Environmental monitoring of oil and gas fields in Region II, 2018

Summary report

STIM

STIM Environment Report 29-2019

Content

Summary

On behalf of Equinor Energy AS, Fishguard Environment Department Bergen conducted the environmental monitoring of Region-II Sleipner area in 2018. (Please note that Fishguard became STIM on September 1, 2019).

The following fields were included with regular follow-up surveys: Gaupe North and South, Sleipner East and West, Volve, Gina Krog, Varg, Glitne, Gudrun, Svalin C, Jotun, Alvheim, Heimdal, Byggve, Atla, Vilje, Johan Sverdrup, Edvard Grieg, Ivar Aasen, Grane, Balder, Bøyla, Volund, Skirne and Ringhorne. In addition, a baseline survey was carried out at Utgard, Langfjellet and Grand, as well as two new templates at Johan Sverdrup and Balder. Samples were also taken at 13 regional stations. The Ringhorne field was followed up with new stations in addition to sectioned sediment samples due to previous discharges.

The sample collection was conducted from 22 May to 5 June 2018 with MS Olympic Orion. Surveys were hired from Fugro AS. In total, samples were collected from 282 stations.

- As in 2015, the region was divided into three sub-regions. Northern subregion consists only of the Langfjellet field, while the Shallow subregion and Central subregion consist of four and 23 fields respectively in this year's survey.
- Analyzes of Total Organic Carbon (TOC) conducted for the first time in 2015 have been followed up. The highest average proportions of TOC are found at Langfjellet and Ringhorne. At the regional stations, as well as five fields, both average values and maximum values are somewhat lower in 2018, compared to 2015.
- For the first time arsenic has been analyzed in Region-II. For the determination of the Limit of Significant Contamination (LSC) for arsenic, only this year's data from the regional stations is used and the estimate is therefore uncertain. Most fields have average values at or very close to LSC, besides Gaupe Nord, Varg and Ringhorne with average values well above LSC.
- Only Ringhorne and Sleipner Vest had average values of THC above 50 mg/kg. In addition, Langfjellet, Volve and Jotun had maximum values above 50 mg/kg. Twelve fields had average THC concentrations above LSC, and 2 fields had average THC concentrations approximately at LSC.
- Barium had average concentrations above LSC in 12 fields. The highest average values were found on Grane, where there has been extensive drilling activity and on Ringhorne where there has been a leakage of oil from the ground.
- The highest metal concentrations were found at Ringhorne and the station 250 m southwest of the Bøyla field center.
- The fauna in the area around the leakage point at Ringhorne was still affected.
- One or more of the outermost stations were contaminated by THC (>LSC) in 16 fields. The total area with THC> LSC is 15.47 km^2. The total area with THC> 50 mg/kg is 0.80 km^2. Only Ringhorne had bottom fauna defined as affected, with an area of 0.17 km^2.
- In general, in 2018 there was a connection between drilling activity, leaks and emissions and the levels of hydrocarbons and metals in the sediment.

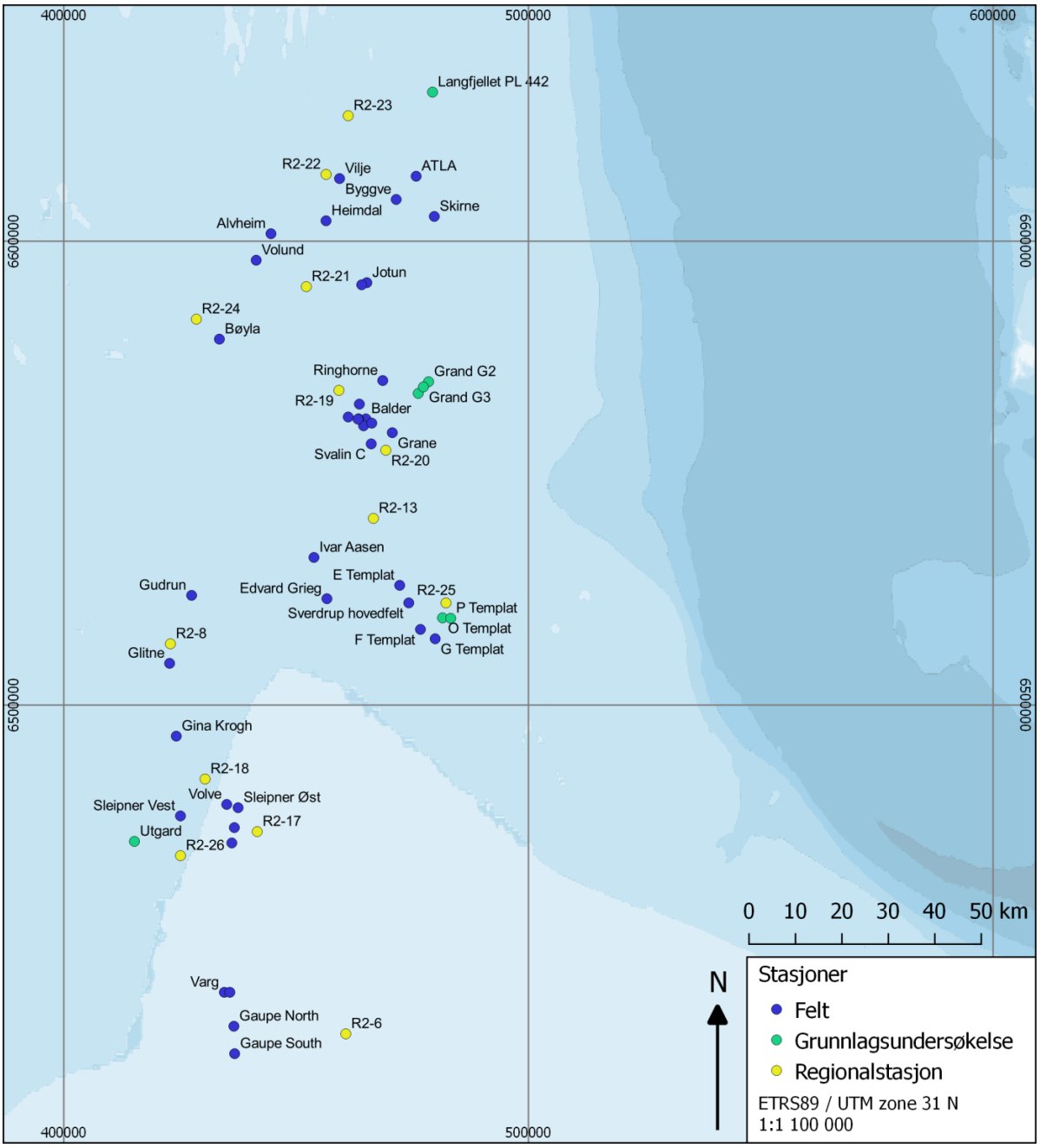


Figure 1. Overview of fields included in the monitoring in Region-II in 2018. Blue: fields. Green: baseline surveys. Yellow: regional stations.

Table 1 Overview of the fields included in the monitoring of Region-II in 2018

Operator	Field	Type of survey in 2018	Subregion
Shell	Gaupe South & North	Follow-up survey	Shallow
Equinor	Sleipner West	Follow-up survey	Central
	Sleipner East	Follow-up survey	Shallow
	Johan Sverdrup	Follow-up survey	Central
	Johan Sverdrup templates	Baseline surveyr	Central
	Glitne	Follow-up survey	Central
	Grane	Follow-up survey	Central
	Svalin C	Follow-up survey	Central
	Heimdal	Follow-up survey	Central
	Volve	Follow-up survey	Shallow
	Gudrun	Follow-up survey	Central
	Utgard	Baseline survey	Central
	Gina Krog	Follow-up survey	Central
	Grand	Baseline survey	Central
Point Resources	Balder	Follow-up survey	Central
	Jotun	Follow-up survey	Central
	Ringhorne	Follow-up survey	Central
Repsol	Varg	Follow-up survey	Shallow
Total	Byggve	Follow-up survey	Central
	Atla	Follow-up survey	Central
	Skirne	Follow-up survey	Central
AkerBP	Bøyla	Follow-up survey	Central
	Volund	Follow-up survey	Central
	Alvheim	Follow-up survey	Central
	Vilje	Follow-up survey	Central
	Ivar Aasen	Follow-up survey	Central
	Langfjellet (PL 442)	Baseline survey	Northern
Lundin	Edvard Grieg	Follow-up survey	Central

1 Introduction

The summary report summarizes the most important results from the Region II environmental monitoring carried out by Fishguard Environment on behalf of Equinor Energy AS in 2018. The purpose of the study was to study environmental effects from the petroleum activity in the region.

In total, samples were collected from 282 stations distributed across 28 fields, as well as associated templates and regional stations (Table 1 and Figure 1). The samples collected have been examined for physical characteristics, chemical content and bottom fauna. Samples were collected for analysis of THC and metals in the sediment from all fields. Geological and biological samples were taken from 14 fields in addition to the regional stations.

The survey follows up on previous surveys conducted in 2015, 2012, 2009, 2006, 2003, 2000 and 1997. In addition, Baseline surveys from 2013 (Volund), 2011 (Atla and Bøyla), 2010 (Gaupe Nord and Sør), 2005 (Vilje), 2004 (Alvheim) and 2002 (Byggve and Skirne) are followed up.

2 Fieldwork and analysis

Sampling was conducted from 22 May to 5 June 2018 with MS Olympic Orion. Surveys were hired from Fugro AS. In total, samples were collected from 282 stations with the number of samples for analysis of the various parameters presented in Table 2. The results of analysis of perfluorinated compounds (PFAS) are not presented in the 2018 report. Sampling followed the updated program reported in Fishguard Environment Note 06-2018.

Table 2. Number of samples for analysis of the various parameters in Region II 2018.

Analysis	Fauna	Grain size/TOC	THC	NPD/PAH	Metals	Radioactivity	PFAS
N.o. samples	821	161	854	382	842	78	15

Grabs were used for bottom sampling. The samples collected were examined for physical characteristics, chemical content and bottom fauna. Sample collection, sample preparation and processing of the results were carried out in accordance with the Directorate of the Environment's M-300 | 2015, rev. 2016 - Environmental monitoring of offshore petroleum activities. Specific procedures are described in NS-EN ISO 5667-19 for sediment sampling, and NS-EN ISO 16665 for bottom fauna, as well as accredited internal procedures of Fishguard Environment, Eurofins Environment Testing Norway AS and their subcontractors. All sampling personnel received extensive training prior to the survey and/or have long experience of soft bottom sampling in Fishguard. All sampling was logged, along with equipment ID, any incidents or nonconformities that could be of significance. The samples were frozen (chemistry and support parameters) or fixed on formalin (fauna) as quickly as possible to prevent degradation.

Limit of Significant Contamination (LSC)

Based on data analyzes of the regional stations, the region was previously divided into three sub-regions: Northern, Central and Shallow. To obtain the most robust data base for LSC for THC and metals, LSC was calculated from all available data from the regional stations from 1997 up to and including 2018 (Table 3). The changes in calculated LSC values in 2018 were relatively small compared to previous calculations. For arsenic (As *) that was first monitored in 2018, values were calculated from data from the regional stations in 2018.

Table 3 shows the calculated Limit of Significant Contamination (LSC) values from 1997 to 2018 for chemical parameters (THC, PAH, NPD, Ba, Cd, Cr, Cu, Hg, Pb and Zn) at regional stations in the three sub-regions (Northern, Central and Shallow). Values are given in mg / kg dry weight.

		THC	PAH	NPD	Ba	Cd	Cr	Cu	Hg	Pb	Zn	As*
LSC northern	1997-2018	10,0	0,032	0,015	43	0,022	5,8	1,2	0,007	4,1	7,7	#
LSC shallow	1997-2018	6,8	0,030	0,016	22	0,027	11,4	1,1	0,006	6,3	9,9	#
LSC central	1997-2018	11,0	0,126	0,045	150	0,034	10,5	2,7	0,012	6,8	14,4	2,2
LSC reg II	1997-2018	10,0	0,110	0,04	131	0,031	10,3	2,3	0,01	6,2	12,8	2,8

not enough data

3 Status for the Region

Regional stations

The concentration of hydrocarbons measured as THC, NPD and PAH-16 was low at the regional stations and the THC content had decreased at all stations compared to previous years. The highest concentrations of THC, NPD and PAH-16 were found in the Central subregion. Compared to historical studies, metal concentrations were generally lower in 2018 than in previous years. Regarding hydrocarbons and metals, the regional stations appear to be undisturbed.

Radioactivity

Analyzes of radioactive isotopes (226-Ra, 228-Ra, 228-Th, 210-Pb and 40-K) in sediments at the Jotun, Alvheim, Grane and Balder fields in the Central subregion gave low concentrations and were approximately at the same level as the regional station R2-21. The remaining fields were not analyzed for radioactive isotopes.

Grain size distribution of the sediment

The sediment in Region II consisted mainly of very fine / fine sand, accounting for 81% to 98% of the sediment. The variation was greatest on Ringhorne and Grand (Figure 2). The content of gravel in the sediment was usually below 4%, but at some stations at Ringhorne and Grand the gravel content was above 20% (Figure 3). The average pelite content of the sediment ranged from 2 to 16%. The lowest proportion of pelite was found on Varg (1%) and the highest on Volund (20%) (Figure 4).

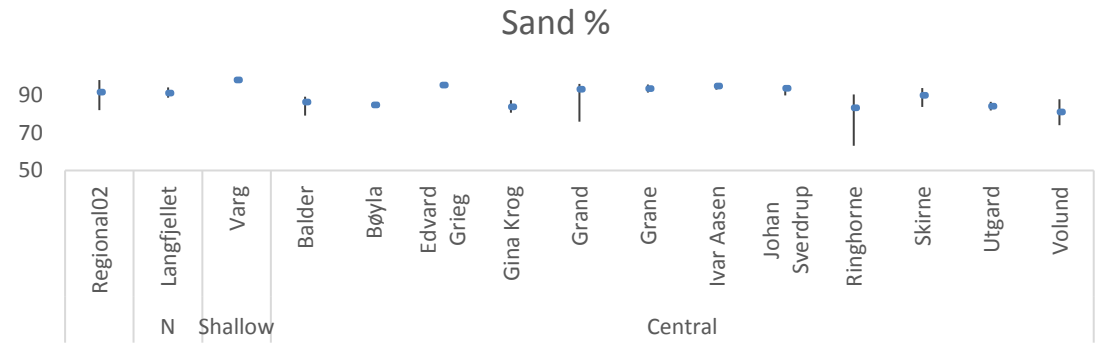


Figure 2 Average, minimum and maximum concentrations of sand (%) in 2018, measured in one mixed sample per station. N=Northern subregion. Note that the y-axis starts at 50%.

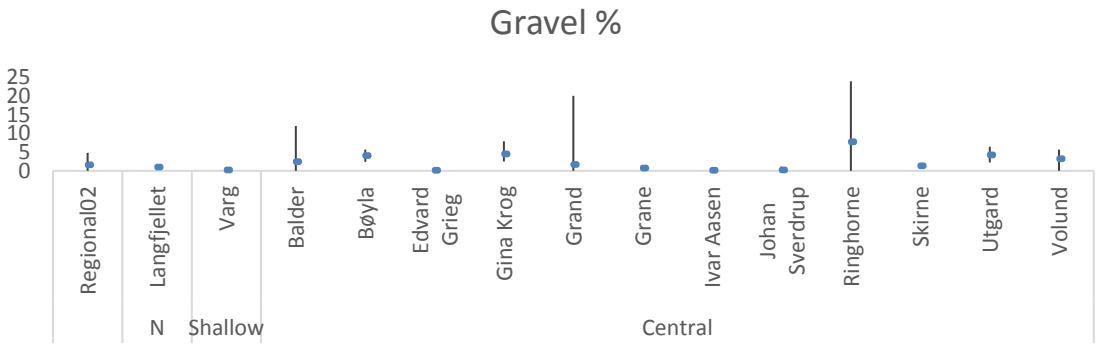


Figure 3 Average, minimum and maximum concentrations of gravel (%) in 2018, measured in one mixed sample per station. N=Northern subregion.

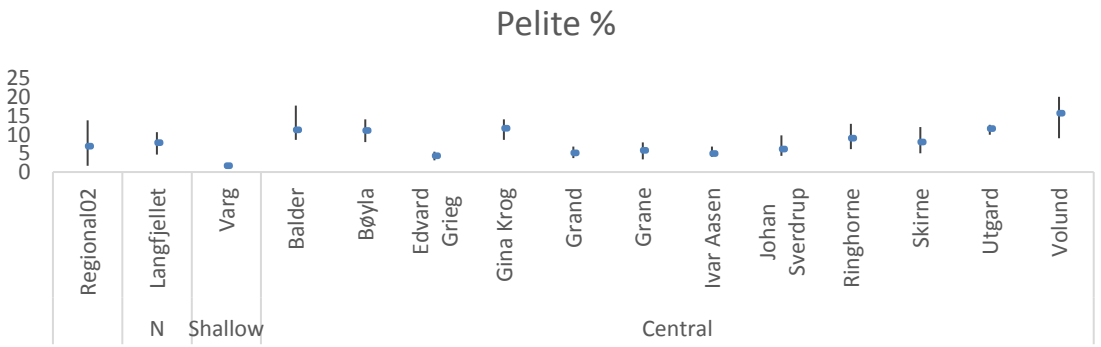


Figure 4 Average, minimum and maximum concentrations of pelite (%) in 2018, measured in one mixed sample per station. N=Northern subregion.

Total Organic Carbon (TOC)

TOC has previously only been monitored in 2015 in Region II. The highest average proportions of TOC in 2018 were found on Langfjellet and Ringhorne and are probably related to leaks from the seabed (Figure 5). At Johan Sverdrup, there is a single value that leads to a high maximum value and is probably a measurement error. Apart from that, a slight decline has been observed in terms of average value and maximum value at regional stations, as well as the fields Balder, Bøyla, Edvard Grieg, Grane and Volund. None of the fields has had increasing average TOC proportions in the sediment.

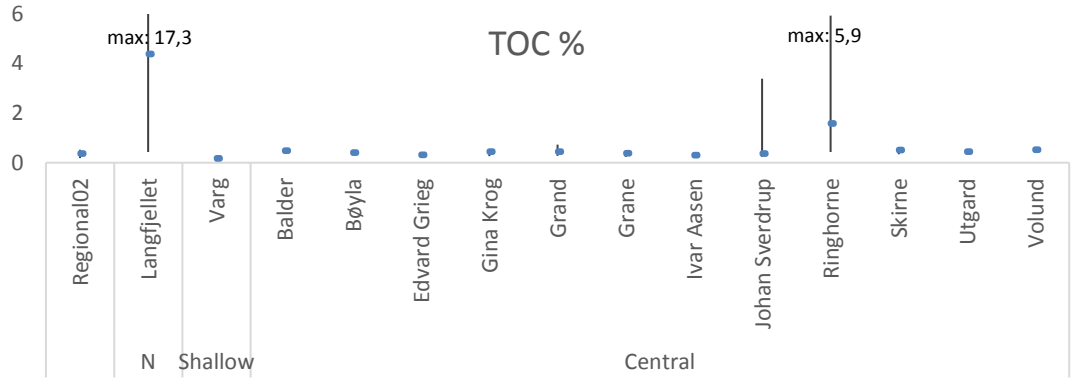


Figure 5 Average, minimum and maximum concentrations of TOC (%) in 2018, measured in one mixed sample per station. N=Northern subregion. The highest value at Johan Sverdrup is probably a measurement error.

Hydrocarbons

At Ringhorne, concentrations of total hydrocarbons (THC) at the stations around the field center ranged from 25 to 60 mg / kg dry matter (TS) with an average of 39 mg / kg. The highest concentrations on Ringhorne were found at the leak point west of the field center, where concentrations ranged from 90 to 79,000 mg / kg THC (Figure 6). The stations located between the field center and the leak point had higher THC concentrations than in 2015. Apart from the Ringhorne leak area, no fields had an average THC concentration above 50 mg / kg.

Disregarding Ringhorne, Langfjellet and Sleipner Vest had the highest concentrations at individual stations with respectively 41 and 60 mg / kg THC. At Langfjellet, where a baseline survey was conducted, oil-based mud (OBM) has seeped out in connection with exploration drilling.

At Byggve THC was above 30 mg / kg at the station 265 m north of the field center. There has been an external gas leak, but it is uncertain whether the leakage and THC concentration can be seen in context. In most other cases where there were THC concentrations above LSC, this was related to activity and emissions in the fields.

At Bøyla and Edvard Grieg, where sediment concentrations of THC in 2015 were at 174 mg / kg and 144 mg / kg, levels had dropped to 20 mg / kg and 8 mg / kg in 2018.

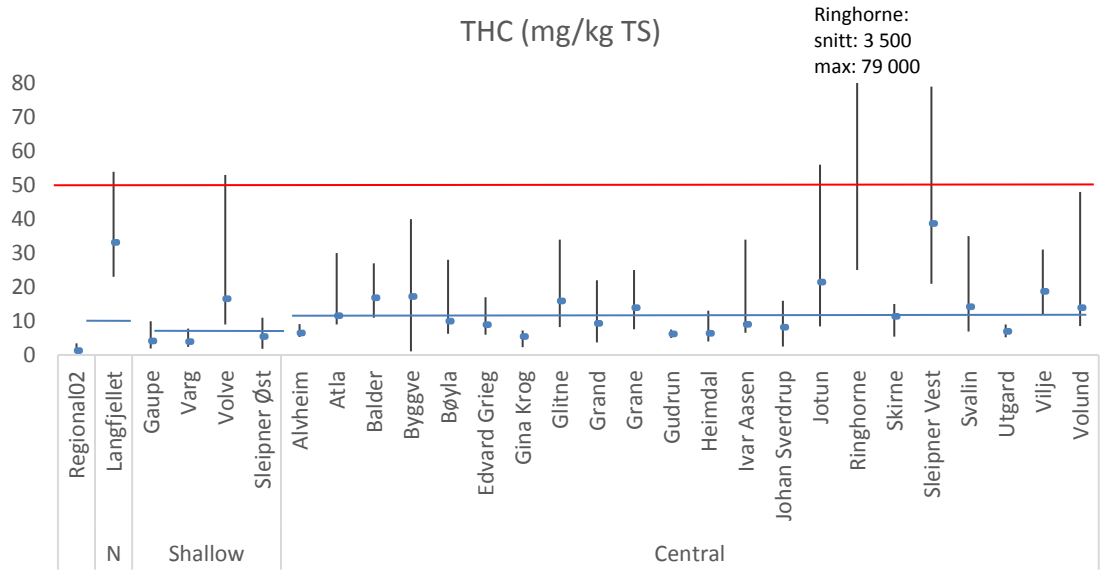


Figure 6 Average, min and max. concentrations of THC (mg / kg dry matter (DM)) in 2018, based on three replicates per station. N = Northern subregion. LSC for THC is highlighted in blue for the different subregions. Red line marks 50 mg / kg DM.

Metals

The concentrations of metals in the sediment were somewhat lower in the shallow subregion than in the central, which can be seen in context of bottom depth and sediment type.

Barium concentrations in the sediment ranged from 4 to 1700 mg / kg (Figure 7). The average concentration of barium was highest at Grane and Ringhorne. There has been extensive drilling activity at Grane during the last three-year period. At ten of the fields monitored in 2018, the average concentration of barium concentration was above 2xLSC. One station at Bøyla, which had a barium concentration of 7713 mg / kg in 2015, had dropped to 1013 mg in 2018.

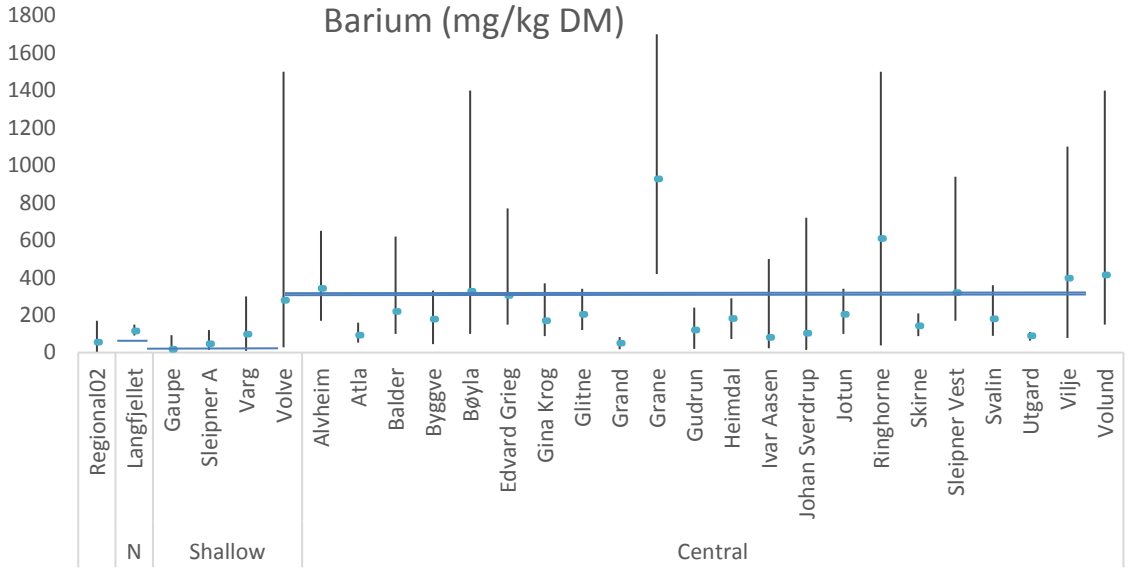


Figure 7 Average, min and max. concentrations of barium (mg / kg DM) in 2018, based on three replicates per station. N = Northern subregion. LSCx2 for barium is marked with blue bar for the different subregions.

Mercury ranged from 0.001 to 0.055 mg / kg (Figure 8). The average concentrations were below LSC for all the surveyed fields in 2018 and were mostly lower than in 2015. The highest maximum concentrations were found at Ringhorne and Byggve, followed by Regional stations. The leak at Ringhorne is probably the cause of the increased concentrations here. There has been a gas leak at Byggve, but this is not expected to have affected the mercury concentration.

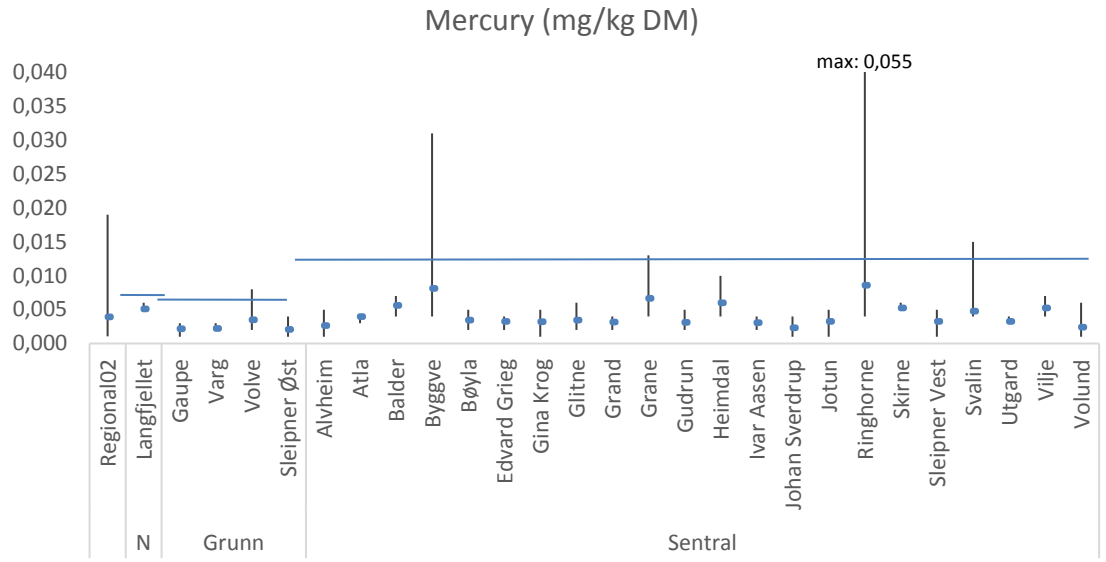


Figure 8 Average, min and max. mercury concentrations (mg / kg DM) in 2018, based on three replicates per station. N = Northern subregion, Grunn= Shallow subregion. Sentral= Central subregion. Mercury LSC is marked with blue bars for the different sub-regions.

Cadmium concentrations ranged from 0.005 to 0.290 mg / kg (Figure 9). The average concentrations were slightly above LSC for three of the studied fields; Ringhorne and Langfjellet, probably because of leaks; as well as Bøyla, where a station with an unidentified top layer had levels of several metals above LSC.

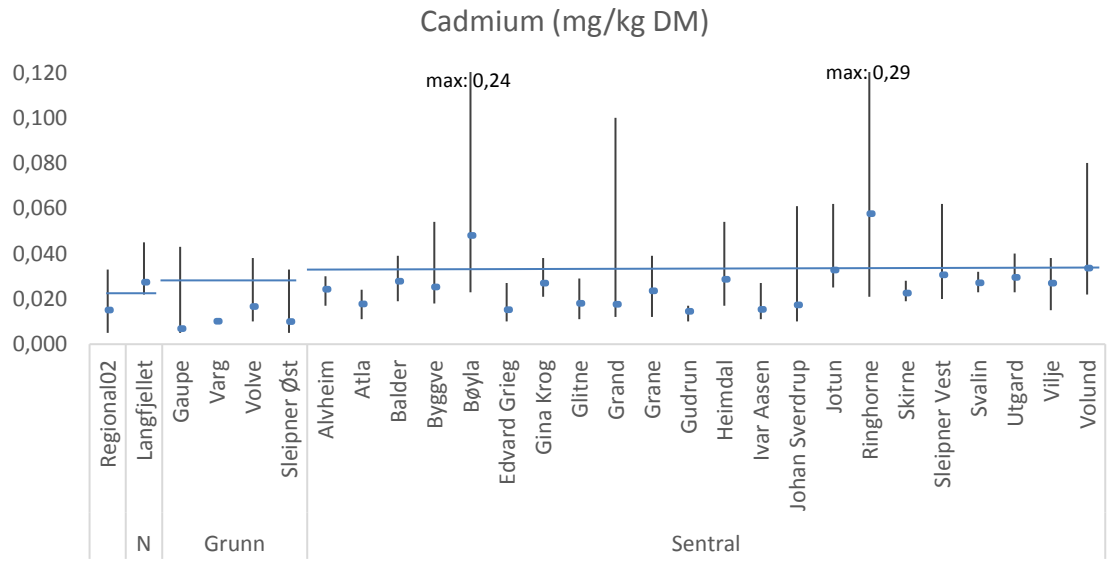


Figure 9 Average, min and max. cadmium concentrations (mg / kg DM) in 2018, based on three replicates per station. N = Northern subregion, Grunn= Shallow subregion. Sentral= Central subregion. Cadmium LSC is marked with blue bars for the different sub-regions.

Zinc concentrations ranged from 2.9 to 190 mg / kg (Figure 10). The average zinc concentrations were slightly above LSC for seven of the studied fields, with the highest mean value at Bøyla due to the station with the unidentified top layer in the sediment.

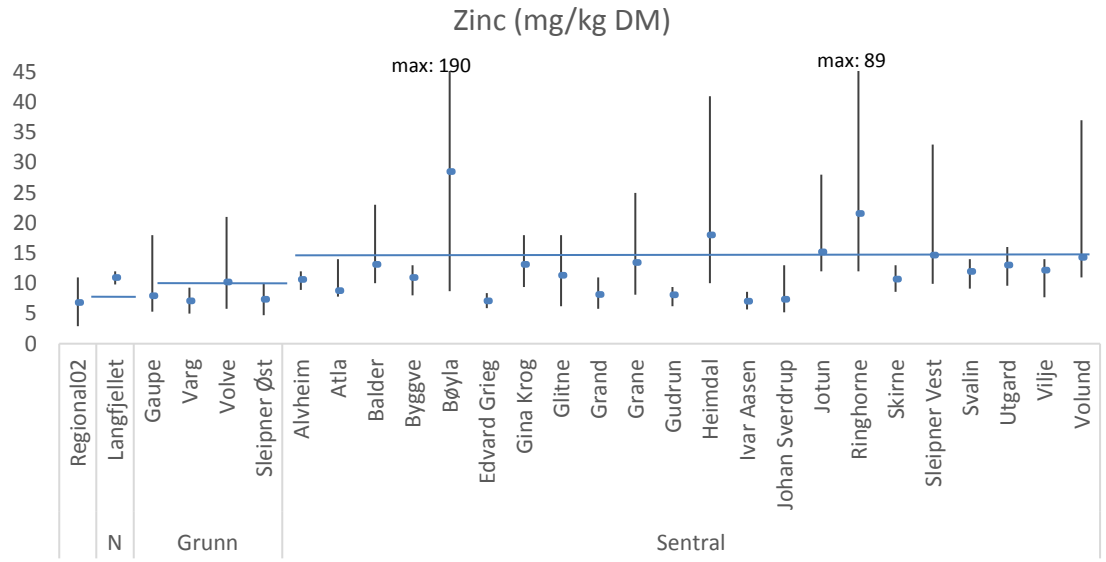


Figure 10 Average, min and max. zinc concentrations (mg / kg DM) in 2018, based on three replicates per station. N = Northern subregion, Grunn= Shallow subregion. Sentral= Central subregion. Zinc LSC is marked with blue bars for the different sub-regions.

Lead concentrations ranged from 2.2 to 24 mg / kg (Figure 11). The average concentrations were slightly above LSC on Langfjellet, where there has been a leak. Heimdal and Sleipner Vest had average concentrations well above LSC. The highest concentration was found at Bøyla.

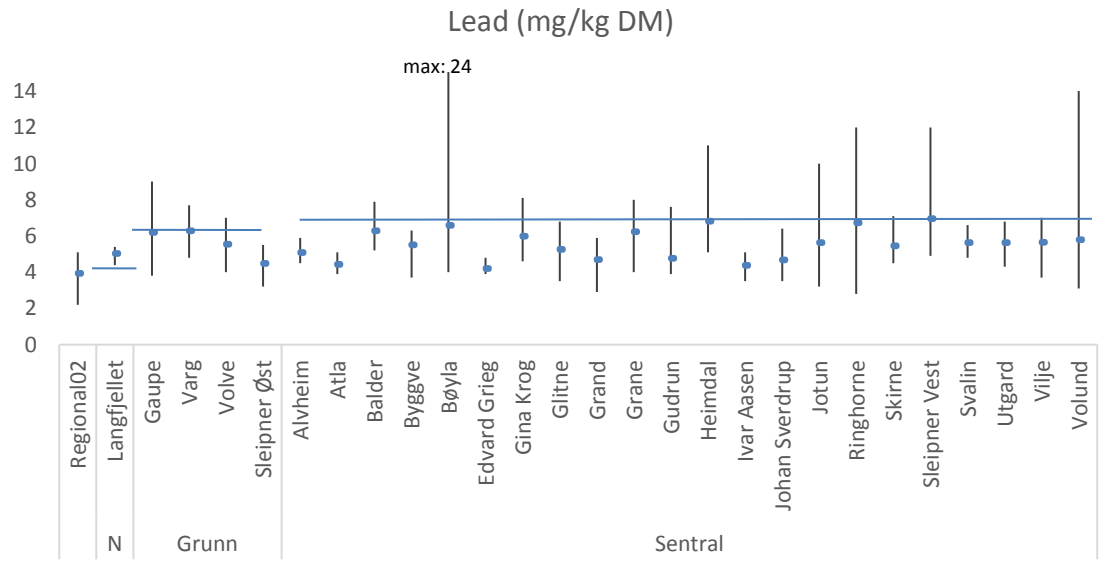


Figure 11 Average, min and max. lead concentrations (mg / kg DM) in 2018, based on three replicates per station. N = Northern subregion, Grunn= Shallow subregion. Sentral= Central subregion. Lead LSC is marked with blue bars for the different sub-regions.

Copper concentrations ranged from 0.25 to 180 mg / kg (Figure 12). The average concentrations were slightly above LSC at eight of the studied fields. The highest concentration was found at Bøyla.

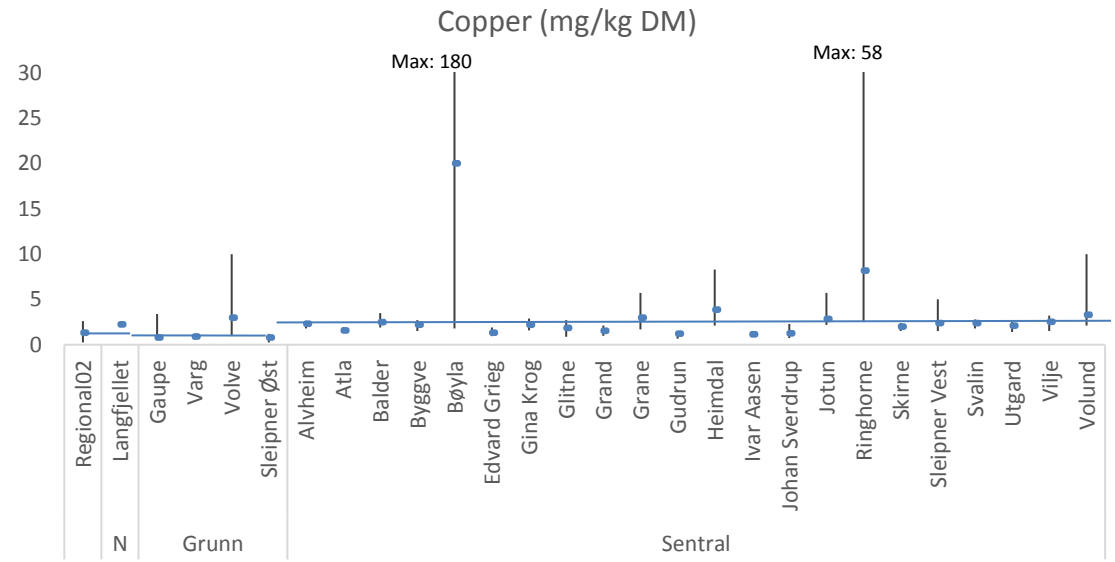
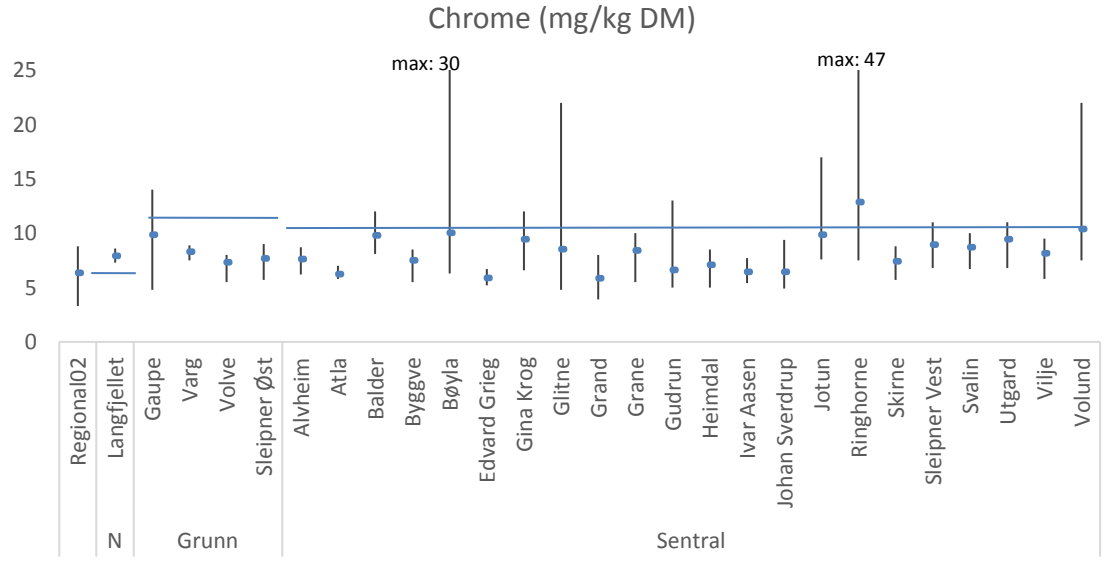


Figure 12 Average, min and max. copper concentrations (mg / kg DM) in 2018, based on three replicates per station. N = Northern subregion, Grunn= Shallow subregion. Sentral= Central subregion. Copper LSC is marked with blue bars for the different sub-regions.

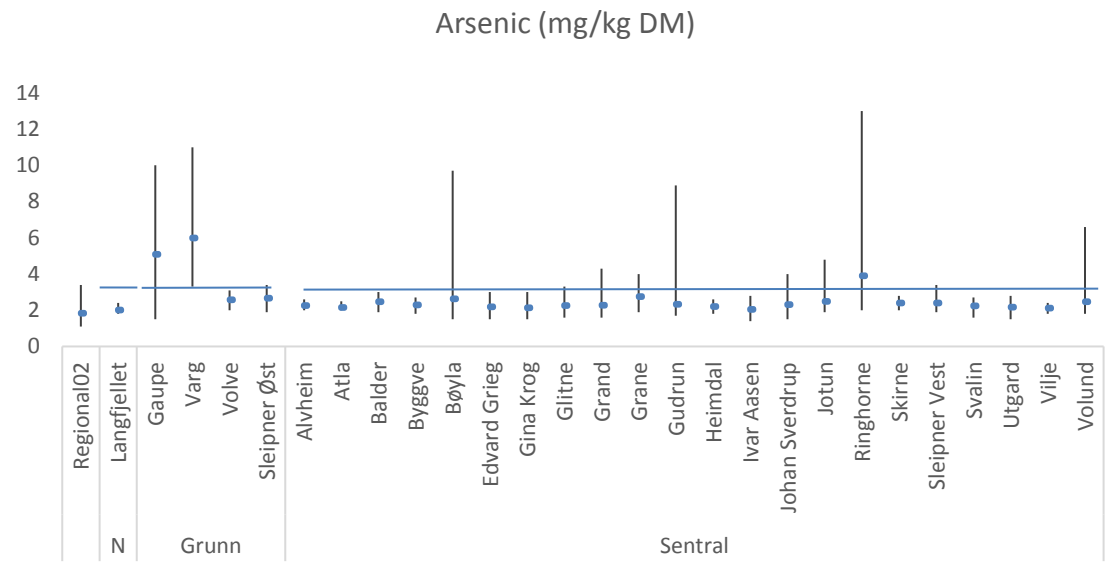
Chrome concentrations ranged from 3.3 to 47 mg / kg (Figure 13). The average concentrations on Langfjellet and Ringhorne were above LSC. The highest single concentrations were found at Bøyla and Ringhorne, followed by Glitne and Volund.



Figur 13 Average, min and max. chrome concentrations (mg / kg DM) in 2018, based on three replicates per station. N = Northern subregion, Grunn= Shallow subregion. Sentral= Central subregion. Chrome LSC is marked with blue bars for the different sub-regions.

Arsenic is analyzed for the first time on Region II (Figure 14). Hence, for the determination of LSC, only this year's data from the 13 regional stations were available and the estimate is therefore

uncertain. Most fields have average values at or very close to LSC. Gaupe Nord, Varg and Ringhorne have average values well above tentative LSC.



Figur 14 Average, min and max. arsenic concentrations (mg / kg DM) in 2018, based on three replicates per station. N = Northern subregion, Grunn= Shallow subregion. Sentral= Central subregion. Arsenic LSC is marked with blue bars for the different sub-regions.

Fauna

Fields

In several of the fields in the Central and Northern subregions and regional stations, high occurrences of juvenile individuals of the systematic class Echinoidea and polychaetes in the Pectinariidae family were recorded as recently settled. As this is a seasonal occurrence, these were not included in the evaluation of the environmental quality state at the fields.

The number of species in the fields varied on average from 75 species at Varg to 141 species at Skirne (Figure 15). The variation in Ringhorne ranged from 54 species to a maximum of 134 species. The individual numbers varied from 683 individuals on Varg to 2680 individuals on Volund (Figure 16). At Ringhorne, the diversity H 'ranged from 3.0 to 4.9 and by 4.1 on average for the field (Figure 17). Apaprt from Ringhorne, the average diversity H 'in the fields ranged from 4.2 at Langfjellet in the northern sub-region to 5,6 at Utgard in the Central sub-region.

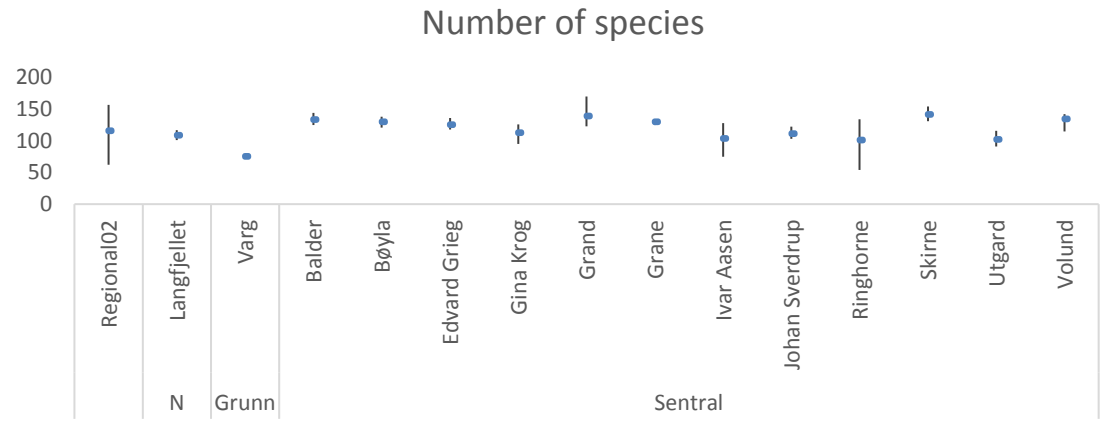


Figure 15 Average, min and max. for the number of species per field, based on 5 replicate grabs per station. N = Northern subregion. Grunn= Shallow subregion. Sentral= Central subregion. At Ringhorne the number of species varied from 54 to 134 species. (The number of species was 14 on the RinEx-5 based on only 1 grab sample, hence this station is not included in the overview).

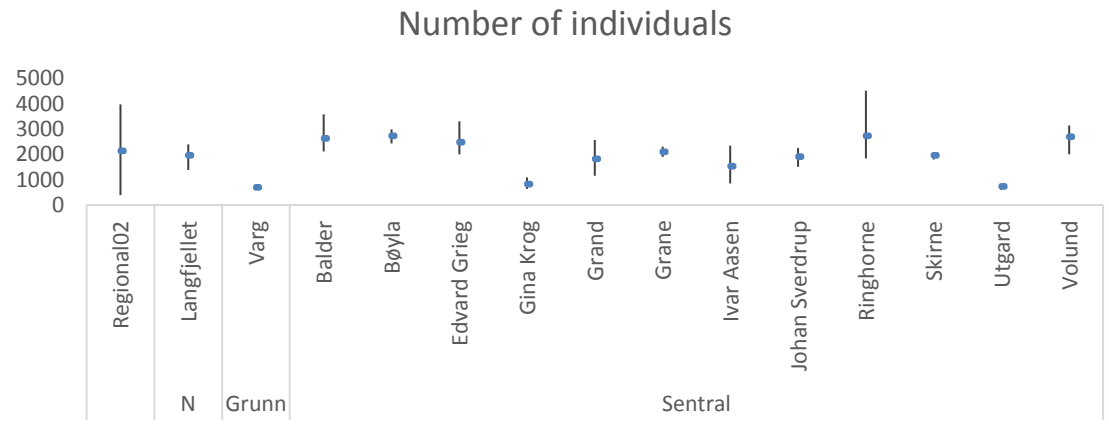


Figure 16 Average, min and max. for the number of individuals per field, 5 replicate grabs per station. N = Northern subregion. Grunn= Shallow subregion. Sentral= Central subregion. At Ringhorne, the number of individuals ranged from 1837 to 4511. (The number of individuals was 136 on the RinEx-5 based on only 1 grab sample, hence this station is not included in the overview).

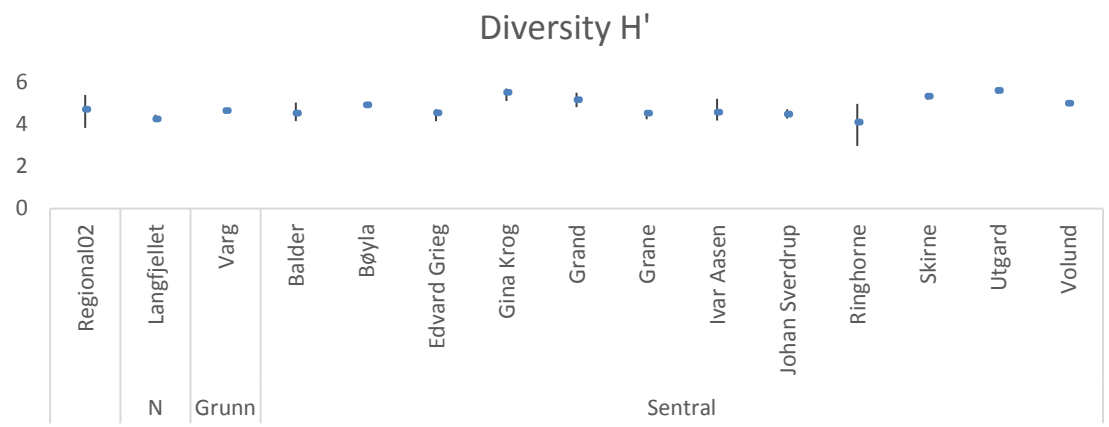


Figure 17 Average, min and max. diversity per field, 5 replicate grabs per station. N = Northern subregion. Grunn= Shallow subregion. Sentral= Central subregion. (The diversity was 1,6 on the RinEx-5 based on only 1 grab sample, hence this station is not included in the overview).

Regional stations

At the regional stations, on average there were most taxa in the Central sub-region (127 ± 26). In the shallow subregion (R2-06 and R2-17) the amount was 65 ± 4 and in the northern subregion 105. The average number of individuals at the regional stations in the northern subregion (R2-23) was highest (2886), while the central subregion had 2320 ± 1388 individuals and the shallow subregion 731 ± 392 individuals. In the transition zone between the shallow and central subregions, analyzes showed that the fauna composition differed slightly from the two subregions. The species diversity (H') was high at all regional stations and ranged from 3.8 to 5.4.

4 Development 2015-2018

Tables 4-6 show the range of the average values from the surveyed regional and field-specific stations for the three sub-regions in Region II in 2015 and 2018. The number of stations is not identical between the two years, which is based on which fields that have been included in the survey. The stations that had fewer grab samples than required at Ringhorne (RinEx-4 and RinEx-5) and Gina Krohg (DAG-01 and DAG-11) are not included in the overview. Since high THC content affects and creates elevated TOC content, TOC from Langfjellet stations LF2 and LF4 are removed. A probable miscalculation of TOC at Johan Sverdrup (JS19) is also removed from the 2018 overview.

At the field-specific stations, the highest concentrations of THC were somewhat higher, and for barium slightly lower, in the three sub-regions in 2018 compared to 2015. The maximum levels of the metals cadmium, chrome, copper, mercury, lead and zinc were slightly higher in 2018 compared to 2015 in the central subregion. The maximum value for copper was somewhat higher in 2018 than in 2015 in the shallow subregion.

Table 4 The range of average values from stations in the Northern sub-region. Data is calculated from the stations that had 3 samples for chemistry, 5 samples for biology and 1 mixed sample from 3 grabs for geological analyzes. Data from 2015 is mainly obtained from the Environmental Monitoring Database (MOD).

Nordlig subregion	Regional stations		Field specific stations	
Parameter	2015	**2018**	2015	**2018**
Depth (m)	112	**112**	115 - 118	**117**
N.o. stations (chemistry)	1	**1**	8	**5**
THC (mg/kg)	1,7	**0,5**	3,8 - 4,8	**25,0 - 41,0**
Ba (mg/kg)	18	**16**	60 - 316	**100 - 147**
Cd (mg/kg)	0,01	**<0,01**	0,01 - 0,02	**0,02 - 0,03**
Cr (mg/kg)	4,2	**3,4**	4,7 - 5,6	**7,4 - 8,3**
Cu (mg/kg)	0,9	**0,8**	1,3 - 1,8	**2,1 - 2,4**
Hg (mg/kg)	0,004	**0,001**	0,004 - 0,006	**0,005**
Pb (mg/kg)	2,7	**2,3**	3,4 - 4,7	**4,6 - 5,2**
Zn (mg/kg)	5,0	**4,1**	8,3 - 11,3	**10,3 - 11.3**
As (mg/kg)	-	**1,1**	-	**1,8 - 2,2**
N.o. stations (bio. & geo.)	1	**1**	0	**5**
Sand (%)	97,9	**96,7**	-	**89,0 - 94,4**
Pelite (%)	2,1	**3,3**	-	**4,7 - 10,6**
Gravel (%)	0,0	**0,0**	-	**0,4 - 1,4**
TOC (%)	0,3	**0,2**	-	**0,4 – 0,5**
N.o. species/station	100	**105**	-	**138 - 151**
N.o. individuals/station	1491	**2886**	-	**3870 - 4816**
Diversitet H'	4,1	**3,8**	-	**4,62 - 4,92**

Table 5 The range of the average values from stations in the Shallow subregion. Data is calculated from the stations that had 3 samples for chemistry, 5 samples for biology and 1 mixed sample from 3 grabs for geological analyzes. Data from 2015 is mainly obtained from the Environmental Monitoring Database (MOD).

Grunn subregion	Regional stations		Field specific stations	
Parameter	2015	**2018**	2015	**2018**
Depth (m)	74 - 82	**74 - 82**	70 - 90	**79 - 89**
N.o. stations (chemistry)	3	**2**	59	**43**
THC (mg/kg)	1,1 - 1,2	**0,5**	0,3 - 10,5	**2,6 - 33,0**
Ba (mg/kg)	7 - 9	**5 - 6**	7 - 1610	**6 - 1213**
Cd (mg/kg)	0,008 - 0,01	**0,005**	0,006 - 0,031	**0,005 - 0,033**
Cr (mg/kg)	6,7 - 9,9	**5,6 - 8,6**	7,1 - 15,2	**6,3 - 13,3**
Cu (mg/kg)	1,0 - 1,4	**0,3 - 0,5**	0,5 - 2,1	**0,5 - 7,6**
Hg (mg/kg)	0,003 - 0,004	**0,001 - 0,003**	0,000 - 0,014	**0,001 - 0,007**
Pb (mg/kg)	4,2 - 5,6	**3,3 - 4,7**	4,3 - 9,2	**3,6 - 8,3**
Zn (mg/kg)	4,0 - 6,3	**3,1 - 4,7**	6,0 - 22,3	**5,4 - 17,0**
As (mg/kg)	-	**1,5 - 3,3**	-	**2,3 - 10,6**
N.o. stations (bio. & geo.)	3	**2**	4	**3**
Sand (%)	98,5 - 100	**98,0 - 98,4**	97,6 - 98,6	**98,0 - 98,4**
Pelite (%)	0,0 - 1,5	**1,6 – 2,0**	1,4 - 2,4	**1,4 - 1,7**
Gravel (%)	0,0 - 0,1	**0,0**	0,0 - 0,1	**0,0 - 0,4**
TOC (%)	0,19 - 0,21	**0,19 - 0,32**	0,16 - 0,19	**0,16 - 0,17**
N.o. species/station	50 - 65	**62 - 68**	66 - 83	**73 - 76**
N.o. individuals/station	370 - 556	**453 - 1008**	711 - 818	**594 - 737**
Diversitet H'	4,0 - 4,8	**3,9 - 4,7**	4,2 - 4,6	**4,6 - 4,7**

Table 6 The range of the average values from stations in the Central subregion. Data is calculated from the stations that had 3 samples for chemistry, 5 samples for biology and 1 mixed sample from 3 grabs for geological analyzes. Data from 2015 is mainly obtained from the Environmental Monitoring Database (MOD).

Central subregion	Regional stations		Field specific stations	
Parameter	2015	**2018**	2015	**2018**
Depth (m)	107 - 128	**105 - 128**	120 - 130	**105 - 155**
N.o. stations (chemistry)	11	**10**	194	**219**
THC (mg/kg)	2,0 - 4,2	**0,5 - 2,0**	1 - 6368	**1 - 8610**
Ba (mg/kg)	23 - 121	**42 - 118**	29 - 7713	**24 - 1633**
Cd (mg/kg)	0,02 - 0,03	**0,01 - 0,03**	0,01 - 0,38	**0,01 - 0,20**
Cr (mg/kg)	7,0 - 10,0	**5,7 - 7,5**	5,1 - 53,1	**4,4 - 20,7**
Cu (mg/kg)	1,2 - 2,7	**1,0 - 2,2**	1,0 - 216,4	**0,8 - 91,7**
Hg (mg/kg)	0,006 - 0,012	**0,003 - 0,011**	0,000 - 0,056	**0,001 - 0,015**
Pb (mg/kg)	3,8 - 5,5	**3,6 - 5,0**	3,3 - 22,9	**3,8 - 14,7**
Zn (mg/kg)	7,3 - 17,0	**6,1 - 9,8**	6,3 - 250	**5,8 - 103**
As (mg/kg)	-	**1,5 - 2,2**	-	**1,6 - 6,3**
N.o. stations (bio. & geo.)	11	**10**	144	**144**
Sand (%)	78,6 - 94,1	**82,3 - 94,2**	69,8 - 99,9	**74,2 - 96,8**
Pelite (%)	5,8 - 24,2	**5,2 - 13,8**	0,01 - 30,2	**3,2 - 20,1**
Gravel (%)	0,0 - 0,2	**0,0 - 4,9**	0,0 - 9,1	**0,0 - 20,0**
TOC (%)	0,33 - 0,65	**0,28 - 0,53**	0,20 - 1,00	**0,24 – 1,59**
N.o. species/station	84 - 159	**85 - 157**	58 - 159	**54 - 170**
N.o. individuals/station	482 - 3561	**395 - 3974**	527 - 4343	**395 - 4511**
Diversitet H'	3,4 - 5,3	**4,4 - 5,4**	3,2 - 5,2	**3,0 - 5,7**

5 Contaminated area over time

One or more of the outermost stations were contaminated with THC (> LSC) in 16 fields (Table 7). The total area with THC> LSC was estimated 15.47 km^2. The total area with THC> 50 mg / kg was estimated 0.80 km^2. Affected bottom fauna was only found at Ringhorne, with an estimated area of 0.17 km^2. Looking only at the fields that were also surveyed in 2015, there has been an increase of 4.19 km^2 with THC values above LSC. Note that the number of stations and the incorporation of templates is not identical between the two years.

Table 7 Area (km^2) contaminated with THC in 2018 compeared with 1997 to 2015 (historical data downloaded from MOD). **) Incl. Sleipner A. **) Incl. all templates*

Field	1997	2000	2003	2006	2009	2012	2015	2018	THC>50 2018	Outermost stations THC>LSC 2018	Affected fauna 2018
Alvheim					0,20	0,20	0,20	0,20			
Atla							0,20	0,20		250 S	
Balder	59,44	4,57	14,93	1,12	0,88	0,88	0,40	1,95		All directions	
Byggve				0,20	0,20	0,20	0,20	0,29		All directions Except south	
Bøyla							0,29	0,30			
Edvard Grieg							0,49	0,20		250 E	
Gaupe Nord							0,20	0,39		500 NE	
Gaupe Sør							0,20	0,20			
Glitne			2,95	0,59	0,59	0,68	0,52	0,66		All directions	
Grane			1,00	0,33	0,33	0,20	0,20	1,19		All directions	
Gudrun							0,39	0,21			
Heimdal	1,31	0,79	0,60	0,60	0,86	0,39	0,30	0,39			
Jotun		5,30	5,30	0,20	0,20	0,20	0,20	0,79		All directions	
Ringhorne		30,48	15,71	0,80	0,71	0,80	0,71	0,47	0,21	All directions	0,17
Skirne				0,20	0,20	0,20	0,20	0,29		500 m S	
Sleipner Øst*	2,35	1,38	0,44	0,44	0,59	0,20	0,49	0,89		SV, NE	
Sleipner Vest	7,07	6,28	5,30	0,59	0,88	0,88	0,59	0,88	0,59	All directions	
Svalin C							0,29	0,29		Alle retning Except NW	
Varg		2,36	0,88	0,59	0,59	0,81	0,29	0,29			
Vilje					0,20	0,20	0,20	0,29		All directions	
Volund							0,20	0,58		500 NV	
Volve					0,29	0,29	0,29	0,29			
Utgard								0,20			
Gina Krog								0,20			
Johan Sverdrup**								1,49			
Ivar Aasen								0,29			
Grand								1,76			
Langfjellet								0,29		All directions	
Sum Region II								**15,47**	**0,80**		**0,17**

6 Conclusions

The highest average proportions of TOC were found on Langfjellet and Ringhorne, which is probably related to high THC values because of oil leakage from the seabed. Affected fauna was found only at Ringhorne. At this field, an increased spreading of THC was observed in 2018 towards the south-southeast. In addition to Ringhorne, average THC above 50 mg / kg was found at Sleipner West at a station 250 m to the northeast. The highest average metal concentrations were found at Grane, Ringhorne and Bøyla. In most cases there was a connection between drilling activity, leaks and emissions and the levels of hydrocarbons and metals in the sediment.

7 Recommendations

- Some priority and water region-specific environmental pollutants are found at quantifiable levels in the marine environment around land-based industry on the Norwegian coast. To know if any of these are also found in the environment around installations in the North Sea, it will be useful to conduct a screening on selected platforms where there has been comprehensive activity in recent years. A thorough assessment should be made in advance, to evaluate which of the environmental pollutants that are relevant, based on usage and the properties of the pollutants.
- The regional stations appear to cover the various fields in the region and should therefore be retained in future monitoring surveys. The R2-13 in the Central subregion stands out with twice as high mercury levels as the other stations. If this persists, the station should be replaced.
- At Ringhorne, the extent of the leakage from the sea floor should be more precisely mapped in the different directions. The presence of levels above 50 mg / kg of THC at the station 500 m southwest of the field center indicates that there has been a spreading in several directions from the leak point.
- Threshold values should be developed for the fauna indices NQI1, NSI and ISI adapted to conditions on the Norwegian continental shelf.

8 Literature

For literature list and reports from analyzing laboratories, see main report (STIM Report 26-2019).