APPENDIX 11 – ASSESSMENT

A11.a Approach

A11.a.1 Introduction

The assessment for this SEA was a staged process (Figure A11.a.1) which has incorporated inputs from a variety of sources:

- The receptors in the SEA 7 and previous SEA areas grouped according to the SEA Directive (see Appendices 3 to 9 and 12, and the range of underpinning technical reports produced for SEA 7 and earlier SEAs) together with the likely evolution of the baseline conditions.
- The likely activities and potential sources of effect (see Appendix 11) and the existing regulatory and other controls (see Appendix 10).
- The SEA objectives (see Section 3).
- The information base regarding the relative risks and potential for significant effects from oil and gas related activities in the SEA areas.
- Steering Group and stakeholder perspectives on important issues, information sources and gaps, and potential areas to exclude from licensing derived from assessment workshop, meetings and scoping communications.

Figure A11.a.1 – Assessment process

The evidence based consideration of the potential for significant effects is given in Appendix 11 and summarised in Section 5.

A11.a.2 Assessment workshop

An assessment workshop was held in Glasgow in October 2006. The participants were comprised of the SEA Steering Group, the SEA Team and the authors of the underpinning technical reports with the aim of bringing this expertise together to consider the key issues to be addressed in the assessment for SEA 7. The workshop was chaired by Professor Bill Ritchie of Aberdeen University Institute of Coastal Science and Management. The workshop used the principles of the Chatham House rule to allow for free discussion and for issues and outputs to be captured without attribution.

The objectives of the assessment workshop were to:

- To discuss and agree the draft objectives for SEA 7
- To identify the main environmental issues that should be considered further in the SEA 7 Environmental Report
- Review areas, sites and features of the SEA 7 region to identify any requiring additional protection over and above that available through existing mechanisms
- Identify any gaps in information and understanding, and assess their influence on the confidence with which the SEA 7 assessment of likely effects and necessary mitigation can be made
- To consider the re-offer of blocks for oil and gas licensing within areas previously subject to SEA

The workshop was structured as follows:

- Agreement of ground rules and workshop processes
- Round table discussion – technical reports issues and clarifications – see list below
- Work Session (1) – Review and discussion of SEA objectives and suggestion of indicators
- Work Session (2) - Offer of blocks in SEA 7 area for licensing
    - What are the main issues and sensitivities relevant to oil and gas?
    - Any areas that should not be offered for licensing and why?
    - Any temporal/spatial control on activities in blocks offered for licensing?
    - Are any additional operational controls needed?
- Work Session (3) – re-offer of blocks in previous SEA areas. Consideration of any:
    - Changes in environmental regulations?
    - New information on the environment of the areas?
    - Changes in understanding of environmental effects from potential activities?
    - New pollution control techniques and technology?

Outputs from the sessions are summarised below.

Round table discussion – technical report issues and clarifications

Geology

- Currently limited prospectivity – but possible future increase due to advancing technologies. Therefore increased economic viability etc.

- St. Kilda - thick basalt layers
- Earthquake activity submarine landslides especially in sea lochs.
- Nearshore statistics information shows 2 earthquakes a year (roughly of magnitude 4).
- Knowledge gap: Banner banks, release pollutants overtime unless storm hits = quick release.
- Any increase in prospectivity will be addressed in future SEAs and EAs
- Atlantic Conveyor System. Very powerful current (intermittent/seasonal). Feeds into North Sea (potential for substantial spread of spills etc). Very important to ecosystem in area. 80km wide, infrastructure would not impede current.
- Possible mitigation measure? Prospectivity for CO_2 storage in the ground? In theory, possible to inject CO_2 into deep formations, a porous reservoir at a suitable level is self-sealing.
- Use 'acid' resistant pipework etc in development to set scene for CCS in future.

Hydrography

- Inputs and mixing of water masses in the area. Tracking different water masses. Link to sediment and underwater currents more powerful than people thought – capable of moving discharges
- Thermoclines: seasonal and spatial variations

Underwater Noise

- This is truly deep water – basin sensitivity to accumulative surveys. Strong bathymetry = reverberation in basins.
- Ambient noise, predominantly, is from weather (low shipping use in area). Weather = wave action on shallow shelf. When absence of weather noise - shipping noise becomes predominant.
- Recommendation for acoustic budget i.e. determined by location of survey; and to mitigate the number of surveys taken at any one time rather than limiting total number of surveys.

Benthos

- Conservation agencies are giving serious consideration to the potential for marine SACs in the area on account of seabed habitats and species
- Comparative summary of this SEA to others? Relative richness etc (note legacy of fishing activity in other SEAs has contributed to lesser biodiversity).
- Must keep a broad view in relation to biodiversity and look below the surface e.g. remember the worms! The sedimentary environment – the most important.
- Incorporation of shallow water ecology – there a good resource of existing information which should be included in the Environmental Report.

Plankton

- Short lived events (related to oil and gas) would have limited impact on plankton.
- Impacts will be localised.
- Information gap on coelenterates and very little survey coverage of these groups.

Marine Mammals

- Could SMRU highlight comparative richness of different SEAs (and other EU areas)?
- Beaked whales are more prolific in area than studies currently suggest.

- Other studies have been done and should be located/incorporated.
- Identify data gaps within the report.
- WWF offered a report: impact of vessels on small cetaceans.
- SEA funds have been put into looking at 'Cetacean offshore distribution and abundance'.

Offshore Seabirds

- Seabird density appears to decrease as you travel westwards/further offshore. Lack of good information in these areas.
- Recommendation for seabird surveyor to be present on any other surveys which may take place in the area.
- Existing datasets should be identified and merged.
- Data gaps have been reported and are available on the SEA website.
- Inshore report and technical update.
- Note: Study to start soon: Marine feeding areas and offshore SPAs

Fish

- Fish log book data not used (at present relatively unreliable due to under-reporting)
- ICES have an electronic fish distribution atlas. The SEA area is relatively under-represented at present and should be included.
- Biggest fishery in area = blue whiting.
- Trend/status – ICES information.
- Management of fishing activity over Hatton and Rockall is problematic.
- Fisheries generally within 1500 metres water depth (few fisheries beyond this)

Cephalopods

- Hotspots: West of Hebrides and Rockall Bank
- As finfish stocks decrease importance of cephalopod fishery may increase.
- Bioaccumulation of heavy metals in food chain (especially with regard to whales including beaked whale)
- Deepwater area = deepwater and oceanic species
- Affect of bioaccumulation e.g. heavy metals upon deep water species – data gap

Archaeology

- In terms of both submerged prehistory and maritime archaeology, the SEA 7 area is far from marginal. It is an arena within which many of today's cultural identities have been forged, which is important to how current populations view this area and its history.
- The potential for the presence of submerged prehistoric sites depends on a complex history of changes in relative sea-level that vary markedly across the region.
- There has been extensive maritime activity - which has been central to human cultural development - within the SEA 7 area from at least the Mesolithic period. The greatest density of maritime archaeological remains probably lies within the bay closing lines, but there will be wrecks of ships and aircraft throughout the SEA 7 area.
- Workshop participants should bear in mind the implications of the recent Storaa judgements regarding the protection (and public profile) of military remains. Also, the wrecks of military aircraft are automatically protected.
- Wreck sites = point sources of pollution.
- WHS sites may be de-classified if surrounding activity has altered cultural value of site i.e. WHS site may be de-listed if setting becomes too degraded.

Conservation sites

- Existing designated sites are coastal/onshore.
- High density and overlap of sites along coast.
- Especially important for ornithology and geology
- 3 offshore sites: one possible and two drafts.
- Again, offshore SPA work to begin soon

Users

- Low population density
- Marked division between bay enclosures and offshore areas.
- Highest activity in bay enclosures – much lower activity on offshore areas
- Mariculture – high importance in area and contributes over 60% of Scotland's mariculture output.
- Shipping activity is low to moderate
- Tourism and recreation and impact on natural character and ecosystem. Main draw = Natural Environment.
- 5 MEHRAs have been identified in SEA 7 (including St. Kilda)
- Renewables should be considered.

Socio-economic

- One scenario = if Benbecula well successful, would necessitate gas pipeline to shore and onshore terminal.
- Three possible routes, preferred route likely to be across the north coast of Scotland to St. Fergus
- Potential synergy between electrical stations and gas terminal (if Ullapool) – need to look for cumulative impacts

Other points raised during discussion

- Where reliable, historical data sets exist, useful time series data could be generated. However, there is a danger of misleading comparisons being made where robust scientific data is not available.
- Comparison studies between SEA 7 and other SEA areas and between SEA 7 and Europe should be made and in particular e.g. benthos, marine mammals etc
- Cumulative impacts of hydrocarbons. Knock on impacts include indirect effect of climate change on SEA 7. Cumulative etc. built into SEA 7 Directive.
- Can the relationship of licensing SEA 7 and its relationship with climate change be dealt with here?

Session 1

The proposed objectives for the SEA were discussed with feedback sought on workable indicators that could be used to measure attainment of the objectives. The revised objectives and indicators (which also reflect scoping feedback from the Consultation Bodies (see Appendix 1) can be found in Section 3.2 of the report.

Session 2

1. What are the main issues and sensitivities relevant to oil and gas activity in SEA 7?

- Seismic survey and other acoustic pollution (esp. with regard to cetaceans). More information required on distribution and acoustic behaviour of marine mammals in deeper waters further offshore.
- Fisheries interactions (especially with regard to small shellfish species and deepwater, slow growing benthic species)
- Seabird colonies (e.g. St. Kilda and North Rona) feeding and breeding areas
- Sensitive habitats e.g. Hutton Bank, St. Kilda, Hebridean machair and deepwater slow growing habitats
- Risk of storm surge, submarine landslides and tsunami in relation to the placing of nearshore and coastal infrastructure
- Introduction of alien species through ballast water
- Oil spill issues and transfer of pollutants from Hebrides Margin to North Sea, Norway, by the European Slope Current
- No scope for using existing infrastructure for export transport

2. Are there any areas that you feel should not be offered for licensing in and why?

- Internationally designated sites (and those soon to be designated) and their environments e.g. St. Kilda and Darwin Mounds
- Special attention to be paid if blocks are in areas of potential archaeological value
- Designated (and those soon to be designated) seabird colonies e.g. St. Kilda
- Biogenic reefs, coastal zones around Outer Hebrides, Northern Ireland and to the east of the Western Isle.
- Anton Dohrn and other sea mounts, regions of coral reefs, other important habitats such as upwellings and fronts and Area 152 which is important to cetaceans.
- Missile testing range
- Consenting system should be sufficient to prevent unacceptable impacts upon designated sites
- Mitigation strategies should be in place for developments and seismic exploration on shelf edge should be stringently controlled

3. Are there any temporal/spatial controls necessary on activities in blocks offered for licensing?

- Temporal control to take account of seabird breeding and moulting sensitivities (esp. to minimise oil spill risk)
- Phasing of ‘noisy’ activities – possible use of acoustic budgets in the future
- Special attention to infrastructure traversing potential archaeologically rich sites
- Seasonal restrictions on seismic to protect fish spawning, cetaceans breeding and migratory patterns – though better understanding of impact of seismic upon marine mammals is required
- MMOs should have hydrophones

4. Do you feel that there should be any additional operational controls introduced?

- Acoustic management and related options should be investigated, e.g. acoustic budget and measurements of background ambient noise. Establish a noise monitoring scheme and acoustic budgets for seismic survey
- Spill planning to take account of coastal sensitivities and dispersal patterns

Session 3

1. Is there any new relevant information on the environment of any of the areas?

- SCANS survey data summer 2005 – cetaceans
- Seawatch Foundation
- JNCC and CCW new aerial surveys – scoter in Liverpool Bay
- Aerial surveys – divers in Thames and the Wash
- Aerial surveys – Cardigan Bay
- Better understanding of impacts of sound
- Marine ALSF projects – new knowledge regarding seabed prehistory
- Contaminant monitoring of shellfish recommended (suggested species *Nephrops*)
- Hydrographic seabed topography and sediment sampling – new surveys have been completed
- 2005/6 surveys and identification of cold water corals etc (SEA 7)
- New data from F-S Channel and sponges W -T Ridge
- New info. on tidal/wind/wave resources

2. Do any new environmental regulations change perspectives?

- Appropriate Assessment (ECJ judgement ruling re. Habitats Directive)
- Public Participation Directive and freedom of information
- Water Framework Directive – only applicable to 1nm offshore
- The Marine Act and Marine Spatial Planning
- Renewables obligations including Kyoto Protocol and UK domestic CO2 reduction targets
- Environmental Liability Directive
- Registration, Evaluation and Authorisation of Chemicals (REACH)
- 'Storaa' judicial review and appeal: some merchant ship wrecks eligible for designation as military remains

3. Is there new understanding of environmental effects from potential activities?

- Ongoing OGP led research on sound and marine mammals
- Climate change
- New understanding of cumulative, synergistic and transboundary issues
- New hydrographic data
- More information on acoustic impact on the environment
- Generally increasing body of experience in relation to marine historic environment
- The importance of banner banks to function as long-term reservoirs of pollutants

4. Are there any new pollution controls and technology?

- Potential for Carbon Capture and Storage
- 30ppm oil in water limit from 40ppm
- Better design of acoustic sources, improved vertical processes and improved mitigation measures to reduce receptors vulnerability to acoustic energy
- Improved diver and ROV based methodologies
- Improved geophysics acquisition and processing methodologies for historic environment

5. Are there any areas that you feel should not be reoffered for licensing and why?

- Every block should be considered in light of new information
- Pockmark areas from SEA 2 and possible marine SPAs
- Cardigan Bay SAC, Liverpool Bay pSPA, the Thames, the Wash and the Moray Firth

A11.a.3 Stakeholder meeting

Overview

The SEA 7 stakeholder workshop took place in March 2007 in Glasgow. A wide variety of potential stakeholders, drawn from UK regulators, government advisers, local authorities, other industry representatives, academics and NGOs and those who registered with the SEA website were invited to the session. The workshop was chaired by Professor William Ritchie. The workshop had two key objectives:

1. To update stakeholders on the SEA 7 progress and issues
2. To gather stakeholder input to and comments on the information and analysis on which SEA 7 is being based

A document providing background for stakeholders on the current DTI offshore energy SEA (SEA 7) was forwarded to delegates in advance of the workshop. During the workshop, delegates were also provided with a workshop feedback questionnaire.

The workshop used the principles of the Chatham House rule to allow for free discussion and for issues and outputs to be captured without attribution. The workshop was structured in three sessions:

Session 1

Session 1 comprised a series of introductory presentations covering:

- **SEA 7 purpose, area and process** - SEA 7 area and previous SEA areas, licensing of blocks (including licensing alternatives), purpose of SEA 7, current activities in the area and the overarching objectives of SEA.
- **DTI role and context** – Regulation at various stages of operation (including permits, EIA and SEA), licensing and control of systems.
- **Overview of environment** – Overview of available data sources: review of existing information, acquisition of new information, key environmental features, existing and potential conservation sites, other activities.

A short ‘question and answer’ session followed to allow delegates to clarify any issues.

Session 2

Session 2 took the format of a ‘poster’ session with the delegate feedback questionnaires providing a framework for stakeholders to capture feedback.

Posters were divided into themes:

- Regulatory and licensing context
- SEA 7 area overviews (e.g. seabed and substrates, plankton and benthos, fisheries, conservation, archaeology and other users)
- Previous SEAs 1-6
- Sources of effects, existing controls and potential mitigation
- SEA 7 draft recommendations

The delegates were asked to capture feedback under the following headings:

A. Points for discussion in plenary
B. Information base for SEA 7 - Are there studies, reports, or other information which should be considered for the SEA 7 Environmental Report?
C. Draft Recommendations - Having reviewed the draft recommendations and other posters, consider the following questions:
   1. Are there any areas that you feel should not be offered for licensing in the 24th Round and why?
   2. Similarly are there any temporal/spatial controls necessary on activities in blocks offered for licensing?
   3. Do you feel that there should be any additional operational controls introduced?
D. Other comments for consideration in SEA 7?

Session 3

Session 3 was a facilitated discussion in plenary. Points raised and discussed are listed below.

A. POINTS FOR DISCUSSION IN PLENARY

- There is a lack of recent data regarding many aspects of ecology in the area, notably seabird at-sea distribution and abundance; fisheries e.g. anadromous fish distribution, deep water fisheries
- What is the availability of data for designating conservation sites in this area? How are data distributed seasonally?
- After SEA 8 is complete, will there be any other opportunities/money available for research collaborations between the DTI and stakeholders?
- What is the duration of the SEA approval process, and are the DTI encountering any substantial barriers during this process?
- What were the pertinent results for the environmental baseline arising from the surveys? Proceed with caution in developing the area?
- Should any operational, seasonal or spatial constraints be imposed in light of environmental sensitivities? Are there any environmental thresholds for such constraints?
- Based on SEA findings to date, if additional resources were made available which technical area would most warrant further exploration?
- What are the implications of the Marine Bill on the SEA and EIA process?

A. POINTS FOR DISCUSSION IN PLENARY

- Is there a review process for SEA i.e. will previous SEAs be revisited to see if assessments were correct?
- Is there a sufficient level of coordination between the DTI SEA process and the Scottish Executive renewables SEA to ensure that money and effort are used efficiently?
- Future research/monitoring and consideration of potential environmental impacts of O&G activities should take into account likely environmental change associated with climate change.
- The environmental baseline for SEA 7 has not highlighted the infrastructural needs of O&G activity in the region e.g. port facilities, helicopter bases.
- Care should be taken when licensing O&G activities to avoid loss of areas with valuable potential for alternative uses such as renewables or CO_2 storage.
- How will information arising from additional surveys, in association with specific developments, be put in the context of the wider SEA 7 area – the majority of which will remain largely unsurveyed?
- Increased O&G activity will require increased search and rescue capacity. Has this been considered?
- In the absence of data on the potential impacts of seismic survey on cetaceans in the SEA 7 area, what specific mitigation of these potential impacts can be employed?
- What are the origins of St Kilda 70km radius exclusion zone?
- Will the gaps in seabird data be filled prior to oil spill contingency plans (OSCP) being created? How can this be done if the necessary data cannot be obtained through SEA?
- Many years of data on seabird space usage will be required to account for large inter-annual variability.
- The headline statistics on seabirds fail to mention the importance of the area for Leach's petrel and gannet.
- The SEA 7 area is part of a migration route for large cetaceans; can controls be placed on seismic survey activities in the area?
- The SEA 7 area shows considerable potential for renewable energy generation.
- There appears to be an inconsistency in seabird statistics, with text stating a 7% survey coverage of the SEA 7 area, whereas the maps presented appear to show a larger proportion of survey coverage.
- What does SEA add to the EIA process for individual plans/projects?
- Why should licensing be considered even in areas where there is very limited/inadequate environmental information available?
- Surely one of the main uses of SEA is to identify information gaps?
- Have areas of high vulnerability for bird populations to oil pollution been identified?
- Is there evidence to support a view of "no-harm" to cetaceans from seismic survey?

B. INFORMATION BASE FOR SEA 7

- How do the gaps in seasonal bird coverage in SEA 7 compare to those of other SEAs?
- At present, are there any ongoing noise impact studies to assist future renewable SEAs?
- Scheduled wrecks form a very small percentage of the actual number of wrecks on the seabed. More information on wrecks in the SEA 7 area is available.
- The list of seabird species considered seems limited; species such as guillemot and razorbill require consideration.

B. INFORMATION BASE FOR SEA 7

- New information on seabird distribution should be collected to assist future EIA. In SEA 7 there is a major need for "life after SEA".

C. DRAFT RECOMMENDATIONS

Questions asked:

Q1. Are there any areas that you feel should not be offered for licensing in the 25th Round and why?

Q2. Similarly are there any temporal/spatial controls necessary on activities in blocks offered for licensing?

Q3. Do you feel that there should be any additional operations controls introduced?

Q1. What about the proposed Marine National Park?
Q2. No blocks specified, but assessment of activities should be based on seasonal environmental sensitivities. However, a balance must be achieved between economic and environmental sensitivities. Providing Operators have to undertake EIA process to aid in developing reasonable mitigation measures, and have OSCP etc., then controls can be left out of SEA until further surveys have been done in EIA.
Q3. If development takes place within near-shore area or in close proximity to the coast, it may be worth considering the value of Coastal Protection Plans (with part funding by operators/councils).

Q1. Care should be taken to avoid loss of areas with valuable potential for alternative uses such as renewables or CO_2 storage.
Q2. –
Q3. –

Q1. No concerns raised with regard to excluding specific blocks.
Q2. Periods of concern for drilling and seismic activity (for new licence blocks) should be identified in the same way as previously licensed blocks. This should use the seabird vulnerability indices and fisheries and cetacean information.
Q3. –

Q1. –
Q2. Temporal and spatial controls on seismic survey relating to cetaceans on migration routes. Is recommendation # 4 (birds and OSCP) a signal to operators that they should be commissioning seabird abundance data where this is lacking?
Q3. Before and after impact studies for exploration wells?

Q1. The continental slope area (important for cetaceans and seabirds due to upwelling), existing SACs (e.g. Cardigan Bay).
Q2. Seasonal controls on seismic activity needed.
Q3. SEA needs to consider cumulative impacts with other sectors (e.g. renewables, interconnection, fishing etc).

Q1. There should be the same considerations as West of Shetland? Inclusive of St Kilda? Very sensitive sites within reason.
Q2. The St Kilda 70km exclusion zone – does this need to be increased with appreciation of St Kilda's special sites?
Q3. Potentially, controls are needed for cetacean movements – very unknown migration paths in deep waters off Scotland? This may also include discharges within certain areas.

Q1. Exploration EIAs should include summer and winter bird survey data for a minimum of 2 years. Areas currently identified as high risk areas for birds and oil pollution should be excluded from licensing process. There is a legal duty to keep conservation value of areas (e.g. SACs).
Q2. Where current analyses reveal high vulnerability to oil pollution, blocks should be precluded from licensing for exploration – or a presumption against.
Q3. As new information comes in from EIAs, vulnerability classifications should be adjusted accordingly with concurrent adjustments in licensing practices.

C. DRAFT RECOMMENDATIONS

Q1. –

Q2. For sensitive areas, licence conditions can include additional environmental reports on baseline assessments/monitoring or operational controls for work in these areas (negotiated with licence holder?) – for Recommendation 2 and 3.

Q3. –

D. OTHER COMMENTS

1. If significant data gaps exist in any of the SEA areas, additional funding should be made available to aid research and the decision making process.
2. This issue of avoiding loss of areas with valuable potential for alternative uses, such as renewables or CO_2 storage, should be addressed in update of other SEAs and in SEA 7 appendices.
3. The management of O&G industry is to be kept separate from that of other sectors under proposed Marine Bill; how does this sit with SEA 7 recommendation No. 1?
4. In view of the fact that SEA 7 contains ~ 40% of UK breeding seabird population (~16% of EU population) and that there is very little information on seabirds at sea, it will have to be considered whether adequate information exists to carry out an adequate SEA.
5. Continental slope habitat is still relatively unexplored and this area SEA 7 is UK's prime area for this.
6. Minimal data has been gathered in relation to habitats. This must be considered slightly higher than normal in relation to other North Sea SEA areas?
7. The re-formation of the AFEN group is a useful idea. There perhaps should also be further collaboration between potential developers (e.g. O&G, renewables) and scientific community in order to amalgamate knowledge and development all the way through the process, including decommissioning.
8. The oil pollution map is very odd: St Kilda the single most important seabird site in Europe has lower vulnerability than East side of Lewis. Unclear why this should be the case.
9. Regarding seabirds, the exclusion of guillemots and razorbills from offshore seabird report is potentially a serious omission.
10. A single survey visit is insufficient to detect seasonal and inter-annual variation in seabird distribution.
11. Climate change will be a pressure on biodiversity. In principle this should add urgency to measures that maintain and protect important habitats. This will maximise the resilience of biological systems.
12. There is an important need for a collaborative approach with renewable energy potential to maximise opportunities, such as the use of groups/workshops between developers to combine survey work at an early stage.
13. A comment on the report "An introduction to the benthic ecology of SEA 7" – Chapter 6 Anthropogenic activities and impacts, O&G developments (P61) – the discussion on drill cutting piles needs to be more accurate. The information cited refers to different conditions of the North Sea (depths 20-200m). Deeper parts of the North Sea have slow flow bottom current, hence piles remain. Evidence of piles in deep waters >500m to 2530 is different – often only a thin layer remains as cuttings are dispersed in the water column before being deposited. Hence impact is less significant than observed in Northern North Sea.

E. The following is a summary of input received from stakeholders unable to attend meeting:

- Previous SEAs have identified gaps in information but not filled them before reaching a

E. The following is a summary of input received from stakeholders unable to attend meeting:

conclusion. SEA 7 should attempt to fill gaps or where this is not possible a precautionary approach should be taken and licensing not undertaken in sensitive areas.

- Protected areas should generally be excluded from licensing. For European protected sites it must be shown beyond reasonable scientific doubt that there will not be an adverse impact on the integrity of European sites. If the SEA is unable to show absence of an adverse effect then, under the Habitats Directive, area should be excluded from licensing
- For the SEA 7 area, the protected area network is not complete. There are no protected areas for cetaceans within the area, despite its importance for a number of species. Therefore potential protected areas, including offshore sites, should be considered and excluded from licensing.
- Outwith protected or potentially protected areas, the wider provisions of the Habitats Directive, especially with regard to disturbance must be taken into account.
- A variety of suggestions were received on where climate change could be further considered in the SEA 7 Environmental Report

A11.b Background for re-offer of blocks in previous SEA areas

A11.b.1 Introduction

As described in Section 2, offshore licensing for oil and gas exploration and production on the UKCS has proceeded in a series of licensing rounds since 1965. Over time, a number of blocks or part blocks have been relinquished by the operator and therefore become available for re-offer for licensing. Since 2002 the DTI has introduced an active process to encourage relinquishment of "fallow" blocks so that their potential may be explored or developed by others. Fallow blocks are currently defined as those where the initial term of the licence has expired and there has been no drilling for a period of 4 years, and there has been no dedicated seismic or other significant activity in the last 2 years. Some fallow blocks contain hydrocarbon discoveries, which for a variety of reasons have not been developed. Since the fallow acreage process began in 2002, 75 exploration or appraisal wells have been drilled with 14 exploration or appraisal wells drilled on fallow blocks released in 2006. Eighteen fallow discoveries have had substantive work programmes agreed, 5 have had appraisal drilling and 10 field development plans on fallow discoveries have been approved. Four fallow discoveries have had new seismic data acquired over them (http://www.og.dti.gov.uk/UKpromote/fallow_assets.htm).

In the licence rounds that followed SEA 3, SEA 4, SEA 5 and SEA 6, in addition to the blocks covered by the respective SEA, the DTI offered for licensing unlicensed blocks in areas previously subject to SEA. These unlicensed blocks in the area included those blocks for which licences were not applied for in the previous round and those which had been relinquished in the intervening period. The issue of how to assess within a SEA the implications of the re-offer of blocks in previously SEA areas was discussed at a previous Assessment Workshop (SEA 5) in 2004. It was concluded that the reoffer of blocks needed to be addressed on a case by case basis taking due account of:

- The previous activity scenarios used in the original SEA and the scale of subsequent activity in the area
- Changes in environmental regulations
- New information on the environment of the area (see Appendices 4-9)
- Changes in understanding of environmental effects from potential activities

- New pollution control techniques and technology

It was also agreed that the reoffer of blocks should be an agenda item for future SEA Assessment Workshops. This process has also been followed for the SEA 7 consideration of the reoffer of blocks.

The 25th licensing round planned to follow SEA 7, could include unlicensed blocks within the SEA 1, SEA 2, SEA 3, SEA 4, SEA 5 and SEA 6 areas and a consideration for each area is given below. To reduce the need for cross referencing between the original SEA documents and this environmental report, a summary of the environment and uses, key new information sources, and then and now licensing status schematics are provided for each SEA area. These are followed by a discussion of potential licensing of blocks in previous SEA areas.

SEA 1 Overview

The overall topography of the SEA 1 area is dominated by a number of large-scale features; the deep water Faroe-Shetland and Faroe Bank Channels and the Wyville Thomson Ridge rising to within 400m of the water surface and dividing the Faroe Bank Channel from the Rockall Trough to the south. Numerous small to medium scale seabed features are also present resulting from past volcanic and glacial activity as well as modern sediment erosion, transport and deposition. Seabed sediments in the area vary with depth, with sediments in the deeper areas usually consisting of mud or muddy sand, and the proportion of mud decreasing upslope to the continental shelf break where the sediments are predominantly sands and gravel. Contaminant concentrations in sediments and seawater in the area are low and generally at, or close to, background levels.

The area has a complex hydrographic regime, with distinct water masses resulting in a pronounced difference in temperature between shallow and deeper waters. The main surface and slope currents flow northwards across the Wyville Thomson Ridge in water depths to around 500m, with a deeper southwesterly flowing cold current deflected westwards along the Faroe Bank Channel. Large scale atmospheric systems in the North Atlantic can induce significant variability to water mass characteristics and water flow patterns.

The topography and associated hydrographic conditions are strong determinants of the ecological character of the SEA 1 area. Phytoplankton productivity in the area varies seasonally. In the North Atlantic, the spring diatom bloom generally peaks in May with a sharp decline in June. Zooplankton communities are dominated by the copepod *Calanus finmarchicus* which represents an important food source for the young of many fish species and is important in the recruitment of fish stocks of the area. The Faroe-Shetland Channel is an important over-wintering area for *C. finmarchicus* which are transported into the North Sea in spring. Seabed communities in the area are characteristic of the interface of several biogeographic zones although they are widely distributed across the region. Water temperature and bathymetry are the primary environmental influences on distribution patterns in both community and species composition.

The Darwin Mounds on the southern flank of the Wyville Thomson Ridge were first discovered in 1998 and appear to be unique geological and biological features. The mound tails appear to have no physical expression, but are inhabited by dense populations of xenophyophores (single celled animals of up to 10cm diameter). The central mound appears to consist of blocky rubble with the cold water coral *Lophelia pertusa* usually present. The ecological significance of the mounds is unclear, although both *Lophelia* and xenophyophores are widely distributed elsewhere in the region. Following the introduction of enabling legislation, the mounds will be put forward as the UK's first offshore Special Area of

Conservation (SAC) under the EU Habitats Directive. An area of Annex I reef habitat on the Wyville Thomson Ridge has also been proposed as an offshore SAC.

The SEA 1 area has no coastline, although in adjacent SEA areas 4 and 7, islands and coasts all have important conservation sites on international, European and national scales. Designated conservation sites include World Heritage Sites (St Kilda and parts of Orkney), Biosphere Reserves, Special Protection Areas (SPAs), Special Areas of Conservation (SACs), and Ramsar sites. These have variously been designated for importance in relation to breeding seabirds, wildfowl and moorland birds, seals, otters, vegetated sea cliffs, submerged caves, reefs, lagoons and archaeology.

Seabird populations within the SEA 1 area consist mainly of breeding birds (fulmars, storm petrels, gannets, kittiwakes and various auks) from major colonies in the Faroe, Shetland, and Orkney Islands and more northerly breeding areas such as Norway and Iceland. In addition, a number of species migrate through the area in late summer and autumn (skuas and shearwaters), or are winter visitors (some gulls and little auk). The region to the north and west of Scotland contains substantial proportions of the northeast Atlantic breeding populations of some species, in particular great skua, gannet, puffin and black guillemot.

In a UK and North Atlantic context, the area is of high importance for marine mammal populations. Cetaceans in the area and adjacent waters can be broadly distinguished into several groups, on the basis of distribution and feeding:

- Baleen whales (blue, fin, sei and humpback) are mainly recorded in deep water
- Minke whales are summer visitors to shelf areas
- Sperm and beaked whales are concentrated on the eastern flank of Rockall Trough, the southern flank of Wyville Thomson Ridge and along the eastern side of the Faroe-Shetland Channel
- Atlantic white-sided and common dolphins are widely distributed in deep water
- White-beaked and Risso’s dolphins are concentrated in shelf waters
- Killer whale, bottlenose dolphin and harbour porpoise are all widely distributed over deep and shelf waters.

Shetland and Orkney support large numbers of grey and common seals which breed on the islands and forage in coastal and offshore waters. Recent tagging data suggests that these animals forage more widely than previously thought, although numbers in the SEA 1 area are likely to be small as sightings over deep water are rare. Hooded seals utilise deep water in the Faroe-Shetland Channel and north of the Faroes, throughout the year.

The cold Norwegian Sea water of the deep Faroe-Shetland and Faroe Bank Channels supports a sparse and distinct fish fauna, of little commercial value, with very few of the Atlantic deep water species which are found on the upper slopes of the Faroe-Shetland Channel being present. The Wyville Thomson Ridge appears to form a major faunal barrier to deeper water fish.

The main commercial pelagic species found in the area are mackerel, Norway pout and blue whiting. Herring may also occur in the area and greater silver smelt is also present. Other than the greater silver smelt, commercial pelagic species are generally concentrated over the continental shelf and shelf break to the east. Deep-water vessels from Scotland, France, Spain and Norway dominate fishing in the area, with fishing vessels from England, Faroe, Germany, Netherlands, Denmark and Ireland also present. The main demersal gears employed are otter trawls and long-lines, with some gill netting also being used. Demersal fishing effort in the area is relatively low compared to other UK waters with greatest effort being seen around the Wyville Thomson Ridge. Pelagic effort over the upper slope is at similar levels to that seen in other areas around the UK.

Within the SEA 1 area, a significant oil and gas discovery was made in 2004 at the Rosebank/Lochnagar well (Block 213/27) with further appraisal of the discovery currently ongoing. The recent licence awards as part of the second Faroese licensing round may result in increased exploration activities in adjacent Faroese waters. The waters of the SEA 1 area are of minor importance for shipping. Coastal industry and activities in adjacent areas (the Faroe, Shetland, Orkney and Western Isles and northwest Scotland) include fishing, aquaculture, tourism and recreation. All are of considerable importance to local economies.

SEA 2 Overview

The SEA 2 area covers a large part of the southern, central and northern North Sea and contains the majority of the UK's oil and gas producing fields. Water depths gradually deepen from south to north and the main topographic features are the Dogger Bank which divides the southern and central North Sea, the Fladen/Witch Ground, a large muddy depression between the central and northern North Sea, and the Norwegian Trench, a deep water channel to the east of the northern SEA 2 area.

Various inflows of Atlantic water into the North Sea occur from the west and north, with outflow mainly via the Norwegian Trough and along the Norwegian coast. Water circulation in the North Sea is anticlockwise, with an eddy forming over the Fladen Ground. The water column of the southern North Sea remains mixed throughout the year while to the north it becomes stratified in summer, effectively isolating surface and near bottom waters until autumn gales break down the stratification.

Seabed sediments over the majority of the area are sand or mud, or a mixture of the two. Typically, sandier sediments are found in the south and north, and in coastal waters, with muddy sediments present in the deeper areas of the central North Sea. Pockmarks (shallow seabed depressions formed from the seepage of gas) are found in muddy areas in particular the Fladen and Witch Grounds. Most pockmarks are relict features but a few continue to leak natural gas and some contain carbonate rocks which provide a habitat for encrusting and other surface living seabed animals.

The DTI commissioned survey for SEA 2 investigated habitats of potential conservation interest within the area. These covered potential areas of Annex I habitats defined by the EU Habitats Directive as *sandbanks in shallow water* and *submarine structures made by leaking gases*. Since SEA 2, the Dogger Bank has been proposed as an offshore SAC for the qualifying feature *sandbanks which are slightly covered by sea water all the time.* Other relevant sites that have been proposed as offshore SACs include the 'Saturn' *Sabellaria spinulosa* reef site between Swarte and Broken Banks in the southern North Sea and the Scanner pockmark in the Witch Ground. Relevant areas of Annex I habitat that may be designated in the near future include the Braemar pockmarks; the North Norfolk Sandbanks; Haddock Bank; Haisborough Tail, Hewett Ridges, Hammond Knoll & Smiths Knoll.

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

Recently, phytoplankton biomass has increased in the SEA 2 area possibly associated with large scale meteorological and hydrographical variations. The zooplankton community has also shown significant changes particularly in the proportions of the dominant copepod species, which have been linked to increasing sea surface temperatures. The ecological importance of these changes to the plankton community has yet to be fully understood. Benthic communities are also determined broadly by hydrographic conditions with water temperature particularly important. On a smaller scale, community types reflect local sediment distribution patterns.

Offshore areas of the North Sea including the SEA 2 area contain peak numbers of seabirds following the breeding season and through winter, with birds tending to forage closer to coastal breeding colonies in spring and early summer. Many shorebirds and waterfowl also use North Sea coastal waters and shores extensively, particularly during spring and autumn migrations and some species overwinter in large numbers.

A wide range of cetaceans are sighted in the North Sea, the most common being the harbour porpoise, minke whale and white beaked dolphin. Bottlenose dolphins from the nearshore population of the Moray Firth are rarely seen far offshore. Important grey and common seal breeding colonies on the UK east coast have been protected through designation as Special Areas of Conservation. Recent tagging studies indicate that both species forage extensively in nearshore and offshore areas of the North Sea.

The North Sea coastline has many sites of conservation, economic and human interest. A large number of coastal sites have been protected at a European level under the EU Habitats and Birds Directives. Important archaeological sites dating back to prehistoric times have been found in coastal areas surrounding the North Sea with significant offshore sites likely although few have yet been discovered.

Fish species diversity in the SEA 2 area is higher in the central and northern North Sea and in inshore waters. The North Sea is one of the world's most important fishing grounds with extensive fisheries for pelagic species (e.g. herring and mackerel) demersal species (cod, haddock and whiting in the central and northern North Sea, with plaice and sole targeted in the south). In addition there are important shellfisheries for Norway lobster, crab and scallop and industrial fisheries for sandeel and Norway pout. Commercial fishing in the area is of significant importance for both the UK and other North Sea states.

The oil and gas fields of the SEA 2 area have formed the focus of much of the UK offshore industry over the last 30 years. Recent high oil prices have led to an upturn in activity in the central North Sea with the number of exploration, appraisal and development wells drilled in the region increasing since 2003. Shipping is another major user of offshore areas of the North Sea, particularly in southern parts with the large ports on the UK east coast forming an important focus for many of the shipping routes.

Contamination concentrations are typically very low but in some (usually coastal) areas they can be high enough to result in marked biological effects (e.g. through eutrophication). The historic discharge of oil based drill muds with rock cuttings from oil and gas well drilling has resulted in numerous piles of cuttings on the seabed in the northern and central SEA 2 areas. Produced water from existing oil industry activities remains a source of contaminants although company, national and OSPAR actions have succeeded in reducing the average concentration of oil in these discharges.

SEA 3 overview

The SEA 3 area covers a large part of the central and southern North Sea and includes the entire coast of eastern England. Water depth gradually deepens from south to north with the Dogger Bank, the main topographic feature of the region. Water circulation consists of a southerly coastal flow which in the southern part moves offshore across the North Sea. There is a relatively minor inflow of water into the area through the English Channel.

Seabed sediments in SEA 3 are generally sandy and gravelly in the south and in coastal waters. Large sandbanks of variable morphology and sediment composition are present in both coastal and offshore waters. Rocky outcrops and platforms are associated with discrete sections of the coast, primarily in the northern part of the area. Several large estuaries including the Thames estuary and Wash embayment are also present. Many of these coastal habitats support a diverse range of benthic species as well as internationally important numbers of seabirds, waterbirds and marine mammals which are protected at national and international levels. Further offshore, the DTI survey of the SEA 2 and adjacent areas highlighted the species richness of certain types of sandbank. As mentioned in the SEA 2 overview, the Dogger Bank has been proposed as an offshore SAC and a number of sandbanks are likely to be proposed as SACs (some of which may extend into the SEA 3 area) in the near future.

The SEA 3 area supports a wide variety of fish species although in general, diversity is highest in the central and northern North Sea and in inshore waters. Coastal waters of SEA 3 support important fixed gear fisheries for crab, lobster, whelk, and cockles as well as netting for a number of fish species, including cod, herring and sole. Salmon netting off the North East coast has declined significantly due to a recent buy-out of fishing licences. Further offshore, a mixed demersal fishery primarily targets cod, whiting, plaice and sole. Herring are taken from northwest of the Dogger Bank and in the coastal waters of eastern England. An industrial sandeel fishery targets the Dogger Bank as well as coastal and offshore areas of the northern part of the SEA 3 area.

Sandeels represent an important prey species for a number of seabird species, many of which utilise internationally important seabird breeding colonies along the SEA 3 coast in the spring and early summer. Offshore areas of SEA 3 contain peak numbers of seabirds following the breeding season and throughout the winter. Many of the estuaries along the English east coast also support important populations of migratory and wintering wildfowl and waders, as well as breeding birds. Many of the coastal sites of international importance for seabirds and waterbirds have been protected through various designations at national, European and international levels.

The SEA 3 area is of less overall importance to cetaceans compared to more northerly parts of the North Sea, although some areas are important for harbour porpoise and white-beaked dolphin. The SEA 3 coast, particularly around the Farne Islands and the Wash, supports internationally important (and protected) grey and common seal breeding sites and both species forage extensively in nearshore and offshore areas.

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

The SEA 3 marine environment provides an important resource for a wide variety of users. The extensive natural gas reservoirs of the southern North Sea have attracted significant infrastructure development and a number of oil and gas pipelines traverse the SEA 3 area. The greater Wash area and the Thames estuary are the focus of considerable development in offshore wind farms with large areas licensed recently for development. The Scroby Sands windfarm off Great Yarmouth is now operational. The presence of offshore sand and gravel deposits in coastal waters provides an important source of marine aggregates and, within the same area there are a number of marine disposal sites for spoil from harbour and other dredging operations.

SEA 4 overview

Broadly, the SEA 4 area consists of two contrasting environments; an area of continental shelf and upper slope to the north and west of Orkney and Shetland characterised by relatively high temperatures, hydrodynamic energy and primary productivity; and the much colder, less dynamic and dark waters of the deep Faroe-Shetland and Faroe Bank Channels (described previously for SEA 1).

On shelf areas, 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 productive coastal, intertidal and terrestrial systems through the export of detritus, and through foraging and seasonal migrations of fish, seabirds and marine mammals.

The deep channels and basins of the SEA 4 area are characterised by a lower hydrodynamic energy, although still mobile (and in places erosive) seabed environment; contrasting with most other areas in comparable water depth which are more quiescent and depositional. There is distinct zonation of species assemblages with depth; and less direct pelagic-benthic coupling. Vertical transfers of carbon and energy also result from diurnal migrations of zooplankton, cephalopods and fish, and 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.

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 presence in close spatial proximity of contrasting seabed habitats and communities. Deep water cetacean populations of the SEA 4 area are 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 and seal colonies. Offshore, an area of the Wyville Thomson Ridge has been proposed as an SAC for reef habitat and similar habitat in the Judd Deeps may be protected in the future following further survey work. In addition, the Pilot Whale diapirs (mud volcanoes) in the north of the area are large features with the possible presence of seep chemosynthetic communities and are of conservation interest.

A large number of internationally important seabird colonies are found on the cliffs of the SEA 4 area coast and huge numbers of breeding seabirds are associated with these in spring and early summer. 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.

A wide variety of marine mammals occur in the SEA 4 area, 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. Offshore 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 found in considerable numbers in the deeper waters of the SEA 4 area.

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.

Parts of the area have been licensed for oil & gas exploration since 1965 and approaching 200 exploration and appraisal wells have been drilled to date. There are currently three major oilfields in production (Foinaven, Schiehallion and Clair) with the significant Rosebank/Lochnagar discovery undergoing further appraisal. Since SEA 4, levels of exploration and appraisal drilling to the west of Shetland have remained low however the first half of 2005 has seen more development drilling (7 wells) in the region than took place throughout the whole of 2004 (6 wells). The Sullom Voe and Flotta oil terminals provide facilities for the export of resources from developments to the east and west of the islands. A pipeline transports surplus gas from the Clair, Foinaven and Schiehallion fields to the Sullom Voe terminal where the gas is enhanced with natural gas liquids before being piped to the Magnus oilfield in the northern North Sea for use in enhanced oil recovery. Exploration success in adjacent Faroese waters has been limited to date (e.g. the Marjun appraisal well was deemed not to contain sufficient hydrocarbons to justify a well test). However, the Rosebank/Lochnagar discovery and the recent licence awards as part of the second Faroese licensing round may stimulate exploration activity in the region.

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. 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. Much of the SEA 4 coast is rural in nature and attracts tourists to its unspoilt scenery and natural history interest. Sheltered coastal waters are important for both finfish and shellfish cultivation.

The coastal region supports many prehistoric sites and due to changes in relative sea level, prehistoric submarine archaeological remains of up to about 9,000 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.

The SEA 4 area is remote from areas of major industrial activity. However, there are local sources of various contaminants and the atmospheric and hydrographic transport of persistent contaminants into the SEA 4 area has probably resulted in detectable pollution throughout the region. However, contaminant concentrations in water and sediments are typically at background levels.

SEA 5 overview

The SEA 5 area is bounded to the west by the continental shelves of Shetland, Orkney and the Scottish mainland and to the north and east by the deep basins of the northern North Sea. The seabed over the area is relatively flat deepening to the north and east with localised depressions (e.g. the Southern Trench) and highs (e.g. Smith Bank, Pobie Bank). Sediments consist predominantly of sands, sandy gravels and gravel, particularly in nearshore areas with strong currents. Muddy sediments are restricted to deeper waters and sheltered coastal areas.

Cliffs and large firths and estuaries characterise much of the coast of the Scottish mainland with the Shetland and Orkney archipelagos displaying a variety of coastal habitats, many of which are protected by international and national conservation designations. Potential reef habitat to the east of Shetland may be designated as an offshore SAC in the future following further survey work.

Water circulation in SEA 5 is dominated by significant inflows of Atlantic water. Inflow variability associated with NAO-related atmospheric forcing can result in significant seasonal and annual changes to circulation patterns and water masses with profound implications for the circulation of nutrients and contaminants, and for the supply of oceanic planktonic species and fish larvae. For example, in recent years, spring and autumn plankton blooms have become more evident and primary production has increased throughout the year. Recent changes in the abundance of key zooplankton species (e.g. copepods *Calanus helgolandicus* and *C. finmarchicus*) with potentially important ecological (and economic) consequences have been linked to changes in sea surface temperatures.

The nature and extent of benthic communities are linked to the physical nature and characteristics of the substrate. Offshore communities are spatially distributed over large scales, with distinctive species assemblages associated with particular substrate types. Sedentary species with high abundance and biomass dominate sheltered coastal areas whereas exposed beaches have lower diversity, abundance and biomass. Dense populations of intertidal benthos in many of the sheltered inner firths and estuaries support important fish populations.

Fish spawning areas are found throughout SEA 5 with the juvenile stages of many commercial fish species remaining within coastal nursery areas for a year or two before moving offshore. Offshore areas are characterised by fish communities dominated by haddock, whiting and cod. Migratory species such as herring and mackerel are also found although their distribution is seasonal. Sandeels, a key prey species for a number of seabird and marine mammal species are associated with well-oxygenated sandy sediments. Diadromous species such as salmon, sea lamprey and eels are present with coastal rivers supporting internationally important populations. Commercially important *Nephrops* stocks are found on muddy-sand sediments within the Moray Firth, Firth of Forth and offshore on the Fladen Ground.

The abundant intertidal benthos of the inner firths and estuaries also supports large numbers of breeding, over-wintering and migratory waterbirds. The extensive coastal cliffs of the region support breeding seabirds including auks, kittiwakes, fulmars and gannets with important feeding areas in both nearshore and offshore waters. Many of these bird populations and aggregations are internationally important and protected as Special Protection Areas with work ongoing to extend coastal sites and identify new marine SPAs in the region.

Other key predators include marine mammals which are present in both coastal and offshore waters. The harbour porpoise is the most abundant cetacean species, particularly in summer with white-beaked dolphins and minke whales also present during summer months. A resident population of bottlenose dolphins also inhabits coastal waters of eastern Scotland, particularly the inner Moray Firth where they are protected by an SAC designation. Both grey and common seals forage extensively within the area, targeting fish and cephalopods with coastal areas supporting important breeding colonies for both species. Given the importance of the region for marine mammal species listed on Annex II of the Habitats Directive (i.e. harbour porpoise, bottlenose dolphin, grey and common seals), application of the Directive offshore may, following further research, result in further areas of SEA 5 being protected for these species.

The SEA 5 area supports a range of human activities including recreation, tourism and industrial uses. Coastal areas support significant oil and gas infrastructure with key distribution ports providing a focus for shipping in the area. The Beatrice platform in the Moray Firth represents the only significant offshore infrastructure in the area. Proposals to develop the platform to support an offshore windfarm are under development with a two turbine demonstrator project currently at a consultation stage. In general, coastal development has centred upon the large firths with much of the rest of the coast rural in nature. The fishing industry, whilst generally in decline, remains a key industry for many communities in the area, as is aquaculture on Shetland and Orkney. Generally, anthropogenic contamination of the marine environment is low and restricted largely to industrialised coastal areas.

Coastal and offshore areas of SEA 5 contain important archaeological remains dating back to prehistoric times. A large number of archaeological sites have been identified and some protected, although evidence suggests that a large number of sites in both the coastal and marine environment have yet to be discovered.

SEA 6 overview

The SEA 6 area covers the semi-enclosed Irish Sea, a dynamic area exposed to considerable variation in tidal range, tidal currents and wave action which are important determinants of the region's physical and biological environment.

The Irish Sea is open-ended, connected at both ends to the Atlantic Ocean, in the south via St. George's Channel and in the north, via the North Channel. The extent of Atlantic inflow to the region varies with changes to large scale circulation patterns in the north-east Atlantic and weather, particularly the strength and direction of the prevailing winds. Freshwater run-off from coastal areas is important in determining the salinity of water masses particularly in coastal areas. River run-off and inputs from industrialised areas are responsible for the majority of contaminants with sediments from areas such as the Mersey and Ribble estuaries, containing elevated levels of contaminants (often from historical discharges). Throughout much of the region tidal mixing is sufficiently intense to ensure that the water column remains well mixed throughout the year. However, there are regions where temperature and/or salinity differences between water masses result in stratification in summer and autumn. Frontal areas between these mixed and stratified regions are often areas of enhanced biological production attracting fish, marine turtles, seabirds and marine mammals.

Seabed sediments include large areas of mud to the east and west of the Isle of Man where currents are weak; coarser sand and gravel in areas of stronger tidal and wave-driven currents, and rock and boulders in the most exposed areas. Large sandwaves and sandbanks are also present off the Isle of Man, Lleyn Peninsula and within the major estuaries of the region and some of these areas may be of conservation interest. Seabed surveys carried out for SEA 6 identified and described a number of seabed features of potential conservation interest, including possible occurrences of methane-derived authigenic carbonate (MDAC).

Benthic species and habitats of conservation interest include biogenic reefs of the horse mussel, *Modiolus modiolus*, the distribution and abundance of which were surveyed as part of SEA 6. Muddy areas particularly to the east and west of the Isle of Man support important *Nephrops* fishing grounds with scallop and queen scallop found on gravelly substrates. Fish communities are diverse and determined largely by sediment type with coastal sandy areas for example supporting large numbers of juvenile flatfish, sand eels, and seasonal populations of sprat, herring and juvenile gadoids.

The region also provides important breeding and over-wintering areas for a wide variety of seabirds and coastal waterbirds. During spring and summer months, almost half a million pairs of seabirds including Manx shearwater, gannet, lesser black-backed gull and guillemot breed at locations (primarily on cliffs and islands) throughout the region. The estuaries of the region hold internationally important numbers of breeding, wintering and migratory waterbirds, with shallow offshore waters of Liverpool and Cardigan Bays supporting internationally important numbers of wintering common scoter and red-throated diver.

Harbour porpoise and bottlenose dolphin are present throughout the year while others are more commonly seen in summer months (e.g. minke whale, Risso's dolphin and short-beaked common dolphin). In general, southern areas are more important for cetaceans with coastal waters of Cardigan Bay supporting a protected bottlenose dolphin population of about 220 individuals and harbour porpoise also numerous along the Welsh coast. A relatively small population of grey seals utilise all but the north-west Irish Sea while harbour seals are found primarily in the far north of the area.

Some parts of the SEA 6 area are intensively used and developed but the region also includes rural areas and many sites and features of conservation importance. Tourism and leisure contributes in the order of £2.5 billion per annum to the regional economy, with between 100,000-200,000 people directly employed in the sector. Oil and gas activity is centred on fields in Liverpool and Morecambe Bays. A number of pipelines connect these fields with onshore terminals and several gas interconnector pipelines link mainland Britain to Ireland. There are several major ports in the SEA 6 area notably Belfast, Liverpool and Milford Haven with large parts of the SEA 6 area experiencing moderate to high shipping densities (5,000-20,000 vessels per annum). Other activities include renewable and nuclear energy facilities, military activities, telecommunications, aggregate extraction and marine disposal. Recent initiatives including the Defra Marine Spatial Planning Pilot have explored options for strategic planning in the Irish Sea

A11.b.2 Perspectives on prospectivity, scenarios and activity

Overview

The previous SEAs (1-6) have provided estimates of the potential hydrocarbon prospectivity expected for the individual SEA areas after each award round covering the respective SEAs. From the 21st Licensing Round (2003), blocks have been re-offered in previous SEA areas.

In the 24th Seaward Licensing Round, 150 Production Licences have been offered to 104 companies, continuing the trend of high numbers of licences issued in the 23rd Round. The offers include 79 traditional, 6 frontier and 65 promote licences. Figure A11.b.1 overleaf shows the blocks that were offered for licence in the 24th Round, while Figure A11.b.2 shows the blocks that have been awarded (subject to confirmation). The maps show that the main acreage under offer was in SEA areas 1, 3, 4, 5 and 6 with fewer blocks available for licensing in SEA 2 (Figure 10.1). Despite this, the actual uptake of blocks and the number of licences awarded in SEA 2 has remained relatively high compared to the other areas. In the following sections, more information is provided about the activity predicted for each SEA area and the actual work programmes accepted by the DTI as part of the licence award. The changes that have occurred in block licensing status between the time of the relevant SEAs and today are also given. Comparisons have been made based upon licensing activity within each SEA area for consistency with previous years; it should be noted however that the re-offer of blocks has meant that some licences, and therefore work programmes also, may be shared with adjacent SEA areas.

Figure A11.b.1 – Map showing the blocks offered for the 24th Licensing Round and the licensing status of the remaining blocks before the 24th Licence Awards.

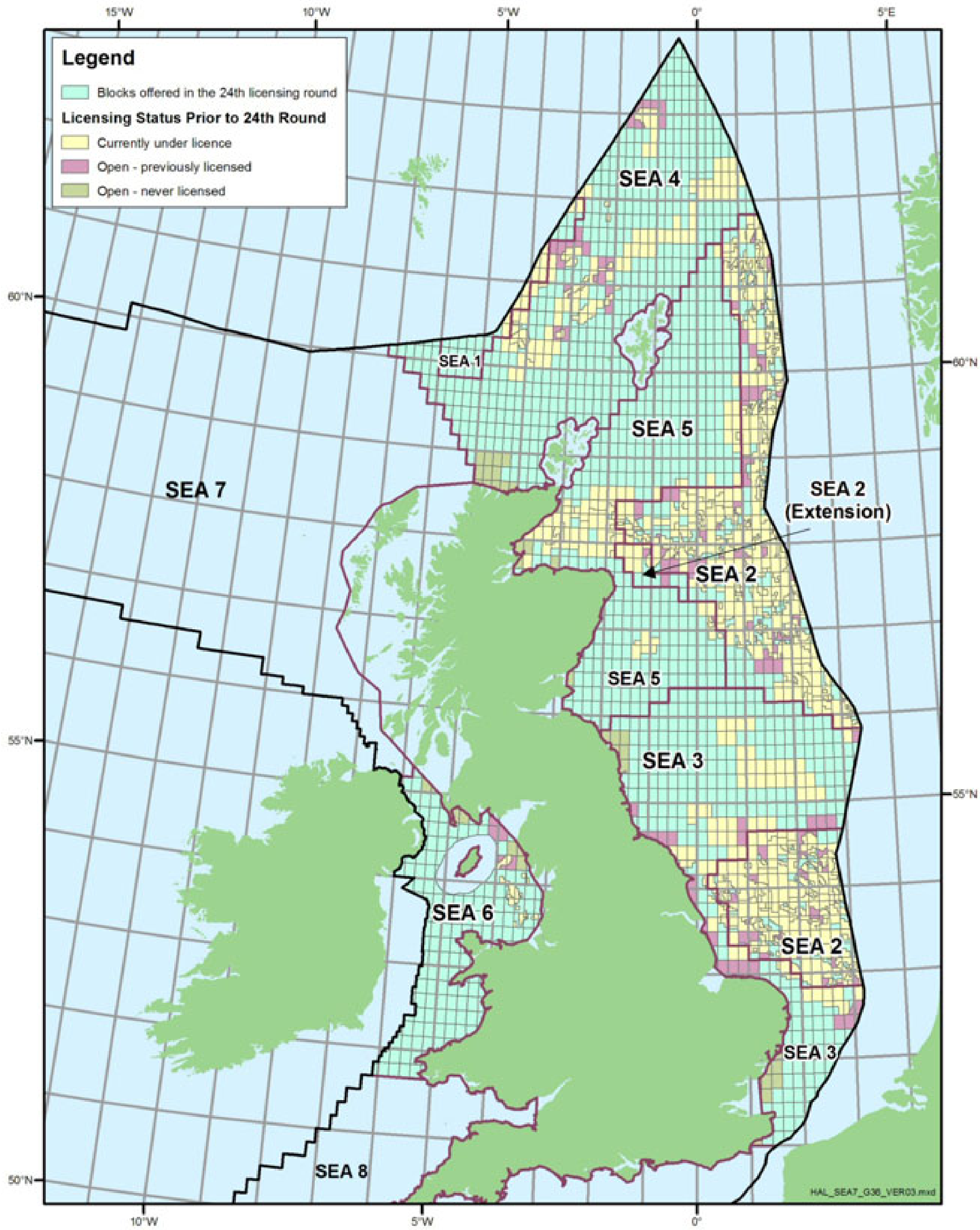
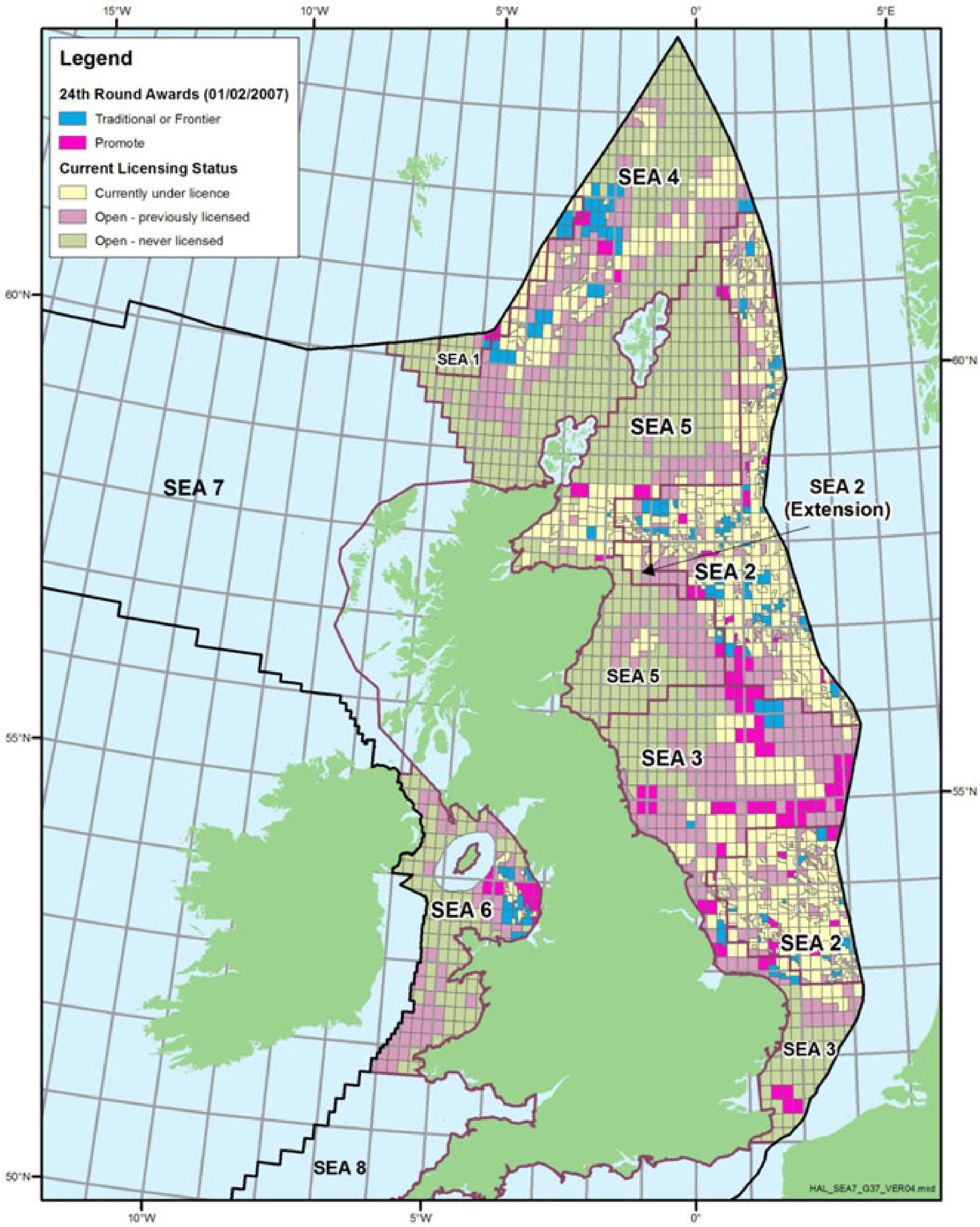


Figure A11.b.2 – Map showing the blocks awarded in the 24th Licensing Round and the current licensing status of the remaining blocks.



SEA 1

The licences awarded for SEA 1 in the 19th Round all had existing 3D seismic data and therefore the majority of work programmes offered reprocessing of existing 3D surveys rather than the collection of new data. Additionally, only some blocks had a commitment to acquire new 2D seismic surveys. In subsequent rounds, work programmes for seismic data were low, both for the collection of seismic data and exploration drilling. In the 24th Round, work programmes have increased slightly over previous years with 4 licences awarded.

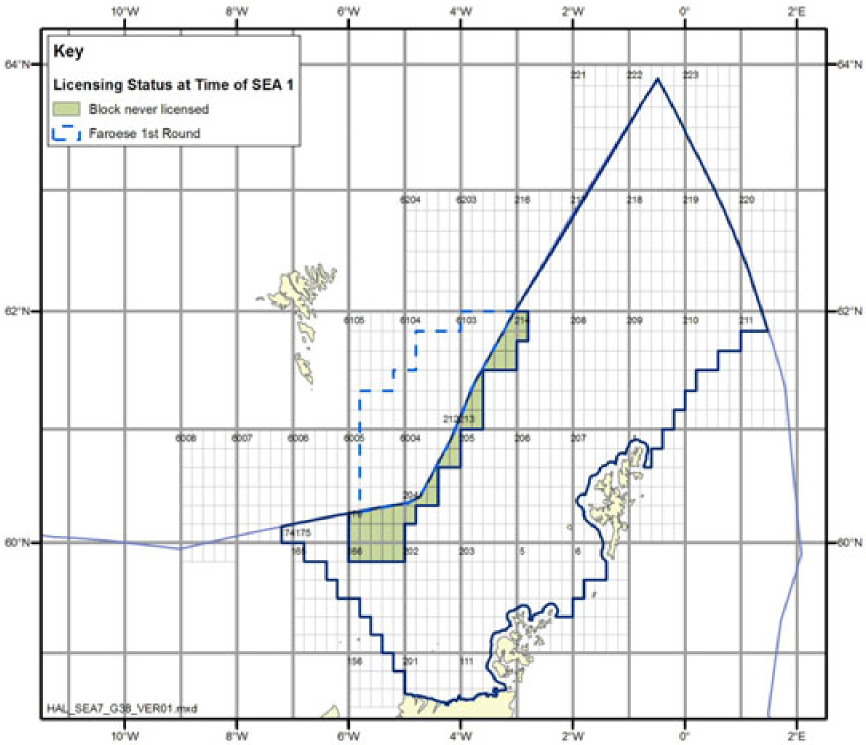
SEA 1 predicted activity levels and programmes bid

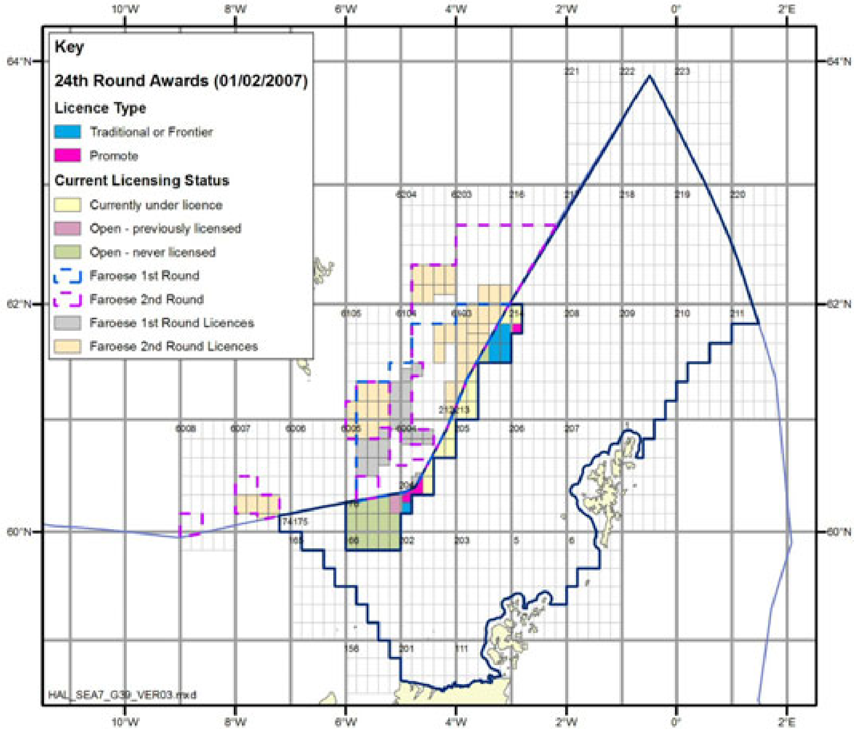
Award Round	Seismic surveys		Exploration wells	
	Predicted	Programmes Bid[1]	Predicted	Programmes Bid
19 (2001)	10	5 Firm 3 Contingent, D/D	15	7 Firm 6 Contingent 3 D/D
Re-offer 22 (2004)	-	2 Firm[2]	-	1 Contingent 2 D/D
Re-offer 23 (2005)	-	2 Firm	-	2 D/D
Re-offer 24 (2006/07)[3]	-	7 Firm[2]	-	4 D/D[2]

Notes:

1. *Where work programmes have indicated, "acquire seismic data" or "acquire and reprocess data", this has been interpreted for comparison purposes as a new seismic survey although it can also represent the purchase of existing seismic data i.e. not involving new survey. Reprocessing of existing seismic data has not been included.*
2. *Some licence awards include blocks that are within another SEA area, and therefore a work programme may be carried out within the other SEA.*
3. *Licences for the 24th Round were awarded on the 1st February 2007. The work programmes indicated here remain to be confirmed, dependent upon awards being accepted.*

Figure A11.b.3 – Pair of maps of blocks within the SEA 1 area indicating licensing status before the 19th licensing round (this page) and the current licensing status since the 24th licensing round (overleaf)





SEA 2 & SEA 2 Extension

The SEA 2 areas cover the mature area of the North Sea (those areas that have been licensed since the early days of oil and gas exploration in the North Sea). Most blocks in this area are currently under licence or have previously been licensed, with very few that have never been licensed. Consequently, there is already extensive seismic coverage of most of the area; nevertheless, work programmes to carry out further seismic surveys have steadily increased since the 20th Round and remain high.

Take-up of relinquished blocks in the SEA 2 area continues to be strong. In the 24th Round, there are 13 firm commitments to drill exploration wells in the central North Sea (subject to confirmation), which is over twice as many as for the previous round. These are shown in Figure A11.b4.

In the SEA 2 Extension there has been little activity since the 21st Round, with no licences awarded for blocks that were re-offered in the 24th Round.

SEA 2 predicted activity levels and programmes bid

Award Round	Seismic surveys		Exploration wells	
	Predicted	Programmes Bid[1]	Predicted	Programmes Bid
20 (2002)	16	11 Firm 3 Contingent, D/D	21	4 Firm 5 Contingent 19 D/D
Re-offer 21 (2003)	-	43 Firm 3 Contingent, D/D	-	3 Firm 4 Contingent 64 D/D
Re-offer 22 (2004)	-	58 Firm[2] 14 Contingent, D/D	-	2 Firm 4 Contingent 65 D/D[2]
Re-offer 23 (2005)[3]	-	73 Firm[2] 15 Contingent, D/D[2]	-	5 Firm 4 Contingent 78 D/D[2]
Re-offer 24 (2006/07)	-	68 Firm	-	13 Firm 12 Contingent 70 D/D[2]

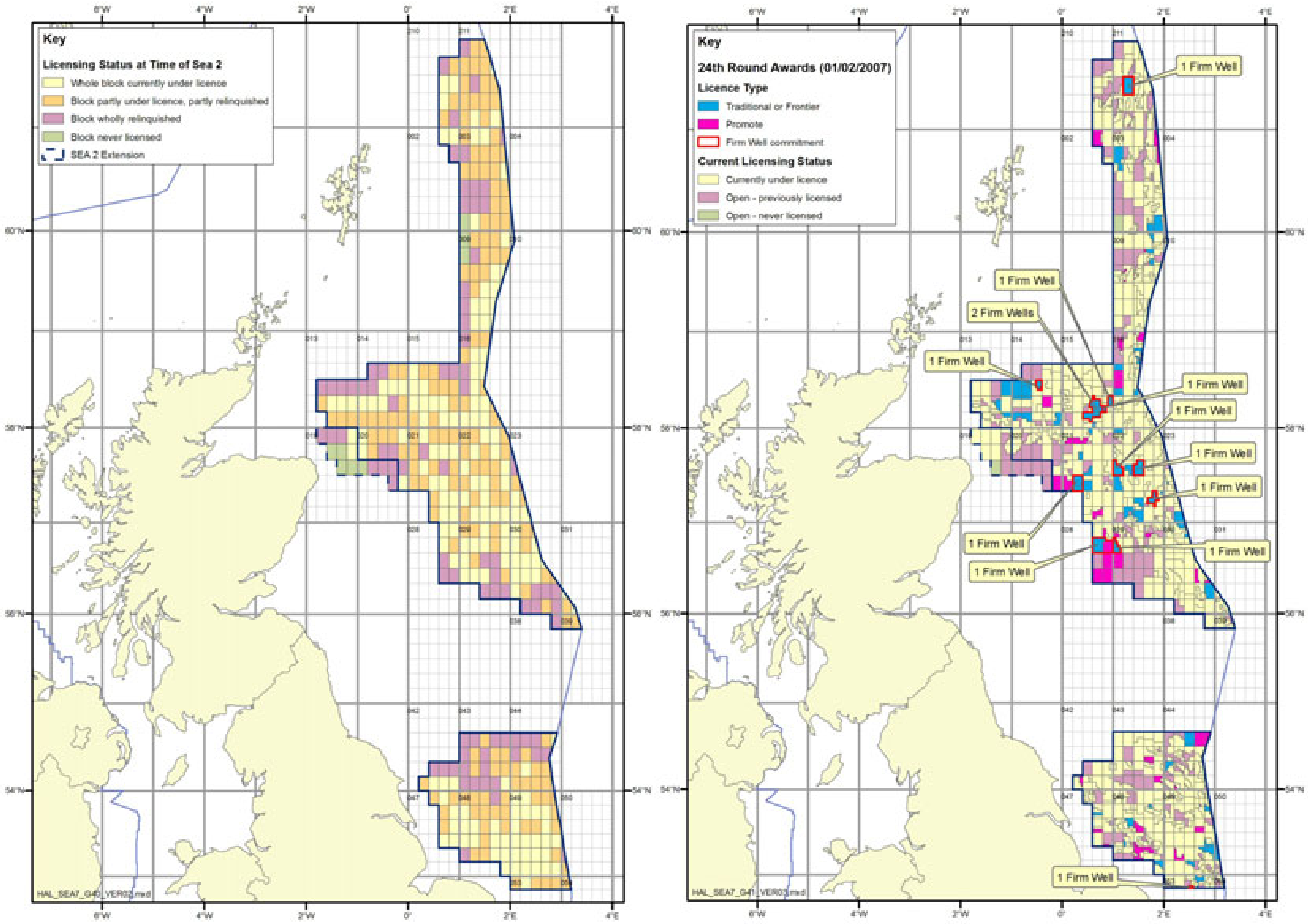
SEA 2 Extension predicted activity levels and programmes bid

Award Round	Seismic surveys		Exploration wells	
	Predicted	Programmes Bid[1]	Predicted	Programmes Bid
21 (2003)	3	5 Firm	11	5 Firm 5 Contingent 2 D/D
Re-offer 22 (2004)	-	1 Firm	-	1 D/D

Notes:

1. *Where work programmes have indicated, "acquire seismic data" or "acquire and reprocess data", this has been interpreted for comparison purposes as a new seismic survey although it can also represent the purchase of existing seismic data i.e. not involving new survey. Reprocessing of existing seismic data has not been included.*
2. *Some licence awards include blocks that are within another SEA area, and therefore a work programme indicated here may actually be carried out within the other SEA.*
3. *Licences for the 24th Round were awarded on the 1st February 2007. The work programmes indicated here remain to be confirmed, dependent upon awards being accepted.*

Figure A11.b.4 – Pair of maps of blocks within the SEA 2 area indicating licensing status before the 20th licensing round (left) and the current licensing status since the 24th licensing round (right)



SEA 3

The SEA 3 area is regarded as an area of low prospectivity, and seismic and drilling activity has been relatively low compared to the adjacent SEA 2 blocks. In the 24th Round, the uptake of blocks remains moderate compared to the number offered, although more licences have been awarded than in the previous round.

SEA 3 *predicted activity levels and programmes bid*

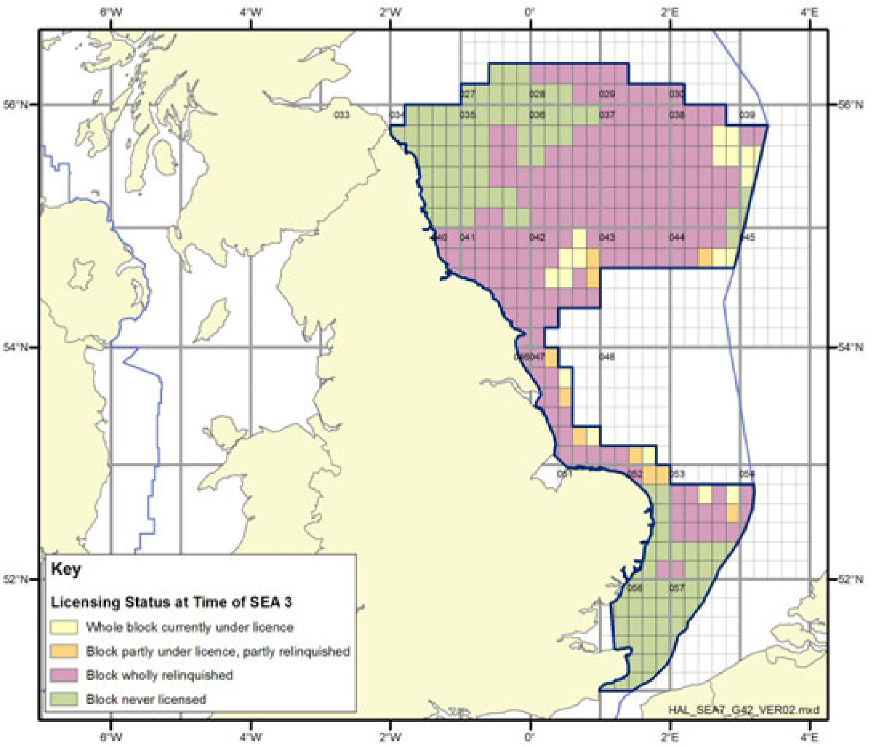
Award Round	Seismic surveys		Exploration wells	
	Predicted	**Programmes Bid[1]**	**Predicted**	**Programmes Bid**
21 (2003)	100-200 km 2D 500-2500 km^2 3D	8 Firm	15	11 D/D[2]
Re-offer 22 (2004)	-	8 Firm[2] 1 Contingent, D/D	-	1 Firm 7 D/D[2]
Re-offer 23 (2005)	-	16 Firm[2] 2 Contingent, D/D[2]	-	1 Firm 1 Contingent

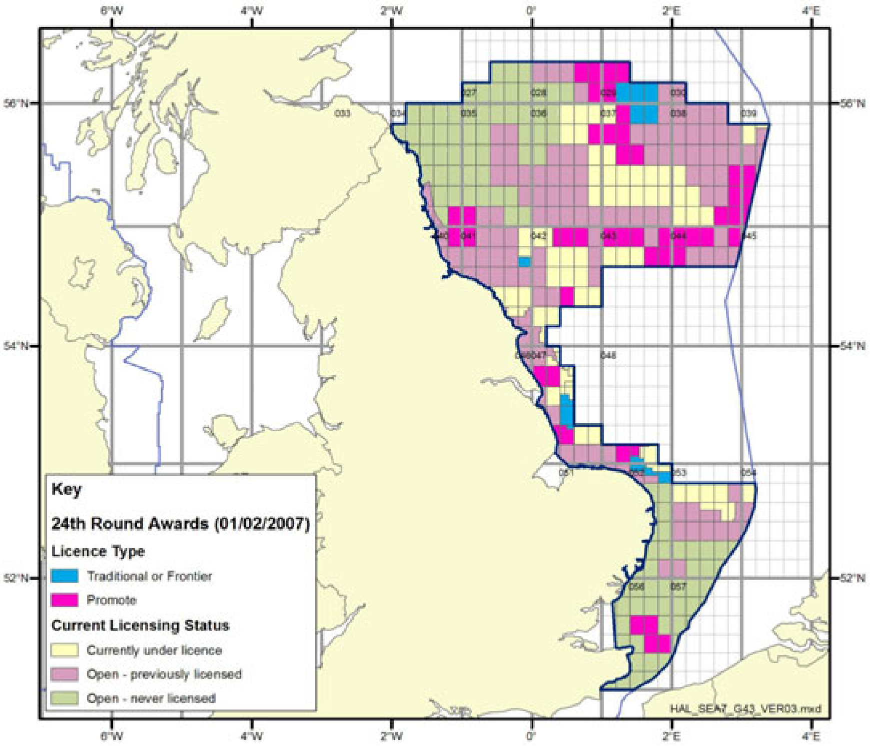
Award Round	Seismic surveys		Exploration wells	
	Predicted	**Programmes Bid**[1]	**Predicted**	**Programmes Bid**
				11 D/D[2]
Re-offer 24 (2006/07)[3]	-	20 Firm[2]	-	23 D/D[2]

Notes:

1. *Where work programmes have indicated, "acquire seismic data" or "acquire and reprocess data", this has been interpreted for comparison purposes as a new seismic survey although it can also represent the purchase of existing seismic data i.e. not involving new survey. Reprocessing of existing seismic data has not been included.*
2. *Some licence awards include blocks that are within another SEA area, and therefore a work programme indicated here may actually be carried out within the other SEA.*
3. *Licences for the 24th Round were awarded on the 1st February 2007. The work programmes indicated here remain to be confirmed, dependent upon awards being accepted.*

Figure A11.b.5 – Pair of maps of blocks within the SEA 3 area indicating licensing status before the 21st licensing round (top) and the current licensing status since the 24th licensing round (overleaf)





SEA 4

As with SEA areas 1 and 3, the prospectivity for blocks in SEA 4 is low. Fewer licences have been awarded in the 24th Round than in previous years; the awards that have been made are mostly frontier or traditional licences to the west and north west of Shetland. There are no firm well commitments.

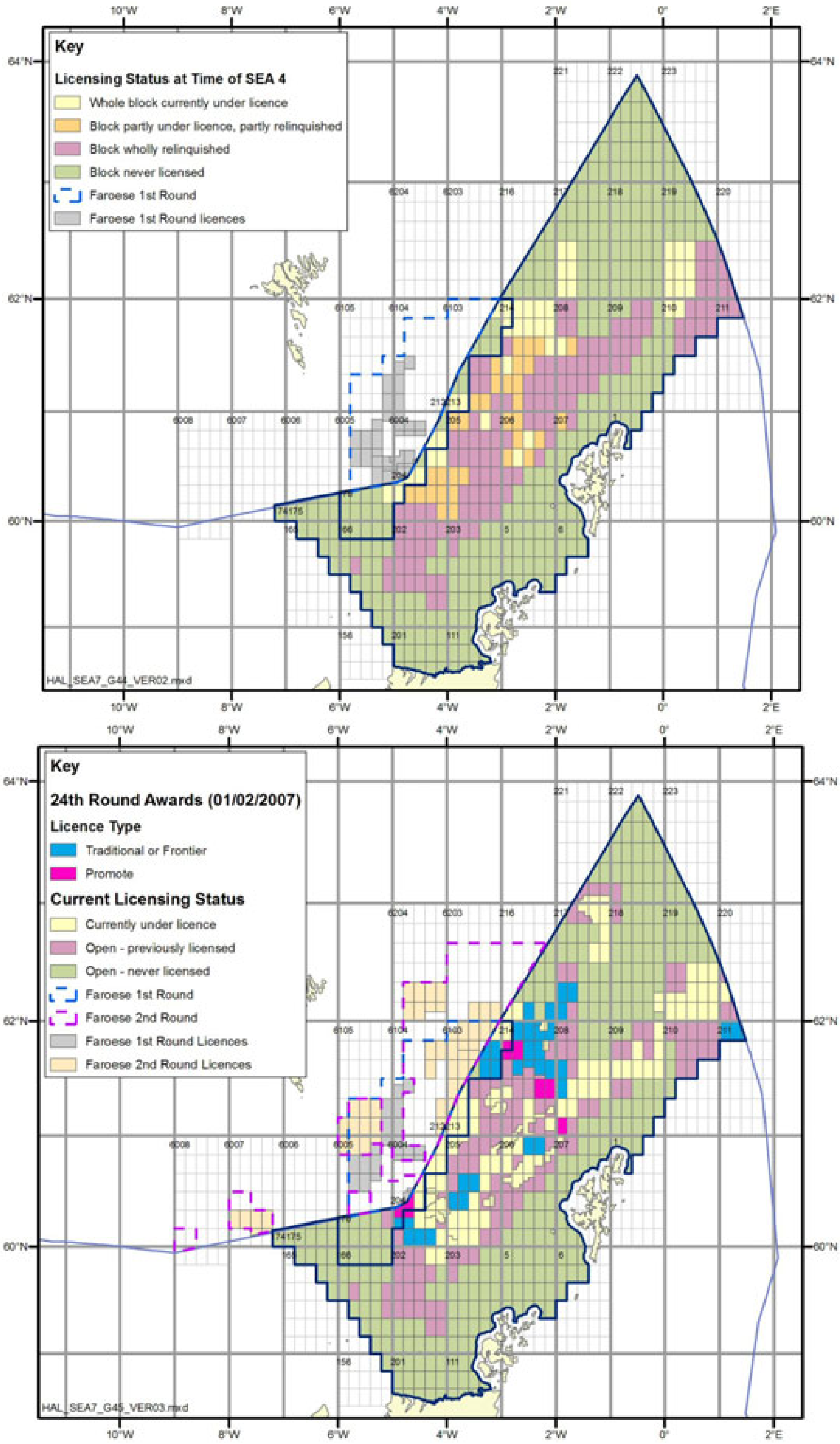
SEA 4 predicted activity levels and programmes bid

Award Round	Seismic surveys		Exploration wells	
	Predicted	**Programmes Bid**[1]	**Predicted**	**Programmes Bid**
22 (2004)	17	7 Firm[2] 1 Contingent, D/D	8	2 Contingent[2] 12 D/D
Re-offer 23 (2005)[3]	-	12 Firm 2 Contingent, D/D	-	3 Firm 1 Contingent 12 D/D
Re-offer 24 (2006/07)	-	16 Firm[2]	-	12 D/D[2]

Notes:

1. *Where work programmes have indicated, "acquire seismic data" or "acquire and reprocess data", this has been interpreted for comparison purposes as a new seismic survey although it can also represent the purchase of existing seismic data i.e. not involving new survey. Reprocessing of existing seismic data has not been included.*
2. *Some licence awards include blocks that are within another SEA area, and therefore a work programme indicated here may actually be carried out within the other SEA.*
3. *Licences for the 24th Round were awarded on the 1dt February 2007. The work programmes indicated here remain to be confirmed, dependent upon awards being accepted.*

Figure A11.b.6 – Pair of maps of blocks within the SEA 4 area indicating licensing status before the 22nd licensing round (top) and the current licensing status since the 24th licensing round (bottom)



SEA 5

The greatest areas of prospectivity in the SEA 5 region are thought to be in the areas south of the Unst Basin (Quadrants 2 and 8) and the Northern part of the Moray Firth, increasing into the Inner Moray Firth. In the 24th Round, licences have again been primarily awarded in these areas, although there are fewer than in the previous round with no firm wells.

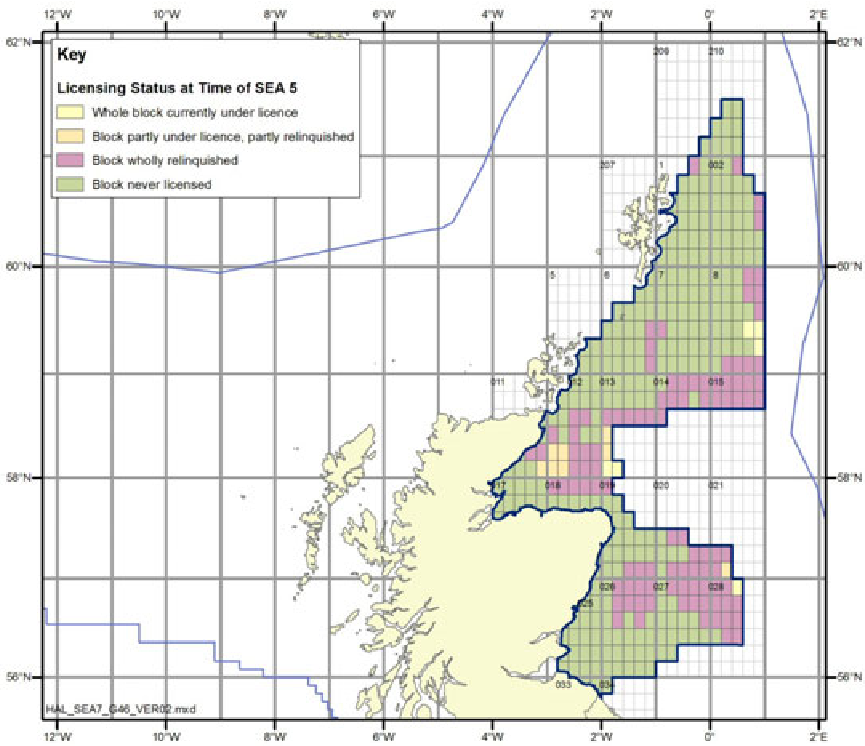
SEA 5 predicted activity levels and programmes bid

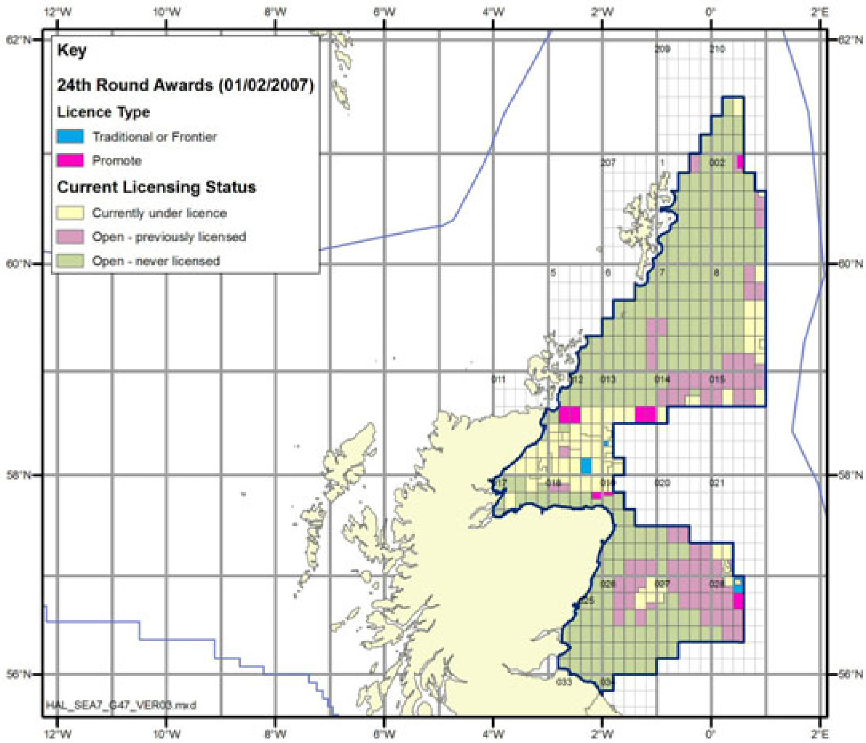
Award Round	Seismic surveys		Exploration wells	
	Predicted	Programmes Bid[1]	Predicted	Programmes Bid
23 (2005)	16	34 Firm[2] 4 Contingent, D/D[2]	12	8 Firm 4 Contingent 29 D/D[2]
Re-offer 24 (2006/07)[3]	-	7 Firm[2]	-	8 D/D[2]

Notes:

1. *Where work programmes have indicated, "acquire seismic data" or "acquire and reprocess data", this has been interpreted for comparison purposes as a new seismic survey although it can also represent the purchase of existing seismic data i.e. not involving new survey. Reprocessing of existing seismic data has not been included.*
2. *Some licence awards include blocks that are within another SEA area, and therefore a work programme indicated here may actually be carried out within the other SEA.*
3. *Licences for the 24th Round were awarded on the 1st February 2007. The work programmes indicated here remain to be confirmed, dependent upon awards being accepted.*

Figure A11.b.7 – Pair of maps of blocks within the SEA 5 area indicating licensing status before the 23rd licensing round (top) and the current licensing status since the 24th licensing round (overleaf)





SEA 6

Blocks within the SEA 6 area were first offered for licensing in 1965. At the time of the SEA, 2 blocks were licensed, 13 partly licensed and partly relinquished and 57 wholly relinquished. Many blocks that had previously been offered for licensing were never applied for. Prospectivity for the SEA 6 area has been assessed based upon 7 scenario areas chosen for their geological characteristics and potential for finding hydrocarbon reserves (DTI 2005). From the assessment it was expected that most new activity would occur in the mature Irish Sea and immediately surrounding areas (the North East Irish Sea). In the 24th Round all awards have, as anticipated, been made in this area with firm commitments to drill 4 wells.

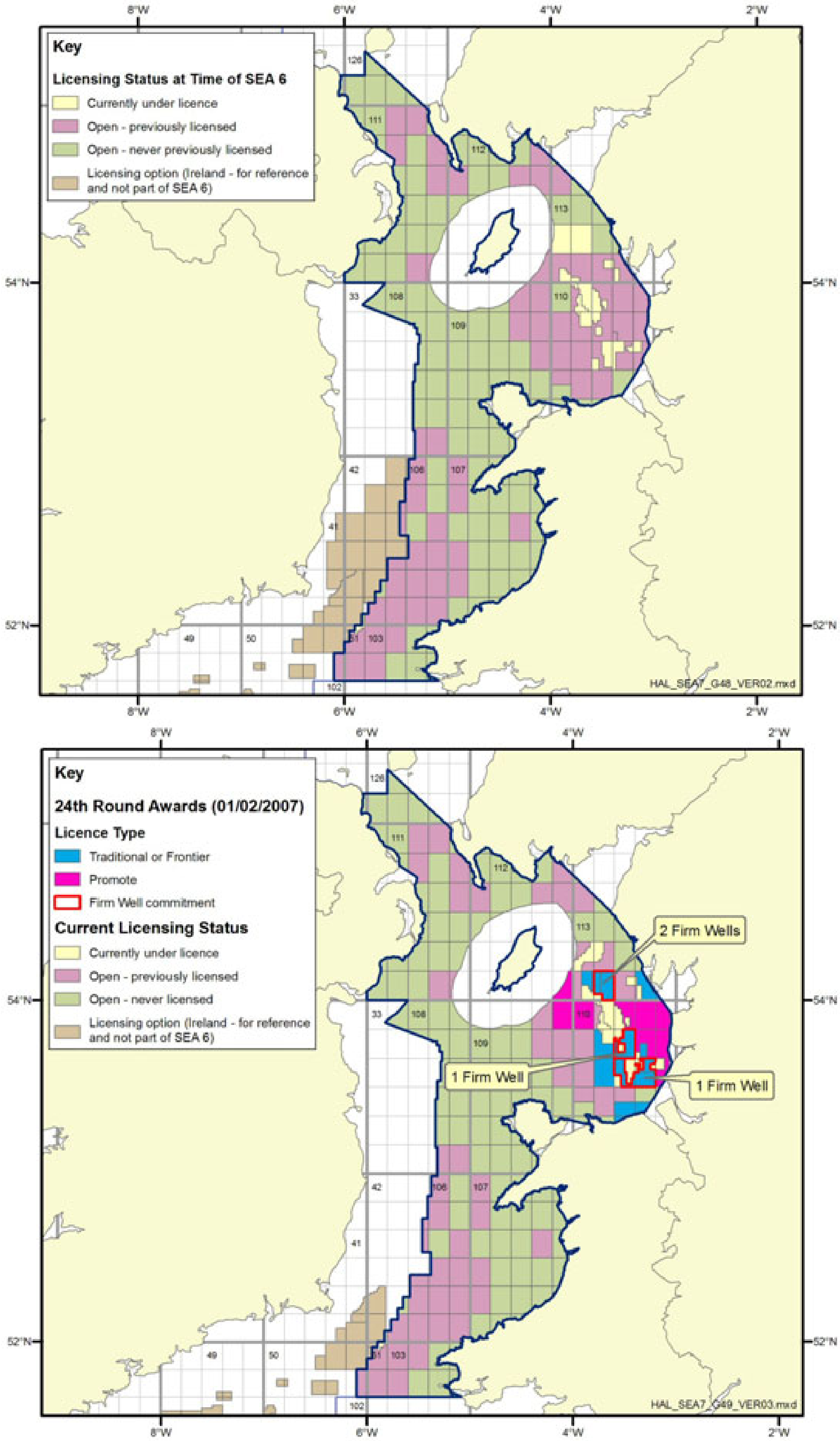
SEA 6 predicted activity levels and programmes bid

Award Round	Seismic surveys		Exploration wells	
	Predicted	**Programmes Bid**[1]	**Predicted**	**Programmes Bid**
24 (2006/07)[3]	3500 – 4200 km^2 3D	15 Firm	7 - 10	4 Firm 1 Contingent 11 D/D

Notes:

4. *Where work programmes have indicated, "acquire seismic data" or "acquire and reprocess data", this has been interpreted for comparison purposes as a new seismic survey although it can also represent the purchase of existing seismic data i.e. not involving new survey. Reprocessing of existing seismic data has not been included.*
5. *Some licence awards include blocks that are within another SEA area, and therefore a work programme indicated here may actually be carried out within the other SEA.*
6. *Licences for the 24th Round were awarded on the 1st February 2007. The work programmes indicated here remain to be confirmed, dependent upon awards being accepted.*

Figure A11.b.7 – Pair of maps of blocks within the SEA 6 area indicating licensing status before the 24th licensing round (top) and the current licensing status since the 24th licensing round (bottom)



A11.b.3 Discussion

A summary of existing and new environmental regulations covering offshore oil and gas activities is given in Appendix 10 of this Environmental Report. In addition, the processes and potential areas for designation as coastal and offshore conservation sites have become clearer (see underpinning reports for SEA 2 onwards) although most offshore sites have yet to be proposed, with potential areas of qualifying habitat illustrated on the JNCC website.

Updates to the environmental information base for the various SEA areas are outlined in Section 4.5 and Appendices 4 to 9. These generally support the existing perspectives on sensitive features and species. Similarly, the new information on the effects of oil and gas activities has not shown any new significant or unanticipated sources of significant effect that would alter the conclusions of the earlier DTI SEAs.

Of relevance to previous SEA areas are the sites recently identified by the JNCC as possible and draft SACs. These are the Darwin Mounds (SEA 4), the Wyville Thomson Ridge (SEA 1 and 4), the Dogger Bank (SEA 2 and 3), the Scanner pockmark (SEA 2), the North Norfolk Sandbanks and Saturn Reef (SEA 2 and 3) and the Braemar pockmarks (SEA 2). Other areas of potential Annex I habitat within previous SEA areas are also in the process of being considered for SAC designation.

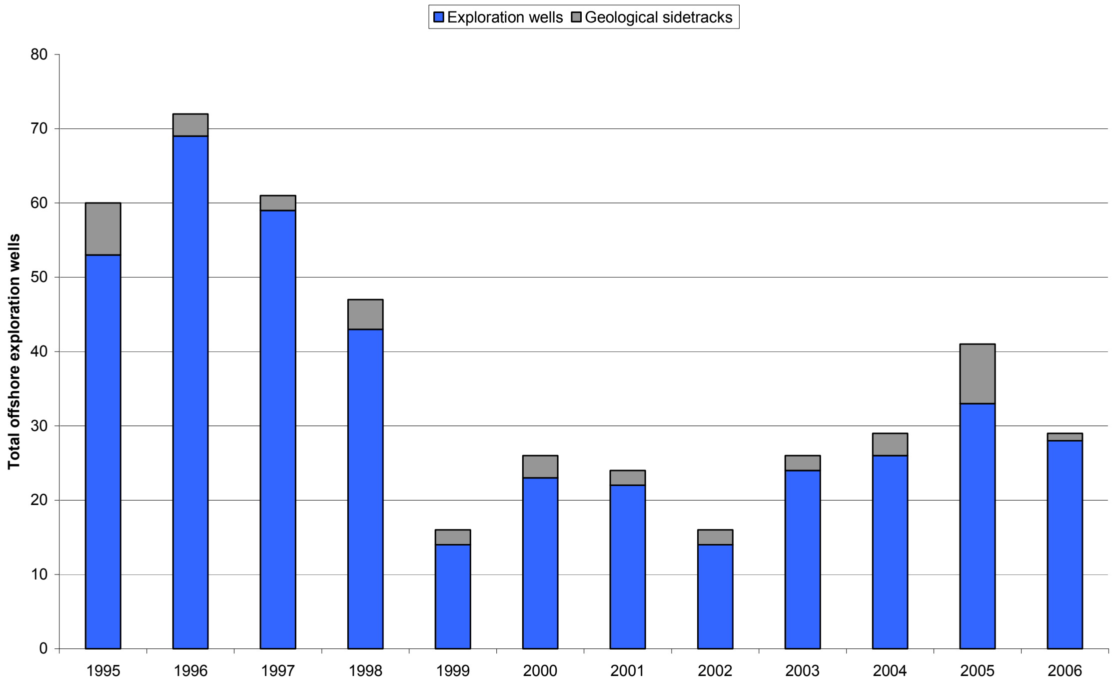
Following SEA 2, certain blocks in Quadrant 15 (Scanner pockmark) in the central North Sea were not offered for oil & gas licensing as they contained seabed gas pockmark features that were of conservation interest. This recommendation has been maintained through subsequent SEAs and licensing rounds in relation to reoffer of these blocks. The Joint Nature Conservation Committee has subsequently proposed pockmarks features in several blocks as offshore Special Areas of Conservation (e.g. the Scanner and Braemar pockmarks).

A report on the nature and sources of the gas supplying the pockmarks has been commissioned from the British Geological Survey and this is available as a downloadable document from the SEA website. On the basis of the BGS report conclusions, the DTI is now considering offering blocks 15/20c and 15/25d for licence subject to strict spatial and other controls aimed at ensuring protection of the conservation interests they contain.

From this consideration it is concluded that the findings of the previous SEAs in terms of areas to be excluded from licensing or blocks requiring additional mitigation measures if licensed, remain generally valid. This assumes appropriate mitigation with respect to the recently identified conservation sites. Designation of an SAC would not preclude licensing as long as appropriate spatial or other necessary constraints are applied to prevent damage to the features of conservation interest. If blocks/part blocks previously excluded from licensing on environmental grounds are to be offered in subsequent licensing rounds, this needs to be supported by a documented rationale (typically based on better understanding of the features of interest in the blocks and the process that formed/maintain them).

As a context for the consideration of the likely scale of drilling activity which could follow a 25th offshore licensing round Figure A11.b.8 shows the number of exploration wells drilled on the offshore UKCS over the last ten years. The number of wells shows a general decline over time although with a slight increase since 2002.

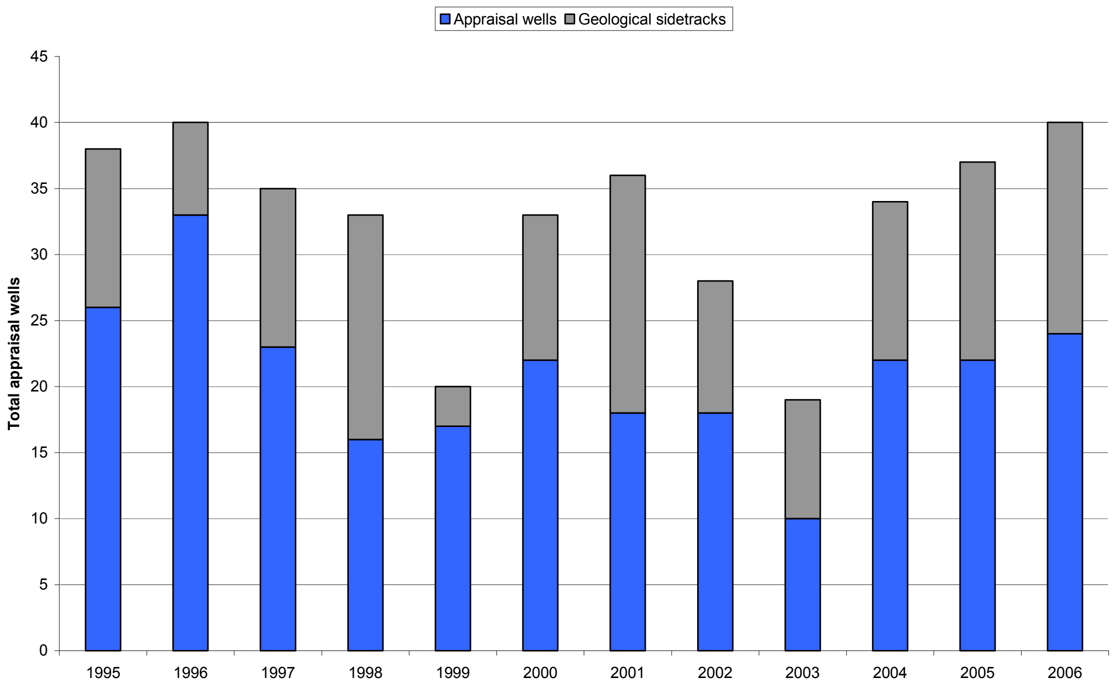
Figure A11.b.8 – Number of exploration wells and their sidetracks drilled in all areas of offshore UKCS



Note: Sidetrack wells are only counted where the intent was to acquire new geological data. Source: DTI website

In contrast to exploration wells, the number of appraisal wells shows less of a clear cut trend – see Figure A11.b.9.

Figure A11.b.9 – Number of appraisal wells and their sidetracks drilled in all areas of offshore UKCS



Note: Sidetrack wells are only counted where the intent was to acquire new geological data. Source: DTI website

A11.c Consideration of effects of licensing

A11.c.1 Potential sources of effect

Potential sources of effects (see Figures A11.c.1 to 3) from the activities which may result from implementation of the draft plan have been considered in terms of the likely significant effects on the environment, including on the SEA topics – see listing below.

Figure A11.c.1 – Potential sources of effect from seismic operations

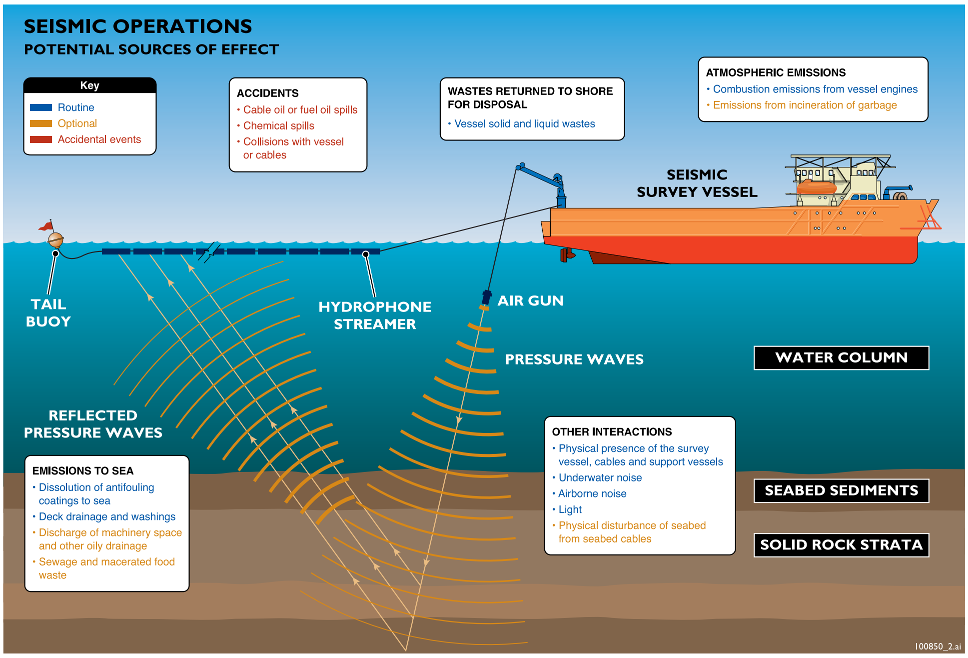


Figure A11.c.2 – Potential sources of effect from drilling operations

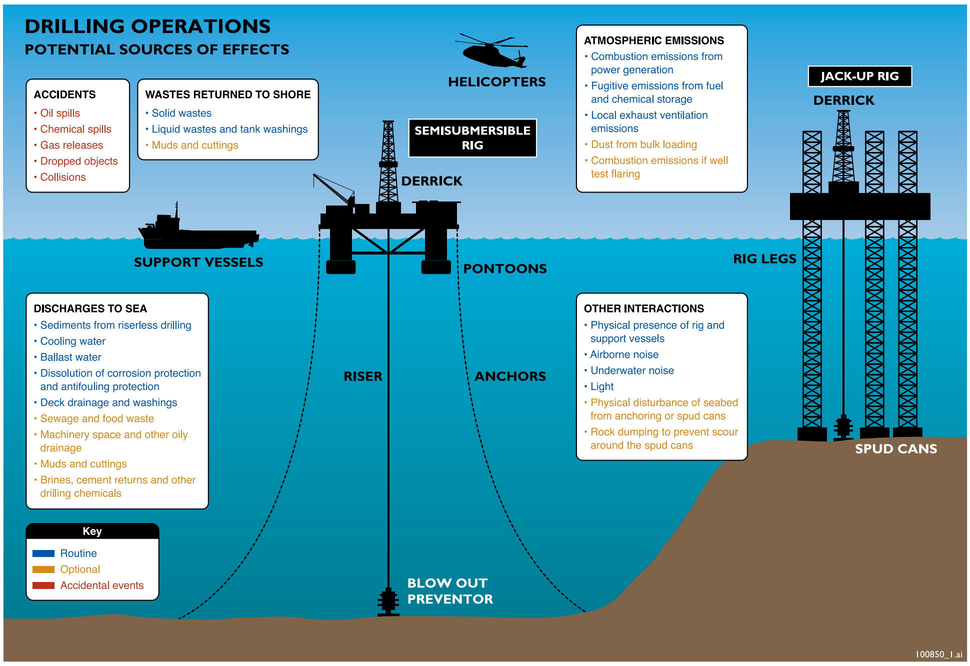
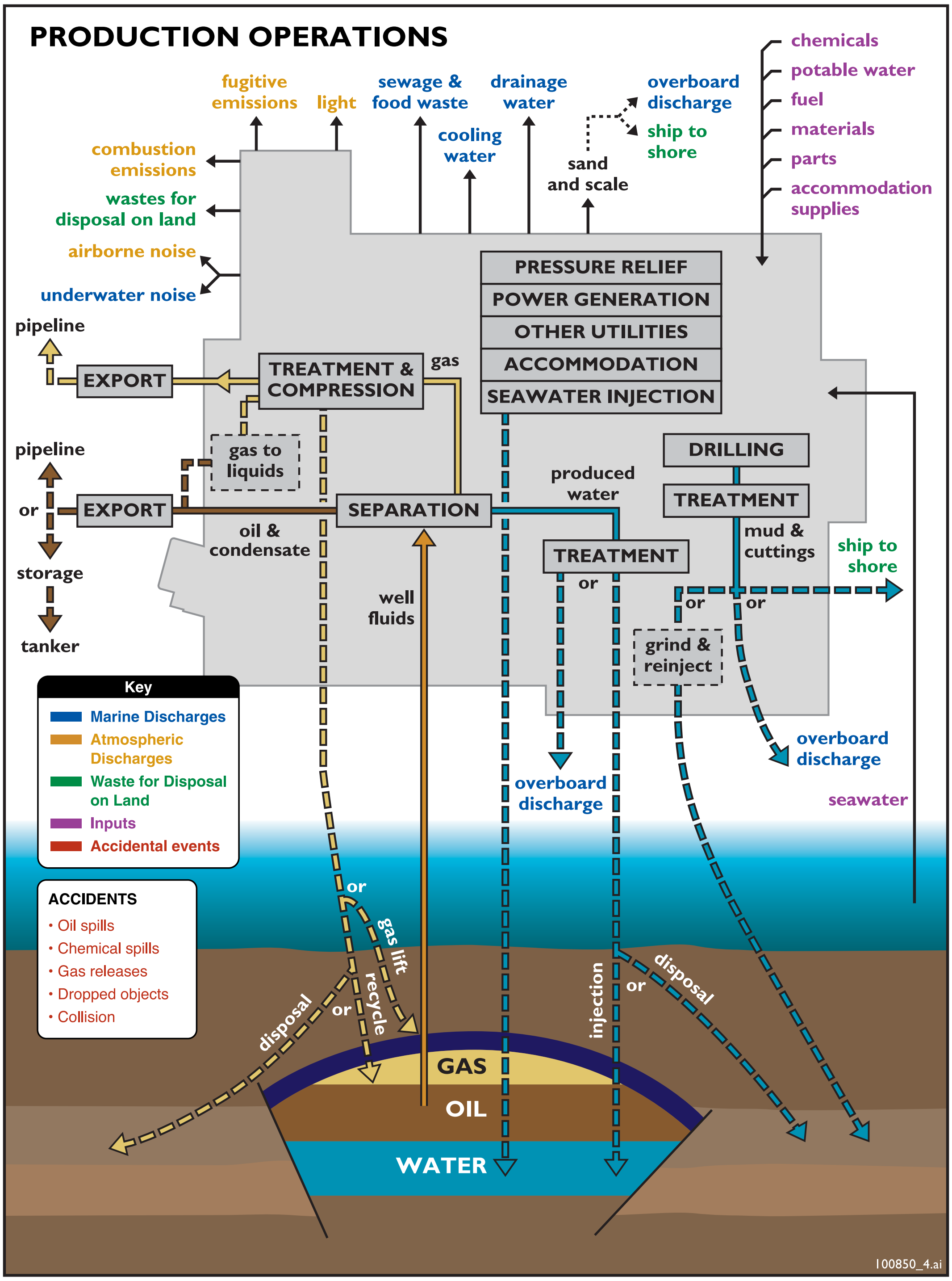


Figure A11.c.3 – Potential sources of effect from production operations



SEA Topic	Potential sources of significant effect
Biodiversity, habitats, flora and fauna	Physical damage to biotopes from pipeline construction, rig anchoring etc Potential behavioural and physiological effects on marine mammals and fish associated with seismic surveys Potential for non-native species introductions in ballast water discharges Disturbance to fish, birds and marine mammals etc from physical presence of infrastructure and support activities Potential for effects on flora and fauna of produced water and drilling Major oil spill effects and associated damage to species, habitats and ecosystem function
Geology and sediments	Physical effects of anchoring and infrastructure construction on seabed sediments and geomorphological features Sediment modification and contamination by particulate discharges from drilling etc Effects of reinjection of produced water and cuttings Onshore disposal of returned wastes – requirement for landfill Risk of sediment contamination from oil spills
Landscape/seascape	Potential visual impacts of nearshore exploration and development including seascape effects Change to character
Water environment	Contamination by soluble and dispersed discharges Risk of contamination of the water column by dissolved and dispersed hydrocarbons from oil spills
Air quality	Local air quality effects resulting from exhaust emissions, flaring and venting Emissions of acid gases Air quality effects of a major gas release or volatile oil spill
Climatic factors	Contributions to greenhouse gas emissions
Population Human health	Interactions with fishing activities (exclusion, seismic, snagging) Other interactions with shipping, military, potential renewables and other human uses of the offshore environment Socio-economic consequences of oil spills Positive socio-economic effects of potential activities, in terms of employment, expenditure and tax revenue Potential for effects on human health associated with - effects on local air quality resulting from atmospheric emissions - discharges of naturally occurring radioactive material in produced water”

SEA Topic	Potential sources of significant effect
	- potential food chain effects of major oil spills
Material assets	None
Potential effects in relation to known or postulated archaeological heritage	Potential effects in relation to known or postulated historical or archaeological heritage
The Interrelationship between issues - Cumulative and Transboundary issues	

A11.c.2 Noise

Summary of effects considerations from previous SEAs

Previous SEAs have considered the potential for acoustic disturbance by noise generated by exploration and production activities. In general, marine mammals show the highest sensitivity to acoustic disturbance, and the severity of potential effect has therefore been related to marine mammal species composition and abundance in the area under consideration. In addition, seismic surveys generate the highest source levels of any oil & gas-related activity; the potential for significant effect is therefore largely related to the anticipated type, extent and duration of seismic survey in activity scenarios. Although less commonly used in recent years, explosive cutting of wellheads or decommissioned structures may also produce high intensity impulsive noise. The range over which noise propagates (and effects may result) varies with water depth, density stratification, substrate and other factors; and is therefore area-specific. Finally, the sensitivity of species such as marine mammals may be influenced by previous experience (i.e. sensitisation / habituation) and by the level of background ambient noise in the area.

Generic SEA of potential acoustic disturbance in the UKCS therefore considers in turn:

- Ambient noise
- Noise sources associated with seismic surveys and other oil & gas activities
- Propagation of noise in the marine environment
- Sensitivities to acoustic disturbance
- Control and mitigation of acoustic disturbance
- Summary of potential effects

Ambient noise is generally made up of three constituent types – wideband continuous noise, tonals and impulsive noise. The latter is transient in nature and is usually of wide bandwidth and short duration. In deep water the levels of ambient noise are now well defined and the contributions from various sources well understood and categorised according to dominant source and frequency (Urick 1983).

Noise associated with exploration and production is produced by both continuous and impulse sources and has been discussed, in terms of source characteristics, in previous SEAs and supporting studies (e.g. Hammond *et al*. 2003, 2004). With the exception of explosives, airgun arrays used for seismic surveys are the highest energy man made sound sources in the sea; broadband source levels of 248-259 dB re 1μPa are typical of large arrays (Richardson *et al*. 1995). Seismic survey duration may extend from a period of a few hours, to several weeks. Smaller sources may be used for specific purposes, including high resolution site surveys and Vertical Seismic Profiling (VSP) or borehole seismic used in connection with well operations.

Airgun noise is impulsive (i.e. non-continuous), with a typical duty cycle of 0.3% and slow rise time (in comparison to explosive noise). Most of the energy produced by airguns is below 200 Hz, although some high frequency noise may also be emitted (Goold 1996, Gordon and Moscrop 1998). Peak frequencies of seismic arrays are generally around 100Hz; 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.

Piling operations, mainly used during installation of fixed jacket platforms in relatively shallow water, also produce impulsive noise over the construction period (typically a few weeks or months). Fixed platforms are unlikely to be used in the water depths typical of prospective parts of the SEA 7 area. Available measurements indicate that drilling activities produce mainly low-frequency continuous noise from several separate sources on the drilling unit (Richardson *et al*. 1995, Lawson *et al*. 2001). The primary sources of noise are various types of rotating machinery, with noise transmitted from a semi-submersible rig to the water column through submerged parts of the drilling unit hull, risers and mooring cables, and (to a much smaller extent) across the air-water interface. Under some circumstances, cavitation of thruster propellers is a further appreciable noise source, as may be the use of explosive cutting methods (e.g. for conductor removal).

Measured farfield sound pressure of around 170dB re. 1μPa, in the frequency range 10 - 2000Hz (Davis *et al.* 1991) is probably typical of drilling from a semi-submersible rig and is of the same order and dominant frequency range as that from large merchant vessels (e.g. McCauley 1994). Drilling noise has also been monitored west of Shetland, in the vicinity of the Foinaven and Schiehallion developments (Swift & Thompson 2000). High and variable levels of noise in three noise bands (1-10Hz,10-30Hz and 30-100Hz) were initially believed to result from drilling related activity on two semi-submersible rigs operating in the area. However, subsequent analysis showed that noise events and drilling activity did not coincide. In contrast, a direct correlation between the use of thrusters and anchor handlers, during rig moves, and high levels of noise in all three bands was found (Swift & Thompson 2000). Drilling duration may range from a few weeks for an exploration well, to years in the case of a large development programme.

Pipelay operations will result mainly in continuous noise (associated with rotating machinery), with relatively little impulse or percussive noise in comparison to many other marine construction activities. The overall source levels resulting from pipelay operations on the UKCS have not been measured, however, near-field cumulative sound levels associated with pipelay for the Clair project were predicted to be a maximum of 177dB (Lawson *et al*. 2001), with a duration of weeks or months.

Although there is little published data, noise emission from production platforms is qualitatively similar to that from ships, and is produced mainly by rotating machinery (turbines, generators, compressors). It is possible that the compression required for gas export may be a significant source of noise, propagation into the water column will be limited.

A further source of noise associated with all stages of offshore industry is helicopter overflights. There is relatively little quantitative information on the transmission of helicopter airborne noise to the marine environment (Richardson *et al*. 1995). Recent measurements of an air-sea rescue helicopter over the Shannon estuary (Berrow *et al*. 2002) indicated that due to the large impedance mismatch when sound travels from air to water, the penetration of airborne sound energy from the rotor blades was largely reflected from the surface of the water with only a small fraction of the sound energy coupled into the water.

General aspects of noise propagation are discussed in Box A11.c.1. 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 A11.c.4). 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 (see SEA 4). 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.

Box A11.c.1 - Acoustic propagation

Sound produced by various ambient noise sources propagates to a receiver through the very complex underwater environment. Because of variation in temperature, salinity and pressure the path followed by the sound waves can deviate markedly from a straight line. The structuring is most marked in the vertical plane, causing sound to be refracted upwards or downwards, depending on the temperature gradient, but horizontal structuring can also be encountered. As sound is refracted up or down it may interact with the surface and the sea bed by reflection and scattering. The level of signal arriving at a distant point is a complex sum of many paths that may or may not interact with the seabed and sea surface. Variations of salinity are generally very small, except perhaps at the mouth of major rivers, and pressure variations are due entirely to depth so temperature variations have the major effect on sound propagation in shallow water.

Under some conditions, a mixed isothermal layer forms close to the sea surface that traps the acoustic signals and a source and receiver located within this surface duct experience significantly less propagation loss than when there is no surface duct. During the day the sea surface can heat up and introduce a temperature gradient close to the sea surface that causes downwards refraction and hence increased propagation loss.

Because the sound can interact strongly with the seabed, the sediment types and sea bed roughness can affect propagation loss. Similarly, waves on the surface can also affect propagation loss by scattering the sound interacting with the surface rather than just reflecting it.

Suspended sediments or bubbles can also cause additional propagation loss.

Propagation loss varies on a diurnal basis, particularly during the early summer, and on an annual cycle, as the air temperature variations through the year warm and cool the water. A period of sustained strong wind can also disrupt the temperature structuring.

Multi-path effects
Because of the surface and sea bed reflections sound can travel between a source and receiver by a multitude of paths. This has the effect of dispersing the arrived signal in time. This effect is particularly import for wideband impulsive sounds such as explosions, pile driving or seismic exploration air-guns. If any of the propagation effects are frequency sensitive then frequency dispersion will also occur. A common example of this is the sound of air guns operating at distances of 20-30 miles in which the low frequencies travel more slowly than the high frequencies so the single impulse at the source turns into a pronounced frequency sweep at the receiver. The effect of time dispersion is to reduce the peak energy in the received signal. The integrated level is unchanged by time dispersion, but the peak levels can be significantly reduced. When considering the contribution to ambient noise levels this can be an important factor.

Source and receiver depth

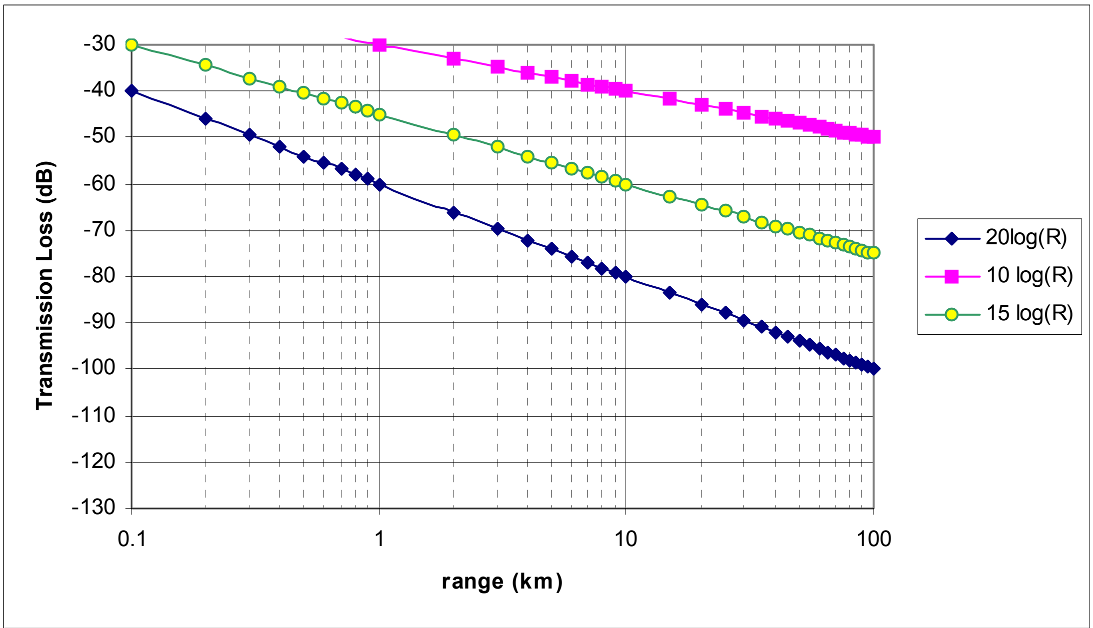
The vertical temperature and pressure structure described above can lead to significant variations in the propagation loss between a sound source and the receiver as the depth of the source and/or the receiver is varied. The most extreme example is the surface duct where a shadow zone may form under the duct. Within the shadow zone levels from a distant sound source in the duct are much reduced compared with the level from the same source within the duct.

Tides

In the deep waters to found in west of the SEA 7 area, the variations in depth due to tides is insignificant. However, in inshore waters the effect is much more pronounced and can significantly alter ambient noise fields through the tidal cycle.

Source: Harland & Richards (2006)

Figure A11.c.4 – Theoretical Transmission Losses (TL) calculated for spherical spreading 20log(R), cylindrical spreading 10log(R) and intermediate spreading 15log(R).



Source: SEA 4 (DTI 2003)

Typical spatial extents of 3D seismic surveys are of the order of 25km in any direction (625 km^2 area). Assuming propagation distances of around 100km in all directions (see above), the theoretical instantaneous area of effect is a circular area of 31,400 km^2, and the total area ensonified during a survey is a rectangular area of 50,625km^2. As noted in Box A11.c.1 the frequency spectrum will be modified over ranges >50km and peak received level in each seismic pulse will be reduced by time dispersion ("smearing") of the signal.

It is generally considered (e.g. by SEAs 1-6) that **the most sensitive receptors** of acoustic disturbance in the marine environment are marine mammals, due to their use of echolocation and vocal communication. 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 (Hammond *et al*. 2001, 2002, 2003, 2004, 2005); 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) include 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.

Research effort in the effects of anthropogenic noise on marine mammals has concentrated on seismic exploration, with a particular focus on baleen whales. However, it is increasingly clear that airgun arrays produce significant energy over the frequency range in which behavioural audiograms suggest that dolphins are most sensitive. Behavioural responses to anthropogenic noise have generally been studied by visual or acoustic monitoring of abundance. Visual monitoring of cetaceans during seismic surveys has been carried out for several years throughout the UKCS. Statistical analysis of 1,652 sightings during 201 seismic surveys, representing 44,451 hours of observational effort, was reported by Stone (2003). 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. 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 and sperm whales showing no observed effects.

There have been far fewer studies of marine mammal responses to continuous drilling noise (Richardson *et al*. 1995), with most available data relating to baleen whales. Sorensen *et al*. (1984) observed distributions of a similar range of small cetacean species to that found around the proposed well location (including common, Risso's, bottlenose and *Stenella* dolphins), in the vicinity of drilling activities off New Jersey, and reported no difference in sightings per unit effort with and without the presence of rigs.

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. As the limited evidence for this mechanism is limited to military sonar sources, concerns that the cumulative effect of sequential seismic surveys could act as a barrier to migration are probably more meaningful in an SEA context. For example, in relation to the Atlantic Margin area 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 1 µPa, would form a "virtually unbroken barrier to any marine mammal wishing to move north-south along the shelf edge". However, there is currently no data suggesting that broadscale marine mammal distribution patterns have been influenced by historic seismic activity...

In addition to marine mammals, effects of noise are possible in other species. Many species of fish are highly sensitive to sound and vibration (reviewed by MMS 2004), and effects on fishing success ("catchability") have been demonstrated following seismic survey ((Pearson *et al*. 1992, Skalski *et al*. 1992, Engås et al. 1993). MMS (2004) consider that the "consensus is that seismic airgun shooting can result in reduced trawl and longline catch of several species when the animals receive levels as low as 160 dB". However, no associations of lower-intensity, continuous drilling noise and fishing success have been demonstrated, and large numbers of fish are typically observed around North Sea and other production platforms.

Planktonic and benthic invertebrates generally do not have gas-filled body cavities and are considered less susceptible to acute trauma and behavioural disturbance resulting from noise and vibration. Cephalopods, with a well-developed nervous system and complex behavioural responses, are a possible exception (although they lack resonating structures analogous with the middle ears, lungs, tracheal cavities and sinuses of mammals).

Both **planning and operational controls** cover acoustic disturbance resulting from seismic surveys and other E&P activities on the UKCS. Regulation 10 of *The Offshore Petroleum Activities (Conservation of Habitats) Regulations 2001* - now amended by the *Offshore Petroleum Activities (Conservation of Habitats) (Amendment) Regulations 2007*, to include all areas within territorial waters – 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. Application for consent to conduct seismic and other geophysical surveys 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 are conducted prior to issuing consent, and JNCC may request additional risk assessment, specify timing or other constraints, or advise against consent.

Any proposed activity with a potential acoustic impact within a designated SAC or SPA would also be subject to the requirement for Appropriate Assessment under the *Conservation (Natural Habitats, &c.) Regulations 1994* which apply within territorial waters.

The major operational 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 200*4). These were originally introduced on a voluntary basis as part of the UK's commitment under ASCOBANS, but have subsequently been required by licence conditions and through the PON14 approval process. The guidelines were initially prepared by a Working Group convened at the request of the Department of the Environment, developed from a draft prepared by the Sea Mammal Research Unit (SMRU). The guidelines have subsequently been reviewed three times by the Joint Nature Conservation Committee following consultation with interested parties and in the light of experience after their use since 1995.

Under the Guidelines there is a requirement for visual monitoring of the area by a dedicated Marine Mammal Observer (MMO) 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. Passive Acoustic Monitoring (PAM) may also be required. In general, the guidelines appear to be reasonably effective.

Update on effects consideration

The above consideration of effects, based on previous SEAs, can be updated by a number of supplementary studies and sources of information.

The difficult issue of determining when noise causes biologically significant effects in marine mammals has been addressed by NRC (2005). This clarifies the term *biologically significant* in the context of the US Marine Mammal Protection Act (MMPA), which considers two levels of harassment – level A and level B harassment (in turn specified by National Marine Fisheries Service (NMFS) criteria as noise pressure thresholds of 180 and 160 dB re 1 μPa rms respectively). NRC (2005) describe a conceptual model framework that identifies the different stages required to move from marine mammal behaviour to a determination of population effects of behavioural change. The proposed model first characterises an acoustic signal, the resulting behavioural change, and a determination of the "life function" or activity affected. It then describes the resulting change in vital rate, such as life span, and finally suggests population effects – effects on following generations. A series of recommendations were made to assist in further development and implementation of the model:

- Completion of previously identified high-priority research
- Further model development including sensitivity analysis
- Development of a centralised database of marine mammal sightings and responses to anthropogenic sound (in the US)
- Development of methods, including using glucocorticoid and other serum hormone concentrations, to assess stress
- Intensive exploratory modelling effort to develop a series of individual-based models and stage- or age-structured demographic models for selected species
- Development of a practical process – similar to the NOAA Fisheries Potential Biological Removal (PBR) model to help in assessing the likelihood that specific acoustic sources will have adverse effects
- Improvement of the PBR model to reflect total mortality losses and other cumulative impacts more accurately
- Development of an intelligent-decision system to determine a de minimis standard for allowing proposed sound-related activities.

In a paper presented to the twenty-second annual Gulf of Mexico Information Transfer Meeting, Nedwell *et al*. (2003) reported on measurements of noise from a 3D seismic survey in the northern North Sea (block 14/4), including an assessment of the effectiveness of soft-start. The quantitative results of this study generally supported the assumptions typically used in propagation modelling. Axial directivity of the array (14 gun, 3335 cubic inch firing flip-flop) was around 10dB, with linear propagation approximated reasonably well by a 25.35 log [R] curve. Extrapolation of measured sound pressures indicated a source level of 262 re 1µPa @1m, higher than expected. This apparent discrepancy was attributed to either non-linear range effects, or to sound trapping in a surface channel.

A significant degree of scattering of measured sound levels, over a range of 10dB, was noted including non-systematic differences between approach and retreat of the array from the measurement location attributed to spatial or temporal inhomogeneities of the sea. Measurement during soft-starts, achieved by gradual increase in the number of airguns being discharged, showed a fairly consistent relationship between the total volume discharged by the array and the resulting level of sound. Frequency-weighting of received sound using an audiogram for harbour porpoise (i.e. emphasising high frequencies) increased the observed scatter in weighted levels, due either to variability in propagation or variability in array characteristics. Nedwell *et al*. (2003) conclude that their results indicate that at the measured range, the effectiveness of the soft start procedure (as perceived by marine mammals) is masked by the random variability in received level.

The Inter-Agency Committee on Marine Science and Technology (IACMST) working group on Underwater Sound and Marine Life reported in August (2005). This report made recommendations on steps needed to achieve a well-justified regulatory framework for controlling the generation of sound in the UK marine environment. These included:

- To authorise through the appropriate authorities the careful and well planned use of Controlled Exposure Experiments, which have the potential to yield much needed quantifiable information on the effects of different sound sources on marine animals.
- To better inform the framing of future regulation, systematic and comprehensive mapping of noise in the ocean at appropriate space/time resolution needs to be undertaken.

- In consultation with stakeholders, Government needs to establish standardised protocols for testing the extent to which sources radiate sound in the marine environment. This needs to include a system for depositing data in appropriate formats so that they can be used in future models predicting ambient noise in the oceans.
- A Marine Environmental Noise Assessment for UK waters should be undertaken and permits for activities that generate noise should be issued within it.

In May 2006, a new research programme was started by the International Association of Oil and Gas Producers (OGP) under the title Joint Industry Programme (JIP) "E & P Sound and Marine Life". Initial direct funding of at least US$ 5 M per year has been committed by the JIP partners and to date, 34 research topics have been proposed based on knowledge gaps identified by international workshop in Halifax, September 2005. Research topics under consideration include:

- **Category 1, Sound Source Characterization and Propagation**: Detailed information on characteristics of sound sources and improved models of sound transmission and Propagation
- **Category 2, Physiological Effects (Auditory and Non-Auditory):** Greater understanding of the potential impacts of sound sources on the hearing ability of animals, as well as the potential to stress and damage non-auditory tissues, such as lungs or fish eggs
- **Category 3, Behavioral Reactions:** Greater understanding of the behavioral responses of animals to different sound sources, as well as their perception and sensitivity, and the potential effects of auditory masking Audiograms – Small Cetaceans and Pinnipeds
- **Category 4, Mitigation and Monitoring:** Development of alternative sound sources or operating procedures that would lessen risk for acoustic impacts on marine animals, and research to evaluate, improve, or develop new mitigation methods or monitoring techniques
- **Category 5, Research Tools:** Need for new or updated equipment or techniques to improve research data collection or monitoring efficacy
- **Category 6, Biological Significance**: Greater understanding of the potential for effects from sound on behaviour, physiology, and reproduction to impact marine species at the population level
- **Category 7, Cumulative Effects:** Greater understanding of the long-term effects of exposure to sound from E & P operations on marine animals, with an understanding of synergistic effects from other anthropogenic environmental stressors

SEA 7 specific consideration

The most likely dominant noise sources across the SEA 7 area were mapped by Harland & Richards (2006), based on the information gleaned during this study, from the experience of the authors when working in the SEA 7 area and from a much wider experience of studying the various sources of ambient noise over many years of sonar trials. Figure A11.c.4 represents the situation at low wind speeds and no precipitation noise. Shipping noise is likely to dominate across large parts of the SEA 7 area, including the shipping lanes which pass through the region and also the shelf edge, which is where fishing activities are likely to be most prevalent. The overall noise field from the fishing gear consists of low frequency noise from the rollers, mid and high frequency noise from the general disturbance of the seabed and high frequency noise from the chains. No published information on absolute levels or typical spectra has been found. No appropriate statistics on fishing activity were available during the preparation of this report to judge the level of the impact of this noise source. Personal observation by Harland & Richards (2006) indicates that trawling noise has been tracked on military sonars at ranges in excess of 8 km along the shelf-edge to the west of the Hebrides.

In addition there are a number of ferry routes operating between the Hebrides and the mainland which will also contribute to the local shipping noise.

The shoreline is likely to be dominated by surf noise in those areas where there is a shoreline. Because of the exposure to waves coming in off the Atlantic, it is likely that shore and surf noise will be a major contributor to ambient noise in coastal waters in the SEA 7 area. The noise will mostly be impact noise as the wave hits the rocks, spray noise as the water falls back onto the sea, bubble oscillation noise and some limited sediment transport noise.

Data from a series of automated recording units (ARUs) deployed within the SEA 7 area indicated considerable temporal and spatial variability in ambient noise, as reported by Harland & Richards (2006) and summarised in Appendix 3.

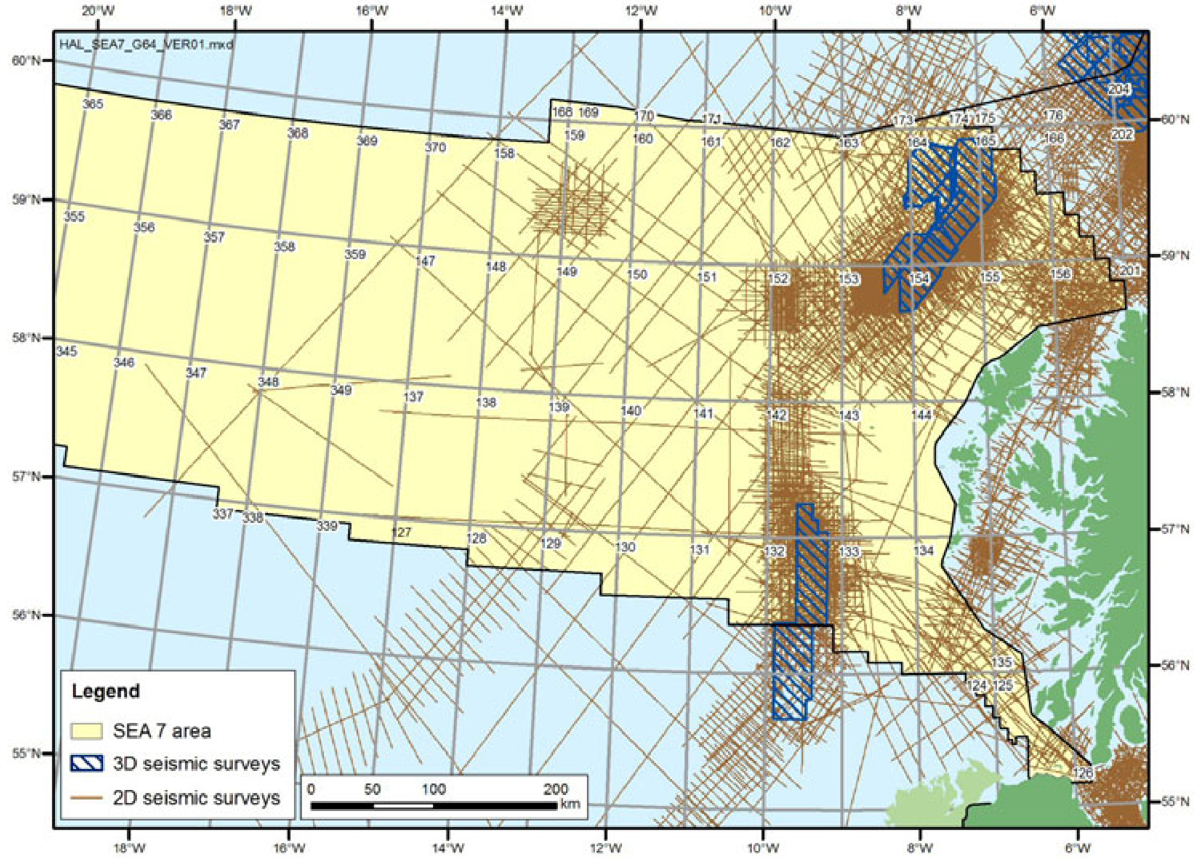
The deep water SEA 7 area is particularly prone to reverberation due to scattering from the edge of the continental shelf, the Wyville Thomson Ridge, the Rockall Bank and seamounts. At the low frequencies used by seismic exploration and some military sonars this can cause the build-up of reverberation leading to the masking of lower level sounds.

Activity scenarios for potential licences in the SEA 7 area assessment involve the possibility of 2500-5000 km 2D seismic (2 surveys) and 500-2000 km^2 3D seismic (2-8 surveys) in area 1 (a southward trend from the Benbecula gas accumulation to the Dooish well, water depths 700-2000m). Estimated activity in other parts of the SEA 7 area is limited to a very small amount in area 2 (previously licensed acreage), and 2500-5000 km 2D in area 4 (deepwater SEA 7); although it is possible that high-take-up of Frontier licences might increase this effort.

As context, a total of seven 3D seismic surveys are recorded by the DEAL database from the SEA 7 area, all conducted in 1997 and 1998. Spatial coverage and duration are not recorded consistently, although the total coverage is of the order of 8500 km^2 (Figure A11.c.5). A significant amount of 2D seismic has also been shot in the SEA 7 area under existing exploration and production licences, although recent activity (since 1998) has been relatively low.

The maximum forecast seismic activity is therefore substantially less than the total coverage of previous seismic in the SEA 7 area to date. All scenario areas have experienced previous seismic activity, although this is sparse in area 4.

Figure A11.c.5 – Previous seismic survey coverage in the SEA 7 area



Marine mammal distributions in the SEA 7 area are reviewed in section 4.2 and Appendix 3a.1.7 (both based on supporting technical report Hammond *et al*. 2006), with a general distinction, in terms of species composition, between shelf and deep-water species. However, both species groups are considered important in a national and international context for marine mammals (Reid *et al*. 2003). To the south of SEA 7, a similar assemblage of species with the same habitat preferences were recorded off the west coast of Ireland by Ó Cadhla *et al*. (2004) and Wall *et al*. (2006).

Delphinid species such as white-sided dolphins, white-beaked dolphins, common dolphins, and long-finned pilot whales can also be detected acoustically during passive acoustic surveys for cetaceans (Hammond *et al*. 2006). It is, however, very difficult to determine species from their vocalistions. In opportunistic surveys carried out to the north and west of Scotland from oceanographic and fisheries survey vessels since December 2000, delphinid species were heard throughout the survey area, though concentrated away from shore. Opportunistic sightings during the surveys suggest that white-beaked dolphins are concentrated to the north of the Outer Hebrides, whereas white-sided and common dolphins are found throughout the area. Opportunistic sightings of long-finned pilot whales were recorded in the deep waters of the Faroe-Shetland Channel, and frequently in deep waters to the west of the shelf edge.

Sperm whales are regularly sighted in deep waters beyond the shelf break and it is likely that SEA 7 covers a migratory route for some portion of the North-eastern Atlantic sperm whale population at times of the year. In addition, passive acoustic surveys have been carried out from herring abundance surveys on the shelf waters from west of Coll and Tiree to the west of the Orkneys. Sperm whales were found to be common in the deeper waters to the west of the shelf edge, with much higher numbers in May than in October between the Faroes and the Shetlands (Hastie *et al*., 2003), though large numbers were found in deep waters further south (in the Rockall Trough) in October 2005.

The two-year AFEN-funded study of blue, fin and humpback whale vocalisation in the SEA 1, 4 and 7 areas (and south to the Bay of Biscay) indicated that all three species displayed distinct seasonal cycles (Clark and Charif 1998, Charif and Clark 2000). Fin whale signals were the most frequently detected calls, occurring in all months but with highest vocal activity between October and January and minimal levels between May and July. Peak detection of blue whales was between November and December, and minimal between March and June. Humpbacks were the least frequently detected species, occurring mainly west of Britain and Ireland between October and April. The data suggested a north to south progression in peak humpback vocal activity from early January to mid-March; coupled with data on individual humpbacks tracked for periods of several hours, this suggests a late-winter/early-spring southward migration of singing humpbacks through the SEA 1, 4 and 7 areas. Seasonal sightings data west of Britain also suggests migratory movements in the north-east Atlantic, similar to those known in the north-west Atlantic (Weir *et al*. 2001). Acoustic data did not suggest any such systematic seasonal migration for blue or fin whales; and there was no apparent response in terms of vocalisation with the 3D seismic surveys which were undertaken in the SEA 7 area during the study period. This data was collected using naval bottom-mounted hydrophone arrays (SOSUS arrays), between October 1996 and September 1998, and in view of known changes in planktonic and fish communities over decadal periods, it would be beneficial to update acoustic monitoring data for large whales in this area. MacLeod *et al*. (2005) have concluded, on the basis of cetacean strandings in north-west Scotland from 1948-2003, that changes in the local cetacean community (before and after 1988) are being driven by increases in local water temperature. A visual and acoustic survey of offshore waters of the European margin including much of the SEA 7 area (CODA, Cetacean Offshore Distribution and Abundance) is due to start in July 2007. Target species include common dolphin, bottlenose dolphin and deep diving species. However, the SOSUS data would complement this and provide a direct temporal comparison with existing data.

The shelf waters west of the Outer Hebrides are extensively used by grey seals, and there are “hot spots” on Stanton Bank to the south of Barra, waters to the west of Islay and Jura, and waters east of Lewis. Because of limited data on numbers of seals around offshore islands, estimates of usage around St Kilda, the Flannan Isles, North Rona and Sula Sgeir may not be very accurate. The SEA 7 shelf is clearly very important as foraging habitat for the large numbers of grey seals hauling out in the Inner and Outer Hebrides. The waters of the Minch and the Hebridean Sea are known to be important foraging areas for the large numbers of harbour seals in the SEA 7 area, and there are also haul-outs in sheltered areas on the west side of the Outer Hebrides (for example Loch Roag and the Sound of Harris). Hooded seals are known to forage in deep offshore oceanic waters along and off the continental shelf in the SEA 7 area, but there is no current estimate of the size of the population using the area.

Given propagation characteristics, it is likely that the predicted seismic survey activity will ensonify most of the marine mammal habitat between the Rockall Bank and Western Isles.

In relative terms, and in the overall context of the UKCS, the sensitivity of much of the SEA 7 area to acoustic disturbance is high or very high. In contrast to inshore areas such as Shetland, Orkney, the Moray Firth and Cardigan Bay where in many cases the local distributions of marine mammals are known to be linked to topographic or hydrographic features, the distributions of deep-water species may be widely dispersed (with the probable exception of a large-scale linear distribution along the shelf edge). Hastie *et al*. (2005) have demonstrated that patterns of distribution of dolphins (mainly Atlantic white-sided dolphin) in the Faroe Shetland Channel are closely linked to the bathymetric regime within the area. A model created using data collected during 2001 suggests that “water noise level” (qualitatively assessed), time of day, survey month, water depth, and surface temperature are all significant predictors of dolphin distribution. However, these factors did not vary in a way which suggests localised patterns of spatial usage.

The balance of evidence suggests that effects of seismic activities are limited, in species present in significant numbers within the SEA 7 area, to behavioural disturbance which is likely to be of short duration, limited spatial extent and of minor ecological significance. The numbers of individuals likely to be influenced represent a small to moderate proportion of biogeographic populations. Existing control and mitigation methods are probably generally effective in preventing physical damage.

The proposed seismic activity levels are similar to those previously undertaken in the area, which are not known to have resulted in significant environmental effects.

However, the potential significance of the prospective parts of the SEA 7 area to migrating species (principally humpback whales) and species characteristic of the shelf edge (principally beaked and pilot whales) should be recognised in the management of seismic surveys through the PON14 process (see below).

Other sources of noise from exploration and production produce continuous noise at lower source levels, which are unlikely to have a significant effect on marine mammal populations.

Local, short-term effects of seismic surveys on other activities, such as fishing catch rates, are hypothetically possible. However, potential acoustic effects are likely to be overshadowed by the required physical exclusion of fishing activities in the vicinity of seismic operations, this process is mitigated and managed through established procedures.

Conclusions and data gaps

A number of specific concerns in relation to noise disturbance and marine mammals are identified below:

- limited, and potentially dated, information concerning large whale distributions, and the significance of the SEA 7 area in biogeographic terms (i.e. as a migration route)
- coincidence of the predicted area of maximum seismic effort, with the shelf edge habitat particularly utilised by beaked and pilot whales, also by common dolphins. This issue is linked to a significant lack of population and ecological information in relation to beaked whales (especially in relation to localised distributions and temporal variability); together with suspected sensitivity of these species to noise disturbance (in relation to active military sonar systems), probably as a result of physiological responses to deep-diving.
- the tendency for periods of high seismic survey activity associated with licensing rounds (e.g. the intense 3D seismic coverage in 1997-1998 which followed the 17th Round); interspersed with periods of relatively low activity. The relative merits of a more “spread-out” dose are unknown (see below).
- Although relatively sparsely distributed, the population sizes of most cetacean species in the SEA 7 area may be comparable to (or substantially higher than) inshore populations recognised by conservation designations under the Habitats Directive. For example,

Gunnlaugsson and Sigurjónsson (1990) estimated a minimum population size of 308 sperm whales for waters around the UK and the Faroe Islands, approximately equivalent to the combined populations of bottlenose dolphins in the Moray Firth and Cardigan Bay SACs. (However, the mean estimate of Hastie *et al*. (2003) for sperm whale density in the Faroe Shetland Channel, based on acoustic detection, was almost exactly the same as a recent mean density estimate for the 25% of the worlds oceans that have been visually surveyed (Whitehead and Planck 2002), suggesting that there is little basis for site selection in this species). Minimum numbers of fin whales detected by SOSUS data (i.e. vocalising) in the B1 and B2 regions, corresponding approximately to the SEA 7 area, were of the order 5-10 individuals (Charif and Clark 2000) – of dubious consistency with an estimated North Atlantic population of 47,300 (Buckland *et al*. 1992). There have, as yet, been no credible estimates of cetacean population numbers in the SEA 4, 7 and 8 areas, which would be required as a basis for consideration of the requirement for further conservation designations.

- It may be noted that the Irish government has declared all Irish waters (within the EEZ) to be a whale and dolphin sanctuary in 1991 (Rogan and Berrow 1995), although it is less clear what regulatory powers this provides. In the UK, the PON14 process provides an effective basis for prohibition and regulatory control over seismic surveys where appropriate.

- To date, lack of progress with research concerning potential effects and mitigation of seismic – with the exception of increased use of Passive Acoustic Monitoring (PAM). Recommendations of various initiatives described above are similar to those identified by previous SEAs, with little progress in implementing studies to address identified gaps in understanding. It is expected that the CODA and OGP Sound and Marine Life programmes will make substantive progress in the next few years.

- As noted above, understanding of ambient noise is limited and recommendations were made by Harland *et al*. (2006) for further field measurement and modelling. However, the issue of anthropogenic ambient noise involves many industrial sectors (e.g. fishing and shipping) and would be best addressed through a cross-sectoral initiative – as recommended by the IACMST (2005) study. Current understanding is considered adequate for the purposes of this SEA.

Previous SEAs have identified data gaps and made recommendations for research and mitigative measures, including acoustic research on cetacean distribution and passive acoustic monitoring prior to, and during surveys. It has also been previously recommended that consideration should be given to establishment of criteria for determining limits of acceptable cumulative impact; and for subsequent regulation of cumulative impact (for example, in terms of total "exposure days" of individual blocks to received levels in excess of 120 dB). A similar acoustic dose concept was recommended for the SEA 7 area – particularly the deep water part – by Harland & Richards (2006). As noted above, the merits of a limited acoustic dose approach, in contrast to a shorter period of intense activity, are unknown. It is noted that the DTI seek advice from JNCC during the consenting process for seismic surveys.

Previous SEAs also noted the widespread consensus in the academic community that controlled exposure experiments represent the most objective approach to reducing uncertainty in assessing acoustic effects on cetaceans; despite considerable practical and ethical difficulties (Tyack et al. 2004, Hammond *et al*. 2004). Within appropriate international collaborative frameworks, such as the OGP Sound and Marine Life programme, it is recommended that UK Government and industry support and participate in this approach, in order to maximise the relevance of resulting information to UK habitats and species (cf. MMC 2007). A similar recommendation, "to authorise the careful and well planned use of Controlled Exposure Experiments, which have the potential to yield much needed quantifiable information on the effects of different sound sources on marine animals", was made by IACMST (2005).

A11.c.3 Physical damage to features and biotopes

Introduction

Several activities associated with exploration and production can lead to physical disturbance of seabed habitats, with consequent effects on benthic communities and potentially on archaeological artefacts. The main sources of disturbance are:

- Anchoring of semi-submersible rigs
- Placement of jack-up rigs (seabed disturbance by spud cans)
- Wellhead placement and recovery
- Production platform jacket installation and piling
- Subsea template and manifold installation and piling
- Pipeline, flowline and umbilical installation and trenching
- Decommissioning of infrastructure

Summary of effects considerations from previous SEAs

Previous SEAs have compared the disturbance effects of oilfield activities to those of fishing and natural events (e.g. storm wave action), concluding generally that oilfield effects are minor on a regional scale. It is generally accepted that the principal source of physical disturbance of the seabed and seabed features, is trawling. Trawl scarring is still effectively unregulated in the UK and is a major cause of concern with regard to conservation of shelf slope habitats and species (e.g. Witbaard & Klein 1993, de Groot and Lindeboom 1994, Jennings and Kaiser 1998, Kaiser *et al*. 2002a, Kaiser *et al*. 2002b). Estimates of the intensity of trawling disturbance, and of the resilience and recovery timescale of benthic communities, vary for different parts of the UKCS, although for context a conservative estimate of the scale of effect (assuming a fishing effort of 2000 hours per year per 0.5º ICES rectangle, average trawl speed of 4 knots, twin scars from trawl doors, 1m scar width; neglecting clump weights used in twin-trawl gears) is of the order of several billion square meters per year of trawl scar in the North Sea.

On the basis of known fishing activities, trawl scarring is likely to be present over much of the UKCS seafloor; with the effects of scallop dredging particularly significant in shallow water (since the gear is more damaging and sensitive habitats – such as biogenic reef – may be affected). Trawling in very deep water (>1000m) requires heavy gear, including clump weights of several tonnes, and may therefore also be more damaging than typical whitefish or *Nephrops* trawling. Trawl / dredge scarring is evident in sidescan coverage acquired from all previous SEA areas.

Although the depth of sediment over-turned (and possibly therefore the recovery timescale) of E&P activities may be greater; and it is also possible that fishing effort may reduce in future; the contribution of E&P on the UKCS to cumulative disturbance of the seabed (of the order of 0.1-1% of fishing-related disturbance) is not considered likely to be generally significant.

In general, effects on benthic populations and communities may result from smothering which can be direct (from physical disturbance or discharges of particulate material) or indirect (from winnowing of disturbed material). Habitat recovery from the processes of anchor scarring, anchor mounds and cable scrape will depend primarily on re-mobilisation of sediments by current shear. On the basis that seabed disturbance is qualitatively similar to the effects of wave action from severe storms; it is likely that that sand and gravel habitat recovery from the processes of anchor scarring, anchor mounds and cable scrape is likely to be relatively rapid (1-5 years) in most of the shallower parts of the UKCS. Muddier sediments support benthic communities characterised by the presence of large burrowing crustaceans and pennatulid sea-pens (*Virgularia mirabilis* and *Pennatula phosphorea*). Pennatulid mortality is probably high following physical disturbance, although crustacea are probably able to restore burrow entrances following limited physical disturbance of the sediment surface (a few cm). However, mud habitats are probably more sensitive to physical disturbance than coarser sediments typical of high wave- and current-energy areas.

Herring are demersal spawners and dependant on localised areas of suitable substrate (in relatively shallow water); herring eggs are believed to be particularly susceptible to smothering, and there has therefore been a requirement for many years that potential herring spawning areas are identified by sidescan sonar and seabed sampling in advance of drilling and development; and that appropriate mitigation such as timing and/or avoidance of specific areas is undertaken with the prior approval of regulatory agencies.

In addition to the potential effects of smothering, sediment plumes in the water column and settling to the seabed from construction activities and pipeline trenching activities can potentially result in effects on pelagic and benthic biota through clogging of feeding mechanisms, temporarily altering the nature of the seabed sediments or in near surface waters, reduction of light for photosynthesis (Newell et *al.* 1998). The extent of effects will vary according to the frequency of occurrence and the tolerance of the species involved, itself a function of the average and extreme natural levels of sediment transportation/deposition experienced in an area. Near-bed concentrations of suspended particulate material (SPM) in coastal and southern North Sea areas are high, and the effects of anthropogenic sediment plumes are unlikely to be significant or long-term.

On the UKCS, habitats which potentially qualify as reefs under the Habitat and Species Directive Annex I are associated with several species: blue mussels *Mytilus edulis*, horse mussels *Modiolus modiolus*, ross worms *Sabellaria* spp., the serpulid worm *Serpula vermicularis*, and cold-water corals such as *Lophelia pertusa*. These habitats may be vulnerable to physical damage and smothering. In the case of designated, proposed or candidate Natura 2000 conservation sites (including potential offshore sites which may be designated in future), existing controls include the requirement for an Appropriate Assessment before consent for the proposed activity can be given.

Oil and gas activities also have the potential to damage archaeological artefacts and sites, in particular through the trenching of pipeline into the seabed and through rig anchoring. However, in addition to the potential for damage, oil and gas activity is also recognised to present the opportunity to provide beneficial new archaeological data, for example through rig site or pipeline route mapping and sediment coring. Flemming (2005) therefore suggested that rather than seeking to prevent or limit oil and gas activities, “it is therefore in the interests of long term preservation of the archaeological sites, and in the interests of acquisition of archaeological knowledge, that we use industrial and commercial activities as a means of identifying archaeological prehistoric sites in the offshore area". The recognition of the importance of prehistoric submarine archaeological remains has led to a number of recent initiatives.

A legal and policy framework for protection of maritime archaeology is in place. Guidance notes for the aggregates industry have been formally published (BMAPA and English Heritage, 2003) covering legislation, statutory controls, possible effects of aggregate extraction, obtaining archaeological advice, application procedures, assessment, evaluation, archaeological investigation, mitigation, and monitoring. Flemming (2005) suggested that an equivalent guide could be produced for the offshore oil and gas industry and its contractors.

Update on effects consideration

The environmental impacts of trawling continue to be catalogued from a range of seabed habitats around the world (e.g. Mediterranean – Smith *et al*. 2000; Clyde Sea area – Hauton *et al*. 2003; Australian seamounts – Koslow *et al*. 2001; New Zealand seamounts – Clark & O'Driscoll 2003, Campbell & Gallagher 2007). However, implementation of effective mitigation measures is proving difficult at either a national or international scale (Gianni 2004, UNEP 2006).

SEA 7 specific consideration

In general, water depths in prospective parts of the SEA 7 area indicate that jack-up drilling rigs would not be used, leaving anchor scarring and disturbance of the immediate wellhead area as the most likely sources of disturbance from exploration activities. The scale of these disturbances is minimal, and they are most likely to occur on the widespread, homogenous sediments of the continental slope. Slope sediments consist of well-sorted sand contourites with linear bedforms indicative of bed transport by the slope current; the persistence of physical disturbance features is therefore likely to be comparable to shelf locations.

Potential reef habitat is predominantly associated with banks and seamounts, which are of low prospectivity and unlikely to be influenced by well locations

Trawl scarring and damage has been widely reported from the SEA 7 area and adjacent north-east Atlantic (Bett 2000, see Figure A11.c.6), including damage to the Darwin Mound area (Johnston & Tasker 2002, see Figure A11.c.7) and other sediment and reef habitats (e.g. Roberts *et al*. 2000, Hall-Spencer *et al*. 2002, Gage *et al*. 2005, Wheeler *et al*. 2005). The intensity of trawling in the SEA 7 area is unclear, but from studies conducted on the Hebrides slope off Scotland, trawling marks are clearly visible in 2 – 12 % (Roberts *et al*. 2000, see Figure A11.c.8) and 5 - 47 % of seabed photographs (Lamont & Gage 1998). In the context of this level of effect, exploration activities are likely to have a beneficial (through exclusion of fishing) rather than detrimental influence.

Figure A11.c.6 – Schematic representation of box core sample (AFEN station 54538#2, site L4, water depth 500m) showing the apparent impact of deep-sea trawling on the seabed and its fauna. Source: Bett 2000

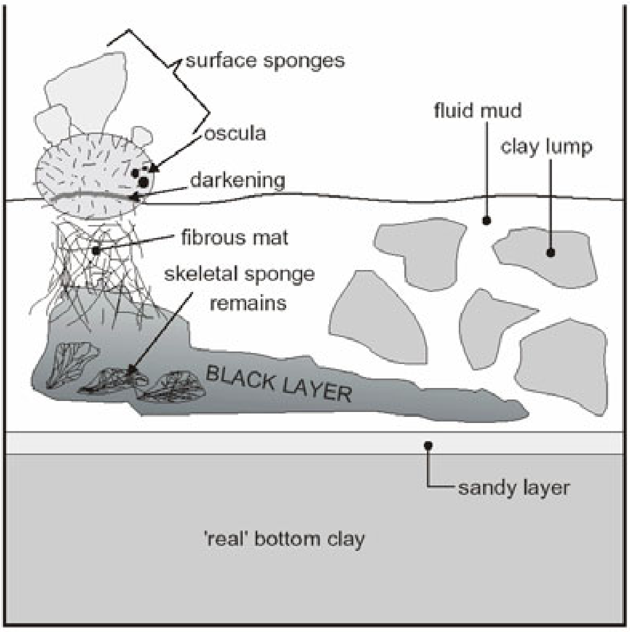


Figure A11.c.7 – Sidescan image of individual Darwin Mound (c. 70m diameter) believed to show the effects of deep sea trawling. Dark areas represent Lophelia colonies and are much reduced, and there are clear streak-like, linear marks believed to be left by a trawl. Source: Johnston & Tasker 2002

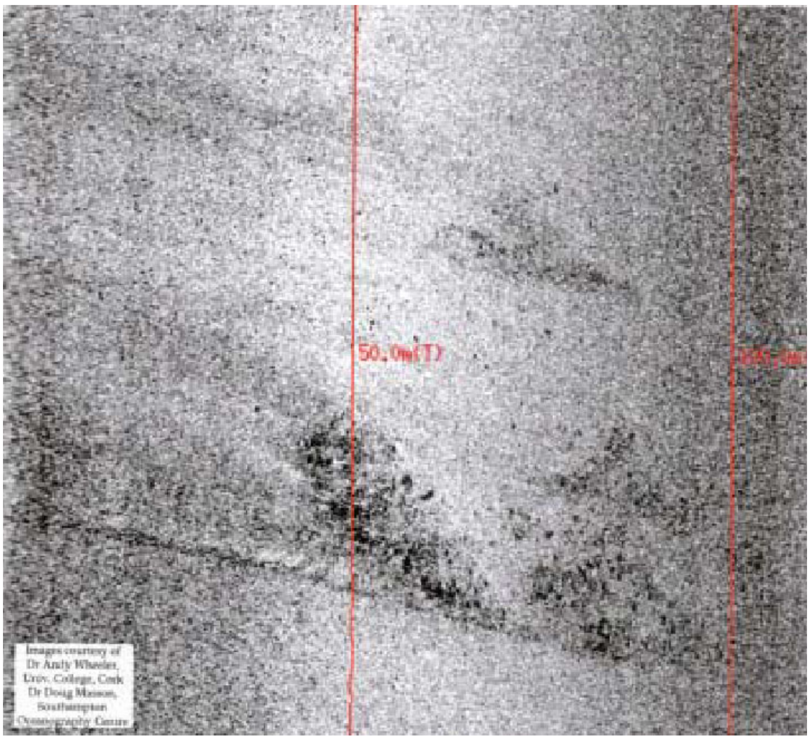
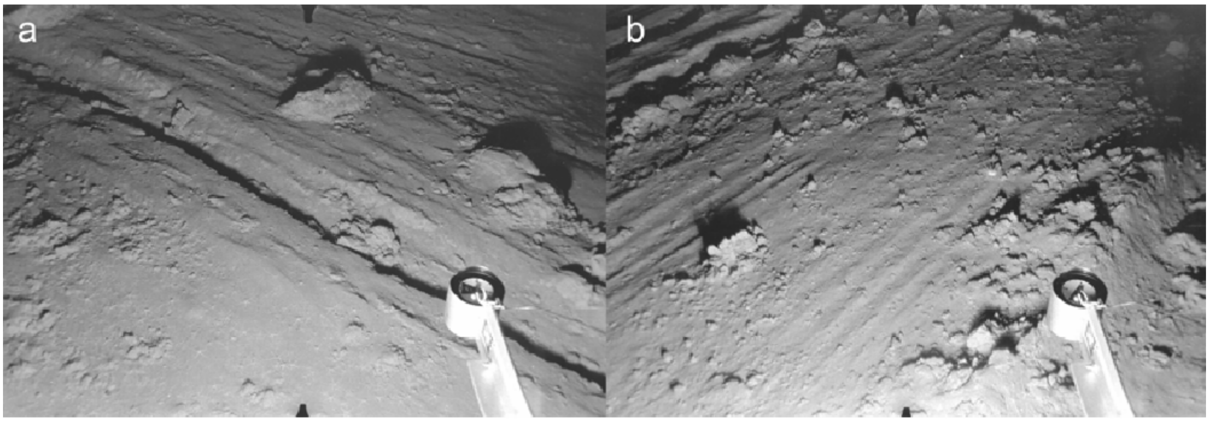


Figure A11.c.8 – Trawl marks at 885m depth from the Hebrides Slope in 1988. a) trawl scar about 25cm wide and 8cm deep. b) trawl scars and scattered sediment. Source: Roberts et al. 2000



Conclusions and data gaps

Physical disturbance resulting from proposed SEA 7 activities will be small in scale and duration, in comparison to natural disturbance and the effects of demersal fishing, and will be mitigated by existing regulatory mechanisms.

The broadscale distribution of biotopes of conservation importance on the continental shelf and slope is relatively well mapped, and sufficient information is available to assess the probability of sensitive habitats in proximity of proposed activities. Similarly, specific projects can be assessed in terms of likelihood of occurrence of significant archaeological features. In both cases, however, detailed site surveys (which are routinely acquired prior to drilling or development operations) should be evaluated with regard to environmental and cultural sensitivities. Where the likelihood of sensitive features is high, the scoping of site surveys should be reviewed by relevant conservation and heritage agencies.

However, west of 14 degrees west there is a paucity of information on many potentially vulnerable components of the marine environment; and the analysis of SEA collected seabed data on carbonate mounds and coral reefs in the area and hence potential designation of areas as Natura 2000 sites is not yet complete. The offer of licences east of 14 degrees west is supported since there is relatively more data available including that generated during past seismic and drilling activities in the area.

A11.c.4 Physical presence

The potential interactions between oil and gas activities and other users of the sea, in particular fishermen and shipping, together with the various mitigation measures were described in detail in the SEA 5 Environmental Report (Section 10.3) and these are not reiterated here. Three additional aspects are considered in the following sections.

Marine spatial planning

In the context of moves towards marine spatial planning for marine environmental management the potential interactions of activities that could follow further oil and gas licensing are considered below. Within the SEA 7 area the location of hydrocarbon prospectivity is well offshore and the number of other users of the area is limited. Consequently, no significant interactions are predicted; any that do occur can be expected to be mitigated through normal notification and communication channels. In some previous SEA areas (particularly SEA 3, 5 and 6) there is the potential for overlap in the areas of interest for hydrocarbon and windfarm (and other renewable energy) developments. However, since the regulator for both industries in England and Wales is the DTI, and there is good liaison with the Scottish Executive on renewable energy developments in the waters adjacent to Scotland, such potential conflicts as may occur can be expected to be resolved at the licensing/leasing and project approvals stages. In advance of any potential future marine spatial plans, there are already a number of areas (such as shipping traffic separation schemes, and air exclusion zones) where other potential activities may be curtailed in the interests of navigation safety. Such areas are already considered by the DTI in consultation with other government departments/agencies during the licensing process. As a result certain blocks (or parts of blocks) are already excluded from licensing or have stringent activity restrictions placed on them (e.g. no exploration drilling may be undertaken from within the block). The anticipated spatial focus and scale of exploration activity (and likely methods of development) are such that limited interaction is predicted with other existing or potential uses of the sea.

Visual intrusion

In view of the offshore location of the SEA 7 area hydrocarbon prospectivity, significant visual intrusion would not occur as activities would be well beyond sight of land. E&P activity supply and support vessel traffic would represent a minor increment to existing vessel traffic in coastal and offshore waters.

Ecological interactions

Physical presence of infrastructure and support activities may cause behavioural responses in fish, birds and marine mammals. The majority of such interactions (whether positive or negative) are viewed as insignificant.

The physical presence of structures in the sea provides hard surfaces for biological colonisation. The development and succession of this fouling growth on North Sea production platforms has recently been summarised by Whomersley & Picken (2003) and similar patterns can be expected in the majority of SEA areas, including SEA 7, based on the intertidal and shallow subtidal biological communities recorded at St. Kilda and Rockall. Fouling growth can result in a number of subtle ecological impacts (e.g. enrichment) in the vicinity of the structure but these are not regarded as significant effects.

Conclusion and data gaps

The UK oil and fishing industries have successfully co-existed for over 30 years. Although exclusion could represent a significant conflict between fishing and hydrocarbon 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 occur during seismic survey and pipeline construction, although in view of the predicted level of activity in the SEA 7 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.

No significant visual intrusion is predicted based on the anticipated location and scale of activities.

A11.c.5 Marine discharges

Introduction

As described in previous SEAs, marine discharges from exploration and production activities include produced water, sewage, cooling water, drainage, drilling wastes and surplus WBM, which in turn may contain a range of hydrocarbons in dissolved and suspended droplet from, 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 infrastructure (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).

Discharges from offshore oil & gas facilities have been subject to increasingly stringent regulatory controls over recent decades, and oil concentrations in the major streams (drilling wastes and produced water) have been substantially reduced. However, due mainly to increasing water cut from mature reservoirs, and the use of water injection to maintain reservoir pressure, the total volume of produced water discharges on the UKCS has increased and is expected to continue to increase in the foreseeable future (DTI website http://www.og.dti.gov.uk/environment/index.htm).

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 SEAs 2 and 3 and are not repeated here.

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. Water-based mud 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. 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 waste material.

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.

Summary of effects considerations from previous SEAs

Produced water

OSPAR Recommendation 2001/1 for the Management of Produced Water from Offshore Installations includes a presumption against the discharge to sea of produced water from new developments. The assumption that reinjection will be the normal method of produced water disposal (at least 95% by volume) is fundamental to the consideration of potential effects of produced water in the SEA process, although it is also noted that under certain circumstances (e.g. injection pump maintenance) the effluent may be routed to sea. Any produced water discharged will be treated since it is still required to meet legal quality standards in terms of oil in water concentration.

Potential effects of produced water discharges are described in previous SEAs. Most studies of produced water toxicity and dispersion (see E&P Forum 1994, 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. The SEA 6 commissioned study (Kenny *et al*. 2005) reviewed recent studies and data (including analyses of produced water composition from Irish Sea facilities), and reached a similar conclusion.

The recent ICES Biological Effects Monitoring in Pelagic Ecosystems workshop (BECPELAG) analysed samples from caged organisms and passive samplers using a wide range of biomarkers and bioassays for chemical, molecular, cellular and physiological changes. e.g. toxicity bioassays, enzymatic induction (EROD), lysosomal damage, Scope for Growth (SFG), genotoxicity, endocrine disruption effects, metallothionein induction, PAH metabolites, acetylcholinesterase inhibition, bacterial diversity. Although a variety of detectable responses (in caged organisms) to proximity to an oil platform were observed and attributed to produced water effects, the ecological significance of these responses is unclear.

Drilling discharges

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. 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, the toxicity of settled drill cuttings appears to be related primarily to hydrocarbon content, even in WBM discharges; probably because in the past hydrocarbon spotting fluids had been used as a contingency measure (UKOOA 2002, Hartley Anderson 2003).

Dispersion of mud and cuttings is influenced by various factors, including particle size distribution and density, vertical and horizontal turbulence, current flows, and water depth. In deep water, the range of cuttings particle size results in a significant variation in settling velocity, and a consequent gradient in the size distribution of settled cuttings, with coarser material close to the discharge location and finer material very widely dispersed away from the location, generally at undetectable loading.

Limited experience to date suggests that cuttings dispersion (due to water depth and current regime) prevents detectable accumulation of metals around drilling sites on the west

Shetland slope, at equivalent depths to the SEA 7 area. Following the drilling of ten development wells at the two Foinaven drill centres, the distribution of nitric acid extractable metals (excluding barium) indicated marginal variation across a sampling grid with no discernable patterns of distribution around the Foinaven location (ERT 1998).

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 a*l. 1989, Olsgard & Gray 1995, Daan & Mulder 1996). These effects resulted from the interplay of a variety of factors of which direct toxicity (when diesel based muds were used) or secondary toxicity as a consequence of organic enrichment (from hydrogen sulphide produced by bacteria under anaerobic conditions) were probably the most important. 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 further.

In contrast to historic 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 usually subtle or undetectable, although the presence of drilling material at the seabed close to the drilling location (<500m) 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 localised physical effects are the dominant mechanism of ecological disturbance where water-based mud and cuttings are discharged.

However, 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 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.

Most studies of ecological effects of drilling wastes have involved soft-sediment species and habitats. 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). These effects were attributed to the physical effects of particulate loading, namely disruption of feeding or respiration, or the burial of settled larvae.

The introduction of non-native species through vessel ballast water discharges was considered in the SEA 6 Environmental Report. In the case of potential activities resulting from a 25th licensing round, the vast majority of rigs and vessels likely to be used will already be operating in NW Europe and hence not a potential source of exotic species introductions (although they could facilitate the spread of species). In view of the limited scale of activity predicted significance effects are not anticipated.

Update on effects consideration

A comprehensive synthesis and annotated bibliography of the composition, environmental fates and biological effect of WBM and cuttings was prepared on behalf of the Petroleum Environmental Research Forum (PERF) and American Petroleum Institute by Neff (2005). The review, covering more than 200 publications and reports, concludes that effects of WBM cuttings piles on bottom living biological communities are caused mainly by burial and low sediment oxygen concentrations caused by organic enrichment. Toxic effects, when they occur, probably are caused by sulphide and ammonia byproducts of organic enrichment

The US Minerals Management Service (MMS) has funded several studies to examine the fates and effects of Synthetic Base Fluids (SBF) on the seafloor in the Gulf of Mexico (Boatman 2003), including a study of the spatial and temporal distribution of discharges on the continental shelf and upper slope. The MMS is funding a study of the fates and effects of discharges at deepwater sites (1000m) from both drilling sites and production facilities. A laboratory study into the degradation rates of SBF under the conditions found in deepwater is also being funded by MMS.

In a further Gulf of Mexico study (Hart *et al*. 2003), geophysical, hydrocarbon, and macroinfauna data has been collected at Viosca Knoll Area Block 916, Mississippi Canyon Area Block 292, and Garden Banks Area Block 602 study sites (water depths 1000-1100m) at which both water based and synthetic based muds have been used. Initial analysis revealed several preliminary conclusions:

- Based on interpretation of the side-scan sonar data collected around the three study sites, cuttings may occur up to 1000 m from a drilling site.
- Concentrations of SBM and total petroleum hydrocarbons (TPH) were measured in samples collected from box cores. SBM and TPH concentrations are highly correlated, and near-field SBM concentrations can exceed 10,000 :g/g.
- After drilling activities have occurred, annelids appear to dominate the near-field macroinfauna assemblage. In some instances, correlation between the abundances of macroinfauna and the concentration of SBM occurred.

In a study of the fate of Nonaqueous Drilling Fluid (NADF) cuttings discharged from a well in 950m water depth in the South Atlantic, Nedwed *et al*. (2006) reported on the use of ROV-deployed sediment traps to sample drill cuttings on arrival at the seabed. Total Petroleum Hydrocarbon (TPH) concentrations in sediment core samples and solids accumulating in sediment traps were significantly lower than the concentrations of discharged cuttings, indicating loss of hydrocarbon base fluid to the water column during settling. Data from both sediment traps and sediment cores showed high spatial variability in accumulations thickness and hydrocarbon concentrations, supporting a general conclusion (from other recent studies) that NADF-cuttings settle to the seabed in a patchy manner rather than forming a uniform coating on the seabed. Model predictions of cuttings thickness were in general agreement with observed thickness of sediment trap accumulations.

SEA 7 specific consideration

Aspects of the SEA 7 which are specific, although not unique on the UKCS, are the relatively deep water and high current velocities of the prospective areas, and the presence of reef-forming species (notably *Lophelia*) and sponge aggregations.

As noted above, produced water discharges during the production phase of any development in the SEA 7 area are not considered likely (reinjection being the preferred option; as is the case currently for the Foinaven, Schiehallion and Clair developments west of Shetland). Reinjection of development well cuttings is also a likely scenario; however, WBM cuttings from exploration and appraisal wells are likely to be discharged to sea in the conventional way.

Cuttings dispersion for the 164/28-A exploration well (Agip 1998), which was drilled in 844m water depth using WBM, was predictively modelled using the ASA model MUDMAP. The dispersion of WBM cuttings is sensitive to the particle size distribution assumed (which in turn varies with formation, bit type, and Rate of Progress, ROP). In this case, three particle size distributions were modelled. Concentrations of discharged cuttings on the seabed were predicted to be insufficient to cause development of a cuttings pile, with redistribution of settled cuttings also likely to occur due to hydrodynamic re-suspension. ROV observations during and after the well confirmed that measurable cuttings accumulation was limited to tophole (riserless) discharges directly at seabed.

Similar modelling for the 153/5-A well (Marathon Oil UK Ltd 1998), in 1231m water depth, was carried out using the BMT model PROTEUS and predicted a maximum thickness of surface-discharged cuttings of 0.28mm close to the well location. In general, the environmental effects of WBM surface-discharged cuttings in the water depths and current profiles of the prospective area of SEA 7 are likely to be limited to chemically detectable concentrations of barium (from barite) over a footprint of a few km^2; ecological effects will be negligible. Barite formation has been shown to be intimately related to settling biogenic material (decaying phytoplankton and faecal pellets) and accumulation of barite in sediments (above the depth of dissolution) has been shown to form a useful proxy for past productivity of the overlying waters (Francois *et al*. 1995, Torres *et al*. 1996). Barium sulphate crystals are also known to be present within the protoplasm of xenophyophores, one species of which (*Syringammina fragilissima*) is widely distributed in the Rockall Trough and was recorded in substantially elevated densities on the Darwin Mound tails (Bett 2000, Hughes & Gooday 2004). The role of barite in xenophyophore metabolism is questionable, its formation (if it is indeed formed within the protoplasm) may simply be a defence mechanism, providing protection against the toxic effects of soluble barium compounds (Bett 2000).

The longevity of surface hole cuttings mounds will be dependant on the rate of erosion, which is a function of the nature of the material and current speeds in the area. This suggests that in the majority of the prospective SEA 7 area along the shelf edge, surface hole material mounds will be short lived, being eroded and widely dispersed by currents. Lethal effects may result from smothering by sediment of sessile and mobile animals, if the depth of burial is beyond their powers of escape or clearance. This smothering can be direct or indirect (from winnowing disturbed material) and effects on infauna are normally short lived and similar to those from severe nearshore storms and dredge spoil disposal where recovery is normally well underway within a year (Rees *et al*. 1977, SOAEFD 1996). Benthic storms can generate substantially elevated suspended sediment loads in deep waters, for example at the HEBBLE site on the Nova Scotia rise during a 10 week period several elevations in sediment concentrations occurred (lasting days), peaking at over 10mg/l (Hollister *et al*. 1984). There is limited information on the sediment clearance abilities of continental shelf and slope sessile epifauna or the effects of sedimentation on them, especially on long-lived species such as scleractinian and other corals. Work on tropical reefs indicates that excessive sedimentation can adversely affect the structure and function of the coral reef ecosystem by altering both physical and biological processes. Tropical reef corals are particularly susceptible to sedimentation effects as they contain symbiotic algae and are dependant on light for photosynthesis; cold water corals do not have such symbioses. The strong currents generally typical of areas of *Lophelia* and sponge occurrence (e.g. Frederiksen *et al*. 1992) may both cause sediment suspension and transport and alleviate the effects of increased sediment load. Bett (2000) notes evidence of active sediment transport (rippled sand) in the area of the Darwin Mounds and suggests that the corals present there are normally subject to particulate deposition and to sediment scour from particle laden bottom waters. It is also noteworthy that *Lophelia* has been found growing on various oil installations in the northern North Sea (Bell & Smith 1999), suggesting greater larval dispersive ability and adult tolerance to oilfield drilling solids and other discharges than has been hitherto recognised.

Control and Mitigation

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 Offshore Petroleum Activities (Oil Pollution Prevention and Control) Regulations came into force during 2005 and have updated and largely superseded the Prevention of Oil Pollution Act, 1971 (POPA). A system of permits for oil discharges has been introduced to replace the POPA exemptions and more wide-ranging powers have been given to inspectors. Operators are required to regularly make reports of actual oil discharge. The regulations are a mechanism to continue implementation on the UKCS of OSPAR Recommendation 2001/1 and make provision for the introduction of the dispersed oil in produced water trading scheme.

A permit is required in advance for the use of chemicals offshore including drilling, well workover, production and pipeline chemicals (Offshore Chemicals Regulations 2002). Permit application includes mandatory risk assessment. Any variation in use from permit must have prior approval. Chemical use and discharge must be reported at the end of the activity. Chemicals are ranked by hazard, based on a PEC:PNEC (Predicted Effect Concentration : Predicted No Effect Concentration) approach.

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.

Conservation sites

Potential offshore conservation sites and additional sites in territorial waters in the SEA 7 area, are summarised in Appendix 3. Live coral reef framework composed of *Lophelia* and *Madrepora* is known to be present on the Wyville Thomson Ridge, Rockall Bank, Lousy Bank, Hatton Bank and George Bligh Bank. Aggregations of the hexactinellid sponge *Pheronema carpenteri* are also locally distributed at depths of *ca*. 1,000-1,300m in the area (e.g. Hughes & Gage 2004). Given the anticipated location of SEA 7 prospective areas well offshore and the dispersion of any discharges by tidal and other currents, effects on the benthos of designated coastal conservation sites are unlikely.

Cuttings discharges could, if a well location was sufficiently close to an offshore 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; and potential effects from specific projects would require to be evaluated (through the Appropriate Assessment mechanism) and mitigation measures adopted. However, until the available data has been fully evaluated and the appropriate site designations are made, it is recommended that the SEA 7 areas adjacent to the banks are not licensed.

Conclusions & data gaps

The environmental effects of the major discharges from oil and gas activities have been extensively studied, and are considered to be relatively well understood. The environmental effects of produced water discharges not reinjected are limited primarily by dispersion. Discharges of WBM cuttings in the North Sea and other dispersive environments have been shown to have minimal ecological effects.

"Ground-truthing" data to validate cuttings dispersion models for WBM in deep water are sparse, and additional post-drilling sampling effort should be targeted at exploration, appraisal and development wells in water depths in the range 800-1500m on the UKCS.

A11.c.6 Atmospheric emissions from oil and gas operations

Introduction

Gaseous emissions from offshore exploration and production of oil and gas contribute to global atmospheric concentrations of greenhouse gases, regional and local acid gas loads and potentially to local tropospheric ozone and photochemical smog formation.

Sources

The major sources of emissions to atmosphere from offshore oil and gas exploration and production are internal combustion for power generation by installations, terminals, vessels and aircraft, flaring for pressure relief and gas disposal, flaring from well clean-up and testing, cold venting from storage and loading operations 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.

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 was 1,372,893 tonnes in 2004 (an increase of approximately 2.3% above 2003 figures), compared to 1,699,978 tonnes in 1999.

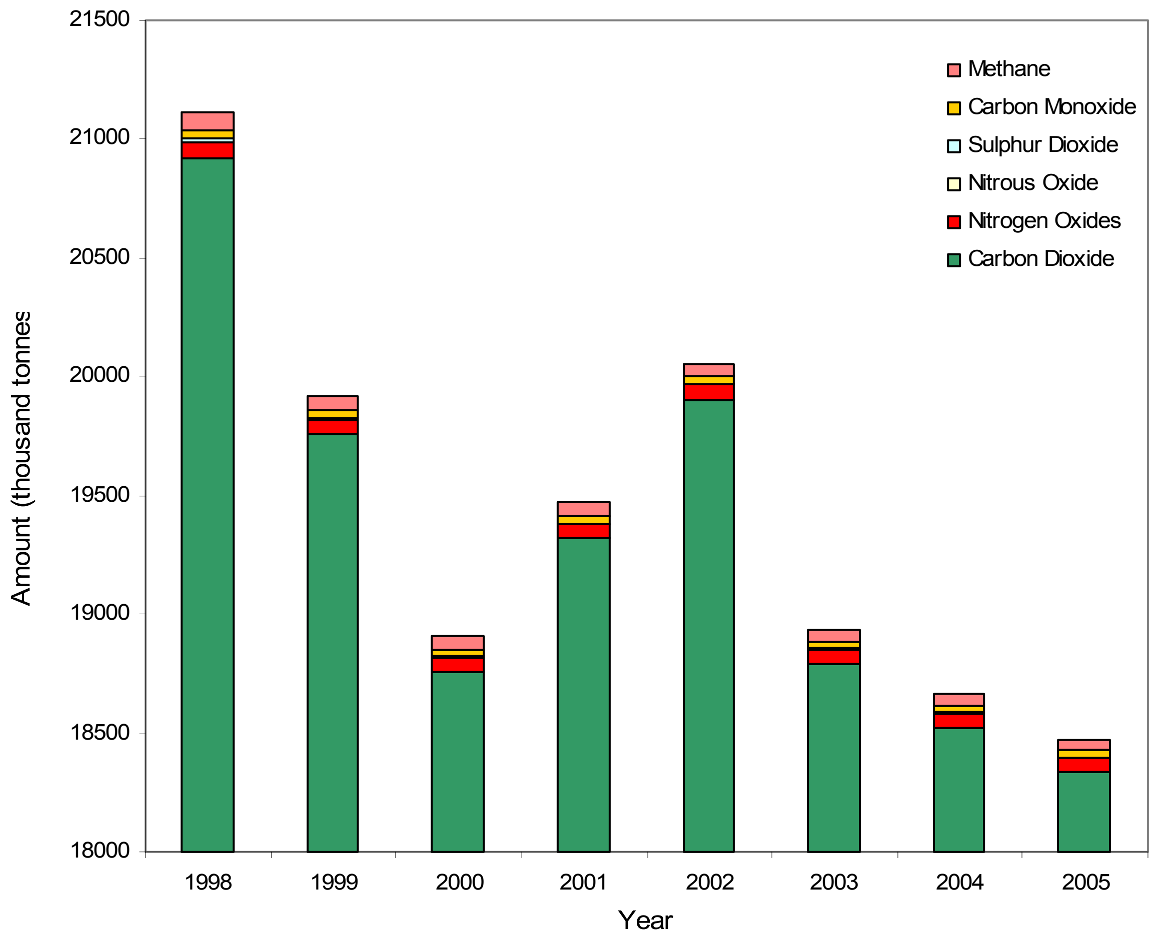
New developments will generally flare in substantial quantities only for well testing, start-up and emergency pressure relief, with "zero routine flaring" now considered a realistic design target for planned developments. Other than start-up flaring, subsea tie-back developments, which are predicted to account for the majority of production from proposed licence areas, will generally have little effect on host platform flaring.

The Environmental Emissions Monitoring System (EEMS) database was established by UKOOA in 1992 to provide a more efficient way of collecting data on behalf of the industry. Atmospheric data from the EEMS system is produced on an annual basis and can be used to show trends in UK offshore oil and gas activity greenhouse gas emissions. Emissions for the period 1998 to 2005 are summarised in Figure A11.c.9.

The dominant greenhouse gas discharged by the offshore oil and gas industry is CO_2, largely from combustion in turbines. Although short-term trends in CO_2 emissions from exploration and production are variable, the overall trend is one of reduction in discharge with emissions in 2005 showing a 1% reduction over 2004 (see Figure A11.c.9).

The overall decrease in 2003 - 2005 emissions may be attributed to a decline in exploration activity and falling production. However it would be expected that CO_2 emissions would increase due to greater power demands associated with operating mature fields, the use of injection as a method of disposal of produced water and drill cuttings and the potential use of reservoirs for gas storage. UK overall emissions of CO_2 fell by 5.6% between 1990 and 2003 to 572.2 million tonnes (Baggott *et al.* 2005) with offshore E&P activities contributing less than 4 % of this total.

Figure A11.c.9 – Atmospheric emissions from combined UKCS production and exploration activities



Source: EEMS

SEA 7 atmospheric emissions

DTI forecasts of exploration activity in the SEA 7 area have been used to calculate indicative emissions from SEA 7 exploration drilling activities (see table below). For these calculations, it has been assumed that wells will be drilled using semi-submersible rigs, requiring 16 tonnes of diesel per day to operate and the duration of each well is 40 days. Calculations of atmospheric emissions have been generated using emission factors from the UKOOA Environmental Emissions Monitoring System Guidelines for the Compilation of an Atmospheric Emissions Inventory (2002).

Principal routine operational emissions during drilling would be from combustion products (CO_2, CO, NO_X, SO_2, CH_4 and VOCs) from power generation and engines on the rig, vessels and helicopters. Atmospheric emissions would also be expected from well test operations, however, for the purpose of this assessment no well tests are proposed.

Indicative atmospheric emissions resulting from DTI forecast of SEA 7 area exploration drilling

	CO_2 (tonnes)	NO_X (tonnes)	N_2O (tonnes)	SO_2 (tonnes)	CO (tonnes)	CH_4 (tonnes)	VOC (tonnes)
Areas 1 to 4[1]	20,480	86	1	26	6	<1	2

Notes:

Emissions are rounded and based on:

1. *Total of 10 wells being drilled in SEA 7 (up to 5 exploration wells and up to 5 appraisal wells)*

The Table below uses 2005 data to indicate the effect this additional exploration would have on atmospheric emissions from offshore oil and gas activities.

Comparison of atmospheric emissions resulting from additional SEA 7 area exploration activity

Year	CO_2 (tonnes)	NO_X (tonnes)	N_2O (tonnes)	SO_2 (tonnes)	CO (tonnes)	CH_4 (tonnes)	VOC (tonnes)
2005 [1]	18,333,624	59,779	1,217	2,937	28,572	41,236	66,073
SEA 7 [2]	10,240	43	<1	13	3	<1	<1
SEA 7 %age	0.06%	0.07%	0.08%	0.44%	0.01%	<0.01%	<0.01%

Notes:

1. *Total 2005 offshore emissions from UKCS oil and gas exploration and production activity (EEMS 2006)*
2. *Estimated overall emissions based on worst case assumption of 5 wells drilled in a single year.*

As can be seen from the indicative information in the table above, contributions as a result of exploration activities in the SEA 7 area to UKCS exploration emissions would be minimal. Contributions to UK and European atmospheric emissions would be extremely small and would be expected to have, at most, a negligible local and wider environmental impact.

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.

Anthropogenic sources of greenhouses gases are implicated in amplifying the natural greenhouse effect resulting in global warming and potential climate change (IPCC 2001). Carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF_6) are termed “direct” greenhouse gases as they have a direct effect on radiative forcing within the atmosphere. Other gases including carbon monoxide (CO), volatile organic compounds (VOC), oxides of nitrogen (NO and NO_2) and sulphur dioxide (SO_2) although not significant direct greenhouse gases, are reactive and impact upon the abundance of the direct greenhouse gases through atmospheric chemistry.

Atmospheric acid gases include sulphur dioxide (SO_2) and oxides of nitrogen (NO_X). These gases can be react with water vapour forming acids, to increase 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 surfaces through dry deposition (close to the source) causing similar damage to acid rain (UKTERG 1988). The overall contribution of acid emissions from shipping increased during the 1990s (ICES 2003). Shipping contributes up to 15% of the deposition of these gases in some coastal areas. Deposition is higher around major shipping routes such as the south western approaches and English Channel. The potential effects of emissions of acid gases are considered to be most important at a regional to local 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. Ozone is known to impair lung function and NO_X causes irritation of the airways and can be particularly problematic for asthma sufferers (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.

The absorption of anthropogenic CO_2 in sea water appears to be causing the gradual acidification of sea water. The potential effects of this acidification such as the dissolution of the shells of plankton and coral skeletons have been raised as a concern (Feely *et al.* 2004) and a recent paper by Orr *et al.* (2005) raises the level of concern about potential effects.

Conclusions and data gaps

Potential environmental effects of acid gas and greenhouse emissions are, respectively, regional and global in nature. Of the 4 areas, area 1 (which includes the Benbecula discovery and runs south following the shelf edge to the most southerly licensed acreage in South Rockall) is considered the most prospective area, with the remaining areas thought to be of limited potential. Given the distance of area 1 from the coastline, local air quality effects from atmospheric emissions are not expected.

Significant combustion emissions from flaring are not expected from potential development in the possible SEA 7 licence areas, given the availability of existing gas process and export infrastructure. 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.

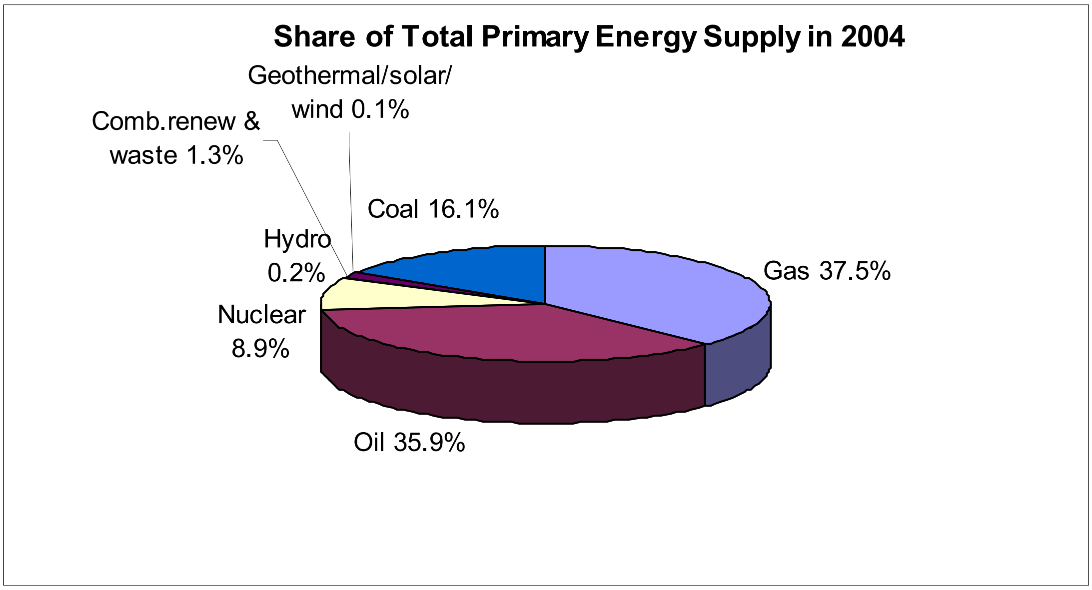
A11.c.7 Climatic factors

Background

The European Commission's (EC) White Paper on Renewable Energy Sources sets out a comprehensive strategy and action plan to achieve the ambitious goal of doubling the renewables' share of the EU's total energy supply from 6% to 12% (22% electricity) by 2010. Renewable energy is an integral part of the UK Government's long-term aim of reducing CO_2 emissions by 60% by 2050. Under the UK's Renewables Obligation, licensed electricity suppliers have to source a specific and annually increasing percentage of electricity from renewable sources. The proportion of renewables covered by the Renewables Obligation (i.e. biofuels, wave, solar photovoltaic, onshore/offshore wind and small scale and re-furbished hydro) in energy supply has grown from just under 1% in the early 1990s to close to 4% in 2005, and is set to grow rapidly towards the targets of 10% by 2010 and 20% by 2020 (DTI 2006a).

Currently, fossil fuel energy is the primary source of energy supply in the UK followed by nuclear power, the remainder coming from hydro and wind power (RCEP 2000).

Share of Total UK Primary Energy Supply in 2004



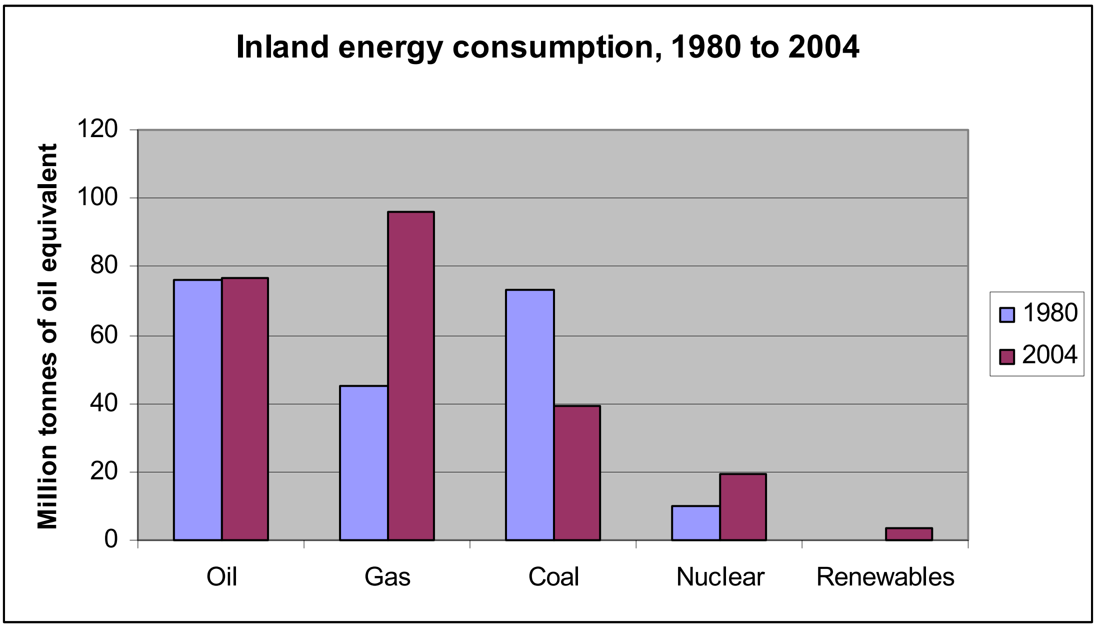
Source: EIA 2004 (excludes electricity trade)

The UK is presently the EU's largest and the world's seventh-greatest energy producer due to energy production and exports of oil and gas from the North Sea (CSLforum 2004). In the 1990s, the UK changed from an energy net importer to a net exporter, with government's policy designed to maximise production from domestic reserves for as long as possible. To achieve this end, the licensing system was reformed with the introduction of two new licences: i) the 'promote' licence and ii) the 'frontier' licence (DTI 2005, IEA 2004). However, with oil & gas production having peaked during 1999, the UK oil & gas production is falling and by the end of this decade the UK will be a net importer of oil (DTI 2004), having become a net importer of gas in 2004.

Energy Demand and Consumption

Since 1965 demand for energy and subsequent consumption by final users has increased by 16% and 24% respectively. This increase is linked to the growing output of goods and services associated with economic growth, increasing travel, rising numbers of households and the gradual increase in population. Annual primary energy use in the UK averages about 300GW, with almost 90% coming from fossil fuel (RCEP 2000). Since 1980, consumption of natural gas and primary electricity has risen considerably, whilst consumption of oil has remained around the same and coal has fallen (DTI 2006b).

Onshore energy consumption, 1980 to 2004



Source: DTI 2006b

The final consumers of energy in the UK can be divided into four groups: a) industry, b) domestic sector, c) transport and d) services. The following table shows final energy consumption for the main sectors, indicating that overall energy consumption has stayed stable over the last five years:

Energy Consumption by Sectors (million tonnes of oil equivalent)

	2000	**2003**	**2004**	**2005**
Industry	35.2	33.7	33.0	33.1
Domestic sector	46.9	48.2	48.6	47.0
Transport	55.6	56.5	58.2	59.2
Services	21.5	19.7	20.2	20.0
Total final energy consumption	**159.2**	**158.0**	**159.9**	**159.5**

Source: DTI 2006b

Energy consumption by individual sectors has changed substantially since the 1980s: there have been rises of 67% for transport, 18% for the domestic sector and 8% for the service sector, whilst consumption by industry has fallen by 31%[1].

[1] *http:www.dti.gov.uk/files/file29698.pdf*

Trends in UK GDP, carbon intensity and energy efficiency

Carbon intensity (the level of greenhouse gas emission per unit of economic output) reflects both a country's level of energy efficiency and its overall economic structure. Over the last 30 years, total UK CO_2 emission in relation to total economic output has fallen by a factor of two. During 1995 and 2000 carbon intensity of primary energy consumption has fallen significantly due to the 'dash for gas' within the electricity generating sector (and to a lesser extent within industry as a whole), increased use of more efficient generation technology such as combined cycle gas turbines and combined heat and power plants (CHP) as well as better performance by nuclear power stations (House of Commons 1999, Baumert *et al.* 2005, Bishop & Watson 2005). The 1999 Department of Environment, Transport & the Regions (DETR) Climate Change consultation paper allocates the estimated fall in UK industrial emissions of 6 million tonnes of carbon equivalent (MtC) between 1990 and 2000 as follows: 70% to a reduction in carbon intensity, 20% to increased energy efficiency and 10% to changes in industrial structure (House of Commons 1999). Overall, energy consumption has risen more slowly than economic activity (as measured by gross domestic product), reflecting the tendency of organisations and individuals to find ways of using energy more efficiently (DTI 2006b). This trend is likely to continue due to the Climate Change Levy that came into effect in 2001, encouraging industries to examine more energy efficient production methods.

The UK Government has promoted energy efficiency with subsidies, advice and publicity campaigns. The DEFRA Energy Efficiency Plan for Action (April 2004) outlined potential future measures to improve energy efficiency by 2010. It has been estimated that improvement in energy efficiency could generate energy savings of approximately 30% across the economy as a whole leading to savings of 10MtC/year by 2010 (DEFRA 2004).

Key UK energy efficiency measures and programmes

Name of Programme/Funding	Summary
Energy Savings Trust (~£100million per year depending on take-up)	An organisation, funded by the Government, providing information on best practice, support networks and manages grant schemes and campaigns across the domestic, transport and public sector
Carbon Trust (~£40million per year)	Supports measures for businesses investing in energy saving technology; funding for R&D of new low-carbon technologies
Warm Front (~£170million for 2004/05)	The governments' main grant-funded programme for tackling fuel poverty. It provides grants for low income households towards different packages of insulation and heating measures
Community Energy Programme (~£60million (2002-08)	Launched in 2001 aims to provide £50M of government funding to upgrade or install new CHP and community heating systems

Source: DTI websites

In addition, there are a number of UK initiatives promoting renewable energy sources and technology developments. The DTI, for example provides Research & Development [2] funding and capital grants (approx. £500 million between 2002 and 2008), while DEFRA participates in and funds the Carbon Trust[3]. Other programmes are either directed at homeowners, schools and communities, such as the government's Low Carbon Building

[2] *see: http://www.dti.gov.uk/energy/sources/renewables/business-investment/funding/page19360.html*
[3] *see: http:// www.carbontrust.co.uk*

Programme[4], or renewable energy, such as the Marine Renewable Deployment Fund[5](a £50million fund supporting the continued development of the marine renewables sector), wind energy[6] or biofuel[7].

The pathways by which climate change may affect health are diverse and complex (WHO 2003). The IPCC 3rd assessment (IPCC 2001) concluded that overall, negative effects are expected to outweigh positive impacts. It is predicted that climate change impacts will affect some regions more than others Important influences on health will include changes in the frequency and intensity of extremes of heat, cold, droughts, floods, hurricanes, tornadoes and other forms of extreme weather. Climate change also will impinge on health by disrupting ecological and social systems, resulting in changes in infectious disease transmission, food production, air pollution, population displacement and other forms of social disruption.

A11.c.8 Waste

In 2005, UKCS offshore oil and gas operations produced around 125,517 tonnes (2004 amount -127,080 tonnes) of waste of which 3,760 tonnes was reused, 21,830 tonnes recycled, 3,456 tonnes used in waste to energy and 71,049 tonnes were landfilled (EEMS 2005). The transfer of offshore wastes to shore for treatment and disposal can result in a variety of effects including nuisance, changes in air quality, onshore land use and cumulative effects.

The return of drill muds and cuttings to shore for treatment and disposal is the major change in offshore waste disposals in recent years. In 2005, 46,507 tonnes of treated cuttings were disposed of to landfill. It is unlikely that major changes to these volumes would result from licensing in the SEA 7 area as the projected number of exploration and appraisal wells is limited (up to 10) and many or most would be drilled with water based drill fluids. 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.

Produced water, and drill muds and cuttings may be ground and reinjected to rock formations rather than discharged to sea or returned to land. A permit is required for UK interfield transfer of oily cuttings for reinjection. 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. Cuttings cleaning technologies which are capable of reducing oil on cuttings to levels below 1% may have a future positive impact on quantities of cuttings disposed of to land.

A limited number of developments are projected to result from SEA 7 area licensing. At the end of field life these facilities would be removed with the bulk of materials reused or recycled.

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[4] *see: http://www.lowcarbonbuildings.org.uk*
[5] *see: http://www3.dti.gov.uk/renewables/renew_marinerenewdf.htm*
[6] *see: http://www.bwea.com*
[7] *see: http://www.supergen-bioenergy.net/?_id=288*

A11.c.9 Accidental events

Introduction

Oil spills are probably the issue of greatest public concern in relation to the offshore oil and gas industry. The risks of large oil spills resulting from E&P are potentially associated with major incidents on production platforms, export (pipeline and tanker loading sources), with the additional potential for loss of well control and subsequent oil blowout. The historical frequency of such events in the UK and Norwegian continental shelves has been very low; in contrast, major oil spills from shipping, although infrequent, may be large.

Other accidental events (with environmental consequences) include gas releases and chemical spills.

The SEA 7 activity scenarios are low intensity (a forecast maximum of around 7-10 exploration / appraisal wells, with possibly one TLP (for a possible Benbecula development), 1-2 FPSO and 1-2 subsea tieback developments. This represents a relatively small proportion (<10%) of anticipated UKCS activity and risks of significant accidental events are correspondingly proportionate.

Environmental risk is generally considered as the product of probability (or frequency) and consequence. The environmental consequences of oil (and chemical) spills are associated primarily with seabirds, marine mammals, fisheries and coastal sensitivities; and these sensitivities are considered in the appropriate environment description sections (sections 5-8) and supporting studies. The sources, frequency, magnitude and potential consequences of hydrocarbons spills are considered below. Much of the information is common to previous SEAs, and is therefore summarised with updates where appropriate.

Specific issues associated with SEA 7 include the location of sensitive coastlines, such as the numerous breeding bird colonies of international conservation importance; the importance of coastal tourism and recreation; and fisheries generally within the area.

It should be noted that the purpose of SEA 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 7-related activity.

Summary of effects considerations from previous SEAs

Accident scenarios and historic frequency

Previous SEAs have reviewed hydrocarbon spills reported from exploration and production facilities on the UKCS since 1974 under PON1 (formerly under CSON7); annual summaries of which were initially 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 UKCS data. (The only significant blowouts on the UKCS to date have been from West Vanguard (1985) and Ocean Odyssey (1988), both involving gas.) A review of blowout frequencies cited in UKCS Environmental Statements gives occurrence values in the range 1/ 1000 - 10,000 well-years. These are generally consistent with derived annual frequencies based on worldwide database maintained by SINTEF and Scandpower.

A 1999 study for the US Minerals Management Service summarised the status of existing and emerging technologies for oil spill containment, remote sensing and tracking for oil released from deepwater blowouts; complementing an International Association of Drilling Contractors study (IADC, 1998) which focused on blowout contingency planning, vertical intervention, relief wells, dynamic kill considerations, and spill control. The MMS (1999) study developed blowout scenarios for the drilling, completion and workover phases of subsea oil production, and for producing wells, and described the relative likelihood and consequence of each exit point being the most probable failure point.

During drilling, completion and workover operations, a moderate probability of a deepwater blowout was assigned to problems associated with the wellhead connector, lower marine riser package (LMRP), well flow through the riser, or a broach. There is a lower probability of a deepwater blowout to problems associated with leak paths on the BOP, through the drill pipe/tubing or the casing hanger seals. For producing wells, a moderate probability was assigned to problems associated with the annulus valve, while all other components were assigned a low probability. Consequence was considered to be primarily related to the ability to isolate the leak point via active barriers; and therefore the likelihood that a sustained blowout would result from a leak at any given point. Based on industry experience with the very few problems that have been associated with these components, a "catastrophic" rating was assigned to a release through the drill pipe or from a broach, because the drill rig would likely shut down and be abandoned, or move off location. A "severe" ranking was assigned to blowouts originating at the wellhead connector or through the riser; while those associated with the BOP and LMRP were assigned a "minor" ranking. For producing wells, a "catastrophic" consequence was assigned to a deepwater blowout to a broach, and "severe" to blowouts resulting from the wellhead connector or casing hanger seals, while all other components were assigned a low probability. However, it should be noted that all the above scenarios involve multiple system failures, of at least two independent barriers to flow. If the well is in a static condition (i.e., no flow from the reservoir) the primary barrier is usually the hydrostatic pressure exerted by the fluid column (either static or dynamic). The secondary barriers would be the pressure control equipment such as the BOP, the wellhead (innermost casing hanger seal), and the choke/kill line valves. If the well is flowing (i.e. producing oil and/or gas), the primary barrier is that which is closest to the reservoir. This typically includes the packer and associated seal assemblies, the tubing between the packer and the Surface-Controlled Subsurface Safety Valve (SCSSV) and the SCSSV itself. The secondary barriers would then include the tubing above the SCSSV, the master valve of the Christmas tree, the casing and tubing hanger seals and the annulus valves.

The major difference between a blowout during the drilling phase versus the completion or workover phases is the drilling well tendency to "bridge". Bridging is a phenomenon that occurs when severe pressure differentials are imposed at the well/reservoir interface, and the formation around the wellbore collapses and seals the flow path. Completion schemes often include methods to stabilize the reservoir during production in order to reduce the production of solids in the flow stream; therefore a completed well may not have the same tendency to passively bridge off as would a drilling well involving an open hole (uncased) interval. The tendency to passively bridge may also be inhibited by the seawater column back pressure which may limit the flow rate and prevent collapse of the well. In these cases, active bridging methods may be considered to close the hole. Bridging may have a beneficial effect for spill control by slowing or stopping the flow of oil from the well.

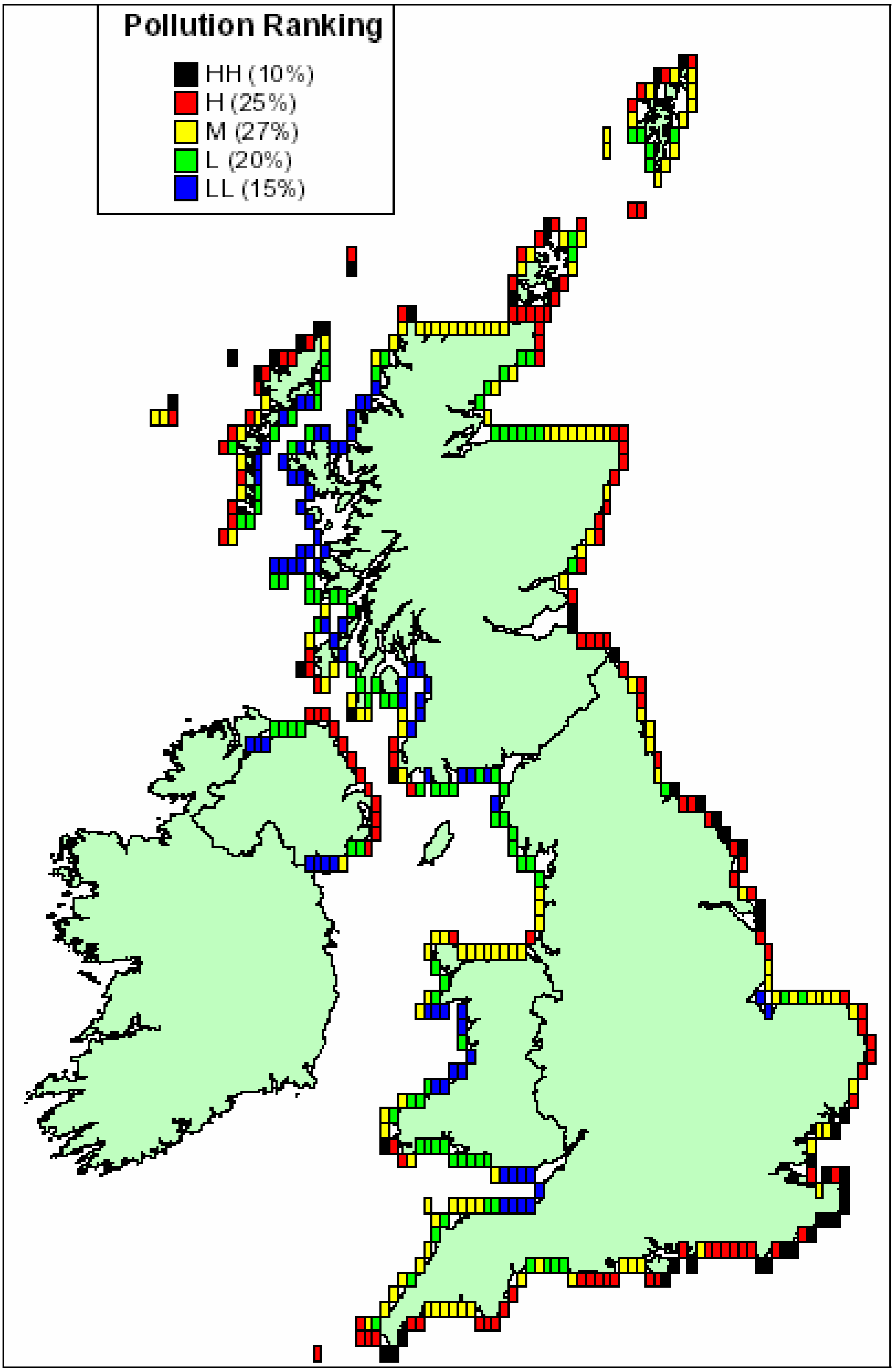
DTI data indicates that the major types of spill from mobile drilling rigs have been organic phase drilling fluids (and base oil), diesel and crude oil. Topsides couplings, valves and tank overflows; and infield flowlines and risers are the most frequent sources of spills from production operations, with most spills being <1 tonne. A large proportion of reported oil spills in recent years (since about 1990) have resulted from process upsets (leading to excess oil in produced water). Estimated spill risk from UKCS subsea facilities was equivalent to a risk of 0.003 spills / year for an individual facility, with almost all reported spills <5bbl in size.

Historically, major spill events from UKCS production facilities include the Claymore pipeline leak, 1986 (estimated 3,000 tonnes), Piper Alpha explosion, 1988 (1,000 tonnes), Captain spill, 1996 (685 tonnes) and Hutton TLP spill, 2000 (450 tonnes). 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*), 1979 (Ixtoc 1 blowout and *Atlantic Empress* tanker spill), 1983 (Nowruz blowout and *Castillo de Bellver* tanker spill) and 1991 (Gulf War). Within the SEA 6 area, the *Sea Empress* spill (1996) resulted in significant bird kill and effects on benthic organisms; apparently, however, without major long-term effects (see section 5.5.3). As with the preceding *Braer* spill in Shetland, the timing of the spill was extremely fortuitous in limiting environmental effects and prevailing weather conditions assisted in natural dispersion.

In 2000, the MCA commissioned Safetec UK Ltd (Safetec) to provide data to assist the MCA with regard to decision making on the placement of Emergency Towing Vessels (ETV's) in different locations around the UK Coastline. This involved an assessment of incident frequencies and the likelihood of different types of accidental events in causing pollution which would then impinge on the coastline (Safetec 2000); including both incidents which occur at the coastline (e.g. grounding incidents), as well as incidents that occur at sea but could encroach on the coastline. It should be noted that no intervention in terms of tugs, etc., has been included within the assessment. The risk of oil spills resulting from shipping casualties in the SEA 7 area was considered to be low through the Minches, but high or very high around St Kilda and the Flannans, on the west coast of Lewis and around the Butt of Lewis (Figure A11.c.10). The Minch-based ETV (currently *Anglian Prince*) typically carries out 50-60 tasks per year (e.g. 55 in 99/00), of which a high proportion are precautionary escorting of tankers through the Minch.

Figure A11.c.10 – Pollution risk ranking of the UK coastline



Source: Safetec (2000)

Oil spill fate & trajectory

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 and biodegradation – these are reviewed in SEAs 1, 2 and 3. Coincident with these weathering processes, surface and dispersed oil will be transported as a result of tidal (and other) currents, wind and wave action.

Surface oil spill trajectory modelling can be carried out using commercial models deterministically (i.e. with defined arbitrary metocean conditions, usually "worst case") or stochastically (i.e. using statistical distributions for wind and current regimes). To support environmental assessments of individual drilling or development projects, 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.

Ecological effects

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, with mortality of intertidal organisms occurring as a result of direct oiling; while subtidal communities may be affected by dissolved hydrocarbons (e.g. SEEC 1998). Disruption of intertidal communities over a range of timescales has been observed following many major oil spills; typically with disturbance of the balance between algal populations, grazing species and predators on rocky shores. Effects on sediment communities are typically associated with deoxygenation and organic enrichment. In both cases, the effects of chemical dispersants may be more severe than those of oil.

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 and Monaghan 1987).

Fortunately, there is little experience of major oil spills in the vicinity of seabird colonies in the UK. Census of seabird colonies in south-west Wales following the *Sea Empress* spill concluded that only guillemot and razorbill populations were impacted by the spill (Baines & Earl 1998). The *Sea Empress* spill occurred in February, when seabird numbers at colonies were relatively low, but the density of wintering birds including common scoter was high. Some species, particularly puffins, Manx shearwaters and storm petrels, had not returned to the area to breed and so avoided significant impact. Around 7,000 oiled birds were washed ashore following the spill, although it is likely that the total number of birds killed was several times higher than this (SEEC 1998). Examination of seabird corpses suggested that most died directly from oil contamination rather than, for example, food chain effects. Over 90% of the oiled birds were of three species – common scoter, guillemot and razorbill. Counts of the breeding populations confirmed the impact on guillemots and razorbills. There were 13% fewer guillemots and 7% fewer razorbills counted at breeding colonies in the area in 1996 compared with 1995, while numbers for both species increased at nearby colonies. The SEEC (1998) report concluded that by the 1997 breeding season, numbers had recovered significantly.

Oil spill risks to marine mammals have been reviewed by Hammond *et al*. 2006. Direct mortality of seals 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. 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 considered to be 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 and particularly the pupping season. 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.

Intertidal habitats and species are vulnerable to surface oil pollution, and 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 ecological effects of chemical spills are clearly dependent on the physical properties and toxicity of the chemical involved. Since chemical selection and use on offshore facilities is tightly regulated (section 3.3) and the majority of chemicals are in low risk categories, the potential risk is considered to be relatively low (e.g. in contrast to bulk shipping of hazardous chemicals).

Minor gas releases subsea would be expected to result in significant dissolution in the water column, with a proportion of gas released to atmosphere. Major releases, and all releases direct to atmosphere, will contribute to local air quality effects and to global greenhouse gas concentrations. The relative contribution of all foreseeable releases is minor.

Socio-economic effects

All hydrocarbon spills have the potential to affect fish and shellfish populations by tainting caused by ingestion of hydrocarbon residues in the water column and on the sea bed. If large-scale releases of oil were to reach the sea bed, there is potential for smothering of habitats 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).

Impact on the recreational, tourism and amenity appeal in the event of a major oil spill would be influenced both by the severity of oiling and by the extent, duration and tone of media reporting and resulting public perception of the severity of the event. For example, following the *Sea Empress* spill, the local economic impact on tourism was relatively minor (SEEEC 1998). Analysis of the impact on tourism throughout Pembrokeshire suggested a downturn of about £2 million in the commercial service sector in 1996 set against an estimated £160 million contributed by tourists to the economy in 1995. Nevertheless, despite satisfaction with the quality of the environment by those visiting the area, there was evidence from further questionnaires that for one in five who actually considered visiting Pembrokeshire in 1996, the *Sea Empress* spill was significant in leading to rejection.

Major gas releases and chemical spills both have some potential for significant effects in terms of short-term safety issues and longer-term socio-economic effects. As noted above, chemicals used in offshore E&P are generally in low risk categories, and the socio-economic effects are generally similar in nature, but of lower severity, to oil spill. Potential safety issues of gas releases include explosion and (for subsea releases) loss of buoyancy for vessels and floating installation, although recent studies (e.g. May & Monaghan 2003; Beegle-Krause & Lynch 2005) suggest that the latter may not be a significant concern.

Oil spill response preparedness

Spill prevention and mitigation measures are implemented for offshore exploration and production through 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, under terms laid out by the Offshore Installations (Emergency Pollution Control) Regulations 2002. The Maritime and Coastguard Agency (MCA) is responsible for a National Contingency Plan in consultation with other relevant departments, agencies and stakeholders, a latest revision of which was issued in August 2006. The MCA is the competent U.K. authority that responds to pollution from shipping and offshore installations, although offshore installations have a statutory responsibility for clean-up in their jurisdictions, up to and including a Tier 3 incident (a large spill requiring national assistance and resources). Local authorities (and in Northern Ireland, the Environment and Heritage Service) have accepted a non-statutory responsibility for shoreline clean-up.

MCA maintains four Emergency Towing Vessels (ETVs) including one in the Minches, which remain on standby at sea. In addition, the MCA maintains a contractual arrangement for provision of aerial spraying and surveillance, with aircraft based at Coventry and Inverness. Within two days, aircraft 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 arrangement and undertakes regular aerial surveillance of offshore installations. MCA holds 1,400 tonnes of dispersant stockpiled in 11 locations around the UK, in addition to counter-pollution equipment (booms, adsorbents etc, locations including Oban and Belfast) 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").

In general, the response policy in the UK for offshore spills is to allow natural dispersion processes to occur; except where chemical dispersion is clearly advantageous (usually to protect birds). This contrasts with a generally more interventionist approach in some other jurisdictions, for example the US where *in-situ* burning of surface oil is considered as advantageous in some circumstances. The feasibility of containment and recovery in offshore locations is generally considered low in the UK, although various US studies have considered the feasibility of ship-based and sub-surface collection systems, specifically engineered to enable operations in the vicinity of a blowout; or to collect oil directly from a blowing wellhead. In general, these feasibility studies have not lead to full-scale deployment. The status (as of 1999) of existing or developing technologies that could be used to sense, track, contain and recover oil released by deep water blowouts or pipeline ruptures was reviewed by MMS (1999). In the UK, the MCA ETVs have very limited capability for surface oil recovery, and there is currently no capacity for large-scale containment and recovery in the offshore UKCS (or in adjacent national waters, including Norway and Ireland).

Update on effects consideration

Accident scenarios and historic frequency

As noted above, one specific factor in the spill risk assessment for drilling activities in deep water is riser integrity. The marine riser is the tubular assembly from the rig (or drillship) to the wellhead (at seabed level for an exploration or appraisal well), consisting of a series of piping joints supported by buoyancy. At the wellhead, a Blowout Preventer (BOP) stack comprises a series of valves, which in an emergency, seal the well and prevent uncontrolled flow of formation fluids. A flex joint above the BOP stack and telescopic joint immediately below drill floor level accommodate any vertical misalignment and allow for heave due to wave action. The integrity of the riser has been a particular cause for concern in deep water wells, due to mechanical considerations, the high magnitude of wave action, and the potential fatigue effects of vibration caused by vortex shedding in strong currents. There have been no cases of riser failure resulting in spillage on the UKCS; however, in 2003 a catastrophic riser failure occurred on the dynamically positioned TSF *Discoverer Enterprise* while drilling a production well on BP's Thunder Horse development in the Gulf of Mexico (water depth 1841m). The riser parted in two places - just above the (LMRP) at about 55 ft above the seafloor and at 3,200 ft (RK), resulting in riser joints falling to the seafloor. When the riser parted, the BOP "dead man" system activated, and all fail safe valves, casing shear rams, and lower blind shear rams were closed. The drillpipe was successfully sheared by this activation. At a later point, an ROV used a hot stab to activate a second set of upper blind shear rams to provide another barrier on the wellbore. Although the well control equipment functioned as designed, the parting of the marine riser resulted in a release of synthetic based mud, estimated at 2,450 bbl of Synthetic Base Fluid (SBF, approximately 390 m^3) was released. A Minerals Management Service (MMS) assessment (MMS 2004) concluded that the released SBF dispersed into the water, settled to the seafloor, and biodegraded. The SBF would cause a temporary decrease in dissolved oxygen at the sediment water interface. Impacts to fish resources and commercial fisheries would be negligible to nonexistent because of their mobility, the dispersion of the SBF, and the absence of toxicity of the released SBF.

A previous case of riser failure had occurred in 2002, offshore Malaysia in a water depth of 1740m (*Ocean Baroness*). This case was attributed to failure of bolt assemblies at a riser connection, causing the riser to separate. In both cases, effective control of a potentially major incident was achieved without significant spillage of reservoir fluids or environmental effects.

An annual review of reported oil and chemical spills in UK waters – covering both vessels and offshore installations – is made on behalf of the Maritime and Coastguard Agency by the Advisory Committee on Protection of the Sea (e.g. ACOPS 2006). These reviews split the UK Pollution Control Zone into 11 enumeration areas, of which Area 8 (Western Scotland) approximates to the SEA 7 area. In 2005, a total of 12 spills were reported from vessels in the West of Scotland area (of which eight were in port – six in Lochinver). Similar statistics were reported for 2004, indicating that coastal and offshore waters in the SEA 7 area are among the least affected by oil spills in the UK. However, for the entire UK Pollution Control Zone in 2005, 27 of the 37 reported spills >2 tonnes were from oil and gas installations. Several of the spills from installations involved chemical or hydraulic fluids, which are considered to cause negligible impact to the environment (ACOPS 2006). (2005 was also notable in that the single largest spill, 180 tonnes, with 96t subsequently recovered, was from an MCA Emergency Towing Vessel.) It is possible that the prevalence of fixed installation sources reflects under-reporting of spills from vessels, particularly those in transit through UK waters.

Excluding approximately 100 permitted produced water discharges, a total of 282 oil discharges was attributed to oil and gas installations during 2005 including those operating in the west Shetland Basin, Liverpool Bay and off the coast of eastern England.

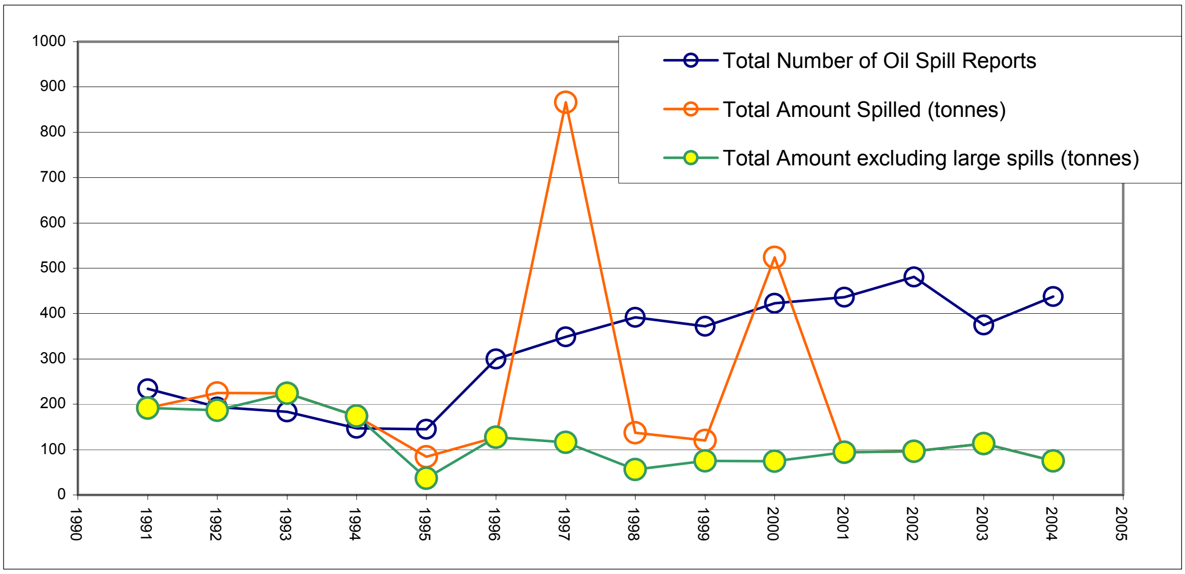
In addition, the authorities were notified of 101 discharges of chemicals and other substances during 2005. The reported discharges included a biocide, brine silicate, calcium bromide, flourescein dye, glycol solutions, methanol, oil-based mud, oxygen scavenger, pig wax, scale dissolver, silicone, sodium bromide and sodium hypochlorite.

The distribution pattern for volumes of discharges from oil & gas installations, where known, was markedly skewed with 79% less than 455 litres. Individual spill volumes ranged from less than 0.01 litres to 66 tonnes. Analysis of oil types showed 38% of reported discharges were crude oils followed by 26% for lubrication and hydraulic oils and 21% for fuel oils.

The PON1 reports indicated that remedial actions were taken by operators following most accidental discharges. The responses included identification of root causes of spills, improvements in operational control procedures, recommendations concerning preventative actions and carrying out any necessary repairs and modifications to faulty or damaged equipment. In addition, several reports referred to operators sealing systems and shutting down operations in order to prevent any further pollution.

Over the preceding decade, DTI data indicates that the reported number of spills has increased (A11.c11), consistent with more rigorous reporting of very minor incidents. However, the underlying trend in spill quantity (excluding specifically-identified large spills) suggests that an annual average around 100 tonnes has been consistently achieved. In comparison, oil discharged with produced water from the UKCS in 2005 totalled 4972 tonnes.

Figure A11.c.11 – Reported oil spills on the UKCS, 1991-2005



Source: DTI data (http://www.og.dti.gov.uk/)

Five Marine Environmental High Risk Areas (MEHRA's) were established in February 2006 in the SEA 7 area including Gallan Head on the west coast of Lewis, two cells west of Islay, and two further cells at North St Kilda and South St Kilda. Despite considerable lobbying, no MEHRAs have been designated in the Minches, although new protective routeing measures for the Minches were recommended by the Government to the International Maritime Organization in July 2006.

Oil spill fate & trajectory

The behaviour of crude oil releases at depth will depend on the immediate physical characteristics of the release, and on subsequent plume dispersion processes. Advances in laboratory and field studies, and in modelling, have been made since the last "deep water"

SEA (SEA 4) – mainly in the US and Norway – and the summary in Box A11.c.2 is drawn largely from a review by Adams & Socolofsky (2005).

Box A11.c.2 - Behaviour of crude oil releases at depth

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 orifice diameter and pressure differential between the source and hydrostatic pressure at the release point will be critical factors in determining the form of the oil, and size of gas bubbles, as the plume 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. At sufficiently high pressure and/or low temperature (corresponding to seawater below a depth of about 450m), natural gas bubbles could react with seawater to form gas hydrates (Sloan, 1998). Solid hydrate particles of natural gas are much less buoyant than pure gas bubbles, and hence substantial hydrate formation would significantly reduce plume buoyancy. Even partial hydrate formation, in the form of a thin skin surrounding the gas bubble, would reduce the rate of dissolution. Laboratory studies of jet break-up, droplet size distribution and hydrate formation have been conducted at University of Hawaii (Masutani & Adams 2000; Tang *et al*. 2003; Tang 2004). Application of the UH results to a field scale deep oil spill suggests that hydrate formation on natural gas bubbles is probably not a significant consideration because 1) hydrate formation requires high concentrations of dissolved gas in the seawater and that is unlikely to happen in a large continuous flow of gas which forms a plume and hence tends to disperse the bubbles, diluting their concentration, 2) it was inferred that the hydrate formed in the lab was in the form of a thin coating shell surrounding the gas bubble; while this could affect mass transfer, the mass fraction of the solid shell would be too small to affect buoyancy, and 3) an oil film surrounding a gas bubble further impedes hydrate growth.

Mathematical models of oil and gas plumes (see below) are patterned after models of single-phase plumes such as those that result from the discharge of fresh water into seawater (e.g., a coastal sewage outfall) or from the discharge of warm water into cold water (e.g., a thermal discharge from an electric power plant). However, the presence of the dispersed phases (oil and natural gas) complicates the plume dynamics in several respects. Firstly, the dispersed phase *is* the source of buoyancy (with typical gas to oil ratios, the buoyancy is mainly contributed by the natural gas) and secondly, the gas and oil will tend to separate from the plume due to the effects of ambient stratification and/or current. Modeling studies at MIT (Masutani & Adams 2000; Socolofsky 2001; Socolofsky & Adams 2002; Socolofsky & Adams 2003) focused on characterising the influence of a dispersed phase on plume dynamics and in particular, quantifying the nature of phase separation.

The DeepSpill experiment was conducted by SINTEF during 26-29 June 2000, at the Helland Hansen site in the Norwegian Sea (at 65° N, 4° 50□Œ E) to test the behavior of accidental oil releases in deep water. The results of the experiments are summarised by Johansen *et al*. (2000a, b, 2003a, b). The goals of the experiment were to:

- Obtain data for verification and testing of numerical models for simulating accidental releases in deep water
- Test equipment for monitoring and surveillance of accidental releases in deep water
- Evaluate safety issues for accidental releases of oil and gas in deep water.

The DeepSpill results showed that some oil droplets rose to the surface faster than predicted based on the rise velocity of individual droplets, causing some oil to surface closer than expected to the release point. However, most oil was not recovered at the surface suggesting it was in the form of widely dispersed fine droplets. Slicks from submerged oil releases are thinner than those from surface spills allowing them to weather more rapidly.

Two workshops to compare deep-water oil spill models among themselves and to the DeepSpill data took place in New Orleans (October 2001) and Seattle (April 2003). The purpose of the workshops was to review existing models, understand their formulations and differences, compare their results to the DeepSpill data, develop an assessment of their accuracy, and identify areas of improvement. The first workshop focused on the subsurface simulation, which tracks oil from the release to just below the water surface; with second also considering coupling of each model with a traditional surface spill model.

Three models were initially considered:
- DeepBlow, a comprehensive integral plume model developed by SINTEF
- CDOG, a comprehensive integral plume model developed by Clarkson University
- An MIT parametric model developed through correlations to the MIT laboratory experiments

A new plume model from ASA was also considered in 2003. As a result of the two modeling workshops SINTEF and Clarkson completed a detailed model intercomparison report involving 8 test cases designed around conditions in the Gulf of Mexico (Yapa *et al*. 2003).

Based on the models and experimental studies, an accidental release of oil and/or natural gas obeys the following staged pattern. Near the release, oil, gas and entrained seawater rise as a coherent buoyant plume. A few meters above a point-source release, ambient conditions begin to affect the plume: crossflows cause the plume to deflect in the downstream direction and stratification retards the upward plume motion by entrainment of ambient seawater. For cases similar to the DeepSpill experiment, at a height of order 100 m, these ambient effects arrest the plume, and cause the entrained seawater and the dispersed phases to separate. The arrest takes the form of a completely bent over plume in the case of a strong crossflow, or a trap height and intrusion in the case of a stratification dominated plume. At this terminal level, there is rapid spreading, either by advection from the crossflow or gravitational collapse of the intrusion layer, and the oil is distributed over a wide area. Above this trapping zone, the oil rises as individual droplets.

Comparison of the DeepBlow and CDOG results to the DeepSpill data indicate that the rise time for the bubbles is over-predicted in the models by about 1 hour in 850 m depth of water. This fact suggests that the post-plume stage likely consists of some organized group flows that permit the oil droplets to travel faster their natural slip velocity. This may be in the form of subsequent intermediate plumes or merely group effects of rising bubbles, such as wake shadowing. Unfortunately, the physics of this stage is not well known, and the models can only rely on the droplet slip velocity for guidance.

Integrated simulation results, including surface slick behaviour, were dominated by the post-plume stage. Differences in rise heights for the plume stage are due to local differences in the simulated plumes. Each model uses a different algorithm for hydrate formation (ASA assumes no hydrates) and for separation between the entrained fluid and the dispersed phase(s). Although differences in hydrate formation and phase separation between the models can result in a factor of three variation for the plume stage height, time to surface and slick formation were much less affected because, for the simulated water depths, the plume stage is relatively short. Overall, it was concluded that the oil droplet size distribution was a key parameter for predicting the fate of the oil using these models; and that details of the plume stage are insignificant to the overall model prediction for a deep spill.

Source: summarised from Adams & Socolofsky (2005).

SEA 7 specific consideration

The majority of the anticipated reservoir hydrocarbons in the SEA 7 area are gas, with a limited prospectivity for oil. A dry gas blowout would not result in significant deposition of liquid hydrocarbons to the sea surface, and there have been no large condensate spills on the UKCS resulting from E&A drilling in a comparable reservoir. Although model predictions are that even a large condensate spill would evaporate and disperse relatively quickly, there is little field data to validate this expectation. However, there has been one comparable incident in Canada: the condensate blowout at Shell's Uniacke G-72 well, 16.9km NE of Sable Island (east of Nova Scotia). The Uniacke blowout occurred in February 1984 and continued for 10 days. The gas and condensate aerosol plume was estimated to rise approximately 10m above its point of exit at the rotary table on the drilling floor. The slick that formed from the condensate fallout was approximately 300m wide near the source and spread to a width of approximately 500m. It was estimated that between 50 to 70% of the condensate volume evaporated in the air prior to reaching the water although monitoring studies detected condensate up to 10 km from the well, in concentrations generally below 100 ppb. The slick was observed to physically dissipate once the well was capped and there were no visual observations of a residual slick on over-flights the day after capping (Martec Limited 1984).

In order to indicate the likely fate and trajectory of oil spills within the SEA 7 area, two representative cases are summarised below (both taken from ES for 17th Round exploration wells).

Stochastic modelling for the 153/5-A well, operated by Marathon Oil U.K. considered three representative scenarios (surface and wellhead blowouts @ 1400 T/day for 120h; mid-water loss of riser @ 191 T instantaneous; and surface 250 T instantaneous diesel spill). Modelling was carried out using OSIS. Probability contours for surface oiling at adjacent coastlines range from 10% (surface blowout, beaching at west Orkney) to negligible (diesel spill). Surface oiling could occur on the west coast of Lewis for all simulations using the properties of Foinaven crude oil, but the probability is generally less than 10%. In all crude oil release scenarios, the north-west sides of Lewis and North Uist, together with St Kilda had a probability of surface oiling of 5-10%; South Uist down to Barra Head had a probability <5%. The Orkneys (primarily Mainland, Rousay and Hoy) also had a low probability (<10%) of surface oiling and relatively small volumes of oil beaching following a crude oil spill. The most southerly Faroe Islands had a very low probability of surface oiling (1%) and this only occurred for low probability wind speeds (sustained >40 knots).

Modelling using OILMAP for the 164/28-A well, operated by Agip (UK), considered 2700 T/day surface and subsurface releases and 250 T instantaneous crude and diesel spills. Surface oiling probability contours for this modelling showed most probable direction of movement in a north-easterly direction, with no land areas being impacted by oil (over five days).

Deterministic modelling for these two locations, under conditions of sustained 30 knot wind, indicated minimum times to beaching of 34-85h, depending on direction. Minimum times are in the direction of Sula Sgeir.

The general conclusion of a low probability of spill movement to the south is considered to be valid for all of the prospective regions of the SEA 7 area.

Offshore seabird vulnerability to surface pollution in the SEA 7 area was reviewed in Appendix A3a1.6. During the summer months, vulnerability was low in offshore waters, with some moderate areas of vulnerability along the shelf edge. Waters around the offshore colonies of St. Kilda, North Rona and Sula Sgeir and in some inshore areas were highly vulnerable at this time. Seabird vulnerability in inshore waters was generally moderate with localised areas of higher vulnerability. Overall, seabird survey coverage in SEA 7 was the lowest of all SEA areas, with only a quarter of the recommended area surveyed; largely as a result of survey effort commissioned by AFEN following the 17th Round. Survey coverage was especially limited in the winter months, particularly between October and December.

Of the species commonly present in the SEA 7 area, Manx shearwater, gannet, auk species and seaducks, in particular common scoter and divers are the most vulnerable to oil pollution due to a combination of heavy reliance on the marine environment, low breeding output with a long period of immaturity before breeding, the regional presence of a large percentage of the biogeographic population and that some species congregate in large concentrations on the sea surface and are flightless due to annual moults. In contrast, the aerial habits of fulmar and gulls, together with large populations and widespread distribution, reduce vulnerability of these species.

The specific vulnerability of coastal waterbirds (including divers, grebes and seaduck) has not been quantified with a methodology comparable to the seabird OVI, although these species are included in calculations of OVI. In general, waterbird sensitivity is highly seasonal and is predominantly associated with wintering species. The SEA 7 region is of national and international importance for a variety of seaducks, divers and grebes outside of the breeding season; however, important areas are concentrated around the east coast of the Outer Hebrides, the Inner Hebrides and mainland coasts. Important sites, which are potentially vulnerable to a spill originating west of the Outer Hebrides, include Traigh Luskentyre and the Sound of Taransay, Sound of Harris, Howmore (South Uist) and Eriskay.

Grey and harbour seals spend significantly more time ashore, and are especially vulnerable to oil spills, during the moulting period (February-April in grey seals; August-September in harbour seals) and particularly the pupping season. In the SEA 7 area, grey seal pups are born in October-late November; harbour seals pup in June-July (see Appendix 3a.1).

The western coastlines of the Outer Hebrides, which have a relatively higher probability of oiling, have a combination of high energy rock, boulder, cliff and sand shores which are generally of low or moderate vulnerability. Higher vulnerability shore types are distributed in sea lochs, sounds and embayments. Shoreline types have been mapped as part of coastal protection planning carried out on behalf of AFEN (Dykes *et al*. 2000).

Considerable numbers of salmon and mussel farms are found throughout the SEA 7 area and the aquaculture industry has become an important constituent of the local economy. The *Braer* spill had particularly severe effects on the fish farming industry in Shetland, 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 Hebridean and mainland coastlines would have a similar effect.

In addition to fishing, coastal industry and activities in adjacent areas to the SEA 7 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 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.

Minimum beaching times from some parts of the SEA 7 area are relatively short in relation to the area's remoteness and may not provide sufficient time for appropriate response measures as described above. Coastal oil spill risks would therefore be a key issue in assessment and risk management of proposed developments within parts of the SEA 7 area. (Some equipment was left in place in Stornoway following exploration drilling in the late 1990s.)

Conclusions and data gaps

The environmental risks of accidental events associated with proposed activities in the SEA 7 area are qualitatively similar to those of previous and ongoing activities in the North Sea and west of Shetland, and mitigation in the form of risk assessment and contingency arrangements is well established.

Project specific risk is highly associated with reservoir fluid type (i.e. heavy oil >>condensate>gas) and distance from sensitive coastal habitats and locations. The likelihood of E&P activity is highest along the shelf edge from Quadrant 165, through parts of 164, 152, 153, 154, 141, 142 to 132; these areas are in the approximate range 90-150km west of the Outer Hebrides with a worst-case response window of ca. 30-40h. Slick movement towards the north-east is more likely; with potentially significant consequences for seabird colonies to the north (Sula Sgeir and North Rona), and for the Orkney coastline. Anticipated reservoir fluids have a high probability of gas.

Subsea drilling equipment has evolved over the years into complex yet reliable systems. The subsea drilling pressure control system comprises several inter-related components including the wellhead assembly, BOP stack, choke & kill line system and riser. There have been very few deepwater drilling incidents resulting in loss of well control, and in two recent cases of deepwater riser failure, effective control of a potentially major incident was achieved without significant spillage of reservoir fluids or environmental effects.

Historic improvements in spill prevention and mitigation have stabilised the volume of oil spilled from E& P operations on the UKCS at a relatively low level, primarily through identification of root causes of spills and improvements in operational control procedures.

The risk context to the activities resulting from proposed licensing in the SEA 7 area includes other hydrocarbon discharges; and spills associated with shipping. In general, the SEA 7 area has few hydrocarbon discharges and a low incidence of accidental spills. However, in a national context the risk of oil spills resulting from shipping casualties is high or very high around St Kilda and the Flannans, on the west coast of Lewis and around the Butt of Lewis. This risk is, in part, mitigated by the provision of an Emergency Towing Vessel in the Minches.

In some cases, there is strong seasonality in specific species' sensitivities – in particular in relation to bird populations and breeding/moulting seals. Existing regulatory controls emphasise the risk management and contingency planning aspects of environmental management, including the timing of operations; and additional controls at an SEA level are not considered to be necessary.

Data gaps identified by the SEA process in relation to accidental events include quantification of the vulnerability of offshore seabirds (especially in winter) and coastal waterbird populations. This lack of detailed data does not compromise the SEA process significantly, and a precautionary assessment of proposed activities (at a project-specific EA level) is recommended. However, it is recommended that further bird survey effort is commissioned in order to support future assessments: this effort should also take into account the potential locations of SPA extensions.

Oil spill response planning and capability, by the MCA, the oil industry and local authorities, is generally consistent with provisions in other sensitive and remote areas of the UK (e.g. west of Shetland). It is clear that prevailing weather conditions will rarely facilitate offshore containment and recovery of surface oil (also that the emphasis should be on prevention rather than cure); however, it is recommended that further consideration should be given to an appropriate level of response capability in the Western Isles. This may be especially relevant if activities following the proposed licensing are concentrated into a limited period (as followed the 17^{th} Round).

A11.c.10 Cumulative effects

As noted above, the SEA Directive (footnote to Annex I) requires *inter alia* that secondary, cumulative and synergistic effects should be considered. Stakeholder consultation has confirmed the importance of cumulative effects within the overall process. 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) have been prepared on behalf of the EU, although this was primarily targeted at Environmental Impacts Assessments and Integrated Pollution Prevention and Control. A practical guide to the SEA Directive has recently been produced by the Office of the Deputy Prime Minister (ODPM 2005). 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).

Secondary, cumulative and synergistic effects are not defined by the SEA Directive, and a range of definitions have been used. ODPM (2005) notes that the terms are, to some extent, not mutually exclusive and that often the term cumulative effects is taken to include secondary and synergistic effects. An additional term, incremental effects, has been used by previous DTI SEAs to distinguish those effects which result from activities which may be carried out under the proposed licensing; together with activities carried out under previous licensing.

Secondary effects comprise indirect effects which do not occur as a direct result of the proposed activities, but as a result of a more complex causal pathway (which may not be predictable).

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); in an SEA 7 context 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 secondary, 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.

Although the sequential effect concept is considered by the SEA mainly in the context of acoustic or other physical disturbance, the term sequential effect has been developed primarily in the context of sequential visual impact (e.g. for onshore windfarms, from the point of view of a moving observer: SNH 2005).

The SEA Directive (Annex II) also requires consideration of environmental problems relevant to the plan or programme as a criterion for determining the likely significance of effects. On the assumption that environmental "problems" are a result of some anthropogenic effect, the potential interactions between potential activities following a 25th Round and recognised environmental problems in the SEA 7 area are considered in this section of the SEA document.

Those potentially significant effects considered to be cumulative are assessed below.

Underwater noise

Consideration of propagation ranges for noise resulting from seismic surveys in the SEA 7 area suggests that consecutive surveys have the potential to produce sequential acoustic disturbance over large parts of the Hebridean shelf, slope and Rockall Trough. However, the extent of this is dependent on exploration activity level, operational and timing factors and is impossible to predict. 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 or sequential disturbance.

In principle, the multiple sources may comprise for example two seismic surveys or a seismic survey and another source of noise (e.g. shipping). Although there is no direct evidence for "multiple source confusion" in marine mammals, this represents a possible mechanism for synergistic effect which should be considered further. Possible synergistic effects between seismic survey and military sonars should also be considered further.

In deep water SEA areas, offshore marine mammals distribution has been considered not to be generally confined to localised areas and therefore it is unlikely that individuals in these areas would be exposed to sound levels sufficient to cause significant biological effects for the full duration of a survey. However, in the SEA 7 area, harbour and grey seal distributions are likely to be associated with particular areas, especially during the pupping and moulting seasons. Existing regulatory controls over seismic surveys are applied to one survey at a time and there is no clear regulatory mechanism for consideration of cumulative effect, although JNCC and DTI will take account of sequential surveys when this is notified through the PON14 system. In view of the predicted (relatively low) level of activity in scenario area 1, consideration should be given to a precautionary limit on the frequency of seismic survey consented within this area. No marine mammal species are known to follow regular, tightly defined migration pathways in the SEA 7 area, which could be "blocked" by cumulative seismic disturbance, although it is likely that some baleen whale species make regular seasonal movements between sub-tropical and sub-arctic regions through the Rockall Trough and Faroe-Shetland Channel.

The potential for secondary effects of noise disturbance, such as indirect effects on marine mammal predation, are largely unknown although to date, there is no evidence for significant impacts. There is also potential ambiguity on the harm/benefit of behavioural disturbance of marine mammal populations (for example, outside the SEA 7 area, seals are widely perceived to have significant impact on coastal and estuarine salmonid populations, although dietary evidence does not support this conclusion).

Overall, the likelihood of cumulative noise effects from seismic surveys will depend on the timing and location of seismic, but is considered to be moderate in view of the low predicted activity levels in the SEA 7 area following a 25th Round. There is no evidence that substantial E&P activity to date in the North Sea has resulted in direct mortality or acute trauma to marine mammals.

Incremental	Simultaneous and sequential surveys in SEA 7 and previously licensed areas.
Cumulative	Seismic survey noise and broadband impulse noise, for example military sonars, and continuous mobile sources e.g. shipping
Synergistic	Possible multiple source acoustic disturbance
Secondary	None known

Physical damage to features and biotopes

Potential sources of physical disturbance to the seabed, and damage to biotopes, were identified as anchoring of semi-submersible rigs, wellhead placement and recovery, production platform jacket installation and piling, subsea template and manifold installation and piling, pipeline, flowline and umbilical installation and trenching and decommissioning of infrastructure. Given the forecast scale of exploration and production for the SEA 7 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. Incremental effects are therefore not considered significant.

Effects of seabed disturbance resulting from SEA 7 activities will be cumulative to those of other activities, notably demersal fishing. In a UKCS context, the contribution of all other sources of disturbance are minor in comparison to the direct physical effects of fishing, and it can be argued that the positive effect of fisheries exclusion offsets any negative effects of exploration and production. On balance, however, the spatial extents of both positive and negative effects are probably negligible for most seabed habitats.

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 (as amended 2007)*. 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. In these areas the disturbance effect of oil and gas development is likely to be offset by fishing exclusion.

Synergistic None known

Secondary 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). The predicted incremental effect of exploration and development in the SEA 7 area amounts to 5-10 temporary exclusion zones (not all would be concurrent and spread over a 4 to 5 year period) and the possibility of several longer term exclusion zones associated with production developments.

Incremental Small increment to existing exclusion zones and obstructions, visual intrusion and disturbance

Cumulative Exclusion and snagging risks are cumulative to those resulting from natural obstructions, shipwrecks and other debris. Extent of cumulative effect associated with 25th Round is negligible.

Synergistic None known

Secondary None known

Marine discharges

Total produced water discharge from UKCS oil production was 240 million tonnes in 2005, with an average oil in water content of 20.47mg/kg (DTI website). In comparison with this, the potential discharge from new developments following a 25th Round 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 presumption against the discharge of oil in produced water 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 7 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 7 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 probability of reinjection drill cuttings from any 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 SEA 7 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.

Secondary None known

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.

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. In addition, offshore oil industry emissions are subject to an Emissions Trading Scheme. 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. Other than start-up flaring, subsea tie-back developments in SEA 1-6 areas will generally have little effect on host installation flaring.

Atmospheric emissions from activities that may result from implementation of draft plan alternative 2 or 3, and the end use of any hydrocarbons produced will contribute to the overall global emissions of greenhouse gases and consequently to climate changes, ocean acidification and other indirect effects. However, the scale of such emissions although uncertain would be relatively small, and they will be included in overall UK emissions inventories and the longer term initiatives to shift the balance of energy demand and supply towards a low carbon economy.

The pathways by which climate change may affect health are diverse and complex (WHO 2003). The IPCC 3rd assessment (IPCC 2001) concluded that overall, negative effects are expected to outweigh positive impacts. It is predicted that climate change impacts will affect some regions more than others Important influences on health may include changes in the frequency and intensity of extremes of heat, cold, droughts, floods, hurricanes, tornadoes and other forms of extreme weather. Climate change also will impinge on health by disrupting ecological and social systems, resulting in changes in infectious disease transmission, food production, air pollution, population displacement and other forms of social disruption. The UK response to this challenge is part of the broader policy framework of the 2003 Energy White Paper Our energy future - creating a low carbon economy.

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 are therefore considered to be cumulative. On a global scale, cumulative contributions of emissions resulting from SEA 7 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 following a 25th Round in the SEA 7 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 a 25th Round.

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

Secondary 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 7 is moderate or low. In a study of accidental oil spills and maritime casualties carried out on behalf of the MCA to inform the placement of emergency towing vessels, Safetec (2000) ranked pollution risk[8] around St Kilda, the Flannans, North Rona, Cape Wrath and along the west coast of Lewis as high or very high. High or very high risk rankings were also widely distributed through the North Channel, west coasts of Orkney and Shetland, through the Pentland Firth, east coasts of Scotland and England, Dover Straits and through the English Channel. In relative terms, SEA 7 related activity would not have a significant influence on this assessment and the cumulative risk in the SEA 7 area is therefore not significantly influenced by the proposed activities.

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

[8] The risk assessment methodology considered frequency, but not sensitivity or consequence

trajectory modelling conditions, are very short. Effective contingency planning and local resources are therefore necessary 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 7 area (mainly from outside the area) include rivers and land run-off, coastal sewage discharges, 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, it 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 – 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 7 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 7 activities.

Cumulative There are a range of cumulative sources of hydrocarbons to the SEA 7 area. Depending on magnitude, accidental spills represent a minor to major contribution to overall regional inputs of oil.

Synergistic None known

A11.c.11 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 (the *Espoo Convention)* was signed in 1991. 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 by government if necessary.

Offshore activities have the potential for transboundary effects, both because of location adjacent to international boundaries and due to the unbounded nature of the marine and atmospheric environment.

The SEA 7 area is contiguous with waters under the jurisdiction of the Republic of Ireland and the Faroes. Based on the likely area where blocks would be applied for prevailing wind and major water mass movements will normally result in the transport of atmospheric emissions, marine discharges and spills towards the west coast of Scotland. However, SEA 7 activities may occur adjacent to the median lines and sources of potentially significant environmental effects, with the additional potential for transboundary effects, therefore include:

- Underwater noise
- Marine discharges
- Atmospheric emissions
- Accidental events – oil spills

All of the four aspects above may be able to be detected physically or chemically in Irish or Faroese waters. A similar consideration applies to the potential for transboundary effects from activities in SEA areas 1 to 6, variously in the waters of adjacent States.

The scale and consequences of environmental effects in adjacent state territories due to activities resulting from the proposed 25th Round licensing will be less than those in UK waters and are unlikely to be significant.

A11.c.12 Alternatives

The Plan alternatives were described in Section 2.4 and include

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

Based on the preceding consideration of effects, the potential effects of the plan alternatives in relation to the SEA topics is summarised below.

The assessment summary uses key below:

	Major positive impact on topic
	Minor positive impact on topic
	Neutral impact on topic
	Minor negative impact on topic
	Major negative impact on topic

SEA Topic	Potential sources of significant effect	Alt 1	Alt. 2	Alt. 3
Biodiversity, habitats, flora and fauna	Physical damage to biotopes from pipeline construction, rig anchoring etc			
	Potential behavioural and physiological effects on marine mammals and fish associated with seismic surveys			
	Potential for non-native species introductions in ballast water discharges			
	Disturbance to fish, birds and marine mammals etc from physical presence of infrastructure and support activities			
	Potential for effects on flora and fauna of produced water and drilling discharges			
	Major oil spill effects and associated damage to species, habitats and ecosystem function[9]			
Sediments and geology	Physical effects of anchoring and infrastructure construction on seabed sediments and geomorphological features			
	Sediment modification and contamination by particulate discharges from drilling etc			
	Effects of reinjection of produced water and cuttings			
	Onshore disposal of returned wastes – requirement for landfill			
	Risk of sediment contamination from oil spills [9]			
Landscape and seascape	Visual intrusion and changes to character			
	Potential visual impacts of nearshore exploration and development including seascape effects			
Water	Contamination by soluble and dispersed discharges			
	Risk of contamination of the water column by dissolved and dispersed hydrocarbons from oil spills [9]			
Air quality	Local air quality effects resulting from exhaust emissions, flaring and venting			
	Emissions of acid gases			

[9] Assumes remote likelihood of major oil spill from SEA 7 activities

SEA Topic	Potential sources of significant effect	Alt 1	Alt. 2	Alt. 3
	Air quality effects of a major gas release or volatile oil spill			
Climatic factors	Contributions to UK greenhouse gas emissions [10]			
Population **Human health**	Interactions with fishing activities (exclusion, seismic, snagging)			
	Other interactions with shipping, military, potential renewables and other human uses of the offshore environment			
	Socio-economic consequences of oil spills [11]			
	Positive socio-economic effects of potential activities, in terms of employment, expenditure and tax revenue			
	Potential for effects on human health associated with			
	- effects on local air quality resulting from atmospheric emissions			
	- discharges of naturally occurring radioactive material in produced water"			
	- potential food chain effects of major oil spills [9]			
Material assets	None			
Cultural heritage	Potential effects in relation to known or postulated archaeological heritage [12]			
The inter-relationship between the issues				

[10] Assumes the need to meet UK hydrocarbon demand through imports which from other producer nations

[11] Assumes the spill risk associated with the shipment of increased imports

[12] Assigned to neutral although minor positive benefit may accrue from identification of unknown archaeological remains during E&P site investigations