Akvaplan niva

Rapport Report

Hringsdalur, Arnarlax
B survey,
September 2023
(max biomass)

NORSK
AKKREDITERING
TEST 079

Akvaplan-niva AS: APN 65250.B01

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Information client			
Title	Hringsdalur, Arnarlax. B survey (max biomass, September 2023		
Report number	APN-65250.B01		
Site name	Hringsdalur	Coordinates site	65°44,416N 23°45,777V
County	Vesturbyggð	Municipality	Bíldudalur
MTB-or estimated max biomass	8.300 tonnes	Site manager/contact	Silja Baldvinsdóttir
Client name	Arnarlax		

Biomass/production/status at date of survey			
Biomass at date of survey	8.300 t	Feed use	8.361 t
Fish type	Salmon	Amount produced	10.641 t
Type/time of survey		Comments	
At maximal biomass see kap 7.9	☒	First generation after transfer of frame approx. 300m eastward from previous placement and extension of cages from 12 to 18.	
A follow up survey	☐		
Half maximal biomass	☐		
Survey prior to putting out smolt	☐		
A pre-survey new site	☐		
Other	☐		
Last fallowing period:			

Results from B-survey according to NS 9410:2016 (main results)			
Parameters and indexes		**Parameters and site status**	
Gr. II. pH/Eh	1,30	Gr. II. pH/Eh	2
Gr. III. Sensory	0,78	Gr. III. Sensory	1
GR. II + III	1,04	GR. II+ III	1
Date fieldwork	29.09 2023	**Date report**	25.10 2023
Site status (NS 9410:2016):			**1**

Report writing and project leader	Snorri Gunnarsson	Signature	
Quality control	Rikke Stabell	Signature	

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Preface

The B-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 following have participated in the survey:

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

The sampling at Hringsdalur was done 29.09 2023.

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.

Akvaplan-niva AS thanks Arnarlax and their personnel for the cooperation during the conductance of this site survey.

Kópavogur 25.10.2023

Snorri Gunnarsson
Project manager

1 Introduction

Sampling was undertaken on 29.09.2023 by Akvaplan-niva AS, who has been contracted by Arnarlax in relation to the company's fish farming activity at the site Hringsdalur in Arnarfjörður, Vesturbyggð municipality.

The objective of the B-survey is to document the environmental condition in the near zone (beneath and in the close vicinity) 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 survey was undertaken at the time of max biomass of current production cycle. Sampling stations in this survey are placed within the near zone of the current farm location. Hringsdalur has an estimated max. biomass of 8.300 t for current generation farmed fish (Nikolas Tzamouranis, personal reference) and thus a total of 20 stations were sampled.

Figure 1 shows a map of the Arnarfjörður in Vestfirðir where Hringsdalur is located (Hringsdalur in upper left corner).

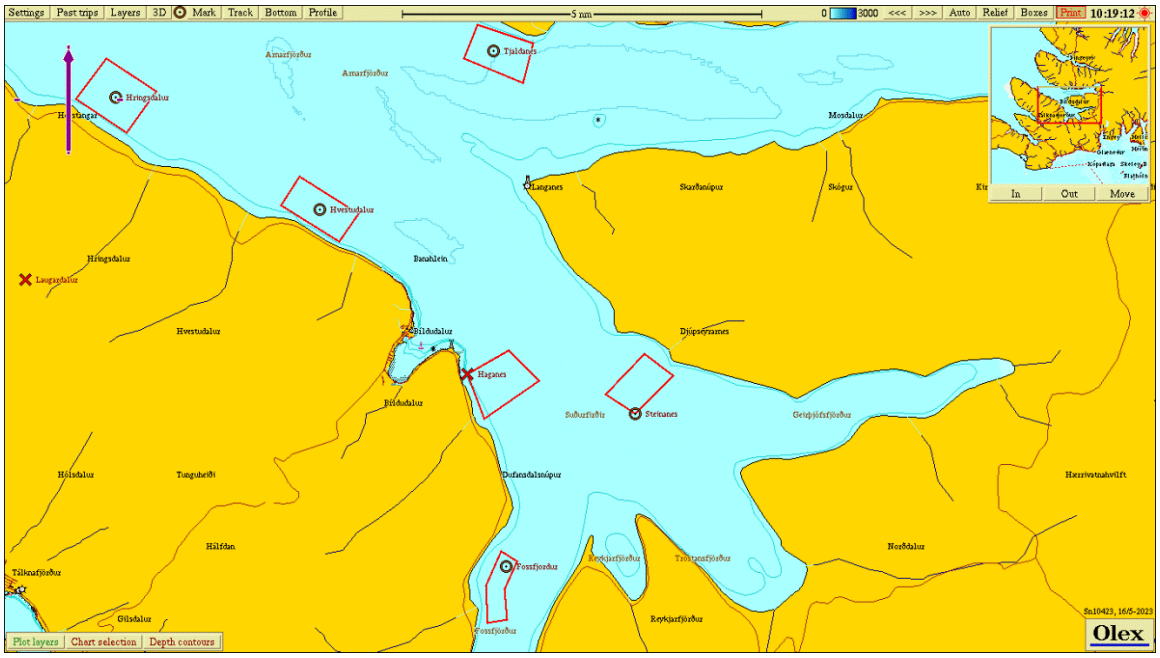


Figure 1. An overview map where Hringsdalur farm is marked. Other fish farming areas in the nearest vicinity (Arnarfjörður) are also shown.

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. This B-survey follows 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 cm^2). Sediment condition for each sample is assessed using three indicators: sediment chemistry (pH and redox potential), sensory evaluation (gas bubbles, smell, texture, color 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: - 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 m^2
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

Hringsdalur is located in the southern part of Arnarfjörður, approximately 6nm northwest of the town of Bíldudalur. The installed frame is suited for up to 18 net-pens with a circumference of 200 m. The frame is positioned in north- northwest direction from land (343°) with depth below the cages ranging from 58 to 88 m.
This is the first-generation farmed fish at the site after the frame was extended (from 6 to 18 net-pens) and moved approximately 300 m eastwards. At the previous placement of the frame there were farmed two generations fish. The current generation was produced in 13 cages, 12 with 200 m circumference and one with 160 m circumference. The majority of smolts were put into sea in spring/summer 2022. At the date of the B-survey the standing biomass was 8.300 tons.

Table 2 shows the production and feed usage for previous and current generation to sampling date.

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

Generation of fish (G)	Production (tonnes)	Feed usage (tonnes)
Generation 2022- 29.09 2023	8.361	10.641
Generation 2018-2020	6.281	7.617
Generation 2016-2018	3.613	3.914

3.2 Present and past site surveys

Table 3 provides an overview of sampling dates and results of current and historic B-surveys.

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

Date of sampling	Report number	Survey type	Overall site status
29.09 2023	APN-6250.B01 (Gunnarsson, 2023)	B survey max biomass	1
26.04.2022	APN 64042.B01 (Gustavsson, 2022)	Fallow period	1
19.11.2019	APN-61656.B01 (Gustavsson, 2020)	B survey max biomass	1
16.05.2018	APN-60320.B01 (Gunnarsson, 2018b)	Fallow period	1
01.11.2017	APN-9187.B02 (Gunnarsson, 2018a)	B survey max biomass	1
22.10.2013	AR131125A (Moe, 2013)	B survey new site	1

3.3 Hydrodynamic conditions

Current measurements were undertaken in Jan-Feb 2014 at 60 m, which is the dispersing depth for Hringsdalur site (Moe, 2014). The dominating current at 60 m is in south-eastly direction (120-165 degrees) with a small counter current in opposite direction (Figure 2). Average current speed is 6 cm/s. Highest current speed is measured to be 29 cm/s and 2.54 % of the measurements are zero current.

3.4 Survey design

The placement of the 20 sampling stations is shown in Figure 2 with positions listed in Table 4. Stations are distributed within the near zone of the new frame position following criteria outlined in NS 9410:2016. The typical depth in the local impact zone is in the range from 56 – 88 m, with the deepest waters being located in the northern part of the frame area (from land 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. During the present production cycle 13 cages were used at the site. Therefore, the 20 stations sampled were distributed with emphasis around these 13 cages according to guidance in NS 9410, chapter 7.6. The sampling stations had a depth varying from 61 to 86 m. The placement of sampling stations is regarded to be in accordance with the requirements outlined in NS 9410:2016.

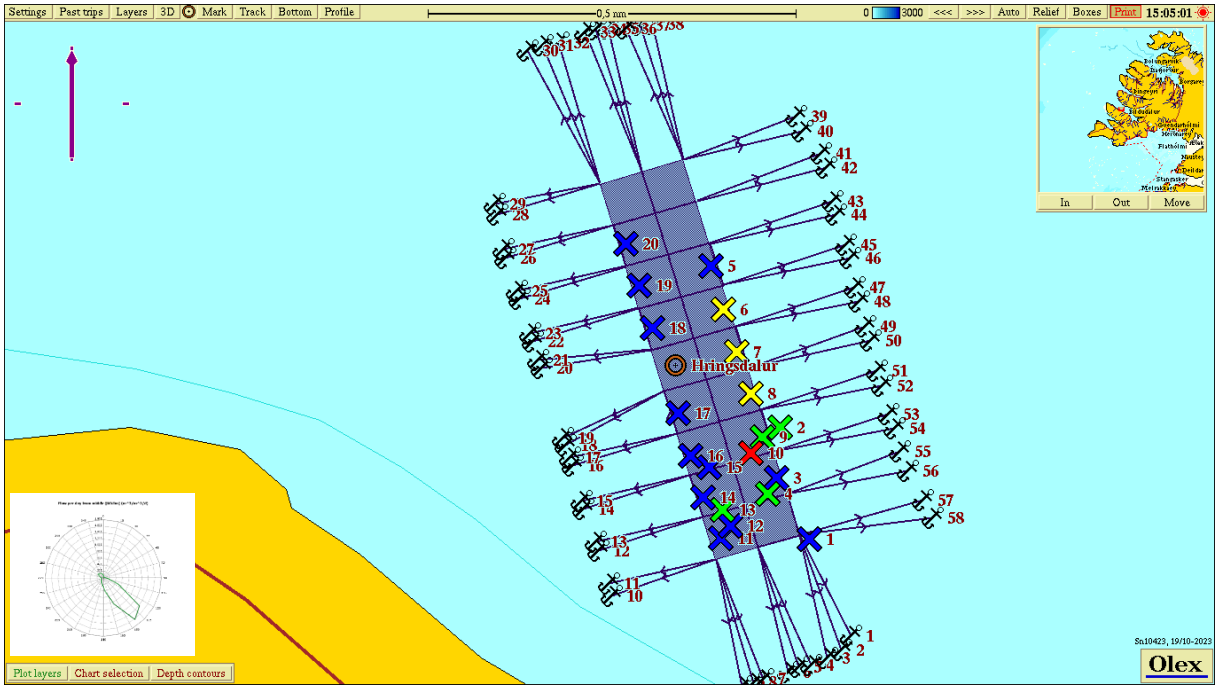


Figure 2. Site specific map of Hringsdalur showing frame, mooring lines and farming area. Sampling stations st. 1 – 16 are marked with crosses. The color of each cross represents the environmental condition at the respective station following the classification as outlined in NS 9410:2016, chapter 7.11. Color codes: Blue = very good, green = good, yellow = bad, red = very bad. Ocean current rose placed in the lower left corner shows main current direction at 60 m (Moe, 2013).

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

Station number	North	West	Depth (m)
St 1	65°44,171	23°45,414	72
St 2	65°44,323	23°45,511	78
St 3	65°44,255	23°45,523	74
St 4	65°44,233	23°45,551	72
St 5	65°44,543	23°45,739	86
St 6	65°44,484	23°45,698	84
St 7	65°44,425	23°45,653	85
St 8	65°44,369	23°45,608	79
St 9	65°44,310	23°45,569	77
St 10	65°44,288	23°45,607	75
St 11	65°44,172	23°45,708	61
St 12	65°44,189	23°45,674	65
St 13	65°44,211	23°45,700	68
St 14	65°44,228	23°45,766	67
St 15	65°44,269	23°45,745	69
St 16	65°44,285	23°45,808	69
St 17	65°44,343	23°45,847	74
St 18	65°44,458	23°45,933	81
St 19	65°44,515	23°45,987	83
St 20	65°44,573	23°46,022	85

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)	2
Group III – parameters, (sensory)	1
Group II + III – parameters (mean value)	1
Site condition	**1**

Substrate was collected at all 20 sampling stations (100% soft bottom). Sediment samples consisted mainly of mud and mixture of mud and silt at the southern part of the local impact zone. Fauna was recorded at all stations with polychaetes being most prominent. No signs of out-gassing were observed at any of the sampling stations. The substrate was of brown/black colour at six stations and light grey colour at the resting fourteen stations. No smell of H_2S was at ten sampling stations and light smell at ten stations. Feed particles were observed at two stations, faeces at three stations and the bacteria *Beggiatoa* were observed at one sampling station.

Based on the classification of sediment chemistry (ph/Eh) and the sensory assessments twelve stations of this survey received status 1 – "very good", four stations received status 2 – "good", three stations status 3 – "bad" and one station status 4 – "very bad" (Figure 2). Overall, the index score for parameter II (pH/Eh) was lower than the index score for the sensory parameters III, or 1,30 for parameter II but 0,76 for parameter III.

Taken together the site receives the environmental status was 1 – "good" (average group II-III index =1.04).

5 Conclusion

Applying the indicator thresholds and classification outlined in NS 9410:2016 it is shown that Hringsdalur receives overall site status 1 – "very good" at the time of this B survey. Samples were collected with a Van Veen grab (0,1 m^2) at 20 stations distributed around the 13 cages, that were used for farming salmon during present production cycle. Twelve sampling stations received status 1 – "very good", four stations received status 2 – "good", three stations status 3 – "bad" and one station status 4 – "very bad"

The survey was undertaken during the time of max biomass for the present production cycle. The results indicate that in parts of the local impact zone there is some organic load. The one station with status "very bad" and the three stations with condition bad are all located at the eastern part of the frame indicating higher organic load in that part of the local impact zone which is in line with direction of the spread current at the site. There was some inconsistency in the score for parameters II (pH/redox) having overall group status 2 (good) and parameters III (sensory) having overall group status 1 (very good). The average group status of II and III resulted in status 1 (very).

In previous B-surveys prior to putting out current generation farmed fish at the site the farm had been expanded and moved to a new position within the defined farming area (Gustavsson, 2022) and there were no signs of organic enrichment within the footprint of the new farm location. So during the farming of the current generation at Hringsdalur site there are been some build-up of organic load since previous fallow period, mainly at the eastern part of the local impact zone.

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., 2018a. Arnarlax. B-undersøkelse, november 2017 Hringsdalur, APN-9187.B02. Akvaplan-niva AS.

Gunnarsson, S., 2018b. Arnarlax hf. B-undersøkelse, mai 2018 Hringsdalur (undersøkelse ved brakklegging), APN-60320.B01. Akvaplan-niva AS.

Gustavsson, A., 2020. Hringsdalur, Arnarlax ehf B-bottom survey, November 2019 (Maximum biomass survey), APN-61656.B01. Akvaplan-niva AS.

Gustavsson, A., 2022. Hringsdalur, Arnarlax B survey, April 2022 (post fallow), APN-64042.B01. Akvaplan-niva AS.

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 akvakultur-anlegg.

Moe, A.A., 2013. Environmental monitoring (MOM B) at finfish farm site Hringsdalur October 2013. AR131125A. Helgeland Havbruksstasjon AS.

Moe, A.A, 2014. Current investigation at finfish farm site Hringsdalur February 2014. Helgeland Havbruksstasjon AS.

Personal reference. Nikolas Tzamouranis, Quality and fish health coordinator, Arnarlax. 2023

7 Appendix

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

Sample scheme B.1

Company	Arnarlax	Date:	29.09 2023
Site:	Hringsdalur (max biomasss)	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	7.53	7.11	7.61	7.34	7.68	6.82	7.07	7.09	7.31	6.38
	Eh (mV)	ORP	-30	-243	-61	-171	-70	-233	-230	-220	-221	-198
		plus ref. verdi	170	-43	139	29	130	-33	-30	-20	-21	2
	pH/Eh	from figure	0	2	0	1	0	3	3	3	2	5
	Status station		1	2	1	1	1	3	3	3	2	4
			Buffer-temp	9.1 C		Sea temp	8.1 C		Sediment temp		6.1 C	
		pH sea 8.08	ORP sea	169.0 mV		Eh sea	369.0 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					
		Brown/black (2)				2		2	2	2	2	2
	Smell	None (0)	0				0					
		Light (2)		2	2	2		2	2	2	2	2
		Strong (4)										
	Consistency	Solid (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
	Thickness of slidge (t)	t < 2 cm (0)	0	0	0	0	0	0	0	0	0	0
		2 < t < 8 cm (1)										
		t > 8 cm (2)										
		Sum	2.0	4.0	4.0	6.0	2.0	6.0	6.0	6.0	6.0	6.0
		Corrected (*0,22)	0.4	0.9	0.9	1.3	0.4	1.3	1.3	1.3	1.3	1.3
	Status station		1	1	1	2	1	2	2	2	2	2
	Average group II & III		0.2	1.4	0.4	1.2	0.2	2.2	2.2	2.2	1.7	3.2
	Status station		1	2	1	2	1	3	3	3	2	4

Grab ID	K-3
pH / Eh ID	Ysi prof. Plus

page 1 of 4 pages

Sample scheme B.1

Company:	**Arnarlax**	**Date:**	**29.09 2023**
Site:	**Hringsdalur (max biomasss)**	**Site no.:**	**0**
Fieldworker:	**Snorri Gunnarsson**		

Gr	Parameter	Point	Sample number 11	12	13	14	15	16	17	18	19	20	Index S%	H%
	Bottom type: S (soft) or H (hard)		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		
II	pH	value	7.67	7.51	6.91	7.16	7.42	7.68	7.65	7.61	7.77	7.85		
	Eh (mV)	ORP	-31	-184	-195	-150	-181	-53	-157	-63	-30	-31		
		plus ref. verdi	169	16	5	50	19	147	43	137	170	169		
	pH/Eh	from figure	0	1	3	1	1	0	1	0	0	0	1.30	
	Status station		1	1	3	1	1	1	1	1	1	1		
	Status group II		2	**Buffer temp**	9.1 C		**Sea temp**	8.1 C		**Sediment temp**	6.1 C			
	pH sea	8.08	**ORP sea**	169 mV		**Eh sea**	369 mV		**Reference electrode**		200 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)												
	Smell	None (0)	0	0		0		0	0	0	0	0		
		Light (2)			2		2							
		Strong (4)												
	Consistency	Solid (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)	1											
		v > 3/4 (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		
		2 < t < 8 cm (1)												
		t > 8 cm (2)												
		Sum	1.0	2.0	4.0	2.0	4.0	2.0	2.0	2.0	2.0	2.0		
		Corrected (*0,22)	0.2	0.4	0.9	0.4	0.9	0.4	0.4	0.4	0.4	0.4	0.78	
		Status station	1	1	1	1	1	1	1	1	1	1		
		Status group III	1											
		Average group II & III	0.1	0.7	1.9	0.7	0.9	0.2	0.7	0.2	0.2	0.2	1.04	
		Status station	1	1	2	1	1	1	1	1	1	1		
		Status group II & III	1											

pH/Eh Corr.sum Index Average	**Status**
< 1,1	1
1,1 - <2,1	2
2,1 - <3,1	3
≥3,1	4

Status site: 1

Grab ID	K-3
pH / Eh ID	Ysi prof. Plus

Sample scheme B.2

Company:	**Arnarlax**	**Date:**	**29.09 2023**
Site:	**Hringsdalur (max biomasss)**	**Site no.:**	**0**
Fieldworker:	**Snorri Gunnarsson**		

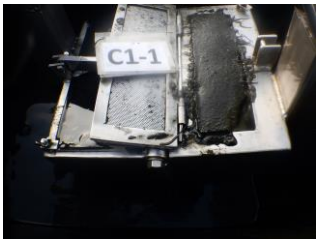
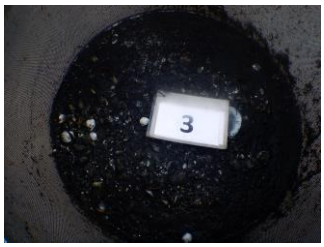
Sample number		1	2	3	4	5	6	7	8	9	10
Depth (m)		72	78	74	72	86	84	85	79	77	75
Number of trials		1	1	1	1	1	1	1	1	1	1
Gas bubbles (in sample)		No	No	No	No	No	No	No	No	No	No
Sediment type	**Clay**	X	X	X	X	X	X	X	X	X	X
	Silt	X	X								
	Sand										
	Gravel										
	Shellsand										
Reef											
Rocky bottom (cobbles, boulders)											
Echinodermata, count											
Crustaceans, count											
Molluscs, count						5					
Polychaetes, count		>10	>10	>50	>50	>50	>20	>20	>50	>50	>50
Other animals, count											
Beggiatoa											
Feed											
Faeces									X	X	
Comments		Stations 3, 4, 6, 7, 8 and 9: Some black algae in sample.									
Grab	**Area [m^2]**	0.1			**Grab ID**		K-3				

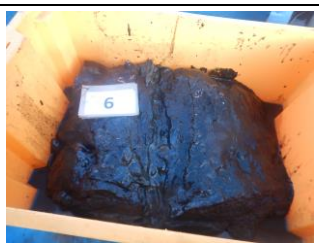
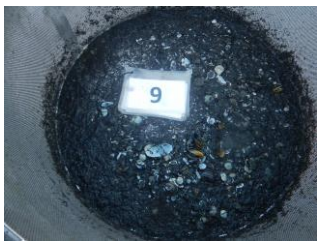
Sample scheme B.2

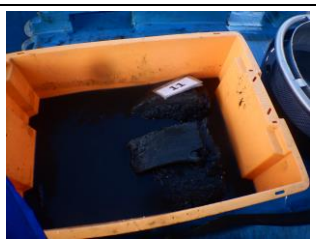
Company:	**Arnarlax**		**Date:**	**29.09 2023**
Site:	**Hringsdalur (max biomasss)**		**Site no.:**	**0**
Fieldworker:	**Snorri Gunnarsson**			

Sample number		11	12	13	14	15	16	17	18	19	20
Depth (m)		61	66	68	67	69	69	74	81	83	85
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	X
	Silt	X	X	X	X						
	Sand										
	Gravel										
	Shellsand										
Reef											
Rocky bottom (cobbles, boulders)											
Echinodermata, count											
Crustaceans, count											
Molluscs, count		7	>5		>10		2	>10	>7	6	5
Polychaetes, count		>10	>20	>50	>20	>10	>10	>20	>100	>20	>20
Other animals, count											
Beggiatoa									X		
Feed			X					X			
Faeces											X
Comments		Stations 11 - 17 som black algae.									
Grab	**Area [m^2]**	0.1			**Grab ID**			K-3			
Signature fieldworker:											

7.2 Pictures of samples at Hringsdalur.

St 1		
St 2		
St 3		
St 4		
St 5		

St 6		
St 7		
St 8		
St 9		
St 10		

St 11		
St 12		
St 13		
St 14		
St 15		

St 16		
St 17		
St 18		
St 19		
St 20		

7.3 Bottom topography and 3D view

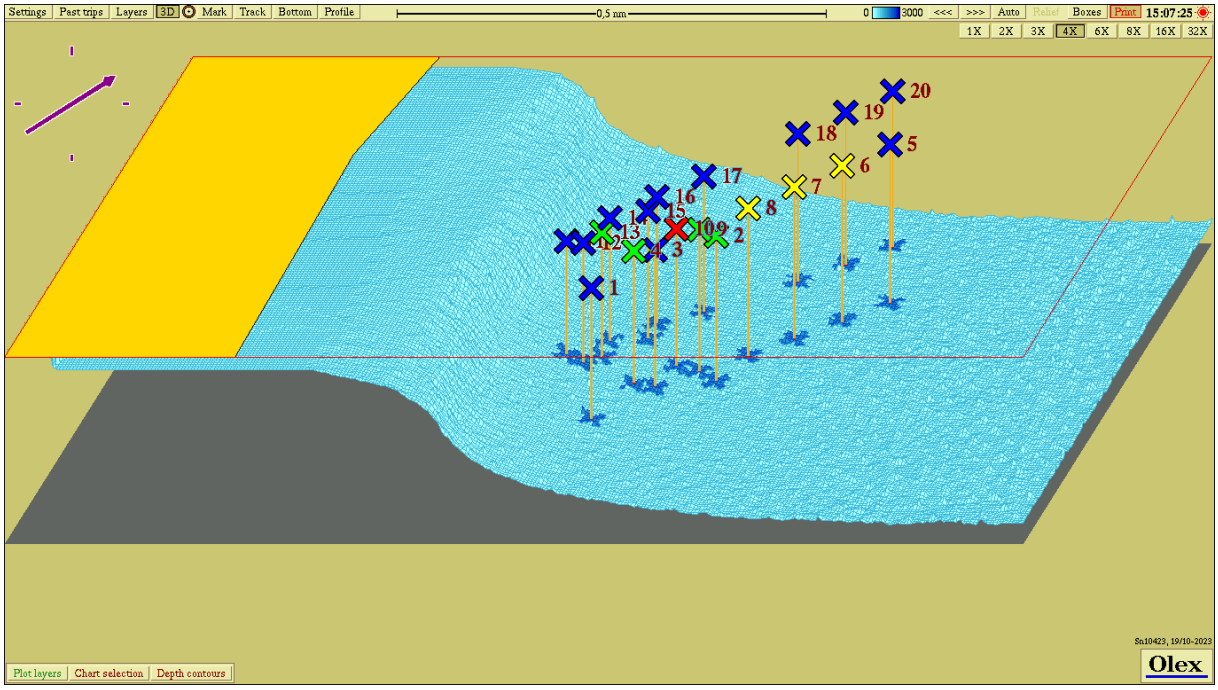


Figure 3. Bottom topography in 3D at Hringsdalur with each sampling station according to info in Figure 1 and Table 4.