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Influence of Anthropogenic Factor on Freshwater Fish Population and Human Health in Yakutia

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Abstract:
This article discusses the problems of three environmental disasters as a result of mass overfishing of valuable commercial fish, mass influx of people, aerotechnogenic emissions, negative discharge of industrial and agricultural effluents to the main spawning and feeding areas of large freshwater sections of river systems: Lena, Yana, Indigirka and Kolyma. There has been a sharp decline in the number and biological diversity of fish including valuable commercial fish such as Siberian sturgeon as taimen, nelma, muksun, chir, peled, Siberian vendace, etc. Their inhibitory effect on the functional systems of the body is accompanied by a change in the basic biological parameters of fish, a decrease in numbers, a decrease in the proportion of older age groups and the replacement of valuable long-cycle stenobiont species with low-value short-cycle eurybionts. The reasons for the annual spawning of fish may be delays in oogenesis or atresia of eggs depending on the nature of the disturbance of the normal reproductive cycle, fish population density, availability of males, contamination of spawning grounds, impairment of vitellogenesis and reconstruction of all oocytes of vitellogenesis onset under unfavorable temperature conditions and insufficient nutrition. Morphopathological analysis of whitefish has revealed the following anomalies in the structure and condition of organs: weak pigmentation of the body, shortening of the jaws, weak turgor of the muscles, curvature and an uneven number of rays in the fins, curvature of the spine, curvature and bifurcation of gill stamens, mucus galling, pale liver discoloration, not gonads, swelling of the kidneys, the presence of parasites in more than two organs, obesity of the heart. The Index of Dysfunctional State (ANN) varied from 0 to 8, an average of 2.02. Despite the rather high occurrence of anomalies in fish, the results of morphopathological analysis make it possible to attribute the studied watercourses to the zone of relative ecological well-being. Thus, taking into account the leading role of whitefish in the creation of ichthyomass in northern ecosystems and taking into account two main forms of their economic use (fishing and commercial cultivation), we can give a general assessment of the potential opportunities for whitefish and outline promising ways of maintaining whitefish.

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I. INTRODUCTION

The inhibitory effect on the functional systems of the fish organism is accompanied by a decrease in number, a decrease in proportion of older ages, and the replacement of valuable long-cycle stenobiont species with low-value short-cycle eurybiont species. Currently, this problem is partially addressed in science.

In this regard, a reliable assessment of the morphofunctional state of ecologically significant and economically valuable species is necessary in order to prevent crisis phenomena in a timely manner.

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II. METHODS

Fish from the reservoirs of Yakutia living in conditions of anthropogenic pollution has becomethe main object of our research. Expeditionary work has been carried out throughout the territory covering almost the entire northern territory of Yakutia (the basins of the Lena, the Vilyui, the Amga, the Botuobiya, the Yana, the Khroma, the Indigirka, the Kolyma, etc.), as well as the Vilyuiskoye reservoir from 1970 to 2018. The collection of material has been confined to the seats of bump of industrial effluents (factories of diamond, gold and lead extraction enterprises) and has been carried out during the open water period.

The analysis has been carried out on fresh material according to the method of I. F. Pravdin [1] taking into account the recommendations of Yu. S. Reshetnikov [2] as applied to whitefish. The rate of linear and weight growth of fish has been analyzed by the traditional method of N.I. Chugunova [3] using the guidelines of M.V. Mina [4], M.V. Mina and G. A. Clevezal [5].

The content of heavy metals has been determined in the gills, muscles, skeleton, liver and kidneys of fish. 5-10 specimen of one-dimensional fish have been taken from the landing for analysis and slices of gills, muscles, skeleton, liver and kidney have beenhacked out with a stainless steel knife using a weight of 3-8 g. Samples have been placed in plastic bags and quickly frozen in liquid nitrogen or plastic boxes with “dry” ice totransportat to the laboratory. Primary processing of fish organs and tissues (weighing, drying to constant weight at a temperature of 105 ° C) and determination of metal content (Co, Pb, Cd) has been carried out in the sanitary-hygienic laboratory of the Federal State Health Institution “Center for Hygiene and Epidemiology in the Republic of Sakha (Yakutia)”. The resulting solution has been analyzed by an atomic absorption spectrophotometer (AAS-3, Perkin-Elmer) in an air-propane (Co, Pb, Cd) flame. All metal concentrations are expressed in micrograms per gram (μg / g) dry weight.

III. DISCUSSION

Environmental pollution by waste from basic industries (agriculture, transport, metallurgy, etc.) leads to degradation of ecosystems and a threat to human health, which remains the main environmental issue and a priority of social and economic policy in the development of measures that contribute to the conservation of biological diversity in fresh water systems of the Republic of Sakha (Yakutia).

Yakutia is one of the few regions of Russia that are abundant in lake and river reservoirs and inhabited by valuable commercial fish species (Siberian sturgeon, goldfish and crucian carp, Arctic cisco, muksun, broadwhitefish, pelyad, lake herring, nelma, arctic grayling, lenok, ordinary taimen, etc.). In the rivers and lakes of Yakutia, there are 43 species and subspecies of cyclostomatous and fish. Currently, industrial and amateur fishing is mainly carried out in large reservoirs of river basins, such as the Lena, the Vilyuy, the Yana, the Indigirka, theKolyma in the amount of up to 5 thousand tons per year. According to the data of Yakutrybvod, the main catch occurs in valuable commercial fish species, such as cisco, heriing, pelyad, broad whitefish, muksun, cisco whitefish, gold fish and crucian carp, etc. [6].

Based on the studies, a number of patterns have been revealed in the changes of fish populations living on the northern boundary of occurrence in the conditions of water reservoirs pollution with heavy metals from mining enterprises [7 - 16]. The sublethal toxicity of the environment causes deep damage to the vital organs in fish leading to a reduction in their life expectancy, a sharp rejuvenation of the population due to increased death of older fish groups, a slowdown in growth rates, early onset of puberty at extremely small sizes for species, and an increase in the percentage of fish missing spawning among mature individuals [17 - 20].

IV. RESULTS

The organs, which are considered as bio-indicators in assessing the status of both individuals and the species as a whole - the gill apparatus, scale,

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bones, kidneys, liver and gonads have been studies. Causes of non-annual-spawning may be delays in oogenesis or atresia of caviar, depending on the nature of the disturbance of the normal reproductive cycle determined by conditions in the spawning season: fish population density, male accessibility, contamination of spawning grounds (in case of spawning delay); violations of vitellogenesis and destruction of all oocytes of the onset of vitellogenesis (in the case of atresia) with an unfavorable temperature regime and malnutrition. In recent years, whitefish and other fish species have increased the incidence of anomalies and structures, and the development of the reproductive system caused by intense technogenic impact [21 - 26, etc.]. The defeat of gonads is manifested in many ways: structural anomalies, asynchrony in their development, impaired normal course of gametogenesis, decreased fertility, missing spawning, the appearance of intersex individuals, accelerated maturation and the formation of dwarf forms [27 - 29, 6].

The first major environmental catastrophe in Yakutiahas been associated with the years of World War II when as a result of mass overfishing of fish in the main spawning and feeding areas of large freshwater river systems: the Lena, the Yana, the Indigirka and the Kolyma caught up to 68,500 tons of fish products (1941-1945), including only in 1943 in the river. It has been caught a total of 10,166 tons, of which 190 have been Siberian sturgeon, 7205 - whitefish, including 3686 tons of muksun in the Lena. A significant reduction in fish stocks is observed mainly in fish with a longlife cycle, such as Siberian sturgeon, taimen, nelma and muksun.

The second environmental catastrophe in Yakutia associated with the chemical effect on aquatic biota occurred in the 50-60s of the last century as a result of the massive discharge of man-made waters from mining and processing enterprises, domestic and agricultural effluents into river systems and water bodies of the republic, as well as unaccounted chemical elements during aerotechnogenic emissions into the atmosphere.

The third one occurred due to the overlap of the first two catastrophes in the early 1980s, as a result of a change in the dominant species in the fish population, which is accompanied by a change in the main biological parameters of fish populations, resulting in a decrease in biological diversity in many reservoirs of Yakutia.

The regulation of river flow and the formation of a reservoir made significant changes to the fish fauna of the flooded section of the river basin of the Vilyui and the tail race. A change in the ecological situation in the tail race led to the complete destruction of large spawning grounds of nelma, which came into the riverVilyui to spawn from the river Lena, which, of course, has been reflected in the number and size of its landing in the river Lena.

Crucian carp and gold fish and lake minnow entered the reservoir partially from the flooded lakes but mainly the fish fauna of the Vilyui reservoir was formed due to native species.

In the spring of 1972, the Vilyui experimental fish breeding farm in the Vilyui variable backwater zone released the first larvae of pelyad, the introduction of lake herring began in 1975, and Baikal omul - from 1999.

Thus, the formation of ichthyofauna in the Vilyui reservoir occurred due to native fish, immigrants from flooded lakes and due to invaded pelyad and herring. The environmental conditions of the fish in the reservoir leave a peculiar imprint on their ecology, on the composition, structure and dynamics of the population size (table).

The dam of the first stage of the Vilyui hydroelectric station, built in 1966, made significant changes to the structure and functioning of the water population of the river Vilyuy.

Peculiar public attention is focused on the problem of the Vilyuy. The alarms are justified and caused by sharp changes in the natural environment, the borders of which extend far beyond the areas of the diamond mining industry and hydroelectric power plants in the tail race. Powerful impact and directivity technogenic impact in the time interval

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led to a violation of the structural and functional unity of the water community through changes in the optimal parameters of the habitat. The revealed indicators of the environmental consequences of anthropogenic impact are: a change in the average biomass of the populations of planktonic and benthic organisms, a decrease in the number of individual groups, and an abundant development of indicator species. In modern conditions, the effect of pollutants has become a powerful evolutionary factor. Due to selection, it often leads to the dawn of low-value organisms that have adapted to new hydrochemical conditions and to the displacement of economically significant species that have not adapted to them [6].

Table:Dominant fish speciesover the years

Year	Fish species			
1973	Pike	Perch	Сиговые	-
1977	Pike	Perch	-	-
1980	Perch	Pike	Burbot	-
1982	Perch	Burbot	Pike	Roach
1985	Perch	Burbot	Roach	Pike
1987	Burbot	Perch	Roach	Pike
2009	Perch	Pike	Roach	Whitefish
2012	Perch	Roach	Whitefish	-
2016	Perch	Roach	Whitefish	-

In 1989, comprehensive studies were conducted to study the impact of the diamond mining industry and hydroelectric power plants on the components of the environment and human health in the Vilyuy river basin on a monitoring basis. Studies performed in 1989-1991 showed that the upstream water of the riverVilyuy, which does not experience a technogenic press, still belongs to the hydrocarbonate class of the calcium group of the second type. It is characterized by a high content of dissolved oxygen (8-9 mg / l), low salinity (89-141 mg / l) with an average value of 95.74 mg / l. No changes in the maximum permissible concentrations for nutrients and organic matter have been observedobserved [30].

In the river below the Vilyui reservoir, which is under the influence of villages and enterprises of the diamond mining industry, a different picture is observed. Mineralization is relatively high - 128 mg / l versus 95 mg / l. The pH value is shifted to the alkaline side. Fluctuations in nutrients over three years are not large and do not exceed the LOC values. Maximum marked indicators are usually confined to settlements such as Bordon, Neck, Vilyuisk. In 1991, the phosphate content in the villages of Sul'dukar, Suntar, and the city of Vilyuisk increased 5 times against the 1989 indicators [30].

At all stations of the Vilyui Group, a high content of organic matter is observed (COD ranges from 39.6 to 109.8 mgO2 / L). For example, in the Nyurba settlement, COD is 109 mgO_2/l and exceeds the LOC by 4 times. Compared to previous years, the value of COD at most stations located near villages has increased. The effect of the influx of domestic and agricultural effluents, the effect of the reservoir and industrial facilities are observed [30].

Particular pollution is represented by volatile phenols and petroleum products. According to these indicators, LOC excess is found in almost all villages. So, volatile phenols were found at Suldyukar settlement - 10 LOC, Suntar - 30 LOC, Vilyuisk city - 10 LOC, Sheya - 3 LOC, Bordon - 30 LOC. The content of petroleum products in these villages is 2 LOC.

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There are frequent cases of oil pollution of rivers during the destruction of coastal oil depots and pipelines during floods and other disasters. So, in 2001 there was a terrible flood on the river Lena when the city of Lensk was completely destroyed. Over 10 thousand tons of oil spilled during the ice drift and flooding in the river Lena, the damage amounted to more than 2 billion roubles. Studies have shown a sharp increase in the oil content in water of more than 160 LOC and phenol more than 10 LOC.

Species mostly preferred for fishing (muksun, broad whitefish, nelma) experience a very strong fishing presuure and steadily reduce their numbers [31].

Therefore, a return to the initial state of the Arctic ecosystems after high anthropogenic stress will have a long process [32, 33]. Fish, as representatives of the highest trophic level of freshwater ecosystems, is characterized by a long life cycle, during which numerous xenobiotics accumulate.

Maintaining the species population at an acceptable level is ensured by the stable functioning and high reliability of the generative system in various environmental conditions throughout the entire period of reproductive activity [34, 35, etc.]. Whitefish is the most sensitive and least resistant to different types of toxicants. Whitefish accounted for up to a third of landing.

Currently, the main industrial and amateur fishing in Yakutia is carried out in large reservoirs. One more problem is added to the problems of irrational use of fish stocks: the problem of the construction and operation of oil, gas and mining enterprises in Yakutia, which is accompanied by significant pollution of water reservoirs, irreversible water consumption is growing, river channels are disturbed, feeding and wintering areas of cotadromous fish are in the zone of intensive negative impact of industrial activity [36 - 42].

With an increase in the scale of mining operations, the degree of influence on the hydrochemical regime of surface waters also increases. The nonpoint discharge of pit water, containing pollutants such as arsenic, zinc, lead, cyanides, as well as lead, mercury, cadmium, and othersis of particular importance. Fish and other representatives of the animal and plant world die from their influence in contaminated water [43 , 44]. The use of drilling and blasting operations, powerful mining and loading transport and dump equipment leads to air pollution with fine dust and toxic gases [45]. Dumps are vast areas of artificial embankments. More than 450 thousand tons of waste are generated at MirnyMPP in a year [15]. The Klerichi liquid, which is a mixture of thallium salts of formic and malonic acids, is used in the workshops for the final finishing of diamondsin the diamond mining industry. In 1989, its annual consumption by the Yakutalmaz association was about 1.5 tons [46] and, as a result, the thallium content in water amounted to 300 and 400 LOC, respectively [47, 16].

In 2004, 52.01 million m^3 of fresh water was withdrawn from surface waters by the enterprises of the diamond mining industry of Yakutia, of which 51.72 million m^3 of water was taken by ALROSA divisions while the efficiency of the treatment facilities of the diamond mining industry is very low and only 5,4% of wastewater is treated to established standards. As of January 1, 2004, there were about 707 million tons of waste of all hazard classes at ALROSA enterprises. By 2004, the total area of disturbed land in the company was 10,490 ha. The atmospheric emissions of pollutants (up to 41 items, including carbon monoxide, sulfur dioxide, nitrogen dioxide) amounted to 8.22 thousand tons [48 - 51].

The most dangerous and unpredictable of all these factors are emergency discharges of water from the water reservoirs of the recycled water supply to the hydrographic network, since the suspension does not settle because of its smallness and fineness even over a long period of time; due to the low temperature of ambient natural water in the study area, the dilution rate of discharged

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wastewater is very low and does not ensure the safety of habitat of aquatic organisms [6].

Morphopathological analysis of whitefish in many confluents of Yakutia river revealed the following anomalies in the structure and condition of organs: weak pigmentation of the body, shortening of the jaws, weak muscle turgor, curvature and an uneven number of rays in the fins, curvature of the spine, curvature and bifurcation of gill stamens, mucosal gills pale liver color, asymmetrical form of gonads, swelling of the kidneys, the presence of parasites in more than two organs, obesity of the heart. The Index of Dysfunctional State (IDS) varied from 0 to 8, an average of 2.02. Despite the rather high occurrence of anomalies in fish, the results of morphopathological analysis make it possible to attribute the studied watercourses to the zone of relative ecological well-being [52, 6].

The negative consequence of eutrophication is also enhanced by intensive fisheries; in practice, it is difficult to separate the effects of fishing and the eutrophication process. Thus, taking into account the leading role of whitefish in the creation of ichthyomass in northern ecosystems and taking into account two main forms of their economic use (fishing and commercial cultivation), we can give a general assessment of the potential opportunities for whitefish and outline promising ways of maintaining whitefish.

1. Fishing in northern reservoirs with its existing forms is approaching the maximum possible limit for removals, and it is unlikely that a sharp increase in landing can be expected since less and less non-harvested reservoirs remain and existing landing rates approach the annual increase in production and in some cases even exceed them.
2. Commercial fish farming is the only possible way to increase whitefish production. This is the creation of special commodity farms both at existing and newly emerging reservoirs. Using the principle of exploitation of young ecosystems, in which the main energy is used to increase production and using the principle of polyculture, allows you to get a large yield of products. Undoubtedly, the experience of growing whitefish in cages, especially in the zone of action of warm waters, deserves attention [53, 54].

It is of particular importance is in the Far North where fishing is often the main source of life for the people living there including small and indigenous peoples. The rational use of fish in our diet will not only preserve our health but also help to cure many diseases, to withstand the onslaught of environmental impact.

Important components of heavy metals, including mercury, are their biological activity and toxicity from the sanitary and epidemiological point of view. Fish and fish products including preserves that are made in our country in Yakutia, are one of the sources of minerals in human nutrition but at the same time one cannot but take into account the harmful ability and harmfulness to accumulate some trace elements in the body over time including heavy metals.

V. CONCLUSION

Thus, during the period of anthropogenic pressures, the aquatic ecosystem of Yakutia underwent significant changes that affected all its structural components. The hydrochemical regime in the past of oligotrophic ultrafresh reservoirs with calcium-carbonate mineralization with low concentrations of suspended material and trace elements has been transformed during the anthropogenic load: the waters began to correspond to the class of sulfates of anthropogenic nature, the content of suspended solids increased. Heavy pollution of water and bottom sediments by heavy metals has occurred. Despite a decrease in pollution levels, especially by heavy metals and suspended solids in recent decades, water quality remains unfavorable.

The structure of the fish population in the water reservoirs of Yakutiahas been compared, the deterioration of water quality and changes in the structure of the population of invertebrate organisms

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have been revealed which affected the state of the final producers - fish. As a result of the activities of mineral processing enterprises in the republic's water reservoirs, the following trends in water quality have been observed: its salinity has increased, its ion composition has changed in the direction of increasing sulfate content, water transparency has decreased due to the increased content of suspended particles, siltation of the bottom by solid waste from industrial enterprises has taken place, as a result, toxic compounds have accumulated. Environmental pollution with toxic metals like Pb, Hg and Cd affects human health. We have studied the common species of fish that live in the rivers of Yakutia, which are representatives of the food chain "water - fish - man."

The structure of the fish population has changed in the direction of reducing the share of valuable whitefish, and the main biological indicators of whitefish have also changed. Due to the toxic load on the fish organism, premature death of older age groups occurs, growth rates are inhibited. Along with a decrease in the growth rate, the metabolism of fish changes towards fat accumulation instead of the consumption of plastic substances for protein growth, which is a reaction to adverse living conditions.

Processes of fish reproduction of have been broken. One of the reactions of fish to changing conditions is the transition to a shorter cycle of life and reproduction. However, the most typical ones are slowing of fish maturation and frequent, prolonged omissions of the spawning season.

In natural reservoirs –the rivers Vilyui, Chroma, Indigirka and Kolyma –renal lithiasis(nephrolithiasis) has been discovered, which is associated with the influx of contaminated water. Pathologies in the fish skeleton have also been noted - a pug-nosed snout, curvature of gill stamens and ribs, the formation of a hump and the fusion of 2-3 vertebrae in the thoracic region. When the body was intoxicated, the following anomalies of the liver and kidneys were found: cell death and the appearance of connective tissue in their place.

Violation of the structure and functioning of fish populations, the emergence of deep pathologies and dysfunctions in their bodies has led to a decrease in the fishery potential of the water bodies of Yakutia. It shall be noted that studied fish samples often did not have visible anatomicpathological characteristic of poisoning with mercury, lead, and cadmium salts. Therefore, chemical and toxicological studies are of particular importance in the veterinary and sanitary examination of fish and fish products.

However, it should be noted that many researchers have observed pathologies characteristic of water reservoirs contaminated with heavy metal compounds, which indicate environmental toxicity for aquatic organisms. For example, at the beginning of the nineteenth century, gold mining began in the upper river Kolyma in the middle of the twentieth century on the river. A cascade of hydroelectric power plants has been built in the Kolyma providing cheap electricity to the territory of the Magadan Region. All these transformations have affected the structure of the fish part of the community of the river basin Kolyma. The given materials show the main directions of anthropogenic successions of the Arctic aquatic ecosystems under the influence of a large complex of anthropogenic factors that may arise in other water systems during the development of the Arctic regions.

It should be emphasized that the quality of food raw materials, regardless of origin, primarily depends on the state of the environment. Changes in environmental conditions under the influence of chemical pollution, as a result, causes the tension of adaptive mechanisms, which can lead to the development of pathological changes in the human body.

VI. REFERENCES

[1] Akimova, N. V., Ruban, G. I. (1996) "Systematization of breeding sturgeon (Acipemeridae) under anthropogenic impact" // Vopr. ichthyology. - Vol. 36. - Issue. 1. - pp. 65-80.

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ISSN: 0193 - 4120 Page No. 1286 - 1295

[2] Akimova, N.V., Popova, O.A., Reshetnikov, Yu.S., Kashulin, N.A., Lukin, A.A., Amundsen P.A. (2000) "Morphological state of the reproductive system of fish in water bodies of the Kola Peninsula" // Vopr. ichthyology. - Vol. 40. - Issue. 2 .-- p. 282-285.

[3] Bănărescu P. (1964) "Fauna RepubliciiPopulareRomîne". Pisces - Osteichthyes. Buc .: Academiei. - Vol. 13. - 959 p.

[4] Bradley, R.W., Morris, J.R. (1986) "Heavy metals in fish from a series of metalcontaminated lakes near Sudbury, Ontario" // Water, aur and soil pollut. - Vol. 27/6. - No. 3-4. - pp. 341-354.

[5] Brazhnik, S.Yu. (2011) "Bioresources of fresh waters of Russia: yesterday, today, tomorrow" // Current status of bioresources of inland waters: Mater. doc. I Vseros. conf. from the international participation (Borok city). - M .: Aquareos.- Vol. 1. - p. 91-98.

[6] Bryzgalo, V.A., Ivanova, I.M. (2009) "Anthropogenic transformation of the hydro-ecological state of the rivers of the Russian Arctic" // Water Resources. - Vol. 36. - No. 3. - p. 277-288.

[7] Chebotareva, Yu.V.,Savoskul, S.P., Savvaitova, K.A. (1996) "Anomalies in the structure of the reproductive system of male fish of the Norilo-Pyasinsky water system (Taimyr)" // Vopr. ichthyology. - Vol. 36. - No. 5. - p. 653-659.

[8] Chikidov, A.I., Zakharova, S.M. (1992) "Purification of industrial waste from the concentrates of the Diamonds of Yakutia Concern from thallium ions" // Man and the North: historical experience, current status, development prospects: Materials region. Intersectoral scientific and practical. conf. - Yakutsk: NSC SB RAS, 1992. - P. 41-45.

[9] Chugunova, N.I. (1959) "A guide to studying the age and growth of fish". - M.: Publishing House of the Academy of Sciences of the USSR. – p. 162.

[10] Dormidontov A.S. (1974) "Features of gametogenesis of whitefish in the northern reservoirs of Yakutia" // In the book: Zool. researched Siberia and the Far East. - Vladivostok.- p. 169-173.

[11] Ecology of the Vilyui river basin: industrial pollution - Yakutsk: NSC SB RAS, 1992. - 119 p.

[12] Ecology of the Vilyui River: state of the environment and public health. - Yakutsk: NSC SB RAS, 1993. - 140 p.

[13] Elin, E.S. (2000) "The geoecological role of phenolic compounds in the Tyumen oil and gas region" // Studies of environmental and geographical problems of environmental management to ensure the territorial organization and sustainability of the development of oil and gas regions of Russia: Theory, methods and practice. - Nizhnevartovsk: NGPI, KhMRO RANS, IOA SB RAS, 2000 .-- p. 162-166.

[14] Gribovskaya, I.V., Tyaptirgyanov, M.M., Kalacheva, G.S., Ustyugova, T.T., Zinenko, G.K., Ilyashevich, T.I., Gladchenko, I.A., Degree, A.V. (1992) "Microelement composition of fish in the Vilyui river basin" // Analytical chemistry in the service of human health: Tr. Region. Scientific and practical conf. (Tomsk, May 22-24, 1991). - Tomsk: DPR. ETNT. - No. 7. - 129. - p. 58-65.

[15] Isakov, P.V. (2009) "Whitefish in the Gulf of Ob: reproductive cycles, the state of vital organs": Dis. ... cand. biol. sciences. - Borok: Institute of Biol. ext. Waters RAS.-- 221 p.

[16] Isakov, P.V., Selyukov, A.G. (2009) "Whitefish in the Gulf of Ob: the state of the reproductive system, liver and gill apparatus" // Scientific Bulletin of the Yamalo-Nenets Autonomous Okrug. Biological resources of Yamal-Nenets Autonomous Okrug and problems of their rational use. - Salekhard. - Vol. 1 (63). - pp. 29-46.

[17] Khodulov, V.V. (2006) "Assessment of the impact of river pollution in Western Yakutia by the diamond mining industry and urban areas on the ecology of fish": Abstract. dis. ... cand. biol. sciences. - Yakutsk: Publishing House of the NSC SB RAS. - 21 p.

[18] Khodulov, V.V. (2008) "Assessment of the negative impact on the water ecosystems of Yakutia during the implementation of the scheme for the integrated development of the productive forces of the Republic of Sakha (Yakutia)" // Ecological Safety of Yakutia: Mater. scientific-practical Conf. The 15th anniversary of the FSII IPES. - Yakutsk: Publishing House of the YaNTS SB RAS.-- pp. 394-400.

[19] Kirillov, A.F., Khodulov, V.V., Sobakina, I.G., Sokolova, V.A., Ushnitskaya, L.A., Ivanov, E.V., Solomonov, N.M. (2007) "Biology of the Anabar River". - Yakutsk: Publishing House of the NSC

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ISSN: 0193 - 4120 Page No. 1286 - 1295

SB RAS. - 224 p.

[20] Koshelev B.V. (1996) “Some features of reproductive cycles in fish with synchronous and asynchronous growth of oocytes in reservoirs of various latitudes” // In: Patterns of the dynamics of the abundance of fish in the White Sea and its basin. - M .: Nauka.-- p. 79-82.

[21] Makarov, V.N., Sleptsov, A.N. (2002) “Ecological and geochemical situation in the region of the diamond mining mine Anabar” // Science and Education. Issue 4. - pp. 22-26.

[22] Marshintsev, V.K., Tyaptirgyanov, M.M., Kopylov, R.N. (1993) “The general ecological situation of the territory of Yakutia” // Radiation pollution of the territory of the Republic of Sakha (Yakutia): Problems of radiation safety. Sat doc. I rep. scientific-practical conf. (Yakutsk, January 14-15, 1993). - Yakutsk: NSC SB RAS. - p. 3-10.

[23] Mina, M.V. (1973) “Fish growth (research methods in natural populations)” // Animal Growth. Zoology of vertebrates. - M.: VINITI. - Vol. 4. - pp. 68-115.

[24] Mina, M.V., Klevezal, G.A. (1976) “The growth of animals”. - M .: Nauka.—p. 291.

[25] Moiseenko, T.I., Lukin, A.A. (1999) “Pathology of fish in polluted water bodies of the Subarctic and their diagnosis” // Vopr. ichthyology. - Vol. 39. - Issue 4. - pp. 535-547.

[26] Moiseenko, T.I., Ganshina, N.A., Sharova, A.N., Vandysh, O.I., Kudryavtseva, L.P. (2009) “Anthropogenic transformation of the Arctic ecosystem of Lake Imandra: trends towards recovery after a long period of pollution” // Water Resources. - Vol. 36. - No. 3. - p. 312-325.

[27] Mukhachev, I.S. (2007) “Guide for the cultivation of fish in the waters of the Trans-Urals: a Training manual”. - Tyumen: Publishing house of the Tyumen state. University.-- 252 p.

[28] Mukhachev, I.S., Kubyshkin V.I. (1975) “The role of environmental factors in the artificial expansion of the range of peled and chira” // Acclimatization of fish and invertebrates in the reservoirs of the USSR. - L., 1975 .-- pp. 129-133.

[29] Pravdin, I.F. (1996) “Guide to the study of fish”. - M .: Food. industry. – p. 376.

[30] Reshetnikov, Yu.S. (1980) “Ecology and taxonomy of whitefish”. - M .: Nauka.—p. 300.

[31] Reshetnikov, Yu.S.,Akimova, N.V., Popova, O.A. (1999) “Anomalies in the fish reproduction system of the Kola Peninsula under anthropogenic impact” // Biological foundations of the study, development and protection of the animal and plant world, soil cover of Eastern Fennoscandia: Abstract. doc. Int. conf. and an exit session of the Department of General Biology of the Russian Academy of Sciences (September 6-10, 1999). - Petrozavodsk: IB Kar. SC RAS.-- pp. 155, 285-286.

[32] Reshetnikov, Yu.S.,Akimova, N.V., Popova, O.A. (2000) “Anomalies in the fish reproduction system under anthropogenic impact” // Izv. Samara Scientific Center of the Russian Academy of Sciences. - Vol. 2. - No. 2. - pp. 274-282.

[33] Reshetnikov, Yu.S.,Popova, O.A, Kashulin, N.A., Lukin, A.A., Amundsen, P.A., Staldvik, F. (1999) “Assessment of the well-being of the fish portion of the aquatic community based on the results of morphopathological analysis of fish”. // Successes of modern biology. - Vol. 119. - No. 2. - p. 165-177.

[34] Savvaitova, K.A., Chebotarev, Yu.V.,Pichugina, M.Yu., Maksimov, S.V. (1995) “Anomalies in the structure of fish as an indicator of the state of the environment” // Issues of ichthyology. - No. 2. - p. 182-188.

[35] Selyukov, A.G., Moiseevsky, A.S., Koev, A.V., Tokarev, I.N. (1994) “The state of vital fish organs in conditions of intensive pollution of the Ob and the problem of preserving their biopotential” // Mater.V All-Russian. conference by biol. and biotechnology. intelligence. whitefish fish. - M..-- pp. 125-127.

[36] Shatunovsky, M.I., Akimova, N.V., Ruban, G.I. (1996) “Reaction of the fish reproductive system to anthropogenic effects” // Issues of ichthyology. – Vol. 36. - Issue. 2. - p. 229-247.

[37] Shor, E.L., Khurshudov, A.G. (2000) “Estimation of average background concentrations of oil products in surface water soils of oil fields in the Nizhnevartovsk region” // Studies of environmental and geographical problems of environmental management to ensure the territorial organization and stability of the oil and gas regions of Russia: Theory, methods and practice. - Nizhnevartovsk: NGPI, KhMRO RAEN, IOA SB RAS. - p. 147-148.

[38] State report. On the state of the natural

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ISSN: 0193 - 4120 Page No. 1286 - 1295

environment of the Republic of Sakha (Yakutia) in 2004. / M-in nature protection Rep. Sakha (Yakutia). - Yakutsk: Sakhapoligrafizdat, 2005. - 80 p.

[39] State report. On the state of the natural environment of the Republic of Sakha (Yakutia) in 2005-2010 - Yakutsk: Sakhapoligrafizdat, 2006-2011. - 196-205 p.

[40] State report on the state and environmental protection of the Republic of Sakha (Yakutia) in 2011-2014 - Yakutsk: Dani Almas Company, 2012-2015. - 216-304 p.

[41] State report on the state and environmental protection of the Republic of Sakha (Yakutia) in 2015.– Yakutsk: NEFU Publishing House , 2016.– 546 p.

[42] Tazacharev, V.V. (2003) “Environmental problems in the development of diamond deposits of the pipe "Udachnaya" // Materials of the VII Intern. Environmental Student Conf. “Ecology of Russia and adjacent territories. Ecological catalysis. " - Novosibirsk: Novosib. state Univ.-- p. 246.

[43] Tyaptirgyanova, V.M., Tyaptirgyanov, M.M. (2014) “The effect of water quality in the reservoirs of Yakutia on the fish organism (on the example of the rivers Vilyui, Chroma, Indigirka and Kolyma)” // Yakutsk Medical Journal. - Yakutsk: YaNTS KMP SB RAMS. - No. 3 (47). - pp. 66-69.

[44] Tyaptirgyanov, M.M. (1988) “Anthropogenic succession of the aquatic ecosystem of the Chroma River”. - Yakutsk: NF SO SSSR. - 168 p.

[45] Tyaptirgyanov, M.M., Tyaptirgyanova, V.M. (2014) “Ecological and hygienic assessment of the accumulation and distribution of cadmium compounds in organs and tissues of freshwater fish in Yakutia” // Yakutsk Medical Journal. - Yakutsk: YaNTS KMP SB RAMS. - No. 3 (47). - pp. 69-73.

[46] Tyaptirgyanov, M.M., Tyaptirgyanova, V.M. (2014) “Ecological and hygienic assessment of the accumulation and distribution of lead compounds in organs and tissues of freshwater fish in Yakutia” // Yakutsk Medical Journal. - Yakutsk: YaNTS KMP SB RAMS. - No. 4 (48). - pp. 47-50.

[47] Tyaptirgyanov, M.M., Tyaptirgyanova, V.M. (2015) “Ecological and biological analysis of mercury accumulation in organs and tissues of freshwater fish in Yakutia” // Proceedings of the Second International Symposium "Mercury in the Biosphere: Ecological and Geochemical Aspects." September 21-25, 2015 - Novosibirsk: SB RAS.-- pp. 357-361.

[48] Tyaptirgyanov, M.M. (2016) “Changes in the fish population of freshwater reservoirs in Yakutia under conditions of anthropogenic pollution”. - M .: POLIGRAF-PLUS LLC. – p. 308.

[49] Yablokov, A.V., Ostroumov, S.A. (1985) “Levels of wildlife conservation”. - M .: Nauka.-- 175 p.

[50] Yagnyshev, B.S. (2004) “On the results of advanced geoecological studies in the areas of mining and diamond mining” // Environmental safety in the development of placer diamond deposits: Sat. scientific tr - Yakutsk.-- pp. 32-42.

[51] Yagnyshev, B.S., Zinchuk, M.N. (2003) “The threat of thallium ecological hazard in the development of primary deposits of the Sredne-Markhinsky diamondiferous region of Yakutia” // Applied Ecology of the North: research experience, current status and prospects: Proceedings of the Intern. scientific-practical Conf., Yakutsk, March 20-21, 2003. - Yakutsk: Nuclear Physics Publishing House of the SB RAS. - p. 292.

[52] Zakharova, T.G. (1984) “Change in the quality of river waters as a result of the development of mining enterprises” // Anthropogenic impact on the water resources of Yakutia. Sat scientific tr - Yakutsk: Publishing House of the Siberian Branch of the Academy of Sciences of the USSR. - pp. 36-39.