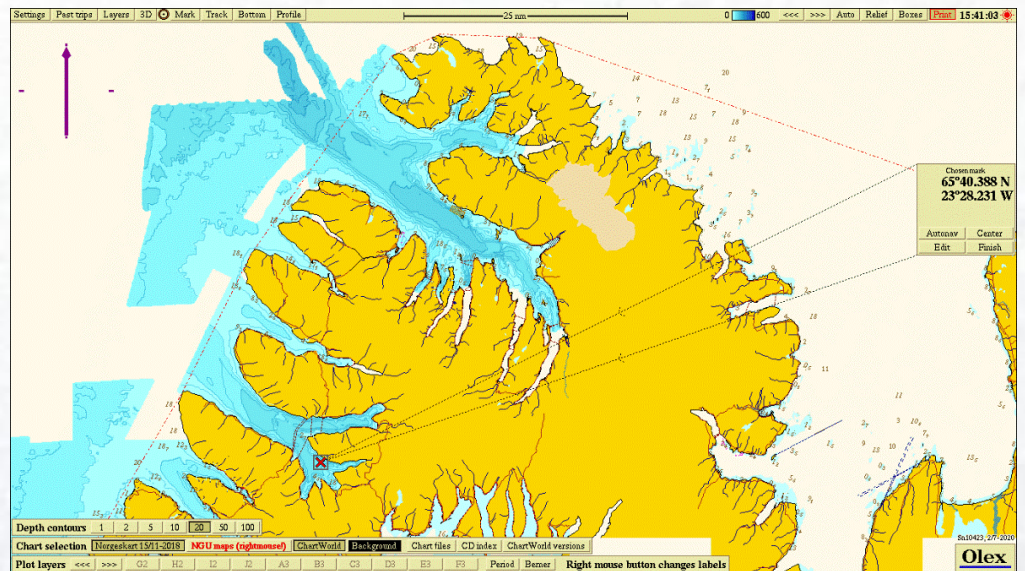


Steinanes, Arnarlax ehf.
B-bottom survey,
October 2021
(maximum biomass survey)



Information client			
Titel	Steinanes, Arnarlax ehf. B-bottom survey, October 2021		
Report number	APN-63543.B01		
Site name	Steinanes	Coordinates site	65°40.388 N 023°28.231 V
County		Municipality	Vesturbyggð
MTB-or estimated max biomass	7.409 ton	Site manager/contact	Silja Baldvinsdóttir
Client name	Arnarlax ehf.		

Biomass/production/status at date of survey			
Biomass at date of survey	6.766 ton	Feed use	8.425
Fish type	Salmon	Amount produced	
Type/time of survey	Mark with X	Comments	
At maximal biomass see kap 7.9	<input checked="" type="checkbox"/>		
A follow up survey	<input type="checkbox"/>		
Half maximal biomass	<input type="checkbox"/>		
Survey prior to putting out smolt	<input type="checkbox"/>		
A pre-survey new site	<input type="checkbox"/>		
Other	<input type="checkbox"/>		
Last following period:			

Results from B-survey iht. NS 9410:2016 (main results)			
Parameters and indexes		Parameters and site status	
Gr. II. pH/Eh	3,47	Gr. II. pH/Eh	4
Gr. III. Sensory	1,67	Gr. III. Sensory	2
GR. II + III	2,31	GR. II+ III	3
Date field work	12.10 2021	Date report	10.12 2021
Site status (NS 9410:2016):			3



Report writing and project leader	Snorri Gunnarsson	Signature	
Quality control	Arnbór Gústavsson	Signature	

Table of contents

PREFACE.....	2
1 INTRODUCTION	3
2 PROFESSIONAL PROGRAM AND METHODS	4
2.1 Field equipment	4
3 SITE DESCRIPTION AND BOTTOM TOPOGRAPHY	5
3.1 Info site operation.....	5
3.2 Present and past site surveys	5
3.3 Dispersing current	6
3.4 Position of sampling stations.....	6
4 RESULTS.....	8
5 CONCLUSION	9
6 REFERENCES	10
7 APPENDIX:	11
7.1 Sheet (B.1 og B.2) NS 9410:2016	11
7.2 Pictures of samples at Steinanes.....	15
7.3 Bottom topography and 3D view	19

Preface

The survey is carried out according to guidelines in NS 9410:2016 which includes evaluation of sediment, faunal investigation and bottom topography. The environmental survey is regulated by § 35 in the Norwegian «akvakulturdriftsforskriften. The survey also fulfills the requirements regarding bottom surveys in the standard ISO 12878.

The primary objective of a B-survey is to investigate state of health of seabed in local impact zone according to requirements defined in NS9410:2016. The estimated max biomass for the current generation farmed salmon at the site Steinanes is 7.409 MTB ton. There is a requirement of at least 20 sampling stations within the mooring lines of the fish farm. The methods applied in this survey follow guidelines in chapter 5 (NS6410:216) and fulfil the requirements described in ISO 12878. Requirements that samplings stations should be placed just beside the cages or under cages that have been used is fulfilled.

The following have participated in the survey:


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

The sampling at Steinanes was done 12.10 2021.

Accredited survey:

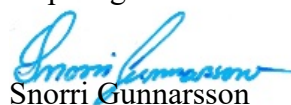
The following parts of the survey are done in accordance to accreditation methods:

Sampling and treatment of sediment samples, analysis of samples and evaluations of the results. It should be pointed out that as Icelandic officials have not set standards regarding different parameters based on samplings at Icelandic conditions so the site characters in this report should be interpreted with that disclaimer in mind.

	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 ehf. and their personnel for the cooperation during the conductance of this site survey.

Kópavogi 9. februar 2022



Snorri Gunnarsson
Project manager

1 Introduction

The sampling date for the present site survey was 12.10 2021 and done by Akvaplan-niva AS contracted by Arnarlax in relation to the company's fish farming activity at the site in Steinanes, Arnarfjörður.

The objective of the B-survey is to document the environmental condition of the local impact zone of the fish farm according to NS 9410:2016 (and ISO 12878) which includes condition of the seabed, faunal evaluation and bottom topography registration.

The survey gives an estimate and evaluation of the site condition regarding organic load and feasibility assessment of the site for fish farming activity.

Figure 1 shows map of the fjord system of Vestfirðir where the site Steinanes is located.

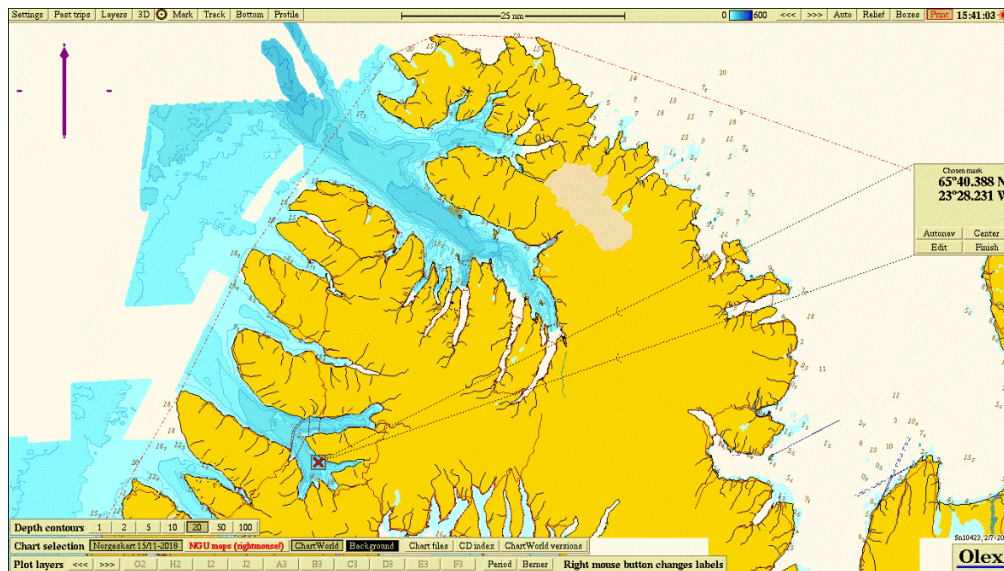


Figure 1. An overview map with the Steinanes site marked with a red cross.

2 Methods

Environmental monitoring of the impact from the fish farming activities on the seabed is a standardised system. All fish farming sites in the sea are to be regularly assessed. The methods for monitoring in Iceland, are based on description in the ISO 12878 standard and methodology described in the NS 9410:2016 is followed. The Icelandic Environmental agency (Umhverfisstofnun) can also set forward specific requirements regarding frequency of samplings for different fish farming sites that can overrule the requirements in the above-mentioned standards.

The B-survey is a trend study of the benthic conditions at, or in close proximity to the fish farming site (local impact zone). Sediment is collected by use of grab (min 250 cm²). Each grab sample is investigated with regard to three observation types of benthic characters; faunal parameters, chemical parameters (pH and redox-potential) and a sensory evaluation (gas bobbles, smell, texture, colour and the thickness of the precipitated slam layer in the sediment). The different benthic parameters are given a character on the scale from 1 to 4, according to the scale of the impact on the benthic conditions from organic load, see criteria in table 1. The number of sampling stations are decided based on the estimated max standing biomass for the given year class for farmed fish at the site and it is the weighted average for all the sampling stations that gives the sites condition.

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	<p>Prior to putting next generation into sea. Based on the site condition prior to putting next generation into sea:</p> <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 <p>If any of the samples result in character 4 it is a sign of overload.</p>
4-very bad	Overload

2.1 Field equipment

The following field equipment was used during the site survey:

Grabb: Van Veen grabb (0,025 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

Olex mapping software

3 Site description and bottom topography

3.1 Info site operation

The Steinanes site is located in Arnarfjörður Iceladn about 5.5 km north-east from Bíldudalur. The cages are lined in a southwest direction from land (227 degrees). The depth under cages ranges from about 62 m closer to land up to about 92 further into the fjord. The shallower area of the farm is at the northernmost part.

The current generation of farmed Atlantic salmon is the second generations at the site. The fish farm at Steinanes has a single frame 2x7 mooring system with a possibility total of 14 cages, each with 160 m circumference. The current generation was put into sea summer/fall 2020. The first generation at Steinanes was salmon farmed from June 2017 to late fall 2019.

Table 2 shows the production and feed usage for the past generation.

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

Generation of fish (G)	Production (ton)	Feed usage (ton)
Generation 2017-2019 salmon	8.964	13.704
Summer/fall 2020 - present	6.766	8.425

3.2 Present and past site surveys

There have previously been done three type B-surveys at the Steinanes site (Table 3), pre survey in 2017, at max biomass for first farmed generation in 2018 and at fallow period in 2020. The results from the B survey at max biomass in 2018 gave overall site condition 2 «good» and at last B-survey at fallow gave overall site condition 1 «very good».

Despite the overall very good condition at the Steinanes site during the fallow period in 2020 (Gunnarsson 2020b), the local impact zone condition was varying with four stations out of the twenty with condition very bad. This indicated some level of organic load mainly northern part of the Steinanes site. The prior B-survey during max biomass in 2018 (Gunnarsson 2020a) resulted in overall condition 2 «good». The conditions seemed therefore to have overall improved during last fallow period even though at the Steinanes site some organic load effects were visible in parts of the local farming area.

Table 3. Past surveys in the local impact zone for Steinanes.

Date of sampling	Report number	Survey type	Overall site status
10.06 2020	APN-62254.B01 (Gunnarsson 2020b)	Fallow period	1
25.09 2018	APN-60526.01 (Gunnarsson 2020a)	Max biomass	2
27.06 2017	Pre farming B survey not published	Pre survey new site	1

3.3 Dispersing current

Dominating dispersion current (60 m) is in direction NV (315 degrees) with a slight current to SE (135 degrees) (Hermansen, 2020). Average current speed at 60 m is measured to be 4,1 cm/s. Highest current speed is measured to be 14,2 cm/s and 5 % of the measurements are < 1 cm/s.

3.4 Position of sampling stations

Description of the stations in the survey is given in Figure 2 and Table 4. Positioning of the stations was chosen based guidance and perimeters described in NS 9410:2016 and the bottom topography and planned configuration of the farm. Steinanes site is in Arnarfjörður. Depth at the site is in the range from about 62 to 92 meters. The placement of sampling stations was chosen to give a good picture of the whole local impact zone in the area with cages that were used during previous production cycle. The sampling stations had a depth varying from 55 m to 91 m. The placement of the sampling stations is regarded to be in accordance with the descriptions for local impact zone given in NS 9410:2016.

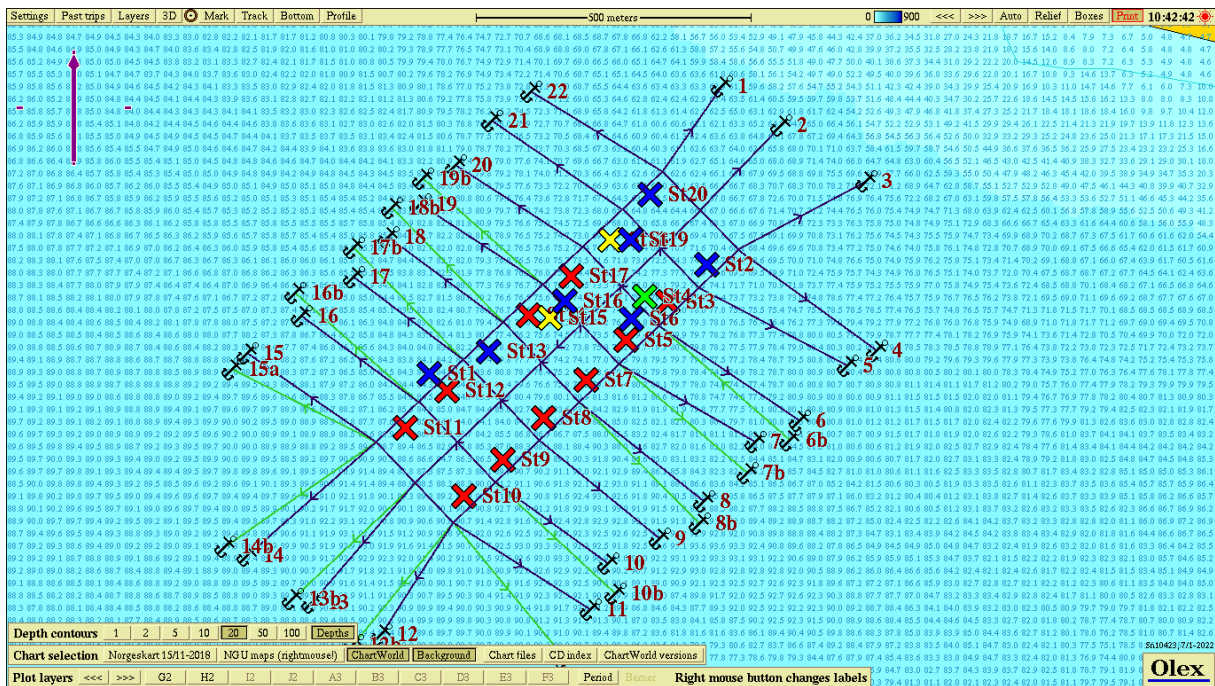


Figure 2. Chart showing depths at the site Steinanes. Sampling stations st. 1 – 20 are marked with color codes that describe the condition according to NS 9410:2016, chapter 7.11. Color codes: Blue = very good condition, green = good condition, yellow = bad condition, red = very bad condition.

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

Station number	North	Vest	Depth (m)
St 1	65°40.379	23°28.496	85
St 2	65°40.486	23°27.834	76
St 3	65°40.450	23°27.927	80
St 4	65°40.455	23°27.983	79
St 5	65°40.412	23°28.027	79
St 6	65°40.433	23°28.015	78
St 7	65°40.373	23°28.123	79
St 8	65°40.336	23°28.224	86
St 9	65°40.295	23°28.321	89
St 10	65°40.259	23°28.414	90
St 11	65°40.326	23°28.554	88
St 12	65°40.363	23°28.455	85
St 13	65°40.401	23°28.355	82
St 14	65°40.437	23°28.260	77
St 15	65°40.434	23°28.208	75
St 16	65°40.451	23°28.174	75
St 17	65°40.475	23°28.158	75
St 18	65°40.511	23°28.065	71
St 19	65°40.511	23°28.016	71
St 20	65°40.555	23°27.970	64

4 Results

Results for the different parameters are given in Table 5. The overall site condition was 3 «bad» and is the result of the weighted average for all sampling stations. The results were however a little bit mixed with 10 stations having condition bad and 7 stations having condition very good. Overall, the condition for group II parameters (pH/Eh) was 4 «very bad», the condition for group III parameters (sensory) was 2 «good» and condition for combined group II + III parameters was 3 «bad». A complete filled sampling sheet with calculations for each parameter is attached.

Table 5. Results from the classifications of the local impact zone of the fish farm Steinanes in October 2021.

Parameter	Condition
Group II - parameters (pH/Eh)	4
Group III – parameters, (sensory)	2
Group II + III – parameters (mean value)	3
Site condition	3

There were collected valid sediment samples at seventeen stations out of the twenty sampled i.e. three stations were assigned as hard bottom all in the more shallower areas of the local impact zone. This indicates that most of the local impact zone is soft bottom with a hard bottom closer to land (north). The sediment type consisted mainly of fine clay.

For the group II parameters (pH/redox), four out of twenty stations had conditions 1 «very good», one station had conditions 2 «good», two stations had conditions 3 «bad» and ten stations had conditions 4 «very bad». For sensory parameters (group III) six out of twenty stations had condition 1 «very good», six stations had condition 2 «good», six stations had condition 3 «bad» and two stations had condition 4 «very bad». For combined parameters II and III (pH/redox and sensory) seven out of twenty stations had condition 1 «very good», one station had conditions 2 «good», two stations had conditions 3 « bad» and ten stations had conditions 4 «very bad». Animals were present in all soft bottom samples mainly in the form of polychaetes. Gas bubbles were detected in five grab samples (stations 5, 7, 9, 10 and 17) mainly in the eastern part of the local impact zone.

5 Conclusion

Based on the criteria given in NS 9410:2016 the fish farming site has been assigned a site condition 3 «bad» at the date of sampling. A total of 34 grab trial attempts were done with Van Veen grab (0,025 m²), divided on the 20 sampling stations placed around the Steinanes local impact zone. For combined parameters II and III (pH/redox and sensory) seven out of twenty stations had condition 1 «very good», one station had conditions 2 «good», two stations had conditions 3 « bad» and ten stations had conditions 4 «very bad».

This survey in the local impact zone at max biomass indicates some substantial organic load in the fish farming area mainly in the deeper areas of the local impact zone. The local impact zone is sloping from north to south and from west to east (see Figure 3 in Appendix). The four out of five stations where gas was detected in samples were located in the deeper area (east and south), indicating highest organic load in this part of the local impact zone but to a lesser degree in the shallower areas to west and north at the site. The previous B-survey during fallow period resulted in overall condition 1 «very good» (Gunnarsson 2020b) and the previous B-survey at max biomass in 2018 resulted in overall condition 2 «good». The conditions seem therefore to have deteriorated at the Steinanes site during the farming of present generation and some form of counteractive measures are recommendable.

The site is assigned a condition factor 3 "bad" according to calculations based on methodology described in NS 9410:2016 and sample sheet Table B.1 and B.2 (se chapter 7 Appendix).

6 References

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

Gunnarsson, S. 2020a (revised edition). Arnarlax hf, B-undersøkelse, Steinanes (undersøkelse ved maksimal belastning. Akvaplan-niva AS rapport nr. 60526.01.

Gunnarsson, S. 2020b (revised edition). Steinanes Arnarlax hf, B-bottom survey, June 2020 (fallow period). Akvaplan-niva AS report nr. 62254.B01.

Hermansen, S. 2020. Steinanes current measurements, 5, 15 and 60 meters. Akvaplan-niva AS report nr. 62191.04.

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.

Steinanes Miljøundersøkelser type B (pre-survey), by av Akvaplan-niva AS sommer 2017 (not published data).

www.fiskeridir.no

7 Appendix:

7.1 Sheet (B.1 og B.2) NS 9410:2016

Sample scheme B.1												
Company		Arnarlax										
Site:		Steinanes ps 63543										
Fieldworker:		Snorri Gunnarsson										
Date:		12.10.2021										
Site no.:												
Parameter	Point	Sample number										
Bottom type: S (soft) eller H (hard)		1	2	3	4	5	6	7	8	9	10	
		S	S	S	S	S	S	S	S	S	S	
Animals > 1mm	Yes (0) No (1)	0	0	0	0	0	0	0	0	0	0	
pH	value	7,6	7,7	6,6	7,2	6,6	7,6	6,1	6,5	6,4	6,2	
Eh (mV)	ORP	-94	27	-209	-234	-192	-84	-215	-210	-196	-218	
	plus ref. verdi	106	227	-9	-34	8	116	-15	-10	4	-18	
pH/Eh	from figure	0	0	5	2	5	0	5	5	5	5	
Status station		1	1	4	2	4	1	4	4	4	4	
Buffer-temp		8,0 C			Sea temp			6,0 C		Sediment temp		4,0 C
pH sea		7,96		ORP sea		138,0 mV		Eh sea		338,0 mV		
Reference electrode		200,0 mV										
Gas bubbles	Yes (4) No (0)	0	0	0	0	4	0	4	0	4	4	
Colour	Light/grey (0)	0					0					
	Brown/black (2)		2	2	2	2		2	2	2	2	
Smell	None (0)	0					0					
	Light (2)		2	2	2							
	Strong (4)					4		4	4	4	4	
Consistency	Solid (0)	0	0				0					
	Soft (2)			2	2	2			2	2	2	
	Aqueous (4)							4				
Grab volume (v)	v < 1/4 (0)		0									
	1/4 < v < 3/4 (1)	1		1	1	1	1	1	1		1	
	v > 3/4 (2)									2		
Thickness of sludge (t)	t < 2 cm (0)	0	0			0						
	2 < t < 8 cm (1)		1	1	1		1	1	1	1	1	
	t > 8 cm (2)											
Sum		1,0	5,0	8,0	8,0	13,0	2,0	16,0	10,0	15,0	14,0	
Corrected (**0,22)		0,2	1,1	1,8	1,8	2,9	0,4	3,5	2,2	3,3	3,1	
Status station		1	2	2	2	3	1	4	3	4	3	
Average group II & III		0,1	0,6	3,4	1,9	3,9	0,2	4,3	3,6	4,2	4,0	
Status station		1	1	4	2	4	1	4	4	4	4	
Grab ID	K22											
pH / Eh ID	Ysi professional plus											

Sample scheme B.1

Company:	Amarlax	Date:	12.10 2021
Site:	Steinanes ps 63543	Site no.:	0
Fieldworker:	Snorri Gunnarsson		

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	H	S	S	S	S	S	H	H	85	15
I	Animals > 1mm	Yes (0) No (1)	0	0	Ut	0	0	0	0	0	Ut	Ut		
II	pH	value	6,5	6,1	Ut	6,2	6,8	7,3	6,0	6,9	Ut	Ut		
	Eh (mV)	ORP	-238	-250		-250	-197	-135	-285	-184				
		plus ref. verdi	-38	-50		-50	3	65	-85	16				
	pH/Eh	from figure	5	5	ut	5	3	1	5	3	ut	ut	3,47	
	Status station		4	4	ut	4	3	1	4	3	ut	ut		
	Status group II		4	Buffer temp	8,0 C		Sea temp	6,0 C		Sediment temp	4,0 C			
	pH sea	7,96	ORP sea	138	mV	Eh sea	338 mV		Reference electrode	200 mV				
	Gas bubbles	Yes (4) No (0)	0	0	0	0	0	0	4	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	0			
	Light (2)	2				2	2		2					
	Strong (4)		4		4			4						
Consistency	Solid (0)			0						0	0			
	Soft (2)	2	2			2	2	2	2					
	Aqueous (4)				4									
Grab volume (v)	v < 1/4 (0)			0		0	0	0	0	0	0			
	1/4 < v < 3/4 (1)	1	1		1									
	v > 3/4 (2)													
Thickness of sidge (t)	t < 2 cm (0)			0			0		0	0	0			
	2 < t < 8 cm (1)	1	1		1	1		1						
	t > 8 cm (2)													
Sum		8,0	10,0	0,0	12,0	7,0	4,0	13,0	6,0	0,0	0,0			
Corrected (*0,22)		1,8	2,2	0,0	2,6	1,5	0,9	2,9	1,3	0,0	0,0	1,67		
Status station		2	3	1	3	2	1	3	2	1	1			
Status group III		2												
Average group II & III		3,4	3,6	0,0	3,8	2,3	0,9	3,9	2,2	0,0	0,0	2,31		
Status station		4	4	1	4	3	1	4	3	1	1			
Status group II & III		3												
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:												3		

Grab ID	K22
pH / Eh ID	Ysi professional plus


Sample scheme B.2

Company:	Arnarlax	Date:	12.10 2021
Site:	Steinanes ps 63543	Site no.:	0
Fieldworker:	Snorri Gunnarsson		




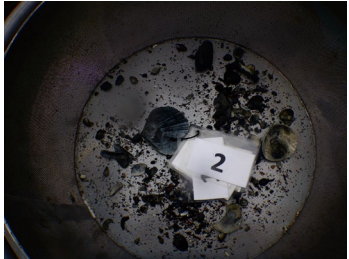

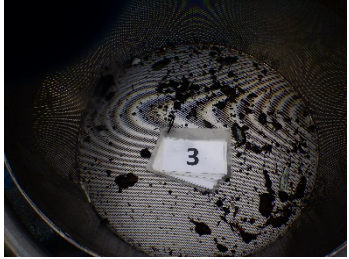




Sample number	1	2	3	4	5	6	7	8	9	10
Depth (m)	85	76	80	79	79	78	79	86	89	90
Number of trials	3	2	1	1	2	1	1	1	1	1
Gas bubbles (in sample)	No	No	No	No	Yes	No	Yes	No	Yes	Yes
Sediment type	Clay	X	X	X	X	X	X	X	X	X
	Silt					X				
	Sand									
	Gravel	X								
	Shellsand	X								
Reef										
Rocky bottom (cobble, boulders)										
Echinodermata, count										
Crustaceans, count										
Molluscs, count										
Polychaetes, count	>50	>40	>30	>50	>100	>100	>100	>50	>10	10
Other animals, count										
<i>Beggiatoa</i>										
Feed										
Faeces							X			
Comments										
Grab	Area [m ²]	0,025	Grab ID				K22			




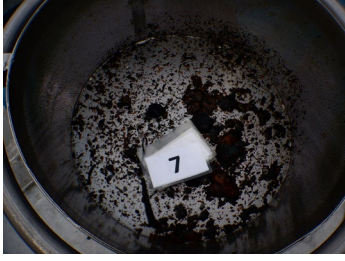






Sample scheme B.2


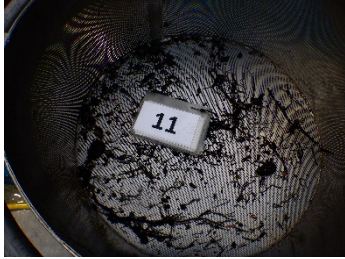






Company:	Arnarlax	Date:	12.10 2021
Site:	Steinanes ps 63543	Site no.:	0
Fieldworker:	Snorri Gunnarsson		





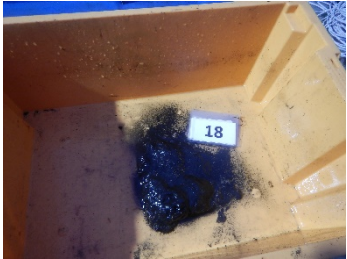
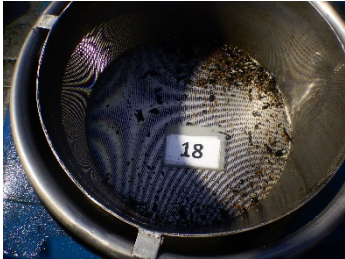
Sample number	11	12	13	14	15	16	17	18	19	20
Depth (m)	88	85	82	77	75	75	75	71	71	64
Number of trials	1	1	3	2	3	1	1	2	3	3
Gas bubbles (in sample)	No	No	No	No	No	No	Yes	No	No	No
Sediment type	Clay	X	X		X	X	X	X		
	Silt									
	Sand									
	Gravel									
	Shellsand									
Reef										
Rocky bottom (cobble, boulders)			X						X	X
Echinodermata, count										
Crustaceans, count										
Molluscs, count										
Polychaetes, count	>20	>100		>20	>50	>100	>20	>100		
Other animals, count										
<i>Beggiatoa</i>										
Feed				X						
Faeces		X		X			X			
Comments										
Grab	Area [m ²]	0,025	Grab ID				K22			
Signature fieldworker:										
page 4 of 4 pages										

7.2 Pictures of samples at Steinanes

<i>St 1</i>		
<i>St 2</i>		
<i>St 3</i>		
<i>St 4</i>		
<i>St 5</i>		

<i>St 6</i>		
<i>St 7</i>		
<i>St 8</i>		
<i>St 9</i>		
<i>St 10</i>		

<p><i>St 11</i></p>		
<p><i>St 12</i></p>		
<p><i>St 13</i></p>	<p>NA</p>	<p>NA</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>	<p>NA</p>	<p>NA</p>
<p><i>St 20</i></p>	<p>NA</p>	<p>NA</p>

7.3 Bottom topography and 3D view

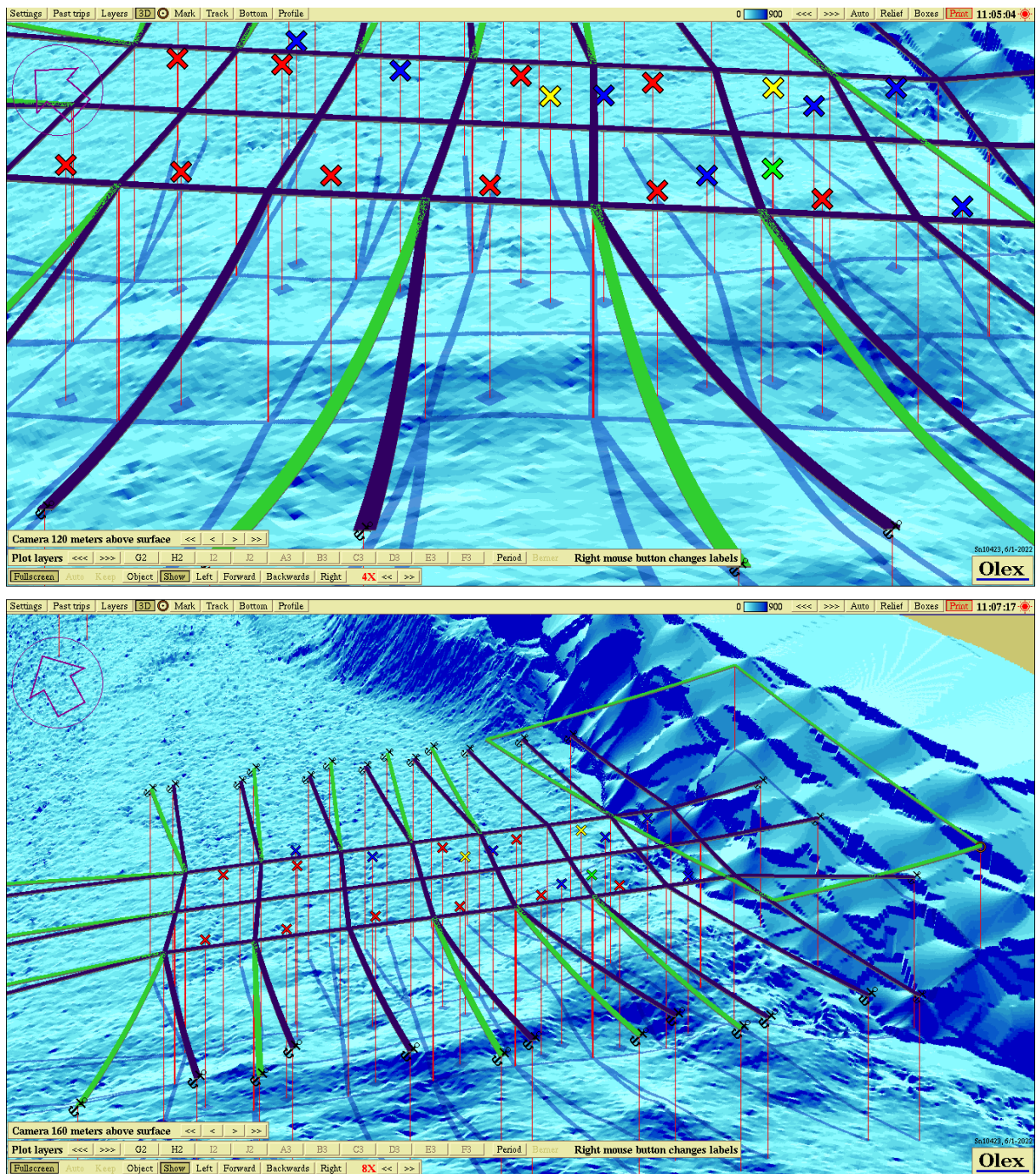


Figure 3. Showing bottom topography 3D at Steinanes with each sampling station according to info in figure 2 and Table 3.