Lake brief Ladoga Lake

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Introduction.

Northern territories of Russia within the limits of Baltic, Barentz and the White Seas basins are full of huge hunber of greater and small lakes. In this region which right can be considered as ”lake-land“, the central place (not so much by position, but by importance) with good reason occupies Ladoga Lake – the largest in the Europe and the second (after Baikal) in in Russia. Owing to location in the east part of Baltic Sea basin, Ladoga accumulates the water drain formed both in Russia, and in neighbor states – Finland and Belarus. Together with connected with Ladoga by water drain 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 social and economic and other life of region. Water system as a whole and Ladoga Lake in particular are under power influence different economic activities of large economically developed region of Russia, and also from the adjacent states and, in turn, reciprocally influence on the state of their water bodies.

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 activity, etc.), water resources of all considered region experience essential ”pressure“ of diverse anthropogenous factors. All these influences finally can affect ecological state of Ladoga Lake as closing water object.

Due to historical reasons the lake for a long time attracted attention of people, providing needs of society for natural resources (biological, water, etc.) and as a transport artery. Development of adjoining territories especially actively occurs last 300 years after Russia getting out to the Baltic Sea coast, increase of local population in density, beginning of intensive using of forest resources, minerals, development of large industrial productions, etc. Actual problems of preservation of optimal ecological state of lake under conditions of total growth of social production have arisen as a result.

General characteristic of Ladoga Lake.

Ladoga Lake is northern water body. It is located between N59°54' and N61°47'. In the western part of the waste catchment basin located between N56° and N64° and E26° and E38°. The area of drainage basin of lake is 258.6 thousand km^2, and its ratio to the area of water surface (relative drainage) is 14.5. This parameter essentially above the specific relative drainage of Great North American Lakes equal to 1.6–3.4. High value of relative drainage of Ladoga Lake results its high sensitivity of its ecosystem to the processes in the drainage area that is expedient to consider estimating character degree of anthropogenous influences on the water body. magnitude of Ladoga drainage area 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) (Fig. 1).

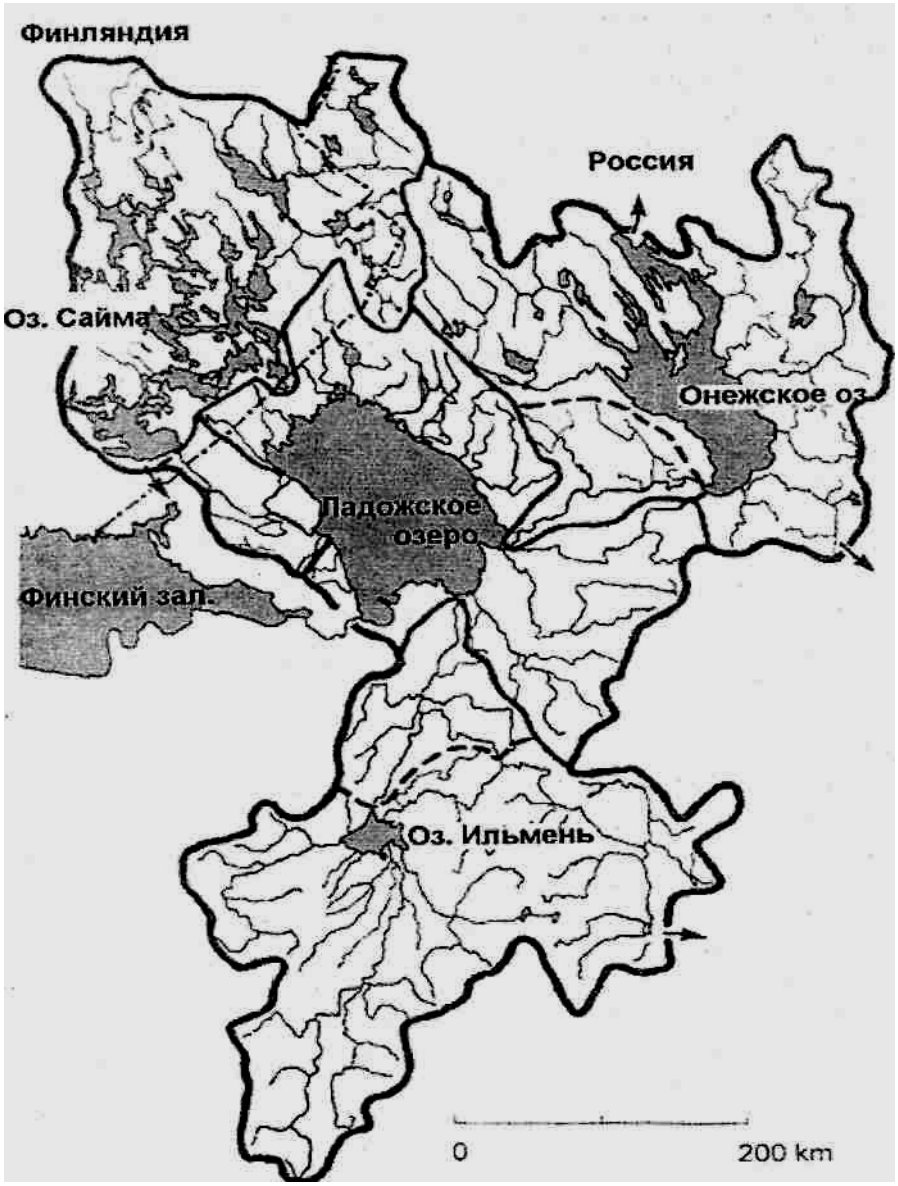

Fig. 1. Scheme of Ladoga Lake drainage area.

The drainage area by geographical sence is divived 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: Leningrag Region – 39%, Kareliya – 29%, Novgorod Region – 17%, Pskov Region – 6%, Tver Region – 4%, Vologda Region – 3% and the Arkhangelsk Region – 2%.

The sizes of drainage area cause 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. Forests, as it is known, together with soil significantly influence on the regime of surface drain and its chemical features.

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).

On the Ladoga drainage area is rich of marches which somewhere occupy significant areas. In Vuoksa 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' a marsh landscape makes even 60–70% (Lesnenko et al., 1988; Istomin, Yakovlev, 1989). Large bogs together with numerous lakes create high regulation 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 basin there are counted 10570 water-currents with total length 34475 km that averages 0.41 km/km^2, and in Volkhov-Ilmen part there are counted 24841 with total length 59921 km, or 0.75 km/km^2. The rivers are short mainly. Most long are Lovat and Msta. They have length 530 km and 445 km respectively (Grigoryev, Gritsevskaya, 1959; Istomin, Yakovlev, 1989).

Climate in basin of Ladoga Lake is moderated. Owing to softening influence of the North Atlantic atmospheric center, it is warmer than climate of located to the east areas of Northwest region (Veselov, Kirillov, 1966; Gorelov, 1982). In 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 is July: from +15.2°C up to +17.2°C. Last decades in the northern hemisphere global rise in temperature of air is observed which 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). Atmospheric precipitation and evaporation usually have essential significance for drainage area. During the recent period precipitation are 650 mm/years, value of evaporation from the surface of lake is 380 mm/year (Raspletina, Susareva, 2006). So, the observed picture is characteristic for humid geographical zone.

Extensiveness of catchment area in combination with superfluous humidifying of territory causes formation of significant volumes ofsurface drain. The main mid-annual volume of water drain (70.5 km^2) goes to Ladoga Lake (without taking into account precipitations on the water area of lake) from such areas as Svir-Onega (20.8 km^3), Volkhov-Ilmen (16.9 km^3), Vuoksa-Saimaa (19.3 km^3) and private catchment area of the lake (13.5 km^3). Relative density of each of these areas is following: 29.5%, 24.0%, 27.4% and 19.1%. So, the drain to Ladoga Lake is formed mainly on 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 Baltic Sea.

Together with water drain from the lake catchment area various pollutants and biogenic elements negatively influencing quality of water and ecological state of water body are brought. Economic activities in those parts of catchment area which are located in Kareliya and the Vologda Region (basin of Onega Lake), the Novgorod Region (Lake Ilmen basin), Finland (Lake Saimaa basin), and also on a private catchment area of the lake essentially influences on the water quality in Ladoga Lake. In this connection management of economic activities in such catchment area is not simple problem and its solution needs significant efforts from nature protection structures and administrative bodies of various levels.

Key parameters describing Ladoga Lake, are given in tab. 1 (Naumenko, Karetnikov, 2002).

Table 1.The basic morphometric characteristics of Ladoga Lake.

Characteristics	Unit	Value
Elevation over sea level	m	5.1
Catchment area	km²	258600
Total lake area	km²	18135
Area of water surface	km²	17872
Water volume	km³	838 ± 2.4
Average depth	m	46,9
Maximal depth	m	230
Maximal length	km	219
Maximal width	km	125
Shore line length	km	1570
Water exchange time	years	11

The lake has shape close to rectangular, its long axis (219 km) is extended in direction NW–SE. It is located (by average long-term data) only at mark +5.1 m a.s.l. In this connection, considering value of the maximal depth, the bottom of the hollow is by 225 m below sea level. The area of this cryptodepression at its top mark is 16060 km^2, or 89.9% from the area of lake water surface, and water volume filling cryptodepression is 751.6 km^3, or 89.7% from the total water volume in the lake. Despite of significant deepening of lake hollow under sea level, hydraulic connection of cryptodepression on underground horizons with the nearest part of Gulf of Finland is absent.

Ladoga Lake is deep water body. Located in the northern part of the hollow maximal depth reaches 230 m, Average depth is 46.9 m. areas with depths of 50 m and more Is occupy 42.8% of water area, areas with depths of 100 m and more – 11.7%. In these deep areas it is concentrated the main part of lake water : in layers from 50 m and more – 638.3 km^3 (76.1% of the total volume), from 100 m and more – 270.1 km^3 (32.2%). Because of significant size of the hollow and accumulation of great volume of water in it, water exchange in lake appears slowed down, despite of the significant drain acting from an large catchment area. Change of water in lake occurs once in 11 years.

Because of great depths and concentration of significant mass of water in the central hollow, water in the lake during summer gets warm insufficiently and its temperature does not reach values peculiar to great shallow lakes of the same system of Great European Lakes (Ilmen, Pskovskoe-Chudskoe). Therefore Ladoga Lake constantly keeps coldwater character even in conditions of warmest years. Evident representation about thermal features of Ladoga in comparison with lakes of more southern zones gives Fig. 2 (Naumenko, Karetnikov, 2002) on which dates of beginning of “biological summer” are given, that is dates of transition of temperature of surface water layer through +10°C.

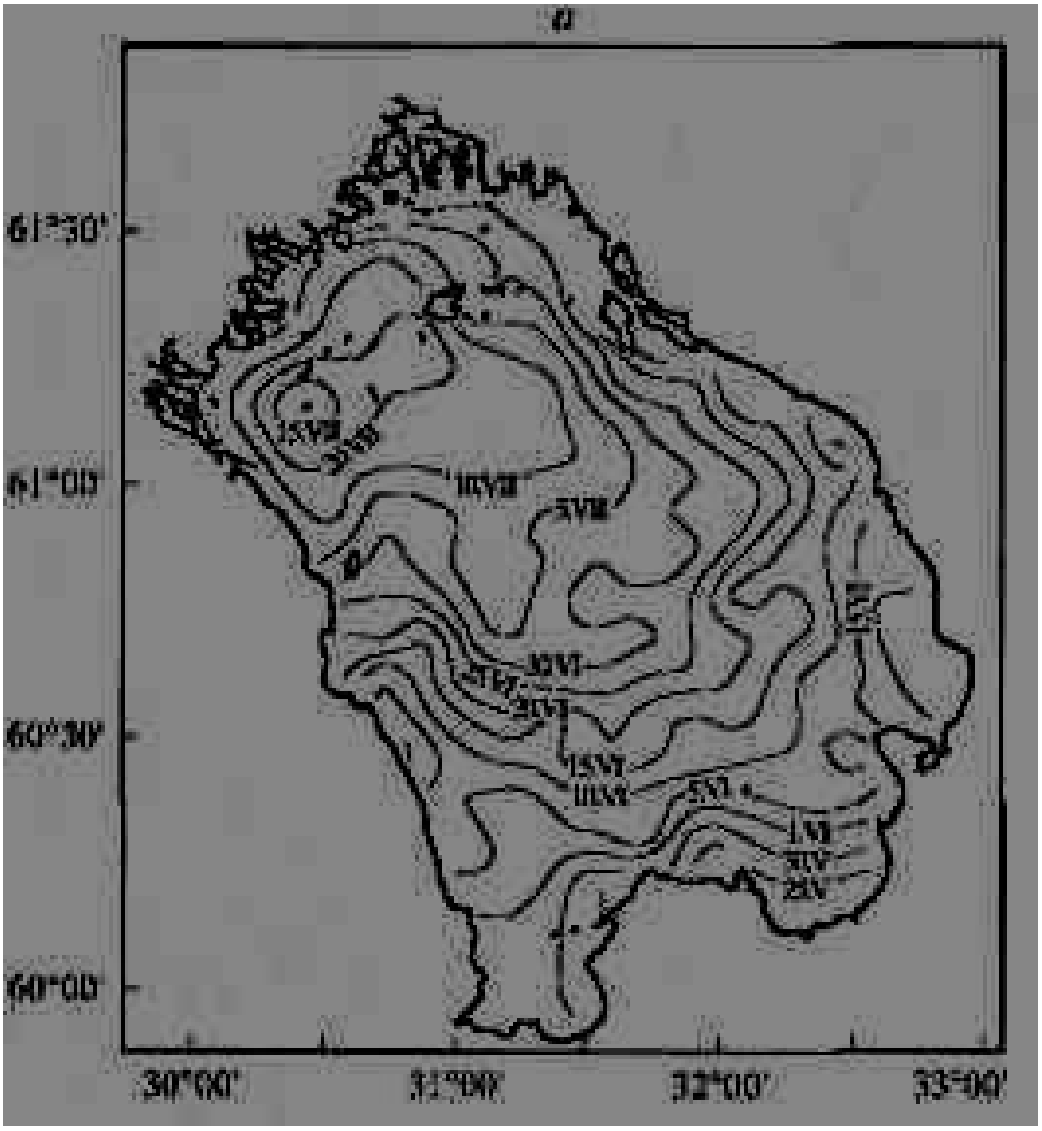

Fig. 2. Dates of beginning of "biological summer" on the surface of water of Ladoga Lake.

Apparently from the figure, "the biological summer" in the south of lake in shallow Volkhov Bay comes on the average on May, 25th, in the north over deep-water hollow on July, 15th. Thus it lasts in the south up to 130 days, in the north no more than 65 days (Naumenko, Karetnikov, 2002). The temperature of surface water layer in the middle of May in the south of lake is about +6°C, in the north is less than +2°C. During the maximal warming up in the middle of July – beginning of August it on the average reaches in the south +19°C, in the skerries it is up to +16°C, and over the northern hollow it is only from +12°C up to +14°C.

In the lake there is well-marked vertical temperature stratification, and depth of thermocline is about 30–40 m. Below thermocline water temperature decreases quickly and in July–August at the bottom it makes +4 – + 5°C. The thermal regime of waters essentially influences on the structure of lake biota, defines its coldwater character and causes low level of production parameters.

The ice cover on lake starts to be formed on the average in the second half of November. 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 separate years blocks of ice can be met up to the middle of June. Full freezing of lake occurs not every year. In the connection with the greater resources of heat accumulated in huge water mass during summer period, in warm winters the central part of lake remains free from ice cover.

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 makes by Secci 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 the summer the water transparency is lower because of intensive phytoplankton development and also changes within the limits of 2–3 m. Transparency in southern bays is lower and rises at transition to the central areas.

Water of Ladoga Lake possesses high natural properties. It is "soft", low mineralized (63.7 mg/l on average) and in this respect does not concede to water of Baikal (mineralization about 90–100 mg/l) well-known by the quality. This feature of the Ladoga water is caused by structure of the catchment area on which the drain coming to lake is formed. Such areas of catchment area as Svir-Onega, Vuoksa-Saimaa, and also western, northern and eastern of private catchment area are formed by poorly soluble crystal rocks or by washed up and leached glacial deposits. Carrying out of mineral substances from them is minimal. There is noted relatively increased income of dissolved mineral substances from Volkhov-Ilmen area where catchment areas and agricultural lands prevail. In connection with differences in the structure of catchment areas, extent of mineralization of drain from each of these sites appears various and in the closing parts of rivers in 2004–2005 it was: Svir 39.1–39.5 mg/l, Vuoksa–Burnaya 44.4–52.2 mg/l, Volkhov 105.0–145.1 mg/l (Raspletina et al., 2006). Despite of noted differences, coming from the rivers waters are averaged in the lake during hydrodynamical processes, and also owing to life activity of organisms both in the middle and the central areas mineralization of water varies in narrow limits. 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). Interannual stability of parameters of water mineralization is supported also by the slowed down water exchange. Noted high constancy of mineralization can play a positive role at realization of water withdrawal for the household (drinking) purposes from the central areas of lake.

Water of lake in ordinary years is characterized by rather stable (especially in the central area) pH close to 7.2–7.6 feebly changing over 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) near to mouths of large trubutaries can noticeably deviate from normal amounts (Ladoga lake, the Atlas, 2002). Deviations of pH and the concentration of oxygen in water from normal values observed in rare (abnormal) years do not have catastrophic character and do not influence negatively specific biota of Ladoga Lake.

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. 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.

As have shown by researches of last time, phytoplankton development in the lake corresponds to the parameters peculiar mesotropic water body (biomass 1.1–1.8 g/m^3, chlorophyll "a" 4.8–8.5 mg/m^3) (Rumyantsev, Drabkova, 2007; Letanskaya, 2002). However the resulted estimation of phytoplankton development creating the basic mass of the primary production is too generalized. Because of the huge sizes of lake and because its separate areas are polytypic it appears to be differentiated by areas and changes from oligotrophic in the central water area up to oligotrophic-mesotropic in transitive water area and up to mesotropic in southern bays. Such conclusion proves to be true by data on zooplankton development. In the upper water layers in which the maximal concentration of zooplankters is marked, their number and biomass correspond to weakly mesotropic and in hypolimnion to oligotrophic levels of trophism. Thus during

30 years (1970s – beginning of 2000s) biomass in the most productive layer 0–10 m remains stable (Rumyantsev, Drabkova, 2007).

Benthos in the lake is distributed non-uniformly. 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/m^2, on depths 20–70 m it raises up to 3.0–5.9 g/m^2. In shallow areas of western and east littoral benthos biomass varies within limits of 2.2–3.6 g/m^2, in bays it is 5.4 g/m^2, and in Volkhov Bay it reaches 12.6 g/m^2 (Barbashova, Slepuhina, 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/m^2 and by this parameter they surpass other groups of benthos (oligochaetes, chironomids). 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.

Ladoga Lake has large fish stocks. Such valuable species live in it, as lake salmon, lake trout, lake char, many forms of whitefishes, vendace and its large form ripus. Pike perch, bream and other fishes are numerous in the lake. Owing to presence of valuable species, the lake has big value for fishery. Catches in it in separate years reached almost 6900 tons. However because of oligothrophic 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 values specified above. Valuable species of the Ladoga fishes are widely used for acclimatization. Such forms as Volkhov whitefish, ripus, and smelt were widely settled in various water bodies of the country and were taken out to some foreign countries.

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 (Fig. 3; Kudersky, 2000). 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.

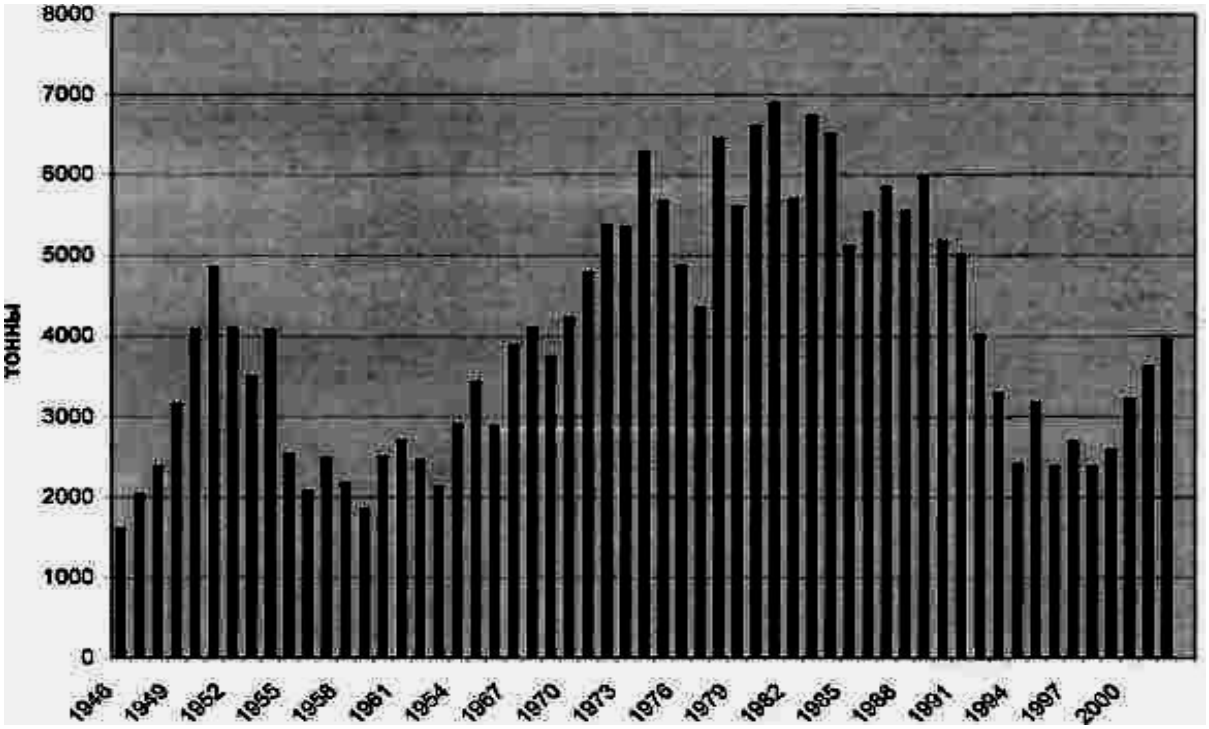

Fig. 3. The total fish catches in Ladoga Lake.

But it is necessary to consider, that last decrease in size of catches is connected not only with natural decrease in bioproductivity 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.

Long-term dynamics merits special attention in connection with features of the data used at its analysis. Unlike hydrological and hydrobiological materials available only for some years or limited by duration groups of years, data on catches is accessible in the form of long continuous series of years. Across Ladoga this series covers an interval of time from 1946 prior to the beginning of 2000s (Kudersky et al., 1997; The Modern condition …, 2004). This series represents the big interest not only for fishery, but also for general ecology as illustrating changes of stocks (catches) of fishes it simultaneously characterizes long-term dynamics of bioproduction potential of lake. Therefore fig. 3 can be considered as the certain mirror reflecting variability bioproduction phenomena occured in Ladoga Lake within about 60 years. Taking it into consideration it is possible to approve, that in the beginning of considered long-term cycle (the end of 1940–1950s) the lake was typical oligotrophic water body. Then its biological productivity increased, and from the end of 1980s – beginnings of 1990s it began to decrease, coming back in the central areas to oligotrophic, and in more shallow areas to oligotrophic-mesotrophic trophic level.

History of formation of lake and its biota.

Ladoga Lake is young. The history of its formation and development is closely connected with degradation existed in the north of the Europe of last (Valdai) glaciation and the subsequent reorganizations of water system of region in Pleistocene–Holocene time. About 15000 years ago territory of lake still was under glacial cover. After 13000–10500 years ago on the place of lake there was a gulf of large glacial water body connected with the Baltic glacial lake (Fig. 4; Subetto, 2002).

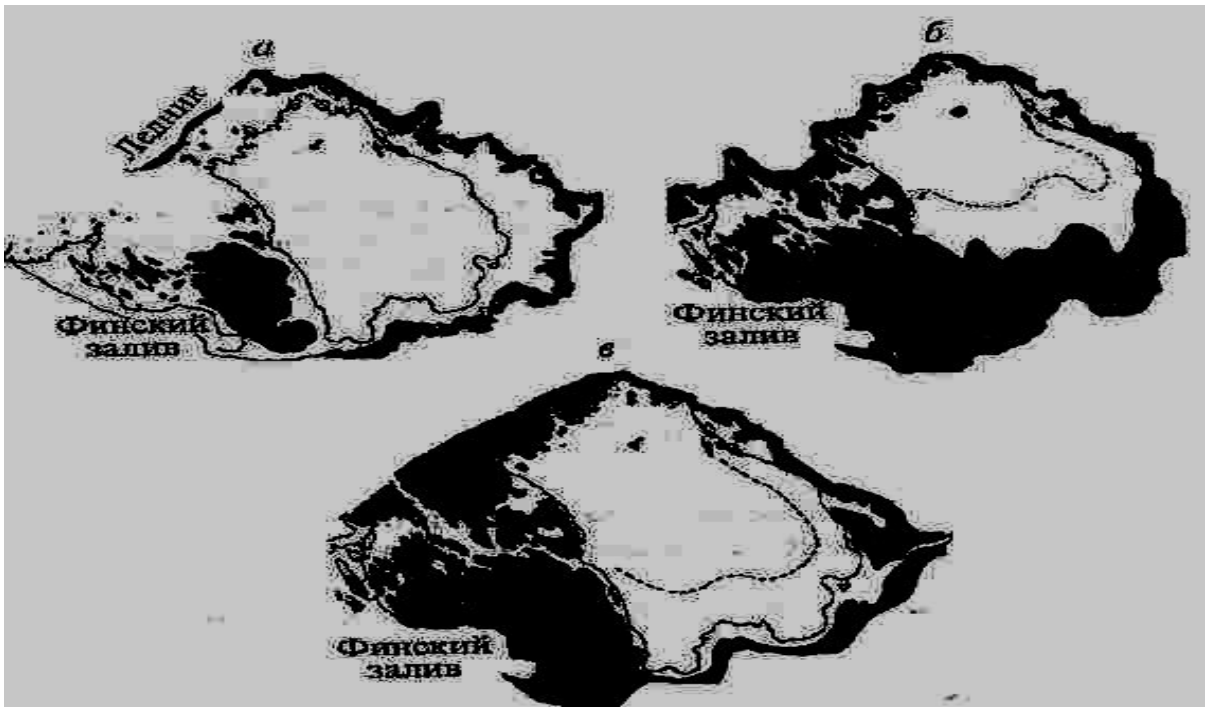

Fig. 4. Stages of Ladoga Lake development: a – about 10300 years ago; b – about 9200 years ago; c – about 3100 years ago.

After glacier contraction to the north, the lake became separate water body that has found reflection in character of bottom sediments. In early Holocene 10300–9500 years ago glacial-lacustrine type of bottom sediments was replaced with lacustrine one and on the greater part of bottom began to collect homogeneous clay, and then silts, playing the leading part during the modern period (Subetto, 2002). At that time the climate in region was severe, essentially colder than recent, the organic world of lake was poor with species, and biological productivity was the lowest. By general characteristics the lake quite corresponded to modern arctic water bodies.

The important stage in history of lake was Atlantic Time when the climate has considerably become warmer and even became warmer than recent. These changes have found reflection in the bottom sediments: in them concentration of organic substance considerably increased what testifies increase of general biological productivity in the lake ecosystem. In the followed then sub-boreal epoch some cold snap has occurred and climate gradually (with fluctuations) has passed into modern condition (Davidov, 2002) which while, however, concedes by temperature regime (and so by intensity of biotadevelopment) to Atlantic Time.

Changes in the state of this lake and climate of territories surrounded it most directy affected state of organic world of water body what it is possible to show evidently taking fish population as example. One part of the fishes, occupying now Ladoga Lake, has got in it from preceded postglacial water body. This is so-called relicts of *Mikulinsk* interglaciational period which have survived during glaciation in severe conditions glacial water bodies. From recent ichthyofauna to them valuable commercial fishes from salmons and whitefishes belong, the most cryophilic species, including unique glacial-marine relict – fourhorn sculpin, and also some eurythermic species are related. Species structure of fish population was sharply impoverished (in comparison with the recent) and was characteristic for lake and its basin before warm Atlantic Time. Fishes of Pre-Atlantic time (as well as corresponding them recent ones) occupied mainly open and deep-water parts of Ladoga being under weak influence of continental drain.

During warm epoch of Atlantic Time, in the period of raised humidity of considered territory of the European North including the Ladoga basin, owing to the appeared wide water communications, the second wave of fishes-invaders has got on the North from Ponto-Caspian basin. These are thermophilic species and, unlike invaders of first wave, they spread out in the beginning (as well as now) mainly to shallow well warmed up areas (bays), and also in many small

lakes of the Ladoga basin. Invaders of the second wave live mainly in the places being under influence of continental drain or in the rivers running into lake. They have essentially enriched specific structure of the fish population and have given to it the character mixed in the biogeographical relation which have kept till now (Kudersky, 2007).

The similar general history of formation is characteristic also for other groups of the water organisms inhabiting Ladoga Lake. Not stopping on the analysis of origin of these groups, we shall note the following detail having essential value concerning nature protection. Concerning structure of Ladoga Lake fauna is unique. This lake is the only water body in Russia in which the full complex of glacial-marine relic organisms, which are inhabiting North-Europian fresh waters, was kept since epoch of last glaciation. In the number of these species there are, as is known, planktonic crustaceans *Limnocalanus macrurus*, benthic amphipods *Pontoporeia affinis*, *Pallasiola quadrispinosa*, *Gammaracanthus lacustris* and isopods *Mysis relicta*, *Saduria entomon*. There are relic fish fourhorn sculpin *Triglopsis quadricornis*, and from mammals there is fresh-water seal. In water bodies of Russia from the listed species aquatic sow bug *Saduria entomon* meets only in Ladoga Lake, and fourhorn sculpin is in four lakes of Kareliya. As for seal the form of seal close to it lives only in Baikal.

Presence of unique glacial-marine relicts and groups of cryophilic organisms including salmons and whitefishes (Mikulinsk time relicts) causes necessity of strengthening of actions on protection Ladoga ecosystem from negative anthropogenous influences.

Value of Ladoga Lake in social and economic life of region.

Ladoga Lake is natural object important by its social and economic value. Activity of numerous water-users located as just near the lake as on in the catchment area and also over its bounds. In the lake there is a 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. Main of them are presented below in generalized form.

Value 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.

The population of region reaches 9 million people from which more than 5.0 million people lives than 5.0 million people in cities, including 4.8 million people in St.-Petersburg, the largest political, economic, historical and cultural center not only in the country, but also in the world. On territory of catchment area the are living almost 4 million people, including 2.7 million city dwellers. Population density in the Russian part of catchment area on the average makes 12.4 ind./km^2 (Rumyantsev, Drabkova, 2007), and in the basin of Volkhov 40 ind./km^2 and the basin of Syas' 20 ind./km^2 (Raspletina, Susareva, 2006).

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.

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 Kareliya (Rumyantsev, Drabkova, 2007). Among industrial branches fuel and energy, pulp-and-paper, woodworking and chemical industry, nonferrous metallurgy has big relative weight. Pulp-and-paper industry concerns to the largest con-

sumers of water. Significant industrial potential is located on territory of Finland in basin of Vuoksa (Lake Saimaa basin) where the pulp-and-paper enterprises prevail; there is steelmaking industry, etc.

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 Vuoksa there are four (including two in Finland), by one hydroelectric power station are on the rivers Volkhov, Janisjoki, Tulema and on six northern trubutaries of Ladoga 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, Vuoksa. It has essentially affected state of populations of such through diadromous fishes as lake salmon, lake trout, lacustrine-riverine whitefishes.

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

Forestry. Forests occupy 55% all Ladoga basin area and 70% of proper catchment area of lake. They play important role formation of surface drain, influencing on its seasonal distribution and chemical composition of water. Protective forest strips along 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 anthropogenous 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 iside and outside the Ladoga basin. Thus the significant part of wood is delivered for export. By present time the large areas of forests appear cut down and are partially restored due to forestation.

Ladoga Lake as a source of drinking water. The main consumer of the Ladoga water is St.-Petersburg. The population of city daily uses 2.9 million m^3 of drinking water, or 1.1 km^3 in a year. Ladoga Lake for St.-Petersburg is unique uncontested source of water supply as stocks of underground (artesian) waters and also resources of surface drain (besides Ladoga Lake) are insufficient. The state of city dwellers health substantially depends on quality of the Ladoga water. Except for St.-Petersburg, the Ladoga water is used for water supply of some other cities of Leningrad region (Kronstadt, Priozersk, etc.) and Kareliya. Therefore stocks of fresh water in the Ladoga basin must be treated as renewed strategic resource which quality entirely depends on an ecological condition of water body and catchment area.

Drain from Ladoga Lake and its influence on quality of water in Neva within boundaries of St.-Petersburg. In the boundaries of St.-Petersburg of 98% Neva discharge is provided by Ladoga drain. 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 autopurification amplify. Secondly, in the cases of polluted waters icome the additional negative contribution to state of aquatic environment of city is brought.

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 km^3 (average long-term) makes two thirds of income part of water balance

of this area of Baltic Sea. Because of this the Ladoga 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 specified above, this lake is unique water body in Russia in which complex of glacial-marine relic organisms is presented with its full complement. All of them have got into Ladoga Lake from brackish-water sea areas through glacial water bodies during last glacial period and are alive witnesses of complex geological history of this lake. Glacial-marine and glacial relic organisms cause original current of bioproduction processes and give unique charcter to the Ladoga Lake ecosystem. The genofund of Ladoga organisms already now partially finds application in the economic purposes. It concerns to the category of national property, requires constant attention and deserves effective protection.

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 Kareliya 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, ripus) and large ordinary fishes (pike perch, 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 presence of valuable fishes it serves as the supplier of scarce fish production for some industrial centers and first of all for St.-Petersburg.

Ladoga Lake as a part of water transport system. The lake has nation-wide value as the important part of the water transport highways 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 pass. Alongside with transit, on the lake intensive local navigation is carried out.

The volume of transportations of cargoes makes about 10 million tons in a year, passengers – more than 450 thousand persons. The general length of navigable lines in lake exceeds 1500 km and makes about 0.1 km on 1 km^2 of water area. Freight traffic density exceeds 550 tons/km^2. In 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 Red and Mediterranean seas.

Ladoga Lake and its basin as 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 is located in the Karelian and Novgorod parts of the Ladoga basin. Through Ladoga Lake tourist routes in other regions pass. 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 parts) here are available wide prospects of recreation development which can be combined with ama-

teur fishery and other forms of productive leisure on the nature. At development and this form of natural resources use, the general streams of tourists considerably will increase.

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: restoration and protection.

Natural resources of Ladoga Lake and its basin are widely used in economy and other spheres and provide effective society functioning in considered region. Intensity of using natural resources here is high, that should influence 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 appares 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 by diverse activity in the catchment area.

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. And in the structure of industries resource-consuming and water-consuming manufactures prevail causing due to features of technology raised influence on environment due to great volumes of sewage dumped into water bodies, coming into atmosphere smoke and dust emissions, and also firm waste concentrating dumps. In the Leningrad part of the Ladoga basin fuel and energy, wood, pulp-and-paper, chemical and petrochemical enterprises, mechanical engineering, black and nonferrous metallurgy big 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.

Listed above enterprises concern to the leading branches making basis of industrial potential of Russia and adjacent Finland. In this connection questions of regulation of their activity with the purpose of prevention of infringements of ecological condition of environment as a whole and including Ladoga Lake ecosystem get a special acuteness.

On the territory of basin in the Leningrad and Karelian parts for a long time are there are carried out forest harvesting works and as a result of which extensive spaces become bare from forest that influences character of water drain formed here and its quality. Carried out reforestation actions yet completely compensate actual loss of wood fund.

Alongside with the industry, in the Ladoga Lake basin agriculture is intensively developed. Its functioning is closely connected with the large-scale meliorative works changing char-

acter 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. At agricultural production greater losses of fertilizers and pesticides which finally with a superficial drain get in reservoirs are made, promoting eutrophication.

Из-за имеющих место частичных несоблюдения требований природоохранного законодательства промышленными и сельскохозяйственными предприятиями, качество водного стока, формирующегося на водосборе, не всегда соответствует санитарно-гигиеническим нормам. В ряде рек отмечается повышенный уровень загрязнения водной среды (Свирь, Волохов, Вуокса и др.; Аналитический обзор…, 2004). Так в р. Свири содержание хлорорганических пестицидов превышает предельно-допустимые концентрации (ПДК). В воде этой реки наблюдается также повышенное содержание меди, марганца, железа, нефтепродуктов, высока концентрация фенолов. В воде р. Волхов превышены нормы биологического потребления кислорода, а также меди, марганца, нефтепродуктов, фенолов и т.д. Очень загрязнены воды реки Сяси. В р.Вуоксе высоки концентрации меди, нефтепродуктов, нормы биологическое потребление кислорода.

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 on catchment area, not always corresponds to sanitary-and-hygienic norms. In a number of the 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 water of this river the raised concentration of copper, manganese, iron, mineral oil is observed also, concentration of phenols is high. In water of Volkhov norms of biological consumption of oxygen, and also copper, manganese, mineral oil, phenols, etc. are exceeded. Waters of the river Syas are much polluted. In Vuoksa concentration of copper, mineral oil, norms biological consumption of oxygen are exceeded.

By the general level of influence of economic activities on environment in the Leningrad part of the Ladoga basin three are certain so-called «hot points» to which are related Syas pulp-and-paper factory, «the Volkhov aluminium» plant, pig-breeding complex "East" (Analytic review …, 2004).

To the second group of the anthropogenous factors influencing ecological processes in Ladoga Lake, various forms of economic activities in the coastal zone concern. Here a number of cities (Priozersk, Novaya Ladoga, Syasstroy, Pitkyaranta, Impilahti, Laskela, Sortavala, etc.) and the large pulp-and-paper enterprises and the enterprises of other branches are located. In the boundaries of Leningrad region in water-security zone of the Ladoga basin the significant number of cattle, and also pigs, birds, fur animals is concentrated. In this zone the big number of warehouses of mineral fertilizers and agricultural pesticides is placed.

By the general state of economic and municipal activity the coastal zone of lake appears to be zone of the raised risk. Sewage of the enterprises and cities here act in the coastal areas limited by the 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. On such sites at strong pollution by organic substances "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 of organisms of the extremely resistant to organic pollution can develop in mass. Similar zones were marked in a gulf Schuchiy nearby of Priozersk, in a fiord close to Sortavala, in the mouth of Volkhov at ship-repair factory, in the Volkhov Bay near to dump 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.

Hydroconstruction influences negatively on fish resources. The dams constructed in lower reaches of the rivers block ways of migration of lacusrine-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.

The third direction of influence of anthropogenous 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 connection with the general decrease in economic activity in the country intensity of navigation in Ladoga Lake has decreased a little. However this is temporary phenomenon. 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.

Fishing has essential influence on the ecological state of Ladoga Lake and, first of all, on the ecosystem structure and its icthyological component. In the ecological aspect it is essential that fishing is made not on 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 all water area. Influence of fishing on the ecosystem is amplified also in the connection with its directed character: not all species of fishes are caught but mainly the most valuable (whitefishes, ripus, pike-perch, bream, pike, etc.).

As a result the fish population is under double "pressure": on the one hand it is negatively influenced by various forms of economic activities (hydroconstruction, dump of the polluted drains, toxic substances, mineral oil, etc.), on the other hand it is under selective influence of intensive fishing. All of this causes undesirable changes in the general state of stocks of fishes and proportion between various commercial species and ichthyocenosis structure as a whole. These processes in turn influence other parts of ecosystem and its bioproductional potential.

Recreational use of Ladoga Lake is not wide yet. Nevertheless, on the lake there is numerous fleet of small size, and also the great army of fishermen of fans works. Fleet of small size (especially in the places of higher concentration) promotes pollution of water environment by mineral oil and various dross, and practically not ordered amateur fishery causes noncontrollable damage to fish stocks. Quite often activity of fishermen-fans develops into typical poaching.

The fourth direction of influence of economic activities to Ladoga Lake is transboundary transport of toxic substances, coming to atmosphere with smoke and dust emissions, 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. In the structure of sediments from atmosphere sulfur dioxide, carbon oxide, oxidized nitrogen prevail. But 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.

About probable income of toxic substances at transboundary transport it is possible to judge receipt evidently from example of sulfur (Fig. 5; The State Report …, 2003).

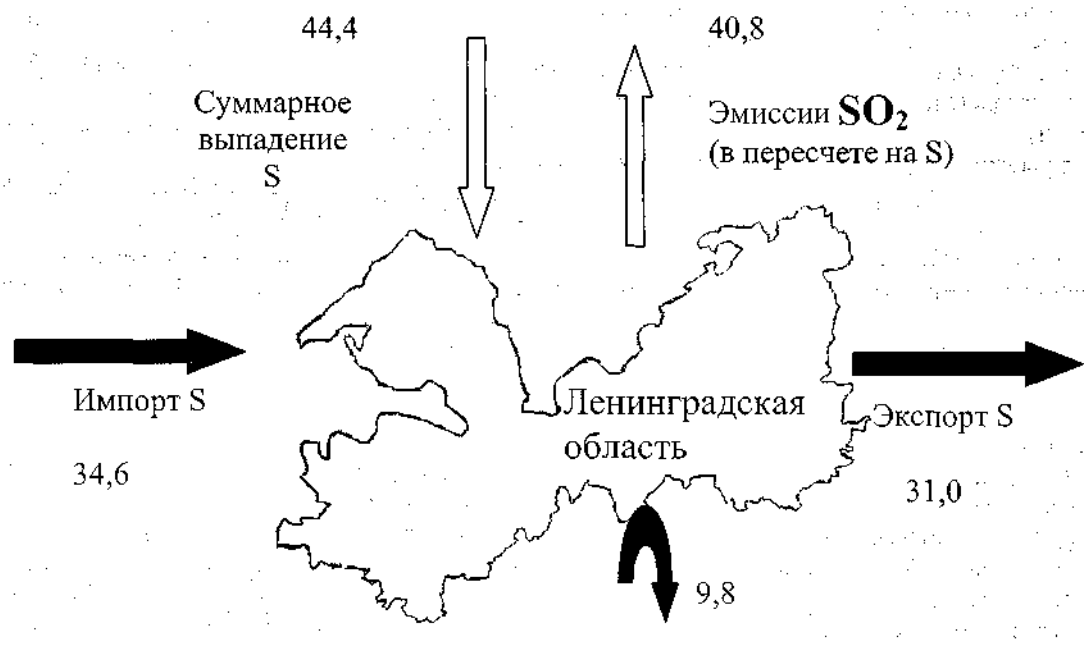

Fig. 5. Balance of streams of sulfur for Leningrad region in 2000 (thousand tons of S)

In 2000 on the territory of Leningrad region through atmosphere 44.4 thousand tons of sulfurs, including 9.8 thousand tons from own sources and 34.6 thousand tons from foreign has come. 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. For full representation about income of sulfur to the lake it is necessary to add to these figures its washout from the catchment area.

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

- anthropogenous 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 lake.

Anthropogenous eutrophication. To the beginning of 1960s Ladoga Lake by the level of trophia was typical oligotrophic water body with water rich with oxygen. Concentration of the dissolved oxygen in water during this period in the open part of lake did not fall below 90–120% of saturation. At the bottom even on the maximal 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 (on which the level of primary production depends) was low and averaged for a year: the general phosphorus 10 mkg/l, mineral phosphorus 3 mkg/l. However to the beginning

of 1980s ecological state of lake has sharply changed. Concentration of phosphorus in water during 1976–1980 has risen up to 26 mkg/l (Raspletina, Susareva, 2002). Concentration of oxygen during the winter period in deep-water areas has gone down not only at the bottom, but also on the surface. Areas with the relative concentration of oxygen in water less than 90% in the spring were clearly distinguishable. In the places which are being under direct influence of sewage, periodically or constantly there was deficiency of oxygen. Concentration of mineral phosphorus in central and northern areas of lake has increased by 4–5 times, in the southern and east by 3 times that was consequence of growth of phosphorus income from the catchment area and with precipitations. If in 1959–1962 to the lake on the average in a year 2430 tons of phosphorus came, 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 (Anthropogenous 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 connection with anthropogenous eutrophication in the open parts of the lake 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 surface layers of water.

However the increase in parameters of water trophic in various parts of lake proceeded not in regular intervals and was reflected differently 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. By zooplankton coastal sites and the top layer of water can be characterized as mesotrophic areas of lake while the deep zone has kept oligotrophic character. This circumstance testifies that change of the trophic status of lake was unstable and acceptance of necessary measures return to the initial oligotrophic to a condition could be possible.

State of the aquatic environment. Alongside with eutrophication in 1970–1980s in Ladoga Lake the significant acuteness was got with a problem of ecological state of aquatic environment. Because of slow realization of necessary nature-conservative measures (purification sewage water and atmospheric air), recycling of industrial and other waste including highly toxic, etc.) remained from intensively developed industrial and an agricultural production and growth of urban population, to the lake came escalating volumes of polluting substances together with sewage, various emissions, transboundary air streams, etc. 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, ternenes, sulfur-containing substances. Concentration of high-molecular sunstances (in particular, polychlorinated biphenils) in number of areas (bay Petrokrepost, the Volkhov bay, area of Pitkyaranta, etc.) has considerably exceeded maximum concentration limit.

Water quality has worsened not only near to the sources of pollution and in gulfs, but also in the open areas. Pollution was incidentally marked in the central deep-water zone that is especially dangerous to destiny of lake. If in littoral zone owing to the intensive hydrodynamical phenomena and water heating in summertime autopurification of water mass proceeds quickly enough, on greater depths at the slowed down water exchange and constantly low water temperatures other picture is marked. Even at the full termination of income of pollutants to depths a long number of decades are necessary for clearing water mass of this zone from xenobiotics.

Change in biota. Anthropogenous eutrophication and pollution of water environment with xenobiotics has negatively affected 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 valency, 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*, known only from 3 lakes of Russia, 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 ofa 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 benthis 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.

Changes in the fish population. Various anthropogenous "pressure" upon environment of Ladoga Lake and its basin has affected negatively the fish population. Fishes are sensitive bioindicators of ecosystem state and react to anthropogenous influences by changes of species structure, proportion of ichthyomass of various species, size of commercial stock and catches, etc. In Ladoga Lake there are registered all these reactions of fishes to anthropogenous factors. The most essential changes have occured in group of lacustrine-riverine fishes. About ti became extinct there was Atlantic sturgeon which was commercial fish still in the beginning of XX century. Because of construction of hydrostation on Volkhov spawning areas became inaccessible for Volkhov whitefish. Other forms of lacustrine-riverine whitefishes (from Svir, Vuoksa) have lost commercial importance. Last decades stocks of lake salmon and lake trout were reduced sharply.

Change in Ladoga Lake ecosystem affect state of stocks of not only lacustrine-riverine, but also lacustrine fishes. So stocks of salveling, occupying deep zone of lake were considerably reduced. It has lost commercial importance. Because of pollution spawning areas with mineral oil and high level of eutrofication эвтрофирования of lake stocks and catches, characteristic for Ladoga Lake ecosystem, of lacustrine forms of whitefishes have decreased. The negative phenomena occurring in the lake, have affected stocks of such leading commercial fish as pike perch. Decrease in stocks and catches of listed above lacustrine-riverine and lacustrine species of fishes with long life cycle is accompanied by increase of catches of short cycle fishes (vendace, smelt). However neither by quality, nor by economic parameters of catches these species are not equivalent replacement of lost valuable fishes. The listed changes in the fish population of Ladoga Lake cause greater anxiety, as fish is not only abstract component of lke biota, but also a source of food production – deficit animal protein.

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 marked 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 is marked. Because of pathogenic influence of accumulated in body and internals toxic substances toxicoses (lesion of liver, spleen, brain, etc.) develop at fishes.

Toxic substances income into fish both through external covers, and with fodder organisms which accumulate in itself all spectrum of the polluting substances which are available in lake. Thus, toxic substances not only are present in water, but also circulate in the ecosystem of Ladoga Lake in trophic circuits.

Health of the population. Bad ecological situation developed in Ladoga Lake and nearby territories affects not only the organic world, but also influences people living here. As supervision shows, 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.

Given above materials enough pronounced characterize situation in which Ladoga Lake ecosystem has fallen as a result of the disordered economic activities on the lake itself and in its catchment area. With the purpose of overcoming of unfavorable position formed during some decades acceptance of some large measures directed on restoration of normal ecological state of lake and prevention of negative infringements in the future was required.

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 (Leningrad region) Priozersk pulp-and-paper factory and the similar enterprise in Harlu (Kareliya) 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 that has allowed to stop income of lots of the phosphorus, dumped to the lake earlier in the structure of sewage of this enterprise, is changed. 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 basin, they have soon yielded positive results. In water of lake concentration of phosphorus – the main element responsible for eutrophication growth of water has started to decrease. This process has continued the next years that is evidently visible on fig. 6 (Raspletina, Susareva, 2002).

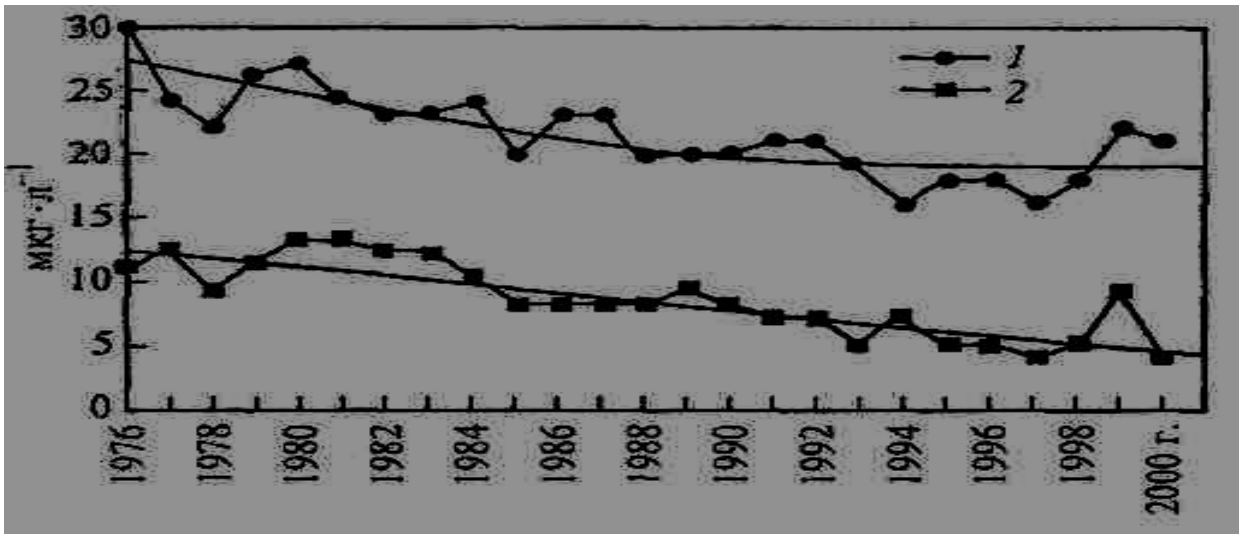

Fig. 6. Change of average concentration of the general (1) and inorganic (2) phosphorus in the water of Ladoga Lake (period of open water).

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 connec-

tion 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.

At discussion of the reasons of improvement of ecological state of Ladoga Lake in the end of XX century usually is taken into consideration the first, less often the first and second factors mentioned above. However at such approach is lost from sight role of long-term dynamics productive potential of 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 more correctly to consider, that observed improvement of ecological state of Ladoga is consequence of action of such anthropogenous factors as nature protection actions and recession in economy and the natural factor – decrease of lake productive potential as a whole.

In connection with acceptance of some essential limited measures (closing of the some enterprises, strengthening of work on sewage purification, etc.), the 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 ыефеу 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, in unsatisfactory state there are 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 restoration and the further protection of ecological state of 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 accepts a number of laws promoting nature protection activity from which it is necessary to note the following: «About especially protected natural territories» (1995), «About preservation of the environment» (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.

Though these legal acts promote decision of nature protection problems in considered region, but by virtue of the generality they not always can consider a number of the 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, etc. Therefore work on creation of uniform legal base, obligatory for all subjects of Federation located in the basin of Ladoga Lake is carried out in order to create legal basis absent till now for uniform purposeful actions of nature protection and administrative structures of federal and local levels. Only such solution of complex ecological problematic in conditions of administrative dissociation and prevalence of local interests over nation-wide is possible. Necessary legal base is formulated in the special project «the Law on protection of Ladoga Lake».

For acceptance of such law and its realization now there are favorable conditions. Revival of economy and growth of business activity is expedient for carrying out not at the level of old becoming obsolete or already become obsolete conceptions about mutual relations «person – wildlife», and on new high-quality basis which can be incorporated in the spirit and the letter of this law. In this case it is possible to rely on real change of ecological situation to the best direction.

Проект закона «Об охране Ладожского озера» уже подготовлен (Румянцев и др., 2008) и представлен в Государственную Думу, пройдя предварительное обсуждение на ряде конференций и совещаний (Алхименко и др., 2007). Применение закона обеспечит

правовые основы не только для восстановления и дальнейшего сохранения естественной экологической обстановки в Ладожском бассейне, но и создаст предпосылки для развития экономики Северо-Западного региона (включая добывающие и перерабатывающие отрасли) на базе прогрессивных экологически безопасных технологий.

The bill «About protection of Ladoga Lake» is already prepared (Rumyantsev, et al., 2008) and presented to the State Duma, having passed preliminary discussion in the number of conferences and meetings (Alhimenko, et al., 2007). Application of the law will provide legal bases not only for restoration and the further preservation of natural ecological conditions in the Ladoga basin, but also will create preconditions for development of economy of Northwest region (including extracting and processing branches) on the basis of progressive ecologically safe technologies.

References.

Alhimenko A.P., Kudersky L.A., Rumyantsev V.A., Sobol I.A. About conception of federal law "About protection of Ladoga Lake" // Water resources under conditions of changing climate. – St.-Petersburg: Lymnological Institute RAS. – 2007. – Pp. 192-226. [in Russian]

Analytical review. About state and protection of environment of St.-Petersburg and Leningrad region in 2003. – St.-Petersburg. – 2004. – 356 p. [in Russian]

Anthropogenous eutrophication of Ladoga Lake. – Leningrad: Nauka. – 1982. – 304 p. [in Russian]

Barbashova M.A., Slepuhina T.D. Macrozoobenthos and its long-term variability in open part of the lake // Ladoga Lake – past, present, future. – St.-Petersburg: Nauka. – 2002. – Pp. 202-210. [in Russian]

Veselova M.F., Kirillova V.A. Climatic features of Ladoga Lake // Hydrological regime and water balance of Ladoga Lake. – Leningrad: Nauka. – 1966. – Pp. 81-103. [in Russian]

Gorelova E.M. Main trends in climatic processes within catchment area // Anthropogenous eutrophication of Ladoga Lake. – Leningrad: Nauka. – 1982. – Pp. 13-31. [in Russian]

State Report. About state and protection of environment of St.-Petersburg and Leningrad region in 2002. – St.-Petersburg. – 2003. – 344 p. [in Russian]

Grogoryev S.S., Gritsevskaya G.L. Catalogue of Karelia lakes. – Moscow–Leningrad: AS USSR. – 1959. – 239 p. [in Russian]

Davidova N.N. Evolution of lake ecosystem in late and postglacial time according composition of complexes od diatoms in bottom sediments // Ladoga Lake – past, present, future. – St.-Petersburg: Nauka. – 2002. – Pp. 157-164. [in Russian]

Istomina E.G., Yakovlev E.M. Blue miracle, historical-geographical hand-book on the rivers, lakes and marches of Novgorod Region. – Leningrad: Lenizdat. – 1989. – 222 p. [in Russian]

Kalesnik S.V. Ladiga Lake. – Leningrad: Gidrometeoizdat. – 1968. – 159 p. [in Russian]

Kudersky L.A. State of fish stocks in large lakes of the USSR // Problems of studies of large lakes of the USSR. – Leningrad: Nauka. – 1985. – Pp. 28-38. [in Russian]

Kudersky L.A. Changes in the fish population of Ladoga Lake during last 50 years // Ladoga Lake; monitoring, studies of modern state and problems of management of Ladoga Lake and other large lakes. – Petrozavodsk: Karelian SC RAS. – 2000. – Pp. 298-311. [in Russian]

Kudersky L.A. Ways of Ladoga Lake ichthyofauna formation // Society, environment, development. – 2007. – No. 3 (4). – Pp. 102-110.

Kudersky L.A., Pechnikov A.S., Shimanovskaya L.N. Fish resources of Ladoga and Onega lakes. – Moscow: VNIERH. – 1997. – Fish economy, ser. ”Biopromyslivye I ekonomicheskie voprosy mirovogo rybolovstva”. Review. – 1. – 39 p. [in Russian]

Kudersky L.A., Rumyntsev V.A., Drabkova V.G. Ecological state of aquatic sysem of Onega Lake – Ladoga Lake – Neva River. – Gulf of Finland on the eve of XXI century. – St.-Petersburg: Lymnological Institute RAS. – 2000. – 79 p. [in Russian]

Ladoga Lake, Atlas. – St.-Petersburg: Lymnological Institute RAS. – 2002. – 128 p. [in Russian]

Ladoga, criteria of ecosystem state. – St.-Petersburg: Nauka. – 1992. – 325 p. [in Russian]

Lesnenko V.K., Slinchak A.A., Abrosov V.E., Semenova A.A., Nedospasova G.v., Sudnitsina D.N., Denisenko A.I., Ermakova A.E., Kostychenko V.P. Nature of lakes of Polost march landscape and perspectives of their use in fish economy. – Leningrad: A.I.Gertzen Ped. Inst. A.I.Gertzen. – 1988. – 56 p. [in Russian]

Letanskaya G.I. Modern state of phytoplankton and tendencies of its changes durin period of lake summer stagnation // Ladoga Lake – past, present, future. – St.-Petersburg: Nauka. – 2002. – Pp. 165-174. [in Russian]

Naumenko M.A., Karetnikov S.G. Morphometry and zoning of lake depths // // Ladoga Lake – past, present, future. – St.-Petersburg: Nauka. – 2002. – Pp. 16-49. [in Russian]

Raspletina G.F., Kulish T.P., Petrova T.N. Hydrochemical characteristic of rivers – tributaries of Ladoga Lake and Neva River // Evaluation of ecological state of rivers in Ladoga Lake basin by hydrochemical indexes and structure of biocenioses. – St.-Petersburg: Lymnological Institute RAS. – 2006. – Pp. 11-35. [in Russian]

Raspletina G.F., Kulish T.P., Chernyh O.A., Krylenkova N.L., Susareva O.M., Scherbak V.A. Income of substances into the lake together with riverine flow and outcome with Neva River waters // Ladoga Lake – past, present, future. – St.-Petersburg: Nauka. – Pp. 56-71. [in Russian]

Raspletina G.F., Susareva O.M. Biogenes // Ladoga Lake – past, present, future. – St.-Petersburg: Nauka. – 2002. – Pp. 77-85. [in Russian]

Raspletina G.F., Susareva O.M. Physic-geographic and economic-geographical characteristics of Ladoga Lake catchment area // Evaluation of ecological state of rivers in Ladoga Lake basin by hydrochemical indexes and structure of biocenioses. – St.-Petersburg: Lymnological Institute RAS. – 2006. – Pp. 6-11. [in Russian]

Rumyantsev V.A., Alhimenko A.P., Kudersky L.A., Sobol I.A. Conception and project of federal law “About protection of Ladoga Lake“. – St.-Petersburg: Lymnological Institute RAS. – 2008. – 109 p. [in Russian]

Rumyantsev V.A., Drabkova V.G. Forming of Ladoga Lake water quality in modern conditions as basis of its natural resources // Studies on ichthyology and adjacent branches of science on continental water bodies in the beginning of XXI century (to 80 years of prof. L.A. Kudersky). – St.-Petersburg – Moscow: KMK. – 2007. – Pp. 472-482. [in Russian]

Modern state of fish economy on internal water bodies of Russia. – St.-Petersburg: GosNIORH. – 2004. – 580 p. [in Russian]

Subetto D.A. Structure, peculiarities and history of bottom deposits forming // Ladoga Lake – past, present, future. – St.-Petersburg: Nauka. – 2002. – Pp. 122-135. [in Russian]

Trapeznikov Yu.A., Efimova L.K. Reaction of ladoga water level on climatic changes // Water resources of land under conditions of changing climate. – St.-Petersburg: Lymnological Institute RAS. – 2007. – Pp. 235-241. [in Russian]