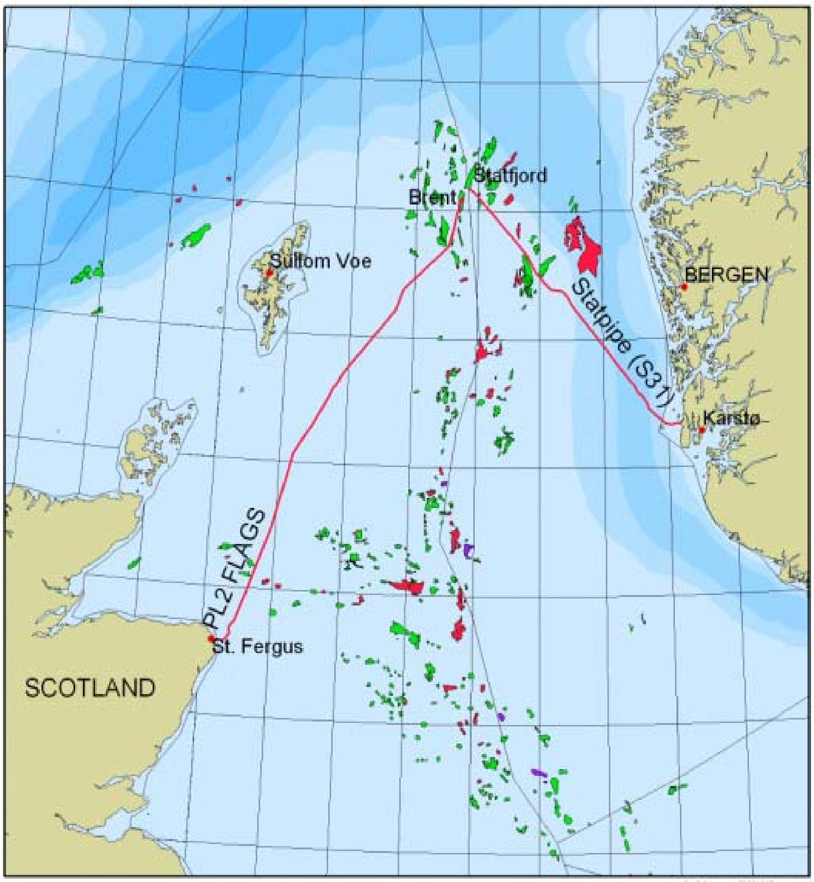
STATOIL



Environmental Statement for the Statfjord Late Life

December 2004

ExxonMobil Shell ConocoPhillips bp centrica

Standard Information Sheet

Project name:	Statfjord Late Life (SFLL) project
DTI Project reference:	D/2429/2004
Type of project:	Field Development
Undertaker Name:	Statoil ASA
Address:	Statoil ASA 4035 Stavanger Norway
Licensees/Owners:	Statoil ASA (operator) 44.34% Exxon Mobil Norge AS 21.37% Norske ConocoPhillips AS 10.33% AS Norske Shell 8.55% Enterprise Oil Norge AS (Shell) 0.89% ConocoPhillips (U.K.) Limited 4.84% Britoil 4.84% Centrica 4.84%
Short description:	Statoil is proposing to modify existing Stafjord A, B and C platforms as part of the SFLL project in order to increase the recovery factor at the field By changing from pressure maintenance (current strategy) to pressure relief (late life) the reservoir pressure will gradually be reduced and gas can be produced. The production can be prolonged by 9 years, compared to the current plans for cessasation of production. Statfjord A, B and C will be modified to handle the changed operational conditions following the implementation of late life production, and to ensure compliance with all regulatory requirements relating to the field's prolonged life, including those regarding health, safety and the environment .
Dates	
Anticipated commencement of works:	April 2005
Date and reference number of any earlier Statement related to this project:	Not applicable
Significant environmental impacts identified:	Disharges to sea Emissions to air Accidental oil spills
Statement Prepared By:	Statoil ASA

Abbreviations

APES	Area of Particular Environmental sensitivity
BA	Brent A
BAT	Best Available Techniques
BB	Brent B
BC	Brent
BD	Brent D
BoG	Project Sanction (Statoil internal project milestone)
BoV	Provisional project sanction (Statoil-internal project milestone)
BREF	Best Reference
BTEX	Benzene Toulene Ethylene Xylene
CAPEX	Capital expenditure
CEFAS	Centre for Environment, Fisheries and Aquaculture Sicence
CH_4	Methane
CO_2	Carbon dioxide
CPR	Continuous Plankton Recorder
cSAC	(candidate) Special Areas of Conservation
DEFRA	Department of Enviroment Food and Rual Affairs
DETR	Department of Enviornment Transport and the Regions
E&P	Energy and Petroleum
EWD	European Wildlife Division
DF	Directorate of Fisheries (Norwegian FID)
DLE turbine	Dry low emission turbine
DN	Direktoratet for Naturforvalting (Directorate for Nature management)
DNM	Directorate for Nature Management
DREAM	Dose-related Risk and Effects Assessment Model
DSHA	Defined Situation for Hazard and Accident
DTI	Department of Trade and Industry
EC	European Commission
EIA	Environmental Impact Assessment
EIF	Environmental Impact Factor
ES	Environmental Statement
ESAS	Seabird and Cetacean Distribution Atlas
ESP	Electrical submerged pump
EU	European Union
FDP	Field Development Plan (Norwegian PAD)
FLAGS	Far northern liquids and associated gas system
FRS	Fisheries Research Services
GSm^3	Giga (10 E 09) standard cubic meter
H_2S	Hydrogen sulphide
HAB	Harmful Algal Blooms
HI	Havforskningsinstituttet (Institute of Marine Research)
HMS	Helse, miljø- og sikkerhet (HSE)
Hot-Tap	Hole drilled through pressure-barrier with welded connection, ensuring access without loss of fluid or pressure.
HSE	Health, safety and the environment
ICES	International Council for the Exploration of the Seas
IMR	Institute of Marine Research
IPPC	Integrated Pollution Prevention Control

JNCC	Joint Nature conservation Committee
KU	Konsekvensutredning (Norwegian EIA)
LSC	Level of Significant Contamination
MCA	Maritime Coastgurad Agency
ME	Ministry of the Environment
MF	Ministry of Finance
MFi	Ministry of Fisheries
MLA	Ministry of Labour and Administration
MOB	Modell for miljøprioriteringer i oljevernberedskapen (Model for prioritising oil spill contingency effort)
MOD	Ministry of Defence
MPE	Ministry of Petroleum and Energy
MRDB	Marin Resource Data Base
MSFR	Minimul Sand Free Rate
MillionSm³/cd	Million standard cubic meters per calendar day
NCD	Norwegian Coast Directorate
NFFO	National Federation of Fishermen's Organisations
NFL	The Norwegian Fishermen’s Association
NGL	Natural gas liquid
NGO	Non-governmental organisation
NLGP	Northern Leg Gas Pipeline
nmVOC	Volatile organic compounds
NOFO	Norsk Oljevernforening For Operatørselskap **(**Norwegian Clean Seas Association for Operating Companies)
NOK	Norwegian kroner
NOX	Nitrogen oxides
NPCA	Norwegian Pollution Control Authority
NPD	Norwegian Petroleum Directorate
o.e.	Oil equivalents
OLF	Oljeindustriens landsforening (The Norwegian Oil Industry Association)
OPEX	Operating expenditure
OSPAR	Convention for the Protection of the Marine Environment of the North-East Atlantic
PAH	Polycyclic aromatic hydrocarbons
PDO	Plan for Development and Operation (Norwegian PUD)
PEC	Predicted Environmental Concentration
PIO	Plan for Installation and Operation
PLONOR	Pose little or no risk to the environment
PNEC	Predicted no-effect concentration
PON	Petroleum Operations Notice
PROOF	Research Program for long-term impacts of discharges to sea from petroleum activities
PSAN	Petroleum Safety Authority Norway
PWA	Pipeline Work Authorisation,
PWRI	Produced Water Re-Injection
RF	Rogaland Research
RFO	Ready for operation
RIA	Regional Impact Assessment (Norwegian RKU)
RNB	Revised National Budget
RSPB	Royal Society of the Protection of Birds
SAC	Special Areas of Conservation
SF	Statfjord
SFA	Statfjord A
SFB	Statfjord B
SFC	Statfjord C

SFD	Statfjord D (New platform)
SFLL	Statfjord Late Life
SFT	Statens forurensningstilsyn (NPCA)
SMO	Environmentally sensitive area
SNH	Scottish Natural Heritage
SoS	Secretary of State
SPA	Special Protection Areas
SSB	Statistisk Sentral Byrå (Central Bureau of Statistics)
STIG turbin	Steam-injected gas turbine
St.prp	Proposition to the Storting (Parliament)
THC	Total Hydrocarbon Consentration
UK	United Kingdom
ULCS	United Kingdom Continental Shelf
UKDMAP	United Kingdom Digital Marine Atlas
UN	United Nations
VEC	Valued Ecosystem Component
WAF	Water Accomomodated Fraction
WHRU	Waste heat recovery unit
WSF	Water Soluble Fraction
1000Sm^3/cd	Thousand standard cubic meter pr calender day

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1 Non-Technical Summary

1.1 Description of the Project and the EIA Process

The Statfjord field is an existing oil field consisting of three platforms: Statfjord A, B and C. Statfjord Late Life (SFLL) is a project that entails shifting from oil production to gas production by relieving the pressure in the reservoir. SFLL makes it possible to prolong the production at Statfjord in relation to the current drainage strategy (the Statfjord reference alternative), thereby exploiting a larger share of the total gas and oil resources at the Statfjord field. The recovery factor will now be 68 and 74 per cent for oil and gas, respectively; high figures in both a national and international context.

The realisation of Statfjord Late Life will provide significant value creation for society. However, the project is only marginally profitable to the owners, and is critical in time due to the extensive modification of the platforms.

Since 2001, the Statfjord Late Life project has identified and assessed various development alternatives in order to increase exploitation of the Statfjord field. Over 50 alternatives were originally considered. A study to select the three most promising development alternatives was concluded in June 2003. These alternatives were compared with each other and with the current drainage strategy. The project recommended re-construction and modifications to existing platforms (removal of bottlenecks) for development of the Statfjord field for late life production. This recommendation was made on the basis of an overall assessment of technical, financial, operational, environmental and resource-related factors.

SFLL is based on a change of drainage strategy in order to increase the recovery factor at the field. By changing from pressure maintenance (current strategy) to pressure relief (late life), the reservoir pressure will gradually be reduced. Gas will be released from the remaining oil and collect in the gas layer of the reservoir for production. Gas will no longer be reinjected into the reservoir, but exported via the new gas export pipeline, the Tampen Link, which links Statfjord to the existing infrastructure on the UK side of the North Sea (FLAGS). Statfjord A, B and C will be modified to handle the changed operational conditions following the implementation of late life production, and to ensure compliance with all regulatory requirements relating to the field’s prolonged life, including those on health, safety and the environment

The Statfjord Treaty of 1979 regulates the exploitation of petroleum from the Statfjord field, the requirements for documentation, and the approval of plans and agreements for the field by the public authorities. According to the “*Agreement between the Government of the Kingdom of Norway and the Government of the United Kingdom of Great Britain and Northern Ireland on the Exploitation of the Statfjord Reservoirs and the Transport of Petroleum from these Reservoirs*” (the “Statfjord Treaty”), cf. Proposition to the Storting (the Norwegian Parliament) no. 15, 1980-81, a field development plan will have to be prepared with subsequent approval by the public authorities of both countries.

In consultation with the public authorities of both countries, a decision was made to prepare a joint plan for the planned alterations and modifications at the Statfjord field, which would meet both countries’ guidelines for approval documents: the, Plan for Development and Operation (PDO) in Norway and the Field Development Plan in the UK.

In connection with Statfjord Late Life, a new gas export pipeline, the Tampen Link, is planned for the transport of gas from the Statfjord field. The installation of a new gas export pipeline from Statfjord to FLAGS is regulated by the framework agreement of 1998 between Norway and the United Kingdom (the “1998 Agreement”). This framework agreement also requires processing and approval by the public authorities of both countries. In consultation with the public authorities of both countries, a decision was made to prepare a joint plan for the Tampen Link, which would meet both countries’ guidelines of for approval documents: the Plan for Installation and Operation (PIO) in Norway and the Pipeline Work Authorisation (PWA) in the UK.

The EIA/ES documentation for Statfjord Late Life and the Tampen Link will also be prepared jointly and will meet both the UK and Norwegian assessment requirements and guidelines. This EIA will deal with the field modifications in Statfjord Late Life. The EIA/ES for the Tampen Link is available as a separate document /86/. A summary of this EIA/ES is included in appendix D.

1.2 Natural Resources and Environmental Conditions in the Area of Influence

The North Sea is one of the world's most biologically productive ocean areas, and it is of great commercial importance. High production of plankton results in rich marine life. The North Sea in general is an important area for many species, including species that are vulnerable to acute oil pollution. Commercially important species of fish are present in the North Sea.

No stable productive eddies or frontal systems which would cause organisms to accumulate in specific areas, form in the North Sea. Fish eggs and larvae are therefore relatively homogenously distributed over a large area. The transportation of fish eggs and larvae is dependent on the predominant current directions, which are largely influenced by water from the Atlantic entering the North Sea from the west and north, and the Norwegian Coastal Current flowing northward.

Due to the lack of distinct eddies/fronts large aggregations of seabirds at specific fronts will not normally occur in the North Sea, as they do, for example, in the Norwegian and Barents Seas. However, seabird aggregation can be observed in the North Sea as well.

The analysis area also covers the southern parts of the Norwegian Sea. Here, Atlantic water and the Norwegian Coastal Current both flow northward. The Norwegian Coastal Current forms eddies in the shallower waters along the Norwegian coast, and plays an important role in the transportation of eggs and larvae in this area.

The Norwegian Coastal Current with its low salinity forms more or less clearly demarcated fronts against the water from the Atlantic Ocean in the west, which has a higher salinity and nutrient content. This means that the biological production is particularly high in these frontal areas.

As the number of daylight hours increases in April and May, primary production increases, providing the basis for the growth of fish fry and seabirds. The most intense frontal processes occur where several currents converge, i.e. around the Frøya Bank, Halten Bank and Sklinna Bank. In addition, nutrient-rich Atlantic water from greater depths will rise and mix with the surface water in these areas (up-welling). These areas in the Norwegian Sea are located on the margins of the area of influence of the Statfjord Late Life project.

The following biological resources in the influence area are deemed to be the most sensitive:

- Seabirds in the open sea, particularly the pelagic divers such as common guillemot, puffin, razorbill and little auk
- Sensitive life stages of fish, i.e. the egg and larval stages
- Sensitive coastal habitats.

As regards discharges of produced water, the most sensitive life stages of fish, i.e. the egg and larvae stages, are the most important.

1.3 Planned Emissions to Air

1.3.1 Planned Mitigating Measures

A number of emission-reducing measures have been assessed during several phases of the planning of the SFLL project, on the basis of the potential for emission reduction, environmental cost efficiency and the framework conditions of the environmental authorities with respect to international agreements and the EU's IPPC directive (Integrated Pollution Prevention Control).

Statfjord will implement flare gas recovery at SFB before SFLL.

The Statfjord Late Life project is marginal in financial terms, and has a tight implementation plan. Over and above the CO_2 and NO_x reductions that will result directly from late-life production as compared with current production, the project has not recommended further measures for reducing emissions to air. An imposed requirement for low NO_x turbines would have very low environmental cost efficiency and, due to the increased costs, would make it impossible to realise Statfjord Late Life within a profitable framework.

1.3.2 Emission Reduction

Statfjord's emissions to air are considerable in a national context, and a number of emission-reducing measures have been implemented at Statfjord during the period 1999-2003. SFLL will lead to significant reductions in emissions to air, primarily due to the cessation of seawater and gas injection. The development of emissions during SLFF has been calculated based on already implemented measures and planned measures.

The emissions from drilling and well activities in connection with power generation are included in the emissions from production. Flaring will not take place in connection with drilling and well operations.

The average annual emissions of CO_2 and NO_x will be 49 and 42 per cent lower, respectively, than in 2001.

Table 1-1summarises some main figures pertaining to emissions to air during SFLL, and Table 1-2 shows emissions during SFLL compared with the emissions reported in 2001.

Table 1-1 Emissions to air during SFLL compared with emissions reported at the field in 2001

Parameter	**2001**	**SFLL**		
		Peak year	**Average per year**	**Accumulated 2008 - 2018**
CO_2 (million tonnes)	1.54	1.02	0.78	8.59
NO_X (1,000 tonnes)	6.2	4.7	3.6	39.6
CH_4 (1,000 tonnes)	1.2	0.8	0.5	5.1
Nm VOC (1,000 tonnes)	70.9	12.4	5.2	57.7
CO_2 per o.e. kg/Sm^3	41	160	99	
NO_X per o.e. kg/Sm^3	0.17	0.73	0.45	

Table 1-2 Reduction in annual emissions during SFLL compared with emissions at the field in 2001

Parameter	**Reduction (%) Peak year during SFLL compared with 2001**	**Reduction (%) Peak year during SFLL compared with 2001**
CO_2	32 %	49 %
NO_X	23 %	42 %
CH_4	34 %	60 %
Nm VOC	83 %	93 %

1.3.3 Environmental Impacts

The annual emissions from the Tampen area during 2008-2018, i.e. the production period for SFLL, will be lower than the emissions estimated for the peak year 2000, which was the basis for the impact assessments in the Regional Impact Assessment for the North Sea (RIA).

The Tampen area's environmental impacts in the form of acidification, eutrophication and the formation of tropospheric ozone will be considerably lower during 2008-2018 than that described in the North Sea RIA. The largest proportion of the emissions will be transported towards the Norwegian coast, and crossboundary impacts in the UK will be marginal.

1.4 Planned Discharges to Sea and to the Utsira Formation during Drilling and Well Operations

1.4.1 Discharges from Drilling

Drilling will chiefly consist of sidetrack drilling in existing wells, and top-hole drilling will not normally take place.Drilling in the deeper sections will be carried out will oil-based drilling fluid. Oily cuttings will be injected into the Utsira formation together with residues of completion, gravel packing and cementing chemicals. At present approx. 66 per cent of the oil-based mud is reused, and this will be continued in late life. A total of approx. 35,000 tonnes of cuttings and oil-based drilling fluids will be injected into the Utsira formation over a period of six years.

Drilling and drilling operations will gradually become more difficult after 2007, due to pressure relief in the reservoir. Pressure relief means that the density of the drilling fluid will have to be reduced. If the density becomes too low, the above-lying shale sections could collapse as a result of low hydrostatic pressure in the well. Chemicals can be added to the drilling fluid to compensate for this.

The consumption of chemicals used to compensate for the low hydrostatic pressure in the wells will therefore increase during SFLL, but this consumption has not been estimated.

1.4.2 Discharges from Well Operations

At present, cementing and completion chemicals are used in connection with well completion and cleaning. This will also be the case during SFLL. Like the drill cuttings, these chemicals are for the most part returned to collection tanks on the platform and injected into the Utsira formation, or sent ashore for recycling.

During well clean-ups, the platform’s test separator will be used, and residues from the cementing and completion chemicals together with oily water from the wells will be treated in the platform’s cleaning plant.

The annual discharges of cementing and completion chemicals during late life will correspond to that previously reported for Statfjord. These chemicals are classified as “green” and “yellow” and pose little risk to aquatic organisms.

During production, scale inhibitors and scale dissolvers will be used to handle scale problems in the wells. The chemicals are injected into the wells and, together with the scale, they follow the production flow back to the platforms. They are then discharged together with the produced water.

Discharges of scale dissolvers and scale inhibitors are expected to increase during late life due the potential for increased scale formation in the wells. These chemicals are classified as "yellow".

The drainage water from the platform’s drillfloor will be collected and injected into the Utsira formation.

1.4.3 Impacts of Discharges to Sea from Drilling and Well Operations

The chemicals used during drilling and well operations pose little risk to the environment, and the environmental impacts of discharges from today’s production are marginal. Impacts during late life are also expected to be small, even though the discharges will increase.

Statoil is actively seeking substitution with more environmentally friendly chemicals, and this work will also continue in late life. A more detailed overview of chemicals to be used during drilling and well operations in late life: consumption, discharges to sea, proportions designated for recovery and injection into the Utsira formation, including any mitigating measures, will be prepared as a basis for the application for a discharge permit. A more detailed overview of the scope of well cleaning, discharges and any mitigating measures, will also be provided

1.5 Planned Discharges to Sea of Produced Water

1.5.1 Planned Mitigating Measures

Several mitigating measures relating to discharges of produced water have been implemented at Statfjord. Further measures have been adopted for implementation, among other things to comply with the company's "zero mindset" and the environmental authorities' framework conditions for produced water, including the OSPAR regulations and the target of zero harmful discharges of produced water.

Mitigating measures for Statfjord operations and SFLL have been selected on the basis of available technology, the Statfjord field's limitations/ framework conditions, environmental impacts and assessment of environmental cost efficiency.

The zero discharges report for Statfjord (2003) was based on the following measures:

1) Substitution of red chemicals (corrosion inhibitors)
2) Reducing the consumption of chemicals through optimising dosing
3) Optimising existing hydrocyclones
4) Implementation of the new CTour cleaning technology
5) Reinjection of produced water at SFC for pressure support (PWRI).

Statoil has recommended that PWRI be stopped at Statfjord, primarily because continued operation will increase H_2S production and the consumption of H_2S scavenger.

The SFLL project will be based on the use CTour cleaning technology, which will be upgraded to:

- facilitate low-pressure production
- treat satellite water at SFC
- include cooling measures to increase the amounts of condensate at SFB and SFC.

In addition, SFLL will continue the efforts to optimise the CTour technology and work towards further substitution of corrosion inhibitors as part of the project's continuous improvement work.

The injection of H_2S scavenger in a separate well has been assessed. This solution has very low environmental cost-efficiency at SFA and relatively low cost efficiency at SFB and SFC. The project does not recommend that H_2S scavenger be injected at SFA or, for the time being, at SFB and SFC. The measure will be further assessed for SFB and SFC.

The injection of produced water into the Utsira formation is the only real alternative to CTour, technically speaking. The environmental cost-efficiency of the solution is very low compared with CTour, and it would also lead to an increase in emissions to air. An official order for the injection of produced water into the Utsira formation would make it financially unviable and would preclude the realisation of Statfjord Late Life.

<u>CTour cleaning technology</u>
The Statfjord licence has been the driving force behind the qualification of the CTour cleaning technology to reduce the environmental risk associated with produced water. Compared with other technology, it is particularly effective for the removal of dissolved natural components, and it is very efficient for the cleaning of those natural components in produced water to which the greatest environmental uncertainty attached (C4+ phenols and PAH compounds). CTour has also demonstrated that it is capable of handling peak loads and variations in oil concentration very effectively, and it is therefore expected that the discharge concentrations will be kept at an even and low level. CTour removes 30 per cent of the active components in the corrosion inhibitors used at Statfjord. The BTEX content (Benzene, Toulene, Ethylbenzene, Exylene) in the discharge water will increase as a result of CTour. The technology is efficient in relation to the composition of the water at Statfjord.

1.5.2 Reductions in Discharges

Based on the current drainage strategy and forecasts for produced water, water production at Statfjord will peak in 2006 at approx. 150,000 m^3/d. Statfjord C will account for half of this amount. The annual discharges of produced water in SFLL will not increase in relation to the Statfjord reference alternative, but the period of production will be prolonged.

Discharges of certain natural components in produced water have already been considerably reduced at Statfjord as a consequence of measures already implemented, and most of the natural components will be further reduced by the implementation of CTour. In Statfjord Late Life, discharges of natural components will peak in 2011, when the discharge laods will typically have increased by 10-20 per cent in relation to the year with the lowest discharge loads in the Statfjord reference alternative (2006).

The reduction in discharges of natural components in late life will be considerable compared with the current levels (2003).

Total hydrocarbons at the field have been reduced considerably since the year 2000 and the current forecasts indicate further reductions. The OSPAR target of 15 per cent reduction by 2006 is a national target, but Statfjord will contribute its share. Discharges of total hydrocarbons will be reduced by approx. 40 per cent in the period 2000-2006, even if the BTEX level will increase as a result of the implementation of CTour.

The dispersed oil concentration in the produced water is much lower than the OSPAR requirement of 30 mg/l by 2006, and the field has shown a very positive trend. The dispersed oil concentration will be further reduced through the implementation of CTour, and is typically expected to be in the range of 6-9.5 mg/l in SFLL. Compared with Statfjord in the year 2000, discharges of dispersed oil in SFLL will have been more than halved.

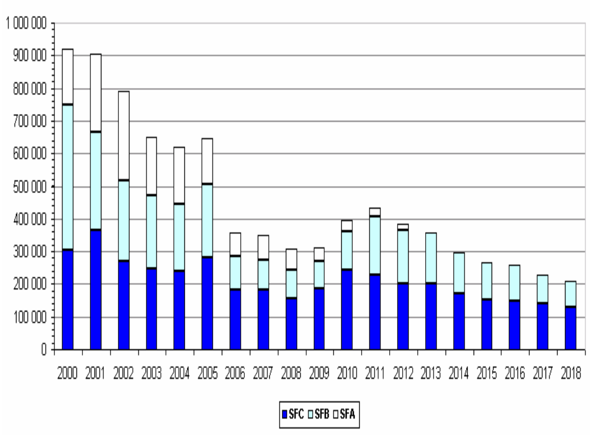


Figure 1-1: Reported and forecast discharges of dispersed oil at the Statfjord field (kg/year)

Discharges of C0-C3 phenols will increase with the water volumes, and will not be reduced as a result of the implementation of CTour. Discharges of C4-C5 and C6+ phenols, on the other hand, will be reduced by 23 and 45 per cent, respectively, in 2006 compared with the current levels. By 2011 late life discharges of C4-C5 will have been reduced by approx. 20 percent and C6+ phenols by 30 per cent compared with the current levels. Late life discharges of C0-C3 and C4-C5 phenols will remain at the same level as in the lowest year in the SF reference alternative, but discharges of C6+ will increase by 25 per cent compared with 2006.

Discharges of naphthalenes, 2-3 ring PAH and 4+ ring PAH will be halved compared with the current discharges (2003) when CTour is implemented. Discharges will increase somewhat in SFLL compared with the reference alternative, but will still be approx. 45 per cent lower in the peak year (2011) than they are at present (2003).

1.5.3 Environmental Impacts

Statfjord's discharges compared with other fields

Of the total discharges of produced water that have a bearing on the water quality in the Tampen area, an estimated 75 per cent originate from installations in the UK sector, while approx. 25 per cent can be attributed to installations on the Norwegian side (based on figures from the North Sea RIA, 1999). Statfjord accounts for approx. half of the total Norwegian discharges.

Environmental risk and dispersion of natural components

There is a considerable decrease in environmental risk (expressed as the Environmental Impact Factor - EIF) compared with 2003 both as regards the SF reference alternative and SFLL. The EIF will be reduced by 85 per cent during the period 2003-2011 and by 45 per cent during the period 2004-2011.

The risk level at the field will remain relatively stable and low during the period 2006-2012, and will vary in the range of 1000-800 EIF. The risk level will then decrease towards the end of the field's life in step with the reduction in water volumes.

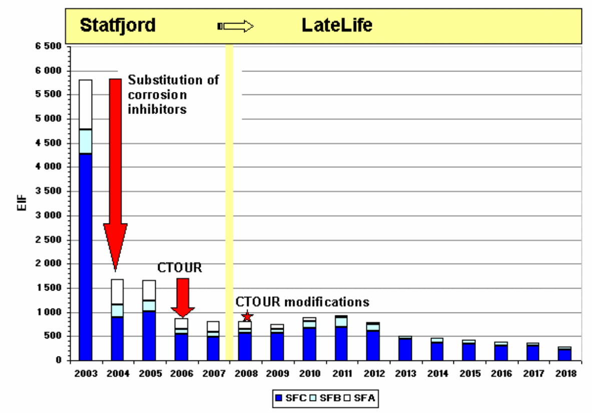


Figure 1-2: Development of EIF at Statfjord before and after Statfjord Late Life

The most significantdecrease in the environmental risk can be attributed to the substitution of corrosion inhibitors. The substitution of corrosion inhibitors during the period 2003-2004 will reduce the environmental risk by approx. 70 per cent. Corrosion inhibitors at SFA were mostly substituted in 2002 and the effects of substitution are therefore even greater than shown.

The use of production chemicals is limited to those that are easily degradable and do not involve any risk of bioaccumulation.

There will also be a marked decrease in environmental risk as a result of the implementation of the CTour cleaning technology in 2005. The technology will be fully effective from 2006. The positive development in terms of environmental risk will be maintained through capacity expansion and modifications to the CTour cleaning technology in SFLL.

The areas with PEC/PNEC >1 will be significantly reduced in SFLL compared with 2003. The areas with PEC/PNEC >1 are relatively limited, and will not increase as a result of overlapping fields of concentration between SFA, SFB and SFC.
The dispersion maps for 2-3 ring PAH, dispersed oil and C4-C5 phenols show that in 2003 concentrations of PEC/PNEC>1 for these substances were present in a very limited area only. In SFLL, only a small area around SFC will have PEC/PNEC>1.

Overlapping concentration fields

Even if the discharges from the various installations in the Tampen area could potentially become mixed and create overlapping concentration fields, the calculations show that the concentration levels in the overlapping areas will be low, and that such overlapping will not increase the environmental risk.

The discharges of produced water will primarily be dispersed on the Norwegian side of the continental shelf, and the risk of transboundary impacts is low.

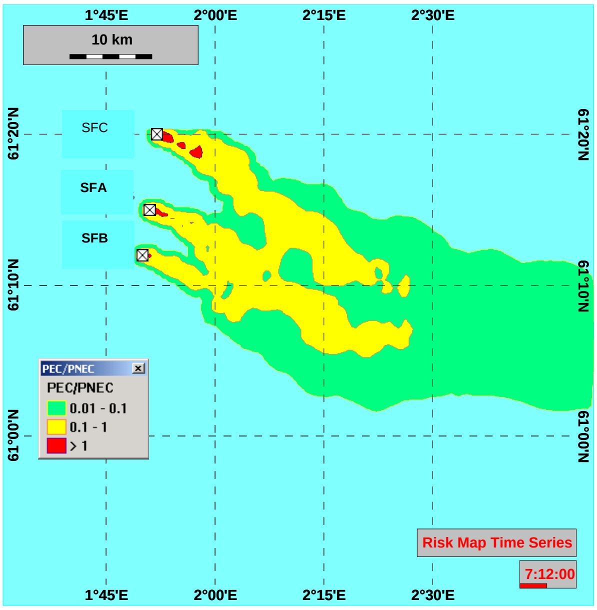


Figure 1-3: Environmental risk map, calculated for a 30-day period.

Natural resources

In principle, all natural resources in the area could potentially become exposed to discharges of produced water from the installations at Statfjord, but on the basis of existing knowledge it is primarily fish at different stages of development that are deemed to be vulnerable. In the Tampen area, most of the important species of fish are present, such as herring, cod, saithe, haddock, plaice, Norwegian pout, sandeel and mackerel. Marine mammals and seabirds are present in the area during migration and foraging periods, but are not regarded as vulnerable to ordinary discharges of produced water.

Monitoring and research data

Components of produced water that adhere to particles and sediments could potentially affect benthic organisms. In the Tampen area, however, the benthic fauna has been monitored for more than 20 years, and it has not been possible to find any relationship between observed effects and discharges of produced water.

Results from monitoring of the water column and research into the impacts of natural components in produced water show weak indications of biological effects in the organisms studied, but the possible significance of these indications in the long term is uncertain.

Discharges of C_4+ alkylphenols will be significantly reduced as a result of cleaning with CTour. On this basis and based on the research data, there is reason to believe that, in Statfjord Late Life, the risk of endocrine effects on fish will be significantly reduced and that there is no risk of any impacts of significance to the fish populations.

Additionally, at the concentrations calculated for the Statfjord area, there considered to be negligible probability that fish populations will be affected by PAH. Considering that the PAH compounds will be reduced by approx. 50 per cent in relation to current levels, it is clear that the risk of damaging effects will be reduced further in Statfjord Late Life.

1.6 Planned Discharges of Produced Sand

Section 59 of the Activities Regulation requires that there is less than one per cent by weight of oil adhesion to discharged sand. At Statfjord, this means that a sand cleaning plant must be installed on each platform. The Statfjord licence has appealed against this requirement to the Ministry of the Environment and has been granted dispensation until 31 December 2006.

No environmental impacts of discharging oily sand have been proven. However, short-term effects of dispersed oil in being discharged together with the sand cannot be ruled out, but it is not probable that there will be any measurable effects considering the duration and dispersion of the discharges.

Statoil’s view is that the environmental benefit of sand cleaning as a measure to meet the authorities’ requirement for less than one per cent by volume of oil adhesion to sand is small, and that the environmental benefit in relation to the cost (226 million) is very small.

Sand cyclones will reduce the discharges of dispersed oil, but the cleaning process will have little environmental effect. In order to eliminate any uncertainties relating to local effects of dispersed oil in the discharge jet, the project is of the opinion that alternative measures to sand cleaning are more relevant.

The project therefore recommends an alternative strategy for handling the environmental issues relating to discharges of sand. All the measures included have in common that they will not meet the authorities’ requirements for less than one per cent by volume of oil adhesion to sand, but the project believes that they will give at least the same environmental benefit as cleaning plants for sand, and at a far lower cost.

The alternative strategy involves the following measures:

- Installation of sand control equipment in most wells
- Monitoring of sand production
- Improving the measurement program for discharges of dispersed oil and oil adhering to sand
- Optimisation of the jetting process
- Assessing the use of pre-jetting in combination with automatic jetting and the installation of sand detectors.

1.7 Environmental Risk and Contingency Planning

Relevant accident scenarios in SFLL include:

- Oil spills during transfer of oil from loading buoy to shuttle tanker
- Shipping accident
- Oil leakages from intrafield pipelines
- Storage tank failure
- Uncontrolled blowout.

The majority of these events involve limited oil spills only, or have a very low probability of occurrence.

An uncontrolled blowout from a platform has been identified as design incident. An uncontrolled blowout could entail discharges of large quantities of oil and potentially harm the natural environment.

The blowout scenario has the following specifications:

• Probability of occurrence:	$8.9\text{x}10^{-4}$
• blowout rate:	1,820 m^3/day
• maximum duration:	90 days

The overall environmental risk associated with a blowout is a function of the probability of occurrence and the estimated environmental harm. The probability of a blowout from the Statfjord field is very low. The very low probability of a blowout combined with the probability of vulnerable biological resources being present in the area hit by the oil, leads us to conclude that the overall environmental risk relating to the SFLL project is very low or insignificant.

Hypothetically, if a blowout occurred, the most exposed resources would be fish eggs and larvae, seabirds in the open sea and sensitive coastal habitats along the Norwegian coast. The probability of sensitive coastal habitats being exposed is, however, very low. Sensitive habitats along the coast of Shetland are even less exposed.

The impacts on vulnerable resources in the water column (i.e. fish eggs and larvae) are considered to be small. This is because there is little overlapping between spawning grounds for fish and the areas in which the total hydrocarbons concentrations exceed the PNEC (Predicted No Effect Concentration) for these resources.

The potential harm to seabird populations caused by a blowout is categorised as “minor” or “moderate”, i.e. it will take less than 3 years to restore the population. The probability of experiencing this level of damage is, however, very low.

These assessments do not take account of the effects of emergency response measures. In the event of an accidental oil spill, the impacts would be further reduced by oil spill response measures. Local oil spill response scheme has been established for the Tampen area, and this would also cover SFLL.

1.8 Waste Handling

Statfjord Late Life will generate increased amounts of waste during the development phase compared with current operations. No special waste problems are expected, however, as a result of Statfjord Late Life given the mitigating measures that will be implemented. During the production period, and to a large extent also during the development phase, it will be possible to adapt waste handling for SFLL to the existing arrangements for transport and receipt at the Statfjord field.

To ensure adequate handling of waste in the development phase in line with applicable requirements and guidelines, contractors will be required to document an HSE/ internal control system that includes waste management.

1.9 Socio-economic Effects and Employment

The socio-economic profitability and employment effects of the reference alternative and SFLL have been estimated.

Capital expenditure (capex) and operating expenditure (opex) for the reference alternative amount to approximately NOK 5.5 billion (2004 NOK) and NOK 11 billion (2004 NOK) respectively. Comparable figures for the SFLL case are approximately NOK 16 billion and NOK 26 billion (accumulated over the period 2005-2018)). Investments in the SFLL alternative will be made throughout the period 2004-2018, i.e. some before and some after the development period (2005-2011). Expenditure in connection with decommissioning is estimated to be in the range NOK 11 billion for both alternatives.

The socio-economic profitability, net present value of prospective income and expenditure at a discount rate of seven per cent before tax is estimated to be approximately NOK 12 billion for the reference alternative and approximately NOK 22 billion for Statfjord Late Life.

The calcualtion of employment effects includes direct, indirect and consumption effects.

The total employment effect of the reference alternative is estimated to be 36,000 man-years, of which approximately 20,500 during the development period and 15,500 during the decommissioning phase.

The SFLL case will generate a total employment effect of 79,300 man-years for the period 2005 – 2026, of which approximately 44,300 will be generated during the development phase (2005 – 2011), 19,500 during the production phase and 15,500 during the decommissioning phase. The employment effect of the new gas export pipeline comes in addition to this.

1.10 Environmental Management

Statoil has established an environmental policy which supports the goals of zero harm to the environment and sustainable development. Statoil’s environmental policy has been adopted by the company’s top management and applies to all the company’s activities and to all employees.

The commitments that follow from the environmental policy are realised through Statoil’s establishment of mechanisms and systems for efficient implementation, measurement, control and improvement of all the activities and processes carried out by the company and its suppliers.

This system will also apply to SFLL, and this environmental impact assessment will serve as a planning and decision-support document within the framework of this system. The environmental impact assessment identifies mitigating measures and possible improvements that will be assessed in the further planning work. These measures will be followed up by the project on a running basis in the development and production phase.

The project will also try to identify new mitigating measures. This is part of the project’s ordinary work relating to health, safety and the environment (HSE), and is in accordance with Statoil’s own guidelines for further development of the project.

2 Introduction

2.1 The Statfjord Field

The Statfjord field is located in the North Sea, 220 kilometres north-west of Bergen (at the latitude of the mouth of the Sognefjord) and northeast of Shetland. The field extends across the dividing line between Norway and the UK.

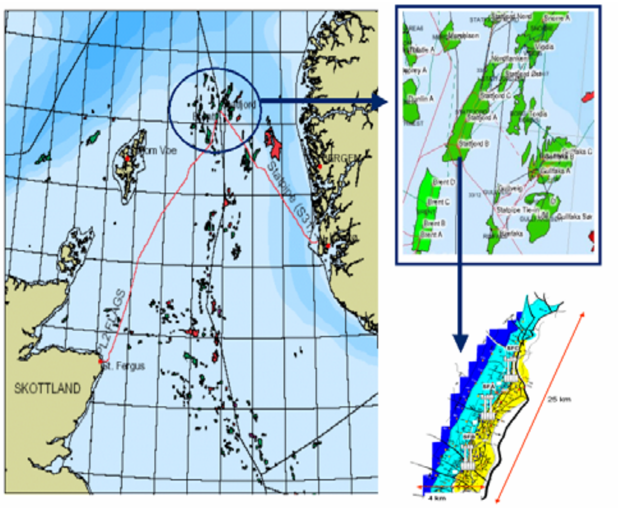


Figure 2-1: The Statfjord field with the Statfjord and Brent platforms

The field designated as the ”Statfjord Unit” consists of the Statfjord and Brent formations and is exploited jointly by the Norwegian licence PL037 and the two UK licences P104 and P293. The Norwegian owner interest is currently approx. 85.5 per cent and the UK owner interest approx. 14.5 per cent.

Statfjord has been the largest oil-producing field on the Norwegian continental shelf and has been in production since 1979. Production of gas began in the autumn of 1985 and formed the basis for the development of the Statpipe gas pipeline (Gassled Area A). Statoil ASA took over as operator from Mobil in 1987. The highlights of the field’s history can be summarised as follows:

- Award of licence 037: August 1973
- Start of exploration drilling: December 1973
- First find: February 1974
- Declaration of commerciality: August 1974
- Start of development Statfjord A: September 1974
- Start of production: 1979
- Start of gas sales: October 1985

The Statfjord field has been developed with three large, fixed concrete platforms for the production of oil and gas: Statfjord A (SFA), Statfjord B (SFB) and Statfjord C (SFC). These platforms are integrated platforms, with drilling and process plants, storage facilities for oil, and accommodation.

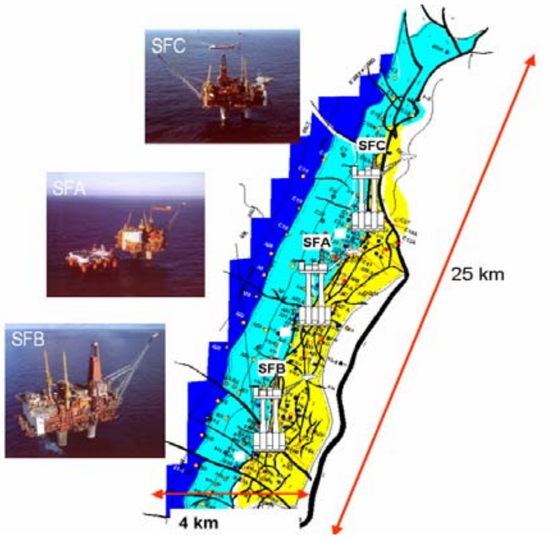


Figure 2-2: Statfjord A, Statfjord B and Statfjord C

SFA, SFB and SFC process petroleum from other fields in addition to their own oil and gas. Statfjord C processes oil and gas from the satellites Statfjord East, Statfjord North and Sygna, while Statfjord A finalise the processing of oil and gas from Snorre A. Statfjord B serves as storage and offloading centre for oil from Snorre B.

Processed oil from all platforms is offshore-loaded and transported to the recipients by oil tankers. The gas pipelines from Statfjord A, B and C converge at Statfjord B and the gas is transported by Gassled Area A pipeline to Kårstø (Norway) and via the FLAGS pipeline to St. Fergus (Scotland) for processing.

2.2 Background to the Statfjord Late Life Project and the Gas Export Pipeline Tampen Link

With the current drainage strategy, production at the Statfjord field is drawing to a close. Statfjord A, B and C will close down their own production in 2009.

By changing the drainage strategy so that less pressure is exerted on the reservoir (cessation of seawater and gas injection), it is possible to extend the life of the field and exploit a larger proportion of the remaining gas and oil resources, including the gas that was previously injected.

Since 2001, the Statfjord Late Life project has evaluated different development alternatives in order to secure such increased exploitation of the Statfjord field. Over 50 alternatives were originally considered. The number of alternatives in addition to the current drainage strategy was reduced to 16 in December 2001, to five in February 2002 and to three in September 2002.

A study for the three most promising development alternatives was concluded in June 2003. The alternatives were compared with each other and the current drainage strategy (the Statfjord reference alternative). The project recommended modifications to existing platforms (removal of bottlenecks) for development of the Statfjord field for late life production. This recommendation was made on the basis of an overall assessment of technical, financial, operational, environmental and resource-related factors. In connection with the selection of the development alternative, an environmental and socio-economic assessment of the various development alternatives was also carried out /90/.

After further optimisation of the recommended development alternative in the autumn of 2003, in which it was recommended, among other things, to carry out investment and work gradually over an extended period of time, the licence decided to develop this alternative in preparation for the Provisional Project Sanction in March 2004. The two other alternatives assessed, i.e. conversion of existing platforms to minimum processing platforms in combination with 1) construction of a new platform on Statfjord or 2) transporting oil and gas to the Brent platforms on the UK side and processing it there, were abandoned. The development alternatives and criteria for selection are discussed in further detail in appendix C.

In connection with the various development alternatives for processing oil and gas, alternative gas transport solutions were also considered. The alternative developed for the Provisional Project Sanction in March 2004 was the export of all gas to the United Kingdom through a new pipeline to FLAGS, but with the possibility of continued transport of gas to Kårstø via Gassled Area A and to the United Kingdom via Spur/NLGP. In the period leading up to the Project Sanction, other gas transport solutions were considered. These are discussed in greater detail in the Environmental Statement for the gas export pipeline Tampen Link /86/.

2.3 Plans for Development and Transport and Treaties between the United Kingdom and Norway

The Statfjord Treaty of 1979 regulates the exploitation of petroleum from the Statfjord field, the requirements for documentation, and the approval of plans and agreements for the field by the public authorities in both countries. According to the “Agreement between the Government of the Kingdom of Norway and the Government of the United Kingdom of Great Britain and Northern Ireland on the Exploitation of the Statfjord Reservoirs and the Transport of Petroleum from these Reservoirs” (the “Statfjord Treaty”), cf. Proposition to the Storting (the Norwegian Parliament) no. 15, 1980-81, a field development plan will have to be prepared with subsequent approval by the public authorities of both countries/113/.

In Norway, such a field development plan is referred to as a “Plan for Development and Operation of a petroleum deposit” (PDO). For Statfjord Late Life the PDO is referred to as a revised PDO, since Statfjord is a field already in operation and the plan involves modifications and not the development of a new field. The Norwegian PDO consists of 2 parts. Part 1 (technical/financial part) and part 2 (environmental impact assessment). In the United Kingdom an equivalent plan is called a “Field Development Plan” (FDP). In the United

Kingdom the environmental impact assessment is not a part of the FDP, but is submitted as a basis for the approval of the FDP if the project is required to submit an Environmental Statement (ES). In consultation with the public authorities of both countries, it has been decided to prepare a joint plan for the planned field modifications on Statfjord, satisfying both countries' guidelines for PDO (part 1) and FDP, respectively (/122/ and /114/).

In connection with Statfjord Late Life, an export pipeline is planned for the transport of gas from the Statfjord field. The development of a new gas export pipeline from Statfjord B to FLAGS, the Tampen Link, is regulated by the framework agreement of 1998 between Norway and the United Kingdom (the "1998 Agreement"). This framework agreement also requires processing of plans and approval by the public authorities of both countries/112/.

In Norway, such a plan is referred to as a "Plan for installation and operation of facilities for transport and utilisation of petroleum" (PIO). An equivalent plan for the laying and operation of pipelines is called a "Pipeline Work Authorisation" (PWA) in the UK. In consultation with the public authorities of both countries, it has been decided to prepare a joint plan for the planned pipeline, satisfying both countries' guidelines for PIO and PWA, respectively (/122/ and /115 /).

The EIA/ES documentation for the field modifications and the Tampen Link gas export pipeline will also be prepared jointly and will meet both British and Norwegian assessment requirements and guidelines. This EIA will deal with the field modifications relating to Statfjord Late Life. The ES for the gas export pipeline the Tampen Link is discussed in a separate document/86/.

The basis of the EIA/ES in national legislation and the process in relation to the authorities of both countries will be the same for the two environmental impact assessments and is described in the following chapters.

2.4 The Purpose of the Environmental Impact Assessment

In Norway, the Environmental Impact Assessment (EIA) is an integrated part of the planning of major development projects, and included in the PDO and PIO. The EIA is intended to ensure that factors associated with the environment, society and natural resources are included in the planning work on a par with technical, financial and safety-related factors.

The EIA is intended to contribute to shedding light on matters that are relevant to both the internal and external decision-making processes, and to guarantee the general public information on the projects. The process must be an open one, whereby the various players have the opportunity to express their opinions and influence the design of the project.

The purpose of the Environmental Statement (ES) in the United Kingdom is similar to that of the EIA in Norway; it is meant to ensure consideration by the Secretary of State for Trade and Industry (SoS) of factors associated with the environment and natural resources, before consent to offshore activities is given. The ES is a means of submitting to the regulatory authority, statutory consultees, non-government organisations and the wider public the findings of an assessment of the likely affects on the environment of the proposed activity. The size and scope of the environmental assessment will be related to the size and nature of the activity but it should always examine thoroughly all the proposed activities and their consequences/116/.

In the UK, the ES is not part of the FDP or the PWA, but the environmental impact assessment obligation must be met before these plans can be approved. Several other approvals and consents must also be in place before the FDP and PWA can be approved.

2.5 Legislative EIA Requirements

2.5.1 International Legislation

The requirement for an environmental impact assessment is reflected in the EU regulations that both Norway and the UK have implemented. EU

Council Directive 97/11/EC, which is a Directive amending Council Directive 85/337/EEC, requires an environmental impact assessment for public and private projects that may have significant environmental and/or economic impacts/118/.

Possible transboundary environmental impacts are regulated by the UN "Convention on Environmental Impact Assessment in a Transboundary Context" (ESPOO (EIA) Convention, 1991)/117/.

2.5.2 Norwegian Legislation

The planned project, including the planned gas export pipeline to the United Kingdom, is subject to an environmental impact assessment obligation pursuant to the provisions of the Norwegian Petroleum Act sections 4.2 and 4.3/124/.

The Norwegian Petroleum Act's Regulations sections 20, 22, 22a, 22b, 22c and 29 regulate the contents of an environmental impact assessment. The Norwegian Pollution Control Act section 13 also has provisions on notification (assessment programme) and environmental impact assessment in connection with the planning of activities that may cause pollution/125/.

2.5.3 UK Legislation

The requirement for an ES is regulated by the Petroleum Production and Pipelines (Assessment of Environmental Effects) Regulations (1999)/123/.

Based on the ESPOO Convention and the Statfjord Treaty among others, the Department of Trade and Industry (DTI), which is the regulatory authority for oil and gas developments, requires a joint Environmental Statement for Norway and the United Kingdom, as well as an EIA process in the United Kingdom.

2.6 The Relationship between UK and Norwegian Legislation and Formal Requirements for EIA/ES Documentation

In a Norwegian EIA, meant for the Norwegian authorities and consultation bodies only, the environmental assessment process and the requirements for documentation are known. The same applies to the ES in relation to the UK authorities and consultation bodies. For this reason the environmental assessment process and requirements for the contents of the EIA/ES documents are not normally discussed in detail. In this joint environmental impact assessment, however, which is meant for both the Norwegian and the UK authorities, it is necessary to outline the processes in each country and the requirements relating to the contents of the documents. This section describes the requirements for ES/EIA documentation in the UK and Norway, while section 2.7 outlines the environmental assessement processes.

2.6.1 Environmental Impact Assessment Programme

Norway has requirements for consultation on an assessment programme prior to preparing the environmental impact assessment. The Norwegian Petroleum Act Regulations section 22 regulate the requirements for an assessment programme:

"The licensee must, in good time before submitting the plan for developing and operating a petroleum deposit, send the Ministry a draft assessment programme. The draft must provide a brief description of the development, relevant development solutions and, on the basis of available knowledge, expected effects on other businesses and the environment, including any transboundary environmental effects. Moreover, the draft must clarify the requirements for documentation. If an environmental impact assessment has been prepared for the area in which the development is planned to be implemented, the draft must clarify the requirements for further documentation or updating."

The purpose of the EIA programme is to give public authorities and other consultation bodies information and notice of what is planned for development and where and how the development is planned. The assessment programme forms the basis for the environmental impact assessment and is adopted by the competent authority (the Ministry of Petroleum and Energy) after prior public consultation.

By commenting on the programme, both public authorities and other consultation bodies are given the opportunity to influence what is to be assessed in the EIA and thus also what is to be used as the basis for the decisions to be taken.

There are no formal requirements in UK legislation for consultation prior to the preparation of an environmental impact assessment. However, the operator is strongly encouraged to engage in informal consultations with the interested parties such as the local authorities, conservation groups, naturalists, special interest groups, users of the sea and where appropriate, the interested public, during the environmental assessment. The relevant environmental authorities should also be involved in this process. Experience of the Regulations/116/ has clearly demonstrated that such informal consultation can identify potential difficulties before the ES is prepared and hence reduce or eliminate delay at the formal consultation stage of the process. It is, moreover, confirmed by the guidelines to the Petroleum Production and Pipelines (Assessment of Environmental Effects) Regulations (1999) that the preparation of a Scoping Document, summarising the proposed activity, highlighting the sensitivities and proposed mitigating measures has been found to be a very valuable aid in the early, informal consultations and can be considered best practice, particularly for large projects or those in potentially sensitive locations /116/.

Since the UK consultations prior to preparing the ES are informal, there are no formal requirements stipulating how a document in that connection is to be prepared. Norwegian legislation, on the other hand, requires an extensive assessment programme in accordance with certain requirements concerning its contents and the consultation process.

The UK authorities have requested a joint environmental impact assessment that includes measures on both the Norwegian and UK sides and an associated consultation process in the UK. It was therefore deemed expedient to also prepare a joint document in connection with the consultation prior to the impact assessment (the scoping phase) in order to agree on the content of the further assessment process and to ensure that those consulted in both countries have a good overview of the interconnectedness of the project.

The assessment programme/87/ which was sent out for consultation in both the United Kingdom and Norway comprised both the field modifications and the new gas export pipeline. The programme and the consultation statements received are described in more detail in section 2.9 and appendix B.

2.6.2 Regional and Strategic Impact Assessments

2.6.2.1 RegionalIimpact Assessment for the North Sea

The regional impact assessment for the petroleum activities in the North Sea (the ”North Sea RIA”) was approved by the Norwegian public authorities in 1999/98/. In accordance with the guidelines issued by the Norwegian Ministry of Petroleum and Energy (MPE), the obligation to prepare an environmental impact assessment for new development projects may be met by means of a field-specific environmental impact assessment, a combination of a field-specific assessment and a regional assessment or, in some cases, a regional environmental impact assessment alone.

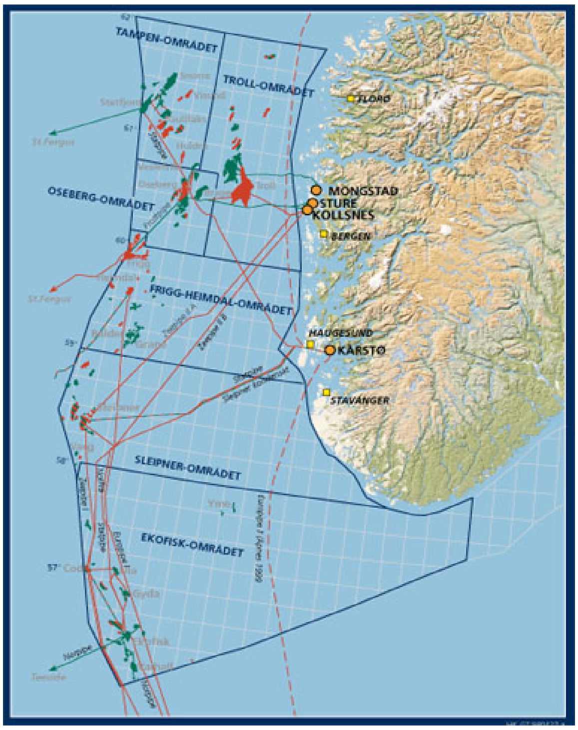


Figure 2-3: North Sea RIA

For Statfjord Late Life, a field-specific environmental impact assessment has been prepared, but with reference to the North Sea RIA for some assessment items/98/.

The North Sea RIA (figure 2-3) discusses the total impact of the petroleum activities on the Norwegian continental shelf south of 62 °N. The area is divided into six sub-areas: The Tampen area, in which the Statfjord platforms are located, and the Troll, Oseberg, Frigg-Heimdal, Sleipner and Ekofisk areas. The following sources of discharges and emissions and other environmental impacts are included in the RIA:

- Developed fields and fields planned for development
- All transport activity by ship and helicopter
- Pipelines on and between fields and major export pipelines
- Planned exploration drilling.

2.6.2.2 Strategic Impact Assessment in the United Kingdom

No equivalent regional impact assessment is prepared for the UK sector. However, strategic environmental impact assessments have been prepared.

The Strategic Environmental Assessment (SEA) is a process for predicting and evaluating the environmental implications of a policy, plan or programme. SEA is conducted at a strategic level - this contrasts with Environmental Impact Assessment (EIA) which is carried out for a specific development or activity.

In 1999 the DTI instituted the practice of carrying out Strategic Environmental Assessments (SEA), as part of the offshore licensing process, as an aid to determining which areas should be offered for licensing for oil & gas development. In doing this, the DTI was anticipating the implementation of the EU directive, the Environmental Assessment of Plans and Programmes Directive, 2001/42/EC/119/, which will become mandatory for a very wide range of activities, mostly onshore, in 2004. This now means that environmental assessments carried out for individual projects can take advantage of additional data and information on the regional context of their proposals specific to the E&P industry.

In this environmental impact assessment for Statfjord Late Life field modifications, information from the SEA has been used.

2.6.3 Contents and Structure of the EIA Documents

The content of the EIA documents for field modifications and the gas export pipeline Tampen Link /86/ is determined by each country’s requirements and guidelines, the assessment programme and comments to the programme. Applicanle guidelines are: ”Guidance Notes on the Offshore Petroleum Production an Pipelines (Assessment of Environmental Effects) Regulations”/116/ and in “Guidelines to plan for development and operation of a petroleum deposit (PDO) and in “Guidelines to plan for installation and operation of facilities for transport and utilisation of petroleum (PIO)”/122/.

The topics assessed and the level of detail may therefore deviate somewhat from the typical UK ES and the typical Norwegian EIA. Socio-economic consequences are, for example, not usually a topic for assessment in the UK ES. On the other hand, environmental impacts may be examined in somewhat greater detail in the UK than in Norway.

The guidelines and requirements for the contents of the EIA/ES in Norway and the UK are considered to be relatively similar and can be summed up as follows:

- Summary (”Non technical summary” in the UK)
- Legislation
- Comments to the environmental assessment programme (the results of informal consultations in the UK)
- Development alternatives
- Substantiation for the selection of the development alternative in terms of technical, financial, safety-related and environmental criteria
- Description of the selected alternative

- Description of
    - the environment
    - natural resources (for offshore development projects - fisheries)
    - other user interests
    - sosio-economic considerations (in Norway only)
- Impacts of the chosen alternative on
    - the environment
    - natural resources
    - other user interests
    - socio-economics
- Proposed mitigating measures are to be described in the context of an environmental programme, in which the selection of mitigating measures is described on the basis of safety and cost-efficiency.

2.7 The Impact Assessment Process towards British and Norwegian Authorities

The administration of the EIA process and approval of the plans for field modifications (PDO/FDP) and the gas export pipeline Tampen Link (PIO/PWA) by the Norwegian and UK authorities, respectively, will be in accordance with the national legislation in each country.

The process towards British and Norwegian autorities has been established based on on the guidelines prepared for the EIA process as described in appendix A, agreements between Norway and the United Kingdom, including the Statfjord treaty and the 1998 Agreement, experience of previous developments and conversations and meetings between the Norwegian and UK authorities. The process is shown in Figure 2-4.

The figure shows that, in addition to the formal EIA/ES documents, the process started in 2003 with the preparation of an environmental impact assessment to evaluate and compare the different development alternatives, which were: 1) New platform, 2) Field modifications (bottleneck removal) and 3) Processing on Brent. This environmental impact assessment /90/, was sent to both the Norwegian MPE and the UK DTI for information purposes. The purpose of the assessment was to shed light on the environmental and socio-economic impacts of the alternative development solutions, and to support the further discussion of the process in relation to the Norwegian and UK authorities, respectively. This was followed by the environmental assessment programme and the final EIA/ES document. This document will be considered by the Storting in Norway and by the Secretary of State in the UK. Regular meetings have taken place with both the UK and Norwegian authorities during the process.

Figure 2-5 and Figure 2-6 show the timetable for the process in relation to the Norwegian and UK authorities respectively. The timetable for the project is shown in section 3.

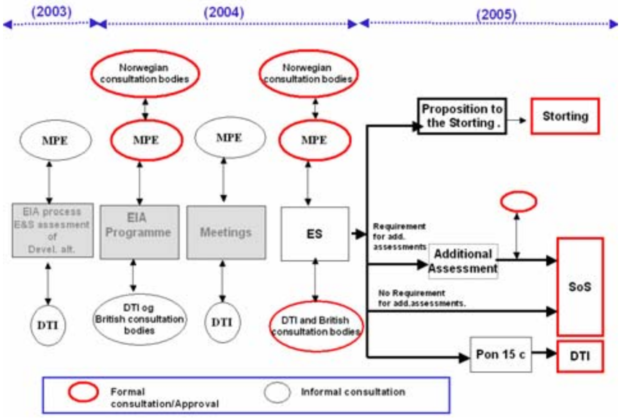
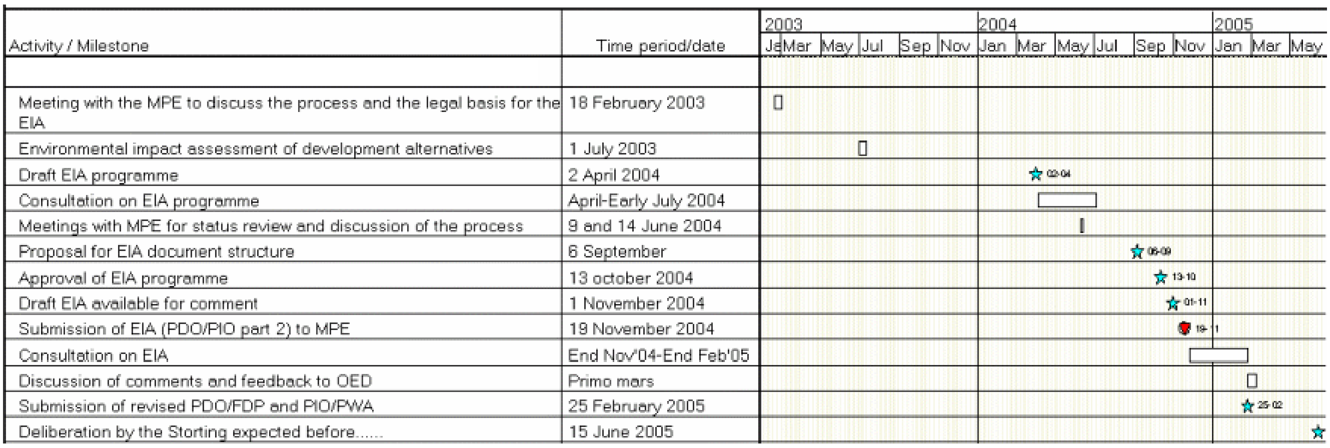
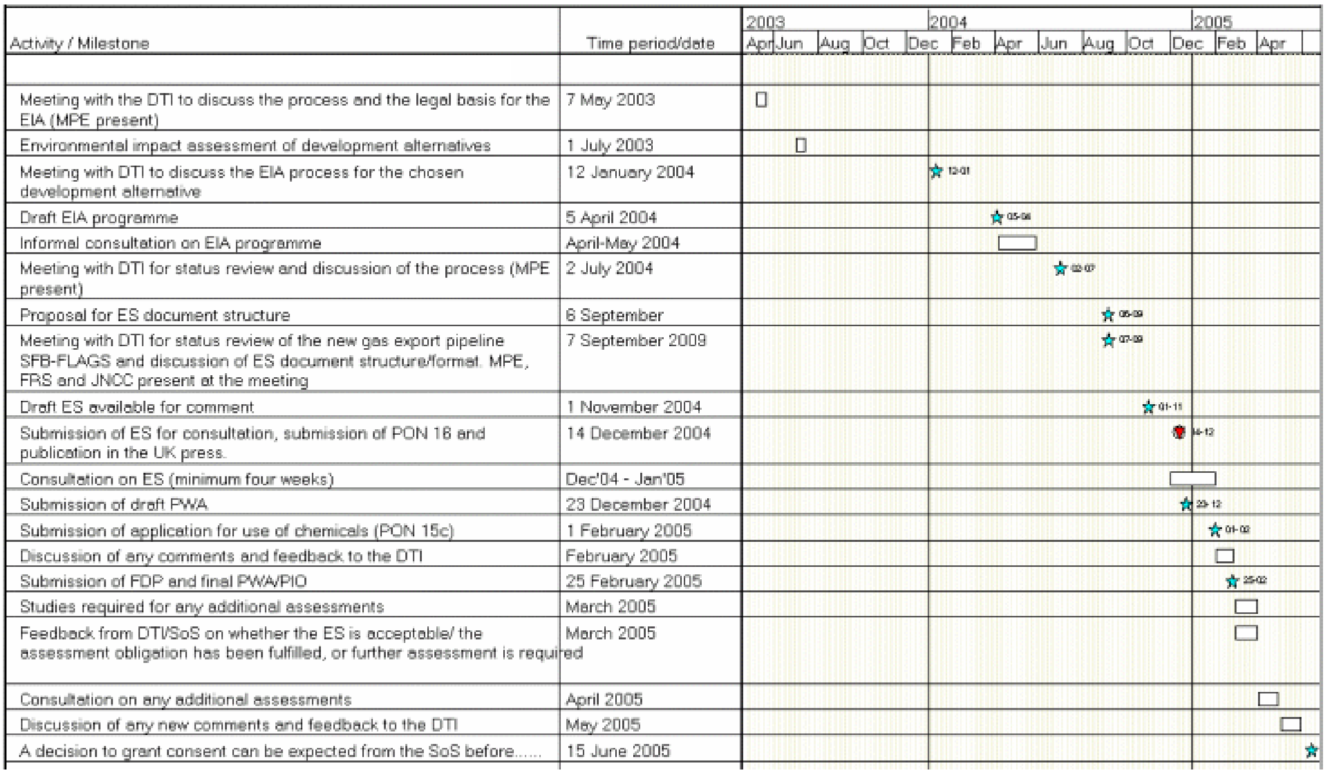


Figure 2-4: EIA process for Statfjord Late Life and the new gas export pipeline



Activity / Milestone	Time period/date
Meeting with the MPE to discuss the process and the legal basis for the EIA	18 February 2003
Environmental impact assessment of development alternatives	1 July 2003
Draft EIA programme	2 April 2004
Consultation on EIA programme	April-Early July 2004
Meetings with MPE for status review and discussion of the process	9 and 14 June 2004
Proposal for EIA document structure	6 September
Approval of EIA programme	13 october 2004
Draft EIA available for comment	1 November 2004
Submission of EIA (PDO/PIO part 2) to MPE	19 November 2004
Consultation on EIA	End Nov'04-End Feb'05
Discussion of comments and feedback to OED	Primo mars
Submission of revised PDO/FDP and PIO/PWA	25 February 2005
Deliberation by the Storting expected before......	15 June 2005

Figure 2-5: Schedule for the EIA process in relation to the Norwegian authorities



Activity / Milestone	Time period/date
Meeting with the DTI to discuss the process and the legal basis for the EIA (MPE present)	7 May 2003
Environmental impact assessment of development alternatives	1 July 2003
Meeting with DTI to discuss the EIA process for the chosen development alternative	12 January 2004
Draft EIA programme	5 April 2004
Informal consultation on EIA programme	April-May 2004
Meeting with DTI for status review and discussion of the process (MPE present)	2 July 2004
Proposal for ES document structure	6 September
Meeting with DTI for status review of the new gas export pipeline SFB-FLAGS and discussion of ES document structure/format. MPE, FRS and JNCC present at the meeting	7 September 2009
Draft ES available for comment	1 November 2004
Submission of ES for consultation, submission of PON 16 and publication in the UK press.	14 December 2004
Consultation on ES (minimum four weeks)	Dec'04 - Jan'05
Submission of draft PWA	23 December 2004
Submission of application for use of chemicals (PON 15c)	1 February 2005
Discussion of any comments and feedback to the DTI	February 2005
Submission of FDP and final PWA/PIO	25 February 2005
Studies required for any additional assessments	March 2005
Feedback from DTI/SoS on whether the ES is acceptable/ the assessment obligation has been fulfilled, or further assessment is required	March 2005
Consultation on any additional assessments	April 2005
Discussion of any new comments and feedback to the DTI	May 2005
A decision to grant consent can be expected from the SoS before......	15 June 2005

Figure 2-6: Schedule for the EIA process in relation to the UK authorities

2.8 Applications, Consents, Licences/Permits and Duty of Information in addition to the Revised PDO/FDP

In addition to the approval of the PDO/FDP, it will be necessary to obtain several licences/permits and consents from both Norwegian and UK planning and licensing authorities. Some of the licences/permits will have to be obtained in the planning phase, others in the development phase and some are only relevant for the decomissioning phase.

It has been established with the Norwegian and UK authorities which licences/permits and consents are required. Consents and licences/permits in connection with field modifications are mainly required by the Norwegian authorities.

The most important licences and consents to be obtained from the planning and licensing authorities in Norway in connection with the field modifications are listed below. No consents or licences on the corresponding level will have to be obtained from British authorities.

Applications for emission permits pursuant to the Norwegian Pollution Act section 11. The competent authority is the Norwegian State Pollution Control Authority (SFT).

- Emission permits for the drilling phase
- Emission permits for the installation phase
- Emission permits for the production phase

Production license pursuant to the Norwegian Petroleum Act for recovery, processing and flaring of hydrocarbons. The competent authority is the MPE.

Whether it is necessary to obtain licences other than those already mentioned, will be clarified in the continued planning process and through the processing of the environmental impact assessement.

The Norwegian Information Duty Regulation (section 5) also contains requirements for consent to certain petroleum activities. Among other things, the operator must obtain consent:

- for use of drilling platforms prior to drilling of wells (application for consent pursuant to the Norwegian Petroleum Act). The competent authority is the Norwegian Petroleum Directorate (NPD).
- for implementation of manned underwater operations. The competent authority is the NPD.
- for putting into service a facility or parts thereof. The competent authority is the NPD.

If the conditions on which the consent was granted are significantly changed, the supervisory authorities may require the operator to obtain a new consent before continuing with the activities.

2.9 The Environmental Impact Assessment Programme

The environmental assessment programme which included both the field modifications and the gas export pipeline was distributed for consultation at the beginning of April 2004. The comments of the UK consultation bodies were received in the course of May/April 2004, and the comments from the Norwegian consultation bodies were received in June 2004 after a three-month consultation period.

The final assessment programme, adopted by the MPE in a letter of 13 October 2004 is enclosed to this Environmental Impact Assessment (appendix B). This section summarises the comments of the UK and Norwegian consultation bodies, while the consultation statements are included in appendix C.

The comments of the Norwegian consultation bodies are mainly linked to the field modifications and not to the gas export pipeline. None of the UK consultation bodies have commented on the field modifications. The comments of the UK consultation bodies are related to the planned gas export pipeline Tampem Link only, and are elaborated on in the EIA/ES for the Tampen Link gas export pipeline /86/.

The following UK consultation bodies received the programme for consultation:

1) DTI-Department of Trade and Industry,
2) DEFRA-Department of Environment Food and Rural Affairs, Rural and Marine Environment Division,
3) CEFAS, Centre for Environment, Fisheries and Aquaculture Science
4) European Wildlife Division (EWD), DETR (Department of Environment Transport and the Regions)
5) Fisheries Research Services , FRS Marine Laboratory,
6) JNCC-Joint Nature Conservation Committee,
7) MCA-Maritime Coastguard Agency,
8) Ministry of defence liaison, Head Office,
9) NFFO -National Federation of fishermen's Organisations, Chief Fisheries Liaison Officer,
10) Scottish Fishermen's Federation,
11) RSPB –Royal Society for the Protection of Birds,
12) Scottish Environmental Protection Agency,
13) Scottish Environment Link,
14) Scottish Natural Heritage,

Table 2-1 lists the Norwegian consultation bodies that have submitted statements to the programme and includes references to the sections of this Environmental Impact Assessment in which these comments are described in detail.

Table 2-1: Summary of consultation statements

Consultation bodies*	Topic commented on	Reference
Ministry of Fisheries (MFi)	No comments over and above those submitted by the DFi, NCD and IMR	
Directorate of Fisheries (DFi)	None	
Norwegian Coast Directorate (NCD)	None	
Institute of Marine Research (IMR)	Produced water Preparation of pipelines	Section 6.2 ES for the gas export pipeline Tampen Link /86/
The Norwegian Fishermen's Association (NFL)	Produced water Discharges of oily sand	Section 6.2 and appendix G Section 6.3 and appendix H
Ministry of the Environment (ME)	No comments over and above those of SFT	
State Pollution Control Authority (SFT)	Drilling Produced water and mitigating measures Discharges of oily sand Emissions to air and mitigating measures	Section 5.1 and 6.1 Section 6.2 and appendix G Section 6.3 and appendix H Secrion 5 and appendix F
Directorate for Nature Management (DNM)	General comments on the knowledge base relating to the marine ecosystem Vulnerable natural resources Environmental monitoring	Section 4 and appendix E
County Governor of Rogaland	Emissions to air Produced water Oily sand North Sea RIA	Section 5 Section 6.2 and appendix G Section 6.3 and appendix H Section 4 and Appendix E
Sogn og Fjordane County	Higher level of activity for Sogn og Fjordane	
Ministry of Labour and Administration (MLA)/ Petroleum Safety Authority Norway (PSA)	MLA: No comments over and above those from PSA PSA: No comments to the external environment	
County Governor of Sogn og Fjordane	Accidental discharges	Section 7 and appendix E

The following Norwegian consultation bodies have not submitted any comments: Ministry of Defence, Directorate of Labour, Labour Inspection Authority, Petroleum Directorate, Directorate of Cultural Heritage, County Governor of Hordaland, Hordaland County, Rogaland County, Norwegian Nature Conservation Association, Nature and Youth, the Norwegian Bellona Foundation, the Norwegian Institute for Urban and Regional Research, Norwegian Association for Environmental Protection.

2.10 Scope of Assessment and Supporting Reports for the EIA

Supporting reports prepared as a part of the EIA documentation to describe the impact of field modifications are shown in Table 2-2.

Table 2-2: Supporting reports for the EIA

Study	Institution reporting	Key words	Reference
Description of natural resources and environmental risk assessment	Alpha Miljørådgivning (Alpha Environmental Consultants)	Natural resources and environmentally sensitive areas (SMO) Dimensioning acute discharge Oil operation calculations and areas of influence Exposure and damage analysis Assessment of oil spill response preparedness	/4/
Impact of oily sand discharges in connection with jetting	Akvaplan Niva	Forecasts for sand production and discharges Acute and chronic effects of oily sand discharges Cost-benefit of measures	/51/
Impact of produced water	Rogaland Research	Short-term and long-term effects of produced water for Statfjord Late Life and Statfjord reference alternative, respectively, based on the environmental risk assessment and research results	/26/
Socio-economic impact	Rogaland Research	The economy Deliveries of goods and services Employment	*

* The report is included in this ES

3 Project Description

3.1 Licensees, Ownership

The licensees of the Statfjord field and their respective owner interests are shown in Table 3-1.

Table 3-1: Licensees and owner interests

Statoil Asa (operator)	44.33688%
ExxonMobil Norge AS	21.36717%
Norske ConocoPhillips AS	10.32747%
AS Norske Shell	8.54687%
Enterprise Oil Norge AS (Shell)	0.89030%
ConocoPhillips (U.K.) Limited	4.84377%
Britoil	4.84377%
Centrica	4.84377%

3.2 Resources and Production Plans

The Statfjord field covers an area of 100 km^2 and is over 25 km long and 4 km wide. The field consists of the Statfjord and Brent reservoirs, two oil and gas-bearing sandstone strata, which were deposited at the base of the geological North Sea basin in the Jurassic period 150 million years ago.

The Statfjord Late Life project (SFLL) is based on a change in the drainage strategy in order to increase the recovery factor at the field. The recovery factor for the Statfjord oil reservoir will reach 68 and 74 per cent for oil and gas, respectively, which is high in both the national and international context.

A change from pressure maintenance (current strategy) to pressure relief (late life) will gradually reduce the reservoir pressure in the Brent and Statfjord reservoirs. Pressure reduction below the boiling point will cause the dissolved gas to be released from the oil, move upwards and form a secondary gas layer that can be produced. In the first few years the gas will primarily come from the Statfjord reservoir, in which the secondary gas layer will consist mainly of gas, whic is injected to provide for pressure support prior to late life. The secondary gas layer from the Brent reservoir will be produced as it reaches the top of the reserrvoir.

After stop in gas-injection in 2007, all gas will be exported via the new gas export pipeline Tampen Link.

Forecasts for oil and gas production from the main Statfjord field during SFLL and the Statfjord reference alternative are shown in Figure 3-1 and Figure 3-2. Figure 3-2 also shows gas export from the main Statfjord field during SFLL[1].

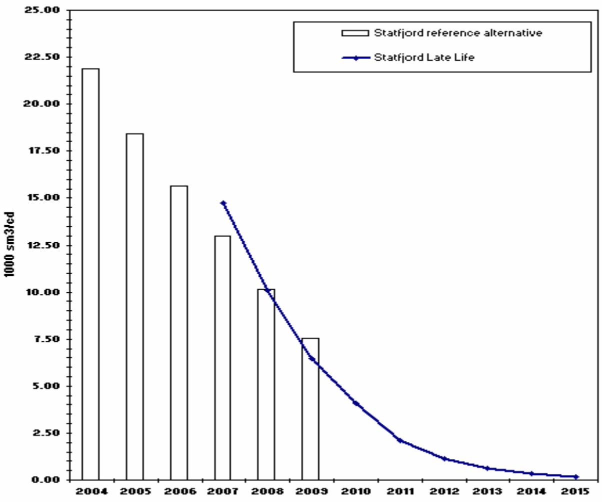


Figure 3-1: Oil profiles for the main Statfjord field (1,000 Sm^3/ day)

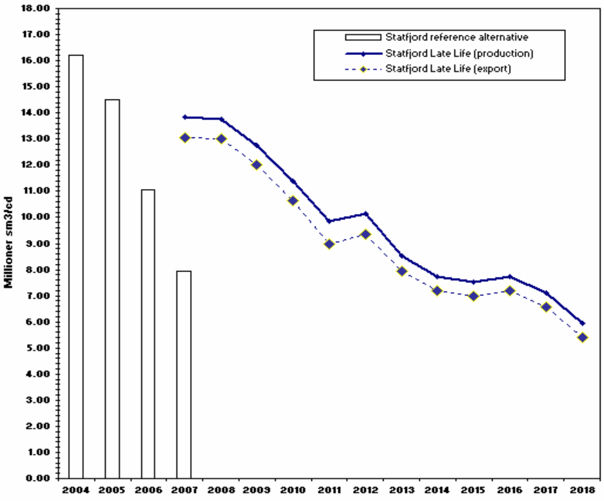


Figure 3-2: Gas profiles for the main Statfjord field (millions of Sm^3/ day)

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[1] Gas export in 2007only represents the last 3 months of the year.

Table 3-2 shows financially recoverable resources compared with the reference alternative. Financially recoverable resources are usually somewhat less than the technically recoverable resources, and are defined as those resources that it is profitable to recover.

The sum of dry-gas and NGL in the table below represets the production of wet-gas in the figure above, but the figures are represented by different units.

Table 3-2: Financially recoverable reserves

Financial reserves	**SF-Reference case (04-09)**	**SFLL (06-18)**	**Delta**
Oil(MSm3)	31.7	35.1	3.4
Dry gas (GSm3)	6.3	36.7	30.4
NGL(mill. tonn)	2.3	11.6	9.3

3.3 Development Alternatives for Processing Oil and Gas and Selection Criteria

Three development alternatives for processing of oil and gas were developed before selecting a development alternative:

Alternative 1 – New platform
Alternative 2 –Bottleneck removal – Reconstruction and modifications to existing platfoms

Alternative 3 – Processing at Brent

These have been compared with each other and the reference alternative (current drainage strategy). The choice of development alternative is explained in the impact assessment programme and summarised in Appendix C.

Alternative 2 – Modifications to existing platforms was selected as the development alternative for processing oil and gas, and has been further developed for the project sanction.

The development alternative was ranked as the best after a comprehensive evaluation, based on:

- Profitability
- Flexibility
- Resource utilisation

Modifications to the existing SF platforms were considered the best alternative for both Norway and the UK based on overall environmental considerations.

The alternative will necessitate major modifications to the existing platforms at Statfjord, and transport of gas to the UK via a new gas export pipeline (Tampen Link).

The biggest changes for this alternative compared to how it was described in the Environmental Impact Assessment Programme is that SFA will be shut down earlier than planned. The work at this platform will therefore be less extensive than under the previous plans. SFB and SFC will produce from 2008 until and including 2018.

A brief description of the alteration and modification work is given in section 3.5.2. The drilling program is described in section 3.5.1. Section 3.4 contains a brief description of the Statfjord reference alternative.

3.4 SF reference Alternative – Current Drainage Strategy (2004-2009)

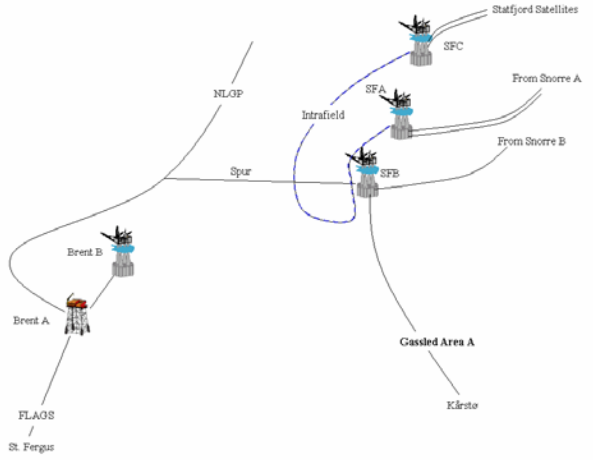


Figure 3-3: SF-Reference alternative

As mentioned in the introduction, SFA, SFB and SFC also process petroleum from other fields. Statfjord C processes oil and gas from the satellites Statfjord East, Statfjord North and Sygna, while final processing of partially processed oil and gas from Snorre A takes place at Statfjord A. Statfjord B serves as storage and offloading centre for oil from Snorre B. After final processing, the oil from all the platforms is turret loaded and shipped by tankers to the receiver. The gas pipelines from Statfjord A, B and C converge at Statfjord B and the gas is transported by pipeline (Gasled, zone A) to Kårstø (Norway) and via FLAGS to St. Fergus (Scotland) for processing.

The Statfjord reference alternative is based on the Statfjord operations' budget and working programme for the period 2004-2009.

Drilling plant

No major alterations will be implemented with respect to drilling plant. The planned upgrading of drilling plant is limited to that required to maintain compliance with requirements relating to technical condition and HSE. Well plugging operations will start in 2010.

Platform modifications

Modifications will be carried out to maintain the technical condition of and safety levels on board the platforms. HSE work at Statfjord is based on the zero emissions mindset and is described in detail in Statfjord's HSE programme/92/. Measures to achieve the goal of zero harmful emissions are described in Statfjord's zero emissions report /91/, and include among others the installation of the CTour technology for cleaning produced water (see chapters 5 and 6 for planned environmental measures relating to emissions/ discharges to air and sea).

If SFLL is not sanctioned, the extent of the modification work at the platforms will gradually be reduced towards 2009 when, pursuant to the plans, the field will be shut down.

The plans for shutting down the field are the same as for Statfjord Late Life (section 3.8).

3.5 Selected Development Solution – Reconstruction and Modification of the Statfjord Platforms

3.5.1 Drilling and Well Operations

3.5.1.1 Drilling Operations

New wells will be drilled from each of the three platforms SFA, SFB and SFC. Drilling will start in January 2006 and continue into the production phase until 2011. In addition, existing wells will be recompleted for gas production.
Some previous water injection wells will be converted to water production with the use of ESP pumps (Electrical Submerged Pumps).

There are plans for a total of 76 wells, of which 26 will be new wells, 38 are gas and liquid producing wells that will be recompleted for lifting gas and 12 are water zone producers with ESP pumps. The drilling programme is shown in Table 3-3.

Table 3-3: Drilling programme for Statfjord Late Life

	Period (2006-2011)						**Sum**
	06	07	08	09	10	11	
New wells with gaslift	5	6	9	2	0	0	**22**
New wells excl. gaslift	1	3	0	0	0	0	**4**
Aqua zone producers (ESP)	0	0	0	1	5	6	**12**
Re-Completion of wells	14	10	6	8	0	0	**38**
Total	**20**	**19**	**15**	**11**	**5**	**6**	**76**

Drilling and drilling operations will gradually become more difficult after 2007 due to pressure relief in the reservoir. Pressure relief means that the density of the drilling fluid will have to be reduced. If the density becomes too low, the above-lying shale sections could collapse due to low hydrostatic pressure in the well. Chemicals can be added to the drilling fluid to compensate for this.

Drilling in SFLL will be carried out in the same manner as in current operations at the Statfjord platforms. There will be no drilling in the top section, since new wells will be drilled by entering the existing wells and drilling one or two sidetrack wells. This means that water-based drilling fluids will not be used, and hence no drill cuttings or water-based fluids will be deposited on the seabed. If drilling in the top section should be undertaken in exceptional cases, water-based drilling fluids will be used.

Oil-based drilling fluid will, as in the current operations, be used in the two bottom sections of the wells. Drill cuttings with adhering oil-based drilling fluid will be injected into dedicated wells in the Utsira formation together with drilling and well chemicals from the well operations.

The environmental impacts of drilling are described in detail in sections 5.1 and 6.1.

3.5.1.2 Well Completion

Drilling and well chemicals will be used for well completion. Well completion will be carried out in accordance with the drilling programme as described above.

Most of the chemicals used in connection with well completion and cleaning will be returned to collection tanks on the platform and injected into Utsira or sent ashore for recycling.

The platform’s test separator will be used during well cleaning, and residues of cementing and completion chemicals will be treated in the platform’s cleaning plant together with oily water from the wells (see section 6.1).

Scale inhibitors and scale dissolvers will be used during operation to prevent scaling and to dissolve and remove scale from the wells. The chemicals will be injected into the wells and, together with the scale, they will follow the production stream back to the platform, where they will be discharged together with the produced water.

No flaring will take place in connection with well cleaning.

3.5.2 Modifications to Existing Statfjord Platforms

SFLL will involve major modifications to and replacement of existing equipment on board the existing platforms as a consequence of the prolonged field life and to enable the platforms to handle large amounts of gas and produced water at low pressure.

It is not adequate to describe the existing platforms in detail in this document, and we have therefore only outlined what the development entails of:

1) modifications (reconstruction and minor modifications)
2) equipment groups to be replaced.

Modification work and replacement of equipment will, as mentioned before, be undertaken, partly as a result of late-life production (changed drainage strategy and low-pressure production), and partly as a result of the prolonged field life. For some of these modifications there is no clear delineation between these two categories of changes, but a rough outline of the scope of each of these two categories in SFLL is given below.

3.5.2.1 Changed Drainage Strategy – Modifications for Low-Pressure Production

In the beginning the need for rebuilding the existing production systems on Statfjord A, B and C will be limited.

However, the need for modifications will increase as the pressure is reduced. This applies specifically to Statfjord B and C, where the operational pressure will be reduced as a consequence of late-life production.

This enables phased implementation of alterations. Two operational phases have therefore been defined:

<u>Milestone 1: 01.10.2007</u>
The first modifications will be made before the start of late-life production.

The platforms’ processing systems will mainly remain unchanged, and the platforms will operate with both high-pressure and low-pressure production. Production will be limited by the capacity of the current production systems.

Milestone 2: 01.10.2009

In the period before 1 October 2009 major platform modifications and equipment replacements will be carried out as a consequence of low-pressure production on SFB and SFC.

Bottlenecks will be removed to enable the handling of large volumes of gas and produced water. This entails:

- rebuild from four-step to three-step separation of oil, water and gas,
- upgrading of internal separator components,
- reconfiguration of compressors to adapt to new operating conditions,
- upgrading of gas scrubbers (liquid separators), and
- installation of new coolers.

Low-pressure production also entails relatively extensive replacement of flowlines and manifolds due to the increase in gas speed and the consequent risk of corrosion and erosion.

Water and gas injection will be stopped, and gas lift will be installed on all the platforms to lift the gas from the reservoir to the platform. Electrical pumps (ESP pumps) will be installed in the water zone for pressure relief of the reservoir.

SFLL production entails a minimum of modifications at SFA. Statfjord A will continue to operate as it does today, with both high-pressure and low-pressure production, i.e. with a high-pressure manifold leading to a high-pressure inlet separator, and a low-pressure manifold leading to another inlet separator.

The gas that is produced in late life will be transported via the Tampen link. A more detailed description of this solution can be found in the environmental impact assessment for the gas export pipeline Tampen Link/86/. See Appendix D for a summary of the environmental impact assessment for the gas export pipeline Tampen Link.

3.5.2.2 Prolonged Life for the Statfjord Platforms

Late life entails that the life of the installations will be prolonged. In addition to an upgrading of the process systems, late-life production will also require upgrading to maintain satisfactory safety levels on the platforms, handle requirements relating to the external environment and maintain sufficient regularity.

In order to ensure a sufficient safety level, the lifeboats on SFB and SFC will be replaced and the fire alarm systems will be upgraded on all the platforms.

To meet the requirements relating to the external environment, Statfjord Late Life will expand the capacity of the CTour cleaning technology on SFC to include treatment of produced water from the SF satellites. CTour will also be upgraded for low-pressure production on all the platforms (section 6.2). The plan is to install sand-cleaning plants on the platforms by 2006 (section 6.3).

The platforms will continue to operate using the existing turbine and compressor configurations, but with fewer turbines in operation. No measures have been planned to reduce emissions to air beyond the reduction that follows from Statfjord late-life production. The assessed emission-reducing measures are discussed in detail in chapter 5.

To maintain sufficient regularity, it will be necessary to replace some of the existing equipment and auxiliary systems in the following categories:

- System for ventilation and heating
- Electrical systems
- Mechanical equipment
- Safety and control systems
- Drilling plant

3.6 Project Economics and Timetable for the Development

The capital expenditures of the project during the development phase and for a typical year in the production period are shown in the tables below.

Table 3-4: Capital Expenditure (NOK million)

Cost element	Investment
Facilities, excluding the gas export solution	7 659
Drilling and well (2006-2011)	4 121
Total	**11 780**

Table 3-5: Annual operating expenditure (NOK million)

Cost element	Operating costs
Operation and maintenance of installations in the production phase, shown for 2010 (incl. Insurance)	1 725
Average for drilling and well (2006-2010)	100
Average for drilling and well (2011-2018)	250
Total	**1 825/** **1 975**

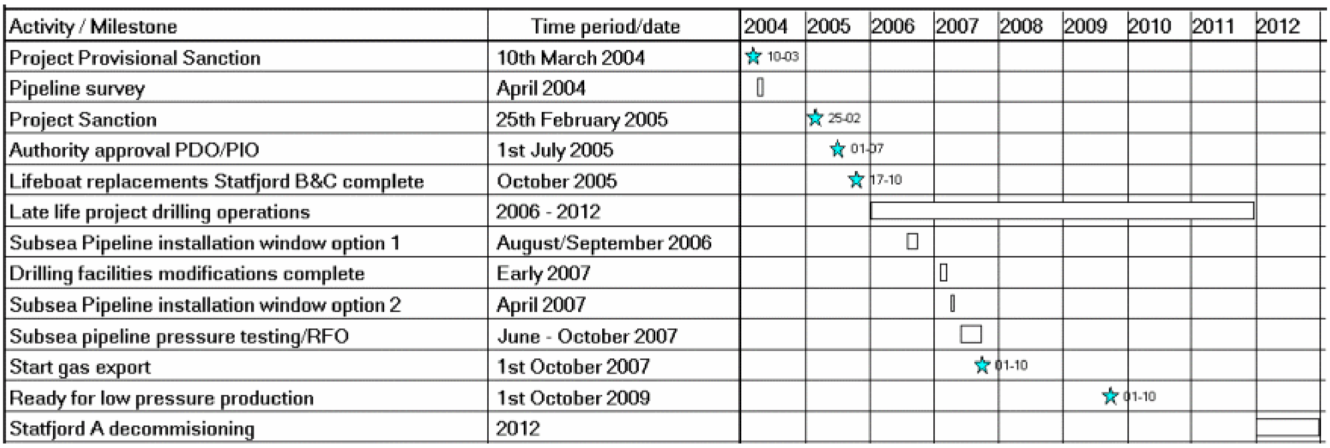
The investments controlled by the SFLL project in the development phase are considerable, approx. NOK 12 billion. The total investments in connection with SFLL are, as shown in section 9.1, approx. NOK 16 billion. [2]

The annual operating expenditures are also considerable. The operating expenditures vary during the field's life and are of approximately NOK 2 billion per year in the period 2008-2018 for all three platforms combined. The annual operational expenses will be approx. NOK 1.7 billion when SFA is closed down. The total operating expenditures for SFLL in the period 2005-2018 will be approx. NOK 26 billion.

The project has a positive present value, but its profitability is considered to be marginal.

The project is also critical in terms of time. High operating costs that are independent of production means that it is important to recover the resources fast. The timetable for the project is shown in Figure 3-4.

Table 3-4 shows the investments controlled by the SFLL project in the development phase only, while Table 9-1 in chapter 9 shows total relating to the Statfjord platforms provided that the SFLL project is realised. This means that the approx. NOK 15 billion in Table 9-1 also cover investments in the period preceding the investments controlled by the project (2004/2005). Subsequent investments of NOK 0.7 billion come in addition to this.



Activity / Milestone	Time period/date	2004	2005	2006	2007	2008	2009	2010	2011	2012
Project Provisional Sanction	10th March 2004	☆ 10-03								
Pipeline survey	April 2004	▯								
Project Sanction	25th February 2005		☆ 25-02							
Authority approval PDO/PIO	1st July 2005		☆ 01-07							
Lifeboat replacements Statfjord B&C complete	October 2005		☆ 17-10							
Late life project drilling operations	2006 - 2012			▭	▭	▭	▭	▭	▭	
Subsea Pipeline installation window option 1	August/September 2006			▯						
Drilling facilities modifications complete	Early 2007				▯					
Subsea Pipeline installation window option 2	April 2007				▯					
Subsea pipeline pressure testing/RFO	June - October 2007				☐					
Start gas export	1st October 2007				☆ 01-10					
Ready for low pressure production	1st October 2009						☆ 01-10			
Statfjord A decommisioning	2012									▭

Figure 3-4: Timetable for the project

3.7 Decomissioning

Well in advance and no later than two years before shutting down production (2018), a decomissioning plan will be submitted, including proposals for disposal of the seabed installations and pipelines. The principles to be applied and the details will be clarified with the competent authorities.

General assessments of field decomissioning methods are described in the revised PDO (part I)/FDP and PIO (part I)/PWA for the gas export pipeline Tampen Link.

4 Description of the Environmental Setting

In order to assess the potential environmental impacts of the activities associated with the Statfjord Late Life project, a description of the environment in the project's area of influence is required. This chapter contains a summary of the description of the environment. A more detailed description is given in appendix E.

The description of the environment contains an evaluation of the most sensitive natural resources and an overview of the current level of pollution. The description is based on the data currently available. No new compilation of data has been undertaken in connection with this project.

The description of the environmental setting provided in this document is more comprehensive and detailed than normally seen in field-specific EIAs for the Norwegian continental shelf. The reason for this is two-fold:

- Since the ES is subject to approval by the UK authorities (Department of Trade and Industry (DTI)), the statement includes a description of the environmental setting on the UK continental shelf, including the coastal areas of Shetland. Main data sources are UKDMAP and the Strategic Environmental Assessments (SEA) for the relevant areas.

- The Norwegian system of Regional Environmental Impact Assessments (RIA) offers a very comprehensive description of the environmental setting and hence provides the basis for substantial simplification of the documentation needed for field-specific EIAs. References to the RIA for the North Sea will not, however, meet the requirements of the UK authorities. A full description of the environmental setting on the Norwegian side is therefore provided. Where new data is available, the data on which the RIA for the North Sea was based have been updated for the project's area of influence.

The relationship of this document to the RIA for the North Sea and the Strategic Environmental Assessment system in the UK is discussed in the following.

4.1 The Project's Area of Influence

The project's area of influence is defined as an area with a more than five per cent probability of oiling in the event of an accidental oil spill from the Statfjord field, see Figure 4-1. The probability of oiling is estimated on the basis of a total of 3,600 simulations of an oil spill from the field, see also section 7. The coastal areas of eastern Shetland have been included in the area of influence, although the probability of oil reaching these areas is slightly less than five per cent.

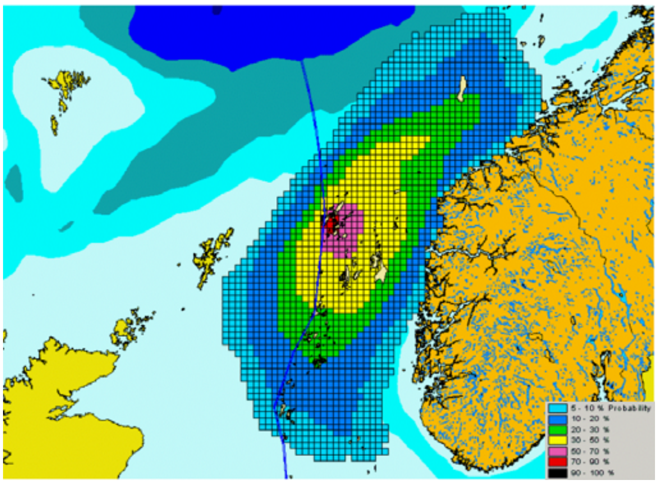


Figure 4-1: The area of influence

4.2 Regional Environmental Impact Assessment for the North Sea

A Regional Environmental Impact Assessment (RIA) has been conducted for the petroleum activity in the Norwegian sector of the North Sea. The RIA assesses the impacts of the total current and future petroleum activity south of 62 °N. The RIA comprises a series of subject reports that can in principle stand alone. The description of the environmental setting is one such subject report, which is frequently referred to in the following /98/.

The purpose of the RIA is to visualise the impacts of the total petroleum activity on the continental shelf in a better way than can be achieved by field-specific EIAs. In addition, the RIA is intended to provide a basis for simplifications in the preparation of field-specific EIAs.

The RIA is based on official forecasts for the future petroleum activity. As long as a new field development is reasonably in accordance with the forecasts employed in the RIA, the RIA will be used as a reference document for future field-specific EIAs and will normally make the assessment work significantly easier.

Since the Statfjord Late Life EIA/ES must also satisfy the UK authorities and stakeholders, a simplification of the field-specific EIA/ES documentation based on the RIA is not possible in this project. However, the RIA is used as an important source of reference.

4.3 Strategic Environmental Impact Assessment in the UK

The Department of Trade and Industry (DTI) has made a policy decision that Strategic Environmental Assessments (SEAs) must be implemented before any new licences can be awarded for oil and gas exploration and production on the UKCS. Since 2000, four SEAs have been prepared for the UKCS. The Strategic Environmental Assessment of the Mature Areas of the Offshore North Sea (SEA2) coincides with the project's area of influence, and is particularly relevant to this project. In this EIA/ES, data from the strategic environmental assessments has been used to provide a regional perspective/32/.

4.4 Description of the Environmental Setting

The biological resources and their vulnerability (appendix E) are primarily described from the perspective of an accidental oil spill. An accidental oil spill will determine the extent of the area of influence as well as the scope of the impacts on the environment and natural resources.

The description of the environment and natural biological resources is, however, also used as the basis for describing the impacts of other activities, such as discharges of produced water etc.

The North Sea is one of the world's most biologically productive ocean areas and commercially very important. High production of plankton results in a rich marine life. The North Sea is generally an important area for many species, among them species that are vulnerable to acute oil pollution.

No stable, productive eddies or frontal systems that would cause organisms to accumulate in specific areas form in the North Sea. Fish eggs and larvae are therefore distributed relatively homogenously over a large area. The transportation of fish eggs and larvae is dependent on the predominant current directions, which are largely influenced by water from the Atlantic entering the North Sea from the west and north and by the Norwegian Coastal Current flowing northward.

Due to the lack of distinct eddies/fronts, large seabird aggregations at specific fronts will not normally occur in the North Sea as they do, for example, in the Norwegian and Barents Seas, although some seabird aggregation can be observed in the North Sea as well.

The analysis area also covers the southern parts of the Norwegian Sea. Here, water from the Atlantic and the Norwegian Coastal Current both flow northward. The Norwegian Coastal Current forms eddies in the shallower waters along the Norwegian coast, and plays an important role in the transportation of eggs and larvae in this area.

The Norwegian Coastal Current with its low salinity forms more or less distinct fronts against the water from the Atlantic in the west, which is more saline and has a higher nutrient content. This results in a particularly high biological production in the area of these fronts.

As the number of daylight hours becomes longer in April and May, primary production increases, providing the basis for the growth of fish fry and seabirds. The most intense frontal processes occur where several currents converge, i.e. around the Frøya Bank, Halten Bank and Sklinna Bank. In addition, nutrient-rich Atlantic water from greater depths will rise and mix with the surface water in these areas (up-welling). These areas of the Norwegian Sea are located on the margins of the area of influence of the Statfjord Late Life project.

Most of the commercially important species of fish are present in the area of influence. Significant fishing stocks of herring, mackerel, cod, saithe, haddock, plaice, Norwegian pout and sandeel can be found in this area. The situation as regards stocks of most of these species is considered to be good and is clearly within safe biological limits. Weak recruitment and over-fishing have reduced some important species of spawning stocks, including cod, sandeel and Norwegian pout, for which record-low spawning stocks have been reported. The spawning stocks of cod and sandeel are already regarded as being below the safe biological limits, while stocks of Norwegian pout are expected to fall below the safe biological limits in 2005.

There are important breeding grounds for many species of seabird and important habitats for grey seal and common seal at the relevant latitudes on both sides of the North Sea. In the open sea areas in the northern part of the North Sea, varying numbers of foraging seabirds may be present for shorter or longer periods. Seabirds that spend much of their time on the sea's surface are most exposed to oil pollution. This applies to several species of auks in general, and to birds that cannot fly in the moulting period and younglings of particularly puffin and common guillemot that follow the adult birds out to sea shortly after being hatched.

Small numbers of whale may be present sporadically in the relevant areas. Porpoise is the most commonly observed species of whale in the open sea areas in the northern part of the North Sea.

The following are deemed to be the most sensitive biological resources in the influence area:

- Seabirds in the open sea, particularly the pelagic divers such as common guillemot, puffin, razorbill and little auk
- Fish at vulnerable life stages, i.e. the egg and larval stages
- Sensitive coastal habitats.

The resources that are most vulnerable to discharges of produced water are the early life stages of fish, i.e. the egg and larval phases.

4.5 Environmental Monitoring and Current Levels of Pollution

A description of the environmental monitoring efforts and the current level of pollution in the influence area is provided in the following.

Environmental monitoring on the Norwegian continental shelf has primarily been concerned with sediments and benthic communities, and the description given below is mainly a summary of the monitoring results.

In 1999 the monitoring programs were extended to include monitoring in the water column. A brief description of the water column monitoring is included at the end of this chapter, while a more detailed description can be found in the section on produced water (section 6.2).

4.5.1 Monitoring Program

In the past 25 years, there has been extensive oil and gas exploration and production activities on the Norwegian continental shelf. Environmental monitoring programmes for the purpose of deciding the magnitude and geographical extent of the environmental impacts of the offshore industry have been imposed since 1970.

Requirements for monitoring will normally be one of the conditions in the field-specific discharge permits issued by the Norwegian State Pollution Control Authority (SFT). The monitoring requirements are in accordance with the provisions of the Oslo-Paris Convention (OSPAR).

The surveys have traditionally been concerned with sediment sampling and analyses of the following parameters:

- grain size distribution
- content of organic materials
- content of hydrocarbons
- content of synthetic base oils
- content of metals
- analyses of benthic communities

A particularly important milestone was reached in 1996, when the Norwegian authorities made fundamental changes to the monitoring strategy. Prior to 1996, a *field-specific approach* was employed, whereby each oil field was surveyed and evaluated independently of other fields in the area. The new *regional approach* adopted in 1996 still involves sediment sampling around each installation, but includes focus on regional characteristics.

During the period from 1996 to 1998, all monitoring regions in the project's area of influence were surveyed. An overview of monitoring regions is shown in Figure 4-2. Regions I and IV were surveyed in 1996, Regions II and VI in 1997, and Region III in 1998. These surveys included a total of 87 regional and reference stations for the determination of background values, and 687 field stations for the assessment of the effects of petroleum-related activities.

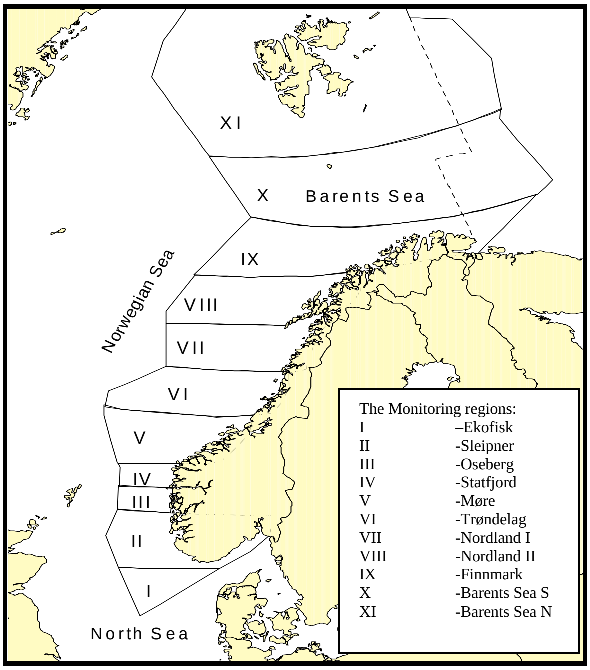


Figure 4-2: Monitoring regions

4.5.2 *Current Levels of Pollution*

4.5.2.1 Sediments and Bottom Fauna

In the following the main conclusions of the regional environmental surveys are summarised, with particular focus on the Statfjord region:

The description is mainly taken from the report "Environmental Status of the Norwegian Offshore Sector Based on the Petroleum Regional Monitoring Programme, 1996-1998", prepared for the Norwegian Oil Industry Association (OLF) in 2000 /3/.

The range of natural background levels and field-related levels of various physical, chemical and biological parameters for each of the monitoring regions are summarised in Table 4-1.

These data form the basis for determining the impacts, pollution levels and the variation in the impacts of petroleum-related activities. Due to natural variations in the levels of chemical components in the sediments and in the composition of benthic communities, it is important to understand the extent of such natural variations in order to be able to assess the impact that can be attributed to the petroleum activities.

Total hydrocarbons (THC), aromatic hydrocarbons, decalins and metals are naturally present in the sediments. Natural variations within an area are determined by the sediment type and texture. THC background levels in sediments typically vary between 1 and 30 mg/kg dry sediment.

Based on the results of analyses at stations presumed to be unaffected by industrial activities, threshold values have been established for significant contamination (LSC – Level of Significant Contamination). The LSC will vary from one geographical region to another.

Synthetic base oils such as esters, ethers and olefins used by the industry in synthetic drilling muds are not naturally present in sediments. Where these components are found in sediments, the sediments are deemed to be contaminated. The input of mineral oil from petroleum activity to the sediment gives an easily recognizable gas chromatographic pattern. Traces of most pseudo-oils are also easily detected by this analytical method.

Table 4-1: Range of values of several physical, chemical and biological parameters, 1996-1998.

Parameter	Background range*				
	Region I Ekofisk	**Region II Sleipner**	**Region III Oseberg**	**Region IV Statfjord**	**Region VI Trøndelag**
Total number of background stations	12	23	18	17	17
Depth (m)	65 - 87	71 – 123	93 – 356	115 – 330	212 – 434
Average grain size (Md)	2.5 – 3.6	1.6 – 3.9	2.6 – 9.8	1.1 – 6.1	3.0 – 6.4
Lead (mg/kg)	6.0 – 9.7	2.4 – 6.1	1.9 – 46.5	4.0 – 15.6	9.2 – 26.2
Cadmium (g/kg)	3 – 20	3 – 23	4 – 113	30 – 1800	30 – 80
Barium (mg/kg)	6 - 118	6 – 176	14 – 462	30 – 554	48 – 220
THC (mg/kg)	3.6 – 6.8	2.0 – 11.3	1.2 – 13.6	1.0 – 12.8	1.1 – 4.9
Diversity (Shannon-Wiener Index)	3.7 – 5.2	3.2 – 6.1	3.6 – 5.7	4.8 – 5.8	4.6 – 6.2
Number of species per station	65 – 87	67 – 158	52 – 139	80 – 135	41 – 133
No. of individuals per stn (0.5 m^2)	462 – 931	402 – 2744	293 – 1704	98 – 2280	127 – 631
Parameter	**Range of field stations**				
Total number of field stations	139	168	108	186	86
Depth (m)	64 – 90	78 – 126	99 – 350	112 – 340	235 – 403
Average grain size (Md)	2.5 – 3.8	2.3 – 4.1	1.0 – 10.8	0.5 – 6.3	3.1 – 5.9
Lead (mg/kg)	3.9 – 32.1	2.0 – 26.3	1.9 – 78.6	1.1 –172	12.4 – 50.3
Cadmium (g/kg)	5 –45	5 –85	4 – 289	<20 –,70	<30– 90
Barium (mg/kg)	32 – 3997	11 – 2480	11 – 4362	63 – 9100	111 – 7800
THC (mg/kg)	1.2 – 137	1.1 – 418	0.7 – 2100	1 – 5520	1.1 – 106
Diversity (Shannon-Wiener Index)	1.6 – 5.6	3.9 – 5.9	2.3 – 5.8	2.0 – 5.9	4.4 – 6.5
Number of species per station	62 – 111	54 – 173	36 – 148	38 – 147	53 – 139
No. of individuals per stn (0.5 m^2)	362 – 2488	235 – 3748	113 – 5424	59 – 4480	127 - 1024

** Background range is the range of values at the regional stations and the reference stations of the fields.*

The natural levels of metals in sediments vary with the sediment type and texture. Oilfield activities may result in elevated levels of various metals. The samples were therefore analysed for the presence of selected heavy metals such as mercury, cadmium, zinc, copper, chromium and lead. In addition to environmentally hazardous metals, the sediments were analysed for barium. Barium sulphate is used to increase the density of drilling muds, and barium is therefore an important indicator of how discharges from drilling are dispersed on the sea floor.

The species composition of the benthic communities is influenced by many factors, including the sediment characteristics and the impacts of any contamination. In undisturbed communities, the number of species present (i.e. diversity) is relatively high and the distribution of individuals per species is relatively even. External impacts in the form of physical or chemical stress factors will, if the threshold limits are exceeded, typically lead to a reduction in diversity, where some species decrease in numbers and others become more abundant. All animals present in the sediment samples are sorted by species, where possible, and the number of individuals per species is recorded. Finally, the data are processed statistically to provide an indication as to whether or not the environmental conditions around the installations are affected by the petroleum activities.

Statistical analyses combined with an evaluation of the faunal data (number of taxa and individuals, diversity indices, dominant taxa etc.) at each station, serve as basis for defining four faunal groups. A different level of impact is identified for each faunal group:

Group A: Undisturbed fauna, usually with low dominance of any one taxa and containing a wide range of taxa from different taxonomic groups. Polychaetes, molluscs, echinoderms and crustacea are among the species normally present. Taxa that characteristically appear in disturbed sediments are absent or occur in very low numbers.

Group B: Slightly disturbed fauna, generally with somewhat higher dominance of individual taxa, but still containing a wide range of taxa from different taxonomic groups. The faunal composition is slightly, but noticeably, changed compared to adjacent reference stations with equivalent natural environmental conditions. Taxa that characteristically appear in disturbed sediments, including bristleworms and molluscs, show an increase in numbers, but are not usually dominant.

Group C: Distinctly disturbed fauna, generally with higher dominance of individual taxa and a lower number of taxa (less diversity). The faunal composition is distinctly changed. Taxa indicative of disturbed sediments, including bristleworms and molluscs, dominate. Echinoderms, which are characteristic for undisturbed areas, are rare.

Group D: Highly disturbed fauna, totally dominated by small detritus-feeding bristleworms and particularly tolerant bivalves with symbiotic bacteria. Echinoderms and crustaceans are rare or absent. The bottom fauna is characterised by a low number of taxa (little diversity).

Natural variation can affect several of the faunal parameters within each group. The classification is therefore based on a holistic interpretation of the fauna. For example, at stations with undisturbed fauna, certain taxa can be present in high numbers, resulting in a lowered diversity. This applies, among others, to the bristleworms *Euchone sp., Myriochele oculata* and *Owenia fusiformis*. The distribution of these taxa has shown great variations, both in time and space, independently of the petroleum activities in the area.

The most common taxa appearing in greater abundance in contaminated/ organically enriched sediments are the bristleworms *Capitella capitata, Chaetozone spp*., *Ophryotrocha sp*. and *Ditrupa arietin* , and the molluscs *Thyasira sarsi*, *T. flexuosa* and *Lucinoma borealis*. Echinoderms, such as the brittle star *Amphiura filiformis*, decrease in abundance or disappear under such conditions.

In all monitoring regions, the proportion of the area measurably affected by petroleum activities represents far less than 1 per cent of the total offshore area, see Table 4-2. The proportion of the area in which the bottom fauna is affected ranged from 0.004 per cent in Region II to a maximum of 0.07 per cent in Region IV, and values for the THC indicator ranged from 0.01 per cent in Region VI to 0.3 per cent in Region IV.

The highest impacts are found in the older regions (I and IV), where oil-based mud was discharged before 1993.

Table 4-2: Disturbed areas compared with total area of each region

Region	Total Area of Region (km^2)*	Survey Year	Proportion of Biologically Disturbed Area to Total Area (%)	Proportion of THC Contaminated Area to Total Area (%)
Region I Ekofisk	52253	1996	0.03	0.02
Region II Sleipner	48592	1997	0.004	0.02
Region III Oseberg	17465	1998	0.02	0.1
Region IV Statfjord	17527	1996	0.07	0.3
Region VI Trøndelag	96237	1998	0.007	0.01

** Based on a calculation from the inshore basis line to the offshore boundary of the Norwegian sector, between the latitudinal boundaries set for each region by SFT.*

The Statfjord region - Region IV

The Norwegian Trench and its western slope are the dominant features in the region. The deepest part of the region has sediments with a high content of pelite (i.e. fine grained sediments). There is a correlation between high background concentrations of heavy metals and large amounts of pelite in the sediments. In these areas benthic communities are richer and more diverse than those found in the shallower areas where the sediments are coarser.

Figure 4-3 shows the monitoring stations in Region IV.

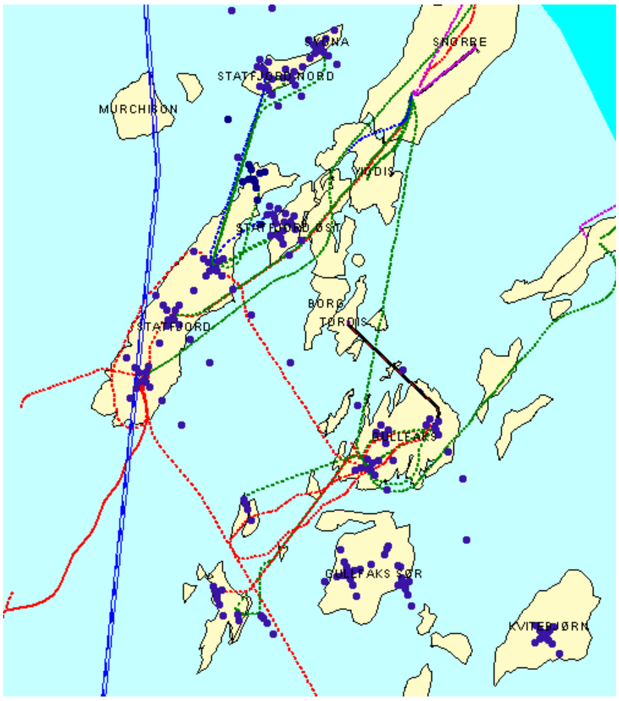


Figure 4-3Monitoring stations in Region IV

The regional survey in 1996 covered the fields Snorre, Tordis, Vigdis, Statfjord, Gullfaks, Rimfaks and Visund, in addition to 10 regional stations.

Levels of total hydrocarbons (THC) in surface sediments varied from less than 4 to 5,520 mg/kg, with the highest levels found at the stations closest to the older multi-well platforms.

Eight of 15 production units had levels below 25 mg/kg at all stations. The remaining seven units had levels above 100 mg/kg at some stations. The fauna at the regional stations was undisturbed and highly diverse. The older fields had a clearly disturbed fauna close to the platforms, although some indications of improvement from earlier surveys were detected. At five of the 15 production units, the fauna was undisturbed while at the remaining 10 units, slight to moderate disturbance was detected at the stations closest to the platforms.

Later monitoring surveys in the Statfjord region, i.e. the Regional Monitoring in Region IV in 2000 /2/, confirms the above trends, although a slight reduction in the extent of the THC contaminated areas and areas with disturbed benthic fauna can be observed. In the same report it was concluded that there is no indication of recent additions to the contents of oil components in the sediments.

4.5.2.2 Results of Water-column Monitoring

Monitoring of the water column has only been required since 1999, and has primarily been concerned with the impacts, if any, of produced water. It is difficult to interpret the data and, so far, no interpretation of the total data has been published.

For 2001, it was decided to use the impact monitoring budget to partially finance the BECPELAG project. This project includes studies of organisms collected at the field – from bacteria to fish. The results of this project and subsequent studies are further discussed in section 6.2.

On the basis of the monitoring and research results that are available so far, we can draw the conclusion that in some of the organisms studied there are weak indications of biological impacts, but uncertainty is attached to the long-term significance of these signals.

5 Planned Emissions to Air

This chapter provides an overview of emissions to air during the period 1999-2018. Current production (SF reference alternative) refers to emissions during the period 1999-2009, while Statfjord Late Life refers to the period 2008-2018. In the event that Statfjord Late Life is not implemented, the current field production will be closed down in 2009. The impacts of emissions are discussed in section 5.2.

The emission calculations take account of the measures already implemented and the measures adopted for implementation. An overview of all the emission-reducing measures that have been considered is provided in section 5.3, while the grounds for choosing the selected measures are detailed in Appendix F.

5.1 Overview of Planned Emissions

5.1.1 Assumptions underlying the Emission Calculations

5.1.1.1 Drilling and Construction Phase

The emissions from drilling and well activities in connection with power generation are included in the emissions from production, and are described in section 5.1.2

No flaring is expected to take place in connection with well completion or well cleaning. The flare boom previously used for this purpose has been removed from Statfjord and residues are routed via the test separator and into the process system (section 6.1).

5.1.1.2 Emissions during Production

Emissions in the production phase are calculated for the reference alternative and late life based on forecasts for:

- Power production
- Compression work
- Flaring
- Generation of heating media
- Emissions relating to turnarounds
- Diffuse and cold-ventilated emissions (CH_4 og nmVOC)
- Emissions of CH_4 and nmVOC during loading.

Implemented and planned measures, described in detail in section 5.3.1, are included in the calculations.

Emissions for the period 1999 to 2002 are based on annually reported data. For the Statfjord reference alternative and Statfjord Late Life, the revised National Budget 2005 has been used as basis for emissions during the period 2003-2018.

5.1.2 Emission Reductions and Emission Trends

Figure 5-1 to Figure 5-6 show emission profiles for CO_2, NO_X, CH_4 and nmVOC from the Statfjord platforms as reported during the period 1999-2002, emission forecasts for the Statfjord reference alternative during the period 2003-2009 and emission forecasts for late life during the period 2008-2018.

Figure 5-2 and Figure 5-4 also show emissions of CO_2 and NO_X in late life, broken down by platform. Figure 5-7 and Figure 5-8 show forecasts for CO_2 and NO_X emissions per oil equivalent (o.e.). The figures show the effect of measures already implemented and committed measures on Statfjord, and the effect of the reduction in emissions to air that will follow from the implementation of SFLL compared to the current emission levels.

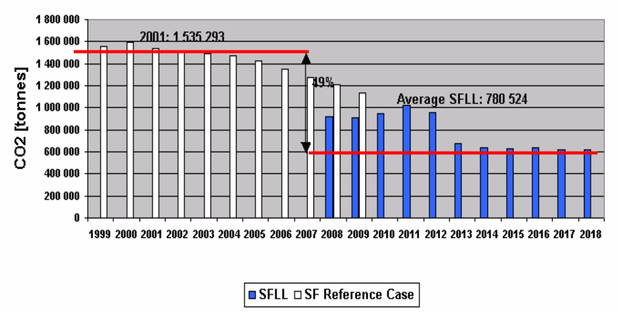


Figure 5-1: Emissions of CO_2 for Statfjord reference alternative and in SFLL

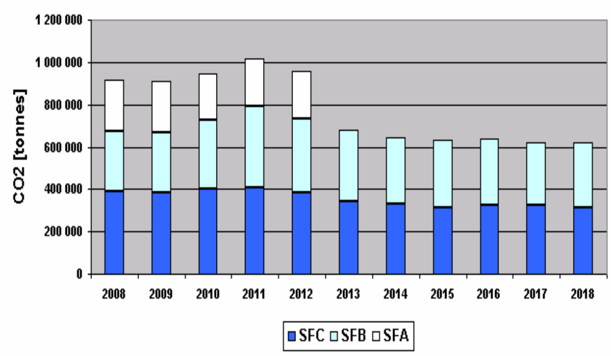


Figure 5-2: Emissions of CO_2 for SFLL per platform

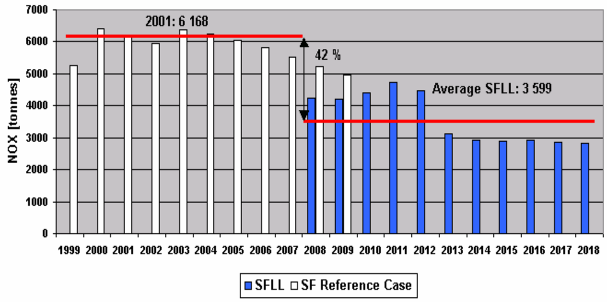


Figure 5-3: Emissions of NO_X for Statfjord reference alternative and in SFLL

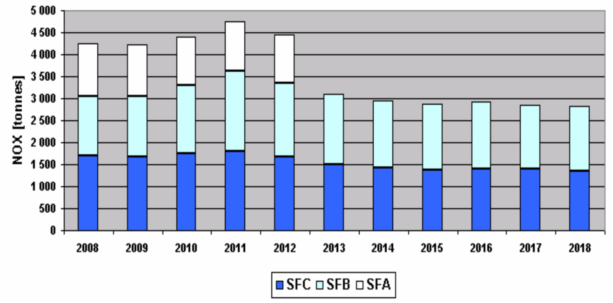


Figure 5-4: Emissions of NO_X for SFLL per platform

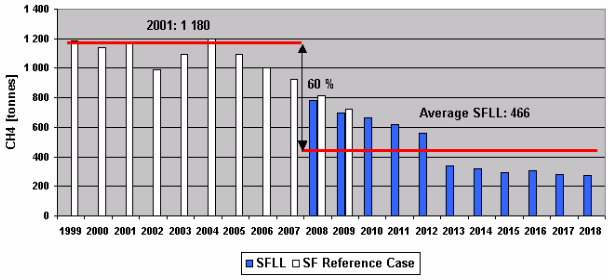


Figure 5-5: Emissions of CH_4 for Statfjord reference alternative and in SFLL

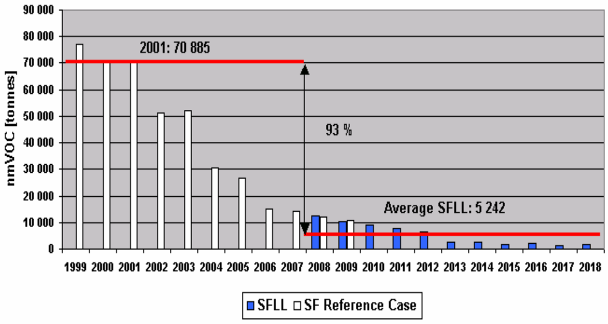


Figure 5-6: Emissions of nmVOC for Statfjord reference alternative and in SFLL

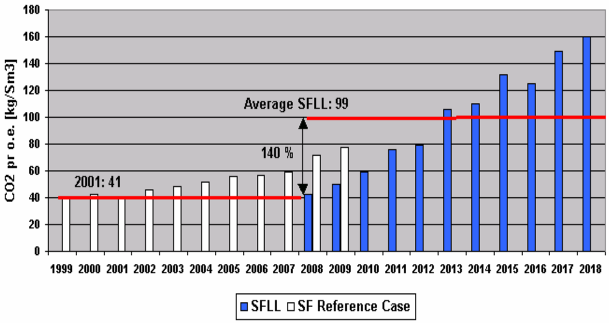


Figure 5-7: Emissions of CO_2 per o.e. for Statfjord reference alternative and in SFLL

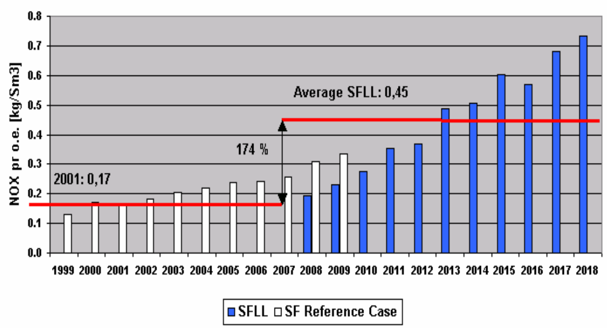


Figure 5-8: Emissions of NO_X per o.e. for Statfjord referance alternative and in SFLL

SFLL will lead to significant reductions in annual emissions compared to current emissions as a result of the cessation of seawater and gas injection and decreasing oil production. This is also the case for flaring. In 2003 a total of approx. 74 million Sm^3 of fuel gas was flared on the field. Throughout late life, the annual flaring rate will be below this level and the average flaring rate will be approx. 47 million Sm^3 of fuel gas per year.

Emissions per source during Statfjord Late Life can be broken down as shown in Figure 5-9.

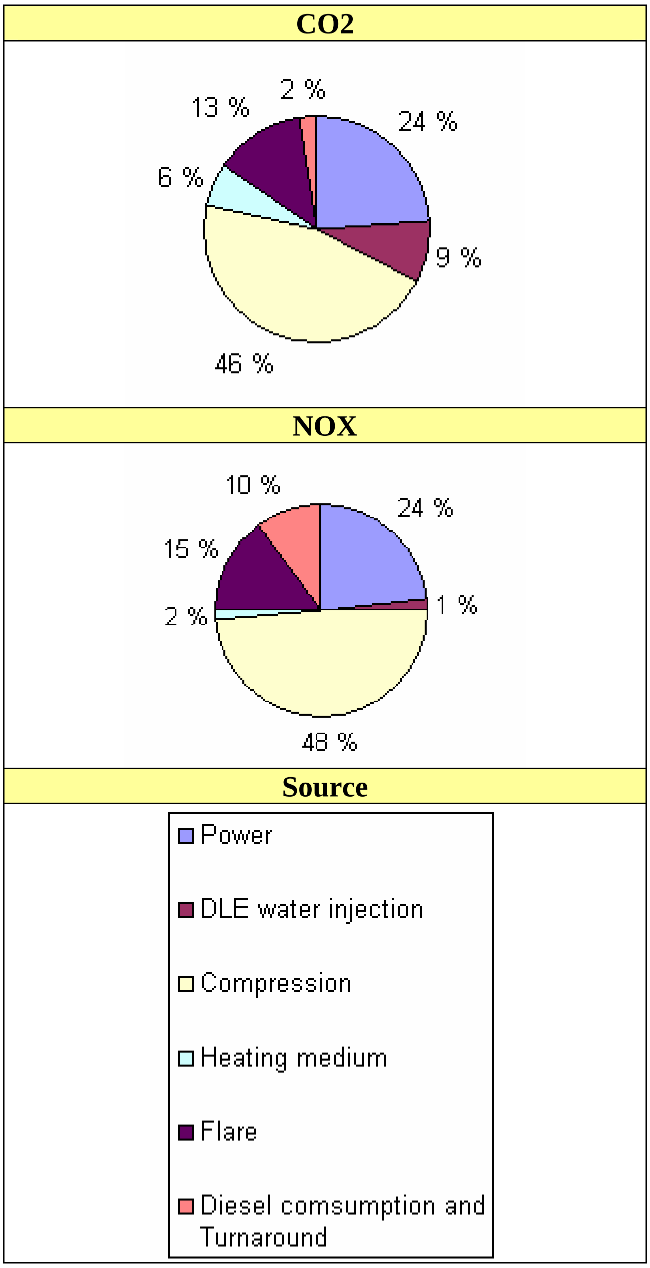


Figure 5-9: CO_2 and NO_X emissions broken down by source in late life.

Annual emissions will as a result of late life be, compared with the curren production, reduced by 49 per cent (CO_2) and 42 per cent (NO_X), respectively. The calculations are based on average annual emissions during Statfjord Late Life's production phase (2008-2018) compared with emissions in 2001 (Figure 5-1 and Figure 5-3)

VOC emissions will be reduced considerably before late life, compared to the current emissions, as a result of the installation of VOC-recovery systems on board shuttle tankers. Emissions will also be reduced in late life as a result of reduced oil production. Emissions were 77,000 tonnes/year in 2001 and approx. 50,000 tonnes/year in 2003. Emissions in late life will be reduced by more than 90 per cent compared with 2001 (Figure 5-6). Emissions of methane, CH_4, will show a downward trend in late life, compared to current production, due to reduced oil production, reduced energy requirements for power generation and compression work, and reduced flaring. The VOC-recovery systems on board the shuttle tankers are not expected to recover methane, and the reduction of methane emissions from loading will therefore be entirely due to decreasing oil production at the field. Compared with emission volumes in 2001, methane emissions will be reduced by 60 per cent during late life (Figure 5-5).

Emissions per oil equivalent will increase in late life as a result of the decrease in oil and gas production being greater than the decrease in power consumption, see Figure 5-7 and Figure 5-8. Among the reasons for power consumption not decreasing in step with production are increasing water volumes and the rising share of gas production in relation to oil production. The compression of gas for export requires considerably more energy than the export of an equivalent amount of oil.

Emission volumes for the reference alternative and late life, respectively, are shown in Table 5-1. The table also shows emissions per oil equivalent for CO_2 and NO_X.

Table 5-1 Emissions to air for the reference alternative and SFLL

Parameter	**1999-2007**			**Reference alternative (2008-2009)***			**SFLL (2008-2018)**		
	Average	Peak year	Accu-mulated	Average	Peak year	Accu-mulated	Average	Peak year	Accu-mulated
CO_2 (million tonnes)	1.47	1.60	13.2	1.18	1.21	2.35	0.78	1.02	8.59
NO_X (1,000 tonnes)	5.9	6.4	53.8	5.1	5.2	10.2	3.6	4.7	39.6
CH_4 (1,000 tonnes)	1.1	1.2	9.8	0.8	0.8	1.5	0.5	0.8	5.1
nm VOC (1,000 tonnes)	45.5	77.2	409.1	11.4	12.2	22.9	5.2	12.4	57.7
CO_2 per o.e., kg/Sm^3	49	59		74	77		99	160	
NO_X per o.e., kg/Sm^3	0.20	0.26		0.32	0.34		0.45	0.73	

*Overlap year with SFLL

As shown in Table 5-1, late life production will increase the accumulated CO_2 emissions by 6.2 million tonnes compared with the reference alternative.

5.2 Impacts

5.2.1 *Emissions at Statfjord compared with the Tampen area, the Norwegian Continental Shelf and Total National Emissions.*

Emissions from Statfjord are considerable in a national context. Figure 5-10 compares emissions of CO_2, NOx and VOC from Statfjord, the Tampen area, oil and gas activities on the Norwegian continental shelf and total national emissions. For purposes of comparison, emissioins of CO_2 and NO_x on the UK continental shelf are shown for 2001.

Emissions from the Statfjord field currently constitute something in the range of 10-15 per cent of CO_2 and NO_X emissions from the Norwegian continental shelf.

Statfjord is a part of the Tampen area, the sub-area of the North Sea that makes the greatest single contribution to emissions of CO_2, NO_X and nmVOC.

Statfjord's current share of approx. 45 and 43 per cent of CO_2 and NOx emissions from the Tampen area will be reduced to an estimated 35 per cent for both emission components in SFLL.

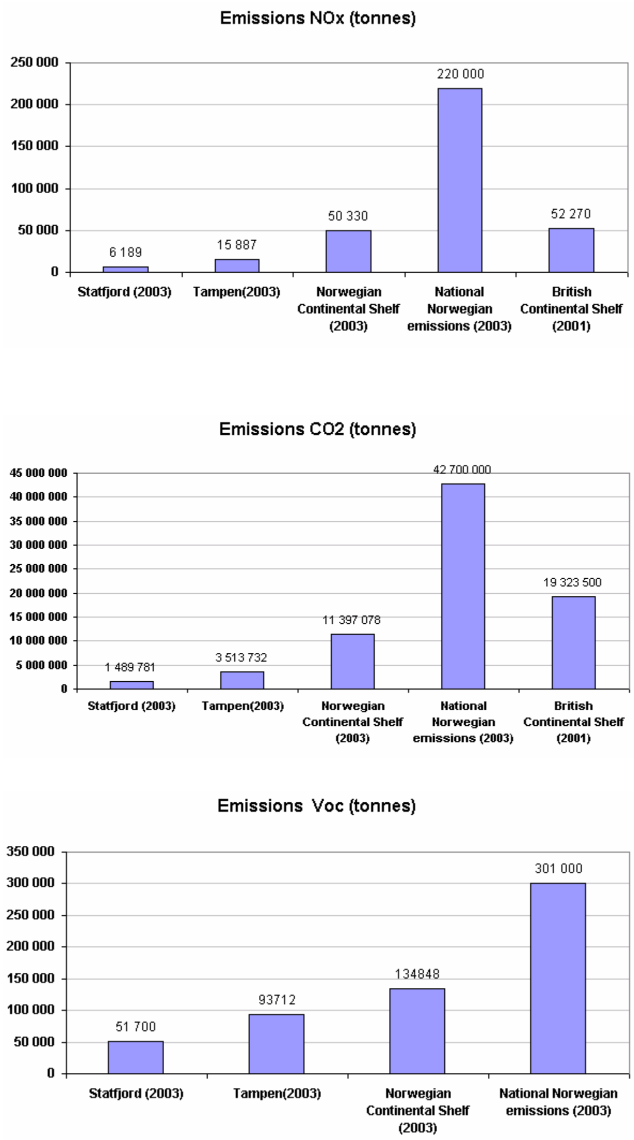


Figure 5-10: Emissions from Statfjord, Tampen, the Norwegian continental shelf and and national emissions in 2003

For NO_x and CO_2, emissions from the UK continental shelf in 2001 are also shown

5.2.2 *North Sea RIA*

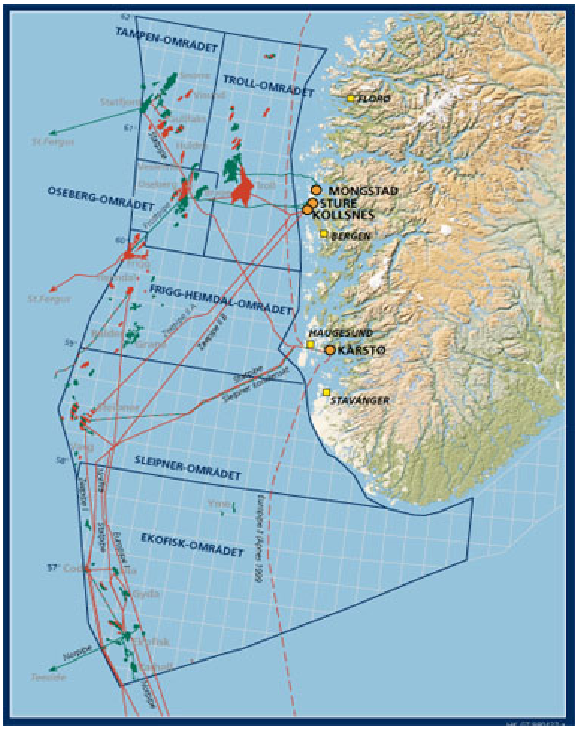


Figure 5-11: The North Sea RIA

The North Sea RIA (Figure 5-11) discusses the total impact of the petroleum activities on the Norwegian continental shelf south of 62 °N. The area is divided into six sub-areas: the Tampen, Troll, Oseberg, Frigg-Heimdal, Sleipner and Ekofisk areas /98/. The Tampen area.will cover Statfjord Late Life. The following sources of emissions and other environmental impacts are included in the RIA:

- Developed fields and fields planned for development
- All transport activity by ship and helicopter
- Infield and intrafield pipelines and major export pipelines
- Planned exploration drilling.

<u>Sub-report 2</u>
This RIA provides detailed forecasts relating to production, dischareges to sea and emissions to air during the period 1999-2015, based on the companies' reports to the revised national budget (RNB) in 1998. The companies' forecasts take account of measures adopted for implementation at the rime of reporting**.** In addition, emission forecasts for marine support services, shuttle transport, helicopter traffic and exploration

activities are also included, based on empirical figures, number of facilities and oil transport.

The RIA forecasts themselves are not directly relevant to SFLL, but they are compared with current forecasts to assess whether the emission impacts described in the RIA is applicable for the SFLL EIA.

Sub-report 5
This report discusses regular emissions to air, deposition of nitrogen and the contribution of petroleum activities to nitrogen deposition and tropospheric ozone in the area of influence. The impacts of nitrogen deposition are described in relation to tolerance limits for acidification and eutrophication, while the impacts of ozone formation are described on the basis of vegetation damage and non-compliance with air quality criteria.

The RIA may be used as the basis for a description of the impacts of emissions to air to the extent that the forecasts tally with the current forecasts for the Tampen area.

Environmental load
Total deposition of nitrogen has a clear north-south gradient-, with maximum loads furthest south, which reflects the proximity to the European continent. The contribution from the North Sea shows maximum values in Sogn og Fjordane and reflects the emissions from Tampen. In relative terms, petroleum emissions account for 10-20 per cent of the total deposition in the coastal areas from Sogn to Sør-Trøndelag. Further south in the area with the greatest environmental load, the contribution from the North Sea is small.

The contribution to ozone formation is greatest in Sogn og Fjordane and in Møre og Romsdal.

Acidification
Emissions of NO_X from the petroleum activities in the North Sea may have a certain impact on the situation as regards acidification in parts of the area of influence. The total area in which the tolerance limit for acidification of surface water is exceeded is calculated to increase by three per cent as a consequence of emissions in the North Sea. The areas in which the tolerance limit is exceeded lie between Nordfjord and Nord-Trøndelag.

Eutrophication
The main conclusion is that, seen in isolation, the contribution from the petroleum activities in the North Sea will not have any measurable eutrophication effects in Vest-Agder, the greater part of Møre og Romsdal or the Trøndelag counties. However, the contribution could affect vegetation types that have adapted to lower nitrogen levels. Rogaland is most at risk due to a high background levels, while the relative contribution from the North Sea is greatest in Sogn og Fjordane and Hordaland.

Ozone formation
The RIA concludes that, based on the available knowledge, it is virtually impossible to say how much the contribution from the North Sea to ozone exposure affects vegetation. Since the tolerance limit for plants has generally been exceeded in most places, the probability of any effects on plants is greatest where the contributions are greatest, i.e. in the coastal areas, particularly from Stadtlandet and further south.

The contribution from the North Sea will increase the number of hours in which the ozone concentration exceeds the air quality criteria of 100 μg/m. The significance of this for animal is uncertain.

5.2.3 Impacts of Emissions as a result of Statfjord Late Life

Statfjord Late Life will in itself contribute significantly to reducing annual emissions to air from the Statfjord field and Tampen area, compared with current emission levels, since power for water and gas injection will no longer be required

Annual emissions from the Tampen area in the years 2008-2018, i.e. the Statfjord Late Life production phase, will be lower than the estimated emissions in the peak year 2000, on which the environmental impact assessments in the RIA for the North Sea were based.

In the Statfjord late-life production phase (2008-2018) total NO_X emissions from all petroleum-related activities in the Tampen area will peak in 2008. The emissions in 2008 are estimated at 17,800 tonnes of NO_x/year. This can be compared with the estimated emissions of nearly 27,000 tonnes in the peak year 2000 in the RIA.

The reduction in emissions is even more marked for VOC. Annual VOC emissions from the Tampen area in 2008 are estimated at around 30,000 tonnes, while the VOC emissions in the peak year 2000 in the RIA totalled nearly 180,000 tonnes.

The Tampen area's environmental impact contribution in the form of acidification, eutrophication and the formation of tropospheric ozone in the period 2008-2018 will therefore be significantly lower than described in the RIA for the North Sea, quoted above.

Decreasing production at several of the major production units in the Tampen area will be reflected in a general trend towards lower emissions to air. The proportionate reduction in VOC emissions will be greater than for other emissions, due to implementation of efficient measures to recover VOC vapour during the loading and transport of oil.

Most of the emissions will be transported towards the Norwegian coast, and any transboundary impacts on the UK side will be marginal.

5.3 Assessment of Emission-reducing Measures

Measures have been assessed for Statfjord with and without late life production, based on:

- The authorities' framework conditions
- Available and promising technology
- Technical, operational and financial framework conditions
- Environmental benefit and cost efficiency.

5.3.1 Measures Implemented and Emission-reducing Commitments

Several emission-reducing measures have been implemented at Statfjord during the period 1999-2003, at a total cost of approx. NOK 450 million. In addition, considerable amounts have been invested in upgrading VOC systems on board shuttle tankers. The measures include:

Reduction of VOC emissions

- Reduced vapour pressure to reduce VOC evaporation at SFC
- Installation of VOC systems on board shuttle tankers

By 2005, measures will have been implemented to meet the regulatory requirements relating to storage and loading of oil and condensate using nm VOC-reducing technology. VOC-reducing technology has already been installed for some of the vessels trafficking the Statfjord field. This measure (implemented and planned equipment installation) has been taken into account in the emission forecasts for RNB 2005 and Statfjord Late Life.

Reduced flaring

- Recirculation of gas for flaring
- Reduced flaring at SFA due to condensate recovery
- Recovery of gas from produced water at SFA
- Recovery of gas from produced water at SFB (to be implemented in 2005)
- Use of nitrogen instead of hydrocarbon gas (Minox) as stripping gas in connection with water injection at SFC.

A relatively large amount of gas is flared at Statfjord. This is due to considerable degassing of produced water, and to the fact that natural gas is used as stripping gas for removing oxygen from the injection water. Flaring in connection with the degassing of produced water has been reduced, however, as a result of the recovery of this gas at SFA. Flaring is also reduced through the recirculation of gas that was previously flared. As a CO_2-reducing measure, SFC now uses nitrogen gas as stripping gas in connection with water injection.

Process and turbine optimisation

- Waste Heat recovery units (WHRU) on SFC (two) and SFA
- Optimisation of gas recompression
- One low-NO_X turbine (DLE) on SFC
- New control systems for turbines and compressors on SFA, SFB and SFC.
- New air intake filters on turbines for SFA, SFB and SFC.

Eighteen LM2500 turbines are currently installed, of which 16 are in use during normal operation. At present emissions from turbines account for around two thirds of total emissions of NO_X and CO_2.

Exhaust heat from turbines is used to meet heating requirements on SFA and SFC. SFC has a gas turbine-powered pump for injecting seawater and produced water. The gas turbine has DLE technology installed to reduce emissions of NO_X.

Degassing of produced water with recovery of gas
Degassing of produced water at Statfjord B and Statfjord C with the recovery of gas (reduced flare gas) has been assessed as an emisson-reducing measure for current production and for SFLL. A decision has been taken to implement gas recovery at Statfjord B and the late-life emission forecasts have been made on this basis.

5.3.2 Emission-reducing Measures assessed for Statfjord Late Life

Emission-reducing measures assessed for SFLL are briefly described in the following. A more detailed description of the measures, the process for selecting measures and the justification for excluding measures is provided in Appendix F.

Low-NOx turbines (DLE technology)
Studies in connection with the installation of low-NOx burner technology in the existing turbines at SFA, SFB and SFC show that the costs of this measure will be in the range of NOK 120-300 per kilo NO_X reduction. The investment costs are greater than the project can sustain.

Power cable from shore
The installation of a power cable from shore has been studied on the basis of a report by the MPE and Norway's Resources and Energy Directorate from 1997, and more recent studies of technological developments for this type of power transmission. The very high costs (estimated negative present value of NOK 5,538 million) and the low environmental cost efficiency of this measure, makes it unfeasible for SFLL. The cost of the measure is greater than the project can sustain.

Steam power plant (combined cycle)
A combined cycle power plant (CCPP) was assessed and rejected at an early stage for SFA and SFC on account of weight and space limitations, and the fact that waste heat recovery units have already been installed on these platforms. A CCPP was also assessed for the purpose of exploiting the exhaust heat from the two compressors on SFB, but it was rejected due to the high investment costs, limited environmental benefits and very low environmental cost efficiency of the measure (approx. NOK 590 per tonne CO_2 reduction and approx. NOK 770 per kilo NO_X reduction).

Intrafield power cables
Intrafield power cables is a capital-intensive measure with low environmental cost efficiency as regards both CO_2 and NO_X (approx. NOK 620 per tonne CO_2 reduction and approx. NOK 110 per kilo NO_X reduction). The closing down of SFA in 2012 and the reduction forecast in the power demand means that the environmental benefits of installing intrafield power cables will not be as great as foreseen in the EIA programme. Power coordination during the decommissioning period represents this measures' greatest contribution to reducing emissions from the field.

Waste heat recovery unit on SFB
Waste heat recovery units (WHRUs) have already been installed on SFC and to some extent on SFA. Additional installations at SFA have been assessed, but rejected on account of weight and space limitations. The installation of WHRUs on SFB has also been assessed and rejected on the grounds that the environmental cost efficiency is too low (approx. NOK 170 per tonne CO_2 reduction and NOK 140 per kilo NO_X reduction)

New electrical compressor on SFB
Due to the reduced availability of associated gas on SFB as a result of reduced oil production, the project has considered replacing 1. and 2. stage compressor with a new electrical compressor unit. This measure has so far been rejected on account of low environmental cost efficiency. The cost efficiency of the measure is still being evaluated.

STIG on SFB
STIG entails the injection of high-pressure steam into the gas turbines' combustion chambers, thereby reducing combustion temperatures and NO_X emissions in the flue gas. The installation of STIG on SFA, SFB and SFC has been assessed, but rejected – on SFA and SFC on account of weight and space limitations, and on SFB due to poor environmental cost efficiency (approx. NOK 920 per tonne CO_2 reduction and approx. NOK 23 per kilo NO_X reduction). STIG is, moreover, not regarded as qualified for offshore production.

Degassing of produced water and recovery of the gas (reduced flare gas)

Gas recovery from produced water has already been adopted as a measure for SFB. Recovery has similarly been assessed for SFC, but rejected due to low cost efficiency (approx. NOK 160 per tonne CO_2 reduction and approx. NOK 32 per kilo NO_X reduction), and because of the risk that such recovery may reduce the effect of the planned Ctour cleaning technology for produced water.

Summary

Low NO_x turbines and a power cable from shore are capital-intensive measures with low environmental cost efficiency. Both these measures are financially unviable for the project and a potential enforcement would make it impossibe to realise late-life production.

With STIG on SFB, power cables between platforms, a waste heat recovery unit on SFB, flare gas recovery on SFC and new electrical driven compressor on SFB, the reduction in CO_2 and NO_X emissions would be in the range of 2-6 per cent and 2-17 per cent, respectively, over and above the reduction in annual average emissions that follow from late life production (see Figure F-2 and Figure F-3).

Of the assessed measures, recovery of gas from produced water at SFC is environmentally the most cost efficient for both CO_2 and NO_X. The environmental cost efficiency of WHRU is relatively good for CO_2 depending on the performance indicators used to define environmental cost efficiency. The same is true of STIG with respect to NO_X. Technical challenges can have a limiting effect on the implementation of measures.

The replacement of internal compressor components will be implemented in late life as part of the modifications relating to late-life production.

The SFLL project is marginal in financial terms, and has a tight implementation plan with a high level of activity for the modifications required by the project. The project has therefore not implemented any further emission-reducing measures over and above those that have already been implemented or has been decided to implement at Statfjord.

6 Planned Discharges to Sea

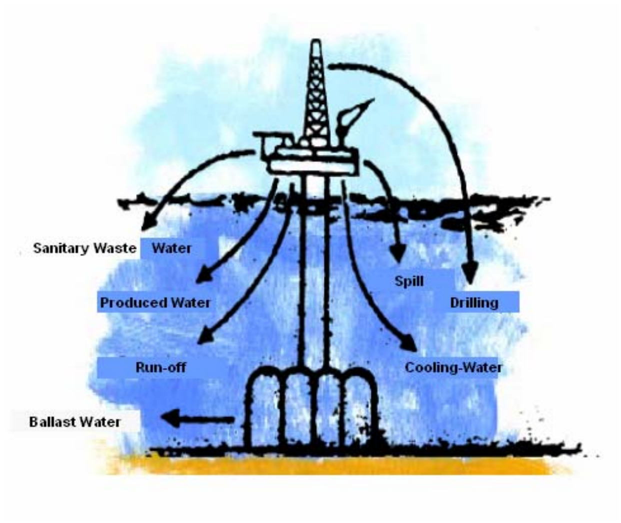


Figure 6-1: Sources of planned discharges to sea (Miljøsok, 2000)

For discharges to sea, a distinction is made between discharges in the drilling and construction phase, discharges during regular production and accidental discharges (spills). This EIA focuses particularly on the impacts of discharges from the drilling and construction phase, discharges of produced water, discharges of produced sand and the possibility of accidental spills (The impacts of discharges of sand are discussed in particular, due to the authorities' requirements relating to such discharges).

6.1 Drilling and Well Operations

6.1.1 Discharges from Drilling

As described in section 3.5.1, drilling in the top section will not normally take place, while drilling in the deeper sections will be carried out using oil-based drilling fluid. Oily cuttings will be injected into the Utsira formation together with residues of completion, gravel packing and cementing chemicals. At present approx. 66 per cent of the oil-based mud is recycled, and this will be continued during SFLL.

Table 6-1 shows amounts of injected drill cuttings and oil-based drilling fluid in the Utsira formation, calculated on the basis of the late-life drilling programme. A total of 38 wells will be recompleted during late life, and 30 of these will be drilled with short sidetracks. The injected amounts of oily cuttings have been calculated on the basis of empirical figures from corresponding well programmes in previous years.

Table 6-1 Planned amounts of injected drill cuttings and oil-based drilling fluid during late life (tonnes/year)

Year	**New wells**		**Short sidetracks**		**Total amount**
	No. of wells	**Amount injected**	**No of side-tracks**	**Amount injected**	
2006	6	5,400	14	550	5,950
2007	9	8,000	10	390	8,390
2008	9	8,000	6	230	8,230
2009	3	2,700	0	0	2,700
2010	5	4,500	0	0	4,500
2011	6	5,400	0	0	5,400

A total of approx. 35,000 tonnes of cuttings and oil-based drilling fluid will be injected into the Utsira formation over a period of six years. In connection with the injection of produced water into the Utsira formation, the possibility of local reservoir fracturing was assessed, and a certain risk of this occurring was identified. The plan was to inject a total of approx. 500 million tonnes of water during the period 2008-2018. The injected drilling mud will amount to approx. 0.035 million tonnes during the same period. The Utsira formation will have the capacity to receive these volumes without any measurable pressure build-up in the reservoir. No local pressure build-up around the injectors is expected either, based on approx. ten years of experience of injecting cuttings into the Utsira formation which accumualted represents the kinds of volumes that late life production will involve.

The amounts of chemicals used to compensate for low hydrostatic pressure in the wells will increase, but is not estimated.

6.1.2 Discharges from Well Operations

At present, cementing and completion chemicals are used in connection with well completion. This will also be the case during SFLL. These chemicals are for the most part returned to collection tanks on the platform and injected into the Utsira formation, or sent ashore for recycling.

Well completion will be followed by well cleaning to prepare the wells for production. During well testing, the platform's test separator will be used, and residues of cementing and completion chemicals will be treated together with the oily water in the platform's treatment plants.

The annual discharges of these chemicals in late life will correspond to those previously reported for Statfjord. In 2003, approx. 22 tonnes of cementing chemicals (cement) and approx. 230 tonnes of completion chemicals were reported discharged. These chemicals are classified as "green" and "yellow" in SFT's system for classification of chemicals[3] and pose little environmental risk to the aquatic environment.

Scale inhibitors and scale dissolvers will be used to prevent scale and remove the scale from the wells. These chemicals are injected into the wells and, together with the scale, follow the production flow back to the platform, where they are discharged together with the produced water.

Discharges of scale inhibitors and dissolvers are expected to increase in late life, due to increased scaling potential in the wells. The current discharges are in the magnitude of 80 and 140 tonnes for scale inhibitors and scale dissolvers, respectively. The preliminary estimates for SFLL are160 and 280 tonnes, respectively. These chemicals are classified as "yellow".

The drainage water from the platform's drillfloor will be collected and injected into the Utsira formation.

6.1.3 Impacts of Discharges from Drilling and Well Completion

Discharges of chemicals used to compensate for low hydrostatic pressure in the wells and of scale inhibitors/ dissolvers will increase in late life. It is estimated that the current discharges of scale inhibitors and dissolvers will be doubled in SFLL.

The consumption of chemicals, which will be used to compensate for low hydrostatic pressure in the wells, has not been estimated.

The chemicals used in well operations are not very harmful environmentally and the environmental impacts of discharges from the current operations are marginal. The impacts are also expected to be minor in late life.

Statoil is, however, engaged in active efforts to substitute these chemicals for more environmentally friendly chemicals, and this work will also continue in late life. A more detailed overview of the chemicals that will be used for drilling and well operations in late life, consumption, discharges to sea, recovery rates and injection into the Utsira formation, as well as mitigating measures, will be prepared as a basis for the application for a discharge permit. The extent of well cleaning, discharges and any mitigating measures will also be described in more detail.

6.2 Produced Water

This chapter provides an overview of discharges of produced water during the period 2000-2018 (section 6.2.1). The current production (SF reference alternative) refers to discharges in the period 2000-2007, while Statfjord Late Life refers to the period 2008-2018. If Statfjord Late Life is not sanctioned, Statfjord will close down production in 2009.

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[3] Chemicals are divided into groups according to their ecotoxicological properties: *Black chemicals*: chemicals for which a discharge permit is only granted in exceptional cases. *Red chemicals*: chemicals for which substitution must be given special priority in accordance with SFT's criteria.· *Yellow chemicals*: chemicals with acceptable environmental properties. *Green chemicals*: chemicals on the PLONOR list (Substances used and discharged offshore which are considered to Pose Little Or No Risk to the Environment)

The discharge calculations (section 6.2.3) take account of discharge-reducing measures already implemented and adopted for implementation on Statfjord before and during SFLL (section 6.2.2). All the discharge-reducing measures that have been considered are described. The CTour cleaning technology and injection of produced water into the Utsira formation are described in particular.

Environmental risk, fields of concentration that overlap other discharges in the region and the impacts of the discharges are described in section 6.2.4.

6.2.1 Discharges of Produced Water

6.2.1.1 Discharges from Statfjord compared with other Fields in the Tampen Area

Of the total discharges of produced water that impact the water quality in the Tampen area, an estimated 75 per cent originate from installations in the UK sector, while approx. 25 per cent can be ascribed to installations on the Norwegian side (based on figures from the North Sea RIA, 1999).

Statfjord is a mature field, with large water volumes compared with other fields.In 2003 Statfjord contributed to 52 per cent of the water volumes in the Norwegian part of the Tampen area. During SFLL, the discharges of produced water will peak in 2010, and Statfjord will contribute with 46 per cent of this.

For discharges on the Norwegian side, updated discharge forecasts are available on the basis of the figures reported to the 2004 national budget (RNB). According to these forecasts discharges in the Tampen area will peak in 2008, at just under 120 million m^3 of produced water and approx. 1,800 tonnes of oil in the produced water. For purposes of comparison, the figures in the North Sea RIA (RNB figures for 1999) showed peak discharges in 2002 with approx. 70 million m^3 of produced water and approx. 1,800 tonnes of oil. Improved cleaning technology has resulted in that oil discharges will not increase even if the water volumes increase.

SFLL will not lead to any increase in the peak discharges of produced water in the Tampen area, but the total volumes will increase over time. This is shown inFigure 6-2.

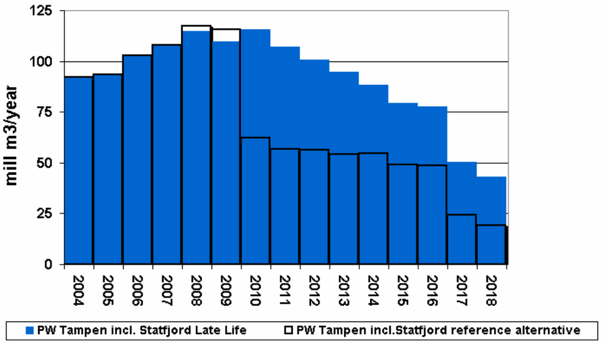


Figure 6-2: Discharges of produced water from Norwegian installations in the Tampen area.

Figure 6-3 shows total discharges (million Sm^3/year) of produced water from SFA, SFB and SFC for the SF reference alternative and planned discharges for SFLL. The planned discharges for Statfjord Late Life are slightly lower than the planned discharges for the SF reference alternative in comparable years. The annual water volumes during SFLL will not increase in relation to the reference alternative. However, production will be extended by nine years.

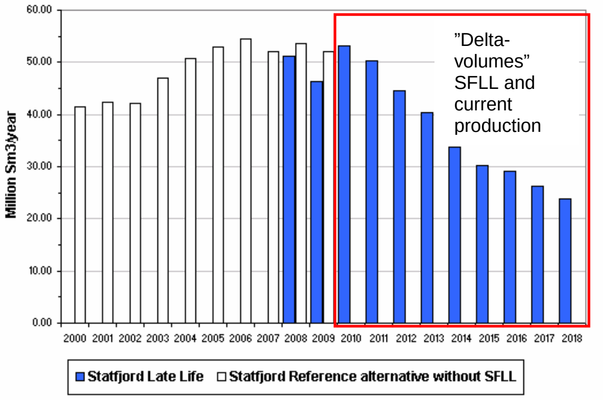


Figure 6-3: Produced water in Statfjord Late Life and the SF reference alternative (million m^3/year)

Based on the current drainage strategy and forecasts for produced water, water production in Statfjord Late Life will peak in 2010 at approx. 150,000 m^3/d. Water production will then decrease at an almost linear rate until 2018.

6.2.1.2 Produced Water if Statfjord Late Life is Sanctioned

Figure 6-4 shows the distribution of produced water between SFA, SFB, and SFC provided that SFLL is sanctioned. Discharges of produced water from SFC represent approx. one half of the water volumes being processed at Statfjord (including the SF satellites, which are processed at SFC).

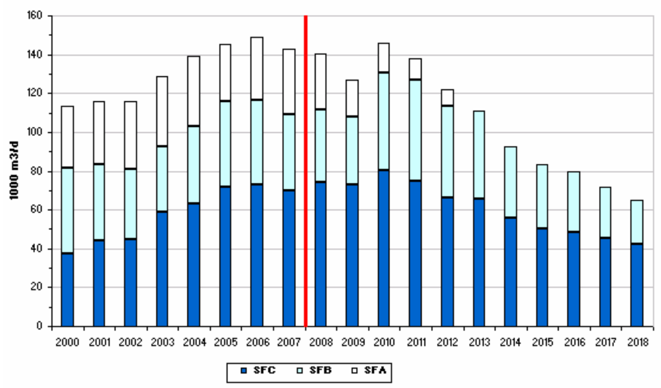


Figure 6-4: Distribution of produced water between SFA, SFB and SFC, 1,000 m^3/d.

Figure 6-5, Figure 6-7and Figure 6-8 show the forecasts for produced water at SFC, SFB and SFA. These forecasts have been used for calculating the environmental risk and the amounts of natural components discharged. As shown in Figure 6-5, the satellites account for a considerable share of the water volumes on SFC. Currently some of the produced water volumes are being reinjected at Statfjord C. Figure 6-6 shows reinjected water volumes at SFC (PWRI) and the actual volumes that are discharged to sea.

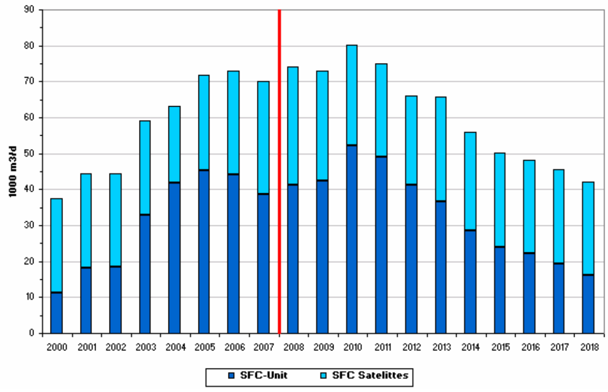


Figure 6-5: Produced water at SFC, 1,000 m^3/d

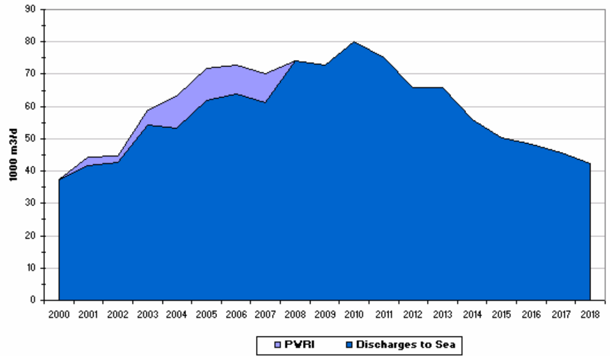


Figure 6-6: PWRI in relation to the total volume of produced water at SFC (1,000 m^3/d).

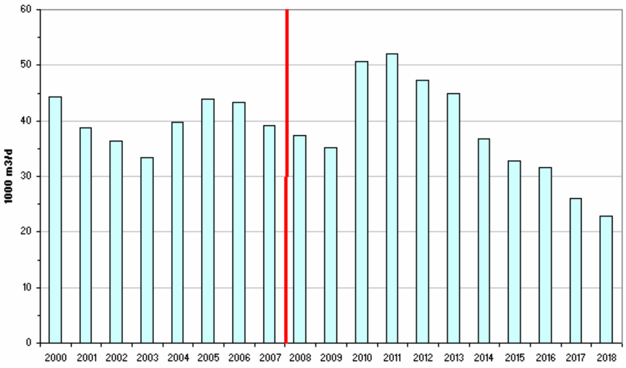


Figure 6-7: Produced water at SFB (1000 m^3/d)

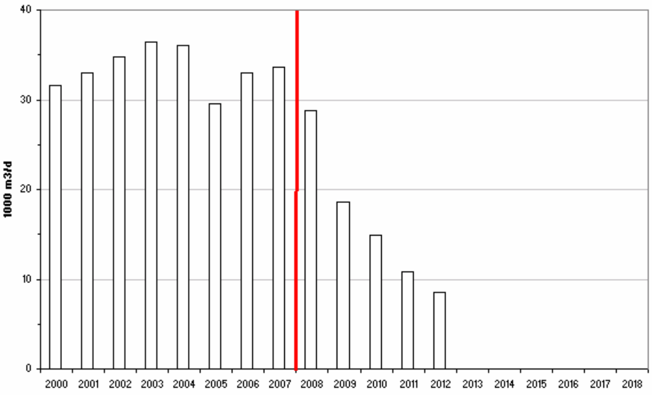
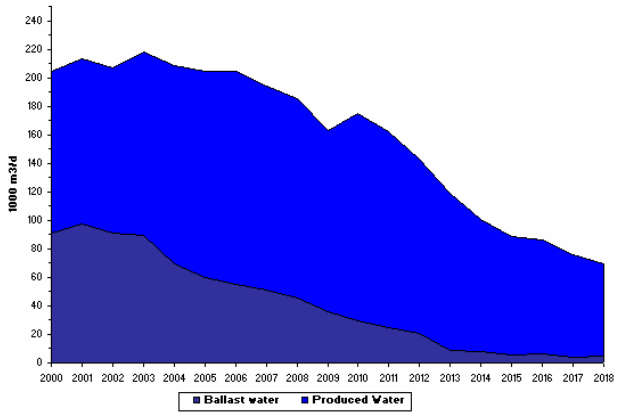


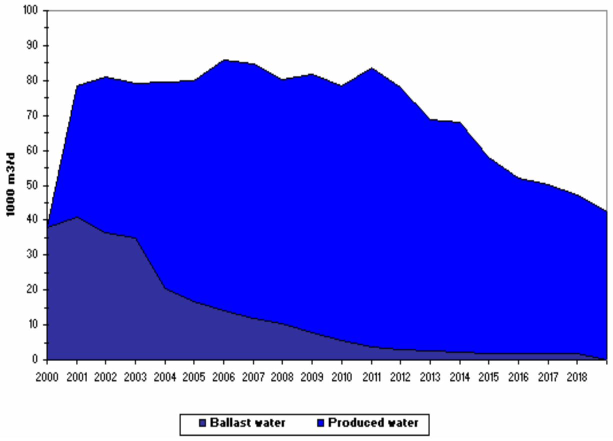
Figure 6-8: Produced water at SFA (1,000 m^3/d),

Produced water is discharged together with ballast water. Figure 6-9 shows total discharges of produced water and ballast water for all platforms, SFC, SFB and SFA. In SFLL, the ballast water volumes will decrease in step with oil production.

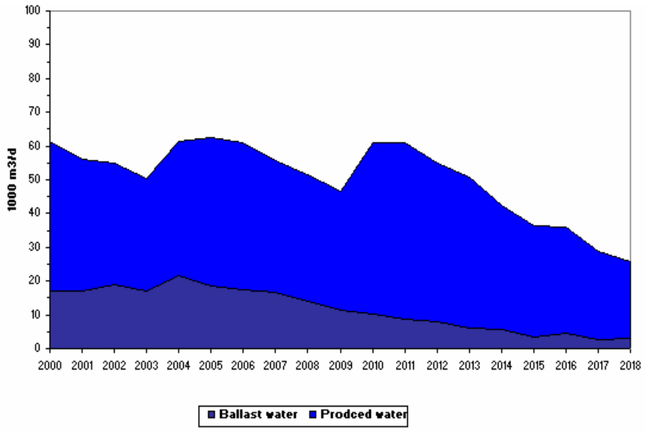
Total produced water and ballast water, all platforms



Total produced water and ballast water, SFC



Total produced water and ballast water, SFB



Total produced water and ballast water, SFA

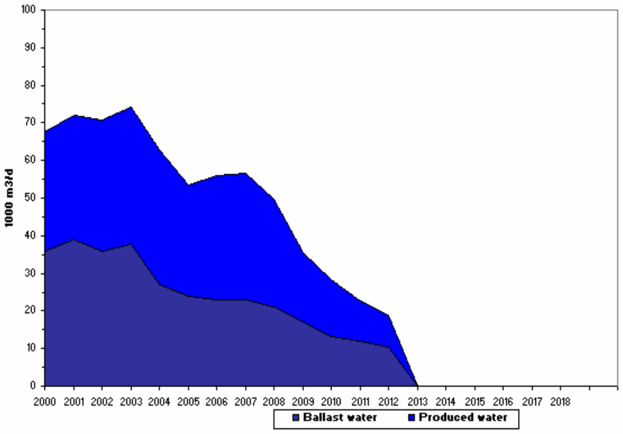


Figure 6-9: Produced water and ballast water at the Statfjord field (SFA, SFB and SFC), 1,000 m^3/d

6.2.2 *Measures to Reduce Discharges*

Several measures have been implemented at Statfjord, and it has been decided to implement further measures to reduce the environmental risk in connection with produced water. The selection of measures has been made on the basis of the authorities' and the companies' environmental policy, the available technology, the Statfjord fields' limitations/ framework conditions, environmental impacts and an assessment of environmental cost efficiency.

6.2.2.1 *Measures implemented and planned Measures to reduce Discharges at Statfjord*

The zero discharge report for Statfjord (2003) outlined the following measures/91/:

- Substitution of red chemicals (corrosion inhibitors)
- Reducing the consumption of chemicals through optimising dosing
- Optimising existing hydrocyclones
- Implementation of the new CTour cleaning technology
- Reinjection of produced water at SFC for pressure support (PWRI)

Table 6-2 shows measures implemented and measures planned for the period 2000-2005. Planned measures will be implemented in accordance with the zero discharge report, but Statfjord operations has recommended that PWRI at SFC be stopped. The recommendation has been made on various grounds, but primarily because continued PWRI will lead to an increase in H_2S production and chemical consumption (H_2S scavenger). The environmental benefit of continuing to reinject produced water at SFC would be small in relation to the increased impact of discharges of H_2S scavenger during SFLL. The grounds for stopping PWRI at SFC are described in appendix G

Table 6-2: Implemented and planned measures at Statfjord

YEAR	SFA	SFB	SFC
2000			
2001		- Replacing internal hydrocyclone components (more stable cleaning effect)	-Some reinjection of produced water -Installation of more hydrocyclones at SFC (test and second stage separator)
2002	- Replacing internal hydrocyclone components (more stable cleaning effect) -Substitution of corrosion inhibitor PK 6050 (red) with KI 3699 (yellow), effective from 2003		-Continued reinjection, but pump failure
2003	-Optimisation of produced water cleaning, including training of operators -Optimisation of chemical consumption (lower consumption)	-Optimisation of produced water cleaning, including training of operators -Optimisation of chemical consumption (lower consumption) -Substitution of corrosion inhibitor PK 6050 (red) with KI 3699 (yellow), effective from 2004	-Increased reinjection -Optimisation of produced water cleaning, including training of operators -Optimisation of chemical consumption (lower consumption) -Substitution of corrosion inhibitor PK 3698 (red) with KI 3793 (yellow), effective from 2004
2004			-CTour for low pressure, but small share of total water volumes. CTour is not expected to be fully effective before 2006 -PWRI approx. 9,000m^3/d[4]
2005	CTour will be installed within 2005 to handle all water at SFA, but is not expected to be effective before 2006	CTour will be installed within 2005 to treat all water at SFB, but is not expected to be effective before 2006	-CTour will be expanded (1 May 2005) to handle high and low pressure water from the SF C unit, but not the satellite water that is processed on SFC. CTour is not expected to be fully effective before 2006

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[4] PWRI at SFC is designed for 18,000m^3/d, but operational experience shows only 50 per cent regularity. This means that 9,000m^3/d will be injected.

6.2.2.2 *Planned Discharge Reducing Measures for SFLL*

In selecting mitigating measures for produced water for Statfjord Late Life, the project was faced with virtually the same challenges as in the current production.

The following framework conditions determined the selection of possible measures for SFLL:

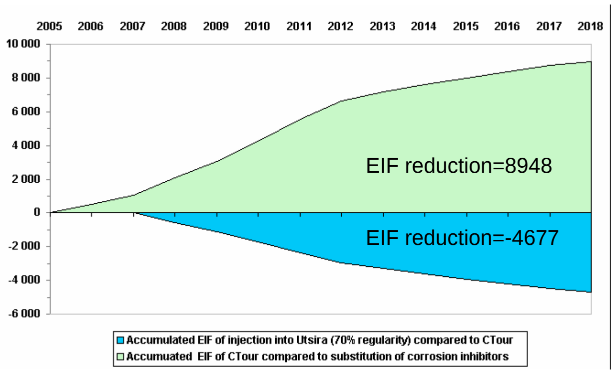
- Drainage strategy with pressure relief
- Statfjord's volumes of produced water and the composition of the water (contribution to the EIF from added chemicals versus natural components)
- Available space and weight on the existing platforms
- Technology planned for implementation before late life
- Safety
- Project economics and environmental cost efficiency
- Availability and maturity of technology
- Operational criteria

The changed drainage strategy in late life will preclude measures such as cessation of water production, downhole separation, reinjection of produced water as pressure support etc. Furthermore, the large water volumes, the composition of the produced water at Statfjord and the wish for high cleaning efficiency limited the choice of cleaning technology. The water volumes also limited the choice of technology, on account of the space and weight limitations on the existing platforms.

On the basis of these framework conditions, two measures were singled out as technically feasible for late life:

- Injection of produced water into the Utsira formation
- Modification and extension of the CTour cleaning technology for late-life production

Injection of produced water into the Utsira formation would preclude the realisation of Statfjord Late Life within economic feasibe frames. The environmental cost-efficiency of the solution is moreover very low in relation to CTour, and it would lead to an increase in emissions to air.



Cost-benefit of CTour: 50 276 (NOK/EIF) (EIF≈ 9000)
Additional cost-benefit of injection in relation to CTour: 913 139 (NOK/EIF) (EIF≈ 4700)
Cost-benefit of injection, 70% (NOK/EIF): 346 439 (NOK/EIF) (EIF≈ 13700)

Figure 6-10: Cost-benefit of CTour compared with injection into Utsira

The CTour technology will be implemented on SFA, SFB and SFC within 2005. The SFLL project plans for the following upgrades:

- preparation for low-pressure production on SFA, SFB and SFC
- preparation for treatment of satellite water on SFC
- cooling measures to increase the quantities of condensate on SFB and SFC

In addition, SFLL will continue the effort to optimise the CTour technology and seek further substitution of corrosion inhibitors as part of the project's continuous improvement work.

The injection of H_2S remover in a separate well has been assessed for SFLL. This solution has a very low environmental cost-efficiency at SFA and relatively low cost-efficiency at SFB and SFC. The project does not recommend that H_2S remover be injected at SFA or, for the time being, at SFB and SFC. The measure will be further assessed for SFB and SFC. The process of selecting measures, rejected measures (including injection of produced water into the Utsira-formation), and measures still being assessed are discussed in more detail in Appendix G. The CTour technology is described below.

6.2.2.3 CTour Cleaning Technology

The Statfjord licence has been one of the driving forces for qualification of the CTour cleaning technology to reduce the environmental risk associated with produced water. CTour is based on the injection of condensate as a coagulation and extraction medium to reduce the quantities of dispersed oil and dissolved components that exist naturally in produced water.

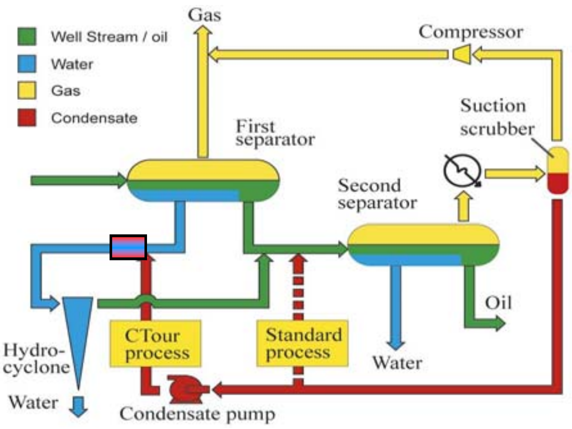


Figure 6-11: The CTour process

The CTour process builds up oil drop size (flocculation) by coagulation. Large condensate drops are injected into the water stream and remixed with it to ensure an even distribution of oil/ condensate drops. Larger drops facilitate the separation of oil and water by the hydrocyclone and increase its efficiency. The condensate also acts as an extraction medium for the dissolved components in the produced water. This applies to both hydrocarbons and process chemicals that are partly soluble in oil.

The CTour process is illustrated in Figure 6-11 and consists of the following steps:

- Harvesting of suitable condensate from the process
- Injection of condensate into the produced water
- After a certain retention time, dispersed and dissolved components will exist in the condensate phase
- The condensate, with the dissolved and dispersed oil components, is removed in a standard hydrocyclone
- The condensate, with the extracted components, is recirculated back to the production flow.

The cleaning efficiency of CTour is high and comparable for both high and low pressure production. Injection of condensate in the range of 0.5-0.75 per cent by volume is recommended for maximum utilisation of the technology.

The cleaning efficiency of CTour as a function of condensate injection, compared with cleaning by hydrocyclones alone, is shown in Table 6-3. The test figures are shaded and the estimated values based on testing are shown in italics[5].

The cleaning efficiency for the different components is used together with the condensate profiles for SFA, SFB and SFC to estimate environmental risk and discharges of natural components in produced water. The condensate profiles are shown in Appendix G.

Table 6-3: Cleaning efficiency (%) of CTour as a function of injection of condensate

	Condensate rate (v/v %)				
Component group	**0.25**	**0.37**	**0.5**	**0.62**	**0.75**
BTEX	-5	*-11*	-16	*-28*	-39
Naphthalenes	36	*42*	47	*55*	62
2-3 ring PAH	31	*36*	41	*49*	56
4-ring+ PAH	33	*37*	41	*48*	55
Phenol C0-C3	0	*0*	0	*0*	0
Phenol C4-C5	13	*17*	21	*27*	33
Phenol C6+	37	*40*	42	*51*	59
Dispersed oil	32	*33*	33	*44*	54
Corrosion inhibitor	30	*36*	41	*43*	44

The total results for dissolved natural components are particularly good compared with other technology, and the technology is efficient given the composition of the water at Statfjord (Table 6-4 and the EIF pie chart in Appendix G)[6]. CTour also

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[5] The cleaning efficiency is based on testing in the spring of 2004. The tests carried out since then indicate an even better cleaning efficiency, which is less dependent on condensate. This is caused by a secondary cleaning effect in the degassing tank after the hydrocyclone. These degassing tanks are large and have sufficient retention time for additional stripping over and above that which is achieved by removal in the hydrocyclones.

[6] In this context it should be mentioned that the increased understanding in recent years of the relationship between cleaning of dispersed oil and heavy organic components such as aromatic compounds and phenols, generally

has a good cleaning effect as regards the active component in the corrosion inhibitors used at Statfjord. The BTEX components (Benzene, Toluene, Ethylene, Exylene) in the condensate are extracted into the water, and the contents of these components in the discharge water increase as a result of CTour.

6.2.3 Planned Discharges

6.2.3.1 Composition of Produced Water

Produced water from the Statfjord platforms consists of:

- Natural components
- Added production chemicals

Added production chemicals
All production chemicals used or planned to be used in late life are approved chemicals in SFT's yellow or green (PLONOR) categories (see section 6.1.2 for a definition of the categories).

Chemicals used to prevent corrosion (corrosion inhibitors) and H_2S scavenger are the largest environmental risk contributors among the production chemicals used at Statfjord.

It has been assessed whether the consumption of corrosion inhibitors will be reduced in late life as a result of carbon steel being replaced by duplex steel, but taking everything into account, it seems that the total consumption of corrosion inhibitors will remain at the current level.

The use of H_2S scavenger will increase on all platforms during SFLL and for the reference alternative as a result of increased H_2S production. The consumption of H_2S remover at SFC will depend on whether reinjection of produced water at SFC continues until late life or if it is shut down in the course of 2004.

The consumption of H_2S scavenger and the development of environmental risk for the field have therefore been calculated for two alternatives:

a. Alternative 1: PWRI is stopped in the course of 2004 to prevent further acidification of the reservoir and thereby reduce the formation of H_2S.
b. Alternative 2: PWRI is continued until late life and will further increase H_2S at Statfjord C over and above the corresponding increase at Statfjord A and B

Figure 6-12 shows the development for H_2S scavenger for late life and for the reference alternative with and without cessation of PWRI at Statfjord C. The whole difference in the consumption of H_2S scavenger can be ascribed to the increase at SFC. The increase in H_2S scavenger is relatively large in relation to the injected water volumes. This is due to the relatively high contents of organic acids in produced water, which contribute to creating an anaerobic environment in the reservoir and to the formation of H_2S with the aid of sulphate-reducing bacteria (SRB).

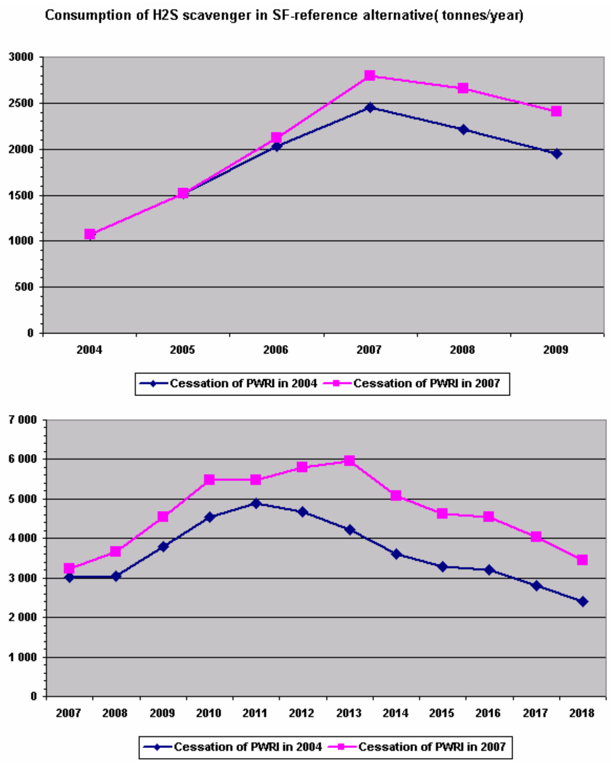

Figure 6-12: Consumption of H_2S scavenger (tonnes/year)

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shows that these substances are reduced as a result of the reduction in the quantity of dispersed oil. This is because these larger molecules have greater affinity to oil. This means that the reduction of dispersed oil in recent years, has contributed to the reduction of these other substances.

Other production chemicals used are flocculants, emulsion breakers, scale inhibitors, methanol and TEG. Flocculants are used to improve the separation properties in the degassing tanks, separators and flotation cells. Emulsion breakers are used to prevent the formation of emulsions and thereby improve oil/water separation. Scale inhibitors are used to prevent the formation of solid deposits (scaling) in the process equipment. The formation of scale, e.g. in hydrocyclones, will reduce efficiency and raise the oil-in-water level. TEG and Methanol are used as hydrate inhibitors in the gas phase and for the sub-sea frames.

The chemicals are used in relatively limited quantities, have a low toxicity, are easily degradable and do not bioaccumulate. The chemicals do not contribute significantly to the environmental risk expressed as the EIF.

<u>Natural components</u>
The most important natural components of produced water and their concentrations are shown in Table 6-4

Table 6-4: Concentrations (mg/l) in 2003 of a selection of natural components in produced water*

Components	SFA	SFB	SFC
BTEX	12.22	4.89	4.35
Naphthalenes	1.22	0.93	1.00
2-3 ring PAH	0.145	0.094	0.156
4-ring+ PAH	0.002	0.001	0.003
Phenol C0-C3	3.37	4.22	4.36
C4+ phenol/C4-C5 phenol	0.138	0.116	0.110
C6+ phenol	0.001	0.002	0.0035
Dispersed oil	13.3	14	12.4
Cu	0.004	0.004	0.003
Zn	0.001	0.001	0.001

*after cleaning in hydrocyclones

The concentrations were measured in 2003 in the discharge after cleaning in the existing hydrocyclones on the platforms. There is no basis for expecting any change in the concentration profiles for natural components in late life.

The CTour technology will reduce the discharge concentrations as a function of the cleaning efficiency shown in Table 6-3 and the condensate profiles included in Appendix G.1. The development in discharge concentrations for the different natural component groups is shown in Appendix G.2.

Ballast water discharged together with produced water contains dispersed oil, but in much lower concentrations than the produced water (approx. 1.3 mg/l). The concentrations of other components in the ballast water that are discharged together with the produced water are negligible.

6.2.3.2 Discharges of Natural Components

The amounts of natural components in produced water discharged at the field are shown below for the period 2000-2018. The calculations are based on implemented and adopted measures[7]. Reductions in discharges have been calculated for the following periods:

- 2000-2006 (Ospar's reference year – the first year following the implementation of zero discharge measures),
- 2000-2003 (Ospar's reference year – current discharges/ last reported year),
- 2000-2011 (Ospar's reference year – the year of the largest amounts discharged during late life),
- 2003-2011 (current emissions/ last reported year – the year of the largest amounts discharged during late life) and
- 2006-2011 (first year following the implementation of zero discharge measures – the year of the largest amounts discharged during late life).

The amounts of discharges are calculated for the component groups that are the greatest contributors to the environmental risk. In addition, total hydrocarbons are calculated with and without the inclusion of BTEX. Table 6-5 shows which component groups the discharges have been calculated for and which components are included in each group. For historical data (reported values) the table shows whether any of the components have been left out of the reports for any single years.

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[7] For the period 2005-2007, the discharges are shown for the event that reinjection of produced water at Statfjord C continues until late life.

Table 6-5: Overview of natural components on which the environmental impact assessment is based

Group	Components	Comments
BTEX	Benzene, Toluene , Ethylene, Xylene	
Naphthalenes	Naphthalene, C1-naphthalene, C2-naphthalene, C3-naphthalene	For the years 2000-2001, only naphthalene has been included
2-3 ring PAH	Acenaphthene, Acenaphthylene, Anthracene, Fluorene, Phenanthrene, C1-Phenanthrene, C2-Phenanthrene, C3-Phenanthrene, Dibenzotiophene	For the years 2000-2001, C1-Phenanthrene, C2-Phenanthrene, C3-Phenanthrene are not included. Nor is Dibenzotiophene included for the years 2001-2002, but constitutes only a minor contribution.
4-ring+ PAH	Benzo(a)anthracene, Benzo(a)pyrene, Benzo(b)fluoranthene , Benzo(ghi)perylene, Benzo(k)fluoranthene, Crysene, Dibenzo(ah)antracene, Fluoranthene Indeno(123cd)pyrene, Pyrene	
Phenol C0-C3	Phenol, C1 Phenol, C2 Phenol, C3 Phenol	Method of analysis changed in 2001. In 2000, Benzo acids were not distinguished from Phenolene.
Phenol C4-C5	C4 Phenol, C5 Phenol	
Phenol C6+	C6 Phenol, C7 Phenol, C8 Phenol, C9 Phenol	Included in the C4-C5 group for 2000-2001
Dispersed oil		
Metals I (Zn)	Zinc (ZN)	Representative for the metal group
Metals II (Cu)	Copper (Cu)	Representative for the metal group
TH1-Sum Total-hydrocarbons	Naphthalenes+2-3 ring PAH+4-ring+ PAH+ Dispersed oil	Excluding BTEX
TH2-Sum Total-hydrocarbons	BTEX+ Naphthalenes+2-3 ring PAH+4-ring+ PAH+ Dispersed oil	Including BTEX

The amounts of discharges are presented in more detail below, and the development of discharge concentrations for each of the component groups is shown in Appendix G.

The figures also show that the amount discharged for some of the natural components in produced water has already been reduced considerably at Statfjord as a result of the measures implemented, and that discharges of most natural components will be considerably reduced by the implementation of CTour. In Statfjord Late Life, discharges of natural components will reach a peak in 2011. In that year, the discharges will typically be 10-20 per cent higher than in the year with least discharges in the SF reference alternative (2006).

The reduction in discharges of natural components in late life will be considerable compared with the current levels (2003).

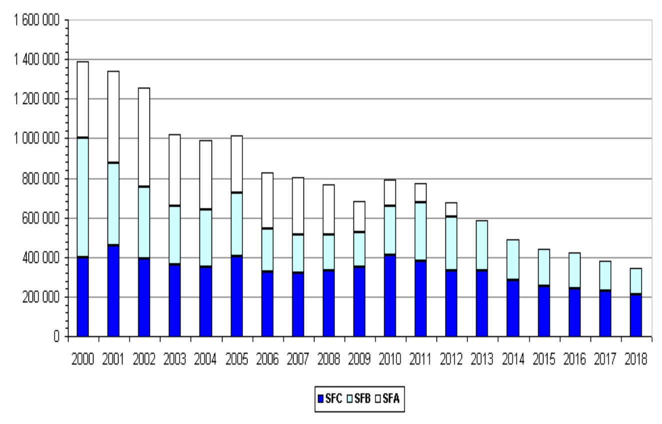
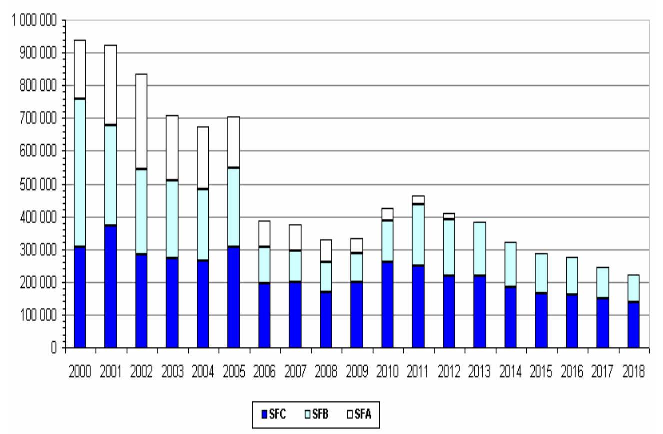
Total hydrocarbons incl. BTEX (kg/year)	Total hydrocarbons excluding BTEX (kg/year)
	
Percentage reduction (2000-2006): 41% OSPAR target (2000-2006): 15% Percentage reduction (2003-2006): 19%	Percentage reduction (2000-2006): 59% OSPAR target (2000-2006): 15% Percentage reduction (2003-2006): 46%
Percentage reduction (2000-2011): 45% Percentage reduction (2003-2011): 25% Percentage reduction (2006-2011): 7%	Percentage reduction (2000-2010): 51% Percentage reduction (2003-2010): 35% Percentage reduction (2006-2010): -20%

Figure 6-13: Discharge of total hydrocarbons (2000-2018)

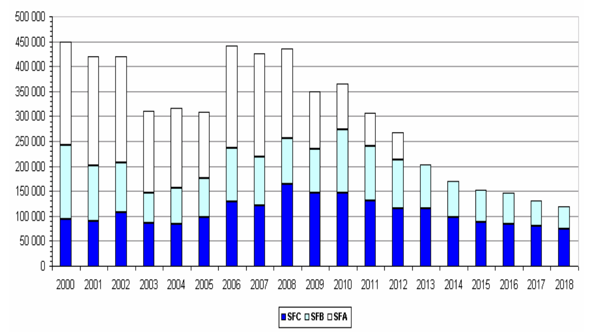
BTEX (kg/year)

Percentage reduction (2000-2006): 2% Percentage reduction (2003-2006): -42%
Percentage reduction (2000-2011): 32% Percentage reduction (2003-2011): 1% Percentage reduction (2006-2011): 30%

Figure 6-14: Discharge of BTEX (2000-2018)

Figure 6-13 shows that the discharges of total hydrocarbons at the field have been reduced considerably since the year 2000 and will with the current forecasts be reduced further. The OSPAR target of 15 per cent reduction by 2006 is a national target, but Statfjord will contribute its share. The discharges of total hydrocarbons will be reduced by approx. 40 per cent in the period 2000-2006, even if the BTEX level will increase following the implementation of CTour (Figure 6-14). The BTEX discharges will be reduced in late life compared with the reference alternative.

The development of dispersed oil concentrations in produced water is shown for the whole field for the period 1990-2020 (Figure 6-15andFigure 6-16). The concentration is much lower than the OSPAR requirement of 30 mg/l by 2006, and the field has shown a positive trend. The concentration will be further reduced following the implementation of CTour, and is expected to be in the range of 6-9.5 mg/l during late life. Discharges of dispersed oil will in late life have been reduced by 1/3 compared with 2003.

CTour has also proved able to handle peak loads and variations in oil concentrations very effectively, and an even and low concentration of dispersed oil is therefore expected.

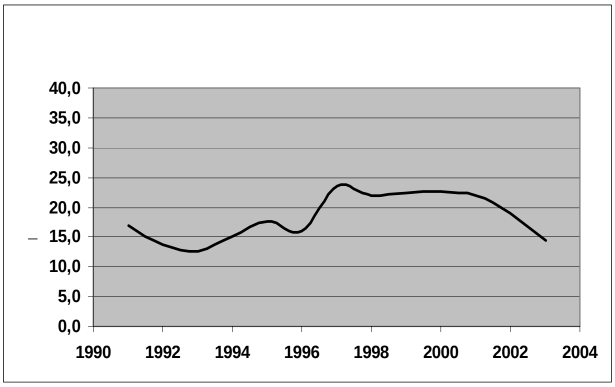


Figure 6-15: Dispersed oil in produced water (mg/l) in the period 1990-2003

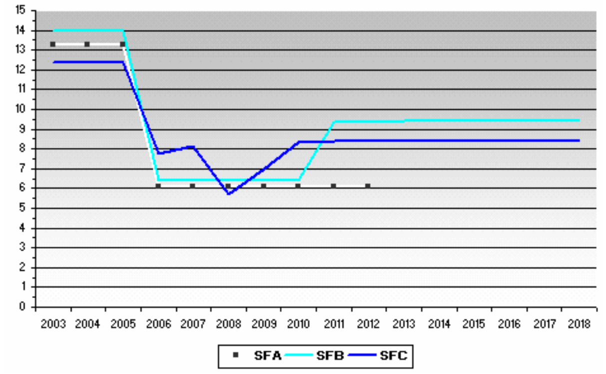
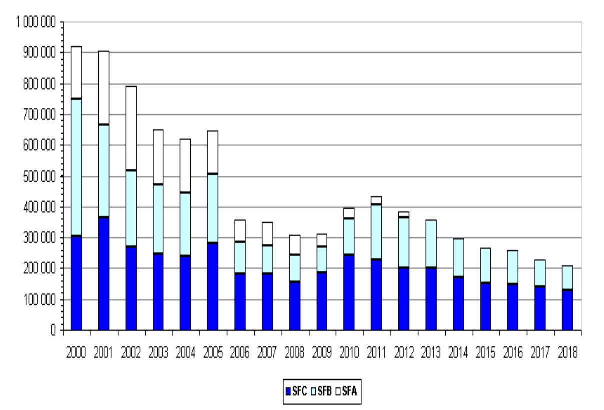


Figure 6-16: Dispersed oil in produced water (mg/l) in the period 2003-2018

As explained earlier, concentrations of dispersed oil in ballast water are much lower than for produced water. The concentration will be approx. 1.3 mg/l for all three platforms. Discharges of dispersed oil from ballast water will be reduced as a result of a reduction in the amount of ballast water

Utslippet av dispergert olje i SFSF vil være redusert med en 1/3 i forhold til utslipp i 2003, og vil være mer enn halvert sammenlignet med år 2000 (Figure 6-17).

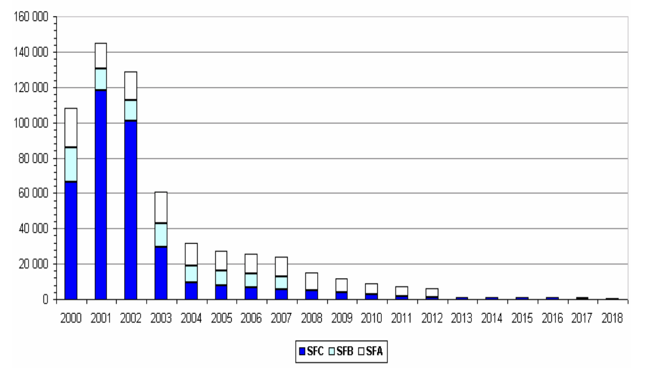
Dispersed oil from produced water (kg/year)



Percentage reduction (2000-2006): 61%
Percentage reduction (2003-2006): 45%

Percentage reduction (2000-2011): 53%
Percentage reduction (2003-2011): 34%
Percentage reduction (2006-2011): -21%

Dispersed oil from ballast water (kg/year)



Percentage reduction (2000-2006): 77%
Percentage reduction (2003-2006): 58%

Percentage reduction (2000-2011): 93%
Percentage reduction (2003-2011): 88%
Percentage reduction (2006-2011): 71%

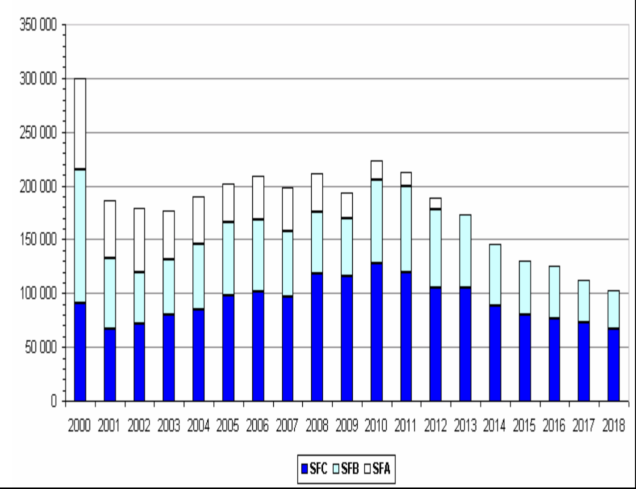
Figure 6-17: Discharges of dispersed oil from produced water and ballast water, kg/year

Discharges of C0-C3 phenols (Figure 6-18) will increase accordingly with the water volumes, and will not be reduced following the implementation of CTour.

The reduction in discharges of phenols in the period 2000-2006 is not real, but primarily reflects the development of the method of analysis (see Table 6-5). Discharges of C4-C5 and C6+ phenols (Figure 6-19 and Figure 6-20), on the other hand, will be reduced by 23 and 45 per cent, respectively, in 2006 compared with the current levels. This will be a result of the implementation of CTour. By 2011

SFLL discharges of C4-C5 will have been reduced by approx. 20 percent and C6+ phenols by 30 per cent compared with the current levels. SFLL discharges of C0-C3 and C4-C5 phenols will remain at the same level as the lowest discharge year in the reference alternative, but discharges of C6+ will increase by 25 per cent compared with 2006.

C0-C3 Phenols (kg/year)

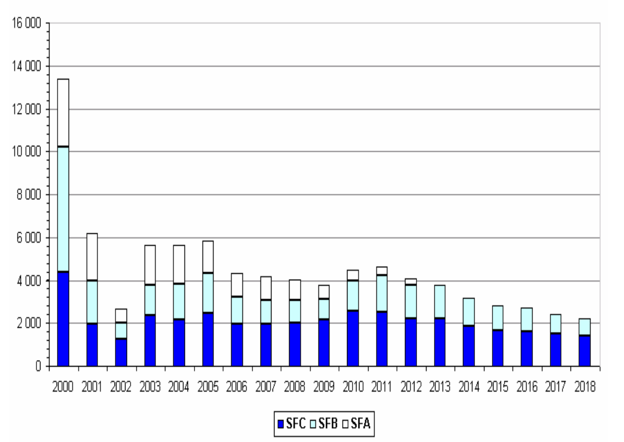


Percentage reduction (2000-2006):
Percentage reduction (2003-2006): -19%

Percentage reduction (2000-2011):
Percentage reduction (2003-2011): -21%
Percentage reduction (2006-2011): -2%

Figure 6-18: Discharges of C0-C3 phenols , kg/year

C4-C5 Phenols (kg/year)

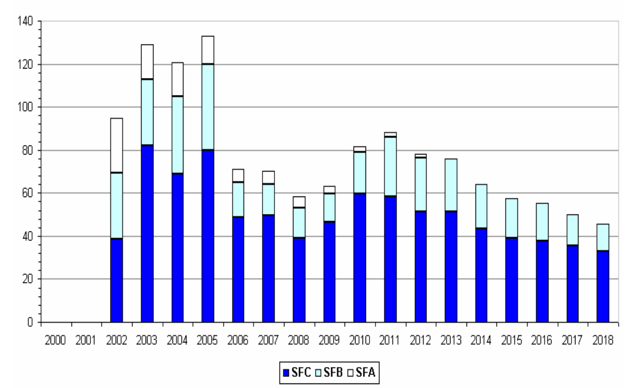


Percentage reduction (2000-2006):
Percentage reduction (2003-2006): 23%

Percentage reduction (2000-2011)
Percentage reduction (2003-2011): 18%
Percentage reduction (2006-2011): -7%

Figure 6-19: Discharges of C4-C5 phenols in kg/year

C6+ Phenol (kg/year)



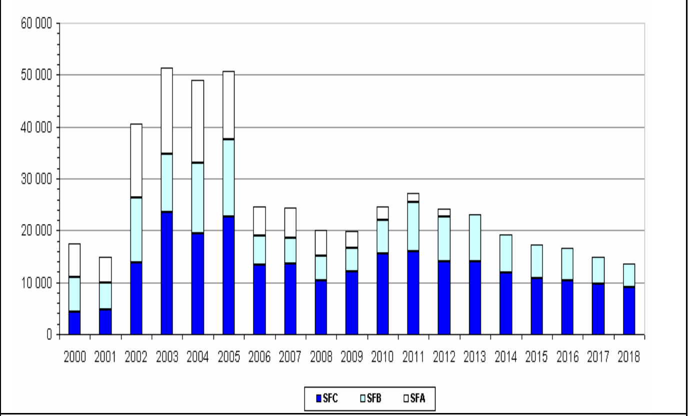
Percentage reduction (2000-2006):
Percentage reduction (2003-2006): 45%

Percentage reduction (2000-2011):
Percentage reduction (2003-2011): 32%
Percentage reduction (2006-2011): -24%

Figure 6-20: Discharges of C6+ phenols in kg/year

The increased discharges of naphthalenes and 2-3 ring PAH in the period 2000-2004 is not real, but caused by a change in the reporting routines(Figure 6-21 and Figure 6-22). The increase is also due to larger water volumes. Discharges of naphthalenes, 2-3 ring PAH and 4+ ring PAH will be halved compared with the current discharges (2003) when CTour is implemented. Discharges will increase somewhat in SFLL compared with the reference alternative, but remain considerably lower (approx. 45 per cent) in 2011 compared with current discharges (2003).

Naphthalenes (kg/year)

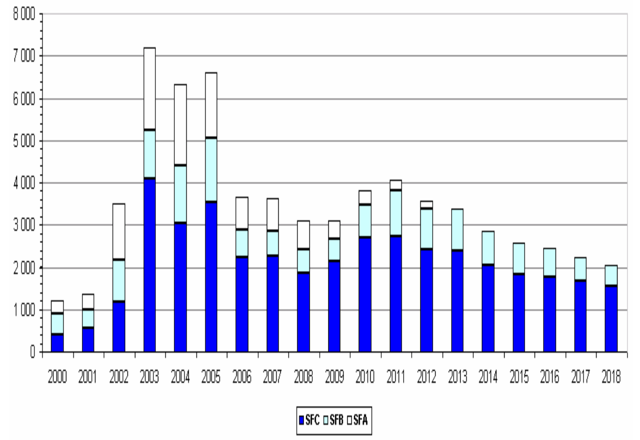


Percentage reduction (2000-2006):
Percentage reduction (2003-2006): 52%

Percentage reduction (2000-2011):
Percentage reduction (2003-2011): 47%
Percentage reduction (2006-2011): -11%

Figure 6-21: Discharges of naphthalenes, kg/year

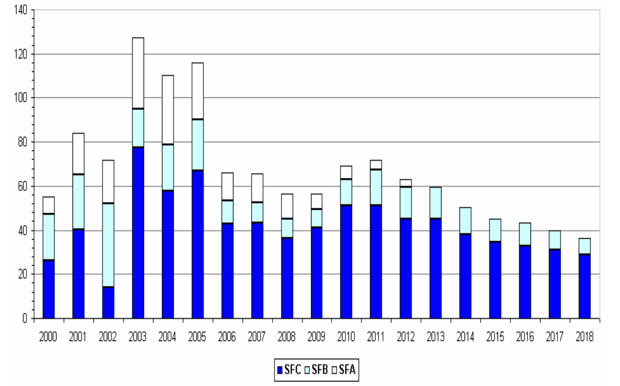
2-3 Ring PAH (kg/year)



Percentage reduction (2000-2006):
Percentage reduction (2003-2006): 49%

Percentage reduction (2000-2011):
Percentage reduction (2003-2011): 44%
Percentage reduction (2006-2011): -11%

4+ Ring PAH (kg/year)



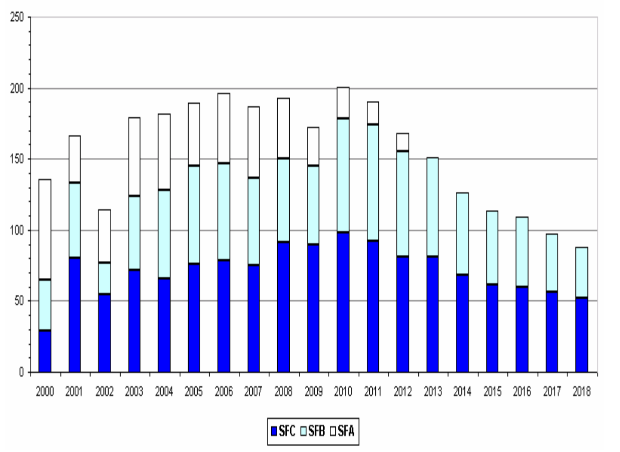
Percentage reduction (2000-2006):
Percentage reduction (2003-2006): 48%

Percentage reduction (2000-2011):
Percentage reduction (2003-2011): 44%
Percentage reduction (2006-2011): -8%

Figure 6-22: Dischrages of 2-3 ring PAH and 4+ring PAH , kg/year

The discharges of metals follow the produced water volumes and will not be ireduced by CTour (Figure 6-23). Only minor quantities of metals will be discharged, and this will not have any significant effect on the EIF. Copper, which belongs to metal group II, will only contribute around 1-2 per cent, while zinc, which belongs to metal group I, will not contribute to the EIF (see the EIF pie chart in Appendix G).

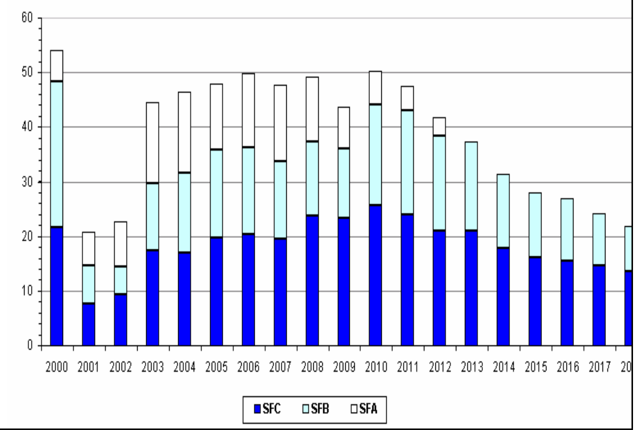
Zinc (Zn) - Metals I, (kg/year)



Percentage reduction (2000-2006): -44%
Percentage reduction (2003-2006): -9%

Percentage reduction (2000-2011): -40%
Percentage reduction (2003-2011): -6%
Percentage reduction (2006-2011): 3%

Copper (Cu) - Metals II, (kg/year)



Percentage reduction (2000-2006): 8%
Percentage reduction (2003-2006): -12%

Percentage reduction (2000-2011): 12%
Percentage reduction (2003-2011): -7%
Percentage reduction (2006-2011): 5%

Figure 6-23: Discharges of Zinc and Copper, kg/year

6.2.4 Impacts of Discharges of Produced Water

The descriptiom of the impacts of discharges of produced water for the reference alternative and Statfjord Late Life, in this section is based on:

- Environmental risk
- Environmental risk map
- Amounts of discharges of different components
- Dispersion map for some selected component groups
- Statfjord's discharges compared with other discharges
- Fields of concentration overlapping other discharges in the region
- Overview of natural resources
- Results of monitoring
- Results of research relating to short and long term effects.

6.2.4.1 Calculation of Environmental Risk - EIF

The Environmental Impact Factor (EIF) is an environmental index which quantifies the risk of environmental damage associated with offshore discharges of produced water. The EIF is also used as an aid to determine and compare the environmental benefits of one or more mitigating measures in relation to specific discharges. The EIF takes account of produced water volume, water composition (natural and added components) and dispersion of the discharge.

By determining the accumulated EIF for the field's lifecycle, discharge-reducing measures can be ranked on the basis of cost-benefit considerations. This method of calculating the EIF also makes it possible to compare discharges from different fields.

The environmental risk, expressed as the EIF, is based on a comparison between the expected actual concentration in the discharge area in question and the concentration that represents the lower impact limit for a representative selection of components in the produced water, a so-called PEC/PNEC factor. PEC=Predicted Environmental Concentration, PNEC = Predicted No Effect Concentration. The environmental risk for each component (group) is the relationship between the predicted environmental concentration (PEC) and the PNEC value. For a composite discharges the total environmental risk is calculated as the sum of the environmental risks for each component (group). When the relationship between the PEC and PNEC is calculated as being less than one for the accumulated discharges, the environmental risk to the recipient is regarded as acceptable.

The PNEC value of a substance is calculated on the basis of the most sensitive species for which impact data are available. The lowest available impact value, whether acute (EC50/LC50) or chronic (NOEC), is divided by a safety factor. The size of the safety factor is determined by the amount of the data describing the impacts and by whether data on acute and chronic effects are available. In addition, each component is weighted to take account of other effects than chronic and acute toxicity, such as degradability and bioaccumulation.

The EIF describes the water volumes exceeding a resultant (and weighted) PEC/PNEC = 1. This water volume, i.e. the model, has a geographical resolution of 100m*100m*10 m (0.01 km^2*0.01km).

A further description of the EIF and the detailed method for calculating the EIF is provided by Johnsen et al/47 / and in the EIF guidelines /71/

Figure 6-24 shows the development of the EIF. The EIF is shown as the accumulated EIF for all three platforms.

The figure shows two possible alternatives, in which:

a. PWRI is stopped to reduce H_2S production in the reference alternative and late life, and
b. PWRI is continued until late life.

Alternative a) will increase the EIF before late life, with a corresponding reduction in the EIF during late life. Alternative b), on the other hand, will contribute less to the EIF during the period 2005-2007, with a corresponding increase in the EIF during the period 2008-2018. The Statfjord operationhas recommended cessation of PWRI (see Appendix G).

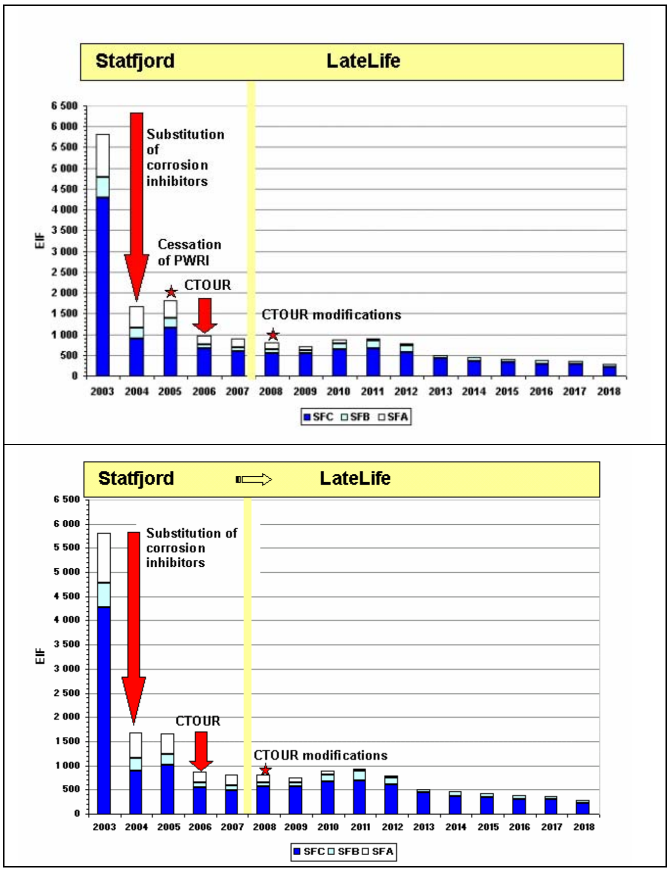


Figure 6-24: The development of the EIF at Statfjord before and after Statfjord Late Life

Above: cessation of PWRI at SFC and
Below: operation of PWRI at SFC until 2007

In an overall assessment of environmental risk, expressed as the EIF, there are small differences between cessation of PWRI in 2004 alternatively in 2007. The environmental impact assessment for produced water is the same for the alternatives a) and b).

Figure 6-24 shows a significant reduction in environmental risk at the Statfjord field compared with 2003. The figure shows a percentage reduction in EIF for the period 2003-2011 of approx. 85 per cent, and of 45 per cent in the period 2004-2011.

The environmental risk, expressed by EIF, for 2006 (lowest environmental load in the reference alternative) compared with 2011 (peak environmental load in SFLL) is relatively small and will depend on whether PWRI on SFC is continued. Alternative a) will increase the EIF by seven per cent in 2011 compared with 2006 and alternative b) will decrease the EIF by seven per cent in 2011 compared with 2006.

The risk level at the field will remain relatively stable and low during the period 2006-2012, and will vary in the range of 1000-800 EIF. The risk level will then decrease towards the end of the field's life in step with the reduction in water volumes.

The most significant decrease in the environmental risk can be ascribed to the substitution of corrosion inhibitors. The substitution of corrosion inhibitors during the period 2003-2004 will reduce the environmental risk by approx. 70 per cent. Corrosion inhibitors at SFA were mostly substituted in 2002, and substitution therefore has an even greater effect than shown.

As regards production chemicals, only yellow and green chemicals are used, which are easily degradable and do not involve any risk of bioaccumulation.

There is also a marked drop in environmental risk following the implementation of CTour in 2005. The technology gives full effect from 2006. The expansion of CTour capacity to include the treatment of water from the satellites means that the positive trend for the environmental risk will continue into SFLL.

6.2.4.2 Environmental Risk Map and Dispersion of Natural Components

Figure 6-25 shows the extent of the Statfjord field, and Figure 6-26 shows the environmental risk maps (PEC/PNEC) for SFA, SFB and SFC for 2003 and for the peak year in late life.

Figure 6-27 and Figure 6-28 show how fields of concentration which the environmental risk maps are based on is overlapping in 2003 and in the peak year in late life for SFA, SFB and SFC. The border with the UK and other installations in the area (blue dots) are shown. It is mostly areas of PEC/PNEC (0.01-0.1) that overlap, which means that the overlapping of fields of concentration between SFA, SFB and SFC will not increase the extent of areas in which PEC/PNEC > 1.

In general, the figures show that the areas in which PEC/PNEC >1 will be considerably reduced from 2003 until the peak year in late life, and that the area for which an environmental risk has been calculated is relatively limited

Dispersion of natural components that contribute the most to the EIF at Statfjord (2-3 ring PAH, dispersed oil and C4-C5 phenols). is shown in Appendix G.3 in Figure G-6 to Figure G-14.
The dispersion maps show that the area in which PEC/PNEC>1 is very limited for these component groups in 2003, is nonexistent for SFA and SFB in the peak year in late life and only exist in a marginal area at SFC in the peak year in SFLL.

The impacts of discharges of produced water and dispersion from other fields is further discussed below.

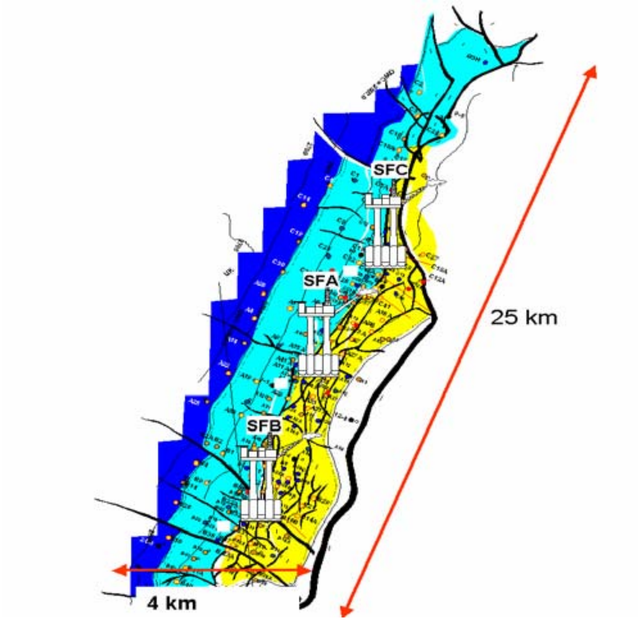


Figure 6-25: Extent of the Statfjord field

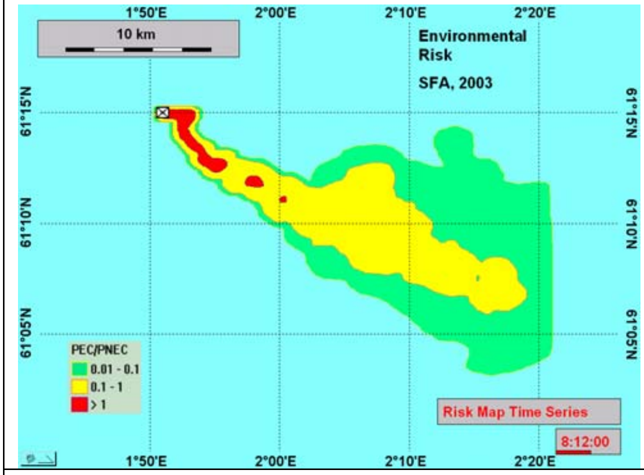
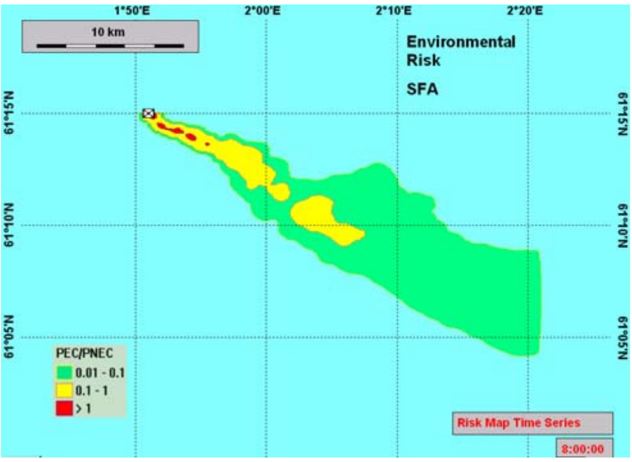
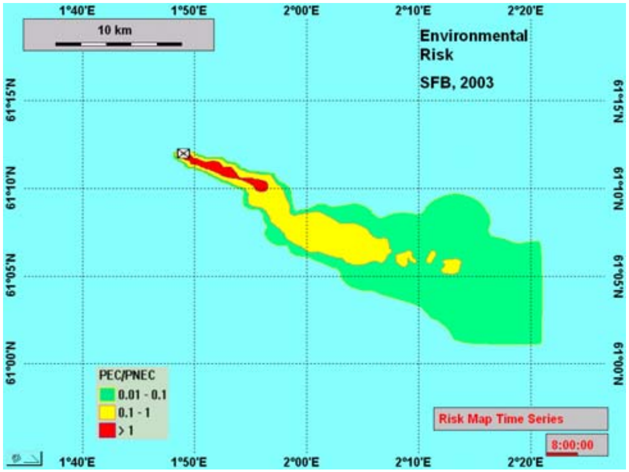
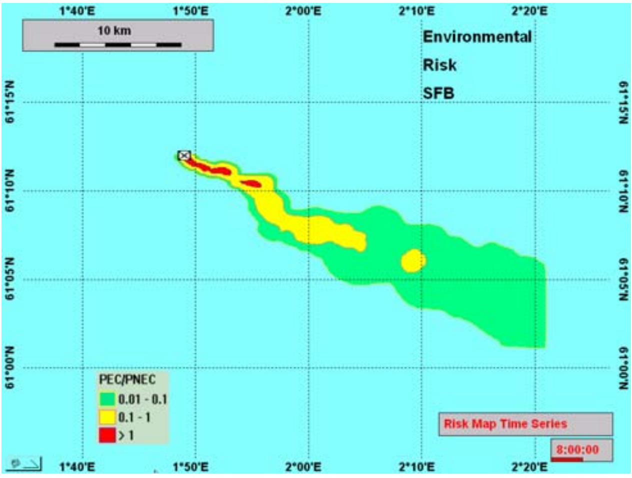
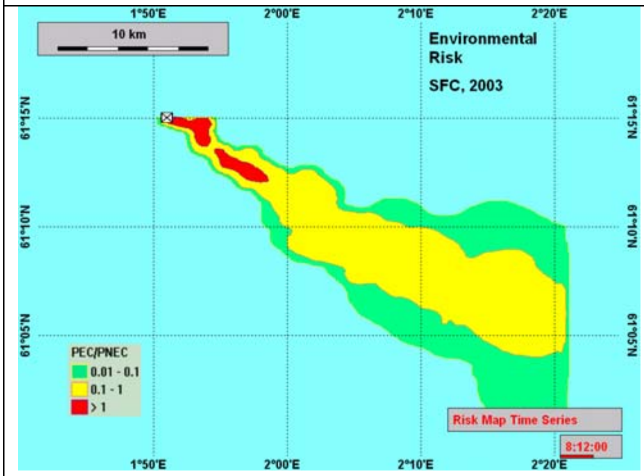
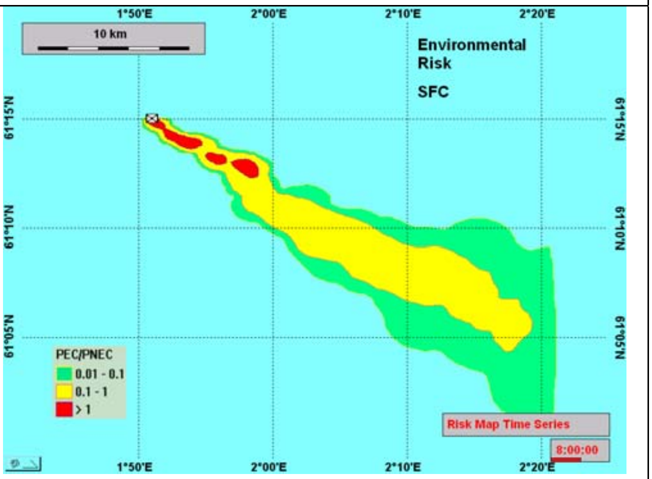
2003	Peak year in late life
	
	
	

Figure 6-26: Environmental risk maps for SFA, SFB and SFC

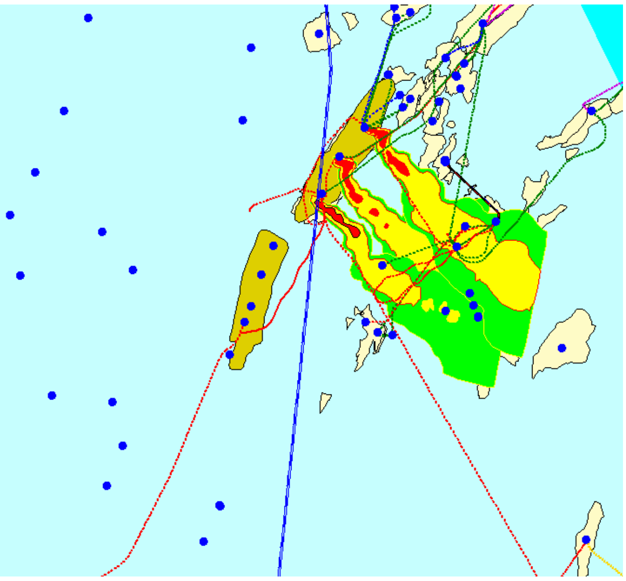


Figure 6-27: Environmental risk map for SFA, SFB and SFC with overlapping concentration fields (2003)

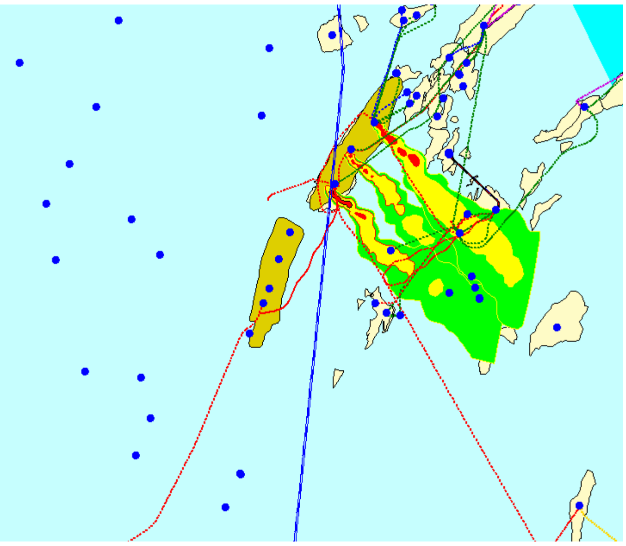


Figure 6-28: Environmental risk map for SFA, SFB and SFC with overlapping concentration fields (SFLL)

Overlapping fields of concentration in the Tampen area

To get an indication of the presence of overlapping concentration fields, model calculations were made in 2004 for discharges of natural components from produced water and ballast water from all the platforms in the Tampen area, both on the Norwegian and UK side. For discharges in the UK sector, figures from the North Sea RIA were used, while figures from the annual report 2003 were used for discharges on the Norwegian side.

The calculations showed that the currents transport discharges from the UK side to the Norwegian side relatively quickly, and potentially creating overlapping fields of concentration.

To find out whether the environmental risk is increased by overlapping concentration fields, new simulations have been run, using updated figures. For the Statfjord installations, updated discharge figures for 2004 have been used, and all components (production chemicals and natural components) in produced water and ballast water have been included. For the other fields, forecast discharges for 2004 of produced water and ballast water have been used, and the average contents of natural components from installations on the Norwegian side in 2003. Production chemicals for these fields have not been included.

For the UK installations, figures from the North Sea RIA have been used.

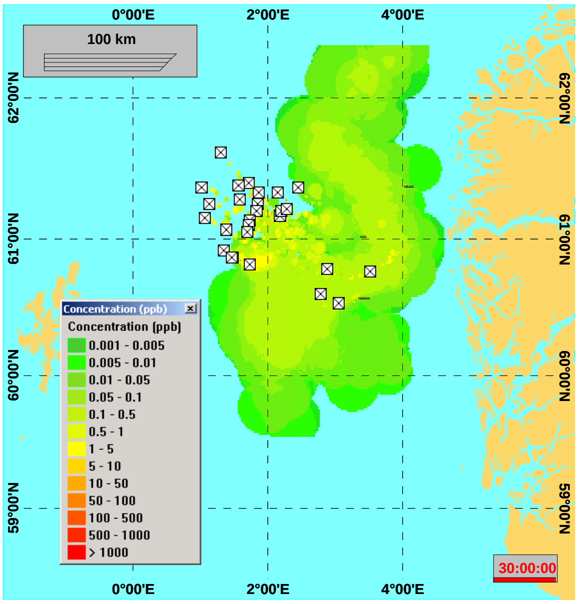


Figure 6-29: Model calculations of overlapping fields of concentration for discharges from the Tampen area

To prepare environmental risk maps simulations have been run for a 30-day period in May, and the "snapshot" showing the greatest extent of the risk area is shown (PEC/PNEC >1). The map in Figure 6-30 shows areas with PEC/PNEC values in the range of 0.01-0.1(green) and 0.1-1 (yellow), but the scale makes it impossible to view areas with values

>1. The water volume in which PEC/PNEC >1 is used for calculating the EIF.

Figure 6-31shows the overlap in environmental risk on a large scale for the Statfjord field alone. The map shows that areas with a defined environmental risk (PEC/PNEC >1) do not occur as a result of overlapping fields of concentration, but are linked to local areas near the platforms. For Statfjord C, the calculations indicate that areas with PEC/PNEC >1 could occur at a distance of up to five kilometres from the platform The EIF is calculated on the basis of the water volumes in which the PEC/PNEC value exceeds one.

Even if the discharges from the various installations in the Tampen area could potentially become mixed and create overlapping fields of concentration, these calculations show that the concentration levels in the overlapping areas will be low, and that such overlapping will not increase the environmental risk. The risk of transboundary impacts on the UK side is low.

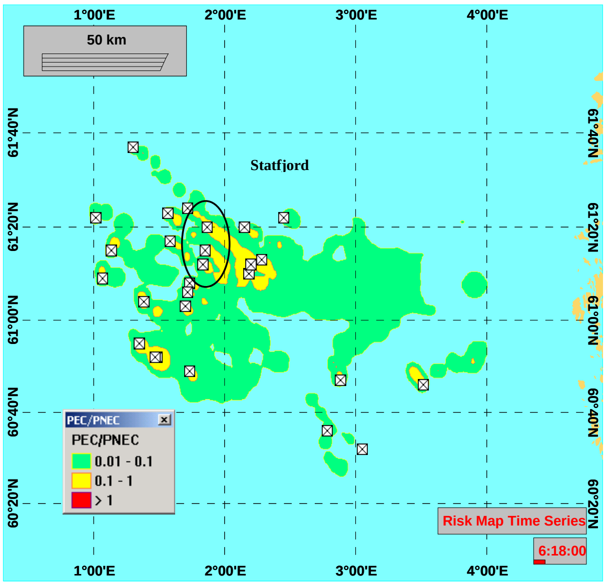


Figure 6-30: Environmental risk map, calculated for a 30-day period.

The maximum extent of areas with a potential environmental risk is shown.

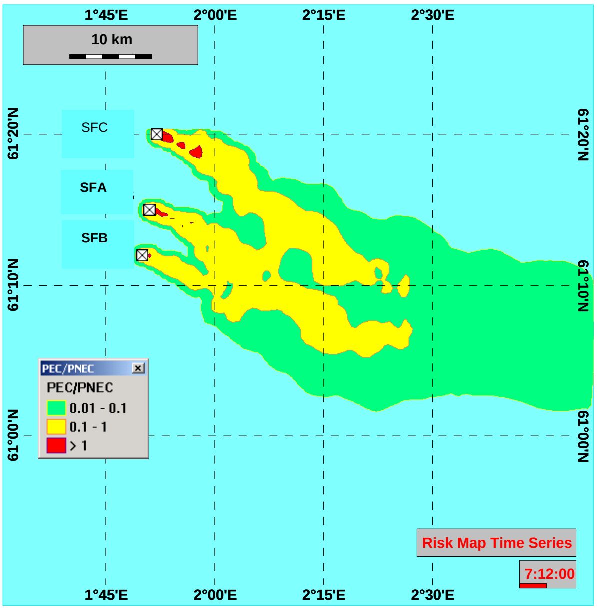


Figure 6-31: Environmental risk map, calculated for a 30-day period.

The maximum extent of areas with a potential environmental risk is shown.

6.2.4.3 *Natural Resources in the Area of Influence*

All natural resources in the area could potentially become exposed to discharges of produced water from the installations at Statfjord, but on the basis of the existing knowledge it is primarily fish at different development stages that are deemed to be vulnerable. In the Tampen area, most of the important species of fish are present, such as herring, cod, saithe, haddock, plaice, Norwegian pout, sandeel and mackerel (see chapter 4 and Appendix E).

Marine mammals and seabirds are present in the area during migration and foraging periods, but are not regarded as vulnerable to regular discharges of produced water.

6.2.4.4 *Results of Monitoring and Research relating to Short and Long Term Effects.*

Components of produced water that adhere to particles and sediments, could potentially affect benthic organisms. In the Tampen area, however, the benthic fauna has been monitored for more than 20 years, and it has not been possible to find any relationship between observed effects and discharges of produced water.

Monitoring of the sediment chemistry and benthic fauna is primarily relevant as regards discharges of drill cuttings and drilling fluids. The most recent results of monitoring in the Tampen area (1999 and 2002) show that high concentrations of hydrocarbons exist to a sediment depth of 1-3 cm. This indicates that no new mineral oil is being added to the sediments. An improvement has also been registered in the condition of benthic organisms both at Visund and Tordis and at Statfjord A, B and C. At the Statfjord locations, disturbance of the benthic fauna is more than halved since 1999.

Monitoring of the water column has been a requirement since 1999. Field studies of the Ekofisk field were made in 1999 and of the Sleipner area in 2000. Both calculated and modelled concentrations were very low in relation to the established PNEC values, and the calculated environmental risk was low, based on both approaches.

For 2001 it was decided to use the impact-monitoring budget to partially finance the BECPELAG project. This project included studies of organisms collected from the fields, ranging from bacteria to fish. No clear impact on fish larvae was registered along a transect from Statfjord B, and there were no differences in PAH metabolite levels in gall in either saithe or mackerel.

However, some tissue changes were found in the livers of herring and saithe near the Statfjord B platform and, correspondingly, experiments with cages showed some changes in the liver mass in mussels. In cod, a clear gradient was found in PAH metabolites. These parameters are regarded as biomarkers, and changes can in general be interpreted as early signs of pollution. It is often difficult, however, to interpret such bio-markers, and in the BECPELAG workshop this was particularly difficult since it was the first time such surveys were being carried out in the North Sea.

The BECPELAG workshop was followed up by new biomarker surveys in 2003, in which cages were set out in close vicinity to the Troll B platform. These surveys showed only negligible changes in mussels and cod. This could be related to the fact that the amount of produced water is significantly less from Troll B than from Statfjord B. New results from corresponding experiments at Statfjord B in 2004 will be available in 2005.

Based on the monitoring results so far, we can draw the conclusion that weak indications of biological effects are present in some of the organisms studied, but the possible significance of these signals in the long term is uncertain.

The Norwegian Institute of Marine Research’s laboratory experiments in which cod were exposed to different concentrations of C_4+ alkylphenols in feedstuffs showed, among other things, reduced oestrogen levels in female fish, reduced testosterone levels in male fish and tendencies to heightened vitellogene levels in male fish. Vitellogene is an egg yolk protein, not normally found in male fish.

The finds raise questions as to whether the results may be valid under natural conditions as well, and if so, whether there is a risk of adverse effects on population levels. Myhre, Baussant et al (2004) have assessed the risk of population impacts occurring as a result of endocrine effects of the impact of C_4+ alkylphenols in connection with discharges from Statfjord in 2002 and 2006, respectively/ 65/. These assessments concluded that there is no significant risk of such impacts on the populations. The cleaning of produced water using CTour effectively removes the relevant alkylphenols, and discharges are reduced compared with current levels, even though there is an increase in the discharged volumes of produced water.

Laboratory experiments have shown that polar PAH compounds can have a harmful effect on the DNA molecule, cause deformities, inhibit growth and increase mortality in fish, and the possible biological effects of such compounds are receiving more attention than previously. Fish eggs and larvae are assumed to be potentially the most vulnerable organisms. Some research remains to be done concerning the impact of these compounds in connection with discharges of produced water in the North Sea, and how these compounds are affected by the cleaning processes on the platforms/26/.

In general, exposure to high concentrations of BTEX components can have an anaesthetic-like effect, slowing down the functioning of organisms. In many organisms, this effect seems to disappear when they are re-exposed to water with lower concentrations. In fish larvae and zoo plankton, such exposure may temporarilty reduce the ability to avoid predators, which may in turn increase the mortality rate /26/.. There is no documentation to indicate that discharges of produced water at Statfjord will give rise to any such effects.

6.2.4.5 Summary of the Environmental Impact Assessment

In late life, the environmental risk, measured as the EIF, will have been reduced by 85 per cent since 2003, and over the field's life, it will be equal to or lower than that associated with the reference alternative. The period of discharges will however be extended as a result of extending the field's production phase beyond the Statfjord reference alternative.

Statfjord Late Life will cause the concentrations of several of the potentially most environmentally damaging components of produced water to be considerably reduced compared with current levels, and thereby further reduce the probability of negative effects.

The Tampen area has some overlapping fields of concentration as a result of many discharges of relatively large volumes of produced water in close vicinity to each other. It has been shown that these overlapping areas have low concentrations of components and that the overlapping does not contribute to increased environmental risk.

Discharges of C_4+ alkylphenols will be significantly reduced as a result of cleaning with CTour. In relation to the current levels, discharges will be reduced by 20-30 per cent in late life. On this basis and based on the assessments made by Myhre, Baussant et al /65/, there is reason to believe that, in SFLL, the risk of endocrine effects on fish will be significantly reduced and there will be no risk of significant impacts on fish populations.

With the concentrations calculated for the Statfjord area, there is not considered to be any probability that fish populations will be affected by PAH. Considering that the PAH compounds will be reduced by approx. 50 per cent in relation to current levels, the risk of any damaging effects will clearly be reduced further in Statfjord Late Life.

6.2.5 Discharges and Impacts of Naturally Occurring Radio-active Components

This section discusses the impacts of radioactive components discharged together with the produced water.

6.2.5.1 Dissolved Radioactive Compounds in Produced Water

Concentrations and discharges

Both uranium and thorium occur naturally in various concentrations in the rock bed. These substances cause the formation of the radium isotopes ^{226}Ra and ^{228}Ra. Radium is more soluble in the formation water than both uranium and thorium, and it will therefore seep into the formation water and be transported upwards through the production equipment. The radioactive isotope ^{210}Pb is also present in the sea and it originates from atmospheric fall-out and from decomposition of the ^{226}Ra already present in the water /100/.

A summary of existing data on produced water and radioactivity was made in 2002 and is presented in the report ”Produsert vann og radioaktivitet – sammenfatning av eksisterende data” (“Produced water and radioactivity – a summary of existing data” – in Norwegian only.) (Strålberg et al., 2002.) The report concludes that the typical concentration of radioactivity in produced water is in the range of 3.8-4.8 Bq/l for ^{226}Ra and in the range of 2.1-4.2 Bq/l for ^{228}Ra /101/.
Table 6-6 shows measured concentrations of the radium isotopes ^{226}Ra and ^{228}Ra and the lead isotope ^{210}Pb in produced water at Statfjord between September 2003- January 2004.
Table 6-7 shows discharges of these radium nuclides.

Table 6-6: Contents of ^{226}Ra, ^{228}Ra and ^{210}Pb in produced water, Bq/litre

Isotope	SFA*	SFB*	SFC*	SF* satellites
^{226}Ra	<0.32	0.76	0.98	2.77
^{228}Ra	0.27	0.42	0.91	2.43
^{210}Pb	<0.54	<0.62	<0.55	<0.6
Annual discharges of prod. water (2003)	13.5 million m³	12.2 million m³	13.0 million m³**	8.6 million m³**

*Average values of five sets of measurements between September 2003 and January 2004

**Discharges to sea of produced water from SFC + satellites amount to 21.6 mill. m³ (≈60% from SFC and ≈40% from the satellites).

Table 6-7: Total annual discharges (billion Bq) of ^{226}Ra, ^{228}Ra and ^{210}Pb from Statfjord*

Isotopes	SFA	SFB	SFC	SFC Satellites	Total
^{226}Ra	4.32	9.27	12.74	23.82	50.15
^{228}Ra	3.64	5.12	11.83	20.90	41.49
^{210}Pb	<7.29	<7.56	<7.15	<5.16	<27.16

The average content of ^{226}Ra for Statfjord is 1.06 Bq/l, which at present is generally lower than for other fields (see the abovementioned summary by Strålberg et al., 2002).

The original formation water (not influenced by injection water/ seawater) at the Statfjord field contains 5-6 Bq/l of the isotope ^{226}Ra. This content has gradually been reduced as the wells started producing a mixture of seawater and formation water. Some of the wells at the main field are now producing 70-90 per cent seawater. This is also reflected in the content of ^{226}Ra, which is less than 1 Bq/l at the main field. The produced water from the Statfjord satellites contains approx. 2.77 Bq/l. This water contains approx. 50% seawater. This corresponds well with the original content of 5Bq/l of ^{226}Ra.

The contents of ^{226}Ra and ^{228}Ra in the produced water from the Statfjord field, and from the Statfjord satellites in particular, is above the level naturally present in seawater and causes increased levels locally at the discharge points for produced water.

Impacts of discharges

The natural content of ^{226}Ra in seawater varies a lot and depends on the proximity to the coast. The range of variation is 0.001-0.01Bq/l. There have been many studies of naturally occurring radioactivity in seawater, but few data exist about the North Sea.

In 2002, the seawater around the Gullfaks platforms and Sleipner A and T was sampled to measure the content of ^{226}Ra. The samples were taken in the main current direction from the platforms, at different depths. The radioactive content in discharges of produced water measured in becquerel at Gullfaks corresponds to that of Statfjord, and the measurements made at the Gullfaks platforms are therefore assumed to be representative for discharges of radioactive components from the Statfjord platforms as well.

Corresponding seawater samples from the Egersund Bank were used as reference (unaffected by discharges from the petroleum industry). The purpose of the study was to determine whether an increase in the radium content could be detected in the samples taken from the sea currents around the platforms. The results of this study show that the content of ^{226}Ra in the seawater surrounding the platforms is at the same level as in the seawater at the Egersund Bank (ref. unpublished report from the Norwegian Radiation Protection Authority, 2004, /102/)

- Gullfaks: 0.0009-0.0016 Bq/l (+/- 0.0002)
- Sleipner: 0.0012-0.0016 Bq/l with a variation of +/- 0.0002
- The Egersund Bank: 0.0011-0.0015 Bq/l with a variation of +/- 0.0002

One of the nine measurements showed 0.0025 Bq/l

This means that the content of ^{226}Ra in the samples taken around the Gullfaks and Sleipner platforms is within the natural variation for ^{226}Ra in seawater. It indicates that discharges of produced water have not contributed to any measurable increase in the concentration levels in seawater in the North Sea. The same is assumed to apply at Statfjord.

6.2.5.2 Discharge of Radioactive Compounds in Scale that follows the Produced Water

Scale formation

Statfjord uses seawater injection to maintain the pressure in the reservoir. This contributes to a considerable increase in the degree of oil recovery. Seawater injection leads to the formation of mineral scale when the seawater, which is rich in sulphate, is mixed with the original saltwater in the reservoir (formation water), which contains barium. Barium sulphate is deposited in the reservoir, in the proximity of the wells and throughout the production system for treating oil and produced water.

The saltwater in the reservoir also contains naturally occurring radioactive isotopes in the uranium and thorium series. Radium reacts chemically in the same way as barium, and the barium sulphate deposits therefore contain radium. These deposits are called low-level radioactive scale.

Chemicals used to inhibit scale formation and remove scale are called scale inhibitors and scale dissolvers, respectively.

Impacts

The addition of scale inhibitor inhibits the formation of barium sulphate scale on pipe walls and surfaces. This means that crystals of barium sulphate and scale inhibitor end up in the sea, where the bond between the scale inhibitor and the crystal is broken. The chemical (scale inhibitor) is broken down (mineralised), while the salt crystals which are thermodynamically stable, insoluble and biologically unavailable will be dispersed with the sea currents and sediment.

A dissolver is used to remove scale already present in the reservoir, in proximity to the wells and in the perforations. Dissolvers contain a molecule which binds barium, strontium and radium in a complex compound, so that they are dissolved, become mobile and are transported out of the wells and process systems. When these complex compounds enter the sea, the complex binding is immediately dissolved due to the reduction in the pH value, and the original scale deposit is re-formed into small salt crystals. These are thermodynamically stable, insoluble and biologically unavailable. In seawater, the bond between barium, strontium and radium and the sulphate ions is more stable than the bond between the same ions and the substance forming the complex compound. After being discharged to sea, the substance that formed the complex compound (dissolver) is present as individual ions, which will eventually be biologically degraded.

Hence the bioavailability of the radioactive substances (226-Radium, 228-Radium) will not increase as a result of using scale inhibitors. As mentioned before, the barium and strontium salt crystals, which are contaminated by small quantities of radium, are insoluble and biologically unavailable.

Finally, it must be emphasised that salt crystals of barium and strontium sulphate are not radioactive. It is only when these salts are contaminated by minute quantities of radium (radioactive) that the deposits are designated as low-level radioactive scale. As an example, 100 tonnes of low-level radioactive scale contains approx. 0.1 grams of radium.

6.3 Discharges of Oily Sand

Article 59§ of the Activities Regulation entails a requirement for less than one per cent by weight of oil adhesion to the sand that is discharged. At Statfjord, this means that a sand cleaning plant must be installed on each of the platform. The Statfjord licence has appealed this requirement to the Ministry of the environment and been granted dispensation until 31 December 2006.

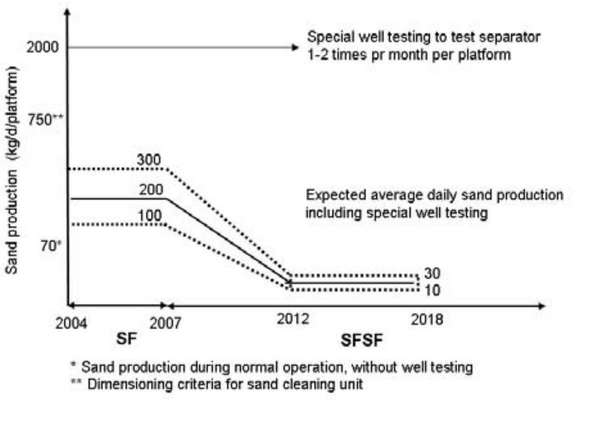
This section outlines the impacts of discharges of oily sand and dispersed oil discharged together with the sand. The consequences are assessed on the basis of the study ”Statfjord Late Life-Environmental effects of discharges of oily sand”/51/.

The section also includes an overview of the costs of installing sand-cleaning plants to meet the requirements of the authorities, the benefits of such plants and other measures that have been assessed. The project’s recommended alternative strategy for the installation of sand-cleaning systems is outlined.

6.3.1 Sand Production and Oil Discharges

Figure 6-32 shows current sand production and forecast sand production during Statfjord Late Life.

The well stream received at the platform for processing contains sand. The sand is separated from the rest of the well stream (oil, water and gas) and is currently being discharged to sea without treatment in a separate cleaning plant.



* Sand production during normal operation, without well testing
** Dimensioning criteria for sand cleaning unit

Figure 6-32: Forecast sand production at the Statfjord platforms (2004-2018)

The figure shows that approx. 70 kg of sand per day is currently produced at each platform. During normal production, the sand is removed twice per week, and the actual process (jetting process) takes 30 minutes. The wells are tested specifically to establish the maximum permitted sand production per well. On average, such testing takes place once or twice a month on each platform and may generate up to 2,000 kg of sand in the course of 24 hours. This sand is removed and discharged to sea in the course of two hours. The average daily sand production is therefore 200 kg/d based on annual sand production (sand production on a normal day, plus 24 MSFR tests per year).

In order to ensure gas recovery in SFLL, pressure relief of the reservoirs is necessary. This produces large volumes of produced water, which in combination with pressure relief increase sand production. Plans for downhole sand control measures are therefore included for most of the production wells. According to the plan, the downhole sand control measures will be implemented during the period 2006-2011.

Sand control measures will lead to a reduction in sand production as a function of time (Figure 6-32), and after 2011 it will have been reduced to 10 per cent of the current level. Sand production after 2011 is expected to be 20 kg per day per platform. During the period after 2011, there may be some well testing, but only sporadically. Sand production on a normal day during the period after 2011 will therefore be approximately equal to the average daily sand production for the year.

In the jetting process for discharging sand, oil is also discharged, in the form of dispersed oil in the produced water that is discharged together with the sand and in the form of oil adhering to the sand.

The percentage oil adhesion to sand will vary and be in average around four per cent by weight, based on measurements at Statfjord. Due to differences in measurement methods, there is some uncertainty attached to the actual percentage of oil by weight that is discharged together with the sand. Model calculations of the dispersion of oily sand are based on conservative assumptions, and oil adhesion to sand has been set to ten per cent by weight.

The quantity of dispersed oil that is discharged as a result of the discharge of sand is determined on the basis of the reported oil discharges in the annual emission reports for the Statfjord field. The reported amounts are stated as the sum of dispersed oil and oil adhesion to sand.

6.3.2 Impacts of Discharges

The acute and long-term effects on the pelagic environment (water column) and benthic environment (seabed) resulting from jetting at Statfjord have been studied. The impacts of both dispersed oil and oil adhesion to sand have been assessed.

The potential impacts for the periods before and after the implementation of Statfjord Late Life have been studied for each of the three platforms SFA, SFB and SFC. Three main alternatives for the handling of sand, different jetting frequencies for normal production jetting and jetting in connection with well testing have been assessed. For a description of model scenarios, see Appendix H.1.

The impacts described in the following are based on the most conservative scenarios, i.e. current sand production and scenarios for normal and test jetting whereby the sand is discharged just as it is today without any particular measures to reduce oil adhesion.

6.3.2.1 Potential Long-Term Impacts

Any long-term impacts are assessed on the basis of how they will affect the benthic and pelagic environments.

Benthic environment

The annual sedimentation of sand, given ten per cent oil adhesion, sand production at the current level and no cleaning of discharges, will result in a sedimentation rate of 52 grams of oil/m^2/year at Statfjord A and 24 grams of oil /m^2/year at Statfjord B and Statfjord C, covering areas of 0.14, 0.3 and 0.3 km^2, respectively. The differences between the quantities accumulated per area unit are due to differences in dispersion from the three platforms. Differences in dispersion are due to different amounts of produced water, temperatures and localisation of the discharges.

Monitoring data from the calculated sedimentation area data for the period 1990-2002 indicates no measurable effects of sand jetting in the form of either higher total hydrocarbon concentrations in the sediments or effects on the benthic fauna. One of the main conclusions of the most recent monitoring report from 2002 is that the sediments have not been subject to any recent additions of mineral oil, and that the results of monitoring correspond well with drilling discharges and the prohibition on discharging oily cuttings /51/.

Pelagic environments

Increased concentrations of particles in the water column could increase the general turbidity, which could in turn reduce primary production. A reduction in primary production could in turn affect the supply of food to secondary producers. Discharges from jetting will be dispersed over a distance of 3-5 km from the platforms. Current knowledge of whether pelagic organisms are affected by particles in general is limited. However, the discharges from jetting at the Statfjord platforms are negligible in relation to the content of particles naturally present in the water column, and the discharges are of brief duration. There is a low probability that oil adhesion in connection with jetting will cause any chronic damage or give acute effects in the water column/51/.

The assessment of long-term impacts of dispersed oil on the pelagic environment is based on annual discharges of sand compared with discharges of produced water and ballast water. During the period 2004-2007, discharges of aliphatic hydrocarbons from jetting will be in total 45 tonnes per year for all three platforms. Half of this will be in the form of oil adhesion to sand, while the other half will be in the form of dispersed oil. In 2003 the quantity of oil discharged in connection with jetting was estimated at and reported as 50 tonnes. This means that these discharges constituted approx. seven per cent of the total discharges of dispersed oil from the platforms (produced water and ballast water), see section 6.2. Approx. 50 per cent of discharges from jetting is in the form of dispersed oil. This share represents approx. 3.5 per cent of the discharges of dispersed oil from produced water and ballast water.

After 2011, when downhole sand control has been implemented, the field's discharges of oil from jetting will average approx. 4 tonnes per year (2 kg as dispersed oil and 2 kg adhering to sand per day per platform). Discharges of dispersed oil from produced water and ballast water will be reduced by 40 per cent during the same period following the implementation of the CTour technology. This means that in 2011, the quantity of oil discharged as a result of jetting at Statfjord will represent around one per cent of the discharges of produced water and ballast water; and only one half of this will be in the form of dispersed oil and directly comparable with the latter discharges. The impacts of produced water and ballast water were assessed in section 6.2. The total quantity of dispersed oil discharged in connection with jetting is marginal compared with these discharges. Jetting will cause discharges of dispersed oil to the pelagic environment in relatively high pulses of short duration. Given the short period of exposure, however, these discharges are not likely to have any long-term effects.

6.3.2.2 Potential Acute Effects

In assessing acute effects, the current jetting in connection with well tests represents the worst scenario (2,000 kg sand per day discharged without cleaning in the course of two hours). As mentioned before, such discharges will occur once or twice a month during the period until 2011. In the period after 2011 such discharges will only occur sporadically.

In comparison, jetting twice a week, given the current sand production, will have only half the concentration of jetting in connection with well testing. Such discharges will also be of much shorter duration (30 minutes). ”Normal jetting” after 2011 will have a quarter of the concentration of ”well test jetting” and last for no more than 30 minutes.

Benthic environment

When 2,000 kg of sand is jetted, it sediments at a distance of between 3.2 and 3.5 km from SFA, over an area of 0.14 km^2, which means that the calculated sedimentation rate for each well test is 1.42 g oil/m^2. At B and C, the sand sediments across an area that is twice as big (0.3 km^2), and the calculated concentration for each well test is 0.7 g oil/m^2. The potential acute effects of the sedimentation of oily sand are not considered relevant and, as mentioned above, no measurable long-term effects have been registered by the sediment monitoring stations in this area.

Pelagic environment

In assessing potential acute effects of discharges of dispersed oil and oily sand on the pelagic environment, it is important to take account of the nature of these discharges compared with other discharges. Produced water is continually being discharged at the Statfjord platforms, while the jetting operations cause discharge pulses for limited periods (1/2-2 hours). Discharges in connection with jetting last for ½-2 hours. Discharges are dispersed and the concentrations in the water column will mainly be present for periods of 5-6.5 hours.

As mentioned above, there is little probability that there will be any acute effects of oily particles in the water column. The acute impacts of dispersed oil in the water column have been assessed by comparing simulated concentrations in the water column caused by jetting (PEC=Predicted Effect Concentration) with PNEC values (Predicted No Effect Concentrations) for dispersed oil and other natural oil components. Akvaplan Niva's study /51/. assumed the same relationship between dispersed oil and other oil components as for produced water (see section 6.2). The relevance of using PEC/PNEC values and the weaknesses of this method in relation to the type and duration of the discharge must, however, be taken into account in assessing possible impacts. The PNEC values have been determined on the basis of an exposure period of 48-96 hours. Acute toxicity will be reduced if the exposure time is reduced. Jetting usually involves an exposure time of 5-6.5 hours. Even if the model for one or more components resulted in PEC/PNEC values of more than one in the jet stream six kilometres downstream of the discharge, the ecological impacts are likely to be very limited since exposed volumes are small (number of individuals affected is low) and the exposure period is brief. The study /51/concludes that while there is little probability that the discharges will have any long-term impacts, impacts in the jet stream cannot be precluded.

6.3.3 Mitigating Measures

As a consequence of the requirement for max. one per cent by weight of oil adhesion to sand, the project has assessed several measures as alternatives to sand cleaning, which are included in the current plans. This section looks briefly at the cost-efficiency of sand cleaning plants, discusses those measures that have been assessed and rejected, and the measures recommended for implementation by the project as an alternative to sand cleaning. All these measures are described in further detail in Appendix H.

6.3.3.1 Assessment of Cost-efficiency

Sand cleaning plants (plants with sand cyclones and sand cleaning, see Appendix H2) will meet the requirements of the authorities for oil adhesion to sand of less than one per cent by weight. The cost of this measure will be NOK 226 million (see Table 6-8).

Table 6-8: Costs of sand cleaning (NOK million)

NPV (2004)	SFA	SFB	SFC	Total
Investment	66	31.5	44	141
Operation	21	32	32	85
Total	**87**	**63.5**	**76**	**226**

The study/51/concludes that the current discharges of sand will probably have very little effect on the environment and that sand cleaning plants (sand cyclones and cleaning of sand) therefore will have no measurable environmental benefits. The benefits will be even smaller in Statfjord Late Life when downhole sand control measures are installed and sand production is reduced to ten per cent of the current level.

Hence the environmental benefit of this measure is very small in relation to the costs.

6.3.3.2 Rejected Measures

Other solutions that have been assessed to meet the requirement for less than one per cent by weight of oil adhesion to sand, but which have been rejected are:

1. Reinjection into the Utsira formation together with drill cuttings
2. Transport to shore
3. Disposal of storage cells.

These measures and how they have been assessed are described in more detail in Appendix H.

6.3.3.3 The Project's recommended Measures for handling Sand

Dispensations from the requirement for a maximum of one per cent oil adhesion to sand discharged to sea will expire on 31 December 2006. The requirement implies that a sand cleaning plant (sand cyclones and a separate process for cleaning the sand) must be installed on each of the platforms. According to the plan, work on installing these plants will start in April 2006 at SFA, in June 2006 at SFB and in August 2006 at SFC. The plants will have been installed before the end of 2006.

As shown above, there are no proven environmental impacts of discharging oily sand. However, short-term effects in the jet stream of the dispersed oil that is discharged together with the sand cannot be precluded, but it is not probable that there will be any measurable effects considering the duration and dispersion of the discharges. Sand cyclones will reduce the discharges of dispersed oil, but the cleaning process will have little environmental impact. In order to eliminate any uncertainties relating to local effects of dispersed oil in the jet stream, Statoil is of the opinion that alternative measures to sand cleaning are more relevant.

Statoil's view is that sand cleaning as a measure to meet the authorities' requirement for less than one per cent by weight oil adhesion to sand carries little environmental benefit in relation to the costs. This also constitutes the grounds for Statoil's appeal against the order to install sand cleaning plants on all the Statfjord platforms.

The project therefore recommends an alternative strategy for handling the environmental issues relating to discharges of sand. All the measures included have in common that they will not meet the authorities' requirements for less than one per cent by weight of oil adhesion to sand, but in Statoil's opinion they will give at least the same environmental benefits as cleaning plants for sand, and at a far lower cost.

The alternative strategy involves the following measures:

- Installation of sand control equipment in most wells
- Monitoring of sand production
- Improve the measurement program for discharges of dispersed oil and oil adhesion to sand
- Optimisation of the jetting process
- Assessing the use of pre-jetting in combination with automatic jetting and the installation of sand detectors

These measures are described in more detail in Appendix H.

6.4 Other Regular Discharges to Sea

Sources of other regular discharges to sea from the Statfjord fields are:

- Surface water/ drainage water
- Ballast water from ships
- Sanitary wastewater
- Cooling water from the process

Small volumes of sanitary wastewater and cooling water are discharged at Statfjord. These discharges do not constitute an environmental risk and will not increase as a result of late life. These discharges will therefore not be discussed in further detail.

6.4.1 Drainage Water

On Statfjord A, B and C, drainage water is routed from the platforms to a mud cell in which, after a certain retention period, oil is separated from the water. The oil fraction is returned to the crude oil in connection with loading. Cleaned drainage water is mixed with ballast water on the platform and discharged together with it. Oil in the drainage water is not measured separately, but is measured as part of the ballast water. The ballast water from the storage cells is discharged together with the produced water. Discharges and impacts are discussed in section 6.2.

6.4.2 Ballast Water from Ships

The greatest potential environmental problem relating to ballast water on ships concerns the introduction of species into areas in which they do not naturally belong. The risk of such an introduction is only present if the ships call at ports in various ecological regions between which there are no natural routes of dispersion, or at ports receiving calls from ships from other ecological regions (secondary dispersion). The ships that load oil at the Statfjord platforms, traffic ports in Northern Europe. The ecological conditions at the discharge locations are significantly different from those in the unloading ports, and the risk of undesirable dispersion is considered to be small.
In addition, shuttle traffic will decrease due to reduced oil production during SFLL.

Ships trafficking the Statfjord field have installed CBS (Clean Ballastwater System), whereby the ballast water on board the vessels is stored in separate tanks that are physically separated from the crude oil tanks. Thus, there are no oil spills in connection with ballast water from shuttle tankers on the Statfjord field.

7 Accidental Discharges and Contingency Planning

7.1 Accidental Discharges and Probability

Relevant accident scenarios in connection with SFLL include:

- Oil spills during transfer of oil from loading buoy to shuttle tanker
- Shipping accident
- Oil spills from intrafield pipelines
- Storage tank failure
- Uncontrolled blowout

The majority of these events involve limited oil spills only, or have a very low probability of occurrence. The scenario anticipated to have the greatest potential of releasing large quantities of oil and causing harm to the natural environment is an uncontrolled blowout from the platform, although it is considered to be unlikely. The uncontrolled blowout represents a realistic “worst case” scenario, and is taken as the basis for the discussion of environmental impacts of accidental discharges in this chapter.

The same scenario has been selected as the dimensioning incident for emergency response and oil spill contingency planning.

Based on the Statfjord field reservoir’s characteristics and the production forecasts, a dimensioning blowout rate of 1,820 m^3/day has been established.

The maximum duration of a blowout of this magnitude is 90 days, which corresponds to the time it takes to drill a relief well. However, the probability of collapsing walls blocking the flow path makes it very likely that the blowout will be choked in a much shorter time. There is more than 70 per cent probability that the blowout will last less than two days.

A blowout frequency of 8.9×10^{-4} for the discharge scenario of 1,820 m^3/d has been calculated by Scandpower /111/.

7.2 Oil Drift Modelling

7.2.1 The Statfjord Oil

The Statfjord C Blend oil was selected as input for the oil drift model. The Statfjord C Blend is considered representative of all the oil types at the Statfjord field (SINTEF 2001).

The oil type is paraffinic. Typical physical characteristics of the Statfjord C Blend are as follows:

- Density of 834 kg/m^3
- Relatively high rate of evaporation: Approximately 41 per cent will have evaporated after 2 days at a wind speed of 10 m/s and a water surface temperature of 15 ºC. Approx. 38 per cent will have evaporated after 2 days at a wind speed of 10 m/s and a water surface temperature of 5 ºC.
- Maximum water content of the emulsion is approx. 70 per cent in both winter (5 ºC) and summer (15 ºC) (at a wind speed of 10 m/s and after 2 days).
- The Statfjord C Blend is chemically dispersible within 0.25 - 6 hours under winter conditions and 2.5-36 hours under summer conditions, depending on wind speed. After 24 hours, chemical dispersibility is reduced or low at all wind speeds, both at 5 °C (winter conditions) and 15 °C (summer conditions).
- At a sea temperature of 15 ºC (summer conditions) and a wind speed of 5 m/s, the Statfjord C Blend will have a high viscosity (>10,000 cP) after 3 days; at 10 m/s and above, the viscosity will be greater than 10,000 cP during all seasons. At a sea temperature of 5 ºC (winter conditions), viscosity will only be less than 10,000 cP at 2 m/s (0-3 days) and at 5 m/s during the first day. At all other wind speeds during winter, the oil will have a viscosity above 10,000 cP.

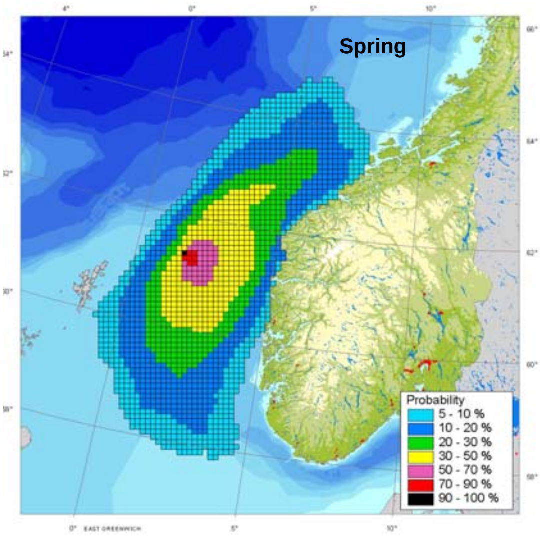
7.2.2 Surface Blow-outs

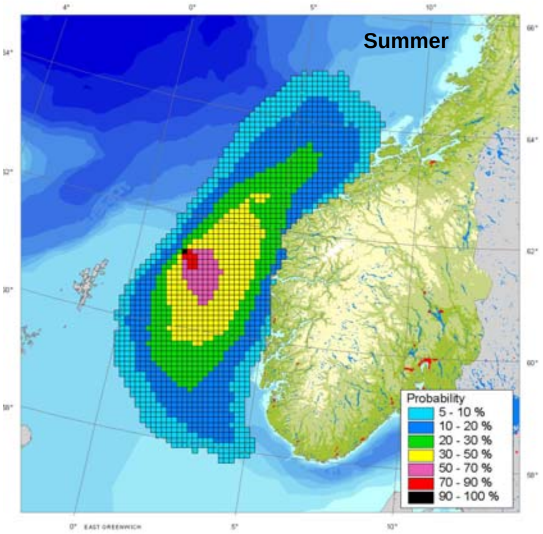
Oil drift was modelled for a surface blowout at the Statfjord A platform by Det Norske Veritas using the OILTRAJ model /80/. In total, 3,600 simulations were carried out with input parameters as follows:

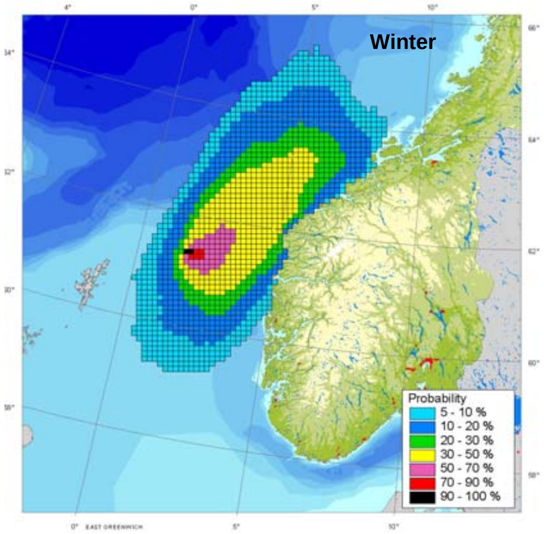
1. Location: 61º 15' 20.46"N, 01º 51' 13.96"E
2. Discharge rate: 1,820 Sm^3/d
3. Oil type: Statfjord C Blend
4. Oil density: 834 kg/m^3
5. Gas to oil ratio (GOR): 600 Sm^3/Sm^3

The results of the oil drift simulations are shown in Figure 7-1. The statistical probability of oiling in different parts of the area of influence is shown for winter (December – February), spring (March – May), summer (June – August), and autumn (September – November). It can be seen that the area of influence is greatest during the summer, but the probability of oil reaching the Norwegian west coast is highest during the autumn and winter.

The simulations indicate that the likelihood of contamination of the Shetland shoreline is less than 5 per cent on an annual basis, while the probability of contamination of the Norwegian coast is estimated at 10-20 per cent on an annual basis.







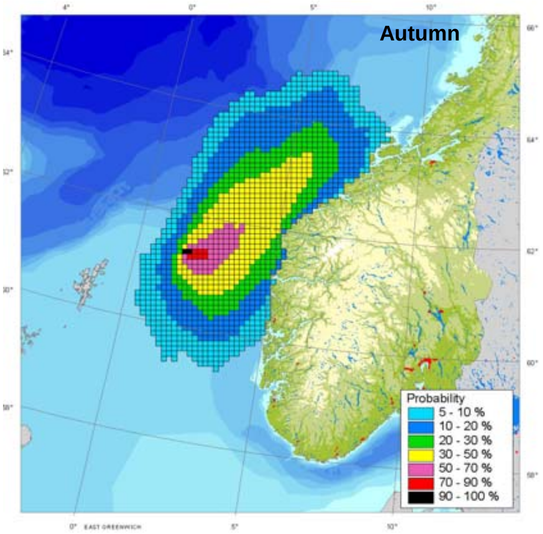


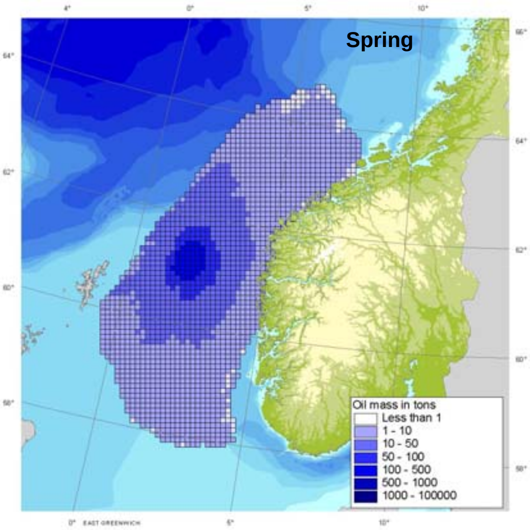
Figure 7-1: Probability of oil in winter, spring, summer and autumn.

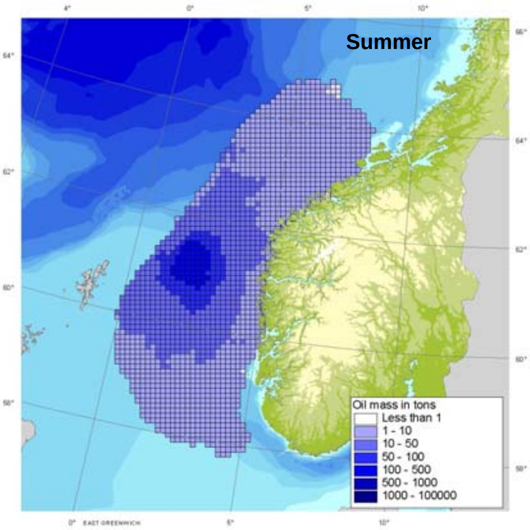
The shortest drifting time for oil to shore (Norway) is estimated at approximately five days.

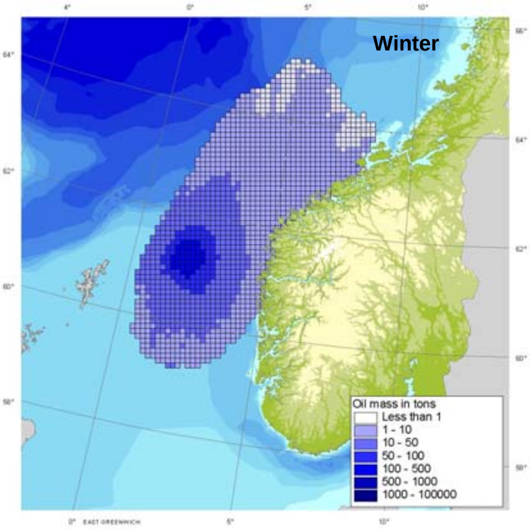
The average accumulated oil mass within a 10x10 km grid cell varies between 0.4 and 250 tonnes in the winter and between 0.02 and 300 tonnes in the summer. In the coastal areas, the maximum average accumulated oil mass varies from 21 tonnes to 39 tonnes. Figure 7-2 shows the average oil mass on the surface for each 10x10 km grid cell.

Figure 7-2 shows the aggregate result of 3,600 individual scenarios. For the purpose of illustrating the fate of the oil and the impacted area if a blowout really occurred, selected individual scenarios from the oil drift modelling are presented in Figure 7-3 and Figure 7-4. The three scenarios constitute a conservative selection (3 of 3,600 individual scenarios), and can be considered as extreme situations involving different courses of events. The three scenarios are as follows:

- The scenario that affects the largest area (green)
- The scenario with the largest amount of stranded oil mass (red)
- The scenario with the shortest drift time to land (black)







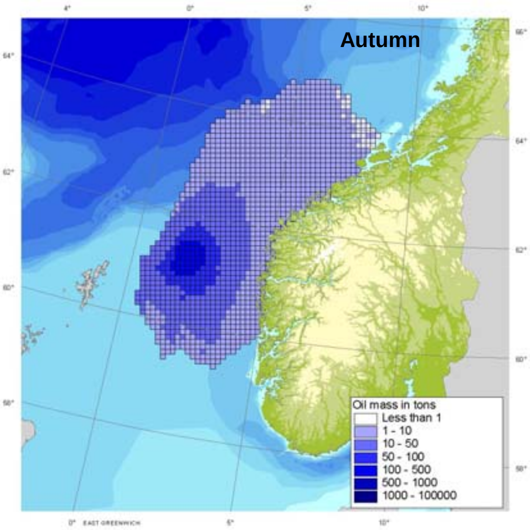


Figure 7-2: Average oil mass in tonnes for winter, spring, summer and autumn.

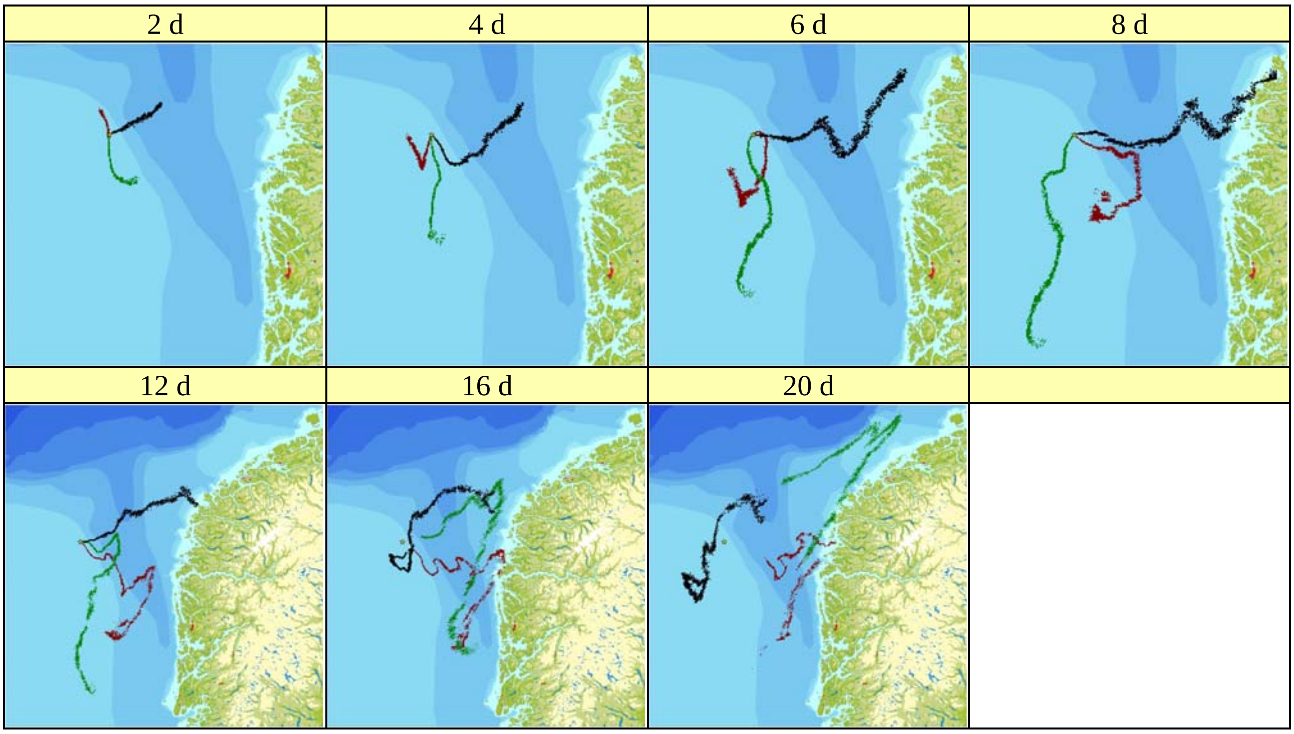


Figure 7-3: Progress of three individual scenarios during the spring.

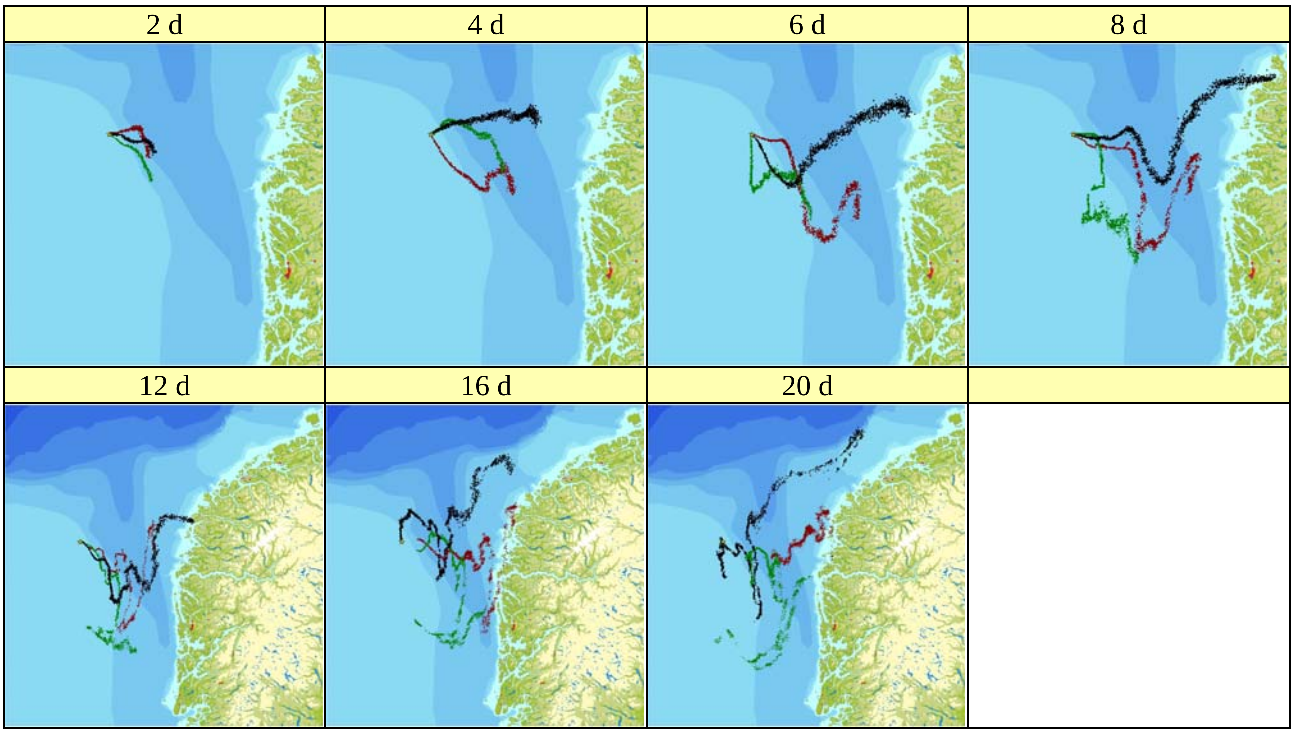


Figure 7-4: Progress of three individual scenarios during the summer.

7.2.3 Water Column – Hydrocarbon Concentrations

The oil drift simulations do not provide any data on water column concentrations. However, certain assumptions have been made to identify those parts of the area of influence in which the THC (Total Hydrocarbon Concentration) in the water column can be expected to exceed the PNEC (Predicted No Effect Concentration). It has been conservatively assumed that all the surface oil will be naturally dispersed into the water column at a depth of 10 metres(Figure 7-5).

Fifty tonnes of surface oil within one 10x10 km grid cell corresponds to a concentration of 50 ppb (PNEC) in the water column. This is used to illustrate the potential area containing hydrocarbon concentrations above the PNEC value. The area in which the THC is expected to exceed the PNEC of 50 ppb is illustrated in Figure 7-5.

The above calculations show that the maximum THC is limited to 300 pbb, with only minor variations in the course of the year.

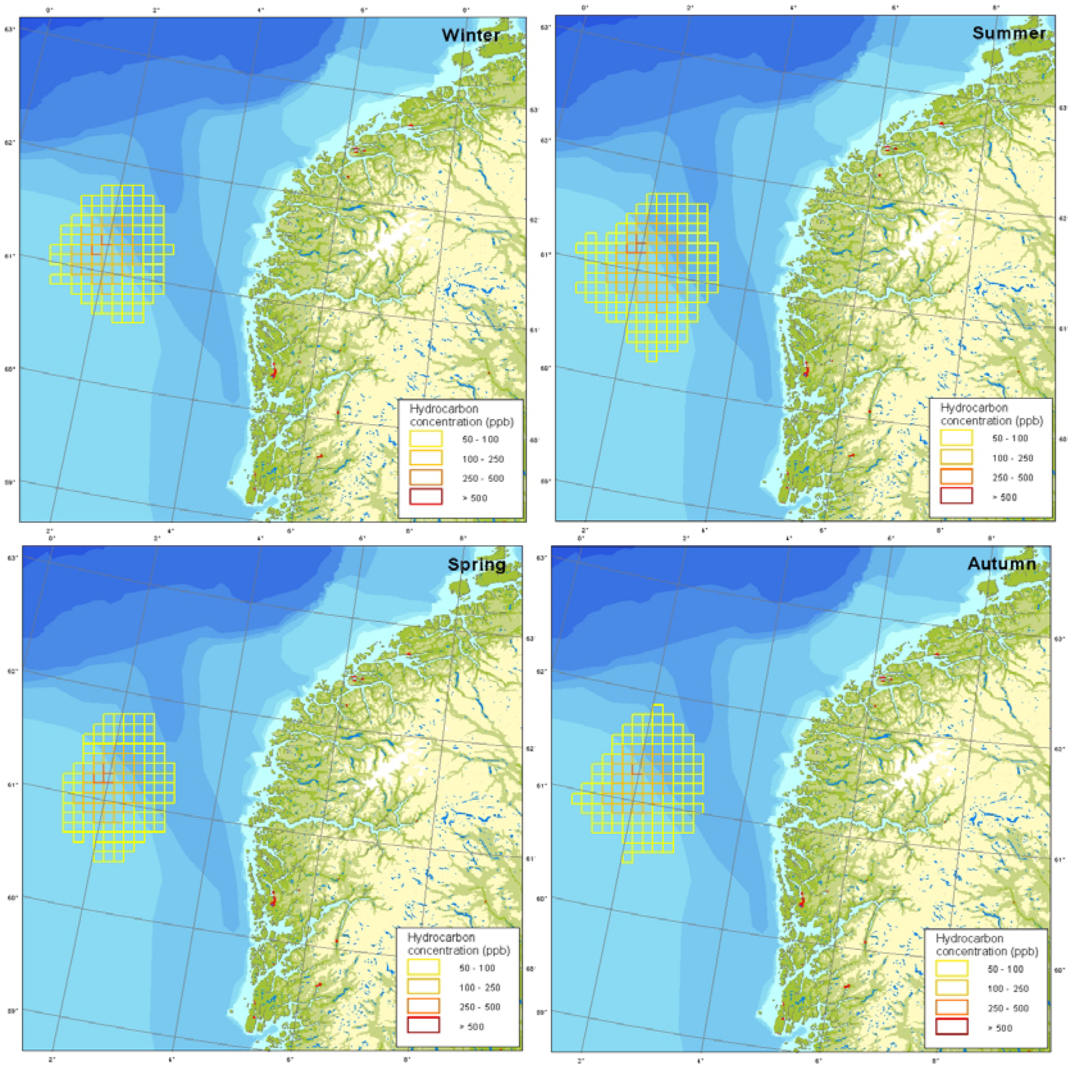


Figure 7-5: Indication of areas with THC concentrations above PNEC (50 ppb) in the water column

7.3 Impacts of Accidental Discharges

A general discussion of the vulnerability of biological resources to oil spill pollution is provided in chapter 4 and appendix E. The location of the Statfjord Late Life project in the middle of the North Sea and the results of the oil drift modelling indicate that biological resources such as fish eggs and larvae and seabirds in the open sea are the most exposed resources in the unlikely event of an accidental oil spill from the Statfjord field.

The environmental impacts of accidental spills have been analysed in detail in an environmental risk analysis (ERA) /4/. The impact evaluations given in the following are largely based on the results from this ERA.

By combining the likelihood of an oil spill, the results of the oil drift modelling and the likelihood of the presence of biological resources in affected areas during different seasons, the environmental risk can be determined as the combination of probability and impact.

7.3.1 Environmental Risk

The probability of a blowout from the Statfjord field in the production phase of SFLL is very low, estimated at 8.9 x 10^{-4}, which corresponds to a frequency of once every 1,125 years. If we combine this very remote probability of the blowout itself with the probability of oiling from the oil spill modelling and the likelihood of the presence of vulnerable biological resources in the area affected by the oil, it is clear that the overall environmental risk from the SFLL operations is very low or negligible /4/.

Even if it can be easily established that the environmental risk involved in the SFLL project is negligible, it is still pertinent to evaluate what the hypothetical impacts would be if a dimensioning oil spill were to occur. Such an evaluation is provided in the following.

7.3.2 Hypothetical Environmental Impacts if an Oil Spill Occurred

The environmental risk has been quantified in the environmental risk analysis (ERA)/4/. The environmental risk is expressed as the combination of the probability of an incident and the resultant impacts in the event of an incident. Environmental damage is categorised into four impact categories based on the magnitude of the damage. The magnitude of the damage is defined in terms of the time required for the population to recover from the damage:

- Minor environmental damage, recovery time 1 month - 1 year
- Moderate environmental damage, recovery time 1-3 years
- Significant environmental damage, recovery time 3-10 years
- Serious environmental damage, recovery time more than 10 years

Figure 7-6 shows the distribution of the environmental impacts throughout the year //on 10x10 km grid cells. This distribution does not take into account the probability of a blowout, but it shows instead the potential impacts if the modelled oil volumes were to come into contact with the natural resources present in each grid cell. The oil volumes refer to the volumes shown in Figure 7-2.

These volumes are the average oil volumes of 3,600 simulations. Consequently, the surface area shown in Figure 7-2 is the combined result of all the simulations, and is much bigger than would be the case in the event of an actual oil spill (see the examples in Figure 7-3 and Figure 7-4). On the other hand, in an actual oil spill scenario, the oil volumes in the affected area could be greater than the volumes shown in Figure 7-2. In any case, the estimates below are regarded as conservative, since the most exposed biological populations (seabirds and fish) are relatively evenly distributed in the open sea.

The results indicate that there are more grid cells that fall into the impact categories “significant” and “serious” in the spring and summer than is the case in the autumn and winter. This is due to a combination of increased accumulated oil mass in the affected area in the spring and summer seasons, and that seabirds are more vulnerable during the nesting season.

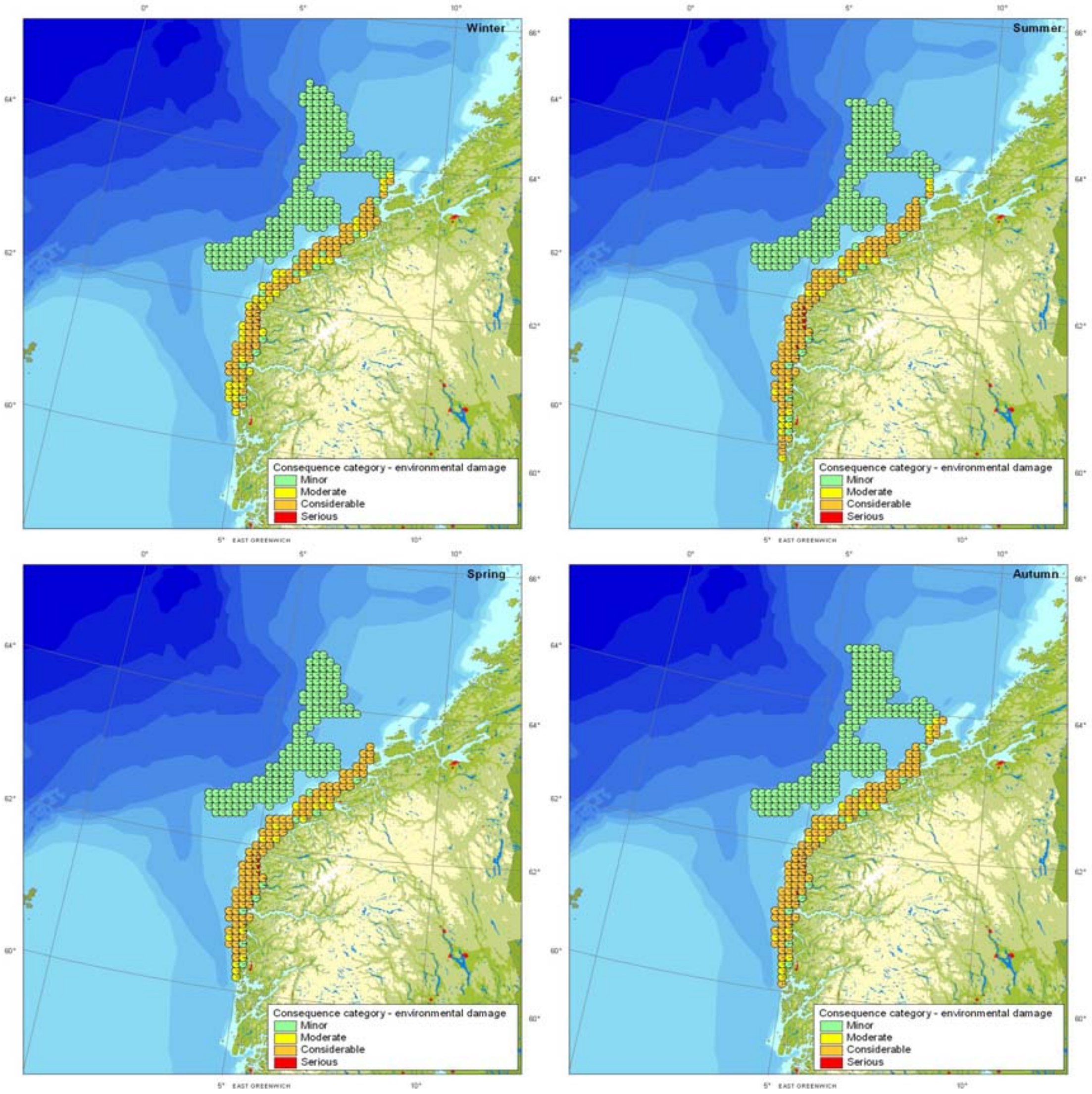


Figure 7-6: Classification of impact categories for a surface blowout from Statfjord A

The environmental damage potential shown in Figure 7-6 represents the combined damage to all biological resources present in a specific grid cell. Depending on which grid cell is examined and the time of year, the grid cell may contain vulnerable fish resources, seabirds, marine mammals and shoreline habitats or combinations of these.

For the purpose of analysing the impacts on biological resources, indicator species or VECs (Valued Ecosystem Component) are selected to represent the different categories of biological resources.

A VEC is defined as a natural resource that fulfils one or more of the following criteria:

- It is important (not necessarily for economic reasons only) to a local human population.
- It has national or international conservation value.
- Alterations to its status will entail specific measures on the part of the planning and environmental authorities, e.g. conservation measures or planning restrictions pursuant to the planning and building legislation.

Based on the definition of the project's area of influence and the resource description in section 4, the following groups of species and habitats are considered to be VECs:

- Fish – fish eggs and larvae
- Seabirds – guillemot, razorbill, puffin, shag, common eider and gannet
- Marine mammals – grey seal
- Shoreline habitats – habitats of national or international conservation value (see Figure E-24 in Appendix E.

7.3.2.1 Fish Eggs and Larvae

The environmental impacts on resources in the water column are considered to be small. This is because there is little overlapping between spawning grounds for fish and the areas in which the THC exceeds the PNEC for these resources (see section 7.2.3). As the area with THC above PNEC in the event of an actual oil spill will be even smaller than the combined statistical result, there is little probability that vulnerable life stages for fish such as mackerel and herring will be affected (Figure 7-7).

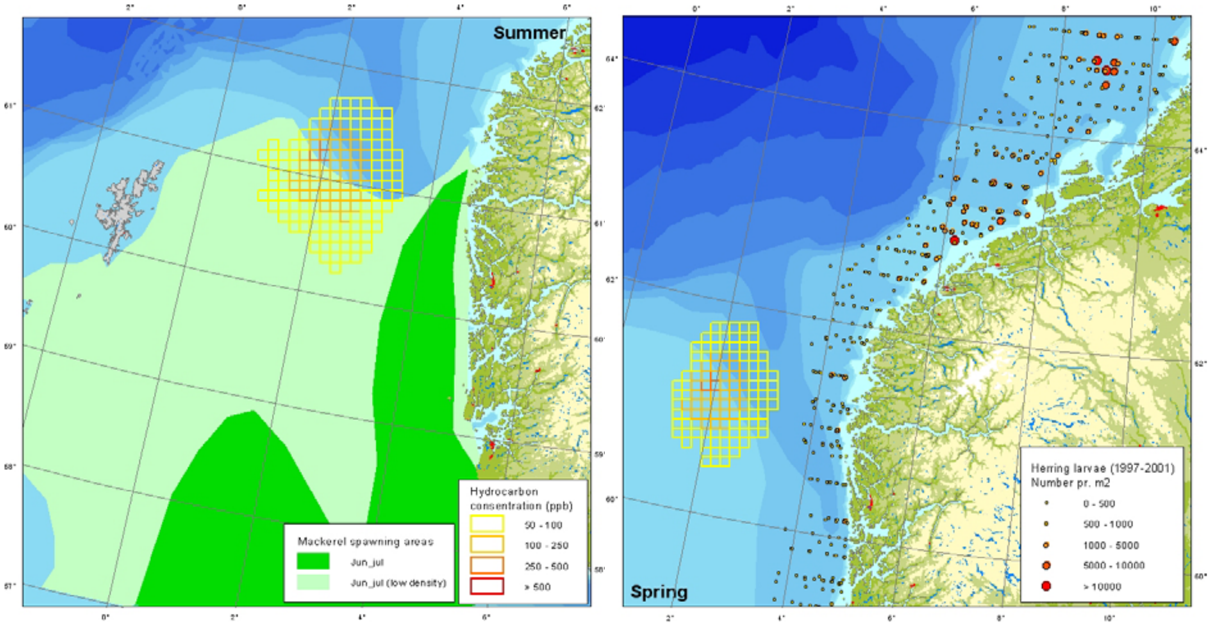


Figure 7-7: Spawning grounds for mackerel and survey data on herring eggs and larvae*

*The Spawing grounds are plotted together with the area of influence of THCs exceeding the PNECs for vulnerable resources in the water column

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7.3.2.2 Seabirds and Marine Mammals

An estimate of the expected damage to the population level has been made in the environmental risk analysis /4 / for selected seabird VECs (guillemot, razorbill, puffin, shag, common eider and gannet) and for grey seals.

By combining the vulnerability of the individual VEC species with the probability of oiling and the average accumulated oil volumes in the grid cells, the probable population reduction can be calculated.

The minimum, average and maximum calculated population reduction for each VEC is shown in Figure 7-8. The probability of a reduction in the population is less than five per cent for all the oil spill scenarios. By employing the damage key for seabirds and marine mammals provided by the Norwegian Oil Industry Association (OLF, 2001), the distribution of expected environmental damage will be in the "minor" and "moderate" impact categories, i.e. less than 3 years' restoration time for the population.

The probability that this damage will occur is necessarily equal to or lower than the blowout frequency. As seabirds could be located close to a possible oil spill throughout the year, the probability of seeing impacts to seabirds in the lowest impact category is in the same range as the blowout probability (8.9 x 10^{-4}), while the probability of damage to grey seal is estimated to be as low as 1 x 10^{-6}.

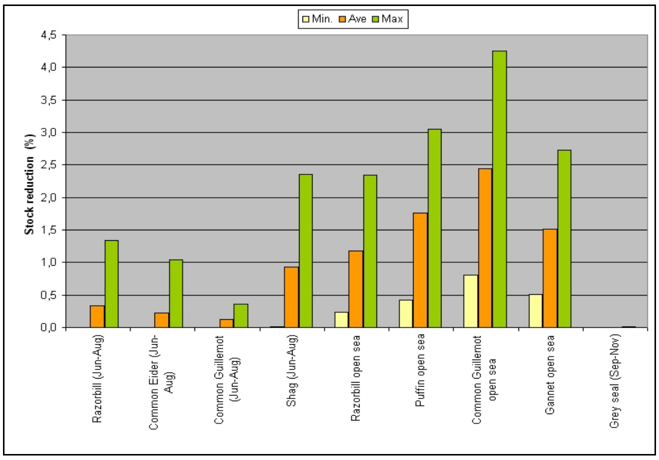

Figure 7-8: Estimated reduction in the size of the population of selected species (VECs) of seabirds and marine mammals

7.3.2.3 Coastal Habitats and Communities

The environmental risk analysis /4 / estimates the environmental damage to coastal habitats based on two different approaches and data sets:

- the VEC habitats
- the geographical distribution of vulnerable coastal habitats (Figure E-23 in Appendix E)

The environmental damage to VEC habitats is distributed between all impact categories (minor, moderate, significant and serious). However, the risk to the selected VEC habitats is generally very low due to low probability of oiling and little oil accumulation. The probability of damage is less than 1 x 10^{-4} in the impact categories “minor”, “moderate” and “significant” (less than 10 years’ restoration time), and as remote as 5 x 10^{-7} in the impact category “serious”.

Results from the simulations run on the basis of the new data set on sensitive seashore habitats (Figure E-23 in appendix E) indicate that a maximum of 1.2 per cent of the communities could be affected by oil. The corresponding mean value is 0.3 per cent. This means that approx. 28 km of sensitive shoreline could be affected. The corresponding distribution of the environmental damage is categorised as “minor”, “moderate” and “significant”, with a probability of between 4.4 x 10^{-4} and 1.32 x 10^{-4}, which means that the overall risk to the shoreline habitats is clearly negligible.

7.4 Oil Spill Contingency Plan

Effective oil spill response measures will further reduce the environmental impacts of an accidental oil spill in relation to the scenario described above.

Provisions for regional oil spill response measures have been made for the Tampen area of which the Statfjord field is a part. A gap analysis has been carried out to ascertain whether the existing oil spill response regime will meet the requirements of the SFLL project /5/.

The capacity of the existing regional oil spill response regime is determined based on an analysis of the dimensioning DSHA (Defined Situation of Hazard and Accident) for the region. The Regional Contingency Plan for Region 3 /137/ has established a large-scale accidental oil spill from the Troll C platform as the dimensioning DSHA for the region at all times of the year.

A direct comparison of oil drift data between Statfjord Late Life DSHA and the Troll C DSHA cannot be made due to the significant geographical distance between the platforms. The gap analysis has therefore been carried out by comparing the Statfjord Late Life DSHA with a corresponding situation at Gullfaks A. The Gullfaks A platform is located near to the Statfjord field, and it has already been established in the Regional Contingency Plan for Region 3 /137/ that the Gullfaks A DSHA is covered by corresponding situations at Troll C.

The areas of influence of oil spills from Statfjord Late Life and Gullfaks A are fairly similar in extent. Although the probability of oiling of the shoreline is higher and the maximum duration is longer in the case of Statfjord Late Life, the blowout rate, the maximum rates of coastal oil emulsion and oiling rates are significantly higher in the case of an oil spill from Gullfaks A.

An oil spill contingency plan that is adequate for Gullfaks is therefore considered to be adequate for Statfjord Late Life. A possible acute oil spill from Troll C will still be the dimensioning DSHA for the Tampen area (Region 3).

8 Waste Disposal

8.1 Current Practice and Guidelines

OLF’s guidelines for waste management and waste handling are currently used at Statfjord and will be used for SFLL.

OLF’s guidelines are provided for in Statoil’s Environmental Strategy for Exploration and Production Norway (UPN’s Environmental strategy) and in Statoil’s internal requirements for handling waste. Among other things, the preparation of a plan for waste management is required (work requirement document WR 1152).

Sorting waste at source at the field will also be done in accordance with OLF’s guidelines, and Statfjord/ Statoil has drawn up a separate framework agreement with a waste contractor to ensure the proper treatment of this waste.

Environmentally harmful waste, including LRA (low radioactive waste), will be handled in accordance with the applicable guidelines.

8.2 Environmental Impacts associated with Waste Handling

Statfjord Late Life will generate increased amounts of waste during the development phase compared with current operations.

No special waste problems are expected, however, as a result of Statfjord Late Life, given the mitigating measures that will be implemented. During the production period, and to a large extent also during the development phase, it will be possible to adapt waste handling for SFLL to the existing arrangements for transport and receipt at the Statfjord field.

8.3 Mitigating Measures

The HSE programme for the project will define the main activities and division of responsibility for handling waste. Waste will be sorted as far as possible and into those categories which are deemed practical and economical both for collection and final disposal. Environmentally harmful waste will at all times be handled in accordance with the applicable guidelines.

To assure responsible handling of waste in the development phase in line with applicable requirements and guidelines, contractors will be required to document an HSE/ internal control system that includes waste management.

9 Socio-economic Effects and Employment

This chapter describes socio-economic and employment effects of the Statfjord Late Life project and the SF reference alternative. Section 9.1 describes the major capital and operating expenditure relating to these two alternatives. The second section elaborates on the socio-economic profitability of these alternatives. In the ES/EIA for the Tampen Link, socio-economic profitability has not been calculated explicitly for the Tampen Link /86/, but capital expenditure for the new gas export pipeline and pertaining facilities topside SFB is included in the calculation of the profitability of the SFLL presented in section 9.2.

Section 9.3 discusses the employment effects for different sectors of the economy during the construction phase. Section 9.4 discusses the same topics for the operation phase and the decommissioning phase.

9.1 Capital and Operating Expenditure relating to SFLL and the Reference Alternative

The SFLL will be carried out between 2005 and 2009. The main capital expenditure (capex) items for the reference alternative and the SFLL case are shown in Table 9-1 below and also include capex for 2004. The capital expenditure does not include investments relating to the gas export solution (Tampen Link and related elements topside SFB).

Table 9-1 Capital expenditure 2004-2011 (million 2004 NOK)

Expenditure Item	SF-reference alternative	SFLL
Management and administration		336
Topside modifications on SFA, SFB and SFC*)	2 458	7 104
HSE		1 094
Drilling	2 943	5 673
Drilling module modifications		1 069
Total	**5 401**	**15 276**

*) The main items in the reference alternative comprise investments for sand removal, firewater systems, HVAC, electrical heat tracing, instrument panels and H_2S removal.

Table 9-2 below shows the aggregate operating expenditure and expenditure on decommissioning in the reference alternative and the SFLL development alternative for the whole period. All figures are exclusive of CO_2 tax. Capital expenditure relating to the decommissioning of the Statfjord platforms is estimated to be approximately NOK 11 billion for both alternatives

Table 9-2 Operating and decommissioning expenditure (million 2004 NOK)

	SF-Reference alternative	SFLL
Operating expenditure (2005 – 2020)	10 766	28 638
Decommissioning (2009 – 2026)	10 916	10 826

The estimate of operating expenditure is based on closing down the reference alternative in 2009 and the SFLL case in 2018. For the SFLL case, plugging at SFA is planned to start in 2013. For SFB and SFC, plugging will take place within two years of production stop in 2018. Removal will start when all wells have been plugged (2020) and is estimated to take six years for all three platforms.

9.2 Socio-economic Profitability

Socio-economic profitability of the Statfjord Late Life project is calculated based on the income and expenditure forecasts (capital and operating expenditure). Total income is calculated on the basis of forecast income from oil, gas and NGL, and tariffs for processing of oil and gas from Snorre and the Statfjord satellites.

Some of the most important economic assumptions are:

1) an oil price of USD17 (2002 USD) per barrel,
2) a gas price of NOK 0.7 (2002 NOK) per Sm^3 and
3) an NGL price of USD 182/ tonne minus USD 2.2 /tonnes at Kårstø, and USD 182 / tonne minus USD11.5/ tonne at Mossmorran in Scotland (2002).

The marginal costs of using existing infrastructure in both Norway (Statpipe) and the UK (FLAGS) are assumed to be small and have therefore been set to zero in this economic analysis.

Table 9-3 shows income for the reference alternative and SFLL. All figures are discounted to the 2004 value before tax (seven per cent discount rate). In Table 9-3 the income from oil in the reference alternative and SFLL reflects the price of oil delivered to Europe. For both alternatives the gas and condensate income reflects the price at St. Fergus and at Kårstø (market price). The tariffs for processing oil from Snorre and the Statfjord satellites at the Statfjord platforms are included in these economic calculations.

Table 9-3: Income (million 2004 NOK)

Present value at 7% discount rate	SF reference alternative	SFLL
Oil income	23 612	25 576
Gas income	4 234	18 028
NGL income	2 799	10 762
Third-party processing income	5 065	7 332
Total income	**35 710**	**61 698**

Table 9-4 shows the expenditure on the reference alternative and in SFLL. All figures are calculated as present value at a discount rate of seven per cent. The capital expenditure also includes investments in the new export pipeline and the gas export facilities topside Statfjord B. The VOC cost is a specific fee for the transportation of oil on shuttle tankers. This fee reflects the cost of VOC recovery equipment installed on the tankers. The CO_2 charge is regarded as an ordinary tax and is excluded from the calculation of economic profitability.

Table 9-4: Expenditure (million 2004 NOK discounted (7 per cent) to present value)

Present value at 7% discount rate	SF reference alternative	SFLL
Capital expenditure *)	4 864	14 526
Operating expenditure (incl. insurance and VOC tax)	11 266	19 501
Processing of NLG at Kårstø and NGL - price of transport penalty	2 324	2 812
Plugging and decommissioning	4 900	2 971
Total costs	**23 354**	**39 810**

*) A Tampen Link of 32” dimension instead of 22” will increase the capital expenditure by approximately NOK 130 million.

By deducting the expenditure from the income, we get the net present value before tax. This is an expression of the economic profitability of the Statfjord Late Life project and the reference alternative. Table 9-5 below shows the net present value before tax.

Table 9-5 Profitability (million 2004 NOK discounted (7 per cent) to present value)

Present value at 7% discount rate	SF reference alternative	SFLL
Total income	35 710	61 698
Total expenditure	23 475	40 152
Net present value before tax	**12 356**	**21 888**

The table above shows that the net present value of income and expenditure is estimated to be approximately NOK 12 billion for the reference alternative and approximately NOK 22 billion for Statfjord Late Life.

9.3 Deliveries of Goods and services and Employment during the Construction Phase

The cost estimates are used as the basis for the description of deliveries in the investment and production phases. The estimated effects on employment during the period 2005-2012 (development phase) are based on these cost estimates. Capital expenditure in 2004 has also been included since, according to the model, it will generate employment in subsequent years. The figures shown in Table 9-1 for SFLL also include capital expenditure (approx. NOK 0.7 billion) for the period 2012-2018, after the SFLL development, which are not included in Table 9-1.

Capex for the reference alternative for the period 2004-2009 amounts to NOK 5.4 billion (2004 NOK). Capex for SFLL for the period 2004-2018 amounts to NOK 16 billion (2004 NOK) peaking in 2006 and 2007.

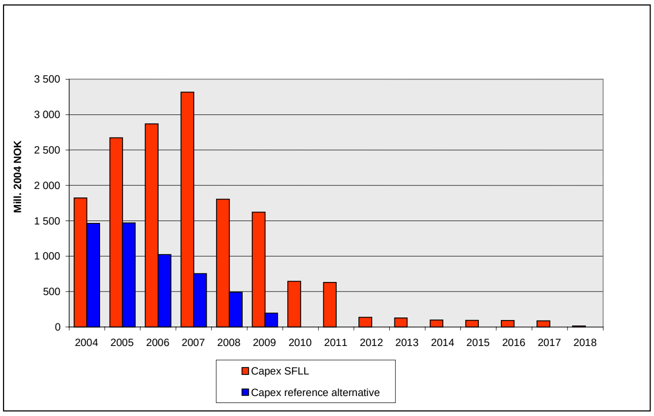

Figure 9-1: Capital expenditure distributed over the period 2004 – 2018

All major capital investment items are broken down into costs relating to different tasks, such as project management, engineering, procurement, onshore fabrication, offshore construction, offshore operation and decommissioning. The figure below shows the capital expenditure for SFLL broken down into different items.

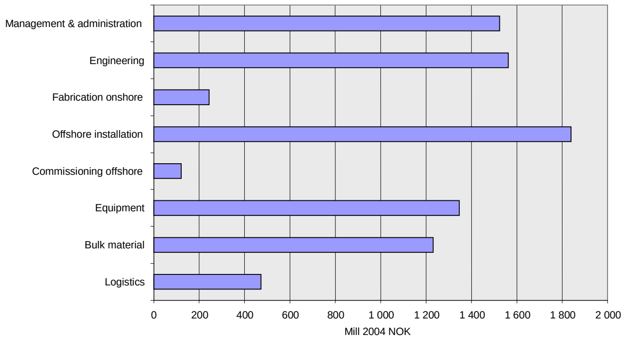

Figure 9-2: Capital expenditure distributed over the period 2005-2011, SFLL-alternative

Offshore installation, management and administration and engineering are important capex elements during the construction phase. Drilling and completion of wells is, however, the major capex element, with annual expenditure of NOK 500-900 million in the period 2005-2011 and with a total expenditure of NOK 5.1 billion (2004 NOK).

It is assumed that the mechanical engineering industry and engineering companies will account for a major share of the deliveries to SFLL. Transport, logistics and trade in goods are other important sectors for deliveries to SFLL. Drilling companies can also expect considerable orders.

9.3.1 The Calculation Model

Calculations of the effects of the development and operation of the Statfjord Late Life project on employment are based on the Panda model. The model calculates direct, indirect and consumption effects (employment generated by increased consumption) on employment, on the basis of capital and operating expenditure. The model breaks down the employment effects by year and sector on the basis of the time period and industry profiles of expenditure. The direct and indirect effects include the procurement of goods and services, spreading from main contractors to subcontractors and to other industrial segments, thereby influencing the total added value in the economy.

The calculation model is based on estimated deliveries of goods and services by different sectors over the period. It calculates total production in the industry by both main contractors and their subcontractors. The value of the production is then converted into employment (man-years) by the use of statistics for production value per man-year in different industries/business sectors.

The causal connection consists of a chain of deliveries by industry generated by the main deliveries from main and subcontractors. The calculations for the reference alternative and SFLL include capital expenditure and operating expenditure in the period 20054-2026. All planned removal of installations at Statfjord will be completed by 2026.

The results of the calculations are shown for three different types of employment effects:

1. Direct employment by the operator (Statoil) and integrated contractors
2. Indirect employment by main contractors and subcontractors
3. Derived employment generated by increased consumption by employees of the operators and contractors.

9.3.2 Employment during the Construction Phase

The diagram below shows the employment effect during the construction phase for the reference alternative and for SFLL. The diagram includes employment effects generated by both capex and opex during this period.

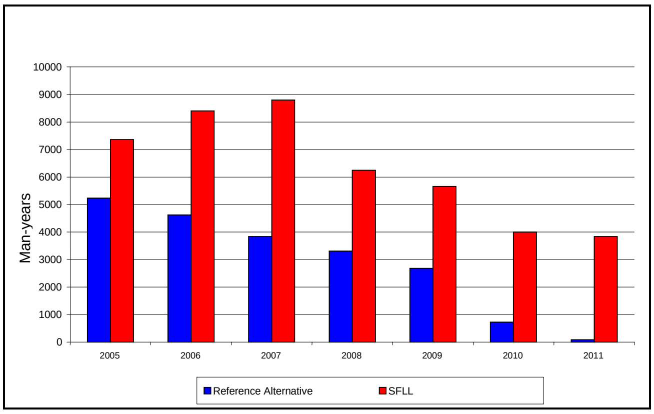

Figure 9-3: Employment effects of capex and opex during the construction phase

The employment effect during the construction phase (2005-2011) will amount to 20,500 man-years for the reference alternative, maintaining steady operations based on the current production strategy. The employment effect for SFLL during the construction phase (2005-2011) will amount to 44,300 man-years – more than twice the employment effect in the reference alternative. The maximum employment effect of the SFLL case during the construction phase will occur in 2007 with close to 9,000 man-years including consumption effects. This is commensurate with 2007 being the peak year for investments in SFLL.

Figure 9-4and Figure 9-5 show these employment effects in the development phase, broken down by sector. Employment in the "production of oil and gas" sector amounts to 30 per cent of the total employment in the reference alternative. This share is reduced to 20 per cent in the SFLL case. The engineering industry and commercial services account for a larger share in the SFLL alternative than in the reference alternative (18 per cent compared with 10 per cent).

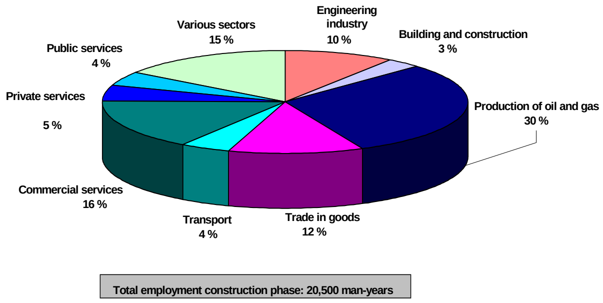

Figure 9-4: Sector distribution of employment effects in the reference alternative (construction phase)

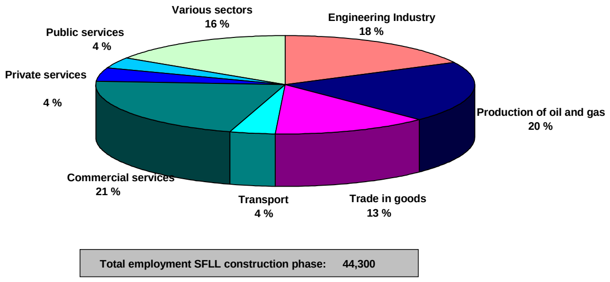

Figure 9-5: Sector distribution of employment effects in SFLL (construction phase)

9.4 Deliveries of goods and services and employment during the production phase

The production phase for the reference alternative is assumed to last until 2009. In the SFLL case, the production phase is assumed to last until 2018. Plugging and abandonment of wells and platform removal will take place from the end of the production phase. The decommissioning phase is estimated to last for 6-8 years.

Deliveries will mainly consist of production materials and production chemicals and maintenance materials and spare parts. Platform personnel will include operating, maintenance and catering personnel. In addition, there will be services relating to the modifications. Logistical services will include onshore supply bases, helicopters and supply vessels and stand-by vessels. There will be an administrative and support organisation onshore.

9.4.1 Operating Expenditure

The diagram below shows operating expenditure for the period 2005-2009 for the reference alternative and for the period 2005-2018 for the SFLL case.

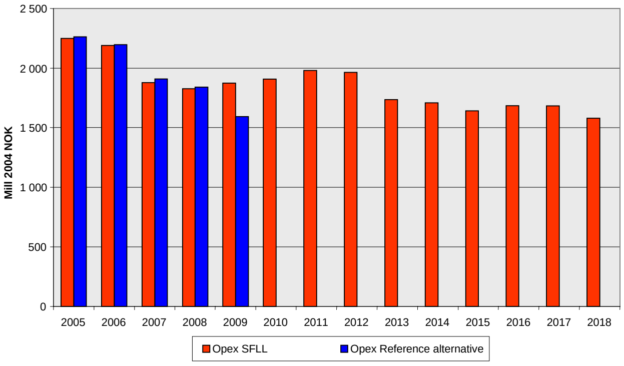

Figure 9-6: Operating expenditure broken down by year (CO_2 and NOx fee excluded)

The figures for the reference alternative and SFLL are quite similar for the period 2005-2009. The production phase is assumed to last until 2009 for the reference alternative. Opex for the SFLL case is estimated at approximately NOK 2 billion (2004 NOK) for every year from 2005-2012.

SFA will be plugged in 2013 and, from that point onwards, opex will be approximately NOK 1.7 billion per year. The total opex will amount to NOK 10 billion (2004 NOK) for the reference alternative (accumulated over the period 2005-2009) and approximately NOK 26 billion (2004 NOK) for the SFLL case (accumulated over the period 2005-2018).

9.4.2 Employment during the Production Phase for SFLL

Figure 9-3 above shows the employment effects of the reference alternative and includes employment generated by capex and opex during the period 2005-2011. Figure 9-7 shows the total employment effect for typical years during the SFLL production phase. When the construction phase ends in 2010/2011, the total annual expenditure will decline and stabilise at a lower level.

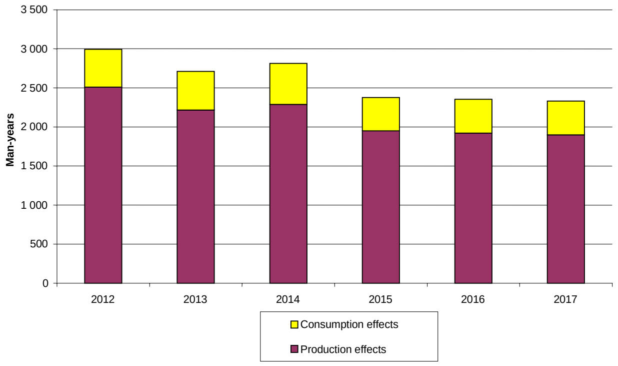

Figure 9-7: Employment effects during the production phase, SFLL

The total employment effect during the operation phase will be almost 3,000 man-years in 2012, declining gradually to 2,400 man-years in 2017. The total employment effect in the SFLL case for the production phase as a whole (the period 2012-2018) amounts to approximately 18,000 man-years. Figure 9-8 shows the employment effect broken down by sector in the production phase.

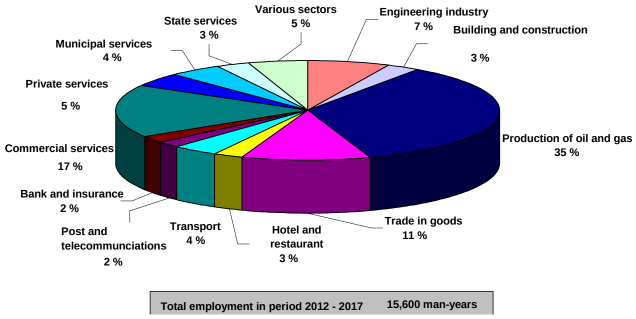

Figure 9-8: Employment effect by sector during the production phase

The "production of oil an gas" sector accounts for 35 per cent of total employment during the production phase.

9.5 Decommissioning Phase

The plugging of wells and decommissioning of platforms will take place partly on a sequential basis and partly concurrently and will last for approximately seven years. The total expenditure on plugging, abandonment and removal is estimated at NOK 10.9 billion (2004 NOK) for the reference alternative and NOK 10.8 billion (2004 NOK) for the SFLL case. Figure 9-9 shows the decommissioning expenditure for the reference alternative and the SFLL case.

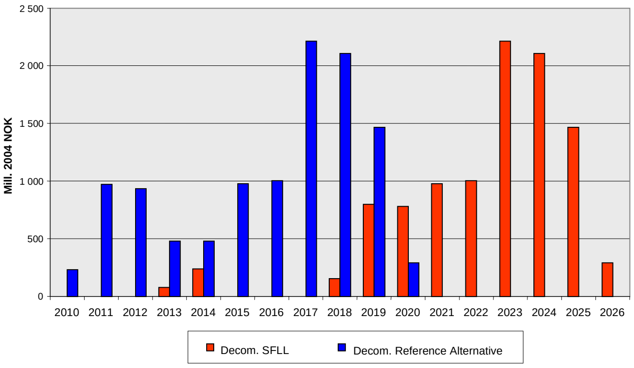

Figure 9-9: Decommissioning expenditure

(includes OPEX during plugging and abandonment and SF unit OPEX during the cold phase 2013-14 for the reference alternative)

Figure 9-10 shows the employment effects of the decommissioning phase for the reference alternative and the SFLL case. The employment effects will be in the same range in both alternatives, but the effects will take place 4-5 years later in the SFLL case than in the reference alternative. Peak employment will be in the range of 3,000-3,500 man-years and will occur in 2017/ 2018 for the reference alternative and in 2023/ 2024 for the SFLL alternative.

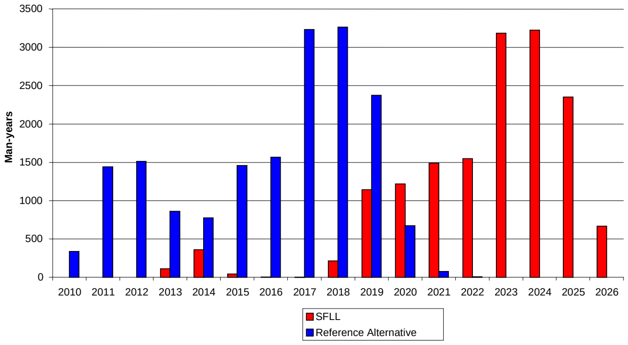

Figure 9-10: Employment effects of decommissioning

9.6 Comparison of the Employment Effects of the Reference Alternative and the SFLL

The total expenditure differs considerably for the two alternatives and the profiles for the period also differ, resulting in different employment effects for the two alternatives. Figure 9-11 shows the total employment effect for the whole period (2005 – 2026). Capex, opex and expenditure relating to the decommissioning phase are included.

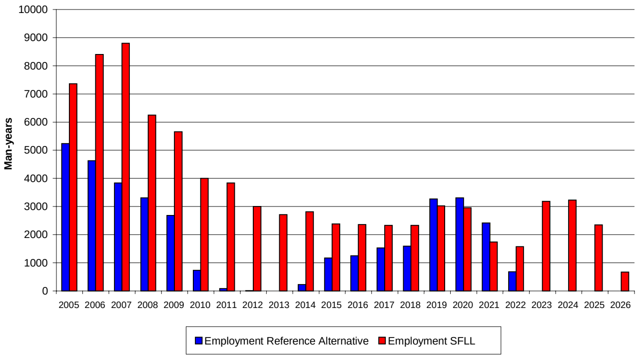

Figure 9-11: Total employment effects of both alternatives broken down by year

The employment generated by the reference alternative will decline to approximately zero after 2010, but from 2015 onwards there will be considerable activity relating to abandonment and the removal of installations.

The level of employment generated by the SFLL case will be high during the construction phase, declining to a lower level during the operation phase and then rising considerably as a result of the decommissioning of installations.

Table 9-6 shows the total employment effects broken down by phase and type of effect. The figures below may differ slightly from the figures presented above, due to a different distribution of capex and opex in the different phases.

Table 9-6: Employment effects of the reference alternative and SFLL

	Reference alternative		
	Production effect	Consump-tion effect	**Total effect**
Construction phase 2005 - 2011	16 000	4500	20 500
Production phase 2012 - 2018			
Decommissioning phase	12 500	3000	15 500
Total employment	**28 500**	**7500**	**36 000**
	Statfjord Late Life		
	Production effect	Consump-tion effect	**Total effect**
Construction phase 2005 - 2011	35 500	8800	44 300
Production phase 2012 - 2018	15 600	3900	19 500
Decommissioning phase	12 500	3000	15 500
Total employment	**63 600**	**15 700**	**79 300**

The total employment effect of the reference alternative is estimated at 36,000 man-years, of which approximately 20,500 during the period 2005-2011 and 15,500 during the decommissioning phase.

The SFLL case will generate a total employment effect of 79,300 man-years during the period 2005-2026, of which approximately 44,300 (55 per cent) during the construction phase (2005 – 2011), 19,500 (25 per cent) during the operating phase and 15,500 (20 per cent) during the decommissioning phase.

The employment effect of the new Tampen Link pipeline between SFB and FLAGS that constitutes the selected gas-export solution for the SFLL case is not included in the above calculations. Based on the current estimates, the cost estimate for the Tampen Link (22” dimension), including gas export and gas import solutions at SFB, is approximately

NOK 1,550 million (2004 NOK), alternatively (32” dimension) NOK 1,680 million (2004 NOK).

The employment effect of the gas export solution will occur in the period 2005-2007 and be in the range of 2,300-3,200 man-years. If this employment effect is added to the effects of the SFLL alternative, the total effect during the construction period (2005-2011) will be 47,000 man-years.

10 Environmental Management

10.1 Company Policy

Statoil has an Environmental Policy which supports the goals of zero harm to the environment and sustainable development. Statoil's environmental policy is set by the company's senior management and applies to all the company's activities worldwide and to the whole workforce. Statoil's Environmental Policy is:

- We will act according to the precautionary principle
- We will minimise impact on the environment, whilst continuing to address health, safety and economic issues
- We will comply with applicable legislations and regulations

- We will continuously improve our energy efficiency, products and environmental performance
- We will set specific targets and improvement measures based on relevant knowledge of the area affected, and by applying risk analyses to assess environmental health effects
- We will consult and cooperate with relevant stakeholders and strive for solutions acceptable to all affected parties
- We will make our policy available to the public, openly report our performance and use a competent and independent body to verify our reported data
- We will seek to make the best possible utilization and use of natural resources
- We will contribute to the reduction of Green House Gases (GHG) by reducing relevant emissions from our activities and by participating in emission trading and utilising project based mechanisms
- We will prepare for a carbon constrained energy market and engage in the development of non-fossil energy sources and carriers

10.2 Policy Implementation and Environmental Management Systems

The commitments of the environmental policy are enacted by mechanisms that Statoil puts in place to effectively implement, measure, control and improve the activities and processes that are carried out by the company and its contractors. These activities and processes form an integral part of the business, commercial planning and decision-making processes at Statoil. Statoil's requirements for managing activities and processes are described in the document *HSE management in Statoil.*

This document specifies standards for management, the organisation, expertise, risk management and emergency response, as well as technical requirements for health and the working environment, the natural environment, safety, emergency response and security. HSE is a line management responsibility in Statoil. Managers have a particular duty to ensure that goals are met, but all employees in the company share a personal responsibility for this. Statoil requires that all entities have established and documented appropriate systems, which ensure that HSE requirements are met.

Such a system will apply to the SFLL project, and this Environemntal Statement being a planning and decision making document within that system.

10.3 Project Specific Environmental Management – Mitigating Measures and Activities to follow up

The environmental impact assessment describes mitigating measures and potential improvements that will be further assessed in the planning work. The project will follow up these measures continuously during the development and production phase.

In addition, the project will try to identify new mitigating measures, as part of its ordinary health, safety and environment (HSE) work pursuant to Statoil's own guidelines for all project phases (for the engineering, development and production phases.)

Table 10-1: Planned measures and follow-up activities

Planned measures and follow-up activities					
Possible impacts	**Mitigating measures**			**Discharge reporting**	**Monitoring and development of knowledge**
	Design	Operative	Responsible		
Discharges of produced water	CTour at SFA, SFB, SFC (2005)		Statfjord	Annual discharge reporting	Regional programme for monitoring sediment and the water column
	Adaptation of CTour for low-pressure production at SFA, SFB and SFC		Statfjord Late Life		
	Capacity expansion of CTour for the treatment of satellite water (SFC)		Statfjord Late Life		
	Cooling measures for the increase of condensate quantities at SFB and SFC in connection with CTour		Statfjord Late Life		
		Optimising of hydrocyclones and CTour	Statfjord and Statfjord Late Life		
		Working towards further substitution of corrosion inhibitors	Statfjord and Statfjord Late Life		Testing of new chemicals
Emissions to air	Gas recovery fom produced water at SFB (currently flared)		Statfjord	Annual discharge reporting	

Tabell 10-1: Planned measures and follow-up activities (continues)

Planned measures and follow-up activities					
Possible impacts	**Mitigating measures**			**Discharge reporting**	**Monitoring and development of knowledge**
	Design	Operative	Responsible		
Discharges of produced sand	Sand cyclones with cleaning units at SFA, SFB and SFC		Statfjord Late Life	Annual discharge reporting	Improved documentation of discharges of oily sand and dispersed oil in the "jetting" water
	Sand control measures planned for installation in all new and most of the re-completed wells (2006-2011)		Statfjord Late Life		
	Two sand detectors per flow line*	Monitoring of sand production for the optimising of jetting operations	Statfjord and Statfjord Late Life		
Discharges in connection with drilling		Re-use of oil-based mud	Statfjord Statfjord Late Life	Annual discharge reporting	Regional programme for monitoring sediment and water column
		Injection of oil-based drillcuttings and drilling mud into the Utsira formation	Statfjord Statfjord Late Life		
		Working towards further substitution of cementing and completion chemicals	Statfjord Statfjord Late Life		
		Working towards further substitution of scale inhibitors and scale dissolvers	Statfjord Statfjord Late Life		

*Two sand detectors per producer are currently installed (Nov. 2004) and this practice will be continued in late life

Tabell 10-1: Planned measures and follow-up activities (continues)

Planned measures and follow-up activities					
Possible impacts	**Mitigating measures**			**Discharge reporting**	**Monitoring and development of knowledge**
	Design	Operative	Responsible		
Accidental discharges		Current emergency response plan		Reporting pursuant to the specific requirements stated in the discharge permit. Annual reporting	Procedures decribed in NOFO's emergency response plan
Waste		LRA in accordance with the guidelines			
		Sorting at source and waste handling in accordance with OLF's guidelines.			
		Requirements for contractors' HSE systems			

Table 10-2: Planned measures and follow-up activities for consideration

Planned measures and follow-up activities (for consideration)					
Possible impacts	**Mitigating measures**			**Discharge reporting**	**Monitoring and development of knowledge**
	Design	Operative	Responsible		
Discharges of produced water (H_2S formation and use of H_2S scavenger)		Cessation of PWRI at SFC	Statfjord		
	Injection of H_2S scavenger into separate wells at SFB and SFC		Statfjord Late Life		
Discharges of produced sand*		Optimising of the jetting process based on improved sampling points and measurement programme	Statfjord and Statfjord Late Life		
	Use of pre-jetting in combination with automatic jetting and sand detectors in the jetting-water outlet	Use of pre-jetting	Statfjord and Statfjord Late Life		
Emissions to air	New electrical 1 and 2 stage compressors at SFB		Statfjord Late Life		

*Alternative to sand cleaning

11 References

11.1 Reports and Scientific Publications

1 ABB Offshore Systems (2004). *Tampen Hub Study*. Document No: ABB-O-04-00158. Project: 003239. 63pp.

2 Akvaplan niva (2002). Miljøundersøkelse i Region IV. Report number: APN-411.2520-2.

3 Akvaplan-niva (2000). Environmental Status of the Norwegian Offshore Sector Based on the Petroleum Regional Monitoring Programme, 1996-1998. Prepared for the Norwegian Oil Industry Association (OLF),

4 Alpha (2004). Environmental Risk Analysis, Statfjord Late Life. Report no: 1199-01-01

5 Alpha (2004). Gap-analysis of contingency plan. Statfjord Late Life. Report no: 1199-04-02

6 Alpha (2004). Miljørisikoberegning for strandressurser. Alpha Miljørådgivning. Internt notat: OWB140904. 5s. In Norwegian.

7 Alpha (2003). ActLog 2003. Alpha Miljørådgivning.

8 Alpha (2002). Implementering av eksponeringsbasert (e-MIRA) og skadebasert (s-MIRA) miljørisikomoduler i ArcView. (http://www.alphaenv.no/faktaark_contact_emira.htm og http://www.alphaenv.no/faktaark_contact_smira.htm). In Norwegian.

9 Alpha (2000). Testing og validering av DamE-Shore for praktisk anvendelse i miljørisikoanalyser. Alpha Notat KAM201100_1. 12 s. In Norwegian.

10 Anker-Nilssen, T., Bakken, V., Golovkin, A.N., Bianki, V.V. & Tatarinkova, I.P. (red.). (2000). The status of marine birds in the Barents Sea breeding region. Norsk Polarinstitutt meddelelser no. 113. 213 pp.

11 Bakken, V., Runde, O & Tjørve, E. (2003) Norsk Ringmerkingsatlas. Vol. 1 Stavanger Museum, Stavanger. In Norwegian.

12 Basford *et al*,. (1989). *The epifauna and infaruna of the northern North Sea (56° - 61°N).* Journal of Marine Biology Association, UK. 69, pp.387-407.

13 Basford DJ, Eleftheriou A and Raffaeli D (1990). *The Infauna and Epifauna of the Northern North Sea*. Netherlands Journal of Sea Research. 25: pp.165-173.

14 Basford DJ, Eleftheriou A, Davies IM, Irion G and Soltwedel (1993). *The ICES North Sea benthos survey: the sedimentary environment*. ICES Journal of Marine Science. 50: pp.71-80.

15 Bjørn, T.H. (2000). Oteren i Finnmark. Report from Fylkesmannen I Finnmark. 31 pp. In Norwegian.

16 BODC (1998). United Kingdom Digital Marine Atlas – An Atlas of the seas around the British Isles (CD-ROM) British Oceanographic data Centre, Merseyside, UK. Natural Environment Research Council, 3rd. ed. 1998

17 Brander K (1992). A re-examination of the relationship between cod recruitment and Calanus finmarchicusin the North Sea. ICES mar. Sci. Symp., 195: pp.393-401.

18 Brattegard T. and Holthe T. (eds.) (1997) Distribution of marine, benthic macro-organisms in Norway. Research report for DN 1997-1 Directorate for Nature Management).

19 Brattegard, T. & Holthe, T. (red.) (1995), Kartlegging av marine verneområder i Norge. Tilråding fra rådgivende utvalg, - Utredning for DN 1995-3. Direktoratet for naturforvaltning.179 pp. In Norwegian.

20 Brude, O.W., Moe, K.A., Skeie, G.M., Østby, C. & Engen, F. (2004), An approach to Net Benefit Analysis (NEBA) for the Norwegian Continental Shelf. Paper presented at the Interspill 2004

Conference, Trondheim, Norway, June 14th to 17th 2004.

21 Brude, O.W., Moe, K.A., Østbye, C., Stige, L.C & Lein, T.E. (2003 a). Strand – Olje. Implementering av Damα-Shore for norskekysten. Alpha Rapport 1111-01 42 pp. In Norwegian.

22 Brude, O.W., Systad, G.H. , Moe, K.A., & Østby, C. (2003 b). Uhellsutslipp til Sjø. Miljøkonsekvenser på sjøfugl, sjøpattedyr, strand, iskant mv. ULB Delutredning – studie 7-b. Alpha Miljørådgivning rapport nr. 1157-01. In Norwegian.

23 Brude, O.W, Østby, C., Moe, K.A., Lorentsen, S.-H., Follestad, A., Fossum, P., Heide, M.A., Sunde, L.M. & Melbye, A.G. (2002) Regional konsekvensutredning, Norskehavet. Underlagsrapport: Oversikt over miljøressurser. SINTEF Rapport STF66 A02059. 146 pp. In Norwegian.

24 Brude, O.W., Ugland, K.I. & Moe, K.A.. (2000). Olje-Fisk – Barentshavet. Anskueliggjøring av miljørisiko i forbindelse med Borekampanjen 2000-2001. Alpha Miljørådgivning Report no. 1057-1. 32 pp. In Norwegian.

25 Brude, O.W., Moe, K.A., Skeie, G.M. & Østby, C. (1999). SMO modul – ArcView extension. Alpha CD 1047-01-99. Elektronisk publikasjon. In Norwegian.

26 Børseth, J.F., Skadsheim, A., Myhre, L.P, (2004), Statfjord Late Life environmental assessment of produced water, Report RF-2004/173

27 Connor, D.W., Breen, J., Champion, A., Gilliland, P.M., Huggett, D., Johnston, C., Laffoley, D.d'A., Lieberknecht, K., Lumb, C., Ramsey, K., and Shardlow, M. (2002). *Rationale and criteria for the identification of nationally important marine nature conservation features and areas in the UK. Version 02.11.* Peterborough, Joint Nature Conservation Committee (on behalf of the statutory nature conservation agencies and Wildlife and Countryside Link) for the Defra Working Group on the Review of Marine Nature Conservation.

28 DN, (2004): Råd til utforming av marin verneplan for marine beskyttede områder i Norge – Endelig tilråding med forslag tilreferanseområder. Rådgivende utvalg for marin verneplan. 20. juni 2004. Directorate of Nature management. 35 pp. In Norwegian.

29 DN, (2003): Råd til utforming av marin verneplan for marine beskyttede områder i Norge - Foreløpig tilråding fra Rådgivende utvalg for marin verneplan pr. 17. februar 2003. Directorate of Nature management. 187 pp. In Norwegian.

30 DN, (1988): Nasjonal rødliste for truede arter 1998. Norwegian Red-list 1998. Directorate for Nature Management. DN-rapport 1999-3. 162 pp.

31DTI, (2002). Strategic Environmental Assessment of parts of the central and southern North Sea, SEA3.

32 DTI (2001a). Strategic Environmental Assessment of the Mature Areas of the Offshore North Sea SEA2. Report to the Department of Trade and Industry. Consultation Document, September 2001.

33DTI (2001b). An Overview of Plankton Ecology in the North Sea. Technical Report produced for Strategic Environmental Assessment – SEA2. Technical Report TR_005. Produced by The Sir Alister Hardy Foundation for Ocean Science (SAHFOS).

34DTI (2001c). Background Information on Marine Mammals Relevant To SEA2. Technical Report TR_006. Produced by Sea Mammal Research Unit, August 2001.

35DTI (2001d). North Sea Fish and Fisheries Technical Report TR_003 produced for Strategic Environmental Assessment – SEA2.

36 Eleftheriou, A and Basford, D.J. (1989). The macrobenthic fauna of the offshore northern North Sea. Journal of the Marine Biological Association of the UK. 69, pp.123-143.

37 European Commission: http://www.europa.eu.int/comm/index_en.htm

38 Fossum, P. & Øiestad, V. (1992). De tidlige livsstadiene hos fisk i møte med trusselen fra petroleumsvirksomheten. Sluttrapport fra

Havforskningsinstituttets egg og larveprogram – HELP (1985-1991). 78 pp. In Norwegian.

39 Fosså, J.H., Mortensen P.B. & Furevik, D.M. (2000). *Lophelia*-korallrev langs norskekysten – Forekomst og tilstand.Fisken og Haven no. 2-2000. Havforskningsinstituttet (Institute of Marine Research). 94 pp. In Norwegian.

40 Føyn, L., von Quillfeldt, C.H. & Olsen, E. (2002). Miljø- og ressursbeskrivelse av området Lofoten-Barentshavet. Fisken og Havet, Nr. 6 – 2002. In Norwegian.

41 Gassco, 2004, Transport Analyse - Tampen Link, Doknr: ISU-2004-RA-002

42 George, S.G., Wright, J. & Conroy, J. (1995). Temporal Studies of the Impact of the Braer Oilspill on Inshore Feral Fish from Shetland, Scotland. *Arch. Environ. Contam. Toxocol.* 29: 530-534 (1995).

43 Gjershaug, J.O., Thingstad, P.G., Eldøy, S., & S. Byrkjeland (red.). (1994). Norsk Fugleatlas. Hekkefuglenes utbredelse og bestandsstatus i Norge. Norsk Ornitologisk Forening, Klæbu. 552 pp. In Norwegian.

44 Hall, A., Watkins, J. & Hiby, L. (1996). The impact of the 1993 Braer oil spill on grey seals in Shetland. The Science of the Total Environment 186 (1996) 119-125.

45 Institute of Petroleum, (2000); Learn IT Summary Reports 2001, 2002

46 Johansen, Ø., Skognes, K., Aspholm, O.Ø., Moe, K.A., Østby, C., Fossum, P. (2003). Utredning av helårs oljevirksomhet i området Lofoten- Barentshavet. Uhellsutslipp av olje – konsekvenser i vannsøylen. ULB Delutredning – studie 7-c. SINTEF rapport nr. STF66 F03028. In Norwegian.

47"Johnsen, S, Frost, T.K; Hjelsvold, M and Røe Utvik, I.M: (2000)"The environmental Impact Factor - a proposed tool for produced water impact reduction, management and regulation", SPE-paper 61178, presented at the SPE Conference in Stavanger June 2000."

48 Johnson, H., Richards, P.C., Long, D. and Graham, C.C. (1993). *United Kingdom Offshore regional Report: The geology of the northern North Sea*. London, HMSO for the British Geological Survey.

49 Joint Nature Conservation Committee (JNCC) (1996): Guidelines for selection of biological SSSI's, intertidal marine habitats and saline lagoons. Joint Nature Conservation Committee, Peterborough.

50 Künitzer, A., Basford, D., Craemeersch, J. A., Dewarumez, J. M., Dörjes, J., Duineveld, G. C. A., Eleftheriou, A., Heip, C., Herman, P., Kingston, P., Niermann, U., Rachor, E., Rumohr, H., and de Wilde, P.A.J. (1992). *The benthic infauna of the North Sea: species distribution and assemblages.* ICES Journal of Marine Science, 49, pp.127-143.

51Larsen, Skardhamar, Hylland, Molvær (2004), Statfjord Late Life-Environmental effects of discharges of oily sand

52 McLeod, CR, Yeo, M, Brown, AE, Burn, AJ, Hopkins, JJ, & Way, SF (eds.). (2002). The Habitats Directive: selection of Special Areas of Conservation in the UK. 2nd edn. Joint Nature Conservation Committee, Peterborough. www.jncc.gov.uk/SACselection

53 Melle, W., Serigstad, B. & Ellertsen, B. (2001). Environmental risk of deep water oil drilling. A preliminary analysis. IMR Report 1/2001. Institute of Marine Research, Bergen, Norway. 50 pp.

54 Meteorological Office, (2000). *Annual wind data for sea area 60.5°N to 62.5°N, 0°E to 03°E.*

55 Michalsen, K.(ed.) (2003). Havets ressurser 2003. Fisken og havet, særnr. 1-2003. In Norwegian.

56 Miljøsok (2000), Final report -MILJØSOK Phase 2, One environment–One endeavour.

57 Mitchell, P.I., Newton, S.F., Ratcliffe, N. & Dunn, T.E. Seabird Populations of Britain and Ireland (Executive Summary) T. & A.D. Poyser, London.

58 Moe, K.A. & Brude, O.W. (2002). RKU Norskehavet: konsekvenser av uhellsutslipp til sjø.

Aktivitet 3: Virkninger av Akutte Oljeutslipp – Vannsøylen. Alpha Notat. 1098-IV. In Norwegian.

59 Moe, K.A., Skeie, G.M., Brude, O.W., Løvås, S.M., Nedrebø, M. & Weslawski, J.M. (2000a). the Svalbard Intertidal Zone; a concept for the use of GIS in applied oil sensitiviety, vulnerability and impact analysis. Spill Science & Technology Bull. 6(2): 187-206

60 Moe, K.A., Ugland, K.I., Brude, O.W. & Skeie, G.M. (2000b). Fisk & Olje - Et integrert konsept for skade- og risikoberegninger. Rapport 1028-1. Alpha Miljørådgivning. 34 s. In Norwegian.

61 Moe, K.A., Anker-Nilssen, T., Bakken, V., Brude, O.W., Fossum, P., Lorentsen, S.H. & Skeie, G.M. (1999). Spesielt Miljøfølsomme Områder (SMO) og petroleumsvirksomhet. Implementering av kriterier for identifikasjon av SMO i norske farvann med fokus på akutt oljeforurensning. Alpha Miljø-rådgivning-Havforskningsinstituttet-Norsk institutt for naturforskning-Norsk Polarinstitutt. Alpha Rapport 1007-1 (51 s.) + Web-Atlas CD-ROM. In Norwegian.

62 Moe, K.A., Serigstad, B. & Brude, O.W. (1998). Olje-fisk; en reduksjonistisk tilnærmelse til skade- og risikoberegninger. Rapport 1012-98-1. Alpha Miljørådgivning. 26 s. In Norwegian.

63 Moen, F.E. & Svendsen,E. S., (2003). Dyreliv i havet – Nordeuropeisk marin fauna. KOM Forlag. 3. ed. 608 pp. In Norwegian.

64 MRDB, (2004). Marine Resources Data Base - Environmental management tool for Norwegian offshore operators.

65 Myhre, L. P., T. Baussant, et al. (Draft 2004). Risk assessment of reproductive effects of alkyl phenols in produced water on fish stocks in the North Sea, RF-Akvamiljø, AM-2004/018**:** 77.

66 Nilsen. (2004). Innspill til MRA SFLL ang. rater og varigheter. Notat fra Espen Fyhn Nilsen, F&T MST til Øyvind Strøm, F&T MST, 29.07.2004. In Norwegian.

67 Nilssen, K.T., Institute of Marine Research (Havforskningsinstituttet), pers. medd. 9. februar, (2004).

68 Nilssen, K.T., Corkeron, P., Haug, T. Skavberg, N.E., Jenssen, B.M. & Henriksen, G.(2004), Status for havertbestandens ungeproduksjon langs norskekysten i 2001 – 2003. Fisken og havet No. 2/2004. In Norwegian.

69 NRC, (2003). Oil in the Sea. Inputs, Fates and Effects. National Research Council. The National Academies Press, Washington. 2003 edition. 265 pp

70 NSTF, (1993). *North Sea Quality Status Report 1993.* Oslo and Paris Commissions, London. Olsen and Olsen, Denmark. 132 + vi pp.

71 OLF, (2003), EIF COMPUTATIONAL GUIDELINES; “Manual For Standardised Modelling And Determination Of The Environmental Impact Factor (EIF)”, version 1.0,

72 OLF (2001). Miljørisiko. Veiledning for gjennomføring av miljørisikoanalyser for petroleumsaktiviteter på norsk sokkel. Metode for Miljørettet Risiko Analyse (MIRA). Report (56pp.)/Electronic publikation. Oljeindustriens Landsforening. In Norwegian.

73Oljedirektoratet (2001) ”Utredning av NO_X – reduserende tiltak for kraftgenerering til havs”, 2001

74 Olsen, E. & von Quillfeldt, C.H. (red.) (2003). Identifisering av særlig verdifulle områder i Lofoten-Barentshavet. Norsk Polarinstitutt & Havforskningsinstituttet, Tromsø/Bergen, 14. mars 2003. In Norwegian.

75 OSPAR (2003), Initial OSPAR List of Threatened and/or Declining Species and Habitats. Ref.No.2003-14. http://www.ospar.org/documents/dbase/decrecs/agreements/03-14e_Initial%20List%20of%20S%20and%20H.doc

76 OSPAR Commision (2000). Quality Status Report 2000. Region II Greater North Sea.OSPAR Commission, London, 136 + xiii pp.

77 Pollock, C.M., Mavor, R., Weir, C.R., Reid, A., White, R.W., Tasker, M.L., Webb, A & Reid, J.B (2000). The distribution of seabirds and mammals in the Altantic Frontier, north and west of Scotland. Seabirds & Cetaceans Joint Nature Conservation Committee, Aberdeen, Scotland. 91 pp.

78 Reid, J.B, Evans, P.G.H & Northridge, S.P. (eds.) (2003) . Atlas of Cetacean distribution in north-west European waters. Joint Nature Conservation Committee, Peterborough

79 Richie, W. Environmental impacts of the *Braer* oil spill and development of a strategy for the monitoring of change and recovery. Marine Policy, September: (1993), 434-440.

80 Rudberg, A. (2004). Oil Drift Simulation At Statfjord. DNV Report No. 2004-1030. Rev 01. 9 pp.

81 SFT & DN (1996). Beredskap mot akutt forurensning. Modell for prioritering av miljøressurser ved akutte oljeutslipp langs kysten. Statens forurensningstilsyn, Horten, Direktoratet for naturforvaltning, Trondheim. Veileder. 16 s. In Norwegian.

82 Shaw, D.N., Holt, C.A., Maggs, H.E. & de Palacio D. (2000). Fair Isle Seabird Studies 2000. JNCC Report No. 32. Joint Nature Conservation Committee, Aberdeen, Scotland. 56 pp.

83 SINTEF, (2001). Statfjord A, B og C. Egenskaper og forvitring på sjøen, karakterisering av vannløselige komponenter relatert til beredskap. Rapport STF66 F00138. In Norwegian.

84 SNH, (2003). SNH Facts and Figures 2002/2003, partial report concerning designated sites. http://www.snh.org.uk/pdfs/publics/ff2003/designated.pdf

85 Spikkerud, C.S., Randall, M.E., & Brude, O.W (2004).Environmental Risk Analysis – Statfjord Late Life, 1199-04-01

86 Statoil (December, 2004), Environmental Statement for the gas export pipeline Tampen Link

87 Statoil (April, 2004), Environmental Impact Assessment Programme, Statfjord Late Life

88 Statoil, (2004). Statfjord Late Life Design Basis. Technical and professional requirements TR1113, Version 1, Valid from 29.03.2004. Validity area: Tampen area/Statfjord Late Life/On- and offshore.

89 Statoil (September 2003), CO_2 and NO_X assessment for NPCA.

90 Statoil (July, 2003), SFLL Environmental and Social Assessment, SF-ZZ-Z-RS-056

91 Statoil (June 2003), Zero Discharge to Sea-Status Statfjord with Satellites, M-TO SF 0094.

92 Statoil (2003), HMS program for Statfjord

93 Statoil (2003), Miljøstrategi for UPN 2003-2010, PB019

94 Statoil (2003), Notat om teknologivalg for produsert vann

95Statoil (2002), Statfjord Late Life Project, “Emission to air summary report, Feasibility report”, dok.nr. 5593-RE-R-001, 15.04.2002

96 Statoil et al (1999), Regional Konsekvensutredning Nordsjøen. Temarapport 3: Beskrivelse av influensområdet til havs og på land. In Norwegian.

97 Statoil (1999, 2000, 2001, 2002), Statfjord’s Annual emission reports to NPCA.

98 Statoil et.al.(1999), Regional Environmental impact assessment for petroleum activities in the North Sea.

99 Statoil (October 1998), CO_2 mitigating measures, Offshore installations, CO_2-03/98.

100 Strålberg, E., Raaum,A. Varskog, P. (2003), Naturlige radionuklider i det marine miljø - en oversikt over eksisterende kunnskap med vekt på Nordsjø-området, ND/E-17/03, NorseDecom

101 Strålberg, E., Sidhu, R. S. and Varskog, P. (2002). Produsert vann og radioaktivitet - sammenfatning
av eksisterende data, ND/E-05/02, Norse Decom.

102 Strålevernet (2004) (in draft), "Natural Radioactivity in Produced Water from the Norwegian Oil and Gas Industry in 2003"

103 Sætre, R. 1999. Features of the central Norwegian shelf circulation. Continental Shelf Research 19: 1809-1831.

104 Sætre, R. (1983). Strømforholdene i øvre vannlag utenfor Norge. Havforskningsinstituttet. Rapport: FO 8306. 34 pp. In Norwegian.

105 Sætre R. & Bjørke, H. (1988). Oljevirksomhet på Møre. Konsekvenser for fiskeressursene. HELP-rapport nr. 19. Havforskningsinstituttets egg- og larveprogram (HELP). In Norwegian.

106 Sætre R. & Mork, M. (eds.) (1981). The Norwegian Coastal Current. Vol. 1 and 2. Proc. From the Norwegian Coastal Current Symp., Geilo, 9-12 September 1980. University of Bergen. 795 pp.

107 Thomassen, J., Hansson, R., Hoell, E.E. & Moe, K.A. 1997. Evaluering av metode for miljørettet risikoanalyse – MIRA ved bruk av AEAM-metoden. Arbeidsdokument fra et arbeidsseminar i Oslo 18-20. november 1996. NINA Oppdragsmelding 449: 1-125. In Norwegian.

108 Toresen, R. (1998). Havets resssurser. Bergen, Norge, Havforskningsinstituttet. In Norwegian.

109UKDMAP (1998). *United Kingdom Digital Marine Atlas – An atlas of the seas around the British Isles*. Software third edition compiled by British Oceanographic Data Centre, Birkenhead.

110 UKOOA (2000). UK Benthos Marine Environmental Survey Database.

111 Wiklund. J. Statfjord Late Life - Blowout Quantities (2007). Email as of 30.08.2004.

11.2 Agreements, Conventions, Regulations and Guidelines

112 Framework Agreement between the Government of the United Kingdom of Great Britain and Northern Ireland and the Government of the Kingdom of Norway relating to the Laying, Operation and Jurisdiction of Inter-connecting Submarine Pipelines (1998)

113”The Stafjord Treaty”, Agreement between the Government of the Kingdom of Norway and the Government of the United Kingdom of Great Britain and Northern Ireland on the Exploitation of the Statfjord Reservoirs and the Transport of Petroleum from these Reservoirs (1979)
114 DTI, Guidance notes on procedures for regulating offshore oil and gas field development, FDP

115 DTI, Guidelines for the completion of pipeline work authorisations (PWA’s)

116 DTI, Guidance notes on the Offshore Petroleum Production and Pipelines Assessment of Environmental Effects, Regulations 1999.

117 ESPOO (EIA), Convention on Environmental Impact Assessment in a Transboundary Context (1991)

118 EU Council Directive 97/11/EC, which is a Directive amending Council Directive 85/337/EEC

119 EU directive, the Environmental Assessment of Plans and Programmes Directive, 2001/42/EC

120 EC Directive on the conservation of wild birds (79/409/EEC) (“Birds Directive”)

121 EU Water Framework Directive

122 NPD (2000), Guidelines to plan for development and operation of a petroleum field (PDO) and plan for installation and operation of facilities for transport and utilisation of petroleum (PIO).

123 Petroleum Production and Pipelines (Assessment of Environmental Effects) Regulations (1999).

124 The Norwegian Petroleum Act

125 The Norwegian Pollution Control Act

11.3 WEB Adresses

126http://www.jncc.gov.uk/ProtectedSites/marine/marine_spa.htm

127http://www.jncc.gov.uk/

128http://www.snh.org.uk/default.htm

129http://europa.eu.int/eur-lex/en/consleg/pdf/1979/en_1979L0409_do_001.pdf

130http://europa.eu.int/comm/environment/nature/nature_conservation/eu_nature_legislation/habitats_directive/index_en.htm

131http://www.wetlands.org/RDB/quick.html

132http://whc.unesco.org/pg.cfm

133http://www.ospar.org/

134http://www.biodiv.org/default.aspx

135http://www.jncc.gov.uk/marine/irishsea_pilot/rmncdefault.htm

136 http://www.ukbap.org.uk/.

137 http://planverk.nofo.no/r3a_oil.htm
138http://europa.eu.int/smartapi/cgi/sga_doc?smartapi!celexapi!prod!CELEXnumdoc&lg=EN&numdoc=31992L0043&model=guichett

139http://www.jncc.gov.uk/ProtectedSites/SACselection/species.asp?FeatureIntCode=S1364)).

140http://www.dirnat.no/wbch3.exe?p=2410

141www.snh.org.uk

142http://www.jncc.gov.uk/ProtectedSites/SACselection/1542

Appendix A The EIA Process in Norway and the United Kingdom

A.1 The Process in relation to the Norwegian Authorities

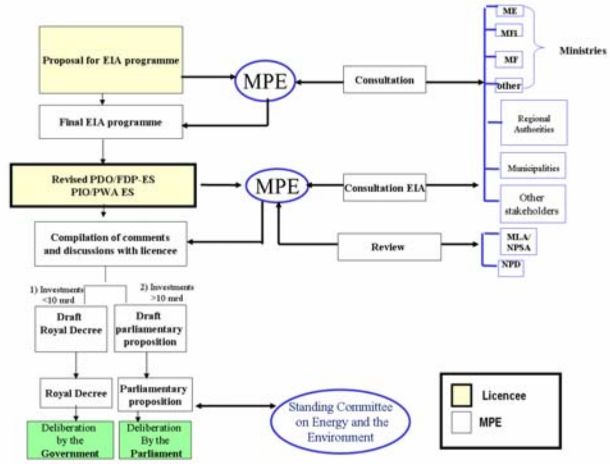

Figure A-1: The EIA process in Norway

The EIA process formally starts with a discussion of the framework for the process with the Norwegian Ministry of Petroleum and Energy (MPE) as the regulatory authority. A draft assessment programme is then sent to the MPE for consideration (Figure A-1).

The Ministry decides which are the relevant consultation bodies, distributes the programme and obtains statements from these. When the consultation round has been completed, the MPE submits the comments on the assessment programme to the developer and, when the developer’s views on these comments have been received, adopts the final assessment programme for the environmental impact assessment.

On the basis of the assessment programme adopted, the developer will prepare an environmental impact assessment as part of the PDO (Plan for Development and Operation) and/or PIO (Plan for Installation and Operation).

The MPE distributes the environmental impact assessment to the same consultation bodies that were consulted on the draft assessment programme, and obtains statements from these. Statements on the PDO and/or PIO are also obtained from the Norwegian Ministry of Labour and Government Administration through the Petroleum Safety Authority (working environment and safety) and the Norwegian Petroleum Directorate (resource factors).

The statements from the EIA consultations are then submitted to the developer for comment. The ministry will be in charge of the further consideration of the EIA and the consultation statements received, and will ultimately decide whether the assessment obligation has been met. The EIA will be dealt with by Royal Decree or by the Storting.

On account of its investment budget of more than NOK 10 billion, Statfjord Late Life will require approval by the Storting. MPE will therefore make a recommendation in the form of a Proposition to the Storting which will be considered by the Storting’s committees before it is submitted to the Storting for final approval. The Proposition to the Storting summarises the project in its entirety, including its impacts and any preconditions and measures on which approval is based.

A.2 The Process in relation to the UK Authorities

A simplified presentation of the UK EIA process is shown in Figure A-2.

The Department of Trade and Industry (DTI) is made aware of the project and may be asked to decide on an application for dispensation from the requirement to prepare an Environmental Statement in the form of a ”Petroleum Operation Notice (PON) 15”.

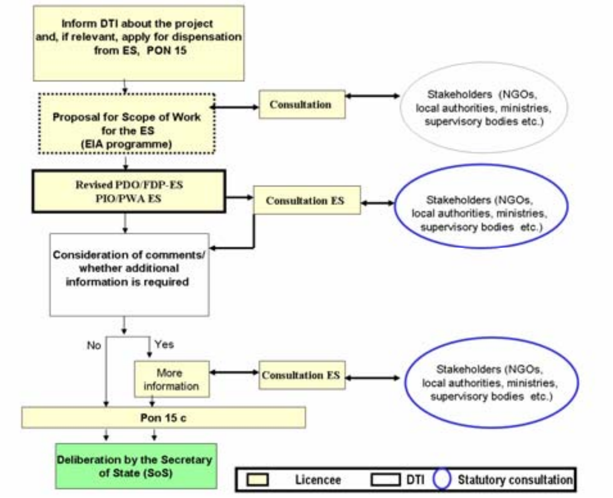

Figure A-2: The EIA process in the UK

If an Environmental Statement is required, the DTI recommends that the general public, fisheries organisations, environmental authorities and other relevant authorities and stakeholders be consulted before the ES is prepared. The licensee is responsible for this communication, and the DTI is consulted on an equal basis with other consultation bodies. Furthermore, there are as mentioned no documentation format requirements for this preliminary consultation (e.g. letter of information, EIA programme etc.).

PON 16 for “Submission of an Environmental Statement in support of an Application for Consent” is submitted together with the ES. PON 16 may alternatively be submitted together with any approved dispensation from preparing an ES.

The licensee must send an ES for consultation for a minimum of 28 days and, as part of the consultation, the general public must be informed in at least two national newspapers. Unlike in Norway, the licensee is responsible for the consultation process, but the comments are sent to the DTI for compilation. The DTI may decide to send comments from the consultation round to the licensee for elaboration and comment.

The DTI will determine whether the assessment obligation has been met or whether further information is required on the basis of the ES and any consultation statements that the DTI receives. If further documentation is required, the licensee must procure it and send it for consultation to the same consultation bodies that received the ES. The DTI will normally need eight weeks to process the ES.

In addition to the ES, the licensee must submit an application for the approval of any chemicals that are to be discharged (PON 15). A full risk assessment is required as basis for such an application. For Statfjord Late Life, it will be necessary to submit a PON 15c in connection with the activities of laying and starting up the gas export pipeline Tampen Link. The PON 15c does not require public consultation, but in this case (the new Tampen Link gas export pipeline) JNCC and FRS will be consulted about the application. The DTI will normally require 28 days to process the application.

The development is subject to approval by the Secretary of State (SoS). The SoS will only approve the development if the information provided in the ES and any additional information is found to be satisfactory, and it has been documented that the development will not have any significant environmental impact. If the environmental impact is considered to be significant, consent may be granted on the condition that certain mitigating measures are implemented. Whether consent is granted is based on a balanced evaluation of beneficial and adverse impacts on the environment and socio-economic benefit. This consent is a precondition for approval of the field development and pipeline. The decision can be appealed within six weeks.

Appendix B EIA Program and Consultation Statesment

B.1 Approval of the EIA Program

The program was approved by MPE 13 October 2004 and is presented below in B1.1 and B1.2.

B.1.1 Content of the EIA

The plan is to carry out a field-specific environmental impact assessment which will make use of the assessment work carried out in the Regional Impact Assessment for the North Sea. This means that no new studies will be carried out for assessment items already covered. References to the Regional Impact Assessment will be used instead. The items this concerns are described in the following.

Based on this EIA-programme, the environmental impact assessment will include a discussion of the assessed development alternatives and transport solutions and state the grounds for the selection of the development solution. This means that an account will be given of the selection made in respect of technical feasibility, safety, project economics and environmental impact, including the impact on fisheries and other industry. The socio-economic impacts of alternative developments and gas transport solutions will also be described.

The EIA will provide a supplementary description of the development and transport solution selected and assess its impacts on the environment and the economy. Mitigating measures on the basis of the company's zero harm philosophy and the authorities' environmental policy and regulations will be documented in further detail.

An account will also be given of the licences, approvals or consents to be applied for in accordance with the existing legislation and the plans for abandonment and emergency response.

Consultation statements received on the assessment programme will be commented on with a possible reference to where in the assessment the various items are discussed.

B.1.2 Topics to be Assessed

B.1.2.1 Overview of Vulnerable Natural Resources

The Regional Impact Assessment for the North Sea (Sub-report 3) contains a description of natural resources and their utilisation. The Regional Impact Assessment is generally regarded as being adequate for the EIA for Statfjord Late Life. However, the information will be updated where more recent data is available. Information relevant to describe potential impacts of the gas export pipeline on the UK territory will also be collected if necessary, such as information about habitats, benthos, sea birds, sea mammals and fisheries, including spawning and nursery areas.

B.1.2.2 Emissions to Air

The development will involve emissions to air associated with:

- Drilling
- Marine operations
- Well operations
- Production/processing
- Storage, loading and transport of gas/oil

The EIA will update the calculations for energy requirements and emissions to air for the parameters CO_2, NO_X, CH_4 and nmVOC. The EIA will highlight the authorities' environmental policy and regulations and how the measures assessed are based on these.

Statfjord Late Life is a modification project for a field that has been producing for 25 years. There will therefore also be a detailed description of emissions, the measures implemented in a historical perspective and the factors that limit the selection of measures in the late life project.

The emissions associated with the development will be compared with emissions from:

- Tampen/North Sea
- Total emissions from the Norwegian continental shelf
- National emissions
- Emissions from Statfjord in a historical perspective

The environmental impacts of emissions to air will be assessed on the basis of the Regional Impact Assessment for the North Sea.

B.1.2.3 Discharges to Sea

Discharges to sea in Statfjord Late Life could occur from:

- The use of well chemicals for well operations
- The use of chemicals when preparing pipelines
- Discharges of produced water, including chemicals used in the process
- Other discharges includet ballastwater

The EIA will highlight the companies' and authorities' environmental policies and how it is planned to implement them in this project. Both planned and assessed mitigating measures will be described.

The quantities of various components that are discharged to sea as a consequence of the development will, where possible, be related to discharges from:

- Tampen/North Sea
- Norwegian continental shelf
- Discharges from Statfjord in a historical perspective

Where possible, the discharges will be quantified with and without mitigating measures.

Drilling and well operations
Oily cuttings and drilling fluid will be injected. There will be no drilling in the top sections and there will therefore be no discharges of water-based drilling fluid and cuttings. There will only be minor discharges of well chemicals to sea.

An overview will be provided of the chemicals that are to be used in connection with drilling and completion of wells, special challenges associated with late-life drilling and any discharges and effects of well chemicals.

Preparation of pipelines
Discharges of chemicals in connection with preparation of the export pipeline will be described. This includes chemicals that will be used to prevent corrosion and fouling and any dyes used for pressure testing and leakage detection. Any local effects and the times of discharges will be described. Measures to limit any effects will also be documented.

Produced water
Produced water volumes, quantities of substances/dissolved components in the water and contributions to environmental risk from produced water will be described in the EIA. The content of radioactive components in produced water and the formation of low-level radioactive waste will also be elucidated.

Discharges of produced water and mitigating measures (assessed and planned) will be described for all the platforms. Measures implemented for handling produced water will also be described, as well as the factors that limit the selection of late-life measures.

The EIF method and environmental risk will be used to describe the impacts of produced water. In this connection, the EIF calculations will be updated in accordance with new water profiles, an updated late-life chemicals programme and any other changed conditions. The EIF method will be described in further detail and there will be an interpretation of the EIF figures produced with regard to acute toxic effects and chronic effects, including the risk of bioaccumulation and the degradability of the substances.

The results from monitoring and from research programmes, including PROOF (2002-2008), which discuss the long-term effects of discharges to sea from petroleum activities, will be used where possible. The environmental risk analysis, commissioned by OLF (the Norwegian Oil Industry Association) and to be carried out by the Norwegian Institute of Marine Research and Rogaland Research Aquatic Environment in 2004, to describe the real environmental risk to fish posed by alkyl phenols, will also be used as a basis where results are available. Furthermore, results from the sampling of produced water with regard to radioactive components will be used.

The possible impact of produced water will also be assessed on the basis of the resources and species present in the area and their prevalence and movements. The PEC/PNEC ratio versus the available resources will be presented on a map. In order to evaluate the representativeness of the data on which the EIF calculations are based, an evaluation of the presence of species in relation to the species on which the PNEC values used in the calculation of the EIF will also be carried out.

Other regular discharges
Other discharges such as drainage water, sanitary waste water, cooling water, displacement water, ballast water on ships, discharges from pipelines in connection with operation and discharges of oily sand are not expected to have any appreciable impacts. The discharges and the implemented and planned mitigating measures will, however, be described.

Among other things, importance will be attached to describing the discharges of oily sand, the environmental risk these discharges are deemed to represent, and the contribution to total risk in relation to regular discharges.

B.1.2.4 Accidental Discharges

The EIA will assess the probability of acute discharges associated with the drilling and production phases, oil drift and the extent of any damage. The degradation properties of the oil and any changes in the existing oil spill response plans since the Regional Impact Assessment for the North Sea was approved will also be described.

The assessment will be based on the material underlying the Regional Impact Assessment for the North Sea, existing environmental risk analyses for Statfjord and new environmental risk calculations that will be made in connection with Statfjord Late Life.

The risk associated with transport of oil (shuttle tankers and tankers) will also be assessed. For a description of environmental damage after a possible acute discharge of oil, reference will be made to the Regional Impact Assessment (Sub-reports 4 and 7).

The following items are regarded as largely covered by the Regional Impact Assessment but will be supplemented where necessary by updated information:

- Description of environmental damage after an acute oil discharge (Sub-report 4, chapter 6)
- Description of existing oil protection emergency plans in the area (Sub report 4, chapter 7)
- Aquaculture in the area of influence of oil spills (Item Assessment Report 7, chapter 9)

B.1.2.5 Impacts of Pipelines and Area Occupation

The environmental impact assessment will, in addition to discharges associated with the pipeline, describe:

- Pipelines and pipeline routes
- Laying period
- Requirements for protection of pipelines including rock/gravel dumping
- Activities and impacts in connection with laying and operation
- Any measures to reduce the impacts.

The development alternative selected is expected to have insignificant impacts for fisheries, any habitats/benthos worthy of protection and cultural heritage.

The Regional Impact Assessment for the North Sea and the provisional EIA (issued in relation to selection of development alternative) will be used as the basis for a description of the impacts of area occupation and pipelines, in particular with regard to fisheries.

Descriptions of fish resources on the Norwegian side will be updated and fisheries statistics, including spawning and nursery areas, will be obtained from the area of influence on the UK side. Any impact on habitats or species worthy of protection, particularly with respect to the EC Habitat Directive e.g. pockmarks, will also be elucidated. Subsea photos/video will as far as possible be used for documentation.

It will also be established whether the presence and laying of the pipeline will have other impacts that need to be addressed in the EIA.

Where protection of the pipelines is required, the extent of rock dumping will be assessed. A description of the type of laying vessel will also be provided where information is available.

A final assessment of these factors cannot be made until after the route has been surveyed. The route survey will be carried out as part of the pre-engineering, but the route will not be finally decided until the detailed project engineering.

However, the EIA will discuss the impacts of possible scenarios for the extent of rock dumping and type of laying vessel.

In connection with connection to FLAGS, old heaps of oily cuttings downstream of Brent A will be surveyed to avoid them when laying the pipeline. Other mitigating measures will also be described.

B.1.2.6 Socio-Economic Impacts

The impact assessment will be based on experience from previous developments, updated investment profiles, income forecasts and other conditions, and calculate and analyse:

- Expected supplies of goods and services in the development and production phases
- Manpower requirements and employment effects of the development and production phases
- Socio-economic profitability of the selected development alternative and gas transport solution.

Employment effects and the potential for supplies of goods and services are based on what can be expected on the basis of previous experience. All contracts associated with specific projects will be awarded in accordance EU’s competition rules and on the basis of technical and commercial assessments.

Furthermore, the EIA will give an illustration and justification of the factors to which importance was attached when selecting the gas transport solution.

Effects on production in other fields following pressure reduction at Statfjord will also be assessed in further detail.

B.1.2.7 Environmental Monitoring and Research

The environmental impact assessment will contain a detailed description of the regional and local environmental monitoring currently taking place and will assess its results. The Regional Impact Assessment will be used as the basis together with the results from recent years’ survey expeditions. The results available will be compiled and, where possible, presented on a map.

The EIA will also assess the extent to which it is necessary to carry out specific studies and monitoring as a result of the development in the light of the impacts of the development and the existing guidelines for monitoring.

The research in progress to describe the effects of petroleum activities and the results of this research will, where relevant to Statfjord Late Life, be commented on.

B.2 Consultation Statements

B.2.1 Ministry of Fisheries (MFi)

The Ministry of Fisheries refers to the statements of the Directorate of Fisheries, the Institute of Marine Research and the Norwegian Coast Directorate, and requests that these be taken into account in the EIA work. The Ministry of Fisheries has no further comments.

Statoil's comments:
See the comments in section B.2.4 (Institute of Marine Research).

B.2.2 Directorate of Fisheries (DFi)

The DFi is of the opinion that matters relating to the fisheries in the area are adequately covered in the draft assessment programme. The DFi has no further comments.

B.2.3 Norwegian Coast Directorate (NCD)

The Norwegian Coast Directorate cannot see that the planned measures will have any significant impact on the directorate's areas of responsibility and authority. Neither the Coastal Administration West nor the Norwegian Coast Directorate find any basis for further requirements to the EIA programme over and above those already included in the draft programme.

The directorate has taken into account that any changes to the existing plans which may influence shipping, the safety of seafarers or the danger of pollution, must be taken into consideration in the EIA.

Statoil's comments:
Statoil confirms that any changes to the plans and related consequences and mitigating measures will be described in the EIA.

B.2.4 Institute of Marine Research (IMR)

The Institute of Marine Research finds the programme proposal to be a good and clear presentation of the proposed development and the planned EIA. The following comments have been submitted:

1. Reference to the profitability requirement should not have an effect on the selection of environmentally sound solutions.

2. The IMR expresses concern in relation to the risk of possible chronic effects on the marine environment resulting from large and continuous discharges of produced water and its contents of released components. BTEX discharges will increase as a result of CTour cleaning technology, which the IMR finds very unfortunate.

3. The IMR calls attention to the importance of shedding light on the following items relating to the discharge of produced water:

i. In addition to the quantities of dissolved components mentioned in the assessment programme, the IMR requests that the expected quantity of carboxyl acids be assessed. It is the IMR's understanding that carboxyl acids constitute the largest proportion of the dissolved components in terms of quantity. The IMR would also request the evaluation of the effect of carboxyl acid discharges on bacterial communities in the area of influence, which also entails the evaluation of the effects higher up in the food chain.
ii. The depth of discharge and the depth of intercalation/thermal cline have significance for the dispersion of the components in produced water, other physical processes (e.g. evaporation of BTEX) and any decomposition processes. A report on the dispersion of the most important components, including the expected daily and annual discharges, is requested.
iii. The discharge of radioactive components is also related to "scale" inhibitors. It is requested that their use, including how such use makes radioactive components more available to marine organisms, be evaluated and reported.

iv. The programme does not state whether methanol will be utilised in connection with hydrate formation. If the use of methanol is planned, the IMR requests that the EIA report on the consumption and whether the use of methanol can increase the concentration of environmentally hazardous components.

v. It is requested that the EIA evaluate the expected discharges from Statfjord in relation to other discharges in the area.

4. In connection with the preparation of pipelines it is important to involve the IMR as early as possible in the planning phase with a view to offering advice on the most critical time periods for discharges.

Statoil's comments:

Profitability requirement

The realisation of Statfjord Late Life will provide significant socio-economic value creation. Nevertheless, the project has marginal profitability for the licensees, and is associated with a relatively high financial risk. An extensive assessment has been implemented to arrive at measures providing the best solutions for the environment. Measures with the greatest environmental benefit versus cost have been prioritised and selected within acceptable financial, safety and technical limits.

Chronic effects

Statoil notes the IMR's comments. BTEX discharges will increase as a result of the implementation of CTour, while other components will be reduced as a result of the same technology. CTour is a highly efficient cleaning technology and, compared with other technology, it is particularly effective in removing dissolved natural components. The technology also removes approx. 30 per cent of the corrosion inhibitors. The technology is effective in relation to the composition of the water at Statfjord and, as opposed to other known technology, it will be able to handle the water volumes at Statfjord within the given space and weight limits. The CTour technology will be implemented as a zero emissions measure on Statfjord A, B and C before 2005. This measure will considerably reduce the total environmental risk, expressed as the EIF, on the field. In its letter (dated 31 August 2004) in response to the Statfjord licence's zero emissions work, SFT stated that Statoil, by installing CTour, is making a considerable effort to reduce oil discharges and that the authority was satisfied that the work was progressing according to plan. The possible chronic effects of produced water at Statfjord, will be described and assessed in the light of our current knowledge level and based on discharge and EIF modelling, results of monitoring the water column insofar at such results are available and published, and on knowledge made available through research into long-term effects. See also comment 4 ii.

Produced water

i. *Carboxyl acid*: In quantitative terms, carboxyl acid represents a considerable share of the natural components in produced water, but it is not included in the EIF calculations relating to discharges of produced water. The background to this is that the quality of relevant toxicity data relating to carboxyl acid available at the time when EIF modelling was introduced as a tool (2000), was such that the data could not be used for environmental risk modelling. Available toxicity data chiefly concerned fresh-water species. Based on the available literature, it was considered, however, that carboxyl acids represent a modest contribution to toxicity compared with other components. Carboxyl acids were not therefore included in the method for calculating the EIF, which included only the most important groups of natural oil components. A registration of recent toxicity data relating to carboxyl acids will be carried out in connection with the updating of the EIF for produced water on all fields in 2005, and based on the results, the inclusion of carboxyl acids in the EIF calculations/ methodology will be reconsidered.

ii. *BTEX*: EIF modelling takes account of the dispersion of components and their intercalation/thermal cline at different water depths. The depth of the discharges and density of the discharged water are used as basis for the calculations. This means that BTEX evaporation is included in the EIF calculation. The EIF is visualised on maps, and will show the dispersion of the relevant components in terms of the total environmental risk. In addition, the dispersion (concentrations chart) of the natural component groups representing the greatest contribution to the EIF at Statfjord will be presented (2-3 ring PAH, dispersed oil and C4-C5 fenols). As mentioned previously, the expected quantities of natural component discharges will be documented.

iii. *Scale inhibitors:* It is confirm that this will be commented on in the EIA.

iv. *Methanol* will probably not be used in connection with the preparation of the gas export pipeline. Consumption and discharges, if any, will be described in more detail in the EIA for the new gas export pipeline Tampen Link.

Methanol is however used to avoid the formation of hydrate in the oil pipelines from the satellites, and will end up in the process. In assessing the environmental risk for produced water, the concentrations of both added and natural components are used as basis. The environmental risk associated with methanol is therefore calculated as part of the EIF. The consumption of methanol for this purpose will not increase in late life.

v. Discharges from Statfjord Late Life will, as far as possible and in accordance with the programme, be evaluated in relation to other discharges in the area.

Preparation of pipelines
Discharges to sea in connection with the preparation of the new gas export pipeline will mainly take place in the UK sector, except for marginal discharges in connection with the preparation of risers and tie-in spools on the Norwegian side. In connection with the discharges on the UK side, a PON (Petroleum Operation Notice)15C will be prepared, which will describe the chemicals used and the environmental impact of the discharges. The impact will be determined on the basis of modelling. Emptying of pipelines will be planned taking due account of spawning periods and concentrations of fish eggs and fish larvae, based on the description of natural resources that will be carried out as part of the EIA. The environmental impact of the pipeline preparation is described in more detail in the EIA for the gas export pipeline Tampen Link.

B.2.5 The Norwegian Fishermen's Association (NFL)

1. The draft programme mainly covers the areas with a bearing on the fisheries.

2. The NFL requests that the planned discharges to sea be assessed with a view to reducing such discharges to an absolute minimum.

3. The NFL would advise that a thorough description be made of the measures that must be implemented to avoid discharges of produced water, without emphasising cost-benefit analysis.

4. The NFL would like a description of whether discharges of oily sand can be avoided and, if so, how.

Statoil's comments:

2. and 3. Produced water
Statoil notes the NFL's comments and confirms that there has been an extensive evaluation of measures to reduce discharges to sea to a minimum in accordance with the company's zero harm philosophy and the public authorities' environmental policy. This also includes a cost-benefit analysis.

4. Discharges of oily sand
An assessment has been made of measures to reduce discharges of oily sand. These measures will be described as part of the EIA.

B.2.6 Ministry of the Environment (ME)

The ME supports the main points in the consultation statement from the SFT, and has no further comments.

B.2.7 State Pollution Control Authority (SFT)

1. The draft programme gives a good and clear presentation of the proposed development and the planned environmental impact assessment.

2. Only oil-based fluids will be used for drilling, and these will be injected into the Utsira formation together with cementing chemicals. Since this will involve a great amount of drilling waste, the environmental impact assessment should include an assessment of the potential impact on the Utsira formation and the probability of leakages to the seabed.

3. The SFT requests a description of the scope of flaring in connection with well cleaning and quantities of emissions to air in connection with such flaring.

4. The environmental impact assessment should include calculation of the cleaning effect of using CTour technology, and the quantities of the most important dissolved components in produced water expected to be discharged at the field. The SFT also requests that the discharges be considered in relation to the total discharges in the region, and that the significance of any overlapping with areas of influence affected by other discharges be assessed.

5. The SFT requests that the environmental impact assessment includes a description of expected discharges of oil to sea in connection with discharges of oily sand, and which measures Statoil will implement to meet the requirements of the Activities Regulation section 59 which states that oil adhesion must be less than one per cent by weight.

6. The SFT requests that low NO_X turbines and injection into Utsira be further discussed and evaluated in the environmental impact assessment.

Statoil's comments:

<u>Injection of drilling waste into the Utsira formation</u>
The quantities of drilling waste and an assessment of the potential impact on Utsira will be described in the EIA.

<u>Flaring</u>
The scope of flaring in connection with well cleaning will be elaborated on in the EIA.

<u>Produced water</u>
Statoil confirms that the SFT's comments are taken into account in the programme. An assessment will be made of the significance of any overlapping in the area of influence by other discharges in the area. The assessment will be based on existing information from other fields and simulations carried out as a part of the EIA for Statfjord Late Life.

<u>Discharges of oily sand</u>
Statoil confirms that the impact assessment will address the quantity of oily sand discharges and measures planned to meet the requirements of the Activities Regulation.

<u>Measures to reduce discharges</u>
Statoil confirms that the impact assessment will describe the measures to reduce discharges that have been considered, including the criteria used in the selection of measures to comply with the companies' zero harm philosophy, the authorities' goal of "zero discharges to sea" and the IPPC Directive.

B.2.8 Directorate for Nature Management (DNM)

1. It is the DNM's opinion that an RIA should be used to analyse the data basis in order to assess whether the information is satisfactory. The DNM indicates that the RIA has not fulfilled the need for more knowledge.

2. The DNM recommends that the planned assessments be carried out relating to vulnerable natural resources:

i. A GAP analysis of existing documentation/ knowledge level in general in the North Sea area. Quality assurance and supplementing of data with the assistance from the county governor. The EIA should be able to recommend supplemental/updated studies and data capture where there is an insufficient data basis from which to make decisions.

ii. Alternative pipeline routes should be assessed to avoid unnecessary destruction in vulnerable coral areas, spawning/ nursery areas for fish and vulnerable regions of the seabed.
iii. Coral reefs and potential consequences of pipes and well activities should be identified.
iv. Areas worthy of protection should be identified offshore and within the area of influence in the event of an accident on either the Norwegian or UK side.
v. It is requested that the impact of assumed accidents on vulnerable communities and the effect of emergency response measures, including the impact on and measures for seabirds, be assessed. The DNM recommends the assessment of alternatives for seasonal adaptation of emergency response.
vi. The DNM recommends the coordination of environmental monitoring with existing activity and the environmental directorates. If the EIA discovers insufficient knowledge of environmental issues, the assessment should conclude with recommended research measures.

Statoil's comments:

<u>Knowledge base</u>
Statoil confirms that an RIA will be used in conjunction with updated data from other data sources, and that a thorough description of natural resources both on the Norwegian and UK side will be made.

<u>Planned assessments – Vulnerable natural resources</u>
i. *Data base:* Available data will be utilised, and the EIA will identify insufficient knowledge, if any, relating to areas of influence relevant to the project.

ii. *Alternative pipeline routes* have been considered and surveyed. The selected pipeline route does not appear to conflict with vulnerable natural resources. The EIA will discuss this in further detail.

iii. Existing documentation on coral reefs and results from lateral sonar scanning conducted in connection with the documentation of routes, indicate that pipes and well activities do not come into conflict with coral reefs.

iv. Statoil confirms that offshore areas worthy of protection will be identified, and the impact in connection with possible accidental discharges will be evaluated.

v. Statoil confirms that the impact of assumed accidents for vulnerable communities and the effect of emergency response measures will be assessed. The environmental risk and emergency response analysis of Statfjord will be updated as part of the project. Ways in which emergency response can be adapted seasonally will also be considered.

vi. Any insufficiencies in knowledge relating to the Statfjord Late Life development will be identified. Monitoring will be implemented in accordance with the Activities Regulation, but the coordination of monitoring efforts is considered to be a task for the national authorities.

B.2.9 County Governor of Rogaland

1. Little direct effect in Rogaland, with the exception of accidental discharges that may affect seabirds.

2. The reduction of emissions to air is positive, but the assessment needs to document whether the total quantities of the different components will be increased or reduced over time.

3. The injection of cuttings is positive, and the assessment should also consider whether it would be expedient to inject oily sand in the same manner.

4. The assessment should also address the quantities of various components discharged over time in produced water.

5. Updating the RIA should be considered.

6. The EIA must assess the environmental assessment criteria, and how mitigating measures are to be documented and reported.

Statoil's comments:

Quantity of emissions to air
Pursuant to the programme the EIA will show discharged quantities per year of the various components over the field's life.

Oily sand
The injection of oily sand has been considered as a measure, but was rejected. The EIA will explain the measures considered.

Quantity of component discharges in produced water
Pursuant to the programme the EIA will explain the quantity of component discharges in produced water.

Updating of the North Sea RIA
The EIA will update the data basis relevant to the project where new data is available. Any decision to update the North Sea RIA will have to be considered by the affected companies and the MPE.

Evaluation criteria and mitigating measures
Evaluation criteria for the choice of concept, including environmental criteria, as well as mitigating measures and their selection will be explained.

B.2.10 Sogn og Fjordane County

1. As operator, Statoil must be in close dialogue with fishery organisations in order to minimise harmful effects relating to area occupation and seasonal activities.

2. Sogn og Fjordane refers to Report no. 38 (2003-2004) to the Storting, which states that activity on the Norwegian Continental Shelf must be reflected in onshore activity. Expected activities for Sogn og Fjordane and the scope of these activities in connection with the development and operating phase of Statfjord Late Life must be addressed.

3. The county council refers to the KonKraft report, which documents the costs on the Norwegian Continental Shelf. The report shows that supply vessels and helicopters account for 44 and 32 per cent, respectively, of the total costs of logistics. The county council recommends the use of Florø, which is closest to the field.

Statoil's comments:

Dialogue with fisheries organisations
Reference is made to the comments from the consultation bodies, including the Norwegian Fishermen's Association, which protects the interests of fishermen in the area.

Scope of activity for Sogn og Fjordane
The EIA will assess the scope of delivery of goods and services to the development, but will not address the scope of such activities for Sogn og Fjordane in particular. The bases in Bergen and Florø will, as in current operations, be used as supply bases.

B.2.11 Ministry of Labour and Government Administration

The MLA has no comments over and above those from the PSA. The PSA has no comments relating to the external environment. The information relating to safety and the working environment is insufficient for evaluating consequences. The impact assessment of safety and working environment factors will be conducted in connection with the evaluation of the PDO.

Statoil's comments:
Safety and working environment factors will be sufficiently assessed as a part of the PDO and PIO.

B.2.12 County Governor of Sogn og Fjordane

The Environmental Protection section indicates that the coast of Sogn og Fjordane is particularly susceptible to any accidental discharges from the Statfjord field.

Statoil's comments:
The environmental risk assessment and emergency response plans for Statfjord will be updated as a part of Statfjord Late Life.

Appendix C Plans for Development and Operation

Three development alternatives for processing oil and gas, were developed up to selection of development alternative

Alternative 0 – Current drainage strategy
Alternative 1 – New platform
Alternative 2 – Bottleneck removal
Alternative 3 – Processing on Brent

These were compared with each other and the reference alternative (the current drainage strategy).

The grounds for our selection of alternative were explained in the EIA programme and are also summed up here.

C.1.1 Alternative 1-New Platform – not Selected Solution

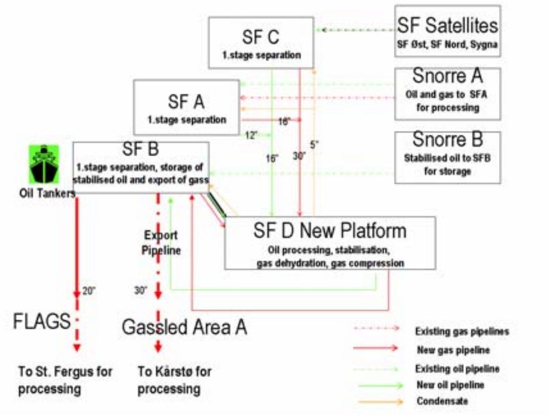

Figure C-1: Alternative 1-New processing platform

Alternative 1,"New platform", requires conversion of the existing platforms SFA, SFB and SFC to minimum processing platforms with 1-stage separation and transport of oil and gas in separate pipelines to a new processing platform called Statfjord-D (SFD) for further separation. SFD is planned as an 8-leg steel platform including a processing deck with a gas compression unit, flare tower and bridge connection to SFB. The alternative includes gas lift on SFA, SFB and SFC, and ESPs (Electrical Submerged Pumps) in the water zone on SFB and SFC to pump up water and thus reduce the pressure in the reservoir. Replacement of the flow pipes and manifold system (distribution header) were also required.

Stabilised oil will be returned from SFD to SFB for storage, while dehydrated and compressed gas can be sent via SFB to Gassled Area A and on to Kårstø, and/or in a new 20" gas export pipeline to FLAGS and on to St. Fergus in Scotland. Transport of gas to the United Kingdom via the existing pipelines Spur/NLGP and FLAGS in combination with export to Kårstø is also assessed.

It is assumed that drilling and maintenance would continue at SFA, SFB and SFC as for the reference alternative.

Moreover, it is planned that SFB would retain its auxiliary systems, oil storage and offloading facilities and shall be able to meet the power requirements of the new platform. Power generation and some of the auxiliary systems at SFA and SFC are also planned to be in operation. The "New platform" alternative is based on the existing turbine configuration but with a smaller number in operation. The new platform will have emission-efficient turbines (and compressors), including low-NO_X turbines. For the existing SF platforms, several emission-reduction measures are assessed.

Sand handling and CTour$^{®}$ for handling produced water shall be installed on each of the three existing platforms. The CTour$^{®}$ process requires condensate and will necessitate a 5" return pipe with condensate to the three platforms from Statfjord D. Sand-handling involved measures to reduce sand quantities, measures to reduce oil adhesion to sand to less than one per cent by weight and measures to optimise the cleaning process.

Other new internal field pipelines includes a 16" oil pipeline from SFC to SFD with a 12" branch pipeline to SFA, and a new 30" gas pipeline from SFC to SFD with a 16" branch pipeline to SFA.
A pig launcher is required only on SFC.

C.1.2 Alternative 3-Processing on Brent – not Selected Solution

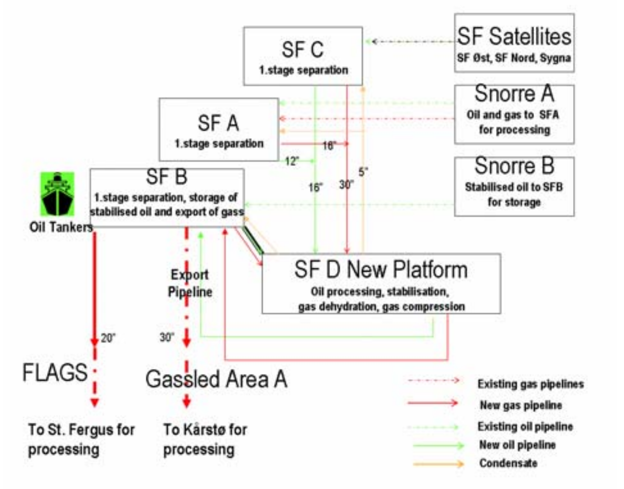

Figure C-2: Alternative 3-Processing on Brent

The development alternative "*Processing on Brent*" is comparable with "*New platform*" in many ways. The main difference is that oil and gas from Statfjord, its satellites and Snorre is intended to be processed on the Brent platforms on the British continental shelf instead of on a new platform. The extent of the pipelines is therefore greater than for a new platform (number of pipelines, lengths and dimensions).

New pipelines includes a 5" condensate pipeline from Brent C to SFA, SFB and SFC, three separate 26" gas pipelines from each of the Statfjord platforms to each of the Brent platforms and a joint 22" oil pipeline from SFA, SFB and SFC to Brent B and C. The "Processing on Brent" alternative also requires a new 30" gas return pipeline from Brent B to Gassled Area A for the gas transport alternatives involving transport of parts of the gas to Kårstø in combination with transport via FLAGS to the United Kingdom. As for development alternative 1, this alternative required gas lift on SFA, SFB and SFC, as well as ESPs (Electrical Submerged Pumps) on SFB and SFC and replacement of flowlines and manifold systems (distribution header).

On the Brent platforms, the gas is to be fed into high-pressure separators and on to high-pressure compression. The oil from the three platforms will be mixed with oil from the SF satellites and oil from Snorre and then fed into a low-pressure separator at Brent.

Fully processed and partially stabilised oil is required to be mixed with other oil from Brent and transported via existing pipelines to the Sullom Voe terminal in Scotland. At the Sullom Voe terminal, the oil will have to be heated up again after transport before it could be finally stabilised.

Risers for transport of oil and gas are required to be installed on all SF platforms, with pig launchers on all Statfjord and Brent platforms. For the oil pipeline, however, arrangements will be made for pig launchers for Statfjord C and Brent B only.

As for the other development alternatives assessed, the plan is for produced water and sand to be handled locally at SFA, SFB and SFC. However, with the Brent alternative, a small proportion of the total volumes of produced water will be separated out at Brent and mixed with other produced water from Brent.

Power generation and some of the auxiliary systems at SFA, SFB and SFC are required to be in operation, and drilling and maintenance will be carried out at all the platforms as for the other development alternatives. For the SF platforms, several emission-reduction measures are assessed.

It is required that production at Brent will take place with the existing turbine and compressor configuration. The Brent platforms are already ready for late-life production, but transfer of gas and oil from Statfjord will, as mentioned above, entail a few modifications such as risers, pig launchers, modification of test separators, new upgraded measurement facilities and some pipelaying at the platforms.

C.1.3 Alternative 2- Modification of Existing SF Platforms (Bottleneck removal)

The development alternative selected, Alternative 2 – Bottleneck removal, entails modifications to the existing platforms to enable them to handle large volumes of gas and produced water at low pressure.

The development alternative in its current form (drilling and modification work) is described in section 3.4. The EIA/ES for the Tampen Link /86/ describes the solution for the gas export pipeline.

The development alternative as it was when selected is illustrated in Figure C-3 and described in the following.

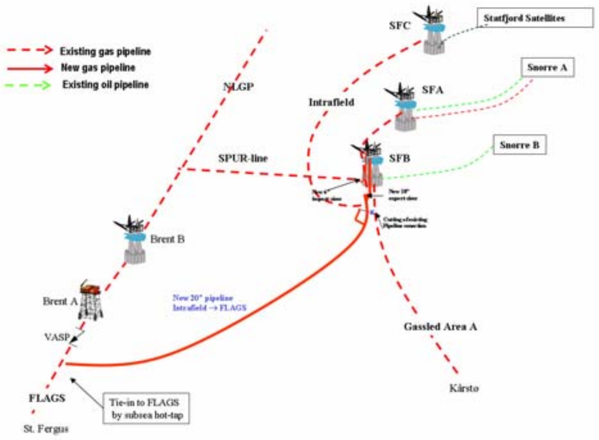

Figure C-3: Alternative 2-"Bottlekneck removal" - modification of existing Statfjord platforms

The modifications are to be implemented in their entirety but in two phases:

In phase 1 (01/10/2007→01/10/2009), no major modifications will be made to the processing systems. They are to operate with both high-pressure and low-pressure production on all platforms with the same capacity as in current production. Low-pressure processing of produced water at SFC will, however, have to be expanded, and CTour® will be installed for treatment of produced water that is currently injected as pressure support. In addition, gas lift will be installed at all platforms and ESPs will be installed at SFB and SFC. Technical upgrades and HSE modifications will also be implemented and arrangements will be made for gas export to FLAGS.

In phase 2 (01/10/2009→), the processing systems at SFB and SFC will be upgraded to deal with low-pressure production from all wells, and general technical modifications and HSE upgrades will be implemented.

Low-pressure production will result in bottlenecks being removed. This means a transition from 4-step separation of oil, water and gas to 3-step separation, upgrading of the inner components of separators, reconfiguration of compressors to adapt to new operating conditions, upgrading of gas scrubbers (liquid separators) and installation of new coolers.

Low-pressure production also entails relatively extensive replacement of flowlines and manifolds on account of the increased gas speed and consequent risk of corrosion. The auxiliary systems will be upgraded on the two platforms to a minor extent.

Statfjord A will continue with both low-pressure and high-pressure production, but the inner components of the compressor must be replaced. This means that Statfjord A will be operated as today with a high-pressure manifold that leads to a high-pressure inlet separator, and a low-pressure manifold leading to another inlet separator.

Drilling and maintenance will be carried out at all the platforms, but the gas and water injection systems will be closed down.

Produced water are planned to be handled as for the other development alternatives.

The platforms will operate with the existing turbine and compressor configuration, but with a smaller number of turbines in operation.

The alternative will also entail a 20" export pipeline from SFB to FLAGS. The new pipeline will be connected to SFA and SFC via the intrafield pipeline at Statfjord, 2.5 km south of SFB. The export pipeline will be connected to SFB with one 10" riser. In addition, the development alternative includes a new 6" import riser from the intrafield pipeline to SFB to receive gas from Snorre and the satellites (third-party gas) and to be able to transport it on to Gassled Area A and the Kårstø gas processing plant.

The reason for selecting the development alternative for processing oil and gas are described in the next section.

C.1.4 Reasons for Selecting the Removal of Bottlenecks as the Development Alternative

Table C-1 summarises the results of the process of selecting the development alternative, and the criteria used for selection.

The environmental criteria with which the development alternatives were compared and which were considered in a separate assessment to illustrate the environmental and socio-economic impact of the various development alternatives /90/ are elaborated on in particular.

Project economics and resource utilisation

The technically extractable resources are the same for all the Statfjord Late Life alternatives. “New platform” and “bottleneck removal” scored however, best with regard to economically recoverable resources. The “Processing on Brent” alternative would involve closing down the Brent platforms in 2014. The investment level was high, irrespective of the development alternative, but clearly lowest for bottleneck removal. None of the alternatives stands out as having low operating costs.

Implementation

All the development alternatives were considered to represent a challenge in terms of the extent of the work in relation to the timetable. “Processing on Brent” represented the greatest commercial risk because there were only non-binding tenders for oil transport and processing when the development alternative was selected.

Area considerations

Bottleneck removal was considered to be the best alternative on the basis of an overall assessment of the Tampen area.

Reasons for selection

“Bottleneck removal” with modifications to existing platforms was ranked as the best development alternative in an overall assessment on account of:

- Profitability
- Flexibility
- Resource utilisation

Table C-1: Evaluation of development alternatives

Evaluation Criteria for Selecting the Development Alternative	**Statfjord Late Life Alternative**			
	0	**1**	**2**	**3**
Health, safety and the environment				
Zero harm (produced water)	🟨	🟨	🟨	🟨
Emissions to air	🟨	🟩	🟨	🟨
Technical safety	🟨	🟩	🟨	🟨
Working environment	🟩	🟩	🟩	🟩
Investments				
Complexity in connection with installation		🟥	🟩	🟨
Investment level	🟩	🟥	🟨	🟥
Operating costs				
Operating costs	🟨	🟨	🟨	🟨
Regularity	🟩	🟩	🟩	🟨
Technical condition	🟩	🟨	🟨	🟨
Production				
Financial reserves	🟥	🟩	🟩	🟨
Production flexibility	🟨	🟨	🟩	🟥
Effect on current production at installation	🟩	🟨	🟨	🟨
Timetable				
Flexibility with regard to startup		🟥	🟩	🟨
Offshore working hours		🟨	🟨	🟨
Risk				
New technology		🟥	🟨	🟥
Non-compliance with design basis (water content and pressure for gas export)		🟩	🟨	🟥
Area considerations				
Flexibility with regard to third-party production	🟩	🟩	🟨	🟥

Green: Highest ranking (best)
Yellow: Medium ranking
Red: Lowest ranking (worst)

Evaluation criteria for the environment and society

The first part of Table C-1 shows that discharges to sea of produced water and emissions to air of CO_2 and NO_X do not differ greatly between the development alternatives.

Table C-2 shows a more detailed comparison of the late-life alternatives based on environmental and social impacts.

Even though there are relatively small differences in discharges and emissions for the three alternatives, alternative 2 – “Bottleneck removal” proves best with regard to environmental cost efficiency for planned and potential mitigating measures. For produced water, the difference is primarily a result of alternatives 1 and 3 requiring pipelines for condensate and therefore involving higher costs. For emissions to air, the measures are most environmental cost-efficient for alternative 2 because it has the greatest potential for emission reductions for all measures seen as a whole.

Table C-2: Comparison of impacts of development alternatives

Topic/Indicator	**Statfjord Late Life Development Alternatives** 1- New platform 2 - Bottleneck removal 3 - Processing on Brent		
	1	**2**	**3**
Discharges of produced water			
Discharges of produced water	🟨	🟨	🟨
Environmental cost efficiency, CTour®	🟨	🟩	🟥
Environm.ental cost eff., injection-Utsira	🟥	🟥	🟥
Emissions to air			
Total emissions of CO_2	🟨	🟨	🟨
Total emissions of NO_X	🟩	🟨	🟨
National emissions in Norway	🟨	🟨	🟩
National emissions in the UK	🟩	🟩	🟥
Cost efficiency of potential measures	🟨	🟩	🟨
Fisheries			
Restriction zones	🟩	🟩	🟩
Pipelines and consequences for trawling	🟨	🟩	🟥
Economy			
Economic profitability for Norway	🟨	🟩	🟥
Economic profitability for the UK	🟥	🟨	🟩
Employment in Norway	🟩	🟩	🟨

Green: Highest ranking (best)
Yellow: Medium ranking
Red: Lowest ranking (worst)

Discharges of produced water

Substitution of chemicals and installation of the CTour technology at SFA, SFB and SFC were the two most important measures used as the basis for the treatment of produced water in all the alternatives. The impacts of discharges of produced water would have been almost the same in all the development alternatives.

Emissions to air

The reductions in emissions to air were calculated to be large for all development alternatives compared with current production. The reductions are achieved as a result of reduced power requirements with the new drainage strategy (cessation of seawater and gas injection). Reductions in emissions of NO_X would have been greatest if the new platform alternative had been selected, in which case low NO_X technology could have been implemented. However, the life-cycle environmental impacts are not assessed, which indicates that a new platform would prove worse than shown (production of materials, construction phase and abandonment).If national emissions to air are evaluated, processing on Brent will prove worse for the UK and better for Norway.

Impacts on fisheries

“Bottleneck removal” and “Processing on Brent” will not entail any increase in area restrictions. A new platform would have entailed a marginal increase in the restriction zone (approximately 0.5 km^2) but would not have an adverse impact on fisheries. The pipelines required for “Bottleneck removal” was assessed not to have any significant effect on fisheries on either the Norwegian or UK side. The pipelines required for a “New platform” would probably have entailed disturbance in the Statfjord area, while “Processing on Brent” might have caused impacts in the Tampen area on account of the increased number of pipelines and pipeline crossings with gravel and rock dumps.

Socio-economic considerations

From a socio-economic point of view, “Bottleneck removal” is the best development alternative.

Overall assessment

In an overall environmental assessment, modifications to the existing SF platforms were regarded as the best alternative for both Norway and the UK.

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Appendix D Non Technical Summary -ES for the Gas Export Pipeline Tampen Link

D.1 The Project

The Statfjord Field is located in the northern North Sea, approximately 140 km east of Shetland and 220 km west of Norway (Figure D-1). The field crosses the UK/Norway median line, and encompasses Blocks 33/9 and 33/12 in the Norwegian Sector and Block 211/15 in the UKCS. Norway (appr. 85%) and the United Kingdom (appr. 15%) jointly exploit the Statfjord and Brent formations which comprise the Statfjord Field.

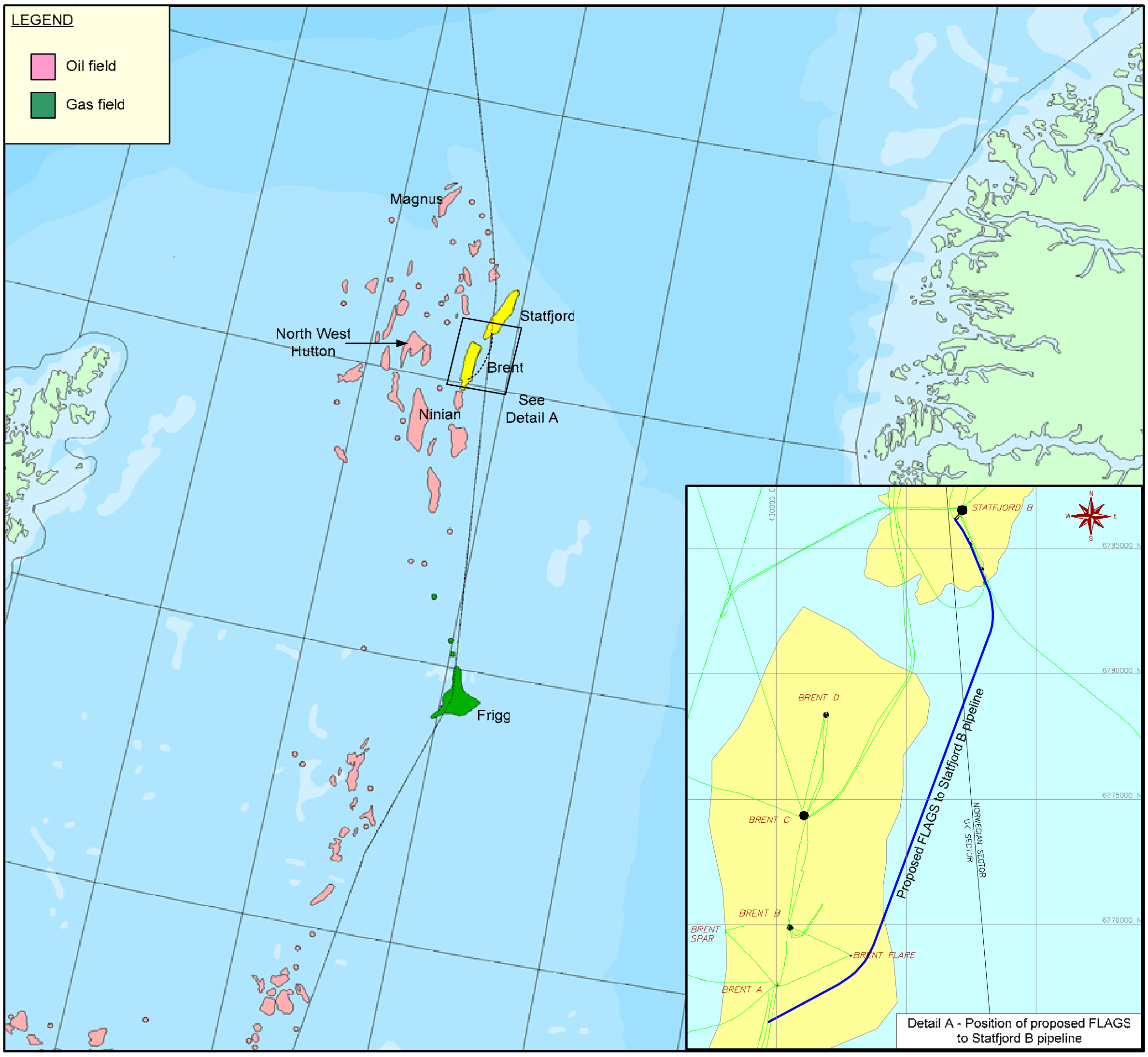

Figure D-1: Location of the Statfjord Field and proposed pipeline

Production at the Statfjord Field started in 1979, and under present recovery strategies oil and gas production at the field is estimated to end in 2009. The Statfjord Late Life (SFLL) project will extend the oil and gas production at the Statfjord Field by a further nine years.

As part of the SFLL project Statoil, on behalf of the partners of the Statfjord Field, is proposing to install a new 23.2 km gas pipeline between the Statfjord Field and the Far North Liquids and Gas System (FLAGS) pipeline, 1.4km south of the Brent Alpha platform (Figure D-2). Approximately 15.5km of the new gas export pipeline will be laid in UK waters. The pipeline will have the capacity to transport all the gas produced at the Statfjord Field to the UK. Production from the SFLL project is scheduled to begin in October 2007.

The Norwegian share of gas from the Statfjord field is currently transported via the Gassled pipeline to Kårstø (Gassled Area A) for processing, while the UK share is transported via the Spur pipeline and NGLP to FLAGS for processing at St. Fergus in Scotland. The development of Statfjord Late Life (SFLL) entails a 36 GSm^3 increase in the gas transport compared to the reference alternative (current drainage strategy). Several alternatives for gas export from SFLL have previously been assessed and compared. The evaluations have proven the alternative of exporting all gas to FLAGS via a new gas export pipeline (the Tampen Link) to be the best solution. The Tampen Link alternative has been established as the base case solution. The pipeline dimension needed to cover the SFLL gas production capacity is a pipeline diameter of at least 22” (OD-outer diameter).

After the selection of the field concept and gas transport solution for Statfjord Late Life (Tampen Link) several Norwegian 3rd party companies have expressed an interest in co-ownership of the new export pipeline. The background for this being the limited capacity for gas processing at Kårstø in relation to the total demand on the Norwegian Continental Shelf. A transport analysis carried out by Gassco (Operator of gas export pipelines on the Norwegian Continental Shelf) indicates that the demand for capacity in the Tampen Link will require a bigger pipeline diameter /41/. An increased capacity in Tampen Link will contribute to both increased flexibility for gas export from the Tampen area as a total and, at the same time, enable optimisation of the value of Norwegian gas by transporting the gas to the market with the highest price.

The outer diameter (OD) of the new pipeline will be either 22” or 32”; a final decision will be made in 2005. In this ES both dimensions are discussed on an equal basis. Whenever the impact assessment indicates there are significant differences between the alternatives, this will be highlighted in the text.

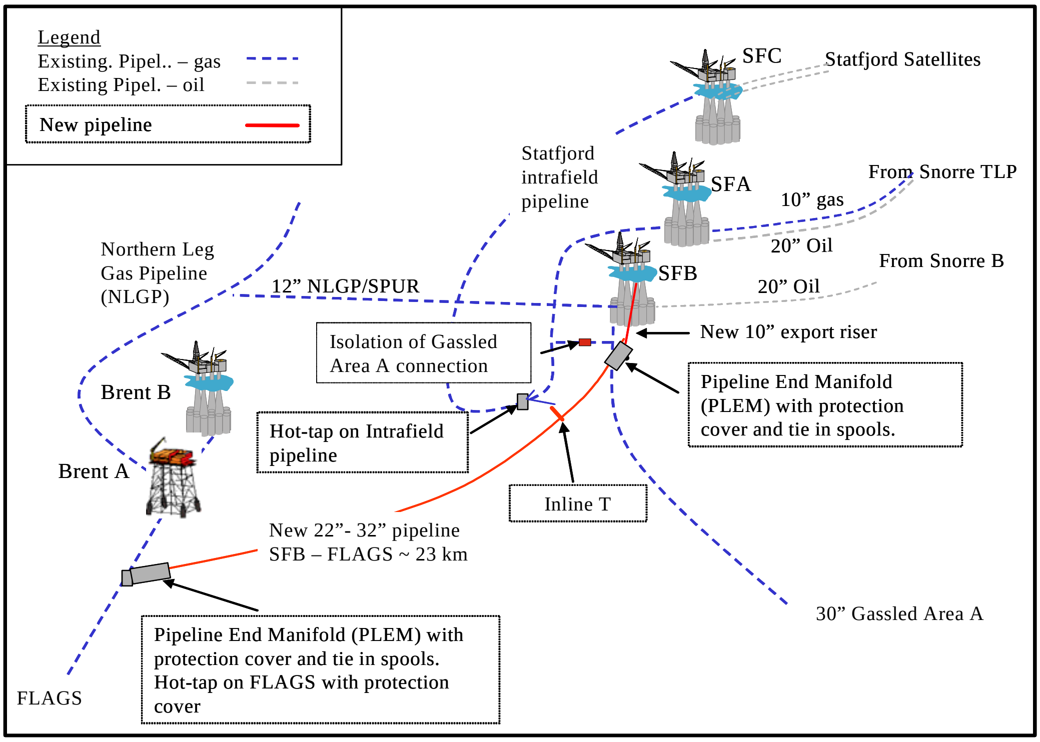

Figure D-2: Proposed layout of the new gas export pipeline

The new pipeline will be made of carbon steel, with a protective coating of asphalt and a 40-60 mm thick coating of concrete, to prevent corrosion, protect the pipeline from external loads and provide stability. The pipeline will be laid directly onto the surface of the seabed in either a conventional manner (i.e. along a more or less straight line route between Statfjord and the FLAGS tie-in), or in a “snake-lay” formation in which the pipe is laid in a series of gentle curves. If the pipe is laid conventionally, approximately 27,000 m^3 (22” alternative) or 88,000 m^3 (32” alternative) of rock-dumping would be required at various locations along the route to stabilise the pipeline. If it is laid as a “snake-lay”, only about 7,000/8,000 m^3 (22”/32”) of rock-dumping would be required because the long sweeping curves will accommodate movement of the pipe and prevent buckling. At this stage of the planning of the project, it is not yet decided whether the pipeline will be laid from a vessel positioned using anchors, or a dynamically positioned (DP) vessel.

The new export pipeline will be connected to the Statfjord B platform via a new 0.5 km 10" riser and to the Statfjord A and C platforms via the existing Statfjord Intrafield pipeline. The new export pipeline will be connected to FLAGS via a new Hot Tap Tee-piece welded onto the existing FLAGS pipeline. All connections at Statfjord and at FLAGS will be stabilised using gravel and rock, and will be fitted with protective structures.

The pipeline installation will take place in August/September 2006 or April 2007. Tie-ins, hydrotesting, dewatering and commissioning in general will take place within the period April to October 2007.

D.2 The Existing Environment and Main Environmental Impact Statement

The environmental sensitivities and their seasonal variations in the zone of influence of the proposed pipeline are summarised in Table D-1. It can be seen from Table D-1 that sensitive biological resources and commercial interests (fishing activity) are represented within the zone of influence of the project throughout the year.

The SFLL project is located in the Mid North Sea. In this area both sensitive biological resources and the fishing efforts are relatively homogenously spread out over a large area. The directly affected area in the case of the SFLL pipeline installation and operation is small. The interaction with the environment and the commersial interests will be very localized accordingly.

It should also be noted that the construction phase when the interference with the surrounding environment is at its highest, is temporary and the duration is short.

It is therefore highly unlikely that biological resources will be significantly exposed to damage, or that commercial fisheries will be significantly impeded.

Table D-1: Environmental Sensitivities in the zone of influence

<table>
<tr><td rowspan="5">KEY</td><td>■</td><td>Very high sensitivity</td></tr>
<tr><td>▩</td><td>High sensitivity</td></tr>
<tr><td>▨</td><td>Moderate sensitivity</td></tr>
<tr><td>░</td><td>Low sensitivity</td></tr>
<tr><td>□</td><td>Unsurveyed / No data available</td></tr>
</table>

<table>
<tr><th>Jan</th><th>Feb</th><th>Mar</th><th>Apr</th><th>May</th><th>Jun</th><th>Jul</th><th>Aug</th><th>Sep</th><th>Oct</th><th>Nov</th><th>Dec</th></tr>
<tr><td colspan="12">Likely Project Schedule : April 2006 to October 2007</td></tr>
<tr><td colspan="12">Plankton
Plankton are vulnerable to oil and chemical discharges, but due to their wide distribution there is no direct threat to the viability of the populations. Indirect effects may exist for organisms further up the food chain. Main periods of bloom are in spring and summer. Any impacts from offshore oil and gas operations, including operations to install the pipeline, are likely to be small in comparison with natural variations.</td></tr>
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<tr><td colspan="12">Benthic Fauna
Benthic fauna are an important food resource for fish and shellfish, and are vulnerable to the disturbance of seabed sediments which is likely to occur during pipeline installation. However, no rare benthic species are known to occur in this area and the benthic communities in the development area are similar to those found throughout the surrounding area. Therefore, there is no direct threat to the viability of the local benthic community.</td></tr>
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<tr><td colspan="12">Marine mammals
Harbour porpoise are the most commonly recorded cetacean in this area; numbers are greatest in July. Few other species of cetaceans have been sighted along the route of the proposed pipeline, but killer whale, minke whale, white-beaked dolphin, white-sided dolphin and Risso's dolphin have been sighted in adjacent quadrants. Marine mammals are vulnerable to chemical discharges, acoustic disturbance from vessel operations, and injury from collisions with vessels. Marine mammals can easily avoid disturbed areas.</td></tr>
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<tr><td colspan="12">Finfish Populations
Fish are vulnerable to pollution, particularly during the egg, larval and juvenile stages of their lifecycle. The proposed pipeline is located in spawning grounds for cod, haddock, saithe and Norway pout. With the exception of cod, fish communities in this area are present throughout large areas of the North Sea, therefore there is no direct threat to the viability of the populations. However, this region of the North Sea constitutes an important area for cod spawning activity. The main schedule for the pipeline laying activities will not coincide with peak spawning (February and March) for this species.</td></tr>
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<tr><td colspan="12">Fisheries
The development area is of "moderate" commercial value; fishing occurs throughout the year, mainly in the autumn but effort is lower in December and January. The area is targeted for both pelagic and demersal species of fish. Although demersal trawling dominated fishing methods, pelagic species, such as mackerel and herring have dominated landings during recent years. From 1999 to 2003, pelagic landings occurred predominantly between October and December. The most important period for white-fish trawling on the Norwegian side is January-February.</td></tr>
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<tr><td colspan="12">Seabird populations
Seabird vulnerability to surface pollution have been described by the JNCC as "low" to "moderate" for most of the year, but is "high" in July, October and November. Vulnerabilities are related to the position of the proposed development area in relation to the Northern Isles (particularly Shetland) which are of significant importance for large numbers of birds during the breeding season. Important species in this area include fulmar gannet, kittiwake and skua.</td></tr>
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<tr><td colspan="12">Conservation areas and species
Based on generally available information and specific bathymetric survey data from the pipeline route there are no reef habitats or pockmark areas of conservation value or any other Annex I Habitats in the area of the proposed pipeline. Neither have any objects of cultural heritage importance been identified in the area of the proposed pipeline.
The harbour porpoise is the only Annex II species known to occur in this region of the North Sea. The JNCC and other country agencies are currently analysing distribution data for harbour porpoise in UK waters to determine whether any suitable sites for SAC designation can be found. Currently no conservation designation.</td></tr>
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D.3 Significant Risks and Mitigating Measures

A risk assessment was undertaken to identify the range of impacts and risks that could arise as a result of the proposed development. The significant environmental effects and Statoil's planned mitigation measures are summarised in Table D-2, while Table D-3 summarises the impacts and risks that were assessed to be non-significant . No impacts were found to be highly significant.

Table D-2: Significant environmental impacts and planned mitigation measures

Potential source of impact	Potential impact or risk to the environment	Planned mitigation measures
Physical presence of pipelay vessels	• Temporary restrictions to sea access during the construction period (0.8km^2 to 12.6km^2) in an area of moderate levels of fishing effort and shipping traffic in the UKCS and NCS.	• The pipelaying will be advertised through Notice to Mariners in the UK and Norway • The operational area will be monitored during pipelaying to alert shipping and fishing vessels on approach to the area • Activities and restrictions will only last for 2-3 months.
Anchoring of vessels during pipeline installation.	• Anchor mounds can form on clay seabed, and potentially become long-term, localised obstructions that could interact with fishing gear.	• Exact location of the anchors will be planned • An post-lay ROV (Remotely Operated Vehicle) inspection will be conducted to ensure anchors were placed on the seabed correctly • A survey of the pipeline route will be undertaken on completion of the activities to identify any seabed discontinuities • Statoil will ensure any significant mounds formed will be flattened using suitable methods.
Pipeline installation	• Installation will disturb the seabed sediments, and the benthic organisms living in or on the sediments, in a small area of seabed beneath the pipeline and rock dumps • The pipeline and rock dumps will create a new area of habitat for benthic organisms that live on hard surfaces, and provide additional habitat for crevice-dwelling fish • Potential impedance to commercial fishing (see also **Physical presence of pipelines**)	• A pipeline route survey has been conducted and has been used to plan the optimum pipeline route • A survey vessel will be on station during installation to ensure that the pipeline is laid in the correct location • Rock-dumping will be supervised by use of sonar, and will be post-dump surveyed by an ROV to ensure that material is placed accurately and in the correct location • FEPA licence and Pipeline Works Authorisation (PWA) applications will be made • Location and profile of rock dumps will be made available to fishermen and fishing interests • Characteristics and profiles of the rock dumps will be designed to minimise the risk of interference with fishing activity.
Physical presence of the pipeline and subsea structures	• Impedance to military exercises is not envisaged as the project area is not utilised for these purposes • Loss of access to fishing grounds will be insignificant as all subsea structures can be trawled over by demersal trawling gear • Marginal risk of damage or loss of fishing gear or vessel caused by gear entanglement on the pipeline, subsea structures or rock dumps.	• No mitigation planned • Mariners will be notified of the location, dimensions and heights of all seabed structures • Locations of all subsea structures, including pipelines, will be recorded on Admiralty charts • The pipeline, the HTT and PLEM and their protective structures, and the rock dumps will be designed to be over-trawlable and do not impede fishing activities • The seabed will be surveyed after the gas export pipeline has been laid and any significant obstructions will be levelled

Table D-2 continued: Significant environmental impacts and planned mitigation measures

Potential source of impact	Potential impact	Planned mitigation measures
Pipeline chemicals	• Toxicity of chemicals in linefill. Dilution modelling results indicate there would only be a minor localised impact immediately around the discharge point at the PLEM 1.4 km south of Brent A.	• Further dilution modelling for the discharge of chemicals with the linefill water will be conducted in compliance with the **Offshore Chemicals Regulations 2002** • The permit application will be accompanied with a PON 15C which requires that only approved chemicals to be selected and risk assessments be carried out for the chemical discharges. Any conditions set by the authorities will be complied with • Pipeline flooding, gauging, testing, dewatering and drying operations will be designed and carried out by experienced, specialist contractors, whose performance will monitored by Statoil. • There will be a strict requirement for contractors to adhere to the conditions of the chemical permit • Discharges will be made from designated points, will be controlled by means of the appropriate equipment and procedures, and will be carried out according to specification • The spill contingency provisions will include response requirements for chemical spillage.
Accidental spill of diesel	• Diesel would disperse rapidly. No residual impacts would be expected on the local environment	Statoil will put in place a number of mitigation measures to reduce the risk of oil spills from the pipelaying vessels: • The pipelaying vessel will monitor the exclusion zone around the pipelaying vessel • The pipelay vessel will be equipped with all necessary navigation and communication equipment • All the relevant maritime authorities, and representative fishing organisations, will be notified of the proposed pipelaying activities • As required under MARPOL 73/92 Amended, the laybarge and other qualifying vessels will have in place Shipboard Oil Pollution Emergency Plans (SOPEPs) • The plans will detail the actions to be taken in the event of a loss of shipboard containment • Vessels will have sufficient equipment to enable them to respond, contain on board and clean up minor pollution events • In the unlikely event that a large release occurred, there is the capacity to engage specialist spill response organisations, who can provide an on-scene response, if required. These third party specialists would be brought in under the provisions that vessel operators have with their insurers • Statoil also have in place agreements with third party specialists

Table D-3: Non-significant environmental impacts and planned mitigation measures

Potential source of impact	Potential impact or risk to the environment	Planned mitigation measures
Noise from vessels during pipelaying activities	• Noise could potentially disturb low densities of marine mammals in the area	• Noise will be minimised through well maintained equipment
Power generation on vessels during pipelaying and decommissioning activities	• Short-term, localised air quality deterioration around exhaust outlets.	• Emissions will be managed through the use of well maintained equipment • Compliance with IMO/MARPOL requirements
Discharge of treated bilge from vessels during pipelaying and decommissioning activities	• Localised deterioration in seawater quality around discharge point • Potential for minor oil slick formation, but local environmental conditions will rapidly disperse any hydrocarbon discharges	• Bilge treated prior to discharge. • Compliance with IMO/MARPOL requirements • Vessel audits
Sewage discharged from vessels during pipelaying and decommissioning activities	• Localised increase in biological oxygen demand around point of discharge • Increase in fish and plankton productivity • Offshore currents will readily disperse sewage	• Sewage treated prior to disposal or contained and shipped to shore • Compliance with IMO/MARPOL requirements • Vessel audits
Emissions from anodes during production activities	• Release of contaminants (metal ions) into water column and seabed • Concentrations of metal ions on the anodes are very low and would not cause toxic effects • Rapid dispersion and dilution in the offshore area.	• No particular mitigation planned
Dropped objects during production and decommissioning activities	• Possible obstruction to fishing • Creation of artificial substrata to be colonised by organisms.	• Adherence to procedures and use of certified equipment • Retrieval of major items of debris on seabed
Removal of PLEMs, HTTs and other forms of subsea intervention	• Temporary disturbance to seabed and benthos.	• Post operational seabed surveys to be conducted if judged necessary.

D.4 Socio-Economic Impacts and Employment

The major capital expenditures (capex) relating to the new gas export solution will be related to the pipeline itself and the pertaining gas export facilities at SFB. Based on the present cost estimates, the development will result in a total capex of more than NOK 1.5 billion (2004 NOK). Construction and installation of the gas export solution will provide opportunities for the delivery of goods and services by private companies during the period 2005 – 2007.

Calculation of the employment effect is based on an empirical model. In total, the gas export solution (22” Tampen Link) will create an employment effect for the three years in the range of 2,300 to 3,200 man-years including the consumption effect.

Increasing the dimensions of the Tampen Link to a 32”pipeline will increase capital expenditure by approximately NOK 130 million (2004 NOK) and the employment effect by approximately 200 man-years.

D.5 Conclusions

The environmental assessment undertaken for the Tampen Link gas export pipeline has established that sufficient information has been optained on both the environment and the proposed pipeline operations to evaluate the potential environmental consequences of the development.

The proposed pipeline chemicals will be subject to a separate permit under the **Offshore Chemical Regulations 2002**. The regulations require that operators use only approved chemicals, and support their permit application by providing detailed chemical information and environmental risk assessments for each chemical discharged. Statoil will comply in full with these regulations.

The potential environmental impacts of the project can be summed up as follows:

- The Tampen Link project will have an impact in a small area in the middle of the North Sea. In the area in question, both environmental resources and fishing activities are relatively evenly distributed over a large area. The area directly affected by the pipeline project is very small. Accordingly, the potential for coming into conflict with environmental or fishery interests is limited.

- The project activity with the greatest impact on the surroundings, will be the actual installation of the new pipeline. This phase will be transient and of short duration.

- The area of influence of the pipeline part of the Statfjord Late Life project does not include any habitats listed in Annex I to the **EU Habitat Directive**.

- Seabirds in the area in the middle of the North Sea may be particularly vulnerable to surface oil pollution in July and October/November. Statoil has established procedures to ensure that all necessary measures to prevent accidental spills will be implemented.

- Fishing activities in the area are limited. The most common fishing method is bottom trawling.
  It is considered that any conflicts with fishery interests in the operating phase of the Tampen Link pipeline will be minimal, since all subsea installations are designed to be over-trawlable. During the actual installation of the pipeline, certain traffic restrictions in the area must be expected, due to the presence of a pipelaying vessels, possibly with deployed anchor chains. Notification and monitoring procedures will be established, so that any conflict with the fishery interests and other shipping can be avoided as far as possible.

- For these reasons, there is little probability that the project will have any significant impacts on the environment or the fisheries.

Appendix E Description of the environment

E.1 Meteorology

The North Sea is situated in temperate latitudes with a climate that is strongly influenced by an inflow of oceanic water from the Atlantic Ocean, and by the large-scale westerly air circulation which frequently contains low pressure systems /76/. The extent of this influence is variable over time, and the winter North Atlantic Oscillation (NAO) Index (a pressure gradient between Iceland and the Azores) governs the strength and persistence of westerly winds. The North Sea climate is characterised by large variations in wind direction and speed, significant cloud cover, and relatively high precipitation /76/.

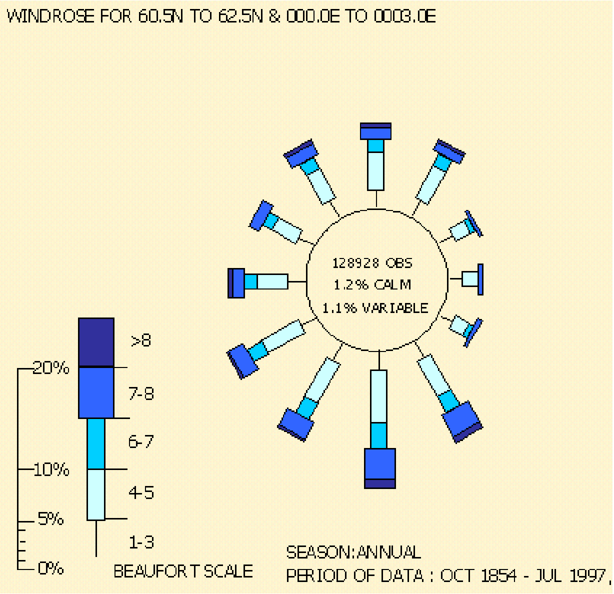


Figure E-1: Annual windrose for the proposed pipeline development area

Figure E-1 shows annual wind speed, frequency and direction in the area of the project. Winds in this region of the North Sea are most frequently from south to south-west. Winds stronger than Force 7 (28m/s) occur most frequently during the winter months (September to March), and may occur from any direction. Wind speeds during the summer months (May to August) are generally much lower, with dominant wind speeds ranging between Force 4 and Force 6 (5 to 14m/s) /54/.

E.2 Oceanography

E.2.1 Seabed Topography

The bottom topography of the area of influence is shown in Figure E-2. The figure also shows the division of the area used for environmental monitoring on the Norwegian continental shelf. This will be referred to frequently in the following.

The Norwegian sector of the North Sea is dominated by the relatively shallow North Sea Plateau (approx. 100 m) and the deeper Norwegian Trench (300-400 m). The Norwegian Trench runs along the Norwegian coast through the Ekofisk, Sleipner, Oseberg and Statfjord areas. To the west and south of the trench there is a graded slope up to the North Sea Plateau. In the north, the Trøndelag area is dominated by a wide and relatively deep shelf area in eastern parts and deeper waters outside the continental shelf to the west (down to 3000 m).

The Ekofisk and Sleipner areas are dominated by the shallow North Sea Plateau. As the Norwegian sector narrows in the northern parts of the North Sea, the Norwegian Trench and its western slope become the dominant features in the Oseberg area and particularly in the Statfjord area.

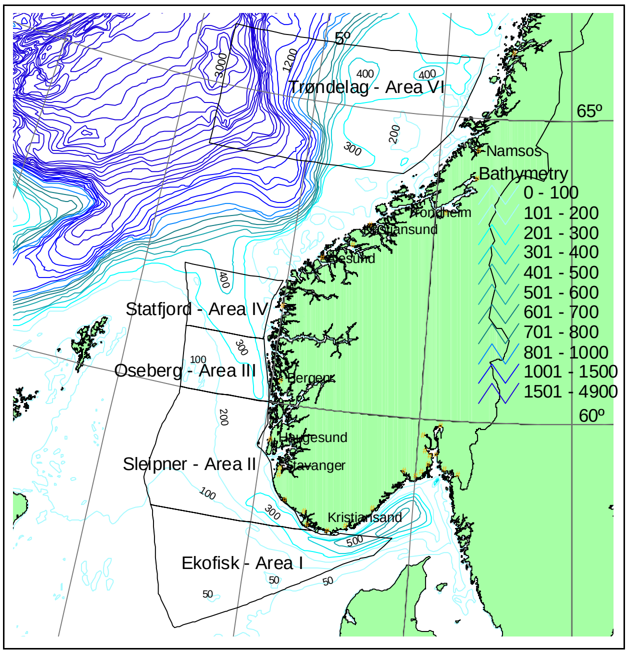


Figure E-2: Bathymetry in the environmental monitoring regions.

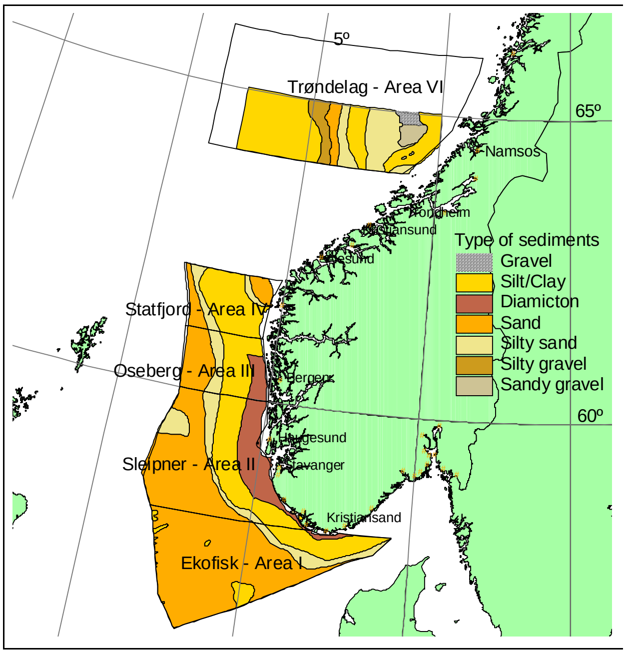


Figure E-3: Sediment distribution in North Sea

E.3 Sediment Characteristics

The sediments on the North Sea Plateau mainly consist of sand and become generally finer at depths down to approximately 120 m (Figure E-3). Fine and silty sands occur on the plateau at depths below 120 m, and on the western slope of the Norwegian Trench at depths between 120 and 300 m.

The sediments in the shallow parts of the Ekofisk and Sleipner regions mainly consist of sand. In the Oseberg and Statfjord areas, there are sandy sediments in the western parts while the sediments of the Norwegian Trench consist of silt and clay. The centre of the Norwegian Trench is characterised by sediment deposition.

Undisturbed sediments in the North Sea are primarily olive-grey in colour, with good penetration of oxygen into the sediment. The sediment is notably darker in colour in locations where contamination has led to a reduction in oxygen availability. This is due to the formation of sulphides in the absence of oxygen. Accumulation of oil in the sediment is also observable both visually and by smell.

As indicated above, the grain size distribution in the sediments varies from clay and fine mud to very coarse sand. Many benthic organisms are adapted to a particular range of sediment grain sizes, so a shift in this parameter may affect faunal communities. Grain size distribution is indicative of current conditions in the area, but may also be affected by anthropogenic discharges. Fine-grained sediments are found where currents are relatively slow, whilst strong currents result in coarser bottom sediments. Discharges from the oil industry (e.g. from drilling) are examples of anthropogenic discharges that may have an impact on particle size distribution in the sediments.

The amount of organic material in the sediment depends upon the deposition of plant and animal material from the water column above. Under normal conditions, benthic fauna and bacteria will break down deposited organic detritus, so that no net accumulation of organic material will occur in the sediment. In certain areas, human activities result in an increase in the organic content of the sediment.

The natural levels of chemical parameters like total hydrocarbons (THC), aromatic hydrocarbons, decalins and metals in sediments vary with sediment type and texture. The composition of the benthic fauna is also influenced by the sediment characteristics. In undisturbed conditions, the number of species present (i.e. richness) is relatively high and there is a relatively even distribution of the number of individuals per species. Table E-1 summarises typical background values for monitoring parameters frequently used by the offshore oil and gas industry.

Table E-1: Background levels in sediments

Parameter	**Background Range**				
	Region I Ekofisk	**Region II Sleipner**	**Region III Oseberg**	**Region IV Statfjord**	**Region VI Trøndelag**
Total number of background stations	12	23	18	17	17
Depth (m)	65 - 87	71 – 123	93 – 356	115 – 330	212 – 434
Average grain size (Md)	2.5 – 3.6	1.6 – 3.9	2.6 – 9.8	1.1 – 6.1	3.0 – 6.4
Lead (mg/kg)	6.0 – 9.7	2.4 – 6.1	1.9 – 46.5	4.0 – 15.6	9.2 – 26.2
Cadmium (mg/kg)	0.003 – 0.020	0.003 – 0.023	0.004 – 0.113	0.030 – 1.8	0.030 – 0.080
Barium (mg/kg)	6 - 118	6 – 176	14 – 462	30 – 554	48 – 220
THC (mg/kg)	3.6 – 6.8	2.0 – 11.3	1.2 – 13.6	1.0 – 12.8	1.1 – 4.9
Diversity (Shannon-Wiener Index)	3.7 – 5.2	3.2 – 6.1	3.6 – 5.7	4.8 – 5.8	4.6 – 6.2
Number of species per station	65 – 87	67 – 158	52 – 139	80 – 135	41 – 133
No. of individuals per stn (0.5 m^2)	462 – 931	402 – 2744	293 – 1704	98 – 2280	127 – 631

** Background Range is the range of values at the regional stations and the reference stations of the fields.*

E.4 Currents and Bodies of Water

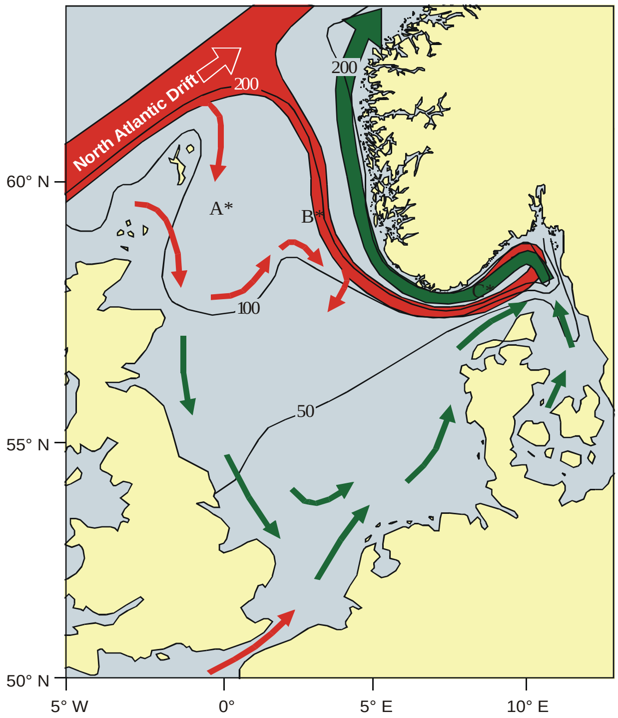
The water masses of the North Sea originate from North Atlantic water and freshwater run-off from adjacent landmasses. Bottom topography is important in relation to circulation and vertical mixing. Flows tend to concentrate in areas with the steepest slopes, with the currents flowing along the contours. The major ocean currents in the North Sea are shown in Figure E-4

The major inflow of water to the North Sea consists of Atlantic water that follows the 200 m depth contour to the north of the Shetland Islands before passing southward along the western edge of the Norwegian Trench. A smaller flow, the Fair Isle Current, follows the 100 m depth contour, entering the North Sea between the Shetland and Orkney Islands. This flow is a mixture of coastal and Atlantic water that crosses the northern North Sea along the 100 m contour in a narrow band known as the Dooley Current. In the southern North Sea, Atlantic water enters through the English Channel and moves towards the Skagerrak together with coastal water of low salinity.

The North Sea has one dominating outflow. It starts in the Skagerrak and is formed from all the above inflows, from water originating in the Baltic Sea and from Norwegian coastal run-off. This current, known as the Norwegian Coastal Current, has a volume of approximately 10^6 m^3/s as it leaves the North Sea. The greater North Sea circulation is normally stronger in winter than in summer because it is enhanced by south-westerly winds.

The North Atlantic Drift (the GOM current) crosses the entrance to the North Sea and flows northward along the continental slope of Norway with a lower boundary at a depth of 500-600 m on the coastal slope of Trøndelag. Coastal water forms a wedge overlying the heavier Atlantic water. The position of the coastal water's outer boundary shows seasonal variation, usually being at its most extensive during summer. At greater depths (deeper than 600 meters) outside the continental shelf of Møre and Trøndelag, a mixture of Atlantic water and the upper part of deep water in the Norwegian Sea, dominates.

Bottom water currents can deviate from the dominant surface water currents and show seasonal variations. In the eastern parts of the Norwegian Trench, the bottom topography causes deviation from the dominant northern flow. In the central part of the trench there are great variations in the bottom flow, but with a dominance of current flow towards the north and east. On the western slope of the Norwegian Trench, waters below 100 m have a fairly stable current flow towards south-southwest and southeast. In large areas of the central and northern North Sea, the bottom water becomes almost motionless during summer, particularly at depths greater than 70 m, except in areas adjacent to bottom slopes.



Redrawn with permission from Institute of Marine Research, Bergen.

Figure E-4: Major sea currents in the North Sea.

Maximum surface tidal streams vary from 0.25 to 0.5m/s over most of the northern North Sea, and are in excess of 1.0m/s on the Orkney-Shetland Platform/48/. Information for the Brent facilities indicate that average tidal currents in this region range from 0.10m/s (neap tides) to 0.20 m/s (spring tides), with the major directional axis being in a north-south direction.

E.4.1 Temperature and Salinity

Most areas of the North Sea are vertically well-mixed during the winter months. In spring, as solar heat input increases, a thermocline (a pronounced vertical temperature gradient) develops, which separates the upper and lower layers of the water column. Thermal expansion of the upper layers of water reduces its density, and self-stabilising stratification develops. The typical depth at which the thermocline forms is 50m in the northern North Sea. Seasonal surface cooling in autumn, as well as the increased number and severity of storms, results in vertical mixing of the water column and subsequently destroys the thermocline.

Data from a study of the area suggests that minimum and maximum seabed temperatures are 3.5^{o}C and 11^{o}C, respectively /1/. In the open waters of the North Sea, seasonal changes in sea surface salinity are comparatively small /76/. Data for the area suggests that values range from 35 to 35.3ppt at all depths /1/.

E.5 Biological Resources

E.5.1 Introduction

In this chapter, the biological resources in an extensive area around Statfjord are described. The description covers the defined zone of influence of the project,. from mid-North Sea in the south to the southern Norwegian Sea and from the Norwegian coast to the eastern coast of Shetland/Scotland. Included is also a discussion of the general vulnerability of the biological resources to discharges from the oil and gas activities offshore with a particular emphasis on vulnerability of the resources in the event of an acute oil spill.

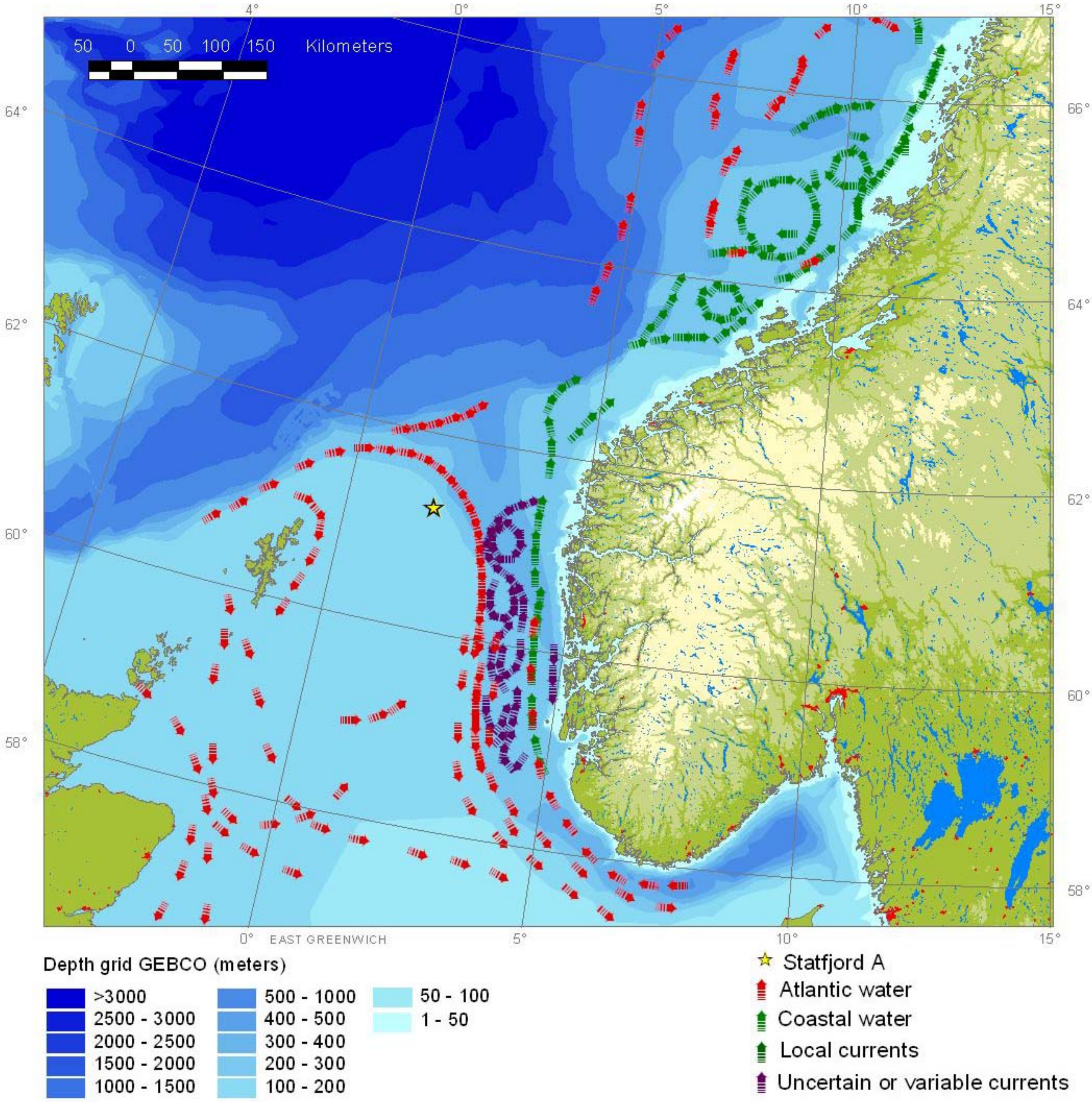


Figure E-5: Currents and depths in the northern North Sea and southern Norwegian Sea

The ocean currents in the North Sea and Norwegian Sea have an important impact on the transportation and distribution of planktonic organisms within the area of influence. The plankton distribution will in turn determine the distribution of biological resources higher up in the food chain, such as fish and seabirds. The ocean currents in the area of influence are shown in Figure E-5

No distinct stable, highly productive eddies or frontal systems which would cause organisms to accumulate in specific areas, form in the North Sea. In the North Sea, eggs and larvae of fish resources are therefore spread out over a large area. The transport of eggs and larvae of the different species depend upon predominant current directions.

For the same reason, the North Sea does not show the same high numbers of congregating seabirds at specific fronts as for example in the Norwegian Sea and the Barents Sea, although seabirds tend to congregate in the North Sea as well. The North Sea is one of the world's most biologically productive ocean areas, and it is commercially important /96/. High production of plankton results in rich marine life. The North Sea is generally an important area for many species, among them species that are vulnerable to acute oil pollution.

The analysis area also covers the southern parts of the Norwegian Sea. Here, Atlantic water and the Norwegian Coastal Current both flow northward. Unlike the North Sea, in the Norwegian Sea bathymetry is highly significant for movement of water masses. The formation of eddies and fronts forms the basis for large concentrations of fish larvae, and these in turn provide a basis for high densities of seabirds. The Norwegian Coastal Current forms circular currents in the shallower waters on the coastal side of the Continental shelf and plays an important role in the transportation patterns of eggs and larvae in this area /103/.

The Norwegian Coastal Current (with water of lower salinity) forms more or less distinct fronts against the Atlantic water with higher salinity from the west, which results in particularly high biological production. The most intense frontal processes occur where there are converging currents i.e. around the Frøya Bank, Halten Bank and Sklinnabanken bank. . Production in these areas is also boosted by by the upwelling of nutrient-rich Atlantic water from greater depths. /103/.

The most sensitive biological resources present in the analysis area are presented below. The analysis area is covered by the Resource description for the Regional EIA for The North Sea, which also covers relevant parts of the Norwegian Sea/96/. This Regional EIA is the most important source of data for the description below.

Where possible, more updated data have been included, e.g. by the use of the updated edition of MRDB (2004), /64/. Data from the United Kingdom Digital Marine Atlas (UKDMAP, /16/) is also presented where appropriate, in order to present a more complete description of British waters that may be exposed.

E.5.2 Plankton

The planktonic community is composed of a range of plants (phytoplankton) and animals (zooplankton) that drift freely on the ocean currents, and together form the basis of the marine food chain. Planktonic organisms, primarily copepods, constitute a major food resource for many commercial fish species, such as cod and herring /17/, and any changes in their populations are of considerable importance.

The most common phytoplankton groups are the diatoms, dinoflagellates and the smaller flagellates; together they are responsible for most of the primary production in the North Sea. In the northern North Sea, the dinoflagellate genus *Ceratium* dominates the phytoplankton community. Plankton in the North Atlantic and North Sea has been monitored using the Continuous Plankton Recorder (CPR) over the last 70 years, and the results of this programme have shown an increase in dinoflagellates, with a gradual decrease in diatom species. The zooplankton communities of the northern and southern North Sea regions are broadly similar. The most abundant group is the copepods, which are dominated by *Calanus* spp.

The larger zooplankton (or megaplankton) includes the euphausiids (krill), thaliacea (salps and doloids), siphonophores and medusae (jellyfish). Blooms of salps and doloids produce large swarms of individuals from late summer to October, which deplete food sources for other herbivorous plankton. Krill is abundant throughout the North Sea and is a primary food source for fish and whales /32/.

Changes in nutrient inputs affect the size structure of phytoplankton populations, which in turn affects the energy fluxes in the ecosystem and the subsequent transfer to species higher up the food chain /70/. Most phytoplankton species have short maximum doubling times, and when light and nutrient conditions are favourable, 'blooms' of these organisms can develop. In the North Sea, a 'bloom' of phytoplankton occurs every spring, often followed by a smaller 'bloom' in the autumn. Essentially, these spring and autumn 'blooms' are normal events. Under certain conditions, however, blooms can occur at other times of year. The concentrations of organisms in these ‘blooms’ can be very high and may involve nuisance or noxious species. These ‘Harmful Algal Blooms’ (HAB) can have detrimental effects, such as deoxygenation, foam formation, fish and marine mammal mortality and a change in the ecosystem/33/.

It is sometimes difficult to distinguish anthropogenic impacts on the marine environment from the background ‘noise’ caused by hydro-climatic variations /33/. The effects of small-scale events such as small oil or petro-chemical spills, for example, are difficult to quantify.

E.5.3 Benthic Communities

Seabed sediments are utilised as a habitat and nutrient source by organisms living either in, on or in close association with the seabed. The distribution of benthic fauna is influenced by water depth and sediment type; the major influence for epifauna appears to be depth, whereas sediment characteristics are more important for infauna/13/. Other important factors include the influence of different water masses and the food supply to the benthos/14/ Fluctuations in benthic populations may also be caused by natural spatial or temporal variations in the environment, as well as by anthropogenic effects. For example, the typical infaunal community response to an increase in the organic content of sediments is a reduction in species richness and diversity, usually accompanied by an increase in the density of species which are able to exploit disturbed environments.

With respect to geographical variation in benthic communities, the most comprehensive survey of the central North Sea was that carried out by Eleftheriou and Basford /12/, who sampled 97 stations for ***infauna*** and identified four major groupings of stations. In offshore environments relevant to the project influence area, typically coarser/sandy sediments (sub-group 3) are characterised by *Thyasira* spp. (bivalve mollusc), *Prionospio multibranchiata* and the polychaete *Spiophanes bombyx.* Deeper siltier parts (sub-group 4) are characterised by *Lumbrineris gracilis, Ceratocephale loveni* and *Eriopisa elongate.*

Much of the survey work in different parts of the North Sea has been carried out using different methods and techniques and, as a consequence, the results are not always comparable. However, Eleftheriou and Basford’s /36/ results were included in a synoptic survey of the North Sea conducted under the auspices of ICES in 1986, which used standard techniques and equipment. The infaunal results were published by Künitzer *et al*/50/ including a classification analysis of all North Sea stations. This survey identified that species distributions and assemblages were influenced by temperature, sediment type and different water masses, and the food supply to the benthos. Kunitzer *et al.* /50/ classified the infauna of the deeper (>100m) northern North Sea into two groups according to sediment type, with the indicator species on finer sediments being the polychaetes *Minuspio cirrifera, Aricidea catherinae* and *Exogene verugera*, and the bivalve *Thyasira* spp., and on the coarser sediments the polychaetes *Ophelia borealis, Exogone hebes, Spiophanes bombyx* and *Polycirrus* spp.

Data from benthic surveys around the Brent facilities indicate that characteristic infaunal species associated with this region of the North Sea include the polychaete *Owenia fusiformis* (tube worm), *Thyasira* spp (bivalve mollusc) and *Myriochele* spp /110/.

The ***epifauna*** of the project area can be characterised by the hermit crab *Pagurus bernharus*, the crustacean *Crangon allmani*, the purple heart urchin *Spatangus purpureus* and the mollusc *Colus gracilis* (/12/ and / 13/).

A regional environmental study of Statfjord region (Region IV) in the North Sea commissioned by Statoil and Norsk Hydro included a macrofaunal assessment of the Statfjord area /2/. In general, there were large variations in the number of individuals (293-3955 individuals per station), taxa (35-110) and diversity (H’ 2.1-5.8) over the Statfjord field. The monitoring results from a sampling station 1000 meters south-west of the Statfjord B and close to the UK-Norway boarderline in the Brent area, are assumed to be representative of a typical, unaffected environment in this area. In 2002, the benthic community at this station was undisturbed, indicated by a Shannon-Wiener diversity index value of 5.6 (94 taxa, 355 individuals). This represents a community with a low dominance and a broad range of taxa from several major groups (polychaetes, echinoderms, crustaceans); taxa known to represent disturbed conditions are absent or occur in very small numbers. The numerically dominant species at this station included the polychaetes *Owenia fusiformis* (juvenile), *Ophiuroidea indet*. (juvenile), *Sphiophanes kroyeri, Pista banesi, Amythasides macroglossus* and *Phoronis* sp. (phylum Phorondia).

The same regional study established that areas with slightly and distinctly disturbed faunal groups were dominated by the polychaetes *Chaetozone* sp. and *Cirratulus incertus,* and the bivalve *Thyasira sarsi*. Such species are known to increase in number with increasing contamination and organic enrichment in the sediment. Slightly disturbed stations had higher individual numbers of *Chaetozone* sp. and *C. incertus* than stations with undisturbed fauna, but taxa which are characteristic for undisturbed sediment were also well represented.

E.5.4 Fish

Generally, the North Sea is an important area with respect to fish resources, as the North Sea is a spawning and nursery area for many of the commercially important fish species. The spawning areas in the North Sea are more widely distributed in time and space than spawning areas further north along the Norwegian coast.

The highest concentrations of eggs, larvae and juveniles may occur during, and immediately after the spawning periods. After spawning, eggs and larvae will drift passively with the currents and spread widely throughout most parts of the North Sea. Along the Norwegian coast, larvae also tend to drift northwards on the Norwegian Coastal Current.

The main spawning periods for the most important species are in early spring, mainly from February to April/May, but some species, such as mackerel, spawn from later in May until the end of July. Species that qualify as Valued Ecosystem Components (VECs) / 107/ are focused in the following:

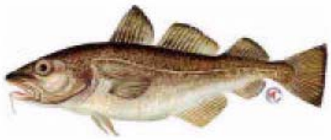
- Species of significant ecological or economic importance
- Species that spawn in concentrated or distinct areas
- Species whose eggs and/or larvae are pelagic

The early life stages of fish (e.g. eggs, larvae and partly spawn) are considered to be the most vulnerable to acute oil pollution, with lethal and teratological effects on larvaes. Adult fish are generally considered to be more robust (/53/ and /62/). Effects on fish resources are therefore ecologically significant when loss of early life stages influences recruitment to the spawning part of the population /60/.

The main data concerning the distribution of fish resources have been taken from the MRDB database/64/ and UKDMAP/109/. The original references for the data sets are given in the figures and text.

Commercially important species of fish in the analysis area include cod *(Gadus morhua),* haddock *(Melanogrammus aeglefinus),* saithe *(Pollachius virens),* Norway pout *(Triopterus esmarkii),* sandeel *(Ammodytes spp.),* Common scad/horse mackerel *(Trachurus trachurus),* mackerel *(Scomber scombrus),* herring *(Clupea harengus),* plaice *(Pleuronectes platessa),* whiting *(Merlangius merlangus),* sole *(Solea solea),* and sprat *(Spratus sprattus)*. The most important of these species are described in more detail below.

E.5.4.1 Cod (Gadus morhua)



North Sea cod belongs to the coastal cod stocks, and consists of three components, with spawning areas widely distributed over the whole North Sea in the period from January to May. Cod eggs and larvae are pelagic and are concentrated mostly in the upper water layers. Eggs and larvae will therefore be distributed with the currents.

Coastal cod is found all along the Norwegian coast, but is most abundant north of 67 °N/ 55/. This stock is more stationary than Norwegian Arctic cod, and has a longer spawning period /105/. This stock spawns closer to land and over a larger area. The stock of coastal cod has been reduced from 310,000 tonnes in 1994 to 128,000 tonnes in 2000; the spawning part of this stock was estimated at only

74,000 tonnes in 2000 /76/, and 30,000 tonnes in 2001/55/. It is expected to decrease further, and the spawning stock is now considered to be below safe biological limits (SBL) for the species/76/.

The stock of Norwegian Arctic cod spawns along the coast from Stadt to Sørøya. Lofoten – Vesterålen is the most important area for this stock (qualifying as an APES /61/), but a significant part spawns off the coast of Møre, varying between 15-20% of the spawning population in different years/105/. This stock arrives from The Barents Sea in January – February, and spawns over the following two months, peaking in March-April /38/.

As mentioned, cod eggs and larvae are pelagic, and concentrated in the upper layers of the water column. This means that they will drift northwards with the currents throughout the analysis area (see Figure E-5 (currents) and Figure E-6). Most years, the eggs that are spawned within the analysis area will have reached north of Vestfjorden by the time they hatch, which is outside the analysis area.

The Norwegian Arctic cod population has been estimated to be 1.3 million tonnes, of which the spawning stock biomass (SSB) is 430,000 tonnes /55/. This stock is also considered to be below the safe biological limits for sustainability/76/. Cod is listed on the OSPAR list of Threatened and/or Declining Species and Habitats as threatened in all regions/75/.

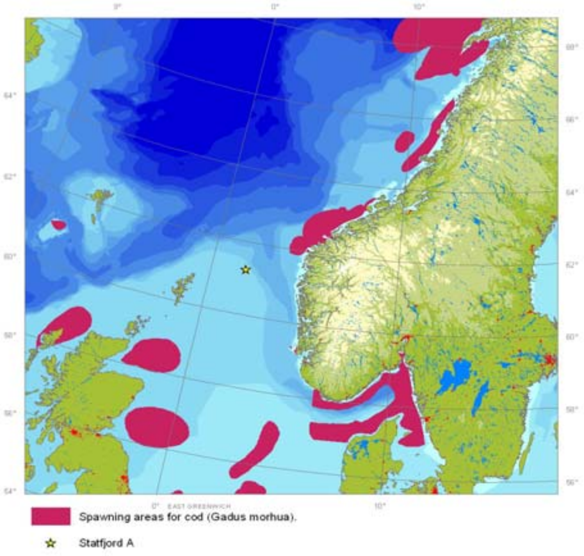


Figure E-6: Spawning areas for cod

Source: MRDB (2004) /64/

E.5.4.2 Herring (Clupea harengus)

Spawning areas for herring in the North Sea and Norwegian Sea are shown in Figure E-7. Herring can be divided into two components of the total stock: Atlanto-Scandic herring and North Sea herring /96/. The stock of North Sea herring spawns in the area surrounding Shetland, the eastern coast of England and in the Channel from February to April. Corresponding nursing areas are found in eastern parts of the North Sea and in Skagerrak, along the western coast of Denmark and southwards /16/.

Norwegian spring-spawning herring is a sub-component of the Atlanto-Scandic herring /96/. Herring spawn close to the coast. The eggs are placed on sandy and rocky seabeds at depths between 40 (50) and 200 metres. Important spawning areas for Norwegian spring-spawning herring have included the banks off the coast of Møre (between 60 °N and 64 °N), where previously 80% of the stock has been estimated to spawn /105/. A recent analysis by the Norwegian Institute for Marine Research indicates that a change seems to have taken place in recent years involving a division into two distinct components of Norwegian spring-spawning herring consisting of 50% which spawn off the coast of Møre (southern component), and 50% on Røstbanken (northern component) (P. Fossum, HI, *pers. comm.* 2003). An area that would qualify as an area of particular environmental sensitivity (APES) has recently been identified for herring off the coast of Møre (see Figure E-30). Fry that drift northward are by the time they arrive in the Lofoten area large enough to be especially important for supporting the colonies of puffins around Røst and northward /43/.

The spawning areas of herring vary within different data sets, and temporal distribution will vary with the age of the spawning stock, taking place later in years when the proportion of first-time spawners is high. The main spawning period off the coast of Møre (which is important for the present analysis) is the beginning of March, but it can be expected to take place in late February in years to come /58/. Eggs that are produced in the areas west of Shetland may be expected to drift north of Shetland and follow the Atlantic current that is divided into a northbound and a southbound stream north of Statfjord. Eggs that are spawned off the coast of Møre and Trøndelag may be expected to drift northwards and spread out. (See also Figure E-5 (currents)).

Following the collapse in the Norwegian spring-spawning herring population in the late 1960s, the stock remained low until 1986-1987. There was an increase in the 1990s, reaching a peak of 8-9 million tonnes in 1997-98 /96/. Since then, herring stocks have decreased. In 2002, the stock was estimated to be approximately 5 million tonnes. It is expected that the decreasing trend will be halted due to the coming recruitment of the 1998 year class /55/.

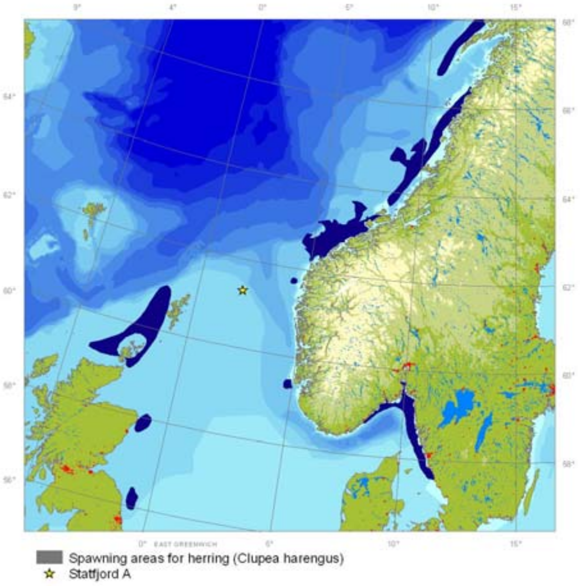


Figure E-7: Spawning areas for herring

Source: MRDB (2004) /64/

E.5.4.3 Saithe (Pollachius virens)

Saithe is a northern species which spawns within the influence area of Statfjord. Saithe eggs are pelagic. Saithe in the North-East Atlantic can be divided into five different populations: Norwegian Arctic saithe, North Sea saithe, Faeroe Island saithe, Iceland saithe, and West Scotland saithe. Of these, Norwegian Arctic saithe and North Sea saithe are the two most important populations in the analysis area.

Saithe in the North Sea and western parts of Scotland spawn from January to March in the area east of Shetland, Tampen and the Viking bank /96/. The pelagic eggs drift with the currents and will be distributed as indicated by the currents shown in Figure E-5, and can be expected to be distributed over most of the North Sea. Important nursing areas are along the coasts of Scotland, the Orkney Islands, Shetland and the southern and western parts of Norway.

Norwegian Arctic saithe spawn along the coast of Møre and on the Halten Bank from mid-February to April, peaking in February and March /105/. After spawning, the pelagic eggs will be transported north with the coastal currents. The data on general spawning areas in Figure E-8 are also available in UKDMAP /16/.

The total stock of saithe in the North Sea was estimated to be more than 1 million tonnes in the early 1970s. Since then, the stock has been reduced, and it was estimated to be only 440,000 tonnes in 1996 /108/, but increased to 734,000 tonnes in 2000 /55/. The spawning stock, which was estimated at 453,000 tonnes in 1973, was at a minimum of 80,000 tonnes in 1990, but has later been estimated at 134,000 tonnes in 1997 /108/ and 247,000 tonnes at the beginning of 2001/55/. The stock of spawning saithe in the North Sea was below biologically acceptable levels/76/, but has been above such levels since 1999 /55/.

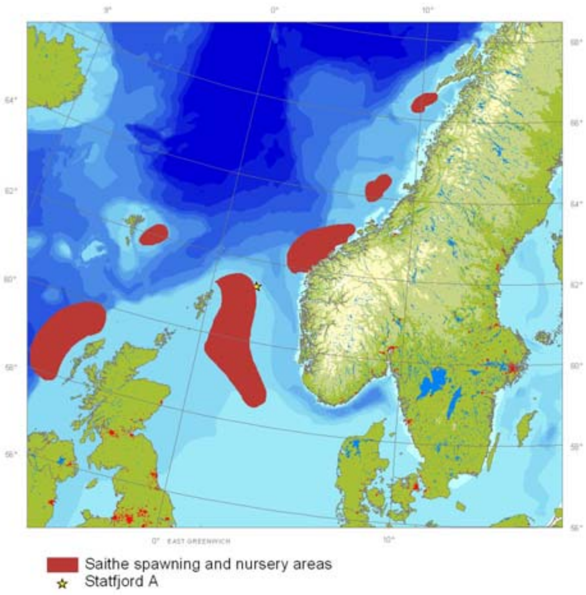
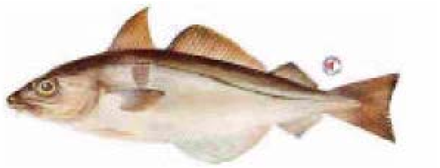


Figure E-8: Spawning areas for saithe

Source: MRDB (2004) /64/

E.5.4.4 Haddock (Mellanogrammus aeglefinus)



Haddock spawns over the continental shelf, with a distribution of eggs and larvae that also covers the analysis and influence area (Figure E-9). The eggs are spawned at depths of 100-150 metres, and eggs and larvae are pelagic (Moen & Svendsen, 2003). Spawning takes place from January to June, with April to May being the most important period. The most important spawning areas for the species as a whole seem to be west of Tromsøflaket, north of the influence area. Spawning that takes place off the coast of Møre may be a local population /96/, and therefore potentially at risk. Spawning here takes place some 1-3 weeks earlier than further north, from April to mid-May (/105/; /96/). Spawning areas for haddock in the North Sea are located in the north-western parts of the area, north of Newcastle. The spawning period for haddock in the northern North Sea and west of the Orkneys is from March to mid-May. Nursing areas for the northern North Sea haddock can be found north of a line from Newcastle to Egersund. The stock of haddock is estimated at 347,000 tonnes /55/; it has declined somewhat since peaking at 600,000 tonnes in the years 1994-1995. The ICES expects the stock of haddock to be within biologically acceptable levels for the time being, following strong recruitment in 1999, but the year class of 2001 was the lowest on record, and the 2002 year class is also well below average. At the present fishing mortality rate, it is therefore expected that the stocks will continue to decrease /55/.

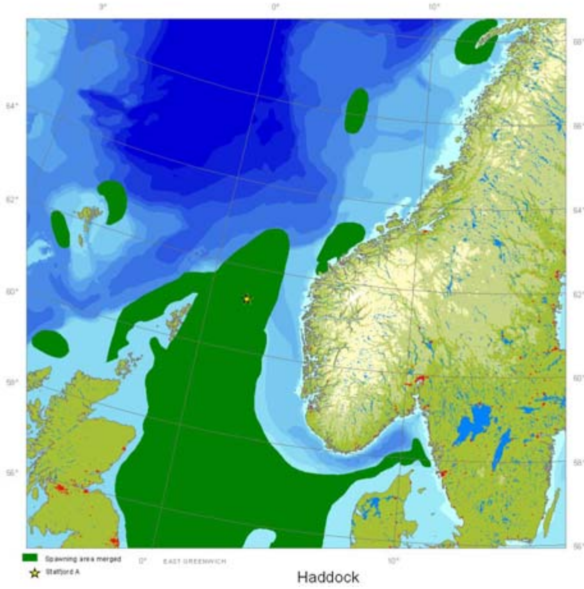


Figure E-9: Spawning and nursery areas for haddock

Source: MRDB (2004) /64/

E.5.4.5 Sandeel (Ammodytes spp.)

Sandeel is the common name for species in the family *Ammodytidae*. These species are distributed over large parts of the North Sea (Figure E-10). Sandeel spawn in winter on the sandbanks in the North Sea, down to 100 m. Spawning periods vary between the different species; small sandeel and sandeel spawn from November to February, while the greater sandeel spawns from April to August. Their eggs are demersal. Most eggs hatch in March-April (for those species that spawn in the winter). The larvae are pelagic for 4-5 months before they move to the bottom /96/).

Patchy distributed spawning areas are located from the Viking bank to the coast of Denmark, on Dogger and near the coast of Denmark, England and Scotland /64/. With reference to the currents in the area and the fact that eggs are demersal, it is not expected that eggs will drift widely into the areas around Statfjord, pelagic fry may follow the wind-driven currents of the southern North Sea. The spawning stock of *Ammodytes marinus* has varied over the years, hence also recruitment to the populations. Toresen /108/ estimates that the spawning stock varies around 1 million tonnes, and it is stated to have been stable for the past 20 years /55/. Although the stock of Sandeel was considered to be above the biological safe limits as late as in 2003 (/55/), recent estimates from ICES state that the spawning stock in 2004 is the lowest that has ever been observed (325,000 tonnes), which is below safe biological limits. The rapid and drastic change is due to weak recruitment and over-fishing. This can lead to dramatic population effects in a short time for short-lived species like Sandeel (T. Johannesen, IMR, *pers. Comm.)*

The ecological significance of sandeel can be illustrated by the collapse of the sandeel stock around Shetland between 1985 and 1990, which caused dramatic reductions in the breeding successes of Arctic terns, Arctic skuas, great skuas, black-legged kittiwakes and Atlantic puffins, and subsequent declines in these species /57/.

E.5.4.6 Plaice (Pleuronectes platessa)

A large spawning area for Plaice has been registered in the southern North Sea and the English Channel (the spawning period is from February to March). There are two smaller areas in the Firth of Forth and Moray Firth/ Dornoch Firth in eastern Scotland where spawning take place a little later than further south (March-April) /64/. See Figure E-10.

Plaice is an important and numerous species in the North Sea, but ICES assesses the stock number to be below safe biological limits /76/. Spawning takes place at the seabed (50-200 metres) and the eggs float upward in the water masses. The larvae are pelagic until they are transformed into fry which move down to the bottom in very shallow waters.

E.5.4.7 Norway pout (Triopterus esmarkii)

Norway pout is widely distributed from the English Channel to the Barents Sea, and is abundant throughout the North Sea. The species seems to be divided into different populations, of which the North Sea component and the Norwegian Sea component are in the analysis area. The spawning and nursery areas extend over most of the northern North Sea, and in the near coastal areas of the Norwegian Sea. Of these two components, the North Sea component is the most numerous. Spawning takes place at approximately 100 metres when the water temperature is 7 °C. This implies a spawning period from January to July, which takes place in the southern areas first /96/, (Figure E-10). The main spawning periods are in March-April, and larvae may be observed in most parts of the distribution area of the stock.

After low estimates at the end of the 1980s, the species has shown increasing stock growth. In 1997 stocks were estimated at 240,000 tonnes. The extent of recruitment to the spawning stock is unknown /108/. In 2002, ICES assessed that the stock in the North Sea and Skagerrak was above safe biological limits, based on recent observations the spawning stock now seems to be close to the safe biological limit at 90,000 tonnes, which is considered critical. The reason for the dramatic situation for the spawning stock is low recruitment in 2002. This has a rapid populational effect for short lived species like Norway Pout. Even with a ban on fisheries, the stock is expected to fall below SBL in 2005.

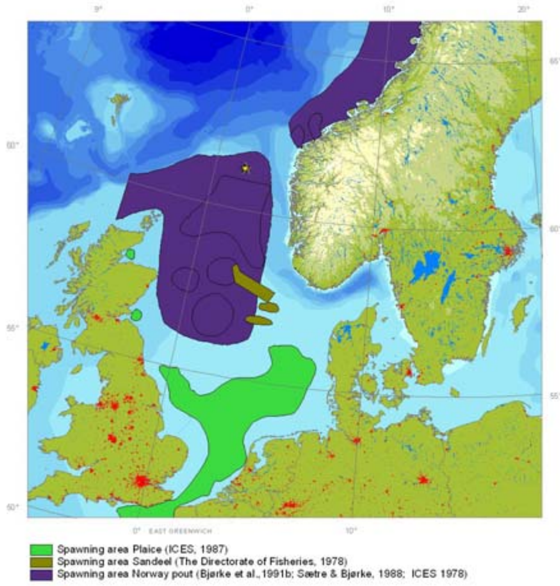
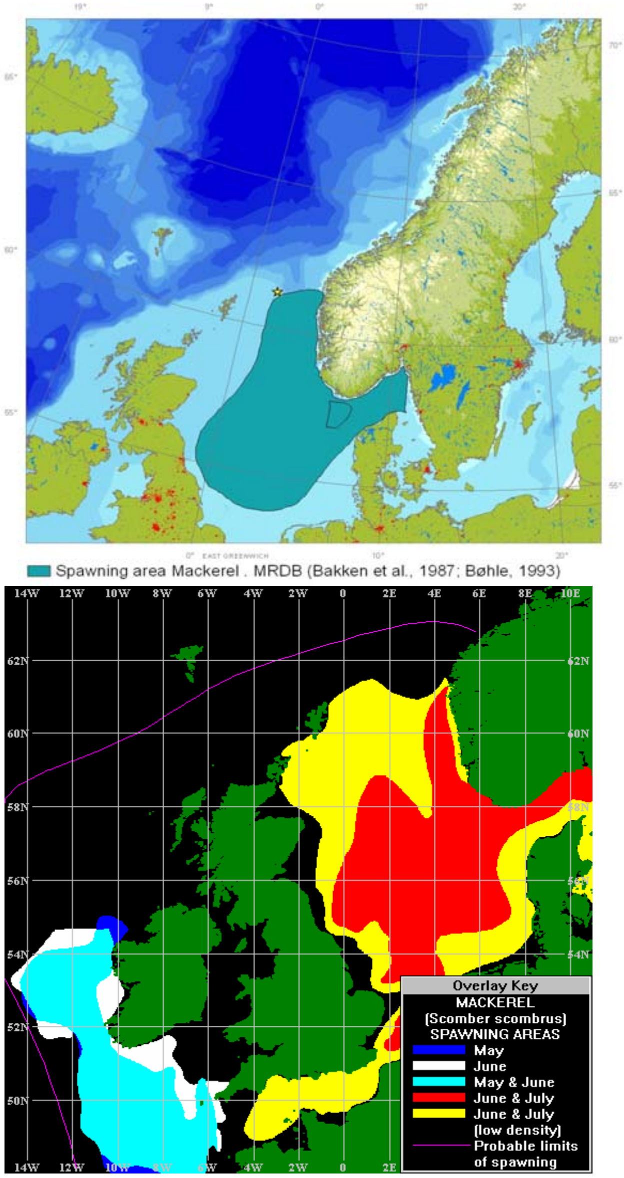


Figure E-10: Spawning areas for Plaice, sandeel and Norway pout

Source: MRDB (2004) /64/

E.5.4.8 Mackerel (Scomber scombrus)

The north-eastern Atlantic stock of mackerel consists of three different spawning components (Michalsen, 2003). The North Sea mackerel spawns in central areas of the North Sea and Skagerrak (Figure E-11a), the western mackerel spawns west of Ireland (Figure E-11b) and the British Isles, and the southern mackerel spawns in Spanish and Portuguese waters (not shown). Nursing areas for these stocks are the North Sea, west of the British Isles and west of Portugal, respectively. In recent years there has been a decrease in the southern and western spawning components, while the spawning stock biomass in the North Sea seems to have increased from 70,000 tonnes in 1999 to 210,000 tonnes in 2002/55/. It is this latter component which is of chief concern within the Statfjord's influence area. The North Sea component spawns from May to July /96/, peaking in June. The western component spawns in the same period, but peaks earlier. Eggs are pelagic, floating with the currents in the upper 10 metres of the water column. Hatching takes place after 3-7 days, and the larvae are distributed in the upper 20 metres, most of them concentrated in the layer between 10-20 metres in the water column /96/. After spawning, the western component (Figure E-11b) migrates to the North Sea. Mackerel migrate north in late autumn: Wintering areas for North Sea mackerel are west of Shetland and in deep waters in the Norwegian Trench.



Above: Data from MRDB. Below: Data from UKDMAP, indicating spawning areas stretching somewhat further west to the east coast of Shetland and the Orkney Islands.

Figure E-11: Spawning areas for North Sea mackerel.

E.5.4.9 Blue whiting (Micromesistus poutassou)

The blue whiting spawns west of the British Isles (see Figure E-12) but spawning may also occur in deep-sea areas along the Norwegian coast. Eggs and larvae are pelagic. After spawning, some of the larvae drift eastwards and enter the North Sea, while others drift northwards with the currents into the Norwegian Sea as juveniles. Nursing areas are located all the way from Morocco to Lofoten./16/. Data in MRDB confirm an area containing blue whiting larvae in the Norwegian Sea from Stadt following the continental shelf some 360 km further north/64/.

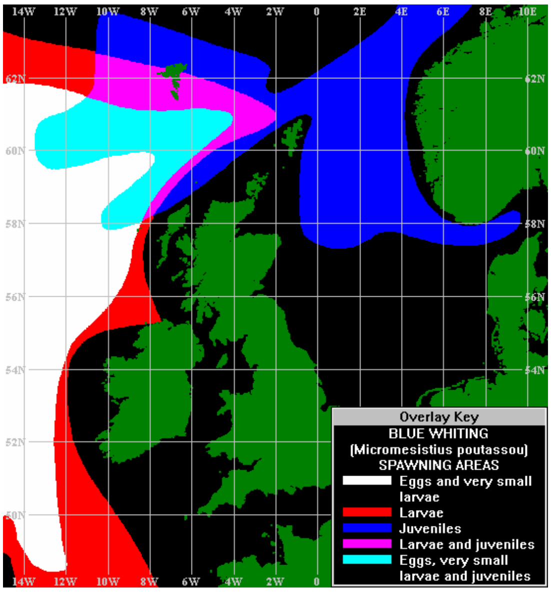


Figure E-12: Presence of juvenile blue whiting in the northern North Sea and Norwegian Sea

Source: UKDMAP(BODC 1998).

E.5.4.10 Horse mackerel (Trachurus trachurus)

Horse mackerel, or Common scad, is a relatively "new" species to the fisheries in the North Sea. It migrated to the North Sea and Norwegian Sea for the first time in 1987, and has since been targeted by Norwegian fisheries. It prefers warmer waters. Eggs and larvae are pelagic/96/; /63/. The spawning stock has declined since 1995 /55/.

E.5.4.11 Other Fishery Resources

Foto: Rudolf Svendsen

Squid larvae have been registered in a small area north of Stadt, off Ålesund and Molde. Adult squid are mainly found in the Norwegian Sea and Barents Sea (north of Stadt).

Norway lobster (*Nephrops norvegicus*) and deep water shrimp (*Pandalus borealis*) /96/.; /76/.) are also commercially important to fisheries. The spawning period of *Pandalus borealis* is during autumn. *Pandalus* in Northern Norway spawn in August; further south they spawn later. However, the female prawn carries the eggs under its tail for a further 5 months in the southern parts of Norway, and for a longer period further north (Moen & Svendsen, 2003). Larvae are pelagic for a three-month period after hatching, and may therefore be exposed to hydrocarbons in the water masses below an oil slick.

E.5.4.12 Conflict Potential for Fish and Crustaceans

Following an oil spill or during a blow-out, the oil components will be distributed between the environmental compartments according to the many variables that make up the identity of the incident and the combination of these factors (primarily from /62/):

- The nature of the oil spill – whether it takes place from a platform topside, from a subsea production manifold or from a ship:
  The initial release point is highly significant for the fate of the plume and oil slick. A subsea blow-out will generally lead to a higher amount of oil in the water column and a thinner oil slick on the surface than a surface blow-out. In the case of SFLL, an oil spill or blow-out will take place from the platform topside. The extent to which an oil slick on the surface will spread over an area will depend on wind, currents and the earth's rotation/62/, generally drifting at a speed of 3% of the wind speed.

- The physico-chemical properties of the components of the oil type:
  Composition of the hydrocarbon mixture, with each chemical component contributing to important fate-defining parameters such as e.g. water solubility, dispersibility, droplet size, volatility, adsorption to particulate matter etc. Some of the substances with relatively low molecular weight are significantly water soluble, but will also escape the water column relatively quickly due to volatilisation from the surface depending on equilibrium constants defined by water solubility and vapour pressure. This is true for some of the more toxic components, such as BETX and phenols, as well as for the less toxic short-chain aliphatic hydrocarbons.

- The weather at the time of the incident:
  Strong wind and high waves will lead to stronger mechanical forces that disperse the oil and lead to a higher proportion of oil in the water column. The mixing of oil in the water column is primarily dependent on wave height. The diffusional forces, primarily the effect of breaking waves (turbulence), are reduced at increasing depths. As a rule of thumb, the oil will be mixed down to a depth corresponding to 1-2 times the wave height. A high degree of turbulence may lead to efficient mixing, and may lead to high concentrations of particulate matter in the water column, e.g. if the spill happens in shallow waters. The effect of the combination of these two circumstances (high degree of mixing combined with high concentrations of particulate matter) was seen when the *Braer* was wrecked on the Shetland coast during extreme weather conditions (see below).

- Weathering of the oil:
  Weathering processes will cause the oil properties to change with time. Chemical, physical and biological degradation contributes to changes in e.g. toxicity and distribution. Acute toxicity of the Water Accommodated Fraction (WAF) is reduced with age. This is due to volatilisation (see above) as well as the fact that most of the water *soluble* components in the Water Soluble fraction (WSF) will be dissolved in water before the water-in-oil emulsion is formed. Under a fresh oil slick, 90-95% of the WSF will consist of polar and aromatic components, and saturated higher molecular-weight components will only be present to a lesser extent. After a few days, this relationship will be reversed, and the total WSF concentration will be low. This reflects the conflict potential for species in the water column. In general, the oil is expected to be toxic to eggs and larvae for 5-15 days following the spill /62/.

For pelagic resources such as fish, the concentrations of water soluble components and oil droplets at the varying depths of the water column as well as toxicity are the most important factors. In addition to the fate and distribution of oil in the water column, as discussed above, the temporal and spatial distribution of sensitive resources (in this case eggs and/or larvae of fish and crustaceans) is also a defining parameter of whether the resources will be exposed, and hence of the size of the impact on the population/stock.

The resources are distributed both horizontally and vertically throughout the water column. Horizontal distributions can be seen from the figures that show the geographical distribution of each species (Figure E-6 to Figure E-12). The vertical distribution is also important for exposure, especially since the most toxic components will mainly be present in the upper parts of the water column.

The distribution of eggs is dependent on the currents at the relevant depth at which the eggs are present, which in turn is defined by their density and the turbulence of the water /62/.

Eggs that are spawned demersally may exhibit different distributional patterns from eggs that are spawned pelagically, depending on the currents at the seabed level. In the North Sea, the currents are generally wind driven surface currents. Herring *(Clupea harengus)* is one species that spawns *demersal* eggs (at depths of 40(50)-200 metres). In some places, the eggs may cover the seabed in thick layers, and generally only the top 1-2 layers of eggs survive and hatch due to lack of oxygen, bacterial growth, coverage by sediments etc. Two to six days after hatching, the larvae are *phototactic*, and will move to the upper layers where there is more light, and hence more food, although this behaviour differs from region to region /62/.The youngest stages of marine fish, i.e. eggs and larvae, are generally accepted as being the most susceptible to acute oil pollution, while the WSF of the oil is considered to be the most toxic /53/. It is at this stage that the conflict potential for herring will be at its greatest (generally for the first 5-15 days).

The results of a series of experimental studies at the Institute of Marine Research in Norway have shown that eggs and larvae of several fish species are affected by oil concentrations of 30 micrograms WSF per litre and above /53/. The observations indicated depressed metabolic activity measured by reduced oxygen uptake. The impact may be severe on sensitive developmental stages, when the larvae are developing from endogenous to exogenous food uptake (the phase when the egg-yolk sac is almost used up). Young life stages may be aggregated in smaller geographical areas, and if their presence coincides with the presence of an oil spill with significantly high concentrations of toxic oil components in the water masses below the slick, the traditional view that fish are not at risk from oil spills may need a slight modification /62/. There is also some question as to whether the general view that adult fish will swim away from an area with oil will hold true in real situations, although laboratory studies detect stress reactions to such sensory effects /62/.

Adult fish have an effective detoxifying system, and if exposure ceases, accumulated hydrocarbons may be excreted over time. Adult fish that are exposed to polyaromatic hydrocarbons will exhibit enzymatic changes, i.e. an increase in fish hepatic mixed function oxygenase cytochrome – P450 1A (CYP1A). This was shown, for instance, after the *Braer* oil spill off the coast of Shetland in January 1993. Elevation of enzyme levels was shown in non-commercial species of demersal fish /42/. It should be noted, however, that at the *Braer* oil spill, due to the extreme weather conditions almost all of the oil was dispersed into the water column, and high amounts of oil were adsorbed to particular matter which subsequently settled on the seabed (/79/; /42/; /69/, see above). This led to an unusually high exposure of *demersal* fish and *benthic* organisms, such as the crustacean Norway lobster *(Nephrops norvegicus)* (see below)/69/. The level of suspended oil was only high for a few weeks following the spill. However, although there was no detectable increased level of petroleum-derived PAHs in the muscle tissue from fish sampled 3 months after the spill, the enzymatic response persisted for some 5 months, indicating a sub-lethal response to the oil spill /42/. It is generally perceived that enzymatic stress may affect the general health of an organism.

Crustaceans are generally sensitive to oil chemotoxicity. However, effects on different species may be very different, mostly ascribable to differences in acute and/or chronic exposure. The *Braer* spill is an example of this. The *epibenthic* European lobster *(Hommarus gammarus)* eliminated PAH levels to the background levels within a month, whereas the burrowing benthic *(infaunal)* species Norway lobsters *(Nephrops norvegicus)* remained contaminated (above background levels) for more than five years /69/, due to higher chronic exposure from the sediments (see above). After the *North Cape* incident, approximately 9 million American lobsters (mostly juveniles) were killed /69/. In both the *Braer* and *North Cape* cases, oil dispersed near the coast, and exposure of crustaceans was unusually high compared with what could be expected from an offshore oil spill. The *North Cape* was wrecked at a site particularly rich in clams and juvenile lobsters /69/. Only fresh oil in inshore areas is expected to constitute a potential conflict to crustaceans such as lobsters and crabs. The probability of exposure of deep water shrimp *(Pandalus borealis)* to an oil spill is expected to be low, due to the depths at which they live, on or just above the seabed sediments/63/. However, they migrate upwards within the water column at regular intervals, and may be exposed to oil components that are dispersed in the water column. During the three-month pelagic larvae stage, prawn larvae may be exposed to oil components below an oil slick.

The relevant reproductive properties and potential conflict for some important fish species can be summarised as follows:

- Coastal cod: Spawns in shallow waters close to the coast (e.g. fjords) (Figure E-6). Eggs are pelagic, present mostly in the upper water layers. The conflict potential will depend strongly on the age of the oil when it reaches the coastal areas where the larvae may be present, as the concentration and toxicity of WSF is reduced in 5-15 days.

Herring: Demersal spawning at 40 (50) -200 metres; eggs are demersal, but larvae are pelagic and phototactic. Conflict potential if this coincides with a fresh oil spill (5-15 days). If fresh oil reaches the area outside Møre (

- Figure E-7) which has a high concentration of larvae, a potential conflict could be expected for the stock.

- Saithe: The spawning depth for saithe is 100-200 metres, the pelagic eggs hatch after 6-15 days. One of the discrete spawning areas of saithe is very close to and around the Statfjord field (Figure E-8), and the eggs will drift northward through the influence area, although the depth distribution of drifting eggs is not well known. A large, fresh oil spill could come into conflict with eggs and larvae.

- Haddock: The spawning depth is 100-150 metres, and eggs and larvae are pelagic. The spawning area overlaps with the influence area, but haddock have a larger general spawning area than saithe according to MRDB /64/ (Figure E-9). Pelagic larvae may be exposed, but the impact on the stock could be expected to be lower than for saithe.

- Norway pout: The spawning depth is approximately 100 metres, and the eggs are pelagic. A fresh oil spill could be in potential conflict with some parts of the spawning area (Figure E-10), but the species spawns over a relatively large area, and the impact on the stock is therefore expected to be low.

- Sandeel: Sandeels spawn demersally down to 100 metres, and the eggs are also demersal. Hatching takes place after approximately 20 days, and the larvae are pelagic for 4-5 months. Larvae may be exposed to hydrocarbons in the upper layers of the water column, but this species is not expected to be particularly exposed to an oil spill from Statfjord (Figure E-10) because of the distance to the spawning grounds and the general drift of larvae, which will distribute them over a large area, and reduce the concentration of larvae that could potentially be exposed.

- Plaice: Spawns demersally at 50-200 metres, but eggs are pelagic (float upwards). Larvae are also pelagic. The main spawning areas are located south of the analysis area, and larvae will be widely distributed by they time they reach the potential influence area, thus reducing the concentrations of larvae or eggs that might be exposed, and causing the potential impact on the stock to be low.

- Mackerel: Eggs are pelagic, floating within the upper 10 metres of the water column; the larvae are distributed within the upper 20 metres, which means that eggs/larvae could be exposed. The northernmost limits of the spawning area might therefore represent a conflict potential, but the spawning area comprises large parts of the North Sea (Figure E-11 a-b), indicating that impacts on the stock will be low.

The conflict potential to fish is generally assessed as relatively low as the extent of the areas with elevated concentrations of toxic components from a potential oil spill is small compared with areas where sensitive stages of fish may be present in upper layers of the water column.

E.5.5 Seabirds

The North Sea is generally an important area for seabirds, containing breeding, moulting and wintering areas for a number of species /96/. Their distribution is highly seasonal, as they utilise different areas for breeding, migration, moulting, wintering and foraging.

E.5.5.1 General Vulnerability

The seasonal changes in the vulnerability of seabirds to oil spills is mainly dependent on the seasonal changes in behavioural factors, and therefore varies with the species' life habits and the life stage of individuals. Seabirds can be divided into the following groups (focus species in brackets):

- Pelagic divers (auks): common guillemots *(Uria aalge)*, puffins *(Fratercula arctica)*, razorbills *(Alca torda)* and little auks *(Alle alle)*.

- Pelagic surface-feeding species: fulmars *(Fulmarus glacialis)*, gannets *(Sula bassana)*, and gulls such as kittiwakes (*Rissa tridactyla*) and lesser black-backed gulls (*Larus fuscus*)

- Coastal diving species: divers (*Gavidae*), grebes, cormorants/shags, ducks: red-breasted mergansers *(Mergus serrator)*, common eiders *(Somateria mollissima)*, velvet scoters *(Melanitta fusca)*, common scoters *(Melanitta nigra)*, long-tailed ducks *(Clangula hyemalis)*, and black guillemots *(Cephus grylle)*

- Coastal surface-feeding species (other ducks and gulls).

Vulnerability to oil spills is similar within these ecological groups, varying with the stage in the yearly life-cycle the birds are in at the time of the spill. This analysis distinguishes between breeding, moulting and wintering seasons. Both the *Braer* (Shetland, January, 1993) and the *Sea Empress* (South-West Wales, February, 1995) incidents killed thousands of seabirds, but impacts would have been far larger had those incidents occurred in the breeding season /57/. The *Erika* (Brittany, December, 1999) and *Prestige* (Galicia, Spain, November 2002) incidents killed large numbers of non-breeding auks from colonies in Britain, but the birds were mainly immature birds, so that the impact on breeding population was much less than it would have been if the same numbers of adult birds had been killed. However, the true impact will first be evident years later, when the recruitment to the breeding population may be lower/57/.

Diving through the water surface when foraging and resting on the water surface etc. increases the likelihood of exposure. Pelagic and coastal diving species at all life stages/seasons are therefore the most vulnerable. Pelagic species, both diving and surface-feeding, are heavily dependent on the marine environment and some only come ashore to breed. Access to food is dependent on oceanographic conditions and even in the breeding season many of these birds spend the majority of their time feeding at sea. In winter, these seabirds mostly disperse from their breeding sites and may range considerable distances over open sea in search of food. Pelagic diving species (e.g. auks) have an especially high individual vulnerability toward acute oil pollution as they spend much of their time on the open sea, both for foraging and for resting close to the breeding colonies. During moulting, many birds will move to open sea in order to avoid predators on land.

Coastal diving species are also subject to high individual vulnerability if an oil spill comes close to shore. Pelagic surface-feeding species are also vulnerable in open sea foraging areas (and during the seasons when foraging occurs in open sea), as well as in their wintering areas, but can avoid oil. Coastal surface-feeding species are vulnerable if an oil spill hits them in breeding areas/seasons and moulting areas/seasons.

Seabirds in the open sea tend to congregate in large flocks, further increasing the vulnerability of the population if exposed to oil, as a great number of birds may be killed. This tendency also leads to generally poor numerical data quality for seabirds in the open sea. This can be counteracted by conducting a sensitivity analysis for possible environmental consequences.

A vulnerability scoring system based on different species' vulnerability to oil spills was introduced by the Norwegian Pollution Control Authority and the Directorate for Nature Management for use in prioritising between areas for protection and clean-up (MOB Areas) /81/. Many of the areas with the highest status are important sites for birds. Vulnerability is one of the factors in the MOB model, and indicates the biological vulnerability to (in this case) oil spills. “MOB-vulnerability” scores have therefore been determined for several species of seabirds, with seasonal (monthly) variations. The scale runs from 0-3, where 3 denotes “high” (the highest) and 0 denotes “insignificant vulnerability”. For a number of species, this MOB-vulnerability score is shown in the following sections.

E.5.5.2 Data on Seabirds

In UKDMAP, data from offshore, ship-based and aerial surveys have been combined to form a North Sea Seabird Database, produced by the Joint Nature Conservation Committee’s Offshore Animal Branch (JNCC/ESAS Seabird and Cetacean Distribution Atlas, 1998 /16/.) Citations of seabird distributions have been updated where relevant/77/.

Data for seabird breeding numbers on Shetland have been obtained from UKDMAP /16/., Mitchell *et al.* (2004) /57/, Pollock *et al.*, (2000) /77/.and Shaw *et al.* (2000)/82/.

Many species of interest are also listed in Annex I of the EC Directive on the conservation of wild birds (79/409/EEC) (“Birds Directive”)/120/. Sites of special importance to these species may be designated or considered for classification as Special Protection Areas (SPAs) (/126/), and over 40% of SPAs are listed in Annex 1 because of seabird interest/57/. The breeding populations of many British and Irish seabirds are increasing, but in areas with the densest populations the number may be declining slightly, e.g. the population of northern fulmars in northern Scotland. The total population in Britain and Ireland has increased by 74% since 1969-70, indicating that spatial distributions are changing /57/.. For the Atlantic frontier, north and west of Scotland, data on the distribution of seabirds were obtained from Pollock *et al.* /77/. The locations of seabird breeding colonies are undergoing changes /57/, and the migration routes to open sea areas might therefore be changing as well. In Norwegian waters, data on seabirds in open seas have not been systematically collected in the influence area, and the data quality therefore varies/61/.

E.5.5.3 Pelagic Divers

The species with the highest individual vulnerability to oil spills (with a MOB-vulnerability value of 3 all year round) that are most common within the analysis area include the pelagic divers:

- the common guillemot *(Uria aalge)*,
- razorbill *(Alca torda)* and
- Atlantic puffin *(Fratercula arctica)*.

These auks are character species of the North Sea and the southern Norwegian Sea. The auks breed within the analysis area, and their breeding sites are on large seabird cliffs. In the breeding season (see each species) seabirds at sea will mainly remain close to the breeding areas, with the highest concentrations being around the breeding colonies. A common feature of auks is that they moult at sea following the breeding season, rendering them flightless and particularly vulnerable to oil spills.

Common guillemot *(Uria aalge)*

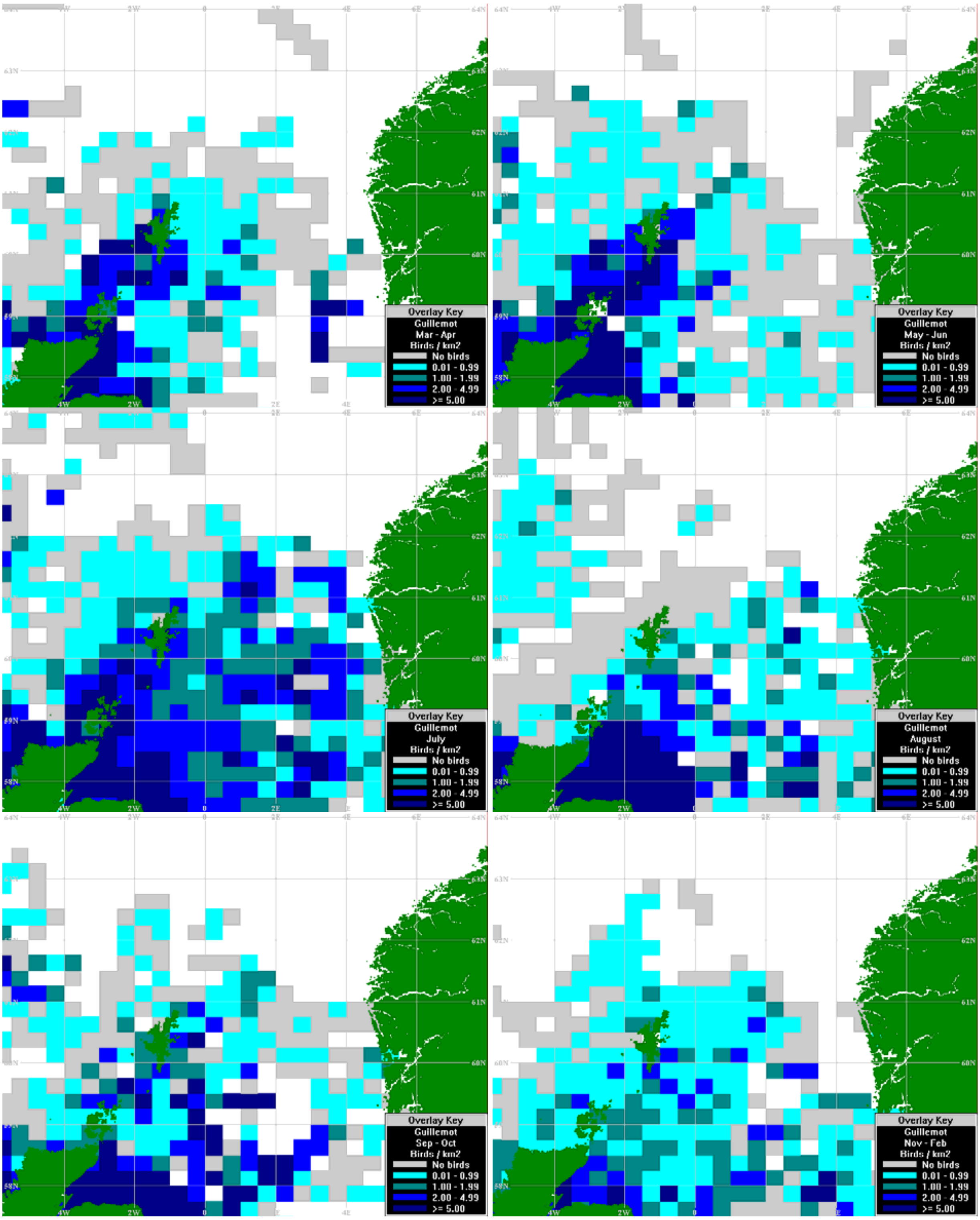
MOB-vulnerability/81/: January – December (3)

The population of common guillemot in Norway is on the decline. Between the mid-1960s and 1984, the breeding population in the largest Norwegian colonies was reduced by 70-90%, and a further decline followed the breakdown of capelin stocks (/43/; /96/). The species is on the breeding birds Red List in Norway (DN, 1998). Of the Norwegian population, 90% breed north of Lofoten, but these populations are threatened (/11/; /96).

The species is migratory, and reaches breeding maturity at 4-5 years. A breeding pair will lay one egg in May-June. The egg hatches after approximately 32 days. When the offspring is approximately 3 weeks old, the male will take it to open sea. During this period, they will be flightless and therefore especially vulnerable to oil spills (July- August). Losses in this period may represent a large part of a colony's successful breeding males, along with their offspring. Within the influence area, there are some breeding colonies along the Norwegian coast, although the main breeding colonies are further north. Some of the common guillemot from breeding colonies in southern Norway migrate south of the analysis area to the coast of Sørlandet, Norway's south coast, and Skagerrak, where they winter together with guillemots from Great Britain and the Faeroe Islands /43/. The wintering population of guillemots in Skagerrak has been estimated at approx. 200,000 individuals /96/. Guillemots moult from July to October/96/. The most important moulting areas are located outside the influence area (Outer Oslofjord and Kattegat) as well as areas off the coast south-west of Lindesnes and Stavanger. The total moulting population in Skagerrak is estimated at approx. 220,000 individuals /96/.

Shetland supports important breeding areas in the UK. The breeding period in the UK is from May to July. There are 1.6 million individuals in Britain /Ireland, including 1,167,841 individuals in Scotland/57/. The common guillemot was the most abundant and widespread species of auk in the study by Pollock *et al.,/77/*. Shetland is one of the areas with the highest densities. During post-breeding, moulting and flightlessness, Shetland-breeding guillemots are thought to move south and east into the North Sea */77/*.

The number of breeding pairs around the North Sea coast (total) has been estimated at 680,400 /16/.. Data on the distribution of common guillemot from UKDMAP is shown in Figure E-13.



Note that white areas on the map mean that no data is available.

Source: UKDMAP (BODC, 1998)

Figure E-13: Seasonal distribution of common guillemot in the North Sea

Razorbill (Alca torda)

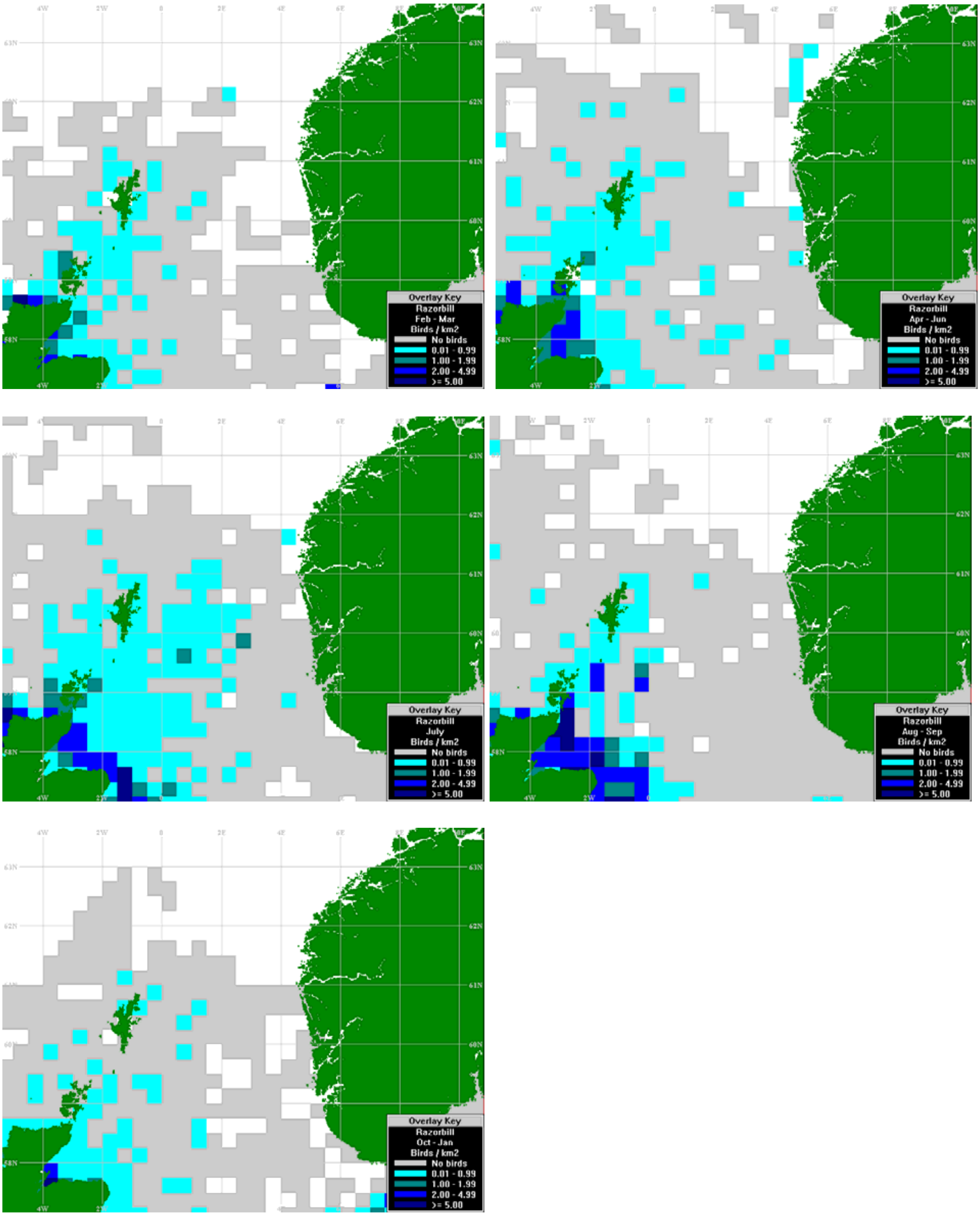
MOB-vulnerability /81/: January – December (3).

The breeding population of razorbills in Norway is thought to be undergoing a slight decline/43/, but not as drastic as for the common guillemot/96/. Like the common guillemot, razorbills produce one egg (mid-May to the beginning of June). The egg hatches after 35 days. At 3 weeks, the flightless chick will leave the nest for the open sea along with one of the parents, rendering the birds especially vulnerable to oil spills. There are breeding colonies of razorbills along the Norwegian coast within the analysis and influence area /43/, where parents and offspring might be exposed (July – August). Of the Norwegian population of razorbills, 90% breed north of the Polar Circle /11/. According to Gjershaug *et al/* 43/,, Norwegian razorbills migrate to Skagerrak and the North Sea after breeding (after July).

The UK razorbill population was estimated at 144,000 breeding pairs in 1969-1970/ 43/. The numbers are currently 189,000 individuals in the UK, 139,000 of which are individuals in Scotland /57/. Approximately 20% of the world's razorbills breed in Britain. The main UK breeding sites are in the coastal areas of western Scotland. Another important site is east of the Orkney Islands /77/.

The main moulting areas for razorbill in the North Sea are well south of the analysis area, mainly off the north-west coast of Jutland (Denmark). The estimated moulting population is 100,000 individuals. The wintering areas are mainly located in the Danish parts of Skagerrak, and the wintering population in the whole area has been estimated at 120,000 individuals/96/.

The number of breeding pairs around the North Sea coast (total) has been estimated at 73,100/16/. UKDMAP data on the distribution of razorbill sightings is shown in Figure E-14.



Note that white areas on the map mean that no data is available.
Source: UKDMAP (BODC, 1998)

Figure E-14: Seasonal distribution of razorbill in the North Sea

Atlantic puffin (Fratercula arctica)

MOB-vulnerability/81/: January – December (3).

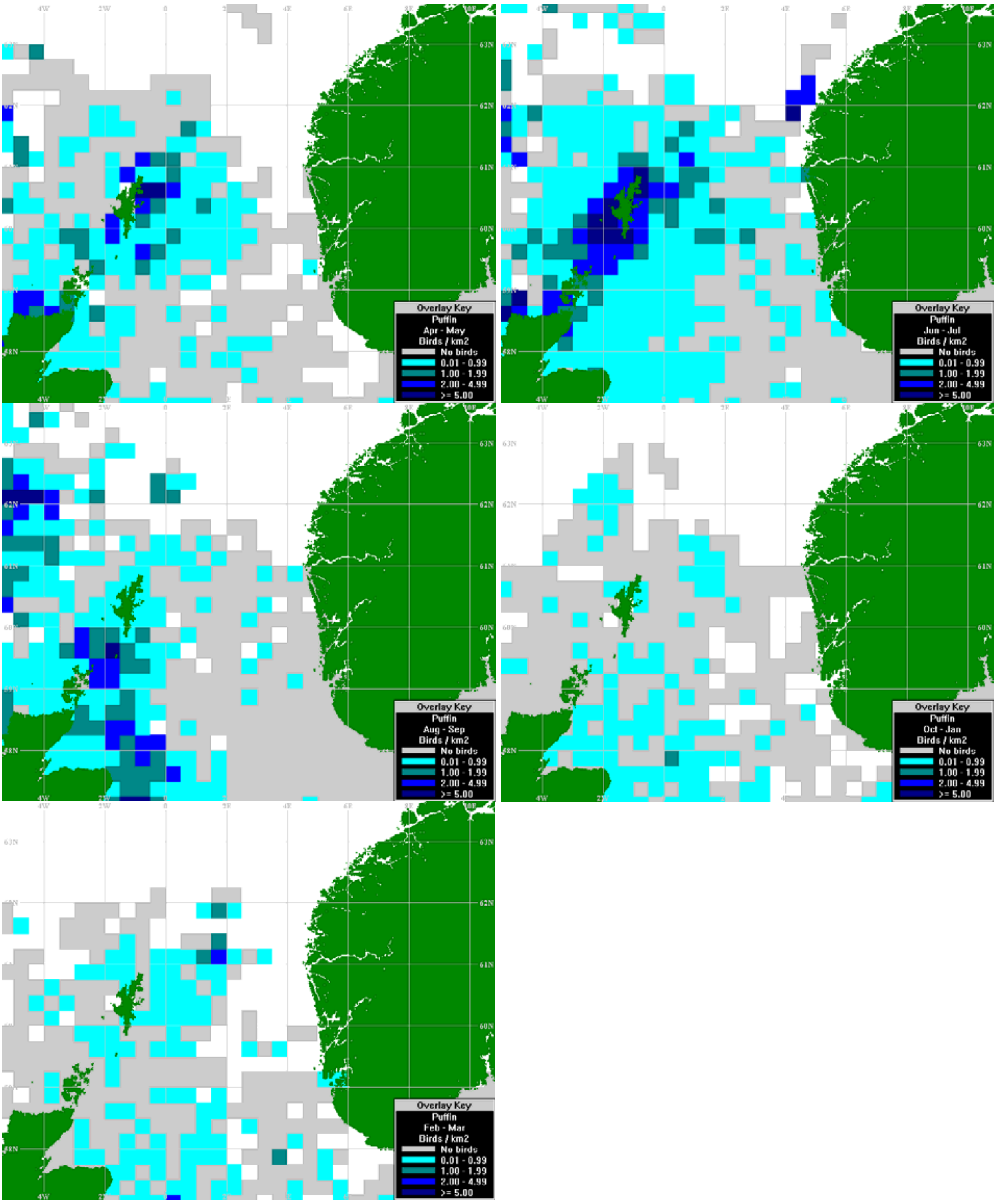
Seventy-five per cent of the Norwegian population of Atlantic puffins (approximately 2 million breeding pairs in total) breed in Nordland and Troms /43/, /11/. The approximately 35-40 Norwegian breeding sites support 21-33% and colonies in Great Britain support some 12% of the world's approximately 6 million (4-8) puffins.

The puffin is on the Norwegian breeding birds Red List /30/, and is a responsibility species in Norway. There are a relatively high number of colonies around Stadt as a result of the strong frontal systems between the coastal and Atlantic currents. Since the 1960s, Norwegian puffins have had low reproduction rates measured in terms of the number of raised chicks, because of reduced herring stocks. This has affected the largest Norwegian breeding colonies on Røst in particular, and the populations have decreased markedly as a result/96/. Herring spawning areas in the southern Norwegian Sea produce juveniles that, by the time they reach Lofoten, are large enough to be suitable for feeding chicks.

Puffins arrive at the breeding colonies in March, and the nesting period lasts until August. The single egg is laid at the end of April in southern Norway (one month later in northern Norway). The egg hatches after 40-45 days and the chick normally stays in the nest until it can fly (6-10 weeks). Fertility is reached at the age of 4-6 years, and the birds are long-lived (the Norwegian record is 29 years). Migration routes in Norway are not very well known. The birds spread out over very large areas in the winter months /43/ . The number of breeding pairs around the North Sea coast (total) has been estimated at 226,000 /16/.

In UK waters, the Atlantic puffin is a widely distributed species (more than common guillemots and razorbills), and it is often more abundant in oceanic waters than inshore. Most eggs are laid in April. Moderate to high densities of Atlantic puffin were observed around Shetland in the study by Pollock *et al*/77/. Densities increase from June to July with the highest concentrations around the main breeding sites of Shetland, Orkney, North Rona, the Shiants and St. Kilda. Low to moderate densities (0.50-0.99 birds/ km^2) have been observed in June and July in the open sea area from north of Shetland to the Norwegian Sea. These individuals are most likely non-breeders, as breeding individuals are thought to feed near the colony within a feeding range of maximum 40 km. During periods with low food availability, the birds foraging ranges may be larger /77/.

After fledging, the birds leave the colonies on Shetland for the open sea. Densities of 0.01-0.99 birds/km^2 are found all around Shetland in August and September, with higher densities (1.00-1.99 and 2.00-4.99 birds/km^2) in the Fair Isle Channel between Orkney and the Shetland Islands, especially around Fair Isle. From October to November, puffins are found even further out to sea, and at lower densities (0.01-0.99 birds/km^2). Between December and March, they are again found somewhat closer to land /77/. Based on the breeding biology of puffins, it is to be expected that the numbers close to shore increase in March compared with December, as the birds come ashore to breed in the spring, but the charts in Pollock *et al.* /77/ do not show this clearly. There are 1.2 million adults (0.6 mill. pairs) breeding in Britain and Ireland /57/, of which 493,042 breeding pairs in Scotland /57/. Based on the density distribution charts of Pollock *et al., /*77/ and UKDMAP /16/ can be assumed to be an especially important area for puffins in the UK. The distribution of sightings is shown in Figure E-15 (UKDMAP)

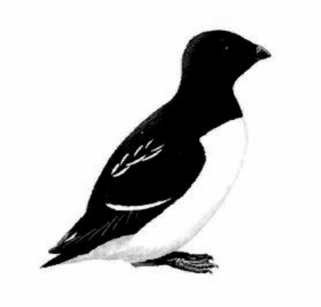


Note that white areas on the map mean that no data is available.

Source: UKDMAP (BODC, 1998

Figure E-15: Seasonal distribution of Atlantic puffin in the North Sea

Little auk (Alle alle)



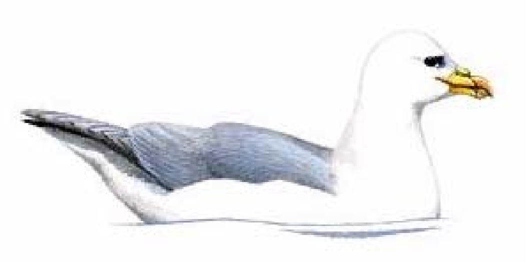
MOB-vulnerability /81/: January – December (3).

The little auk is a winter visitor to the North Sea. The wintering population in the North Sea has been estimated to be 1.1 million individuals /96/. Little auks are less frequent around the Shetland Islands /77/.) and, although spread throughout the analysis area, the highest densities are off the north-west coast of Denmark. Particularly large concentrations of little auks are also found in March and April, on the shelf off the coast of Sunnmøre. The indications are that this area is important for migrating birds on their way north /96/.. Densities around Shetland are highest between September and December (0.01-0.99 birds / km^2), with 1.00-1.99 birds / km^2 being registered infrequently in smaller areas. By April and May most of them have migrated north, and only a few scattered birds are left /77/.

E.5.5.4 Pelagic Surface-feeding Species

Pelagic surface feeders are less vulnerable to oil spills than auks, and are also widely spread and more abundant in the area. Lesser black-backed gulls, kittiwakes, fulmars, and gannets are important species in the area. With the exception of the lesser black-backed gull, they are tied to the popular breeding areas around seabird cliffs. In Norway, there are particularly high densities of these species around Gurskøy in Møre og Romsdal, and between Florø and Askvoll in Hordaland(/96/.

Fulmar (Fulmarus glacialis)



MOB-Vulnerability /81/: January – December (2).

Fulmars spend most of their life in open seas. The population on the Norwegian mainland is increasing, and has been estimated at approximately 7,000 breeding pairs; the largest breeding colony is on Runde (5,000 breeding pairs) (/43/; /96/.). There are high densities of fulmar around Gurskøy in Møre og Romsdal, and between Florø and Askvoll in Hordaland /96/. In Norway, breeding can take place as early as late winter.

The fulmar was the most abundant and widespread species in the study by Pollock *et al*/77/. It is present in northern UK waters all year round, and is found in the greatest numbers in the summer months. On Shetland they are associated with fishing vessels. The breeding season in the UK area is from May to July.

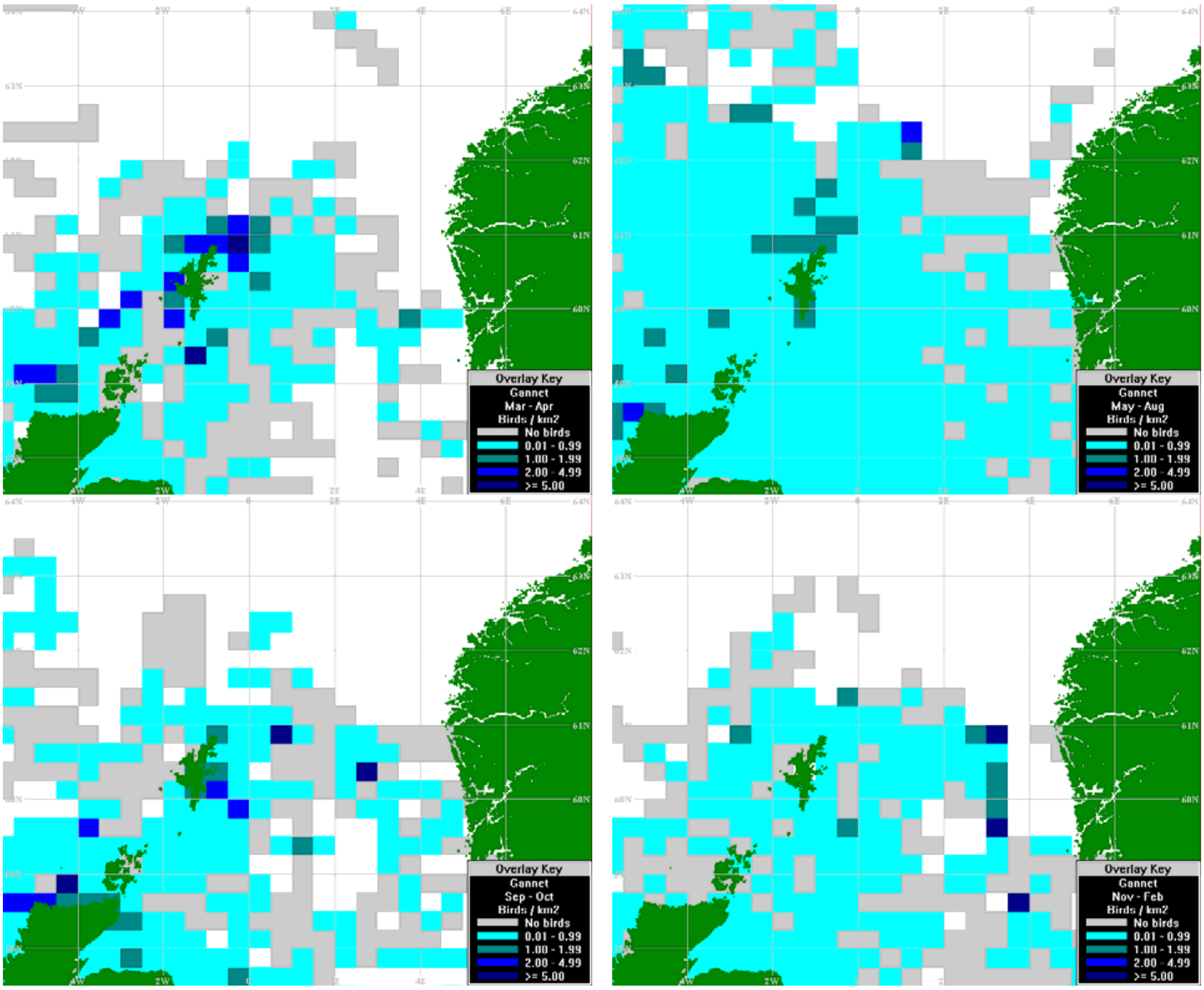
Moderate to high densities (+5 birds/km^2) of fulmar were recorded over the deep waters of the Norwegian Sea beyond the continental shelf in May to July. Around Shetland the numbers are also high from August to October, which might reflect the presence of recently fledged birds /77/. Population numbers in the UK were estimated at 1.1 million breeding pairs in Britain /Ireland, and 485,852 breeding pairs in Scotland. We have not found an estimate of the population in the whole of the North Sea area. Breeding birds may forage up to 320 km from the breeding colony for food /43/.

Gannet (Morus bassanus)

MOB-vulnerability /81/: January – December (2).

Gannets *(Morus bassanus)* are partial migrants. The species is widespread at low densities, and occurs frequently in open seas in the analysis area. There are high densities around the breeding sites on Shetland (March- August). Breeding birds will stay within 150 km of the breeding site. In open sea areas south-east of Statfjord moderate to high densities of birds have also been recorded in the winter months /77/; UKDMAP /16/.

The total breeding population is estimated at 259,311 pairs in Britain and Ireland. This corresponds to 68% of the world’s population of gannets, and 187,363 breeding pairs are registered in Scotland /57/. In the Norwegian part of the analysis area, the only confirmed breeding site is on Runde, with an estimated total of 3,500 breeding pairs distributed among a total of five colonies /96/.. /43/ state that there are eight confirmed gannet breeding sites in Norway. There are high densities of gannets around Gurskøy in Møre and Romsdal, and between Florø and Askvoll in Hordaland /96/. Data from UKDMAP are shown in Figure E-16.



Note that white areas on the map means no data.
Source; UKDMAP /16/

Figure E-16: Seasonal distribution of gannet in the North Sea

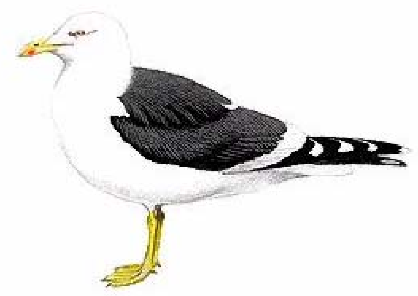
Kittiwake (Rissa tridactyla)

MOB-Vulnerability /81/: January – December (2).

Kittiwakes are migratory birds. In Norway they are mainly distributed from Runde and northwards, although some breed as far south as Rogaland. There are high densities of kittiwake around Gurskøy in Møre og Romsdal, and between Florø and Askvoll in Hordaland /96/.. The number of breeding pairs is declining in the southern colonies, whereas the others are more stable /96/.. With 40% of the world's total breeding population breeding in Norway, kittiwakes are a Norwegian Red List responsibility species /30/.

In the UK, there are 282,213 breeding pairs in Scotland, and a total of 800,000 breeding birds. Kittiwakes have declined by 23% since 1985-88. The number of breeding kittiwakes around Shetland has declined by 69% in the last 15 years /57/. Even so, kittiwake were the most abundant and widespread gull species in the study by Pollock *et al/*77/.. Between January and April, they are widely spread throughout inshore and offshore waters around Shetland, the Fair Isle Channel, the Orkney Islands, northern Scotland and the Faeroe-Shetland Channel, with the highest densities over the continental slope. The birds are often associated with fishing vessels. One of the areas with the highest density from January to April was off the north-eastern coast of Shetland. From May to July the birds are still widespread, but the highest numbers are then found in coastal waters close to the colonies, especially around Orkney and the northern coast of mainland Scotland. Foraging ranges vary with the abundance of food; most birds were recorded within 25 km of the nearest colony. From October to December, kittiwakes again move out to sea, congregating in certain areas. One such area is south-east of Fair Isle */*77/.

Lesser black-backed gull *(Larus fuscus)*



MOB-vulnerability /81/: December – February (-), March – April (1), May – August (2), September – Nov (1)

The lesser black-backed gull is a migratory bird. It is listed on the breeding birds Red List in Norway /30/. and the OSPAR list of threatened and/or declining species and habitats /75/ (although on the latter list *Larus fuscus* is cited as being present in Region I (the Arctic). It is cited as being threatened in all regions where it occurs. This species has two sub-species in Norway: *Larus fuscus fuscus*, which breeds mainly from Trøndelag northwards, and whose numbers are declining, and *Larus fuscus intermedius*, which mainly breeds south of Trøndelag and has a more varying population development /96/.. The population in Sogn og Fjordane has declined in particular (90%) /43/. The two sub-species use different migration routes. Population numbers are uncertain.

There are 72,130 breeding pairs in Scotland. In the UK, the species seems to be changing its nesting sites. The number of roof-nesting lesser black-backed gulls in UK cities (total number) was 11,000 pairs in the study carried out by Mitchell et al. in 1998-2002, which was four times more than 4-8 years earlier. For lesser black-backed gulls in natural nesting sites, the situation is far more serious, and the total population has declined by 50% since 1969-1970, which might be due to a reduction in fisheries activity /57/.

E.5.5.5 Coastal Diving Species

Coastal divers can be further divided into benthic feeders and fish-eating species. There are high occurrences of breeding sites along the entire Norwegian coast, especially in Trøndelag (Froan, Tarva-Melstein, south-west Vikna, Frøya north and surrounding islands) /96/.. Moulting birds of these species may largely be found along the entire Norwegian coast within the analysis area. Froan north, Fastfrøya north (with surrounding islands) and Ørland – Leksa are important areas for the benthic feeding species (eider).

Red-throated diver *(Gavia stellata)*

MOB-vulnerability /81/: January – December (3).

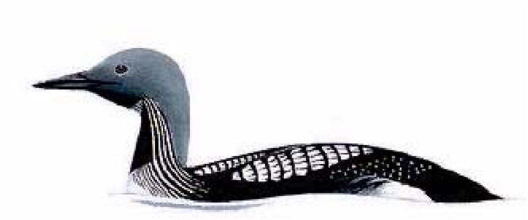
Red throated divers move to coastal waters outside the breeding season: Most sightings therefore occur between May and September /77/. Migrant birds arrive from Scandinavia in autumn. There are many breeding colonies along the Norwegian coast, with the highest densities of colonies south of the Sognefjord, and from Stadt to Lofoten. The breeding population is estimated at 2,000-5,000 pairs. The species breeds both inland and along the coast throughout Norway /43/. The moulting period is late September, when they are flightless for a month and susceptible to surface oil pollution. Sightings have been made all over Shetland, usually from 2-5 sightings per year /77/. with the most sightings from October to May. The red throated diver is on the breeding birds Red List in Norway /30/, and is listed in Annex I of the Birds Directive.

Great northern diver *(Gavia immer)*

MOB-Vulnerability /81/: January – December (3)

The great northern diver is an inshore species, primarily a winter visitor. Sightings on Shetland were made at 5 locations, with 2-6 sightings per year /77/. The great northern diver is a responsibility Red List species in Norway, as 25% of the total world's population winters in Norway /30/. It is a possible, but not confirmed breeder in Norway. The species is listed in Annex I of the Birds Directive.

Black-throated diver *Gavia arctica)*



MOB-Vulnerability /81/: January – June (3), July – August (-) September – December (3)

Confirmed breeding sites have been recorded all over Norway, inland and along the coast. A Norwegian breeding population of 5,000-10,000 pairs has been suggested. /43/ The species is on the breeding birds Red List Norway /30/ and is an Annex I species (Birds Directive). The black-throated diver is a rare species in Britain, breeding only in Scotland, and mostly in the west of Scotland.

Great cormorant (Phalacrocorax carbo)

MOB-vulnerability /81/: January – December (3)

The great cormorant *(Phalacrocorax carbo)* is a migratory bird. With 30% of the total world population wintering in Norway, it is a Norwegian Red List responsibility species /30/. The number of birds in Norway was reduced in the years 1985-1986, but increased again by 1999 /96/.. The total Norwegian population was approximately 24,000 breeding pairs in 1994. Breeding colonies are located along the North Norwegian coastline from Frøya in the analysis and influence area to Finnmark. The largest colony on Vega (north of the analysis area) supports 1,300-1,400 pairs /43/. It does not migrate over open sea and is rare in open seas, as it needs to roost on land or on hard structures (/43/; /77/.).

The species has increased by 15% in Britain and Ireland since 1985-1988 through the influx from Europe of the sub-species *P. carbo sinensis*, an inland-breeding breed of great cormorant, thus increasing the numbers of cormorants. The endemic stock of *P. carbo carbo* – a predominantly coastal cormorant race, has suffered a substantial decline in north-east Scotland. The number of breeding pairs (both breeds) in Scotland was recently estimated to be 3,626 /57/. There are breeding colonies of cormorants on Shetland and on Fair Isle (JNCC website; /77/).

European shag (Phalacrocorax aristotelis)

MOB-Vulnerability /81/: January – December (3)

The European shag is also a migratory bird. With 25% of the world's total population wintering in Norway, it is a Norwegian Red List responsibility species /30/.

With the exception of the coastline between the Hardangerfjord and the Sognefjord, breeding colonies of shag are found along the Norwegian coast from Rogaland to Finnmark. The Norwegian population was reduced dramatically around 1986-1987, when the largest colony on Runde was reduced from 5,000 to 2,000 pairs. In recent years the status of this species has increased markedly, especially in the breeding colonies in Rogaland, which, following a six-fold increase, now supports some 1,500 pairs, making the Rogaland population of shags particularly important. The recovery has not been as good further north /96/. Important wintering areas are in Møre and South Trøndelag /43/.

21,487 breeding pairs are registered in Scotland /57/. Breeding sites are in the sea lochs of north and west Scotland as well as near Fouls in the Shetlands, which has 2,400 breeding pairs in the breeding season /77/.

Great crested grebe *(Podiceps cristatus)*

MOB-vulnerability /81/: January – April (3), May – July (-), September - December (3)

The great crested grebe *(Podiceps cristatus)* is a migratory bird which does not breed in the part of Norway covered by the analysis. (Breeding sites are in the inner parts of the Trondheimsfjord (Levanger) and in Akershus, Østfold, and Oslo.) /43/. It has not been recorded on Shetland */77/.*

Red-necked grebe (Podiceps grisegena)

MOB-Vulnerability /81/: January – May (3), June – July (-), August - December (3)

The red-necked grebe is a migratory bird which breeds in freshwater lakes. It is mainly present in Denmark. Confirmed breeding in Norway is rare. Wintering areas are along the coast of southern Norway. The species is not mentioned by */77/*, /57/ or UKDMAP /16/ as being present in the UK.

Slavonian grebe (Podiceps auratus)

The Slavonian grebe *(Podiceps auritus)* is also in Annex I of the Birds Directive. The species is not mentioned by Pollock *et al/*77/., Mitchel *et al.* /57/ or UKDMAP /16/ as being present in the UK. The breeding sites in Norway are mainly in lowland inland waters along the coast of northern Norway, from North Trøndelag to Finnmark, and one near Haugesund /43/.

Red-breasted merganser *(Mergus serrator)*

MOB-Vulnerability /81/: January - December (3).

The red-breasted Merganser has a wide distribution in Norway. It is an adaptable species, able to utilise both inland and coastal habitats. It is most numerous in sheltered marine areas /43/. The red-breasted merganser is a Norwegian responsibility species, with 30% of the north-western European population wintering in Norway. The species is numerous in Norway, with an estimated breeding population of 25,000-30,000 out of a total of approximately 100,000 pairs in north-western Europe. Wintering and breeding is not mentioned as occurring on Shetland; the species breeds in northern and western Britain and is considered to be rare */77/.*

Common eider (Somateria mollissima)

MOB-Vulnerability /81/: January - December (3)

The common eider is a migratory bird and a benthic feeder with a high vulnerability to oil spills. It breeds on small inshore islands along the entire Norwegian coast, also in the fjords. In Norway the population has increased since the 1970s, the most probable reason being a reduction of species that compete with the eider for the mussel *Mytilus edulis*, thereby increasing breeding success. The numbers of competitors are, however, again increasing, and the populations of eiders are now expected to stabilise /96/.. In the study carried out by Pollock *et al.* /77/, eiders were the most numerous of the six ducks that were recorded as present in relatively high densities in inshore wintering areas around the Minch and the Inner and Outer Hebrides. There is a wintering area with 0.01-0.49 birds/ km^2 on South Shetland, and one with 0.50-0.99 birds/ km^2 on North Shetland.

Eiders lay 4-6 eggs in May (southern Norway). Further north, egg laying takes place in June. The eggs hatch after 4 weeks, and the chicks leave the nest at the age of 1-2 days. Females may form groups to assist each other in looking after the chicks. It is also common to find young non-breeding females (aunts) with the mother, assisting in minding the chicks. Eiders reach maturity at 3 years (2 for some females) /43/.

Long-tailed duck (Clangula hyemalis)

MOB-Vulnerability /81/: January - December (3)

The long-tailed duck is a migratory bird, which in southern Norway breeds near inland freshwater lakes and ponds in the central mountainous areas (April – June). After breeding, the long-tailed duck migrates to inshore coastal areas, where it forms large groups of wintering birds.

The Norwegian coast provides wintering habitats for these birds and most wintering sites are from Central Norway northwards. During the wintering season, long tailed ducks are especially vulnerable to oil spills, because of their aggregation, relatively small oil spills may kill many individuals. Oil spills are considered to be a significant threat to long-tailed ducks /43/. The species is a breeding birds Red List species in Norway /30/. Some wintering birds have been registered around the Orkney Islands and south of Fair Isle in the UK (densities of 0.01-0.46 birds/km^2 /77/. Wintering populations in Norway have been estimated at 50,000-100,000 pairs, and the Norwegian breeding population at roughly one tenth of this (5,000-10,000 pairs) /43/.

In Britain, it is a winter visitor in inshore areas. The only noticeable concentration was on the Orkney Islands. Some sightings have also been recorded in summer /77/.

Black (Common) Scoter *(Melanitta nigra)*

MOB-vulnerability /81/: January – May (3), June – August (-), September - December (3).

This migratory species is on the Norwegian breeding birds Red List /30/ and on the UK Red List. In Norway, it breeds near inland lakes and is a relatively rare breeder along the coast, but like the long-tailed duck, the common scoter is considered to be especially vulnerable to oil spills when wintering in coastal inshore areas /43/. The Norwegian breeding population has been estimated at 1,000-5,000 pairs, the number of wintering birds or the exact migratory routes are not exactly known /43/.

The UK wintering numbers have been estimated at some 25,000 birds, although not in the analysis area /77/. Data indicate that there might be common scoter in open seas south-east of Shetland, between 58-59 °N and 1° E and 2° W, and in open sea off the Rogaland coast (density 0.01-0.99 birds/km^2). The British/Irish breeding population is less than 200 pairs /77/. Another important area for this species seems to be off the coast of Denmark (UKDMAP /16/).

Velvet scoter (Melanitta fusca)

MOB-vulnerability /81/: January – June (3), July – August (-), September - December (3).

The velvet scoter is on the breeding birds Red List in Norway /30/. Like the common scoter, it breeds near inland lakes, but some coastal breeding sites have been registered within the analysis area around the Sognefjord and in northern Norway. The breeding population is estimated to be approximately 1,500 pairs and declining. It winters along the coast even more than the common scoter, important areas being the coasts of Trøndelag and Rogaland/43/. Its migratory routes are not well known, and it is suggested that Norwegian-bred birds may winter in Scotland.

In the UK it is a winter visitor, with an estimated winter population of approximately 2,500-10,000, most of which winter along the east coast of Scotland. Two birds were recorded to the north of Unst in the Shetland Islands */77/.*

Black guillemot *(Cepphus grylle)*

MOB-vulnerability /81/: January – December (3).

Black Guillemots are not counted in Norway and their status is uncertain /96/. It breeds along the outer parts of the Norwegian coastline. Gjershaug *et al.*, /43/ state that the most important breeding sites are the outer coastal areas and islands from Møre og Romsdal and northwards to Finnmark, and quote recent estimates of the breeding population to be around 40,000 pairs. Although the estimates of Norwegian population numbers are uncertain, the species has almost certainly suffered a substantial decline in recent years, and may be on the verge of disappearing in some areas. The species is on the breeding birds Red List in Norway. The main reason for the decline is suspected to be wild American mink (an introduced species to Norway), but the species is also susceptible to being caught in fishing nets. Black guillemots were badly hit by the *Deifovos, Sonata, Arisan* and *Braer* oil spills (/43/; /57/).

Between March and August, black guillemots are widespread in low densities (0.01-0.49 birds/km^2) around north-west Scotland, the Orkney Islands, the Fair Isle Channel and Shetland. The number of birds is somewhat reduced between September and February, especially around Orkney and Shetland. There are breeding colonies on Shetland. The shallow inshore waters of Shetland provide an important gathering area for flocks of moulting black guillemots during autumn and winter. However, birds from the sites on Foula and Fair Isle move further than birds from other breeding sites after the breeding period, which is thought to be due to lack of shelter */77/.*

In Scotland the numbers of Black Guillemots were recently estimated at 37,505 pre-breeding adults (Mitchell *et al.*, 2004 /57/). The total UK number is 39,000 adults which is similar to previous counts in 1982-91. The species has increased by 14% in the Northern Isles, which is the core UK area, in spite of considerable numbers being killed in the *Braer* oil spill in 1993. Elsewhere in the UK, colonies are increasing on offshore islands, while the number of breeding pairs has declined on inshore islands and on the mainland of Scotland. Here also, the cause is suspected to be introduced American mink /57/.

E.5.5.6 Costal Surface-feeding Species

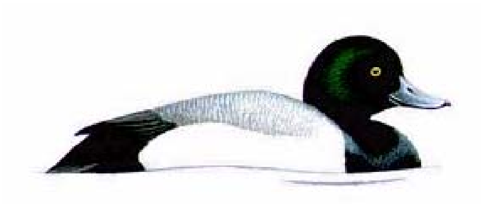
Coastal breeding species in this ecological group can be found in the whole area, along the Norwegian coast. The density of breeding sites is especially high in South Trøndelag /96/..

Manx shearwater (Puffinus puffinus)

MOB-vulnerability /81/: June – December: (2). January – Mai: (-)

Ninety per cent of the world's Manx shearwater population breeds in Britain/Ireland /57/. There are 332,000 breeding pairs in Britain, 126,545 of them in Scotland, mainly in western Scottish waters. However, the species is only found in low densities around Shetland in June to August, and these birds are most likely non-breeding birds /77/. Manx shearwaters have been registered in Norway, but are not known to breed in Norway, although it is possible /43/.

Greater scaup *(Aythya marila)*



MOB-vulnerability /81/: January – May: (3). June – August (-), September – December (3).

Like the other scoters, the greater scaup breeds in inland mountainous lakes and migrates to the coast for wintering in September – November, where large groups may form in shallow waters and estuaries/brackish waters /43/. The Norwegian breeding population is approximately 1.000 pairs. There are important wintering areas in the south. There is no mention of this species in UKDMAP /16/, Mitchell *et al*/57/ or Pollock *et al. /77/.* as being present in the UK.

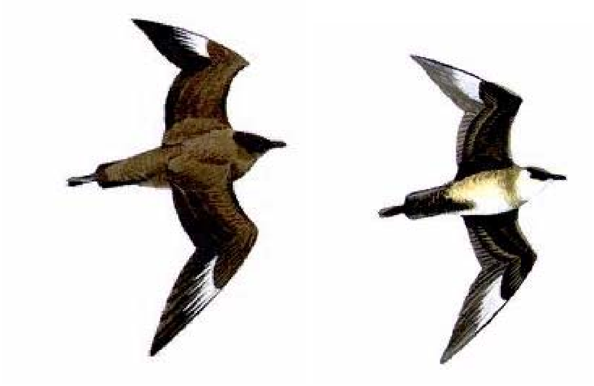
Red-necked phalarope *(Phalaropus lobatus)*

MOB-vulnerability /81/: October – April: (-). May-June (1), July – August (2), September (1).

The red-necked phalarope is an Annex I species (Birds Directive).

The distribution of this rare species was studied by Pollock *et al. /77/..* A small group of three birds was recorded in August, just east of the Shetland Islands (60°05'N, 00°04'W), which is the main breeding area for the species in Britain, with a population of almost 40 breeding males. In Norway, this species is mainly an inland species found in southern and central Norway. Coastal breeding sites in Norway are mainly found north of Lofoten /43/.

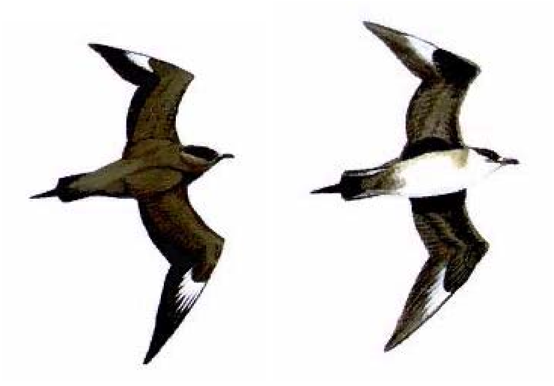
Pomarine skua (Stercorarius pomarinus)



MOB-vulnerability /81/: December – March: (-). April-November (2).

Data suggest that migrating pomarine skuas use the waters over the Faeroe – Shetland channel as a migration route (UKDMAP /16/), although a couple of sightings of migrating birds were made in a few places east of Shetland/77/.

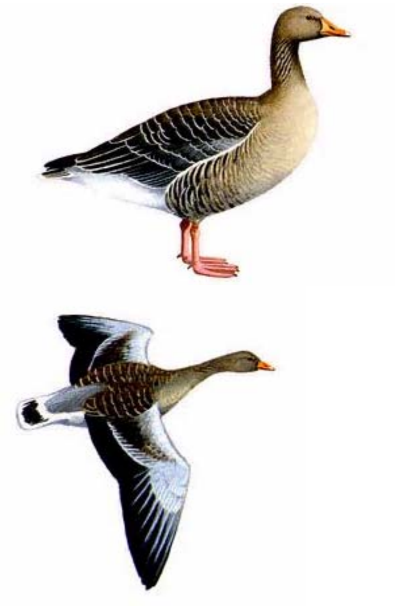
Arctic skua (Stercorarius parasiticus)



MOB-vulnerability /81/: December – March: (-). April (1), May – August (2), September - November (1).

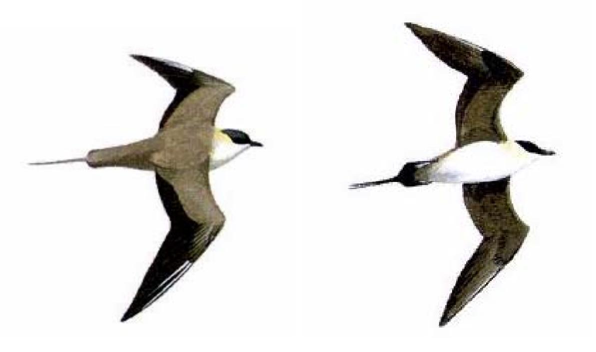
From March to May, Arctic skuas return from their southern wintering areas to their main UK breeding areas on Shetland and Orkney /77/.. In Norway, the species breeds along most of the coastline of the analysis area, returning from the wintering sites as late as April (southern Norway) and in May further north). The total breeding population of Arctic skuas in Norway is approximately 5,000-10,000 pairs, and it has declined since the 1970s /43/. Breeding pairs in Scotland have declined by 37% since 1985-88. There are currently 2,136 breeding pairs registered in Scotland (including Shetland). The main reason for the decline in Scottish areas is suspected to be competition from and predation by great skuas /57/.

Grey goose (Anser anser)



Grey goose breeding sites in the Norwegian section of the analysis area are widely distributed along the coast. The Norwegian population is increasing, and is currently estimated at 7,000-10,000 breeding pairs. /43/, /96/.). Moulting areas are mainly along the coast from Smøla to Helgeland /96/.

Long-tailed skua (Stercorarius longicaudus)



MOB-vulnerability /81/: November – March: (-), April – October (2).

The long-tailed skua breeds inland in southern Norway /43/. As Arctic breeders they migrate north and pass the open sea areas of the Atlantic Frontier (Faeroe – Shetland Channel) in May and June /77/.

Great skua (Stercorarius skua)

Peter LaTourrette, http://birdphotography.com/

MOB-vulnerability /81/: December – February: (-), March – May (1), June – August (2) September – November (1).

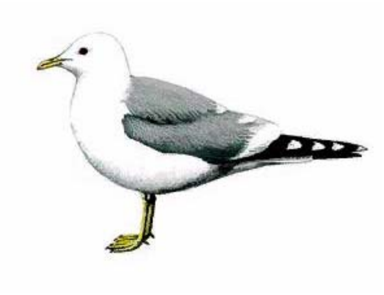
There are confirmed breeding sites for great skua in Norway at Sørøyane just north of Stadt, and ten years ago the number of breeding pairs was approximately 30-40 pairs /43/. Great skuas are widespread, but at low densities in all north-western Scottish waters, including Shetland and Orkney. They are often associated with fishing vessels /77/. Sixty per cent of the world's population of great skuas breed in Britain and Ireland. 9,634 breeding pairs are registered in Scotland. This includes birds breeding within the analysis area /57/. The largest great skua colony in the world is on Foula on Shetland. The maximum foraging range is 60 km from the colony. Non-breeding great skua may also be found over open sea areas in summer (June – July). The birds start departing in August /77/. A few adults may stay behind. Shetland-breeding birds migrate to south-western Europe /43/.

Black-headed gull *(Larus ridibundus)*

MOB-vulnerability /81/: September- March (1), April – August (2).

Breeding sites for black-headed gulls within the analysis area are localised from the Sognefjord and northwards /43/. It is a common bird in both Norway and the UK. In both Norway and the UK, many breed inland. The Norwegian population is expanding and was approximately 20,000-30,000 breeding pairs ten years ago /43/. The species has also expanded in Scotland to 43,191 breeding pairs /57/, but it has not been registered on Shetland /77/.

Common gull *(Larus canus)*



MOB-vulnerability /81/: September- April (1), May – August (2).

The common gull is migratory, and is it the most widely occurring gull in Norway. It is both a coastal and inland species. Gjershaug *et al*/43/ estimate the population to be at least 150,000 pairs. More than 25% of the world's common gulls breed in Norway. Of the UK population, 97% breed in Scotland (48,113 breeding pairs). 57% of UK common gulls breed inland. There has been a 65% increase in coastal common gulls since 1969-1970 and a 39% increase since 1985-88. The distribution of nesting sites is also changing for common gulls /57/. The species was registered in small numbers in all months in the study by Pollock *et al., /77/.*

Herring gull (Larus argentatus)

MOB-vulnerability /81/: September- March (1), April – August (2).

The herring gull is a migratory species. Its numbers are increasing strongly in Norway, as they are in the rest of Western Europe /96/. The breeding population (1994) was estimated at approximately 150,000-200,000 pairs /43/. There are 72,130 breeding pairs in Scotland. The species is able to utilise a number of breeding sites; 20,000 pairs were recorded nesting on rooftops in cities in Britain, which is more than twice the number counted 4-8 years earlier. In natural breeding sites, however, the population has declined in Britain by 50% since 1969-70 /57/. Sightings by Pollock *et al.* /77/. in the breeding and post-breeding season (May to September) were almost entirely coastal. From October to April there are favoured offshore areas to the east and north of Shetland, with some areas with densities of > 5.00 birds/km^2 there and east of Fair Isle.

Glaucous gull (Larus hyperboreus)

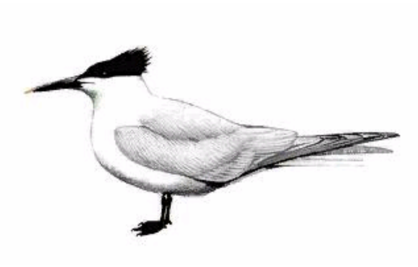
The glaucous gull is a migratory species which is a scarce but regular guest from eastern Greenland and Arctic Europe. Some recordings have been made south-east of the Fair Isle Channel (approx. 2 sightings per year between November and March) /77/. Not present in Norway.

Great black-backed gull *(Larus marinus)*

MOB-vulnerability /81/: September- March (1), April – August (2).

The great black-backed gull is a migratory species with an increasing population in Norway, following a reduction at the beginning of the 1980s /96/.. It is a Red List species for which Norway has responsibility /30/. Thirty-one per cent of the world's total breeding population breeds in Norway, breeding sites are distributed along the entire Norwegian coastline /43/. The breeding stock is 14,776 pairs in Scotland, the population is Britain as a whole is unchanged /57/. It is the least common of the *Larus*-species in north-western Scotland, including Shetland. The majority of British breeding sites are on Shetland, Orkney and the Western Isles. From January to April there are medium to high numbers of great black-backed gulls around Shetland, especially off the coast of north-eastern Shetland /77/.

Sandwich tern (Sterna sandvicensis)



The sandwich tern is listed in Annex I of the Birds Directive. There are no breeding sites for sandwich tern in the Norwegian section of the analysis area /43/. Breeding sites are located on Orkney; sightings of sandwich terns are therefore sometimes registered in inshore waters around the Shetland Islands, although the species does not breed on Shetland /77/.. There has been an 11% decrease in the population in the UK. The reasons for this are unclear. There are 1,068 breeding pairs in Scotland /57/.

Common tern (Sterna hirundo)

MOB-vulnerability /81/: October- March (-), April (1), May – August (2), September (1).

The common tern is a common breeding species along the entire Norwegian coastline. The Norwegian population has been estimated at between 10,000-20,000 pairs, but may be declining due to the loss of eggs and chicks to predators /43/. Common terns visit the British Isles, including several sites on Shetland, between May and August /77/.. In the UK, there seems to be a stable total population, but with a varying distribution. The common tern has a greater tendency than other terns to nest inland, but the number nesting inland has declined by 51% since 1988-91. 4,784 breeding pairs are registered in Scotland /57/.

Arctic tern (Sterna paradisaea)

MOB-vulnerability /81/: October- April (-), May – August (2), September (1).

The Arctic Tern is an Annex I species (Birds Directive). It breeds in colonies along the entire Norwegian coast from Rogaland to Finnmark, as well as inland, although predominantly in the outer coastal areas. The breeding population is estimated at some 40,000 pairs and appears to be declining in most areas /43/. In the UK, the main breeding stronghold is on Shetland which, together with Orkney has 80% of the UK breeding population /77/.. The Scottish population totals 47,306 breeding pairs, but there has been a 29% decrease due to the reduced availability of sandeel around Shetland /57/.

Little tern (Sterna albifrons)

Little terns are listed in Annex I of the Birds Directive. The species does not breed in Norway, although attempts have been made /43/. Small numbers have bred in Orkney in recent years /77/., but the UK population has suffered a 25% decrease due to the reduced availability of sandeel around Shetland, and the loss of chicks to predatory foxes and kestrels /57/. The Scottish population currently numbers 331 breeding pairs /57/.

Great shearwater *(Puffinus gravis)*

The great shearwater does not breed in the UK or Norway. Offshore sightings in UK waters are most frequent in August; most sightings were in the Faeroe – Shetland Channel, far west of Shetland. No sightings of great shearwaters were recorded near Shetland in the study by Pollock *et al.* /77/. or in UKDMAP /16/.

Sooty shearwater (Puffinus griseus)

MOB-vulnerability /81/: January – July (-) August – December (2)

Sooty shearwaters do not breed in Norway or the UK, but are widespread at low densities throughout the Atlantic Frontier, mainly in the Faeroes – Shetland Channel. Sightings have been recorded around northern Shetland between July and

October, with densities around 0.01-0.49 birds / km^2 /77/.. UKDMAP /16/ reports occasional sightings in the North Sea Basin, also closer to the Norwegian Coast in the autumn months, but at lower densities (0.01-0.09 birds/km^2).

European storm-petrel *(Hydrobates pelagicus)*

The European storm-petrel is listed in Annex I of the Birds Directive. 125,000 pairs breed in Britain and Ireland, 21,370 of which are breeding pairs in Scotland /57/. There are only a few confirmed breeding sites in Norway /43/. One possible breeding site is located on Runde; approximately 4,000 individuals have been registered here. Registrations in UKDMAP and in Pollock *et al/*77/..) suggest that the main areas are in the waters west of the British Isles. A few sightings have been recorded in the North Sea within the analysis area during summer. Densities here are lower than west of Ireland (0.01-0.49 birds/ km^2) (UKDMAP, /16/).

Leach's storm-petrel (Oceanodroma leucorhoa)

There are some 48,000 breeding pairs of Leach's storm-petrel in Scotland, 94% of which breed on four small islands in the St. Kilda archipelago (80 km west of the Outer Hebrides). The UK population constitutes less than 1% of the world population, but the species is listed in Annex I of the Birds Directive, due to its relative rarity. They are predated on by great skuas /57/. Leach's storm-petrel has only once been confirmed as having bred in Norway, on Røst, where individuals are occasionally caught /43/.

E.5.5.7 Summary of Bird Sensitivities

From the description above some species can be seen to be particularly sensitive. A listing of these species is provided in Table E-2. The selection is based on the following criteria:

- All-year vulnerability = 3
- Vulnerability = 3 in the periods when they are present
- Vulnerability is lower, but the species is a Red List species for which Norway is responsible, or is listed on the breeding birds Red-list with declining colonies in the area.
- Vulnerability is lower, but their largest breeding colony lies within the influence area.

Table E-2: Summary of focus species of seabirds within the analysis area

Focus species	***Lists***	***Vulnerability comments and status***	*J*	*F*	*M*	*A*	*M*	*J*	*J*	*A*	*S*	*O*	*N*	*D*
Common guillemot *Uria aalge* (Norw. Lomvi)	Breeding Red List (Norway)	Congregate at open sea. Declining.	3	3	3	3	3	3	3	3	3	3	3	3
Razorbill *Alca torda* (Norw. Alke)		Congregate at open sea.	3	3	3	3	3	3	3	3	3	3	3	3
Atlantic puffin *Fratercula arctica* (Norw. Lunde)	Breeding Red list (Norway) Norwegian. responsibility species.	21-33% of WBP in Norway. 12% WBP in Britain. Congregate at open sea.	3	3	3	3	3	3	3	3	3	3	3	3
Fulmar *Fulmarus glacialis* (Norw. Havhest)		Largest colony in influence area (Runde) High numbers in open sea.	2	2	2	2	2	2	2	2	2	2	2	2
Gannet *Morus bassanus* (Norw. Havsule)		68% of WPB population in Britain. Only confirmed Norwegian breeding site in influence area (Runde).	2	2	2	2	2	2	2	2	2	2	2	2
Kittiwake *Rissa tridactyla* (Norw. Krykkje)	Breeding Red List (Norway). Norw. responsibility species.	40% of WPB population in Norway. Decl. in southern col. breeding site mainly North of Runde. Declining.	2	2	2	2	2	2	2	2	2	2	2	2
Lesser black-backed gull *Larus fuscus* (Norw. Sildemåke)	Breeding Red list (Norway)	Declining.	-	-	1	1	2	2	2	2	1	1	1	-
Red-throated diver *Gavia stellata* (Norw. Smålom)	Breeding Red list (Norway) Norwegian responsibility species. Annex I (BD)	Many breeding colonies south of the Sognefjord, and north of Stadt.	3	3	3	3	3	3	3	3	3	3	3	3
Great northern diver *Gavia immer* (Norw. Islom)	Red List responsibility species in Norway Annex I (BD)	25% of the TWP winters in Norway /30/	3	3	3	3	3	3	3	3	3	3	3	3
Black-throated diver *Gavia arctica* (Norw. Storlom)	Breeding birds Red List (Norway) Annex I-(BD).		3	3	3	3	3	3	-	-	3	3	3	3
Great cormorant *Phalacrocorax carbo* (Norw. Storskarv)	Red List responsibility species (Norway)	30% TWP wintering in Norway.	3	3	3	3	3	3	3	3	3	3	3	3
European shag *Phalacrocorax aristotelis* (Norw. Toppskarv)	Red List responsibility species (Norway)	25% TWP wintering in Norway (Møre). Declining. Largest breeding colony on Runde.	3	3	3	3	3	3	3	3	3	3	3	3
Long-tailed duck *Clangula hyemalis* (Norw. Havelle)		Esp. vulnerable to oil spills (aggr. at coast (wintering)).	3	3	3	3	3	3	3	3	3	3	3	3
Black (Common) scoter *Melanitta nigra* (Norw. Svartand)	Norwegian breeding birds Red List UK Red List	Esp. vulnerable to oil spills (aggr. at coast (wintering))	3	3	3	3	3	-	-	-	3	3	3	3
Velvet scoter *Melanitta fusca* (Norw. Sjøorre)	Norwegian breeding birds Red List	Esp. vulnerable to oil spills (aggr. at coast (wintering), even more than common scoter) Esp. Rogaland/ Trøndelag Some coastal breeding sites in Sogn og Fjordane.	3	3	3	3	3	3	-	-	3	3	3	3
Black guillemot *Cephus grylle* (Norw. Teist)		Most important breeding sites are the outer coastal areas and islands from Møre og Romsdal. Declining, uncertain pop. no.	3	3	3	3	3	3	3	3	3	3	3	3
Common eider *Somateria Mollisima* (Norw. Ærfugl)			3	3	3	3	3	3	3	3	3	3	3	3

WBP: World's breeding population
TWB Total world population
BD: Birds Directive

E.5.6 Marine mammals

E.5.6.1 General Vulnerability

As with seabirds, the vulnerability of marine mammals varies with the seasonal variations in spatial and temporal distribution. Otters and seals that rely on fur for insulation are vulnerable in breeding and moulting areas. Species that may be present at the sea surface are susceptible to inhalation toxicity. Some of the more toxic components, BETXs and n-hexane, are relatively volatile, and may cause inhalation toxicity and ocular irritation effects. The volatile hydrocarbons also have a general narcotic effect on the brain. Fresh oil is therefore generally regarded as the most toxic.

Some species (e.g. grey seals) are sensitive to toxic effects of orally ingested oil. Although they do not groom their fur, they may ingest oil through contaminated food. Seal pups are more susceptible to loss of insulating properties of their fur than adult seals.

Otters may ingest oil when they groom their fur after oil contamination. Factors that lower mammalian susceptibility to the soiling effects of oil are: reliance on other means of thermoregulation than fur (such as blubber), utilisation of larger areas (a lower probability of oil exposure on the sea surface), a large body volume, or skin that does not adsorb or absorb oil as easily. This reduces the vulnerability of e.g. cetaceans (whales and porpoises).

Estimates that have been made indicate that whales would have to ingest large amounts of oil in order to induce toxicity /22/. Cetaceans are therefore not a focus group for the ERA, although a brief account of their distribution is given. The MOB-vulnerability value for marine mammals is also stated, indicating the seasonal changes in vulnerability /81/.

The highest damage potential to seals in Norway occurs when they aggregate in large colonies for pupping, breeding and moulting, as well as in haul-out sites. These sites may therefore be identified as APES/62/. Otters *(Lutra lutra)* are widely spread out, and an oil spill is unlikely to expose a high number of otters on the Norwegian side of the North Sea.

On Shetland, the presence of grey seals, harbour seals or otters may be more dense, and a high proportion of the UK population/ annual pup production may form the basis for classifying a site as an SAC in the UK.

The estimated numbers of seals, harbour porpoises, dolphins and minke whales in the North Sea that are quoted in the following sections for each marine mammal are taken from OSPAR/76/. and Reid *et al./*78*/*, with the exception of the estimated population of grey seals and harbour seals in Norway for which more recent data is available /68/. Note that estimated numbers from different literature sources may be produced by different methods. Generally, marine mammals are considered to be on the decline, and may be on national Red Lists and Annex II of the Habitat Directive.

E.5.6.2 Pinnipeds

Grey seal (Halichoerus grypus)

MOB Vulnerability /81/:

Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
0	1	1	0	0	0	0	0	3	3	3	3

Grey seals are present in colonies of varying sizes along the Norwegian coast from Rogaland to Finnmark. Within the analysis area, Froan is an important site, with 303 pups born in the period from 2001-2003 /68/. Recent estimates put the Norwegian population of grey seal at approximately 7,000 (K.T. Nilssen, HI, *pers. comm.*). OSPAR /76/ estimates the numbers in Norway to be 2,100, and the UK North Sea population at 58,300 individuals (See Figure E-17). The recent estimate by Nilssen is considered to be the most accurate figure for Norway.

The grey seal is listed in Annex II of the Habitats Directive (no. 1364), and it is one of the species for which the UK has a special responsibility. The UK population of grey seals represents 40% of the world's population, with approximately 124,000 grey seals at the beginning of the 2000 breeding season /77/; JNCC/139/.

Both the Norwegian and the UK grey seals belong to the East Atlantic stock. There are pupping sites around the coast of Shetland and the Orkney Islands, which may lead to a site being designated a Special Area of Conservation (SACs) /52/. The SAC site "Faray and Holm of Faray" on the Orkney Islands supports a well established grey seal breeding colony. The Orkney Islands support the second-largest breeding colony in the UK, contributing around 9% of annual UK pup production. Before the *Braer* incident, the seal colonies on Lady's Holm on Shetland represented approximately 1% of the British grey seals /44/. These are counted among the Scottish population, which in the year 2000 consisted of some 114,200 individuals. Since hunting was stopped in the late 1970s, the population of grey seals in the UK has increased /52/.

Grey seals can migrate over large distances, but will stay close to the coast throughout their life cycle. They form colonies for breeding from September to December, and in the moulting season from February to March. During the rest of the year, grey seals will be more spread out along the coast for foraging, being less attached to permanent locations outside the breeding seasons than, for instance, the harbour seal.

Harbour (Common) seal *(Phoca vitulina)*

MOB-vulnerability /81/

Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
0	0	0	0	0	3	3	1	0	0	0	0

Harbour seals are present in colonies along the Norwegian coastline (Figure E-17). The species is relatively closely tied to permanent coastal colonies all the year round, using only a few haul-out sites. Their most vulnerable period is the pupping period in June and July and the moulting season in August. Harbour seals will rest on land at regular intervals. The total Norwegian population of harbour seals has recently been estimated at 6,800 animals (/40/;/74/). OSPAR/76/ estimates that there are some 3,400 individuals on the west coast of Norway, the North Sea coast of Norway and in the Oslofjord. The corresponding population figures for the UK are: 14,100 individuals in Orkney and Shetland, and 1,700 in eastern Scotland /76/.

The harbour seal is on the Norwegian National Red List/30/. The harbour seal is listed in Annex II of the Habitats Directive /52/, (No. 1365) but the selection of sites for this wide-ranging species, has also presented certain difficulties /142/. The SCA Site, Sanday, on the Orkney Islands supports the largest group of *Phoca vitulina* at any discrete site in Scotland. The breeding groups, which are found on intertidal haul-out sites unevenly distributed around the Sanday coast, represent over 4% of the UK population. Near-shore kelp beds that surround Sanday are important foraging areas for the seals, and the colony is linked to a very large surrounding population in the Orkney archipelago. There are several breeding sites for common seals and sightings on Shetland. In the study carried out by /77/., harbour seals were recorded in all months except November, peaking from June to August.

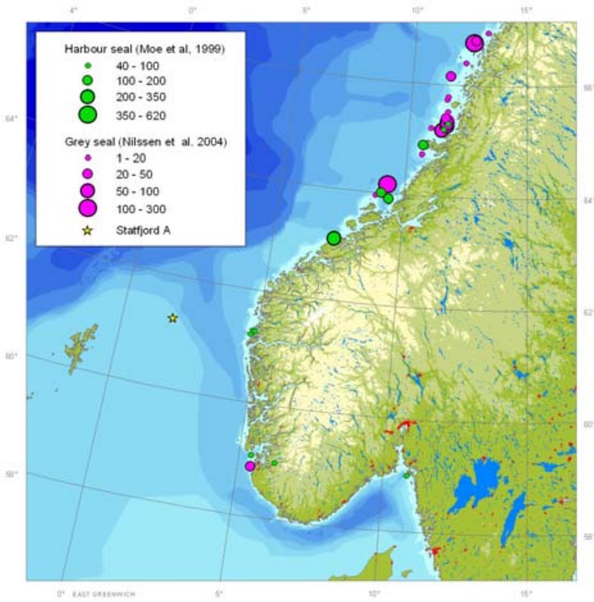


Figure E-17: Localisation and estimates of populations of important areas for grey seals and harbour seals

Source: /68/ and /61/

E.5.6.3 Otter (Lutra lutra)

MOB-vulnerability /81/

Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
3	3	3	3	3	3	3	3	3	3	3	3

The otter has been protected since 1982 because the numbers were declining in large parts of their habitats. Internationally, otter is also a Red List species (threatened), and is protected by many conventions. The otter is one of the species where 25% of the European population is assumed to be present in Norway, and it is therefore on the National Red List /30/, the list of species whose status should be monitored, and it is a species for which Norway has a special responsibility /30/. The Norwegian otter population seems to be increasing. In 1990, the number was estimated to be 9,000-11,000 individuals, and the corresponding figure for 1995 is 17,000-21,000 individuals. Bjørn /15/ estimated that if the same rate of increase continued after 1995, the numbers may have been approximately 30,000 individuals in 2000. The populations in Mid- and North Norway seem to be especially strong. From South Trøndelag and northwards, the distribution seems to be continuous.

The otter is an Annex II species (no. 1355) of the Habitats Directive /52/, although the selection of sites as SACs has been subject to discussion. The presence of otters in SACs on Shetland can be seen in Table E-5. The Yell Sound coastal population of *Lutra lutra* is estimated to be more than 2% of the entire UK otter population, and the stock here is believed to be genetically distinct from the mainland population/127/.

E.5.6.4 Cetaceans

Minke whale (Balaenoptera acutorostrata)

OSPAR /76/ estimate the North Sea population of minke whales at 7,200 – 20,000 individuals. Sightings data from MRDB /64/ and UKDMAP /16/ are shown in Figure E-18. There are occasional sightings off the coast of north-western Shetland /78/. (data not in MRDB)). Most sightings of minke whale occur between May and September. From July to September individuals may form groups to feed, particularly near shore /78/.

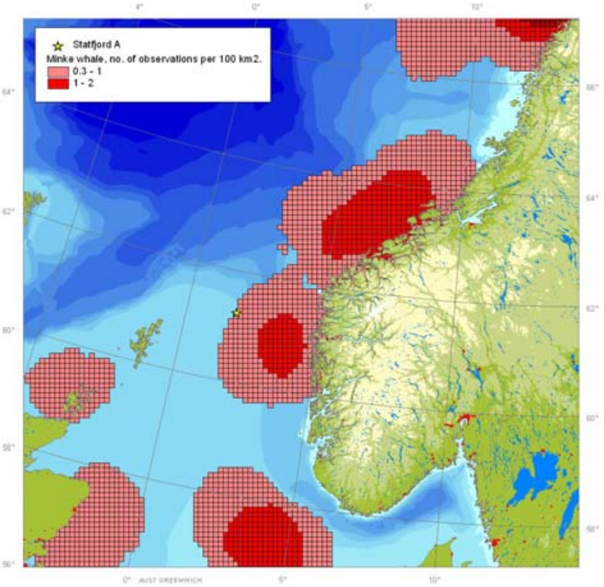


Figure E-18: Minke whale sightings

Source MRDB /64/

Killer whales (Orcinus orca)

Killer whales seem to be the most vulnerable cetacean species in Norwegian waters, since they aggregate in larger flocks /96/. In UKDMAP, killer whales have mainly been recorded in the waters between Shetland and the Faeroe Islands. Killer whales have been observed in the waters surrounding Statfjord. In UK waters, killer whales occur in all months of the year /78/.. In the analysis area between Shetland and Norway, observations have been made regularly between November and March. Killer whales concentrate along the continental slope north of Shetland during May and June. The animals will follow their prey, e.g. come closer to land when seals haul out to breed (June – October) and during the herring season in Møre (February – March) /78/.. The distribution of sightings is presented in Figure E-19.

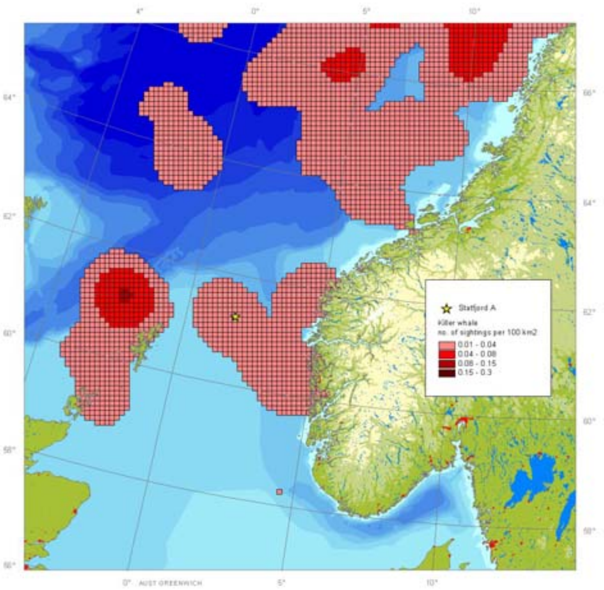


Figure E-19: Killer whale sightings

Source MRDB /64/

White-sided dolphin (Lagenorhynchus acutus)

Data from UKDMAP shows sightings of white-sided dolphins at the northern and western boundaries of the analysis area (most frequent from June to August off the western coast of Shetland) (Figure E-20). These data have later been updated, but are not digitally available /78/. Little is known about the seasonal movements and the population size of this species, as the species may be confused with the white beaked dolphin /78/. OSPAR estimates the North Sea population at some 10,900 individuals /76/. The white-sided dolphin is on the Norwegian National Red List /30/.

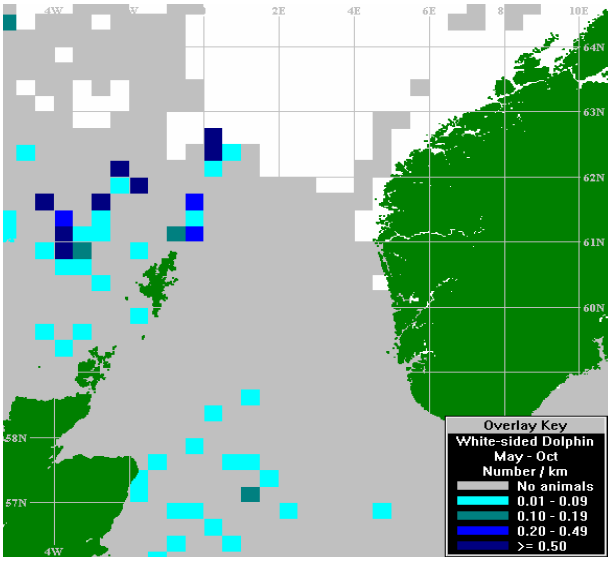


Figure E-20: Sightings of white-sided dolphin.

Source: UKDMAP /16/

Harbour porpoise/Common porpoise *(Phocoena phocoena)*

This species occurs in the whole North Sea, and it is one of the most common cetaceans, also in the analysis area. OSPAR, /76/ estimates the total North Sea population at a total of 268,300 individuals, and the species is listed on the OSPAR list of threatened and/or declining species and habitats /75/. The number is reported to be 82,000 for the northern North Sea and southern Norwegian Sea /78/. The harbour porpoise is an Annex II species (no. 1351) of the Habitats Directive /52/, but site selection in the UK of this wide ranging species is still being considered by the UK conservation agencies, as the species is widely distributed throughout Northern Europe, making it difficult to select a certain site as specially important for the maintenance of a favourable conservation status for harbour porpoise. This species is reported to be declining /78/. It is on the Norwegian National Red List as a species for which Norway has a special responsibility /30/. The distribution of sightings shows that harbour porpoise utilise the analysis and influence area (Figure E-21).

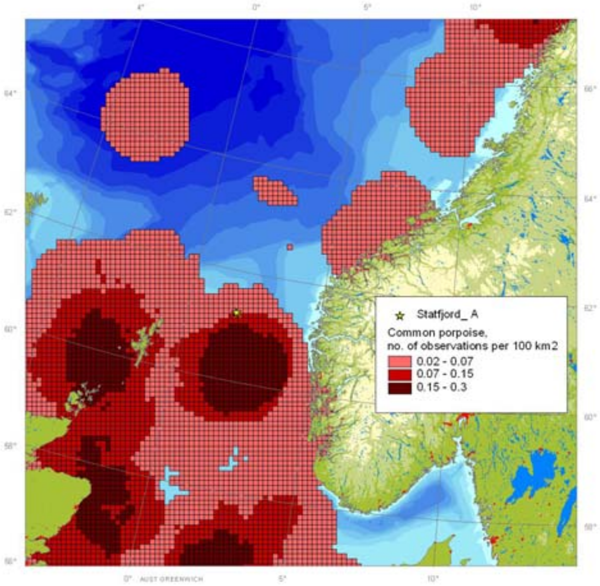


Figure E-21: Harbour/Common porpoise sightings in the North Sea

Soruce; MRDB /64/

White-beaked dolphin (Lagenorhynchus albirostris)

Sightings are most frequent in July and August, around Shetland, the Orkney Islands and the coast of eastern Scotland. The main areas for the species are south of the analysis area (population size for the North Sea and Fair Isle Channel 7,800) /78/; MRDB, 2004; UKDMAP /16/). Figure E-22 shows sightings of white-beaked dolphins from UKDMAP/16/.

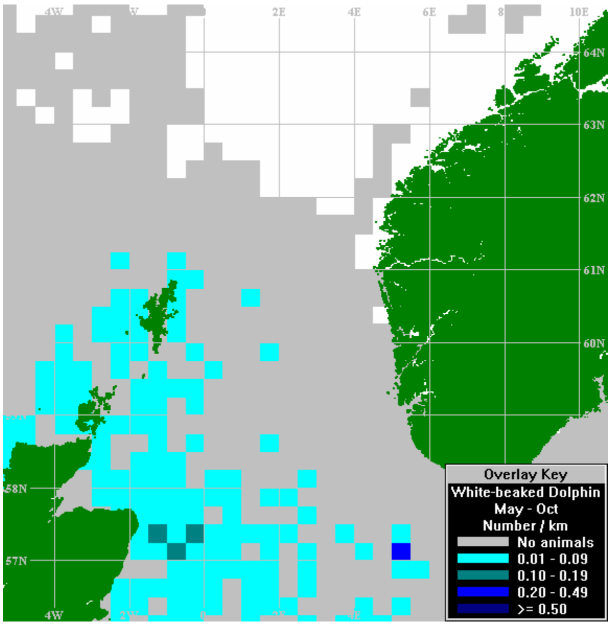


Figure E-22: Sightings of white-beaked dolphin

Source: UKDMAP /16/

<u>Other cetaceans</u>

Of other species of cetaceans than those discussed in detail, UKDMAP /16/ and Reid *et al.* /78/ report some sightings of the following species in the analysis area:

Pilot whale *(Globicephala melas)* (although mainly observed between Shetland and the Faeroe Islands, some sightings have been recorded near Statfjord (/16/; /78/).

The following species have not been sighted in the analysis area, or are very infrequent (UKDMAP /16/ and /78/):

- Rissos dolphin *(Grampus griseus)*. A few sightings have been made around the west and north coast of Shetland, but most sightings are from western Scotland.
- Short beaked common dolphin *(Delphinus delphis)*
- Common bottlenose dolphin *(Tursiops truncates)*. (Habitat Directive no. 1349). This specie is the primary reason for the choice of the Moray Firth (Scotland) as an SAC, where the only resident population is present (130 individuals) /127/.
- Humpback whale *(Megaptera novaeangliae)*. This is a very rare species, 54 humpbacks were sighted between 1990 and 1999. Most sightings have been made between May and September /78/. It is listed on the Norwegian National Red List /30/.
- Northern bottlenose whale *(Hyperoodon ampullatus)*

<u>Conflict potential for cetaceans</u>
As indicated by the figures, an oil spill may affect areas frequented by cetaceans. Cetaceans seem to exhibit different behaviour when it comes to avoiding oil spills. Their individual vulnerabilities are considered to be low, and these species are therefore not considered to be at risk. Consequently, cetaceans are not a focus species in the present report; although the influence area is part of the area used by cetaceans such as the Red-List species harbour porpoise.

The general vulnerability of cetaceans to oil spills is low all year round.

Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1	1	1	1	1	1	1	1	1	1	1	1

E.5.6.5 Summary of Marine Mammals Sensitivities

A summary of the vulnerability of marine mammals with respect to oil spills is given in Table E-3.

Table E-3: Summary of focus species of marine mammals within the analysis area*

Focus species	***Lists***	***Vulnerability comments and status***	*J*	*F*	*M*	*A*	*M*	*J*	*J*	*A*	*S*	*O*	*N*	*D*
Grey seal *Halichoerus grypus* (Norw. Havert)	Annex II Habitat Dir.	Colonies, local aggregation in breeding and moulting periods lead to high population vulnerability	0	1	1	0	0	0	0	0	3	3	3	3
Harbour seal *Phoca vitulina* (Norw. Steinkobbe)	Annex II Habitat Dir. Norwegian Red List	Colonies, local aggregation in breeding and moulting periods lead to high population vulnerability	0	0	0	0	0	3	3	1	0	0	0	0
Otter *Lutra lutra* (Norw. oter)	Annex II Habitat Dir. Norw. responsibility species. Red-List	High ind. vulnerability, but are "evenly" widespread.	3	3	3	3	3	3	3	3	3	3	3	3

*The table also shows monthly vulnerability and comments

E.5.7 Shoreline

The Norwegian coastline has recently been modelled with respect to sensitivity to oil spills /21/, based on the DamαShore model. This model forms an integrated concept for semi-quantitative analysis of the damage potential in cases of acute oil spills on shorelines, which combines extensive mappings of substrate types, wave exposure and the biological resources expected to be present with a biological exposure scale/21/, and applies a model of the damage size and potential restitution time of the shoreline type. The result is a distribution of the principal sensitivity index (Pi) along the coast Figure E-23 shows the sensitivity index of the central part of the analysis area. A new data set have been generated for use in risk calculations, consisting of coastal segments with high sensitivity values (Pi > 0.5); see Figure E-23.

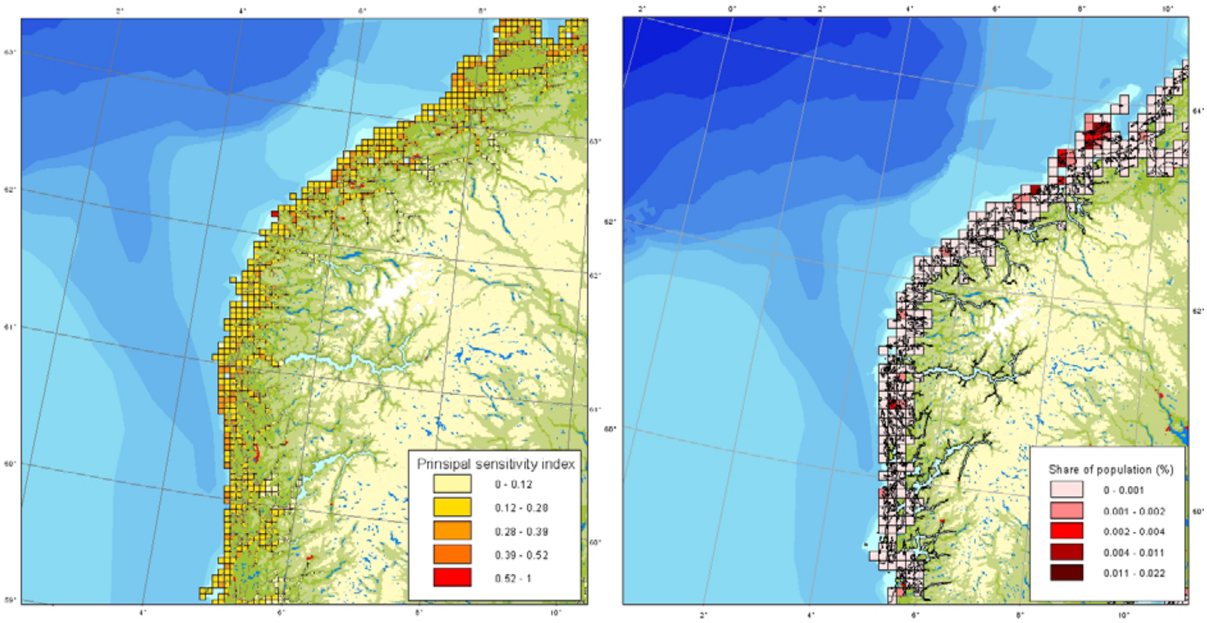


Figure E-23: Sensitivity index (Pi)*

*For littoral communities to oil pollution (left) and distribution of the most sensitive of these communities (Pi > 0.5) on 10x10 km grid cells right (//21/;/6/).

The most dominant substrate types in the analysis area are the shore meadows, which are a sheltered shoreline type of high vulnerability (MOB-vulnerability 2) /81/ Seaweed banks are also vulnerable, and are fairly abundant in the areas covered by the data sets and for which shoreline type is specified. These two shoreline types are not specified for Sogn og Fjordane, the central part of the analysis and influence area Figure E-24a-d shows recordings of various shoreline types/64/. Note that the data sets from different counties may be recorded differently, e.g. the “unspecified botanical areas” of Sogn og Fjordane.

The most sensitive and unique (national or international conservation value) of these habitats have been selected as VECs (Valued Ecosystem Components) Figure E-25).

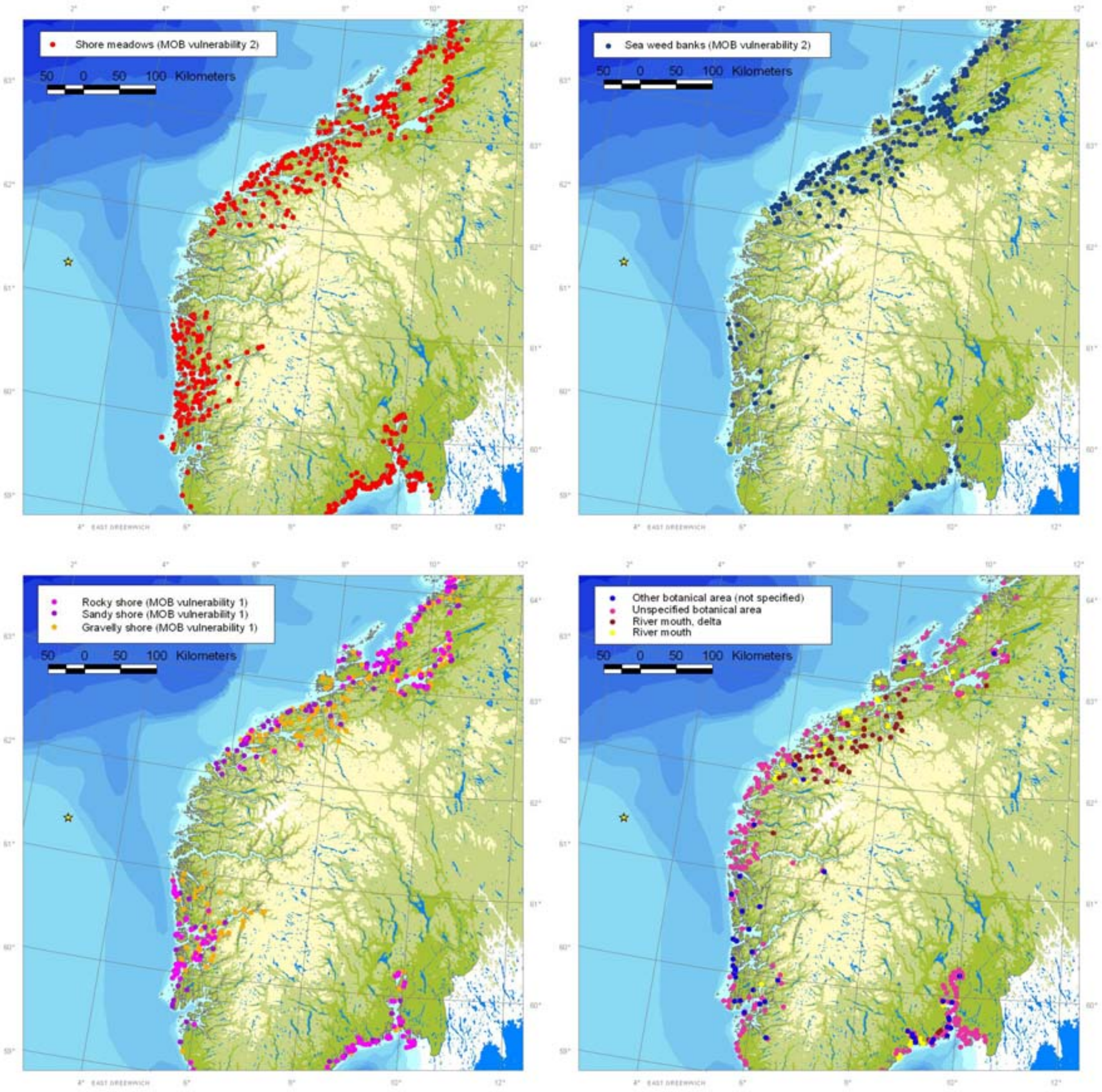


Figure E-24: Distribution of recorded shoreline types in the analysis area

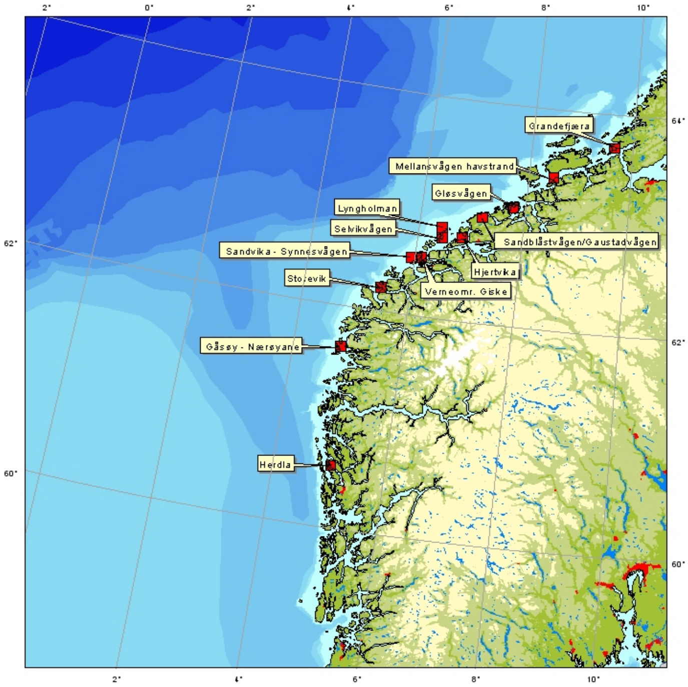


Figure E-25: Selected VEC (Valued Ecosystem Component) habitats

Shoreline substrate maps for the UK are available in UKDMAP /16/. Figure E-26a shows that the most abundant shoreline type on Shetland is cliffs. There are many salt marshes as well. Vulnerable areas with important shoreline habitats may also fulfil the criteria for Special Areas of Conservation (SAC), and these two concepts should be viewed in context. A map of sites that are considered sensitive to oil pollution is shown in Figure E-26b /16/.

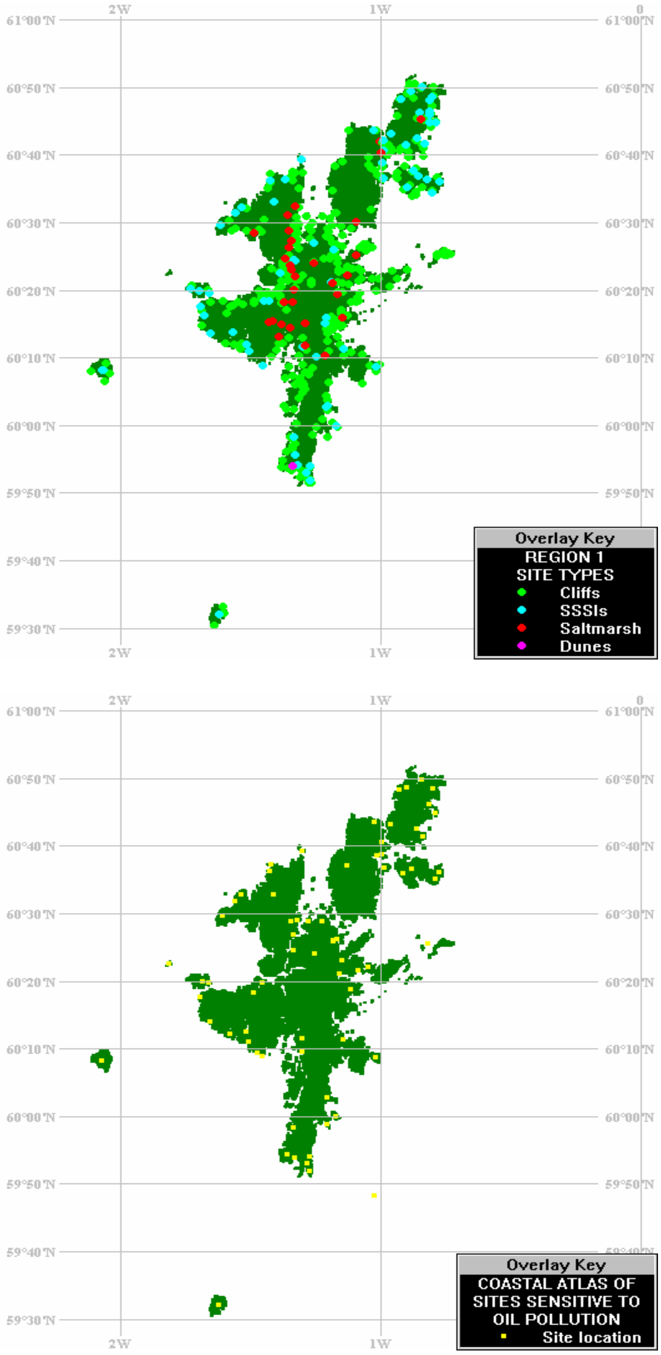


Figure E-26: Shoreline types and coastal sites on Shetland and Fair Isle*

*Top: Shorelines types on Shetland and Fair Isle
Bottom: Coastal sites on Shetland and Fair Isle considered sensitive to oil pollution
Source: UKDMAP /16/

E.5.8 Corals

Coral reefs in Norwegian waters are formed by the cold water coral *Lophelia pertusa*, and are generally found at depths between 200 and 500 metres. *Madrepora oculata* is another coral species frequently found with *Lophelia*, but this species does not form reefs like *Lophelia*. Biodiversity is generally high on coral reefs, and they form suitable habitats for many species. Coral reefs are therefore also important areas for fisheries.

In the UK, there are areas with coral reefs formed by *Lophelia* north and north-west of Scotland, on Rockall and the surrounding banks /39/. In Norwegian waters they are in greatest abundance in the Norwegian Sea along the Norwegian Trench and northern Norway. Until recently, the Sula Reef in the analysis area of the present report was considered to be the largest coral reef in Norway, but as late as in 2002, the Institute for Marine Research carried out a survey of what is probably the largest *Lophelia*-type coral reef ever recorded, located off Røst (the Røst Reef). There are also registrations in well investigated areas such as the areas around Bergen /19/. The Røst Reef and the Sula Reef have been proposed as a Marine Protected Area under the Marine Protection Plan for Norway, the latter as a general reference area for extended research and long-term monitoring /28/.

The presence of corals may cause an area to be designated a vulnerable marine area. *Lophelia pertusa* reefs are listed (as a habitat) on the OSPAR list of Threatened and/or Declining Species and Habitats /75/. The status of Norwegian coral reefs was reviewed in a report by the Institute of Marine Research /39/. Many occurrences of corals have been damaged. The Norwegian populations of *Lophelia* are of great scientific interest, and are unique in the European context/19/.

E.5.8.1 Conflict Potential of Lophelia-reefs in the Area

As a deep sea coral, *Lophelia* is generally not considered to be as vulnerable to acute oil spills as corals in shallow waters (such as tropical corals) /69/, unless the oil type and weather conditions lead to large amounts of oil being mixed down to the seabed at depths that are relevant for *Lophelia*. Upon exposure of *Lophelia* to the water-soluble fraction of Statfjord oil, (WSF) (28 ppb), the Institute for Marine Research detected that the behaviour of the corals changed with the respect to the number of outstretched polyps. Following 24 hours of exposure to uncontaminated water, the differences between the control group and exposed group were no longer significant/23/.

Figure E-27: Occurrences of corals in Norway

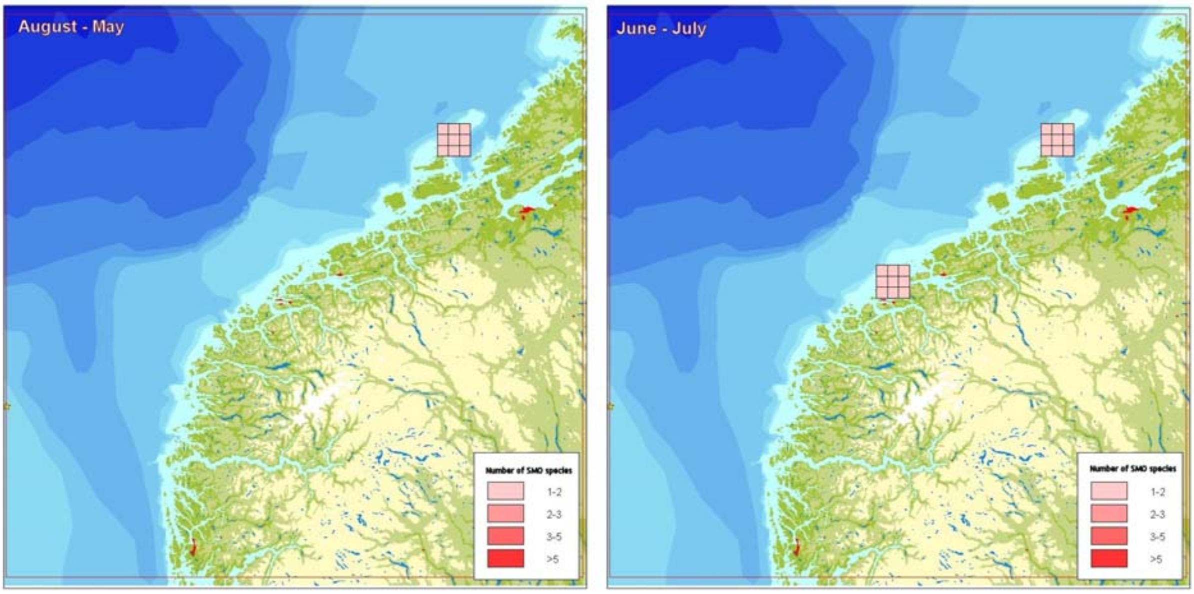
E.5.9 Areas with Special Environmental Status in Norway

E.5.9.1 Areas of Particular Environmental Sensitivity (APES) (Norway)

The Directorate for Nature Management (Norway) and the Norwegian Pollution Control Authority has performed an analysis to identify areas of particular environmental sensitivity (APES) in Norwegian coastal and oceanic areas/61/. The results of this analysis identify APES according to regional, national and international criteria for a number of species and species groups. An APES is defined as a geographically distinct area which supports one or more especially important occurrences of natural resources which are vulnerable to a specific environmental hazard – in this context oil pollution – and which at best will need a long time to be restored to a natural level after a significant impact. “Significant impact” means that parts of the population may be lost. The criteria for identification of the various APES are given as follows:

- 5% reduction of an international population (qualifies for an international APES)
- 10% reduction of a national population (qualifies for a national APES)
- 20% reduction of a regional population (qualifies for a regional APES).

The criteria have been applied to selected natural resources in Norwegian waters within the resource groups shoreline, fish, seabirds and marine mammals. There are national APES for marine mammals (grey seals and harbour seals) (Figure E-28a-b) and seabirds (Figure E-29a-d) within the influence area. During an update of the regional EIA for the Norwegian Sea, an area outside Møre has been found to qualify as a national APES for herring (Figure E-30).



Areas in the region that supports grey seals qualify for APES all year round, whereas areas supporting common (harbours) seals qualify in June and July.

Figure E-28: National APES for marine mammals for August – May, and June-July

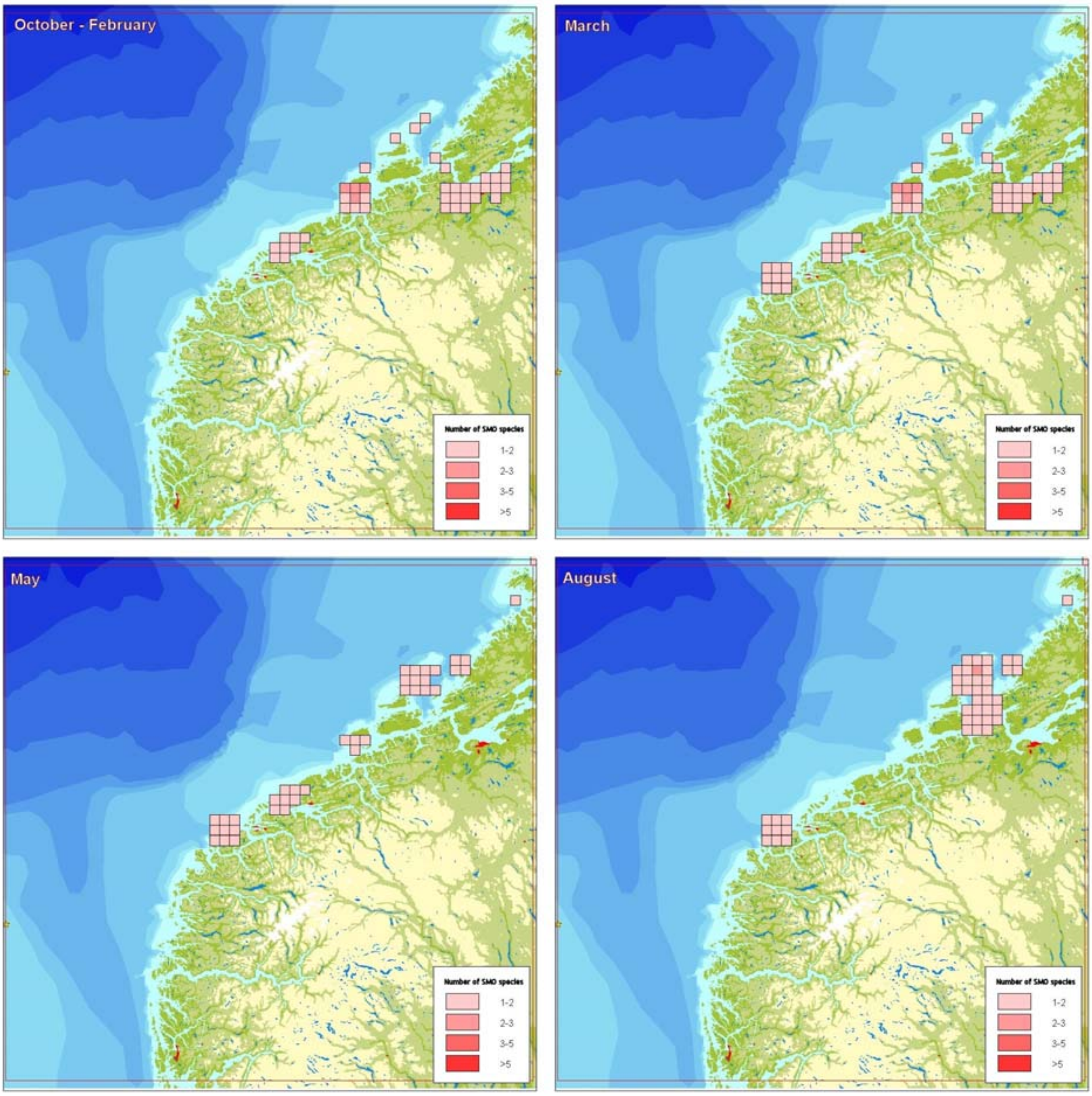


Figure E-29: National APES for seabirds for highlighted periods

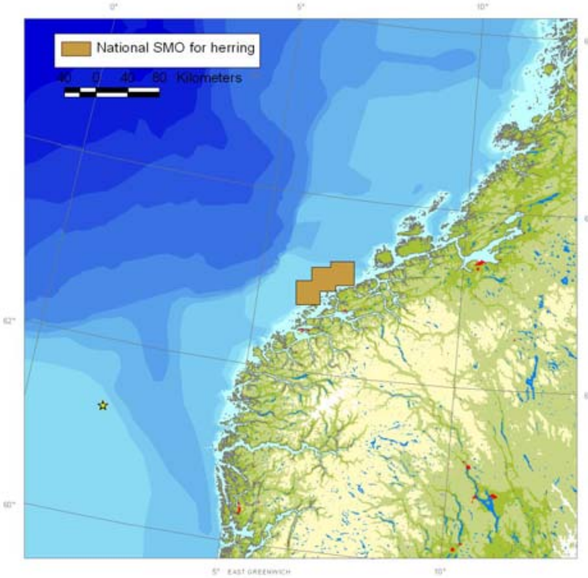


Figure E-30: National APES for fish (herring).

E.5.9.2 MOB Areas (Norway)

MOB areas are areas that fulfil the criteria for environmentally prioritised areas according to the MOB model /81/. Data sets for areas along the Norwegian coast that are prioritised for protection and clean-up in accordance with the criterion of the MOB-model are provided in MRDB /64/. The model takes into consideration the conservation value of the resource that is supported by the area, its vulnerability, naturalness of the species/resource, and whether economic compensation is possible.

1. Whether the species is a natural part of the ecosystem or introduced (1 (introduced) – 2 (natural))
2. Vulnerability (0 (insignificant vulnerability) – 3 (high vulnerability))
3. Conservational value (0 (insignificant value) – 1 (local value) – 2 (regional value) - 3 (national/international value))
4. Whether loss of the resource can be compensated economically (1 (can be compensated) -2
5. (can not be compensated))

Each of these attributes of a given resource is assigned a factor value (see scale above). All factor values for all characteristics are multiplied. The resulting number indicates priority on a scale from A (36) – B (24) C (12) – D (8) – E (2), where MOB A reflects highest priority status. The MOB-status of an area might vary with seasonal changes in the presence of resources.

Figures Figure E-31 a-b show the seasonal status of areas within the Norwegian coastal analysis area to which a MOB status has been assigned. Comparison with the information given in the sections E.5.5 on seabirds and E.5.6.2 on pinnipeds shows that areas with high concentrations of breeding, moulting, wintering/haul-out sites etc. for the most vulnerable birds and seals and international conservation value will be given a high priority for protection. MOB-areas are used in contingency planning, and for prioritising sites for protection/clean-up in cases of oil spills, in which case localities with MOB-status A and B will be given priority /81/. In order to provide detail, a close-up of sites within the analysis area is shown.

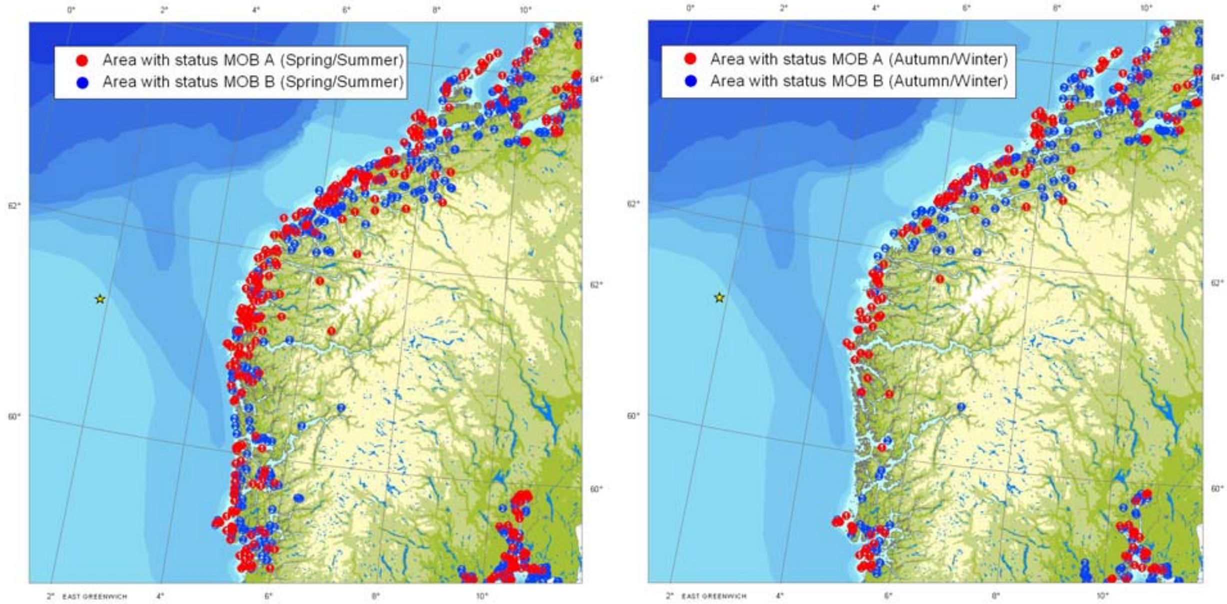


Figure E-31: Seasonal changes in the status of areas that have been assigned MOB-values A or B

E.5.9.3 Marine Protected Areas in Norway

Efforts to establish Marine Protected Areas in Norway have been going on since 1987. In 1995, Brattegard & Holthe /18/ published a report on the mapping of possible Marine Protected Areas in Norway, which suggested criteria for the selection of candidate areas. The mapping of possible marine protected areas is based on knowledge about the distribution of benthic habitats and their organisms. An Advisory Committee for Marine Protected Areas in Norway has proposed 36 areas in Norway as candidate Marine Protected Areas /29/;/28/. These areas have been selected on the basis of certain criteria outlined in a report on mapping of possible marine protected areas in Norway (representativeness of the sub-region in which the site is located and its uniqueness/19/.; /29/). In these areas, research is needed to ascertain the background situation of the habitats and species in the area. This research will play an important role in mapping biological diversity. More information can be found at the web site of The Directorate for Nature Management (DN) /140/.

These sites are considered to constitute a representative and balanced selection of sub-surface marine areas. The current list is based on currently available data, and the committee has therefore also suggested further work. Phase 2 of the work on Marine Protected Areas will be to consider the total need for protection of marine nature in Norwegian Sea areas, also including offshore areas. This will be based on updated knowledge and national and relevant international objectives. The choice of marine reference areas in other contexts than the Marine Conservation Plan is also currently in progress, e.g. Norwegian follow-up of international obligations.
The areas are separated into the following six categories:

1. Polls (landlocked fjords) (5 areas)
2. High current areas (5 areas)
3. Shallow water areas (5 areas)
4. Fjords (8 areas)
5. Open coastal areas (6 areas)
6. Transects-coast-shelf and offshore areas (7 areas)

The different areas proposed by the Advisory Committee as Marine Protected Areas /28/. may have varying degrees of suggested restrictions with respect to human activities and exploitation; some may be suggested as *reference areas* for *extended research and long-term monitoring*, *seaweed harvest-free areas,* they may be *areas of scientific interest because of ongoing research,* etc.

(SeeTable E-4) Decisions on a national network of Marine Protected Areas are planned in 2007. The Marine Protection Plan will be co-ordinated with the national programme for monitoring biodiversity and national implementation of the EU Water Framework Directive (2000/60/EC)/121/.

Of the 36 areas listed in List A of the Advisory Committee report /28/ the following lie within the analysis area. (Note that there might also be areas on list B (Alternative sites).) The areas vary in size from 5 to 3,450 km^2, and they cover a total area of almost 16,000 km^2. See Figure E-32 and Table E-4.

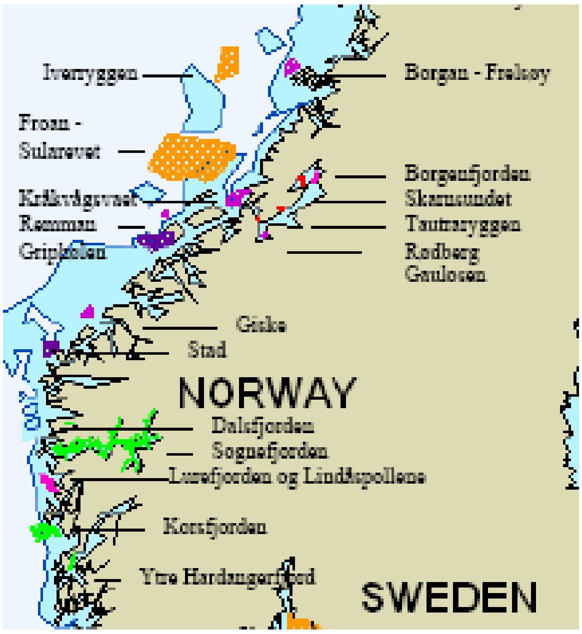


Figure E-32: Map of suggested Marine Protected Areas (Adapted from DN/28/)

Table E-4: Suggested Marine Protection Areas under the proposed Norwegian Marine Protection Plan

It is indicated which areas overlap with areas suggested for the monitoring of biodiversity and for implementing the Water Framework Directive

Site name	No. in List	Status	Selection features (category)
Outer Hardangerfjord	120205		4 (Fjords)
The Korsfjord	120206	General reference area for extended research and long-term monitoring. Reference area: seaweed harvest-free, trawl-restrictions. Overlaps areas suggested for monitoring of biodiversity and in connection with Water Framework Directive.	4 (Fjords)
The Lurefjord and Lindåspollene	120207	Scientific interest	1 (Polls - landlocked fjords)
The Sognefjord	140209	Scientific interest. Overlaps with areas suggested in connection with the Water Framework Directive.	4 (Fjords)
The Dalsfjord	140210	Overlaps with areas suggested in connection with Water Framework Directive, and is an alternative suggested area for the monitoring of biodiversity.	4 (Fjords)
Stad	140212	Reference area, seaweed harvest-free. Overlaps areas suggested for monitoring of biodiversity.	5 (Open coastal areas)
Giske	150213	Reference area, seaweed harvest-free. Overlaps areas suggested for monitoring of biodiversity.	3 (Shallow water areas)
Griphølen	120217	Scientific interest. Reference area, seaweed harvest-free.	5 (Open coastal areas)
Rødberg	160219	Scientific interest. Overlaps areas suggested for monitoring of biodiversity and in connection with the Water Framework Directive.	2 (High current areas)
Gaulosen	160220	Scientific interest. Overlaps areas suggested for monitoring of biodiversity and in connection with the Water Framework Directive.	3 (Shallow water areas)
Tautraryggen (= Selligrunnen)	170243	Scientific interest (world's shallowest *Lophelia* reef). Overlaps areas suggested for monitoring of biodiversity and in connection with the Water Framework Directive.	2 (High current areas)
Remman	160242	Scientific interest. Reference area, seaweed harvest-free	3 (Shallow water areas)
Skarnsundet	170122	Overlaps areas suggested for monitoring of biodiversity and in context with Water Framework Directive.	2 (High current areas)
The Borgenfjord	170223	Reference area, scientific interest. Overlaps areas suggested for monitoring of biodiversity and in connection with Water Framework Directive.	1 (Polls (landlocked fjords))
Kråkvågsvaet – Grandefjæra – the Bjugnfjord	160221	General reference area for extended research and long-term monitoring.	3 (Shallow water areas)
Froan - Sularevet	160218	General reference area for extended research and long-term monitoring. Reference area, seaweed harvest-free, trawl-restrictions.	6 (Transects-coastal-shelf and offshore areas)
Iverryggen	170347		6 (Transects-coastal-shelf and offshore areas)
Borgan - Frelsøy	170244		3 (Shallow water areas)

E.5.10 Areas with Special Environmental Status in UK

The Joint Nature Conservation Committee in the UK is advisor to the UK Government in matters of UK responsibilities regarding conservation of species and habitats in both a national and international context. General reference for the following sections is the JNCC website: /127/ and the Scottish Natural Heritage websit/128/. In order to ensure and enhance the protection of species and habitats (flora, fauna, or geological or physiographical features) pursuant to national and international agreements, national suites of protected sites have been established according to certain criteria. These sites are listed in the sections below. The system of protected sites (SACs and SPAs) also provides statutory protection for terrestrial and coastal sites which are important within the EU (NATURA 2000 network) and internationally. Local Nature Reserves can also be established. Landscape designations aim to protect special areas of national or international significance in terms of their outstanding scenic interest and attractiveness (e.g. Areas of Outstanding Natural Beauty and natural World Heritage Sites). These protected sites are available in UKDMAP/16/ in a data set from JNCC, but due to many more recent updates and additions of sites, the website provides the most recent and updated reference for SACs and SPAs (McLeod, *pers. comm.*). Regulations to implement the Habitats and Birds Directives in UK offshore waters are due in early 2004. The currently proposed marine SACs and SPAs are limited to UK inshore (within 12 nautical miles) waters.

In addition to various national legislation to ensure implementation, important international agreements in this context are as follows (The list of OSPAR Marine Protected Areas is in progress, and is not available yet.):

- SPAs: EU Birds Directive /129/
- SACs: EU Habitats Directive/130/
- RAMSAR (wetlands) /131/
- World Heritage /132/
- OSPAR Conventions/ 133/
- Convention on Biological Diversity:/134/
- Marine nature conservation provision in the UK, including mechanisms such as Marine Protected Areas, is currently being reviewed under Defra's Review of Marine Nature Conservation /27/. Reference to web site/135/

A list of designated sites on Shetland is maintained by the Scottish Natural Heritage (Latest update 31 March, 2003, John Uttley, SNH Northern Isles, Shetland, *pers. comm.*) /84/. The number of each site-type on the Shetland Islands in parenthesis where this is provided by SNH.

International statutory site types (international conventions and directives):
- (Candidate) Special Areas of Conservation (cSAC) (12)
- Special Protection Areas (SPA) (12)
- Ramsar sites (1)
- (Natural) World Heritage Sites (WHS)
- Biogenetic Reserves

Non-statutory sites of international importance:
- Biosphere Reserves
- European Diploma Areas

National statutory site types are:
- Sites of Special Scientific Interest (SSSI) (81)
- Areas of Special Protection (AoSP)
- National Scenic Areas (NSA) (1)
- National Parks (NP) (0)
- Regional Parks (RP)
- Country Parks (CP)(0)
- Long Distance Routes (LDR)
- Local Nature Reserves (LNR) (0)
- National Nature Reserves (NNR) (3)

Non-statutory site types of national importance in Scotland
- Historic Gardens and Designated Landscapes (HGDL) (4)
- Marine Consultation Areas (MCA)

E.5.10.1 Candidate Special Areas of Conservation (SACs)

There are several candidate SACs within the analysis area. These sites have been selected according to criteria adopted as part of the British adaptation to the 1992 EU Habitats Directive (Council Directive 92/43/EEC on the conservation of natural habitats and of wild fauna and flora)/138/ ;/52/. The candidate sites are submitted to the EU by the Scottish Executive /84/.

169 habitat types and 623 species identified in Annexes I and II of the Directive have been selected as being most in need of conservation at a European level. A number of the listed habitat types and species are given priority status in the Directive (Article 1d; Article 1h). Each member state is required to prepare and propose to the European Commission (EC) a national list of sites for each of the "features" (e.g. species) which occurs in their European territory, which will be evaluated in order to form a European network of sites of community importance (SCIs). UK "European territory" includes the continental shelf and British waters up to 200 nautical miles. These will eventually be designated by the member states as special areas of conservation (SACs) (Article 4.4). These SACs, together with Special Protection Areas (SPAs) classified under the Birds Directive (79/409/EEC), collectively form the Natura 2000 network. Sites that are considered to be particularly vulnerable and mainly, or exclusively, found within the European Union, are designated "Annex I priority habitat types". There are 76 Annex I habitat types believed to occur in the UK, of these 23 are defined as priority habitat types (terrestrial and inshore marine habitats (UK territorial waters)). Selection of offshore marine habitats is currently under investigation under NATURA 2000 /52/., JNCC website/127/ and UK Biodiversity Action Plan/136/. See Map of Shetland with SACs in Figure E-33.

The Directive is now being implemented in UK offshore waters (which also falls within the influence and analysis area), as is the Birds Directive for identifying SACs and SPAs in UK offshore waters. Marine habitats listed in Annex I of the Habitats Directive that are known to, or potentially occur in UK offshore waters (outside UK territorial waters and coastline) (JNCC Natura 2000 in UK Offshore Waters) are listed below. Annex I number in parentheses.

Open sea and tidal habitats:

- Sandbanks which are slightly covered by sea water at all times (EU no. 1110)
- Posidonia beds (1120)
- Estuaries (1130) *
- Mudflats and sand flats not covered by sea water at low tide (1140)*
- Coastal lagoons (1150)*
- Large shallow inlets and bays (1160)*
- Reefs (1170)
- Submarine structures made by leaking gases (1180).
- Other rocky habitats
- Submerged or partially submerged sea caves. (8330) (Marine invertebrates and algae)

The four habitats: reefs, sandbanks, structures made by leaking gases and submerged caves are considered to be offshore marine habitats.

Marine species in Annex II that may be found in UK waters are:

- Grey seal - *Halichoerus grypus*
- Common (or harbour) seal - *Phoca vitulina*
- Harbour porpoise – *Phocoena phocoena*
- Bottlenose dolphin - *Tursiops truncates*
- Otter - *Lutra lutra*
- Loggerhead turtle – *Caretta caretta*
- Lamprey – *Petromyzon marinus*
- Sturgeon – *Acipenser sturio*
- Shad – *Alosa spp.*

The SACs on Shetland (including Fair Isle) are listed in Table E-5. Both the habitats that are the main reson for SAC status and other Annex II habitats are listed, both terrestrial and marine.

Table E-5: SACs located on the Shetland Islands (incl. Fair Isle)

Site name	**EU Code**	**Area (ha)**	**Selection features (primary and secondary)**
Keen of Hamar	UK0012815	38.52	Annex I Habitats 6130 Calaminarian grasslands of the *Violetalia calaminariae*. 8120 Calcareous and calcshist screes of the montane to alpine levels (*Thlaspietea rotundifolii*) 4030 European dry heaths Annex II Species: None
North Fetlar	UK0030226	1584.43	Annex I Habitats 4030 European dry heaths 7230 Alkaline fens Annex II Species: None
Sullom Voe	UK0030273	2698.55	Annex I Habitats 1160 Large shallow inlets and bays 1150 Coastal lagoons 1170 Reefs Annex II Species: None
Mousa	UK0012711	530.6	Annex I Habitats 1170 Reefs 8330 Submerged or partially submerged sea caves Annex II Species 1365 Common seal *Phoca vitulina* pupping, breeding and moulting. The site supports just over 1% of the UK population.
Fair Isle	UK0030149	561.27	Annex I Habitats: 1230 Vegetated sea cliffs of the Atlantic and Baltic coasts (oceanic) 4030 European dry heaths Annex II Species: None
Yell Sound Coast	UK0012687	1540.55	Annex 1 Habitats: None Annex II Species: 1355 Otter *Lutra lutra* the site is believed to support more than 2% of the entire GB otter population, and the stock here believed to be genetically distinct from the mainland population. 1365 Common Seal *Phoca vitulina* Yell Sound Coast supports a colony representing over 1% of the UK population.
Hascosay	UK0019793	164.92	Annex 1 Habitats 7130 Blanket bogs Annex 1I Species: 1355 Otter *Lutra lutra*
Papa Stour	UK0017069	2076.69	Annex I Habitats: 1170 Reefs 8330 Submerged or partially submerged sea caves Annex II Species: None
Ronas Hill – North Roe (Site is close to coast)	UK0019797	4900.9	Annex I habitats; 3130 Oligotrophic to mesotrophic standing waters with vegetation of the *Littorelletea uniflorae* and/or of the Isoëto-Nanojuncetea Vegetation habitat supporting *Gavia stellata (Red Throated Diver)* 3160 Natural dystrophic lakes and ponds 4060 Alpine and Boreal heaths 7130 Blanket bogs 4010 Northern Atlantic wet heaths with *Erica tetralix* 4030 European dry heaths 8110 Siliceous scree of the montane to snow levels (*Androsacetalia alpinae* and *Galeopsietalia ladani*) Annex II species : None

Site name	**EU Code**	**Area (ha)**	**Selection features (primary and secondary)**
The Vadills	UK0017068	62.43	Annex I Habitats: 1150 Coastal lagoons Annex II Species: None
Tingon	UK0019799	569.3	Annex I Habitats: 7130 Blanket bogs 3160 Natural dystrophic lakes and ponds
East Mires and Lumbister	UK0019795	620.32	Annex I Habitats: 7130 Blanket bogs 4010 Northern Atlantic wet heaths with *Erica tetralix*

E.5.10.2 Special Protection Areas (SPAs)

Special Protection Areas are classified according to the criteria set up to implement to the Birds Directive. Important sites for Birds on Annex I to the Birds Directive may be classified as SPAs. See Figure E-33, which shows sites on Shetland that are currently classified as SPAs (JNCC website/(/127/).

Table E-6: Special Protection Areas on Shetland (incl. Fair Isle) classified according to the Birds Directive

Site name	**Site code**	**Area (ha)**	**Latitude**	**Longitude**	**Status**
Fair Isle	UK9002091	561.27	59 32 15 N	01 37 00 W	Classified
Fetlar	UK9002031	2594.91	60 36 35 N	00 51 20 W	Classified
Foula	UK9002061	1323.31	60 08 20 N	02 05 00 W	Classified
Lochs of Spiggie and Brow	UK9002651	141.48	59 56 00 N	01 20 00 W	Classified
Mousa	UK9002361	197.98	60 00 00 N	01 10 20 W	Classified
Noss	UK9002081	343.82	60 08 40 N	01 01 00 W	Classified
Otterswick and Graveland	UK9002941	2241.41	60 33 35 N	01 06 30 W	Classified
Papa Stour	UK9002051	569.03	60 20 10 N	01 42 00 W	Classified
Ramna Stacks and Gruney	UK9002021	11.59	60 39 10 N	01 18 10 W	Classified
Ronas Hill – North Roe and Tingon	UK9002041	5470.2	60 33 00 N	01 25 00 W	Classified
Sumburgh Head	UK9002511	39.04	59 51 55 N	01 16 05 W	Classified

E.5.10.3 RAMSAR Sites

The wider area of Ronas Hill – North Roe and Tingon on Shetland forms the only RAMSAR wetland on Shetland. (Note the previous sections - the area also has SAC and SPA status). This RAMSAR site supports the following nationally important species: Shetland endemic higher plant *Hieracia*, harbour seal *(Phoca vitulina)*, otter *(Lutra lutra)*, and the invertebrate *Eurycercus glacialis*. It is also a wintering site for 50 pairs of red-throated divers *(Gavia stellata)*. The latter corresponds to 5.5% of the GB population (/127/; /84/.).

Table E-7: Attributes of the RAMSAR wetland Ronas Hill – North Roe and Tingon on Shetland

Name	Site Code	Country	Area (ha)	Latitude	Longi-tude	Status
Ronas Hill – Roe and Tingon	7UK113	Scotland	5470.2	60 33 00 N	01 25 00 W	Designated

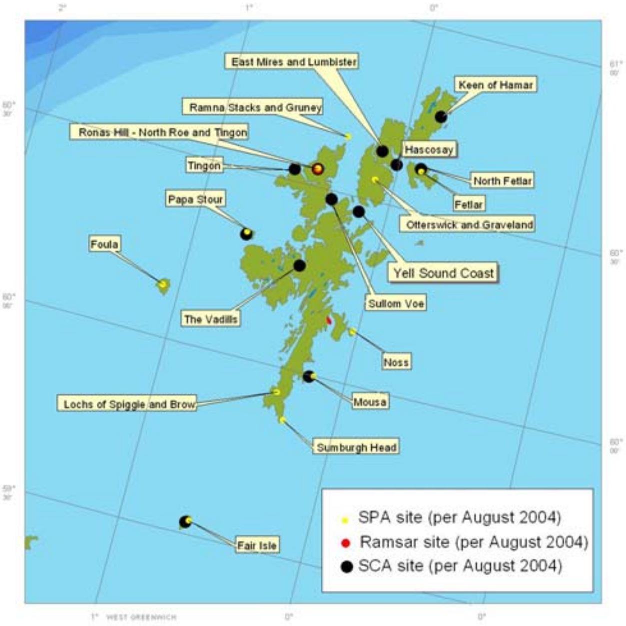


Figure E-33: Map of Shetland and Fair Isle with SPAs, SACs and RAMSAR sites shown.

E.5.10.4 Geological Conservation Review protected Sites (GCR Sites)

Geological Conservation Review protected sites (GCR Sites) on the Shetland Islands are: Balta Island, Cullivoe, Hagdale Chromite Quarry, Ham Ness, Lunda Wick, Nikka Vord, Norwick, Queyhouse Talc Quarry, Qui Ness to Pund Stacks, Skelda Ness, Skeo Taing to Clugan, The Punds to Wick of Hagdale, Tonga - Greff Coast, Wick of Hagdale (JNCC website /127/, 2004).

E.5.10.5 Marine Protected Areas (MPAs)

An interim report of the Review of Marine Nature Conservation (RMNC) was produced in March 2001. This work was followed up by the "Irish Sea Pilot Project" for classifying the Marine Environment into Ecological Units and for refinement of the draft criteria which were suggested by Connor *et al.* (2002) to identify nationally important marine nature conservation features. The final report from the Irish Sea Pilot Project containing the results of the testing of the criteria will be published in summer 2004 (as of August 2004). For this reason, no sites have as yet been selected on Shetland (see Figure E-34 which shows survey areas).

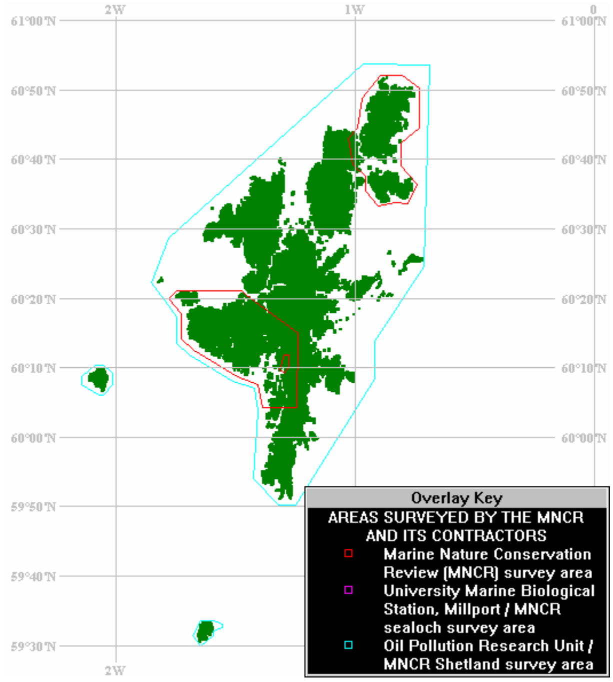


Figure E-34: Survey areas for the Marine Nature Conservation Review

Source: UKDMAP /16/

E.5.10.6 Sites of Specific Scientific Interest (SSSIs)

Coastal *Sites of Specific Scientific Interest (SSSIs)* are included in UKDMAP /16/. There are guidelines for the selection of these SSSIs, i.e. for intertidal marine habitats and saline lagoons /49/. Such sites may be subject to regulations, e.g. Nature Conservation Orders or Special Nature Conservation Orders. Damage to these sites is reported. Figure E-35 shows coastal SSSI-sites on Shetland per 1998. The Scottish Natural Heritage/141/ document “Facts and Figures 2002-2003” /84/. lists the following SSSI-sites on Shetland, some of which are geological SSSIs (G) and some of which are biological SSSIs (B). Sites denoted (M) are sites with mixed biological and geological interests.

The text includes an updated list from SNH of all sites on Shetland This list does not distinguish between coastal and inland sites:

- Burn of Aith (G), Balta (G), Clothister Hill Quarry (G), Easter Rova Head (G), Eshaness Coast (G), Fidlar Geo to Watsness (G), Foula Coast (G), Fugla Ness – North Roe (G), Funzie (G), Gutcher (G), Ham Ness (G), (G), Melby (G, Ness of Clousta – The Brigs (G), Ness of Cullivoe (G), North Sandwick (G), Norwick (G), Punds to Wick of Hagdale (G), Qui Ness to Pund Stacks (G), Quoys of Garth (G), Ronas Hill – North Roe (M), Sel Ayre (G), Skelda Ness (G), Skeo Taing to Clugan (G), St. Ninians’s Tombolo (G), The Ayres of Swinister (G), The Cletts, Exnaboe (G), Tonga Greff (G), Tressa Ness to Colbinstoft (G), Ueya, North Roe Coast (G), Villians of Hamnavoe (G), Virva (G), Voxter Voe & Valayre Quarry (G)
- Aith Meadows (B), Breckon (B), Burn of Lunklet (B), Burn of Valayre (B), Culswick Marsh (B), Catfirth (B), Dales Voe (B), Dalsetter (B), East Mires and Lumbister (B), Easter Loch (B). Foula (B), Graveland (B), Hill of Colvadale and Sobul (B), Kergord Plantations (B),), Mousa (B), Muckle Roe Meadows (B), North Fetlar (B), North Roe Meadow (B), Pool of Virkie (B), Norwick Meadows (B), Noss (B), Quendale (B), Ramna Stacks and Gruney (B), Sandness Coast (B), Sandwater (B), Saxa Vord (B), South Whiteness (B), Tingon (B), Trona Mires (B), Valla Field (B), Ward of Culswick (B) and Yell Sound Coast (B)
- Crussa Field and the Heogs (M), Hascosay (M), Hermaness (M), Keen of Hamar (M), Otterswick (M), Papa Stour (M), Sumburgh Head (M), Fair Isle (M)

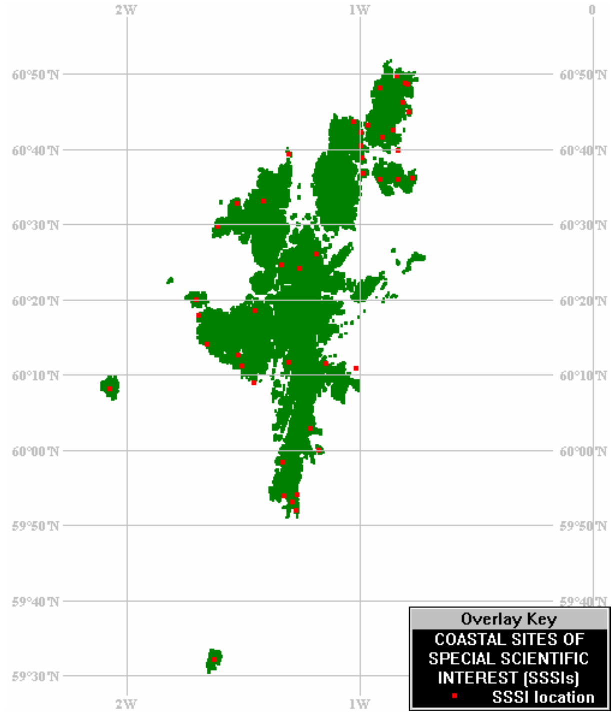


Figure E-35: Coastal Sites of Special Scientific Interest (SSSIs) on Shetland, as of 1998

Source: /16/

E.5.10.7 Areas of Special Protection (AoSP)

Areas of Special Protection are areas that are designated by the Secretary of State for Scotland as Wild Bird Sanctuaries under the Protection of Birds Act (1954) or the Wildlife and Countryside Act (1981). The Island of Fetlar, covering 683.6 hectares, is the only AoSP on Shetland /84/..

E.5.10.8 Other Sites with Special Status

There are currently no *World Heritage Sites, Biogenetic Reserves, Biosphere Reserves, National Parks, Regional Parks, Country Parks, Long Distance Routes, or Local Nature Reserves* on Shetland .) /84/. The island of Fair Isle has been awarded a Diploma by the Council of Europe for “exemplary management and protection of areas of outstanding conservation and landscape importance” /84/.

11,600 hectares have been designated as *National Scenic Areas* on Shetland .) /84/.. The map in Figure E-36a is from UKDMAP /16/.

The *Marine Consultation Areas* on the Shetland Islands are Brindister Voe and Vadills (131 ha), Swinister Voe and the Houb of Fora Ness (32 ha), The Houb, Fugla Ness (30ha) and Whiteness Voe (338 ha). These were all listed as MCAs in 1990, the map in Figure E-36 b/16/ is therefore updated.

National Nature Reserves on Shetland are: Hermaness, Keen of Hamar and Noss) /84/.. There is one *Protected Wreck Site* on Shetland (Figure E-36 c) (UKDMAP, /16/).

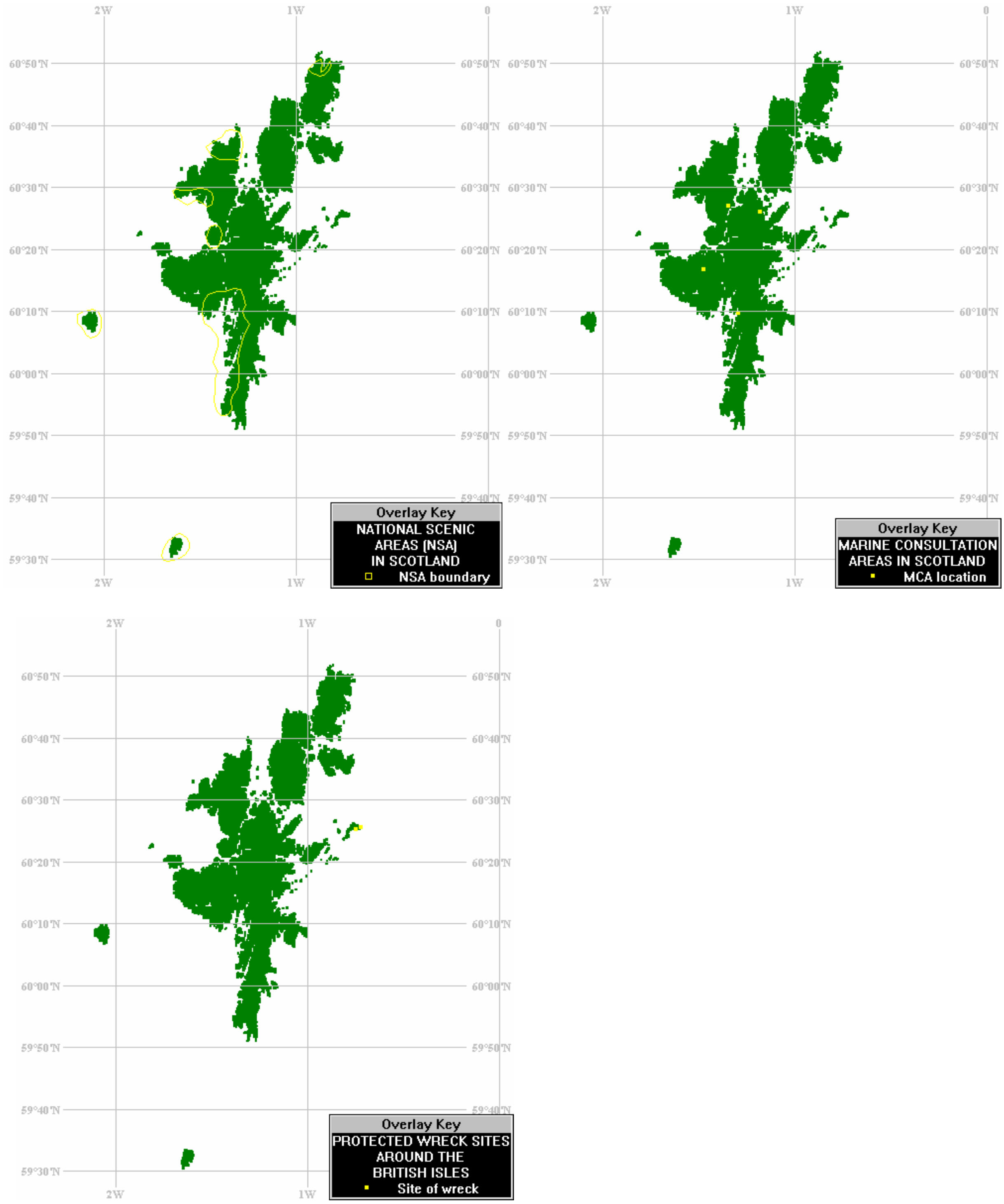


Figure E-36: Shetland and Fair Isle Maps of National Scenic Areas, Marine Consultation Areas and Protected Wreck Sites

Source: UKDMAP /16/

Appendix F Emissions to Air – Emission-reducing Measures and Selection Process

F.1.1 The Environmental Authorities' Framework Conditions

The companies' framework conditions for emissions to air are primarily provided for with a view to fulfilling international obligations and directives, and Norwegian legislation on pollution. The following international agreements and regulations are of particular relevance:

- The Gothenburg protocol
- The Kyoto protocol
- The IPPC Directive

The international obligations are implemented in national environmental protection policy, and have resulted in the following objectives:

- NO_X: In accordance with the Gothenburg protocol, Norway must reduce NO_X emissions by 29 per cent by 2010 in relation to 2001.

- CO_2: Norway will comply with the Kyoto protocol and not increase its emissions of greenhouse gases by more than one per cent during the period 2008-2012 in relation to the 1990 level.

In addition to this, the requirements of the IPPC Directive must be met. The Directive applies to all new installations as of 1999, and to all existing installations by 2007.

The IPPC Directive has requirements for:

- Integrated assessment of environmental impacts (water, air, soil, waste, energy efficiency etc.)
- Use of the Best Available Techniques (BAT)

The definition of BAT is based on an evaluation of the effect of a measure on various environmental aspects, an evaluation of the costs versus the environmental benefits and the suitability of the measure in relation to technical and operational conditions such as space, weight, the technology's maturity, availability etc. The IPPC Directive has been implemented in the Norwegian Pollution Act.

In connection with the Directive, so-called BREF documents (BAT Reference Documents) have been prepared, listing possible technology that can be defined as BAT. Statfjord Late Life will fall under the scope of the BREF for Large Combustion Plant. This document does not contain a clear recommendation for the use of technology, particularly not in relation to existing installations where the question of whether the technology can be defined as BAT is determined by several factors.

In other words, the IPPC Directive is a target-based regulation that requires a specific assessment in each individual case and attaches importance to the cost/ environmental benefit of measures in relation to other considerations. Statoil understands that an integrated assessment of measures in relation to their environmental benefit is also emphasised by the environmental authorities.

F.1.2 Methods

Measures have been assessed for Statfjord with and without late-life production, based on:

- The authorities' framework conditions relating to the environment
- Available and promising technology
- Technical, operational and financial framework conditions
- Environmental benefits and cost-efficiency.

The cost-efficiency of measures is expressed in terms of NOK/tonne reduction in CO_2 and NOK/kg reduction in NO_x. Statoil's/UPN's environmental strategy contains the following guidelines for environmentally cost-efficient measures:

- A cost of less than NOK 40/ kg NO_X reduction
- A cost of less than NOK 300/ tonne CO_2 reduction.

If the EU system of CO_2 emission trading is implemented in 2008, to meet the requirements of the Kyoto protocol, the current CO_2 tax will be replaced by quota. In this case the quota prices will reflect how the society measures the benefits of CO_2 reductions. The price of the CO_2 quotas is expected to lie somewhere between NOK 50 and NOK 150 per tonne of CO_2.

F.1.3 Mitigating Measures that have been assessed

F.1.3.1 The SF Reference Alternative (current Production)

In addition to those already implemented, the following emission-reducing measures have been assessed for the current operations at Statfjord, /89/.

- Replacement of internal compressor components at SFB and SFC to reduce energy requirements and achieve more optimal operation.
- Waste heat recovery unit at SFB.
- Degassing of produced water at Statfjord B and C and recovery of the gas (reduced flare gas).

The latter two measures have also been assessed for late life. Recovery of flare gas at SFB has been assessed and adopted for implementation and, as mentioned in chapter 5, it is one of the assumptions underlying the calculations. The replacement of internal compressor components at SFA, SFB and SFC will be carried out as a consequence of Statfjord Late Life.

F.1.3.2 Measures assessed for Statfjord Late Life before selection of the Concept

Low-NO_X turbines (DLE technology)

Low-NO_X turbines with DLE technology have been assessed for late life, based on a national study carried out by the NPD in 2001, ref. /73/. In this study, the cost of investment in DLE turbines at Statfjord was estimated at NOK 474 million (2003) per turbine. Statfjord has not been adapted for the installation of new DLE turbines. Such installation would require extensive modification work on the platforms. In addition, because lifting capacity at the field is limited, external cranes would have to be hired to lift heavy components onto the platforms. On this basis it was estimated that the cost of the offshore work would constitute NOK 350 million of the total cost of installing one DLE turbine.

The study estimated the environmental cost per DLE Dual Fuel turbine to be approx. NOK 200 per kg NO_X reduction at SFA and NOK 173 at SFB and SFC. The estimates in the study do not have the same level of detailing as the more recently assessed measures, and a direct comparison is therefore not possible. The project has therefore made its own estimates to assess the environmental cost efficiency of new DLE turbine installations at the field. These calculations are based on the cost estimates from the study, the shutting down of SFA in 2012 and the most recently updated profiles relating to electric power generation and compression work.

In periods of maximum power demand in late life, six generators and six compressor turbines will be in operation at the Statfjord field. Based on the average power requirements, 10 turbines will be in operation, distributed between the platforms as follows:

- SFA: one generator and two compressor turbines
- SFB: one generator and two compressor turbines
- SFC: two generators and two compressor turbines

This means that there will be three new DLE turbines on SFA and SFB, respectively, and four on SFC. The following periods have been used for calculating present value:

- Investments: 2005-2007 (40% in 2005, 40% in 2006 and 20% in 2007)
- Operating costs: 2008-2012 for SFA, 2008-2018 for SFB and SFC

Table F-1 shows cost profiles for the measures in 2004 NOK.

Table F-1: Cost of installing new DLE turbines at Statfjord (MNOK)

Measures **(- cost,** **+ cost saving)**	**Present value (2004) of investment**	**Present value (2004) of operating costs***
Installation of 3 new DLEs on SFA	-1 200	- 42
Installation of 3 new DLEs on SFB	- 1 200	- 73
Installation of 4 new DLEs on SFC	-1 600	-95

* Operating costs do not include CO_2 tax, only costs of operation and maintenance.

Figure F-1 shows the cost efficiency (positive y-axis) of the measure for NO_X. Emissions in Statfjord Late Life are defined as the basis and are represented on the x-axis (y=0). Annual emission reductions from any eventual measures are illustrated, in addition to the reductions resulting from Statfjord Late Life (negative y-axis)

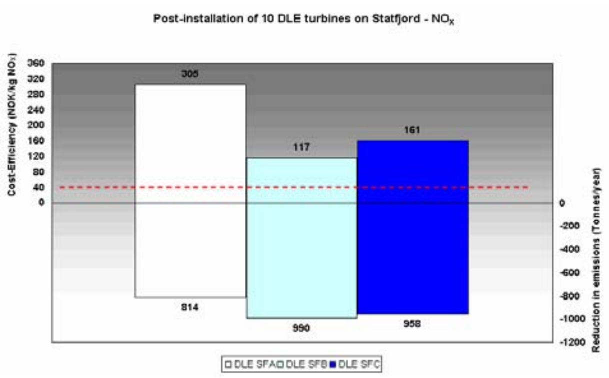


Figure F-1:Environmental cost efficiency of new DLE turbine installations at Statfjord

The environmental cost relating to NO_X as estimated by the project, is approximately the same as the result of the study undertaken by the NPD in 2001. Based on average annual emissions, the installation of new DLE turbines will reduce NO_X emissions in late life by approx. 2,300 tonnes per year for the field as a whole, but the measure still has limited environmental cost efficiency as regards NO_X due to the high investment cost. If a tax of NOK 30 per kg NO_X is included in the calculations, the environmental cost per kg NO_X reduction will be NOK 288, 104 and 147 for SFA, SFB and SFC, respectively. The tax costs saved are small in relation to the total cost picture, and hence do not significantly change the environmental cost of this measure.

The environmental cost relating to CO_2 is not shown in Figure F-1, but it is high compared with other emission-reducing measures assessed by the project. This is because low-NO_X turbines when operating at part-load have up to 13 percentage points lower efficiency than traditional turbines, ref. /73/. The calculations carried out by the project assume that low-NO_X turbines have five per cent lower efficiency than the turbines currently in operation at the Statfjord field. This means that the installation of 10 DLE turbines would increase CO_2 emissions in late life by 30,000 tonnes per year, on average.

The installation of one DLE turbine on SFB and one DLE turbine on SFC has also been evaluated, based on the cost estimates in ref /73/ and the electric power profile for late life. The present value of the investment cost for this measure is NOK 400 million per platform, with an environmental cost per kg NO_X reduction of NOK 128 and 131 for SFB and SFC, respectively. This measure will reduce annual NO_X emissions in late life by 595 tonnes, on average. However, as was the case when assessing the installation of 10 DLE turbines, the investment costs are not justified by the reductions in emissions; hence this measure, too, has low environmental cost efficiency. The costs saved in terms of future NO_X taxes are small in relation to the total costs, and the inclusion of this tax in the calculations does not significantly change the environmental cost of the measure.

A requirement for the use of low-NO_X technology for Statfjord Late Life would involve investments with a present value of NOK 4 billion for 10 DLE turbines. This estimate does not take account of the synergies of installing several turbines at the same time, but the investment costs are nevertheless great enough to bar this project. Empirical data from the operation of other low-NO_X turbines show that they are less reliable than the conventional SAC turbines. Moreover, the maintenance costs for low-NO_X systems are considerably greater than for SAC systems, see/73/The installation of new DLE turbines was therefore rejected as an emission-reducing measure at an early stage in the project.

Steam power plants/ combined cycle

Steam power plants/ combined cycle (CC) were assessed for the Statfjord platforms at an early stage in the project. The measure was rejected for SFA and SFC, on account of space and weight limitations. Furthermore, waste heat recovery units (WHRU) had already been installed on these platforms, and the energy gain was therefore regarded as small compared with SFB.

In late life, SFB will, on average, require 14 MW of electric power. This means that, most of the time the platform will have one turbine in operation, with relatively highly efficiency. Only during periods when more power is required, will both generators on SFB be in operation. The calculations relating to a steam power plant on the platform were based on the utilisation of exhaust heat from the two compressor turbines on the platform, with a maximum output of 12 MW from the steam generator. This is not sufficient to cover the platform's requirements for electric power, and additional power must be supplemented from the existing power generator, which will then be operating in a partially loaded state and with lower efficiency and relatively higher emissions.

The investment costs relating to power generation using steam turbines on SFB were estimated to have a negative present value of NOK 621 million (2003), and an environmental cost of NOK 593 per tonne CO_2 reduction and NOK 772 per kg NO_X reduction. The measure was rejected on account of high investment costs and low environmental cost efficiency.

Power cable from shore

On behalf of the Ministry of Oil and Energy, the NPD and Norway's Water Resources and Energy Directorate (NVE) prepared a report in which the possibility of electrification of the Norwegian continental shelf was evaluated (NVE 1997). The study concluded that this was not relevant based on the current (1997) technology, since the investment costs were high compared with the potential reductions in emissions.

More recent studies have been carried out and there has been some progress in the technology for, among other things, long-distance transmission of direct current. The present value is estimated to be minus NOK 5,538 million. Due to disproportionately high investments costs and low environmental cost efficiency, this was not deemed to be a relevant measure for the Statfjord Late Life project.

Table F-2: Costs of steam power plants at SFB and power cable from shore (MNOK)

Measure (- cost, + cost saving)	**Present value (2003) of investment**	**Present value (2003) of operating costs***
Steam power plants – Combined Cycle (CC)	-621	+ 192
Cable from shore	-5 538	+ 650

* Operating costs do not include CO_2 tax

F.1.3.3 *Measures assessed for Statfjord Late Life before the Project Sanction*

Power cables between the platforms, STIG (Steam Injected Gas Turbine) on SFB, waste heat recovery unit (WHRU) on SFB and recovery of gas from produced water at SFC were assessed in detail. The installation of a new electrical compressor on SFB was also assessed. The environmental cost benefit calculations for these measures have since been updated to take account of new emission profiles and the shutting down of SFA in 2012.

Power cables between the platforms

A total of eight power generators are installed at the Statfjord field: three on SFA, three on SFC and two on SFB. Table F-3 shows the number of power generators that will be in operation during late life, based on the average requirement for electrical power. When more power is required, for instance in connection with drilling activities and loading of crued oil, the number of generators in operation on SFA and SFB will be increased from one to two.

Table F-3: Generator configuration in late life, load per turbine and efficiency

Yr	**No. of turbines in operation**			**Load per turbine [MW]**			**Efficiency per turbine [%]**		
	SFA	**SFB**	**SFC**	**SFA**	**SFB**	**SFC**	**SFA**	**SFB**	**SFC**
2008	1	1	1	12	11	18	32	31	36
2009	1	1	1	11	10	17	31	30	36
2010	1	1	1	11	14	19	31	34	37
2011	1	1	2	11	17	10*	30	36	30
2012	1	1	2	9	15	10*	28	35	29
2013		1	1		15	13		35	33
2014		1	1		15	13		35	33
2015		1	1		14	13		34	33
2016		1	1		15	13		34	33
2017		1	1		14	13		34	33
2018		1	1		14	13		34	33
2019		1	1		14	13		34	33
2020		1	1		14	13		34	33

*Two turbines in operation, each at 10 MW

Based on the power requirements, the optimum generator configuration will be chosen to achieve optimum generator operation and to reduce emissions linked to power generation. When the power load on the generators increases, the efficiency increases, thereby reducing the relative quantity of emissions per produced power unit. At the Statfjord field this means that, today as in late life, for any given power requirement it is preferable to select one power turbine operating at high load than two turbines operating at partial load.

The power requirements can be further optimised by coordinating the requirements at the Statfjord field using intrafield power cables. Intrafield power cables would give environmental benefits in that the transmission of available power between the platforms would increase the power load and hence also the efficiency of the generators in the power network. During some periods, intrafield power cables could also reduce the number of turbines in operation. In late life this would apply during the period 2011-2012, when the power requirements are at the highest. Table F-3 shows that the field's average requirements for electric power during this period will be 48 MW and 44 MW, respectively. If the platforms are not connected to a joint power network, four generators will be required to be in operation. Given a maximum output of 18.6 MW per generator, an intrafield power cable would make it possible to meet the power requirements during this period using only three generators.

In addition to allowing for better coordination of power distribution at the field, intrafield power cables would also reduce the number of generators in standby mode, and hence reduce the related operating costs. The power cables could also be designed to supplement or replace the existing emergency generators on the Statfjord field. This would reduce the operating costs of these systems. During turnarounds and in the abandonment phase intrafield power cables at Statfjord would enable the current diesel power generation to be replaced by gas. This would reduce emissions to air as well as fuel costs. The environmental cost efficiency of intrafield power cables is, however, to low for this measure to be implemented. The measure is further discussed in section F.1.3.4.

STIG on SFB

Upgrading of existing gas turbines to steam injected gas turbines (STIG) would involve the reinjection of high-pressure steam. Steam reduces the temperature in the turbine combustion chamber and emissions of NO_X. NO_X emissions from a typical LM 2500 PC turbine are approx. 180 ppm. Steam injection would make it possible to reduce emissions to 25 ppm / 95/. Emissions of CO_2 would also be somewhat reduced in that the thermal efficiency of the turbines would increase.

Steam for injection is generated from seawater which is cleaned and ionised before being heated in heat exchangers connected to the turbines' exhaust outlets. The main challenge involved in the use of STIG technology offshore is to produce sufficient quantities of water/ steam of the quality required by the turbines. In this type of system, the cleaning plant therefore occupies the greatest area and represents the greatest weight.

The project has assessed the installation of STIG on SFB as an emission-reducing measure in late life. It was also assessed for SFA and SFC, but rejected on account of space and weight limitations. The environmental cost efficiency of STIG on SFB is discussed in further detail in section F.1.3.4.

WHRU on SFB

The principle behind waste heat recovery units (WHRU) is to utilise exhaust heat from the turbines for generating energy to the heating medium used by the platforms' process systems. WHRUs is an energy-efficiency measure in that they can replace heat generation from gas-fuelled boilers.

WHRUs have already been installed on SFA and SFC. On SFC the WHRU meets the total heating requirements, while a gas-fuelled boiler is used to meet additional heating requirements on SFA. The project has assessed the installation of further WHRUs on SFA, but this has been rejected on account of space and weight limitations.

Two gas-fuelled boilers are currently used as energy sources and for heating the heating medium on SFB, and the project has therefore assessed the installation of a WHRU to replace these. A WHRU with a design capacity of 20 MW could utilise the heat from the exhaust outlets on the platform's compressor turbines. The environmental cost efficiency of a WHRU on SFB is discussed in further detail in section F.1.3.4.

Recovery of gas from produced water at SFC

Gas from the produced water drums at SFC is currently flared and accounts for approx. 40 per cent of the total flaring rate for the platform. The share will be the same in late life, and recovery of this gas would thus constitute an emission-reducing measure in relation to both CO_2 and NO_X.

Recovery of gas from produced water will be installed on SFB in 2005. Recovered gas is sent to the platform's export compressors via an inline separator located upstream of the produced water drums. A corresponding technical solution has been assessed for SFC. The environmental cost efficiency of the measure is discussed in further detail in section F.1.3.4.

New electrical compressor on Statfjord B

The decline in oil production in late life means that the quantities of associated residual gas from oil will be reduced. This gas is vaporised in the final stage of separation on the platforms and is introduced to the first and second compressorstage (low pressure) to be sent on for export. At SFB these gas rates will be lower than the operating range for which the compressor steps on the platform are designed and, based on a preliminary assessment, this will happen in 2011. This will not be a problem on SFA and SFC, since SFA receives partially processed oil from Snorre A and SFC receives oil from satellite production.

The low rates for associated residual gas at SFB after 2011 cannot be handled by the compressor train, but will be routed to the flare boom and flared. Since the first and second compressor stage will no longer be available, gas previously recovered from produced water will also be flared. This is because the composition of this gas will be outside the compressor's operating range, and the gas cannot be compressed alone when it is not mixed with the associated gas from the oil.

The project has therefore assessed a measure to limit the increase in the flaring rate at SFB after 2011. The measure involves the installation of a new electrical compressor unit to replace first and second compressor stage in late life. The environmental cost efficiency of the measure is discussed in further detail in section F.1.3.4

F.1.3.4 Environmental Cost-efficiency

In order to estimate the environmental cost efficiency of the various measures assessed by the project in the period leading up to project sanction, the following periods have been used for present value calculations:

- Investment years:

o 2005-2007 (40% in 2005, 40% in 2006 and 20% in 2007) for intrafield power cables, WHRU on SFB and STIG on SFB
o 2006 for recovery of gas from produced water at SFC
o 2009 for new compressor unit on SFB

- Operating costs: 2008-2018 (11 years).

The calculations relating to the intrafield power cables also take account of the field's decommissioning and abandonment period 2019-2026. For SFA, it is expected that after closing down production in 2012, the platform will be in the "light beacon" mode until 2019.

Table F-4 shows the cost profiles for these measures in 2004 NOK.

Table F-4: Emission-reducing measures matured before the project sanction (MNOK)

Measure (- cost, + cost saving)	**Present value (2004) of investment**	**Present value (2004) of operating costs***
Power cables between the Statfjord-platforms (SFB-SFA-SFC)	-673	+356
WHRU on SFB	-94	+0.8
STIG on SFB	-135	-20.9
Recovery of gas from produced water on SFC	-49	+10.0
New electrical compressor on SFB	-93	+9.4

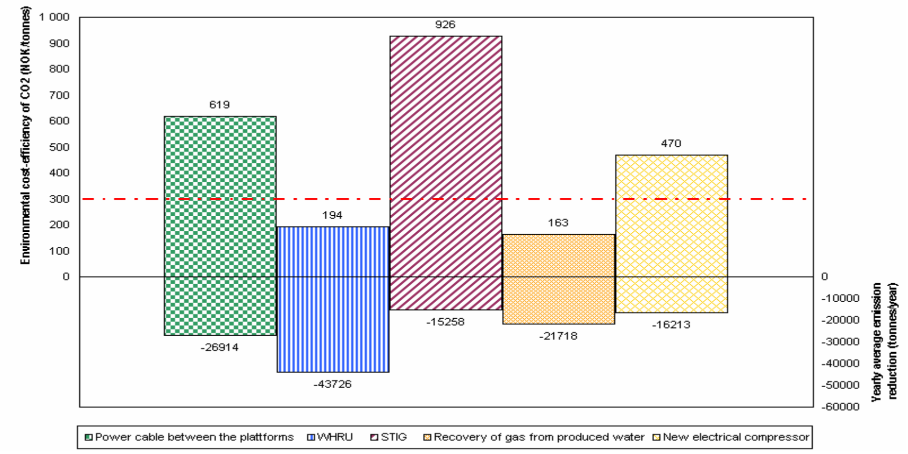
* Operating costs do not include CO_2 tax.

Environmental cost efficiency (emission reduction per NOK) is calculated for CO_2 and NO_X based on the net present value (2004) of the measures and emission reductions over the life of the measures. The cost efficiency of the measures for CO_2 and

NO_X is expressed as NOK/tonne CO_2 reduction and NOK/kg NO_X reduction, respectively. The different ”measures” for expressing environmental cost efficiency (discussed in section F.1.2) have been included as horizontal lines.

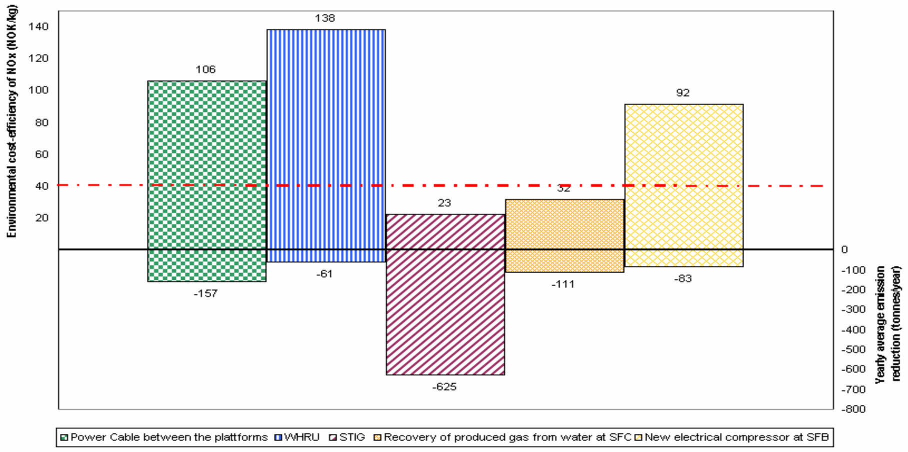
Figure F-2 and Figure F-3 show the cost efficiency (positive y-axis) of emission-reducing measures for CO_2 and NO_X, respectively. Emissions from Statfjord Late Life are defined as the basis and are represented by the x-axis (y=0). Annual emission reductions resulting from measures have been illustrated, in addition to the reductions resulting from Statfjord Late Life (negative y-axis). Good measures have low costs in relation to emission reductions (small bar extending along the positive y-axis) combined with large emission reductions (big bar extending along the negative y-axis)

The production period 2008-2018 (11 years) is used to calculate the average reduction in emissions for the measures per year. For the intrafield power cables the figure shows average annual emission reduction during the period 2008-2026, while annual emission reductions in the production phase and the decommissioning and abandonment phase are stated below the figures.



Intrafield cables (2008-2018): 0.008 million tonnes CO_2/year,
Intrafield cables (2019-2023): 0.031 million tonnes CO_2/year,

Figure F-2: The environmental cost efficiency for CO_2 and annual emission reductions for the assessed measures



Intrafield cable (2008-2018): 34 tonnes NO_X/year
Intrafield cable (2019-2023): 187 tonnes NO_X/year

Figure F-3: The environmental cost efficiency for NO_X and annual emission reductions for assessed measures

Appendix G Produced Water

G.1 Condensate Profiles

The availability of condensate in late life is calculated mainly on the basis of the oil profiles. Figure G-1 shows the availability of condensate at SFA, SFB and SFC. There is plenty of condensate at Statfjord A, but the availability at SFC and SFB will decline in late life.

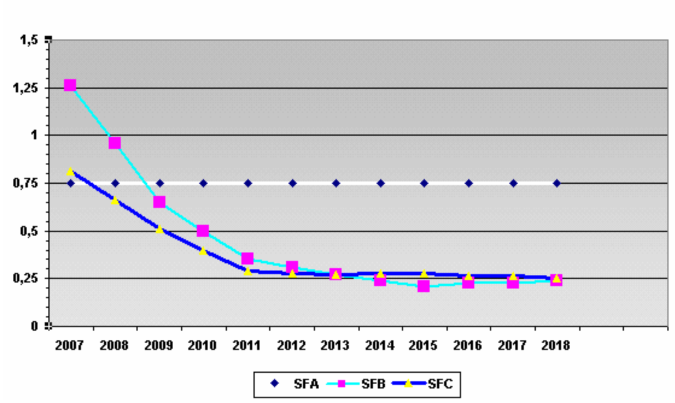


Figure G-1: Condensate availability (% (v/v))

Several alternative measures to increase condensate availability have been assessed.

Figure G-2 shows condensate availability provided that cooling measures are implemented on SFC and SFB.

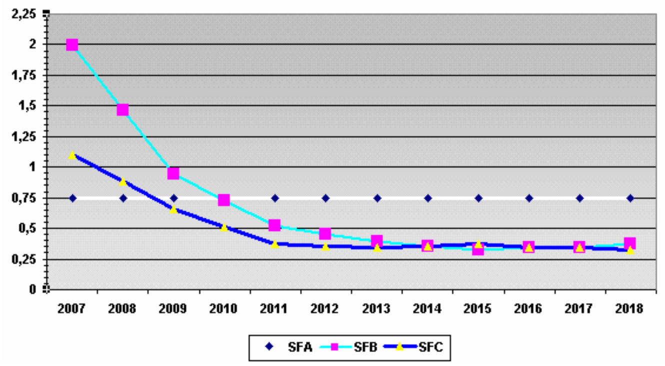


Figure G-2: Condensate availability (% (v/v)) w/cooling of condensate at SFB and SFC

It has been decided to implement cooling measures on SFB and SFC as part of the upgrading of the CTour technology for late life production. The model profiles used for SFA, SFB and SFC for calculating discharges and environmental risks are shown in Figure G-3 and have been drawn up on the basis of Figure G-2. In the Statfjord reference alternative the water treated in CTour contains 0.75 per cent by volume or more of condensate.

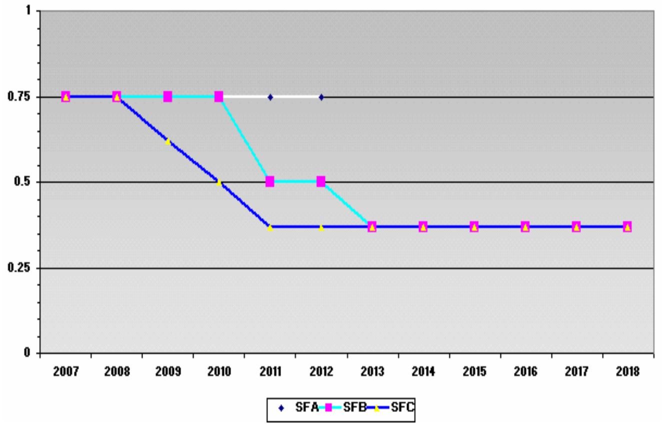
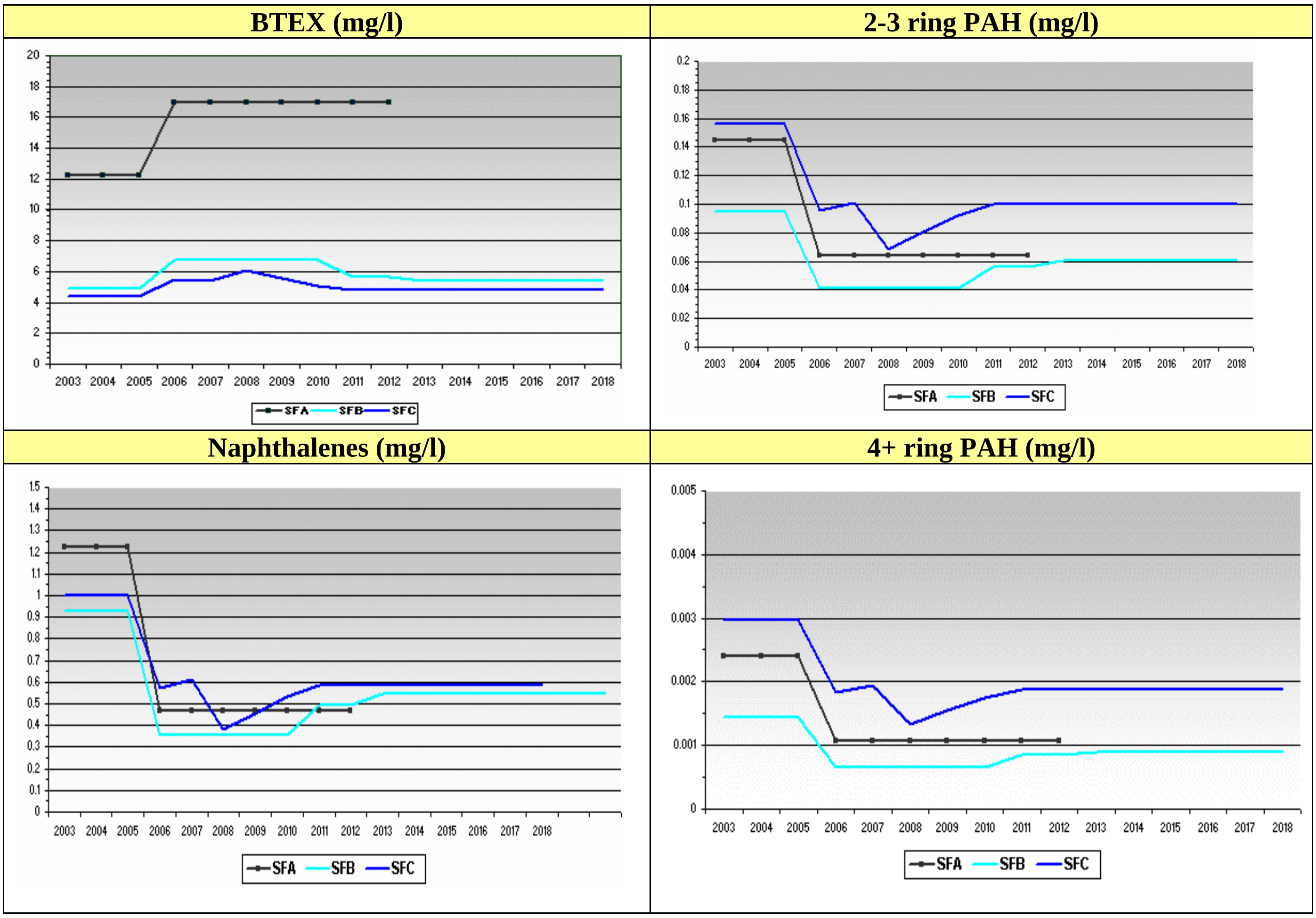


Figure G-3: Model profiles for condensate on SFA, SFB and SFC

G.2 Development of Concentrations of Natural Components in Discharges of Produced Water


BTEX (mg/l)

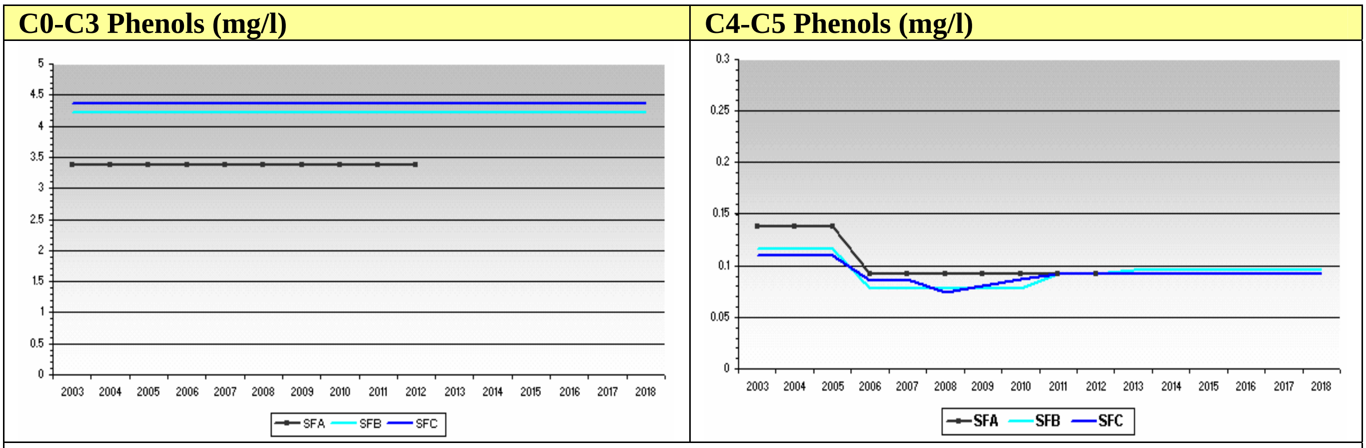
2-3 ring PAH (mg/l)

Naphthalenes (mg/l)

4+ ring PAH (mg/l)

Figure G-4: BTEX, Naphthalenes, 2-3 ring PAH and 4+ ring PAH in produced water, mg/l

C0-C3 Phenols (mg/l) **C4-C5 Phenols (mg/l)**



C6+ Phenols (mg/l)

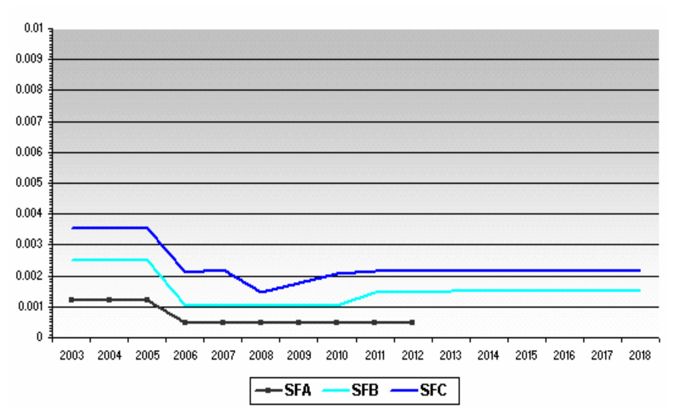


Figure G-5: Phenols in produced water, mg/l

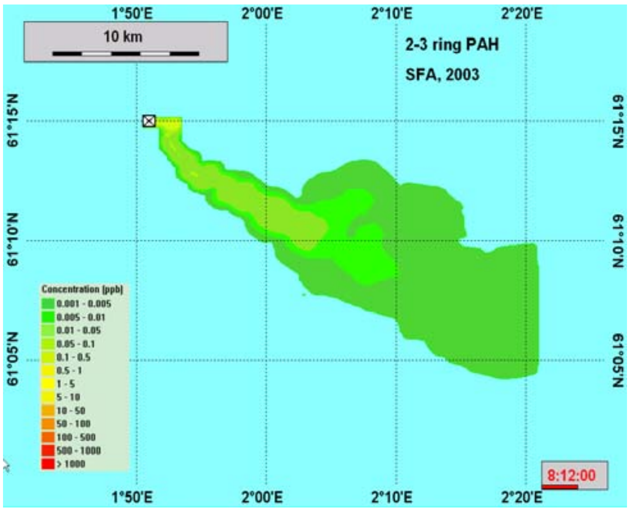
G.3 Dispersion Map for Natural Components

The dispersion of the natural components that contribute the most to the EIF at Statfjord is shown in Figure G-6 to Figure G-15 (2-3 ring PAH, Dispersed oil and C4-C5 phenols). Table G-1 shows PNEC values for the same components.

Table G-1: PNEC values for 2-3 ring PAH, C4-C5 phenols and dispersed oil.

Components	PNEC values (ppb)
2-3 ring PAHs	0.15
C4-C5 phenols	0.36
Dispersed oil	40.4

2003



Peak year in late life

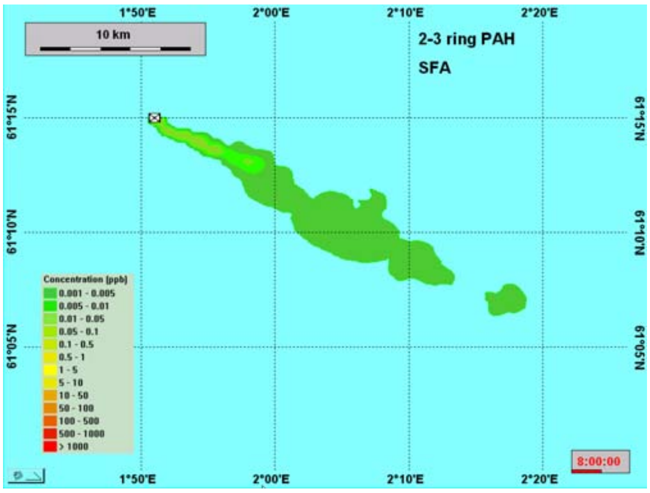
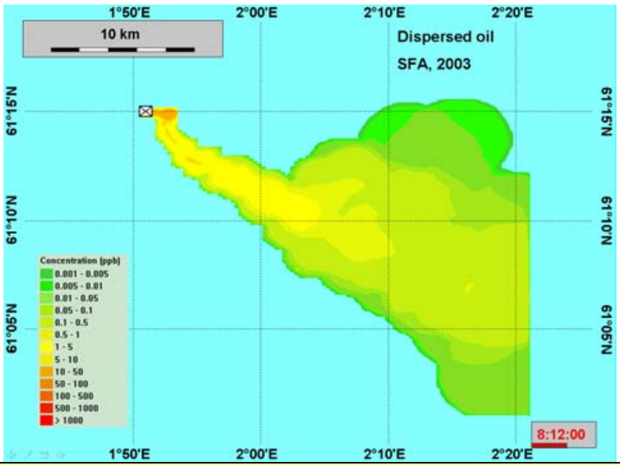


Figure G-6: SFA, dispersion of 2-3 ring PAH (PNEC=0.15 ppb)

2003



Peak year in late life

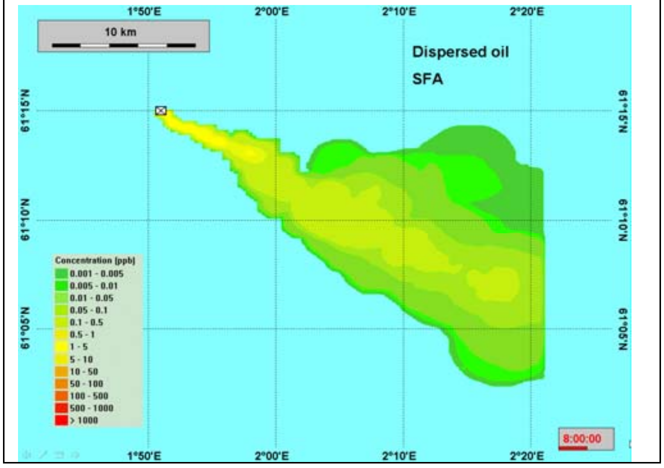
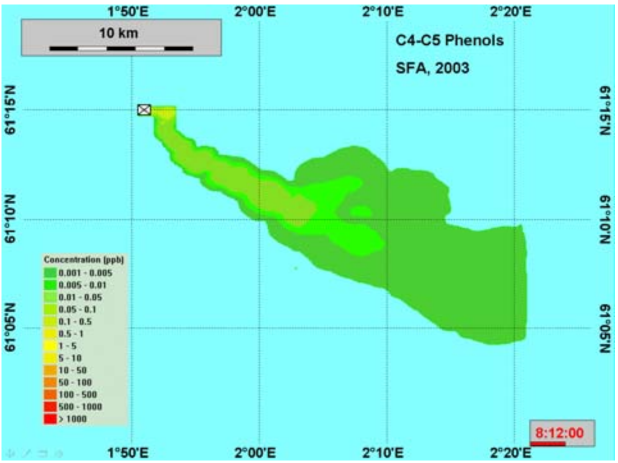


Figure G-7: SFA, dispersion of dispersed oil (PNEC=40.4 ppb)

2003



Peak year in late life

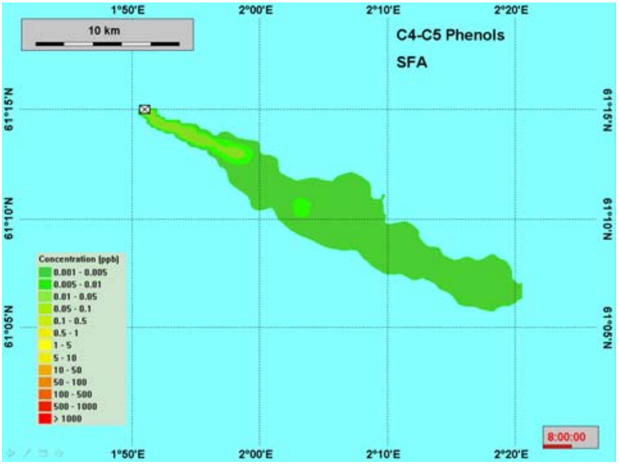
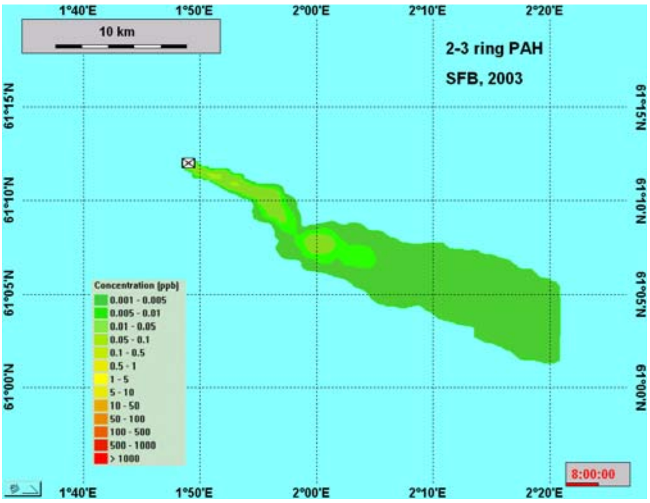


Figure G-8: SFA, C4-C5 phenols (PNEC=0.36 ppb)

2003



Peak year in late life

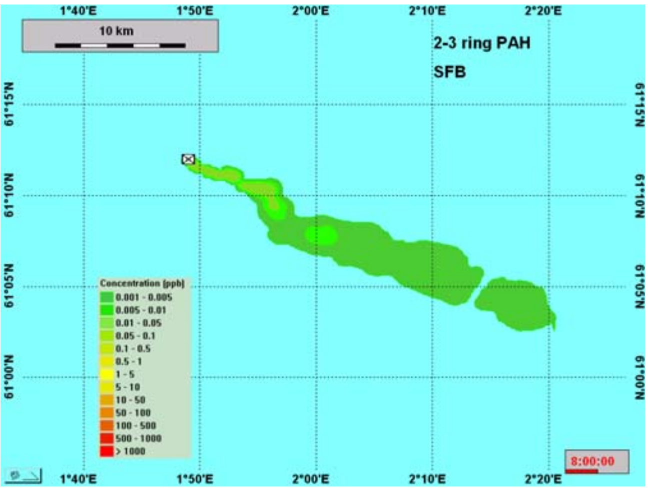
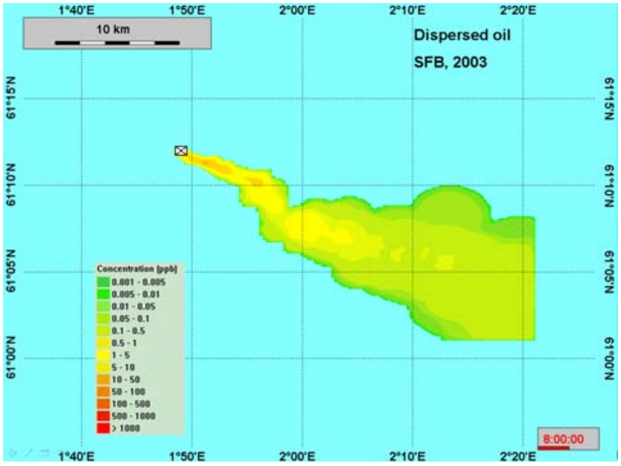


Figure G-9: SFB, dispersion of 2-3 ring PAH (PNEC=0.15 ppb)

2003



Peak year in late life

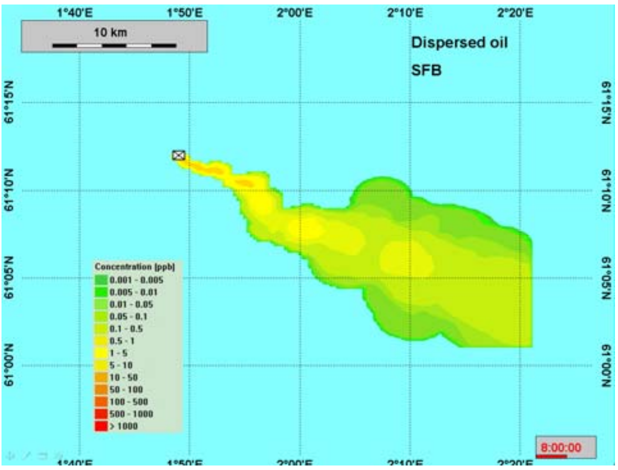
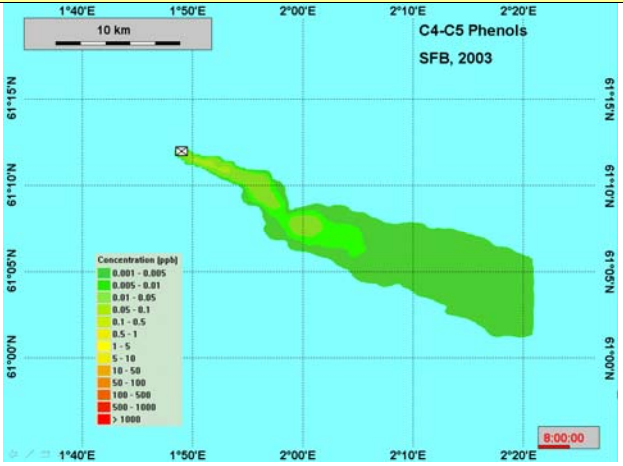


Figure G-10: SFB, dispersion of dispersed oil (PNEC=40.4 ppb)

2003



Peak year in late life

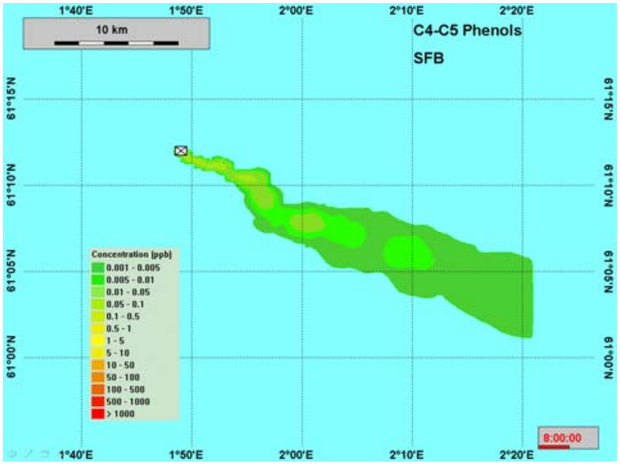
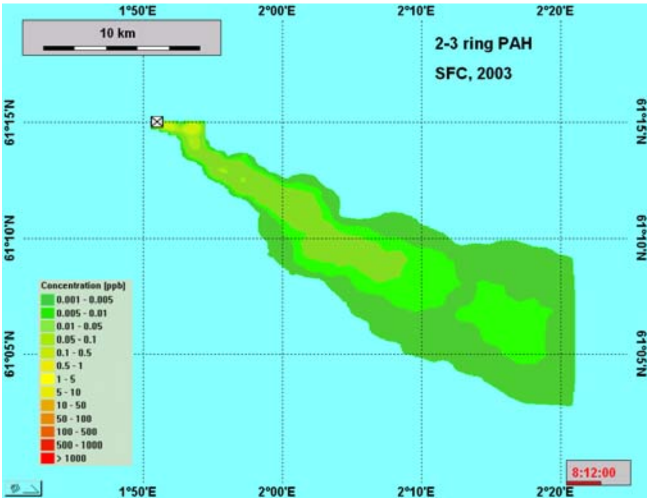


Figure G-11: SFB, dispersion of C4-C5 phenols (PNEC=0.36 ppb)

2003



Peak year in late life

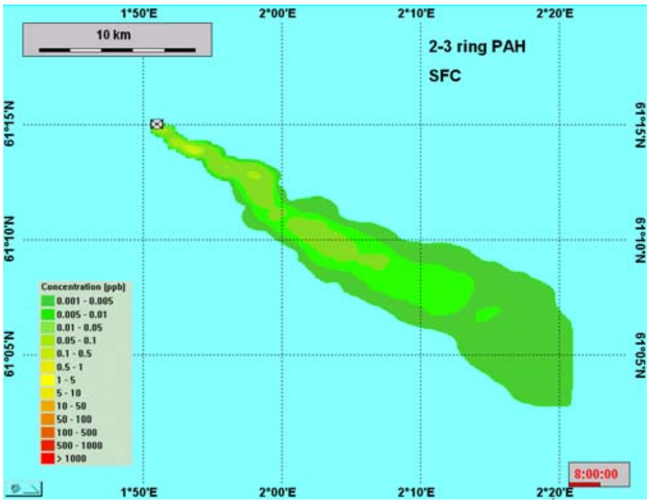


Figure G-12: SFC, dispersion of 2-3 ring PAH (PNEC=0.15 ppb)

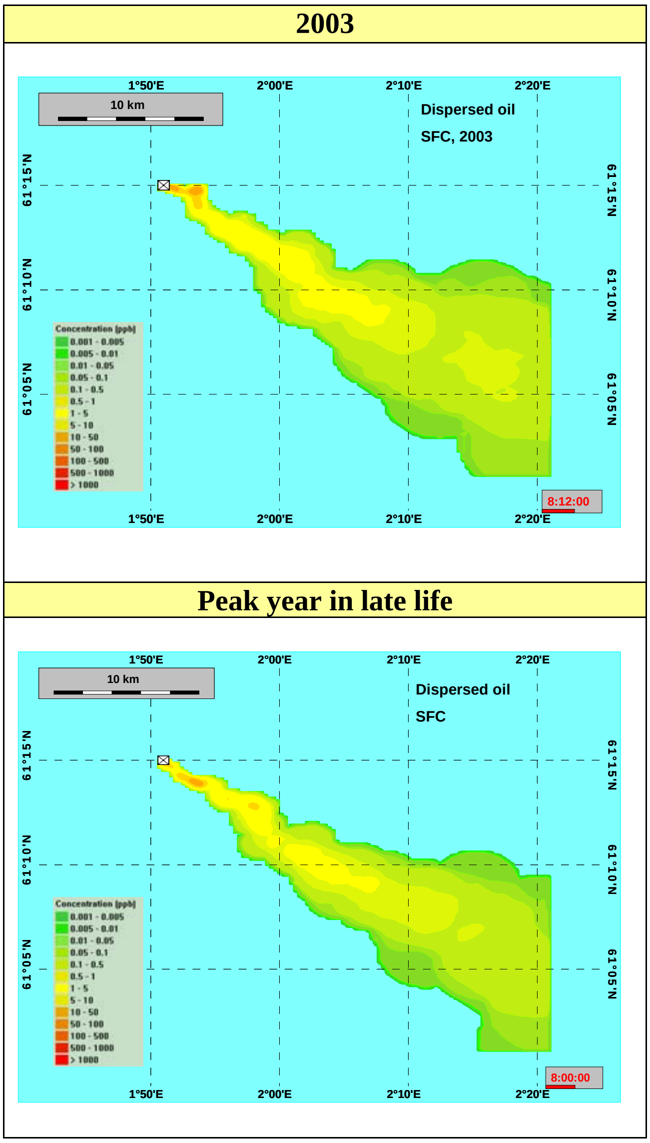


Figure G-13: SFC, dispersion of dispersed oil (PNEC=40.4 ppb)

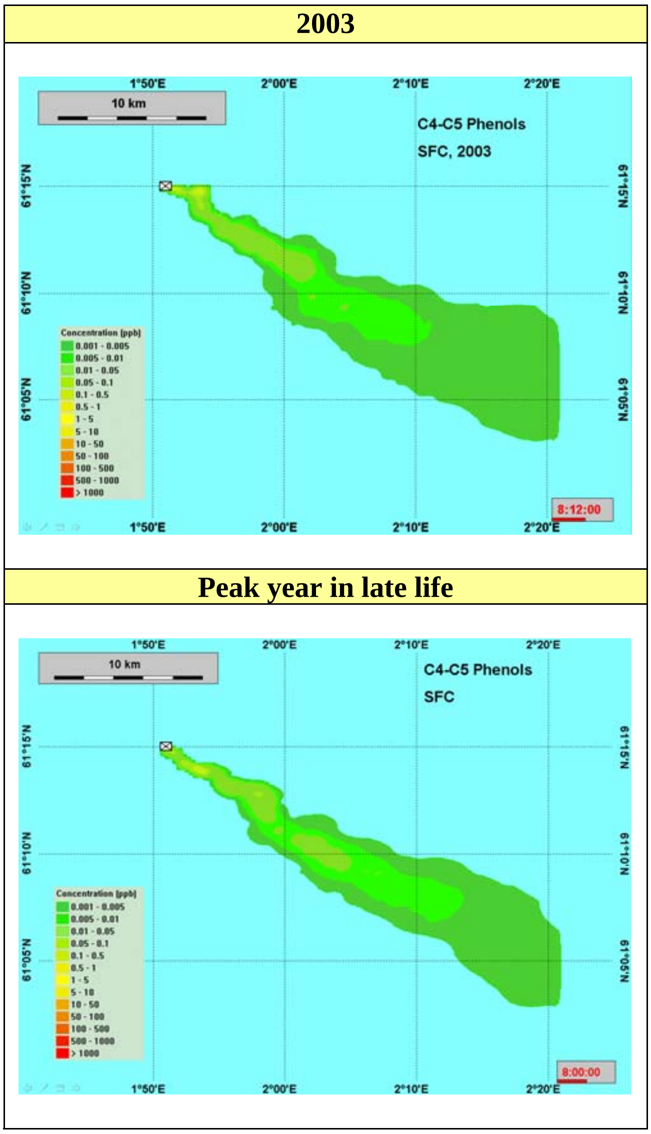
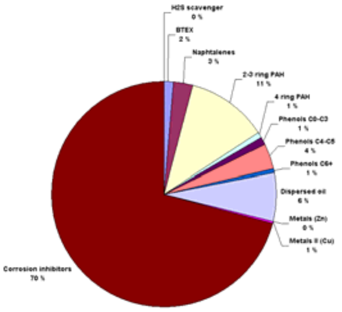


Figure G-14: SFC, dispersion of C4-C5 phenols (PNEC=0.36 ppb)

G.4 Contribution to the EIF

<table>
<tr><th></th><th>SFA</th><th>SFB</th><th>SFC</th></tr>
<tr>
<td>2003: Without substitution corrosion inhibitors at SFB and SFC and partly substitution at SFA</td>
<td>
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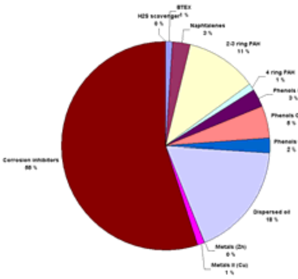
<td>
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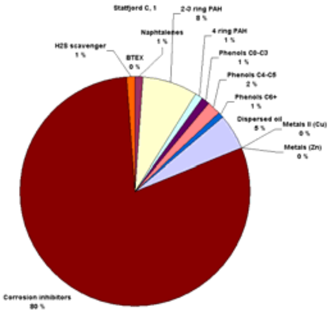
<td>
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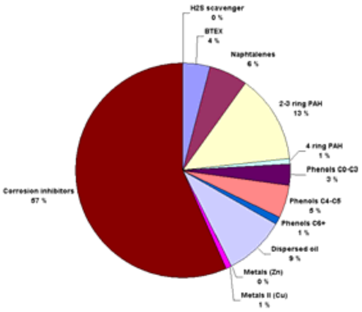
</tr>
<tr>
<td>2004: Substitution of corrosion inhibitors at SFB and SFC</td>
<td>
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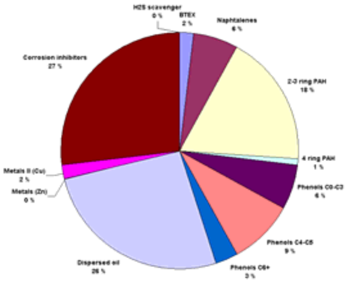
<td>
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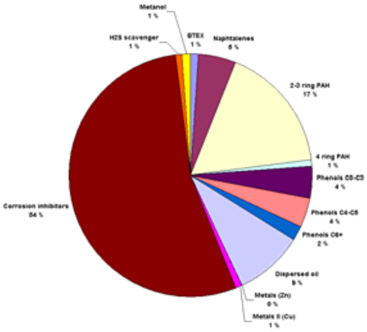
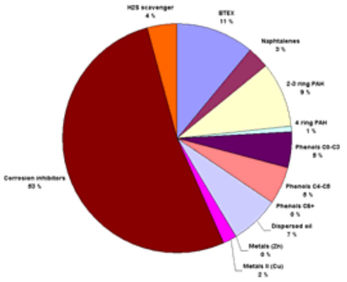
<td>
</td>
</tr>
<tr>
<td>2010: Substitution of corrosion inhibitors. + CTour, H_2S scavenger is discharged (low H_2S)</td>
<td>
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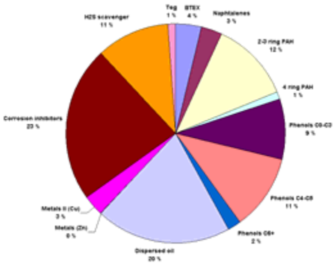
<td>
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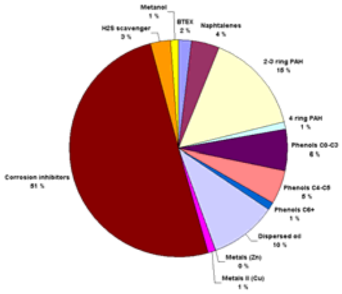
<td>
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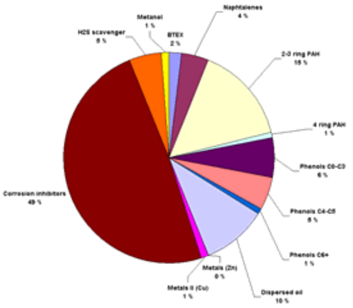
<td>
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Figure G-15: Components contributing to the EIF at Statfjord

G.5 Assessed Mitigating Measures and Selection Process

G.5.1 The Environmental Authorities' Framework Conditions

The companies' environmental framework conditions for produced water are determined by the OSPAR regulations and the Norwegian authorities objective of "zero discharges" by 2005.

OSPAR
OSPAR's objectives are to:

- reduce the content of dispersed oil from 40 mg/l to 30 mg/l by 2006,
- reduce discharges of total hydrocarbons by 15 per cent by 2006, based on the discharge level in 2000.

"Zero discharges" by 2005
The authorities' requirements for "zero discharges" by 2005 *laid down in Government White Paper no. 25 (2002/2003)* The government's environmental policy and the environmental state of the nation:

Environmentally hazardous substances:

- No discharges, or minimisation of discharges, of naturally occurring micro-pollutants that fall under the scope of the first-priority objective for chemicals that are hazardous to health or the environment. See table 8.1 in Government White Paper no. 25.
- No discharges of chemical additives in the State Pollution Control Authority's (SFT) black category (the use and discharge of which is basically prohibited) and red category (high priority for phasing out by substitution). See the Regulation relating to conduct of activities in the petroleum activities (Activities Regulation).

Other chemical substances:

No discharges, or minimisation of discharges, that could cause environmental harm from:

- Oil (non-hazardous components)
- Substances in SFT's yellow and green categories
- Drill cuttings
- Other substances that could be environmentally harmful.

The EIF (Environmental Impact Factor) is used to quantify potential damage/ environmental risk, and in assessing measures account is taken of the cost-benefit of such measures.

The integrated assessment of measures, including environmental benefits, is also a central feature of Norwegian pollution legislation. Section 2 of the Pollution Act confirms that the law shall be used to achieve an environmental quality that is satisfactory on the basis of an overall assessment of health, welfare, the natural environment, the costs relating to the measures and financial considerations.

G.5.2 Methods

Several mitigating measures to reduce the risk associated with produced water at Statfjord have been implemented and further measures have been assessed to comply with the company's "zero mindset", the environmental authorities' objective of "zero discharges" by 2005 and the OSPAR requirements.

The measures have been assessed for Statfjord with and without late-life production on the basis of:

- available and promising technology
- technical, operational and financial framework conditions
- environmental benefit and cost efficiency.

The benefit of a measure is expressed as reduction in environmental risk/potential damage, expressed as EIF over the measure's life. Cost efficiency is defined as NOK per reduced EIF over the measure's life. Statoil operates with a limit of NOK 200,000 per reduced EIF as an upper limit for measures to be recommended. This is described in document PB019, Environmental strategy for UPN 2003-2010/93 /.

The assessment of possible technology for Statfjord and the selection of measures are documented in a memo on the selection of technology for produced water /94 / and in the Statfjord zero discharges report to the authorities /91/.

EIF pie charts, showing the contribution from different components (see G.4 above), are used together with the EIF to demonstrate what components should be focused on at any time and hence prioritise research efforts and measures.

G.5.3 Reasons for selecting CTour rather than Injection into the Utsira Formation

The Utsira formation is a shallow water-bearing sandstone reservoir that extends over large parts of the North Sea. The Utsira reservoir is regarded as a possible storage location for produced water on the basis of technical and operational considerations, but there is some risk associated with local pressure build-up in the reservoir as a result of large water volumes. This could lead to local fracturing of the reservoir and hence a danger that the produced water could leak out.

Injection into Utsira also poses other challenges that are specific to Statfjord. Based on the current challenges relating to the injection of produced water at SFC, there will also be a risk of operational problems in late life. Particles and scale have created problems for technical process equipment as a result of erosion and blocking. There is also a certain risk of blocking the injection wells. Due to the high content of organic acids and sulphates in the water at Statfjord, anaerobic conditions may also lead to the formation of H_2S. Since this solution was rejected, the problems relating to any local pressure build-up and H_2S have not been explored in detail.

For injection into Utsira a regularity of 70 per cent has been assumed on the basis of current experience of PWRI. Due to the aforementioned problems relating to technical process equipment, the regularity of the current PWRI is only 50 per cent. In the case of Statfjord, it is unrealistic to envisage that injection into Utsira would give a regularity of 90 per cent, which is the figure normally referred to for injection solutions. However, the EIF for injection into the Utsira formation has also been calculated on the assumption of 90 per cent regularity.

Figure G-16 shows the development of the total EIF at Statfjord with injection into Utsira (70 per cent regularity) compared with CTour (90 per cent regularity).

The environmental risk associated with injection into Utsira (70 per cent regularity) is approx. one third of that involved in the use of CTour.

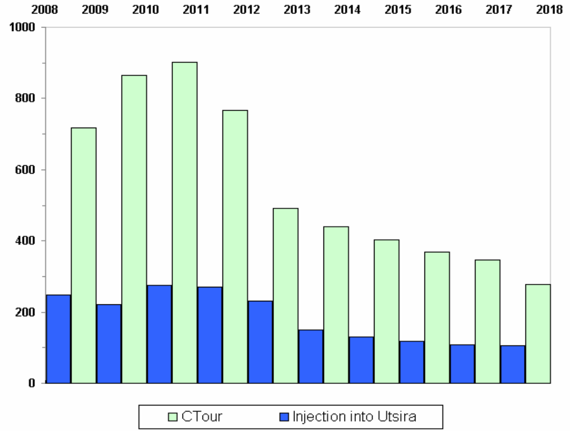


Figure G-16: Total EIF in late life associated with injection into Utsira compared with the EIF associated with the use of CTour

The cost efficiency of injection into the Utsira formation is low compared with CTour. In Figure G-17 the measures used as basis for the treatment of produced water at Statfjord and by the SFSF project (modification of CTour and substitution of corrosion inhibitors) are represented by y=0. The figure shows:

1) Accumulated benefit of CTour over the field's life (green bar above the x-axis),
2) Extra benefit of injection into Utsira in relation to the use of CTour, given a regularity of 70 and 90 per cent, respectively, for injection into the Utsira formation (light blue and blue fields under the x-axis),
3) The environmental cost efficiency expressed in NOK/EIF for all the platforms jointly and for each of the platforms separately relating to:
    a) CTour, (Green bar combined with the costs of CTour)
    b) Injection into Utsira as an alternative to CTour for 70 and 90 per cent regularity, respectively, (green+ blue bars combined with costs of injection)
    c) ”Additional” cost-benefit of injection into Utsira in relation to the use of CTour (blue bar combined with costs of injection)

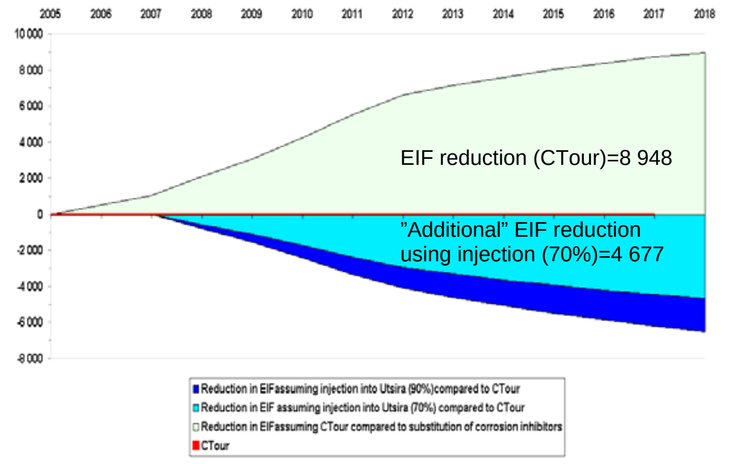
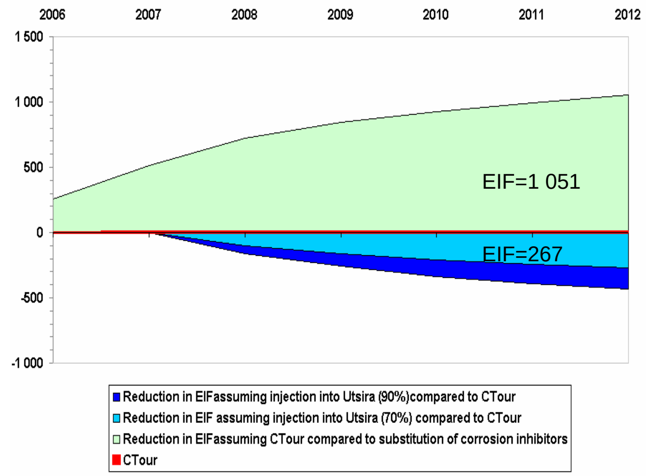
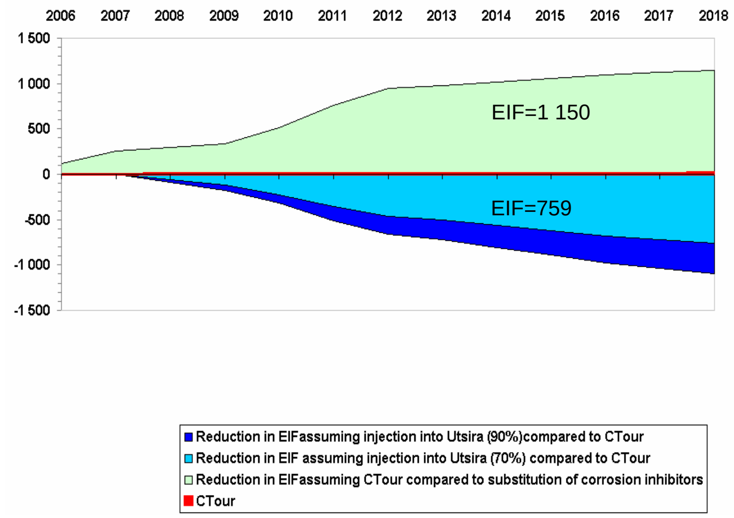
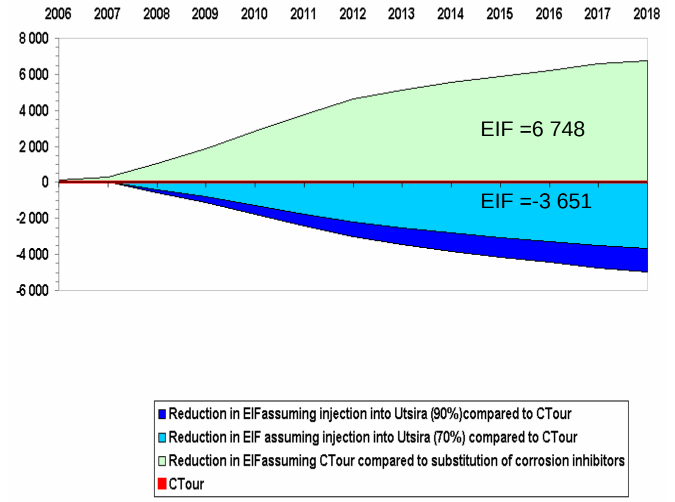
	
Cost-benefit of CTour (NOK/EIF): 50 276	**Cost-benefit of CTour (NOK/EIF): 140 390**
Additional cost-benefit of injection compared with CTour (NOK/EIF): 913 139	**Additional cost-benefit of injection compared with CTour (NOK/EIF): 6 572 848**
Cost-benefit of injection, 70% (NOK/EIF): 346 439	**Cost-benefit of injection (NOK/EIF): 1 444 989**
Cost-benefit of injection, 90% (NOK/EIF): 305 539	**Cost-benefit of injection, 90% (NOK/EIF): 1 285 535**
	
Cost-benefit of CTour (NOK/EIF): 92 344	**Cost-benefit of CTour (NOK/EIF): 29 070**
Additional cost-benefit of injection compared with CTour (NOK/EIF) 720 143	**Additional cost-benefit of injection compared with CTour (NOK/EIF): 538 614**
Cost-benefit of injection (NOK/EIF): 341 910	**Cost-benefit of injection (NOK/EIF): 207 959**
Cost-benefit of injection, 90% (NOK/EIF): 290 652	**Cost-benefit of injection, 90% (NOK/EIF): 184 474**

Figure G-17: Accumulated EIF and cost-benefit of CTour and injection into the Utsira formation

Injection into Utsira would require the installation of two seabed templates with pertaining pipelines of approx. 24 km, which would entail an investment of NOK 4.2 billion. In addition, operating costs of approx. NOK 500 million would be required over the life of the measure. Total investment and operating costs for CTour, including modifications to CTour in late life, would amount to NOK 450 million.

The investment and operating costs for CTour and injection at the three platforms are shown in Table G-2 and Table G-3 as NPV.

Table G-2: Costs of CTour (NOK million)

NPV (2004)	SFA	SFB	SFC	Total
Investment	132	85	161	378
Operation	16	21	35	72
Total	**148**	**106**	**197**	**450**

Table G-3: Costs of injection (NOK million)

NPV (2003)	SFA	SFB	SFC	Total
Investment	1709	563	1966	4237
Operation	197	89	197	483
Total	**1905**	**652**	**2162**	**4720**

The justification for using CTour rather than injection into Utsira is the same as described in the impact assessment programme:

- Injection into Utsira will require an investment of NOK 4.2 billion and considerable operating costs, and it will render the late-life project financially unviable. Considerable value contribution to the economy will be lost.
- The environmental cost efficiency of injection into Utsira is small compared with CTour, and it will increase emissions to air compared with CTour. The increase will be somewhere in the range of 90,000 tonnes of CO_2/year and 375 tonnes of NO_X/year.
- The Utsira reservoir is regarded as a possible storage location for produced water on the basis of technical and operational considerations, but involves certain technical and operational risks.
- Together with other measures implemented before late life (in particular substitution of corrosion inhibitors), CTour will lead to a considerable reduction in environmental risk in relation to the risk level in 2003, i.e. ≈85 per cent reduction from 2003 to the peak year in SFLL.
- CTour has good cleaning efficiency for the natural components that are associated with the greatest environmental uncertainty.

G.5.4 Measures to increase the Amount of Condensate at SFB and SFC and to optimise CTour

Water and condensate will be routed via the hydrocyclone and through the last stage separator of the process. This means that a lot of the condensate used for CTour will be recirculated through the process plant. The availability of condensate at Statfjord B and Statfjord C is still very low, as shown above.

Cooling measures

Cooling of condensate, which will change the equilibrium conditions and increase the amount of condensate, has been included as a measure to optimise the CTour efficiency. This measure involves a lowering of condensate temperatures from 31°C, 34 °C and 32 °C to 25 °C, 25 °C and 30°C, respectively. The plan is to achieve this by utilising the capacity of the existing 1. and 2. stage recompression coolers and the new 3. stage recompression coolers that will be installed by SFLL

Figure G-18 shows the effect of cooling measures and the ”additional” potential of CTour, if condensate availability is increased (accumulated EIF over the field’s lifetime). CTour modifications and substitution of corrosion inhibitors are represented by y=0.

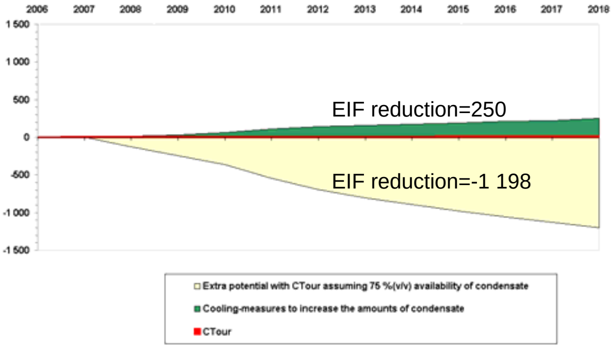


Figure G-18: Impacts of cooling measures and 0.75% (v/v) condensate for CTour

CTour has ”additional” potential if the condensate availability at Statfjord B and Statfjord C is increased. This ”additional” impact (≈1200 EIF) is a lot lower than the reduction achieved by CTour and the currently available condensate (see Figure G-17 ≈9000 EIF).

Heading of aquifer water

In addition to condensate cooling, other measures to increase condensate availability have been assessed, including heating of the aquifer water. In late life, some of the produced water will come from the aquifer zone. This water has a lower temperature than is normal for produced water, and this could in turn influence the amount of condensate due to changed equilibrium conditions. In order to reduce this negative temperature effect, this water could be heated to between 60 and 82 °C. This would require the installation of new equipment, a heater on the intake at SFC and a new heater on the intake plus an exhaust boiler at SFB. The estimated cost of these measures is approx. NOK 100 million NOK at SFC and NOK 200 million at SFB.

The increase in condensate resulting from the heating of aquifer water would be minor, and it would not contribute any additional benefit expressed as the EIF.

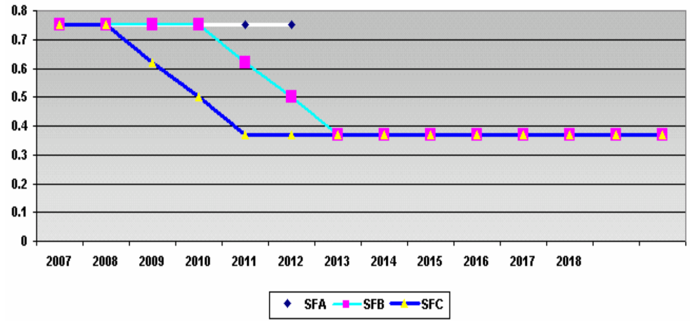


Figure G-19: Condensate profile associated with the heating of aquifer water

Measures for further optimisation of CTour

Given the available condensate volumes and the adopted cooling measures, CTour cleaning will in any case be very efficient. It must also be emphasised that tests conducted from the spring of 2004 and up until today (section 6.2) indicate that the cleaning efficiency is less dependent on condensate volumes. This is due to a secondary cleaning effect in the degassing tank after the hydrocyclone. Such degassing tanks are large and the retention time is sufficient for a stripping effect to occur. This in turn means that the cleaning efficiency is probably better, the potential of CTour higher and the ”additional” potential of increased condensate availability smaller than shown inFigure G-18.

However, the active effort to optimise the CTour technology continues, including:

- Optimisation of the mixer set-up to use the condensate more efficiently
- Research into pressure losses across mixers with a view to optimising the conditions for droplet formation, and hence increase hydrocyclone efficiency.
- Studies of optimum condensate volumes in relation to gas formation to increase hydrocyclone efficiency.
- Testing of different types of cyclone.

In addition, the ongoing work to optimise operation and maintenance of the hydrocyclones will be continued.

G.5.5 Treatment of Satellite Water in SFLL

Due to the reduced availability of condensate, an assessment has also been made relating to the treatment of satellite water.

The biggest CTour modification measure in SFLL will be the expansion of CTour at SFC to include the treatment of satellite water. This measure will cost approx. NOK 63 million. It will not significantly reduce the content of any natural components but, compared with non-implementation of the measure, it will reduce the EIF in late life. The reduction of the EIF during late life’ lifetime will total approx. 1,500 EIF. This reduction can primarily be ascribed to the fact that CTour also removes the corrosion inhibitors. As one of the mitigating measures in SFLL, this measure alone will have an environmental cost efficiency of approx. 40,000 NOK/EIF.

G.5.6 Cessation of PWRI at Statfjord C

As briefly described in section 6.2, continued PWRI at Statfjord C will lead to further acidification of the reservoir and increased use of H_2S-scavenger chemicals compared with cessation of injection. Increased H_2S production will also increase the load on the process plant in terms of safety and the working environment.

Statfjord operations has recommended cessation of PWRI at SFC in the course of the autumn of 2004.

The impacts of a cessation of PWRI in 2004 have been assessed in relation to continued PWRI until the start of SFLL in 2007.

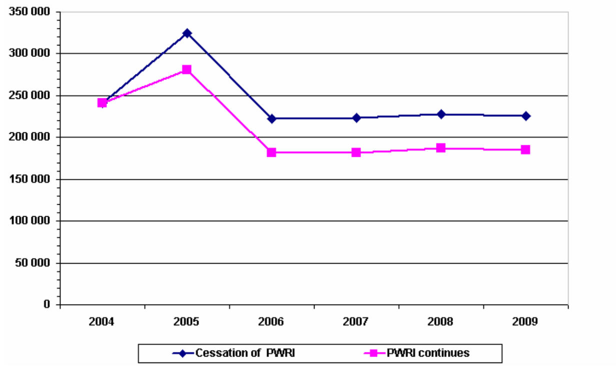


Figure G-20: Discharges of aliphates (kg/year) with and without reinjection at SFC (2004 2009)

Figure G-21: EIF at Statfjord C with and without cessation of PWRI at Statfjord C

Cessation of PWRI (Figure G-20) will increase discharges by approx. 50 tonnes of dispersed oil per year for the reference alternative during the period 2005-2007.

EIF calculations (Figure G-21) have also been carried out for the two alternatives 1) Cessation of PWRI in 2004 and 2) Cessation of PWRI in 2007. These calculations show that the increased environmental risk resulting from the cessation of PWRI in the period 2005-2007 will be largely compensated for by lower discharges of H_2S remover in the period 2008-2018.

G.5.7 Injection of H_2S Scavenger into a Separate Well

The injection of H_2S remover into a separate well has been assessed. The potential for reducing the EIF and the environmental cost efficiency of such a measure are shown in Figure G-22.

Injection of H_2S remover into a separate well in late life has been assessed on the assumption that PWRI will be stopped in 2004

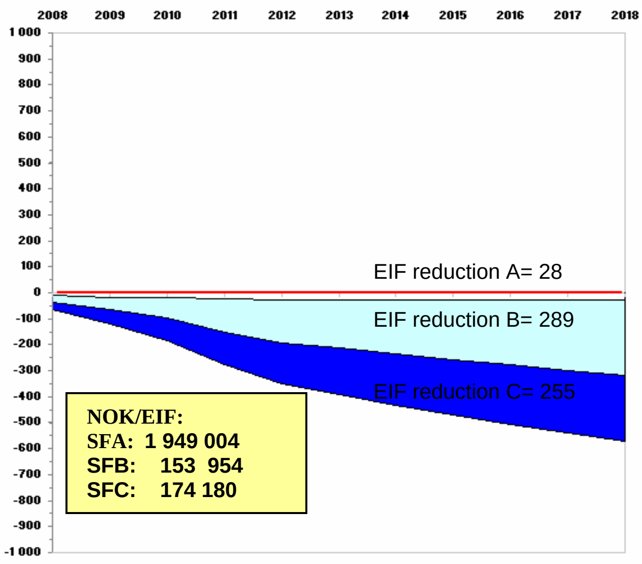


Figure G-22: Cost efficiency of injection of residual products from H_2S scavenger

The environmental cost efficiency of injecting H_2S remover into a separate will be very low at SFA and relatively low at SFB and SFC. The project does not recommend injection of H_2S remover at SFA, and, for the time being, not at SFB or SFC either. The measure will be further assessed for SFB and SFC.

Table G-4: Costs of injection of H_2S scavenger (NOK million)

NPV (2004)	**SFA**	**SFB**	**SFC**	**Total**
Capex	48	35	35	118
Opex	6	9.5	9.5	25
Total	**54**	**44.5**	**44.5**	**143**

G.5.8 Substitution of Chemicals

G.5.8.1 Further Work on the Substitution of Corrosion Inhibitors

The contribution to the EIF from corrosion inhibitors at the Statfjord platforms remains relatively high (see the above EIF pie chart). Work is in progress, however, to find even more environmentally friendly chemicals.

Statoil has an ongoing project in cooperation with the chemicals supplier MI Production Chemicals to develop new environmentally friendly corrosion inhibitors. This R&D project was started in 2003, and new and promising products were developed already in the course of the first year. These products were tested on Statfjord C in March 2004, and the results were encouraging. A significant reduction in the EIF would be achieved by switching to these products, but unfortunately they do not at present provide sufficient corrosion protection to enable implementation at the Statfjord field. Statoil and MI have drawn up a plan for the further development of these environmentally friendly products, and new field tests will be carried out at the turn of the year 2004/2005.

The work to substitute corrosion inhibitors seems promising, and substitution may be implemented in the course of 2005, in which case the EIF will be further reduced, especially at Statfjord C, in relation to the EIF in Figure 6-24.

G.5.8.2 Environmentally Friendly Emulsion Breakers

Testing of new environmentally friendly emulsion breakers in combination with flocculants has some potential for further improving separation capacity, which would result in cleaner discharge water. Statfjord operations will continue to test this during 2004 and 2005.

Appendix H Produced sand

H.1 Model Scenarios

The project has studied the acute and long-term impacts on the pelagic environment (water column) and the benthic environment (seabed) of discharges from jetting at Statfjord. The impacts of dispersed oil and oily sand have both been assessed.

Potential impacts before and after the implementation of Statfjord Late Life have been studied for each of the three platforms SFA, SFB and SFC. Three main alternatives for the handling of sand, and different jetting frequencies for “normal” production jetting and jetting in connection with well testing have been assessed.

The following three main alternatives for the handling of sand have been studied:

1) Discharges corresponding to current production without mitigating measures
2) Simplified sand treatment including the use of sand cyclones to separate sand and water
3) Complete sand treatment including use of sand cyclones and sand cleaning.

Only alternative 3 meets the authorities’ requirement for less than one per cent by weight oil adhesion to sand.
Table H-1 shows the estimated discharges and cleaning efficiency resulting from current production and measures 2 and 3 above.

Table H-1: Assumptions underlying the assessment of discharges with and without measures

Alternatives for handling sand	Dispersed oil	Adhesion per cent
1) No mitigating measures	Assumed to be proportional to current sand production and reported discharge quantities.	10 %
2) Simplified sand treatment	Returned to process: 80 %	4 %*
3) Complete sand treatment	Returned to process: 80 %	1%

*60 per cent reduction in adhesion after one cycle in the cyclone

For all three alternatives, the impacts of discharges have also been assessed for the handling of sand by:

a. jetting during normal production – once per week for a duration of 30 minutes
b. jetting during normal production – twice per week (current jetting frequency), duration: 30 minutes
c. test jetting of 2,000 kg sand, duration: two hours.

H.2 Technical Description of Sand Cleaning plant

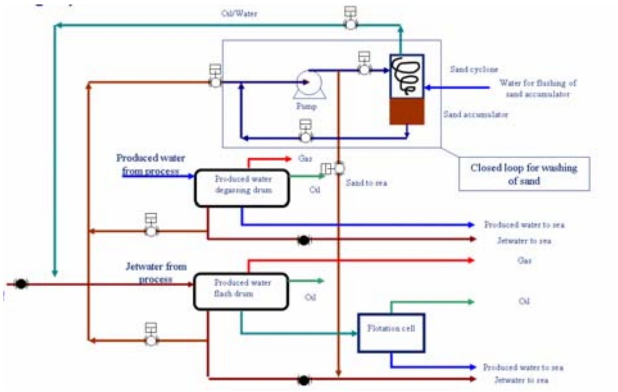


Figure H-1: Flow diagram of the complete sand cleaning plant

Figure H-1 shows a simplified flow diagram of the sand cleaning plant planned for installation at Statfjord A, B and C for sand cleaning.

The sand-cleaning unit is made up of a sand cyclone which is placed above a sand accumulator/ collection tank. The sand cyclone separates the sand from the jetting water and returns water and oil to the produced water tank for recovery. The sand is collected in the accumulator and stored until the jetting operation is completed or the accumulator is full.

The automatic sand-cleaning process is then started. The sand is washed out of the accumulator using seawater, and circulated in a closed loop until oil adhesion is less than one per cent by weight. The sand is then discharged to sea. The dispersed oil that is removed from the sand is routed back to the produced water tank.

The sand cleaning plant is designed for 750 kg of sand per day and is not based on maximum production. In the event that sand production reaches 2,000 kg/ day, jetting will take place several times a day in order for the plant to clean all of the sand. Jetting of such quantities of sand in connection with well testing, will take place mainly up to and including the year 2011. Thereafter, testing of the maximum sand rate will occur only sporadically.

H.3 Alternative Measures to Sand Cleaning

H.3.1 Rejected Measures

Other solutions that have been assessed, but rejected, with a view to meeting the authorities' requirement for less than one per cent by weight of oil adhesion to sand include:

1. Re-injection into the Utsira formation together with drill cuttings
2. Transport to shore
3. Deposition in storage cells

Using the re-injection system for drill cuttings for the handling of produced sand requires the use of sand cyclones. The sand must be degassed to atmospheric pressure and the quantity of sand in the water must be reduced before injection. In addition to the investment in sand cyclones, this solution entails relatively high operating costs, extra work loads on the operating and drilling personnel, and increased emissions to air.

Transporting the sand to shore will also entail the use of sand cyclones to separate the sand from the jetting water. Two solutions for transporting sand to shore have been identified: the use of "Big Bags" and the use of "Tote" tanks.

If the injection system for drill cuttings is not available, it is possible to fill the drill cuttings into so-called "Big Bags". This solution can also be used for sand. This solution is not recommended based on working environment considerations due to the hydrocarbon vapours.

A "Tote" tank in combination with a sand cyclone is, however, a possibility, since the sand would be stored in a closed system. Such a system would most likely have to be located on the top deck of one of the platforms, it would involve a lifting height of 30-40 metres, and the technical requirements for pump and transport solutions would be considerable.

The transporting of sand to shore was rejected first and foremost on account of working environment considerations. In addition, the costs associated with transport and on-shore disposal were high compared with cleaning of the sand on board the platforms before discharging it to sea.

Storing sand in storage tanks for crude oil was evaluated but rejected, because no existing pipelines in the cells could be used for this purpose. For structural reasons, it is moreover impossible to install new pipelines in the cells.

There are several other measures that have been assessed as alternatives to sand cleaning, to reduce any adverse short-term impacts that may occur in the water column. These measures have in common that they will not be able to meet the authorities' requirement for <1 per cent by weight of oil adhesion to sand; rather, according to the project's assessment, their environmental impact would correspond to or be greater than that of a sand cleaning plant.

H.3.2 Recommended Measures as an Alternative to a Sand Cleaning Plant

Sand control equipment is planned for installation in all new and most of the recompleted wells in SFLL. Installation is planned for implementation in the period from 2006 up to and including 2011. As mentioned before, and as shown inFigure 6-32, this will reduce sand production and discharges to a minimum.

Currently two sand detectors are installed on the inlets to the platforms to maintain good control of the quantity of sand produced. Monitoring will continue in SFLL. Statfjord also proposes the implementation of an improved measurement programme to achieve better estimates of per cent oil adhesion and quantities of dispersed oil. Improved control of sand production and improved control of discharges of oil can be utilised to optimise the jetting process and assess which measures are the most efficient.

Pre-jetting is partly carried out at the Statfjord field to reduce oil discharges in connection with discharges of sand. This measure entails that sand is cleaned in the produced water tanks before it is discharged to sea. During pre-jetting, seawater is injected through the jetting nozzles in short pulses, prior to the actual jetting, thereby lifting the sand from the bottom of the separator tanks without interrupting the separation process. Some of the oil adhering to the sand particles will be washed out in the produced water and will rise to the water surface together with the rest of the dispersed oil. The dispersed oil is captured through the oil phase in the tanks. When pre-jetting is finished, the sand sinks to the bottom of the tank before it is discharged to sea by jetting. Pre-jetting thus reduces the percentage oil adhesion to sand and the quantity of dispersed oil discharged in connection with jetting. The impact of such a procedure can be estimated on the basis of the proposed measurement programme in combination with the testing of pre-jetting.

Statfjord will continue to work on the evaluation of pre-jetting in combination with automatic jetting and the installation of sand detectors on the jetting water outlets. Automatic jetting is currently installed for the produced water tanks on SFB, while jetting is carried out manually on SFA and SFC. Pre-jetting is a time-consuming operation if done manually, and will increase the work load on the operators. Automatic jetting will reduce the work load and allow for better management of the jetting operations. Sand detectors on the jetting water outlets will also enable optimisation of the jetting process.

<u>Other measures that have been assessed, but rejected</u>

An increased jetting frequency was recommended by Akvaplan Niva/51 /as a measure to reduce any short-term impacts of jetting in the water column. The measure was rejected on the grounds that the operational disadvantages were greater than the benefits provided by the measure.

The sand cleaning plant could be simplified by removing the equipment connected to the sand cleaning process itself. The sand would then be routed through the sand cyclone only once before being discharged to sea. Dispersed oil separated from the sand would be returned to the process as described for the sand cleaning plant. The investment costs of a simplified cleaning plant would be the same as for a plant with a separate cleaning process, but would, based on the experience of other fields, pose fewer operational problems. This type of simplified sand treatment plant without a sand cleaning process would not meet the authorities’ requirement for less than one per cent by weight of oil adhesion to sand, but would reduce the amount of dispersed oil discharged with the sand (see the conditions used in the model scenarios above). The environmental benefit of the measure would be very low in relation to the costs.