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The Norwegian Oil Industry Association

Emissions and Discharges from the Exploration Activities

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Abstract:

The report summarises the emissions to air and the discharges to sea from the offshore activity related to exploration. The report is updated with emissions- and discharges data for 1998. Estimates are established for data which are not subject to reporting regulations.

Subject words:

Exploration Activities, Emissions & Discharges

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1 Summary and Conclusions

A summary of emissions and discharges from the exploration of oil and gas on the Norwegian continental shelf have been made, including a comparison with the total oil and gas industry. The first draft was issued 15.07.98 updated with numbers from 1996.

The total Norwegian offshore oil and gas activity (exclusive of marine and helicopter services) accounts for approximately **[1]:**

- 23 % of the national CO_2-emissions
- 13 % of the national NO_X-emissions
- 55 % of the nmVOC emissions
- 5 % of the CH_4-emissions.

The exploration activity's share of the offshore petroleum industry's emissions to air and the national emissions is presented in Table 1. National emissions are from SSB **[13]**. Exploration and total oil and gas numbers are from tables 5-10

Table 1 Summary of emissions to air.

Summary of Emissions from the Exploration Activities				
CO_2 mill. tonnes	NO_X 1000 tonnes	VOC tonnes	CH_4 tonnes	SO_X tonnes
0,32	6,7	0	5	184

Emission from Exploration as share of Total Oil and Gas Activities				
CO_2 %	NO_X %	VOC %	CH_4 %	SO_X %
3,7	12,5	0,3	0,02	12,5

Emission from Exploration as share of National Emissions				
CO_2 %	NO_X %	VOC %	CH_4 %	SO_X %
0,8	3,0	0,1	<< 0,01	0,6

NO_X is considered the most significant emission gas from the exploration activity. The reason is that all power generation in exploration is by diesel engines, having high specific NO_X-emission factors. The use of diesel engines also causes the relatively high share of SO_X from the exploration activity.

The exploration activities, including seismic surveys, marine support and helicopter traffic, accounts for approximately 25-30 % of the liquid fuel consumption in the

Norwegian offshore oil and gas industry. The share has a decreasing trend since 1996.

Combustion of oil during well testing contributes to the national emissions. Relative to the committed national emissions of PAH and dioxin the exploration activities account for 1% or less. For PCB, no comparision with national emissions are available. The knowledge of the emission of these compounds is still limited and the reported emission levels uncertain.

Exploration is a marginal contributor to the industry's operational discharges of oil (1 %). This number is equivalent to 0,01 % of the total oil input to the North Sea. The accidental discharges of oil, chemicals and drilling fluids are small.

Approximately 20 % of the chemical discharges from the offshore oil industry come from exploration drilling. Most of these discharges are chemicals on the State Pollution Control Authorities (SFT's) list A which are used in water based drilling fluid. The chemicals are not considered to represent any environmental hazards. For 1998 approximately 93 % of the total discharges of 28 000 tonnes from exploration drilling activities were chemicals on SFT's list A and water. Of the remaining quantity, only 55 tonnes or 0,2 % were chemicals prioritised for phasing out. Continuous work is going on to replace chemicals that are not environmentally acceptable.

The exploration activities are responsible for 2,3 % of the hazardous waste brought onshore.

2 Introduction

This report is based on a draft report which was originally the result of a work initiated by a OLF workgroup in 1998 The group should assess the environmental effects of the exploration drilling activity on the Norwegian continental shelf.

The work group wanted a brief report showing emission and discharge levels from the exploration activities. The report should give a status of emissions and discharges, including comparisons with total Norwegian offshore oil and gas activity. Historical trends should be indicated if information was available.

This report is extended and updated with 1997 and 1998 numbers. The emission and discharges overviews are based upon data from the following sources:

- Data presented in the emission reports for the industry, prepared annually by OLF
- Systematised background data from the NPD annual reports.
- Estimates of diesel consumption by supply- and standby vessels and helicopters.
- Estimates of diesel consumption by seismic survey vessels.

Availability of Data

From 1997 on, the oil companies have reported emission and discharge data split on exploration and production. For the previous years no such split of the data is available except if a comprehensive and time consuming new data recording process is done, using the oil companies discharge reports to SFT.

Where relevant, approximate trends have been made by scaling emissions based on drilling statistics presented in the NPD annual reports **[2]**.

Emissions from support activities, such as supply services, stand-by vessels, helicopter traffic are included in the report according to the scope of work, however, emissions from such activities are not required to be reported by the authorities in Norway in the same way as the emissions from the core petroleum activities. The availability of emission data from these activities is therefore very limited. Approximations of the emissions have been made through some dedicated studies during the preparing of this report. The results from these studies are used as a basis for the emission data that are presented in this report. The 1997 and 1998 numbers are based on these studies and scaled according to the activity level. Based on the experiences with the original version of this report the seismic industry (IAGC) has initiated a work at MARINTEK where the actual data are assembled. The result of this work will be ready for publication next year.

This study has been based on already available data.

3 Scope of Study

The report covers the emissions and discharges reported in the annual reports to SFT. In addition the report covers:

- Emissions and discharges from seismic surveys.
- Emissions from marine support vessels and helicopter transport for the exploration activities.

Emission and discharge data are given for 1997 and 1998. Data from previous years are included where relevant and/or good quality data are available.

4 Operational Emissions to Air

4.1 Emission Sources

The main emission sources are:

- Diesel engines. All marine vessels participating in the exploration activities use diesel engines for power and heat generation.
- Jet fuel for helicopters.
- Well testing. The most common practice is that produced oil and gas in the well test is burned, however, an option is to collect oil production from well tests by special ships.

4.2 Diesel Fuel Consumption.

Fuel consumption in 1996-1998 is shown in table 2.

Table 2 Diesel consumption in exploration activities.

Facility	Fuel type	Consumption [tonnes]			Comments
		1996	1997	1998	
A Exploration Facilities	Diesel	33 856	36 899	32 982	Note A: Good Quality Data
B Seismic Activities	Diesel	48 926	28 695	35 894	Note B: Estimates
C Marine Support Fleet	Diesel	21 453	27 705	21 991	Note C: Estimates
D Helicopter	Jet Fuel	995	1 285	1 020	Note D: Estimates
E Total		105 230	94 584	91 887	

Notes:

A. Based on the operators annual reports to SFT for 1996, 1997 and 1998.
B. Based on approximate data of specific fuel consume from PGS, scaled according to activity.
C. Based on calculated diesel consumption for supply and stand-by vessels for 1992 **[3]** and distributed between exploration and production in relation with activity levels for each year.
D. Calculated according to the same principles as C.

It should be noted that there has been no data or study available indicating split of fuel consumption on exploration activity for marine support vessels and helicopters traffic. The distribution given in table 2 is an estimate based on activity levels from the NPD annual reports. The diesel consumption estimate for supply and standby vessels for 1998 is controlled using a different method based on numbers from the Sleipner Vest Field. These number scaled for total activity gives approximately 22 000 tonnes.

For seismic activity the diesel consumption is based on an estimate for total activity, which do contain activity related to production.

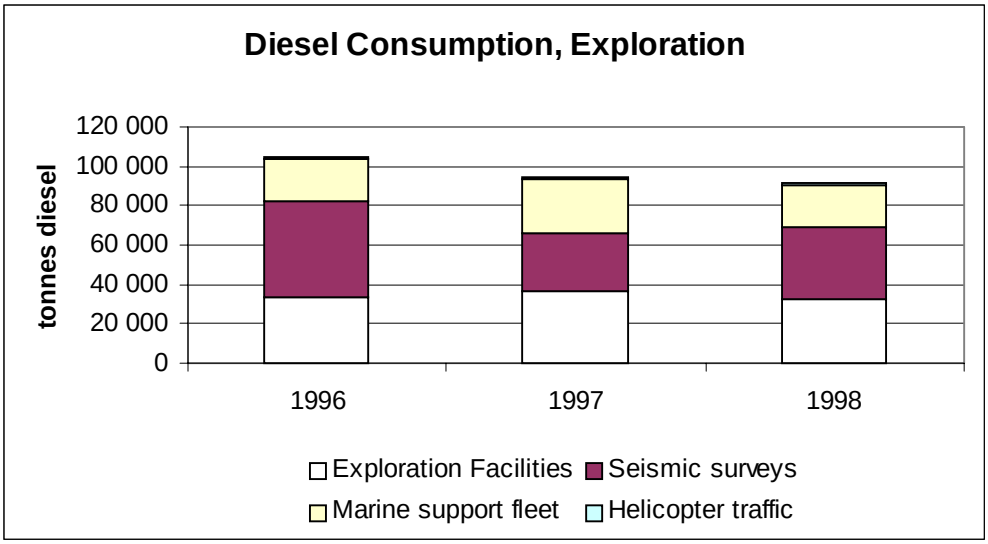

Figure 1 Diesel consumption in exploration activities from 1996 to 1998.

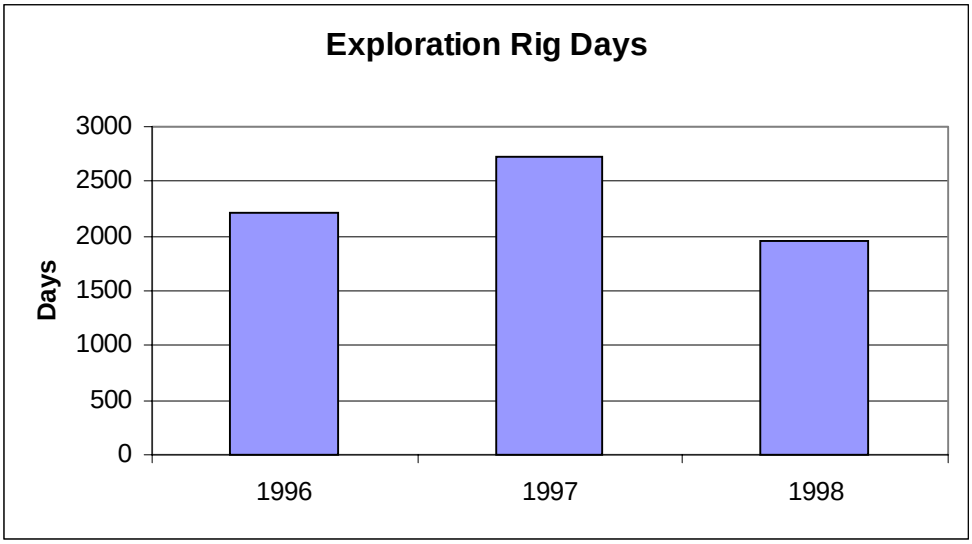

Figure 2 Exploration activity level represented by number of rig days **[2]**.

Figure 2 shows the development of the exploration activity represented by number of rig days. The activity can be compared with the diesel consumption on exploration

facilities in Figure 1 and Table 2. The diesel consumption is relatively higher in low activity years.

The seismic activity accounts for approximately 35 000 tonnes of diesel consumption for 1998. The activity level varies from one year to another but the diesel consumption pr. km. has dropped significantly from 1994 to 1998 for 3D seismic which dominates the market. The diesel consumption may depend on:

- Number of streamers pr. boat.
- Organisation of surveys among the oil companies.

The exploration activity's part of the total liquid fuel consumption within the offshore oil and gas activity is 25-30%. The reason being that all power generation is based on burning liquid fuel compared to the predominant use of gas fuel in the production activity.

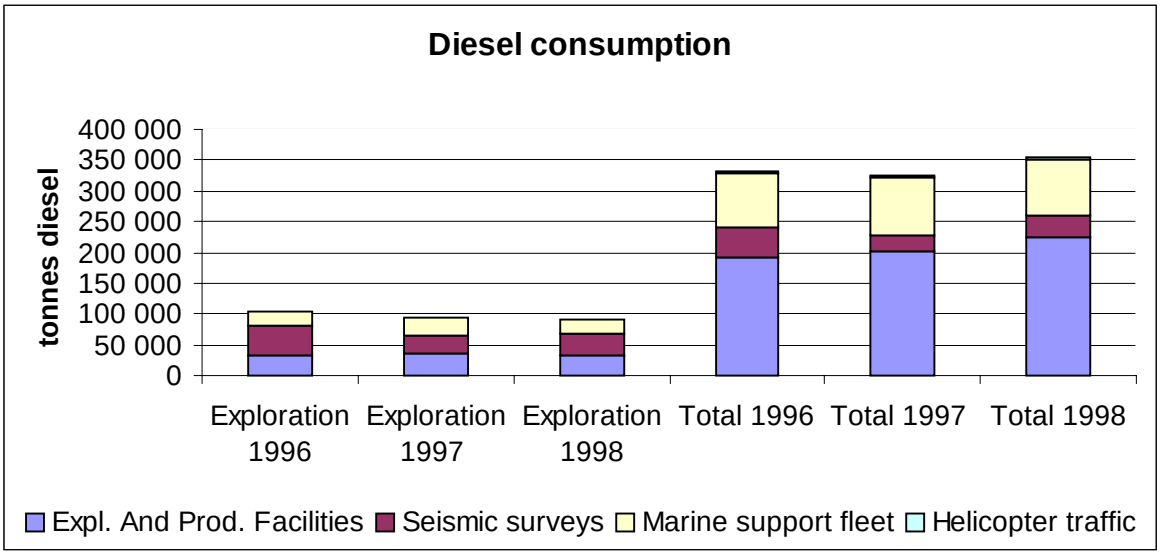

Figure 3 Consumption of liquid fuel in the Norwegian oil and gas activity. Exploration activity and total industry numbers are from table 2 and annual emissions and discharges reports **[4].**

4.3 Well Testing

Well test data are shown in table 3.

Table 3 Quantities of oil and gas burned in the period 1995 to 1998. Data for 1995 and 1996 are from NPD, while the 1997 and 1998 numbers are from annual reports to SFT. **[2]**, **[4]**

	Exploration		Total Activity	
Year	Gas burned 1000 Sm^3	Oil Burned Sm^3	Gas burned 1000 Sm^3	Oil Burned Sm^3
1995	17 000	15 000	22 000	17 600
1996	13 000	17 000	24 300	29 600
1997	4 700	3 200	11 700	34 900
1998	6 600	11 000	19 300	26 800

4.3.1 The Burner Tests at Tau

The tests were performed as a co-operation between Norsk Hydro as the owner of PL 169 and OLF, as a part of the OLF Environmental programme. Several full-scale burner tests were performed with two of the major service companies at North Sea Drilltrainer's facility at Tau, mainly to:

- Identify and try to quantify air emissions and oil fall out from offshore burners.
- Study the combustion process and identify ways to improve burner technology.

The results of the tests showed that emitted concentrations of CO, NO_X, CH_4 and nmVOC were considerably higher than permitted by Norwegian regulatory requirements for onshore waste incineration.

The tests also discovered small quantities of PAH and chlorinated organic compounds in flue gas and fall out.

These environmentally harmful compounds are anticipated to be formed as a result of the chlorine content in produced water associated with the oil, and possibly also by direct cooling of the flame by seawater. If the test should be representative with regards to these emissions, the emissions of dioxins from burning of oil during well testing would be less than 1 % of the total reported and concessed Norwegian PAH and dioxin emissions For PCB-emissions no references to national emissions are made **[5]**.

Oil discharges to sea from fall-out from well-testing is estimated to approximately 0,1 % of the total oil discharges from the Norwegian petroleum activities **[6]**. The quantities of micropollutants in the fall-out were negligible compared to the amount found in the flue gas.

The report identifies a number of possible improvements to reduce fall out and enhance combustion efficiency:

- Better training of personnel.
- Optimise water/oil ratio.
- Optimise water pressure/velocity.
- Optimise air pressure for atomisation of oil **[5].**

4.3.2 Burner Improvements since 1992.

As a follow-up of the tests at Tau, OLF has prepared a report summarising the development of burners after the Tau tests. The conclusions in this report is **[7]**:

Two of the major service companies, Halliburton and Schlumberger have greatly improved their burners since the tests in 1992. Halliburton did not participate in the tests at Tau but has developed a highly efficient burner capable of burning flowrates up to 4000 m^3/day without significant fall-out (0,025%) **[8]**. This burner has during testing proven a highly efficient combustion when burning regular oil. The burner has also proven efficient combustion with heavy oil when the oil was preheated (88 °C).

Schlumberger has been working on several burner modification and development projects since 1992. They have also through a business merge got access to efficient Canadian burners capable of burning flowrates up to 4000 m^3/day without significant fall-out.

4.4 Fugitive Emissions

OLF Environmental Programme **[9]** identified fugitive emissions of natural gas (CH_4 and nmVOC) from the handling of cuttings. The average emissions were calculated to 0,25 tonne CH_4 and 0,55 tonne nmVOC per production well. The study done by Aker Engineering **[10]** concludes with 4 main sources of fugitive emissions from production drilling operations:

- Shallow gas from drilling without riser.
- Migration and circulation of gas from reservoir.
- Gas migration due to poor casing and cement work.
- Treatment of oil based drilling fluids.

Similar statistical data do not exist for exploration wells. Assuming the same emission factor for exploration wells classified as discoveries and no emission from the other wells may give an indication of the emission level.

Table 4 Fugitive emissions from exploration wells.

	1996	1997	1998
Number of wells	30	50	26
Discoveries **[2]**	10	17	8
CH_4-emissions [tonnes]	2,5	4,3	2,0
nmVOC-emissions [tonnes]	5,5	9,4	4,4

For comparison the total Norwegian petroleum activities in 1998 were responsible for:

CH_4-emissions: 30 200 tonnes
nmVOC-emissions: 175 700 tonnes

Oil loading is the dominant source of these emissions **[6]**. The emissions from the exploration activities hence are negligible.

A quantification of the different sources was not done in the study but the major source of emissions from mud treatment is venting from mud pits only covered by grating. Assuming this source minimised since 1993 the major source of emission from drilling operations would be formation gas. Cuttings drilled with oil based drilling fluids is not allowed for discharges since 1993, hence the frequency of sections drilled with oil based drilling fluids during exploration activities has been reduced.

4.5 Summary of Emissions to Air from Exploration Activities

The emissions to air from exploration compared with total activity for 1996 to 1998 are shown in Table 5 to Table 10.

Table 5 Emissions to air from exploration activities in 1996.

1996 Exploration								
Source	CO2 tonnes	NOx tonnes	VOC tonnes	CH4 tonnes	SOx tonnes	Dioxin grams	PAH kg	PCB kg
Exploration Facilities	108 339	2 370	169		62			
Seismic Activities	156 562	3 425	245		90			
Marine Support Fleet	68 650	1 502	107		39			
Helicopter Traffic	3 184	70	5					
Fugitive emissions & Cold venting			6	3				
Oil Loading								
Well testing	76 600	209	49	3	35	0,145	173	3,2
Total	413 335	7 576	581	6	225	0,145	173	3,2

Table 6 Emissions to air from total petroleum activities in 1996.

1996 Total Activity								
Source	CO2 tonnes	NOx tonnes	VOC tonnes	CH4 tonnes	SOx tonnes	Dioxin grams	PAH kg	PCB kg
Expl. and Prod. Facilities	8 239 637	40 716	1 515	2 694	810			
Seismic Activities	156 562	3 425	245		90			
Marine Support Fleet	274 600	6 007	429		158			
Helicopter Traffic	12 736	279	20					
Fugitive emissions & Cold venting			3 000	5 000				
Oil Loading			166 400	21 200				
Well testing & maintenance	137 363	384	85	6	61	0,25	302	5,5
Total	8 820 898	50 810	171 694	28 900	1 118	0,25	302	5,5

Table 7 Emissions to air from exploration activities in 1997.

1997 Emissions to air								
1997 Exploration								
Source	CO2 tonnes	NOx tonnes	VOC tonnes	CH4 tonnes	SOx tonnes	Dioxin grams	PAH kg	PCB kg
Exploration Facilities	118 078	2 583	184	0	68			
Seismic Activities	91 823	2 009	143		53			
Marine Support Fleet	88 655	1 939	139		51			
Helicopter Traffic	4 112	90	6					
Fugitive emissions & Cold venting			9	4				
Oil Loading								
Well testing	21 405	50	16	1	12	0,03	33	0,6
Total	324 072	6 671	498	5	184	0,03	33	0,6

Table 8 Emissions to air from total petroleum activities in 1997.

1997 Total Activity								
Source	CO2 tonnes	NOx tonnes	VOC tonnes	CH4 tonnes	SOx tonnes	Dioxin grams	PAH kg	PCB kg
Expl. and Prod. Facilities	8 339 872	44 501	2 893	3 160	1 289			
Seismic Activities	91 823	2 009	143		53			
Marine Support Fleet	295 516	6 464	462		51			
Helicopter Traffic	13 706	300	21					
Fugitive emissions & Cold venting			5 113	9 349				
Oil Loading			183 502	19 388				
Well testing & maintenance	122 425	250	99	3	79	0,29	356	6,5
Total	8 863 342	53 524	192 233	31 900	1 473	0,29	356	6,5

Table 9 Emissions to air from exploration activities in 1998.

1998 Exploration Source	CO2 tonnes	NOx tonnes	VOC tonnes	CH4 tonnes	SOx tonnes	Dioxin grams	PAH kg	PCB kg
Exploration Facilities	105 541	2 301	164	0	89			
Seismic Activities	114 860	2 513	179		66			
Marine Support Fleet	70 372	1 539	110		41			
Helicopter Traffic	3 264							
Fugitive emissions & Cold venting			4	2				
Oil Loading								
Well testing	45 489	114	31	2	26	0,09	112	2,1
Total	339 526	6 467	490	4	221	0,09	112	2,1

Table 10 Emissions to air from total petroleum activities in 1998.

1998 Total Activity Source	CO2 tonnes	NOx tonnes	VOC tonnes	CH4 tonnes	SOx tonnes	Dioxin grams	PAH kg	PCB kg
Expl. and Prod. Facilities	8 914 805	44 533	1 818	2 856	754			
Seismic Activities	114 860	2 513	179		66			
Marine Support Fleet	293 217	6 414	458		41			
Helicopter Traffic	13 599	297	21					
Fugitive emissions & Cold venting			4 984	10 471				
Oil Loading			170 689	19 751				
Well testing & maintenance	118 283	316	77	5	46	0,23	273	5,0
Total	9 454 765	54 074	178 226	33 083	907	0,23	273	5,0

Based on the numbers in table 9 and 10, the contribution of the exploration activities to the overall emissions from the Norwegian offshore oil and gas activity in 1998 is shown in Figure 4.

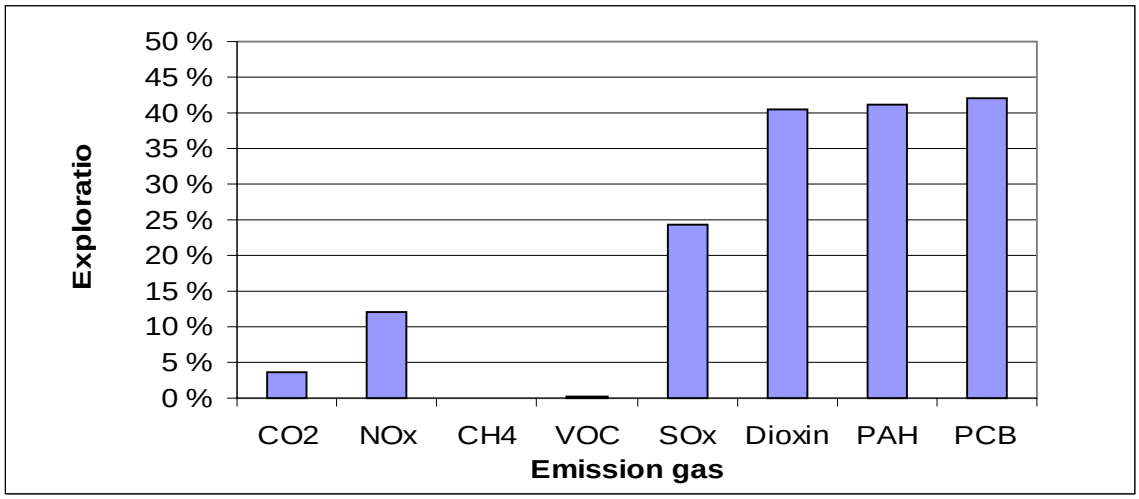

Figure 4 Exploration activity's contribution to emissions to air from the offshore oil and gas industry. All numbers are from 1998. The differences in the percentages between dioxin, PAH and PCB are due to rounding.

The larger contribution to the total NO_X- and SO_X-emissions is a result of the relatively high use of liquid fuel in the exploration activity compared to production. The exploration activity's share of CH_4 and nmVOC emissions is negligible.

Combustion of oil during well tests and well maintenance is the only recorded contributor to the emissions of PAH and dioxin to air from the oil and gas industry. Emission factors are not established in the reporting regulations.

It should be noted that the dioxins and PAHs are calculated based upon emission factors established during one single test programme **[5]**

To put the emissions from exploration into perspective. The total offshore oil and gas industry's contributions to the total national emissions are approximately **[1]**:

CO_2	=	23%
NO_X	=	13%
nmVOC	=	55%
CH_4	=	4%

The oil industry share of the national SO_X-emissions is not quantified.

The share of micro pollutants from respectively exploration activity and total oil and gas activity related to national committed and reported emissions is approximately **[11]**:

	Exploration	Total Activity
PAH	< 1 %	< 1 %
Dioxins	< 1 %	1 %

No records of committed national emissions of PCB are known.

A comparison of CO_2 and NO_X emissions with marine coastal traffic - and fishing activity based on SSB numbers show **[13]**:

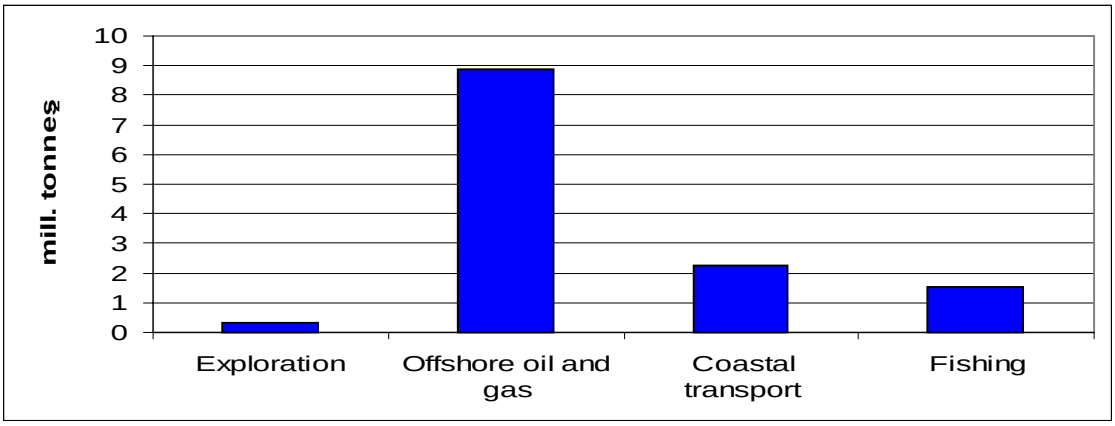

Figure 5 Emission of CO_2. Exploration, total offshore oil and gas industry, marine coastal transportation and fishing. Numbers for exploration are from Table 7. Total offshore oil and gas are from Table 8. All emissions are 1997 numbers.

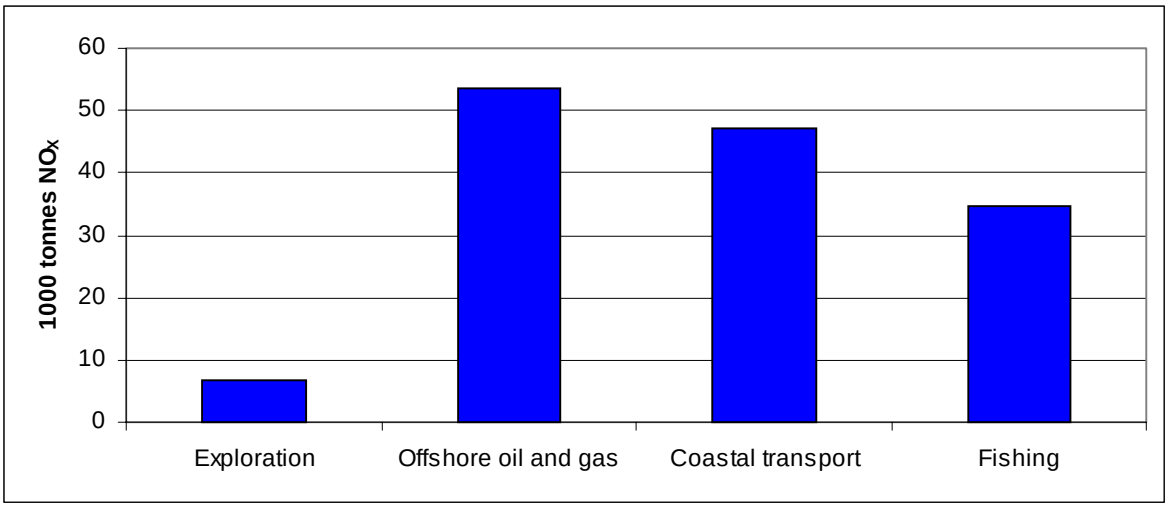

Figure 6 Emission of NOx. Exploration, total offshore oil and gas industry, marine coastal transportation and fishing **[13].** Numbers for exploration are from Table 7. Total offshore oil and gas are from Table 8. All emissions are 1997 numbers.

The 1998 data from SSB is currently only preliminary.

5 Discharges from drilling operations

5.1 Drilling Operations

The drilling of a typical exploration well starts after the conductor pipe (large diameter) has been set. The conductor shoe is typically set around 100–200m below seabed. The first section is normally drilled with seawater as drilling fluid in an open system (no riser from seabed to rig installed). In areas where shallow gas are expected, the riser is normally installed prior to spudding. Exploration wells are usually drilled with water based drilling fluids but oil based drilling fluids are being used in demanding sections of the well. For exploration wells only water based drilling fluid and cuttings can be discharged, hence oil based and synthetic drilling fluids and cuttings has to be transported onshore for destruction or reinjected to the formation.

A total of 26 exploration and appraisal wells were started in 1998. The historical development is shown in Figure 7.

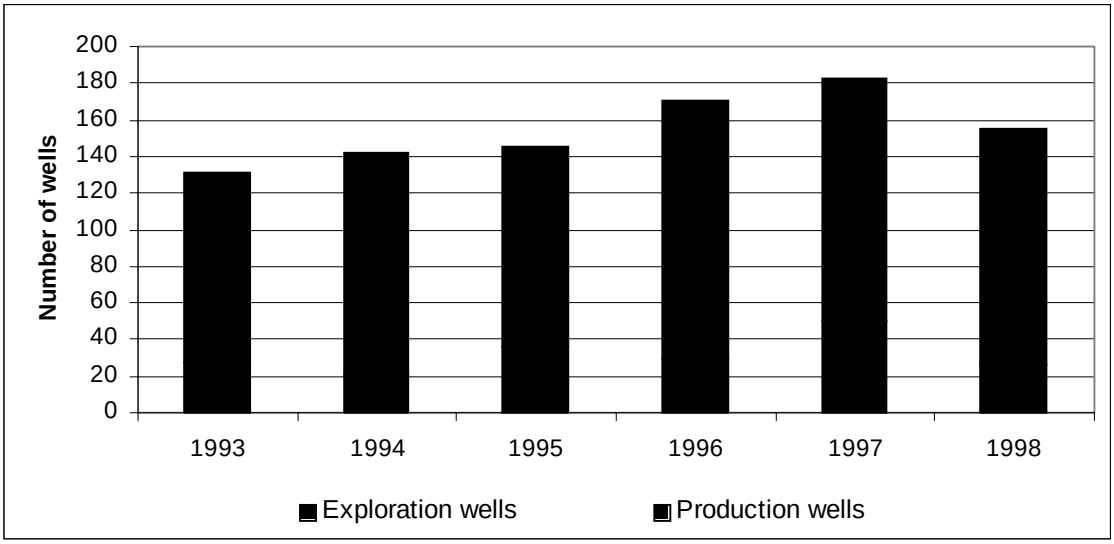

Figure 7 Summary of exploration and production drilling from 1993 to 1998 **[2]**.

Drilling data is presented in the tables 11-14 below. Prior to 1997 numbers distributed by exploration and production of drilling discharges and drilling waste was not reported.

Table 11 Key figures for drilling with water based drilling fluids in 1998 and 1997 **[6]**.

	Generated Cuttings [tonnes]	Drilling fluid consumption [m3]	Drilling fluid discharges [m3]	Drilling fluid discharges [tonnes]	Length of wells [m]
Exploration Activities 1998	22 557	56 197	46 461	58 541	53 705
Production Activities 1998	57 953	136 468	112 346	145 117	159 404
Sum 1998	80 510	192 665	158 807	203 657	213 108
Exploration Activities 1997	28 439	64 377	61 215	81 018	77 876
Production Activities 1997	69 665	152 467	125 760	164 871	157 217
Sum 1997	98 104	216 844	186 975	245 889	235 093

Table 11 shows that the exploration activity is a major contributor to discharges of water based drilling fluids and cuttings. Both cuttings and used water based drilling fluids are allowed for discharges.

Table 12 Drilling with oil based drilling fluids in 1998.

	Generated Cuttings [tonnes]	Drilling fluid consumption [tonnes]	Cuttings and drilling fluids [tonnes]	Base oil consumption [tonnes]	Length of wells [m]	Number of wells [m]
Exploration Activities	2 556	4 664	7 228	2 042	16 337	7
Production Activities	45 677	66 578	112 255	22 951	175 566	63
SUM	48 233	71 242	119 484	24 993	191 903	70

Table 12 shows that exploration activities account for less than 10% of the total drilling activities with oil based drilling fluids. Neither oil based drilling fluids nor cuttings are allowed for discharges, hence the quantity in column "Cuttings and drilling fluids" must be disposed off by reinjection or by transportation onshore for treatment. This disposal is shown in Table 13.

Table 13 Disposal of cuttings and used drilling fluids from oil based drilling fluids in 1998.

	Cuttings and used fluids [tonnes]	Discharges [tonnes]	Imported from other field [tonnes]	Exported to other field [tonnes]	Reinjected [tonnes]	Onshore treatment [tonnes]
Exploration Activities	7 228	0	1 490	760	1 813	6 144
Production Activities	112 255	0	760	0	88 725	22 433
SUM	119 483	0	2 250	760	90 538	28 577

Table 14 Key figures from drilling with synthetic drilling fluids in 1998.

	Generated Cuttings [tonnes]	Drilling fluid consumption [tonnes]	Length of wells [m]	Number of wells [m]	Cuttings and drilling fluids [tonnes]	Disposal of cuttings and embedded drilling fluids		
						Discharges to sea [tonnes]	Reinjected [tonnes]	Onshore treatment [tonnes]
Exploration Activities	1 696	3 057	5 719	1	4 752	4 752	0	0
Production Activities	13 475	23 064	76 581	26	36 603	29 904	5 212	1 046
SUM	15 171	26 121	82 300	27	41 355	34 656	5 212	1 046

The exploration activity use mainly water based or oil based drilling fluids, in 1998, only one well was drilled with syntethic drilling fluids. For exploration drilling where discharge permits are not applied for, cuttings embedded with drilling fluids must be disposed off by reinjection or by transportation onshore for treatment. The disposal is shown in Table 14 in the 3 last columns.

5.2 Chemicals

Figure 8 show the development in discharges of chemicals from 1995 to 1998. Discharges of drilling chemicals from exploration are compared with discharges from production activities.

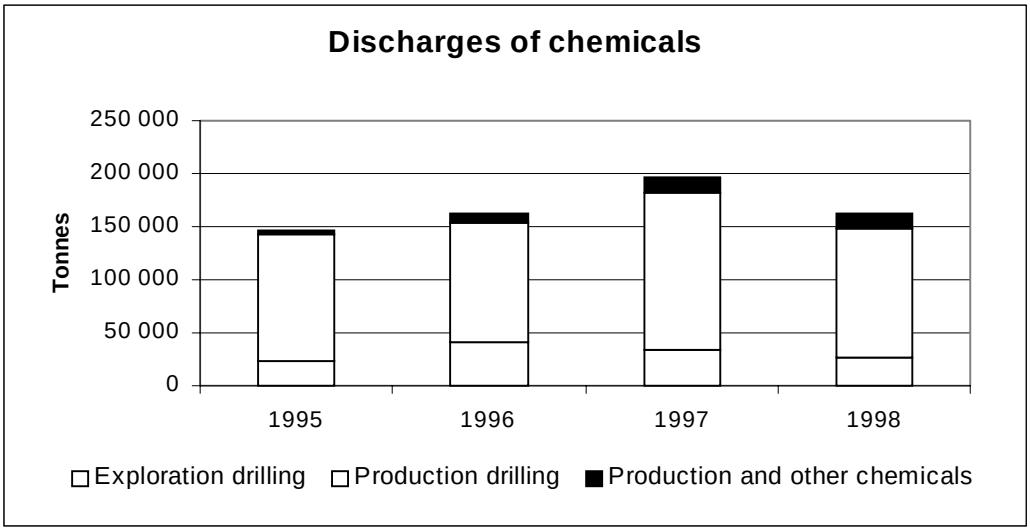

Figure 8 Discharges of chemicals from exploration drilling and from the total oil and gas production activity for the years 1995-98

Overviews of chemicals discharged distributed by environmental properties are available for 1997 and 1998 only. These are presented in Figure 9. The terms green, yellow and red chemicals used in the figure are explained in Chapter 9.3

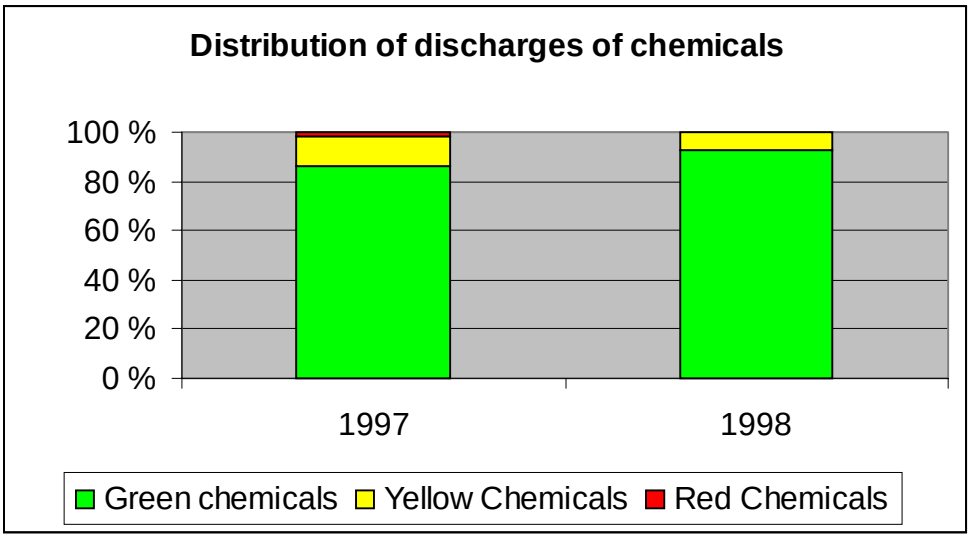

Figure 9 Discharges of chemicals distributed by environmental properties.

Approximately 20 % of the chemical discharges from the offshore oil industry come from exploration drilling. Most of these discharges are chemicals on the State Pollution Control Authorities (SFT's) list A which are used in water based drilling fluid. The chemicals are not considered to represent any environmental hazards. For 1998 approximately 93 % of the total discharges of 28 000 tonnes from exploration drilling activities were chemicals on SFT's list A and water. Of the remaining quantity, only 55 tonnes or 0,2 % were chemicals prioritised for phase-out **[4].**

Continuous work is going on to replace chemicals that are not environmentally acceptable.

The long-term effects of the discharges of the large quantities of drilling chemicals from exploration activities are less focused than those from production since the discharge periods at each exploration field are short.

6 Discharges of Oil

The dominant sources of discharges of oil from exploration activities are general spills and fall-out from burning of oil during well testing .The discharges from well testing is based upon estimated discharge factors established as a result of the well testing test at Tau in 1992. Recent improvements in burner technology **[8]** indicate discharges 4 times lower than the number calculated in the OLF study **[5]**. Discharge data according to the discharge factors established in the Tau test are shown in Table 15.

Table 15 Discharges of oil from the exploration activity, tonnes.

Source/tonnes of oil	1995	1996	1997	1998
Drain water		< 0,1	< 0,1	< 0,1
Well testing	13	15	3	9
Spills	3	6	5	0,4
Totals	16	21	8,0	9,4

The discharges from well testing if factors from improved burner technology are used would be:

1995: 3200 kg 1996: 3600 kg 1997: 700 kg 1998: 2300 kg

Compared to the oil discharges during oil and gas production, the contribution from exploration is practically negligible (<< 1 %).

According to the OLF Environmental Programme, **[9]** the total Norwegian offshore oil exploration and production activity contributed in 1991 with approximately 1% of the total oil input to the North Sea. The main sources are rivers (59 %), and oil and gas production activities in other countries (21 %).

7 Accidental Discharges

Data showing accidental discharges from the exploration activity are available for from 1995 on. The numbers do not include marine- and seismic activity

Table 16 Overview of accidental discharges from the exploration activity and total activity respectively.

Exploration Activities			
Year	Oil [tonnes]	Chemicals and drilling fluids [tonnes]	Gas (halon) [kg]
1995	3	19	n.a.
1996	6	23	n.a.
1997	5	68	0
1998	0,4	63	45
Total Activities			
Year	Oil [tonnes]	Chemicals and drilling fluids [tonnes]	Gas (halon) [kg]
1995	146	96	n.a.
1996	62	165	n.a.
1997	92	558	1298
1998	157	664	982

The numbers in Table 16 are from OLF **[6]** Quantities in m^3 are converted to tonnes using a specific weight of 0,85 kg/cm^3 for oil and 1,3 kg/cm^3 for chemicals and drilling fluids.

The seismic activity causes accidental discharges of streamer fluids, of which the most common is kerosene. Discharges can occur when the streamers are damaged. No available data exists however the industry practice has since 1990 been to bring used streamer fluid onshore for disposal or regeneration **[12]**.

Accidental discharge of seismic survey streamer fluid is specific to the exploration activity. The environmental properties of these fluids are not known.

8 Hazardous waste

The hazardous waste generated during exploration activities is dominated by oil based drilling fluid and cuttings. 848 tonnes of hazardous waste were generated during exploration activities in 1998.

The hazardous waste generation from total activities were 36 000 tonnes in 1998.The exploration share of the total quantity was 2,3 % in 1998.

The distribution is shown in Table 17.

Table 17 Hazardous waste brought onshore (tonnes).

	Exploration	Total Activities
Oil containing waste	454,2	17627,5
Drilling waste	380,9	17499,4
Chemical containing fluids	1,9	526,4
Batteries	2,1	79,7
Paint	4,9	121,3
Spray boxes	0,1	4,9
Fluorescent tubes and bulbs	0,3	25,1
Medical waste	< 0,1	0,1
NORM/LSA	< 0,1	< 0,1
Blast sand	< 0,1	0,7
Explosives	< 0,1	< 0,1
Other	3,9	282,2
Sum	848	36167

9 Enclosures

9.1 Graphic Presentations of Emission Summaries for CO_2 and NO_X

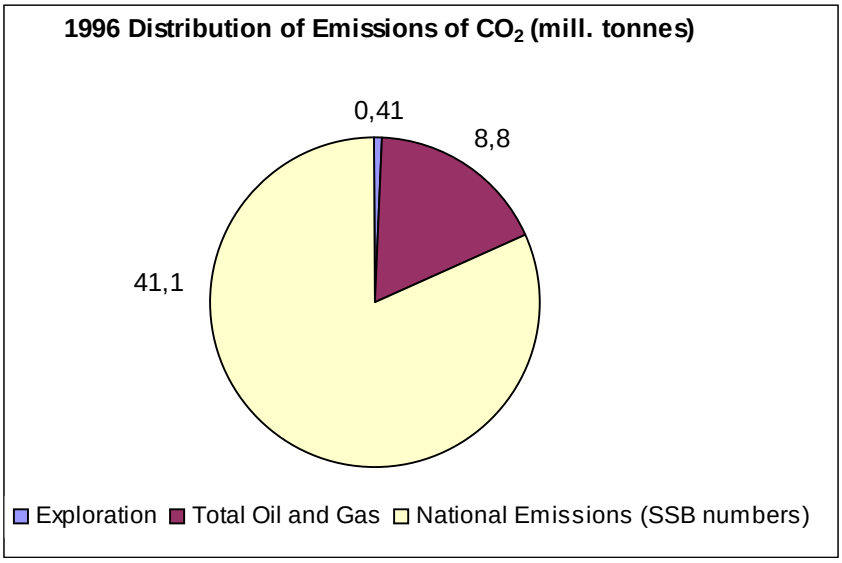

Figure 10 Emissions of CO_2 from exploration activities in 1996 relative to total oil and gas and national emissions.

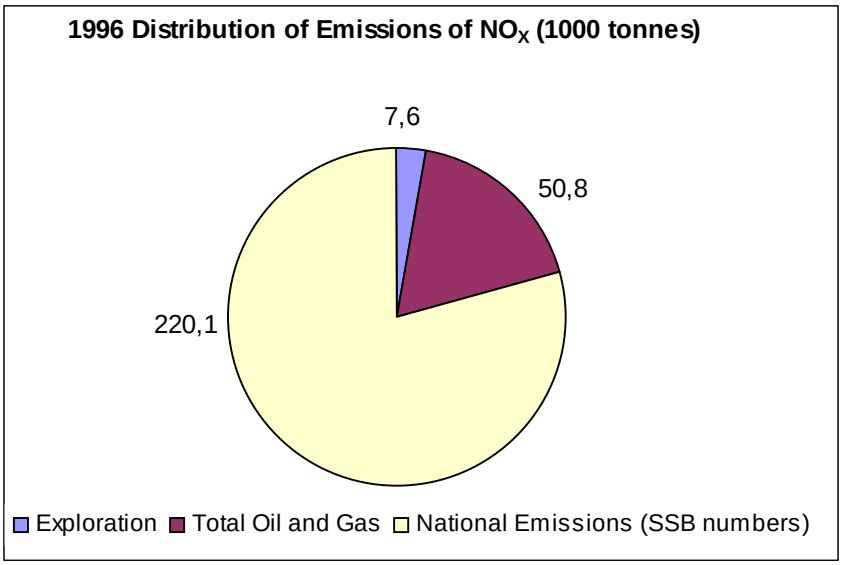

Figure 11 Emissions of NO_X from exploration activities in 1996 relative to total oil and gas and national emissions.

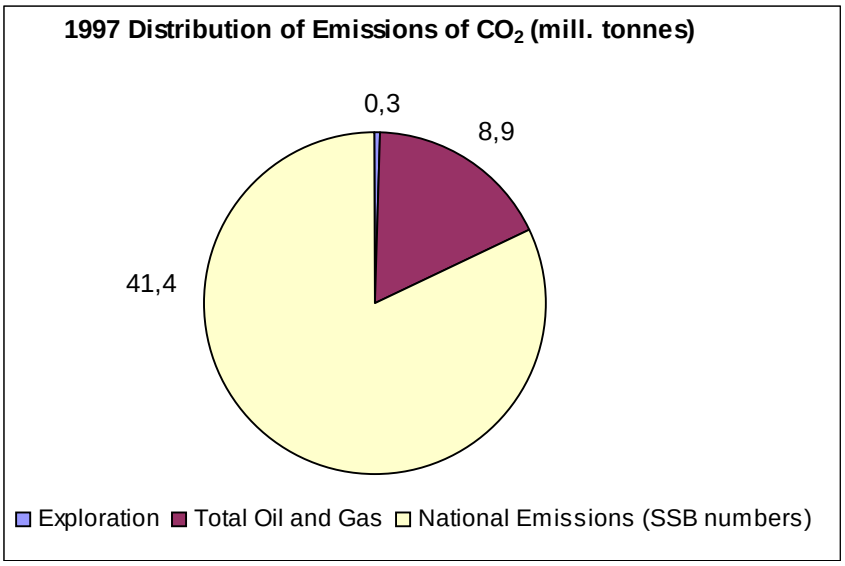

Figure 12 Emissions of CO_2 from exploration activities in 1997 relative to total oil and gas and national emissions.

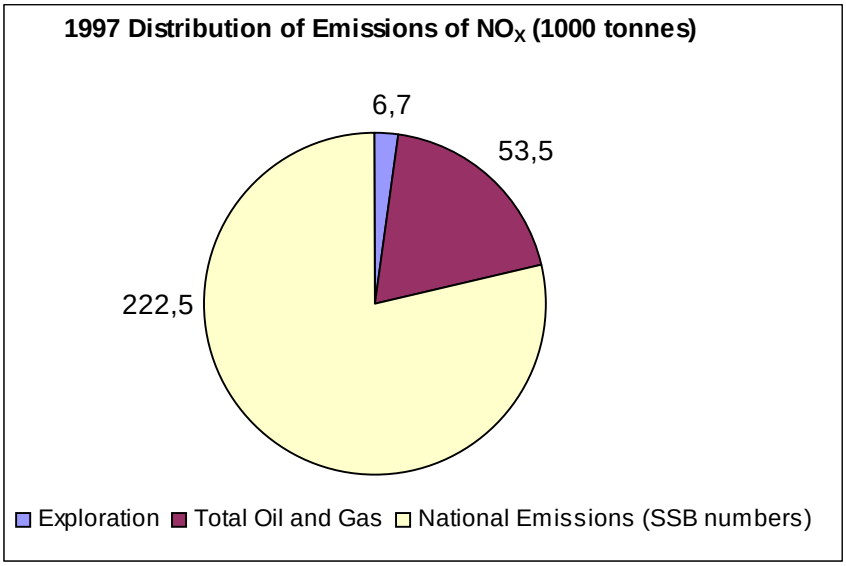

Figure 13 Emissions of NO_X from exploration activities in 1997 relative to total oil and gas and national emissions.

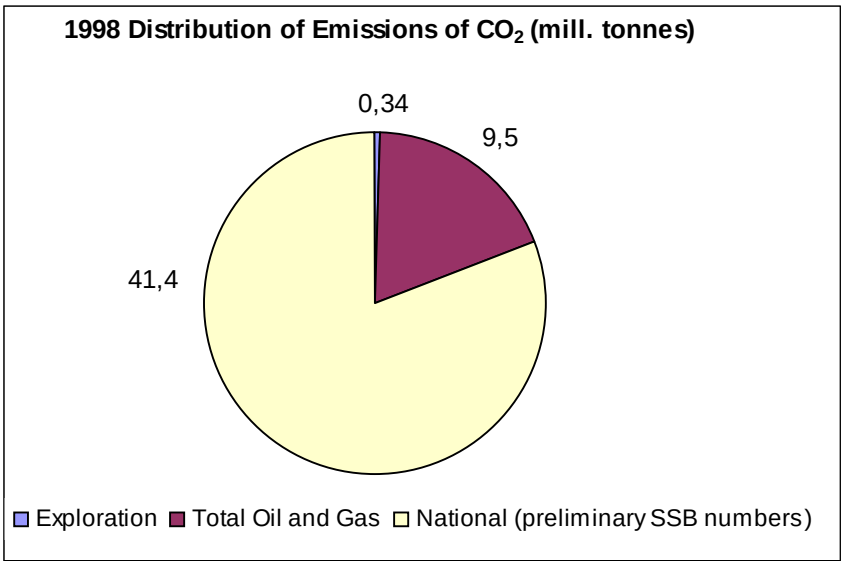

Figure 14 Emissions of CO_2 from exploration activities in 1998 relative to total oil and gas and national emissions.

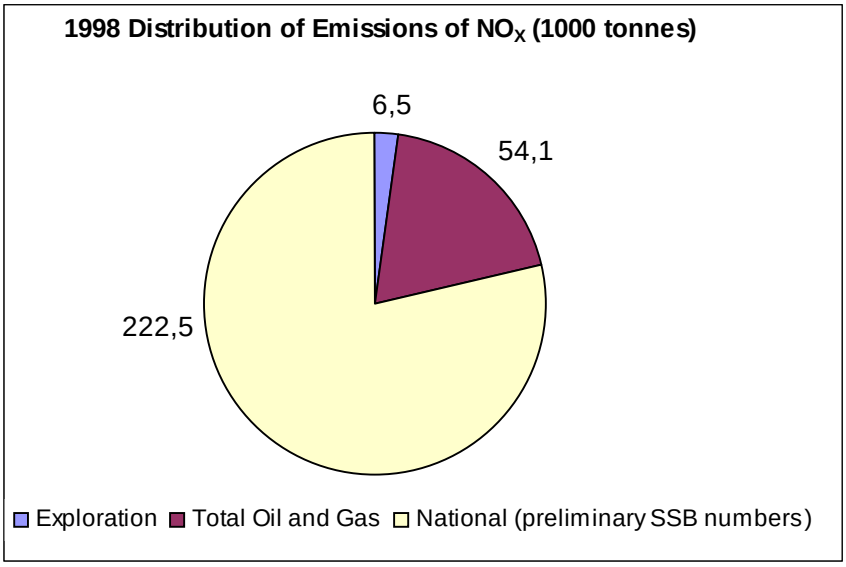

Figure 15 Emissions of NO_X from exploration activities in 1998 relative to total oil and gas and national emissions.

9.2 Emissions and Discharges Factors

For PAH, PCB and dioxins the following factors are used **[5]:**

Table 18 Emission factors for micropollutants from combustion of oil over burner boom.

PAH:	$12*10^{-6}$ kg/kg oil
Dioxin:	$10*10^{-12}$ kg/kg oil
PCB:	$220*10^{-9}$ kg/kg oil

For all other emissions to air the following factors are valid:

Table 19 OLF's emission factors for combustion with natural gas as fuel.

Emission gas	**Fuel – natural gas**				
	Gas turbine	Boilers	Gas-engines	Gas-flaring	Well-testing
CO_2 (tonne/Sm^3 gas)	$2,34 * 10^{-3}$	$2,34 * 10^{-3}$	$2,34 * 10^{-3}$	$2,34 * 10^{-3}$	$2,34 * 10^{-3}$
NOx (tonne/Sm^3 gas)	$5,16 * 10^{-6}$ *		See below		
CO (tonne/Sm^3 gas)	$1,7 * 10^{-6}$		"	$1,5 * 10^{-6}$	$1,5 * 10^{-6}$
N_2O (tonne/Sm^3 gas)	$0,019 * 10^{-6}$		"	$0,020 * 10^{-6}$	$0,020 * 10^{-6}$
CH_4 (tonne/Sm^3 gas)	$0,91 * 10^{-6}$		"	$0,24 * 10^{-6}$	$0,24 * 10^{-6}$
NmVOC (tonne/Sm^3)	$0,24 * 10^{-6}$		"	$0,06 * 10^{-6}$	$0,06 * 10^{-6}$

* Industrial turbines ** Air-derived turbines *** Low- NO_X gas turbines
The OLF standard factors are not available for boilers and gas engines for all emission gases except CO_2

Table 20 OLF's emission factors for combustion with diesel oil or crude oil as fuel.

Emission gas	**Fuel - crude oil/diesel oil**			
	Gas turbine	Engines	Boilers	Well-testing
CO_2 (tonne/tonne oil)	3,20	3,20	3,20	3,20
NO_x (tonne/tonne oil)	$16 * 10^{-3}$	$70 * 10^{-3}$ *		$3,7 * 10^{-3}$
CO (tonne/tonne oil)	$0,7 * 10^{-3}$	$7 * 10^{-3}$		$18 * 10^{-3}$
N_2O (tonne/tonne oil)		$0,2 * 10^{-3}$		
CH_4 (tonne/tonne oil)	-	-		
VOC (tonne/tonne oil)	$0,03 * 10^{-3}$	$5 * 10^{-3}$		$3,3 * 10^{-3}$
SO_2 (tonne/tonne oil)**	$2,8 * 10^{-3}$	$2,8 * 10^{-3}$	$2,8 * 10^{-3}$	

* To be used when engine specific factor is not known.
** Based on a sulphur content in oil of 0.14 %
Lack of data indicates that no factor is available.
- indicates that the emission is negligible.

9.3 Abbreviations and Explanations

nmVOC:	non methane Volatile Organic Compounds
PAH:	Poly Aromatic Hydrocarbons
PCB:	Poly Chlorinated Biphenyls
OLF:	Oil Industry Association
NPD:	Norwegian Petroleum Directorate
SFT:	State Pollution Control Authorities
SSB:	Statistics Norway.
Appraisal Wells	Wells drilled after a discovery to verify the size.

Chemicals grouped according to environmental properties:

Green chemicals:	Chemicals listed on SFT's list A, list B and from 1998 on also water.
Yellow chemicals:	Chemicals that are not prioritised for phase-out which is not qualified as green chemicals.
Red chemicals:	Chemicals prioritised for phase-out and chemicals not allowed for discharges according to the following properties or categories:

- MiBu box 6.2 A or B[1]
- Log P_{OW} > 5 and BOD < 20%
- Alkyl phenols, phtalates and bisphenol A
- BOD < 20
- Log P_{OW} > 3 and BOD < 60%

The above categories for red chemicals are for 1998, the 1997 categories are slightly different.

[1] St meld 58 – Miljøvernpolitikk for en bærekraftig utvikling

9.4 References

[1]: St meld nr 46 (1997-1998) Olje- og gassvirksomheten, OED 1998.
[2]: NPD Annual Reports 1995 – 1998.
[3]: NO_X Emissions from Norwegian Offshore Petroleum Industry, OLF 1997.
[4]: Annual Emissions and Discharges Reports from operators to SFT.
[5]: Emissions and Discharges from Well Testing, OLF Project C01, 1994
[6]: Emissions and Discharges from the Norwegian Petroleum Industry, OLF 1998.
[7]: Kjelås & Kviljo: Well Test Burners, a status report, OLF 1994.
[8]: Halliburton Burner Test, Fall-out from Well Test Burners, Final Report 1994.
[9]: OLF Environmental Programme, OLF 1993.
[10]: Direct Hydrocarbon Emissions, OLF Project C05, 1993.
[11]: Numbers for committed national emissions from SFT, no reference available.
[12]: Note from, and telephone call with Erik Haugane, PGS
[13]: Statistics Norway (SSB) 1997 data. Data for coastal transport may include transport related to the petroleum activity.