spend a high proportion of their time ashore during this period. As the annual moult is centred around August and extends into September, and moulting seals spend a high proportion of time ashore, from June until September harbour seals are ashore more often than at other times of the year.

Despite there being four subspecies of harbour seal, only the eastern Atlantic seal, *Phoca vitulina vitulina* occurs in the SEA 4 area. Counts of seals hauled out on land during the moulting season (August) only represents approximately 60-70% of the total eastern Atlantic population, a minimum estimation of which is around 70,000 individuals. It is estimated that 18% of this subspecies breeds on the north coast of Scotland and in Orkney and Shetland. Table 6.7 shows the minimum estimates of population size for these areas based on aerial surveys of animals hauled out on land during the annual moult or the pupping season.

Table 6.7 Counts of harbour seals in Orkney, Shetland and North coast of Scotland

Area	Count (Year)
Orkney	7800 (2001)
Shetland	4900 (2001)
North Coast	265 (1997)

Source: Hammond et al. 2003.

Harbour seals are widely distributed around most of the coasts of Orkney and Shetland. At sea, distribution of harbour seals is constrained by the need to periodically return to land. As a result, it was thought that harbour seals were unlikely to be found more than 60km from shore. However, recent satellite telemetry studies have shown that harbour seals from Scotland, Denmark and the Netherlands are widely distributed across the North Sea. Despite the lack of direct comparable data for harbour seals in the SEA 4 area, it is highly probable that similar offshore movements occur around northern Scottish coasts. If harbour seals inhabiting Orkney, Shetland and the north coast of Scotland exhibit similar foraging habits to those in the central North Sea, as expected, harbour seals are likely to be distributed over much of the SEA 4 area, with densities highest on southern areas over shallower waters (Hammond *et al.* 2003).

There are three recognised populations of grey seals: the north west Atlantic; the Baltic and the north east Atlantic (primarily offshore islands around the British Isles, but also in Iceland, the Faroe Islands, France, the Netherlands, central and northern Norway and around the Kola peninsula in Russia). They haul out on land between foraging trips and for breeding, with timing of pupping in northern Britain occurring from October to November, while the annual moult occurs in February and March. Breeding populations of grey seals in Northern Ireland, the Western Isles, Orkney, Shetland and the north west Scottish mainland are of international importance, comprising about 40% of the world population (Thompson 1992), while the status of the Faroes population is unknown (Mikkelsen & Haug 1999).

Since the 1960s the British grey seal population has increased annually by approximately 6% with its current size estimated at between 130,000 and 140,000 individuals. Approximately 63,000 are associated with the colonies in Shetland, Orkney and the North Scottish coast and North Rona. Table 6.8 summarises information on the estimated population size of grey seals breeding in areas adjacent to the SEA 4 area. Abundance estimates are expressed as pup population and total non-pup population.

Table 6.8 - Numbers of grey seal pups born in SEA 4 and adjacent areas

Area	Pup production (year)	Total production
North Coast	900 (2000)	2760
Orkney	17,500 (2001)	54000
North Rona	1,050 (2001)	3200
Shetland	1000 (1977)	3100
Faroe Islands	Unknown (some hundreds)	Approximately 4000 (1966)

Source: Hammond et al. 2003

From October to December and again in February and March, most of the grey seal population will be on land for several weeks. As a consequence, densities at sea are likely to be lower during these periods than at other times of the year. Tagging studies of pups have shown that young seals disperse widely in the first few months of life, with pups tagged in the UK being recaptured or recovered along the North Sea coasts of Norway, France and the Netherlands (Wiig 1986).

SAST/ESAS surveys recorded grey seals most frequently in shelf waters with rare observations in water deeper than 200m. Grey seals are known to make long foraging trips from haul out sites (Thompson *et al.* 1996) and to make trips from the UK to the Faroe Islands (Boyd & Campbell 1974, McConnell *et al.* 1999).

Hooded seals are found throughout the northern North Atlantic and are regarded as comprising two separate groups: the Greenland sea stock and the north west Atlantic stock (Reijnders *et al.* 1997a cited in Hammond *et al.* 2003). Hooded seals breed on pack ice and the nearest breeding population to SEA 4 is around Jan Mayen, 900km north of the Faroe Islands, with an estimated population of *c.* 250,000 animals (Reeves *et al.* 1993). In May and June of 1997 SAST/ESAS recorded two sightings of individual hooded seals in deep water north of Shetland, followed by further sightings in all seasons. They have also been sighted in Faroese coastal waters and regularly observed in the salmon fishery *c.*300km north of the Faroes (Dánjalsson 1960, Reinart 1982). Based on satellite telemetry data, hooded seals observed in SEA 4 are likely to be members of the Jan Mayen stock. Unfortunately there are no reliable estimates of the proportion of the population using the SEA 4 area (Hammond *et al.* 2003).

6.8.4 Ecological importance

There is relatively little information on the ecology of cetaceans in the North Sea and the Atlantic Frontier (Hammond *et al.* 2003). In Scottish waters harbour porpoise appears to feed mainly on fish found on or near the seabed, with the main prey species (identified in samples recovered mainly from fishing nets from the Scottish east coast in the 1960s) being herring, sprats, whiting, sandeels, cod, Norway pout and other gadoids, as well as decapod shrimps (Rae 1965, 1975). Samples collected from Scottish waters between 1992 and 1994, yielded mainly small gadoids and sandeels (Santos *et al.* 1994). Greater Argentines were also recovered from at last six animals around Shetland (Martin 1995). Samples from fifty animals stranded or bycaught in the North Sea between 1995 and 2002 showed the diet to comprise 90% whiting and small amounts of herring, sandeels, sprat and cod (SMRU/IOZ unpublished data).
Over the past 40 years there has been some evidence that the harbour porpoise diet has changed from one composed mainly of herring to the current diet dominated by whiting. Harbour porpoise are probably the most numerous marine mammals in the SEA 4 area, with an estimated population of around a quarter of a million animals in the North Sea, and densities around Shetland among the highest anywhere in the north east Atlantic. Total annual fish consumption is likely to run into hundreds of thousands of tonnes for the North Sea region as a whole. The significance of this species' predation from an ecological perspective has not been assessed, nor has the importance of the SEA 4 with respect to the entire North Sea.

Minke whale are known to feed on various fish species including herring, cod saithe haddock and sandeels. They adopt a variety of feeding methods and in Scottish waters, feeding minke whales in late summer can be associated with various gull species (Reid *et al* 2003).

White-beaked dolphins take whiting and other cod-like fish, sandeels, herring and octopus in Scottish waters. The diet of Atlantic white-sided dolphins in the SEA 4 area is unknown as they tend to occur in the deeper waters of the area. Elsewhere, herring, mackerel, horse-mackerel, silvery pout and squid have all been recorded as prey species. This suggests a pelagic mode of feeding. Within the SEA 4 area, mackerel and squid would both be expected in deep water areas.

Killer whales are frequently found around Shetland and further north and west in deeper waters. They are thought to prey upon seals around haul out sites in Shetland and possibly offshore, as well as feeding on mackerel (Fisher & Brown 2001). Long-finned pilot whales are believed to feed primarily on cephalopods. The diet of fin whales in the SEA 4 area is unknown. Elsewhere their diet consists of both pelagic crustaceans and small schooling fish such as herring, capelin and sandeels. Sperm whales are also predominantly reported from deep water areas and it is generally assumed that their diet in the SEA 4 area is likely to consist mainly of squid. There is nothing known of the Risso's dolphin feeding habitats or foraging strategies in the SEA 4 area, but they are presumed to feed mainly on squid (Hammond *et al.* 2003).

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 the SEA 4 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 (Hammond *et al.* 2003).

Harbour seals, the smaller of the two pinniped species that breed in Britain are important marine predators in coastal waters. In Shetland, their diet was found to consist of gadids (53%), sandeels (28%) and pelagic fishes (14%), with whiting and saithe the dominant gadids taken. Diet varies seasonally and from region to region; with gadids important in winter and sandeels important in spring and early summer. The main pelagic species, herring, garfish and mackerel, were important in late summer and autumn (Hammond *et al.* 2003).

Although there are no published estimates of prey consumption by harbour seals in the SEA 4 area, they do require about 304kg per day, depending on the prey species. Based on estimates of the population in the SEA 4 area (approximately 21,000), an approximate estimate of annual consumption of prey by harbour seals in the SEA 4 area would be in the region of 11,000-15,000 tonnes. It must be stressed that there are no confidence intervals with this estimate, which therefore should be treated with caution.

Within SEA 4, previous studies showed that harbour seals moved only to alternative haul out sites within a range of 75km and foraged within 60km of their haul out sites. However, recent studies have shown that this species forage much further offshore than previously thought, up to 200km from land. Therefore harbour seals are capable of foraging over much of the SEA 4 area.

Grey seals are also important marine predators in the North Sea. In Orkney, their diet comprises primarily of sandeels (almost 50%), whitefish and flatfish but their diet varies seasonally and from region to region. The average daily requirement of a grey seal is approximately 7kg of cod or 4kg of sandeels. Using a population distribution model and diet composition information, the estimated consumption of prey in SEA 4 is approximately 40,000 tonnes, almost 50% of which is sandeels. As the confidence intervals cannot be calculated for this figure it should be treated with caution.

It should also be noted that these consumption estimates assume that diet composition has not changed in recent years. However, the size of fish stocks in the North Sea are known to have changed and it is likely that the grey seal diet composition has also changed.

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. Long distance travel included visits to Orkney, Shetland, the Faroes and far offshore into the eastern Atlantic. Foraging destinations at sea were often localised areas characterised by a gravel/sand seabed sediment, the preferred burrowing habitat of their preferred prey species, sandeels (Hammond *et al.* 2003). Foraging activity in the SEA 4 area is concentrated in the southern half of the area, closest to haul out sites, therefore the ecological impact of seal predation may be greater within coastal zones rather than further offshore.

There are no published data on the diet of hooded seals in the SEA 4 area. As a result there are no estimates of probable prey consumption within this area. From seismic surveys and satellite transmitter data it appears likely that substantial numbers move into the north western sections of SEA 4 to forage.

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. Since 1993, work by SMRU has been targeted at determining accidental catch (bycatch) rates of marine mammals in several fisheries in UK waters.

Fishing vessels from several EU countries exploit the SEA 4 area and a lack of detailed information on the activities of these vessels hinders assessments of the overall scale of bycatches in the area.

Marine mammal bycatch in other areas are primarily associated with gill and tangle nets and certain specific types of trawling, with trawling for pelagic species particularly linked to marine mammal bycatch in some parts of the world (Hammond *et al.* 2003). However, despite this general trend, an ongoing study of cetacean bycatch in pelagic trawling in the North Sea and in waters to the west of Scotland has not, so far, revealed any potentially significant conservation issues (SMRU unpublished data).

The only other current significant threat to marine mammals from fishing gear stems from the use of static nets, most notably bottom set gill and tangle nets. These nets ensnare bottom feeding cetaceans and seals 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.

Harbour porpoises are known to be taken in bottom set gill and tangle nets. A predominantly bottom feeding species, the harbour porpoise appears to be particularly vulnerable to accidental entanglement in such nets. A typical bycatch rate is approximately one porpoise in every 70-420 net trawls, depending on the type of fishery. Within the SEA 4 area, gillnet fisheries are limited in scale compared with some other areas of the north east Atlantic. In the past, locally based vessels have operated gill and tangle nets for dogfish, cod and monkfish in the SEA 4 area, while English and Danish vessels also fish on Papa Bank for cod and other species. There are larger freezer netting vessels working deeper waters, further offshore, for monkfish and certain deepwater fish species. However, marine mammal bycatch has not been monitored in these offshore vessels. Bycatch of other small cetacean species in the North Sea and the SEA 4 area have been recorded very rarely and present information suggests bycatch rates are unsustainable only for harbour porpoises .

Tags returned from seals found in fishing gear have been used to estimate the minimum level of seal bycatch mortality. Hall *et al.* (2001) estimated that a minimum of approximately 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 (Hammond *et al.* 2003).

6.8.6 Conservation framework

Marine mammals are afforded protection under a wide range of conservation legislation. All cetacean species are listed on Annex IV (Animal and Plant Species of Community Interests in Need of Strict protection) of the European Commission's Habitats Directive. Annex IV prohibits the keeping, sale or exchange of such species as well as the 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. EU member states 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. Although no candidate SACs have been established for the harbour porpoise, the identification of SACs for this species is still under consideration (JNCC website 2003, Hammond *et al.* 2003). A number of terrestrial candidate SACs have been established for grey and harbour seals around the coast of the UK. There have also been a number of marine SACs identified in the SEA 4 area which cite either the grey or harbour seal as the Annex II species that are a primary reason for selection of the site (Table 6.9)

Table 6.9 Candidate SACs in the SEA 4 area for common and harbour seals

Site	Species	Description
Mousa (Shetland)	Common Seal	Exposed rocky island supports one of the largest groups of common seal in Shetland and is one of the most northerly groups in the UK
Yell Sound coast (Shetland)	Common seal	The most northerly UK site selection for this species, the rocky shores & islands support a colony representing >1% of the UK population
Sanday (Orkney)	Common seal	Site supports largest group of this species at any discrete site in Scotland. Breeding group represents >4% of the UK population
Faray & Holm of Faray (Orkney)	Grey seal	Islands support second-largest breeding colony in the UK contributing to approx. 9% of the annual UK pup production
North Rona	Grey seal	This remote and exposed island supports the third largest breeding colony in the UK representing approx. 5% of the annual pup production

Source: JNCC website (2003)

Under the Agreement on the Conservation of Small cetaceans of the Baltic and North Seas (ASCOBANS), provision is made for the 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. At present there are seven Parties to ASCOBANS (Belgium, Denmark, Germany, the Netherlands, Poland, Sweden and the United Kingdom) - the most recent signatory being Poland who acceded to the Agreement in January 1996. There are currently proposals to extend the ASCOBANS area (and name) on the 21st of August 2003.

In UK waters, all species of cetacean are protected under the Wildlife and Countryside Act 1981 and the Wildlife (Northern Ireland) Order 1985, while 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.

Under the Conservation of Seals Act 1970 grey and harbour seals in the vicinity of fishing nest can be killed to prevent damage to the nets or to fish in the nets. Although both species are protected during the breeding season: September-December for grey seals; June-August for harbour seals, licenses to kill seals may be granted for any time of the year for specific listed purposes. However, in July 2002 the Scottish Executive issued a Conservation Order in order to protect the Scottish seal population ahead of the anticipated spread of Phocine Distemper Virus (PDV) to Scottish waters. This Order is due to be in force until the 3rd of September 2004. The Order prohibits the killing, injuring or taking of harbour seals in Scotland and adjacent territorial waters and the killing, injuring or taking of grey seals in a defined area within the Moray Firth (subject to provisions of Section 9 and 10 of the 1970 Act).

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7. COASTAL AND OFFSHORE CONSERVATION

7.1 Overview

The SEA 4 area displays a wide variety of habitat types, from those of a coastal nature, such as tidal rivers, mud flats, sand flats, rocky reefs, sea cliffs and rocky shores, to those associated with the offshore environment. The predominant coastal features of the area are the high, rugged cliffs which stretch along much of the north coast of Scotland, and border many of the islands that make up Orkney and Shetland. These form an important habitat for large numbers of breeding seabirds which benefit from the protection afforded by the cliffs as well as the rich feeding grounds in adjacent waters.

Many of these coastal habitats and species have been protected through the designation of conservation sites as well as a range of conservation measures designed to protect individual species. At present, protection of important offshore habitats and areas important for a number of marine mammals and bird species is still at the discussion stage although areas containing habitats of potential conservation importance have been identified.

As well as containing important sites for nature conservation, the SEA 4 area also boasts sites of archaeological importance including the important Neolithic site of *'Skara Brae'*. Many areas of SEA 4 have also been recognised for their intrinsic scenic value.

7.2 Existing coastal conservation sites within the SEA 4 area

This section identifies those coastal and nearshore sites protected by international, national and local conservation designations. The coastal zone of SEA 4 has been divided into four sections:

- The Shetland Islands
- The Orkney Islands
- North Highland
- Other Islands (includes Fair Isle and the two small islands of Sule Skerry and Sule Stack, which lie 60km west of Orkney)

Much of the information for this section comes from the international site description and data sheets held on the JNCC website (http://www.jncc.gov.uk/idt/default.htm). The JNCC Coastal Directory series (Barne *et al*. 1996, 1997a, b) have also proved useful, as have the relevant Scottish Natural Heritage offices.

7.2.1 The Shetland Islands

7.2.1.1 Overview

The coastline of Shetland is long, intricate and dominated by rocky formations. Soft shorelines are rare and therefore have added environmental and ecological interest. It is a coastline of submergence and, as such, is best understood by assuming that a series of mountains, hills, ridges and valleys, normally glaciated, have been drowned by a post-glacial rise in sea level.

The coast contains large, diverse and spectacular lengths of cliff and cliff-top habitat of considerable landscape and nature conservation value. The highest vertical cliffs reach 370m at The Kame of Foula on the west coast of the island. The extensive cliff habitat provides important nesting sites for a large number of seabirds.

Overall, the coastline is among the most wave-exposed in Britain although in places the high west-facing vertical cliffs give way to sheltered inlets or voes. There are also numerous stacks and islets, some of them connected to the islands by thin stretches of sand or shingle, known as tombolos. Areas of sand dunes are small and few in number due not only to the steeply shelving offshore sea bed, which limits sand supply, but also the frequent exposure to gales which prevents significant accumulation.

7.2.1.2 Nature and landscape conservation

The Shetland Islands play host to a variety of important coastal habitats and species as well as bird areas which are protected under international, national and local designations (Table 7.1).

Table 7.1 – Coastal protected sites in Shetland	
International	
Candidate Special Areas of Conservation (cSAC)	9
Special Protection Areas (SPA)	11
Ramsar	1
Environmentally Sensitive Areas (ESA)	1
National and Local	
National Nature Reserve (NNR)	3
Sites of Special Scientific Interest (SSSI)	48
Geological Conservation Review Sites (GCR)	39
Royal Society for the Protection of Birds Sites (RSPB)	6
National Trust for Scotland Sites	7
National Scenic Area (NSA)	1
Preferred Conservation Zone (PCZ)	1
Marine Conservation Area (MCA)	4

Sites of international importance

The principal European designations are Special Protection Areas (SPAs) established under the 1979 EC Directive on the Conservation of Wild Birds and Special Areas of Conservation (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.

Shetland is internationally important for its cliff and island-nesting seabirds, particularly fulmar, gannet, arctic skua, kittiwake, puffin and guillemot. During the breeding season, the coastal waters near the breeding colonies support large concentrations of seabirds and sheltered areas of the islands are important for wintering birds, especially eiders and black guillemot. The area is also important for migrant waterfowl in spring and autumn as it lies on the migratory flyway for birds moving between southern wintering areas and northern breeding grounds. There are a number of sites designated for their internationally important bird assemblages (Table 7.2).

Table 7.2 - Sites of international importance for birds in Shetland			
Site	**Area (ha)**	**Status**	**Conservation interest**
Sumburgh Head	39	SPA/IBA	Breeding seabirds
Lochs of Spiggie and Brow	141.5	SPA/IBA	Wintering wildfowl
Foula	1,323	SPA/IBA	Breeding seabirds and divers
Papa Stour	569	SPA/IBA	Breeding seabirds and waders
Ronas Hill-North Roe and Tingon	5470	SPA/IBA/ Ramsar	Breeding moorland- and sea-birds
Ramna Stacks and Gruney	11.6	SPA/IBA	Breeding seabirds
Otterswick and Graveland	To be confirmed	SPA	Breeding divers
Hermaness, Saxa Vord and Valla Field	1037.7	SPA/IBA	Breeding seabirds and divers
Fetlar	2594.9	SPA/IBA	Breeding seabirds
Noss	343.8	SPA/IBA	Breeding seabirds
Mousa	198	SPA/IBA	Breeding seabirds

Shetland also supports a range of important coastal and marine habitats as well as a number of non-avian species of international conservation importance. Marine habitats include the extensive bedrock and boulder reefs surrounding Papa Stour and the sheltered and species-rich inlets and lagoons of Sullom Voe and the Vadills. Yell Sound supports the highest density of otters in Shetland and the exposed rocky island of Mousa provides an important breeding and pupping site for one of the largest groups of common seal in Shetland.

Table 7.3 provides details of the coastal and marine cSACs in Shetland. 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.

Table 7.3 - cSACs in Shetland			
Site	**Area (ha)**		**Qualifying features**
The Vadills	62.4	-	Coastal lagoons
Papa Stour	2076.7	-	Reefs and submerged or partially submerged sea caves
Tingon	569.3	-	Blanket bogs
Ronas Hill-North Roe	4900.9	-	Oligotrophic to mesotrophic standing waters with vegetation of the *Littorelletea uniflorae* and/or of the Isoëto-Nanaojunctea
		-	Natural dystrophic lakes and ponds
		-	Alpine and boreal heaths
		-	Blanket bogs
Sullom Voe	2698.5	-	Large shallow inlets and bays
Yell Sound Coast	1540.5	-	Otter *Lutra lutra* and common seal *Phoca vitulina*
Keen of Hamar	38.5	-	Calamarian grasslands of the *Violetalia calaminariae*
		-	Calcareous and calcshist screes of the montane to alpine levels (*Thlaspietea rotundifolii*)
North Fetlar	1584.4	-	European dry heaths
		-	Alkaline fens
Mousa	530.6	-	Common seal *Phoca vitulina*

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 their objectives. The Shetland Islands ESA was designated in 1987.

Sites of national and local importance

National conservation designations provide underpinning protection for most of the European sites, as well as safeguarding sites of national importance. These sites include National Nature Reserves (NNRs) and 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, non-government organisations (NGOs), including the National Trust for Scotland and the RSPB, also protect a range of coastal sites on Shetland.

The nature conservation importance of coastal waters around Shetland has been recognised by the identification of four Marine Consultation Areas (MCAs). These sites are "considered to be of particular distinction in respect of the quality and sensitivity of their marine environment". Whilst not a statutory designation, SNH wish to be consulted over proposals for developments in MCAs.

National Scenic Areas (NSAs) form the basis of statutory landscape conservation in Scotland and are designed to conserve the best of Scotland's landscapes. An NSA extends over a number of the islands and covers a total area of 11,600ha. Similarly, a fragmented Preferred Conservation Zone (PCZ) covers much of the coast. A number of Geological Conservation Review sites are also present.

7.2.2 The Orkney Islands

7.2.2.1 Overview

The group of islands forming the Orkney archipelago is generally low with gentle slopes and rounded topography. The most southerly island lies less than 10km from the Scottish mainland. The exception is the west Atlantic coastline of the main island (Mainland) and Hoy, which is characterised by some of the most spectacular cliff and rock formations in Britain.

There are almost ninety islands and numerous rocks and skerries, all of which are separated by shallow and often narrow strands and inlets. Some of these, in response to their position between different tidal regimes in the Atlantic, North Sea and Pentland Firth, have strong tidal currents.

The eastern coasts of many of the islands are predominantly rocky shorelines interspersed with sandy and shingle beaches and sand dunes. Many of the shingle beaches are important for migrant and wintering waders. Along the west coast of Mainland there are numerous geos and caves, features also found on other islands within the archipelago. Many of the islands support internationally important numbers of both common and grey seals, and the otter is also common in coastal and inland waters.

Estuarine habitat is limited in Orkney but remains undisturbed and supports breeding waders and wildfowl populations, as well as tern colonies. There are also a number of coastal lagoons although the only one of any significant size is the Loch of Stenness, the largest brackish lagoon in the UK.

7.2.2.2 Nature and landscape conservation

The nature conservation importance of the Orkney coast is acknowledged through the designation of international, European and nationally recognised conservation areas (Table 7.4).

Table 7.4 – Coastal protected sites in Orkney	
International	
Candidate Special Areas of Conservation (cSAC)	5
Special Protection Areas (SPA)	11
Ramsar	1
World Heritage Site	1
National and Local	
Sites of Special Scientific Interest (SSSI)	22
Geological Conservation Review Sites (GCR)	14
Royal Society for the Protection of Birds Sites (RSPB)	8
Scottish Wildlife Trust (SWT)	2
National Scenic Area (NSA)	1
Local Nature Reserves (LNR)	1
Preferred Conservation Zone (PCZ)	1

Sites of international importance

The Orkney Islands are internationally important for breeding seabirds and wintering waterfowl. Seabirds colonise much of the coastline with some sections housing contiguous colonies, while the nearshore waters of the region hold vulnerable concentrations of seabirds and seaduck species such as eiders and long-tailed duck throughout the year. A number of Orkney sites are designated for their internationally important bird assemblages (Table 7.5).

Table 7.5 - Sites of international importance for birds in Orkney

Site	Area (ha)	Status	Conservation Interest
Pentland Firth Islands	170.5	SPA/IBA	Breeding seabirds
Switha	57.4	SPA	Wintering wildfowl
South Walls and Switha	57.4	IBA	Breeding seabirds, waders and wintering geese
Hoy	9499.7	SPA/IBA	Breeding falcons and seabirds
Marwick Head	8.7	SPA/IBA	Breeding seabirds
Rousay	633.4	SPA/IBA	Breeding sea and moorland birds
South Westray Coast	530	IBA	Wintering waders
West Westray	350.6	SPA/IBA	Breeding seabirds and breeding waterbirds
Papa Westray (North Hill and Holm)	245.7	SPA/IBA	Breeding seabirds
Calf of Eday	238	SPA	Breeding seabirds
Eday	238	IBA	Breeding seabirds
East Sanday Coast	1515	SPA/Ramsar	Wintering seabirds and waders
East Sanday	1515.2	IBA	Wintering seabirds and waders
Auskerry	102	SPA/IBA	Breeding seabirds
Copinsay	125.4	SPA/IBA	Breeding seabirds

Orkney supports a large and diverse spectrum of marine and coastal habitats in addition to nationally scarce species, with many reaching the most northern limits of their distribution. Marine habitats between the islands include areas of bedrock, boulders, gravel and sand with occasional deposits of mud. Biogeographically, Orkney lies at the boundary between the rich marine life of the western British Isles and the less diverse area of the North Sea. Those areas of international importance for habitats and/or non-avian species are described in Table 7.6.

Table 7.6 - cSACs in Orkney

Site	Area (ha)	Qualifying features
Hoy	9499.7	- Vegetated sea cliffs of the Atlantic and Baltic Coasts - Natural dystrophic lakes and ponds - Northern Atlantic wet heaths with *Erica tetralix,* alpine and boreal heaths - Blanket bogs
Loch of Stenness	791.9	- Coastal lagoons
Stromness Heaths and Coasts	635.8	- Vegetated sea cliffs of the Atlantic and Baltic coasts - European dry heaths
Faray and Holm of Faray	785.7	- Grey seal *Halichoerus grypus*
Sanday	10971.6	- Reefs - Common seal *Phoca vitulina*

World Heritage Sites are listed by UNESCO to provide recognition that a site is of "outstanding universal value" and also that the national Government has provided it with an especially high level of protection. The Heart of Neolithic Orkney is included as a World Heritage site and the citation includes coastal archaeological sites such as *'Skara Brae'*.

Sites of national and local importance

The Orkney coastline contains a number of areas designated as nationally and locally important, including 22 SSSIs scattered throughout the coastal region and a National Scenic Area covering a total of 14,800ha to the south west of the archipelago (extending across Hoy and West Mainland). To the north-east of the mainland there is also a Local Nature Reserve. The RSPB protect a number of coastal sites, and two Scottish Wildlife Trust (SWT) reserves support important bird populations (such as terns and skuas) and special habitats such as maritime heathland.

Landscape conservation is also represented by the designation of a number of Geological Conservation Review sites and a Preferred Conservation Zone, which exists as a fragmented area encompassing much of the Orkney coastline.

7.2.3 North Highlands

7.2.3.1 Overview

This coastline is defined as lying within the counties of Sutherland on the west and Caithness on the east, and is bounded by high spectacular cliffs, including Cape Wrath and Duncansby Head. Most of the coastline is open to the full exposure of the Atlantic Ocean but the eastern part looks across a narrow strait, the Pentland Firth, to the southern islands of Orkney. For the most part, the coast is characterised by cliff formations, including some of the tallest sea cliffs on mainland Britain. The limestone cliffs in the Durness area contain notches, benches and caves; the latter including Smoo Cave, one of the best known natural landmarks of the north coast. Many of the regions cliffs are colonised by seabirds, some in internationally important numbers.

Three large inlets, extending 10-12km inland, carve into the western part of the coast. The Kyle of Durness and Kyle of Tongue are extremely shallow with sand flats exposed at low water. In contrast, the subsea slopes of Loch Eriboll are steep and much of the seabed lies more than 30m below sea level. The shores of Loch Eriboll contain many examples of raised beaches and fossil cliffs.

To the east, the cliffs are further broken at Dunnet and Sinclair Bays, where there are fringing sand dunes up to 15m high and extensive areas of species rich dune plain or machair. There are also a number of small islands off the north coast, the largest being Stroma.

7.2.3.2 Nature and landscape conservation

The nature conservation importance of the north coast of Scotland is acknowledged through the designation of international and nationally recognised conservation areas (Table 7.7).

Table 7.7 – Coastal protected sites in the North Highlands	
International	
Candidate Special Areas of Conservation (cSAC)	5
Special Protection Areas (SPA)	3
Ramsar	1
National and Local	
National Nature Reserves (NNR)	2
Sites of Special Scientific Interest (SSSI)	21
Geological Conservation Review Sites (GCR)	20
National Scenic Area (NSA)	1
Preferred Conservation Zone (PCZ)	2
Marine Conservation Area (MCA)	1

Sites of international importance

The north coast of Scotland is home to a number of internationally important bird populations, such as puffin, guillemot and Leach's petrel. Several areas have been designated Special Protection Areas (SPA's) to provide protection for such species (see Table 7.8).

Table 7.8 – Sites of international importance for birds in the North Highlands

Site	Area (ha)	Status	Conservation Interest
Cape Wrath	1019.2	SPA/IBA	Breeding seabirds
Ciathness and Sutherland Peatlands	143539	Ramsar	Breeding waterfowl
North Sutherland Coastal Islands	221.1	SPA	Breeding seabirds and wintering wildfowl
Eilean Hoan & Eilean nan Ron	221.1	IBA	Breeding seabirds and wintering wildfowl
North Caithness Cliffs	557.7	SPA/IBA	Breeding seabirds, water birds and falcons

A number of sites have been designated candidate Special Areas of Conservation (cSACs), for containing important coastal habitats such as vegetated sea cliffs and a variety of dune habitats (Table 7.9).

Table 7.9 - cSACs in the North Highlands			
Site	**Area (ha)**		**Qualifying features**
Cape Wrath	1019.2	-	Vegetated sea cliffs of the Atlantic and Baltic coasts
Durness	1212.7	-	Fixed dunes with herbaceous vegetation ('grey dunes')
		-	Hard oligo-mesotrophic waters with benthic vegetation of *Chara* spp
		-	Alpine and subalpine calcareous grasslands
		-	Limestone pavements
Invernaver	294.5	-	Fixed dunes with herbaceous vegetation ('grey dunes')
		-	Atlantic decalcified fixed dunes (Calluno-Tlicetea)
		-	Dunes with *Salix repens* ssp *argentea* (*Salicion arenariae*)
		-	Coastal dunes with *Juniperus.*spp
		-	Alpine and boreal heaths
		-	Alpine and subalpine calcareous grasslands
River Borgie	32.7	-	Freshwater pearl mussel *Margaritifera margaritifera*
Strathy Point	203.6	-	Vegetated sea cliffs of the Atlantic and Baltic coasts

Sites of national and local importance

There are two NNRs at Invernaver and Dunnet Links and a number of SSSIs extend along the coast. The Kyle of Tongue NSA was established in 1980. Extensive areas of coastline are also protected as Preferred Conservation Zones and there are a number of Geological Conservation Review sites. Loch Eriboll is a Marine Consultation Area.

7.2.4 Other Islands

7.2.4.1 Overview

The two small and remote islands of Sule Skerry and Sule Stack lie in the North Atlantic, west of Orkney. Sule Skerry is about 60km from Orkney, while Sule Stack is another 8km to the south-west. Sule Skerry is the larger of the two islands and is low-lying and covered by peaty soil with rocky outcrops. Vegetation is limited by the combination of salt spray and seabird activity. Sule Stack is a higher, bare rock with no vascular plants.

Fair Isle lies about 40km south of Sumburgh Head, mid-way between Shetland and Orkney. There are steep cliffs on the north and west coasts whilst the southeast is lower lying. Most of the island is extremely exposed to wave action although the east coast is less exposed than the Atlantic west coast. Tidal streams are of moderate strength around the headlands but negligible elsewhere.

7.2.4.2 Nature and landscape conservation

Sites of international importance

Sule Skerry and Sule Stack SPA/IBA covers an area of 18.9ha and supports a large number of seabird species including petrels, auks and gannet, which feed in the waters off the north coast of Scotland. The site is also one of only seven known nesting localities in the EU for Leach's petrel.

Fair Isle SPA/IBA covers a total area of 561ha and provides a breeding ground for a number of birds including Arctic tern and the endemic Fair Isle wren. The sea cliffs of the island also qualify the area as a cSAC under the Habitats Directive. Fair Isle is also part of the Shetland Islands ESA and has also been awarded the Council of Europe Diploma, an accolade to acknowledge the European interest of the site and the quality of protection and management.

Sites of national and local importance

The islands of Sule Skerry and Sule Stack each contain a SSSI. Sule Skerry has the largest of the two at 16ha, whilst the Sule Stack site covers an area of 3ha.

The Fair Isle SSSI has been designated for its geological and ornithological interest. The island is a National Trust for Scotland site.

7.3 Species conservation within the SEA 4 area

In addition to the designation of specific conservation sites within the SEA 4 area, a number of individual marine species have been afforded protection. At a European level, a number of marine species including all cetacean species and otters, a number of fish species and a range of marine invertebrates are listed on Annex IV (Animal and Plant Species of Community Interest in Need of Strict Protection) of the Habitats Directive. Under this Annex, the deliberate capture, killing or disturbance of such species is banned, as is their keeping, sale or exchange.

Several marine species are also protected in UK waters under Schedule 5 of The Wildlife And Countryside Act, 1981. These include all cetacean species, otters, all turtle species, a range of fish including sturgeon, allis shad, twaite shad and basking shark, and a number of marine invertebrates.

The management and monitoring of protected species as well as many additional marine species, is co-ordinated through the implementation of individual and grouped species action plans under the UK Biodiversity Action Plan (http://www.ukbap.org.uk/Plans/index.htm).

7.4 Potential for coastal and offshore sites within the SEA 4 area

7.4.1 Overview

Currently, *The Offshore Petroleum Activities (Conservation of Habitats) Regulations 2001* regulates UKCS offshore oil and gas activities with respect to the Habitats and Birds Directives. However, initiatives at both national and European level are in the process of identifying selection criteria and potential offshore sites which may warrant protection. These initiatives include the Offshore Natura 2000 Project and OSPAR's Marine Protected Areas programme.

The JNCC has completed an assessment to inform the selection of Natura 2000 sites in offshore waters (Johnston *et al*. 2002). The report describes selection criteria and identifies potential areas which may qualify for protection.

A summary of this report, as well as a description of the OSPAR MPA initiative, was provided for SEA 3 (http://www.offshore-sea.org.uk/sea/dev/html_file/pdf2.cgi/TR_010_W.pdf). This current section will not re-examine issues covered by the SEA 3 review but will rather describe progress in identifying potential offshore conservation sites.

Progress in identifying offshore Natura 2000 sites

A more recent update on the selection of criteria and potential areas for SACs and SPAs is provided in the JNCC paper Johnston *et al.* 2003.

Following consideration of selection criteria and principles, areas of Annex 1 habitat within the 12-200 nautical mile zone have been classified into Group 1 or Group 2 depending (respectively) on the confirmation/suspicion of the presence of Annex I habitat, adequacy/inadequacy of biological information, and absence/presence of sites of such character in territorial waters (0-12nm).

It is noted that sites will need to be selected from Group 2 as well as areas of habitat in Group 1 to fully represent the range of marine habitat types under Annex I of the Directive in UK waters.

Darwin Mounds

In summer 2002, the JNCC formally submitted to DEFRA its recommendations that the Darwin Mounds should be a Special Area of Conservation (SAC). The area of sandy mounds on the Wyville Thomson Ridge currently supports the best known natural occurrence of the cold water coral, *Lophelia pertusa* in UK waters. Formal proposing of the site by the UK Government will proceed when regulations are in place to implement the EC Habitats Directive in UK offshore waters.

A public consultation on the Offshore Marine Conservation (Natural Habitats &c.) Regulations 2003 was launched by DEFRA in August 2003. This sets out the proposed Regulations to apply the Habitats and Birds Directives to the UK Continental Shelf and waters beyond 12 nautical miles over which the UK exercises sovereignty. The consultation document can be found on the DEFRA website (http://www.defra.gov.uk/corporate/consult/offshore-marine/index.htm).

The European Commission has, as of the 20th August 2003, adopted emergency measures immediately banning the use of bottom trawled gear over the Darwin Mounds. Under new measures adopted last December to reform the Common Fisheries Policy, the UK government requested Commission action because of the damage the gear is causing to the corals. The emergency measures are applicable for 6 months and will allow time for the Commission to adopt a Council Regulation permanently banning the use of the fishing gear concerned (EUROPA website).

Qualifying habitats and species in the SEA 4 area

As mentioned above, Johnston *et al.* (2003) identifies potential areas of Annex I habitat and the distribution of Annex II species in UK offshore areas. This report remains the main source of information regarding offshore sites and includes distribution maps which should be referred to for further information.

From the report, potential areas of 'reef' habitat relevant to SEA 4 include iceberg ploughmarks along the West Shetland Slope and Wyville Thomson Ridge; the Judd Deeps; Solan Bank; Turbot and Otter Banks, and areas around the Shetland Islands. Of the potential areas, Johnston *et al*. (2003), identify the Wyville Thomson Ridge as the only area of reef habitat within the SEA 4 area for which there is sufficient information to class it in Group 1.

Pockmarks with carbonate structures formed by leaking gases are the only features known to occur in UK offshore waters that may conform to the Annex I habitat 'Submarine structures made by leaking gases'. To date, a number of pockmark regions have been identified in the northern North Sea to the east of the SEA 4 area.

The SEA 4 area also supports a number of Annex II species for which offshore SACs may possibly be designated. These include grey seal, common seal, bottlenose dolphin and harbour porpoise. Further research is needed to clarify the offshore distributions of these species but it is likely, given the importance of the coastal regions of SEA 4 for seal breeding and haul out sites as well as our current knowledge of cetacean distribution, that offshore areas of SEA 4 may be protected in the future.

The importance of the coastal waters of SEA 4 for a large number of seabirds also make it likely that coastal SPAs in the region may be further extended into the marine environment and offshore areas important for feeding or overwintering may be designated.

Progress in identifying OSPAR Marine Protected Areas (MPAs)

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'* and an accompanying OSPAR Strategy. The objective being 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.

At a meeting in January 2003, in Dublin, the Biodiversity Committee published *Draft OSPAR Recommendations on a Network of Marine Protected Areas*. Once adopted by OSPAR, these Recommendations will help to establish marine protected areas in the OSPAR maritime area by 2010.

A Summary Record of the Dublin meeting including a list of threatened species and habitats can be found on the OSPAR website (http://www.ospar.org/eng/html/welcome.html).

A review of distinctive habitats and species as well as those of conservation interest in the OSPAR maritime area was produced by WWF in October 2002 (Gubbay *et al.* 2002). *The Offshore Directory – Review of a selection of habitats, communities and species of the north-east Atlantic* aims to provide a useful reference to those working towards marine habitat and species conservation and the identification, establishment and management of MPAs in the OSPAR maritime area.

7.5 Marine and coastal archaeological resources and sites

7.5.1 Overview

Information for this section has been taken from Dr Flemming's report *'The scope of Strategic Environmental Assessment of Continental Shelf Area SEA 4 in regard to prehistoric archaeological remains'*. The report focuses on prehistoric maritime archaeology and the potential resource available in SEA 4. Information relating to other elements of the SEA 4 archaeological resource has come from Historic Scotland, the Royal Commission on the Ancient and Historical Monuments of Scotland (RCAHMS) and a number of other sources, including UKOOA.

The present day SEA 4 coast contains a wealth of archaelgical sites dating back to prehistoric times, including standing stones, burial chambers (cairns), iron age forts (brochs) and neolithic farms. The sophistication of many of these sites suggests that earlier coastal settlements are likely to have existed in areas that have since been drowned by the sea. Archaeological evidence of these sites may exist in suitable areas of the present seabed.

There are also numerous wrecks within the SEA 4 area, a small number of which have been protected. The true number of military and civilian wrecks is unknown and likely to be significantly greater than those presently identified.

7.5.2 Coastal and offshore archaeological sites in SEA 4

There is evidence to suggest that Scotland's first occupiers settled on the coast (which at that time, roughly 9000 years BC, was tens of metres below the present sea level) and gradually moved inland as the Devensian icesheet retreated and the sea level rose. The present day SEA 4 coast is home to a significant number of Neolithic and Mesolithic structures dating as far back as 4600 years BP and it is possible that older structures exist in the surrounding waters of the continental shelf.

Prospective submerged archaeological sites (hotspots) in SEA 4 include:

- "Fossil" estuaries and river valleys.

- The flanks of banks and ridges which have been proven to have peat layers, or which are likely to have peat layers.
- Valleys, depressions, or basins with wetland or marsh deposits.
- Nearshore creeks, mudflats, and peat deposits.
- "Fossil" archipelago topographies where sites would have been sheltered by low-lying islands as the sea level rose.
- Niche environments in present coastal zones, wetlands, intertidal mudflats, lochs, and estuaries.
- Caves and rock shelters in re-entrant bays, fossil erosional shorelines, submerged rocky shores protected by other islands, or in archipelagos.
- Deposits of sediments formed within, or washed into rocky gullies and depressions.
- Coastal sites comparable by analogy to modern Inuit migratory sites, adjacent to sea ice, giving access to marine mammals as a food resource.

Strong current conditions, exposure to full North Atlantic storm conditions, thin sediment cover in many places, and large areas of exposed bedrock, make the exposed areas of the SEA 4 shelf statistically poor prospects for the survival of prehistoric deposits *in situ*, other than in submerged caves.

7.5.2.1 Coastal discoveries

The encroaching sea is an ever present threat to coastal sites in SEA 4 and led to the compilation of an extensive coastal database of archaeological sites by Dr Dawson (University of St. Andrews), in collaboration with Historic Scotland.

The database lists 845 recorded coastal archaeological sites on or extremely close to the shore of Shetland, of which 181 are prehistoric (earlier than 2000 years BP) and 37 date to 6,000-5,000 years BP. In Orkney, there are 744 recorded coastal sites, of which about 40 date to the 1st millennium BC, 20 to the 2nd millennium, 70 to the 3rd millennium, and 20 to the 4th millennium BC. On the north coast of Scotland, there are 498 recorded sites, of which only 13 are recorded as prehistoric, with promontory forts, cairns, shell mounds, and some cave sites.

Existing prehistoric sites include settlements such as the Neolithic farming complex at Knap of Howar which dates back to 4600 years BC. Defensive structures (such as Broch Mousa, the most complete example of an Iron Age broch) and tombs and burial grounds (such as the Quoyness Cairn on the Orkney Isle of Sanday which dates as far back as 2,900BP) are also found in the area.

Hundreds of reindeer horns found in the Cave of Creag nan Uamh, in Sutherland, have recently been dated between 44,000 and 22,000BP. It is uncertain how this accumulation was formed and if, indeed, it was caused by hominids. However, the animal remains are evidence of an abundant Palaeolithic food supply in the region.

7.5.2.2 Offshore Discoveries

The discovery of a single flint tool off the Viking Bank (150km north-east of Lerwick) has been the only deep water prehistoric find close to SEA 4. The discovery is unique not just for its depth, but also for its distance from the shore. The flint could be as old as 11,000BP and implications of such a find are discussed in Dr Flemming's report.

Research (carried out by Heriot Watt University and the Orkney Diving Centre) to detect submerged Neolithic or Mesolithic sites in Orkney is in its earliest stages. Discoveries include what appears to be a collapsed cave on the west coast of Mainland Orkney and a submerged stone structure in the Bay of Firth. Orkney is also one of the areas included in a University of Newcastle upon Tyne project to search for submerged early postglacial sites using GIS based predictive models.

National Monuments Record (NMR)

The National Monuments Record of Scotland can be accessed through the CANMORE database which contains details of many thousands of archaeological sites, monuments, buildings and maritime sites in Scotland. The database can be found on the Royal Commission on the Ancient and Historical Monuments of Scotland website (http://www.rcahms.gov.uk/canmoreintro.html).

A CANMORE search of the 'Maritime' records for the Orkney and Shetland Islands Council areas revealed 851 and 622 matches, respectively. The records are diverse and include a large number of sunken cargo, fishing and whaling vessels as well as military vessels and coastal defences.

Scheduled monuments

Scheduled monuments are protected under the *Ancient Monuments and Archaeological Areas Act 1979* and consent is normally required before any alteration or development can take place. A search of Historic Scotland's online database of scheduled monuments (http://www.historic-scotland.gov.uk/wwd_ancientmonuments) revealed a large number of monuments (almost 700) on Orkney and Shetland, although the majority of these were terrestrial in nature.

Two areas of Scapa Flow, containing seven wrecks (three battleships and four cruisers) of the German High Seas Fleet scuttled in 1919, are scheduled.

Wrecks

Designated wrecks

Two shipwrecks in the SEA 4 area have been protected under the *Protection of Wrecks Act 1973*. These are the *Kennemerland*, a Dutch East Indiaman which sank in December 1664 on Stoura Stack, Out Skerries, Shetland and the *Wrangels Palais*, a Dutch warship which sank in 1687 on the Out Skerries, Shetland.

War graves

The *Protection of Military Remains Act 1986* provides a means of protecting marine war graves (shipwrecks and aircraft). Under the Act, a number of wrecks (all war graves) have been designated as 'controlled sites'. Within the SEA 4 area, these controlled sites include *HMS Hampshire*, sunk off Orkney in 1916 with the loss of 650 lives; *HMS Vanguard*, sunk in Scapa Flow in 1917 with the loss of 667 lives; and *HMS Royal Oak*, sunk in Scapa Flow in 1939 with the loss of 833 men.

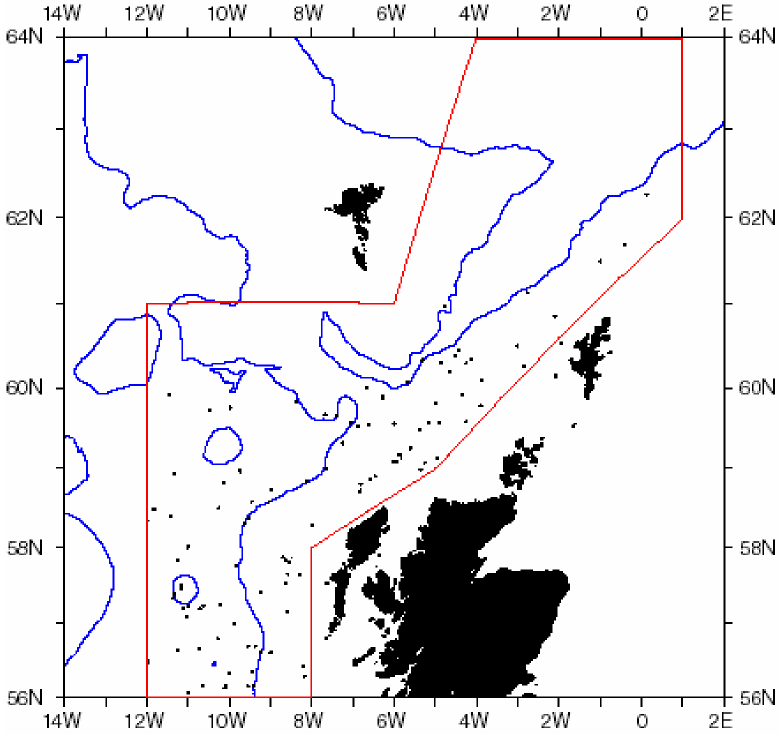
Wrecks in the SEA 4 area

Information relating to the locations of a large number of shipwrecks and aircraft losses within UK waters is kept by the UK Hydrographic Office. However, this database likely represents a small fraction of the actual number of shipwrecks and aircraft losses whose locations remain unknown.

As part of the 1996 and 1998 AFEN surveys of the Atlantic Margin, the UK Hydrographic Office provided information relating to the locations of known wrecks in the area. Given that the region known as the Atlantic Margin covers a large part of the SEA 4 area, the results are of relevance to the present study.

The AFEN study restricted the list of wrecks found in the area to those which might have a significant environmental effect, and therefore only the wrecks of large vessels, defined as being over 60 metres in length or over 1,000 gross tons were included. This resulted in a total of 112 wrecks of which 24 were sunk by U-boat in the First World War and 52 were sunk by U-boat in the Second World War (Figure 7.1).

Figure 7.1 – Location of significant wrecks located within the AFEN area, defined by the red lines. The 1000m isobath is shown in blue



(Source – AFEN CD-ROM).

7.5.3 Implications for Strategic Environmental Assessment

Information regarding the large number of coastal conservation sites within SEA 4 is available and has been compiled in the SEA 4 Conservation Report. Of considerable importance to SEA 4 are the ongoing programmes to identify offshore conservation sites.

The SEA 4 area contains a large number of known important coastal archaeological sites. However, the archaeological resource is likely to be much greater given that both offshore and coastal sites have yet to be discovered. Despite this, it is unlikely that the limited activity predicted following licensing of SEA 4 would adversely affect this resource.

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

7.6 Unique Science Priority Areas

Thiel (2002) proposed the concept of Unique Science Priority Areas (USPA) in recognition of science as a stakeholder in the consideration of the establishment of protected areas. Scientific research and monitoring projects would have the dominant rights in such areas (as distinct from nature protection). A European Deep-Sea Transect USPA was proposed covering a broad area to the southwest of Ireland where there has been a history of long-term scientific study. The proposed USPA extends beyond the Exclusive Economic Zone (EEZ) and thus would need the establishment of international agreements to allow its protection in this area. Gage (2003) commenting on the USPA proposal noted that a variety of other European USPAs could be proposed (including some within the SEA 4 area) but that a system of criteria was needed to allow such areas to be considered on the basis of the future value to science as opposed to nature conservation per se.

8 USERS OF THE SEA AND COASTAL ENVIRONMENT

8.1 Introduction

The SEA 4 area supports a range of different users and activities. The predominantly rural nature of much of the coast and unspoilt nature of the surrounding coastal waters has led to the development of an important mariculture industry, especially in Shetland. The fishing industry, whilst in decline, still remains important, both culturally and economically. Similarly, the region has played a central role in the development of the North Sea oil and gas industry over the last 30 years. Tourism is increasingly important with many visitors attracted by the dramatic and spectacular coastal scenery of the area.

8.2 Oil and gas

8.2.1 Overview

Historically, the area north and west of Shetland and Orkney has, in general, been too difficult from a technical perspective to develop. Consequently, there are currently only two producing fields, Foinaven and Schiehallion within the SEA 4 area, while consent to develop the Clair Field (75km west of Shetland) was granted in November 2001 (Figure 8.1). Phase 1 of the development will focus on 3 reservoir areas, which have an estimated 1.75 billion barrels of oil in place, 250 million of which are recoverable. Oil from the platform will be exported to the Sullom Voe terminal in Shetland via a pipeline, with gas either reinjected into the reservoir or exported by the new Magnus enhanced recovery pipeline.

The Magnus enhanced recovery pipeline currently transports surplus gas from the Foinaven and Schiehallion fields west of Shetland, to the Sullom Voe oil terminal where the gas is enhanced with natural gas liquids. A further pipeline transports the enhanced gas to the Magnus oilfield in the northern North Sea, where it is re-injected into the oil reservoir to enhance recovery of the remaining oil reserves (Figure 8.1).

The Sullom Voe and Flotta oil terminals provide facilities for the import of resources from developments to the east and west of the islands and there are also support facilities at Lerwick.

8.2.2 Management issues and initiatives

Atlantic Frontier Environmental Network (AFEN)

Full members of AFEN include the Department of Trade and Industry, the Scottish Executive and the Joint Nature Conservation Committee, as well as a number of oil and gas operators. The group has been instrumental in originating and focusing environmental studies in the Atlantic Frontier area (see AFEN 2000 & 2001).

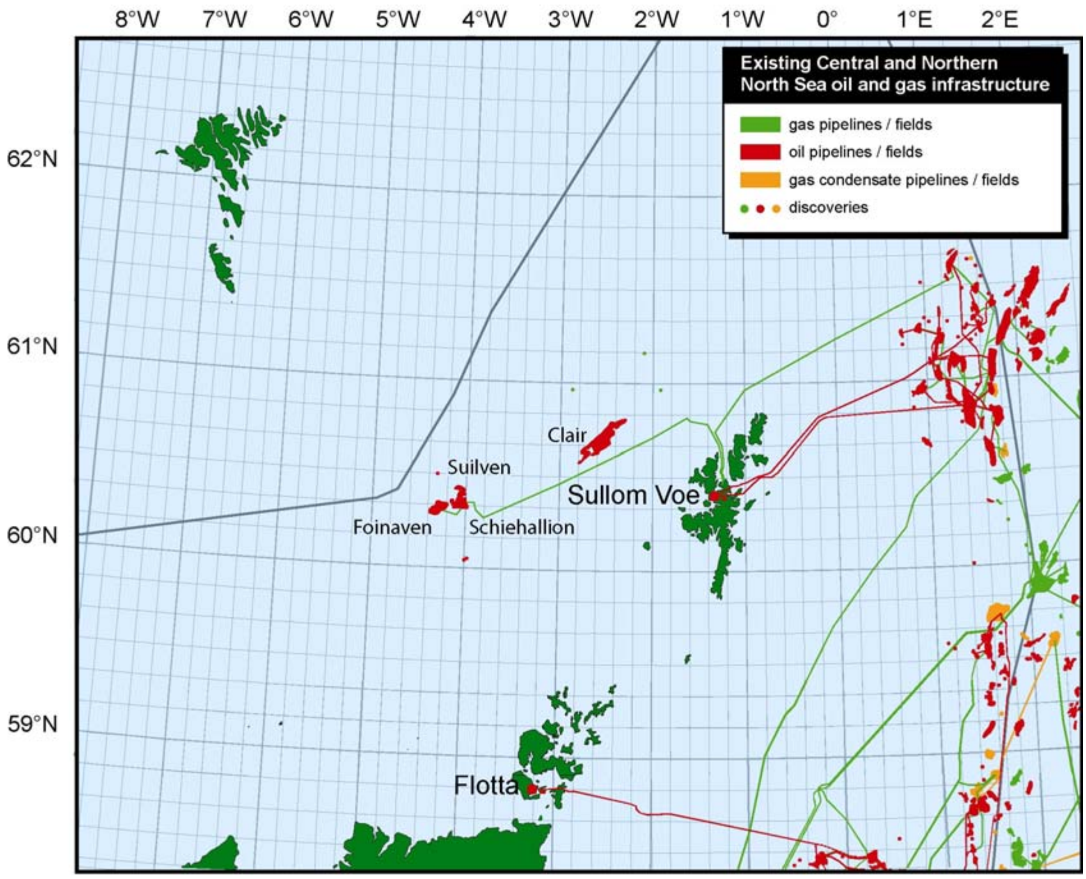
The Atlantic Frontier Environmental Forum was established to ensure that results from AFEN studies were distributed as widely as possible as well as ensuring that AFEN were addressing matters important to local communities.

Shetland and Orkney initiatives

SOTEAG (the Shetland Oil Terminal Environmental Advisory Group) was set up in 1977 to advise, monitor and report on the performance and the effect the oil terminal has on the Shetland environment.

The potential impact of the Flotta terminal on the Orkney marine environment led to the establishment of the Orkney Marine Biology Unit of the University of Dundee in the late 1970s. The Unit was contracted by Orkney Islands Council to carry out a programme of biological monitoring around the terminal from the 1970s until 1990. Since 1990 shoreline monitoring has been carried out by Orkney Islands Council and extensive work has been done on an environmental database which complements the Port Oil Spill Contingency Plan.

Figure 8.1 – Oil and gas infrastructure in the SEA 4 area



8.3 Fisheries

8.3.1 Overview

In terms of employment and economic revenue, fishing is an important industry in the SEA 4 area. Many of the rural coastal communities rely on small-scale coastal fishing whilst larger ports in the region service a sizable offshore fishing fleet (see Section 8.10.2).

Much of the information in this section is taken from the underpinning report on fish and fisheries in the SEA 4 area (Gordon 2003).

8.3.2 Activity in the SEA 4 area

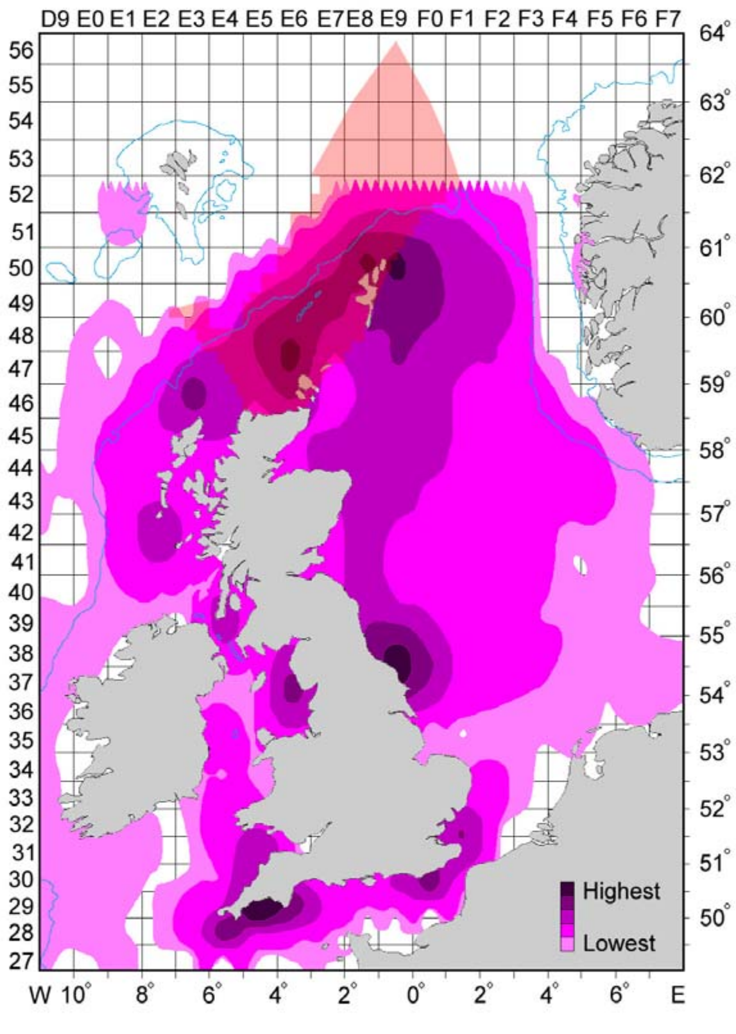
Demersal fishery

The mixed fishery targeting cod, haddock and whiting is one of the most important fisheries in the SEA 4 area. Although the greatest fishing effort takes place to the east of Shetland there is also fishing to the west of the islands throughout the year. The anglerfish (monkfish) is a major bycatch of the mixed demersal fishery as well as a target for specialised bottom trawls in deeper water.

The trawl fishery for saithe takes place in deeper water along the shelf edge and upper slope. In recent years a deep-water fishery for Greenland halibut has also developed in the transition zone between the warmer Atlantic and colder Norwegian Sea waters. Below the transition zone (*c.* 700m) there are no commercial fisheries and it is unlikely that any will develop due to the low fish biomass.

The bottom trawl fishery for *Nephrops* (Norway lobster) takes place throughout the year and in areas of muddy seabed. The most important location in SEA 4 is in an area called the Noup that lies to the north west of Orkney. Dredging for scallops is an important fishery where there is suitable sand and gravel seabed. There are scallop grounds around both Orkney and Shetland and especially to the north and west of Shetland. The demersal (excluding beam trawls) fishing effort by UK vessels is highlighted in Figure 8.2.

Figure 8.2 – Demersal fishing effort by UK vessels (Source: Gordon 2003)

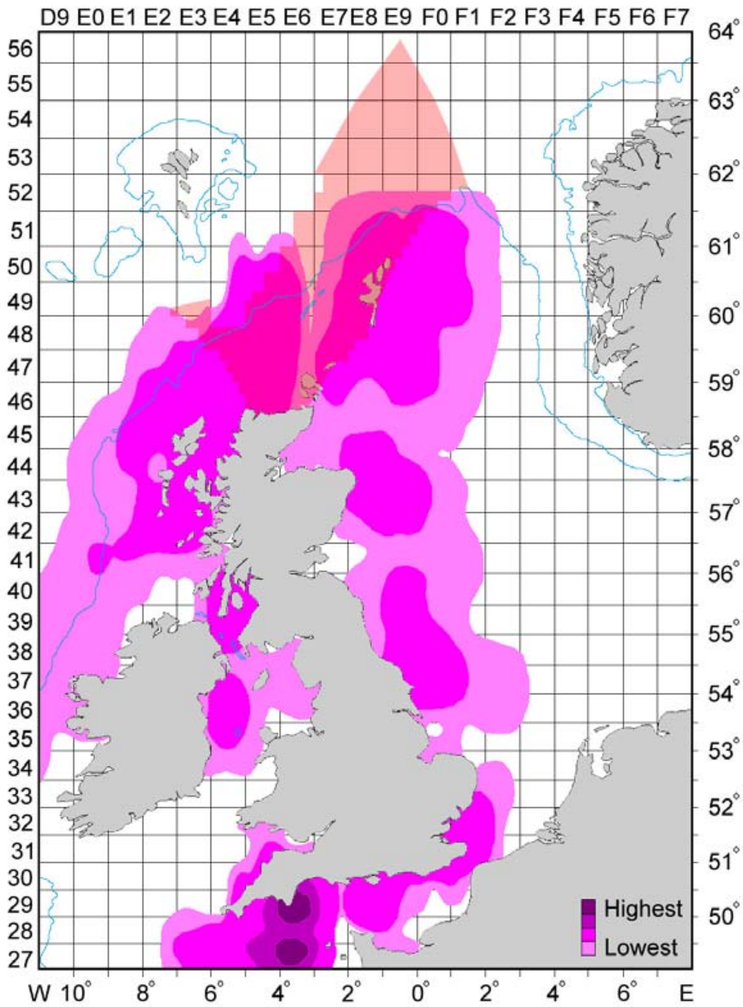


Pelagic fishery

The pelagic fisheries are more international than those for demersal species and tend to be prosecuted by larger vessels using purse seine and midwater trawling. The two largest fisheries, for herring and mackerel, are seasonal. The herring fishery takes place during the summer and autumn whilst the main mackerel fishery focuses on the southerly winter migration through the area.

The pelagic fishing effort is shown in Figure 8.3. The apparent division into two areas of greater effort is most likely an artefact of misreporting of pelagic catches between ICES Sub-areas IV and VI when quotas become restrictive.

Figure 8.3 – Pelagic fishing effort by UK vessels (Source: Gordon 2003)



Industrial fisheries

There has been a rapid expansion of the blue whiting fishery in the North East Atlantic and catches reached 1.7 million tonnes in 2001. The fishery targets spawning and juvenile fish along the upper continental slope.

The Norway pout fishery is mainly by Danish and Norwegian vessels and has declined in recent years. The Norway pout box prohibits fishing in areas around Shetland and Orkney.

The sandeel fishery was completely closed between 1991 and 1994 following a decline in recruitment and poor breeding success of sandeel-dependent seabirds. Since 1995 the number of vessels licensed to fish has been limited and the fishery is closed during June and July.

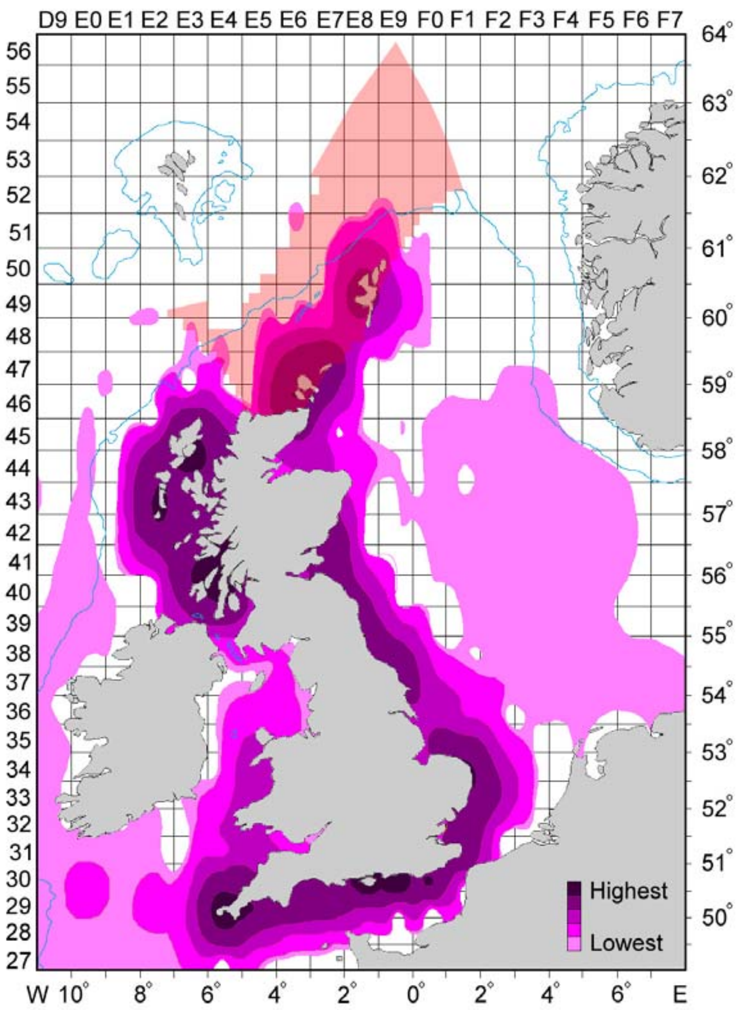
Static gear fishery

The Norwegian longline fishery for ling and tusk extends from the continental shelf off Norway, the Shetlands, the Hebrides, Ireland, the Faroes and the Rockall Bank.

Inshore creel fisheries occur in the SEA 4 area, particularly around Shetland where lobsters have been seriously depleted. As a result, effort has been transferred to other species such as brown, velvet and green crabs. There is also a small gill net fishery for anglerfish around Shetland.

The total fishing effort by static gear is high around both Orkney and Shetland (Figure 8.4).

Figure 8.4 – Static gear fishing effort (Source: Gordon 2003)



Note: Static gear fishing effort includes longline, bottom-set gill net and creel fisheries

Fisheries for migratory species

Salmon and sea trout migrate from the sea to breed in freshwater. In Scotland the fisheries for these species are of both commercial and recreational importance, with the most significant fisheries principally taking place outwith the SEA 4 area. Scotland's north coast supports a moderate salmon fishery, in contrast to the small rod and line catch fishery present in Shetland.

8.3.3 Management issues and initiatives

There is concern about the stocks of many of the fish species found in the SEA 4 region. 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 thus encourage stock recovery.

In December 2002, the European Commission Agriculture and Fisheries Council agreed to significant reforms of the Common Fisheries Policy (CFP). The new measures entered into force on 1 January 2003 and include the setting of multi-annual recovery plans, temporary recovery measures for cod and associated species through fishing effort limitations, and a range of measures to limit the fishing capacity of the EU fleet.

The Shetland Shellfish Management Organisation manages the inshore fisheries for shellfish around Shetland and has the right to regulate the fisheries for oysters, mussels, clams, lobsters, scallops, queens, crabs, whelks and razorshells. Discussions are in progress to establish similar management schemes for Orkney and the Highlands.

Salmon fisheries in Scotland are protected by the Salmon Act 1986, as amended by the Salmon Conservation (Scotland) Act 2001. This contains provisions for the conservation and sustainable management of salmon and sea trout through regulating permissible methods and times during which fishing is permitted.

8.4 Shipping

Nearshore areas of SEA 4, particularly around the Pentland Firth, Fair Isle Channel and the larger coastal ports, experience moderate shipping densities of between 1,000-5,000 vessels per annum. Further offshore, the region experiences lower shipping pressure equivalent to 1,000 vessels or less per annum. Since many of the vessels are involved in the transport of petroleum products, the risk of marine pollution has lead to the designation of a number of *Areas to be avoided* for tanker traffic (Figure 8.5).

The sensitivity of the marine and coastal environment of SEA 4 is also reflected by the potential designation of a number of Marine Environment High Risk Areas (MEHRAs) designed to protect marine areas of high environmental sensitivity at risk from shipping (Figure 8.5, DETR 1999).

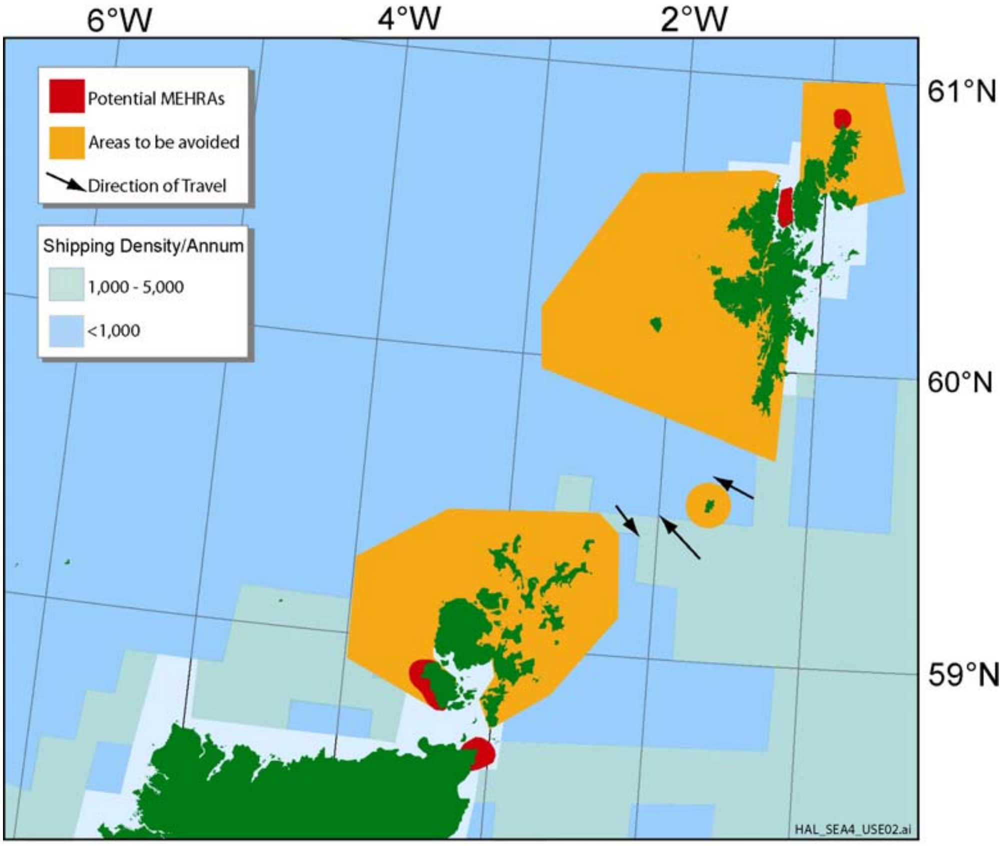
8.4.1 Management issues and initiatives

One of the main issues relating to shipping in the SEA 4 area is the environmental sensitivity of much of the coastal region and the risk of marine pollution from shipping activity.

Although shipping density is relatively low throughout the area, there are locations such as Sullom Voe Oil Terminal where levels are significant. Both Sullom Voe and Flotta Voe have well-developed procedures for vessel passage to and from the terminals.

The UK has obligations under two key international conventions concerned with protecting the marine environment from pollution; the MARPOL Convention (1973) and the OPRC Convention (1990). MARPOL (International Convention for the Prevention of Pollution from Ships) regulates the discharge of harmful substances from ships, while the OPRC Convention (Oil Pollution Preparedness, Response and Co-operation) requires ships, offshore installations, ports and harbours to have their own approved oil pollution contingency plans and to report pollution incidents when they occur.

Figure 8.5 – Shipping in the SEA 4 area



Note: MEHRA boundaries are shown as being offshore for illustrative purposes only.

Proposal for a Western European Waters PSSA

A number of European states including the United Kingdom submitted a proposal to the 49th session of the International Maritime Organisation Marine Environment Protection Committee (IMO MEPC) (July 2003) for an area of North Western European waters stretching from the Shetland Isles to Portugal to be designated as a Particularly Sensitive Sea Area (PSSA) (IMO website - http://www.imo.org/home.asp).

Guidelines on designating a PSSA are contained in resolution A.927(22) Guidelines for the Designation of Special Areas under MARPOL73/78 and Guidelines for the Identification and Designation of Particularly Sensitive Sea Areas. A PSSA is defined by the IMO as an area that needs special protection because of its significance for recognised ecological, socio-economic or scientific reasons and which may be vulnerable to damage by international maritime activities. Specific measures can be used to control the maritime activities in the PSSA, such as vessel routeing, and strict application of MARPOL discharge and equipment requirements for ships.

There are currently six designated PSSAs: the Great Barrier Reef, Australia (designated a PSSA in 1990); the Sabana-Camagüey Archipelago in Cuba (1997); Malpelo Island, Colombia (2002); around the Florida Keys, United States (2002); the Wadden Sea, Denmark, Germany, Netherlands (2002); and Paracas National Reserve, Peru (2003).

The MEPC approved in principle the proposal for the Western European Waters PSSA, subject to the area being reduced to bring the easterly line off the Shetlands Isles to the Greenwich meridian. The states proposing the measure also withdrew an earlier proposal to ban carriage of heavy fuel oil in single hull tankers in the PSSA and instead agreed that the Associated Protective Measures linked to the PSSA would, at this stage, concern a proposed 48-hour reporting rule for ships carrying certain cargoes entering the PSSA.

The Western European Waters PSSA will be considered for potential final designation by the MEPC in October 2004.

8.5 Mariculture

8.5.1 Overview

Farming for fin and shellfish species principally takes place along Scotland's western seaboard, with the Inner and Outer Hebrides and the Northern Isles providing the most favourable operational conditions. Shetland in particular, supports a large number of finfish and shellfish farming operations that provide important economic revenue to the islands.

8.5.2 Activity in the SEA 4 area

Finfish

Extensive numbers of salmon farms are found throughout Shetland and Orkney, with a small number along the north coast of Scotland. The many voes, inlets and firths around Shetland and Orkney provide good shelter and adequate water exchange for mariculture operations and the industry has become an important constituent of the local economy. Currently, there are approximately 174 finfish sites in Shetland (Pers. comm. M Holmes, Shetland Islands Council) and 33 on Orkney (Pers. comm. A Montgomery, Orkney Fish Farmers Association). In 2001, salmon farms on Shetland and Orkney produced 39,745 (29% of the Scottish total) and 5,588 (4% of the Scottish total) tonnes of fish respectively (FRS 2001a), and between them employed almost 370 people.

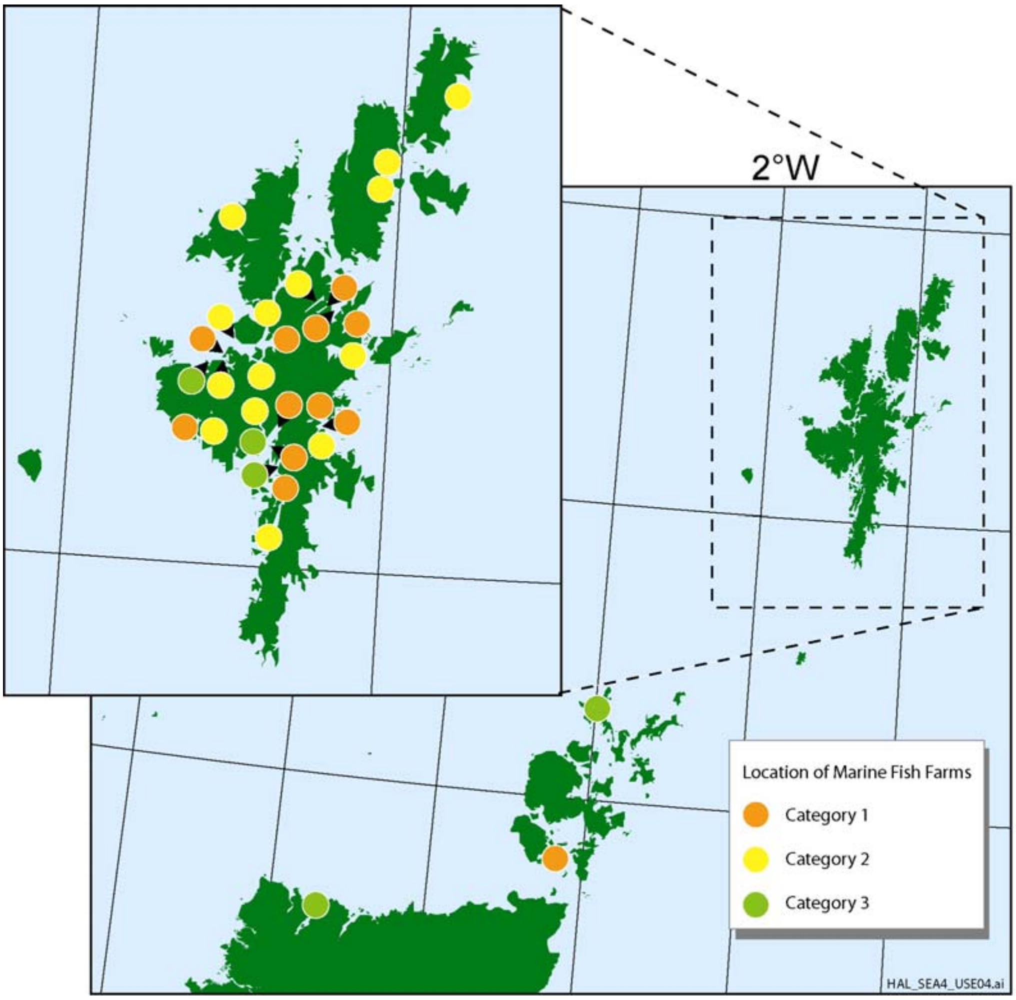
Shellfish

Mussels dominate Scottish shellfish production, with smaller volumes of Pacific oysters, queens, scallops and native oysters also produced. There are currently approximately 90 shellfish sites in Shetland (Pers. comm. M Holmes, Shetland Islands Council). In 2001, Shetland accounted for over 27% of Scotland's total mussel production (2,992 tonnes), an increase of more than 100% from previous years. Orkney shellfish farming is predominantly for Pacific oyster. Almost 30% of the people employed in the Scottish shellfish industry in 2001 worked in Shetland and Orkney (FRS 2001b).

8.5.3 Management issues and initiatives

The growth of mariculture, especially finfish farming in Scotland has lead to increased concern over associated pollution levels in many of the sheltered areas that support fish farms. The Scottish Executive has introduced locational guidelines for fish farms in an effort to inform the planning process and avoid further pollution. The location and categorisation of coastal waters with regard to finfish farming in the SEA 4 area are shown in Figure 8.6 (SEERAD 2003). Similarly, shellfish for human consumption are harvested from classified production areas (Figure 8.7; Food Standards Agency website). The sites marked on Figures 8.6 and 8.7 do not reflect the total number of finfish and shellfish sites within the region but rather the main coastal areas from which they have been produced.

Figure 8.6 - Location and categorisation of coastal waters in the SEA 4 area



8.5.4 Implications for Strategic Environmental Assessment

The *Braer* spill (which was related to the transport of crude oil rather than to the exploration and production of hydrocarbons) had particularly severe effects on the fish farming industry in the Shetland Islands. Experience 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. The incremental risk associated with SEA 4 related activities is considered to be very small.

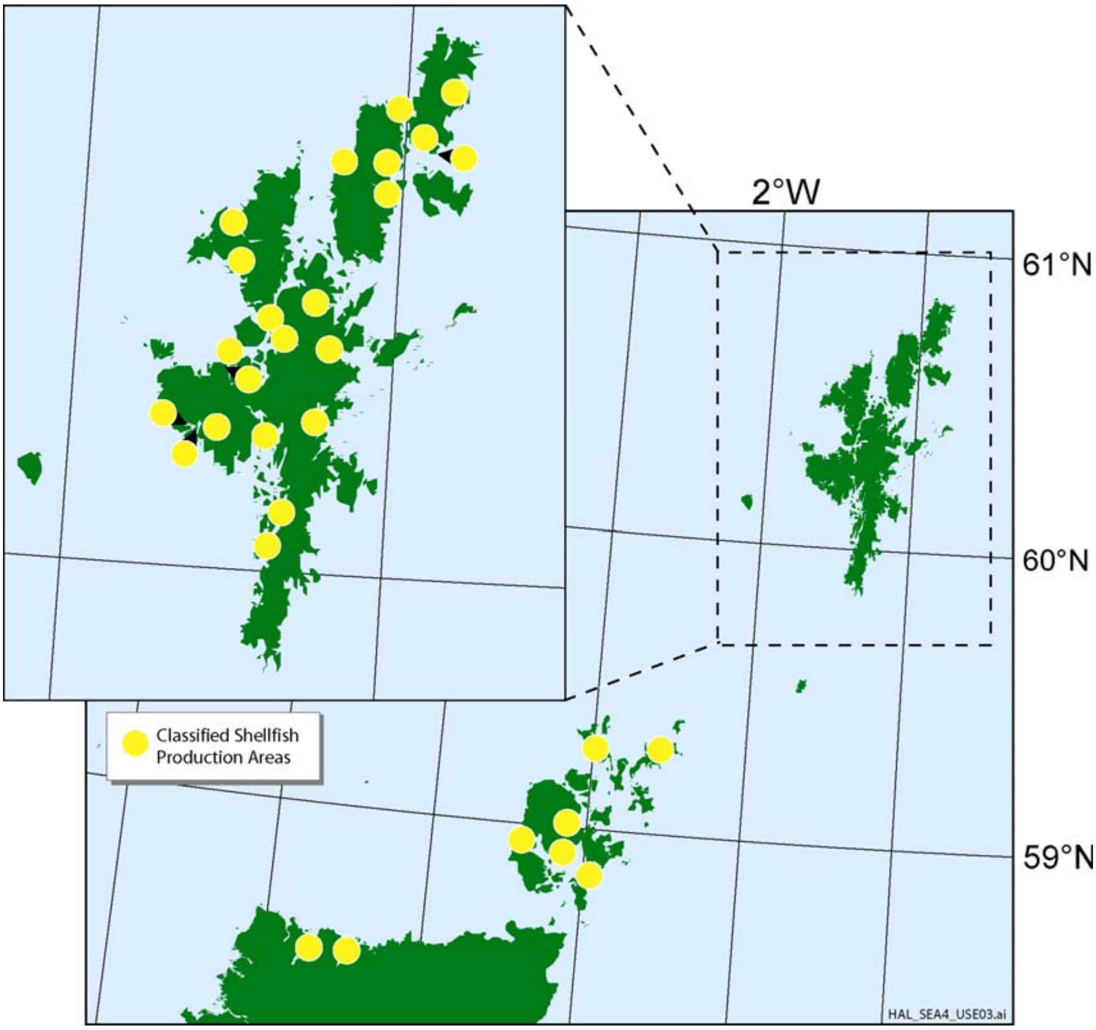
8.6 Tourism and leisure

The unspoilt coastal environment of SEA 4 and the wild natural scenery attract tourists in pursuit of a wide range of activities and interests including walking, bird and cetacean watching, wildfowling, sailing, fishing, diving and the maritime and wartime history of the region.

The Shetland Visitor Survey of 2000 found that, excluding the cruise and yacht market, over 47,000 people visited Shetland with a total expenditure of over £11 million. Approximately 113,000 visited Orkney in the same year.

Foremost attractions in Shetland include the Fair Isle bird observatory, the National Nature Reserve on the Isle of Noss, Fetlar Nature Reserve and Sumburgh Head RSPB Nature Reserve. Wildlife interests are also important in Orkney and include a popular bird observatory at North Ronaldsay and several popular RSPB and Scottish Wildlife Trust reserves. Scapa Flow is a focus for waterskiing, windsurfing, motorised watersports and wreck diving, while there are a number of coastal paths on the north coast of Scotland, including those at Duncansby Head, John O'Groats and Sandside Bay.

Figure 8.7 – Shellfish production areas in the SEA 4 area



8.6.1 Management issues and initiatives

The three local authorities in the SEA 4 area - Shetland Islands Council, Orkney Islands Council and Highlands and Islands Council - recognise the importance of tourism to the area and have implemented structure plans that contain tourism policies aimed at taking a proactive approach to the industry. Key objectives of these policies are to significantly increase and enhance the tourism industry, while ensuring wise and sustainable use of the natural environment and considering the needs of local communities.

8.7 Cables

Over the past three years there has been a 500% increase in global electronic data transmission due to the growth in Internet use and the development of e-commerce. 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, as well as connecting Europe to North America.

There are four operational telecommunication cables that traverse the SEA 4 area, primarily connecting mainland Europe with the eastern seaboard of America (Figure 8.8, Kingfisher Cable Awareness Charts).

8.8 Military activity

The coastal waters north of Cape Wrath and including Loch Eriboll support several practice and exercise areas that are used by the Navy for a number of activities. Naval submarines, aircraft and vessels also use The Minch, to the south west of the SEA 4 area. Within SEA 4, there are a number of areas which have airspace reservations including the Sumburgh Control Area, which covers a large area to the south of Shetland. To the east of Orkney and outwith the area covered by SEA 4, there are several large Air Force practice areas (PEXA Chart Q6404).

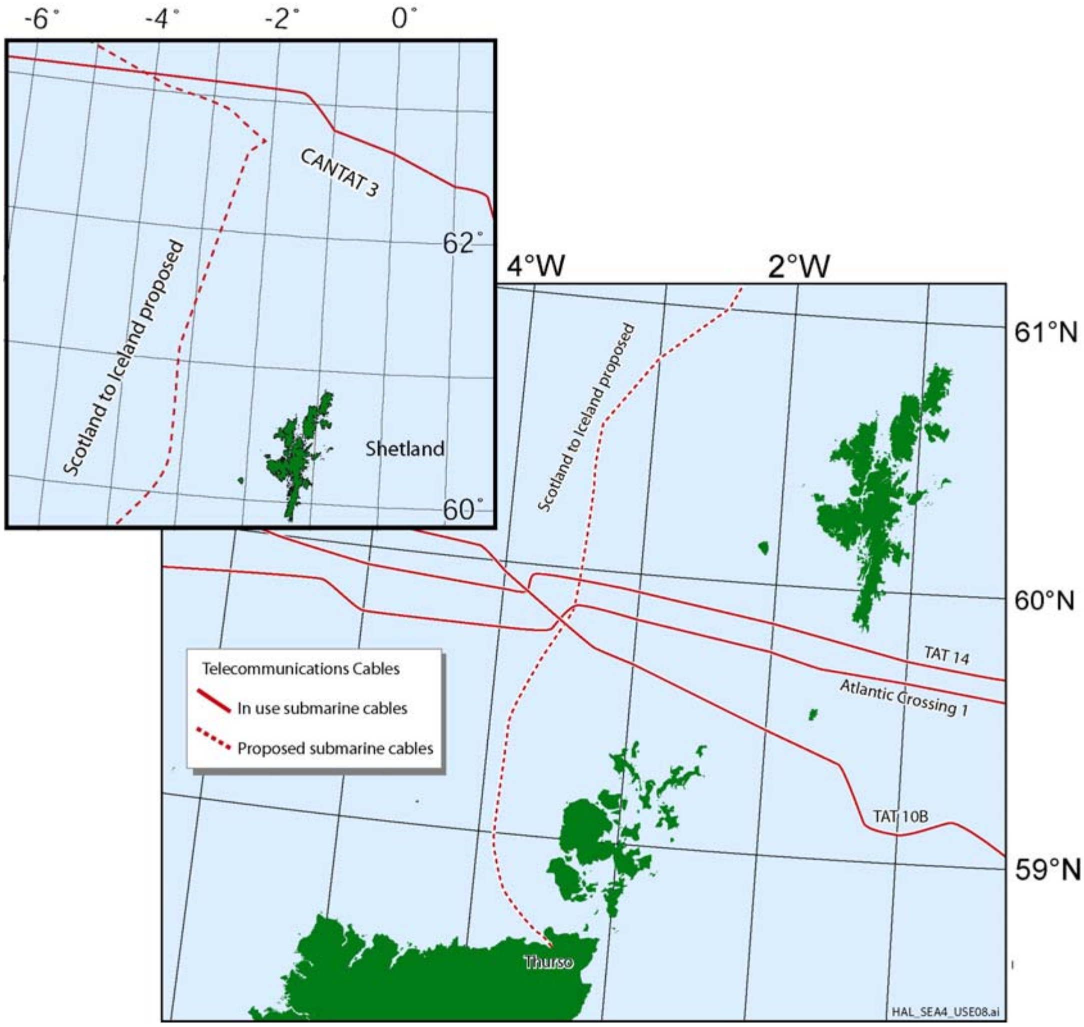
Military operations in Scottish waters include the triennial exercises run jointly by the Royal Navy and the Royal Air Force. The exercises, called Joint Maritime Courses (JMCs), provide collective training for the warships and aircraft of the UK and allied forces (including German, Canadian and Scandinavian units). JMCs take place mainly off the west coast, but do include operations to the north and east of Scotland as well. The Cape Wrath firing range is extensively used during these courses for naval gunfire support and exercise areas in the North Sea provide large areas for both anti-submarine and air defence exercises (ETS News website). Other military operations in the area will include the NATO Exercise Northern Light taking place off the west coast of Scotland in September 2003. The NATO force will comprise 50 ships and submarines, 15 fighter aircraft, numerous military helicopters and approximately 800 amphibious and land troops from twelve NATO nations (US Department of State – International Information Programmes website).

8.9 Renewable energy

Scotland has an immense offshore renewable energy resource including wind, wave and tidal, and it is estimated that the potential resource may be capable of generating 46.5 GW (Gigawatts) by 2010 (Scottish Executive: Scotland's Renewable Resources, 2001)
At present there are no existing or current proposals for offshore wind farms within the SEA 4 area. Nor are there any commercial wave devices in operation. This notwithstanding, Seapower International, a Swedish company, has proposed the construction of a prototype wave device, 500m off Mu Ness, near the Dale of Walls in Shetland in 2003. There is also a proposal to build a marine test centre in Orkney (Stromness), expected to open late 2003 and provide test facilities for the first, full scale, pre-production prototype Pelamis, a novel offshore wave converter.

Stingray, the world's first large-scale tidal stream generator system, was deployed in Yell Sound off the Shetland coast in 2002 for preliminary testing. *Stingray* is due to be redeployed in spring 2003 for additional testing, with plans for connecting the *Stingray* power station to the local network in 2004.

Figure 8.8 – Telecommunication cables in the SEA 4 area



8.9.1 Management issues and initiatives

In Scotland, support for renewable resources now comes from the Renewables Obligation Scotland (RSO), which came into force in 2002. There are also a number of new market based measures which directly benefit renewable energy including capital grants, the climate change levy (CCL), and Scottish initiatives such as the Scottish Community Renewable Initiative (SCRI).

8.10 Other users of the coastal environment

8.10.1 Coastal settlements

The coasts of the SEA 4 region are generally rural in nature with a number of relatively small settlements. Of these, Lerwick is home to over 33% (7,270 inhabitants) of the Shetland population. Similarly, Kirkwall is the major population centre on Orkney, supporting 31% (6,130 inhabitants) of the islands' population. Thurso is the largest settlement (7,880 inhabitants) on the north coast of Scotland (Scotland's Census 2001 website).

8.10.2 Ports

There are a number of large ports in the SEA 4 area that form an important focus for shipping in the northern North Sea (Figure 8.9). Sullom Voe in Shetland and the Flotta Terminal in Orkney handle much of the crude oil traffic in the northern part of the North Sea. In 2001, Sullom Voe was the third largest UK port for oil and gas traffic handling over 31 million tonnes of traffic. There are no major ports in terms of commercial tonnage on the north coast of Scotland (DFT Transport Statistics).

Fishing, whilst in general decline, still represents an important industry in the SEA 4 area with important coastal fishing ports, particularly in Shetland and at Scrabster on the Caithness coast (Figure 8.9). Landings into the Shetland district in 2001 amounted to 59,141 tonnes (£27.3 million), representing over 20% of the Scottish landings by UK vessels (DEFRA 2001).

8.10.3 Marine disposal

Since 1994, the dumping of most forms of industrial waste at sea has been prohibited, with the disposal of sewage sludge phased out at the end of 1998. The majority of the remaining material eligible for disposal at sea is now dredging waste from excavated ports, navigation channels and coastal engineering projects.

Within the last few years there have been a number of coastal sites around Shetland, Orkney and the north coast of Scotland, which have been licensed for the disposal of dredged material. Of those licenses granted within the last three years, only one at Stromness remains valid in 2003 (55,679 tonnes of dredge spoil) (Pers. comm. Peter Hayes, FRS).

8.10.4 Aggregate extraction

Sand and gravel are important sources of industrial aggregate, utilised in concrete production, road and building construction, beach replenishment and coastal defenses. The small, local aggregate extraction activity in Shetland, Orkney and the north coast of Scotland is overwhelmingly land-based.

It is widely accepted that in such areas as Shetland, Orkney and the north coast of Scotland, local crofters have traditional rights to remove small quantities of sand and shingle from local formations for use on the croft. Little use seems to be made of this right at this time.
There are maerl beds found in coastal waters around Shetland and Orkney, and Loch Eriboll on the north coast. Although maerl is a valuable commercial resource, extraction in the SEA 4 area is on a very small scale.

8.10.5 Dounreay decommissioning

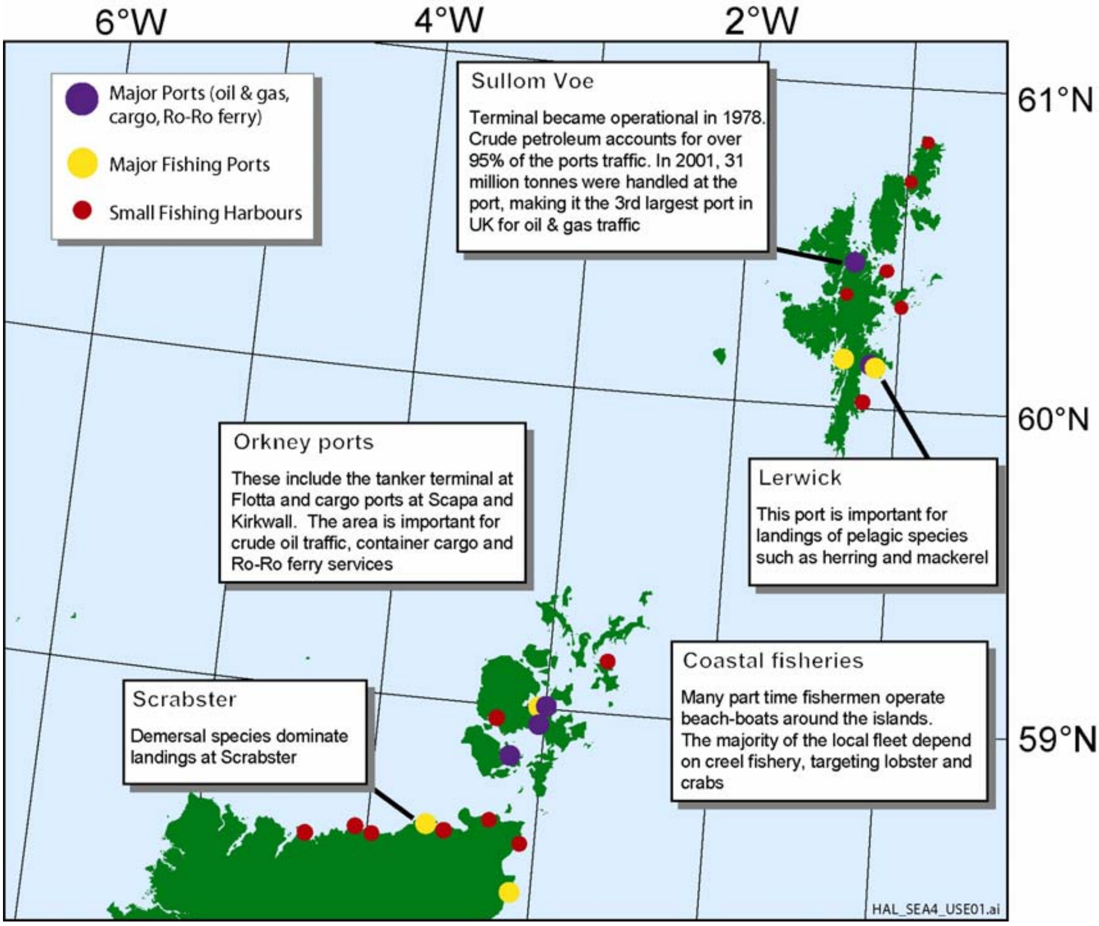
The 200MW Dounreay Fast reactor ceased generation of electricity in 1994 and the facilities are currently being decommissioned. The change from operations to decommissioning has led to a substantial increase in employment in recent years. Staffing levels have risen from 1,100 in the mid-1990s to about 2,000 in 2001 and UKAEA recruited an additional 250 staff during 2001/2002. According to the UKAEA, some £61 million is injected into the economy of Caithness each year as a result of decommissioning.

Management issues and initiatives

Management at the site is now focused on decommissioning of the reactors, ancillary nuclear facilities and the restoration of the environment. The Dounreay Site Restoration Plan is expected to take 50-60 years to complete and cost in the region of £4 billion.

In recent years, a number of radioactive particles have been washed up on the nearby public beach at Sandside. The Dounreay Particle Advisory Group (DPAG) was convened by SEPA in 2000 to provide UKAEA and SEPA with independent expert advice on the particles and suitable monitoring and research programmes.

Figure 8.9 – Ports and harbours in the SEA 4 area



8.11 Coastal and marine management initiatives

8.11.1 Introduction

The SEA 4 coastal environment supports a range of important habitats and species and provides an important resource for a variety of different users. A number of overarching management initiatives and schemes seek to balance the environmental sensitivity of the coastal area with its resource potential. These initiatives apply to a range of coastal users rather than the more specific management initiatives described within the previous sections and include a range of:

- Coastal planning initiatives
- Coastal water quality initiatives
- Coastal and marine nature conservation initiatives
- Integrated Coastal Zone Management initiatives

This section provides a brief summary of information contained in Section 1.16 of the Existing Users and Management Initiatives Relevant to SEA 4 report.

8.11.2 Coastal planning initiatives

The rural nature of much of the SEA 4 coast means that coastal planning management is of great importance in maintaining the character of the area. To this end, a number of statutory and non-statutory plans and initiatives help to guide development within the coastal zone. These include:

- National Planning Policy Guidelines (NPPG) 13 sets out the Scottish Executive's policy on coastal planning matters. The Guidelines are transposed into a strategic planning policy through the creation of development plans.
- Development plans are made up of two parts - a structure plan and a local plan. The structure plan for an area takes a long-term view of development, considering its general scale and broadly where it should be located. Local plans are often for smaller areas and set out more detailed policies and proposals to guide development.

8.11.3 Coastal water quality initiatives

There are specific classification schemes for shellfish harvesting areas and bathing waters that are monitored and regulated by SEPA as well as more general classification schemes for coastal and estuarine waters. The Water Framework Directive (Directive 2000/60/EC) was adopted by the European Parliament and the Council of the European Union in December 2000. It introduces two key changes to the way the water environment will be managed:

- New, broader ecological objectives, designed to protect and where necessary, restore the structure and function of aquatic ecosystems.
- A river basin management planning system which will be the key mechanism for ensuring the integrated management of groundwater, rivers, canals, lochs, reservoirs, estuaries and other brackish waters, and coastal waters.

The Directive was transposed into Scottish law through the passing of the Water Environment and Water Services (Scotland) Bill in January 2003.

8.11.4 Coastal and marine nature conservation initiatives

Presently, there are a number of initiatives underway which may influence conservation management of the SEA 4 coastal and marine resource:

- Continued development of management plans for marine SACs.
- Initiatives to establish offshore conservation sites including the Offshore Natura 2000 Project and OSPAR's Marine Protected Areas programme.
- The Review of Marine Nature Conservation (RMNC) was set up in 1999 to examine the effectiveness of the system for protecting nature conservation in the marine environment. The Review's recommendations are currently being tested through the Irish Sea Pilot.
- A number of biodiversity initiatives including Biodiversity Action Plans, a Scottish Biodiversity Strategy and a Draft Nature Conservation (Scotland) Bill.

The Scottish Executive launched the first phase of a 'Sustainable Scottish Marine Environment Initiative' in November 2002. The aim of the initiative is to develop and then test the benefits of possible new management framework options for the sustainable development of Scotland's marine resources through the establishment of a number of pilot projects. (Sustainable Scottish Marine Environment Initiative website - http://www.scottish-marine-sustainability.co.uk/).

8.11.5 Integrated Coastal Zone Management (ICZM) Initiatives

Integrated Coastal Zone Management (ICZM) is a process that brings together all those involved in the development, management and use of the coast within a framework that facilitates the integration of their interests and responsibilities. The Scottish Coastal Forum is currently in the process of developing a national coastal strategy for Scotland which will address the main areas identified in the EU ICZM Recommendation.

Relevant ICZM initiatives in SEA 4

- Fair Isle Marine Environment and Tourism Initiative (FIMETI) is a partnership of the Fair Isle community, Fair Isle Bird Observatory Trust and the National Trust for Scotland.
- Orkney Marine and Coastal Forum are assisting the Orkney Islands Council in the development of a Coastal Zone Management Plan for the whole of Orkney.
- Orkney Islands Council commissioned the International Centre for Island Technology (ICIT) to produce a Scapa Flow Management Strategy in 1998. The Strategy described the baseline environment and potential benefits of an ICZM strategy for Scapa Flow.
- In 2002, Highlands and Islands Enterprise set up a Marine Science Strategy Group to develop a strategy for better exploration of Scottish marine resources.

Relevant European initiatives

OSPAR Commission

In 1992, the Oslo and Paris conventions were merged and modernised to form the OSPAR Convention for the Protection of the Marine Environment of the North East Atlantic. In 1998 and 1999 the OSPAR Commission adopted a number of Annexes to guide its work in the medium to long term (OSPAR website - http://www.ospar.org/eng/html/welcome.html):

- Annex I — On the prevention and elimination of pollution from land-based sources
- Annex II — On the prevention and elimination of pollution by dumping or incineration
- Annex III — On the prevention and elimination of pollution from offshore sources
- Annex IV — On the assessment of the quality of the marine environment
- Annex V — On the protection and conservation of the ecosystems and biological diversity of the maritime area

In the UK, OSPAR is coordinated by DEFRA (supported by JNCC in the development and implementation of the Biodiversity strategy) and the DTI (responsible for the Offshore Activities strategy).

EU marine strategy

The development of an EU marine strategy is still very much in its infancy, but will cover a range of themes including: loss of biodiversity and destruction of habitats; hazardous substances; eutrophication; radionuclides; chronic oil pollution; litter; maritime transport; health and environment; climate change; enhancing co-ordination and co-operation, and improving the knowledge base.

9 OTHER EUROPEAN RESOURCES OF POTENTIAL RELEVANCE TO THIS SEA

9.1 Introduction

The south west coast of Norway lies to the east of the SEA 4 area, while to the north lie the Faroe Islands. This section presents a summary of the coastal resources of these countries as well as a brief overview of coastal conservation within each country and a listing of important conservation sites.

The coastal resources of Norway and the Faroe Islands have previously been described for SEA 1, SEA 2 and SEA 3. Much of the information presented in this summary comes from the OSPAR Commission Quality Status Reports for Region I – Arctic Waters and Region II – Greater North Sea (OSPAR Commission 2000) together with subsequent data gathering.

9.2 Norway and the Faroe Islands

9.2.1 Overview

Norway occupies the western part of the Scandinavian peninsula and is bordered by the North Sea, the Norwegian Sea and Barents Sea and the land masses of Russia, Finland and Sweden. It has a long and rugged coastline with numerous fjords and small islands that attract tourists interested in nature and outdoor sport. Since oil and gas were discovered off the Norwegian coast in the 1960s, Norway has become one of the world's most important oil producing countries. The country also has a number of additional natural resources including natural gas, coal, timber and hydropower, while other industries include fishing, fish farming and shipbuilding.

The Faroe Islands is an archipelago of 18 islands, 17 of which are inhabited, that lie between the Norwegian Sea and the North Atlantic Ocean. The Faroe Islands have been a self-governing region of the Kingdom of Denmark since 1948. The most important source of income for the Faroes is the fishing industry, followed by tourism. Smaller industries include the production of woollen and other manufactured products. Oil and gas exploration off the Faroe Islands has become increasingly favourable with a variety of companies showing considerable interest in the area.

9.2.2 Fisheries and mariculture

Fisheries

The produce of the fisheries and aquaculture industries of Norway are the country's second largest export, sold to more than 150 countries around the world. In 2002 Norwegian vessels landed 2.7 million tonnes of fish and shellfish with an estimated value of nearly NOK 11 billion. Species caught included cod (227,000 tonnes, which accounted for 26% of the total catch value), herring (565,000 tonnes, 18%), mackerel (184,000 tones, 12%), capelin (531,000 tonnes, 6%) and blue whiting (558, 000 tonnes, 5%) (Statistics Norway – website).

The Faroe Island's economy is largely dependent on fisheries, with fishing, fish farming and processing contributing to over 97% of the export volume in 2002 (Faroe Islands Tourist Board website). In 2001 the total Faroese catch amounted to nearly 525,000 tonnes. The main demersal species were saithe (45,792 tonnes), cod (38,706 tonnes), capelin (32,110 tonnes) and haddock (16,061 tonnes) while the main pelagic species caught by the Faroese in 2001 included blue whiting (259,761 tonnes), herring (35,172 tonnes), mackerel (24,005 tonnes) and sand eel (6,030 tonnes) (Hagstova Føroya 2003).

Norwegian and Faroese vessels landed similar quantities of demersal and pelagic fish into UK ports during 2001. Vessels from Norway accounted for over 23% (value £683,000) of demersal fish landed into the UK by foreign vessels, while the Faroe Islands accounted for nearly 20% (value £7,805,000). Landings of pelagic species into the UK by Norwegian and Faroes vessels accounted for slightly less overall at 12% (value £190,000) and 7% (value £354,000) respectively (UK Sea Fisheries Statistics 2001).

Norway has a differentiated fishing fleet which utilises both coastal and deep sea fishing. The gear type used in coastal fisheries include gillnets, coastal purse seines and Danish seines, while the deep sea fishing fleet utilise purse seines and pelagic trawls (OSPAR 2000). The deep sea Faroes fishing fleet consist of longliners, shrimp, whitefish and factory trawlers and purse seiners. They also have a smaller coastal fleet fishing in shallower inshore waters.

Queen scallops occur all around the Faroe Islands but two areas on the Faroe Plateau are of particular importance, one to the north of the islands and one to the east (Bruntse & Tendal 2000). The ground to the east is fished regularly, however no scallop dredging currently occurs in the northerly ground due to protests by long-line fishermen.

Mariculture

Maricutlure takes place at over 3,000 sites spread along the entire coast of Norway. Employment in fish farming has been stable since 1997 with around 3,682 people employed in 2001 (Statistics Norway). Salmon is the main cultivated species and in 2001 a total of 438,000 tonnes of salmon were sold, with a value of NOK 8 billion. Other species cultivated include trout, 71,000 tonnes of which were sold in 2001, halibut, cod, turbot and eel. Oysters are also cultured along the coast of Norway.

Both salmon and trout are farmed around the Faroe Islands in sheltered fjords and sounds. In 2001 approximately 41,000 tonnes of frozen and chilled salmon and nearly 2,500 tonnes of trout were exported (Hagstova Føroya 2003). There are currently over 300 people directly employed on freshwater and seawater farms with an estimated additional 1,000 people employed in fish farm support industries. There is also growing interest in the cultivation of other species with the first successful rearing of Atlantic halibut in 2001.

Kelp (*Laminaria hyperbore*a) and other brown seaweeds are harvested for alginate production along the west coast of Norway. Kelp is the most common seaweed harvested in Norway with an average harvest of approximately 90,000 tonnes per year (OSPAR 2000).

9.2.3 Energy industries

The offshore oil industry has been important to the Norwegian economy since the early 1970s. In 1999 Norway had 56 oil and gas fields in production in the North and Norwegian Seas, with a further 136 small and medium-sized discoveries waiting to be developed. Thirty of them will be developed over the next 10 years and a further 50 in the subsequent decade, according to current estimates from the Norwegian Petroleum Directorate (Haglands 1999). The majority of Norwegian oil and gas fields are situated in the Norwegian sector west and south of Shetland, with little or no production close to the SEA 4 area. In 2002 a total of nearly 138 million tonnes of crude oil and over 63 million m^3 of natural gas were exported with a value of 200 billion and 70 billion Kroner respectively (Tostensen *et al.* 2003). At the present time there is no information available regarding any current or future Norwegian offshore renewable energy projects.

In the Faroe Islands, the first licensing round on the Faroe shelf was launched in February 2000 with the Ministry of Petroleum receiving 22 licence applications from 17 oil companies. In August 2000 the Ministry issued 7 exploration and production licenses to 12 oil companies. The first three wells were drilled in 2001 at the south eastern corner of the Faroese continental shelf close to UK territory.

Further wells are set to be drilled in 2004. Plans are also underway for a second licensing round with the focal area close to existing licenses and along the Faroe-Shetland Channel (Oljumálarádid, Ministry of Petroleum website).

Energy from offshore wave, wind and tidal power is a growing sector in many countries. A new Scottish-Faroe project is underway to develop wave power using tunnels cut into cliffs along parts of the Faroese shoreline to form chambers which are expected to facilitate energy capture. The first phase of this joint venture is expected to cost around £600,000, with the second phase involving the building of a wave power station, costing up to £7m. The Faroese currently meet their electricity needs through a mixture of diesel powered generators, hydro-electricity and wind power. (Scottish Energy Efficiency Office 2003 website).

9.2.4 Ports and shipping

The coastal cities and towns in south western Norway owe much of their development and wealth to maritime trade although the emphasis has changed over the years. The city of Stavanger has been dependent on shipping and sea trade for many centuries, when in the mid-19th century the emphasis shifted to fisheries with the city a focal point for sardine canneries. Since the 1960s this has been superseded by the importance of the oil industry. The same pattern can be seen in many of the smaller towns such as Haugesund and Florø in Sognefjorden that expanded on the basis of its trade in herring but is better known today for its role in the offshore oil industry.

Bergen is a major commercial port and hub for shipping lines operating from the major European ports. In 2002 a total of 24,191 vessels visited the port and port traffic amounted to 93.9 million tonnes. New terminals are likely to expand the harbour area and this, together with well developed road and rail networks, is expected to increase cargo handling at both the public and private quays. In 2002 the number of Ro-Ro ferry passengers into Bergen was 273,172, down 0.3% from 2001. In 2002 a total of 192 cruise ships called at Bergen (Bergen Harbour Annual Report 2002).

The seven largest harbours in the Faroe Islands, based on levels of activity, are: Tórshavn and Kollafjørdur on Streymoy, Klaksvík in the North Isles, Fuglafjørdur and Runavík on Eysturoy, and Tvøroyri and Vágur on Suduroy (AMG 1997). Most locations were originally designed as fishing harbours and for general cargo, although some container facilities are available at Tórshavn, Runavík, Klaksvík and Tvøroyri. Tórshaven, on the south east coast of Streymoy, is the largest harbour in the Faroe Islands and is principally a fishing port. Merchant shipping traffic in and out of the islands is dominated by international arrivals and departures of ferries, cargo vessels and cruise liners. International passenger and car ferries operate to and from Iceland, mainland Europe, as well as the UK.

Ferries form an important part of communication through the movement of local population and trade between islands in the archipelago. The most frequent sailings are between Vestmanna on Streymoy and Oyrargjógv on Vágar and between Leirvík on Eysturoy and Klaksvík on the northern island of Bordoy.

9.2.5 Tourism and leisure

Outdoor recreation is central to leisure activities in Norway - walking, cycling, swimming, sailing, mountaineering, skiing, white-water canoeing and fishing are all popular with local people and visitors alike. Visitors also support a thriving cruise ship and leisure craft business that take people on short journeys up some of the fjords as well as on longer trips along the coast and up to the Arctic Circle. The many sheltered harbours provide ideal stopping off points and towns such as Haugesund and Florø provide berthing facilities for many small craft.

In southern Norway, Bergen is an important urban centre for tourism, particularly the remains of the first city and wharf that is now a UNESCO Word Heritage Site. Maritime heritage is also an attraction elsewhere from the canneries at Stavanger that show the importance of the sardine industry in the 19th century, to the old fishing and shipping center of Haugesund, a busy seaway between Stavanger and Bergen and the islands.

In the Faroe Islands tourism is the second largest industry and the islands attract approximately 22,000 tourists per year (Faroese Tourist Board 2000). Due to the islands' geography, topography and dependence on the sea, the main tourist attractions concentrate on marine and coastal environments. Sea angling is common amongst islanders and tourists with the most popular months being August and September. Swimming and other beach orientated pursuits are not common in the Faroe Islands as the number of sandy bays are limited and sea temperatures are low, even during summer months.

9.2.6 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 large cities (Bergen), while some oil refineries are located in the coastal zone. There is a small marine aggregate extraction industry in Norway with 86,111m^3 of sand and gravel extracted in 1996 and an average of 118,333m^3 extracted between 1992 and 1997 (OSPAR 2000).

Coastal industries in the Faroe Islands are largely restricted to fish processing from fisheries and mariculture. In 2001, 13 companies actively involved in farming salmon and trout were registered, operating 23 sites. Fish farms are located in almost every suitable bay and fjord in the Islands (Aquamedia website).

There are two main sites for commercial sand dredging in the Faroes, one located in the sound between the islands of Streymoy and Eysturoy and the other in a sound in the North Isles. Some 10,000-15,000m^3 of sand are extracted from each site per year (Poulsen, Pers. comm. cited in Atlantic Margin Group 1997).

9.3 Protected sites

At the present time, the only area in Norway that is protected specifically for its marine life are the Froan Skerries. However, the Norwegian Government is expected to be reviewing potential sites identified in earlier conservation programmes in order to draw up a marine conservation plan for the country by 2004.

Four types of protected area can be established under Norwegian conservation legislation at the present time – national parks, nature reserves, landscape protection areas and flora and fauna protection areas (otherwise known as biotope protections). All of these are found in south-western Norway. The most numerous protected areas are nature reserves with several hundred located on the islands, fjords, open coast and adjacent land. The region of Møre og Romsdal is the most significant for areas of flora and fauna protection (biotope protection) with 12 sites having this status along its coast.

Most of Norway's national parks and landscape protected areas are found inland but they do extend to the shore: around Sauda and the Sognefjorden, at Lysefjorden and the inland reaches of the Tingvollfjorden. The country also has several Important Bird Areas (IBAs) along this section of coast (Figure 6.7.1) and a number of Wetlands of International Importance that have been defined under the Ramsar Convention - Giske; Harøya; Mellandsvågen; Sandblåst/Gaustadvågen; Jaeren; Froan; Ørland and Trondeimsfjord.

The Faroe Islands are a self governing region of the Kingdom of Denmark. As such, the islands are not covered by the Bern Convention, World Heritage Convention nor the EC Wild Birds Directive, unlike mainland Denmark. As a result, the Islands are not obliged to designate sites of conservation value which fall under criteria stipulated by these Conventions. The Islands, as part of Denmark, are however covered by the Bonn Convention and the Ramsar Convention, although no Ramsar sites have been designated on the islands. There are a number of Important Bird Areas on the Faroe Islands, most of which are internationally important for their seabird or other waterbird assemblages

There are 19 IBAs on the Faroe Islands, and 10 on the south west coast of Norway (Table 9.1, Heath & Evans 2000).

Table 9.1 IBAs on the south west coast of Norway and the Faroe Islands

Site*	Approximate number of birds	Species
South west coast of Norway		
Froan	Large concentrations of moulting and wintering waterbirds	Breeding red-throated diver, cormorant and shag, wintering white-tailed eagle, visiting eider, red-breasted merganser
Ørland wetland system	Notable numbers	Wintering cormorant, eider, velvet scoter and red-breasted merganser
Inner Trondheimsfjord wetland system	35,000-60,000 staging birds	Staging post for migrating Svalbard population of pink-footed goose, common scoter, velvet scoter, goldeneye and long-tailed duck
Stjørdals Fjord	20,000-30,000 staging birds	Seabird and waterbirds
Gaulosen	Area holds a range of waders and wildfowl in good numbers	Pink-footed goose, other waders and wildfowl
Havmyran	Notable numbers	Breeding golden plover, dunlin and whimbrel
Smøla archipelago	Important numbers	Highest densities of white-tailed eagle, wintering divers, grebes and seaducks
Runde	Important numbers	Largest seabird colony in Norway, breeding great skua and Arctic skua
Kjørholmane seabird reserve	Notable numbers	Southernmost colony of notable size, breeding shag and lesser black-backed gull
Jæren wetland system	Notable numbers	Core breeding area for corncrake, important wintering and staging area for inland waterbirds – red-throated diver, black-throated diver, great northern diver and red-necked grebe
Faroe Islands		
Mykines & Mykineshólmur*	250,000 pairs of breeding seabirds	Fulmar, Manx shearwater, storm petrel, gannet, black guillemot and puffin.
Vágar*	50,000 pairs of breeding seabirds	Storm petrel, shag, great skua, black guillemot and puffin
Streymoy*	*c*.130,000 pairs of breeding seabirds	Fulmar, storm petrel, shag, great skua, black guillemot and puffin
Eysturoy*	*c*.50,000 pairs of breeding seabird	Manx shearwater, storm petrel and black guillemot
Kalsoy*	*c*.70,000 pairs of breeding seabird	Storm petrel, black guillemot and puffin
Kunoy*	20,000 pairs of breeding seabird	Storm petrel and black guillemot

Site*	Approximate number of birds	Species
Bordoy*	Internationally Important numbers	Storm petrel and black guillemot
Vidoy*	50,000 pairs of breeding seabird	Storm petrel, black guillemot, kittiwake and guillemot
Fugloy*	*c*.80,000 pairs of breeding seabirds	Storm petrel, whimbrel, black guillemot, puffin, kittiwake and guillemot.
Svínoy*	30,000 breeding seabirds	Storm petrel, black guillemot and puffin
Nólsoy*	*c*.90,000 pairs of breeding seabirds	Storm petrel, black guillemot and puffin.
Koltur*	*c*.30,000 pairs of breeding seabird	Storm petrel, black guillemot and puffin.
Hestur*	70,000 pairs of breeding seabirds	Kittiwakes, guillemot, storm petrel, black guillemot and puffin
Sandoy*	*c*.170,000 pairs of breeding seabirds	Kittiwake, guillemot, fulmar, Manx shearwater, storm petrel, shag, great skua and puffin.
Vøtnini á Sandoy	Important for breeding waders	Whimbrel.
Skúvoy*	*c*.280,000 pairs of breeding seabird	Kittiwake, fulmar, Manx shearwater, storm petrel, whimbrel, great skua, guillemot, black guillemot and puffin
Stóra Dímun*	*c*.130,000 pairs of breeding seabirds	Kittiwake, guillemot, storm petrel, black guillemot and puffin
Lítla Dímun*	30,000 pairs of breeding seabird	Kittiwake, guillemot, storm petrel and puffin.
Suduroy*	200,000 pairs of breeding seabirds	Kittiwake, guillemot, fulmar, storm petrel, shag, black guillemot and puffin

*Note: * indicates sites of international importance.*

10 CONSIDERATION OF THE EFFECTS OF LICENSING

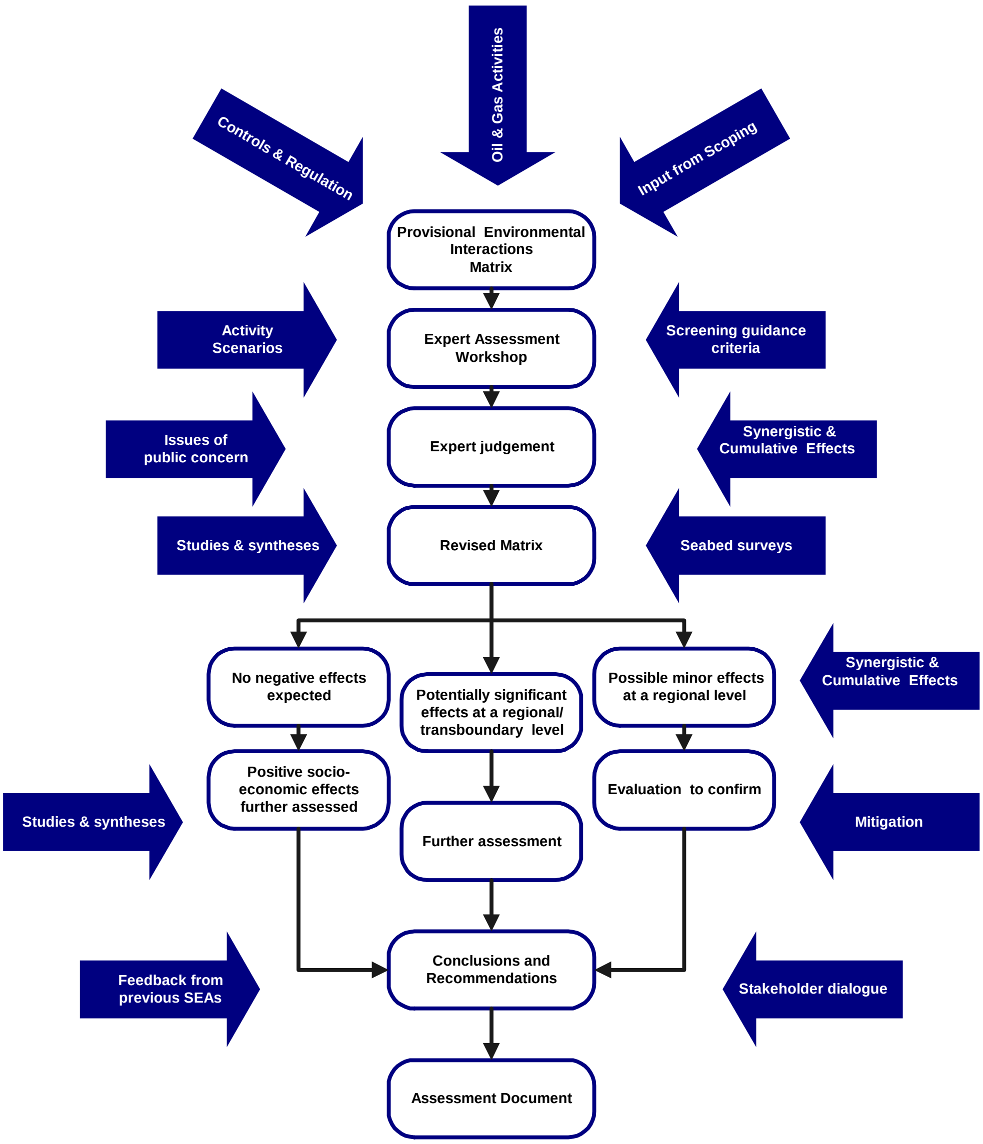
10.1 Introduction

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 4 licensing, and to assess them for significance are outlined below. The base case for the assessment was 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 4 assessment process



The initial stage was the identification of interactions between the potential activities following licensing of the SEA 4 area 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, previous DTI SEAs and the EU SEA Directive.

The next stage was to review the 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 assessment workshop held in May 2003 (see Appendix 2). Workshop participants included authors of supporting technical documents, representatives of main regulatory agencies and the SEA steering group. The process followed is illustrated in Figure 10.1 which includes the input information and outputs. Prior to the workshop, a pack of background information was circulated including a provisional environmental interactions matrix and the scale of potential activity in the SEA 4 area (see Section 4.2.3).

The 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 Nairn in July 2003 – see Appendix 3 and Report No. SD_004.

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 4 area.

Issues considered to be of negligible or minor importance in terms of a Strategic Assessment are not considered further.

10.3 Consideration of effects

10.3.1 Underwater Noise

10.3.1.1 Introduction

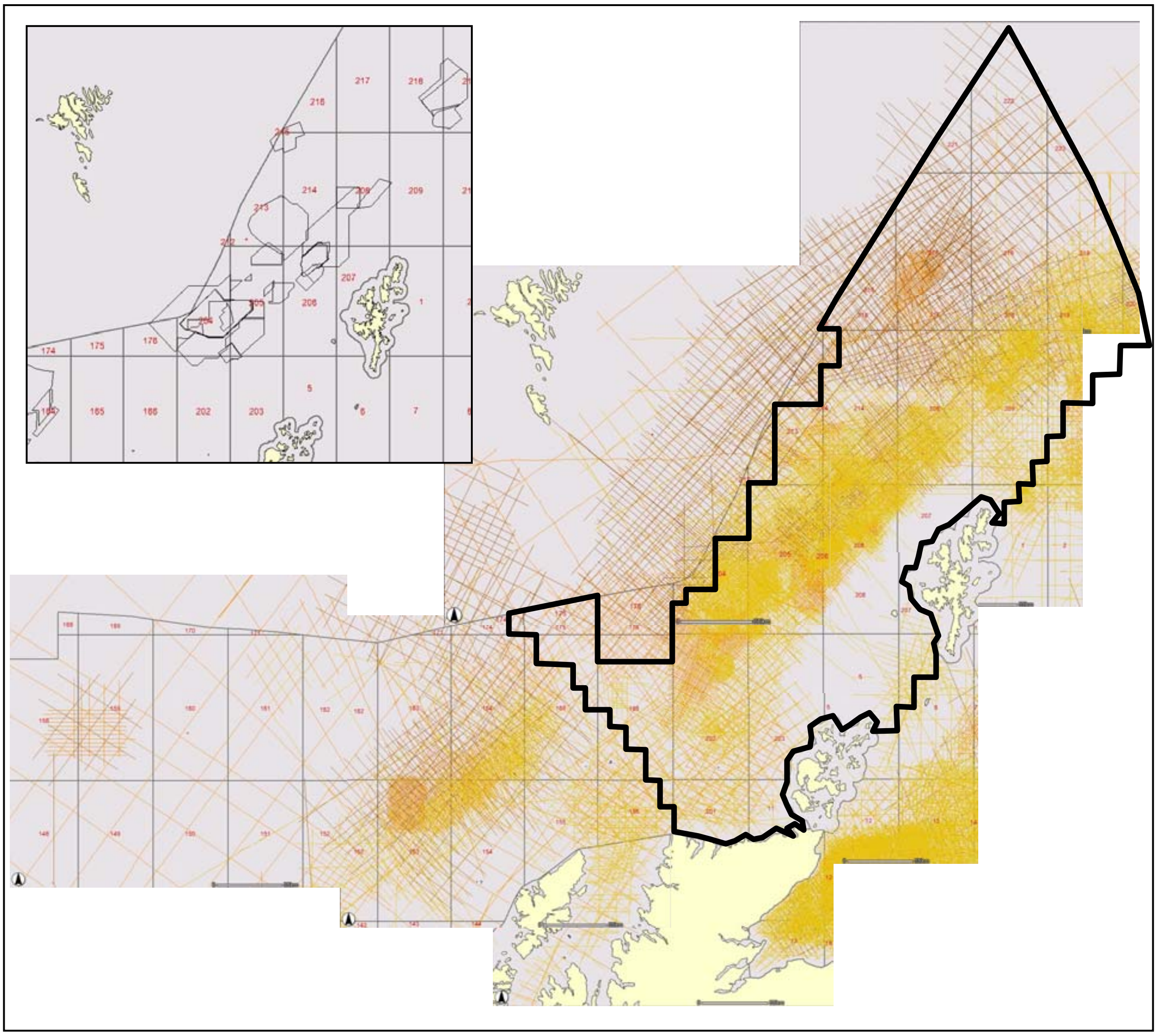
The potential effects of seismic (and other industrial) noise, principally on marine mammals and identified conservation sites, was highlighted as an area of importance in relation to proposed SEA 4 activity. In comparison to oil and gas activities in mature areas of the North Sea (SEAs 2 and 3), the issue is heightened due to the undoubted importance of the SEA 4 area for cetacean populations. The potential effects of other noise sources (for example, continuous noise associated with drilling, construction and production), and the effects of noise on other receptors, were considered to require further consideration only with regard to designated conservation sites (see SEA 2 and SEA 3 for discussion of these noise sources).

Assessment of the risks associated with noise generally follows a Source : Path : Receiver approach (Lawson *et al*. 2001) and considers:

- Potential sources of underwater noise associated with proposed activities
- The likely propagation of underwater noise, defined as sound pressure, from the proposed areas of activity
- The distribution and potential sensitivity of, and effects on environmental "receptors" of received underwater sound pressure

Much of the available data on potential effects of noise was reviewed in previous SEAs, and only a brief synopsis is provided below, updated where new information is available. By way of context, the extent of previous 2D and 3D seismic survey work in the SEA 4 and adjacent areas is shown in Figure 10.2 derived from the DEAL (Digital Energy Atlas and Library, http://www.ukdeal.co.uk/).

Figure 10.2 - Distribution of 2D seismic surveys with inset of 3D seismic surveys



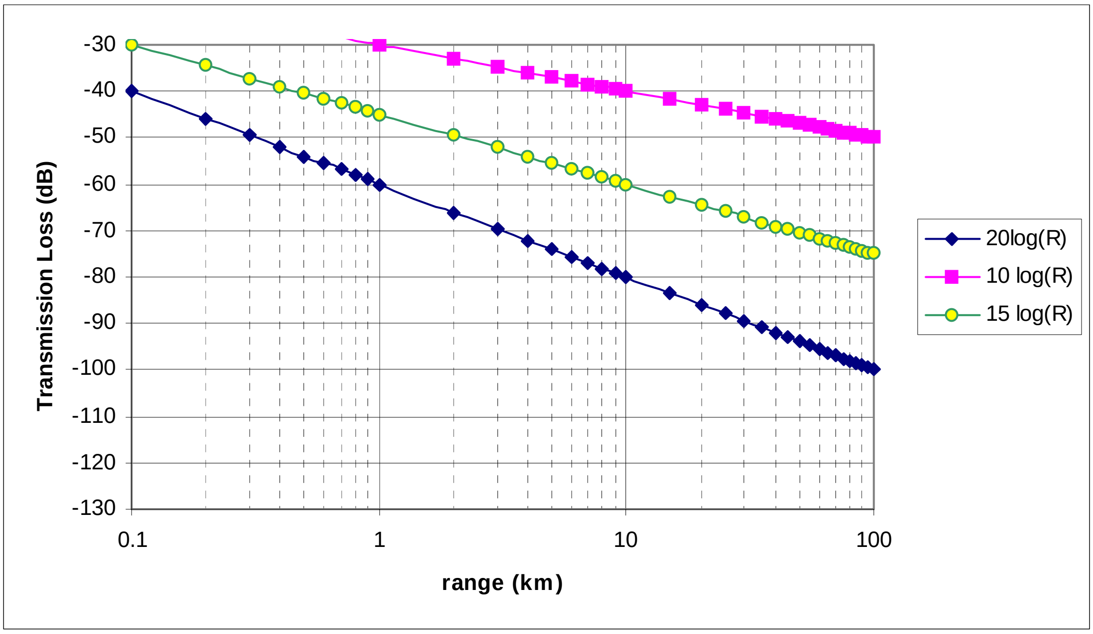
Source: Digital Energy Atlas and Library, http://www.ukdeal.co.uk/

10.3.1.2 Seismic noise characterisation and propagation

Seismic noise has been discussed, in terms of source characteristics and propagation, in SEAs 1, 2 and 3 and supporting studies (Hammond *et al*. 2001, 2002, 2003). With the exception of explosives, airgun arrays are the highest energy man made sound sources in the sea; broadband source levels of 248-259dB re 1µPa are typical of large arrays (Richardson *et al*. 1995). Airgun noise is impulsive (i.e. non-continuous), with a typical duty cycle of 0.3% (Jacques Whitford Environment Ltd 2003) and slow rise time (in comparison to explosive noise). Most of the energy produced by airguns is below 200Hz, although some high frequency noise may also be emitted (Goold 1996, Gordon & Moscrop 1998). Barger & Hamblen (1980) reported a bandwidth of 40Hz centred about 120Hz. The peak spectral level occurred between 35 and 50Hz, 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 8kHz sounds above background levels at a range of 8km from the source, even in a high noise environment.

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 (Figure 10.3). Cylindrical spreading, **SPL = SL – 10log(R)**, is usually assumed in shallow water, depth < **R**. However, several workers have measured or modelled additional signal modification and attenuation due to a combination of reflection from sub-surface geological boundaries, 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, Gausland 1998, VerWest & Bremner 1998, Lawson *et al*. 2001). 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). 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 the 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.

Figure 10.3 - Theoretical Transmission Losses (TL) calculated for spherical spreading 20log(R), cylindrical spreading 10log(R) and intermediate spreading 15log(R).



Detailed, site-specific propagation modelling has been conducted for the Clair field development, for a range of frequencies, source depths and directions (Lawson *et al*. 2001). Three representative test tracks were selected for use in propagation modelling: an ENE track along the depth contour, modelled with a single reflective seabed; an upslope SE track, also modelled with a single reflective seabed; and a downslope NW track towards the Faroe-Shetland Channel, modelled with a layer boundary in reflectivity. A "Range-dependent Acoustic Model" (RAM), with provision for range-dependent parameters such as a sloping, non-uniform seabed and range-varying sound speed profiles, was used to compute transmission loss characteristics for selected transmission paths for frequencies of 400Hz and below. The Weston/Smith analytic/empirical model (Weston 1976, expanded and formulated by Smith in Malme *et al*. 1986) was used for frequencies above 400Hz where sub-bottom acoustic influence is low. Compilation of predicted Transmission Loss (TL) vs. range and frequency, in combination with data on source levels and frequencies, allow estimation of received level spectra at various ranges from specific sound.

Initial studies using the downslope NW track showed that, as expected because of strong downward refracting conditions, the highest TL values were predicted for summer conditions with a stratified water column. Lowest TL values were predicted for winter conditions, with small upward refracting gradients associated with colder surface water. Winter TL predictions for frequencies below 200Hz and a seabed source on the NW track were generally consistent with a 10log(R) transmission loss in the midrange (0.2-10km) with small frequency dependence; with increasing loss beyond the shelf break (>10km) and overall TL between the Clair location and the Faroe-Shetland Channel (60km range) of 95dB or greater (*cf* Figure 10.2). For a shallow source depth of 7m and the same assumed receiver depth of 20m, the TL for a 12.5Hz source is about 10dB greater, although TLs at higher frequencies are similar to the deep source.

Summer TL characteristics for downslope propagation were also frequency-independent in mid-range (0.3-10km) for a deep source, but with spreading loss approaching 15log(R) probably as a result of refraction by the strong sound velocity profile gradient. There is also predicted to be much higher TL for propagation downward off the shelf, with a TL at the Faroe-Shetland Channel of 100-110dB.

With a shallow source, the increased TL at 12.5Hz was again evident with generally greater frequency dependence.

Broadly similar TL characteristics, source depth dependence and frequency dependence were predicted for along-slope and up-slope tracks, with cylindrical spreading (10log(R)) in the mid-range (0.3-10km) and greater TL (15log(R)) at greater ranges.

Sound velocity profile gradients for the deeper waters of the Faroe-Shetland Channel show that a sound channel exists, centred at about 600m (Lawson *et al*. 2001). The sound channel is strongest in summer, and has a low sound speed compared with that at shallower and deeper depths, resulting in a tendency for sound to refract into the channel. The predicted net effect of the sound channel is to produce a sound shadow of 0 to 30dB excess attenuation near the surface, and nearly normal TL near the axis of the channel and below. Sound levels in the channel are not enhanced beyond those that would exist in the absence of strong surface refraction (such as in winter).

Some anecdotal evidence, and limited quantitative data, for long range propagation of seismic noise are available. During acoustic surveys of cetaceans off the Irish coast, noise from 3D seismic up to 500km distant could be detected by hydrophone (Aguilar de Soto *et al*. 2003), although the received level was not quantified. 50-75km detection range in water 25-50m deep is reported by Greene & Richardson (cited by Simmonds *et al*. 2003). The detection range is clearly dependant on source levels, transmission losses and local ambient sound pressures, which are relatively high in the SEA 4 area due to metocean conditions and shipping activity (in the broad range 70-100dB re 1μPa; Swift & Thompson, 2001, Lawson *et al*. 2001). These reports are broadly consistent with model predictions, and suggest that seismic impulse noise, with a source level of 140-150dB re 1μPa, may be audible to cetaceans over distances of the order of 100km (corresponding to a predicted TL of ca. 100dB).

However, it should also be noted that both modelling and experimental estimates of response thresholds are based mainly on continuous noise sources, often measured as peak pressures. For impulse noise such as seismic, characteristics such as duty cycle and rise time may have a significant influence on marine mammal sensitivity. Most reports on the effects of sounds on marine mammals express sound as average (rms) pressures (Richardson *et al*. 1995), which are usually 10-12dB lower than the peak pressure and 16-18dB lower than the peak-to-peak pressure for airgun arrays (Greene 1997, Greene *et al*. 2000). For example, it is suggested that although simple spherical spreading would suggest a range of audibility of 1800km for a 255dB re 1μPa seismic source, in practice it is likely to be heard at between one-tenth and one-hundredth of this value (18-180km) (Jacques Whitford Environment Ltd 2003). In part, this indicates the difference between quantitatively measured - i.e. with a hydrophone - and perceived noise (which is well-known as a complicating factor in studies of noise effects on humans).

10.3.1.3 Noise effects on marine mammals

Richardson *et al.* (1995) defined a series of zones of noise influence on marine mammals, which have been generally adopted by SMRU commissioned reports for SEAs 2, 3 and 4 (Hammond *et al*. 2001, 2002, 2003); and in relation to which data on marine mammal responses have been exhaustively reviewed (e.g. Richardson *et al*. 1995, Gordon *et al*. 1998, Lawson *et al*. 2001, Simmonds *et al*. 2003). 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. Potential acute effects include physical damage, noise-induced hearing loss (temporary and permanent threshold shifts) and short-term behavioural responses. Postulated chronic effects (for which evidence is almost entirely absent) including long term behavioural responses, exclusion, and indirect effects. The most likely physical/physiological effects are generally considered to be shifts in hearing thresholds and auditory damage.

A range of threshold sound pressures for physiological and behavioural responses have been suggested. Threshold peak impulse sound pressure for direct physical trauma in marine mammals, birds and fish is generally considered to be >200dB (McCauley 1994, Richardson *et al*. 1995, Evans & Nice 1996, Gordon *et al*. 1998), although conclusive studies are limited by ethical considerations. Behavioural and physiological responses to experimental noise occur at received levels of 150-170dB in bottlenose dolphins (e.g. Tyack *et al*. 1993) and seals (Thompson *et al*. 1998), with the response varying from avoidance or investigation. A source intensity of 120dB has been suggested by Whitehead (2001) as the precautionary threshold above which underwater noise may have an impact on marine mammal populations.

Non-observable behavioural effects, such as auditory masking (interference with the ability to detect other sounds) have been proposed for marine mammals (Richardson *et al*. 1995), although any assessment of the significance of such effects must be speculative. Audiograms for several dolphin species indicate hearing thresholds of 120-140dB at 100Hz (Lawson *et al*. 2001). Masking is a natural phenomenon to which marine mammals must be adapted, with physiological systems and behaviour that reduce the impacts of masking (Lawson *et al*. 2001); these adaptive measures may include the use of high frequency, structured signals (e.g. echolocation click sequences in dolphins, directional discrimination and frequency selection). Data demonstrating adaptations for reducing masking pertain mainly to the high frequency echolocation signals of odontocetes (dolphins, porpoises and toothed whales), which are the most abundant species present in region. Nevertheless, high levels of anthropogenic noise may mask communication or echolocation sounds by some marine mammals in the area.

Behavioural responses of marine mammals to seismic exploration, in the immediate vicinity of the seismic vessel, have been monitored since 1996 by JNCC (Stone 1997, 1998, 2000, 2001, 2003a, 2003b). Statistical analysis of 1,652 sightings during 201 seismic surveys, representing 44,451 hours of observational effort, is reported by Stone (2003b) and can be summarised as follows:

- Sighting rates of white-sided dolphins, white-beaked dolphins, *Lagenorhynchus* spp., all small odontocetes combined and all cetaceans combined were found to be significantly lower during periods of shooting on surveys with large airgun arrays. Sighting rates of the other species or species groups tested did not differ significantly with seismic activity.

- Killer whales, all baleen whales combined, and all of the small odontocete species tested were found to be significantly further from large airgun arrays during periods of shooting than when the airguns were silent.

- Some effects of seismic activity on the behaviour of marine mammals were evident during seismic surveys with large airgun arrays. Positive interactions (e.g. bow-riding) occurred significantly less often during periods of shooting, with a corresponding increased tendency for negative interactions during periods of shooting.

- In general, small odontocetes showed the strongest avoidance response to seismic activity, with baleen whales and killer whales showing some localised avoidance, pilot whales showing few effects (although sightings of pilot whales declined after 1998 for unknown reasons) and sperm whales showing no observed effects from these data.

It should be noted that all seismic monitoring data are from within the range of visual observation of the seismic source vessel (ca. 500m) and therefore relate to the seismic noise “nearfield”. Baleen whales have often been considered to be more vulnerable to disturbance from seismic activity than odontocetes (e.g. Evans & Nice 1996), as the frequencies they use overlap with those produced by seismic airguns. Few effects of seismic activity have been observed in fin, minke and humpback whales in UK waters (Stone 2003b). However, analysis of combined baleen whale data indicated an increased distance from airguns during periods of shooting. Whales were also observed to alter course more often during periods of shooting and more were heading away from the vessel at these times. These results indicate that there may be at least some level of localised avoidance of seismic activity by baleen whales.

Sperm and pilot whales around the UK showed little or no observable effects of seismic activity, while killer whales showed a limited avoidance response in terms of distance from active gun arrays. Although the frequency response and sensory mechanism is uncertain, it is clear that small odontocetes (i.e. dolphins and porpoises) showed a greater variety of behavioural response to seismic shooting. These responses are mostly temporary with no evidence of declining sighting rates throughout the course of seismic surveys (although sightings of pilot whales declined over a three-year period). Virtually no data is available concerning the effects of seismic noise on beaked whale species.

Most of the responses observed could be classed as avoidance reactions, with more limited evidence for disruption of feeding patterns - to what extent this poses a serious threat to the health of marine mammals is not known. Other potential effects of seismic activity remain largely unknown, for example long-term effects, effects on vocalisations, social behaviour and physiology, consequences of auditory masking and the potential for damage to hearing (Stone 2003b).

Other effects of sound have been postulated, including triggering the onset of Decompression Sickness (DCS) either through behavioural modification or direct physical activation of microbubbles in cetacean tissues. This concern is speculative at present, although stranded whales in the Bahamas show signs of internal bleeding that appeared to be acoustically induced (Goold, pers. comm. to Potter and Dolman, in Simmonds *et al*. 2003). This observation related to a mass stranding of 17 cetaceans (including two species of beaked whales and minke whales) that occurred in March 2000, in the Bahamas. A US governmental report has determined that mid-frequency sonar (3-7kHz) being used in a US military exercise was responsible for this mass stranding. The levels of sound that would have been received by the whales were estimated to be between 140dB and 160dB. This is sufficient to cause resonance in the cranial air spaces of the cetaceans (Balcomb & Claridge 2001).

Probably more meaningful in an SEA 4 context, concerns have been raised that the cumulative effect of sequential seismic surveys could act as a barrier to migration, for example Gordon *et al*. (1998) considered that sound fields from planned seismic surveys in 1997, assuming a spherical propagation model and a threshold intensity of 160dB re 1µPa, would form a "virtually unbroken barrier to any marine mammal wishing to move north-south along the shelf edge". Acoustic monitoring (Clark & Charif 1998) has indicated that fin whales in particular do not all follow the previously assumed migration, and the available evidence indicates that broadscale marine mammal distribution patterns have not been influenced by seismic activity to date. Nevertheless, there is little doubt that successive seismic surveys could have a cumulative effect, either in terms of repetitive behavioural disturbance, or cumulative physiological effects (e.g. TTS).

10.3.1.4 Marine mammal species, distributions and abundance

Marine mammal distribution in the SEA 4 area has been reviewed in the commissioned report by SMRU (Hammond *et al*. 2003), and previously by SEA 1, Pollock *et al*. (2000), Taylor & Reid (2001) and Harwood & Wilson (2001). In addition, further data derived from observations during seismic surveys in 2000 is provided by Stone (2003a); the general distribution and seasonal patterns of movement of some cetacean species is assessed using acoustic data from the US Navy's SOSUS hydrophone array and low frequency sonobuoy deployments by Swift *et al*. (2002); and relevant data from towed hydrophone surveys west of Ireland are reported by Aguilar de Soto *et al*. (2003).

For assessment purposes, the categorisation of marine mammal species in the area presented by SEA 1 is useful in consideration of likely exposure to offshore noise sources. This distinguished nine groups in terms of distribution and feeding ecology:

- **Deep water baleen whales** (blue, fin, sei and humpback) – recorded in deep water (>1000m), north and south of the Wyville Thomson Ridge. Not associated with the shelf edge. Pelagic feeders, with varying degrees of specialisation in terms of prey selection and feeding method. Migratory, although some individuals may utilise the region throughout the year.

- **Shelf baleen whales** (minke) – summer visitor to shelf areas. Winter distribution unknown.

- **Deep water, squid-eating whales** (sperm, beaked and pilot) – along the 1000m contour. Sperm and beaked whales concentrated on eastern flank of Rockall Trough, southern flank of Wyville Thomson Ridge and along eastern side of Faroe-Shetland Channel. Northern bottlenose whale possibly more westerly distribution.

- **Deep water dolphins** (Atlantic white-sided, common) – widely distributed in deep water, not associated with shelf break. Pelagic feeders, with differing species-specific geographical distributions (not directly related to water temperature).

- **Shelf dolphins** (white-beaked, Risso's) – concentrated in shelf waters, with occasional records at shelf edge. White-beaked predominantly piscivorous, Risso's may also feed on cephalopods. Both species show localised distribution centres.

- "**Generalist cetaceans**" (killer whale, bottlenose dolphin, harbour porpoise) – widely distributed over deep and shelf waters. Killer whales have a broad diet, probably mainly piscivorous offshore, with seals, small cetaceans and birds nearshore.

- **Breeding seals** – harbour and grey seals associated with defined haul-out and breeding locations, predominantly coastal foraging. Grey seals and possibly harbour seals forage over considerable distances, although deep water sightings are rare.

- **Deep water seals** – hooded seals utilise deep water in the Faroe-Shetland Channel and north of the Faroes, throughout the year. Deep diving (1000m).

- **Vagrants** - striped dolphin, beluga, narwhal, false killer whale, bearded seal, harp seal, ringed seal and Atlantic walrus are probably vagrants.

Using the 1% of biogeographical population criterion used for seabird populations (e.g. Lloyd *et al*. 1991), the continental shelf break west of Ireland and Scotland and the Faroe-Shetland Channel can collectively be considered important for most of the marine mammal species present; an assessment which is consistent with the views of NGOs (e.g. Hughes *et al*. 1998, Moscrop 1997). However, even the highest estimates of overall population density (0.05 animals/km^2, Hughes *et al*. 1998) of the most abundant offshore species (Atlantic white-sided dolphin) are low in absolute terms, and density estimates for other species (e.g. baleen whales) are at least an order of magnitude lower. Population density estimates may be biased by the temporal and spatial distribution of survey effort - for example reflecting the distribution of seismic surveys, Stone (2003) - and it is difficult to reconcile the findings of different studies. For example, fin whale encounter rates recorded by Hughes *et al*. (1998) in a short duration survey are much higher than those recorded by SAST/ESAS surveys (29 fin whale sightings in 48,221km^2 survey effort with 33% effort in deep water >200m, Pollock *et al*. 2000), or suggested by SOSUS monitoring (minimum numbers of 6 to 20 vocalising fin whales in Region A during 1996-1997, Clark & Charif 1998). Such discrepancies are likely to be due to a combination of detection efficiency, localised distribution patterns (e.g. over the shelf break) and aggregation of individuals.

The potential for underestimation of cetacean population and density estimates based on visual transect surveys alone is widely recognised, for example Aguilar de Soto *et al*. (2003) considered it noteworthy that a team of five visual observers operating simultaneously was required to achieve a similar detection level to that achieved by acoustic methods, and that there is a "high probability" that cetacean occurrence is under-estimated by a single-observer sighting survey. However, it is apparent that no cetacean survey method is perfect and acoustic systems can miss non-vocalising or duplicate contacts. It is likely that future developments in automated acoustic detection of cetaceans will improve understanding of spatial and temporal variations of the distribution of some species (i.e. those which vocalise, with distinctive vocal signatures).

Quantitative estimates of cetacean density in the SEA 4 area, in terms of sightings/transect km have been mapped (Pollock *et al*. 2000 & Reid *et al*. 2003). Distribution maps indicate considerable variation in abundance and for gregarious species abundance estimates should not be extrapolated over wide areas.

10.3.1.5 Drilling, construction, production and decommissioning noise

Sources and characteristics of non-seismic noise sources associated with E&P were discussed in SEAs 2 and 3, and in relation to the Clair Field development in the SEA 4 area by Lawson *et al*. (2001).

In general, these noise sources are continuous, broadband and low frequency-dominated; with documented (predicted or measured) source levels including 108db (helicopter overflight at 305m), 145dB (predicted cumulative production noise at Clair), 170dB (mobile drilling rig) and 177dB (cumulative source level for pipelay operations) (data from reviews of Richardson *et al*. (1995) and Lawson *et al*. 2001).

As discussed above, modelled propagation of noise indicates transmission losses of around 100dB over ranges of 60-100km. All coastal conservation sites are at least this distance from prospective areas identified by DTI, and are therefore unlikely to receive significant sound levels from offshore activities. Helicopter overflights are considered unlikely to result in significant underwater noise (Lawson *et al*. 2001).

Noise from explosive cutting during well abandonment and installation decommissioning was raised as an issue for consideration at the Assessment Workshop. It is noted that explosive cutting is not a given for these activities since alternative cutting techniques exist. The existing SEA 4 fields are produced via FPSOs which on field decommissioning would not require cutting to remove. In view of this and the potential to control such activities at the decommissioning plan approval stage, noise from explosive cutting is not seen as a significant issue for SEA 4. However, it is noted that at present the removal of suspended wellheads requires notification to the DTI via the PON 5 route as opposed to an approval being granted on the basis of a risk assessment. Consequently a recommendation is made that such activities should be approved by the DTI in consultation with their advisers, which would also have the effect of permitting any chemicals used in the process.

No offshore conservation sites have been identified within the SEA 4 area. The Darwin Mounds SAC is over 50km from the SEA 4 boundary and significant propagation of noise to them or effects on the features and species are not expected.

10.3.1.6 Potential effects of proposed SEA 4 licensing

DTI have estimated that SEA 4 related seismic activity may comprise 500-1000km of 2D and 500-2500km^2 of 3D in Area 1 (existing and previously licensed acreage, along the shelf break) and 1000-4000km of 2D and 500-2500km^2 of 3D in Area 2 (north of Shetland). Taking the upper limits of these estimates, and assuming acquisition rates of 200km/day for 2D and 25km^2/day for 3D, the total predicted survey effort is approximately 225 days, over a possible 2 year timescale. It is likely that this would take place over two or three distinct periods (as Operators seek to maximise vessel utilisation), most likely during summer months of two or three years. It is unlikely that more than two or three surveys would be conducted simultaneously, due to vessel availability and interference between surveys (requiring “timesharing”).

Typical spatial extents of 3D seismic surveys are of the order of 25km in any direction. Assuming propagation distances of around 100km in all directions (see above), the theoretical instantaneous area of effect is a circular area of 31,400km^2, and the total area ensonified during a survey is a rectangular area of 50,625km^2 (Figure 10.4). The extent to which areas ensonified by successive surveys would overlap is uncertain; however, further assuming a total of 5 surveys in each of areas 1 and 2, the cumulative ensonified area is represented in Figure 10.5. It is clear that the cumulative exposure to seismic sound pressures, considered sufficient to result in behavioural responses in marine mammals, includes a substantial proportion of the total SEA 4 area. However, it is also important to note that this level of activity does not represent a significant change to recent seismic survey effort; Stone (2003a) records a total of about 130 days survey effort (49 days shooting) west of Shetland during 2000. This effort, and similar levels of activity during the previous 5 years, does not appear to have resulted in significant changes in sightings frequency or behavioural responses (Stone 2003b). The likely areas of seismic activity, and range of noise propagation, indicate that all marine mammal populations in the area are likely to be exposed to sound levels which are biologically significant (i.e. eliciting some observable behavioural or physiological response).

Seasonal variations in cetacean distribution are subject to considerable uncertainty associated with survey effort and sightings efficiency, although effort-corrected sightings rates clearly show a maximum in August with sightings concentrated between April and November (coinciding with the preferred period of seismic activity). In terms of seasonal abundance and migration of individual species, sperm whale sightings peaked during the early part of the survey season (April), while sightings of fin whale, minke whale, white-beaked dolphin and white-sided dolphin all peaked in summer and autumn. There is no obvious possibility of mitigation through seasonal timing of seismic operations.

As discussed above, transmission losses for propagated noise are predicted to be higher in summer, due to the refraction by the sound velocity gradient and establishment of a sound channel in the Faroe-Shetland Channel. The increase in TL during summer can be up to 15-20dB at 60km range, which is likely to result in a significant reduction in the area of biologically significant noise propagation and is a factor in favour of the current preference for summer operations. Other relevant factors are better sightings efficiency of marine mammal observations during seismic surveys in summer due to lower sea states (see below), and the probable increase in survey duration during winter operations.

Available information on the distribution patterns of marine mammals does not indicate strong dependence on localised areas, with the possible exception of beaked whales which are thought to be concentrated over the flanks of deep water channels. However, no topographic features have been identified in the SEA 4 area comparable, for example, to the Gully canyon system which supports populations of bottlenose whales off the coast of Nova Scotia.

The major control and mitigation over seismic surveys in the UK are through JNCC’s *Guidelines for minimising acoustic disturbance to marine mammals from seismic surveys (April 1998).* These were originally introduced on a voluntary basis as part of the UK’s commitment under ASCOBANS, but have subsequently been made mandatory through the DTI and are currently under review. (The ASCOBANS area has now been extended to include areas of the Atlantic to 15ºW). In addition, Regulation 10 of *The Offshore Petroleum Activities (Conservation of Habitats) Regulations 2001* states that oil and gas activities shall not deliberately disturb any creature listed on Annex IVa of the Habitats Directive (which includes all cetaceans), nor cause deterioration or destruction of breeding sites or resting places of any such creature.

Under the JNCC Guidelines there is a requirement for visual monitoring of the area (and acoustic surveys if feasible) 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. In general, the guidelines appear to be effective, although various recommendations are made by Stone (2003a) for future revisions.

It should also be recognised, in the context of SEA, that seismic survey technology is continually developing, in many cases with concomitant changes in environmental effects. For example, the commercial drive to reduce the duration (i.e. cost) of seismic acquisition through, for example, increased number of streamers from larger vessels, will reduce the exposure duration of marine mammals to seismic noise. Possibly the major area which could be addressed through technology development is a reduction in source power levels, for example through improved streamer and survey design, or (in the longer term) through replacement of seismic surveys with electromagnetic seabed logging. Further technology development, particularly in acoustic detection, identification and monitoring of cetaceans, could also substantially improve the effectiveness of mitigation through the established procedures.

Underwater noise can affect marine turtles (Macaulay *et al.* 1994) and although the period of turtle occurrence coincides with the main seismic survey season, in view of the small number of animals involved the potential for adverse effects is seen as remote.

Figure 10.4 - Schematic representation of typical 3D survey area (2500 km^2) and ensonified areas

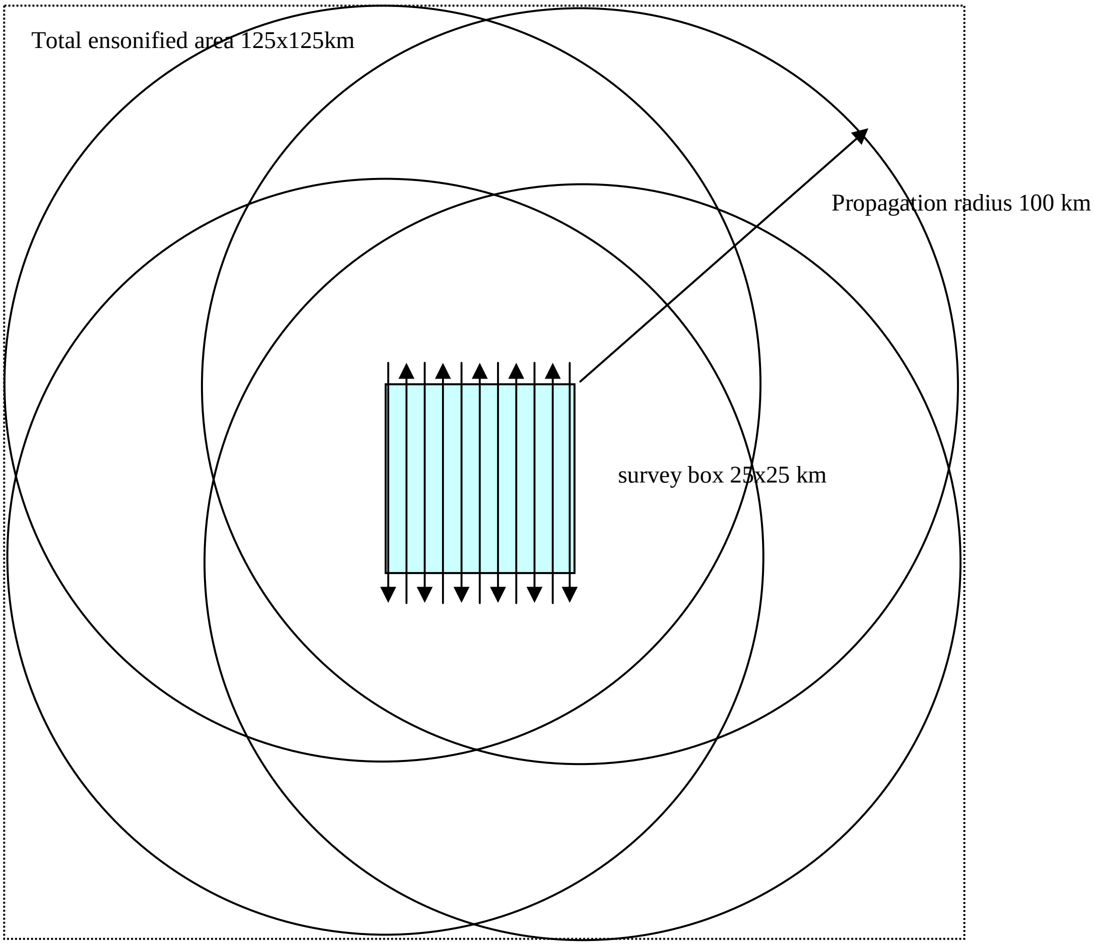
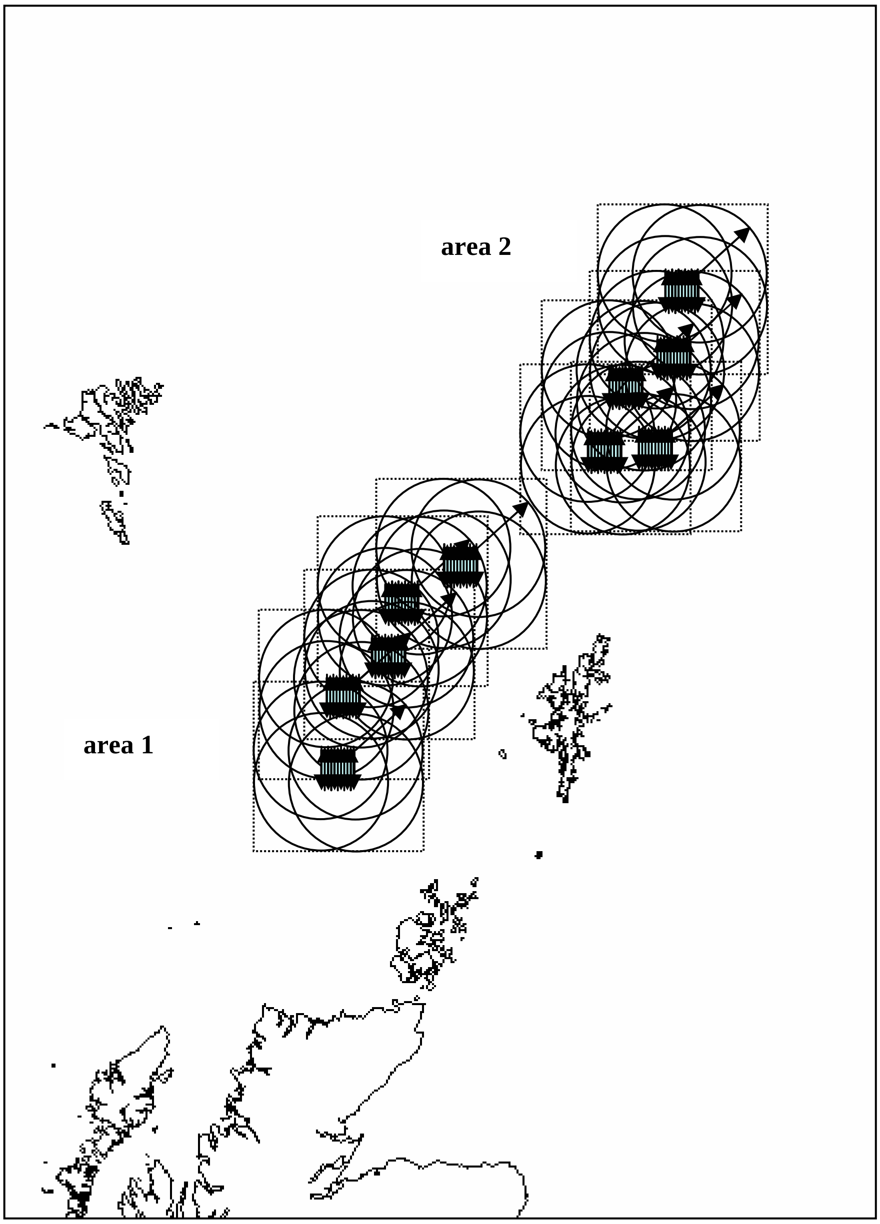


Figure 10.5 - Schematic of cumulative exposure to sound pressure levels exceeding threshold values for behavioural response. Note: survey locations are for illustrative purposes only.



The potential effects of seismic and other oil industry noise on fish and shellfish were addressed in SEA 1 Volume 3 Section 4.7.2. No substantive new information has appeared since and the conclusion of SEA 1 is still regarded as valid. Note, it is possible that precautionary, block specific activity timing restrictions may be applied to some of the SEA 4 blocks before licensing as a result of discussions between the DTI and SEERAD.

10.3.1.7 Conclusions and data requirements

The potential effects of seismic noise remain a significant area of uncertainty, and important issue for offshore exploration activities. The range of potential behavioural effects, and the consequently large potential for cumulative effects, indicate that all marine mammal populations in the area are likely to be exposed to biologically significant sound levels. There is no obvious possibility of mitigation through seasonal timing of seismic operations, and no localised areas which would justify exclusion from licensing.

Monitoring of marine mammal distribution and behaviour is still largely based on visual sighting methodologies, which are known to have low reliability in poor observational conditions. The proposed level of activity does not represent a significant change to recent seismic survey effort; which do not appear to have resulted in significant changes in sightings frequency or behavioural responses. Mitigation measures already implemented, together with proposed modifications, appear to provide some degree of protection from acute effects and are generally followed by the industry.

Coastal conservation sites are remote from prospective areas identified by DTI, and are therefore unlikely to receive significant sound levels from offshore activities. Support vessel movements and helicopter overflights are considered unlikely to result in significant underwater noise.

It is therefore concluded that there is an acceptably low risk of potential effects of underwater noise resulting from SEA 4 activity. A number of recommendations are made, in relation to remaining uncertainties and data gaps:

- It is noted that the JNCC Guidelines are currently under revision after consultation. A presumption in favour of the use of acoustic detection methods during seismic surveys, would provide a means of improving detection efficiency and extending the range over which commencement of seismic operations is delayed (the current 500m is considered to be insufficient). Compilation and interpretation of seismic monitoring data by JNCC should be continued and expanded to include acoustic data.

- Further acoustic research on cetacean distribution should be conducted in the Faroe-Shetland Channel and Faroe Bank Channel, concentrated particularly on beaked whale species. This could involve a combination of deployed static instruments (“pop-ups”) and towed hydrophone surveys.

- Consideration should be given to establishment of criteria for determining limits of acceptable cumulative impact; and for regulation (through established permitting procedures) of cumulative impact (for example, in terms of total “exposure days” of individual blocks to received levels in excess of 120dB).

- Further consideration should be given to developing objective criteria for establishment of measures (as opposed to sites) for the protection of cetacean species (in particular, baleen, sperm, pilot and beaked whales), and the SEA 4 area should be reviewed against such criteria. The criteria should consider the utilisation by cetacean species of definable areas (e.g. shelf break and channel flanks) and should be broadly consistent with the approaches taken in other countries (e.g. Canada and Australia).

It is noted that DTI and a Joint Industry Project group are funding a three-year project aimed at developing and validating a systematic approach to assessing sensitivity to acoustic disturbance in fish and marine mammals, involving an assessment of frequency response in individual species in relation to received power spectra from a variety of sources. This information should inform future assessments of acoustic disturbance.

10.3.2 Physical damage to features and biotopes

10.3.2.1 Archaeology

The subject of prehistoric marine archaeological remains has received comparatively little attention in the planning or assessment of offshore oil and gas activities. A review of the topic was commissioned for SEA 4 (Flemming 2003) which complements a similar review covering the North Sea conducted for SEA 3.

Prehistoric submarine archaeological remains of up to approximately 9000 years old could occur in the SEA 4 area down to water depths of around 150m. Coastal prehistoric sites indicate the area was occupied by advanced culture(s) at least 9000 years ago and submerged sites found in Orkney, Shetland, the Viking Bank and Denmark show that remains can survive marine transgression. The most likely places for survival of submarine archaeological remains is in sheltered sea lochs, enclosed bays, submerged gullies and areas with thick Recent sediment deposits. Such areas are found only in coastal waters, with the continental shelf having statistically poor prospects for finds on account of the shallow sediment cover, strong water currents and exposure to Atlantic storms. 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 pipelines 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 and 4 reports on marine archaeology include 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 4 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. The subject of a reporting regime and access to suitable technical support and advice has been followed up with a variety of stakeholders since SEA 3 and it is hoped that this will lead to improved awareness and mitigation measures for existing and potential future oil and gas activity in the SEA 4 area (and other UK waters).

10.3.2.2 Physical damage to biotopes and other sensitive seabed features

A number of receptors were identified in Appendix 2 as potentially susceptible to physical damage from oil and gas activities in the SEA 4 area. However, with the exception of archaeological remains and vulnerable benthic species or colonies, it is believed that the effects of the range of potential SEA 4 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, at least 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 either for further investigation and/or alterations to planned activities so that such features are not damaged or unacceptable affected. In the case of Natura 2000 conservation sites, existing controls include the requirement for an Appropriate Assessment before consent for the proposed activity can be given.

10.3.3 Physical presence

10.3.3.1 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 4 Effects Assessment Workshop identified potential effects on inshore and offshore fishing as a significant issue. Offshore fishing activities and concerns were reviewed by Gordon (2003) in a commissioned study for this SEA, and a representative of the Scottish Fishermen's Federation participated in the Effects Assessment Workshop.

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.

Safety zones are listed by DEAL (Digital Energy Atlas and Library, http://www.ukdeal.co.uk/), and the number and extent of exclusion zones in the SEA 4 area is low. Predicted activity levels in the SEA 4 area involve a total of 4-8 exploration wells, which will typically require a temporary (30-60 day) exclusion zone; 1-2 subsea tiebacks which may require exclusion zones; and 1-2 stand-alone developments using FPSO vessels requiring exclusion zones for the life of the installations.

The exclusion of fishing activity from these zones does not adversely affect fish catch rates, as fishing effort is simply diverted to other regions. 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 however, only anecdotal evidence to support this assertion.

Trawling interactions

The safety of all users of the sea is a 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).

Several factors influence the decision whether a pipeline is trenched or placed on the sea bed, 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 than 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). However, since the loss of the trawler *Westhaven* in the North Sea, 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)

Lobster, edible crab and other shellfish trapping fisheries off the Orkney, Shetland and north Scottish coasts are undertaken primarily by local inshore vessels operating generally within a few miles of the coast (see Gordon 2003). Shellfish are captured in baited traps (pots or creels) laid in groups of 20 or more depending on vessel size and are usually hauled once every 24 hours. Some larger vessels can work up to 1000 traps.

The major interaction of fixed gear fisheries and oil industry activities 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 although this is regarded as a remote likelihood in the case of SEA 4.

In advance of exploration or development activities, particularly within locally important fishing areas (e.g. pipelaying in Yell Sound, Shetland), 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, although it is noted that further major infrastructure development is not anticipated from SEA 4 activities.

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 herring, which is a demersal spawning species dependant on localised areas of clean gravel substrate on which to lay their eggs (Gordon 2003, Section 3.6).

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 general, effects on benthic communities (including commercial shellfish) 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 fauna 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 across the continental shelf section of the SEA 4 area indicate active sediment transport and smothering effects are therefore unlikely to be significant at benthic species population and community levels in the SEA 4 area.

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 in the shelf and slope sections of the SEA 4 area are high (at least episodically), and the effects of anthropogenic sediment plumes are thus unlikely to be significant or long lasting.

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 national fisheries representative bodies. Local fisheries associations, which are usually sector-specific, would 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 fixed gear fisheries (mainly shellfish trapping) may be necessary during pipeline construction to landfalls, although in view of the predicted level of activity in the SEA 4 area this disruption will be limited.

The oil industry and UK fishing industry maintain consultation, liaison and compensation mechanisms, which should serve to mitigate and resolve any conflicts.

10.3.3.2 Other interactions

The extent of interference with other commercial shipping and recreational vessels, is judged to be minor, in view of the forecast extent and locations of SEA 4 activities. Existing consultation, notification and management procedures will mitigate effects.

Coastal amenity and prehistoric marine archaeological remains could be affected by pipelaying or other activities in sheltered nearshore waters although further major infrastructure development is not anticipated from SEA 4 activities.

10.3.4 Marine discharges

10.3.4.1 Introduction

The SEA 4 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.

10.3.4.2 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 (note, they would be considered in detail in Environmental Statements and chemical risk assessments under existing permitting procedures).

Produced water is derived from reservoir (“fossil”) water and through condensation. The majority of produced water discharge volume to the North Sea and elsewhere is associated with oil production and produced water volumes from gas fields are extremely small in comparison. The chemical composition and effects of produced water discharges have been previously summarised in SEA 2 and 3 and are not repeated here.

Fundamental to the consideration of potential effects of produced water in the SEA 4 region is that the two existing oilfields (Foinaven and Schiehallion) are disposing of at least 95% of produced water through reinjection to deep rock strata. Similarly, for the proposed Clair field development the design performance is for at least 98% of produced water to be reinjected. For these fields reinjection is the normal method of produced water disposal although under certain circumstances (e.g. injection pump maintenance) the effluent may be routed to sea. Any produced water discharged is treated since it is still required to meet legal quality standards in terms of oil in water concentration.

10.3.4.3 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 4 licence areas are a total of between 4 and 8 exploration and appraisal wells (with up to 10 possible drill or drop/contingent wells in the area north of Shetland), together with one or 2 subsea developments and up to 1 to 2 possible FPSO vessel developments involving 8-12 development wells (Section 4.2). Cuttings discharges from these activities would therefore total a maximum of around 30,000 tonnes, assuming the use of water-based muds. (Use of oil-based mud systems, for example in highly deviated sections or in water reactive shale sections, would require the onshore disposal or reinjection of a proportion of this material.)

Predicted drilling activity in blocks already licensed in the SEA 4 area, from DTI forecasts, suggests about 5 exploration or appraisal wells per year during the period 2002 – 2005 (i.e. annual cuttings discharges of around 5000 tonnes). In addition, the proposed development of the Clair field will involve some 23 new wells although the cuttings from these will be reinjected except for cuttings from riserless drilling. Forecast drilling discharges resulting from SEA 4 licence areas over the same period would represent an annual increment of up to 50% on predicted discharges.

By way of context, 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 2001). These discharges resulted from 36 exploration/appraisal and 225 development wells (DTI website) together with workovers, giving an average WBM chemicals discharge of 603 tonnes per well.

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 (e.g. 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 2001b).

10.3.4.4 Potential effects of produced water

Potential effects of produced water discharges are described in previous DTI SEAs and studies of produced water toxicity and dispersion (see E&P Forum 1994, and OLF 1998) have 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. In addition, in a trenchant editorial on real and perceived risks of produced water Gray (2002) concludes that the risks to ecologically or commercially important marine populations do not appear to be significant.

OSPAR Recommendation 2001/1 for the Management of Produced Water from Offshore Installations 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. The recommendation also includes a presumption against the discharge to sea of produced water from new developments

The existing producing fields in the SEA 4 area dispose of the great majority of the produced water by reinjection rather than discharge and this is planned for currently proposed field developments. In view of these factors it is concluded that any effects of produced water discharge in the area will be transient and minor and are not considered further.

10.3.4.5 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 4 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 effects are 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 2001b) and toxicological studies of the major individual constituents have reported limited or no effects (e.g. Tagatz & Tobia 1978, Starczak *et al*. 1992). Similarly, the effects of WBM discharges on water quality are viewed as transient and unlikely to result in significant effects.

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 mounds in all but the deepest parts of the SEA 4 area will be dispersed, typically over a time scale of 1-10 years, mainly through re-suspension and bedload transport due to tidal, storm and surge induced currents. Near-bed current velocities and sediment mobility in the SEA 4 area appear generally sufficient to prevent detectable local accumulation of cuttings (see e.g. Wynn *et al*. 2002).

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. Barlow and Kingston (2001) report damage to the gills of two species of coastal bivalves where barite was added to experimental system although no controls with other sediment added were tested and the concentrations of material added were very high so it is unclear how or if the results apply to the field situation.

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. Studies of particle uptake in deep cold water sponges by Witte *et al*. (1997) indicates that only smaller particles (<10µm) are ingested. Such particulates from drilling discharges in the SEA 4 area would be expected to dispersed very widely and thus be unlikely to be present in sufficient quantities to cause potential effects on filter feeding animals. It is unlikely that drilling over hard seabed substrates would occur in the SEA 4 areas.

10.3.4.6 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. The DTI have recently completed a consultation exercise on the *Offshore Petroleum Activities (Oil Pollution Prevention and Control) Regulations 2003* which will largely replace POPA and introduce a new permitting regime for oily discharges. 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, are also feasible for drilling with water-based mud (for example, if particular benthic biotope sensitivities were identified).

No additional mitigation measures are currently regarded as necessary.

10.3.4.7 Conservation sites

Potential offshore conservation sites and additional sites in territorial waters in the SEA 4 area, are summarised in Section 7. Given the small volumes of SEA 4 related exploration and production discharges, their anticipated location in prospective areas well offshore 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.

10.3.4.8 Conclusions

The environmental effects of produced water discharges not reinjected are limited primarily by dispersion, below NEC.

Discharges of WBM cuttings in the North Sea and other dispersive environments have been shown to have minimal ecological effects.

10.3.4.9 Ballast water exotics

There have been a number of deliberate and accidental introductions of marine animals and plants to the North Sea and UKCS (see e.g. Reise *et al.* (1999) and Kerckhof & Cattrijsse (2001)). 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 reviews conducted for the SEAs by the Sir Alister Hardy Foundation for Ocean Science. These summarise 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 addition, the potential exists for transfer between European locations of native species in ballast water which under certain conditions can bloom, resulting in for example, paralytic shellfish poisoning. Such blooms can lead to negative economic impacts on shell- and fin- fisheries. 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, see Sutherland *et al.* (2001)) 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 significant effects arising from oil and gas activities involving ballast water discharge that might follow SEA 4 licensing is seen as remote. This is because the majority of ballast water is carried by ships and oil production from the area is exported by shuttle tanker to Sullom Voe and Flotta (or by pipeline in the case of the Clair field development). In view of the limited number of wells anticipated the likelihood of the use of a rig which has just undergone transatlantic (or wider) transfer is low.

As an additional mitigation, the current IMO voluntary guidelines on ballast water management should be followed for SEA 4 and wider UKCS oil and gas activities. In July 2003, the IMO's Marine Environment Protection Committee (MEPC) agreed a finalized draft of a proposed International Convention for the Control and Management of Ships' Ballast Water and Sediments.

10.3.5 Subsurface discharges

A range of subsurface discharges may be made as a result of oil and gas activities. Of prime relevance to the SEA 4 area would be produced water or drill muds and cuttings which may be ground and reinjected to rock formations rather than discharged to sea or returned to land. The reinjection of wastes to source is generally regarded as resulting in positive benefits, such as reduced requirement for landfill space. However, the process of reinjection can be energy intensive and thus result in increased atmospheric emissions from an installation.

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 this Section.

10.3.6 Atmospheric emissions

10.3.6.1 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 4 areas, the Assessment Workshop concluded that potential effects of emissions on local air quality may require further consideration.

The SEA 4 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.

10.3.6.2 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 including from offshore loading of shuttle tankers and fugitive emissions.

Power requirements for the UK 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 use 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.

10.3.6.3 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).

Hiscock *et al*. (2001) conjecture the potential effects of climate change on seabed wildlife in Scotland and suggest various northern species may decrease or disappear while various southern species may extend their ranges or colonise Scottish waters. The assessment by Hiscock *et al*. (2001) is predicated on climate change resulting in warming air and seawater temperatures and the alternative scenario of cooling through changes in thermohaline circulation (i.e. reductions in the amount of heat translated to northern latitudes by the Gulf Stream and North Atlantic Current) is not addressed. The uncertainties of present models of likely outcomes and effects of climate change are summarised by Rahmstorf (1997). If such cooling were to occur, opposite patterns of species response to those outlined above would be expected to occur.

10.3.6.4 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 4 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.

10.3.7 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 follow from licensing in the SEA 4 area (up to 12 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 now permitted 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 limited number of subsea tiebacks and FPSO production developments are projected to be the likely scale of field development in the SEA 4 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.

10.3.8 Accidental events

10.3.8.1 Introduction

Oil spills are probably the issue of greatest public concern in relation to the offshore oil and gas industry. However the Assessment Workshop also identified chemical spills and gas release as subjects for consideration. The risks of large oil spills resulting from E&P are potentially associated with export (pipeline and tanker loading sources) and with the additional potential for uncontrolled oil blowout, though the historical frequency of such events in the UK and Norwegian continental shelves has been very low.

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 the appropriate Environment Description sections and supporting studies. The sources, frequency and scale of hydrocarbons spills are considered below. Much of the information is common to previous SEAs, and is therefore summarised below with updates where appropriate.

Specific issues associated with SEA 4 (and SEA 1) include the location of prospective areas upwind from sensitive coastlines; the importance of aquaculture along adjacent coastlines; and the relative remoteness of the area from stockpiles of oil spill response resources.

It should be noted that the purpose of SEA spill risk assessment is not to anticipate the detailed risk assessment and contingency planning which would be required in advance of any development; but to evaluate the overall contribution to risk associated with possible SEA 4-related activity.

10.3.8.2 Historical oil spill scenarios and frequency

Previous Environmental Statements, Contingency Plans, databases, guidelines and SEAs have devoted considerable effort to assessment of potential spill scenarios in the SEA 4 area and elsewhere – in terms of magnitude, source, fluid characteristics and frequency – mainly on the basis of historical data. Relevant information is summarised below.

SEAs 1, 2 and 3 reviewed hydrocarbon spills reported from exploration and production facilities on the UKCS since 1974 under PON1 (formerly under CSON7), annual summaries of which were published in the "Brown Book" series (now superseded by on-line data available from the DTI website www.og.dti.gov.uk).

Well control incidents (i.e. "blowouts" involving uncontrolled flow of fluids from a wellbore or wellhead) have been too infrequent on the UKCS for a meaningful analysis of frequency based on historic data. (The only significant blowouts on the UKCS to date have been from *West Vanguard* (1985) and *Ocean Odyssey* (1988), both involving gas.) Blowout frequencies cited in Environmental Statements for west of Shetland exploration and development range from 2.8×10^{-5} to 2.1×10^{-4} (i.e. 1 in 35,714 to 1,075 well-years; highest frequency is for combined drilling scenarios, from Clair Phase 1 Environmental Statement based on Scandpower database). These are generally consistent with derived annual frequencies based on worldwide databases maintained by SINTEF and Scandpower.

Blowout rates may vary widely, dependent on reservoir characteristics, and the reasons for loss of containment. Seabed blowout flow rates in deeper water will be limited by hydrostatic pressure from the overlying water column. Qualitative analysis and modelling suggests that high flow rate blowout scenarios (e.g. to surface via drillpipe) will tend to bridge relatively quickly, however, sustained well flow at lower rates can be simulated under some circumstances, which could result in a prolonged release in the absence of intervention.

DTI data indicates that the major types of spill from mobile drilling rigs have been organic phase drilling fluids (and base oil), diesel and crude oil. Topsides and infield flowlines and risers are the most frequent sources of spills from production operations, with most spills being <1 tonne. A large proportion of reported oil spills in recent years (since about 1990) have resulted from process upsets. Estimated spill risk from UKCS subsea facilities averaged just over 0.11 spills per year (equivalent to a risk of one spill in any one year of 0.003 from an individual facility), with almost all reported spills <5bbl in size.

Statistical analysis of oil spill incidents to support impact assessment of year-round petroleum operations in the Lofoten-Barents Sea area (http://odin.dep.no/oed/) derived frequencies for four scenarios. Expected return periods for the "moderate" activity level (1-5 fields in production) were 190-450 years for pipeline leakages not resulting in surface oiling (low release rates with long duration); 660 years for pipeline leakage resulting in surface oiling; 630 years for a blowout, and 1,500 years for a major spill from FPSOs.

Major spill events from UKCS production facilities include the Claymore pipeline leak, 1986 (estimated 3,000 tonnes), the Piper Alpha explosion, 1988 (1,000 tonnes) and Captain spill, 1996 (685 tonnes). Although significant, these volumes are minor in comparison to other anthropogenic sources of oil in the marine environment. For example, in 1995 a total of 11,800 tonnes of oil was discharged by the offshore oil and gas industry to the North Sea, of which 2% originated from accidental spills (OSPAR 2000). Estimates of oil inputs from other sources have not been subject to regular reporting within OSPAR, although the 1993 Quality Status Review estimated a total oil input of 85,000-209,000 tonnes per year to the North Sea, including oil-based drilling fluids, riverine sources, shipping and natural seepage (NSTF 1993).

Globally, the total amount of oil spilled annually depends largely on the incidence of catastrophic spills (Etkin 1999), with less than 300,000 tonnes in most years, but exceptional quantities spilled to sea in 1978 (*Amoco Cadiz* tanker spill, 233,670 tonnes), 1979 (Ixtoc 1 blowout, Gulf of Mexico, 476,190 tonnes; and *Atlantic Empress* tanker spills), 1983 (Nowruz blowout, Persian Gulf, 272,109 tonnes and *Castillo de Bellver* tanker spill) and 1991 (Gulf War I, 816,300 tonnes to land and sea). Two major spills in or close to the SEA 4 area have occurred in recent years, both were coastal tanker incidents (*Esso Bernicia*, 1,174 tonnes, December 1978; and *Braer*, 85,035 tonnes, January 1993).

10.3.8.3 Oil spill fate

The fate of oil spills to the sea surface is relatively well understood, in contrast to subsea spills in deep water. Following a surface oil spill, there are eight main oil weathering processes: evaporation, dispersion, emulsification, dissolution, oxidation, sedimentation/sinking, biodegradation and combine processes – these are reviewed in SEAs 1, 2 and 3.

The behaviour of crude oil releases at depth will depend on the immediate physical characteristics of the release, and on subsequent plume dispersion processes.

In qualitative terms, if associated gas is released from a wellhead, manifold, flowline, pipeline or riser along with crude oil, the mixing conditions at the release point will be very intense. The pressure differential between the source and hydrostatic pressure at the release point will be a critical factor in determining the form of the oil as it is released. If the release pressure is high and the size of the escape orifice is small, the oil will be converted almost instantly into a jet or plume of small oil droplets by the effect of its escape velocity and gas expansion, and mechanically dispersed into the sea. These very small oil droplets will have a low buoyant ascent velocity, but will be propelled towards the sea surface by the sea water entrained by the buoyant gas plume. Increased plume buoyancy due to gas expansion may be reduced by gas hydrate formation under deepwater temperature and pressure conditions.

The DEEPSPILL Joint Industry Project tested deepwater blowout models and equipment for spill monitoring surveillance, using an experimental release in the Norwegian Sea. The results indicated that existing models could predict the course of a possible spill with some degree of accuracy. Modelling generally indicates that neutrally buoyant hydrates may form from some of the gaseous components in well fluids following a deepwater blowout (GEM 2001, BP 2001, Hess 2002). This would result in a buoyant plume and oil surfacing as dispersed oil droplets, although viscous water-in-oil emulsions may also form. The surface signature of the spill may occur some considerable distance from the sub-sea source. Field trials have also indicated that current shear and stratification in the water column may prevent, or reduce the quantity of oil which reaches the surface. Modelling undertaken for the Assynt well in block 204/18 (BP 2001) indicated that a 76 day blowout at seabed would produce a coherent plume to a depth approximately 60m above seabed; at which point the associated released gas would form hydrates and continue to the surface. This simulation reported only a limited amount of horizontal displacement of the surface slick.

10.3.8.4 Oil spill trajectory

Oil spill trajectory modelling can be carried out deterministically (i.e. with defined arbitrary metocean conditions, usually "worst case") or stochastically (i.e. using statistical distributions for wind and current regimes). Modelling is usually carried out for a major crude oil release, corresponding to a blowout, and for smaller diesel or fuel oil releases which are expected to be less persistent. A review of trajectory modelling carried out in twelve representative Environmental Assessments for exploration wells and developments west and north of Shetland has been carried out as part of the SEA 4 process – see Table 10.1 below.

Table 10.1 - Review of representative trajectory modelling for west of Shetland exploration and developments

Block	Water depth (m)	Spill type	Spill size	Model used & conditions	Time to beach
204/16	Ca 1000	Blow out, Foinaven type crude	30m^3/hr 24hr period total 720m^3	OSIS 3 30knot wind to Shetland (290°) & Faroes (145°)	Foula 46hrs Shetland 67hrs Faroe 62hrs
204/10	Ca 1000	Blow out, Foinaven type crude	30m^3/hr 24hr period total 720m^3	OSIS 3 30knot wind to Shetland (295°) & Faroes (125°)	Shetland 45hrs Faroe 55hrs

Block	Water depth (m)	Spill type	Spill size	Model used & conditions	Time to beach
204/21	Ca 800	Blow out, Brent type crude	$30m^3$/hr 24hr period total $720m^3$	OSIS 3 30knot wind to Orkney (275°) & Faroes (145°)	Orkney 51hrs Faroe 63hrs
204/17	983	Blow out, type of crude not stated	4800 m^3 instantaneous Also – GEM scenario for stochastic modelling $126m^3$ for 120hrs total spill of $15000m^3$	OSIS 3 30knot onshore winds	Foula 48hrs Shetland 63hrs Orkney 51hrs Faroe 59hrs Stochastic 5 to <10% probability of oil beaching on Shetland and 1 to <5% for Orkney, Faroe mainland Scotland
219/12	911	Diesel spill	$658m^3$ instantaneous	OSIS 3 stochastic	0m/s wind 28hrs to disperse otherwise max persistence was 18hrs in which travel is ca. 32km
206/8	140	Clair crude blowout (seabed & at surface)	$35000m^3$ over14 days	OSIS 3 deterministic (30knot onshore wind) & stochastic	Shetland 25hrs worst case but in winds <13knots would not beach on Shetland Orkney 118-130hrs Faroe 122-133hrs Mainland Scotland 118-130hrs
204/20 Schiehallion field	350-450	Not given but Schiehallion crude spills		OSIS 30knot wind to Shetland (270°)	45hrs
204/24, 25, 19, 20	500-550	Surface spill of Foinaven crude	100 tonne	Not stated but probably OSIS (30 knot onshore winds)	45hrs Shetland 48hrs Orkney 76hrs Caithness
204/25 East Foinaven	370	Surface spill	100 tonne	OSIS 30knot winds to 4 compass points	45hrs Shetland 48hrs Orkney 76hrs Caithness
204/14 & 204/15	Ca 800	Instantaneous release at surface of Foinaven crude	$1000m^3$	OSIS 2.2.3 30knot winds to variety of surrounding coasts	40hrs Foula 42hrs Shetland 45hrs Orkney 53hrs Faroe
204/14	Ca 1000	Foinaven crude	Not stated	OSIS 2.0 30knot winds to variety of surrounding coasts	40hrs Foula 42hrs Shetland 53hrs Orkney 75hrs Caithness
213/25	1178	Instantaneous release at surface of Foinaven crude	$1000m^3$	OSIS 30knot onshore winds to variety of surrounding coasts	35hrs Shetland 70hrs Orkney 133hrs Caithness
214/24	653	Diesel	10, 100, 2000 tonne	OSIS 30knot winds to 4 compass points	Disperses in 6, 8 and 9hrs. Max slick travel 20, 34, 36km
164/28	850	Instantaneous surface spill of Foinaven crude Instantaneous diesel spill	250 tonne 250 tonne	OILMAP 30knot winds – deterministic. Also stochastic	Sula Sgeir 38hrs Lewis 48hrs St Kilda 84hrs
153/5	1231	Instantaneous release at surface of Foinaven crude plus blowouts at surface and seabed	250 m^3 (licence condition stip) and 1400 tonnes per day for 5 days, total spill of 7000 tonnes	OSIS 30knot winds – deterministic. Also stochastic	Minimum beaching time 34hrs max, 120hrs

Deterministic estimates of Time to Beach (TTB) from exploration and development locations in the SEA 4 area, extracted from the review, fall within the following ranges:

- Foula 40-48h
- Orkney 45-118h
- Shetland 25-67h (25h from block 206/8)
- Faroe 53-122h
- Mainland 75-118h

These estimates are reasonably consistent and indicate, unsurprisingly, that TTB to Orkney, Shetland and the Faroes are broadly comparable with minimum TTB of 40-50h. The Scottish mainland has significantly longer TTB.

Relatively little stochastic modelling has been carried out, with available results indicating probabilities of surface oiling resulting from uncontrolled crude oil blowout scenarios, of 30% along the north-east Shetland coast, but <10% south of St Magnus Bay and <5% for Orkney, the Faroes and mainland Scotland. Diesel spills had an insignificant (<1%) probability of surface oiling of coastlines. The predicted distribution of spill trajectories was dominated by prevailing south-westerly winds, with limited tidal influence.

10.3.8.5 Ecological and economic effects of oil spills

The most vulnerable components of the ecosystem to oil spills in offshore and coastal environments are seabirds and marine mammals, due to their close association with the sea surface. These sensitivities are discussed below. Benthic habitats and species may also be sensitive to deposition of oil associated with sedimentation. Studies of macrobenthic infauna following the *Braer* spill (Kingston *et al*. 1995) found no significant changes in benthic community structure, as characterised by species richness, individual abundance and diversity, which could be related to the areas of seabed affected by the spill. This may have been because *Braer* oil was of such low toxicity as to significantly disrupt benthic community structure, or because the sampling programme was carried out too soon after the spill to enable the full effects of its impact to be detected. In recognition of this, the DTI intends to conduct further sampling of the study area, ten years after the spill event.

It was noted in SEA 1 that military casualties over the course of two world wars resulted in unquantified, but substantial release of crude and heavy fuel oils in the region within relatively short timescales, apparently without catastrophic ecological consequences. Military wrecks in Scapa Flow continue to be a source of chronic oil pollution.

Oil spills have a potentially severe effect on fishing activities, particularly in coastal fisheries and aquaculture; and also potential impacts on tourism and recreation. These are further discussed below.

Seabirds and wintering waterbirds

Direct mortality of seabirds in the event of oil spill is undoubtedly the most widely perceived risk associated with the proposed licensing and subsequent activities. Spills affecting waters near major colonies during the breeding season could be catastrophic (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).

Offshore vulnerability of seabirds to surface pollution in the SEA area was reviewed in section 6.7 and concluded to be very high in parts of Quadrants 1, 5, 6, 7, 11, 12, 17, 18, 156, 201, 203, 207, 208 and 209; corresponding to SEA 4 areas north of the Scottish mainland, in the Fair Isle Channel and nearshore north and west of Shetland. Much of the seabird vulnerability is associated with proximity of breeding colonies and post-breeding dispersal of auks and is therefore seasonal. Probabilities of surface oiling, following spills in prospective areas of SEA 4, are relatively low in these Quadrants with the exception of the nearshore north-west of Shetland, in close proximity to the major colony at Hermaness which supports gannets, shags and cliff-nesting auks. Other colonies of national importance on the north-west Shetland coastline comprise the arctic and great skua colonies on Unst, and at Tingon and North Roe, which may be less vulnerable to surface pollutants. However, atypical wind patterns could result in surface oiling of any part of the western Shetland and Orkney coasts which support significant breeding colonies of vulnerable seabird species.

The vulnerability of coastal waterbirds (including ducks, geese and waders) has not been quantified with a methodology comparable to the seabird Offshore Vulnerability Index (OVI). In general, the seasonality of vulnerability is high with particular exposure of important biogeographical populations during migration periods. Most wintering waterbirds in Shetland and Orkney are concentrated in sheltered coastal areas and voes (divers and grebes); or are primarily associated with freshwater, wet grassland and moorland habitats (ducks, geese and waders); neither of which would be affected by offshore oil spill under most circumstances.

Marine mammals

Oil spill risks to marine mammals were reviewed by SEA 1 and Hammond *et al*. 2003. Direct mortality as a result of contaminant exposure associated with major oil spills has been reported, e.g. following the *Exxon Valdez* oil spill in Alaska in 1989. Many animals exposed to oil developed pathological conditions including brain lesions. Additional pup mortality was reported in areas of heavy oil contamination compared to unoiled areas.

More generally, marine mammals are less vulnerable than seabirds to fouling by oil, but 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. Symptoms from acute exposure to volatile hydrocarbons include irritation to the eyes and lungs, lethargy, poor coordination and difficulty with breathing. Individuals may then drown as a result of these symptoms.

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 particularly the pupping season (October-January in grey seals; June-July in harbour seals). Animals most at risk from oil coming ashore on seal haul-out sites and breeding colonies are neonatal pups, which are therefore more susceptible than adults to external oil contamination. Both grey and harbour seal haul-outs are distributed widely throughout the west coast of Shetland, and there are numerous well dispersed haul-outs on Orkney.

Intertidal and maritime habitats

Intertidal habitats and species are vulnerable to surface oil pollution, or to windblown oil in the case of onshore maritime habitats (e.g. machair). After seabirds and wildfowl, seals and otters are probably the most obvious potential casualties (and certainly the most emotive in terms of press coverage), with vulnerability of intertidal habitats also high, particularly in the event of oiling of sheltered coastlines. The vulnerability of different shore types to oil pollution is largely dependent on substrate and wave exposure, and is reviewed below (after Gundlach & Hayes 1978):

- **Exposed rocky headlands** – wave reflection keeps most of the oil offshore
- **Eroding wave cut platforms** – wave swept. Most oil removed by natural processes within weeks
- **Fine grained sand beaches** – where oil penetrates into sediment, may persist over several months. Penetration can occur due to wave action and tidal movements
- **Coarse grained beaches** – oil may sink and/or be buried rapidly. Under moderate to high energy conditions, oil will be removed naturally from most of the beachface
- **Exposed compacted tidal flats** – oil will not adhere to, nor penetrate into compacted sediments
- **Mixed sand and gravel beaches; shingle beaches** – oil may penetrate rapidly and be buried resulting in persistence over years. Solid asphalt pavement may form under heavy oiling conditions
- **Sheltered rocky coasts** – reduced wave action. Oil may persist for years
- **Sheltered tidal flats** – low wave energy; and high productivity, biomass and possibly bioturbation. Oil may persist for years
- **Salt marshes** – highly productive and vulnerable. Oil may persist for years.

The western coastlines of Shetland and Orkney, which have a relatively higher probability of oiling, have predominantly high energy rock, boulder or cliff shores which are generally of low vulnerability. Higher vulnerability shore types are distributed in voes, sounds and embayments. Shoreline types have been mapped as part of coastal protection strategies (AFEN 2001), and Appropriate Assessments carried out for areas designated as SACs or SPAs.

The overall assessment of oil spill risk associated with SEA 4 is, in part, based on the existing level of risk associated with offshore production but mainly with commercial shipping. Shetland and Orkney coasts are exposed to risks associated with high levels of tanker traffic in the Fair Isle Channel and north of Shetland (Lord Donaldson 1994). These routes are close to shore and upwind of vulnerable coastlines, and limited time is available for effective response measures in the case of accidents. It is generally accepted (e.g. Ritchie & O'Sullivan 1994) that natural dispersion (with some chemical dispersion) of spilled oil from the Braer was exceptionally rapid, due to prevailing weather conditions, and far greater ecological effects could have resulted from a similar event in summer weather.

Tourism and recreation

In addition to fishing and aquaculture, coastal industry and activities in adjacent areas to the SEA 4 area include tourism and recreation. Both are of considerable economic importance to local economies and are vulnerable to the effects of major oil spills.

Impact on the tourism and amenity "appeal" of Shetland, Orkney and other coastal areas in the event of a major oil spill, primarily in terms of tourist numbers, would be influenced primarily by the extent, duration and tone of media reporting, and by public perception of the severity of the event. These factors cannot be reliably predicted. Medium and long-term influences of the previous *Esso Bernicia* and *Braer* tanker spills have not been quantified, but have not been catastrophic.

Fisheries and aquaculture sensitivities

All hydrocarbon spills have the potential to affect fish and shellfish populations by tainting which is caused by ingestion of hydrocarbon residues in the water column and on the sea bed. If large-scale releases of oil were to reach the sea bed, there is potential for smothering of features that are used by fish either as spawning, feeding or nursery grounds. In addition to direct toxicity of oil and dispersants, oil and certain chemicals have the potential to introduce taint (defined as the ability of a substance to impart a foreign flavour or odour to the flesh of fish and shellfish following prolonged and regular discharges of tainting substances (Guidelines for the UK Revised Offshore Chemical Notification Scheme, July 1999). Possible effects on human consumers of seafood are also an issue of concern in relation to accidental spills and industrial discharges.

Government may issue exclusion orders preventing marketing of seafood from areas considered to be contaminated following a spill or other incident, resulting in economic impacts on local fisheries and associated processing. Historical experience (e.g. the *Braer* spill) indicates that irrespective of actual contamination levels, 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 fishing industry (and associated industries).

Extensive numbers of salmon farms are found throughout Shetland and Orkney, with a smaller number along the North coast of Scotland. The many voes, inlets and firths around the Shetland and Orkney coastlines provide good shelter and adequate water exchange for mariculture operations and the industry has become an important constituent of the local economy. 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. It is likely that significant oiling of any part of Shetland, and to a lesser extent Orkney and mainland coastlines, would have a similar effect.

10.3.8.6 Oil spill response preparedness – organisation and management

Spill prevention and mitigation measures are implemented for offshore exploration and production 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.* The required measures include spill prevention and containment measures, risk assessment and contingency planning.

Offshore primary responsibility for oil spill response lies with the relevant Operator, although the Secretary of State's Representative (SOSREP) may intervene if necessary. The Maritime and Coastguard Agency (MCA) is responsible for a National Contingency Plan in consultation with other relevant departments, agencies and stakeholders, last revised in February 2000 following recommendations from Lord Donaldson. MCA maintains four Emergency Towing Vessels (ETVs) including one each in the Minches and Fair Isle, which remain on standby at sea. In addition, the MCA maintains a contractual agreement for provision of aerial spraying and surveillance, with aircraft based at Coventry and Inverness. The aircraft can reach a forward operating base at Sumburgh in 1¾ hours and within two days, can deliver sufficient dispersant to treat a 16,000 tonne spill within 50 miles of the coast anywhere around the UK (National Audit Office 2002). The DTI is a partner in this contractual arrangement and undertakes regular aerial surveillance of offshore installations. MCA holds 1,400 tonnes of dispersant stockpiled in 14 locations around the UK, in addition to counter-pollution equipment (booms, adsorbents etc.) which can be mobilised within 2-12 hours depending on incident location.

Similar response capabilities, providing a tiered response capability, must be available to Operators prior to commencing drilling or production activities. These provisions are made under various long-term commercial contracts with specialist contractors, supplemented where necessary (e.g. for remote locations) with additional stockpiles. Site-specific Oil Spill Contingency Plans must also be submitted to DTI for approval prior to operations. Additional conditions can be imposed by DTI, through block-specific licence conditions (i.e. "Essential Elements").

Minimum beaching times from some parts of the possible licence area with sustained 30 knot winds, are of the order of 40 hours and provide sufficient time for appropriate response measures as described above. Coastal oil spill risks would be a key issue in assessment and risk management of proposed developments in the SEA 4 area. In consultation with local authorities and conservation agencies, AFEN has developed coastal response plans (AFEN 2001) which cover Shetland, Orkney, the Hebrides, north and west coasts of Scotland.

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.

10.3.8.7 Information gaps

Vulnerability data are relatively adequate for most of the SEA 4 area, with the exception of the most northern region. However, data gaps are present for two or more consecutive months in parts of Quadrants 205, 208, 217, 218, 219, 220 and 222. Contingency planning for activities which could affect these areas should take note of these gaps, particularly with regard to the consequent difficulty in deciding whether application of chemical dispersants is appropriate.

Use of dispersants is a key aspect of oil spill response strategy in the UK, where there are no ecological or fisheries conflicts. There have been no specific studies on the direct acute or chronic toxicity of oil dispersants to seals and cetaceans.

10.3.8.8 Conclusions

Although the consequences of major oil spills in the area may clearly be severe, in both ecological and economic terms, the incremental risk associated with the predicted level of activity is moderate or low. Existing exposure to risk is "high" or "very high" as a result of shipping around the north of Shetland, Fair Isle Channel and western Orkney (National Audit Office 2002) and oil spill contingency arrangements have been revised and significantly upgraded since 1999.

DTI has regulatory mechanisms in place to require Operators to develop effective oil spill mitigation measures, covering organisational aspects and the provision of physical and human resources. Times to beach, under deterministic trajectory modelling conditions, are sufficient to allow the deployment of response measures where appropriate; and the probability of surface oiling in coastal waters is low or moderate. Uncertainties noted in SEA 1, regarding the fate and consequences of deepwater oil releases, have been addressed.

10.3.8.9 Chemical spills

The methods of transport and quantities associated with forecast levels of activity in SEA 4 area, together with low toxicity of the majority of chemicals used, indicate that the likelihood of a large spill with significant effects is unlikely. In general, the fate and consequence processes which affect chemicals in the environment are comparable to those for hydrocarbon components, and are dependent on the partitioning of individual compounds between dissolved oil and particulate phases in the water column. Direct and indirect effects of chemical spills on seabed, benthic fauna, fish and shellfish, seabirds, marine mammals and fisheries are considered to be minor. Chemical selection, transport and use is strictly regulated under environmental and health & safety legislation. The incremental risk associated with SEA 4 activity (in the context of bulk carrier transport of chemicals to UK and mainland European ports) is small.

10.3.8.10 Gas releases

Gas production involves an associated risk of accidental gas release, at rates ranging from small (fugitive emissions) to catastrophic. Environmental and safety consequences of gas releases will depend both on scale, location, water depth and on whether released gas ignites. Health and safety consequences of gas clouds and explosions are outside the scope of this assessment.

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 emissions (which include very large fluxes through natural processes) will be negligible.

Large-scale gas releases from wellheads or trunk pipelines in shelf depths present a theoretical risk of effects on floating installations and vessels, through loss of buoyancy. This risk is extremely remote, and comprehensive control systems are in place to prevent and mitigate such events (including well control, pipeline integrity monitoring, depressurisation and venting systems).

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 and SEA 3 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 an area with a long history of exploration activity are cumulative, insofar 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; or

- the effects of multiple sources clearly act on a single receptor or resource (for example a fish stock or seabird population); or

- 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 22nd 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 amount of seismic to be shot associated with SEA 4 exploration is predicted to be of the order of 1500-5000km 2D seismic and 1000-5000km^2 3D seismic. Such coverage is expected to entail some 130 days of survey effort of which up to half may involve airgun use. This level of survey effort is similar to that over the last 5 years in the area. Species for which SEA 4 information is available suggests that offshore, marine mammals are not generally confined to localised areas and it is unlikely that individuals would be exposed to sound levels sufficient to cause significant biological effects for the full duration of a survey. No marine mammal species are known to follow regular tightly defined migration pathways in the SEA 4, 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 west of Shetland area to date has resulted in direct mortality or acute trauma to marine mammals.

Incremental Simultaneous and sequential surveys in 22nd Round and previously licensed areas. Seismic and operational noise (e.g. drilling, thruster and FPSO noise).

Cumulative Seismic survey noise and broadband impulse noise, for example military sonars, and continuous mobile sources e.g. shipping

Synergistic None known

Physical damage to features and 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 and rock-dumping; of these, rig anchoring and pipelay accounted for greatest spatial extent. Given the forecast scale of exploration and production for the SEA 4 area, 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 continental shelf and slope depths but potentially much longer in deep water muds (although it is unlikely that anchored rigs would be used in such areas).

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 afforded appropriate protection.

Incremental Physical footprint incremental to existing oil and gas activity – minor increment

Cumulative Cumulative effects dominated by trawling on the continental shelf and upper and mid slope. In these areas the overall effect of oil and gas development is likely to be positive through fishing exclusion. There is limited commercial bottom trawling in the deep cold water areas.

Synergistic None known

Physical presence

The physical presence of offshore infrastructure (with associated 500m radius safety exclusion zones) required for exploration and production in shallow waters can have significant direct effects on other users of the affected areas (notably the fishing industry). For example, in the early 1980s 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 in the SEA 4 area amounts to 18 temporary (not all would be concurrent and spread over a 4 to 5 year period) and up to 4 longer term exclusion zones, a minor increment to the existing area covered by exclusion zones to the west of Shetland.

Incremental Small increment to existing exclusion zones and obstructions

Cumulative Exclusion and snagging risks are cumulative to those resulting from natural obstructions, shipwrecks and other debris. Extent of cumulative effect associated with 22nd Round is negligible.

Synergistic None known

Marine Discharges

Total produced water discharge from UKCS oil production was 272 million tonnes in 2002, with an average oil in water content of 21.0mg/kg (DTI website). In comparison with this, the potential discharge from SEA 4 developments will be negligible since it is expected that the bulk of produced water will be reinjected rather than 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.

Environmental effects of produced water discharges are limited primarily by dispersion, to below No Observed Effect Concentrations (NOECs). Synergistic interactions are possible between individual components, particularly PAHs, specific process chemicals (especially those which are surface-active, including demulsifiers), and other organic components. However, given the anticipation that the bulk of produced water from SEA 4 area field developments will be reinjected rather than discharged, and that such discharges as are made will be treated to required quality standards, the scope for incremental, cumulative or synergistic effects is remote.

Previous discharges of WBM cuttings in the SEA 4 area have been shown to disperse rapidly and to have minimal ecological effects. Dispersion of further discharges of mud and cuttings could lead to localised accumulation in areas where reduced current allows the particles to settle on the seabed. However, in view of the scale of the area, the water depths and currents, and plans to reinject drill cuttings from a major field development in the area, this is considered unlikely to be detectable and to have negligible incremental or cumulative ecological effect.

Incremental Produced water – incremental contribution of produced water is dependent on the extent of reinjection from existing and SEA 4 developments but noting the presumption against new produced water discharges, the scale of discharge and effects will be negligible. 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" may occur in areas of sediment accumulation although this is considered unlikely to be detectable.

Cumulative Principal cumulative sources of major contaminants, including hydrocarbons and metals, are shipping (including wrecks) and atmospheric inputs. Cumulative sources of particulate contaminants include aeolian dust and sediment disturbance from trawling, although these are negligible in the context of natural suspended particulate loads.

Synergistic Synergistic effects of chemical contaminants in produced water and drilling discharges are conceivable, although substantive data is almost entirely lacking and it is considered unlikely that significant synergistic effects would result from chemicals used in exploration and production operations.

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 for 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 facilities 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 emergency pressure relief, with "zero routine flaring" now considered a realistic design target for new developments including for the FPSOs predicted for the SEA 4 area. Other than start-up flaring, subsea tie-back developments will generally have little effect on host installation flaring.

Incremental Incremental emissions resulting from internal combustion for power generation by installations, terminals, vessels and aircraft, flaring for pressure relief and gas disposal, and fugitive emissions during tanker loading.

Cumulative Greenhouse and acid gas emissions effectively contribute to a mixed regional or global "pool" and can therefore considered to be cumulative. On a global scale, cumulative contributions of emissions resulting from SEA 4 activities and 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 the SEA 4 area, and recent establishment of a licensing mechanism to allow interfield cuttings reinjection, it is considered unlikely that major incremental or cumulative landfill requirement will result from SEA 4.

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

Accidental events

Although the consequences of a major oil spill in the area could be severe, in both ecological and economic terms, the incremental risk associated with the predicted level of activity in SEA 4 is moderate or low. In contrast, existing exposure to risk is "high" or "very high" as a result of shipping around the north of Shetland, Fair Isle Channel and western Orkney. Regulatory mechanisms already in place require Operators to develop effective oil spill mitigation measures, covering organisational aspects and the provision of physical and human resources which will minimise incremental risks. Times to beach, under worst case trajectory modelling conditions, are sufficient to allow the deployment of response measures where appropriate.

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. While some control and response measures have been implemented, for example following the Donaldson inquiry into the *Braer* incident, the residual risk remains relatively high (in comparison to other oil spill sources including E&P).

Other cumulative sources of anthropogenic hydrocarbon input to the SEA 4 area include rivers and land run-off, coastal sewage/sewage sludge, dredge spoil, operational shipping discharges and atmospheric deposition. 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. In size and frequency terms the majority of oil spills most likely to result from E&P operations will make an insignificant contribution to overall regional inputs.

As context may be noted that overall, although the acute effects of oil spills can 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 4-related activity, assuming that effective risk management practices continue to be implemented, will be minimal.

Incremental Hydrocarbons from oil spills will be incremental to (minor) offshore exploration and operational discharges; however, it is considered very unlikely that oil spill footprints will overlap given the predicted spill frequency associated with SEA 4 activities.

Cumulative There are a range of cumulative sources of hydrocarbons to the SEA 4 area. Depending on magnitude, accidental spills represent a minor to major contribution to overall regional inputs of oil.

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 4 area is contiguous with waters under the jurisdiction of Norway and the Faroes. Prevailing wind and residual water circulation of the SEA 4 area 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 4 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 22nd Round licensing.

10.6 Potential socio-economic implications

10.6.1 Overview

The report, provided by Mackay Consultants, outlines the predicted socio-economic impacts of licensing the SEA 4 area. Scenarios of possible developments in the region were provided by the Department of Trade and Industry (listed in the box below) and used by Mackay Consultants to produce forecasts in the following areas:

- Oil and gas production and reserves
- Capital, operating and decommissioning expenditure
- Existing facilities
- Employment
- Tax revenue

Two geographical areas have been used for the purposes of the assessment:

Area 1. Area of existing and previously licensed acreage (west of Shetland)
Area 2. Northern area which has never been licensed

The third area (the coastal region close to Shetland and Orkney), has not been assessed as hydrocarbon potential in this zone is poor.

Department of Trade and Industry (Dti) Scenarios		
	Area 1	**Area 2**
Seismic activity	2 2D seismic surveys 2-5 3D surveys	2-5 2D seismic surveys 2-5 3D seismic surveys
Exploration wells	3-5 wells	1-3 wells
	Both areas	
Developments	1-2 subsea system tied to existing infrastructure 1-2 FPSO (floating production, storage, offloading) 8-12 development wells	

Forecasts of UKCS oil and gas activity have been included to demonstrate the relationship between SEA 4 and the rest of the UK, in particular, the impact any future SEA 4 developments would have upon the British oil and gas industry as a whole. Note is also made in the report to activities in adjacent waters (i.e. Faroes and Norway) and any possible impact that they may have on the SEA 4 region.

The SEA 4 oil and gas industry is one of the largest industries in the region and as such has a range of effects. Some of these effects are more obvious than others (e.g. employment opportunities onshore and offshore) while others are more difficult to predict (e.g. the demands for housing, health service and public services).

The report concludes that "overall, the licensing of the SEA 4 area could have a significant impact on the UKCS oil and gas industry. Production from fields in the area could make significant contributions to overall UKCS production, employment and tax revenues, as well as extending the lives of the facilities such as the Sullom Voe and Flotta terminals".

10.6.2 Existing facilities and activity in the area

10.6.2.1 Existing discoveries

There are four producing fields in the area, *Foinaven*, *East Foinaven, Schiehallion* and *Loyal* with the *Clair* field under development and due to come on line in late 2004. The main fields are summarised below.

Foinaven field and satellites

Blocks	204/24a, 204/25b and 204/19a	**Production start date**	November 1997
Water Depth	480m	**Original recoverable reserves estimate**	49.6mt (370mb) oil 6.1bcm of gas
Operator	BP-Amoco	**Remaining reserves estimate**	30mt
Discovery date	October 1992	**Infrastructure**	FPSO with shuttle tankers to Flotta terminal and gas line to Sullom Voe.

The East Foinaven satellite (36 million barrels) was brought online in September 2001, using a 5 well subsea tieback to the FPSO.

Schiehallion field and satellites

Blocks	204/2a	**Production start date**	July 1998
Water Depth	425m	**Original recoverable reserves estimate**	79.9mt (600mb) oil 1.1bcm gas
Operator	BP-Amoco	**Remaining reserves estimate**	60mt
Discovery date	October 1993	**Infrastructure**	FPSO with shuttle tankers and gas line to Sullom Voe terminal.

The **Loyal field** overlies the Schiehallion reservoir and had its original recoverable reserves estimated at 85mb oil. During the Phase 4 development of Schiehallion, 5 subsea wells are being tied back to the FPSO with first oil expected October 2003.

Clair field

Blocks	206/8, 206/7a and 207/9	**Production start date**	Late 2004
Water Depth	140m	**Original recoverable reserves estimate**	4 billion barrels
Operator	BP and partners	**Infrastructure**	Fixed steel platform and pipeline to Sullom Voe.
Discovery date	1977		

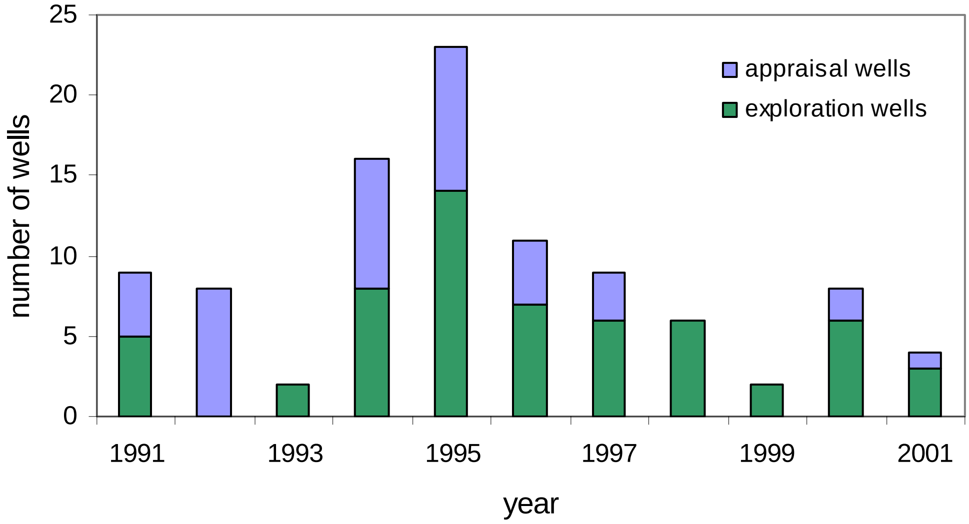
Other Discoveries

Solan and *Strathmore* (150km due west of Lerwick in the West Shetland basin, block 205/26a) are two discoveries close to Foinaven and Schiehallion put forward under the Satellite Accelerator initiative (an initiative aimed at speeding up the development of technically marginal or commercially challenging discoveries). Another discovery, *Suilven*, (blocks 204/14 and 204/15) is still to be developed. There have also been a number of gas discoveries in the area (in blocks 206/1, 207/1 and 214/30).

10.6.2.2 West of Shetland exploration activity

To date, over 100 exploration and appraisal wells have been drilled to the west of Shetland with a peak in activity in 1995 (see Figure 10.6).

Figure 10.6 - West of Shetland: exploration and appraisal wells (Source: DTI)



10.6.2.3 Onshore facilities

Shetland has a well-established range of existing infrastructure, which includes the Sullom Voe oil terminal, Scatsta and Sumburgh airports and a supply base in Lerwick.

The Sullom Voe oil terminal, which was originally built to handle oil from the East Shetland basin (outwith the SEA 4 area), has been operating for over 26 years. From Sullom Voe, oil is taken by tanker to the UK, the USA and other export markets. As production in the East Shetland basin has fallen, so too has throughput at Sullom Voe. This trend is discussed in detail in the report and highlighted later in this assessment. Scatsta and Sumburgh airports, the supply base in Lerwick and other supporting facilities (e.g. tugs), are considerably underutilised at the present time. As such, any new developments in SEA 4 would be of great benefit to the oil terminal and to a number of other onshore facilities.

The only significant facility in Orkney is Flotta oil terminal which, as with Sullom Voe, is experiencing a decline in throughput. Peak throughput occurred in 1995 and has fallen since then, though oil from Foinaven has slowed down the rate of decline.

The north coast of Scotland is home to several ports (such as Scrabster) which have been used by seismic vessels, supply boats and other oil-related traffic in the past, although recent use has been sporadic. A number of fabrication yards which used to operate in the area have closed down, though a few remain: Nigg on the Cromarty Firth (platform fabrication), Wester in Caithness (pipeline fabrication) and Evanton on the Cromarty Firth (platform fabrication). Also, the main centre in the UK for the inspection, repair and maintenance of mobile drilling rigs is based at Invergordon on the Cromarty Firth.

Onshore facilities in SEA 4 are underutilised. Indeed, the decline in oil production has made a number of facilities obsolete and closures have resulted. It is estimated that licensing of SEA 4 and any associated increase in oil production could be accommodated by existing infrastructure and would be extremely beneficial to the area.

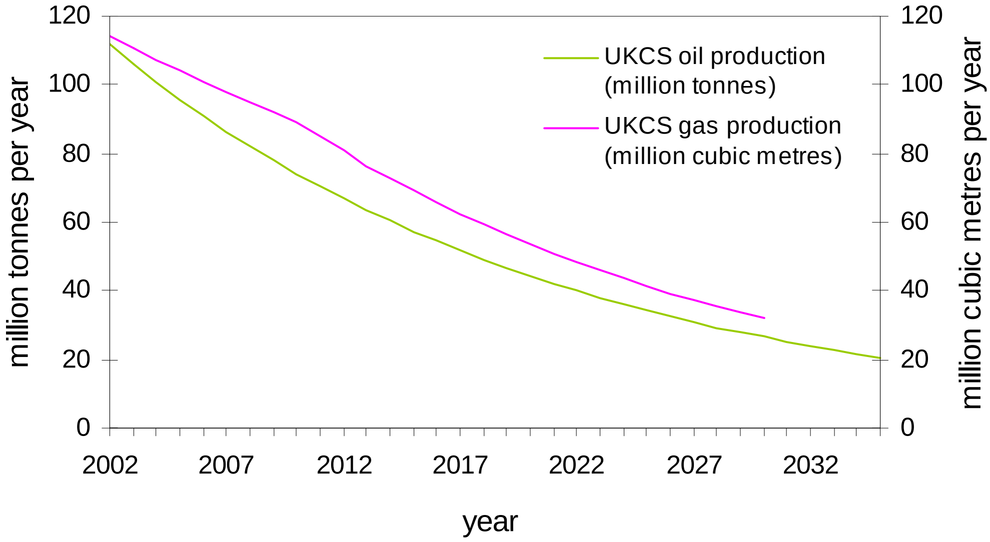
10.6.3 Activity in adjacent waters

The boundary of SEA 4 abuts upon Norwegian and Faroese waters. Consequently, any activities in these areas could affect SEA 4. If new discoveries are made in the Faroes, it is likely that Sullom Voe and Flotta oil terminals will be utilised. However, there is little evidence to suggest that any new discoveries will be made in the near future. Therefore, there is only a slight possibility of any impact on SEA 4. Similarly, there are no foreseeable Norwegian activities.

10.6.4 Implications for oil and gas production and reserves

The UKCS peak of oil production has passed and a gradual fall in production has been predicted for the future and although the rate of this decline is difficult to forecast, an annual average of -5.0% has been estimated. Similarly, UKCS gas production peaked in 2000 and is now in a decline which is expected to continue at a slow and steady rate (see Figure 10.7).

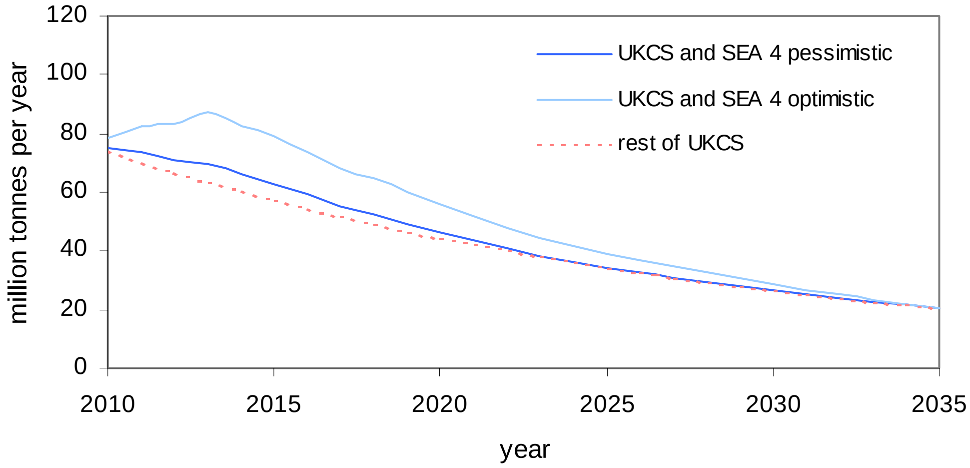
Figure 10.7 - Oil and gas production: UKCS forecast



10.6.4.1 SEA 4 oil production

Predictions of future SEA 4 oil production showed that total production under the optimistic scenario would be 173 million tonnes of oil (129mt more than the pessimistic forecast), with a peak in 2013 of 360,000bpd. When these projections are combined with the rest of the UKCS, the following patterns emerge (see Figure 10.8).

Figure 10.8 - Oil production: UKCS and SEA 4 combined forecasts

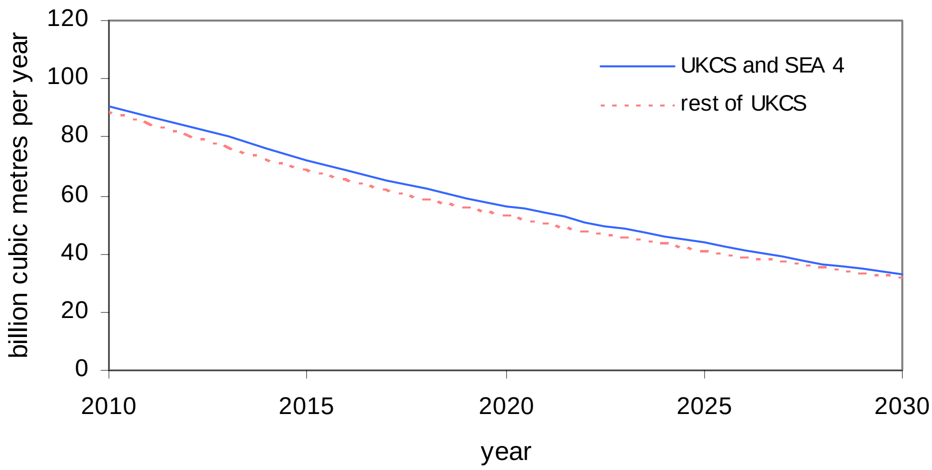


The pessimistic forecast shows that SEA 4 production from 2010 will slow down the total UKCS decline. Whereas the optimistic forecast shows that SEA 4 activity could actually 'increase' total UKCS (2009-13) oil production and thus pause the decline. As a consequence, 2009-15 UKCS production would be relatively stable. Indeed, under the optimistic scenario, peak UKCS production (2013) could be 38% higher due to SEA 4 oil.

10.6.4.2 SEA 4 gas production

In general, prospecting in SEA 4 is for oil rather than gas, the production of the latter is also more difficult to predict and analyse. Nevertheless, when the estimated gas production of SEA 4 is added to the estimated gas production for the rest of the UK (see Figure 10.9), three main trends are to be noted. Firstly, that SEA 4 production would constitute 5.7% of the UKCS total. Secondly, that this percentage would rise steadily for the first ten years (whilst the UKCS continues to decline) and finally, that although SEA 4 gas cannot compensate for the fall in UKCS gas production it can slow it down (from 2010 onwards).

Figure 10.9 - Gas production: UKCS and SEA 4 combined forecast



10.6.4.3 Oil and gas reserves

It is estimated that most of the oil in the UKCS has already been developed. At best, SEA 4 contains 12.3% of the remaining UKCS reserves (or alternatively, under the pessimistic scenario, contains 2.9%). There is however a greater percentage of gas still to be recovered on the UKCS although it is estimated that SEA 4 contains only a fraction of these reserves (between 3.1% and 11.6%).

10.6.5 Exploration, capital, operating and decommissioning expenditure

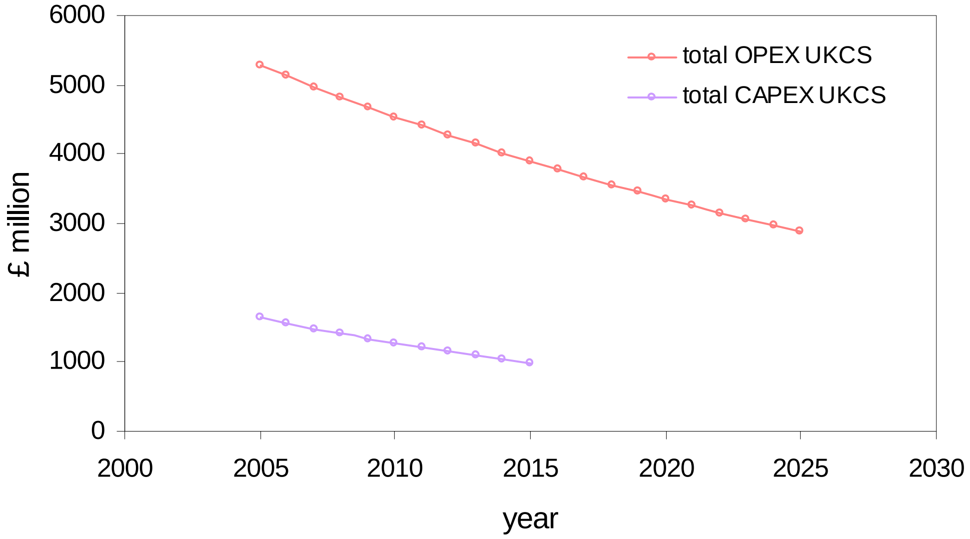
10.6.5.1 Exploration expenditure

The cost of initial exploration expenditure is relatively small in comparison to capital and operating expenditures. It has been estimated that seismic activity in SEA 4 could cost up to £20 million while exploration wells could cost £40-£80 million.

10.6.5.2 Capital and operating expenditure

Capital expenditure is particularly important for the business operations of UK oil and gas industry suppliers. However (partly due to falling development activity), the total capital expenditure of the UKCS is in decline (estimated at -5.0% per year from 2005 onwards) (see Figure 10.9). It is expected that the rate of this decline will gradually slow down. UKCS operating expenditure has peaked most recently in 2001 (at around £5,805 million). An average decline of -3.0% from 2005 onwards has been predicted for the future (see Figure 10.10).

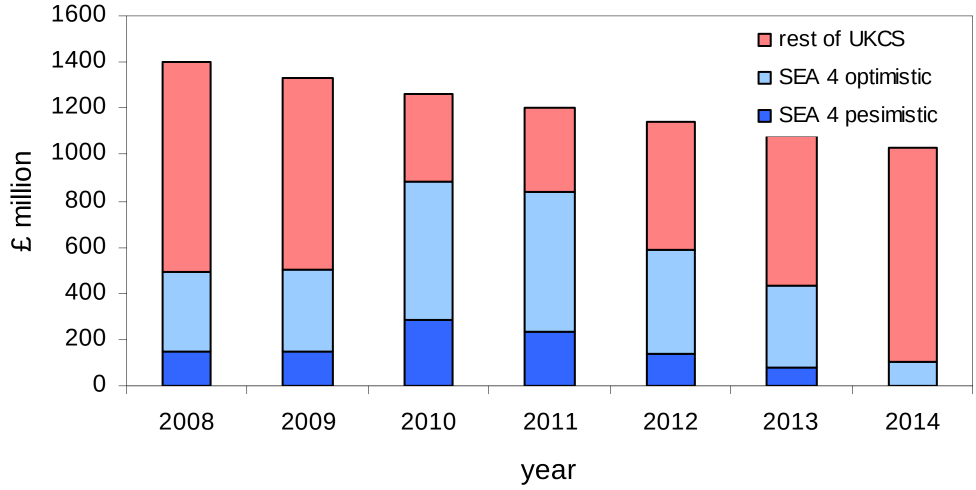
Figure 10.10 - Capital and operating expenditure: UKCS forecast



SEA 4 Capital expenditure

Using the pessimistic scenario, SEA 4 capital expenditure would account for a sizeable proportion of UKCS total expenditure during 2008-13. This percentage rises significantly under the optimistic scenario (see Figure 10.11) which sees SEA 4 account for a major proportion (70% of 2010 total) of overall UKCS expenditure. More than half of the UKCS total 2008-14 would be attributed to SEA 4 activity.

Figure 10.11 - Capital expenditure: UKCS, SEA 4 optimistic and SEA 4 pessimistic forecasts

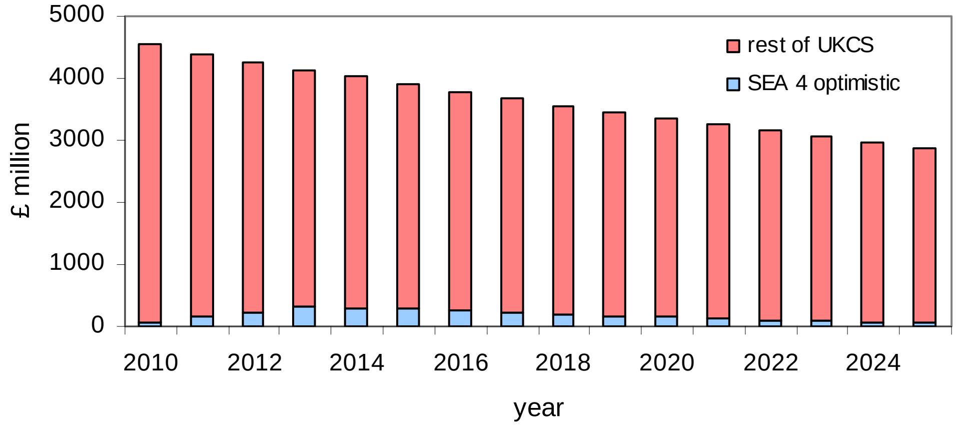


It is predicted that SEA 4 capital expenditure will be very important to UK business. This is especially true as the rest of the UKCS is in decline. Many businesses (e.g. subsea equipment companies and supply boat and helicopter operators) would therefore benefit from SEA 4 licensing.

SEA 4 Operating expenditure

Using the pessimistic scenario, the total operating expenditure for SEA 4 would be £899 million (with an annual average of £60 million). Pessimistic SEA 4 expenditure will peak in 2013 at £126 million (3% of UKCS total). The total operating expenditure under the optimistic scenario (see Figure 10.12) rises to £3,108 million, with a peak in 2013 (£326 million) which constitutes 7.9% of the total UKCS operating expenditure. With an annual average of £124.5 million SEA 4 could be a significant part of UKCS spending for nearly two decades.

Fig 10.12 - Operating expenditure: UKCS and SEA 4 optimistic forecast.



In a similar way to the predicted capital expenditures of SEA 4, the operating expenditures from the region will significantly contribute to the UKCS, particularly as the rest of UKCS is in decline.

10.6.5.3 Decommissioning expenditure

Decommissioning generally costs 10% of original capital costs. However this figure can be lowered for SEA 4 where the existing FPSO structures are easier to remove and/or re-use than fixed production platforms. As such, decommissioning costs should not exceed 5% of original capital costs (around £200 million).

10.6.6 Implications for existing facilities

The main impacts of SEA 4 licensing would come from the development of any new fields found in the area. For example, the pipeline from Clair field to Sullom Voe (Shetland) could improve the economics of developments in the area if new discoveries were to be made. The gas pipeline which runs between the Foinaven/Schiehallion fields and the Magnus field in the East Shetland Basin (via the Sullom Voe terminal) could also provide a market for any gas discoveries. The development of new fields however could only produce incremental or marginal change to the area as there is a well-established and substantially under-utilised infrastructure which would absorb any new discoveries.

10.6.6.1 Sullom Voe oil terminal

Sullom Voe oil terminal has a throughput design capacity of 1.2 million bpd and an actual current throughput of 5000,000bpd i.e. a utilisation rate of 42% (of which Schiehallion field is the main contributor at 27%). If no further SEA 4 discoveries are made, then Sullom Voe output/throughput will decline at about -10% per year (and the output could cease entirely between 2012-17) despite the forthcoming production from Clair (which will add around 60,000bpd from 2004). It is likely that in the next twenty years operating costs for the terminal will become unviable and lead to its closure. Optimistic and pessimistic scenarios alter this projection only slightly showing that the main effects of new discoveries would be to:

- Slow down the rate of decline
- Extend the life of the terminal by a few years

Only substantial production could impact positively on Sullom Voe (e.g. 1 million bpd) but present evidence shows that such a discovery would be unlikely.

10.6.6.2 Flotta Oil terminal

As is the case with Sullom Voe, the Flotta Oil terminal activity is in decline. With a current throughput of 225,000bpd, the terminal is working to just over half its capacity. Foinaven field production (the main contributor to Flotta oil throughput) could be maintained until 2007, but after this will decline at -10% each subsequent year. It is expected that production from Outer Moray Firth fields will cease soon after (between 2012 and 2017). The decision to export oil from the Buzzard field (outwith SEA 4 in block 20/6, 100km northeast of Aberdeen) by using Flotta pipeline systems, is currently under consideration. Future production from this field is expected to be substantial and could therefore have a positive impact upon Flotta oil terminal. Optimistically, in the event of such new developments, the terminal could reach maximum capacity in 2012 (400,000bpd) but would then decline steeply once more. Similarly, the pessimistic scenario sees a peak in 2012 but then decline. Therefore, impacts from SEA 4 discoveries would most likely:

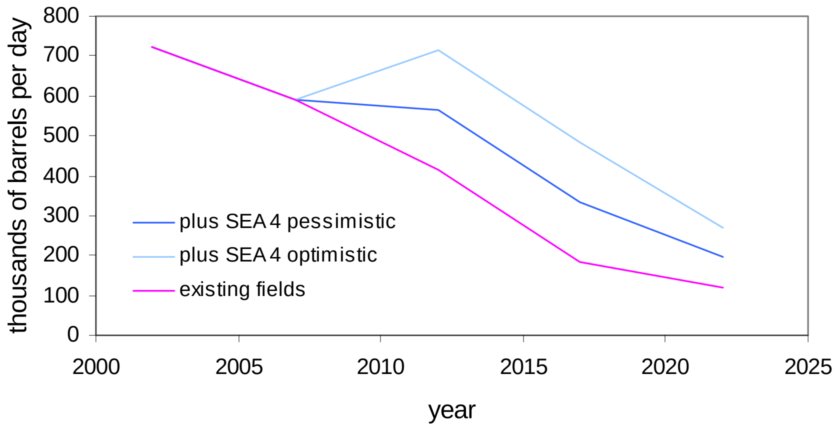
- Slow down the rate of decline
- Extend the life of the terminal by a few years

As with Sullom Voe oil terminal, any positive impacts would require major discoveries which seem, at this time, to be unlikely.

10.6.6.3 Sullom Voe and Flotta oil terminals

Any future SEA 4 production, however marginal, is very important in sustaining one or both of the terminals and in extending their working lives. During the estimated peak in 2012, SEA 4 production could be contributing as much as 42% to the combined total throughput of the two terminals (see Figure 10.13) with hydrocarbons from the East Shetland basin (outwith SEA 4) providing the rest. This percentage will vary as the years follow but will remain above 50% for the remaining life of the terminals. The resulting effect on employment is discussed later in this assessment.

Figure 10.13 Forecasts of combined Sullom Voe oil and Flotta oil throughput



10.6.7 Other facilities - Shetland and Orkney

10.6.7.1 Other industries

An increase in SEA 4 production would impact other industries in the area. A rise or fall in production would be felt most strongly by households (i.e. through the payment of oil terminal employees), distribution industries, ports and harbours and business services.

Fishing is one of the most important industries in Shetland and Orkney and as such there is concern by fishermen over possible damage to stocks by oil spills from the platforms, from Flotta and Sullom Voe oil terminals or from somewhere along the pipelines. A large percentage of the salmon sites in Shetland are in St Magnus Bay to the west of Sullom Voe and there is also some concern by the Shetland Salmon Farmers Association that the future potential for fish farming using offshore and submersible cage technology may be restricted.

Tourism is also an important industry in Shetland and Orkney. It is estimated that a high percentage is business (oil-related) tourism whilst a large part of the market is environmental tourism and, as such, the threat of pollution (especially by oil spills) is potentially damaging. However, Sullom Voe and Flotta oil terminals (and their associated tankers) have excellent records. Oil spills are very unlikely. Thus it is not anticipated that any SEA 4 field will have any significant adverse effects on the tourist industry in the region.

10.6.7.2 Social impacts

It is expected that the social impacts of licensing SEA 4 will be very small. Any impacts upon population will most likely stem from employment changes. For example, Shetland's population is falling but the licensing of SEA 4 and any associated development could help thwart this decline (notably by helping to secure the long term future of the Sullom Voe and Flotta oil terminals).

Impacts on housing will, again, be small and linked primarily to the retention of employment at the terminals. There could also be minor positive implications for:

- Education/school rolls
- Health services
- Other public services
- Local public finance effects

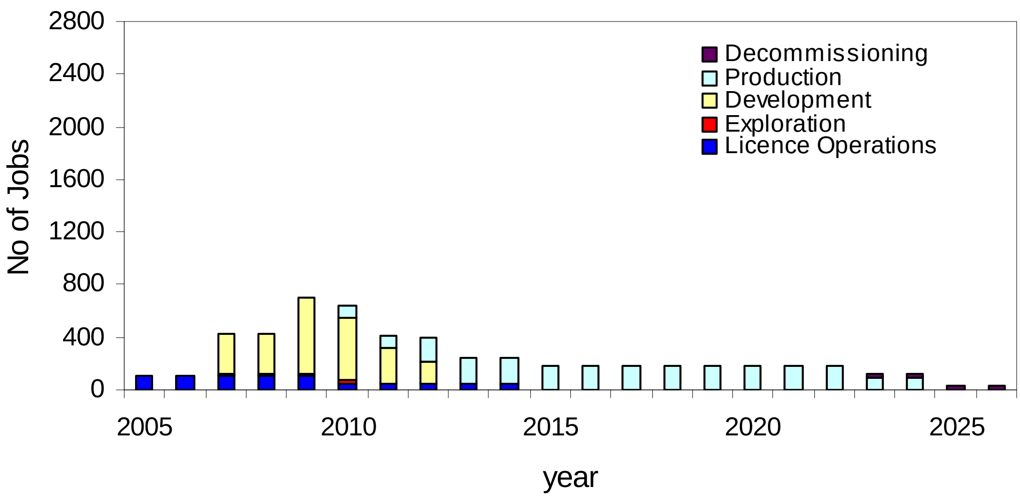
10.6.8 Implications for employment

The licensing of the SEA 4 area will generate employment at different stages of activity:

- Exploration
- Development
- Operational/production
- Decommissioning

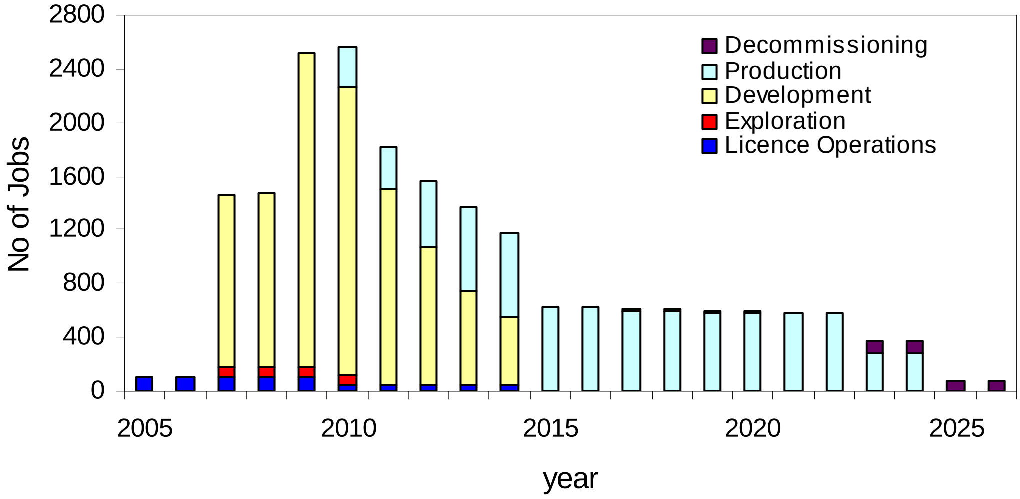
Optimistic and pessimistic employment scenarios have been calculated for SEA 4 according to each phase and are illustrated in the following graphs. The pessimistic scenario (see Figure 10.14) has a peak in 2009 (695 jobs), produced mainly by development activities (e.g. the construction of FPSO's, subsea systems and other equipment).

Figure 10.14 - SEA 4 pessimistic employment scenarios



The peak (2010), under the optimistic scenario (see Figure 10.15), is significantly higher at 2,555 jobs. Again, the majority of these jobs will be created due to development activities. Employment generated by production activities is also markedly higher. SEA 4 is home to a workforce skilled in the oil and gas industry and, as such, the creation of more jobs would help sustain this important resource.

Figure 10.15 SEA 4 optimistic employment scenarios



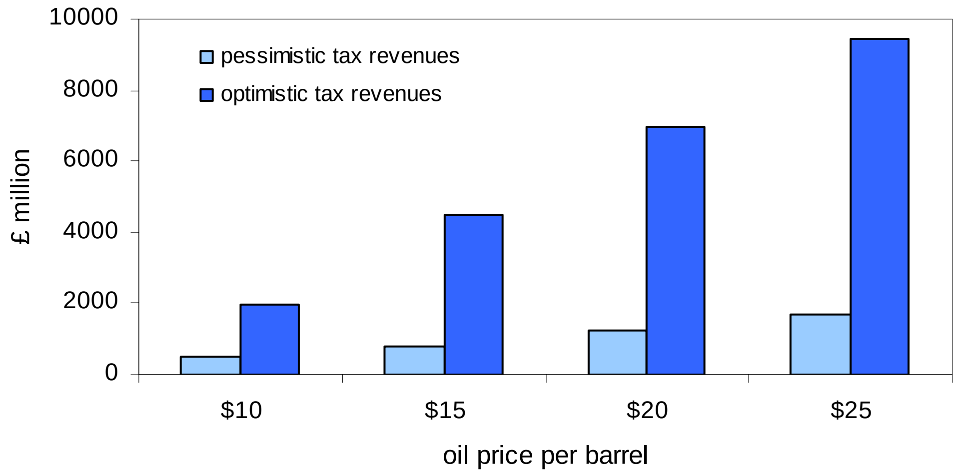
10.6.9 Implications for tax revenues

Implications of future tax revenues are difficult to calculate (primarily due to the high variance of oil prices). However, for the purposes of the report, a simple assessment has been made. A barrel of oil can be broken down into its four key components:

- Capital expenditure
- Operating expenditure/costs
- Tax payments
- Profits

Calculations have assumed that capital and operating costs are constant and do not vary with the price of oil. Thus, the following graph (see Figure 10.16) has been constructed to show the estimated SEA 4 tax revenue according to changes in oil prices.

Figure 10.16 Tax revenues: SEA 4 pessimistic and optimistic forecasts



"These estimates are the undiscounted totals over the lifetimes of the SEA 4 fields. They demonstrate the importance of oil price. The key point to stress is that the tax revenue increases at a much higher rate than the rise in prices" (Mackay Consultants).

Oil prices over the lifetime of the SEA 4 fields are almost impossible to predict. However, present evidence would indicate an average of $20 a barrel as being the most realistic assumption, therefore, SEA 4 fields could generate between £1,232 and £6,968 million (pessimistic and optimistic respectively) in tax revenues. If UKCS tax revenues averaged £1,000 million per year, then SEA 4 could account for 4.1% - 9.2% of that total. It is likely that tax revenues will fall in the coming years as oil and gas production falls.

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11 CONCLUSIONS

11.1 Conclusions

Conclusions from the consideration of potential effects of licensing the SEA 4 area in Section 10, are summarised below:

Noise – The SEA 4 area is important for a wide range of marine mammals, including beaked whales for which there is limited information on distribution and ecology. The potential effects of seismic and other underwater noise on whales and dolphins remain a significant area of uncertainty, and issue of importance for offshore exploration activities. The range of potential behavioural effects, and the consequent potential for cumulative effects, indicates that all marine mammal populations in the area are likely to be exposed to biologically significant sound levels. However, the proposed level of activity does not represent a significant change to recent seismic survey effort which in turn does not appear to have resulted in significant changes in frequency of sightings or behavioural responses. Mitigation measures already implemented, including the use of passive acoustic monitoring in the SEA 4 area, together with proposed modifications to the consent procedure to manage cumulative effects, appear to provide some degree of protection from acute effects. The JNCC Guidelines are under review and the DTI will shortly consult on the regulation of seismic surveys and necessary mitigation measures. It is therefore concluded that there is an acceptably low risk of potential effects of underwater noise resulting from SEA 4 activity. The SEA makes a number of recommendations, in relation to remaining uncertainties and data gaps.

Physical damage at the seabed - The predicted scale of physical disturbance of the seabed, resulting from potential activity scenarios for SEA 4 area, is very small in comparison with the total SEA 4 area. Recovery of the affected seabed is expected to be rapid on the continental shelf and slope whilst in the deep water muds to the north of the area physical evidence of activities can be expected to be long lasting. Prehistoric marine archaeological remains could be affected by pipelaying or other activities in sheltered nearshore waters although further major infrastructure development is not anticipated from SEA 4 activities. Nevertheless, as part of mitigation, a number of initiatives are underway (see Flemming 2003) to promote the awareness and reporting of archaeological finds during oil industry activities on the UKCS. 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 subsea wellheads. However, although FPSO developments occupy slightly more sea-room than fixed installations, the small scale of such effects which could follow from SEA 4 licensing indicates that the number of exclusion zones that may be established is unlikely to cause significant economic impacts. The established 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 chemicals. However, for new developments there is a presumption against discharge of produced water in favour of reinjection to sub-surface geological formations and existing developments in the area already reinject the vast majority of the water produced. As a consequence of this, produced water discharges are not viewed as a significant consideration for SEA 4 licensing.

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. Discharges of water based muds and cuttings in the SEA 4 area (and elsewhere) have been shown to disperse rapidly with minimal ecological effects. Dispersion of further discharges of mud and cuttings could lead to accumulation in regional sinks (areas where reduced current allows the particles to settle on the seabed). However, in view of the scale of the area, the water depths and currents, and projected level of activity 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. Incremental contribution to regional and global effects will not be significant.

Combustion emissions from power generation would represent only be a minor contribution to oil and gas production industry, other industry and national totals. Similarly, significant combustion emissions from oil or gas flaring are not expected from potential developments in the SEA 4 area in view of regulatory controls and commercial considerations.

Wastes to shore - Oil based muds (OBMs) may be needed to drill through some of the rock types found in the SEA 4 area. Rock cuttings contaminated with oil based mud (i.e. >1% oil on cuttings) are no longer discharged to sea and are either reinjected into underground rock formations or shipped to land to undergo treatment prior to onshore disposal. Sustainable options for onshore disposal of OBM cuttings remain a challenge for the industry. However, the majority of recent exploration wells in the west of Shetland area have been drilled with water based muds and have not involved the shipment to shore of drill cuttings. The transfer between installations for reinjection of OBM cuttings is now permitted under a FEPA licence. The environmental management of treatment and disposal of such cuttings, both onshore and offshore, is strictly controlled. The incremental volumes of cuttings associated with 22nd licensing round activities will be small in the context of overall waste disposals from offshore.

Accidental events - Specific concerns in relation to oil spills in the SEA 4 area include the location of prospective areas upwind from sensitive coastlines; the importance of aquaculture along adjacent coastlines; and the relative remoteness of the area from stockpiles of oil spill response resources. 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, although the consequences of major oil spills in the area may clearly be severe, in both ecological and economic terms, the incremental risk associated with the predicted level of activity is moderate or low. Existing exposure to risk is “high” or “very high” as a result of shipping around the north of Shetland, Fair Isle Channel and western Orkney; and the DTI has regulatory mechanisms in place that require Operators to develop effective oil spill mitigation measures, covering organisational aspects and the provision of physical and human resources. Times to beach, under worst case trajectory modelling conditions, are sufficient to allow the deployment of response measures where appropriate.

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.

Cumulative effects - Cumulative effects from activities resulting from the proposed 22nd Licensing Round, have the potential to act additively with those from other oil and gas activities including both existing activities and new activities in currently 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 exploration and production 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 (noise, physical presence, physical damage, emissions, discharges), or unlikely (accidental events), although further research is recommended into possible cumulative effects of seismic noise on whales and dolphins. No synergistic effects were identified that were considered to be potentially significant.

Transboundary effects – The SEA 4 area adjoins areas under the jurisdiction of the Faroe Islands and Norway. Prevailing winds and residual water circulation will result in the transboundary transport of discharges to water (including particulates), atmospheric emissions and spills.

The environmental effects of underwater noise, drilling discharges, atmospheric emissions and oil spills may be detected physically, chemically and biologically in the marine environments of adjacent states, particularly where activities are undertaken close to international boundaries. The scale and consequences of environmental effects in adjacent state territories will be comparable to those in UK waters at equivalent distances. Through the 1991 Espoo Convention (see Section 3.3), projects with the potential for significant transboundary effects are subject to Environmental Impact Assessment and international consultation as necessary.

Socio-economic effects – The economic impacts of licensing the SEA 4 area are likely to be incremental rather than absolute. Production from fields in the SEA 4 area would serve to slow down declines in overall UKCS production, employment and tax revenues, as well as extending the lives of facilities such as the Sullom Voe and Flotta terminal and assisting in maintaining employment in areas such as Shetland and Orkney. Shetland and Orkney have experienced influences from activity on the UKCS for about 30 years and the oil and gas industry is now a well-established and important part of the two local economies.

Forecasts of UKCS oil production suggest an average decline of 5% per year. Under a pessimistic scenario SEA 4 production would slow the decline, whereas an optimistic scenario predicts that production would actually increase during the five years 2009-13 before the decline resumed.

Under the pessimistic scenario, SEA 4 expenditure could account for 22.5% of total UKCS capital expenditure in 2010. With the optimistic scenario, the SEA 4 expenditure could reach 70% of the total in 2010. Total capital expenditure under an optimistic scenario is estimated at over £4.4 billion. The implications for employment have also been considered. For the optimistic scenario the overall UK total is 19,830 person years, with a peak of 1970 in 2010. For the pessimistic scenario the overall total is 5440 person years, with a peak of 695 in 2009.

Wider policy objectives - At a wider scale of assessment it is clear that, with the probable exception of seismic noise, the major present day environmental pressures on the SEA 4 area are not associated directly with hydrocarbon exploration and production, but with other sources of disturbance (OSPAR 2000). Fishing mortality (of both target species and bycatch of fish and other animals), and trawling disturbance effects are probably the most significant direct anthropogenic effects on the ecology of the SEA 4 and adjacent areas. In a longer timeframe, the potential interruption of the thermohaline circulation as an outcome of climate change would result in a dramatic (but not unprecedented) ecological shift to cold water communities. In this context, the combined effects predicted as a result of routine and accidental E&P activities which may arise from 22nd Round licensing, are minimal.

Provision of oil and gas from UK resources will contribute to the security of national energy supply. Activities resulting from SEA 4 licensing would have positive socio-economic effects on Shetland, Orkney and north eastern Scotland as well as the UK as a whole.

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. No significant effects are predicted on UK Government or other wider policy and commitments, from the activities likely to follow the proposed 22nd Licensing Round.

11.2 Information gaps

A number of significant gaps identified during the SEA 4 assessment (some of which were also identified during earlier SEAs) are summarised as follows:

- Further information on the “uniqueness” or otherwise of the benthic habitats and fauna of the deeper water areas
- The location of cephalopod spawning areas in the region
- Seasonal data gaps in the information on offshore seabird distribution
- The location of offshore SACs and SPAs
- The potential presence of chemosynthetic seep communities on the Pilot Whale Diapirs
- Further definition of cetacean occurrence (both spatial and temporal) and abundance in the area
- The importance of and key habitats for beaked whales in the region (see Section 10.3.1.7)
- Sound propagation and the effects of noise on marine mammals (see Section 10.3.1.7 and Hammond *et al*. 2003)

These gaps are important for overall consideration of management and minimisation of adverse effects on the environment of the area. However, in view of the projected scale and location of activity that could follow SEA 4 licensing, coupled with the array of control (and mitigation) mechanisms now in place, these gaps were not viewed as preventing or invalidating the SEA 4 assessment.

11.3 Recommendations

In the process of conducting this SEA a number of gaps in understanding and potential improvements in control and mitigation measures were identified. Recommendations for these are made below. A number of recommendations have also been made in previous SEAs, many of which have been addressed as a direct or indirect result of the SEA process. It should be noted that the recommendations made below are predicated on the understanding that because of poor hydrocarbon prospectivity, nearshore blocks are unlikely to be applied for.

Licensing

1. Blocks in Quadrant 217 which include the Pilot Whale diapirs should be considered for exclusion from licensing until they are better understood (particularly the possible presence of seep chemosynthetic communities) or if licensed, should include explicit controls to avoid potentially damaging activities such as anchoring and cuttings discharge

Regulatory and Other Controls

2. Feedback mechanisms should be explored with the DTI Licensing & Consents Unit so that the accuracy of predictions made in Environmental Statements including effectiveness of mitigation measures are assessed and documented, for example, through publicly available post activity reviews
3. The JNCC guidelines for minimising acoustic disturbance to marine mammals from seismic surveys are currently under review. Similarly, the DTI is soon to consult on regulatory mechanisms for seismic survey. The improvements to the mitigation methods for seismic survey proposed in the recent JNCC Report No. 323 (Stone 2003b) and extended in Section 10.3.1.7 of this SEA should be considered in any revision of the regulatory regime and guidelines.
4. In recognition of the importance of the SEA 4 area for cetaceans and the raising profile of marine noise pollution, reduction of noise transmission into the sea should be considered in

the design of new FPSOs (and other vessels) intended for use in the area. The assessment of underwater noise/vibration and proposed mitigation measures for development projects should be reflected as appropriate in Environmental Statements (as required by the EIA Directive 85/337/EEC and implementing UK regulations).

5. The potential for effects on marine mammals during removal of suspended wellheads using explosives was raised (Hammond *et al.* 2003) and it is recommended that the PON 5 applications to the DTI for such activities should be supported by specific risk assessments for this aspect.
6. The current system of control over discharges from exploration and production appears comprehensive and effective, suggesting that environmental monitoring in the area should be primarily regional

Environmental Understanding

It is recognised that there are many stakeholders with interests and involvement in efforts to improve environmental understanding (e.g. DTI, Operators, Conservation Agencies, Research Councils, NGOs etc). The following 3 recommendations are made to the group of stakeholders in general, and to the DTI to champion their implementation as appropriate.

7. The ecology of marine mammals in the SEA 4 area off the continental shelf should continue to be a focus of research to identify areas and times of special importance particularly for endangered species and very poorly understood species such as beaked whales
8. The suggestion that some deep cold water habitats present in the SEA 4 area are unique, rare or unusual should be kept under review in the light of new information from the SEA 4 area and comparable regions such as Atlantic Canada
9. Basic research into the identity, distribution and biological functioning of the species and communities present in the SEA 4 area should be promoted and as appropriate supported, consistent with Government policies on biodiversity and conservation

SEA Process

10. At the Stakeholder Meeting, a number of suggestions were made (see Appendix 3) on how to improve the process for future SEAs. It is recommended that these are evaluated with the SEA Steering Group and taken forward as appropriate

11.4 Overall Conclusion

Alternatives proposed for the development of the oil and gas resources within the proposed 22nd 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

After consideration of the nature of the area and the potential effects and benefits of 22nd Round licensing, both in isolation and in the context of existing activities in the adjacent area (considered in SEA 1), it is recommended that the DTI proceed with licensing (Alternatives 2, or 3 if the blocks in Quadrant 217 which include the poorly explored Pilot Whale Diapirs are excluded). 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 through a major discovery in an area previously evaluated as of low prospective, 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)
A/A	High and Low-angle Gunnery
A/C	Aircraft
A/S	Anti Submarine Practice
AA	Appropriate Assessment
AAF	Air-to-Air Flying
Acute	Of relatively short duration
AFEN	Atlantic Frontier Environmental Network
Alluvium	Sediment deposited by flowing water, as in a riverbed, flood plain, or delta
Amphipods	Marine crustaceans (e.g“sandhoppers”)
Anadromous	Migratory behaviour of fish that spend most of their lives at sea but migrate to fresh water to spawn
Anaerobic	Use 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
Anoxic	Absence, or severe deficiency, of oxygen
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
Archipelago	A group of many islands in a large body of water
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)
ASF	Air-to-Surface Firing
Ballast water	Water put into a vessel to enhance stability
Barchan sand dunes	Type of sand dune found in areas of limited sediment supply with peak currents in excess of 0.4ms-1
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
Barrel of oil	42 gallons (158.98 litres)
Base fluid	The liquid component of drilling mud
BAT	Best Available Techniques
Bathymetric contours	Lines on a map showing depth below sea surface
Bathymetry	Measurement and study of ocean depth and floor

Term	Definition
bbl	Barrel (= 0.1589m^3)
Bcm	Billion cubic metres
Benthic	Relating to organisms living in or on the seabed
Bentonite	Naturally occurring clay mineral; used in drilling fluids to increase viscosity
BEP	Best Environmental Practice
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
Biodegradation	Decomposed by biological agents
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
Biota	The total flora and fauna of a given area
Biotope	A physical habitat and its associated biological community
Block	See Licence Block
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
BP	Before Present
Bpd	Barrels per day
Brochs	Circular, two-story, drystone structures of the iron age
Bunkering	Transfer of fuel from supply vessel to rig or platform
Bycatch	The portion of a fishing catch that is discarded as unwanted or commercially unusable
Cairns	Neolithic burial chambers
Caledonian orogeny	Period of volcanic activity, folding, faulting and metamorphism between the Cambrian and Devonian periods (544-410 million years ago)
CANMORE	Computer Application for National Monuments Record Enquiries
Casing	Steel lining used to prevent caving of the sides of a well, to exclude unwanted fluids and to provide a means of control for well pressures and oil and gas production
CATS	Central Area Transmission System
CCL	Climate Change Levy
CEFAS	Centre for Environment, Fisheries and Aquaculture Science

Term	Definition
Cephalopods	Marine molluscs including squid, cuttlefish and octopus
Cetaceans	Aquatic mammals including whales, dolphins and porpoises
CFCs	Chlorofluorocarbons
CFP	Common Fisheries Policy
Christmas tree (xmas tree)	Valve assembly at the top of a well used to control the flow of oil or gas
Chronic	Of relatively long duration
CITES	Convention on International Trade in Endangered Species
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
Continental shelf	The shallow, near-horizontal sea floor extending from the coast to the upper continental slope
Continental slope	The sloping sea bottom of the continental margin that begins at a depth of about 100 to 200m at the shelf edge and ends at the top of the continental rise or in a deep-sea trench
Continuous Plankton Recorder Survey (CPR)	SAHFOS survey which monitors the near-surface plankton of the North Atlantic and North Sea on a monthly basis, using Continuous Plankton Recorder on a network of routes to cover the area.
Contour	A line on a map that joins points of equal elevation
Copepod	Small crustaceans, usually planktonic
CPA	Coast Protection Act
Crust	Earth’s outermost solid layer
Crustaceans	Aquatic athropods (including lobsters crabs, shrimps and barnacles)
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 drill cuttings (mainly rock chips) deposited on the seabed as a result of drilling
Dalradian	Period of geological time in the late Precambrian
dB	Decibel
DDT	Dichlorodiphenyltrichloroethane (a pesticide)
Decapod	A crustacean which characteristically has ten legs e.g. crab, lobster or shrimp
DEFRA	Department for Environment, Food and Rural Affairs
Dehydration	The process of removing water from a pipeline (during pre-commissioning); also removal of water from gas as part of the production process
Demersal	Living at or near the bottom of the sea
Demersal trawl fishing	Method of fishing for the fish that live on or near the seabed (such as cod, haddock and whiting).

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
Devonian	A period of time in the Paleozoic Era that covered the time span between 400 and 345 million years
Downhole injection	Injection of gas, water or slurrified solids to a porous receiving rock formation
DPAG	Dounreay Particle Advisory Group
Drill cuttings	Rock chips produced as a result of drilling
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)
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
ES	Environmental Statement
ESA	Environmentally Sensitive Area
ESAS	European Seabirds At Sea

Term	Definition
ESDV	Emergency Shut Down Valve
ETV	Emergency Towing Vessels
EU	European Union
Exploration well	Well drilled to determine whether hydrocarbons are present in a particular area
Fauna	Animals of an area or period
FEED	Front End Engineering Design
FEPA	Food and Environment Protection Act
FIMETI	Fair Isle Marine Environment and Tourism Initiative
Finfish	A term used to separate true fish from shellfish, crayfish, jellyfish etc.
Flare	Controlled burning of gas for pressure relief (or during well testing for disposal of excess gas)
Flora	Plants of an area or period
Fluvial	Produced by the action of a river or stream
Formation	An assemblage of rocks or strata
FPS	Floating Production System
FPSO	Floating, Production, Storage and Offloading Facility
FPV	Floating Production Vessel
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
GCR	Geological Conservation Review
Geology	Physical structure and substance of the earth
Geomorphology	The study of the underlying form, and weathering processes, of rocks
Giga	Billion (10^9)
Glacial erosion	Erosion caused by the action of glaciers
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
GW	Giga Watts
GWh	Giga Watts per hour
Ha	Hectare
HCB	Hexachlorobenzene
HCH	Hexachlorocyclohexanes
HOCNF	Harmonised Offshore Chemical Notification Format

Term	Definition
Holocene	Geological period since latest glaciation; from about 10,000 years ago to present
Hominids	Members of the family of humans (of which *Homo sapiens* are the only extant species)
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
Hz	Hertz (unit of frequency)
IBA	Important Bird Area
Iceberg ploughmarks	Furrow created by icebergs scraping along the seabed, typically consist of a pair of raised ridges separated by a central depression
ICES	International Council for the Exploration of the Sea
ICIT	International Centre for Island Technology
ICZM	Integrated Coastal Zone Management
Igneous rocks	Rocks formed from magma
IMO	International Maritime Organisation
Injection well	Well into which gas or water is pumped to maintain reservoir pressure
Invasive species	Introduced species that evolved elsewhere and have been purposefully or accidentally relocated
IOPP	International Oil Pollution Prevention
IPPC	Integrated Pollution Prevention and Control
IRM	Inspection, Repair and Maintenance
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
Kimmeridge Clay Formation	Organic-rich mudstones laid down between 154-136 million years ago (late Jurassic to Ryazanian). Principal source rock for hydrocarbons in the SEA 4 area
Km	Kilometre
Lacustrine	Of or relating to lakes
LB	Live Bombing
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. A Block is approximately 200-250 square kilometres
Licensing round	An allocation of licences made to oil companies
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
Ma	Million years ago
Macrofauna	Larger benthic organisms, defined as >0.5mm or 1.0mm in size
Macrozooplankton	Larger free-floating microscopic animals

Term	Definition
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
Mariculture	The cultivation of marine species within coastal wasters including shellfish, finfish and seaweed farming
MARPOL	International Marine Pollution Convention
Mattresses	Concrete structures used to protect pipelines or other subsea structures
Mb	Million barrels
MCA	Marine Consultation Area
Megaplankton	Extra-large zooplankton between 20 and 200cm in size
MEHRA	Marine Environment High Risk Area – area of high environmental sensitivity at risk from shipping
Meroplanktonic	Plankton that spend only part of their life cycle in the water column before settling to the bottom
Mesolithic	Middle Stone Age (10,000-4,000 BP)
Meso-pelagic	Relating to the middle section of the water column
Metamorphic rocks	Rocks that have undergone chemical or structural changes as a result of heat, pressure, or a chemical reaction
mg	Milligrams
Micro-zooplankton	Small free-floating microscopic animals
MLWS	Mean Low Water Springs (of tides)
mm	Millimetres
Molluscs	Marine invertebrates typically having a soft unsegmented body, a mantle, and a protective shell
Moraines	Stones and gravel deposited typically at the edge of a glacier
Morphology	The form and structure of an organism or one of its parts
MPA	Marine Protected Area
Mt	Million tonnes
Mud	See Drilling Mud
Mud diapirs	Result from the upward migration of mud or semi-consolidated sedimentary rock which may be extruded at the seabed
Mutagenicity	A chemical, ultraviolet light, or a radioactive element, that can induce or increase the frequency of mutation in an organism
MW	Megawatt
Nano plankton	Extra-small zooplankton between 2 and 20 microns in size.
NASCO	North Atlantic Salmon Conservation Organisation
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	The 'new' Stone Age beginning around 10,000 B.C.
NERC	UK Natural Environment Research Council
NGLs	Natural Gas Liquids
NGO	Non-Government Organisation
Nm	Nautical mile
NNR	National Nature Reserve
NORM	Naturally Occurring Radioactive Materials

Term	Definition
North Atlantic Oscillation (NAO)	The NAO is the dominant mode of winter climate variability in the North Atlantic region ranging from central North America to Europe and into Northern Asia
NPE	Nonylphenol ethoxylates
NPPG	National Planning Policy Guidelines
NSA	National Scenic Area
OCNS	Offshore Chemicals Notification Scheme
Odontocetes	Toothed whales
Oestrogen	Female hormone
OILMAP	Computer model used to predict oil spill trajectories
OLF	The Norwegian Oil Industry Association
Ontogenetic	Relating to the development of an individual organism
OPE	Octylphenol ethoxylates
OPF	Organic-Phase Drilling Fluids
OPRC	Oil Pollution, Prepardeness, Response and Cooperation
Organic compounds	Materials containing carbon combined with hydrogen, often with other elements
OSD	Offshore Safety Division
OSIS	Oil Spill Information System (Computer model used to predict oil spill trajectories)
OSPAR	Oslo and Paris Commission
Ova	Egg cell produced by female
OVI	Offshore Vulnerability Index – measure of seabird vulnerability to surface pollution including oil spills
OWSM	Ocean Weather Station Mike
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
Palaeolithic	The 'old' Stone Age (being the period of the emergence of primitive man) about 2.5 million to 3 million years ago until about 12000 B.C.
Paralytic Shellfish Poisoning (PSP)	An illness caused by poisons concentrated in clams, mussels, oysters, snails and scallops
PCB	Poly Chlorinated Biphenyls – synthetic organic chemicals previously (until 2000) used as specialist lubricants and electrical insulating fluids. Bioaccumulate and cause a range of effects in animals
PCDD/Fs	Polychlorinated dioxins and dibenzofurans
PCZ	Preferred Conservation Zone
PEC:PNEC	Predicted Effect Concentration: Predicted No Effect Concentration
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
Phenology	The scientific study of periodic biological phenomena, such as flowering, breeding, and migration, in relation to climatic conditions
Photosynthesis	Process by which plants convert carbon dioxide into organic compounds using the energy of light absorbed by chlorophyll
Phytoplankton	Free floating microscopic plants (algae); including diatoms and dinoflagellates

Term	Definition
Pico plankton	Tiny plankton between 0.2 and 2 microns in size, mostly bacteria
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
Pleistocene	An epoch in Earth history from about 2-5 million years to 10,000 years ago
PLONOR	Posing Little or No Risk to the Environment
PNEC	Predicted No Effect Concentration
PON	Petroleum Operations Notice
POPA	The Prevention of Oil Pollution Act, 1971
Porosity	Ratio of volume of pore space to total volume (of for example rock)
Post-glacial	Relating to or occurring during the time following a glacial period
PPC	Pollution, Prevention and Control
ppm	Parts per million
Precambrian	All geologic time from the beginning of Earth history to 570 million years ago
Produced water	Water removed from the reservoir along with oil and natural gas
PTA	Pilotless Target Aircraft
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
RAM	Range-dependent Acoustic Model
Ramsar Sites	Areas designated by the UK under the Ramsar Convention (Convention on Wetlands of International Importance especially as waterfowl habitat)
RCAHMS	Royal Commission on the Ancient and Historical Monuments of Scotland
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
Rock outcrop	part of a rock formation that appears above the surface of the surrounding land
Ro-Ro	Roll on-roll off
ROV	Remotely Operated Vehicle
RSO	Renewables Obligation Scotland
RSPB	Royal Society for the Protection of Birds
S/M	Submarine Exercises
SAC	Special Area of Conservation
Sacrificial anodes	Metal plates placed on underwater structures to prevent corrosion
SAHFOS	Sir Alister Hardy Foundation for Ocean Science
Saline	Containing salt

Term	Definition
SAMS	Scottish Association for Marine Science
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)
SCRI	Scottish Community Renewable Initiative
SEA (Strategic Environmental Assessment)	An appraisal process through which environmental protection and sustainable development is considered in decisions on policy, plans and programmes
Sedimentary rocks	Rocks formed by sediment; containing matter that has subsided
Sediments	Loose material, such as sand and mud, laid down at the bottom of the sea, river or lake
SEERAD	Scottish Executive Environment & Rural Affairs Department
Seine net fishing	Method of fishing for the fish that live on or near the seabed (such as cod, haddock and whiting)
Seismic survey	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
Seismicity	Earthquake potential
SEPA	Scottish Environment Protection Agency
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.
SMP	Shoreline Management Plan
SMRU	Sea Mammal Research Institute
SNH	Scottish Natural Heritage
SOAEFD	Scottish Office Agriculture, Environment and Fisheries Department
SOPEP	Shipboard Oil Pollution Emergency Plan
SOTEAG	Shetland Oil Terminal Environmental Advisory Group
SPA	Special Protection Area
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
Spud	Installation of conductor; the date of commencement of a drilling operation
SSIV	Subsea Isolation Valve

Term	Definition
SSSI	Sites of Special Scientific Interest
Strategic Environmental Assessment (or Appraisal)	See SEA
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
SU	Firing at surface target
Sweep	Addition of a batch of additive to a drilling fluid; typically of a viscous additive to clear the hole of cuttings
SWT	Scottish Wildlife Trust
T	Torpedo
TA	Torpedo from Aircraft
TBT	Tributyl tin
Tectonic events	Refers generally to the deformation and resultant structure of the Earth's crust and upper mantle; encompasses such geologic processes as folding, faulting, volcanism, and seismicity
THC	Total Hydrocarbons
Thermocline	Stable boundary between two layers of water of different temperature
Tie back	Connecting one pipeline to another or to equipment
TL	Transmission Loss
TLP	Tension Leg Platform
Topography	Surface features of an area
Topsides	Section of an offshore facility above the water level
Trenching	Excavation of a trench into the seabed for a pipeline or umbilical
Trophic level	The position occupied by an organism in a food chain or a food web
Troposphere	The layer of the atmosphere below the stratosphere extending from ground level to 10-15km above the Earth's surface
TT	Target Towing
UA	Unitary Authorities
UCM	Unresolved complex material
UK	United Kingdom
UKAEA	United Kingdom Atomic Energy Authority
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
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
UNESCO	United Nations Educational, Scientific and Cultural Organisation
Venting	Release of gas to atmosphere for operational or emergency reasons

Term	Definition
Viscosifier	Component of drilling fluids used to increase viscosity; usually an organic polymer or bentonite
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
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: ASSESSMENT WORKSHOP

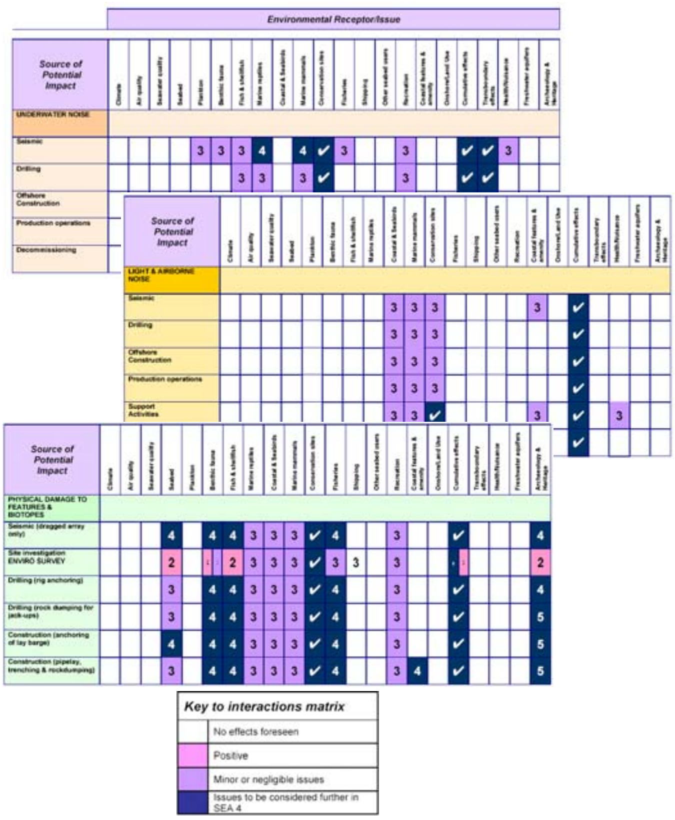
An expert assessment workshop was held over two days in May 2003. The workshop brought the expertise of the SEA Steering Group, the authors of the SEA 4 underpinning technical reports, other users of the offshore area and the SEA team to bear on the assessment process for SEA 4 – see Appendix 2 for more 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 4 area
- Screen potential environmental interactions and identify Strategic Issues so that these could be considered further in this Public Consultation Document
- Review areas, sites and features of the SEA 4 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 4 assessment of likely effects and necessary mitigation can be made

Workshop preparation materials included the draft SEA 4 technical reports, an overview of oil and gas activities and sources of effects, potential activity scenarios that might follow from licensing of the SEA 4 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.

Figure A1 – Example working interaction matrices



These materials were used during the workshop to facilitate the review of the interactions matrix and to identify those issues of strategic importance which should be examined in detail in the SEA 4 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). The consideration of effects assumed compliance with all relevant legislation and controls and the application of current standard operational controls and mitigation

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 4 consultation document – see Matrices Section in this Appendix.

Figure A 2 - Revised Assessment Screening Criteria

Potential consequences	**Key[4]**	
No detectable effects	**1**	
Activity may contribute to recovery of habitats Incidental positive benefits to local, regional or national economy May generate information useful for understanding or management	**2**	
Change is within scope of existing natural variability but potentially detectable	**3**	
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[3] 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	**4**	**Issues to be considered further in SEA 4**
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[3] 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	**5**	
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[3] 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	**6**	

Notes to matrix:

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*
3. *Damage - an injury or harm impairing the function or condition of a person or thing.(*
4. *Colour and numerical code used in interactions matrices*

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 screening process and as such are not an endpoint or conclusion. The SEA 4 area adjoins the coast and although the prospective areas lie offshore, the ranking substantially erred on the side of precaution. Note the “score” numbers 2-6 relate to the Assessment Screening Criteria.

Source of Potential Impact	Score 2	Score 4-6	Climate	Conservation Sites	Cumulative Effects	Transboundary Effects
UNDERWATER NOISE						
Seismic		Marine mammals Marine reptiles		4	4	4
Drilling				4	4	4
Offshore Construction				4	4	4
Production operations				4	4	4
Decommissioning		Fish & shellfish Marine mammals Marine reptiles		4	4	4
LIGHT and AIRBORNE NOISE						
Seismic					4	
Drilling					4	
Offshore Construction					4	
Production operations					4	
Support Activities				4	4	
Decommissioning					4	
PHYSICAL DAMAGE TO BIOTOPES						
Seismic (dragged array only)		Seabed Benthic fauna Fisheries Fish and shellfish Archaeology & Heritage		4	4	
Site investigation “Environmental survey”	Seabed Benthic fauna Fish & shellfish Archaeology & Heritage			4	4	
Drilling (rig anchoring)		Benthic fauna Fish & Shellfish Fisheries Archaeology		4	4	
Construction (anchoring of lay barge)		Seabed Benthic fauna Fish & Shellfish Fisheries Archaeology & Heritage		4	4	
Construction (including pipelay, trenching & rockdumping)		Benthic fauna Fish & Shellfish Fisheries Coastal & amenity Archaeology & Heritage		4	4	
PHYSICAL PRESENCE						
Seismic survey (towed streamers)		Fisheries Shipping		4	4	
Drilling (rig & anchors)		Other seabed users Archaeology & heritage		4	4	
Production (installations and pipelines		Seabed Fisheries Other seabed users Coastal& amenity Archaeology & heritage		4	4	

Source of Potential Impact	Score 2	Score 4-6	Climate	Conservation Sites	Cumulative Effects	Transboundary Effects
Depletion of reservoir (seabed subsidence)						
MARINE DISCHARGES						
Drilling (muds and cuttings)		Seawater quality* Seabed Benthic fauna Health/Nuisance Archaeology & heritage		4	4	4
Construction (hydrotest and pipeline drying)		Seawater quality*				
Production (produced water)		Seawater quality* Fish & shellfish* Health/Nuisance		4	4	4
Other discharges		Coastal & seabirds		4	4	4
Ballast water (exotics & PSP etc)		Plankton Benthic fauna Fish & shellfish Fisheries Health/Nuisance		4	4	4
Low specific activity material					4	
SUBSURFACE DISCHARGES						
Drilling (muds and cuttings injection)	Onshore/Land use	Seabed				
Production (produced water injection)						
ATMOSPHERIC EMISSIONS						
Drilling (well test/clean-up)		Air quality	4		4	4
Production (power generation)		Air quality	4		4	4
Production (flaring/venting)		Air quality	4		4	4
Production (tanker loading - VOCs)		Air quality	4		4	4
Production operations (Fugitives emissions)		Air quality	4		4	4
Support vessels		Air quality	4		4	4
WASTES TO SHORE						
Drilling (muds and cuttings)		Air quality Health/Nuisance Onshore/Land Use	4		4	
Low specific activity scale		Health/Nuisance Onshore/Land Use			4	
General oil field waste		Air quality Health/Nuisance	4		4	
Decommissioning		Air quality Health/Nuisance	4		4	
ACCIDENTS						
Oil spills 1000-t diesel nearshore		Coastal features & amenity Air Quality Fish & shellfish Marine reptiles Coastal & Seabirds Marine mammals Fisheries Recreation Health/Nuisance Seawater quality Seabed Plankton Benthic fauna Other users		4	4	4

Source of Potential Impact	Score 2	Score 4-6	Climate	Conservation Sites	Cumulative Effects	Transboundary Effects
Chemical spills		Fisheries Recreation Coastal features & amenity Health/Nuisance Air quality Seawater quality Seabed Plankton Benthic fauna Fish & shellfish Marine reptiles Coastal & Seabirds Marine mammals Other users Archaeology & Heritage		4	4	4
Gas releases		Air quality Seabed Benthic fauna Coastal features & amenity Health/Nuisance	4	4	4	4
Injection accidents						

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APPENDIX 3: STAKEHOLDER WORKSHOP

A stakeholder workshop meeting was held in Nairn on 1 July 2003, facilitated by independent facilitators People=Positive™ 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:

- Update stakeholders on SEA 4 progress and issues
- Gather stakeholder input to and comments on the information and analysis on which SEA 4 will be based
- 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.

A summary of the issues raised, information sources and suggestions for future SEA process improvements are given below:

SEA 4 - Context and Background

Who to involve and how? The ocean is not on doorstep, therefore may be lower on people's agenda.

How to get the public on board. Need involvement at an earlier stage?

Identifying all the stakeholders is not a perfect science. Knowing who to contact in organisations – Chief Executives and then cascade or multiple contacts?

Should the Hebridean WDT or WCS be contacted?

Potentially involve more local groups eg. Lobster fishing groups

Promote licenses - should be taken into account in predictions.

If activity estimates too low – could SEA conclusions be invalid i.e. if one found more and it became necessary to increase facilities/onshore plant, how would this be taken account of?

What type of study contracts? Sample collection, sea-bed, topography - studies to fill the data gaps.

EIA process can pick up on information gaps identified in SEA. Results could impact development plans.

Energy policy - what's the SEA link with it?

Could shortage of fuel source override environmental impacts?

How does and SEA take account of possible developments across SEA border? Previous SEA's are taken into account.

How similar are UK processes with e.g. Norway/Faeroes?

SEA approach is creating best practice ahead of legislation. Is there an overarching process?

How do the DTI make assessments/judgements decisions?

SEA 4 – Ecological and Physical Environment

Landscape impact.

Summaries and conclusions, in expert reports, are needed.

Extreme meteorological conditions – hazard!

Offshore SPA's maybe designated.

Coastal SPA extensions.

Uncertainty not considered enough?

Difficulty of establishing 'cause and effect'.

Sharing of data (North Sea Bird Club·and bird foraging data).

Long term benthic data.

Further survey? There is tremendous coverage for the whole area. May be some additional survey in future.

Is the fishing catch data accurate?

Hadley – Meteorological Office

SCANS II (repeat and extension of SCANS I) - DTI funding?.

Site investigation surveys – European projects meta data.

Noise and marine mammals – American study (MMS report).

Satellite deep detection as data source for sea floor to sea surface hydrocarbon migration and effects.

ChevronTexaco 204/17 work.

Oil industry data -BP Suilven, Foinaven/Schiehallion, Clair and Flotta pipeline route.

BGS – loads of data donated by oil companies.

Sea 4 - Human Environment

MEHRA's – do they still exist? (or will they?)

Is there a traffic (shipping) separation scheme?

Uncertainty of extent of 'reef' rock on shelf.

Information management and/or sharing.

List of National Trust for Scotland sites is incomplete.

Is Dounreay a conservation and/or management issue?

How credible/valid is data on fisheries?

There is a potential conflict between the robustness of the SEA process and lack of SEA type process for fishing.

Fishing creates greater damage to seabed environment than oil & gas exploration.

Mapping old coastlines – existing surveys inadequate, requires new surveys using swathe bathymetry.

Why did we not use more site investigation surveys (commercial)?

How credible is the archaeological issue?

Coastal zone management initiatives (Fair Isle)

Aquaculture - more sites on Orkney than shown on fisheries map.

Shipping data – sources?

Shortage of archaeological data.

SEA 4 – Consideration of Implications of Licensing

Were other sources of impact included into the interaction matrix and then screened out? Yes.

Oil companies – technology development· - Increased and improved technology - Impact relates to deep water effects of engineering ·- More monitoring is required ·- Potential for drilling fewer wells as technology improves.

Need to put across output from the assessment process in a simple and effective way the public.

Has potential for climate change and increased storminess been taken into account? - Safety design/construction do take this into account.

Low frequency seismic and non-seismic noise - new techniques which are having an impact on cetaceans, is this taken into account?

Is recent published data on cetaceans deaths and low seismic noise taken account of?

Noise from construction and operation should be taken into account. Not just underwater noise.

DTI – noise studies – are there preliminary results and if so these should be included?

Getting information out to the public is essential.

Flaring? – Yes, but is minimal and requires consent.

Assessment workshop would be enhanced if there was more local community involvement?

Decommissioning information available? Growing information all the time - Steep learning curve. - Scale is the difficulty ie. deep steel submersibles. - Smaller unit – a lot of information & actual experience is available.

Need for transparency - strategic assessment informs decisions and potential restrictions/limitations.

What is the link between SEA and DTI decisions - specific details are required.

Future SEA process improvements

How best to involve and inform?

- *Advertise in journals e.g. Birds, Wildlife. Also appropriate local papers.*
- *Could use local radio to inform local people/public.*
- *Publicise the website using a variety of methods – eg. Posters in libraries.*
- *Organise local meetings, those with interest will come.*
- *Point of contact for councils could be via community (environmental) forums (through LA).*
- *Invitations to Norway, Faeroe Islands or EU to participate in Stakeholder Workshop?*
- *CD ROMs are circulated, including to universities. Consider developing information for teachers.*
- *What about a road-show (BP did this with Foinaven)?*
- *Information boards to public libraries?*
- *Not everyone uses web!*
- *Should public dialogue come in earlier?*

Provide clarity on what requires protection on protected habitats to allow site specific surveys to identify protected habitats/species to enable developments to avoid these areas or provide mitigation.

Process should start off with a 'simple high impact' i.e. man, sea, biology/animals.

Fulfilment of earlier SEA's – monitoring?

Make up of steering group – Who? DTI, NGO's (RSPB, WWF), Government bodies (JNCC, FRS, CEFAS) academic institutions, industry).

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APPENDIX 4: SPECIES ACCOUNTS OF SEABIRDS & COASTAL WATERBIRDS

Species accounts – seabirds

Synopses were given in SEA 1 and SEA 2 of the population, distribution and general biology of individual seabirds regularly recorded in the North Sea and north and west of Scotland: fulmar (*Fulmarus glacialis*), Gannet (*Morus bassanus*), herring gull (*Larus argentatus*), great black-backed gull (*larus marinus*), kittiwake (*Rissa tridactyla*), common guillemot (*Uria aalge*), razorbill (*Alca torda*), puffin (*Fratercula arctica*), European storm-petrel (*Hydrobates pelagicus*), lesser black-backed gull (*Larus fuscus*), great skua (*Stercorarius skua*), Leach's petrel (*Oceanodroma leucorhoa*), manx shearwater (*Puffinus puffinus*), Arctic tern (*Sterna paradisea*), Arctic skua (*Stercorarius parasiticus*), Iceland gull (*Larus glaucoides*), glaucous gull (*Larus hyperboreus*), little auk (*Alle alle*), great shearwater (*Puffinus gravis*), sooty shearwater (*Puffinus griseus*), long-tailed skua (*Stercorarius longicaudus*) and Pomarine skua (*Stercorarius pomarinus*).

These synopses are further summarised for the most abundant species, in relation to the SEA 4 area, below:

Seabird species present all year round in SEA 4 and adjacent waters

SAST/ESAS surveys of the Atlantic frontier, north and west of Scotland, found the following species were present all year round.

Fulmars (*Fulmarus glacialis*) are the most numerous and widespread seabird breeding in Britain (537,000 pairs, Lloyd *et al.* 1991, cited in Mavor *et al.* 2002), and the Faroe Islands (800,000 pairs, Taylor & Reid 2001). For over a century, this species has undergone a spectacular population and range expansion in Western Europe. The precise reasons for this expansion remain unclear. In the North Sea, fulmars prefer stratified and highly saline waters which provide them with a variety of prey species including planktonic crustaceans, cephalopods and small fish. Their diet is also supplemented with fishery waste and fulmars regularly follow fishing vessels, scavenging on discards. Despite this, the availability of discards is not believed to influence the overall distribution of fulmars at sea (Pollock *et al.* 2000).

Within the SEA 4 area, the fulmar is the most abundant species recorded and is present throughout the year (Pollock *et al.* 2000, Taylor & Reid 2001 & Skov *et al.* 1995). During the breeding season (May to June) high densities of fulmars occur over the continental shelf, particularly around Shetland and Orkney. Moderate to high numbers are also recorded over the deeper waters of the Norwegian Sea and north and west of Scotland during this time. Fulmars continue to range widely when feeding during the breeding season, with some birds recorded 466km away from their colonies (Pollock *et al.* 2000).

In late summer, fulmars leave their breeding colonies to moult. During autumn (August to October), high densities are concentrated over shelf waters, particularly north of Scotland and around Shetland, probably due to the presence of recently fledged birds.

Wintering densities are relatively low with the majority of the breeding population thought to remain within a few hundred kilometres of the breeding colonies. While adult birds remain close to land, juvenile birds are thought to disperse over large distances. High densities of fulmars are concentrated along the continental slope south of 60°N and around Shetland from January to April, prior to the breeding season. During April, these concentrations are more pronounced when breeding birds undergo an exodus from their colonies.

During 2000 and 2001 breeding numbers were found to have decreased at the majority of monitored colonies in Shetland, including, Sumburgh Head and Burravoe, where significant decreases were recorded and Eshaness and Troswick Ness.

Breeding fulmars begin the return to Faroe Island colonies during November. By January, high densities of fulmars are concentrated in shelf waters, particularly close to large colonies such as Vágar, (estimated to hold in excess of 100,000 pairs (Taylor & Reid 2001), over the Faroe Bank as well as the Faroe Bank Channel.

There is an estimated 207,100 breeding pairs of **northern gannet** (*Morus bassanus*) in Britain (Mavor *et al.* 2002), with a further 2,000 pairs in the Faroe Islands. The North Sea, Channel and waters west of Britain are extensively used throughout the year by this partial migrant and while some adults winter in the area, some adults and most immature birds move south in winter towards the tropics. Gannets feed on shoaling fish and a supplementary diet of fishery discards.

Adult gannets return to the waters of the SEA 4 area in March, with immature birds tending to arrive in May. Distribution, at low densities, is widespread throughout this area between March and August, regardless of water depth. During this time, high densities of adults are found near breeding colonies at Shetland, foraging within a maximum of 150km from the colonies. Immature birds not tied to colonies were more widely dispersed, with the proportion of immature birds reaching a peak in July.

Winter densities are low after gannets leave the area during September and October for wintering grounds as far south as west Africa (Pollock *et al.* 2000).

In 2001, the gannet colony on Fair Isle (the only colony to be counted in both 2000 and 2001) was found to have increased by 21% from 2000, while productivity had increased at Hermaness and Noss (Mavor *et al.* 2002). Gannets are also known to breed on Sula Sgeir, with high numbers found near the island largely confined to areas bounded by the 100m isobath (Benn *et al*. 1986). Benn *et al*. (1986) also found that the Sula Sgeir gannetrie had remained relatively unchanged since 1969. Young Gannets at this colony are still harvested in a traditional hunt dating back several centuries and as a consequence, the rate of growth of this colony is not as high as at other sites (JNCC website). There is no information regarding the colony counts at Sula Sgeir gannetry for 2001.

The only gannet colony on the Faroe Islands is Mykineshólmur, located in the west of the islands. Few birds are present in the area during winter, with birds beginning to return during February. The number of birds peaks in June. The arrival of non-breeding birds swells numbers in the area between mid July and early August, which is followed by a widespread dispersion over the Faroes plateau during August and September when breeding adults disperse from the colony (Taylor & Reid 2001).

The **Herring gull** (*Larus argentatus*) is the most widespread species of large gull in the northern hemisphere. There are 150,000 pairs in Britain (Lloyd *et al.* 1991, cited in Mavor *et al.* 2002) with a further 1,500 pairs on the Faroe Islands (Taylor & Reid 2001). Herring gulls prefer shelf seas and coastal habitats and utilise most of the North Sea throughout the year. Their diet consists mainly of fish and invertebrates, a considerable amount of which is obtained as fishery waste (Skov *et al.* 1995). Herring gulls are regularly associated with fishing vessels and during spring (March-April), concentrations of birds can be found in important numbers near Fair Isle, possibly due to local presence of fishing fleets (Skov *et al.* 1995).

During the pre-breeding and breeding periods, between May and September, herring gull distribution is almost entirely coastal throughout the northwest and northeast of Scotland and up to Shetland, while the number of birds at sea decreases (Skov *et al.* 1995, Pollock *et al.* 2000). Migrants arrive during September and October and leave in March and April for favoured wintering grounds. Favoured offshore areas lie to the west and north of Shetland and to the west of Scotland, south of 60ºN.

Despite few herring gull colonies counted regularly, limited data suggests that coastal populations were roughly stable or declining between the mid 1980s and mid 1990s. As population trends at individual colonies vary within regions, small samples of data from these colonies are not necessarily indicative of widespread changes (Mavor *et al.* 2002).

The **Great black-backed gull** (*Larus marinus*) breeding population from the North Sea are thought to be largely sedentary, while birds from higher latitudes migrate south in Autumn (Skov *et al.* 1995). This species is the least common of the *Larus* species breeding regularly in the SEA 4 area. Britain has a recorded 18,400 pairs (Lloyd *et al.* 1991, cited in Mavor *et al.* 2002), while the Faroe Islands recorded a further 1,200 pairs (Taylor & Reid 2001). This species is an opportunistic scavenger and takes a variety of food including other birds, eggs, fish and invertebrates. It is known to scavenge around fishing vessels and land-fill sites during winter.

Distribution during the pre-breeding and breeding season, between May and September, is widespread, at low densities, within 50km of the colonies. Orkney, Shetland and the Western Isles hold the majority of the breeding population of great black-backed gulls in Britain, as well as the largest colonies (Pollock *et al.* 2000). North Rona has always supported a large colony of great black-back gulls. At sea records are generally adult birds near the islands, while immature birds are found further offshore (Benn *et al*. 1986).

The limited available data suggests that UK coastal population of great black-backed gulls generally increased or remained roughly stable between 1986 and 1994 (Welsh & Gordon 1994, cited in Mavor *et al.* 2002). 62 pairs bred on Noss (Shetland) compared to 56 pairs in 2000. However, only 0.47 chicks fledged per pair, compared to 0.61 in 2000. Breeding performance on Orkney appeared mixed. On Faray, 90 chicks were found on July 1st 2001, compared to almost 900 the same day the previous year. While on Papa Westray 48 pairs were recorded at the North Hill RSPB reserve in 2001, compared to 85 in 1997.

This species is the least numerous gull species breeding in the Faroe Islands with sparse distributions over offshore banks.

The **kittiwake** (*Rissa tridactyla*) is the most abundant and widespread gull species throughout the SEA 4 area (Taylor & Reid 2001, Pollock *et al.* 2000). There are 492,000 pairs in Britain (Lloyd *et al.* 1991, cited in Mavor *et al.* 2002), with up to as many as 230,000 pairs in the Faroe Islands (Taylor & Reid 2001). Small shoaling fish dominates this species diet, which is generally supplemented by fishery waste, particularly in winter (Skov *et al.* 1995).

From January to April kittiwakes are widely distributed along the continental slope and on the shelf north and north-east of Scotland, with fewer birds in shelf waters to the west of Scotland. Kittiwakes concentrate in coastal waters close to colonies from May to June, particularly around Orkney and the northern coasts of Caithness and Sutherland. These areas hold the majority of Scotland's breeding kittiwakes (Pollock *et al.* 2000). Foraging during breeding can range from less than 5km to 160km from the colony. During the breeding season few birds are distributed in offshore areas such as the Faroe-Shetland Channel. The birds that are present there are thought to be predominantly Faroese birds and birds congregating around fishing boats.

Distribution becomes patchy later in the year, with movement away from the colonies around the north coast and Orkney to the Minch and other inshore areas west of Scotland. Distribution also extends to offshore waters south of the Faroes around 60ºN. Lowest numbers of birds are found offshore between October and December, with some dispersal out into the North Atlantic. High numbers of birds remain concentrated in inshore waters west and north of Scotland, around Orkney and to the east of Fair Isle.

Mavor *et al.* (2002), found that between 2000 and 2001, overall numbers of kittiwakes declined slightly in most regions surveyed in the UK, however, large declines were recorded in north east and south east Scotland. A complete breeding failure was monitored at eight colonies in Shetland, with food shortage the most likely cause. On Fair Isle, productivity was as low as that recorded in 1990, when there was complete breeding failure. In 2001, most broods were left unattended for long periods of time, with many chicks found dying in the nest. Although kittiwakes fared better in Orkney, breeding performance was still below average than that recorded in 2000 at colonies at Papa Westray, Rousay, Costa Head and Gultak. The only colonies were productivity was higher than in 2000 were Marwick Head and Row Head (Mavor *et al.* 2002).

SAST/ESAS surveys found the **Common guillemot** (*Uria aalge*) to be the most abundant and widespread auk species throughout the SEA 4 area (Pollock *et al.* 2000). The total British population stands at over one million individuals (Lloyd *et al.* 1991, cited in Mavor *et al.* 2002) with a further 175,000 pairs recorded in the Faroe Islands (Taylor & Reid 2001). This species is primarily a shelf species preferring waters less than 100m deep, but are recorded along the shelf break in low densities throughout the year. They mainly feed on sandeels and clupeids during the summer and a wider selection of fish species in winter (Skov *et al.* 1995).

From May to July guillemots are concentrated around Shetland, Orkney, the northern coast of Caithness and Sutherland and off the west coast of Scotland. These areas contain most of the breeding bird population in Scotland (Pollock *et al.* 2000). During the breeding season, most breeding birds feed within 55km of their colony. After the breeding season, (August-September) guillemots disperse from the colonies and congregate in inshore waters where the adults undergo a complete moult.

By late Autumn/early winter, moulting flocks have dispersed further offshore, with low densities found along the shelf-edge over the Wyville Thomson Ridge, the Faroe-Shetland Channel and some birds wintering in the North Sea. Distribution is more widespread between December and April with highest densities remaining in inshore waters around Orkney and the southern half of Shetland.

The southern islands of Sandoy, Skúvoy, Stóra Dímun and Suðuroy contain the largest breeding colonies of guillemot in the Faroe Islands. During the breeding season birds are rarely found more than 60km from the colony. When the adults and juveniles disperse from the colonies after the breeding season, they disperse to the offshore banks in the area (Taylor & Reid 2001).

There were large decreases in the number of adult guillemots attending breeding ledges at study plots in Shetland in 2001 (Mavor *et al.* 2002). Declines were recorded at colonies at Sumburgh Head, Eshaness, Troswick ness, Fair Isle and Hermaness, with particularly low counts recorded during the second week in June. This was thought to be as a result of low attendance of non-breeding or off-duty birds responding to low food availability (Mavor *et al.* 2002). In 2001, guillemots had a relatively poor breeding season, with productivity the lowest on record for Fair Isle and Papa Westray.

The **Razorbill** (*Alca torda*) is primarily a shelf species, with few records of birds in deep waters (>200m). There is an estimated 147,000 individuals (Lloyd *et al.* 1991, cited in Mavor *et al.* 2002), in Britain and 4,500 breeding pairs in the Faroe Islands (Taylor & Reid 2001). It is estimated that approximately 70% of the breeding pairs in Britain, breed in Scotland (Skov *et al.* 1995), with highest concentrations found inshore off the west coast of Scotland (Pollock *et al.* 2000). Like guillemots, razorbills leave the colonies in late June, with the area south of Orkney in the Pentland Firth becoming important for gathering, moulting, razorbills from Orkney and Shetland.

Significant decreases of adult razorbills attending colonies occurred at Sumburgh Head and Burravoe, while elsewhere in Shetland there were non-significant decreases recorded at Troswick Ness, Hermaness, Eshaness and Fair Isle (Mavor *et al.* 2002). Numbers at colonies were thought to be as a result of low attendance by non-breeding and off duty birds responding to low food availability.

Puffins (*Fratercula arctica*) are more widespread than guillemots or razorbills (Pollock *et al.* 2000). There are approximately 898,000 individuals in Britain (Lloyds *et al.* 1991, cited in Mavor *et al.* 2002) and 550,000 pairs in the Faroe Islands (Taylor & Reid 2001). They are more common in deep water and are often more abundant in oceanic rather than inshore waters. Their diet predominantly consists of clupeids and sandeels.

At the onset of the breeding period (April-May), puffins are widespread and numerous within the SEA 4 area. The majority (55%) of puffins that breed in North Sea colonies, breed in Shetland and Orkney (Skov *et al.* 1995). During this time puffins can also be found over deeper waters, as far west as the Rockall Trough and north to the Norwegian Sea. Breeding birds are thought to forage within 40km of the colony at this time, therefore birds found in deeper waters are thought to be non-breeding birds. However, during times of low food availability foraging distance by breeding birds can increase.

After breeding (August-September), distribution becomes more widespread into deeper waters south and west of the Faroes and shelf waters between Orkney and Shetland. In winter and early spring, (October-March), distribution becomes scattered, with birds from the Shetland and Orkney colonies moving south and wintering in the North Sea. Some birds move north-west of Shetland to beyond the shelf break and over deeper waters of the Faroe Bank, the Faroe-Shetland Channel and the Wyville Thomson Ridge (Pollock *et al.* 2000).

Few data on puffin breeding numbers were collected in 2001. Productivity on Fair Isle was found to be low in 2001, with many starved fledglings found at the mouth of burrows and some adults still attending burrows at the end of August. Dozens of dead, emaciated chicks were found around burrow entrances on Foula, with few fish-carrying adults observed (Mavor *et al.* 2002).

Summer seabird visitors to the SEA 4 area and adjacent waters

Petrels that are summer visitors to the SEA 4 area include the **European storm petrel, Leach's storm petrel** and **Manx shearwater**. The European storm petrel is widespread throughout the area from June until August. There are important colonies on Sule Skerry and Sule Stack as well as Mousa in Shetland, Auskerry in Orkney and North Rona/Sula Sgeir. Storm petrels have been recorded on North Rona and Sula Sgeir since 1885 (JNCC website). Breeding success on North Rona was determined with the help of Tape-playback for the first time in 2001. 147 responses were obtained, equating to 414 apparently occupied sites (AOS), while on nearby Sula Sgeir there were an estimated eight AOS (Mavor *et al.* 2002).

European storm petrels return to the Faroe Island colonies from their wintering grounds at the end of May. The islands are thought to hold 40% of the world population (Taylor & Reid 2001), with the eastern island of Nólsoy alone supporting 100,000 pairs. At-sea densities are highest in July and August, when numbers are swelled by the presence of immature and non-breeding birds.

During May and June small numbers of Leach's petrel can be found to the north and west of Shetland, with highest densities generally recorded during August (Pollock *et al.* 2000). Distribution is widespread over deep waters north west of Scotland, with birds also recorded along the Faroe-Shetland Channel. Four of the UK's six colonies are within the SEA 4 area - North Rona and Sula Sgeir, Foula, Ramna Stacks and Gruney, Sule Skerry, and Sule Stack. The first accurate census on North Rona revealed 2,263 AOS, which makes this the second largest colony in Great Britain after St Kilda, while on nearby Sula Sgeir there were an estimated nine AOS (Mavor *et al.* 2002).

UK Breeding colonies of the Manx shearwater are all west of mainland Britain. Birds believed to be immature, non-breeding birds are widespread throughout the southern SEA 4 area around Orkney and Shetland and along the Faroe-Shetland Channel between June and August. Manx shearwaters return to the breeding colonies on the Faroe Islands in May (Taylor & Reid 2001). They are widely dispersed over much of the Faroese shelf and the deep water beyond the shelf edge during the breeding season. At-sea distribution at high densities are predominantly found on the west coast of the islands. Numbers at colonies decrease during August and September as adults depart to wintering grounds, with fledgling shearwaters leaving the area shortly afterwards to fly south.

Two species of skua summer in the area: **Arctic skua and great skua.** Arctic skuas have a predominantly inshore distribution from March to August, particularly around main breeding colonies on Shetland and Orkney as well as near colonies on the north and west coasts of Scotland. During this time only low densities are found over deeper water. This species leave their breeding colonies around August, migrating southwards largely via inshore waters down the east coast of Britain (Pollock *et al.* 2000).

In 2001, increases of adults Arctic skuas were recorded on Foula and Fair Isle, with numbers of apparently occupied territories (AOT) increasing by 8% and 20% respectively. A decline from nineteen to nine AOTs was recorded on Mousa, the lowest recorded for twelve years, while numbers on Noss, Hermaness and Fetlar remained stable. Data from only two sites in Orkney were available – at North Hill (Papa Westray), numbers declined by 22% and The Loons (mainland Orkney) there was only one AOT, the same as that recorded in 2000.

The shortage of available sandeels from mid June 2001 is thought to have been the cause of the worst breeding season for Arctic skuas on Shetland since the sandeel crisis of 1989 and 1990. Chicks were reported to be starving, with poor attendance on territories by adults rendering nests more susceptible to predation by great skuas. There were complete failures at Hermaness, noss, Fetlar and Mousa, while no fledged young were recorded on south Bressay or in the Dalsetter area, south Mainland. On Foula, 66 chicks from 116 pairs were raised, with only ten fledglings remaining alive at the beginning of August. Only five chicks fledged at North Hill (Papa Westray – Orkney) in 2001, the worst year on record (Mavor *et al.* 2002)

Nearly 60% of the world population of 14,000 pairs of great skua breed in Orkney-Shetland (Skov *et al.* 1995). They are highly concentrated round their colonies in summer and dispersed in the Atlantic in the winter. Waters around Shetland and Foula and off western Orkney are of international importance for this species in the early breeding season (April-June). Adults range further offshore in the later part of the breeding season, while fledglings remain at the colonies until the beginning of July.

Two other summer visitors to the region are **Arctic tern** and **lesser black-backed gulls**. Arctic terns are predominantly coastal between May and October, and found mainly around Shetland, Orkney and the Western Isles from May to June. Orkney and Shetland are estimated to hold around 80% of the British breeding population (Pollock *et al.* 2000). Dispersion from main breeding sites begins in August, with low densities found in deep waters around the shelf break south of the Faroes. By late autumn migration has begun to wintering grounds in the south. Faroese Arctic terns return to the islands in high numbers by June, with peak numbers recorded close inshore.

Indications from the few monitored sites in Shetland and Orkney in 2001, were that breeding numbers were higher than in 2000 (Mavor *et al.* 2002). There were *c.*800 pairs recorded on Foula (similar to 2000), 350 pairs on Fetlar (97 pairs in 2000), 206 adults on Mousa (twice that in 2000), 2,836 pairs on Fair Isle (up 127% from 2000), 34 pairs on Noss (29 pairs in 2000), with a record 43 pairs at Hermaness and over 400 pairs on the Skerries. In Orkney 1,615 adults were counted at North Hill, Papa Westray (up 58%), 413 adults at ten colonies on North Ronaldsay (256 at six in 2000) and 16 pairs at Onzibust, Eigilsay (down from 19 pairs). Numbers remained low at Auskerry, with only 30 birds attempting to breed.

Low sandeel availability from mid June is thought to be the cause of the worst breeding season since 1990, with Shetland only producing 14 fledged chicks from a combined total of 4,200 pairs on Foula, Fetlar, Fair Isle, Noss, Hermaness, Mousa and Whalsay. The colonies at Dalsetter and Eshaness, Mainlad Skerries, West Burra and Looss Laward, Grutness also completely failed. In Orkney only three young fledged from around 1,536 pairs on Papa Westray, while no chicks fledged from over 600 pairs on Rousay. Onziebust was the most successful colony where 16 pairs fledged eight chicks.

Lesser Black-backed gulls have a widespread distribution at low densities over shelf and slope waters. They are regularly associated with fishing vessels, particularly south of 60ºN along shelf waters.

Winter and migrant visitors to the SEA 4 area and adjacent waters

Three species are regarded as winter visitors to the Atlantic Frontier and waters north and west of Scotland: Iceland gull, glaucous gulls and little auk, while four seabird species are migrants that pass through the area: great shearwater, long-tailed skua, pomarine skua and sooty shearwater.

Iceland gulls are scarce winter visitors to the area and are mainly found over slope and inshore waters. Glaucous gulls are concentrated over the Faroe-Shetland Channel and Rockall Trough in low densities between October and April. Little auk are winter visitors from islands of Arctic Europe. Low densities are observed in the Faroe-Shetland Channel while higher numbers winter in the northern North Sea.

The great shearwater breeds in the South Atlantic and is believed to complete a clockwise migration circuit of the Atlantic Ocean. The highest number of sightings for the long-tailed skua are in the north end of the Faroe-Shetland Channel in May and August-September. Pomarine skuas move through the area as they travel between their wintering grounds off west Africa and breeding grounds in the high Arctic. Relatively high numbers have been observed along the shelf edge and Faroe-Shetland Channel. The sooty shearwater has a similar migration and distribution pattern to the great shearwater, insofar that low densities are found throughout the area with small concentrations found over the Wyville Thomson Ridge.

Other bird species in the SEA 4 area and adjacent waters

Despite occasional records in deeper waters, ten species: red-throated diver (Gavia stellata), great northern diver (*Gavia immer*) cormorant (*Phalacrocorax carbo*), shag (*Phalacrocorax aristotelis*), common eider (*Somateria mollissima*), long-tailed duck (*Clangula hyemalis*), black-headed gull (*Larus ridibundus*), common gull (*Larus canus*), common tern (*Sterna hirundo*), and black guillemot (*Cepphus grylle*) – have a largely inshore distribution.

Shetland supports 300 great northern divers (approximately 10% of the GB population) and 2,500-3,000 long-tailed ducks (approximately 12% of GB population) (Tasker 1997a). Approximately 7% (5,900 birds) of the GB population of eider ducks were present in nearshore areas of Shetland in 1996. Eiders move to long-established sites around the islands to moult following the breeding season, while great northern divers are scattered around the coasts and long-tailed ducks favour sheltered areas, particularly the Bluemill-Fetlar area.

Black guillemots are widespread in low densities in coastal waters within the SEA 4 area in summer and winter. Birds from Shetland and Orkney colonies remain within 15km and 50km respectively, of their colonies, while birds from Foula and Fair Isle move further than birds from other colonies. During Autumn and winter, waters of Shetland provide important gathering areas for flocks of moulting black guillemots.

Inland areas of the Orkney Islands are major strongholds of the red-throated diver, supporting over 11% of the British breeding population. This species normally feed in coastal waters close to their breeding areas (Gibbons *et al.* 1993). Large concentrations of shags can be found in the two entrances to Scapa Flow, while the Sounds of Eynhallow, Rousay and Gairsay hold large numbers of shags, eiders and long-tailed ducks.

Species account – coastal waterbirds

Although many are primarily associated with freshwater, wet grassland and moorland habitats, rather than strictly coastal locations, species of waterbirds known to breed in the SEA 4 includes several wildfowl and wader species as well as one diver: red-throated diver (*Gavia stellata*), teal (*Anas crecca*), mallard (*Anas platyrhynchos*), pintail (*Anas acuta*), shelduck (*Tadorna tadorna*), wigeon (*Anas penelope*), red-breasted merganser (*Mergus serrator*), shoveler (*Ana clypeata*), eider (*Somateria mollissima*), tufted duck (*Aythya fuligula*), gadwall (*Anas strepera*), greylag goose (*Anser anser*), mute swans (*Cygnus olor*), whimbrel (*Numenius phaeopus*), red-necked phalarope (*Phalaropus lobatus*), lapwing (*Vanellus vanellus*), redshank (*Tringa totanus*), snipe (*Gallinago gallinago*), dunlin (*Calidris alpina*), black-tailed godwit (Icelandic race) (*Limosa limosa*), ringed plover (*Charadrius hiaticula*), oystercatcher (*Haematopus ostralegus*), golden plover (*Pluviallis apricaria*), greenshank (*Tringa nebulari*), curlew (*Numenius arquata*), common sandpiper (*Actitis hypoleucos*).

The Shetland Islands are a major stronghold of the whimbrel, with approximately 95% of Britain's breeding population found on the islands (May & Law 1997a). This species favours sandy, muddy and rocky shores as well as the exposed heathlands and moorlands of the islands. The islands are also a stronghold for red-necked phalarope – Fetlar holds 90% of the British breeding population. Large areas of bog and moorland on the islands provide suitable breeding habitat for species characteristic of wet grassland including lapwing, teal, redshank, mallard, snipe and pintail.

Fetlar supports nationally important numbers of dunlin, which utilise the moorland and upland mire areas of the islands. Fetlar also supports a small population of the Icelandic race of black-tailed godwit which prefer area of marsh/wet grassland and flat coastal pastures.

The island of Papa Stour is nationally important for ringed plover and Shetland as a whole holds over 12% of the British species' total. Ringed plover is characteristic of shingle, sand dunes and other dry grassland habitats. Half of the British breeding population of red-throated diver (approximately 700 pairs on Shetland, Gibbons *et al.* 1993), utilises both coastal areas and boggy moorland of Shetland and regularly commutes several kilometres between nesting and foraging areas (May & Law 1997a).

Breeding waterfowl assemblages in Orkney are very diverse with very high densities of breeding birds, particularly waders. Curlew populations in Orkney are considered to be amongst the most dense in Europe (Meek 1997b), with numbers at levels of international importance – 4% of the north-west and central European breeding population. Other breeding wader species that occur at levels of international importance includes the oystercatcher (5% of the north-west and central European breeding population) and ringed plover (4% of north-west and central European breeding population and 7% of the British population), both of which nest in coastal habitats (sand, shingle, machair or adjacent farmland). In addition to these, more than 1% of the British breeding population of whimbrel, lapwing, redshank, dunlin and snipe are present, making the region nationally important for these species.

Duck species that breed in Orkney in nationally important numbers include: pintail (57% of British breeding population) – Orkney's most important breeding duck found mainly on lochs on West Mainland, Shapinsay and Stronsay; wigeon (18%); red-breasted merganser (7%); shoveler (6%); eider (3%); teal (3%); mallard (>1%); tufted duck (1%) and shelduck (>1%). Orkney supports one of Scotland's main concentrations of shelduck (100-150 pairs), nesting in holes in coastal and estuarine areas.

Other bird species of notable interest breed on Orkney. Peregrine falcons, the greatest majority of which are sea-cliff nesters and dependant to a large extent on seabirds as prey, number around 15 pairs. Corncrake, twite and the rock pipit, the latter of which utilises the shoreline habitat of the islands, all reach significant population levels in Orkney.

Along the northern coastline of Sutherland and the Coast of Caithness, large stretches of the coast are cliff-bound. As a result, breeding birds typical of soft coastlines, such as waders and other waterbirds are restricted in occurrence (Stroud & Craddock 1997). Although these areas may be lacking in breeding birds Caithness and Sutherland are strongholds for the red-throated diver, the little grebe (*Tachybaptus ruficollis*), has expanded its range into Caithness, while there remains a long-established breeding population of gadwall in the wetlands of Caithness and Sutherland (Gibbons *et al.* 1993).

In addition to coastal breeding species, numbers of migrant and wintering waders and wildfowl (divers, grebes, ducks geese and swans, as well as coot, *Fulica atra*), use the SEA 4 area.

Shetland is not of major importance to wintering wildfowl and the coastal regions holds relatively small numbers of wildfowl in relation to the rest of Scotland and the UK (Tasker 1997a). In contrast, the area is important for migrating wildfowl in spring and autumn as it lies on the principal migratory path of many birds moving to and from wintering areas in the south to northern Arctic breeding grounds. The main concentrations of wintering wildfowl in Shetland are at Loch Brow and Loch Spriggie, the latter of which is of international importance for wintering whooper swan populations. Eider and long-tailed duck are the most common wintering duck species (May & Law 1997a). The islands also support notable numbers of autumn passage greylag geese, barnacle geese and pink-footed geese. While the muddy and other non-cliff shores provide suitable habitat for waders such as redshank, purple sandpiper and ringed plover, all wintering wader species avoid steep shores and cliffs – over half of the coastal habitat. The most abundant wintering waders are turnstone and redshank.

Some of Shetland's designated sites (e.g. National Nature Reserves; Sites of Special Scientific Interest and Special Protection Areas) have been selected partly for their migrant and wintering wildfowl interest (May & Law 1997).

In Orkney, twelve species of wintering waterbirds reach levels of international significance, while an additional fourteen species reach nationally important levels (Table 1).

Table 1 Internationally and nationally important wintering waterbird species

Internationally significant species, (Orkney population & % of British population)	Nationally significant species, (Orkney population & % British population)
Great northern diver (400, 13.0%)	Mute swan (450, 1.7%)
Slavonian grebe (80, 20.0%)	Greenland white-fronted goose (220, 1.6%)
Whooper swan (300, 5.5%)	Teal (3,500, 2.5%)
Greylag goose (5,000, 5.0%)	Mallard (5,000, 1.1%)
Barnacle goose (1,100, 4.1%)	Tufted duck (2,750, 4.6%)
Wigeon (20,000, 7.1%)	Scaup (370, 3.4%)
Pochard (4,000, 9.1%)	Eider (5,000, 6.7%)
Ringed plover (1,600, 5.5%)	Long-tailed duck (3,500, 15.2%)
Purple sandpiper (5,700, 27.1%)	Velvet scoter (150, 5.0%)
Curlew (>20,000, 16.7%)	Goldeneye (850, 5.0%)
Redshank (7,000, 6.4%)	Red-breasted merganser (650, 6.5%)

Internationally significant species, (Orkney population & % of British population)	Nationally significant species, (Orkney population & % British population)
Turnstone (6,000, 9.4%)	Golden plover (3,000*, 1.2%) Sanderling (850, 3.7%) Bar-tailed godwit (770, 1.5%)

*Source: May & Law 1997b * is best estimate population*

Key habitats in Orkney for wintering waterbirds species are the lochs and the rocky and sandy shoreline, however birds interchange between sites during the course of a winter. Therefore the importance of individual sites cannot be considered in isolation. The number of birds utilising the shore can vary with weather conditions as they tend to be more numerous on shores in cold weather, when there are fewer grassland invertebrates available inland. Sandy coastlines, such as those at Northern Isles and Deerness, Mainland and Sanday, as well as Deer Sound/Scapa Bay support wintering ringed plover, oystercatcher, dunlin, knot and bar-tailed godwit. While turnstone, purple sandpiper, redshank and snipe can be found on rocky shores in the region. Inland, the most conspicuous wader during winter is the curlew, particularly on Mainland, South Ronaldsay and Shapinsay.

Orkney is important for several species on autumn and spring passage. Notable numbers of barnacle goose, whooper swan , snipe, ringed plover, ruff, gadwall and whimbrel utilise the islands in autumn. While purple sandpiper, turnstone, sanderling, knot and oystercatcher are some of the species that use the islands, Sanday in particular, as a migration staging post in the spring (Meek 1997).

Scapa Flow is nationally important for wintering red-throated and black-throated diver and red-necked grebe, as well as being of international importance for the Slavonian grebe and great northern diver (Pollitt *et al*. 2003). Also of international importance for the great northern diver is Deer/Shapinsay Sounds and Tankerness.