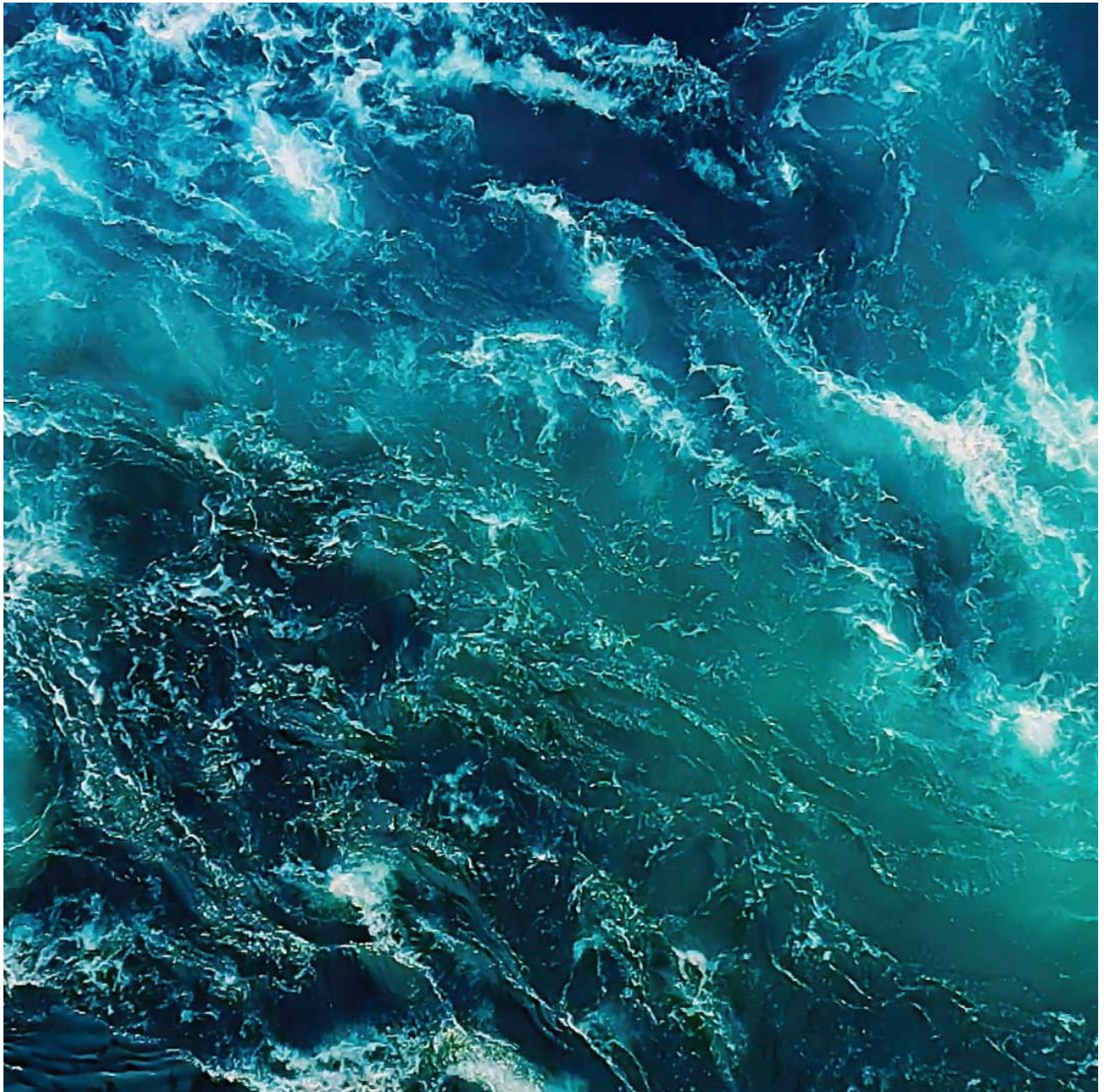# C-survey at Eyrarhlíð I, 2022

Arctic Sea Farm ehf

Akvaplan-niva AS Report: 2023 64476.01

Arctic Sea Farm ehf. C-Survey at Eyrarhlíð I, 2022.

Author(s)	Kamila Sztybor, Snorri Gunnarsson

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Arctic Sea Farm ehf

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Summary

The results from the monitoring at the farming site Eyrarhlíð I in November 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 which showed good conditions and no impact at any of the stations (> 0.6) except station C1. The diversity index H ' was below 3 at C1 and above 3 at the other stations and ranged from 3,12 to 3,54. The NS 9410:2016-assessment of the community in the local impact zone (C1) showed environmental condition 2 (Good). Pollution indicator was recorded among the top-10 species at C1 but not on 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 November was good in the whole water column with 86 % in the bottom water.

Approval

Project leader   Quality control

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Preface

Akvaplan-niva carried out a type C (NS 9410:2016) environmental survey at the Eyrarhlíð I 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 contributed:

Snorri Gunnarsson	Akvaplan-niva	Field work, report, project leader.
Kamila Sztybor	Akvaplan-niva	Report, professional assessments, and interpretations.
Hans-Petter Mannvik	Akvaplan-niva	Identification of bottom fauna (Echinodermata). QA report, professional assessments, and interpretations.
Roger Velvin	Akvaplan-niva	Identification of bottom fauna (Various taxa).
Rune Palerud	Akvaplan-niva	Identification of bottom fauna (Crustaceans). Statistics.
Jesper Hansen	Akvaplan-niva	Identification of bottom fauna (Mollusca).
Charlotte P. Ugelstad	Akvaplan-niva	Identification of bottom fauna (Polychaeta).
Anne T. Aasen	Akvaplan-niva	Hydrographical vertical profiles
Kristine H Sperre	Akvaplan-niva	Coordination of sorting of bottom fauna.
Ingar H. Wasbotten	Akvaplan-niva	Coordination of geo-chemical analyses.

Akvaplan-niva would like to thank Arctic Sea Farm ehf and Maria E. Chiarandini for good cooperation.

Accreditation information:

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

NORSK
AKKREDITERING
TEST 079

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

Czech Accreditation Institute (Lab nr 1163)

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

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

Kópavogur, 10.03 2023

Snorri Gunnarsson (Project Manager)

1 Data Summary

Client information			
Report title:	C-Survey at Eyrarhlíð I, 2022.		
Report nr.	2023 64476.01	Site:	Eyrarhlíð I
Municipality:		Map Coordinates (construction):	65º54,898 N 23º40,390 V
MTB permitted:	6.047	Operations manager:	Egill Ólafsson
Client:	Arctic Sea Farm ehf		

Biomass/production status at time of survey (22.11 2022)			
Fish group:	Salmon	Biomass on examination:	5.551
Feed input:	9.774	Produced amount of fish:	7.626
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)	0.314	Fauna C1 (impact zone)	1.53
Fauna C2	0.668	Fauna C2	3.37
Fauna C3	0.677	Fauna C3	3.54
Fauna C4 (deep area)	0.662	Fauna C4 (deep area)	3.12
Fauna C5	0.666	Fauna C5	3.30
Date fieldwork:	22.11.2022	**Date of report:**	07.03 2023
Notes to other results (sediment, pH/Eh, oxygen)			nTOC from 27.5 to 37.9 mg/g DS. Copper 51.0 mg/kg DS 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	Signature: SGU

2 Introduction

2.1 Background and aim of the study

On behalf of Arctic Sea Farm ehf, Akvaplan-niva completed a survey (type C) for a fish farming site at Eyrarhlíð I (Figure 1). The survey fulfils the requirements of the Icelandic authorities for bottom surveys according to ISO 12878 and the requirements for environmental bottom surveys (according to Vöktunaráætlun). An environmental study was simultaneously undertaken, with reference to Chapter 5.0 in NS 9410:2016 which follows the methodology for C- study. A survey (type C) is aimed at studying the environmental conditions of the bottom sediments along a transect sector from the fish farm that extends from the local, to the intermediate and to the regional impact zones. The main emphasis is on the study of the soft bottom fauna which is conducted according to standards ISO 5567-19:2004 and ISO 16665:2014. The obligatory parameters that are included in the survey are described in NS 9410:2016.

A classification or threshold values for this type of survey have not been developed by Icelandic officials so it is not possible to strictly apply the classification based on Norwegian threshold values to Icelandic conditions. We do however report the results with these same indexes with reference to Norwegian threshold values, but it should be emphasized that some of these (such as NSI) are developed according to Norwegian conditions. For further descriptions of these indexes see details in Appendix 1 and Miljødirektoratets Veileder 02:2018.
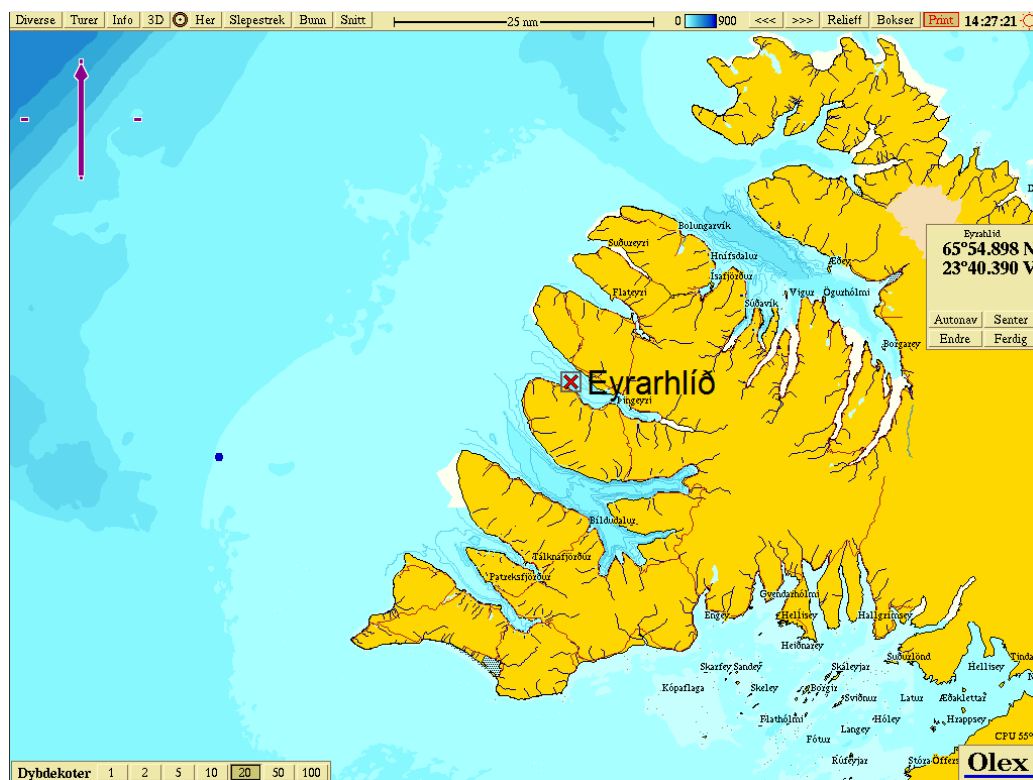

Figure 1 Overview of Vestfjords Iceland with the farming site Eyrarhlíð I (red cross). The map coordinates for the midpoint of the farming site are given to the right.

2.2 Site operation and feed use

The site has been in production since 2018 and this is the second generation farmed fish at the site. At the time of the survey (22.11 2022), the standing stock was approximately 5.551 tonnes of salmon (2021 generation) with an average weight of 5.4 kg per fish (Egilsson, pers. comm.). Until the date of survey the produced amount of fish for the current generation is 7.626 ton and the feed use was 9.774 ton.

The Eyrarhlíð site is located in Dýrafjörður about 9 km west from Þingeyri. The cages are lined in a northern direction from land (19 degrees). The depth under cages ranges from about 40 - 42 m. The fish farm at the site is a two-frame mooring system, each frame having 6 cages total 12 cages each with 160 m circumference. During the last production cycle all 12 cages of were used.

In Iceland, the MTB (maximum allowable biomass) is not given a site level as in Norway. The MTB limit determines how much live fish the holder of the permit can have standing in the sea at any time. In Iceland the allowed production is regulated at two levels, site level and company level. For this site the estimated maximal standing biomass for the current generation is 6.047 tonnes, used as MTB here (Egilsson, pers. comm).

2.3 Previous surveys

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

Table 1: Previous surveys at Eyrarhlíð I.

Survey date	Report reference (author, year)	Production (tonnes)	Type of survey
05.06 2018	Gallo, 2019	0	Baseline survey
25.03 2020	Mannvik & Gunnarsson, 2020	8.602	ASC/C survey at Max biomass
15.04 2021	Mannvik & Gunnarsson, 2021	0	C survey at Fallow period

3   Materials and methods

3.1   Survey program

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

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

- ISO 5667-19:2004: *Guidance on sampling of marine sediments.*

- ISO 16665:2014. *Water quality – Guidelines for quantitative sampling and sample processing of marine soft-bottom macro fauna.*

- NS 9410:2016. *Miljøovervåking av bunnpåvirkning fra marine oppdrettsanlegg.*

- Internal procedures. *Quality Manual for Akvaplan-niva.*

- Veileder 02:2018 (rev. 2020). *Klassifisering av miljøtilstand i vann.* Norsk klassifiseringssystem for vann i henhold til Vannforskriften. Veileder fra Direktoratgruppen.

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

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

Field work was completed on 22.11 2022.

Placement of stations and local conditions

The number of stations was calculated with reference to the sites estimated maximal standing biomass for the current generation which is 6.047 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 3 and shown in Figure 2. The stations were placed in accordance with the main current direction at 39 m depth (Gustavsson, 2019) which shows the main direction of oceanic flow is in a SE direction (135 degrees).

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

Station	Depth, m	Distance from frame, m	Position	
			N	W
C1	41	25	$65^0$34.863	$24^0$02.684
C2	41	500	$65^0$35.098	$24^0$02.994
C3	42	100	$65^0$34.903	$24^0$02.776
C4	41	150	$65^0$34.932	$24^0$02.984
C5	41	250	$65^0$35.336	$24^0$03.303
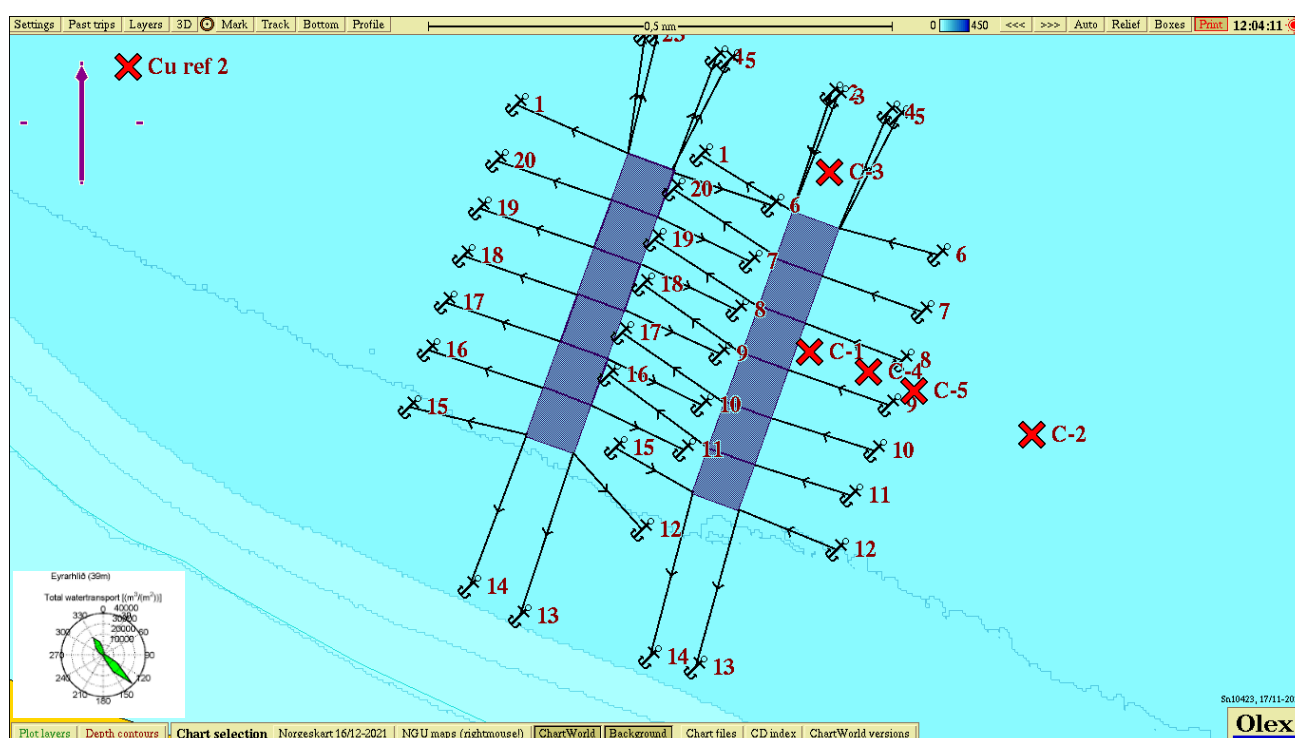
Figure 2. Map showing the sampling stations for the C-survey at Eyrarhlíð I, 2022. Current measurements used were from 39 m depth (Gustavsson, 2019).

3.2 Hydrography and oxygen

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

3.3 Soft bottom sampling and analyses

3.3.1 Fieldwork

Sediment samples were collected with a 0.1 m² bottom grab (van Veen). The sample material was collected through inspection openings. Samples for TOC, TN and Cu were taken from the top 1 cm layer of the sediment and for TOM and grain size analyses from the top 5 cm using a hollow pipe. Only samples with an undisturbed surface were used. The samples were frozen prior to further processing in the laboratory.

3.3.2   Total organic material (TOM)

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

3.3.3   Total nitrogen (TN)

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

3.3.4   Total organic carbon (TOC) and grain size

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

After drying the samples at 40 °C, the content of total organic carbon (TOC) was determined by NDIR-detection in accordance with 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 the proportion of fine substance (nTOC) using the equation: $nTOC = TOC + 18 (1 – F)$, where TOC and F represent a measured TOC value and the proportion of fine substance (%) in the sample (Aure *et al.,* 1993).

3.3.5   Metal analysis - copper (Cu)

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

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, that is dependent on favourable conditions for the fauna. However, moderate increases in organic load can stimulate the fauna and result in an increased number of species found. Larger organic loads can result in less favourable conditions where opportunistic species increase their individual numbers, while the species not suited are knocked out resulting in a reduced diversity of species. Changes in species diversity near emission points of feed and faecal matter can, to a large degree, be attributed to changes in organic content (from the feed and faecal matter) in the sediment.

3.4.2 Sampling and fixation

All the bottom fauna samples were taken with a $0.1\ m^2$ van Veen grab. Only grab samples where the grab was completely closed and the surface undisturbed were approved. The contents were washed through a 1 mm sieve and the remaining material fixed with 4 % formalin with Bengal Rose dye added and then neutralized with borax. In the laboratory, the animals were sorted from the remaining sediment.

3.4.3 Quantitative bottom fauna analysis

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

- Shannon-Wiener diversity index (H')
- Hurlberts diversity index (ES_{100}) – expected number of species pr. 100 individuals
- Pielou's evenness index (J)
- Sensitivities index (Ømfintlighet) (ISI_{2012}), unsuitable at low individual/species number
- Sensitivity index (NSI)
- Composite index for diversity of species and sensitivity (NQI1)
- Sensitivities index which is included in NQI1 (AMBI)
- Normalized EQR (nEQR)
- Number of species plotted against the number of individuals in geometric arts classes
- Cluster analyses
- The ten most dominant taxa per station (top-ten)

4 Results

4.1 Hydrography and oxygen

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

Temperature was around 6 °C from top to bottom, with oxygen saturation 97 % in the upper layer and 86 % in the bottom layer.
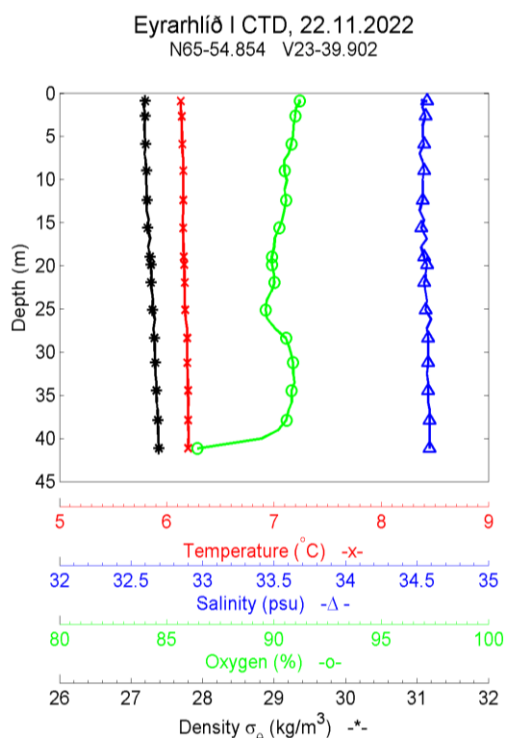
Figure 3. Vertical profiles. Temperature, salinity, density, and oxygen at C4 at Eyrarhlíð I, 2022.

4.2 Sediment

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

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

TOM-levels varied from 9,2 to 10,0 %. TN-levels were low (2,0– 2,5 mg/g) and the C/N-ratio was slightly elevated. TOC was rather high at all stations and nTOC varied from 27,5 to 37,8 mg/g DS. The bottom sediments grain size was fine with a pelite ratio ranging from 80,0 to 84,6 %.

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 (pelite ratio % <0,063 mm) and pH/Eh. Eyrarhlíð I, 2022.

St.	Sediment description	TOM	TOC	nTOC	TN	C/N	Pelite	pH/Eh
C1	Olive green/grey mud, no smell of H_2S	9,7	33,2	36,4	2,2	15,3	82,4	7,56/245
C2	Olive green/grey mud, no smell of H_2S	9,6	28,5	31,3	2,0	14,5	84,6	7,51/165
C3	Olive green/grey mud, no smell of H_2S	9,2	24,6	27,5	2,1	11,5	83,6	7,68/184
C4	Olive green/grey mud, no smell of H_2S	10,0	31,7	35,3	2,5	12,9	80,0	7,21/183
C5	Olive green/grey mud, no smell of H_2S	9,9	34,9	37,8	2,2	16,1	83,9	7,18/179

4.2.2 Copper

Level of copper in bottom sediments at station C1 is shown in Table 5. The level of copper was 51,0 mg/kg DS.

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

St.	Cu
C1	51,0

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 6.

The number of individuals varied from 557 (C2) to 1368 (C3) and number of species from 29 (C1) to 44 (C5). The diversity H' varied from 1.53 to 3.54. At all stations except C1, the overall index of nEQR was higher than 0.6. The nEQR values at these stations 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 0.36 (C1) and 0,61 to 0,71 (rest of the stations) which indicates a somewhat uneven distribution at station C1.

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 Eyrarhlíð I, 2022.

St.	No. of individuals.	No. of species	H´	ES_{100}	NQI1	ISI_{2012}	NSI	nEQR	AMBI	J
C1	667	29	1.53	10.36	0.43	5.32	9.82	0.314	4.984	0.36
C2	557	36	3.37	19.58	0.72	8.18	22.63	0.668	1.765	0.71
C3	1368	37	3.54	19.96	0.72	8.52	22.37	0.677	1.602	0.71
C4	1087	42	3.12	21.22	0.72	8.05	22.42	0.662	1.865	0.61
C5	942	44	3.30	21.59	0.73	7.92	22.32	0.666	1.803	0.64

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 m² and that none of these are in numbers exceeding 65 % of the individuals (Table 7).

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

Station	Site name	Num. species	Dominating taxa	Environmental condition-NS 9410
C1	Eyrarhlíð I	29	Capitella capitata - 80 %	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 (≤ 15 species) and stretched out in varying degrees towards higher classes. These did not give any clear indications of fauna condition.
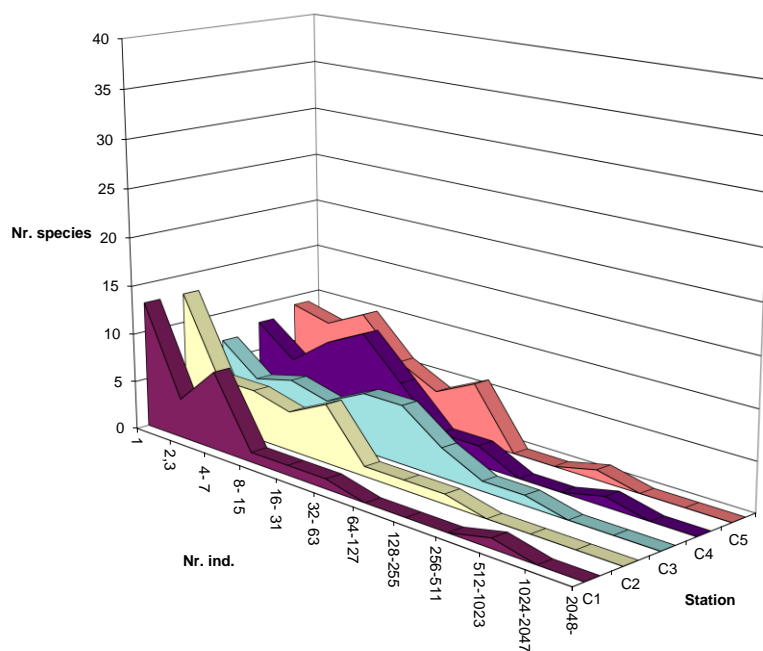
Figure 4. The soft bottom fauna shown as number of species against number of individuals pr. species in geometric classes. Eyrarhlíð I, 2022.

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 73 % similar for all stations in the survey except C1, which was only 46 % similar with the other stations.
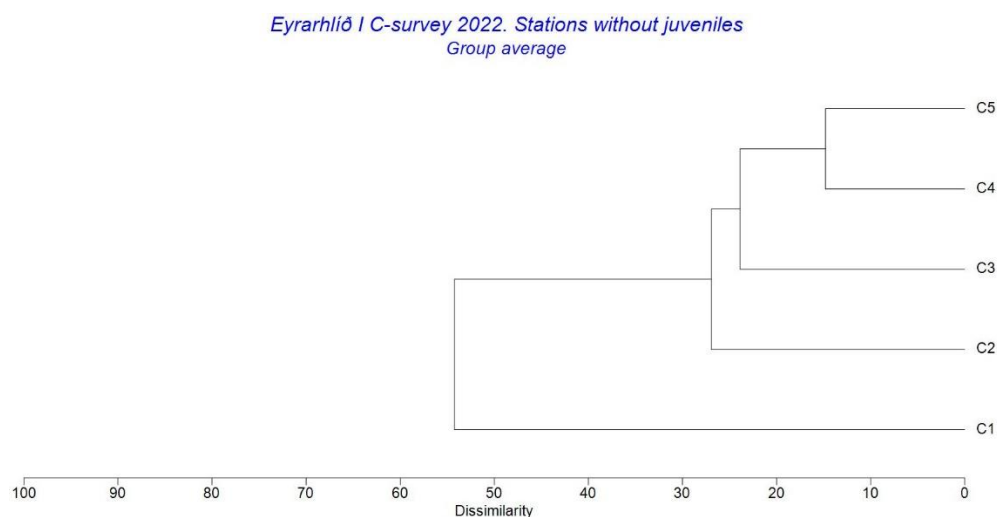
Figure 5. Cluster diagram for the soft bottom fauna at the C- sampling stations at Eyrarhlíð I, 2022.

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

Fauna at station C1 was dominated by a pollution indicator *Capitella capitata* with 80 % of the individuals. The other most dominant species were neutral, tolerant, and opportunistic species.

At the other stations the fauna was dominated by the neutral bivalve *Ennucula tenuis* with between 35 and 50 % of the individuals. The other most dominant species at the stations were a mixture of neutral, tolerant, and opportunistic species.

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

C1	EG	Numb.	Cum.	C2	EG	Numb.	Cum.
Capitella capitata	V	538	80 %	Ennucula tenuis	II	221	39 %
Ennucula tenuis	II	32	85 %	Levinsenia gracilis	II	64	50 %
Thyasira sarsii	IV	23	88 %	Galathowenia oculata	III	34	56 %
Lagis koreni	IV	8	90 %	Nuculana pernula	II	29	61 %
Pholoe baltica	III	7	91 %	Abra nitida	III	25	66 %
Thyasira gouldii	IV	7	92 %	Leucon sp.	Ik	23	70 %
Eteone flava/longa	Ik	6	93 %	Thyasira gouldii	IV	23	74 %
Oedicerotidae indet.	Ik	6	93 %	Sternaspis scutata	Ik	20	78 %
Mytilus edulis	IV	5	94 %	Thyasira sarsii	IV	17	81 %
Scalibregma inflatum	III	5	95 %	Axinopsida orbiculata	Ik	13	83 %
C3	**EG**	**Numb.**	**Cum.**	**C4**	**EG**	**Numb.**	**Cum.**
Ennucula tenuis	II	497	35 %	Ennucula tenuis	II	560	50 %
Thyasira gouldii	IV	163	47 %	Lagis koreni	IV	68	56 %
Galathowenia oculata	III	88	53 %	Levinsenia gracilis	II	67	62 %
Levinsenia gracilis	II	76	59 %	Axinopsida orbiculata	Ik	53	67 %
Owenia sp.	II	75	64 %	Galathowenia oculata	III	43	70 %
Sternaspis scutata	Ik	61	69 %	Ophiuroidea indet. juv.	II	36	74 %
Axinopsida orbiculata	Ik	58	73 %	Abra nitida	III	30	76 %
Leucon sp.	Ik	40	76 %	Thyasira sarsii	IV	28	79 %
Praxillella praetermissa	II	39	78 %	Yoldia hyperborea	Ik	21	81 %
Abra nitida	III	34	81 %	Sternaspis scutata	Ik	19	82 %

C5	EG	Numb.	Cum.
Ennucula tenuis	II	447	46 %
Lagis koreni	IV	56	51 %
Levinsenia gracilis	II	52	57 %
Axinopsida orbiculata	Ik	51	62 %
Abra nitida	III	40	66 %
Galathowenia oculata	III	37	70 %
Ophiuroidea indet. juv.	II	37	74 %
Thyasira sarsii	IV	34	77 %
Thyasira gouldii	IV	26	80 %
Owenia sp.	II	21	82 %

*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 Eyrarhlíð I, 2022, can be summarised as follows:

- The hydrography measurements showed good oxygen conditions throughout the water column with 86 % saturation in the bottom layer in November 2022.

- TOC was rather high at all stations and nTOC varied from 27,5 to 37,8 mg/g DS. TOM-levels varied from 9,2 to 10,0 %. TN-levels were low (2,0 – 2,5 mg/g) and the C/N-ratio was somewhat elevated. The copper level in the sediment at C1 was elevated (51,0 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 80 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 557 to 1368 and number of species from 29 to 44. The diversity H' varied from 1,53 to 3,54. At all stations except C1, the overall index of nEQR was higher than 0,6. The nEQR values at these stations indicate good conditions and no disturbance of the communities.

5.2   Conclusions

The results from the monitoring at the farming site Eyrarhlíð I in November 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 which showed good conditions and no impact at any of the stations (> 0.6) except station C1. The diversity index H ' was below 3 at C1 and above 3 at the other stations and ranged from 3,12 to 3,54. The NS 9410:2016-assessment of the community in the local impact zone (C1) showed environmental condition 2 (Good). Pollution indicator was recorded among the top-10 species at C1 but not on 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 November was good in the whole water column with 86 % in the bottom water.

Previously there have been three bottom surveys at the Eyrahlíð I site, a base line study with sampling in June 2018 (Gallo, 2019) and a C-survey at max biomass in March 2020 (Mannvik and Gunnarsson, 2020) and C-survey at fallow period in April 2021 (Mannvik and Gunnarsson, 2021).

There were made some changes in the placement of the stations between the two max biomass surveys in 2020 and now in 2022 so only peripheral comparison can be made. The results from the present survey in November 2022 compared to previous C survey at max biomass in March 2020 indicates however similar faunal condition between the two surveys. The pollution indicator *Capitella capitata* that was only found at both stations C1 and C4 in 2021 is only found among the top ten species at C1 in 2022.

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7 Appendix (in Norwegian)

7.1 Statistiske metoder

Diversitet

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

<u>Shannon-Wieners indeks</u> (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 Eyrarhlíð I, 2022

Benthos indices per replicate

st.nr.	tot.	C1_01	C1_02	C2_01	C2_02	C3_01	C3_02	C4_01	C4_02	C5_01	C5_02
no. ind.	5019	444	223	260	297	785	583	527	560	439	503
no. spe.	68	11	22	26	29	30	33	34	37	34	39
Shannon-Wiener:		0,50	2,56	3,39	3,34	3,50	3,58	3,18	3,07	3,25	3,34
Pielou		0,14	0,57	0,72	0,69	0,71	0,71	0,62	0,59	0,64	0,63
ES100		5,35	15,36	18,96	20,21	19,78	20,15	21,03	21,40	20,80	22,38
SN		1,33	1,83	1,90	1,94	1,79	1,89	1,92	1,96	1,95	2,00
ISI-2012		4,64	6,00	8,17	8,19	8,02	9,02	8,33	7,77	8,18	7,67
AMBI		5,777	4,191	1,733	1,796	1,608	1,595	1,931	1,798	1,776	1,830
NQI1		0,33	0,53	0,72	0,72	0,72	0,73	0,71	0,73	0,73	0,74
NSI		7,40	12,24	22,48	22,78	22,18	22,55	22,19	22,64	22,34	22,30
DI		0,60	0,30	0,36	0,42	0,84	0,72	0,67	0,70	0,59	0,65

Geometrical classes

int.	cla.	C1	C2	C3	C4	C5
1	1	13	13	7	8	9
2,3	2	4	5	4	5	8
4- 7	3	8	5	5	8	10
8- 15	4	1	4	4	10	6
16- 31	5	1	6	6	6	4
32- 63	6	1	1	6	2	6
64-127	7	0	1	3	2	0
128-255	8	0	1	1	0	0
256-511	9	0	0	1	0	1
512-1023	10	1	0	0	1	0
1024-2047	11	0	0	0	0	0
2048-	12	0	0	0	0	0

7.3 Species lists

Artsliste pr stasjon

Eyrarhlíð I ASC-C-survey 2022

Rekke	Klasse	Orden	Art/Taxa	Replikat:	01	02	-	Sum

Stasjonsnr.: C1

NEMERTINI

			Nemertea indet.			1	-	1

ANNELIDA
Polychaeta
Orbiniida

			Levinsenia gracilis			1	-	1

Spionida

			Chaetozone setosa			2	-	2
			Malacoceros vulgaris		3		-	3
			Spio limicola			1	-	1

Capitellida

			Capitella capitata		418	120	-	538
			Mediomastus fragilis		2		-	2

Opheliida

			Scalibregma inflatum			5	-	5

Phyllodocida

			Eteone flava/longa			6	-	6
			Goniada maculata		1		-	1
			Microphthalmus sczelkowii		2	2	-	4
			Nephtys ciliata			2	-	2
			Nephtys paradoxa			1	-	1
			Pholoe assimilis			1	-	1
			Pholoe baltica		7		-	7
			Syllis fasciata		1		-	1

Oweniida

			Galathowenia oculata			1	-	1

Terebellida

			Lagis koreni			8	-	8

CRUSTACEA
Malacostraca
Amphipoda

			Caprellidae indet.		1		-	1
			Ischyroceridae indet.		1		-	1
			Oedicerotidae indet.			6	-	6

MOLLUSCA
Bivalvia
Nuculoida

			Ennucula tenuis			32	-	32
			Yoldia hyperborea			1	-	1

Mytiloida

			Mytilus edulis		4	1	-	5

Veneroida

			Abra nitida			1	-	1
			Axinopsida orbiculata			1	-	1
			Macoma calcarea			4	-	4
			Thyasira gouldii			7	-	7
			Thyasira sarsii		4	19	-	23

ECHINODERMATA
Ophiuroidea

			Ophiuroidea indet. juv.		1	3	-	4

Maksverdi:	418	120	538
Antall arter/taxa:	12	23	30
Sum antall individ:			671

Stasjonsnr.: C2

NEMERTINI

			Nemertea indet.		1		-	1

Rekke	Klasse	Orden	Art/Taxa	Replikat: 01	02	-	Sum
ANNELIDA							
	Polychaeta						
		Orbiniida					
			Levinsenia gracilis	24	40	-	64
			Paradoneis lyra	1		-	1
		Spionida					
			Chaetozone setosa	1		-	1
			Spio limicola	1		-	1
		Capitellida					
			Maldane sarsi	4	3	-	7
			Praxillella gracilis	3	4	-	7
			Praxillella praetermissa	1		-	1
		Opheliida					
			Scalibregma inflatum		1	-	1
		Phyllodocida					
			Eteone flava/longa		2	-	2
			Nephtys ciliata	5	2	-	7
			Pholoe baltica		1	-	1
		Sternaspida					
			Sternaspis scutata	9	11	-	20
		Oweniida					
			Galathowenia oculata	17	17	-	34
			Myriochele malmgreni/olgae		11	-	11
			Owenia sp.	1	1	-	2
		Terebellida					
			Lagis koreni	8	4	-	12
			Polycirrus sp.	1	1	-	2
CRUSTACEA							
	Malacostraca						
		Cumacea					
			Eudorella sp.	1	2	-	3
			Leucon sp.	16	7	-	23
		Amphipoda					
			Caprellidae indet.		1	-	1
			Lysianassidae indet.	3	2	-	5
			Oedicerotidae indet.	3	4	-	7
			Protomedeia fasciata		1	-	1
MOLLUSCA							
	Opistobranchia						
		Cephalaspidea					
			Retusa obtusa		1	-	1
	Bivalvia						
		Nuculoida					
			Ennucula tenuis	99	122	-	221
			Nuculana pernula	20	9	-	29
			Yoldia hyperborea		8	-	8
		Mytiloida					
			Mytilus edulis		1	-	1
		Veneroida					
			Abra nitida	13	12	-	25
			Axinopsida orbiculata	4	9	-	13
			Macoma calcarea		1	-	1
			Thyasira gouldii	14	9	-	23
			Thyasira sarsii	7	10	-	17
ECHINODERMATA							
	Asteroidea						
		Forcipulatida					
			Leptasterias muelleri	1		-	1
	Ophiuroidea						
		Ophiurida					
			Ophiocten affinis	2		-	2
			Ophiuroidea indet. juv.	5	4	-	9
			Maksverdi:	99	122		221
			Antall arter/taxa:	27	30		37
			Sum antall individ:				566

Stasjonsnr.: C3

NEMERTINI

Rekke	Klasse	Orden	Art/Taxa	Replikat:	01	02	-	Sum
			Nemertea indet.		1		-	1
ANNELIDA								
	Polychaeta							
		Orbiniida						
			Levinsenia gracilis		42	34	-	76
		Spionida						
			Dipolydora coeca			2	-	2
			Prionospio steenstrupi		6	4	-	10
			Spio limicola		5	4	-	9
		Capitellida						
			Maldane sarsi		14	11	-	25
			Praxillella gracilis		8	11	-	19
			Praxillella praetermissa		18	21	-	39
		Phyllodocida						
			Eteone flava/longa		2		-	2
			Nephtys ciliata		16	2	-	18
			Nephtys paradoxa			1	-	1
			Pholoe assimilis		4		-	4
			Pholoe baltica		1	4	-	5
		Sternaspida						
			Sternaspis scutata		41	20	-	61
		Oweniida						
			Galathowenia oculata		44	44	-	88
			Myriochele malmgreni/olgae		2	4	-	6
			Owenia sp.		34	41	-	75
		Flabelligerida						
			Saphobranchia longisetosa			1	-	1
		Terebellida						
			Ampharete borealis			1	-	1
			Lagis koreni		16	6	-	22
		Sabellida						
			Euchone sp.		1		-	1
CRUSTACEA								
	Malacostraca							
		Cumacea						
			Eudorella sp.		1	3	-	4
			Leucon sp.		29	11	-	40
		Amphipoda						
			Lysianassidae indet.		6	2	-	8
			Oedicerotidae indet.		5	1	-	6
			Syrrhoe crenulata			1	-	1
MOLLUSCA								
	Caudofoveata							
			Caudofoveata indet.			2	-	2
	Bivalvia							
		Nuculoida						
			Ennucula tenuis		292	205	-	497
			Nuculana pernula		12	22	-	34
			Yoldia hyperborea		14	7	-	21
		Veneroida						
			Abra nitida		18	16	-	34
			Astarte montagui			1	-	1
			Axinopsida orbiculata		32	26	-	58
			Macoma calcarea		5	4	-	9
			Thyasira gouldii		99	64	-	163
			Thyasira sarsii		16	6	-	22
ECHINODERMATA								
	Ophiuroidea							
		Ophiurida						
			Ophiocten affinis		1	1	-	2
			Ophiuroidea indet. juv.		21	12	-	33
			Maksverdi:		292	205		497
			Antall arter/taxa:		31	34		38
			Sum antall individ:					1401

Stasjonsnr.: C4

PRIAPULIDA

Rekke	Klasse	Orden	Art/Taxa	Replikat:	01	02	-	Sum
			Priapulus caudatus			1	-	1
ANNELIDA								
	Polychaeta							
		Orbiniida						
			Levinsenia gracilis		35	32	-	67
		Cossurida						
			Cossura sp.		1		-	1
		Spionida						
			Prionospio steenstrupi		1		-	1
			Spio limicola		4	8	-	12
		Capitellida						
			Maldane sarsi		5	3	-	8
			Mediomastus fragilis		3	2	-	5
			Praxillella gracilis		5	3	-	8
			Praxillella praetermissa		6	3	-	9
		Phyllodocida						
			Eteone flava/longa		8	2	-	10
			Eteone sp.			1	-	1
			Microphthalmus sczelkowii			1	-	1
			Nephtys ciliata		6	8	-	14
			Pholoe assimilis			2	-	2
			Pholoe baltica		1	4	-	5
			Polynoidae indet.			2	-	2
			Syllis cornuta			3	-	3
		Eunicida						
			Mammiphitime cosmetandra		2	3	-	5
		Sternaspida						
			Sternaspis scutata		9	10	-	19
		Oweniida						
			Galathowenia oculata		16	27	-	43
			Myriochele malmgreni/olgae		4	2	-	6
			Owenia sp.		5	6	-	11
		Terebellida						
			Lagis koreni		43	25	-	68
		Sabellida						
			Euchone sp.		5	6	-	11
CRUSTACEA								
	Malacostraca							
		Cumacea						
			Eudorella sp.		1	3	-	4
			Leucon sp.		10	7	-	17
		Amphipoda						
			Lysianassidae indet.		2	5	-	7
			Oediceropsis brevicornis			1	-	1
			Oedicerotidae indet.		9	7	-	16
			Protomedeia fasciata		2		-	2
		Decapoda						
			Brachyura indet.			1	-	1
MOLLUSCA								
	Bivalvia							
		Nuculoida						
			Ennucula tenuis		260	300	-	560
			Nuculana pernula		2	6	-	8
			Yoldia hyperborea		14	7	-	21
		Mytiloida						
			Mytilus edulis		2		-	2
		Veneroida						
			Abra nitida		11	19	-	30
			Axinopsida orbiculata		27	26	-	53
			Macoma calcarea		2	2	-	4
			Thyasira gouldii		9	6	-	15
			Thyasira sarsii		14	14	-	28
ECHINODERMATA								
	Asteroidea							
		Paxillosida						
			Ctenodiscus crispatus		1		-	1
	Ophiuroidea							
		Ophiurida						
			Ophiocten affinis		2	2	-	4
			Ophiuroidea indet. juv.		22	14	-	36

Rekke	Klasse	Orden	Art/Taxa	Replikat:	01	02	-	Sum
				Maksverdi:	260	300		560
				Antall arter/taxa:	35	38		43
				Sum antall individ:				1123

Stasjonsnr.: C5

Rekke	Klasse	Orden	Art/Taxa	01	02	-	Sum
ANNELIDA							
	Polychaeta						
		Orbiniida					
			Levinsenia gracilis	25	27	-	52
		Spionida					
			Chaetozone setosa	1	1	-	2
			Prionospio steenstrupi	1		-	1
			Spio limicola	1	4	-	5
		Capitellida					
			Maldane sarsi	2	1	-	3
			Maldanidae indet.	1		-	1
			Mediomastus fragilis		1	-	1
			Praxillella gracilis	3	1	-	4
			Praxillella praetermissa	4	5	-	9
		Phyllodocida					
			Eteone flava/longa		3	-	3
			Microphthalmus sczelkowii		1	-	1
			Nephtys ciliata	6	4	-	10
			Pholoe assimilis	1	2	-	3
			Pholoe baltica	1	3	-	4
			Polynoidae indet.	3		-	3
			Syllis cornuta	1	4	-	5
		Eunicida					
			Mammiphitime cosmetandra		5	-	5
		Sternaspida					
			Sternaspis scutata	1	5	-	6
		Oweniida					
			Galathowenia oculata	16	21	-	37
			Myriochele malmgreni/olgae	6	6	-	12
			Owenia sp.	13	8	-	21
		Flabelligerida					
			Saphobranchia longisetosa		1	-	1
		Terebellida					
			Ampharete borealis		1	-	1
			Lagis koreni	18	38	-	56
			Melinna cristata		1	-	1
		Sabellida					
			Euchone sp.		2	-	2
CRUSTACEA							
	Malacostraca						
		Cumacea					
			Eudorella sp.	2		-	2
			Leucon sp.	11	6	-	17
		Amphipoda					
			Dulichiidae indet.		1	-	1
			Lysianassidae indet.	3	5	-	8
			Oediceropsis brevicornis	2	2	-	4
			Oedicerotidae indet.	4	9	-	13
MOLLUSCA							
	Opistobranchia						
		Cephalaspidea					
			Retusa obtusa	2	3	-	5
	Bivalvia						
		Nuculoida					
			Ennucula tenuis	209	238	-	447
			Nuculana pernula	6	6	-	12
			Yoldia hyperborea	9	12	-	21
		Mytiloida					
			Mytilus edulis	2		-	2
		Veneroida					
			Abra nitida	17	23	-	40
			Axinopsida orbiculata	30	21	-	51
			Macoma calcarea	3	1	-	4
			Thyasira gouldii	12	14	-	26
			Thyasira sarsii	21	13	-	34

Rekke	Klasse	Orden	Art/Taxa	Replikat:	01	02	-	Sum
ECHINODERMATA								
	Ophiuroidea							
		Ophiurida						
			Amphipholis squamata			1	-	1
			Ophiocten affinis		2	3	-	5
			Ophiuroidea indet. juv.		11	26	-	37
			Maksverdi:		209	238		447
			Antall arter/taxa:		35	40		45
			Sum antall individ:					979

7.4 Analytical report

ANALYSIS REPORT

Customer:	Arctic Sea Farm / Arctic Fish	Report no.:	P2200207
Client reference:	Eyrarhlíð I		
Client person:		Report date	2023-01-13
Project no.:	64476	Date Registrered:	2022-11-18

Lab-id. P2200207-01

Sample type	Kundens ID	Description	Note	Mottatt lab
Sediment	C1	64476 - Eyrarhlíð I		2022-11-18

Analyseresultat

Parameter	Resultat	Unit	Analysis date start	Analysis date end	Norm	Measurement uncertainty
TOC	33	mg/g TS	2022-12-12	2022-12-15	DIN 19539:2016	±3.3
TNb	2.2	mg/g TS	2022-12-12	2022-12-15	NS-EN 16168:2012	±0.7
N TOC	36.4	mg/g TS	2022-12-19	2022-12-19	Veileder 02:2018	
C/N - ratio	15.3		2022-12-19	2022-12-19		
TOM	9.7	% TS	2022-12-06	2022-12-08	Internal method	±0.0
Weight % 2 mm	0.7	wt% TS	2022-12-05	2022-12-12	Internal method (Bale/Kenny 2005)	±0.0
Weight% 1 mm	0.3	wt% TS	2022-12-05	2022-12-12	Internal method (Bale/Kenny 2005)	±0.0
Weight% 0.500 mm	0.2	wt% TS	2022-12-05	2022-12-12	Internal method (Bale/Kenny 2005)	±0.0
Weight% 0.250 mm	2.0	wt% TS	2022-12-05	2022-12-12	Internal method (Bale/Kenny 2005)	±0.1
Weight% 0.125 mm	6.4	wt% TS	2022-12-05	2022-12-12	Internal method (Bale/Kenny 2005)	±0.3
Vekt% 0.063 mm	8.0	wt% TS	2022-12-05	2022-12-12	Internal method (Bale/Kenny 2005)	±0.4
Weight% < 0.063 mm	82.4	wt% TS	2022-12-05	2022-12-12	Internal method (Bale/Kenny 2005)	±4.1
Pelite	82.4	wt% TS	2022-12-05	2022-12-12	Internal method (Bale/Kenny 2005)	±4.1
Sand	16.9	wt% TS	2022-12-05	2022-12-12	Internal method (Bale/Kenny 2005)	±0.8
Gravel	0.7	wt% TS	2022-12-05	2022-12-12	Internal method (Bale/Kenny 2005)	±0.0
Copper (Cu) [a]	51.0	mg/kg TS	2022-12-08	2022-12-08	Intern metode	

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

★ = Non-accredited result

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Lab-id. P2200207-02

Sample type	Kundens ID	Description	Note	Mottatt lab
Sediment	C2 / ASCref / Curef2	64476 - Eyrarhlíð I		2022-11-18

Analyseresultat

Parameter	Resultat	Unit	Analysis date start	Analysis date end	Norm	Measurement uncertainty
TOC	29	mg/g TS	2022-12-12	2022-12-15	DIN 19539:2016	±2.9
TNb	2.0	mg/g TS	2022-12-12	2022-12-15	NS-EN 16168:2012	±0.6
N TOC	31.3	mg/g TS	2022-12-19	2022-12-19	Veileder 02:2018	
C/N - ratio	14.5		2022-12-19	2022-12-19		
TOM	9.6	% TS	2022-12-06	2022-12-08	Internal method	±0.0
Weight % 2 mm	0.3	wt% TS	2022-12-05	2022-12-12	Internal method (Bale/Kenny 2005)	±0.0
Weight% 1 mm	0.4	wt% TS	2022-12-05	2022-12-12	Internal method (Bale/Kenny 2005)	±0.0
Weight% 0.500 mm	0.3	wt% TS	2022-12-05	2022-12-12	Internal method (Bale/Kenny 2005)	±0.0
Weight% 0.250 mm	1.4	wt% TS	2022-12-05	2022-12-12	Internal method (Bale/Kenny 2005)	±0.1
Weight% 0.125 mm	4.8	wt% TS	2022-12-05	2022-12-12	Internal method (Bale/Kenny 2005)	±0.2
Vekt% 0.063 mm	8.1	wt% TS	2022-12-05	2022-12-12	Internal method (Bale/Kenny 2005)	±0.4
Weight% < 0.063 mm	84.6	wt% TS	2022-12-05	2022-12-12	Internal method (Bale/Kenny 2005)	±4.2
Pelite	84.6	wt% TS	2022-12-05	2022-12-12	Internal method (Bale/Kenny 2005)	±4.2
Sand	15.1	wt% TS	2022-12-05	2022-12-12	Internal method (Bale/Kenny 2005)	±0.8
Gravel	0.3	wt% TS	2022-12-05	2022-12-12	Internal method (Bale/Kenny 2005)	±0.0
Copper (Cu) [a]	48.4 49.8	mg/kg TS	2022-12-08	2022-12-08	Intern metode	

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

* = Non-accredited result

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ANALYSIS REPORT

Customer:	Arctic Sea Farm / Arctic Fish			Report no.:	P2200207
Client reference:	Eyrarhlíð I				
Client person:				Report date	2023-01-13
Project no.:	64476			Date Registrered:	2022-11-18

Lab-id. P2200207-03

Sample type	Kundens ID	Description	Note	Mottatt lab
Sediment	C3 / ASC2	64476 - Eyrarhlíð I		2022-11-18

Analyseresultat

Parameter	Resultat	Unit	Analysis date start	Analysis date end	Norm	Measurement uncertainty
TOC	25	mg/g TS	2022-12-12	2022-12-15	DIN 19539:2016	±2.5
TNb	2.1	mg/g TS	2022-12-12	2022-12-15	NS-EN 16168:2012	±0.6
N TOC	27.5	mg/g TS	2022-12-19	2022-12-19	Veileder 02:2018	
C/N - ratio	11.5		2022-12-19	2022-12-19		
TOM	9.2	% TS	2022-12-06	2022-12-08	Internal method	±0.0
Weight % 2 mm	0.4	wt% TS	2022-12-05	2022-12-12	Internal method (Bale/Kenny 2005)	±0.0
Weight% 1 mm	0.4	wt% TS	2022-12-05	2022-12-12	Internal method (Bale/Kenny 2005)	±0.0
Weight% 0.500 mm	0.6	wt% TS	2022-12-05	2022-12-12	Internal method (Bale/Kenny 2005)	±0.0
Weight% 0.250 mm	1.4	wt% TS	2022-12-05	2022-12-12	Internal method (Bale/Kenny 2005)	±0.1
Weight% 0.125 mm	4.7	wt% TS	2022-12-05	2022-12-12	Internal method (Bale/Kenny 2005)	±0.2
Vekt% 0.063 mm	8.9	wt% TS	2022-12-05	2022-12-12	Internal method (Bale/Kenny 2005)	±0.4
Weight% < 0.063 mm	83.6	wt% TS	2022-12-05	2022-12-12	Internal method (Bale/Kenny 2005)	±4.2
Pelite	83.6	wt% TS	2022-12-05	2022-12-12	Internal method (Bale/Kenny 2005)	±4.2
Sand	16.0	wt% TS	2022-12-05	2022-12-12	Internal method (Bale/Kenny 2005)	±0.8
Gravel	0.4	wt% TS	2022-12-05	2022-12-12	Internal method (Bale/Kenny 2005)	±0.0

* = Non-accredited result

ANALYSIS REPORT

Customer: Arctic Sea Farm / Arctic Fish	**Report no.:**	P2200207
Client reference: Eyrarhlíð I		
Client person:	**Report date**	2023-01-13
Project no.: 64476	**Date Registrered:**	2022-11-18

Lab-id. P2200207-04

Sample type	Kundens ID	Description	Note	Mottatt lab
Sediment	C4 / ASC3	64476 - Eyrarhlíð I		2022-11-18

Analyseresultat

Parameter	Resultat	Unit	Analysis date start	Analysis date end	Norm	Measurement uncertainty
TOC	32	mg/g TS	2022-12-12	2022-12-15	DIN 19539:2016	±3.2
TNb	2.5	mg/g TS	2022-12-12	2022-12-15	NS-EN 16168:2012	±0.7
N TOC	35.3	mg/g TS	2022-12-19	2022-12-19	Veileder 02:2018	
C/N - ratio	12.9		2022-12-19	2022-12-19		
TOM	10.0	% TS	2022-12-06	2022-12-08	Internal method	±0.0
Weight % 2 mm	0.2	wt% TS	2022-12-05	2022-12-12	Internal method (Bale/Kenny 2005)	±0.0
Weight% 1 mm	1.1	wt% TS	2022-12-05	2022-12-12	Internal method (Bale/Kenny 2005)	±0.1
Weight% 0.500 mm	0.8	wt% TS	2022-12-05	2022-12-12	Internal method (Bale/Kenny 2005)	±0.0
Weight% 0.250 mm	1.5	wt% TS	2022-12-05	2022-12-12	Internal method (Bale/Kenny 2005)	±0.1
Weight% 0.125 mm	5.1	wt% TS	2022-12-05	2022-12-12	Internal method (Bale/Kenny 2005)	±0.3
Vekt% 0.063 mm	11.3	wt% TS	2022-12-05	2022-12-12	Internal method (Bale/Kenny 2005)	±0.6
Weight% < 0.063 mm	80.0	wt% TS	2022-12-05	2022-12-12	Internal method (Bale/Kenny 2005)	±4.0
Pelite	80.0	wt% TS	2022-12-05	2022-12-12	Internal method (Bale/Kenny 2005)	±4.0
Sand	19.8	wt% TS	2022-12-05	2022-12-12	Internal method (Bale/Kenny 2005)	±1.0
Gravel	0.2	wt% TS	2022-12-05	2022-12-12	Internal method (Bale/Kenny 2005)	±0.0
Copper (Cu) [a]	50.6 50.7	mg/kg TS	2022-12-08	2022-12-08	Intern metode	

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

* = Non-accredited result

ANALYSIS REPORT

Customer:	Arctic Sea Farm / Arctic Fish		**Report no.:**	P2200207
Client reference:	Eyrarhlíð I			
Client person:			**Report date**	2023-01-13
Project no.:	64476		**Date Registrered:**	2022-11-18

Lab-id. P2200207-05

Sample type	Kundens ID	Description	Note	Mottatt lab
Sediment	C5 / ASC4	64476 - Eyrarhlíð I		2022-11-18

Analyseresultat

Parameter	Resultat	Unit	Analysis date start	Analysis date end	Norm	Measurement uncertainty
TOC	35	mg/g TS	2022-12-12	2022-12-15	DIN 19539:2016	±3.5
TNb	2.2	mg/g TS	2022-12-12	2022-12-15	NS-EN 16168:2012	±0.6
N TOC	37.8	mg/g TS	2022-12-19	2022-12-19	Veileder 02:2018	
C/N - ratio	16.1		2022-12-19	2022-12-19		
TOM	9.9	% TS	2022-12-06	2022-12-08	Internal method	±0.0
Weight % 2 mm	0.2	wt% TS	2022-12-05	2022-12-12	Internal method (Bale/Kenny 2005)	±0.0
Weight% 1 mm	0.4	wt% TS	2022-12-05	2022-12-12	Internal method (Bale/Kenny 2005)	±0.0
Weight% 0.500 mm	0.7	wt% TS	2022-12-05	2022-12-12	Internal method (Bale/Kenny 2005)	±0.0
Weight% 0.250 mm	1.4	wt% TS	2022-12-05	2022-12-12	Internal method (Bale/Kenny 2005)	±0.1
Weight% 0.125 mm	5.2	wt% TS	2022-12-05	2022-12-12	Internal method (Bale/Kenny 2005)	±0.3
Vekt% 0.063 mm	8.1	wt% TS	2022-12-05	2022-12-12	Internal method (Bale/Kenny 2005)	±0.4
Weight% < 0.063 mm	83.9	wt% TS	2022-12-05	2022-12-12	Internal method (Bale/Kenny 2005)	±4.2
Pelite	83.9	wt% TS	2022-12-05	2022-12-12	Internal method (Bale/Kenny 2005)	±4.2
Sand	15.9	wt% TS	2022-12-05	2022-12-12	Internal method (Bale/Kenny 2005)	±0.8
Gravel	0.2	wt% TS	2022-12-05	2022-12-12	Internal method (Bale/Kenny 2005)	±0.0
Copper (Cu) [a]	50.7 47.5	mg/kg TS	2022-12-08	2022-12-08	Internal method	

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

Customer:	Arctic Sea Farm / Arctic Fish		Report no.:	P2200207
Client reference:	Eyrarhlíð I			
Client person:			Report date	2023-01-13
Project no.:	64476		Date Registrered:	2022-11-18

Lab-id. P2200207-06

Sample type	Kundens ID	Description	Note	Mottatt lab
Sediment	ASC1	64476 - Eyrarhlíð I		2022-11-18

Analyseresultat

Parameter	Resultat	Unit	Analysis date start	Analysis date end	Norm	Measurement uncertainty
TOC	30	mg/g TS	2022-12-12	2022-12-15	DIN 19539:2016	±3.0
TNb	2.0	mg/g TS	2022-12-12	2022-12-15	NS-EN 16168:2012	±0.6
N TOC	33.9	mg/g TS	2022-12-19	2022-12-19	Veileder 02:2018	
C/N - ratio	15.5		2022-12-19	2022-12-19		
TOM	9.8	% TS	2022-12-06	2022-12-08	Internal method	±0.0
Weight % 2 mm	0.2	wt% TS	2022-12-05	2022-12-12	Internal method (Bale/Kenny 2005)	±0.0
Weight% 1 mm	0.4	wt% TS	2022-12-05	2022-12-12	Internal method (Bale/Kenny 2005)	±0.0
Weight% 0.500 mm	0.8	wt% TS	2022-12-05	2022-12-12	Internal method (Bale/Kenny 2005)	±0.0
Weight% 0.250 mm	1.8	wt% TS	2022-12-05	2022-12-12	Internal method (Bale/Kenny 2005)	±0.1
Weight% 0.125 mm	5.7	wt% TS	2022-12-05	2022-12-12	Internal method (Bale/Kenny 2005)	±0.3
Vekt% 0.063 mm	10.4	wt% TS	2022-12-05	2022-12-12	Internal method (Bale/Kenny 2005)	±0.5
Weight% < 0.063 mm	80.8	wt% TS	2022-12-05	2022-12-12	Internal method (Bale/Kenny 2005)	±4.0
Pelite	80.8	wt% TS	2022-12-05	2022-12-12	Internal method (Bale/Kenny 2005)	±4.0
Sand	19.0	wt% TS	2022-12-05	2022-12-12	Internal method (Bale/Kenny 2005)	±1.0
Gravel	0.2	wt% TS	2022-12-05	2022-12-12	Internal method (Bale/Kenny 2005)	±0.0

* = Non-accredited result

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ANALYSIS REPORT

Customer:	Arctic Sea Farm / Arctic Fish		**Report no.:**	P2200207
Client reference:	Eyrarhlíð I			
Client person:			**Report date**	2023-01-13
Project no.:	64476		**Date Registrered:**	2022-11-18

Lab-id. P2200207-07

Sample type	Kundens ID	Description	Note	Mottatt lab
Sediment	Curef1	64476 - Eyrarhlíð I		2022-11-18

Analyseresultat

Parameter	Resultat	Unit	Analysis date start	Analysis date end	Norm	Measurement uncertainty
Copper (Cu) [a]	49.8 44.8	mg/kg TS	2022-12-08	2022-12-08	Intern metode	

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

Lab-id. P2200207-08

Sample type	Kundens ID	Description	Note	Mottatt lab
Sediment	Curef3	64476 - Eyrarhlíð I		2022-11-18
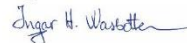
Analyseresultat

Parameter	Resultat	Unit	Analysis date start	Analysis date end	Norm	Measurement uncertainty
Copper (Cu) [a]	44.2 44.9	mg/kg TS	2022-12-08	2022-12-08	Intern metode	

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

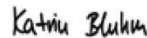Analytical chemist:

Ingar H. Wasbotten

Signature:

Katrin Bluhm

Signatory:

Signatur:

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