C-survey at Eyri (max biomass), 2022

Arnarlax ehf

Akvaplan-niva AS Report: 2023 64474.01

Fram Centre | P.O. Box 6066 Stakkevollan | 9296 Tromsø | Norway | +47 777 50 300 | www.akvaplan.niva.no

Arnarlax ehf. C-Survey at Eyri (max biomass), 2022.

Author(s) Kamila Sztybor, Snorri Gunnarsson

Date 01.03 2023
Report no. 2023 64474.01
No of pages 38
Distribution Through customer only

Customer

Arnarlax ehf
Contact person Silja Baldvinsdóttir
Address Strandgötu 1, 456 Bíldudal.

Summary

The results from the monitoring at the farming site Eyri in November 2022 showed that the sediment was loaded with organic carbon and the copper concentration at C1 was above reported natural levels for bottom sediment around Iceland (Egilsson *et al.*, 1999).

A load effect was recorded in the fauna and the faunal index nEQR showed disturbed conditions at all stations except C2 (> 0.6). The diversity index H ' was below 3 at all stations except C2. The NS 9410:2016-assessment of the community in the local impact zone (C1) showed environmental condition 3 (Bad). A pollution indicator (*Capitella capitata*) was recorded among the top-10 species at all stations except C2.

The redox measurements (pH/Eh) gave point 0 acc. Appendix D in NS 9410:2016 for station C1. The oxygen saturation in November was good in the whole water column with 90 % in the bottom water.

Approval

Project leader

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Quality control

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Preface

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

Snorri Gunnarsson	Akvaplan-niva	Field work, report, project leader.
Kamila Sztybor	Akvaplan-niva	Report, professional assessments, and interpretations.
Hans-Petter Mannvik	Akvaplan-niva	Identification of bottom fauna (Echinodermata). 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.
Marina V. Alonso	Akvaplan-niva	Identification of bottom fauna (Polychaeta).
Jesper Hansen	Akvaplan-niva	Identification of bottom fauna (Mollusca).
Stine Hermansen	Akvaplan-niva	Hydrographical vertical profiles
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 carried out by Akvaplan-niva AS with ALS Laboratory Group (Czech Republic) as a sub-contractor.

NORSK AKKREDITERING TEST 079

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, 01.03. 2023

Snorri Gunnarsson (Project Manager)

1 Data Summary

Client information			
Report title:	C-Survey at Eyri (max biomass), 2022.		
Report nr.	2023 64474.01	Site:	Eyri
Municipality:		Map Coordinates (construction):	65°34,723 N 23°58,675 V
MTB permitted:	8.193	Operations manager:	Silja Baldvinsdóttir
Client:	Arnarlax ehf		

Biomass/production status at time of survey (18.11 2022)			
Fish group:	A. Salmon	Biomass on examination:	7.699 t
Feed input:	10.468 t	Produced amount of fish:	7.986 t
Type/time of survey			
Maximum biomass:	X	Follow up study:	
Fallow (resting period):		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)	0,136	Fauna C1 (impact zone)	0,36
Fauna C2	0,748	Fauna C2	4,63
Fauna C3	0,218	Fauna C3	1,00
Fauna C4 (deep area)	0,404	Fauna C4 (deep area)	2,31
Fauna C5	0,204	Fauna C5	0,84
Fauna C6	0,557	Fauna C6	2,95
Date fieldwork:	18.11.2022	**Date of report:**	28.02 2023
Notes to other results (sediment, pH/Eh, oxygen)			nTOC from 29,9 to 71,2 mg/g DS. Copper 144 mg/kg DS at C1 Fosfor from 568 to 1550 mg/kg DS. Eh positive at all stations O_2-conditions were good throughout the water column.
Responsible for field work:	Signature: SGU	Project manager Snorri Gunnarsson	Signature: SGU

2 Introduction

2.1 Background and aim of the study

On behalf of Arnarlax ehf, Akvaplan-niva completed a survey (type C) for a fish farming site at Eyri (Figure 1). The survey fulfils the requirements of 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 (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 Icelandic officials so it is not possible to strictly 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.

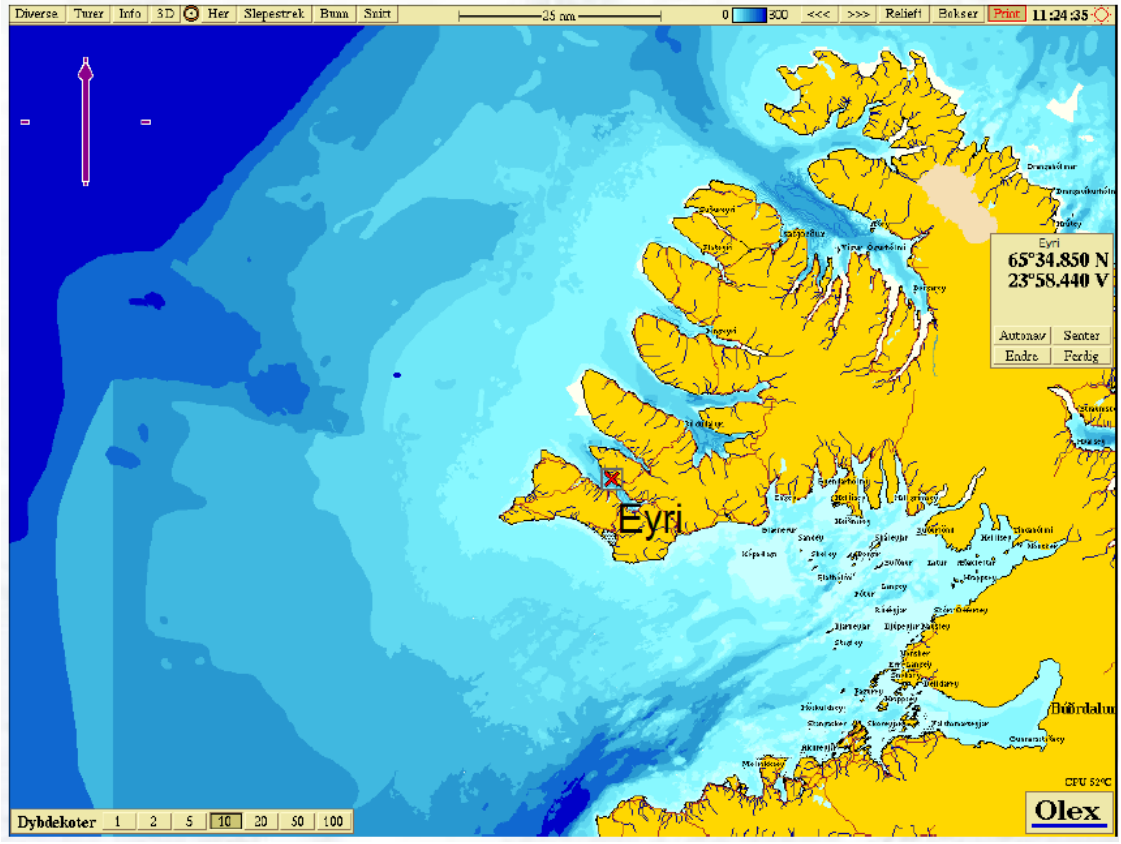

Figure 1 Overview of Vestfjords Iceland with the farming site Eyri in Patreksfjörður (red cross). The map coordinates for the midpoint of the farming site are given to the right.

2.2 Site operation and feed use

This is the second generation farmed fish at the site that started with putting fish into sea in summer 2021. At the time of the survey, the standing stock was approximately 7.699 tonnes of salmon (3rd generation) with an average weight of 4.8 kg per fish (Tzamouranis pers. comm.). Total production of salmon for the current generation was 7.986 ton and feed use was 10.468 ton.

The plant is a frame mooring with a total of fourteen 160 meters circumference cages in a 2 x 7 configuration.

In Iceland, the MTB (maximum allowable biomass) 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 current generation is 8.193 tonnes, used as MTB here (Tzamouranis, pers. comm).

2.3 Previous surveys

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

Table 1: Previous surveys at Eyri.

Survey date	Report reference (author, year)	Production (tonnes)	Type of survey and result
17.05 2018	Mannvik & Gunnarsson 2019	0	Pre-survey (type C)
05.03 2020	Mannvik & Gunnarsson 2020	5.143	ASC/C survey at max biomass
28.05 2021	Sztybor & Gustavsson 2021	0	C survey fallow period

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 for the 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 (rev 2020). *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 Eyri, 2022. TOC = total organic carbon. GSA = grain size analysis 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. GSA, TOM. TN. Cu. pH/Eh.
C2 (transition zone outer)	Quantitative analyses of bottom fauna. TOC. GSA, TOM. TN.
C3 (transition zone)	Quantitative analyses of bottom fauna. TOC. GSA, TOM. TN.
C4 (transect zone, deep area)	Quantitative analyses of bottom fauna. TOC. GSA, TOM. TN. Hydrography/O_2.
C5 (transition zone)	Quantitative analyses of bottom fauna. TOC. GSA, TOM. TN.
C6 (transition zone)	Quantitative analyses of bottom fauna. TOC. GSA, TOM. TN.

Field work was completed on 18.11.2022.

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 8.193 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. The stations were placed in the direction of the main oceanic current direction at 43 m depth (Hermansen, 2020).

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

Station	Depth, m	Distance from frame, m	Position	
			N	W
C1	54	25	65°34.786	23°59.156
C2	45	500	65°34.957	23°59.620
C3	55	100	65°34.816	23°59.224
C4	56	175	65°34.847	23°59.290
C5	54	115	65°34.839	23°58.782
C6	56	300	65°34.887	23°59.422

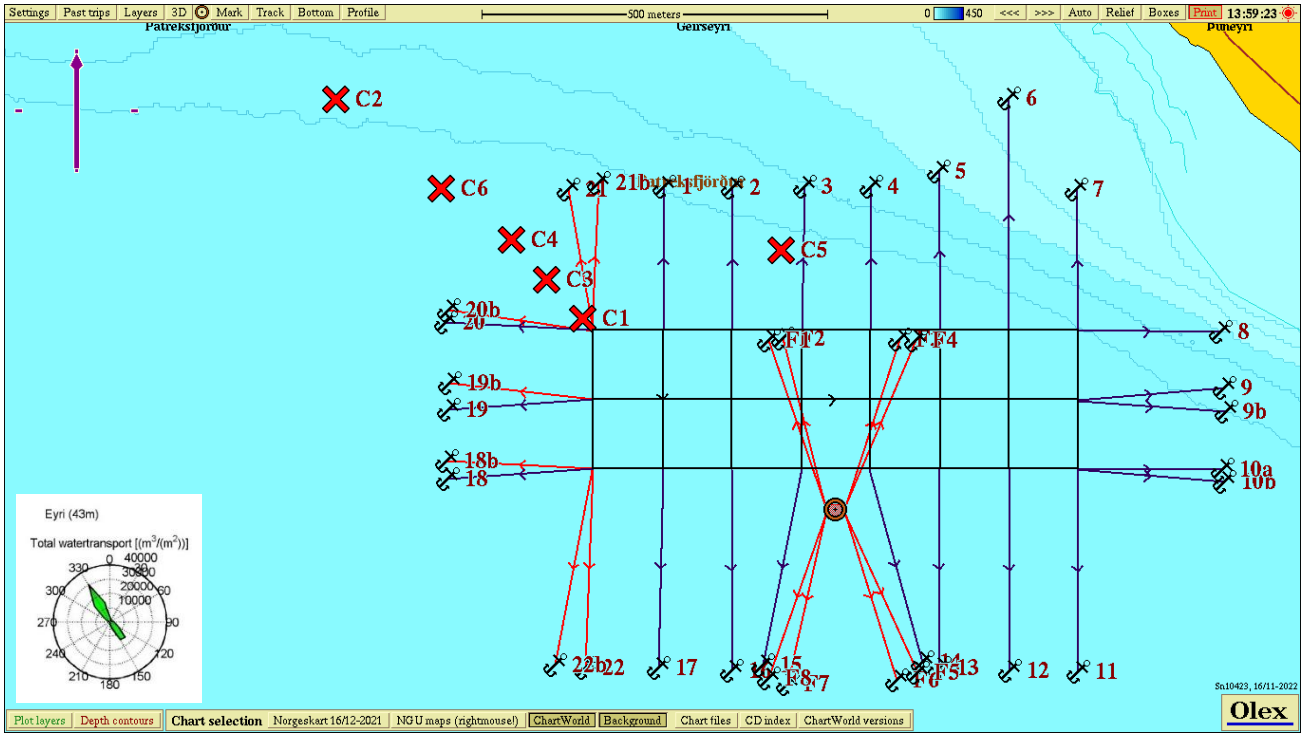

Figure 2. Map showing the sampling stations for the C-survey at Eyri, 2022. Current measurements used were from 43 m depth (Hermansen, 2020).

3.2 Hydrography and oxygen

At station C4, hydrographic measurements, salinity, temperature, density, and oxygen saturation were taken for vertical surface to bottom profiles using a Sensordata CTDO 204 probe.

3.3 Soft bottom sampling and analyses

3.3.1 Fieldwork

Sediment samples were collected with a 0.1 m^2 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 prior to 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 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 Akvaplan niva internal standard 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 DIN EN 17505:2022 (Investigation of solids – Temperature-dependent differentiation of total carbon (TOC_{400}, ROC, TIC_{900})). To classify the environmental conditions based on the content of TOC, the measured concentrations are normalized for the 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 in accordance with SS-EN ISO 17294-2:2016 and US EPA Method 200.8:1994.

3.3.6 Phosphorus (P)

Following a pre-treatment, the samples were quantified according to ČSN 720116-1 (720116) where phosphoruspentaoxide, P_2O_5 forms a phosphorusmolybden-vanadiumcomplex. 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.

3.3.7 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 with 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, that is 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 m^2 van Veen grab. Only grab samples where the grab was completely closed and the surface undisturbed were approved. The contents were washed through a 1 mm sieve and the remaining material fixed with 4 % formalin with Bengal Rose dye added and then 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 taxonomic level possible and quantified by specialists (taxonomists). The quantitative lists of species were statistically analysed. 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 (ES_{100}) – expected number of species pr. 100 individuals
- Pielou's evenness index (J)
- Sensitivities index (Ømfintlighet) (ISI_{2012}), 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 Hydrography and oxygen

The hydrographical profile for the deep station C4 in November 2022 is presented in Figure 3.

Temperature was between 6,4 °C and 6,6 °C from top to bottom, with oxygen saturation 97 % in the upper layer and 90 % in the bottom layer.

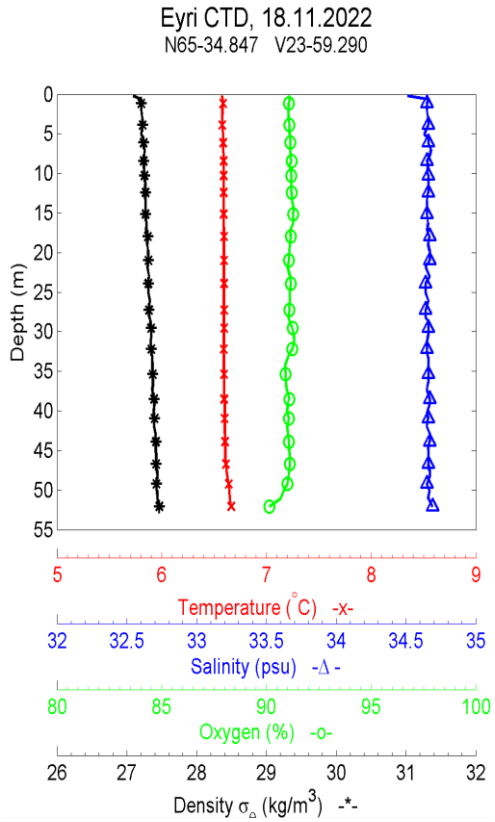

Figure 3. Vertical profiles. Temperature, salinity, density, and oxygen at C4 at Eyri, 2022.

4.2 Sediment

4.2.1 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 6,7 to 15,4 %. TN-levels were low (1,4 – 3,1 mg/g). The C/N-ratio was high at all stations. TOC was high at all stations and nTOC varied from 29,9 to 71,2 mg/g DS. The bottom sediments grain size varied from moderately coarse to fine grained with a pelite ratio ranging from 45 to 85 %.

Redox measurements (pH/Eh) gave a point of 0 for station C1 according to Appendix D in NS 9410:2016.

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

St.	Sediment description	TOM	TOC	nTOC	TN	C/N	Pelite	pH/Eh
C1	Brown/black sediment consisting mainly of mud. Some dead algae in the sample.	15,4	64,1	71,2	1,4	46,5	60,5	7,71/353
C2	Grey/olive green sediment consisting mainly of mud with mixture of sand, shellsand and small stones.	6,7	20,1	29,9	1,9	10,5	45,8	7,60/395
C3	Grey/olive green sediment consisting mainly of mud. Some smell in second grab replicate. Thin black organic layer in top.	13,5	41,0	44,0	2,5	16,2	83,2	7,68/351
C4	Grey/olive green sediment consisting mainly of mud. Some smell. Thin black organic layer in top.	13,3	47,2	50,7	2,0	23,9	80,8	7,77/343
C5	Grey/olive green sediment consisting mainly of mud. Thin black organic layer in top.	15,3	58,7	66,8	1,8	33,2	54,8	7,72/364
C6	Grey/olive green sediment consisting mainly of mud. Some smell. Thin black organic layer in top.	14,7	48,3	50,8	3,1	15,6	85,9	7,59/232

4.2.2 Copper

Levels of copper in bottom sediments at station C1 are shown in Table 5. The level of copper was 144 mg/kg DS.

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

St.	Cu
C1	144

4.2.3 Phosphorus

Levels of phosphorus in bottom sediments at Eyri are shown in Table 5. The level of phosphorus varied from 568 mg/kg (C2) to 1550 mg/kg (C1) was DS.

Table 6. Phosphorus (P), mg/kg DS. Eyri, 2022.

St.	P
C1	1550
C2	568
C3	926
C4	892
C5	1190
C6	1080

4.3 Soft-bottom fauna

4.3.1 Faunal indices

Results from the quantitative soft bottom faunal analyses at the C-stations are presented in Table 7.

The number of individuals varied from 344 (C4) to 2464 (C1) and number of species from 7 (C1) to 67 (C2). The diversity H' varied from 0,36 to 4,63. At all stations except C2, the overall index of nEQR was lower than 0.6. The nEQR values indicate 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 0.16 to 0.80 which indicates a somewhat uneven distribution at most of the stations.

Table 7. Number of species and individuals pr. 0,2 m2. H´ = Shannon-Wiener's diversity index. ES100 = Hurlberts diversity index. NQI1 = overall index (diversity and sensitivity). ISI2012 = 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 Eyri, 2022.

St.	No. of individuals.	No. of species	H´	ES_{100}	NQI1	ISI_{2012}	NSI	nEQR	AMBI	J
C1	2464	7	0,36	2,99	0,24	4,17	7,08	0,136	5,777	0,16
C2	1208	67	4,63	31,11	0,78	9,30	21,56	0,748	1,639	0,80
C3	853	16	1,00	6,81	0,35	4,37	7,86	0,218	5,641	0,27
C4	344	19	2,31	12,37	0,50	5,77	12,51	0,404	4,033	0,59
C5	1016	14	0,84	5,76	0,33	4,71	7,94	0,204	5,574	0,25
C6	467	30	2,95	15,01	0,66	6,64	18,69	0,557	2,242	0,68

4.3.2 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 3 "Bad". The criteria for condition 2 are that there are 5 to 19 species/0.2 m^2 and that none of these are in numbers exceeding 90 % of the individuals (Table 8). The data for number of species and dominating taxa at station C1 is given in Table 7 and Table 9.

Table 8. Classification of the environmental status of the soft bottom fauna at station C1 at the Eyri site 2022.

Station	Site name	Num. species	Dominating taxa	Environmental condition-NS 9410
C1	Eyri	7	Capitella capitata – 94 %	3 - Bad

Geometric classes

Figure 4 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 except C2 started relatively low (≤ 15 species) and stretched out in varying degrees towards higher classes. The curves at C1, C3 and C5 indicates faunal disturbance at these stations.

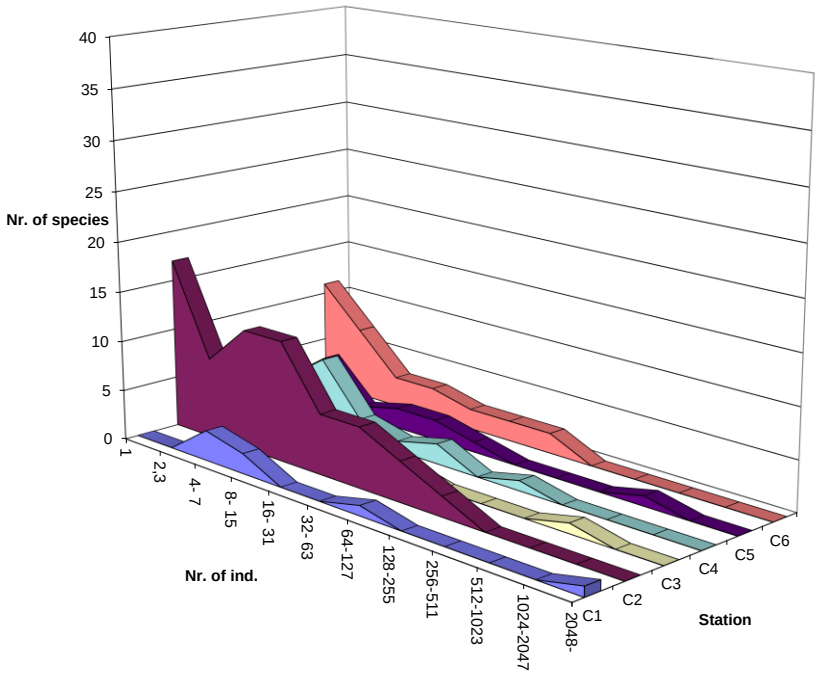

Figure 4. The soft bottom fauna shown as number of species against number of individuals pr. species in geometric classes. Eyri, 2022.

4.3.3 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 5.

The fauna composition at station C3 and C5 was 70 % similar, and 50 % similar with C4 and C6. Station C1 was 40 % similar to those 4 stations and station C2 was only 23 % similar with the other stations.

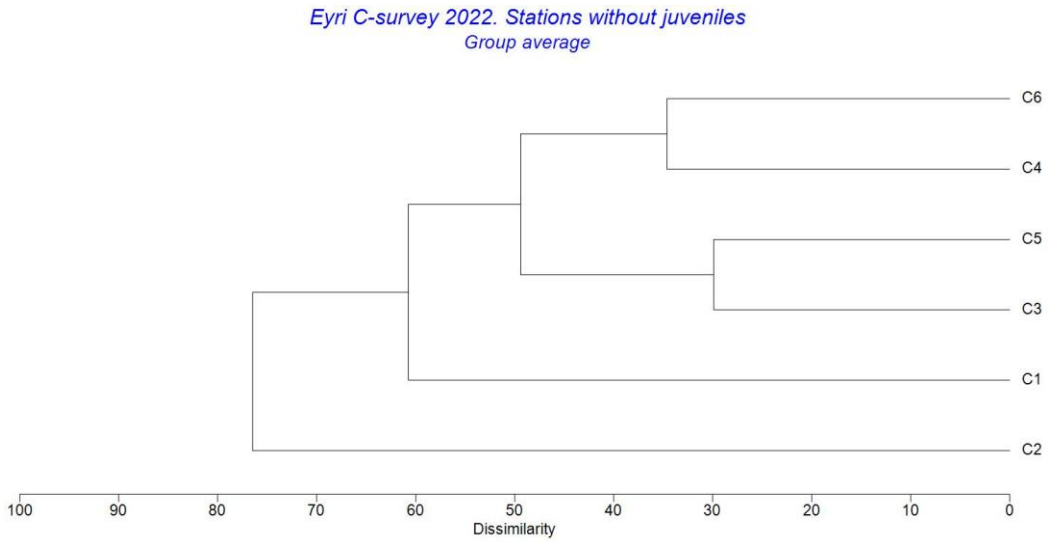

Figure 5. Cluster diagram for the soft bottom fauna at the C- sampling stations at Eyri, 2022.

4.3.4 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 9.

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 (EG I) to pollution indicators (EG V).

Stations C1, C3, C4 and C5 were dominated by the pollution indicator species *Capitella capitata* (polychaeta) with between 49 and 94 % of the individuals. The other most dominant species at the stations were a mixture of sensitive, neutral, tolerant, and opportunistic species.

Station C2 and C6 were dominated by the tolerant polychaeta *Galathowenia oculata* with 12 and 26 % of the individuals. The other most dominant species at stations C2 were sensitive, neutral, tolerant, and opportunistic species. At station C6 the other most dominant species were neutral, tolerant, opportunistic and one pollution indicator (*Capitella capitata*).

Table 9. Number of individuals, cumulative percentage, and ecological group for the ten most dominant species at the C stations. Eyri, 2022.*

C1	EG	Numb.	Cum.	C2	EG	Numb.	Cum.
Capitella capitata	V	2324	94 %	Galathowenia oculata	III	149	12 %
Microphthalmus sczelkowii		108	99 %	Gammaridea indet.		145	24 %
Mytilus edulis	IV	12	99 %	Maldane sarsi	IV	115	33 %
Malacoceros vulgaris		8	99 %	Ennucula tenuis	II	77	39 %
Ennucula tenuis	II	4	100 %	Scoloplos armiger	III	70	45 %
Mediomastus fragilis	IV	4	100 %	Lagis koreni	IV	69	51 %
Nemertea indet.	III	4	100 %	Pholoe assimilis	III	51	55 %
Ophiuroidea indet. juv.	II	4	100 %	Nuculana pernula	II	40	58 %
				Nothria conchylega	I	34	61 %
				Prionospio steenstrupi	II	33	63 %
C3	**EG**	**Numb.**	**Cum.**	**C4**	**EG**	**Numb.**	**Cum.**
Capitella capitata	V	736	86 %	Capitella capitata	V	168	49 %
Thyasira sarsii	IV	36	90 %	Thyasira sarsii	IV	46	62 %
Malacoceros vulgaris		31	94 %	Ennucula tenuis	II	36	72 %
Mediomastus fragilis	IV	16	96 %	Eteone flava/longa		17	77 %
Scalibregma inflatum	III	10	97 %	Microphthalmus sczelkowii		15	82 %
Microphthalmus sczelkowii		6	98 %	Pholoe baltica	III	12	85 %
Eteone flava/longa		4	98 %	Axinopsida orbiculata		7	87 %
Pholoe baltica	III	4	99 %	Yoldia hyperborea		7	89 %
Chaetozone setosa	IV	2	99 %	Macoma calcarea	IV	6	91 %
Yoldia hyperborea		2	99 %	Laonice bahusiensis	I	5	92 %
C5	**EG**	**Numb.**	**Cum.**	**C6**	**EG**	**Numb.**	**Cum.**
Capitella capitata	V	873	86 %	Galathowenia oculata	III	122	26 %
Mediomastus fragilis	IV	60	92 %	Ennucula tenuis	II	117	51 %
Pholoe baltica	III	22	94 %	Capitella capitata	V	63	64 %
Thyasira sarsii	IV	21	96 %	Thyasira sarsii	IV	36	72 %
Scalibregma inflatum	III	13	97 %	Axinopsida orbiculata		28	78 %
Eteone flava/longa		8	98 %	Yoldia hyperborea		21	82 %
Malacoceros vulgaris		4	99 %	Lagis koreni	IV	14	85 %
Echiurus echiurus		3	99 %	Pholoe baltica	III	12	88 %
Ennucula tenuis	II	3	99 %	Eteone flava/longa		10	90 %
Gattyana amondseni		3	99 %	Microphthalmus sczelkowii		6	91 %

*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 Eyri, 2022, can be summarised as follows:

- The hydrography measurements showed good oxygen conditions throughout the water column with 90 % saturation in the bottom layer in November 2022.
- TOC was rather high at all stations and nTOC varied from 29,9 to 71,2 mg/g DS. TOM-levels varied from 6,7 to 15,4 %. TN-levels were low (1,4 – 2,5 mg/g) while the C/N-ratio was high. The copper level in the sediment at C1 was elevated (144 mg/kg) according to Norwegian standards, and above 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 45 and 85 %. The redox measurements (pH/Eh) gave point 0 acc. Appendix D in NS 9410:2016 for station C1.
- The number of individuals varied from 344 to 2464 and number of species from 7 to 67. The diversity H' varied from 0,36 to 4,63. At all stations except C2, the overall index of nEQR was lower than 0.6. The nEQR values indicates some disturbance of the communities.

5.2 Conclusions

The results from the monitoring at the farming site Eyri in November 2022 showed that the sediment was loaded with organic carbon and the copper concentration at C1 was above reported natural levels for bottom sediment around Iceland (Egilsson *et al.*, 1999). A load effect was recorded in the fauna and faunal index nEQR which showed disturbed conditions at all stations except C2 (> 0.6). The diversity index H ' was below 3 at all stations except C2. The NS 9410:2016-assessment of the community in the local impact zone (C1) showed environmental condition 3 (Bad). A pollution indicator (*Capitella capitata*) was recorded among the top-10 species at all stations except C2. The redox measurements (pH/Eh) gave point 0 acc. Appendix D in NS 9410:2016 for station C1. The oxygen saturation in November was good in the whole water column with 90 % in the bottom water.

Since the previous C-survey at fallow period in 2021 (Sztybor and Gustavsson, 2021) the station placement in the 2022 study area is somewhat different as station C5 is now in the northern part of the farm area, orthogonal to the main spread current and in the current survey C4 represents the previous C6 station and visa versa. In comparison with the results from previous C-survey at fallow the diversity index H´ and the faunal index score is trending lower at all stations except C2 and C6. No pollution indicators were recorded among the top-10 species on any of the stations in the 2021 survey, but the pollution indicator (*Capitella capitata*) was recorded among the top-10 species at all stations except C2 in the present survey. NS 9410:2016-assessment of the community in the local impact zone (C1) showed environmental condition 1 (Very good) at fallow period in 2021 but now at max biomass has environmental condition 3 (bad).

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Pers. comm. Nikolas Tzamouranis, project manager, Arnarlax

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 indeksen 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, ... 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 kvadratrot-transformert. 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):

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

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 trediagram (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 makroevertebratsamfunnet 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:

NQI1 (Norwegian quality status, version 1) = [0.5* (1-AMBI/7) + 0.5*(SN/2.7)* (N/(N+5)]

Diversitetsindeksen SN = lnS/ln(lnN), hvor S er antall arter og N er antall individer i prøven

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7.2 Statistical results Eyri, 2022

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.	6352	1156	1308	665	543	309	544	179	165	621	395	238	229
no. spe.	79	5	5	53	59	15	10	17	12	13	7	22	19
Shannon-Wiener:		0,29	0,43	4,60	4,66	1,35	0,64	3,34	1,28	1,20	0,47	3,24	2,66
Pielou		0,13	0,19	0,80	0,79	0,35	0,19	0,82	0,36	0,32	0,17	0,73	0,63
ES100		3,16	2,82	30,53	31,70	8,34	5,27	15,29	9,45	7,60	3,92	16,79	13,23
SN		0,82	0,82	2,12	2,22	1,55	1,25	1,72	1,52	1,38	1,09	1,82	1,74
ISI-2012		4,17	4,17	9,41	9,19	4,50	4,23	6,72	4,82	4,80	4,61	6,52	6,77
AMBI		5,865	5,688	1,768	1,509	5,537	5,744	2,765	5,300	5,331	5,817	2,898	1,586
NQI1		0,23	0,24	0,76	0,80	0,39	0,32	0,61	0,40	0,37	0,28	0,62	0,70
NSI		7,10	7,05	21,47	21,64	8,30	7,43	16,34	8,68	8,52	7,35	16,52	20,87
DI		1,01	1,07	0,77	0,68	0,44	0,69	0,20	0,17	0,74	0,55	0,33	0,31

Geometrical classes

int.	cla.	C1	C2	C3	C4	C5	C6
1	1	0	17	6	2	2	11
2,3	2	0	8	2	4	5	7
4- 7	3	3	12	3	7	1	3
8- 15	4	2	12	1	2	2	3
16- 31	5	0	6	2	1	2	2
32- 63	6	0	6	1	2	1	2
64-127	7	1	4	0	0	0	2
128-255	8	0	2	0	1	0	0
256-511	9	0	0	0	0	0	0
512-1023	10	0	0	1	0	1	0
1024-2047	11	0	0	0	0	0	0
2048-	12	1	0	0	0	0	0

7.3 Species lists

Artsliste pr stasjon

Eyri ASC-C-survey 2022

Rekke	Klasse	Orden	Art/Taxa	Replikat:	01	02	-	Sum
Stasjonsnr.:	**C1**							
NEMERTINI								
			Nemertea indet.		4		-	4
ANNELIDA								
	Polychaeta							
		Spionida						
			Malacoceros vulgaris		4	4	-	8
		Capitellida						
			Capitella capitata		1112	1212	-	2324
			Mediomastus fragilis			4	-	4
		Phyllodocida						
			Microphthalmus sczelkowii		24	84	-	108
MOLLUSCA								
	Bivalvia							
		Nuculoida						
			Ennucula tenuis			4	-	4
		Mytiloida						
			Mytilus edulis		12		-	12
ECHINODERMATA								
	Ophiuroidea							
			Ophiuroidea indet. juv.		4		-	4
				Maksverdi:	1112	1212		2324
				Antall arter/taxa:	6	5		8
				Sum antall individ:				2468
Stasjonsnr.:	**C2**							
NEMERTINI								
			Nemertea indet.		2	1	-	3
SIPUNCULIDA								
			Phascolion strombus		4	1	-	5
ANNELIDA								
	Polychaeta							
		Orbiniida						
			Aricidea catherinae		1	4	-	5
			Leitoscoloplos mammosus		4	1	-	5
			Levinsenia gracilis		7	8	-	15
			Paraonidae indet.		1	1	-	2
			Scoloplos armiger		33	37	-	70
		Spionida						
			Apistobranchus sp.			1	-	1
			Chaetozone setosa		8	2	-	10
			Laonice bahusiensis		3	1	-	4
			Prionospio cirrifera			3	-	3
			Prionospio sp.			1	-	1
			Prionospio steenstrupi		17	16	-	33
			Spio armata			1	-	1
			Spio limicola		3	4	-	7
			Tharyx killariensis			1	-	1
		Capitellida						
			Maldane sarsi		68	47	-	115
			Maldanidae indet.		8	5	-	13
			Mediomastus fragilis		1	2	-	3
			Praxillella gracilis		11	16	-	27
			Praxillella praetermissa		20	12	-	32

Rekke	Klasse	Orden	Art/Taxa	Replikat:	01	02	-	Sum
			Rhodine gracilior		7	4	-	11
		Opheliida						
			Ophelina acuminata			1	-	1
			Scalibregma inflatum		6	5	-	11
		Phyllodocida						
			Eteone flava/longa		5	5	-	10
			Goniada maculata			1	-	1
			Pholoe assimilis		29	22	-	51
			Pholoe baltica		16	10	-	26
			Phyllodoce groenlandica		1		-	1
			Polynoidae indet.		1	7	-	8
			Syllis cornuta		7	10	-	17
		Eunicida						
			Lumbrineridae indet.		4	1	-	5
			Lumbrineris mixochaeta		3		-	3
			Nothria conchylega		21	13	-	34
			Parougia eliasoni		3	1	-	4
			Scoletoma fragilis		8	9	-	17
		Sternaspida						
			Sternaspis scutata		8		-	8
		Oweniida						
			Galathowenia oculata		129	20	-	149
			Myriochele malmgreni/olgae		1		-	1
			Owenia sp.			1	-	1
		Flabelligerida						
			Saphobranchia longisetosa		3	1	-	4
		Terebellida						
			Ampharete lindstroemi			1	-	1
			Amphicteis gunneri			1	-	1
			Cistenides hyperborea			1	-	1
			Lagis koreni		41	28	-	69
			Laphania boecki		6	3	-	9
			Melinna cristata		2		-	2
CRUSTACEA								
	Ostracoda							
			Ostracoda indet.		4		-	4
	Malacostraca							
		Amphipoda						
			Dulichiidae indet.			1	-	1
			Gammaridea indet.		34	111	-	145
			Hippomedon sp.			1	-	1
MOLLUSCA								
	Caudofoveata							
			Caudofoveata indet.		1	4	-	5
	Bivalvia							
		Nuculoida						
			Ennucula tenuis		43	34	-	77
			Nuculana pernula		21	19	-	40
			Yoldia hyperborea		14	10	-	24
		Mytiloida						
			Crenella decussata		2	2	-	4
		Veneroida						
			Abra nitida		9	5	-	14
			Arctica islandica		1	4	-	5
			Astarte elliptica		1		-	1
			Axinopsida orbiculata		18	14	-	32
			Ciliatocardium ciliatum			1	-	1
			Macoma calcarea		5	6	-	11
			Parvicardium pinnulatum		1	2	-	3
			Thyasira gouldii		7	13	-	20
			Thyasira sarsii		10	4	-	14
		Myoida						
			Mya sp. juv.		1		-	1
		Pholadomyoida						
			Lyonsia arenosa		1	2	-	3
ECHINODERMATA								
	Ophiuroidea							
		Ophiurida						
			Ophiocten affinis		1		-	1
			Ophiuroidea indet. juv.		13	12	-	25

Rekke	Klasse	Orden	Art/Taxa	Replikat:	01	02	-	Sum
				Maksverdi:	129	111		149
				Antall arter/taxa:	55	60		69
				Sum antall individ:				1234

Stasjonsnr.: C3

ECHIURIDA							
			Echiurus echiurus		1	-	1
ANNELIDA							
	Polychaeta						
		Spionida					
			Chaetozone setosa	1	1	-	2
			Malacoceros vulgaris	26	5	-	31
		Capitellida					
			Capitella capitata	240	496	-	736
			Mediomastus fragilis	1	15	-	16
		Opheliida					
			Scalibregma inflatum	9	1	-	10
		Phyllodocida					
			Eteone flava/longa	2	2	-	4
			Microphthalmus sczelkowii	1	5	-	6
			Pholoe baltica	3	1	-	4
		Eunicida					
			Parougia eliasoni	1		-	1
		Terebellida					
			Lagis koreni	1		-	1
CRUSTACEA							
	Malacostraca						
		Cumacea					
			Leucon sp.	1		-	1
MOLLUSCA							
	Bivalvia						
		Nuculoida					
			Ennucula tenuis	1		-	1
			Yoldia hyperborea	2		-	2
		Veneroida					
			Abra nitida	1		-	1
			Thyasira sarsii	19	17	-	36
ECHINODERMATA							
	Ophiuroidea						
			Ophiuroidea indet. juv.		1	-	1
				Maksverdi:	240	496	736
				Antall arter/taxa:	15	11	17
				Sum antall individ:			854

Stasjonsnr.: C4

ANNELIDA							
	Polychaeta						
		Spionida					
			Laonice bahusiensis	5		-	5
			Malacoceros vulgaris	1	2	-	3
		Capitellida					
			Capitella capitata	38	130	-	168
			Mediomastus fragilis	2		-	2
		Opheliida					
			Scalibregma inflatum	1	2	-	3
		Phyllodocida					
			Eteone flava/longa	14	3	-	17
			Microphthalmus sczelkowii	14	1	-	15
			Pholoe baltica	10	2	-	12
			Syllis cornuta		1	-	1
		Oweniida					
			Galathowenia oculata		3	-	3
		Terebellida					
			Lagis koreni	1		-	1

Rekke	Klasse	Orden	Art/Taxa	Replikat:	01	02	-	Sum
CRUSTACEA								
	Malacostraca							
		Cumacea						
			Leucon sp.		4		-	4
		Amphipoda						
			Oedicerotidae indet.		4		-	4
MOLLUSCA								
	Bivalvia							
		Nuculoida						
			Ennucula tenuis		36		-	36
			Yoldia hyperborea		7		-	7
		Veneroida						
			Abra nitida		3	1	-	4
			Axinopsida orbiculata		6	1	-	7
			Macoma calcarea		5	1	-	6
			Thyasira sarsii		28	18	-	46
ECHINODERMATA								
	Ophiuroidea							
			Ophiuroidea indet. juv.		2		-	2
				Maksverdi:	38	130		168
				Antall arter/taxa:	18	12		20
				Sum antall individ:				346

Stasjonsnr.: C5

NEMERTINI								
			Nemertea indet.		2		-	2
PRIAPULIDA								
			Priapulus caudatus		1	1	-	2
ECHIURIDA								
			Echiurus echiurus		3		-	3
ANNELIDA								
	Polychaeta							
		Spionida						
			Dipolydora sp.		1		-	1
			Malacoceros vulgaris		1	3	-	4
		Capitellida						
			Capitella capitata		505	368	-	873
			Mediomastus fragilis		42	18	-	60
		Opheliida						
			Scalibregma inflatum		13		-	13
		Phyllodocida						
			Eteone flava/longa		8		-	8
			Gattyana amondseni		3		-	3
			Pholoe baltica		21	1	-	22
		Eunicida						
			Parougia eliasoni			1	-	1
MOLLUSCA								
	Bivalvia							
		Nuculoida						
			Ennucula tenuis		3		-	3
		Veneroida						
			Thyasira sarsii		18	3	-	21
				Maksverdi:	505	368		873
				Antall arter/taxa:	13	7		14
				Sum antall individ:				1016

Stasjonsnr.: C6

NEMERTINI

Rekke	Klasse	Orden	Art/Taxa	Replikat:	01	02	-	Sum
			Nemertea indet.		1		-	1
PRIAPULIDA								
			Priapulus caudatus			1	-	1
ANNELIDA								
	Polychaeta							
		Orbiniida						
			Scoloplos armiger			1	-	1
		Spionida						
			Prionospio steenstrupi			1	-	1
			Spio limicola		2	1	-	3
		Capitellida						
			Capitella capitata		63		-	63
			Maldane sarsi			1	-	1
		Opheliida						
			Scalibregma inflatum		3		-	3
		Phyllodocida						
			Eteone flava/longa		10		-	10
			Microphthalmus sczelkowii		6		-	6
			Nephtys ciliata			2	-	2
			Pholoe baltica		7	5	-	12
			Polynoidae indet.		1		-	1
			Syllis cornuta			1	-	1
		Eunicida						
			Parougia eliasoni		2		-	2
		Oweniida						
			Galathowenia oculata		32	90	-	122
			Myriochele malmgreni/olgae			1	-	1
		Terebellida						
			Lagis koreni		9	5	-	14
CRUSTACEA								
	Malacostraca							
		Cumacea						
			Leucon sp.		1		-	1
		Amphipoda						
			Dulichiidae indet.			1	-	1
			Oedicerotidae indet.		2	3	-	5
MOLLUSCA								
	Prosobranchia							
		Mesogastropoda						
			Euspira pallida		1		-	1
	Bivalvia							
		Nuculoida						
			Ennucula tenuis		58	59	-	117
			Nuculana pernula		2	4	-	6
			Yoldia hyperborea		11	10	-	21
		Veneroida						
			Abra nitida		2		-	2
			Axinopsida orbiculata		6	22	-	28
			Macoma calcarea		2		-	2
			Thyasira sarsii		16	20	-	36
ECHINODERMATA								
	Ophiuroidea							
		Ophiurida						
			Ophiocten affinis		1	1	-	2
			Ophiuroidea indet. juv.		1	2	-	3
				Maksverdi:	63	90		122
				Antall arter/taxa:	23	20		31
				Sum antall individ:				470

7.4 Analytical report

Akvaplan niva

NORSK AKKREDITERING TEST 079

ANALYSIS REPORT

Customer:	Arnarlax	**Report no.:**	P2200206
Client reference:	Eyri (Island)		
Client person:		**Report date**	**2023-02-16**
Project no.:	**64474**	**Date Registrered:**	2022-11-17

Lab-id. P2200206-01

Sample type	Kundens ID	Description	Note	Mottatt lab
Sediment	C1	64474 - Eyri C/ASC og B undersøkelse 2022	TOC-resultat større enn ca 60 mg/g TS kan gi underestimert TN-resultat og derved gi forhøyet C/N-verdi.	2022-11-17

Analyseresultat

Parameter	Resultat	Unit	Analysis date start	Analysis date end	Norm	Measurement uncertainty
TOC	64	mg/g TS	2022-12-13	2022-12-15	DIN EN 17505:2022	±6.4
TNb	1.4	mg/g TS	2022-12-13	2022-12-15	NS-EN 16168:2012	±0.4
N TOC	71.2	mg/g TS	2022-12-19	2022-12-19	Veileder 02:2018	
C/N - ratio	46.5		2022-12-19	2022-12-19		
TOM	15.4	% TS	2022-12-06	2022-12-08	Internal method	±0.0
Weight % 2 mm	0.8	wt% TS	2022-12-05	2022-12-12	Internal method (Bale/Kenny 2005)	±0.0
Weight% 1 mm	0.2	wt% TS	2022-12-05	2022-12-12	Internal method (Bale/Kenny 2005)	±0.0
Weight% 0.500 mm	0.5	wt% TS	2022-12-05	2022-12-12	Internal method (Bale/Kenny 2005)	±0.0
Weight% 0.250 mm	16.7	wt% TS	2022-12-05	2022-12-12	Internal method (Bale/Kenny 2005)	±0.8
Weight% 0.125 mm	15.3	wt% TS	2022-12-05	2022-12-12	Internal method (Bale/Kenny 2005)	±0.8
Vekt% 0.063 mm	6.2	wt% TS	2022-12-05	2022-12-12	Internal method (Bale/Kenny 2005)	±0.3
Weight% < 0.063 mm	60.5	wt% TS	2022-12-05	2022-12-12	Internal method (Bale/Kenny 2005)	±3.0
Pelite	60.5	wt% TS	2022-12-05	2022-12-12	Internal method (Bale/Kenny 2005)	±3.0
Sand	38.8	wt% TS	2022-12-05	2022-12-12	Internal method (Bale/Kenny 2005)	±1.9
Gravel	0.8	wt% TS	2022-12-05	2022-12-12	Internal method (Bale/Kenny 2005)	±0.0
Copper (Cu) [a]	144	mg/kg TS	2022-12-08	2022-12-08	Intern metode	
P (Fosfor) [a]	1550	mg/kg TS	2022-12-08	2022-12-08	Intern metode	

[a] The analytical testing has been carried out by an external laboratory, ALS Laboratory Group

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Akvaplan-niva
Fram Centre
P.O. Box 6606 Stakkevollan
N-9296 Tromsø

kjemi@akvaplan.niva.no
www.akvaplan.niva.no

ph.: +47 77 75 03 00
NO 937 375 158 MVA

The analysis report is digitally signed by:
Ingar H. Wasbotten

ihw@akvaplan.niva.no

ANALYSIS REPORT

Customer:	Arnarlax	**Report no.:**	P2200206
Client reference:	Eyri (Island)		
Client person:		**Report date**	**2023-02-16**
Project no.:	**64474**	**Date Registrered:**	2022-11-17

Lab-id. P2200206-02

Sample type	Kundens ID	Description	Note	Mottatt lab
Sediment	C2 / ASCref	64474 - Eyri C/ASC og B undersøkelse 2022		2022-11-17

Analyseresultat

Parameter	Resultat	Unit	Analysis date start	Analysis date end	Norm	Measurement uncertainty
TOC	**20**	mg/g TS	2022-12-13	2022-12-15	DIN EN 17505:2022	±2.0
TNb	**1.9**	mg/g TS	2022-12-13	2022-12-15	NS-EN 16168:2012	±0.6
N TOC	**29.9**	mg/g TS	2022-12-19	2022-12-19	Veileder 02:2018	
C/N - ratio	**10.5**		2022-12-19	2022-12-19		
TOM	**6.7**	% TS	2022-12-06	2022-12-08	Internal method	±0.0
Weight % 2 mm	**7.5**	wt% TS	2022-12-05	2022-12-12	Internal method (Bale/Kenny 2005)	±0.4
Weight% 1 mm	**2.2**	wt% TS	2022-12-05	2022-12-12	Internal method (Bale/Kenny 2005)	±0.1
Weight% 0.500 mm	**2.7**	wt% TS	2022-12-05	2022-12-12	Internal method (Bale/Kenny 2005)	±0.1
Weight% 0.250 mm	**11.2**	wt% TS	2022-12-05	2022-12-12	Internal method (Bale/Kenny 2005)	±0.6
Weight% 0.125 mm	**8.8**	wt% TS	2022-12-05	2022-12-12	Internal method (Bale/Kenny 2005)	±0.4
Vekt% 0.063 mm	**21.8**	wt% TS	2022-12-05	2022-12-12	Internal method (Bale/Kenny 2005)	±1.1
Weight% < 0.063 mm	**45.8**	wt% TS	2022-12-05	2022-12-12	Internal method (Bale/Kenny 2005)	±2.3
Pelite	**45.8**	wt% TS	2022-12-05	2022-12-12	Internal method (Bale/Kenny 2005)	±2.3
Sand	**46.7**	wt% TS	2022-12-05	2022-12-12	Internal method (Bale/Kenny 2005)	±2.3
Gravel	**7.5**	wt% TS	2022-12-05	2022-12-12	Internal method (Bale/Kenny 2005)	±0.4
Copper (Cu) [a]	**30.0 31.5**	mg/kg TS	2022-12-08	2022-12-08	Intern metode	
P (Fosfor) [a]	**568**	mg/kg TS	2022-12-08	2022-12-08	Intern metode	

[a] The analytical testing has been carried out by an external laboratory, ALS Laboratory Group

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Akvaplan-niva
Fram Centre
P.O. Box 6606 Stakkevollan
N-9296 Tromsø

kjemi@akvaplan.niva.no
www.akvaplan.niva.no

ph.: +47 77 75 03 00
NO 937 375 158 MVA

The analysis report is digitally signed by:
Ingar H. Wasbotten

ihw@akvaplan.niva.no

ANALYSIS REPORT

Customer:	Arnarlax	**Report no.:**	P2200206
Client reference:	Eyri (Island)		
Client person:		**Report date**	**2023-02-16**
Project no.:	**64474**	**Date Registrered:**	2022-11-17

Lab-id. P2200206-03

Sample type	Kundens ID	Description	Note	Mottatt lab
Sediment	C3 / ASC1	64474 - Eyri C/ASC og B undersøkelse 2022		2022-11-17

Analyseresultat

Parameter	Resultat	Unit	Analysis date start	Analysis date end	Norm	Measurement uncertainty
TOC	**41**	mg/g TS	2022-12-13	2022-12-15	DIN EN 17505:2022	±4.1
TNb	**2.5**	mg/g TS	2022-12-13	2022-12-15	NS-EN 16168:2012	±0.8
N TOC	**44.0**	mg/g TS	2022-12-19	2022-12-19	Veileder 02:2018	
C/N - ratio	**16.2**		2022-12-19	2022-12-19		
TOM	**13.5**	% TS	2022-12-06	2022-12-08	Internal method	±0.0
Weight % 2 mm	**0.1**	wt% TS	2022-12-05	2022-12-12	Internal method (Bale/Kenny 2005)	±0.0
Weight% 1 mm	**2.0**	wt% TS	2022-12-05	2022-12-12	Internal method (Bale/Kenny 2005)	±0.1
Weight% 0.500 mm	**3.3**	wt% TS	2022-12-05	2022-12-12	Internal method (Bale/Kenny 2005)	±0.2
Weight% 0.250 mm	**6.3**	wt% TS	2022-12-05	2022-12-12	Internal method (Bale/Kenny 2005)	±0.3
Weight% 0.125 mm	**3.0**	wt% TS	2022-12-05	2022-12-12	Internal method (Bale/Kenny 2005)	±0.2
Vekt% 0.063 mm	**2.1**	wt% TS	2022-12-05	2022-12-12	Internal method (Bale/Kenny 2005)	±0.1
Weight% < 0.063 mm	**83.2**	wt% TS	2022-12-05	2022-12-12	Internal method (Bale/Kenny 2005)	±4.2
Pelite	**83.2**	wt% TS	2022-12-05	2022-12-12	Internal method (Bale/Kenny 2005)	±4.2
Sand	**16.8**	wt% TS	2022-12-05	2022-12-12	Internal method (Bale/Kenny 2005)	±0.8
Gravel	**0.1**	wt% TS	2022-12-05	2022-12-12	Internal method (Bale/Kenny 2005)	±0.0
P (Fosfor) [a]	**926**	mg/kg TS	2022-12-08	2022-12-08	Intern metode	

[a] The analytical testing has been carried out by an external laboratory, ALS Laboratory Group

* = Non-accredited result

Akvaplan-niva
Fram Centre
P.O. Box 6606 Stakkevollan
N-9296 Tromsø

kjemi@akvaplan.niva.no
www.akvaplan.niva.no

ph.: +47 77 75 03 00
NO 937 375 158 MVA

The analysis report is digitally signed by:
Ingar H. Wasbotten

ihw@akvaplan.niva.no

ANALYSIS REPORT

Customer:	Arnarlax	**Report no.:**	P2200206
Client reference:	Eyri (Island)		
Client person:		**Report date**	**2023-02-16**
Project no.:	**64474**	**Date Registrered:**	2022-11-17

Lab-id. P2200206-04

Sample type	Kundens ID	Description	Note	Mottatt lab
Sediment	C4 / ASC3	64474 - Eyri C/ASC og B undersøkelse 2022		2022-11-17

Analyseresultat

Parameter	Resultat	Unit	Analysis date start	Analysis date end	Norm	Measurement uncertainty
TOC	47	mg/g TS	2022-12-13	2022-12-15	DIN EN 17505:2022	±4.7
TNb	2.0	mg/g TS	2022-12-13	2022-12-15	NS-EN 16168:2012	±0.6
N TOC	50.7	mg/g TS	2022-12-19	2022-12-19	Veileder 02:2018	
C/N - ratio	23.9		2022-12-19	2022-12-19		
TOM	13.3	% TS	2022-12-06	2022-12-08	Internal method	±0.0
Weight % 2 mm	0.2	wt% TS	2022-12-05	2022-12-12	Internal method (Bale/Kenny 2005)	±0.0
Weight% 1 mm	1.7	wt% TS	2022-12-05	2022-12-12	Internal method (Bale/Kenny 2005)	±0.1
Weight% 0.500 mm	3.4	wt% TS	2022-12-05	2022-12-12	Internal method (Bale/Kenny 2005)	±0.2
Weight% 0.250 mm	6.6	wt% TS	2022-12-05	2022-12-12	Internal method (Bale/Kenny 2005)	±0.3
Weight% 0.125 mm	3.8	wt% TS	2022-12-05	2022-12-12	Internal method (Bale/Kenny 2005)	±0.2
Vekt% 0.063 mm	3.6	wt% TS	2022-12-05	2022-12-12	Internal method (Bale/Kenny 2005)	±0.2
Weight% < 0.063 mm	80.8	wt% TS	2022-12-05	2022-12-12	Internal method (Bale/Kenny 2005)	±4.0
Pelite	80.8	wt% TS	2022-12-05	2022-12-12	Internal method (Bale/Kenny 2005)	±4.0
Sand	19.0	wt% TS	2022-12-05	2022-12-12	Internal method (Bale/Kenny 2005)	±1.0
Gravel	0.2	wt% TS	2022-12-05	2022-12-12	Internal method (Bale/Kenny 2005)	±0.0
Copper (Cu) [a]	40.6 41.3	mg/kg TS	2022-12-08	2022-12-08	Intern metode	
P (Fosfor) [a]	892	mg/kg TS	2022-12-08	2022-12-08	Intern metode	
Emamectinbenzoat [b]	*940	ng/kg TS	2023-02-06	2023-02-06	Intern metode	

[a] The analytical testing has been carried out by an external laboratory, ALS Laboratory Group

[b] Prøvingen er utført av eksternt laboratorium, NIVA

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Akvaplan-niva
Fram Centre
P.O. Box 6606 Stakkevollan
N-9296 Tromsø

kjemi@akvaplan.niva.no
www.akvaplan.niva.no

ph.: +47 77 75 03 00
NO 937 375 158 MVA

The analysis report is digitally signed by:
Ingar H. Wasbotten

ihw@akvaplan.niva.no

ANALYSIS REPORT

Customer:	Arnarlax	**Report no.:**	P2200206
Client reference:	Eyri (Island)		
Client person:		**Report date**	**2023-02-16**
Project no.:	**64474**	**Date Registrered:**	2022-11-17

Lab-id. P2200206-05

Sample type	Kundens ID	Description	Note	Mottatt lab
Sediment	C5 / ASC2	64474 - Eyri C/ASC og B undersøkelse 2022		2022-11-17

Analyseresultat

Parameter	Resultat	Unit	Analysis date start	Analysis date end	Norm	Measurement uncertainty
TOC	**59**	mg/g TS	2022-12-13	2022-12-15	DIN EN 17505:2022	±5.9
TNb	**1.8**	mg/g TS	2022-12-13	2022-12-15	NS-EN 16168:2012	±0.5
N TOC	**66.8**	mg/g TS	2022-12-19	2022-12-19	Veileder 02:2018	
C/N - ratio	**33.2**		2022-12-19	2022-12-19		
TOM	**15.3**	% TS	2022-12-06	2022-12-08	Internal method	±0.0
Weight % 2 mm	**0.1**	wt% TS	2022-12-05	2022-12-12	Internal method (Bale/Kenny 2005)	±0.0
Weight% 1 mm	**1.0**	wt% TS	2022-12-05	2022-12-12	Internal method (Bale/Kenny 2005)	±0.0
Weight% 0.500 mm	**0.9**	wt% TS	2022-12-05	2022-12-12	Internal method (Bale/Kenny 2005)	±0.0
Weight% 0.250 mm	**20.2**	wt% TS	2022-12-05	2022-12-12	Internal method (Bale/Kenny 2005)	±1.0
Weight% 0.125 mm	**18.0**	wt% TS	2022-12-05	2022-12-12	Internal method (Bale/Kenny 2005)	±0.9
Vekt% 0.063 mm	**5.1**	wt% TS	2022-12-05	2022-12-12	Internal method (Bale/Kenny 2005)	±0.3
Weight% < 0.063 mm	**54.8**	wt% TS	2022-12-05	2022-12-12	Internal method (Bale/Kenny 2005)	±2.7
Pelite	**54.8**	wt% TS	2022-12-05	2022-12-12	Internal method (Bale/Kenny 2005)	±2.7
Sand	**45.1**	wt% TS	2022-12-05	2022-12-12	Internal method (Bale/Kenny 2005)	±2.3
Gravel	**0.1**	wt% TS	2022-12-05	2022-12-12	Internal method (Bale/Kenny 2005)	±0.0
P (Fosfor) [a]	**1190**	mg/kg TS	2022-12-08	2022-12-08	Intern metode	

[a] The analytical testing has been carried out by an external laboratory, ALS Laboratory Group

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Akvaplan-niva
Fram Centre
P.O. Box 6606 Stakkevollan
N-9296 Tromsø

kjemi@akvaplan.niva.no
www.akvaplan.niva.no

ph.: +47 77 75 03 00
NO 937 375 158 MVA

The analysis report is digitally signed by:
Ingar H. Wasbotten

ihw@akvaplan.niva.no

ANALYSIS REPORT

Customer:	Arnarlax	**Report no.:**	P2200206
Client reference:	Eyri (Island)		
Client person:		**Report date**	**2023-02-16**
Project no.:	**64474**	**Date Registrered:**	2022-11-17

Lab-id. P2200206-06

Sample type	Kundens ID	Description	Note	Mottatt lab
Sediment	C6 / ASC4	64474 - Eyri C/ASC og B undersøkelse 2022		2022-11-17

Analyseresultat

Parameter	Resultat	Unit	Analysis date start	Analysis date end	Norm	Measurement uncertainty
TOC	**48**	mg/g TS	2022-12-13	2022-12-15	DIN EN 17505:2022	±4.8
TNb	**3.1**	mg/g TS	2022-12-13	2022-12-15	NS-EN 16168:2012	±0.9
N TOC	**50.8**	mg/g TS	2022-12-19	2022-12-19	Veileder 02:2018	
C/N - ratio	**15.6**		2022-12-19	2022-12-19		
TOM	**14.7**	% TS	2022-12-06	2022-12-08	Internal method	±0.0
Weight % 2 mm	**0.7**	wt% TS	2022-12-05	2022-12-12	Internal method (Bale/Kenny 2005)	±0.0
Weight% 1 mm	**2.6**	wt% TS	2022-12-05	2022-12-12	Internal method (Bale/Kenny 2005)	±0.1
Weight% 0.500 mm	**2.6**	wt% TS	2022-12-05	2022-12-12	Internal method (Bale/Kenny 2005)	±0.1
Weight% 0.250 mm	**3.2**	wt% TS	2022-12-05	2022-12-12	Internal method (Bale/Kenny 2005)	±0.2
Weight% 0.125 mm	**2.2**	wt% TS	2022-12-05	2022-12-12	Internal method (Bale/Kenny 2005)	±0.1
Vekt% 0.063 mm	**3.0**	wt% TS	2022-12-05	2022-12-12	Internal method (Bale/Kenny 2005)	±0.1
Weight% < 0.063 mm	**85.9**	wt% TS	2022-12-05	2022-12-12	Internal method (Bale/Kenny 2005)	±4.3
Pelite	**85.9**	wt% TS	2022-12-05	2022-12-12	Internal method (Bale/Kenny 2005)	±4.3
Sand	**13.5**	wt% TS	2022-12-05	2022-12-12	Internal method (Bale/Kenny 2005)	±0.7
Gravel	**0.7**	wt% TS	2022-12-05	2022-12-12	Internal method (Bale/Kenny 2005)	±0.0
Copper (Cu) [a]	**43.1 46.8**	mg/kg TS	2022-12-08	2022-12-08	Intern metode	
P (Fosfor) [a]	**1080**	mg/kg TS	2022-12-08	2022-12-08	Intern metode	

[a] The analytical testing has been carried out by an external laboratory, ALS Laboratory Group

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Akvaplan-niva
Fram Centre
P.O. Box 6606 Stakkevollan
N-9296 Tromsø

kjemi@akvaplan.niva.no
www.akvaplan.niva.no

ph.: +47 77 75 03 00
NO 937 375 158 MVA

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Ingar H. Wasbotten

ihw@akvaplan.niva.no

ANALYSIS REPORT

Customer:	Arnarlax	**Report no.:**	P2200206
Client reference:	Eyri (Island)		
Client person:		**Report date**	**2023-02-16**
Project no.:	**64474**	**Date Registrered:**	2022-11-17

Lab-id. P2200206-07

Sample type	Kundens ID	Description	Note	Mottatt lab
Sediment	Cu ref1	64474 - Eyri C/ASC og B undersøkelse 2022		2022-11-17

Analyseresultat						
Parameter	Resultat	Unit	Analysis date start	Analysis date end	Norm	Measurement uncertainty
Copper (Cu) [a]	39.0 38.6	mg/kg TS	2022-12-08	2022-12-08	Intern metode	

[a] The analytical testing has been carried out by an external laboratory, ALS Laboratory Group

Lab-id. P2200206-08

Sample type	Kundens ID	Description	Note	Mottatt lab
Sediment	Cu ref2	64474 - Eyri C/ASC og B undersøkelse 2022		2022-11-17

Analyseresultat						
Parameter	Resultat	Unit	Analysis date start	Analysis date end	Norm	Measurement uncertainty
Copper (Cu) [a]	34.9 33.7	mg/kg TS	2022-12-08	2022-12-08	Intern metode	

[a] The analytical testing has been carried out by an external laboratory, ALS Laboratory Group

Analytical chemist: Katrin Bluhm

Signature: Katrin Bluhm

Signatory: Ingar H. Wasbotten

Signatur: Ingar H. Wasbotten

Given results are valid only for the samples tested, and do not consider any errors due to sampling, inhomogeneities or other circumstances that may have influenced the sample condition before Akvaplan-Niva AS received it. This report can only be reproduced in its entirety and without any alterations. Complaints must be given to the laboratory within one month after reporting of the analytical results. More information about analytical methods (uncertainty, method principle etc) can be obtained by contacting Akvaplan-Niva AS.

* = Non-accredited result

Akvaplan-niva
Fram Centre
P.O. Box 6606 Stakkevollan
N-9296 Tromsø

kjemi@akvaplan.niva.no
www.akvaplan.niva.no

ph.: +47 77 75 03 00
NO 937 375 158 MVA

The analysis report is digitally signed by:
Ingar H. Wasbotten

ihw@akvaplan.niva.no