ASSESSMENT OF THE HABITAT CONDITIONS FOR THE FRESHWATER PEARL MUSSEL *MARGARITIFERA MARGARITIFERA* (L.) IN THE HEADWATERS OF MAJOR RIVERS OF MURMANSK REGION

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Surveys to assess habitats of the European pearl mussel *Margaritifera margaritifera* (L.) in upper reaches of the major rivers of Murmansk Region were carried out. The main aim was to investigate the upper reaches of the main rivers with the "salmon-inhabited" status – the area around the deposit proposed for mining – as a potential habitat of the pearl mussel. It was found that the distribution of *M. margaritifera* depends on the hydrological and hydrochemical parameters of waters and the availability of river sites suitable for spawning and growth of salmonids. On the whole, the conditions in the very upstream of the rivers surveyed are not favorable for the mollusk because of heavily silted channels and the absence of host-fish species. Among-year variation of the water level in rivers was found to be one of the key factors for mollusk finding.

Key words: pearl mussel, headwaters, habitat conditions, water quality

INTRODUCTION

The freshwater pearl mussel *Margaritifera margaritifera* (L.) has become endangered as the result of growing anthropogenic pressure. Very high water quality requirements and peculiarities of the life cycle, which is strongly dependent on symbiotic relations with salmonids – *Salmo salar* L. and *Salmo trutta* L., make this species unique. The freshwater pearl mussel is widespread in the biggest salmon rivers of Murmansk Region, but there is little information about potential habitats of *M. margaritifera* in the headwaters of these watercourses, although quite a number of papers deal with its biology in their middle and lower courses (Prokhorov, 1995, 1996; Zyuganov et al., 1993, 1998, 2000, 2001). However the existing populations of mussels are exposed to human impact and their abundance it therefore decreasing. More detailed information is needed on the population abundance and the spatial limits of its extension upstream. As a rule, habitat conditions in the headwaters of so-called "salmon" rivers are not favorable for *M. margaritifera*, but any human activity there would be a serious threat to the mussel populations downstream. The main aim of this study was to monitor potential habitats of the freshwater pearl mussel in the area of the planned mining and ore processing enterprise (headwaters of the Murmansk Region major rivers: Umba, Varzuga, Voron'ya).

MATERIALS AND METHODS

The study area is situated in the vicinity of the planned mining and ore processing enterprise right in the middle of the Kola Peninsula, where its three main river systems originate (Fig. 1). Three river sites were investigated: Kitsa–Umba river system – the 5 km long stretch upstream of the Kitsa River mouth; Tsaga–Voron'ya river system – from the source to the point 2 km downstream of Lake Nizniy Tsagajavr; Pana–Varzuga river system – from the source of the Pana River to the point 1 km downstream of its confluence with the Chernaya River.

Hydrochemical analysis. Water sampling was carried out in the rivers during the year in the period of 2004-2008. Chemical analyses were performed in the laboratory. The samples were analyzed for pH, total mineralization, organic matter, water color, P, N, Fe, oxidation characteristics. All the analytical methods applied to determine the above hydrochemical parameters conformed to international standards (Lurje, 1984; Standard method…, 1975).

Analysis of water mosses. Samples were collected from the river sections with the highest percent cover of mosses: 70–100%. Determination of the species composition and description of the ecological characteristics of the mosses were carried out following Garibova et al. (1978), Abramova et al. (1961), Abramova &Volkova (1998), Ignatov & Ignatova (2003, 2004).

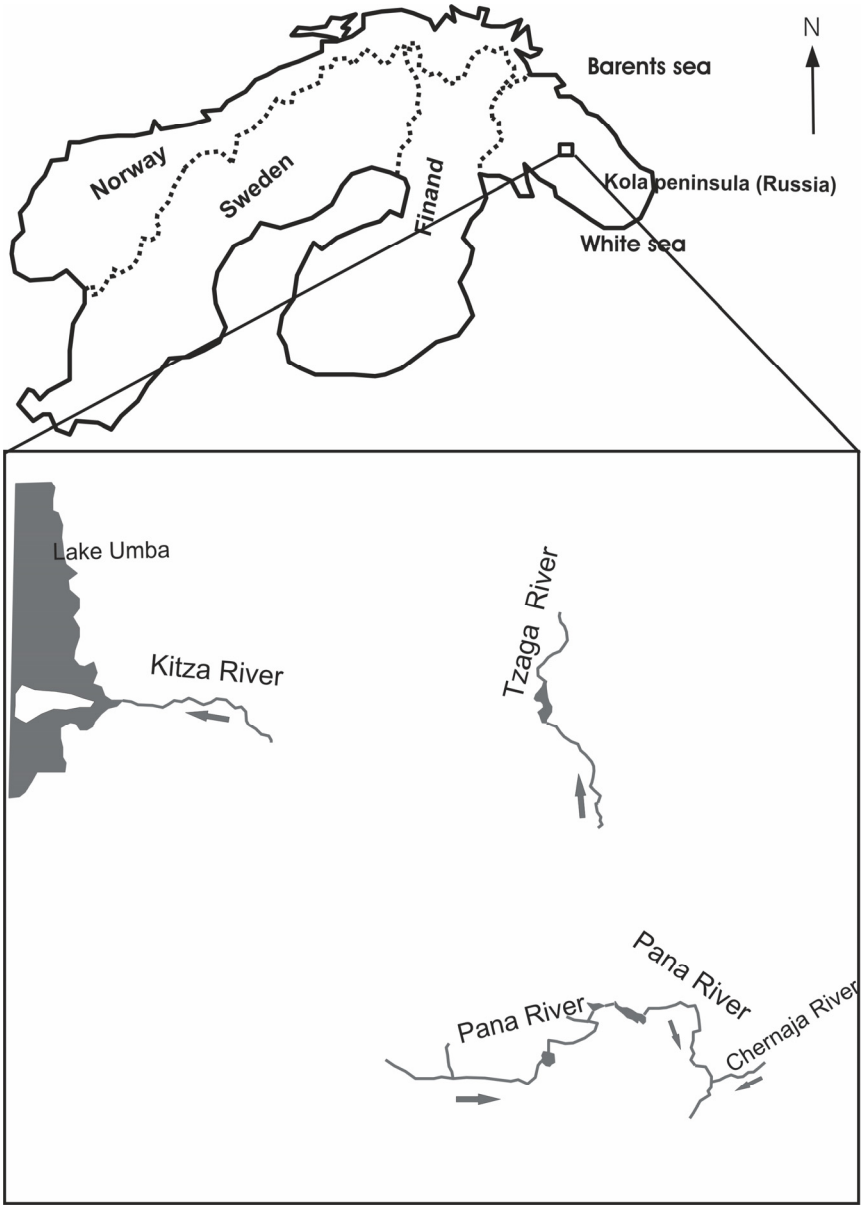

Fig. 1. Locations of the surveyed sections in the headwaters (Kitsa River – Umba River basin; Tsaga River – Voron'ya River basin; Pana River – Varzuga River basin)

Ichthyological surveys. Determination of the fish species composition was conducted in August–September of 2008. Special focus was on detailed assessment of potential spawning and nursery areas of *S. salar* and *S. trutta.* The surveys were conducted using portable equipment manufactured by Ing. S. Paulsen FA-3 (Trondheim, Norway) as in Amundsen et al. (2004), Bohlin et al. (1989), Reynolds (1996), Young and Schmetterling (2004). The density of salmon and trout parr was estimated through

electrofishing following the technique by Zippin (1956) and Karlstrem (1976). Each individual was analyzed for weight, length and age (by scales).

Mussel surveys. The presence of *M. margaritifera* in the rivers was estimated by visual examination of the bottom and by findings of shells on the banks. The mussels were analyzed for weight, length and age (Semyonova et al., 1992; Prokhorov, 1995, 1996; Zyuganov et al., 1993, 1998, 2000, 2001).

RESULTS

Hydrochemistry. The river sites surveyed have the following hydrochemical characteristics: Tsaga River (pH – 5.93-7.26, mineralization –9.8-43.8 mg/l, oxygen content – 8.87 mg/l, oxidation capacity – up to 8.63 mgO/l, water colour – 16-96°); Kitsa River (pH – 6.33-7.21, mineralization – 14.1-54.0 mg/l, oxygen content – 8.03 mg/l, oxidation capacity – up to 12.12 mgO/l, water colour – 30-144°); Pana River (pH – 6.04-7.16, mineralization –5.15-51.1 mg/l, oxygen content – 8.02 mg/l, oxidation capacity – up to 8.12 mgO/l, water colour – 24-58°).

Analysis of P, N, Fe and organic matter content in the investigated river sites demonstrated a similar pattern during the period of 2004-2008, but the values of these elements in the Kitsa River and the Tsaga River were higher than in the Pana River. P, N and Fe content showed high variation in all the rivers studied (Fig. 2).

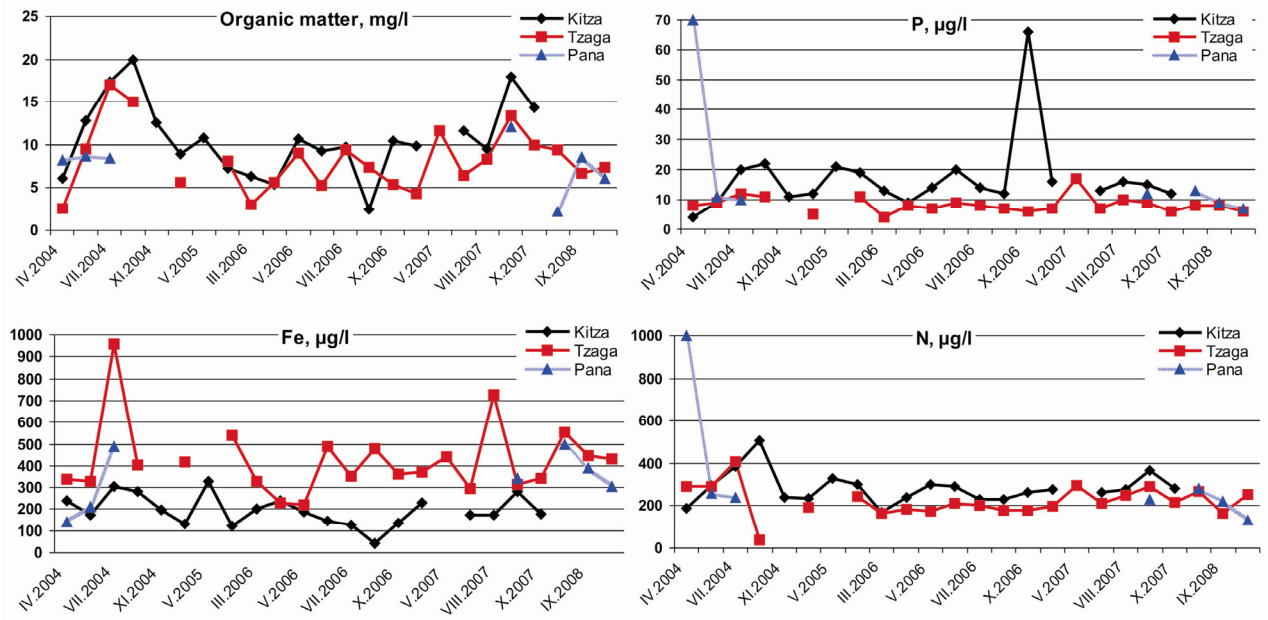

Fig. 2. Long-term data on some hydrochemical parameters (organic matter, P, Fe and N) in the surveyed river sections

Water mosses. Seven moss taxa were found in the investigated river sites: Pana River (*Fontinalis antipyretica* Hedw., *Fontinalis dalecarlica* B.S.G.); Tsaga River (*Warnstorfia fluitans* (Hedw.), *Campilium sp.; Ochyrea alpestris* (Sw. ex Hedio), *Bryum sp.*); Kitsa River (*Hygrohynella ochracea* (Turn. Ex Wils.)). These mosses are widespread arctic and polar taxa typical of oligotrophic waters.

Fish fauna. On the whole, the most common fish species in the headwaters of the rivers are: *Thymalllus thymallus* (L.), *Lota lota* (L.), *Perca fluviatilis* L., *Esox lucuis* L. and *Phoxinus phoxinus* (L.). The most favorable conditions for spawning and growth of salmonids were found in the Chernaya River (Pana River tributary) and in the Pana River (at the confluence with the Chernaya River), where *S. salar* parr were registered (Fig. 3, Tab. 1). Downstream of where the Chernaya River empties, Pana has all the characteristics needed to maintain salmon spawning, as well as salmon parr and the freshwater pearl mussel.

The total density of *S. salar* parr in the spawning and nursery areas is high (Tab. 2), with the age class 1+ prevailing. These data are in conformity with previous results obtained for the Pana River (Kalyuzhin, 2003).

The Kitsa River was found to have *S. trutta* spawning areas and juveniles in all riffle sites of the investigated section. The total density of trout parr in the spawning and nursery areas ranged within 18.4-48 individuals per 100 m^2, which corresponds to the moderate level, with domination of the 1+ age class (Fig. 4, Tab. 3).

Table 1. Size-at-age characteristics of salmon parr in the Chernaya River

Age class	Length AB, cm	Length AC, cm	Weight, g
0+ (n=6)	3.3±0.09	3.13±0.07	0.33±0.02
1+ (n=12)	5.78±0.07	5.48±0.07	1.5±0.05
2+ (n=8)	8.3±0.04	7.85±0.06	4.2±0.07

Table 2. The density of salmon parr in the spawning and nursery areas of the Chernaya River in 2008 (ind./100 m^2) (N = 26)

Density in different age classes			
0+	1+	2+	Total
31.5	63.0	42.0	136.5

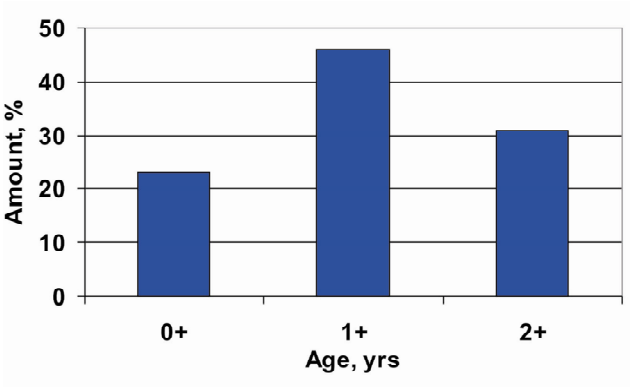

Fig. 3. Age composition of Atlantic salmon parr in the surveyed sections of the Pana River in 2008 (N = 26)

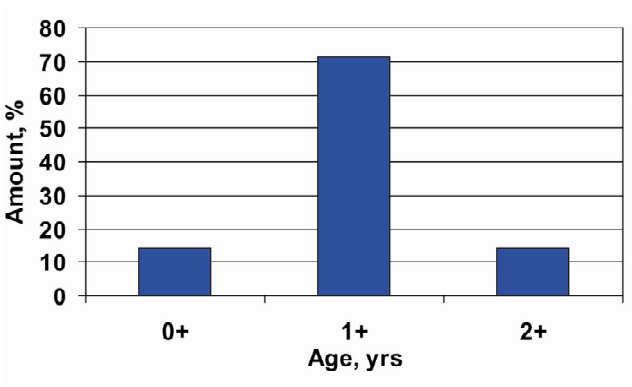

Fig. 4. Age composition of trout parr in the surveyed sections of the Kitsa River in 2008

Table 3. Size-at-age characteristics of trout parr in the Kitsa River (N = 7)

Age class	Length AB, cm	Weight, g
0+ (n=1)	1.2	5.5
1+ (n=5)	9.6±0.3	6.6 ±0.6
2+ (n=1)	11.2	11.4

The surveys of the Tsaga River upper reaches revealed no sites potentially suitable for trout spawning and growth because of unfavorable riverbed characteristics, but presence of suitable trout spawning sites in the river lower reaches cannot be excluded.

Benthic fauna and the European pearl mussel. The benthic community in the studied rivers comprises 12 groups (*Oligohaeta, Hirudinea, Gastropoda, Bivalvia, Chironomidae, Ceratopogonidae, Thrihoptera, Coleoptera sp, Ditiscidae, Ephemeroptera, Odonata, Plecoptera)*. All the invertebrate groups detected are included in the diet of salmonids (Shustov, 1983). Indicator-species of high water quality (*Ephemeroptera, Plecoptera*) were recorded in all rivers surveyed.

Among-year variation of the water level in rivers is one of the key factors for finding mollusks. E.g., the exceptionally high water level in all studied rivers in 2008 made the survey results on potential mussel colonies unreliable. Further surveys of the Pana River in 2009 yielded more accurate results. The average length of the mussels (N = 30) found in the Pana River upstream of the confluence with the Chernaya River is 54.4 mm (ranging from 47 to 65 mm), average weight is 18 g (13–-28 g), height – 28.8 mm (27–

33 mm). The age of the mussels ranged from 12.7±0.25 to 17.7±0.25 years, averaging 17.9 ± 2.5 years. The corresponding parameters of mollusks from the Chernaya River were as follows (N = 31): length – 93.4 mm (56-101 mm), weight – 71 g (15–93 g), height – 44 mm (28-50 mm). The age of the smallest mussels was 15±0.25 years. Bigger specimens were older than 45 years. Although the density of mussels in the Pana River is low, the presence of relatively young individuals presumably testifies to ongoing reproduction of the *M. margaritifera* population in the upper reaches of the river.

The low flow rate and riverbed characteristics in the upstream of the Tsaga River are unfavorable for pearl mussel habitation.

DISCUSSION

Some authors argue that water oxidation capacity of more than 15 mgO/l is a limiting factor for mussel populations (Zyuganov et al., 1993). Hydrochemically, the localities surveyed are favorable for the mollusk, especially the riffles, where salmonid juveniles were found, but at the very source of the rivers the flow rate is low, the bottom is silty, and host-fish are absent.

It is common knowledge that, being natural adsorption agents, mosses play an important role in self-purification of water ecosystems. The species composition of mosses in the region evidences good condition for *M. margaritifera*: oligotrophic, cold, transparent, fast-flowing waters.

Analysis of the *S. salar* size-at-age structure in the Pana River shows relatively slow growth as compared with salmon from the other rivers. Besides, these values in 2008 were much lower than those previously recorded for the Varzuga River salmon. The reason for that could be negative hydrometeorological conditions during the year. A similar relationship was noted for trout parr in the Kitsa River.

Surveys of the Tsaga River upper reaches did not reveal presence of pearl mussel populations either, but the river also lacked potential trout spawning and nursery areas. Low flow rate and riverbed characteristics in the upstream of the Tsaga River are unfavorable for pearl mussel habitation. Yet, one cannot exclude the mollusk may be present in the river lower reaches. It has to be mentioned that reliability of a study is strongly dependent on the water regime, as has been demonstrated by two-year studies. Thus, no definite conclusion can be drawn about the absence of the pearl mussel from the Kitsa River. Although the density of mussels in the Pana River in 2009 was very low, the presence of young individuals presumably testifies to ongoing reproduction of the *M. margaritifera* population in the upper reaches of the river.

Special attention should be paid to the Pana River ecosystem as a significant salmon watercourse and to the Tsaga River, which will be exposed to serious impact after operation of the mining and processing enterprise begins. Its activities may jeopardize reproduction and spread of salmonid and mussel populations. Further control of the water quality and pollution, and study of the distribution of potential mussel habitats are needed.

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