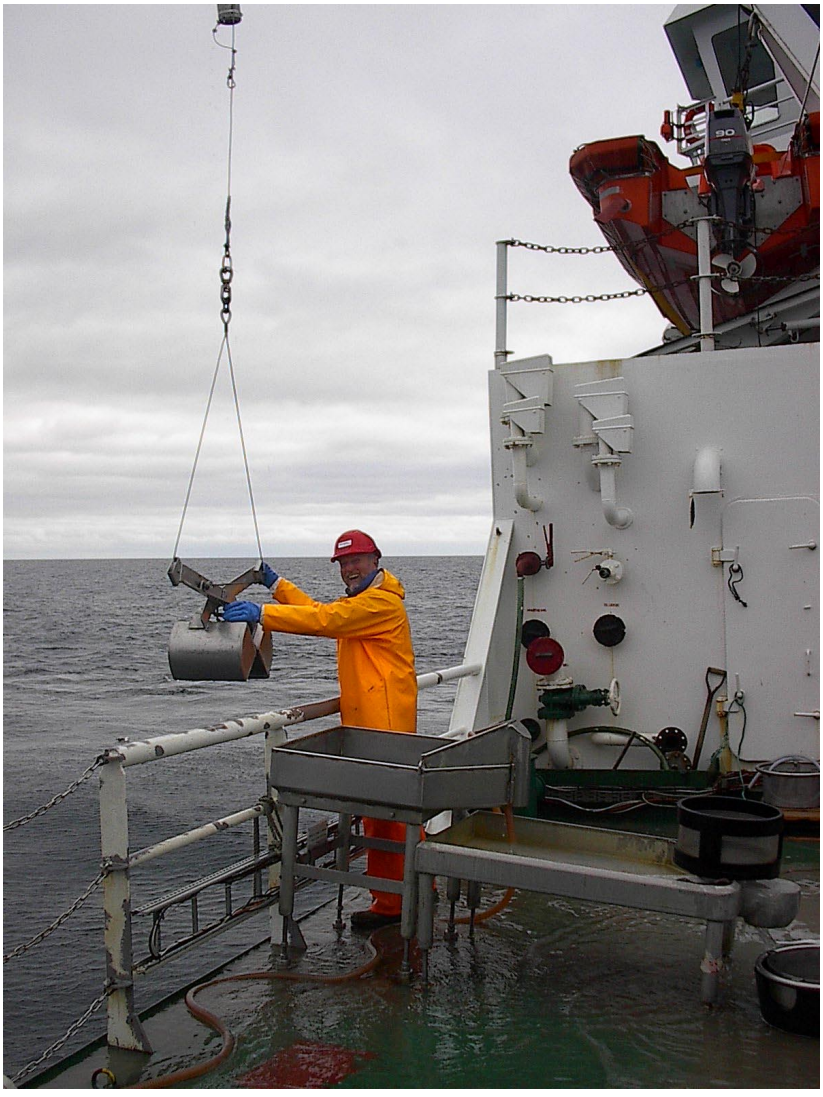
Akvaplan-niva rapport

Grunnlagsundersøkelse på Snøhvit og Område C i Barentshavet, 2003



APN-411.2785-1

Akvaplan niva

Introduction

Statoil and Norsk Hydro commissioned Akvaplan-niva AS to perform baseline surveys at Snøhvit, where Statoil is the operator, and Lisens C, where Norsk Hydro is the operator (contract no. 4500603342 and order no. 5218118, respectively). In addition 2 stations that have been previously sampled (stations F10 and F25) are included. The results from these two stations are presented together with the Hydro-results, and are included in the present survey to get information on the temporal natural variation in the area.

The aim of the study is to provide information on the status of the field with regard to the content of hydrocarbons, sediment characteristics and soft bottom communities according to the Activity Regulation Appendix 1: Krav til miljøovervåking av petroleumsvirksomheten på norsk kontinentalsokkel. 46 stations were sampled; 41 from Snøhvit, 3 from Area C, in addition to the stations that are sampled previously.

Region IX, where the fields are located, is situated from 71°00 to 72°00 north and from 20°00 to 22°00 east. The depth of the stations varies from approximately 320 m to 400 m. The main current direction in the region is towards east. The background information for each field is presented in the respective result chapters.

A map showing the Goliat- and Snøhvit-fields and the Hydro-station in Area C is given in Figure E1. The results from the survey of the Goliat-field are presented in a separate report as that survey is not a part of the required survey of the region. However, the results from the reference station at Goliat are included in the present report, to be able to compare the results with the results from Snøhvit and Area C.

So far only exploratory drilling has been carried out in Region IX, and have been conducted since the 1980'ies. Most wells have been drilled in or in the close vicinity to the Hammerfest basin, which is the most explored part of the Barents Sea. However, in the vicinity of the stations that are investigated in the present survey, there has not been any activity since the middle of the 1980'ies.

This is the third survey carried out in Region IX. The survey is a baseline survey, and with exception from two stations none of the stations are sampled previously. The sampling of the two first surveys (DNV, 1999; 2001) was conducted according to a grid system and covered a large area. In the present survey the stations from Snøhvit are place in transects surrounding the position of four future wells.

The field survey was carried out aboard the vessel "Geobay" from 8th. to 18th June 2003. Station positions (degrees and distances from the centre and UTM-coordinates) together with depth and sediment volume (biological samples) for all stations are given in the main report and appendix.

Positioning of the vessel was carried out by positioning personnel, the captain and second officer on board the vessel based on the designated station locations. The positions were localised by use of GPS (Global Positioning System) and the vessel was kept in position by use of DP2 (Dynamic Positioning). The position of the vessel was moved 2 m between every third grab cast to avoid that the exact same sediment location was resampled, which otherwise would have resulted in rejected samples.

With the exception of station SD05 at Snøhvit, that was moved 50 m from its original position due to stony bottom conditions, the field work was carried out according to the program.

Sampling was carried out with a 0.1 m^2 lead-weighted van Veen grab. The grab had hinged and lockable inspection flaps constructed of 0.5 mm mesh. The upper side of each flap was covered by an additional rubber flap allowing water to pass freely through the grab during lowering, yet closing the grab during retrieval to prevent the sediment surface being disturbed by water currents.

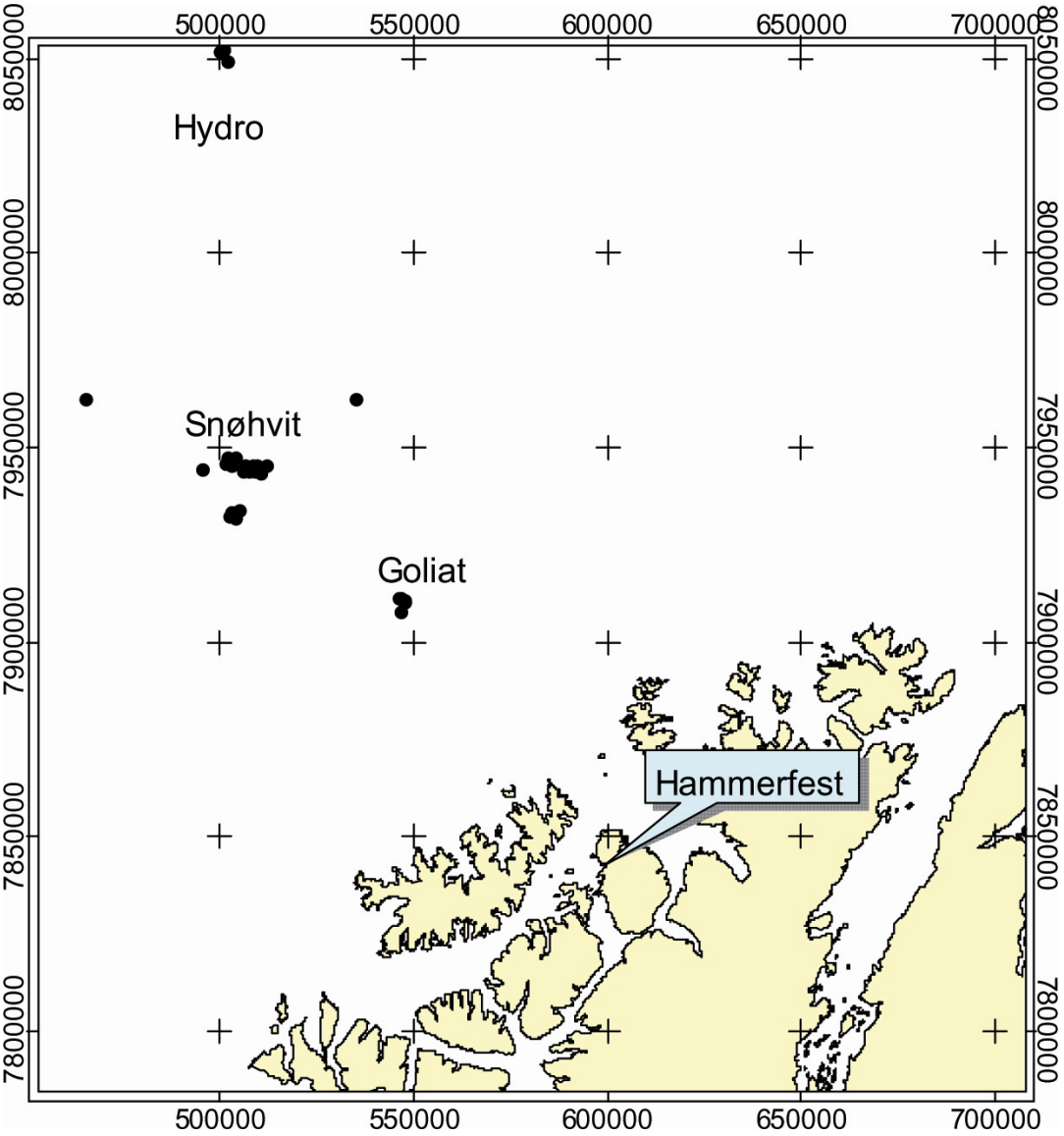


Figure E1: Location of the Goliat, Snøhvit and Hydro fields in Region IX, Finnmark. The two points next to the Snøhvit-field represent the two stations F10 and F25.

The following analyses were carried out on samples:

- grain size distribution
- organic material content
- hydrocarbon content
- metal content
- faunal analyses

Undisturbed sediment in the Barents Sea is primarily olive-grey in colour, with good penetration of oxygen into the sediment. The sediment is notably darker in colour in locations where contamination has led to a reduction in oxygen availability. This is due to the formation of sulphides in the absence of oxygen. Accumulation of oil in the sediment is also recognisable both visually and by smell.

The grain size distribution in the sediments varies from clay and fine mud to very coarse sand. Many benthic organisms are adapted to a particular range of sediment grain sizes so a shift in this parameter may affect faunal communities. Grain size distribution is also indicative of current conditions in the area; fine-grained sediments are found where currents are relatively slow, whilst strong currents result in coarser bottom sediments. The accumulation of material from industrial discharges may also affect the sediment grain size composition.

The amount of organic material in the sediment depends upon the deposition of plant and animal material from the water column above. Under normal conditions, benthic fauna and bacteria will break down deposited organic detritus, so that there is no net accumulation of organic material in the sediment. In certain areas, human activities result in an increase in the organic content of the sediment.

The background levels of total hydrocarbon content in sediments from different parts of the Barents Sea typically vary from 1 - 15 mg/kg dry sediment. Hydrocarbons are analysed using gas chromatography. Input of mineral oil from petroleum activity to the sediment, gives an easily recognisable gas chromatographic pattern. Traces of most pseudo-oils are also easily detected by this analysis method. In addition to the total amount of hydrocarbons analysed at all stations, the amount of specific aliphatic and aromatic hydrocarbons were quantified at selected stations.

The natural levels of metals in sediments vary with sediment type and texture. Industrial activities at a field may result in elevated levels of various metals. Therefore, samples were analysed for the presence of selected heavy metals such as mercury, cadmium, zinc, copper, chromium and lead. In addition to environmentally hazardous metals, the sediments are analysed for barium. Because barium sulphate often is used to increase the density of drilling mud, barium is an important indicator of the spread of drill cuttings on the sea floor.

Natural background levels of THC, aromatic hydrocarbons, metals, and to some extent, decalins will always be present in the sediments. Different natural background levels of chemical parameters reflect differences in sediment characteristics across an area. Based on the analytical results of sediment at the reference station presumed to be undisturbed by industrial activities, the background levels for chemical parameters are calculated for the field. Statistical treatment of the analytical results allows the determination of specific limits (LSC) above which a sediment sample might be said to contain higher levels than the natural background levels. The criteria for using LSC to indicate contaminated sediment are based on the assumption that the sediment at the reference station is representative of natural variation in the field area. Synthetic base oils as esters, ethers and olefins that are included in synthetic drilling mud are not present in uncontaminated sediments. If these compounds are found in the sediments, the sediments are considered as contaminated.

The species composition of benthic faunal communities is influenced by many factors, including the sediment characteristics and eventual contamination effects. In undisturbed conditions, the number of species present (i.e. richness) is relatively high and there is a relatively even distribution of the number of individuals present per species. Organic enrichment or other physical or chemical stress factors lead to a reduction in diversity, where some species decrease and others increase in species abundance. All animals collected in the samples were sorted from the remaining sediment, identified to species level wherever possible, and the number of individuals of each species recorded.

The results from statistical analyses give an indication as to whether the environmental conditions around the installations are affected by the petroleum activities. This is done by

comparing the results from the individual stations within the field and with the regional/reference stations. In monitoring surveys, the results are compared with those obtained in previous investigations. Eventual correlations between the measured environmental variables and the faunal composition are analysed by means of canonical correspondence analyses (CCA).

Criteria for identifying faunal impacts are based on a combination of multivariate analyses (cluster analysis and MDS), correlation analyses (CCA) and an evaluation of the faunal data (number of taxa and individuals, diversity indices, dominant taxa etc.) at each station. In this way the following four faunal groups are defined in this report:

Group A: Undisturbed fauna, usually with low dominance and containing a wide range of taxa from different taxonomic groups, including polychaetes, molluscs, echinoderms and crustaceans. Taxa that characteristically appear in disturbed sediments are absent or occur in very low numbers.

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

Group C: Distinctly disturbed fauna, generally with higher dominance and lower number of taxa. The faunal composition is distinctly changed. Taxa indicative of disturbed sediments, including bristleworms and molluscs, occur among the dominant taxa, and echinoderms are rare.

Group D: Highly disturbed fauna, totally dominated by small detritus-feeding bristleworms and particularly tolerant bivalves with symbiotic bacteria. Echinoderms and crustaceans rare or absent. Low number of taxa.

Natural variation can affect several of the faunal parameters within each group. The classification is therefore based on a holistic interpretation of the fauna. For example, at stations with undisturbed fauna, certain taxa can be present in high numbers, resulting in a lowered diversity.

CCA combines the environmental parameters with the faunal composition and in particular seeks to identify patterns in the faunal composition that can be related to gradients in those parameters. The analyses also calculate how much of the variance in the biological data can be described by the individual or collective environmental parameters. This gives a measure of the extent to which those parameters represent factors that influence the fauna.

More detailed information is given in the main report.

The laboratories are accredited by Norsk Akkreditering; Akvaplan-niva with number TEST 079, Unilab Analyse with number TEST 061. Analytica, with number 1087, is a laboratory accredited by Swedac.

Results

Snøhvit

This survey is a baseline survey in connection with four new wells in the Snøhvit-area in the Hammerfest basin in Region IX. The depth varies from 321 m to 355 m.

The results from the analyses that were carried out on Snøhvit are presented in Table E1 and Table E2. The sediment in the area is classified as silt having a high content of pelite (54.4% - 90.3%) and TOM (3.4% - 8.6%).

The sediments from Snøhvit have low concentrations of THC (2,3 - 7,5 mg/kg). With the exception of the sediments at the outermost station NV of F1 (Ba: 945 mg/kg), barium is evenly distributed over the field (Ba: 68-133 mg/kg). The concentration of the remaining heavy metals varies a lot across the surveyed area.

The concentrations of hydrocarbons and metals are comparable to values in previous surveys in the region and the sediments are also in the present survey regarded as non contaminated. The only exception is elevated levels of Ba in the sediments at the outermost station NV of frame F1. There has been exploratory drilling activity at Snøhvit earlier, but not near the locations where the four wells will be placed.

There are large variations in the number of individuals (339 - 1192) and taxa (73 - 126) over the field. At the same time the diversity is high on all stations (H' 5.1 - 6.1). The multivariate analyses show a large similarity in the fauna among the stations, and the reference station is not separated from the other stations to a large extent. The correlation analysis shows that the faunal composition is structured by natural variables. Furthermore, the composition of the most dominating taxa indicates stable communities. On this background it is concluded that the fauna at Snøhvit is unaffected by petroleum activity.

Table E1: Chemical data for Snøhvit, 2003. All concentrations are in mg/kg dry sediment (minimum and maximum values in bold).

St. no.	Degrees	Distance (m)	THC	Ba	Cd	Cr	Cu	Hg	Pb	Zn
SD01	150	500	3.8	144	0.199	33.1	**17.3**	na	**32.3**	**61.9**
SD02	150	1000	5.4	102	0.117	24.5	12.3	na	21.0	44.8
SD03	60	250	3.9	96	0.118	21.9	11.4	0.051	16.2	40.5
SD04	60	500	3.8	89	0.095	25.5	11.0	na	15.6	42.0
SD05*	60	950	3.4	76	0.097	21.5	9.6	na	15.3	39.0
SD06	60	2000	3.6	117	0.128	33.0	16.0	0.049	21.6	56.6
SD07	240	500	**2.3**	116	0.138	**37.1**	14.6	na	21.7	61.3
SD08	240	1000	4.9	81	0.085	24.7	10.1	na	15.8	41.3
SD09	330	500	5.4	102	0.114	27.8	12.5	na	19.6	51.1
SD10	330	1000	**7.5**	**945**	0.078	19.7	12.3	na	14.3	42.3
SE01	150	500	6.0	107	**0.057**	26.5	9.9	na	**11.1**	44.3
SE02	150	1000	4.8	128	0.074	24.3	9.6	na	12.7	40.9
SE03	60	250	4.6	124	0.076	27.3	11.1	**<0.04**	13.4	45.3
SE04	60	500	4.4	105	0.075	24.2	9.8	na	12.7	41.8
SE05	60	1000	5.3	167	0.084	22.8	9.1	na	13.5	40.2
SE06	60	2000	5.9	90	0.093	23.8	10.1	0.041	14.6	42.2
SE07	240	500	5.5	132	0.081	20.9	8.7	na	14.3	39.4
SE08	240	1000	6.0	89	0.073	20.5	8.5	na	13.1	37.4
SE09	330	500	5.4	111	0.080	24.2	8.9	na	12.1	41.9
SE10	330	1000	4.6	124	0.075	21.4	8.6	na	12.7	38.2
SF01	150	500	4.5	119	0.112	35.2	12.9	na	19.3	59.4
SF02	150	1 000	4.4	105	0.107	29.7	11.6	na	15.6	50.1
SF03	60	250	4.7	105	0.103	31.7	12.6	0.049	17.2	53.2
SF04	60	500	4.5	93	**0.269**	29.4	12.2	na	15.4	49.5
SF05	60	1 000	2.3	94	0.079	22.0	9.2	na	13.3	41.0
SF06	60	2 000	5.7	104	0.088	31.9	12.9	0.044	15.1	53.9
SF07	240	500	6.5	90	0.097	21.8	11.0	na	14.3	44.7
SF08	240	1 000	3.9	93	0.091	25.6	10.2	na	14.0	41.3
SF09	330	500	6.9	87	0.082	23.8	10.4	na	14.6	42.2
SF10	330	1 000	6.8	92	0.090	26.9	11.5	na	15.9	47.1
SN01	150	500	6.0	85	0.094	20.7	9.7	na	14.1	37.2
SN02	150	1 000	5.0	119	0.130	30.0	14.4	na	21.4	55.8
SN03	60	250	5.9	133	0.148	31.5	14.3	0.047	21.3	56.8
SN04	60	500	7.3	111	0.134	24.6	12.3	na	19.3	48.2
SN05	60	1 000	4.6	102	0.105	26.5	12.1	na	15.6	49.1
SN06	60	2 000	5.7	99	0.101	25.6	12.4	0.048	16.1	42.9
SN07	240	500	5.0	**68**	0.095	**3.6**	6.7	na	15.7	41.9
SN08	240	1 000	5.0	75	0.124	4.5	9.8	na	19.1	45.4
SN09	330	500	5.7	71	0.124	4.0	9.5	na	18.3	41.2
SN10	330	1 000	6.5	70	0.088	10.5	7.2	na	15.7	**35.8**
FIN15 ref			4.4	125	0.178	32.7	16.1	**0.081**	25.2	60.0
LSC			**10,8**	**157**	**0,228**	**39**	**19**	**0,127**	**36**	**70**

n.a.: not analysed

Table E2: Biological parameters, TOM and pelite (%) for Snøhvit, 2003 (minimum and maximum values in bold).

St. no.	Degrees	Distance (m)	No. of ind.	No. of taxa	H'	J	ES_{100}	Pelite	TOM
SD01	150	500	514	94	5.5	0.85	45	78.3	5.8
SD02	150	1000	663	98	5.4	0.81	42	85.8	4.9
SD03	60	250	458	97	5.6	0.85	45	82.0	5.7
SD04	60	500	342	77	**5.1**	0.82	**41**	84.7	4.8
SD05*	60	950	400	90	5.3	0.82	45	62.8	3.7
SD06	60	2000	616	92	5.5	0.84	43	79.3	5.1
SD07	240	500	673	114	5.6	0.81	45	83.2	5.7
SD08	240	1000	684	93	5.3	0.82	**41**	69.5	4.3
SD09	330	500	539	85	5.4	0.84	**41**	69.1	4.5
SD10	330	1000	351	**73**	5.2	0.84	**41**	78.5	5.0
SE01	150	500	573	87	5.4	0.84	42	68.3	4.1
SE02	150	1000	508	87	5.2	0.81	**41**	71.4	4.3
SE03	60	250	388	78	5.3	0.85	42	69.8	4.5
SE04	60	500	453	94	5.5	0.84	45	71.3	4.0
SE05	60	1000	546	95	5.4	0.82	44	70.9	3.9
SE06	60	2000	434	83	5.4	0.84	43	73.9	4.6
SE07	240	500	411	93	5.5	0.85	46	66.0	4.3
SE08	240	1000	485	91	5.5	0.84	44	62.4	**3.4**
SE09	330	500	412	82	5.3	0.84	42	69.6	4.0
SE10	330	1000	380	85	5.2	0.81	43	68.5	4.2
SF01	150	500	875	115	5.6	0.81	43	82.5	**8.6**
SF02	150	1 000	392	83	5.2	0.82	**41**	**54.4**	3.9
SF03	60	250	366	77	5.4	0.86	43	64.0	5.9
SF04	60	500	387	79	5.3	0.84	42	70.8	4.9
SF05	60	1 000	409	88	5.4	0.84	44	64.6	4.2
SF06	60	2 000	653	108	5.5	0.82	44	80.7	7.0
SF07	240	500	989	112	5.6	0.83	45	89.0	6.9
SF08	240	1 000	477	85	5.6	0.88	46	60.6	4.4
SF09	330	500	695	117	5.8	0.85	49	81.7	6.1
SF10	330	1 000	349	77	5.4	0.86	44	70.4	4.2
SN01	150	500	**330**	83	5.7	**0.89**	47	65.7	4.0
SN02	150	1 000	735	114	5.8	0.84	47	90.2	6.3
SN03	60	250	672	125	**6.1**	0.87	**52**	88.8	6.6
SN04	60	500	810	107	5.3	**0.79**	42	84.7	5.2
SN05	60	1 000	467	89	5.4	0.84	43	76.2	4.4
SN06	60	2 000	514	97	5.6	0.85	46	80.9	4.4
SN07	240	500	851	121	6.0	0.87	51	83.6	6.0
SN08	240	1 000	**1192**	**126**	5.8	0.83	47	89.1	7.4
SN09	330	500	934	126	6.0	0.85	50	**90.3**	6.4
SN10	330	1 000	627	103	5.8	0.87	49	55.0	4.0
FIN15 ref1			1150	123	5.7	0.82	45	60.5	8.2
FIN15 ref2			974	121	5.7	0.82	45	-	-

Area C and the stations F10 and F5

The three Hydro-stations in Area C (HYD-01, HYD-02 and HYD-03) are located in the northern part of Region IX, and will provide baseline data in an area where exploratory drilling will be conducted. Analyses of the stations F10 and F25 are also included in the Hydro-project, and are reported together with the Hydro-station in Area C, although they are located approximately 90 km south of these. The F-stations are also located over 60 km away from each other. These stations are investigated earlier; station F10 in both 1998 and 2000 and station F25 in 1998.

The depth of the Hydro-stations is from 372 m to 393 m and 278 m on station F10 and F25, respectively.

The results from the analyses that were carried out on the stations in Area C and the stations F10 and F25 are given in Table E3 and Table E4. The sediment is classified as silt on all stations, having a high content of pelite (57,4% - 91,6%) and TOM (3,9% - 7,9%). At the station F10 the amount of TOM has been reduced since 1998. However, this cannot be attributed to changes in the grain size.

Contamination with hydrocarbons and metals are not found in the sediments. The new Hydro-stations (THC: 10-15 mg/kg) differ from the F-stations (THC: 5 - 8 mg/kg) with naturally higher concentrations of THC. Barium is evenly distributed across the area (Ba: 87 - 96 mg/kg). The concentration of the other metals varies somewhat across the surveyed area. The concentrations of hydrocarbons at the F-stations are comparable to values in previous surveys in the region (THC: 0,7 - 9 mg/kg). The concentrations of barium are low and comparable to concentrations in 1998 and 2000.

At the Hydro-station there is only a small variation in the number of individuals (475 - 593), number of taxa (79 - 85) and diversity (H' 5,2 - 5,4). The station F10 is characterised by having a large number of individuals and taxa. At this station it was recorded a large amount of spicules from dead sponges during the field work, which may have increased the number of available niches and thereby lead to a richer community. The number of individuals at this station is higher than in 1998 and 2000. On the other hand, the number of taxa was reduced from 1998 to 2000, but then increased from 2000 to 2003. At station F25 the number of individuals and taxa are comparable with the Hydro-stations, and the diversity is high. At this station both the number of individuals and taxa and the diversity was somewhat higher in 2003 than in 1998.

Regarding the composition of the communities, the multivariate analyses show that the F-stations are very different from each other and also very different from the Hydro-stations, while the Hydro-stations are very similar to each other. It is normal that stations located far from each other are different, and this result is therefore in accordance with the geographical positioning of the stations. All stations are characterised by species requiring stable conditions, and none of the stations have high density of typical opportunistic species. On this background it is concluded that the fauna on all stations are unaffected by petroleum activity.

Table E3: Chemical data for the stations in Area C, 2003. All concentrations are in mg/kg dry sediment (minimum and maximum values in bold).

St. no.	UTM North	UTM East	THC	Ba	Cd	Cr	Cu	Hg	Pb	Zn
HYD-01	8050946	499432	14,96	88	**0,059**	**23,3**	**10,8**	<0,04	14,5	**44,3**
HYD-02	8048369	501765	12,28	**87**	0,068	24,0	11,3	<0,04	14,6	47,7
HYD-03	8051742	500718	10,16	90	0,068	24,1	11,1	<0,04	**12,8**	46,6
F10	7961553	465046	7,72	90	**0,250**	27,1	17,0	0,062	**29,8**	54,7
F25	7961553	534953	**4,72**	**96**	0,091	**37,3**	**14,4**	<0,04	17,5	**60,3**

Table E4: Biological parameters, TOM and pelite (%) for the stations in Area C, 2003 (minimum and maximum values in bold).

St. no.	UTM North	UTM East	No. of ind.	No. of taxa	H'	J	ES_{100}	Pelite	TOM
HYD-01	8050946	499432	593	85	5,4	**0,84**	41	63,0	**7,9**
HYD-02	8048369	501765	**475**	**79**	5,2	0,82	**37**	60,2	5,4
HYD-03	8051742	500718	526	80	5,3	0,83	39	**57,4**	4,3
F10	7961553	465046	**1416**	**128**	**5,1**	**0,73**	39	73,8	4,1
F25	7961553	534953	616	94	**5,5**	0,83	**42**	**91,6**	**3,9**

Status Region IX

The variation in selected physical, chemical and biological parameters in the present and earlier surveys (DNV, 1999; 2001) in Region IX is presented in Table E5. It is important to be aware of the fact that the stations in the previous surveys were placed according to a grid system ranging over a large area, while the stations in 2003 represent a smaller area, as 40 station are sampled in transects surrounding four future wells at Snøhvit, 3 stations are sampled close to each other in Area C, in addition to the reference station at Snøhvit and the stations F10 and F25.

Generally the results from 2003 correspond well with the findings in Region IX in the two previous surveys, both with regard to physical, chemical and biological parameters. An exception is barium, having elevated concentration at the station 1000 m NW of the F1 well at Snøhvit. Furthermore, the maximum concentration of hydrocarbons is somewhat higher than in 1998 and 2000. This can be attributed to a natural higher content of THC, NPD and 16 EPA in the sediments at the three new Hydro-stations.

Table E5: Minimum- and maximum values for the physical, chemical and biological parameters in Region IX, 2003 and previous surveys (conducted in 1998 and 2000). The metal analyses are carried out according to NS 4770.

Parameter	Previous (1998/2000)	2003 (field stations)	2003 (ref. values)
Total no. of stations	53	45	1
Depth	160 - 365	278 - 393	332
% pelite	5,9 - 92,4	54,4 - 90,3	60,5
% TOM	1,3 - 11,3	3,4 - 8,6	8,2
Lead (mg/kg)	3,1 - 37,9	11,1 - 32,3	25,2
Copper (mg/kg)	1,9 - 19,1	6,7 - 17,3	16,1
Zinc (mg/kg)	9,8 - 148,6	35,8 - 61,9	60,0
Cadmium (mg/kg)	<0,1 - 0,23	0,059 - 0,269	0,178
Crom (mg/kg)	5,4 - 39,5	3,6 - 37,3	32,7
Barium (mg/kg)	19 - 120	68 - 945 (167*)	125
THC (mg/kg)	0,7 - 9,0	2,25 - 14,96	4,4
NPD (mg/kg)	0,008 - 0,126	0,070 - 0,443	0,099
16 EPA-PAH (mg/kg)	0,009 - 0,144	0,073 - 0,231	0,124
No. of ind. per station	151 - 1573	330 - 1192	1150/974 **
No. of taxa per station	65 - 160	73 - 126	123/121 **
Diversity H'	4,2 - 6,1	5,1 - 6,1	5,7/5,7 **

* Second highest concentration
** Two dataset