DISTRIBUTION AND SIZE COMPOSITION OF THE SNOWY SCULPIN *MYOXOCEPHALUS BRANDTII* (COTTIDAE) NEAR THE MAINLAND COAST OF THE NORTHERN SEA OF JAPAN

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Two groups of the snowy sculpin *Myoxocephalus brandtii* have been identified off the mainland coast of the northern part of the Sea of Japan, separated by the area of pronounced dynamics of water masses near the 43th N parallel. Individuals of the southern group reach a length of 48 cm and those living to the north, 51 cm. From early spring to late fall, the snowy sculpin inhabits depths < 1 meter. In summer, it is found up to 100 m, concentrating mainly at 11–30 m. In autumn, it moves to shallow waters, where it begins spawning in late November at depths ~ 4–7 m. In winter, some males remain to guard clutches of eggs, while the remaining fish of the spawning part of the population move away from the upper part of the shelf, spreading to a depth of 141 m. Immature individuals throughout the year live mainly in the upper part of the shelf, which is most exposed to seasonal changes in temperature, as they are more eurythermal than adults. In summer, the snowy sculpin prefers temperatures of 8.1–18.0°C. Adults are found in waters warmed to no higher than 20°C and juveniles, up to 22.5°C.

Keywords: snowy sculpin *Myoxocephalus brandtii*, distribution, density, depth, size, temperature, Sea of Japan.

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INTRODUCTION

Fish of the sculpin family (Cottidae) occupy one of the leading places in the bottom ichthyocenes of the Far Eastern seas in terms of biomass and numbers (Fighter, 1997; Shuntov, 2022).The largest representatives of the family belong to the genus*Myoxocephalus*. Snow sculpin *M. brandtii* is a sublittoral, low-boreal, peri-Asian species inhabiting the Sea of Japan, Sea of Okhotsk, and Bering Sea, as well as near Southeastern Kamchatka, the Kuril Islands, and Honshu Island (Lindberg, Krasyukova, 1987; Amaoka et al., 1995; Novikov et al., 2002; Mecklenburg et al., 2002; Fedorov et al., 2003; Sokolovsky et al., 2007; Parin et al., 2014).

Information about the biology, including the distribution of snow sculpin across most of its range, is incomplete and fragmentary. The species has been studied most extensively in the Sea of Japan. Here, in a relatively small area, the Peter the Great Bay (Fig. 1), it was found that snow sculpin spawns in the coastal zone in late autumn-early winter (Panchenko, 2001), the size of larvae at hatching, which occurs in spring, is ~8 mm (Gnyubkina, Panchenko, 2001), and at the end of the pelagic stage - 15 mm (Sokolovsky, Sokolovskaya, 1997). During the first year of life, by the end of spring, it grows to a length of ≥7 cm, with an average of ~10 cm (Panchenko, 2000). Males usually reach sexual maturity in their third year of life, females in their fourth. Males mature en masse at a length of 22-24 cm, females at 26-28 cm. The feeding of both juveniles and adult fish is described in the literature (Pushchina, Panchenko, 2002; Pushchina et al., 2016).

In Peter the Great Bay, the distribution of snow sculpin has also been studied, but usually only during the summer period (Panchenko, 1999; Panchenko, Zuenko, 2009). Analysis including spring and autumn months has been performed only for coastal areas - depths up to 7 m (Panchenko, 2002). North of Peter the Great Bay, the distribution of snow sculpin has been studied exclusively during the summer period (Panchenko, Vdovin, 2023).

The aim of this work is to analyze general patterns and regional characteristics of the bathymetric and spatial distribution of snow sculpin during the spring-autumn period, as well as the variability of its size composition near the continental coast of the northern part of the Sea of Japan .

MATERIAL AND METHODOLOGY

The work is based on materials from bottom trawl surveys and diving research. Trawl surveys were conducted by TINRO in March-December 1983 - 2017. The research covered the waters of the northern part of the Sea of Japan along its continental coast: from the mouth of the Tumannaya River (42 ° 18′ N, 130 ° 42′ E) in the south to the traverse of Cape Yuzhny (51 ° 41′ N, 141 ° 06′ E) in the north (Fig. 1). A total of 8355 trawls were performed (of which 3812 included measurements of bottom water layer temperature) using bottom trawls with soft groundropes of various designs at speeds of 1.8-3.5 (average 2.6) knots at depths up to 935 m. In most of the surveyed area, the minimum trawling depth was 11-20 m, while in the south, in Peter the Great Bay, trawling in some surveys was conducted at shallower depths: in summer and autumn - from 3-5 m, in spring - from 6-10 m. The minimum mesh size in the trawl bag was usually 10 × 10 mm, but in some catches conducted in Peter the Great Bay, a trawl with 30 × 30 mm mesh was used. However, we did not observe a significant difference in the size composition of the snowy sculpin in such catches, so we combined the available data. The absence of obvious differences in the sizes of caught fish has been shown for similar catches using another representative of the Cottidae family - the thread sculpin *Gymnocanthus pistilliger* (Panchenko, 2013).

To obtain comparable results, catches of snowy sculpin from each trawl were recalculated to density using the formula: $P = N/S$, where P - density (specific abundance), ind/km ^{2}; N - catch, ind.; S - trawling area, km ^{2}. Catchability coefficients were not introduced in the recalculation. The frequency of occurrence was determined as the ratio of the number of successful trawls to their total number in a certain bathymetric interval and expressed as a percentage.

Fish from trawl catches were measured with an accuracy of 1 cm for total body length (*TL*). A total of 9094 specimens were measured.

In the shallow water zone not covered by trawling (depths up to 3 m) in Peter the Great Bay, data on the presence and size of the great sculpin were obtained during diving operations at depths from ~0.5 m. Additionally, diving operations were carried out at greater depths (up to 10 m). The work was performed by staff of the NSCMB FEB RAS in 1999-2000 and 2019-2023 from March to December and was accompanied by measurements of bottom water temperature. During dives, visual observations were conducted, some fish were caught with a hand net for subsequent research, including body length measurements with an accuracy of 1 mm. In cases when great sculpins were not caught, the size of specimens was determined underwater with an accuracy of 1 cm, using the handle of the net marked as a ruler. When the species was highly abundant, total measurements were not carried out and only typical sizes were established. A total of 219 diving operations were conducted, during which 230 specimens of great sculpin were measured. The frequency of occurrence during diving operations was calculated as the ratio of the number of dives in which great sculpin was observed to their total number in a certain bathymetric interval and expressed as a percentage.

When analyzing seasonal distribution, the division into hydrological seasons was based on Zuenko's classification (1994). According to it, the spring period includes March-April, summer – June-September, autumn – November-December. May is a transitional month between spring and summer seasons, October – between summer and autumn. Meanwhile, analysis of the great sculpin distribution showed that in May it is closer to the spring period than to summer, and in October – to autumn. We used the following division into seasons: spring – March-May, summer – June-September, autumn – October-December. In spring, 2197 trawls and 92 diving operations were conducted, in summer 5225 and 53 respectively, in autumn – 933 and 74.

Analysis of the spatial distribution of fish was carried out for each season based on trawl catch data using the Surfer software package.

RESULTS

The great sculpin was found at the minimum study depths in all seasons. The maximum depths of the species habitation varied: in spring – 141 m, in summer – 100 m, in autumn – 76 m.

The great sculpin was unevenly distributed throughout the studied area (Fig. 1). In the south, in the Peter the Great Bay, it was found from its southern border. In all seasons, areas with its increased density were consistently observed in the bay's waters. With movement northward from Cape Povorotny, the species density noticeably decreased. Then in the area adjacent to Cape Tumannyy (43°00′ N, 134°07′ E), the great sculpin was not recorded in catches during any season. Here, the southernmost trawling that recorded the species was at coordinates 42°51′ N, 133°47′ E, after which it was absent from catches until coordinates 43°08′ N, 134°24′ E. It should be noted that research was conducted regularly in this area. A total of 164 trawls were made here, of which 74 were at depths where the species lives.

North of the gap identified in the Cape Tumannyy area, a mosaic pattern in the distribution of the great sculpin is observed: areas with its increased density alternated with regions where concentrations were not detected . For the northern area along the mainland coast of the Tatar Strait, the most characteristic feature was the low specific abundance of the great sculpin, preceding its absence in catches in the northernmost areas. The northernmost catch of the species along the mainland coast of the Tatar Strait in spring and summer seasons was recorded between 50° and 51° N , in autumn – between 49 ° and 50° N (Fig. 1) . It would seem possible to speak of the great sculpin avoiding the area located further north, where a total of 89 trawls were conducted at depths of 10 – 86 m (the lower limit is close to the maximum depth for this part of the Tatar Strait). However, in this case, the slight increase in its density noted in summer when approaching 51° N appears illogical (Fig. 1b)

The distinctiveness of the southern region in the spatial distribution of the great sculpin raises no doubts. The analysis of size composition of catches confirmed the validity of its designation and allowed the division of the remaining water area into two regions. Further generalization of the material was carried out according to three regions of the species habitat: southern (Peter the Great Bay and adjacent waters to the southern boundary of the distribution gap near Cape Tumannyy), central (from the northern boundary of the gap to Cape Zolotoy), and northern (from Cape Zolotoy to the northern boundary of distribution) (Fig. 1).

As it was revealed, the snowy sculpin inhabiting the southern region reaches smaller sizes than in the central region. Despite a wide range of observations on size composition, fish *TL* > 48 cm were not recorded in the bay and nearby (Fig. 2). In the central region, the largest recorded sizes of snowy sculpin increased to 51 cm. Specimens of this size were also noted further on up to the waters adjacent to Cape Zolotoy from the south. North of this cape, the indicator decreased to 45 cm.

Not only the maximum sizes of the snowy sculpin changed in the latitudinal direction, but also the size composition of fish in catches. Since depths < 11-20 m in the central and northern regions were not surveyed, for the southern region in this case we will also only operate with data from depths >10 m. As with the maximum values, the body length of fish in the predominant size groups in catches at these depths was greatest in the central region. Specimens with *TL* 37-45 cm dominated here, whereas in the northern region they were 35-41 cm, and in the southern region only 27-35 cm (Fig. 2).

The average size of fish in catches was also the smallest in the southern region - 29.5 cm, the largest in the central region - 37.9 cm, and in the northern region it occupied an intermediate position (but closer to the central) - 35.1 cm. In addition to these differences in fish sizes (both maximum and in dominant size groups) of the studied regions, this was also due to different amounts of juveniles present in the catches. The proportion of juveniles was highest in the southern region, where at depths > 10 m the smallest size of specimens was 6 cm (Fig. 2). In the central region, this indicator increased - a single specimen with *TL* 11 cm was noted, the length of the rest was ≥ 16 cm. In the northern region, the smallest size of fish in catches increased to 22 cm, i.e., corresponded to the size of the snowy sculpin approaching sexual maturity.

When examining the distribution of fish of different size classes by depth (Fig. 3), let's start with the relatively stable water regime of the summer period (Fig. 3b). Using the example of Peter the Great Bay, it is clearly noticeable that in the warm period of the year, juvenile snow sculpin prefers the warmed shallow water zone, and as it grows, the species prefers less warmed water layers. Note that the minimum depth at which an individual of this species was encountered during summer diving was 0.5 m. In general, at depths of up to 3 m, fish with *TL* 2.5-15.0 cm were observed, mainly small-sized juveniles, resulting in an average *TL* of 5.8 cm. Deeper, at 3-5 m, according to both diving data and trawling data, there were also only individuals belonging, judging by their size, to the group of immature fish, but their maximum size was already larger. The average size of fish increased with depth, small-sized juveniles with *TL* < 10 cm were observed up to depths of 21-30 m.

In the central and northern regions, where trawling was conducted from depths of 11-20 m, significant catches of juveniles were not observed, and there was no trend of increasing proportion of larger fish with increasing depth in summer. The minimum size of fish in catches here in this season was 26 cm, i.e., corresponded to mature or nearly mature individuals. Meanwhile, in both the central and southern regions, snow sculpin juveniles do inhabit, which is noticeable from the results of spring and autumn fish measurements (Fig. 3a, 3c). Apparently, in the central and northern regions, juveniles in summer were concentrated mainly at unexplored depths < 11-20 m.

In spring and autumn periods, in none of the areas did trawl catches show a pronounced increase in average fish size depending on increasing depth (Fig. 3a, 3c). However, judging by the minimum sizes of individuals present in the catches, the habitat of immature fish was universally limited to the upper part of the shelf. According to diving data in the southern region, during this time, the snow sculpin, as in summer, inhabited depths starting from the minimum surveyed depths (0.5 m). At depths < 3 m in spring, it was represented only by immature individuals *TL* < 17 cm. In autumn, in addition to these, single individuals of *TL* > 20 cm were noted, which could belong to either immature or first-maturing fish. Thus, in the coastal area at depths < 3 m from March to December, during all months, both at high water temperatures in summer and at temperatures close to 0°C characteristic of pre-wintering and post-wintering periods, juvenile snow sculpin predominated. The smallest individuals with lengths from 1.5 cm were observed in May. These are fry that hatched in April and settled after the pelagic larval stage. It should be noted that such fry in May and early June were found not only at depths up to 3 m but also deeper, up to 9 m.

We have already mentioned that, as a rule, in all areas, the snow sculpin was observed from the minimum depths of the study. The only exception is its absence in autumn catches in the northern region at depths of 11-20 m - the minimum investigated for the area (table). However, this is most likely due to insufficient data: in this area, where the species does not form aggregations (Fig. 1), only three trawls were conducted in autumn at 11-20 m.

Frequency of occurrence of the snowy sculpin *Myoxocephalus brandtii* in different seasons at the surveyed bathymetric ranges of the southern (South), central (Center), and northern (North) regions of the Sea of Japan, %

Depths, m	Spring			Summer			Autumn		
	South	Center	North	South	Center	North	South	Center	North
<3	(39)	–	–	(47)	–	–	(60)	–	–
3–5	(86)	–	–	15 (78)	–	–	17 (89)	–	–
6–10	75 (36)	–	–	24 (33)	–	–	46 (47)	–	–
11–20	39	92	29	51	69	67	39	38	
21–30	16	83	54	50	67	38	34	68	25
31–40	9	56	44	48	44		34		14
41–60	6	24		26	9		7	17	
61–80		5	7	2	8			20	
81–100		1	6	1	5				
101–141		5							
>141									

Note. Values are given according to trawling data (without brackets) and/or diving observations (in brackets); "–" – no data.

The maximum depths at which the species was observed in the studied areas varied by season. The preferred depths were more similar. During the spring and autumn periods of interseasonal migrations, no significant differences in the bathymetric distribution of the snowy sculpin could be traced from the available data (table). In these seasons, among the ranges surveyed in each area, depths of 11–20 and 21–30 m predominated in different proportions. However, as data from the southern region show, during this time the snowy sculpin actively uses shallower depths as well. In spring and autumn periods, its frequency of occurrence in the southern region in trawl catches was highest at depths of 6–10 m. According to diving data, its occurrence increases at shallower depths. Speaking about the greatest depths of habitation in different seasons, it should be noted that in general, in spring, the snowy sculpin was recorded at greater depths than in summer, while in autumn, on the contrary, at lesser depths.

During the summer feeding period, when fish concentrations are quite stable, universally the highest frequency of fish occurrence according to trawl data was observed in the range of 11-20 m and to a lesser extent 21-30 m (table). According to diving data, the maximum occurrence was observed in the range of 3-5 m. This was achieved by accounting for juveniles (Fig. 3b). A peculiarity of the northern region was that, according to the results of trawl operations deeper than 30 m, no Arctic staghorn sculpin was observed during this time, whereas in other areas it was found at much greater depths. Undoubtedly, differences in water regimes played a significant role in the distribution patterns of fish in these areas. In the northern region, the temperature of the bottom water layer at depths > 20 m was much lower than in the rest of the water area. Moreover, the greatest differences were noted in the layer adjacent to the 30-meter mark - at depths of 31-40 m (Fig. 4).

As the analysis of the Arctic staghorn sculpin distribution showed, its temperature preferences in the studied areas are similar. In spring and autumn periods, corresponding to water temperature increase and decrease, Arctic staghorn sculpin was found in a wide temperature range: from −1.2 to 17°C. At extreme negative and positive temperature values, it was found in the upper part of the shelf, where water cools to the greatest extent during the cold season and warms up during the warm season.

In summer, the minimum water temperature at which Arctic staghorn sculpin was recorded was 1.5 °C. Such temperature in the summer season was only in the middle part of the shelf and deeper. Since the shallow zone at depths up to 10 m was covered by research only in the southern region, the most warmed waters were noted here in summer - up to 23 °C. Further north, where depths less than 11 m were not surveyed, the temperature background did not exceed 15 °C. In this regard, let us consider the patterns of Arctic staghorn sculpin distribution during the relatively stable hydrological regime of the summer period using the southern region as an example. The frequency of occurrence of the species increased with rising temperature background, and the highest frequency, over 50%, was observed at temperatures > 8 °C (Fig. 5). Peak occurrence values were confined to the range of 12.1-14.0°C . Here, specimens of the snowy sculpin were recorded in 2/3 of the observations conducted. Further, the frequency of occurrence decreased, but only at temperatures > 18 °C did it fall below 50%. The snowy sculpin was observed up to 22.5°C, i.e., almost to the maximum of the recorded temperatures . At temperatures > 20°C, only individuals belonging to the group of immature fish were found.

DISCUSSION

Along the continental coast of the Sea of Japan north of 51° N, the snowy sculpin has not been recorded. However, it cannot be definitively stated that it is absent in these waters, as the shallow zone here has not been surveyed. Moreover, in summer at the surveyed depths north of 50° N, no decrease in the species density is observed (Fig. 1b).

Meanwhile, we can speak about a general trend of decreasing fish density in the northern part of the studied area in all seasons. In summer, it is traced northward from Cape Zolotoy, in spring - from approximately 49°N, and in autumn - from 48°N (Fig. 1). Probably, the decrease in snowy sculpin density along the continental coast of the northern part of the Tatar Strait is due to the peculiarities of the hydrological regime. During the cold period of the year, a subsurface layer of water with lower temperature and salinity forms here. The low salinity is caused by the intensity of continental runoff, mostly from the Amur River. This subsurface water layer descends due to winter convection into the bottom areas and forms a cold underlying layer. Moving southward along the continental coast of the Tatar Strait, its influence gradually decreases (Zuenko, 2008). The snowy sculpin obviously avoids these freshened waters (especially in the northern part of the strait).

Moving south from Cape Zolotoy, a mosaic pattern can be observed in the distribution of the Myoxocephalus brandtii (Fig. 1). Perhaps, in the central region, it would be less pronounced if we had data for the shallow zone. In the central and northern regions, the minimum trawling depths were in the range of 11-20 m, but according to data from the southern region, it is known that this species also concentrates at lesser depths, especially during the summer period. However, the gap in distribution observed in the waters near Cape Tumannyi, preceded by a decrease in fish density in adjacent areas, is objective and due to the peculiarity of the water regime. Between the 42nd and 44th parallels, where the dynamics of water masses is pronounced (up to the contact of warm and cold waters), the meandering of fronts is clearly manifested (Yarichin, Pokudov, 1982; Nikitin, Dyakov, 2016). Due to the hydrological features in this area, there is a gap in the distribution of many fish species, and the ichthyogeographic zoning of Primorye's marine waters is often oriented to the 43rd parallel north (Dudarev et al., 1998; Vdovin et al., 2004).

The groups of Myoxocephalus brandtii, separated at the 43rd parallel north, are isolated from each other, as evidenced by the results of size composition analysis. As was shown, in the southern region the maximum size of fish is smaller than in the central region - 48 versus 51 cm. The same pattern, expressed to an even greater degree, can be traced in the predominant size groups of fish in trawl catches: in the southern region, individuals of *TL* 27-35 cm dominated, in the central region - 37-45 cm (Fig. 2). The difference in sizes is due to the peculiarities of the aquatic environment parameters. The water area north of the distribution gap separating the groups is influenced by the cold Primorye Current coming from the north. Between the 42nd and

44th parallels, its influence generally ceases. Moving further south, into Peter the Great Bay, where the main mass of fish from the southern group concentrates, the influence of southern subtropical waters begins to be felt (Zuenko, 2008). Apparently, the temperature regime of the group inhabiting the area north of the gap is more favorable for the species.

A smaller fish size in catches than in the central area is also characteristic of the northern area, where individuals only up to 45 cm in length were recorded, while in the central area up to 51 cm. But the difference in the length of fish from the dominant size groups in catches, noted in the northern and central areas, is not so significant: 35-41 versus 37-45 cm (Fig. 2). Besides, there is no gap in the distribution of the sculpins at the border of the central and northern areas in any season (Fig. 1). It is obvious that the fish observed in the northern area belong to the same group as in the central area. The smaller size of sculpins in the northern area may be related to the avoidance of unfavorable water regimes by large-sized individuals that are close to their maximum age. Indeed, as an organism ages, not only does the preferred temperature range narrow, but there is also a general tendency toward more stable conditions (Zotin, Zotina, 1993). In this case, the limiting factor may be the significant decrease in salinity in the northern Tatar Strait described above, which disrupts stable living conditions.

The bathymetric distribution of sculpins in the studied areas is similar. In summer, the highest frequency of occurrence is observed at depths of 11-30 m everywhere. Judging by the fact that in the southern area, according to diving data, it is found from depths < 3 m, and the occurrence of fish due to juveniles at depths of 3-5 m is the highest, it also inhabits such a shallow zone in the central and northern areas. In the northern area, the temperature regime, as described above, is more severe than in other habitat areas. In this regard, in particular, in summer at depths > 30 m, the temperature of the bottom layer here is lower than in other areas (Fig. 4), and sculpins, unlike in the southern and central areas, are not observed at these depths (table). Here, due to the peculiarities of hydrology in the summer period, the species is shifted more to the upper part of the shelf than in the central and southern areas. For many other representatives of the Cottidae family, it has been noted that north of Cape Zolotoy, their distribution in summer tends toward lesser depths than in the south (Panchenko, Vdovin, 2023).

In autumn, the maximum depths at which the species was observed decreased. According to data from the southern region, this occurs due to the shift of fish toward the shore. This is partly explained by the approach to the shallow zone for spawning, which begins in late November and takes place at depths of ~4-7 m (Panchenko, 2001). However, the shift begins as early as October, i.e., long before spawning, and is caused by the cooling of the shallow zone to a more comfortable temperature than in summer. Based on the results of net catches, it was previously shown that adult sculpins approach the shore closer at the beginning of autumn water cooling than in summer (Panchenko, 2002). This group of fish is present at lesser depths than in summer also during the spring period.

After spawning, spent males overwinter in shallow waters at negative water temperatures, remaining here to guard the egg clutches until the spring hatching of larvae (Panchenko, 2001). Other individuals in the adult fish group leave the cooled shallow zone, preferring to overwinter in more comfortable temperature conditions of the middle and lower parts of the shelf. This is confirmed by the fact that in the post-wintering period, the sculpin was observed at the deepest point - up to 141 m, while in the middle and lower parts of the shelf, the fish sizes corresponded only to adult specimens (Fig. 3a).

For poikilothermic organisms, as they grow, a narrowing of the range of temperature tolerance is characteristic (Sukhanov, 1979), which is fully confirmed by the data we obtained using the example of Peter the Great Bay - juveniles in their first year of life inhabit depths of less than 1 m throughout all the periods covered by research, which are most susceptible to seasonal temperature changes. Previously, based on non-trawl catches, it was concluded that in the warmest summer months, July and August, the scaled sculpin leaves the shallow zone of less than 1.5 m (Panchenko, 2002). However, as the data from diving observations in this study showed, its small-sized juveniles are present in shallow water during this time as well, although its abundance here apparently decreases compared to the adjacent months. A significant number of such fish, according to diving data, was observed in summer also at deeper depths of 3-5 m. It should be noted that in this range, according to diving and trawl data, the maximum fish sizes were similar, while the minimum and average sizes according to diving data were smaller than according to trawl data (Fig. 3b), i.e., divers were better at recording small-sized individuals. This is related to the peculiarity of accounting by trawling gear, which has low catchability until fish reach certain sizes, with the lowest catchability for small-sized juveniles (Vdovin, 2000).

During the hydrological spring and hydrological autumn, the smallest number of recorded juvenile scaled sculpins at depths up to 3 m was characteristic for March and December (months adjacent to the winter season). Probably, during the winter period, this age group massively leaves the most cooled coastal zone. But unlike adults, extensive migrations to deeper waters by immature fish, especially their small-sized portion, are unlikely, as evidenced by the data on size composition by depth (Fig. 3).

During the relatively stable summer period in terms of temperature indicators, the scaled sculpin generally prefers temperatures of 8.1-18.0°C (Fig. 5), but is observed up to 22.5°C, which is close to the maximum recorded temperature values. The occurrence of fish at such high temperatures is provided precisely by juveniles, which, constantly inhabiting the upper part of the shelf subject to the greatest temperature fluctuations, are more eurythermal than adult individuals

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COMPLIANCE WITH ETHICAL STANDARDS

The Biomedical Ethics Commission of NSCMB FEB RAS considers that the manipulations with fish provided for in the project comply with the current Russian and international legal norms and regulations on animal research (Protocol No. 2-240124 dated January 24, 2024).

CONFLICT OF INTEREST

The authors of this paper declare that they have no conflict of interest.

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FIGURE CAPTIONS

Fig. 1. Seasonal distribution of the Snowy sculpin *Myoxocephalus brandtii* in the northern part of the Sea of Japan along the mainland coast according to trawl catch data: a – spring, b – summer, c – autumn. The upper boundary of each fragment corresponds to the latitude of the northernmost catch of the species in the respective season. The dashed line in the inset is drawn parallel to the northern boundary of the surveyed area, the solid line below it is parallel to the boundary of the northernmost catches at similar coordinates in spring and summer seasons. Regions: *1* – southern, *2* – central, *3* – northern.

Fig. 2. Size composition (total length – *TL*) of the Snowy sculpin *Myoxocephalus brandtii* from trawl catches at depths over 10 m in the southern (——), central (═══) and northern (– – –) regions of the northern part of the Sea of Japan along the mainland coast.

Fig. 3. Size composition (absolute length - *TL*) of the snowy sculpin *Myoxocephalus brandtii* by depth ranges in the northern part of the Sea of Japan near the mainland coast in different seasons: a - spring, b - summer, c - autumn. Ranges of fish size variation: (▒), (□), (░) - from trawl catches in the southern, central and northern areas respectively; (|) - according to diving data. (—), (×) - mean values.

Fig. 4. Average summer temperature of the bottom water layer in the southern (——), central (═══) and northern (– – –) areas of the northern part of the Sea of Japan near the mainland coast.

Fig. 5. Frequency of occurrence of the snowy sculpin *Myoxocephalus brandtii* depending on the temperature of the bottom water layer during the summer period in the southern area of the northern part of the Sea of Japan near the mainland coast (combined results of trawling and diving).