10 CONSIDERATION OF THE EFFECTS OF LICENSING THE SEA 5 AREA

10.1 Introduction

The overall process adopted for this Strategic Environmental Assessment is described in Section 2. The approach and methods used to identify the potential effects that could follow from SEA 5 licensing, and to assess them for significance are outlined below. The base case for the assessment was Alternative 2 in Section 4.2 (i.e. to offer the area for licensing) since this was judged to represent the greatest scale of potential interactions and effects.

10.2 Approach

The assessment for this SEA was a staged process which has incorporated inputs from a variety of sources (outlined below) and shown in Figure 10.1.

Figure 10.1 – SEA 5 assessment process

The initial stage was the identification of interactions between the potential activities following licensing of the SEA 5 area and receptors within the environment (both the natural environment and human uses of the area). The interactions and implications considered include positive, negative, direct, indirect, cumulative, synergistic and transboundary effects. This initial step drew on input from scoping, published descriptions of the effects of oil and gas activities, previous DTI SEAs and the EU SEA Directive.

The next stage was to review the potential interactions to identify those which might potentially have effects of a scale which should be considered further in the SEA. This was achieved through an assessment workshop held in May 2004 (see Appendix 2). Workshop participants included authors of supporting technical documents, representatives of main regulatory agencies and the SEA steering group. The process followed is illustrated in Figure 10.1 which includes the input information and outputs. Prior to the workshop, a pack of background information was circulated.

The interactions were reviewed at the workshop building on the experience from previous SEA Assessment Workshops. Expert judgement was used to identify those interactions which should be considered further in the SEA – see Appendix 2. The consideration included the scale, severity and duration of effects on the environment, human health and socio-economics, together with issues of public concern and took into account the criteria for determining the likely significance of effects included as Annex 2 to the SEA Directive. In this way the review attempted to ensure balanced consideration of scientific and perception issues.

The outcome of the assessment workshop were presented and discussed at a stakeholder dialogue meeting held in Aberdeen in June 2004 – see Appendix 3.

The final stage was detailed consideration of the interactions agreed at the workshop and the input from the stakeholder meeting. This stage is documented in Sections 10.3-10.6 and included quantification of the scale and magnitude of the potential activities and interactions, consideration of the sensitivity and ability to recover of the receptor(s), existing controls and agreements in place (see Section 3.3), information gaps, and a conclusion regarding the potential effect of further licensing in the SEA 5 area.

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

10.3 Consideration of effects

Potential sources of effects 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 issues such as biodiversity, population, human health, fauna, flora, soil, water, air, climatic factors, material assets, cultural heritage including architectural and archaeological heritage, landscape and the interrelationship between the factors – see cross referenced summaries below.

Issue	Potential sources of significant effect	See Section
Biodiversity	Physical damage to biotopes, associated with pipeline construction	10.3.2
	Marine discharges – potential effects of non-native species introductions in ballast water discharges	10.3.4
	Major oil spill effects and associated damage to habitats and ecosystem function	10.3.8
Population	Interactions with other users – principally associated with commercial implications of exclusion of fishing activities in vicinity of infrastructure, and safety risks of interactions between fishing gear and subsea infrastructure.	10.3.3
	Other interactions with shipping, military and other human uses of the offshore environment (excluding fishing)	10.3.3
	Socio-economic consequences of oil spills	10.3.8
	Positive socio-economic effects of potential activities, in terms of employment, expenditure and tax revenue	10.6
Human health	Potential for effects on human health associated with	10.3.6
	- effects on local air quality resulting from atmospheric emissions	10.3.8
	- discharges of naturally occurring radioactive material in produced water”	10.3.4.4
	Potential food chain effects of major oil spills	
Fauna **zooplankton** **benthos** **cephalopods** **fish** **marine reptiles** **birds** **marine mammals**	Underwater noise - potential behavioural and physiological effects on marine mammals and fish associated with seismic surveys	10.3.1
	Physical damage to biotopes – potential effects on benthos, associated with anchoring and infrastructure construction	10.3.2
	Physical presence of infrastructure and support activities may cause behavioural disturbance to fish, birds and marine mammals	10.3.3
	Marine discharges – potential effects of	10.3.4

Issue	Potential sources of significant effect	See Section
	produced water discharges on zooplankton and fish; drilling wastes effects on benthos	
	Oil spills – risks of effects on all faunal groups	10.3.8
Flora phytoplankton macroalgae seagrass	Marine discharges – potential effects of non-native phytoplankton species introductions in ballast water discharges	10.3.4
	Oil spills – risks of effects of beached oil on intertidal algal and macrophyte populations	10.3.8
Soil	Physical effects of anchoring and infrastructure construction on seabed sediments	10.3.2
	Marine discharges – sediment modification and contamination by particulate discharges	10.3.4
	Permanent effects of reinjection of produced water and cuttings	10.3.5
	Onshore disposal of returned wastes – requirement for landfill	10.3.7
	Oil spills (with or without chemical dispersion) – risk of sediment contamination	10.3.8
Water	Marine discharges – contamination by soluble and dispersed discharges	10.3.4
	Oil spills (with or without chemical dispersion) – risk of contamination of the water column by dissolved and dispersed hydrocarbons	10.3.8
Air	Local air quality effects resulting from exhaust emissions, flaring and venting	10.3.6
	Emissions of acid gases	10.3.6
	Air quality effects of a major gas release or volatile oil spill	10.3.8
Climatic factors	Contributions to greenhouse gas emissions	10.3.6
	Greenhouse gas emissions associated with combustion of hydrocarbons produced as a result of proposed activities, are outside scope of assessment	10.3.6
Material assets	None	

Issue	Potential sources of significant effect	See Section
Cultural heritage, including architectural and archaeological heritage	Potential effects in relation to known or postulated archaeological heritage	10.3.2
Landscape	None, assuming offshore locations of proposed activities	10.3.3
	Potential visual impacts of nearshore exploration and development including seascape effects	10.3.3
The inter-relationship between the issues	Multiple effects – biodiversity and faunal effects associated with habitat disturbance; contamination of water, sediment and fauna; oil spill risks	10.3.2, 10.3.4, 10.3.8, 10.4
	Conflicts between issues and receptors – reinjection vs marine discharges; and options for oil spill contingency	10.3.4, 10.3.5, 10.3.8, 10.4

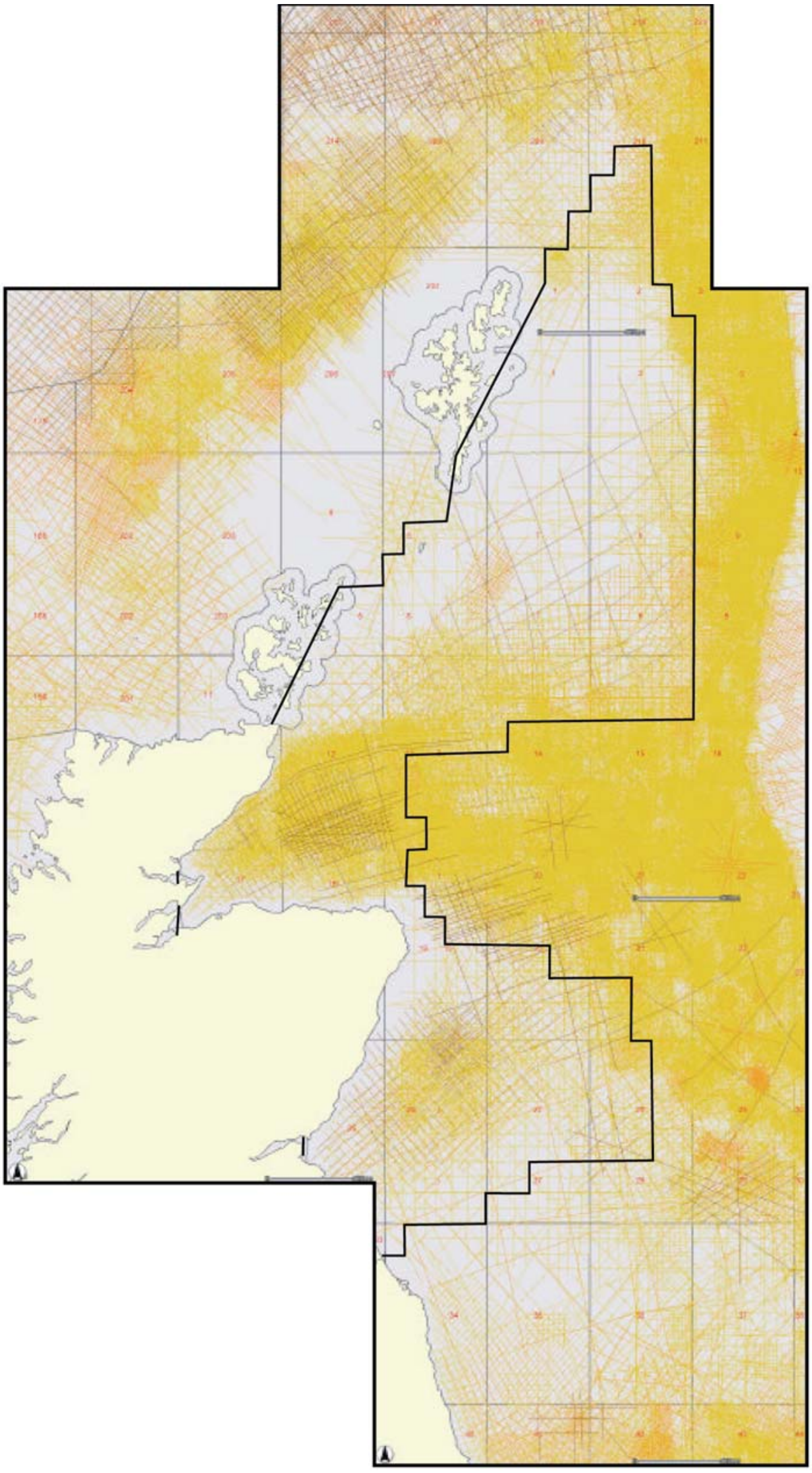
10.3.1 Underwater noise

Previous DTI oil and gas SEAs have reviewed and summarised available information concerning the characteristics of noise sources associated with exploration (principally seismic surveys), construction and production; the propagation of sound in the marine environment; and effects (physical, physiological and behavioural) on marine mammals and fish. This information is not re-iterated here, although a synopsis of new information and developments relating to these issues is provided.

As with previous SEAs, the proposed activities, including seismic surveys, are an increment to previous activities rather than new activities in a pristine area. To illustrate this, the extent of previous 2D seismic survey work in the SEA 5 and adjacent areas is shown in Figure 10.2 derived from the DEAL (Digital Energy Atlas and Library, http://www.ukdeal.co.uk/ which also shows the boundaries of 3D surveys but not the intensity of coverage). This indicates that the outer Moray Firth (Quadrants 11, 12, 13, 17, 18 & 19) and southeast of Aberdeen (Quadrant 28) have been intensively surveyed in the past; with lower survey coverage in other parts of the SEA 5 area. Sources of construction and production noise associated with Exploration and Production (E&P) in the area are currently limited to the Beatrice field.

Potential effects of underwater noise are associated principally with seismic reflection surveys, which use low frequency, high amplitude airgun sources. The key receptors are marine mammals, due to their sensitive hearing and use of acoustic communication and echo-location, and fish. The potential effects of noise on marine mammals in the SEA 5 area were considered by the supporting study (Hammond *et al*. 2004). Sensitivities of invertebrate animals and seabirds are generally considered to be lower and are not considered to be significant concerns.

Figure 10.2 – Coverage by previous seismic surveys in the SEA 5 and adjacent areas



Source: DEAL database

Information and developments not identified in previous SEAs (including international context) are outlined below:

Increase in ambient noise levels

Ocean ambient sound data from 1994 to 2001, collected using a receiver on the continental slope off Point Sur, California, were compared with long-term averages of earlier measurements over the period from 1963 to 1965 (Andrew *et al*. 2002). This comparison shows that the 1994 to 2001 levels exceed the 1963 to 1965 levels by about 10dB between 20 and 80Hz and between 200 and 300Hz, and about 3dB at 100Hz. Increases in (distant) shipping sound levels may account for this.

A comparison between the Ligurian Sea (part of the multi-national Pelagos Sanctuary in the Mediterranean Sea) and the Gulf of California (IWC-SC 2004). In the Ligurian Sea, ambient noise levels (primarily from shipping) in the fin whale song frequency band (15-30Hz) were so high as to mask all but the closest singers and were two to three orders of magnitude greater (20-30dB) than noise levels in the Gulf of California.

Acoustic monitoring in Cape Cod Bay, a critical habitat for the northern right whale, revealed persistently elevated levels of low-frequency vessel noise from January through May, a period of relatively low fishing and recreational boating activity (IWC-SC 2004). Average spectrum noise levels in the 50-200Hz frequency band were above 110dB re 1µPa2/Hz.

Acoustic monitoring was carried out throughout a shelf-break, deep water habitat in the western North Atlantic Ocean over a one week period in the late summer of 2003, during which several fishing vessels and a single seismic survey were operating along one edge of the region. When the seismic survey was active, ambient noise levels increased by two orders of magnitude throughout almost the entire 100,000 square nautical mile region and persisted so as to be nearly continuous for days at a time.

Developments in source level definition, propagation and exposure / “sonic dose”

A range of measurement methods have been used to quantify source levels, complicating the comparison of different sources and assessment of potential effects. McCauley (2000) developed an Equivalent Energy approach to characterise pulsed noise sources, using a conversion factor based on direct measurements in the field. For an airgun array in the open ocean, Equivalent Energy values averaged about 13dB lower than Root-Mean-Square (RMS) values, and 28dB lower than peak-to-peak values.

McCauley (2000) also developed an approach to assessing cumulative exposure likely over the course of a full seismic survey. The model considers the number of individual air gun shots received at a level of 155dB re 1μPa^2.s (equivalent energy) or higher; over the course of an illustrative four-month survey, an area of about 150km by 120km would experience 20,000 shots, and an area of 240km by 200km would experience 1000 shots in the course of the survey.

A different perspective is provided by geophysical contractors and other participants in the seismic survey industry; for example Caldwell (2002), in a review of various research initiatives (including tagging techniques and the Sperm Whale Acoustic Monitoring Program (SWAMP) in the Gulf of Mexico, notes that the operational design of most seismic surveys – where sequential lines are shot “Zamboni-style” (i.e. separated by at least the length of the streamer, typically 6km or greater than the effective range of ensonification) – suggest that "an individual mammal will only experience sounds above a level of 180dB re 1µPa-m for ~40 shots and ~6.5 minutes once a day or so for a few days".

General acceptance of risks of seismic / anthropogenic noise, and precautionary approach to regulation

In October 2002, a US Federal Court stopped a geological research project in the Sea of Cortez when two beaked whales were found dead, despite a lack of undeniable evidence that the seismic activity was responsible (Cummings 2003).

Episodes of increased stranding in humpback whales along coastal Brazil in 2002 (SC/56/E28) have resulted in a precautionary approach by the Brazilian Environmental Agency (IBAMA) in its recent guidelines for licensing oil exploration activities; including a prohibition of seismic surveys during the whale breeding season from July to November (IWC-SC 2004).

Displacement of the western North Pacific gray whale population from a primary feeding area off Sakhalin Island, have been attributed to seismic (IWC-SC 2004) activity.

Recent strandings of whales off Senegal appear to coincide with seismic exploration in the area (IWC-SC 2004).

The US Minerals Management Service (MMS 2004) has completed an environmental assessment evaluating the potential environmental impacts of geological and geophysical (G&G) activities in the Gulf of Mexico, including seismic surveys, deep-tow side-scan surveys, electromagnetic surveys, geological and geochemical sampling, and remote-sensing surveys. The impact-producing factors considered in the EA include seismic survey noise, vessel and aircraft noise, seafloor disturbance, and space-use conflicts with seismic arrays. The conclusion of the EA was that G&G activities are not expected to result in significant adverse impacts to any of the potentially affected resources. Potentially adverse but not significant impacts were identified for marine mammals. As a result, MMS has issued a "Finding of No Significant Impact".

Mass strandings of beaked whales and other cetaceans

Several recent mass strandings of beaked whales suggest that these species, particularly Cuvier's beaked whale (*Ziphius cavirostris*), are prone to stranding following exposure to high intensity sound that is associated with naval operations and seismic exploration activities (Hildebrand 2004). Two such strandings have been documented by investigative reports: the Kryparissiakos Gulf, Greece, incident of May 1996 (D'Amico & Verboom 1998), and the Bahamas incident of March 2000 (Evans & England 2001); with other incidents reported in Italy and the Canaries. Both events are listed by IWC-SC (2004), probably based on a global list of *Ziphius cavirostris* strandings involving two or more animals compiled by the National Museum of Natural History, Smithsonian Institution (James Mead, pers. comm. to John Hildebrand, noted in Hildebrand 2004). The sound exposure levels modelled at positions of beaked whale sightings in the Bahamas do not exceed 160-170 dB re 1µPa @ 1m for 10-30 sec. These level are not sufficient to produce even temporary threshold shift (hearing loss) for the affected animals, based on studies of captive bottlenose dolphin and beluga whales. Other mechanisms suggested include physiological non-auditory impacts, or behavioural responses leading to physiological impact.

Issues related to the vulnerability of beaked whales to anthropogenic sound were reviewed by a technical workshop sponsored by the US Marine Mammal Commission, April 13-16, 2004. A full report from the workshop is expected in autumn 2004 (http://www.mmc.gov/sound/beakedwhalewrkshp/beakedwhalewrkshp.html).

The formation of gas bubbles, either due to a behavioural response or directly induced by sound, is one hypothesis currently under investigation, with a recent exchange of views in *Nature* following work by Jepson *et al*. (2003) relating to the examination of cetaceans from the Canaries (Fernández *et al.* 2004, Piantadosi & Thalmann 2004).

Ten mass strandings of Cuvier's beaked whales with 47 whales, and one mass stranding of four Baird's beaked whales *(Berardius bairdii)* have occurred in Japan within the period between 1960 and 1995. A US Naval operation area is offshore from where the mass strandings occurred and tactical mid-frequency sonars have been implicated as the probable cause for these strandings (IWC-SC 2004).

Several unusual cetacean stranding events occurred in Chinese waters in February-March 2004, coincident with large-scale naval exercises (IWC-SC 2004). The pattern of injuries found in the only available carcass of a ginkgo-toothed beaked whale (*Mesoplodon ginkgodens*), was consistent with blast trauma.

Fourteen harbour porpoise stranded in Washington State, coincided with the use of mid-range sonar by the naval vessel *USS SHOUP* in Haro Strait between Vancouver Island (Canada) and San Juan Island (US) on 5 May 2003 and observations by researchers and the public who reported altered behavior of marine mammals in the area. Eleven porpoises were collected for necropsy. Cause of death was determined for 5 animals, two of which were found to have suffered blunt force trauma, while illness (peritonitis, salmonellosis, pneumonia) was implicated in the remaining three cases. No cause of death could be determined for the remaining six animals. The examinations did not reveal definitive signs of acoustic trauma in any of the porpoises examined, although the possibility of acoustic trauma as a contributory factor in the mortality of the porpoises examined could not be ruled out (NMFS 2004).

Conservation of key habitats for cetaceans

In several countries, specific management and mitigation measures intended to protect specific habitats or areas considered to be important for marine mammals, have been implemented in recent years:

As noted above, a precautionary approach has been adopted by the Brazilian Environmental Agency (IBAMA) in relation to humpback whales that aggregate at Abrolhos Bank on the northeastern coast of Brazil during the spring-winter season for breeding and calving. This includes a prohibition of seismic surveys during the whale breeding season from July to November.

The Gully Marine Protected Area (MPA) and adjacent canyons of the outer Scotian Shelf and Slope (Canada) have been identified as an important habitat for bottlenose whales (*Hyperoodon ampellatus*). Mitigation and monitoring includes prohibition of seismic acquisition within the proposed Gully area; orientation of seismic lines in adjacent areas to reduce propagation towards the Gully; shut down during turns and ramp-up procedures; and implementation of safety radius/shut downs based on noise modelling. In addition, the COOGER seismic project, carried out by the Canadian Centre for Offshore Oil and Gas Environmental Research, includes deployment of autonomous Ocean Bottom Seismometers (OBS), water-column hydrophones and marine mammal observers to investigate marine mammal distribution and behaviour, and to quantify acoustic signals of seismic origin and validate sound propagation models.

The Great Australian Bight region contains important habitat for the endangered southern right whale and the Australian sea lion, Australia's only endemic pinniped. The Great Australian Bight Marine Park – Commonwealth Waters was declared in April 1998. Directly adjacent to the State Marine National Park is the Marine Mammal Protection Zone from three nautical miles to a maximum of approximately 12 nautical miles offshore. This area is primarily to complement the State Marine Park in providing for undisturbed calving for the southern right whale and protection of Australian sea lion colonies (Environment Australia 2000). An independent review of available information on the potential sensitivity of marine mammals to mining and exploration within the Marine Mammal Protection Zone has been undertaken with particular references to vulnerability during calving (DEH 2004). This will form part of a review of the entire Plan of Management for the park. (The review also includes a useful comparison of current management and best practice in Australia, Brazil, Canada, New Zealand, the UK and the US).

The Environment Protection and Biodiversity Conservation Act 1999 established the waters of Australia’s EEZ as the Australian Whale Sanctuary. Environment Australia developed a guideline regarding seismic activities in 2001. Draft revised cetacean guidelines (issued for public consultation in July 2004) indicate that proponents will be required to undertake a referral, assessment and approval process for any seismic survey proposed within 20km of a feeding, breeding, calving or resting area of a large cetacean species, during the period when they are present; or when a seismic survey will be carried out in or near migratory paths for large cetaceans. The timing, duration and intensity of the seismic survey will also influence the potential significance of the proposal.

10.3.1.1 Specific consideration of the SEA 5 area

The activity levels forecast by the DTI for the SEA 5 area comprise:

- In the year of award – 2 x 2D seismic surveys
- In the year following award – 4 x 2D seismic and 3 x 3D seismic surveys
- In the year 2 years after award – 2 x 2D seismic and 3 x 3D seismic surveys
- In the year 3 years after award – 2 x 3D seismic surveys
- In the year 4 years after award – no seismic envisaged

i.e. a total of 8 2D surveys and 8 3D surveys. It is clear from Figure 10.2 that this represents a modest increment to existing coverage in the area.

As noted in Section 6.8, the six most frequently recorded species of cetacean in the SEA 5 area are the harbour porpoise, white-beaked dolphin, Atlantic white-sided dolphin, killer whale, bottlenose dolphin and minke whale. Harbour and grey seals are also abundant in the area. A range of threshold sound pressures for physiological and behavioural responses have been based on experimental data (McCauley 1994, Richardson *et al*. 1995, Evans & Nice 1996, Gordon *et al*. 1998), audiograms generally indicating that low frequency hearing thresholds for odontocetes and seals are higher than have been postulated for large mysticete whales (e.g. Ketten 1999).

Audiograms for harbour seals are typical for pinnipeds (Hammond *et al*. 2004, based on data from Richardson *et al*. 1995), indicating a fairly flat frequency response between 0.1 and about 40kHz, with hearing thresholds between 60 and 85dB re 1μPa. Sensitivity decreases rapidly at higher frequencies but in the one animal tested at low frequency, the threshold at

0.1kHz was 96dB re 1μPa., indicating good low frequency hearing. No behavioural audiograms are available for grey seals, but electro-physiological audiograms (based on auditory evoked potentials) showed a typical pinniped pattern over the range of frequencies tested (Ridgeway & Joyce 1975). The fact that grey seals make low frequency calls suggests that they also have good low frequency hearing.

Hearing thresholds have been measured in the smaller toothed whales (dolphins and porpoises). These are most sensitive to sounds above about 10kHz and below this sensitivity deteriorates (Hammond *et al*. 2004). For the species regularly recorded in the SEA 5 area, a hearing threshold of 110-140dB at 100Hz is probably reasonable at dominant seismic frequencies.

Behavioural and physiological responses to experimental (broadband) noise occur at received levels of 150-170dB in bottlenose dolphins (e.g. Tyack *et al*. 1993) and seals (Thompson *et al*. 1998), with the response varying from avoidance or investigation. Threshold peak impulse sound pressure for direct physical trauma in marine mammals, birds and fish is generally considered to be >200dB. A received intensity of 120dB has been suggested by Whitehead (2001) as the precautionary threshold above which underwater noise may have an impact on marine mammal populations.

Broadband source levels of 248-259dB re 1μPa@1m are typical of large seismic arrays (Richardson *et al*. 1995), although smaller arrays with source levels 200-220dB may also be used where shallow formations are targeted. Noise propagation from a point source can be modelled using the general expression **SPL = SL – N log(R) - αR**, where SPL = received sound pressure levels (dB) at range R (m); SL = source level (dB); N = geometrical spreading coefficient (=20 for spherical spreading); α = absorption coefficient (dB/km) summarised from individual studies at differing frequencies (Jensen *et al.* 1994). Predicted SPL curves within 50km of the source indicate that frequency-dependent attenuation within this horizontal range is relatively minor (<10% of total transmission losses).

Noise propagation in the SEA 5 area will be influenced by relatively shallow water, and by complex topography and variable seabed in some areas, so that the assumption of spherical spreading may not be reliable. The effects of slope and substrate reflectivity on propagation have been assessed on the west Shetland shelf, for a range of frequencies, source depths and directions (Lawson *et al*. 2001, reviewed by DTI 2003). These studies used a “Range-dependent Acoustic Model” (RAM) (with provision for range-dependent parameters such as a sloping, non-uniform seabed and range-varying sound speed profiles) to compute transmission loss characteristics for selected transmission paths for frequencies of 400 Hz and below. Broadly similar TL characteristics, source depth dependence and frequency dependence were predicted for down-slope, along-slope and up-slope tracks, equivalent to cylindrical spreading (10log(R)) in the mid-range (0.3-10km) and greater TL (15log(R)) at greater ranges (Lawson *et al*. 2001). The implication of this is that propagation distances in the SEA 5 area may be significantly greater than predicted by simple spherical spreading. It is therefore probable that the forecast levels of seismic activity will result in ensonification of virtually all the SEA 5 area at levels audible to marine mammals, although exposure to sound pressures which have been clearly associated with behavioural responses in cetaceans will be more limited, both spatially and temporally.

JNCC guidelines requiring (visual) monitoring and reporting of cetacean responses to seismic surveys on the UKCS have generated some useful data on behavioural effects. Statistical analysis of 1,652 sightings during 201 seismic surveys, representing 44,451 hours of observational effort, is 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 (although sightings of pilot whales declined after 1998 for unknown reasons) and sperm whales showing no observed effects (DTI 2003). The long-term ecological implications of observed behavioural responses are unknown, with a wide range of postulated severity ranging from highly significant (e.g. in relation to energy budgets or interference with migratory behaviour) to negligible (in view of extensive distributions, apparent wide ranging foraging and transient nature of disturbance).

Both harbour and grey seals showed short-term avoidance behaviour during controlled exposure experiments with small airguns (Thompson *et al.* 1998). In both cases seals abandoned foraging sites and swam away from airguns but returned to forage in the same areas on subsequent days. Again, long-term ecological implications (if any) of these responses are unknown.

Particularly stringent constraints, or prohibitions, have been placed on seismic surveys in areas considered to be of particular significance for marine mammals by several countries, including Australia, Brazil and Canada (see above). However, the SEA 5 area does not support equivalent populations of species with threatened status. Similar precautionary levels of protection are therefore not considered to be justified.

Clear-cut conclusions on the significance of potential effects of seismic exploration in the SEA 5 area on marine mammals, cannot be reached on the basis of available scientific data. Against precautionary (and claimed ethical) considerations, should be balanced the lack of observed effects in one of the most intensively studied cetacean populations (in close proximity to more than 30 years of intensive seismic survey effort); the establishment of mitigation measures which are probably generally effective in preventing at least physical damage (Hammond *et al*. 2004); and the relatively low importance of the area for threatened species, in a national and international context.

The other receptor group of significant concern in the SEA 5 area is fish, specifically with regard to herring spawning grounds. Studies have suggested that seismic surveys may influence fishing success ("catchability"), although long-term ecological effects have been considered unlikely (see reviews in SEAs 2, 3 & 4). Recent work (McCauley *et al*. 2003) has shown that the ears of fish exposed to an operating air-gun sustained extensive damage to their sensory epithelia that was apparent as ablated hair cells. The damage was regionally severe, with no evidence of repair or replacement of damaged sensory cells up to 58 days after air-gun exposure, although the fish were caged, and video monitoring suggested that fish would have escaped the source if possible. In addition, the sound pressures involved were relatively high, approximately equivalent to a large array at a distance of <500m. It is unlikely that a survey resulting in this noise intensity over a herring spawning ground, during the spawning season, would be consented under existing regulatory mechanisms (see below).

10.3.1.2 Control and mitigation

Both planning and operational controls are in place for seismic surveys on the UKCS. Regulation 10 of *The Offshore Petroleum Activities (Conservation of Habitats) Regulations 2001* states that oil and gas activities shall not deliberately disturb any creature listed on Annex IVa of the Habitats Directive (which includes all cetaceans), nor cause deterioration or destruction of breeding sites or resting places of any such creature. Application for consent to conduct seismic and other geophysical surveys is made using *Petroleum Operations Notice No 14* (PON14) supported by an environmental narrative with an assessment of the likely 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. SEERAD would also consider potential impacts on herring spawning grounds or other fishery sensitivities. Within the SEA 5 area, any proposed seismic survey with a potential acoustic impact within the Moray Firth cSAC 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 1998)*. 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 in many areas. Member companies of the UK Offshore Operators Association UKOOA) have indicated that they will comply with these Guidelines in all areas of the UK Continental Shelf.

Under the Guidelines there is a requirement for visual monitoring of the area (and acoustic surveys if feasible) prior to seismic testing to determine if cetaceans are in the vicinity, and a slow and progressive build-up of sound to enable animals to move away from the source. In general, the guidelines appear to be reasonably effective, although various recommendations were made by Stone (2003) for future revisions. In relation to sensitivities in the SEA 5 area, it is likely that visual detection of the most abundant species (seals and harbour porpoise) will be of limited efficiency. In September 2003, the DTI circulated a position paper on mitigation and management of oil and gas marine seismic surveys and invited comment from interested parties. The role of Passive Acoustic Monitoring (PAM), is one tool which is under discussion.

JNCC, in partnership with the US Marine Mammal Commission, is sponsoring an international policy workshop on the impacts of sound on marine mammals in September 2004. This is aimed at international co-operation at a strategic level on noise emissions, particularly from shipping, but may also influence future regulation of geophysical surveys.

10.3.1.3 Conclusions and data requirements

As with previous SEAs, it is considered that there is an acceptably low risk of potential effects of underwater noise resulting from forecast activity in the SEA 5 area. The proposed level of activity does not represent a significant increment to recent seismic survey effort; which does not appear to have resulted in significant changes in sightings frequency or behavioural responses. Mitigation measures already implemented, together with proposed modifications, appear to provide some degree of protection from acute effects and are generally followed by the industry. There is no obvious possibility of further mitigation through seasonal timing of seismic operations (beyond those noted in Section 10.3.1.2) and no localised areas which would justify exclusion from licensing.

The potential effects of seismic noise remain a significant area of uncertainty and conflicting information. A general international trend towards a precautionary approach to this issue is noted. However, a 2004 US Minerals Management Service assessment of the potential impacts of seismic and other acoustic surveys in the Gulf of Mexico concluded with a "Finding of No Significant Impact".

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 120dB). Progress in these areas has been slow and therefore it is recommended that the requirement for more precautionary (and if necessary prescriptive) regulation of underwater noise associated with seismic exploration is critically reviewed within the future SEA process.

There is widespread consensus 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).

10.3.2 Physical damage to features and biotopes

10.3.2.1 Archaeology

The subject of prehistoric marine archaeological remains has received comparatively little attention in the planning or assessment of offshore oil and gas activities. A review of the topic was commissioned for SEA 5 (Flemming 2004) which complements a similar review covering the North Sea conducted for SEAs 3 & 4.

Prehistoric submarine archaeological remains back to a date of about 12,000 years ago, palaeolithic, mesolithic and neolithic, could occur with low probability anywhere in the SEA 5 area between the northern mainland coast and the eastern boundary of SEA 5. The existence and possible survival of prehistoric sites is complicated by:

- the rapid and continuing uplift of the east coast of Scotland and the immediately adjacent shelf in the Moray Firth
- the fact that an ice sheet covered part of the seabed obliterating most artefacts earlier than about 20,000 years BP
- and that the seabed towards the median line has subsided, and was associated with extensive sea-water lakes and floating sea ice during the glacial maximum.

Known submerged prehistoric sites in Orkney, Shetland, Viking Bank, the Yorkshire coast, and Denmark, show that prehistoric sites from the last 5-10,000 years can survive marine transgression. The generally strong current conditions in the SEA 5 area, the exposure to storms, the thin sediment cover in many places, and the large areas of exposed bedrock, make the exposed areas of the shelf statistically poor prospects for the survival of prehistoric deposits *in situ*, other than in submerged caves and gullies. The report provides an overview of known and likely areas with prehistoric and archaeological remains but no submarine sites were identified as of such importance as to suggest exclusion of the area from licensing.

Oil and gas activities have the potential to damage archaeological artefacts and sites, in particular through the trenching of pipelines into the seabed and through rig anchoring. However, oil and gas activity is also recognised to present the opportunity to provide beneficial new archaeological data, for example through geophysical mapping of a rig site or pipeline route and sediment coring. The recognition of the importance of prehistoric submarine archaeological remains has led to a number of recent initiatives. Draft guidance has been produced for the British Marine Aggregate Producers Association and the Royal Commission on the Historical Monuments of England. This guidance aims to provide best practice and practical advice regarding the archaeological impacts of marine aggregate dredging. Fleming (2004) provides some initial suggestions for discussion of protocols and a reporting regime relevant to the oil and gas industry.

In conclusion, while prehistoric marine archaeological remains may occur in the SEA 5 area, and there is a small possibility that exploration activity may coincide with the location of artefacts, the benefits of new information that may flow from oil and gas activity in the area are judged to outweigh the risk of potential damage to such remains. The subject of a reporting regime and access to suitable technical support and advice has been followed up with a variety of stakeholders and it is hoped that this will lead to improved awareness and mitigation measures for existing and potential future oil and gas activity in the SEA 5 area (and other UK waters).

10.3.2.2 Physical damage to biotopes and other seabed sensitive features

A number of receptors were identified by the assessment process as potentially susceptible to physical damage from oil and gas activities in the SEA 5 area. This potential effect is associated primarily with anchor and rig positioning, the construction of platform jackets, subsea wellheads and other infrastructure, and pipelines. In addition to habitats and communities (collectively termed “biotopes”) of conservation value, herring spawning areas were identified as potentially sensitive features of considerable ecological and commercial importance.

However, the proposed activity levels – 20 exploration/appraisal wells, up to three stand-alone developments and one new pipeline to shore over 4+ years, with a possible area of effect of 100,000-200,000m^2 (see SEA 2 for review of calculations) – represents a very modest increment to historic levels of physical disturbance of the seabed in the central and northern North Sea. It is generally accepted that the principal source of physical disturbance of the seabed and seabed features, is trawling. Trawl scarring is 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, Klein & Witbaard 1995, de Groot & Lindeboom 1994, Dorsey & Pederson 1998, Jennings & Kaiser 1998, Kaiser & de Groot 2000, Coggan *et al*. 2001, Johnson 2002, 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, although 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 metres **per year** of trawl scar in the North Sea, and 10^7-10^8m^2/y in the SEA 5 area. 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 in the SEA 5 area to cumulative disturbance of the seabed (of the order of 0.1-1% of fishing-related disturbance) is not considered likely to be significant.

The broadscale distribution of biotopes of conservation importance is relatively well understood and it is believed that the effects of the range of potential SEA 5 activities would be mitigated to acceptable levels by existing controls. Site-specific, pre-activity assessment and survey can be expected to identify the presence of exceptional features and to thus allow either for further investigation and/or alterations to planned activities so that such features are not damaged or unacceptably affected.

In the case of 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.

The physical effects and ecological consequences of seabed disturbance were reviewed in SEA 2, and considered to be qualitatively similar to those of severe storms; it was concluded that habitat recovery from the processes of anchor scarring, anchor mounds and cable scrape is likely to be relatively rapid (1-5 years). Muddier sediments in the SEA 2 and SEA 5 areas, particularly in the Moray Firth and Fladen Ground, support benthic communities characterised by the presence of large burrowing crustaceans (*Nephrops norvegicus* and *Calocaris macandreae*) and pennatulid sea-pens (*Virgularia mirabilis* and *Pennatula phosphorea*). *Nephrops* and *Calocaris* are able to restore burrow entrances following limited physical disturbance of the sediment surface (a few centimetres), and video observations of burrow and pennatulid densities on Fladen ground sediments show surprisingly little cumulative effect of fishing disturbance.

10.3.2.3 Conclusions

In conclusion, therefore:

- The predicted spatial scale of physical disturbance of the seabed, resulting from activity scenarios for potential licensed areas, is very small in comparison to the extent of physical disturbance from trawling and other activities. The major sources of physical disturbance from E&P activities are predicted to be rig anchoring and pipelay activities.

- Recovery of affected seabed through sediment mobility, and faunal recovery and re-colonisation, is expected to be rapid where the source of effects is transient (e.g. anchoring); less than five years in most cases.

- Mitigation measures, principally the identification and avoidance of habitats and populations of particular sensitivity, will be implemented through established project assessment and planning controls.

10.3.3 Physical presence

10.3.3.1 Fishery and shipping interactions

Offshore areas of SEA 5 experience low to moderate shipping density. Coastal areas around Fraserburgh, Peterhead and Aberdeen experience relatively high shipping densities (5,000-20,000 vessels) primarily associated with fishing vessels and the movement of support vessels for the North Sea oil industry. High shipping densities are also found at the mouth of the Firth of Forth extending down the southeast coast (DETR 1999). These are associated with the transit of cargo vessels and tankers between the Forth ports and other North Sea ports. Mobile and transient exploration activities (seismic and drilling), support vessel traffic and the physical presence of offshore infrastructure required for production may have direct effects on shipping and fishing activities within the affected area, in terms of:

- Loss of access due to exclusion zones and obstructions
- Safety risks associated with “fastening” of fishing gear to obstructions
- Increased collision risk

The SEA 5 Expert Assessment Workshop identified potential effects on inshore and offshore fishing as a significant issue. Shellfisheries were reviewed by Chapman (2004) in a commissioned study for this SEA, with other fishing activities considered previously in reports for SEA 2 and SEA 4 (CEFAS 2001 and Gordon 2003). A representative of the Scottish Fishermen’s Federation participated in the Expert Assessment Workshop.

Where obstruction or danger to navigation is caused or is likely to result, prior written consent of the Secretary of State for the Department for Transport is required for the siting of the offshore installation - whether mobile or permanent - in any part of the UK designated areas of the Continental Shelf. In practice, this means that consent must be obtained for each drilling operation and for all offshore production facilities – see Section 3.

Installation safety zones

The *Petroleum Act 1987* allowed for the creation of safety zones at all offshore surface installations and subsea structures, excluding pipelines. Under this legislation, a zone of 500m radius (an area of approximately 78 hectares) is created when surface structures such as platforms become operational, and when mobile drilling rigs are on location. It is normal practice to apply for a safety zone around subsea developments, but these may not be marked with surface buoys. Without such visible markers, the offshore oil and gas industry is dependent on fishing vessels maintaining a safe distance from all seabed structures.

To ensure that the risk of shipping and fishery interactions is reduced, pipeline route and locations of subsea structures are notified to fishermen and other mariners through direct liaison with representative organisations and established publications such as Admiralty charts, Kingfisher charts and FishSafe computer systems. Support vessels normally patrol exclusion zones around manned platforms, and the proximity of other vessels can be monitored from the installations themselves.

Safety zones are listed by DEAL (Digital Energy Atlas and Library**,** http://www.ukdeal.co.uk/), and the number and extent of exclusion zones in the SEA 5 area is low. Predicted activity levels in the SEA 5 area involve up to 20 exploration/appraisal wells, which will typically require a temporary (30-60 day) exclusion zone; 3 stand-alone developments requiring exclusion zones for the life of the installations, and one pipeline to shore (no exclusion zone but a linear footprint).

The exclusion of fishing activity from these zones does not adversely affect fish catch rates, as fishing effort is simply diverted to adjacent areas. The loss of area does not result in a proportional loss of catch, and the individual zones themselves are so small that they do not completely obscure any one fishing ground.

Conversely, these safety zones act as closed areas protecting individuals from capture by fishing gears. However, there is no firm evidence that safety zones serve to protect populations or enhance fish stocks.

Trawling interactions

The safety of all users of the sea is a primary concern during the design and construction of subsea structures, particularly to ensure that if over-trawled, gears do not become snagged. Where possible, vulnerable structures such as templates, wellheads, subsea valve assemblies and manifolds are placed within a safety zone and provided with further protection such as a composite structure with a steel framework, designed with sloping sides to deflect trawls. Pipelines may be protected by the addition of a protective coating or by burial. In all cases, these extra measures are expensive and the offshore industry has recently revised its guidelines to take account of recent advances in technology and the changing requirements of the industry (DNV 1997).

Several factors influence the decision over whether a pipeline is trenched or placed on the seabed, taking into account the need for pipeline protection, the reduction of obstruction to fishing gears, seafloor conditions etc. Although pipelines can cause accidental interference, it has been reported that they are used by some trawlers as tows, presumably on the assumption that pipelines aggregate fish and so provide greater catch rates than similar tows nearby. A recent Norwegian study involving experimental trawling of pipelines with gill nets and otter trawls concluded that they had only limited ability to aggregate fish (Valdemarsen 1993, Soldal 1997). However, since the loss of the trawler *Westhaven* in the North Sea, there have been a number of initiatives to ensure that pipeline spans and subsea structures do not pose a threat to fishing vessels.

Traditionally, pipelines of diameter less than 16 inches were buried for their own protection, while larger diameter pipelines were left on the seabed and were unlikely to be seriously damaged. Although there is evidence that pipelines up to a diameter of 40 inches cause only minimal gear damage, they can affect the gear geometry and efficiency once past the obstruction (Valdemarsen 1993). Even surface laid pipelines which are protected by rock dumping can also present a hazard to towed fishing gears (Soldal 1997).

Debris outside exclusion zones, such as containers lost from supply vessels in transit is also of concern to fishermen. All reasonable measures are taken by the industry to prevent losses and to recover debris where possible. In addition, there is the UKOOA Fishermen's Compensation Fund covering claims where attribution to a company cannot be made.

Interactions of fixed gear and E&P (seismic and pipelay)

Lobster, edible crab and other shellfish trapping fisheries off the Orkney, Shetland and east Scottish coasts are undertaken primarily by local inshore vessels operating generally within a few miles of the coast (see Chapman 2004). Shellfish are captured in baited traps (pots or creels) laid in groups of 20 or more depending on vessel size and are usually hauled once every 24 hours. Some larger vessels can work up to 1,000 traps.

The major interaction of fixed gear fisheries and oil industry activities results from seismic survey and (to a lesser extent) site survey and pipelay operations, since these vessels have restricted manoeuvrability and it is usually necessary to remove fishing gear for the duration of the operation. Installation exclusion zones, as discussed above, may also cause disruption to fixed gear fisheries although this is regarded as of limited significance in the case of SEA 5.

In advance of exploration or development activities, particularly within locally important fishing areas, established fisheries liaison mechanisms are used to minimise conflicts (through a combination of route selection, timing and operational procedures), and to agree management and control methods such as the use of seismic guard vessels (in many cases these are chartered fishing vessels).

Fisheries liaison is conducted in accordance with guidelines established by UKOOA.

Physical disturbance and discharge effects on commercial species

Indirect ecological effects on commercially targeted species (and result in economic impacts on fisheries) may result from impacts on benthic or pelagic prey species and predators, but are particularly of concern in relation to herring, which is a demersal spawning species dependant on localised areas of clean gravel substrate on which to lay their eggs.

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

In general, effects on benthic communities (including commercial shellfish) may result from smothering which can be direct (from physical disturbance or discharges of particulate material) or indirect (from winnowing of disturbed material). Effects on continental shelf fauna are normally short lived and similar to those from severe storms and dredge spoil disposal where recovery is normally well underway within a year (Rees *et al*. 1977, SOAEFD 1996). Habitat recovery from the processes of anchor scarring, anchor mounds and cable scrape will depend primarily on re-mobilisation of sediments by current shear. Smothering effects are unlikely to be significant at benthic species population and community levels in the SEA 5 area.

In addition to the potential effects of smothering, sediment plumes in the water column and settling to the seabed from construction activities and pipeline trenching activities can potentially result in effects on pelagic and benthic biota through clogging of feeding mechanisms, temporarily altering the nature of the seabed sediments or in near surface waters, reduction of light for photosynthesis (Newell *et al.* 1998). The extent of effects will vary according to the frequency of occurrence and the tolerance of the species involved, itself a function of the average and extreme natural levels of sediment transportation/deposition experienced in an area. Near-bed concentrations of suspended particulate material in the SEA 5 area are (at least episodically) high in most coastal areas, and the effects of anthropogenic sediment plumes are thus unlikely to be significant or long lasting.

Control and mitigation

Key control and mitigation measures in place to minimise effects on shipping and fisheries are the statutory consultations required under for example *The Offshore Petroleum Production and Pipe-lines (Assessment of Environmental Effects) Regulations 1999*, PON 14 for seismic survey, application for Pipeline Works Authorisations, consents to locate rigs and other facilities etc., which includes regulatory agencies and advisers (SEERAD) and national fisheries representative bodies. Local fisheries associations, which are usually sector-specific, would also be consulted where relevant (usually for inshore areas).

Guidelines have been established for fisheries liaison, and compensation mechanisms for gear damage are implemented through UKOOA.

Advance notice of exploration and production operations (and other marine activities) in UK national waters are provided through Coastguard broadcasts on VHF radio, and through published Notices to Mariners. To ensure that the risk of fishery interactions is reduced, pipeline routes and locations of surface installations and subsea structures will be notified to fishermen and other mariners through direct liaison at national and local levels and the established mechanisms:

- Admiralty charts
- Kingfisher charts
- FishSafe computer systems

Conclusions

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 be necessary during pipeline construction to landfalls, although in view of the predicted level of activity in the SEA 5 area this disruption will be limited.

The oil industry and UK fishing industry maintain consultation, liaison and compensation mechanisms, which should serve to mitigate and resolve any conflicts.

10.3.3.2 Other interactions

The physical presence of rigs and production facilities may have a range of other interactions including seascape, spatial and habitat influence.
The scale of existing and projected exploration and production activities in the SEA 5 area is such that significant interaction with seacape in terms of visual intrusion would not be expected. A potential exception to this is the "stacking" of rigs in the sheltered east Scottish mainland firths (e.g. the Cromarty Firth), although the rig presence is temporary and they are generally viewed with interest.

The go-ahead has recently been announced for a windfarm demonstrator project at the Beatrice oilfield some 25km off the Caithness coast. The demonstrator project involves the installation, of 2 turbines in water depths of 35-45m and would provide electricity for the Beatrice field installations. Installation is planned for 2006 and if the technology evaluation is successful it could lead to a windfarm development of some 200 turbines with electricity exported to shore. If major wind or other marine renewable energy developments occur in the future in the SEA 5 area, there will be the potential for cumulative footprints/exclusion zones that would require detailed assessment to minimise interference with other users of the area, notably fishing and shipping.

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). 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.

10.3.4 Marine discharges

10.3.4.1 Introduction

The SEA 5 Assessment Workshop identified a number of marine discharges from E&P operations as potential sources of significant environmental effect. These related primarily to produced water and drilling discharges, with other (non-significant) potential sources of effect including drainage, sewage, subsea control and pipeline commissioning discharges.

10.3.4.2 Sources – produced water and other aqueous discharges

As described in previous SEAs, marine discharges from exploration and production activities include produced water, sewage, cooling water, drainage and surplus water based mud (WBM), which in turn may contain a range of hydrocarbons in dissolved and suspended droplet form, various production and utility chemicals, metal ions or salts (including Low Specific Activity (LSA) radionuclides). In addition to these mainly platform-derived discharges, a range of discharges are associated with operation of subsea 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).

Produced water is derived from reservoir ("fossil") water, and as fields age from breakthrough of seawater, injected to maintain reservoir pressure. The majority of produced water discharge volume to the North Sea and elsewhere is associated with oil production and produced water volumes from gas fields are extremely small in comparison. The chemical composition and effects of produced water discharges have been previously summarised in SEA 2 and 3 and are not repeated here.

Fundamental to the consideration of potential effects of produced water in the SEA 5 region is the assumption that reinjection will be the normal method of produced water disposal (at least 95% by volume), although 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.

10.3.4.3 Sources – drilling wastes and other solid discharges

Drilling wastes are a major component of the total waste streams from offshore exploration and production, with typically around 1,000 tonnes of cuttings resulting from an exploration or development well. Cuttings are discharged at, or relatively close to, sea surface during "closed drilling", whereas surface hole cuttings will be discharged at seabed during "open-hole" drilling.

Levels of drilling activity identified for exploration and development of SEA 5 licence areas are a total of 20 exploration and appraisal wells, together with up to 3 stand-alone developments, each of which would typically involve 8-12 production wells. Cuttings discharges from these activities would therefore total a maximum of around 55,000 tonnes, assuming the use of water-based muds. (Use of oil-based mud systems, for example in highly deviated sections or in water reactive shale sections, would require the onshore disposal or reinjection of a proportion of this material.)

By way of context, in 1999 157,253 tonnes of water-based drilling chemicals and additives (including some 54,000 tonnes of barite and other weighting agents) were reported as being discharged to the UKCS (CEFAS 2002). These discharges resulted from 36 exploration/appraisal and 225 development wells (DTI 2001) together with workovers, giving an average WBM chemicals discharge of 603 tonnes per well.

The contaminant composition of drilling wastes has changed significantly over the last few decades, in response to technical and regulatory developments. Previous widespread and substantial discharges of oil-based muds, and later synthetic muds, have been superseded by alternative disposal methods (either containment and onshore treatment, or reinjection) or by use of water-based muds.

Mud systems used in surface hole drilling for exploration wells are usually simple (seawater with occasional viscous gel sweeps) and would not result in significant contamination of sediments. However, the composition of closed drilling discharges likely to result from exploration, appraisal and development drilling (and to a lesser extent from well maintenance activities) is more complex, and will include cuttings (i.e. formation solids, in varying degrees of consolidation and in a range of particle sizes), barite, salts (sodium and potassium chloride), bentonite and a range of mud additives in much smaller quantities. Water-based mud additives perform a number of functions, but are predominantly polymeric organic substances and inorganic salts with low toxicity and bio-accumulation potential. In addition to mud on cuttings, surplus water-based mud may be discharged at the sea surface during or following drilling operations. Due to its density, a proportion of the particulate component of the mud (including barite) may settle in the immediate vicinity of the discharge.

A major insoluble component of water-based mud discharges, which will accumulate in sediments, is barite (barium sulphate). Barite has been widely shown to accumulate in sediments following drilling (reviewed by Hartley 1996). Barium sulphate is of low bioavailability and toxicity to benthic organisms (e.g. Starczak *et al*. 1992). Other metals, present mainly as salts, in drilling wastes may originate from formation cuttings, from impurities in barite and other mud components or from other sources such as pipe dopes (which can contain native metal). Although a variety of metals (especially chromium) are widely recorded to accumulate in the vicinity of drilling operations (e.g. Engelhardt *et al*. 1989, Kröncke *et al*. 1992), the toxicity of settled drill cuttings appears to be related primarily to hydrocarbon content, even in WBM discharges (e.g. ERTSL 2001).

10.3.4.4 Potential effects of produced water

Potential effects of produced water discharges are described in previous DTI SEAs. Most studies of produced water toxicity and dispersion (see E&P Forum 1994, and OLF 1998) have concluded that the necessary dilution to achieve a No Effect Concentration (NEC) would be reached at 10 to 100m and certainly less than 500m from the discharge point.

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. In view of these factors it is concluded that any effects of produced water discharge in the area will be transient and minor and are not considered further.

The potential effects of naturally occurring radioactive materials (NORM) in produced water discharges have been raised for example through OSPAR and the EU. A recent EU study, MARINA II, (EU 2003) provides comprehensive and up-to-date information on radioactive discharges, concentrations in North European marine waters and an assessment of their impact on humans and marine biota. The MARINA II study was a contribution to the OSPAR strategy with regard to radioactive substances.

Overall civil nuclear and other anthropogenic inputs of radioactivity into the North East Atlantic have decreased by several orders of magnitude since the maximum levels were reached in 1960s and early 1970s. Discharges from the offshore oil and gas industry, which made a small contribution over much of the period from 1981 to 1999, have become relatively more important as other discharges have declined.

An estimate was made of the collective human dose rates from discharges from all sources (including offshore oil and gas) over the period 1981 to 2000. At its peak in 1984, collective dose rate of about 760 man Sv y^{-1} is around a factor of 20 less than the annual collective dose from natural radioactivity in the marine environment. Although the methodology for determining the impact of radioactivity on marine biota is still under development, based on available information, there is no identifiable impact on populations of marine biota from these radioactive discharges.

Based on this information it is concluded that the increment in NORM discharges resulting from licensing blocks in the SEA 5 area will not result in significant effects.

10.3.4.5 Potential effects of drilling discharges

The past discharge to sea of drill cuttings contaminated with oil based drill mud resulted in well documented acute and chronic effects at the seabed (e.g. Davies *et al*. 1989, Olsgard & Gray 1995, Daan & Mulder 1996). However, through OSPAR and other actions, the discharge of oil based and other organic phase fluid contaminated material is now effectively banned and the effects of such discharges are not considered relevant to the SEA 5 process.

Surface hole cuttings (surficial and shallow formation sediments with small quantities of gel sweep additives) are normally discharged at the seabed. Subsequent discharges of WBM cuttings from closed drilling are dispersed more widely in the water column, and deposition is often detectable only through chemical analysis of characteristic tracer components (e.g. barium). Quantities of cement may also be discharged directly to seabed during installation of casing.

Surface hole cuttings mounds in all but the deepest parts of the SEA 5 area will be dispersed, typically over a time scale of 1-10 years, mainly through re-suspension and bedload transport due to tidal, storm and surge induced currents. Seabed substrates and topographical features indicate that near-bed current and wave-induced velocities in most of the SEA 5 area are sufficient to result in significant sediment mobility; and therefore appear generally sufficient to prevent detectable local accumulation of cuttings.

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.

Water based muds are of low inherent toxicity (e.g. Ray *et al*. 1989, ERTSL 2001) and toxicological studies of the major individual constituents have reported limited or no effects (e.g. Tagatz & Tobia 1978, Starczak *et al*. 1992).

In contrast to the general picture of limited effects of WBM discharges, Cranford & Gordon (1992) reported low tolerance of dilute bentonite clay suspensions in sea scallops (*Placopecten magellanicus*). Cranford *et al*. (1999) found that used water based mud and its major constituents, bentonite and barite caused effects on the growth, reproductive success and survival of sea scallops, which were attributed to chronic toxicity and physical disturbance. It may be that *Placopecten* is especially sensitive to drill muds (or fine sediments in general) or that in the field, water based drilling discharges very rapidly disperse to below effective concentrations. Barlow and Kingston (2001) report damage to the gills of two species of coastal bivalves where barite was added to experimental system although no controls with other sediment added were tested and the concentrations of material added were very high so it is unclear how or if the results apply to the field situation.

Studies of the effects of water-based mud discharges from 3 production platforms in 130-210m water depth off California found significant reductions at some stations in the mean abundance of 4 of 22 hard bottom taxa investigated using photographic quadrats (Hyland *et al*. 1994). Hyland *et al*. (1994) concluded that these reductions reflected possible negative responses to drilling discharges, attributed to the physical effects of particulate loading, namely disruption of feeding or respiration, or the burial of settled larvae. In view of the limited extent of hard seabed in the SEA 5 area, it is unlikely that wells will be located over such substrates.

10.3.4.6 Control and mitigation

Produced water discharges are regulated under the *Prevention of Oil Pollution Act 1971* with limits set for the proportion of oil in water (currently 40mg/litre) and the daily flow which may be discharged. Through OSPAR, the UK is committed to a reduction in oil in water standard to 30mg/litre, a 15% reduction in total discharged volume of oil in produced water by 2006 and there is a presumption against discharge from new developments. Chemical selection and use are regulated by the *Offshore Chemicals (Pollution Prevention and Control) Regulations 2002*. These regulations implement a permit system for the testing, use and discharge of chemicals offshore and include requirement for site specific risk assessment.

The management of produced water and chemical discharges in planned developments will continue to be a key issue addressed through the environmental assessment process (under *The Offshore Petroleum Production and Pipe-lines (Assessment of Environmental Effects) Regulations 1999*).

The oil content of solid and aqueous waste discharges from exploration and production operations, including drilling wastes 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 reinjection or onshore treatment as currently used for organic phase fluids, are also feasible for drilling with water-based mud (for example, if particular benthic biotope sensitivities were identified).

No additional mitigation measures are currently regarded as necessary.

10.3.4.7 Ballast water discharges

The actual or potential introduction of non-native species through vessel ballast water discharges has been an issue for a number of years and was a specific part of the remit of the reviews conducted for the SEAs by the Sir Alister Hardy Foundation for Ocean Science. These summarise changes in plankton communities of the North Sea and adjacent areas due to either natural changes in distribution attributed to climatic shifts, and accidental introductions of non-native species.

Introduced, non-native species can have a number of negative effects including algal blooms and ecological impacts through predation, resource competition or habitat exclusion of native species. In response to this, a number of technical and procedural measures have been proposed (such as the use of ultraviolet radiation to treat ballast water) or introduced such as a mid-ocean exchange of ballast water (the most common form of preventing invasion by non-native species). In addition, the International Maritime Organisation (IMO) has introduced guidelines for the control and management of ships' ballast water (originally proposed in Agenda 21 at the United Nations Conference on Environment and Development (UNCED) in 1992, and adopted in Resolution A.868 (20) Agenda item 11, in 1997).

The potential for significant effects arising from oil and gas activities involving ballast water discharge as a direct result of E&P activities in the SEA 5 area is limited to discharges from rigs which have transited over considerable distances, since other ballast discharges (e.g. from shuttle tankers) are unlikely to contain non-native species. The risk of accidental introductions by this route is considered to be very low, and to make a negligible contribution to the overall risk associated with general shipping.

10.3.4.8 Conclusions

The effects of the majority of marine discharges are judged to be negligible, with the exceptions of produced water, mud and cuttings, and ballast water. Discharge of produced water will be limited primarily by the presumption of reinjection from new developments; and potential environmental effects of residual discharges will be reduced by treatment and by dispersion, below NEC.

Discharges of organic phase drilling fluids and contaminated cuttings are effectively prohibited, and discharged WBM cuttings in the North Sea and other dispersive environments have been shown to have minimal ecological effects.

The potential for significant effects arising from ballast water discharge as a direct result of E&P activities in the SEA 5 area is considered to be very low.

10.3.5 Subsurface discharges

A range of subsurface discharges may be made as a result of oil and gas activities. Of prime relevance to the SEA 5 area would be produced water, and drill muds and cuttings which may be ground and reinjected to rock formations rather than discharged to sea or returned to land. The reinjection of wastes to source is generally regarded as resulting in positive benefits, such as reduced requirement for landfill space. However, the process of reinjection can be energy intensive and thus result in increased atmospheric emissions from an installation.

The target formation(s) for reinjection of such materials is selected on the basis of geological understanding from previous drilling in the area, with performance monitored over time. Any release to sea or to other unintended rock strata is regarded as an accident and considered later in this section.

10.3.6 Atmospheric emissions

10.3.6.1 Introduction

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

10.3.6.2 Sources

The major sources of emissions to atmosphere are internal combustion for power generation by installations, terminals, vessels and aircraft, flaring for pressure relief and gas disposal, cold venting 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. Gas, fuel and diesel consumption accounted for 80% of total CO_2 emissions from the UKCS in 2003 (EEMS 2003).

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 1,342,231 tonnes in 2003, 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.

The dominant greenhouse gas discharged by the offshore oil and gas industry is $CO_{2,}$ largely from combustion in turbines. Short-term trends in CO_2 emissions from exploration and production are variable. CO_2 emissions in 1999 and 2000 decreased by 6% and 5% respectively before rising slightly (3%) in 2001 and 2002 then falling by 6% in 2003, (see Figure 10.3). However the overall trend is one of reduction in discharge.

Methane emissions have decreased by varying amounts in each year shown (10% in 1999, 2000 and 2002 and 1% and 2% in 2001 and 2003 respectively) this is largely due to the annual reduction in offshore flaring. Carbon monoxide emissions have also decreased or remained constant in each year. NOx emissions have decreased in all but one year 2002 which saw an increase of 30%. This increase is attributed to a change in the method of calculating emissions from turbines. SO_2 has also seen a drop in emissions for all years except one. Following a decrease of 68% in 2002 emissions of SO_2 increased by 27% in 2003.

The overall decrease in 2003 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.

A comparison between UKCS offshore oil and gas sector atmospheric emissions and total UK and European emissions can be made using data from the European Environment Agency (EEA 2003). Data from 1998-2001 indicates that offshore UKCS oil and gas contributed an almost constant percentage of total UK emissions (see Figure 10.4). No emission comprises more than 8% of total UK emissions. CO_2 emissions from the UKCS contribute less than 4% to total UK emissions whilst methane is almost double, at nearly 8% for all years. A similar trend can be seen when comparing UKCS emissions against total Europe wide emissions over the same time scale. No emission accounted for more than 2.2% of the European total and the majority are below 1%.

Figure 10.3 – Atmospheric emissions from combined UKCS production and exploration activities (EEMS)

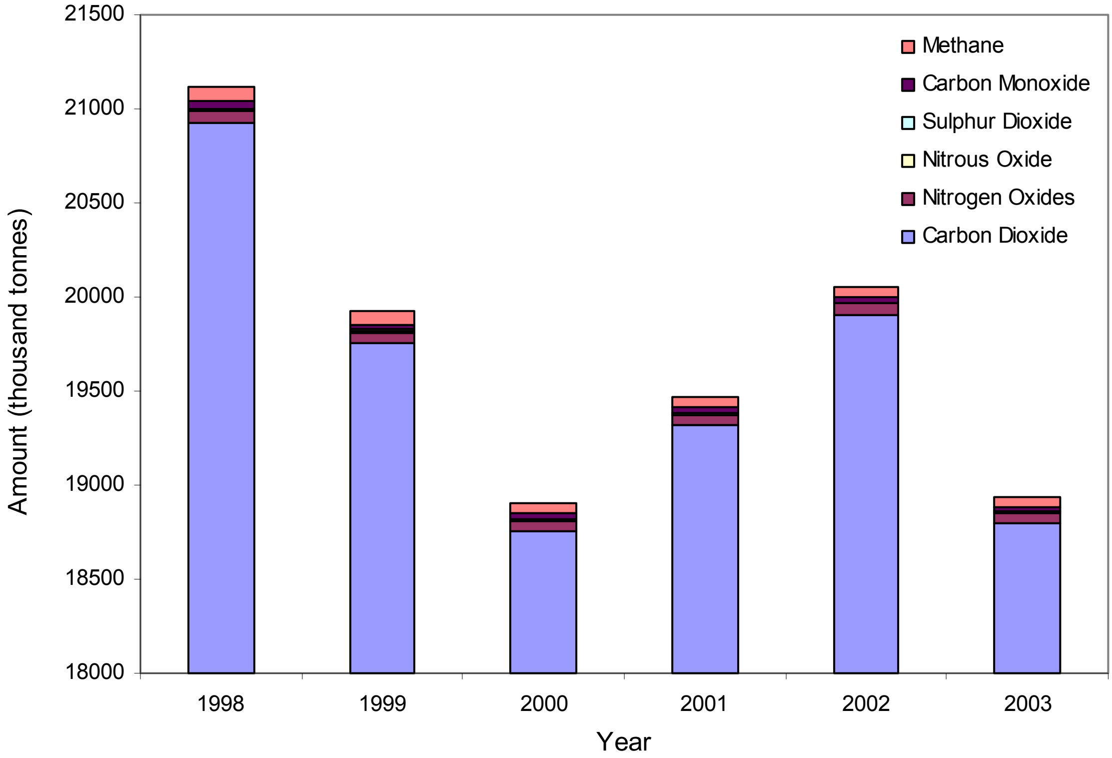
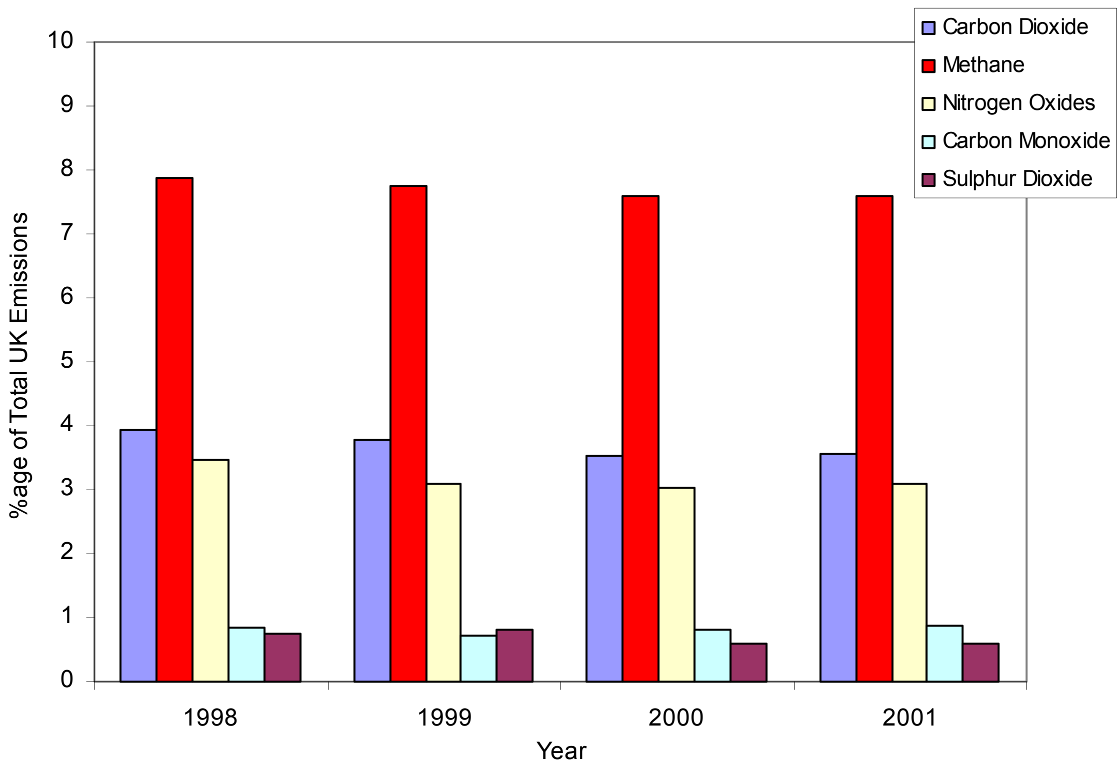


Figure 10.4 – UKCS oil and gas emissions as a percentage of total UK emissions



10.3.6.3 SEA 5 atmospheric emissions

DTI forecasts of exploration activity in the SEA 5 area, have been used to calculate indicative emissions from SEA 5 exploration activities. 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.

Table 10.1 – Indicative atmospheric emissions resulting from DTI forecast of SEA 5 exploration activity

Year following award[1]	CO_2 (tonnes)	NO_X (tonnes)	N_2O (tonnes)	SO_2 (tonnes)	CO (tonnes)	CH_4 (tonnes)	VOC (tonnes)
1	8192.0	34.6	0.56	10.2	2.36	0.1	0.76
2	10240.0	43.2	0.70	12.8	2.94	0.1	0.94
3	10240.0	43.2	0.70	12.8	2.94	0.1	0.94
4	12288.0	51.8	0.85	15.4	3.53	0.1	1.13

Notes: 1. Data on initial year of award has not been included as no wells were forecast

The DTI forecast the drilling of a maximum of six wells during the fourth year after awarding of blocks (3 exploration and 3 appraisal wells) therefore this year produces the highest additional emissions. Table 10.2 below uses 2003 data to show the effect this additional exploration would have on atmospheric emissions from drilling operations.

Table 10.2 – Comparison of atmospheric emissions resulting from additional SEA 5 exploration activity

Year	CO_2 (tonnes)	NO_X (tonnes)	N_2O (tonnes)	SO_2 (tonnes)	CO (tonnes)	CH_4 (tonnes)	VOC (tonnes)
2003	412658	5192	23	190	1709	1700	730
Year 4 following award	12288.0	51.8	0.85	15.4	3.53	0.1	1.13
SEA 5 %age	**2.98**	**1.0**	**3.7**	**8.1**	**0.21**	**0.01**	**0.16**

As can be seen from the indicative information in the table above, contributions as a result of exploration activities in the SEA 5 area to UKCS exploration emissions would be minimal, and even smaller if forecast drilling is not realised. 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.

10.3.6.4 Potential effects

Gaseous emissions from the combustion of hydrocarbons and other releases of hydrocarbon gases contribute to atmospheric concentrations of greenhouse gases, acid gases and reduction in local air quality.

Atmospheric greenhouse gases include carbon dioxide (CO_2), methane (CH_4), and oxides of nitrogen (NO_X). Anthropogenic sources of greenhouses gases (particularly CO_2) are implicated in amplifying the natural greenhouse effect resulting in global warming and potential climate change (IPCC 2001). The potential effects of emissions of greenhouse gases are therefore global in scale.

Atmospheric acid gases include sulphur dioxide (SO_2) and oxides of nitrogen (NO_X). These gases react with water vapour forming acids, 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 terrestrial surfaces through dry deposition (close to the source) causing similar damage to acid rain (UKTERG 1988). The potential effects of emissions of acid gases are considered to be most important at a regional scale.

Reduction in local air quality through inputs of contaminants such as oxides of nitrogen (NO_X), volatile organic compounds (VOCs) and particulates, which contribute to the formation of local tropospheric ozone and photochemical smogs, which in turn can result in human health effects. 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 may 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 recently been raised as a concern (Feely *et al.* 2004).

10.3.6.5 Conclusions

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

Significant combustion emissions from flaring are not expected from potential development in the possible SEA 5 licence areas, in view of regulatory controls and commercial considerations, and combustion emissions from power generation are unlikely to represent a major contribution to industry or national totals.

10.3.7 Waste

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. However, it is unlikely that major effects would result from licensing in the SEA 5 area as the projected number of exploration and appraisal wells is limited (up to 20 over four years), many or most would be drilled with water based drill fluids, and interfield transfer of oily cuttings for reinjection is now permitted in UK waters.

Similarly, air quality and cumulative effects have potentially moderate effects. In view of the very limited volumes of material (drilling wastes and general oilfield waste) likely from drilling or operations together with the stringent control of waste disposal activities under IPPC and the Landfill Directive it is believed that any effects on land will be negligible.

A limited number of developments are projected to result from SEA 5 area licensing. At the end of field life these facilities would be either removed for reuse or for recycling. The bulk of any returned material for recycling would be steel, for which there is currently a buoyant market and consequently significant cumulative or air quality effects are not viewed as likely.

10.3.8 Accidental Events

10.3.8.1 Introduction

Oil spills are probably the issue of greatest public concern in relation to the offshore oil and gas industry. 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.

Environmental risk is generally considered as the product of probability (or frequency) and consequence. The environmental consequences of oil spills are associated primarily with seabirds, marine mammals, fisheries and coastal sensitivities; and these sensitivities are considered in the appropriate Environment Description sections and supporting studies. The sources, frequency and scale of hydrocarbons spills are considered below. Much of the information is common to previous SEAs, and is therefore summarised with updates where appropriate. In particular, SEA 2 and the SEA 2 extension (DTI 2001, 2002) contain relevant information for the SEA 5 area.

Specific issues associated with SEA 5 (and SEAs 2 & 3) include the location of sensitive coastlines, including numerous breeding bird colonies of international conservation importance; the presence of significant concentrations of wintering seabirds and coastal waterbirds; the importance of aquaculture along adjacent Shetland coastlines; and fisheries generally within the area.

It should be noted that the purpose of SEA spill risk assessment is not to anticipate the detailed risk assessment and contingency planning which would be required in advance of any development; but to evaluate the overall contribution to risk associated with possible SEA 5-related activity.

10.3.8.2 Historical oil spill scenarios and frequency

Previous Environmental Statements, Contingency Plans, databases, guidelines and SEAs have devoted considerable effort to assessment of potential spill scenarios on the UKCS – in terms of magnitude, source, fluid characteristics and frequency – mainly on the basis of historical data. Relevant information is summarised below.

Previous SEAs reviewed hydrocarbon spills reported from exploration and production facilities on the UKCS since 1974 under PON1 (formerly under CSON7), annual summaries of which were published in the "Brown Book" series (now superseded by on-line data available from the DTI website http://www.og.dti.gov.uk). In 2003, 68 tonnes of oil were spilled from UKCS operations comprised of 365 spills of <1 tonne and 7 spills> 1 tonne.

Well control incidents (i.e. "blowouts" involving uncontrolled flow of fluids from a wellbore or wellhead) are prevented by multiple equipment and operational measures, and a significant blowout event would require escalation of several failures. Actual incidents 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.) Recommended blowout frequencies as input basis data for risk analysis of North Sea installations are provided by Holand (1996, Table 12.2), based on the SINTEF database. These vary from 0.0049 shallow gas blowouts/well for exploration drilling, to 0.00005 blowouts per production well-year (equivalent to 0.00075 assuming a typical 15 year well life). These values are generally consistent with derived annual frequencies based on worldwide databases maintained by SINTEF and Scandpower.

Theoretical blowout rates may vary widely, dependent on reservoir characteristics, and the reasons for loss of containment. Seabed blowout flow rates in deeper water will be limited by hydrostatic pressure from the overlying water column, and in most UKCS reservoirs, formation pressures are too low to produce high flow rates. Qualitative analysis and modelling suggests that high flow rate blowout scenarios (e.g. to surface via drillpipe) will tend to bridge relatively quickly. However, sustained well flow at lower rates can be simulated under some circumstances, which could result in a chronic release in the absence of detection and intervention.

DTI data indicates that the most frequent types of spill from mobile drilling rigs have been organic phase drilling fluids (and base oil), diesel and crude oil. Topsides and infield flowlines and risers are the most frequent sources of spills from production operations, with most spills being <1 tonne. A large proportion of reported oil spills in recent years (since about 1990) have resulted from process upsets. Estimated spill risk from UKCS subsea facilities averaged just over 0.11 spills per year (equivalent to a risk of one spill in any one year of 0.003 from an individual facility), with almost all reported spills <5bbl in size.

Major spill events from UKCS production facilities include the Claymore pipeline leak, 1986 (estimated 3,000 tonnes), Piper Alpha explosion, 1988 (1,000 tonnes) and the Captain spill, 1996, which occurred close to the SEA 5 area (685 tonnes, see text box). Although significant, these volumes are minor in comparison to other anthropogenic sources of oil in the marine environment. For example, in 2001 a total of 9317 tonnes of oil was discharged by the offshore oil and gas industry to the North Sea (excluding organic drilling fluids), of which <2% originated from accidental spills (OSPAR 2003a). Estimates of oil inputs from other sources have not been subject to regular reporting within OSPAR, although the 1993 Quality Status Review estimated a total oil input of 85,000-209,000 tonnes per year to the North Sea, including oil-based drilling fluids, riverine sources, shipping and natural seepage (NSTF 1993).

Globally, the total amount of oil spilled annually depends largely on the incidence of catastrophic spills (Etkin 1999), with less than 300,000 tonnes in most years, but exceptional quantities spilled to sea in 1978 (*Amoco Cadiz* tanker spill, 233,670 tonnes), 1979 (Ixtoc 1 blowout, Gulf of Mexico, 476,190 tonnes; and *Atlantic Empress* tanker spills), 1983 (Nowruz blowout, Persian Gulf, 272,109 tonnes and *Castillo de Bellver* tanker spill) and 1991 (Gulf War I, 816,300 tonnes to land and sea). Two major spills in or close to the SEA 5 area have occurred in recent years, both were coastal tanker incidents (*Esso Bernicia*, 1,174 tonnes, December 1978; and *Braer*, 85,035 tonnes, January 1993). The *Braer* spill, which occurred on the margin of the SEA 5 area, ranks eleventh largest in the table of oil spills in the world (in terms of the amount of oil spilled), and constitutes the largest ever pollution incident in Scotland. Fortunately, the timing, location and the weather resulted in the rapid dispersion of the oil in the water column. A useful synopsis of the *Braer* incident is available at http://www.wildlife.shetland.co.uk/braer/index.html#Index, including a bibliography of published monitoring and reports.

10.3.8.3 Oil spill fate

The fate of oil spills to the sea surface is relatively well understood, in contrast to subsea spills in deep water. Following a surface oil spill, there are eight main oil weathering processes: evaporation, dispersion, emulsification, dissolution, oxidation, sedimentation 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.

The behaviour of subsea crude oil releases will depend on the water depth and structure of the water column, immediate physical characteristics of the release, and on subsequent plume dispersion processes. In general, theoretical considerations and experimental releases (e.g. the DEEPSPILL Joint Industry Project) suggest that neutrally buoyant hydrates may form from some of the gaseous components in well fluids following a deepwater blowout. This would result in a buoyant plume and oil surfacing as dispersed oil droplets, although viscous water-in-oil emulsions may also form. The surface signature of the spill may occur some considerable distance from the subsea source. Field trials have also indicated that current shear and stratification in the water column may prevent, or reduce the quantity of oil which reaches the surface. DEEPSPILL was conducted on the Helland Hansen ridge, about 2100km from land, at 800m depth and environmental conditions were therefore more extreme than would be the case anywhere in the SEA 5 area. However, experience in the North Sea suggests that low flow, chronic leaks from subsea equipment may persist for considerable durations with no evidence of a surface slick.

The Captain Oil Spill
(Extracted from House of Commons First Standing Committee on Delegated Legislation. Wednesday 5 November 1997. Food Protection (Emergency Prohibitions) (Oil and Chemical Pollution of Fish) Order 1997)

Oil from the Captain field is held in a floating production, storage and offloading facility FPSO-and then transhipped by dedicated shuttle tanker. On 12 August the shuttle tanker collided with the FPSO. Although there was damage to both vessels, no oil was spilled. The incident did require a shut-down for two weeks for essential repairs. During that period Texaco carried out a maintenance programme on the FPSO. Production resumed just before midnight on 24 August and only at daybreak was it discovered that oil was being discharged into the sea.

The agreed oil spill response procedures were implemented immediately with notification to the coastguard and the Department of Trade and Industry, which then informed the Scottish Office. Approved dispersants were used almost immediately from the stand-by vessel as the slick moved slowly westward and later in the day from specialist aircraft chartered by the marine pollution control unit. The company reported that a slick of only seven tonnes remained on the surface of the sea at dusk on 25 August.

Texaco's initial estimate of the spill on 25 August was 150 tonnes; later that day, that was revised downwards successively to 100 tonnes. From both fishery and environmental points of view, that size of spill would not normally trigger post-spill monitoring. Recent experience from a number of spills shows that dispersant use will disperse oil into the top few metres of the water column. Sampling experience, backed up by research undertaken by the marine pollution control unit, confirms that the deeper one goes. the lower the concentration of oil in water becomes. Therefore, the long-term effects on the underlying sediment and the marine life that it supports should be minimal.

However, on 3 September Texaco announced in a press release that the spill had in fact been 685 tonnes and that it was commissioning post-spill monitoring programmes of seabed sediment and fish and shellfish. Texaco took advice from the marine laboratory in Aberdeen on the nature of the programmes. On behalf of Texaco, sediment samples were taken from a number of points across the whole area affected by the spill and sent to an independent laboratory for analysis and three trawls of roundfish and shellfish samples were taken from different locations under the path of the spilt oil and were sent for analysis to the marine laboratory.

The results from the sediment analysis showed elevated levels of sediment up to five times the background levels which occur naturally.

Analysis of the fish samples involves a two-stage process: first, a trained panel of individuals taste batches to detect taint; thereafter gas chromatography and mass spectroscopy chemical analysis are carried out to establish the level of contamination for comparison with reference levels which occur naturally. Shellfish from one trawl were found to be tainted. Three or four aggregate samples of shellfish from the trawl were subsequently found to be contaminated with hydrocarbons of petrogenic origin. The tainted sample was the most contaminated and had polycyclic aromatic hydrocarbon levels--that is PAH levels--45 times higher than a reference sample.

http://www.publications.parliament.uk/pa/cm199798/cmstand/deleg1/st971105/71105s01.htm

10.3.8.4 Oil spill trajectory

Oil spill trajectory modelling can be carried out deterministically (i.e. with defined arbitrary metocean conditions, usually sustained "worst case" which may not be realistic) or stochastically (i.e. using statistical distributions for wind and current regimes). Modelling scenarios generally include a major crude oil release, corresponding to a blowout, and smaller diesel or fuel oil releases which are expected to be less persistent, but are more likely to occur. Quantitative spill trajectory modelling has not been carried out as part of the SEA 5 process, although it may be noted that previous modelling has been carried out in Environmental Assessments and Oil Spill Contingency Planning for exploration wells and developments within the area, including the Beatrice Field and nearshore exploration drilling close to the Caithness coast.

Under "Essential Elements" criteria for oil spill response measures used in UKCS licence conditions, deterministic calculations are carried out to estimate the time to beach assuming constant 30 knot wind speed. Throughout most of the SEA 5 area, with the exception of areas close to Orkney and the Pentland Firth, tidal current velocities are moderate and oil spill trajectory will be most influenced by wind. Most frequent wind directions vary seasonally and geographically, but prevailing winds are generally offshore (i.e. away from the adjacent UK coastline). It should be noted, however, that dominance by winds from any direction is low and wind (and therefore wind-driven oil spill track) may occur in any direction throughout the year.

Deterministic calculations can be carried out using proprietary software, or more simply by assuming that a slick front will move at 3% of wind speed giving times to beach in the range 0-122h (assuming distance to shore in the range 0-110 nautical miles).

Areas of relatively high prospectivity in the SEA 5 area include close to the east Caithness shore and east of Orkney, and to a lesser extent north of the "Banff fault zone". These areas are most likely to attract exploration activity and potential production, and spill risks are consequently relatively high (although low in absolute terms). A persistent oil spill in these areas could potentially be transported westwards via the Pentland Firth, with consequent risks to north mainland and south Orkney shores. Prospectivity adjacent to the Shetland coast and mainland coastline south of the Moray Firth are lower, and spill risks associated with E&P are correspondingly reduced.

10.3.8.5 Ecological and economic effects of oil spills

The most vulnerable components of the ecosystem to oil spills in offshore and coastal environments are seabirds and marine mammals, due to their close association with the sea surface. These sensitivities are discussed below. Benthic habitats and species may also be sensitive to deposition of oil associated with sedimentation. Studies of macrobenthic infauna following the *Braer* spill (Kingston *et al*. 1995) found no significant changes in benthic community structure, as characterised by species richness, individual abundance and diversity, which could be related to the areas of seabed affected by the spill. This may have been because *Braer* oil was of such low toxicity as to significantly disrupt benthic community structure, or because the sampling programme was carried out too soon after the spill to enable the full effects of its impact to be detected. In recognition of this, DTI has conducted further sampling of the study area, ten years after the spill event, early results from which has indicated a substantial decline in sediment hydrocarbon concentrations.

Previous SEAs have noted that military casualties over the course of two world wars resulted in unquantified, but substantial releases of crude and heavy fuel oils in the region within relatively short timescales, apparently without catastrophic ecological consequences. Military wrecks in Scapa Flow continue to be a source of chronic oil pollution.

Oil spills have a potentially severe effect on fishing activities, particularly in coastal fisheries and aquaculture; and also potential impacts on tourism and recreation. These are further discussed below.

Seabirds and waterbirds

Direct mortality of seabirds in the event of oil spill is undoubtedly the most widely perceived risk associated with the proposed licensing and subsequent activities. Spills affecting waters near major colonies during the breeding season could be catastrophic (Tasker 1997). Seabirds are affected by oil pollution in several ways, including oiling of plumage and loss of insulating properties, and ingestion of oil during preening causing liver and kidney damage (Furness & Monaghan 1987).

Offshore vulnerability to surface pollution in the SEA 5 area was reviewed in section 6.7, with overall vulnerability scored as very high in the majority of the area (Quadrants 1, 6, 7, 11, 12, 13, 14, 17, 18, 19, 20, 25, 26, 27, 33 and 34). Vulnerability is very high for between 9 and 12 months in parts of Quadrants 6, 7, 11, 12, 17, 18, 19, 25, 26, 33 and 34, associated in part with the proximity of major breeding colonies, and in part with post-breeding dispersal of vulnerable species such as auks. It is therefore clear that more prospective SEA 5 areas coincide with coastal and offshore waters characterised as high vulnerability in terms of seabirds, and that there is little scope for mitigation of risk through operational timing.

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 Offshore Vulnerability Index (OVI). Analysis of seasonal importance of sub-areas of SEA 5, in terms of abundance of divers, grebes and seaduck, was carried out as part of supporting studies for SEA 5 (Barton & Pollock 2004). This indicated that Shetland, Aberdeenshire, Angus and the Forth coastal waters held internationally important numbers in both summer and winter; whereas Orkney, the Moray Firth, Tay/St. Andrews, Firth of Forth and Lothian/Borders held internationally important numbers in winter only. Much of this importance is associated with eiders: excluding this species, all areas held nationally important numbers in winter with Shetland, Orkney, the Moray Firth and Firth of Forth holding internationally important numbers; and (excluding eiders) the coast between Aberdeenshire and the Forth holding nationally important numbers in summer.

Marine mammals

Oil spill risks to marine mammals have been reviewed by Hammond *et al*. (2004). 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 less vulnerable than seabirds to fouling by oil, but they are at risk from hydrocarbons and other chemicals that may evaporate from the surface of an oil slick at sea within the first few days. Symptoms from acute exposure to volatile hydrocarbons include irritation to the eyes and lungs, lethargy, poor coordination and difficulty with breathing. Individuals may then drown as a result of these symptoms.

Grey and harbour seals come ashore regularly throughout the year between foraging trips and additionally spend significantly more time ashore during the moulting period (February-April in grey seals; August in harbour seals) and particularly the pupping season (October-January in grey seals; June-July in harbour seals). Animals most at risk from oil coming ashore on seal haul-out sites and breeding colonies are neonatal pups, which are therefore more susceptible than adults to external oil contamination. Harbour seals are found throughout the year on haul-out sites in Orkney, Shetland and along the east coasts of Scotland, and are densely distributed at sea to the east of Shetland and Orkney and off southeast Scotland (Hammond *et al.* 2004). More than half the northeast Atlantic population of grey seals are associated with the colonies in Orkney, Shetland, and the east coast of Scotland, and are widely distributed in the SEA 5 area throughout the year.

Intertidal and maritime habitats

Intertidal habitats and species are vulnerable to surface oil pollution, or to windblown oil in the case of onshore maritime habitats (e.g. dune systems). After seabirds and wildfowl, seals are probably the most obvious potential casualties (and most emotive in terms of press coverage), with vulnerability of intertidal habitats also high, particularly where oiling of sheltered coastlines occurs. The vulnerability of different shore types to oil pollution is largely dependent on substrate and wave exposure, and is reviewed in relation to SEA 5 coastlines below (Table 10.3, vulnerablity assessed using the criteria of Gundlach and Hayes 1978).

Table 10.3 – Vulnerability of SEA 5 shorelines to oil pollution

Shoreline type	General location in SEA 5	Vulnerability to oil
Exposed rocky cliffs and headlands	Exposed areas of Shetland and Orkney, outer Moray Firth and much of the east coast	Low vulnerability. Wave reflection keeps most of the oil offshore
Fine and coarse grained beaches	Sheltered areas of Shetland and Orkney, inner Moray Firth, areas of NE coast and within Tay and Forth estuaries.	Low to moderate vulnerability. Where oil penetrates into the sediment, may persist over several months.
Mixed sand and gravel beaches; shingle beaches	Sheltered areas of Shetland and Orkney, inner Moray Firth	Moderate to high vulnerability. Oil may penetrate rapidly and be buried resulting in persistence over years. Solid asphalt pavement may form under heavy oiling conditions
Sheltered rocky coasts	Sheltered areas of Shetland and Orkney, inner Moray Firth, areas within Tay and Forth estuaries	Moderate to high vulnerability. Oil may persist for years
Sheltered tidal flats	Inner areas of the Moray Firth, Tay and Forth estuaries	High vulnerability. Low wave energy; high productivity and biomass. Oil may persist for years
Salt marshes	Sheltered areas of Shetland and Orkney, south coast of Moray Firth, local areas on NE coast and within Tay and Forth estuaries.	High vulnerability. Highly productive. Oil may persist for years.

Source: Adapted from Gundlach & Hayes 1978

The exposed eastern coastlines of Shetland and Orkney have predominantly high energy rock, boulder or cliff shores which are generally of low vulnerability. Higher vulnerability shore types are distributed in voes, sounds and embayments. Shoreline types have been mapped as part of coastal protection strategies (AFEN 2001). On mainland coasts, rock platforms and cliffs are interspersed with exposed sandy beaches; with extensive mud and sand flats, and limited areas of saltmarsh, in inner areas of the Moray Firth, Tay and Forth. A Shoreline Protection Strategy Plan has been compiled on behalf of a number of Operators covering the Moray Firth area between Duncansby Head and Rattray Head. The document identifies the most vulnerable sites and outlines the most effective methods of protecting the area (Briggs Marine Environmental Services 2000). Contingency plans are also in place within areas under the jurisdication of port and harbour authorities.

The overall assessment of oil spill risk associated with SEA 5 is, in part, based on the existing level of risk associated with offshore production but mainly with commercial shipping. In particular, Shetland and Orkney coasts are exposed to risks associated with high levels of tanker traffic in the Fair Isle Channel and north of Shetland (Lord Donaldson 1994). These routes are close to shore and limited time is available for effective response measures in the case of accidents. Oil spill risks to mainland coasts are dominated by nearshore shipping traffic associated with major ports and terminals, including Nigg and Hound Point. The Firth of Forth and adjacent waters to the south were rated “very high” in terms of oil spill risk and impacts on the environment by the (former) Department for Transport, Local Government and the Regions (National Audit Office 2002).

Tourism and recreation

In addition to fishing and aquaculture, coastal industry and activities in adjacent areas to the SEA 5 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 principally 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.

Fisheries and aquaculture sensitivities

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 features that are used by fish either as spawning, feeding or nursery grounds. In addition to direct toxicity of oil and dispersants, oil and certain chemicals have the potential to introduce taint (defined as the ability of a substance to impart a foreign flavour or odour to the flesh of fish and shellfish following prolonged and regular discharges of tainting substances (Guidelines for the UK Revised Offshore Chemical Notification Scheme, July 1999). Possible effects on human consumers of seafood are also an issue of concern in relation to accidental spills and industrial discharges.

Government may issue exclusion orders preventing marketing of seafood from areas considered to be contaminated following a spill or other incident, resulting in economic impacts on local fisheries and associated processing. Temporary exclusion orders were implemented following both the *Braer* and *Captain* spills (see above). Historical experience (e.g. the *Braer* spill) indicates that irrespective of actual contamination levels, spills may result in significant loss of public confidence in seafood quality from the perceived affected area, and therefore in sales revenue. Either perceived or actual contamination of target species with hydrocarbons or other chemicals may therefore result in economic damage to the fishing industry (and associated industries).

Extensive numbers of salmon farms are found throughout Shetland and Orkney, with a smaller number along the North coast of Scotland. The many voes, inlets and firths around the Shetland and Orkney coastlines provide good shelter and adequate water exchange for mariculture operations and the industry has become an important constituent of the local economy. The *Braer* spill had particularly severe effects on the fish farming industry in the Shetland Islands, while commercial fishing activities were only affected in a small area of the Burra Haaf. It is likely that significant oiling of any part of the Shetland, and to a lesser extent Orkney and mainland, coastlines would have similar effect.

10.3.8.6 Oil spill response preparedness – organisation and management

Spill prevention and mitigation measures are implemented for offshore exploration and production under *The Offshore Petroleum Production and Pipe-lines (Assessment of Environmental Effects) Regulations 1999* and *The Merchant Shipping (Oil Pollution Preparedness, Response and Co-operation) Regulations 1998.* The required measures include spill prevention and containment measures, risk assessment and contingency planning.

Offshore, primary responsibility for oil spill response lies with the relevant Operator, although the Secretary of State's Representative (SOSREP) may intervene if necessary. The Maritime and Coastguard Agency (MCA) is responsible for a National Contingency Plan in consultation with other relevant departments, agencies and stakeholders, last revised in February 2000 following recommendations from Lord Donaldson. MCA maintains four Emergency Towing Vessels (ETVs) including one each in the Minches and Shetland, 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 14 locations around the UK, in addition to counter-pollution equipment (booms, adsorbents etc.) which can be mobilised within 2-12 hours depending on incident location.

Similar response capabilities, providing a tiered response capability, must be available to Operators prior to commencing drilling or production activities. These provisions are made under various long-term commercial contracts with specialist contractors, supplemented where necessary (e.g. for remote locations) with additional stockpiles. Site-specific Oil Spill Contingency Plans must also be submitted to DTI for approval prior to operations. Additional conditions can be imposed by DTI, through block-specific licence conditions (i.e. "Essential Elements").

Minimum beaching times from some parts of the possible licence area with sustained 30 knot winds, are short 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 5 area.

Coastal oil spill contingency response arrangements are currently the responsibility of local authorities. Following previous licence Rounds, Operators of nearshore blocks have consulted and co-operated with local authorities and conservation agencies on contingency planning, and in some cases have developed Coastal Protection Plans (e.g. for the Moray Firth); and trained local authority personnel and provided response equipment. The Atlantic Frontier Environmental Network (AFEN, a consortium of Operators and Government departments) has also commissioned coastal response plans (AFEN 2001) which cover Shetland, Orkney, the Hebrides, north and west coasts of Scotland.

10.3.8.7 Information gaps

Within the SEA 5 area, seabird vulnerability data are relatively comprehensive. However, data gaps are present for two or more consecutive months in blocks within Quadrants 210, 20, 26, 27 and 28. Contingency planning for activities which could affect these areas should take note of these gaps, particularly with regard to the consequent difficulty in deciding whether application of chemical dispersants is appropriate.

Use of dispersants is a key aspect of oil spill response strategy in the UK, where there are no ecological or fisheries conflicts. There have been no specific studies on the direct acute or chronic toxicity of oil dispersants to seals and cetaceans.

10.3.8.8 Conclusions

Although the consequences of major oil spills in much of the SEA 5 area may clearly be severe, in both ecological and economic terms, the incremental risk associated with the predicted level of activity is moderate or low. It is clear that more prospective SEA 5 areas coincide with coastal and offshore waters characterised as high vulnerability in terms of seabirds, and that there is little scope for mitigation of risk through operational timing. For some locations, times to beach under deterministic trajectory modelling conditions, may not be sufficient to allow the deployment of response measures.

However, existing exposure to risk is “high” or “very high” as a result of shipping around the north of Shetland, Fair Isle Channel and western Orkney, and Firth of Forth (National Audit Office 2002) and oil spill contingency arrangements have been revised and significantly upgraded since 1999.

DTI has regulatory mechanisms in place to require Operators to develop effective oil spill mitigation measures, covering organisational aspects and the provision of physical and human resources; and to refuse consents for specific activities (including exploration drilling and development) where adequate risk management cannot be provided. Within the SEA 5 area, the long term operation of the Beatrice Field (since 1981) with no major pollution incidents indicates that nearshore production in relatively sensitive areas can be undertaken with acceptable levels of risk.

It is therefore concluded that, subject to regulatory controls outlined above, there are no areas within the SEA 5 scope which should be excluded from licensing, and no general timing constraints which can be justified. Risk assessment for specific activities should take particular note of seasonal variations in seabird vulnerability and seal moulting/pupping periods.

10.4 Cumulative effects

As noted above, the SEA Directive requires *inter alia* that cumulative and synergistic effects should be considered. Stakeholder consultation has confirmed the importance of cumulative effects within the overall process. The approach adopted for assessment of cumulative effects within the DTI SEA process reflects guidance from a range of sources within the UK, EU and internationally. Guidelines on the range of techniques for assessing cumulative impacts (and indirect impacts & impact interactions) has been prepared on behalf of the EU, although this was primarily targeted at Environmental Impacts Assessments and Integrated

Pollution Prevention and Control. Other background literature utilised included best practice guidelines from other countries and industries and published work including Bain *et al*. 1986, Canter & Kamath 1995, Irwin & Rodes 1992, Lane & Wallace 1998, Vestal *et al*. 1995, Cumulative Effects Assessment under the U.S. National Environmental Policy Act (NEPA website), and Canadian Environmental Assessment Act (Canadian Environmental Assessment Agency website).

Incremental effects have been considered within the SEA process as effects from licensing E&P activities, which have the potential to act additively with those from other oil and gas activity, including:

- forecast activity in newly licensed areas
- new exploration and production activities in existing licensed areas
- existing production activities
- forecast decommissioning activities
- "legacy" effects of previous E&P activities, post-decommissioning (e.g. unrecovered debris and cuttings material)

Cumulative effects are considered in a broader context, to be potential effects of E&P activities which act additively or in combination with those of other human activities (past, present and future), notably:

- fishing
- shipping, including crude oil transport
- military activities, including exercises (principally in relation to noise)

Synergistic effects – synergy occurs where the joint effect of two or more processes is greater than the sum of individual effects – in this context, synergistic effects may result from physiological interactions (for example, through inhibition of immune response systems) or through the interaction of different physiological and ecological processes (for example through a combination of contaminant toxicity and habitat disturbance).

To some extent, all potential sources of effect (i.e. disturbance, emissions and discharges) resulting from oil and gas activity within an area with a long history of exploration activity are cumulative, insofar as they are incremental to previously existing sources (although the net trend of overall source level may be a reduction, due to improved environmental management and/or declining production levels).

Therefore, effects are considered incremental, cumulative or synergistic only if:

- the physical or contamination "footprint" of a predicted project overlaps with that of adjacent activities; or
- the effects of multiple sources clearly act on a single receptor or resource (for example a fish stock or seabird population); or
- if transient effects are produced sequentially.

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

Underwater noise

Although the distant propagation of seismic noise makes incremental exposure to noise from sequential surveys in potential 23rd round acreage and noise from seismic surveys in previously licensed blocks possible (both in the SEA 5 and adjacent areas), the extent of this is dependent on exploration activity level, operational and timing factors and is impossible to predict. However, simultaneous seismic surveys cause acoustic interference and are therefore managed on a cooperative basis ("timeshared"). This has the effect of substantially mitigating the probability of a single receptor receiving disturbance from two or more sources concurrently, but can increase the duration of continuous disturbance.

The number of seismic surveys to be shot following SEA 5 licensing is predicted to peak in the first year after licence award and consist of four 2D and three 3D seismic surveys. Offshore marine mammals distribution is not generally confined to localised areas and it is unlikely that individuals would be exposed to sound levels sufficient to cause significant biological effects for the full duration of a survey. No marine mammal species are known to follow regular, tightly defined migration pathways in the SEA 5 area, which could be "blocked" by cumulative seismic disturbance.

Overall, the likelihood of incremental noise effects from seismic surveys will depend on the timing and location of seismic, but is considered to be low both in terms of simultaneous surveys, and also in terms of sequential surveys affecting the same receptors (marine mammals). There is no evidence that substantial E&P activity to date in the North Sea has resulted in direct mortality or acute trauma to marine mammals.

Incremental Simultaneous and sequential surveys in 23rd Round and previously licensed areas. Seismic and operational noise (e.g. drilling, thruster and FPSO noise).

Cumulative Seismic survey noise and broadband impulse noise, for example military sonars, and continuous mobile sources e.g. shipping

Synergistic None known

Physical damage to features and biotopes

Potential sources of physical disturbance to the seabed, and damage to biotopes, were identified as rig and laybarge anchoring, wellheads and templates, jacket footings, pipelay activities including trenching and rock-dumping; of these, rig anchoring and pipelay accounted for greatest spatial extent. Given the forecast scale of exploration and production for the SEA 5 area, it is likely that there would be considerable spatial separation between disturbance "footprints" and a low probability of incremental overlap of affected areas. Recovery of affected seabed through sediment mobility, and faunal recovery and re-colonisation, is expected to be rapid where the source of effects is transient (e.g. anchoring), less than five years in continental shelf and slope depths but potentially much longer in mud sediments such as the edge of the Fladen Ground.

Existing control and mitigation measures are provided through the *Offshore Petroleum Production and Pipe-lines (Assessment of Environmental Effects) Regulations, 1999* or (in the vicinity of an SAC) from *The Offshore Petroleum Activities (Conservation of Habitats) Regulations, 2001*. The required consenting procedure for specific projects ensures that biotopes of particular conservation or ecological value are identified and afforded appropriate protection.

Incremental Physical footprint incremental to existing oil and gas activity – minor increment

Cumulative Cumulative effects dominated by trawling on the continental shelf. In these areas the overall effect of oil and gas development is likely to be positive through fishing exclusion.

Synergistic None known

Physical presence

The physical presence of offshore infrastructure (with associated 500m radius safety exclusion zones) required for exploration and production in shallow waters can have significant direct effects on other users of the affected areas (notably the fishing industry). For example, in the early 1980s it was estimated that the loss of fishing area in the North Sea caused by these zones was ~0.25% of the total area of the North Sea. The predicted incremental effect of exploration and development in the SEA 5 area amounts to 20 temporary (not all would be concurrent and spread over a 4 to 5 year period) and up to 3 longer term exclusion zones, a minor increment to the existing area covered by exclusion zones in the SEA 5 and adjacent areas.

Incremental Small increment to existing exclusion zones and obstructions

Cumulative Exclusion and snagging risks are cumulative to those resulting from natural obstructions, shipwrecks and other debris. Extent of cumulative effect associated with 23rd Round is negligible.

Synergistic None known

Marine discharges

Total produced water discharge from UKCS oil production was 272 million tonnes in 2002, with an average oil in water content of 21.0mg/kg (DTI website). In comparison with this, the potential discharge from SEA 5 developments will be negligible since it is expected that the bulk of produced water will be reinjected rather than discharged. Through OSPAR, the UK is committed to a 15% reduction in total discharged volume of oil in produced water by 2006 and there is a presumption against discharge from new developments.

Environmental effects of produced water discharges are limited primarily by dispersion, to below No Observed Effect Concentrations (NOECs). Synergistic interactions are possible between individual components, particularly PAHs, specific process chemicals (especially those which are surface-active, including demulsifiers), and other organic components. However, given the anticipation that the bulk of produced water from SEA 5 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 5 area have been shown to disperse rapidly and to have minimal ecological effects. Dispersion of further discharges of mud and cuttings could lead to localised accumulation in areas where reduced current allows the particles to settle on the seabed. However, in view of the scale of the area, the water depths and currents, and plans to reinject drill cuttings from a major field development in the area, this is considered unlikely to be detectable and to have negligible incremental or cumulative ecological effect.

Incremental Produced water – incremental contribution of produced water is dependent on the extent of reinjection from existing and SEA 5 developments but noting the presumption against new produced water discharges, the scale of discharge and effects will be negligible. WBM drilling discharges generally disperse widely and significant accumulations do not occur. It is therefore possible that discharge footprints will overlap, although the ecological effects will be undetectable. Potential "sinks" may occur in areas of sediment accumulation although this is considered unlikely to be detectable.

Cumulative Principal cumulative sources of major contaminants, including hydrocarbons and metals, are shipping (including wrecks) and atmospheric inputs. Cumulative sources of particulate contaminants include aeolian dust and sediment disturbance from trawling, although these are negligible in the context of natural suspended particulate loads.

Synergistic Synergistic effects of chemical contaminants in produced water and drilling discharges are conceivable, although substantive data is almost entirely lacking and it is considered unlikely that significant synergistic effects would result from chemicals used in exploration and production operations.

Atmospheric emissions

Atmospheric emissions from offshore oil and gas exploration and production activities may contribute to reduction of local air quality. Greenhouse and acid gas emissions effectively contribute to a mixed regional or global "pool" and can therefore be considered cumulative.

It should be noted that implications of the ultimate use of oil and gas production from UKCS for greenhouse gas emissions and UK commitments under the Kyoto Protocol, were not considered here since these are subjects for a different appraisal forum.

Flaring from existing UKCS facilities has been substantially reduced relative to past levels, largely through continuing development of export infrastructure and markets, together with gas cycling and reinjection technologies. 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 will generally have little effect on host installation flaring.

Incremental Incremental emissions resulting from internal combustion for power generation by installations, terminals, vessels and aircraft, flaring for pressure relief and gas disposal, and fugitive emissions during tanker loading.

Cumulative Greenhouse and acid gas emissions effectively contribute to a mixed regional or global "pool" and are therefore considered to be cumulative. On a global scale, cumulative contributions of emissions resulting from SEA 5 activities and developments will be negligible in comparison to the influence of onshore sources.

Synergistic None known

Wastes to land

In view of the relatively small number of wells predicted in the SEA 5 area, and recent establishment of a licensing mechanism to allow interfield cuttings reinjection, it is considered unlikely that major incremental or cumulative landfill requirement will result from SEA 5.

Incremental Incremental return of general oilfield wastes insignificant; incremental return of drilling wastes also unlikely to represent a significant contribution to onshore waste disposal requirements.

Cumulative Not quantified

Synergistic None known

Accidental events

Although the consequences of a major oil spill in the area could be severe, in both ecological and economic terms, the incremental risk associated with the predicted level of activity in SEA 5 is moderate or low. In contrast, existing exposure to risk is "high" or "very high" as a result of shipping around the north of Shetland, Fair Isle Channel and western Orkney. Regulatory mechanisms already in place require Operators to develop effective oil spill mitigation measures, covering organisational aspects and the provision of physical and human resources which will minimise incremental risks. Times to beach, under worst case trajectory modelling conditions, are sufficient to allow the deployment of response measures where appropriate.

In terms of cumulative risk, there is little doubt that due to scale and consequence, the major risk of significant oil spills is associated with tanker transport of crude oil and refined products. While some control and response measures have been implemented, for example following the Donaldson inquiry into the *Braer* incident, the residual risk remains relatively high (in comparison to other oil spill sources including E&P).

Other cumulative sources of anthropogenic hydrocarbon input to the SEA 5 area include rivers and land run-off, coastal sewage/sewage sludge, dredge spoil, operational shipping discharges and atmospheric deposition. Although cumulative hydrocarbon inputs are often summed for comparative purposes, it is important to note that the environmental effects and fate of individual oil types and sources may be very different. Simple comparison of cumulative inputs may therefore be misleading in terms of effects assessment. In size and frequency terms the majority of oil spills most likely to result from E&P operations will make an insignificant contribution to overall regional inputs.

As context, 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 to the North Sea – and thirty years of oil and gas development – do not appear to have resulted in wide-scale or chronic ecological effects. It is therefore concluded that the limited incremental effects of SEA 5 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 5 activities.

Cumulative There are a range of cumulative sources of hydrocarbons to the SEA 5 area. Depending on magnitude, accidental spills represent a minor to major contribution to overall regional inputs of oil.

Synergistic None known

10.5 Transboundary effects

It is a requirement for Strategic Environmental Assessment that transboundary effects are identified, under *European SEA Directive (2001/41/EC)* and the *Espoo Convention*; and this requirement also applies to project environmental assessments conducted under the *Offshore Petroleum Production and Pipe-lines (Assessment of Environmental Effects) Regulations 1999*.

Consideration of transboundary effects is intended to promote adequate consideration of, and consultation between the relevant governments, on transboundary effects where a plan or programme in one state may have significant effects on the environment of another.

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

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 5 area is not contiguous with waters under the jurisdiction of any other state as it is buffered from Norwegian waters to the east by the SEA 2 area and from Faroese waters to the west by SEA 4. However, prevailing wind and residual water circulation of the SEA 5 area will result in the transport of atmospheric emissions and spills towards Norway.
Sources of potentially significant environmental effects, with the additional potential for transboundary effects, are:

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

All of the above aspects may be able to be detected physically or chemically in adjacent state territories. The scale and consequences of environmental effects in adjacent state territories due to activities resulting from the proposed 23rd Round licensing will be less than those in UK waters and are unlikely to be significant.

10.6 Potential socio-economic implications

10.6.1 Context

Gas gap

UK natural gas production in 2002 was 5.7% less than peak production in 2000. At the same time there has also been a substantial increase in the UK demand for natural gas, up 37% between 1993 and 2002. Demand for gas is projected to rise at an annual rate of 1.7% until 2012/13. Despite the decline in production and rise in consumption, the UK continued to be a net-exporter of natural gas in 2002, a status it has held since 1997. However, due to the decline in production from mature natural gas fields and limited opportunities to find new, significant prospects, the UK is expected to become a natural gas importer within the next few years.

The volume of imports is set to increase substantially during the next ten to fifteen years and in the next twenty years, as production from the UK Continental Shelf (UKCS) declines and the UK becomes more dependent on imported gas, there will be an increasing need for new gas supply sources as well as investment in infrastructure projects to meet both annual demand and the seasonal and daily swings in demand. There are a number of potential market options:

- additional import connections from Norway, direct to shore or via existing UKCS infrastructure
- liquefied natural gas (LNG) terminals to import gas from worldwide sources
- more interconnection with Europe to import gas from the Netherlands, Norway and beyond
- pipeline upgrades to existing interconnectors to increase import capacity
- gas storage, both onshore and offshore, to provide additional seasonal and daily swing capacity and to replace capacity which will be lost with the decline in UKCS swing capacity

Oil gap

North Sea oil output peaked at about 2.9 million barrels per day in 1999 and, having already fallen by one sixth, is predicted to fall to only 1.6 million barrels per day by 2007. It has been estimated that by 2020 the UK could be dependent on imported energy for 80% of its needs.

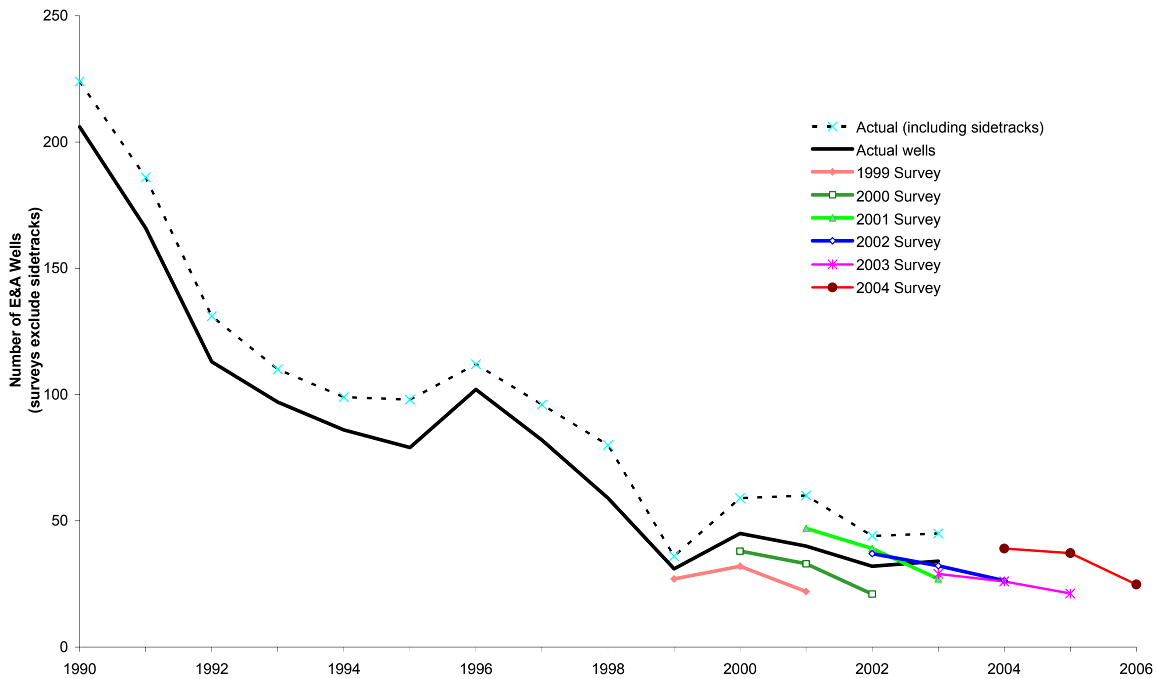
Gross production of crude oil and NGLs in 2003 was 106 million tonnes, a decline of 8½ per cent on 2002 and 23 per cent lower than the peak production level of 137 million tonnes in 1999. Almost three-quarters of the United Kingdom’s primary oil production in 2003 was exported and imported crude oil accounted for 64 per cent of UK requirements.

One reason for this decline in production is the maturity of the UKCS fields. Other reasons include smaller fields being brought into production and the application of new technologies which can result in particular fields being exhausted at a quicker rate. It is also becoming costlier to extract as they are located in more remote regions and contain smaller quantities of oil.

Exploration activity on the UKCS

The most recent of the DTI’s surveys of oil and gas operators’ intentions to drill offshore exploration and appraisal wells was conducted in early 2004, and covered the period up to the year 2006. The survey showed that, after allowing for probabilities, operators expected to drill some 39 exploration and appraisal wells in the UK in 2004 and 37 in 2005 (these figures exclude sidetrack wells). The overall trend is of decline in activity – see Figure 10.5 below. However, total intentions for the three forward years are higher than given by all surveys since 1998, except the 2001 survey.

Figure 10.5 – E&A Drilling: Comparison of recent surveys with wells drilled



Source DTI Oil and Gas Website

Government action

The UK Government has identified the need to stimulate investment and activity to ensure that indigenous production of oil and gas remains at significant levels into the future. In response to declining oil and gas supplies the government has undertaken initiatives to prolong hydrocarbon production.

PILOT taskforce

In January 2000, the government created the PILOT program to help secure long-term production of oil and natural gas from the UKCS. The PILOT concept aims to unite the senior management of operators, contractors, suppliers, unions and relevant Government Departments, thereby working to address the need to reduce the cost base of activity in the UKCS. It also wishes "to create a climate for the UKCS to retain its position as a pre-eminent active centre of oil and gas exploration and development and production and to keep the UK contracting and supplies industry at the leading edge in terms of overall competitiveness" (PILOT 2004).

The PILOT taskforce has a ten year strategy for industry/government co-operation aimed at achieving the following targets by the year 2010:

- 3 million boe/day production beyond 2010

- £3 billion per annum Industry investment
- Prolonged self-sufficiency in Oil & Gas
- Up to 100,000 more jobs (than there would otherwise have been)
- 50% increase in exports (by 2005)
- £1 billion per annum additional revenue for new business
- In 2010, the UK is the safest place to work in the world wide oil and gas industry

The PILOT taskforce has in turn created the Fallow blocks process and Promote licence.

Fallow blocks process

This PILOT initiative was introduced in 2002 with the aim of stimulating drilling and development activity on blocks and discoveries which have seen no activity for four years or more. On 9th January 2004, the Department of Trade and Industry and its partners in PILOT published a new listing of Fallow Blocks and Discoveries. This fifth release has added 17 Fallow Discoveries and 109 new Fallow Blocks to the list, for a total of 83 Fallow Discoveries and 151 Fallow Blocks.

The list of fallow blocks has been divided into two different classes by the DTI:

- Class A - Those where the current licensees are doing all that a technically competent group with full access to funding could reasonably be expected to do.

- Class B - Those where the current licensees are unable to progress towards activity due to misalignment within the partnership, a failure to meet economic criteria, other commercial barriers or a combination of these.

Since the Fallow process began there have been eight exploration or appraisal wells drilled in class B blocks. As a result of this drilling the Seymour field began producing condensate in March 2003, two fields are being developed (Caravel and Arthur) and there have been two new fields discovered.

The Promote Licence

The Promote UKCS project has been designed to attract new entrants onto the UKCS (UK Continental Shelf). This licence costs 90% less than a traditional licence for two years and allows companies to assess the value of a field before committing to it, therefore providing more opportunity for smaller companies to enter the North Sea market. This two year period is intended to give companies a chance to explore for oil and natural gas before promoting the licensed area to investors to acquire funding for drilling and other work.

The response to the new licence was evident in the 21st round, with 53 of the 89 licences awarded being the new “Promote” licences.

It is recognised that there is a need to attract new entrants into the UKCS to ensure the survival of the UK oil and gas industry. This could lead to the evolution of the UKCS into an area where many smaller independent oil and gas companies are active. Lessons learnt from regulatory and business practises in the US Gulf of Mexico may help speed up this process. A clear message from the Gulf is that rapid turnover of leases stimulates exploration and appraisal activity. This is of particular importance when development opportunity size is decreasing and value must substitute for volume.

10.6.2 SEA 5 consideration

The report, provided by Mackay Consultants, outlines the predicted socio-economic impacts of licensing the SEA 5 area. Scenarios of possible developments in the region were provided by the Department of Trade and Industry (listed in the box below) and used by Mackay Consultants to produce forecasts in the following areas:

- Oil and gas production and reserves
- Capital, operating and decommissioning expenditure
- Employment
- Tax revenue
- Social impacts

Five distinct areas have been used for the purposes of the assessment:

Area 1. Shetland Islands
Area 2. Orkney Islands
Area 3. the Moray Firth area
Area 4. the Aberdeen area
Area 5. the East Coast of Scotland south of Aberdeen

These divisions have been proposed due to the existing oil related activity in these areas. For the purpose of the DTI scenarios provided, the SEA 5 area has been assessed as one and not split into the five areas listed above.

Department of Trade and Industry (DTI) Scenarios			
Year	**Seismic Activity**	**Exploration/Appraisal Wells**	**Developments**
Year of award	2 x 2D seismic surveys	0 exploration wells 0 appraisal well	Depends on drilling success rate. 3 new stand-alone developments are envisaged with potentially one new pipeline to shore. It is anticipated that the remaining developments would tie-back to existing infrastructure.
Year following award	4 x 2D seismic 3 x 3D seismic surveys	3 exploration wells 1 appraisal well	
Year 2 years after award	2 x 2D seismic 3 x 3D seismic surveys	3 exploration wells 2 appraisal well	
Year 3 years after award	2 x 3D seismic surveys	3 exploration wells 2 appraisal well	
Year 4 years after award	No seismic envisaged	3 exploration wells 3 appraisal well	

Forecasts of UKCS oil and gas activity have been included to demonstrate the relationship between SEA 5 and the rest of the UK, in particular, the impact that any future SEA 5 developments would have upon the British oil and gas industry as a whole.
The report shows that the licensing of the SEA 5 area could have a significant impact on the UKCS oil and gas industry. Production from fields in the area could make important contributions to overall UKCS production, employment and tax revenues, as well as extending the lives of facilities such as the Sullom Voe and Flotta terminals. Although SEA 5 development cannot compensate for the fall in UKCS production, the over-riding impact will be a slowing down of the overall rate of decline.

10.6.2.1 Existing facilities and activity in the area

Existing discoveries

The SEA 5 area comprises a large part of the undeveloped area of the UK sector of the Northern North Sea. There is only one producing field in the area, Beatrice. To the immediate east of the SEA 5 boundary there are numerous oil and gas fields in production.

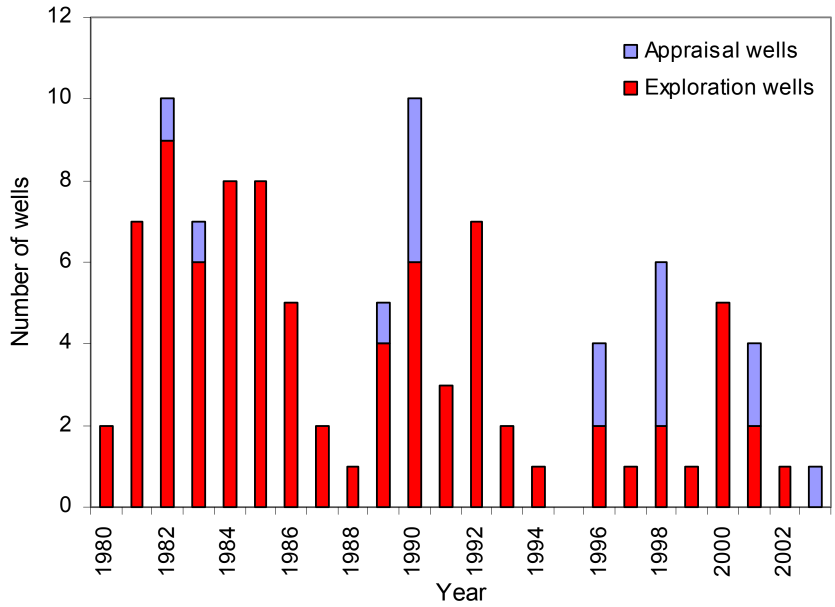
Beatrice Field

The Beatrice oil field is located in block 11/03a in the Moray Firth area. Beatrice has been producing since 1981; its oil is currently transported by a 67km pipeline to a terminal at Nigg Bay on the Cromarty Firth in Easter Ross. Production from the Beatrice field was expected to cease a few years ago, however, Talisman have managed to extend its field life. Current production from Beatrice is less than 5,000bpd (barrels per day).

10.6.2.2 SEA 5 exploration activity

Over the last 20 or so years there has been just over 100 exploration and appraisal wells drilled in the SEA 5 area (see Figure 10.6). Exploration in this area started as far back as the 1960s, however, drilling activity in the blocks concerned has never been at the same level as elsewhere in the UKCS (i.e. SEA 2 area).

Figure 10.6 – SEA 5 - exploration and appraisal wells (Source: DTI)



10.6.2.3 Onshore facilities

Shetland has had over 30 years involvement with the UKCS oil and gas industry and has a well established range of existing infrastructure, which includes the Sullom Voe oil terminal, Scatsta and Sumburgh airports and a supply base in Lerwick.

The Sullom Voe oil terminal, which was originally built to handle oil from the East Shetland Basin (outwith the SEA 5 area), has been operating for over 27 years. Facilities at Sullom Voe include storage tanks, processing facilities and export jetties. From Sullom Voe, oil is taken by tanker to the UK, the USA and other export markets. Peak throughput at the terminal was reached in 1984 and has declined substantially in recent years as a result of falling production in the East Shetland Basin fields. This trend is discussed in further detail in the report and highlighted later in this assessment. Scatsta and Sumburgh airports, the supply base in Lerwick and other supporting facilities (e.g. tugs), are considerably underutilised at the present time. As such, any new developments in SEA 5 would be of great benefit to the oil terminal and to a number of other onshore facilities.

The only significant facility in Orkney is Flotta oil terminal which handles oil from 16 fields immediately to the south and east of the SEA 5 area. BP also uses Flotta to handle oil from the Foinaven field, transporting the oil via shuttle tanker rather than pipeline. As with Sullom Voe, Flotta is experiencing a decline in throughput primarily as a consequence of falling production from the Moray Firth fields. Peak throughput occurred in 1995 and has fallen since then, though oil from Foinaven has slowed down the rate of decline.

The north coast of Scotland is home to several ports (such as Scrabster) which have been used by seismic vessels, supply boats and other oil-related traffic in the past, although recent use has been sporadic. A number of fabrication yards which used to operate in the area have closed down, though a few remain: Nigg on the Cromarty Firth (platform fabrication), Wester in Caithness (pipeline fabrication) and Evanton on the Cromarty Firth (platform fabrication). Also, the main centre in the UK for the inspection, repair and maintenance (IRM) of mobile drilling rigs is based at Invergordon on the Cromarty Firth.

Peterhead is an important oil supply base for UKCS oil and gas operations. Oil related cargo peaked in 1998-99 at 1,429,000 tonnes, this had fallen to 1,009,000 tonnes in 2002-03. Recently BP has transferred the majority of their supply boat traffic from Peterhead to Aberdeen which has reduced traffic substantially. Cargo for 2003-04 has been estimated by the Peterhead Bay Authority to be in the region of 700,000 tonnes. Current spare capacity in the port has been estimated at approximately 60%.

Aberdeen is now firmly established as the main centre of the oil and gas industry in the UK, as such there are many oil-related businesses located in the city and the surrounding area providing employment for approximately 40,000 people. Industry in the area is comprised of the operating companies, contractors and a large number of service companies. Recently many of the multinational North Sea operators have reduced employment in the area, preferring to concentrate their efforts on more prospective areas such as West Africa and the Russian Federation. Additionally, many of the Aberdeen-based contractors and service companies have compensated for the downturn in business by building up overseas business. Aberdeen harbour has also seen a decline in oil-related traffic from 4,910 vessels in 2001 to 4,343 in 2003 and, therefore, also has spare capacity to handle any SEA 5 related activity.

The area south of Aberdeen supports a few oil-related businesses including a small oil supply base at Montrose utilised by only one vessel and Dundee harbour which is used by a few oil supply boats and for some rig IRM operations. The large fabrication yard in Methil, Fife which was used to build many of the steel platforms in the UKCS has had little recent work although the Burntisland yard has been more successful. Additional facilities include Braefoot terminal and Hound Point terminal. The Braefoot terminal is a marine export facility for a large petrochemicals complex in Fife. The complex receives wet gas from the St. Fergus pipeline and separates the liquid petroleum gases (LPG). Current throughput at the terminal is approximately 2 million tonnes per year. Hound Point terminal is discussed in further detail later in this assessment.

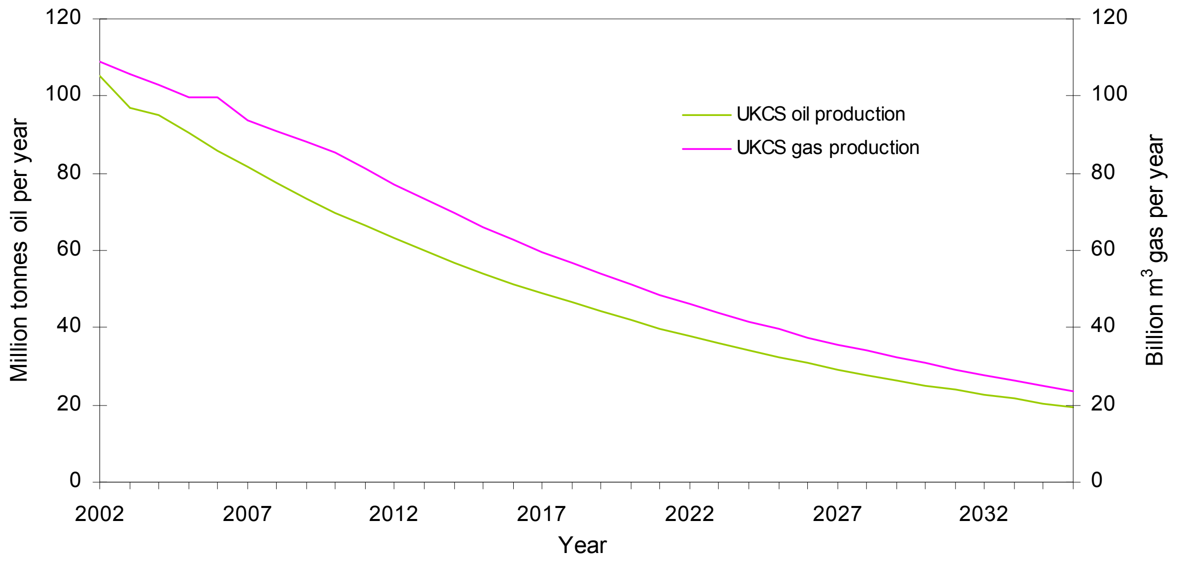
Onshore facilities in SEA 5 are under-utilised. Indeed, the decline in oil production has made a number of facilities obsolete and closures have resulted. It is estimated that licensing of SEA 5 and any associated increase in oil production could be accommodated by existing infrastructure and would be extremely beneficial to the area.

10.6.2.4 Implications for oil and gas production and reserves

Scenarios for possible future SEA 5 development have been outlined in section 10.1.1. New developments anticipated, depending on the success of exploration and appraisal drilling, include three new stand alone developments with the possibility of one new pipeline to shore. These scenarios have been converted into pessimistic and optimistic scenarios.

UKCS oil production peaked at 124.9 million tonnes in 1999 and has gradually fallen to 96.8 million tonnes in 2003. There is general agreement that future production figures will show a slow decline. Although the rate of decline is difficult to forecast, a reasonable forecast of an annual average decline of -5.0% can been estimated. Similarly, UKCS gas production peaked in 2000 and is now in a decline which is expected to continue at a slow and steady rate (see Figure 10.7).

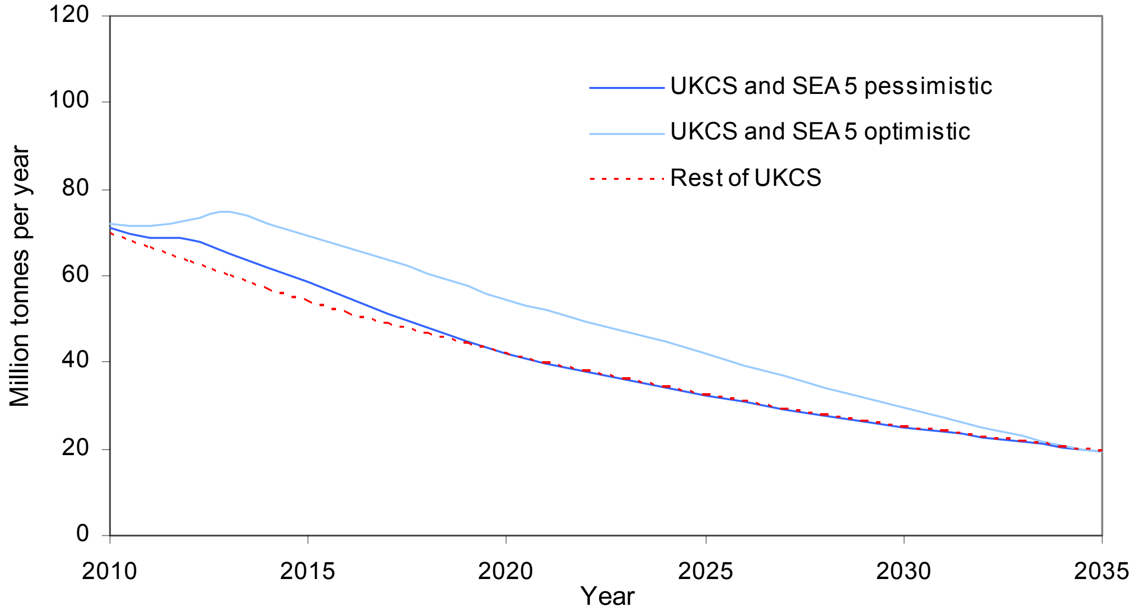
Figure 10.7 – Oil and gas production: UKCS forecast



SEA 5 oil production

Predictions of future SEA 5 oil production under the optimistic scenario shows production continuing for 25 years, reaching a peak of 15 million tonnes between 2013 and 1017. Total oil production under this scenario is estimated at 218.75 million tonnes, seven times more than that produced under the pessimistic scenario. When these projections are combined with the rest of the UKCS, the following patterns emerge (see Figure 10.8).

Figure 10.8 – Oil production: UKCS and SEA 5 combined forecasts

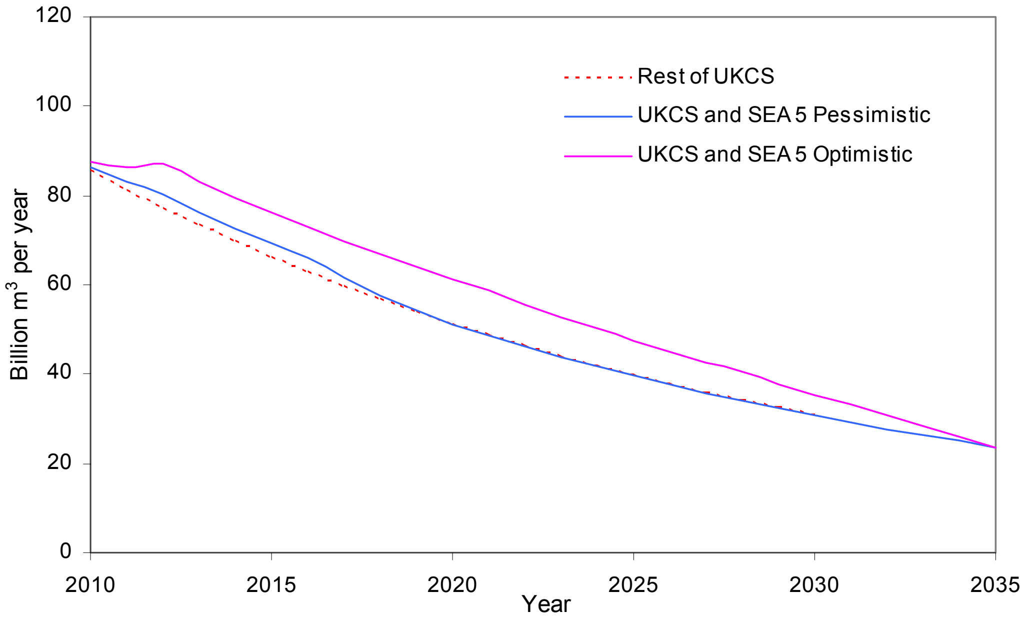


The pessimistic forecast shows that SEA 5 production from 2010 will slow down the total UKCS decline. Conversely the optimistic forecast shows that SEA 5 activity could actually 'increase' total UKCS oil production in 2012 and 2013 before the decline resumes. As a consequence, UKCS production would be relatively stable between 2010 and 2015 at approximately 70 million tonnes per year.

SEA 5 gas production

In general, the SEA 5 area is more prone to oil than gas, therefore it is more difficult to predict and analyse gas production than oil. Gas production from the SEA 5 area can be assumed to begin in 2010 and last for 25 years under both the optimistic and pessimistic scenarios. Addition of SEA 5 gas to the rest of the UKCS could be expected to result in an increase of 3.9% in 2012 and 5.9% in 2021, under the pessimistic scenario (see Figure 10.9). As with oil production, gas production under the optimistic scenario would be expected to 'increase' total UKCS production in 2012 before the decline resumes again. Although SEA 5 developments cannot compensate for the fall in UKCS gas production, under both scenarios the overriding impact would be a slowing down of the actual rate of decline.

Figure 10.9 – Gas production: UKCS and SEA 5 combined forecast



Oil and gas reserves

It is estimated that the majority of oil in the UKCS has already been developed. It has been assumed that the SEA 5 area contains 22.3% of the remaining UKCS reserves to be discovered (or alternatively, under the pessimistic scenario, 3%). The SEA 5 area is also assumed to contain a similar percentage of undiscovered UKCS gas reserves (between 2.6% and 22.5%).

10.6.2.5 Exploration, capital, operating and decommissioning expenditure

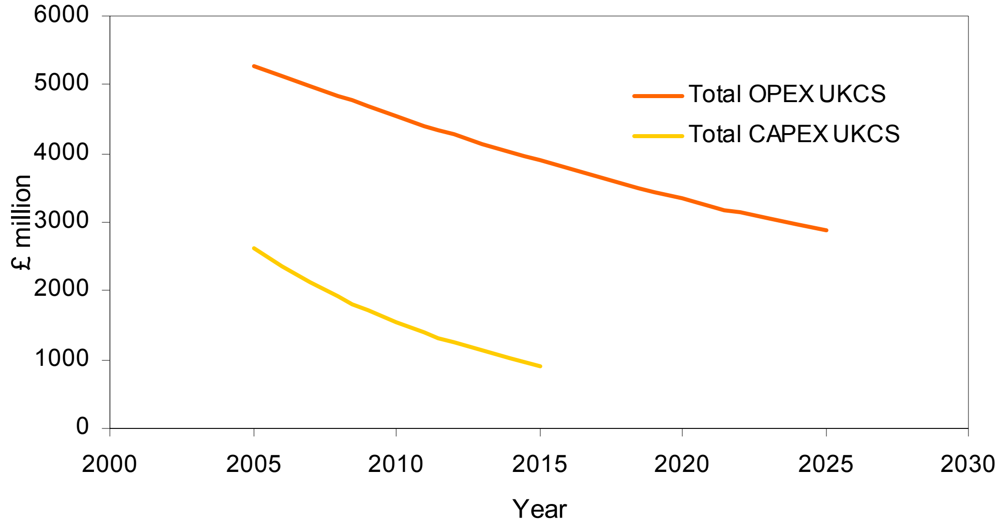
Exploration expenditure

The cost of initial exploration expenditure is relatively high in comparison to capital and operating expenditures. The DTI scenarios estimated a possible 20 exploration and appraisal wells which could amount to an expenditure of £200 million, assuming a cost of £10 million per well.

Capital and operating expenditure

Capital expenditure is particularly important for the business operations of UK oil and gas industry suppliers. However (partly due to falling development activity), the total capital expenditure of the UKCS is in decline (estimated at -10.0% per year in the future) (see Figure 10.10). It is expected that the rate of this decline will gradually slow down. UKCS operating expenditure peaked most recently in 2002 (at around £4,595 million). Currently more fields are being brought onstream than are being decommissioned and many are relatively small with above average operating costs. In spite of this, it is predicted that operating costs will decline over time and an annual decrease of -3% has been assumed for the UKCS for 2005 onwards (see Figure 10.10).

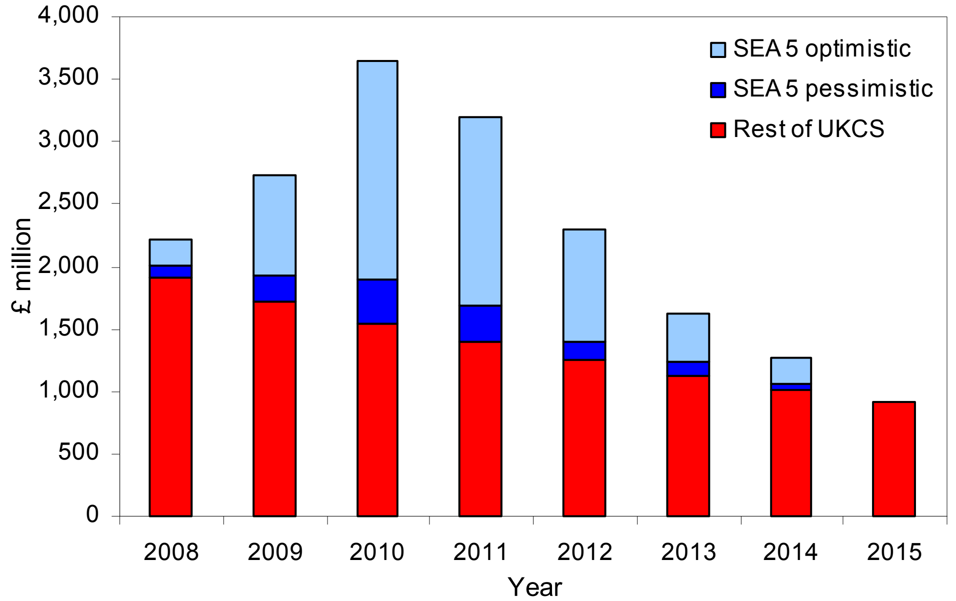
Figure 10.10 – Capital and operating expenditure: UKCS forecast



SEA 5 Capital expenditure

Under the pessimistic scenario, SEA 5 capital expenditure would account for a sizeable proportion of UKCS total expenditure during 2010-11 (almost a quarter). This percentage rises significantly under the optimistic scenario (see Figure 10.11) which could see SEA 5 account for over half of overall UKCS expenditure, exceeding the rest of the UKCS expenditure by 35% in 2010 alone.

Figure 10.11 – Capital expenditure: UKCS, SEA 5 optimistic and SEA 5 pessimistic forecasts

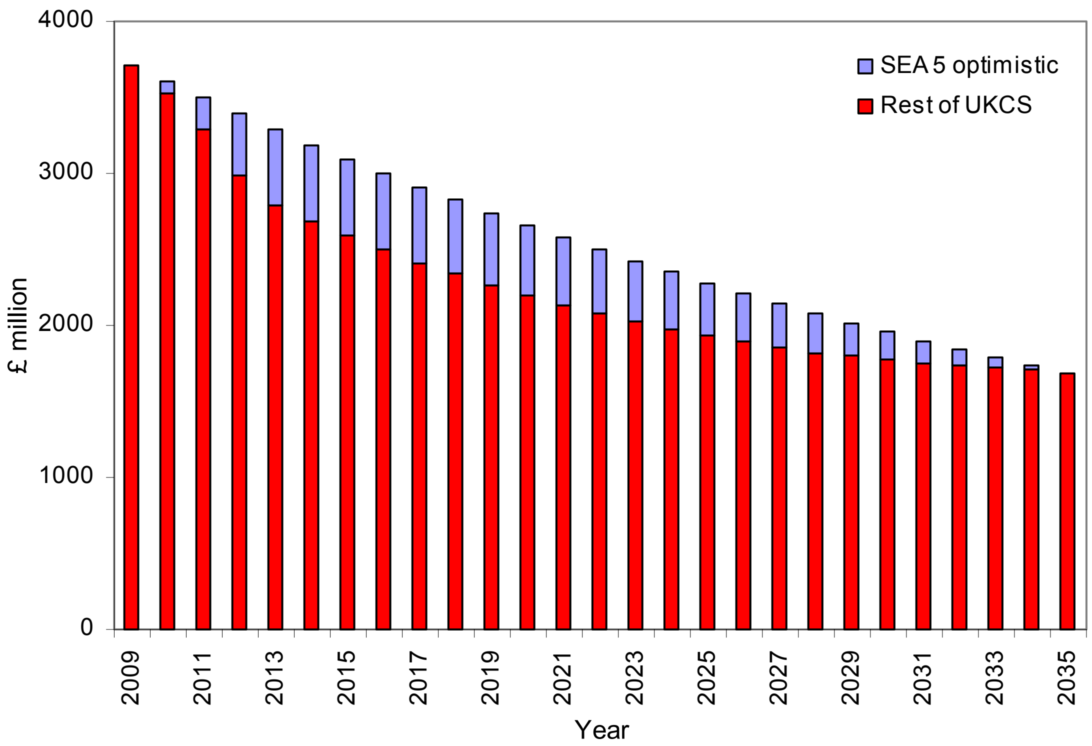


SEA 5 capital expenditure is predicted to be of great importance to UK business. This is especially true as the rest of the UKCS is in decline. Many UK based businesses (e.g. FPSO, subsea equipment, installation contractors and supply boat and helicopter operators) would be keen to win work for SEA 5 fields and would therefore benefit from SEA 5 licensing.

SEA 5 Operating expenditure

Optimistic and pessimistic operating expenditure for the SEA 5 area has been calculated assuming an average cost of £20 per tonne of oil or bm^3 of gas, and £25 per tonne of oil or bm^3 of gas respectively. Under the optimistic scenario, expenditure would be relatively stable at over 15% between 2013 and 2025, peaking at 17.3% in 2021. Expenditure would then reduce in line with the forecast decline in SEA 5 production. Operating expenditure under the pessimistic scenario is forecast to last for 10 years between 2010 and 2019, and will peak at only 6.3% in 2014. With an annual average of £328.2 million, SEA 5 could be a significant part of UKCS spending for in excess of 20 years (see Figure 10.12).

Figure 10.12 – Operating expenditure: UKCS and SEA 5 optimistic forecast.



In a similar way to the predicted capital expenditures of SEA 5, operating expenditures from the region will significantly contribute to the UKCS, particularly as the rest of UKCS is in decline.

Decommissioning expenditure

Decommissioning facilities generally costs 10% of the original capital costs. Should the stand-alone developments envisaged in the DTI scenarios use FPSOs the figure of 10% can be lowered as these structures are easier to remove and/or re-use than fixed production platforms.

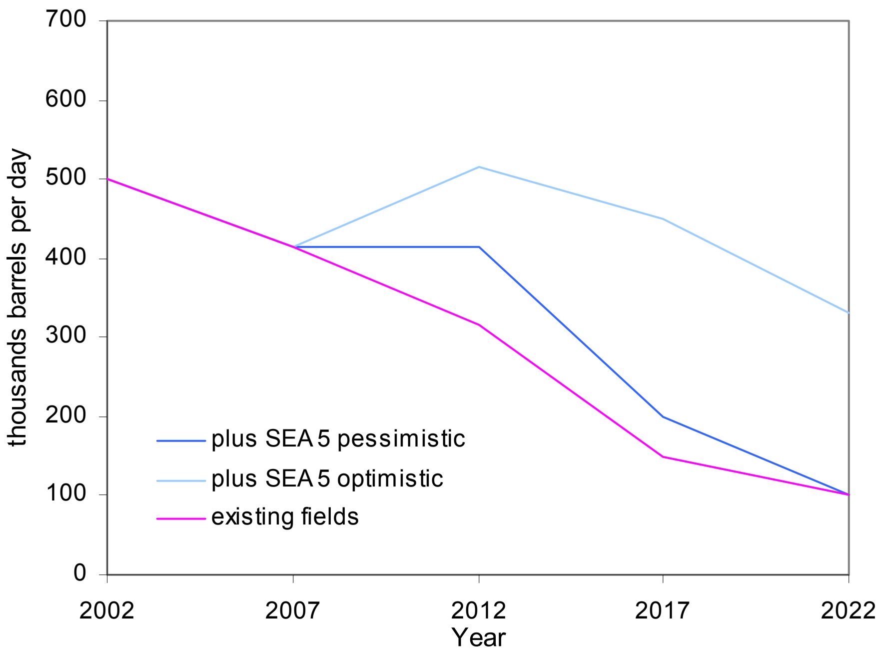
10.6.2.6 Implications for existing facilities

The primary impacts of SEA 5 licensing would come from the development and operation of any new fields in the area. Development and construction activities would last for only a short period of time, however, the resulting operational activities would be likely to last for numerous years. The impact on existing facilities in the SEA 5 area will depend on the location of the new field. The SEA 5 area contains five onshore terminals, Sullom Voe, Flotta, Nigg, St. Fergus and Cruden Bay/Hound Point, all of which would welcome new business. Socio-economic impacts in this area would be incremental or marginal as new developments would be absorbed by the existing well established infrastructure of the SEA 5 area.

Sullom Voe oil terminal

If a new field was discovered in the northern part of the SEA 5 area the oil would most likely be landed at the Sullom Voe terminal via tankers. Sullom Voe oil terminal has a throughput design capacity of 1.2 million bpd and an actual current throughput of 500,000bpd, implying a utilisation rate of 42%. Current output/throughput from the East Shetland Basin fields are declining at approximately -10% per year and could stop altogether by 2017. Output from fields to the West of Shetland is also predicted to decline from 500,000bpd in 2002 to 315,000bpd in 2012 and 100,000bpd in 2022. In the event that no SEA 5 discoveries are made, then Sullom Voe output/throughput will decline to the point that at some time in the future, likely to be before 2022, the operating costs for the terminal will become unviable and lead to its closure. Under optimistic conditions there will be a greater throughput in the period between 2007 and 2012, remaining relatively high until 2017. The pessimistic scenario will maintain throughput at approximately 415,000bpd until 2012 however the impact of this increased throughput will cease in 2019.

Figure 10.13 – Forecasts of Sullom Voe oil throughput



Flotta oil terminal

If a new field were discovered further south in the SEA 5 area the preferred location would most likely be the Flotta terminal in Orkney. Oil from sixteen North Sea fields is piped to the

Flotta Terminal and BP also transports oil from the Fionaven field using shuttle tankers to Flotta. The terminal's capacity is about 400,000bpd and current throughput is in the region of 250,000bpd. As is the case with Sullom Voe, throughput at Flotta is also declining primarily as a consequence of falling production from the Moray Firth fields. Foinaven field production (the main contributor to Flotta oil throughput) could be maintained until 2007, but after this will decline at -10% each subsequent year. It is expected that production from Outer Moray Firth fields will cease soon after (between 2012 and 2017). In the event of new SEA 5 developments, the terminal would welcome new business which ideally would contribute to a slowing down in the rate of the terminal's declining activity and act to extend the life of the terminal by a few years.

Other facilities

Nigg terminal in the Moray Firth has two storage tanks, one of which is currently being used to store fluids form the Beatrice field. The second tank has a capacity of 700,000 barrels. Four other fields have used the Nigg terminal: Blake, Captain, Gryphon and Ross. These fields are all developed using FPSOs (floating, production, storage and offloading vessels) and shuttle tankers to transport produced fluids to shore. However, none of these developments have utilised Nigg facilities recently, preferring to use ship-to-ship transfers instead. Nigg currently has an excess of available storage facilities and would welcome any business generated by new SEA 5 developments.

The St. Fergus gas terminal is the largest in the UK and handles gas from most of the fields in the UK sector of the Northern North Sea via six separate pipelines. In 2002 the terminal handled 35.6% of the total handled by all gas terminals in the UK – throughput at this terminal has increased in three of the last four years shown (see Table 10.4). Currently five of the six pipelines to St. Fergus are operating at peak capacity, however, there is a little spare capacity in the Britannia line. Although the gas infrastructure in the area is well developed, new pipelines would have to be constructed to allow new SEA 5 discoveries to export gas to shore.

Table 10.4 – St. Fergus Terminal gas throughput

	BCM (billion cubic metres)	%age Change
1998	29.5	-
1999	35.1	+19.0
2000	37.4	+6.6
2001	36.7	-1.9
2002	37.3	+1.6

The Cruden Bay oil terminal south of Peterhead handles oil from a large number of North Sea fields. Oil is then piped from Cruden Bay to the Hound Point terminal in the Firth of Forth via an underground pipeline. In 2002, the Cruden Bay and Hound Point terminals handled 34.1 million tonnes of oil which equates to 45.5% of the total of all UK terminals. Throughput figures for these terminals indicate that there is spare capacity available for any new SEA 5 developments to utilise.

Other industries

An increase in SEA 5 production would undoubtedly impact other industries in the area. A rise or fall in production would be felt most strongly by households (i.e. through the payment of oil terminal employees), distribution industries, ports and harbours and business services.

Fishing is one of the most important industries in the SEA 5 area and some of the UK's largest fishing ports lie within the boundaries of the SEA 5 area, Peterhead is in fact the largest fishing port in the UK. This area supports a wide variety of commercial fishing activity. Demersal fishing has recently been badly affected by declining stocks and consequent reductions in fishing quotas. Pelagic fisheries, particularly in Shetland, are becoming more important in an attempt to compensate for declining demersal activity. Shellfish and caged fish farming are also of prime importance to the economies of the SEA 5 area. A large percentage of the salmon sites in Shetland are in St. Magnus Bay to the west of Sullom Voe and there is also some concern by the Shetland Salmon Farmers Association that the future potential for fish farming using offshore and submersible cage technology may be restricted.

The primary concern of local fishermen and fish farmers is the threat of possible damage to stocks by oil spills from the platforms, oil terminals or from damage to existing pipelines. Other possible negative impacts from oil and gas development in the area could include the loss of access to fishing areas during seismic surveys, exploration drilling and production, although given the level of forecast activity, these impacts would be minimal.

Tourism is also an important industry in some regions of the SEA 5 area, particularly the Highlands, Orkney and Shetland. It is estimated that a high percentage is business (oil-related) tourism whilst a large part of the market is environmental tourism and, as such, the threat of pollution (especially by oil spills) is potentially damaging. However, Sullom Voe and Flotta oil terminals (and their associated pipelines and tankers) have excellent records in relation to oil spills and pollution.

10.6.2.7 Social impacts

As with economic impacts, the social impacts of licensing the SEA 5 area are expected to be incremental or marginal rather than absolute. Any impacts upon population will most likely result from changes in employment levels. The preservation of existing jobs and creation of new jobs would help to retain people in Shetland and Orkney which could slow down the ongoing population decline in these areas. Declining populations in these small settlement areas could result in closure of schools, medical facilities and other services, therefore licensing of the SEA 5 area may help prevent or delay such impacts. More densely populated areas, e.g. Aberdeen, would not follow the same trend. Licensing of the SEA 5 area would undoubtedly impact on the local community, however, the magnitude of this change would be on a much smaller scale than that generated by North Sea oil and gas developments in the 1970s and early 1980s.

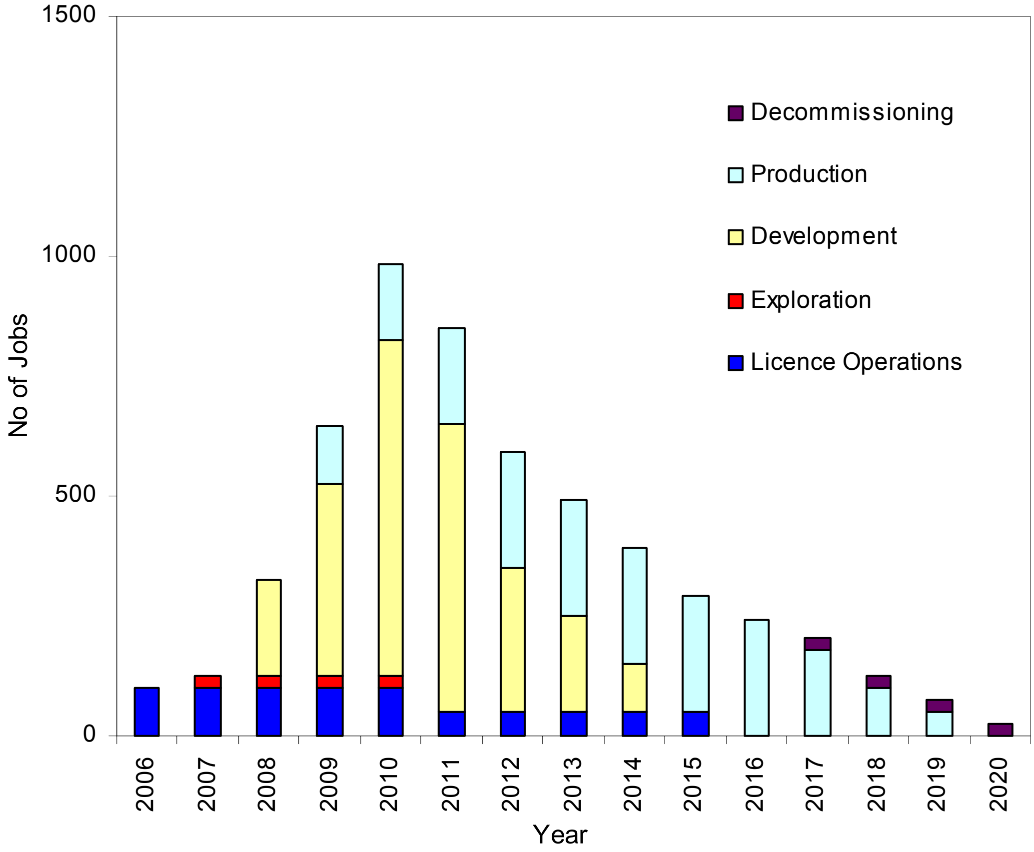
Implications for employment

The licensing of the SEA 5 area will generate employment during the following stages of activity:

- Exploration
- Development
- Operational/production
- Decommissioning

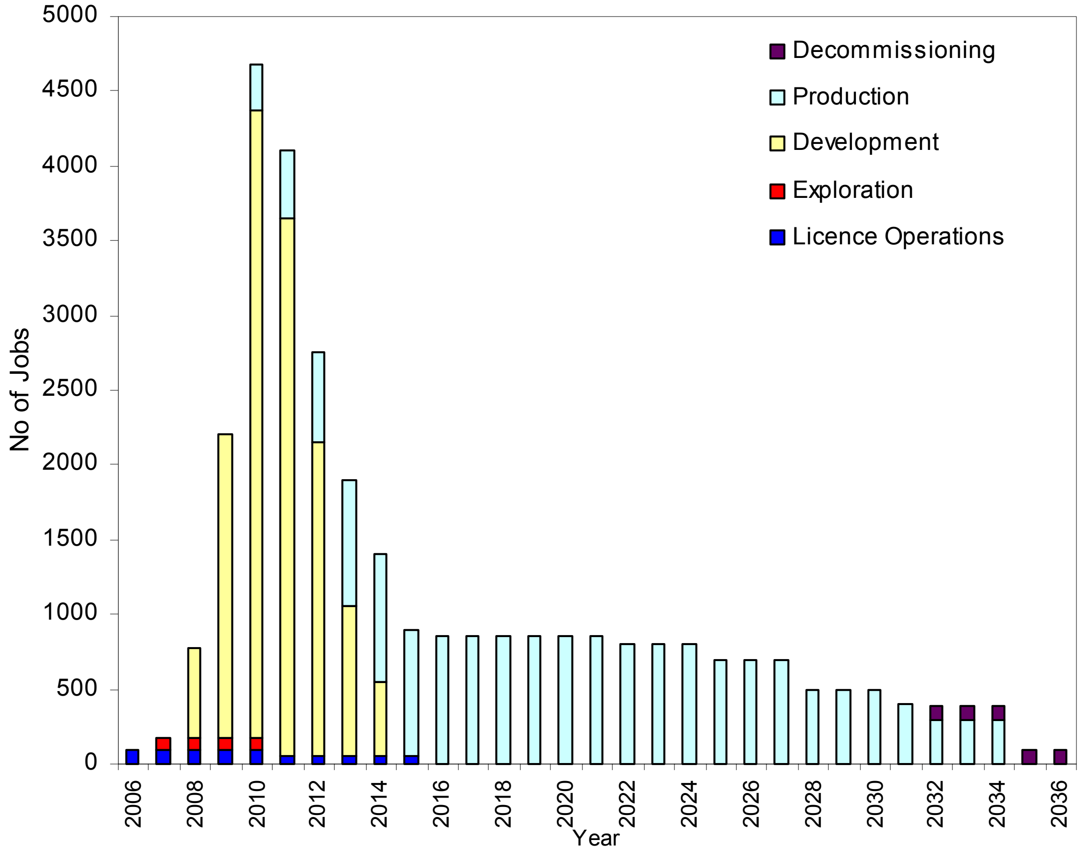
Optimistic and pessimistic employment scenarios have been calculated for SEA 5 according to each of the four phases and are illustrated in the following graphs. The pessimistic scenario (see Figure 10.14) shows a peak in 2010 (985 jobs), produced mainly by development activities (e.g. the construction of FPSOs, subsea systems and other equipment).

Figure 10.14 – SEA 5 pessimistic employment scenarios



The peak (2010), under the optimistic scenario (see Figure 10.15), is significantly higher at 4,675 jobs. Again, the majority of these jobs will be created due to development activities. Employment generated by production activities is also markedly higher. SEA 5 is home to a workforce skilled in the oil and gas industry and, as such, the creation of more jobs would help sustain this important resource.

Figure 10.15 – SEA 5 optimistic employment scenarios



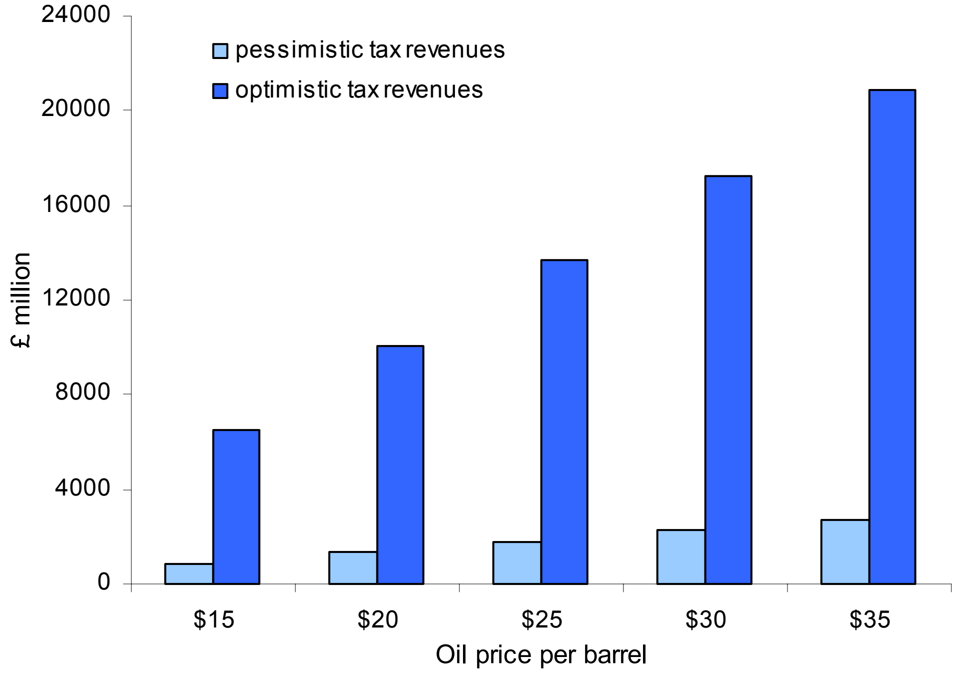
10.6.2.8 Implications for tax revenues

Implications of future tax revenues are difficult to calculate (primarily due to the high variance of oil prices). However, for the purposes of the report, a simple assessment has been made. A barrel of oil can be broken down into its four key components:

- Capital expenditure
- Operating expenditure/costs
- Tax payments
- Profits

Calculations have assumed that capital and operating costs are constant and do not vary with the price of oil. Thus, the following graph (see Figure 10.16) has been constructed to show the estimated SEA 5 tax revenue according to changes in oil prices.

Figure 10.16 – Tax revenues: SEA 5 pessimistic and optimistic forecasts



"These estimates are the undiscounted totals over the lifetimes of the SEA 5 fields. They demonstrate the importance of oil price. The key point to stress is that the tax revenue increases at a much higher rate than the rise in prices" (Mackay Consultants).

Oil prices over the lifetime of the SEA 5 fields are almost impossible to predict. In order to produce these estimates, various assumptions have been made about future oil prices. During the preceding six years oil prices have fluctuated between $9 and $36 a barrel. Over the last few years prices have been quite high and at the time the estimates were made (February 2004) Brent crude was valued at approximately $30 a barrel. Given the present volatility of oil prices a range of oil prices have been used to generate tax revenue estimates. At $15 a barrel SEA 5 fields could generate between £851 and £6,470 million (pessimistic and optimistic respectively) in tax revenues and between £2,741 and £20,848 million at $35 a barrel (pessimistic and optimistic respectively). It is worth noting that the current oil price (August 2004) is approximately $39 a barrel; this price would further increase tax revenues should it remain at this level. Tax revenue would however, be expected to decline in future years as a consequence of falling oil and gas production although the £:$ exchange rate and oil price will play an important role in the extent of this decline. If UKCS tax revenues averaged £1,000 million per year, then producing SEA 5 fields could account for between 9.5% and 18% of that total.