

**ANTHROPOGENIC IMPACTS ON THE BIODIVERSITY OF BENTHIC
ANIMAL COMMUNITIES IN THE NEVA ESTUARY**

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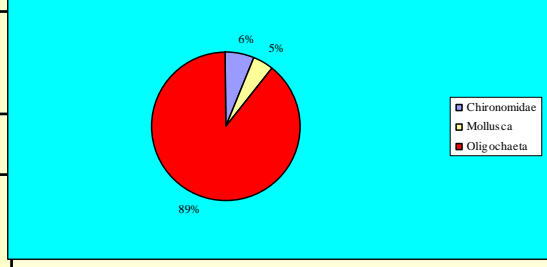
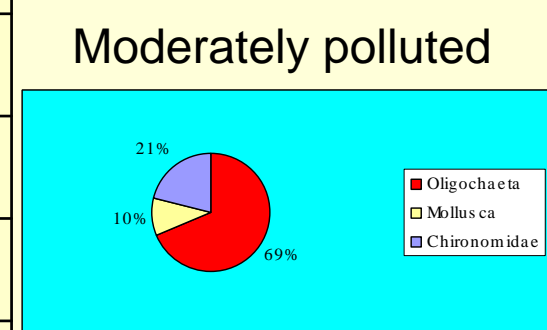
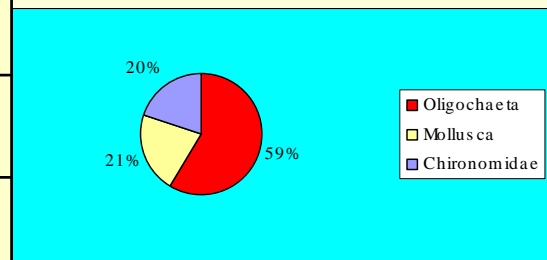
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Classes of water quality by zoobenthos indices St, No/Nc, Kch, 1/BI and Integrated Index IP

St	No/Nc	Kch	1/BI	IP	№	Classes of waters and state of the ecosystem
					1	Very clean
25	0	1.22	10	36.2		
					2	Clean
37.5	50	9.4	20	116.9		Relatively satisfactory
					3	Moderately polluted
62.5	60	56.5	33	212		Tense
					4	Polluted
				265		Critical
					4 – 5	Polluted – Dirty
87.5	80	78.26	50	295.8		Crisis
					5	Dirty
100	100	100	100	400		Catastrophic

Changes of the structural characteristics in zoobenthic communities and assessment of the water quality and state of ecosystem of the Neva Bay at station 14 in 1994 - 2004.

Years	1994	1995	1996	1997	1998	2001	2002	2003	2004
Total abundance (ind.m ⁻²)	16260	9560	7360	2010	6560	6400	25936	25260	26.320
Total biomass (g m ⁻²)	21.34	19.84	16.5	162	177	629	54.308	20.06	27.022
Biomass without unionids (g m ⁻²)	21.34	19.84	2.38	1.85	7.11	4.4	14.3	9.204	19.19
Number of species	12	13	14	27	17	16	21	16	22
Shannon index (bit ind. ⁻¹)	2.2	2.5	2.4	3.8	2.3	3.14	2.6	2.5	2.98
Index No/Nc (%)	90.5	68.7	70.6	58.7	95.6	97.5	85.1	92.5	85.7
Index St (%)	69.7	75	82.5	57	57.5	46.8	71.1	63.2	67.5
Index Kch (%)	69.7	69.8	39	67.4	63.8	56.5	56.5	78.3	56.5
Index BI (%)	33.3	33.3	33.3	14.3	33.3	50	33.3	33.3	50
Integrated Index IP (%)	263.2	246.7	225.4	197.4	250.2	250.8	246	267.3	259.8
Classes of water	4	4	4	3	4	4	4	4-5	4
Quality of waters	Polluted	Polluted	Polluted	Moderately polluted	Polluted	Polluted	Polluted	Polluted – Dirty	Polluted
State of ecosystem	Critical	Critical	Critical	Tense	Critical	Critical	Critical	Crisis	Critical



Seasonal dynamics of structure characteristics of zoobenthos
at the station F10 in the eastern Gulf of Finland

Date	Number of species	Shannon Index	Numbers ind./m ²	Biomass g/m ²
July, 15	4	0.51	26020	41.64
July, 28	8	0.97	40380	49.53
August, 20	6	0.72	61580	72.83
September, 10	8	0.80	30320	47.27
October, 10	6	1.23	50300	57.11
Mean	6.4	0.85	41720	53.68
Variation coef	21.35	28.28	31.18	20.10

Seasonal dynamics of St, No/Nc, 1/BI, Kch and Integrated Index IP
at the station F10 in the eastern Gulf of Finland;

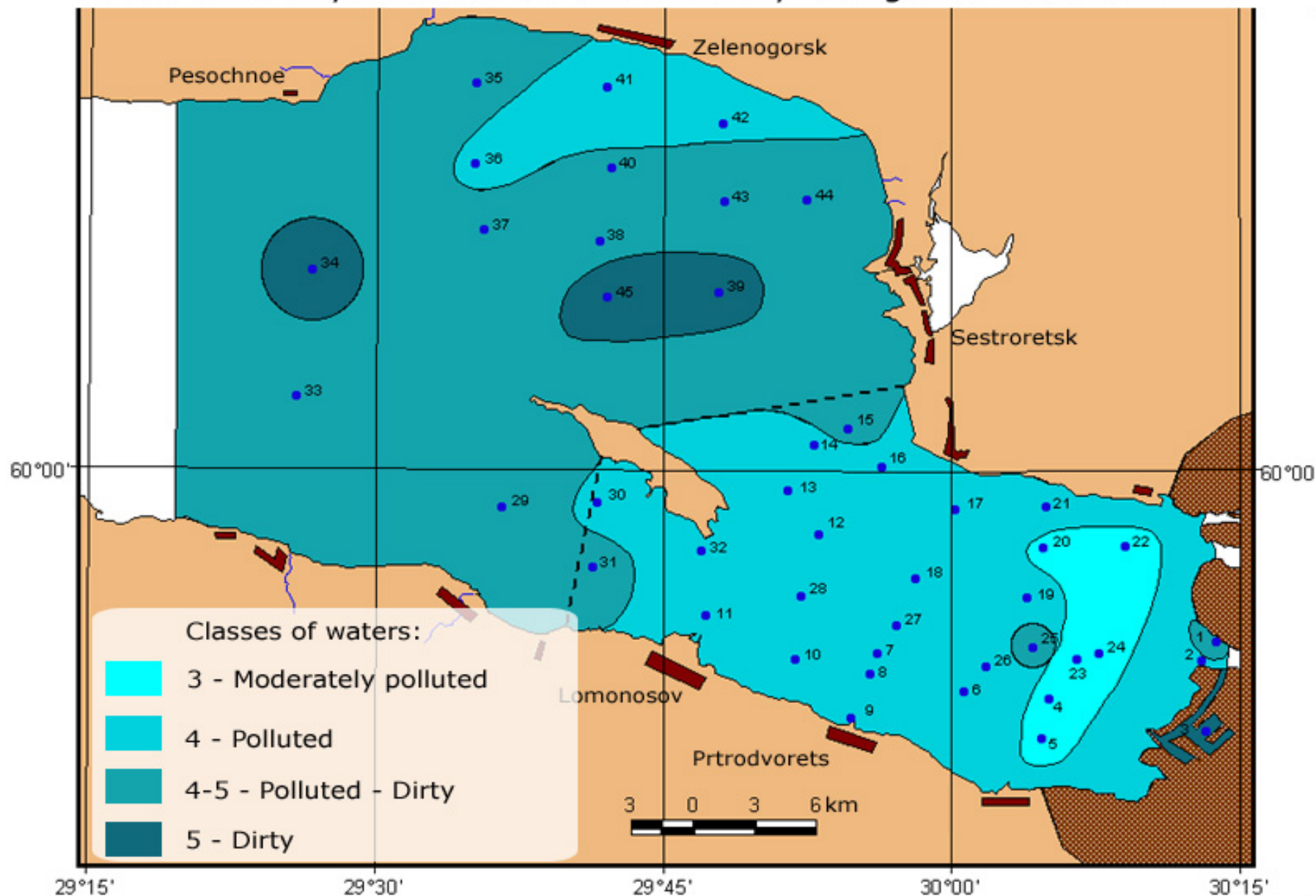
Date	IP	St	No/Nc	BI	Kch
July, 15	288.0	84.0	97.5	50.0	56.5
July, 28	289.8	82.0	99.4	50.0	58.4
August, 20	290.3	84.3	97.7	50.0	58.4
September, 10	261.3	81.3	98.5	25.0	56.5
October, 10	264.2	84.5	98.1	25.0	56.5
Mean	278.7	83.2	98.2	40.4	57.3
Variation coef.	4.7	1.6	0.7	30.6	1.6

Pearson correlation coefficients of structural characteristics of benthic communities and hydrophysical and hydrochemical parameters of the Neva River estuary; per data set, each variable is assigned to the factor that was significant (probability level 0.05) as indicated by red and was significant (probability level 0.10) as indicated by blue.

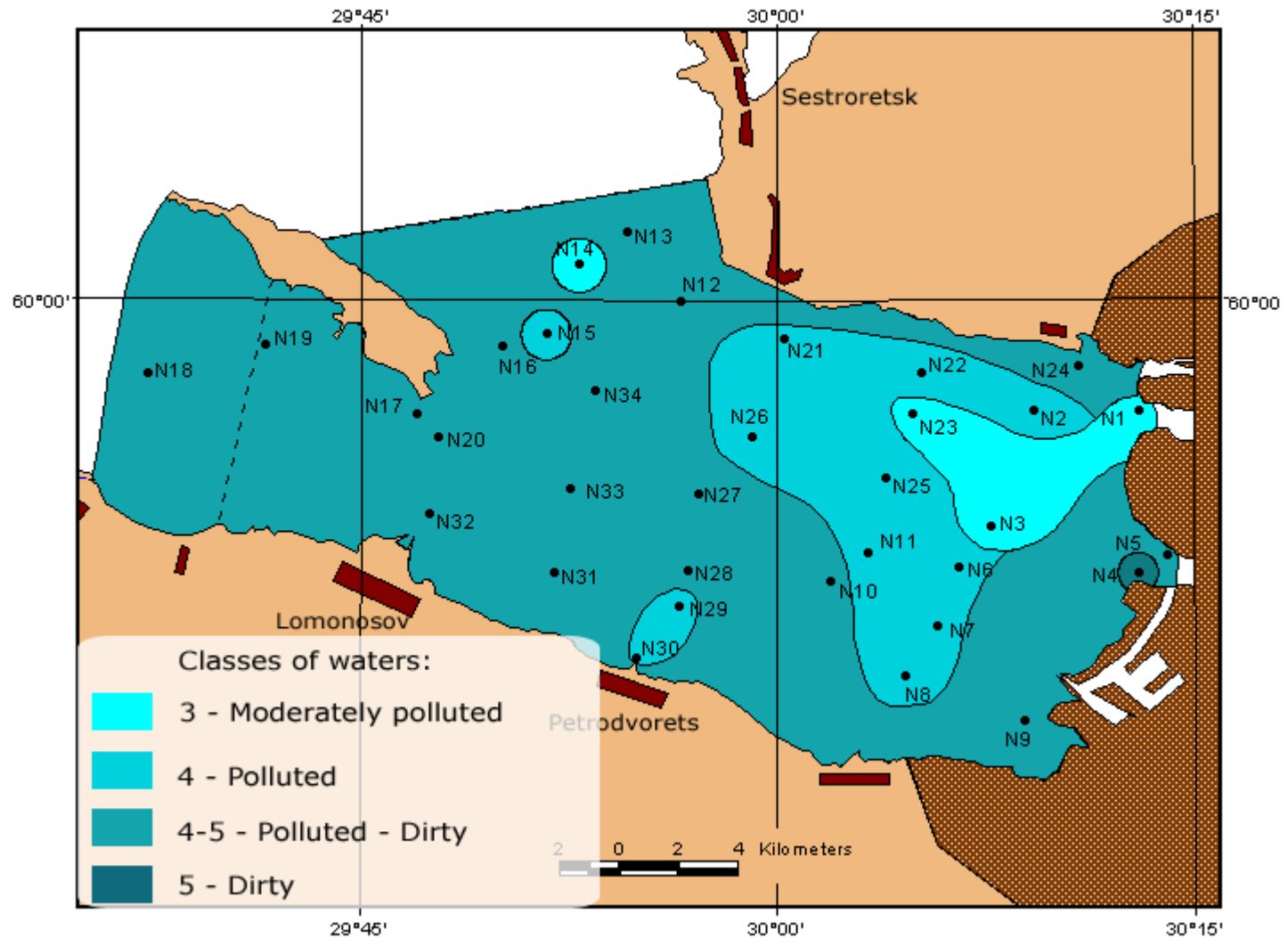
Variable	N	B	Nsp	H	1/BI	Kch	St	No/Nc	IP
Biomass, (B)	0.62								
Number of species, (Sp)	0.47	0.16							
Shannon indices, (H)	0.23	0.00	0.67						
Chloroformic bitumoid	0.75	0.57	-0.77	-0.97	0.92	-0.36	0.32	0.45	0.71
Methane-naphthene hydrocarbons	0.42	0.89	0.03	-0.39	-0.14	0.57	-0.21	-0.73	-0.35
Cl	0.32	0.48	-0.37	-0.62	0.04	-0.02	0.32	0.28	0.19
O ₂ , %	-0.25	-0.24	0.36	0.34	-0.15	-0.17	-0.12	-0.11	-0.08
NO ₃	-0.29	-0.36	0.11	0.32	0.02	-0.21	-0.48	-0.28	-0.33
NH ₄	0.02	-0.11	0.35	0.28	0.75	-0.48	0.25	-0.48	0.01
Oil products	0.97	0.42	-0.43	-0.95	-0.42	0.15	0.72	0.97	0.62
Surfactants	0.20	-0.45	-0.12	0.25	0.56	-0.22	0.22	0.38	0.35
D.D.T.	-0.70	-0.61	-0.31	0.36	-0.24	-0.11	-0.39	-0.54	-0.43
DDE	-0.20	-0.29	-0.19	-0.17	-0.02	0.59	-0.18	-0.08	0.20
Hg in water	0.70	-0.12	-0.95	-0.93	1.00	-0.57	0.38	0.71	0.84
Pb	-0.22	0.15	-0.62	-0.51	-0.11	0.03	-0.17	-0.31	-0.39
Cd	0.35	0.36	-0.24	-0.43	0.30	0.10	0.36	0.06	0.35
Al	-0.10	-0.12	0.28	0.41	-0.49	0.45	-0.13	0.20	0.07
Zn	0.28	0.78	-0.30	-0.32	0.24	-0.25	-0.03	-0.11	-0.03
Mn	-0.20	-0.08	-0.20	-0.25	0.54	-0.34	0.04	-0.60	-0.25
Fe	-0.12	-0.18	0.24	0.10	-0.04	-0.14	-0.73	-0.79	-0.76
Ag	-0.03	-0.18	0.51	0.75	-0.47	-0.12	-0.86	-0.01	-0.53
Total suspended matter	0.53	0.10	0.50	0.57	0.48	-0.28	0.44	0.75	0.68
Suspended organic matter	0.29	-0.15	0.12	0.41	0.44	-0.59	0.68	0.83	0.65

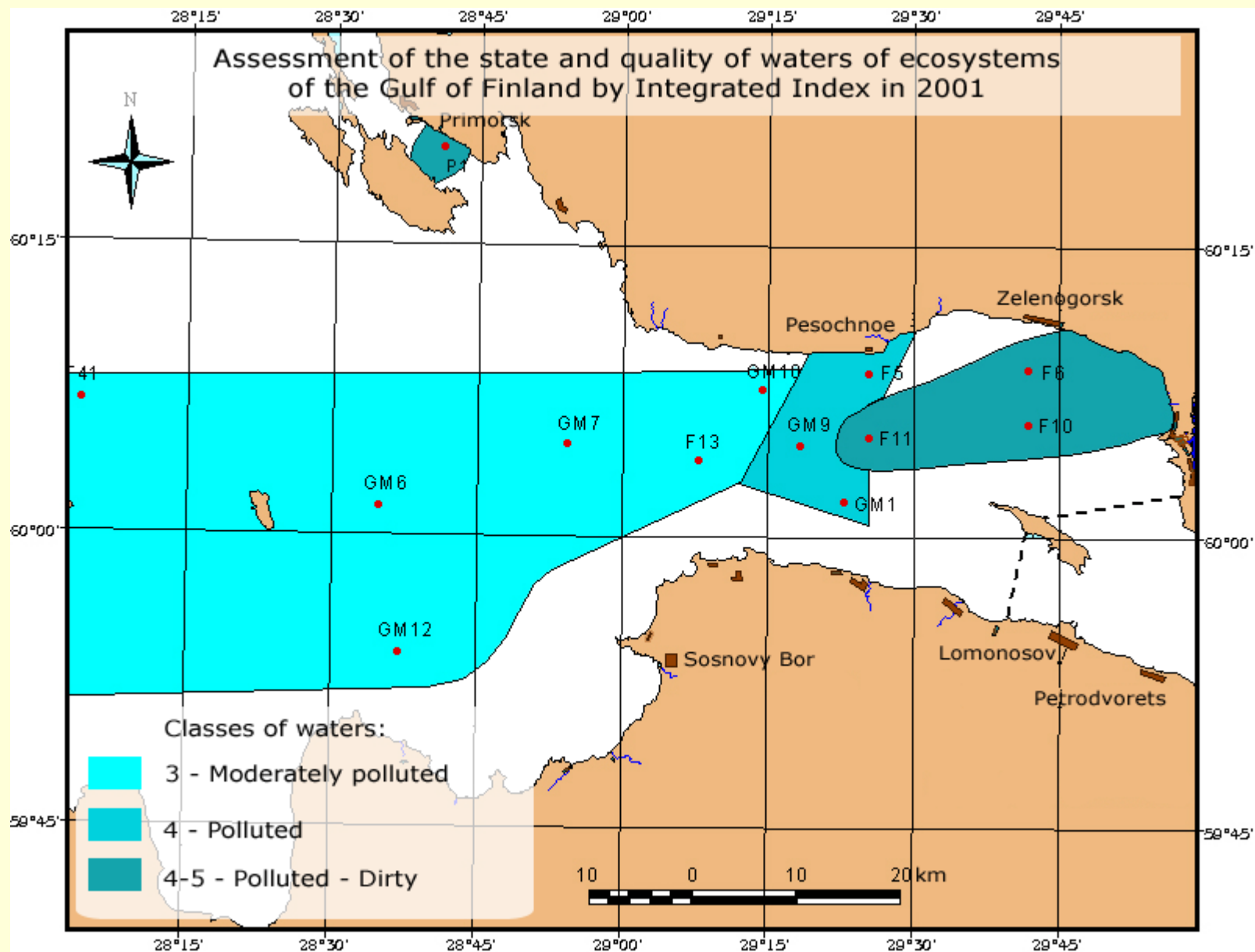
The number of species in the Neva Bay and the Gulf of Finland is determined by high concentrations of toxicants, heavy metals, and oil products. A decline in the number of species is brought about by an increase of concentrations of oil products, and mercury in water and bottom sediments. Growing concentration of oil products and mercury lead to a decline of species diversity and growth of abundance of animals, i.e. predominance of separate species resistant to their action; increase of DDT concentrations results in death of animals and a decline of total abundance.

Assessment of the state and quality of waters of ecosystems of the Neva Bay and the Gulf of Finland by Integrated Index in 1996

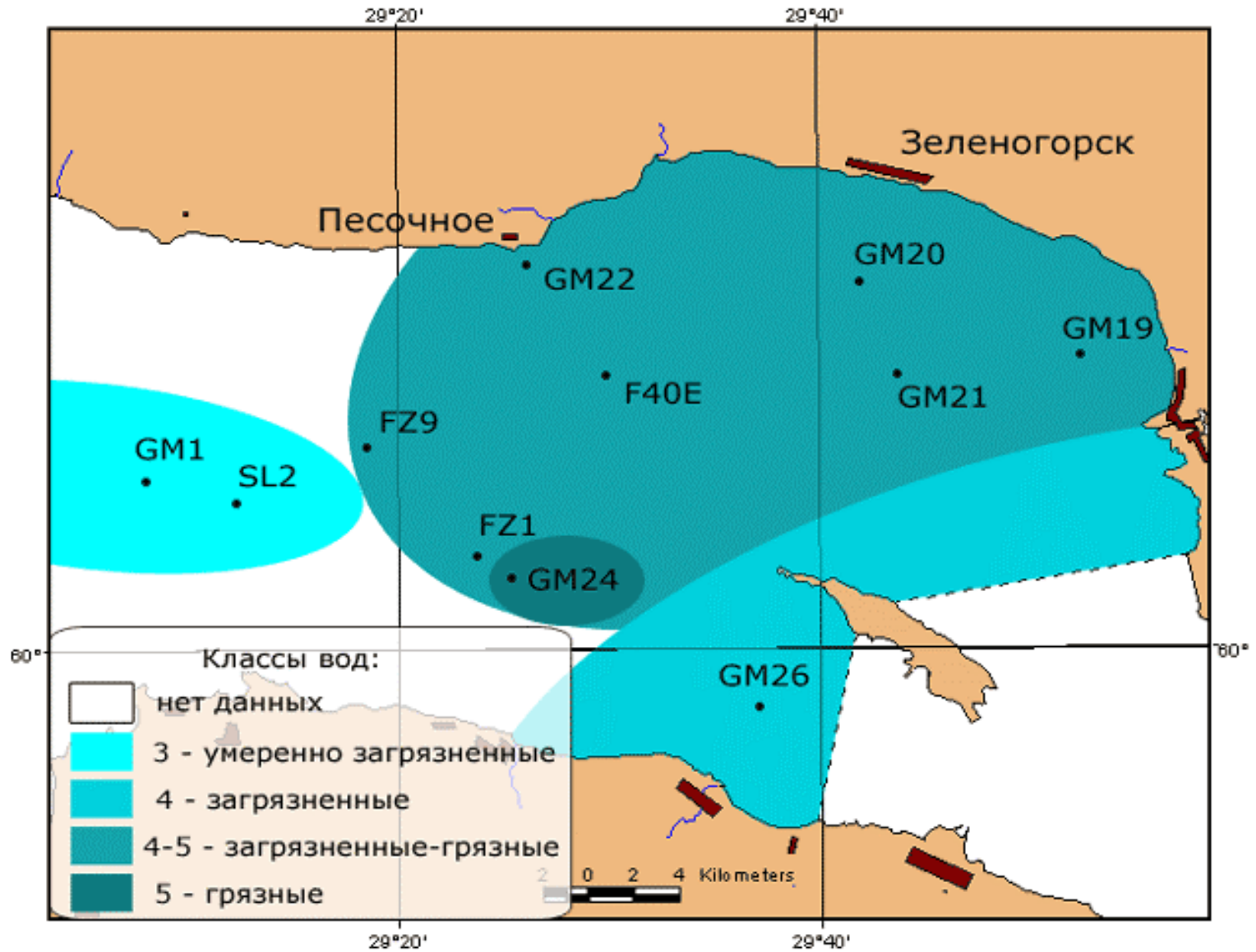


Assessment of the state and quality of waters of ecosystems of the Neva Bay by Integrated Index in 1998

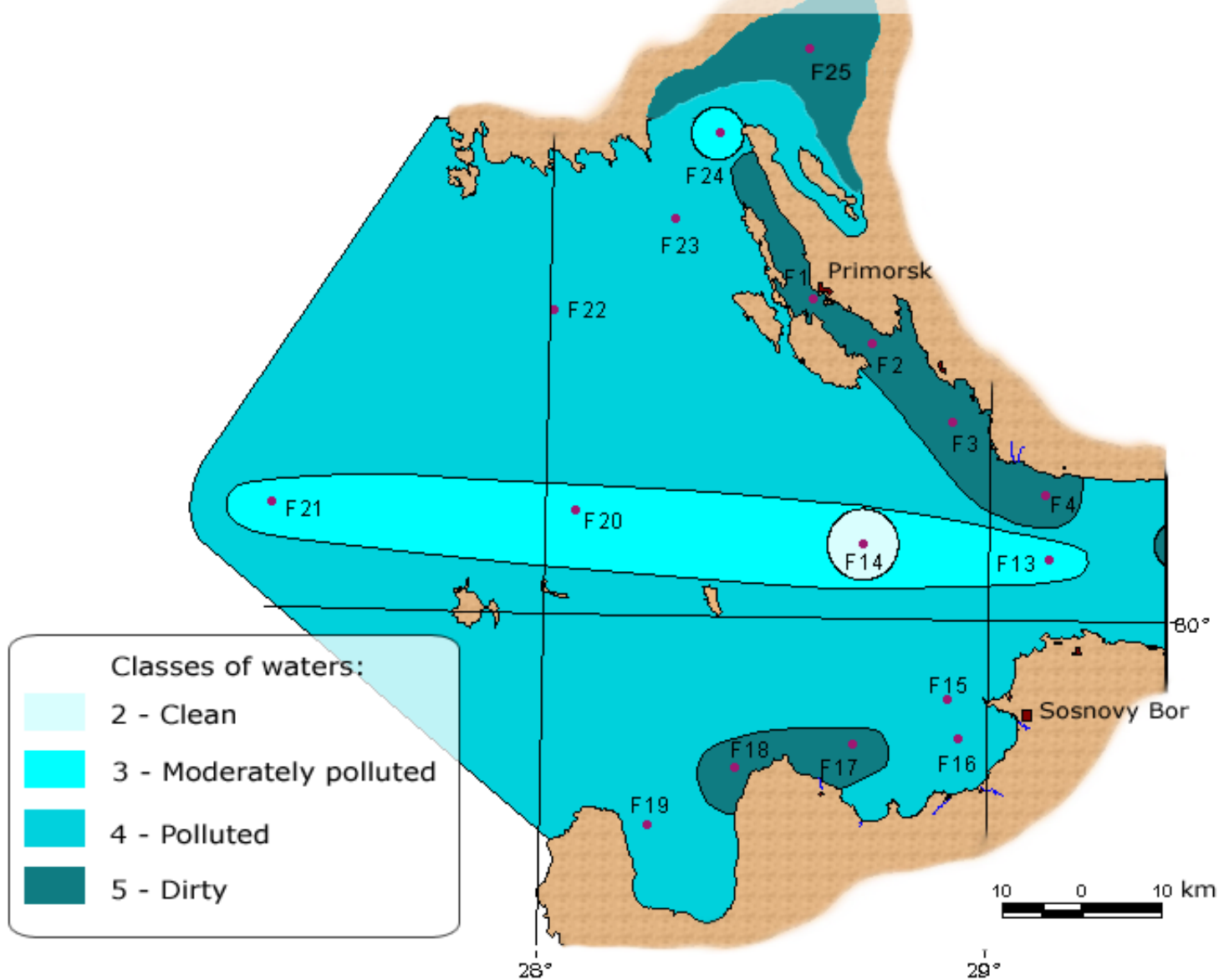




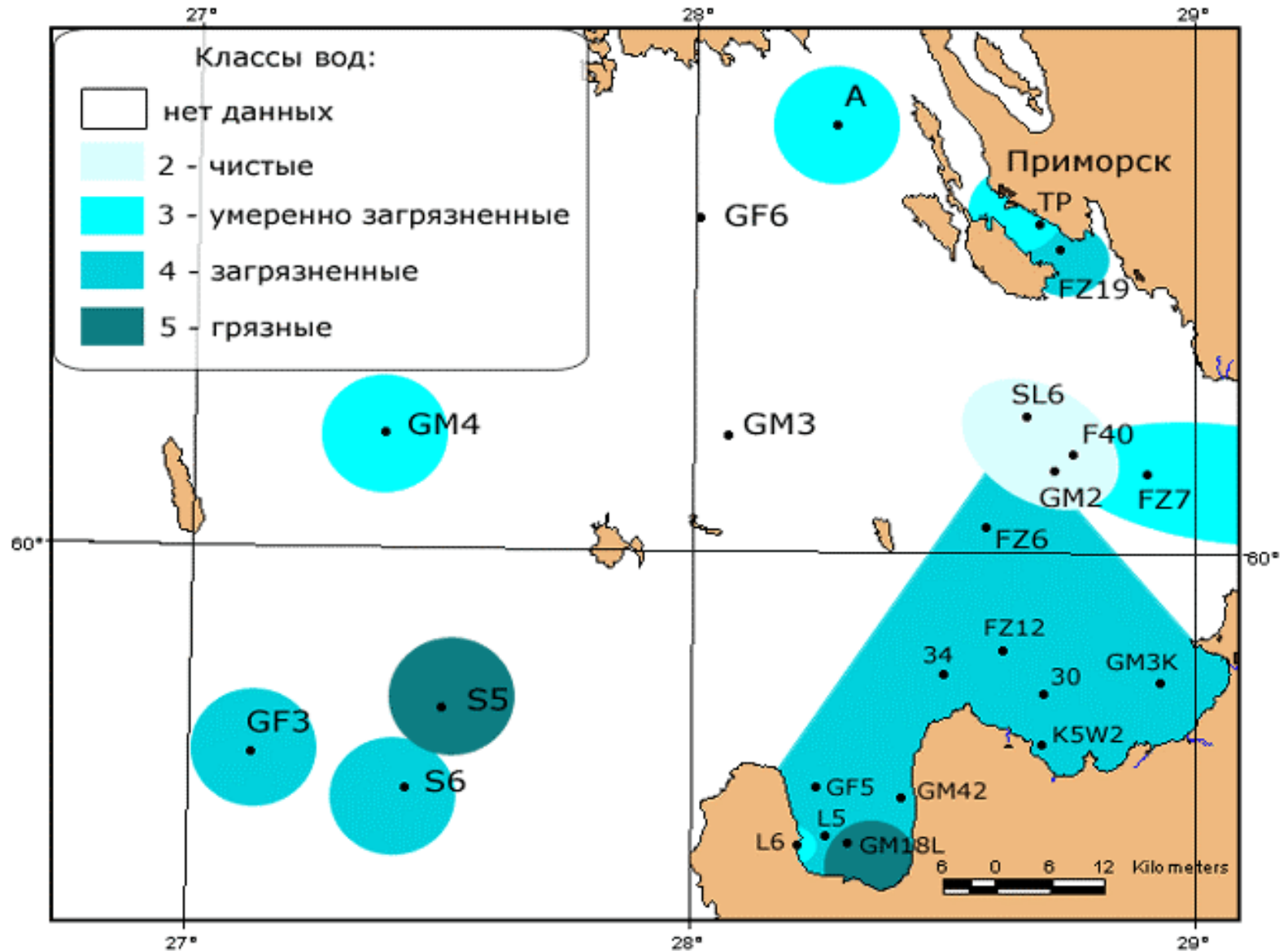
Assessment of the state and quality of waters of ecosystems of the eastern Gulf of Finland by Integrated Index in 2002.

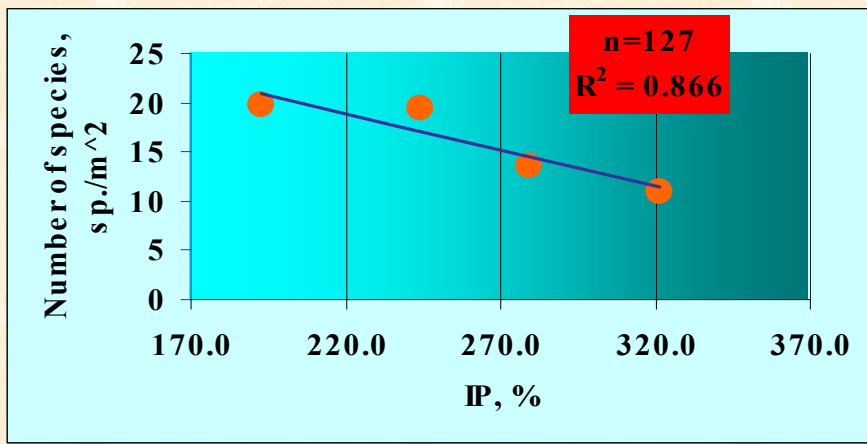


Assessment of the state and quality of waters of ecosystems of the Gulf of Finland by Integrated Index in 1997



Assessment of the state and quality of waters of ecosystems of the eastern Gulf of Finland by Integrated Index in 2002.



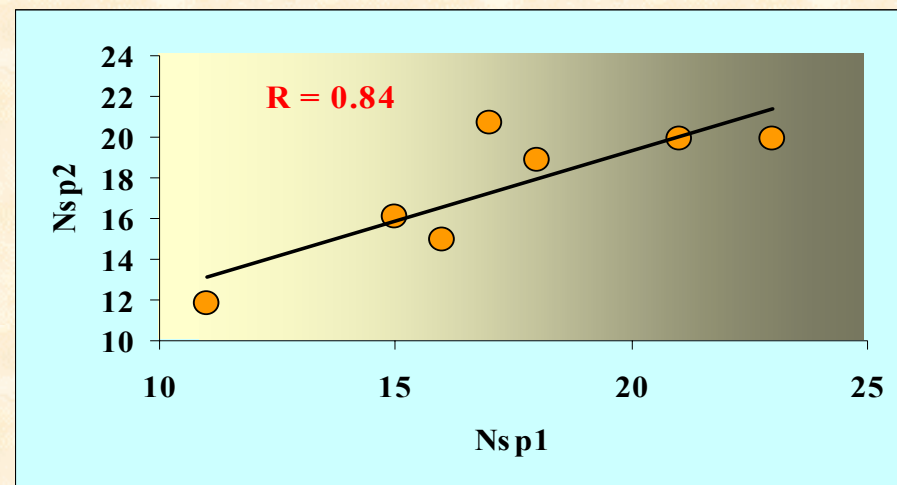


Relationship of number of zoobenthic species and Integrated Index in the Neva Bay in 1994—2001.

Average characteristics of benthic animal communities in 1994 through 2001 for 127 examined stations showed a high value of relationship of species number and pollution in the Neva Bay.

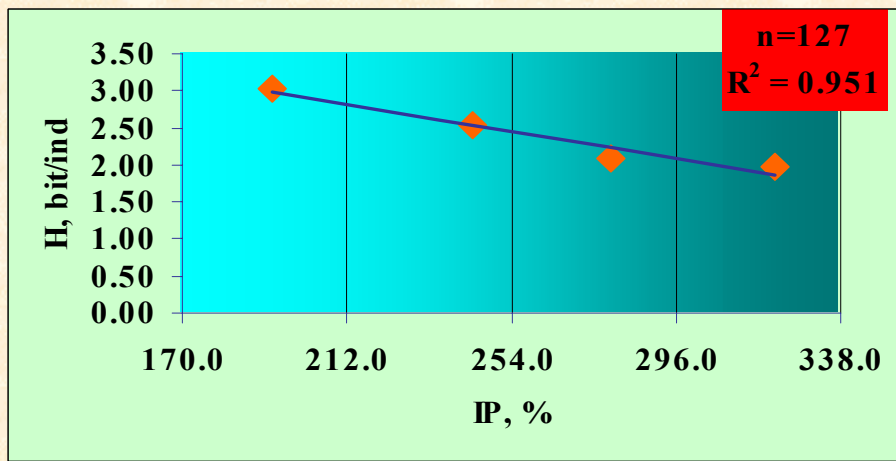
	Beta	Std.Err.	B	Std.Err.	t(4)	p-level
Intercept			35.08	5.90	5.94	0.0040
St	-0.74	0.28	-0.25	0.09	-2.67	0.06
A	-0.29	0.28	-4.57	4.40	-1.04	0.36

Equation of relationship of number of species and saprotobity index and primary production concentration in the Neva Bay in 2003.



Correlation of number of species (Nsp1), in certain samples of benthic animals and Nsp2 calculated from values of primary production and values of saprotobity indices (St).

Equation of multiregression of relationship of number of species and saprotobity index and primary production in the Neva Bay in 2003 means that the number of species of animals is determined mostly by toxic pollution (St, saprotobity index), which is suggested by a high level of significance of this factor (p-level=0.06). The level of significance of the second parameter, primary production value is much lower.

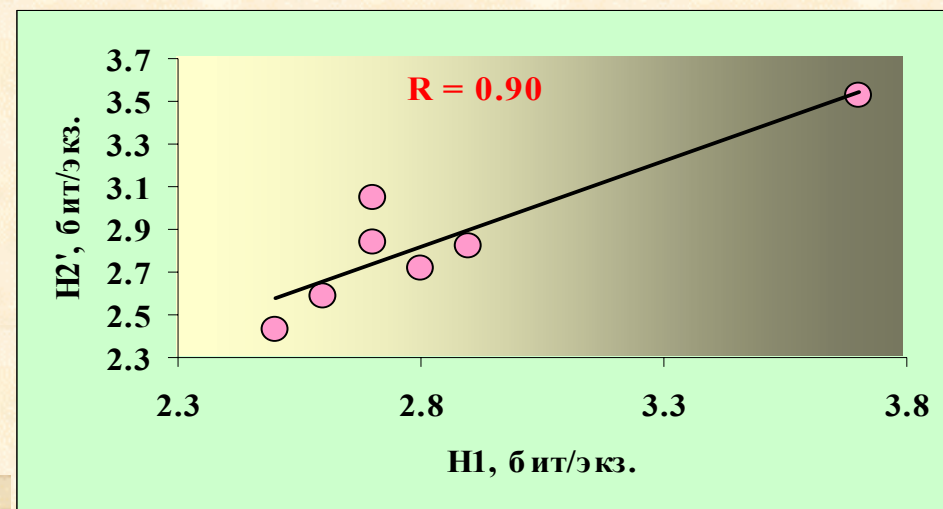


Relationship of zoobenthos species diversity index and Integrated Index in the Neva Bay in 1994-2001.

Average characteristics of benthic animal communities in 1994 through 2001 for 127 examined stations showed a high value of relationship of species diversity index and pollution in the Neva Bay

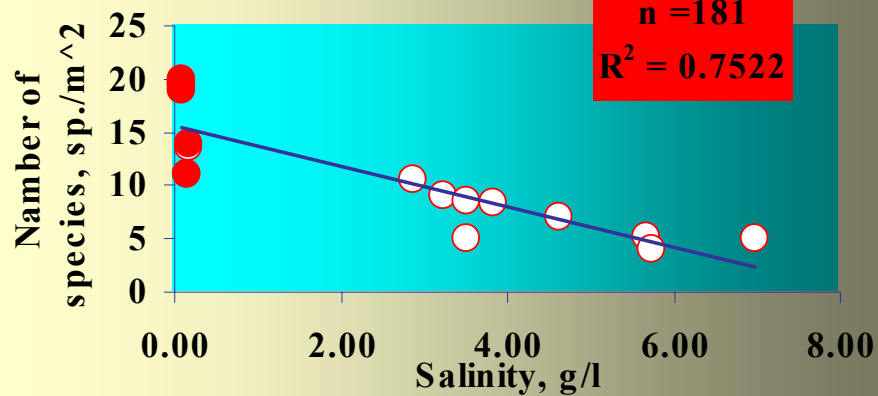
	Beta	Std.Err.	B	Std.Err.	t(4)	p-level
Intercept			4.23	0.35	12.11	0.0003
A	-0.65	0.22	-1.04	0.35	-2.95	0.04
Chl	-0.65	0.22	-0.05	0.02	-2.94	0.04

Equation of relationship of Shannon's index of species diversity and values of primary production and chlorophyll "a" concentration in the Neva Bay in 2003.

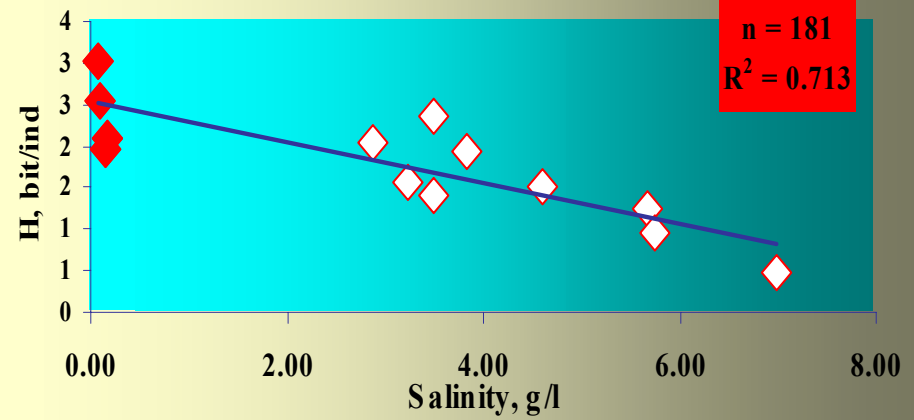


Correlation of Shannon's index (H1) calculated from abundance of benthic animals and (H2) calculated from values of primary production and concentration of chlorophyll «a».

Equation of multiregression of relationship of Shannon's species diversity index and chlorophyll "a" concentrations and values of primary production in the Neva Bay in 2003 indicates that these parameters are highly and equally significant. Values of p-level indicate that in only 8% of cases deviations from 0-hypothesis can be expected. 0-hypothesis: 100% of values of indices of species diversity are determined by values of primary production and chlorophyll "a".



Relationship of number of zoobenthic species and salinity (‰) in the Neva River estuary in 1994—2001; red dot - Neva Bay, empty - Gulf of Finland.

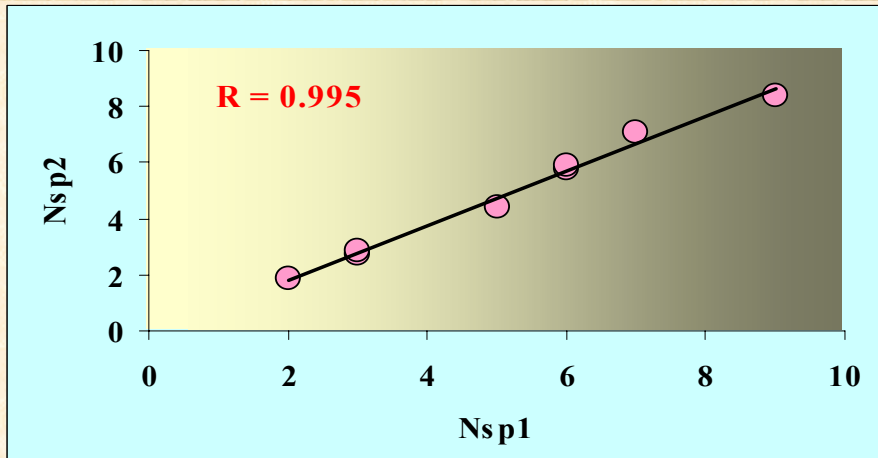


Relationship of zoobenthos species diversity index and salinity (‰) in the Neva River estuary in 1994—2000; red dot - Neva Bay, empty - Gulf of Finland.

Communities of benthic animals of the Gulf of Finland are characterized in the first turn by a relative poverty of species composition. In the open part of the Gulf of Finland apart from the impact of pollution there is a growing impact of salinity on species composition and quantitative development of benthic animals. In the Gulf of Finland, when salinity exceeds 3‰ chironomids disappear from zoobenthos. Under the influence of salinity the number of species, species diversity of benthic animals decline. In the freshwater part of the estuary the number of species of benthic animals (depending on the degree of their pollution) varies from 11 to 23 species, and in the brackish water part of the estuary declines from 12 at 2.8‰ to 5 at 7‰. Values of the index of species diversity decline from 1.9-3.3 bit/specimen in the freshwater part of the estuary up to 0.5 bit/specimen under salinity of 7‰. The decline of the number of species and index of species diversity under the influence of salinity occurs against the background of decline of the degree of pollution of waters; the maximum values of number of species and species diversity were noted in the zone of maximum pollution.

	Beta	Std.Err.	B	Std.Err.	t(2)	p-level
Intercept			1.33	2.93	0.45	0.70
Chl	1.12	0.21	0.98	0.18	5.38	0.03
A	0.65	0.09	12.00	1.68	7.13	0.02
Ptot	-0.48	0.09	-0.08	0.01	-5.39	0.03
H, m	-0.67	0.23	-0.20	0.07	-2.86	0.10
St	-0.34	0.13	-0.04	0.01	-2.55	0.13

Equation of relationship of number of species of benthic animals and biotic and abiotic characteristics of the eastern Gulf of Finland.



Correlation of number of species (Nsp1), in certain samples of benthic animals and Nsp2 calculated from values of primary production, concentrations of chlorophyll «a» and total phosphorus, values depth and saprotoxobity indices (St).

Analysis of the impact of biotic and abiotic factors in the eastern Gulf of Finland in 2003 showed high significance of primary production, concentrations of chlorophyll «a» and phosphorus and lower significance of depth and saprotoxobity index (St) for species richness of communities of benthic animals. Primary production is the most significant parameter. The number of species (Nsp) declines with an increase of depth and increases with an increase of chlorophyll «a» concentration. Increase of saprotoxobity index (St) does not cause a decline of species richness because its absolute values in the eastern Gulf of Finland are lower than in the Neva Bay. The degree of coincidence of the number of species determined experimentally (Nsp1) and obtained with the calculation method (Nsp2) is very high ($R=0.995$, $P=0.05$).

The decline the number of species with depth increasing in the western direction reflects also an impact of salinity as a rule growing with depth.

Conclusions

- 1. The studies conducted show a high extent of dependency of structural characteristics of benthic animals s species composition, number of species, abundance, biomass, Shannon species diversity index, indices No/Nc, Kch, St and IP on hydrophysical and hydrochemical characteristics of water.**
- 2. Water quality in the major part of the Neva Bay and the eastern Gulf of Finland were assessed for 2001 as “polluted—dirty”. The state of a large part of the Neva Bay and the eastern Gulf of Finland by characteristics of benthic communities may be assessed as “crisis” of the ecosystem. According to the classification of the Ministry of Nature Protection (Criteria of assessment, 1992) ecological unfavourable situation “crisis” is characterized by stable negative changes in an ecosystem that pose a threat to the population.**
- 3. Results of multiregression analysis show that the number of bottom species in the Neva Bay is determined largely by toxic pollution (heavy metals, oil products and mercury in water and bottom sediments) and to a lesser extent by primary production values of the ecosystem.**
- 4. Results of multiregression analysis show that values of Shannon’s species diversity index for benthic animals in the Neva Bay are determined equally by values of primary production and chlorophyll «a» concentrations.**
- 5. Analysis of the factors influencing the values of production of benthic animal communities shows that production of benthic animal communities in the Neva Bay increases with growing chlorophyll «a» concentration. Toxic pollution did not have a suppressive impact on production values of benthic animals.**
- 6. Species richness of benthic animal communities in the eastern part of the Gulf of Finland depended largely on primary production values. It is shown that the number of species declines with an increase of primary production, depth and salinity.**