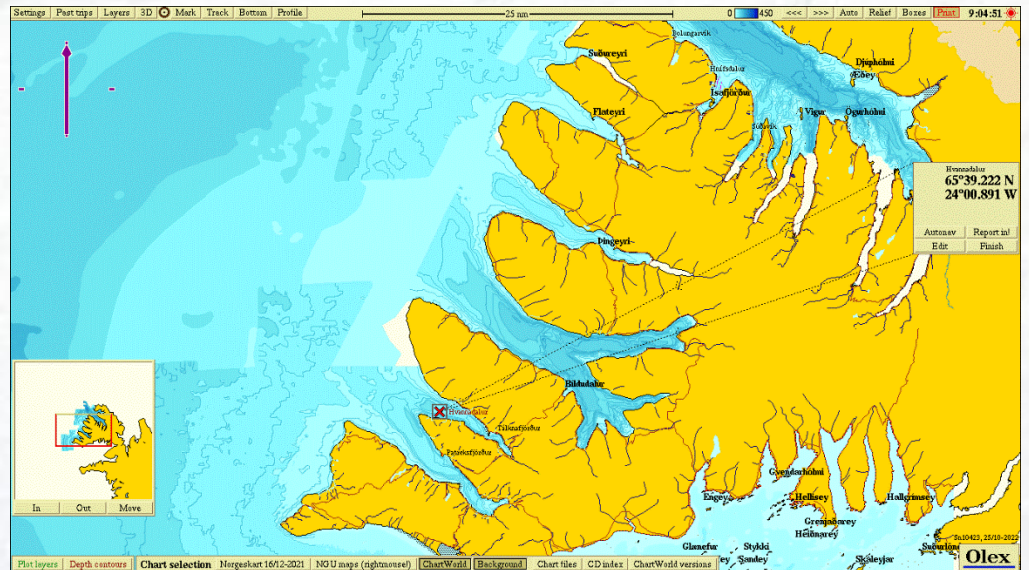


Hvannadalur, Arctic Sea Farm
B survey,
September 2022
(post fallow)



Information client			
Title	Hvannadalur, Arctic Sea Farm. B survey (post fallow), September 2022		
Report number	APN-64286.B01		
Site name	Hvannadalur	Coordinates site	65°39,222N 024°00,891V
County	Tálknafjarðahreppur	Municipality	Tálknafjörður
MTB-or estimated max biomass	6.400 tonnes	Site manager/contact	Steinunn G. Einarsdóttir
Client name	Arctic Sea Farm		

Biomass/production/status at date of survey			
Biomass at date of survey	0 t	Feed use	0 t
Fish type	Salmon	Amount produced	
Type/time of survey	Mark with X	Comments Fallow state since 26 th of March 2022	
At maximal biomass see kap 7.9	<input type="checkbox"/>		
A follow up survey	<input type="checkbox"/>		
Half maximal biomass	<input type="checkbox"/>		
Survey prior to putting out smolt	<input checked="" type="checkbox"/>		
A pre-survey new site	<input type="checkbox"/>		
Other	<input type="checkbox"/>		
Last following period:			

Results from B-survey according to NS 9410:2016 (main results)			
Parameters and indexes		Parameters and site status	
Gr. II. pH/Eh	0,11	Gr. II. pH/Eh	1
Gr. III. Sensory	0,91	Gr. III. Sensory	1
GR. II + III	0,51	GR. II+ III	1
Date fieldwork	05.09 2022	Date report	05.12 2022
Site status (NS 9410:2016):			1


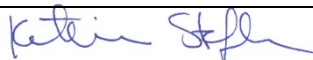
Report writing and project leader	Snorri Gunnarsson	Signature	
Quality control	Kristine Steffensen	Signature	

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Preface

The survey is carried out in accordance with the Norwegian standard NS 9410:2016 - "Environmental monitoring of benthic impact from marine fish farms". Impact assessment is based on sediment condition (chemistry, sensory & presence/absence of fauna). The environmental survey is regulated by § 35 in the Norwegian "akvakulturdriftsforskriften". The survey also fulfills the requirements regarding seabed surveys outlined in the standard ISO 12878.

The primary objective of a B-survey is to assess the benthic impact beneath and in the close vicinity (near zone) of a marine fish farm by applying methods, thresholds and classifications as defined in NS9410:2016. The current survey was undertaken after fallowing and prior to the start of a new production cycle. Sampling stations in this survey are placed within the near zone of the current farm location. Hvannadalur has an estimated max biomass (next generation) of 6.400 T and thus a total of 19 stations were sampled.

The following have participated in the survey:


Snorri Gunnarsson	Akvaplan-niva AS	Prosjektleder.
Snorri Gunnarsson	Akvaplan-niva AS	Fieldwork and Report. Charts (Olex).
Kristine Steffensen	Akvaplan-niva AS	Quality assurance

The sampling at Hvannadalur was done 05.09 2022.

Accredited survey:


The following parts of the survey are done in accordance with accreditation methods:

Sampling and treatment of sediment samples, analysis of samples and evaluations of the results. Thresholds and classifications of assessment criteria applied in this report are based on Norwegian environmental conditions as Iceland specific criteria have yet not been developed. This should be taken into consideration when reviewing site status.

	Akvaplan-niva AS er akkreditert av Norsk Akkreditering for prøvetaking og faglig vurderinger og fortolkninger, akkrediteringsnummer TEST 079. Akkrediteringen er iht. NS-EN ISO/IEC 17025 Akkrediteringen omfatter bla. NS 9410, NS-EN ISO 5667-19 og NS-EN ISO 16665.
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Akvaplan-niva AS thanks Arctic Sea Farm and their personnel for the cooperation during the conductance of this site survey.

Kópavogi, 05.12 2022


Snorri Gunnarsson
Project manager

1 Introduction

Sampling was undertaken on 05.09.2022 by Akvaplan-niva AS, who has been contracted by Arctic Sea Farm in relation to the company's fish farming activity at the site Hvannadalur in Tálknafjörður, Tálknafjarðahreppur municipality.

The objective of the B-survey is to document the environmental condition in the near zone of a fish farm by evaluating sediment condition (chemistry, sensory & presence/absence of fauna) as defined in NS 9410:2016 (and ISO 12878). The B-survey is a tool for trend monitoring and allows to assess the status of organic enrichment beneath the net pens at various stages of the production cycle.

The here presented survey was undertaken after fallowing and prior the start of the next production cycle. Sampling stations in this survey are placed within the near zone of the current farm location. Hvannadalur has an estimated max. standing biomass of 6.400 tons for the next generation and thus a total of 19 stations were sampled.

Figure 1 shows a map of the southern part of Vestfirðir where Hvannadalur is located in the fjord Tálknafjörður.

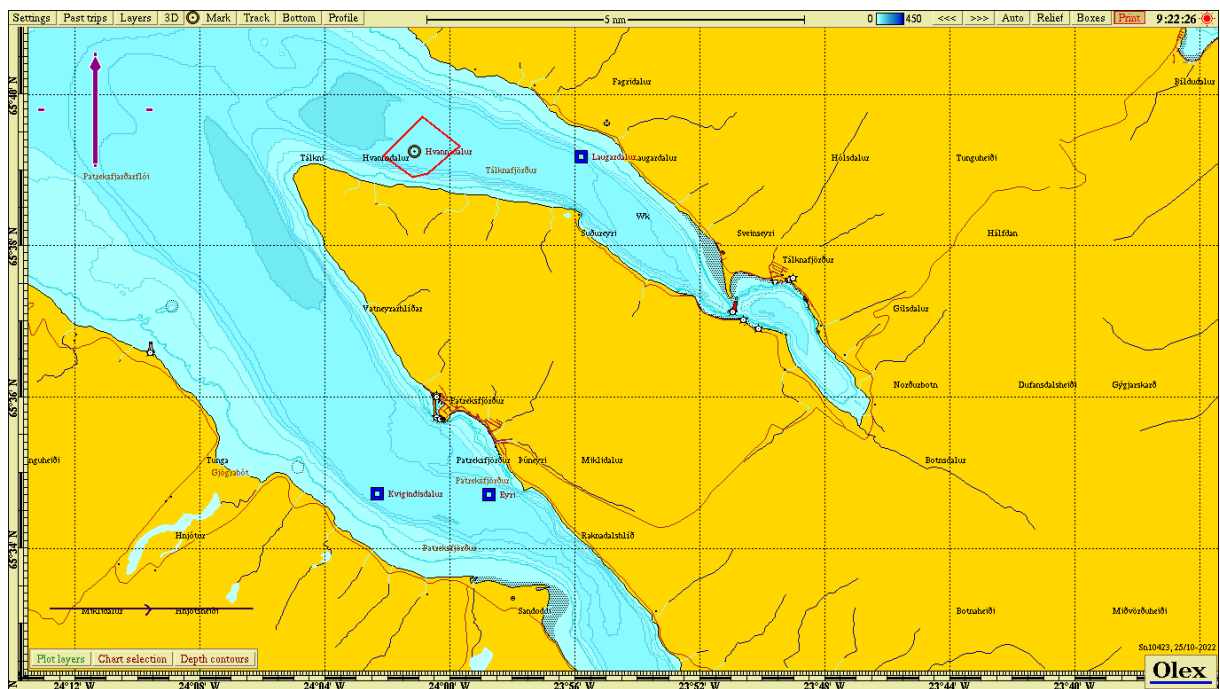


Figure 1. An overview map where Hvannadalur site is marked with a red box. Other fish farms in the nearest vicinity (Tálknafjörður and Patreksfjörður) are also shown with a smaller blue box and name.

2 Methods

Monitoring of the environmental impact of fish farming activities on the seabed is standardised and regulated. All fish farming sites in the sea are to be regularly assessed. Environmental monitoring in Iceland is following guidelines and methods outlined in NS 9410:2016 and ISO 12878. The Icelandic Environmental agency (Umhverfisstofnun) can also set specific requirements regarding frequency of surveys for different fish farming sites, which can overrule the above-mentioned standards.

The B survey is a trend monitoring tool with the focus on sediment condition (benthic impact) beneath and in the close vicinity of the fish cages (near zone). Sediment is collected using a grab (min 250 cm²). Sediment condition for each sample is assessed using three indicators: sediment chemistry (pH and redox potential), sensory evaluation (gas bubbles, smell, texture, colour and thickness of sludge) and the presence or absence of fauna. The performance of these indicators against predefined thresholds categorizes the farming locations into four different site conditions (see Table 1), which are used to determine the sampling frequency.

Table 1. Frequency of category B-research for the location of the farm based on state of the defined farming area.

Site condition at the time of sampling	Sampling frequency for B-surveys (NS 9410:2016)
1-very good	At next max biomass
2-good	Prior to putting next generation into sea and again at next max biomass.
3-bad	Prior to putting next generation into sea. Based on the site condition prior to putting next generation into sea: <ul style="list-style-type: none">- Condition 1 – next site survey at next max biomass- Condition 2 – next site survey at next 50% max biomass and at max biomass- Condition 3 – next site survey at next 50% max biomass and at max biomass. Some conditions should apply for farming of next generation at the site If any of the samples result in character 4 it is a sign of overload.
4-very bad	Overload

2.1 Field equipment

The following field equipment was used during the site survey:

Grab: Van Veen grab 0,1 m²

Sieve 1 mm: Akvaplan-niva

pH meter: Electrode, YSI Professional Plus

Redox-meter: Electrode, YSI Professional Plus

Position determination– Garmin GPS mapping tool.

Digital camera

3 Study site, production and survey design

3.1 Study site and production

Hvannadalur is located in the south-western side of Tálknafjörður, approximately 4,5 nm northwest of the town of Tálknafjörður. The fish farm at the site is a two frame mooring system, each frame having 6 cages, total 12 cages each with 160 m circumference. During the last production cycle 11 cages of the total 12 have been used (Frederik Hanssen Mosti, biological controller ASF, pers. info). The mooring frame is positioned in northwesterly direction (45°) from land with depth below the cages ranging from 53 to 58 m.

Hvannadalur has been fallowed since 26th of March 2022. The previous generation was the first production cycle at the site.

Table 2 shows the production and feed usage for previous generations.

Table 2. Production and feed usage at Hvannadalur, data is based on info given from the fish farmer.

Generation of fish (G)	Production (tonnes)	Feed usage (tonnes)
Past generation 1	7.366	9.560

3.2 Present and past site surveys

Table 3 provides an overview of sampling dates and results of current and historic B surveys undertaken at the site following NS 9410:2016.

Table 3. Current and historic B surveys taken at Hvannadalur.

Date of sampling	Report number	Survey type	Overall site status
05.09.2022	APN 64286.B01 (Gunnarsson, 2022)	Fallow period	1
09.07.2021	APN-62907.B01 (Gunnarsson, 2021)	B survey max biomass	1
15.07.2019	APN-61376.B01 (Gustavsson, 2019)	B survey new site	1

3.3 Hydrodynamic conditions

Measurement of dispersing current was done at the site in 24th of September – 29th of October 2020 measurements at 48 m depth (Hermansen. 2020). Dominating current (48 m) is in direction southeast (135 degrees). Average current speed was measured to be 6.4 cm/s. Highest current speed is measured to be 26.3 cm/s and 4.2 % of the measurements were < 1 cm/s.

3.4 Survey design

The placement of the 19 sampling stations is shown in Figure 2 with positions listed in Table 4. Stations are distributed within the near zone of the two frame positions following criteria outlined in NS 9410:2016. Depth beneath and in the close vicinity of the cage varies between 53– 58 m, with the deepest waters located in the northern part of the frame and outer into the fjord. Sampling stations were placed to represent the varied environmental conditions within the near zone and cover thus both the deeper and shallower areas. The sampling stations had a depth varying from 56 to 58 m. The placement of sampling stations is regarded to be in accordance with the requirements outlined in NS 9410:2016.

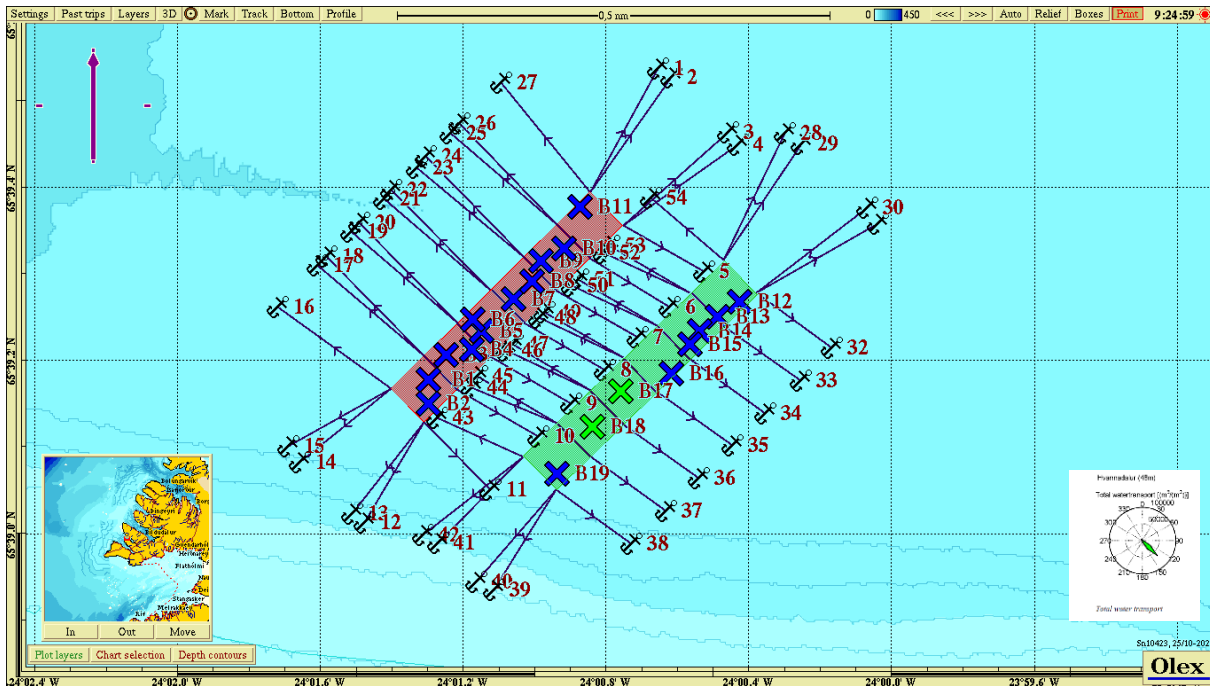


Figure 2. Site specific map of Hvannadalur showing frame, mooring lines and farming area. Sampling stations st. 1 – 19 are marked with crosses. The color of each cross represents the environmental condition at the respective station following the classification as outlined in NS 9410:2016, chapter 7.11. Color codes: Blue = very good, green = good, yellow = bad, red = very bad. Current rose placed in the lower right corner shows main dispersing current direction at 48 m depth (Hermansen, 2020).

Table 4. Position and depth of the sampling stations in the B-survey.

Station number	North	West	Depth (m)
St 1	65°39,177	024°01,297	58
St 2	65°39,150	024°01,328	57
St 3	65°39,206	024°01,248	58
St 4	65°39,212	024°01,175	58
St 5	65°39,234	024°01,148	58
St 6	65°39,247	024°01,074	58
St 7	65°39,270	024°01,060	58
St 8	65°39,291	024°01,008	58
St 9	65°39,315	024°00,981	58
St 10	65°39,329	024°00,918	57
St 11	65°39,377	024°00,874	58
St 12	65°39,267	024°00,427	57
St 13	65°39,250	024°00,487	57
St 14	65°39,234	024°00,537	57
St 15	65°39,218	024°00,566	58
St 16	65°39,184	024°00,616	58
St 17	65°39,164	024°00,758	58
St 18	65°39,123	024°00,838	57
St 19	65°39,096	024°00,937	56

4 Results

Results for the different parameters are given in Table 5. The completed fieldwork sampling sheet with calculations for each parameter is attached in appendix.

Table 5. Results from the parameter classifications in the near zone of the fish farm.

Parameter	Condition
Group II - parameters (pH/Eh)	1
Group III – parameters, (sensory)	1
Group II + III – parameters (mean value)	1
Site condition	1

Substrate was collected at all 19 sampling stations (100% soft bottom). Sediment samples consisted mainly of clay in all parts of the local impact zone. Fauna was recorded at all stations with polychaetes being most prominent group of animals. The substrate was of light grey colour at thirteen stations and brown/black colour at six stations. Signs of out-gassing were not observed. A slight smell of H₂S was recorded at ten sampling stations.

Based on the classification of sediment chemistry (pH/Eh) and the sensory assessments seventeen stations of this survey received status 1 – "very good" and two stations received status 2 – " good" (Figure 2). The site receives an overall environmental status 1 – "very good".

5 Conclusion

Applying the indicator thresholds and classification outlined in NS 9410:2016 it is shown that Hvannadalur receives site status 1 – "very good" at the time of this B survey. Samples were collected with a Van Veen grab (0,1 m²) at 19 stations distributed around the 12 cages, which are planned to be used for the next production cycle. Sediment was successfully collected at all stations and seventeen stations in this survey received status 1 – "very good" and two stations received status 2 – "good".

The here presented survey was undertaken after fallowing (just over five months) and prior to the start of the next production cycle. The results from the current survey compared with results from last B-survey at max biomass in July 2021 (Gunnarsson, 2021) indicate overall improvement of the status of the bottom sediment in the local impact zone. The overall site status was 1 "very good" in both surveys. However, in the 2021 survey, based on the classification of sediment chemistry (ph/Eh) and the sensory assessments, ten stations had status 1 «very good», three stations had condition 2 «good», two stations had condition 3 «bad» and one station had condition 4 «very bad», contra seventeen stations with condition 1 – "very good" and two stations received condition 2 – "good" in the current survey. In the 2021 survey bacteria formations most likely *Beggiatoa* was apparent at two stations, but no such observations were made at any of the sampling stations in the current survey.

Following the criteria outlined in NS 9410:2016 the site receives the status 1 - "very good".

6 References

Forskrift om drift av akvakulturanlegg (akvakulturdriftsforskriften) §§ 35 og 36.

Gunnarsson, S., 2021. Hvannadalur, Arctic Sea Farm B-bottom survey, April 2021 (maximum biomass survey). APN report. nr. 62907.B01

Gústavsson, A., 2019. Hvannadalur, Arctic Sea Farm. B-bottom pre-survey, July 2019. APN report nr. 61376.B01.

Hermansen, S., 2020. Arctic Sea Farm hf. Current measurements at Hvannadalur, 2020. APN report nr. 62459.02.

ISO 5667-19:2004. Guidance on sampling of marine sediments.

ISO 12878:2012. Environmental monitoring of the impacts from marine finfish farms on soft bottom.

Norsk Standard NS 9410:2016. Miljøovervåking av bunnpåvirkning fra marine akvakulturanlegg.

7 Appendix

7.1 Survey data sheet (B.1 & B.2), NS 9410:2016.

Sample scheme B.1																			
Company		Arctic Sea Farm						Date:		05.09 2022									
Site:		Hvannadalur						Site no.:											
Fieldworker:		Snorri Gunnarsson																	
Gr	Parameter	Point	Sample number																
			1	2	3	4	5	6	7	8	9	10							
	Bottom type: S (soft) eller H (hard)		S	S	S	S	S	S	S	S	S	S							
I	Animals > 1mm	Yes (0) No (1)	0	0	0	0	0	0	0	0	0	0							
II	pH	value	7,8	7,9	7,7	7,8	7,8	7,7	7,7	7,8	7,9	7,7							
	Eh (mV)	ORP	70	63	53	62	59	49	46	38	-41	19							
		plus ref. verdi	270	263	253	262	259	249	246	238	159	219							
	pH/Eh	from figure	0	0	0	0	0	0	0	0	0	0							
	Status station			1	1	1	1	1	1	1	1	1	1						
			Buffer-temp	C			Sea temp			C			Sediment temp		C				
			pH sea	ORP sea			mV			Eh sea			mV			Reference electrode		200,0 mV	
	III	Gas bubbles	Yes (4) No (0)	0	0	0	0	0	0	0	0	0	0						
		Colour	Light/grey (0)	0	0	0	0	0	0	0	0	0	0						
			Brown/black (2)										2						
Smell		None (0)				0	0			0	0		0						
		Light (2)	2	2	2				2			2							
		Strong (4)																	
Consistency		Solid (0)	0	0	0	0	0	0	0	0	0	0	0						
		Soft (2)																	
		Aqueous (4)																	
Grab volume (v)		v < 1/4 (0)																	
	1/4 < v < 3/4 (1)																		
	v > 3/4 (2)	2	2	2	2	2	2	2	2	2	2	2							
Thickness of sludge (t)	t < 2 cm (0)	0	0	0	0	0	0	0	0	0	0	0							
	2 < t < 8 cm (1)																		
	t > 8 cm (2)																		
Sum			4,0	4,0	4,0	2,0	2,0	4,0	2,0	2,0	6,0	2,0							
Corrected (**0,22)			0,9	0,9	0,9	0,4	0,4	0,9	0,4	0,4	1,3	0,4							
Status station			1	1	1	1	1	1	1	1	2	1							
Average group II & III			0,4	0,4	0,4	0,2	0,2	0,4	0,2	0,2	0,7	0,2							
Status station			1	1	1	1	1	1	1	1	1	1							
Grab ID																			
pH / Eh ID		Ysi professional plus																	

Sample scheme B.1

Company:	Arctic Sea Farm
Site:	Hvannadalur
Fieldworker:	Snorri Gunnarsson

Date:	05.09 2022
Site no.:	0

Gr	Parameter	Point	Sample number										Index					
			11	12	13	14	15	16	17	18	19	20	S%	H%				
	Bottom type: S (soft) or H (hard)		S	S	S	S	S	S	S	S	S	S	S	S	100	0		
I	Animals > 1mm	Yes (0) No (1)	0	0	0	0	0	0	0	0	0	0	0					
II	pH	value	7,9	7,8	7,8	7,8	7,8	7,8	7,7	7,6	7,8							
	Eh (mV)	ORP	39	58	42	11	21	-52	-155	-178	-23							
		plus ref. verdi	239	258	242	211	221	148	45	22	177							
	pH/Eh	from figure	0	0	0	0	0	0	1	1	0				0,11			
	Status station			1	1	1	1	1	1	1	1	1	1					
	Status group II			1	Buffer temp	0,0 C		Sea temp	0,0 C		Sediment temp	0,0 C						
	pH sea		0	ORP sea	0 mV		Eh sea	mV		Reference electrode	200 mV							
	III	Gas bubbles	Yes (4) No (0)	0	0	0	0	0	0	0	0	0						
		Colour	Light/grey (0)	0	0	0		0										
			Brown/black (2)				2		2	2	2	2						
Smell		None (0)	0	0		0	0											
		Light (2)			2			2	2	2	2							
		Strong (4)																
Consistency		Solid (0)	0	0	0	0	0	0										
		Soft (2)								2	2	2						
		Aqueous (4)																
Grab volume (v)		v < 1/4 (0)																
	1/4 < v < 3/4 (1)																	
	v > 3/4 (2)	2	2	2	2	2	2	2	2	2	2							
Thickness of sludge (t)	t < 2 cm (0)	0	0	0	0	0	0											
	2 < t < 8 cm (1)								1	1	1							
	t > 8 cm (2)																	
Sum			2,0	2,0	4,0	4,0	2,0	6,0	9,0	9,0	9,0							
Corrected (*0,22)			0,4	0,4	0,9	0,9	0,4	1,3	2,0	2,0	2,0				0,91			
Status station			1	1	1	1	1	1	2	2	2	2						
Status group III			1															
Average group II & III			0,2	0,2	0,4	0,4	0,2	0,7	1,5	1,5	1,0				0,51			
Status station			1	1	1	1	1	1	2	2	1							
Status group II & III			1															
pH/Eh																		
Corr.sum																		
Index																		
Average																		
< 1,1			1															
1,1 - <2,1			2															
2,1 - <3,1			3															
≥3,1			4															
Status site:			1															
Grab ID																		
pH / Eh ID	Ysi professional plus																	


Sample scheme B.2

Company:	Arctic Sea Farm	Date:	05.09 2022
Site:	Hvannadalur	Site no.:	0
Fieldworker:	Snorri Gunnarsson		

Sample number	1	2	3	4	5	6	7	8	9	10	
Depth (m)	58	57	58	58	58	58	58	58	58	57	
Number of trials	1	1	1	1	1	1	1	1	1	1	
Gas bubbles (in sample)	No	No	No	No	No	No	No	No	No	No	
Sediment type	Clay	x	x	x	x	x	x	x	x	x	
	Silt										
	Sand										
	Gravel										
	Shellsand										
Reef											
Rocky bottom (cobbles, boulders)											
Echinodermata, count	2	2			4		2				
Crustaceans, count	2										
Molluscs, count										2	
Polychaetes, count	>20	>20	>20	>50	>10	>20	>30	>40	>50	>10	
Other animals, count											
<i>Beggiatoa</i>											
Feed											
Faeces											
Comments											
Grab	Area [m ²]									Grab ID	0








Sample scheme B.2


Company:	Arctic Sea Farm	Date:	05.09 2022
Site:	Hvannadalur	Site no.:	0
Fieldworker:	Snorri Gunnarsson		









Sample number	11	12	13	14	15	16	17	18	19	20
Depth (m)	58	57	57	57	58	58	58	57	56	
Number of trials	1	1	1	1	1	1	1	1	1	
Gas bubbles (in sample)	No	No	No	No	No	No	No	No	No	
Sediment type	Clay	x	x	x	x	x	x	x	x	x
	Silt									
	Sand									
	Gravel									
	Shellsand									
Reef										
Rocky bottom (cobbles, boulders)										
Echinodermata, count		1					1			
Crustaceans, count						1				
Molluscs, count	5									
Polychaetes, count	>20	>10	>20	>20	>10	>10	>20	>40	>50	
Other animals, count										
Beggiatoa							x			
Feed										
Faeces										
Comments	Station 17 littlebit of Beggiatoa, some smell and black in color.									
Grab	Area [m ²]	0				Grab ID	0			
Signature fieldworker:										



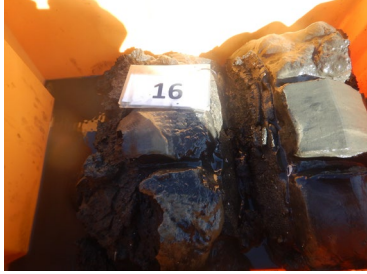







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7.2 Pictures of samples at Hvannadalur.

<p><i>St 1</i></p>		
<p><i>St 2</i></p>		
<p><i>St 3</i></p>		
<p><i>St 4</i></p>		

<p><i>St 5</i></p>		
<p><i>St 6</i></p>		
<p><i>St 7</i></p>		
<p><i>St 8</i></p>		
<p><i>St 9</i></p>		

<p><i>St 10</i></p>		
<p><i>St 11</i></p>		
<p><i>St 12</i></p>		
<p><i>St 13</i></p>		
<p><i>St 14</i></p>		

<p><i>St 15</i></p>		
<p><i>St 16</i></p>		
<p><i>St 17</i></p>		
<p><i>St 18</i></p>		
<p><i>St 19</i></p>		

7.3 Bottom topography and 3D view

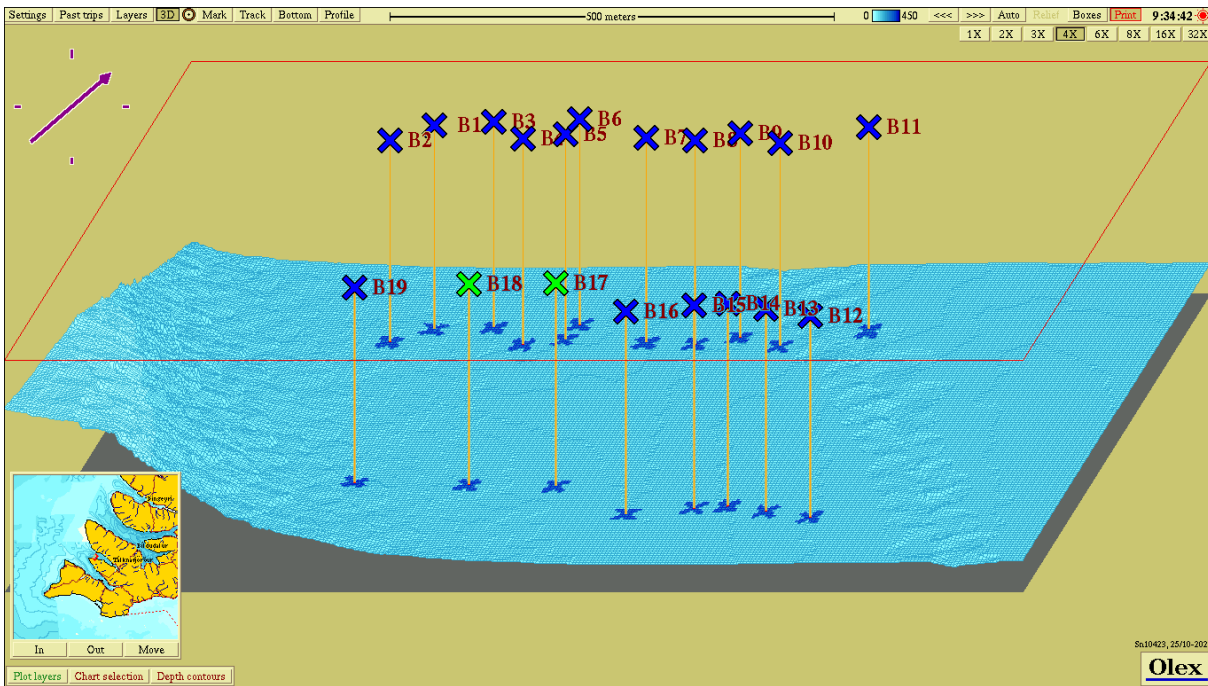


Figure 3. Bottom topography in 3D at Hvannadalur with each sampling station according to info in Figure 1 and Table 4.