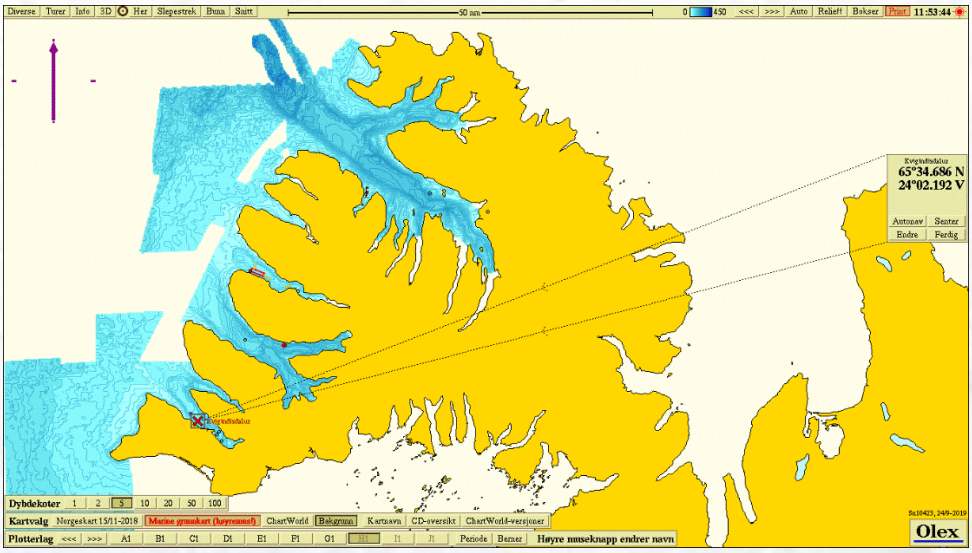
Akvaplan niva

Rapport Report

Arctic Sea Farm

Pre survey (type C)

Kvigindisdalur, 2019.



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Summary / Sammendrag
The results from monitoring at the farming site Kvigindisdalur in May 2019 showed that the sediment was somewhat loaded with organic carbon. Copper concentrations were within natural levels identified from bottom sediments around Iceland (Egilsson *et al.*, 1999). No load effect was recorded in the fauna and fauna and the index nEQR showed good conditions and no impact for all stations (> 0.6). The diversity index H' was just below 3 on C5ref and above 3 at all the other stations and ranged from 2,93 (C5ref) to 3,49. NS 9410:2016-assessment of the community in the local impact zone (C1) showed environmental condition 1 (Very good). No pollution indicators were recorded among the top-10 species at any of the stations. The redox measurements (pH/Eh) gave points 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 90 % in the bottom water.

Project manager / Prosjektleder

Snorri Gunnarsson

Quality control / Kvalitetskontroll

Hans-Petter mannvik

Contents

Foreword

Akvaplan-niva completed an environmental pre-survey of the type C at the Kvigindisdalur site. The C-survey is carried out in accordance with NS 9410:2016, and is part of a pre-survey of new locations and is in accordance with Chapter 5.0. Accordingly a reference station about 1 km away from the fish farm was included in the study. The survey includes pH/redox measurements (Eh), hydrography, geochemical analyses and analyses of the bottom fauna at the fish farming site. Results from five stations are included in the pre-survey. This survey is done upon request from Arctic Sea Farm hf.

The following personnel have contributed in this work:

Snorri Gunnarson	Akvaplan-niva	Field work, report, project leader.
Roger Velvin	Akvaplan-niva	Identification of bottom fauna (Various taxa). Report, professional assessments and interpretations.
Hans-Petter Mannvik	Akvaplan-niva	Identification of bottom fauna (Echinodermata). QS report, professional assessments and interpretations.
Rune Palerud	Akvaplan-niva	Identification of bottom fauna (Crustaceans). Statistics.
Thomas Hansen	Akvaplan-niva	Identification of bottom fauna (Polychaeta and Mollusca).
Stine Hermansen	Akvaplan-niva	Hydrographical vertical profiles
Kristine H Sperre	Akvaplan-niva	Coordination of sorting of bottom fauna.
Ingar H. Wasbotten	Akvaplan-niva	Coordination of geo-chemical analyses.

Akvaplan-niva would like to thank Steinunn G. Einarsdóttir, Arctic Sea Farm for good cooperation.

Accreditation information:

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

NORSK AKKREDITERING TEST 079	Akvaplan-niva AS er akkreditert av Norsk Akkreditering for feltinnsamlinger av sediment og fauna, analyser av TOC, TOM, TN, kornstørrelse, makrofauna og faglig vurderinger og fortolkninger, akkrediteringsnr. TEST 079. Akkrediteringen er i hht. NS-EN ISO/IEC 17025.
Czech Accreditation Institute (Lab nr 1163)	ALS Laboratory Group er akkreditert av Czech Accreditation Institute (Lab nr 1163) for analyser av kobber.

Kópavogur, 07.10 2019

Snorri Gunnarson

Project leader

1 Summary

1.1 Summary of C-results

Information client			
Title :	C-survey Kvigindisdalur, 2019.		
Report nr.	61207.01	Site:	Kvigindisdalur
Site nr.		Map coordinates (construction):	65°34,686 N 24°02,192 W
		Municipal:	Vesturbyggð
MTB-permission:	6.800	Operations manager: rett navn	Stein Ove Tveiten
Client:	Arctic Sea Farm hf		

Biomass/production status at time of survey 07.03.2019			
Fish group:	Salmon	Biomass on examination:	0
Feed input:	0	Produced amount of fish:	0
Type/time of survey			
Maximum biomass:		Follow up study:	
Fallow (resting period):		New locationi:	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 (closest to farm)	0.657	Fauna C1 (closest to farm)	3.49
Fauna C2	0.631	Fauna C2	3.10
Fauna C3	0.645	Fauna C3	3.29
Fauna C4 (deep area)	0.633	Fauna C4 (deep are)	3.28
Fauna C5ref	0.640	Fauna C5	2.93
Date fieldwork:	03.05.2019	**Date of report:**	07.10 2019
Notes to other results (sediment, pH/Eh, oxygen)			nTOC from 28.4 to 35.1 mg/g TS. Copper 32.6 at C1 Eh positive at all stations O_2-conditions were good throughout the water column.
Responsible for field work:	Snorri Gunnarson	Signature:	

2 Introduction

2.1 Background and aim of study

Akvaplan-niva on behalf of Arctic Sea Farm completed a pre-survey (type C) for a new fish farming site Kvíginidsdalur in Patreksfjörður, Iceland (Figure 1). The survey fulfils the requirements from the Icelandic authorities regarding bottom surveys referring to the standard 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.

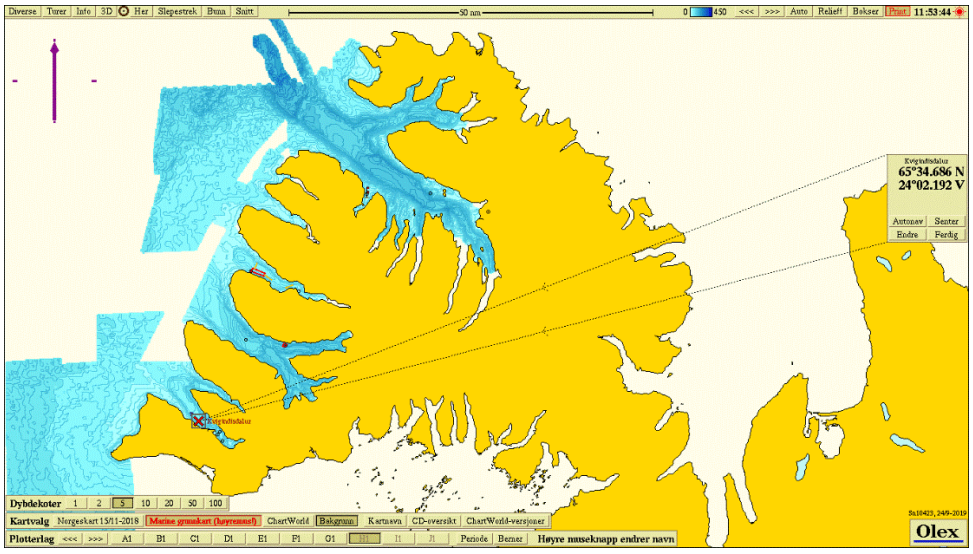

Figure 1. Overview of Patreksfjörður with the farming site Kvigindisdalur (red cross). The map coordinates for the midpoint of the farming site are given at right site of the picture.

2.2 Site operation and feed use

Kvígindisdalur is new fish farming site and has not been in operation before. Therefore, a pre-survey is carried out for the area. The plant is a frame mooring with a total of ten 160 meters circumference cages in a 2 x 5 comfiguration.

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 6800 tonnes, used as MTB here (Einarsdóttir, pers reference).

2.3 Previous surveys

Kvigindisdalur is a new fish farming site. Akvaplan-niva AS has not done any previous environmental surveys of the type B/C (NS 9410) at the Kvigindisdalur site. The contracting fish farmer has not presented any previous specific surveys for the soft bottom fauna of the site Kvígindisdalur. There are some other investigations that have been conducted in Patreksfjörður related to fish farming activities, but none directly affiliated with Kvígindisdalur.

3 Materials and methods

3.1 Professional 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. *Kvalitetshåndbok for Akvaplan-niva.*
- Veileder 02:2018. *Klassifisering av miljøtilstand i vann*. Norsk klassifiseringssystem for vann i henhold til Vannforskriften. Veileder fra Direktoratgruppen.
- M-608/2016. Grenseverdier for klassifisering av vann, sediment og biota. Miljødirektoratet, 2016.

Table 1. The planned professional program for the C-survey at Kvigindisdalur, 2019. TOC = total organic carbon. Korn = grain size in sediment. TOM = total organic material. TN = total nitrogen. Cu = Copper. pH/Eh = acidity and redox potential.

Station	Type analyses/parameters
C1 (local impact zone)	Quantitative analyses of bottom fauna. TOC. Korn. TOM. TN. Cu. pH/Eh.
C2 (transect zone)	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. 2 x Cu. pH/Eh.
C4 (transect zone, deep area)	Quantitative analyses of bottom fauna. TOC. Korn. TOM. TN. 2 x Cu. Hydrography/O_2. pH/Eh.
C5/Cu ref1 (Cu reference station)	Quantitative analyses of bottom fauna. TOC. Korn. TOM. TN. 2 x Cu pH/Eh.
Cu ref2 (reference station)	2 x Cu.

Field work was completed on 03.05.2019.

3.2 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 6.800 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 15 m depth (Heggem, 2018).

Table 2. Depth, distance between the nearest frame of the fish farm and sampling stations and coordinates for C-stations at Kvigindisdalur, 2019.

Station	Depth, m	Distance from frame, m	Position N	Position W
C1	55	25	65º34.863	24º02.684
C2	57	500	65º35.098	24º02.994
C3	58	100	65º34.903	24º02.776
C4	59	235	65º34.932	24º02.984
C5/Cu ref1	56	1000	65º35.336	24º03.303
Cu ref2	58	750	65º34.420	24º00.828

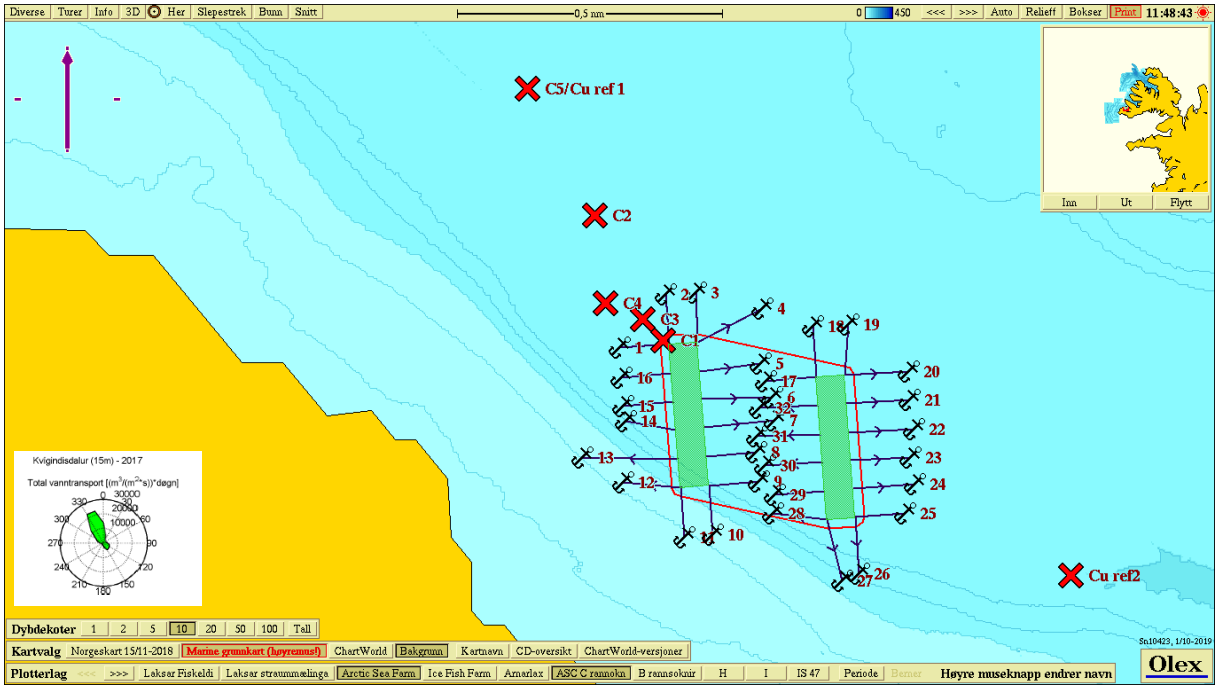

Figure 2. Map showing the sampling stations for the C-survey at Kvigindisdalur, 2019. Current measurements used were from 15 m depth (Heggem, 2018).

3.3 Hydrography and oxygen

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

3.4 Soft bottom sampling and analyses

3.4.1 Fieldwork

The samples were collected with a 0.1 m^2 bottom grab (van Veen). The sample material was collected through inspection openings. Samples for TOC, TOM, TN and Cu were taken off from the top 1 cm layer of the sediment and for grain size analyses from the top 5 cm using a hollow pipe. Only samples with an undisturbed surface were approved. The samples were frozen for further processing in the laboratory.

3.4.2 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.

3.4.3 Total nitrogen (TN)

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

3.4.4 Total organic carbon (TOC) and grain size

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

After drying the samples at 40 °C, the content of total organic carbon (TOC) was determined by NDIR-detection in accordance with DIN19539:2016 (Investigation of solids – Temperature-dependent differentiation of total carbon (TOC_{400}, ROC, TIC_{900})). In order to classify the environmental conditions based on the content of TOC, the measured concentrations are normalized for proportion of fine substance (nTOC) using the equation: nTOC = TOC + 18 (1 – F), where TOC and F represent a measured TOC value and the proportion of fine substance (%) in the sample (Aure *et al.*, 1993).

The classification of the environment conditions for the sediment is based on normalized TOC, and was carried out according to "Veileder" 02:2018.

Classification of condition for organic content in the marine sediment.

nTOC, mg/g	< 20 I Very good	20 - 27 II Good	27 - 34 III Average	34 - 41 IV Bad	> 41 V Very bad

3.4.5 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.

Classification of the environmental condition with respect to Cu is based on reference to the Norwegian Environmental Directorate's veileder M-608/2016.

Classification for copper in the marine sediment.

Cu mg/kg	< 20 Klasse I	20 - 84 Klasse II	20 - 84 Klasse III	84 - 147 Klasse IV	> 147 Klasse V

3.4.6 Redox- and pH measurements

At all the stations, a quantitative chemical examination of the sediment was carried out. Acidity (pH) and redox potential (Eh) were measured using electrodes and the YSI Professional Plus instrument. In accordance to the manual of the instrument, 200 mV was added to the measured ORP (the Oxydation Reduction Potential) value.

3.5 Soft bottom fauna investigation

3.5.1 About effect of organic material on bottom fauna

The emission of organic material from fish farms can contribute to the deterioration of conditions for many of the organisms living in the bottom sediment. Negative effects in the

bottom fauna can best be assessed through quantitative bottom fauna analyses. Many soft bottom species have low mobility, the fauna composition will largely reflect the local environmental conditions. Changes in the bottom fauna communities are a good indication of unwanted organic loads. Under natural conditions, the communities typically consist of many species. High number of species (diversity) is, amongst other things, dependent on favorable conditions for the fauna. However, moderate increases in organic load can stimulate the fauna and result in an increased number of species found. Larger organic loads can result in less 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.

3.5.2 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 seive 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.

3.5.3 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
- Clusteranalyes
- The ten most dominant taxa per station (top-ten)

4 Results

4.1 Hydrography

The hydrographical profile for the deep station C4 in May 2019 is presented in Figure 3. Temperature was around 4 ºC from top to bottom, and oxygen saturation 100 % in the upper layer and 90 % in the bottom layer.

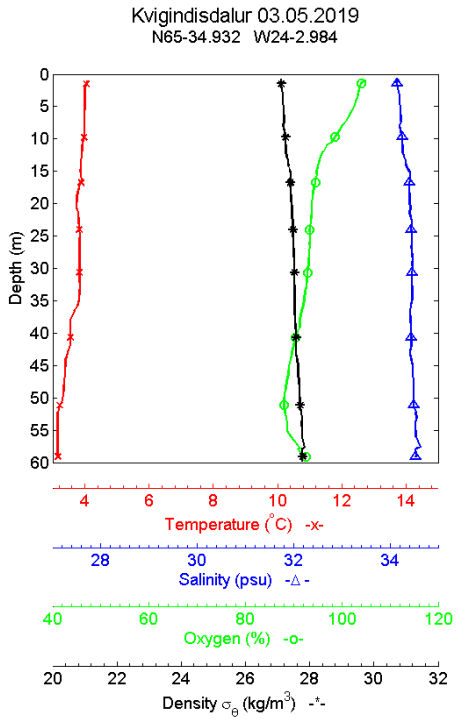

Figure 3. Vertical profiles. Temperature, salinity, density and oxygen at C4 at Kvigindisdalur, 2019.

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

The level of total organic material (TOM), total organic carbon (TN), C/N-relationship, grain size distribution in sediment (Pelitt) and pH/Eh in the sediment is presented in Table 3.

TOM-levels varied from 10,1 to 12,5 %. TN-levels were low (2,6 – 3,7 mg/g) as was the C/N-ratio. TOC was rather high at all stations and nTOC varied from 28,4 to 35,1 mg/g TS. The bottom sediments grain size were moderately fine with pelite ratio between 52 and 61 %.

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. Kvigindisdalur, 2019.

St.	Sediment description	TOM	TOC	nTOC*	TN	C/N	Pelitt	pH/Eh
C1	Clay, silt and some dead black algae	10,1	24,0	32,1	2,6	9,3	55	7,8 / 230
C2	Clay, silt and some dead black algae	10,9	26,8	33,9	3,0	8,9	61	7,6 / 139
C3	Clay, silt and some dead black algae	12,5	27,4	35,1	3,7	7,4	57	7,8 / 248
C4	Clay, silt and some dead black algae	11,4	25,7	34,4	3,7	7,0	52	7,7 / 158
C5ref	Clay, silt and some dead black algae	10,1	21,2	28,4	3,0	7,0	60	7,6 / 161

4.3 Copper

The level of copper in the bottom sediments are shown in Table 4. The level of copper varied from 26,9 to 33,7 mg/kg.

Table 4. Copper (Cu), mg/kg TS. C Kvigindisdalur, 2019.

St.	Cu repl. 1	Cu repl. 2
C1	26,9	32,6
C2	28,3	28,3
C3	30,9	33,7
C4	29,5	30,6
C5/Cu ref1	28,6	31,1
Cu ref2	33,2	31,1

4.4 Soft bottom fauna

4.4.1 Faunal indexes and ecological classification

Results from the quantitative soft bottom faunal analyses at the C-stations are presented in Table 5. Faunal index nEQR is presented without the density index (DI) in accordance with recommendations from the Norwegian Environment Agency (Miljødirektoratet).

The number of individuals varied from 630 (C2) to 1215 (C3) and number of species from 33 (C2) to 49 (C1). The diversity H' varied from 2,93 to 3,49. 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 0,59 to 0,66 which indicates a somewhat uneven distribution.

Table 5. Number of species and individuals pr. 0,2 m2. H´ = Shannon-Wieners 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 Kvigindisdalur, 2019.

St.	Numb. ind.	Numb. species	H´	ES_{100}	NQI1	ISI_{2012}	NSI	nEQR	AMBI	J
C1	1202	49	3,49	20,0	0,72	7,87	21,77	0,657	2,025	0,66
C2	630	33	3,10	17,3	0,72	7,29	22,12	0,631	1,805	0,61
C3	1215	36	3,29	18,0	0,70	7,66	22,25	0,645	1,933	0,66
C4	800	36	3,28	18,9	0,69	7,27	21,97	0,633	2,135	0,63
C5	1025	39	2,93	17,7	0,71	7,71	22,47	0,640	1,878	0,59

4.4.2 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 is 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 Kvigindisdalur site 2019.

Station	Site name	Num. species	Dominating taxa	Environmental condition-NS 9410
C1	Kvigindisdalur	49	Ennucula tenuis – 31 %	1 - Very good

4.4.3 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 3.

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.

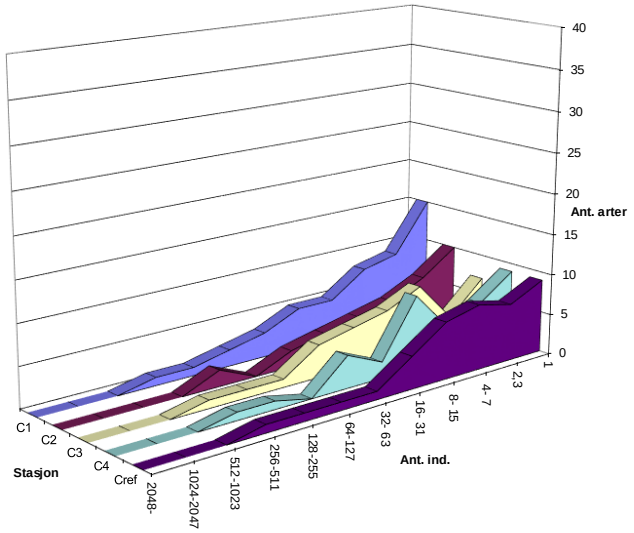

Figure 4. The soft bottom fauna shown as number of species against number of individuals pr. species in geometric classes. Kvigindisdalur, 2019.

4.4.4 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 75 % similar for all stations in the survey.

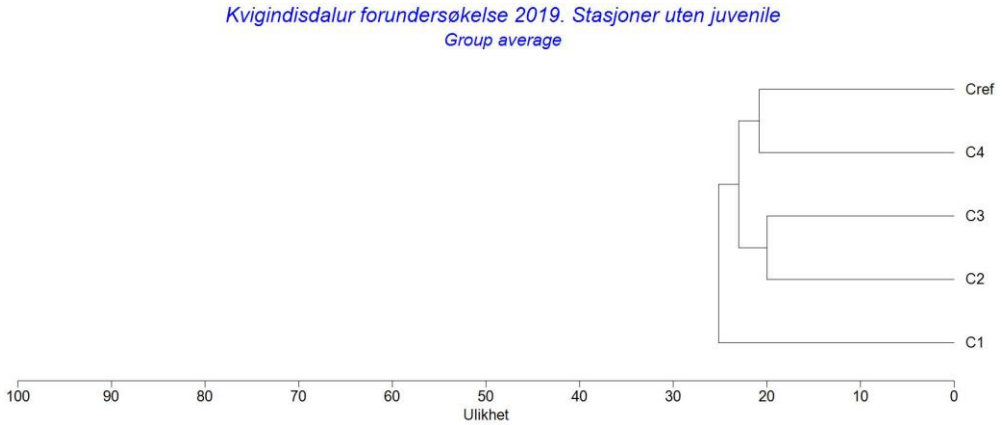

Figure 5. Cluster diagram for the soft bottom fauna at the C- sampling stations at Kvigindisdalur, 2019.

4.4.5 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).

All stations were dominated by the neutral bivalve *Ennucula tenuis* with between 31 and 48 % of the individuals. The other most dominant species at the stations were a mixture of neutral, tolerant and opportunistic species.

No pollution indicators were recorded among the top-10 at any of the stations.

Table 7. Number of individuals, cumulative percentage and ecological group for the ten most dominant species on the C stations. Kvigindisdalur, 2019.*

C1	Numb.	Cum.	EG	C2	Numb.	Cum.	EG
Ennucula tenuis	378	31 %	II	Ennucula tenuis	246	39 %	II
Galathowenia oculata	235	51 %	III	Galathowenia oculata	129	59 %	III
Nuculana pernula	112	60 %	II	Nuculana pernula	63	69 %	II
Prionospio steenstrupi	81	67 %	II	Owenia sp.	32	74 %	II
Thyasira sarsii	56	72 %	IV	Macoma calcarea	22	78 %	IV
Macoma calcarea	51	76 %	IV	Thyasira sarsii	22	81 %	IV
Yoldia hyperborea	36	79 %	ik	Prionospio steenstrupi	17	84 %	II
Owenia sp.	30	81 %	II	Maldane sarsi	15	87 %	IV
Nephtys ciliata	24	83 %	III	Sternaspis scutata	12	88 %	ik
Sternaspis scutata	24	85 %	ik	Myriochele malmgreni/olgae	10	90 %	ik
C3	**Numb.**	**Cum.**	**EG**	**C4**	**Numb.**	**Cum.**	**EG**
Ennucula tenuis	411	34 %	II	Ennucula tenuis	306	38 %	II
Galathowenia oculata	243	54 %	III	Galathowenia oculata	151	57 %	III
Owenia sp.	123	64 %	II	Nuculana pernula	50	63 %	II
Prionospio steenstrupi	63	69 %	II	Thyasira sarsii	46	69 %	IV
Nuculana pernula	57	74 %	II	Abra nitida	44	75 %	III
Sternaspis scutata	49	78 %	IV	Prionospio steenstrupi	39	80 %	II
Thyasira sarsii	49	82 %	IV	Sternaspis scutata	21	82 %	ik
Macoma calcarea	29	84 %	IV	Owenia sp.	16	84 %	II
Parougia eliasoni	23	86 %	ik	Euchone sp.	15	86 %	II
Yoldia hyperborea	22	88 %	ik	Axinopsida orbiculata	9	87 %	ik

C5ref	Numb.	Cum.	EG
Ennucula tenuis	495	48 %	II
Galathowenia oculata	154	63 %	III
Nuculana pernula	88	72 %	II
Prionospio steenstrupi	39	75 %	II
Thyasira sarsii	31	78 %	IV
Abra nitida	29	81 %	III
Sternaspis scutata	22	83 %	ik
Owenia sp.	19	85 %	II
Axinopsida orbiculata	14	87 %	ik
Euchone sp.	14	88 %	II

*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.

4.5 Summary and conclusions – C-survey

4.5.1 Summary

The results from the environmental monitoring (type C) at Kvigindisdalur, 2019, can be summarized as follows:

- The hydrography measurements showed good oxygen conditions throughout the water column with 90 % saturation in the bottom layer in May 2019.
- TOC was rather high at all stations and nTOC varied from 28,4 to 35,1 mg/g TS. TOM-levels varied from 10,1 to 12,5 %. TN-levels were low (2,6 – 3,7 mg/g) as was the C/N-ratio. The copper level in sediments were slightly elavated (26,9 to 33,7 mg/kg) according to Norwegian standards, but well within reported natural levels in Icelandic coastal areas (Egilsson *et al*. 1999). The sediment was moderately fine grained with a pelite share between 52 and 61 %. 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 630 to 1215 and number of species from 33 to 49. The diversity H' varied from 2,93 to 3,49. At all stations, the overall index of nEQR was higher than 0.6. The nEQR values indicates good conditions and no disturbance of the communities.

4.5.2 Conclusion

The results from the monitoring at the farming site Kvigindisdalur in May 2019 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 all stations (> 0.6). The diversity index H ' was just below 3 on C5ref and above 3 at the other stations and ranged from 2,93 (C5ref) to 3,49. NS 9410:2016-assessment of the community in the local impact zone (C1) showed environmental condition 1 (Very good). No pollution indicators were recorded among the top-10 species on any of the stations. The redox measurements (pH/Eh) gave point 0 acc. Appendix D in NS 9410:2016 for all the sampling stations. The oxygen saturation in May was good in the whole water column with 90 % in the bottom water.

5 References

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Appendix 1. Bunndyrstatistikk og artslister (in norwegian)

Diversitetsmål

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

Referanser:

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Antall arter og individer per stasjon

st.nr.	tot.	C1	C2	C3	C4	C5ref
no. ind.	4872	1202	630	1215	800	1025
no. spe.	66	49	33	36	36	39

Bunndyrindekser per replikat

st.nr.	tot.	C1_01	C1_02	C2_01	C3_01	C3_02	C4_01	C5ref_01	C5ref_02
no. ind.	4872	568	634	630	602	613	800	612	413
no. spe.	66	42	35	33	34	29	36	34	28
Shannon-Wiener:		3,6	3,4	3,1	3,6	3,0	3,3	2,9	3,0
Pielou		0,67	0,66	0,61	0,71	0,61	0,63	0,56	0,63
ES100		21	19	17	20	16	19	18	18
SN		2,02	1,91	1,88	1,90	1,81	1,89	1,90	1,86
ISI-2012		7,35	8,38	7,29	7,64	7,68	7,27	7,79	7,62
AMBI		2,051	1,998	1,805	1,926	1,94	2,135	1,884	1,871
NQI1		0,72	0,71	0,72	0,71	0,69	0,69	0,71	0,71
NSI		21,6	21,9	22,1	22,1	22,4	22,0	22,5	22,4
DI		0,704	0,752	0,749	0,730	0,737	0,853	0,737	0,566

Bunndyrindekser, gjennomsnitt per stasjon

st.nr.		C1	C2	C3	C4	C5ref
Shannon-Wiener:		3,49	3,10	3,29	3,28	2,93
Pielou		0,66	0,61	0,66	0,63	0,59
ES100		20,0	17,3	18,0	18,9	17,7
SN		1,97	1,88	1,86	1,89	1,88
ISI-2012		7,87	7,29	7,66	7,27	7,71
AMBI		2,025	1,805	1,933	2,135	1,878
NQI1		0,72	0,72	0,70	0,69	0,71
NSI		21,77	22,12	22,25	21,97	22,47
Normalisert EQR:						
Shannon-Wiener:		0,655	0,611	0,632	0,631	0,588
ES100		0,635	0,603	0,611	0,622	0,608
ISI-2012		0,635	0,567	0,615	0,565	0,620
NQI1		0,691	0,690	0,677	0,668	0,684
NSI		0,671	0,685	0,690	0,679	0,699
Tilstandsklasse nEQR *)		0,657	0,631	0,645	0,633	0,640

Geometriske klasser

int.	C1	C2	C3	C4	C5ref
1	15	10	7	9	9
2,3	9	7	3	6	7
4- 7	8	5	8	4	8
8- 15	5	4	6	9	7
16- 31	5	3	5	2	4
32- 63	3	2	4	4	1
64-127	2	0	1	0	1
128-255	1	2	1	1	1
256-511	1	0	1	1	1
512-1023	0	0	0	0	0

Artsliste

Kvigindisdalur forundersøkelse

Rekke	Klasse	Orden	Art/Taxa	01	02	Sum
Stasjonsnr.: C1						
NEMERTINI						
			Nemertea indet.	1	2	3
ANNELIDA						
	Polychaeta					
		Orbiniida				
			Scoloplos armiger	4	1	5
			Aricidea sp.	2	4	6
		Cossurida				
			Cossura longocirrata	11		11
		Spionida				
			Prionospio steenstrupi	40	41	81
			Spio limicola	3	2	5
			Chaetozone setosa		3	3
			Chaetozone sp.	3		3
		Capitellida				
			Capitella capitata	2		2
			Mediomastus fragilis	1	2	3
			Maldane sarsi	3	16	19
			Praxillella gracilis	1	2	3
			Praxillella praetermissa	7	5	12
		Phyllodocida				
			Eteone flava/longa	10	7	17
			Phyllodoce groenlandica	1		1
			Gattyana amondseni	1		1
			Pholoe assimilis		1	1
			Nereimyra punctata	1		1
			Syllis sp.	1	1	2
			Nephtys ciliata	14	10	24
		Amphinomida				
			Paramphinome jeffreysii	1		1
		Eunicida				
			Parougia eliasoni	2	11	13
		Sternaspida				
			Sternaspis scutata	9	15	24
		Oweniida				
			Galathowenia oculata	83	152	235
			Myriochele malmgreni/olgae	4		4
			Owenia sp.	11	19	30
		Terebellida				
			Lagis koreni	2	2	4
			Ampharete borealis	1	1	2
			Ampharete baltica	1		1
			Melinna cristata		1	1
		Sabellida				
			Euchone papillosa	11	4	15
			Euchone sp.	2		2
CRUSTACEA						
	Malacostraca					
		Cumacea				
			Leucon sp.	5	4	9
		Amphipoda				
			Oedicerotidae indet.		1	1
MOLLUSCA						
	Caudofoveata					

Rekke	Klasse	Orden	Art/Taxa	01	02	Sum
			Caudofoveata indet.		1	1
	Prosobranchia					
		Mesogastropoda				
			Euspira montagui		1	1
	Bivalvia					
		Nuculoida				
			Ennucula tenuis	190	188	378
			Nuculana pernula	49	63	112
			Yoldia hyperborea	17	19	36
		Mytiloida				
			Crenella decussata		1	1
		Veneroida				
			Axinopsida orbiculata	3	3	6
			Thyasira sarsii	36	20	56
			Kurtiella bidentata	1		1
			Ciliatocardium ciliatum	1		1
			Serripes groenlandicus	1		1
			Macoma calcarea	25	26	51
			Abra nitida	3	4	7
			Arctica islandica	1		1
ECHINODERMATA						
	Ophiuroidea					
		Ophiurida				
			Ophiocten affinis	3	1	4
			Ophiuroidea indet. juv.	3		3
			Maks:	190	188	378
			Antall:	43	35	50
			Sum:			1205

Stasjonsnr.: C2

NEMERTINI						
			Nemertea indet.	3		3
ANNELIDA						
	Polychaeta					
		Orbiniida				
			Scoloplos armiger	1		1
			Aricidea sp.	4		4
		Cossurida				
			Cossura longocirrata	1		1
		Spionida				
			Prionospio steenstrupi	17		17
			Spio limicola	6		6
			Chaetozone setosa	3		3
			Chaetozone sp.	1		1
		Capitellida				
			Maldane sarsi	15		15
			Praxillella praetermissa	1		1
		Phyllodocida				
			Eteone flava/longa	1		1
			Nephtys ciliata	3		3
		Eunicida				
			Paarougia eliasoni	2		2
		Sternaspida				
			Sternaspis scutata	12		12
		Oweniida				
			Galathowenia oculata	129		129
			Myriochele malmgreni/olgae	10		10

Rekke	Klasse	Orden	Art/Taxa	01	02	Sum
			Owenia sp.	32		32
		Terebellida				
			Lagis koreni	1		1
			Melinna cristata	2		2
		Sabellida				
			Euchone papillosa	5		5
			Euchone sp.	2		2
CRUSTACEA						
	Malacostraca					
		Cumacea				
			Leucon sp.	8		8
		Amphipoda				
			Gammaridea indet.	1		1
		Decapoda				
			Hyas coarctatus	1		1
MOLLUSCA						
	Opistobranchia					
		Cephalaspidea				
			Retusa obtusa	1		1
	Bivalvia					
		Nuculoida				
			Ennucula tenuis	246		246
			Nuculana pernula	63		63
			Yoldia hyperborea	6		6
		Veneroida				
			Axinopsida orbiculata	6		6
			Thyasira sarsii	22		22
			Macoma calcarea	22		22
			Arctica islandica	1		1
ECHINODERMATA						
	Ophiuroidea					
		Ophiurida				
			Ophiocten affinis	2		2
			Ophiuroidea indet. juv.	1		1
			Maks:	246		246
			Antall:	34	0	34
			Sum:			631

Stasjonsnr.: C3

NEMERTINI						
			Nemertea indet.		1	1
ANNELIDA						
	Polychaeta					
		Orbiniida				
			Scoloplos armiger	3	2	5
			Aricidea sp.	2	2	4
		Cossurida				
			Cossura longocirrata	4		4
		Spionida				
			Prionospio steenstrupi	34	29	63
			Spio limicola	4	4	8
			Chaetozone setosa	2	1	3
		Capitellida				
			Maldane sarsi	5	3	8
			Praxillella gracilis	4	1	5
			Praxillella praetermissa	16	2	18
		Phyllodocida				
			Eteone flava/longa	2	4	6
			Pholoe assimilis	1		1

Rekke	Klasse	Orden	Art/Taxa	01	02	Sum
			Syllis sp.	1		1
			Nephtys ciliata	3	3	6
		Eunicida				
			Parougia eliasoni	18	5	23
		Sternaspida				
			Sternaspis scutata	21	28	49
		Oweniida				
			Galathowenia oculata	88	155	243
			Myriochele malmgreni/olgae	13	4	17
			Owenia sp.	53	70	123
		Terebellida				
			Lagis koreni	2	3	5
			Melinna cristata	1	1	2
		Sabellida				
			Euchone papillosa	4	4	8
			Euchone sp.	8		8
	Oligochaeta					
			Oligochaeta indet.	1		1
CRUSTACEA						
	Malacostraca					
		Cumacea				
			Leucon sp.	6	8	14
		Amphipoda				
			Lysianassidae indet.	1	2	3
			Oedicerotidae indet.	1	3	4
			Gammaridea indet.	1		1
MOLLUSCA						
	Bivalvia					
		Nuculoida				
			Ennucula tenuis	191	220	411
			Nuculana pernula	35	22	57
			Yoldia hyperborea	13	9	22
		Veneroida				
			Axinopsida orbiculata	8	3	11
			Thyasira sarsii	36	13	49
			Macoma calcarea	19	10	29
ECHINODERMATA						
	Asteroidea					
		Paxillosida				
			Ctenodiscus crispatus	1		1
	Ophiuroidea					
		Ophiurida				
			Ophiocten affinis		1	1
			Ophiuroidea indet. juv.	1		1
			Maks:	191	220	411
			Antall:	35	29	37
			Sum:			1216

Stasjonsnr.: C4

Rekke	Klasse	Orden	Art/Taxa	01	02	Sum
ANNELIDA						
	Polychaeta					
		Orbiniida				
			Scoloplos armiger	3		3
			Aricidea sp.	2		2
		Cossurida				
			Cossura longocirrata	5		5
		Spionida				
			Prionospio steenstrupi	39		39
			Spio limicola	8		8

Rekke	Klasse	Orden	Art/Taxa	01	02	Sum
			Chaetozone setosa	5		5
		Capitellida				
			Mediomastus fragilis	1		1
			Maldane sarsi	8		8
			Praxillella gracilis	3		3
			Praxillella praetermissa	9		9
		Phyllodocida				
			Eteone flava/longa	8		8
			Pholoe baltica	2		2
			Microphthalmus sczelkowii	1		1
			Syllis cornuta	1		1
			Syllidae indet.	1		1
			Nephtys ciliata	9		9
		Sternaspida				
			Sternaspis scutata	21		21
		Oweniida				
			Galathowenia oculata	151		151
			Owenia sp.	16		16
		Terebellida				
			Lagis koreni	7		7
			Melinna cristata	1		1
			Pista maculata	1		1
		Sabellida				
			Euchone papillosa	4		4
			Euchone sp.	15		15
CRUSTACEA						
	Malacostraca					
		Cumacea				
			Leucon sp.	8		8
		Amphipoda				
			Oedicerotidae indet.	1		1
			Gammaridea indet.	1		1
MOLLUSCA						
	Bivalvia					
		Nuculoida				
			Ennucula tenuis	306		306
			Nuculana pernula	50		50
			Yoldia hyperborea	8		8
		Veneroida				
			Axinopsida orbiculata	9		9
			Thyasira sarsii	46		46
			Ciliatocardium ciliatum	1		1
			Macoma calcarea	2		2
			Abra nitida	44		44
ECHINODERMATA						
	Ophiuroidea					
		Ophiurida				
			Ophiocten affinis	3		3
			Maks:	306		306
			Antall:	36	0	36
			Sum:			800

Stasjonsnr.: Cref

NEMERTINI						
			Nemertea indet.	2		2
ANNELIDA						
	Polychaeta					
		Orbiniida				

Rekke	Klasse	Orden	Art/Taxa	01	02	Sum
			Scoloplos armiger	3	3	6
			Levinsenia gracilis		1	1
			Aricidea sp.	3	1	4
		Cossurida				
			Cossura longocirrata	5		5
		Spionida				
			Dipolydora sp.		1	1
			Laonice cirrata	1		1
			Prionospio steenstrupi	23	16	39
			Spio limicola	1	3	4
			Chaetozone setosa	2	2	4
		Capitellida				
			Mediomastus fragilis	1		1
			Maldane sarsi	5	5	10
			Praxillella gracilis	1	1	2
			Praxillella praetermissa	4		4
		Phyllodocida				
			Eteone flava/longa	2	1	3
			Nephtys ciliata	3	4	7
		Eunicida				
			Parougia eliasoni	1		1
		Sternaspida				
			Sternaspis scutata	8	14	22
		Oweniida				
			Galathowenia oculata	96	58	154
			Myriochele malmgreni/olgae	9	2	11
			Owenia sp.	10	9	19
		Terebellida				
			Lagis koreni		1	1
			Laphania boecki	1		1
		Sabellida				
			Euchone papillosa	1	7	8
			Euchone sp.	14		14
	Oligochaeta					
			Oligochaeta indet.	1		1
CRUSTACEA						
	Malacostraca					
		Cumacea				
			Leucon sp.	7	6	13
		Amphipoda				
			Oedicerotidae indet.	2		2
			Dulichiidae indet.		2	2
			Crustacea indet. juv.	1	1	2
MOLLUSCA						
	Caudofoveata					
			Caudofoveata indet.		2	2
	Prosobranchia					
		Mesogastropoda				
			Euspira pallida	1		1
	Bivalvia					
		Nuculoida				
			Ennucula tenuis	306	189	495
			Nuculana pernula	48	40	88
			Yoldia hyperborea	7	6	13
		Veneroida				
			Axinopsida orbiculata	7	7	14
			Thyasira sarsii	17	14	31
			Astarte sp. juv.	1		1
			Macoma calcarea	3	3	6
			Abra nitida	15	14	29
ECHINODERMATA						
	Ophiuroidea					
		Ophiurida				
			Ophiocten affinis	2	1	3
			Ophiuroidea indet. juv.		1	1
			Maks:	306	189	495
			Antall:	36	30	42
			Sum:			1029
					TOTAL:	***Maks:*** 495
						Sum: 4881

Appendix 2. Analyserapport – Geokjemiske analyser (in norwegian)

Framsenteret
Postboks 6606 Langnes, 9296 Tromsø
Foretaksnr.: NO 937 375 158 MVA
Tel: 77 75 03 00
E-post: kjemi@akvaplan.niva.no

ANALYSERAPPORT
Sedimentprøver

Kunde:	**Arctic Sea Farm**
Kunde referanse:	**Kvígindisdalur forundersøkelse v 2019**
Kontaktperson kunde:	
e-post:	
Kontaktperson Akvaplan-niva:	Snorri Gunnarsson
Dato:	18.06.2019
Rapport nr.:	**61207**
Analyseparameter(e):	Korn, TOM, TOC, TN, Cu
Kontaktperson:	Ida Giæver Tveter
Analyseansvarlig:	Ida Giæver Tveter (sign.)
Underskriftsberettiget:	Anja Sjøvoll (sign.)

Prøvene ble sendt/levert til Akvaplan-Niva AS av oppdragsgiver, og merket som angitt i tabellen på side 2.
Resultater av analysene er gitt fra side 3.

MERKNADER:

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

Lab-id.	Kundens id.	Materiale	Mottatt lab	Parametere	Analyse-periode
61207/C1	61207/C1	Sediment	20.05.2019	Korn, TOM, TOC/TN, 2xCu	21.05.19-29.05.19
61207/C2	61207/C2	Sediment	20.05.2019	Korn, TOM, TOC/TN**, 2xCu	21.05.19-29.05.19
61207/C3	61207/C3	Sediment	20.05.2019	Korn, TOM, TOC/TN, 2xCu	21.05.19-29.05.19
61207/C4	61207/C4	Sediment	20.05.2019	Korn, TOM, TOC/TN**, 2xCu	21.05.19-29.05.19
61297/Cref	61297/Cref	Sediment	20.05.2019	Korn, TOM, TOC/TN, 2xCu	21.05.19-29.05.19
61207/Cu-ref2	61207/Cu-ref2	Sediment	20.05.2019	2xCu	24.05.19-03-06.19

** Analysen er uakkreditert

Følgende analysemetoder er benyttet

Parameter	Metoderereferanse
Kornfordeling (splitt i to)	Sikting, basert på Bale, A.J. & Kenny, A.J. 2005. Sediment analysis and seabed characterisation . In: Eleftheriou,A; McIntyre, A.D. "Methods for the study of marine benthos", 3rd ed. Blackwell Science, Oxford, UK. ISBN 0-632-05488-3, pp. 43-86
Totalt organisk materiale-TOM	Intern metode basert på NS 4764:1980
Totalt organisk karbon-TOC	NDIR-deteksjon. Intern metode basert på DIN 19539:2016
Totalt bundet nitrogen - Total-N	Elektrokjemisk deteksjon. Intern metode basert på NS-EN 12260:2003. MERK: ved TOC-verdier større enn ca 60 mg/g TS kan TN-resultater bli underestimert
Kobber-Cu / Kadmium-Cd (utført av underlev.)	EPA 200.7, ISO 11885, EPA 6010 og SM 3120

Resultater

	TOC	TN	TOM	Pelitt	> 0,063 mm	Cu*	Cu*	N TOC	C/N #
Kundens id.:	mg/g TS	mg/g TS	% TS	vekt%	vekt%	mg/kg TS	mg/kg TS	mg/g TS	
61207/C1	24.0	2.6	10.1	55.0	45.0	29.6	32.6	32.1	9.3
61207/C2	26.8	3.0	10.9	60.8	39.2	28.3	28.3	33.9	8.9
61207/C3	27.4	3.7	12.5	57.1	42.9	30.9	33.7	35.1	7.4
61207/C4	25.7	3.7	11.4	51.9	48.1	29.5	30.6	34.4	7.0
61297/Cref	21.2	3.0	10.1	59.8	40.2	28.6	31.1	28.4	7.0
61207/Cu-ref2	ia	ia	ia	ia	ia	33.2	31.2	ia	ia

* Analysen er utført av ALS Laboratory Group, ALS Czech Republic s.r.o, Na Harfě 9/336, Praha, Tsjekkia

Akkreditering: Czech Accreditation Institute, labnr. 1163

N TOC (Normalisert TOC) = målt TOC mg/g + 18*(1-F), der F=andel finstoff (pellitt) gitt ved %pellitt/100.

ia = ikke analysert

#) TOC-resultat større enn ca 60 mg/g TS kan gi underestimert TN-resultat og derved gi forhøyet C/N-verdi

Tilstandsklassifisering for organisk innhold i marine sedimenter ihht. Veileder 02:2018:

Normalisert TOC, mg/g TS	< 20 I Svært god	20-27 II God	27-34 III Moderat	34-41 IV Dårlig	> 41 V Svært dårlig	

Tilstandsklassifisering for kobber (Cu) i marine sedimenter (grenseverdier fra M-608/2016):

Cu, mg/kg TS	< 20 Klasse I	20-84 Klasse II/III	84 - 147 Klasse IV	> 147 Klasse V

Tilstandsklassifisering for kadmium (Cd) i marine sedimenter (grenseverdier fra M-608/2016):

Cd, mg/kg TS	< 0,2 Klasse I	0,2 - 2,5 Klasse II	2,5 - 16 Klasse III	16 - 157 Klasse IV	> 157 Klasse V	