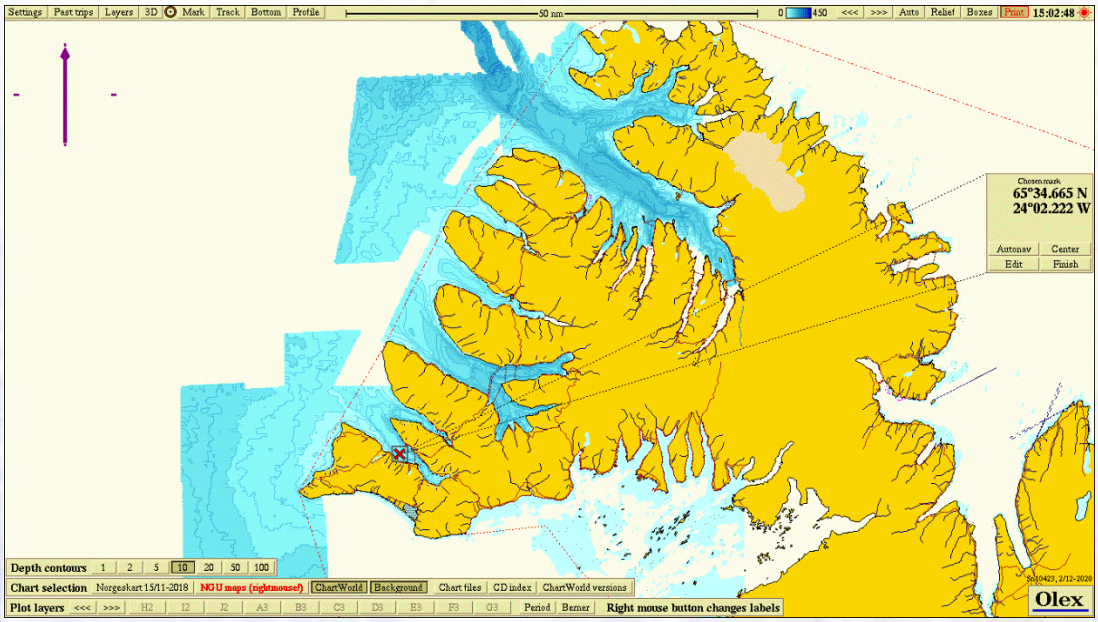
Akvaplan niva

Rapport Report

Kvígindisdalur, Arctic Sea Farm
B-bottom survey,
September 2021
(fallow period)



NORSK
AKKREDITERING
TEST 079

Akvaplan-niva AS: APN 63430.02

Akvaplan-niva AS
Rådgivning og forskning innen miljø og akvakultur
Org.nr: NO 937 375 158 MVA
Akralind 4, 201 Kópavogi
www.akvaplan.niva.no

Information client			
Title	Kvígindisdalur, Arctic Sea Farm. B-bottom survey, September 2021		
Report number	APN-63430.02		
Site name	Kvígindisdalur	Coordinates site	65°34.665 N 24°02.222 V
County	Vesturbyggð	Municipality	Patreksfjörður
MTB-or estimated max biomass	4.300 ton	Site manager/contact	Steinunn Guðný Einarsdóttir
Client name	Arctic Sea Farm		

Biomass/production/status at date of survey			
Biomass at date of survey	0 ton	Feed use	0
Fish type	Salmon	Amount produced	

Type/time of survey	Mark with X	Comments
At maximal biomass see kap 7.9	☐	
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 iht. NS 9410:2016 (main results)			
Parameters and indexes		**Parameters and site status**	
Gr. II. pH/Eh	0,07	Gr. II. pH/Eh	1
Gr. III. Sensory	0,59	Gr. III. Sensory	1
GR. II + III	0,33	GR. II+ III	1
Date field work	02.09 2021	**Date report**	20.04.22
Site status (NS 9410:2016):			**1**

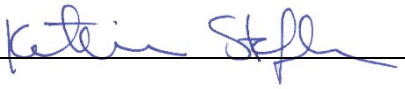
Report writing and project leader	Snorri Gunnarsson	Signature	
Quality control	Kristine Steffensen	Signature	

Table of contents

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 primary objective of a B-survey is to fulfil the requirements regarding bottom survey in the local impact zone at fallow period as they are defined in NS9410:2016. There is a requirement of 15 sampling stations within the mooring lines of the fish farm. The estimated max biomass for the next generation farmed salmon at the site Kvígindisdalur is 4.300 ton.

The following have participated in the survey:

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

The sampling at Kvígindisdalur was done 02.09 2021.

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. 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.

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 Arctic Sea Farm and their personnel for the cooperation during the conductance of this site survey.

Kópavogi 20. april 2022

Snorri Gunnarsson
Project manager

1 Introduction

The sampling date for the present site survey was 02.09 2021 and done by Akvaplan-niva AS contracted by Arctic Sea Farm in relation to the company's fish farming activity at the site Kvígindisdalur in Patreksfjörður, Vesturbyggð municipality.

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 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 impact assessment of the site from fish farming activity.

Figure 1 shows map of the fjord system of southern part of Vestfirðir where the site Kvígindisdalur is located.

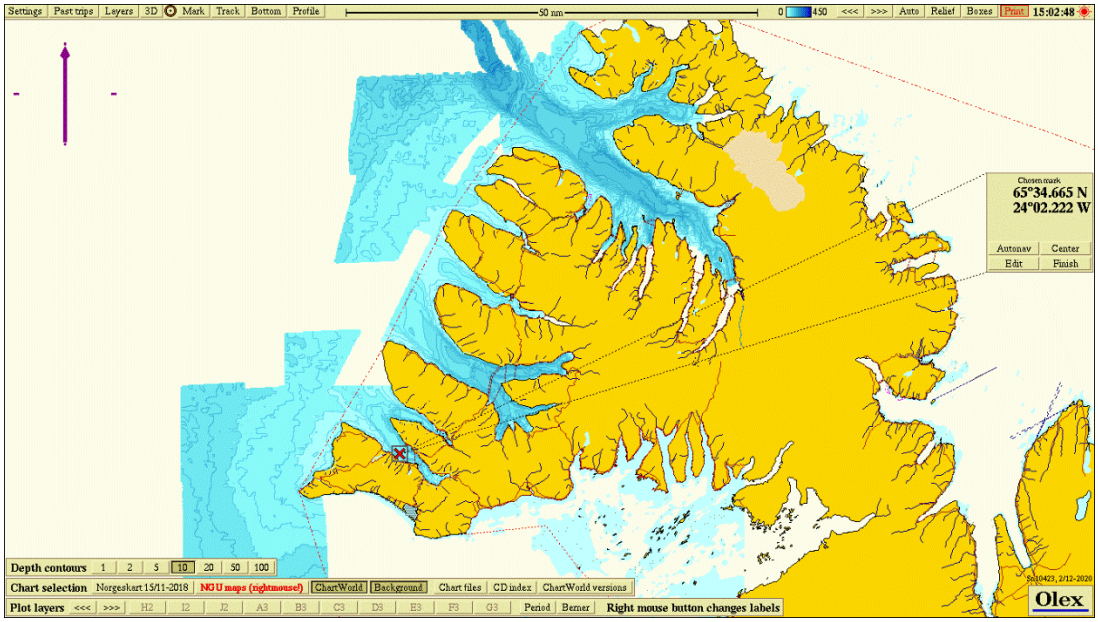


Figure 1. An overview map with the Kvígindisdalur site market by its name with a red cross.

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 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 cm^2). 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 bubbles, 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 and it is the weighted average for all the sampling stations that gives the sites condition. 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.

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:
Grabb: Van Veen grabb (0,025 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 Site description and bottom topography

3.1 Info site operation

The Kvígindisdalur site is located in Patreksfjörður about 2 km west from town Patreksfjörður harbor. The cages are lined in a northern direction from land (354 degrees). The depth under cages ranges from about 33 - 58 m.

Previously there has been farmed one generation at the site that. The smolts were put out in summer 2019 and farmed until 3rd of April 2021. At the time of the survey, the Kvígindisdalur site had been in a fallow period for about 5 months. The fish farm is a two-frame mooring system, each frame having 5 cages with a total og 10 cages, each with 160 m circumference. During the last production cycle 8 cages were used at some point (Steinunn G. Einarsdóttir, pers. info).

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

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

Generation of fish (G)	Production (ton)	Feed usage (ton)
Generation 2019 - 2021	6.533	7.935

3.2 Present and past site surveys

Previously there have been done three B bottom surveys at the Kvígindisdalur site.
There was done a base line study (B-survey) at the site prior to putting fish into sea (Gunnarsson, 2019) with sampling date in May 2019. Bottom was described as muddy for the most part with some hard bottom closer to shore at less depths and visual and chemical parameters did not show any signs of organic load at the site. Redox potential was positive at all eleven sampling stations.
Second B survey was done at max biomass during the first generation with sampling in November 2020 with overall site condition 2 "Good" (Gunnarsson, 2021a). The results indicate some organic load at the Kvígindisdalur site that had accumulated in the local impact zone during the this first production cycle. The accumulation of organic material seemed to be more accumulated at the eastern part of the fish farming area coherent with the direction of the spread current for the site in SSE direction (165 degrees). For combined parameters II and III (pH/redox and sensory) out of total 15 sampling stations, ten stations had status 1 «very good», two stations had condition «good», three stations had condition «bad» and three station had condition «very bad».
The third B survey was done upon request from Arctic Sea farm as a follow up study after previous B survey around max biomass at the site in November 2020 (Gunnarsson, 2021b). The sampling for the follow up study was done in February. The overall results from the survey in February 2021 (about three months after the previous B survey November 2020) indicated some improvements in the environmental status at the site. The overall condition improves from being 2 «good» to 1 «very good». In the November 2020 survey for combined parameters II and III (pH/redox and sensory) two station had condition 3 «bad» and three stations had condition 4 «very bad» contra one stations in each category in the latter survey three months later.

Table 3. Past site studies for Kvígindisdalur site

Date of sampling	Report number	Survey type	Overall site status
03.05.2019	APN-61207.B01	B pre survey	1 (very good)
10.11.2020	APN-62579.B02	B survey max biomass	2 (good)
10.02.2021	APN-62868.B01	B survey follow up survey after max biomass	1 (very good)

3.3 Dispersing current

Measurement of dispersing current was done at the site in 24th of September – 30th of October 2020 measurements at 51 m depth (Akvaplan-niva unpublished data PS 62459). Dominating current (51 m) is in direction south-southeast (165 degrees). Average current speed was measured to be 6.3 cm/s. Highest current speed is measured to be 19.5 cm/s and 4.3 % of the measurements were < 1 cm/s.

3.4 Position of sampling stations

Description of the 15 stations in the survey is given in figure 2 and table 4. Positioning of the stations was chosen based on guidance and perimeters described in NS 9410:2016 and spread around the periphery of the cages. At the site the typical depth in the local impact zone is in the range from 34 – 42 m, with a slightly deeper area into the fjord (NNV). The placement of sampling stations was chosen to give a good picture of the condition of the whole local impact zone. It is important to evaluate the status in both the deeper and shallower parts of the local impact zone of the fish farm. The sampling stations had a depth varying from 40 to 41 m. The placement of the sampling stations is regarded to be in accordance with the descriptions for survey of local impact zone given in NS 9410:2016.

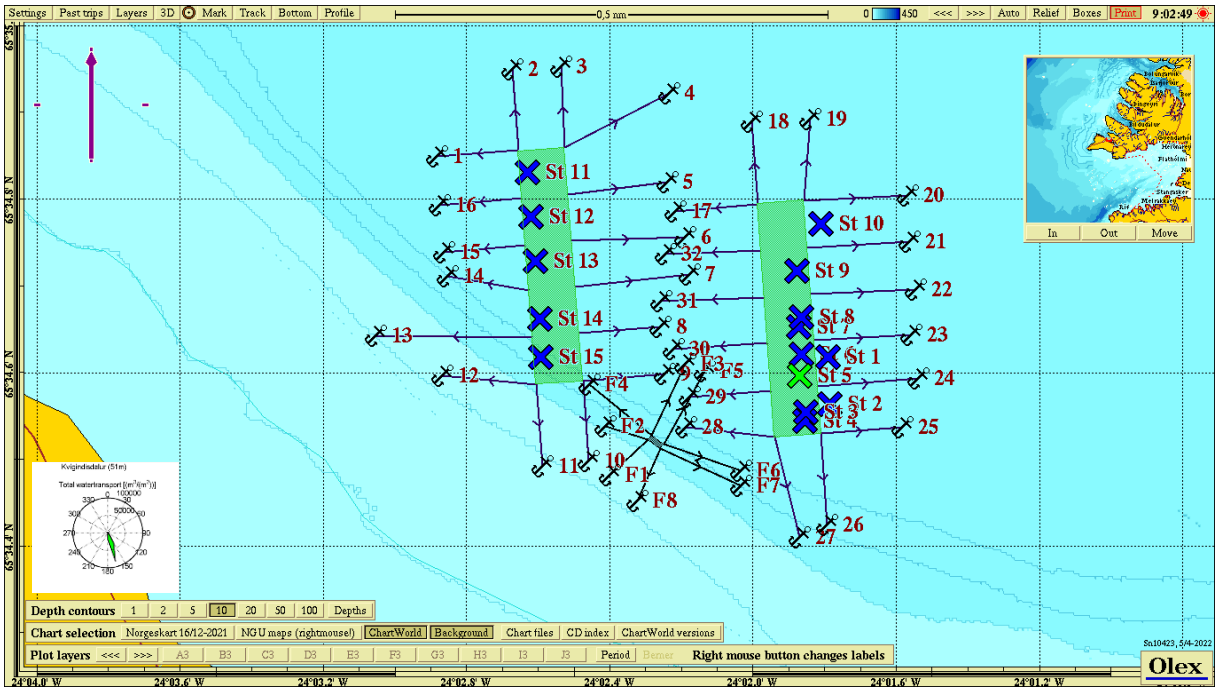


Figure 2. Chart showing depths at the site Kvígindisdalur. Sampling stations st. 1 – 15 are marked with color codes that describe the condition according to NS 9410:2016, chapter 7.11. Color codes: Blue = very good condition, green = good condition, yellow = bad condition, red = very bad condition.

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

Station number	North	West	Depth (m)
St 1	65°34.618	24°01.791	57
St 2	65°34.563	24°01.087	58
St 3	65°34.554	24°01.852	58
St 4	65°34.544	24°01.856	57
St 5	65°34.596	24°01.871	58
St 6	65°34.621	24°01.864	57
St 7	65°34.653	24°01.873	57
St 8	65°34.664	24°01.865	57
St 9	65°34.717	24°01.877	55
St 10	65°34.771	24°01.811	55
St 11	65°34.831	23°02.631	58
St 12	65°34.780	23°02.619	58
St 13	65°34.728	23°02.607	57
St 14	65°34.662	23°02.596	55
St 15	65°34.618	23°02.593	46

4 Results

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

Table 5. Results from the classifications of 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 (mean value)	1
Site condition	1

There were collected valid sediment samples at all the fifteen sampling stations (in 17 grab trials). This indicates that in general there is soft bottom in the local impact zone. The sediment type consisted mainly of clay with mixture of silt in the whole farming area. For the group II parameters (pH/Eh), all fifteen stations had conditions 1 «very good». For group II parameters (sensory parameters) twelve stations had condition 1 «very good» and three stations had condition 2 «good». For combined parameters II and III (pH/redox and sensory) fourteen stations had status 1 «very good» and one stations had condition 2 «good». Animals where present in all the fifteen soft bottom samples mainly in the form of polychaetes.

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 17 grabs were taken with Van Veen grab (0,025 m^2), divided on 15 stations placed around the 10 cages that are installed at the Kvígindisdalur site during the last production cycle.

For combined parameters II and III (pH/redox and sensory) fourteen stations had status 1 «very good» and one station had condition 2 «good». The station with status 2 (sampling station 5) is placed at the south end of the eastern frame at the fish farming area. These results indicate in general very good status of the bottom sediment at the local impact zone estimated according to according to methodology in NS 9410:2016 but it can be detected that there is some organic load in the local impact zone especially at the eastern part of the site.

The previous B bottom surveys at max biomass (Gunnarsson, 2021a) and again three months later (Gunnarsson, 2021b) gave overall condition 2 «good» and 1 «very good». There was a trend for improvement of the overall status of the bottom sediment between these two surveys and that trend for improvement continuous now with the current B-survey at fallow period. In the current study fourteen out of the total fifteen sampling stations have condition 1 «very good» for combined parameter II and III (pH/redox and sensory) and one stations has condition 2 « good» whereas in the previous B-survey there was one station that had condition 3 «bad» and 4 «very good» for combined parameter II and III. Still, it can be detected that organic load has been accumulating at higher degree at eastern and southern part of the local impact sone. The three stations that had condition 2 « good» (stations 4, 5 and 7) are all located at that part of the local impact zone.

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

Akvaplan-niva unpublished data. Measurement of spread current Kvígindisdalur PS 62459.

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

Gunnarsson, S. 2019. Kvígindisdalur, Arctic Sea Farm. B-bottom pre-survey, May 2019. Akvaplan-niva AS report nr. 61207.01.

Gunnarsson, S. 2021a. Kvígindisdalur, Arctic Sea Farm. B-bottom survey, November 2020 (max biomass survey). Akvaplan-niva AS report nr. 62579.B02.

Gunnarsson, S. 2021b. Kvígindisdalur, Arctic Sea Farm. B-bottom survey, February 2021 (a follow up survey). Akvaplan-niva AS report nr. 62868.B01.

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.

www.fiskeridir.no

7 Appendix:

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

Sample scheme B.1

Company	Arctic Sea Farm	Date:	02.09 2021
Site:	Kvígindisdalur	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	7,87	7,90	7,89	7,85	7,68	7,74	7,81	7,81	7,81	7,83
	Eh (mV)	ORP	112	80	119	45	-171	17	-71	27	-16	46
		plus ref. verdi	312	280	319	245	29	217	129	227	184	246
	pH/Eh	from figure	0	0	0	0	1	0	0	0	0	0
	Status station		1	1	1	1	1	1	1	1	1	1
			Buffer-temp	5,0 C		Sea temp	11,1 C		Sediment temp		9,7 C	
		pH sea 8,1	ORP sea	131,9 mV		Eh sea	331,9 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	0	0
		Brown/black (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	0	0	0		0		0	0	0
		Soft (2)					2		2			
		Aqueous (4)										
	Grab volume (v)	v < 1/4 (0)										
		1/4 < v < 3/4 (1)				1	1	1	1			
		v > 3/4 (2)	2	2	2					2	2	2
	Thickness of slidge (t)	t < 2 cm (0)	0	0	0	0	0	0	0	0	0	0
		2 < t < 8 cm (1)										
		t > 8 cm (2)										
	Sum		4,0	2,0	4,0	5,0	7,0	1,0	7,0	2,0	2,0	2,0
	Corrected (*0,22)		0,9	0,4	0,9	1,1	1,5	0,2	1,5	0,4	0,4	0,4
	Status station		1	1	1	2	2	1	2	1	1	1
	Average group II & III		0,4	0,2	0,4	0,6	1,3	0,1	0,8	0,2	0,2	0,2
	Status station		1	1	1	1	2	1	1	1	1	1

Grab ID	k-22
pH / Eh ID	Ysi professional plus

page 1 of 4 pages

Sample scheme B.1

Company:	Arctic Sea Farm	Date:	02.09 2021
Site:	Kvigindisdalur	Site no.:	0
Fieldworker:	Snorri Gunnarsson		

Gr	Parameter	Point	Sample number 11	12	13	14	15	16	17	18	19	20	Index S%	H%
	Bottom type: S (soft) or H (hard)		S	S	S	S	S						100	0
I	Animals > 1mm	Yes (0) No (1)	0	0	0	0	0							
II	pH	value	7,8	7,7	7,7	7,7	7,8							
	Eh (mV)	ORP	11	-30	-16	67	76							
		plus ref. verdi	211	170	184	267	276							
	pH/Eh	from figure	0	0	0	0	0						0,07	
		Status station	1	1	1	1	1							
		Status group II	1	Buffer temp	5,0 C		Sea temp	11,1 C		Sediment temp	9,7 C			
		pH sea 8,1	ORP sea	132 mV		Eh sea	332 mV		Reference electrode		200 mV			
III	Gas bubbles	Yes (4) No (0)	0	0	0	0	0							
	Colour	Light/grey (0)	0	0	0	0	0							
		Brown/black (2)												
	Smell	None (0)	0	0	0	0	0							
		Light (2)												
		Strong (4)												
	Consistency	Solid (0)	0	0	0	0	0							
		Soft (2)												
		Aqueous (4)												
	Grab volume (v)	v < 1/4 (0)					0							
		1/4 < v < 3/4 (1)		1	1									
		v > 3/4 (2)	2			0								
	Thickness of slidge (t)	t < 2 cm (0)	0	0	0	0	0							
		2 < t < 8 cm (1)												
		t > 8 cm (2)												
		Sum	2,0	1,0	1,0	0,0	0,0							
		Corrected (*0,22)	0,4	0,2	0,2	0,0	0,0						0,59	
		Status station	1	1	1	1	1							
		Status group III	1											
		Average group II & III	0,2	0,1	0,1	0,0	0,0						0,33	
		Status station	1	1	1	1	1							
		Status group II & III	1											

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

Status site: 1

Grab ID	k-22
pH / Eh ID	Ysi professional plus

Sample scheme B.2

Company:	Arctic Sea Farm	Date:	02.09 2021
Site:	Kvígindisdalur	Site no.:	0
Fieldworker:	Snorri Gunnarsson		

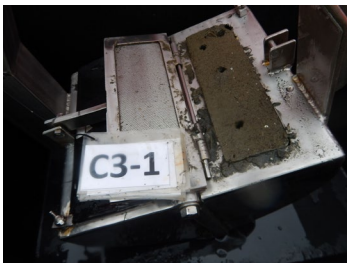
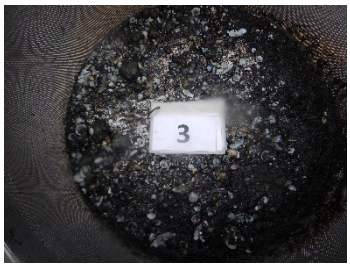
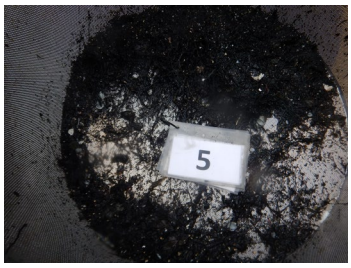
Sample number		1	2	3	4	5	6	7	8	9	10
Depth (m)		57	58	58	57	58	57	57	57	55	55
Number of trials		1	1	1	1	1	1	1	1	1	1
Gas bubbles (in sample)		No	No	No	No	No	No	No	No	No	No
Sediment type	Clay	X	X	X	X	X	X	X	X	X	X
	Silt	X	X	X	X	X	X	X	X	X	X
	Sand										
	Gravel										
	Shellsand										
Reef											
Rocky bottom (cobbles, boulders)											
Echinodermata, count											
Crustaceans, count											
Molluscs, count											
Polychaetes, count		>50	>20	>20	>50	>10	>10	>10	>50	>50	>20
Other animals, count											
Beggiatoa											
Feed											
Faeces											
Comments											
Grab		Area [m^2]		0,025		Grab ID			k-22		

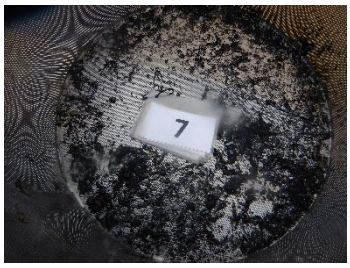
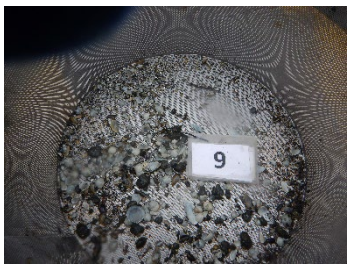
Sample scheme B.2

Company:	Arctic Sea Farm	Date:	02.09 2021
Site:	Kvígindisdalur	Site no.:	0
Fieldworker:	Snorri Gunnarsson		

Sample number		11	12	13	14	15	16	17	18	19	20
Depth (m)		58	58	57	55	46					
Number of trials		1	1	1	1	3					
Gas bubbles (in sample)											
Sediment type	Clay	X	X	X	X	X					
	Silt	X	X	X	X	X					
	Sand										
	Gravel										
	Shellsand										
Reef											
Rocky bottom (cobbles, boulders)											
Echinodermata, count											
Crustaceans, count											
Molluscs, count					1						
Polychaetes, count		>10	>10	>10	3	>15					
Other animals, count											
Beggiatoa											
Feed											
Faeces											
Comments											
Grab		Area [m^2]		0,025		Grab ID			k-22		
Signature fieldworker:											

7.2 Pictures of samples at Kvígindisdalur

St 1		
St 2		
St 3		
St 4		
St 5		

St 6		
St 7		
St 8		
St 9		
St 10		

St 11	NA	
St 12		
St 13		
St 14		
St 15		

7.3 Bottom topography and 3D view

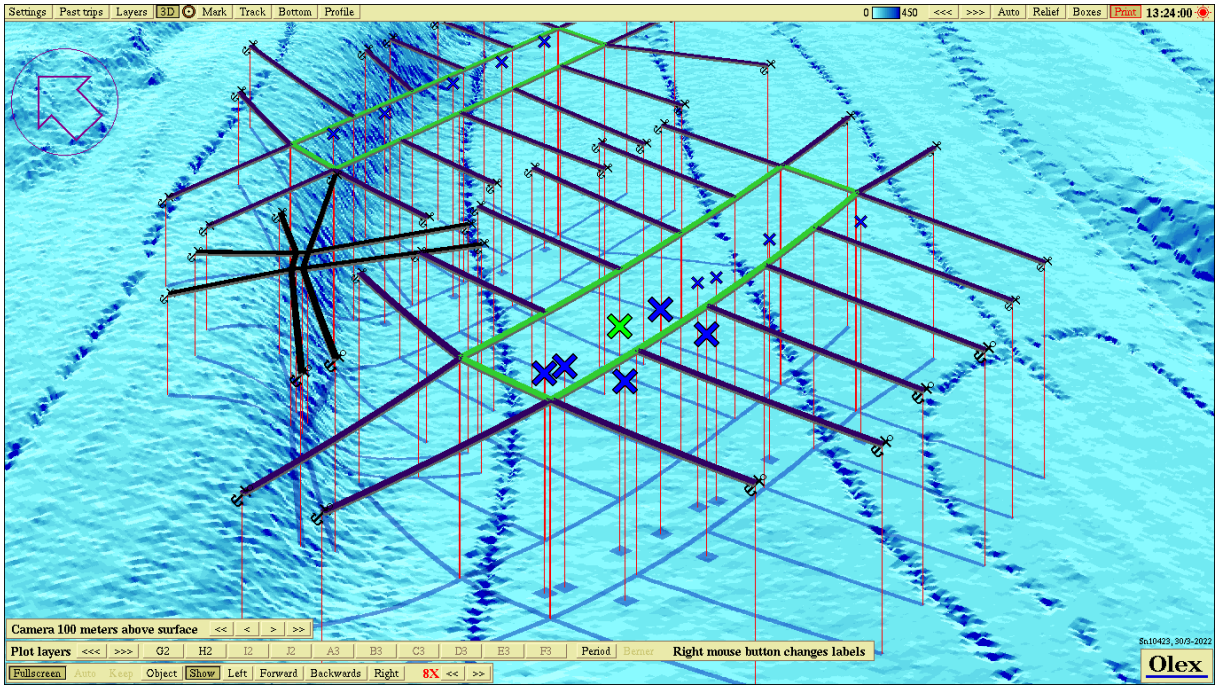


Figure 3. Showing bottom topography 3D at Kvígindisdalur with each sampling station according to info in figure 2 and Table 3.