ENVIRONMENTAL MONITORING AT THE SEQI OLIVINE MINE 2008-2009

NERI Technical Report no. 753 2009

NATIONAL ENVIRONMENTAL RESEARCH INSTITUTE
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Abstract: The olivine mine at Seqi in West Greenland has been operating since 2005. Every year since opening, environmental monitoring studies have been conducted to assess the impact from mining. This report contains the results from monitoring studies in 2008 and 2009. The results show that dust from the operation has caused levels of some elements, particularly chromium and nickel, to increase in lichens, blue mussels, and seaweed. The spreading of dust increased from 2007 to 2008, but decreased again in 2009, and can now be measured in lichens at a distance of up to 8 km from the mine. In seaweed and blue mussels, however, elevated concentrations of Cr and Ni could only be measured at a few stations near the mine site. No contamination could be measured in fish (Arctic char and shorthorn sculpin). Thus, the impact of the mine is still considered insignificant for the Niaquungunaq fjord system.

Keywords: Olivine, mining, Greenland, nickel, chromium.

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Front cover photo: The olivine piles ready for shipping and the surrounding area at Seqi. Photo: Sigga Joensen.

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Contents

Summary

Since 2005, the mineral olivine has been mined at Seqi in Niaquungunaq (Fiskefjord) in West Greenland. Prior to mining, baseline studies were performed in 2004 and 2005 to characterize the natural state and variability of the environment. These studies included measurements of element concentrations in biota such as lichens, seaweed, blue mussels or fish and in the water of the fjord. No measureable natural elevation of elements was found in biota or in water near the mining area.

After the mining activity started, environmental studies have been conducted at Seqi every year to monitor the impact from mining. In this report, the results from sampling in 2008 and 2009, which includes lichens (*Cetraria nivalis*), brown seaweed (*Fucus vesiculosus*), blue mussels (*Mytilus edulis*), shorthorn sculpins (*Myoxocephalus scorpius*), and Arctic char (*Salvelinus alpinus)* are presented and discussed.

Elevated concentrations of some elements, particularly chromium (Cr) and nickel (Ni), were measured in lichens at a distance of up to 8 km from the mine, indicating a significant spreading of dust related to the mining activity. Close to the mine site, concentrations of up to 45µg/g dry wt Cr and 96µg/g dry wt Ni were measured, corresponding to 100-200 times higher levels than those measured at the reference sites (0.2 – 0.5µg/g dry wt for both elements). The spreading of dust varied between years with higher levels in 2008 than in 2009, probably due to a decrease in mining activities in late 2008 and 2009. Elevated concentrations of Cr and Ni were also observed in blue mussels [Ni 5.98 µg/g dry wt (2008); Cr: 4.24µg/g dry wt (2008)] and brown seaweeds [Ni 3.43 µg/g dry wt (2009) and Cr 0.54 µg/g dry wt (2009] but only at a few stations in close vicinity to the mine site. When classifying the environmental impact, these stations may be considered as insignificantly to moderately polluted. In fish caught in the fjord around Seqi (shorthorn sculpin) or in Long Lake near Seqi (Arctic char), no elevated element concentrations were found.

Based on these results, it is concluded that spreading of dust near the mine increased from 2007 to 2008 but decreased again in 2009. The impact of the mine on the marine environment, however, is still very local and regarded as insignificant for the Niaquungunaq fjord system.

Eqikkaaneq

Olivenisiorfik Kitaani Niaqunngunami Seqinnersuusamiittoq 2005-imili ingerlasimavoq. Aatsitassarsiorfiup ammarnissaa sioqqullugu 2004-imi aamma 2005-imi pinngortitap allanngortinneqanngikkallarnermini pissusia sanilliussivissamik misissuiffigineqarpoq ilaatigut qillinerni (ujaqqat naanerini), qeqqussani, uilluni aalisakkanilu sananeqaatit misissorneqarnerat aqqutigalugu. Misissuinerni taakkunani uumassusilinni aatsitassarsiorfiup eqqaaniittuni sananeqaatinik immikkut annertussusilinnik nassaartoqanngilaq.

Aatsitassarsiorfik 2005-imi ammarmalli ukiut tamaasa avatangiisit misissuiffigineqartarput aatsitassarsiorfiup sunniutai malinnaaffiginiarlugit. Imaqarniliaq taanna 2008 aamma 2009-imi misiligutit misissorneqarnerinik imaqarpoq, misissuiffigineqartullu tassaapput qillinerit, qeqqussat, uillut, kanassut aammalu eqaluit.

Sananeqaatit ilaat pingaartumik krom (Cr) aammalu nikkel (Ni) Seqinnersuusap eqqaani qillinerni naammatoorneqarput, taamaalillunilu aatsitassarsiorfimmiit pujoralannik malunnartumik siammarterisoqarsimanera takuneqarsinnaavoq. Aatsitassarsiorfimmut qanittumi 45µg/g Cr aamma 96µg/g Ni tikillugit annertutigisut naammattoorneqarput, taakkulu sanilliussivinniit 100-200-eriaammik annerupput (sananeqaatini taakkunani marlunni 0,2 – 0,5µg/g). Pujoralaat siammarnerat tamanna 2007-imiit 2008-imut qaffariarpoq taavalu 2008-imiit 2009-mut appariarluni. Cr-p kiisalu Ni-p uilluni [Ni 5.98 µg/g (2008); Cr: 4.24µg/g (2008)] kiisalu qeqqussani [Ni 3.43 µg/g (2009) aammalu Cr 0.54 µg/g (2009] qaffariarsimanerat takuneqarpoq, taamaallaalli aallarussuiffiup eqqaani misissuivinni ikittuinnarni. Kanassuni uillunilu tamaaniittuni, tassa Seqinnersuusap eqqaani kangerlummi Long Lakellu aatsitassarsiorfiup eqqaaniittuni sananeqaatinik qaffariartoqarsimanngilaq.

Paasisat taakku tunngavigalugit oqaatigineqarsinnaavoq aatsitassarsiorfimmiit pujoralatserineq 2007-08-mut qaffariartorsimammat kisiannili 2009-imi appariaqqissimalluni, aamma immami avatangiisit sunnigaanerat tamaaniinaq pisuuvoq taamaammallu Niaqunngunap eqqaani kangerlunnut sunniuteqangaanngittutut nalilerneqarluni.

Resume

Olivin minen ved Seqi, der er beliggende i Niaquungunaq (Fiskefjord) i Vestgrønland, har været i drift siden 2005. Inden minen åbnede, blev der i 2004 og 2005 udført baggrundsundersøgelser med det formål at bestemme den upåvirkede naturs tilstand, bl.a. ved at undersøge grundstofsammensætningen i lav, tang, blåmusling og fisk. Ved disse undersøgelser blev der ikke påvist nogen naturligt forhøjede grundstofkoncentrationer i organismer nær minen.

Siden minen åbnede i 2005, har der hvert år været gennemført studier af miljøet i området for at følge påvirkningen fra minen. Denne rapport indeholder resultater af prøver indsamlet i 2008 og 2009 og omfatter prøver af lav, tang, blåmuslinger, ulke og fjeldørreder.

Forhøjede koncentrationer af nogle grundstoffer, især krom (Cr) og nikkel (Ni), blev observeret i lavprøver indsamlet nær Seqi, hvilket peger på en tydelig støvspredning, der kan relateres til minen. Tæt på minen blev der fundet op til 45µg/g Cr og 96µg/g Ni, hvilket er 100-200 gange højere end i referenceområder (0,2 – 0,5µg/g for begge grundstoffer). Denne støvspredning viste en stigning fra 2007 til 2008 og et fald fra 2008 til 2009, sandsynligvis på grund af en faldende produktion af olivin i den sidste del af 2008 og i 2009. Forhøjede koncentrationer af Cr og Ni blev også målt i musling [Ni 5.98 µg/g (2008); Cr: 4.24µg/g (2008)] og tangprøver [Ni 3.43 µg/g (2009) and Cr 0.54 µg/g (2009)], men kun ved nogle få stationer nær udskibningskajen. Der blev ikke fundet nogen forhøjede koncentrationer af nogen grundstoffer i ulke og ørreder i området, henholdsvis i fjordområdet ved Seqi og i Long Lake nær minen.

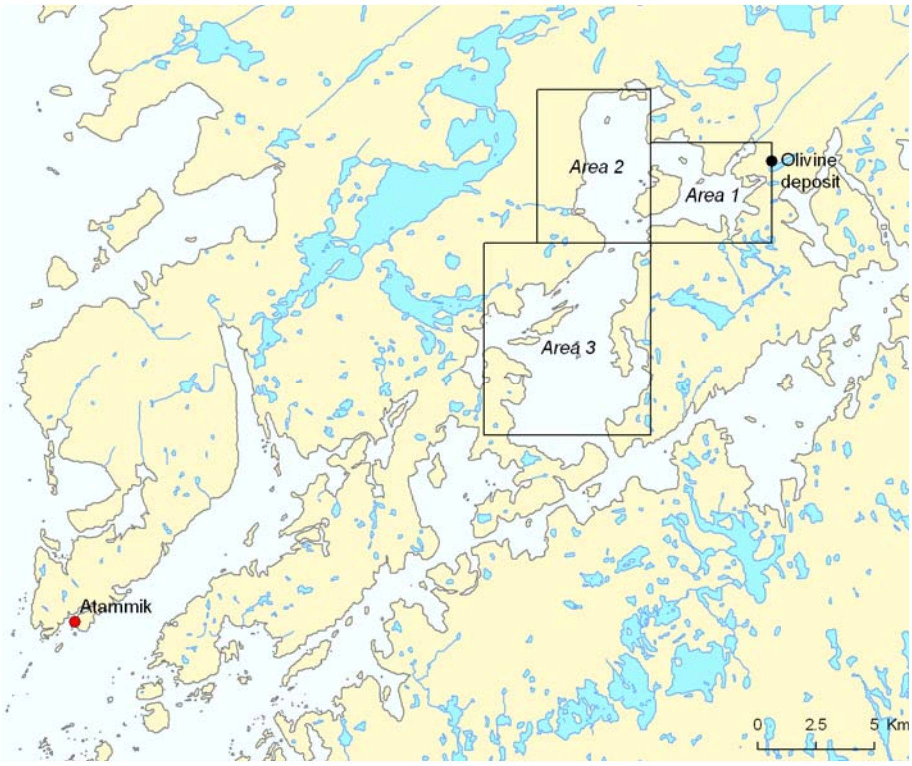
Baseret på disse resultater kan det konkluderes, at støvspredningen fra minen steg fra 2007 til 2008, men faldt igen i 2009, og at påvirkningen af det marine miljø stadig er meget lokal og vurderes som ubetydelig for miljøet i Niaquungunaq fjordsystemet.

1 About the Seqi olivine mine

The Seqi olivine mine is located in West Greenland at a long and narrow fjord called Niaquungunaq (in Danish Fiskefjord) (Fig. 1 and 2). The mine is accessible for ships most of the year due to limited sea ice cover. The fjord is characterised by strong tidal currents caused by its shape and topography and is only navigable for larger ships during a short period of time around high tide. The nearest settlement is Atammik at the inlet of the fjord.

Figure 1. Map of Greenland with the location of Seqi and Nuuk.

Figure 2. Map of Fiskefjord and the olivine deposit at Seqi. Area 1-3 refers to sampling locations for shorthorn sculpin.



Olivine is a common mineral on earth and is mined in several countries today, among others Norway. It is an industrial mineral with the composition $(Fe,Mg)_2SiO_4$ and is mainly used in the steel industry. Olivine is used for sand blasting, as foundry sand as well as a slag conditioner.

The olivine deposit at Seqi has been known for a long time and has previously been described in detail geologically (Nielsen, 1976). The deposit was expected to contain at least 100 million tons of first grade olivine. In 2005, the company Seqi Olivine A/S was granted concession for mining at Seqi. In 2006, the company conducted a drilling campaign to estimate the size of the deposit. The results indicate that the deposit may be larger than the previously estimated 100 million tons (Råstofdirektoratet, 2008). In 2007, construction of mining facilities and associated infrastructure was finished and the production began. In 2007, the mine produced approx. 620.000 tons and in 2008 approx. 450.000 tons of olivine (Råstofdirektoratet, 2008).

The deposit is mined in an open pit and the ore is crushed and stored at the coast before being shipped out in bulk carriers (Photo 1 and 2). These bulk carriers have capacity of up to 50.000 tons. Approximately 30 persons are employed at the mine (Råstofdirektoratet, 2008). An overview of the mining area with roads, buildings, and quay areas is shown in Fig. 3.

In 2007, the mining company changed its name from Seqi Olivine A/S to Minelco A/S. Minelco A/S is a daughter company of Swedish LKAB, which is owned by the Swedish state.

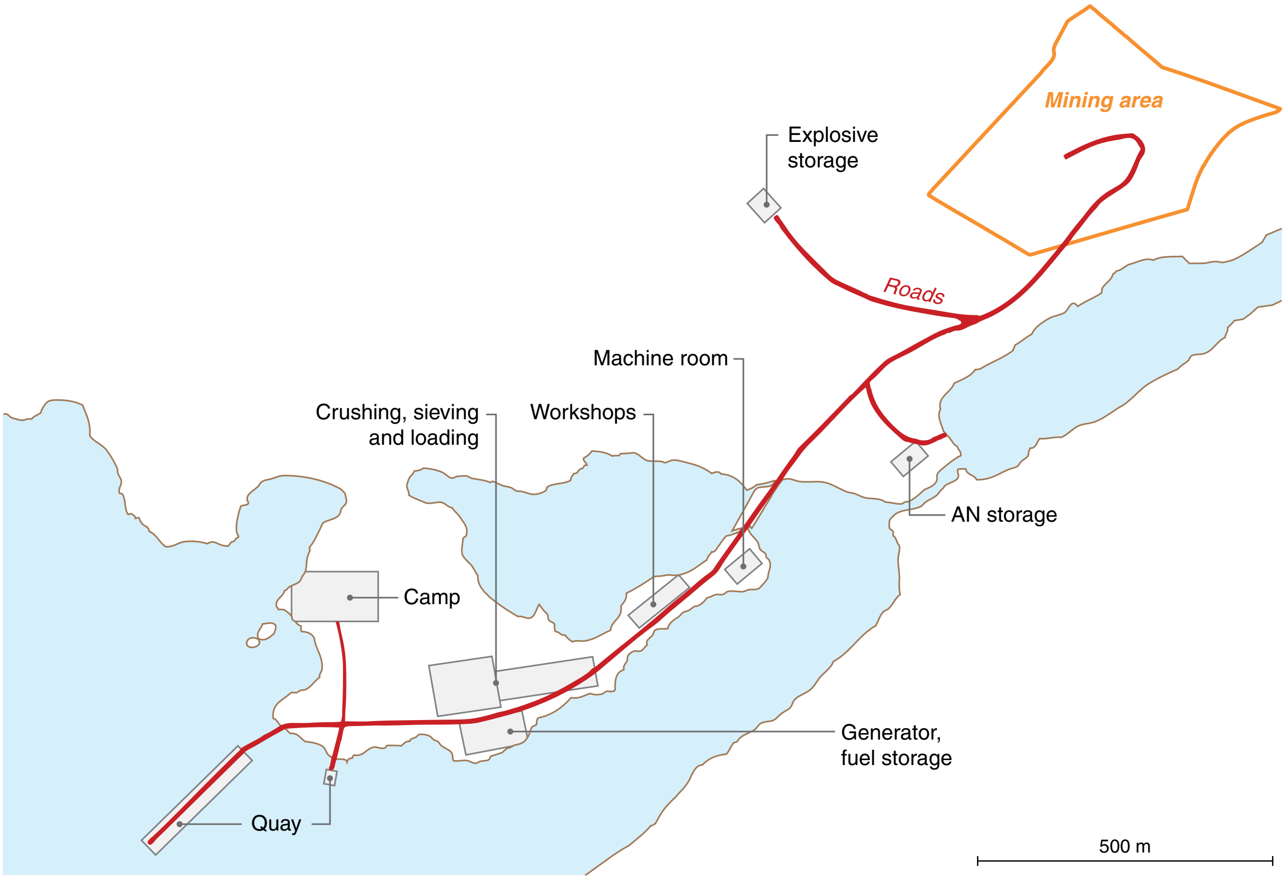


Figure 3. Roads, buildings, quays, and mining area at Seqi.

Photo 1. Mining of olivine at Seqi. Photo: Doris Schiedek.

Photo 2. The ore treatment and storage at Seqi. Photo: Sigga Joensen.

2 Environmental studies

In 2004 and 2005, prior to mining, baseline studies were conducted in the Seqi area by NERI. The first background studies were carried out in May 2004 with the research vessel Adolf Jensen. Thereafter, studies were performed with assistance from people from the mining company, using a smaller boat.

The baseline studies in 2004 and 2005 included sampling of blue mussels, seaweed, snow crabs, Greenland cod, shorthorn sculpin, lichens, sediments as well as water from the river running out of Long Lake near Seqi. In addition, in 2004, a general survey of fish and shellfish in the inlet of Tasiussarsuaq was conducted and bird observations were made.

In 2006 and 2007, similar samples of biota and water were collected and the environmental effects of the mining activity during these first two years were evaluated. This was done by comparing the pre-mining concentrations of certain elements in the sampled biota and water to concentrations in samples from 2006 and 2007. The spatial extent of environmental effects was evaluated by analyzing samples collected within the entire Fiskefjord area. A full description of the sampling performed between 2005 and 2007 and the results obtained are given in Asmund et al. (2009).

In 2008 and 2009, samples of blue mussels, seaweed, shorthorn sculpins, and lichens as well as Arctic char from Long Lake near Seqi were collected as described in the following. All samples were frozen at the mining company's camp and then sent to NERI. This work was done by Lene Bruun, Sigga Joensen and Doris Schiedek (only in 2009), all from NERI, with assistance of local people working for Minelco A/S at the mine site.

In the monitoring programme, focus is on four species: blue mussel (*Mytilus edulis*), brown seaweed (*Fucus vesiculosus*), a lichen (*Cetraria nivalis*), and shorthorn sculpin (*Myoxocephalus scorpius*). These species have been selected, because they will be well suited as indicators of spatial and time trends of metal pollution. They are widely used in other monitoring programs in Greenland (e.g. Riget et al. 1997a, Riget et al. 1997b, Riget et al. 2000a, Riget et al. 2000b, Johansen et al. 2008, Glahder et al. 2008, Schiedek et al. 2009).

Lichens are known as bioaccumulators of atmospheric contaminants and are abundant in the Arctic environment. The lack of roots, a large surface area, and a long life span enable them to effectively bioaccumulate air contaminants. In many studies, it has been shown that lichens are good indicators for various kinds of air contaminants including those caused by mining activities (e.g. Naeth and Wilkinson, 2008).

Blue mussels are well-suited since they are widely distributed and sessile and thus able to concentrate metals. In this respect they reflect contamination in the marine environment. i. e. metals bound to particles, as well as those dissolved in the seawater (Rainbow, 1995).

Brown seaweed (*Fucus vesiculosus*) is also a well suited indicator, but in contrast to blue mussels the metals accumulated in seaweed are reported to reflect only dissolved metals in seawater and not metals bound to particles (Rainbow, 1995). Since only the growing tips were analyzed each year, the accumulated metals in seaweed are expected to reflect the year to year variations in dissolved metals at each station.

Shorthorn sculpin is known to be a sensitive indicator species for marine pollution in fish, as they live near the bottom and are very stationary (Riget et al., 2000b).

2.1 Sampling 2008-2009

In the area around Seqi, a total of 26 tidal stations (St. 1-26, Fig. 4) have been established in the past years with highest density closest to the mine site. The stations furthest away from the mine, St. 22 and St. 23 situated outside the inlet of the inner fjord Tasiussarsuaq, are regarded as reference stations not impacted by mining activities.

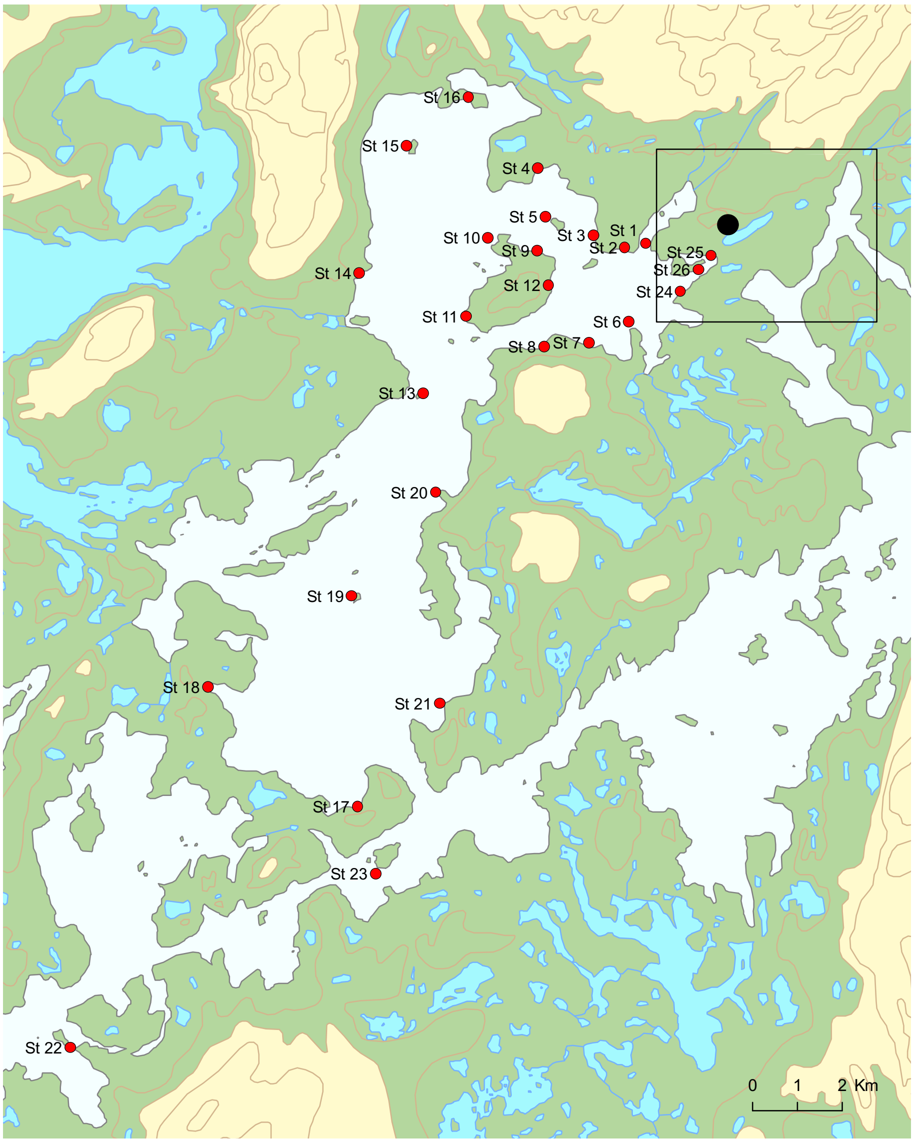


Figure 4. Map showing the area around the mine site (black dot) and the tidal stations (St. 1-26) where blue mussels, seaweed, and lichens are sampled. The box indicates the area where additional lichens stations have been established (see also Fig. 5).

In 2008 and 2009, at most of the 26 stations, blue mussels (*Mytilus edulis*), seaweed (*Fucus vesiculosus*), and lichens (*Cetraria nivalis*) were sampled (see Appendix 1-6 for a detailed description). In addition, blue mussels from St. 23 were transplanted to St. 1, St. 25, and St. 26 to monitor the uptake of metals during the next year. Moreover, salinity was measured with a refractometer at selected tidal stations during low tide (Table 1).

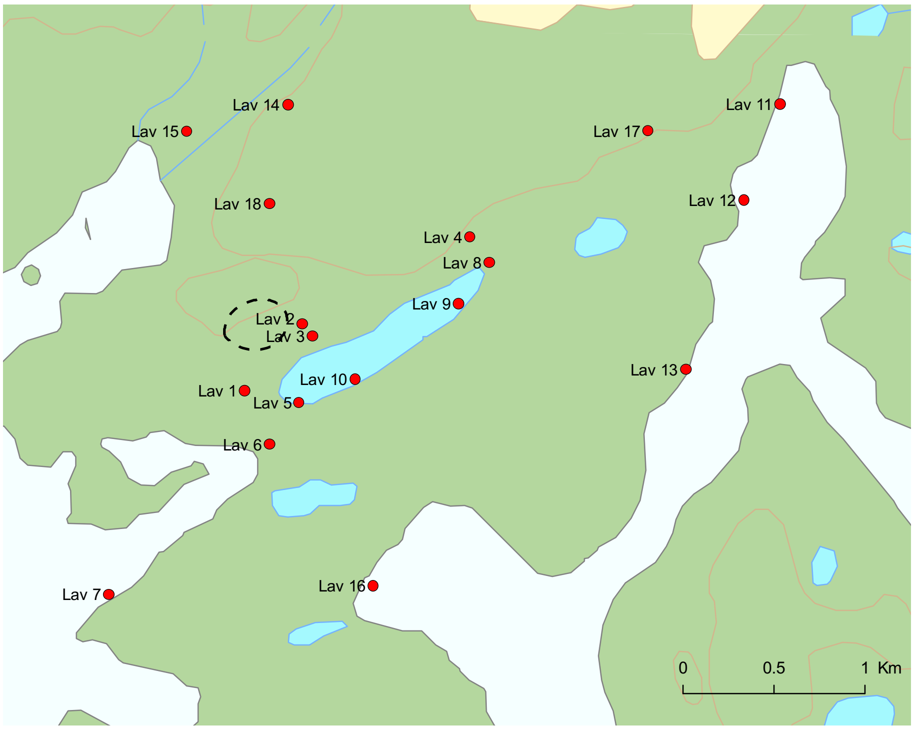
Table 1. Positions of tidal stations (St. 1-26) and lichen stations as well as measured salinity expressed in Practical Salinity Unit (PSU) at selected tidal stations.

Station	Position		Salinity (‰)	Station	Position		Salinity (‰)
	64 N + min.	51 W + min.			64 N + min.	51 W + min.	
St. 1	59.082	35.489		St. 24	58.354	34.767	
St. 2	58.922	35.981	22	St. 25	58.839	33.617	10-24
St. 3	59.342	37.292	18	St. 26	58.594	34.107	
St. 4	59.747	39.142	24				
St. 5	59.172	38.428		Lichen stations			
St. 6	57.922	35.789	12	Lav 1	58.932	33.665	
St. 7	57.721	37.699	16-22	Lav 2	59.125	33.206	
St. 8	57.584	38.449	16	Lav 3	59.096	33.195	
St. 9	58.839	38.564	28	Lav 4	59.392	32.099	
St. 10	59.007	39.838	28	Lav 5	58.898	33.281	
St. 11	58.048	40.587	28	Lav 6	58.774	33.486	
St. 12	58.021	38.815	30	Lav 7	58.326	34.596	
St. 13	57.030	42.073	28	Lav 8	59.317	31.965	
St. 14	58.554	43.561		Lav 9	59.196	32.174	
St. 15	60.037	42.334	22	Lav 10	58.972	32.890	
St. 16	60.527	40.556		Lav 11	59.794	29.939	
St. 17	52.056	43.592		Lav 12	59.509	30.188	
St. 18	53.415	47.788		Lav 13	59.006	30.583	
St. 19	54.604	43.767		Lav 14	59.781	33.377	
St. 20	55.846	41.395		Lav 15	59.699	34.083	
St. 21	53.292	41.252		Lav 16	58.359	32.751	
St. 22	49.124	51.672		Lav 17	59.712	30.859	
St. 23	51.264	43.094	28	Lav 18	59.486	33.503	

In addition to the tidal stations, 18 stations were established close to Seqi where only lichens were sampled (Lav 1-18, Fig. 5). As the results from the previous years have indicated an increased spreading of dust, the lichen stations were set up to better monitor the spatial distribution of the dust in the area. These stations were also used to transplant lichens from a reference station (St. 23). The coordinates of the tidal stations and lichens stations are listed in Table 1.

Data of all samples being taken are kept in a database at NERI, containing information about sampling (date, position, time etc.) and biometric measures for blue mussels and fish, such as length and weight.

Figure 5. Map showing the lichens stations (Lav 1-18) around the Seqi mine site. The circle indicates the mining area.



2.1.1 Blue mussels

Blue mussels (*Mytilus edulis*) were collected by hand at the tidal stations at low tide.

At the mine camp, the mussels were measured and separated into two size groups (4-5 cm and 5-6 cm) if possible. For each size group, 20 mussels were cut open and left for drainage for a few minutes. Thereafter, the soft parts were scraped out with a scalpel into a polyethylene bag. The pooled samples were then weighed and deep-frozen (-20°C) and kept at the mine site before being sent to Denmark.

2.1.2 Seaweed

Brown seaweed (*Fucus vesiculosus*) was also sampled at the tidal stations (Photo 3). At each station, two 10 litres plastic bags were filled with seaweed. These two samples were collected 10 to 20 meters apart, thus constituting two separate samples.

In the camp, the year's growth tips were cut of with a pair of stainless steel scissors. The tips were then washed three times with clean fresh water, packed in polyethylene bags and deep-frozen (-20°C) before being sent to Denmark.

Photo 3. Lene Bruun collects seaweed as part of the environmental monitoring in 2009. Photo: Sigga Joensen.

2.1.3 Lichens

Samples of lichens (C*etraria nivalis*) were collected at most of the tidal and lichen stations in 2008 and 2009 (for details, see Appendix 4). Only lichens growing on dead organic matter were collected to ensure that the lichens would only be able to accumulate metals from the air and not from the underlying rock. Before 2009, only naturally occurring lichens were sampled. In 2009, lichens that had been transplanted from an unpolluted area (St. 23) the year before were sampled too. In that way, it was possible to monitor the accumulation of dust during one year. The collected lichens were kept in paper bags until they were analyzed.

2.1.4 Shorthorn sculpin

Shorthorn sculpins (*Myoxocephalus scorpius*) were caught by angling in Area 1, 2, and 3 in 2008 and in Area 1 and 3 in 2009 (Fig. 2). Approximately 20 individuals were caught in each area.

At the mine camp, the fish were measured, weighted and their sex determined. The liver was then cut out using a stainless steel scalpel, packed in polyethylene bags and deep-frozen (-20°C) before being sent to Denmark.

2.1.5 Arctic char

Four Arctic char (*Salvelinus alpinus*) were caught with a gillnet in Long Lake near the mine in 2008 and one in 2009.

At the mine camp, the fish were measured, weighted and their sex determined. The liver was then cut out using a stainless steel scalpel, packed in polyethylene bags and frozen before being sent to Denmark.

3 Analytical methods

A selection of the samples collected in 2008 and 2009 was analyzed at the Department of Arctic Environment, NERI, in Roskilde, Denmark by Inductively Coupled Plasma Mass Spectrometry (ICP-MS) using an Agilent 7500ce. Samples were analyzed for the elements: Li, Al, V, Cr, Mn, Fe, Ni, Cu, Zn, Co, As, Se, Rb, Y, Ag, Cs, Ba, Nd, Hg, and Pb after pre treatment as described in the following.

3.1 Mussels

The soft parts of the blue mussels were freeze dried to constant weight and the weights before and after drying were noted in order to determine the dry matter percentage of the sample. After drying, the sample was homogenized in an agate mortar. A 0.3 g sub-sample was then digested in a mixture of 4 ml concentrated Merck suprapure nitric acid and 4 ml milliQ water in Teflon bombs in an Anton Paar Multiwave 3000 Microwave Oven. After this treatment, the remaining solution was diluted to 25 grams with milliQ water and stored in polyethylene bottles until analyzed by ICP-MS.

3.2 Seaweed

Seaweed was treated in the same way as blue mussels but the dry matter percentage was not determined.

3.3 Lichens

Lichen samples were rinsed mechanically and only fresh looking parts of the lichens were used. Remains of other plants, moss, soil, or dead lichens were removed. After rinsing, the lichens were dried at 105° C for 24 hours, then digested and analysed in the same way as mussel, seaweed, and fish.

3.4 Shorthorn sculpin and Arctic char

For both fish species, a subsample of the liver (ca. 1 gram) was cut out with stainless steel blade from the inner part in order to avoid contamination from the outer exposed part of the liver. The cutting was done on a plastic carving board, while the sample was still partly frozen, using plastic pincers. The sample was then digested, treated, and analyzed in the same way as mussels and seaweed, the only difference being that the elements were determined on a wet weight basis. To determine the dry weight percentage of the sample, 2-3 g of liver was added to a porcelain crucible and dried at 105° C until constant weight.

3.5 Detection limits and quality control

Detection limits for the measured elements using ICP-MS were calculated based on measurements of blank solutions as three times the standard deviation on these. Blank solutions are the digestion solution alone, treated in the Teflon bombs and diluted in the same way as the samples. One blank solution was prepared for every series of microwave-digestions, containing a total of 16 vials. Since different blank solutions are included in each series of ICP-MS analyses, different detection limits for each element is computed in each series of analyses. The detection limits shown in this report are the mean values of the detection limits found in all series of ICP-MS analyses of the 2008 and 2009 samples.

All relevant concentration values were used to calculate the mean concentrations used in this report, also the concentrations below the detection limit. The concentration values below the detection limit were used as they were computed based on an external calibration line and subtracted the concentration of the blank solutions.

In addition to a blank solution included in every series of microwave-digestions, two replicates of one sample (same sample ID but two difference acid digestions) and one sample of certified standard reference material were analyzed. The duplicate sample was analyzed to check the repeatability of the measurement and the standard reference materials were measured to check the accuracy. The standard reference materials used include Dorm-2, Dolt-3, and Tort-2.

The laboratory at the Department of Arctic Environment (DAE) at NERI is accredited by the Danish Accreditation and Metrology Fund DANAK to analyses of biota for Cr, Ni, Cu, Zn, As, Se, Cd, Hg, and Pb.

The quality of the methods is documented by participating in the QUASIMEME laboratory proficiency testing.

The results of DAE's participation in the QUASIMEME testing during the past five years are shown in Fig. 6. In these graphs each point represents one sample. On the x-axis, the assigned concentration values for the different samples are shown and on the y-axis the relative deviation from these assigned concentrations measured by DAE. The lines represent the allowed uncertainty on a 95% confidence level, based on the accredited detection limit and relative accuracy.

These results document that for Cu, Zn, Cd, and As, the uncertainty by DAE-NERI is 20% for samples with concentrations well above the detection limit. For Cr, Ni, Se, and Pb, the uncertainty by DAE-NERI is 30%. Close to the detection limit, the uncertainty increases.

The elements that are not part of the accreditation by DANAK have a higher uncertainty as they have not been controlled by independent organisations like DANAK and QUASIMEME. We expect that the uncertainty for concentrations well above the detection limit for these elements is approximately 30% relative on a 95% confidence level.

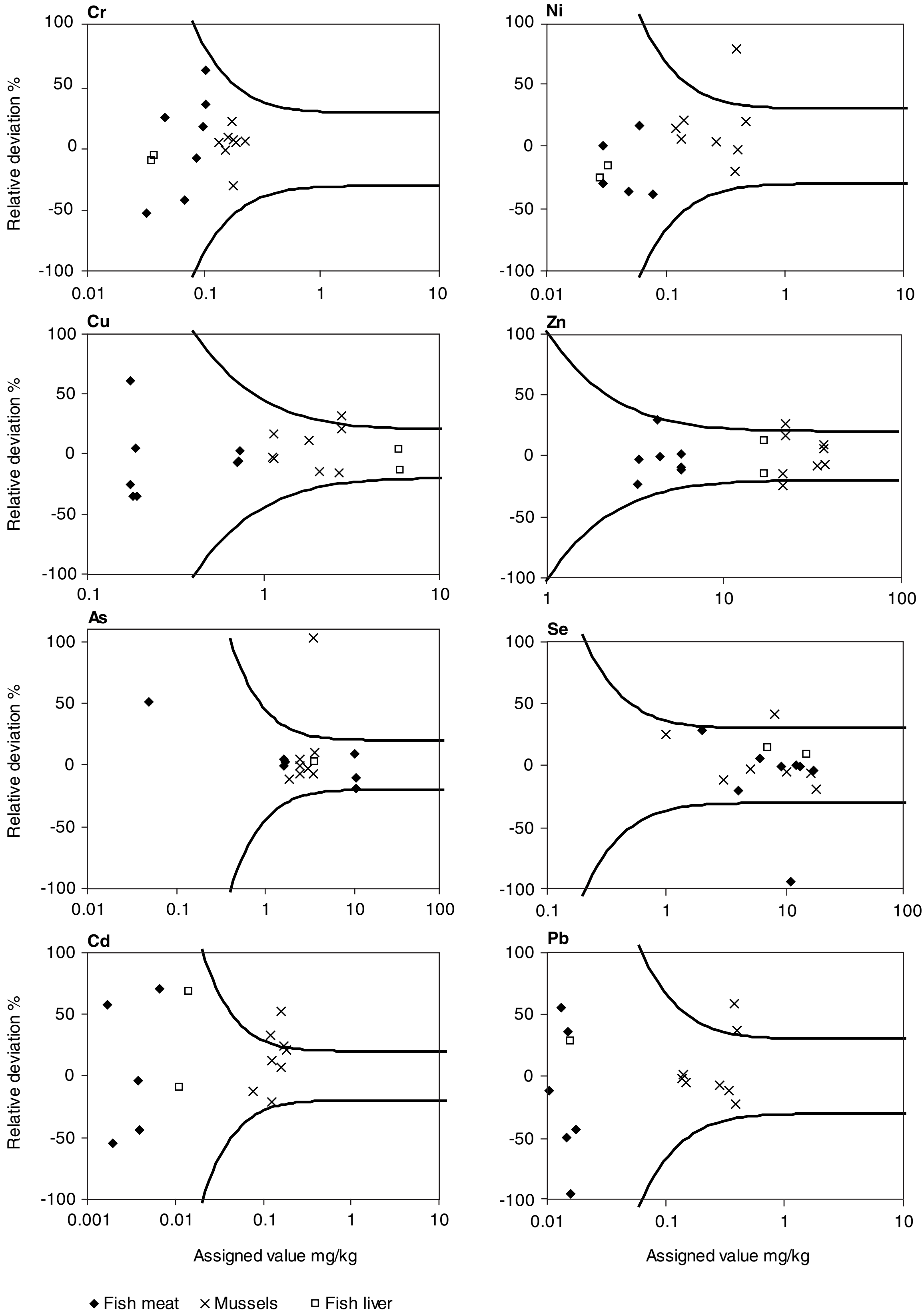


Figure 6. DAE-NERI results in the QUASIMEME laboratory proficiency testing in the period 2004-09 using ICP-MS.

4 Results and discussion

In this chapter results from 2008 and 2009 on blue mussels, seaweed, lichens, and fish are described and compared with results from the previous years.

4.1 Blue mussels

Table 2 shows the mean concentrations of a range of elements measured in blue mussels at the tidal stations at Seqi in 2008 and 2009 and in previous years (2004-2007). In 2008, elevated concentrations of Cr and Ni were measured at the stations St. 24, 25, and 26 closest to the mine site (Table 2). Concentrations of these elements were in average 2-3 times higher compared to the mean concentrations at the other stations. The measured concentrations of Cr and Ni were above the mean concentration plus three times the standard deviation of pre-mining measurements. Statistically, it means that the probability that the samples contain elevated concentrations of Cr and Ni compared to pre-mining levels is more than 99%. Aside from St. 24, 25, and 26, elevated element concentrations were not measured in blue mussels. In 2009, concentrations of Cr and Ni were still elevated but less than in 2008.

Table 2. Mean element concentrations (µg/g dry weight) in blue mussels (4-6 cm's length) in the period 2004-2009. For 2008 and 2009, separate mean values are calculated for the stations closest to the mine site (St. 24-26) and the rest of the stations (mean all, excl. St. 24-26). d.l. = mean detection limit for 2008-09 samples.

		2004	2005	2006	2007	2008		2009	
Element	**d.l.**	**Mean, all**	**Mean, all**	**Mean, all**	**Mean, all**	**Mean, St. 24-26**	**Mean, all excl. St. 24-26**	**Mean, St. 24-26**	**Mean all, excl. St. 24-26**
Li	*0.02*	0.86	0.63	0.53	0.69	0.57	0.59	0.78	0.69
Al	*1*	177	146	50	98	308	65	190	108
V	*0.01*	0.65	0.52	0.42	0.56	0.59	0.44	1.23	0.91
Cr	*0.12*	1.51	1.25	1.04	1.66	4.24	2.27	2.78	1.65
Mn	*0.08*	6	5	3	5	6	4	7	6
Fe	*8*	199	215	118	156	217	109	312	182
Ni	*0.16*	3.28	2.85	1.55	2.31	5.98	1.70	5.59	2.51
Cu	*0.04*	5.91	5.77	5.20	6.92	6.06	6.71	8.63	7.81
Zn	*0.08*	82	71	61	80	78	84	93	93
Co	*0.42*	0.52	0.40	0.27	0.40	0.51	0.38	0.60	0.45
As	*0.09*	10.0	11.0	9.3	11.1	12.6	12.2	20.6	14.9
Se	*0.04*	3.22	4.63	4.17	3.30	5.06	5.66	5.28	4.90
Rb	*0.01*	7.35	4.90	4.24	6.89	5.17	5.89	7.86	7.89
Y	*0.0004*	0.11	0.10	0.06	0.11	0.09	0.10	0.14	0.10
Ag	*0.02*	0.07	0.17	0.06	0.10	0.07	0.04	<d.l.	<d.l.
Cs	*0.01*	0.02	0.02	0.01	0.03	<d.l.	0.04	0.05	0.04
Ba	*0.01*	2.44	1.58	0.45	1.56	1.58	0.71	2.10	1.42
Nd	*0.003*	0.28	0.32	0.21	0.29	0.25	0.22	0.46	0.29
Hg	*0.02*	0.16	0.24	0.16	0.12	0.18	0.20	0.12	0.14
Pb	*0.03*	0.39	0.37	0.32	0.41	0.39	0.36	0.50	0.39

Elevated concentrations of Cr and Ni were also measured in blue mussels at St. 25 in 2007 (St. 26 was not established until 2008) but concentrations measured in 2008 and 2009 were not higher than in 2007. Therefore there is no indication of an increase in accumulation rate of Cr and Ni in blue mussels at St. 25. Elevated concentrations of Cr at St. 24 were measured in 2008 and 2009 but not in 2007, indicating that the affected area may have increased slightly (<1 km) during this period.

The elevated concentrations of Cr and Ni observed in blue mussels are most likely caused by higher dissolved and particle-bound Cr and Ni caused by mining-related dust spreading. That conclusion is based on the observation that no measureable contamination was observed in the fresh water draining from Long Lake into the fjord near Seqi (Asmund et al., 2009).

4.2 Seaweed

Table 3 shows the mean concentrations of a range of elements measured in seaweed at the tidal stations at Seqi from 2004 to 2009. Elevated concentrations of Cr and Ni were measured in 2008 and 2009 at only one station, St. 25, located closest to the ore-treatment facility. The concentrations of these elements were 3-5 times higher compared to mean concentrations found in seaweed from the other stations (Table 3).

Table 3. Mean element concentrations in seaweed (µg/g dry weight) in the period 2004-2009. For 2008 and 2009, separate mean values are calculated for St. 25 close to the quay area and the rest of the stations (mean all, excl. St. 25). d.l. = mean detection limit for 2008-09 samples.

		2004	2005	2006	2007	2008		2009	
Element	**d.l.**	**Mean, all**	**Mean, all**	**Mean, all**	**Mean, all**	**Mean, St. 25**	**Mean, all excl. St. 25**	**Mean, St. 25**	**Mean all, excl. St. 25**
Li	*0.02*	0.548	0.348	0.422	0.578	0.286	0.377	0.400	0.472
Al	*1*	33	30	13	21	30	8	74	20
V	*0.01*	0.587	0.182	0.237	0.318	0.313	0.206	0.534	0.300
Cr	*0.12*	0.546	0.232	0.364	0.480	1.027	0.346	0.969	0.185
Mn	*0.08*	21	14	18	20	61	19	21	14
Fe	*8*	97	38	29	56	94	21	197	107
Ni	*0.16*	2.76	1.74	1.24	1.56	4.47	1.07	5.40	1.58
Cu	*0.04*	2.1	1.7	2.2	4.9	2.5	2.8	3.3	4.7
Zn	*0.08*	14.6	9.3	8.4	13.0	10.3	7.4	16.7	12.4
Co	*0.42*	0.788	0.362	0.294	0.452	0.661	0.275	0.665	0.411
As	*0.09*	45	39	48	58	49	52	61	58
Se	*0.04*	0.238	0.260	0.450	0.306	<d.l.	0.116	<d.l.	0.058
Rb	*0.01*	9	9	10	18	20	14	12	12
Y	*0.0004*	0.078	0.047	0.035	0.066	0.053	0.041	0.136	0.106
Ag	*0.02*	0.136	0.072	0.053	0.128	<d.l.	0.037	<d.l.	<d.l.
Cs	*0.01*	0.028	0.031	0.034	0.055	0.039	0.039	<d.l.	<d.l.
Ba	*0.01*	10.3	9.6	7.3	11.1	23.2	12.3	29.7	12.5
Nd	*0.003*	0.142	0.161	0.078	0.135	0.087	0.053	0.336	0.185
Hg	*0.02*	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	0.200	<d.l.	<d.l.
Pb	*0.03*	0.066	<d.l.	<d.l.	0.066	0.025	<d.l.	0.066	<d.l.

The measured concentrations of Cr and Ni at St. 25 are above the mean concentration plus three times the standard deviation of pre-mining measurements. Consequently, the statistical probability that the samples contain elevated concentrations of Cr and Ni compared to pre-mining levels is more than 99%. Aside from St. 25, no other stations showed clearly elevated element concentrations in seaweed.

Elevated concentrations of Cr and Ni were also measured in seaweed from St. 25 in 2007, but the concentrations measured in 2008 and 2009 were not higher than in 2007. Therefore, there is no indication of an increase in accumulation rate of these elements in seaweed at St. 25.

The elevated concentrations of metals observed in seaweed are most likely caused by higher dissolved metal concentrations in the seawater caused by dust spreading from mining as no measureable contamination was observed in the fresh water draining from Long Lake into the fiord near Seqi (Asmund et al., 2009).

4.3 Lichens

4.3.1 Elevated elements

Table 4 shows the mean concentrations of a range of elements measured in natural lichens in the period 2004 to 2009. The mean concentrations are given for lichens sampled in an area close to the mine (Lav 1-10, see also Fig. 5) and further away from the mine site (St. 1-26, see also Fig. 4).

Table 4. Measured element concentrations (µg/g dry weight) in lichens sampled close to the mine (Lav 1-10) versus lichens sampled further away (St. 1-26) during the period 2004-09. No lichens were sampled at the stations Lav 1-10 in 2004. d.l. = mean detection limit for 2008-2009 samples.

		2004	2005		2006		2007		2008		2009	
Element	**d.l.**	**Mean, all**	**Mean, Lav 1-10**	**Mean, St. 1-26**	**Mean, Lav 1-10**	**Mean, St. 1-26**	**Mean, Lav 1-10**	**Mean, St. 1-26**	**Mean, Lav 1-10**	**Mean, St. 1-26**	**Mean, Lav 1-10**	**Mean, St. 1-26**
Li	*0.02*	0.04	0.04	0.06	0.07	0.03	0.12	0.06	0.12	0.07	0.07	0.05
Al	*1*	184	142	280	223	173	317	281	344	357	240	269
V	*0.01*	0.22	0.14	0.32	0.45	0.21	0.65	0.38	0.37	0.33	0.35	0.41
Cr	*0.12*	0.37	0.17	0.38	2.72	0.38	9.91	1.22	22.66	3.28	10.41	1.14
Mn	*0.08*	50	88	90	75	43	50	42	113	61	50	32
Fe	*8*	108	75	151	251	113	578	138	872	155	414	183
Ni	*0.16*	1.11	0.52	1.14	6.91	0.78	20.83	2.38	55.71	6.63	16.46	1.87
Cu	*0.04*	0.79	0.76	1.13	0.66	0.56	0.60	0.95	1.25	0.71	0.77	0.71
Zn	*0.08*	19	27	25	20	16	18	14	27	20	14	11
Co	*0.42*	0.17	0.10	0.26	0.33	0.10	1.18	0.23	2.50	0.40	0.79	0.19
As	*0.09*	0.21	-0.15	0.43	0.01	0.04	0.07	0.09	0.04	0.06	0.06	0.12
Se	*0.04*	0.05	0.07	0.07	0.05	0.07	0.08	0.07	0.10	0.12	0.08	0.07
Rb	*0.01*	2.2	3.3	2.2	3.6	1.8	6.6	3.1	6.2	2.8	5.1	2.4
Y	*0.0004*	0.06	0.06	0.09	0.10	0.06	0.22	0.11	0.20	0.09	0.13	0.10
Ag	*0.02*	0.01	0.03	0.02	0.01	0.01	0.04	0.02	0.05	0.03	0.11	0.05
Cs	*0.01*	0.04	0.04	0.04	0.07	0.03	0.11	0.04	0.16	0.06	0.11	0.04
Ba	*0.01*	10	9	16	10	7	16	13	14	12	11	8
Nd	*0.003*	0.17	0.16	0.32	0.47	0.18	0.48	0.22	0.50	0.21	0.33	0.23
Hg	*0.02*	0.03	1.39	0.08	0.03	0.03	0.03	0.03	0.16	0.10	0.02	0.02
Pb	*0.03*	0.47	0.54	0.75	0.52	0.56	0.68	0.75	0.99	0.70	1.06	0.52

The results obtained show that lichens collected close to Seqi in 2008 and 2009 contain elevated concentrations of particularly Cr and Ni, but also a range of other elements including Fe, Co, Rb, Y, Ag, Cs, and Nd. All these elements were found in concentrations above the mean concentration plus three times the standard deviation of pre-mining measurements, which results in a probability of more than 99%.

4.3.2 Spatial distribution of dust deposition

Fig. 7 and 8 give a spatial overview of Cr and Ni concentrations measured in lichens in the Seqi area. The concentrations shown are the mean values of the 2008 and 2009 samples.

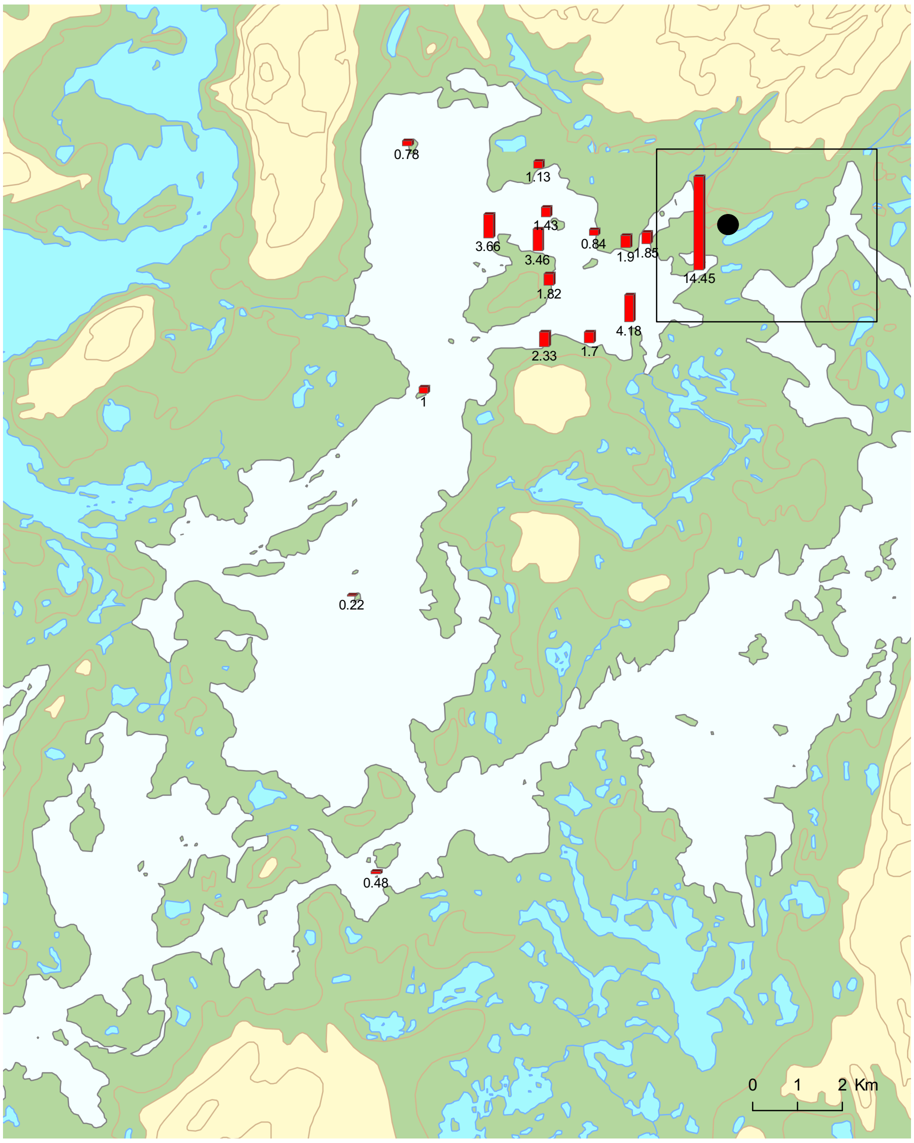
In lichens from the reference stations located far away from Seqi, concentrations of approx. 0.2-0.5 µg/g dry weight (d.w.) for both Cr and Ni were measured, which can be regarded as the natural background level. Close to the mine site, up to 45 µg/g d.w. Cr and 96 µg/g d.w. Ni were measured, corresponding to concentrations up to 100-200 times higher than in the reference samples. Elevated concentrations were measured in lichens sampled at stations as far away as St. 13, located 8 km from the mine, which also indicate that the area impacted by dust spreading was larger in 2008/2009 than in 2007 (Asmund et al., 2009).

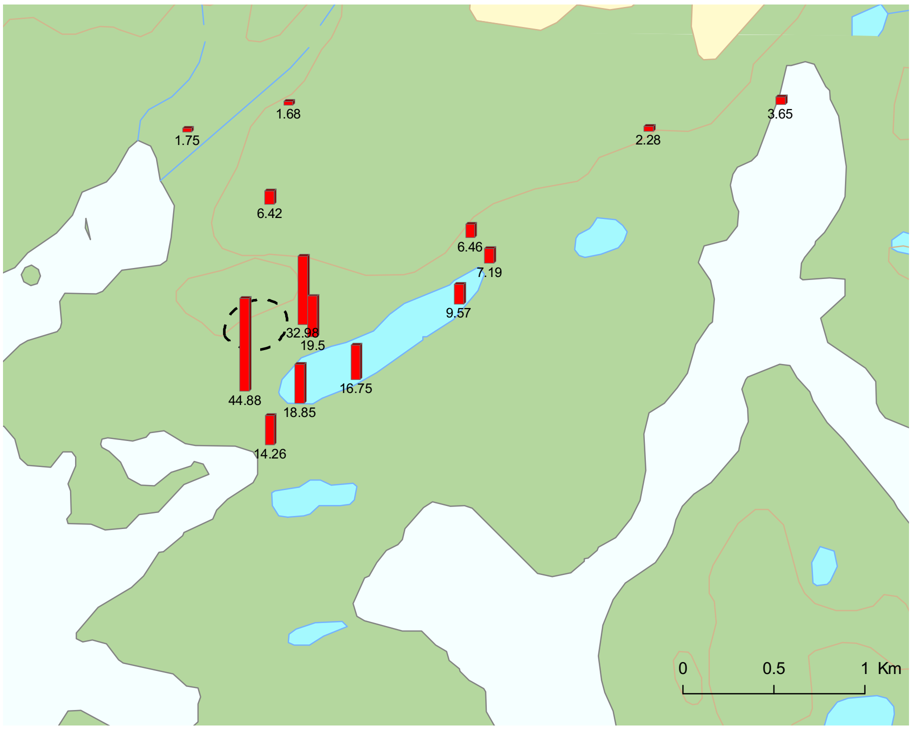
4.3.3 Annual variations of dust deposition

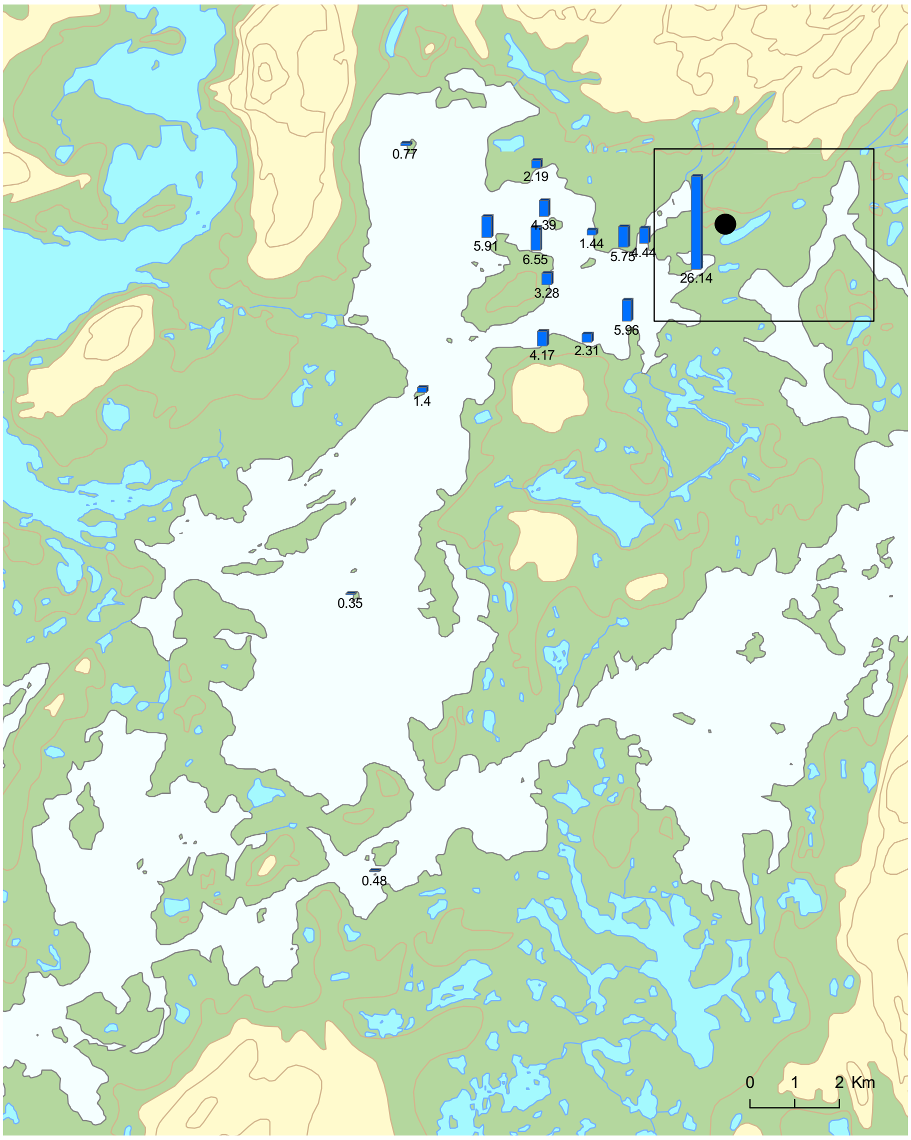
In order to assess the annual variations in dust deposition after the mining started, lichens from the same stations have to be used (the deposition rate at a specific location varies with distance from the mine, local topography etc.). The mean values listed in Table 4 are therefore not suitable for a comparison between years as the stations included have varied from year to year. To perform these temporal comparisons, lichens stations were selected, which are located close to the mine and for which metal levels have been measured for several years during the monitoring period. These selected stations are Lav 1, 3, 4, 5, 6, 9, and 10.

Roughly speaking, there are two ways to estimate the annual accumulation rate in lichens: 1) In measuring the concentrations in natural lichen sampled at the same location in two consecutive years and then calculate the difference in concentration between years; 2) By transplanting lichens from an unpolluted area to the sample station and collecting and analyzing them the year after. The last option is generally preferred as natural lichens response to variations in deposition rate is not well defined (e.g. the concentration may not increase linearly as a response to a constant dust deposition and may not decrease if the deposition rate decreases). Furthermore, by using transplanted lichens one is sure to sample from the same lichens before and after the exposure, whereas this is not the case when collecting natural lichens.

Figure 7. Mean Cr concentrations in lichens (µg/g dry weight) measured in 2008 and 2009 in the area around Seqi (upper graph) and closer to the mine site (lower graph). The dot marks the location of the mining area.







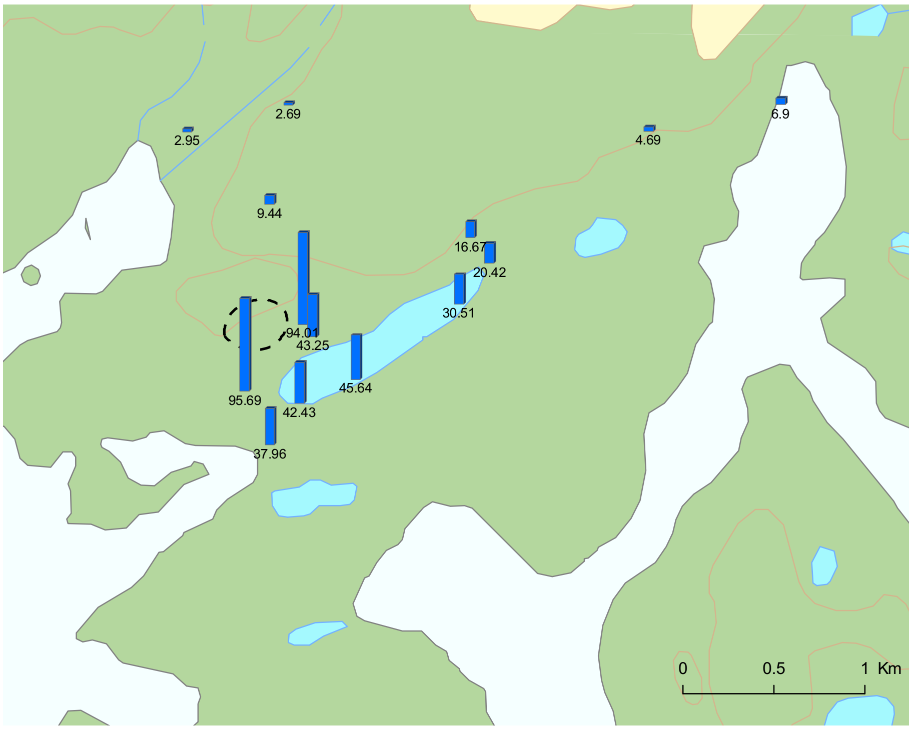


Figure 8. Mean Ni concentrations in lichens (µg/g dry weight) measured in 2008 and 2009 in the area around Seqi (upper graph) and closer to the mine site (lower graph). The dot marks the location of the mining area.

Lichens were not transplanted to the area before 2008. Therefore, the annual variation in dust deposition for the period 2005-2008 was estimated based on collection of natural lichens using method 1) and for 2009 on transplanted lichens using method 2). The variation in Cr and Ni deposition, based on lichen sampling, can be seen in Fig. 9.

As shown in Fig. 9, the annual accumulation of Cr and Ni has generally increased from 2006 to 2007 and from 2007 to 2008. From 2008 to 2009 the annual accumulation of Cr and Ni decreased.

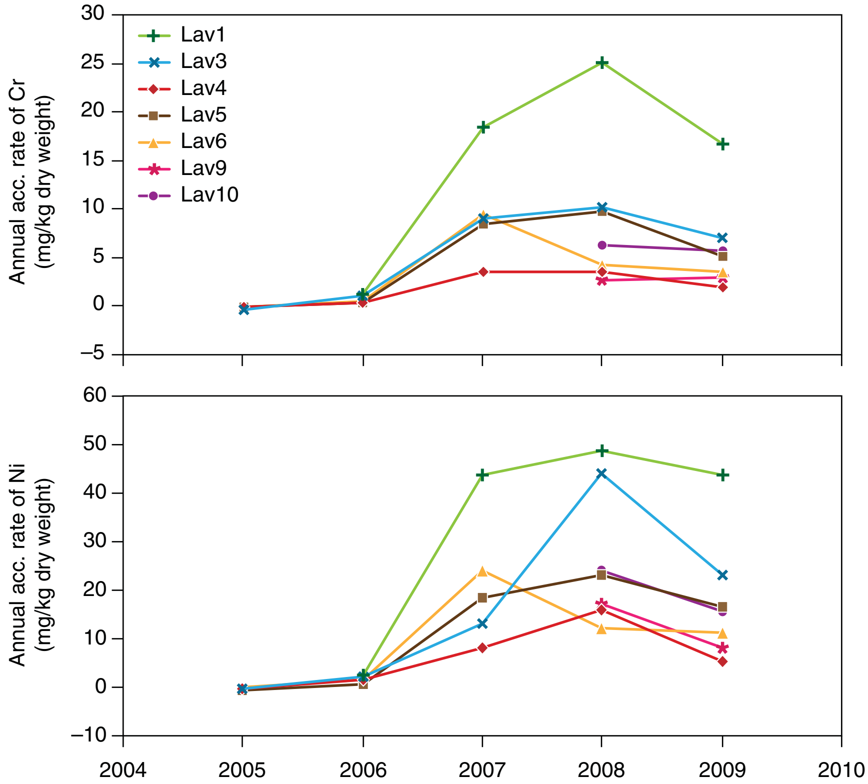


Figure 9. Annual accumulation rate of Cr (upper graph) and Ni (lower graph) in lichens located within 1 km from the mine site (mg/kg dry weight). The annual accumulation rate in lichens from the stations Lav 1-10 is estimated either as the difference in concentrations measured in natural lichens during two consecutive years (2005-2008); or the concentrations measured in lichens transplanted from an unpolluted area the year before (2009).

One station (Lav 2) was omitted from the analysis of annual dust deposition, even though it was measured continuously. High concentrations of Cr and Ni were measured in natural lichens at Lav 2 in 2006 and in 2007. However, the concentration was lower in 2007 than in 2006, resulting in a negative accumulation rate for that year, which is unlikely. Lav 2 is located in immediate vicinity of the mining area and the observed variation is likely due to the fact that it is not possible to sample natural lichens at exactly the same place each year.

4.4 Shorthorn sculpin

Spreading of some elements related to mining at Seqi, Cr and Ni in particular, were observed in lichens, blue mussels, and seaweed. In order to monitor whether the mine had any effect on the marine fish, shorthorn sculpin (*Myoxocephalus scorpius)* were sampled in the areas 1, 2, and 3 (Fig. 2).

Table 5 shows the mean concentrations of a range of elements measured in shorthorn sculpin liver in the period 2004 to 2009. For 2008 and 2009, separate mean concentrations are shown for Area 1 closest to the mine and for Area 2-3 further away. If mining has an impact on these fish the liver should contain higher Cr and Ni concentrations compared to baseline levels measured in 2004 and 2005; and fish in Area 1 should have higher Cr and Ni concentrations compared to fish from Area 2-3. However, very low (below detection limit) concentrations of Cr and Ni were measured in shorthorn sculpin liver in all areas in the period 2004 to 2009.

Consequently, it is not likely that the mining operation has affected the marine fish near Seqi.

Table 5. Mean element concentrations in shorthorn sculpin liver (µg/g wet weight) in the period 2004-2009. For 2008 and 2009, separate mean values are calculated for the sampling area closest to the mine site (Area 1) and the sampling areas further away (Area 2-3). d.l. = mean detection limit for 2008-09 samples.

		2004	2005	2006	2007	2008		2009	
Element	**d.l.**	**Mean, all**	**Mean, all**	**Mean, all**	**Mean, all**	**Mean, area 1**	**Mean, area 2-3**	**Mean, area 1**	**Mean, area 2-3**
Li	*0.01*	0.03	0.02	0.02	0.03	0.01	0.01	0.02	0.01
Al	*1*	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.
V	*0.01*	0.064	0.043	0.066	0.050	0.033	0.246	0.076	0.150
Cr	*0.02*	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.
Mn	*0.02*	0.63	0.56	0.38	0.76	0.78	0.75	0.80	0.81
Fe	*5*	238	137	124	115	235	210	244	156
Ni	*0.24*	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.
Cu	*0.01*	4.51	2.31	1.03	2.16	2.16	3.92	3.83	3.43
Zn	*0.09*	56	32	27	27	91	78	32	36
Co	*0.23*	0.09	0.06	0.04	0.10	<d.l.	<d.l.	<d.l.	<d.l.
As	*0.04*	7.43	4.28	3.31	4.17	5.55	14.68	22.01	10.29
Se	*0.02*	1.57	1.44	1.20	1.12	1.78	2.64	1.62	1.83
Rb	*0.01*	0.53	0.51	0.34	0.98	0.76	0.93	0.78	0.86
Y	*0.0003*	<d.l.	<d.l.	<d.l.	<d.l.	0.0008	0.0011	0.0013	<d.l.
Ag	*0.01*	0.37	0.17	0.11	0.12	0.20	0.39	0.38	0.49
Cs	*0.01*	0.02	0.02	0.01	0.01	0.01	0.02	0.03	0.02
Ba	*0.006*	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.
Nd	*0.003*	<d.l.	<d.l.	<d.l.	<d.l.	0.004	0.003	<d.l.	<d.l.
Hg	*0.02*	0.14	0.10	0.09	0.08	0.14	0.15	0.11	0.04
Pb	*0.01*	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	0.02	<d.l.	<d.l.

4.5 Arctic char

Arctic char (*Salvelinus alpinus*) was caught in Long Lake, which is located a few hundred meters southeast of the olivine deposit. Four fish were caught in 2008 and one in 2009. This lake and the short river that flows to the fjord can receive drainage water and dust directly from the deposit and from the mining operations. Consequently, Long Lake is the fresh water body, which is most likely to be affected by the mining activity.

Water samples from Long Lake were taken in 2004, 2005, 2006, and 2007 and the results were reported in Asmund et al. (2009). The report concludes that there was no indication of higher element concentrations in fresh water from Long Lake after the mining started.

Sampling of liver from Arctic char can be considered an indicator for pollution of Long Lake. Table 6 shows the mean concentrations of a range of elements measured in the Arctic chars caught in 2008 and 2009. A total of five fish samples are very little in order to make a reliable evaluation on the pollution state of the lake, but the levels measured were as low as those in Arctic char from unaffected streams in Greenland (Glahder et al., 2008).

Consequently, there is no indication that the mining activity has an impact on the fresh water environment in Long Lake.

Table 6. Mean element concentrations in Arctic char liver (µg/g wet weight) sampled in Long Lake in the period 2008-2009. No samples were collected before 2008. d.l. = mean detection limit for 2008-09 samples.

Element	d.l.	2008 Mean, all (n=4)	2009 Mean, all (n=1)
Li	***0.01***	**<d.l.**	**<d.l.**
Al	*0.5*	<d.l.	1.1
V	*0.01*	0.01	0.01
Cr	*0.02*	<d.l.	0.03
Mn	*0.02*	1.35	1.78
Fe	*5*	137	100
Ni	*0.24*	<d.l.	<d.l.
Cu	*0.01*	29	2
Zn	*0.09*	54	27
Co	*0.23*	0.13	0.08
As	*0.04*	0.48	0.19
Se	*0.02*	1.78	0.78
Rb	*0.01*	0.97	3.66
Y	*0.0003*	<d.l.	0.0005
Ag	*0.01*	0.09	<d.l.
Cs	*0.01*	0.02	0.02
Ba	*0.006*	0.011	0.007
Nd	*0.003*	<d.l.	0.005
Hg	*0.02*	0.10	<d.l.
Pb	*0.01*	<d.l.	<d.l.

5 Evaluation

5.1 Environmental evaluation

The elevated concentrations of Cr and Ni measured in seaweed at St. 25 and in blue mussels at St. 24, 25, and 26, nearest to the mine site can be environmentally evaluated based on a classification system developed by The Norwegian Pollution Control Authority (SFT) in Norway (Molvær et al., 1997).

Based on this classification system, the level of pollution can be divided into five pollution classes based on the concentrations of metals, including Cr and Ni, measured in indicator species such as seaweed and blue mussels.

Table 7 shows the mean concentrations of Cr and Ni measured in seaweed and blue mussels at the stations St. 24, St. 25, and St. 26 as well as at the other stations sampled in 2008 and 2009. The concentrations defining the five pollution classes are listed below.

Table 7. Mean concentrations in seaweed and blue mussels at the stations St. 24-26, where elevated concentrations were observed, and at the other stations monitored in 2008 and 2009. Pollution classes according to the Norwegian Pollution Control Authority (SFT) are listed below.

		Cr		Ni	
		Seaweed	blue mussels	Seaweed	blue mussels
Measured mean concentrations					
All stations excl. St. 24-26	2008	0.4	2.3	1.1	1.7
	2009	0.2	1.7	1.6	2.5
St. 24	2008	0.3	2.8	2.2	2.4
	2009	0.3	2.6	2.4	4.0
St. 25	2008	1.0	4.2	2.4	7.9
	2009	1.0	3.0	5.4	7.0
St. 26	2008	0.2	5.7	2.1	7.6
	2009	0.2	1.5	2.0	3.3
Classification concentration levels					
Insignificantly polluted		1	3	5	5
Moderately polluted		5	10	25	20
Pronounced polluted		15	30	50	50
Strongly polluted		50	60	100	100
Very strongly polluted		>50	>60	>100	>100

As shown in Table 7, blue mussels at St. 24 may be considered as "Insignificantly polluted" and seaweed at St. 25 and blue mussels at St. 25 and St. 26 as "Insignificantly polluted" to "moderately polluted". The other pollution classes: "Pronounced polluted", "Strongly polluted", and "Very strongly polluted" are not relevant for the Seqi area.

The elevated concentrations of elements found in lichens in the area due to dust spreading can not be classified using this system.

5.2 Overall assessment

Contamination due to olivine mining was observed in the marine indicator species, blue mussels and seaweed, but only at a few stations located in close vicinity to the mine site. These contaminated samples can be classified as insignificantly to moderately polluted with Cr and Ni. The spreading of dust in the area, however, is significant and observed as elevated concentrations of Cr and Ni and some other elements in lichens. The area where elevated concentrations are observed now covers an area within ~8 km from the mine and has increased from 2007 to 2008-09. A major source of dust spreading appears to be the transport of the ore by trucks from the mine to the ore crusher. The dust deposition rate near the mine increased from 2007 to 2008 but was lower again in 2009. The variation in the dust spreading between years is likely due to a variation in mining activity and production as there has been no change in the methods used in the mining operation as a whole.

6 Conclusion

Baseline studies conducted in 2004 and 2005, before the mine started, revealed no natural elevation of elements in biota at Seqi. After the mine started in late 2005, spreading of dust could be measured as elevated concentrations of several elements including Cr and Ni in lichens. In 2008 and 2009, the area where elevated concentrations were observed in lichens covered a distance of ~8 km from the mine, which is an increase from 2007. Dust deposition rates near the mine increased from 2007 to 2008 but decreased from 2008 to 2009.

Elevated concentrations of Cr and Ni were also observed in the marine indicator species, blue mussels and seaweed, but only at a few stations located in close vicinity to the mine site. No measureable contamination was observed in Arctic char from Long Lake near Seqi or in shorthorn sculpins caught in the Fiskefjord. Consequently, the effect of the mine on the marine environment is very local and assessed as insignificant. A continuing deposition of dust, however, may eventually lead to an impact on the marine environment and therefore a reduction of the dust spreading is recommended.

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Appendix 1. Biometric data for fish

Description of the fish caught in 2008 and 2009, Shorthorn sculpin (*Myoxocephalus scorpius*) and Arctic char (*Salvelinus alpinus)*

ID no.	Sample type	Collection date	Station	Sex	Length (cm)	Weight (g)
39101	shorthorn sculpin	20080820	Område 3	female	40	610
39102	shorthorn sculpin	20080820	Område 3	female	36	553
39103	shorthorn sculpin	20080820	Område 3	female	33	472
39104	shorthorn sculpin	20080820	Område 3	female	33	520
39105	shorthorn sculpin	20080820	Område 3	male	25,5	216
39106	shorthorn sculpin	20080820	Område 3	female	30	315
39107	shorthorn sculpin	20080820	Område 3	female	31	414
39108	shorthorn sculpin	20080820	Område 3	male	29,5	344
39109	shorthorn sculpin	20080820	Område 3	female	26,5	226
39110	shorthorn sculpin	20080820	Område 3	female	28	248
39111	shorthorn sculpin	20080820	Område 3	female	28	244
39112	shorthorn sculpin	20080820	Område 3	female	25,5	192
39113	shorthorn sculpin	20080820	Område 3	male	30	266
39114	shorthorn sculpin	20080820	Område 3	female	21	127
39115	shorthorn sculpin	20080820	Område 3	male	27	263
39116	shorthorn sculpin	20080820	Område 3	male	25,5	232
39117	shorthorn sculpin	20080820	Område 3	male	26	184
39118	shorthorn sculpin	20080820	Område 3	male	26	198
39119	shorthorn sculpin	20080820	Område 3	male	25,5	196
39120	shorthorn sculpin	20080820	Område 3	male	24,5	172
39121	shorthorn sculpin	20080820	Område 3	female	32	348
39122	shorthorn sculpin	20080820	Område 1	female	32	400
39123	shorthorn sculpin	20080824	Område 1	female	33	487
39124	shorthorn sculpin	20080824	Område 1	female	32	368
39125	shorthorn sculpin	20080824	Område 1	female	27,5	224
39126	shorthorn sculpin	20080824	Område 1	male	26,5	194
39127	shorthorn sculpin	20080824	Område 1	female	30	320
39128	shorthorn sculpin	20080824	Område 1	male	25	174
39129	shorthorn sculpin	20080824	Område 1	female	28	236
39130	shorthorn sculpin	20080824	Område 1	male	28	205
39131	shorthorn sculpin	20080824	Område 1	female	25	168
39132	shorthorn sculpin	20080824	Område 1	female	26	186
39133	shorthorn sculpin	20080824	Område 1	male	24	147
39134	shorthorn sculpin	20080824	Område 1	male	24	151
39135	shorthorn sculpin	20080824	Område 1	male	26,5	212
39136	shorthorn sculpin	20080824	Område 1	male	28	220
39137	shorthorn sculpin	20080824	Område 1	male	26	153
39138	shorthorn sculpin	20080824	Område 1	male	24	147
39139	shorthorn sculpin	20080824	Område 1	male	23,5	156
39140	shorthorn sculpin	20080824	Område 1	female	23	137
39141	Arctic char	20080820	Long Lake	male	49,5	1158
39142	Arctic char	20080820	Long Lake	male	43	894
39143	Arctic char	20080820	Long Lake	male	45	1040
39144	Arctic char	20080820	Long Lake	male	46	963
39145	Arctic char	20080820	Long Lake	female	46,5	1186

ID no.	Sample type	Collection date	Station	Sex	Length (cm)	Weight (g)
39146	Arctic char	20080820	Long Lake	male	51	1362
39147	Arctic char	20080820	Long Lake	male	47	1276
39148	Arctic char	20080820	Long Lake	female	44,5	1102
39149	Arctic char	20080820	Long Lake	female	45,5	1040
39150	Arctic char	20080820	Long Lake	female	45	995
39151	Arctic char	20080820	Long Lake	male	41	825
39152	Arctic char	20080820	Long Lake	female	44,5	983
39153	Arctic char	20080820	Long Lake	female	41	558
39154	Arctic char	20080820	Long Lake	male	34,5	411
39155	Arctic char	20080821	Long Lake	male	49	1051
39156	Arctic char	20080821	Long Lake	male	38	615
39157	Arctic char	20080822	Long Lake	female	50,5	1326
39158	Arctic char	20080822	Long Lake	male	41	788
39159	Arctic char	20080822	Long Lake	male	42,5	820
39177	shorthorn sculpin	20080822	Område 2	female	39	921
39178	shorthorn sculpin	20080822	Område 2	female	37	674
39179	shorthorn sculpin	20080822	Område 2	male	29	276
39180	shorthorn sculpin	20080822	Område 2	female	31	400
39181	shorthorn sculpin	20080822	Område 2	male	29,5	355
39182	shorthorn sculpin	20080824	Område 2	female	38	667
39183	shorthorn sculpin	20080824	Område 2	female	34,5	464
39184	shorthorn sculpin	20080824	Område 2	male	27	268
39185	shorthorn sculpin	20080824	Område 2	male	27,5	264
39186	shorthorn sculpin	20080824	Område 2	male	25,5	199
39187	shorthorn sculpin	20080824	Område 2	male	23,5	155
39188	shorthorn sculpin	20080824	Område 2	male	21,5	133
41201	Shorthorn sculpin	20090701	Område 1	male	30	253
41202	Shorthorn sculpin	20090701	Område 1	female	32	43
41203	Shorthorn sculpin	20090701	Område 1	female	30	368
41204	Shorthorn sculpin	20090701	Område 1	female	29	308
41205	Shorthorn sculpin	20090701	Område 1	male	30	247
41206	Shorthorn sculpin	20090701	Område 1	male	30	255
41207	Shorthorn sculpin	20090701	Område 1	male	26	215
41208	Shorthorn sculpin	20090701	Område 1	female	25	167
41209	Shorthorn sculpin	20090701	Område 1	male	25	188
41210	Shorthorn sculpin	20090701	Område 1	male	28	222
41211	Shorthorn sculpin	20090701	Område 1	male	27	200
41212	Shorthorn sculpin	20090701	Område 1	male	23	176
41213	Shorthorn sculpin	20090701	Område 1	male	25	168
41214	Shorthorn sculpin	20090701	Område 1	male	25	148
41215	Shorthorn sculpin	20090701	Område 1	male	23	141
41216	Shorthorn sculpin	20090701	Område 1	male	24	149
41217	Shorthorn sculpin	20090701	Område 1	female	23	158
41218	Shorthorn sculpin	20090701	Område 1	male	24	140
41219	Shorthorn sculpin	20090701	Område 1	male	19	94
41220	Shorthorn sculpin	20090701	Område 1	male	21	122
41240	Shorthorn sculpin	20090702	Område 3	female	34	350
41241	Shorthorn sculpin	20090702	Område 3	female	28	257
41242	Shorthorn sculpin	20090702	Område 3	female	34	338
41243	Shorthorn sculpin	20090702	Område 3	male	25	181
41244	Shorthorn sculpin	20090702	Område 3	female	30	268
41245	Shorthorn sculpin	20090702	Område 3	male	27	214
41246	Shorthorn sculpin	20090702	Område 3	male	23	158

ID no.	Sample type	Collection date	Station	Sex	Length (cm)	Weight (g)
41247	Shorthorn sculpin	20090702	Område 3	female	26	200
41248	Shorthorn sculpin	20090702	Område 3	female	23	140
41249	Shorthorn sculpin	20090702	Område 3	female	23	139
41250	Shorthorn sculpin	20090702	Område 3	female	22	131
41265	Shorthorn sculpin	20090703	Område 3	female	46	1288
41266	Shorthorn sculpin	20090703	Område 3	female	33	569
41267	Shorthorn sculpin	20090703	Område 3	male	26	231
41268	Shorthorn sculpin	20090703	Område 3	female	28	249
41269	Shorthorn sculpin	20090703	Område 3	female	27	236
41270	Shorthorn sculpin	20090703	Område 3	female	20	95
41271	Shorthorn sculpin	20090703	Område 3	male	25	185
41272	Shorthorn sculpin	20090703	Område 3	female	31	333
41273	Shorthorn sculpin	20090703	Område 3	male	26	204
41296	Arctic char	20090703	Long Lake	female	38	540

Appendix 2. Analyses of blue mussels

Chemical analyses of blue mussels (*Mytilus edulis*) µg/g dry weight.

ID no.	Station	Length	Year	Dry matter %	Li	Al	V	Cr	Mn	Fe	Ni	Co	Cu	Zn
d.l.					**0.02**	**1**	**0.01**	**0.12**	**0.08**	**8**	**0.16**	**0.04**	**0.08**	**0.42**
39169	St. 1	4-5 cm	2008	14	0.66	91	0.55	2.84	4.78	165	2.45	0.46	6.66	83.12
39170	St. 1	5-6 cm	2008	15	0.56	81	0.47	2.56	4.37	146	2.02	0.43	6.60	73.46
39171	St. 2	4-5 cm	2008	15	0.66	43	0.35	2.81	4.26	107	2.16	0.36	6.59	68.71
39172	St. 2	5-6 cm	2008	16	0.63	37	0.31	2.67	4.08	98	1.90	0.33	6.65	76.85
39173	St. 3	4-5 cm	2008	14	0.66	48	0.49	2.36	4.89	130	2.14	0.46	6.76	90.83
39174	St. 3	5-6 cm	2008	15	0.59	38	0.37	2.29	3.83	96	1.59	0.38	6.82	80.27
39226	St. 4	4-5 cm	2008	17	0.63	32	0.37	2.40	3.73	91	1.39	0.33	6.44	80.63
39227	St. 4	5-6 cm	2008	16	0.56	102	0.34	2.42	3.79	89	1.26	0.35	6.57	83.86
39228	St. 5	4-5 cm	2008	16	0.57	28	0.36	2.48	3.95	84	1.49	0.35	7.39	82.01
39228	St. 5	4-5 cm	2008	16	0.55	26	0.32	2.34	3.72	78	1.36	0.33	6.88	78.42
39229	St. 5	5-6 cm	2008	17	0.56	31	0.32	2.52	3.63	85	1.40	0.35	7.40	75.42
39205	St. 6	4-5 cm	2008	15	0.64	74	0.45	2.93	4.29	126	3.80	0.38	6.78	71.25
39206	St. 6	5-6 cm	2008	14	0.70	72	0.49	2.79	4.31	130	1.74	0.39	6.65	86.19
39207	St. 7	4-5 cm	2008	16	0.56	28	0.42	2.55	4.24	79	1.29	0.33	6.47	79.84
39272	St. 8	4-5 cm	2008	13	0.68	69	0.47	2.28	4.48	120	1.58	0.38	6.51	78.44
39273	St. 8	5-6 cm	2008	14	0.69	65	0.58	2.59	4.53	134	1.86	0.41	6.80	91.89
39230	St. 9	4-5 cm	2008	17	0.59	42	0.35	2.88	3.81	93	1.57	0.34	6.60	81.29
39231	St. 9	5-6 cm	2008	16	0.59	39	0.37	2.51	3.73	94	1.48	0.35	6.58	72.14
39232	St. 10	4-5 cm	2008	16	0.64	81	0.54	2.82	4.45	124	2.10	0.44	7.28	90.87
39233	St. 10	5-6 cm	2008	15	0.61	67	0.48	2.71	4.28	122	1.93	0.44	6.81	96.91
39236	St. 12	4-5 cm	2008	17	0.52	491	0.60	2.51	6.21	173	1.48	0.33	6.43	80.55
39274	St. 13	4-5 cm	2008	8	0.70	36	0.50	1.91	4.68	115	1.85	0.39	6.86	90.52
39275	St. 13	5-6 cm	2008	15	0.60	26	0.54	1.73	4.31	100	1.68	0.39	6.68	91.08
39275	St. 13	5-6 cm	2008	15	0.57	26	0.50	1.66	4.04	96	1.57	0.37	6.29	89.36
39278	St. 15	4-5 cm	2008	17	0.44	17	0.31	2.17	4.23	72	1.22	0.33	7.21	87.79
39279	St. 15	5-6 cm	2008	15	0.34	24	0.43	2.21	4.35	94	1.45	0.41	6.76	98.50
39242	St 19	4-5 cm	2008	16	0.56	30	0.41	0.95	4.46	77	1.11	0.35	5.86	83.91
39243	St 19	5-6 cm	2008	14	0.65	23	0.44	1.00	4.00	86	1.11	0.35	5.69	90.46
39260	St. 23	4-5 cm	2008	18	0.57	107	0.60	0.95	6.42	142	1.64	0.43	7.06	105.03
39261	St. 23	5-6 cm	2008	15	0.53	79	0.47	1.26	5.60	129	1.53	0.47	7.36	89.62
39209	St. 24	4-5 cm	2008	19	0.46	56	0.43	2.66	4.52	112	2.23	0.39	7.27	79.50
39210	St. 24	5-6 cm	2008	14	0.68	70	0.53	2.96	4.83	154	2.56	0.46	5.90	92.60
39275	St. 25	4-5 cm	2008	14	0.69	868	1.13	6.91	8.74	455	13.22	0.83	7.29	99.20
39276	St. 25	5-6 cm	2008	14	0.24	173	0.27	1.53	1.96	99	2.66	0.20	2.09	28.70
39211	St. 26	4-5 cm	2008	16	0.61	348	0.58	5.99	6.66	239	7.77	0.59	6.89	75.55
39212	St. 26	5-6 cm	2008	13	0.72	335	0.58	5.41	6.36	242	7.45	0.59	6.91	91.06
41221	St. 23	4-5 cm	2009	15	0.70	138	1.09	1.22	7.55	209	2.30	0.48	8.61	105.07
41221	St. 23	4-5 cm	2009	15	0.72	169	1.16	1.48	7.88	207	2.39	0.51	8.52	109.51
41222	St. 23	5-6 cm	2009	15	0.73	76	0.93	1.03	7.09	178	2.06	0.49	8.41	105.07
41225	St. 19	4-5 cm	2009	16	0.65	40	0.80	0.76	5.76	130	1.83	0.38	7.52	90.96
41228	St. 1	4-5 cm	2009	11	0.69	131	0.95	1.99	5.50	222	3.35	0.47	8.61	84.98
41229	St. 1	5-6 cm	2009	12	0.67	188	1.04	2.54	6.35	249	3.29	0.57	8.85	103.81
41230	St. 24	4-5 cm	2009	12	0.70	169	1.24	2.57	6.76	260	4.01	0.54	8.12	87.55

ID no.	Station	Length	Year	Dry matter %	Li	Al	V	Cr	Mn	Fe	Ni	Co	Cu	Zn
41231	St. 26	4-5 cm	2009	10	0.74	195	1.23	3.33	6.97	298	5.22	0.63	9.08	93.57
41251	St. 6	4-5 cm	2009	14	0.69	85	0.83	1.62	5.16	171	1.96	0.40	7.75	82.31
41252	St. 7	4-5 cm	2009	17	0.53	49	0.69	1.32	5.37	129	2.40	0.40	7.25	95.05
41253	St. 8	4-5 cm	2009	17	0.47	124	0.74	1.33	6.73	144	3.07	0.42	7.88	109.14
41259	St. 25	4-5 cm	2009	13	0.83	233	1.44	2.76	7.34	398	5.85	0.66	9.11	97.40
41260	St. 25	5-6 cm	2009	12	0.90	251	1.37	3.23	7.05	419	8.07	0.70	8.00	97.26
41261	St. 26	5-6 cm	2009	14	0.71	104	0.88	1.99	5.79	185	4.82	0.48	8.83	89.04
41276	St. 9	4-5 cm	2009	15	0.71	92	0.95	2.14	5.33	172	2.21	0.44	7.62	100.71
41276	St. 9	4-5 cm	2009	15	0.72	90	0.93	2.03	5.51	169	2.38	0.46	7.34	102.86
41277	St. 10	4-5 cm	2009	14	0.78	239	1.24	5.28	6.63	302	4.58	0.65	7.74	97.59
41278	St. 12	4-5 cm	2009	15	0.73	147	0.96	1.31	6.54	199	1.94	0.40	7.68	85.02
41279	St. 15	4-5 cm	2009	13	0.77	48	0.80	1.25	4.91	155	1.91	0.44	7.55	91.00
41280	St. 5	4-5 cm	2009	13	0.80	140	1.09	1.77	5.67	235	2.68	0.46	7.99	91.93
41286	St. 2	4-5 cm	2009	13	0.67	69	0.83	1.59	4.59	145	2.34	0.39	7.45	81.17
41287	St. 3	4-5 cm	2009	14	0.53	46	0.68	1.33	5.08	130	2.52	0.43	8.37	83.29
41288	St. 4	4-5 cm	2009	13	0.72	46	0.74	1.18	4.69	137	<d.l.	0.41	7.81	79.66
41289	St. 13	4-5 cm	2009	14	0.77	41	0.82	1.06	5.48	142	<d.l.	0.43	7.18	92.61
41294	Ref	4-5 cm	2009	16	0.69	67	0.74	1.03	6.20	143	<d.l.	0.39	6.91	84.24
41297	Ref	5-6 cm	2009	16	0.75	253	1.17	1.46	8.45	261	1.90	0.44	6.94	75.67

ID no.	Station	Length	Year	As	Se	Rb	Y	Ag	Cs	Ba	La	Ce	Nd	Hg	Pb	Th
d.l.				**0.09**	**0.04**	**0.01**	**0.0004**	**0.02**	**0.01**	**0.01**	**0.002**	**0.005**	**0.003**	**0.02**	**0.03**	**0.04**
39169	St. 1	4-5 cm	2008	15.14	6.61	6.06	0.11	<d.l.	<d.l.	0.94			0.25	0.19	0.39	
39170	St. 1	5-6 cm	2008	14.71	5.85	5.81	0.11	0.07	0.04	0.86			0.27	0.22	0.49	
39171	St. 2	4-5 cm	2008	11.94	5.94	5.93	0.09	0.03	<d.l.	0.67			0.19	0.17	0.25	
39172	St. 2	5-6 cm	2008	11.47	5.63	5.61	0.07	0.03	<d.l.	0.47			0.17	0.15	0.22	
39173	St. 3	4-5 cm	2008	14.54	6.17	6.64	0.10	0.04	<d.l.	0.57			0.24	0.22	0.40	
39174	St. 3	5-6 cm	2008	11.52	5.62	5.56	0.08	<d.l.	<d.l.	0.45			0.19	0.15	0.34	
39226	St. 4	4-5 cm	2008	10.31	5.62	5.75	0.10	0.03	<d.l.	0.54			0.25	0.22	0.31	
39227	St. 4	5-6 cm	2008	10.00	5.36	5.56	0.10	<d.l.	<d.l.	1.80			0.30	0.20	0.37	
39228	St. 5	4-5 cm	2008	10.85	6.51	5.81	0.09	0.03	<d.l.	0.40			0.20	0.21	0.26	
39228	St. 5	4-5 cm	2008	10.19	5.94	5.76	0.08	<d.l.	<d.l.	0.37			0.18	0.21	0.24	
39229	St. 5	5-6 cm	2008	10.92	5.35	5.63	0.08	0.03	<d.l.	0.66			0.18	0.20	0.31	
39205	St. 6	4-5 cm	2008	12.53	6.10	5.71	0.10	0.07	0.03	0.96			0.23	0.22	0.33	
39206	St. 6	5-6 cm	2008	12.15	6.14	5.96	0.10	0.03	<d.l.	0.90			0.22	0.22	0.31	
39207	St. 7	4-5 cm	2008	10.84	5.88	5.67	0.07	0.03	<d.l.	0.37			0.16	0.15	0.26	
39272	St. 8	4-5 cm	2008	11.58	6.33	6.04	0.09	<d.l.	<d.l.	1.07			0.28	0.21	0.33	
39273	St. 8	5-6 cm	2008	12.56	5.95	6.03	0.13	<d.l.	<d.l.	1.04			0.42	0.20	0.48	
39230	St. 9	4-5 cm	2008	11.15	5.36	5.40	0.09	0.09	<d.l.	0.53			0.19	0.22	0.31	
39231	St. 9	5-6 cm	2008	11.12	5.23	5.74	0.10	0.03	<d.l.	0.45			0.22	0.23	0.40	
39232	St. 10	4-5 cm	2008	14.42	5.76	6.03	0.11	0.04	<d.l.	0.88			0.25	0.21	0.38	
39233	St. 10	5-6 cm	2008	14.38	5.11	5.83	0.13	0.03	<d.l.	0.79			0.28	0.24	0.56	
39236	St. 12	4-5 cm	2008	10.66	5.64	5.75	0.12	0.03	<d.l.	2.12			0.31	0.16	0.30	
39274	St. 13	4-5 cm	2008	12.70	5.79	6.24	0.10	<d.l.	<d.l.	0.48			0.19	0.22	0.36	
39275	St. 13	5-6 cm	2008	12.29	5.55	6.16	0.10	<d.l.	<d.l.	0.37			0.20	0.19	0.34	
39275	St. 13	5-6 cm	2008	11.83	5.60	6.03	0.10	<d.l.	<d.l.	0.38			0.20	0.19	0.32	
39278	St. 15	4-5 cm	2008	10.25	6.30	5.94	0.06	0.04	<d.l.	0.28			0.12	0.17	0.22	
39279	St. 15	5-6 cm	2008	11.42	6.31	6.14	0.10	<d.l.	<d.l.	0.40			0.21	0.28	0.34	
39242	St 19	4-5 cm	2008	12.32	4.42	5.55	0.09	0.02	<d.l.	0.40			0.16	0.17	0.34	
39243	St 19	5-6 cm	2008	11.43	4.41	5.70	0.10	<d.l.	<d.l.	0.35			0.19	0.19	0.43	

ID no.	Station	Length	Year	As	Se	Rb	Y	Ag	Cs	Ba	La	Ce	Nd	Hg	Pb	Th
39260	St. 23	4-5 cm	2008	15.93	4.90	6.39	0.09	0.03	<d.l.	1.04			0.17	0.18	0.61	
39261	St. 23	5-6 cm	2008	14.17	4.51	6.33	0.08	0.01	<d.l.	0.87			0.17	0.16	0.55	
39209	St. 24	4-5 cm	2008	10.43	5.59	5.92	0.08	0.12	<d.l.	0.86			0.22	0.17	0.33	
39210	St. 24	5-6 cm	2008	12.37	5.88	5.53	0.12	0.03	<d.l.	0.96			0.32	0.25	0.41	
39275	St. 25	4-5 cm	2008	21.55	5.87	6.18	0.12	0.05	<d.l.	3.26			0.35	0.21	0.72	
39276	St. 25	5-6 cm	2008	6.26	1.64	1.73	0.03	0.03	<d.l.	0.74			0.09	0.05	0.23	
39211	St. 26	4-5 cm	2008	11.42	6.01	5.70	0.09	0.09	<d.l.	1.95			0.25	0.18	0.28	
39212	St. 26	5-6 cm	2008	13.41	5.36	5.96	0.11	0.08	<d.l.	1.73			0.26	0.20	0.37	
41221	St. 23	4-5 cm	2009	18.83	4.84	8.57	0.12	<d.l.	<d.l.	2.02	0.446	0.474	0.29	0.22	0.66	<d.l.
41221	St. 23	4-5 cm	2009	19.28	4.83	8.56	0.12	<d.l.	<d.l.	2.61	0.426	0.442	0.27	0.14	0.63	<d.l.
41222	St. 23	5-6 cm	2009	18.27	4.65	8.29	0.12	<d.l.	<d.l.	0.88	0.368	0.312	0.23	<d.l.	0.65	<d.l.
41225	St. 19	4-5 cm	2009	14.78	4.00	7.87	0.08	<d.l.	<d.l.	1.02	0.283	0.210	0.17	<d.l.	0.35	<d.l.
41228	St. 1	4-5 cm	2009	16.33	5.45	8.05	0.12	<d.l.	<d.l.	1.38	0.621	0.508	0.39	0.14	0.37	<d.l.
41229	St. 1	5-6 cm	2009	17.99	4.40	7.74	0.14	<d.l.	<d.l.	1.71	0.656	0.528	0.41	0.15	0.41	<d.l.
41230	St. 24	4-5 cm	2009	15.54	5.20	7.32	0.15	<d.l.	<d.l.	2.14	0.786	0.751	0.51	0.12	0.34	0.05
41231	St. 26	4-5 cm	2009	17.14	6.10	7.66	0.16	<d.l.	<d.l.	2.16	0.820	0.811	0.55	0.15	0.36	0.06
41251	St. 6	4-5 cm	2009	15.02	5.20	7.96	0.11	<d.l.	<d.l.	1.03	0.453	0.373	0.30	0.13	0.29	<d.l.
41252	St. 7	4-5 cm	2009	12.32	4.58	7.84	0.08	<d.l.	<d.l.	0.79	0.348	0.317	0.23	<d.l.	0.50	<d.l.
41253	St. 8	4-5 cm	2009	13.10	4.59	7.92	0.08	<d.l.	<d.l.	3.02	0.411	0.391	0.25	<d.l.	0.30	<d.l.
41259	St. 25	4-5 cm	2009	26.34	5.26	8.66	0.14	<d.l.	0.05	2.26	0.638	0.666	0.43	0.12	0.61	<d.l.
41260	St. 25	5-6 cm	2009	27.26	4.62	7.99	0.15	<d.l.	0.04	2.76	0.787	0.757	0.48	0.12	0.81	<d.l.
41261	St. 26	5-6 cm	2009	16.57	5.19	7.67	0.10	<d.l.	<d.l.	1.19	0.478	0.424	0.33	0.10	0.36	<d.l.
41276	St. 9	4-5 cm	2009	14.37	4.81	7.80	0.11	<d.l.	<d.l.	1.16	0.580	0.516	0.39	0.15	0.46	<d.l.
41276	St. 9	4-5 cm	2009	14.72	5.03	7.64	0.12	<d.l.	<d.l.	1.07	0.501	0.395	0.33	0.14	0.43	<d.l.
41277	St. 10	4-5 cm	2009	16.10	4.83	8.60	0.12	<d.l.	<d.l.	2.28	0.470	0.414	0.32	0.12	0.36	<d.l.
41278	St. 12	4-5 cm	2009	13.20	5.37	8.00	0.10	<d.l.	<d.l.	1.75	0.557	0.620	0.35	<d.l.	0.27	<d.l.
41279	St. 15	4-5 cm	2009	15.32	5.18	7.57	0.09	<d.l.	<d.l.	0.60	0.450	0.333	0.26	0.15	0.32	<d.l.
41280	St. 5	4-5 cm	2009	14.20	5.38	7.69	0.12	<d.l.	<d.l.	1.47	0.555	0.476	0.36	0.14	0.30	<d.l.
41286	St. 2	4-5 cm	2009	12.84	5.44	7.74	0.09	<d.l.	<d.l.	0.88	0.448	0.345	0.29	0.12	0.27	<d.l.
41287	St. 3	4-5 cm	2009	12.69	5.76	7.45	0.10	<d.l.	0.04	0.63	0.417	0.311	0.28	0.12	0.25	<d.l.
41288	St. 4	4-5 cm	2009	13.21	5.24	7.36	0.10	<d.l.	<d.l.	0.63	0.451	0.324	0.29	0.15	0.28	<d.l.
41289	St. 13	4-5 cm	2009	13.65	5.55	7.48	0.09	<d.l.	<d.l.	0.70	0.359	0.254	0.23	<d.l.	0.33	<d.l.
41294	Ref	4-5 cm	2009	13.49	3.91	7.96	0.07	<d.l.	<d.l.	1.26	0.266	0.209	0.16	<d.l.	0.35	<d.l.
41297	Ref	5-6 cm	2009	13.73	3.83	7.66	0.11	<d.l.	<d.l.	2.98	0.428	0.460	0.27	<d.l.	0.39	<d.l.

Appendix 3. Analyses of seaweed

Chemical analyses of brown seaweed (*Fucus vesiculosus*), µg/g dry weight.

ID no.	Station	Year	Li	Al	V	Cr	Mn	Fe	Ni	Co	Cu	Zn	As
d.l.			**0.02**	**1**	**0.01**	**0.12**	**0.08**	**8**	**0.16**	**0.04**	**0.08**	**0.42**	**0.09**
39161	St. 1	2008	0.35	15	0.19	0.31	26.55	27	1.258	0.363	3.678	9.245	68.381
39162	St. 1	2008	0.42	9	0.20	0.24	19.80	25	1.083	0.303	3.498	9.253	56.657
39163	St. 2	2008	0.41	6	0.19	0.28	14.63	20	1.088	0.241	3.084	8.472	55.121
39164	St. 2	2008	0.51	5	0.19	0.29	15.30	20	1.008	0.221	3.123	7.709	52.924
39164	St. 2	2008	0.42	5	0.18	0.25	14.22	18	0.951	0.211	2.955	7.358	49.342
39165	St. 3	2008	0.26	10	0.17	0.41	20.68	27	1.013	0.320	3.213	10.329	57.400
39166	St. 3	2008	0.25	9	0.16	0.28	18.75	24	0.937	0.290	3.027	9.260	53.005
39214	St. 4	2008	0.30	3	0.18	0.43	65.08	19	1.066	0.373	2.935	7.983	67.604
39215	St. 4	2008	0.40	5	0.17	0.32	52.68	19	0.996	0.337	2.676	8.063	65.996
39216	St. 5	2008	0.33	5	0.15	0.40	46.60	28	1.032	0.391	2.732	9.087	65.071
39217	St. 5	2008	0.33	5	0.16	0.31	35.35	22	0.960	0.390	2.768	9.226	63.873
39197	St. 6	2008	0.28	6	0.21	0.29	25.79	24	1.162	0.341	2.441	7.056	50.513
39198	St. 6	2008	0.36	6	0.21	0.30	13.75	22	0.944	0.227	3.397	7.802	49.150
39199	St. 7	2008	0.28	4	0.24	0.37	18.35	18	1.133	0.282	2.451	6.189	49.150
39200	St. 7	2008	0.31	12	0.25	0.33	18.73	18	1.296	0.346	2.382	6.504	52.541
39262	St. 8	2008	0.34	5	0.18	0.25	11.29	22	0.790	0.191	2.417	6.328	44.966
39263	St. 8	2008	0.29	8	0.17	0.36	10.28	26	0.865	0.203	3.134	7.648	46.811
39218	St. 9	2008	0.41	3	0.16	0.24	13.38	19	1.138	0.223	3.146	6.194	46.001
39218	St. 9	2008	0.46	3	0.16	0.24	13.85	17	0.983	0.227	3.258	6.467	48.121
39219	St. 9	2008	0.45	3	0.20	0.25	11.44	14	0.794	0.219	3.225	5.949	49.965
39220	St.10	2008	0.33	29	0.23	2.15	22.42	54	1.493	0.430	3.911	7.487	68.296
39221	St.10	2008	0.42	52	0.23	0.36	19.96	24	1.038	0.312	3.018	7.412	55.299
39224	St.12	2008	0.36	7	0.16	0.23	11.84	20	0.956	0.231	2.518	6.847	46.079
39225	St.12	2008	0.49	13	0.23	0.27	12.81	21	1.055	0.240	2.270	6.442	51.058
39264	St.13	2008	0.40	4	0.26	0.31	9.22	16	1.127	0.186	2.431	6.256	39.499
39265	St.13	2008	0.45	4	0.20	0.22	8.19	16	0.946	0.185	3.221	6.474	41.390
39268	St.15	2008	0.35	3	0.20	0.22	15.26	15	1.200	0.230	2.026	5.820	46.120
39269	St.15	2008	0.44	4	0.20	0.22	13.07	21	0.935	0.214	3.140	6.780	47.812
39252	St.19	2008	0.43	<d.l.	0.27	<d.l.	10.73	<d.l.	1.041	0.228	2.792	6.159	39.069
39253	St.19	2008	0.40	2	0.25	0.18	15.98	13	1.193	0.278	2.488	6.511	49.648
39258	St.23	2008	0.38	2	0.29	0.14	12.30	14	1.270	0.340	1.766	5.565	52.937
39259	St.23	2008	0.43	3	0.28	0.42	9.64	16	1.284	0.245	2.170	7.962	37.966
39259	St.23	2008	0.39	3	0.26	0.20	9.71	15	1.292	0.244	2.142	7.907	37.564
39201	St.24	2008	0.28	2	0.17	0.43	73.37	19	1.211	0.374	2.724	11.991	61.904
39202	St.24	2008	0.31	2	0.18	0.24	61.54	19	1.214	0.343	2.962	9.556	58.927
39167	St.25	2008	0.27	26	0.30	1.01	56.77	111	4.272	0.655	2.602	10.352	52.915
39168	St.25	2008	0.31	33	0.33	1.04	65.50	76	4.666	0.668	2.312	10.327	45.489
39203	St. 26	2008	0.28	2	0.15	0.18	82.50	21	1.387	0.391	2.890	9.317	57.923
39203	St. 26	2008	0.25	3	0.18	0.24	92.43	22	1.434	0.438	2.436	10.041	63.612
39204	St. 26	2008	0.27	3	0.19	0.23	71.50	22	1.369	0.381	3.039	11.293	61.859
41232	St. 1	2009	0.39	27	0.29	0.25	16.38	123	1.788	0.415	4.803	13.881	65.442
41223	St. 23	2009	0.55	6	0.28	0.10	9.08	85	0.996	0.376	2.584	9.331	58.635
41226	St. 19	2009	0.60	8	0.32	0.12	10.60	90	1.514	0.368	3.776	10.708	48.742
41226	St. 19	2009	0.59	7	0.30	0.12	9.99	86	1.505	0.358	3.679	10.097	45.387

ID no.	Station	Year	Li	Al	V	Cr	Mn	Fe	Ni	Co	Cu	Zn	As
41233	St. 24	2009	0.36	15	0.28	0.28	27.90	116	2.375	0.492	13.076	21.454	74.269
41234	St. 26	2009	0.51	11	0.23	0.18	24.29	92	1.409	0.442	4.082	16.951	84.851
41254	St. 25	2009	0.39	40	0.47	0.58	18.61	179	4.090	0.595	3.288	17.127	64.690
41255	St. 25	2009	0.41	107	0.60	1.36	23.88	215	6.708	0.735	3.310	16.196	57.522
41256	St. 26	2009	0.37	22	0.33	0.29	27.19	117	2.583	0.523	4.793	21.452	68.488
41257	St. 6	2009	0.36	28	0.30	0.23	17.75	125	2.416	0.452	9.928	13.700	64.695
41258	St. 8	2009	0.41	74	0.49	0.31	14.85	173	1.540	0.432	8.942	14.815	64.667
41281	St. 9	2009	0.43	25	0.28	0.20	11.99	103	1.280	0.391	3.599	11.087	55.912
41282	St. 10	2009	0.52	23	0.40	0.21	13.29	112	1.976	0.486	5.043	12.050	59.634
41283	St. 12	2009	0.48	32	0.26	0.20	11.24	114	1.136	0.456	3.281	10.137	54.785
41284	St. 15	2009	0.43	13	0.27	0.21	11.80	95	1.289	0.384	3.594	9.763	53.544
41285	St. 5	2009	0.42	12	0.25	0.12	12.64	87	1.425	0.398	3.760	12.911	57.629
41290	St. 2	2009	0.52	12	0.28	0.19	19.37	102	2.008	0.422	4.257	15.304	60.227
41290	St. 2	2009	0.52	12	0.28	0.26	19.98	102	2.026	0.424	4.231	15.534	60.354
41291	St. 3	2009	0.37	26	0.29	0.21	16.84	135	1.748	0.465	5.146	15.714	60.561
41292	St. 4	2009	0.43	10	0.21	0.09	18.22	86	1.434	0.395	3.961	13.644	65.167
41293	St. 13	2009	0.52	10	0.28	0.14	9.05	90	1.277	0.357	3.966	9.695	46.985

ID no.	Station	Year	Se	Rb	Y	Ag	Sn	Cs	Ba	La	Nd	Hg	Pb
d.l.			**0.04**	**0.01**	**0.0004**	**0.02**	**0.09**	**0.01**	**0.01**	**0.002**	**0.003**	**0.02**	**0.03**
39161	St. 1	2008	<d.l.	10.333	0.052	0.05		0.03	11.21		0.07	<d.l.	0.05
39162	St. 1	2008	<d.l.	10.714	0.049	0.05		0.03	10.11		0.06	<d.l.	0.04
39163	St. 2	2008	<d.l.	12.036	0.040	0.04		0.04	9.23		0.05	<d.l.	0.03
39164	St. 2	2008	<d.l.	11.630	0.035	0.04		0.04	9.30		0.04	<d.l.	0.03
39164	St. 2	2008	<d.l.	11.106	0.033	0.02		0.04	9.08		0.04	<d.l.	<d.l.
39165	St. 3	2008	<d.l.	9.147	0.054	0.04		<d.l.	11.19		0.08	<d.l.	0.03
39166	St. 3	2008	0.113	8.599	0.046	0.06		0.05	10.83		0.08	<d.l.	0.04
39214	St. 4	2008	<d.l.	10.127	0.044	0.04		0.04	11.02		0.05	<d.l.	0.03
39215	St. 4	2008	<d.l.	9.617	0.034	0.04		0.04	9.53		0.05	<d.l.	0.04
39216	St. 5	2008	<d.l.	9.543	0.038	0.03		0.04	9.49		0.04	<d.l.	0.03
39217	St. 5	2008	<d.l.	9.379	0.051	0.05		0.04	9.91		0.04	<d.l.	0.04
39197	St. 6	2008	<d.l.	8.737	0.039	<d.l.		0.03	12.70		0.05	<d.l.	0.03
39198	St. 6	2008	<d.l.	9.402	0.053	<d.l.		0.04	10.15		0.05	<d.l.	0.02
39199	St. 7	2008	<d.l.	8.719	0.054	0.03		<d.l.	9.55		0.06	<d.l.	<d.l.
39200	St. 7	2008	<d.l.	8.297	0.039	0.03		<d.l.	10.17		0.07	0.06	0.04
39262	St. 8	2008	<d.l.	9.338	0.043	<d.l.		<d.l.	17.14		0.08	<d.l.	<d.l.
39263	St. 8	2008	<d.l.	11.427	0.032	0.03		<d.l.	36.28		0.16	<d.l.	<d.l.
39218	St. 9	2008	<d.l.	18.970	0.032	0.03		0.04	8.44		0.04	<d.l.	<d.l.
39218	St. 9	2008	<d.l.	19.162	0.036	0.02		0.04	8.54		0.04	<d.l.	<d.l.
39219	St. 9	2008	<d.l.	17.252	0.045	0.03		0.03	8.06		0.04	<d.l.	0.03
39220	St.10	2008	<d.l.	13.987	0.048	0.05		0.04	9.47		0.05	0.07	0.04
39221	St.10	2008	<d.l.	17.418	0.033	<d.l.		0.03	15.88		0.06	1.18	0.09
39224	St.12	2008	<d.l.	18.988	0.037	<d.l.		0.04	16.74		0.04	0.06	<d.l.
39225	St.12	2008	<d.l.	17.821	0.035	0.02		0.03	12.62		0.04	0.20	<d.l.
39264	St.13	2008	<d.l.	18.671	0.032	<d.l.		0.04	14.64		0.04	0.15	<d.l.
39265	St.13	2008	<d.l.	19.249	0.040	<d.l.		0.04	14.82		0.03	0.09	<d.l.
39268	St.15	2008	<d.l.	19.632	0.045	<d.l.		0.04	17.76		0.05	<d.l.	<d.l.
39269	St.15	2008	<d.l.	20.263	0.045	<d.l.		0.04	16.48		0.06	0.08	0.02
39252	St.19	2008	0.119	20.976	0.053	<d.l.		0.05	15.31		0.04	0.06	0.05
39253	St.19	2008	<d.l.	18.732	0.047	<d.l.		0.04	16.21		0.05	<d.l.	0.03

ID no.	Station	Year	Se	Rb	Y	Ag	Sn	Cs	Ba	La	Nd	Hg	Pb
39258	St.23	2008	<d.l.	14.195	0.004	<d.l.		0.03	8.42		0.04	<d.l.	0.03
39259	St.23	2008	<d.l.	22.071	0.041	<d.l.		0.05	8.61		0.04	0.06	0.07
39259	St.23	2008	<d.l.	21.459	0.039	<d.l.		0.04	8.45		0.04	<d.l.	0.06
39201	St.24	2008	<d.l.	13.170	0.037	0.08		<d.l.	19.35		0.05	<d.l.	0.03
39202	St.24	2008	<d.l.	10.632	0.043	0.05		<d.l.	18.78		0.06	0.05	<d.l.
39167	St.25	2008	<d.l.	19.550	0.049	<d.l.		0.04	24.35		0.08	<d.l.	<d.l.
39168	St.25	2008	<d.l.	19.484	0.056	<d.l.		0.04	22.12		0.09	<d.l.	0.03
39203	St. 26	2008	<d.l.	16.286	0.037	0.05		<d.l.	22.78		0.06	0.05	0.03
39203	St. 26	2008	<d.l.	16.626	0.038	0.07		<d.l.	21.82		0.06	0.14	<d.l.
39204	St. 26	2008	<d.l.	16.622	0.041	0.14		<d.l.	20.85		0.06	0.04	<d.l.
41232	St. 1	2009	<d.l.	10.572	0.147	<d.l.	<d.l.	<d.l.	18.02	0.358	0.28	<d.l.	<d.l.
41223	St. 23	2009	<d.l.	14.227	0.078	<d.l.	0.19	<d.l.	7.78	0.042	0.04	<d.l.	<d.l.
41226	St. 19	2009	0.028	11.782	0.095	<d.l.	<d.l.	<d.l.	9.50	0.083	0.07	<d.l.	<d.l.
41226	St. 19	2009	<d.l.	11.335	0.094	<d.l.	<d.l.	<d.l.	8.82	0.075	0.07	<d.l.	<d.l.
41233	St. 24	2009	<d.l.	14.848	0.133	0.19	<d.l.	<d.l.	19.57	0.284	0.23	<d.l.	<d.l.
41234	St. 26	2009	<d.l.	17.510	0.118	0.15	<d.l.	0.06	13.98	0.193	0.18	<d.l.	<d.l.
41254	St. 25	2009	<d.l.	13.019	0.128	<d.l.	<d.l.	<d.l.	32.83	0.406	0.31	<d.l.	<d.l.
41255	St. 25	2009	<d.l.	11.711	0.145	<d.l.	<d.l.	<d.l.	26.60	0.459	0.36	<d.l.	0.07
41256	St. 26	2009	<d.l.	12.060	0.150	0.14	<d.l.	<d.l.	20.01	0.369	0.29	<d.l.	<d.l.
41257	St. 6	2009	<d.l.	11.955	0.115	<d.l.	0.35	<d.l.	13.84	0.219	0.20	<d.l.	<d.l.
41258	St. 8	2009	<d.l.	11.838	0.132	<d.l.	<d.l.	<d.l.	21.01	0.577	0.42	<d.l.	<d.l.
41281	St. 9	2009	<d.l.	10.076	0.091	<d.l.	<d.l.	<d.l.	9.73	0.147	0.14	<d.l.	<d.l.
41282	St. 10	2009	<d.l.	11.301	0.117	<d.l.	<d.l.	<d.l.	11.87	0.218	0.18	<d.l.	<d.l.
41283	St. 12	2009	<d.l.	10.410	0.072	<d.l.	<d.l.	<d.l.	9.87	0.121	0.11	<d.l.	<d.l.
41284	St. 15	2009	<d.l.	9.684	0.109	<d.l.	<d.l.	<d.l.	11.89	0.198	0.16	<d.l.	<d.l.
41285	St. 5	2009	<d.l.	11.066	0.095	<d.l.	<d.l.	<d.l.	10.48	0.152	0.14	<d.l.	<d.l.
41290	St. 2	2009	0.089	13.463	0.113	<d.l.	<d.l.	<d.l.	12.92	0.297	0.26	<d.l.	<d.l.
41290	St. 2	2009	<d.l.	13.627	0.115	<d.l.	<d.l.	<d.l.	13.05	0.299	0.26	<d.l.	<d.l.
41291	St. 3	2009	<d.l.	11.082	0.170	<d.l.	<d.l.	<d.l.	20.27	0.494	0.40	<d.l.	<d.l.
41292	St. 4	2009	<d.l.	14.617	0.081	<d.l.	<d.l.	<d.l.	10.72	0.147	0.14	<d.l.	<d.l.
41293	St. 13	2009	<d.l.	10.884	0.072	<d.l.	<d.l.	<d.l.	10.09	0.103	0.09	<d.l.	<d.l.

Appendix 4. Analyses of lichens

Chemical analyses of lichens (*Cetraria nivalis*) µg/g dry weight.

ID no.	Station	Year	Notes	Li	Al	V	Cr	Mn	Fe	Ni	Co	Cu	Zn	As	Se
d.l.				**0.02**	**1**	**0.01**	**0.12**	**0.08**	**8**	**0.16**	**0.04**	**0.08**	**0.42**	**0.09**	**0.04**
36544	Lav 1	2008	Nat.	0.21	635	0.54	44.88	106.84	1719	95.69	4.08	1.52	24.48	<d.l.	0.11
36544	Lav 1	2008	Nat.	0.22	660	0.62	54.28	109.32	1829	99.52	4.23	1.63	24.36	<d.l.	0.10
36545	Lav 2	2008	Nat.	0.20	628	0.75	32.98	125.31	1533	94.01	4.03	1.57	23.17	<d.l.	0.10
36546	Lav 3	2008	Nat.	0.15	289	0.46	20.47	68.08	957	60.30	2.63	1.74	35.19	<d.l.	<d.l.
36547	Lav 4	2008	Nat.	0.09	221	0.28	7.60	210.71	357	25.93	1.35	1.28	40.98	<d.l.	<d.l.
36548	Lav 5	2008	Nat.	0.11	212	0.18	18.85	129.67	587	42.43	1.98	1.05	32.40	<d.l.	<d.l.
36549	Lav 6	2008	Nat.	0.06	218	0.20	14.26	27.09	440	37.96	1.85	0.71	10.00	<d.l.	0.09
36550	Lav 8	2008	Nat.	0.06	177	0.24	6.99	131.19	289	25.09	1.29	0.94	29.19	<d.l.	0.11
36551	Lav 9	2008	Nat.	0.06	205	0.22	9.57	105.96	408	30.51	1.51	1.08	29.85	<d.l.	0.08
36552	Lav 10	2008	Nat.	0.08	193	0.21	16.75	116.86	605	45.64	2.08	0.98	22.14	<d.l.	0.09
36553	St. 1	2008	Nat.	<d.l.	135	0.16	1.85	82.63	88	4.44	0.24	0.71	22.71	<d.l.	0.09
36554	St. 2	2008	Nat.	0.04	155	0.24	1.90	165.85	121	5.75	0.36	0.69	32.41	<d.l.	0.15
36555	St. 3	2008	Nat.	<d.l.	142	0.18	0.84	17.78	68	1.44	0.10	0.59	7.69	<d.l.	<d.l.
36556	St. 5	2008	Nat.	0.03	164	0.21	1.35	90.67	117	5.74	0.33	0.66	16.97	<d.l.	0.11
36557	St. 6	2008	Nat.	<d.l.	156	0.19	2.02	52.00	104	5.70	0.38	0.60	33.31	<d.l.	<d.l.
36557	St. 6	2008	Nat.	<d.l.	198	0.19	4.18	68.10	114	5.96	0.44	0.61	35.65	<d.l.	0.09
36558	St. 7	2008	Nat.	0.07	416	0.29	2.37	171.28	130	3.18	0.26	1.05	28.25	<d.l.	<d.l.
36559	St. 8	2008	Nat.	0.06	798	0.55	1.90	85.60	214	3.03	0.46	0.83	22.43	<d.l.	0.12
36560	St. 9	2008	Nat.	0.05	531	0.39	3.46	23.70	175	6.55	0.54	0.92	25.16	<d.l.	0.18
36561	St.10	2008	Nat.	0.07	628	0.47	6.17	30.58	228	10.05	0.61	0.88	15.26	<d.l.	0.11
36564	St. 13	2008	Nat.	<d.l.	166	0.18	1.02	11.11	73	1.33	0.15	0.46	15.73	<d.l.	0.11
36566	St. 15	2008	Nat.	<d.l.	161	0.21	0.40	17.07	64	0.64	0.09	0.64	13.89	0.26	0.13
36570	St.19	2008	Nat.	<d.l.	110	0.13	0.22	22.75	44	0.36	0.04	0.54	9.98	<d.l.	<d.l.
36573	St.23	2008	Nat.	0.05	415	0.29	0.55	7.96	103	0.54	0.07	0.63	10.92	<d.l.	0.09
36576	St.26	2008	Nat.	0.10	601	0.69	9.75	59.15	378	25.19	1.17	0.77	12.67	<d.l.	<d.l.
36576	St. 26	2008	Nat.	0.13	932	0.95	14.45	69.23	461	26.14	1.22	0.81	12.15	0.54	0.11
41224	St. 23	2009	Nat.	0.04	213	0.26	0.42	6.66	112	0.42	0.07	0.81	6.42	0.14	0.07
41224	St. 23	2009	Nat.	0.03	178	0.26	0.35	7.62	109	0.42	<d.l.	0.53	7.32	0.15	0.08
41227	St. 19	2009	Nat.	0.02	98	0.14	0.22	11.15	59	0.34	<d.l.	0.49	7.57	0.21	0.04
41235	St. 1	2009	Trans	0.04	266	0.39	1.21	30.27	200	2.99	0.21	0.90	11.71	0.09	0.09
41236	St. 24	2009	Trans	0.16	742	1.66	7.59	47.41	998	22.81	1.89	1.34	16.75	0.08	0.10
41237	St. 26	2009	Trans	0.09	559	0.82	4.21	47.32	475	9.95	0.59	0.92	13.30	0.06	0.07
41238	St. 6	2009	Trans	0.09	505	0.73	1.90	34.30	356	5.02	0.45	0.82	16.31	0.04	0.08
41239	St. 7	2009	Nat.	0.06	251	0.35	1.03	10.83	156	1.44	0.11	0.73	6.86	0.10	0.05
41262	Lav 1	2009	Trans	0.14	338	0.71	17.15	50.37	1054	44.22	1.94	1.02	12.76	0.04	0.08
41263	Lav 5	2009	Trans	0.10	481	0.76	5.56	44.06	575	16.97	0.94	0.95	21.83	0.04	0.07
41264	Lav 6	2009	Trans	0.11	596	1.01	4.02	44.67	570	11.73	0.75	1.10	26.40	0.08	0.09
41295	Lav 11	2009	Nat.	0.08	433	0.59	3.65	58.44	307	6.90	0.60	0.93	14.33	0.16	0.12
41298	St. 2	2009	Trans	0.10	621	0.82	2.28	36.07	438	4.24	0.35	0.78	11.45	0.07	0.12
41299	St. 3	2009	Trans	0.09	722	0.78	2.22	28.99	415	2.87	0.29	0.89	13.53	0.10	0.11
41300	Lav 18	2009	Nat.	0.09	640	0.96	6.42	36.73	478	9.44	0.75	1.63	17.38	0.07	0.13
41301	Lav 15	2009	Trans	0.06	324	0.67	1.75	101.83	270	2.95	0.33	0.74	14.88	0.05	0.07
41302	Lav 8	2009	Trans	0.17	862	1.69	4.37	55.03	849	8.83	0.71	1.21	22.99	0.06	0.10
41303	St. 5	2009	Nat.	0.03	198	0.31	1.51	33.59	144	3.04	0.21	0.52	16.86	0.12	0.06
41304	Lav 14	2009	Nat.	0.04	250	0.36	1.68	46.55	165	2.69	0.22	0.62	17.26	0.02	0.08

ID no.	Station	Year	Notes	Li	Al	V	Cr	Mn	Fe	Ni	Co	Cu	Zn	As	Se
41305	Lav 10	2009	Trans	0.06	282	0.48	6.17	32.50	417	16.20	0.77	0.66	12.99	0.08	0.09
41306	Lav 9	2009	Trans	0.07	450	0.64	3.38	41.44	382	8.67	0.52	0.89	14.47	0.05	0.08
41307	St. 10	2009	Nat.	0.02	122	0.18	1.16	24.48	94	1.77	0.12	0.67	11.05	0.08	0.11
41308	Lav 3	2009	Trans	0.08	293	0.59	7.47	37.33	599	23.44	1.09	0.71	14.48	0.07	0.09
41308	Lav 3	2009	Trans	0.09	380	0.68	8.90	41.18	673	23.39	1.11	0.91	15.16	0.07	0.09
41309	St. 9	2009	Trans	0.10	623	0.93	2.14	49.46	452	5.86	0.56	1.02	24.60	0.06	0.09
41310	Lav 8	2009	Nat.	0.06	205	0.40	7.39	57.30	323	15.75	0.85	0.68	12.16	0.06	0.09
41311	Lav 17	2009	Nat.	0.04	153	0.26	2.28	91.29	150	4.69	0.32	0.53	28.55	0.04	0.06
41312	St. 13	2009	Nat.	0.04	238	0.39	0.98	38.49	165	1.48	0.14	0.55	12.74	0.04	0.05
41313	Lav 3A	2009	Nat.	0.10	286	0.36	18.54	33.63	699	26.20	1.11	0.95	10.59	0.08	0.07
41314	Lav 4	2009	Trans	0.15	783	1.09	2.40	76.50	514	5.89	0.68	1.31	20.46	0.07	0.09
41315	St. 8	2009	Nat.	0.13	636	1.00	2.75	14.68	440	5.31	0.42	0.65	6.93	0.06	0.12
41316	Lav 2	2009	Trans	0.15	391	1.17	12.91	64.03	1030	37.69	1.79	0.77	11.47	0.18	0.13
41316	Lav 2	2009	Trans	0.10	333	0.60	10.30	48.05	629	23.75	1.14	0.70	12.33	0.11	0.12
41317	Lav 4	2009	Nat.	0.05	230	0.30	5.31	59.24	220	7.41	0.41	0.68	17.94	0.05	0.08
41318	St. 4	2009	Nat.	0.04	227	0.39	1.13	161.36	177	2.19	0.21	0.67	24.88	0.03	0.04
41319	St. 12	2009	Nat.	0.04	218	0.31	1.82	24.75	171	3.28	0.24	1.27	9.49	0.07	0.05
41320	St. 15	2009	Nat.	0.10	581	0.88	1.16	13.75	385	0.89	0.16	0.92	12.55	0.27	0.10

ID no.	Station	Year	Notes	Rb	Y	Ag	Sn	Cs	Ba	La	Ce	Nd	Hg	Pb	Th
d.l.				**0.01**	**0.0004**	**0.02**	**0.09**	**0.01**	**0.01**	**0.002**	**0.005**	**0.003**	**0.02**	**0.03**	**0.04**
36544	Lav 1	2008	Nat.	6.89	0.422	<d.l.		0.21	19.18			1.097	0.17	1.79	
36544	Lav 1	2008	Nat.	7.45	0.410	0.03		0.22	20.16			1.148	0.32	1.87	
36545	Lav 2	2008	Nat.	6.28	0.302	0.04		0.21	18.13			0.692	0.47	1.92	
36546	Lav 3	2008	Nat.	7.86	0.176	0.03		0.16	17.56			0.432	0.11	0.68	
36547	Lav 4	2008	Nat.	5.64	0.086	0.08		0.06	14.71			0.198	0.09	0.50	
36548	Lav 5	2008	Nat.	7.51	0.154	0.06		0.19	10.42			0.342	0.05	0.72	
36549	Lav 6	2008	Nat.	3.59	0.118	0.06		0.12	6.01			0.253	0.07	0.56	
36550	Lav 8	2008	Nat.	6.48	0.092	0.07		0.10	8.75			0.202	0.08	0.51	
36551	Lav 9	2008	Nat.	5.71	0.120	0.06		0.13	16.27			0.253	0.08	0.68	
36552	Lav 10	2008	Nat.	4.62	0.159	0.07		0.16	11.14			0.404	0.12	0.63	
36553	St. 1	2008	Nat.	6.51	0.068	0.05		0.13	8.59			0.158	0.13	0.57	
36554	St. 2	2008	Nat.	3.78	0.057	0.05		0.06	12.39			0.136	0.09	0.64	
36555	St. 3	2008	Nat.	0.85	0.057	0.03		<d.l.	3.50			0.145	0.05	0.52	
36556	St. 5	2008	Nat.	3.12	0.057	0.02		0.04	8.81			0.134	0.06	0.54	
36557	St. 6	2008	Nat.	2.81	0.063	<d.l.		0.06	7.06			0.162	0.07	0.50	
36557	St. 6	2008	Nat.	3.10	0.069	<d.l.		0.06	8.48			0.166	0.08	0.50	
36558	St. 7	2008	Nat.	2.35	0.074	<d.l.		0.03	9.72			0.178	0.07	0.68	
36559	St. 8	2008	Nat.	3.18	0.174	0.02		0.04	43.07			0.415	0.08	1.34	
36560	St. 9	2008	Nat.	3.72	0.168	0.04		0.06	14.09			0.399	0.10	1.51	
36561	St.10	2008	Nat.	3.07	0.095	0.03		0.04	29.81			0.212	0.08	0.75	
36564	St. 13	2008	Nat.	1.66	0.066	<d.l.		0.04	4.65			0.172	0.31	0.57	
36566	St. 15	2008	Nat.	2.37	0.056	0.04		0.06	6.25			0.132	<d.l.	0.51	
36570	St.19	2008	Nat.	1.47	0.027	<d.l.		<d.l.	2.83			0.078	<d.l.	0.23	
36573	St.23	2008	Nat.	0.88	0.079	<d.l.		<d.l.	3.30			0.210	0.08	0.57	
36576	St.26	2008	Nat.	2.75	0.113	<d.l.		0.08	9.19			0.278	0.12	0.86	
36576	St. 26	2008	Nat.	2.92	0.146	<d.l.		0.08	18.61			0.379	0.05	0.89	
41224	St. 23	2009	Nat.	0.96	0.071	0.03	<d.l.	0.02	2.62	0.171	0.367	0.150	0.03	0.46	<d.l.
41224	St. 23	2009	Nat.	0.98	0.065	0.02	<d.l.	0.02	3.09	0.162	0.347	0.144	0.02	0.35	<d.l.
41227	St. 19	2009	Nat.	0.90	0.028	<d.l.	<d.l.	0.02	1.56	0.065	0.141	0.054	<d.l.	0.12	<d.l.
41235	St. 1	2009	Trans	3.11	0.096	0.07	<d.l.	0.04	14.89	0.274	0.543	0.209	0.02	1.66	<d.l.

ID no.	Station	Year	Notes	Rb	Y	Ag	Sn	Cs	Ba	La	Ce	Nd	Hg	Pb	Th
41236	St. 24	2009	Trans	3.45	0.363	0.05	<d.l.	0.08	21.56	0.920	1.790	0.716	0.03	1.57	<d.l.
41237	St. 26	2009	Trans	2.70	0.159	0.04	<d.l.	0.06	14.55	0.481	0.946	0.358	0.02	1.20	<d.l.
41238	St. 6	2009	Trans	2.07	0.177	0.02	<d.l.	0.04	12.69	0.468	0.916	0.356	<d.l.	1.18	<d.l.
41239	St. 7	2009	Nat.	1.05	0.088	<d.l.	<d.l.	0.01	3.27	0.285	0.583	0.231	<d.l.	0.26	<d.l.
41262	Lav 1	2009	Trans	2.66	0.178	0.03	<d.l.	0.08	14.32	0.612	1.208	0.499	0.02	1.02	<d.l.
41263	Lav 5	2009	Trans	3.07	0.175	0.04	<d.l.	0.07	15.71	0.478	0.931	0.360	0.02	1.21	<d.l.
41264	Lav 6	2009	Trans	3.70	0.247	0.05	<d.l.	0.09	17.30	0.811	1.577	0.604	0.03	1.74	<d.l.
41295	Lav 11	2009	Nat.	3.24	0.195	0.05	<d.l.	0.05	9.34	0.508	0.990	0.388	0.02	0.68	<d.l.
41298	St. 2	2009	Trans	1.83	0.200	0.07	<d.l.	0.04	17.70	0.588	1.159	0.451	0.01	2.24	<d.l.
41299	St. 3	2009	Trans	2.92	0.226	0.04	<d.l.	0.06	19.32	0.768	1.546	0.598	0.02	1.90	<d.l.
41300	Lav 18	2009	Nat.	3.80	0.284	0.02	<d.l.	0.09	10.02	0.790	1.488	0.526	0.03	2.86	<d.l.
41301	Lav 15	2009	Trans	3.26	0.175	0.02	<d.l.	0.03	19.20	0.433	0.897	0.362	0.02	0.86	<d.l.
41302	Lav 8	2009	Trans	3.10	0.382	0.07	<d.l.	0.07	22.79	1.089	2.130	0.827	0.03	7.40	0.10
41303	St. 5	2009	Nat.	1.88	0.066	0.03	<d.l.	0.04	5.39	0.179	0.371	0.149	<d.l.	0.47	<d.l.
41304	Lav 14	2009	Nat.	4.78	0.092	0.02	<d.l.	0.06	12.43	0.261	0.519	0.198	<d.l.	0.52	<d.l.
41305	Lav 10	2009	Trans	2.46	0.113	0.06	<d.l.	0.07	9.48	0.336	0.669	0.256	<d.l.	0.84	<d.l.
41306	Lav 9	2009	Trans	2.74	0.144	0.07	<d.l.	0.06	12.61	0.418	0.813	0.310	<d.l.	0.98	<d.l.
41307	St. 10	2009	Nat.	5.32	0.053	0.03	<d.l.	0.06	9.85	0.198	0.383	0.140	<d.l.	0.44	<d.l.
41308	Lav 3	2009	Trans	3.02	0.146	0.03	<d.l.	0.07	14.40	0.426	0.831	0.322	<d.l.	5.21	<d.l.
41308	Lav 3	2009	Trans	3.50	0.176	0.03	<d.l.	0.07	17.02	0.542	1.043	0.395	0.02	5.00	<d.l.
41309	St. 9	2009	Trans	4.13	0.210	0.05	<d.l.	0.08	16.44	0.882	1.616	0.571	0.01	1.56	<d.l.
41310	Lav 8	2009	Nat.	5.95	0.142	0.05	<d.l.	0.12	9.70	0.510	0.960	0.361	0.02	0.78	<d.l.
41311	Lav 17	2009	Nat.	5.40	0.063	0.02	<d.l.	0.07	9.96	0.171	0.351	0.142	<d.l.	0.38	<d.l.
41312	St. 13	2009	Nat.	1.53	0.080	0.05	<d.l.	0.04	7.66	0.191	0.402	0.169	<d.l.	0.49	<d.l.
41313	Lav 3A	2009	Nat.	4.87	0.149	0.18	<d.l.	0.13	10.85	0.518	0.988	0.376	0.02	0.85	<d.l.
41314	Lav 4	2009	Trans	3.02	0.236	<d.l.	<d.l.	0.05	30.20	0.555	1.089	0.426	0.03	3.04	<d.l.
41315	St. 8	2009	Nat.	3.05	0.256	0.08	<d.l.	0.08	23.22	0.928	1.774	0.659	<d.l.	1.10	<d.l.
41316	Lav 2	2009	Trans	3.12	0.258	0.06	<d.l.	0.09	19.06	0.813	1.596	0.615	0.02	3.64	<d.l.
41316	Lav 2	2009	Trans	2.91	0.187	0.02	<d.l.	0.07	17.08	0.572	1.091	0.406	0.02	4.18	<d.l.
41317	Lav 4	2009	Nat.	4.42	0.106	<d.l.	<d.l.	0.08	12.56	0.313	0.629	0.242	<d.l.	1.55	<d.l.
41318	St. 4	2009	Nat.	3.63	0.064	0.03	<d.l.	0.06	10.19	0.178	0.360	0.137	<d.l.	0.32	<d.l.
41319	St. 12	2009	Nat.	2.58	0.058	0.06	<d.l.	0.02	7.20	0.198	0.397	0.147	<d.l.	0.29	<d.l.
41320	St. 15	2009	Nat.	5.01	0.223	0.08	<d.l.	0.11	9.03	0.596	1.248	0.525	0.02	1.42	<d.l.

Appendix 5. Analyses of sculpin liver

Chemical analyses of *Shorthorn sculpin* liver µg/g on a wet weight basis.

ID no.	Station	Year	Dry matter %	Li	Al	V	Cr	Mn	Fe	Ni	Co	Cu	Zn	As
d.l.				**0.01**	**1**	**0.01**	**0.02**	**0.02**	**5**	**0.24**	**0.01**	**0.09**	**0.23**	**0.04**
39121	Area 1	2008	22	<d.l.	<d.l.	0.05	<d.l.	0.75	145	0.17	0.12	2.92	80.59	13.11
39122	Area 1	2008	20	<d.l.	<d.l.	0.09	<d.l.	1.09	617	0.09	0.33	1.50	124.25	8.22
39123	Area 1	2008	29	<d.l.	<d.l.	0.08	<d.l.	0.74	448	<d.l.	0.28	3.64	178.67	4.32
39124	Area 1	2008	23	<d.l.	<d.l.	<d.l.	<d.l.	0.51	85	<d.l.	0.06	0.95	31.89	4.61
39125	Area 1	2008	21	<d.l.	<d.l.	0.02	<d.l.	0.91	146	0.17	0.13	3.72	90.49	6.26
39127	Area 1	2008	25	<d.l.	<d.l.	0.03	<d.l.	0.84	105	<d.l.	<d.l.	1.19	80.15	3.47
39129	Area 1	2008	15	<d.l.	<d.l.	0.02	<d.l.	0.82	453	0.06	0.24	1.63	88.83	5.78
39131	Area 1	2008	21	<d.l.	<d.l.	<d.l.	<d.l.	0.78	112	<d.l.	0.11	1.58	74.77	2.53
39132	Area 1	2008	23	<d.l.	<d.l.	<d.l.	<d.l.	0.56	118	<d.l.	0.05	1.42	75.41	4.00
39140	Area 1	2008	23	<d.l.	<d.l.	<d.l.	<d.l.	0.83	119	<d.l.	0.17	3.06	83.11	3.17
39177	Area 2	2008	24	<d.l.	<d.l.	0.06	<d.l.	0.67	148	0.08	0.08	4.09	107.28	13.33
39177	Area 2	2008	24	<d.l.	<d.l.	0.05	<d.l.	0.61	129	0.07	0.07	3.85	97.43	12.75
39178	Area 2	2008	31	<d.l.	<d.l.	<d.l.	<d.l.	0.64	60	<d.l.	0.04	1.37	38.44	4.50
39180	Area 2	2008	25	<d.l.	<d.l.	0.10	<d.l.	0.72	265	<d.l.	0.16	5.27	95.92	4.62
39182	Area 2	2008	20	<d.l.	<d.l.	0.03	<d.l.	0.82	79	<d.l.	<d.l.	3.31	35.32	12.54
39183	Area 2	2008	22	<d.l.	<d.l.	<d.l.	<d.l.	0.71	40	<d.l.	<d.l.	1.70	47.62	13.88
39101	Area 3	2008	17	<d.l.	8	2.29	<d.l.	1.19	1294	1.13	0.46	4.49	178.47	52.21
39102	Area 3	2008	25	<d.l.	<d.l.	0.09	<d.l.	0.55	119	<d.l.	0.17	3.93	35.04	16.65
39103	Area 3	2008	22	<d.l.	<d.l.	0.04	<d.l.	0.82	84	0.08	0.06	10.07	115.61	12.76
39104	Area 3	2008	26	<d.l.	<d.l.	<d.l.	<d.l.	0.95	48	<d.l.	<d.l.	1.54	24.50	4.46
39107	Area 3	2008	26	<d.l.	<d.l.	<d.l.	<d.l.	0.52	46	<d.l.	0.05	3.49	80.09	13.73
41240	Area 1	2009	16	<d.l.	4	0.24	<d.l.	0.95	394	<d.l.	0.15	5.70	31.34	26.81
41241	Area 1	2009	23	<d.l.	<d.l.	0.04	<d.l.	1.08	173	0.24	0.04	8.58	33.24	6.06
41242	Area 1	2009	16	<d.l.	<d.l.	0.22	<d.l.	0.74	694	<d.l.	0.22	10.60	46.38	71.41
41248	Area 1	2009	19	<d.l.	<d.l.	0.04	<d.l.	1.10	204	<d.l.	0.10	3.40	24.76	2.55
41247	Area 1	2009	19	<d.l.	<d.l.	<d.l.	<d.l.	0.65	82	<d.l.	<d.l.	2.86	22.24	3.40
41265	Area 1	2009	21	<d.l.	<d.l.	0.10	<d.l.	0.70	136	<d.l.	0.08	1.95	25.71	41.16
41265	Area 1	2009	21	<d.l.	<d.l.	0.10	<d.l.	0.71	123	<d.l.	0.07	1.99	26.04	41.81
41266	Area 1	2009	26	<d.l.	<d.l.	<d.l.	<d.l.	0.77	130	<d.l.	0.05	1.85	33.52	9.35
41268	Area 1	2009	22	<d.l.	<d.l.	<d.l.	<d.l.	0.90	351	<d.l.	0.06	2.63	43.42	18.80
41269	Area 1	2009	22	<d.l.	<d.l.	<d.l.	<d.l.	0.81	287	<d.l.	0.12	1.18	34.92	5.20
41272	Area 1	2009	33	<d.l.	<d.l.	<d.l.	<d.l.	0.36	108	<d.l.	0.07	1.37	28.34	15.60
41202	Area 3	2009	35	<d.l.	<d.l.	<d.l.	<d.l.	0.57	41	<d.l.	<d.l.	0.91	18.18	5.47
41203	Area 3	2009	21	<d.l.	<d.l.	<d.l.	<d.l.	0.48	165	<d.l.	0.09	1.93	22.98	3.85
41204	Area 3	2009	24	<d.l.	<d.l.	<d.l.	<d.l.	0.75	152	<d.l.	0.12	4.01	37.80	4.62
41205	Area 3	2009	18	<d.l.	<d.l.	1.12	<d.l.	0.83	233	<d.l.	0.11	3.91	42.51	23.12
41206	Area 3	2009	18	<d.l.	<d.l.	<d.l.	<d.l.	0.96	158	<d.l.	<d.l.	0.83	46.64	18.53
41206	Area 3	2009	18	<d.l.	<d.l.	<d.l.	<d.l.	1.03	134	1.81	<d.l.	2.77	47.19	17.11
41207	Area 3	2009	24	<d.l.	<d.l.	<d.l.	<d.l.	0.84	109	<d.l.	0.09	6.00	36.10	3.15
41208	Area 3	2009	20	<d.l.	<d.l.	<d.l.	<d.l.	0.94	153	<d.l.	0.05	3.38	37.48	3.81
41209	Area 3	2009	17	<d.l.	<d.l.	0.33	<d.l.	0.87	276	<d.l.	0.25	5.16	46.23	26.44
41212	Area 3	2009	28	<d.l.	<d.l.	0.07	<d.l.	0.75	98	<d.l.	0.06	1.19	22.92	3.64
41217	Area 3	2009	18	<d.l.	<d.l.	<d.l.	<d.l.	0.85	192	<d.l.	0.14	7.66	39.73	3.43

ID. no.	Station	Year	Se	Rb	Y	Ag	Cs	Ba	La	Ce	Nd	Hg	Pb	Th
d.l.			**0.02**	**0.01**	**0.0003**	**0.01**	**0.01**	**0.01**	**0.0009**	**0.002**	**0.003**	**0.02**	**0.01**	**0.01**
39121	Area 1	2008	1.83	0.78	<d.l.	0.24	<d.l.	<d.l.			<d.l.	0.15	<d.l.	
39122	Area 1	2008	2.19	0.94	0.003	0.09	<d.l.	<d.l.			0.01	0.15	<d.l.	
39123	Area 1	2008	1.90	0.79	0.002	0.07	<d.l.	0.01			<d.l.	0.37	<d.l.	
39124	Area 1	2008	1.04	0.77	<d.l.	0.06	<d.l.	<d.l.			<d.l.	0.08	<d.l.	
39125	Area 1	2008	2.67	0.59	<d.l.	0.88	<d.l.	<d.l.			<d.l.	0.08	<d.l.	
39127	Area 1	2008	1.91	0.89	<d.l.	0.06	<d.l.	<d.l.			<d.l.	0.06	<d.l.	
39129	Area 1	2008	1.94	0.67	<d.l.	0.10	<d.l.	<d.l.			<d.l.	0.12	<d.l.	
39131	Area 1	2008	1.48	0.85	<d.l.	0.15	<d.l.	<d.l.			<d.l.	<d.l.	<d.l.	
39132	Area 1	2008	1.16	0.64	<d.l.	<d.l.	<d.l.	<d.l.			<d.l.	0.34	<d.l.	
39140	Area 1	2008	1.69	0.67	<d.l.	0.35	<d.l.	<d.l.			<d.l.	0.06	<d.l.	
39177	Area 2	2008	2.36	0.90	0.001	0.19	<d.l.	<d.l.			<d.l.	0.14	<d.l.	
39177	Area 2	2008	2.34	0.91	0.001	0.17	<d.l.	<d.l.			<d.l.	0.12	<d.l.	
39178	Area 2	2008	1.25	1.16	<d.l.	0.13	<d.l.	0.01			<d.l.	0.10	<d.l.	
39180	Area 2	2008	2.16	0.79	<d.l.	0.52	<d.l.	<d.l.			<d.l.	0.08	0.03	
39182	Area 2	2008	1.68	0.98	<d.l.	0.51	<d.l.	<d.l.			<d.l.	0.11	<d.l.	
39183	Area 2	2008	1.42	0.73	<d.l.	0.21	<d.l.	<d.l.			<d.l.	0.15	<d.l.	
39101	Area 3	2008	10.33	0.70	0.007	0.87	0.03	0.01			<d.l.	0.52	0.12	
39102	Area 3	2008	2.70	0.88	<d.l.	0.76	0.04	<d.l.			<d.l.	0.18	<d.l.	
39103	Area 3	2008	2.22	0.96	<d.l.	0.56	<d.l.	<d.l.			<d.l.	0.15	<d.l.	
39104	Area 3	2008	0.99	1.19	<d.l.	0.06	<d.l.	<d.l.			<d.l.	0.07	<d.l.	
39107	Area 3	2008	1.63	1.04	<d.l.	0.35	<d.l.	<d.l.			<d.l.	0.09	<d.l.	
41240	Area 1	2009	1.59	0.70	0.006	0.84	<d.l.	<d.l.	0.016	0.019	0.01	0.12	<d.l.	<d.l.
41241	Area 1	2009	1.14	0.72	0.000	0.61	<d.l.	<d.l.	0.007	<d.l.	0.00	<d.l.	<d.l.	<d.l.
41242	Area 1	2009	3.84	0.57	0.003	0.73	<d.l.	<d.l.	0.015	0.011	0.01	0.14	<d.l.	<d.l.
41248	Area 1	2009	0.85	0.62	0.000	0.54	<d.l.	<d.l.	0.005	<d.l.	0.00	<d.l.	<d.l.	<d.l.
41247	Area 1	2009	0.69	0.59	0.000	0.35	<d.l.	<d.l.	<d.l.	<d.l.	0.00	<d.l.	<d.l.	<d.l.
41265	Area 1	2009	1.65	0.65	0.002	0.32	0.06	<d.l.	<d.l.	<d.l.	0.00	0.37	<d.l.	<d.l.
41265	Area 1	2009	1.70	0.68	0.002	0.33	0.06	<d.l.	<d.l.	<d.l.	0.00	0.38	<d.l.	<d.l.
41266	Area 1	2009	1.74	1.65	0.000	0.18	<d.l.	<d.l.	0.004	<d.l.	0.00	<d.l.	<d.l.	<d.l.
41268	Area 1	2009	1.77	1.03	0.001	<d.l.	<d.l.	<d.l.	0.004	<d.l.	0.00	<d.l.	<d.l.	<d.l.
41269	Area 1	2009	1.40	0.73	0.000	<d.l.	<d.l.	<d.l.	0.007	<d.l.	0.00	<d.l.	<d.l.	<d.l.
41272	Area 1	2009	1.41	0.63	0.001	0.14	<d.l.	<d.l.	<d.l.	<d.l.	0.00	<d.l.	<d.l.	<d.l.
41202	Area 3	2009	1.29	0.52	0.000	0.19	<d.l.	<d.l.	<d.l.	<d.l.	0.00	<d.l.	<d.l.	<d.l.
41203	Area 3	2009	1.17	1.19	0.000	0.29	<d.l.	<d.l.	0.004	<d.l.	0.00	<d.l.	<d.l.	<d.l.
41204	Area 3	2009	1.61	0.79	0.000	0.73	<d.l.	<d.l.	<d.l.	<d.l.	0.00	<d.l.	<d.l.	<d.l.
41205	Area 3	2009	2.66	0.59	0.002	0.62	<d.l.	<d.l.	0.006	<d.l.	0.00	<d.l.	<d.l.	<d.l.
41206	Area 3	2009	0.90	1.32	0.000	0.05	<d.l.	<d.l.	<d.l.	<d.l.	0.00	<d.l.	<d.l.	<d.l.
41206	Area 3	2009	0.90	1.30	0.000	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	0.00	<d.l.	0.09	<d.l.
41207	Area 3	2009	1.39	0.56	0.000	0.86	<d.l.	<d.l.	<d.l.	<d.l.	0.00	<d.l.	<d.l.	<d.l.
41208	Area 3	2009	1.50	0.60	0.000	0.77	<d.l.	<d.l.	0.005	<d.l.	0.00	<d.l.	<d.l.	<d.l.
41209	Area 3	2009	5.80	0.74	0.000	0.97	<d.l.	<d.l.	0.018	0.022	0.01	0.14	<d.l.	<d.l.
41212	Area 3	2009	1.50	1.23	0.000	<d.l.	<d.l.	<d.l.	<d.l.	<d.l.	0.00	<d.l.	<d.l.	<d.l.
41217	Area 3	2009	1.38	0.58	0.000	0.74	<d.l.	<d.l.	<d.l.	<d.l.	0.00	<d.l.	<d.l.	<d.l.

Appendix 6. Analyses of Arctic char liver

Chemical analyses of Arctic char liver µg/g on a wet weight basis.

ID no.	Station	Year	Dry matter %	Li	Al	V	Cr	Mn	Fe	Ni	Co	Cu	Zn	As
d.l.				**0.01**	**1**	**0.01**	**0.02**	**0.02**	**5**	**0.24**	**0.01**	**0.09**	**0.23**	**0.04**
39144	Long lake	2008	27	<d.l.	<d.l.	<d.l.	<d.l.	1.28	23	<d.l.	0.21	47.70	83.33	0.54
39145	Long lake	2008	22	<d.l.	<d.l.	<d.l.	<d.l.	1.97	134	<d.l.	<d.l.	1.72	24.31	0.41
39146	Long lake	2008	32	<d.l.	<d.l.	0.02	<d.l.	1.20	346	<d.l.	0.20	43.93	77.83	0.54
39147	Long lake	2008	43	<d.l.	<d.l.	<d.l.	<d.l.	0.94	44	<d.l.	0.09	22.19	31.19	0.43
41296	LongLake	2009	22	<d.l.	<d.l.	<d.l.	<d.l.	1.78	100	0.50	0.08	1.87	26.58	0.19

ID. no.	Station	Year	Se	Rb	Y	Ag	Cs	Ba	La	Ce	Nd	Hg	Pb	Th
d.l.			**0.02**	**0.01**	**0.0003**	**0.01**	**0.01**	**0.01**	**0.0009**	**0.002**	**0.003**	**0.02**	**0.01**	**0.01**
39144	Long lake	2008	1.76	0.87	<d.l.	0.23	<d.l.	<d.l.			<d.l.	0.07	<d.l.	
39145	Long lake	2008	1.03	1.58	<d.l.	<d.l.	0.03	0.02			<d.l.	0.12	<d.l.	
39146	Long lake	2008	2.51	0.84	<d.l.	0.08	<d.l.	<d.l.			<d.l.	0.17	<d.l.	
39147	Long lake	2008	1.83	0.59	<d.l.	0.07	<d.l.	<d.l.			<d.l.	<d.l.	<d.l.	
41296	LongLake	2009	0.78	3.66	0.000	<d.l.	<d.l.	<d.l.	0.014	0.008	0.00	<d.l.	<d.l.	<d.l.

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ENVIRONMENTAL MONITORING AT THE SEQI OLIVINE MINE 2008-2009

The olivine mine at Seqi in West Greenland has been operating since 2005. Every year since opening, environmental monitoring studies have been conducted to assess the impact from mining. This report contains the results from monitoring studies in 2008 and 2009. The results show that dust from the operation has caused levels of some elements, particularly chromium and nickel, to increase in lichens, blue mussels, and seaweed. The spreading of dust increased from 2007 to 2008, but decreased again in 2009, and can now be measured in lichens at a distance of up to 8 km from the mine. In seaweed and blue mussels, however, elevated concentrations of Cr and Ni could only be measured at a few stations near the mine site. No contamination could be measured in fish (Arctic char and shorthorn sculpin). Thus, the impact of the mine is still considered insignificant for the Niaquungunaq fjord system.

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