EURO-ARCTIC FRESHWATER STUDIES - NEW CHALLENGES AND SOLUTIONS

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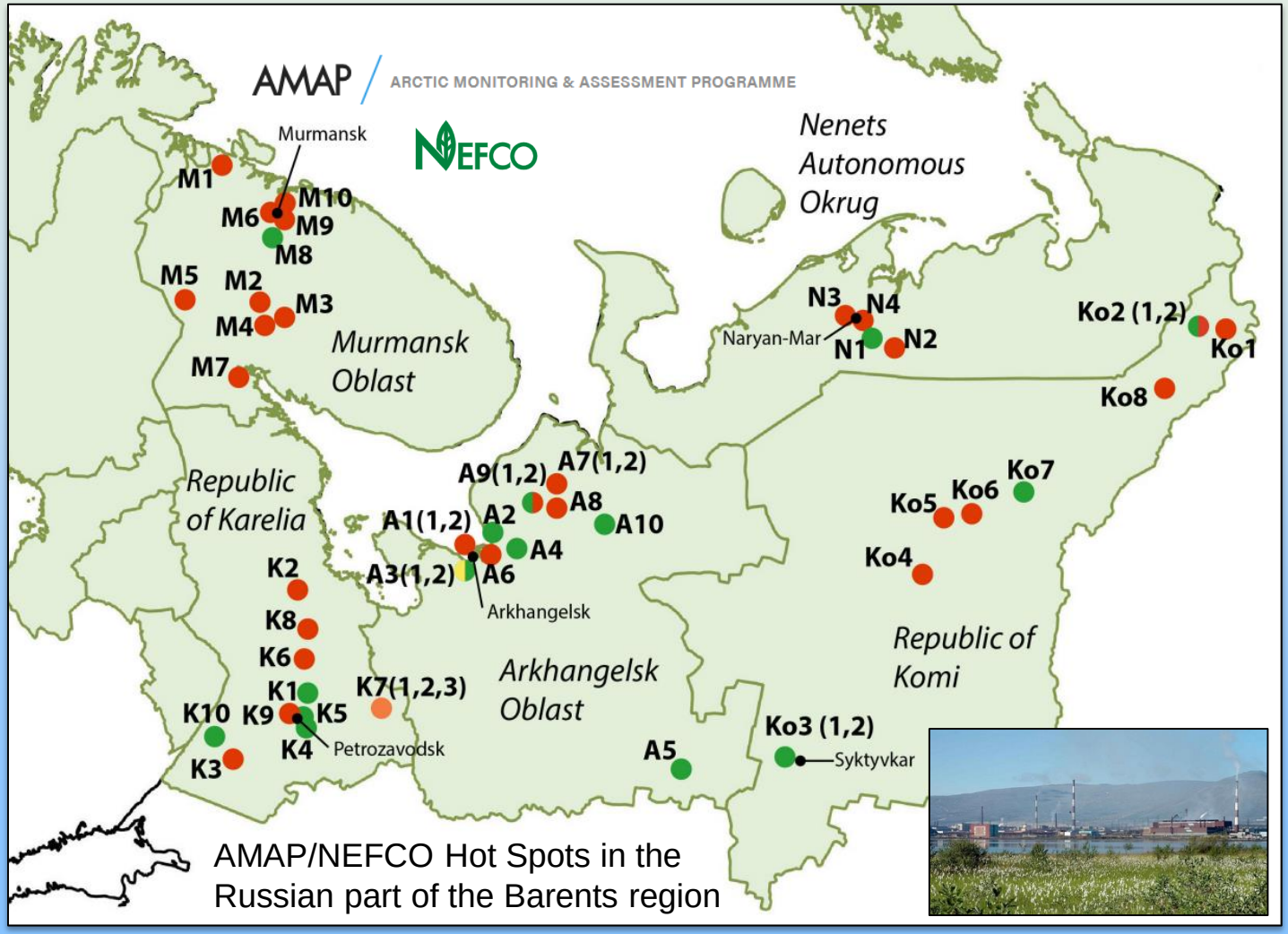
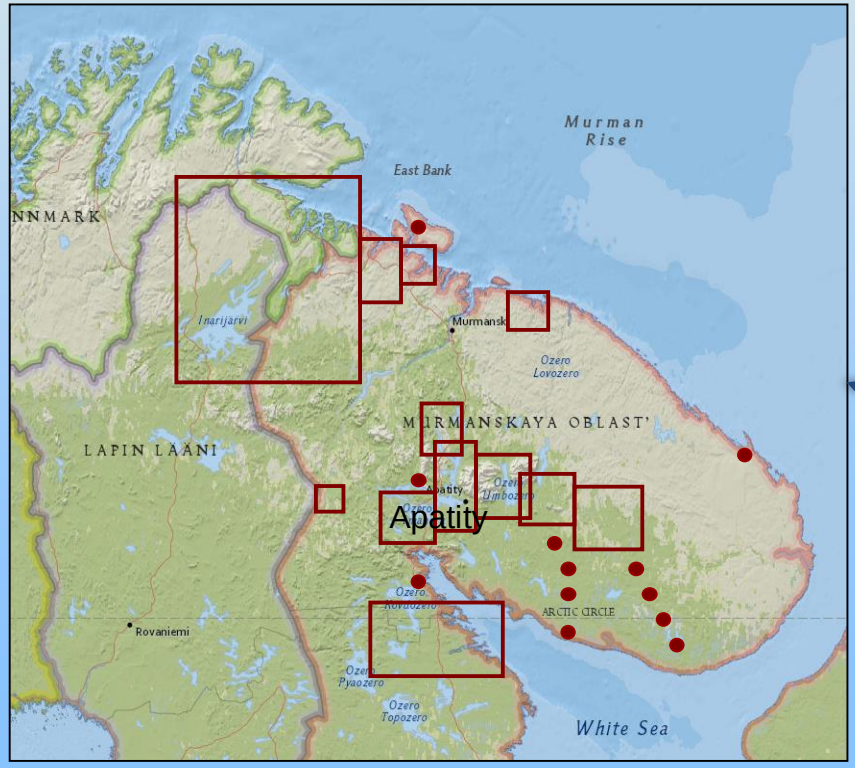
Freshwaters of the Barents Euro-Arctic region extremely sensitive to all changes in the natural environment and climate

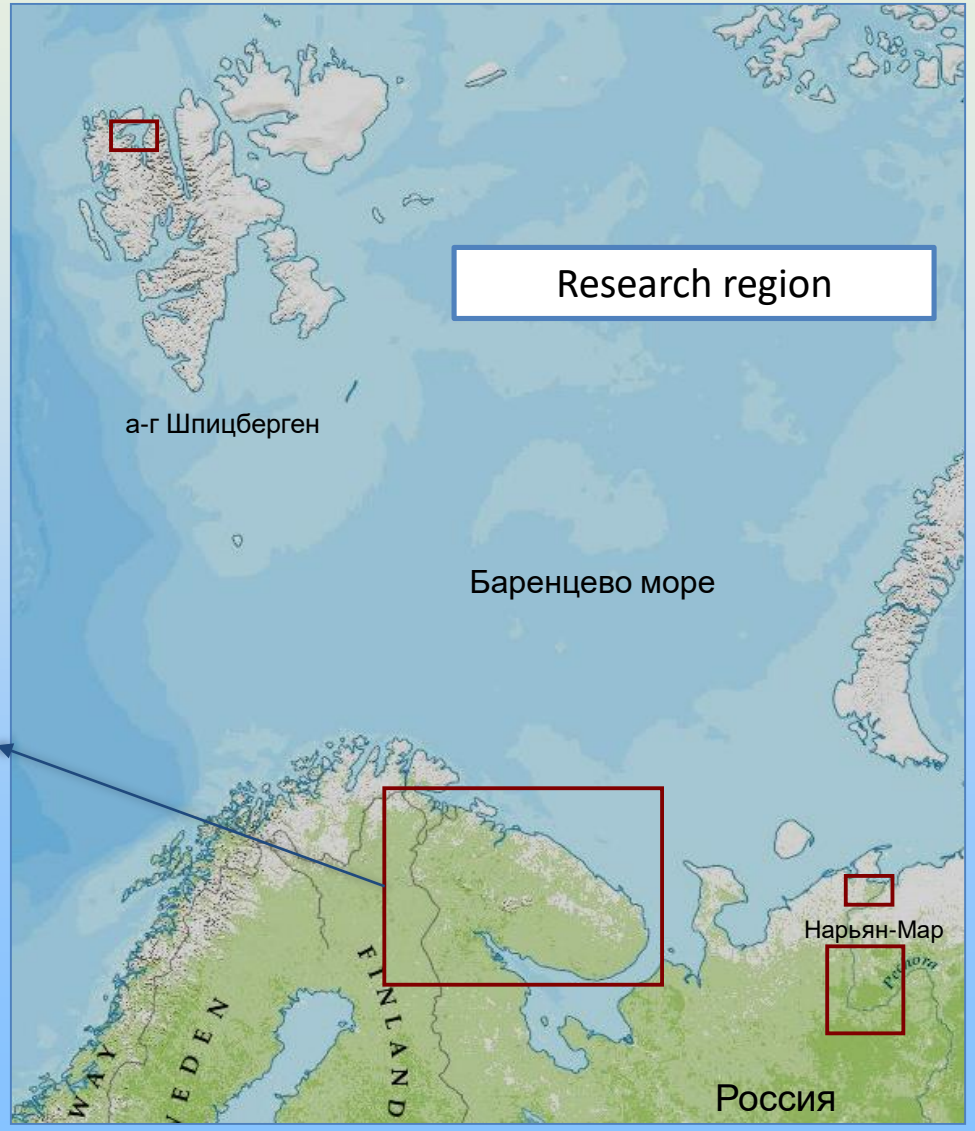
The socio-economic development of the Arctic zone of the Russian Federation provides a powerful mining complex. High industrial impact has aggravated the problems of environmental safety, rational use and quality of fresh water



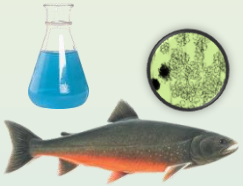
AMAP/NEFCO Hot Spots in the Russian part of the Barents region

Freshwater ecosystems in the Euro-Arctic Barents region research since 1978





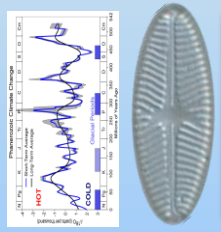
Main research areas of the INEP Aquatic lab



1. dynamics of both abiotic (water, sediments) and biotic (primary producers, invertebrates, fish) components of freshwater ecosystems study;

2. systematization and registration of the long-term integrated monitoring results of the aquatic ecosystems state in the databases;

3. ecological mapping and development of electronic materials based on GIS - technologies for analyzing the spatio-temporal dynamics of key indicators of aquatic ecosystems, as a scientific basis for the rational use of freshwater resources;



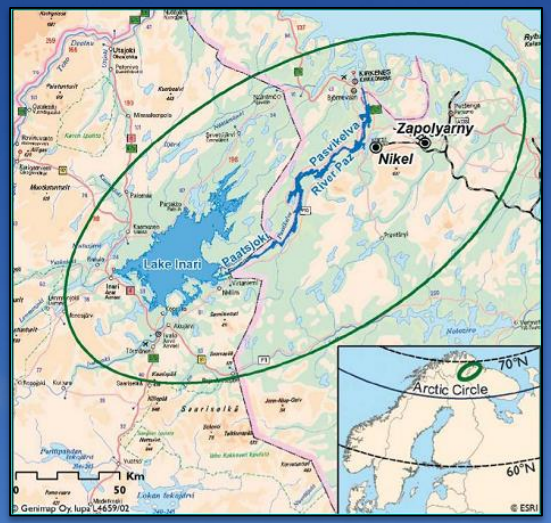
4. paleolimnological reconstructions based on diatom and chemical (layer-by-layer) analysis of lake sediments, assessment of the role of anthropogenic and natural factors in the freshwater ecosystems at the present stage, and reconstruction of the historical dynamics of the natural environment and climate in the Late Pleistocene and Holocene;

WFD Status		
	High	Acceptable WFD status
	Good	
	Moderate	Fails to reach acceptable WFD status
	Poor	
	Bad	

5. development of new and adaptation of existing methods for the water resources quality assessing and the state of Arctic freshwater ecosystems estimation based on various indicators, mitigation and adaptation anthropogenic and climate changes impact on Arctic freshwaters;

6. study of the causes and consequences of new phenomena and processes in Arctic freshwaters (algae and cyanoprokaryotes blooms, biological invasions, expansion of aboriginal species, radical rearrangements of the structure of communities of aquatic organisms)

Trilateral cooperation on environmental challenges in the Joint Border area



International research - sins 1989!

Kolarctic
ENPI CBC | CROSS-BORDER COOPERATION

Bioforsk

Akvaplan niva

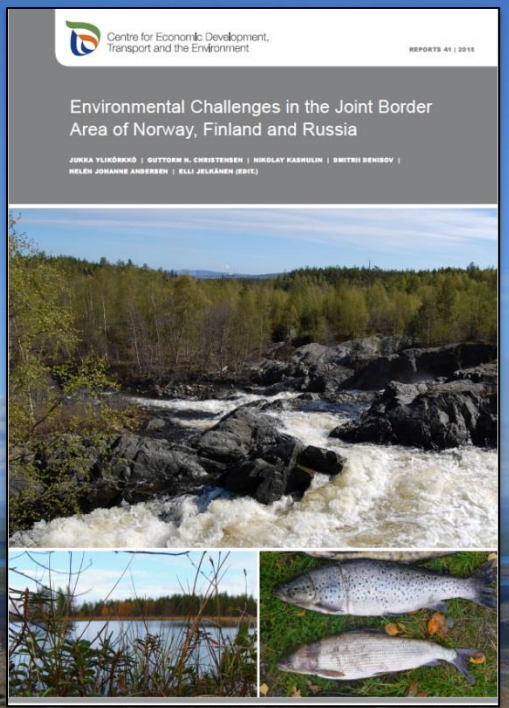
UNIVERSITY OF TROMSØ

Centre for Economic Development, Transport and the Environment

Pasvik Naturreservat
Заповедник Пасвик

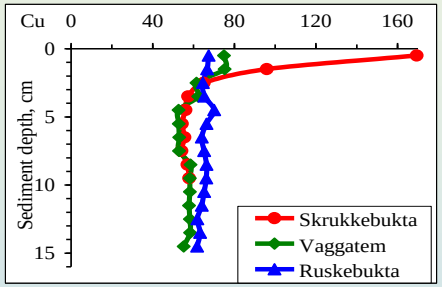
РОСГИДРОМЕТ
ROSHYDROMET

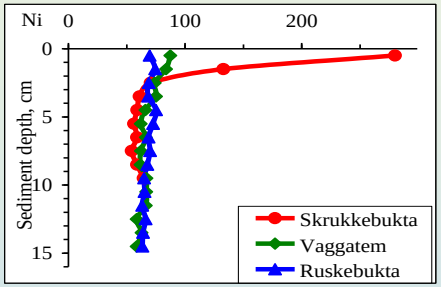
Trilateral cooperation on Environmental Challenges in the Joint Border Area 2012-2014

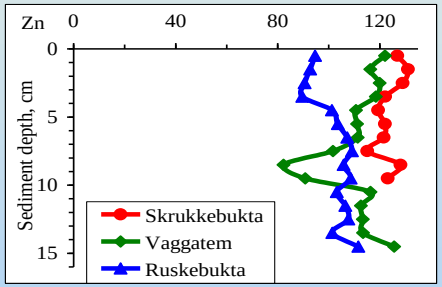


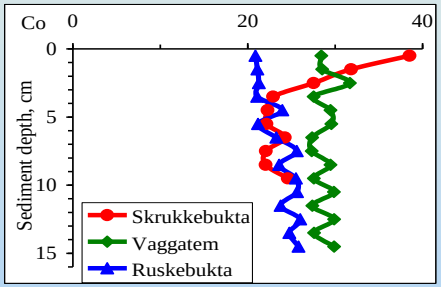
Heavy metals content (µg/g) in the lake sediments of the joint border area

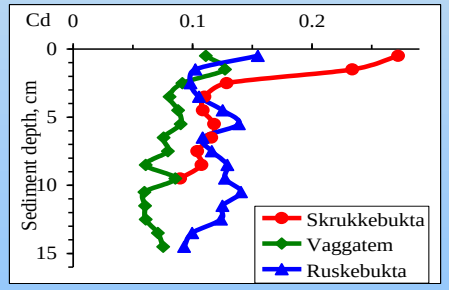
Sediment cores

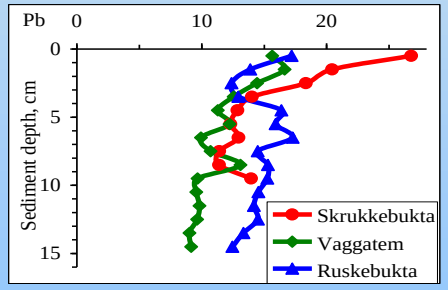


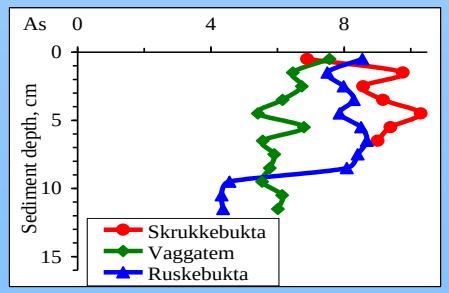


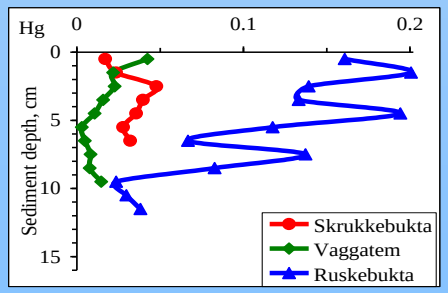




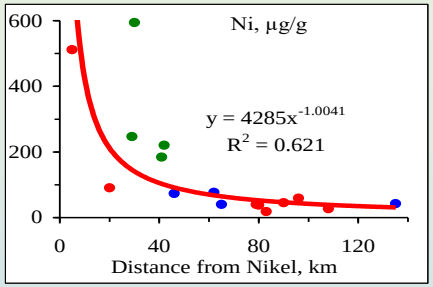


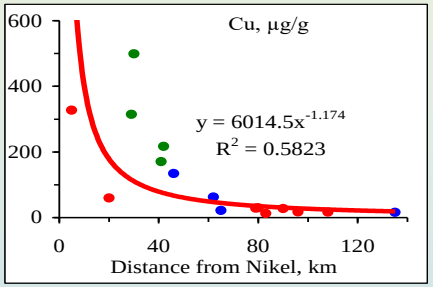


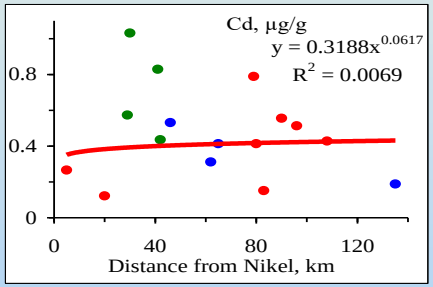


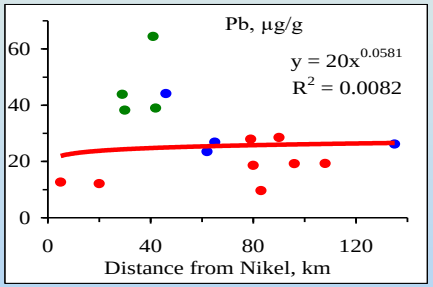


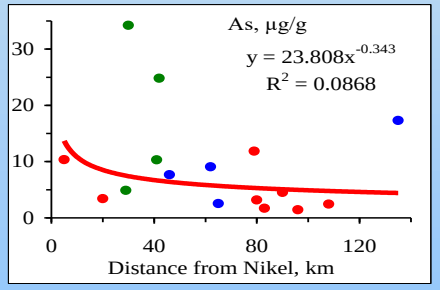
Surface sediments (0-1 cm)

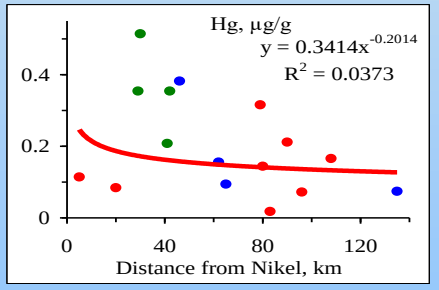


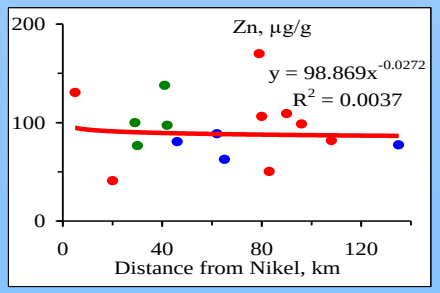


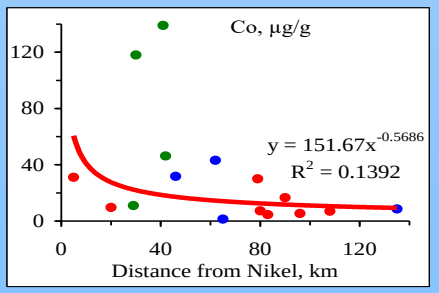




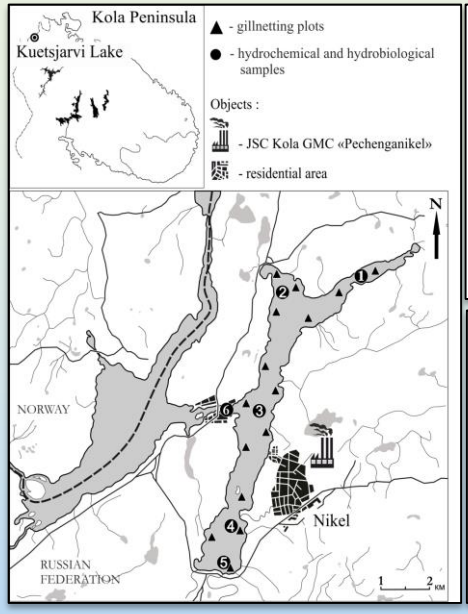


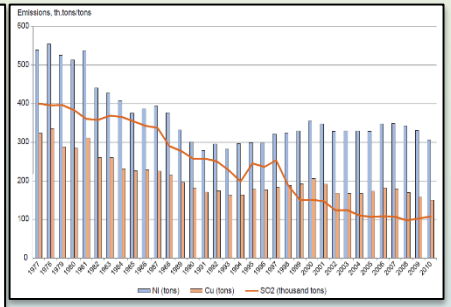


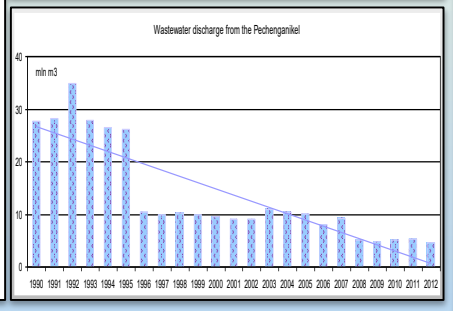


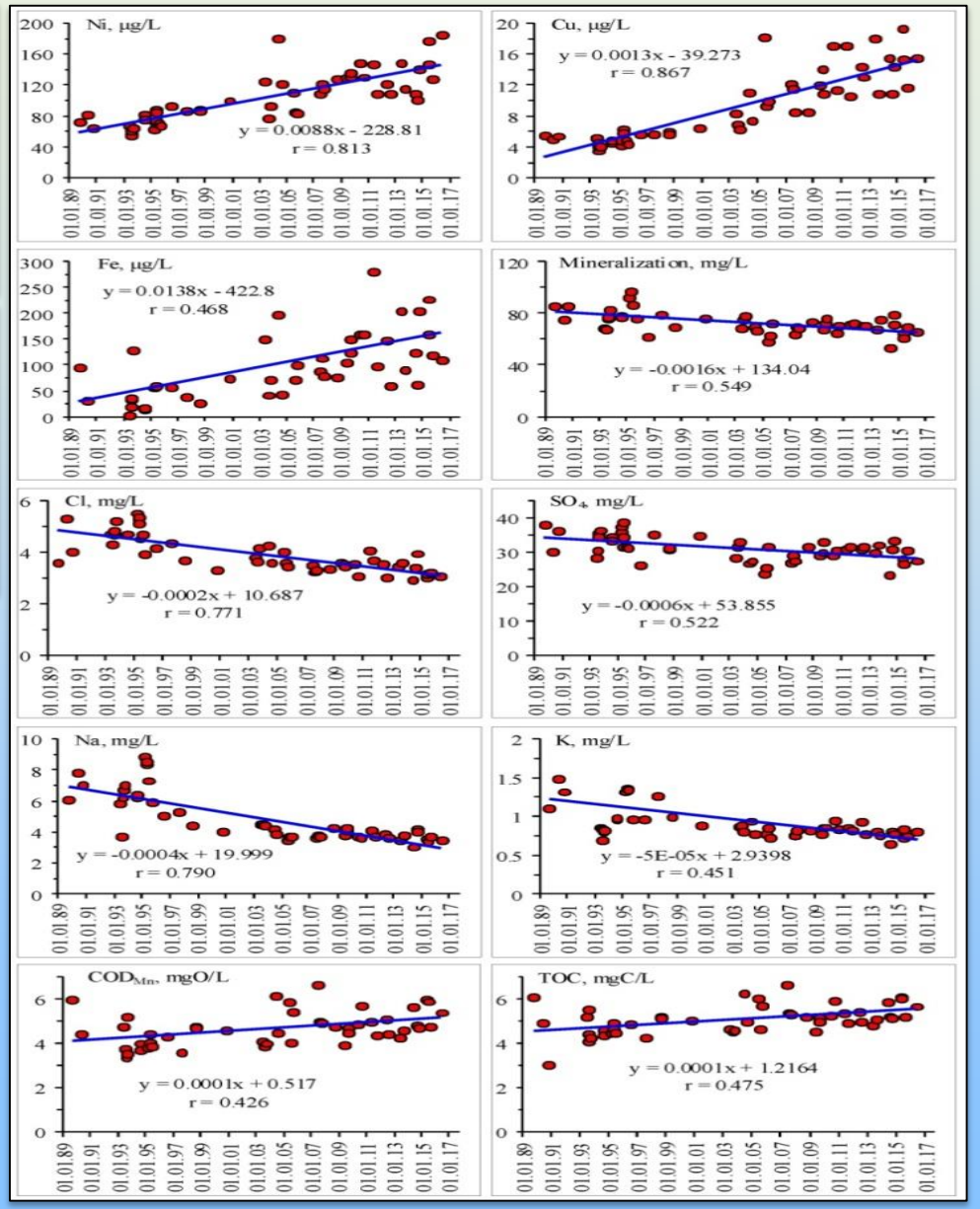


Long-term environmental monitoring in an arctic lake polluted by heavy metals



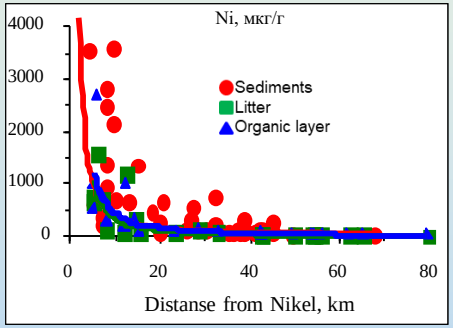


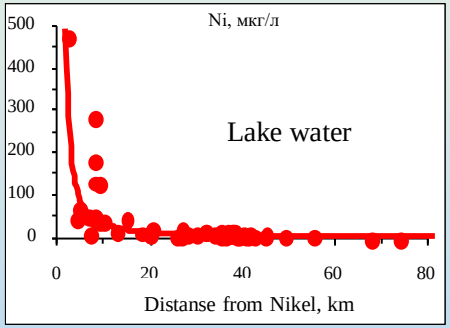


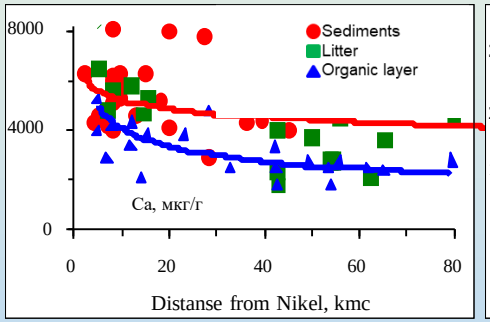


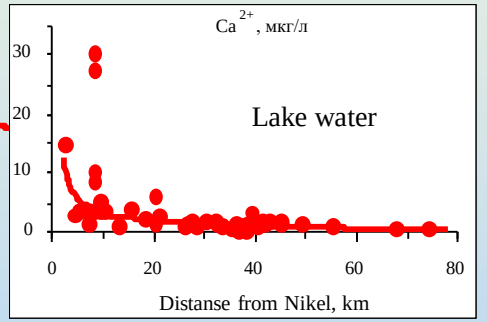
Close of the Nikel smelter late 2020: what could be the environmental consequences for the Lake ecosystem?

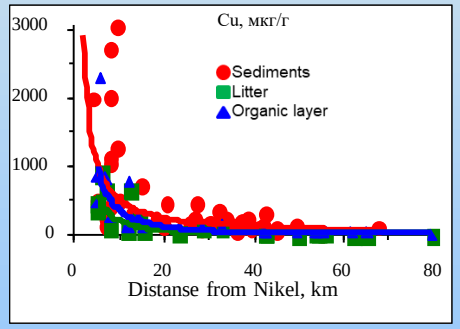
Distribution of the concentrations of the main polluting elements in water (μg / l) and the surface layer (0-1 cm) of bottom sediments of the studied lakes, in the litter and organic layer of the soil (μg / g) with distance from the Pechenganikel smelter.

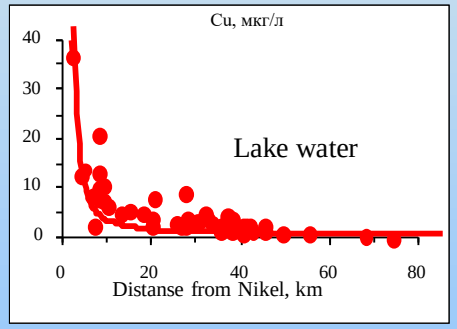


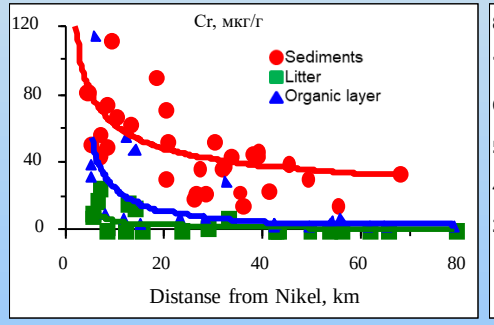


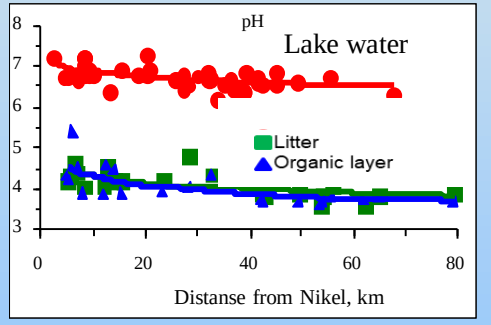


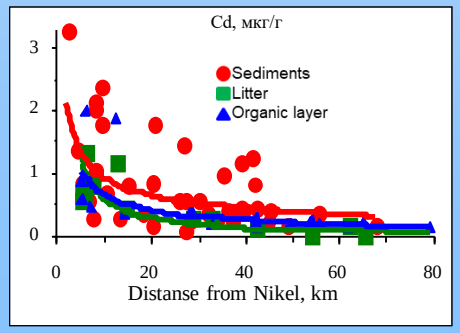


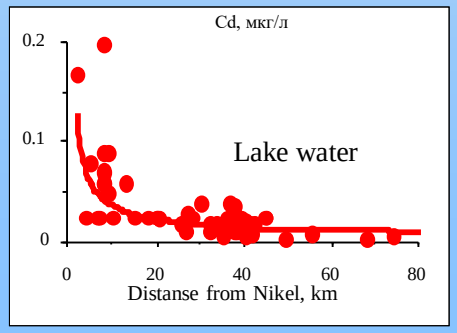










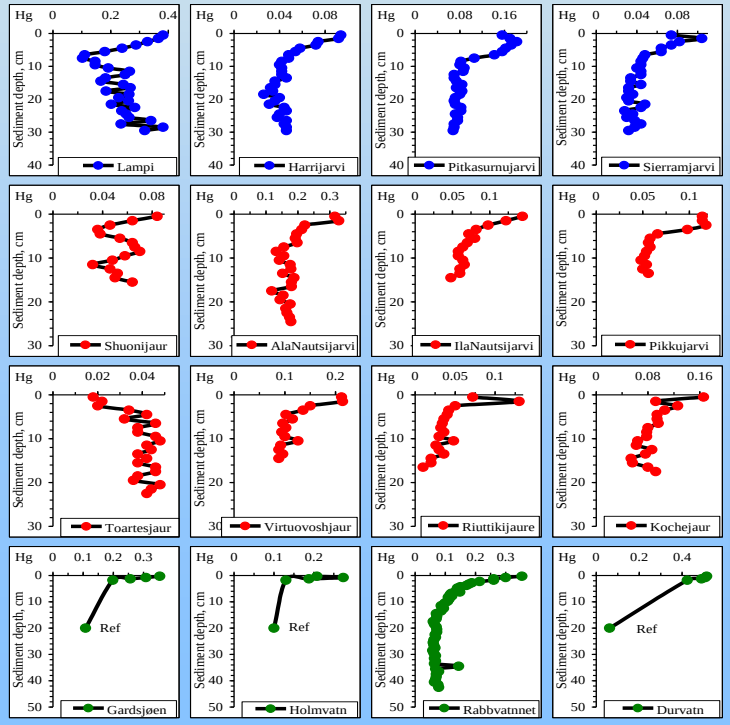


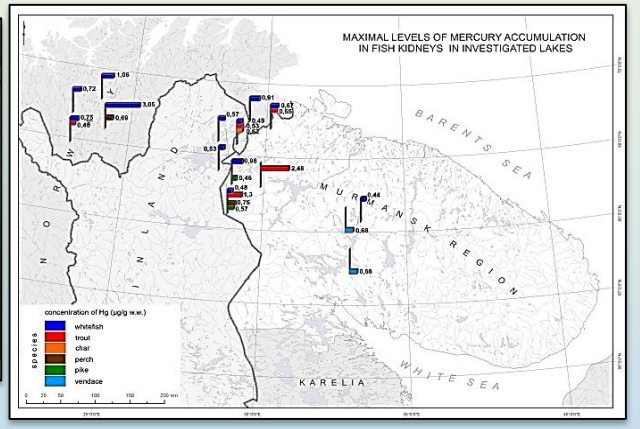
The smelter emissions impact resulted in an increase in the concentrations of HMs in aquatic and terrestrial ecosystems near the plant, as well as in an increase in the content of alkali (Na, K) and alkaline earth (Ca, Mg, Sr) metals.

Geochemical conditions, secondary water pollution from soil?

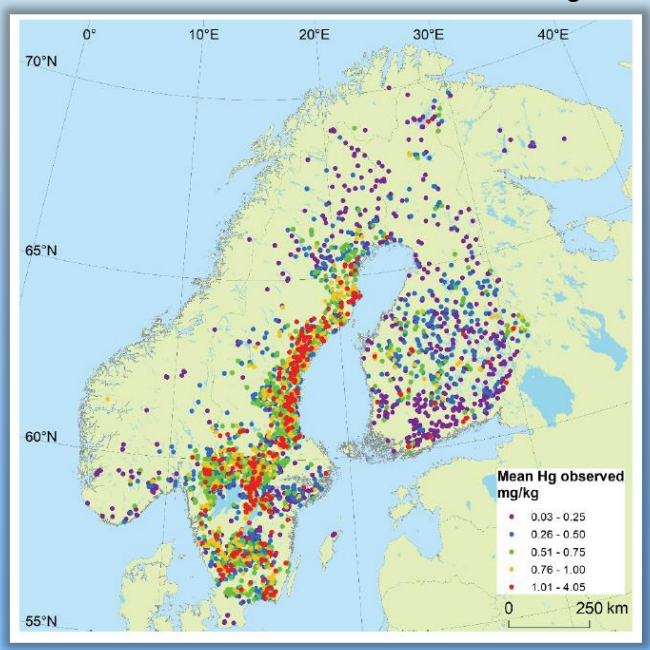
Investigation of mercury (Hg) pollution particularities of North Fennoscandia under the frame of border area cooperation

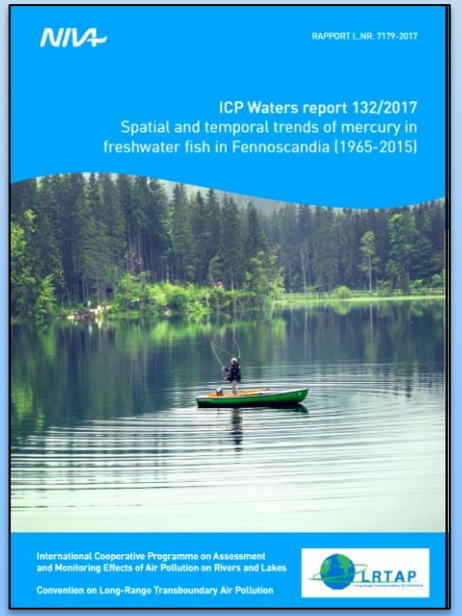
Hg accumulation in water sediments of border area lakes





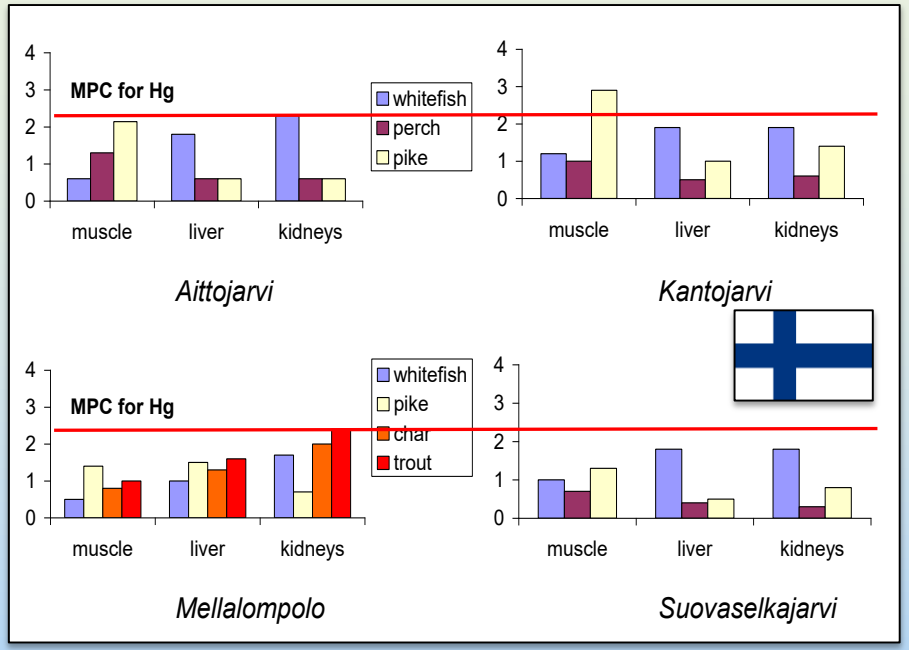
Hg accumulation in fish tissues of border area lakes (maximal levels)

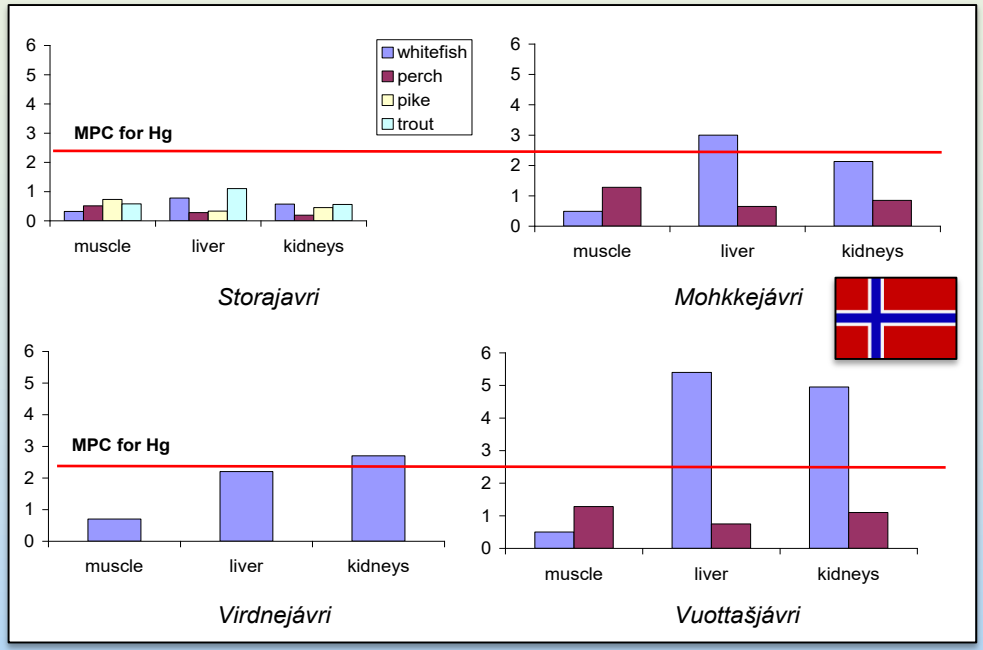


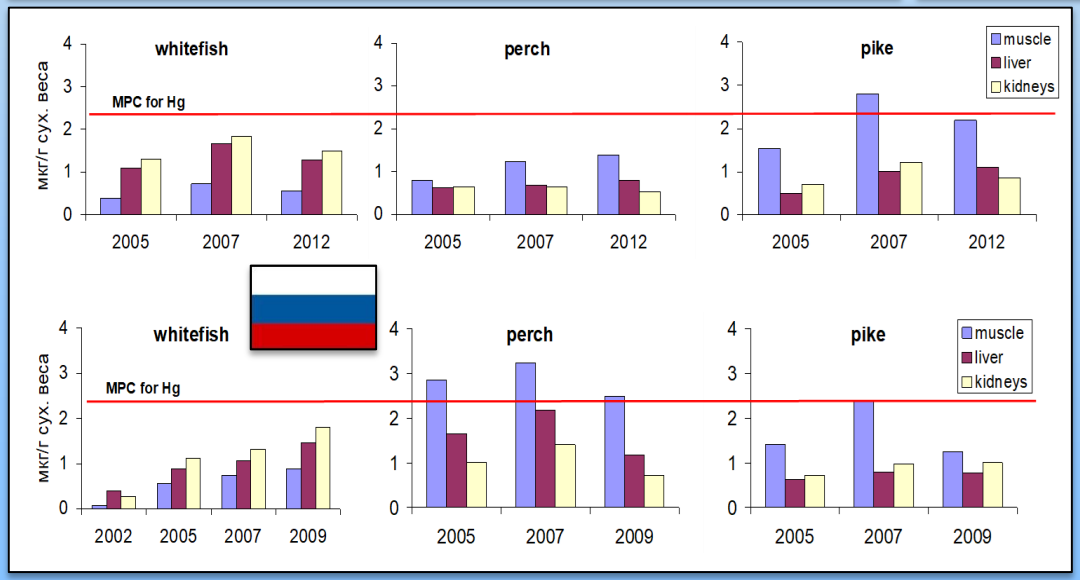


Average values of Hg concentration if fishes of North Fennoscandia (data 1965-2015) : charr, trout, perch, pike and roach)* ICP Waters report 132/2017 NIVA *(Braaten et al., 2017)

Mercury (Hg) content in fish organs (µg / g dry weight) of Northern Fennoscandia



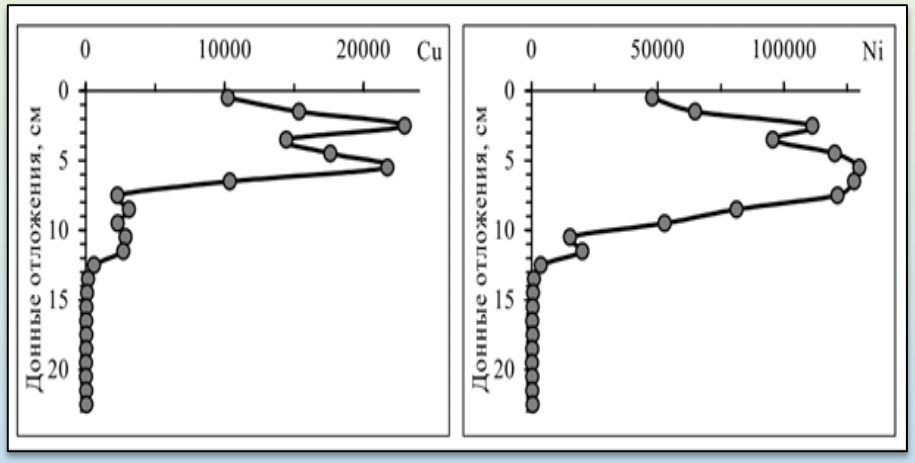




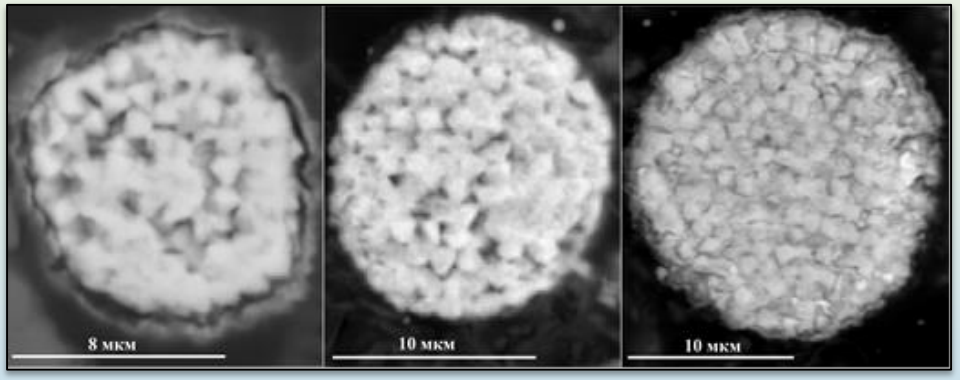
The intensity and accumulation level of mercury in fish organisms is determined by the processes of global pollution of the atmosphere and, to a lesser extent, depend on the intensity of pressure on lake ecosystems from local sources of pollution.

Significant amounts of mercury accumulation have been recorded in almost all the considered fish species in water bodies.

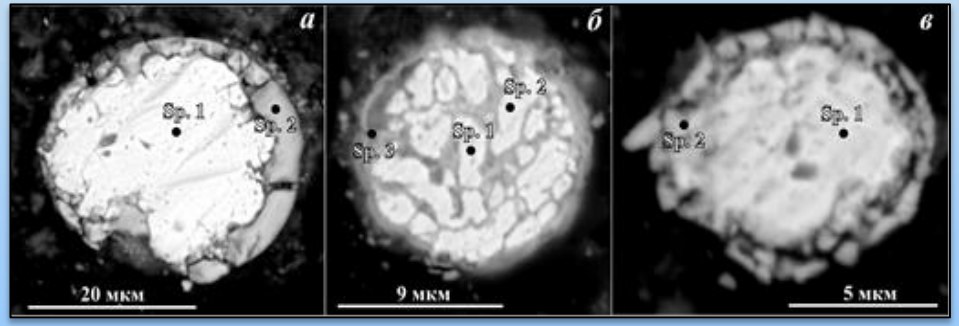
Study of the sediments mineral composition of lakes in the zone of high industrial impact



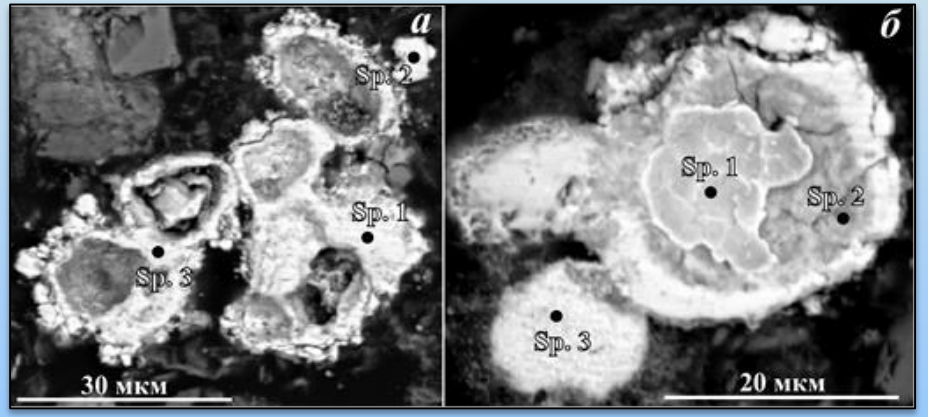
The vertical distribution of Cu and Ni in the sediments of Lake Nyudyavr (in μg / g dry weight)



Technogenic particles from the sediments of Lake Nyudyavr (0-1 cm)



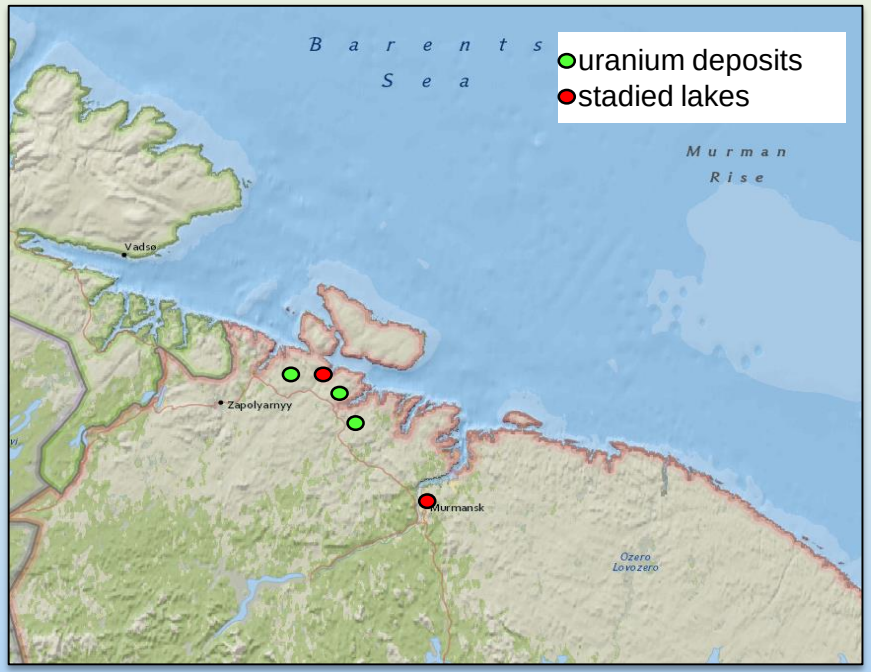
Pyrite globules from bottom sediments of Lake Nyudyavr (12-13 cm)

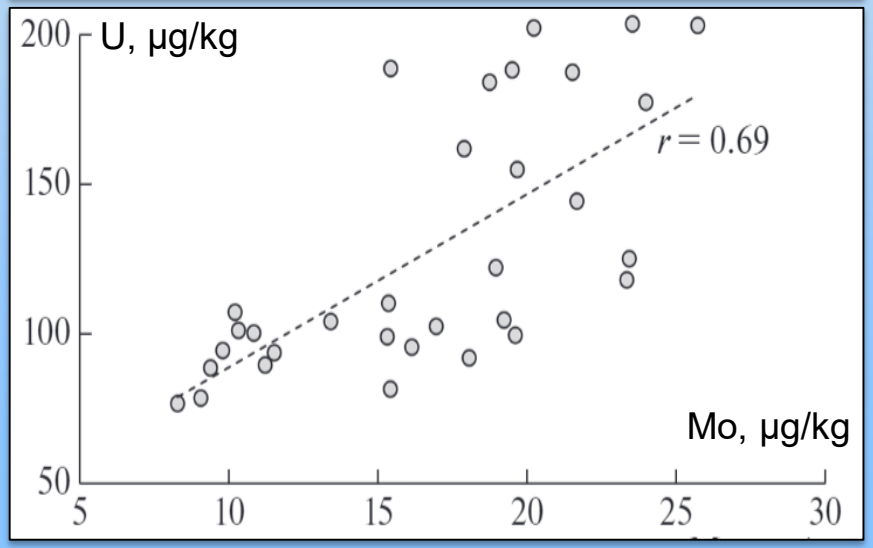


Technogenic particles from the sediments of Lake Nyudyavr (layer 6-7 cm)

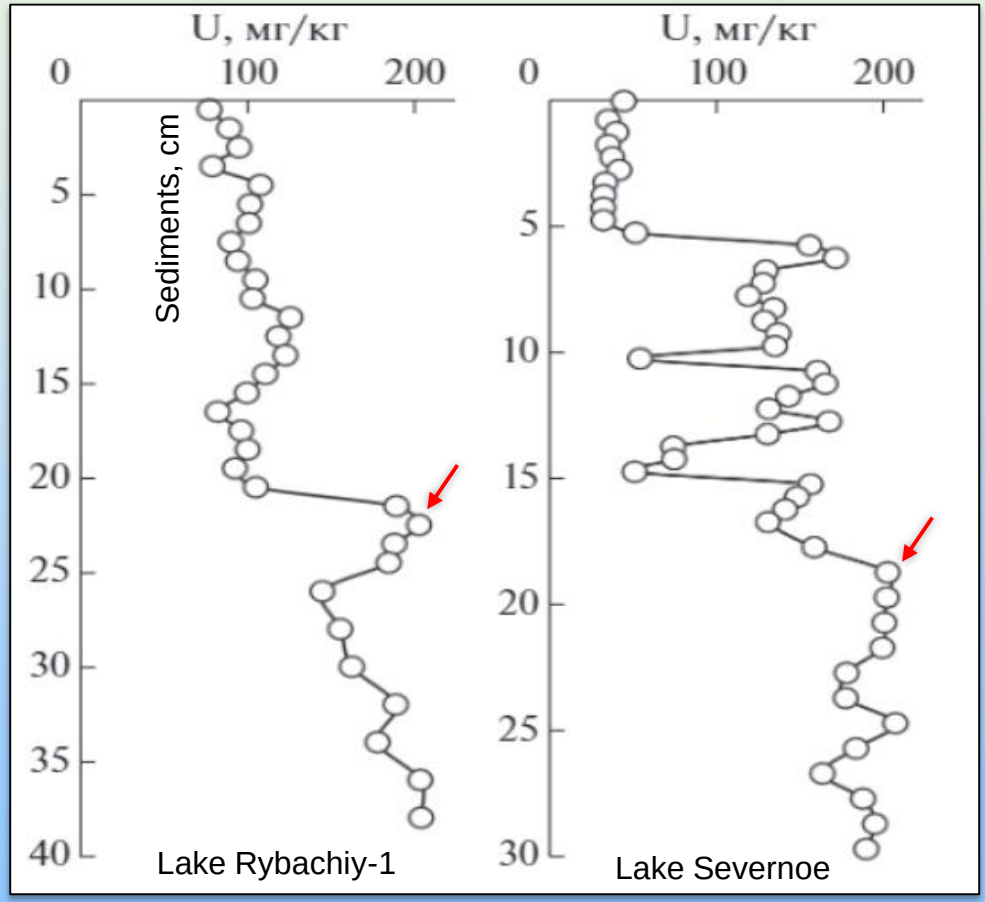
For the first time for the Euro-Arctic zone of the Russian Federation, the study of the mineralogical composition of the lake sediments that receive wastewater from mining enterprises was carried out using a scanning electron microscope. In the studied sediments, two mineral forms of heavy metals (Ni, Cu Co, Cr, Fe) were found - in minerals of technogenic origin and in natural authigenic minerals (mainly pyrite) as impurities. In the first form, the content of heavy metals is many times higher than in the second.

Uranium anomalies in modern lake sediments in the northern part of the Euro-Arctic





Vertical U concentrations distribution in sediments of the studied lakes

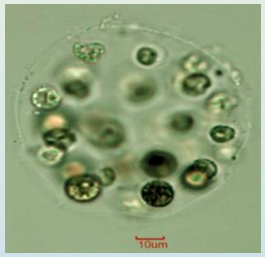
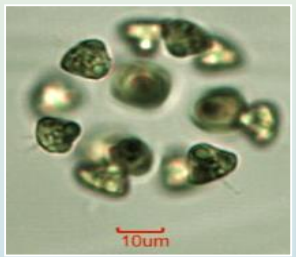
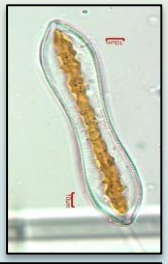


Extreme high uranium concentrations: 100 times higher than the Clarke number!

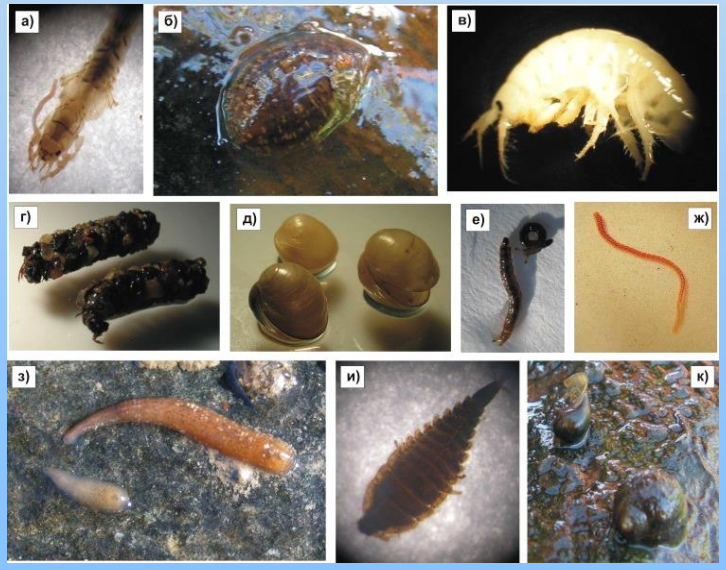
Arctic freshwater biodiversity research

Species inventory

Phyto-, zooplankton, higher vegetation


Benthic invertebrates



Bioindication of the water environment

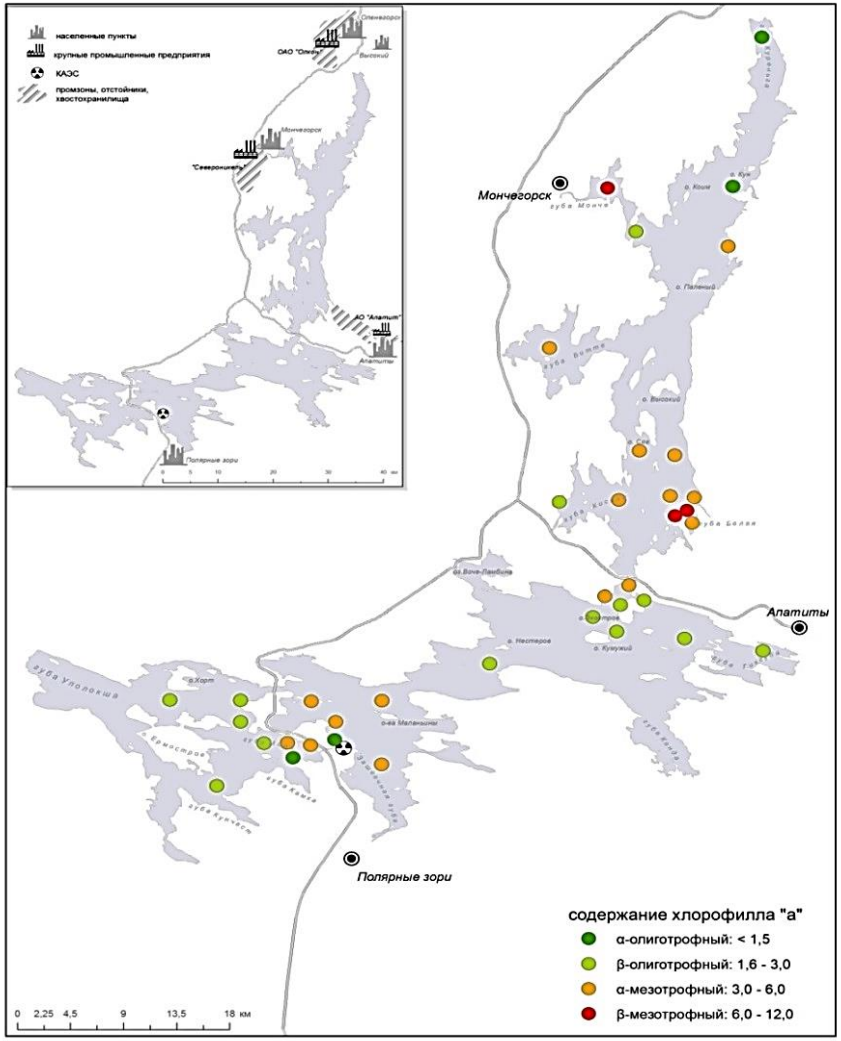
Ecological status assessment of the River Paz (Patsojoki) lakes using the Finnish and Norwegian status assessment methods.

Data	RI		TT50SO		PMA		Total (FI)		TIc	
	EQR	Status	EQR	Status	EQR	Status	EQR	Status	EQR	Status
The Pasvik River (all sites)	0.72	Good	0.62	Good	0.66	Good	0.67	Good	0.90	Good
Hestefoss (new)	0.60	Good	0.70	Good	0.12	Bad	0.47	Moderate	1.11	High
Fjørevatnet (1)	0.65	Good	0.47	Moderate	0.06	Bad	0.39	Poor	0.88	Goog
Vaggatem (2,3,4,5,6)	1.13	High	0.87	High	0.55	Moderate	0.85	High	0.89	Good
Langvatn (7,8)	1.00	High	0.70	Good	0.75	Good	0.82	High	0.98	High
Fuglebukta (9)	1.13	High	1.03	High	0.63	Good	0.93	High	1.00	High
Svanvatn (14, 15, 16)	0.74	Good	0.70	Good	0.61	Good	0.68	Good	0.87	Good
Björnvatn (18, 19)	1.13	High	0.70	Good	0.46	Moderate	0.76	Good	0.91	Good

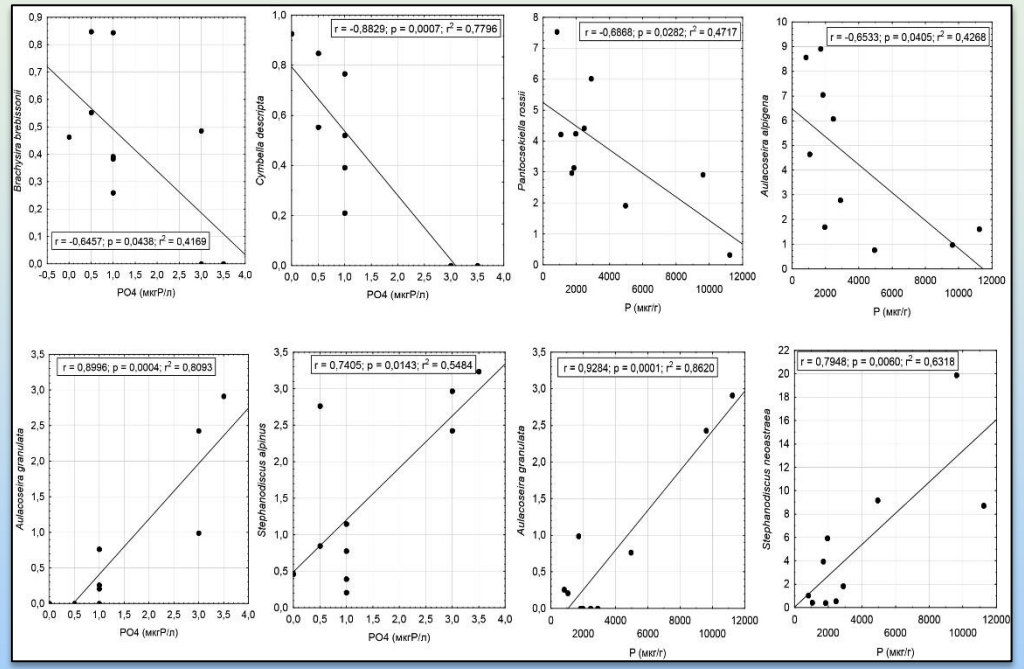
Fish pathology analysis

Bioindication of environmental quality based on algal communities

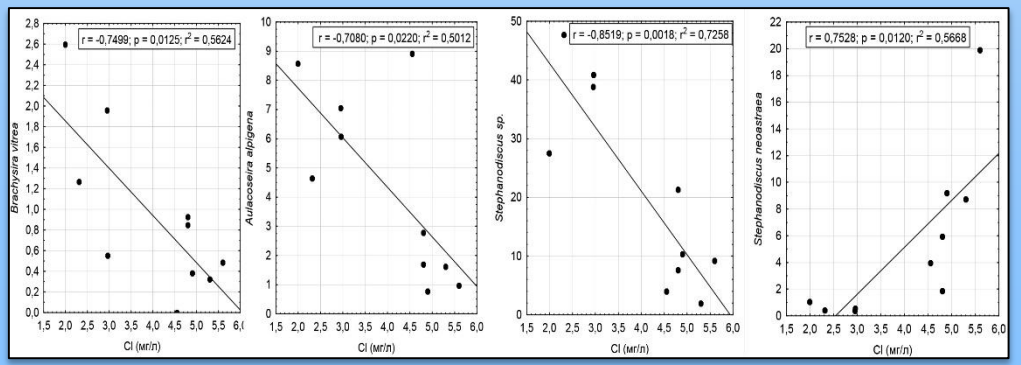
Spatial distribution of the content of chlorophyll "a" (mg / m³) in the plankton of subarctic Lake Imandra



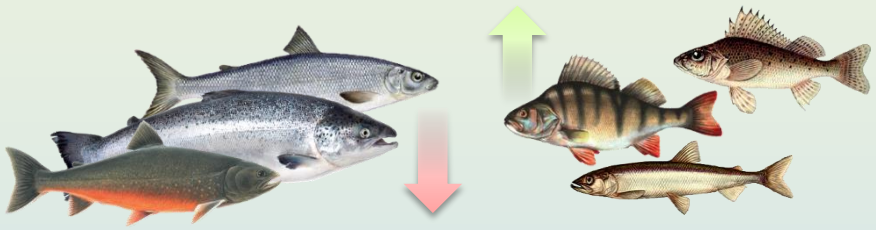
Dependence of the relative abundance (%) of some indicator species of diatoms on the phosphorus content in the surface layers of bottom sediments of Lake Imandra and on the average concentration of phosphates (2011-2014) in water



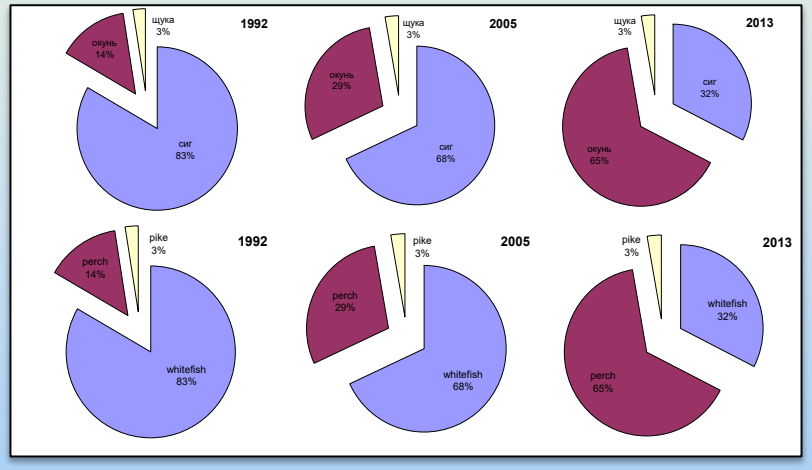
Dependence of the relative abundance (%) of some indicator species of diatoms in the surface layers of bottom sediments of Lake Imandra and on the average concentration of chlorides (2011-2014) in water.

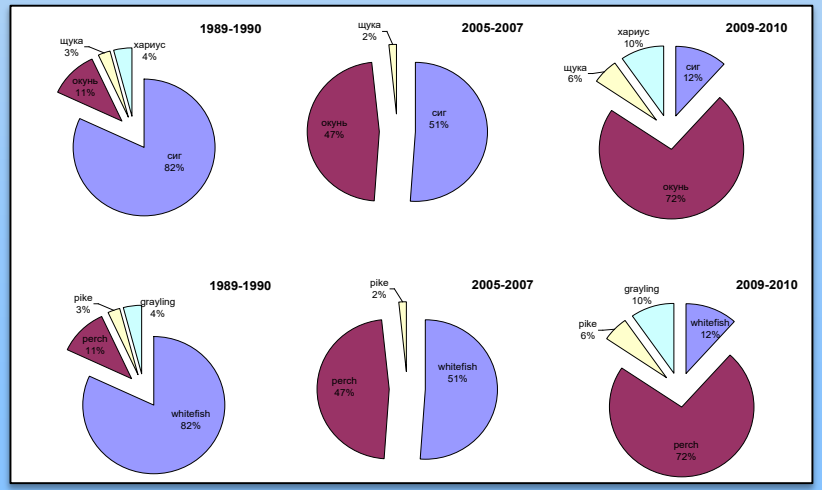


Decrease in commercially valuable fish species populations in the lakes of the Euro-Arctic: the long-term series of observations

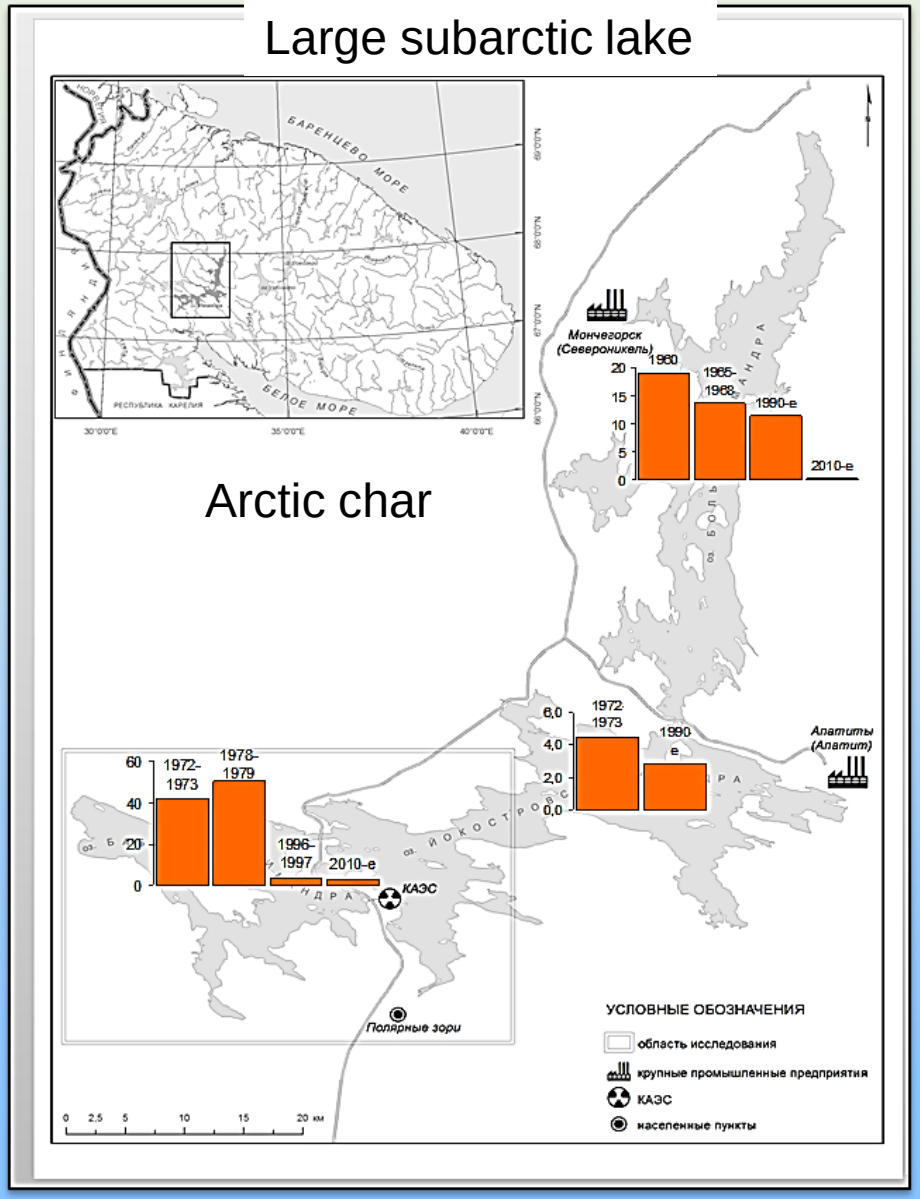


Small lakes





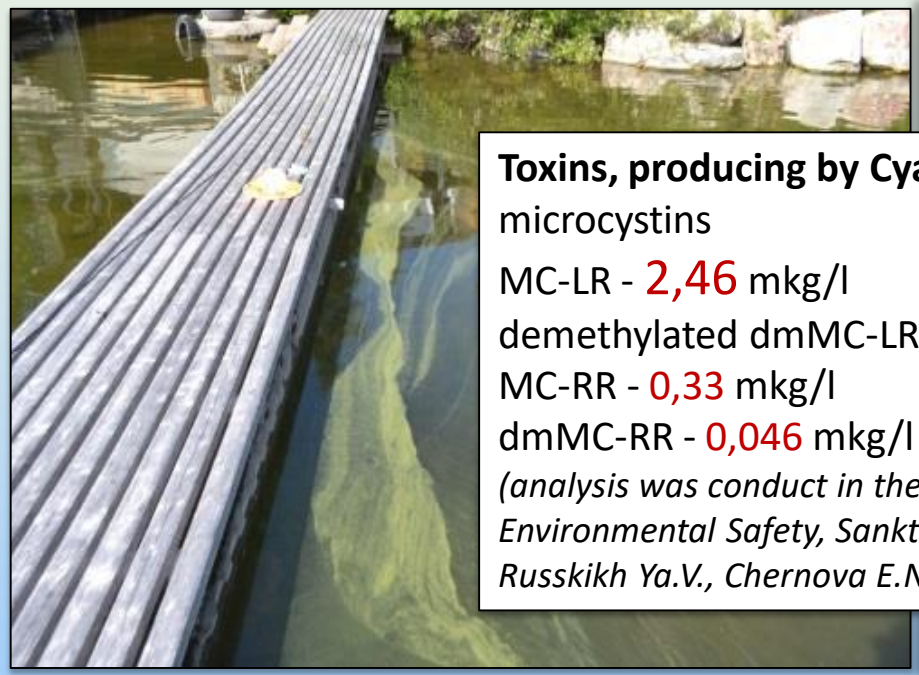
Large subarctic lake

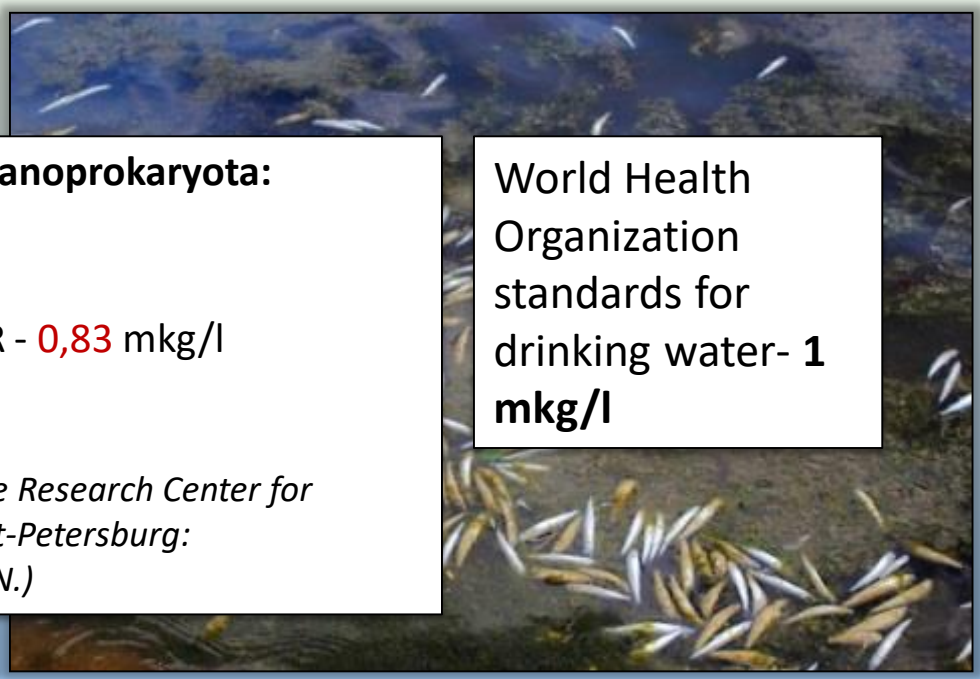


Arctic char

Harmful algal blooms (HABs) of the Arctic lakes: new environmental challenge

In lakes: cyanobacteria bloom spots





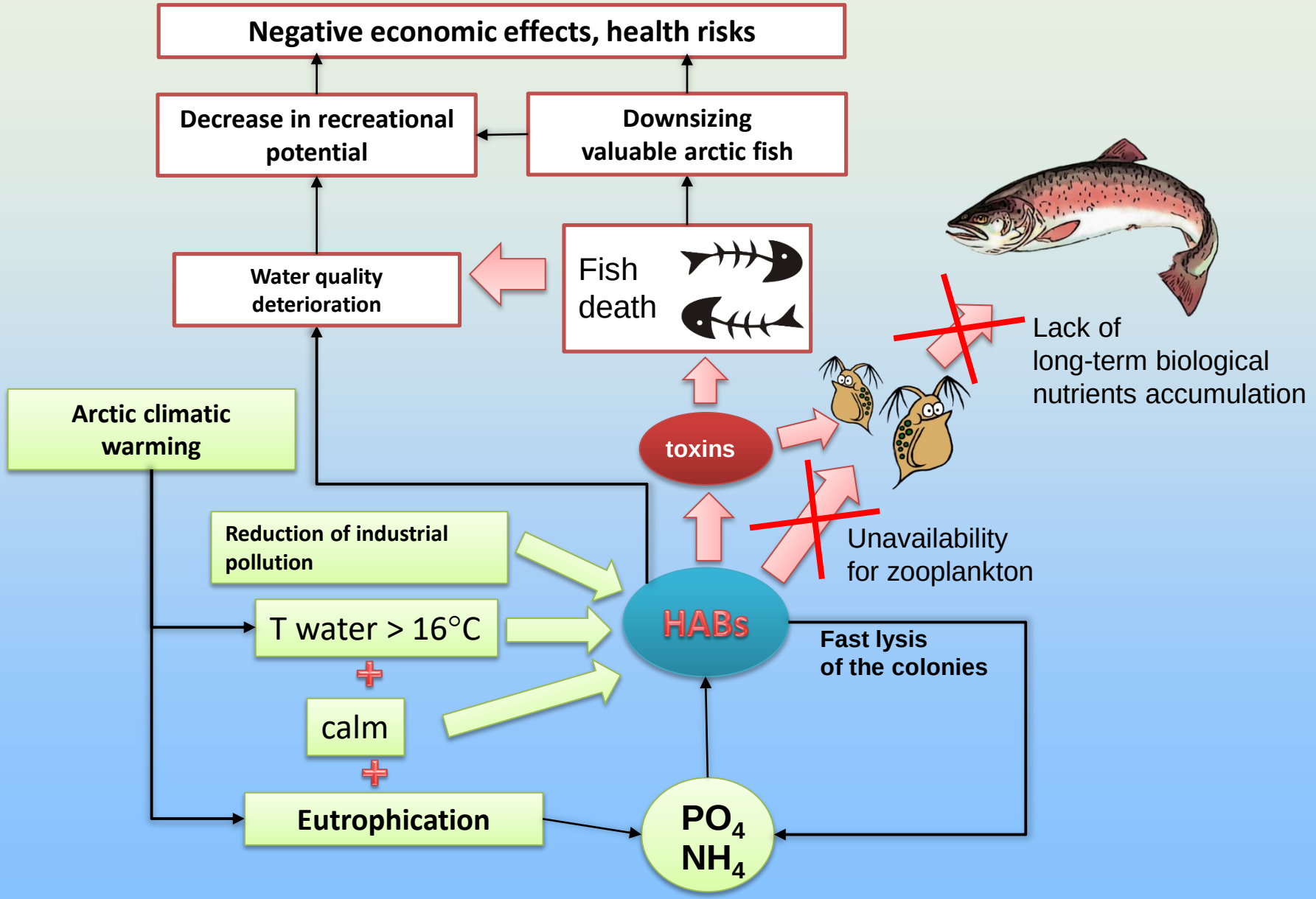
Toxins, producing by Cyanoprokaryota:
microcystins
MC-LR - 2,46 mkg/l
demethylated dmMC-LR - 0,83 mkg/l
MC-RR - 0,33 mkg/l
dmMC-RR - 0,046 mkg/l
(analysis was conduct in the Research Center for Environmental Safety, Sankt-Petersburg: Russkikh Ya.V., Chernova E.N.)

World Health Organization standards for drinking water- **1 mkg/l**

Fish death during and after cyano-HABs including a lot of juveniles

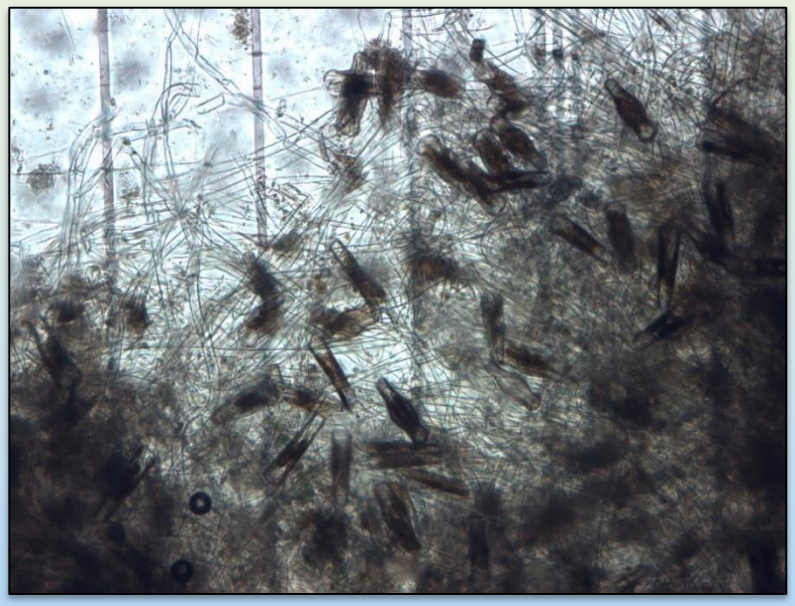
Photo by N.Kashulin

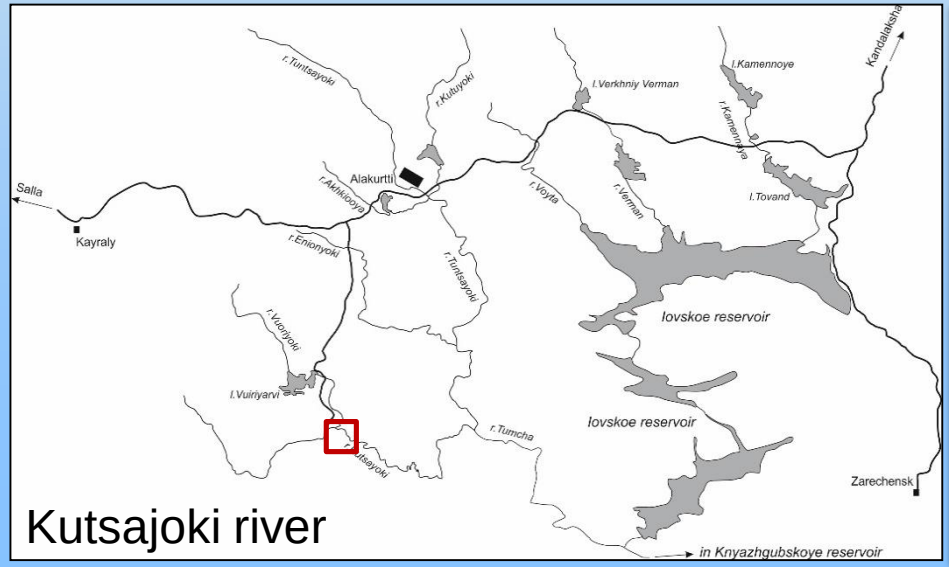
HABs reasons in arctic lakes and the consequences



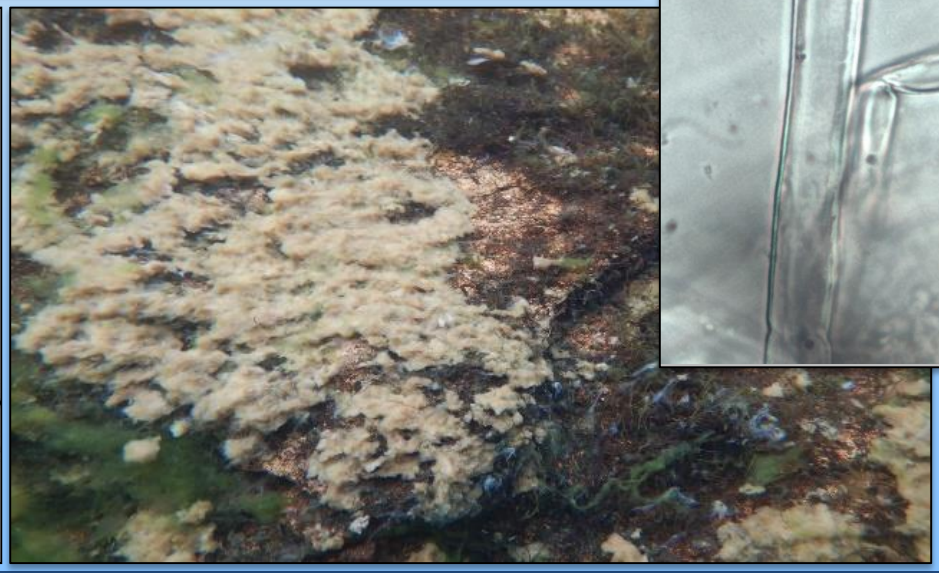
Harmful algal blooms (HABs) of the Arctic lakes: new environmental challenges

In rivers: «Didymo»: diatom blooms





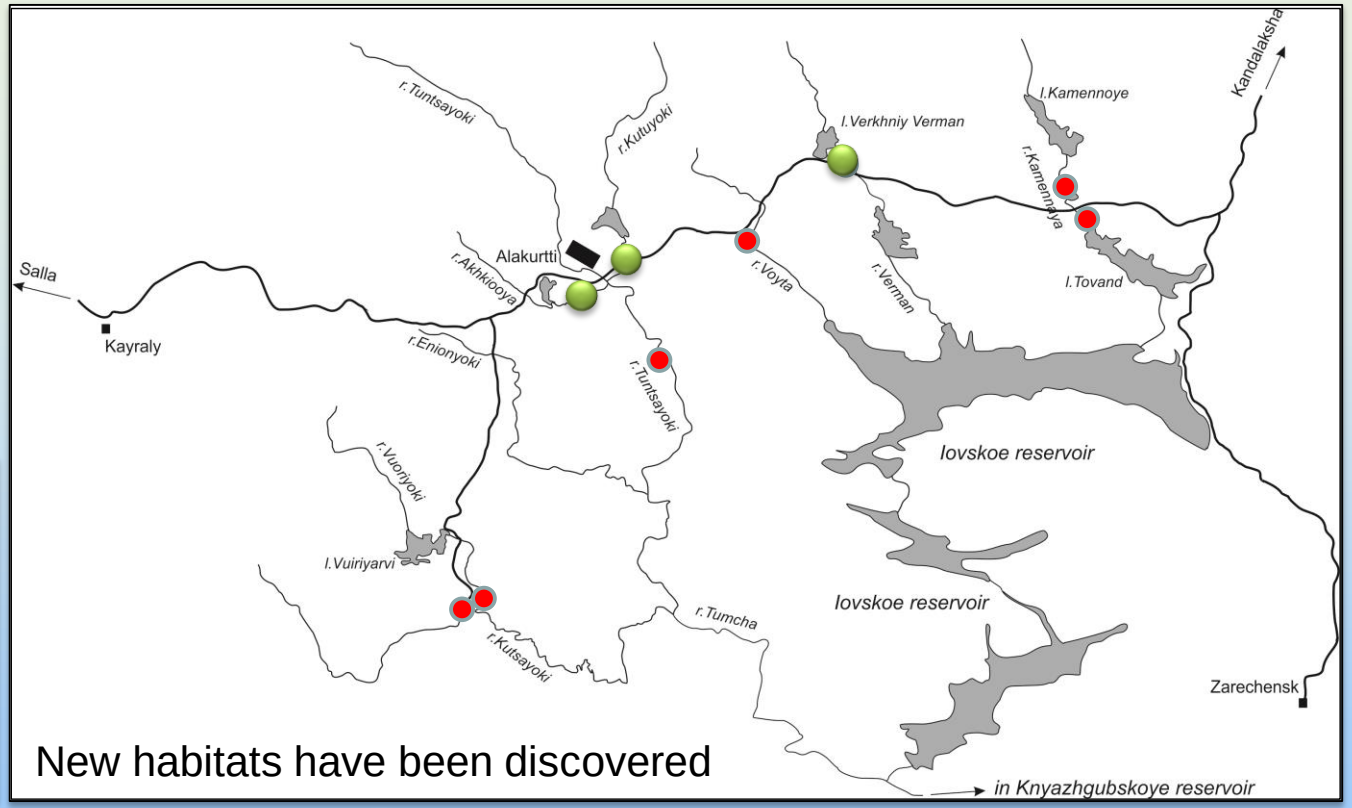
Kutsajoki river



Harmful algal blooms (HABs) of the Arctic lakes: new environmental challenges

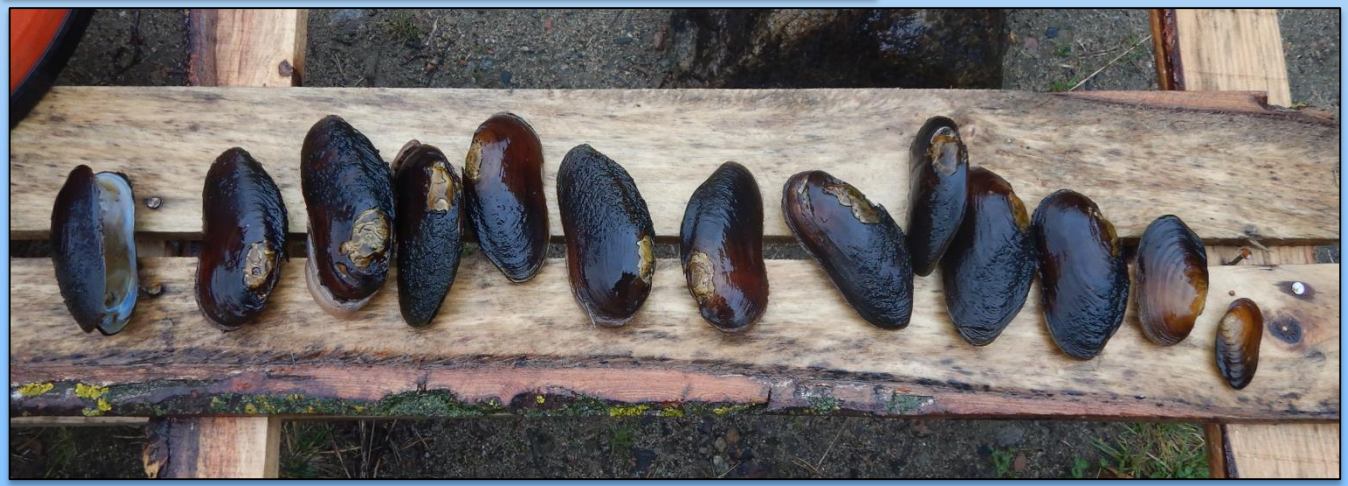
In rivers: «Didymo»: diatom blooms

The freshwater pearl mussel (*Margaritifera margaritifera*) research



The freshwater pearl mussel (*Margaritifera margaritifera*) research

The freshwater pearl mussel (*Margaritifera margaritifera*) research

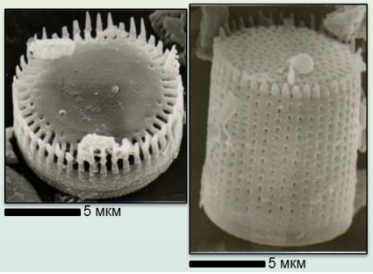


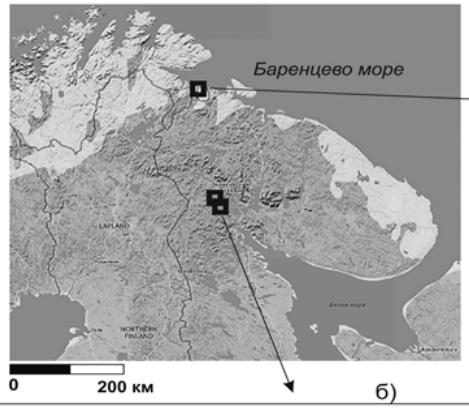
The freshwater pearl mussel (*Margaritifera margaritifera*) research

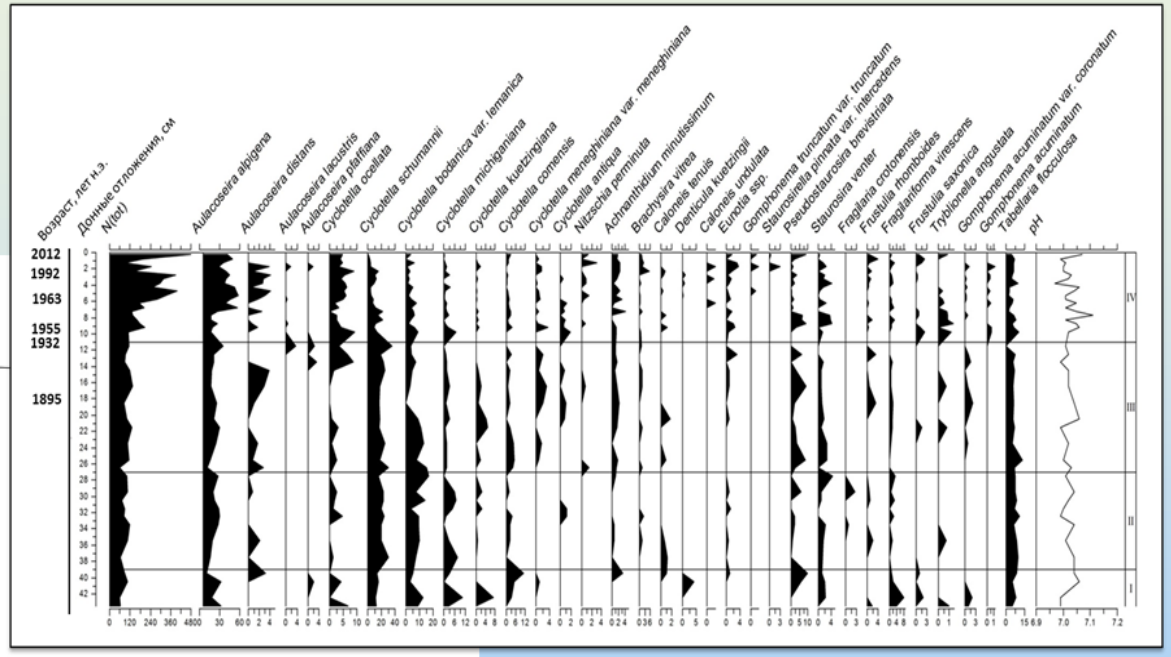
Участок	Площадь, м^2	Количество моллюсков	Минимальная длина, мм
Ahkiooya 2	150	3	-
Ahkiooya 3	25	55	82
Ahkiooya 4	36	19	-
Ahkiooya 5	100	71	-
Kutujoki 1	90	41	76
Kutujoki	80	32	68
Verman	80	89	47

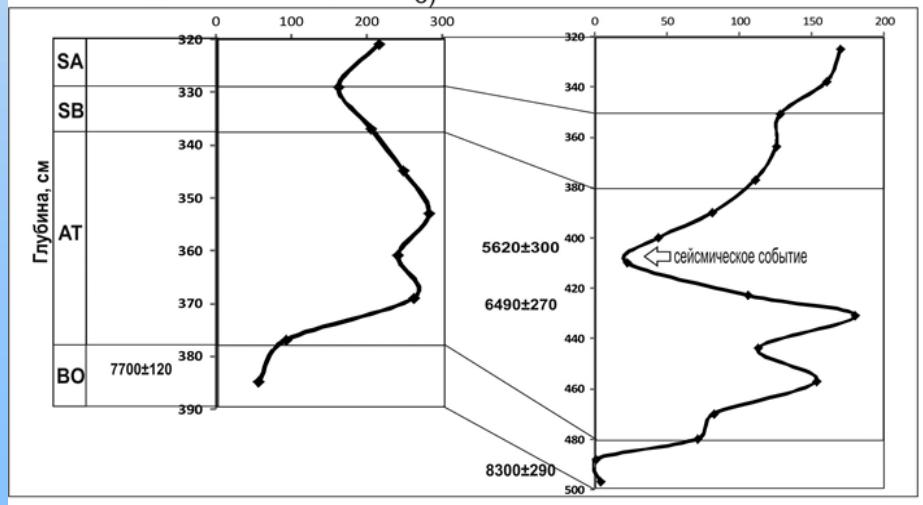
Research of the fish fauna associated with pearl mussel

Paleolimnological approach: diatom-infer environmental historical reconstructions









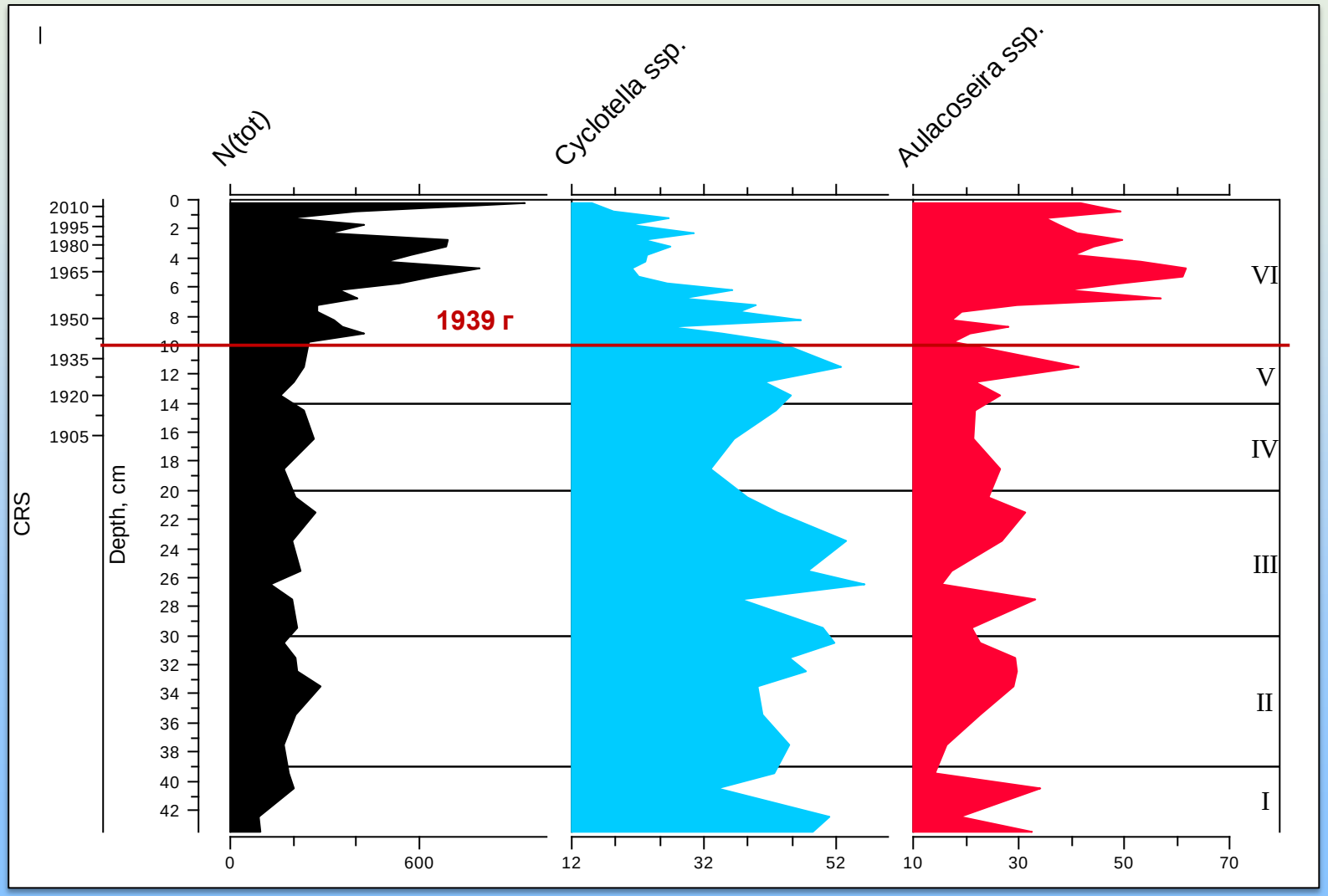
New data about environment and climate transformation of the of the Euro-Arctic region in the Holocene were obtained.

An increase in the productivity of some water bodies at the present stage to the level characteristic of the Atlantic climatic optimum was noted. A sharp increase in the intensity of production processes in lakes in the 20th century was revealed as a result of the Arctic climate modern warming.

The prospects of using diatom analysis for the reconstruction of paleoseismic events in the historical past are shown.

Change in the ratio of relative abundance of *Cyclotella s.l.* and *Aulacoseira spp.* in sediments of Rabbwatn Lake (Nothern Norway) in comparison with the total abundance of diatoms

The result of climatic warming associated with aerotechnogenic pollution



New criteria for water ecosystems pollution assessing for the Euro-arctic Barents region

It is necessary to take into account the current state and regional features of water bodies. It is proposed to take HM concentrations in conditionally background water bodies remote from large industrial sources (eastern part of the Murmansk region)

Criteria for assessing the degree of freshwater pollution of the Murmansk region by heavy metals

Pollutant	water							pollution			
	M	X	min	max	s_n	M+s_n	Φ_n^i	High	Good	Mode-rate	Bad
Cu	0.70	1.37	0.00	22.00	2.49	3.19	3.0	<3	3-15	15-30	>30
Ni	0.6	1.0	0.0	9.0	1.2	1.77	2.0	<2	2-10	10-20	>20
Zn	1.7	2.6	0.0	24.0	3.1	4.82	5.0	<5	5-25	25-50	>50
Co	0.2	0.3	0.0	8.0	0.8	1.00	1.0	<1	1-5	5-10	>10
Cd	0.05	0.10	0.00	0.99	0.16	0.21	0.20	<0.2	0.2-1	1-2	>2
Pb	0.30	0.34	0.00	1.40	0.24	0.54	0.50	<0.5	0.5-2.5	2.5-5	>5
As	0.010	0.070	0.010	0.250	0.096	0.106	0.100	<0.1	0.1-0.5	0.5-1	>1

Median (M), average (X), minimum (min) and maximum (max) concentrations of elements (µg / L), standard deviations (S_n) and background pre-industrial values (Φ_n^i) in the water of 400 lakes in the eastern part of the Murmansk region.

New criteria for water ecosystems pollution assessing for the Euro-arctic Barents region

Criteria for assessing the degree of sediments pollution of freshwater lakes of the Murmansk region with heavy metals.

Pollutant	sediments						pollution			
	X	min	max	s_n	$X+s_n$	C_n^i	High	Good	Moderate	Bad
Cu	27	2	94	22	49	50	<50	50-250	250-500	>500
Ni	27	4	214	27	54	55	<55	55-275	275-550	>550
Zn	96	16	250	48	144	150	<150	150-750	750-1500	>1500
Co	13	2	69	11	23	25	<25	25-125	125-250	>250
Cd	0.23	0.02	2.10	0.26	0.48	0.50	<0.5	0.5-2.5	2.5-5	>5
Pb	4.4	0.5	15.0	3.4	7.8	8.0	<8	8-40	40-80	>80
As	3.2	0.5	13.7	3.2	6.4	7.0	<7	7-35	35-70	>70
Hg	0.035	0.003	0.112	0.021	0.056	0.060	<0.06	0.06-0.3	0.3-0.6	>0.6

Average (X) background minimum (min) and maximum (max) concentrations of elements (µg / g dry weight), standard deviations (S_n) and preindustrial values (C_n^i) in sediments of 80 lakes in the Murmansk region

Conclusion

1. The processes of freshwater ecosystems degradation the Euro-Arctic Barents region as a result of long-term exploitation of natural water resources have now led to a shortage of high-quality fresh water and valuable hydrobiological resources, which can become one of the most important factors of socio-economic and political instability.

2. The phenomena of algae and cyanobacteria HABs, previously characteristic of temperate and southern latitudes, are now regularly manifested in Arctic freshwaters, primarily subject to anthropogenic eutrophication and climatic warming. There are invasions of thermophilic aquatic organisms into Arctic water bodies, expansion of native and invading species. One of the most serious problems is the rapid decline in the number of valuable commercial fish (whitefish, salmonids) against the background of an increase in the number of low-value short-cycle species.

3. The problem of protecting inland water bodies is complicated by the lack of a regionally oriented system for the regulation of anthropogenic load, insufficient knowledge of aquatic ecosystems on the territory of protected areas of the Murmansk region, and the lack of an adequate system for managing the use of water resources.

4. The fundamental importance and relevance of studying the regularities of the functioning of Arctic freshwater ecosystems in the context of changing global and regional environmental factors is determined by the need to develop an adequate, scientifically based system for the rational use and protection of water resources, which is the key to the successful socio-economic development of the Euro-Arctic Barents region.

Thanks for your kind attention!