STATE OF *MARGARITIFERA MARGARITIFERA (L.)* POPULATIONS IN ARKHANGELSK REGION

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At present, freshwater pearl mussel populations in the Arkhangelsk Region have survived in the watersheds of rivers Solza (Rivers Kazanka and Solza) and Onega (River Kozha). The basic negative factor for the pearl mussel in the region is the decline in the numbers of host-fishes – *Salmo salar* (L.) and *S. trutta* (L). The dam blocks access of salmon to the upstream of Solza, which is the eastern limit of the pearl mussel range in Europe. Pearl mussel populations have survived only in the watercourses with artificial reproduction of Atlantic salmon. Thus, the activity of hatcheries secures steady reproduction and preservation of not only salmon, but also its parasite – the pearl mussel.

Key words: Arkhangelsk Region, freshwater pearl mussel, populations

INTRODUCTION

Available 19th – early 20th century publications about pearl harvesting indicate the pearl mussel had been quite widespread in rivers of the region (Bespalaya et al., 2007*a*). Museums and churches still feature items with pearl embroidery – rich peasants' clothes, icons casings, covers of church books, and other objects.

This paper provides information about pearl harvesting and the pearl mussel distribution in Arkhangelsk Region in the 16th–20th centuries (Bespalaya et al., 2007*a*). We know that the greatest resources of pearls have been concentrated in rivers Syuz'ma, Kazanka, Solza, Yaren'ga, Vajga, Hajno-ruchej, Onega (with tributaries), Kozha (with the tributary Syvtyuga), Somba, Nimen'ga, Maloshujka (Bespalaya et al., 2007*a*).

Presumably, the freshwater pearl mussel was a dominant and even the supra-dominant species in benthic communities of the region's fast-flowing small and medium-sized rivers with stony or sandy-stony bottom, rapids and riffles, where significant positions belonged to the main hosts of pearl mussel larvae – Atlantic salmon (*Salmo salar*) and brown trout (*Salmo trutta*) (Veselov et al., 2001; Bespalaya et al., 2007*a*).

Below we summarize the available data on the state of the populations of the freshwater pearl mussel *Margaritifera margaritifera* (L.) in Arkhangelsk Region.

MATERIALS AND METHODS

Freshwater pearl mussel populations in the Solza River watershed were studied in 2005 and 2006 (Bespalaya et al., 2007). Surveys in 2007 included three locations in the Kozha River, Podsiman'ga rapid (Onega River watershed). The sample plots on Kozha were located near a station of the Onezhskiy hatchery, a division of Sevrybvod.

The Solza River watershed, 1400 km^2 in area, lies in the eastern part of the Onega Peninsula (Fig. 1, 2). The river originates from Lake Solozero and flows to the White Sea. It receives discharge from seven tributaries, and from numerous small streams. Solza is 109 km long, 10–20 m wide in the upper course, 20–45 m wide in the middle and lower course. The depth is 0.3–0.4 m in riffles and up to 1.5 m in still sections, the flow velocity averages 0.5–0.8 m/s. The river is mostly fed by wetlands and snowmelt, and annual discharge is variable. The riverbed is made up of crystalline bedrock; riffles and rapids are frequent (Fig. 2) (Bespalaya et al., 2007).

The Kozha River originates from Lake Kozhozero. It is a large left-bank tributary to River Onega. The length of the watercourse is 96 km, the drainage basin is 6210 km^2. The river has 36 tributaries, which are shorter than 10 km, and have a combined length of 75 km. Kozha is a semi-montane river (elevations in the upper course exceed 100 m) (Fig. 2). Most runoff comes from snowmelt. Discharge is the lowest in March (Novoselov et al., 2006).

Surveys of the pearl mussel population followed the procedure proposed by Zyuganov (1993), which has been tested at the Solza River (Bespalaya et al., 2007*b*).

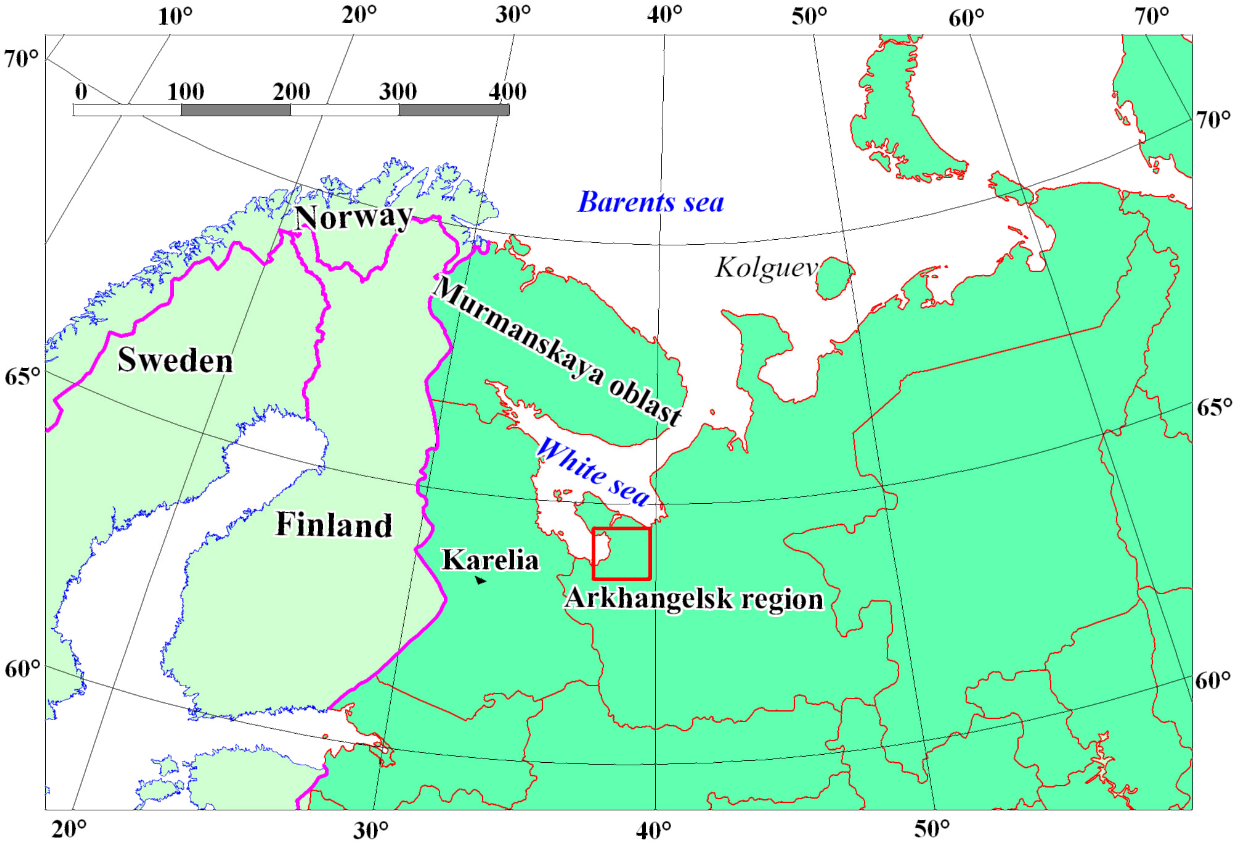

Fig. 1. Overview map of Northern Europe, showing field study areas

The study also included surveys of mollusc communities in the Kazanka River in order to assess the role of the freshwater pearl mussel in the structure of the mollusc fauna in the watercourse. Benthos samples were taken from the upper course of Kazanka upstream of Lake Krivoye, and from the lower reaches of the river downstream of Lake Rechnoye.

Hydrobiological work followed conventional techniques (Mordukhai-Boltovsky, 1975; Semyonova et al., 1992; Zyuganov et al.; 1993; Hastie et al., 2000). Qualitative sampling along the banks was carried out with a sweep net or manually, and a scraper was employed in the open littoral. Samples were also washed off rocks covered with silt or water moss (Mordukhai-Boltovsky, 1975).

Quantitative samples were collected randomly using an Eckman-Berge bottom sampler (1/40 m^2). The samples were washed in a hydrobiological sieve. The molluscs were preserved in 96 % alcohol, which was replaced a day later with 70% alcohol (Zhadin, 1960; Mordukhai-Boltovsky, 1975; Starobogatov et al., 2004). A total of 22 hydrobiological samples were collected. The total number of molluscs in the samples was 238.

The samples were examined in the laboratory under a MBS-10 stereoscopic microscope. Identification was carried out using tables by Starobogatov (1977, 2004), and keys by Kruglov and Starobogatov (1993), Kornyushina (1996), and Kruglov (2005).

The relative abundance of species was calculated as the share of specimens in the sample. The species richness of local groupings of molluscs was assessed using the computational technique of rarefaction followed by graph plotting and analysis (Smith, and van Belle, 1984).

Dominance was determined using the Berger-Parker index, which represents the proportion of the most abundant species (Magurran, 1992). The five point logarithmic scale was employed to determine the relative abundance of species (Pesenko, 1982). Species with an abundance of 4–5 points are considered dominant, with 3 points – common, with 1–2 points – scant.

A

B

Fig. 1. Habitats of the freshwater pearl mussel in Arkhangelsk Region
A – R. Solza, B – R. Kozha (Padun rapid)

RESULTS AND DISCUSSION

In the Solza River watershed, morphometric measurements were taken from 208 specimens from R. Kazanka and 185 specimens from R. Solza.

The average length of mussels in samples from R. Kazanka was 95.9 mm (from 49.5 to 136.3 mm), and that in the sample from the lower reaches of R. Solza was 89.2 mm (from 33.8 to 110.6 mm).

The proportion of juveniles with a shell length ≤70 mm in Kazanka was about 7%, whereas in Solza it was higher (11%). The average calculated age of 10 youngest specimens was 17 years in Kazanka, and 16 yrs. in Solza lower course; the youngest specimens were 13, and 9 years of age, respectively.

In the Kozha River, 4 mussels were found. The shell length in the sample ranged from 93.1 mm to 116.3 mm.

The pearl mussel population density in the Solza River varied from less than 1 ind./m^2 to 4 ind./m^2. The mussel density in different parts of Kazanka varied from 1 ind./m^2 to 68 ind./m^2 (Bespalaya et al., 2007a).

Pearl mussel abundance in the Kozha River has not been studied yet. Kozha is a big river, which abounds in deep pools and waterfalls. Thorough surveys were not possible because of the high water level and strong flow. We believe a promising technique for studying pearl mussel populations on such big rivers is remote sensing of the riverbed using underwater video camera.

Data about benthic communities, where pearl mussels coexist with other mollusc species, are so far insufficient. We have assessed the role of the freshwater pearl mussel in the structure of mollusc communities in small rivers of the Onega Peninsula. According to the studies, the mollusc fauna in R. Kazanka comprises 2 to 17 species in different parts of the channel (Table).

The upper reaches of the Kazanka River are inhabited by 16 mollusc species, which belong to 5 families and 12 genera. The family richest in species is Euglesidae.

The species prevailing in abundance is *Sphaerium westerlundi* (Clessin in Westerlund, 1873) (5 points on the abundance scale). It accounts for 71.3 % of the sample abundance. The only common species (3 points) is *Colletopterum anatinum* (Linnaeus, 1758), which contributes 7.4 % to the sample abundance. All other species are scant – their abundance is within 1–2 points. *Margaritifera margaritifera* is absent from the fauna of this area.

The mollusc species composition in the lower reaches of the river is made up of only two species – *Margaritifera margaritifera* and *Lymnaea intermedia* Lamark, 1822. The greatest abundance (5 points) is demonstrated by the freshwater pearl mussel, which accounts for 90 % of the sample. *L. intermedia* is common (3 points) in this coenosis, and contributes 10 % to the community. Thus, the species richness is the highest in the groupings inhabiting the upper course of Kazanka (Fig. 3).

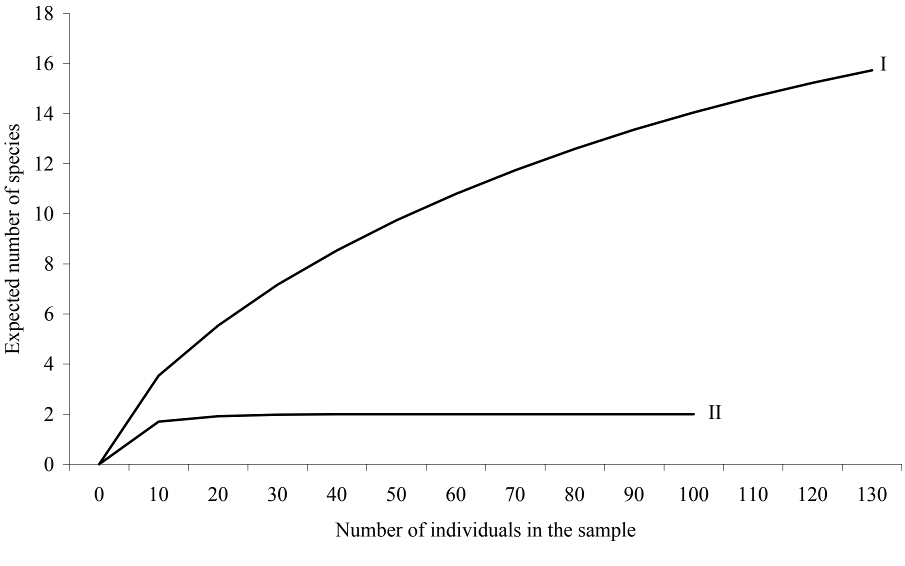

Fig. 3. Rarefaction curves for two variants of local groupings of molluscs in the Kazanka River.

I – headwaters of the river (upstream of Lake Krivoye, Lake Borovoye); II – lower course of the Kazanka River (downstream of Lake Rechnoye)

The structure of local groupings of molluscs in the investigated sites of the Kazanka River is predetermined, first of all, by the distribution of the freshwater pearl mussel through the watercourse, i.e. location of the species populations in Atlantic salmon spawning and nursery areas (Zyuganov, 1993). Apparently, salmon spawners do not reach the upstream of Kazanka. Secondly, being the super-dominant species, which shapes the ecological conditions for benthic communities (Zyuganov, 1993), *Margaritifera margaritifera* may supplant other species of bivalves, whether bigger or smaller in size (Protasov, 2006).

An interesting fact is that pearl mussel populations have survived in the watersheds of the rivers with operating hatcheries – Onezhskiy and Solzenskiy (divisions of Sevrybvod). They have lately considerably increased the release of salmon parr. In 2004, e.g., Onezhskiy hatchery stocked rivers Kozha and Onega with 66 500 salmon aged 2 years, and Solzenskiy hatchery – with 93 700 one- and two-year-old parr.

Activity of the hatcheries ensures regular supply of juvenile salmon, thus maintaining pearl mussel populations in the region.

CONCLUSIONS

Thus, no *M. margaritifera* populations were found in a number of rivers in the Arkhangelsk region that used to be inhabited by the pearl mussel. The main negative factor for the pearl mussel in the region is decline in the numbers of host fishes – *Salmo salar* (L.) and *S. trutta* (L.). E.g., a dam blocks access of salmon to the upstream of Solza, which harbours Europe's easternmost population of the pearl mussel (Bespalaya et al., 2007*b*).

Species structure and relative abundance of molluscs in the Kazanka River

No	Species	upper course of Kazanka (upstream of Lake Krivoye, Borovoye)			lower course of Kazanka (downstream of Lake Rechnoye)		
		N, ind.	I_d, %	*B*, number	*N*, ind.	I_d, %	*B*, number
1	*Margaritifera margaritifera* (Linnaeus, 1758)	–	–	–	91	89.2	5
2	*Colletopterum anatinum* (Linnaeus, 1758)	10	7.35	3	–	–	–
3	*Sphaerium westerlundi* (Clessin in Westerlund, 1873)	97	71.3	5	–	–	–
4	*Tetragonocyclas tetragona* (Normand, 1854)	3	2.2	1	–	–	–
5	*Roseana borealis* (Clessin in Westerlund, 1877)	2	1.5	1	–	–	–
6	*Pseudeupera subtruncata* (Malm, 1855)	6	4.4	2	–	–	–
7	*Cyclocalyx obtusalis* (C. Pfeiffer, 1821)	1	0.74	1	–	–	–
8	*Hiberneuglesa normalis* Stelfox, 1929	1	0.74	1	–	–	–
9	*Cingulipisidium nitidum* (Jenyns, 1832)	4	2.9	2	–	–	–
10	*Cincinna depressa* (C. Pfeiffer, 1828)	1	0.74	1	–	–	–
11	*Cincinna piscinalis* (Müller, 1774)	1	0.74	1	–	–	–
12	*Lymnaea fragilis* (Linnaeus, 1758)	1	0.74	1	–	–	–
13	*L. intermedia* (Lamark, 1822)	2	1.5	1	11	10.8	3
14	*A. acronicus* (Ferussac, 1807)	1	0.74	1			
15	*A. stelmachoetus* (Bourguigant, 1980)	2	1.5	1	–	–	–
16	*Anisus contortus* (Linnaeus, 1758)	2	1.5	1	–	–	–
17	*A. laevis* (Alder, 1838)	2	1.5	1	–	–	–
	Total	136	100		102	100	
	Quantitative sample/sampling area	10			12		
	Average density of molluscs, ind./m^2	56.9			8.5		
	Berger-Parker index	0.71			0.89		
	Simpson's index	0.52			0.81		
	Shannon index *(H')*	1.29			0.34		
	Margalef index	3.26			3.46		

N – total number of specimens in the sample; Id – proportion of specimens of a species in the sample, %; In – relative abundance points of the species on the five-point logarithmic scale (Pesenko, 1982): 1 – very rare, 2 – rare; 3 – common; 4 – abundant, 5 – dominant

Populations of the pearl mussel have survived in those watercourses where artificial reproduction of Atlantic salmon is maintained (Bespalaya et al., 2007*a*). Hence, the activity of hatcheries secures steady reproduction and preservation of not only salmon, but also its parasite – the pearl mussel.

The structure of local groupings of molluscs in the Kazanka River differs notably among sites, which may be due to the life cycle strategy of the freshwater pearl mussel, and its environment-shaping role in benthic communities related to its high biofiltration capacity.

References

Bespalaya Yu.V., Bolotov I.N., Makhrov A.A. 2007b. State of the European pearl mussel *Margaritifera margaritifera* (L.) (Mollusca, Margaritiferidae) populations at the northeastern margin of its range (Solza River, White sea Basin) // Ecologija. V. 38. No 3. P. 222–229. (in Russian)

Bespalaya Yu.V., Bolotov I.N., Makhrov A.A. 2007a. Pearling for (16^{th}–20^{th} cent.) and distribution of the pearl mussel *Margaritifera margaritifera* (L.) in rivers of Arkhangelsk Region // Problems of Study, Sustainable Use and Protection of Natural Resources of the White Sea. Proc. of Int. Conf. Arkhangelsk: SGMU. P. 289–292. (in Russian)

Hastie L.C., Boon P.J., Young M.R. 2000. Physical microhabitat requirements of freshwater pearl mussels, *Margaritifera margaritifera* (L.) // Hydrobiologia. V. 429. P. 59–71.

Kornjushin A.V. 1996. Palearctic Bivalves of the Family Pisidioidae. Fauna, taxonomy, phylogeny. Kiev 165 p. (in Russian)

Kruglov N.D. 2005. Molluscs of the pond snail family in Europe and North Asia. Smolensk: SGPU. 507 p. (in Russian)

Kruglov N.D., Starobogatov Yu.I. 1993. Annotated and illustrated catalogue of species of family Lymnaeidae (Gastropoda, Pulmonata, Lymnnaeformis) of Palearctic and adjacent river drainage areas // Rutenica. V. 3. No 1. P. 65–92.

Magurran E. 1993. Ecological Diversity and Its Measurement. Moscow: Mysl'. 166 p. (Russ. translation)

Mordukhai-Boltovsky F.D. (ed.). 1975. Methods for Studying Biogeocenoses of Inland Waters. Moscow: Nauka. 270 p. (in Russian)

Novoselov A.P., Ustyuzhinskiy G.M., Borkichev V.S. 2006. General characteristics of aquatic ecosystems // V.A. Efimov, A.N. Davydov (eds.). Nature, Historical and Cultural Heritage of Kozhozero Area. Under the editorship of. Arkhangelsk: RAS Ural Branch. P. 51–53. (in Russian)

Pesenko Yu.A. 1982. Principles and Methods of Quantitative Analysis in Faunal Studies. Moscow: Nauka. 82 p. (in Russian)

Protasov A.A. 2006. On typical relations and consortium links in communities // Sibirskij Ekologicheskij Zhurnal. No 1. P. 96–103. (in Russian)

Semyonova M.N., Karpycheva L.A., Voloshenko B.B., Bugaev V.F. 1992. Comparative Analysis of Growth Rates in the European Pearl Mussel *Margaritifera margaritifera* (Bivalvia, Margaritiferidae), Zool. Zhurnal. V. 71, No 5, p. 19–27. (in Russian)

Smith E.P., van Belle G. 1984. Nonparametric estimation of species richness//Biometrics. No 40. P. 119–129

Starobogatov Ya.I. 1977. Identification Guide to Freshwater Invertebrates of the USSR European Part (plankton, benthos). Leningrad: Gidrometeoizdat. P. 152–174 (in Russian)

Starobogatov Ya.I., Prozorova L.A., Bogatov V.V., Saenko E.M. 2004. Identification Guide to Freshwater Invertebrates of Russia and Adjacent Territories. St. Petersburg: Nauka. V. 6. 528 p. (in Russian).

Zhadin V.I. 1960. Hydrobiological Research Methods. Moscow: Vysshaya Shkola. 150 p. (in Russian)

Zyuganov V.V., Zotin A.A., Tret'yakov V.A. Pearl Mussels and Their Relationship with Salmonid Fishes. Moscow : RAS Institute of Developmental Biology. 133 p: RAS Institute of Developmental Biology. 133 p. (in Russian).