C-survey at Haganes, 2022 (max biomass)

Arnarlax ehf

Akvaplan-niva AS Report: 2022 64106.03

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

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Customer

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Summary

The results from the monitoring at the farming site Haganes in June 2022 showed that the sediment was somewhat loaded with organic carbon and the copper concentrations were within reported natural levels for bottom sediment around Iceland (Egilsson *et al.*, 1999). Some load effect was recorded in the fauna (nEQR < 0.6) and faunal index the nEQR at C1 (0.417) indicated somewhat disturbed faunal community. The diversity index H ' was below 3 at all stations and ranged from 1.95 (C5) to 2.36 (C3). NS 9410:2016-assessment of the community in the local impact zone (C1) showed environmental condition 2 (Good). The pollution indicator species *Capitella capitata* dominated the fauna at C1 but was not recorded among the top-10 at any of the other 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 June was good in the whole water column with 77 % in the bottom water.

Approval

Project leader

Kamila Sztybor
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Quality control

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Preface

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

Snorri Gunnarsson	Akvaplan-niva	Field work, report, project leader.
Hans-Petter Mannvik	Akvaplan-niva	Identification of bottom fauna (Echinodermata). Report, professional assessments and interpretations.
Kamila Sztybor	Akvaplan-niva	QA report, professional assessments and interpretations.
Roger Velvin	Akvaplan-niva	Identification of bottom fauna (Various taxa).
Rune Palerud	Akvaplan-niva	Identification of bottom fauna (Crustaceans). Statistics.
Thomas Hansen	Akvaplan-niva	Identification of bottom fauna (Mollusca).
Jesper Hansen	Akvaplan-niva	Identification of bottom fauna (Polychaeta).
Vegard Holen	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 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).

Kópavogur, 20.09 2022

Snorri Gunnarsson

1 Data Summary

Client information			
Report title:	C-Survey at Haganes, 2022.		
Report nr.	64106.03	Site:	Haganes
Municipality:		Map Coordinates (construction):	65°40,451 N 23°32,843 V
MTB permitted:	3.866 t	Operations manager:	Silja Baldvinsdóttir
Client:	Arnarlax ehf		

Biomass/production status at time of survey 21.06.2022			
Fish group:	Salmon	Biomass on examination:	3.866 t
Feed input:	4.824 t	Produced amount of fish:	3.910 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)	0.417	Fauna C1 (impact zone)	2.25
Fauna C2	0.558	Fauna C2	2.18
Fauna C3	0.583	Fauna C3	2.36
Fauna C4 (deep area)	0.575	Fauna C4 (deep area)	2.27
Fauna C5	0.559	Fauna C5	1.95
Date fieldwork:	21.06.2022	**Date of report:**	14.09 2022
Notes to other results (sediment, pH/Eh, oxygen)			nTOC from 29.7 to 33.7 mg/g. Copper 47.7 mg/kg at C1 Eh positive at all stations O_2-conditions were good throughout the water column.
Responsible for field work:	Signature: SGU	Project manager Snorri Gunnarsson	Sign: SGU

2 Introduction

2.1 Background and aim of the study

On behalf of Arnarlax ehf, Akvaplan-niva completed a survey (type C) for a fish farming site at Haganes (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 (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 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.

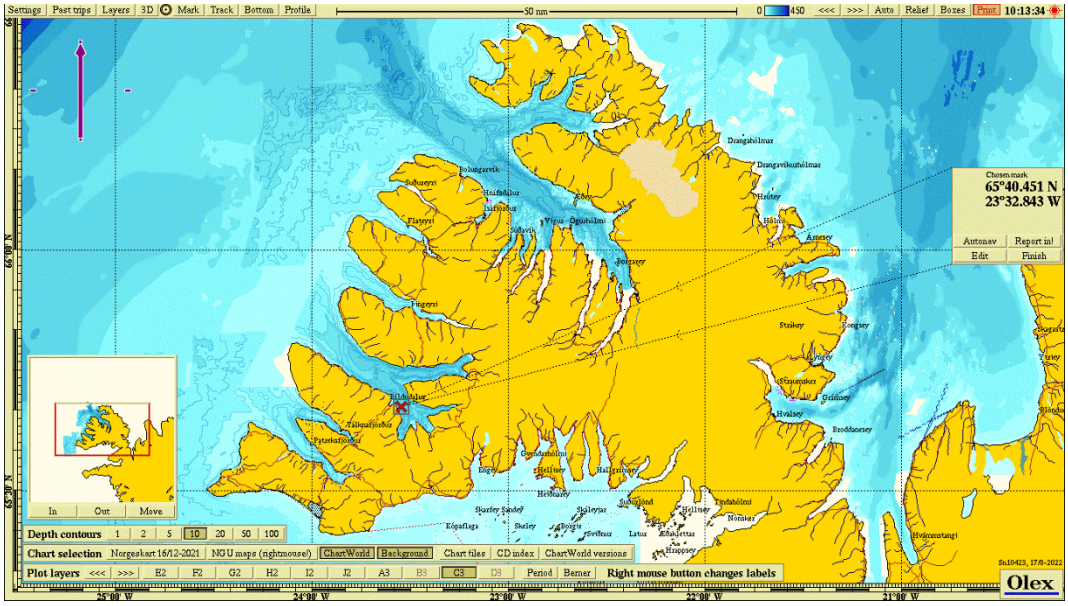

Figure 1 Overview of Arnarfjörður with the farming site Haganes (red cross). The map coordinates for the midpoint of the farming site are given to the right.

2.2 Site operation and feed use

Haganes is located in the southern part of Arnarfjörður, approximately 1,4 nm southeast of the town Bíldudalur. The installed frame is suited for up to 10 net-pens with a circumference of 160 m. The frame is positioned in northeast direction from land (40°) with depth below the cages ranging from 50 to 99 m.

The current generation is the third generation of fish farmed at the site and was put into sea during summer 2020. For this production cycle the frame was extended from 6 to 10 net-pens and the farm was moved approximately 300 m northeast.

In Iceland, the MTB (maximum allowed biomass) limit is not given a site level as in Norway. The MTB limit determines how much live fish the holder of the permit can have standing in the sea at any time. In Iceland the allowed production is regulated at two levels, site level and company level. For this site the estimated maximal standing biomass for the present generation is 3.866 tons, used as MTB here (Silja Baldvinsdóttir, pers reference).

2.3 Previous surveys

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

Table 1: Previous surveys at Haganes.

Survey date	Report reference (author, year)	Production (tonn)	Type of survey and result
11.06 2020	APN 62253.01 (Mannvik and Gunnarsson, 2020)	0	C-survey, fallow period
05.09 2018	APN 60528.01 (Mannvik and Gunnarsson, 2019)	2.049	C-survey, max biomass
27.06 2017	APN 8952.01 (Mannvik and Eriksen, 2018)	305 t	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 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 Haganes, 2022. TOC = total organic carbon. Korn = grain size in sediment. TOM = total organic material. TN = total nitrogen. Cu = Copper. pH/Eh = acidity and redox potential.

Station	Type analyses/parameters
C1 (local impact zone)	Quantitative analyses of bottom fauna. TOC. Korn. TOM. TN. Cu. pH/Eh.
C2 (transect zone outer)	Quantitative analyses of bottom fauna. TOC. Korn. TOM. TN. pH/Eh.
C3 (transect zone)	Quantitative analyses of bottom fauna. TOC. Korn. TOM. TN. pH/Eh.
C4 (transect zone, deep area)	Quantitative analyses of bottom fauna. TOC. Korn. TOM. TN. Hydrography/O_2. pH/Eh.
C5 (transect zone)	Quantitative analyses of bottom fauna. TOC. Korn. TOM. TN. pH/Eh.

Field work was completed on 21.06.2022.

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 3.866 tons (used as MTB here). According to the standard five 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 based on the direction of the main oceanic current

direction at 56 m depth (Hermansen, 2020) and the bathymetry. The mainstream is strongest towards southeast but has also return stream towards north. It has been chosen to place stations in both directions. Stations C1-C4 were placed south-east from the site and station C5 north from the site.

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

Station	Depth, m	Distance from frame, m	Position	
			N	W
C1	98	25	65°40.436	23°32.579
C2	82	500	65°40.278	23°32.088
C3	98	120	65°40.406	23°32.480
C4	98	250	65°40.364	23°32.342
C5	91	80	65°40.616	23°32.903

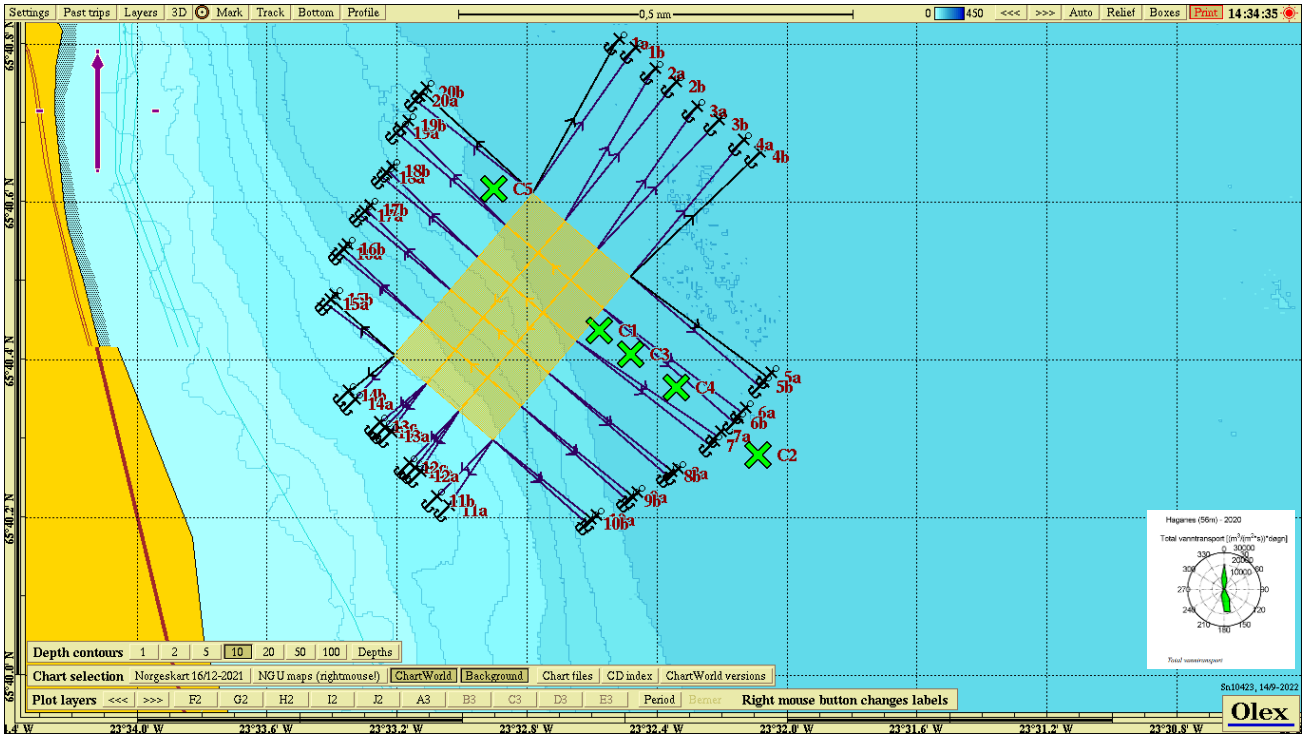

Figure 2. Map showing the sampling stations for the C-survey at Haganes, 2022. Current measurements used were from 56 m depth (Hermansen, 2020).

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})). 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 June 2022 is presented in Figure 3.

Temperature decreased from 9 ^{0}C at the surface to 2 ^{0}C at the bottom, and oxygen saturation decreased from 111 % in the upper layer and 77 % in the bottom layer.

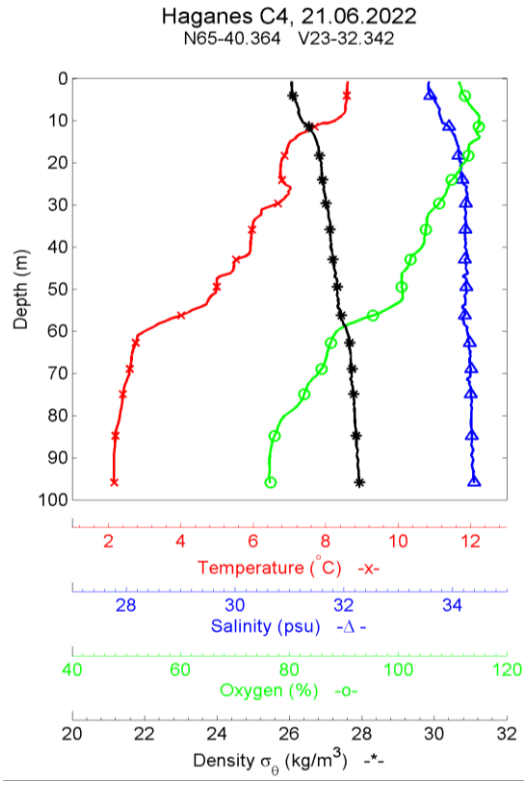

Figure 3. Vertical profiles. Temperature, salinity, density, and oxygen at C4 at Haganes, 2022.

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 (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 13.0 to 14.3 %. TN-levels were low (4.0 – 6.0 mg/g) as was the C/N-ratio. TOC was rather high at all stations and nTOC varied from 29.7 to 33.7 mg/g TS. The bottom sediments grain size was moderately fine with a pelite ratio ranging from 73.7 to 85.1 %.

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. Haganes, 2022.

St.	Sediment description	TOM	TOC	nTOC	TN	C/N	Pelitt	pH/Eh
C1	Olive green clay with a thin layer of black silt on top. Litle smell of sulfur.	14.3	28	32.3	4.0	7.1	76.5	7.6/283
C2	Olive green clay.	13.9	27	30.6	6.0*	4.6	82.4	7.9/279
C3	Olive green clay.	13.6	26	29.7	5.4*	4.9	81.2	7.9/288
C4	Olive green clay.	13.2	31	33.7	5.2*	5.9	85.1	7.8/271
C5	Olive green clay.	13.0	25	30.1	5.6*	4.5	73.7	7.8/302

*Not accredited results.

4.2.2 Copper

Level of copper in bottom sediment at C1 is shown in Table 5. The level of copper was 47.4 mg/kg.

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

St.	Cu
C1	47,4

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.

The number of individuals varied from 172 (C1) to 547 (C4) and number of species from 18 (C1) to 31 (C4). The diversity H' varied from 1.95 to 2.36. At all stations, the overall index of nEQR was lower than 0.6 faunal index nEQR at C1 (0.417) indicated somewhat disturbed faunal community.

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 0.45 to 0.68 which indicates a somewhat uneven distribution.

Table 6. 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 Haganes, 2022.

St.	Numb. ind.	Numb. species	H´	ES_{100}	NQI1	ISI_{2012}	NSI	nEQR	AMBI	J
C1	172	18	2.25	10.25	0.462	6.94	13.34	0.417	4.218	0.68
C2	390	21	2.18	14.29	0.546	8.28	21.55	0.558	3.806	0.53
C3	479	30	2.36	15.26	0.563	8.69	21.64	0.583	3.700	0.53
C4	547	31	2.27	15.16	0.574	8.26	21.69	0.575	3.653	0.50
C5	370	24	1.95	14.90	0.542	8.34	22.33	0.559	4.000	0.45

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 2 "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 Haganes site 2022.

Station	Site name	Num. species	Dominating taxa	Environmental condition-NS 9410
C1	Haganes	18	Capitella capitata - 31 %	2 –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 (≤ 11 species) and stretched out in varying degrees towards higher classes. These did not give any clear indications of fauna condition.

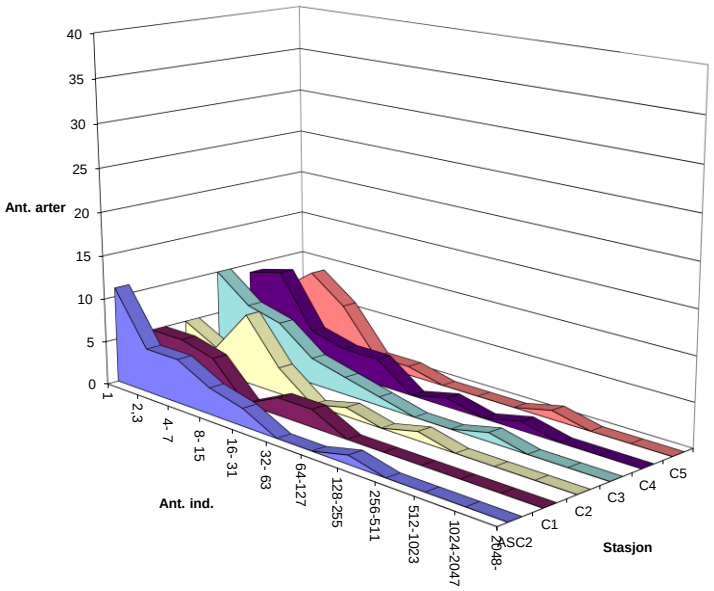

Figure 4. The soft bottom fauna shown as number of species against number of individuals pr. species in geometric classes. Haganes, 2022.

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 compositions at stations C2, C3, C4 and C5 were more than 67 % similar and station C1 was 52 % similar to the other stations.

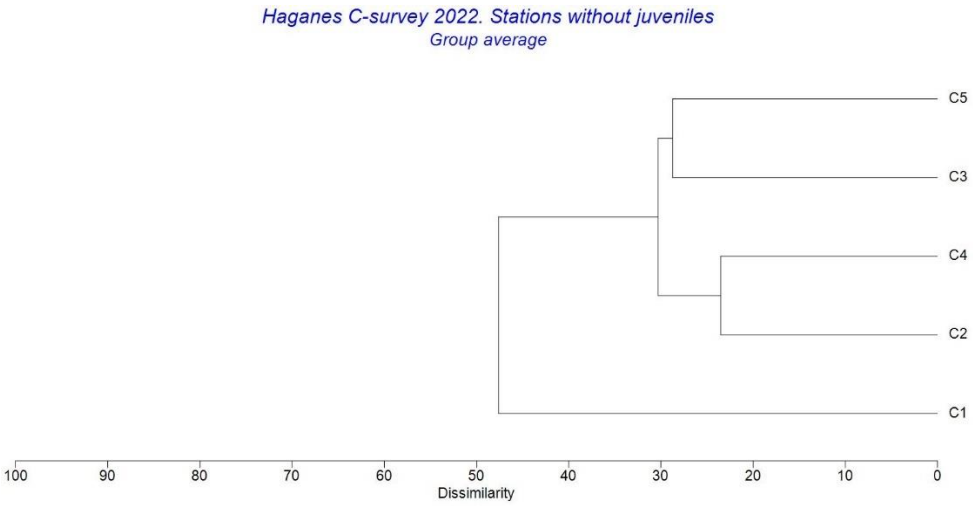

Figure 5. Cluster diagram for the soft bottom fauna at the C- sampling stations at Haganes, 2022.

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 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).

The fauna at C1 was dominated by the pollution indicator species *Capitella capitata* (polychaeta) with 31 % of the individuals. The other most dominants at this station were neutral and opportunistic species.

The other stations were dominated by the neutral polychaeta *Prionospio steenstrupi* with between 60 and 71 % of the individuals. The other most dominant species at the stations were a mixture of neutral, tolerant, and opportunistic species. No pollution indicator species were registered among the most dominants at these stations.

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

C1	EG	Numb.	Cum.	C2	EG	Numb.	Cum.
Capitella capitata	V	54	31 %	Prionospio steenstrupi	II	244	62 %
Thyasira sarsii	IV	41	55 %	Thyasira sarsii	IV	55	76 %
Prionospio steenstrupi	II	24	69 %	Chaetozone setosa	IV	12	79 %
Ennucula tenuis	II	18	80 %	Melinna cristata	II	10	82 %
Aeginina longicornis		5	83 %	Ennucula tenuis	II	9	84 %
Macoma calcarea	IV	4	85 %	Ampharete borealis	III	7	86 %
Ophryotrocha lobifera	IV	4	87 %	Nuculana pernula	II	7	88 %
Yoldia hyperborea		4	90 %	Praxillella gracilis	IV	7	90 %
Chaetozone setosa	IV	3	91 %	Euchone papillosa	III	6	91 %
Philine denticulata		3	93 %	Leucon sp.		6	93 %
C3	**EG**	**Numb.**	**Cum.**	**C4**	**EG**	**Numb.**	**Cum.**
Prionospio steenstrupi	II	287	60 %	Prionospio steenstrupi	II	340	62 %
Thyasira sarsii	IV	60	72 %	Thyasira sarsii	IV	71	75 %
Chaetozone setosa	IV	25	77 %	Leucon sp.		20	78 %
Yoldia hyperborea		16	81 %	Ampharete borealis	III	19	82 %
Ennucula tenuis	II	12	83 %	Chaetozone setosa	IV	16	85 %
Ophelina acuminata	II	12	86 %	Macoma calcarea	IV	10	87 %
Thyasiridae indet.		9	88 %	Ennucula tenuis	II	9	88 %
Praxillella gracilis	IV	6	89 %	Yoldia hyperborea		9	90 %
Ampharete borealis	III	5	90 %	Lumbrineris mixochaeta	IV	6	91 %
Galathowenia oculata	III	5	91 %	Praxillella gracilis	IV	6	92 %

C5	EG	Numb.	Cum.
Prionospio steenstrupi	II	263	71 %
Chaetozone setosa	IV	31	79 %
Thyasira sarsii	IV	13	83 %
Ampharete borealis	III	7	85 %
Parougia eliasoni		7	87 %
Ennucula tenuis	II	6	88 %
Yoldia hyperborea		5	89 %
Leucon sp.		4	91 %
Ophelina acuminata	II	4	92 %
Aeginina longicornis		3	92 %

*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 Haganes, 2022, can be summarized as follows:

- The hydrography measurements showed good oxygen conditions throughout the water column with 77 % saturation in the bottom layer in June 2022.
- TOC was somewhat high at all stations and nTOC varied from 29.7 to 33.7 mg/g TS. TOM-levels varied from 13.0 to 14.3 %. TN-levels were low (4.0 – 6.0 mg/g) as was the C/N-ratio. The copper level in the sediment at C1 was somewhat high (47.4 mg/kg) according to Norwegian standards, but within reported natural levels of 55 mg/kg in Icelandic coastal areas (Egilsson *et al.* 1999). The sediment was fine grained with a pelite share between 74 and 85 %. 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 172 to 547 and number of species from 18 to 31. The diversity H' varied from 1.95 to 2.36. Some load effect was recorded in the fauna (nEQR < 0.6) and faunal index the nEQR at C1 (0.417) indicated somewhat disturbed faunal community.

5.2 Conclusions

The results from the monitoring at the farming site Haganes in June 2022 showed that the sediment was somewhat loaded with organic carbon and the copper concentrations were within reported natural levels for bottom sediment around Iceland (Egilsson *et al.*, 1999). Some load effect was recorded in the fauna (nEQR < 0.6) and faunal index the nEQR at C1 (0.417) indicated somewhat disturbed faunal community. The diversity index H ' was below 3 at all stations and ranged from 1.95 (C5) to 2.36 (C3). NS 9410:2016-assessment of the community in the local impact zone (C1) showed environmental condition 2 (Good). The pollution indicator species *Capitella capitata* dominated the fauna at C1 but was not recorded among the top-10 at any of the other 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 June was good in the whole water column with 77 % in the bottom water.

In comparison with the results from previous C-survey at fallow period in 2020 (Mannvik and Gunnarsson, 2020) the diversity index H´ is in general trending lower than in the previous survey but in general comparable to the results at previous max biomass survey in 2018 (Mannvik and Gunnarsson, 2019). The faunal index score is lower than 0.6 at all stations but was in general higher or similar in the previous fallow survey. The pollution indicator species *Capitella capitata* (polychaete) was registered among the most dominants at station C1 and C3 in 2018 at max biomass, but not among top-10 at any stations in the fallow survey in 2020. In the present survey the pollution indicator species *Capitella capitata* dominated the fauna at C1 but was not recorded among the top-10 at any of the other stations.

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7 Appendix (in Norwegian)

7.1 Statistical methods

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.

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 Haganes, 2022

Number of species and individuals per station

St.	C1	C2	C3	C4	C5
Ant. ind.	172	390	479	547	370
Ant. arter	18	21	30	31	24

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
no. ind.	2298	111	61	168	222	234	245	272	275	220	150
no. spe.	48	15	6	19	16	22	21	25	23	21	19
Shannon-Wiener:		3,0	1,5	2,3	2,1	2,3	2,4	2,4	2,1	1,7	2,2
Pielou		0,76	0,60	0,54	0,52	0,51	0,56	0,52	0,47	0,39	0,51
ES100		14	6	16	13	15	16	16	15	14	16
SN		1,75	1,27	1,80	1,64	1,82	1,79	1,87	1,82	1,81	1,83
ISI-2012		7,59	6,29	8,01	8,54	8,68	8,69	8,22	8,29	8,42	8,25
AMBI		3,212	5,223	3,665	3,747	3,711	3,689	3,597	3,709	4,1	3,9
NQI1		0,58	0,34	0,56	0,53	0,57	0,56	0,58	0,57	0,53	0,55
NSI		17,7	9,0	21,4	21,7	21,3	22,0	21,4	22,0	22,5	22,1

Benthos indices, averages per station

st.nr.		C1	C2	C3	C4	C5
Shannon-Wiener:		2,25	2,18	2,36	2,27	1,95
Pielou		0,68	0,53	0,53	0,50	0,45
ES100		10,2	14,3	15,3	15,2	14,9
SN		1,51	1,72	1,80	1,84	1,82
ISI-2012		6,94	8,28	8,69	8,26	8,34
AMBI		4,218	3,706	3,700	3,653	4,000
NQI1		0,46	0,55	0,56	0,57	0,54
NSI		13,34	21,55	21,64	21,69	22,33
Tilstandsklasse nEQR		0,417	0,558	0,583	0,575	0,559

Geometric classes

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

7.3 Species lists

Artsliste pr stasjon

Haganes ASC-C-survey 2022

Rekke	Klasse	Orden	Art/Taxa	Replikat:	01	02	-	Sum
Stasjonsnr.:	**ASC2**							
NEMERTINI								
			Nemertea indet.		1		-	1
ANNELIDA								
	Polychaeta							
		Spionida						
			Chaetozone setosa		5	9	-	14
			Prionospio steenstrupi		136	71	-	207
		Capitellida						
			Praxillella gracilis		6	7	-	13
		Opheliida						
			Ophelina acuminata		2	4	-	6
		Phyllodocida						
			Gattyana amondseni			1	-	1
			Harmothoe mariannae			1	-	1
			Nephtys ciliata			2	-	2
		Eunicida						
			Lumbrineris mixochaeta		1		-	1
		Oweniida						
			Galathowenia oculata		1		-	1
		Terebellida						
			Ampharete borealis		3	4	-	7
			Ampharete petersenae			1	-	1
			Laphania boecki			1	-	1
			Melinna cristata		3	4	-	7
		Sabellida						
			Euchone papillosa		2		-	2
CRUSTACEA								
	Malacostraca							
		Cumacea						
			Leucon sp.		8	11	-	19
		Amphipoda						
			Deflexilodes tesselatus		1		-	1
			Metopa boeckii		1		-	1
			Oedicerotidae indet.			1	-	1
			Rostroculodes longirostris			2	-	2
MOLLUSCA								
	Prosobranchia							
		Neogastropoda						
			Curtitoma trevelliana		1		-	1
	Bivalvia							
		Nuculoida						
			Ennucula tenuis		5	7	-	12
			Nuculana pernula		2		-	2
			Yoldia hyperborea		1	4	-	5
		Veneroida						
			Macoma calcarea		3	4	-	7
			Thyasira sarsii		9	12	-	21
			Thyasiridae indet.		1	2	-	3
ECHINODERMATA								
	Asteroidea							
			Asteroidea indet. juv.		2	1	-	3
				Maksverdi:	136	71		207
				Antall arter/taxa:	21	20		28
				Sum antall individ:				343
Stasjonsnr.:	**C1**							
ANNELIDA								
	Polychaeta							
		Spionida						
			Chaetozone setosa		3		-	3

Rekke	Klasse	Orden	Art/Taxa	Replikat:	01	02	-	Sum
			Prionospio steenstrupi		24		-	24
			Spio limicola		1		-	1
		Capitellida						
			Capitella capitata		13	41	-	54
			Praxillella gracilis		1		-	1
		Phyllodocida						
			Nephtys ciliata		1		-	1
		Eunicida						
			Ophryotrocha lobifera			4	-	4
			Parougia eliasoni		2		-	2
		Terebellida						
			Cistenides hyperborea		1		-	1
CRUSTACEA								
	Malacostraca							
		Cumacea						
			Leucon sp.			1	-	1
		Amphipoda						
			Aeginina longicornis			5	-	5
MOLLUSCA								
	Opistobranchia							
		Cephalaspidea						
			Philine denticulata		3		-	3
	Bivalvia							
		Nuculoida						
			Ennucula tenuis		18		-	18
			Nuculana pernula		1	1	-	2
			Yoldia hyperborea		4		-	4
		Veneroida						
			Macoma calcarea		4		-	4
			Thyasira sarsii		32	9	-	41
			Thyasiridae indet.		3		-	3
				Maksverdi:	32	41		54
				Antall arter/taxa:	15	6		18
				Sum antall individ:				172

Stasjonsnr.: C2

NEMERTINI								
			Nemertea indet.		1		-	1
ANNELIDA								
	Polychaeta							
		Spionida						
			Chaetozone setosa		5	7	-	12
			Prionospio steenstrupi		104	140	-	244
		Capitellida						
			Mediomastus fragilis		4	2	-	6
			Praxillella gracilis		2	5	-	7
		Opheliida						
			Ophelina acuminata		1	3	-	4
		Phyllodocida						
			Nephtys ciliata		1	1	-	2
		Eunicida						
			Lumbrineris mixochaeta		3	2	-	5
		Terebellida						
			Ampharete borealis		4	3	-	7
			Ampharete lindstroemi			1	-	1
			Ampharete petersenae		1		-	1
			Melinna cristata		1	9	-	10
		Sabellida						
			Euchone papillosa		4	2	-	6
CRUSTACEA								
	Malacostraca							
		Cumacea						
			Leucon sp.		3	3	-	6
		Amphipoda						
			Metopa boeckii			1	-	1
MOLLUSCA								
	Prosobranchia							
		Neogastropoda						
			Curtitoma trevelliana		2		-	2
	Bivalvia							
		Nuculoida						

Rekke	Klasse	Orden	Art/Taxa	Replikat:	01	02	-	Sum
			Ennucula tenuis		4	5	-	9
			Nuculana pernula		2	5	-	7
			Yoldia hyperborea		3		-	3
		Veneroida						
			Macoma calcarea		1		-	1
			Thyasira sarsii		22	33	-	55
ECHINODERMATA								
	Asteroidea							
			Asteroidea indet. juv.		1	1	-	2
				Maksverdi:	104	140		244
				Antall arter/taxa:	20	17		22
				Sum antall individ:				392

Stasjonsnr.: C3

SIPUNCULIDA								
			Phascolion strombus		1		-	1
ANNELIDA								
	Polychaeta							
		Spionida						
			Chaetozone setosa		14	11	-	25
			Prionospio steenstrupi		139	148	-	287
		Capitellida						
			Mediomastus fragilis			3	-	3
			Praxillella gracilis		2	4	-	6
		Opheliida						
			Ophelina acuminata		3	9	-	12
		Phyllodocida						
			Eteone flava/longa		3	1	-	4
			Nephtys ciliata		1		-	1
			Nephtys hystricis		1		-	1
			Pholoe assimilis			1	-	1
		Eunicida						
			Lumbrineris mixochaeta		1		-	1
			Ophryotrocha lobifera			1	-	1
			Parougia eliasoni		2	1	-	3
		Oweniida						
			Galathowenia oculata		5		-	5
		Flabelligerida						
			Diplocirrus longisetosus		1		-	1
		Terebellida						
			Ampharete borealis		2	3	-	5
			Cistenides hyperborea			1	-	1
			Laphania boecki			3	-	3
			Melinna cristata		2	2	-	4
		Sabellida						
			Euchone papillosa		1		-	1
CRUSTACEA								
	Malacostraca							
		Cumacea						
			Leucon sp.		1	2	-	3
		Amphipoda						
			Oedicerotidae indet.			1	-	1
MOLLUSCA								
	Prosobranchia							
		Neogastropoda						
			Curtitoma trevelliana		2		-	2
	Opistobranchia							
		Cephalaspidea						
			Philine denticulata		3		-	3
	Bivalvia							
		Nuculoida						
			Ennucula tenuis		3	9	-	12
			Nuculana pernula		1	3	-	4
			Yoldia hyperborea		7	9	-	16
		Veneroida						
			Macoma calcarea			3	-	3
			Thyasira sarsii		39	21	-	60
			Thyasiridae indet.			9	-	9
ECHINODERMATA								
	Asteroidea							

Rekke	Klasse	Orden	Art/Taxa	Replikat:	01	02	-	Sum
			Asteroidea indet. juv.		2		-	2
				Maksverdi:	139	148		287
				Antall arter/taxa:	23	21		31
				Sum antall individ:				481

Stasjonsnr.: C4

NEMERTINI							
			Nemertea indet.	1	1	-	2
ANNELIDA							
	Polychaeta						
		Orbiniida					
			Scoloplos armiger	1		-	1
		Spionida					
			Chaetozone setosa	9	7	-	16
			Prionospio steenstrupi	160	180	-	340
		Capitellida					
			Mediomastus fragilis	1		-	1
			Praxillella gracilis	4	2	-	6
		Opheliida					
			Ophelina acuminata	1	1	-	2
		Phyllodocida					
			Eteone flava/longa		1	-	1
			Nephtys ciliata	2		-	2
		Eunicida					
			Lumbrineris mixochaeta	2	4	-	6
		Oweniida					
			Galathowenia oculata	2	1	-	3
		Terebellida					
			Ampharete borealis	4	15	-	19
			Ampharete lindstroemi	2	1	-	3
			Ampharete petersenae	1		-	1
			Laphania boecki	4		-	4
			Melinna cristata		5	-	5
		Sabellida					
			Euchone papillosa		2	-	2
CRUSTACEA							
	Malacostraca						
		Cumacea					
			Leucon sp.	12	8	-	20
		Amphipoda					
			Bathymedon longimanus		1	-	1
			Caprellidae indet.		1	-	1
			Rostroculodes sp.	1	2	-	3
MOLLUSCA							
	Prosobranchia						
		Neogastropoda					
			Curtitoma trevelliana	1	1	-	2
	Opistobranchia						
		Cephalaspidea					
			Diaphana minuta	1		-	1
			Philine denticulata		2	-	2
	Bivalvia						
		Nuculoida					
			Ennucula tenuis	7	2	-	9
			Nuculana pernula	1	1	-	2
			Yoldia hyperborea	6	3	-	9
		Veneroida					
			Macoma calcarea	5	5	-	10
			Thyasira sarsii	42	29	-	71
			Thyasiridae indet.	1		-	1
ECHINODERMATA							
	Asteroidea						
		Paxillosida					
			Ctenodiscus crispatus	1		-	1
			Asteroidea indet. juv.	2	1	-	3

Rekke	Klasse	Orden	Art/Taxa	Replikat:	01	02	-	Sum
				Maksverdi:	160	180		340
				Antall arter/taxa:	26	24		32
				Sum antall individ:				550
Stasjonsnr.:	C5							
ANNELIDA								
	Polychaeta							
		Spionida						
			Chaetozone setosa		15	16	-	31
			Prionospio steenstrupi		165	98	-	263
		Capitellida						
			Praxillella gracilis		2	1	-	3
		Opheliida						
			Ophelina acuminata		2	2	-	4
		Phyllodocida						
			Eteone barbata		1		-	1
			Eteone flava/longa		1	1	-	2
			Nephtys ciliata		1	2	-	3
		Eunicida						
			Parougia eliasoni		5	2	-	7
		Oweniida						
			Galathowenia oculata		3		-	3
		Terebellida						
			Ampharete borealis		4	3	-	7
			Laphania boecki		1		-	1
			Melinna cristata		1	1	-	2
		Sabellida						
			Euchone papillosa		2	1	-	3
CRUSTACEA								
	Malacostraca							
		Cumacea						
			Leucon sp.		1	3	-	4
		Amphipoda						
			Aeginina longicornis		1	2	-	3
			Bathymedon longimanus		1		-	1
			Deflexilodes tesselatus			1	-	1
			Metopa boeckii			1	-	1
MOLLUSCA								
	Opistobranchia							
		Cephalaspidea						
			Philine denticulata		1		-	1
	Bivalvia							
		Nuculoida						
			Ennucula tenuis		1	5	-	6
			Nuculana pernula			2	-	2
			Yoldia hyperborea		3	2	-	5
		Veneroida						
			Macoma calcarea		1	2	-	3
			Thyasira sarsii		8	5	-	13
ECHINODERMATA								
	Asteroidea							
			Asteroidea indet. juv.		1		-	1
				Maksverdi:	165	98		263
				Antall arter/taxa:	22	19		25
				Sum antall individ:				371

7.4 Analytical report

ANALYSERAPPORT

Kunde:	Arnarlax	**Rapport nr.:**	P2200112
Kundemerking:	Haganes		
Kontaktperson kunde:		**Rapportdato**	**2022-07-29**
Prosjektnr.:	**64106**	**Ankomst dato**	2022-06-16

Lab-id. P2200112-01

Objekt	Kundens ID	Beskrivelse	Notering	Mottatt lab
Sediment	C1	64106 - Haganes C/ASC 2022		2022-06-16

Analyseresultat

Parameter	Resultat	Enhet	Analysedato start	Analysedato slutt	Standard	Måleusikkerhet
TOC	28	mg/g TS	2022-07-11	2022-07-13	DIN 19539:2016	±2.8
TNb	4.0	mg/g TS	2022-07-11	2022-07-13	NS-EN 16168:2012	±1.2
N TOC	32.3	mg/g TS	2022-07-20	2022-07-20	Veileder 02:2018	
C/N - forhold	7.1		2022-07-20	2022-07-20		
TOM	14.3	% TS	2022-07-18	2022-07-21	Intern metode	±0.0
Vekt % 2 mm	2.1	wt% TS	2022-07-11	2022-07-14	Intern metode	±0.1
Vekt % 1 mm	6.9	wt% TS	2022-07-11	2022-07-14	Intern metode (Bale/Kenny 2005)	±0.3
Vekt % 0.500 mm	6.4	wt% TS	2022-07-11	2022-07-14	Intern metode (Bale/Kenny 2005)	±0.3
Vekt % 0.250 mm	3.8	wt% TS	2022-07-11	2022-07-14	Intern metode (Bale/Kenny 2005)	±0.2
Vekt % 0.125 mm	2.0	wt% TS	2022-07-11	2022-07-14	Intern metode (Bale/Kenny 2005)	±0.1
Vekt % 0.063 mm	2.2	wt% TS	2022-07-11	2022-07-14	Intern metode (Bale/Kenny 2005)	±0.1
Vekt % < 0.063 mm	76.5	wt% TS	2022-07-11	2022-07-14	Intern metode (Bale/Kenny 2005)	±3.8
Pelitt	76.5	wt% TS	2022-07-11	2022-07-14	Intern metode (Bale/Kenny 2005)	±3.8
Sand	21.4	wt% TS	2022-07-11	2022-07-14	Intern metode (Bale/Kenny 2005)	±1.1
Grus	2.1	wt% TS	2022-07-11	2022-07-14	Intern metode (Bale/Kenny 2005)	±0.1
Cu (kobber) [a]	47.4	mg/kg TS	2022-07-14	2022-07-14	Intern metode	
P (Fosfor) [a]	1190	mg/kg TS	2022-07-14	2022-07-14	Intern metode	

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

* = Ikke akkreditert resultat

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ANALYSERAPPORT

Kunde:	Arnarlax	**Rapport nr.:**	P2200112
Kundemerking:	Haganes		
Kontaktperson kunde:		**Rapportdato**	**2022-07-29**
Prosjektnr.:	**64106**	**Ankomst dato**	2022-06-16

Lab-id. P2200112-02

Objekt	Kundens ID	Beskrivelse	Notering	Mottatt lab
Sediment	C2/ASC ref	64106 - Haganes C/ASC 2022		2022-06-16

Analyseresultat

Parameter	Resultat	Enhet	Analysedato start	Analysedato slutt	Standard	Måleusikkerhet
TOC	27	mg/g TS	2022-07-11	2022-07-13	DIN 19539:2016	±2.7
TNb	*6.0	mg/g TS	2022-07-11	2022-07-13	NS-EN 16168:2012	±1.8
N TOC	30.6	mg/g TS	2022-07-20	2022-07-20	Veileder 02:2018	
C/N - forhold	4.6		2022-07-20	2022-07-20		
TOM	13.9	% TS	2022-07-18	2022-07-21	Intern metode	±0.0
Vekt % 2 mm	0.2	wt% TS	2022-07-11	2022-07-14	Intern metode	±0.0
Vekt % 1 mm	2.8	wt% TS	2022-07-11	2022-07-14	Intern metode (Bale/Kenny 2005)	±0.1
Vekt % 0.500 mm	6.8	wt% TS	2022-07-11	2022-07-14	Intern metode (Bale/Kenny 2005)	±0.3
Vekt % 0.250 mm	4.6	wt% TS	2022-07-11	2022-07-14	Intern metode (Bale/Kenny 2005)	±0.2
Vekt % 0.125 mm	1.6	wt% TS	2022-07-11	2022-07-14	Intern metode (Bale/Kenny 2005)	±0.1
Vekt % 0.063 mm	1.5	wt% TS	2022-07-11	2022-07-14	Intern metode (Bale/Kenny 2005)	±0.1
Vekt % < 0.063 mm	82.4	wt% TS	2022-07-11	2022-07-14	Intern metode (Bale/Kenny 2005)	±4.1
Pelitt	82.4	wt% TS	2022-07-11	2022-07-14	Intern metode (Bale/Kenny 2005)	±4.1
Sand	17.3	wt% TS	2022-07-11	2022-07-14	Intern metode (Bale/Kenny 2005)	±0.9
Grus	0.2	wt% TS	2022-07-11	2022-07-14	Intern metode (Bale/Kenny 2005)	±0.0
Cu (kobber) [a]	52.4 47.8	mg/kg TS	2022-07-14	2022-07-14	Intern metode	
P (Fosfor) [a]	1370	mg/kg TS	2022-07-14	2022-07-14	Intern metode	

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

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ANALYSERAPPORT

Kunde:	Arnarlax	**Rapport nr.:**	P2200112
Kundemerking:	Haganes		
Kontaktperson kunde:		**Rapportdato**	**2022-07-29**
Prosjektnr.:	**64106**	**Ankomst dato**	2022-06-16

Lab-id. P2200112-03

Objekt	Kundens ID	Beskrivelse	Notering	Mottatt lab
Sediment	C3/ASC3	64106 - Haganes C/ASC 2022		2022-06-16

Analyseresultat

Parameter	Resultat	Enhet	Analysedato start	Analysedato slutt	Standard	Måleusikkerhet
TOC	26	mg/g TS	2022-07-11	2022-07-13	DIN 19539:2016	±2.6
TNb	*5.4	mg/g TS	2022-07-11	2022-07-13	NS-EN 16168:2012	±1.6
N TOC	29.7	mg/g TS	2022-07-20	2022-07-20	Veileder 02:2018	
C/N - forhold	4.9		2022-07-20	2022-07-20		
TOM	13.6	% TS	2022-07-18	2022-07-21	Intern metode	±0.0
Vekt % 2 mm	1.4	wt% TS	2022-07-11	2022-07-14	Intern metode	±0.1
Vekt % 1 mm	5.3	wt% TS	2022-07-11	2022-07-14	Intern metode (Bale/Kenny 2005)	±0.3
Vekt % 0.500 mm	5.2	wt% TS	2022-07-11	2022-07-14	Intern metode (Bale/Kenny 2005)	±0.3
Vekt % 0.250 mm	3.1	wt% TS	2022-07-11	2022-07-14	Intern metode (Bale/Kenny 2005)	±0.2
Vekt % 0.125 mm	1.6	wt% TS	2022-07-11	2022-07-14	Intern metode (Bale/Kenny 2005)	±0.1
Vekt % 0.063 mm	2.2	wt% TS	2022-07-11	2022-07-14	Intern metode (Bale/Kenny 2005)	±0.1
Vekt % < 0.063 mm	81.2	wt% TS	2022-07-11	2022-07-14	Intern metode (Bale/Kenny 2005)	±4.1
Pelitt	81.2	wt% TS	2022-07-11	2022-07-14	Intern metode (Bale/Kenny 2005)	±4.1
Sand	17.4	wt% TS	2022-07-11	2022-07-14	Intern metode (Bale/Kenny 2005)	±0.9
Grus	1.4	wt% TS	2022-07-11	2022-07-14	Intern metode (Bale/Kenny 2005)	±0.1
Cu (kobber) [a]	48.9 48.8	mg/kg TS	2022-07-14	2022-07-14	Intern metode	
P (Fosfor) [a]	880	mg/kg TS	2022-07-14	2022-07-14	Intern metode	

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

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ANALYSERAPPORT

Kunde:	Arnarlax	**Rapport nr.:**	P2200112
Kundemerking:	Haganes		
Kontaktperson kunde:		**Rapportdato**	**2022-07-29**
Prosjektnr.:	**64106**	**Ankomst dato**	2022-06-16

Lab-id. P2200112-04

Objekt	Kundens ID	Beskrivelse	Notering	Mottatt lab
Sediment	C4/ASC4	64106 - Haganes C/ASC 2022		2022-06-16

Analyseresultat

Parameter	Resultat	Enhet	Analysedato start	Analysedato slutt	Standard	Måleusikkerhet
TOC	31	mg/g TS	2022-07-11	2022-07-13	DIN 19539:2016	±3.1
TNb	*5.2	mg/g TS	2022-07-11	2022-07-13	NS-EN 16168:2012	±1.6
N TOC	33.7	mg/g TS	2022-07-20	2022-07-20	Veileder 02:2018	
C/N - forhold	5.9		2022-07-20	2022-07-20		
TOM	13.2	% TS	2022-07-18	2022-07-21	Intern metode	±0.0
Vekt % 2 mm	0.4	wt% TS	2022-07-11	2022-07-14	Intern metode	±0.0
Vekt % 1 mm	3.8	wt% TS	2022-07-11	2022-07-14	Intern metode (Bale/Kenny 2005)	±0.2
Vekt % 0.500 mm	5.4	wt% TS	2022-07-11	2022-07-14	Intern metode (Bale/Kenny 2005)	±0.3
Vekt % 0.250 mm	3.1	wt% TS	2022-07-11	2022-07-14	Intern metode (Bale/Kenny 2005)	±0.2
Vekt % 0.125 mm	1.0	wt% TS	2022-07-11	2022-07-14	Intern metode (Bale/Kenny 2005)	±0.1
Vekt % 0.063 mm	1.1	wt% TS	2022-07-11	2022-07-14	Intern metode (Bale/Kenny 2005)	±0.1
Vekt % < 0.063 mm	85.1	wt% TS	2022-07-11	2022-07-14	Intern metode (Bale/Kenny 2005)	±4.3
Pelitt	85.1	wt% TS	2022-07-11	2022-07-14	Intern metode (Bale/Kenny 2005)	±4.3
Sand	14.4	wt% TS	2022-07-11	2022-07-14	Intern metode (Bale/Kenny 2005)	±0.7
Grus	0.4	wt% TS	2022-07-11	2022-07-14	Intern metode (Bale/Kenny 2005)	±0.0
Cu (kobber) [a]	46.6 43.2	mg/kg TS	2022-07-14	2022-07-14	Intern metode	
P (Fosfor) [a]	1060	mg/kg TS	2022-07-14	2022-07-14	Intern metode	

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

* = Ikke akkreditert resultat

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ANALYSERAPPORT

Kunde:	Arnarlax	**Rapport nr.:**	P2200112
Kundemerking:	Haganes		
Kontaktperson kunde:		**Rapportdato**	**2022-07-29**
Prosjektnr.:	**64106**	**Ankomst dato**	2022-06-16

Lab-id. P2200112-05

Objekt	Kundens ID	Beskrivelse	Notering	Mottatt lab
Sediment	C5/ASC1	64106 - Haganes C/ASC 2022		2022-06-16

Analyseresultat

Parameter	Resultat	Enhet	Analysedato start	Analysedato slutt	Standard	Måleusikkerhet
TOC	25	mg/g TS	2022-07-11	2022-07-13	DIN 19539:2016	±2.5
TNb	*5.6	mg/g TS	2022-07-11	2022-07-13	NS-EN 16168:2012	±1.7
N TOC	30.1	mg/g TS	2022-07-20	2022-07-20	Veileder 02:2018	
C/N - forhold	4.5		2022-07-20	2022-07-20		
TOM	13.0	% TS	2022-07-18	2022-07-21	Intern metode	±0.0
Vekt % 2 mm	0.6	wt% TS	2022-07-11	2022-07-14	Intern metode	±0.0
Vekt % 1 mm	5.4	wt% TS	2022-07-11	2022-07-14	Intern metode (Bale/Kenny 2005)	±0.3
Vekt % 0.500 mm	7.3	wt% TS	2022-07-11	2022-07-14	Intern metode (Bale/Kenny 2005)	±0.4
Vekt % 0.250 mm	5.5	wt% TS	2022-07-11	2022-07-14	Intern metode (Bale/Kenny 2005)	±0.3
Vekt % 0.125 mm	3.1	wt% TS	2022-07-11	2022-07-14	Intern metode (Bale/Kenny 2005)	±0.2
Vekt % 0.063 mm	4.4	wt% TS	2022-07-11	2022-07-14	Intern metode (Bale/Kenny 2005)	±0.2
Vekt % < 0.063 mm	73.7	wt% TS	2022-07-11	2022-07-14	Intern metode (Bale/Kenny 2005)	±3.7
Pelitt	73.7	wt% TS	2022-07-11	2022-07-14	Intern metode (Bale/Kenny 2005)	±3.7
Sand	25.7	wt% TS	2022-07-11	2022-07-14	Intern metode (Bale/Kenny 2005)	±1.3
Grus	0.6	wt% TS	2022-07-11	2022-07-14	Intern metode (Bale/Kenny 2005)	±0.0
P (Fosfor) [a]	1180	mg/kg TS	2022-07-14	2022-07-14	Intern metode	

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

* = Ikke akkreditert resultat

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ANALYSERAPPORT

Kunde:	Arnarlax	**Rapport nr.:**	P2200112
Kundemerking:	Haganes		
Kontaktperson kunde:		**Rapportdato**	**2022-07-29**
Prosjektnr.:	**64106**	**Ankomst dato**	2022-06-16

Lab-id. P2200112-06

Objekt	Kundens ID	Beskrivelse	Notering	Mottatt lab
Sediment	ASC2	64106 - Haganes C/ASC 2022		2022-06-16

Analyseresultat

Parameter	Resultat	Enhet	Analysedato start	Analysedato slutt	Standard	Måleusikkerhet
TOC	26	mg/g TS	2022-07-11	2022-07-13	DIN 19539:2016	±2.6
TNb	*5.8	mg/g TS	2022-07-11	2022-07-13	NS-EN 16168:2012	±1.7
N TOC	30.6	mg/g TS	2022-07-20	2022-07-20	Veileder 02:2018	
C/N - forhold	4.5		2022-07-20	2022-07-20		
TOM	14.3	% TS	2022-07-18	2022-07-21	Intern metode	±0.0
Vekt % 2 mm	1.0	wt% TS	2022-07-11	2022-07-14	Intern metode	±0.1
Vekt % 1 mm	5.4	wt% TS	2022-07-11	2022-07-14	Intern metode (Bale/Kenny 2005)	±0.3
Vekt % 0.500 mm	7.5	wt% TS	2022-07-11	2022-07-14	Intern metode (Bale/Kenny 2005)	±0.4
Vekt % 0.250 mm	5.5	wt% TS	2022-07-11	2022-07-14	Intern metode (Bale/Kenny 2005)	±0.3
Vekt % 0.125 mm	3.0	wt% TS	2022-07-11	2022-07-14	Intern metode (Bale/Kenny 2005)	±0.2
Vekt % 0.063 mm	2.3	wt% TS	2022-07-11	2022-07-14	Intern metode (Bale/Kenny 2005)	±0.1
Vekt % < 0.063 mm	75.2	wt% TS	2022-07-11	2022-07-14	Intern metode (Bale/Kenny 2005)	±3.8
Pelitt	75.2	wt% TS	2022-07-11	2022-07-14	Intern metode (Bale/Kenny 2005)	±3.8
Sand	23.8	wt% TS	2022-07-11	2022-07-14	Intern metode (Bale/Kenny 2005)	±1.2
Grus	1.0	wt% TS	2022-07-11	2022-07-14	Intern metode (Bale/Kenny 2005)	±0.1

* = Ikke akkreditert resultat

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ANALYSERAPPORT

Kunde:	Arnarlax	**Rapport nr.:**	P2200112
Kundemerking:	Haganes		
Kontaktperson kunde:		**Rapportdato**	2022-07-29
Prosjektnr.:	64106	**Ankomst dato**	2022-06-16

Lab-id. P2200112-07

Objekt	Kundens ID	Beskrivelse	Notering	Mottatt lab
Sediment	Cu ref2	64106 - Haganes C/ASC 2022		2022-06-16

Analyseresultat							
Parameter	Resultat		Enhet	Analysedato start	Analysedato slutt	Standard	Måleusikkerhet
Cu (kobber) [a]	45.8	44.5	mg/kg TS	2022-07-14	2022-07-14	Intern metode	

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

Lab-id. P2200112-08

Objekt	Kundens ID	Beskrivelse	Notering	Mottatt lab
Sediment	Cu ref3	64106 - Haganes C/ASC 2022		2022-06-16

Analyseresultat							
Parameter	Resultat		Enhet	Analysedato start	Analysedato slutt	Standard	Måleusikkerhet
Cu (kobber) [a]	49.1	47.6	mg/kg TS	2022-07-14	2022-07-14	Intern metode	

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

Analyse av EMB på stasjon C3/ASC3 sendes ut i en egen analyserapport

NTOC er klassifisert ihht. veileder 02:2018. Metall(er) er klassifisert ihht. veileder M-608 (Rev. 31.10.2020)

Analyse	Standard	Grenseverdi - farger				
N TOC	Veileder 02:2018	<20	20 - 27	27 - 34	34 - 41	>41
Cu (kobber)	Intern metode	<20	20 - 84	84 - 147	>147	

Analyseansvarlig: Ingar H. Wasbotten

Signatur: Ingar H. Wasbotten

Underskriftsberettiget:

Signatur:

* = Ikke akkreditert resultat

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ANALYSERAPPORT

Kunde:	Arnarlax	**Rapport nr.:**	P2200112
Kundemerking:	Haganes		
Kontaktperson kunde:		**Rapportdato**	2022-07-29
Prosjektnr.:	64106	**Ankomst dato**	2022-06-16

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

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