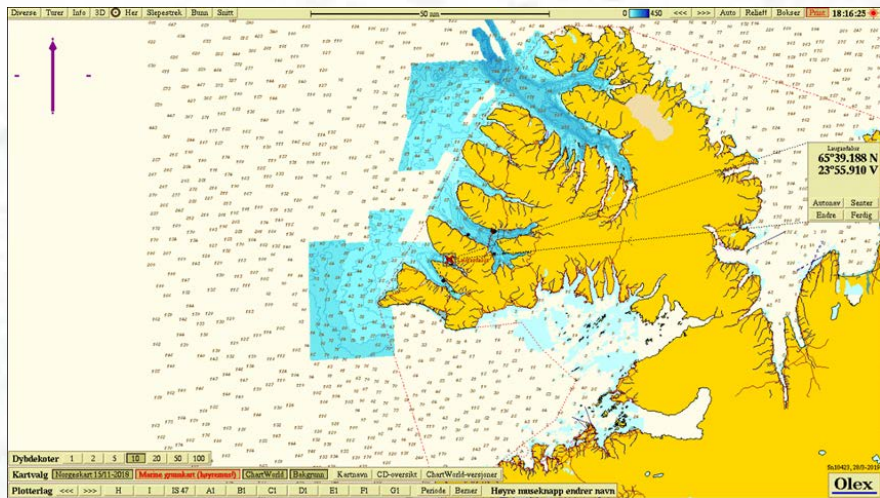




## Arnarlax B-survey local impact zone, Laugardalur, March 2021 (Max biomass)



Information client			
Title	Arnarlax. B-survey local impact zone, Laugardalur, March 2021 (max biomass)		
Report number	APN-62334.B01		
Site number		Coordinates site	65°39.188 N 23°55.910 V
County		Municipality	Tálknafjörður
MTB-or estimated max biomass	6.234 tonn	Site manager/contact	Jónas Snæbjörnsson
Client name	Arnarlax/Fjarðalax		

Biomass/production/status at date of survey			
Biomass at date of survey	6.151 ton	Feed use	7.706 ton
Fish type	Salmon	Amount produced	6.943 ton
<b>Type/time of survey</b>	<b>Mark with X</b>	<b>Comments</b>	
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:	(Sett tidsperiode)		

Results from B-survey iht. NS 9410:2016 (main results)			
Parameters and indexes		Parameters and site status	
Gr. II. pH/Eh	0,67	Gr. II. pH/Eh	1
Gr. III. Sensory	0,89	Gr. III. Sensory	1
GR. II + III	0,78	GR. II+ III	1
Date field work	25.03 2021	Date report	04.05 2021
<b>Site status (NS 9410:2016):</b>			<b>1</b>

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

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# Preface

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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 6.234 ton. Biomass is defined as standing biomass of live fish at any given time (either kg or ton). The estimated max biomass for the present farmed generation of fish demands for 18 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 25.03 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.
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Akvaplan-niva AS thanks Arnarlax their personnel for the cooperation with working on this site survey.

Kópavogi 5. mai 2021

  
Snorri Gunnarsson  
Project manager



# 1 Introduction

The sampling date for the present site survey was the 25.03 2021 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 Vestfirðir including the fjord Tálknafjörður where the site Laugardalur is placed.

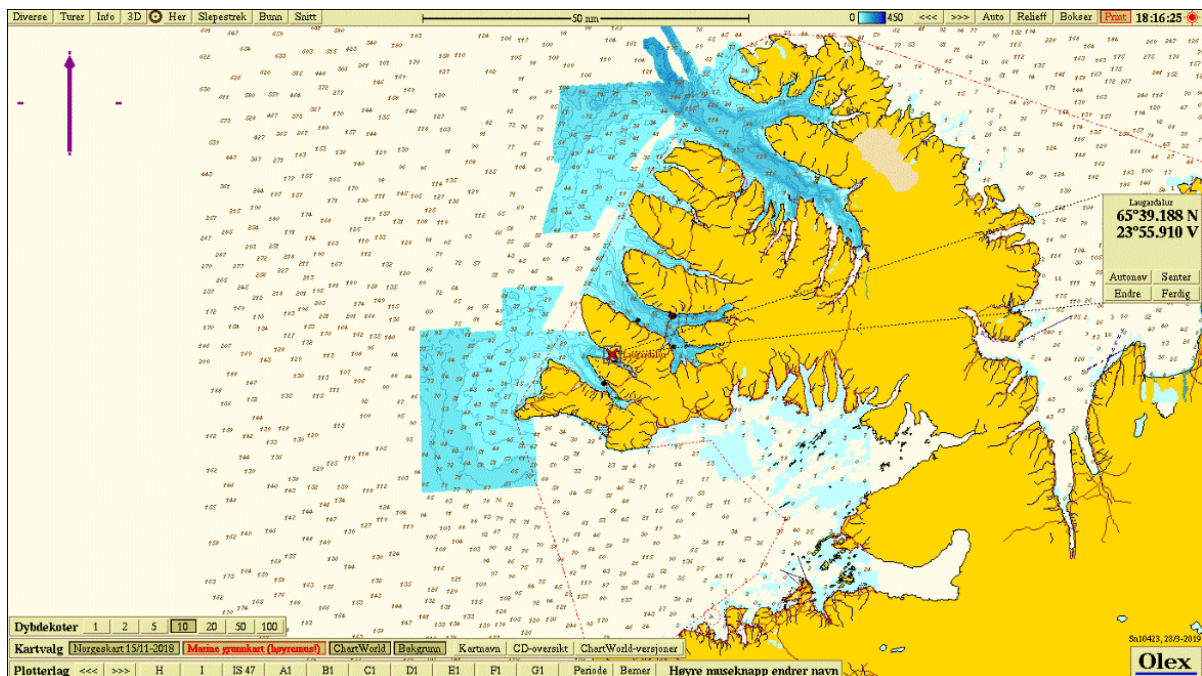


Figure 1. An overview map with the Laugardalur site marked by its name and a red cross.

## 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 cm<sup>2</sup>). 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"><li>- Condition 1 – next site survey at next max biomass</li><li>- Condition 2 – next site survey at next halv max biomass and at max biomass</li><li>- 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</li></ul> 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 m<sup>2</sup>)

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

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### 3.1 Info site operation

The Laugardalur site is currently holding its fourth generation fish and the present generation is close to max biomass. The first generation was farmed at slightly different location within the fish farming are some further out in the fjord. The current generation was put into sea summer 2019. The installed fish farm at the site is a single frame mooring system with 2 x 7 cages with 160 m circumference. During the present production cycle all 14 cages have been used (Nikolas Tzamouranis, pers. info).

Table 2 shows the production and feed usage past three, and the fourth generation to date.

*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 4	6.943	7.706
Past generation 3	4.498	8.107
Past generation 2	2.836	3.406
Past generation 1	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 related 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 second batch of fish 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, 2019a) and at fallow prior to putting the current generation into sea (Gunnarsson, 2019b) 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	Max, biomass	1
27.05 2019	APN B 60938	Fallow period	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 30 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.

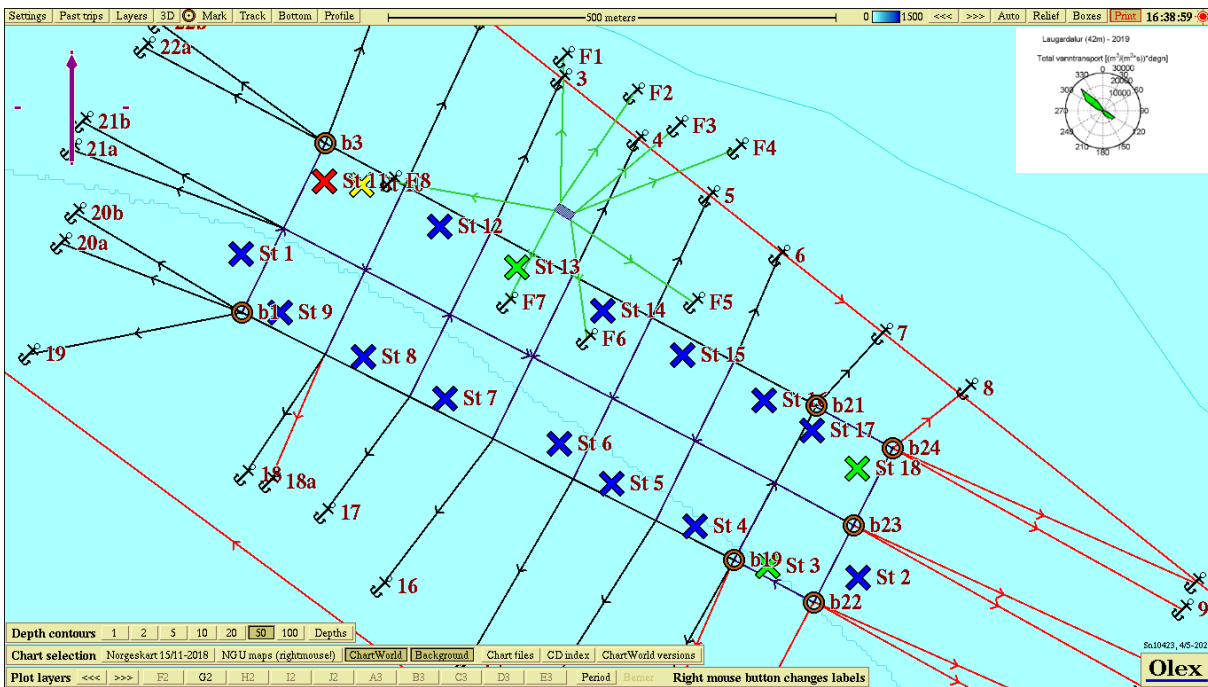


Figure 2. Chart showing depths at the site Laugardalur. Sampling stations St. 1 – 18 are marked with color codes that describe the condition according to NS 9410:2016, chapter 7.11. Color codes: Blue = very good condition, green = good condition, yellow = bad condition, red = very bad condition. (Current 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°39,248	23°55,298	51
St 2	65°39,053	23°55,396	46
St 3	65°39,060	23°55,528	50
St 4	65°39,084	23°55,635	51
St 5	65°39,109	23°55,756	51
St 6	65°39,134	23°55,883	51
St 7	65°39,161	23°56,000	51
St 8	65°39,186	23°56,120	51
St 9	65°39,213	23°56,241	51
St 10	65°39,290	23°56,122	41
St 11	65°39,292	23°56,176	43
St 12	65°39,265	23°56,008	42
St 13	65°39,240	23°55,895	40
St 14	65°39,214	23°55,769	36
St 15	65°39,187	23°55,653	34
St 16	65°39,160	23°55,534	32
St 17	65°39,142	23°55,463	30
St 18	65°39,119	23°55,398	31

## 4 Results

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Results for the different parameters are given in Table 5. A complete filled samples sheet with calculations for each parameter is attached in appendix. The overall site condition is 1 «very good». The status for group II (pH/Eh) was 1 «very good», status group III parameters (sensory) was 1 «very good» and average group II + III parameters is status 1 «very good».

*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 (middelveidi)	1
Site condition	1

There were collected valid sediment samples at 17 out of the total 18 stations. Samples were collected in the first grab taken in 16 stations, one station required 2 grabs and in station it was not possible to collect sediment sample so it was defined as hard bottom station (st. 17). 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 II parameters (pH/Eh), fifteen stations had conditions 1 «very good», one station had condition 2 «good», one station had condition 3 «bad» and one station had condition 4 «very bad». For sensory parameters (group III) ten stations had condition 1 «very good», seven stations had condition 2 «very good» and one station had condition 4 «very bad». For combined group II and III parameters (pH/Eh and sensory), 13 stations had condition 1 «very good», 3 stations had condition «good», one station had condition 3 «bad» and one station had condition 4 «very bad» and at that station (st. 11) gas was detected in the sample. Animals were present in 16 out of the 17 samples. The overall condition for the site is 1 «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 21 grabs were taken with Van Veen grab (0,025 m<sup>2</sup>), divided on 18 stations placed around the fourteen installed cages at the site. For combined parameters II and III (pH/redox and sensory) 13 stations had condition 1 «very good», 3 stations had condition «good», one station had condition 3 «bad» and one station had condition 4 «very bad».

Dominating dispersing current (42 m) is in direction north-west (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 as a whole but at the north-west corner of the site coherent with the direction of dispersing current there was some evidence of high organic load. In a previous B-survey taken at the time of maximal biomass (Gunnarsson, 2019a) the Laugardalur site was assigned an overall condition 1 «Very good» and low level of organic load but the stations with reduced conditions were also then mainly at the western part of the site. At the last B-survey at fallow period (Gunnarsson, 2019b) the resting period resulted in a improved status at the site. The current results show that overall the environmental status of the Laugardalur site between the max-biomass survey in 2017 and the current survey is similar so neither trending for worse or for better.

**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., 2019a. Fjarðalax hf, B-undersøkelse, Laugardalur, (undersøkelse ved maksimal belastning). APN rapport nr. 9207.01. 10 s.

Gunnarsson, S., 2019b. Arnarlax, B-survey local impact zone, Laugardalur, May 2019 (fallow period). APN B rapport nr. 60938. 21 s.

Heggen, 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](http://www.fiskeridir.no)

# 7 Appendix:

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

Sample scheme B.1															
Company		Arnarlax													
Site:		Laugardalur													
Fieldworker:		Snorri Gunnarsson													
Date:		25.03 2021													
Site no.:															
Gr	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			
I	Animals > 1mm	Yes (0) No (1)	0	0	0	0	0	0	0	0	0	0			
II	pH	value	7,7	7,5	7,2	7,6	7,7	7,7	7,7	7,6	7,6	6,9			
	Eh (mV)	ORP	72	-43	-255	-24	10	32	35	108	-59	-230			
		plus ref. verdi	272	157	-55	176	210	232	235	308	141	-30			
	pH/Eh	from figure	0	0	2	0	0	0	0	0	0	3			
	Status station			1	1	2	1	1	1	1	1	1	3		
	Buffer-temp			5,0 C			Sea temp			1,6 C		Sediment temp		NA C	
	pH sea		7,95	ORP sea			201,0 mV			Eh sea		401,0 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	0						
			Brown/black (2)			2					2	2	2		
Smell		None (0)		0		0	0	0							
		Light (2)	2							2	2	2			
Consistency		Strong (4)			4										
		Solid (0)	0	0	0	0	0	0	0	0	0	0			
		Soft (2)													
Grab volume (v)		Aqueous (4)													
		v < 1/4 (0)													
	1/4 < v < 3/4 (1)		1	1	1	1	1	1	1	1	1				
Thickness of sledge (t)	v > 3/4 (2)	2													
	t < 2 cm (0)	0	0		0	0	0	0	0	0					
	2 < t < 8 cm (1)			1							1				
Sum			4,0	1,0	8,0	1,0	1,0	1,0	1,0	5,0	5,0	6,0			
Corrected (**0,22)			0,9	0,2	1,8	0,2	0,2	0,2	0,2	1,1	1,1	1,3			
Status station			1	1	2	1	1	1	1	2	2	2			
Average group II & III			0,4	0,1	1,9	0,1	0,1	0,1	0,1	0,6	0,6	2,2			
Status station			1	1	2	1	1	1	1	1	1	3			
Grab ID	K-22														
pH/ Eh ID	YSI-professional plus														

## Sample scheme B.1

Company:	Arnarlax
Site:	Laugardalur
Fieldworker:	Snorri Gunnarsson

Date:	25.03 2021
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	H	S									94	6	
I	Animals > 1mm	Yes (0) No (1)	1	0	0	0	0	0		0											
II	pH	value	5,7	7,8	7,6	7,6	7,6	7,6		7,5											
	Eh (mV)	ORP	-210	-60	-138	-80	-54	-55			-130										
		plus ref. verdi	-10	140	62	120	146	145			70										
	pH/Eh	from figure	5	0	1	0	0	0	0	0	1										0,67
	Status station			4	1	1	1	1	1	1	1										
	Status group II			1	Buffer temp	5,0 C		Sea temp	1,6 C		Sediment temp	NA C									
	pH sea		7,95	ORP sea		201 mV		Eh sea		401 mV		Reference electrode		200 mV							
	III	Gas bubbles	Yes (4) No (0)	4	0	0	0	0	0	0	0	0									
	Colour	Light/grey (0)									0										
		Brown/black (2)		2	2	2	2	2	2		2										
Smell	None (0)			0				0	0	0											
	Light (2)				2	2							2								
	Strong (4)		4																		
Consistency	Solid (0)			0				0	0	0											
	Soft (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																		
	v > 3/4 (2)																				
Thickness of sledge (t)	t < 2 cm (0)			0	0	0	0	0	0	0											
	2 < t < 8 cm (1)		1																		
	t > 8 cm (2)																				
Sum			16,0	2,0	6,0	6,0	2,0	2,0	0,0	6,0											
Corrected (*0,22)			3,5	0,4	1,3	1,3	0,4	0,4	0,0	1,3										0,89	
Status station			4	1	2	2	1	1	1	2											
Status group III			1																		
Average group II & III			4,3	0,2	1,2	0,7	0,2	0,2	0,0	1,2										0,78	
Status station			4	1	2	1	1	1	1	2											
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:	Arnarlax
Site:	Laugardalur
Fieldworker:	Snorri Gunnarsson


Date:	25.03 2021
Site no.:	0

Sample number	1	2	3	4	5	6	7	8	9	10
Depth (m)										
Number of trials	1	1	1	2	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	X	X	X		X				X
	Gravel									
	Shellsand									
Reef										
Rocky bottom (cobble, boulders)										
Echinodermata, count										
Crustaceans, count										
Molluscs, count										
Polychaetes, count	>50	>100	3	>100	>100	>100	>50	>40	>50	2
Other animals, count										
<i>Beggiatoa</i>										
Feed										
Faeces			Yes							
Comments										
Grab	Area [m <sup>2</sup> ]	0,025			Grab ID	K-22				




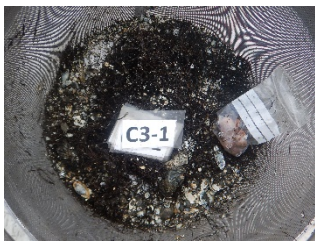




## Sample scheme B.2

Company:	Arnarlax
Site:	Laugardalur
Fieldworker:	Snorri Gunnarsson










Date:	25.03 2021
Site no.:	0

Sample number	11	12	13	14	15	16	17	18	19	20
Depth (m)										
Number of trials	1	1	1	1	1	1	3	1		
Gas bubbles (in sample)	Yes	No	No	No	No	No		No		
Sediment type	Clay	X	X	X	X	X	X		X	
	Silt									
	Sand		X	X	X	X	X		X	
	Gravel									
	Shellsand									
Reef										
Rocky bottom (cobble, boulders)										
Echinodermata, count										
Crustaceans, count										
Molluscs, count										
Polychaetes, count		>50	>50	>10	>5	7		>10		
Other animals, count										
<i>Beggiatoa</i>										
Feed										
Faeces										
Comments										
Grab	Area [m <sup>2</sup> ]	0,025		Grab ID	K-22					
Signature fieldworker:									page 4 of 4 pages	

## 7.2 Pictures of samples at Laugardalur

<i>St 1</i>	 A white tray containing a dark, granular sample. A small white label with the text "C1-1" is placed on the tray.	 A petri dish containing a dark, granular sample. A small white label with the text "C1-1" is placed in the center of the dish.
<i>St 2</i>	 A white tray containing a dark, granular sample. A small white label with the text "C3-1" is placed on the tray.	 A petri dish containing a dark, granular sample. A small white label with the text "C3-1" is placed in the center of the dish.
<i>St 3</i>	 A white tray containing a dark, granular sample. A small white label with the text "3" is placed on the tray.	 A petri dish containing a dark, granular sample. A small white label with the text "3" is placed in the center of the dish.
<i>St 4</i>	 A white tray containing a dark, granular sample. A small white label with the text "4" is placed on the tray.	 A petri dish containing a dark, granular sample. A small white label with the text "4" is placed in the center of the dish.

<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>NA</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>NA</p>	<p>NA</p>
<p><i>St 18</i></p>		



### 7.3 Bottom topography and 3D view

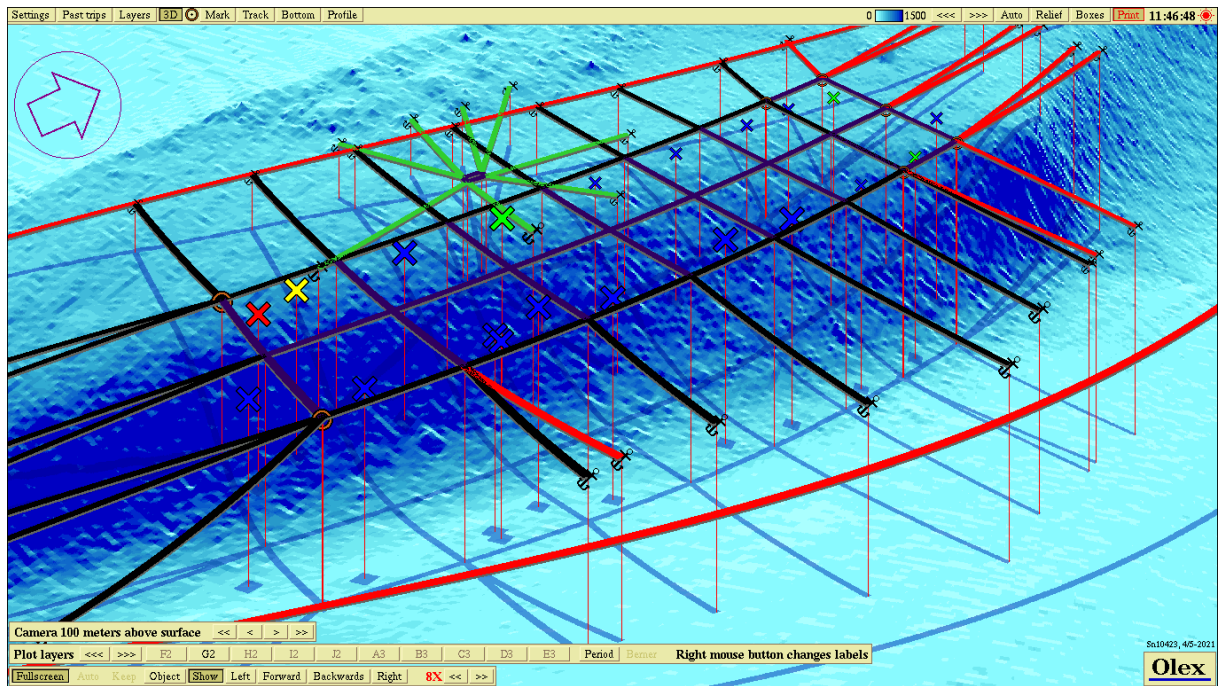


Figure 3. Showing bottom topography 3D at Laugardalur with placement of the 18 sampling stations see also info in figure 2 and Table 4.