Research Notes from NERI No.: 83

Second Baseline Study in the Citronen Fjord Area

North Greenland 1997

Arktisk Miljø/Arctic Environment

Ministry of Environment and Energy, National Environmental Research Institute

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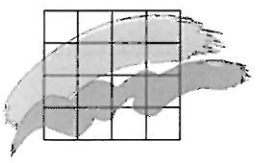

Ministry of Environment and Energy
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Data sheet

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Abstract: The report describes the second year of baseline studies conducted in the Citronen Fjord area in North Greenland during August 1997. In this area a mining company has been prospecting for zinc and lead since 1993. Samples were collected of sea weed, fish, plants, faeces, sediments, sea and fresh water. For the moment only the water samples are analysed for dissolved zinc. Like in 1994 and 1995, a continuous sampling program was performed in the Eastern River, and again the total discharge of zinc was about 2000 kgs. No peak concentrations were found this year due to a later sampling start. Zinc concentrations in the sea water below 2 m were compable to 1994 concentrations, and to uncontaminated Greenlandic fjords. Observations of birds and mammals are reported. A third year of baseline study is recommended.

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Contents

Summary 5

Resumé 6

1 Introduction 7

2 Logistics 8

3 Marine Samples 9
- 3.1 Fish 9
- 3.2 Seaweed 9
- 3.3 Sea water, column 10

4 Limnological Samples 13
- 4.1 Sediment 13
- 4.2 Fresh Water 13

5 Terrestrial Samples 16
- 5.1 Plants 16
- 5.2 Faeces 16

6 Observations on Flora and Fauna 18
- 6.1 Seaweed 18
- 6.2 Mussels 18
- 6.3 Fish 18
- 6.4 Birds 18
- 6.5 Mammals 20

7 Discussion 21

8 References 23

9 Appendices 24

Summary

The report describes the second year of baseline studies conducted in the Citronen Fjord area from 31 July to 13 August 1997. In this area Platinova A/S is prospecting intensively for zinc and lead, and mineral exploration has been carried out each year since the discovery in 1993.

During the study period samples were collected of seaweed *(Laminaria* sp), fish (Fourhorned sculpin), river sediments, Arctic willow, Entired-leafed mountain avens, grasses and faeces from Muskox, Alpine hare and Collared lemming. These samples have been prepared for storage, and are now stored at the National Environmental Research Institute, Department of Arctic Environment together with the samples from the first baseline study in 1994.

Sea water and fresh water were sampled and analysed for dissolved zinc.

The total amount of zinc discharged from the Eastern River during the period from 22 June to 13 August was about 2000 kgs. This is in the same order of magnitude as found in 1994 and 1995, despite a shorter sampling period and lack of peak zinc concentrations in 1997.

Zinc concentrations in sea water below 2 meters in the Citronen Fjord were comparable to concentrations in 1994, and this level is not significantly different from that of uncontaminated fjords in West Greenland.

This year relatively many Collared lemmings were seen which was probably the reason why one pair of Arctic foxes raised six cubs, why two pairs of Long-tailed skuas fled youngs (1 and 2), and why a Gyr falcon, female, was seen (a new species during the five years of mineral exploration).

A third year of baseline study is recommended prior to a possible mineral exploitation, and this should include reference stations.

Resumé

Denne rapport beskriver den miljømæssige baggrundsundersøgelse, der blev udført i Citronen Fjord området i perioden fra 31. juli til 13. august 1997. Dette er anden gang, der er indsamlet baggrundsprøver i området; første gang var i samme periode i 1994. I Citronen Fjord området har Platinova A/S siden 1993 efterforsket en større zink og bly mineralisering.

Der er blevet indsamlet prøver af tang *(Laminaria* sp.), fisk (Hornulk), elvsediment, Arktisk pil, Grønlandsk fjeldsimmer (eller dryas), græsarter, afføringsprøver af halsbåndlemming, arktisk snehare og moskusokse. Disse prøver er enten frosset ned eller tørret og opbevares i Danmarks Miljøundersøgelser, Afdeling for Arktisk Miljø, sammen med de tilsvarende prøver fra 1994.

Havvandsprøver fra fire stationer i Citronen Fjord og ferskvandsprøver fra Østlige elv (Eastern River) og Esrum Elv samt fra søen tæt ved borelejren (Base Camp lake) er alle analyseret for deres indhold af opløst zink.

Som i 1994 og 1995 blev der i 1997 jævnligt indsamlet prøver fra en permanent station i Østlige elv. I perioden 22. juni til 13. august blev der indsamlet prøver hver anden dag i modsætning til i 1994 og 1995, hvor der blev indsamlet hver dag. Den totale mængde zink, der blev udledt med Østlige elv var ca. 2000 kg, hvilket svarer til de udledte mængder i 1994 og 1995. Denne mængde er udledt på trods af, at indsamlingsperioden i 1997 var kortere, og at der ikke blev fundet zink-koncentrationer højere end 38 µg/kg (i modsætning til over 2000 µg/kg i de foregående år). En mulig grund til den relativt høje zink-udledning i 1997 kan være de usædvanligt høje temperaturer (ca. 14°C) i begyndelsen af juli, der har bidraget til en stor afsmeltning fra sne- og permafrostlaget, og dette smeltevand har derpå opløst store mængder forvitret zinksulfid.

Zink-koncentrationerne i havvandet i Citronen Fjord var sammenlignelige med koncentrationerne fundet i 1994, og dette niveau er ikke signifikant forskelligt fra zink-niveauer i uforurenede fjorde i Vestgrønland.

Der var i 1997 relativt mange halsbåndlemminger, hvilket formodentlig var årsagen til, at et par polarræve havde 6 unger, at to par lille kjove fik henholdsvis én og to unger på vingerne, og at en jagtfalk hun blev set for første gang i efterforskningsområdet.

Det skal anbefales, at der inden etablering af en mine i området udføres en tredje års baggrundsundersøgelse, og at der i denne inkluderes fjerntliggende marine og terrestriske referencestationer.

1 Introduction

Mineral exploration

In 1997, from mid June to mid August, Platinova A/S continued the diamond drilling program in its Citronen Fjord license area in North Greenland. This year 15 holes and 3116 m were drilled mainly in the "Beach area" (Platinova A/S 1997) giving a total of about 32000 m drilled since the zinc mineralization was discovered in 1993 (Stijl 1996, 1997 and Platinova A/S 1997).

Second baseline study

In late April 1997 Platinova A/S, the Mineral Resource Administration for Greenland (MRA) and National Environmental Research Institute, Department of Arctic Environment (NERI, Dept. AE) agreed to initiate the second baseline study in the Citronen Fjord area in July/August 1997. The first baseline study is reported in Glahder & Asmund (1995). The 1997 baseline study program is described in detail and compared to the 1994 baseline study program, cf. Appendix 13.

Previous studies

A reconnaissance study was performed in August 1993 (Glahder & Langager 1993), and sea water was sampled in April 1995 (Johansen & Asmund 1995) to compare metal concentrations during the winter with summer concentrations.

This study

It was decided only to analyse seawater and fresh water samples from the 1997 baseline study, whereas analyses of biological samples may be postponed until a decision about exploitation is made.

As in 1994, it was this year not possible to reach the marine and terrestrial reference stations 30 to 50 kms from the Citronen Fjord area. The reason was mainly that no helicopter was situated in the Citronen Fjord area during the baseline study period.

This report describes the work done in the Citronen Fjord area in fourteen days in July and August 1997, and the results of the analyses of sea and fresh water samples.

2 Logistics

The baseline study was carried out in the Citronen Fjord area from 31 July to 13 August 1997 by Sigga Joensen and Christian Glahder from NERI, Dept. AE.

During June 1997 30 plastic bottles of 1 litre together with simple equipment for water level measurement were sent to Platinova A/S, Nuuk, Greenland. This material should be used to follow the metal flow in the Eastern River during the exploration period (21 June to 23 August 1997).

Transportation

On 29 July 1997 we were transported with a military Hercules aeroplane to Keflavik, Iceland, and on 30 July further on to Station Nord, North Greenland. The plane carried also our 180 kgs of equipment including outboard motor, water samplers, fishing nets, survival suits, tents etc.

On 31 July a Twin Otter transported us and the equipment from Station Nord to Citronen Fjord, where most equipment was placed at the old airstrip near the head of the fjord. Accommodation was in a heated Weatherhaven tent in the Platinova A/S Base Camp some two kms from the head of the fjord and close to the fresh water lake.

Transportation in the field was on foot and in the fjord with a Metzeler, Juca S, rubber dinghy borrowed from Platinova A/S. No helicopter was available during the baseline study period.

On 13 August a Twin Otter flew us to Station Nord and on 20 August we and some of our equipment flew to Denmark with a military Hercules.

Acknowledgements

Frank v. d. Stijl, Platinova A/S, mine drillers and helpers as well as the cook are thanked for their help, humour and hospitality, and Frank especially for water sampling in Eastern River, and for the loan of rubber dinghy and radio. Personnel from Station Nord are thanked for hospitality and patience during our prolonged stay in August, and the Danish Defence Command is thanked for the Hercules transportation.

3 Marine Samples

In Citronen Fjord samples were taken of fish, seaweed, and sea water. On a total of 15 stations 133 samples were taken. Fish were sampled at 5 stations: F1 (36 samples), F2 (10), F3 (26), F4 (0), F5 (17), in total 89 samples. Seaweed were sampled at 6 stations, each with two samples, in total 12 samples. Sea water was sampled at 4 stations: H1 (7), H2 (7), H3 (8), H4 (10), in total 32 samples.

In contrast to the baseline study in 1994, this year no samples were taken of sediments and surface sea water, while two samples of seaweed were collected at each station with only one sample in 1994.

3.1 Fish

he Fourhorned Sculpin (*Myoxycephalus quadricornis*) was the only fish caught in Citronen Fjord. A possible Arctic Char (*Salvelinus alpinus*) was almost caught in the net at station F1 at the mouth of Esrum Elv.

Catch

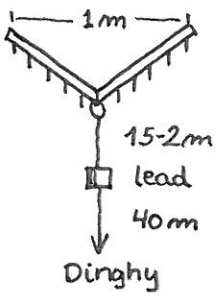
Nets were set at five stations, cf. Appendix 1 and Fig. 1. A total of 89 Fourhorned Sculpins were caught, refer to Appendix 2. At each station a pound net was set along the shore at depths of about 1 meter. The length was 50 m, and the mesh width 2.6 cm. Nets were set from 1 to 3 August and tended every day for three days. Except for the net at station F5 the last net was taken on 5 August. Due to heavy ice floes entering Citronen Fjord from F. E. Hyde Fjord early on 5 August the net was not taken until 9 August. No fish were caught, and parts of the net were lost to the ice. The net at station F4 was set on 3 August, and shortly after half of it was lost to ice floes. No net was set here afterwards because of constant drift of ice floes along this shoreline during the remaining study period.

On the day of catching, the fish were given an identification number (ID no.), packed, and the entire fish were stored in the freezer at the Base Camp. All fish were transported to Denmark and stored in the NERI, Dept. AE, freezer.

3.2 Seaweed

Seaweed was sampled at six stations, cf. Appendix 1 and Fig. 1. At each station two samples each of about five specimens were taken of sweet tangle (*Laminaria* sp - probably *Saccharina*), see Appendix 3.

Sampling



Samples were taken with a self-made rake holding two aluminium "legs" each with six teeth. The legs were bent back in a 260° angle with the teeth pointing in sailing direction. The rake was pulled behind the rubber dinghy moving at low speed. At depths of 10 to 20 meters at least 50 meters of rope were pulled out. A lead was placed a few meters in front of the rake to force the rake to the bottom. The rake was pulled over the bottom for about 5 minutes at transects perpendicular to the coast. A minimum of two transects lines were sam-

pled at each station.

Storage

The seaweed samples were frozen the same day and stored in the Base Camp freezer. Samples from station T3, T4, T5, and T6 were washed in Base Camp water (from the Base Camp lake) before they were frozen. The samples were transported to Denmark where they in the NERI laboratory were washed in milli Q water and stored in a freezer.

3.3 Sea water, column

Sea water column samples were taken at four stations, cf. Appendix 1 and Figure 1. At each station between 7 and 10 samples were taken from the following depths (in meters): 0, 2, 5, 10, 15, 20, 30, 50, 75, and 100, refer to Appendix 4.

Temperatures were measured with two reversible thermometers, but figures are omitted because of obscure results.

Analysis

The sea water samples were collected in 1 litre acid washed polyethylene bottles and shipped untreated to the NERI laboratory. An uncontrolled part of the dissolved metals will precipitate on the walls of the bottle and on the particles in the water samples. These precipitated metals were dissolved again in the laboratory by addition of 1 ml suprapure nitric acid. After a week or more the samples were analysed by anodic stripping voltammetry. The method was checked by analysing the reference sea water sample NASS-4. All samples were analysed for zinc.

Zinc concentrations

Concentrations of zinc in the Citronen Fjord sea water at different depths are shown in Appendix 9 and Figure 2. The Citronen Fjord water samples below 2 m had this year (August, 1997) an average zinc concentration of 1.59 µg/kg (SD = 0.92, N = 24). This is slightly lower than the Citronen Fjord average zinc concentration in 1994 (July/August) of 2.03 µg/kg (SD = 1.86, N = 24). Compared to sea water samples from uncontaminated areas in Uummannaq Fjord in West Greenland with an average zinc concentration of 1.17 µg/kg (SD = 1.31, N = 25), the Citronen Fjord samples are slightly higher in concentration but not statistically significant.

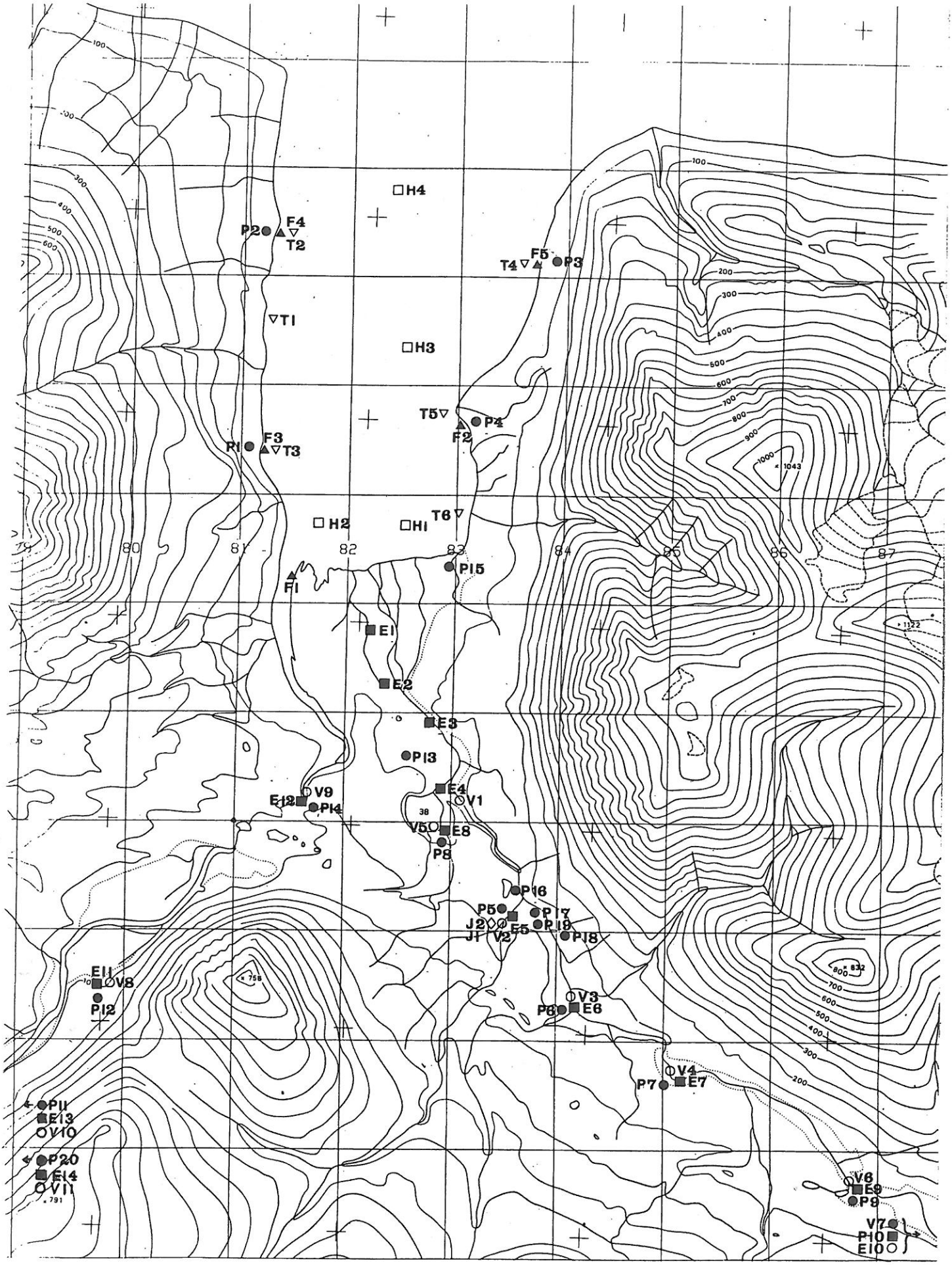


Figure 1. Stations in Citronen Fjord: Fish (▲ F), Seaweed (▽ T), Sea water column (□ H), River sediment (■ E), Soil (◇ J); Plant and faeces (● P) and Fresh water (○ V). Soil was sampled only in 1994.

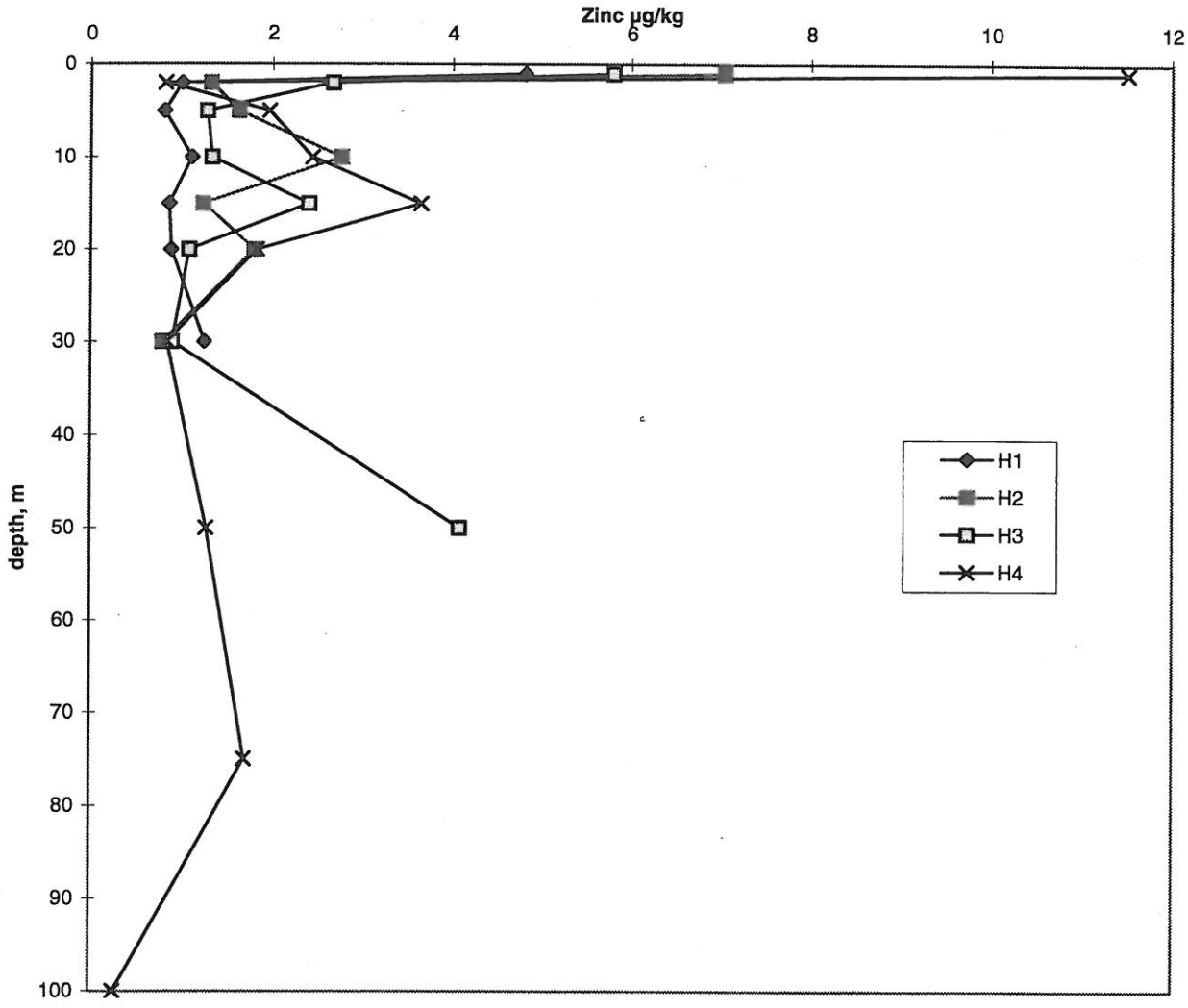


Figure 2. Zinc concentrations (µg/kg) at four sea water column stations (H1-4).

4 Limnological Samples

In the Citronen Fjord area samples of sediment and fresh water have been collected from the Eastern River and Esrum Elv. On a total of 25 stations 50 samples have been taken. Below, the sediment samples and the fresh water samples are described in detail. Compared to the 1994 baseline study four more sediment stations and two more fresh water stations were included in 1997. At the one permanent water station the sampling period was shorter in 1997, and the sampling frequency was reduced to once every second day.

4.1 Sediment

Sediment was sampled at 10 stations in the Eastern River and at four stations in Esrum Elv, cf. Appendix 1 and 5 and Figure 1. Only one sample was taken at each station. Samples were collected in plastic bags, frozen the same day, and transported to Denmark, where they were stored in the freezer.

4.2 Fresh Water

Fresh water was sampled in the Eastern River at the one permanent station (V1) with a total of 26 samples, and at six more stations with one sample at each station. In Esrum Elv four samples were taken, one at each station, cf. Appendix 1 and 8 and Figure 1.

At the stations, a fresh water sample was taken with a one litre plastic bottle stored at the Base Camp and transported to Denmark for analyses. Preparation and analyses of the samples were equal to the sea water column samples, see chapter 5.3.

Permanent station

At the one station, V1, in the Eastern River close to the Base Camp, one sample was collected in the evening (between 7:15 and 11:15 p.m.) every second day. At the same time the water level was read in cm from the folding ruler taped on a staff anchored in the river. Because of very high water level in the beginning of July the staff collapsed on 8 July and was reestablished on 18 July. During this period of 10 days the water level was read from point I, see Appendix 12. Sampling and readings of water level were made by Frank van der Stijl, Platinova A/S, from 22 June to 28 July, and by NERI from 30 July to 11 August.

Zinc concentrations

All samples were analysed for zinc and the results are given in µg/kg in Appendix 10. Figure 3 shows concentrations of dissolved zinc in Eastern River (µg/kg) compared to measurements in 1994 and 1995. Concentrations in 1997 were low during the sampling period and correspond well with concentrations found in previous years. Compared to 1994 and 1995, where sampling started on 8 June and 29 May, respectively, sampling in 1997 was late starting on 22 June. This is probably the reason why no peak in zinc concentrations was found

in 1997.

Discharge of 2000 kgs of zinc

Despite the missing peak concentration in 1997 the total amount of zinc discharged that year was about 2000 kgs, and thus in the same order of magnitude as found in 1994 and 1995 (see Figure 4). Most zinc was discharged during the first period and is in that respect comparable to the 1994 zinc discharge. A very heavy water discharge on 8 July, estimated at about 10 mill. m^3, see Figure 5, due to a very high two days' average temperature of 13.9°C, caused an unusually high zinc discharge of more than 300 kgs, despite the low zinc concentration (Figure 3). The two previous years had only high zinc discharges when zinc concentrations were high and water discharge was low. The water discharge in the Eastern River is calculated from the equation, $Q\ (m^3/s) = 22 \times (2.25\ m - H)^{2.5}$, where H is the distance (in m) from point I to the water level, refer to Appendix 12. It must be stressed that this equation gives only a rough estimate of the water discharge.

Other stations, zinc concentrations

One fresh water sample from each of the other stations was analysed for zinc concentrations (µg/kg), and concentrations were in general low, refer to Appendix 11. Samples from the Eastern River upstream of the showings, V3, 4, 6, and 7, had average zinc concentrations of 0.33 µg/kg (SD = 0.08, N = 4) which is comparable to the 1994 average of about 0.15 µg/kg and significantly lower than the average zinc concentration of 2.00 µg/kg (SD = 0.65, N = 3, period 5-9 August) derived from three samples from the permanent station V1. The zinc concentration from the Base Camp lake, V5, was 0.82 µg/kg. The average zinc concentration from Esrum Elv was 0.78 µg/kg (SD = 0.35, N = 4).

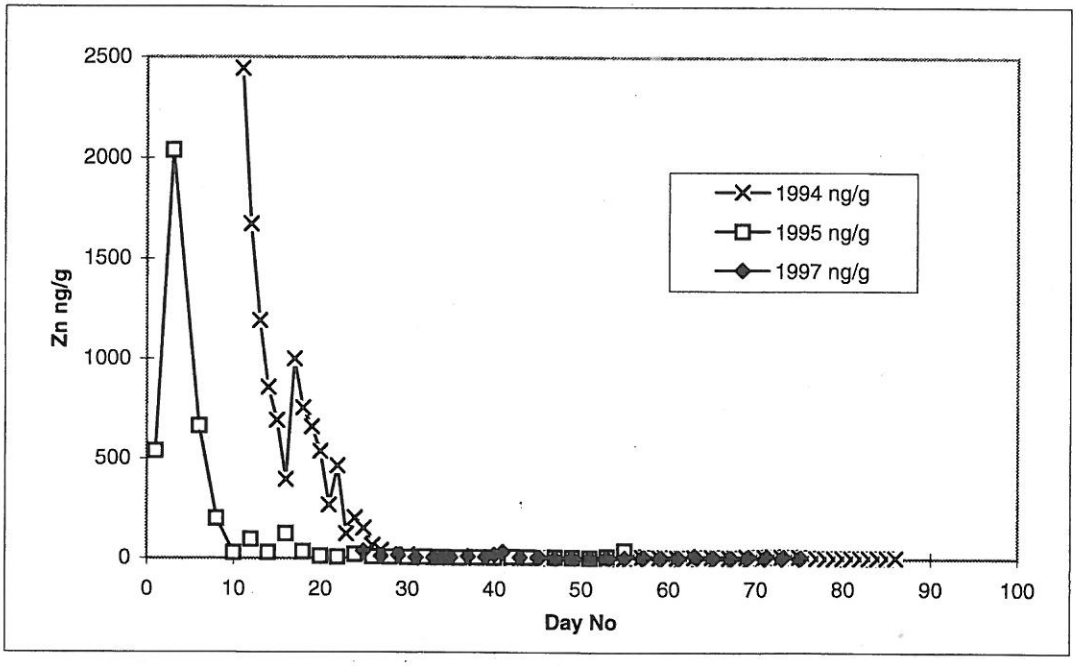


Figure 3. Zinc concentrations in Eastern River at station V1 in 1994, 1995, and 1997. Day 1 is 29 May.

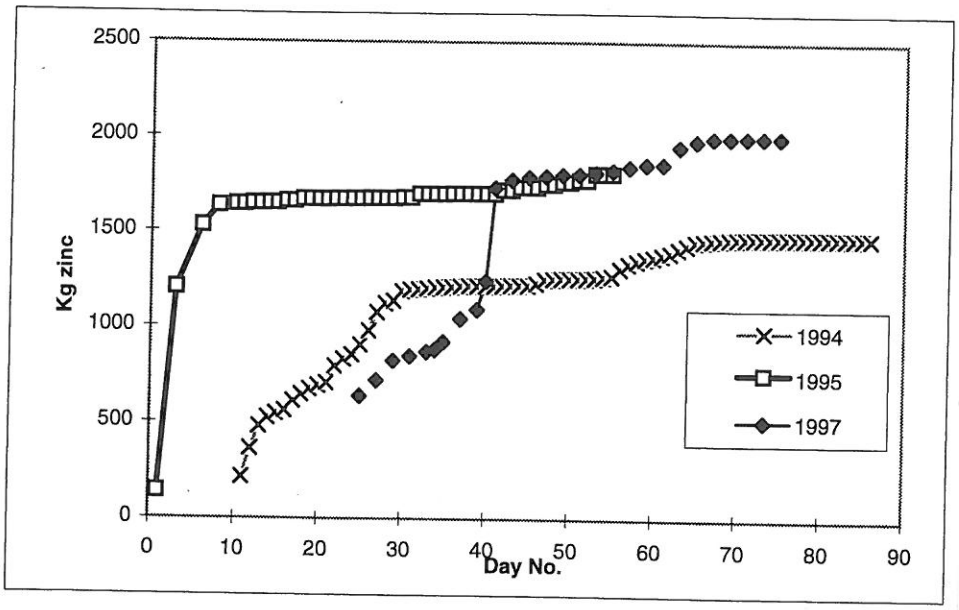


Figure 4. Accumulated zinc (kg) transported out through Eastern River in1994, 1995, and 1997. Day 1 is 29 May.

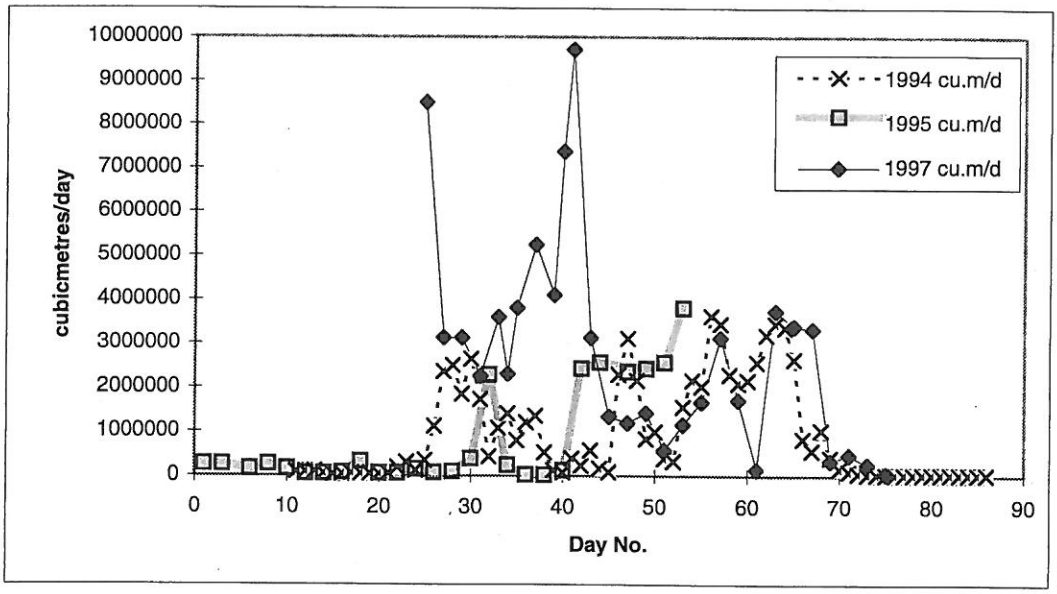


Figure 5. Water discharge (cubic meters) in Eastern River in 1994, 1995, and 1997. Day 1 is 29 May.

5 Terrestrial Samples

In the Citronen Fjord area samples were taken of plants and faeces. On a total of 20 stations 109 samples were collected.

As in 1994 it was the intention also to sample plants and faeces at approximately five reference stations some 30 to 50 km from Citronen Fjord and at two marine stations situated a few kilometres to each side of the North of Citronen Fjord. But, as no helicopter was in the Citronen Fjord area while NERI was in the area, it was not possible to reach these stations in 1997.

Compared to the baseline study in 1994 one more station was added (P20) in 1997, and some more faeces samples were taken.

5.1 Plants

Higher plants were sampled at 20 stations in the Citronen Fjord area with a total of 63 samples, cf. Appendix 1 and 6, and Figure 1.

Plant species

Arctic willow, *Salix arctica,* Entired-leafed mountain avens, *Dryas integrifolia,* and grass species were sampled at the stations in order to be able to chose the best indicator species and to study differences in metal concentrations between species. In Greenland lichen has been used to monitor heavy metal atmospheric deposition, but no lichen species suitable for that purpose has been found in the Citronen Fjord area. The grass species were identified from the dried samples by botanist Christian Bay, Botanical Museum of Copenhagen, and the following species were identified on 12 of the stations: *Poa abbreviata* (5 stations), *Puccinellia angustata* (6 stations) and *Colpodium vahlianum* (5-6 stations) (see also Appendix 6).

Whole plants were sampled, dried as much as possible in open paper bags and transported to Denmark. Here they were dried at 60°C and stored in paper bags. No plant species have been analysed.

5.2 Faeces

In order to establish baseline levels of metal burdens in terrestrial animals, faeces from three animal species were collected at 17 stations in the Citronen Fjord area with a total of 46 samples, cf. Appendix 7 and Figure 1.

Mammal species

The three species were Collared lemming *(discrostonyx torquatus),* Alpine hare *(Lepus arcticus),* and Muskox *(Ovibos moschatus).* The idea is to sample the rather easily accessible faeces from mammals difficult to catch or unacceptable to kill. The Collared lemming is the species best suitable for monitoring as it is stationary, whereas Muskoxen are moving over large areas. The Alpine hare is considered rather stationary mostly like the lemmings. When using faeces as an

indicator it is important to collect faeces as fresh as possible.

The faeces samples were transported to Denmark, dried at 60°C and stored. No samples have been analysed.

6 Observations on Flora and Fauna

In this chapter all observations made in 1997 on flora and fauna are described. Observations include both those from the baseline study in the Citronen Fjord area 31 July to 13 August, and observations from 21 June to 13 August made by Frank van der Stijl, Platinova A/S. Included are also observations made by Bjarne R. Langdahl during the period from 5 to 22 August 1996.

For observations made in 1993 and 1995 and earlier in Citronen Fjord and in Peary Land, reference is made to Glahder & Langager (1993) and Glahder & Asmund (1995).

6.1 Seaweed

As in 1994 three species of seaweed were found: Sweet tangle *(Laminaria* sp - probably *saccharina)* was numerous at all six seaweed stations, and this species is stored in freezers at NERI for possible analyses (see chapter 5.2). *Desmarestia* sp, another brown algae, was numerous, and a smaller red alge species not identified, was often seen together with the *Laminaria* samples.

6.2 Mussels

A few live mussels were sampled during the seaweed sampling. Most of the mussels were sitting between the *Laminaria* "roots".

6.3 Fish

Three species of fish were observed in 1997, as in 1994. Fourhorned sculpin, *Myxocephalus quadricornis,* was caught at four stations in Citronen Fjord with a total of 89 individuals (see chapter 5.1). One possible Arctic char, *Salvelinus alpinus,* was almost caught in the mouth of Esrum Elv, and fry was observed in the shallow waters of the Base Camp lake. One individual of either Polar cod, *Boregadus saida,* or Arctic cod, *Arctogadus glacialis,* was found dead on the shore.

6.4 Birds

Compared with observations in 1993 and 1994, two new species, gyrfalcon and pink-footed goose, were seen in 1997.

Red-throated diver, *Gavia stellata*

One pair on the Base Camp lake and at the head of the fjord was seen from 21 June to 11 August. In 1996 one pair with three juveniles were seen from 5 to 22 August in the Base Camp lake.

Pink-footed goose, *Anser brachyrhynchus*

On 1 July 10 to 15 geese were seen flying, on 2 July flying geese were heard in the fog, and on 3 July 14 pink-footed geese were flying above the Base Camp. On 2 August 23 moulting, i.e. running at a

short distance from the dinghy, Pink-feet were seen on the west coast of Citronen Fjord. Both on the west and on the east coasts of the fjord signs of staging geese were obvious: many foot-prints and droppings, and areas where almost all of the grass species *Poa* and *Pucinellia* were bit to the ground. Perhaps this is the most northern moulting flock encountered (Boertmann 1994). In 1996 a total of at least 250 geese in flocks of 50-100 migrated south between 20 and 22 August.

Snow-goose, *Anser caerulescens*
One on the Citronen Fjord shore on 29 July.

King eider, *Somateria spectabilis*
More than 100 were seen in the head of the fjord on 28 July, and 1 male and 2 female here on 5 August.

Gyr falcon, *Falco rusticolus*
One adult female (white form) was chased by a pair of Long-tailed skuas near the Esrum Elv waterfall.

Ptarmigan, *Lagopus mutus*
At least four family groups with one female having juveniles of: 11, 7, 7, and 1, were observed in the area between 5 and 8 August. In 1996 8, probably one family group, were seen in the Esrum Elv valley.

Ringed plover, *Charadrius hiaticula*
One nest with four eggs was found near the Base Camp on 3 July, and one on 6 August. Two adults with one juvenile were seen. During the period from 1 to 11 August 1 to 4 adults were seen almost every day.

Knot, *Calidris canutus*
One adult with two pulli were seen near the Base Camp on 24 July, 6 adults with 1 juvenile on 5 August, and 1 juvenile on 7 August.

Sanderling, *Calidris alba.*
One pair with two pulli (one newly dead) were seen on the Base Camp lake shore on 1 August, and 4 adults with 4 juveniles were seen on 5 August. During the period from 1 to 8 August 1 and 2 adults were seen almost every day. In 1996 some were seen on the lake shore.

Turnstone, *Arenaria interpres*
On average 5 juveniles (1-11) were seen every day during the period 4 to 12 August. In 1996 some were seen on the lake shore.

Long-tailed skua, *Stercorarius longicaudus*
At least two pairs fled youngs, one and two, respectively, in the Eastern River area this year. One nest was found on 7 July, and two juveniles were seen here together with the adults on 2 August. In the Esrum Elv area 5 adults were seen on 7 August. In 1996 one was seen on 15 August near the Gossan area.

Glaucous gull, *Larus hyperboreus*
One adult was seen in the Citronen Fjord on 1 and 3 August, and two adults on 12 August. In 1996 Glaucous gull was seen in the Citronen Fjord and at the Base Camp.

Ivory gull, *Pagophila eburnea*
One adult was seen in the fjord on 3 August.

Snow bunting, *Plectrophenax nivalis*
On average three (1-6) adults were seen in the area between 3 and 12 August. In 1996 many snow buntings were seen during the entire period (5-22 August).

6.5 Mammals

Ringed seal, *Phoca hispida*

One to two ringed seals were seen in the fjord between 5 and 11 August.

Muskox, *Ovibos moschatus*

A group of three was observed by the twin otter crew just south of the Base Camp on 14 July. In 1996 five were seen in the Eastern River valley on 7 August. Also fresh foot prints from a cow and her calf were observed.

Polar wolf, *Canis lupus*

One wolf was seen on the southern Base Camp lake shore on 17 July, and fresh foot prints were seen in this area on 15 July and 1 August. In 1996 fresh foot prints were seen in the Eastern River valley, and on the shores of F. E. Hyde Fjord.

Arctic fox, *Alopex lagopus*

A den with six cubs was discovered on 11 July, and on 15 July the cubs visited the dump site. One juvenile was seen on 1 August. In 1996 2 adults and 3 juveniles were seen during the whole period.

Alpine hare, *Lepus arcticus*

One and two were seen close to the Base Camp on 6 and 8 August, two were seen in Esrum Elv Valley on 8 August, and three were observed in the mouth of Esrum Elv on 12 August. Only one hare was observed on 20 August 1996.

Collared lemming, *Discrostonyx torquatus*

One juvenile was found dead on 5 August, and one to two adults with four to five juvenile had their borrow below our tent. In 1996 no lemmings or signs of activity were observed.

7 Discussion

1997-study compared to 1994-study

The baseline study in 1997 was the second study in the Citronen Fjord area with the first conducted in 1994. The sampling period was in both years from late July to mid August. Compared to the 1994 study the 1997 baseline study differed only little: In the Citronen Fjord no sediment and surface sea water samples were collected in 1997, while two samples of seaweed were collected at each station compared to one in 1994. In the Eastern River and Esrum Elv four more sediment stations, and two more fresh water stations were added, while the sampling frequency at the permanent Eastern River station was reduced to only one sample every second day. One more plant/faeces station was added this year.

No sediment and surface sea water samples in 1997

It is believed that the sediment samples from 1994 represent sedimentation for many years so that new samples would add little knowledge of metal concentrations as far as no mining activity is taking place. Surface sea water samples could give good indications of metal discharge from the two rivers as well as of sedimentation and flow out of the fjord, but samples should be taken on a more regular basis in combination with fresh water samples, e.g. during the early discharge period with high metal concentrations and in the late discharge period with very low concentrations (refer to Figures 3-5). Two samples of seaweed were taken at each station to improve the statistical analysis. Sampling in Eastern River was reduced because 1994 and 1995 gave similar results and to minimize analysis expenses.

Most samples were stored frozen or dried with only fresh water and sea water samples being analysed.

Zinc discharge in the Eastern River

The measured zinc discharge from 22 June to 11 August in the Eastern River was in 1997 about 2000 kgs which is comparable to the measured discharge in 1994 and 1995 of 1500 and 1800 kgs, respectively. The zinc concentration in the river was this year similar to the zinc concentrations found during the same period in the previous years, with only low concentrations due to the later sampling period this year. Had it not been for the great water discharge on one or two days, causing a high zinc discharge, the total zinc discharge would probably have been lower than in 1994 and 1995. The extraordinary high temperature of 13.9°C, compared to the average of 2.8°C (SD = 2.0, N = 25) for the whole period, quickly melted snow and permafrost layers and brought weathered zinc sulphate (and others) into solution (Glahder et al 1996) with the high zinc discharge as a result.

Zinc concentrations in sea water

The zinc concentrations in sea water below 2 meters were comparable to concentrations in 1994, and the zinc level is not significantly different from that of uncontaminated fjords.

A third year of baseline sampling

It is recommended to repeat this baseline study one more year to bring the total number of sampling years of the baseline program up to three in order to determine variations in baseline levels. It is also

recommended to include reference stations at the head and mouth of F. E. Hyde Fjord for sampling of fish, seaweed, sea water, and sediment, and terrestrial reference stations 30 to 50 kms north and south of Citronen Fjord for sampling of plants and faeces.

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9 Appendices

1. Station Positions 25

2. Fish Samples 27

3. Seaweed Samples 30

4. Sea Water Column Samples 31

5. River Sediment Samples 32

6. Plant Samples 33

7. Faeces Samples 35

8. Fresh Water Samples 37

9. Metal Concentrations (µg/kg) in Sea Water at four Hydrographic Stations 38

10. Metal Concentrations (µg/kg) in Fresh Water from Station V1 (Eastern River) 39

11. Metal Concentrations (µg/kg) in Fresh Water from other Stations 40

12. Water Flow Calculations in Eastern River 41

13. Proposal for a Baseline Study Programme in Citronen Fjord 1997 44

Appendix 1. Station Positions.
Position measured by Gusminy and Garmin, GPS 50, NAD 27-GRN.

Station:	Locality:	Latitude (N):	Longitude (W):	Sample:
F1	Citronen Fjord	83°06.22'	28°23.25'	Fish
F2	Citronen Fjord	83°07.01'	28°16.61'	Fish
F3	Citronen Fjord	83°06.85'	28°25.09'	Fish
F4	Citronen Fjord	83°07.90'	28°24.65'	Fish
F5	Citronen Fjord	83°07.78'	28°13.39'	Fish
T1	Citronen Fjord	83°07.48'	28°24.74'	Seaweed
T2	Citronen Fjord	83°07.90	28°23.96'	Seaweed
T3	Citronen Fjord	83°06.85'	28°25.09	Seaweed
T4	Citronen Fjord	83°07.80	28°13.69	Seaweed
T5	Citronen Fjord	83°07.05'	28°17.10'	Seaweed
T6	Citronen Fjord	83°06.59'	28°16.40'	Seaweed
H1	Citronen Fjord	83°06.50'	28°18.60'	Seawater
H2	Citronen Fjord	83°06.50'	28°22.10	Seawater
H3	Citronen Fjord	83°07.39	28°18.68'	Seawater
H4	Citronen Fjord	83°08.15'	28°19.31'	Seawater
E1	Eastern River	83°05.97	28°19.73'	Sediment
E2	Eastern River	83°05.70'	28°19.11'	Sediment
E3	Eastern River	83°05.49'	28°17.38'	Sediment
E4	Eastern River	83°05.19'	28°16.52'	Sediment
E5	Eastern River	83°04.58'	28°13.75'	Sediment
E6	Eastern River	83°04.16'	28°11.34'	Sediment
E7	Eastern River	83°03.84	28°07.76'	Sediment
E8	Eastern River	83°04.93'	28°16.58'	Sediment
E9	Eastern River	83°03.18'	28°59.68'	Sediment
E10	Eastern River	83°02.23'	28°46.55'	Sediment
E11	Esrum Elv	83°04.18'	28°30.35'	Sediment
E12	Esrum Elv	83°05.06'	28°21.97'	Sediment
E13	Esrum Elv	83°03.59'	28°35.36'	Sediment
E14	Esrum Elv	83°02.50'	28°47.65'	Sediment
P1	Citronen Fjord	83°06.85'	28°25.09'	Plant, faeces
P2	Citronen Fjord	83°07.90'	28°24.65'	Plant, faeces
P3	Citronen Fjord	83°07.78'	28°13.39'	Plant, faeces
P4	Citronen Fjord	83°07.01'	28°16.61	Plant, faeces
P5	Eastern River	83°04.58'	28°13.75'	Plant, faeces
P6	Eastern River	83°04.16'	28°11.34'	Plant, faeces
P7	Eastern River	83°03.84'	28°07.76'	Plant, faeces
P8	Eastern River	83°04.93'	28°16.58'	Plant, faeces
P9	Eastern River	83°03.18'	27°59.68'	Plant, faeces
P10	Eastern River	83°02.23'	27°46.55'	Plant, faeces

P11	Esrum Elv	83°03.59'	28°35.36'	Plant, faeces
P12	Esrum Elv	83°04.18'	28°30.35'	Plant, faeces
P13	Eastern River	83°05.36'	28°18.03'	Plant, faeces
P14	Esrum Elv	83°05.06'	28°21.97'	Plant, faeces
P15	Citronen Fjord	83°06.32'	28°16.39'	Plant, faeces
P16	Eastern River	83°04.70'	28°13.10'	Plant
P17	Eastern River	83°04.60'	28°12.30'	Plant
P18	Eastern River	83°04.50'	28°11.15'	Plant
P19	Eastern River	83°04.56'	28°12.29'	Plant, faeces
P20	Esrum Elv	83°02.50'	28°47.65'	Plant, faeces
V1	Eastern River	83°05.11'	28°16.29'	Freshwater
V2	Eastern River Brook	83°04.58'	28°13.75'	Freshwater
V3	Eastern River	83°04.16'	28°11.34'	Freshwater
V4	Eastern River	83°03.84'	28°07.76'	Freshwater
V5	Base Camp lake	83°05.12'	28°17.80'	Freshwater
V6	Eastern River	83°03.18'	28°59.68'	Freshwater
V7	Eastern River	83°02.23'	28°46.55'	Freshwater
V8	Esrum Elv	83°04.18'	28°30.35'	Freshwater
V9	Esrum Elv	83°05.06'	28°21.97'	Freshwater
V10	Esrum Elv	83°03.59'	28°35.36'	Freshwater
V11	Esrum Elv	83°02.50'	28°47.65'	Freshwater

Appendix 2. Fish Samples

The fish species sampled was Fourhorned sculpin, *Myoxycephalus quadricornis*

Station:	ID-No:	Date:	INI:
F 1	20101	02-08-97	SEJ
F 1	20102	02-08-97	SEJ
F 1	20103	02-08-97	SEJ
F 1	20104	02-08-97	SEJ
F 1	20105	02-08-97	SEJ
F 1	20106	02-08-97	SEJ
F 1	20107	02-08-97	SEJ
F 1	20108	02-08-97	SEJ
F 1	20109	02-08-97	SEJ
F 1	20110	02-08-97	SEJ
F 1	20111	02-08-97	SEJ
F 1	20112	02-08-97	SEJ
F 1	20113	02-08-97	SEJ
F 1	20114	03-08-97	CMG
F 1	20115	03-08-97	CMG
F 1	20116	03-08-97	CMG
F 1	20117	03-08-97	CMG
F 1	20118	03-08-97	CMG
F 1	20119	03-08-97	CMG
F 1	20120	03-08-97	CMG
F 1	20121	03-08-97	CMG
F 1	20122	03-08-97	CMG
F 1	20123	03-08-97	SEJ
F 1	20124	03-08-97	SEJ
F 1	20125	03-08-97	SEJ
F 1	20126	03-08-97	SEJ
F 1	20127	03-08-97	SEJ
F 1	20128	03-08-97	SEJ
F 1	20129	03-08-97	SEJ
F 1	20130	03-08-97	SEJ
F 1	20131	03-08-97	SEJ
F 1	20132	03-08-97	SEJ
F 1	20133	03-08-97	SEJ
F 1	20134	03-08-97	SEJ
F 1	20135	03-08-97	SEJ
F 1	20136	03-08-97	SEJ
F 2	20149	04-08-97	CMG
F 2	20150	04-08-97	CMG

F 2	20183	05-08-97	CMG
F 2	20184	05-08-97	CMG
F 2	20185	05-08-97	CMG
F 2	20186	05-08-97	CMG
F 2	20187	05-08-97	CMG
F 2	20188	05-08-97	CMG
F 2	20189	05-08-97	CMG
F 2	20190	05-08-97	CMG
F 3	20137	03-08-97	SEJ
F 3	20138	03-08-97	SEJ
F 3	20139	03-08-97	SEJ
F 3	20140	03-08-97	SEJ
F 3	20141	03-08-97	SEJ
F 3	20142	03-08-97	SEJ
F 3	20143	03-08-97	SEJ
F 3	20144	03-08-97	SEJ
F 3	20145	03-08-97	SEJ
F 3	20146	03-08-97	SEJ
F 3	20151	04-08-97	CMG
F 3	20152	04-08-97	CMG
F 3	20153	04-08-97	CMG
F 3	20154	04-08-97	CMG
F 3	20155	04-08-97	CMG
F 3	20156	04-08-97	CMG
F 3	20157	04-08-97	CMG
F 3	20158	04-08-97	CMG
F 3	20159	04-08-97	CMG
F 3	20160	04-08-97	CMG
F 3	20161	04-08-97	CMG
F 3	20162	04-08-97	CMG
F 3	20163	04-08-97	CMG
F 3	20164	04-08-97	CMG
F 3	20165	04-08-97	CMG
F 3	20166	04-08-97	CMG
F 5	20147	03-08-97	SEJ
F 5	20148	03-08-97	SEJ
F 5	20167	04-08-97	CMG
F 5	20168	04-08-97	CMG
F 5	20169	04-08-97	CMG
F 5	20170	04-08-97	CMG
F 5	20171	04-08-97	CMG
F 5	20172	04-08-97	CMG
F 5	20173	04-08-97	CMG
F 5	20174	04-08-97	CMG
F 5	20175	04-08-97	CMG
F 5	20176	04-08-97	CMG

F 5	20177	04-08-97	CMG
F 5	20178	04-08-97	CMG
F 5	20179	04-08-97	CMG
F 5	20180	04-08-97	CMG
F 5	20181	04-08-97	CMG

Appendix 3. Seaweed Samples

The seaweed species sampled was Sweet tangle, *Laminaria* sp - probably *Saccharina*

Station:	ID-No:	Date:	INI	Comments:
T 1	20325	10-08-97	SEJ	
T 1	20326	10-08-97	SEJ	
T 2	20327	10-08-97	SEJ	
T 2	20328	10-08-97	SEJ	
T 3	20192	09-08-97	CMG	Washed in base-camp water
T 3	20193	09-08-97	CMG	Washed in base-camp water
T 4	20194	09-08-97	CMG	Washed in base-camp water
T 4	20195	09-08-97	CMG	Washed in base-camp water
T 5	20196	09-08-97	CMG	Washed in base-camp water
T 5	20197	09-08-97	CMG	Washed in base-camp water
T 6	20198	09-08-97	CMG	Washed in base-camp water
T 6	20199	09-08-97	CMG	Washed in base-camp water

Appendix 4. Sea Water Column Samples.				
Station:	ID-No:	Bottle No:	Date:	Depth (m):
H 1	20330	453	11-08-97	0
H 1	20330	454	11-08-97	2
H 1	20330	455	11-08-97	5
H 1	20330	456	11-08-97	10
H 1	20330	457	11-08-97	15
H 1	20330	458	11-08-97	20
H 1	20330	459	11-08-97	30
H 2	20331	460	11-08-97	0
H 2	20331	461	11-08-97	2
H 2	20331	462	11-08-97	5
H 2	20331	463	11-08-97	10
H 2	20331	464	11-08-97	15
H 2	20331	465	11-08-97	20
H 2	20331	466	11-08-97	30
H 3	20332	467	11-08-97	0
H 3	20332	468	11-08-97	2
H 3	20332	469	11-08-97	5
H 3	20332	470	11-08-97	10
H 3	20332	471	11-08-97	15
H 3	20332	472	11-08-97	20
H 3	20332	473	11-08-97	30
H 3	20332	474	11-08-97	50
H 4	20333	475	12-08-97	0
H 4	20333	476	12-08-97	2
H 4	20333	477	12-08-97	5
H 4	20333	478	12-08-97	10
H 4	20333	479	12-08-97	15
H 4	20333	480	12-08-97	20
H 4	20333	481	12-08-97	30
H 4	20333	482	12-08-97	50
H 4	20333	483	12-08-97	75
H 4	20333	484	12-08-97	100

Appendix 5. River Sediment Samples.				
Station:	ID-No:	Locality:	Date:	INI:
E 1	20245	Eastern River	05-08-97	CMG
E 2	20246	Eastern River	05-08-97	CMG
E 3	20247	Eastern River	05-08-97	CMG
E 4	20248	Eastern River	05-08-97	CMG
E 5	20270	Eastern River	06-08-97	CMG
E 6	20256	Eastern River	06-08-97	CMG
E 7	20318	Eastern River	08-08-97	SEJ
E 8	20249	Eastern River	05-08-97	CMG
E 9	20317	Eastern River	08-08-97	SEJ
E 10	20316	Eastern River	08-08-97	SEJ
E 11	20295	Esrum Elv	07-08-97	SEJ
E 12	20276	Esrum Elv	06-08-97	CMG
E 13	20296	Esrum Elv	07-08-97	SEJ
E 14	20294	Esrum Elv	07-08-97	SEJ

Appendix 6. Plant Samples.
Plants: Grass species, *Poa abbreviata, Puccinellia angustata* and *Colpodium vahlianum,* Arctic Willow, *Salix arctica,* and Entired-leafed mountain avens, *Dryas integrifolia.*

Station:	ID-No:	Species:	Date:	INI:
P 1	20201	Salix arctica	02-08-97	CMG
P 1	20202	Salix arctica	02-08-97	CMG
P 1	20203	Grass sp.	02-08-97	CMG
P 1	20204	Dryas integrifolia	02-08-97	CMG
P 2	20214	Salix arctica	03-08-97	SEJ
P 2	20215	Grass sp.	03-08-97	SEJ
P 2	20216	Dryas integrifolia	03-08-97	SEJ
P 3	20207	Salix arctica	02-08-97	CMG
P 3	20208	Salix arctica	02-08-97	CMG
P 3	20209	Puccinellia angustata	02-08-97	CMG
P 3	20210	Dryas integrifolia	02-08-97	CMG
P 4	20220	Salix arctica	03-08-97	CMG
P 4	20221	Salix arctica	03-08-97	CMG
P 4	20222	Poa abbreviata	03-08-97	CMG
P 4	20223	Dryas integrifolia	03-08-97	CMG
P 5	20227	Salix arctica	05-08-97	CMG
P 5	20228	Salix arctica	05-08-97	CMG
P 5	20229	Dryas integrifolia	05-08-97	CMG
P 5	20230	Puccinellia angustata, Colpodium vahlianum	05-08-97	CMG
P 6	20250	Salix arctica	06-08-97	CMG
P 6	20251	Grass sp.	06-08-97	CMG
P 6	20252	Dryas integrifolia	06-08-97	CMG
P 7	20310	Salix arctica	08-08-97	SEJ
P 7	20311	Dryas integrifolia	08-08-97	SEJ
P 7	20312	Puccinellia angustata, (Colpodium vahlianum)	08-08-97	SEJ
P 8	20234	Salix arctica	05-08-97	CMG
P 8	20235	Dryas integrifolia	05-08-97	CMG
P 8	20236	Grass sp.	05-08-97	CMG
P 9	20304	Salix arctica	08-08-97	SEJ
P 9	20305	Dryas integrifolia	08-08-97	SEJ
P 9	20306	Colpodium vahlianum	08-08-97	SEJ
P 10	20298	Salix arctica	08-08-97	SEJ
P 10	20299	Dryas integrifolia	08-08-97	SEJ
P 10	20300	Grass sp.	08-08-97	SEJ
P 11	20277	Salix arctica	07-08-97	SEJ
P 11	20278	Dryas integrifolia	07-08-97	SEJ
P 11	20279	Grass sp.	07-08-97	SEJ

P 12	20283	Salix arctica	07-08-97	SEJ
P 12	20284	Dryas integrifolia	07-08-97	SEJ
P 12	20285	Poa abbreviata, Puccinellia angustata	07-08-97	SEJ
P 13	20239	Salix arctica	05-08-97	CMG
P 13	20240	Dryas integrifolia	05-08-97	CMG
P 13	20241	Colpodium vahlianum	05-08-97	CMG
P 14	20271	Salix arctica	06-08-97	CMG
P 14	20272	Poa abbreviata	06-08-97	CMG
P 14	20273	Dryas integrifolia	06-08-97	CMG
P 15	20319	Salix arctica	10-08-97	SEJ
P 15	20320	Grass sp.	10-08-97	SEJ
P 15	20321	Dryas integrifolia	10-08-97	SEJ
P 16	20257	Salix arctica	06-08-97	CMG
P 16	20258	Poa abbreviata, Puccinellia angustata	06-08-97	CMG
P 16	20259	Dryas integrifolia	06-08-97	CMG
P 17	20260	Salix arctica	06-08-97	CMG
P 17	20261	Grass sp.	06-08-97	CMG
P 17	20262	Dryas integrifolia	06-08-97	CMG
P 18	20263	Salix arctica	06-08-97	CMG
P 18	20264	Colpodium vahlianum	06-08-97	CMG
P 19	20265	Salix arctica	06-08-97	CMG
P 19	20266	Poa abbreviata, Puccinellia angustata	06-08-97	CMG
P 19	20267	Dryas integrifolia	06-08-97	CMG
P 20	20288	Salix arctica	07-08-97	SEJ
P 20	20289	Dryas integrifolia	07-08-97	SEJ
P 20	20290	Colpodium vahlianum	07-08-97	SEJ

Appendix 7. Faeces Samples.
Faeces from: Alpine hare, *Lepus arcticus,* Muskox, *Ovibos moschatus,* Collared lemming, *Discrostonyx torquatus.*

Station:	ID-No:	Species:	Date:	INI:
P 1	20205	Lepus arcticus	02-08-97	CMG
P 1	20206	Ovibos moschatus	02-08-97	CMG
P 2	20217	Lepus arcticus	03-08-97	SEJ
P 2	20218	Ovibos moschatus	03-08-97	SEJ
P 2	20219	Discrostonyx torquatus	03-08-97	SEJ
P 3	20211	Lepus arcticus	02-08-97	CMG
P 3	20212	Ovibos moschatus	02-08-97	CMG
P 3	20213	Discrostonyx torquatus	02-08-97	CMG
P 4	20224	Lepus arcticus	03-08-97	CMG
P 4	20225	Ovibos moschatus	03-08-97	CMG
P 4	20226	Discrostonyx torquatus	03-08-97	CMG
P 5	20231	Ovibos moschatus	05-08-97	CMG
P 5	20232	Lepus arcticus	05-08-97	CMG
P 5	20233	Discrostonyx torquatus	05-08-97	CMG
P 6	20253	Lepus arcticus	06-08-97	CMG
P 6	20254	Ovibos moschatus	06-08-97	CMG
P 6	20255	Discrostonyx torquatus	06-08-97	CMG
P 7	20313	Lepus arcticus	08-08-97	SEJ
P 7	20314	Ovibos moschatus	08-08-97	SEJ
P 7	20315	Discrostonyx torquatus	08-08-97	SEJ
P 8	20237	Lepus arcticus	05-08-97	CMG
P 8	20238	Ovibos moschatus	05-08-97	CMG
P 9	20307	Lepus arcticus	08-08-97	SEJ
P 9	20308	Ovibos moschatus	08-08-97	SEJ
P 9	20309	Discrostonyx torquatus	08-08-97	SEJ
P 10	20301	Lepus arcticus	08-08-97	SEJ
P 10	20302	Ovibos moschatus	08-08-97	SEJ
P 10	20303	Discrostonyx torquatus	08-08-97	SEJ
P 11	20280	Lepus arcticus	07-08-97	SEJ
P 11	20281	Ovibos moschatus	07-08-97	SEJ
P 11	20282	Discrostonyx torquatus	07-08-97	SEJ
P 12	20286	Ovibos moschatus	07-08-97	SEJ
P 12	20287	Lepus arcticus	07-08-97	SEJ
P 13	20242	Lepus arcticus	05-08-97	CMG
P 13	20243	Ovibos moschatus	05-08-97	CMG
P 13	20244	Discrostonyx torquatus	05-08-97	CMG
P 14	20274	Lepus arcticus	06-08-97	CMG
P 14	20275	Ovibos moschatus	06-08-97	CMG
P 15	20322	Lepus arcticus	10-08-97	SEJ

P 15	20323	Ovibos moschatus	10-08-97	SEJ
P 15	20324	Discrostonyx torquatus	10-08-97	SEJ
P 19	20268	Lepus arcticus	06-08-97	CMG
P 19	20269	Discrostonyx torquatus	06-08-97	CMG
P 20	20291	Lepus arcticus	07-08-97	SEJ
P 20	20292	Ovibos moschatus	07-08-97	SEJ
P 20	20293	Discrostonyx torquatus	07-08-97	SEJ

Appendix 8. Fresh Water Samples.						
Station:	Bottle No:	Locality:	Date:	Hour (GMT):	H, distance (m) from I to water level	Temperature (°C) 2 days average
V1	400	Eastern River	22-06-97	21:15	0.53	+ 6.5
V1	401	Eastern River	24-06-97	22:15	1.13	+ 4.3
V1	402	Eastern River	26-06-97	21:15	1.13	+ 1.7
V1	403	Eastern River	28-06-97	20:45	1.28	+ 0.6
V1	404	Eastern River	30-06-97	21:45	1.06	+ 1.6
V1	405	Eastern River	02-07-97	19:15	1.03	+ 1.0
V1	406	Eastern River	04-07-97	21:30	0.85	+ 2.7
V1	407	Eastern River	06-07-97	20:45	0.99	+ 5.1
V1	408	Eastern River	08-07-97	22:00	0.43	+ 13.9
V1	409	Eastern River	10-07-97	21:45	1.13	+ 8.5
V1	410	Eastern River	12-07-97	21:45	1.48	+ 2.9
V1	411	Eastern River	14-07-97	21:45	1.52	+ 0.8
V1	412	Eastern River	16-07-97	21:15	1.46	+ 2.8
V1	413	Eastern River	18-07-97	21:45	1.73	+ 1.9
V1	414	Eastern River	20-07-97	20:30	1.53	+ 2.3
V1	415	Eastern River	22-07-97	21:15	1.40	+ 2.1
V1	416	Eastern River	24-07-97	21:30	1.13	+ 4.5
V1	417	Eastern River	26-07-97	22:45	1.39	+ 3.3
V1	418	Eastern River	28-07-97	20:45	2.00	+ 2.7
V1	419	Eastern River	30-07-97	20:30	1.04	+ 2.8
V1	420	Eastern River	01-08-97	19:45	1.09	- 0.2
V1	421	Eastern River	03-08-97	23:00	1.10	+ 0.1
V1	422	Eastern River	05-08-97	20:30	1.85	+ 1.5
V1	423	Eastern River	07-08-97	21:00	1.78	+ 4.4
V1	424	Eastern River	09-08-97	23:15	1.90	+ 3.1
V1	425	Eastern River	11-08-97	20:45	2.13	+ 3.4
V2	433	Eastern River Brook				
V3	432	Eastern River				
V4	440	Eastern River				
V5	431	Base Camp Lake				
V6	439	Eastern River				
V7	438	Eastern River				
V8	437	Esrum Elv				
V9	434	Esrum Elv				
V10	436	Esrum Elv				
V11	435	Esrum Elv				

Appendix 9. Metal Concentrations (µg/kg) in Sea Water at four Hydrographic Stations			
Station:	Bottle No:	Depth (m):	Zn (µg/kg):
H1	453	1	4,81
H1	454	2	1,00
H1	455	5	0,80
H1	456	10	1,11
H1	457	15	0,86
H1	458	20	0,88
H1	459	30	1,25
H2	460	1	7,04
H2	461	2	1,31
H2	462	5	1,63
H2	463	10	2,77
H2	464	15	1,23
H2	465	20	1,80
H2	466	30	0,79
H3	467	1	5,80
H3	468	2	2,67
H3	469	5	1,28
H3	470	10	1,33
H3	471	15	2,40
H3	472	20	1,08
H3	473	30	0,89
H3	474	50	4,09
H4	475	1	11,51
H4	476	2	0,81
H4	477	5	1,96
H4	478	10	2,44
H4	479	15	3,65
H4	480	20	1,83
H4	481	30	0,84
H4	482	50	1,27
H4	483	75	1,7
H4	484	100	0,27

Appendix 10. Metal Concentrations (µg/kg) in Fresh Water from Station 1 (Eastern River).					
Date:	Bottle No:	Zinc (µg/kg):	Kg Zn/Day:	Kg Zn:	Mill. m3/day:
22-06-97	400	37.46	318.20	636.39	8.49
24-06-97	401	04.09	41.16	82.33	3.12
26-06-97	402	14.25	51.88	103.75	3.12
28-06-97	403	06.56	11.91	23.81	2.25
30-06-97	404	09.00	15.72	31.40	3.59
02-07-97	405	01.59	26.95	53.90	3.81
04-07-97	406	13.11	60.50	121.00	5.24
06-07-97	407	00.13	32.84	65.60	4.10
08-07-97	408	17.32	327.50	655.00	9.71
10-07-97	409	16.23	20.88	41.77	3.12
12-07-97	410	12.27	7.41	14.81	1.34
14-07-97	411	02.34	2.51	5.03	1.19
16-07-97	412	03.20	4.46	8.92	1.42
18-07-97	413	18.00	1.01	2.01	0.58
20-07-97	414	04.06	4.83	9.66	1.16
22-07-97	415	13.38	5.97	11.93	1.67
24-07-97	416	21.18	9.03	18.05	3.12
26-07-97	417	20.19	6.60	13.21	1.72
28-07-97	418	07.12	0.73	1.46	0.14
30-07-97	419	12.01	46.67	93.35	3.73
01-08-97	420	09.18	14.86	29.73	3.39
03-08-97	421	13.23	8.49	16.99	3.32
05-08-97	422	17.50	0.92	1.84	0.34
07-08-97	423	18.28	0.83	1.65	0.47
09-08-97	424	12.14	0.39	0.78	0.26
11-08-97	425	23.19	0.09	0.17	0.04

Appendix 11. Metal Concentrations (µg/kg) in Fresh Water from other Stations.				
Station:		Bottle No:	Date:	Zn (µg/kg):
V2	Eastern River Brook	433	06-08-97	0.15
V3	Eastern River	432	06-08-97	0.25
V4	Eastern River	440	08-08-97	0.32
V5	Base Camp lake	431	05-08-97	0.82
V6	Eastern River	439	08-08-97	0.31
V7	Eastern River	438	08-08-97	0.45
V8	Esrum Elv	437	07-08-97	0.61
V9	Esrum Elv	434	06-08-97	0.67
V10	Esrum Elv	436	07-08-97	0.53
V11	Esrum Elv	435	07-08-97	1.33

Appendix 12.

Water Flow in Eastern River/Citronen Fjord

The water flow conditions as well as the quantity of the annual run-off of the Eastern River in the Citronen Fjord area, Peary Land, North Greenland, have been obtained on the basis of maps, observations from Station Nord, and field registrations.

Although the results give a fine coherence on the basis of a qualified preliminary evaluation, adaptation should be made to later necessary measurements in order to give a reliable reflection of the situation.

1. Water Flow in Eastern River

The position of the discharge cross-section B is shown on the enclosed map. Here one discharge measurement was taken in 1993 by means of an OTT-C2 Flügel current meter and a qualified estimation of the water flow. In 1994 an estimate and a qualified evaluation of the water flow were made. Furthermore, the cross-section was measured in 1994, and in the same year two reference points for future measurement of the water level were made.

In connection with a water sampling program the water level below cross-section B has daily been read from a folding ruler taped on a staff (FR-Staff) during the summer of 1994.

The Q/H relation is based on the following observations:

12 August 1994	water level	=	0 m
at 3-5 p.m. GMT	Ho	=	-0.15 m
	Point I	=	+2.20 m
	Point II	=	+1.61 m
	FR-Staff	=	+ 1 1/4 inch
	Q	~	200 l/s, on the basis of the cross-section and surface water flow.
	Measurement of the cross-section		
6 August 1994	FR-Staff	=	+ 9½ inch
at 10 p.m. GMT	water level	~	"a few cm higher" than on 20 August 1993
	Q	~	"a little bigger" than on 20 August 1993
20 August 1993	water level	~	+ 0.18 m on the basis of the geometry of the cross-section and width of cross section when measuring
at 2 p.m. GMT	Q	=	1.4 m^3/s

18 August 1993 at 10 p.m. GMT	Q	~	6.3 m^3/s

The following Q/H relation has been obtained geometrically by plotting on log-log paper:

$$Q = A \times (H-Ho)^n$$
$$n \sim 2.5$$
$$A \sim 22$$

$$\underline{Q \sim 22 \times (H-Ho)^{2,5}}$$

By using point I: $Q\ (m^3/s) \sim 22 \times (2.35\ m - H)^{2.5}$. H is the vertical distance between point I and the water level, given in metres.

By using point II: $Q\ (m^3/s) \sim 22 \times (1.76\ m - H)^{2.5}$. H is the vertical distance between point II and the water level, given in metres.

The above formula has to be verified by means of field measurements. As the cross-section B can not be considered constant at higher flow speeds the formula should be checked now and then - an alternative would be to establish a permanent weir or to locate another cross-section.

2. Water Flow at the Water Sampling Station in 1994

The following relation can be made if the changes of water level at the sampling site (FR-staff) and cross-section B are considered identical:

$$Q = A_1 \times (H-H_{,1})^n 1$$
$$n_1 \sim 2.5$$
$$A_1 \sim 2.3\ l/s$$
$$H_{,1} \sim -4.7\ inch$$

$$\underline{Q\ (l/s) \sim 2.3 \times (Measuring\ (inch) + 4.7)^{2.5}}$$

The surmise about the changes of water level proves to be rough because the water flow near the sampling site will be swift - but for the want of something better the formula can be recommend for the calculation of a preliminary estimate.

3. Annual run-off from Eastern River

The catchment area, drained through Eastern River, is outlined on the map 1:100,000 (ortho photo map with hights in 100 m). The boundary has been made from the surface water line and some uncertainty is connected to the demarcation of glaciers and the river valley towards south-east. Field work may clarify these conditions.

The catchment area, lined by cross-section B, is calculated to cover 510.8 km^2.

Local glaciers are assumed in balance, which means that the net ablation is 0 mm/year.

The precipitation is estimated from a mean of a 22 year measurement at Station Nord (measured at level 35 metres) with a deduction of evaporation/sublimation (20%), a deduction of difference in coast distance at Station Nord and Eastern River (30%) and with an addition of the higher mean level around Eastern River (30%).

Thus the estimated mean precipitation around Eastern River will be:

$N \sim 201$ mm x 70% x 1/70% x 80% = 160 mm,
the standard deviation of which is presumably 30-40%.

Thus the estimated annual run-off through the cross-section B is:

Q year $\sim 510 \times 10^6 \times 0.16 \sim 80 \times 10^6$ m^3,
covering a period of 5 months (May - September).

A more reliable determination of the annual run-off can only be obtained by means of continuos measurements in the field. To control the field measurements and to determine a possible contribution from ablation the catchment area should, at the same time, be determined and the precipitation should continuously be certified.

Appendixes:
- Cross-section B, 12 August, 1994.
- Map of cross-section B and catchment area - 1:100 000/100 m

Hans Christian Langager, MRA
19 January 1995

Translation Birthe Larsen, DMU
20 April 1998

Appendix 13.

Proposal for a baseline study programme in Citronen Fjord 1997

Prepared 21.03.1997 by NERI, Dept. of Arctic Environment, CMG.

Introduction

This proposal for a baseline study in Citronen Fjord in 1997 is planned to be performed during a three week period from late July to mid August. The study is in principal similar to the 1994 baseline study. It is recommended that only sea and fresh water samples are analysed in 1997, whereas other samples will be stored frozen or dried.

Baseline study program

The study is carried out by a senior biologist and a student from NERI, Dept. of Arctic Environment, during a three week period including transportation. Sampling in Citronen Fjord (CF) and F. E. Hyde Fjord (HF) is carried out from a rubber boat, and at the reference stations in HF also with helicopter assistance. Sampling on land is by foot and at the reference stations with helicopter assistance. Fresh water samples from Eastern River are taken by Platinova A/S from June to September except for the baseline period. In the following the different types of samples are described.

Sea sediment

In 1994 sediments were sampled at 26 stations in CF. In 1997 this is not repeated. In 1997 samples are taken at 4 stations in HF, including two close to CF and two reference stations 30-50 km from CF (e.g. Frigg Fjord and Depot Bugt).

Fish

Fourhorned sculpin was in 1994 sampled at 5 stations in CF. This is duplicated in 1997. Moreover, sculpins are caught at four stations in HF (cf. *sea sediment*). In CF and at the reference stations in HF, Polar cod or Arctic cod will be caught if possible.

Mussels

Only few mussels were collected in 1994. In 1997 we will try to sample mussels both in CF (e.g. three stations of 10 individuals) and HF (e.g. two stations of 10 individuals)(cf. *sea sediment*).

Seaweed

Seaweed *Laminaria* sp was sampled at six stations in CF in 1994; this is duplicated in 1997. In addition seaweed will be sampled at four stations in HF (cf. *sea sediment*). At each station two samples both of at least five specimens are taken.

Seawater

Seawater was sampled at 30 surface stations and four hydrographic stations in CF in 1994. Sampling is repeated in 1997, but only from the four hydrographic stations. Also in 1997 seawater is sampled at four hydrographic stations in HF (cf. *sea sediment*).

River sediment

In 1994 sediment was sampled at 10 stations in Eastern River and two in Esrum Elv. This is duplicated in 1997.

Plants and faeces

Plant (three species) and faeces (from three species) samples were taken at 19 stations in the CF area in 1994. This is repeated in 1997 and in addition plant and faeces samples are taken at five reference stations approximately 40 km north and south of CF. This is supplemented with sampling of moss species at 5-10 stations in the CF area, and at 3-5 reference stations.

Fresh water

In 1994 fresh water samples were taken at eight stations in the Eastern River, including one permanent station, and one in Esrum Elv. In 1997 this is repeated, but only one sample every second day is taken at the permanent station (every day in 1994 and every second day in 1995). As in 1994 and 1995 we hope Platinova A/S will assist in the sampling. Water level is measured at the same time as sampling, and a few water flow measurements are made at different water levels (possibly performed by MRA).

Lemmings

Approximately 20 Collared lemmings will be caught in the CF area if possible.

Precipitation

Precipitation data are valuable when estimating the metal outflow from the Eastern River. Sampling period should at least be when water is running in the Eastern river.

Other meteorological data

These are measured by Platinova A/S as in 1994.

Observations on wildlife

As in 1993 and 1994.

National Environmental Research Institute

The National Environmental Research Institute, NERI, is a research institute of the Ministry of Environment and Energy. In Danish, NERI is called *Danmarks Miljøundersøgelser (DMU)*. NERI's tasks are primarily to conduct research, collect data, and give advice on problems related to the environment and nature.

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