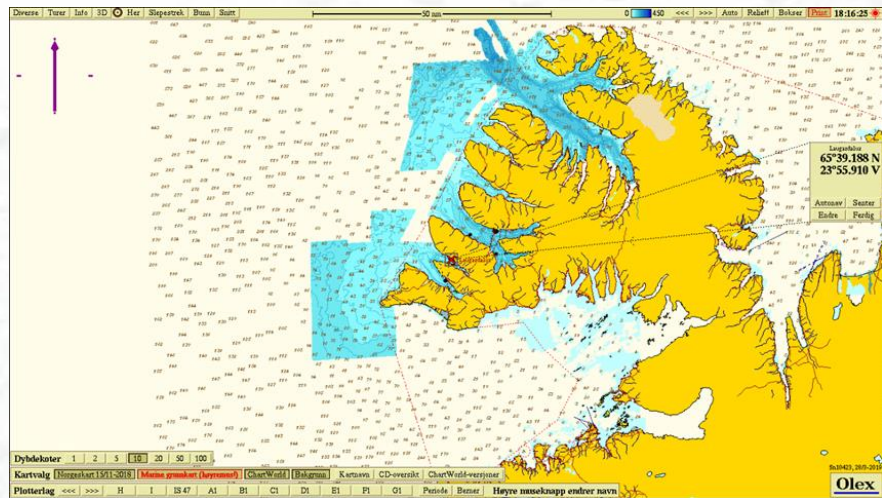



Arnarlax B-survey local impact zone, Laugardalur, May 2019 (fallow period)



Information client			
Title	Arnarlax. B-survey local impact zone, Laugardalur, May 2019 (fallow period)		
Report number	APN-60938		
Site number		Coordinates site	65°39.188 N 23°55.910 V
County		Municipality	Tálknaförður
MTB-or estimated max biomass	7.850 tonn	Site manager/contact	Rolf Ørjan Nordli
Client name	Arnarlax/Fjarðalax		

Biomass/production/status at date of survey			
Biomass at date of survey	0 ton	Feed use	0 ton
Fish type	Laks	Amount produced	Produisert\$ ton
Type/time of survey	Mark with X	Comments	
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:	(Sett tidsperiode)		

Results from B-survey iht. NS 9410:2016 (main results)			
Parameters and indexes		Parameters and site status	
Gr. II. pH/Eh	0,42	Gr. II. pH/Eh	1
Gr. III. Sensory	0,9	Gr. III. Sensory	1
GR. II + III	0,65	GR. II+ III	1
Date field work	27.05 2019	Date report	03.10.19
Site status (NS 9410:2016):			1

Report writing and project leader	Snorri Gunnarsson	Signature	
Quality control	NAVN	Signature	sign

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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 fullfills the requirements regarding bottom surveys in the standard ISO 12878.

The estimated planned max biomass for the next generation fish in Laugardalur according to information from the Arnarlax is 7.850 ton. Biomass is defined as standing biomass of live fish at any given time (either kg or ton). The estimated max biomass for the planned next farmed generation of fish demands for 20 sampling stations.

The following have participated in the survey:


Snorri Gunnarsson	Akvaplan-niva AS	Eks. Prosjektleder. Kvalitetssikring.
Snorri Gunnarsson	Akvaplan-niva AS	Eks. Feltarbeid. Kart (Olex). Rapport.

The date for sampling at the Laugardalur was done 27.05 2019.

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 their personnel for the cooperation with working on this site survey.

Kópavogi 3. oktober 2019


Snorri Gunnarsson
Project manager

1 Introduction

The sampling date for the present site survey was the 27.05 2019 and done by Akvaplan-niva AS contracted by Arnarlax in relation to the companies fish farming activity at the site Laugardalur in Tálknafjörður, Iceland.

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 is also part of fulfilling the requirements set forward in Vöktunaráætlun for the company.

The survey gives an estimate and evaluation of the site condition with regard to organic load and suitability assessment of the site for fish farming activity.

Figure 1 shows map of the fjord system Vesfirðir including the fjord Tálknafjörður where the site Laugardalur is placed.

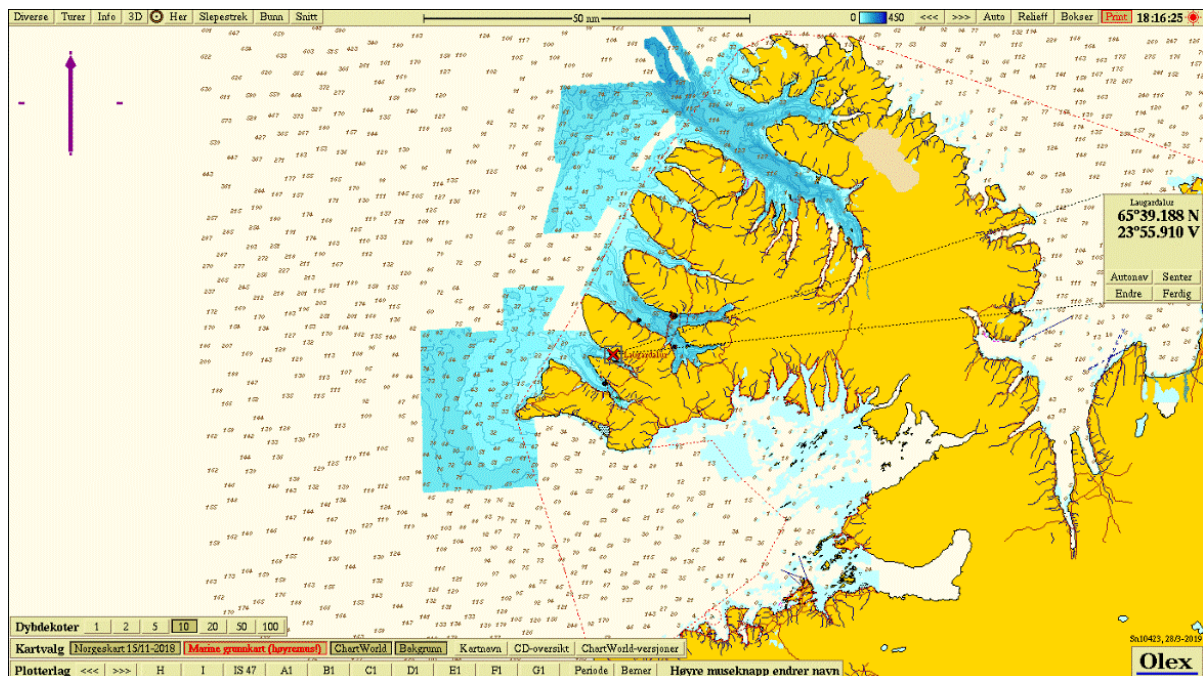


Figure 1. An overview map with the Laugardalur site marked by its name and a red cross.

2 Professional program and 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 is in Iceland based on description in the ISO 12878 standard and we also follow the methodology described in the NS 9410:2016. The Icelandic 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. The frequency of B-surveys in the local impact zone according to site condition with reference to NS 9410:2016 *this standard is not required by Icelandic law.*

Site condition at the time of sampling	Overvåkingsfrekvens for B-undersøkelse (NS 9410:2016)
1-very good	At next max biomass
2-good	Prior to putting nex generation into sea and again at next max biomass.
3-bad	Prior to putting next generataion 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 halv max biomass and at max biomass- Condition 3 – next site survey at next halv 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 (0,025 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

3 Site description and bottom topography

3.1 Info site operation

The present survey was done during fallow period that started 18.09 2018 (8 months resting period). The planned next generation at the site after the present fallow period will be the fourth generation farmed at the site Laugardalur. The installed fish farm at the site is a single frame mooring system with 2 x 6 cages with either 160 or 120 m circumference. The planned timing for putting the next generation smolts into sea is June 2019.

Table 2 shows the production and feed usage past three generations.

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

Generation of fish (G)	Production (ton)	Feed usage (ton)
Present generation	0	0
Past generation 1	4.498	8.107
Past generation 2	2.836	3.406
Past generation 3	734	959

3.2 Present and past site surveys

There are results from two previous B surveys at the site Laugardalur. The fish farm for the first generation (2010 – 2012) at Laugardalur site was placed somewhat further into the fjord about 1 km south-east from the current location. There was not conducted a B-survey relate to this first generation fish but Þórisson et al. 2012 reported results from a bottom fauna survey with samples taken before putting fish into sea and again at time of slaughter. The site for the second generation of fish at Laugardalur (2013 – 2014) was located at the same place as the current site is located. No B examination was carried out related to this but Þórisson et al. 2015 reported results from the bottom fauna survey with samples taken both in the local impact zone and in the transect zone. For the third-generation fish at the site that was put into sea in 2017 there was done a B-survey subsequent with max. biomass (Gunnarsson, 2019). Table 3 shows the dates and results from previous B-surveys for the site.

Table 3. Previous B-surveys from the site Laugardalur.

Dato prøvetaking	Rapportnummer	Type undersøkelse	Lokalitetstilstand
03.11 2017	APN 9207.01 (2019)	Max, biomass	1

3.3 Dispersing current

For the site Laugardalur dominating dispersing current (42 m) is in direction north-vest (315 degrees) with a counter current against south-east (120 degrees). Average current speed is measured to be 4.2 cm/s. Highest current speed is measured to be 21.2 cm/s and 8.2 % of the measurements are < 1 cm/s (Heggem, 2019).

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 upon bottom topography and configuration of the farm. The farming company has informed that all cages were used at some point during rearing of the last generation fish at the site. Bottom topography is a gentle slope from shore to south westerly direction with depths from around 32 m closest to land and to about 53 m at it's deepest. Location of stations were set to best map the entire local impact zone. It is important to cover the local impact zone both for the deeper and shallower areas of the fish farming site within its configuration. The sampling stations were placed at a depth that varied from 51 meters where deepest down to 34 meters where shallowest. The placement of sampling stations is considered representative for a survey of the local impact zone according to ddescription in NS 9410:2016.

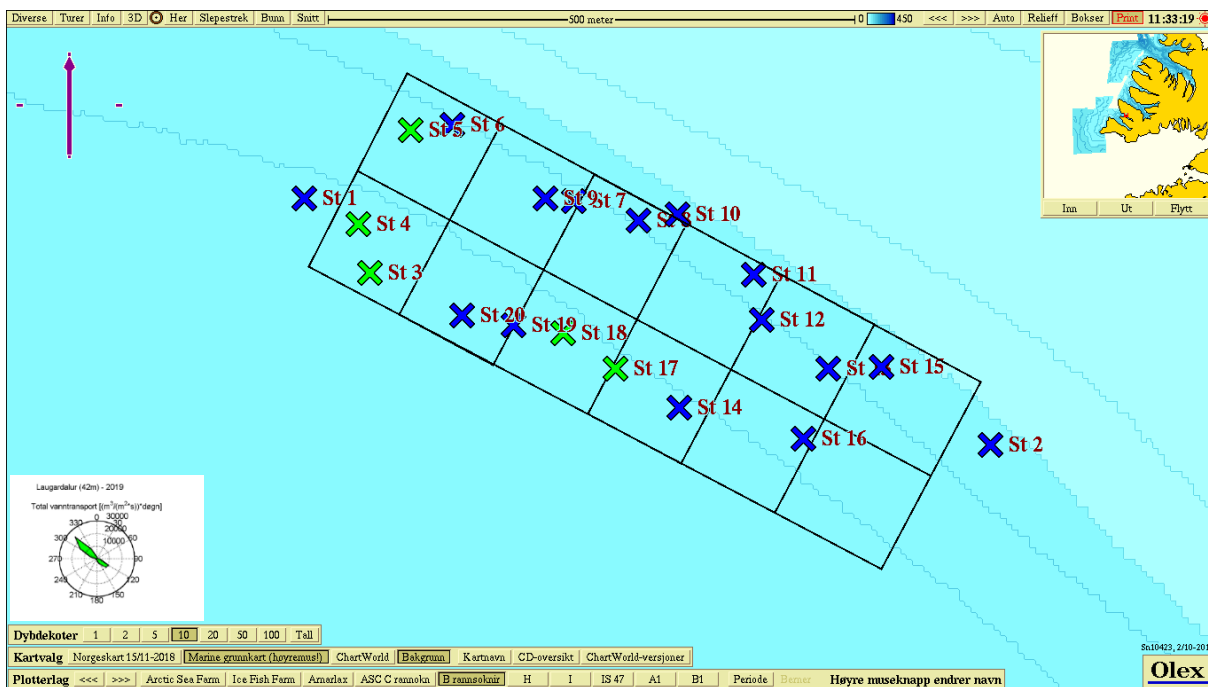


Figure 2. Chart showing depths at the site Laugardalur. Sampling stations St. 1 – 20 are marked with color codes that describe the condition according to NS 9410:2016, chapter 7.11. Color codes: Blue = very good condition, green = good condition, yellow = bad condition, red = very bad condition. (Current rose from Heggem, 2019)

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

Station number	North	Vest	Depth (m)
St 1	65°39,251	23°56,307	51
St 2	65°39,125	23°55,454	34
St 3	65°39,213	23°56,225	51
St 4	65°39,238	23°56,230	51
St 5	65°39,286	23°56,175	44
St 6	65°39,289	23°56,123	41
St 7	65°39,250	23°55,972	42
St 8	65°39,240	23°55,891	39
St 9	65°39,251	23°56,007	43
St 10	65°39,243	23°55,848	34
St 11	65°39,212	23°55,748	34
St 12	65°39,189	23°55,738	41
St 13	65°39,164	23°55,656	41
St 14	65°39,144	23°55,841	36
St 15	65°39,165	23°55,589	35
St 16	65°39,128	23°55,687	48
St 17	65°39,164	23°55,920	51
St 18	65°39,182	23°55,985	51
St 19	65°39,186	23°56,047	51
St 20	65°39,191	23°56,111	51

4 Results

Results for the different parameters are given in Table 5. A complete filled samples sheet with calculations for each parameter is attached in appendix.

Table 5. Results from the classifications of different stations in the local impact zone of the fish farm.

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

There were collected valid sediment samples at all stations. Samples were collected in the first grab taken in 15 stations out of 20 and in most instances were 2 or more trials were needed this was due to strong currents at the site and the grab came down slightly sideways. This indicates that in general there is soft bottom in the whole local impact zone and typical sediment type was a mixture of clay and sand. For the group I and II parameters 17 stations had condition 1 «very good», 2 stations had condition «good» and at one station there was not enough sediment to measure pH/Eh. For sensory parameters (group III) twelve stations had condition 1 «very good» and eight stations had condition 2 «very good». For combined parameters I, II and III (animals, pH/redox and sensory) 16 stations had condition 1 «very good» and 4 stations had condition 2 «good». Animals were present in 18 out of the 20 samples. The overall condition for the site is 2 «very good».

5 Conclusion

Based on the criteria given in NS 9410:2016 the fish farming site has been assigned a site condition 1 «Very good» at the date of sampling. A total of 26 samples were taken with Van Veen grab (0,025 m²), divided on 20 stations placed around the twelve installed cages at the site. For combined parameters I, II and III (animals, pH/redox and sensory) 16 stations had condition 1 «very good» and 4 stations had condition 2 « good».

Dominating dispersing current (42 m) is in direction north-vest (315 degrees) with a counter current to south-east. Average current speed is measured to be 4.2 cm/s. Highest current speed is measured to be 21.2 cm/s and 8.2 % of the measurements are < 1 cm/s.

From an environmental standpoint and according to the methodology applied we report relatively low levels of organic load at the site but the stations with overall condition 2 were mostly situated at the west part of the site and in the outer row. This area is at the food of the decent area where most organic material is precipitating due to direction of spread current and this is the deepest part under the site. In a previous B-survey taken at the time of maximal biomass (Gunnarsson, 2019) the Laugardalur site site was assigned an overall condition 1 «Very good». However in the previous B-survey there was more organic load evident and the environmental condition of the site has therefore improved since the previous B-survey. The next B-survey for Laugardalur site will be at next max biomass. The results from that survey can be matched and used to evaluate the trend for organic load at the site.

Planned time for putting next batch of smolt into sea will be in June 2019.

Based on evaluation from the findings in this and the change in environmental condition since previous B-survey, bottom topography and the measured current on the site indicates that the planned timeframe for a resting period has been favorable.

The site is assigned a condition factor 1 "Very good" 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., 2019. Fjarðalax hf, B-undersøkelse, Laugardalur, (undersøkelse ved maksimal belastning). APN rapport nr. 9207.01. 10 s.

Heggem, T., 2019. Arnarlax hf. Strømmålinger Laugardalur. Spredningsstrøm 42 m. APN report 61178.01. 10 s.

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

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

Þórisson, B., Gallo, C. og Eiríksson, Þ. 2012. Athuganir 2010, 2011 og 2012 á áhrifum laxeldis í sjókvíum í Tálknafirði á botndýralíf. Unnið fyrir Fjarðalax. NV nr. 6-12. 12 s.

Þórisson, B., Gallo, C. og Jóhannesdóttir, E.D. 2015. Vöktun á botndýralífi við fiskeldiskvíar út af Laugardal í Tálknafirði 2013-2014. Unnið fyrir Fjarðalax. NV nr. 10-15. 18 s.

www.fiskeridir.no

7 Appendix:

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

Sample scheme B.1													
Company		Amarlax											
Site:		Laugardalur											
Fieldworker:		Sveinn Gunnarsson											
Date:		27.05.2019											
Site no.:													
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	Presence of items		0	0	1	0	0	0	0	0	0	0	
II	pH	value	7,8	7,0	7,5	7,3	8,2	8,7	7,7	7,8	7,8	7,9	
	Eh (mV)	CRP	137	78	-248	-198	-215	28	-112	-3	-58	-38	
		plus ref. vend	337	276	-40	2	-15	276	89	197	147	170	
	pHEh	from figure	8	0	1	2	1	0	1	0	8	8	
Status station			1	1	1	2	1	1	1	1	1	1	
pH ref.			6,11	ORP ref.		75,0 mV	Eh ref.		275,0 mV	Reference electrode			290,0 mV
III	Gas bubbles		Yes (4) No (0)	0	0	0	0	0	0	0	0	0	
	Colour	Lightness (0)	0	0			0	0	0	0	0	0	
		Brown/black (2)		2	2	2							
	Smell	None (0)	0	0				0	0	0	0	0	
		Light (2)			2	2	2						
		Strong (4)											
	Consistency	Solid (0)	0	0				0				1	
		Soft (2)			2	2	2		2	2	2		
		Aqueous (0)											
	Grab volume (0)	v < 1/4 (0)										0	0
		1/8 < v < 3/8 (1)		1	1	1	1	1	1	1			
		v > 3/4 (2)	2										
	Thickness of sedge (0)	1 < 2 cm (3)	0	0	0	0	0	0	0	0	0	0	
2 < 1 < 5 cm (1)													
1 > 8 cm (2)													
Sieve			2,8	3,0	7,0	7,0	5,0	1,0	3,0	3,0	2,0	1,0	
Corrected (% 22)			3,4	0,7	1,5	1,5	5,1	0,2	0,7	0,7	0,4	0,2	
Status station			1	1	2	2	2	1	1	1	1	1	
Average group II & III			3,3	0,3	1,3	1,6	5,1	0,5	0,8	0,3	0,2	0,1	
Status station			1	1	2	2	1	1	1	1	1	1	
Grid ID		K-22											
pH/Eh ID		YES-Professional plus											

Sample scheme B.1

Company:	Arnarlax
Site:	Laugardalur
Fieldworker:	Snorri Gunnarsson

Date:	27.05 2019
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	1	0	0	0	0	0		
---	---------------	----------------	---	---	---	---	---	---	---	---	---	---	--	--

II	pH	value	7,5	7,3	7,6	ut	7,5	7,5	7,5	7,2	7,3	7,7		
	Eh (mV)	ORP	-27	-52	-10	ut	-56	-5	-112	-280	-82	-40		
		plus ref. verdi	173	148	190		144	195	88	-80	118	160		
	pH/Eh	from figure	0	0	0	ut	0	0	1	2	0	0	0,42	

Status station	1	1	1	ut	1	1	1	2	1	1		
----------------	---	---	---	----	---	---	---	---	---	---	--	--

Status group II	1	Buffer temp	5,0 C	Sea temp	8,7 C	seawater temp	4,3 C
-----------------	---	-------------	-------	----------	-------	---------------	-------

pH sea	8,11	ORP sea	75 mV	Eh sea	275 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	0		
		Brown/black (2)					2		2	2	2				
	Smell	None (0)	0	0	0	0								0	
		Light (2)					2	2	2	2	2				
		Strong (4)													
	Consistency	Solid (0)				0									
		Soft (2)	2	2	2		2	2	2	2	2	2	2		
		Aqueous (4)													
	Grab volume (v)	v < 1/4 (0)	0	0		0									
		1/4 < v < 3/4 (1)			1							1			
		v > 3/4 (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		2,0	2,0	3,0	0,0	8,0	6,0	8,0	8,0	7,0	4,0			
	Corrected (*0,22)		0,4	0,4	0,7	0,0	1,8	1,3	1,8	1,8	1,5	0,9	0,90		

Status station	1	1	1	1	2	2	2	2	2	2	1	
----------------	---	---	---	---	---	---	---	---	---	---	---	--

Status group III	1
------------------	---

Average group II & III	0,2	0,2	0,3	0,0	0,9	0,7	1,4	1,9	0,8	0,4	0,65
------------------------	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	------

Status station	1	1	1	1	1	1	2	2	1	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	K-22
pH / Eh ID	YSI-Professional plus


Sample scheme B.2











Company:	Arealax
Site:	Laugardalur
Fieldworker:	Snorri Gunnarsson

Date:	27.05.2019
Site no.:	0



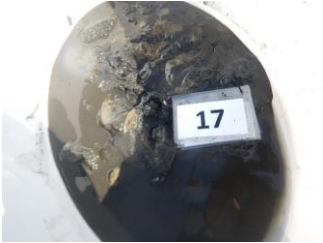

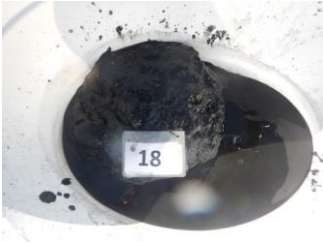



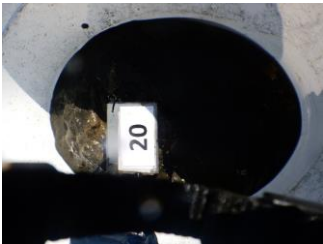

Sample number	11	12	13	14	15	16	17	18	19	20
Depth (m)	34	41	41	36	35	48	51	51	51	51
Number of trials	1	1	1	3	1	1	1	1	2	1
Gas bubbles (in sample)	No	No	No	No	No	No	No	No	No	No
Sediment type	Clay	X	X	X	X	X	X	X	X	X
	Silt									
	Sand	X	X	X	X	X	X	X	X	X
	Gravel									
	Shell sand									
Reef										
Rocky bottom (cobbles, boulders)										
Echinodermata, count										
Crustaceans, count										
Mollusca, count	2		1							3
Polychaetes, count	2	15	>15	>5		>5	>10	3	3	>20
Other animals, count										
Beggiator										
Feed										
Faeces										
Comments										
Grab	Area [m ²]	0,025			Grab ID	R-22				
Signature fieldworker:										

7.2 Pictures of samples at Laugardalur

<p><i>St 1</i></p>		
<p><i>St 2</i></p>		<p>NA</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>		

<i>St 11</i>		
<i>St 12</i>		
<i>St 13</i>		
<i>St 14</i>		
<i>St 15</i>		

<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><i>St 20</i></p>		

7.3 Bottom topography and 3D view

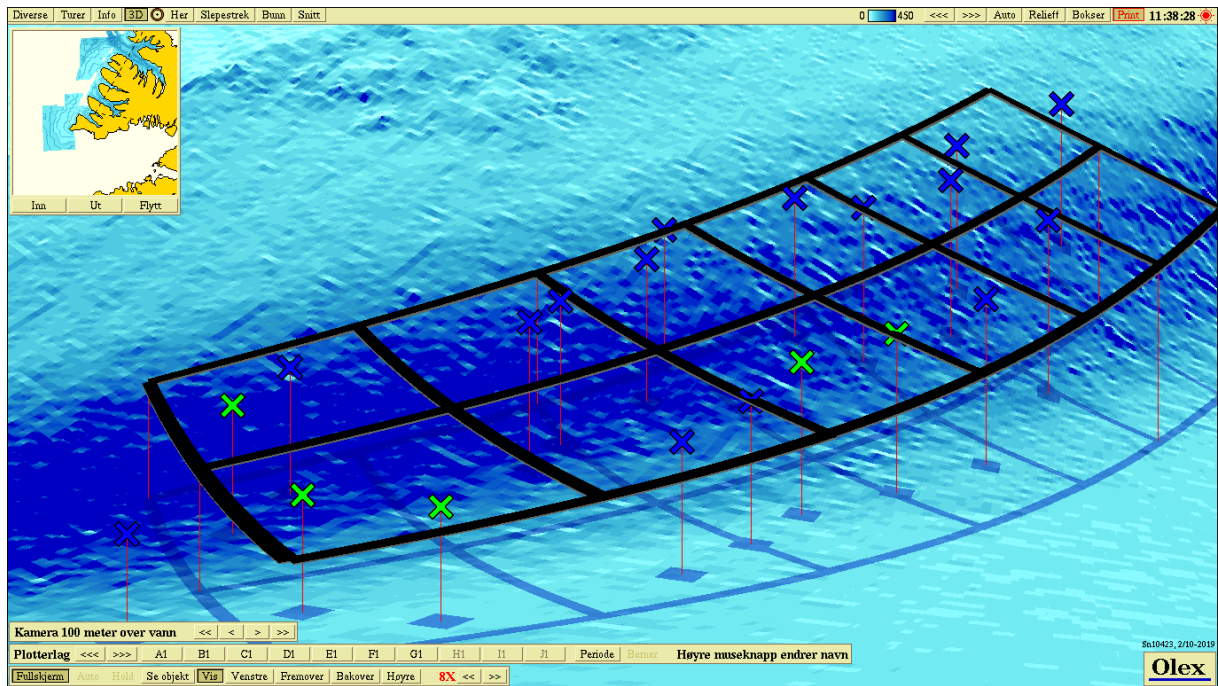


Figure 3. Showing bottom topography 3D at Laugardalur with each station numbered according to info in figure 2 and Table 4.