

Lake Ladoga

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1. Introduction

Lake Ladoga is the largest in the Europe and the second (after Baikal Lake) in Russia. Ladoga accumulates the water drain formed both in Russia and in neighbor states – Finland and Belarus. Together with connected by water drain with Ladoga large lakes Onega, Ilmen and Saimaa and separately located Pskovskoe-Chudskoe Lake, it makes unique system of the Great North European Lakes, characterized by significant natural features and playing essential role in the social and economic and other life of region.

Because of features of location, significant development of industrial production, intensive development of waste territories of not only Ladoga Lake basin but also adjoining to it Northwest of Russia European part, (forest exploitation, mining industry, agricultural production, water transport, recreational and tourist activities, etc.), water resources of all considered region experience essential "pressure" of diverse anthropogenic factors. All these impacts finally can affect ecological state of Lake Ladoga as the closing water object.

2. The Lake

1. Basic Information

1.1 Name(s)

1.1.1 In English (All official names, if called in more than one way.)

Lake Ladoga

1.1.2 In local language(s)

Ладожское озеро (Ладога)

1.2 Location

1.2.1 Latitude (range from West to East)

N 59°54' - 61°47'

1.2.2 Longitude (range from South to North)

E 29°47' - 32°58'

1.2.3 Elevation at water surface from sea level

5.1m

1.2.4 Riparian countries and sub-national (state, province, etc.) jurisdictions

Russia: Leningrad Region (39% of catchment area), Karelia Republic (29% of catchment area)

1.2.5 Non-riparian basin (upstream) countries and sub-national jurisdictions

Russia (80.0% of catchment area): Novgorod region (17%), Pskov region (6%), Tver region (4%), Vologda Region (3%), Arkhangelsk Region (2%); Finland (19.9%); Belorussia (0.1%).

1.3 Origin

1.3.1 In the case of natural lakes

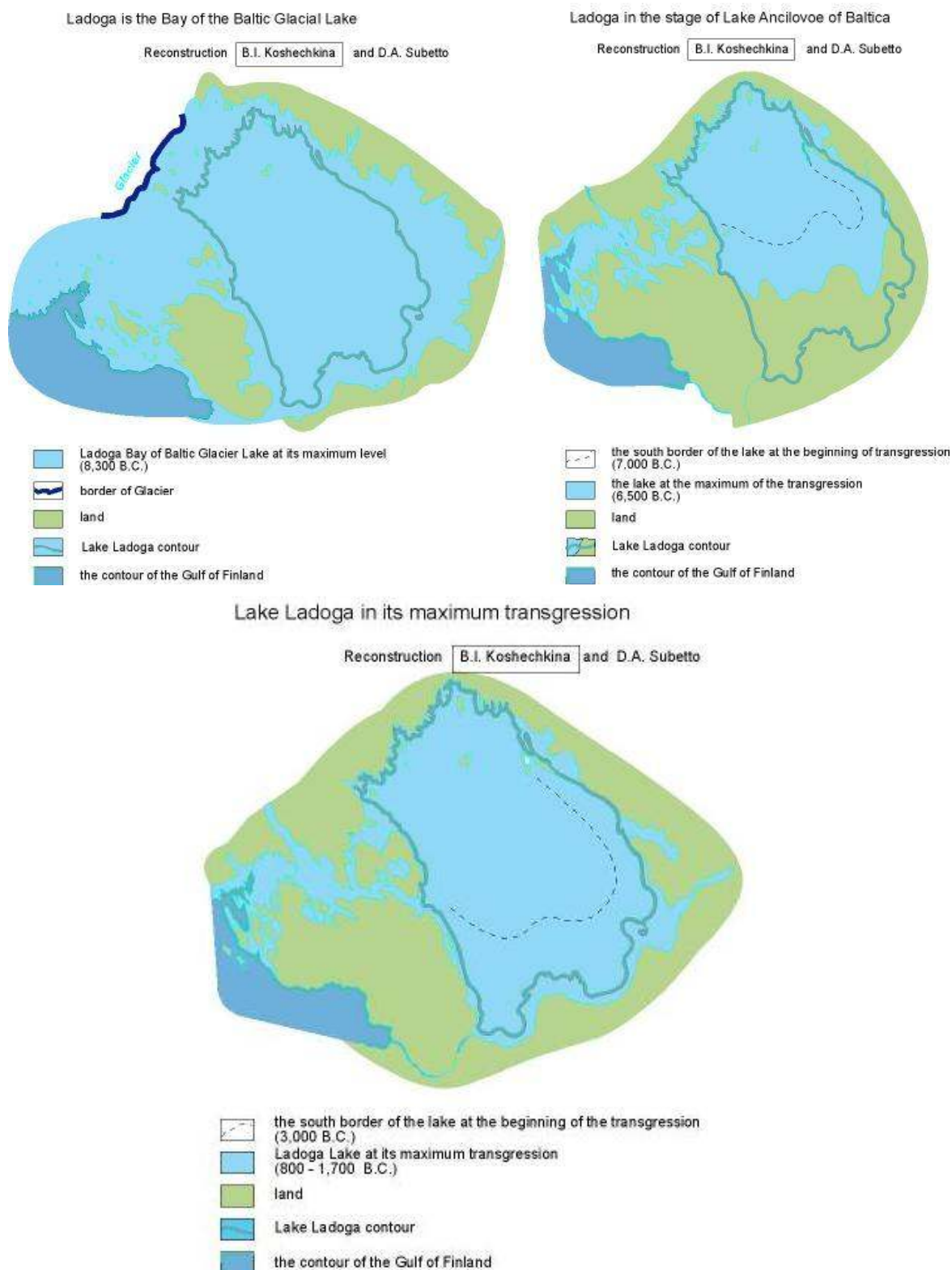
- Origin of the lake (e.g., glacial, tectonic, volcanic, etc.)

The hollow of Lake Ladoga has tectonic origin and is transformed by quaternary glaciers. It is located on border of two largest geological structures of the Europe – the Baltic crystal shield and Russian platform. Northern part of Ladoga is on the margin of crystal shield formed from granites, gneisses, pegmatites, micaceous slates, here and there covered by thin mantle of quaternary deposits. To the south thickness of quaternary deposits increases and there is a gradual sinking of crystal shield under the thick sedimentary mantle of Russian platform (Ladoga Lake, the Atlas, 2002).

Differences in geological structure of the basin are reflected in the structure of hollow and the coast of Lake Ladoga. Northern and northwest coasts are high and strongly split, the shore is bordered by numerous islands. The combination of islands, straits and deeply jutting out into land gulfs creates original skerry area of Ladoga. Relief of bottom of northern lake part is complex, characterized by alternation of deep hollows and shallow areas. In direction to the south relief of coast and bottom becomes smoother, depths decrease. The coast here represents low plain, along the coast there are stretched sandy and stony spits.

- [Estimate of the age of the lake](#)

Ladoga Lake is young. The history of its formation and development is closely connected with degradation existed in the north of Europe of the last (Valdai) glaciation and the subsequent reorganizations of region water system in Pleistocene–Holocene. About 15000 years ago territory of lake still was under glacial cover. Later, 13000–10500 years ago, on the place of lake there was a gulf of large glacial water body connected with the Baltic glacial lake (Subetto, 2002). After glacier contraction to the north, the lake became separate water body. At that time the climate in region was severe, essentially colder than the recent, the organic world of lake was poor with species, and biological productivity was the lowest. By general characteristics the lake quite corresponded to the modern arctic water bodies. The important stage in the history of lake was Atlantic Epoch when the climate has become considerably warmer and even became warmer than the recent. These changes were reflected in the increase of general biological productivity of the lake ecosystem. In the followed then sub-boreal epoch some cold snap has occurred and the climate gradually (with fluctuations) has passed into the modern (Davidova, 2002) which, however, concedes by temperature regime (and so by intensity of biota development) to the Atlantic Epoch.



Fif. 1. Stages of Lake Ladoga evolution in the Late Glacial and Postglacial epochs.

- 1.4 Basin and/or Watershed, Map(s)
- 1.4.1 Major inflowing and out-flowing rivers

By geographical sense the catchment area of Ladoga Lake is divided into four main parts:

Svir-Onega (83.2 thousand km²), Volkhov-Ilmen (80.2 thousand km²), Vuoksi-Saimaa (66.7 thousand km²) and partial catchment area of the lake.

To Lake Ladoga 32 rivers are flowing. Major tributaries – Svir (785 m³/sec), Volkhov (593 m³/sec) and Vuoksi (about 600 m³/sec) provide 86% of the total surface runoff coming to the lake. Among other large rivers there are Syas (55 m³/sec), Naziya, Vidlitsa, Enjajoki, Tulemajoki, Uksunjoki, Janisjoki, Tohmajoki, Burnaya, Morye. Discharge from Lake Ladoga is via Neva River to the Gulf of Finland.

1.4.2 Main cities and other points of interest

In the coastal zone of Lake Ladoga there are a number of cities: Priozersk, Novaya Ladoga, Syas'stroy, Vidlitsa, Pitkyaranta, Impilahti, Sortavala, Lahdenpohja, etc. In the Ladoga catchment area there are such large cities as Velikiy Novgorod, Pertozavodsk, Tikhvin, Volkhov, Kirishi, Staraya Russa, Borovich, Bologoe, Vyshny Volochok and Velikie Luki; in the Finnish part there are Joensuu, Imatra and Lappeenranta.

1.4.3 National/sub-national jurisdictional boundaries

Russia, Finland, Belorussia.

1.4.4 Etc.

1.5 Basin Demography, Map(s)

1.5.1 Population and density distribution

On the territory of Lake Ladoga catchment area there are living almost 4 million people, including 2.7 million city dwellers. Population density in the Russian part of catchment area makes 12.4 ind./km² on the average (Rumyantsev, Drabkova, 2007), 40 ind./km² in the basin of Volkhov and 20 ind./km² the basin of Syas (Raspletina, Susareva, 2006).

1.5.2 Etc.

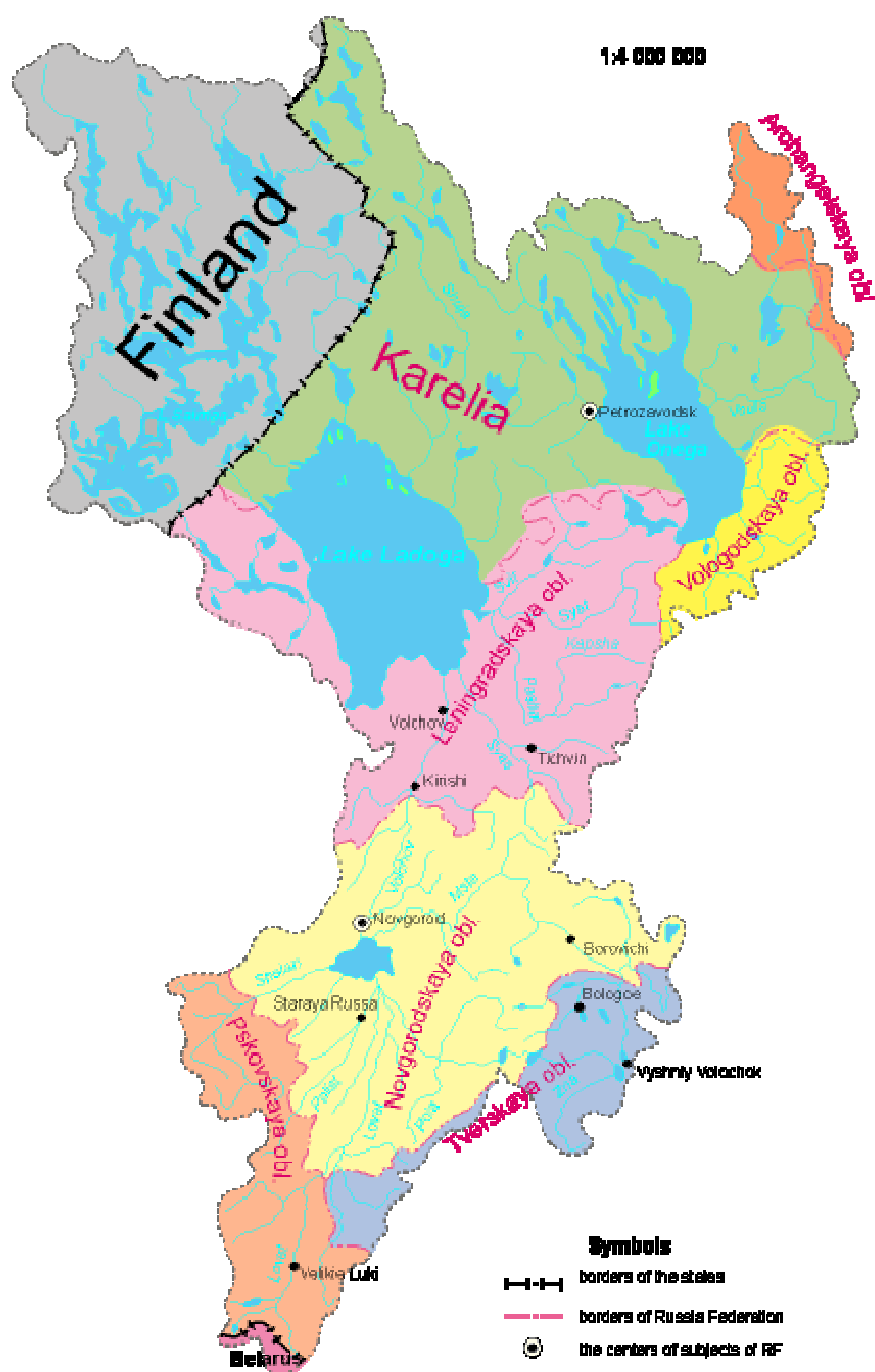


Fig. 2. Political-administrative division of Lake Ladoga basin.

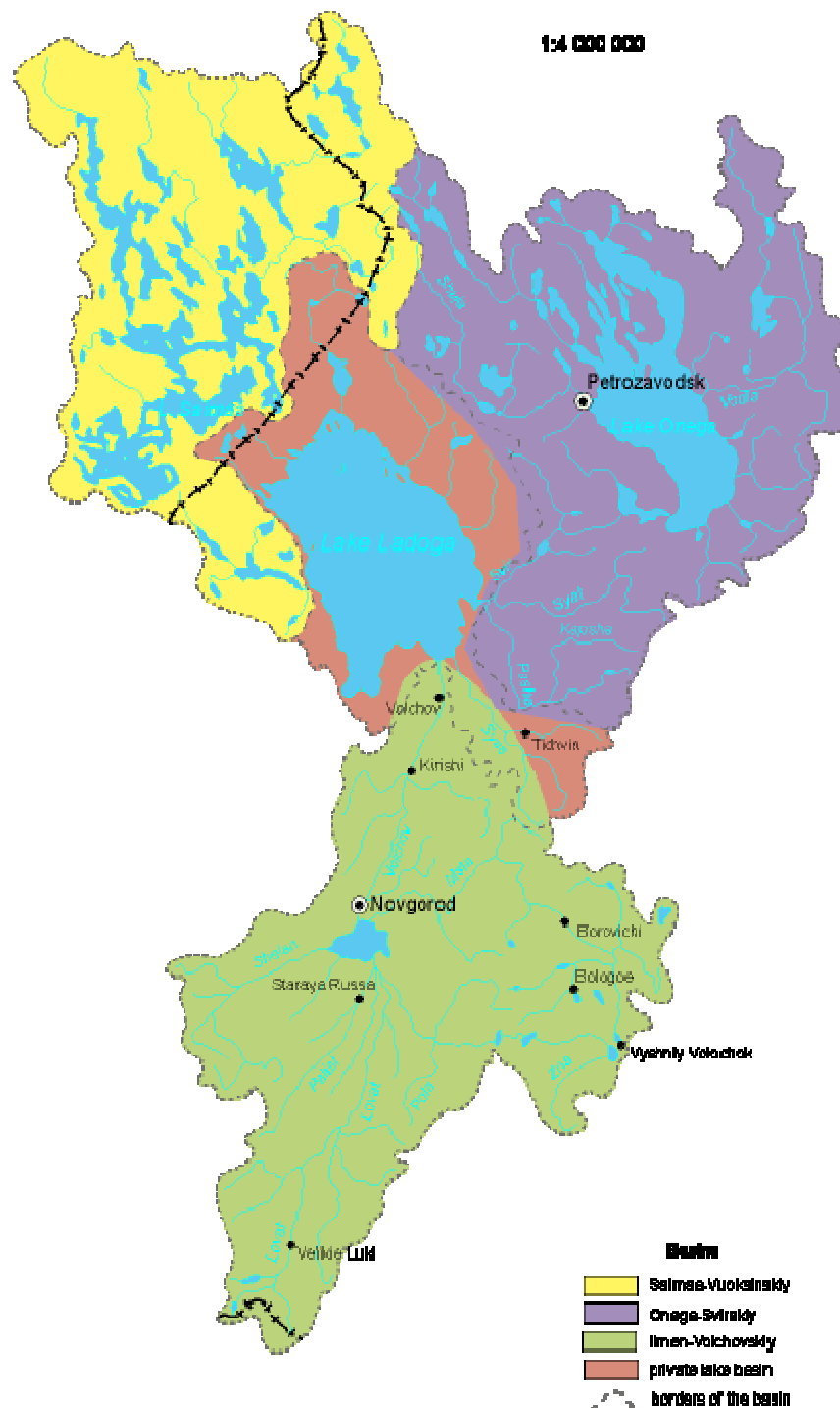


Fig. 3. Catchment area of Lake Ladoga.

- 1.6 Landscape and waterscape
- 1.6.1 Visual features of the lake and its basin

(Photos of various kind including landscape, physical facilities, water quality problems, land and water uses in the riparian as well as upstream regions, biological and ecosystem conditions including unique fauna and flora, etc.)

2. Morphology

2.1 Bathymetric map, if available

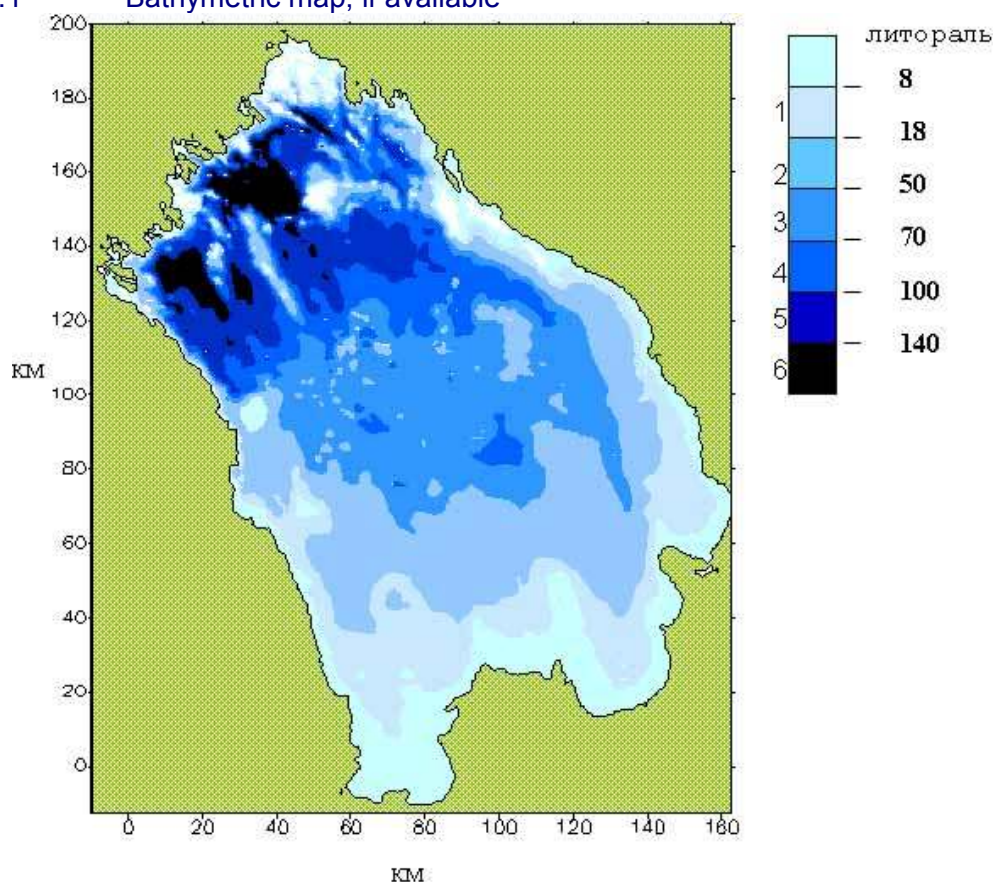


Fig. 4. Bathymetry of Lake Ladoga

2.2 Volume (in km³)

838±2.4 (Naumenko, 1995)

2.3 Surface Area (in km²)

17872 (Naumenko, 1995) (with islands - 18135)

2.4 Length and width (in km)

Maximum length - 219 km (Chernyaeva, 1966)

Maximum - 125 km (Baranov, 1961)

Mean width – 82 km (Chernyaeva, 1966)

2.5 Length of shoreline (in km)

1570 (Chernyaeva, 1966)

2.6 Maximum depth (in m)

230

2.7 Mean depth (in m)

46.9 (Naumenko, 1995)

2.8 Note on intra- and inter-annual changes in water level and volume, if information is available (provide a note on water level changes due to flow regulations)

The highest average annual water level of Lake Ladoga at the mark 6.2 m was observed in 1924, the lowest, 3.64 m, - in 1940. The average annual amplitude of Lake Ladoga level fluctuations is 0.69 m (from 0.21 m in 1940 up to 1.26 m in 1962). Level fluctuations are smooth. By long-term data the annual level course is characterized by increase from the minimal mark in January up to the maximal mark in June and gradual decrease up to the end of year. The absolute amplitude of level fluctuations by average monthly data for the 150-years period of observations has made 3.22 m (Ladoga Lake, the Atlas, 2002).

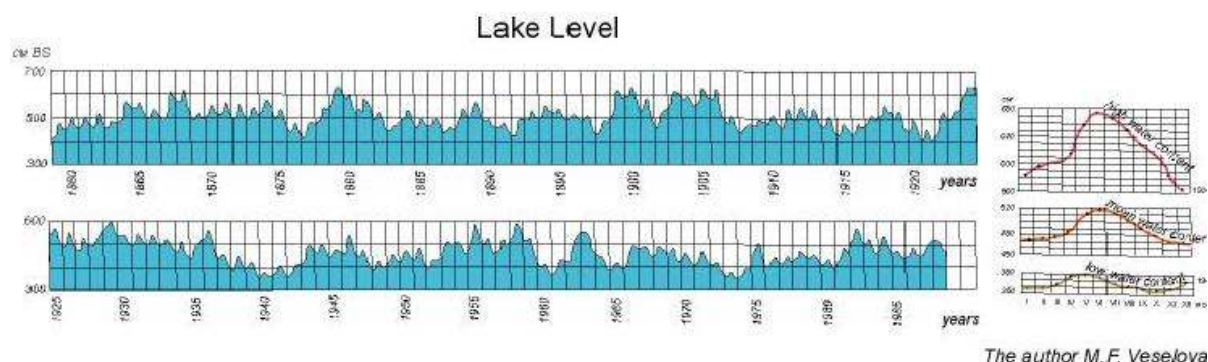


Fig. 5. Long-term fluctuations of water level and fluctuations in characteristic years

3. Water Balance

By ratio of elements of income and outcome parts of water balance, according to classification of B.B. Bogoslovskiy, the lake belongs to drainage-inflow type where prevailing components are inflow and outflow. A role of precipitations and evaporation is insignificant because of the huge size of the catchment area (Ladoga Lake, the Atlas, 2002).

WATER BALANCE

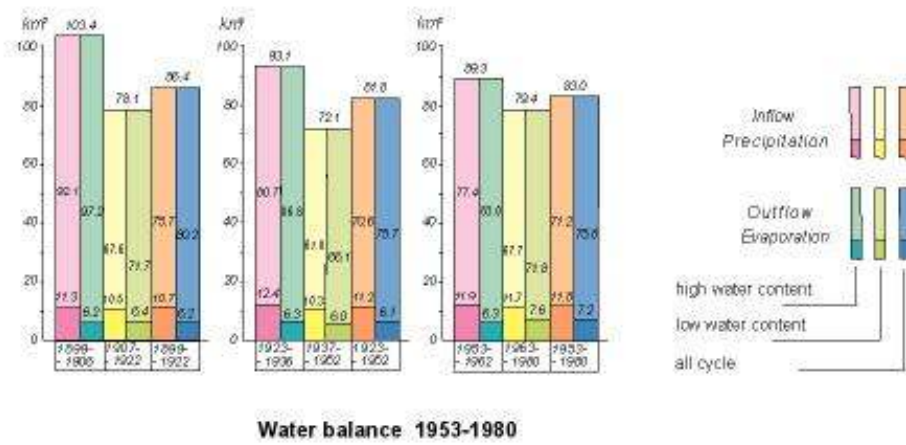


Fig. 6. Water balance in various cycles and phases of water abundance (author: M.F. Veselova)

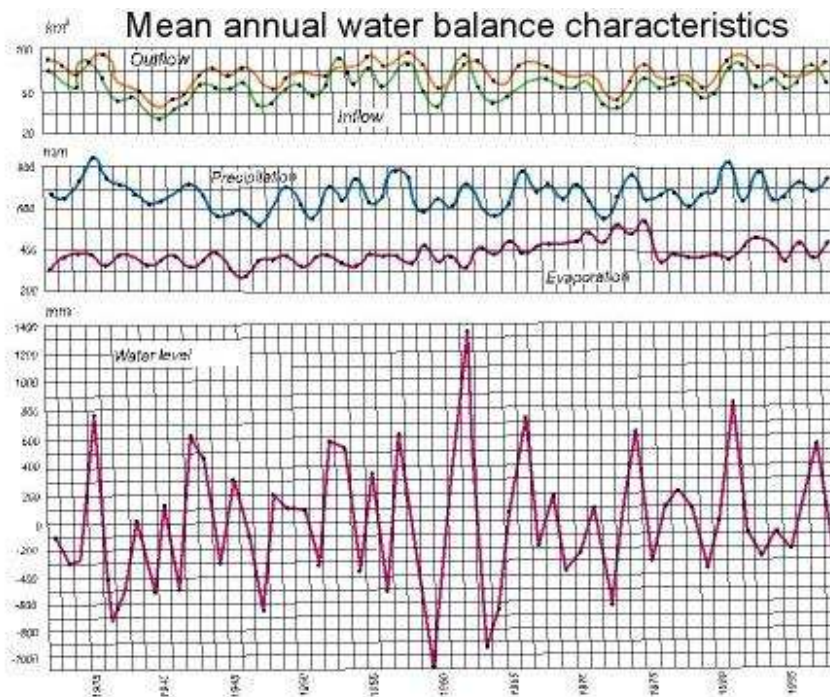


Fig. 7. Variation of annual values of water balance elements (author: M.F. Veselova)

3.1 Inflow (Annual average in m³ per year)

3.1.1 Precipitation

Precipitation amount is 11.8 km³ per year (Ladoga Lake, the Atlas, 2002) or 14% of income part of water balance.

3.1.2 Rivers (Note if they are controlled.)

The main element of Lake Ladoga water balance income part is inflow, which average annual value is 71.2 km³ per year or about 84.5% from the total volume of incoming water. Major tributaries are rivers Svir (controlled, average discharge 785 m³/sec), Volkhov (controlled, average discharge 785 m³/sec) and Vuoksi (controlled, average discharge 785 m³/sec) bringing 66.4 km³ of water per year on the average, i.e. they provide 86% of the total surface inflow (Ladoga Lake, the Atlas, 2002). The largest inflow (89.6 km³) was in 1958, the lowest (37.8 km³) was in 1940. The most of water comes to the lake in spring (35.5% of annual volume), the least – in summer (16.3%), in autumn and in winter – 23-25% (Ivanov, Kirillova, 1966).

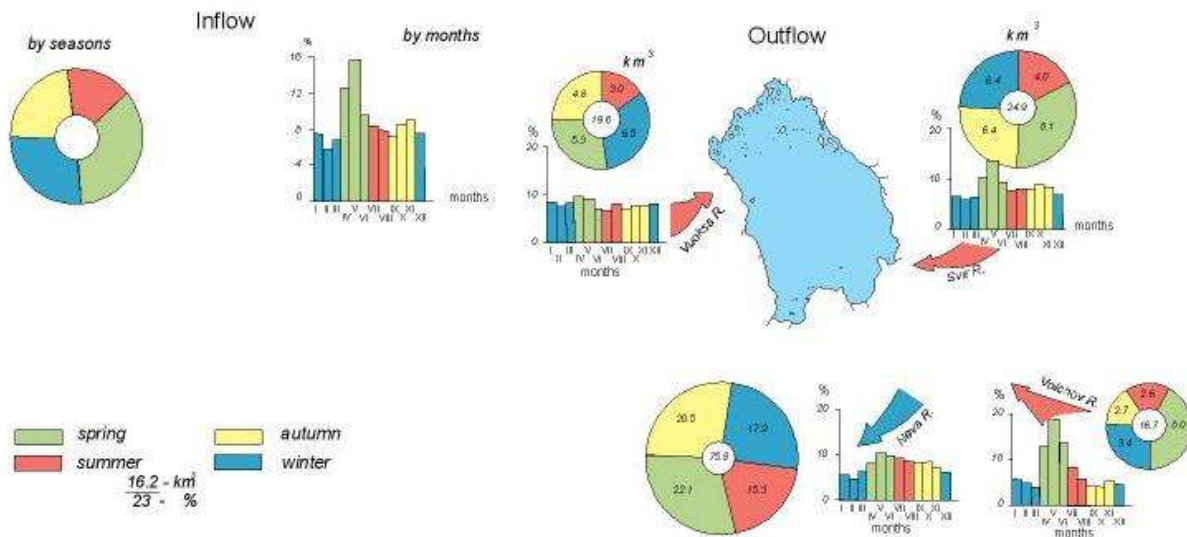


Fig. 8. Distribution of total water income to the Lake Ladoga (author: M.F. Veselova)

3.1.3. Groundwater

Groundwater income to Lake Ladoga is 1.296 km³ on the average or 1.5% of income part of water balance (Kalesnik, 1968).

3.2 Outflow (Annual average in m³ per year, if information is available.)

3.2.1 Evaporation

With evaporation Lake Ladoga loses 7.2 km³ of water per year or 8.6% all outcoming water (Ladoga Lake, the Atlas, 2002).

3.2.2 Rivers (Controlled?)

The main element of outcome part of Lake Ladoga water balance is outflow, its average annual value is 75.8 km³ per year or 91.4% from the total volume of outcoming water. Total outflow from the lake occurs via River Neva (Ladoga Lake, the Atlas, 2002). The maximal runoff was observed in 1958 (100.4 km³), the minimal – in 1940 (42.4 km³). Runoff of water from Ladoga through via River Neva is characterized by rare uniformity; 28.4% of annual discharge is in spring, 20% in summer, 27% in autumn and 24% in winter (Kalesnik 1968).

3.3 Retention time (In years, if information is available)

3.3.1 Theoretical filling time (Lake volume/annual inflow)

11.8 years (Ladoga Lake, the Atlas, 2002)

3.3.2 Theoretical flushing time (Lake volume/annual outflow)

11 years (Ladoga Lake, the Atlas, 2002)

4. Climate

Climate in the Lake Ladoga region is transitional from marine climate of temperate zone to continental climate. It is formed under influence of marine air from Atlantic, continental air from middle latitudes and due to periodical interventions of Arctic air. In the all catchment area significant fluctuations of air temperature, high relative air humidity, nebulosity and large amount of precipitations are typical.

4.1 Average T, min monthly T, max monthly T (in centigrade)

The coldest month is February, monthly average temperature of air at this time is -8.0 – -11.4°C, in the mid area of the lake it is some higher. In the most severe winter, in January and February, temperature of air over the lake water area it drops to -36°C, and at the northern and eastern coast to -54°C. From March temperature of air begins growing reaching in May 6-7°C in the open areas and 8-9°C on the coast. The warmest month is July with monthly average temperature of air 14-16°C over the lake and 16-17°C on the coast. Maximal temperature of air in July is 30-33°C. From September temperature of air begins decreasing and in November becomes subzero in the all catchment area.

Average duration of frost-free period is 120-180 days. Amplitude of annual temperature of air change on the lake is 25°C and 25-27°C on the coast (Ladoga Lake, the Atlas, 2002).

4.2 Average Precipitation, min monthly precipitation, max monthly precipitation (in mm)

Atmospheric precipitation on the shore of Lake Ladoga are distributed unevenly, their annual volume varies from 380-490 mm on northwest coast to 560-630 mm in the southern part of the lake and on islands. Maximum of precipitation is in August-September, minimum is in March-April. The rainiest month is August when monthly amount of precipitation can reach 140 mm. In cold season amount of precipitation decreases but this time they are widespread (Ladoga Lake, the Atlas, 2002).

4.3 Prevailing wind directions by season, strength

During the year southwestern, southern and southeastern winds are prevailing on Lake Ladoga. In the cold season these winds repeat very often (45-65%) on the southern part of the lake. In the warm season (April-October) reiteration of winds of northern directions increases up to 16-27% on the northwest coast and up to 26-28% on the southern coast. Winds of southern compass points are more permanent and can continue uninterruptedly. When cyclones are passing winds are unstable.

Monthly average wind speed in the open lake areas and on islands is 7-9 m/sec in cold season and 5-6 m/sec in warm season. On the shore monthly average wind speed is 2-5 m/sec during the year (Ladoga Lake, the Atlas, 2002).

5. State of Ecosystem

5.1 Description on the state of ecological health including conservation of fauna and flora

Till 1970s Lake Ladoga was remarkable for high quality of water and was characterized as oligotrophic water body. Because of occurred from the second half of XX century active anthropogenic development in the catchment area quality of water became to drop fast, and to the beginning of 1980s ecological state of lake has worsened sharply, the water body has transferred into mesotrophic status. Improvement of ecological state of lake began from 1988 as in the connection with economical recession which has begun in this period, and owing to accepting of some nature protection measures. Studies in the present time show, that because of huge sizes of lake and variety of its different areas ecological status of lake is different over its area, changing from an oligotrophic in the central water area up to oligotrophic-mesotrophic in transitional part and mesotrophic in southern bays. Such conclusion is confirmed by data as on development of phytoplankton as zooplankton.

5.2 Description on the state of biodiversity conservation

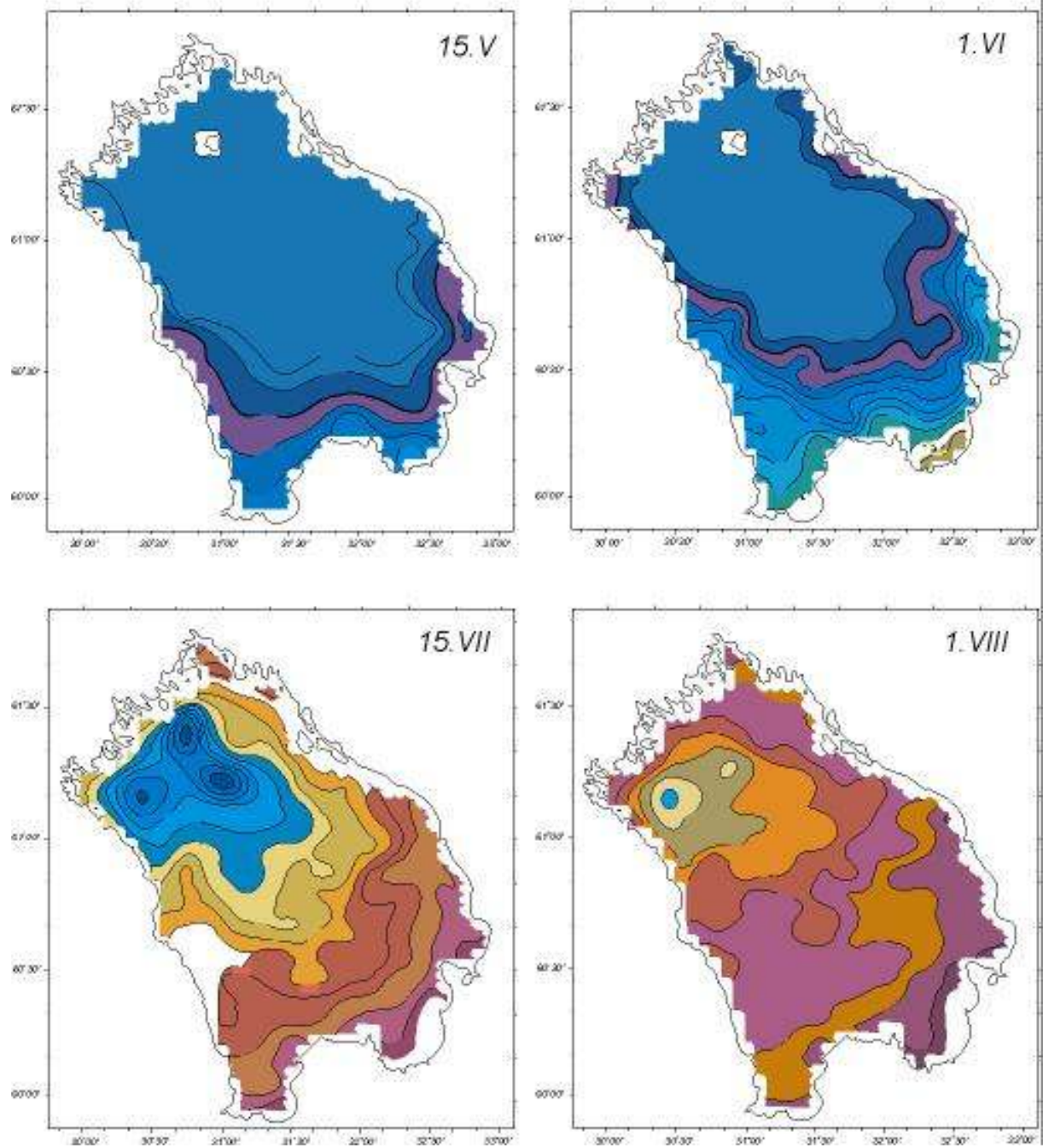
6. Physical Data

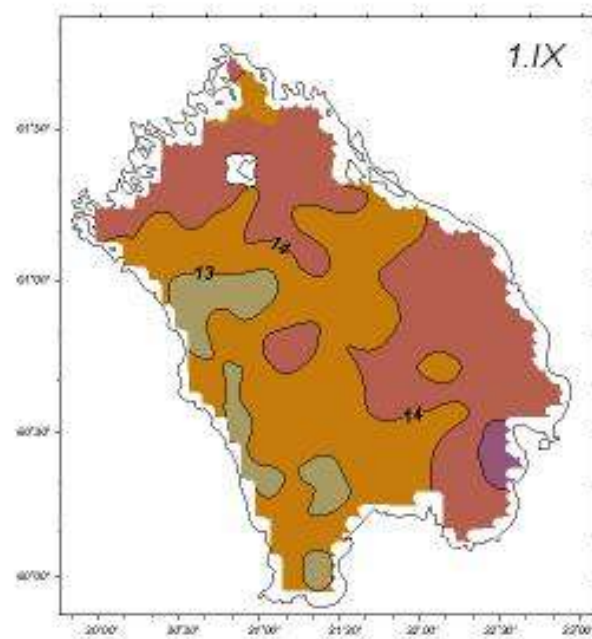
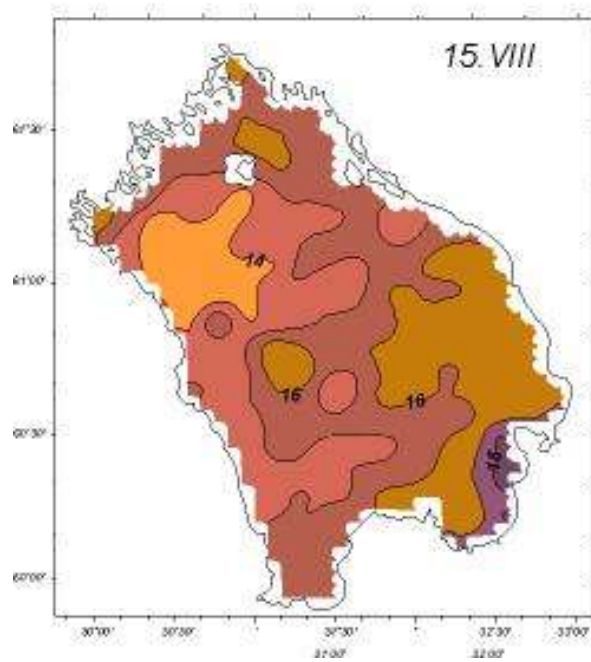
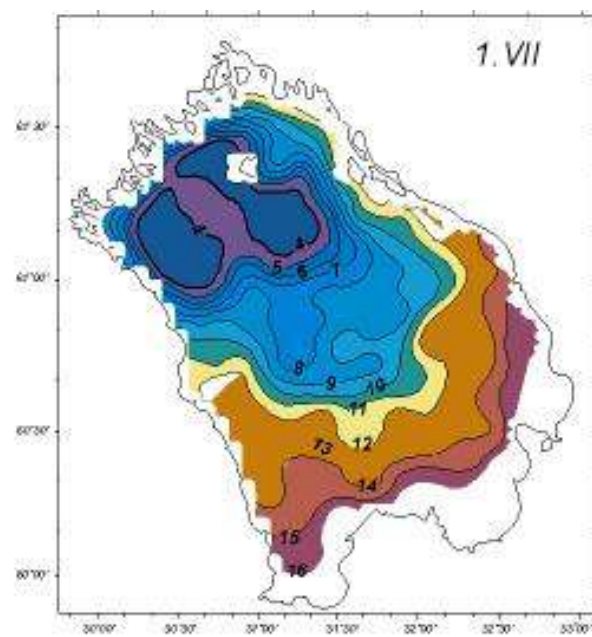
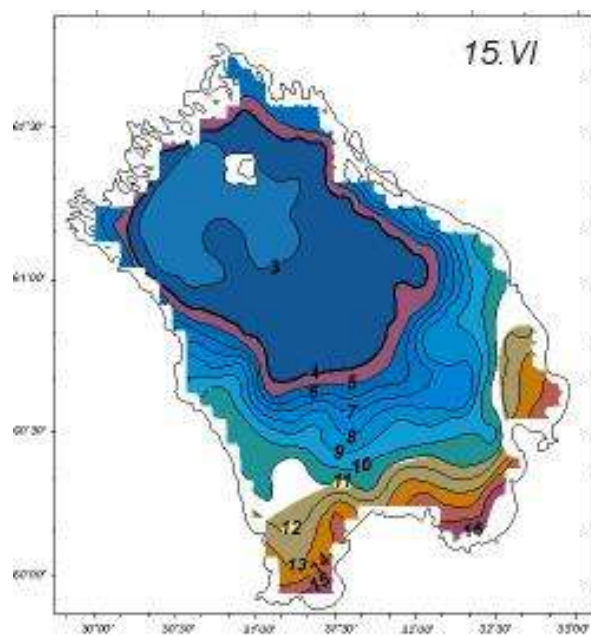
6.1 Temperature of water

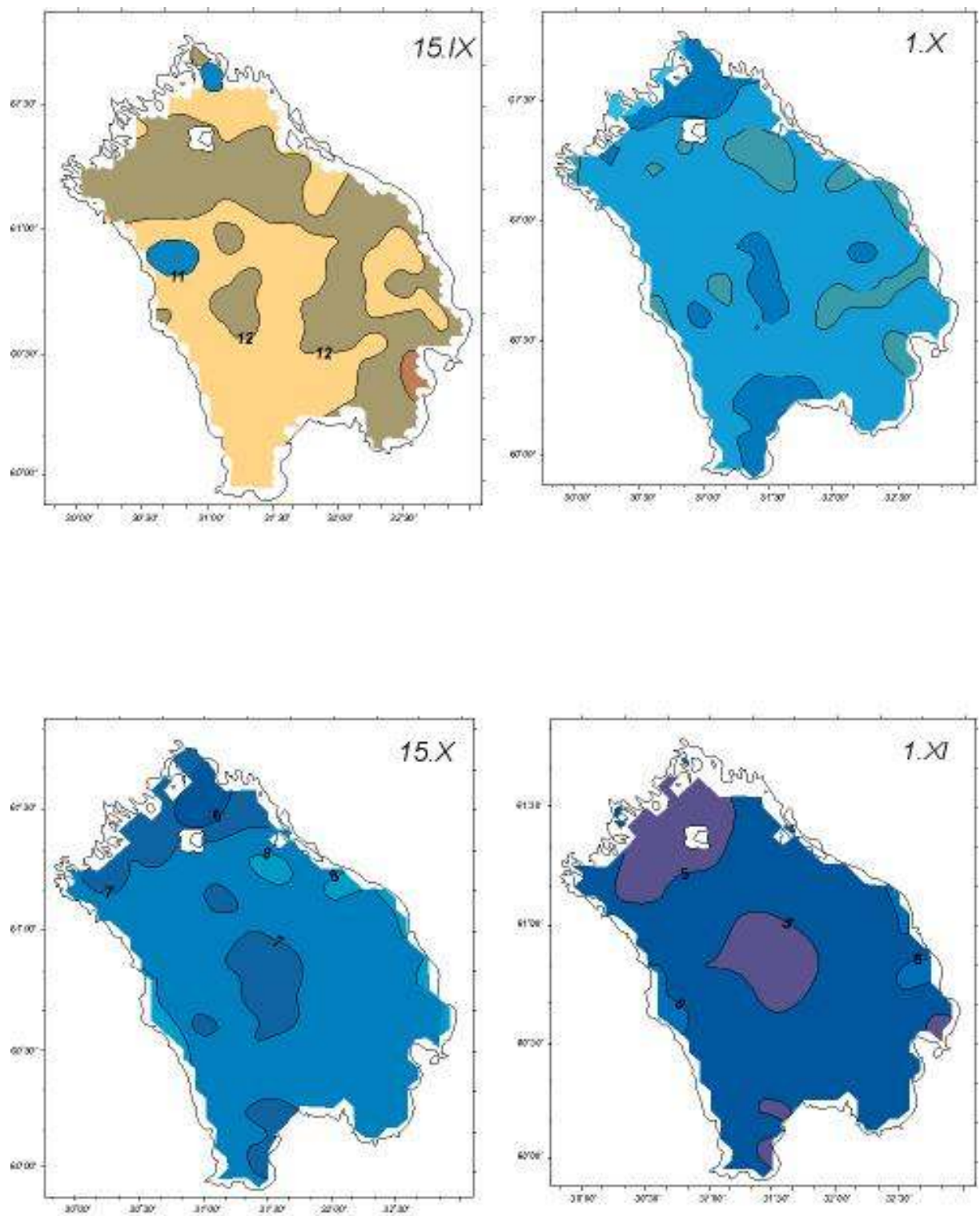
By the character of thermal regime Ladoga belongs to the lakes of moderate zone with surface water temperature in summer above 4°C, and in the winter below 4°C, with significant seasonal fluctuations and two regular periods of circulation – in spring and in the late autumn (Ladoga Lake, the Atlas, 2002).

6.1.1 Versus time

The distribution of surface water temperature





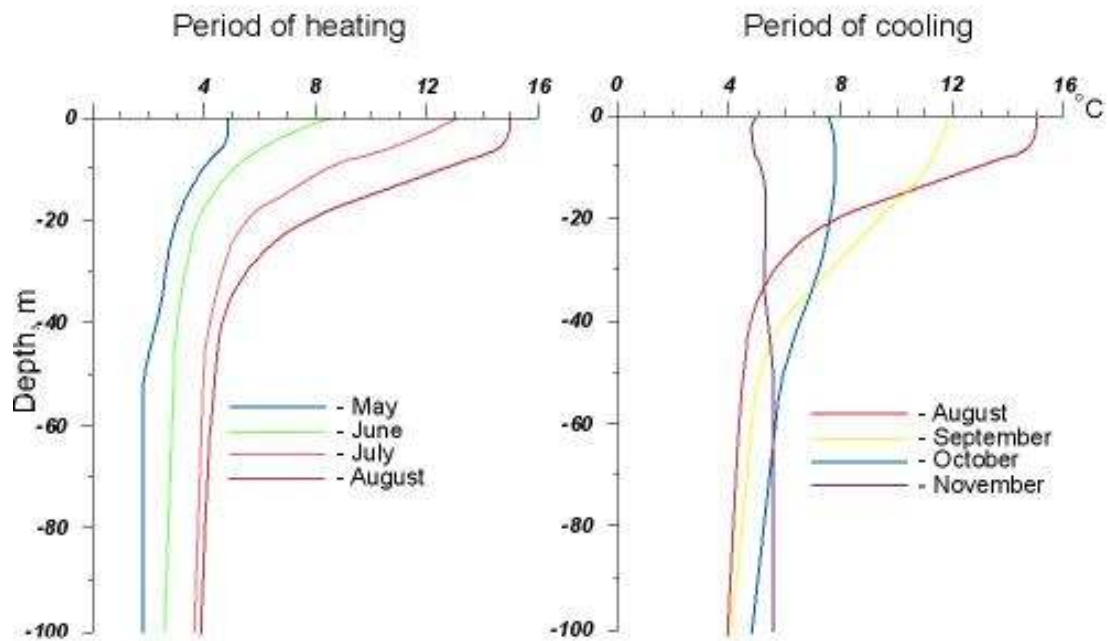


Authors M.A.Naumenko, S.G.Karetnikov, V.V.Guzivatiy

Fig. 9. Average long-term distribution of surface water temperature

6.1.2 Versus depth

The distribution of water temperature by depths



Authors M.A. Naumenko, S.G. Karetnikov, V.V. Guzivatiy

Fig. 10. Average long-term distribution of water temperature by depth

6.2 Freezing period and extent of freezing

The ice cover on lake starts to be formed on the average in the second half of November and become completely formed about February 15. Full freezing of lake occurs not every year. In the connection with the greater resources of heat accumulated in the huge water mass during summer period, in warm winters the central part of lake remains free from ice cover. Ice break is marked in the first decade – middle of May, and getting free of ice occurs in the second half of May, but in some years blocks of ice can be met up to the middle of June.

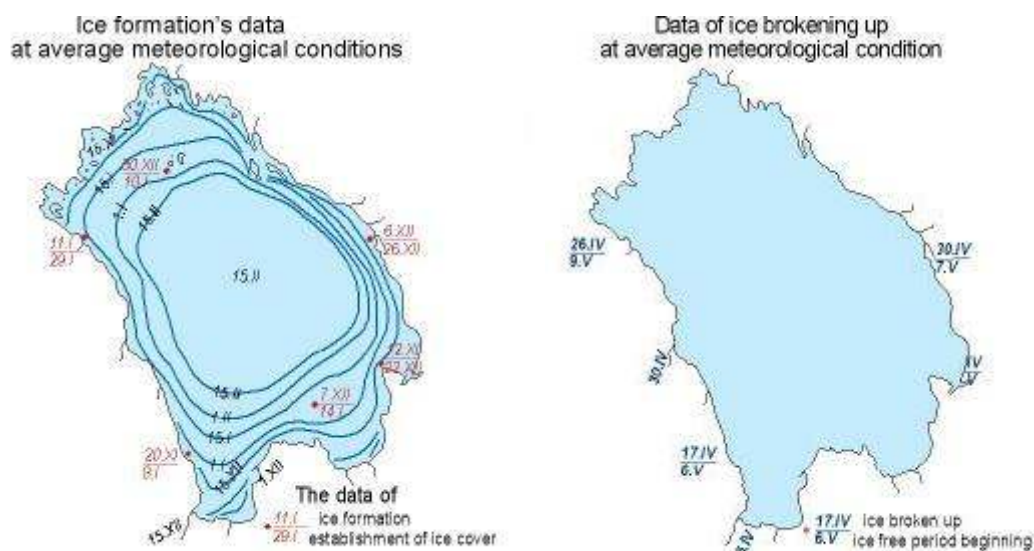


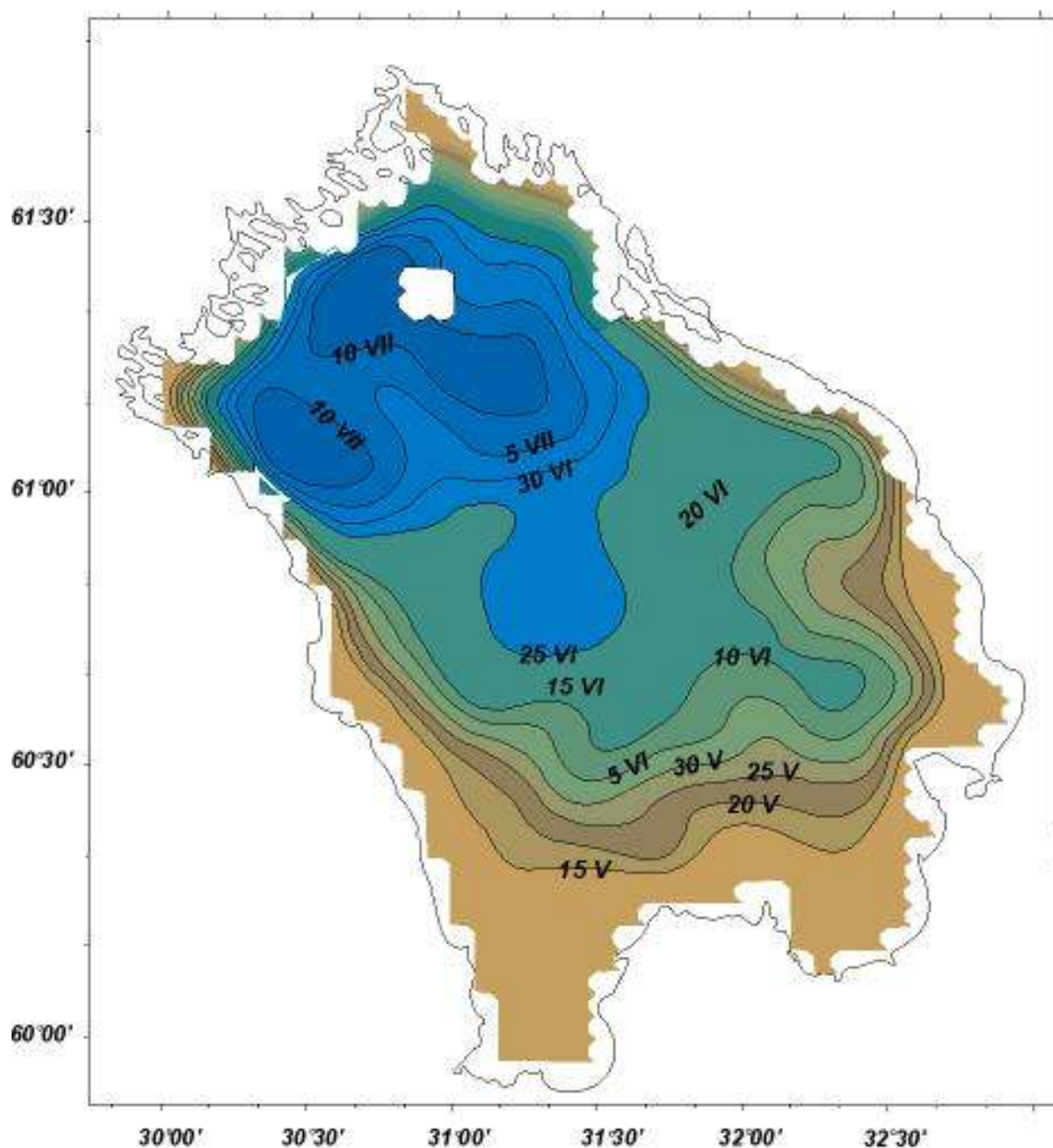
Fig. 11. Typical dates of freezing-over and opening of Ladoga Lake (authors: V.V. Borodulin, V.P. Vlasov, L.K. Egorov, S.G. Karetnikov)

6.3 Mixing

6.3.1 Vertical

The annual thermal cycle of lake consists of four periods: vernal calefaction, summer warming-up, autumn and winter cooling. During periods of vernal calefaction (from beginning of May) and autumn cooling (from beginning of November) in the lake there is thermal bar. In spring first of all offshore areas get warm, and on their border with cold-water central part of lake there is thermal bar which is gradually shifted to deep-water part. To the beginning of hydrological summer the greatest difference in water temperatures on both sides thermal bar is noted. With disappearance of thermal bar in the lake the field of dense water with a top above deep-water area is formed and direct thermal stratification with the layer of thermocline over all water body is formed. (Ladoga Lake, the Atlas, 2002) In the end of July – beginning of August water temperature in epilimnion reaches maximal values 16-18°C whereas under the layer of thermocline there is cold water of 4°C.

Average position of the spring termobar at the water surface



Authors M.A. Naumenko, S.G.Karetnikov, V.V.Guzivatiy

Fig. 12. Average position of spring frontal boundary (termobar) on Ladoga Lake surface

6.3.2 Horizontal (Note main bays, sub-basins of lake.)

Morphological features of the lake hollow and related to them differences in the speed of water warming up over different depths lead to the originating and sustainable in time existence of contrast thermal zones, that in turn defines character and development of

large-scale dynamic processes in the lake. The carried out zoning of depths of Ladoga Lake has allowed here to mark out 6 areas (Naumenko, 2002):

1 - The shallow zone covering coastal water area and including practically all shoals and banks. It is the zone being the most large on area (5550 km^2) in which, however, there is only 5.5% of the Ladoga water volume;

2 - Transition zone (18-50 m) with greater in comparison with the first zone slope of bottom ($9.8 \cdot 10^{-3}$ against $0.3 \cdot 10^{-3}$) and with much greater speed up of wind, its area is 4685 km^2 , here there is 18.3% of water volume;

3 - The zone of lacustrine terrace (50-70 m) traversed by set of ridges, with a little bit smaller slopes of bottom ($0.5 \cdot 10^{-3}$). Area of this zone is 3797 km^2 , here there is the greatest volume of water in the lake - 26.6%;

4 – The slope zone of (70-100 m) with slope of bottom $1.5 \cdot 10^{-3}$. Its area is 1746 km^2 , in it there is 17.3% of the total amount of water;

5 - Deep-water zone (100-140 m) with slope of bottom $5 \cdot 10^{-3}$ and area 1521 km^2 , here there is 21.3% of lake water;

6 - Hollows (more than 140 m) are isolated from each other and occupies total area 568 km^2 , here there is 10.9 % of lake water.

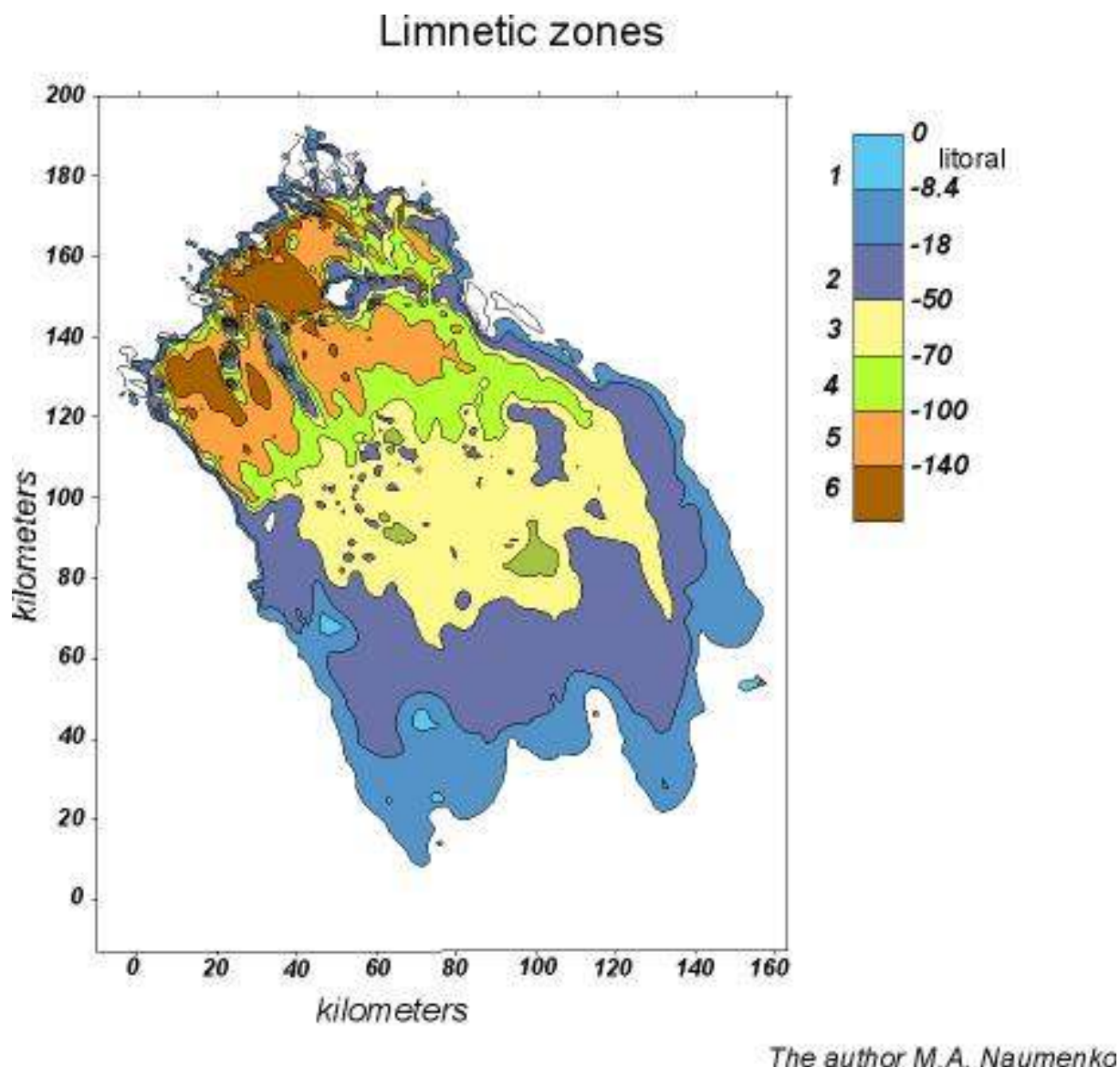


Fig. 13. Limnetic zones of Ladoga Lake

6.4 Stratification

6.4.1 Period and extent of stratification

In the lake there is well-expressed vertical thermal stratification, and depth of thermocline is about 30–40 m. Below thermocline water temperature decreases quickly and in July–August at the bottom it is +4 – +5°C.

7. Chemical Data

Water of Ladoga Lake possesses high natural properties. It is "soft", low mineralized (63.6 mg/l on average). In 1960–2000 it was 55.6–67.4 mg/l depending on abounding in water of separate groups of years (Raspletina et al., 2002). Main water mass of lake (profundal and ultra-profundal) has low spatial and temporal variability. Interannual stability of parameters of

water mineralization is supported also by the slowed down water exchange. Coastal zone is characterized by more significant differences.

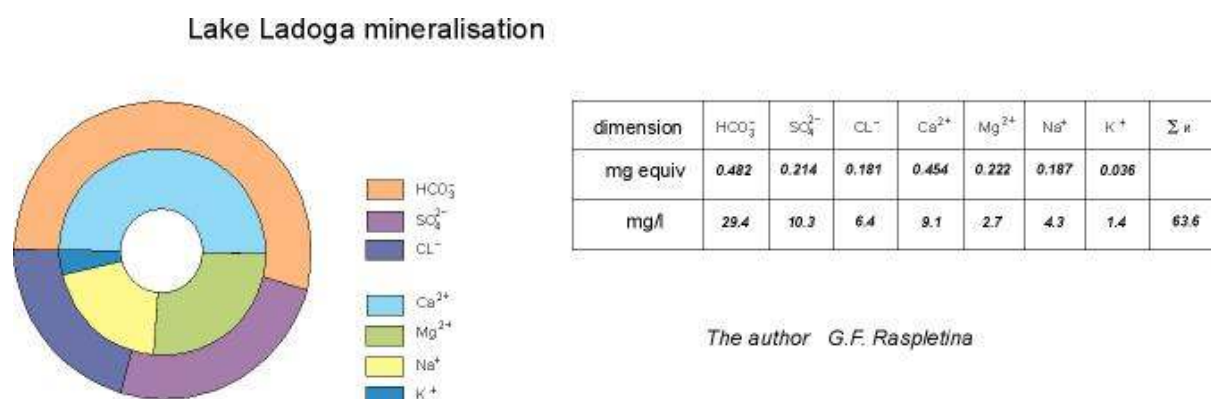


Fig. 14. Mineralization and ionic composition of main water mass in Ladoga Lake

Water transparency in the lake is rather low because of it is colorized by humic substances coming from the catchment area together with paludal drain. During the autumn period it is by Secchi disk 3–4 m (Ladoga Lake, the Atlas, 2002), but in separate sites (to the West from Valaam Island) it can reach 8–9 m (Kalesnik, 1968). In summer the water transparency is lower because of intensive phytoplankton development and also varies within the limits of 2–3 m. Transparency in southern bays is lower and rises as going to the central areas.

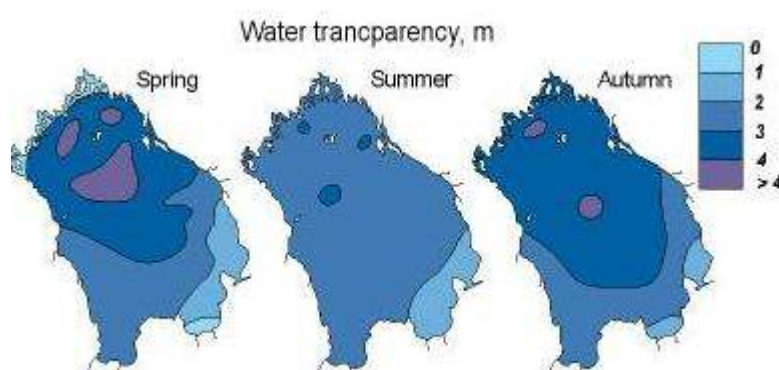


Fig. 15. Water transparency by Secchi disc (author: E.A. Yudin)

Water of lake in ordinary years is characterized by rather stable (especially in the central area) pH being close to 7.2–7.6 feebly and changing with lake areas and seasons. The same picture is peculiar also for the concentration of oxygen in water. In the ice-free period its

concentration at the surface and at the bottom are usually 95–100% and only in some sites of some bays (for example, Volkhov Bay) near to mouths of large tributaries can noticeably deviate from normal values (Ladoga Lake, the Atlas, 2002). Deviations from normal values of pH and the concentration of oxygen in water observed in some (abnormal) years do not have catastrophic character and do not influence negatively specific biota of Lake Ladoga.

As a whole water of Ladoga Lake by the spectrum of hydrochemical parameters is remarkable of high quality and corresponds to the inherent to the lake properties of coldwater northern water body with the favorable environment for life of aquatic organisms the most exigent to conditions of existence.

7.1 Concentrations: The state of chemical water quality in general including the states of eutrophication, i.e., oxygen demand, N and P concentration values (organic, inorganic, particulate, total, if available), salinity, organic and inorganic chemical pollution.

In the beginning of 1960s concentration of dissolved oxygen in the water of Ladoga Lake in the open part of lake did not drop below 90-120% of saturation. At the bottom even on maximum depths (more than 200 m) concentration of oxygen was not lower than 90-95% of saturation. Concentration of biogenic elements and first of all phosphorus was low and averaged for a year was: general phosphorus 10 µg/l, mineral phosphorus 3 µg/l. To the beginning of 1980s ecological state of lake has changed sharply. Concentration of mineral phosphorus in the central and northern areas of lake increased by 4-5 times, in the southern and eastern areas by 3 times that was consequence of increased income of phosphorus from drainage area and with precipitations. Concentration of phosphorus in 1976-1980 was up to 26 µg/l. (Raspletina, Susareva, 2002). Concentration of oxygen during winter period in deep-water areas was depressed not only at the bottom, but also on the surface. In spring there were distinct from others areas with the relative concentration of oxygen in the water less than 90%. In the places which are being under direct influence of run-off waters, periodically or constantly there was deficiency of oxygen. In 1988-1992 in connection with economical recession the ecological state of lake has started to improve. Concentration of phosphorus has dropped up to 20-21 µg/l, in 2000s its further decrease up to 16-18 µg/l was observed. The average concentration of general nitrogen for 1976-2000 was 650 µg/l, a distinct trend has not been observed. Maximal concentration of general organic carbon was observed during 1983-1985 and was 9.1-9.5 g C/m³. From 1986 it was outlined a trend of reduction of pool of organic substance up to 6-7 g C/m³. Maximal concentration chlorine-organic compounds up to 2-5 ng/l are observed in the areas of confluence of rivers Volkhov, Svir, Vuoksi (Drabkova, 2009).

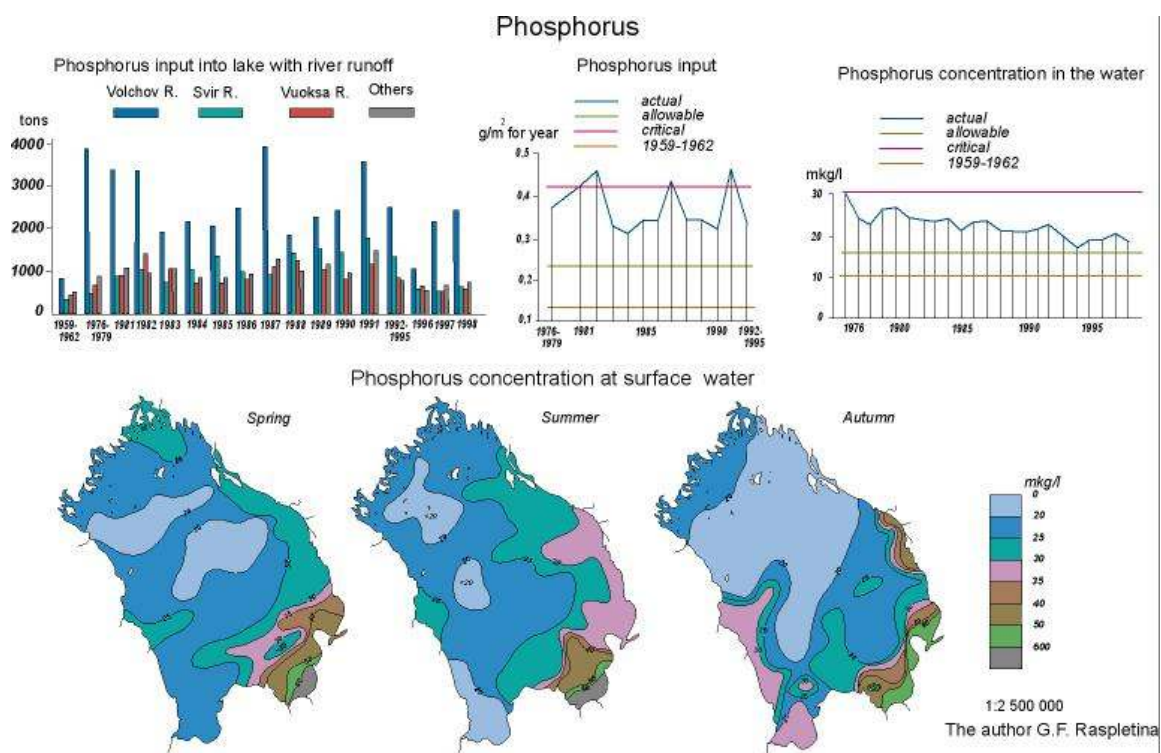


Fig. 16. Income of total phosphorus with riverine water. Phosphorous loading on the lake. Average concentrations of total phosphorus in the lake water. Distribution of total phosphorus in in the surface water layer.

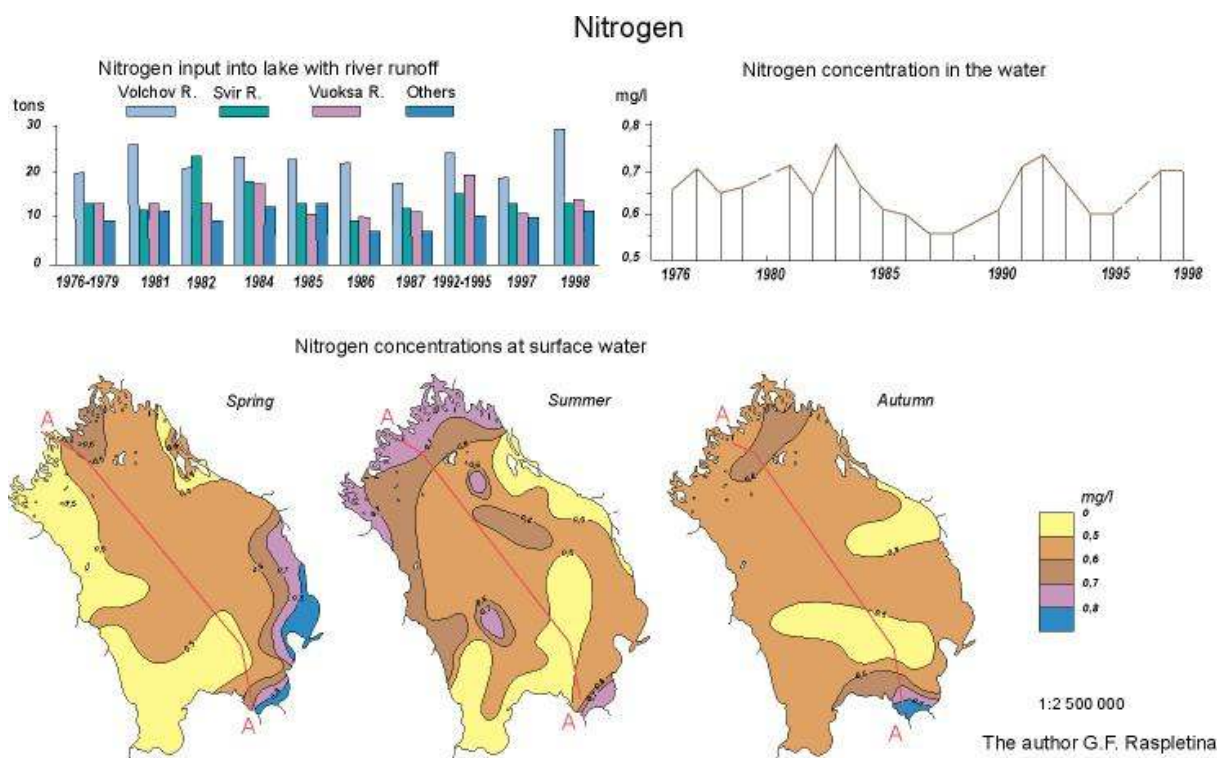


Fig. 17. Income of total nitrogen with riverine water. Average concentrations of total nitrogen in the lake water. Distribution of total nitrogen in in the surface water layer.

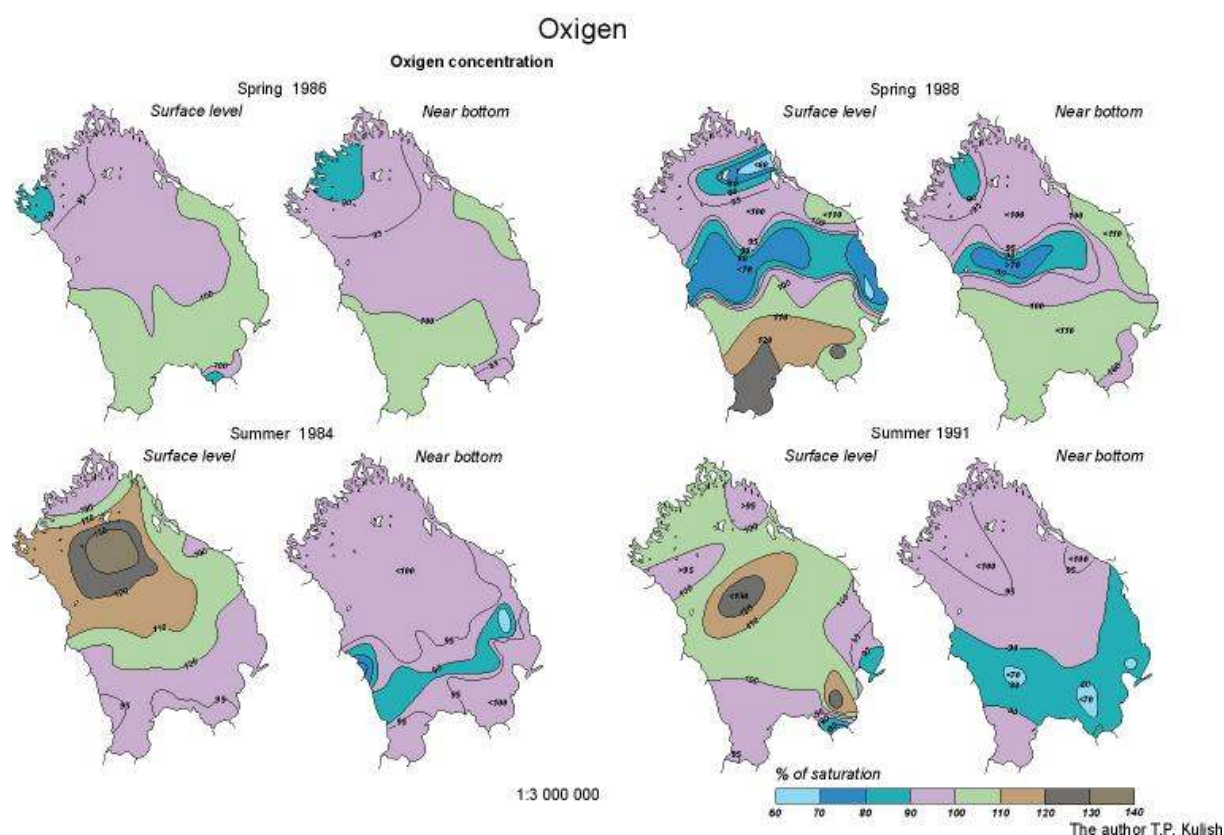


Fig. 18. The oxygen regime.

8. Biotic Data (Main species, exotics, productivity change through time)

8.1 The overall state of the lake ecosystem including its biodiversity

Hydrobiological processes occurring in the lake during last time are characterized by sufficient stability supported by inertness of huge volume of water mass and slowed down water exchange. Prevailing of conservative deep-water zones over dynamical shallow areas of littoral zone and bays has essential significance in the maintenance of biotic component stability in the lake ecosystem.

8.2 Phytoplankton, Zooplankton, Fish

Prior to the beginning of the 1960s phytoplankton of Ladoga Lake was poor and conformed to character of coldwater low-productive oligotrophic water body. During all year diatoms prevailed. The sharp increase in the income of phosphorus, started in the 1960s, stimulated expansion of the circle of mass species and increase of quantitative characteristics of phytoplankton (abundance, biomass, primary productivity) (Ladoga Lake, the Atlas, 2002).

As a result to the 1980s the lacustrine phytoplankton by the majority of numerical parameters and by species composition already conformed to the level mesotrophic water body.

From the beginning of 1990s in connection with accepting of some nature protection measures and the economical recession which has started in this period income of phosphorus to the lake has essentially dropped. As consequence, phytoplankton community has started to be restored gradually. As have shown by researches of last time, phytoplankton development in the lake corresponds to the parameters peculiar to mesotrophic water body (biomass 1.1–1.8 g/m³, chlorophyll "a" 4.8–8.5 mg/m³) (Rumyantsev, Drabkova, 2007; Letanskaya, 2002).

Composition of lacustrine phytoplankton varies during period of vegetation. Intensive development of vernal species, predominantly diatoms, starts from the middle of April in the offshore areas under ice cover and gradually covers all heat-active area of the lake (*Aulacosira islandica*, *Diatoma elongatum*). In much later getting warm deep-water areas the typical vernal plankton (*Asterionella formosa*, *Diatoma elongatum*) practically has no time to be formed before formation of well warmed up epilimnion (Ladoga Lake, the Atlas, 2002).

In shallow areas of lake summer species become numerous from the middle of June, and in the deep-water - from the beginning of July up to the end of August. Summer plankton is the most various by composition, especially during eutrophication, and is quantitatively more uniform over territory, than vernal (Ladoga Lake, the Atlas, 2002). Prior to the beginning of anthropogenic eutrophication diatoms (*Asterionella formosa*) prevailed in it, on the eutrophication stage, up to the middle of 1980s it was mass cyanobacteria of naturally eutrophic lakes (*Oscillatoria tenuis*, *O. planctonica*, *Microcystis aeruginosa*), then the role of dominant has transferred again to oligotrophic species: diatoms (*Fragilaria crotonensis*), yellow-green algae (*Tribonema depauperatum*), cyanobacteria (*Aphanizomenon flos-aque*, *Woronichinia naegeliana*).

In the autumnal plankton there is characteristic combination of late-summer species with spring-autumn diatoms (*Aulacosira islandica*, *Diatoma elongatum*).

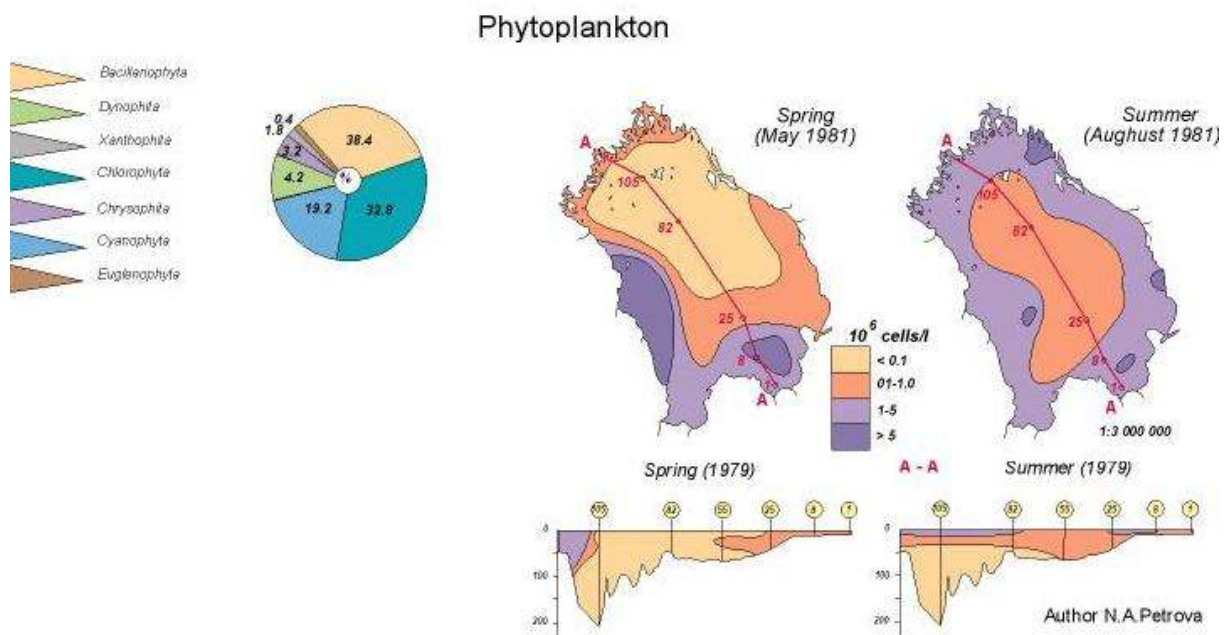


Fig. 19. Phytoplankton (taxonomic composition and spatial distribution).

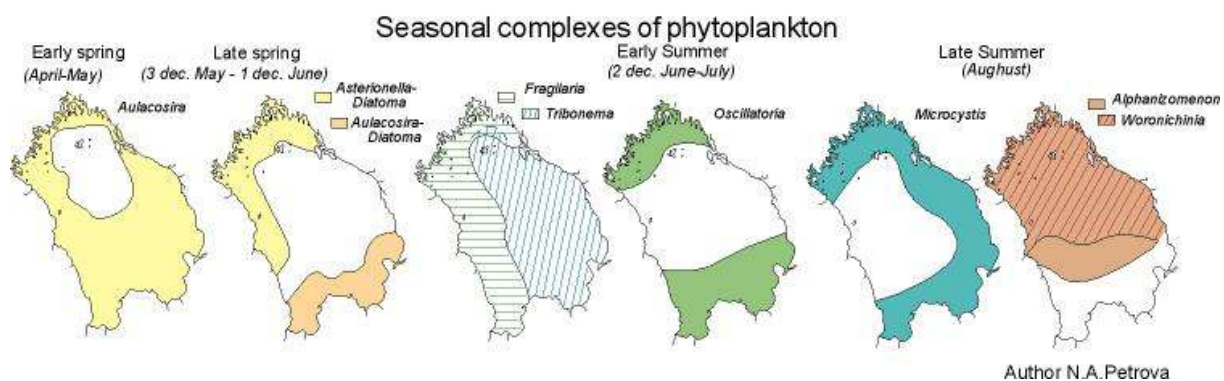


Fig. 20. Main seasonal complexes of phytoplankton.

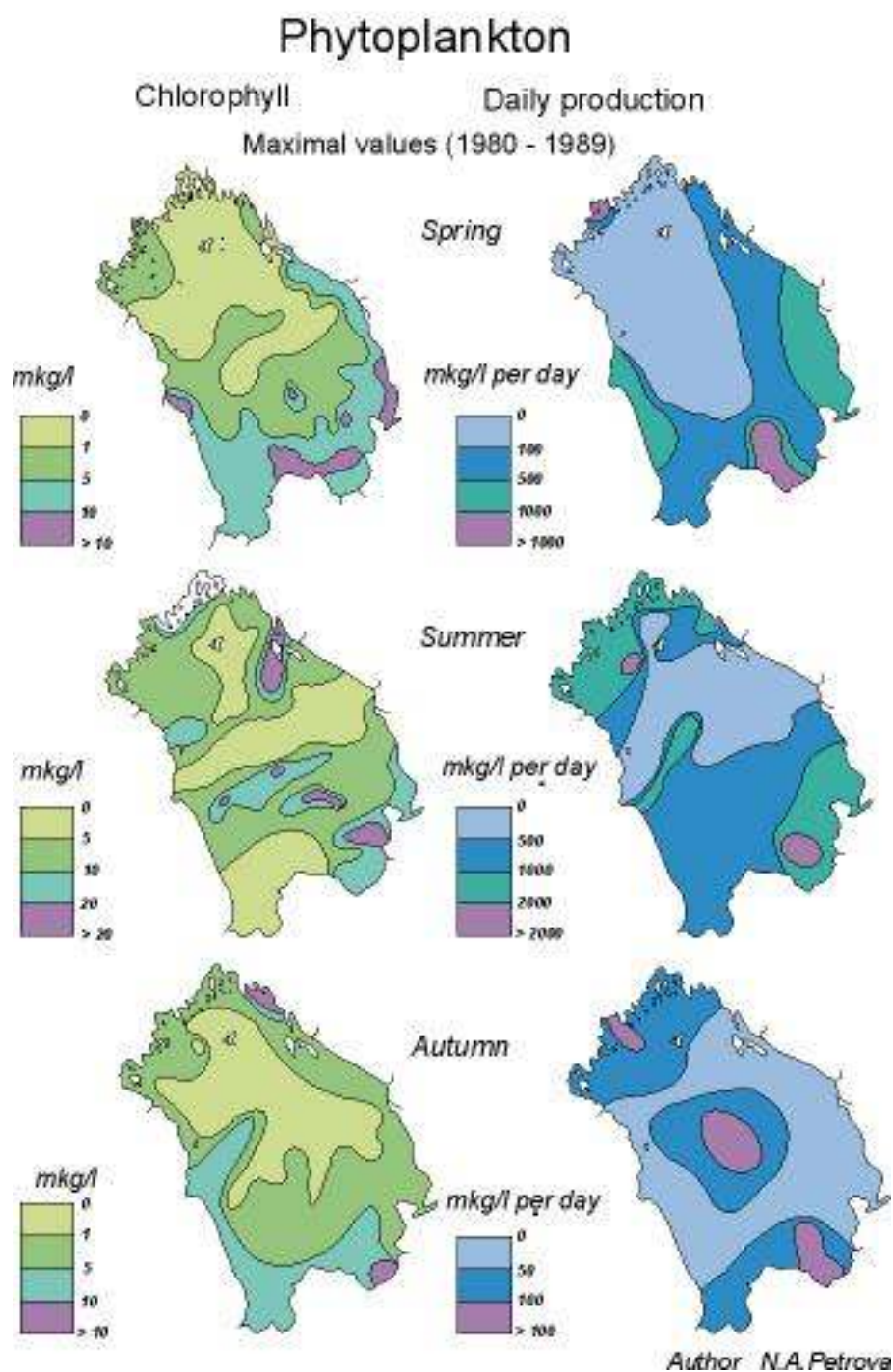


Fig. 21. Spatial distribution of chlorophyll-a and daily production of phytoplankton.

Zooplankton of Ladoga Lake is characterized by great diversity of species among which in the central zone there are dominating *Asplanchna priodonta*, *Conochilus unicornis*, *Kellicotia*

longispina, *Notholca caudata*, *Keratella cochlearis*, *Bosmina longispina*, *B. kessleri*, *Daphnia cristata*, *Bythotrephes cederstroemii*, *Eudiaptomus gracilis*, *Mesocyclops leuckarti*, *M. oithonoides*, *Cyclops lacustris*, *Limnocalanus macrurus*. The same species, except of *Cyclops lacustris*, *Limnocalanus macrurus*, are prevailing in the open littoral of the western and eastern coasts. In the southern bays of lake among dominants such species as *Limnosida frontosa*, *Daphnia cucullata*, *Eurytemora lacustris* are noted. In isolated from the main water area skerries *Trichocerca cylindrica*, *Chydorus sphaericus*, *B. longirostris* are also dominants (Ladoga Lake, the Atlas, 2002).

During the maximal development of zooplankton during summer season extreme heterogeneity of its spatial distribution and large range of quantitative parameters is observed. The minimal values are characteristic for pelagial, maximal - for isolated overgrown with aquatic vegetation bays and skerries. The gradient of seasonal changes of abundance and biomass also is great (Ladoga Lake, the Atlas, 2002).

In the upper water layers where the maximal concentration of zooplankters is noted, nowadays their number and biomass correspond to weakly mesotrophic and in hypolimnion to oligotrophic levels of trophism. During 30 years (1970s – beginning of 2000s) biomass in the most productive layer 0–10 m remains stable (Rumyantsev, Drabkova, 2007).

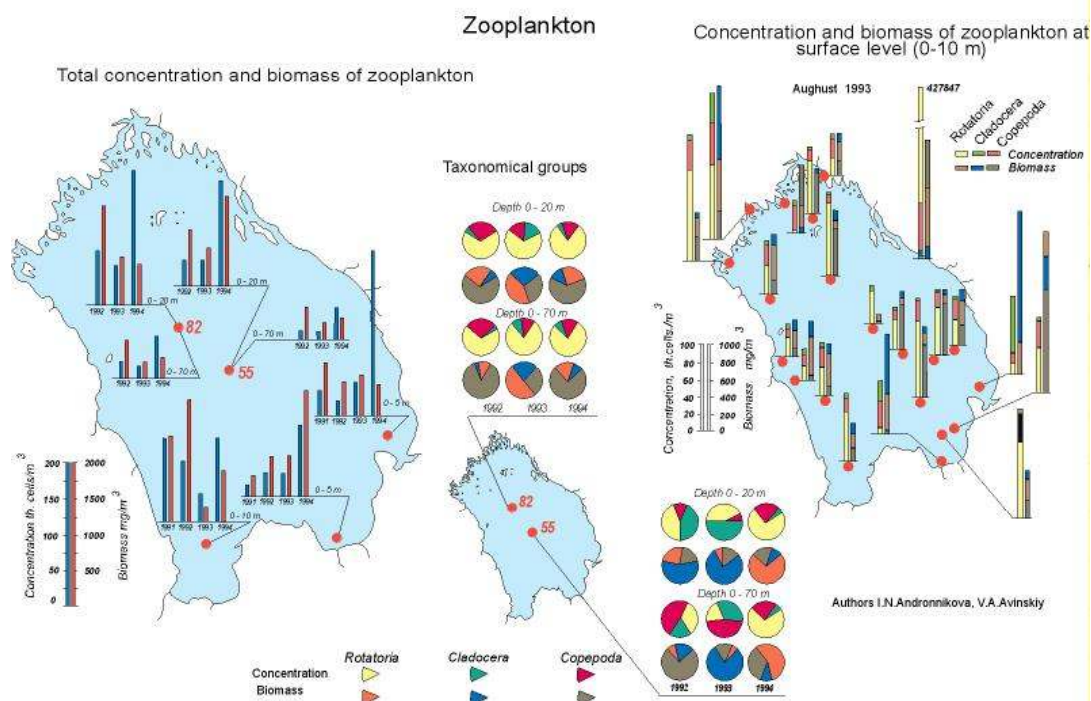
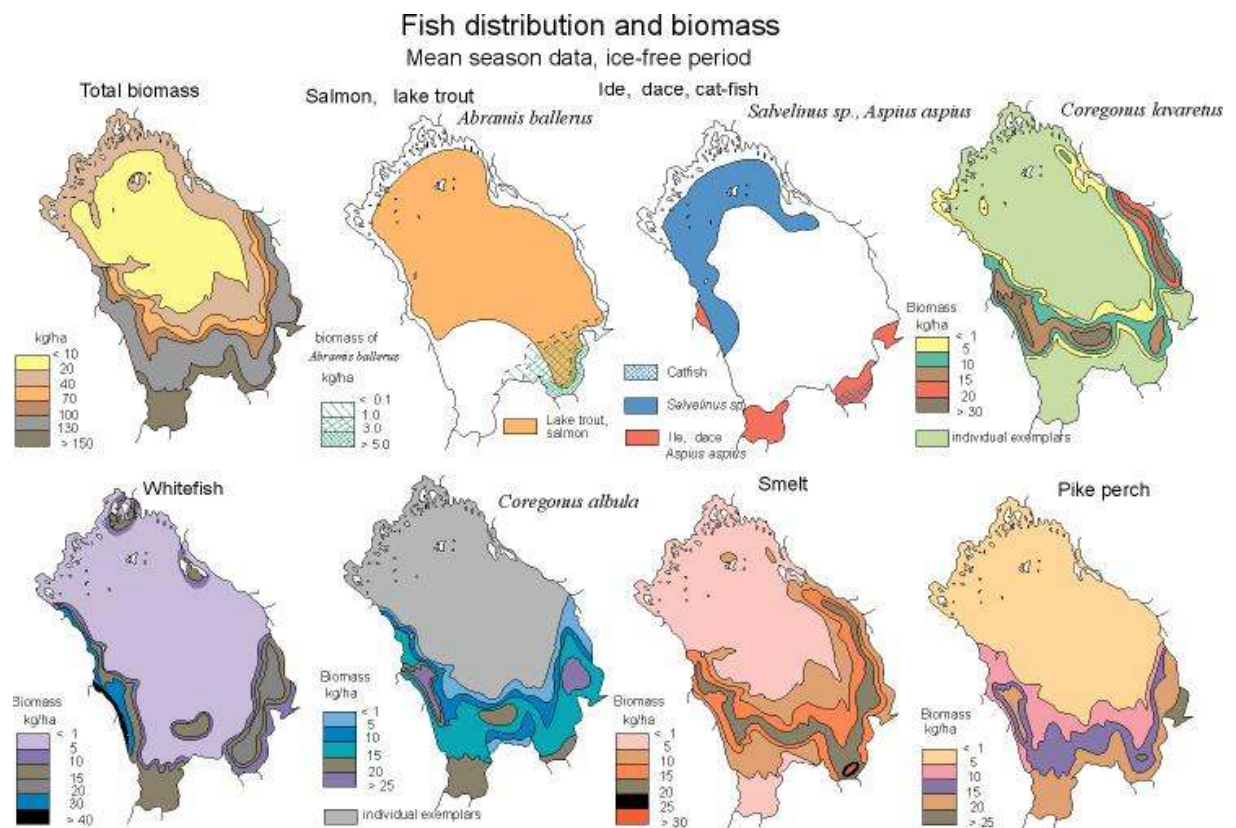


Fig. 22. Zooplankton (total number and biomass, number and biomass in the upper water layer)

Ladoga Lake has large fish stocks. Totally in the lake there find 53 species and varieties of fishes being by origin glacial-marine (Ladoga bullhead), glacial relicts (salmon, trout, bull-trout,

white-fishes, vendace, smelt, lampreys, etc.), southern species (bream, zarte, blue bream, white bream, rudd, asp, wels, zander, etc.). Salmonids and cisco, as northern species, are the most typical for the lake and are distributed over its all water area, unlike the southern species living predominantly in its shallow southern part.

Anthropogenic impact on the water body reduces number of the most valuable fishes - salmon, trout, a bull-trout, lacustrine-riverine white-fishes.



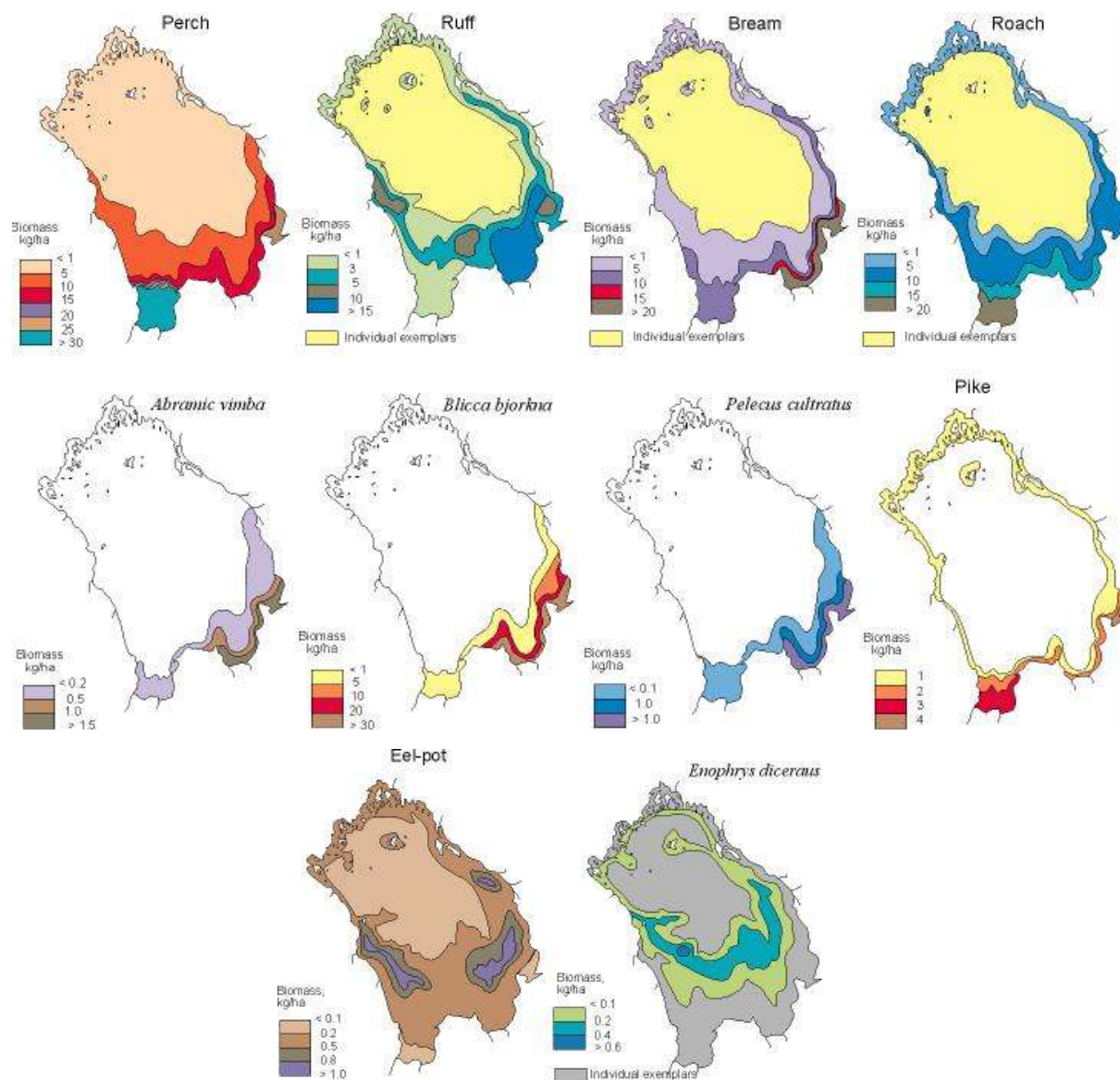


Fig. 23. Distribution and biomass of fishes.

8.3 Benthos, avifauna

The major component of benthic biocenoses of Ladoga Lake is meiobenthos. By origin in its composition there are distinguished constant components (Nematoda, Ostracoda, Harpacticoida, bottom Cyclopoida, Tardigrada, etc.), juvenile stages of macrobenthos organisms (Oligochaeta, Chironomidae, Mollusca, etc.) and benthic stages of pelagial inhabitants. In meiobenthos of Ladoga Lake there are invertebrates from the following taxa: Nematoda, Oligochaeta, Turbellaria, Tardigrada, Bivalvia, Gastropoda, Rotatoria (classes), Ostracoda (subclass), Cladocera, Cyclopoida, Harpacticoida, Acari, Ephemeroptera, Plecoptera (orders), Chironomidae, Ceratopogonidae (families). From these taxa there are

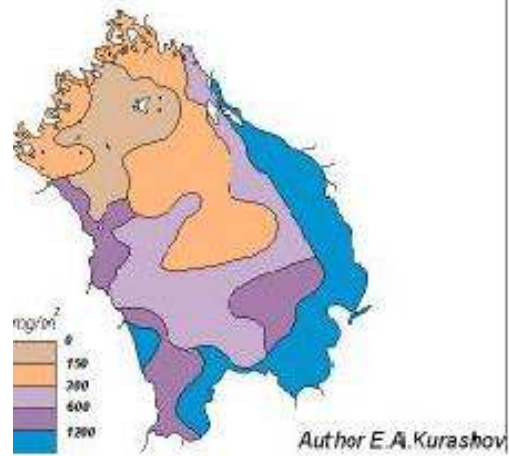
mass and the most met Nematoda, Cyclopoida, Harpacticoida, Oligochaeta, Ostracoda, Cladocera, Chironomidae. Totally in meiobenthos of Ladoga Lake there is found by present time 186 species and varieties of Invertebrata. Meiobenthos plays important role in the processes of creation of secondary production in the lake. In the coastal area it makes 62.3% of total zoobenthos production, in deeper zones its share drops up to 28-32% (Ladoga Lake, the Atlas, 2002).

The most often found in Ladoga Lake group of macrobenthos is Olygochaeta, it is found in all types of grounds and on all depths. In the central area of lake the most typical representatives of Olygochaeta are *Lamprodrilus isoporus*, *Spirosperma ferox* and *Stylodrilus heringianus*. On low depths the most widespread is *Isochaetides newaensis*. Other widespread in Ladoga Lake group of macrobenthos is Amphipoda presented by 5 species and including 3 relicts: *Pontoporeia affinis*, *Pallasea quadrispinosa*, *Gammaracanthus loricatus*. In 1990 baikalian *Gmelinoides fasciatus* has appeared in the lake and quickly has propagated itself. Chironomidae are in the lake much less often, their most typical representative is *Trissocladius parataricus*.

Benthos in the lake is distributed not evenly. Number and a biomass of bottom organisms correlate with depths. In the most deep water areas (70–100 m and more) the biomass of benthos is insignificant and makes 0.4–0.9 g/m², on depths 20–70 m it raises up to 3.0–5.9 g/m². In shallow areas of western and east littoral benthos biomass varies within limits of 2.2–3.6 g/m², in bays it is 5.4 g/m², and in Volkhov Bay it reaches 12.6 g/m² (Barbashova, Slepukhina, 2002). As positive feature Ladoga Lake benthos it is necessary to note mass development of amphipods and mysids on the significant areas of bottom, serving the important food objects for such leading commercial fishes, as whitefishes and pike perch. In the range of depths 20–70 m biomass of amphipods makes 1.9–4.5 g/m² and by this parameter they surpass other groups of benthos (Oligochaeta, Chironomidae). Since the middle of 1990s in the benthos structure some relic species, almost disappeared in the last decades (for example, *Gammaracanthus lacustris*) (Rumyantsev, Drabkova, 2007) began to meet again.

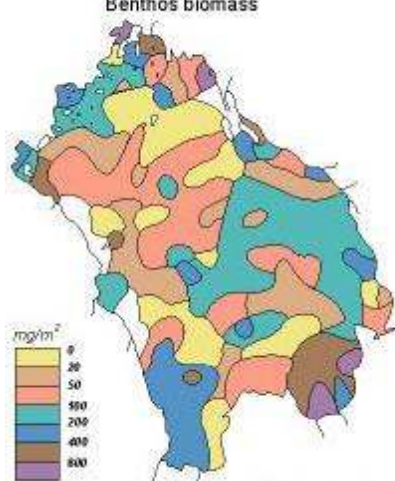
Meyobenthos

Benthos biomass



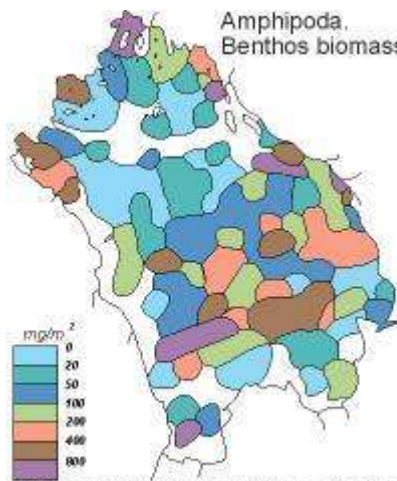
Macrobenthos

Oligochaeta
Benthos biomass



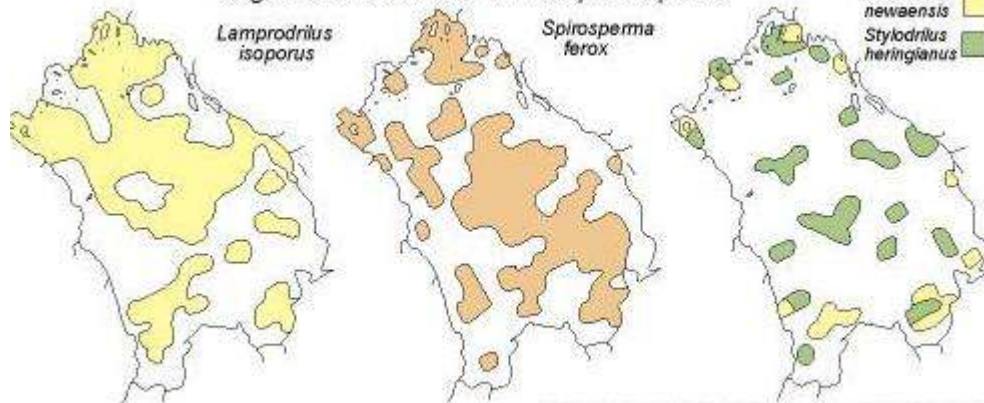
Authors T.D. Slepukina, V.V. Menshutkin, M.V. Menshutkina

Amphipoda
Benthos biomass



Authors T.D. Slepukina, V.V. Menshutkin, M.V. Menshutkina

Oligochaeta. Distribution of widespread species



Authors T.D. Slepukina, V.V. Menshutkin, M.V. Menshutkina

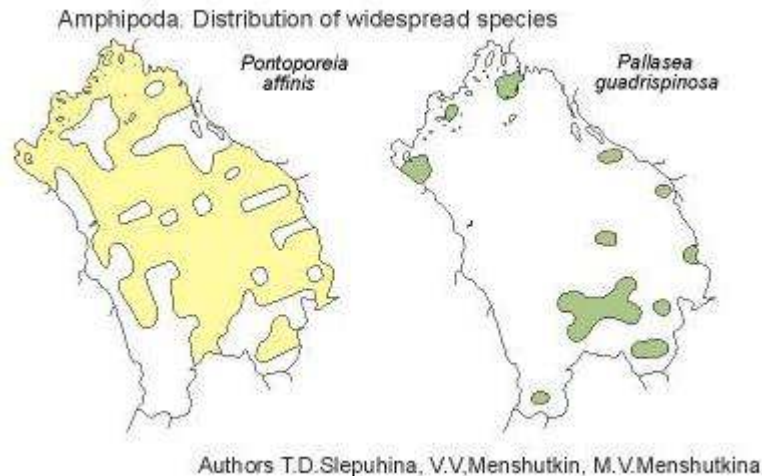


Fig. 24. Distribution of benthos and meiobenthos biomass (Oligochaeta, Amphipoda).

Higher aquatic vegetation in Ladoga Lake is presented by 108 species. The leading part in overgrowing plays ordinary cane (*Phragmites australis*). Plants with floating leaves covers small area, on significant part of littoral groupings of submersed pondweed (*Potamogeton perfoliatus*) are widespread.

Among predominant species of macrophytes there are presented:

Aero-aquatic: *Phragmites australis*, *Scolochloa festuacea*, *Glyceria maxima*, *Scirpus lacustris*, *Eleocharis palustris*, *Equisetum fluviatile*.

Floating: *Nuphar lutea*, *Polygonum amphibium*, *Potamogeton natans*, *Hydrocharis morsus-ranae*, *Stratiotes aloides*, *Sparganium emersum*.

Submersed: *Potamogeton perfoliatus*, *P. gramineus*, *Elodea canadensis*, *Myriophyllum spicatum*.

Production of higher aquatic plants is created mainly by two species - ordinary cane (*Phragmites australis*) and pondweed (*Potamogeton perfoliatus*). The total annual production of macrophytes is evaluated as 63 thousand tons (absolutely dry mass) (Ladoga Lake, the Atlas., 2002). More than ¾ of total production is produced in the southern area of lake and about 15% in the skerry area. Only 6.6% of production is in the areas of open western and eastern shores.

8.4 Linkages (e.g., Describe briefly the ecosystem/biodiversity issues in general with regard to littoral wetlands, rivers, air (birds, etc.).

Anthropogenic eutrophication that became apparent in Ladoga Lake in the beginning of

1980s, and pollution of water environment with xenobiotics has negatively affected the lake biota. The most sensitive to pollution species began to drop out from the structure of planktonic and benthic communities. Increasing role was got by organisms with wide ecological valence, tolerant to organic and toxic pollution. Among benthic organisms number of species from glacial-marine relic complex decreased. Earlier widely widespread in Ladoga Lake crustacean *Pallasea* became small and seldom met. Other representative of this complex *Gammaracanthus* did not meet never during long time. There was essential structural reorganization of zooplankton. Number of crustacean fraction was reduced and in the community fine rotifers began to prevail. Most brightly this process has been expressed in some coastal areas (bays Petrokrepost, Volkhov, etc.). In number of polluted areas of bottom in polysaprobic zones many typical representatives of Ladoga fauna (area of Priozersk, skerries at Sortavala, area at Pitkaranta, etc.) have disappeared. Besides this under influence toxic xenobiotics some planktonic and benthic organisms had various morphological deviations from norm (ugliness). Attributes of deep pathology were marked in zooplankton community close to Pitkaranta. Among benthic organisms ugliness was observed in a gulf Schuchiy, near Laskela, at Pitkaranta, in the Volkhov bay, etc.

9. State of the Basin

9.1 Description of the catchment area including its size (in km²), general geography of the region in relation to the lake and other neighboring water bodies (other lakes connected in chain, for example), catchment (draining-in) system, catchment area of the out-flowing river (draining-out) system

Ladoga Lake is located in the western part of the vast catchment basin between N59° and N61° and N56° and N64° and E26° and E38°. The area of drainage basin of the lake is 258.6 thousand km², and its ratio to the area of water surface (relative drainage) is 14.5. High value of relative drainage of Ladoga Lake results high sensitivity of its ecosystem to the processes in the drainage area that is expedient to consider when estimating character degree of anthropogenic influences on the water body. Size of Ladoga drainage area is emphasized by such figures: its length from South to the North reaches 1100 km, from West to the East is 580 km (Raspletina, Susareva, 2006).

The drainage area by geographical sense is divided into four main parts: Svir-Onega (83.2 thousand km²), Volkhov-Ilmen (80.2 thousand km²), Vuoksa-Saimaa (66.7 thousand km²) and Ladoga Lake properly. At the same time it is divided between three states: Russia – 80.0%, Finland – 19.9% and Belarus – 0.1%. In turn the Russian part of Ladoga drainage area is divided between 7 subjects of the Russian Federation: Leningrad Region, Karelia, Novgorod Region, Pskov Region, Tver Region, Vologda Region and Arkhangelsk Region. The size of drainage area causes essential differences of conditions in its various parts. Though the lake basin as a whole is located in the zone of a taiga, but in the northern part it is middle taiga with prevalence of pine and spruce forests, in the southern part – southern taiga, and to the

south from Ilmen Lake – zone of taiga-broadleaved forests.

9.2 Basin hydrology (Briefly describe basin hydrology, including active as well as non-active parts.)

In Ladoga Lake drainage area there are about 50 thousand large and small lakes. By degree of richness by them the drainage area is divided into two main parts: one to the north from line Svir–Neva, other to the south from it. The main lake fund is located to the north of this line. So regarding river Vuoksa basin on Finland territory richness by lakes is 19.8%, and in the Russian part of this basin it is even 25.6%. In the Northern Ladoga region in Hiitola River basin it is 17.9%, and in the Svir-Onega part of basin it is 16.7%. In the southern part of Ladoga basin in Volkhov-Ilmen drainage area richness by lakes is considerably below – only 3.4% (Kudersky et al., 2000).

Ladoga drainage area is rich of marches which somewhere occupy significant areas. In Vuoksi River basin on territory of Finland level of marshiness varies within the limits of 10–50%. To the south from Ilmen Lake marshiness of territory reaches 3–35%, and in Polist' marsh landscape makes even 60–70% (Lesnenko et al., 1988; Istomin, Yakovlev, 1989). Large bogs together with numerous lakes create high regulation of drain, smoothing seasonal and (partly) interannual fluctuations.

Besides lakes and marches on the Ladoga drainage area there are numerous rivers and small rivers. They are 48 thousand with total length more than 126.5 thousand km. In Svir-Onega part of the basin there are counted 10570 water-currents with total length 34475 km that averages 0.41 km/km², and in Volkhov-Ilmen part there are counted 24841 with total length 59921 km, or 0.75 km/km². The rivers are mainly short. The longest are Lovat and Msta. They have length 530 km and 445 km respectively (Grigoryev, Gritsevskaya, 1959; Istomin, Yakovlev, 1989).

Climate in the basin of Ladoga Lake is moderated. In the connection with the big size of drainage area the mid-annual temperature of air in the south of basin is +3° C and +1.5° C in the north. The coldest month of year is February, monthly average temperature of air at this time is from -9.0° C up to -11.4° C, the warmest month is July: from +15.2°C up to +17.2°C. Atmospheric precipitations are 650 mm/year, evaporation from the lake surface is 380 mm/year (Raspletina, Susareva, 2006). In the last decades in the northern hemisphere global rise in temperature of air is observed that finds reflection in drainage area of Ladoga Lake. At remaining of this tendency of climatic variability it is expected that in 2071–2100 the mid-annual temperature of air at different variants can raise by 4.2–5.2°C (Trapeznikov, Efimov, 2007).

Extensiveness of catchment area in combination with superfluous humidifying of territory causes formation of significant volumes of surface drain. The main mid-annual volume of water drain (70.5 km³) goes to Ladoga Lake (without taking into account precipitations on the

water area of lake) from such areas as Svir-Onega (20.8 km³), Volkhov-Ilmen (16.9 km³), Vuoksi-Saimaa (19.3 km³) and private catchment area of the lake (13.5 km³). Portions of each of these areas are following: 29.5%, 24.0%, 27.4% and 19.1%. So, the drain to Ladoga Lake is formed mainly on the catchment areas of lakes Onega, Ilmen and Saimaa, and the contribution of each of them appears to be close by size. Water incoming the lake is discharged via Neva to the Gulf of Finland of the Baltic Sea.

10. Uses of the Lake and Its Resource Development Facilities

10.1 Water

10.1.1 Flood/drought control facilities

Hydro-electric engineering. Water resources of the Ladoga basin are used for producing electric power. With this purpose on number of the rivers hydroelectric power stations are constructed and work. So on Svir there are two hydroelectric power stations, on Vuoksi there are four (including two in Finland), by one hydroelectric power station are on the rivers Volkhov, Janisjoki, Tulema and on six northern tributaries of Ladoga Lake in Finland. Besides this a number of small dams for the various purposes are constructed. Hydroconstruction has changed regime of the rivers, and it is especially essential for such rivers, as Svir, Volkhov, Vuoksi. While hydroconstruction does not affected directly on the water quality it is affecting on the lake ecosystem transforming structure of fish population. It has essentially affected state of populations of such through diadromous fishes as lake salmon, lake trout, lacustrine-riverine whitefishes.

10.1.2 Drinking water withdrawal and facilities

Ladoga Lake as a source of drinking water. The main consumer of the Ladoga Lake water is St.-Petersburg city. The population of city daily uses 2.9 million m³ of drinking water, or 1.1 km³ in a year. Ladoga Lake for St.-Petersburg is unique uncontested source of water supply because of stocks of underground (artesian) waters and also resources of surface drain (besides Ladoga Lake) are insufficient. The health state of city dwellers depends substantially on the quality of the Ladoga Lake water. Except for St.-Petersburg, the Ladoga water is used for water supply in some other cities of Leningrad region (Kronstadt, Priozersk, etc.) and Karelia. Therefore stocks of fresh water in the Ladoga Lake basin must be treated as renewed strategic resource which quality entirely depends on the ecological condition of water body and catchment area.

10.1.3 Agricultural water withdrawal and facilities

Agriculture. For agricultural purposes in the Ladoga Lake basin is mastered about 11% of the area (Rumyantsev, Drabkova, 2007). The main directions of the agriculture which has been developed here are cattle breeding, poultry farming, and vegetable growing. For maintenance of this branch of national economy with necessary arable lands and meadows in the Ladoga Lake catchment area on significant areas there were performed land-improvement works and drainage of marches. In agriculture there are made great losses

of fertilizers and toxic materials which finally with the surface runoff get into water bodies promoting their eutrophication.

10.1.4 Industrial water withdrawal and facilities

Industrial production in the basin of Ladoga Lake. In the coastal zone of lake and in the catchment area the large industrial potential is concentrated, and among the enterprises water and resources consuming branches prevail. In the Russian part of the Ladoga basin 418 water consuming enterprises are counted. From them 226 are located in Leningrad Region, 76 – in Novgorod Region, 27 – in Pskov Region and 89 – in Karelia (Rumyantsev, Drabkova, 2007). Among industrial branches fuel and energy, pulp-and-paper, woodworking and chemical industry, nonferrous metallurgy has big relative weight. Significant industrial potential is located on territory of Finland in basin of Vuoksi (Lake Saimaa basin) where the pulp-and-paper enterprises prevail; there is steelmaking industry, etc.

Forestry. Forests occupy 55% all Ladoga Lake basin area and 70% of proper catchment area of lake. They play important role in the formation of surface drain, influencing on its seasonal distribution and chemical composition of water. Protective forest strips alongside the coasts of water bodies and water-currents have great value in the nature protection. They carry out important buffer role, protecting water bodies from influence of some negative anthropogenic factors. In particular, protective (water-security) forest strips serve as original biofilters, intercepting biogenic elements carried away with slope drain. At the same time in the forests there are carried out large-scale timber cuttings providing with raw material numerous pulp-and-paper and woodworking enterprises both inside and outside the Ladoga basin.

10.2 Fisheries and their facilities

Importance of Ladoga Lake ecosystem for fish industry. Ladoga Lake belongs to the important fishery water bodies of Russia. On it fishermen of Leningrad region and Karelia are fishing. By total catches Ladoga is on the second place among greater lakes of Russia. In it about 20% of fish from this group of lakes is caught. Basis of catches in Ladoga Lake consists of valuable white-fishes (various forms of whitefish, vendace, rypus) and large ordinary fishes (sander, bream, etc.). By structure of the fish population it belongs to rare type of salmon-whitefish-smelt lakes, characteristic for Scandinavian region. However Ladoga Lake differs from other lakes of similar type because in it salmon and whitefish fishes are presented with the greatest completeness. Owing to the presence of valuable fishes it serves as the supplier of scarce fish production for some industrial centers and first of all for St.-Petersburg.

10.3 Tourism facilities

Ladoga Lake and its basin as a center of inland and international tourism. On Ladoga Lake and in its basin a number of monuments of history, architecture, and also the nature sanctuaries involving (or able to involve) streams of tourists is located. Among monuments of

architecture it is possible to note fortress Korela (established in X century), Valaam monastery (year 992), fortress Oreshek (year 1323), Konevets monastery (year 1393), the first capital of Russia Old Ladoga, etc. Besides them a number of historical monuments are located in the Karelian and Novgorod parts of the Ladoga basin. Tourist routes in other regions pass through Ladoga Lake. In the Ladoga basin there are also potential monuments of history and architecture which can accustom in the process of development of tourist activity in the country. Tourists arrive to the region not only from Russia, but from the countries of near and far abroad.

Owing to the picturesque nature of Ladoga Lake (especially in the northern skerry areas) here are available wide prospects of recreation development which can be combined with amateur fishery and other forms of productive leisure on the nature. Recreational use of Ladoga Lake yet is not wide. Nevertheless, on the lake there is numerous small-size fleet, and also the great army of fishermen-fans. Small-size fleet (especially in the places of its high concentration) promotes pollution of aquatic environment with mineral oil and various garbage, and practically not ranked amateur fishery causes noncontrollable damage to fish stocks. Quite often activity of fishermen-fans develops into typical poaching.

10.4 Others

Ladoga Lake as a part of water transport system. The lake has nation-wide value as the important part of the water transport lines connecting Northwest with the central and southern regions of Russia and providing output to foreign countries. Through lake there is passing the intense passenger-and-freight lines Baltic Sea – Onega – the White Sea and Baltic Sea – Onega – Volga with the further continuation aside the Caspian, Azov and Black seas. A number of routes are stretched to the countries of near and far abroad. On these lines annually thousand passenger and cargo courts are passing. Alongside with transit, intensive local navigation is carried out on the lake. The volume of cargo transportations makes about 10 million tons in a year, passengers – more than 450 thousand persons. The general length of navigable lines in the lake exceeds 1500 km and makes about 0.1 km on 1 km² of water area. Freight traffic density exceeds 550 tons/km². In the process of restoration of industrial production and strengthening of business enterprise activity the role of navigation will increase. It is possible to expect expansion of volumes of transportations through Ladoga Lake between some southern (Iran, etc.) and the European states in connection with their greater efficiency in comparison with roundabout way through the Red and Mediterranean seas.

11. Impairments to Uses

11.1 Increased algal growth

Anthropogenic eutrophication. To the beginning of 1960s Ladoga Lake by the level of trophic was typical oligotrophic water body with water rich with oxygen and low concentration

of biogenes. However to the beginning of 1980s ecological state of lake has sharply changed. Concentration of phosphorus in water has increased significantly. Concentration of oxygen during the winter period in deep-water areas has gone down not only at the bottom, but also on the surface. Increase in the concentration of mineral phosphorus was consequence of growth of phosphorus income from the catchment area and with precipitations. If in 1959–1962 to the lake on the average 2430 tons of phosphorus came in a year, in 1976–1979 this figure has increased up to 6830 tons. There was exceeded limit 4000 tons which separates oligotrophic conditions of Ladoga Lake from mesotrophic (Anthropogenic eutrophication ..., 1982; Ladoga lake – criteria ..., 1992).

In the connection with sharp increase in the income of phosphorus the level of phytoplankton development in littoral zone already in the end of 1970s has grown in comparison with 1960s by 4–5 times, zooplankton by 2.5 times, bacterioplankton by 3 times. In some areas in summertime in still weather "blooming" of water caused by intensive development of cyanobacteria was noticed. In the connection with anthropogenic eutrophication in the lake open parts water transparency has decreased. If in 1962 it was 2.3–3.9 m (on the average 3.5) to the beginning of 1980s it has decreased up to 1.8–3.3 m (on the average 2.2). This change of transparency was consequence of increase of planktonic organisms (phyto- and zooplankton) and detritus amount in the surface layers of water.

Increase in parameters of water trophic in various parts of the lake proceeded not in regular intervals and was differently reflected on separate groups of aquatic organisms. So, northern (skerry) and the central parts have kept oligotrophic features by species structure and quantitative development of zoobenthos. But southern bays Petrokrepost, Volkhov, etc. by same parameters passed to mesotrophic stage. Coastal sites and the top layer of water can be characterized by zooplankton as mesotrophic areas of lake while the deep zone has kept oligotrophic character. This circumstance testifies that change of the lake trophic status was unstable and acceptance of necessary measures for returning to the initial oligotrophic status could be possible.

11.2 Increased salinity

It is not observed.

11.3 Destruction of wetlands

For providing to agriculture necessary plowlands and meadows in the Ladoga Lake drainage area land-improvement works and drainage of swamps were execute on large areas .

11.4 Declining fish stocks

Fish population of Ladoga Lake is under double "pressure": on the one hand it is negatively influence by various forms of economic activities (hydroconstruction, discharge of

polluted waters, toxicants, mineral oil, etc.), on another hand it is under selective affecting of intensive fishery. The dams constructed in the lower reaches of the rivers block paths of migration of lacustrine-riverine fishes to the spawning areas making impossible their reproduction and by that cause disappearance of some populations. As a result of dyke construction of the Volkhov hydroelectric power station the population of Volkhov white-fish which catches exceeded 300 tons in a year has lost commercial importance. Hydroconstruction on Svir River has led to the loss of spawning areas of salmon in this river. Svir lacustrine-riverine white-fish has lost commercial importance also. Spawning areas of salmon in Tulema River have been lost because of a dyke construction in its lower reaches.

Hydroconstruction influences negatively on fish resources. The dams constructed in lower reaches of the rivers block ways of migration of lacustrine-riverine fishes to spawning areas, do impossible their reproduction and by that cause disappearance of separate populations. As a result of construction of dam of the Volkhov hydroelectric power station Volkhov whitefish, which catches exceeded 300 tons in a year, has lost commercial significance. Hydroconstruction on Svir has led to the loss of spawning areas of salmon in this river. Svir whitefish also has lost commercial significance. Spawning areas of salmon in Tulema have been lost because of construction of a dam in its lower reaches. Thus, though hydroconstruction does not have direct influence on the quality of water, but it influences on the lake ecosystem through transformation of structure of fish population.

Fishes are sensitive bioindicators of the state of ecosystems and respond on man impacts by changes of species composition, ratios of ichthyomasses of various species, value of trade stock and catches, etc. In Ladoga Lake all these responses of fishes on anthropogenic factors are noted. The most essential modifications have occurred in the group of lacustrine-riverine fishes. Atlantic sturgeon being commercial fish still in the beginning of XX century has become to be extinct. During last decades stocks of lacustrine salmon and lacustrine trout have sharply decreased.

Changes in the lake ecosystem affect the state of stocks of not only lacustrine-riverine but also lacustrine fishes. So stocks of lake char, inhabiting deep zone of lake have decreased considerably. It has lost commercial value. Because of pollution of spawning areas with mineral oil and a high level eutrophication of lake catches characteristic for ecosystem of Ladoga Lake lacustrine forms of white-fishes were affected. Negative events occurring in the lake have affected stocks of such leading commercial fish as pike-perch. Decrease in the stocks and catches of mentioned above lacustrine-riverine and lacustrine fish species having long-term life cycle is accompanied by increase in catches fishes having short-term life cycle (vendace, smelt). However neither by quality, nor by economical parameters of fishery these species are not equivalent replacing of lost valuable fishes.

Researches of fishes have revealed one more kind of influence on them by unfavorable

ecological conditions. Fattening of fishes occurs mainly in rather shallow areas of southern part of Ladoga, and also in bays Volkhov, Petrokrepost, Svir, etc. Here is noted the greatest pollution of water masses and grounds with various toxic substances and mineral oil. In this connection fishes have high concentration of toxic substances in external covers, internals and meat. Because of pathogenic influence of accumulated in the body and internals toxic substances toxicoses (lesion of liver, spleen, brain, etc.) develop at fishes. Toxic substances income into fishes both through external covers, and with fodder organisms which accumulate in itself all spectrum of the polluting substances which are available in the lake. Thus, toxic substances not only are present in water, but also circulate in the ecosystem of Ladoga Lake in trophic chains.

11.5 Other

Since the second half of XX century and especially in 1970-80s together with sewage water, various emissions, etc. Huge amount of pollutants has income to Ladoga Lake. Slow realization of necessary nature-conservative measures, remained behind intensively developed industrial production and growth of urban population, strengthened negative effect. As a result in large parts of water area (especially in deltaic sites of rivers and near to sewage releases) deterioration of water because of presence of chlopine-organic pesticides, salts of heavy metals, mineral oil, phenols was marked. Quite often on significant spaces of lake water area the oil film was visually observed. In water and ground sediments there were benzene, chlorine-phenols, aldehydes, ketones, spirits, terpenes, sulfur-containing substances. Concentration of high-molecular sunstances (in particular, polychlorinated biphenyls) in the number of areas (bay Petrokrepost, the Volkhov bay, area of Pitkyaranta, etc.) has considerably exceeded maximum concentration limit.

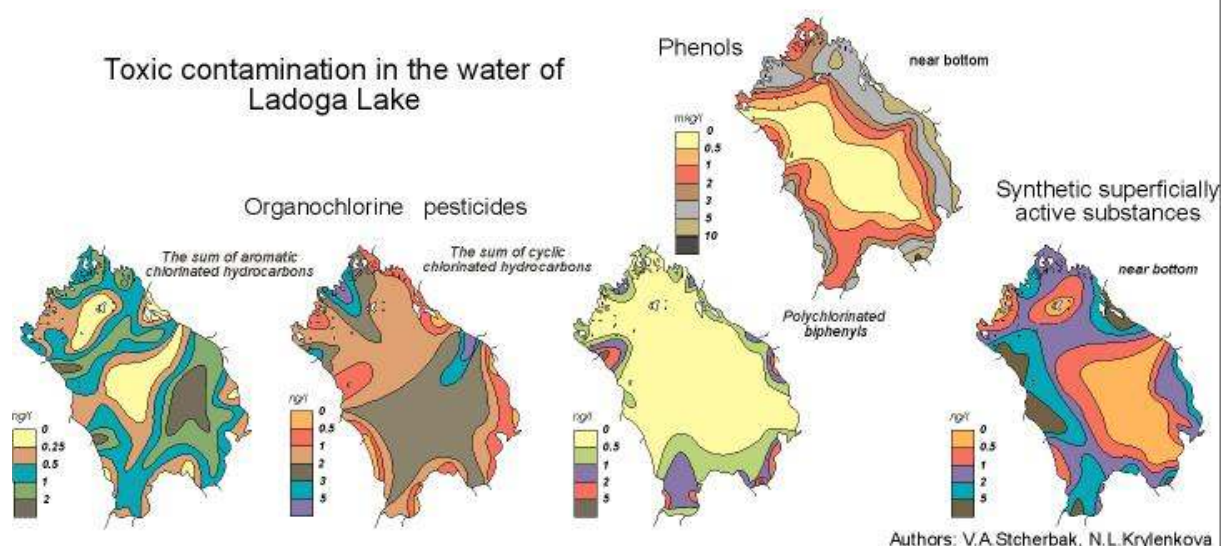


Fig. 25. Pollutants

Health of population. Bad ecological situation developed in Ladoga Lake and nearby territories affects not only the organic world, but also influences people living here. As observations show, in some areas adjoining to Ladoga Lake there are noticed raised level of morbidity at people with malignant tumors, illnesses of digestive apparatus and urinogenital system. The highest parameters of morbidity and mortality are registered among the population living near to the pulp-and-paper enterprises. In some coastal areas of Ladoga Lake with the raised level of economic activities high concentration pathogenic microorganisms and hazardous to people health toxic substances are registered in water and grounds.

12. Causes of Impairments

12.1 Upper-watershed degradation including erosion and siltation

12.2 Point and non-point source runoff from urban areas

According to data of ecologists about 400 million m³ the polluted sewage waters annually enters to Ladoga Lake, and in the catchment area of Ladoga Lake waters 1400 million m³ is coming annually from the works. From the total amount of contamination to Ladoga Lake more than 70 % enter from objects of Leningrad region.

Because of taking place partial non-observance of requirements of the nature protection legislation by the industrial and agricultural enterprises, quality of the water drain formed in catchment area, not always corresponds to sanitary-and-hygienic norms. In the number of rivers the raised level of pollution of the water environment (Svir, Volkhov, Vuoksa, etc.) is noted (Analytic review ..., 2004). So, in Svir concentration of chlorineorganic pesticides exceeds maximum-permissible concentration (maximum concentration limit). In the water of this river the raised concentration of copper, manganese, iron, mineral oil is observed also, concentration of phenols is high. In the water of Volkhov norms of biological consumption of oxygen, and also concentration of copper, manganese, mineral oil, phenols, etc. are exceeded. Waters of river Syas are much contaminated. In Vuoksi concentration of copper, mineral oil, norms biological consumption of oxygen are high.

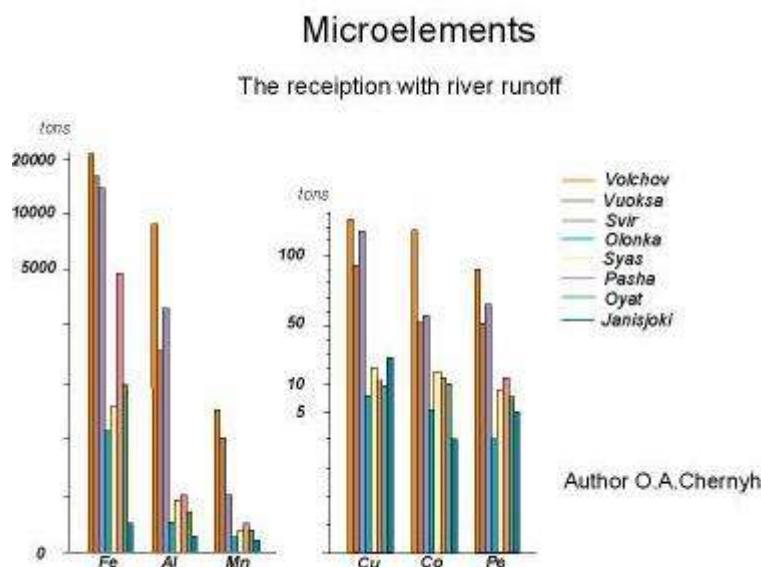


Fig. 26. Income of microelements with river runoff

In the coastal zone Ladoga Lake there are cities (Priozersk, Novaya Ladoga, Syasstroy, Pitkyaranta, Impilahti, Laskela, Sortavala, etc.) and the large pulp-and-paper enterprises and the enterprises of other branches. In the boundaries of Leningrad region in the water-security zone of the Ladoga basin there are large number of warehouses of mineral fertilizers and agricultural pesticides. Sewage waters of enterprises and cities come into coastal water areas limited by sizes (deltaic areas of the rivers, small gulfs, bays), that causes occurrence of the raised "dot" concentration of polluting substances with heavy local consequences for the water environment. In such places at strong pollution by organic substances "dead" and polysaprobic zones can arise. Similar zones were noted in gulf Schuchiy nearby Priozersk, in fiord close to Sortavala, in the mouth of Volkhov at ship-repair factory, in the Volkhov Bay near discharge of polluting sewage of Syas pulp-and-paper factory and also in some other places just at releases of household sewage and waste from farms.

Within the frames of «The Baltic Sea Joint Comprehensive Environmental Action Programme» (JCP), developed by HELCOM, on the territory of the Baltic region 132 most significant sources of environment pollution, so-called "hot spots", are identified and made agreed. In Russia there are 19 of them, including 4 on the territory of Leningrad region 3 of them are within the limits of the Ladoga drainage area. To "hot spots" there are related Syas pulp-and-paper factory, plant of Open Society "Volkhov aluminium" and a pig-breeding complex of joint-stock company "Vostochny" (Analytic review ..., 2004).

12.3 Shoreline degradation and alterations

No data

12.4 Other

Ladoga basin is characterized by high concentration of the industrial enterprises which

emissions pollute atmosphere. Besides this, near to the basin there is industry of St.-Petersburg, and also of Kareliya, Finland, Estonia, etc. Not so far there are located industrially advanced large industrial countries of the Western Europe. Sulfur dioxide, carbon oxide, oxidized nitrogen prevail in the structure of sediments from atmosphere. Together with them compounds of fluorine, ammonia, hydrogen sulphide, formaldehyde, chlorine, manganese, chrome, mercury, etc. come. As a result, tens tons of lead, vanadium, manganese, hundreds tons of zinc, thousand tons of iron, etc. drop out from atmosphere on the lake water area with precipitations or in the form of a dust. For these substances modules of atmospheric receipt by 2-5 times higher, than modules of carrying out with water drain. In 2000 on the territory of Leningrad region 44.4 thousand tons of sulfurs, including 9.8 thousand tons from own sources and 34.6 thousand tons from foreign has come through atmosphere (The State Report ..., 2003). From them over limits of region it has been carried away 31.0 thousand tons and 13.4 thousand tons dropped out on its territory. Considering that the area of Ladoga Lake makes about 21% from the area of region area, that is the lake water area has received directly about 2.7 thousand tons of sulfurs, including about 0.6 thousand tons from foreign sources.

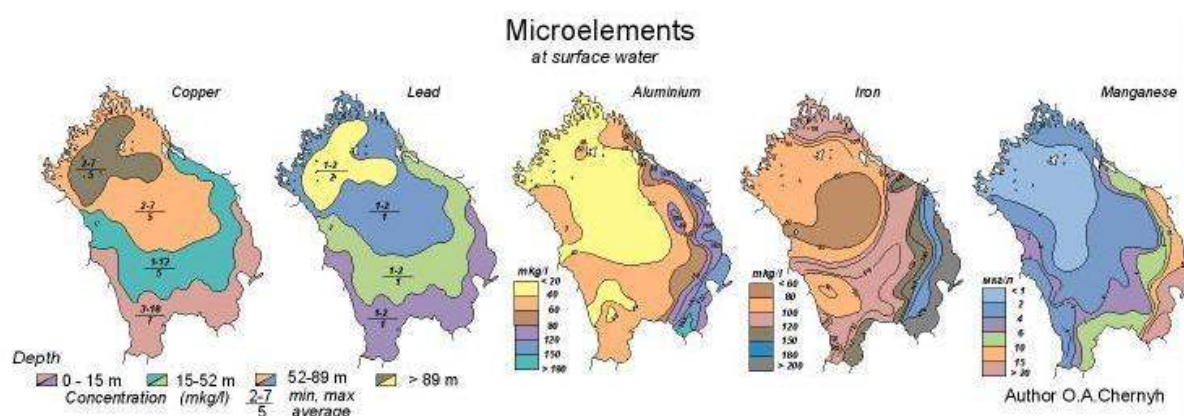


Fig. 27. Distribution of microelements in the water mass

13. Structural Management Response

13.1 Sewerage system

According to the State Report the technical state of objects of municipal water-supply and sewerage objects in Leningrad region already in 1990s was recognized unsatisfactory. In 2000s in the connection with constantly varying belonging of these objects their state catastrophically has worsened. Besides this almost everywhere it is noted the shortage of qualified personnel serving water-supplying and water-purifying that leads to their unsatisfactory exploitation. According to the Committee on housing and communal services last years the most acute problem in water-supply and sewerage economy becomes problem

of water transportation run-off of waters because of critical deterioration of water-supply and sewerage networks. On the balance of municipal authorities of Leningrad region there are about 6000 km of water supply networks with deterioration of 70% and about 5000 km of sewerage networks with deterioration of 60%. One of acute problems is the problem of treatment and recycling of sediments of sewage purification plants continues to remain. For resolving of this problem there is necessary the earning of reliable equipment for dehydration of sediments as for stationary shops for dehydration in regional centers and mobile plants for dehydration to serve of small settlements with population up to 10 thousand person.

13.2 Industrial wastewater treatment system

Today more than 600 enterprises and about 680 agroindustrial complexes discharge industrial wastes to Ladoga Lake. Among them there are pulp-and-paper industrial complexes and agricultural enterprises, being from the point of view of ecology one of the most harmful industrial objects. As a result Ladoga Lake annually receives on the average about 400 million cubic meters of polluting runoffs, including 167 cubic meters without any purification. Unfortunately, the system of sewage purification plants mismatches the modern level in the majority of enterprises for sewage purification. According to the State Report for 2004 in Vyborg region from 19 existing water supply points 11 had no high-performance water purification. In Priozersk region from 7 existing water purification systems all required reconstruction.

13.3 Solid and hazardous waste management system

13.4 Other

Not including chemical poisonous runoffs, into water bodies the huge amount hard scraps is dumped directly. Ladoga Lake in this connection appears to be the most vulnerable. Its coasts are chosen by summer residents and tourists. But far from always they are civilized enough and observe purity. Mainly representatives of aquatic fauna suffer from their acts. In particular it is Ladoga seal being about extinction and included in the Red Book of Russia.

14. Non-structural Management Response Неструктурный Ответ Управления

Since the end of 1990s the number of participants of movement of "greens" and adjoined their movement of ecologists being anxious by problem of Ladoga lake purity actively grows in the Northwest region. Movement will organize monitoring of territory around the lake. At revealing sources of dangerous pollution "greens" attract attention of public and security organizations to it. In their job "greens" actively involve various experts, first of all ecologists.

Now the greatest fear of "greens" and ecologists is called by the situation near of settlement Lepsari where, as coordinators of "Green patrol" report, "on the area of four thousand hectare there are an unauthorized industrial area and a huge scrap-heap "Lepsari" with size of some kilometers and height about the seven-storey house". A scrap-heap

organized by Open Company "Polygon TBO", numbering 250 clients, including such large companies and organizations as "Alliance-Stroy", "Lenenergo", "LOMO", "Lenraumamebel", "Pit-product", "Polimerstroyaterial", city thermal power stations, markets, bus depots, etc. Daily 130 supersize cars, full of various scraps comes from city to the scrap-heap. The scrap-heap is located in a marshland in the former sand-pit. The pit for a long time is filled, therefore toxins, poisons and infection leak through sand or directly run off into ameliorative channels of fields and further into the rivers Lepsar and Morye which run into Ladoga Lake. As researchers from "Green patrol", inspected this area report, " there are no sewage purification plants here, and sewer gutters for a long time are blocked up. Everywhere there is deforestation ».

Besides the problem but nevertheless acting formally within the limits of the law scrap-heaps, on the territory of Leningrad region at the same time there are from five hundred up to six hundred unauthorized ones. Many of them in general are not considered anywhere and are not taken into consideration by anybody, except for simple local inhabitants. Successfully liquidated scrap-heaps after a while or again grow on the same place or are moved on another place. In opinion of officials, the system of penalties concerning the persons responsible for accomplishment of territories does not work. First, the sum of penalty provided in the Administrative Code for similar violations is low; secondly, in the most cases such conflicts do not reach at all a trial and are solved "amicably" on the spot and without drawing up a report.

3. Management of the Lake and Its Basin (based in part on Annex 1 Questionnaire items, 10 through 14)

3.1 Overview of Management Needs

Ladoga Lake is natural object important by its social and economic value. Activity of numerous water-users located as just near the lake as in the catchment area and also over its bounds is connected with this lake. In the lake there is natural reproduction of great volumes of aquatic and biological resources, it serves as a component of inter-regional and local transport systems. Directions of using natural resources for public and individual purposes and favorable geographical position of lake are diverse.

Importance of Ladoga Lake basin for Northwest region and the country as a whole. Ladoga Lake, its basin and concentrated here aquatic and biological resources play a key role in functioning of economic complex of Northwest of the European part of the Russian Federation. At the same time this complex by many parameters has leading position in the national economy of the country in the whole.

Population of region reaches 9 million people from those more than 5.0 million people lives in cities, including 4.8 million people in St.-Petersburg, one of the largest political, economic, historical and cultural centers not only in the country, but also in the world. On territory of the catchment area there are living almost 4 million people, including 2.7 million city dwellers. In this connection the state of water resources, ecosystem of Ladoga Lake and its basin has crucial importance in maintenance of optimum activity of all economy of region and normal residing of the population.

Discharge from Ladoga Lake and its influence on the water quality in Neva River inside boundaries of St.-Petersburg. In the boundaries of St.-Petersburg of 98% Neva discharge is provided by Ladoga Lake. Coming water influences quality of aquatic environment in Neva in the boundaries of city in two main directions. First, because of incoming great volumes of water from Ladoga Lake occurs so-called dilution of polluted and partially purified sewage waters wasted to Neva from industrial enterprises. Owing to dilution by purer waters in the river not only concentration of polluting substances decreases, but also processes of autpurification are speed up. Secondly, in the cases of polluted waters income the additional negative contribution to the state of aquatic environment of city is added.

Drain from Ladoga Lake and its influence on the quality of aquatic environment in the east part of Gulf of Finland. Coming into the east part of Gulf of Finland drain from Ladoga Lake in volume 70.5 km³ (average long-term) makes two thirds of income part of water balance of this area of Baltic Sea. Because of this the Ladoga Lake waters should influence ecological conditions in the gulf.

Biota of Ladoga Lake as possessor of unique genofund. Biota of Ladoga Lake is

characterized by number of unique features. As it is mentioned above, this lake is unique water body in Russia where complex of glacial-marine relic organisms is presented with its completeness. All of them have got into Ladoga Lake from brackish-water sea areas through glacial water bodies during last glacial period and are living witnesses of complex geological history of this lake. Glacial-marine and glacial relic organisms cause original current of bioproduction processes and give unique character to the Ladoga Lake ecosystem. The genofund of Ladoga organisms already now partially finds application in economic purposes. It concerns to the category of national property, requires constant attention and deserves effective protection.

Fish-economy potential. Owing to presence of valuable species, the lake has big value for fishery. Catches in separate years reached almost 6900 tons. However because of oligotrophic character of this water body its fish capacity is insignificant and makes in the best years of 2–3 kg/ha (Kudersky, 1985). Only large water area provides catches of fishes in the amount specified above.

It is necessary to consider, that sizes fish catches in the lake change both in adjacent years, and during long intervals of time. The greatest interest is represented by long-term dynamics of catches which cycle makes about 50–60 years. For 1946–2005 the following stages of this cycle are distinguished:

- Low level fish in the end of 1940s –beginning of 1960s;
- The raised level fish catches in the beginning of 1960s – the end of 1980s years;
- The next decrease in size of catches in 1990s.

But it is necessary to consider, that last decrease in size of catches is connected not only with natural decrease in bioproduktivty within the limits of long-term dynamics, but also with the general negative phenomena in national economy, negatively affected on condition of the Ladoga fishery.

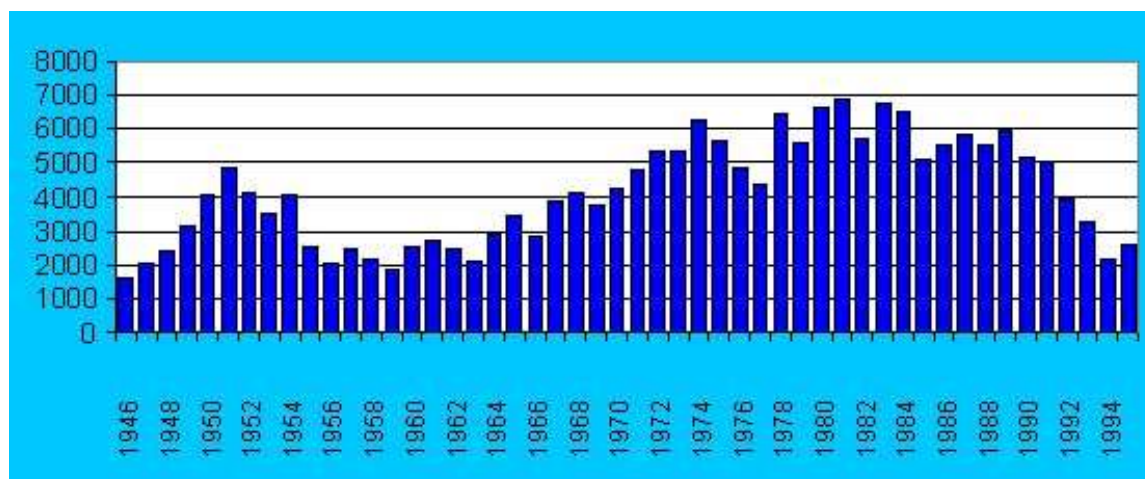


Fig. 28. Dynamics of catches in Ladoga Lake (Author: L.A. Kuderskiy)

Importance of Ladoga Lake for local population. In a coastal zone of Ladoga there are number of cities (Priozersk, Novaya Ladoga, Syasstroy, Vidlitsa, Pitkyaranta, Impilahti, Sortavala, Lahdenpohja, etc.) where life of population is closely connected with lake. For a part of inhabitants it serves as object of labor activity (fishery, navigation, etc.), for a part as area of residing (the person which labor activity is connected with the industrial enterprises located here). Though the general number of inhabitants in coastal zone of lake is rather insignificant (about 0.5 million) but to consider value of lake for their normal residing it is necessary.

Ecological state of Ladoga Lake. High intensity of using natural resources in the Ladoga Lake basin influences differently (including negative) on ecological state of the Ladoga aquatic system. These influences can be grouped in four basic directions:

- Economic activities in the catchment area, influencing lake through surface and underground drain;
- Economic activities in coastal zone which influence is to the greatest degree appears in deltaic areas of rivers and separate gulfs in the places of industrial enterprises, and also near to cities;
- Economic activities in the lake, connected with navigation, fishery, burial of various scrap, etc;
- Activity in the separate areas, influencing lake and its ecosystem owing to atmospheric (transboundary) carries of smoke and dust emissions containing toxic substances.

Leading contribution to the total sum of negative influences on the lake ecosystem contributed in the catchment area by diverse economical activity having here concentration more higher than average in Russia. As a whole the catchment area of Ladoga Lake is characterized by high level of economic development. Concentration of industrial activity here is much above the all-Russian parameters. In the structure of industries of Northeast region resource-consuming and water-consuming manufactures prevail causing due to features of technology raised influence on environment due to great volumes of sewage dischraged into water bodies, smoke and dust emissions coming into atmosphere, and also firm waste concentrating on scrap-heaps. In the Leningrad part of the Ladoga Lake basin fuel and energy, wood, pulp-and-paper, chemical and petrochemical enterprises, mechanical engineering, black and nonferrous metallurgy have large partial weight. In Kareliya there are most developed forestry, woodworking, pulp-and-paper industry and enterprises for mining nonmetallic minerals. In the Novgorod region relative density of the chemical industry, including manufacture of mineral fertilizers is high. In Finland (basin of Lake Saimaa) a number of the large pulp-and-paper enterprises "enriching" an environment by sewage and

smoke emissions are located.

Alongside with the industry, in the Ladoga Lake basin agriculture is intensively developed. Its functioning is closely connected with the large-scale ameliorative works changing character of water drain and influencing water quality. The agricultural production is focused basically on intensive forms of livestock-breeding. Large cattle-breeding farms and complexes pollute environment with huge quantities of not utilized manure.

To the second group of the anthropogenous factors influencing ecological processes in Ladoga Lake, various forms of economic activities in the coastal zone belong. Here there are a number of cities and the large pulp-and-paper enterprises and the enterprises of other branches. In the boundaries of Leningrad region in water-security zone of Ladoga Lake basin significant number of cattle, and also pigs, birds, fur animals is concentrated. In this zone there are large number of warehouses of mineral fertilizers and agricultural pesticides. By the general state of economic and municipal activity the coastal zone of lake appears to be zone of raised risk. In coastal areas, where is getting naximal amount of sewage, "dead" and polysaprobic zones can arise. In them typical representatives of the Ladoga fauna disappear, the species structure of invertebrates appears to be extremely limited. In polysaprobic zones only one-two species extremely resistant to organic contamination can be developed.

The third direction of influence of anthropogenic factors on Ladoga Lake ecosystem is economic activities in the lake itself. This direction includes navigation, fishery, recreation, use of water area of lake for other purposes. Navigation has the greatest influence on the ecological state of water body. Intense cargo-and-passenger lines pass through Ladoga Lake aside the Caspian and White seas and some foreign countries. On the lake intensive local navigation is carried out. Navigation influences ecological state of water body. Last years in the connection with the general decrease in economic activity in the country intensity of navigation on Ladoga Lake has decreased a little. In the process of restoration of industrial production and business activity navigation (considering favorable geographical position of lake) not only will reach existed before parameters, but also will surpass them.

Fishery has essential influence on the ecological state of Ladoga Lake and, first of all, on the ecosystem structure and its ichthyological component. In the ecological aspect it is essential that fishery is not over the all water area but in the most productive areas. Therefore "loading" from fishery on the lake ecosystem locally appears above the average index received at distribution of catches on the all water area. Influence of fishery on the ecosystem is amplified also in the connection with its selective character: not all species of fishes are caught but mainly the most valuable (whitefishes, ripus, zander, bream, pike, etc.).

The fourth direction of influence of economic activities to Ladoga Lake is transboundary transport of coming to atmosphere with smoke and dust emissions toxic substances by air currents. Ladoga basin is characterized by high concentration of the industrial enterprises

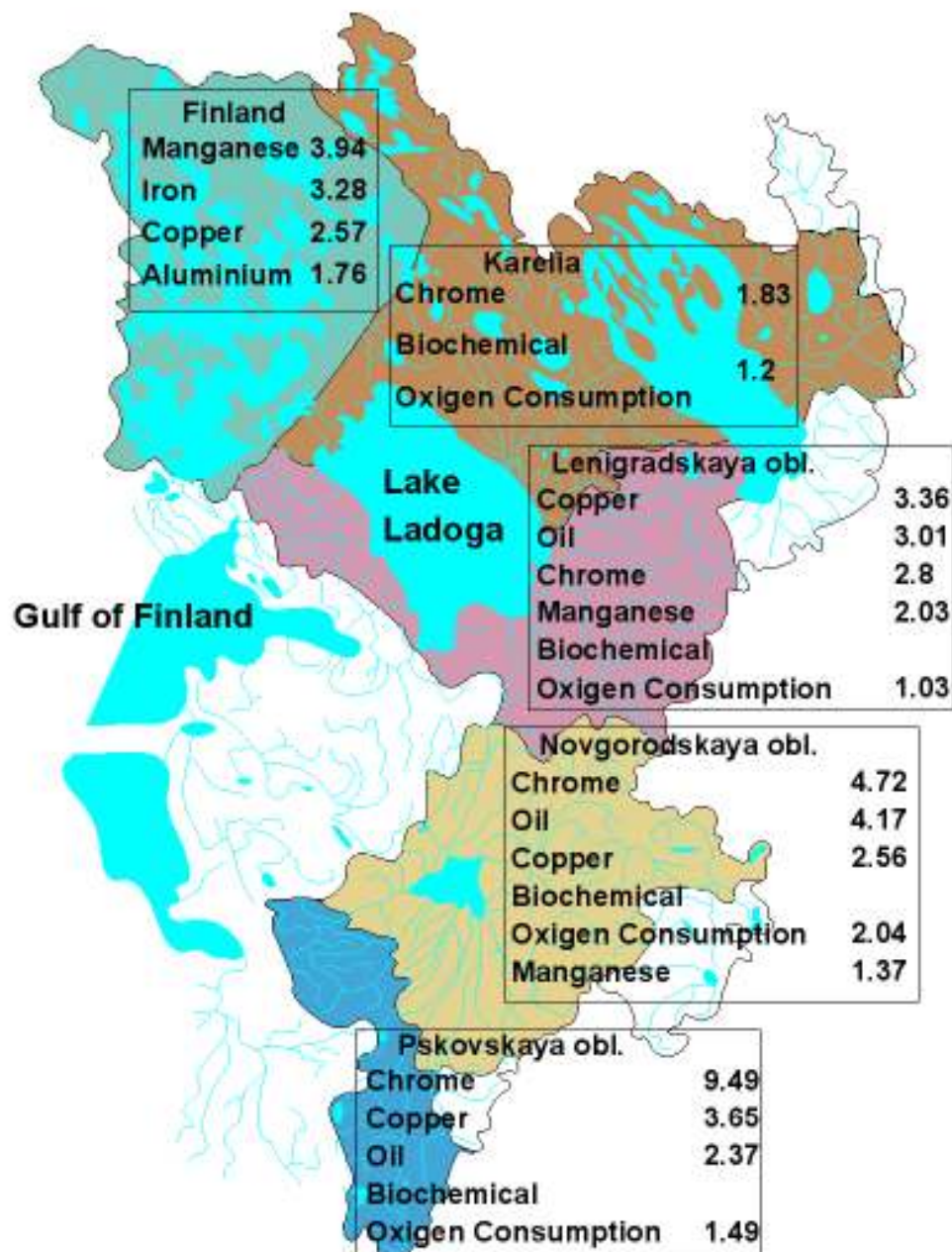
which emissions pollute atmosphere. Besides this, near to the basin there are industry of St.-Petersburg, and also Kareliya, Finland, Estonia, etc. Not so far there are located industrially advanced large industrial countries of the Western Europe whence through atmosphere polluting substances also come. In this connection transboundary carries of pollutants can impact on ecological state of Ladoga Lake and some water bodies of its basin.

Long-term observations testify that all directions of the anthropogenic influences acting during decades are distinctly damaging the natural resources of Ladoga Lake what is the most visible in the following basic lines:

- anthropogenic eutrophication;
- state of aquatic environment;
- change of biota (species composition and structure of biocenoses);
- change of fish population as parts of biota;
- health of the population living near to the lake.

The quality of surface water at Ladoga Lake Basin

Index of excession of Maximum Permissible Concentration (MPC)
in river waters by administrative areas



Authors: S.A.Kondratyev, L.V.Efremova

Fig. 29. Quality of surface waters in the drainage basin of Ladoga Lake.

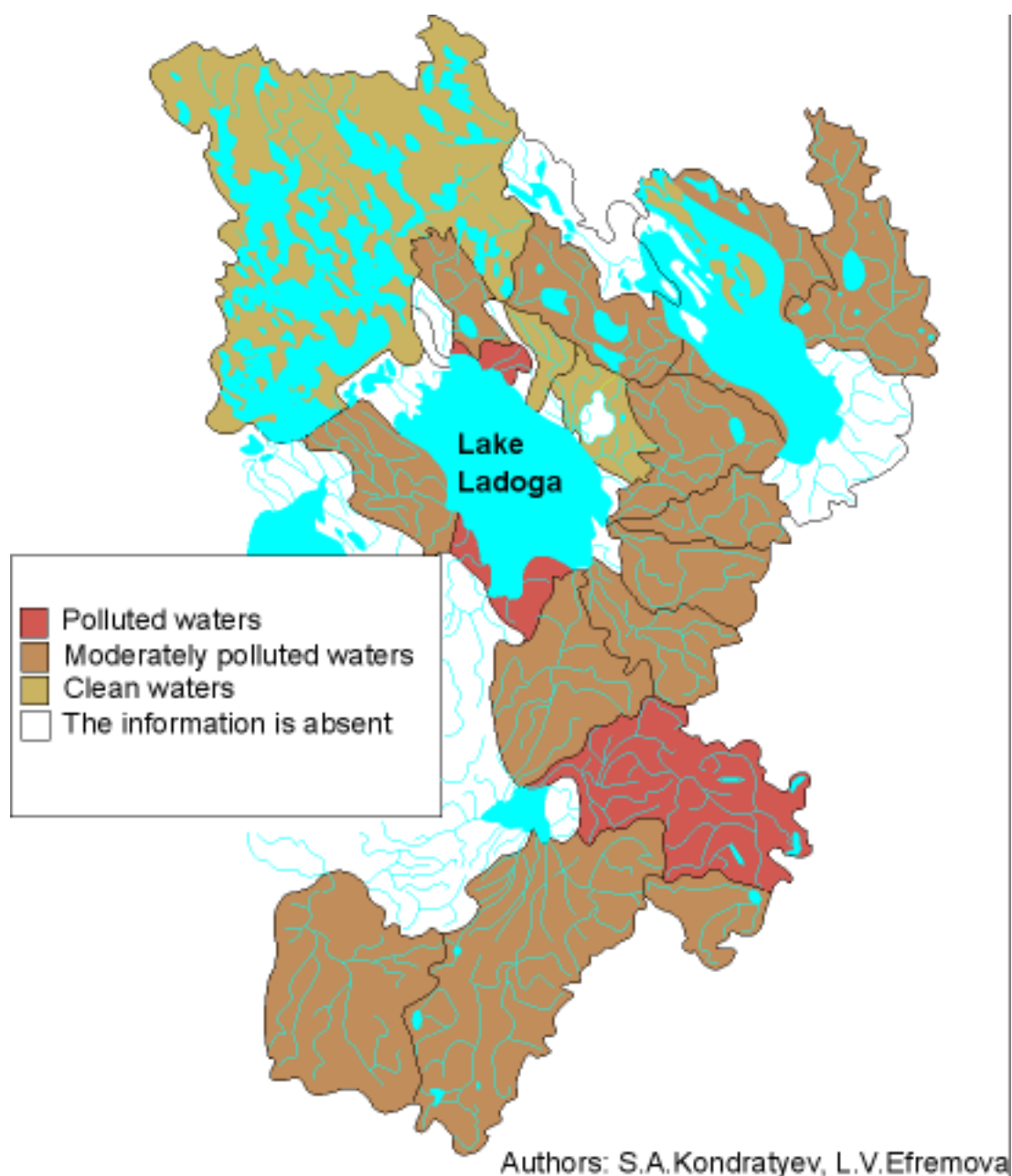


Fig. 30. Quality of surface waters in Ladoga Lake basin.

3.2 Management Programs and Processes

With the purpose of overcoming of unfavorable position formed during some decades acceptance of some large measures directed on the restoration of normal ecological state of lake and prevention of negative infringements in the future were needed. One of the first actions which have positive influence on the ecosystem of lake, was full interdiction of wood drift floating in the rivers of basin. Owing to it cluttering up the rivers with sunken timber has stopped, bark and other rests formed at timber rafting. However the most radical measures directed on improvement of ecological state of Ladoga basin have followed as a result of

acceptance of two special decisions of Ministerial Council of the USSR (in 1984 and 1987) about protection and rational use of natural resources of lakes of the Ladoga basin. As a result Priozersk pulp-and-paper factory (Leningrad region) and the similar enterprise in Harlu (Karelia) have been closed, plant for biological clearing of drains is constructed and release of sewage in Pitkaranta is transferred, technology of preparation of raw material at the Volkhov aluminium factory was changed that has allowed to stop income of lots of the phosphorus, dumped to the lake earlier in the structure of sewage of this enterprise. Besides this the general control over execution of nature protection specifications operated during this period has been strengthened. In spite of the fact that it was only first steps in the solution of environmental problems which have accumulated in the Ladoga Lake basin, they have soon yielded positive results. In water of the lake concentration of phosphorus – the main element responsible for growth of water eutrophication has started to decrease. This process has continued the next years. Besides reduction of phosphorus income, returning to normal ecological state of lake was promoted by decrease of industrial and an agricultural production, occurred in 1990s in the connection with economic reorganization in the country. Owing to these changes in a social production, income of sewage with ecologically dangerous components into aquatic system was reduced.

Discussing the reasons of improvement of ecological state of Ladoga Lake in the end of XX century it is taken usually into consideration the first, less often the first and the second factors mentioned above. However at such approach is lost from sight role of long-term dynamics of productive potential of this lake. As it was noted above, it has decreased from the end of 1980s that should affect level of bioproduction phenomena in the lake ecosystem. Therefore it is more correct to consider that observed improvement of ecological state of Ladoga Lake is consequence of action of such anthropogenic factors as nature protection actions and recession in economy and the natural factor – decrease of lake productive potential as a whole.

In the connection with acceptance of some essential limited measures (closing of the some enterprises, strengthening of work on sewage purification, etc.), general reduction of industrial and agricultural production in 1990s and in the first years of XXI century and downturn of productive potential, the ecological state of Ladoga Lake has been improved a little. Decrease in the general eutrophication of water masses in various areas has come; there was increase of transparency of water, the concentration of oxygen in it, etc. Central and northern parts of lake have kept initial oligotrophic features. In the structure of benthos almost extinct during maximal eutrophication relic species of crustaceans, etc. appear again. However process of full restoration of initial ecological state of lake for the present is not completed, in particular because of high inertness of huge water masses and, including, slowed down water exchange. Problems of restoration of biological resources are kept. In particular, there are in unsatisfactory state stocks of some food fishes, first of all

lacustrine-riverine group (lake salmon and trout, lacustrine-riverine whitefishes, etc.). Therefore the problem of continuation and strengthening of works in the restoration and further protection of ecological state of Ladoga Lake keeps urgency.

Carried out actions on restoration and protection of Ladoga Lake environment and its basin recently have received additional legal maintenance. The State Duma accepted a number of laws promoting nature protection activity from which it is necessary to note the following: «About especially protected natural territories» (1995), «About environment preservation» (2002), «About fishery and preservation of water biological resources» (2004), and also Land and Forest Codes. Among acts especially great value has «the Water Code of the Russian Federation» (2006) in which supervising principles of rational use and protection of water bodies and their water resources are concentrated.

5. Some of the major Lake Basin Governance Issues (See Annex 3)

Annex 3: Getting Clear the Lake Basin Governance Picture

Main principles of water politics of Russia according to the project of the Concept of State Policy of Sustainable Water Management are: basin approach; minimization of damaging impacts on aquatic objects; planned character and validity of reorganizations. The catchment area of Ladoga Lake covers in full or in part territories of several subjects of Russian Federation, so the control system is based on combination of basin planning and territorial on-line control of hydroeconomic activity. Minimization of damaging impacts is understood in two aspects: reducing of dump of pollutants in water objects and reducing of volumes of water intake from natural sources. Economical regulation of use, recovering and protection of water objects is based on principle of paid water management and bases on payments for water use, financing of recovering and protection of water objects and provision of economic incentives for rational water management and protection of water objects (Smirnova et al., 2000)

Basis of environment protection legislation influencing control of Ladoga Lake is “the Water Code of the Russian Federation”, accepted by State Duma October 18, 1995 in the first edition and June 3, 2006 in new wording. The Water Code of the Russian Federation regulates use of aquatic objects; their protection from contamination, pollution and exhaustions; establishment of special regime of economic activities in water-security zones; the state control over use and protection of aquatic objects. Use of aquatic objects with application of constructions, technical facilities means and equipment is implemented only at the presence of license. Each abstractor is obliged to not suppose deterioration of surface and underground waters and to observe the prescribed mode of use of water-security zones. With a view of prevention and clearing of pollution of water objects sources of their pollution are defined. Protection of water objects from pollution is implemented by means of regulating of activity of all polluters, including catchment areas. Application of toxic materials and other chemical agents is supposed only in the case if it will not affect state of aquatic objects and aquatic bioresources.

Normalization of maximum-permissible dumps of harmful substances into aquatic objects and maximum-permissible norms of application of agrochemicals in agriculture is determined by the law “About preservation of the environment” of 2002. Besides this according to this law there are determined sanitary and protective zones for protection of water bodies and other sources of water-supply. The governmental decree from 11/23/1996 No 1404 approves special “Regulations about water-security zones of aquatic objects and their protective coastal zones ».

“Rules of protection of surface waters (standard regulations)” are put into operation since 3/1/1991 and define system of measures directed on goal achievement of water protection. In the Rules there are defined main kinds of water management and as a supplement there are lists of maximum-permissible concentration for water objects used for the various purposes (economic-drinking, household, fish-economy). Lists of normalized substances are specified and published as supplements to Rules in the process of development.

According to the resolving of the Leningrad regional executive committee from 3/29/1976 No. 145 “About creation of preserves and recognizing valuable natural objects on the territory of Leningrad region as natural sanctuaries” in the low current of Svir River and in the water area of the Svir Bay of Ladoga Lake the State natural reserve “Nizhne-Svirsky” has been established. At the same time the Svir Bay is positioned as wetlands of international meaning. In the upper reaches of rivers Pasha and Oyat the national natural park “Vepsian forest” is created. On water bodies of Ladoga Lake basin some preserves of regional meaning are created.

Evaluative and permissive systems influencing water basin include normalization of quality of waters with the purpose to establish maximum-permissible standards of impacts on aquatic objects. With the purpose of checking the matching of economic and other activity to requirements of environmental safety the State ecological expert examination is made. For preserving of valuable natural territories, natural sanctuaries, etc. special protected natural territories are organized.

With the purpose of revealing and assuming the measures for prevention of negative ecological consequences of realization of economic activities the evaluating of affecting on the environment is organized. Limits of water management - maximum permissible volumes of drawoff or dump of sewage into aquatic objects during the certain period of time are determined. The system of of water management licensing, determining the law and order of water management under the certain conditions (Smirnova et al., 2000) is developed.

Inspection and supervision. The control of aquatic objects state is implemented both by abstractors and members of the state control according their competence. Abstractor implements the control over volumes of drawoff and dump and their matching to the positioned limits, over composition and properties of sewage and their matching to the norms of dump, and also over composition and properties of water of aquatic objects in the places of own drawoffs and in background and supervisory section-lines of sewage receiver.

Special authorized state institutions on use and protection of water fund implement registration of abstractor and the control of rational water consuming. Special authorized state institutions of Goskompriroda implement the control over dumps of sewage of all categories. Special authorized state institutions of Fish Supervision implement the control over preserving of conditions of migration, living and reproduction of fish stocks and other

hydrobioresources and performance of the requirements. Special authorized state institutions Gossanepidnadzor implement the control over measures for prevention and liquidations of pollution of the aquatic objects used for drinking, household, health-improving needs, sanitary state of aquatic objects being sources of economic-drinking water supply.

Quality control of water in transboundary aquatic objects is implemented on the basis of bilateral international agreements with use of preconcerted measures and methods of evaluating of surface waters state. In the case of crashes or in the case of licensing water consumption for special large enterprises external experts are involved.

According to the Legislation of the Russian Federation citizens and the legal persons being guilty in breaking of legislation on protection and use of aquatic objects account administrative or criminal liability. Useable sanctions include: penalties, requirings of a clearing of breakings, indemnifications of the caused harm and a measure of the criminal responsibility.

The constant control over water management of all organizations and the enterprises in the basin of Ladoga Lake and also over dumps of sewage is carried out by "Neva-Ladoga basin water control". Practically all abstractors being subjects of water relationships and obliged to observe the established specifications and to carry out requirements of the water legislation are involved in the control of Ladoga Lake. They develop plans of water-control measures in view of stage-by-stage performance of target programs and other nature protection requirements.

Concentrated dumps of the municipal and industrial enterprises into aquatic objects are main polluters of waters in the basin of Ladoga Lake. Large contaminants in the basin are following branches: municipal services; industry, including: pulp-and-paper, nonferrous metallurgy, chemical, oil-refining, mechanical engineering, power engineering, including heat-and-power engineering; agriculture; transport.

For evaluation of pollutants income to Ladoga Lake and forming of its hydrochemical composition there is carried out constant supervision over waters quality of rivers Volkhov, Vuoksi, Svir, Pasha, Oyat, Syas, Olonka.

Measures on the protection of lake and their consequences. By researches of Institute Limnology of Russian Academy of Science in the development of Ladoga Lake ecosystem for the last decades it is possible to distinguish some periods:

1. Up to 1976 Ladoga was oligotrophic lake (average concentration of general phosphorus was about 10 mkg/l);

2. 1976-1983 - period intensive anthropogenic eutrophication ($P_{\text{general}} = 27 \text{ mkg/l}$);

3. 1983-1986 - period of stabilization;

4. Since 1991 - period of decreasing P_{general} .

Period of 1976-1983 is characterized by the greatest changes of lake ecosystem. The sharp raise of phosphorus income occurred in the beginning of 1970s when the Volkhov aluminum plant has transferred on new crude – apatite- nepheline ore. As a result of it average concentration of phosphorus in Volkhov River increased from 46 mkg/l (in 1959-1962) up to 230 mkg/l (in 1976-1979) (Smirnova et al., 2000). In 1980-1983 the measures, undertaken in order to reduce income of phosphorus to the lake with sewage of the Volkhov aluminium plant, allowed to do this by three times in one year. Priozersk cellulose plant dumped Sewage waters to the northern tributary of Vuoksi and then to the gulf Schuchiy of Ladoga Lake. In toe connection with adverse ecological conditions activity of this plant in 1986 has been stopped, in 1987 under the Decision of Ministerial council of the USSR it has been closed. Already from the following after closing year recovering of ecological conditions in this part of lake has started.

In 1980s a number of decisions both on federal and at regional level, ordering introduction of special regime of economic activities in the water-security zones of lake have been accepted. From the beginning of 1990s recession in industrial and agricultural production in the basin of Ladoga, connected with economic crisis in the country, has started. Industrial water consumption and water removal has accordingly decreased. Decrease in anthropogenic press on drainage area in 1990s has led to reduction of external phosphoric load up to 0.32 g P m²/year in 1992-1995 and 0.20-0.23 g P m²/year in 1997-1998. In 2000s reanimation in development of industry, agriculture, transport infrastructure has started that requires intensified attention to ecological state of Ladoga Lake remaining uncontested source of drinking water for such megapolis as St.-Petersburg.

Monitoring of Ladoga Lake state and quality of surface waters in its basin is carried out by the various organizations. The longest rows of supervision and the widest program of monitoring are in Institute of Limnology of Russian Academy of Sciences. In the northern part of lake regular monitoring studies are spent from 1989 by Institute of Aquatic Problems of the North of Karelian Scientific center (Petrozavodsk). Up to 1993 hydrochemical monitoring of lake was carried out by Northwest Branch of Hydrometeorological Service. Aquicultural monitoring in the basin is carried out by special authorized state institutions on the use and protection of water fund. Evaluating of water-control practices is spent incidentally, as a rule for substantiation of development of any projects.

Strong and weak sides in the control.

Advantages:

- In the last years fundamentally new normative and legal documents concerning use

and protection of water resources are developed.

- There are all administrative structures necessary for universal and efficient control of aquatic resources in the basin.
- By means of drastic measures of power structures, such as changing of production type, the introduction of high-performance methods of purification, prohibition of ecologically harmful productions, introducing of protective regime on coastal territories it was possible to reduce considerably anthropogenic load to Ladoga Lake.

Disadvantages:

- There is special legislative basis for protection of Ladoga Lake as unique natural object (special law or status of special protected aquatic object).
- Interbranch coordination in the sphere of control of water use and water protection, including monitoring of aquatic objects is insufficient.

6. The Key Challenges (See Annex 4)

Despite of stabilization of ecological conditions in Ladoga Lake the problem of improvement of quality of its water continues to remain actual. Recovering of lake, despite of reduction of anthropogenic press, goes slow because of significant inertness inside processes of huge lake. Essential recovering is expected under condition of change of orientation of regional development, revision of consumption structure, priorities and means of activity, establishment of legal and economical measures of water management regulation (Drabkova et al., 2000). Now necessity to limit man impact by frameworks of ecological opportunities of water body remains one of the main problems in the field of water-protective activity on Ladoga Lake.

Accepted in 1980-90s and in the beginning of 2000s legal acts, undoubtedly, promote resolving of nature protection problems in drainage area of Ladoga Lake, however by virtue of their generality they not always can consider a row of specific problems taking place at local level and caused, for example, by division of lake between two subjects of Federation, and catchment area between seven ones, etc. Therefore work to create uniform legal base, obligatory for all subjects of Federation in the basin of Ladoga Lake in order to create legal base for uniform purposeful actions of nature protection and administrative structures of federal and local levels. The necessary legal base is formulated in the project of special “Law on protection of Ladoga Lake”. Now there are favorable conditions for accepting such law and its realization. The bill “About protection of Ladoga Lake is already prepared (Rumyantsev et al., 2008) also it is presented in the State Duma, having passed preliminary discussion in some conferences and meetings (Alhimenko et al., 2007). Application of the law will provide legal base not only for recovering and further preserving of natural ecological conditions in

the Ladoga basin, but also will create preconditions for development of economy of Northwest region (including mining and manufacturing branches) on the basis of progressive ecologically secure technologies.

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