Arnarlax, C-survey at Eyri, 2021 (fallow period), May 2021

Akvaplan-niva AS Report: 2021 63202.01

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Contributors

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Summary

The results from the monitoring at the farming site Eyri in May 2021 showed that the sediment was somewhat loaded with organic carbon and the copper concentration was within reported natural levels for bottom sediment around Iceland (Egilsson *et al.*, 1999). The overall index of nEQR varied between 0,548 and 0,737. The diversity index H ' was below 3 at C4 and C5 and above 3 at the other stations and ranged from 2,56 to 4,53. The fauna was generally in good condition and no load effect was recorded. 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. The oxygen saturation in May was good in the whole water column with 87 % in the bottom water.

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Preface

Akvaplan-niva carried out an environmental survey of type C (NS 9410:2016) 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 have contributed in this work:

Arnthor Gustavsson	Akvaplan-niva	Field work, report, project leader.
Kamila Sztybor	Akvaplan-niva	Professional assessments, interpretations and report.
Hans-Petter Mannvik	Akvaplan-niva	Identification of bottom fauna (Echinodermata). QA report, professional assessments and interpretations.
Rune Palerud	Akvaplan-niva	Identification of bottom fauna (Crustaceans). Statistics.
Thomas Hansen	Akvaplan-niva	Identification of bottom fauna (Polychaeta, Mollusca and Varia).
Anne Tårånd Aasen	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 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.

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).

Tromsø, 27.09 2021

Arnthor Gustavsson

Arnthor Gustavsson (Project Manager)

1 Data Summary

Client information			
Report title:	Arnarlax, C-survey at Eyri (fallow period), May 2021.		
Report nr.	2021 63202.01	Site:	Eyri
Municipality:		Map Coordinates (construction):	65°34,850 N 23°58,440 W
MTB permitted:	Site MTB	Operations manager:	Rolf Ørjan Nordli
Client:	Arnarlax		

Biomass/production status at time of survey (28.05 2021)			
Fish group:	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)	0.624	Fauna C1 (impact zone)	3.85
Fauna C2	0.737	Fauna C2	4.53
Fauna C3	0.629	Fauna C3	3.78
Fauna C4 (deep area)	0.548	Fauna C4 (deep area)	2.57
Fauna C5	0.584	Fauna C5	2.56
Fauna C6	0.628	Fauna C6	3.38
Date fieldwork:	(28.05.2021	**Date of report:**	27.09 2021
Notes to other results (sediment, pH/Eh, oxygen)			nTOC from 25,4 to 49,1 mg/g DW. Copper 33,9 mg/kg at C1 Eh positive at all stations O_2-conditions were good throughout the water column.
Responsible for field work:	Signature: Arnþór Gústavsson	Project manager Arnthor Gustavsson	Signature: Arnþór Gústavsson

2 Introduction

2.1 Background and aim of the study

On behalf of Arnarlax, Akvaplan-niva completed a survey of type C for the fish farming site Eyri (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.

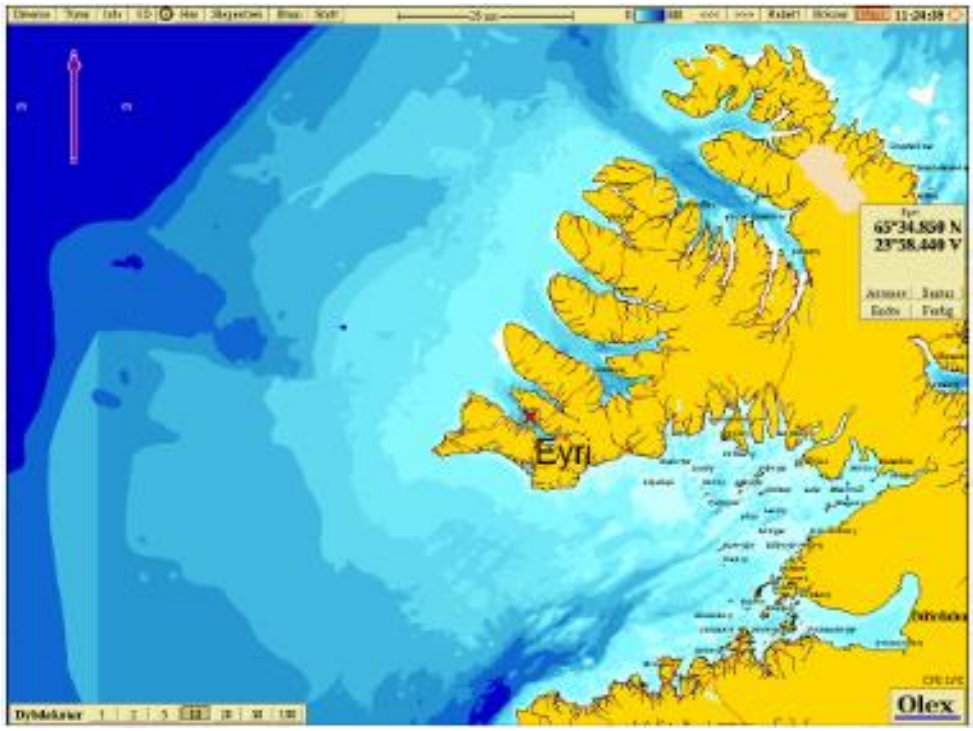

Figure 1 Overview of Patreksfjörður with the farming site Eyri (red cross). The map coordinates for the midpoint of the farming site are given to the right.

2.2 Site operation and feed use

The Eyri site has been in the fallow state since 13th of September 2020. Previously there has been farmed two generation of salmon at the site. The plant is a frame mooring with a total of fourteen 160 meters circumference cages in a 2 x 7 configuration. The planned time for setting out next generation at the site is early June 2021. The last generation salmon was farmed at the site from June 2019 to September 2020.

In Iceland, the MTB (maximum allowed biomass) limit is not given at 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 7.448 tonnes, used as MTB here (Baldvinsdóttir, pers reference).

2.3 Previous surveys

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

Akvaplan-niva AS has done two previous environmental surveys of the type C (NS 9410) at the site Eyri, a pre-study in May 2018 (Mannvik og Gunnarsson, 2019) and at max biomass in March 2020 (Mannvik og Gunnarsson, 2020). The results from the pre-study at Eyri in 2018 indicated that the sediment was somewhat loaded with organic carbon. Some load effect was recorded in fauna at stations C1, C3, C5 and C6 and fauna index nEQR showed moderate impact for these stations (< 0.6). The diversity index H ' was over 3 at C2 and C7, but in the range from 2.15 – 2.99 at other stations. NS 9410:2016-assessment of the fauna community in the local impact zone (C1) was rated with environmental condition 1 (Very good). No pollution indicators were recorded among the top-10 on any of the stations.

The results from the max biomass survey at Eyri in March 2020 showed that the fauna might be considered as disturbed closest to the farm at C1 (nEQR = 0.289) and C5 (nEQR = 0.363) and, to a lesser degree, at C3 (nEQR= 0,537). At C2 and C4 the faunal conditions are considered as good (nEQR > 0.6). The pollution indicator species *Capitella capitata* (polychaete) dominated the fauna at C1 and was the second most dominant at C3 and C5, and not registered among the top-10 species at the two other stations. The sediment had high level of organic carbon closest to the farm at C1 and lower levels at the other stations. The redox measurements (pH/Eh) gave points 0 acc. Appendix D in NS 9410:2016 for all the sampling stations.

Table 1: Previous surveys at Eyri.

Survey date	Report reference (author, year)	Production (tonn)	Type of survey
17.05 2018	Mannvik and Gunnarsson, 2019	0	Pre-survey (type C)
05.03 2020	Mannvik and Gunnarsson, 2020	5.355	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 Eyri, 2021. 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. Hydrography/O_2. 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 28.05 2021

Placement of stations and local conditions

The number of stations was calculated with reference to the site estimated maximal standing biomass for the next generation which is 7.448 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 accordance to 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, 2021.

Station	Depth, m	Distance from frame, m	Position N	Position W
C1	54	25	65°34.786	23°59.156
C2	45	500	65°34.957	23°59.620
C3	54	55	65°34.799	23°59.184
C4	57	350	65°34.875	23°59.529
C5	54	100	65°34.634	23°58.119
C6	55	100	65°34.816	23°59.224

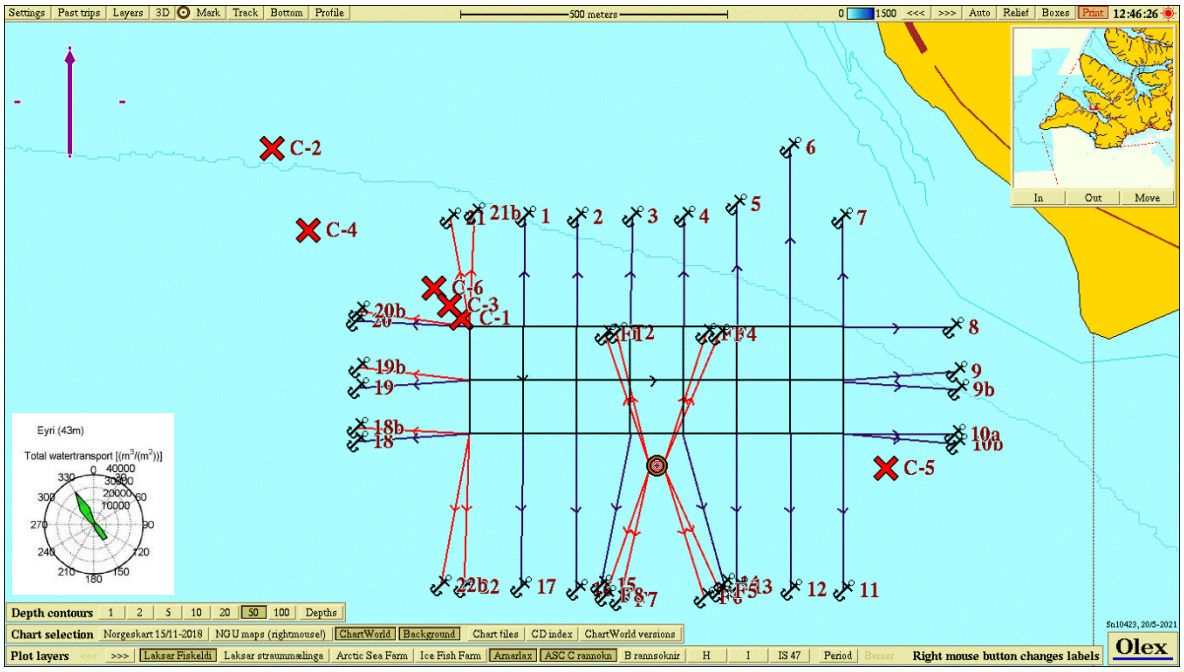

Figure 2. Map showing the sampling stations for the C-survey at Eyri, 2021. Current measurements used were from 43 m depth (Hermansen, 2020).

3.2 Hydrography and oxygen

At station C4, hydrographic measurements, salinity, temperature, density and oxygen saturation were carried out 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 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 (TOC_{400}, ROC, TIC_{900})). In order 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 favorable 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 favorable 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 fecal matter can, to a large degree, be attributed to changes in organic content (from the feed and fecal 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. 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 analyzed 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 (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 May 2021 is presented in Figure 3.

Temperature was around 6 ^{0}C near the surface and 2,7 ^{0}C close to the bottom, and oxygen saturation 109 % in the upper layer and 87 % in the bottom layer.

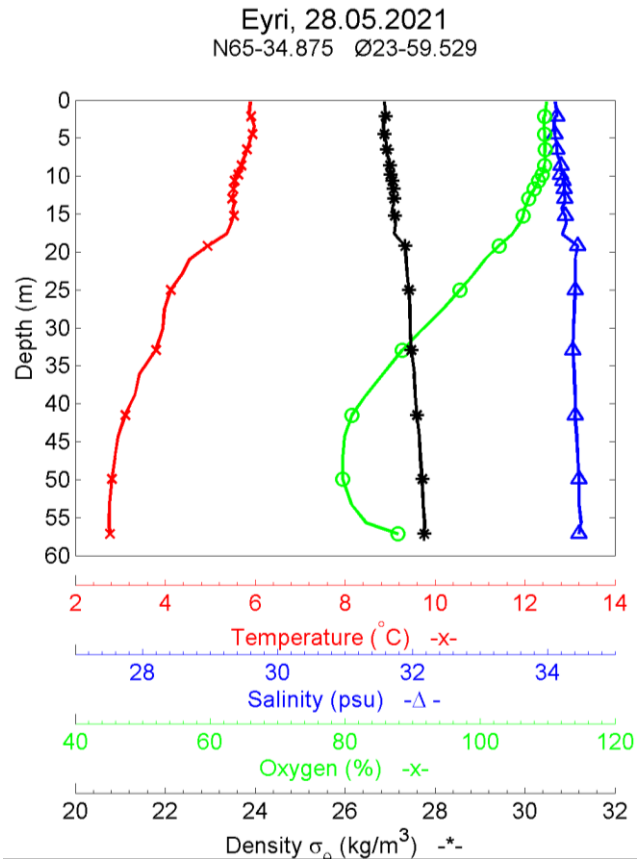

Figure 3. Vertical profiles. Temperature, salinity, density and oxygen at C4 at Eyri, 2021.

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 (TN), C/N-relationship, grain size distribution in sediment (Pelitt) and pH/Eh in the sediment are presented in Table 4.

TOM-levels varied from 6,5 to 15,1 %. TN-levels were low (2,5 – 4,1 mg/g). C/N-ratio was low at C2 and elevated at the other stations. TOC was rather high at all stations and nTOC varied from 25,4 to 49,1 mg/g DW. The bottom sediments grain size was fine with a pelite ratio ranging from 62 to 83 %.

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. Eyri, 2021.

St.	Sediment description	TOM	TOC	nTOC*	TN	C/N	Pelitt	pH/Eh
C1	Olive green/grey, muddy and fine sand. Grabs full with sediment.	14,9	45,2	49,1	3,0	15,3	77,9	7,88/291
C2	Olive green/grey, mud, sand, pebbles and chrushed shells. Grabs full with sediment.	6,5	18,7	25,4	3,8	5,0	62,6	7,82/263
C3	Olive green/grey, muddy and fine sand. Grabs full with sediment.	14,9	45,5	48,7	2,5	18,5	82,2	7,92/291
C4	Olive green/grey, muddy and fine sand. Grabs full with sediment.	15,0	44,0	48,9	4,1	10,8	72,7	7,92/298
C5	Olive green/grey, muddy and fine sand. Grabs full with sediment.	15,0	38,1	41,1	3,5	10,8	83,2	7,92/274
C6	Olive green/grey, muddy and fine sand. Grabs full with sediment.	15,1	41,9	46,5	3,9	10,8	74,8	7,84/259

4.2.2 Copper

Levels of copper in bottom sediments are shown in Table 5. The level of copper was 33,9 mg/kg.

Table 5. Copper (Cu), mg/kg TS. Eyri, 2021.

St.	Cu
C1	33,9

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 6. Faunal index nEQR is presented without the density index (DI) in accordance with recommendations from the Norwegian Environment Agency (Miljødirektoratet).

The number of individuals varied from 166 (C1) to 684 (C2) and number of species from 19 (C4) to 55 (C2). The diversity H' varied from 2.56 to 4.53. Value below ≤3 was registered at stations C4 and C5. The overall index of nEQR varied between 0.548 and 0.737.

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 0.64 to 0.86 which indicates a somewhat even distribution.

Table 6. Number of species and individuals pr. 0,2 m2. H´ = Shannon-Wiener 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, 2021.

St.	Numb. ind.	Numb. species	H´	ES_{100}	NQI1	ISI_{2012}	NSI	nEQR	AMBI	J
C1	166	29	3,85	22,50	0,70	6,67	20,39	0,624	2,37	0,86
C2	684	55	4,53	31,31	0,75	9,08	21,80	0,737	2,06	0,82
C3	301	34	3,78	22,30	0,69	6,99	20,23	0,629	2,34	0,81
C4	374	19	2,57	12,71	0,64	6,86	20,87	0,548	2,33	0,64
C5	380	20	2,56	12,83	0,66	7,50	22,26	0,584	2,05	0,64
C6	252	27	3,38	19,75	0,68	7,33	20,94	0,628	2,33	0,76

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 1 "Very good". The criteria for condition 1 are that there are at least 20 species/0,2 m^2 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 Eyri site 2021.

Station	Site name	Num. species	Dominating taxa	Environmental condition-NS 9410
C1	Eyri	29	Ennucula tenuis – 17 %	1 – Very good

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 started relatively low (≤ 15 species) and stretched out in varying degrees towards higher classes. These did not give any clear indications of fauna condition.

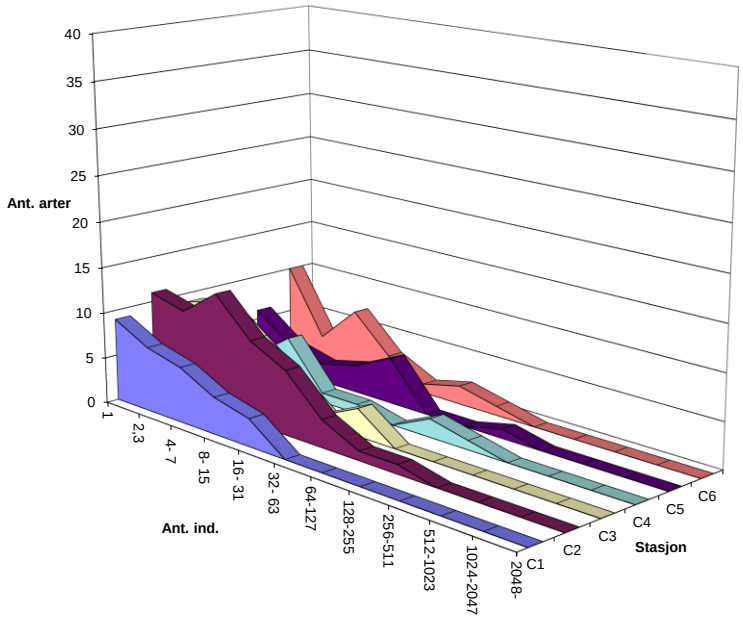

Figure 4. The soft bottom fauna shown as number of species against number of individuals pr. species in geometric classes. Eyri, 2021.

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 faunal composition was around 78 % similar at stations C6 and C3 and at C5 and C2. Station C1 was 70 % similar to C3 and C6. The faunal composition at station C2 was 46 % like the other stations.

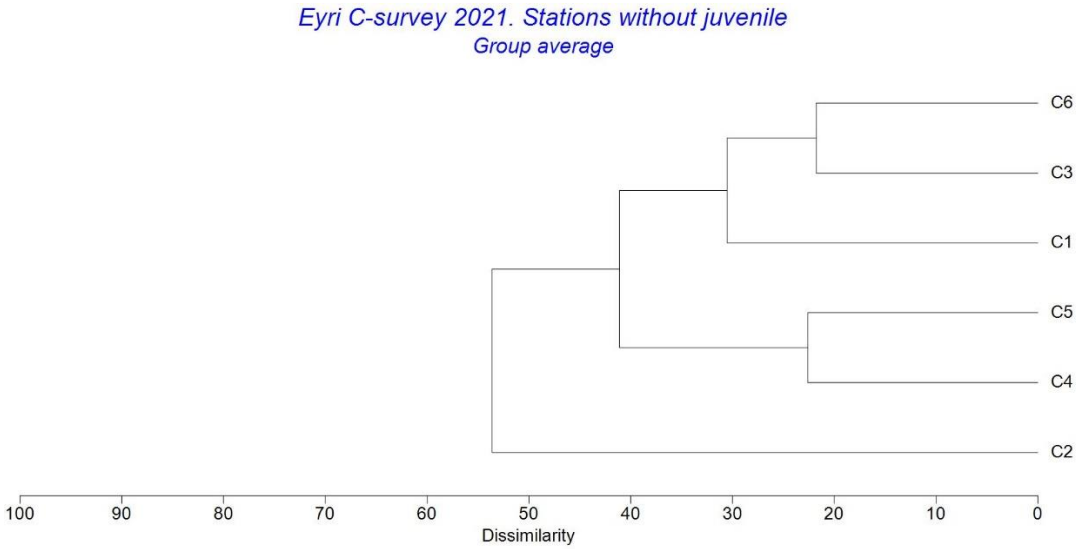

Figure 5. Cluster diagram for the soft bottom fauna at the C- sampling stations at Eyri, 2021.

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 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).

All stations were dominated by the neutral bivalve *Ennucula tenuis* with between 17 and 50 % of the individuals. The other most dominant species at the stations were a mixture of neutral, tolerant and opportunistic species together with one sensitive 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. Eyri, 2021.*

C1	EG	Numb.	Cum.	C2	EG	Numb.	Cum.
Ennucula tenuis	II	29	17 %	Ennucula tenuis	II	130	19 %
Macoma calcarea	IV	26	33 %	Galathowenia oculata	III	78	30 %
Scoloplos armiger	III	22	46 %	Abra nitida	III	49	37 %
Prionospio steenstrupi	II	10	51 %	Maldane sarsi	IV	41	43 %
Thyasira sarsii	IV	10	57 %	Nuculana pernula	II	39	48 %
Priapulus caudatus	III	8	62 %	Pholoe inornata	III	38	54 %
Scalibregma inflatum	III	8	67 %	Lagis koreni	IV	27	58 %
Leucon sp.		7	71 %	Praxillella gracilis	IV	25	61 %
Nuculana pernula	II	5	74 %	Sternaspis scutata		20	64 %
Aricidea sp.	I	4	76 %	Prionospio steenstrupi	II	19	67 %
C3	**EG**	**Numb.**	**Cum.**	**C4**	**EG**	**Numb.**	**Cum.**
Ennucula tenuis	II	62	20 %	Ennucula tenuis	II	154	41 %
Macoma calcarea	IV	50	37 %	Galathowenia oculata	III	77	61 %
Thyasira sarsii	IV	37	49 %	Thyasira sarsii	IV	64	78 %
Prionospio steenstrupi	II	31	59 %	Prionospio steenstrupi	II	20	84 %
Leucon sp.		15	64 %	Abra nitida	III	13	87 %
Scoloplos armiger	III	14	69 %	Maldane sarsi	IV	7	89 %
Axinopsida orbiculata		13	73 %	Sternaspis scutata		7	91 %
Priapulus caudatus	III	9	76 %	Macoma calcarea	IV	6	93 %
Eteone flava/longa		7	79 %	Axinopsida orbiculata		5	94 %
Lagis koreni	IV	6	81 %	Leucon sp.		5	95 %
C5	**EG**	**Numb.**	**Cum.**	**C6**	**EG**	**Numb.**	**Cum.**
Ennucula tenuis	II	189	50 %	Ennucula tenuis	II	77	30 %
Galathowenia oculata	III	30	58 %	Thyasira sarsii	IV	43	47 %
Prionospio steenstrupi	II	30	66 %	Prionospio steenstrupi	II	33	60 %
Thyasira sarsii	IV	28	73 %	Macoma calcarea	IV	16	67 %
Leucon sp.		22	79 %	Nuculana pernula	II	10	71 %
Abra nitida	III	17	83 %	Galathowenia oculata	III	9	74 %
Macoma calcarea	IV	15	87 %	Leucon sp.		8	77 %
Nuculana pernula	II	13	91 %	Abra nitida	III	7	80 %
Sternaspis scutata		13	94 %	Axinopsida orbiculata		7	83 %
Nephtys ciliata	III	6	96 %	Priapulus caudatus	III	6	85 %

*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 in May 2021, can be summarized as follows:

- The hydrography measurements showed good oxygen conditions throughout the water column with 87 % saturation in the bottom layer.
- TOC was rather high at all stations and nTOC varied from 25.4 to 49.1 mg/g DW. TOM-levels varied from 6.5 to 15.1 %. TN-levels were low (2.5 – 4.1 mg/g). C/N-ratio was low at C2 and elevated at the other stations. The copper level in the sediment at C1 was 33.9 mg/kg, which is well within reported natural levels for Icelandic coastal areas (Egilsson *et al.* 1999). The sediment was fine grained with a pelite share between 62 and 83 %. 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 166 (C1) to 684 (C2) and number of species from 19 (C4) to 55 (C2). The diversity H' varied from 2.56 to 4.53. The overall index of nEQR varied between 0.548 and 0.737. No pollution indicator species were recorded among the top-10 at any of the stations.

5.2 Conclusions

The results from the monitoring at the farming site Eyri in May 2021 showed that the sediment was somewhat loaded with organic carbon and the copper concentration was within reported natural levels for bottom sediment around Iceland (Egilsson *et al.*, 1999). The overall index of nEQR varied between 0.548 and 0.737. The diversity index H ' was below 3 at C4 and C5 and above 3 at the other stations and ranged from 2.56 to 4.53. The fauna was generally in good condition and no load effect was recorded. 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. The oxygen saturation in May was good in the whole water column with 87 % in the bottom water.

5.3 Environmental trend since the last C-survey

A C-survey was carried out at the location in 2020 (Mannvik & Gunnarsson, 2020). The conclusion from that study was:" *The results from the monitoring at the farming site Eyri in March 2020 showed that the fauna might be considered as disturbed closest to the farm at Ey1 (nEQR = 0.289) and Ey 5 (nEQR = 0.363) and, to a lesser degree, at Ey 3 (nEQR= 0,537). At Ey 2 and Ey 4 the faunal conditions are considered as good (nEQR > 0.6). The pollution indicator species Capitella capitata (polychaete) dominated the fauna at Ey 1 and was the second most dominant at Ey 3 and Ey 5, and not registered among the top-10 species at the two other stations. The sediment had high level of organic carbon closest to the farm at Ey 1 and lower levels at the other stations. The copper level at Ey 1 was 43. mg/kg, which is within natural levels reported for bottom sediment around Iceland (Egilsson et al., 1999). The redox measurements (pH/Eh) gave points 0 acc. Appendix D in NS 9410:2016 for all the sampling stations. The oxygen saturation in November was good in the whole water column with 99 % in the bottom water and throughout the water column towards the surface.* "

The station positions differ somewhat in these two surveys and therefore only a general comparison of the results has been carried out.

The fauna at the station closest to the farm (Ey1/C1) is not disturbed anymore and both nEQR and H' indexes increased significantly. The pollution indicator species *Capitella capitata,* which dominated the fauna at station Ey1 in the last survey, was not recorded among the top-10 species at any of the stations in the current survey. The levels of organic carbon are slightly lower in current survey (25 - 49 mg/g) then in 2020 (30 - 60 mg/g). The level of copper also slightly decreased and is still well within reported natural levels for bottom sediment around Iceland. The oxygen conditions were good throughout the whole water column in both surveys.

6 References

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7 Appendix (In Norwegian)

7.1 Statistical methods

7.1.1 Diversity

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.

7.1.2 Pielous mål for jevnhet (Pielou, 1966)

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

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

7.1.3 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

7.1.4 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.

7.1.5 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.

7.1.6 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).

7.1.7 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.

7.1.8 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:

7.1.9 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

7.1.10 References

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7.2 Statistical results Eyri, 2021

7.2.1 Number of species and individuals per station

St.	C1	C2	C3	C4	C5	C6
Ant. ind.	166	684	301	374	380	252
Ant. arter	29	55	34	19	20	27

7.2.2 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.	2157	70	96	374	310	163	138	195	179	153	227	133	119
no. spe.	73	23	22	49	44	25	26	16	16	16	16	23	20
Shannon-Wiener:		4,0	3,7	4,4	4,7	3,7	3,9	2,4	2,7	2,5	2,6	3,4	3,3
Pielou		0,88	0,83	0,78	0,85	0,79	0,82	0,60	0,69	0,62	0,66	0,76	0,77
ES100		23	22	31	32	21	23	12	14	14	12	21	19
SN		2,17	2,04	2,19	2,17	1,98	2,04	1,67	1,68	1,72	1,64	1,98	1,92
ISI-2012		6,44	6,90	9,07	9,08	6,96	7,03	6,69	7,02	7,08	7,92	7,38	7,29
AMBI		2,515	2,226	1,961	2,168	2,241	2,435	2,339	2,313	1,964	2,136	2,319	2,346
NQI1		0,69	0,70	0,76	0,74	0,70	0,69	0,63	0,64	0,67	0,64	0,69	0,67
NSI		20,2	20,6	22,0	21,6	20,2	20,2	21,4	20,4	22,8	21,7	21,3	20,6
DI		0,205	0,068	0,523	0,441	0,162	0,090	0,240	0,203	0,135	0,306	0,074	0,026

7.2.3 Benthos indices, averages per station

st.nr.	C1	C2	C3	C4	C5	C6
Shannon-Wiener:	3,85	4,53	3,78	2,57	2,56	3,38
Pielou	0,86	0,82	0,81	0,64	0,64	0,76
ES100	22,50	31,31	22,30	12,71	12,83	19,75
SN	2,10	2,18	2,01	1,68	1,68	1,95
ISI-2012	6,67	9,08	6,99	6,86	7,50	7,33
AMBI	2,371	2,065	2,338	2,326	2,050	2,333
NQI1	0,70	0,75	0,69	0,64	0,66	0,68
NSI	20,39	21,80	20,23	20,87	22,26	20,94
Tilstandsklasse nEQR *)	0,624	0,737	0,629	0,548	0,584	0,628

7.2.4 Geometric classes

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

7.3 Species lists

Artsliste — *Eyri i Patreksfirdi C-survey 2021*

Rekke	*Klasse*	*Art/Taxa*	*01*	*02*	*Sum*
Stasjonsnr.: C1					
PRIAPULIDA					
		Priapulus caudatus	4	4	8
ECHIURIDA					
		Echiurus echiurus	2	2	4
ANNELIDA					
	Polychaeta				
		Aricidea sp.	1	3	4
		Chaetozone setosa	2	1	3
		Cossura sp.		1	1
		Eteone flava/longa	1	1	2
		Gattyana amondseni	2	2	4
		Heteromastus filiformis	1		1
		Lagis koreni	2	2	4
		Mediomastus fragilis	1	1	2
		Nephtys ciliata	2		2
		Nephtys sp. juv.		1	1
		Parougia eliasoni	1		1
		Pholoe baltica	1		1
		Prionospio steenstrupi	3	7	10
		Scalibregma inflatum	7	1	8
		Scoletoma fragilis		1	1
		Scoloplos armiger	12	10	22
CRUSTACEA					
	Malacostraca				
		Gammaridea indet.	1		1
		Leucon sp.	2	5	7
		Oedicerotidae indet.	2		2
MOLLUSCA					
	Opistobranchia				
		Onchidoridiidae indet.	1		1
	Bivalvia				
		Abra nitida		3	3
		Ennucula tenuis	10	19	29
		Macoma calcarea	7	19	26
		Mytilus edulis		1	1
		Nuculana pernula	1	4	5
		Thyasira sarsii	4	6	10
		Yoldia hyperborea		2	2
ECHINODERMATA					
	Ophiuroidea				
		Ophiocten affinis		1	1
		Ophiuroidea indet. juv.		1	1
	Holothuroidea				
		Holothuroidea indet. juv.		1	1
		Maks:	12	19	29
		Antall:	23	25	32
		Sum:			169
Stasjonsnr.: C2					
NEMERTINI					
		Nemertea indet.	3	3	6

Rekke	Klasse	Art/Taxa	01	02	Sum
ECHIURIDA					
		Echiurus echiurus	1	1	2
SIPUNCULIDA					
		Phascolion strombus	5		5
ANNELIDA					
	Polychaeta				
		Aricidea sp.	1	1	2
		Chaetozone setosa		1	1
		Cirratulus cirratus	1		1
		Cistenides hyperborea	4	2	6
		Diplocirrus longisetosus	2	4	6
		Galathowenia oculata	28	50	78
		Gattyana amondseni	1		1
		Lagis koreni	16	11	27
		Laonice cirrata	1		1
		Laphania boecki	2	2	4
		Leitoscoloplos mammosus		3	3
		Levinsenia gracilis	1		1
		Maldane sarsi	21	20	41
		Melinna cristata	1		1
		Myriochele malmgreni/olgae	6	5	11
		Nephtys ciliata	3	3	6
		Nothria conchylega	6	7	13
		Owenia sp.	8	4	12
		Petaloproctus tenuis	1		1
		Pholoe assimilis		1	1
		Pholoe inornata	9	10	19
		Praxillella gracilis	10	15	25
		Praxillella praetermissa	2	4	6
		Prionospio steenstrupi	11	8	19
		Rhodine gracilior	3	2	5
		Scalibregma inflatum	1	3	4
		Scoletoma fragilis	3	5	8
		Scoloplos armiger	6	5	11
		Spio limicola	1	3	4
		Sternaspis scutata	11	9	20
		Syllis sp.	1	2	3
CRUSTACEA					
	Malacostraca				
		Byblis sp.		2	2
		Leucon sp.	4	3	7
		Protomedeia fasciata	3	1	4
MOLLUSCA					
	Caudofoveata				
		Caudofoveata indet.		3	3
	Prosobranchia				
		Cryptonatica affinis	1		1
		Oenopota sp.	1		1
	Bivalvia				
		Abra nitida	21	28	49
		Arctica islandica	1	2	3
		Astarte montagui	1	2	3
		Axinopsida orbiculata	5	2	7
		Bivalvia indet.	3		3
		Crenella decussata		2	2

Rekke	Klasse	Art/Taxa	01	02	Sum
		Ennucula tenuis	101	29	130
		Macoma calcarea	10	6	16
		Musculus niger	1		1
		Mya sp. juv.	2		2
		Nuculana pernula	22	17	39
		Thyasira gouldi	3	6	9
		Thyasira sarsii	6	6	12
		Thyasiridae indet.	7	1	8
		Yoldia hyperborea	8	4	12
ECHINODERMATA					
	Ophiuroidea				
		Ophiocten affinis	6	12	18
		Ophiuroidea indet. juv.	1	9	10
		Maks:	101	50	130
		Antall:	51	45	57
		Sum:			696

Stasjonsnr.: C3

PRIAPULIDA					
		Priapulus caudatus	5	4	9
ECHIURIDA					
		Echiurus echiurus	4		4
ANNELIDA					
	Polychaeta				
		Aricidea sp.		1	1
		Bylgides groenlandicus		1	1
		Chaetozone setosa		2	2
		Eteone flava/longa		7	7
		Galathowenia oculata	1	1	2
		Gattyana amondseni		1	1
		Lagis koreni	3	3	6
		Laonice cirrata		1	1
		Mediomastus fragilis	1	2	3
		Nephtys ciliata		3	3
		Ophelina acuminata	1		1
		Parougia eliasoni		2	2
		Parougia sp.		1	1
		Pholoe assimilis	2		2
		Pholoe inornata	1		1
		Prionospio steenstrupi	17	14	31
		Scalibregma inflatum	2	2	4
		Scoletoma fragilis	1		1
		Scoloplos armiger	8	6	14
		Spio limicola	1		1
CRUSTACEA					
	Malacostraca				
		Byblis sp.	3		3
		Leucon sp.	9	6	15
		Oedicerotidae indet.	2	1	3
MOLLUSCA					
	Bivalvia				
		Abra nitida	2	2	4
		Axinopsida orbiculata	7	6	13
		Bivalvia indet.	1	2	3
		Ennucula tenuis	36	26	62

Rekke	Klasse	Art/Taxa	01	02	Sum
		Macoma calcarea	27	23	50
		Nuculana pernula	2	4	6
		Thyasira sarsii	21	16	37
		Yoldia hyperborea	3		3
ECHINODERMATA					
	Ophiuroidea				
		Ophiocten affinis	3	1	4
		Ophiuroidea indet. juv.	1	1	2
		Maks:	36	26	62
		Antall:	26	27	35
		Sum:			303

Stasjonsnr.: C4

NEMERTINI					
		Nemertea indet.		1	1
ANNELIDA					
	Polychaeta				
		Galathowenia oculata	39	38	77
		Lagis koreni	1		1
		Maldane sarsi	2	5	7
		Nephtys ciliata	2	1	3
		Parougia eliasoni	2		2
		Pholoe inornata	1	1	2
		Prionospio steenstrupi	15	5	20
		Scoloplos armiger	1		1
		Sternaspis scutata	2	5	7
CRUSTACEA					
	Malacostraca				
		Leucon sp.	2	3	5
MOLLUSCA					
	Bivalvia				
		Abra nitida	7	6	13
		Axinopsida orbiculata	1	4	5
		Ennucula tenuis	91	63	154
		Macoma calcarea	1	5	6
		Nuculana pernula	1	3	4
		Thyasira sarsii	27	37	64
		Yoldia hyperborea		1	1
ECHINODERMATA					
	Ophiuroidea				
		Ophiocten affinis		1	1
		Ophiuroidea indet. juv.	1	1	2
		Maks:	91	63	154
		Antall:	17	17	20
		Sum:			376

Stasjonsnr.: C5

ANNELIDA					
	Polychaeta				
		Aricidea sp.		1	1
		Cossura pygodactylata	1		1
		Eteone flava/longa	2		2
		Galathowenia oculata		30	30
		Lagis koreni	1		1
		Nephtys ciliata	5	1	6
		Owenia sp.		1	1

Rekke	Klasse	Art/Taxa	01	02	Sum
		Parougia eliasoni	1	1	2
		Pholoe inornata		1	1
		Prionospio steenstrupi	19	11	30
		Sternaspis scutata	2	11	13
CRUSTACEA					
	Malacostraca				
		Leucon sp.	17	5	22
MOLLUSCA					
	Bivalvia				
		Abra nitida	1	16	17
		Axinopsida orbiculata	1	1	2
		Ennucula tenuis	81	108	189
		Hiatella arctica	1		1
		Macoma calcarea	5	10	15
		Nuculana pernula	6	7	13
		Thyasira sarsii	6	22	28
ECHINODERMATA					
	Ophiuroidea				
		Ophiocten affinis	4	1	5
		Maks:	81	108	189
		Antall:	16	16	20
		Sum:			380

Stasjonsnr.: C6

PRIAPULIDA					
		Priapulus caudatus	2	4	6
ECHIURIDA					
		Echiurus echiurus	3	2	5
ANNELIDA					
	Polychaeta				
		Aricidea sp.	1		1
		Bylgides groenlandicus	1		1
		Chaetozone setosa	1		1
		Eteone flava/longa	1	1	2
		Galathowenia oculata	6	3	9
		Gattyana amondseni	1		1
		Goniada maculata		1	1
		Nephtys ciliata	2	3	5
		Ophelina acuminata	1		1
		Parougia eliasoni		2	2
		Pholoe inornata	1		1
		Prionospio steenstrupi	18	15	33
		Scoloplos armiger	4	2	6
CRUSTACEA					
	Malacostraca				
		Gammaridea indet.		1	1
		Leucon sp.	5	3	8
MOLLUSCA					
	Bivalvia				
		Abra nitida	4	3	7
		Axinopsida orbiculata	2	5	7
		Bivalvia indet.	1		1
		Ennucula tenuis	42	35	77
		Macoma calcarea	6	10	16
		Nuculana pernula	7	3	10
		Thyasira sarsii	20	23	43

Rekke	Klasse	Art/Taxa	01	02	Sum
		Yoldia hyperborea	1	1	2
ECHINODERMATA					
	Ophiuroidea				
		Ophiocten affinis	3	1	4
		Ophiura albida		1	1
		Ophiuroidea indet. juv.	1		1
		Maks:	42	35	77
		Antall:	24	20	28
		Sum:			253
				TOTAL:	***Maks:*** 189
					Sum: 2177

7.4 Analytical report

Akvaplan niva

NORSK AKKREDITERING TEST 079

ANALYSERAPPORT

Kunde:	Arnarlax	**Rapport nr.:**	P2100073
Kundemerking:	63202		
Kontaktperson kunde:		**Rapportdato**	2021-07-22
		Ankomst dato	2021-06-29

Lab-id. P2100073-01

Objekt	Kundens ID	Beskrivelse	Notering	Mottatt lab
Sediment	C1	63202 - Eyri Patreksfirði - C/B study21 post Fallow		2021-06-29

Analyseresultat

Parameter	Resultat	Enhet	Analysedato start	Analysedato slutt	Standard	Måleusikkerhet
TOC	45	mg/g TS	2021-07-12	2021-07-15	DIN 19539:2016	±4.5
TNb	3.0	mg/g TS	2021-07-12	2021-07-15	NS-EN 16168:2012	±0.4
N TOC	49.1	mg/g TS	2021-07-20	2021-07-20	Veileder 02:2018	
C/N - forhold	15.3		2021-07-20	2021-07-20		
TOM	14.9	% TS	2021-07-09	2021-07-13	Intern metode	±0.0
Vekt % 2 mm	2.8	wt% TS	2021-07-09	2021-07-15	Intern metode	±0.1
Vekt % 1 mm	0.3	wt% TS	2021-07-09	2021-07-15	Intern metode (Buchanan 1984)	±0.0
Vekt % 0.500 mm	0.6	wt% TS	2021-07-09	2021-07-15	Intern metode (Buchanan 1984)	±0.0
Vekt % 0.250 mm	7.9	wt% TS	2021-07-09	2021-07-15	Intern metode (Buchanan 1984)	±0.4
Vekt % 0.125 mm	6.8	wt% TS	2021-07-09	2021-07-15	Intern metode (Buchanan 1984)	±0.3
Vekt % 0.063 mm	3.6	wt% TS	2021-07-09	2021-07-15	Intern metode (Bale/Kenny 2005)	±0.2
Vekt % < 0.063 mm	77.9	wt% TS	2021-07-09	2021-07-15	Intern metode (Bale/Kenny 2005)	±3.9
Pelitt	77.9	wt% TS	2021-07-09	2021-07-15	Intern metode	
Sand	19.3	wt% TS	2021-07-09	2021-07-15	Intern metode (Buchanan 1984)	
Grus	2.8	wt% TS	2021-07-09	2021-07-15	Intern metode (Buchanan 1984)	
Cu (kobber) [a]	33.9	mg/kg TS	2021-07-19	2021-07-21	Intern metode	

[a] Prøvingen er utført av eksternt laboratorium, ALS Laboratory Group

* = Ikke akkreditert resultat

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ANALYSERAPPORT

Kunde:	Arnarlax	**Rapport nr.:**	P2100073
Kundemerking:	63202		
Kontaktperson kunde:		**Rapportdato**	2021-07-22
		Ankomst dato	2021-06-29

Lab-id. P2100073-02

Objekt	Kundens ID	Beskrivelse	Notering	Mottatt lab
Sediment	C2	63202 - Eyri Patreksfirði - C/B study21 post Fallow	Prøve C2 inneholder stor stein større som ikke er inkludet i kornanalysen. Steinen ville utgjøre 25,4 vekt% av den totale prøven.	2021-06-29

Analyseresultat

Parameter	Resultat	Enhet	Analysedato start	Analysedato slutt	Standard	Måleusikkerhet
TOC	19	mg/g TS	2021-07-12	2021-07-15	DIN 19539:2016	±1.9
TNb	3.8	mg/g TS	2021-07-12	2021-07-15	NS-EN 16168:2012	±0.6
N TOC	25.4	mg/g TS	2021-07-20	2021-07-22	Veileder 02:2018	
C/N - forhold	5.0		2021-07-20	2021-07-22		
TOM	6.5	% TS	2021-07-09	2021-07-13	Intern metode	±0.0
Vekt% stein	*25.4	wt% TS	2021-07-22	2021-07-22		
Vekt % 2 mm	13.0	wt% TS	2021-07-09	2021-07-15	Intern metode	±0.7
Vekt % 1 mm	2.5	wt% TS	2021-07-09	2021-07-15	Intern metode (Buchanan 1984)	±0.1
Vekt % 0.500 mm	2.1	wt% TS	2021-07-09	2021-07-15	Intern metode (Buchanan 1984)	±0.1
Vekt % 0.250 mm	6.8	wt% TS	2021-07-09	2021-07-15	Intern metode (Buchanan 1984)	±0.3
Vekt % 0.125 mm	4.1	wt% TS	2021-07-09	2021-07-15	Intern metode (Buchanan 1984)	±0.2
Vekt % 0.063 mm	8.8	wt% TS	2021-07-09	2021-07-15	Intern metode (Bale/Kenny 2005)	±0.4
Vekt % < 0.063 mm	62.6	wt% TS	2021-07-09	2021-07-15	Intern metode (Bale/Kenny 2005)	±3.1
Pelitt	62.6	wt% TS	2021-07-09	2021-07-15	Intern metode	
Sand	24.4	wt% TS	2021-07-09	2021-07-15	Intern metode (Buchanan 1984)	
Grus	13.0	wt% TS	2021-07-09	2021-07-15	Intern metode (Buchanan 1984)	

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ANALYSERAPPORT

Kunde:	Arnarlax	**Rapport nr.:**	P2100073
Kundemerking:	63202		
Kontaktperson kunde:		**Rapportdato**	2021-07-22
		Ankomst dato	2021-06-29

Lab-id. P2100073-03

Objekt	Kundens ID	Beskrivelse	Notering	Mottatt lab
Sediment	C3	63202 - Eyri Patreksfirði - C/B study21 post Fallow		2021-06-29

Analyseresultat

Parameter	Resultat	Enhet	Analysedato start	Analysedato slutt	Standard	Måleusikkerhet
TOC	45	mg/g TS	2021-07-12	2021-07-15	DIN 19539:2016	±4.5
TNb	2.5	mg/g TS	2021-07-12	2021-07-15	NS-EN 16168:2012	±0.4
N TOC	48.7	mg/g TS	2021-07-22	2021-07-22	Veileder 02:2018	
C/N - forhold	18.5		2021-07-20	2021-07-22		
TOM	14.9	% TS	2021-07-09	2021-07-13	Intern metode	±0.0
Vekt % 2 mm	1.8	wt% TS	2021-07-09	2021-07-15	Intern metode	±0.1
Vekt % 1 mm	0.8	wt% TS	2021-07-09	2021-07-15	Intern metode (Buchanan 1984)	±0.0
Vekt % 0.500 mm	0.5	wt% TS	2021-07-09	2021-07-15	Intern metode (Buchanan 1984)	±0.0
Vekt % 0.250 mm	8.2	wt% TS	2021-07-09	2021-07-15	Intern metode (Buchanan 1984)	±0.4
Vekt % 0.125 mm	3.8	wt% TS	2021-07-09	2021-07-15	Intern metode (Buchanan 1984)	±0.2
Vekt % 0.063 mm	2.6	wt% TS	2021-07-09	2021-07-15	Intern metode (Bale/Kenny 2005)	±0.1
Vekt % < 0.063 mm	82.2	wt% TS	2021-07-09	2021-07-15	Intern metode (Bale/Kenny 2005)	±4.1
Pelitt	82.2	wt% TS	2021-07-09	2021-07-15	Intern metode	
Sand	16.0	wt% TS	2021-07-09	2021-07-15	Intern metode (Buchanan 1984)	
Grus	1.8	wt% TS	2021-07-09	2021-07-15	Intern metode (Buchanan 1984)	

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ANALYSERAPPORT

Kunde:	Arnarlax	**Rapport nr.:**	P2100073
Kundemerking:	63202		
Kontaktperson kunde:		**Rapportdato**	2021-07-22
		Ankomst dato	2021-06-29

Lab-id. P2100073-04

Objekt	Kundens ID	Beskrivelse	Notering	Mottatt lab
Sediment	C4	63202 - Eyri Patreksfirði - C/B study21 post Fallow		2021-06-29

Analyseresultat

Parameter	Resultat	Enhet	Analysedato start	Analysedato slutt	Standard	Måleusikkerhet
TOC	44	mg/g TS	2021-07-12	2021-07-15	DIN 19539:2016	±4.4
TNb	4.1	mg/g TS	2021-07-12	2021-07-15	NS-EN 16168:2012	±0.6
N TOC	48.9	mg/g TS	2021-07-20	2021-07-20	Veileder 02:2018	
C/N - forhold	10.8		2021-07-20	2021-07-22		
TOM	15.0	% TS	2021-07-09	2021-07-13	Intern metode	±0.0
Vekt % 2 mm	3.3	wt% TS	2021-07-09	2021-07-15	Intern metode	±0.2
Vekt % 1 mm	3.2	wt% TS	2021-07-09	2021-07-15	Intern metode (Buchanan 1984)	±0.2
Vekt % 0.500 mm	5.7	wt% TS	2021-07-09	2021-07-15	Intern metode (Buchanan 1984)	±0.3
Vekt % 0.250 mm	6.2	wt% TS	2021-07-09	2021-07-15	Intern metode (Buchanan 1984)	±0.3
Vekt % 0.125 mm	4.3	wt% TS	2021-07-09	2021-07-15	Intern metode (Buchanan 1984)	±0.2
Vekt % 0.063 mm	4.7	wt% TS	2021-07-09	2021-07-15	Intern metode (Bale/Kenny 2005)	±0.2
Vekt % < 0.063 mm	72.7	wt% TS	2021-07-09	2021-07-15	Intern metode (Bale/Kenny 2005)	±3.6
Pelitt	72.7	wt% TS	2021-07-09	2021-07-15	Intern metode	
Sand	24.1	wt% TS	2021-07-09	2021-07-15	Intern metode (Buchanan 1984)	
Grus	3.3	wt% TS	2021-07-09	2021-07-15	Intern metode (Buchanan 1984)	

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ANALYSERAPPORT

Kunde:	Arnarlax	**Rapport nr.:**	P2100073
Kundemerking:	63202		
Kontaktperson kunde:		**Rapportdato**	2021-07-22
		Ankomst dato	2021-06-29

Lab-id. P2100073-05

Objekt	Kundens ID	Beskrivelse	Notering	Mottatt lab
Sediment	C5	63202 - Eyri Patreksfirði - C/B study21 post Fallow		2021-06-29

Analyseresultat

Parameter	Resultat	Enhet	Analysedato start	Analysedato slutt	Standard	Måleusikkerhet
TOC	38	mg/g TS	2021-07-12	2021-07-15	DIN 19539:2016	±3.8
TNb	3.5	mg/g TS	2021-07-12	2021-07-15	NS-EN 16168:2012	±0.5
N TOC	41.1	mg/g TS	2021-07-20	2021-07-20	Veileder 02:2018	
C/N - forhold	10.8		2021-07-20	2021-07-22		
TOM	15.0	% TS	2021-07-09	2021-07-13	Intern metode	±0.0
Vekt % 2 mm	2.3	wt% TS	2021-07-09	2021-07-15	Intern metode	±0.1
Vekt % 1 mm	0.6	wt% TS	2021-07-09	2021-07-15	Intern metode (Buchanan 1984)	±0.0
Vekt % 0.500 mm	0.6	wt% TS	2021-07-09	2021-07-15	Intern metode (Buchanan 1984)	±0.0
Vekt % 0.250 mm	3.5	wt% TS	2021-07-09	2021-07-15	Intern metode (Buchanan 1984)	±0.2
Vekt % 0.125 mm	4.7	wt% TS	2021-07-09	2021-07-15	Intern metode (Buchanan 1984)	±0.2
Vekt % 0.063 mm	5.0	wt% TS	2021-07-09	2021-07-15	Intern metode (Bale/Kenny 2005)	±0.3
Vekt % < 0.063 mm	83.2	wt% TS	2021-07-09	2021-07-15	Intern metode (Bale/Kenny 2005)	±4.2
Pelitt	83.2	wt% TS	2021-07-09	2021-07-15	Intern metode	
Sand	14.5	wt% TS	2021-07-09	2021-07-15	Intern metode (Buchanan 1984)	
Grus	2.3	wt% TS	2021-07-09	2021-07-15	Intern metode (Buchanan 1984)	

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ANALYSERAPPORT

Kunde:	Arnarlax	**Rapport nr.:**	P2100073
Kundemerking:	63202		
Kontaktperson kunde:		**Rapportdato**	2021-07-22
		Ankomst dato	2021-06-29

Lab-id. P2100073-06

Objekt	Kundens ID	Beskrivelse	Notering	Mottatt lab
Sediment	C6	63202 - Eyri Patreksfirði - C/B study21 post Fallow		2021-06-29

Analyseresultat

Parameter	Resultat	Enhet	Analysedato start	Analysedato slutt	Standard	Måleusikkerhet
TOC	42	mg/g TS	2021-07-12	2021-07-15	DIN 19539:2016	±4.2
TNb	3.9	mg/g TS	2021-07-12	2021-07-15	NS-EN 16168:2012	±0.6
N TOC	46.5	mg/g TS	2021-07-20	2021-07-22	Veileder 02:2018	
C/N - forhold	10.8		2021-07-20	2021-07-22		
TOM	15.1	% TS	2021-07-09	2021-07-13	Intern metode	±0.0
Vekt % 2 mm	0.9	wt% TS	2021-07-09	2021-07-15	Intern metode	±0.0
Vekt % 1 mm	0.4	wt% TS	2021-07-09	2021-07-15	Intern metode (Buchanan 1984)	±0.0
Vekt % 0.500 mm	1.2	wt% TS	2021-07-09	2021-07-15	Intern metode (Buchanan 1984)	±0.1
Vekt % 0.250 mm	17.2	wt% TS	2021-07-09	2021-07-15	Intern metode (Buchanan 1984)	±0.9
Vekt % 0.125 mm	3.0	wt% TS	2021-07-09	2021-07-15	Intern metode (Buchanan 1984)	±0.2
Vekt % 0.063 mm	2.5	wt% TS	2021-07-09	2021-07-15	Intern metode (Bale/Kenny 2005)	±0.1
Vekt % < 0.063 mm	74.8	wt% TS	2021-07-09	2021-07-15	Intern metode (Bale/Kenny 2005)	±3.7
Pelitt	74.8	wt% TS	2021-07-09	2021-07-15	Intern metode	
Sand	24.3	wt% TS	2021-07-09	2021-07-15	Intern metode (Buchanan 1984)	
Grus	0.9	wt% TS	2021-07-09	2021-07-15	Intern metode (Buchanan 1984)	

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ANALYSERAPPORT

Kunde:	Arnarlax	**Rapport nr.:**	P2100073
Kundemerking:	63202		
Kontaktperson kunde:		**Rapportdato**	2021-07-22
		Ankomst dato	2021-06-29

Analyseansvarlig: Ingar H. Wasbotten

Signatur: Ingar H. Wasbotten

Underskriftsberettiget: Oda Sofie Bye Wilhelmsen

Signatur: Oda Sofie Bye Wilhelmsen

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 (måleusikkerhet, metodeprinsipp etc.) fås ved henvendelse til Akvaplan-Niva AS

* = Ikke akkreditert resultat

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