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NINA Report

FREMONEC: Effect of climate change and related stressors on fresh and brackish water ecosystems in Svalbard

A Norwegian and Russian joint scientific project

Inta Dimante-Deimantovica, Mikhail Chertoprud,
Elena Chertoprud, Kirsten S. Christoffersen,
Anna Novichkova and Bjørn Walseng

Norwegian Institute for Nature Research

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Isfjorden and sampling sites around Isfjorden, Svalbard (Photo: B. Walseng)

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CONTACT DETAILS

NINA head office	NINA Oslo	NINA Tromsø	NINA Lillehammer
Postboks 5685 Sluppen	Gaustadalléen 21	Framsenteret	Fakkelgården
NO-7485 Trondheim	NO-0349 Oslo	NO-9296 Tromsø	NO-2624 Lillehammer
Norway	Norway	Norway	Norway
Phone: +47 73 80 14 00	Phone: +47 73 80 14 00	Phone: +47 77 75 04 00	Phone: +47 73 80 14 00

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Abstract

Dimante-Deimantovica, I., Chertoprud, M., Chertoprud, E., Christoffersen, K.S., Novichkova, A. & Walseng, B. 2015. FREMONEC: Effect of climate change and related stressors on fresh and brackish water ecosystems in Svalbard. A Norwegian and Russian joint scientific project. - NINA Report 1218. 40 pp.

This report summarizes the results of the Russian-Norwegian collaboration project FREMONEC which was established as part of POLRES (Polar Research sub-program NORRUSS) with the aim to stimulate bilateral cooperation on polar research. Researchers from The Norwegian Institute for Nature Research and M. V. Lomonosov Moscow State University have studied the effects of climate change and related stressors on fresh and brackish water habitats, by using invertebrates as biological quality elements. Both partners were involved in preparing the study design, as well as participating in meetings, fieldwork (2014 and 2015) and analyzing/reporting of collected material. Altogether, 75 localities in Isfjorden and Kongsfjorden areas, including both lotic and lentic waters, were sampled. pH varied between 6.2 and 9.5 and conductivity from < 0,01 to > 10000 µS/cm. In general, biodiversity was low, especially when we compare Svalbard with other areas in the high and low Arctic. Still this survey revealed 6 microcrustacean taxa new to Svalbard: *Polyphemus pediculus*, *Diaptomidae* sp., *Diacyclops abyssicola, Epactophanes richardi*, *Nitokra spinipes* and *Geeopsis incisipes*. Most likely, some of these newcomers are directly or indirectly linked to the recent climate warming (obtained results were compared with old literature data). For macrozoobenthos it seemed that the origin of habitat, temperature, substrate type and water velocity were of importance. The number of crustaceans increased with the age of the localities (distance to the retreating glacier). For instance, the youngest habitats close to the glacier had the lowest number of copepod species and no cladocerans. The fauna in ‘urban’ ponds near human settlements did not differ from non-urban habitats. In the urban ponds, birds seem to be a more important factor than anthropogenic activities, contributing to diversity. As part of this project, one bachelor and one PhD student completed their theses. The network building between Norwegian and Russian research groups, which has included thematic areas relevant for both countries, has been a positive experience for both partners. Further, new knowledge on Svalbard’s biodiversity might give a contribution to future Arctic Freshwater Biodiversity Monitoring activities and to the implementation of integrated and sustainable Arctic freshwater ecosystems management. Because of FREMONEC, new collaboration projects and dissemination activities have also been initiated (projects NORUSVA and BRANTA-DULCIS).

Bjørn Walseng, Inta Dimante-Deimantovica, NINA, Gaustadalleen 21, N-0349, Oslo, Norway (bjorn.walseng@nina.no)
Mikhail Chertoprud, Elena Chertoprud, Anna Novichkova, M. V. Lomonosov Moscow State University, Vorobyevy Gory, RU-119992, Moscow, Russia (horsax@yandex.ru)
Kirsten S. Christoffersen, The University Centre in Svalbard, N-9171, Longyearbyen, Norway (kchristoffersen@bio.ku.dk)

Sammendrag

Dimante-Deimantovica, I., Chertoprud, M., Chertoprud, E., Christoffersen, K.S., Novichkova, A. & Walseng, B. 2015. FREMONEC: Effekter av klimaendringer og tilknyttete påvirkningsfaktorer på ferskvanns- og brakkvannsøkosystemer på Svalbard. Et felles norsk-russisk forskningsprosjekt. - NINA Rapport 1218. 40 s.

Denne rapporten oppsummerer det norsk-russiske samarbeidsprosjektet FREMONEC som er en del av POLRES (underprogram NORRUSS), og som tar sikte på utvikle bilateralt samarbeide om forskning I nordområdene. Forskere fra Norsk institutt for naturforskning og M. V. Lomonosov Moscow State University har studert mulige indirekte og direkte effekter av klimaendringer på faunaen i fersk- og brakkvann på Svalbard. Samarbeidet har innbefattet utarbeidelse av studiedesign, møtevirksomhet, feltarbeid (2014-2015), analyser og rapportskriving. Tilsammen 75 lokaliteter i Isfjorden- og Kongsfjordenområdet, både stillestående og rennende vann, ble prøvetatt. pH varierte mellom 6,2 og 9,5 mens ledningsevnen var < 0,01- > 10000 µS/cm. Generelt var det lav artsrikhet, særlig når vi sammenligner med andre nordområder. Likevel ble det funnet 6 taksa av småkreps som var nye for Svalbard: *Polyphemus pediculus*, *Diaptomidae* sp., *Diacyclops abyssicola, Epactophanes richardi*, *Nitokra spinipes* og *Geeopsis incisipes*. Enkelte av disse artene har sannsynligvis etablert seg som følge av at klimaet har endret seg, noe som kom fram når resultatene ble sammenlignet med historiske data. For makroinvertebratene var opprinnelsen til habitatet, temperatur, type substrat og vannhastighet viktig. Artsantallet til krepsdyr økte med alderen til lokaliteten, i vårt tilfelle vil det si med avstanden til isbreen. De yngste lokalitetene manglet vannlopper og hadde kun en eller noen få arter av hoppekreps. Vannforekomster nær bebyggelse skilte seg ikke ut med hensyn til fauna. Her er sannsynligvis gjødslingseffekten fra fugl en viktigere faktor enn menneskelige virksomhet. Både en bachelor- og en PhD-student fullførte sine grader i forbindelse med prosjektet. Samarbeidet har inkludert temaer som har vært relevante for begge partnere, og har vært en svært positiv erfaring. Videre vil ny kunnskap om Svalbards biodiversitet gi viktige bidrag til framtidig forvaltning og overvåking av ferskvannsforekomster. I kjølvannet av FREMONEC er det startet opp to nye forskningsrådsprosjekter basert på samarbeid mellom de samme forskerne (NORUSVA og BRANTA-DULCIS).

Bjørn Walseng, Inta Dimante-Deimantovica, NINA, Gaustadalleen 21, N-0349, Oslo, Norway (bjorn.walseng@nina.no)
Mikhail Chertoprud, Elena Chertoprud, Anna Novichkova, M. V. Lomonosov Moscow State University, Vorobyevy Gory, RU-119992, Moscow, Russia (horsax@yandex.ru)
Kirsten S. Christoffersen, The University Centre in Svalbard, N-9171, Longyearbyen, Norway (kchristoffersen@bio.ku.dk)

Аннотация

Инта Диманте-Даймантовица, Михаил Чертопруд, Елена Чертопруд, Кирстен С. Христофферсен, Анна Новичкова и Бьерн Вальсенг. 2015. FREMONEC: Влияние изменений климата, и связанных с ними стресс-факторов, на пресноводные и солоноватоводные экосистемы Шпицбергена. Норвежско-оссийский совместный проект - NINA Отчет 1218. 40 cc.

Этот отчет подытоживает результаты Норвежско-российского сотрудничества в проекте FREMONEC, что был создан в рамках POLRES (Полярной научно-исследовательской подпрограммы NORRUSS (Россия и Крайний Север / Арктика) с целью стимулирования двустороннего сотрудничества в отношении полярных исследований. Исследователи из Норвежского Института Природных Исследований и Московского Государственного Университета имени М.В. Ломоносова изучали последствия изменений климата, и связанных с ними стресс-фактров, на пресноводные и солоноватоводные местообитания, на основании анализа состава беспозвоночных как индикаторной группы. Как норвежские, так и российские ученые были привлечены для разработки плана исследований, участия в совещаниях и в полевых экспедициях на Шпицбергене в 2014-2015 гг., а также для анализа собранного материала и подготовки отчетов. В общей сложности, было посещено 75 точек (в районах Исфьорда и Конгсфьорда), на которых были отобраны пробы включая стоячие и проточные воды. pH колеблется между 6,2 и 9,5; проводимость от <0,01 µS/cm до 10000 µS/cm. В среднем, биоразнообразие в солоноватоводных и пресноводных местообитаниях было низким, особенно если сравнивать Шпицберген с другими районами высокой и низкой Арктики. Тем не менее, в ходе данного исследования обнаружено 6 таксонов новых для Шпицбергена: *Polyphemus pediculus*, *Diaptomidae* sp., *Diacyclops abyssicola*, *Epactophanes richardi*, *Nitokra spinipes* и *Geeopsis incisipes*. Все новые виды относятся к микроракообразным. Некоторые из новых находок очевидно прямо или косвенно связаны с недавним потеплением климата. Тем не менее, для макрозообентоса значимыми факторами являлись: происхождение местообитания, температура, тип субстрата и скорость течения. Число видов микроракообразных увеличивается вместе с увеличением возраста водоема (заключающемся в расстоянии от водоема до отступающего ледника). Например, недавние обитания, ближе к леднику имеет наименьшее количество видов копепод и совсем не кладоцер. В подверженных антропогенному влиянию местообитаниях фауна и видовой состав существенно не отличались от таковых в ненарушенных биотопах. В нескольких подверженных урбанистической нагрузке водоемах, фактор влияния птиц был более значимым по сравнению с антропогенным, что способствовало росту разнообразия. В рамках этого проекта, один бакалавр и один аспирант завершили свои квалификационные работы. Это исследование расширило имеющиеся знания о биоразнообразии Шпицбергена и может предоставить данные для дальнейшего Мониторинга Разнообразия Пресноводных сообществ Арктики, а также для осуществления комплексного и устойчивого управления арктическими пресноводными экосистемами. Начатое научное сотрудничество инициировало разработку новых совместных проектов (NORUSVA и BRANTA-DULCIS).

Бьерн Вальсенг, Инта Диманте-Даймантовица, NINA, Гаустадаллен 21, 0349, Осло,
Норвегия (bjorn.walseng@nina.no)
Михаил Чертопруд, Елена Чертопруд, Анна Новичкова, Московский Государственный
Университет имени М.В. Ломоносова, Воробьевы Горы, 119992, Москва, Россия
(horsax@yandex.ru)
Кирстен С. Христофферсен, Университетский Центр Шпицбергена, 9171, Лонгир,
Норвегия (kchristoffersen@bio.ku.dk)

Contents

Foreword

This report presents the results of the Norwegian and Russian joint scientific project "FREMONEC: Effect of climate change and related stressors on fresh and brackish water ecosystems in Svalbard" (2013 – 2015). The project is managed and conducted by The Norwegian Institute for Nature Research (NINA). The Russian collaboration partner is M. V. Lomonosov Moscow State University, department of Hydrobiology. Also a representative from UNIS (The University Centre in Svalbard) was involved in the project.

The project was established as part of POLRES (Polar Research sub-program NORRUSS (Russia and the high North/Arctic) with the aim to stimulate bilateral cooperation on polar research. As part of the project, a joint scientific team studied the effects of climate change and other stressors on fresh and brackish ecosystems by using invertebrates as biological quality elements. The project was funded by The Research Council of Norway and partly by NINA. Project activities like fieldwork in Svalbard (2014 and 2015) and meetings (2013 and 2015), were organized in synergy with other relevant projects (NORUSVA & BRANTA-DULCS, both funded by The Research Council of Norway).

We are especially grateful to the employees from the Norwegian Polar Institute, the State Trust Arktikugol (Russia), Kings Bay As (Norway) and to Alexander Roskulyak (Barentsburg, Svalbard), who provided logistic solutions during Svalbard fieldwork tours. We thank Jesper R. Schultz, a bachelor student from the University of Copenhagen, for participation and assistance during fieldwork operations in 2014. Many thanks to our colleagues Markus Lindholm The Norwegian Institute for Water Research (NIVA) who identified Ostracoda and to Miloslav Devetter (Centre for Polar Ecology, Academy of Sciences of the Czech Republic) who provided zooplankton material.

Oslo, 18.12.2015.
Inta Dimante-Deimantovica & Bjørn Walseng

1 Introduction

The environment of the Arctic regions is changing rapidly. Due to global climate change, the average Arctic temperatures have increased at about twice the rate compared to the rest of the world over the past few decades. As a result, a number of important Arctic ecosystems have been destabilized and it is therefore of interest to evaluate interactions between ecosystem functions and climatic changes (Meltofte et al. 2008, Sommerkorn & Hassol 2009).

Svalbard has an internationally valuable and sensitive high-arctic ecosystem and about 68% of the land area is protected. It includes both glaciers and freshwater habitats that belong to ecosystems suffering from climate change and other stressors like contaminants, alien species, and UV radiation (Culp et al. 2012). Lakes and ponds (Rautio et al. 2011) occupy a considerable part of the Arctic landscape (in some regions up to 90 %) and contribute significantly to Arctic biodiversity. Here we find hotspots of species diversity and also a biological production that is important for various organism groups in both aquatic and terrestrial ecosystems (Pienitz et al. 1997). The harsh northern climate has a strong influence on the dynamics and structure of these ecosystems. Most of the Arctic freshwater habitats are small and shallow, often drying out during the polar summer or freezing over in winter. During the open water season, there is an extensive development of micro-invertebrates, including microcrustaceans (Rautio et al. 2011). These animals are known to respond to changes in temperature, light and nutrients. In high latitude freshwater ecosystems even slight warming can result in changes in biological communities and to productivity shifts. There is concern that some ecosystems may even disappear (Smol et al. 2005; Smol & Douglas 2007; Rautio et al. 2011). Therefore, it is important to understand climate-induced environmental changes on freshwater biodiversity.

Data from the Arctic region are sparse, there is almost no long-term monitoring data available and little is known about ecological responses to recent warming (Fritz 1996; Smol & Douglas 2007; Culp et al. 2012). As evidence of freshwater ecosystems research needed in the Arctic, a Freshwater Expert Monitoring Group (FEMG) has been established (Culp et al. 2012). This group is presently working on development of an Arctic freshwater biodiversity monitoring plan.

Arctic climate research has become a priority issue also for Norway. There are already many activities dealing with climate, environment and ecosystem issues. Extensive monitoring programs have been conducted (*Environmental Monitoring of Svalbard and Jan Mayen* (MOSJ)) and there are both regional and national contamination monitoring programs covering high-arctic territories in Svalbard. So far, most research and data collection have been carried out on atmosphere, meteorology, glaciers, terrestrial fauna, marine environment etc. However, there are still topics where our knowledge is limited and actual field observation data are missing. One of the existing gaps in knowledge includes the freshwater fauna in shallow lakes, small ponds and temporary waters, often influenced by sea aerosols (Halvorsen & Gullestad 1976; Smol & Douglas 2007).

The primary objective of FREMONEC, presented in this report, refers to the POLRES (Polar Research) sub-program NORRUSS (Russia and the high North/Arctic) which aims to stimulate bilateral cooperation on polar research. In this case – to strengthen the cooperation between Norway and Russia on polar research in Svalbard, a part of the high Arctic area. Svalbard is well suited for scientific activities. There are well-developed, permanent research and monitoring stations, available for local scientists and their collaborators. International cooperation has always been prioritized.

Hence, the project’s practical task is to study effects of climate change and related stressors on poorly investigated high arctic habitats in Svalbard, here represented by invertebrate population structure in fresh and brackish water ecosystems. Collaboration between Norwegian and Russian scientists included a common study design, field- and laboratory work, material processing and analysis. A further goal was to ensure future collaboration via joint papers and other scientific activities.

The Norwegian partner is NINA represented by the researchers Bjørn Walseng (leader), Inta Dimante-Deimantovica and Martin A. Svenning. The Russian partner is M. V. Lomonosov Moscow State University, department of Hydrobiology with the representatives senior researcher Elena Chertoprud, Professor Mikhail Chertoprud and PhD student, engineer Anna Novichkova. Also a representative from UNIS (The University Centre in Svalbard), adjunct professor Kirsten S. Christoffersen (home to the University of Copenhagen) was involved in this project (**figure 1**).

Russian scientists have extensive experience from research in arctic regions in Russia (Palatov & Chertoprud, 2012). Their contribution was therefore requested to improve the quality of the FREMONEC project.

Figure 1. *FREMONEC team. From left to right – Kirsten S. Christoffersen, Mikhail Chertoprud, Martin A. Svenning, Anna Novichkova, Elena Chertoprud, Inta Dimante-Deimantovica and Bjørn Walseng. The picture is taken during the meeting in Riga, Latvia, 2013 before fieldwork.*

Within the project, we wanted to focus on the following questions concerning fresh and brackish water in Svalbard:

- How has the fresh and brackish water invertebrate populations responded to climate change during >30 years in Svalbard?
- What are the differences between population structures of invertebrates in waterbodies of different age (distance from retreating glaciers)?
- Are there any changes in the freshwater fauna because of human induced stressors?

Several secondary objectives and tasks were also brought forward:

- To generate an overview of historical data.
- Initiate a scientific collaboration, exchange knowledge and build up a network between Norwegian and Russian scientists through common fieldwork and laboratory work.
- Compare newly gained data with existing data.
- Establish a database.
- Identify and suggest vulnerable freshwater sites for a global arctic freshwater biodiversity monitoring plan.

2 Materials and Methods

2.1 Description of the investigated sites

Altogether 75 sites were sampled during fieldwork in Svalbard in 2014 and 2015 (**figure 2**). In the period 18– 24 August, 2014 sampling was conducted in different parts of Isfjorden: Longyearbyen (loc. 1-5), Aldegondabreen (in Grønnfjorden) (loc. 6-28) Randvika (loc. 29-41), Barentsburg (loc. 42-43), Ymerbukta (loc. 44-48), Pyramiden (loc. 49-53 and loc. 60-61), Kapp Napier (loc. 54-59), Diabasodden (loc. 62-64). In 2015 (17– 19 August) 11 waterbodies in the Ny-Ålesund area were sampled (loc. 65; 72-78; 80-82) (**figure 2**, **figures 4a-g**). A detailed description of the investigated sites is given in **appendix 1**.

Figure 2. *An overview over the investigated areas in Svalbard, Spitsbergen in 2014 and 2015.*

The waterbodies (**figure 3**) were categorized in four classes according to their size and approximate average depths. The categories were based on an already existing concept presented by the CAFF (Conservation of Arctic Flora and Fauna) Freshwater Expert Monitoring Group for Pan-Arctic Monitoring program and from other literature sources (Culp et al. 2012; Rautio et al. 2011):

1. 17 puddles (area < 0.01 ha, average depth ≤ 0.25 m);
2. 18 small ponds (area ≥ 0.01 – ≤ 0.1 ha, average depth 0.25 – 1 m);
3. 16 large ponds (area > 0.1 ha – ≤ 1 ha, average depth 1 – 2 m);
4. 11 lakes (area > 1 ha, average depth 2 m, usually more).

Large area (> 1 ha) flooded waterbodies were categorized as large ponds. In addition, we have two classes of running waters:

5. 6 streams (width < 1.5m);
6. 6 rivers (width > 2m).

One sampling site is called “wet mosses” (not included in the **appendix 1**). We have also sampled a few habitats close to settlements and possibly under pressure from local human activities.

Depth estimates for the lakes were very rough since we did not use a boat in order to apply a depth recorder. Average depth varied between < 0.25 m and 2 m (or more according to literature data). Stones and mosses were registered in respectively 66% and 54% of the localities. Silt (35%), sand (14%), mud (25%) and pebbles (17%) also occurred quite frequently. While clay (4%), gravel (2%), boulders (1%), algae (8%) and detritus (1%) were registered in few waterbodies.

In the majority of the localities, zooplankton, macrobenthos and meiobenthos were sampled. In running waters only macroinvertebrate sampling was conducted.

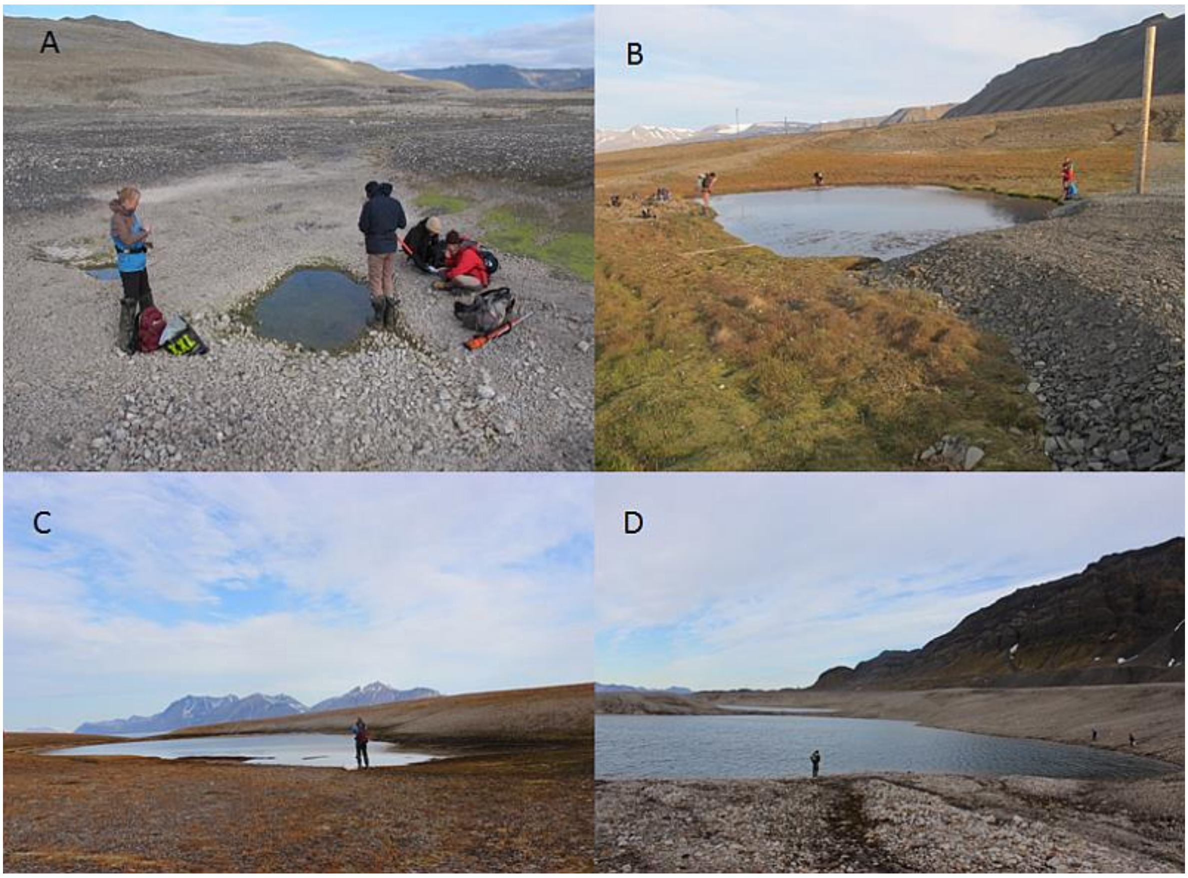

Figure 3. *Examples of a puddle (A), small pond (B), large pond (C) and a lake (D). Photos: Inta Dimante-Deimantovica, Bjørn Walseng.*

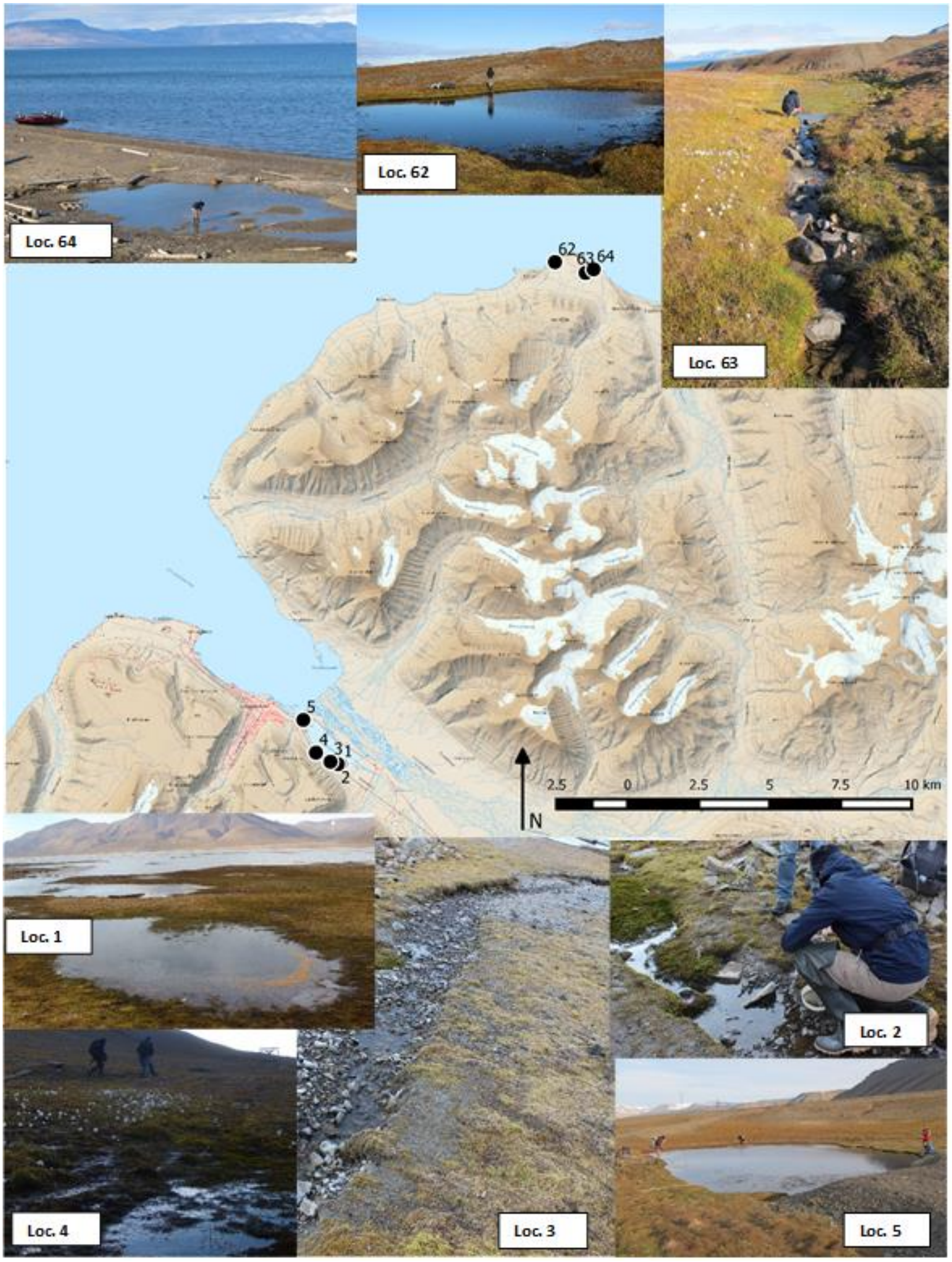

Figure 4a. *Localities in the Longyearbyen area (loc. 1-5) and at Diabasodden (loc. 62-64). Svalbard, Spitsbergen, 2014. Photos: Inta Dimante-Deimantovica, Bjørn Walseng, Anna Novichkova.*

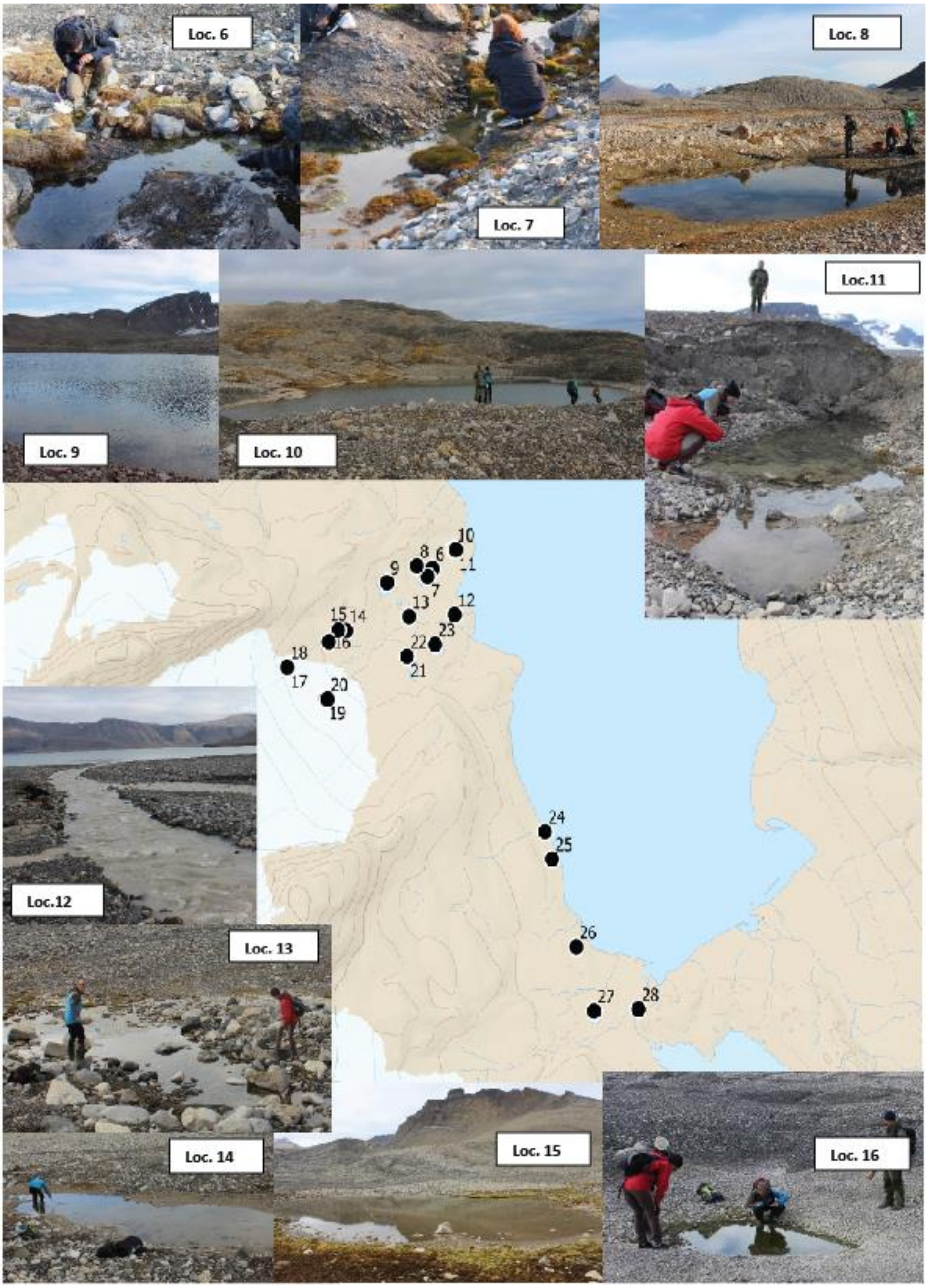

Figure 4b. *Localities in front of Aldegondabreen, Grønfjorden (loc. 6-16), continue next page. Svalbard, Spitsbergen, 2014. Photos: Inta Dimante-Deimantovica, Bjørn Walseng, Anna Novichkova.*

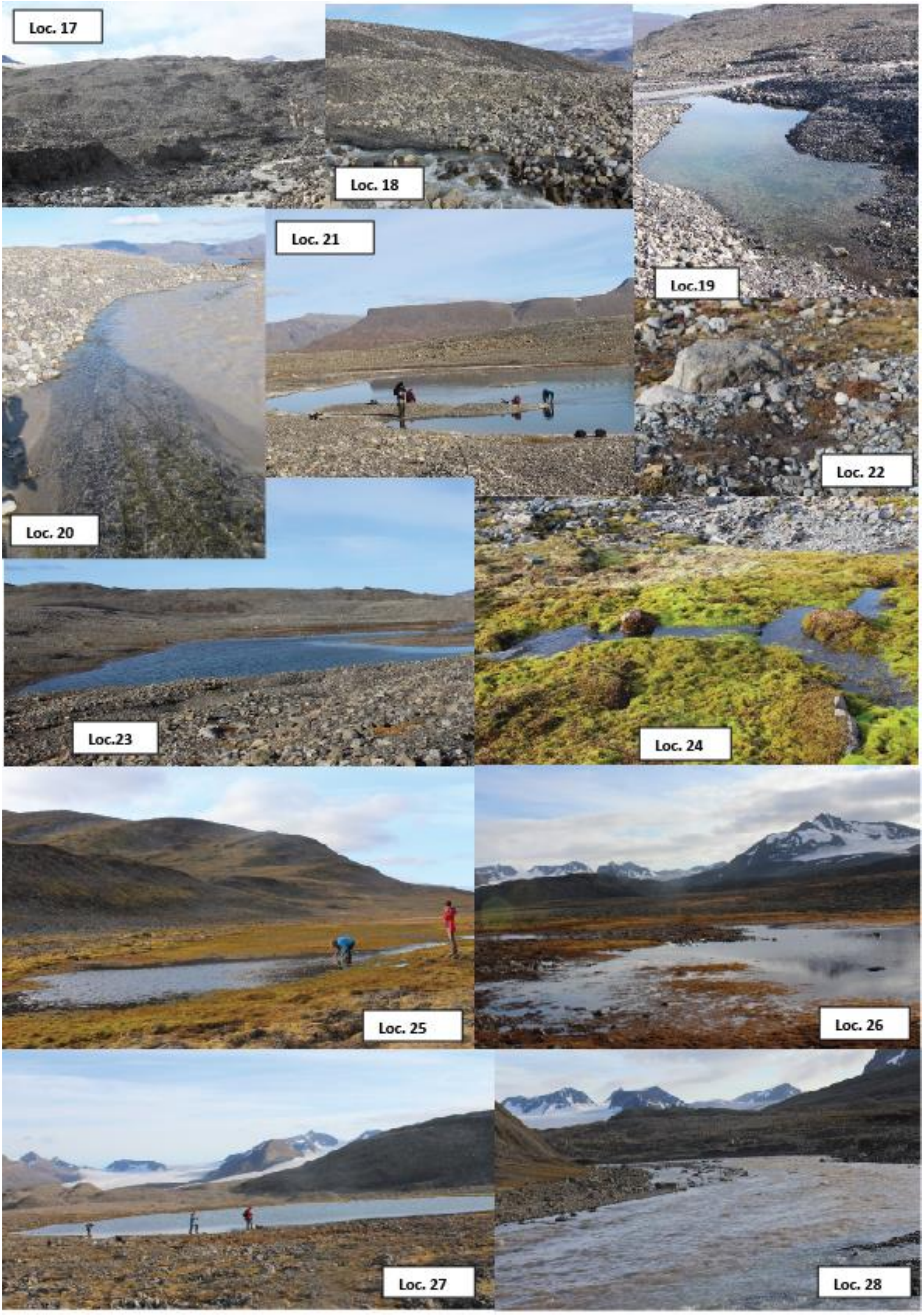

Figure 4c. *Localities in front of Aldegondabreen (loc. 17-23) and in the innermost part of Grønfjorden (loc. 24-28). Svalbard, Spitsbergen, 2015. Photos: Inta Dimante-Deimantovica, Bjørn Walseng, Anna Novichkova.*

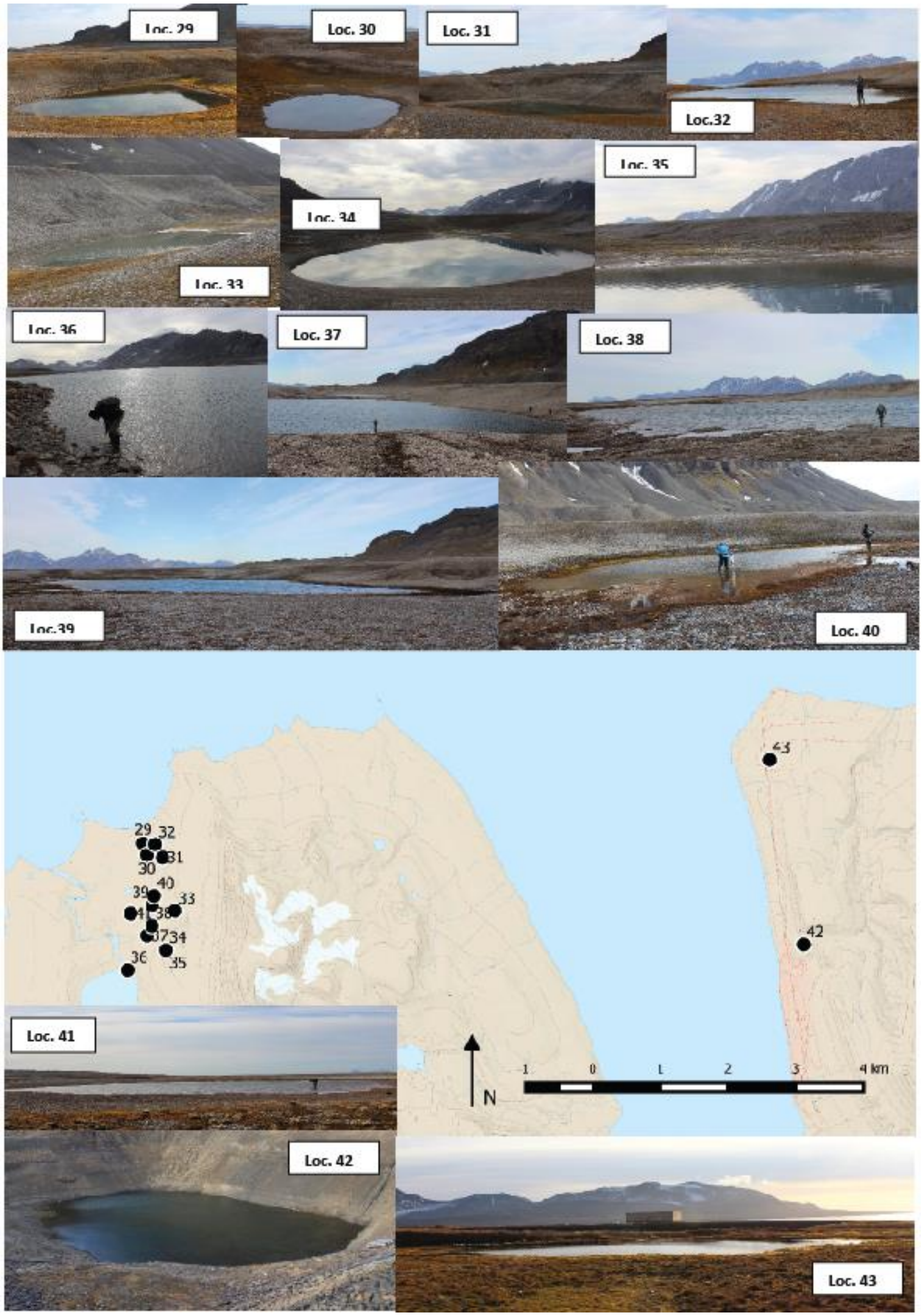

Figure 4d. *Localities at Randvika (loc. 29-40) and in the Barentsburg area (loc. 42-43). Svalbard, Spitsbergen, 2014. Photos: Inta Dimante-Deimantovica, Bjørn Walseng, Anna Novichkova.*

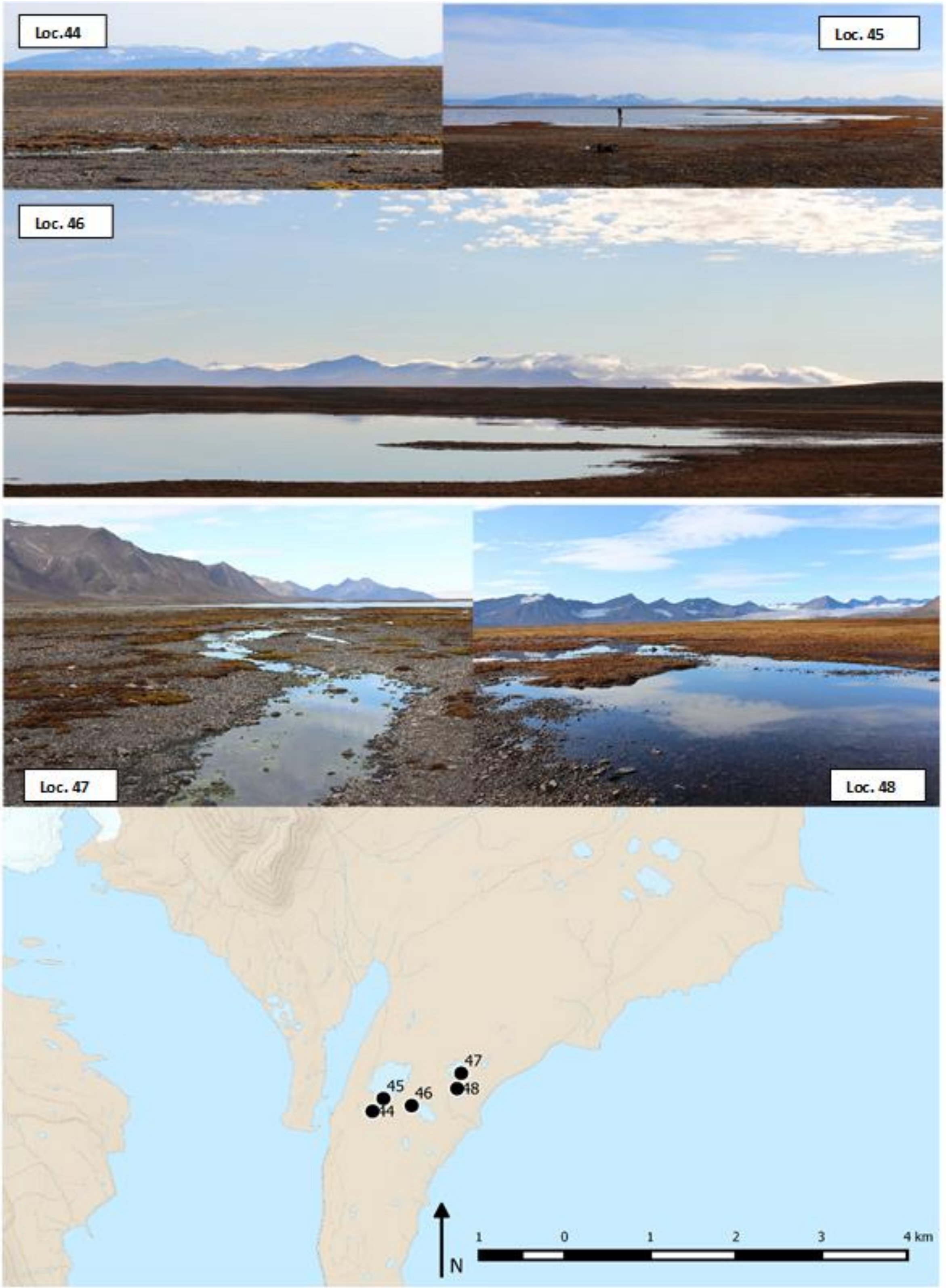

Figure 4e. *Localities in Ymerbukta (loc. 44-48). Svalbard, Spitsbergen, 2014. Photos: Inta Dimante-Deimantovica, Bjørn Walseng, Anna Novichkova.*

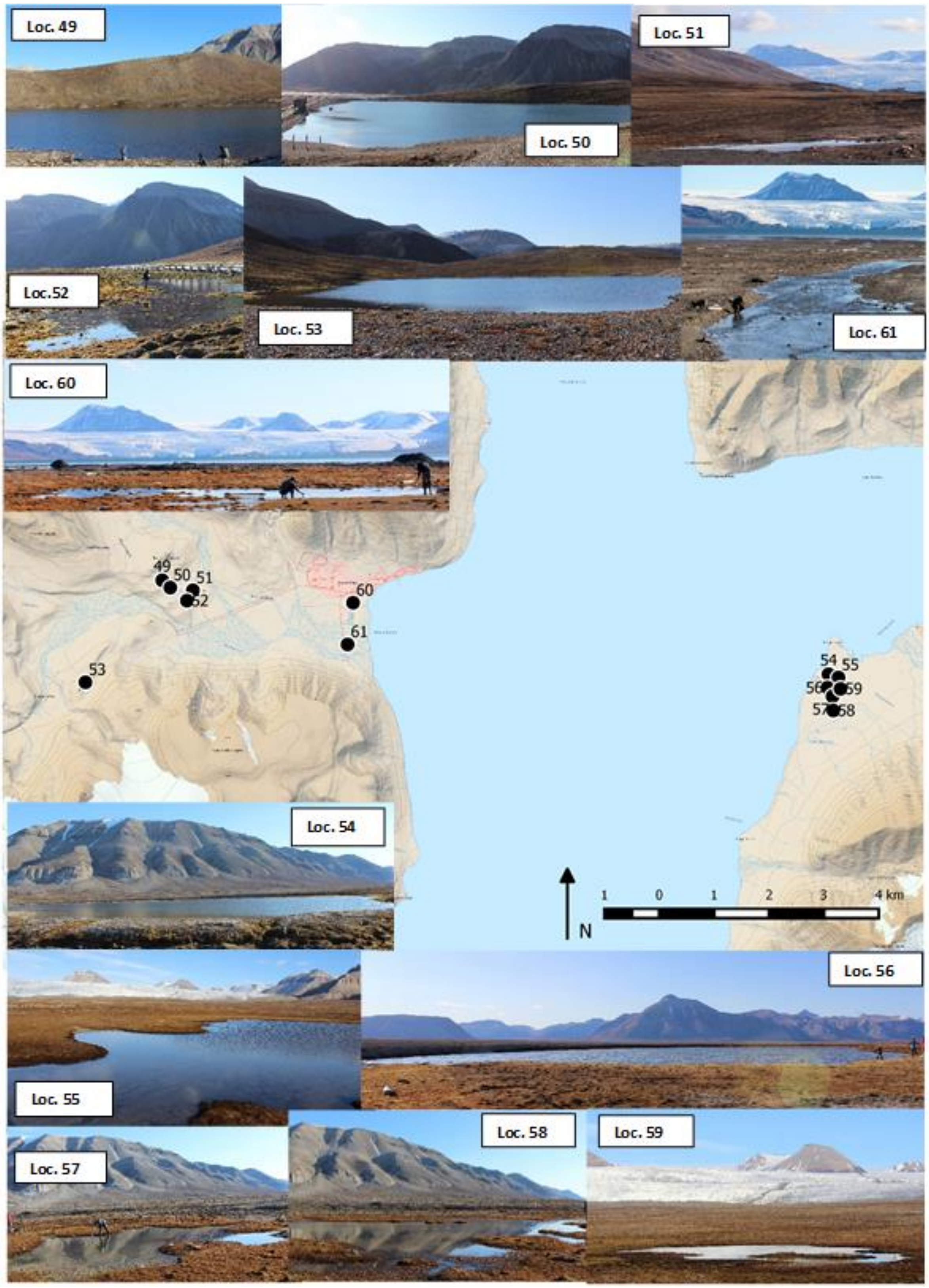

Figure 4f. *Localities in the Pyramiden area (loc. 49-53 and loc. 61-62) and at Kapp Napier (loc. 55-59). Svalbard, Spitsbergen, 2014. Photos: Inta Dimante-Deimantovica, Bjørn Walseng, Anna Novichkova.*

Figure 4g. *Localities in the Ny-Ålesund area (loc. 65, 72-78 and loc. 80-82). Svalbard, Spitsbergen, 2015.Photos: Bjørn Walseng, Anna Novichkova.*

2.2 Environmental variables and general description

All sites were described according to a field protocol that was approved by all participants. It includes position, type of water body, approximate size and depth, estimation of bottom substrate composition, vegetation as well as physical and chemical parameters. If possible, we also recorded absence/presence of fish. Environmental variables pH, conductivity and temperature were measured by applying Hanna Instruments waterproof testers (HI98129 and HI98130). A general description of each site can be found in the **appendix 1**.

2.3 Zooplankton sampling and processing

For each locality several sampling sites were chosen. Hence different biotopes were studied: pelagic zone, littoral, near-bottom water layer and the upper layer of bottom sediment. Sampling was performed from the shore with a zooplankton net (100 mm diameter, 50 μm mesh). Several samples from each locality were preserved with 96 % ethanol. The approach on how to take a sample with the net depends on both surface area and depth. Samples can be taken by throwing the net into the water as vertical and/or horizontal net haul samples (**figure 5**). A bucket can alternatively be used to collect water if the habitat is rather small. For littoral samples, a small net with a long handle was used.

Three replicates were collected in each locality by hauling the plankton net vertically through the water column, engaging the upper layer of the bottom with the detached sediment filtered through the net up to the surface. Excess water was filtered through a piece of net (50 μm). For qualitative sampling in very shallow habitats, we used a small net with a long handle. The abundance of species was calculated as the mean value of the three replicates.

In general, entire samples were counted, but when >400 organisms were present, successive 10 ml subsamples were examined until at least 200 organisms were counted. Nevertheless, the rest of the sample was looked through for rare species. Crustacean identification followed standard taxonomic treatises and recent taxonomic revisions: Cladocera: Alonso (1996), Benzie (2005), Kotov et al. (2009), Smirnov (1992, 1996), Sinev (2002); Copepoda: Alekseev & Tsalolikhin (2010), Brtek & Mura (2000), Borutsky et al. (1991), Borutsky (1952), Dahms et al. (2006), Dussart & Defaye (1983), Harding & Smith (1960), Lang (1948), Rylov (1948); Ostracoda: Sywula (1974), Meisch (2000), Lindholm (2014).

2.4 Macrobenthos sampling and processing

All samples were taken from the littoral zone at depths down to 1.5 m. For collecting, a hemispherical scraper was used (diameter 16 cm, area 0.02 m^2, mesh size 0.5 mm). In each locality, there were 5 to 10 scrapings (depending on the availability of time and density of organisms) which constituted one sample. If necessary, samples from soft bottom (mud, sludge, sand) were washed to get rid of large amount of coarse sand. Samples from stony and gravel bottoms were washed in water. All samples were preserved with 96 % ethanol.

In the laboratory, the samples were washed with freshwater and sorted according to the main taxonomic groups. After sorting, animals were identified under dissecting microscope and light microscope. Identification was done by applying the following identification keys: Andersen et al. (2013), Makarchenko (2001), Sendstad et al. (1976), Stur & Ekrem (2011).

2.5 Meiobenthos sampling and processing

Meiobenthic samples were taken with a plastic tube with diameter 2 cm (**figure 6**). A column of the upper sediment layer (3-4 cm) was pushed out from the tube with a plunger and preserved with 96 % ethanol. Three replicates were ensured from each locality.

All samples were washed through a 50 μm net with freshwater. Species identification separated between males and females and followed standard literature. For cladoceras: Lieder (1996), Kotov et al. (2009), Scourfield & Harding (1966), Sinev (1999, 2002), Smirnov (1996). For group Cyclopoida and Calanoida: Alekseev & Tsalolikhin (2010), Brtek & Mura (2000), Borutsky et al. (1991), Dussart & Defaye (1983), Harding & Smith (1960). Harpacticoids: Lang (1948), Borutsky (1952), Dussart (1967), Wells (2007), Alekseev & Tsalolikhin (2010).

2.6 Data analysis

Patterns of distributions based on absence/presence of species were summarized by Detrended Correspondence Analysis (DCA) (Hill 1979) using the program CANOCO (ter Braak & Smilauer 1998) with down-weighing of rare species. The ordination results are presented in a diagram where the sites are represented by points along axes in two-dimensional space. The diagram is a graphical summary of the data, and the axes can be interpreted as underlying environmental gradients. Sites, which are geographically close, correspond to sites which are similar in species composition. Sites, which are far apart, correspond to sites which are dissimilar in species composition. As input for the analyses we included all lakes that were sampled for crustaceans, meiobenthos and macrobenthos, altogether 58 localities. The total number of taxa was 44.

Figure 6. *Tube for meiobenthos sampling. Photo: Elena Chertoprud.*

Figure 5. *Zooplankton net used for sampling. Photo: Anna Novichkova.*

3 Results and discussion

3.1 Environmental settings

The pH values varied between 6.2 (loc. 80 – small brackish pond with green algae in Ny-Ålesund area) and 9.5 (loc.62 – a small pond with a mossy bottom at Diabasodden). In lakes and rivers pH was between 8.1 and 8.8 while it could be more variable in smaller habitats (**figure 7a-b**).

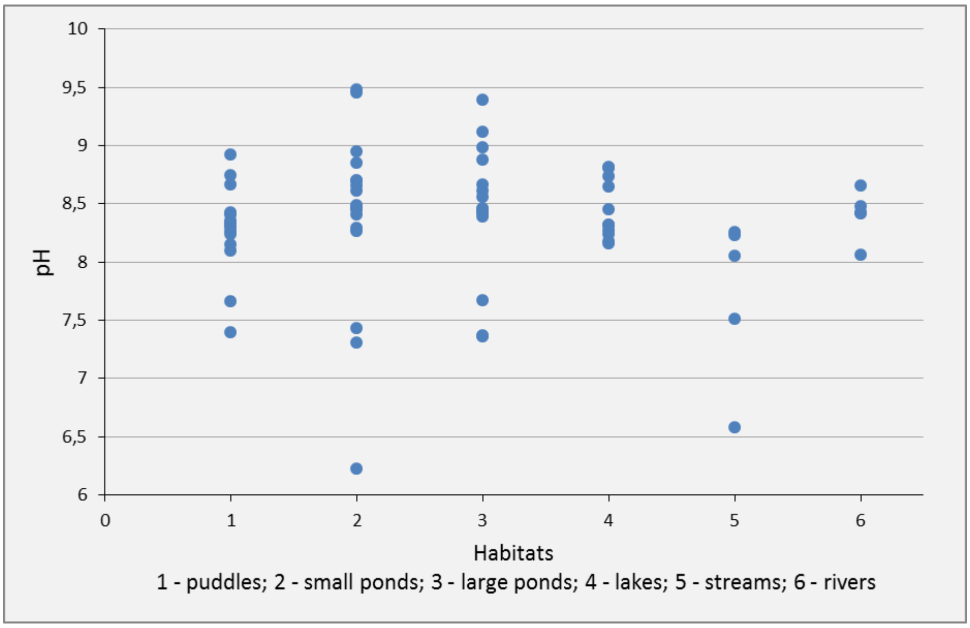

Figure 7a. *pH in all habitat types investigated in Spitsbergen, Svalbard, 2014-2015.*

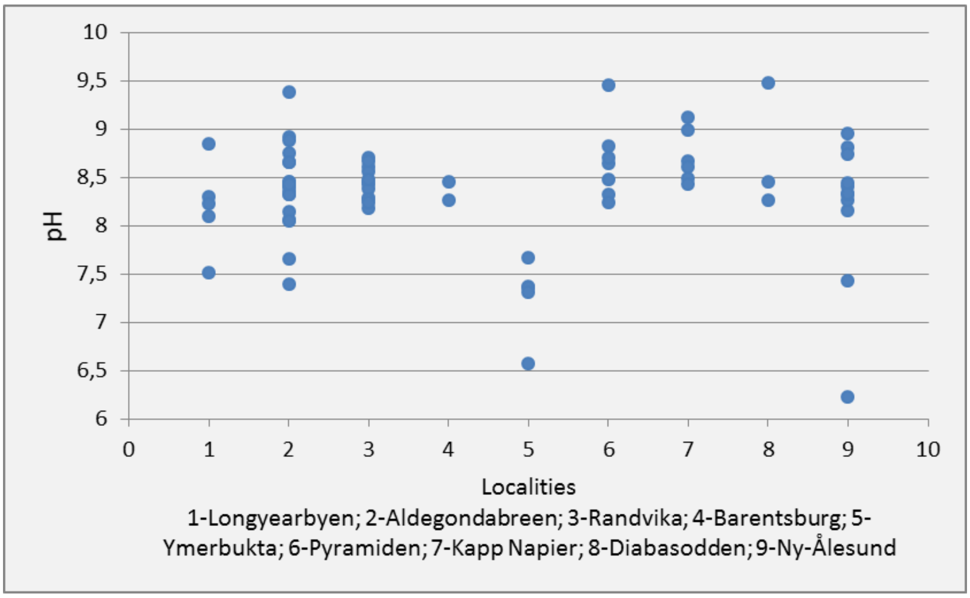

Figure 7b. *pH in the different areas investigated in Spitsbergen, Svalbard, 2014-2015.*

In general, pH and conductivity depend on geology, surficial deposits, habitat type and characteristics like size and distance to sea. The lowest pH was registered in streams, however median values shows no significant difference between the surveyed habitats. Lowest median pH was observed in Ymerbukta, an area dominanted by flooded areas. In Randvika, having lakes of a karstic type, there was small variation in pH. In Ny-Ålesund pH varied by almost three units (**figure 7a-b**).

Conductivity varied between 10 µS/cm (several large ponds, lakes and rivers) and > 10 000 µS/cm (loc. 80 – a small brackish pond close to sea in Ny-Ålesund area). Median conductivity varied less in large ponds and lakes compared to puddles and small ponds (**figure 8a-b**).

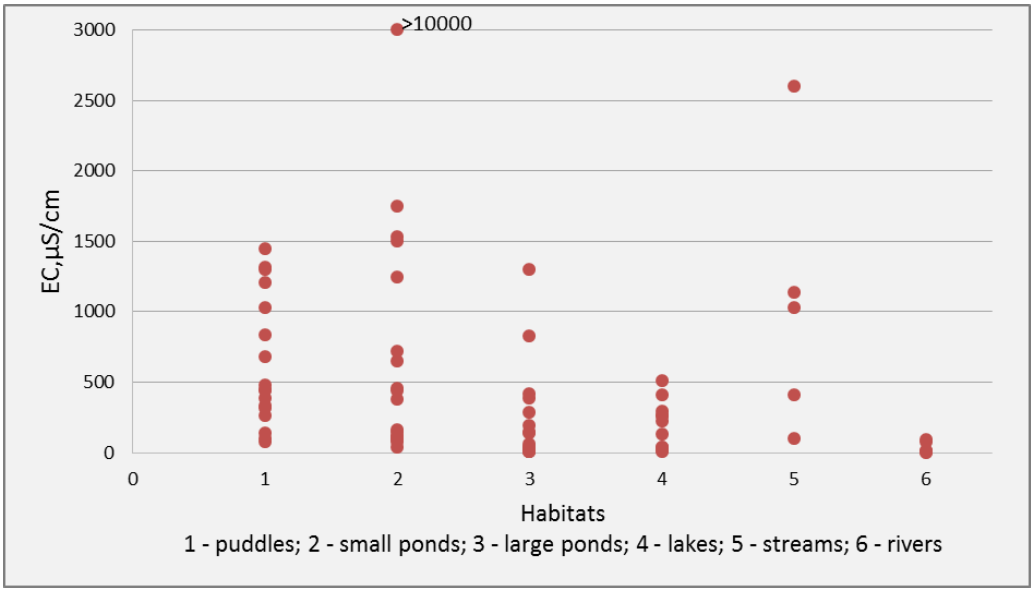

Figure 8a. *Conductivity in all habitat types investigated in Spitsbergen, Svalbard, 2014-2015.*

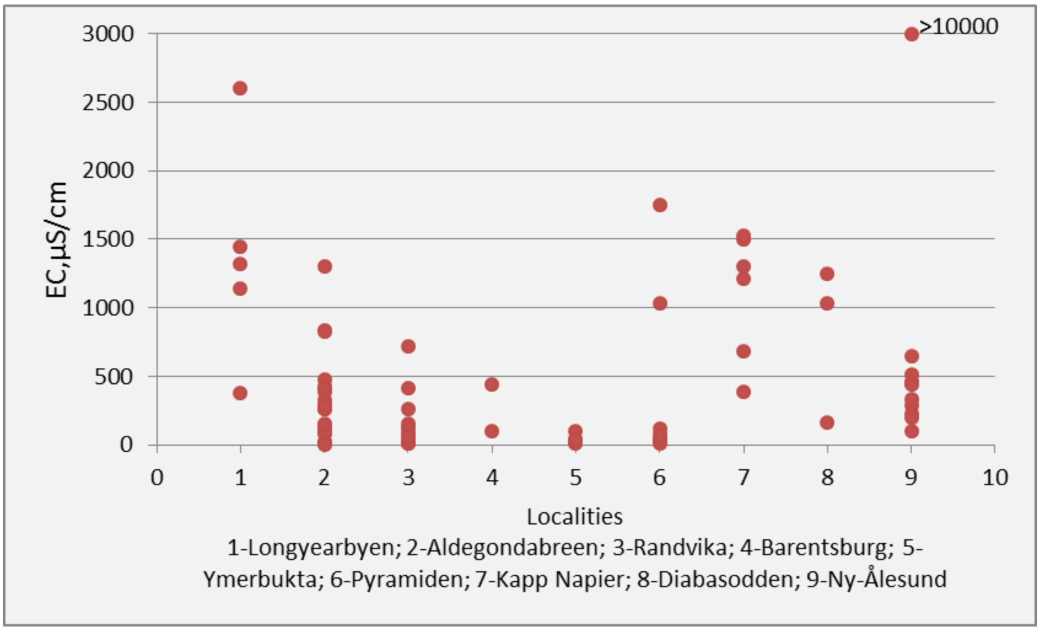

Figure 8b. *Conductivity in the different areas investigated in Spitsbergen, Svalbard, 2014-2015.*

Temperature varied from 0.9°C in a fast running river close to a glacier (loc. 17) to 12.1°C measured in a large flooded pond (loc. 46). Puddles and small ponds also had temperatures above 10°C. As we could expect, the temperature varied more in small than in large habitats. Low temperature in rivers was mainly caused by melting of glaciers. For instance, the widest temperature range is from

Aldegondabreen area where sampling was done purposely along the gradient towards the glacier. The temperature could vary there between < 1°C in a fast running river close to glacier and > 10°C in a lake near the shore. The highest mean temperature was recorded in Ymerbukta and Kapp Napier with large flooded waterbodies (**figure 9a-b**). We must keep in mind that daily variation in temperature may be significant in small ponds.

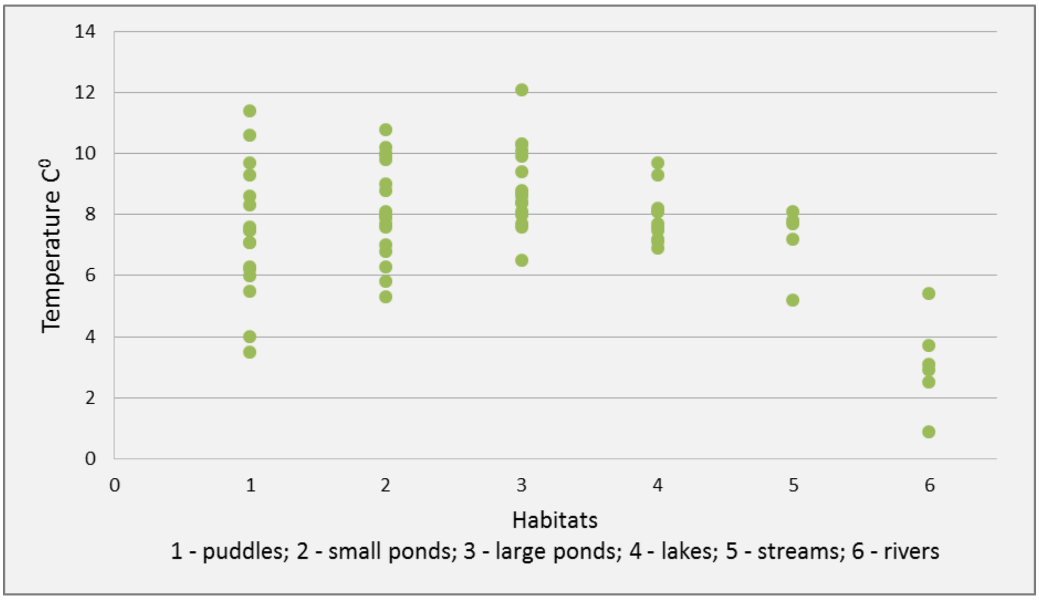

Figure 9a. *Temperature in all habitat types investigated in Spitsbergen, Svalbard, 2014-2015.*

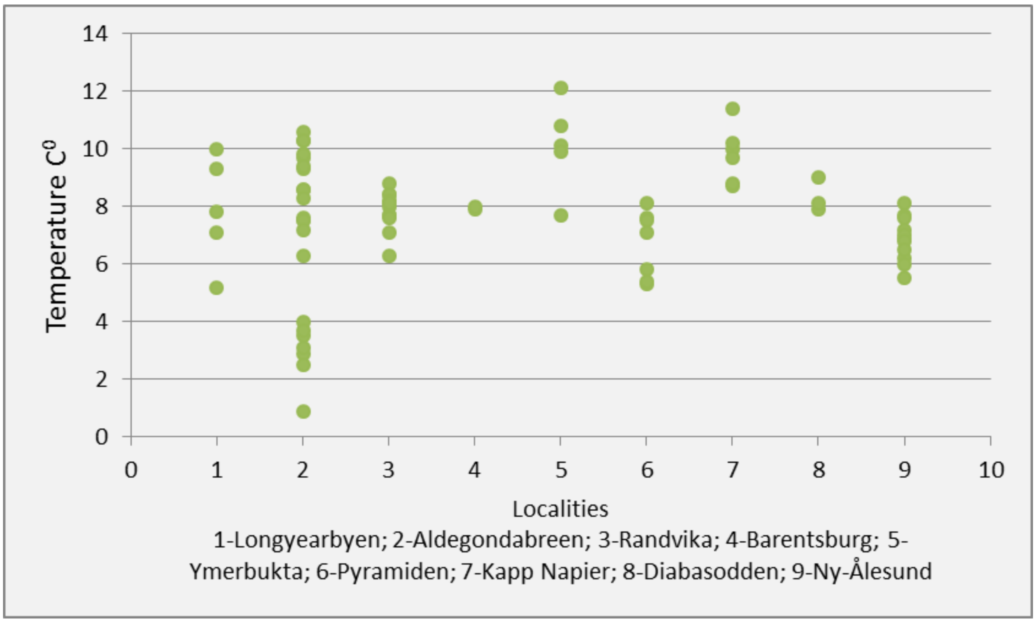

Figure 9b. *Temperature in the different areas investigated in Spitsbergen, Svalbard, 2014-2015.*

3.2 Zooplankton

Altogether, 18 crustacean species were found in zooplankton samples: 7 cladoceran species, 8 copepod species and 3 ostracod species. Of these, *Polyphemus pediculus*, *Diaptomidae* sp., *Epactophanes richardi* and *Nitokra spinipes* were reported for the first time from Svalbard (**table 1**).

Crustaceans were present in most of the waterbodies, with an average of 3 species per site (1-5 species). When fish were absent, *Daphnia* cf. *pulex* dominated in most of the localities, while other crustaceans occurred less frequently. In some of the most densely populated ponds (e.g. loc. 8), truly planktonic species were only found near the bottom, probably because of the heavy pressure of *Daphnia* here.

The average abundance of zooplankton per site was rather low, 430 ind/m^3, varying from 0.4 ind/m^3 and up to 4911 ind/m^3. High abundance was reached in ponds with high density of *D.* cf. *pulex*.

There was no relationship between species composition and the size/depth of the habitats. One exception was the very shallow puddles which can dry out. They were characterized by very low diversity or total absence of zooplankton species (e.g. loc. 14, 15, 16, 19). The effect of high conductivity (salinization) and distance to the sea was clearly documented in brackish water bodies, small ponds and puddles along the seashore, having no or only a few species (loc. 76-80). One of these localities (loc. 80) was represented with the brackish copepods *Eurytemora raboti*, *Tachidius discipes* and *Nitokra spinipes*. The species *E. raboti*, which can inhabit both freshwater and brackish waters was common in water bodies close to the sea.

Table 1. *Zooplankton species found in a survey from Spitsbergen, Svalbard, 2014-2015.*

CLADOCERA	
	Acroperus harpae (Baird, 1834)
	Alona guttata Sars, 1862
	Bosmina cf. *longispina* Leydig, 1860
	Chydorus cf. *sphaericus* (Muller, 1776)
	Daphnia cf. *pulex* Leydig, 1860
	Macrothrix hirsuticornis Norman et Brady, 1867
	<new> *Polyphemus pediculus* (Linnaeus, 1761)
COPEPODA	
	Diacyclops crassicaudis Sars, 1863
	Cyclops abyssorum Sars, 1863
	Eurytemora raboti Richard, 1897
	<new> *Diaptomidae* sp.
	<new> *Epactophanes richardi* Mrazek, 1893
	Maraenobiotus brucei Richard, 1898
	Tachidius discipes Giesbrecht, 1881
	<new> *Nitokra spinipes* Boeck, 1865
OSTRACODA	
	Fabaeformiscandona reticulate (Olofsson, 1918)
	Tonnacypris glacialis (G.O.Sars, 1890)
	Limnocythere inopinata (Baird 1843)

3.3 Meiobenthos

Altogether, 6 groups of invertebrates (Nematoda, Tardigrada, Acari, Ostracoda, Cladocera and Copepoda) were found in meiobenthos samples. Among these, 7 cladoceran species and 11 copepod species were identified. Six of these taxa were new to Svalbard: *Polyphemus pediculus*, *Diaptomidae* sp., *Diacyclops abyssicola, Epactophanes richardi*, *Nitokra spinipes* and *Geeopsis incisipes*, four of them also found in planktonic samples (**table 2**).

Despite low biodiversity compared to continental fauna records, animals were found in all localities. The number of taxa could vary from 2 to 12 different taxa (from 1 to 9 different species) per surveyed locality. Lowest abundance and species richness were found in temporal puddles and small ponds (for instance loc. 1, 5, 55). All types of substrates (rocky ground, stony soil, silt, moss) were equally populated. There were low numbers of animals in small puddles, often drying out during summer.

On average, there were 3 species per locality. The number of dominant species (> 10%, after Schwerdtfeger (1975)) varied between 1 and 4. On average the number of meiobenthos was 148 specimens/10 cm^2 (min 4.2/10 cm^2 (loc.1); max 947/10 cm^2 (loc.60)). Cladocerans could reach high numbers (max. 308 specimens/10 cm^2 in loc. 75) in various types of habitats. However, the highest values were recorded from localities in Ny-Ålesund (loc. 65, 74, 75). Small habitats like puddles and small ponds had no or very few cladocerans. Environmental parameters seemed to a lesser extent to have an influence on diversity. Tardigrades were most numerous in electrolyte rich streams (1140 µS/cm in loc. 2). There was no significant difference in species diversity between freshwater and brackish water habitats.

Size and depth of the habitat was not an important factor, the exception is small puddles drying out during the season. In some of these puddles (loc. 1) meiozoobenthos was very poor, represented mostly by Nematoda.

Table 2. *Meiobenthos species list from Spitsbergen, Svalbard, 2014-2015.*

CLADOCERA	
	Acroperus harpae (Baird, 1834)
	Alona guttata Sars, 1862
	Bosmina cf. *longispina* Leydig, 1860
	Chydorus cf. *sphaericus* (Muller, 1776)
	Daphnia cf. *pulex* Leydig, 1860
	Macrothrix hirsuticornis Norman et Brady, 1867
	<new> *Polyphemus pediculus* (Linnaeus, 1761)
COPEPODA	
	Diacyclops crassicaudis Sars, 1863
	<new> *Diacyclops abyssicola* (Lilljeborg, 1901)
	Cyclops abyssorum Sars, 1863
	Eucyclops sp.
	Eurytemora raboti Richard, 1897
	<new> *Diaptomidae* sp.
	<new> *Epactophanes richardi* Mrazek, 1893
	Maraenobiotus brucei Richard, 1898
	Tachidius discipes Giesbrecht, 1881
	<new> *Nitokra spinipes* Boeck, 1865
	<new> *Geeopsis incisipes* (Klie, 1913)

Conductivity seemed to mean less for the observed communities. However, in the lagoon type habitats with brackish water (up to 10-15 ‰ in the high tide, i.e. 80) the communities were dominated by the brackish water harpacticoids *Nitokra spinipes* and *Tacidius discipes*. The lack of macrobenthic Chironomidae larvae usually abundant in freshwater communities, allows meiozoobenthos fauna to achieve a high abundance and diversity in this type of habitat.

3.4 Macrobenthos

The samples contained 30 taxa of macrozoobenthos: 24 chironomids (larvae), 3 oligochetes (Enchytraeidae) as well as 1 species of caddisfly (*Apatania zonella)*, the tadpole shrimp (*Lepidurus arcticus)* and the marine amphipod *Gammarus setosus* (**appendix 2**). Chironomids were most numerous constituting 90% of the total number found during the survey (10545 individuals), whereas *Lepidurus arcticus* contributed with 41% of the total biomass. Other groups were of secondary importance.

Despite a generally poor diversity compared to continental faunas, almost all the surveyed habitats were inhabited by macrobenthos species. Exceptions were a few streams of glacial origin less than 300 meters from the glacier, with no animals. All the common substrates, rocky ground, pebble, silt and silty stones, and mosses, were populated equally. Macrobenthos was not found on the bottom of termokarst lakes (for example loc. 44, 45, 46).

The diversity of macrobenthos in Svalbard is low. Most of the small habitats were inhabited by a single species, often one of the common chironomids whose presence is associated with the actual environmental conditions. Except for 1 (sometimes 2) dominant species, other species could also be present in low number. *Lepidurus arcticus* occurred in all habitats (except for fast running water) and was often dominating. Apparently, it did not influence the chironomid fauna. Thus, in all the basic types of freshwater habitats in Svalbard, stones, soft bottom and macrophytes, the taxonomic structure is very similar, differing only at the level of genera and species of chironomids present. The size of lakes or streams did also mean less to the observed fauna. All macrobenthic communities had a simple and very similar taxonomical structure, with dominance of chironomid larvae.

On average 770 animals/m^2 were found. These values are small, however characteristic for cold-water oligotrophic waterbodies. Water velocity turned out to be a key factor separating species composition from running and standing waters. Running waters (rivers and streams) were usually dominated by chironomids of the genus *Diamesa* while standing waters (puddles, ponds, lakes) were dominated by other genera of chironomids. Substrate type was the second most important factor determining the distribution of macrobenthos species. In rivers and streams there was little variation, usually substrate is dominated by rocky soils and inhabited by one genus of chironomids. In standing waters, substrate determines the main associations of species as follows: mud (dominated by *Chironomus* spp.), mosses (mainly *Cricotopus* spp., *Orthocladius* spp., *Psectrocladius barbimanus*), silty stones (*Paratanytarsus austriacus*).

Habitat origin, partly connected with the water temperature was important for the running water habitats. There were marked differences in the species composition of the chironomid genus *Diamesa* in streams with glacial origin and soil origin. The first is usually dominated by *Diamesa* gr. *arctica* and the second by *D. aberrata* or *D. bertrami*. Some spring communities were dominated by *Hydrobaenus conformis*. Otherwise water temperature meant less.

Size and depth of the waterbody seems to be of less importance. The only exception was a few temporary small puddles with no macrobenthos present. One puddle (loc. 77) was inhabited by the semiterrestrial chironomids *Paraphaenocladius brevinervis* and *Smittia* sp. Conductivity was not an important factor apart from the lagoon type, brackish water habitats where no typical freshwater associations of chironomid species were present. The fauna was here dominated by *Enchytraeus* sp. (loc. 79, 80, 93) and in one habitat (loc. 79) *G. setosus* was present.

3.5 DCA-analysis

When absence/presence data including 44 taxa (mostly crustaceans and chironomids) were used as input in an ordination analysis (DCA), a site data matrix showed that plots representing the localities in Kapp Linné and Aldegondabreen areas were found in the lower part of axis 2, but spread all along axis 1 (**figure 10**). Plots representing the lakes in Billefjorden (Pyramiden and Kapp Napier) were grouped in the right end of axis 1. The length of axis 1 was 3.43 SD units, explaining 11.2% of the total variance in the dataset, while the length of axis 2 was 3.79 SD units explaining another 8.3% of the total variance in the dataset. We would have expected the fauna in Ny-Ålesund to diverge from the fauna found in the Isfjorden area, but this was not the case. The Ny-Ålesund area shows similarities to localities in all parts of Billefjorden, even with ponds located in Grønfjorden (Aldegondabreen and Barentsburg). The four ponds in Ymerbukta had more or less the same species composition, quite similar to that found in Pyramiden and Kapp Napier.

The "outlayers" shown in the species plot (**figure 11**) are rare species found in one or only a few localities. Examples are two chironomid species, *Paraphaenocladius brevinervis* (*par bre*) and *Oliveridia tricornis* (*oli tri*), which both were found in loc. 19, a very clean pond formed from a river not far from the Aldegondabreen glacier. In the upper end of axis 2 we find two taxa only found in the Ny-Ålesund area, the harpactoid *Tachidius discipes* (*tac dis*) and *Enchytraeus* sp. (*enc sp.*), both in small brackish ponds. The more common species seems to be widely distributed. Two exceptions are the cladoceran *Macrothrix hirsuticornis* (*mac hir*) and the copepod *Eurytemora raboti* (*eur rab*), found in the upper half of axis 2, and which are associated with the localities in Billefjorden and Ny-Ålesund. Here they were found in respectively 50.0% and 53.8% of the investigated waterbodies (n=22). The corresponding figures for the Grønfjorden area were respectively 17.8% and 14.3% (n=28). The two most common species, *Daphnia* cf *pulex* (*dap pul*) and *Maraenobiotus brucei* (*mar bru*), were found in respectively 68.9% and 51.7% of the ponds, both having a central position in the figure.

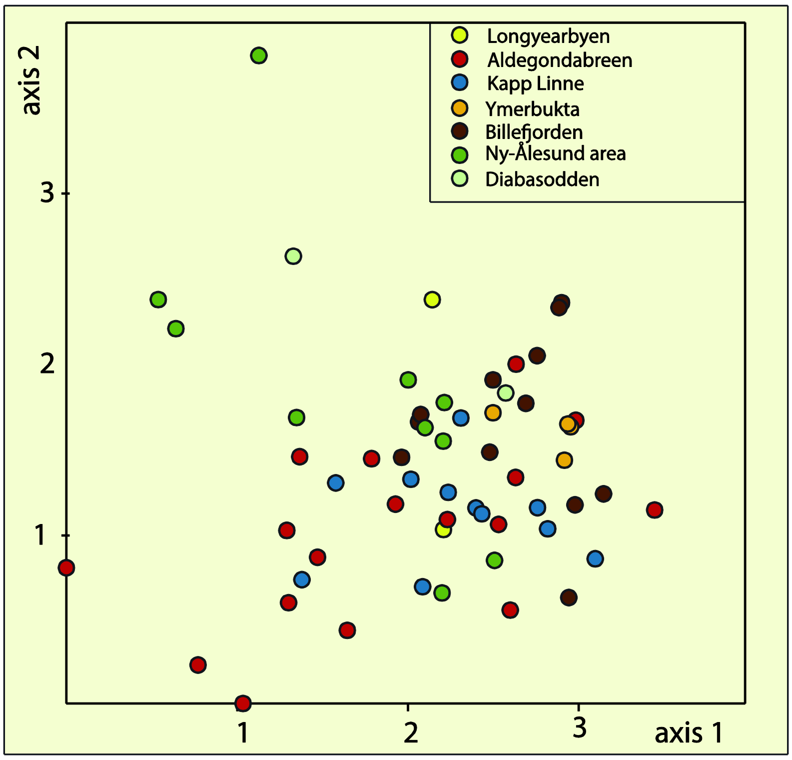

Figure 10. *DCA-ordination of 44 taxa (presence/absence) found in 58 water bodies from Spitzbergen, Svalbard 2014-2015. Billefjorden represents both Pyramiden and Kapp Napier areas. Aldegondabreen represents also Barentsburg areas.*

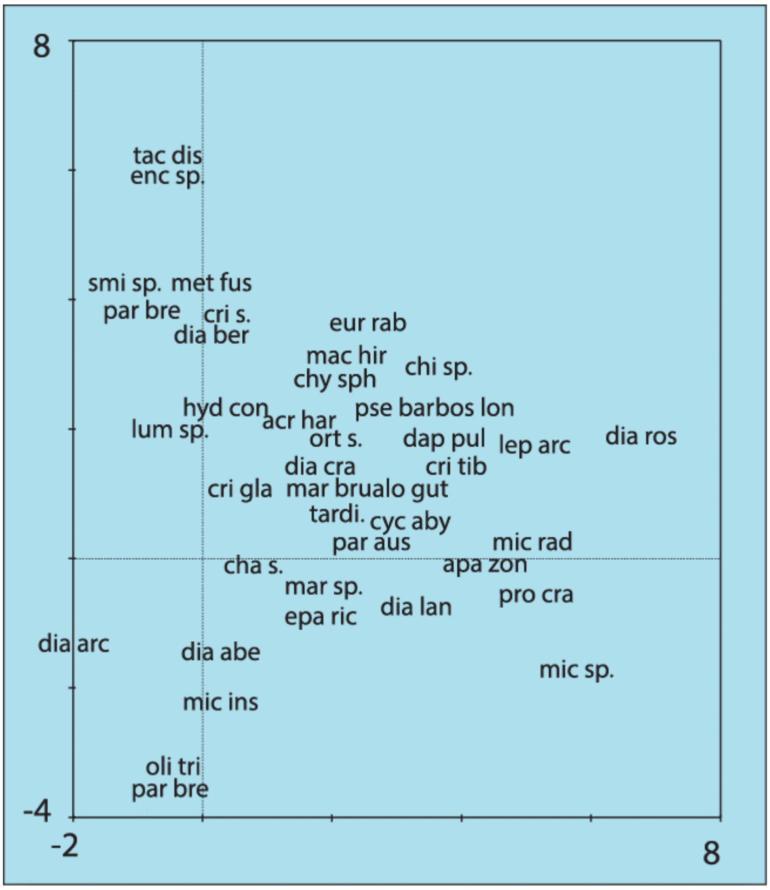

Figure 11. *Species plot based on the DCA-analysis presented in* ***figure 10****.*

There were no significant correlations between axis 1 and diversity (R^2=0,08), area (R^2=0,10), depth (R^2=0,10), temperature (R^2=0,27), pH (R^2= <0,01) or conductivity (R^2= <0,01). Neither along axis 2 did we find any significant correlations with diversity (R^2=0,004), area (R^2=0,02), depth (R^2= <0,01), temperature (R^2=0,05), pH (R^2=0,02) or conductivity (R^2=0,04). Further there were no significant correlations between diversity (number of taxa) and area (R^2=0,02), temperature (R^2= <0,01), depth (R^2=0,11), pH (R^2=0,11) or conductivity (R^2=0,01). Finally, there were no significant correlations between diversity, axis 1 or 2 or with the type of substrate.

To conclude, we are not able to identify a variable that “controls” the actual fauna in the investigated waterbodies in this study. For obvious reasons we could be tempted to explain this by the age of the waterbodies. They are characterized as young, and colonization may depend on bird-traffic.

3.6 Comparison with old data

One of the scientific questions raised for this study, was whether the fresh and brackish water invertebrate populations in Svalbard have responded to climate change during > 30 year? Researchers have sampled and analyzed material from several fresh and brackish water habitats in Svalbard, including lagoons, lakes, temporary waters, ponds, rivers and streams. We wanted to compare our data with historical data. As a basis for comparison we choose Olofsson (1918) who was one of the earlier investigators of the freshwater fauna in Spitsbergen. His fieldwork was conducted in 1910 and except for a few sites in Van Mijenfjorden, all waterbodies were located in Isfjorden. We decided to follow in his footprints and five of the areas he sampled: Longyarbyen, Ymerbukta, Pyramiden, Kapp Napier and Diabasodden, were also sampled during our fieldwork in 2014. Based on descriptions made by Olofsson (1918) we tried to locate his sites during our revisit. This turned out to be a great challenge since the majority of waterbodies were small temporary ponds and puddles. There were only 3 out of 21 waterbodies that we could identify: 2 lakes in Pyramiden (**figure 12**) and 1 pond at Diabasodden (**figure 13**). Concerning the remaining 18 localities, we sampled ponds and puddles in the same area as Olofsson (1918) without being sure if they were exactly the same localities that he sampled.

Two lakes in Pyramiden situated 2.5 km west of the small town, fits well with Olofsson (1918) description and cannot be mixed up with other lakes. Pyramiden belonged to Sweden in the beginning of the 1900s, and this may explain why he was sampling in this remote area. More than 100 years later, two cladocerans, *Dapnhia pulex* and *Chydorus sphaericus*, the cyclopoid copepod, *Diacyclops crassicaudis*, and the harpactoid *Maraenobiotus brucei* were still a part of the zooplankton community in these lakes. Not very surprising, what we suspect to be a “climate change indicator” species, *B. longispina* has colonized both lakes. In addition, the cyclopoid copepod *Cyclops abyssorum* was new to both lakes. In loc. 49, the uppermost lake, a few specimen were identified as the calanoid *Diaptomidae* sp.

Also in the small pond at Diabasodden we noted that *B. longispina* was a new species while the cladocerans *D. pulex*, *M. hirsuticornis* and *C. sphaericus*, were found both in 1910 and 2014.

To illustrate the occurrence of the crustacean fauna in the 5 areas studied in 1910 (Olofsson 1918) and during our sampling in 2014, respectively, we have plotted the absence/presence data

Figure 12. *Loc. 50 outside Pyramiden, Spitsbergen, Svalbard which was sampled both in 1910 (Olofsson 1918) and in 2014. Photo: Inta Dimante-Deimantovica.*

Figure 13. *Loc. 62 at Diabasodden, Spitsbergen, Svalbard which was sampled both in 1910 (Olofsson 1918) and in 2014. Photo: Inta Dimante-Deimantovica.*

of cladocerans and copepods (11 species) using DCA (**figure 14**). This is a small dataset for a DCA-analyses, but may give a visual impression of possible changes in species composition over time. The site data matrix shows that except for Longyearbyen, plots representing species found in 1910 are located in the right end of axis 1. *B. longispina* contributes to this change over time, not found in 1910, but in all areas except Longyearbyen, in 2014. The length of axis 1 was 1.4 SD units, explaining 40.9% of the total variance in the dataset, while the length of axis 2 was 1.0 SD explaining another 7.2% of the total variance in the dataset. *Cyclops abyssorum*, mixed up with *C. strenuus* by Olofsson (1918), seems also to have become more common. It was only found in Longyearbyen in 1910 while it was found in all areas except for Diabasodden in 2014.

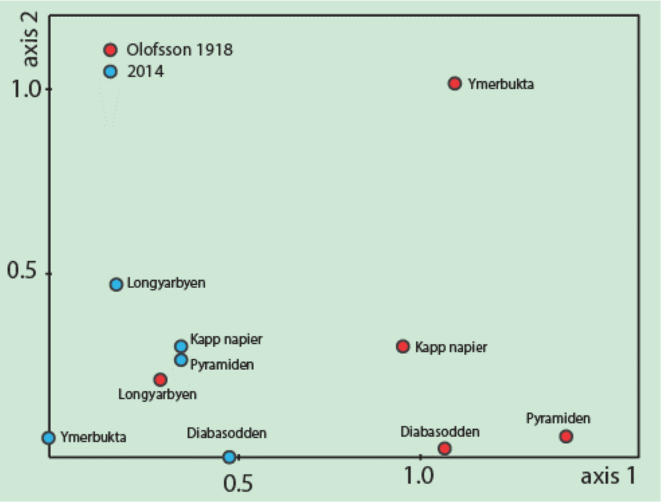

Figure 14. *DCA-analysis comparing species from five areas sampled in 1910 (Olofsson 1918) and in 2014 respectively.*

A much more recent sampling covering the Kapp Linné area (Randvika) and the Ny-Ålesund area was carried out in 2008 as a master project (Skaugrud 2009). This study includes 48 waterbodies at the Kapp Linné area and except for *B. longispina* and *D. abyssicola*, the same species diversity were recorded as in our study in 2014. Furthermore *D. pulex* was the dominating species in both studies. Also in this area *B. longispina* appears for the first time and was found in 4 out of 11 waterbodies and could occur in high number. In loc. 36 it constituted more than 20% of the total number of individuals.

Similarly, in the Ny-Ålesund area the species list from our study matched that of Skaugrud (2009), covering the four cladoceran species; *D. pulex*, *M. hirsuticornis*, *Acroperus harpae* and *C. sphaericus*, and the three copepods; *C. abyssorum, D. crassicaudis* and *Eurytemora raboti*.

3.7 Distance to retreating ice cover

Sampling along the gradient from the coast to the start of the glacier revealed some correlations between age, distance and the microcrustaceans. The number of species increased with the age of the localities (situated at different distances from retreating glaciers). For instance, the youngest habitats close to the glacier (loc. 19, 20) had the lowest number of copepod species and no cladocerans (**figure 15**). With increasing distance from the glacier, the cladoceran species occurred in lakes and ponds (loc. 14, 15, 16) and in the localities furthest from the glacier, *Daphnia* or their ephippia dominated (e.g. loc. 5, 10, 11, 21, 23).

The abundance of all meiobenthos taxonomical groups was low near the glacier (where average temperature was 3.5°C), and increased with distance (1-1.5 km) from the glacier (average water temperature increased up to 9°C). Ostracoda and Cladocera were absent near the glacier (loc.

19). Tardigrada were more abundant (50-178 specimens/10 cm^2) in waterbodies located approximately 400 m from the glacier (loc. 14, 15) with average temperature 8-8.5°C. Cladocera were more abundant in waterbodies with higher average temperature 8.5-10.5°C located on the distance further from glacier (e.g. loc. 8, 26).

For macrobenthic species, distance to the glacier seems to mean less. No clear changes in the composition and abundance of the macrobenthic communities were found between the sea shore (2 km) and up to a distance of 300 from the glacier. However, in localities closer than 300 m from the glacier, no macrobenthos species were detected. We have to keep in mind that few habitats were studied in this particular area.

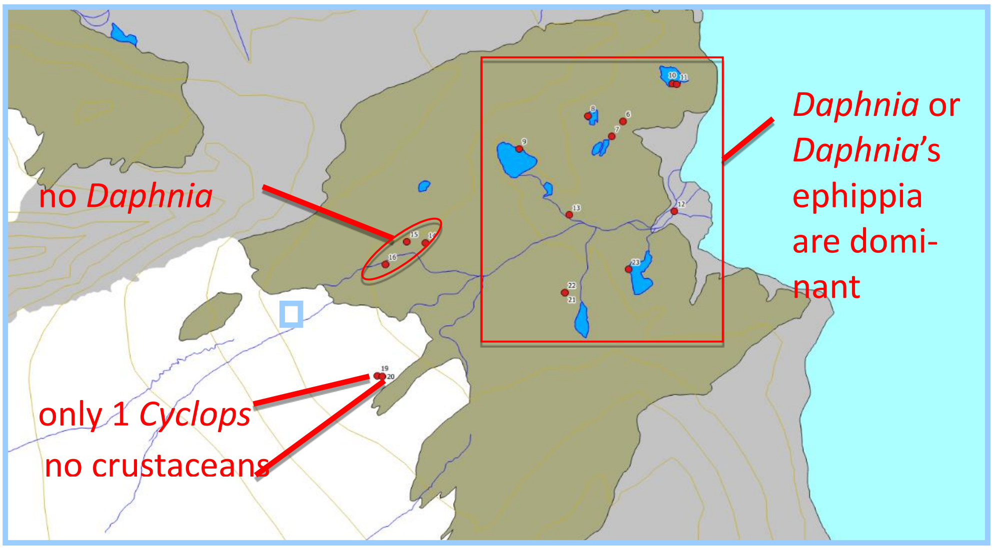

Figure 15. *Findings of zooplankton along the gradient from the coast towards Aldegondabreen, Spitsbergen, Svalbard, 2014-2015.*

3.8 'Urban' habitats

Among habitats that were sampled for zooplankton, meiobenthos and macrobenthos we considered six as 'urban' ponds situated near human settlements (**figure 16, 17);** one in both Longyearbyen and Pyramiden and four in Ny-Ålesund (loc. 5, 60, 65, 73, 74, 75). Loc. 42 in Barentsburg was only sampled for macrobenthos and is not included in the analyses since this lake can be characterized as an atypical urban pond. Loc. 5 was situated just outside the center of Longyearbyen and is called "The dog yard pond" since it is situated next to a dog yard. A small, shallow puddle surrounded with moss was the only 'urban' waterbody that was found in Pyramiden (loc. 60). Lake Storvatet in Ny-Ålesund (loc. 65) was a relatively large lake close to the airport. There were mosses along the shore but no vegetation. Two waterbodies are located in the center of the town, respectively Lake Solvatnet (loc. 74) and a pond (loc. 75) divided in two waterbodies by the road leading to Hollendarhaugen. The fourth locality characterized as urban in Ny-Ålesund is located in the mining area about 500 m southeast of the center (loc.73).

Conductivity varied between 292 µS/cm (loc. 65, Lake Storvatnet in Ny-Ålesund) and 1030 µS/cm (loc. 60, puddle in Pyramiden) and compared with the mean for all studied waterbodies (450 µS/cm), they do not deviate from these. Mean pH in the urban ponds was 8.3 (7.4-8.9) which was higher than the mean pH for all investigated localities (7.6).

The urban ponds and the two lakes used as drinking reservoirs for Pyramiden and Ny-Ålesund respectively are visualized in **figure 18**.

Figure 16. *The dog yard pond (loc. 5) situated in Longyearbyen (left) and the shallow puddle surrounded with moss in Pyramiden (loc. 60), Spitsbergen, Svalbard, 2014. Photos: Inta Dimante-Deimantovica.*

Figure 17. *The mining pond (loc.73) about 500 m southeast of the center in Ny-Ålesund (left) and Lake Solvatnet (loc. 74) in the center of Ny-Ålesund, Spitsbergen, Svalbard, 2015. Photos: Bjørn Walseng, Anna Novichkova.*

The DCA-analyses (**figure 18**) which is based on the same analyses as shown in **figure 10**, illustrates that the dog yard pond in Longyearbyen and the mining pond in Ny-Ålesund are separated along axis 2, while all the urban localities are found in the same area along axis 1. The main reason why the mining pond differs in species composition from the other is the lack of cladoceran species. The cyclopoid *Cyclops abyssorum* and the harpactoid *Maraenobiotus brucei* were the only crustacean species found in this pond. In contrast, the three other localities in Ny-Ålesund had the four cladoceran species in common; *Daphnia pulex, Macrothrix hirsuticornis, Acroperus harpae* and *Chydorus* cf. *sphaericus. D. pulex* and *M. hirsuticornis* were also found both in the dog farm pond in Longyearbyen and in the puddle in Pyramiden. The chironomid, *Metriocnemis* gr *fuscipes*, was only found in the dog farm pond in Longyearbyen and is one reason why this locality was separated from the rest of the urban pond along axis 2.

The number of crustacean species in the urban waterbodies was higher (4.7 in mean) compared with the non-urban sites (3.6). Regarding macrobenthos, there is no difference in mean number of taxa (4). Except for the mining pond (loc. 73), the urban ponds were used for resting and breeding by geese and the input of nutrients may have contributed to a higher diversity in these ponds. The non-urban waterbodies were localities of different age and included therefore a number of localities with none or only a few species.

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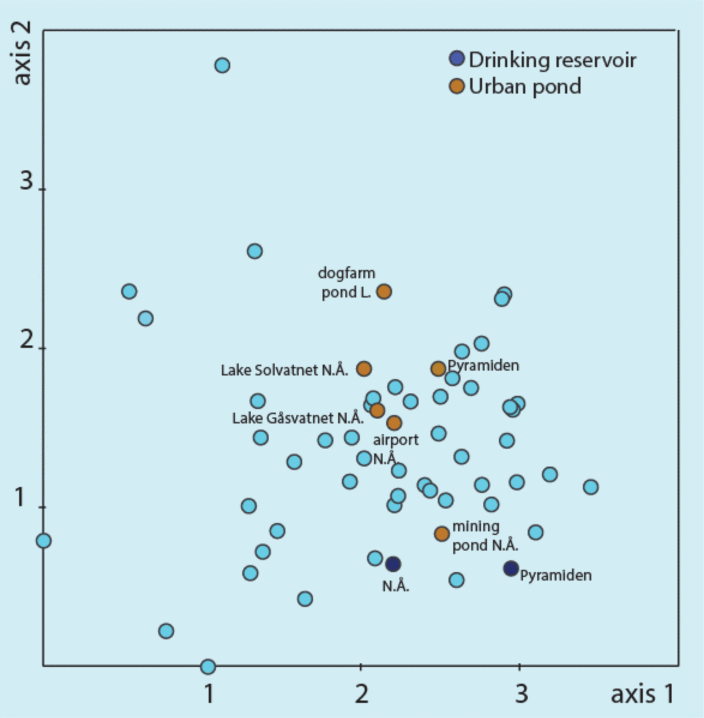

Figure 18. *The position of urban ponds and drinking water reservoirs shown in the DCA-plot.*

The drinking reservoirs (**figure 19**) in Pyramiden (loc. 50) and Ny-Ålesund (loc. 72) had respectively three crustaceans, *D. pulex, C. abyssorum* and *Epactophanes richardi*, and two chironomids, *Cricotopus (s. str.) tibialis* and *Procladius crassinervi*, in common.

To conclude, the urban ponds do not differ from non-urban ponds based on species composition. However, we can guess, in ponds from areas that have suffered from mining activies, high levels of “trace metals” may affect the fauna. Hence, in the mining pond in Ny-Ålesund there were no cladocerans. Except for this lake, one brackish pond and a newly established pond in front of a retreating glacier, all investigated waterbodies in our study included cladocerans. In the few urban ponds in Spitsbergen, geese seem to be a more important factor than human being, in contributing to diversity.

Figure 19. *The drinking reservoirs in Pyramiden (loc. 50, left) and Ny-Ålesund (loc. 72) respectively, Spitsbergen, Svalbard, 2014-2015. Photos: Bjørn Walseng, Anna Novichkova.*

4 Conclusions

The network building between Norwegian and Russian research groups, which has included thematic areas relevant for both countries, has been a positive experience for both partners who have been involved in preparing the study design, as well as participating in meetings, fieldwork (2014 and 2015) and analyzing/reporting of collected material.

The collaboration has resulted in new knowledge on Svalbard's biodiversity that might contribute to future Arctic Freshwater Biodiversity Monitoring activities and to the implementation of integrated and sustainable Arctic freshwater ecosystems management.

Our study resulted in 6 microcrustacean taxa new to Svalbard: *Polyphemus pediculus*, *Diaptomidae* sp., *Diacyclops abyssicola, Epactophanes richardi*, *Nitokra spinipes* and *Geeopsis incisipes*. Some of these newcomers are most likely, directly or indirectly linked to the recent climate warming (obtained results were compared with old literature data).

In general, biodiversity was low, especially when we compare Svalbard with other areas in high and low Arctic. For macrozoobenthos it seemed that the origin of the habitat, temperature, substrate type and water velocity, was of importance. The number of crustaceans increased with the age of the localities (distance to the retreating glacier) and the fauna in urban ponds did not differ from non-urban habitats. In the urban ponds, birds seem to be a more important factor than anthropogenic activities, in contributing to diversity.

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Appendix 1

Sampling localities description. Abbreviations used: Locality: L – Longyearbyen, A – Aldegondabreen, R – Randvika, B – Barentsburg, Y – Ymerbukta, P – Pyramiden, K – Kapp Napier, D – Diabasodden, N – Ny-Ålesund; Habitat: 1 – puddle, 2 – small pond, 3 – large pond, 4 – lake, 5 – stream, 6 – river.

No	Date	Locality	Habitat	E	N	Elevation, masl.	Area, ha (approx.)	Average depth, m (approx.)	pH	EC, µS/cm	Temp, ^{0}C
1	18.08.14.	L	1	15.7625	78.2038	13	0.0005	0.25	8.3	1320	9.3
2	18.08.14.	L	5	15.7585	78.2038	15			8.23	1140	7.8
3	18.08.14.	L	5	15.7473	78.2046	20			7.51	2600	5.2
4	18.08.14.	L	1	15.7249	78.2075	17	0.0002	0.25	8.1	1450	7.1
5	18.08.14.	L	2	15.7060	78.2179	8	0.04	1	8.85	380	10
6	19.08.14.	A	1	14.1857	77.9908	12	0.0002	0.25	7.4	1300	7.5
7	19.08.14.	A	1	14.1839	77.9903	18	0.0002	0.25	7.66	840	3.5
8	19.08.14.	A	1	14.1798	77.9910	25	0.002	0.25	8.36	390	10.6
9	19.08.14.	A	4	14.1685	77.9898	50	1.5	2	8.45	20	9.7
10	20.08.14.	A	3	14.1938	77.9922	6	0.5	1.5	8.45	140	8.6
11	20.08.14.	A	1	14.1945	77.9922	8	0.0008	0.25	8.41	80	7.6
12	20.08.14.	A	6	14.1944	77.9876	8			8.43	20	2.9
13	20.08.14.	A	1	14.1770	77.9874	46	0.0006	0.25	8.32	260	6.3
14	20.08.14.	A	1	14.1532	77.9864	41	0.002	0.25	8.42	480	8.6
15	20.08.14.	A	1	14.1502	77.9864	41	0.003	0.25	8.75	100	8.3
16	20.08.14.	A	1	14.1466	77.9856	93	0.0003	0.25	8.92	140	7.5
17	20.08.14.	A	6	14.1309	77.9837	54			8.06	10	0.9
18	20.08.14.	A	6	14.1309	77.9837	117					2.5
19	20.08.14.	A	1	14.1456	77.9816	44	0.005	0.25	8.15	320	4
20	20.08.14.	A	6	14.1464	77.9815	44			8.42	90	3.1
21	20.08.14.	A	4	14.1765	77.9846	28	1.1	1.5	8.32	260	9.3
23	20.08.14.	A	3	14.1870	77.9855	4	0.7	1.5	8.43	420	10.3
24	20.08.14.	A	5	14.2297	77.9724	3			8.05	410	7.2
25	20.08.14.	A	3	14.2326	77.9705	5	0.2	1	8.88	830	10.3
26	20.08.14.	A	2	14.2421	77.9644	6	0.06	1	8.66	150	9.8
27	20.08.14.	A	3	14.2492	77.9599	12	0.8	1.5	9.39	290	9.4
28	20.08.14.	A	6	14.2660	77.9600	0			8.66	10	3.7
29	21.08.14.	R	2	13.7915	78.0827	42	0.09	1	8.7	120	8.8
30	21.08.14.	R	2	13.7940	78.0812	16	0.04	1	8.29	720	7.7
31	21.08.14.	R	3	13.8041	78.0809	15	0.2	1.5	8.46	150	7.7
32	21.08.14.	R	3	13.7992	78.0826	23	0.2	1	8.61	10	8
33	21.08.14.	R	3	13.8129	78.0738	73	0.2	1	8.43	10	8.4
34	21.08.14.	R	3	13.8076	78.0686	41	0.7	1.5	8.39	30	8.4
35	21.08.14.	R	5	13.8076	78.0686	41					
36	21.08.14.	R	4	13.7831	78.0659	11	460	2	8.18	130	7.11
37	21.08.14.	R	4	13.7951	78.0705	27	1.7	2	8.28	260	8.1
38	21.08.14.	R	4	13.7982	78.0718	28	1.6	2	8.24	410	8.2
39	21.08.14.	R	3	13.7982	78.0746	30	4	1.5	8.56	40	7.6
40	21.08.14.	R	2	13.7992	78.0758	34	0.03	1	8.48	80	6.3
41	21.08.14.	R	3	13.7845	78.0734	34	0.4	1.5	8.67	60	8.1
42	21.08.14.	B	2	14.2162	78.0708	92	0.09	1	8.45	100	7.9
43	21.08.14.	B	2	14.1928	78.0952	51	0.04	1	8.27	440	8

44	22.08.14.	Y	5	14.0720	78.2789	20			6.58	100	7.7
45	22.08.14.	Y	3	14.0776	78.2803	15	15.8	1	7.67	20	10.1
46	22.08.14.	Y	3	14.0921	78.2795	16	4.5	1	7.37	10	12.1
47	22.08.14.	Y	3	14.1174	78.2831	15	1.9	1	7.36	40	9.9
48	22.08.14.	Y	2	14.1154	78.2815	21	0.05	1	7.31	40	10.8
49	23.08.14.	P	4	16.1836	78.6561	110	3.5	2.5	8.32	10	7.6
50	23.08.14.	P	4	16.1902	78.6549	61	3.8	2	8.65	40	8.1
51	23.08.14.	P	2	16.2089	78.6544	50	0.03	1	8.7	1750	5.3
52	23.08.14.	P	2	16.2037	78.6527	52	0.02	1	9.46	120	5.8
53	23.08.14.	P	4	16.1182	78.6398	166	2.7	2	8.82	40	7.5
54	23.08.14.	K	3	16.7343	78.6381	6	1.7	0.4	9.12	1300	8.7
55	23.08.14.	K	2	16.7425	78.6375	8	0.01	1	8.49	1500	10
56	23.08.14.	K	3	16.7331	78.6359	8	7	1.5	8.99	390	8.8
57	23.08.14.	K	1	16.7371	78.6345	15	0.004	0.25	8.67	680	11.4
58	23.08.14.	K	2	16.7373	78.6322	15	0.03	1	8.61	1530	10.2
59	23.08.14.	K	1	16.7438	78.6357	10	0.007	0.25	8.43	1210	9.7
60	24.08.14.	P	1	16.3416	78.6518	8	0.007	0.25	8.24	1030	7.1
61	24.08.14.	P	6	16.3362	78.6450	1			8.48	75	5.4
62	24.08.14.	D	2	16.1083	78.3609	28	0.04	1	9.48	160	7.9
63	24.08.14.	D	5	16.1558	78.3573	20			8.26	1030	8.1
64	24.08.14.	D	2	16.1684	78.3584	4	0.015	1	8.46	1250	9
65	17.08.15.	N	4	11.8776	78.9235	49	16	2	8.81	292	7.7
72	18.08.15.	N	4	11.8637	78.9165	56	3.0	2	8.74	224	7.2
73	19.08.15.	N	2	11.9252	78.9179	62	0.02	1	7.43	650	8.1
74	19.08.15.	N	4	11.9385	78.9252	23	1.1	2	8.16	514	6.9
75	19.08.15.	N	2	11.9233	78.9258	27	0.03	1	8.41	456	7
76	19.08.15.	N	1	11.9537	78.9208	77	0.002	0.25	8.27	334	5.5
77	19.08.15.	N	1	11.9621	78.9187	18	0.004	0.25	8.33	450	6.2
78	19.08.15.	N	1	11.9755	78.9157	19	0.005	0.25	8.34	438	6
80	19.08.15.	N	2	11.9537	78.9235	11	0.04	1	6.23	>10001	6.8
81	19.08.15.	N	2	11.7992	78.9357	60	0.2	1	8.95	97	7.6
82	19.08.15.	N	3	11.8164	78.9343	54	0.2	1	8.44	195	6.5

Appendix 2

List of macrobenthos species found within a survey from Spitsbergen, Svalbard, 2014-2015.

CRUSTACEA, NOTOSTRACA	*Lepidurus arcticus* (Pallas, 1793)
CRUSTACEA, AMPHIPODA	*Gammarus setosus* Dementieva, 1931
TRICHOPTERA, APATANIIDAE	*Apatania zonella* Zetterstedt, 1840
DIPTERA, CHIRONOMIDAE:	
DIAMESINAE	*Diamesa aberrata* Lundbeck, 1898
	Diamesa bertrami Edwards, 1935
	Diamesa gr *arctica*
	Diamesa sp.1
	Diamesa sp.2
ORTHOCLADIINAE	*Paraphaenocladius brevinervis* (Holmgren, 1869)
	Smittia sp.
	Cricotopus (s. str.) *tibialis* (Meigen, 1804)
	Cricotopus s.str.
	Cricotopus (Isocladius) glacialis Edwards, 1922
	Psectrocladius barbimanus (Edwards, 1929)
	Metriocnemis gr *fuscipes*
	Oliveridia tricornis (Oliver, 1976)
	Hydrobaenus conformis (Holmgren, 1869)
	Paraphaenocladius brevinervis (Holmgren, 1869)
	Orthocladius s.str.
	Chaetocladius s.str.
	Limnophyes gr *edwardsi*
TANYPODINAE	*Procladius crassinervis* (Zetterstedt, 1838)
CHIRONOMINAE	*Paratanytarsus austriacus* (Kieffer, 1924)
	Micropsectra insignilobus Kieffer, 1924
	Micropsectra radialis Goetghebuer, 1939
	Micropsectra sp.
	Chironomus sp.
OLIGOCHAETA, ENCHYTRAEIDAE	*Enchytraeus* sp.
	Lumbricillus sp.
	Marionina sp.

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Norwegian Institute for Nature Research
NINA head office
Postal address: P.O. Box 5685 Sluppen, NO-7485 Trondheim, NORWAY
Visiting address: Høgskoleringen 9, 7034 Trondheim
Phone: +47 73 80 14 00
E-mail: firmapost@nina.no
Organization Number: 9500 37 687
http://www.nina.no