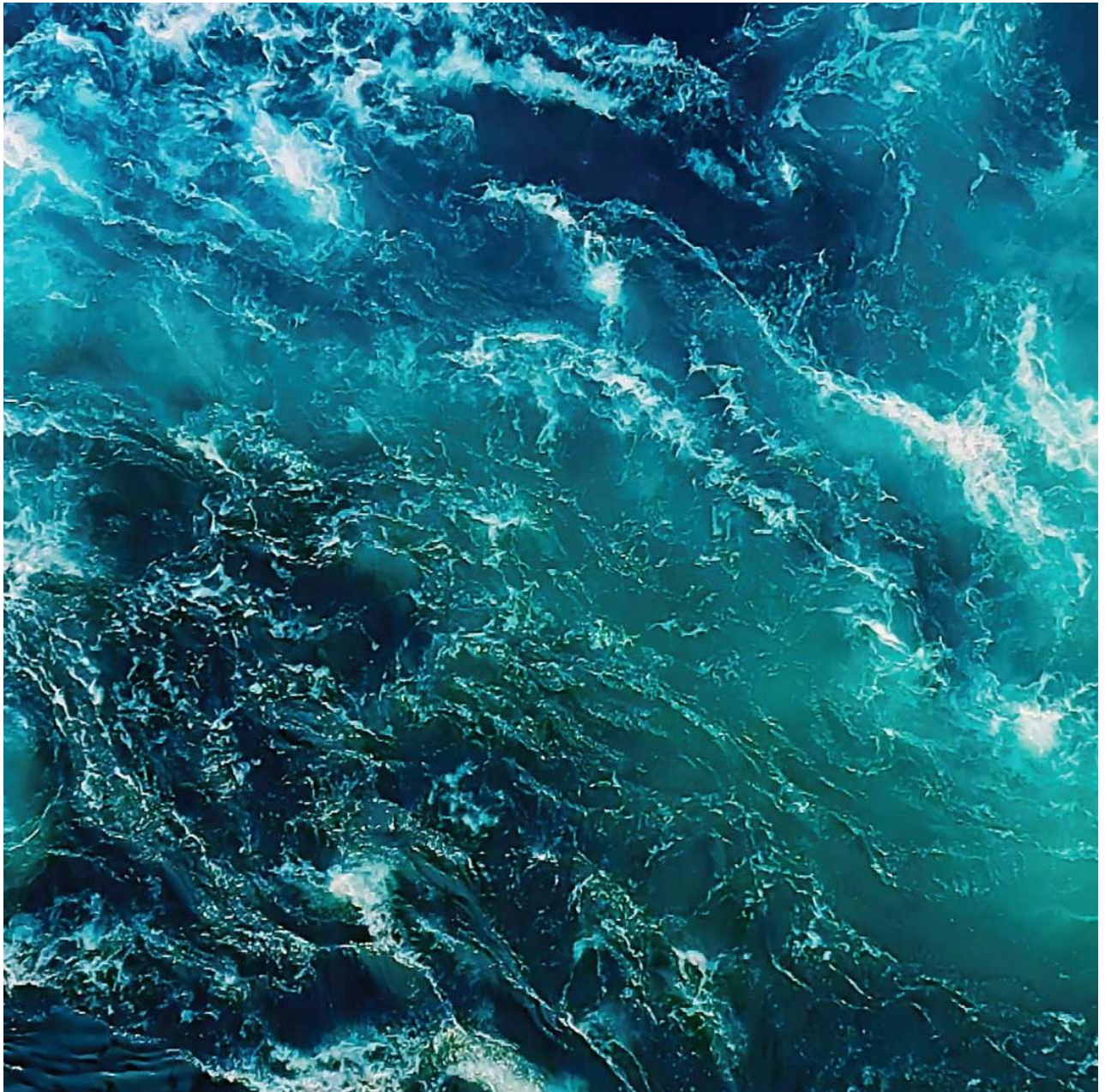


C-survey at Hringsdalur post fallow, 2022

Arnarlax ehf

Akvaplan-niva AS Report: 2022 64042.02



Arnarlax ehf. C-Survey at Hringsdalur post fallow, 2022.

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Summary

The results from the monitoring at the farming site Hringsdalur in April 2022 showed that the sediment was somewhat loaded with organic carbon and the copper concentrations were within reported natural levels for bottom sediment around Iceland (Egilsson *et al.*, 1999). No load effect was recorded in the fauna and faunal index nEQR showed good conditions and no impact at most of the stations (> 0.6). At C4 and C5 n EQR was just below 0.6. The diversity index H' was just below 3 at C4 and C5 and above 3 at the other stations and ranged from 2.48 (C5) to 4.52 (C2). NS 9410:2016-assessment of the community in the local impact zone (C1) showed environmental condition 1 (Very good). No pollution indicators were recorded among the top-10 species on any of the stations. The redox measurements (pH/Eh) gave point 0 acc. Appendix D in NS 9410:2016 for all the sampling stations.

Approval



Prosjektleder

Kvalitetskontroll

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Preface

Akvaplan-niva carried out an environmental survey of type C (NS 9410:2016) at the Hringsdalur site. It includes pH/redox measurements (Eh), geochemical analyses, and analyses of the bottom fauna from six stations at the fish farming site. The following personnel have contributed:

Snorri Gunnarsson	Akvaplan-niva	Report, project leader.
Arnthor Gustavsson	Akvaplan-niva	Field work.
Hans-Petter Mannvik	Akvaplan-niva	Identification of bottom fauna (Echinodermata). Report, professional assessments, and interpretations.
Kamila Szybor	Akvaplan-niva	QA report, professional assessments, and interpretations.
Roger Velvin	Akvaplan-niva	Identification of bottom fauna (Various taxa).
Rune Palerud	Akvaplan-niva	Identification of bottom fauna (Crustaceans). Statistics.
Thomas Hansen	Akvaplan-niva	Identification of bottom fauna (Polychaeta).
Jesper Hansen	Akvaplan-niva	Identification of bottom fauna (Polychaeta and Mollusca).
Kristine H Sperre	Akvaplan-niva	Coordination of sorting of bottom fauna.
Ingar H. Wasbotten	Akvaplan-niva	Coordination of geo-chemical analyses.

Akvaplan-niva would like to thank Arnarlax ehf and Silja Baldvinsdóttir for good cooperation

Accreditation information:

The survey was done by Akvaplan-niva AS with ALS Laboratory Group (Czech Republic) as a sub-contractor.



Akvaplan-niva AS is accredited under NS-EN ISO/IEC 17025 by Norwegian Accreditation for field sampling of sediments and fauna, analyses of TOC, TOM, TN, particle size and macrofauna, and for professional evaluations and interpretations. Our Accreditation number is TEST 079.

Czech Accreditation
Institute (Lab nr 1163)

ALS Laboratory Group is accredited by the Czech Accreditation
Institute (Lab nr 1163) for copper analyses.

Non-accredited services: Hydrographical measurements and mapping of bottom topography (Olex).

Kópavogur, 20.07 2022

Snorri Gunnarsson (Project Manager)

1 Data Summary

Client information			
Report title:	C-Survey at Hringsdalur post fallow, 2022.		
Report nr.	2022 64042.02	Site:	Hringsdalur
Municipality:		Map Coordinates (construction):	65°44,416 N 23°45,777 W
MTB permitted or estimated max biomass:	9.600	Operations manager:	Rolf Ørjan Nordli
Client:	Arnarlax ehf		

Biomass/production status at time of survey (26.04.2022)			
Fish group:	A. salmon	Biomass on examination:	0
Feed input:	0	Produced amount of fish:	0
Type/time of survey			
Maximum biomass:		Follow up study:	
Fallow (resting period):	X	New location:	

Results from the C study /NS 9410 (2016) – Main results from soft bottom fauna			
Faunal index nEQR (Veileder 02:2018)		Diversity index H' (Shannon-Wiener)	
Fauna C1 (impact zone)	0.654	Fauna C1 (impact zone)	3.89
Fauna C2	0.699	Fauna C2	4.52
Fauna C3	0.639	Fauna C3	3.85
Fauna C4 (deep area)	0.590	Fauna C4 (deep area)	2.91
Fauna C5	0.557	Fauna C5	2.48
Fauna C6	0.641	Fauna C6	3.81
Date fieldwork:	26.04.2022	Date of report:	13.07 2022
Notes to other results (sediment, pH/Eh, oxygen)			nTOC from 29.4 to 35.9 mg/g. Copper level 30.1 mg/kg at C1. Eh positive at all stations.
Responsible for field work:	Signature: AGU	Project manager Snorri Gunnarsson	Sign: SGU

2 Introduction

2.1 Background and aim of the study

On behalf of Arnarlax ehf, Akvaplan-niva completed a survey of type C for the fish farming site at Hringsdalur in Arnarfjörður (Figure 1).

The survey fulfils the requirements from the Icelandic authorities for bottom surveys according to ISO 12878 and the requirements for environmental bottom surveys (according to Vöktunaráætlun). An environmental study was simultaneously undertaken, with reference to chapter 5.0 in NS 9410:2016 which follows the methodology for C- study. A survey of type C is aimed at studying the environmental conditions of the bottom sediments along a transect sector from the fish farm that extends from the local, to the intermediate and to the regional impact zones. The main emphasis is on the study of the soft bottom fauna which is conducted according to standards ISO 5567-19:2004 and ISO 16665:2014. The obligatory parameters that are included in the survey are described in NS 9410:2016. A classification or threshold values for this type of survey have not been developed by the Icelandic officials so it is not possible to apply the classification based on Norwegian threshold values to Icelandic conditions. We do however report the results with these same indexes with reference to Norwegian threshold values, but it should be emphasized that some of these (such as NSI) are developed according to Norwegian conditions. For further descriptions of these indexes see details in Appendix 1 and Miljødirektoratets Veileder 02:2018.

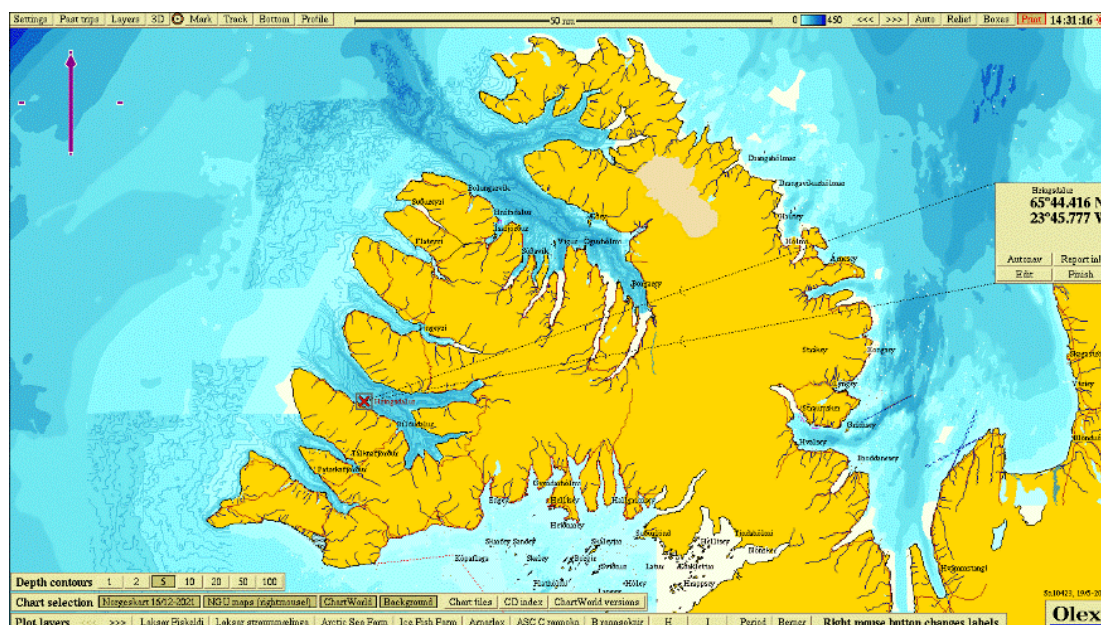


Figure 1 Overview of Vestfjords with the farming site Hringsdalur in Arnarfjörður (red cross). The map coordinates for the midpoint of the farming site are given to the right.

2.2 Site operation and feed use

The plant is a frame mooring with a total of eighteen 160 meters circumference cages in a 2 x 9 configuration. Hringsdalur has been fallowed since mid-April 2020.

Two generations of fish have been reared at site and production volume increased with each production cycle. G18 was produced in six cages with a circumference of 160 m. For the upcoming

production cycle, the frame has been extended (18 net-pens) and moved within the defined fish farming area, approximately 300 m eastwards. The here presented survey was undertaken after fallowing and prior the start of the next production cycle. Sampling stations in this survey are placed around the zone of the new farm location.

In Iceland, the MTB (maximum allowed biomass) limit is not given a site level as in Norway. The MTB limit determines how much live fish the holder of the permit can have standing in the sea at any time. In Iceland the allowed production is regulated at two levels, site level and company level. For this site the estimated maximal standing biomass for the next generation is 9.600 tonnes, used as MTB here (Einarsdóttir, pers reference).

2.3 Previous surveys

An overview of previous surveys carried out at Hringsdalur is shown in Table 1.

Table 1: Previous surveys at Hringsdalur.

Survey date	Report reference (author, year)	Production (tonn)	Type of survey
19.11 2019	APN 61656.02 (Mannvik and Gunnarsson, 2020)	6.479	ASC/C survey at max biomass
16.05 2018	APN 60320.01 (Mannvik and Gunnarsson, 2020)	0	C survey fallow period
01.11 2017	APN 9187.01 (Velvin and Gunnarsson)	4.000	ASC/C survey at max biomass

3 Materials and methods

3.1 Survey program

The choice of study parameters, placement of sampling stations and other criteria for the study is based on descriptions in NS 9410 (C-surveys). An overview of the planned professional program is given in Table 2.

Akvaplan-niva is accredited for field work, analyses of samples and professional evaluation of results in accordance with applicable standards and guidelines ("Veiledere"). For implementation and follow through, the following standards and quality assurance systems were used:

- ISO 5667-19:2004: *Guidance on sampling of marine sediments*.
- ISO 16665:2014. *Water quality – Guidelines for quantitative sampling and sample processing of marine soft-bottom macro fauna*.
- NS 9410:2016. *Miljøovervåking av bunnpåvirkning fra marine oppdrettsanlegg*.
- Internal procedures. *Quality Manual for Akvaplan-niva*.
- Veileder 02:2018. *Klassifisering av miljøtilstand i vann*. Norsk klassifiseringssystem for vann i henhold til Vannforskriften. Veileder fra Direktoratgruppen.

Table 2: Survey program for the C-survey at Hringsdalur, 2022. TOC = total organic carbon. Korn = grain size in sediment. TOM = total organic material. TN = total nitrogen. Cu = Copper. pH/Eh = acidity and redox potential.

Station	Type analyses/parameters
C1 (local impact zone)	Quantitative analyses of bottom fauna. TOC. Korn. TOM. TN. Cu. pH/Eh.
C2 (transect zone outer)	Quantitative analyses of bottom fauna. TOC. Korn. TOM. TN. pH/Eh.
C3 (transect zone)	Quantitative analyses of bottom fauna. TOC. Korn. TOM. TN. pH/Eh.
C4 (transect zone, deep area)	Quantitative analyses of bottom fauna. TOC. Korn. TOM. TN. pH/Eh.
C5 (transect zone, upstream)	Quantitative analyses of bottom fauna. TOC. Korn. TOM. TN. pH/Eh.
C6 (transect zone)	Quantitative analyses of bottom fauna. TOC. Korn. TOM. TN. pH/Eh.

Field work was completed on 26.04.2022.

Placement of stations and local conditions

The number of stations was calculated with reference to the sites estimated maximal standing biomass for the first generation which is 9.600 tonnes (used as MTB here). According to the standard six sampling stations should be examined. Depth and position of the stations are given in Table 3 and shown in Figure 2. Stations C1, C2, C3, C4 and C6 were placed in accordance with the direction of the main oceanic current direction at 60 m depth (Moe, 2014). Station C4 was also covering deeper

area close to the farming site to catch eventual organic accumulation there. Station C5 was placed in deep area close to the northern edge of the farming site.

Table 3: Depth, distance between the nearest frame of the fish farm and sampling stations and coordinates for C-stations at Hringsdalur, 2022.

Station	Depth, m	Distance from frame, m	Position	
			N	W
C1	69	30	65°44.170	23°45.408
C2	63	500	65°44.010	23°44.930
C3	69	130	65°44.140	23°45.300
C4	82	225	65°44.352	23°45.266
C5	86	50	65°44.668	23°46.161
C6	70	260	65°44.092	23°45.173

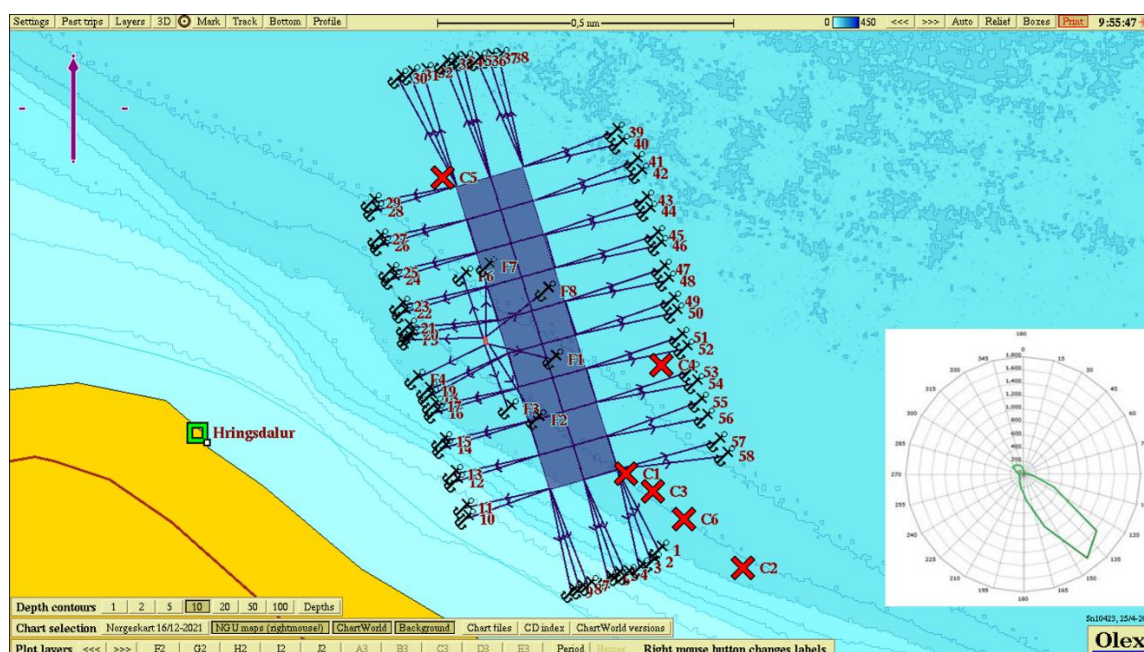


Figure 2. Map showing the sampling stations for the C-survey at Hringsdalur, 2022. Current measurements used were from 60 m depth (Moe, 2014).

3.2 Hydrography and oxygen

By human error hydrographic measurement were not done as planned at station C4.

3.3 Soft bottom sampling and analyses

3.3.1 Fieldwork

Sediment samples were collected with a 0.1 m² bottom grab (van Veen). The sample material was collected through inspection openings. Samples for TOC, TN and Cu were taken from the top 1 cm layer of the sediment and for TOM and grain size analyses from the top 5 cm using a hollow pipe.

Only samples with an undisturbed surface were used. The samples were frozen for further processing in the laboratory.

3.3.2 Total organic material (TOM)

The amount of TOM in sediment was determined by weight loss after combustion at 495 °C. The percent weight loss was calculated. The reproducibility of the TOM analyses is checked during the analyses by using a standard household sediment that contains TOM with a known level. Standard calcium carbonate was burned together with the samples as a control of the amount of carbonate that was not burned in the analyses process.

3.3.3 Total nitrogen (TN)

After drying the samples at 40°C, the amount of total nitrogen (TN) was quantified by electrochemical determination using an internal method that is based on NS-EN 12260:2003 (Vannundersøkelse – Bestemmelse av bundet nitrogen (TNb) etter oksidasjon til nitrogenoksider).

3.3.4 Total organic carbon (TOC) and grain size

The proportion of fine material, the fraction less than 63 µm, was determined gravimetrically after wet sieving of the samples. The results are presented as proportion of fine material on a dry weight basis.

After drying the samples at 40 °C, the content of total organic carbon (TOC) was determined by NDIR-detection in accordance with DIN19539:2016 (Investigation of solids – Temperature-dependent differentiation of total carbon (TOC₄₀₀, ROC, TIC₉₀₀)). To classify the environmental conditions based on the content of TOC, the measured concentrations are normalized for proportion of fine substance (nTOC) using the equation: $nTOC = TOC + 18(1 - F)$, where TOC and F represent a measured TOC value and the proportion of fine substance (%) in the sample (Aure *et al.*, 1993).

3.3.5 Metal analysis - copper (Cu)

The samples for metal analysis were freeze-dried before being placed in a microwave oven in a sealed Teflon container with concentrated ultrapure nitric acid and hydrogen peroxide. The concentration of copper (Cu) was determined by means of ICP-SFMS.

3.3.6 Redox- and pH measurements

At all the stations, a quantitative chemical examination of the sediment was carried out. Acidity (pH) and redox potential (Eh) were measured using electrodes and the YSI Professional Plus instrument. In accordance to the manual of the instrument, 200 mV was added to the measured ORP (the Oxidation Reduction Potential) value.

3.4 Soft bottom fauna investigation

3.4.1 About effect of organic material on bottom fauna

The emission of organic material from fish farms can contribute to the deterioration of conditions for many of the organisms living in the bottom sediment. Negative effects in the bottom fauna can

best be assessed through quantitative bottom fauna analyses. Many soft bottom species have low mobility, the fauna composition will largely reflect the local environmental conditions. Changes in the bottom fauna communities are a good indication of unwanted organic loads. Under natural conditions, the communities typically consist of many species. High number of species (diversity) is, amongst other things, dependent on favourable conditions for the fauna. However, moderate increases in organic load can stimulate the fauna and result in an increased number of species found. Larger organic loads can result in less favourable conditions where opportunistic species increase their individual numbers, while the species not suited are knocked out resulting in a reduced diversity of species. Changes in species diversity near emission points of feed and faecal matter can, to a large degree, be attributed to changes in organic content (from the feed and faecal matter) in the sediment.

3.4.2 Sampling and fixation

All the bottom fauna samples were taken with a 0.1 m² van Veen grab. Only grab samples where the grab was completely closed and the surface undisturbed were approved. After approval, the contents were washed through a 1 mm sieve and the remaining material fixed with 4 % formalin with Bengal Rose dye added and neutralized with borax. In the laboratory, the animals were sorted from the remaining sediment.

3.4.3 Quantitative bottom fauna analysis

At all stations, two samples (replicates) were collected in accordance with guidelines in NS 9410 (2016). After sorting the sample material was processed quantitatively. The bottom fauna was identified to the lowest level possible and quantified by specialists (taxonomists). The quantitative lists of species were analysed statistically. See Appendix 1 for description of analysis methods. The following statistical methods were used to describe community structure and to assess the similarity between different communities:

- Shannon-Wiener diversity index (H')
- Hurlberts diversity index (ES₁₀₀) – expected number of species pr. 100 individuals
- Pielou's evenness index (J)
- Sensitivities index (Ømfintlighet) (ISI₂₀₁₂), unsuitable at low individual/species number
- Sensitivity index (NSI)
- Composite index for diversity of species and sensitivity (NQI1)
- Sensitivities index which is included in NQI1 (AMBI)
- Normalized EQR (nEQR)
- Number of species plotted against the number of individuals in geometric arts classes
- Cluster analyses
- The ten most dominant taxa per station (top-ten)

4 Results

4.1 Sediment

4.1.1 TOC, TOM, TN, C/N, grain size and pH/Eh

Levels of total organic material (TOM), total organic carbon (TOC), total nitrogen (TN), C/N-relationship, grain size distribution in sediment (pelite) and pH/Eh in the sediment are presented in Table 4.

TOM-levels varied from 9.3 to 13.9 %. TN-levels were somewhat high (7.3 – 9.3 mg/g) while the C/N-ratios were low. TOC was somewhat high at all stations and nTOC varied from 29.4 to 35.9 mg/g. The bottom sediments grain size was moderately coarse to fine with a pelite ratio ranging from 48 to 84 %.

Redox measurements (pH/Eh) gave a point of 0 for all the sampling stations according to Appendix D in NS 9410:2016.

Table 4. Sediment description, TOM (%), TOC (mg/g), TN (mg/g), C/N, grain size distribution (pelitt ratio % <0,063 mm) and pH/Eh. Hringsdalur, 2022.

St.	Sediment description	TOM	TOC	nTOC	TN	C/N	Pelite	pH/Eh
C1	Olive green clay and silt with a lot of black algae residues.	9.3	25	34.2	9.3*	2.7	48.7	8.11/ 332
C2	Olive green clay and silt with a lot of black algae residues.	9.6	22	31.6	7.3*	3.1	48.3	8.14/ 289
C3	Olive green clay and silt with a lot of black algae residues.	9.4	27	35.9	8.2*	3.3	50.3	8.15/ 266
C4	Olive green clay and silt with some black algae residues.	13.1	25	30.4	7.5*	3.4	72.6	8.18/ 248
C5	Olive green clay and silt with some black algae residues.	13.9	27	29.4	8.5*	3.1	84.1	8.13/ 242
C6	Olive green clay and silt with a lot of black algae residues.	10.1	23	30.2	6.9*	3.3	57.1	8.10/ 285

*Not accredited results.

4.1.2 Copper

Level of copper in bottom sediment at C1 is shown in Table 5. The level of copper was 30.1 mg/kg.

Table 5. Copper (Cu), mg/kg DS. Hringsdalur, 2022.

St.	Cu
C1	30.1

4.2 Soft-bottom fauna

4.2.1 Faunal indices

Results from the quantitative soft bottom faunal analyses at the C-stations are presented in Table 6.

The number of individuals varied from 842 (C5) to 2083 (C3) and number of species from 37 (C5) to 71 (C6). The diversity H' varied from 2.48 to 4.52. At most of the stations, the overall index of nEQR was higher than 0.6, but somewhat below at C4 and C5. The nEQR values indicate relatively good conditions and no disturbance of the communities.

J (Pielous evenness index) is a measure of how equally individuals are divided between species and will vary between 0 and 1. A station with low value has a "crooked" individual distribution between the species, indicating a disturbed bottom fauna community. The index varied from 0.51 to 0.79 which indicates a relatively even distribution.

Table 6. Number of species and individuals pr. 0,2 m². H' = Shannon-Wiener's diversity index. ES_{100} = Hurlberts diversity index. $NQI1$ = overall index (diversity and sensitivity). ISI_{2012} = sensitivity index. NSI = sensitivity index. J = Pielous evenness index. $AMBI$ = AZTI marine biotic index (part of $NQI1$). $nEQR$ = normalized EQR (excl. DI). C-stations at Hringsdalur, 2022.

St.	Numb. ind.	Numb. species	H'	ES_{100}	$NQI1$	ISI_{2012}	NSI	nEQR	AMBI	J
C1	1880	68	3.89	23.5	0.705	8.08	19.06	0.654	2.461	0.68
C2	1226	70	4.52	28.9	0.735	8.15	20.40	0.699	2.216	0.79
C3	2083	69	3.85	24.0	0.661	8.33	17.65	0.639	0.031	0.67
C4	940	42	2.91	17.7	0.586	8.48	18.12	0.590	3.730	0.58
C5	842	37	2,48	14.5	0.564	8.40	19.04	0.557	3.903	0.51
C6	1881	71	3,81	24.0	0.680	8.15	17.99	0.641	2.870	0.66

4.2.2 NS 9410 Evaluation of the bottom fauna at station C1 (local impact zone).

According to NS 9410 the classification of the environmental status in the local impact zone can also be evaluated based on the number of species and their dominance in the bottom faunal community (see chapter 8.6.2 in NS 9410:2016).

The soft bottom communities were classified to environmental condition 1 "Very good". The criteria for condition 1 are that there are at least 20 species/0,2 m² and that none of these are in numbers exceeding 65 % of the individuals (Table 7). The data for number of species and dominating taxa at station C1 is given in Table 6 and Table 8.

Table 7. Classification of the environmental status of the soft bottom fauna at station C1 at the Hringsdalur site 2022.

Station	Site name	Num. species	Dominating taxa	Environmental condition-NS 9410
C1	Hringsdalur	68	Ampharete petersenae – 20 %	1 – Very good

Geometric classes

Figure 3 shows the number of species plotted against the number of individuals, where the number of individuals is divided into geometric classes. For an explanation of the concept of geometric classes is given in Appendix 1.

All curves started relatively high (≥ 14 species) and stretched out in varying degrees towards higher classes. These did not give any clear indications of fauna condition.

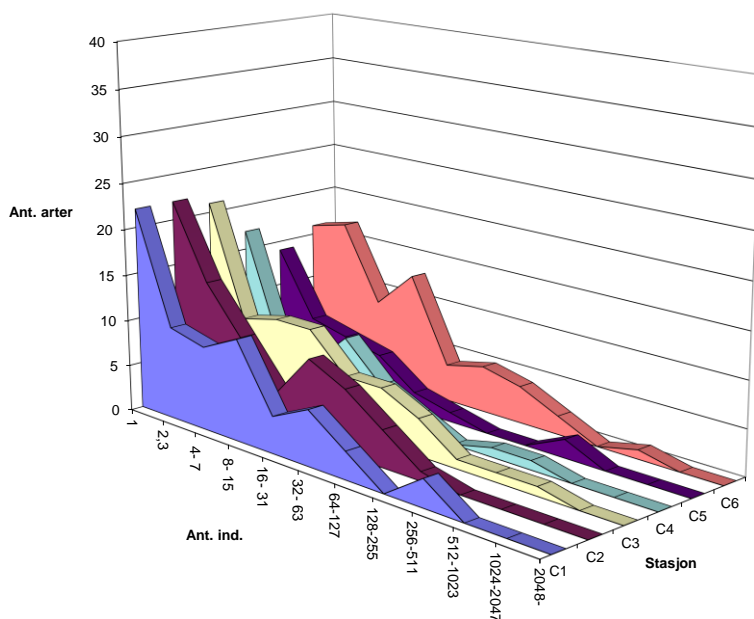


Figure 3. The soft bottom fauna shown as number of species against number of individuals pr. species in geometric classes. Hringsdalur, 2022.

4.2.3 Cluster analyses

To investigate the similarity of the faunal composition between the sampling stations, the multivariate technique cluster analysis was used. The results of this are presented in dendrogram in Figure 4.

The stations were separated in two main groups. The fauna composition at C4 and C5 was 71 % similar while the other stations had more than 76 % similarity. The two station groups were 53 % similar.

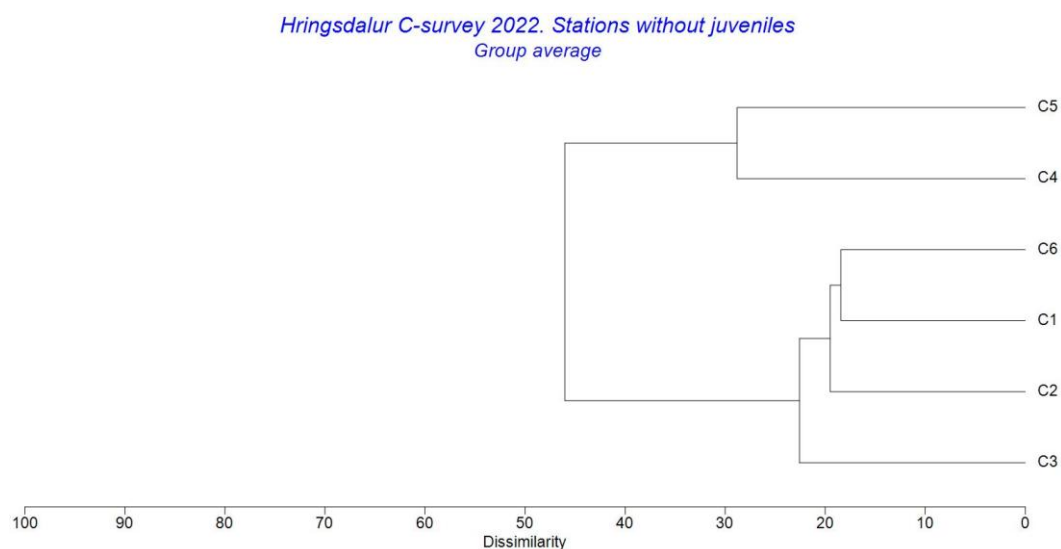


Figure 4. Cluster diagram for the soft bottom fauna at the C- sampling stations at Hringsdalur, 2022.

4.2.4 Species composition

The main features of the species composition are shown in the form of a top ten species list from each station in Table 8.

In Rygg and Norling (2013) the species are divided into five ecological groups (EG) based on the value of the sensitivity index. These groups run from sensitive species (group I) to pollution indicators (group V).

At station C1 the fauna was dominated by the polychaete *Ampharete petersenae* (EG not known) with 20 % of the individuals. The other most dominant species at the stations were a mixture of neutral, tolerant, and opportunistic species.

At C2 the fauna was dominated by the neutral bivalve *Ennucula tenuis* with 18 % of the individuals. The other most dominant species, with known EG, at the station were a mixture of neutral and opportunistic species.

At the rest of the stations the fauna was dominated by the opportunistic polychaete *Chaetozone setosa* with between 32 and 45 % of the individuals. The other most dominant species at the stations were a mixture of neutral, tolerant, and opportunistic species.

No pollution indicators were recorded among the top-10 at any of the stations.

Table 8. Number of individuals, cumulative percentage, and ecological group* for the ten most dominant species on the C stations. Hringsdalur, 2022.

C1	EG	Numb.	Cum.	C2	EG	Numb.	Cum.
Ampharete petersenae	Ik	375	20 %	Ennucula tenuis	II	225	18 %
Chaetozone setosa	IV	373	40 %	Ampharete petersenae	Ik	118	28 %
Ennucula tenuis	II	293	55 %	Myriochele malmgreni/olgae	Ik	85	35 %
Thyasira sarsii	IV	107	61 %	Thyasira sarsii	IV	75	41 %
Euchone papillosa	III	95	66 %	Chaetozone setosa	IV	72	46 %
Axinopsida orbiculata	Ik	77	70 %	Laphania boeckii	II	63	52 %
Macoma calcarea	IV	56	73 %	Macoma calcarea	IV	53	56 %
Laphania boeckii	II	42	75 %	Axinopsida orbiculata	Ik	51	60 %
Phoxocephalus holbolli	Ik	40	77 %	Eteone flava/longa	Ik	47	64 %
Praxillella praetermissa	II	35	79 %	Leitoscoloplos mammosus	Ik	40	67 %
C3	EG	Numb.	Cum.	C4	EG	Numb.	Cum.
Chaetozone setosa	IV	663	32 %	Chaetozone setosa	IV	422	45 %
Ennucula tenuis	II	270	45 %	Prionospio steenstrupi	II	206	66 %
Ampharete petersenae	Ik	220	55 %	Ennucula tenuis	II	51	72 %
Thyasira sarsii	IV	102	60 %	Euchone papillosa	III	32	75 %
Mediomastus fragilis	IV	95	65 %	Thyasira sarsii	IV	31	78 %
Axinopsida orbiculata	Ik	81	68 %	Mediomastus fragilis	IV	26	81 %
Euchone papillosa	III	72	72 %	Laphania boeckii	II	19	83 %
Laphania boeckii	II	62	75 %	Ampharete borealis	III	18	85 %
Eteone flava/longa	Ik	44	77 %	Galathowenia oculata	III	15	87 %
Macoma calcarea	IV	40	79 %	Leucon sp.	Ik	14	88 %
C5	EG	Numb.	Cum.	C6	EG	Numb.	Cum.
Chaetozone setosa	IV	349	41 %	Chaetozone setosa	IV	643	34 %
Prionospio steenstrupi	II	292	76 %	Ennucula tenuis	II	240	47 %
Ennucula tenuis	II	47	82 %	Thyasira sarsii	IV	135	54 %
Euchone papillosa	III	23	84 %	Myriochele malmgreni/olgae	Ik	103	59 %
Mediomastus fragilis	IV	18	86 %	Ampharete petersenae	Ik	95	64 %
Ophelina acuminata	II	12	88 %	Axinopsida orbiculata	Ik	70	68 %
Thyasira sarsii	IV	12	89 %	Laphania boeckii	II	69	71 %
Ampharete borealis	III	11	91 %	Mediomastus fragilis	IV	51	74 %
Galathowenia oculata	III	8	92 %	Eteone flava/longa	Ik	48	77 %
Lumbrineris mixochaeta	IV	8	93 %	Euchone papillosa	III	42	79 %

*Ecological groups: EG I = sensitive species. EG II = neutral species. EG III = tolerant species. EG IV = opportunistic species. EG V = pollution indicator species. From Rygg and Norling, 2013. Ik = unidentified group.

5 Summary and Conclusions

5.1 Summary

The results from the environmental monitoring (type C) at Hringsdalur, 2022, can be summarized as follows:

- TOC was somewhat high at all stations and nTOC varied from 29.4 to 35.9 mg/g TS. TOM-levels varied from 9.3 to 13.9 %. TN-levels were somewhat high (7.3 – 9.3 mg/g) while the C/N-ratios were low. The copper level in the sediment at C1 was somewhat high (30.1 mg/kg) according to Norwegian standards, but within reported natural levels of 55 mg/kg in Icelandic coastal areas (Egilsson *et al.* 1999). The sediment was moderately coarse to fine grained with a pelite share between 48 to 84 %. The redox measurements (pH/Eh) gave point 0 acc. Appendix D in NS 9410:2016 for all the stations.
- The number of individuals varied from 842 to 2083 and number of species from 37 to 71. The diversity H' varied from 2.48 to 4.52. At most of the stations, the overall index of nEQR was higher than 0.6. At C4 and C5 n EQR was just below 0.6. The nEQR values indicates relatively good conditions and no disturbance of the communities.

5.2 Conclusions

The results from the monitoring at the farming site Hringsdalur in April 2022 showed that the sediment was somewhat loaded with organic carbon and the copper concentrations were within reported natural levels for bottom sediment around Iceland (Egilsson *et al.*, 1999). No load effect was recorded in the fauna and faunal index nEQR showed good conditions and no impact at most of the stations (> 0.6). At C4 and C5 n EQR was just below 0.6. The diversity index H ' was just below 3 at C4 and C5 and above 3 at the other stations and ranged from 2.48 (C5) to 4.52 (C2). NS 9410:2016-assessment of the community in the local impact zone (C1) showed environmental condition 1 (Very good). No pollution indicators were recorded among the top-10 species on any of the stations. The redox measurements (pH/Eh) gave point 0 acc. Appendix D in NS 9410:2016 for all the sampling stations.

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7 Appendix (in Norwegian)

7.1 Statistiske metoder

Diversitet

Diversitet er et begrep som uttrykker mangfoldet i dyre- og plantesamfunnet på en lokalitet. Det finnes en rekke ulike mål for diversitet. Noen tar mest hensyn til artsrikheten (mål for artsrikheten), andre legger mer vekt på individfordelingen mellom artene (mål for jevnhet og dominans). Ulike mål uttrykker derved forskjellige sider ved dyresamfunnet. Diversitetsmål er "klassiske" i forurensningsundersøkelser fordi miljøforstyrrelser typisk påvirker samfunnets sammensetning. Svakheten ved diversitetsmålene er at de ikke alltid fanger opp endringer i samfunnsstrukturen. Dersom en art blir erstattet med like mange individer av en ny art, vil ikke det gjøre noe utslag på diversitetsindeksene.

Shannon-Wieners indeks (Shannon & Weaver, 1949) er gitt ved formelen:

$$H' = -\sum_{i=1}^s \frac{n_i}{N} \log_2 \left(\frac{n_i}{N} \right)$$

der n_i = antall individer av art i i prøven

N = total antall individer

s = antall arter

Indeksen tar hensyn både til antall arter og mengdefordelingen mellom artene, men det synes som indeksten er mest følsom for individfordelingen. En lav verdi indikerer et artsfattig samfunn og/eller et samfunn som er dominert av en eller få arter. En høy verdi indikerer et artsrikt samfunn.

Pielous mål for jevnhet (Pielou, 1966)

har følgende formel, der symbolene er som i Shannon-Wieners indeks

$$J = \frac{H'}{\log_2 s}$$

Hurlberts diversitetskurver

Grafisk kan diversiteten uttrykkes i form av antall arter som funksjon av antall individer. Med utgangspunkt i total antall arter og individer i en prøve søker man å beregne hvor mange arter man ville vente å finne i delprøver med færre individer. Diversitetsmålet blir derved uavhengig av prøvestørrelsen og gjør at lokaliteter med ulik individtetthet kan sammenlignes direkte. Hurlbert (1971) har gitt en metode for å beregne slike diversitetskurver basert på sannsynlighetsberegning.

ES_n er forventet antall arter i en delprøve på n tilfeldig valgte individer fra en prøve som inneholder total N individer og s arter og har følgende formel:

$$ES_n = \sum_{i=1}^s \left[1 - \frac{\binom{N-N_i}{n}}{\binom{N}{n}} \right]$$

der N = total antall individ i prøven

N_i = antall individ av art i

n = antall individ i en gitt delprøve (av de N)

s = total antall arter i prøven

Plott av antall arter i forhold til antall individer

Artene deles inn i grupper/klasser etter hvor mange individer som er registrert i en prøve. Det vanlige er å sette klasse I = 1 individ pr. art, klasse II = 2-3 individer, klasse III = 4-7 individer, klasse IV = 8-15 individer, osv., slik at de nedre klassegrensene danner en følge av ledd på formen 2^x , $x=0,1,2, \dots$. En slik følge kalles en geometrisk følge, derfor kalles klassene for geometriske klasser. Hvis antall arter innenfor hver klasse plottes mot klasseverdien på en lineær skala, vil det fremkomme en kurve som uttrykker individfordelingen mellom artene i samfunnet. Det har vist seg at i prøver fra upåvirkede samfunn vil det være mange arter med lavt individantall og få arter med høyt individantall, slik at vi får en entoppet, asymmetrisk kurve med lang "hale" mot høye klasseverdier. Denne kurven vil være godt tilpasset en log-normal fordelingskurve.

Ved moderat forurensing forsvinner en del av de individfattige artene, mens noen som blir begunstiget, øker i antall. Slik flater kurven ut, og strekker seg mot høyere klasser eller den får ekstra topper. Under slike forhold mister kurven enhver likhet med den statistiske log-normalfordelingen. Derfor kan avvik fra log-normalfordelingen tolkes som et resultat av en påvirkning/forurensing. Det har vist seg at denne metoden tidlig gir utslag ved miljøforstyrrelse. Ved sterk forurensning blir det bare noen få, men ofte svært tallrike arter tilbake. Log-normalfordelingskurven vil da ofte gjenoppstå, men med en lavere topp og spredt over flere klasser enn for uforstyrrede samfunn.

Faunaens fordelingsmønster

Variasjoner i faunaens fordelingsmønster over området beskrives ved å sammenligne tettheten av artene på hver stasjon. Til dette brukes multivariate klassifikasjons- og ordinasjons-analyser (Cluster og MDS).

Analysene i denne undersøkelsen ble utført ved hjelp av programpakken PRIMER v5. Inngangsdata er individantall pr. art, pr. prøve. Prøvene kan være replikater eller stasjoner. Det tas ikke hensyn til hvilke arter som opptrer. Forut for klassifikasjons- og ordinasjonsanalysene ble artslistene dobbelt kvadratrotransformert. Dette ble gjort for å redusere avviket mellom høye og lave tetthetsverdier og dermed redusere eventuelle effekter av tallmessig dominans hos noen få arter i datasettet.

Clusteranalyse

Analysen undersøker faunalikheten mellom prøver. For å sammenligne to prøver ble Bray-Curtis ulikhetsindeks benyttet (Bray & Curtis, 1957):

$$d_{ij} = \frac{\sum_{k=1}^n |X_{ki} - X_{kj}|}{\sum_{k=1}^n (X_{ki} + X_{kj})}$$

der n = antall arter sammenlignet

X_{ki} = antall individ av art k i prøve nr. i

X_{kj} = antall individ av art k i prøve nr. j

Indeksen avtar med økende likhet. Vi får verdien 1 hvis prøvene er helt ulike, dvs. ikke har noen felles arter. Identiske arts- og individtall vil gi verdien 0. Prøver blir gruppert sammen etter graden av likhet ved å bruke "group-average linkage". Forholdsvis like prøver danner en gruppe (cluster). Resultatet presenteres i et tredigram (dendrogram).

Ømfintlighet (AMBI, ISI og NSI)

Ømfintligheten bestemmes ved indeksene ISI og AMBI. Beregning av ISI er beskrevet av Rygg (2002). Sensitivitetsindeksen AMBI (Azti Marin Biotic Index) tilordner en ømfintlighetsklasse (økologisk gruppe, EG): EG-1: sensitive arter, EG-II: indifferente arter, EG-III: tolerante arter, EG-IV: opportunistiske arter, EG-V: forurensningsindikerende arter. Sammensetningen av makrovertebratsamfunnet i form av andelen av økologiske grupper indikerer omfanget av en forurensningspåvirkning.

NSI er en sensitivitetsindeks som ligner AMBI, men er utviklet med basis i norske faunadata og ved bruk av en objektiv statistisk metode. En prøves NSI verdi beregnes ved gjennomsnittet av sensitivitetsverdiene av alle individene i prøven.

Sammensatte indekser (NQI1 og NQI2)

Sammensatte indekser NQI1 og NQI2 bestemmes både ut fra artsmangfold og ømfintlighet. NQI1 er brukt i NEAGIG (den nordøst-atlantiske interkalibreringen). De fleste land bruker nå sammensatte indekser av samme type som NQI1 og NQI2.

NQI1 indeksen er beskrevet ved hjelp av formelen:

$$\text{NQI1 (Norwegian quality status, version 1)} = [0.5^* (1-\text{AMBI}/7) + 0.5^*(\text{SN}/2.7)^* (N/(N+5))]$$

Diversitetsindeksen $\text{SN} = \ln S / \ln(\ln N)$, hvor S er antall arter og N er antall individer i prøven

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7.2 Statistical results Hringsdalur, 2022

Number of species and individuals per station

St.	C1	C2	C3	C4	C5	C6
Ant. ind.	1880	1226	2083	940	842	1881
Ant. arter	68	70	69	42	37	71

Benthos indices per replicate

st.nr.	tot.	C1_01	C1_02	C2_01	C2_02	C3_01	C3_02	C4_01	C4_02	C5_01	C5_02	C6_01	C6_02
no. ind.	8852	775	1105	695	531	1107	976	458	482	420	422	938	943
no. spe.	109	47	60	61	47	55	51	33	33	30	28	57	55
Shannon-Wiener:		3,8	4,0	4,6	4,5	3,9	3,8	3,0	2,8	2,5	2,5	4,0	3,6
Pielou		0,69	0,67	0,77	0,81	0,68	0,66	0,59	0,56	0,50	0,52	0,68	0,63
ES100		22	25	29	29	25	23	18	17	14	15	24	24
SN		2,03	2,10	2,19	2,10	2,06	2,04	1,93	1,92	1,89	1,85	2,10	2,08
ISI-2012		7,96	8,21	8,37	7,93	8,20	8,45	8,32	8,64	8,17	8,64	8,16	8,14
AMBI		2,229	2,693	2,161	2,27	3,096	2,966	3,649	3,811	3,932	3,873	2,65	3,089
NQI1		0,71	0,70	0,75	0,72	0,66	0,66	0,59	0,58	0,57	0,56	0,70	0,66
NSI		19,7	18,4	20,0	20,8	17,5	17,8	18,2	18,0	19,3	18,8	18,6	17,4

Benthos indices, averages per station

st.nr.		C1	C2	C3	C4	C5	C6
Shannon-Wiener:		3,89	4,52	3,85	2,91	2,48	3,81
Pielou		0,68	0,79	0,67	0,58	0,51	0,66
ES100		23,5	28,9	24,0	17,7	14,5	24,0
SN		2,07	2,14	2,05	1,92	1,87	2,09
ISI-2012		8,08	8,15	8,33	8,48	8,40	8,15
AMBI		2,461	2,216	3,031	3,730	3,903	2,870
NQI1		0,70	0,74	0,66	0,59	0,56	0,68
NSI		19,06	20,40	17,65	18,12	19,04	17,99
Tilstandsklasse nEQR		0,654	0,699	0,639	0,590	0,557	0,641

Geometrical classes

int.	C1	C2	C3	C4	C5	C6
1	22	22	21	17	14	16
2,3	10	14	9	5	7	17
4-7	9	9	10	4	6	9
8-15	11	4	10	8	5	13
16-31	4	9	6	4	2	4
32-63	6	7	6	2	1	5
64-127	3	4	4	0	0	4
128-255	0	1	1	1	0	2
256-511	3	0	1	1	2	0
512-1023	0	0	1	0	0	1
1024-2047	0	0	0	0	0	0
2048-	0	0	0	0	0	0

7.3 Species lists

Artsliste pr stasjon

Hringsdalur C-survey 2022

Rekke	Klasse	Orden	Art/Taxa	Replikat:	01	02	-	Sum
Stasjonsnr.: C1								
NEMERTINI								
			Nemertea indet.		1	6	-	7
SIPUNCULIDA								
			Phascolion strombus			1	-	1
ANNELIDA								
	Polychaeta							
		Orbiniida	Aricidea sp.			10	-	10
			Leitoscoloplos mammosus			2	-	2
			Levinsenia gracilis	8	13	-	-	21
			Scoloplos armiger	1	1	-	-	2
		Spionida	Chaetozone setosa	90	283	-	-	373
			Prionospio steenstrupi	3	8	-	-	11
			Spio limicola	1		-	-	1
		Capitellida	Capitella capitata	5	16	-	-	21
			Mediomastus fragilis	13	16	-	-	29
			Praxillella gracilis	10	3	-	-	13
			Praxillella praetermissa	16	19	-	-	35
			Rhodine gracilior		1	-	-	1
		Phyllodocida	Eteone flava/longa	19	9	-	-	28
			Gattyana amondseni	1		-	-	1
			Goniada maculata		1	-	-	1
			Nephtys ciliata	2	1	-	-	3
			Nephtys pente		1	-	-	1
			Nereis sp. juv.	1		-	-	1
			Pholoe assimilis	8	26	-	-	34
			Phyllodoce groenlandica	1		-	-	1
			Phyllodoce maculata/mucosa	5	2	-	-	7
			Polynoidae indet.	3	1	-	-	4
			Syllis cornuta	1	1	-	-	2
		Eunicida	Parougia eliasoni	2	12	-	-	14
		Sternaspida	Sternaspis scutata			1	-	1
		Oweniida	Galathowenia oculata	6	9	-	-	15
			Myriochele malmgreni/olgae	2	9	-	-	11
			Owenia sp.	2	9	-	-	11
		Flabelligerida	Brada inhabilis			1	-	1
			Bradabyssa villosa	4	2	-	-	6
			Diplocirrus longisetosus	2	7	-	-	9
			Flabelligera affinis			1	-	1
			Pherusa plumosa	2		-	-	2
		Terebellida	Ampharete borealis	2	5	-	-	7
			Ampharete petersenae	188	187	-	-	375
			Lagis koreni	3	11	-	-	14
			Laphania boeckii	16	26	-	-	42
			Melinna cristata	1	1	-	-	2
			Proclea graffii			1	-	1
			Terebellides sp.	2	2	-	-	4
		Sabellida	Chone sp.			1	-	1
			Euchone incolor			3	-	3
			Euchone papillosa	44	51	-	-	95
			Laonome kroyeri			3	-	3
		Oligochaeta						

Rekke	Klasse	Orden	Art/Taxa	Replikat:	01	02	-	Sum				
CRUSTACEA			Oligochaeta indet.			4	-	4				
			Ostracoda									
			Malacostraca	Ostracoda indet.	1		-		1			
			Cumacea	Leucon sp.	2	3	-		5			
			Amphipoda	Byblis sp.	1		-		1			
				Dulichiiidae indet.			2	-	2			
				Hippomedon sp.	1		-		1			
				Lysianassidae indet.			1	-	1			
				Oedicerotidae indet.			1	-	1			
				Phoxocephalus holbolli	11	29	-		40			
			Isopoda	Pleurogonium spinosissimum			1	-	1			
			Decapoda	Hyas coarctatus			1	-	1			
			MOLLUSCA			Caudofoveata						
						Prosobranchia	Caudofoveata indet.			1	-	1
						Mesogastropoda	Onoba semicostata			1	-	1
Bivalvia	Nuculoida	Ennucula tenuis				150	143	-	293			
		Nuculana pernula				16	16	-	32			
		Nuculana sp. juv.				3	5	-	8			
		Yoldia hyperborea				3	3	-	6			
Veneroida	Abra nitida	4				4	-	8				
	Axinopsida orbiculata	42				35	-	77				
	Macoma calcarea	29				27	-	56				
	Parvicardium pinnulatum	2				1	-	3				
	Thyasira gouldii	2				8	-	10				
Thyasira sarsii	46	61				-	107					
ECHINODERMATA						Ophiuroidea						
						Ophiurida	Ophiocten affinis	1		-	1	
			Holothuroidea	Ophiuroidea indet. juv.	1	2	-	3				
			Dendrochirotida	Psolus sp. juv.	1		-	1				
				Maksverdi:	188	283		375				
				Antall arter/taxa:	51	62		72				
				Sum antall individ:				189				

Stasjonsnr.: C2

NEMERTINI

PRIAPULIDA			Nemertea indet.	1	3	-	4
			Priapulus caudatus	2		-	2
SIPUNCULIDA			Phascolion strombus	1		-	1
ANNELIDA	Polychaeta	Orbiniida	Aricidea sp.	2	6	-	8
			Leitoscoloplos mammosus	15	25	-	40
			Levinsenia gracilis	15	12	-	27
			Scoloplos armiger	1	4	-	5
			Spionida				

Rekke	Klasse	Orden	Art/Taxa	Replikat:	01	02	-	Sum
			Chaetozone setosa		32	40	-	72
			Prionospio steenstrupi		11	8	-	19
			Spio limicola		1	-	-	1
		Capitellida	Capitella capitata		19	5	-	24
			Maldane sarsi			1	-	1
			Mediomastus fragilis		14	9	-	23
			Praxillella gracilis		4	8	-	12
			Praxillella praetermissa		11	10	-	21
			Rhodine gracilior		3	-	-	3
		Opheliida	Ophelina acuminata			1	-	1
			Scalibregma inflatum			1	-	1
		Phyllodocida	Eteone barbata		1	-	-	1
			Eteone flava/longa		15	32	-	47
			Goniada maculata			1	-	1
			Harmothoe mariannae		3	4	-	7
			Nephtys ciliata		1	-	-	1
			Pholoe assimilis		14	8	-	22
			Phyllodoce maculata/mucosa		5	2	-	7
			Polynoidae indet.		2	1	-	3
			Syllis cornuta		1	-	-	1
		Eunicida	Lumbrineris mixochaeta		1	1	-	2
			Nothria conchylega			3	-	3
			Parougia eliasoni		2	4	-	6
		Sternaspida	Sternaspis scutata		1	2	-	3
		Oweniida	Galathowenia oculata		18	14	-	32
			Myriochele malmgreni/olgae		33	52	-	85
			Owenia sp.		1	-	-	1
		Flabelligerida	Bradabyssa villosa		1	-	-	1
			Diplocirrus longisetosus		10	6	-	16
			Pherusa plumosa		1	-	-	1
		Terebellida	Ampharete borealis		2	1	-	3
			Ampharete petersenae		93	25	-	118
			Lagis koreni		8	5	-	13
			Laphania boeckii		35	28	-	63
			Proclea graffii		1	-	-	1
			Terebellides sp.			1	-	1
		Sabelliida	Euchone incolor			1	-	1
			Euchone papillosa		27	5	-	32
			Laonome kroyeri		2	-	-	2
		Oligochaeta	Oligochaeta indet.		2	2	-	4
CHELICERATA		Pycnogonida	Pycnogonida indet.		1	-	-	1
CRUSTACEA		Malacostraca						
		Cumacea	Leucon sp.		2	3	-	5
		Amphipoda	Bathymedon obtusifrons		1	-	-	1
			Dulichiiidae indet.		4	-	-	4
			Gammaridea indet.		2	-	-	2
			Oedicerotidae indet.		1	-	-	1
			Paroedicerus lynceus		1	-	-	1
			Phoxocephalus holbolli		2	-	-	2
			Westwoodilla caecula			1	-	1
		Decapoda	Hyas coarctatus		1	2	-	3
MOLLUSCA		Caudofoveata	Caudofoveata indet.			2	-	2
		Prosobranchia						
		Mesogastropoda	Onoba semicostata		2	-	-	2

Rekke	Klasse	Orden	Art/Taxa	Replikat:	01	02	-	Sum
	Opisthobranchia	Cephalaspidea	Philine denticulata		1	-		1
	Bivalvia	Nuculoidea	Ennucula tenuis		121	104	-	225
			Nuculana pernula		12	6	-	18
			Nuculana sp. juv.		2	5	-	7
			Yoldia hyperborea		1	4	-	5
		Veneroidea	Abra nitida		7	2	-	9
			Axinopsida orbiculata		30	21	-	51
			Macoma calcarea		32	21	-	53
			Parvicardium pinnulatum		2	-	-	2
			Thyasira gouldii		9	9	-	18
			Thyasira sarsii		50	25	-	75
ECHINODERMATA		Ophiuroidea						
		Ophiurida	Ophiocten affinis		1	-	-	1
			Ophiuroidea indet. juv.		2	1	-	3
		Holothuroidea						
		Dendrochirotida	Psolus sp. juv.		1	-	-	1
				Maksverdi:	121	104		225
				Antall arter/taxa:	64	49		73
				Sum antall individ:				123

Stasjonsnr.: C3

NEMERTINI

			Nemertea indet.		3	4	-	7
PRIAPULIDA								
			Priapulus caudatus		2	2	-	4
ANNELIDA		Polychaeta						
		Orbiniida	Aricidea sp.		6	7	-	13
			Leitoscoloplos mammosus		27	5	-	32
			Levinsenia gracilis		6	2	-	8
			Paradoneis sp.		-	1	-	1
			Scoloplos armiger		5	-	-	5
		Spionida	Chaetozone setosa		362	301	-	663
			Prionospio steenstrupi		8	3	-	11
		Capitellida	Capitella capitata		28	4	-	32
			Mediomastus fragilis		54	41	-	95
			Praxillella gracilis		9	4	-	13
			Praxillella praetermissa		11	19	-	30
			Rhodine gracilior		3	1	-	4
		Phyllodocida	Eteone flava/longa		24	20	-	44
			Gattyana amondseni		1	-	-	1
			Goniada maculata		1	-	-	1
			Harmothoe mariannae		4	3	-	7
			Pholoe assimilis		16	9	-	25
			Pholoe baltica		-	1	-	1
			Phyllodoce maculata/mucosa		-	1	-	1
			Polynoidae indet.		1	-	-	1
			Syllis cornuta		2	-	-	2
		Eunicida	Ophryotrocha sp.		3	-	-	3
			Parougia eliasoni		6	10	-	16
			Scoletoma magnidentata		-	2	-	2
		Oweniida	Galathowenia oculata		13	11	-	24
			Myriochele malmgreni/olgae		17	15	-	32
			Owenia sp.		13	8	-	21

Rekke	Klasse	Orden	Art/Taxa	Replikat:	01	02	-	Sum
		Flabelligerida	Bradabyssa villosa		5	-		5
			Diplocirrus longisetosus		4	5	-	9
			Pherusa plumosa		2	-		2
		Terebellida	Ampharete borealis		3	6	-	9
			Ampharete finmarchica		1	-		1
			Ampharete petersenae		74	146	-	220
			Anobothrus gracilis			1	-	1
			Cistenides granulata		1	-		1
			Cistenides hyperborea			1	-	1
			Lagis koreni		6	8	-	14
			Laphania boeckii		37	25	-	62
			Melinna cristata		3	-		3
			Terebellides sp.		1	-		1
		Sabellida	Euchone incolor			3	-	3
			Euchone papillosa		31	41	-	72
			Laonome kroyeri		1	-		1
			Sabella pavonina			2	-	2
		Oligochaeta	Oligochaeta indet.		8	10	-	18
CRUSTACEA		Ostracoda	Ostracoda indet.			1	-	1
		Malacostraca						
		Cumacea	Eudorella sp.			1	-	1
			Eudorellopsis deformis		1	-		1
			Leucon sp.		5	6	-	11
		Amphipoda	Bathymedon obtusifrons			1	-	1
			Byblis sp.		2	-		2
			Caprellidae indet.		1	-		1
			Dulichidae indet.		2	2	-	4
			Oedicerotidae indet.		1	-		1
			Phoxocephalus holbolli		2	3	-	5
			Protomeadia fasciata			1	-	1
		Isopoda	Pleurogonium spinosissimum			1	-	1
MOLLUSCA		Caudofoveata	Caudofoveata indet.		1	3	-	4
		Bivalvia						
		Nuculoidea	Ennucula tenuis		142	128	-	270
			Nuculana pernula		3	4	-	7
			Nuculana sp. juv.		3	4	-	7
			Yoldia hyperborea			2	-	2
		Veneroidea	Abra nitida		7	3	-	10
			Astarte borealis		1	-		1
			Axinopsida orbiculata		40	41	-	81
			Macoma calcarea		21	19	-	40
			Thyasira gouldii		8	4	-	12
			Thyasira sarsii		68	34	-	102
ECHINODERMATA		Asteroidea	Asteroidea indet. juv.			1	-	1
		Ophiuroidea	Ophiuroidea indet. juv.		1	1	-	2
				Maksverdi:	362	301		663
				Antall arter/taxa:	57	54		72
				Sum antall individ:				209

Stasjonsnr.: C4
NEMERTINI

Rekke	Klasse	Orden	Art/Taxa	Replikat:	01	02	-	Sum		
ANNELIDA	Polychaeta	Nemertea	Nemertea indet.		4	4	-	8		
		Cossurida	Cossura longocirrata		1		-	1		
		Spionida	Chaetozone setosa		200	222	-	422		
			Prionospio steenstrupi		96	110	-	206		
			Spio limicola			1	-	1		
			Capitellida	Capitella capitata			1	-	1	
		Capitellida	Mediomastus fragilis		5	21	-	26		
			Praxillella gracilis		4	4	-	8		
			Praxillella praetermissa		1		-	1		
			Rhodine gracilior			1	-	1		
		Opheliida	Ophelina acuminata		2	7	-	9		
		Phyllodocida	Eteone flava/longa		1	1	-	2		
			Nephtys paradoxa		1		-	1		
			Nephtys pente		1		-	1		
		Amphinomida	Paramphinome jeffreysii		1		-	1		
		Eunicida	Lumbrineris mixochaeta		3	3	-	6		
			Lumbrineris sp.			1	-	1		
			Parougia eliasoni		6	3	-	9		
		Oweniida	Galathowenia oculata		7	8	-	15		
			Myriochele malmgreni/olgae		4	2	-	6		
		Terebellida	Ampharete borealis		17	1	-	18		
			Ampharete petersenae		3	7	-	10		
			Laphania boeckii		13	6	-	19		
			Leaena ebranchiata		1		-	1		
			Polycirrus medusa			1	-	1		
			Terebellides sp.			1	-	1		
			Sabellida	Euchone papillosa		20	12	-	32	
		Laonome kroyeri			1		-	1		
		Oligochaeta	Oligochaeta indet.		6	2	-	8		
		CRUSTACEA	Malacostraca	Cumacea	Eudorella sp.			1	-	1
		Amphipoda	Leucon sp.		9	5	-	14		
		Amphipoda	Bathymedon obtusifrons		1	2	-	3		
			Dulichidae indet.		3	3	-	6		
Lysianassidae indet.			1	2	-	3				
Oedicerotidae indet.			1		-	1				
MOLLUSCA	Bivalvia	Nuculoidea	Ennucula tenuis		24	27	-	51		
Nuculoidea	Nuculana pernula		3	2	-	5				
Nuculoidea	Nuculana sp. juv.		4	2	-	6				
Nuculoidea	Yoldia hyperborea			1	-	1				
Veneroidea	Axinopsida orbiculata		1	2	-	3				
	Macoma calcarea			3	-	3				
	Thyasira sarsii		16	15	-	31				
ECHINODERMATA	Asteroidea	Paxillosida	Ctenodiscus crispatus		1		-	1		
				Maksverdi:	200	222	-	422		
				Antall arter/taxa:	34	34	-	43		
				Sum antall individ:			-	946		

Rekke	Klasse	Orden	Art/Taxa	Replikat:	01	02	-	Sum
Stasjonsnr.: C5								
NEMERTINI								
			Nemertea indet.		1	5	-	6
ANNELIDA	Polychaeta							
		Orbiniida	Aricidea sp.			1	-	1
			Levinsenia gracilis			1	-	1
		Spionida	Chaetozone setosa		167	182	-	349
			Prionospio steenstrupi		156	136	-	292
			Spio limicola		1		-	1
		Capitellida	Mediomastus fragilis		10	8	-	18
			Praxillella gracilis		3	1	-	4
			Praxillella praetermissa		1		-	1
		Opheliida	Ophelina acuminata		12		-	12
			Scalibregma inflatum			1	-	1
		Phyllodocida	Eteone flava/longa		1	2	-	3
			Nephtys ciliata		1	1	-	2
			Nephtys sp.		1		-	1
		Eunicida	Lumbrineris mixochaeta		3	5	-	8
			Parougia eliasoni		1	1	-	2
		Oweniida	Galathowenia oculata		3	5	-	8
		Flabelligerida	Diplocirrus longisetosus		1		-	1
		Terebellida	Ampharete borealis		2	9	-	11
			Ampharete finmarchica		1	1	-	2
			Ampharete petersenae		1	2	-	3
			Laphania boeckii		3	1	-	4
			Melinna cristata			1	-	1
			Terebellides sp.			1	-	1
		Sabellida	Euchone papillosa		8	15	-	23
			Laonome kroyeri		1		-	1
CRUSTACEA	Malacostraca							
		Cumacea	Leucon sp.		2	4	-	6
		Amphipoda	Byblis sp.		2	1	-	3
			Dulichiiidae indet.		1	4	-	5
			Metopa sp.			1	-	1
MOLLUSCA	Bivalvia							
		Nuculoida	Ennucula tenuis		25	22	-	47
			Nuculana pernula			3	-	3
			Nuculana sp. juv.			1	-	1
			Yoldia hyperborea		1		-	1
		Veneroida	Abra nitida		1		-	1
			Axinopsida orbiculata		1		-	1
			Macoma calcarea		4	1	-	5
			Thyasira sarsii		5	7	-	12
			Maksverdi:		167	182		349
			Antall arter/taxa:		30	29		38
			Sum antall individ:					843
Stasjonsnr.: C6								
NEMERTINI								
			Nemertea indet.		5	3	-	8
PRIAPULIDA								

Rekke	Klasse	Orden	Art/Taxa	Replikat:	01	02	-	Sum
			Priapulus caudatus		4	4	-	8
SIPUNCULIDA								
			Phascolion strombus			1	-	1
ANNELIDA								
	Polychaeta							
		Orbiniida						
			Aricidea sp.		4	8	-	12
			Leitoscoloplos mammosus		1	2	-	3
			Levinsenia gracilis		3	5	-	8
		Spionida						
			Chaetozone setosa		260	383	-	643
			Prionospio steenstrupi		11	7	-	18
			Spio limicola		1		-	1
		Capitellida						
			Capitella capitata		2	2	-	4
			Mediomastus fragilis		32	19	-	51
			Praxillella gracilis		9	3	-	12
			Praxillella praetermissa		10	10	-	20
			Rhodine gracilior		1	2	-	3
		Phyllodocida						
			Eteone barbata			1	-	1
			Eteone flava/longa		15	33	-	48
			Goniada maculata			1	-	1
			Harmothoe mariannae			3	-	3
			Mystides sp.		1		-	1
			Nephtys ciliata			2	-	2
			Nephtys paradoxa			1	-	1
			Nephtys pente			1	-	1
			Pholoe assimilis		13	7	-	20
			Pholoe baltica		1	3	-	4
			Phyllococe maculata/mucosa		1	8	-	9
			Polynoidae indet.		3		-	3
			Syllis cornuta		3		-	3
		Amphinomida						
			Paramphinome jeffreysii		1		-	1
		Eunicida						
			Lumbrineris mixochaeta			1	-	1
			Parougia eliasoni		5	6	-	11
		Sternaspida						
			Sternaspis scutata		1		-	1
		Oweniida						
			Galathowenia oculata		23	12	-	35
			Myriochele malmgreni/olgae		73	30	-	103
			Owenia sp.		8	1	-	9
		Flabelligerida						
			Bradabyssa villosa		2	4	-	6
			Diplocirrus longisetosus		6		-	6
			Pherusa plumosa		1	4	-	5
		Terebellida						
			Ampharete borealis		3	5	-	8
			Ampharete petersenae		43	52	-	95
			Amphictene auricoma			1	-	1
			Lagis koreni		6	5	-	11
			Laphania boeckii		51	18	-	69
			Melinna cristata		1	1	-	2
			Proclea graffii		1		-	1
			Terebellides sp.		3		-	3
		Sabellida						
			Euchone incolor		1	1	-	2
			Euchone papillosa		25	17	-	42
			Laonome kroyeri		2		-	2
		Oligochaeta						
			Oligochaeta indet.			2	-	2
CRUSTACEA								
	Malacostraca							
		Cumacea						
			Leucon sp.		4	1	-	5
		Amphipoda						
			Bathymedon obtusifrons		1	2	-	3
			Byblis sp.		1	1	-	2
			Caprellidae indet.			1	-	1

Rekke	Klasse	Orden	Art/Taxa	Replikat:	01	02	-	Sum
			Dulichidae indet.		2	4	-	6
			Lysianassidae indet.			7	-	7
			Metopa sp.		1		-	1
			Phoxocephalus holbolli		5		-	5
			Syrrhoe crenulata		1		-	1
		Isopoda						
			Pleurogonium spinosissimum		2		-	2
MOLLUSCA								
	Prosobranchia							
		Mesogastropoda						
			Onoba semicostata			2	-	2
	Opisthobranchia							
		Cephalaspidea						
			Philine denticulata		2		-	2
			Philinidae indet.		1		-	1
	Bivalvia							
		Nuculoidea						
			Ennucula tenuis		139	101	-	240
			Nuculana pernula		14	7	-	21
			Nuculana sp. juv.		6	7	-	13
			Yoldia hyperborea		5	5	-	10
		Veneroidea						
			Abra nitida		9	3	-	12
			Axinopsida orbiculata		36	34	-	70
			Macoma calcarea		2	38	-	40
			Parvicardium pinnulatum			2	-	2
			Thyasira gouldii		6	2	-	8
			Thyasira sarsii		71	64	-	135
ECHINODERMATA								
	Ophiuroidea							
			Ophiuroidea indet. juv.		1	1	-	2
	Echinoidea							
		Echinoida						
			Echinidea indet. juv.		1		-	1
				Maksverdi:	260	383		643
				Antall arter/taxa:	60	57		74
				Sum antall individ:				189

7.4 Analytical report



ANALYSERAPPORT

Kunde: Arnarlax
Kundemerkning: 64042
Kontaktperson kunde:
Prosjektnr.: 64042

Rapport nr.: P2200096
Rapportdato: 2022-06-29
Ankomst dato: 2022-05-19

Lab-id. P2200096-02

Objekt	Kundens ID	Beskrivelse	Notering	Mottatt lab
Sediment	C2	64042 - Hringsdalur C sampling post fallow 2022		2022-05-19

Analyseresultat						
Parameter	Resultat	Enhet	Analyse dato start	Analyse dato slutt	Standard	Målesikkerhet
TOC	22	mg/g TS	2022-05-25	2022-05-27	DIN 19539:2016	±2.2
TNb	*7.3	mg/g TS	2022-05-25	2022-05-27	NS-EN 16168:2012	±2.2
N TOC	31.6	mg/g TS	2022-05-30	2022-05-30	Veileder 02:2018	
C/N - forhold	3.1		2022-05-30	2022-05-30		
TOM	9.6	% TS	2022-05-25	2022-05-31	Intern metode	±0.0
Vekt % 2 mm	0.6	wt% TS	2022-05-20	2022-05-27	Intern metode	±0.0
Vekt % 1 mm	0.3	wt% TS	2022-05-20	2022-05-27	Intern metode (Bale/Kenny 2005)	±0.0
Vekt % 0.500 mm	1.2	wt% TS	2022-05-20	2022-05-27	Intern metode (Bale/Kenny 2005)	±0.1
Vekt % 0.250 mm	3.2	wt% TS	2022-05-20	2022-05-27	Intern metode (Bale/Kenny 2005)	±0.2
Vekt % 0.125 mm	9.9	wt% TS	2022-05-20	2022-05-27	Intern metode (Bale/Kenny 2005)	±0.5
Vekt % 0.063 mm	36.6	wt% TS	2022-05-20	2022-05-27	Intern metode (Bale/Kenny 2005)	±1.8
Vekt % < 0.063 mm	48.3	wt% TS	2022-05-20	2022-05-27	Intern metode (Bale/Kenny 2005)	±2.4
Pelitt	48.3	wt% TS	2022-05-20	2022-05-27	Intern metode (Bale/Kenny 2005)	±2.4
Sand	51.1	wt% TS	2022-05-20	2022-05-27	Intern metode (Bale/Kenny 2005)	±2.6
Grus	0.6	wt% TS	2022-05-20	2022-05-27	Intern metode (Bale/Kenny 2005)	±0.0
P (Fosfor) ^a	1300	mg/kg TS	2022-06-02	2022-06-02	Intern metode	

^a Provingen er utført av eksternt laboratorium, ALS Laboratory Group

* = Ikke akkreditert resultat

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Analysereporten er digitalt undertegnet av:
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ANALYSERAPPORT

Kunde:	Arnarlax	Rapport nr.:	P2200096
Kundemerking:	64042	Rapportdato	2022-06-29
Kontaktperson kunde:		Ankomst dato	2022-05-19
Prosjektnr.:	64042		

Lab-id. P2200096-03

Objekt	Kundens ID	Beskrivelse	Notering	Mottatt lab
Sediment	C3	64042 - Hringsdalur C sampling post fallow 2022		2022-05-19

Analyseresultat						
Parameter	Resultat	Enhet	Analysedato start	Analysedato slutt	Standard	Målesikkerhet
TOC	27	mg/g TS	2022-05-25	2022-05-27	DIN 19539:2016	±2.7
TN _b	*8.2	mg/g TS	2022-05-25	2022-05-27	NS-EN 16168:2012	±2.5
N TOC	35.9	mg/g TS	2022-05-30	2022-05-30	Veileder 02:2018	
C/N - forhold	3.3		2022-05-30	2022-05-30		
TOM	9.4	% TS	2022-05-25	2022-05-31	Intern metode	±0.0
Vekt % 2 mm	0.8	wt% TS	2022-05-20	2022-05-27	Intern metode	±0.0
Vekt % 1 mm	0.2	wt% TS	2022-05-20	2022-05-27	Intern metode (Bale/Kenny 2005)	±0.0
Vekt % 0.500 mm	0.9	wt% TS	2022-05-20	2022-05-27	Intern metode (Bale/Kenny 2005)	±0.0
Vekt % 0.250 mm	2.4	wt% TS	2022-05-20	2022-05-27	Intern metode (Bale/Kenny 2005)	±0.1
Vekt % 0.125 mm	10.3	wt% TS	2022-05-20	2022-05-27	Intern metode (Bale/Kenny 2005)	±0.5
Vekt % 0.063 mm	35.1	wt% TS	2022-05-20	2022-05-27	Intern metode (Bale/Kenny 2005)	±1.8
Vekt % < 0.063 mm	50.3	wt% TS	2022-05-20	2022-05-27	Intern metode (Bale/Kenny 2005)	±2.5
Pelitt	50.3	wt% TS	2022-05-20	2022-05-27	Intern metode (Bale/Kenny 2005)	±2.5
Sand	49.0	wt% TS	2022-05-20	2022-05-27	Intern metode (Bale/Kenny 2005)	±2.4
Grus	0.8	wt% TS	2022-05-20	2022-05-27	Intern metode (Bale/Kenny 2005)	±0.0
P (Fosfor) ^a	1400	mg/kg TS	2022-06-02	2022-06-02	Intern metode	

^a Prøvingen er utført av eksternt laboratorium, ALS Laboratory Group

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Analysereporten er digitalt undertegnet av:
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ANALYSERAPPORT

Kunde:	Arnarlax	Rapport nr.:	P2200096
Kundemerking:	64042	Rapportdato	2022-06-29
Kontaktperson kunde:		Ankomst dato	2022-05-19
Prosjektnr.:	64042		

Lab-id. P2200096-04

Objekt	Kundens ID	Beskrivelse	Notering	Mottatt lab
Sediment	C4	64042 - Hringsdalur C sampling post fallow 2022	Aggleromater i kornfraksjoner > 0,250 mm.	2022-05-19

Analyseresultat						
Parameter	Resultat	Enhet	Analysedato start	Analysedato slutt	Standard	Måleusikkerhet
TOC	25	mg/g TS	2022-05-25	2022-05-27	DIN 19539:2016	±2.5
TNb	*7.5	mg/g TS	2022-05-25	2022-05-27	NS-EN 16168:2012	±2.2
N TOC	30.4	mg/g TS	2022-05-30	2022-05-30	Veileder 02:2018	
C/N - forhold	3.4		2022-05-30	2022-05-30		
TOM	13.1	% TS	2022-05-25	2022-05-31	Intern metode	±0.0
Vekt % 2 mm	0.3	wt% TS	2022-05-20	2022-05-27	Intern metode	±0.0
Vekt % 1 mm	3.6	wt% TS	2022-05-20	2022-05-27	Intern metode (Bale/Kenny 2005)	±0.2
Vekt % 0.500 mm	5.8	wt% TS	2022-05-20	2022-05-27	Intern metode (Bale/Kenny 2005)	±0.3
Vekt % 0.250 mm	4.5	wt% TS	2022-05-20	2022-05-27	Intern metode (Bale/Kenny 2005)	±0.2
Vekt % 0.125 mm	4.0	wt% TS	2022-05-20	2022-05-27	Intern metode (Bale/Kenny 2005)	±0.2
Vekt % 0.063 mm	9.2	wt% TS	2022-05-20	2022-05-27	Intern metode (Bale/Kenny 2005)	±0.5
Vekt % < 0.063 mm	72.6	wt% TS	2022-05-20	2022-05-27	Intern metode (Bale/Kenny 2005)	±3.6
Pelitt	72.6	wt% TS	2022-05-20	2022-05-27	Intern metode (Bale/Kenny 2005)	±3.6
Sand	27.1	wt% TS	2022-05-20	2022-05-27	Intern metode (Bale/Kenny 2005)	±1.4
Grus	0.3	wt% TS	2022-05-20	2022-05-27	Intern metode (Bale/Kenny 2005)	±0.0
P (Fosfor) ^a	1300	mg/kg TS	2022-06-02	2022-06-02	Intern metode	

^a Prøvingen er utført av eksternt laboratorium, ALS Laboratory Group

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ANALYSERAPPORT

Kunde:	Arnarlax	Rapport nr.:	P2200096
Kundemerking:	64042	Rapportdato	2022-06-29
Kontaktperson kunde:		Ankomst dato	2022-05-19
Prosjektnr.:	64042		

Lab-id. P2200096-05

Objekt	Kundens ID	Beskrivelse	Notering	Mottatt lab
Sediment	C5	64042 - Hringsdalur C sampling post fallow 2022	Aggleromater i kornfraksjoner > 0,250 mm.	2022-05-19

Analyseresultat						
Parameter	Resultat	Enhet	Analyse dato start	Analyse dato slutt	Standard	Målesikkerhet
TOC	27	mg/g TS	2022-05-25	2022-05-27	DIN 19539:2016	±2.7
TN _b	*8.5	mg/g TS	2022-05-25	2022-05-27	NS-EN 16168:2012	±2.6
N TOC	29.4	mg/g TS	2022-05-30	2022-05-30	Veileder 02:2018	
C/N - forhold	3.1		2022-05-30	2022-05-30		
TOM	13.9	% TS	2022-05-25	2022-05-31	Intern metode	±0.0
Vekt % 2 mm	3.8	wt% TS	2022-05-20	2022-05-27	Intern metode	±0.2
Vekt % 1 mm	3.2	wt% TS	2022-05-20	2022-05-27	Intern metode (Bale/Kenny 2005)	±0.2
Vekt % 0.500 mm	1.9	wt% TS	2022-05-20	2022-05-27	Intern metode (Bale/Kenny 2005)	±0.1
Vekt % 0.250 mm	1.0	wt% TS	2022-05-20	2022-05-27	Intern metode (Bale/Kenny 2005)	±0.1
Vekt % 0.125 mm	1.3	wt% TS	2022-05-20	2022-05-27	Intern metode (Bale/Kenny 2005)	±0.1
Vekt % 0.063 mm	4.7	wt% TS	2022-05-20	2022-05-27	Intern metode (Bale/Kenny 2005)	±0.2
Vekt % < 0.063 mm	84.1	wt% TS	2022-05-20	2022-05-27	Intern metode (Bale/Kenny 2005)	±4.2
Pelitt	84.1	wt% TS	2022-05-20	2022-05-27	Intern metode (Bale/Kenny 2005)	±4.2
Sand	12.1	wt% TS	2022-05-20	2022-05-27	Intern metode (Bale/Kenny 2005)	±0.6
Grus	3.8	wt% TS	2022-05-20	2022-05-27	Intern metode (Bale/Kenny 2005)	±0.2
P (Fosfor) ^a	1100	mg/kg TS	2022-06-02	2022-06-02	Intern metode	

^a Prøvingen er utført av eksternt laboratorium, ALS Laboratory Group

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ANALYSERAPPORT

Kunde: Arnarlax	Rapport nr.: P2200096
Kundemerking: 64042	Rapportdato: 2022-06-29
Kontaktperson kunde: 64042	Ankomst dato: 2022-05-19

Lab-id. P2200096-06

Objekt	Kundens ID	Beskrivelse	Notering	Mottatt lab
Sediment	C6	64042 - Hringsdalur C sampling post fallow 2022		2022-05-19

Analyseresultat						
Parameter	Resultat	Enhet	Analysedato start	Analysedato slutt	Standard	Målesikkerhet
TOC	23	mg/g TS	2022-05-25	2022-05-27	DIN 19539:2016	±2.3
TNb	*6.9	mg/g TS	2022-05-25	2022-05-27	NS-EN 16168:2012	±2.1
N TOC	30.2	mg/g TS	2022-05-30	2022-05-30	Veileder 02:2018	
C/N - forhold	3.3		2022-05-30	2022-05-30		
TOM	10.1	% TS	2022-05-25	2022-05-31	Intern metode	±0.0
Vekt % 2 mm	0.1	wt% TS	2022-05-20	2022-05-27	Intern metode	±0.0
Vekt % 1 mm	0.3	wt% TS	2022-05-20	2022-05-27	Intern metode (Bale/Kenny 2005)	±0.0
Vekt % 0.500 mm	1.6	wt% TS	2022-05-20	2022-05-27	Intern metode (Bale/Kenny 2005)	±0.1
Vekt % 0.250 mm	3.5	wt% TS	2022-05-20	2022-05-27	Intern metode (Bale/Kenny 2005)	±0.2
Vekt % 0.125 mm	9.1	wt% TS	2022-05-20	2022-05-27	Intern metode (Bale/Kenny 2005)	±0.5
Vekt % 0.063 mm	28.2	wt% TS	2022-05-20	2022-05-27	Intern metode (Bale/Kenny 2005)	±1.4
Vekt % < 0.063 mm	57.1	wt% TS	2022-05-20	2022-05-27	Intern metode (Bale/Kenny 2005)	±2.9
Pelitt	57.1	wt% TS	2022-05-20	2022-05-27	Intern metode (Bale/Kenny 2005)	±2.9
Sand	42.8	wt% TS	2022-05-20	2022-05-27	Intern metode (Bale/Kenny 2005)	±2.1
Grus	0.1	wt% TS	2022-05-20	2022-05-27	Intern metode (Bale/Kenny 2005)	±0.0
P (Fosfor) ^a	1000	mg/kg TS	2022-06-02	2022-06-02	Intern metode	

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ANALYSERAPPORT

Kunde:	Arnarlax	Rapport nr.:	P2200096
Kundemerking:	64042	Rapportdato	2022-06-29
Kontaktperson kunde:		Ankomst dato	2022-05-19
Prosjektnr.:	64042		

Analyseansvarlig:

Oda Sofie Bye Wilhelmsen

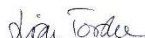
Signatur:



Lisa Torske

Underskriftsberettiget:

Signatur:



Analysene gjelder bare for de prøver som er testet. De oppgitte analyseresultat omfatter ikke feil som måtte følge av prøvetagningen, inhomogenitet eller andre forhold som kan ha påvirket prøven før den ble mottatt av laboratoriet. Rapporten får kun kopieres i sin helhet og uten noen form for endringer. En eventuell klage skal leveres laboratoriet senest en måned etter mottak av analyseresultat. Nærmere informasjon om analysemetodene (målesikkerhet, metodeprinsipp etc.) fås ved henvendelse til Akvaplan-Niva AS

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