B-survey at Tjaldanes, September 2024 (fallow period), Arnarlax ehf

Akvaplan-niva AS Report:
APN 66114.B01

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Customer	Arnarlax ehf
Contact person	Silja Baldvinsdóttir

Summary

Sediment was recovered at all stations but due to rocky bottom, it is registered 86 % soft bottom and 14 % hard bottom at Tjaldnes. The sediments consisted primarily of clay in the deeper areas but mixture of clay (ten stations), clay and gravel (two stations) and as mentioned earlier two stations were defined hard bottom since only stones was retrieved despite tree efforts each station. Fauna was recorded to be present at all soft bottom stations mainly in the form of polychaetes and some mussels were found at two stations. No smell of H_2S was recorded at eight sampling stations, light smell at five stations and strong smell at one station. No signs of outgassing were observed. The substrate was light/grey colour at eight stations and brown/black at six stations. No signs of faeces, feeds or the bacteria Beggiatoa.

Based on the classification of sediment chemistry (pH/Eh) and the sensory assessment twelve stations received status 1 – "Very good", one station received status 2 – "Good" and one station received status received status 3 – "Bad". Overall, the index score for parameter III (sensory parameters) was higher than the index score for the parameter II (pH/Eh), or 0,74 for parameter III but 0,42 for parameter II.

In summary, the site receives the environmental status 1 - "Very good" (average group II-III index =0.55).

Approval

Project Manager

Quality Control

Key information

Site details and license holder information			
Site name	Tjaldanes	Site coordinates	65°45.060' N 23°32.995' V
County	Ísafjarðabær	Municipality	Ísafjarðarbær
MTB (Maximum estimated biomass next generation)	6.137 tonnes	Operations Manager / Contact	Rolf Ørjan Nordli
License holder / customer	Arnarlax ehf		

Production status on date of survey			
Biomass at site	0 tonnes	Total feed use	0 tonnes
Farmed species	Salmon	Total biomass produced	0 tonnes
Type/time of survey	Indicated with X	Comments	
Maximum organic load cf. chapter 7.9	☐		
Follow-up survey	☐		
Half maximum load	☐		
Pre-stock	☒		
Required by the state administrator - baseline survey	☐		
Other	☐		
Last fallowing period:	26.09 2023 - present		

Results from B-survey in accordance with NS 9410:2016 (main results)			
Parameter group and index		Parameter group and status	
Gr. II. pH/Eh	0.42	Gr. II. pH/Eh	1
Gr. III. Sensory	0.74	Gr. III. Sensory	1
GR. II + III	0.55	GR. II+ III	1
Date of fieldwork	17.09 2024	Date of report	28.10 2024
Environmental status (NS 9410:2016):			**1**

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1 Introduction

The present survey was conducted by Akvaplan-niva AS on behalf of Arnarlax in connection with the company's fish farming activities at the site Tjaldanes in Arnarfjörður municipality in Ísafjarðabær county.

The purpose of a B-survey is to document the environmental status in the near zone of a fish farm by evaluating sediment condition (chemistry, sensory and presence/absence of fauna) in accordance with NS 9410:2016.

The B-survey is a tool for trend monitoring and allows to assess the status of organic enrichment beneath the net pens at different stages of the production cycle.

Figure 1 shows a map of the fjord Arnarfjörður where Tjaldanes is located.

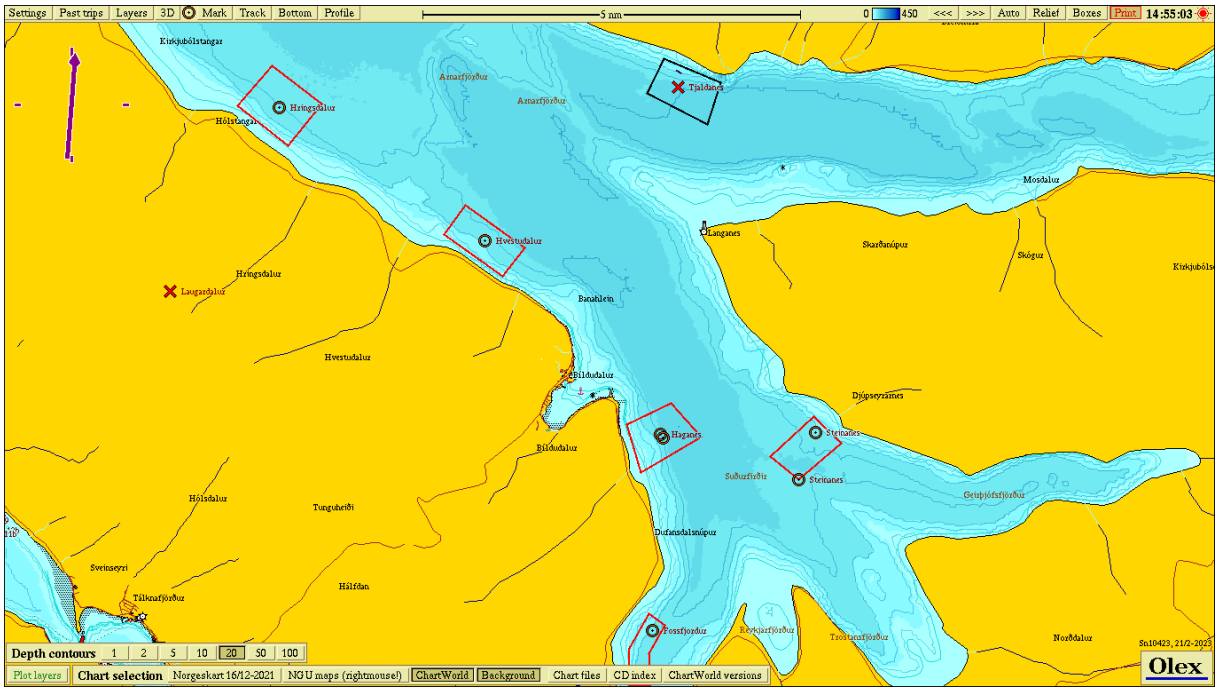


Figure 1. Overview map of Arnarfjörður with Tjaldanes marked by black square and an X. Other aquaculture sites are marked with red squares and locality name.

2 Methods

Monitoring of the environmental impact of fish farming activities on the seabed is standardised and regulated. All fish farming sites that are in use must be regularly assessed. This B-survey follows 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) under and in the immediate vicinity of an aquaculture site. Sediment samples are taken using a grab (min. 250 cm^2). Sediment condition for each sample is assessed applying three indicators: sediment chemistry (pH and redox potential), sensory evaluation (gas bubbles; smell, texture, colour of substrate and thickness of deposited sludge) and the presence or absence of fauna. The performance of these indicators against predefined thresholds allows to categorise the site into four different environmental statuses (Table 1), which are used to determine subsequent sampling frequency. The number of sampling stations is based on the site's allocated MTB (here the estimated max biomass next generation at the site).

Table 1. Frequency of B-survey based on environmental status at site.

Environmental status at maximum organic load (near zone)	Monitoring frequency for B survey
1-very good	At the next maximum load
2-good	Pre-stock and again at maximum load
3-poor	Pre-stock If the survey prior to restocking / end of fallowing provides: Status 1 – survey should be carried out at next maximum load. Status 2 – survey should be carried out at half the maximum load and at the next maximum load. Status 3 – survey should be carried out at half the maximum load and at maximum load. Implementation of measures to reduce impact should be planned for the next production cycle. If any surveys show the environmental status to be 4 – "very poor", the site's environmental capacity has been exceeded.
4- very poor	Environmental capacity at site is exceeded. The authorities decide further measures.

The following equipment was used in this survey:
Grab: Van Veen grab (0.025 and 0.1 m^2)
Sieve 1 mm: Akvaplan-niva
pH meter: Electrode, YSI Professional Plus
Redox meter: Electrode, YSI Professional Plus
Position determination – GPS map 62s
Digital camera

3 Site, production and survey design

3.1 Site characteristics and production

The Tjaldanes site is in Arnarfjörður, about 7.5 km north from town Bíldudalur. The cages are lined in a northerly direction towards land (21 degrees). The depth under cages ranges from about 60 - 104 m. The fish farm at the site is a 3x5 setup, total 15 cages each with 160 m circumference.

There have been farmed two generations farmed salmon at the site. The last generation started with smolt output summer/fall 2021 and finished slaughter on the 26th of September 2023.

Table 2 shows production and feed use for the two previous generations.

Table 2. Production and feed use for farm site Tjaldanes. Data provided by customer.

Generation of fish (G)	Production (tonnes)	Feed use (tonnes)
Preceding generation (2021-2023)	8.816 tonnes	11.007 tonnes
Preceding generation (2019-2021)	6.617 tonnes	8.378 tonnes

3.2 Current and past surveys

Table 3 provides an overview on results and time of sampling for the last B-surveys at site.

Table 3. Present and previously conducted B-surveys at the site.

Date of sampling	Report number	Production status	Location condition
17.09 2024	APN-66114.B01	B survey fallow period	1
01.02 2023	APN-64661.B01	B-survey max biomass	2
04.06 2021	APN 63266.B01	B-survey fallow period	1
15.07.2020	APN-62351.B01	B-survey max biomass	2
07.03.2019	APN-60976.01	B-survey new site	1

3.3 Hydrodynamic conditions

Measurement of dispersing current was done at the site in November 2013 – January 2014 measurements at 60 m depth (Moe and Ottesen, 2014). Dominating current (60 m) is in direction southeast (130 degrees). Average current speed is measured to be 5.0 cm/s. Highest current speed is measured to be 53 cm/s and 2.7 % of the measurements are < 1 cm/s.

3.4 Survey design

Sampling stations were placed following an assessment of site configuration and local environmental conditions, i.e. bathymetry and hydrodynamics. An overview of sampling stations can be found in Figure 2 with coordinates and depth provided in Table 4. Sampling stations were placed to represent the varied environmental conditions within the near zone and cover thus both the deeper and shallower areas. The deeper areas are further into the fjord in the southern and eastern part of the fish farming area. Samples were collected from depths ranging from 104 metres (St 5), the deepest, to 79 metres (St 10 and 14), as the shallowest. The station placement is considered representative for an environmental survey of the farm's near-zone and in accordance with the requirements outlined in NS 9410:2016.

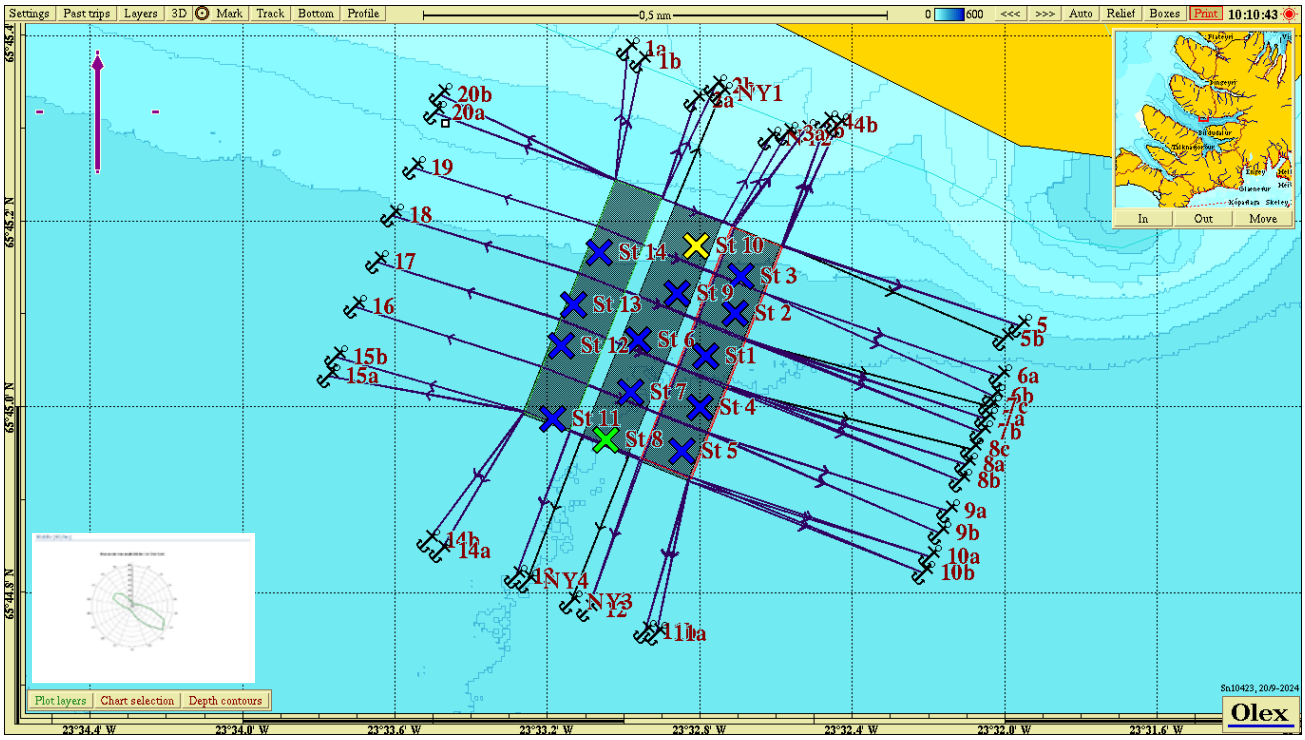


Figure 2. Overview map showing site configuration and local bathymetry at Tjaldanes. Sampling stations are marked by crosses and colour coded to visualise the environmental status at the respective station following the classification outlined in NS 9410:2016, chapter 7.11 (1 = blue, 2 = green, 3 = yellow, 4 = red). The current rose in the left corner shows the direction of water transport at dispersal depths at the site (Moe and Ottesen, 2014).

Table 4. Position and depth of the sampling stations of this survey.

Station number	Northing	Westing	Depth [m]
St 1	65°45,054	23°32,785	99
St 2	65°45,099	23°32,708	93
St 3	65°45,140	23°32,693	83
St 4	65°44,998	23°32,800	102
St 5	65°44,951	23°32,846	104
St 6	65°45,072	23°32,962	98
St 7	65°45,015	23°32,983	100
St 8	65°44,964	23°33,046	101
St 9	65°45,122	23°32,858	87
St 10	65°45,172	23°32,809	79
St 11	65°44,987	23°33,186	96
St 12	65°45,065	23°33,163	96
St 13	65°45,109	23°33,131	91
St 14	65°45,166	23°33,036	79

4 Results

Classified survey results for the different parameter categories as well as the assigned environmental status of the site are shown in Table 5. The complete survey assessment form with results and classifications for each station can be found in the attachment.

Table 5. Results from the environmental assessment of the near zone of Tjaldanes.

Parameter	Status
Group II parameters (pH/Eh)	1
Group III parameters (sensory)	1
Group II + III – parameters (mean)	1
Environmental status (site)	1

Sediment was recovered at all stations, but two station consisted of stones. It is registered 86 % soft bottom and 14 % hard bottom. The sediments consisted primarily of clay in the deeper areas but mixture of clay (ten stations), clay and gravel (two stations) and as mentioned earlier two stations were defined hard bottom since only stones was retrieved despite tree efforts each station. Fauna was recorded to be present at all soft bottom stations mainly in the form of polychaetes and some mussels were found at two stations. No smell of H_2S was recorded at eight sampling stations, light smell at five stations and strong smell at one station. No signs of outgassing were observed. The substrate was light/grey colour at eight stations and brown/black at six stations. No signs of faeces, feeds or the bacteria Beggiatoa.

Based on the classification of sediment chemistry (pH/Eh) and the sensory assessment twelve stations received status 1 – "Very good", one station received status 2 – "Good" and one station received status received status 3 – "Bad". Overall, the index score for parameter III (sensory parameters) was higher than the index score for the parameter II (pH/Eh), or 0,74 for parameter III but 0,42 for parameter II.

In summary, the site receives the environmental status 1 - "Very good" (average group II-III index =0.55).

5 Summary

Applying the indicator thresholds and classification outlined in NS 9410:2016 it is shown that the site Tjaldanes receives an environmental status of 1 – Very good at the time of this B survey (fallow period). Samples were collected with a Van Veen grab at 14 stations distributed around the fish farming area in use during the last production cycle. Two different Van Veen grabs were used during the survey, at station 1, 2 and 3 a smaller grab was used (0.025 m^2) and for remaining station a bigger grab was used (0.1 m^2). Twelve stations received status 1 – "Very good", one station received status 2 – "Good" and one station received status received status 3 – "Bad".

The survey presented here was undertaken at fallow period and the results indicate some organically enriched conditions in parts of the near zone despite that the overall site condition is 1 – "Very good". The two stations in the present survey with status "Good" and "Bad" are located in the northern and southern part of the mid-section of the farming area. In previous B-surveys at max biomass at the site Gunnarsson, 2020 and Gunnarsson, 2023 the overall site condition was 2 "Good" and highest organic load was observed in the deeper areas of the farming area (south and east). In the fallow period survey in 2021 (Gunnarsson, 2021) there were two stations with outgassing (H_2S) with condition 4 "Very bad" located in the deepest parts of the farming area (south east). The results from the current B survey therefore indicate that there have been improvements or recovery in the organic load at the site during the fallow period and the overall site condition has improved from "Good" to "Very good".

Following the criteria outlined in NS 9410:2016 the site receives the status 1 - "Very good".

6 References

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

Gunnarsson, S. 2019. Tjaldaneseyrar, Arnarlax hf, Forundersøkelse (B-undersøkelse) mars 2019. APN report nr. 60976.01.

Gunnarsson, S. 2020. Tjaldanes, Arnarlax, B-bottom survey, July 2020 (maximum biomass survey). APN report nr. 62351.01.

Gunnarsson, S. 2021. Tjaldanes, Arnarlax, B-bottom survey, (fallow period) June 2021. APN report nr. 63266.B01.

Gunnarsson, S. 2023. Tjaldanes, Arnarlax, B survey, February 2023 (max biomass). APN report nr. 64661.B01.

Moe, A.A. and Ottesen, K. 2014. Current investigation at finfish farm site Tjaldaneseyrar November 2013. Helgeland Havbruksstasjon AS. 30 s.

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

ISO 12878:2012. Environmental monitoring of the impacts from marine finfish farms on soft bottom.

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

Personal reference. Silja Baldvinsdóttir, Quality manager Arnarlax. 2024

7 Attachments

7.1 Form (B.1 and B.2) NS 9410:2016

Sample scheme B.1

Company	Arnarlax	Date:	17.09 2024
Site:	Tjaldanes	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	7.65	7.64	7.58	7.72	7.68	7.49	7.63	7.65	7.49	6.91
	Eh (mV)	ORP	-84	-41	57	81	43	-76	-11	-115	-36	-215
		plus ref. verdi	116	159	257	281	243	124	189	85	164	-15
	pH/Eh	from figure	0	0	0	0	0	0	0	1	0	3
	Status station		1	1	1	1	1	1	1	1	1	3
			Buffer-temp	10.0 C		Sea temp	8.7 C		Sediment temp		6.7 C	
	pH sea	7.99	ORP sea	116.0 mV		Eh sea	316.0 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				0	
		Brown/black (2)						2	2	2		2
	Smell	None (0)	0	0	0	0	0					
		Light (2)						2	2	2	2	
		Strong (4)										4
	Consistency	Solid (0)	0	0	0	0	0	0	0	0	0	
		Soft (2)										2
		Aqueous (4)										
	Grab volume (v)	v < 1/4 (0)			0	0	0					
		1/4 < v < 3/4 (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	
		2 < t < 8 cm (1)						1				1
		t > 8 cm (2)										
		Sum	2.0	1.0	0.0	0.0	0.0	7.0	6.0	6.0	4.0	11.0
		Corrected (*0,22)	0.4	0.2	0.0	0.0	0.0	1.5	1.3	1.3	0.9	2.4
		Status station	1	1	1	1	1	2	2	2	1	3
		Average group II & III	0.2	0.1	0.0	0.0	0.0	0.8	0.7	1.2	0.4	2.7
		Status station	1	1	1	1	1	1	1	2	1	3

Grab ID	K-21 and K-3
pH / Eh ID	Ysi prof. Plus

page 1 of 4 pages

Sample scheme B.1

Company:	**Arnarlax**	**Date:**	**17.09 2024**
Site:	**Tjaldanes**	**Site no.:**	**0**
Fieldworker:	**Snorri Gunnarsson**		

Gr	Parameter	Point	Sample number										Index	
			11	12	13	14							S%	H%
	Bottom type: S (soft) or H (hard)		H	S	S	H							86	14
I	Animals > 1mm	Yes (0) No (1)	ut	0	0	ut								
II	pH	value	ut	7.49	7.46	ut								
	Eh (mV)	ORP	ut	-44	-128	ut								
		plus ref. verdi		156	72									
	pH/Eh	from figure	ut	0	1	ut								0.42
	Status station		ut	1	1	ut								
	Status group II		1	**Buffer temp**	10.0 C		**Sea temp**	8.7 C		**Sediment temp**	6.7 C			
	pH sea	7.99	**ORP sea**	116 mV		**Eh sea**	316 mV		**Reference electrode**		200 mV			
III	Gas bubbles	Yes (4) No (0)	0	0	0	0								
	Colour	Light/grey (0)	0			0								
		Brown/black (2)		2	2									
	Smell	None (0)	0		0	0								
		Light (2)		2										
		Strong (4)												
	Consistency	Solid (0)	0	0	0	0								
		Soft (2)												
		Aqueous (4)												
	Grab volume (v)	v < 1/4 (0)	0			0								
		1/4 < v < 3/4 (1)												
		v > 3/4 (2)		2	2									
	Thickness of slidge (t)	t < 2 cm (0)	0	0	0	0								
		2 < t < 8 cm (1)												
		t > 8 cm (2)												
		Sum	0.0	6.0	4.0	0.0								
		Corrected (*0,22)	0.0	1.3	0.9	0.0								0.74
	Status station		1	2	1	1								
	Status group III		1											
	Average group II & III		0.0	0.7	0.9	0.0								0.55
	Status station		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-21 and K-3
pH / Eh ID	Ysi prof. Plus

Sample scheme B.2

Company:	**Arnarlax**	**Date:**	**17.09 2024**
Site:	**Tjaldanes**	**Site no.:**	**0**
Fieldworker:	**Snorri Gunnarsson**		

Sample number		1	2	3	4	5	6	7	8	9	10
Depth (m)		99	93	83	102	104	98	100	101	87	79
Number of trials		1	1	2	2	2	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										
	Sand										
	Gravel				X	X					
	Shellsand										
Reef											
Rocky bottom (cobbles, boulders)											
Echinodermata, count											
Crustaceans, count											
Molluscs, count			5								
Polychaetes, count		>30	>30	6	7	>10	>100	>50	>20	>20	5
Beggiatoa											
Feed											
Faeces											

Comments

St 1 - 3 grab 21 (0.025 cm2). St. 4-10 grab K-3 (0.1 cm2)

Grab	**Area [m^2]**	0.025 og 0.1	**Grab ID**	K-21 and K-3

Sample scheme B.2

Company:	**Arnarlax**	**Date:**	**17.09 2024**
Site:	**Tjaldanes**	**Site no.:**	**0**
Fieldworker:	**Snorri Gunnarsson**		

Sample number		11	12	13	14	15	16	17	18	19	20
Depth (m)		96	96	91	79						
Number of trials		3	1	1	3						
Gas bubbles (in sample)		No	No	No	No						
Sediment type	**Clay**		X	X							
	Silt										
	Sand										
	Gravel										
	Shellsand										
Reef											
Rocky bottom (cobbles, boulders)		X			X						
Echinodermata, count											
Crustaceans, count											
Molluscs, count				>50							
Polychaetes, count			>100	>100							
Other animals, count											
Beggiatoa											
Feed											
Faeces											

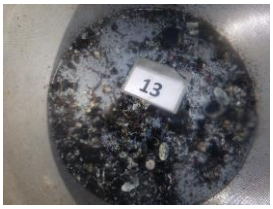
Comments	St 11 - 14 grab K-3 (0.1 cm2). St 11 and st 14. 1 x attempt empty grab 2 x attempts stone in mouth of grab.

Grab	**Area [m^2]**	0.025 og 0.1	**Grab ID**	K-21 and K-3
Signature fieldworker:				page 4 of 4 pages

7.2 Images of samples at Tjaldanes

St	*Image before sieving*	*Image after sieving*
St 1		
St 2		
St 3		
St 4		NA (forgot to take picture)
St 5		

St 6		
St 7		
St 8		
St 9		
St 10		

St 11	Hard bottom	Hard bottom
St 12		
St 13		
St 14	Hard bottom	Hard bottom

7.3 3D-bathymetry

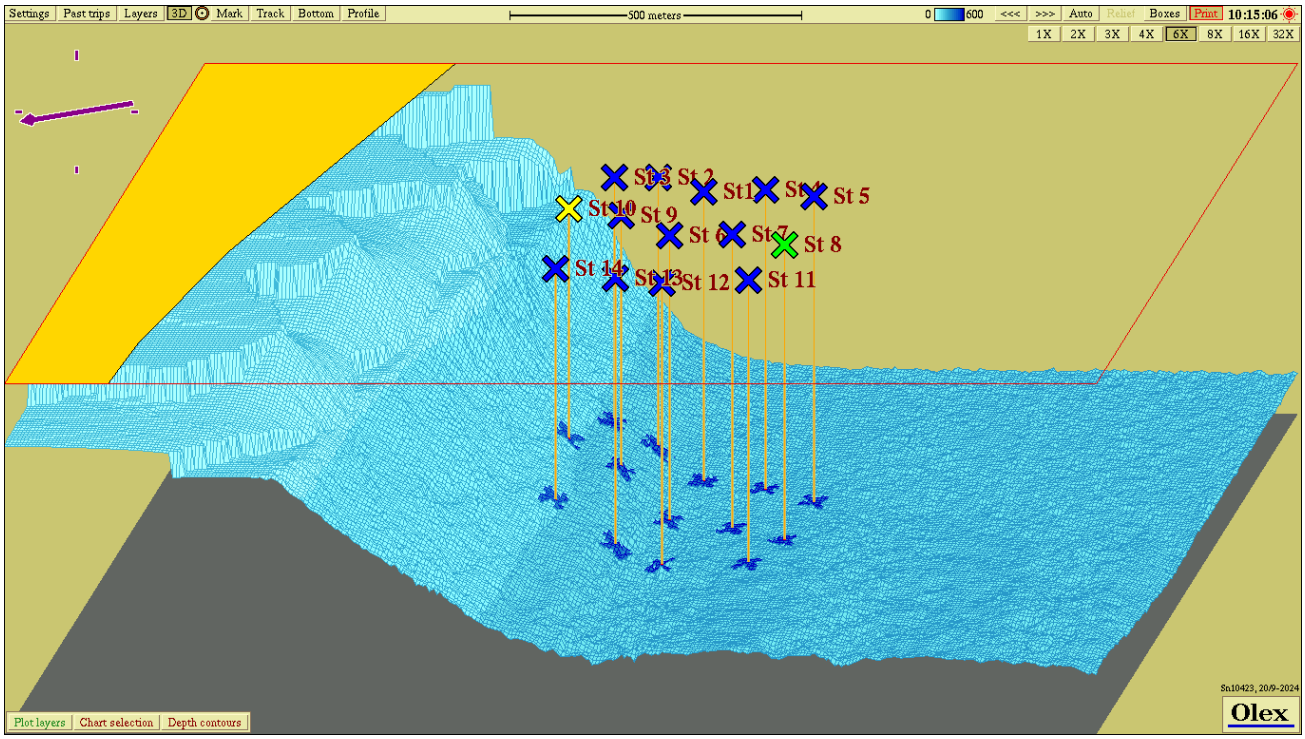


Figure 3. 3D-view of bathymetry at Tjaldanes with stations as shown in Figure 2 and Table 4.