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STATOIL-SHELL-NORSK HYDRO

ENVIRONMENTAL MONITORING
THE HALTENBANK AREA
REGION VI

REPORT No. 98-3187

REVISION No. 01

DET NORSKE VERITAS

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Summary:

In this summary the most important results from the environmental monitoring at the Haltenbank region in 1997 are quoted. There were a total of 6 fields and 10 regional stations in the monitoring. The most important parameters in the investigation were.

- Soft bottom macro fauna
- Grain size distribution
- THC, NPD, 3-6 rings aromates
- metals

The investigation revealed that the Haltenbank area only is slightly and only locally influenced by the petroleum activity in the region. About 10 % of the region is contaminated (concentrations above back ground level) with Ba and THC.

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1 SUMMARY AND CONCLUSIONS

This summary report presents the most important results from the environmental monitoring at the Haltenbank region in 1997. Det Norske VERITAS A/S carried out the investigation in Co-operation with SINTEF-Kjemi. The main results are given in a separate Norwegian main report (DNV, 1998, report no. 98-3106).

The summary report presents the results from the regional stations at the Haltenbank and at following installations; Norne, Åsgard, Heidrun, Heidrun Nord, Draugen and Njord.

The fieldwork was carried out in the period 21 May to 4 June from the vessel *Esvagt Dana*. Totally sediment was taken from 113 stations; ten of these were regional stations.

The following chemical analysis have been performed:

-Total amount of hydrocarbons (THC)

-NPD, decalines

-3-6 ring aromates

-Metals (Ba, Cd, Cu, Hg, Pb and Zn)

Esters, ethers and the substance DFE-622 were analysed from a few stations.

Further sediment was sampled for analysis of:

-Soft bottom macrofauna

-Total organic material

-Grain size distributions

The investigation has revealed the following:

- ◆ The influenced area of the Haltenbank was generally very small.
- ◆ The benthic community was generally healthy in the whole region.
- ◆ Sediments consisting of mud and silt were dominating the area.
- ◆ Depth, grain size and diversity were factors that followed each other. In the deeper areas the sediment was very fine and the diversity was lower than in shallower areas with coarser sediments.
- ◆ More species and individuals were observed at most of the fields compared to the earlier investigations.
- ◆ The hydrocarbon level in the sediments was low at most of the stations and these stations were not polluted.
- ◆ Pollution of NPD and 3-6 ring aromates was not revealed in any of the fields.

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- ◆ The base fluids Petrofree and Aquamul B II have only been in use at Heidrun. Only small amounts of Petrofree were found but more of Aquamul.
- ◆ The concentrations of barium in the sediment have generally increased since earlier investigations. The highest concentrations were found in the sediment around the oldest installations.
- ◆ Cadmium, copper, mercury, lead and sink were below the back ground level
- ◆ Totally 540 species were found distributed among 43542 individuals at the Haltenbank area.

The variation among the different parameters for each field is shown in the tables on this and the following pages. The figures show average, max. and min. values for the different parameters at each of the installations.

Regional stations:	Varies from-to	General
Depth (in m)	212 - 434	Enhanced levels of metals or THC in the sediments were not found.
Average grain size. (Md)	2,97 – 6,42	
Diversity	4,60 – 6,16	The soft bottom community was characterised as healthy with high indices of diversity.
Number of species per stations	41 - 133	
Number of individuals per stations	139 - 631	
Barium (mg/kg)	48 - 150	
THC (mg/kg)	2,1 - 4,9	

Norne	Varies from-to	General
Depth (in m)	373 - 391	The concentrations of hydrocarbons in the sediment have increased since the baseline monitoring.
Average grain size. (Md)	5,27 – 5,94	
Diversity	5,11-5,37	The soft bottom community was characterised as healthy with high indices of diversity.
Number of species per stations	65-87	
Number of individuals per stations	366-580	The condition of the fauna was found to be generally better than in the baseline monitoring.
Barium (mg/kg)	130 - 2990	
THC (mg/kg)	3,1 – 84,8	

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Åsgard	Varies from-to	General
Depth (in m)	281 - 307	<p>The pollution level of hydrocarbons was not high. The concentration of hydrocarbons have increased since 1996 in the sediment around frame G and R and decreased in the sediment around frame F. Concentrations over 1000 mg/kg barium were found at six stations around frame G, I, L and R. The level of barium around frame G has increased Since 1996. Other metals did not pollute the field.</p> <p>The soft bottom community was characterised as healthy with high indices of diversity, but the dominating species constitutes a larger part of the fauna than in 1994 and the indices of diversity was general somewhat lower than in 1996.</p>
Average grain size. (Md)	3,68 – 5,35	
Diversity	5,11 - 6,45	
Number of species per stations	56 - 139	
Number of individuals per stations	218 - 649	
Barium (mg/kg)	111 - 1850	
THC (mg/kg)	2,1 – 106	
Heidrun	Varies from-to	General
Depth (in m)	331 - 360	<p>The THC levels in the sediment samples were low. Enhanced levels were only found in the samples from the three inner stations at 550 m. The concentrations of barium in the samples were low. Enhanced levels were only found in the samples from the three inner stations at 550 m. The concentration of barium in the sediment samples has increased since 1995. The concentrations of the other metals in the sediment samples were low.</p> <p>The soft bottom community was characterised as healthy, but there are indications that the fauna is lightly influenced within a radius of 2000 m from the installation.</p>
Average grain size. (Md)	4,74 – 5,80	
Diversity	4,38 - 5,95	
Number of species per stations	54 - 120	
Number of individuals per stations	224 - 1024	
Barium (mg/kg)	112 - 7800	
THC (mg/kg)	1,1 - 28,8	
Heidrun Nord	Varies from-to	General
Depth (in m)	329 - 403	<p>The concentration of hydrocarbons, barium and heavy metals in the sediment samples were low and the field was not polluted.</p> <p>The soft bottom community was characterised as healthy with high indices of diversity.</p>
Average grain size. (Md)	5,16 – 5,78	
Diversity	5,02 – 5,8	
Number of species per stations	53 - 114	
Number of individuals per stations	127 - 575	
Barium (mg/kg)	152 - 411	
THC (mg/kg)	2,0 - 3,8	

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Draugen	Varies from-to	General
Depth (in m)	235 - 280	Enhanced levels of hydrocarbons in the sediment samples were not found. At Draugen and the NWIT area it was found enhanced levels of barium in the sediment samples. It was only registered small changes since 1994. The soft bottom community was characterised as healthy with high indices of diversity. The condition of the fauna was found to be generally better than in the baseline monitoring.
Average grain size. (Md)	3,10 – 5,86	
Diversity	4,71 – 5,95	
Number of species per stations	66 - 131	
Number of individuals per stations	269 - 834	
Barium (mg/kg)	113 - 3230	
THC (mg/kg)	2,6 – 6,4	
Njord	Varies from-to	General
Depth (in m)	316 - 333	The concentration of hydrocarbons, barium and heavy metals in the sediment samples were low and the field was not polluted. The soft bottom community was characterised as healthy with high indices of diversity. The condition of the fauna was found to be generally better than in the baseline monitoring.
Average grain size. (Md)	4,70 – 5,75	
Diversity	5,10 – 5,95	
Number of species per stations	82 - 113	
Number of individuals per stations	353 - 644	
Barium (mg/kg)	113 - 321	
THC (mg/kg)	3,4 – 5,7	

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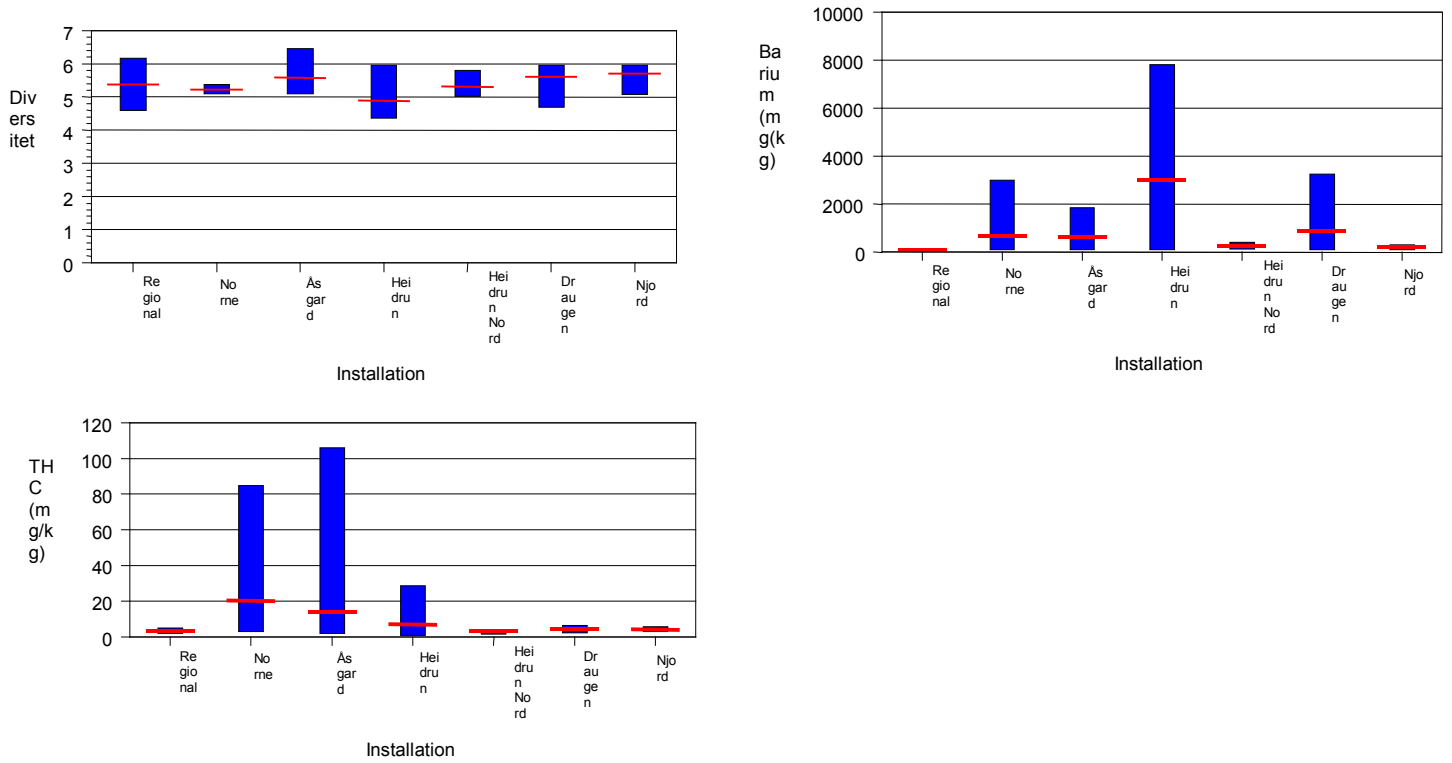


Figure 1.1 showing average values (red line) for the fields located in the Haltenbank area together with max. and min. values for diversity (up to left), barium (up to right) and THC (down to left).

2 INTRODUCTION

This report presents the results from the regional monitoring carried out in the Haltenbank area in 1997. The purpose of this regional monitoring is to study the effect the petroleum activities has on the environment over a larger area, than earlier installations specific investigations. Regional environmental monitoring was first carried out in 1996. The area in this investigation from Njord in the south to Norne in the north is shown in figure 2.1.



Figur 2.1. Map showing the investigated fields in the Haltenbank area.

The environmental monitoring is carried out according to the Governments guidelines (SFT, 90:01 and 97:01). Divergence from these guidelines is given in the main report.

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3 FIELD REPORT

The field work in connection with the environmental monitoring of the Haltenbank region was carried out from *M/S Esvagt Dana* by DNV in co-operation with SINTEF, Oslo, in the period 21 May to 4 June. Sampling and analysis was performed according to the Governments guidelines (se chapter 2) and according to internal DNV procedures for this type of work. There is a separate field report (DNV, 1997) which is quoted in the appendix report. (DNV, 1997 report no. 97-3438). The field report includes a complete overview of the sampling. The overview consist of coordinates (both UTM and degree/minutes), depth, date and time for sampling, volume of sediment samples for analysis of fauna, number of unsuccessful in situ samples, colour of the sediments and some comments.

4 HALTENBANK-REGION

Only the most important results and conclusions are quoted in the summary report. The complete results are found in the main report (DNV, 1998, report no. 98-3106).

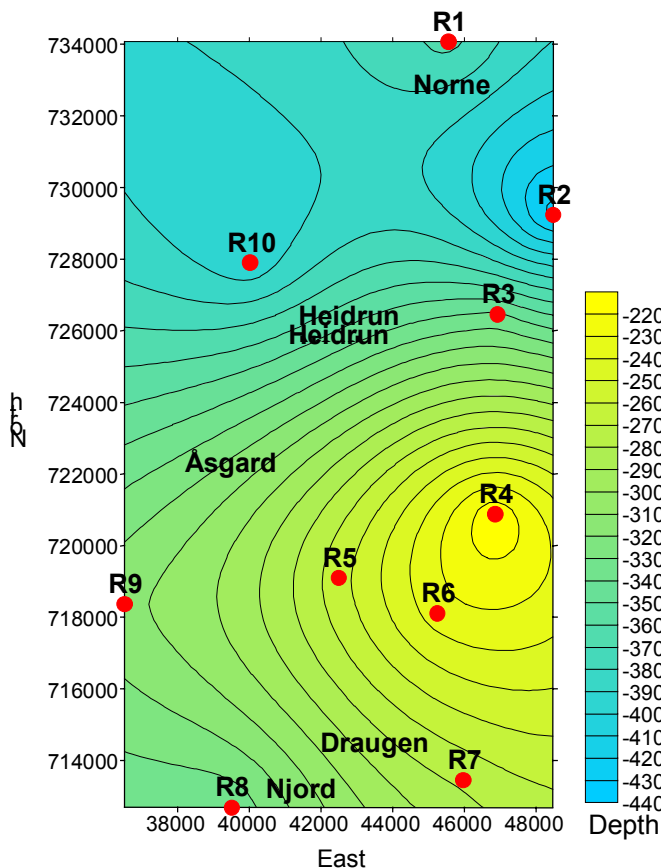


Figure 4.1. Map showing the regional stations, depth is marked (based on the 10 stations).

4.1 Background level

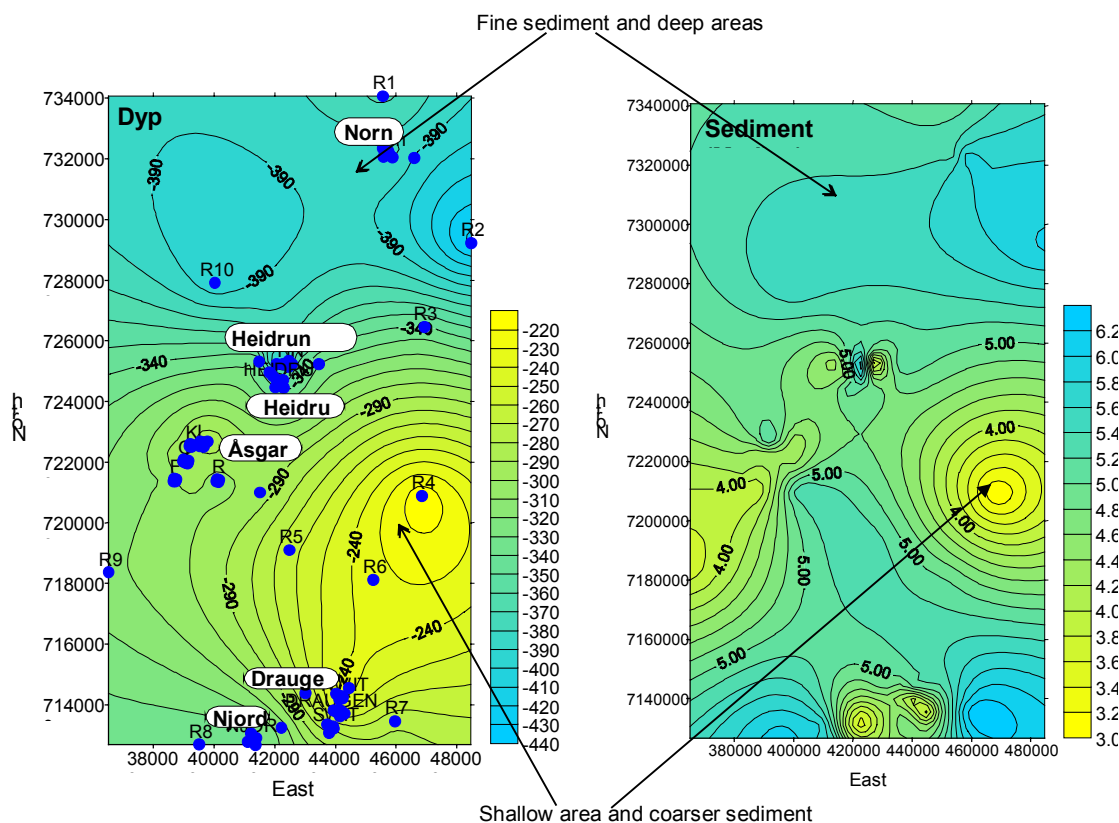
Depth and sediments

Sediment from 10 regional stations was collected, which will give information on the background level in the region. The purpose of the regional stations is to gain further knowledge of the natural variation in the region (variations in depth, sediment texture and diffuse influence). The depth in the region varies from 212 m at stations R4 to 434 m at stations R4, figure 4.1.

The sediment at the Regional stations consists of fine sand to silt, with emphasis on the silt fraction. The values for median particle diameter vary from 2,97 ϕ at Regional 4 to 6,42 ϕ at Regional 7. The gravel content is low, except for Regional 9 where the gravel content is 14,5 %. The variation in the total organic matter content is also large, from 2,9 % at Regional 4 to 10,4 % at Regional 2.

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The concentration of organic material and metals are in a great degree dependent of the grain size in the area. Generally small fine particles has a greater affinity for binding than coarser particles (Burford et. al. 1994*). Because of this, one can expect to find the highest concentrations of metals and organic materials in the finest sediment found in the deepest part of the area. Figure 4.2 show the connection between depth and grain size in the Haltenbank area.



Figur 4.2. Depth and grain size distribution at the Haltenbank area.

Chemical parameters

The concentration of hydrocarbons, barium and heavy metals are low, and the sediments were not polluted at any of the regional stations.

Variations at the Regional stations given in mg/kg:

THC	Ba	Cu	Pb	Zn
2,1 – 4,9	48 – 150	3,1 - 14,7	9,2 - 19,5	22,5 – 71,6

Additional analyses were performed at the regional stations.

* Burford, M.A., Long, B.G. & Rothlisberg, P.C: 1994: Sedimentary pigments and organic carbon in relation to microalgal and benthic faunal abundance in the Gulf of Carpentaria. Mar. Ecol. Prog. Ser., Vol. 103: 11-117.

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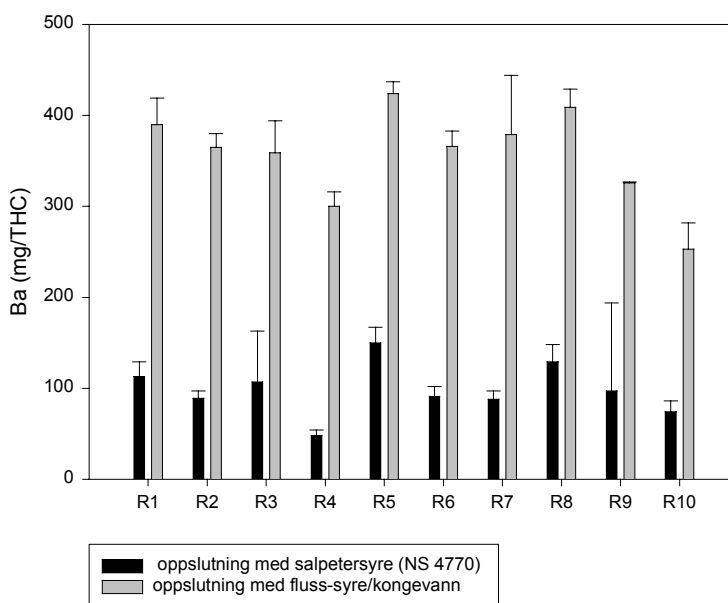
Determination of total organic carbon (TOC):

The concentration in the sediments varies from 3,4 mg/g (3,4 ‰) at Regional 4 to 7,9 mg/g at Regional 7.

The level is about one tenth of the level of total organic matter (TOM).

Determination of metals after digestion with fluoric acid/aqua regia:

The Ba concentrations vary from 253 mg/kg at Regional 10 to 424 mg/kg at Regional 5. The results are three to six times higher compared to the ordinary analyses according to NS 4770. For the other metals smaller differences between the two methods were found, maximum twice the concentration by use of fluoric acid/aqua regia, figure 4.3.



Figur 4.3. Barium content analysed by two different methods

Table 4.1. Regional stations 1997. Total hydrocarbons content, metals (mg/kg dry sediment) and total organic matter (%) and total organic carbon (‰).

Station	THC Dissolution with Nitric acid (NS 4770)						TOM %	Dissolution with fluoric acid/ aqua regia					TOC ‰
	Ba	Cd	Cu	Pb	Zn	Ba		Cd	Cu	Pb	Zn		
Regional 1	3,0	113	0,04	7,4	14,2	44,4	4,8	390	< 0,20	11,1	29,2	72,7	5,6
Regional 2	2,6	89	< 0,04	14,7	14,5	71,6	10,4	365	< 0,20	15,3	28,3	91,5	7,1
Regional 3	2,2	107	< 0,03	8,4	12,8	45,3	6,3	359	< 0,20	13,5	26,2	71,2	5,6
Regional 4	2,1	48	< 0,03	3,1	9,2	22,5	2,9	300	< 0,20	6,8	21,8	43,4	3,4
Regional 5	3,8	150	0,04	8,5	18,3	47,3	6,6	424	< 0,20	15,7	33,1	66,0	6,9
Regional 6	3,2	91	< 0,03	6,6	13,7	37,3	4,8	366	< 0,20	11,3	28,0	60,1	5,4
Regional 7	4,9	88	0,04	10,6	19,5	51,3	5,9	379	< 0,20	17,2	36,7	73,6	7,9
Regional 8	4,8	129	< 0,04	9,2	19,2	48,8	6,6	409	< 0,20	15,6	36,9	66,2	7,0
Regional 9	2,9	97	0,04	7,4	17,2	41,0	4,9	326	< 0,20	12,7	32,8	56,7	5,5
Regional 10	3,2	74	0,04	9,4	14,2	50,9	6,2	253	< 0,20	11,1	31,7	66,2	5,8

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Soft bottom fauna

The conditions in the soft bottom community at the regional stations were good and have to be seen as healthy with high indices of diversity and evenness, table 4.2. The multivariate analysis showed that the stations were divided by depth and consequently by geography. Station R1 and R2 in group 4 showed least resemblance with the fauna at the other stations, figure 4.4.

Table 4.2. Depth, number of species (S) and number of individuals (N) per 0,5 m², Shannon-Wieners diversity index (H'), Pielou's index of evenness (J) and ES₁₀₀. Regional stations 1997.

Station	Depth	S	N	H'	J	ES ₁₀₀
R1	366	41	139	4,60	0,86	34,64
R2	434	51	217	4,80	0,85	36,02
R3	338	85	302	5,68	0,87	48,41
R4	212	133	631	6,16	0,87	53,70
R5	264	68	267	5,40	0,89	43,39
R6	235	77	338	5,40	0,86	42,98
R7	278	64	205	5,51	0,92	46,93
R8	338	79	378	5,04	0,80	40,78
R9	312	95	316	5,71	0,87	49,39
R10	398	78	283	5,51	0,88	45,61

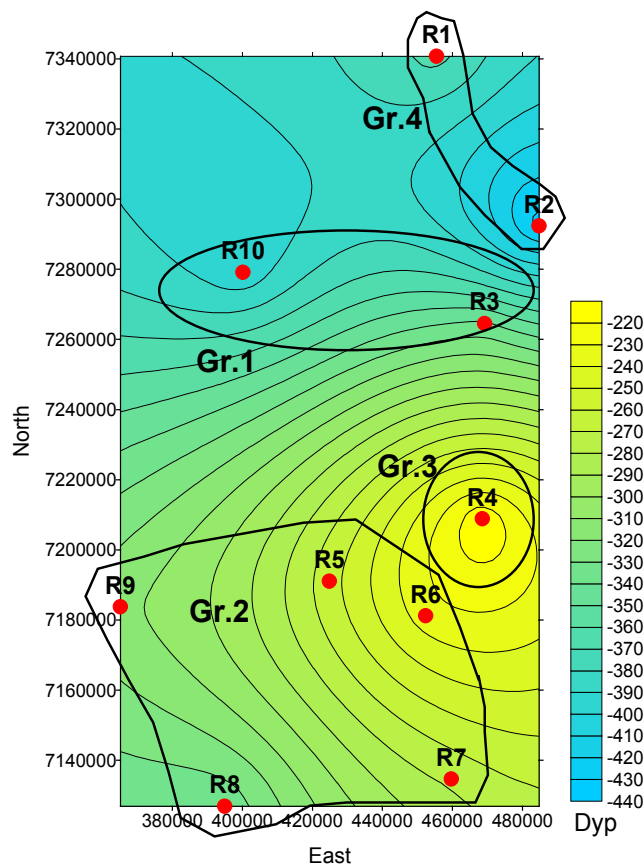


Figure 4.4. Geographical grouping based on dendrogram and MDS-plot. Regional stations 1997.

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4.2 Important results

In this chapter the main trends in the region are quoted.

Characterisation of the sediments

The analysis of the grain size distribution shows that the content of clay and silt dominates in the sediments at all fields, except for Draugen (platform), where the sand fraction is more pronounced. Compared to previous investigations, differences are observed in grain size distribution at the Njord and Draugen fields.

The total organic matter content is relatively high due to the fine-grained sediment, and the content varies from 2,9 % to 10,4 %.

Chemical compounds

The chemical analysis shows that the hydrocarbon content in the sediment is low. Most of the stations are not contaminated. The highest THC concentration, 106 mg/kg, is found in the sediments at template R at Åsgard, figure 4.5.

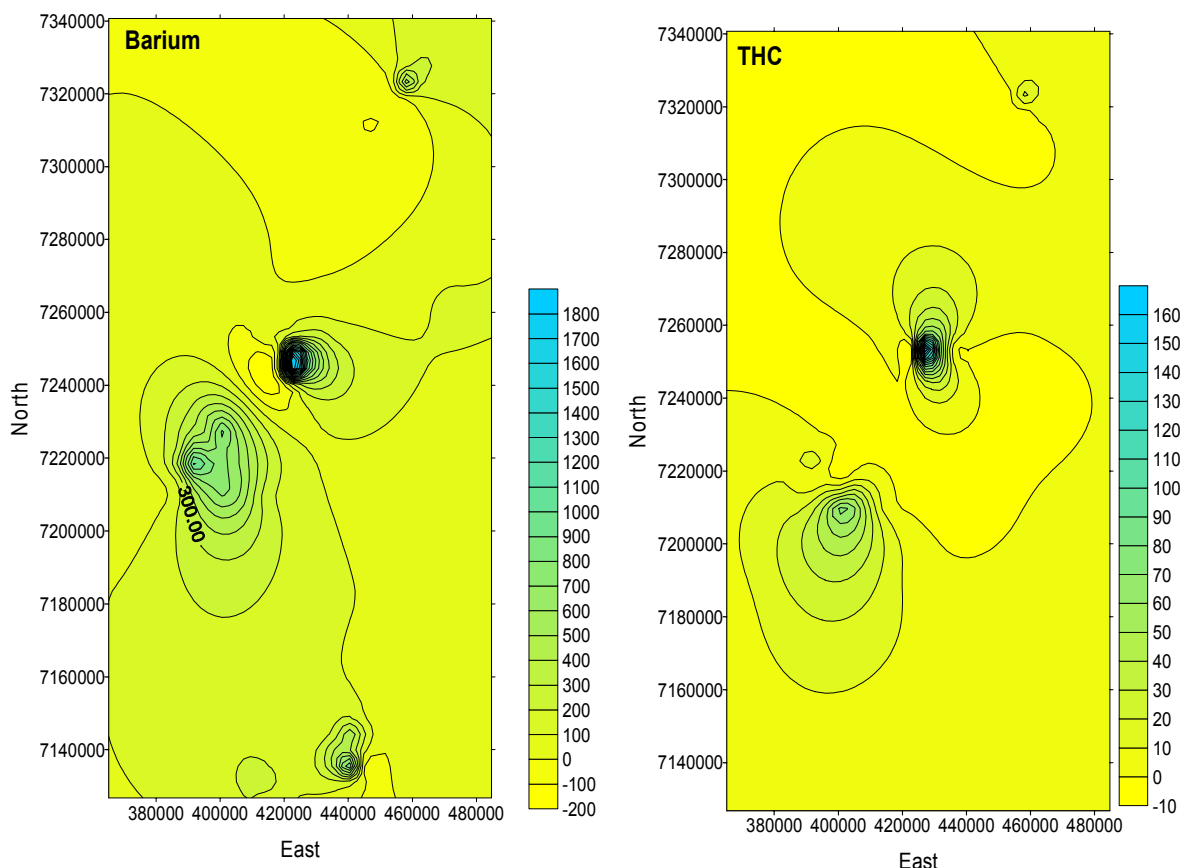


Figure 4.5. The spreading of barium and hydrocarbons in the sediments at all stations in the Haltenbank area.

Contamination of NPD and 3-6 ring aromatics are not found at any fields. However, decalins are found both at Norne and at Åsgard, at concentrations up to 18 mg/kg.

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The base fluids Petrofree and Aquamul B II are only used at Heidrun, and the compounds are found in the sediment at the Heidrun field. The concentrations of Petrofree are low, below 1 mg/kg, while the concentrations of Aquamul B II are higher, up to 271 mg/kg. The drilling mud chemical DFE-622 used at Norne and Heidrun, is not found in the sediments.

The Ba concentrations have generally increased since the previous investigations. As expected the highest concentration was found at the oldest fields. The highest Ba level, 7800 mg/kg, is found at Heidrun. Contamination of cadmium, copper, mercury, lead and zinc were not found.

Soft bottom fauna

The soft bottom fauna in the region was general healthy and the influence on the fauna community by hydrocarbons and metals were very small. The general impression of the area is that depth; grain size and diversity are factors that in general follows each other, figure 4.6.

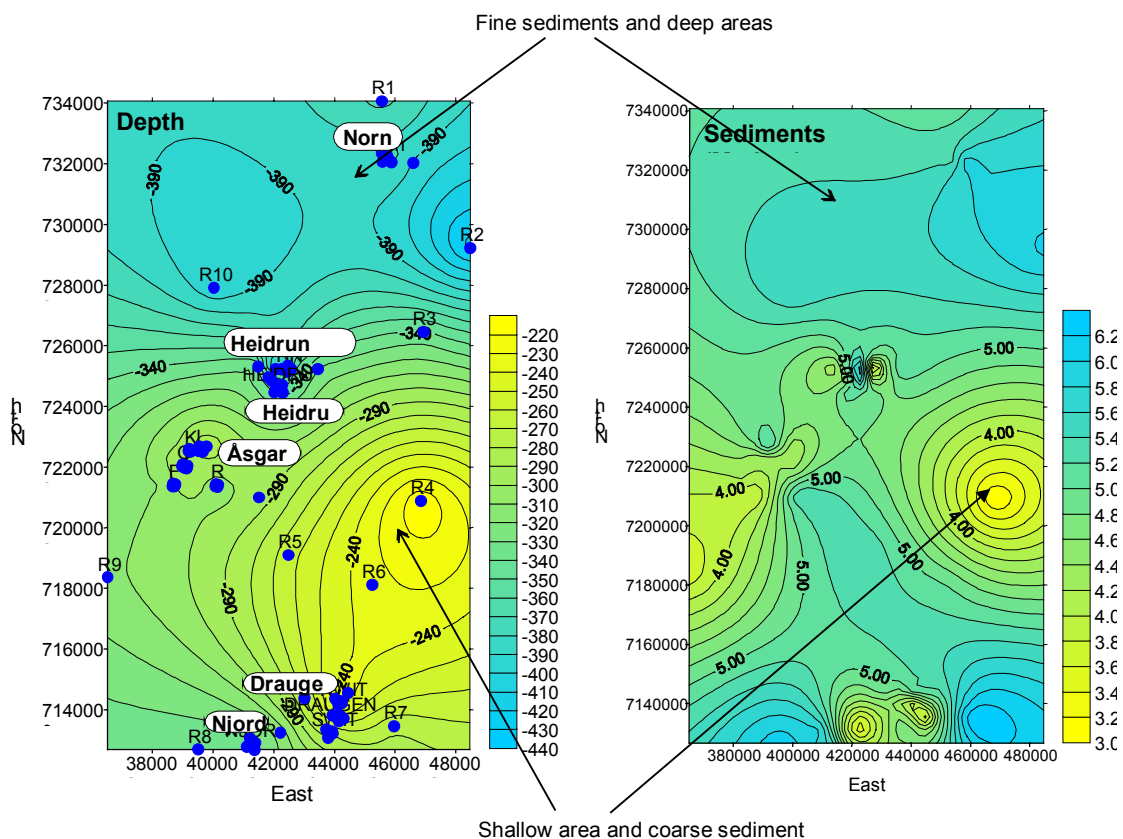


Figure 4.6. Comparison between diversity and sediment characteristics in the Haltenbank region, 1997.

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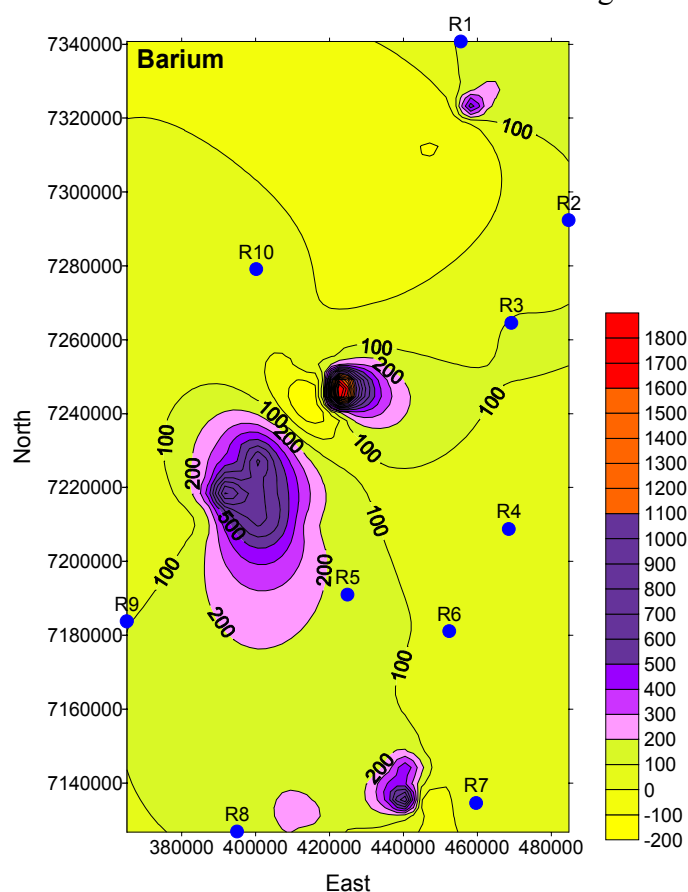
In shallow areas the sediment is general somewhat coarser than it is in the deeper parts of the area, this is mainly a consequence of the speed of the currents, which often is higher in more shallow areas. The diversity in the area was found to be higher in the shallow areas than in the deeper areas.

4.3 Discussion

This investigation has shown that the Haltenbank area have only a small degree of pollution and enhanced levels of THC and barium were only found around separate installations

Contamination means significantly enhanced levels of chemical compounds above the background level. The background level of barium (i.e. diffuse influence) in the Haltenbank area could be set to 150 mg/kg based on the concentration level in the sediment at the regional stations. However the concentration level in the sediment at the reference stations at Åsgard (220 mg/kg) and **Heidrun Nord** (206 mg/kg) were somewhat over this. Figure 4.7 shows a plot over the area which is contaminated with barium, based on the following concentrations: > 200 mg/kg; > 300 mg/kg; > 500 mg/kg; > 1000 mg/kg and > 1500 mg/kg. The area for these areas is calculated with the use of SURFER software and is quoted in table 4.3. The investigated area is calculated to be 27.300 km² and based on this less than 10 % of the Haltenbank area is contaminated by barium (barium concentration >200 mg/kg), and less than 5 % is contaminated with a barium concentration over 300 mg/kg. The contamination is highest at Åsgard and Heidrun.

Hydrocarbons were measured in concentrations less than 5 mg/kg at the regional stations, and this level could represent the background in the Haltenbank area.



Figur 4.7. Distribution of Barium in the region

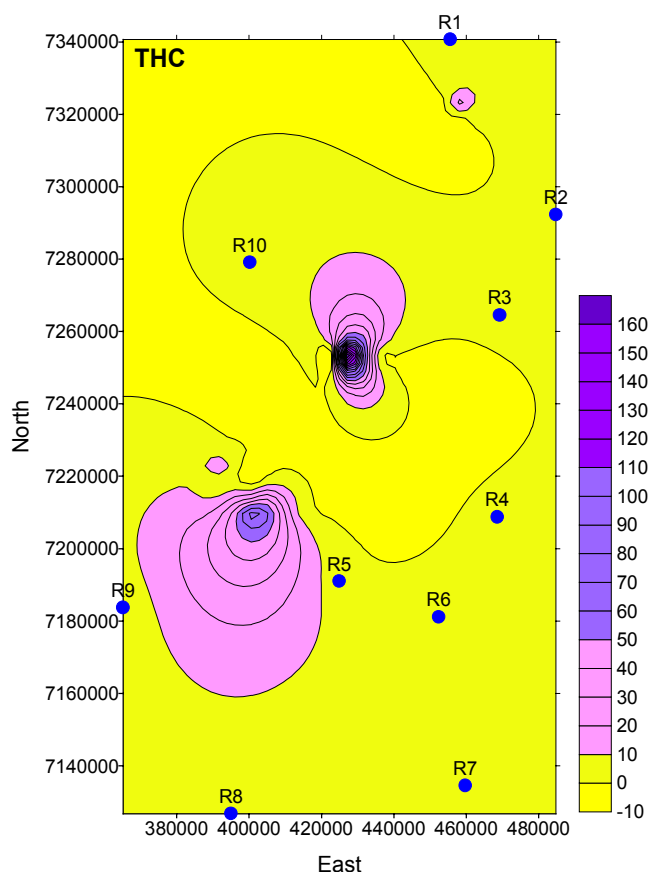
Areas with higher concentration than 10 mg/kg constitutes less than 12 % of the total area. Less than 1 % of the total area has higher concentrations than 50 mg/kg, table 4.3.

Based on this only a part of the Haltenbank area (Heidrun, Åsgard and Norne) was contaminated by THC and it was small.

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Table 4.3. Area of contaminated sediment (barium and THC). Total area is calculated to 27.300 km².

BARIUM			THC		
Concentration	Area (km ²)	% of the region	Concentration	Area (km ²)	% of the region
> 200 mg/kg	2550	9 %	> 10 mg/kg	3204	12
> 300 mg/kg	1334	5 %	> 50 mg/kg	172	0,6
> 500 mg/kg	587	2 %	> 100 mg/kg	21	0,08
>1000 mg/kg	46	0,2%	> 150 mg/kg	1,6	0,01
>1500 mg/kg	11	0,04 %			



In order to evaluate effects on the soft bottom community, multivariate analysis of similarity and different indices are utilised. In the soft bottom fauna of the Haltenbank area low diversity indices are not found and the communities belong into the Government's (SFT) state of class I (very good) (SFT, 1997). That is that the soft bottom communities in the Haltenbank area were healthy, with many and few dominating species.

Figur 4.8. Contaminated area of Haltenbanken with THC

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However it is shown that indices of diversity are not able to detect lesser alterations in the community (Warwick & Clarke, 1991 and 1992*).

Multivariate analyses are much more sensitive than univariate analysis and are able to detect harmful effects at an early stage. Figure 4.9 shows a dendrogram, which is the output from the similarity analysis, for all the stations located in the Haltenbank area. The similarity analysis shows a relatively great resemblance between the stations. But stations H15, H6, D2 and Reg. 1 deviates from the other stations in the area. Stations H15 and H6 are located at the Heidrun field and there are indications that they may be influenced by the petroleum activity in the area. Stations D2 located at Draugen and regional station 1 was characterised with very compact sediment consisting of hard mud.

The multivariate analysis have revealed that only at Heidrun it is possible to see any influence from the petroleum activity. The influence is small and less than 2 km² is likely to be considered as influenced.

An increase in barium and THC level is registered in the sediment since earlier investigations. This is as expected in a relatively newly developed area. The results from each of the fields are quoted in chapter 5.

Regarding the biology results another trend is noticed. At Norne, Draugen and Njord a relatively high increase was found in number of species and individuals compared to earlier investigations. The diversity indices were also found to be higher than in earlier investigations. At Heidrun and Åsgard an increase in number of individuals was noticed but not any substantial increase in the number of species. The increase in number of individuals at Heidrun and Åsgard is due to a few species, which likely profits from the changing environment, perhaps due to an increasing organic load in the field area. These changes can be explained biologically.

The sediment in the Haltenbank area consists of a lot of clay, with a higher degree of silt in the top layer. This top layer could be labile and yearly alterations could be expected. If labile physical conditions cause these alterations, the same alterations should be expected to take place in all the fields in the Haltenbank area. This seems to not be the case. Many species with few individuals were detected and there are relatively large differences in the species composition between years. However this could not explain the considerable increase in number of species and the number of individuals between different investigations.

The differences are most likely to be due to treatment of the samples, as for example use of different sampling equipment, different wash- or filter procedures.

Nevertheless the multivariate analysis seems to be fairly robust so the same conclusions are possible to be drawn for the different years of investigations, but comparison between years are difficult for these fields.

* Warwick, R.M. & Clarke, K.R. 1991: A comparison of some methods for analysing changes in benthic community structure. Jour.Mar. Biol.Ass. U.K. 71: 225-244.

Warwick, R.M. & Clarke, K.R. 1992: Comparing the severity of disturbance: a metaanalysis of marine macrobenthic community data. Mar.Ecol.Prog.Ser. 92: 221-231.

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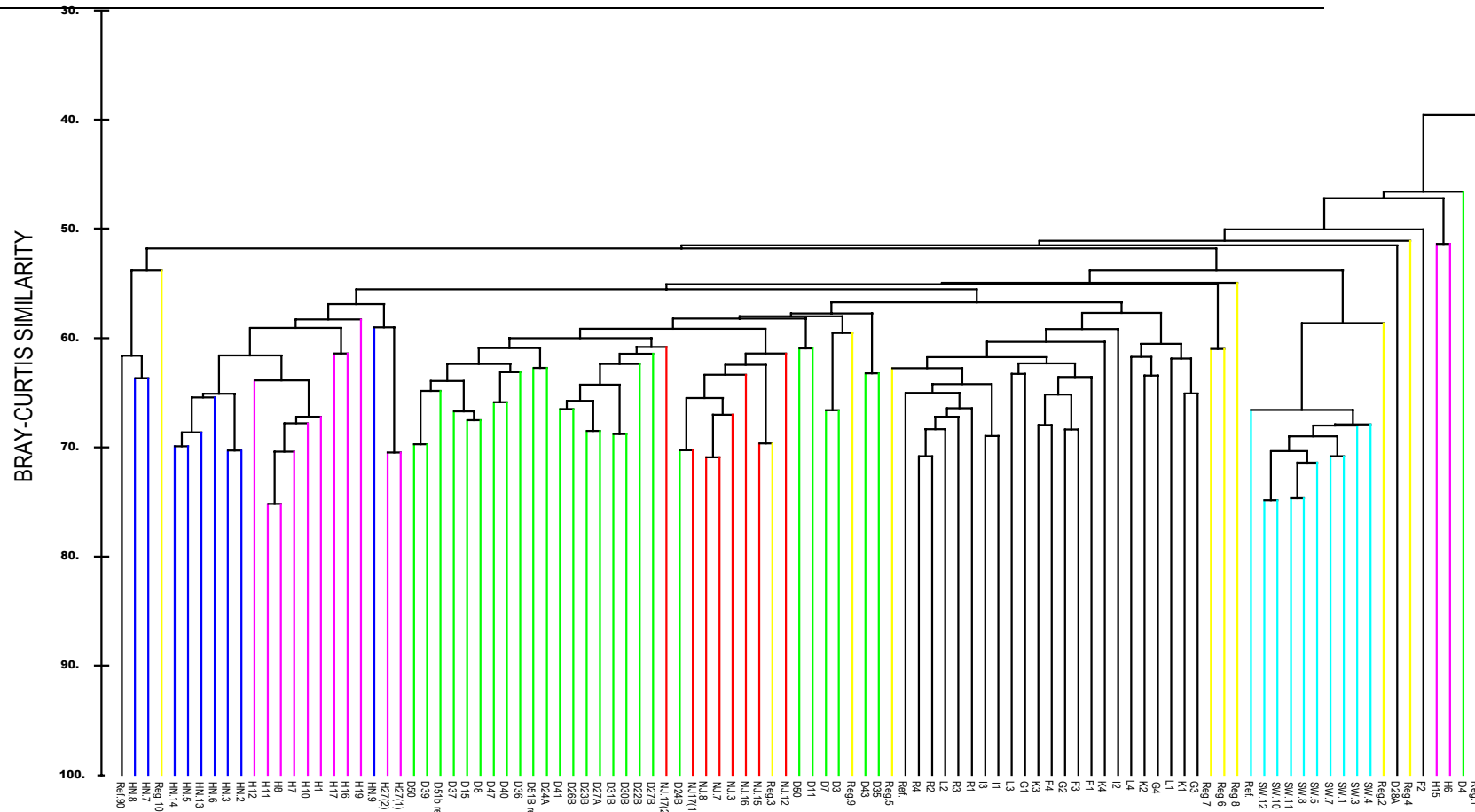


Figure 4.9. Dendrogram, all stations in the Haltenbank area 1997

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5 INSTALLATION SPECIFIC INVESTIGATIONS

5.1 NORNE

Grain size distribution and chemical analysis

The sediments at Norne show a uniform grain size distribution, and the silt content dominates. The average median particle diameter is 5,64 ϕ . The gravel content is low, except for the sediments at station SW3 135°/500 m which contain 4,2 %. There has been little change in the content of silt/clay since the base line survey in 1995.

As in the base line survey the total organic matter content is relatively high, and varies from 6,8 % at station SW12 315°/1000 m to 9,7 % at the reference station.

The hydrocarbon concentrations have increased somewhat since the base line survey. However, high levels are not found, and mean THC values > 10 mg/kg are only found at 4 of the 12 stations analysed. The highest concentration, 85 mg/kg, is found at station SW10 315°/250 m. Elevated hydrocarbon levels are found out to 750 m from the SW template, and the mineral oil HDF 200 is easily identified in the chromatograms. The standard error for THC at the influenced stations is the same as the median value, which indicates that the influence is very random distributed.

The drilling mud chemical DFE-622 is not found in the sediments.

Decalines are found at station SW10 135°/250 m, 17,6 mg/kg. Elevated levels of NPD and 3-6 ring aromatics are not found at any station.

Table 5.1. *Norne 1997. Total hydrocarbon content, NPD, decalins, 3-6 ring aromatics, metals (mg/kg dry sediment) and total organic matter (%).*

Station	THC	NPD	decalins	3-6 ring	Ba	Cd	Cu	Hg	Pb	Zn	TOM
SW1 20°/ 700 m	32,0	-	-	-	874	0,06	12,3	-	24,0	60,7	7,1
SW3 135°/ 500 m	42,1	-	-	-	1090	0,06	17,5	-	22,5	57,4	7,9
SW4 135°/1000 m	4,0	-	-	-	293	0,06	12,4	-	21,4	58,3	7,7
SW5 135°/2000 m	3,3	-	-	-	135	0,05	27,1	-	22,0	74,8	8,4
SW7 225°/ 500 m	9,2	-	-	-	925	0,07	12,0	-	22,2	59,4	7,5
SW8 225°/1000 m	4,7	-	-	-	308	0,07	20,2	-	21,4	65,0	8,1
SW9 225°/2000 m	3,1	-	-	-	149	0,06	11,8	-	20,7	59,9	-
SW10 315°/ 250 m	84,8	0,139	17,6	0,111	2990	0,05	28,5	0,02	27,3	55,2	6,9
1-3 cm	6,5	-	-	-	-	-	-	-	-	-	-
3-6 cm	3,2	-	-	-	-	-	-	-	-	-	-
SW11 315°/ 500 m	44,4	-	-	-	841	0,05	12,6	-	22,9	59,4	7,4
SW12 315°/1000 m	8,4	-	-	-	260	0,05	11,9	-	20,5	57,2	6,8
SW13 315°/2000 m	3,3	0,063	*	0,089	161	0,05	10,2	0,02	20,9	50,2	-
1-3 cm	2,0	-	-	-	-	-	-	-	-	-	-
3-6 cm	1,5	-	-	-	-	-	-	-	-	-	-
Norne ref	3,6	0,083	*	0,128	130	0,06	14,1	0,02	26,2	65,6	9,7
1-3 cm	2,3	-	-	-	-	-	-	-	-	-	-
3-6 cm	2,1	-	-	-	-	-	-	-	-	-	-

- not analysed DFE-622 is not detected

ENGLISH SUMMARY

The Ba concentrations have increased since 1995 at all stations out to 1000 m. The highest levels are found close to the template at station SW10 315°/250 m and at station SW3 135°/500 m, 2990 mg/kg and 1090 mg/kg respectively. Elevated Ba concentrations are not found at the reference station and at the stations at 2000 m distance.

The other metals do not contaminate the field.

Soft bottom fauna

The diversity indices and indices of evenness were high over the whole area, which means a healthy and unaffected fauna (table 5.2). None of the stations separate in the similarity analysis, which shows a fauna resemblance of about 70 % between the stations.

Analyses of correlation did not show any clear relations between fauna, depth, and sediment characteristic or sediment chemistry.

Compared with the baseline investigation in 1995 the number of species, individuals and diversity has increased. In figure 5.1 the diversity indices between years are compared. Altogether 42 more species were found in 1997 than in 1995. The largest increase was in the group bristle worms (polychaeta) while it was only minor changes in the other groups, table 5.3. In addition the dominating species and the sum of the ten dominating species constituted a lesser part of the total individuals in 1997 than in 1995.

The number of species at each station had an average increase of 34 species since 1995. The increase varied among 11 to 49 species per station.

The number of individuals at each station had an average increase of 309 individuals since 1995. the increase varied among 157 to 470 individuals per stations.

The results suggest that the condition in the fauna is better in 1997 than in 1995.

Table 5.2. Depth, number of species (S) and number of individuals (N) per 0,5 m², Shannon-Wiener's diversity index (H'), Pielou's index of evenness (J) and ES₁₀₀. Norne 1997.

Station	Direction	Depth	S	N	H'	J	ES ₁₀₀
SW-1	20/700m	373	74	454	5,26	0,85	40,0
SW-3	135/500m	376	72	411	5,20	0,84	40,3
SW-4	135/1000m	378	77	424	5,26	0,84	40,8
SW-5	135/2000m	380	78	580	5,14	0,82	38,6
SW-7	225/500m	377	81	503	5,33	0,84	41,8
SW-8	225/1000m	373	85	497	5,18	0,81	40,0
SW-10	315/250m	376	75	477	5,16	0,83	38,5
SW-11	315/500m	375	73	459	5,11	0,83	38,1
SW-12	315/1000m	391	87	408	5,37	0,83	43,7
REF.	Norne ref.	391	65	366	5,17	0,86	39,7

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Table 5.3. Number of species per group and portion quoted in percent of total number of species for 1995 and 1997. Pass for common stations (10), Norne.

Main groups	1995		1997	
	Number of species/ part (%)		Number of species/ part (%)	
Bristle worms	39	29,8	84	48,6
Crustacean	45	34,3	36	20,8
Molluscs	31	23,7	37	21,4
Echinoderms	11	8,4	9	5,2
Varia	5	3,8	7	4,0
TOTAL	131	100,0	173	100,0
Average no. of species per station	43		77	

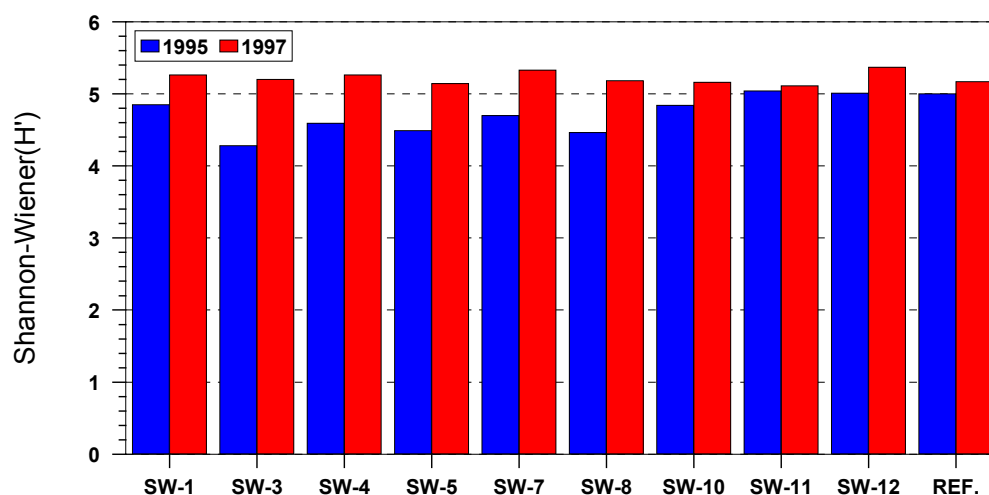


Figure 5.1. Diversity indices at Norne in 1995 and 1997*.

* The columns at the ref. station represents 10 grabs in 1995 and 5 grabs in 1997.

ENGLISH SUMMARY

5.2 ÅSGARD***Grain size distribution and chemical analysis***

The sediments at Åsgard consist of silt and sand, with an average of 50 % silt and 40 % sand. The most coarse sediment is found at template F, and the most fine-grained at template R. The gravel content varies, from 0 % at station R3 240°/500 m to 23 % at station I3 240°/500 m.

The hydrocarbon concentrations in the sediments have increased at templates G and R and decreased at template F since the base line survey in 1996. The contamination level is not high, and THC concentrations above 20 mg/kg are only found at four stations. The highest THC value, 106 mg/kg, is found at station R2 150°/500 m. Decalins are found at station R4 330°/500 m.

Relatively few changes are observed in the Ba level since 1996. The high level found at station F4 330°/500 m in 1996, 4000 mg/kg, is not found in 1997. However, an increase is observed at template G. The highest Ba concentration at the field is found at station G2 150°/500 m, 1850 mg/kg. Ba levels above 1000 mg/kg are found at six stations in the 60° and 150° directions at templates G, I, L and R. The field is not contaminated by the other metals.

Table 5.4. Åsgard 1997, Total hydrocarbon content, NPD, decalins, 3-6 ring aromatics, metals (mg/kg dry sediment) and total organic matter (%).

Station	THC	NPD	Decalins	3-6 ring	Ba	Cd	Cu	Hg	Pb	Zn	TOM
St.1 F1 60°/ 500 m	11,6	-	-	-	299	0,04	12,8	-	17,8	45,3	3,9
St.2 F2 150°/ 500 m	3,9	-	-	-	178	0,05	6,1	-	17,6	34,2	3,2
St.3 F3 240°/ 500 m	17,4	-	-	-	111	0,09	8,1	-	15,2	38,5	3,9
St.4 F4 330°/ 500 m	12,7	-	-	-	331	0,07	7,6	-	20,2	37,4	6,0
St.5 G1 60°/ 500 m	63,2	-	-	-	1040	0,09	8,7	-	18,7	44,5	5,3
St.6 G2 150°/ 500 m	14,4	-	-	-	1850	0,07	8,4	-	17,2	40,0	5,1
St.7 G3 240°/ 500 m	3,9	-	-	-	648	0,07	8,3	-	18,5	42,0	6,4
St.8 G4 330°/ 500 m	17,5	-	-	-	659	0,08	8,6	-	15,8	42,2	4,4
St.9 I1 60°/ 500 m	8,0	-	-	-	1040	0,08	10,1	-	17,7	47,9	5,0
St.10 I2 150°/ 500 m	6,3	-	-	-	1210	0,08	8,7	-	12,4	40,8	5,1
St.11 I3 240°/ 500 m	6,4	-	-	-	786	0,08	9,6	-	15,5	41,4	4,6
St.13 K1 60°/ 500 m	2,7	-	-	-	421	0,07	8,7	-	15,5	39,2	5,7
St.14 K2 150°/ 500 m	3,0	-	-	-	534	0,04	7,6	-	24,0	40,0	5,5
St.15 K3 240°/ 500 m	2,6	-	-	-	427	0,05	7,5	-	22,2	39,4	5,4
St.16 K4 330°/ 500 m	3,2	-	-	-	533	0,07	14,4	-	26,0	49,3	6,0
St.17 L1 60°/ 500 m	3,4	-	-	-	624	0,07	8,0	-	25,1	40,2	4,4
St.18 L2 150°/ 500 m	3,4	-	-	-	430	0,06	8,0	-	23,0	41,1	5,9

ENGLISH SUMMARY

Table 5.4. cont.

St.19	L3 240°/ 500 m	23,7	-	-	-	861	0,05	8,1	-	26,5	40,8	5,7
St.20	L4 330°/ 500 m	2,2	0,074	0,190	0,113	491	0,06	9,7	0,01	25,0	46,2	5,0
	1-3 cm	2,5	-	-	-	-	-	-	-	-	-	-
	3-6 cm	2,7	-	-	-	-	-	-	-	-	-	-
St.21	L5 60°/1000 m	4,2	-	-	-	670	0,06	7,6	-	22,1	39,3	-
St.22	L6 150°/1000 m	3,1	-	-	-	386	0,06	8,5	-	24,4	44,4	-
St.23	L7 240°/1000 m	4,6	-	-	-	661	0,05	8,4	-	25,4	44,2	-
St.24	L8 330°/1000 m	2,1	-	-	-	343	0,06	9,3	0,01	26,0	45,8	-
	1-3 cm	2,0	-	-	-	-	-	-	-	-	-	-
	3-6 cm	1,7	-	-	-	-	-	-	-	-	-	-
St.25	L9 60°/2000 m	3,2	-	-	-	1040	0,07	7,0	-	21,5	36,1	-
St.26	R1 60°/ 500 m	10,7	-	-	-	602	0,07	9,0	-	23,8	44,2	6,5
St.27	R2 150°/ 500 m	106	-	-	-	1030	0,07	9,3	-	24,1	43,0	6,9
St.28	R3 240°/ 500 m	41,0	-	-	-	621	0,09	9,6	-	26,7	49,9	6,2
St.29	R4 330°/ 500 m	15,5	0,101	3,100	0,134	856	0,07	14,5	-	25,9	50,3	5,7
St.30	Ref.	2,9	0,085	'	0,139	220	0,08	9,8	0,02	28	49,0	7,4
	1-3 cm	1,3	-	-	-	-	-	-	-	-	-	-
	3-6 cm	1,5	-	-	-	-	-	-	-	-	-	-

- not analysed

Soft bottom fauna

The diversity indices and the similarity analyse reveals that the condition in the soft bottom fauna at Åsgard is very good, table 5.5. It was difficult to find trends both in the data from 1997 and when the data from 1996 and 1997 were compared. Differences in the number of species and individuals together with diversity indices are relatively small and could be due to random variations between the years. However, an alteration in the species composition has occurred between the years from a relatively large element of molluscs, among the ten dominating species in 1996, to a bristle worm dominated fauna in 1997. In addition the ten dominating species constitutes a larger part of the fauna together with somewhat lower diversity indices in 1997 than in 1996, table 5.6 and in figure 5.2.

ENGLISH SUMMARY

Table 5.5. Depth, number of species (*S*) and number of individuals (*N*) per 0,5 m², Shannon-Wiener's diversity index (*H'*), Pielou's index of evenness (*J*) and *ES*₁₀₀. Åsgard, 1997.

Station	Direction	Depth	S	N	H'	J	ES ₁₀₀
F1	60/500	300	106	550	5,25	0,78	43,3
F2	150/500	299	97	295	5,82	0,88	52,5
F3	240/500	307	90	355	5,69	0,87	49,0
F4	330/500	307	90	463	5,55	0,86	44,0
G1	60/500	287	80	354	5,52	0,87	44,8
G2	150/500	287	91	350	5,66	0,87	47,8
G3	240/500	289	99	390	5,64	0,85	48,2
G4	330/500	284	114	465	5,88	0,86	50,9
I1	60/500	293	72	248	5,57	0,90	47,5
I2	150/500	287	85	279	5,60	0,87	48,3
I3	240/500	291	139	514	6,45	0,91	60,3
K1	60/500	291	95	366	5,81	0,89	49,8
K2	150/500	295	105	403	5,78	0,86	49,5
K3	240/500	300	82	356	5,45	0,86	44,2
K4	330/500	295	87	304	5,66	0,88	48,3
L1	60/500	282	104	492	5,73	0,86	47,5
L2	150/500	285	69	277	5,46	0,89	44,6
L3	240/500	283	83	304	5,47	0,86	46,8
L4	330/500	287	128	649	6,00	0,86	50,9
R1	60/500	302	74	422	5,18	0,83	39,1
R2	150/500	304	66	307	5,25	0,87	41,8
R3	240/500	304	57	227	5,13	0,88	41,3
R4	330/500	304	68	235	5,32	0,87	43,7
REF	Ref.	296	56	218	5,11	0,88	39,8

ENGLISH SUMMARY

Table 5.6. Number of species per group and portion quoted in percent of total number species for 1995 and 1997. Pass for common stations (20), Åsgard.

Main groups	1996		1997	
	Number of species/ part (%)		Number of species/ part (%)	
Bristle worms	119	43,0	126	44,4
Crustacean	68	24,5	68	23,9
Molluscs	64	23,1	58	20,4
Echinoderms	16	5,8	20	7,0
Varia	10	3,6	12	4,3
TOTAL	277,0	100,0	284,0	100,0
Average no. of species per station	93,0		86,0	

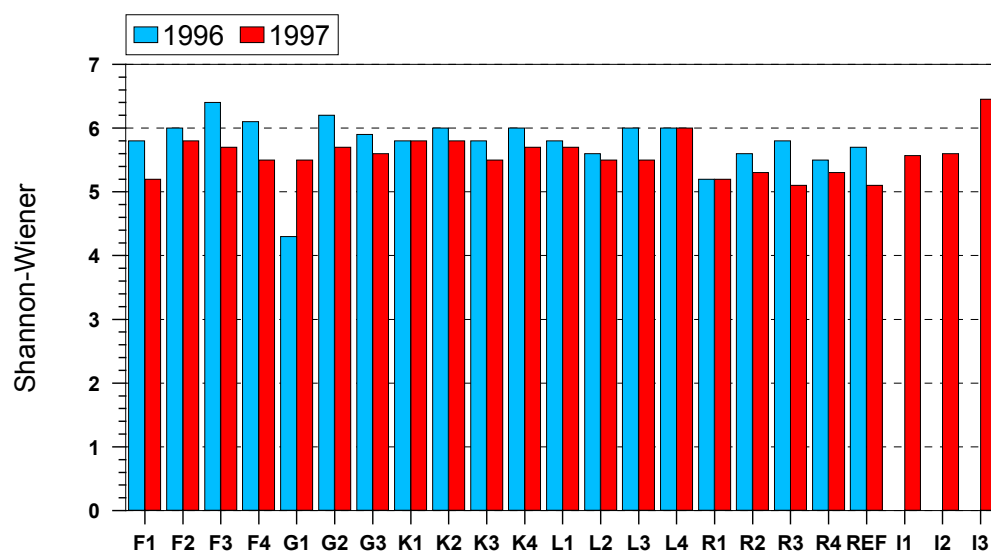


Figure 5.2. Diversity indices at Åsgard 1996 and 1997.

ENGLISH SUMMARY

5.3 HEIDRUN***Grain size distribution and chemical analysis***

The silt content dominates in the sediments at Heidrun. The sand fraction represents about 25 %, except for 45 % at the reference station. The gravel content is low, and the highest value, 5,6 %, is found at station H19 315°/3500 m. In the previous environmental surveys in 1993 and 1995, contamination of hydrocarbons was not found in the sediments. The THC levels are still low and vary from 1,1 mg/kg to 28,8 mg/kg. Elevated THC levels are only found at the three innermost stations at 550 m distance. The elevated values result from hydrocarbons that look like the drilling chemical "Novasol".

The base fluid Petrofree is only found at two stations at 550 m, and the concentrations are less than 1 mg/kg.

The base fluid Aquamul B II was found in the previous environmental surveys, and a pronounced increase was observed from 1993 to 1995. In the present investigation the highest concentrations are at similar level as in 1995. Aquamul B II is found at all six ordinary stations analysed, but not at the reference station. The concentrations vary from 0,3 mg/kg to 271 mg/kg (station H12 120°/550 m).

The drilling mud chemical DFE-622 is not found in the sediments.

The Ba concentrations have increased since 1995 at all stations out to 1000 m, and also out to 2000 m in the 135° direction. The highest levels, 7800 mg/kg, are found at station H12 120°/550 m. The concentrations of the other metals are low, and elevated levels of Cu and Pb are only found at two stations.

Table 5.7. Heidrun 1997, Total hydrocarbon content, Petrofree, Aquamul B II, NPD, decalins, 3-6 ring aromatics, metals (mg/kg dry sediment) and total organic matter (%).

Station	THC	Petro-free	Aquamul B II	NPD	Decalins	3-6 ring	Ba	Cd	Cu	Hg	Pb	Zn	TOM
H1 225°/ 2000 m	2,9	-	-	-	-	-	773	0,06	9,2	-	21,8	41,1	5,7
H6 45°/ 550 m	28,8	0,37	216	-	-	-	7270	0,06	29,9	-	50,3	68,0	6,0
H7 45°/ 1000 m	5,0	< 0,30	1,9	-	-	-	5120	0,09	22,5	-	25,0	59,8	5,8
H8 45°/ 1500 m	3,8	-	-	-	-	-	3430	0,07	11,2	-	21,7	43,5	6,6
H10 135°/ 2000 m	2,4	-	-	-	-	-	1300	0,06	11,5	-	18,9	44,0	6,1
H11 135°/ 1000 m	3,2	< 0,30	5,0	-	-	-	3820	0,07	9,2	-	23,8	41,2	6,4
H12 120°/ 550 m	26,0	0,64	271	-	-	-	7800	0,06	15,3	-	45,6	53,5	6,6
H15 315°/ 550 m	10,6	< 0,30	222	0,091	0,458	0,084	5240	0,07	10,6	0,02	18,4	41,8	6,1
1-3 cm	**	-	-	-	-	-	-	-	-	-	-	-	-
3-6 cm	2,3	-	-	-	-	-	-	-	-	-	-	-	-

ENGLISH SUMMARY

Table 5.7 cont.

H16 315°/ 1000 m	1,7	< 0,30	0,3	-	-	-	3270	0,06	11,1		21,4	47,2	6,1
H17 315°/ 2000 m	2,6	-	-	0,073	*	0,092	856	0,07	10,1	0,02	21,2	46,2	6,2
1-3 cm	1,1	-	-	-	-	-	-	-	-	-	-	-	-
3-6 cm	0,3	-	-	-	-	-	-	-	-	-	-	-	-
H19 315°/ 3500 m	1,2	-	-	-	-	-	247	0,05	10,2	-	20,4	46,3	6,5
H24 315°/ 5000 m	2,1	-	-	-	-	-	138	0,06	10,0	-	21,2	50,2	-
H27 315°/10000 m	1,1	< 0,30	< 0,15	0,061	*	0,144	112	0,05	7,2	0,03	21,2	41,1	5,3
1-3 cm	0,3	-	-	-	-	-	-	-	-	-	-	-	-
3-6 cm	0,7	-	-	-	-	-	-	-	-	-	-	-	-

- not analysed * not found ** not quantified DFE-622 is not found

Soft bottom fauna

The diversity indices and indices of evenness were high over the whole area, which means a healthy and unaffected fauna. However the diversity is higher outside a radius of 2000 m from the installation (figure 5.3). Altogether 23 more species were found in 1997 than in 1995. Since the investigations in 1995 the number of species has increased in the groups of crustacean, molluscs and echinoderms; while it was found the same number of bristle worms at 12 comparable stations.

The BIOENV analysis shows that there was a correlation (0,5) between THC, barium and fauna in the field area.

Average number of species per station shows an increase of 10 species since 1995. The increase varied among 2 to 34 species. The general increase in species number per stations is mainly because the presence of the most species has increased with the increasing number of individuals in the field area. The specie *E. incolor* and the indicator specie *C. setosa* constitute the largest part of the increase in the number of individuals. This together with the results from the similarity analysis indicates that the fauna are effected especially at stations H6 and in some lesser extent the fauna at the stations inside the 2000 m radius.

ENGLISH SUMMARY

Table 5.8. Depth, number of species (S) and number of individuals (N) per 0,5 m², Shannon-Wiener's diversity index (H'), Pielou's index of evenness (J) and ES₁₀₀. Heidrun 1997.

Station	Direction	Depth	S	N	H'	J	ES ₁₀₀
H1	225°/2000m	344	92	823	5,04	0,77	38,8
H6	45°/550m	351	54	318	4,38	0,76	31,0
H7	45°/1000m	356	80	643	4,80	0,76	34,9
H8	45°/1500m	356	92	870	4,48	0,69	32,6
H10	135°/2000m	344	93	746	5,02	0,77	38,4
H11	135°/1000m	344	93	1024	4,58	0,70	33,3
H12	120°/550m	347	84	661	4,80	0,75	36,9
H15	315°/550m	349	57	329	4,64	0,80	33,6
H16	315°/1000m	351	72	372	4,69	0,76	36,6
H17	315°/2000m	347	55	224	4,94	0,86	38,1
H19	315°/3500m	331	79	363	5,42	0,86	44,3
H27a	315°/10000m	333	117	482	5,95	0,87	50,5
H27b	315°/10000m	333	120	471	5,94	0,86	51,4

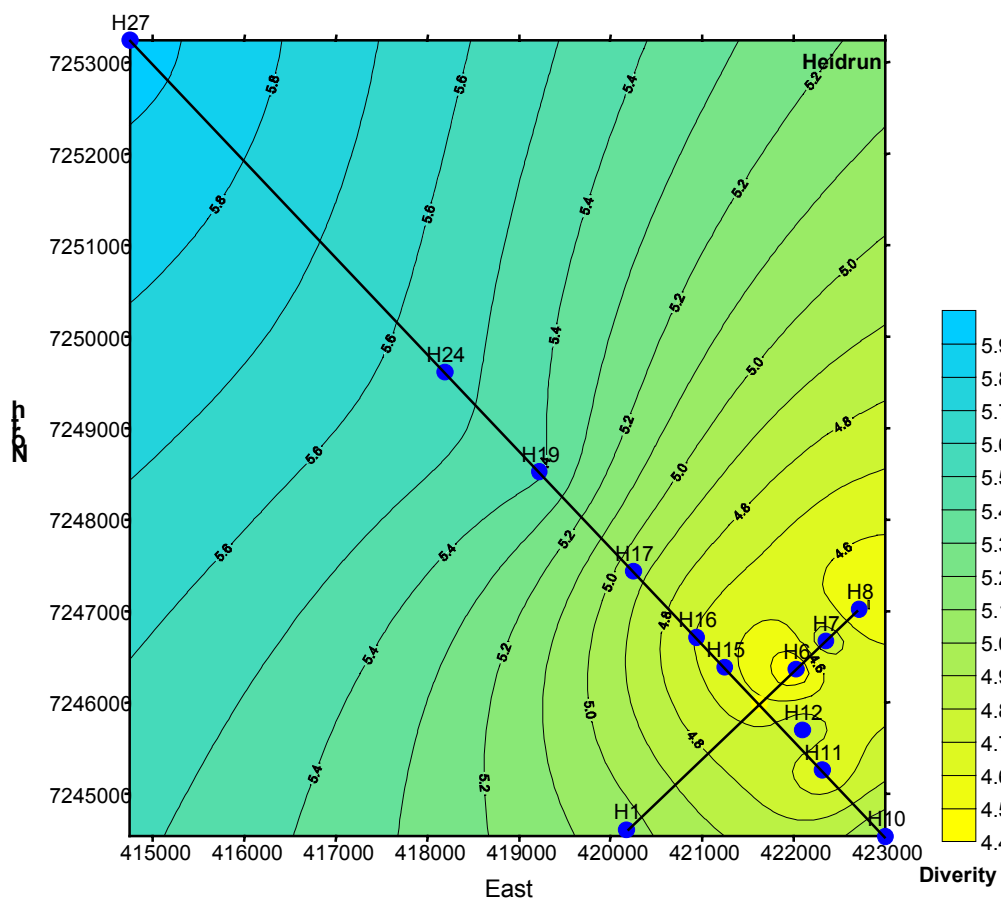


Figure 5.3. General overview of the diversity in the field area. Based on indices of diversity (H'), Heidrun, 1997.

ENGLISH SUMMARY

Table 5.9. Number of species per group and portion quoted in percent of total number species for 1995 and 1997. Pass for common stations (12), Heidrun 1997.

Main groups	1995		1997	
	Number of species/ part (%)		Number of species/ part (%)	
Bristle worms	123	56,2	123	50,8
Crustacean	41	18,7	49	20,2
Molluscs	34	15,5	48	19,8
Echinoderms	9	4,1	14	5,8
Varia	12	5,5	8	3,4
TOTAL	219,0	100,0	242,0	100,0
Average no. of species per station	73,2		83,7	

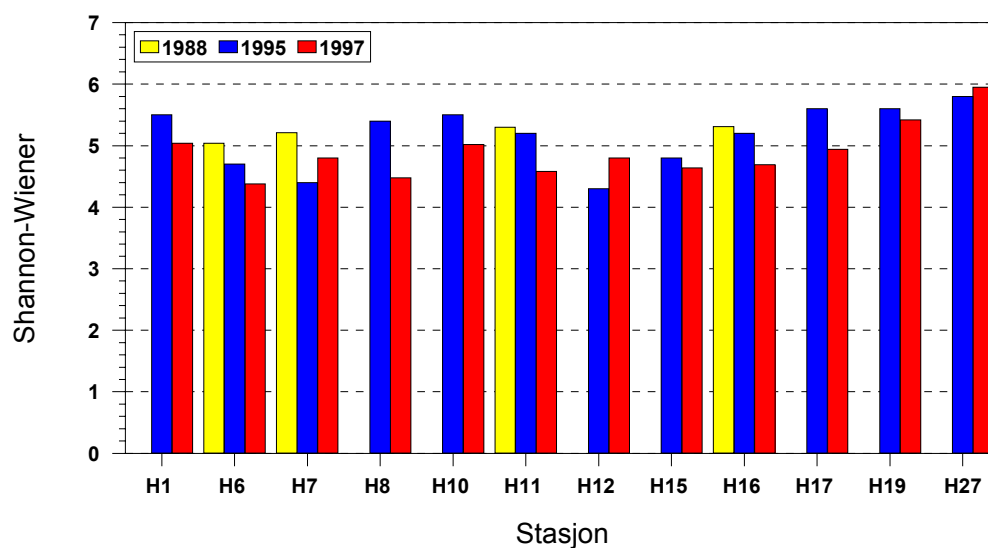


Figure 5.4. Diversity (H') at Heidrun 1988, 1995 and 1997.

ENGLISH SUMMARY

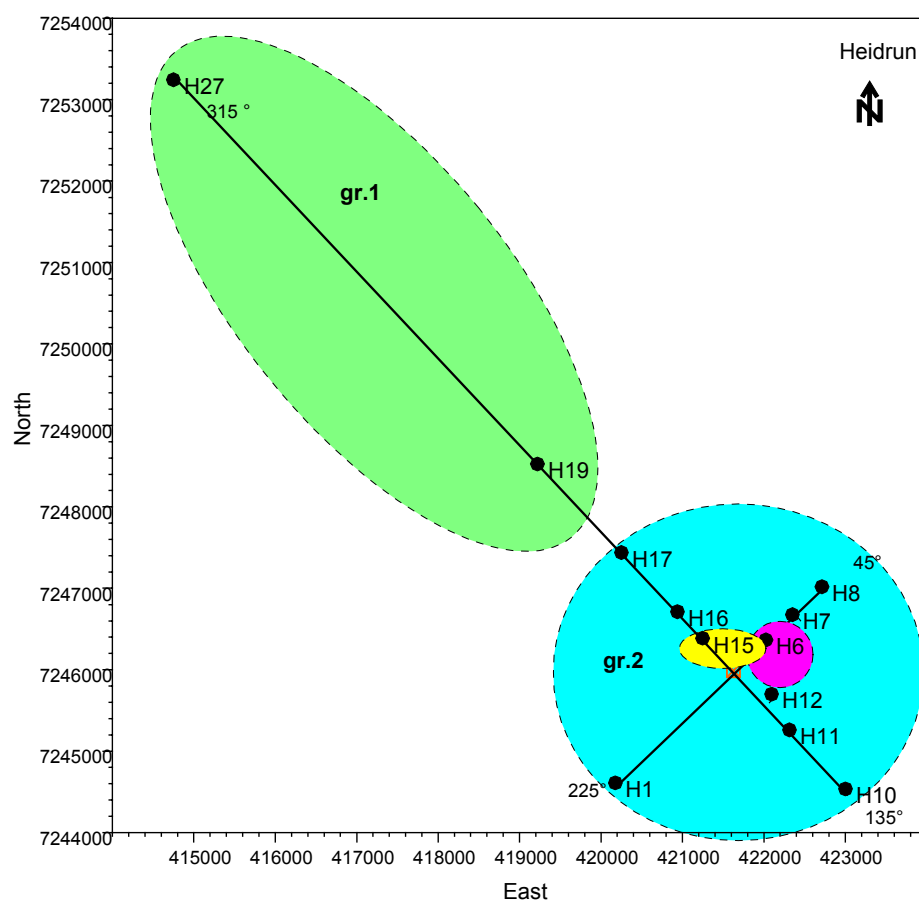


Figure 5.5. Geographical group distribution, based on dendrogram and MDS-plot. Heidrun 1997.

5.4 HEIDRUN NORD

Grain size distribution and chemical analysis

The sediments at Heidrun Nord have a uniform grain size distribution, and the silt content dominates. The average median particle diameter at the field is 5,45 ϕ . The gravel content is low.

The total organic matter content varies from 5,1 % at station HN2 90°/500 m to 7,9 % at stations HN8 270°/500 m and HN9 270°/1000 m. The concentrations are at the same level or a bit higher compared to Heidrun.

In this base line study in 1997 no contamination of hydrocarbons, barium and heavy metals is found in the sediments at Heidrun Nord. The THC level is low and the concentrations vary from 2,0 mg/kg to 3,8 mg/kg. The THC concentration at the reference station, 90°/10000 m is 2,9 mg/kg.

The Ba content in the sediments varies from 152 mg/kg at station HN8 270°/500 m to 411 mg/kg at station HN10 270°/2000 m. The level is relatively high due to the fine sediment (silt) at the field. The concentrations of Cu, Pb and Zn are also low. Cd values lie around the quantitation limit (0,04 – 0,07 mg/kg), and Hg is only just found at three stations.

This investigation gives a basis for assessment of the impact of future development of the field.

ENGLISH SUMMARY

Table 5.9. Heidrun Nord 1997, Total hydrocarbon content, NPD, 3-6 ring aromatics, metals (mg/kg dry sediment) and total organic matter (%).

Station		THC	NPD	3-6 ring	Ba	Cd	Cu	Hg	Pb	Zn	TOM
HN2	90°/ 500 m	2,5	-	-	282	0,07	9,0	< 0,01	17,8	47,8	5,1
HN3	90°/1000 m	2,9	-	-	258	0,06	8,6	< 0,01	16,8	47,7	6,1
HN5	180°/ 500 m	3,4	-	-	313	0,07	16,7	< 0,01	21,4	60,6	6,4
HN6	180°/1000 m	3,4	-	-	361	0,05	8,9	< 0,01	15,2	48,8	6,4
HN7	270°/ 250 m	2,0	0,077	0,095	279	0,04	9,8	0,03	16,8	52,2	6,1
	1-3 cm	2,7	-	-	-	-	-	-	-	-	-
	3-6 cm	1,4	-	-	-	-	-	-	-	-	-
HN8	270°/ 500 m	3,2	-	-	152	0,04	11,6	< 0,01	14,3	56,8	7,9
HN9	270°/1000 m	3,8	-	-	380	0,05	13,4	< 0,01	21,3	62,2	7,9
HN10	270°/2000 m	3,8	0,103	0,149	411	0,04	10,9	0,03	15,6	53,2	-
	1-3 cm	3,2	-	-	-	-	-	-	-	-	-
	3-6 cm	2,3	-	-	-	-	-	-	-	-	-
HN11	270°/4000 m	3,4	-	-	255	0,07	12,2	< 0,01	21,4	57,5	-
HN13	360°/ 500 m	3,4	-	-	273	0,06	11,4	< 0,01	20,4	53,7	7,6
HN14	360°/1000 m	3,6	-	-	276	0,04	9,7	< 0,01	17,2	49,6	6,7
Ref.	90°/10000 m	2,9	0,082	0,106	206	0,05	8,5	0,03	17,0	45,9	6,2
	1-3 cm	2,0	-	-	-	-	-	-	-	-	-
	3-6 cm	1,6	-	-	-	-	-	-	-	-	-

- not analysed Decalins are not found

Soft bottom fauna

The diversity indices and indices of evenness were high over the whole area, which means a healthy and unaffected fauna, table 5.10. The similarity analysis divided the stations into two groups at a similarity of 60 %, this grouping is assumed to be due to random variations in the fauna community in the area.

The analyses of correlation did not show any clear relation between fauna, depth, and sediment characteristic and sediment chemistry.

Table 5.10 Depth, number of species (S) and number of individuals (N) per 0,5 m², Shannon-Wiener's diversity index (H'), Pielou's index of evenness (J) and ES₁₀₀. Heidrun Nord 1997.

Station	Direction	Depth	S	N	H'	J	ES ₁₀₀
HN2	90/500	351	72	256	5,40	0,88	44,5
HN3	90/1000	353	73	370	5,17	0,84	40,8
HN5	180/500	351	91	585	5,21	0,80	40,0
HN6	180/1000	352	67	331	5,04	0,83	39,4
HN7	270/250	351	54	147	5,17	0,90	44,4
HN8	270/500	356	68	251	5,30	0,87	43,2
HN9	270/1000	362	114	575	5,80	0,85	48,2
HN13	360/500	358	96	502	5,53	0,84	44,6
HN14	360/1000	367	84	411	5,46	0,85	43,9
Ref.	90/10000	329	53	127	5,02	0,88	45,8

ENGLISH SUMMARY

5.5 DRAUGEN***Grain size distribution and chemical analysis***

The sediments at the Draugen field consist of silt and sand. The silt fraction dominates at SWIT and NWIT, while the sediments at Draugen consist of equal amounts of silt and sand, and also some gravel.

The field is not contaminated by mineral oil, and elevated hydrocarbon concentrations are not found. The THC concentrations in the sediments vary from 2,6 mg/kg to 6,4 mg/kg.

Elevated Ba levels are found at the Draugen and NWIT areas, up to 3200 mg/kg. Only minor changes are observed since the 1994 survey. The results indicate a main transport in the 300° direction. Low concentrations of the other metals are found, and elevated levels of Cu are found in two samples only.

Table 5.11. Draugen 1997, Total hydrocarbon content, NPD, 3-6 ring aromatics, metals (mg/kg dry sediment) and total organic matter (%).

Station	THC	NPD	3-6 ring	Ba	Cd	Cu	Hg	Pb	Zn	TOM
SWIT D2 230°/ 2000 m	5,7	-	-	145	0,04	8,4	-	17,1	40,2	-
D3 230°/ 1000 m	5,6	-	-	252	<0,03	8,9	-	16,9	41,3	3,1
D4 230°/ 500 m	3,8	-	-	459	<0,03	10,8	-	17,4	44,2	4,2
D6 300°/ 2000 m	5,2	0,055	0,096	311	<0,03	9,4	0,01	18,0	43,3	-
1-3 cm ; 3- 6 cm	4,4 ; 1,9	-	-	-	-	-	-	-	-	-
D7 300°/ 1000 m	4,1	-	-	328	<0,03	9,7	-	19,5	45,2	4,9
D8 300°/ 500 m	4,3	0,069	0,115	375	<0,03	9,6	<0,01	17,5	41,3	4,4
1-3 cm ; 3-6 cm	3,6 ; 3,5	-	-	-	-	-	-	-	-	-
D11 120°/ 500 m	4,7	-	-	255	<0,03	8,7	-	18,5	39,9	4,3
D15 25°/ 500 m	4,0	-	-	247	<0,03	11,4	-	14,9	43,4	4,8
Draugen 21B 300°/ 2000 m	4,3	0,052	0,093	802	<0,03	8,3	0,01	17,8	32,6	-
1-3 cm ; 3-6 cm	1,5 ; 1,2	-	-	-	-	-	-	-	-	-
22B 300°/ 1000 m	4,8	-	-	1170	<0,03	8,4	-	18,0	34,4	3,2
23B 300°/ 500 m	5,5	-	-	2810	<0,04	9,8	-	19,1	59,6	3,2
24A 325°/ 900 m	3,4	-	-	734	0,04	6,5	-	14,8	31,6	3,4
24B 300°/ 250 m	5,3	0,054	0,059	3230	0,04	7,3	<0,01	15,2	36,3	3,2
1-3 cm ; 3-6 cm	5,2 ; 3,2	-	-	-	-	-	-	-	-	-
26B 162°/ 500 m	4,7	-	-	565	0,05	8,4	-	19,1	40,8	3,6
27A 45°/ 750 m	3,8	-	-	256	0,06	7,6	-	17,9	38,2	3,3
27B 162°/ 1000 m	3,0	-	-	495	0,05	25,6	-	22,5	58,7	3,6
28A 45°/ 1500 m	3,1	-	-	156	0,06	9,0	-	18,6	45,1	2,8
30B 325°/ 500 m	5,9	-	-	1120	0,05	8,4	-	20,4	44,4	3,4
31B 35°/ 1000 m	4,1	-	-	497	0,05	7,4	-	17,3	38,0	2,9
51B Ref.	2,6	0,043	0,090	113	0,04	7,7	<0,02	17,1	39,0	3,9
1-3 cm ; 3-6 cm	2,0 ; 2,0	-	-	-	-	-	-	-	-	-

ENGLISH SUMMARY

Table 5.11. cont.

NWIT	D35	215°/ 1000 m	3,8	-	-	549	0,04	7,1	-	17,5	37,6	4,1
	D36	215°/ 500 m	3,3	-	-	1490	<0,03	7,9	-	15,4	44,0	5,1
	D37	215°/ 250 m	3,8	-	-	2010	0,04	7,1	-	16,6	42,4	4,9
	D38	305°/ 2000 m	4,1	0,057	0,108	467	0,04	7,7	0,03	17,9	47,2	-
		1-3 cm ; 3-6 cm	2,7 ; 2,2	-	-	-	-	-	-	-	-	-
	D39	305°/ 1000 m	3,9	-	-	781	0,04	7,2	-	16,4	41,5	5,5
	D40	305°/ 500 m	3,6	-	-	1820	0,05	8,3	-	19,5	46,6	4,2
	D41	305°/ 250 m	6,4	0,059	0,104	2730	0,05	8,8	0,03	18,4	50,0	3,4
		1-3 cm ; 3-6 cm	2,8 ; 1,9	-	-	-	-	-	-	-	-	-
	D43	120°/ 500 m	4,8	-	-	806	0,05	7,4	-	17,0	43,9	4,6
	D47	35°/ 500 m	5,1	-	-	1070	0,05	28,4	-	19,2	61,9	5,7
	D50	35°/ 9000 m	3,8	-	-	161	0,05	6,9	-	16,0	41,0	3,8

- not analysed Decalins are not found

Soft bottom fauna

The diversity indices and indices of evenness were high over the whole area, which means a healthy and unaffected fauna, table 5.12. Station 28 A separated in the similarity analysis and in species composition and diversity. However it was only one grab at this station, which influenced the results for the whole station (5 grabs), which indicates a very local disturbance, which is not necessarily a result of the activity in the area.

Table 5.12. Depth, number of species (*S*) and number of individuals (*N*) per 0,5 m², Shannon-Wiener's diversity index (*H'*), Pielou's index of evenness (*J*) and *ES*₁₀₀, Draugen 1997.

Station	Direction	Depth (m)	S	N	H'	J	ES ₁₀₀
SWIT							
D3	230/1000m	278	87	340	5,79	0,90	50,2
D4	230/500	280	90	372	5,63	0,87	47,0
D7	300/1000m	276	93	511	5,66	0,87	45,9
D8	300/500m	278	102	527	5,60	0,84	45,4
D11	120/500m	280	87	443	5,48	0,85	43,5
D15	25/500m	277	80	401	5,48	0,87	44,3
PLATFORM							
22B	300/1000m	247	86	379	5,65	0,88	47,0
23B	300/500m	252	105	449	5,62	0,84	47,4
24A	325/900m	245	94	361	5,83	0,89	49,9
24B	300/250m	251	131	834	5,82	0,83	47,9
26B	162/500m	253	119	623	5,91	0,86	49,7
27A	45/750m	247	109	447	5,94	0,88	50,9
27B	162/1000m	262	109	519	5,92	0,88	49,9
28A	45/1500m	253	91	616	4,71	0,72	37,1
30B	325/500m	249	98	341	5,90	0,89	52,2
31B	35/1000m	243	103	436	5,87	0,88	49,7
51B(a)	ref.	271	85	379	5,55	0,87	45,2
51B(b)	ref.	271	105	580	5,79	0,86	47,5

ENGLISH SUMMARY

Table 5.12. cont.

NWIT							
D35	35-215/1000m	239	81	322	5,57	0,88	46,8
D36	36-215/500m	242	85	466	5,26	0,82	42,4
D37	37-215/250m	241	87	420	5,47	0,85	44,3
D39	39-305/1000m	242	87	471	5,57	0,86	44,2
D40	40-305/500m	242	81	417	5,38	0,85	41,8
D41	41-305/250m	235	96	377	5,85	0,89	50,3
D43	43-120/500m	244	66	269	5,11	0,85	39,6
D47	47-35/500m	238	103	429	5,95	0,89	51,6
D50a	50-35/9000m	237	85	339	5,41	0,84	44,3
D50b	50-35/9000m	237	89	446	5,43	0,84	44,4

Analyses of correlation did not show any clear relations between fauna, depth, and sediment characteristic or sediment chemistry.

Compared with the investigations in 1992 and 1994 the number of species and individuals together with diversity has increased. In addition the ten dominating species constituted a lesser part of the total number of individuals in 1997 at most of the stations. The comparing of diversity indices between years are shown in figure 5.6.

Altogether 84 more species were found in 1997 than in 1994. The largest increase was in the bristle worms (polychaeta) group, while there were only minor changes in the other groups (table 5.13). There has been an increase in the number of individuals found at the 26 stations since 1994, from a total of 8508 individuals in 1994 to 12514 individuals in 1997.

The number of species had an average increase since 1992 and 1994 of respectively 62 and 36 species. The increase varied from respectively 38 to 88 species at 17 comparable stations from 1992 and 2 to 74 species at 26 comparable stations from 1994.

the number of individuals had an average increase since 1992 and 1994 for respectively 407 and 282 individuals. The increase varied from respectively 241 to 886 individuals at 17 comparable stations from 1992 and 57 to 646 individuals at 26 comparable stations from 1994.

The results suggest that the condition in the fauna is better in 1997 than in 1992 and 1994.

Table 5.13. Number of species per group and portion quoted in percent of total number species for 1994 and 1997. Pass for common stations (26).

Main groups	1994		1997	
	Number of species/	part (%)	Number of species/	part (%)
Bristle worms	90	32,4	174	48,1
Crustacean	86	30,9	92	25,4
Molluscs	66	23,8	60	16,6
Echinoderms	24	8,6	24	6,6
Varia	12	4,3	12	3,3
TOTAL	278	100,0	362	100,0
Average no. of species per station	62		98	

ENGLISH SUMMARY

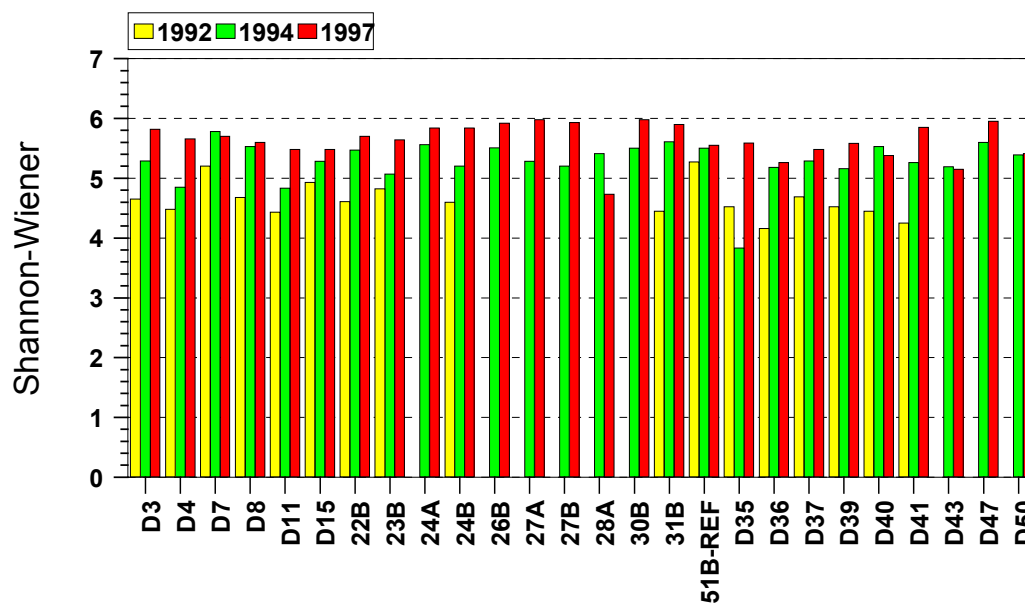


Figure 5.6. The diversity (H') at Draugen in 1992, 1994 and 1997.

ENGLISH SUMMARY

5.6 NJORD***Grain size distribution and chemical analysis***

The stations analysed at Njord in 1997, are situated 1000 m and 2000 m from the platform.

The sediments consist mainly of silt and sand, and the silt fraction dominates. Some gravel is also observed mostly at the reference station where the sediments contain 7,9 % gravel. The average median particle diameter at the field is similar to the results in 1996 (average value 5,46 ϕ), while the silt and clay fractions have decreased, 58 % in 1997 compared to 76 % in 1996.

The total organic matter content varies from 4,0 % at the reference station NJ17 67,5°/10000 m to 5,4 % at station NJ12 247,5°/2000 m. The levels are generally a bit higher than the results from the base line survey in 1996.

The hydrocarbon level is low at all stations, and the mean THC concentrations vary from 3,4 mg/kg to 5,7 mg/kg.

The concentrations of Ba and heavy metals are also low, and only minor changes since the base line survey in 1996 are observed.

Contamination of hydrocarbons and metals is thus not found in the present environmental survey at the Njord field. However, the stations close to the platform were not analysed, and this fact may be a reason for the low levels found.

Table 5.14. *Njord 1997, Total hydrocarbon content, NPD, 3-6 ring aromatics, metals (mg/kg dry sediment) and total organic matter (%).*

Station	THC	NPD	3-6 ring	Ba	Cd	Cu	Hg	Pb	Zn	TOM
NJ3 67,5°/1000 m	3,8	-	-	316	0,06	8,1		24,8	39,2	5,0
NJ7 157,5°/1000 m	4,1	-	-	225	0,06	8,3		24,3	39,3	4,5
NJ8 157,5°/2000 m	4,2	0,082	0,149	141	0,05	6,9	0,02	21,9	35,7	4,7
1-3 cm	1,94	-	-	-	-	-	-	-	-	-
3-6 cm	1,77	-	-	-	-	-	-	-	-	-
NJ12 247,5°/2000 m	3,8	-	-	241	0,05	14,9		23,4	43,6	5,4
NJ15 337,5°/1000 m	5,7	-	-	321	0,04	8,3		21,3	35,8	4,7
NJ16 337,5°/2000 m	3,8	-	-	248	0,04	9,5		22,6	40,9	4,7
NJ17 67,5°/10000 m	3,4	0,063	0,126	113	0,04	7,7	0,01	19,7	34,1	4,0
1-3 cm	2,16	-	-	-	-	-	-	-	-	-
3-6 cm	1,80	-	-	-	-	-	-	-	-	-

- not analysed Decalins are not found

Soft bottom fauna

The diversity indices and indices of evenness were high over the whole area, which means a healthy and unaffected fauna (table 5.15 and figure 5.7). The similarity analysis revealed about 60 % resemblance between the stations. The stations localised far out on the transects separates somewhat from the rest of the stations. One exception was station NJ-8 (2000 m), which were grouped together with the stations 1000 m from the platform.

Analyses of correlation did not show any clear relations between fauna, depth, and sediment characteristic or sediment chemistry.

ENGLISH SUMMARY

Compared with the baseline investigation in 1996 the number of species and individuals together with diversity have increased, figure 5.8. In addition the dominating and the ten most common species constituted a lesser part of the total individuals in 1997 than in 1996.

Altogether 42 more species were found in 1997 than in 1995. The largest increase was in the group bristle worms (polychaeta) while there were only minor changes in the other groups (table 5.16). There has been a general increase in the number of individuals found at the 7 comparable stations since 1996, from 1136 to 3667 individuals.

The number of species had an average increase of 43 species since 1996. The increase varied between 23 to 65 species per station. The increase in number of individuals varied between 222 to 539 individuals per stations.

The results suggest that the condition in the fauna is better in 1997 than in 1996.

Table 5.15 Depth, number of species (S) and number of individuals (N) per 0,5 m², Shannon-Wiener's diversity index (H'), Pielou's index of evenness (J) and ES₁₀₀. Njord 1997.

Station	Direction	Depth	S	N	H'	J	ES ₁₀₀
NJ-3	67.5°/1000m	331	100	435	5,73	0,86	49,0
NJ-7	157.5°/1000m	331	100	421	5,84	0,88	50,9
NJ-8	157.5°/2000m	331	104	404	5,93	0,89	51,9
NJ-12	247.5°/2000m	333	113	644	5,84	0,86	48,3
NJ-15	337.5°/1000m	331	82	603	5,10	0,80	38,7
NJ-16	337.5°/2000m	333	84	361	5,54	0,87	44,8
NJ-17a	67.5°/10.000m	316	97	353	5,90	0,89	52,3
NJ-17b	67.5°/10.000m	316	107	446	5,95	0,88	51,3

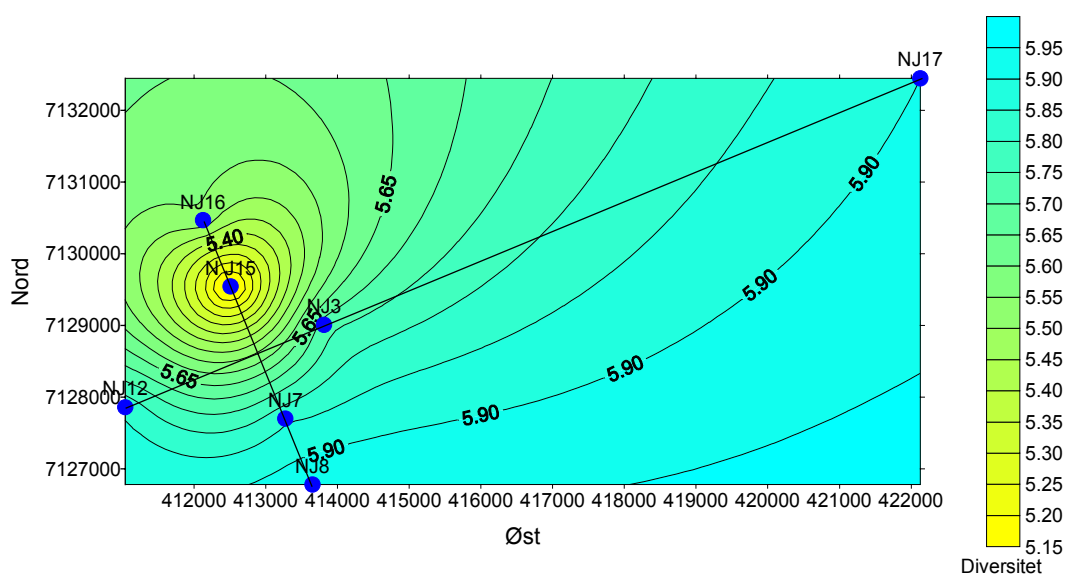


Figure 5.7. General over view of the diversity in the area based on indices of diversity (H'). Njord 1997.

ENGLISH SUMMARY

Table 5.16. Number of species per group and portion quoted in percent of total number species for 1996 and 1997. Pass for common stations (7) Njord

Main groups	1996		1997	
	Number of species/	part (%)	Number of species/	part (%)
Bristle worms	63	36,0	107	49,4
Crustacean	38	21,7	43	19,8
Molluscs	44	25,2	40	18,4
Echinoderms	14	8,0	15	6,9
Varia	16	9,1	12	5,5
TOTAL	175	100,0	217	100,0
Average no. of species per station	59		102	

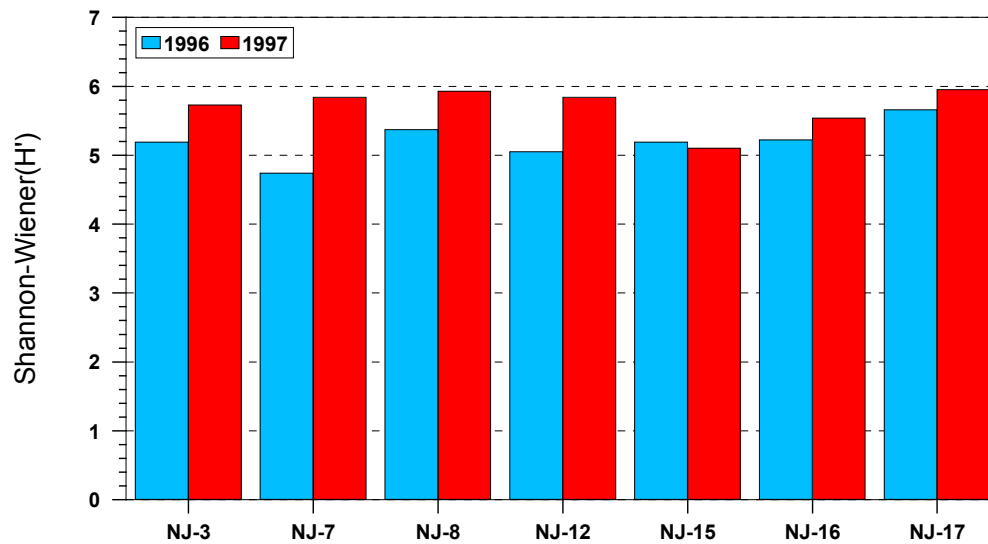


Figure 5.8. Diversity (H') at Njord in 1996 and 1997.

6 RECOMMENDATIONS

Based on the existing results we have the following recommendations for the Haltenbank area:

- Stations grid should generally be chosen based on both the existing results and future drilling activity in the area.
- Aquamul BII levels in the sediment ought to be investigated further at the Heidrun field.
- THC ought to be investigated further at the Heidrun, Åsgard and Norne fields.
- Sampling closer to the installation at the Njord field.
- The substance DFE-622 was not found either at the Heidrun or the Norne field in 1997. It seems to be superfluous to further investigate DFE-622, which is likely to decompose easily.
- Decalines were found together with THC. The results revealed a strong coupling between the amounts of decalines and THC. If the drilling mud HDF-200 will be in use for the future, it seems unnecessary to analyse for decalines, NPD and 3-6 ring aromates. With transition to new drill mud it is recommended to follow the SFT manual.

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