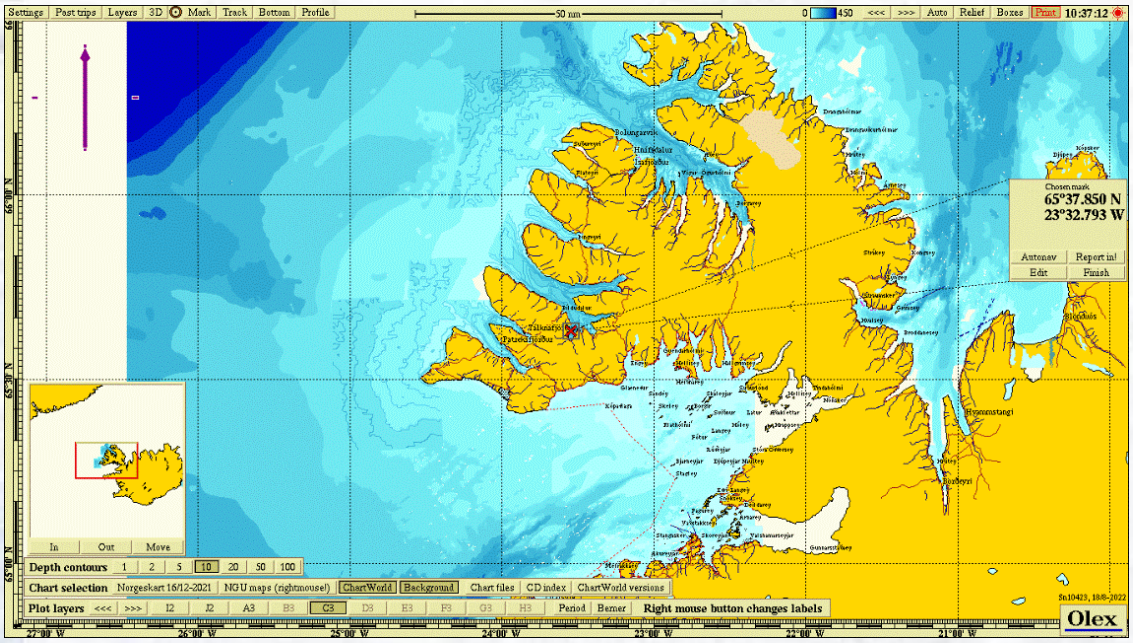
Akvaplan niva

Rapport Report

Fossförður, Arnarlax
B survey,
June 2022
(max biomass)



NORSK
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Akvaplan-niva AS
Rådgivning og forskning innen miljø og akvakultur
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Information client			
Title	Fossfjörður, Arnarlax. B survey (max biomass, June 2022		
Report number	APN-64107.B01		
Site name	Fossfjörður	Coordinates site	65°37,850N 023°32,793V
County	Vesturbyggð	Municipality	Vesturbyggð
MTB-or estimated max biomass	2.182 tonnes	Site manager/contact	Silja Baldvinsdóttir
Client name	Arnarlax		

Biomass/production/status at date of survey			
Biomass at date of survey	2.182 t	Feed use	2.209 t
Fish type	Salmon	Amount produced	2.712 t

Type/time of survey	Mark with X	Comments
At maximal biomass see kap 7.9	☒	The farm has been expanded and moved since the farming previous generations.
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	2,27	Gr. II. pH/Eh	3
Gr. III. Sensory	1,36	Gr. III. Sensory	2
GR. II + III	1,82	GR. II+ III	2
Date fieldwork	22.06 2022	**Date report**	11.10.22
Site status (NS 9410:2016):			**2**

Report writing and project leader	Snorri Gunnarsson	Signature	
Quality control	Steinar D Eriksen	Signature	

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Preface

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

The primary objective of a B-survey is to assess the benthic impact beneath and in the close vicinity (near zone) of a marine fish farm by applying methods, thresholds and classifications as defined in NS9410:2016. The current survey was undertaken during the period at max biomass for current generation farmed fish. Prior to putting out current generation at the site the farm was expanded and moved within the defined farming area. Sampling stations in this survey are placed within the near zone of the current farm location. Fossfjörður has an estimated max biomass of 2.182 t and thus a total of 11 stations were sampled.

The following have participated in the survey:

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

The sampling at Fossfjörður was done 22.06 2022.

Accredited survey:

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

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

NORSK AKKREDITERING TEST 079	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.

Kópavogi 11. October 2022

Snorri Gunnarsson
Project manager

1 Introduction

Sampling was undertaken on 22.06.2022 by Akvaplan-niva AS, who has been contracted by Arnarlax in relation to the company's fish farming activity at the site Fossfjörður in Arnarfjörður, Vesturbyggð municipality.

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

The here presented survey was undertaken 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. The current generation farmed fish is the first at the location but previously a fish farm site was placed further into the fjord about 1 km southeast of the current site. Fossfjörður has an estimated max. biomass of 2.182 t and thus a total of 11 stations were sampled.

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

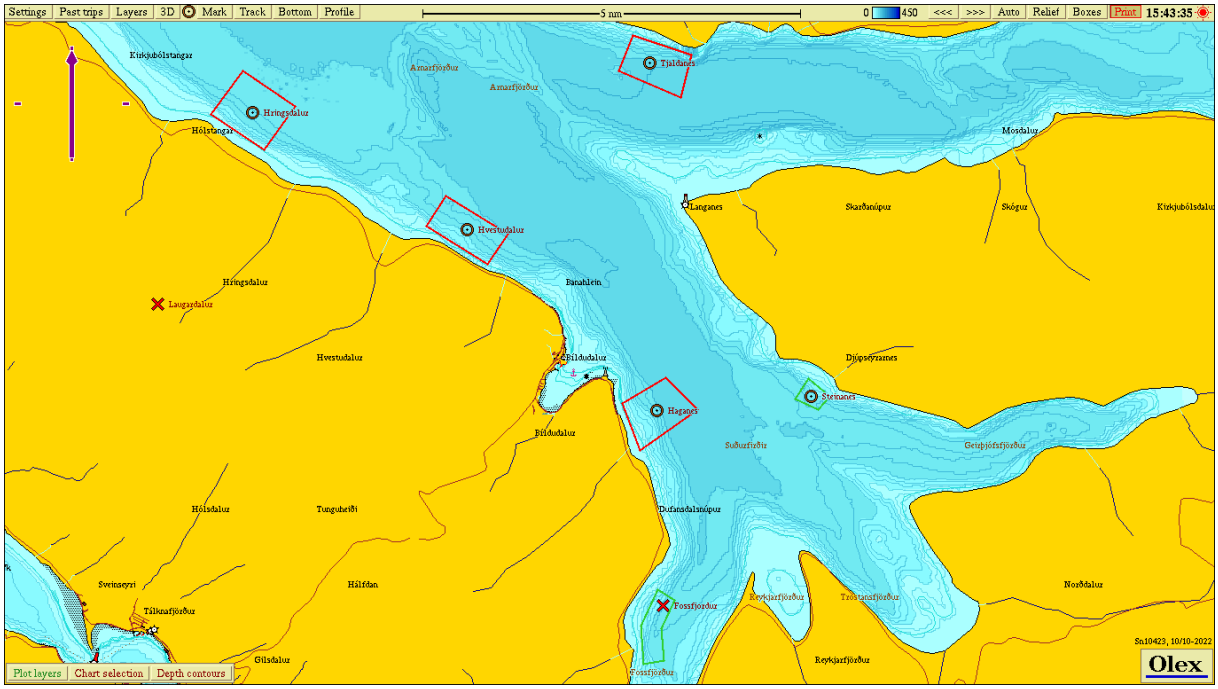


Figure 1. An overview map where Fossfjörður site is marked with a red cross. Other fish farms in the nearest vicinity in Arnarfjörður are also shown.

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. Environmental monitoring in Iceland is following guidelines and methods outlined in NS 9410:2016 and ISO 12878. The Icelandic Environmental agency (Umhverfisstofnun) can also set specific requirements regarding frequency of surveys for different fish farming sites, which can overrule the above-mentioned standards.

The B survey is a trend monitoring tool with the focus on sediment condition (benthic impact) beneath and in the close vicinity of the fish cages (near zone). Sediment is collected using a grab (min 250 cm^2). Sediment condition for each sample is assessed using three indicators: sediment chemistry (pH and redox potential), sensory evaluation (gas bubbles, smell, texture, colour and thickness of sludge) and the presence or absence of fauna. The performance of these indicators against predefined thresholds categorizes the farming locations into four different site conditions (see Table 1), which are used to determine the sampling frequency.

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

Site condition at the time of sampling	Sampling frequency for B-surveys (NS 9410:2016)
1-very good	At next max biomass
2-good	Prior to putting next generation into sea and again at next max biomass.
3-bad	Prior to putting next generation into sea. Based on the site condition prior to putting next generation into sea: - 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

Fossfjörður is located in the southern part of Arnarfjörður, approximately 6,5 km south of the town of Bíldudalur. The installed frame is suited for up to 6 net-pens with a circumference of 120 m. The frame is positioned in southeast direction from land (118°) with depth below the cages ranging from 52 to 74 m.

This is the first generation farmed fish at the current location. Previously a fish farm was placed further south in the fjord about 1 km from the current location. At the older site there had been reared two generations fish but at the time of putting fish into sea at the current site (summer 2020) the area had been in fallow state for 3 years and 8 months. Current generation was put into sea during summer 2020.

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

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

Generation of fish (G)	Production (tonnes)	Feed usage (tonnes)
Generation 1 salmon (old site)	3.215	3.610
Generation 2 salmon (old site)	4.972	6.296
Generation 2020-present new site	2.209	2.712

3.2 Present and past site surveys

Table 3 provides an overview of sampling dates and results of current and historic B surveys undertaken at the site following NS 9410:2016. For the new site Fossfjörður the only previous B survey is from last fallow period in 2020. Other older surveys are of type C surveys (overall site status not available and were sampled around the old placement of cages.

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

Date of sampling	Report number	Survey type	Overall site status
22.06.2022	APN 64107.B01 (Gunnarsson, 2022)	B survey max biomass	2
12.06.2020	APN-62252.B01 (Gunnarsson, 2020)	B survey fallow period	1
October 2015	Gallo 2016	max biomass	NA
Mai 2014	Þórisson et al. 2015	Fallow	NA
June 2013	Þórisson et al. 2015	Fallow	NA
August 2012	Þórisson et al. 2015	Max biomass	NA
2010	Þórisson et al. 2010	Pre survey	NA

3.3 Hydrodynamic conditions

Current measurements were undertaken in March-April 2020 at 15 m, which is used here as substitute to the dispersing current for Fossfjorður site (Hermansen, 2020). The dominating current at 15 m is in west direction (270 degrees) with a mild counter current in opposite direction (60-120 degrees) (Figure 2). Average current speed is 4.1 cm/s. Highest current speed is measured to be 24.0 cm/s and 7.7 % of the measurements are zero current.

3.4 Survey design

The placement of the 11 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. Depth beneath and in the close vicinity of the cage varies between 52– 74 m, with the deepest waters located in the western part of the frame. Sampling stations were placed to represent the varied environmental conditions within the near zone and cover thus both the deeper and shallower areas. The sampling stations had a depth varying from 55 to 72 m. The placement of sampling stations is regarded to be in accordance with the requirements outlined in NS 9410:2016.

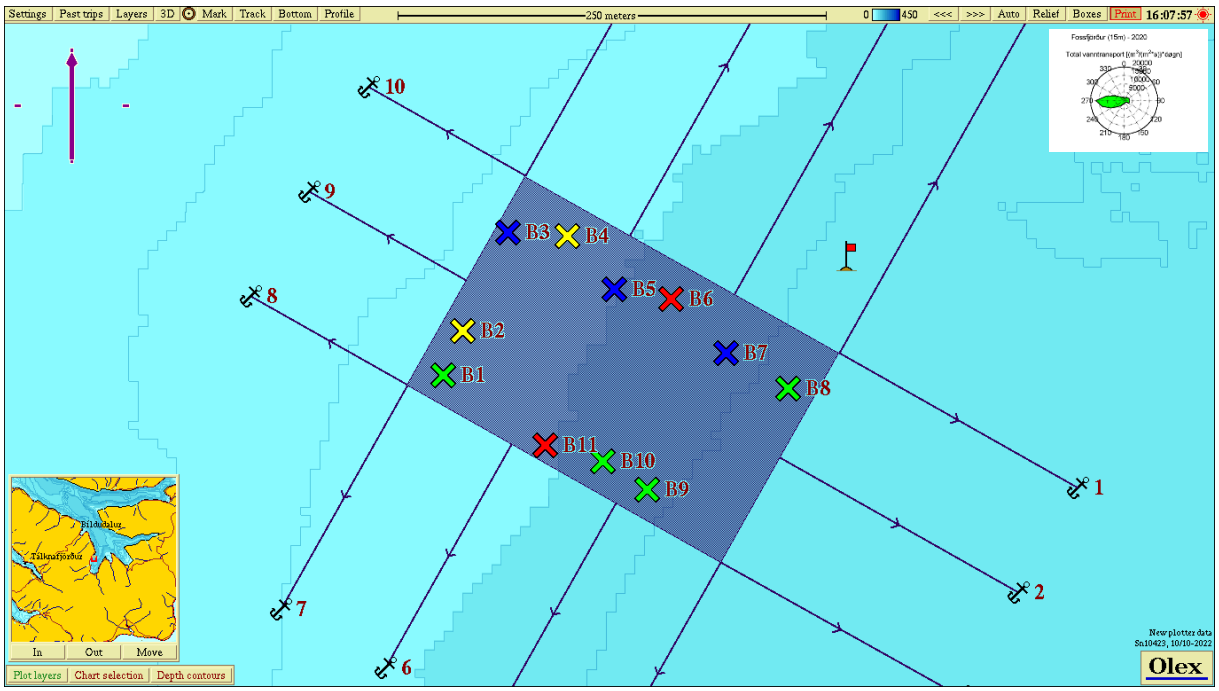


Figure 2. Site specific map of Fossfjörður showing frame, mooring lines and farming area. Sampling stations st. 1 – 11 are marked with crosses. The color of each cross represents the environmental condition at the respective station following the classification as outlined in NS 9410:2016, chapter 7.11. Colour codes: Blue = very good, green = good, yellow = bad, red = very bad. Current rose placed in the lower left corner shows main current direction at 56 m and red flag marks the spot for current measurements (Hermansen, 2020).

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

Station number	North	West	Depth (m)
St 1	65°37,850	023°32,928	55
St 2	65°37,864	023°32,913	55
St 3	65°37,895	023°32,878	53
St 4	65°37,894	023°32,833	57
St 5	65°37,877	023°32,797	60
St 6	65°37,874	023°32,754	63
St 7	65°37,857	023°32,712	68
St 8	65°37,846	023°32,665	72
St 9	65°37,814	023°32,772	69
St 10	65°37,823	023°32,806	63
St 11	65°37,828	023°32,850	59

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)	3
Group III – parameters, (sensory)	2
Group II + III – parameters (mean value)	2
Site condition	**2**

Substrate was collected at all the 11 sampling stations (100% soft bottom). Sediment samples consisted mainly of clay at all the stations. Fauna was recorded at all 11 stations with polychaetes being most prominent. The substrate was of light grey colour at six stations and brown/dark at the resting five stations. Signs of out-gassing was observed at stations 4 and 6 and these two stations had also strong smell of H_2S. Only one station had no smell of H_2S (st. 3). In general, the stations had higher score (higher score indication worse condition) for sediment chemistry (pH/Eh) than for sensory assessments even overall there was a correlation for the score for both parameters for each station.

The organic enrichment is found in alle areas within the near zone of the new frame position but stations with condition 4 – "very bad" are placed in the middle section of the farm (st. 6 and st. 11). Especially at station 6 there was substantial amount of feed residual in the grab sample indicating overfeeding in that part of the farm area.

Based on the classification of sediment chemistry (ph/Eh) and the sensory assessments three stations of this survey received status 1 – "very good", four stations received status 2 – "good", two stations received status 3 – "bad" and two stations received status 4 – "very bad" (Figure 2). Taken together the site receives as a whole the environmental status 2 – "good" (average group II-III index =1,82).

5 Conclusion

Applying the indicator thresholds and classification outlined in NS 9410:2016 it is shown that Fossfjörður receives site status 2 – "good" at the time of this B survey. Samples were collected with a Van Veen grab (0,1 m^2) at 11 stations distributed around the 6 cages, which are placed in the frame during current production cycle. Sediment was successfully collected at all eleven stations. Three stations of this survey received status 1 – "very good", four stations received status 2 – "good", two stations received status 3 – "bad" and two stations received status 4 – "very bad".

The here presented survey was undertaken during the time of max biomass for the present production cycle. This is the first generation farmed fish at the "new" Fossfjörður site. In previous B survey prior to putting salmon into sea (Gunnarsson, 2020) all sampling stations had condition 1 – "very good" whereas in the current survey only three stations have condition 1-"very good", four stations have condition 2 – "good", two stations have condition 3 – "bad" and two stations have condition "very bad". This indicates some substantial organic enrichment within the footprint of the farm location during the current production cycle.

Following the criteria outlined in NS 9410:2016 the site receives the status 2 - "good".

6 References

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

Gallo, C. 2016. Monitoring of the benthic community in Fossfjörður 2015. Worked for Fjarðalax. NV nr. 19-16.

Gunnarson, S., 2020. Fossfjörður, Arnarlax hf B-bottom survey, June 2020 (fallow period), APN-62252.B01. Akvaplan-niva AS.

Hermansen, S. 2020. Arnarlax hf, Lokalitetsrapport og havsjømodellering for lokalitet Fossfjörður, 2020. APN report 62152.01.

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.

Þórisson, B., Gallo, C. and Eiríksson, Þ. 2010. Botndýrarannsóknir á þremur svæðum í Arnarfirði 2010. Unnið fyrir Fjarðalax. NV nr. 8-10.

Þórisson, B., Gallo, C. and Jóhannesdóttir, E.D. 2015. Botndýraathuganir í Fossfirði 2011-14. Unnið fyrir Fjarðalax. NV nr. 02-15.

7 Appendix

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

Sample scheme B.1

Company	**Arnarlax**	**Date:**	**22.06 2022**
Site:	**Fossfjörður**	**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	7,4	7,1	7,3	7,1	7,6	6,8	7,6	7,2	6,9	7,0
	Eh (mV)	ORP	-110	-128	83	-149	28	-182	32	-167	-226	-217
		plus ref. verdi	90	72	283	51	228	18	232	33	-26	-17
	pH/Eh	from figure	1	3	0	3	0	5	0	2	3	3
	Status station		1	3	1	3	1	4	1	2	3	3
			Buffer-temp	5,0 C		**Sea temp**	1,1 C		**Sediment temp**		1,1 C	
		pH sea 8,01	**ORP sea**	186,5 mV		**Eh sea**	386,5 mV		**Reference electrode**		200,0 mV	
III	Gas bubbles	Yes (4) No (0)	0	0	0	4	0	4	0	0	0	0
	Colour	Light/grey (0)			0		0		0	0	0	0
		Brown/black (2)	2	2		2		2				
	Smell	None (0)			0							
		Light (2)	2	2			2		2	2	2	2
		Strong (4)				4		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)			0							
		1/4 < v < 3/4 (1)										
		v > 3/4 (2)	2	2		2	2	2	2	2	2	2
	Thickness of slidge (t)	t < 2 cm (0)			0		0		0	0		0
		2 < t < 8 cm (1)	1	1		1					1	
		t > 8 cm (2)						2				
		Sum	7,0	7,0	0,0	13,0	4,0	14,0	4,0	4,0	5,0	4,0
		Corrected (*0,22)	1,5	1,5	0,0	2,9	0,9	3,1	0,9	0,9	1,1	0,9
		Status station	2	2	1	3	1	3	1	1	2	1
		Average group II & III	1,3	2,3	0,0	2,9	0,4	4,0	0,4	1,4	2,1	1,9
		Status station	2	3	1	3	1	4	1	2	2	2

Grab ID	K-3
pH / Eh ID	Ysi professional plus

page 1 of 4 pages

Sample scheme B.1

Company:	**Arnarlax**	**Date:**	**22.06 2022**
Site:	**Fossfjörður**	**Site no.:**	**0**
Fieldworker:	**Snorri Gunnarsson**		

Gr	Parameter	Point	Sample number 11	12	13	14	15	16	17	18	19	20	Index S%	Index H%
	Bottom type: S (soft) or H (hard)		S										100	0
I	Animals > 1mm	Yes (0) No (1)	0											
II	pH	value	6,7											
	Eh (mV)	ORP	-240											
		plus ref. verdi	-40											
	pH/Eh	from figure	5										2,27	
	Status station		4											
	Status group II		3	**Buffer temp**	5,0 C		**Sea temp**	1,1 C		**Sediment temp**	1,1 C			
	pH sea	8,01	**ORP sea**	187 mV		**Eh sea**	387 mV		**Reference electrode**		200 mV			
III	Gas bubbles	Yes (4) No (0)	0											
	Colour	Light/grey (0)												
		Brown/black (2)	2											
	Smell	None (0)												
		Light (2)	2											
		Strong (4)												
	Consistency	Solid (0)												
		Soft (2)	2											
		Aqueous (4)												
	Grab volume (v)	v < 1/4 (0)	0											
		1/4 < v < 3/4 (1)												
		v > 3/4 (2)												
	Thickness of slidge (t)	t < 2 cm (0)	0											
		2 < t < 8 cm (1)												
		t > 8 cm (2)												
		Sum	6,0											
		Corrected (*0,22)	1,3										1,36	
	Status station		2											
	Status group III		2											
	Average group II & III		3,2										1,82	
	Status station		4											
	Status group II & III		2											

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: 2

Grab ID	K-3
pH / Eh ID	Ysi professional plus

Sample scheme B.2

Company:	**Arnarlax**	**Date:**	**22.06 2022**
Site:	**Fossfjörður**	**Site no.:**	**0**
Fieldworker:	**Snorri Gunnarsson**		

Sample number		1	2	3	4	5	6	7	8	9	10
Depth (m)		55	55	53	57	60	63	68	72	69	63
Number of trials		1	1	2	1	1	1	1	2	1	1
Gas bubbles (in sample)		No	No	No	Yes	No	Yes	No	No	No	No
Sediment type	**Clay**	X	X	X	X	X	X	X	X	X	X
	Silt										
	Sand										
	Gravel			X							X
	Shellsand										
Reef											
Rocky bottom (cobbles, boulders)											
Echinodermata, count											
Crustaceans, count											
Molluscs, count											
Polychaetes, count		>20	>20	>100	>20	>100	>10	>100	>10	>20	>20
Other animals, count											
Beggiatoa					X	X					
Feed							X				
Faeces		X	X						X	X	X
Comments		St. 3. Lots of broken shells/stones/gravel. St.4. Bad smell and gas in sample. St. 6. Bad smell and gas i sample, lots of feed residual.									
Grab		**Area [m^2]**		0,1		**Grab ID**			K-3		

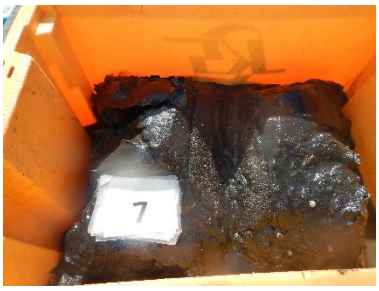
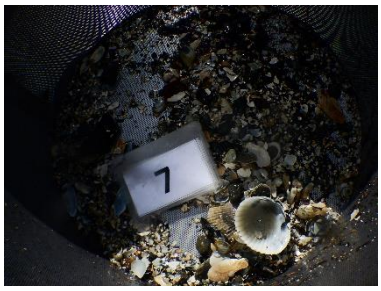
Sample scheme B.2

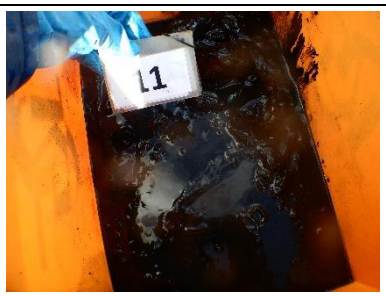
Company:	**Arnarlax**	**Date:**	**22.06 2022**
Site:	**Fossfjörður**	**Site no.:**	**0**
Fieldworker:	**Snorri Gunnarsson**		

Sample number		11	12	13	14	15	16	17	18	19	20
Depth (m)		59									
Number of trials		1									
Gas bubbles (in sample)		No									
Sediment type	**Clay**	X									
	Silt										
	Sand										
	Gravel										
	Shellsand										
Reef											
Rocky bottom (cobbles, boulders)		X									
Echinodermata, count											
Crustaceans, count											
Molluscs, count											
Polychaetes, count		>100									
Other animals, count											
Beggiatoa											
Feed											
Faeces		X									
Comments											
Grab		**Area [m^2]**	0,1			**Grab ID**		K-3			
Signature fieldworker:											

7.2 Pictures of samples at Fossfjörður.

St 1		
St 2		
St 3		
St 4		
St 5		

St 6		
St 7		
St 8		NA
St 9		
St 10		

St 11		

7.3 Bottom topography and 3D view

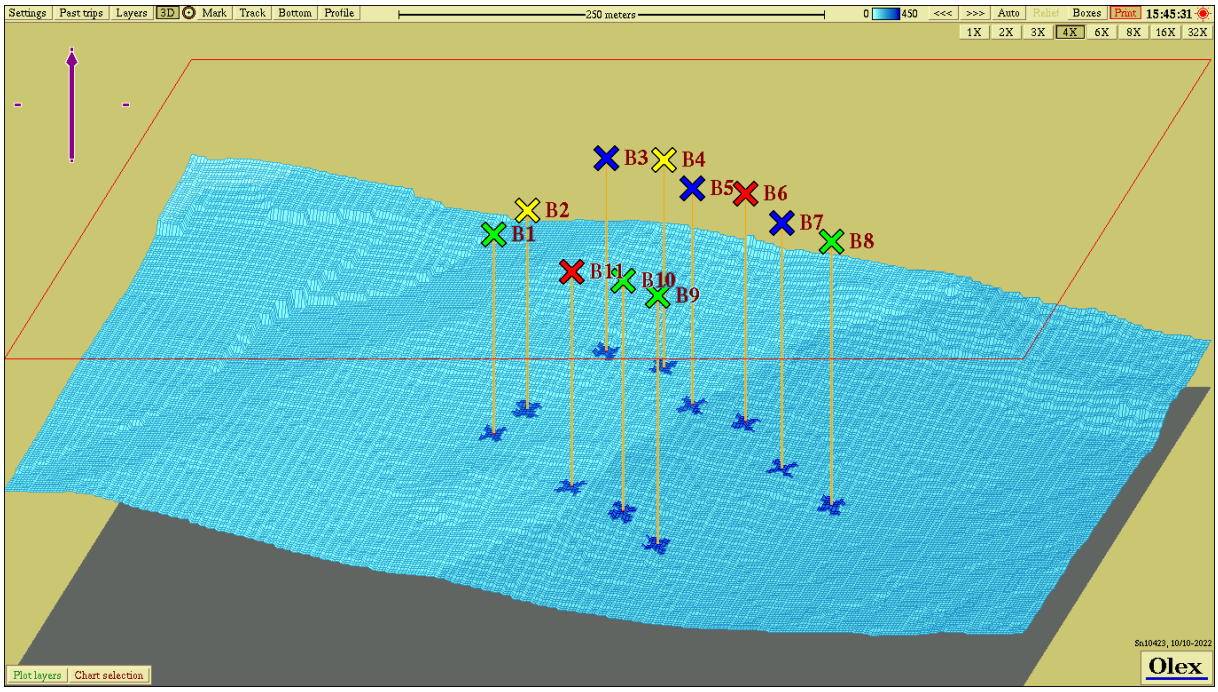


Figure 3. Bottom topography in 3D at Fossfjörður with each sampling station according to info in Figure 1 and Table 4.