Waters of Health 2020 – 2021: Final Report

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with the project team, *August 2021*

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This report has been produced by the coordination team of the Waters of Health project including and with original contributions from Jevgeni Kirillov, Håkan Tunón, Marie Kvarnström, Pauliina Feodoroff, and the community teams. Consent forms and ethical research guidance and methods of the Russian Academy of Sciences, Finnish Academy and Indigenous knowledge standards, including Free, Prior and Informed Consent were used during the project. All photos Snowchange, 2021 unless otherwise defined.

www.snowchange.org

Freshly collected whitefish roe, September, 2020 on Ponoi.

Introduction

Waters of Health 2020-21 is a new action on climate change combining Indigenous and scientific knowledge in monitoring in the Finnish-Norwegian borderlands and in the Murmansk region, Russia, funded by the Nordic Environmental Finance Corporation – NEFCO (The Programme for Environment and Climate Co-operation-PECC).

Waters of Health expands a monitoring network for northern climate change in Murmansk region (Ponoi river) and in Finnish Lapland (Näätämö River). We know that the rapidly proceeding climate change influences biodiversity in these catchment areas. Ground work has been laid out in the previous decade on monitoring in order to detect change in these areas.

Three new locations in the region are included in our work:

- *Voronya River catchment*
- *Lake Lovozero*
- *Lake Vuonnijavr in the Murmansk region*

Simultaneously the monitoring work in Ponoi and Näätämö will continue and expand. Documented Community-based monitoring (CBM) observations are being analyzed by scientific experts in the Nordic partner institutions to provide a socio-ecological view of these central water ways.

In the Näätämö Basin the main local partners are the Indigenous Skolt Sámi. For Ponoi river the focus will be the wilderness communities of Kanevka, Krasnochelye, and Sosnovka. The newly included project areas are: Voronya river catchment, a highly important river way for the Kildin Sámi that has not previously been subject to any CBM action on this level, the lake Lovozero, which is the key site for food security for the Kildin Sámi and the wilderness Lake Vuonnijavr is Western Kola. It has been proposed to be the first north boreal rewilding area in the Russian North due to its high biocultural significance.

Water is directly related to health and especially on Lake Lovozero early indications point to a link between water quality, fish health issues and human stressors. They will be investigated during the project. Indigenous peoples, who are directly beneficiaries of the

whole project, are fully dependent on their home waters and particular ecosystems.

A second and in no way minor issue is the pathway to choose and prepare Lake Vuonnijavr as a first regional rewilding and restoration site, leading to a potential *zakaznik*-level (regional protection) new conservation area.

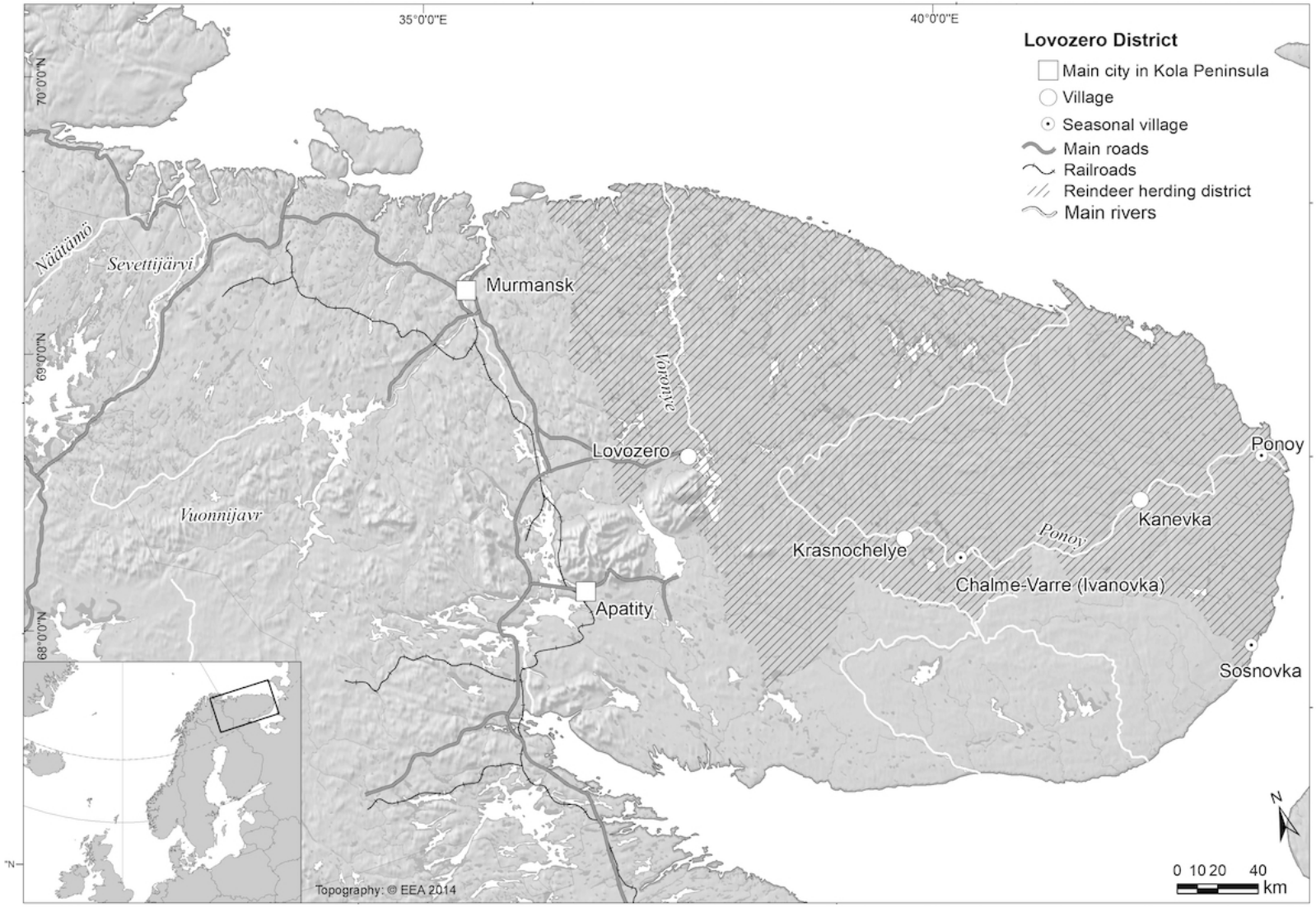
Barents Hot Spot actions are directly compatible with these goals and the lessons learned from the Snowchange-led restoration on river Vainosjoki in Näätämö system 2017-2019 will pave a way for the expansion of the Näätämö restoration too, another potential high profile site for the Barents Hot Spot actions.

Lake Vuonnijavr has been carefully chosen by key Saami experts and Nordic scientists as well as previous consultation with the Murmansk regional authorities (communications in 2019) due to its current status as a partially degraded area (small-scale logging), combined with the potential for rapid returns and high symbolic and intangible cultural value as the home area of the Skolt Saami community of Suonikylä (abandoned in 1944).

Lake Vuonnijavr still has the remnants of Skolt Saami family and community cabins, traditional use areas and communal graveyards. Additionally pre-project planning and assessment studies by Snowchange have detected the presence of wild deer (*Rangifer tarandus*) as well as other keystone species for north boreal rewilding in the area. Murmansk regional authorities (communications in 2019) have indicated this to be a very promising and positive site for a cross-border cooperation on Barents Hotspots and the Greenbelt territories.

Information flows that are captured in the project will contribute significantly to the knowledge regarding biodiversity of the protected areas in the basins, aquatic health, drivers of worsening water quality from past environmental problems as well as the contemporary impacts of Northern climate change.

Harvest of the season, August 2020, Kanevka



Project locations on a regional map. Map: Johanna Roto, 2020

Brief Summary of the Project Partners

Project leader is the non-profit *Snowchange Cooperative* based in Finland. Staff and experts from Snowchange have been working in Kola Peninsula since 1999 and with the Sámi communities since 1996. This science work is carried out with the Russian Academy of Sciences and its research institutes as well as in cooperation with the local authorities.

The Russian coordination work will be carried out by the *Municipal Public Organisation Lovozero Center of Development of Culture* who has operational reach in the remote wilderness communities.

SLU Swedish Biodiversity Centre at the *Swedish University for Agricultural Sciences* has decades of experience in long-term field-based and Indigenous - science interface actions in the European North. Staff involved with this project has been co-leading for example the Nordic IPBES reports and many other initiatives respecting and valuing Indigenous and traditional knowledge. Swedish Biodiversity Centre partnered with Snowchange in 2018 for the large-scale regional work on the community-based monitoring and has for instance capacity to arrange the chemical analysis of freshwater pearl mussel shells, biological detection of fish biology indicators and other key actions of the present project.

Saa'mi Nue'tt is a registered Indigenous association based in Keväjärvi, Finland with the operational reach for the Eastern Saami areas. It has been coordinating and participating in Saami and other Indigenous knowledge projects, including with the Arctic Council, the UN and Nordic Council of Ministers, since 2008. It will coordinate and facilitate the work in the Näätämö catchment area.

Results of the Project 2020-21

Despite the COVID impacts across the region Waters of Health 2020 kicked into action in June 2020. Actions concluded in August 2021. Then establishment of the teams in Näätämö and in the Murmansk region proceeded as well as making of the regional monitoring plans and actions. The following actions were taken in the project locations:

River Vainosjoki, restored, in the Näätämö basin.

Näätämö basin, Finland – Norway

2020

At the start of the summer the Skolt Sámi co-researchers were hired (leads by Kaisja Semenoja and Petteri Feodoroff). These teams conducted water quality, weather and fisheries monitoring across the season, with the hotspots being lake Sevettijärvi and Vainosjoki river, a restored and rewilded stream.

Community meetings and workshops were held in Sevettijärvi town in August 2020 when the national COVID restrictions allowed for the science teams to conduct fieldwork (lead Adjunct professor Tero Mustonen, specialist Lauri Hämäläinen). Interviews with Skolt Sámi Elders unveiled new sub-catchment areas for the study in 2021 and documented locations of the freshwater pearl mussel habitats both from literature and from oral histories. Weather observations continued using Sámi knowledge.

In order to prepare for the field season to detect and monitor micro-plastics a large baseline information was produced on fish growth, size, age and locations. This included the analysis of over 300 samples of perch, Arctic char, salmon and sea trout gill and otolith samples to create an understanding of the fish biology and situation in key parts of the Näätämö basin. This was partially done to complement the lack of access to new freshwater mussel samples, as they are almost extinct from the Näätämö watershed.

Project identified and created the team to start to monitor the micro-plastics situation. Early results included:

- Detection of potential drivers of plastics in the Näätämö basin to include returning fish stocks from the ocean (salmonids), tourist and local sourcing along the main river course, waste in the fjord and other options (snow-driven plastics in spring melt)
- Assessment of the location of a plastic trap for 2021 in the main river course
- Literature screening of Arctic micro-plastics and comparative view with lake Kallavesi in Eastern Finland. These actions have continued into 2021.

In the autumn monitoring a note of concern was that the water temperatures in the neighboring Teno basin were 10°C above the normal in mid-November 2020. This was due to another extremely warm Autumn. Monitoring actions were strengthened on Näätämö as a result.

2021

2021 kicked into gear with the release of the previous seasons' key results in science journal (Mustonen et al. 2021[1]). Between January and March 2021 winter workshops were held in Sevettijärvi community and early control fisheries continued for northern pike (*Esox lucius*) to determine their winter range and extent. A deviation

[1] Mustonen, T., Mustonen, K., Kirillov, J. *et al.* Community-based monitoring in the Ponoy River, Kola Peninsula (Russia): reflections on Atlantic salmon, pink salmon, Northern pike and weather/climate change. *Polar Biol* **44,** 173–194 (2021). https://doi.org/10.1007/s00300-020-02790-4

from the work plan was made on the freshwater mussel – given the lack of samples in the catchment area the surveys of mussel were conducted as a literature survey and the primary sampling directed to the culturally relevant fish of salmon, trout, perch and Arctic Char.

Otolith and Fish Scale Survey Results

In early 2021 SLU and Snowchange completed the analysis of the fish otolith and scale analysis that partially complemented and replaced the mussel detection work, given the lack of specimen for Näätämö. Key results from the survey included:

- Salmon (*Salmo salar*) samples were in line with the expected, similar discoveries – scales may show some wear and tear due to the spawning events and multiple returns to rivers. Overall salmon and trout stocks in Näätämö showed signs of excellent natural ecosystem growth.
- Presence of Arctic Char (*Salvelinus alpinus*) was a positive sign in the catchment area and highland lakes, but was determined to be one of the first fish to suffer from beyond 24°C water temperatures.
- In Perch (*Perca fluvialitis*) a short feeding/growth season during short summers was detectable and also the long age of some of the lake perch harvested for the study, conforming to the oligotrophic northern lake conditions. Fish over 20 years were not uncommon in the sample materials.
- In summary the fish data indicated rather healthy ecosystem composition and especially on perch the fish age reflected the slow and oligotrophic fishing conditions. Primary data results are available from Snowchange and will be used as a baseline for the 2020s on fish health.

On the way to microplastic measurements, July 2021

First-ever Arctic Microplastics Survey

After a lengthy and complex sampling kit development and literature surveys, in June-August 2021 the first ever microplastics surveys were initiated in the project. Locations and suspected potential sites of presence of plastics had been also co-designed with the Skolt Sámi team. The sampling locations were

- Kallokoski at river Kallojoki and Näätämö confluence, July 2021
- On Lake Opukasjärvi, Näätämö river, July 2021
- At the mouth of river Silisjoki, Näätämö, July 2021
- At Kirakkakoski and Vainosjoki, in the NE parts of the catchment area, July-August 2021
- At Jäniskoski rapids, Näätämö river, July 2021
- At Lake Nitsijärvi and Lake Inari (neighboring catchment and waterbody, to offer comparative monitoring results
- Sediment sampling on lake Opukasjärvi, July 2021

The primary team of fieldworkers included Emilia Uurasjärvi and Tuomo Soininen with Tero Mustonen co-leading the sampling, and Jouko Moshnikoff, Kaisja Semenoja and Juha Feodoroff assisting in sampling. Pauliina Feodoroff co-designed the survey and documented the samping in parts.

Methods of Microplastic Surveys

The sampling was conducted between 15th and 18th of July on 9 different sites (Table 1). For sampling a battery-powered garden pump was used to pump the water to a stainless-steel pipe. The pipe was divided in to four pieces with quick release clamps connecting them.

Three different mesh size stainless-steel filters were used inside the tube. The filters were placed between the pipe pieces and the pieces were clamped tightly together. The filter mesh sizes were from top to bottom: 315 µm, 100 µm and 50 µm**.** Also, a 2 mm prefilter was used on the suction hose. After sampling the clamps were opened and the filters were carefully moved to plastic boxes (polypropylene).

Table 1. List of site names, coordinates, numbers and sample volumes.

	Coordinates ETRS-TM35FIN			
Site	N	E	Site number	Volume (l)
Vainosjoki	7719839	575293	1	200
Nitsi Inari	7678655	546065	2	200
Mouth of river Näätämö	7721608	555577	3	200
Kallokoski	7734392	576663	4	600
Silisjoki delta	7722199	555060	5	200
Pahtaniemi	7682208	550483	6	200
Nilijoki	7709606	560724	7	200
Jäniskoski	7720028	566498	8	120
Kankaankoski	7721594	572859	9	200

The samples had to be treated with hydrogen peroxide to separate microplastics from biological compounds, which could hinder identification of microplastics. Around 100 ml of H_2O_2 was used for each sample and the samples were kept in a 50 °C oven for 24 hours. After the H_2O_2 treatment the samples were filtered on silver

membrane filters (Sterlitech Co., 5 µm pore size). Microplastics were identified and counted from the silver membrane filters with Agilent Cary 670/620 imaging FTIR spectrometer equipped with 128x128 focal plane array (FPA). The spectral maps were analyzed using siMPle software. SiMPle provides particle counts, polymer types, dimensions and estimates on mass and volume.

First Results from the Survey

Microplastics (MPs) were found from every site studied (Fig 1.). Highest MP concentrations were found on sites 1 and 2. These two sites both showed concentrations of 185 MPs/m^3. Lowest concentrations were found on sites 8 and 9 with 58 MPs/m^3 and 55 MPs/m^3 respectively. The other five sites had concentrations ranging from 75 to 120 MPs/m^3. The highest average particle size was found on site 9 (132 µm) and the lowest on site 4 (78 µm) (Fig 2.). Most of the MPs found were 20-150 µm in size (Fig 3.), although there were sites with relatively high percentage of MPs in the 150-200 µm range.

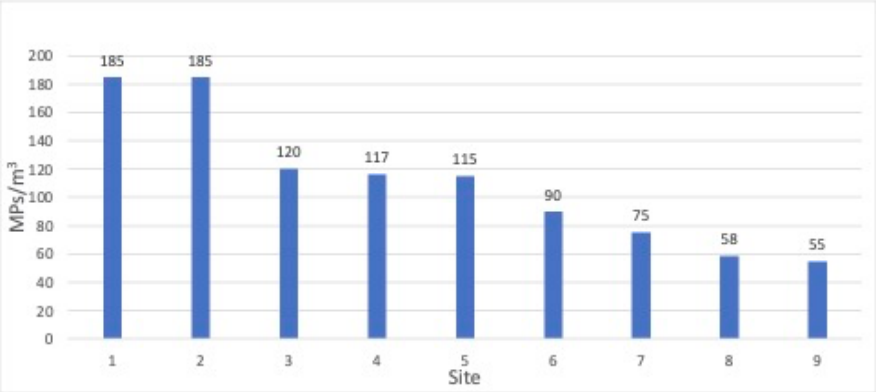


Fig. 1. Particles per cubic meter of pumped water.

Fig. 2. Average and median size of plastic particles in micrometers.

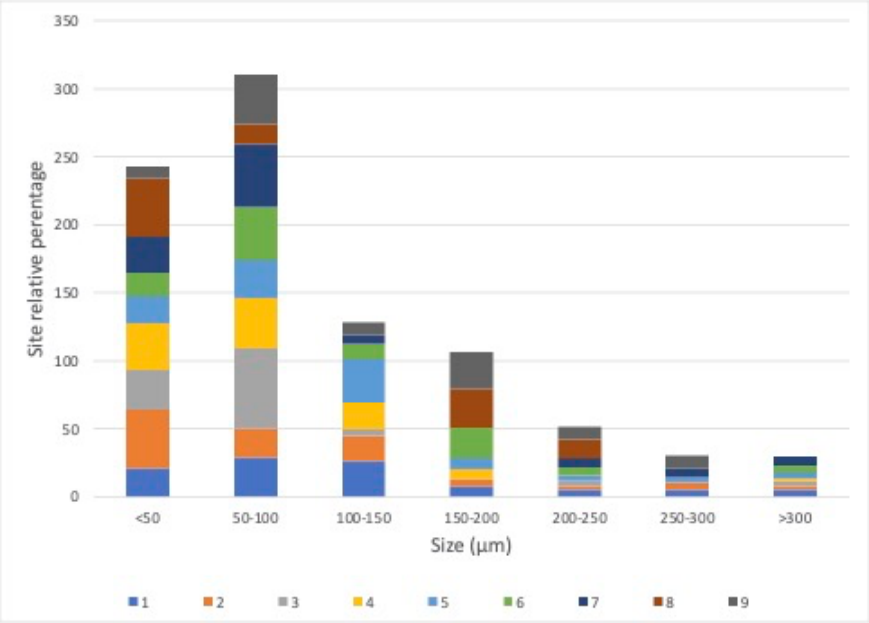


Fig. 3. Site relative percentages of different sized MPs.

Six different polymer types were found (Fig. 4.). The most abundant types were polypropylene (PP) (49,4%), polyethylene (PE) (24,8 %) and polyethylene terephthalate (PET) (18,6 %). Other three polymer types were polystyrene (PS), acrylonitrile butadiene styrene (ABS) and polymethyl methacrylate (PMMA). Site 8 was the only site from which no PP particles were found. Moreover, site 7 on did not contain any PE-particles. Overall, the distribution of polymer types varied remarkably between sites.

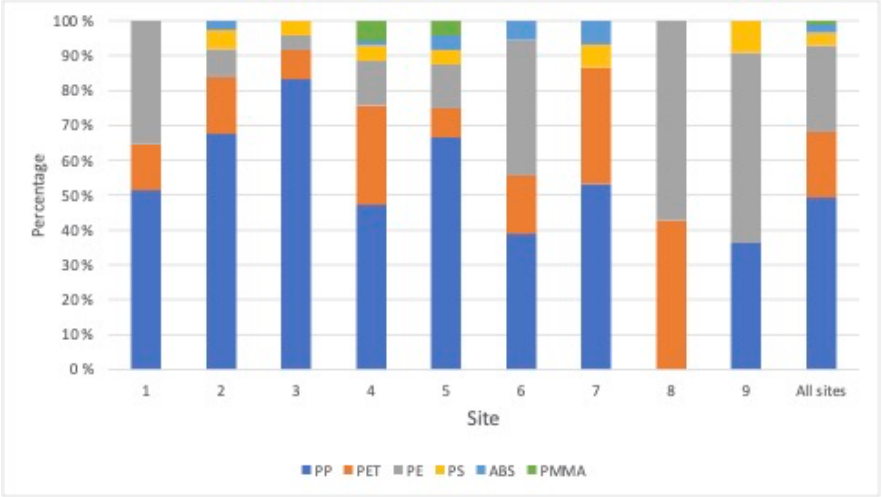


Fig. 4. Percentage of different polymers on each site.

Discussion and Conclusions

This study shows that MPs are present in the freshwater bodies of northeastern Lapland. However, to study the numbers and types of MPs in detail, more samples should be collected during different seasons and weather conditions. The concentrations of MPs varied from 55 to 185 MPs/m^3. Most of the MPs found were 20-150 µm in size, which is in line with other similar studies from different environments. Smaller sized MPs are usually more abundant than larger ones, because larger plastic items and particles constantly degrade in the environment. Interestingly, in the sites where number of MPs was low, the average particle size was high. Degradation may explain this.

Nearly 30 % of all MPs detected were smaller than 50 µm. Although the final sampling filter was 50 µm, smaller MPs could be present, because MPs may aggregate in the waters with each other and

biological solids. Moreover, the sample pre-treatment method may cause fragmentation of some MPs, which may bias the size distribution towards the smaller end. MP analysis is also prone to contamination because MPs are present in the air, equipment, and reagents of the laboratory. Control samples have not been analyzed yet, but the results of them will provide the background MP numbers and limit of detection. However, the results of every measured parameter varied remarkably between the sites, indicating that majority of the MPs found were not contamination but real findings.

Snowchange and UEF teams sampling at Kallokoski, July 2021.

Freshwater Mussel in Näätämö Catchment Area

As Mustonen and Mustonen (2013)[2] point out, the freshwater mussel is of high significance both as a cultural species and ecological indicator species, reliant on salmonids for successful reproduction.

According to the literature survey conducted between August 2020 and July 2021, it was discovered that the freshwater mussel in the river Näätämö catchment area is largely absent, and the "smoking gun" reason has not been detected – there are cultural use remains, such as shell piles and middens across the catchment area, indicating that the mussel was harvested there in 1800s and 1900s.

One potential explanation for the future studies is the sudden peaking of acidity in the spring melt waters that has been detected in the water monitoring for the project (see graph). This topic will continue to be observed and monitored.

Regional Workshops in Näätämö Area

Despite the COVID situation, the 2021 community workshops were held successfully. In March 2021 the discussions focused on the northern pike influence on salmon and expected proliferation of the Pink Salmon, introduced species (Mustonen et al. 2021).

This "prediction" became true. In the June and July 2021 community workshops held in Sevettijärvi, Kirakkajärvi and in Lake Opukasjärvi in the seasonal harvest area many of the Skolt Sámi observed that the pink salmon was returning to Näätämö in large numbers. This proliferation had triggered even local concept names for the fish like *"gorba[3]" and "humpie".*

Summary: Workshops Add to the Näätämö Database

Towards August 2021 Näätämö the community-based monitoring of changes and the detection of drivers started to be complete for the two field seasons. The primary field season results have been inserted into the river database, which is currently administered by the Skolt Sámi and Snowchange.

Based on the Sámi wishes the main results of the database discoveries are being released in English and in Finnish in the rewilding national portal of www.landscaperewilding.org

Key summary of the 2020-2022 project includes that:

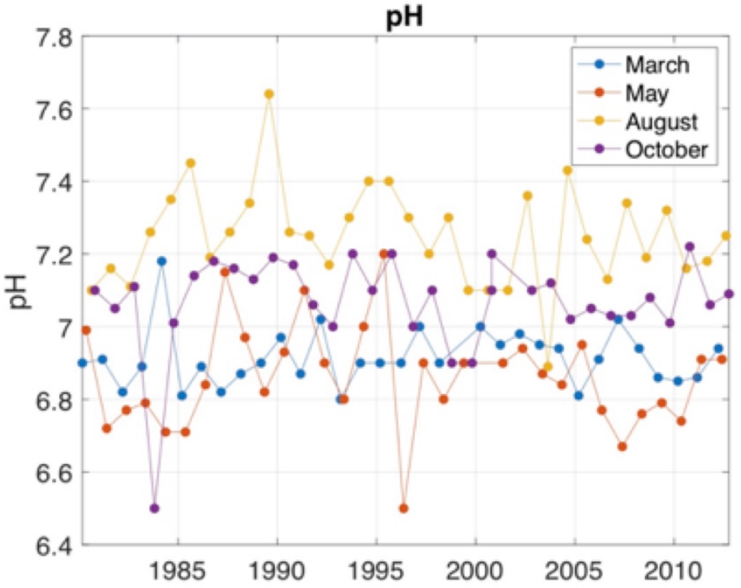
- Climate change continued to influence the Näätämö basin in the form of changing winter conditions, dry spells in the summer, high water temperatures and a risk of regional extinction of especially Arctic Char
- In order to create a baseline of the present fish biological and ecological status, a number of measures were enacted over two years, including Indigenous knowledge documentation of fish health and fish catch diaries, otolith and scale sampling for Arctic Char, salmon, trout and perch. These baseline monitoring efforts point to a relative health of fish stocks. However, the proliferation of Pink Salmon stocks in

[2] Mustonen, T. and Mustonen, K. (2013). Eastern Sámi Atlas. Kontiolahti: Snowchange Cooperative

[3] In reference to Mikhail Gorbatchev, the last Soviet leader, as the Pink Salmon were released by the Soviet authorities in Kola Peninsula starting in 1930s, see on this history at Mustonen et al. 2021.

thousands emerged as a concern for the Sámi in the villages, especially in 2021.

- The lack of freshwater mussel in the Näätämö area continues to be a puzzle. Literature surveys and preliminary scoping in the workshops point to a “mystery” of the loss of the species, even though the context for their healthy populations exists.
- As probably one of the most major breakthrough actions for the river system and a collaboration between Sámi knowledge and science was the first ever microplastics survey conducted in a wide scale across the whole catchment and on Lake Inari. The results indicate that that MPs are present in the freshwater bodies of northeastern Lapland. However, to study the numbers and types of MPs in detail, more samples should be collected during different seasons and weather conditions. The concentrations of MPs varied from 55 to 185 MPs/m^3. Most of the MPs found were 20-150 µm in size, which is in line with other similar studies from different environments. Smaller sized MPs are usually more abundant than larger ones, because larger plastic items and particles constantly degrade in the environment.



Steps to Start Rewilding Lake Vuonnijavr, Russia and Work in the Voronya Catchment, including Lake Lovozero

Lake Vuonnijavr is a major, former Skolt Sámi lake that was used by the Semenov family until 1944. At present it is in a wilderness part of the Murmansk region in the West. For a long time between 1944 and 2000s the lake maintained a rather pristine ecological status.

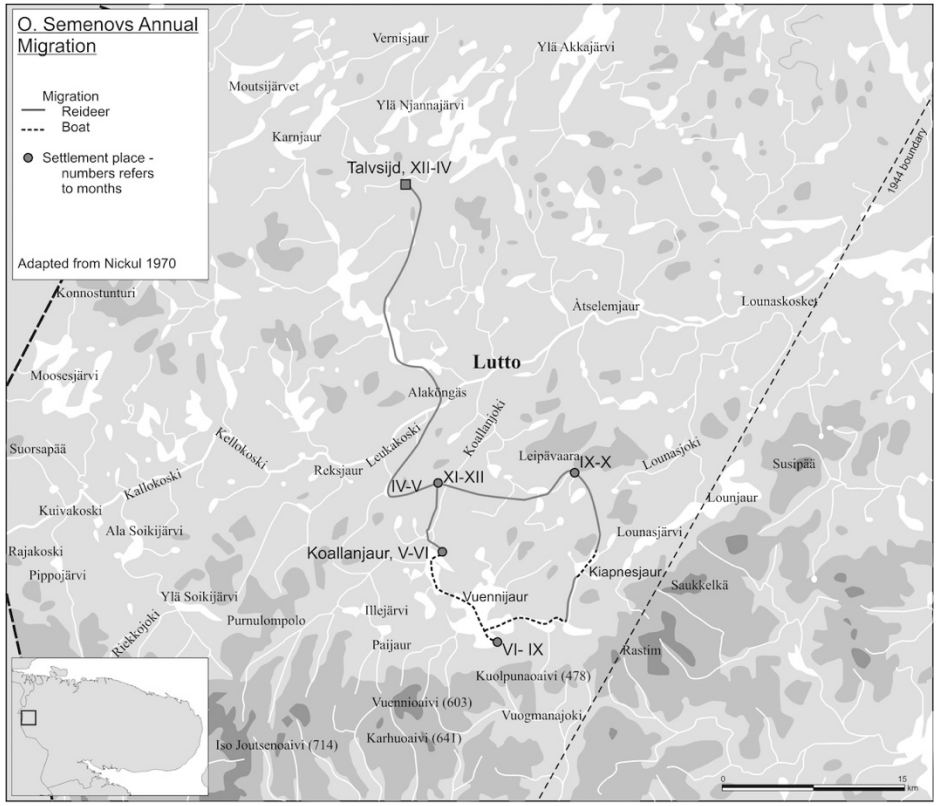
Starting from 2000s the lake catchment area and the water quality have been affected by a number of drivers, including

- holiday home construction
- timber logging in the near-by catchment area of the lake
- climate change extremities
- increased ecological production due to warmer temperatures

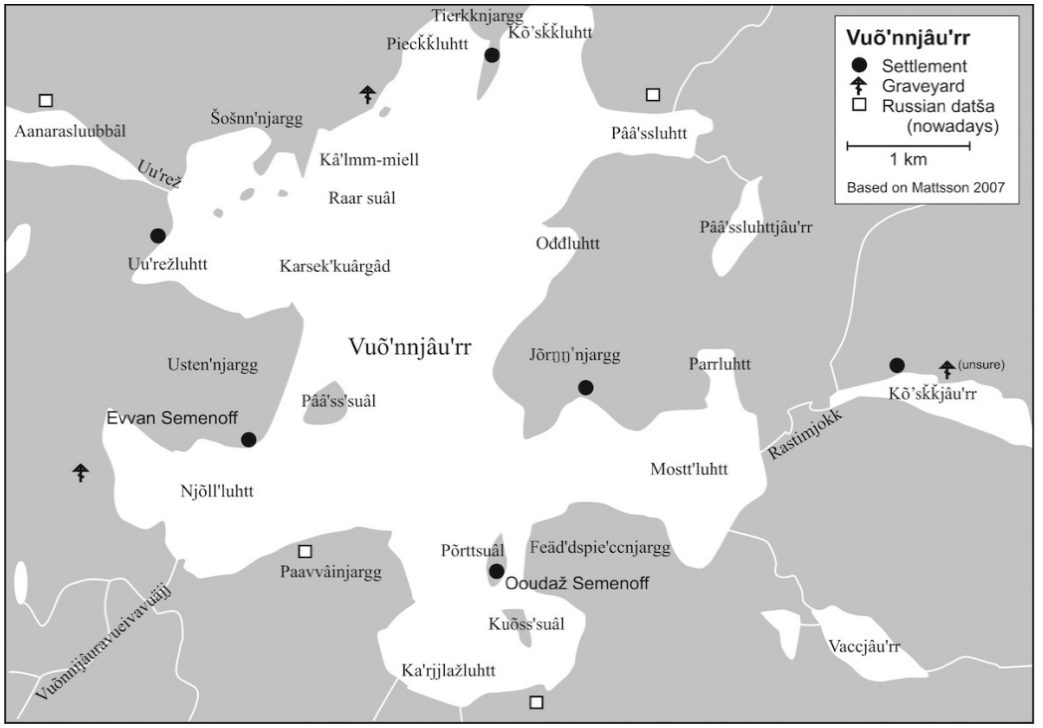
The Sámi and regional authorities in Murmansk (private communications, 2019) have identified the lake and the catchment as a potential for one of the first Arctic "rewilding" sites in NW Russia. During 2020-2021 the groundwork for these actions was completed.

More precisely, intensive work began in June 2020 to review both the cultural heritage and natural values on the lake. Due to COVID no field visits could be made to this remote region but key north boreal ecosystem surveys were available from the literature and the team ecologist began to assess the current status and trends of the lake and its surroundings.

Based on the available public academic sources, a land use re-construction of the Semenov traditional yearly cycle, and seasonal use of the lake was conducted.



Secondly, by investigating archival sources and literature, a reconstruction map of the place names, Sámi seasonal locations, families and both present and past human dwellings on the lake was developed.



These actions enable scientists to detect and determine, where the potential cultural heritage and archaeological surveys could be conducted should the larger ecological and rewilding process continue.

In terms of assessing the ecological status and trends as a basis of "rewilding" the lake, we determined a number of key materials and actions:

- Special attention was paid to the presence of the wild deer (Rangifer tarandus) in and around the lake catchment, both past and present.
- Historical ecological descriptions of the deer hunting pits to reconstruct the wild deer migration patterns of the past and links to present
- Surveys of wolf populations around the lake and other predators
- Water quality indicators based on the 1990s surveys (FI-RU science teams)
- Elimination of organic loading and forestry -associated drivers of aquatic impacts to the lake
- Review of the conservation and policy options on the lake and its surroundings.
- Implications of the present "renting" of the lake by Zapolyarnaya Rybalka Company and their development plans for the lake
- Potential for assigning lake Vuonnijavr as a regional protected area (zakaznik) to enable an ecological corridor between the strict protected area of Laplandsky Biosphere Reserve and the UKK National Park in Finland.

These plans will be developed together with the regional administrations and the Barents development and cooperation forums in the 2020s towards enabling the lake to become the first ever "rewilding area" of the Russian North.

Surveying Lake Lovozero and the River Voronye, Russia

The Voronye river originates from lake Lovozero and flows into the bay of the Voronye in the Barents Sea near the encampments of Gavrilovo. Its length is 155 km, with a catchment area of 9940 km^2.

The river basin is located in the northern half of the central part of the Kola Peninsula. To the south, it is bordered by the water catchment areas of the rivers Umba, Varzuga, Ponoy, on the East by the water catchment areas of the rivers Kharlovka, Rynda, and Olenka and the West – by the rivers of Kola and Teriberka.

The Voronya River is known as a salmon river. There are perch, trout, pike, grayling, char, whitefish, burbot in the river. In 1962 the decision was made on the construction of the Serebryansk hydroelectric power station *Cascade*. When constructing Serebryansky reservoir the following settlements were flooded and the inhabitants resettled:

- Pogost Voroninskiy
- Bolshoy Padun
- Serebryanskiy
- Golitsino

A small boy in Voronye original village, now flooded, in 1958.

After launching the Serebryansk hydroelectric power plant the length of the Voronya river was specified as 155 kilometers in the literature. The “new” length of the river is 50.5 kilometers from Lake

Lovozero to the top step of the Serebryansk hydroelectric power station Cascade and 26 kilometers from the dam of HPP-2 to the river mouth.

Historically the Voronye remains one of the most famous salmon rivers on the Kola Peninsula. It was the salmon that brought original outside fame to the river. In 1924 its size brought joy to Professor V. S. Docturovskiy, and it continues to amaze fishermen. The genetic memory of the fish is remarkable and now the largest schools of wild Atlantic salmon continue to pour into the Voronya River for spawning in the lower un-dammed reaches of the river. From mid-August sea trout starts to arrive into the Voronya River.

In the 19th and early 20th century, the fishing for salmon was carried out mainly in the estuarine habitat with the help of *harvs*[4] and hidings. The annual catch of salmon in the Voronya River exceeded 4,800 kg[5].

In 1925-1926 from 20 to 30 tons[6] were fished. In 1928-1933 up to 1,003 kg[7]. In 1950-1981 0.5-6.3 tonnes[8]. The maximum yield was recorded in 1975. Since 1982, there is no reliable data on the presence of salmon in the upper Voronya River from the estuary to Serebryanskaya HPP-2. This will be one of the future aims of the project investigation.

Monitoring and research work in 2020-21 included the following actions:

- Preliminary interviews in the town of Lovozero regarding the lake health and the river Voronye
- Literature survey of the river Voronye available from public sources
- Photography analysis of ecological change from 1880s photos and 2020s in terms of land use change, vegetation and tree lines on the higher locations (Khibiny)
- A full HD and drone video stocktaking of the lake Lovozero in terms of summer conditions, algal blooms (visible from the air) and other status and trends, completed in August 2021.
- A long visit to the former village sites around river Voronye, to collect primary oral histories and information from the former residents of these villages.
- A plan to publish these results in a scientific paper towards 2022.

[4] Russian salmon fishing net
[5] more than 1,600 salmon
[6] or about 6,800-10,400 spawners
[7] 200-350 spawners
[8] 131-1220 spawners

Surveying lake Lovozero from the air, June 2021

River Ponoi and Sosnovka on the White Sea Coast, Russia

Krasnoschelye

Communications with the largest village on Ponoi were held across the summer 2020, winter and summer 2021 and local co-researchers took note of the summer changes. On early September 2020 a large expedition took place to Krasnochelye and up and down Ponoi to document changes and key messages for the summer season. Small COVID-safe community "workshops" were carried out in early September for 2020. All in all six oral history interviews were carried out then. In 2021 the monitoring was continued through with winter and summer visits and regional work, resulting in total in 12 oral histories documented and a large HD video archive of the upper part of Ponoi river documented.

[9] records are kept since 2005

New playground in the village, 2020.

Some of the Key Observations, 2020-21

In 2020, according to the diary of Vladimir Ylyich Anufriev[9] the ice was formed on October 27 in 2018, in 2019 it arrived October 22 with a difference of 5 days. Three of the respondents noted that the freeze-up has become later and the freezing time of the river has shifted.

Vladimir Ivanovich Filippov said that the freezing time of the river has shifted. Earlier, in the 1990s the river became covered with ice around October 14-15 but now only in November. In good frosts, the

river freezes within three days. "*In mid-November 2019, we already went across the river on snowmobiles*" said Filippov.

Fish being prepared for the season, 2020.

An anonymous respondent[10] believes that the freeze-up has become later. A respondent who wished to remain anonymous recalled: "*According to my parents, there were reindeer migrations with sleds on the river already on November 7th. Already on 7th of November it was a stable winter reindeer road. This year, even tractors did not go to Lovozero, Lake Lovozero was not frozen as it should.*"

Lyubov Konstantinovna believed that the freeze-up in the Ivanovka/Chalme-Varre area happened as before at the same time. According to observations from Vladimir Ylyich Anufriev's diary, ice melt was on

- May 10, 2018
- May 9, 2019
- May 23, 2020.

Krasnochelye River bank, 2020

Three of the research participants noted that recently the ice flow has become slower, the ice "rots", melts gradually, darkens, becomes loose and dissolves in water. Sometimes ice floes are lifted from the bottom and carried away by the river flow. And before the ice floes came out on the banks and cracked, quickly in two days the ice was carried away by the river flow.

[10] Snowchange Oral History Tape Kanevka #3, 2020

In Spring 2020 residents of the village noted a high water level on the river. In an oral history interview with Vladimir Ylyich Anufriev he noted that the water level was higher than in 2014. In the area of the water measuring post on the Ponoi river water was flowing on top of the measurement site.

Vladimir Ivanovich Filippov was on the Saharnaya river in June 2020 and he noted that there was a lot of water. He fished, caught cisco, grayling, and trout, salmon had not come up the river yet at that time.

During a trip to Ivanovka (Chalmny Varre), the team visited the Rim Kurya where in 2018 there was shallow and little water. Team visited the Mishka Eiver where it was very shallow. Compared to 2018 there was a lot of algae in 2020.

All residents noted that the hottest period of summer was mid-July 2020. According to Vladimir Ivanovich Filippov, in the middle of July 2020, it was very hot, up to 30 °C. People were swimming in the river. The Ponoi river became very shallow and dried up.

Vladimir Ylyich Anufriev said that in July it was hot – about 26 °C. On the question about anomalies, Vladimir remembered that his uncle's wife, born in 1908[11] told him that in 1928 the river froze on September 28.

[11] they lived in the Oksino area.

Inspecting whitefish catches, September, 2020

From Vladimir Ivanovich Filippov's oral history observations: "*On lake Losye cisco became larger, mostly in winter, but there was less of vendace. On this lake, local people put nets in winter. They began to catch more fish and therefore the cisco has become larger*". Large salmon does not come to Krasnoshelie because of the tourist camps located lower on the Ponoi. Size of the salmon that reaches the village starts from 1 kg and slightly higher.

"*In June, on the river Losinga I caught five fish on spinning, the largest one weighing four kilograms. Most of the fish are healthy without any changes. One was caught injured, pike are found both on the river and in lakes. I caught one on the spinning weighing five kilograms in the area of Ivanovka. White bubbles started to appear on the liver*" said an anonymous source.

All residents noted that the liver of some fish has damaged by white spots. Spots on the liver of pike rarely appeared. Anonymous source noticed that salmon is not caught in the area of the village. To catch salmon, people go to the Sukhaya river or the Lebyazhka river. "*This year I took six licenses, though I took ten previously, and caught four fish of 1.5 kg. In 2019, I was fishing for a week and caught salmon of four kg. Licenses are sent to the village, one license costs about 300 rubles.*" He noted that until fishing tourist bases appeared, there were plenty of fish.

All residents noted the presence of ducks on the river. Number of hazel grouse (*Bonasa bonasia*) and capercaillies (*Tetrao urogallus*) had decreased near the village. Whooper swans (*Cygnus cygnus)* nest on lake Nizhne-Kamenskoe. White-tailed eagles (*Haliaeetus albicilla*) are now more common over the river.

Vladimir Anufriev noted that this year there are no capercaillies: "*the main thing is that there are berries, but there are no birds near the village. There were traces of an otter during the haymaking, if there is an otter then there are more fish. There are moose, wild reindeer haven't been simply seen at all.*"

Aerial view of Krasnochelye, 2020

According to Lyubov Konstantinovna's observations, the swans arrived on 20.04.2020. There are also many ducks, swans, and eagles in the area of the village. There are also bears (*Ursus arctos*). "*There are a lot of bear tracks, and I only met one bear, but the dogs drove it into the forest*". She noted that otters live on Lake Peschany and began to appear in small rivers. She often watches through the window as moose cross the swamp from forest to forest.

Some of the Main 2021 Results

Summaries of the the 2021 community observations included:

- In the vicinity of the village of Ivanovka, river banks are covered with undersized goat willow (*Salix caprea*). In June, the banks of the river are covered by flowering rowan-trees.
- In the upper part of the river, close to the village of Krasnoshelie, rowan-trees have already bloomed, and below the village of Krasnoshelie, rowan-trees is blooming profusely.
- During June 22-29 the Ponoi river underwent significant changes in water level caused by rains. On the video and photos taken off the coast, the grass growth line is clearly visible. Two of the respondents noted that the water level had risen quite intensively. The coastline has shifted by 50-70 centimeters.
- Observations on northern pike pointed to healthy stocks in the season by the monitoring team. Harvesting was done on Pyatikurya – which is a small lake, the Sakharnaya river - at the first rapids, the Kislaya river and Kislaya lakes (the first and second ones). The catch was three pikes (size 45-55 cm) and six perches (size 20-25 cm). During cleaning and cutting the fish, no affected viscera were found, gills of a healthy pink color. One pike had spawn remains in its spawn bags. However, oral histories conveyed that more often locals catch fish with an affected liver - perch and pike.
- Oral history documentation mentioned for 2021 that salmon spawns in the tributaries of the Ponoi river, located on the left bank of the river (Sakharnaya, Elyok, Suhaya, Lebezhja, Losinga) with a water source in Keivy (the name comes from the Finnish word stone) mountains (heights) (390 m above the sea level)
- Freeze-up on the Ponoi river has shifted, the river froze over only in December 2020 (often first freezeup is in late October)
- There is grayling in the river - it means the river is clean;
- In autumn 2020 (October) there was a high water level, just like in spring period of time;

- For the third year in row the spring ice melt has been very silent - without noise, the ice just 'rotted'
- Cloudberry (*Rubus* chamaemorus) was blooming well, but it was very windy, it is not clear whether the harvest would be good or bad
- Red-bilberry (*Vaccinium vitis*-idaea) blooms well, the rains poured down at the right time, there will be a lot of berries.
- Number of grouse of different species in the area of the village have significantly decreased; sea eagles have increased and are very often seen closer to Krasnoshelie; hawks are found in the Ivanovka area; many ducks and swans can be seen along the river;
- Freeze-up time has shifted, the ice on the river was established in early December only;
- There was little snow in the winter, the main frosts took place in February and were about -30C, in winter time there was a good catch of vendace in lake Losye
- It is almost impossible to catch salmon in 2021 - in the 1990s, 90 salmon were caught for spinning in pits on the Losinga river in one fishing season.

In summary for the 2020-21 discoveries, it can be said that life in Krasnoshchelye is becoming more comfortable, but the traditional way of life is preserved. Noticeable impacts included:

- Climate change is palpable, and warming affects ice and river flooding. The weather is less predictable. Oral histories indicate Ponoi used to freeze in September in 1928 with todays freeze-up usually in late October to early November.
- Health of the river and quality of water in the river do not cause any alarm. However, a new noticeable trend was the poor quality of livers in pikes and perch.
- Salmon season this year was poor, the fish became smaller in size.
- Attention should be paid to changes of the river banks and the erosion events under way.
- The main problems of the community are mostly socio-economic at the moment – COVID impacts, the flight only once a week, the number of residents is decreasing, the lack of jobs for young people, alcoholism.

Kanevka

Preparations for the project actions were carried out in Kanevka with a connection to the local teams. Full visit took place from 9th to 16th September 2020 and in 2021 for the whole season. In summary Kanevka village lives by nature - that means collecting wild berries, mushrooms, fishing, hunting and small businesses: selling mushrooms, berries, horns, fish, and receiving tourists.

Among the main problems of the village residents name lack of medical care, lack of round-the-clock power supply, lack of kindergarten and school. One of the achievements over the past two years is the construction of a new bridge over the Yoganka river connecting two parts of the village. The bridge was built on sponsors' money. Despite the fact that the need to build a new bridge was long overdue, local residents did not want to invest their money and effort in it.

The director of the company "*Serebro Ponoya*" (Ponoi silver) provided construction materials and workers who worked at one of the tourist bases on Ponoi. Construction materials were also provided by the tourist company CJSC "*River Ponoi*". Construction of the bridge was also attended by two local residents and two female local residents made a painting of the bridge.

Also, one of the significant achievements is getting a mobile fire – fighting post, which includes a full set of inventory, equipment and uniform for fire extinguishment. It is a trailer that can be attached to a motorcycle, ATV or other vehicles. The mobile post was handed over by the Murmansk regional branch of the all-Russian voluntary fire society.

According to one of the residents, there are only two such posts in entire Murmansk region. Since the village has mostly wooden houses and fires have often happened before, the villagers are very happy with this acquisition. Residents of the village prepared an appeal to the district administration, and thanks to their perseverance, a volunteer fire brigade was organized in the village, where to this equipment was brought.

In the 1970s and 80s according to locals there were four brigades in the Kanevka branch of the state reindeer farm "*Olenevod*", each consisting of 6-8 people. Number of reindeer was about 15 000 in those days. In 2020 only one person worked in the Kanevka branch of the cooperative "Olenevod" on a permanent basis, three people are hired under a contract in the winter.

Today the number of reindeer is only about 3,000. Kanevka has always been a village of reindeer-herders with the cooperative being a town-forming enterprise. Everyone who lives in the village is somehow connected with reindeer farming. Therefore, residents are worried about the future of the cooperative.

New bridge of Kanevka, 2020

Many people say that the reindeer in Kanevka are larger than in Lovozero and Krasnoshelye, the pastures are richer. But in order to develop reindeer herding leading to more prosperity, reindeer herders should be constantly with their herds taking care of them and protecting them from poachers.

Local residents remember that in autumn in November 15 years ago (2005) reindeer were driven across the river. It is impossible to do the same right now. The climate has become milder, the river does not freeze so early. The river still freezes in the autumn but the quality of the ice has changed. There are less severe frosts in autumn, but more snowfall is noticeable. The ice does not have time to freeze, snow falls that prevents freezing. The ice became like a "*layer cake*".

Ice melt and associated drifting can change from year to year with a difference of a month. In 2016 the ice melted on May 1. Last year and this year it happened closer to June 1. According to local residents, the ice drift has changed compared to the past. The ice melts before it leaves the river. Since the ice is loose, the ice drift has ceased to be "*noisy*". There are no huge boulders, no stones are demolished, there is no hum.

15-20 years ago if standing next to the river during the ice drift talkers did not hear each other. Now the ice is coming off almost noiselessly in a couple of days. But, residents note, this year, due to heavy spring snowfalls, the water in the river rose strongly and the ice descended quite noisily, but still very quickly. This year, ice jams were observed in narrow areas of the Ponoi River. This year, the water level has increased very much. The last time such high water was observed according to locals in 1976.

Locals did not express any particular concern about water quality. Some residents note that there is now more vegetation in the Ponoi. There was a lot of snow this year, so the flood was significant. The river washed away the banks in some places. Pieces of the bank were carried into the center of the river, up to the

formation of islands. At the confluence of tributaries of the Ponoi river, the river mouths change their shape, and "*a braid*"[12] appears.

Low waters of Ponoi at Kanevka, 2020

Over the past two years, there have been no forest fires near the village of Kanevka. Usually fires in this area occur due to dry thunderstorms. This year a summer was not dry but rainy. At the end of July 2020, the highest air and water temperature was observed. The air temperature rose up to 30 °C. The water temperature did not rise above 13 °C.

According to locals, there has been a decrease in the weight of each individual salmon over the past two years. If earlier the average individual fish weighed about three kilograms, now it is 1,8 – 2 kilograms. Changes in the taste of fish were not observed. Size of the salmon has changed according to the observations of residents. In the spring size of the fish was less than usually, but its number was greater.

In the spring, fishing was successful for everyone. Amounts of trout have decreased. Five years ago, there were a lot of trout in the Ponoi river but now the number of trout has sharply decreased. There are fewer large pike - almost no large specimens are found. As for whitefish (also known ascisco) and ide, the situation has not changed much, but some residents note that the number of whitefish, especially large individuals are increasing. Cisco bite even on a spoon which is surprising because cisco is not a predatory fish.

Bank erosion of Ponoi, 2020

[12] a low alluvial strip of land on the riverbank

Residents note that in the area of Kanevka village the number of predatory birds has decreased. There are more waterfowl birds now. In the last two years magpies have appeared though they hadn't existed here before. The number of capercaillies has not changed much, and maybe even have increased. Many residents said that capercaillie hunting is good.

Residents did not notice any abnormalities or deterioration in the quality and taste of fish. In the summer there were no pink salmon in the river. This is natural, since pink salmon spawning in the river comes once every few years. Last year (2019) there were a lot of pink salmon in the Ponoi river.

During the 2020 field visit, the team observed a large number of moths called peppered moth[13] or autumnal moths. According to local elders, this has never happened in their memory. Nobody knows why they appeared in huge numbers. Some people expressed an opinion that it is time not only to take fish from the river, but also fish farming. To do this, they want to organize a fish farm for salmon.

Key Points from the 2021 Season

In the winter of 2020-2021, an interesting phenomenon was observed on the Ponoi river. In the fall 2020 the river froze over, and then there was a thaw and ice started to melt and went down the river as if it was spring time.

Ice hummocks formed on the rapids. It was impossible to drive a snowmobile along the river. The ice height in some places reached up to 1 meter. It was difficult to get through even on foot.

The winter of 2020-2021, according to the observations of the locals, was a little snow. The snow cover was not as high as in previous years. The amount of water in the river is directly dependent on the amount of snow in winter. Because of that there will also be less water in the river this summer, and in some places it may dry up.

Now locals do not observe such a strong ice drift as several years ago. A few years ago, the bridge over Yukonga river was washed away by water in the spring, but last year and this year too this was not the case. In winter, severe frosts were observed - up to -47 °C, lasting up to 3 to 4 days.

The average temperature in winter was 20-22 °C. Some residents note that there are fewer snowstorms in winter and the climate has become milder in winter. Summers, on the contrary, became colder.

On fish quality - According to locals, the quality of the fish has not changed. The respondents did not note anomalies, deterioration in the quality and taste of the fish. Some noted that maybe the salmon is not as oily as before. But basically, the fish is the same as it used to be.

Such fish species as ide and *Coregonus albula* (vendace/ European cisco) are rare "guests" in the Kanevka area. These fish species live

[13] most likely autumnal moth (*Epirrita autumnata*) or possibly winter moth (*Operophtera brumata*); both species have expanded in a north-eastern direction in recent decades into new areas, most likely due to climate change with fewer cold winter days.

upstream of the river, in the Krasnoshelie area. Mostly locals catch trout (*Salmo trutta*), and according to the local population, the number of this type of fish is increasing every year.

Local residents believe that the increase of the number of trout is due to the fact that during the Soviet Union there was a fishing brigade at the mouth of the Ponoi river, which had caught a large amount of salmon-trout with nets, preventing it from going upstream and taking up salmon spawning grounds.

These days no one is catching salmon-trout in such large amounts, therefore trout as more aggressive predator, rises upstream, eating salmon eggs and occupying its spawning grounds.

Pink salmon can be caught in area of Kanevka, but not every year. This fish goes up the river in large numbers about once every 3,5 years. And then one can catch a lot of it. Also, local residents note a decrease in the average size of caught salmon.

Nobody can explain why it happens. Grayling was not caught at all this year. All respondents noted that grayling fishing was not successful this year. In general, it is noted by all respondents that fishing for all types of fish was not so successful throughout the winter as it was in the past.

Reflecting on the summer 2020 moth event, butterflies (*Epirrita autumnata*) or possibly winter moths (*Operophtera brumata*), which were found in large numbers in Kanevka, lived in pine forests, since Kanevka is surrounded mainly by a pine forest.

Some residents think that the absence of midges last fall is due to the large number of these butterflies. The trees were not noticeably damaged. All residents say that such a phenomenon as an invasion of butterflies, was observed for the first time in their life.

Documenting the moth at night time, September, 2020

Sosnovka coast, 2020

Sosnovka

Analysis of the previous data constituted the first summer actions from June to August. A large expedition to document changes and establish local teams was carried out from 12th to 19th August 2020 and then in winter and summer 2021.

In the 2021 a major methodological breakthrough was achieved – monitoring teams documented, using HD video, most of the Kola Peninsula southern coastline from Ponoi mouth to Chapoma for environmental and socio-ecological changes.

These materials will be also shared in the future under the new Arctic Seas portal (at www.arcticseas.org).

2020 Results

In 2020 the visit included interviews with four people. Six audio recordings of the interviews were made, including interviews with the head of the hydrometeorological station and the representative of the Lovozero district administration.

The snowy winter of the end of last year (2019) and this year has caused serious adjustments in the process of ice formation. As all respondents noted there was no solid freeze-up at the end of last year. The winters became warmer, but in Sosnovka, as in the entire Murmansk region, there was a very snowy winter.

This winter was the snowiest winter in the last 50 years. It brought a lot of problems to the inhabitants of Sosnovka. One person reported having to dig out his house and make almost a tunnel with three-meter-high snow walls to get to the firewood that heats the house. Quite similar problems were faced by almost all residents of the village, which does not have public services and special snow removal equipment.

River Sosnovka, 2020

Due to a large amount of snow, the ice has changed a lot. The rivers were clogged with sludge[14], then, at the end of October, all this was covered with quite thin ice, which was raised and broken by the water. Frosts were replaced by thaws, during which still thin ice was covered with a thick layer of snow, then the water broke through the ice to the surface and froze again during the frost. Therefore, the ice mixed with sludge and snow froze in layers and turned out to be very fragile.

Preparing for the winter with firewood

There has been no freeze-up in the sea for several years. As the head of the hydrometeorological Station Vladimir Zotov noted in his observations, a few years ago, the ice came in December, but now only broken ice comes at the end of January and leaves at the end of April. Salma, the strait between Sosnovets island and mainland, has not frozen in winter for five years (2015-2020).

If earlier the sea brought large ice floes that got stuck in the Strait and froze into the coast, connecting the island with the coast of the Kola Peninsula, now there it does not happen. There are also no large ice fields in the open sea. Mostly in the sea, you can see only shallow ice. The reason for this, as Vladimir Zotov thinks, is warming. If earlier the air temperature in winter reached minus 30 C Celsius, this winter

[14] fine loose ice that appears before the freeze-up

lowest air temperature was recorded at only -23.6 °C. The average temperature is -10-12 °C.

Family harvesting on the Sosnovka with fish traps

In the strait between Sosnovets island and the shore where the village is situated, villagers often observe beluga whales (*Delphinapterus leucas*). On 12 August 2020 during a trip to Sosnovets island, Sergey Eliseev observed a beluga while being on a boat near the coast of the island. As Sergey noted, usually at this time belugas appear here in places with more depth and hunt fish.

Sergey Yulin says that there are lot of belugas and he has also repeatedly observed belugas that go out to sea both alone and in schools. In July of this year, he saw three beluga whales hunting fish in the strait. The same observation was made by Ivan Eliseev who watched a school of belugas hunt the fish.

Fish traps, September 2020

The number of ringed seals did not decrease, the only thing is that they left Sosnovets island. All the ringed seals (*Pusa hispida*) were scared away by the dogs living on the island[15] that did not allow them to breed on the island.

But, according to the employee of the lighthouse located on the island next to the hydrometeorological station all the seals are now on Snezhnitsky Cape five kilometers from Sosnovets island and there are a lot of them on it.

[15] there used to be one, but now there are three on the island

Community of Sosnovka

This year, quite a significant amount of navaga (*Eleginus nawaga*) appeared. As Sergey Eliseev noted, it happens that there is a lot of navaga, but it was also so that this fish was not there for three years. Someone said that it was lost, poisoned. But now this type of fish has reappeared. There are both navaga and flounder in the sea.

There is less of the lumpsucker or lumpfish[16]. Previously, there were many lumpfish nearby Sosnovka, but now only one large female and four small ones have been caught in the fyke hoop net[17]. The rest of the sea fish stocks were perceived to be healthy for the most part. White sea herring, flounder, navaga, haddock and gobies are regularly caught. Concern for the amounts of salmon and health of the fish were raised on several occasions later in the season, especially in October and November 2020.

2021 Key Points From the Monitoring

Sosnovka, being the most remote community of the project, is also special due to its position at the White Sea Coast. In the 2021 field season and with the local observation teams, the whole coastal zone from Ponoi mouth to Chapoma was documented using HD video cameras – a powerful testimony of years to come, to detect how change happens and what will be affected (coastal erosion, cultural use areas, water levels).

This action constituted most of the field visits but some of the oral histories and observations were also recorded. Of special note was a co-researcher, Mrs. Larisa Saksa, who returned again to a remote place called Lakhta for the season.

Saksa used to work in a fish processing factory from 1974 to 1965. For 15 years now, this woman has been traveling to this place of her former work every year in order to rest and get "*a boost of vitality*" (according to Saksa) that will allow her to live until the next visit to her "*place of power*". This year she is already 85 years old.

According to local observations May was affected with worse weather than previously. In 2020 the Sosnovits lighthouse on the island was modernized and was put into autonomous service.

[16] *Cyclopterus lumpus* (*Пинагор* - Russian, henfish)

[17] *мерёжа* - Russian

One of the lighthouse-keepers decided to stay on the island and joined the Hydrometeorological Station. The hydrometeorological station is still headed by Vladimir Viktorovich Zotov.

In their notes water in the sea became warmer. After the dogs left the Sosnovits island this winter, people began to observe a large increase in seals and seabirds.

Conclusions

Waters of Health 2020-22 project has been concluded with success. Rather surprisingly, despite the sweeping impacts of COVID, field teams could go out to remote communities safely and without jeopardizing the locals. National and international instructions and guidance were followed carefully to conduct safe and meaningful expeditions. The main deviations from the project plan included

- A lack of a large international workshop in August 2021 that was moved online with the regional summaries, presentations and deductions discussed
- Switching the freshwater mussel samples to the otolith and fish scale analysis, due to lack of samples from the Näätämö river. Instead the presence / absence issues of the mussel were surveyed using literature and archival studies. A potential driver of lack of the mussels was contemplated to be the spring re-occuring acidic 'peak' visible in the water data but this will require further studies.
- Instead of a new net portal, the villages wished the results to be published on the high-traffic sites of Landscape Rewilding (for Näätämö) and at the Arctic Seas sites for the Russian results, thus enabling a larger coverage. Especially the freshly-minted video HD materials from the White Sea coasts will be updated as edits become available on the Arctic Seas portal.

In Lovozero, Sevettijärvi, Murmansk, Uppsala and Selkie the literature surveys and analysis of materials were carried out to support and analyze the field discoveries.

We can see the impacts of climate change across the Näätämö, Vuonnijavr, Voronye and Ponoi systems, with some of the key messages being:

- **Atlantic salmon, a keystone species of the region, was observed to be smaller and less in numbers**, especially in the Näätämö system and parts of Ponoi.
- **Changes to the cryosphere, i.e. snow and ice formation, quality and melt events continue**. For example in November 2020 water temperatures above 10 °C normal were detected in Teno system, close to Näätämö in Finland. Emerging data from oral histories indicate that in 1920s Ponoi used to freeze in September, now the freeze-up can be delayed to November. All across Summer 2021 the temperatures over 25-30 °C were again documented in Näätämö river. The winter sea temperature outside Sosnovka has risen and there has been no freeze-up in the sea for several years.
- **Droughts (despite big snow amounts in the previous winter) and algal blooms were observed in several parts of Ponoi**. In Spring floods and ice dams were noticeable especially in Kanevka.
- **On the White Sea coast, navaga stocks were doing well and seemed to be thriving** and according to Indigenous knowledge the fish operates in three-year-cycles. Lump fish was observed to dwindle.
- **Proliferation of Pink Salmon into Näätämö was observed and to be on the increase in 2021, with thousands of fish in the river.** Norwegian authorities instigated measures to control the arriving populations, but mostly in vain.
- **Beluga whales are healthy and in large numbers** on the White Sea coast.

- **Changes to bird populations especially on Ponoi were observed.** Predator birds seemed to dwindle, except sea eagles whose population has increased.
- **Ecological baseline measurements of Arctic char, perch, salmon and sea trout was conducted on Näätämö**.
- **First event microplastics surveys were conducted on river Näätämö as well as early measurement points on lake Inari. This study shows that MPs are present in the freshwater bodies of northeastern Lapland.** However, to study the numbers and types of MPs in detail, more samples should be collected during different seasons and weather conditions. The concentrations of MPs varied from 55 to 185 MPs/m^3.

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