C-survey at Hvestudalur, 2022, Prestudy (baseline-new site).

Arctic Sea Farm ehf

Akvaplan-niva AS Report: 2022 64085.02

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Summary

The results from the monitoring at the farming site Hvestudalur in May 2022 showed that the sediment was somewhat loaded with organic carbon and the copper concentrations were within reported natural levels for bottom sediment around Iceland (Egilsson *et al.*, 1999). No load effect was recorded in the fauna and faunal index nEQR showed good conditions and no impact at any of the stations (> 0.6). The diversity index H ' was above 3 at all stations and ranged from 3.58 (Cref) to 4.65 (C3). NS 9410:2016-assessment of the community in the local impact zone (C1) showed environmental condition 1 (Very good). The pollution indicator species *Capitella capitata* (polychaeta) was recorded among the top-10 species at C4, but not 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 May was good in the whole water column with 77 % in the bottom water.

Approval

Prosjektleder

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Kvalitetskontroll

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Preface

Akvaplan-niva carried out an environmental prestudy of type C (NS 9410:2016) at the Hvestudalur 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	Report, project leader.
Arnthor Gústavsson	Akvaplan-niva	Field work.
Hans-Petter Mannvik	Akvaplan-niva	Identification of bottom fauna (Echinodermata). Report, professional assessments and interpretations.
Roger Velvin	Akvaplan-niva	Identification of bottom fauna (Various taxa). QA report, professional assessments, and interpretations
Rune Palerud	Akvaplan-niva	Identification of bottom fauna (Crustaceans). Statistics.
Jesper Hansen	Akvaplan-niva	Identification of bottom fauna (Polychaeta and Mollusca).
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 Arctic Sea Farm ehf. and Steinunn G. Einarsdóttir 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, 04.08 2022

Snorri Gunnarsson (Project Manager)

1 Data Summary

Client information			
Report title:	C-Survey at Hvestudalur, 2022, prestudy (baseline-new site).		
Report nr.	2022 64085.02	Site:	Hvestudalur
Municipality:		Map Coordinates (construction):	65°422,845 N 23°38,963 W
MTB permitted:	3.900 ton	Operations manager:	Steinunn G. Einarsdóttir
Client:	Arctic Sea Farm ehf		

Biomass/production status at time of survey (11.05.2022)			
Fish group:	A. Salmon	Biomass on examination:	0
Feed input:	0	Produced amount of fish:	0
Type/time of survey			
Maximum biomass:		Follow up study:	
Fallow (resting period):		New location:	X

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)	0.641	Fauna C1 (impact zone)	3.72
Fauna C2	0.715	Fauna C2	4.15
Fauna C3	0.713	Fauna C3	4.65
Fauna C4 (deep area)	0.663	Fauna C4 (deep area)	4.08
Fauna Cref	0.676	Fauna Cref	3.58
Date fieldwork:	(11.05.2022)	**Date of report:**	04.08 2022
Notes to other results (sediment, pH/Eh, oxygen)			nTOC from 22.1 to 26.9 mg/g DS. Copper from 18.6 to 25.4 mg/kg DS. Eh positive at all stations O_2-conditions were good throughout the water column.
Responsible for field work:	Signature: Arnþór Gústavsson	Project manager Snorri Gunnarsson	SGU

2 Introduction

2.1 Background and aim of the study

On behalf of Arctic Sea Farm ehf, Akvaplan-niva completed a pre-survey (type C) for a new fish farming site at Hvestudalur (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 pre-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.

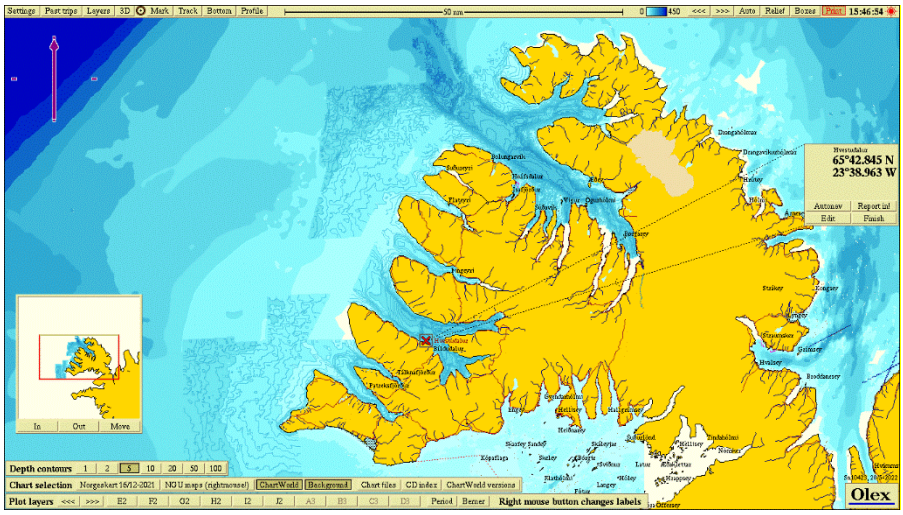

Figure 1. Overview of Westfjords, Iceland with the farming site Hvestudalur (red cross) in Arnarfjörður. The map coordinates for the midpoint of the farming site are given to the right.

2.2 Site operation and feed use

There has been no production at Hvestudalur prior to this survey. First smolt is planned to be set out at Hvestudalur in May 2022. The plant is a frame mooring with a total of eleven 160-200 meters circumference cages 2x 5 and 6 (5 and 6 cages each row) configuration.

In Iceland, the MTB (maximum allowed biomass) limit is not given a site level as in Norway. The MTB limit determines how much live fish the holder of the permit can have standing in the sea at any time. In Iceland the allowed production is regulated at two levels, site level and company level.

For this site the estimated maximal standing biomass for the next generation is 3.900 tonnes, used as MTB here (Einarsdóttir, pers reference).

2.3 Previous surveys

Hvestudalur is a new site with no previous fish farming activity. Akvaplan-niva AS has not done any previous environmental surveys of the type B/C (NS 9410) at the site. The client has not presented any previous specific surveys for the soft bottom fauna of the site. There are some other investigations that have been conducted in Arnarfjörður related to fish farming activities, but none directly affiliated with Hvestudalur.

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 1.

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 1: Survey program for the C-survey at Hvestudalur, 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. pH/Eh.
C2 (transect zone outer)	Quantitative analyses of bottom fauna. TOC. Korn. TOM. TN. 2 x Cu. 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.
Cref (reference station)	Quantitative analyses of bottom fauna. TOC. Korn. TOM. TN. pH/Eh.
Curef1	2 x Cu.
Curef2	2 x Cu.

Field work was completed on 11.05.2022.

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 3.900 tonnes (used as MTB here). According to the standard five sampling stations should be examined. Depth and position of the stations are given in Table 2 and shown in Figure 2. The stations were placed in accordance to the direction of the main oceanic current direction at 51 m depth (dispersing depth) (Gustavsson, 2022).

Table 2: Depth, distance between the nearest frame of the fish farm and sampling stations and coordinates for C-stations at Hvestudalur, 2022.

Station	Depth, m	Distance from frame, m	Position N	W
C1	69	30	65°48,856	023°38,866
C2	63	500	65°42,632	023°38,572
C3	67	150	65°42,797	023°38,799
C4	83	420	65°42,804	023°38,366
Cref/Curef1	76	1000	65°43,471	023°40,277
Curef2	83	1000	65°43,521	023°39,945

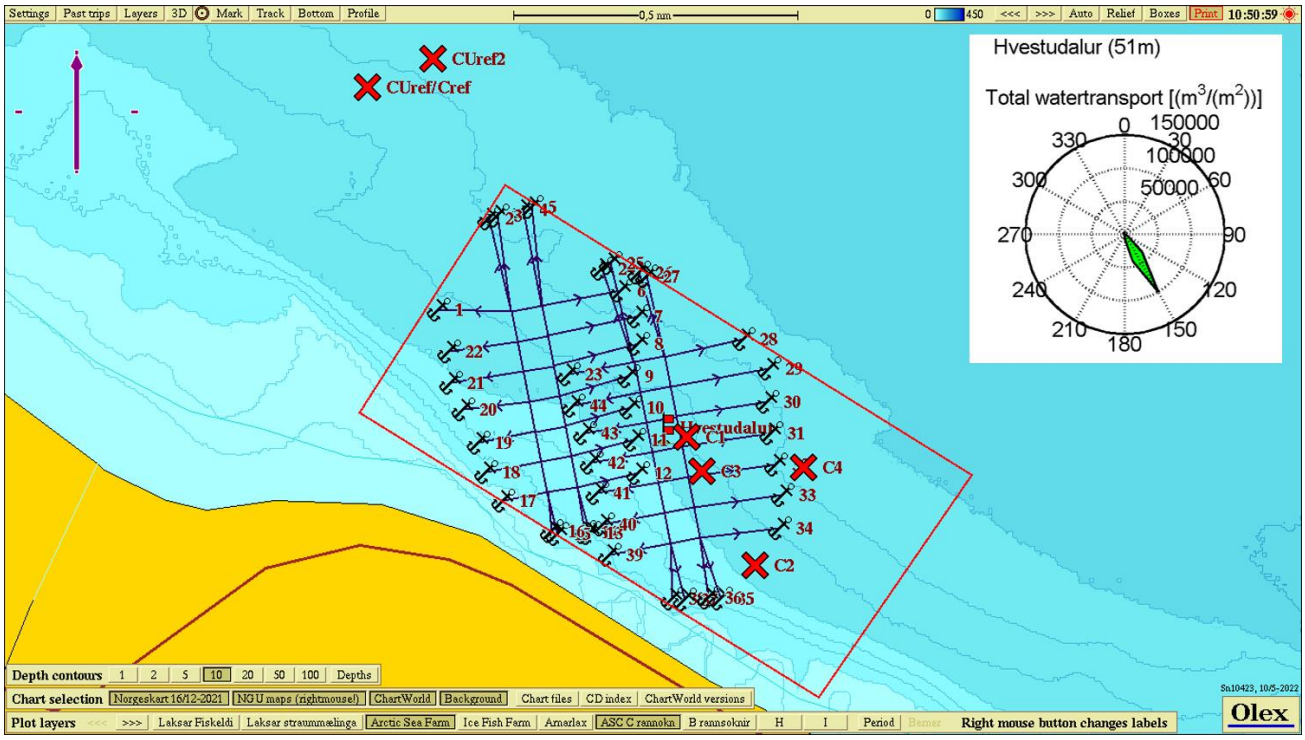

Figure 2. Map showing the sampling stations for the C-survey at Hvestudalur, 2022. Current measurements used were from 51 m depth (Gústavsson, 2022).

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 with the manual of the instrument, 200 mV was added to the measured ORP (the Oxidation Reduction Potential) value.

3.4 Soft bottom fauna investigation

3.4.1 About effect of organic material on bottom fauna

The emission of organic material from fish farms can contribute to the deterioration of conditions for many of the organisms living in the bottom sediment. Negative effects in the bottom fauna can best be assessed through quantitative bottom fauna analyses. Many soft bottom species have low mobility, the fauna composition will largely reflect the local environmental conditions. Changes in the bottom fauna communities are a good indication of unwanted organic loads. Under natural conditions, the communities typically consist of many species. High number of species (diversity) is, amongst other things, dependent on favourable conditions for the fauna. However, moderate increases in organic load can stimulate the fauna and result in an increased number of species found. Larger organic loads can result in less favourable conditions where opportunistic species increase their individual numbers, while the species not suited are knocked out resulting in a reduced diversity of species. Changes in species diversity near emission points of feed and 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 2022 is presented in Figure 3.

Temperature was 3 ^{0}C at the surface and 2 ^{0}C at the bottom, and oxygen saturation was 101 % in the upper layer and 77 % in the bottom layer.

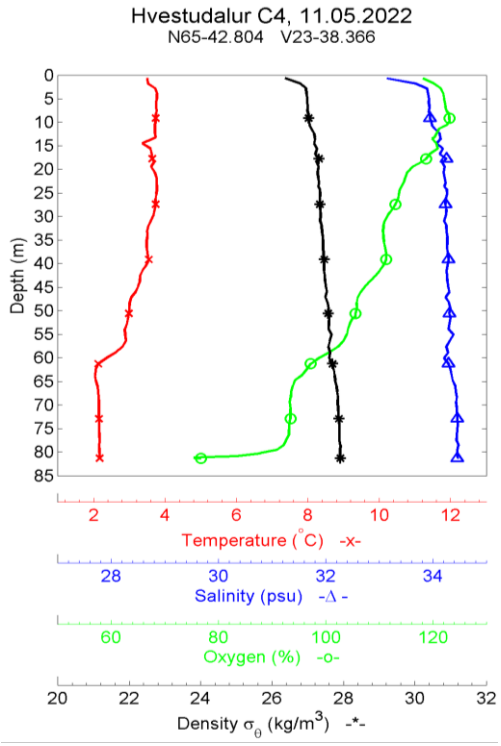

Figure 3. Vertical profiles. Temperature, salinity, density, and oxygen at sampling station C4 at Hvestudalur, 2022.

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 3.

TOM-levels varied from 1.6 to 9.2 %. TN-levels were low (2.7 – 7.0 mg/g) as was the C/N-ratio. TOC was somewhat high at all stations and nTOC varied from 22.1 to 26.9 mg/g TS. The bottom sediments grain size was coarse to moderately fine with a pelite ratio ranging from 6.2 to 56.0 %.

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

Table 3. Sediment description, TOM (%), TOC (mg/g), TN (mg/g), C/N, grain size distribution (pelitt ratio % <0,063 mm) and pH/Eh. Hvestudalur, 2022.

St.	Sediment description	TOM	TOC	nTOC	TN	C/N	Pelitt	pH/Eh
C1	Mostly sand with very little clay. Black, mostly dead, seaweed	1,6	9,2	26,1	2,7	3,4	6,2	7,8/ 300
C2	Sand and clay with a thin layer of silt on top. Some black seaweed and live kelp.	6,9	16	24,4	6,1*	2,6	53,1	4,9/ 278
C3	Mostly sand with some clay and thin layer of silt. Lot of black, mostly dead, seaweed	3,7	8,7	22,1	3,1	2,8	25,5	7,8/ 306
C4	Sand and clay with a thin layer of silt on top. Some black seaweed and live kelp.	9,2	19	26,9	7,0*	2,7	56,0	7,8/ 317
Cref	Sand and clay with a thin layer of silt on top and ground shells/shell sand.	5,9	14	25,4	4,7	2,9	34,5	7,7/ 326

*Not accredited result.

4.2.2 Copper

Levels of copper in bottom sediments are shown in Table 4. The levels of copper were relatively low in the samples analysed.

Table 4. Copper (Cu), mg/kg TS. Hvestudalur, 2022.

St.	Cu	
	Repl. 1	Repl. 2
C2	23,1	22,5
Cref/Curef1	25,4	18,6
Curef2	23,0	21,0

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 5.

The number of individuals varied from 498 (C1) to 1429 (C4) and number of species from 42 (Cref) to 70 (C3). The diversity H' varied from 3.58 to 4.65. At all stations, the overall index of nEQR was higher than 0.6. The nEQR values indicate good conditions and no disturbance of the communities.

J (Pielous evenness index) is a measure of how equally individuals are divided between species and will vary between 0 and 1. A station with low value has a "crooked" individual distribution between the species, indicating a disturbed bottom fauna community. The index varied from 0.70 to 0.80 which indicates an even distribution.

Table 5. 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 Hvestudalur, 2022.

St.	Numb. ind.	Numb. species	H´	ES_{100}	NQI1	ISI_{2012}	NSI	nEQR	AMBI	J
C1	498	47	3.72	22.7	0.675	7.98	19.08	0.641	2.648	0.75
C2	716	54	4.15	24.9	0.737	9.17	22.04	0.715	2.035	0.77
C3	1159	70	4.65	31.0	0.721	8.35	20.99	0.713	2.476	0.80
C4	1429	58	4.08	24.2	0.666	8.46	19.48	0.663	2.872	0.75
Cref	534	42	3.58	22.1	0.687	8.61	22.28	0.676	2.603	0.70

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 6). The data for number of species and dominating taxa at station C1 is given in Table 5 and Table 7.

Table 6. Classification of the environmental status of the soft bottom fauna at station C1 at the Hvestudalur site 2022.

Station	Site name	Num. species	Dominating taxa	Environmental condition-NS 9410
C1	Hvestudalur	47	Scoloplos armiger – 20 %	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 (> 12 species) and stretched out in varying degrees towards higher classes. These did not give any clear indications of fauna condition.

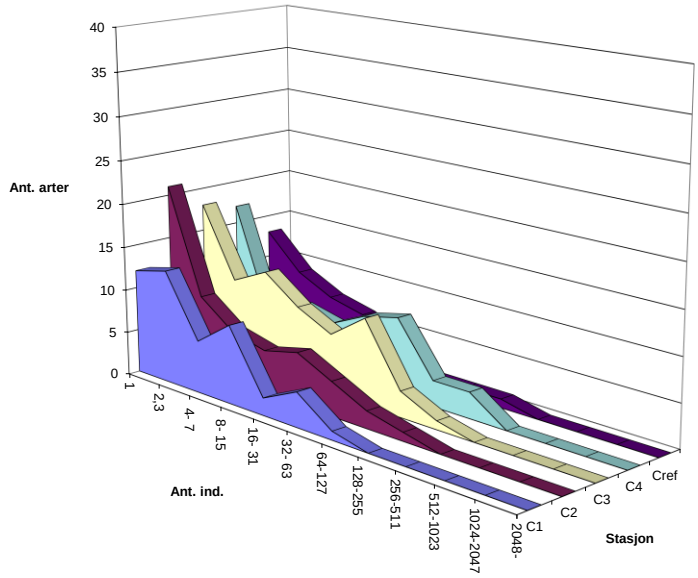

Figure 4. The soft bottom fauna shown as number of species against number of individuals pr. species in geometric classes. Hvestudalur, 2022.

4.3.3 Cluster analyses

To investigate the similarity of the faunal composition between the sampling stations, the multivariate technique cluster analysis was used. The results of this are presented in dendrogram in Figure 5.

The fauna composition was more than 49 % similar for all stations in the survey.

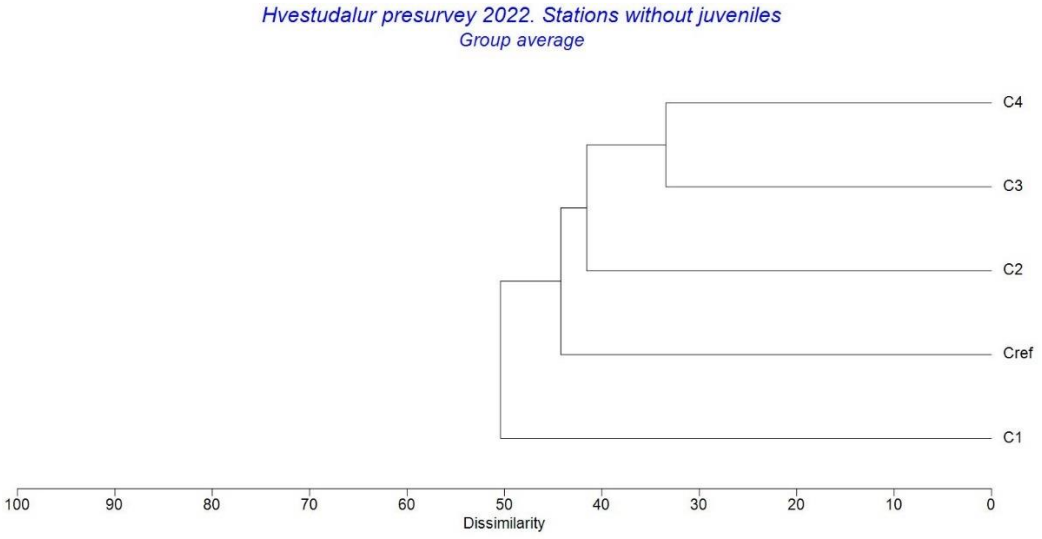

Figure 5. Cluster diagram for the soft bottom fauna at the C- sampling stations at Hvestudalur, 2022.

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 7.

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 station C1 was dominated by the tolerant polychaeta *Scoloplos armiger* with 20 % of the individuals. The other most dominant species at the stations were a mixture of neutral and opportunistic species.

The fauna at station C2 was dominated by the polychaeta *Myriochele malmgreni/olgae* (EG not known) with 19 % of the individuals. The other most dominant species at the stations were a mixture of neutral, tolerant, and opportunistic species.

The fauna at station C3 was dominated by the tolerant polychaeta *Leitoscoloplos mammosus* with 13 % of the individuals. The other most dominant species at the stations were a mixture of neutral, tolerant, and opportunistic species.

The fauna at station C4 was dominated by the polychaeta *Parougia eliasoni* with 10 % of the individuals. The other most dominant species at the stations were a mixture of neutral and opportunistic species together with the pollution indicator species *Capitella capitata* (polychaeta).

The fauna at station Cref was dominated by the neutral polychaeta *Prionospio steenstrupi* with 30 % of the individuals. The other most dominant species at the stations were a mixture of neutral, tolerant, and opportunistic species.

Table 7. Number of individuals, cumulative percentage, and ecological group for the ten most dominant species on the C stations. Hvestudalur, 2022.*

C1	EG	Numb.	Cum.	C2	EG	Numb.	Cum.
Scoloplos armiger	III	102	20 %	Myriochele malmgreni/olgae	Ik	139	19 %
Ampharete petersenae	Ik	63	32 %	Ennucula tenuis	II	80	30 %
Mediomastus fragilis	IV	45	41 %	Prionospio steenstrupi	II	76	40 %
Prionospio steenstrupi	II	44	50 %	Thyasira gouldii	IV	53	48 %
Macoma calcarea	IV	41	58 %	Galathowenia oculata	III	46	54 %
Eteone flava/longa	Ik	22	62 %	Praxillella praetermissa	II	44	60 %
Parougia eliasoni	Ik	16	65 %	Laphania boecki	II	33	65 %
Chaetozone setosa	IV	15	68 %	Abra nitida	III	23	68 %
Axinopsida orbiculata	Ik	13	71 %	Axinopsida orbiculata	Ik	22	71 %
Leucon sp.	Ik	12	73 %	Thyasira sarsii	IV	22	74 %
C3	**EG**	**Numb.**	**Cum.**	**C4**	**EG**	**Numb.**	**Cum.**
Leitoscoloplos mammosus	Ik	150	13 %	Parougia eliasoni	Ik	142	10 %
Myriochele malmgreni/olgae	Ik	120	23 %	Ennucula tenuis	II	130	19 %
Macoma calcarea	IV	65	28 %	Prionospio steenstrupi	II	130	28 %
Praxillella praetermissa	II	65	34 %	Capitella capitata	V	124	36 %
Laphania boecki	II	58	39 %	Laphania boecki	II	115	44 %
Prionospio steenstrupi	II	51	43 %	Ophryotrocha lobifera	IV	108	51 %
Owenia sp.	II	50	47 %	Mediomastus fragilis	IV	63	56 %
Parougia eliasoni	Ik	42	51 %	Chaetozone setosa	IV	45	59 %
Galathowenia oculata	III	39	54 %	Eteone flava/longa	Ik	44	62 %
Pholoe assimilis	III	39	58 %	Axinopsida orbiculata	Ik	40	64 %

Cref	EG	Numb.	Cum.
Prionospio steenstrupi	II	162	30 %
Ennucula tenuis	II	95	48 %
Axinopsida orbiculata	Ik	42	55 %
Galathowenia oculata	III	28	60 %
Laphania boecki	II	28	66 %
Thyasira sarsii	IV	23	70 %
Euchone papillosa	III	17	73 %
Thyasira gouldii	IV	15	76 %
Praxillella gracilis	IV	14	78 %
Abra nitida	III	13	81 %

*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 Hvestudalur, 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 May 2022.
- TOC was rather high at all stations and nTOC varied from 28,4 to 35,1 mg/g TS. TOM-levels varied from 1.6 to 9.2 %. TN-levels were low (2.7 – 7.0 mg/g) as was the C/N-ratio. The copper levels in the sediments analysed were relatively low (18.6 – 25.4 mg/kg) according to Norwegian standards, and within reported natural levels of 55 mg/kg in Icelandic coastal areas (Egilsson *et al.* 1999). The bottom sediments grain size was coarse to moderately fine with a pelite ratio ranging from 6.2 to 56.0 %. 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 498 (C1) to 1429 (C4) and number of species from 42 (Cref) to 70 (C3). The diversity H' varied from 3.58 (Cref) to 4.65 (C3). At all stations, the overall index of nEQR was higher than 0.6. The nEQR values indicate good conditions and no disturbance of the communities. The pollution indicator species *Capitella capitata* (polychaeta) was recorded among the top-10 species at C4, but not at any of the other stations.

5.2 Conclusions

The results from the monitoring at the farming site Hvestudalur in May 2022 showed that the sediment was somewhat loaded with organic carbon and the copper concentrations were within reported natural levels for bottom sediment around Iceland (Egilsson *et al.*, 1999). No load effect was recorded in the fauna and faunal index nEQR showed good conditions and no impact at any of the stations (> 0.6). The diversity index H ' was above 3 at all stations and ranged from 3.58 (Cref) to 4.65 (C3). NS 9410:2016-assessment of the community in the local impact zone (C1) showed environmental condition 1 (Very good). The pollution indicator species *Capitella capitata* (polychaeta) was recorded among the top-10 species at C4, but not at any of the other species. 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 77 % in the bottom water.

6 References

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7 Appendix (not translated)

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 Hvestudalur, 2022

7.2.1 Number of species and individuals per station

St.	C1	C2	C3	C4	Cref
Ant. ind.	498	716	1159	1429	534
Ant. arter	47	54	70	58	42

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	Cref_01	Cref_02
no. ind.	4336	162	336	369	347	555	604	990	439	279	255
no. spe.	112	21	44	39	43	58	52	49	39	34	34
Shannon-Wiener:		3,1	4,3	4,1	4,2	4,8	4,5	4,4	3,7	3,6	3,6
Pielou		0,70	0,80	0,77	0,78	0,81	0,80	0,79	0,71	0,71	0,70
ES100		17	28	24	26	32	30	26	22	22	22
SN		1,87	2,15	2,06	2,13	2,20	2,13	2,02	2,03	2,04	2,06
ISI-2012		7,64	8,32	9,50	8,85	8,30	8,41	8,59	8,33	9,11	8,11
AMBI		2,634	2,662	2,148	1,922	2,881	2,07	3,35	2,394	2,805	2,401
NQI1		0,65	0,70	0,72	0,75	0,70	0,74	0,63	0,70	0,67	0,70
NSI		18,4	19,8	22,1	22,0	20,0	22,0	16,7	22,3	22,3	22,3

7.2.3 Benthos indices, averages per station

st.nr.		C1	C2	C3	C4	Cref
Shannon-Wiener:		3,72	4,15	4,65	4,08	3,58
Pielou		0,75	0,77	0,80	0,75	0,70
ES100		22,7	24,9	31,0	24,2	22,1
SN		2,01	2,10	2,17	2,02	2,05
ISI-2012		7,98	9,17	8,35	8,46	8,61
AMBI		2,648	2,035	2,476	2,872	2,603
NQI1		0,68	0,74	0,72	0,67	0,69
NSI		19,08	22,04	20,99	19,48	22,28
Tilstandsklasse nEQR		0,641	0,715	0,713	0,663	0,676

7.2.4 Geometric classes

int.	C1	C2	C3	C4	Cref
1	12	21	18	17	13
2,3	13	9	10	5	9
4- 7	6	6	12	7	7
8- 15	9	5	9	6	6
16- 31	2	6	7	8	4
32- 63	4	4	10	9	1
64-127	1	2	3	3	1
128-255	0	1	1	3	1
256-511	0	0	0	0	0
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

Hvestudalur presurvey 2022

Rekke	Klasse	Orden	Art/Taxa	Replikat: 01	02	-	Sum
Stasjonsnr.: C1							
NEMERTINI							
			Nemertea indet.	1	1	-	2
ANNELIDA							
	Polychaeta						
		Orbiniida					
			Aricidea sp.		1	-	1
			Levinsenia gracilis		1	-	1
			Scoloplos armiger	50	52	-	102
		Spionida					
			Chaetozone setosa	2	13	-	15
			Chaetozone sp.	4	5	-	9
			Prionospio steenstrupi	13	31	-	44
			Spio limicola		3	-	3
		Capitellida					
			Capitella capitata		3	-	3
			Mediomastus fragilis	33	12	-	45
			Praxillella gracilis		2	-	2
			Praxillella praetermissa		4	-	4
		Opheliida					
			Ophelina acuminata		1	-	1
			Scalibregma inflatum		3	-	3
		Phyllodocida					
			Eteone flava/longa	5	17	-	22
			Gattyana amondseni		1	-	1
			Glycera capitata		1	-	1
			Goniada maculata	2	8	-	10
			Microphthalmus sczelkowii		4	-	4
			Pholoe assimilis	1	5	-	6
			Pholoe baltica	1		-	1
			Polynoidae indet.	1	1	-	2
		Eunicida					
			Mammiphitime cosmetandra		1	-	1
			Parougia eliasoni		16	-	16
			Scoletoma magnidentata		1	-	1
		Terebellida					
			Ampharete petersenae		63	-	63
			Ampharete sp. juv.	5		-	5
			Cistenides hyperborea		2	-	2
			Laphania boecki		1	-	1
		Sabellida					
			Chone sp.	2	1	-	3
			Euchone incolor		4	-	4
			Euchone papillosa		5	-	5
			Euchone sp.		1	-	1
CRUSTACEA							
	Malacostraca						
		Cumacea					
			Leucon sp.		12	-	12
		Tanaidacea					
			Tanaidacea indet.	3		-	3
		Amphipoda					
			Bathymedon obtusifrons		2	-	2
			Dulichiidae indet.		10	-	10
			Lysianassidae indet.	1	3	-	4
			Metopa sp.		2	-	2
			Oedicerotidae indet.	1	7	-	8
			Paroediceros lynceus		2	-	2
			Rhachotropis sp.	1	1	-	2
MOLLUSCA							
	Opistobranchia						
		Cephalaspidea					
			Diaphana minuta		1	-	1
	Bivalvia						
		Nuculoida					

Rekke	Klasse	Orden	Art/Taxa	Replikat:	01	02	-	Sum
			Nuculana sp. juv.		2	4	-	6
		Veneroida						
			Axinopsida orbiculata		8	5	-	13
			Macoma calcarea		27	14	-	41
			Thyasira gouldii		4	4	-	8
			Thyasira sarsii		1	9	-	10
ECHINODERMATA								
	Ophiuroidea							
			Ophiuroidea indet. juv.		1		-	1
TUNICATA								
	Ascidiacea							
			Ascidiacea indet. (solit)		1		-	1
				Maksverdi:	50	63		102
				Antall arter/taxa:	24	45		50
				Sum antall individ:				510

Stasjonsnr.: C2

NEMERTINI								
			Nemertea indet.		2		-	2
SIPUNCULIDA								
			Phascolion strombus			1	-	1
ANNELIDA								
	Polychaeta							
		Orbiniida						
			Leitoscoloplos mammosus		2	6	-	8
			Levinsenia gracilis		11		-	11
			Scoloplos armiger			1	-	1
		Spionida						
			Chaetozone sp.		10	8	-	18
			Dipolydora coeca		1		-	1
			Prionospio steenstrupi		46	30	-	76
			Spio limicola			1	-	1
		Capitellida						
			Maldane sarsi		2	1	-	3
			Praxillella gracilis		6	7	-	13
			Praxillella praetermissa		31	13	-	44
			Rhodine gracilior		1	1	-	2
		Phyllodocida						
			Eteone flava/longa			1	-	1
			Nephtys paradoxa			2	-	2
			Nephtys pente		1		-	1
			Pholoe assimilis		3	3	-	6
			Phyllodoce groenlandica			1	-	1
		Eunicida						
			Lumbrineris mixochaeta		8	1	-	9
			Nothria conchylega			1	-	1
			Parougia eliasoni		1		-	1
		Sternaspida						
			Sternaspis scutata		4	1	-	5
		Oweniida						
			Galathowenia oculata		24	22	-	46
			Myriochele malmgreni/olgae		85	54	-	139
		Flabelligerida						
			Diplocirrus glaucus		1	3	-	4
		Terebellida						
			Ampharete finmarchica		1		-	1
			Amphicteis gunneri			1	-	1
			Cistenides hyperborea			1	-	1
			Lagis koreni		1	4	-	5
			Laphania boecki		20	13	-	33
			Melinna cristata		1	1	-	2
		Sabellida						
			Euchone papillosa		9	9	-	18
			Euchone sp.			1	-	1
CRUSTACEA								
	Malacostraca							
		Cumacea						

Rekke	Klasse	Orden	Art/Taxa	Replikat:	01	02	-	Sum
			Leucon sp.		9	8	-	17
		Amphipoda						
			Bathymedon obtusifrons		1	2	-	3
			Dulichiidae indet.		1	2	-	3
			Gammaridea indet.		1		-	1
			Lysianassidae indet.			2	-	2
			Oedicerotidae indet.		1	3	-	4
			Syrrhoe crenulata		1		-	1
MOLLUSCA								
	Caudofoveata							
			Caudofoveata indet.		1		-	1
	Bivalvia							
		Nuculoida						
			Ennucula tenuis		18	62	-	80
			Nuculana pernula		1	5	-	6
			Nuculana sp. juv.		2	8	-	10
			Yoldia hyperborea			1	-	1
		Mytiloida						
			Crenella decussata		1		-	1
		Veneroida						
			Abra nitida		10	13	-	23
			Astarte montagui			2	-	2
			Axinopsida orbiculata		7	15	-	22
			Ciliatocardium ciliatum		1		-	1
			Macoma calcarea		6	6	-	12
			Mendicula pygmaea			1	-	1
			Thyasira gouldii		27	26	-	53
			Thyasira sarsii		12	10	-	22
ECHINODERMATA								
	Ophiuroidea							
		Ophiurida						
			Amphilepis norvegica			1	-	1
			Ophiuroidea indet. juv.		3	1	-	4
				Maksverdi:	85	62		139
				Antall arter/taxa:	41	45		56
				Sum antall individ:				730

Stasjonsnr.: C3

NEMERTINI								
			Nemertea indet.		7	8	-	15
SIPUNCULIDA								
			Phascolion strombus			2	-	2
ANNELIDA								
	Polychaeta							
		Orbiniida						
			Aricidea sp.		1		-	1
			Leitoscoloplos mammosus		99	51	-	150
			Levinsenia gracilis		4	8	-	12
			Scoloplos armiger		11	2	-	13
		Cossurida						
			Cossura sp.		1		-	1
		Spionida						
			Apistobranchus tullbergi		1		-	1
			Chaetozone setosa		6	12	-	18
			Chaetozone sp.		17	7	-	24
			Dipolydora quadrilobata			1	-	1
			Prionospio steenstrupi		21	30	-	51
			Spio armata		1		-	1
			Spio limicola		6		-	6
		Capitellida						
			Arenicola marina			1	-	1
			Capitella capitata		16	1	-	17
			Maldane sarsi		2	3	-	5
			Mediomastus fragilis		27	8	-	35
			Notomastus latericeus		1		-	1
			Praxillella gracilis		20	13	-	33
			Praxillella praetermissa		47	18	-	65

Rekke	Klasse	Orden	Art/Taxa	Replikat:	01	02	-	Sum
			Rhodine gracilior		5	13	-	18
		Opheliida						
			Scalibregma inflatum		2	1	-	3
		Phyllodocida						
			Eteone flava/longa		13	5	-	18
			Goniada maculata		5	3	-	8
			Harmothoe mariannae			1	-	1
			Nephtys caeca		2		-	2
			Nephtys ciliata			1	-	1
			Nephtys pente		3		-	3
			Pholoe assimilis		29	10	-	39
			Polynoidae indet.		1		-	1
		Eunicida						
			Mammiphitime cosmetandra		5		-	5
			Parougia eliasoni		28	14	-	42
		Sternaspida						
			Sternaspis scutata		3	4	-	7
		Oweniida						
			Galathowenia oculata		12	27	-	39
			Myriochele malmgreni/olgae		2	118	-	120
			Owenia sp.			50	-	50
		Flabelligerida						
			Diplocirrus longisetosus		2	4	-	6
		Terebellida						
			Ampharete petersenae		1	2	-	3
			Ampharete sp. juv.			1	-	1
			Cistenides hyperborea		1		-	1
			Lagis koreni		1	2	-	3
			Laphania boecki		34	24	-	58
			Terebellides sp.		1		-	1
		Sabellida						
			Euchone incolor		3	1	-	4
			Euchone papillosa		7	2	-	9
	Oligochaeta							
			Oligochaeta indet.		11		-	11
CRUSTACEA								
	Malacostraca							
		Cumacea						
			Leucon sp.		3	2	-	5
		Amphipoda						
			Bathymedon obtusifrons		1	3	-	4
			Byblis sp.		1		-	1
			Dulichiidae indet.		7		-	7
			Lysianassidae indet.			1	-	1
			Metopa sp.		1		-	1
			Oedicerotidae indet.		1	2	-	3
			Phoxocephalus holbolli		9	2	-	11
MOLLUSCA								
	Caudofoveata							
			Caudofoveata indet.			4	-	4
	Opistobranchia							
		Cephalaspidea						
			Philine denticulata			1	-	1
	Bivalvia							
		Nuculoida						
			Ennucula tenuis		4	7	-	11
			Nuculana pernula		2	6	-	8
			Nuculana sp. juv.		2	8	-	10
		Mytiloida						
			Crenella decussata			5	-	5
		Veneroida						
			Abra nitida		1	5	-	6
			Astarte elliptica			2	-	2
			Astarte montagui		2	14	-	16
			Axinopsida orbiculata		7	13	-	20
			Macoma calcarea		17	48	-	65
			Parvicardium pinnulatum			1	-	1
			Thyasira gouldii		9	28	-	37
			Thyasira sarsii		26	11	-	37
		Pholadomyoida						
			Thracia myopsis		1	2	-	3
ECHINODERMATA								
	Ophiuroidea							
		Ophiurida						

Rekke	Klasse	Orden	Art/Taxa	Replikat:	01	02	-	Sum
			Ophiocten affinis		3		-	3
			Ophiura carnea		1		-	1
			Ophiuroidea indet. juv.		7		-	7
				Maksverdi:	99	118		150
				Antall arter/taxa:	60	54		73
				Sum antall individ:				117

Stasjonsnr.: C4

NEMERTINI								
			Nemertea indet.		8	2	-	10
ANNELIDA								
	Polychaeta							
		Orbiniida						
			Leitoscoloplos mammosus		24	2	-	26
			Scoloplos armiger		24		-	24
		Spionida						
			Chaetozone setosa		41	4	-	45
			Chaetozone sp.		14	10	-	24
			Malacoceros vulgaris		1		-	1
			Prionospio steenstrupi		34	96	-	130
			Spio armata		1		-	1
			Spio limicola		4	1	-	5
		Capitellida						
			Capitella capitata		123	1	-	124
			Mediomastus fragilis		61	2	-	63
			Praxillella gracilis		18	14	-	32
			Praxillella praetermissa		39	1	-	40
		Opheliida						
			Scalibregma inflatum		2		-	2
		Phyllodocida						
			Eteone flava/longa		37	7	-	44
			Goniada maculata		4	1	-	5
			Microphthalmus sczelkowii		4		-	4
			Nephtys caeca		1		-	1
			Nephtys ciliata			1	-	1
			Nephtys pente		1		-	1
			Nereimyra punctata		2		-	2
			Nereis sp. juv.		1		-	1
			Pholoe assimilis		14		-	14
			Polynoidae indet.		1	1	-	2
			Syllis cornuta		1		-	1
		Eunicida						
			Lumbrineris mixochaeta		2	5	-	7
			Mammiphitime cosmetandra		39		-	39
			Ophryotrocha lobifera		108		-	108
			Parougia eliasoni		138	4	-	142
		Oweniida						
			Galathowenia oculata		2	27	-	29
			Myriochele malmgreni/olgae		3	1	-	4
			Owenia sp.		4	4	-	8
		Terebellida						
			Ampharete octocirrata			1	-	1
			Ampharete petersenae		19	1	-	20
			Anobothrus gracilis		2		-	2
			Cistenides hyperborea		1		-	1
			Laphania boecki		72	43	-	115
			Melinna cristata		2	2	-	4
			Polycirrus medusa			1	-	1
			Terebellides sp.			1	-	1
		Sabellida						
			Euchone incolor		15	1	-	16
			Euchone papillosa		9	7	-	16
CRUSTACEA								
	Malacostraca							
		Leptostraca						
			Nebalia sp.		6		-	6
		Cumacea						
			Leucon sp.		3	8	-	11
		Amphipoda						
			Bathymedon obtusifrons			1	-	1

Rekke	Klasse	Orden	Art/Taxa	Replikat:	01	02	-	Sum
MOLLUSCA								
	Caudofoveata							
			Caudofoveata indet.			1	-	1
	Prosobranchia							
		Mesogastropoda						
			Euspira pallida		1		-	1
		Neogastropoda						
			Propebela sp.		1		-	1
	Opistobranchia							
		Cephalaspidea						
			Diaphana minuta		1		-	1
	Bivalvia							
		Nuculoida						
			Ennucula tenuis		20	110	-	130
			Nuculana pernula		4	8	-	12
			Nuculana sp. juv.		7	23	-	30
		Mytiloida						
			Crenella decussata		1		-	1
		Veneroida						
			Abra nitida			8	-	8
			Astarte montagui			1	-	1
			Axinopsida orbiculata		24	16	-	40
			Macoma calcarea		25	12	-	37
			Mendicula pygmaea			2	-	2
			Thyasira gouldii		8	14	-	22
			Thyasira sarsii		21	17	-	38
ECHINODERMATA								
	Ophiuroidea							
			Ophiuroidea indet. juv.		1		-	1
				Maksverdi:	138	110		142
				Antall arter/taxa:	52	40		61
				Sum antall individ:				146

Stasjonsnr.: Cref

NEMERTINI								
			Nemertea indet.		4	1	-	5
SIPUNCULIDA								
			Sipuncula indet.			1	-	1
ANNELIDA								
	Polychaeta							
		Orbiniida						
			Aricidea sp.		1		-	1
		Spionida						
			Chaetozone setosa		2	2	-	4
			Chaetozone sp.		6	3	-	9
			Prionospio steenstrupi		96	66	-	162
			Spio limicola		1	1	-	2
			Spiophanes kroyeri			1	-	1
		Capitellida						
			Mediomastus fragilis		3	1	-	4
			Praxillella gracilis		7	7	-	14
			Praxillella praetermissa		5	1	-	6
		Opheliida						
			Ophelina acuminata		1	1	-	2
			Scalibregma inflatum			1	-	1
		Phyllodocida						
			Eteone flava/longa		1	1	-	2
			Goniada maculata			4	-	4
			Nephtys ciliata		1	1	-	2
		Eunicida						
			Lumbrineris mixochaeta		3	1	-	4
		Oweniida						
			Galathowenia oculata		12	16	-	28
			Myriochele malmgreni/olgae		2	1	-	3
		Flabelligerida						
			Diplocirrus longisetosus			1	-	1
		Terebellida						

Rekke	Klasse	Orden	Art/Taxa	Replikat:	01	02	-	Sum
			Ampharete borealis		1		-	1
			Ampharete finmarchica			2	-	2
			Ampharete lindstroemi			1	-	1
			Ampharete petersenae		1	2	-	3
			Laphania boecki		24	4	-	28
			Melinna cristata		1		-	1
			Polycirrus medusa		2		-	2
			Terebellides sp.		1		-	1
		Sabellida						
			Euchone papillosa		13	4	-	17
CRUSTACEA								
	Malacostraca							
		Cumacea						
			Leucon sp.		8	5	-	13
		Amphipoda						
			Byblis sp.			1	-	1
			Gammaridea indet.		1		-	1
MOLLUSCA								
	Prosobranchia							
		Mesogastropoda						
			Euspira pallida		1		-	1
	Bivalvia							
		Nuculoida						
			Ennucula tenuis		41	54	-	95
			Nuculana pernula		6	2	-	8
			Nuculana sp. juv.		5	2	-	7
			Yoldia hyperborea		1	1	-	2
		Veneroida						
			Abra nitida		2	11	-	13
			Axinopsida orbiculata		6	36	-	42
			Macoma calcarea		3	4	-	7
			Thyasira gouldii		3	12	-	15
			Thyasira sarsii		18	5	-	23
ECHINODERMATA								
	Ophiuroidea							
		Ophiurida						
			Amphilepis norvegica		1		-	1
				Maksverdi:	96	66		162
				Antall arter/taxa:	35	35		43
				Sum antall individ:				541

7.4 Analytical report

ANALYSERAPPORT

Kunde:	Arctic Sea Farm / Arctic Fish	Rapport nr.:	P2200095
Kundemerking:	64085 Hvestudalur	Revisjon:	3
Kontaktperson kunde:		Rapportdato	2022-06-29
Prosjektnr.:	64085	Ankomst dato	2022-05-19

Lab-id. P2200095-01

Objekt	Kundens ID	Beskrivelse	Notering	Mottatt lab
Sediment	C1	64085 Hvestudalur - prestudy 2022		2022-05-19

Analyseresultat

Parameter	Resultat	Enhet	Analysedato start	Analysedato slutt	Standard	Måleusikkerhet
TOC	9.2	mg/g TS	2022-05-25	2022-05-27	DIN 19539:2016	±0.92
TNb	2.7	mg/g TS	2022-05-25	2022-05-27	NS-EN 16168:2012	±0.8
N TOC	26.1	mg/g TS	2022-05-30	2022-05-30	Veileder 02:2018	
C/N - forhold	3.4		2022-05-30	2022-05-30		
TOM	1.6	% TS	2022-05-25	2022-05-31	Intern metode	±0.0
Vekt % 2 mm	0.0	wt% TS	2022-05-20	2022-05-27	Intern metode	±0.0
Vekt % 1 mm	0.1	wt% TS	2022-05-20	2022-05-27	Intern metode (Bale/Kenny 2005)	±0.0
Vekt % 0.500 mm	0.8	wt% TS	2022-05-20	2022-05-27	Intern metode (Bale/Kenny 2005)	±0.0
Vekt % 0.250 mm	32.2	wt% TS	2022-05-20	2022-05-27	Intern metode (Bale/Kenny 2005)	±1.6
Vekt % 0.125 mm	49.3	wt% TS	2022-05-20	2022-05-27	Intern metode (Bale/Kenny 2005)	±2.5
Vekt % 0.063 mm	11.3	wt% TS	2022-05-20	2022-05-27	Intern metode (Bale/Kenny 2005)	±0.6
Vekt % < 0.063 mm	6.2	wt% TS	2022-05-20	2022-05-27	Intern metode (Bale/Kenny 2005)	±0.3
Pelitt	6.2	wt% TS	2022-05-20	2022-05-27	Intern metode (Bale/Kenny 2005)	±0.3
Sand	93.8	wt% TS	2022-05-20	2022-05-27	Intern metode (Bale/Kenny 2005)	±4.7
Grus	0.0	wt% TS	2022-05-20	2022-05-27	Intern metode (Bale/Kenny 2005)	±0.0

* = Ikke akkreditert resultat

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ANALYSERAPPORT

Kunde:	Arctic Sea Farm / Arctic Fish	**Rapport nr.:**	P2200095
Kundemerking:	64085 Hvestudalur	**Revisjon:**	3
Kontaktperson kunde:		**Rapportdato**	**2022-06-29**
Prosjektnr.:	**64085**	**Ankomst dato**	2022-05-19

Lab-id. P2200095-02

Objekt	Kundens ID	Beskrivelse	Notering	Mottatt lab
Sediment	C2	64085 Hvestudalur - prestudy 2022	TNb er utenfor akkreditert måleområde.	2022-05-19

Analyseresultat

Parameter	Resultat	Enhet	Analysedato start	Analysedato slutt	Standard	Måleusikkerhet
TOC	**16**	mg/g TS	2022-05-25	2022-05-27	DIN 19539:2016	±1.6
TNb	***6.1**	mg/g TS	2022-05-25	2022-05-27	NS-EN 16168:2012	±1.8
N TOC	**24.4**	mg/g TS	2022-05-30	2022-05-30	Veileder 02:2018	
C/N - forhold	**2.6**		2022-05-30	2022-05-30		
TOM	**6.9**	% TS	2022-05-25	2022-05-31	Intern metode	±0.0
Vekt % 2 mm	**0.6**	wt% TS	2022-05-20	2022-05-27	Intern metode	±0.0
Vekt % 1 mm	**0**	wt% TS	2022-05-20	2022-05-27	Intern metode (Bale/Kenny 2005)	
Vekt % 0.500 mm	**0.2**	wt% TS	2022-05-20	2022-05-27	Intern metode (Bale/Kenny 2005)	±0.0
Vekt % 0.250 mm	**1.1**	wt% TS	2022-05-20	2022-05-27	Intern metode (Bale/Kenny 2005)	±0.1
Vekt % 0.125 mm	**14.7**	wt% TS	2022-05-20	2022-05-27	Intern metode (Bale/Kenny 2005)	±0.7
Vekt % 0.063 mm	**30.3**	wt% TS	2022-05-20	2022-05-27	Intern metode (Bale/Kenny 2005)	±1.5
Vekt % < 0.063 mm	**53.1**	wt% TS	2022-05-20	2022-05-27	Intern metode (Bale/Kenny 2005)	±2.7
Pelitt	**53.1**	wt% TS	2022-05-20	2022-05-27	Intern metode (Bale/Kenny 2005)	±2.7
Sand	**46.3**	wt% TS	2022-05-20	2022-05-27	Intern metode (Bale/Kenny 2005)	±2.3
Grus	**0.6**	wt% TS	2022-05-20	2022-05-27	Intern metode (Bale/Kenny 2005)	±0.0
Cu (kobber) [a]	**23.1 22.5**	mg/kg TS	2022-06-08	2022-06-10	Intern metode	

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

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ANALYSERAPPORT

Kunde:	Arctic Sea Farm / Arctic Fish	**Rapport nr.:**	P2200095
Kundemerking:	64085 Hvestudalur	**Revisjon:**	3
Kontaktperson kunde:		**Rapportdato**	**2022-06-29**
Prosjektnr.:	**64085**	**Ankomst dato**	2022-05-19

Lab-id. P2200095-03

Objekt	Kundens ID	Beskrivelse	Notering	Mottatt lab
Sediment	C3	64085 Hvestudalur - prestudy 2022		2022-05-19

Analyseresultat

Parameter	Resultat	Enhet	Analysedato start	Analysedato slutt	Standard	Måleusikkerhet
TOC	**8.7**	mg/g TS	2022-05-25	2022-05-27	DIN 19539:2016	±0.87
TNb	**3.1**	mg/g TS	2022-05-25	2022-05-27	NS-EN 16168:2012	±0.9
N TOC	**22.1**	mg/g TS	2022-05-30	2022-05-30	Veileder 02:2018	
C/N - forhold	**2.8**		2022-05-30	2022-05-30		
TOM	**3.7**	% TS	2022-05-25	2022-05-31	Intern metode	±0.0
Vekt % 2 mm	**0.2**	wt% TS	2022-05-20	2022-05-27	Intern metode	±0.0
Vekt % 1 mm	**0.1**	wt% TS	2022-05-20	2022-05-27	Intern metode (Bale/Kenny 2005)	±0.0
Vekt % 0.500 mm	**0.1**	wt% TS	2022-05-20	2022-05-27	Intern metode (Bale/Kenny 2005)	±0.0
Vekt % 0.250 mm	**5.7**	wt% TS	2022-05-20	2022-05-27	Intern metode (Bale/Kenny 2005)	±0.3
Vekt % 0.125 mm	**50.3**	wt% TS	2022-05-20	2022-05-27	Intern metode (Bale/Kenny 2005)	±2.5
Vekt % 0.063 mm	**18.1**	wt% TS	2022-05-20	2022-05-27	Intern metode (Bale/Kenny 2005)	±0.9
Vekt % < 0.063 mm	**25.5**	wt% TS	2022-05-20	2022-05-27	Intern metode (Bale/Kenny 2005)	±1.3
Pelitt	**25.5**	wt% TS	2022-05-20	2022-05-27	Intern metode (Bale/Kenny 2005)	±1.3
Sand	**74.3**	wt% TS	2022-05-20	2022-05-27	Intern metode (Bale/Kenny 2005)	±3.7
Grus	**0.2**	wt% TS	2022-05-20	2022-05-27	Intern metode (Bale/Kenny 2005)	±0.0

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ANALYSERAPPORT

Kunde:	Arctic Sea Farm / Arctic Fish	**Rapport nr.:**	P2200095
Kundemerking:	64085 Hvestudalur	**Revisjon:**	3
Kontaktperson kunde:		**Rapportdato**	2022-06-29
Prosjektnr.:	64085	**Ankomst dato**	2022-05-19

Lab-id. P2200095-04

Objekt	Kundens ID	Beskrivelse	Notering	Mottatt lab
Sediment	C4	64085 Hvestudalur - prestudy 2022	TNb er utenfor akkreditert måleområde.	2022-05-19

Analyseresultat

Parameter	Resultat	Enhet	Analysedato start	Analysedato slutt	Standard	Måleusikkerhet
TOC	19	mg/g TS	2022-05-25	2022-05-27	DIN 19539:2016	±1.9
TNb	*7.0	mg/g TS	2022-05-25	2022-05-27	NS-EN 16168:2012	±2.1
N TOC	26.9	mg/g TS	2022-05-30	2022-05-30	Veileder 02:2018	
C/N - forhold	2.7		2022-05-30	2022-05-30		
TOM	9.2	% TS	2022-05-25	2022-05-31	Intern metode	±0.0
Vekt % 2 mm	0.3	wt% TS	2022-05-20	2022-05-27	Intern metode	±0.0
Vekt % 1 mm	0.4	wt% TS	2022-05-20	2022-05-27	Intern metode (Bale/Kenny 2005)	±0.0
Vekt % 0.500 mm	1.3	wt% TS	2022-05-20	2022-05-27	Intern metode (Bale/Kenny 2005)	±0.1
Vekt % 0.250 mm	3.4	wt% TS	2022-05-20	2022-05-27	Intern metode (Bale/Kenny 2005)	±0.2
Vekt % 0.125 mm	13.8	wt% TS	2022-05-20	2022-05-27	Intern metode (Bale/Kenny 2005)	±0.7
Vekt % 0.063 mm	24.8	wt% TS	2022-05-20	2022-05-27	Intern metode (Bale/Kenny 2005)	±1.2
Vekt % < 0.063 mm	56.0	wt% TS	2022-05-20	2022-05-27	Intern metode (Bale/Kenny 2005)	±2.8
Pelitt	56.0	wt% TS	2022-05-20	2022-05-27	Intern metode (Bale/Kenny 2005)	±2.8
Sand	43.7	wt% TS	2022-05-20	2022-05-27	Intern metode (Bale/Kenny 2005)	±2.2
Grus	0.3	wt% TS	2022-05-20	2022-05-27	Intern metode (Bale/Kenny 2005)	±0.0

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ANALYSERAPPORT

Kunde:	Arctic Sea Farm / Arctic Fish	**Rapport nr.:**	P2200095
Kundemerking:	64085 Hvestudalur	**Revisjon:**	3
Kontaktperson kunde:		**Rapportdato**	**2022-06-29**
Prosjektnr.:	**64085**	**Ankomst dato**	2022-05-19

Lab-id. P2200095-05

Objekt	Kundens ID	Beskrivelse	Notering	Mottatt lab
Sediment	Cref	64085 Hvestudalur - prestudy 2022		2022-05-19

Analyseresultat

Parameter	Resultat	Enhet	Analysedato start	Analysedato slutt	Standard	Måleusikkerhet
TOC	**14**	mg/g TS	2022-05-25	2022-05-27	DIN 19539:2016	±1.4
TNb	**4.7**	mg/g TS	2022-05-25	2022-05-27	NS-EN 16168:2012	±1.4
N TOC	**25.4**	mg/g TS	2022-05-30	2022-05-30	Veileder 02:2018	
C/N - forhold	**2.9**		2022-05-30	2022-05-30		
TOM	**5.9**	% TS	2022-05-25	2022-05-31	Intern metode	±0.0
Vekt % 2 mm	**0.3**	wt% TS	2022-05-20	2022-05-27	Intern metode	±0.0
Vekt % 1 mm	**0.2**	wt% TS	2022-05-20	2022-05-27	Intern metode (Bale/Kenny 2005)	±0.0
Vekt % 0.500 mm	**0.7**	wt% TS	2022-05-20	2022-05-27	Intern metode (Bale/Kenny 2005)	±0.0
Vekt % 0.250 mm	**5.3**	wt% TS	2022-05-20	2022-05-27	Intern metode (Bale/Kenny 2005)	±0.3
Vekt % 0.125 mm	**31.6**	wt% TS	2022-05-20	2022-05-27	Intern metode (Bale/Kenny 2005)	±1.6
Vekt % 0.063 mm	**27.2**	wt% TS	2022-05-20	2022-05-27	Intern metode (Bale/Kenny 2005)	±1.4
Vekt % < 0.063 mm	**34.5**	wt% TS	2022-05-20	2022-05-27	Intern metode (Bale/Kenny 2005)	±1.7
Pelitt	**34.5**	wt% TS	2022-05-20	2022-05-27	Intern metode (Bale/Kenny 2005)	±1.7
Sand	**65.2**	wt% TS	2022-05-20	2022-05-27	Intern metode (Bale/Kenny 2005)	±3.3
Grus	**0.3**	wt% TS	2022-05-20	2022-05-27	Intern metode (Bale/Kenny 2005)	±0.0
Cu (kobber) [a]	**25.4 18.6**	mg/kg TS	2022-06-08	2022-06-10	Intern metode	

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

* = Ikke akkreditert resultat

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ANALYSERAPPORT

Kunde:	Arctic Sea Farm / Arctic Fish	**Rapport nr.:**	P2200095
Kundemerking:	64085 Hvestudalur	**Revisjon:**	3
Kontaktperson kunde:		**Rapportdato**	2022-06-29
Prosjektnr.:	64085	**Ankomst dato**	2022-05-19

Lab-id. P2200095-06

Objekt	Kundens ID	Beskrivelse	Notering	Mottatt lab
Sediment	Cu-ref2	64085 Hvestudalur - prestudy 2022		2022-05-19

Analyseresultat						
Parameter	Resultat	Enhet	Analysedato start	Analysedato slutt	Standard	Måleusikkerhet
Cu (kobber) [a]	23.0 21.0	mg/kg TS	2022-06-08	2022-06-10	Intern metode	

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

Analyseansvarlig: Oda Sofie Bye Wilhelmsen

Signatur: Oda Sofie Bye Wilhelmsen

Lisa Torske

Underskriftsberettiget:

Signatur: Lisa Torske

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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