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# Regional Characteristics Affecting Distribution of Plain Sculpin *Myoxocephalus jaok* (Cottidae) in the Russian Territorial Waters in the Sea of Japan

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**Abstract**—Two intraspecific groups of the plain sculpin *Myoxocephalus jaok* inhabiting the Russian territoral waters in the Sea of Japan, representing the northern and southern species groups, have been revealed. In a summer season, the species groups are separated from each other by a wide water area extending from 45° to 48° N. The northern species-group nucleus in this period is located in the Tatar Strait inlet, while the southern species group inhabits the Peter the Great Bay. In the summertime, the plain sculpin prefers the upper slope shelf area with water column depths ranged from 80 m (for the southern species group) to 60 m (for the northern species group). The juvenile fish tend to be found in shallower waters as opposed to the mature fish. In a cold season, the majority of fish stocks of the southern species group is still congregating in the Peter the Great Bay, shifting to the shelf edge and the continental slope. Some porton of male fish remains at spawning grounds in the coastal zone to the springtime to guard egg clutches. The specimens of the nothern group leave the shallow-water Tatar Bay inlet at massive level to congregate over the winter in the locations of a deep-water area off the mid-coastal zone of the Sakhalin Island. The specimens of the northern group reach the body length of 67 cm, while the sizes in the southern fish group are larger, reaching 75 cm in length.

**Keywords:** plain sculpin *Myoxocephalus jaok*, distribution, density, depth, sizes, temperature, Sea of Japan

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## INTRODUCTION

The plain sculpin *Myoxocephalus jaok* is predominantly a boreal Asian species in the familiy Cottidae, native to the northern Pacific. It inhabits the coastal waters of Korea and Japan toward the Bering Strait and the waters along the northwest coast of America toward the south up to the Puget Sound. In addition, it is found in the Arctic waters of the southern Chukchi Sea (Lindberg and Krasyukova, 1987; Amaoka et al., 1995; Novikov et al., 2002; Mecklenburg et al., 2002; Fedorov et al., 2003; Fadeev, 2005; Sokolovsky et al., 2007; Parin et al., 2014). The plain sculpin is one of the largest and most numerous representatives of the family Cottidae, playing a significant role in the benthic-pelagic communities (Tokranov, 1988, 2017, 2018; Borets, 1997; Vdovin et., 2004; Solomatov, 2004; Matveev and Terentiev, 2016).

Seasonal distribution of the plain sculpin across the Russian territorial waters in the Sea of Japan was previously described (Panchenko, 2003). However, the issue of this research paper concerned only the species regional-scale bathymetric-habitat preferences, disregarding any characteristics defining the region. The objectives of this survey are to reveal the discrete spatial distribution of the plain sculpin and to identify the possible causes of dissociation between spatial groups of the species.

## MATERIALS AND METHODS

The research is performed based on the data on the bottom trawl surveys carried out in hydrological summer periods in July–September in 2001–2017 (Zuenko, 2008), hydrological autumn periods in October–December, and hydrological spring periods in March. From the early 21st century, trawling in the Russian waters in the Sea of Japan was carried out based on the extended standard framework of survey stations equipped with bottom trawl nets of 23.2 or 27.1 m headrope length, 30 × 30 mm codend mesh size, and 10 × 10 mm mesh size of the escape grid inserted in the codend. In order to investigate the shallow-water zone in the south region (the Peter the Great Bay), the smaller trawl with the headrope of

**Table 1.** Numbers of trawl passes (*N*) and measured specimens (*n*, units) of plain sculpin *Myoxocephalus jaok* in fishing practices in the Russian territorial waters of the Sea of Japan along the coast of continental Russia through different seasons in 1983–2017

| Depths, m | Spring | | Summer | | Autumn | |
|---|---|---|---|---|---|---|
| | *N* | *n* | *N* | *n* | *N* | *n* |
| 2–5 | | | 51 | 22 | 18 | 21 |
| 6–10 | 4 | 11 | 284 | 810 | 70 | 124 |
| 11–20 | 41 | 279 | 503 | 2753 | 145 | 864 |
| 21–40 | 283 | 2980 | 645 | 13525 | 126 | 1197 |
| 41–60 | 206 | 1877 | 471 | 7649 | 112 | 596 |
| 61–80 | 214 | 722 | 594 | 2919 | 137 | 323 |
| 81–100 | 178 | 217 | 210 | 27 | 83 | 43 |
| 101–150 | 262 | 185 | 267 | 12 | 113 | 22 |
| 151–200 | 172 | 256 | 91 | | 98 | 22 |
| 201–250 | 212 | 180 | 128 | 4 | 91 | 9 |
| 251–300 | 112 | 26 | 53 | | 87 | 6 |
| 301–400 | 250 | 39 | 100 | | 110 | |
| 401–515 | 226 | 5 | 87 | | 88 | |
| >515 | 293 | | 67 | | 74 | |
| Total | 2453 | 6777 | 3551 | 27721 | 1352 | 3227 |

14.6 m length and the similar small-mesh grid in the codend. In addition, the data on the results of the surveys performed from the year 1983 by the bottom trawls of various modifications with or without the escape grid for selectivity were taken from the TINRO archive in case of the shortages in materials on some water areas for the spring and autumn seasons. No significant difference in the plain-sculpin size composition between the catches with and without the escape grid was revealed. No obvious difference in sizes of the caught fish was shown for the similar fish landing with the example of the threaded sculpin *Gymnocanthus pistilliger*, another representative of the family Cottidae (Panchenko, 2013).

Overall, 7356 trawl houls were performed at 2–935 m depths with a speed of 1.8–3.5 knots (on average, 2.7 knots). Most of them were followed by bottom water temperature measurements in the lowermost layer of seawater. In general, 37725 plain sculpin specimens were mesured (Table 1).

In order to obtain the comparable results for each trawl event, the plain sculpin landings were estimated for the density with the formula: $P = B/S$, where $P$—density (specific quantity), units/km$^2$; $B$—landing, units; $S$—trawl survey area, km$^2$; catchability coefficients were not used in estimation. The frequency of occurrence was estimated as a ratio of a number of trawl hauls with efficient catching to their total number in a certain bathymetric contour interval to express in percentage.

Besides, distribution of the plain sculpin at different stage of its life cycle was also considered during the analysis. Thus, the males of this species in the Sea of Japan tend to reach matuirity at the fifth year of life at their total length (*TL*) of 32–34 cm, while maturity in females is reached at the seventh–eighth years at *TL* 41–43 cm (Panchenko, 2002a, 2002b). Therefore, the specimens with $TL \leq 32$ cm were assigned to immature fish or juvenile fish, while the specimens of > 43 cm *TL* were assigned to the mature fish.

The analysis of spatial distribution was performed with the Surfer software package. Six regions for the plain-sculpin spatial distribution patterns in the summer season were identified. Two regions were located in the southern area. Region 1 extended from the southern limit of the Russian territoral waters to Cape Povorotny (the Peter the Great Bay). Region 2 represented the water area between Cape Povorotny and Cape Strashny. Central region 3, extending from Cape Strashny to Cape Krestovozdvizhensky, devided the southern and northern marine zones. The northern marine zone involved region 4 extending from Cape Krestovozdvizhensky toward 50° N, region 5 extending from 50° N (the Tatar Strait inlet), and region 6 lying along the island coast south of 50° N (off the central and south coast of the Sakhalin Island) (Fig. 1).

## RESULTS

During the suvey practices in all the seasons, the plain sculpin was generally congregated in the utmost area of southern region 1, located in the Peter the

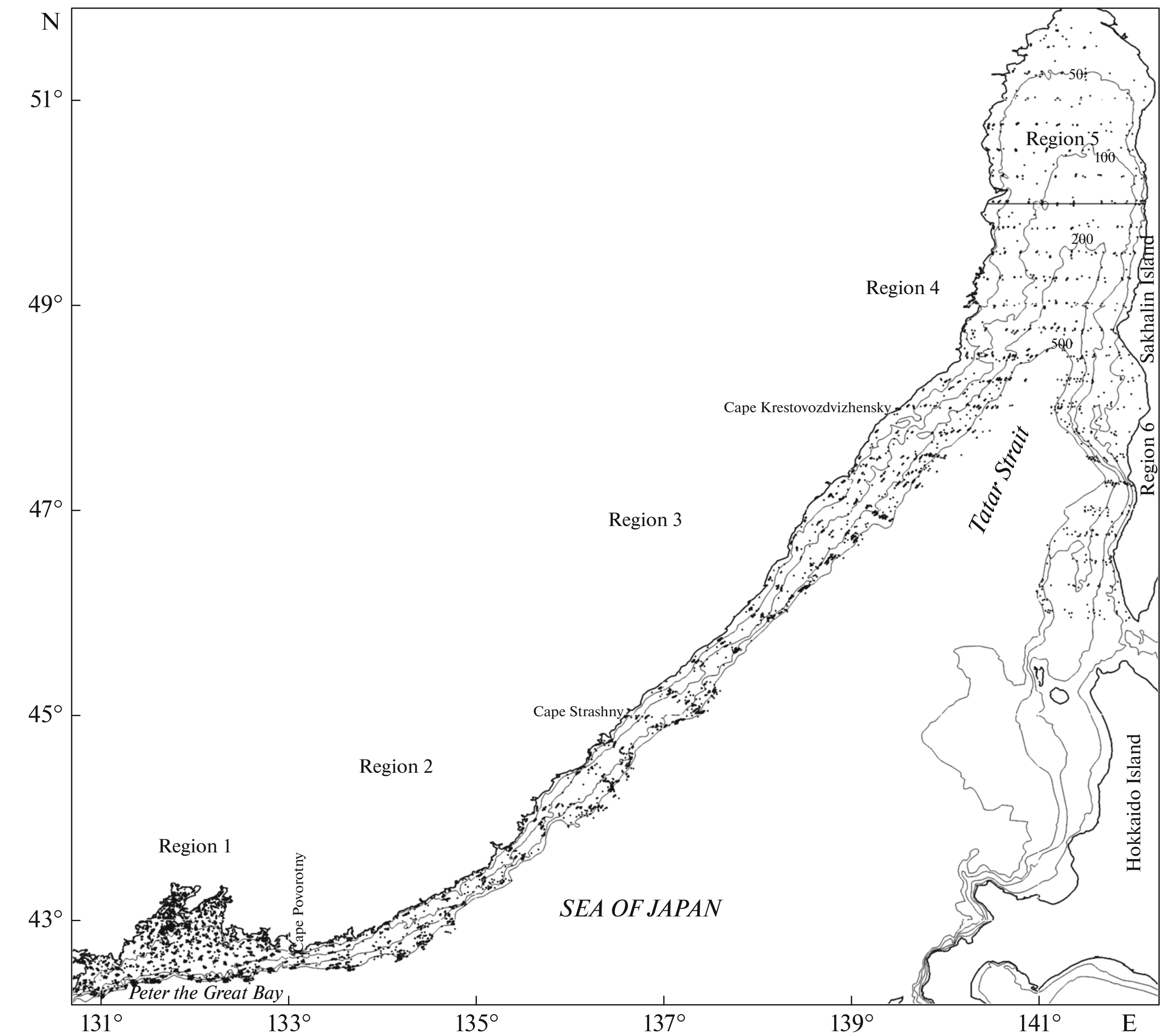


**Fig. 1.** Map chart of trawling (●) and marked areas of plain sculpin *Myoxocephalus jaok* habitats in the Russian territorial waters of the Sea of Japan: (—)—isobaths.

Great Bay (Fig 2). In the summertime, high fish congregations were also typical for the utmost area of northern region 5, locating in the Tatar Strait inlet, extending generally across regions North of 50° N latitude. It was the period, when a complete gap in spatial distribution between the southern and northern species aggregations, covering the whole of the extended zone of central region 3, was identified (Fig. 2b). In the spring and autumn seasons (Figs. 2a, 2c), the plain-sculpin fish caught sporadically, mostly a solitary fish found in catches in the coastal water of the examined central zone were recorded.

In the summer season, the plain sculpin specimens were found in shallow waters throughout the depths available in the region examined, varying from 10 m to 20 m depths at different sites and shallower than 10 m depth as a minimum, except the Peter the Great Bay, where the sites of shallower depths were also examined. The bathymetric pattern ranges of the plane-sculpin habitats in the northern and southern zones were similar. A minimum depth of its detection in the Tatar Strait inlet corresponded to 10 m depth as the minimum depth for trawling. All three landings with substantial amount of the target species caught in this water area at such depth were recorded. In the Peter the Great Bay, a minimum water depth for trawling comprised 2 m, while the plain-sculpin specimens could be found mostly as a solitary fish in waters deeper than the 3-m isobath. It corresponds to the results of operations with nets and seines, proving that the habitats in the areas shallower than 3 m depth are atypical for the plain sculpin fish in the Peter the Great Bay (Panchenko, 2002b). Therefore, high frequencies of occurrence of fish caught by trawling and, conse-

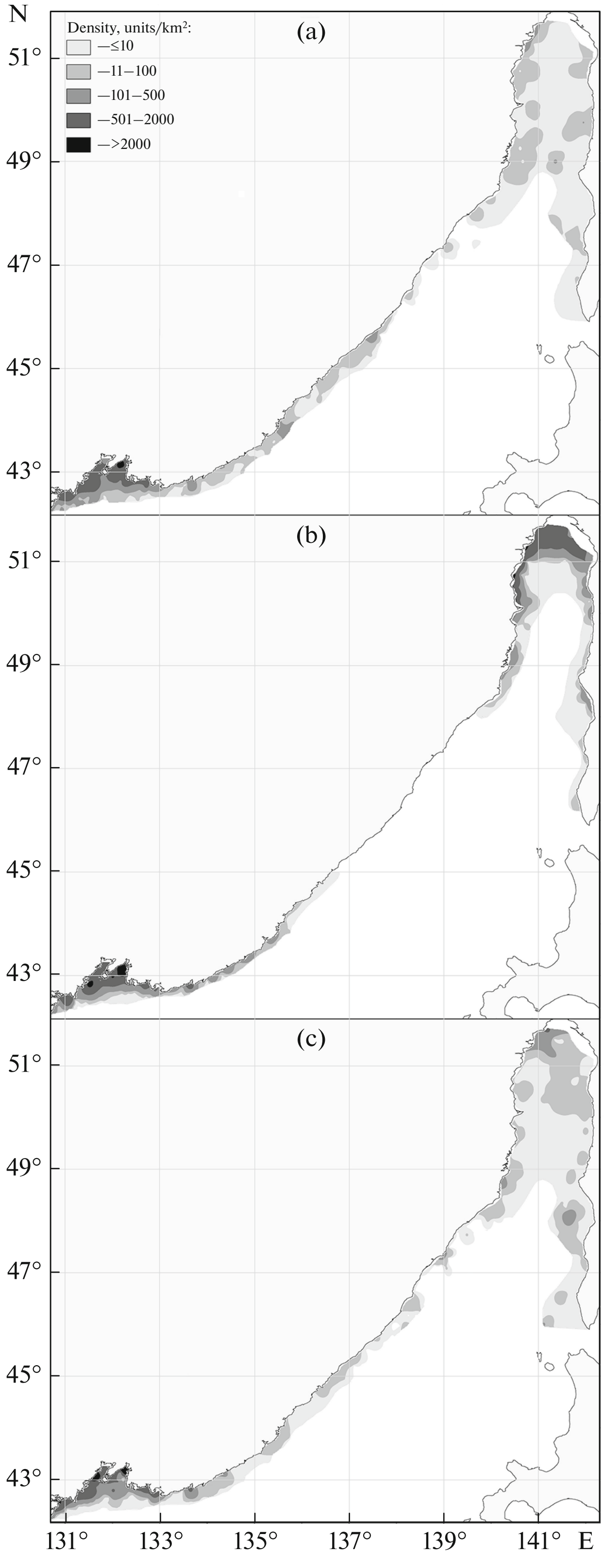


**Fig. 2.** Seasonal distribution of plain sculpin *Myoxocephalus jaok* in the Russian zone in the Sea of Japan: (a) spring, (b) summer, and (c) autumn.

quently, their substantial density levels at a minimum depth throughout the 2–5-m depths available in the region examined were not recorded (Table 2).

A maximum depth inhabited by the plain sculpin fish found in the Tatar Strait inlet (region 5) in the summer season comprised 113 m, while it was a little bit greater than 129 m in the Peter the Great Bay (region 1). With respect to the other water areas, there was generally no overlap in depth-range distribution of the plain sculpin. However, the maximum depth inhabited by the fish caught in the area off the central coast of the West Sakhalin Island (region 6) comprised 150 m, while it was 211 m in the area northward from the Peter the Great Strait (region 2).

The depths preferred by the plain sculpin fish in the summertime in the southern and northern water areas were slightly different. In the north, the depths of 10–40 m (Table 2) in the Tatar Strait inlet (region 5) were predominant in fish density and frequencies of occurrence. It is certainly difficult to measure the accuracy of absolute values for density and frequencies of occurrence, produced there, because of a relatively small number of trawl hauls in northern region 5 at depths less than 20 m below. However, it may be concluded based on the catch statistics available that the depths of 10–20 m along with a range of 21–40 m depth are the depths preferred by the plain sculpin species.

In the Peter the Great Bay (region 1), plain-sculpin congregations across the shallow water area in the summertime were also recorded. Thus, the high landings were recorded in the area down from the 6-m isobath (Table 2). However, a portion of trawl hauls catching no target species or its solitary specimens was high in the 6–10-m depth range. Therefore, the values for the species density and frequencies of occurrence at these depths in the bay were considered significantly lower than that in northern region 5. With subsequent increases in water depths, the plain-sculpin population inhabited the waters of the Peter the Great Bay tended to increase. In the depth range of 11–20 m, the values for the specific quantity and the frequency of occrrence tended to be similar to the values estimated for northern region 5. At the 21–40-m depths, the values considering for two regions reached the comparable outcomes, comprising 1733 units/km$^2$ and 91% for the Peter the Great Bay, respectively, and 1712 units/km$^2$ and 96% for the Tatar Strait inlet, respectively. Down to 41–60 m depth, no decrease in the plain sculpin density across the Peter the Great Bay was revealed, while the frequency of occurrence slightly increased, which allows us to assign this depth range along with the 21–40-m depth range to the first preference depths for the species. It should be noted that the reference bay-water temperature was, on average, 5.7°C. In the Tatar Strait inlet, where no large aggregation of plain-sculpin fish at the 41–60 m depth was found, the average water temperature comprised only 1.5°C. In

**Table 2.** Average values for density (*P*) of plain sculpin *Myoxocephalus jaok* and temperatures (*T*) in the lowermost layer of seawater, frequencies of occurrence (FO) of the species in landings, and numbers of trawl passes (*N*) operated in summer seasons in southern region 1 (the Peter the Great Bay) and norhtern region 5 (the Tatar Strait inlet) at different depths

| Depths, m | Region 1 | | | | Region 5 | | | |
|---|---|---|---|---|---|---|---|---|
| | *P*, units/km$^2$ | *T*, °C | FO, % | *N* | *P*, units/km$^2$ | *T*, °C | FO, % | *N* |
| 2–5 | 141 | 18.1 | 18 | 51 | | | | |
| 6–10 | 521 | 17.4 | 41 | 280 | 1531 | | 100 | 3 |
| 11–20 | 891 | 14.9 | 60 | 466 | 957 | 15.4 | 88 | 8 |
| 21–40 | 1733 | 10.4 | 91 | 472 | 1712 | 10.0 | 96 | 54 |
| 41–60 | 1361 | 5.7 | 93 | 359 | 391 | 1.4 | 71 | 45 |
| 61–80 | 344 | 3.3 | 64 | 452 | 60 | 1.1 | 33 | 45 |
| 81–100 | 9 | 2.2 | 9 | 128 | 2 | 1.4 | 4 | 27 |
| 101–150 | 2 | 1.7 | 3 | 134 | 2 | 1.6 | 10 | 21 |
| 151–200 | 0 | 1.4 | 0 | 30 | 0 | 1.4 | 0 | 5 |
| >200 | 0 | 1.0 | 0 | 139 | | | | |

the latter region at 41–60 m depth, the fish specific quantity compared to that in the depth range of the upper water layer (21–40 m) reduced to more than 4 times (to 391 units/km$^2$), while the frerquency of occurrence fell by 25% (to 71%). Decreases in the quantitative variables to the values similar to the parameter values typical for the southern region in the Peter the Great Bay were revealed only in the range of 61–80 m depth. In the deeper waters, mostly solitary plain-sulpin fish caught sporadically were only recorded across the region.

In the summer season, only the juvenile fish with $TL \leq 16$ cm were recorded at ≤5 m depths in the Peter the Great Bay (Fig. 3a). With respect to the deeper waters down to the 10-m isobath, the maximum fish size became 52 cm, while >80% of fish in the depth range of 6–10 m were composed of specimens with $TL \leq 32$ cm, i.e., immature fish. In the same period, the specimens with $TL \leq 27$ cm were recorded in the Tatar Strait inlet at the 10-m isobath (Fig. 3b), i.e., specimens defenitelly assigned to the immature fish. Across the regions, the proportion of the larger specimens tended to increase along with increasing the water depth, while there were some immature fish present in the catches, also found there later on. The sizes of fish across the population groups, staying around the southern and northern species-group nuclei, became to fit with the mature-specimen sizes only in the areas down from the ~90-m and 75-m depths, respectively. With respect to the other water areas inhabited by the plain sculpin, increases in the proportions of fish with higher minimum and medium sizes along with increasing the water depth can also be observed.

The minimum and medium body sizes of fish caught in southern region 1 (the Peter the Great Bay) in the summer season were considered lower than that in the adjacent area of region 2. With respect to the maximum body sizes, the opposite to that was recorded. In the Peter the Great Bay, a specimen with the minimum body size had 4 cm *TL*, while the largest specimen with 70 cm *TL* was recorded (32.2 cm of the

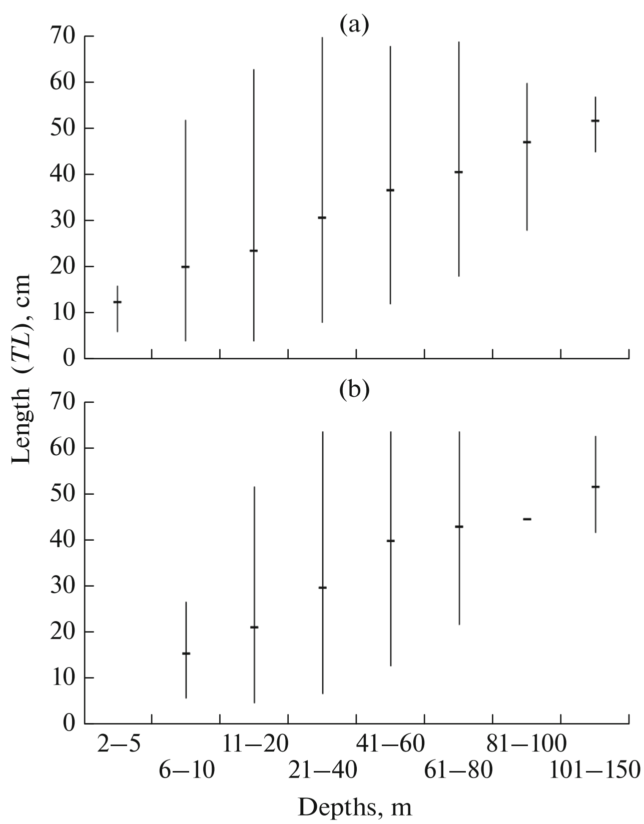


**Fig. 3.** Size composition of plain sculpin *Myoxocephalus jaok* in trawl landings at different depths: (a) Peter the Great Bay (region 1), (b) Tatar Strait inlet (region 5); (–)—average value and ( | )—variable limit data.

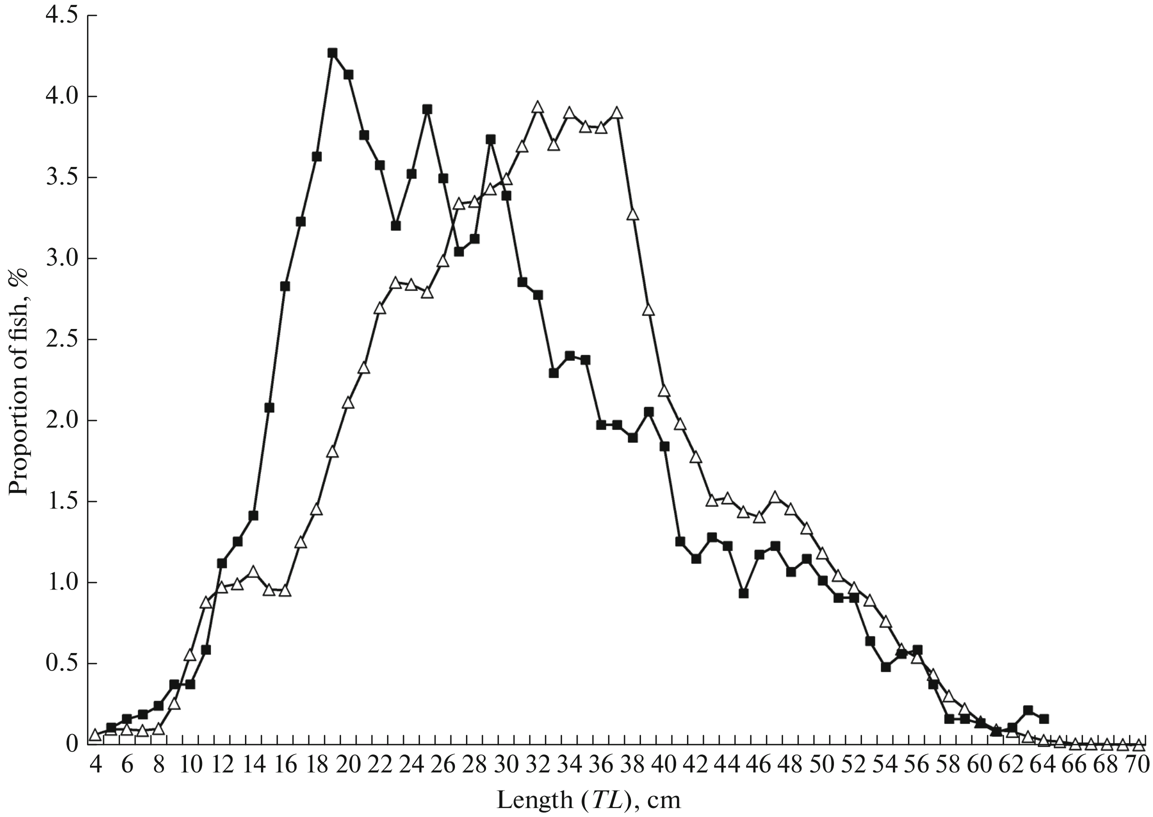


**Fig. 4.** Size composition of of plain sculpin *Myoxocephalus jaok* in trawl landings made in summer seasons regardless of water depths for species habitats for southern (regions 1–2, –△–) and northern species groups (regions 4–6, –■–).

average *TL* measurement). In the adjacent area of region 2, these parameter varibales comprised 20 and 65 cm, respectively (40.3 cm average *TL*). In addition, a similar pattern (a wide body size range for fish in the essential habitat area compared to the adjacent areas inhabited by fish of lower medium sizes) was revealed for the northern marine zone. In northern region 5 (the Tatar Strait inlet), the fish body sizes in the summeretime varied from 5 to 64 cm in lehgth (28.8 cm average). With respect to region 4 adjacent to the continental coastal stretch and region 6 adjacent to the island coast, they varied from 19 to 58 cm in length (36.3 cm average) and from 25 to 51 cm in length (36.8 cm average), respectively.

It should be noted that comparing the body-size composition among the plain sculpin assemblages in the summer season, irrelative to the habitat depths, the proportion of the juvenile fish caught in the northern zone was higher than that in the southern zone. It can be well observed with the examples of regions 1 and 5, shown separetely, regions 1 and 2 integrated into the southern area zone, and integrated regions 4, 5, and 6, unified in the northern area zone (it should be reminded that no plain-sculpin landing in central region 3 in a summer season was recorded). Thus, the immature specimens with 17–32 cm *TL* caught in the northern area zone indicated above dominated the catches, while the predominance of specimens with 27–38 cm *TL*, i.e., the immature and maturing fish were observed in the southern-zone catches (Fig. 4). It should be noted that the shallowest waters (approximately 10 m depth) were investigated only in 2015. It should not be excluded that a high number of the juvenile fish indicated above was caused by the presence of a high-performance fish generation. In the norhtern-region shallow-water area down to a 10-m depth, the fish with 13–19 cm *TL* were completely dominant. By the analogy to the growth rates of fish inhabiting the southern water area, it may be suppposed that they were generally the specimens at age 1+. In the Peter the Great Bay, the plain-sculpin tends to reach 12–13 cm in length, on average, for the first year of its life, which is completed in the late spring, while its medium size comprises 21–22 cm in length at the end of the second year of its life (Panchenko, 2002a). It is supposed based on the long-term data on the shallow waters that the size composition of fish inhabiting the northern water area may be considered more similar to that for the fish associated in the southern water area.

In spring and fall seasons, the plain sculpin fish were more evenly distributed across the water area (Figs. 2a and 2c) than that in the summertime (Fig.

2b). With respect to the northern marine zone, the density of fish inhabited regions 4 (off the continental coast) and 6 (off the island coast) increased along with decreasing the fish density in the Tatar Strait inlet (region 5). In the southern marine zone, the fish specific quantity in region 2 increased. In central region 3 representing a separation zone between the southern and northern species groups in a summer season, the plain sculpin fish caught sporadically were recorded. The depth ranges of species habitats tended to be extended across all regions due to the shift in species distribution towards the offshore marine areas in the regions. The greatest depths in the southern (regions 1 and 2) and northern (regions 4–6) marine zones inhabited by the plain sculpin fish in the pre- and post-winter months reached 418 and 492 m, respectively. With respect to central region 3, where the habitat overlap of specimens assigned to the northern and southern species groups could be observed in the spring, fall, and winter seasons, the plain sculpin was recorded in its deepest area down to a 515-m depth. The appropriate assessment of the minimum depth of its habitats over the months closest to overwintering period (December and March) can only be made in relation to the Peter the Great Bay. Thus, the data on trawling in the water area down from 6-m depth along the upper continental shelf for these months in this region in contrast to the other water areas are available. With respect to the other water areas, the minimum depths for trawling in December and March were in the range of 20–50 m. In that time, the plain sculpin fish inhabiting the Peter the Great Bay were recorded in the water area down from 6 m depth, the minimum depths within the surveys. In addition, both immature and mature specimens represented them in the water area just below these depths.

## DISCUSSION

The surveys have proven that two intraspecific groups of the plain sculpin fish inhabit the Russian territorial waters in the Sea of Japan, which are separated from each other in the summer season by a water area off the continental coast, extending from Cape Strashny to Cape Krestovozdvizhensky (approximately between 45° and 48° N). In a cold season, the edges of the species groups get closer to the central region and, probably, overlap.

They may be characterized as the northern and southern specific groups by the latitudianal distribution. In a summere season, the centers of the northern and southern species groups are located in the Tatar Strait inlet and the Peter the Great Bay, respectively. In the summeretime, the majority of juvenile fish of the appropriate groups tends to congregate in the wide shallow-water areas of the continental shelf. Thus, there are not any other so large shallow-water locations across the other observed water areas suitable for fattening up throughout the summer. A great geographic space of dissociation between the spatial groups of the species inhabiting the Tatar Strait inlet and the Peter the Great Bay tend to cause the gap in the plain sculpin distribution off the central coastal stretch in a summer season. The fish retreat to deeper waters to overwinter can contribute to the northward and southward dispersal migration routes of the fish population portions along the continental coast for their possible closure in the central water region.

The southern-group specimens compared to the norhtern-group fish can reach larger sizes. In the summertime, the maximum size of the plain-sculpin specimen was recoreded in the southern zone edge (the Peter the Great Bay), reaching 70 cm in length, while it was 64 cm for the northern species group (the Tatar Strait). According to the TINRO Archive data, the maximum size of the plain sclupin specimen recorded in the southern zone was even larger. A similar specimen with 75 cm *TL* was recorded with the use of the “Sposobny” sene net vessel operating in the Peter the Great Bay in early January in 1985. It was followed by a specimen with 74 cm *TL*, which was recorded by M.S. Streltsov, the TINRO researcher during trawl operations performed with the “Mys Babushkina” big freezer trawler (BMPT) in the area southward off Cape Strashny (between 44° and 45° N) in early December, 1985. Taking into consideration the fishing vessel location, the specimen was laso assigned to the southern species group.

In the southern zone, the autumn records of specimens larger than those in the summer may be conditioned by catching the specimens of limited size and age ranges in insignificant quantity on some occasions. In case if the trend in the southward increase in fish sizes, recorded in the Russian waters of the Sea of Japan, is evident further south, it may be objectively caused by the fish migration from the more southern Korean water area. It should be noted that according to the outcomes of the operations with the “Mys Babushkina” BMPT trawler in 1985, the maximum size (approximately 67 cm in length) of plain-sculpin specimens recorded in the northern zone in the autumn season was larger than those in the summertime were. The research paper by Sen Tok Kim (2001) describing the fish migration off the southwestern Sakhalin indicates that the plain sculpin is assigned to the species tending to the northward shift along the continental slope for overwintering. In addition, there is a map of its winter aggregations locating in the Tatar Strait waters along the upper continental slope off West Sakhalin at 48° N only. It may be assumed that the paper indicated above deals with describing the fish migration from the southern water area off the island of Hokkaido to overwinter, since any significant aggregations of plain sculpin fish in the water area off West Sakhalin, locating farther south, in the summer season were not found. Therefore, the datasets generated during the current study show that both the specimens congregating farther north, in the Tatar Strait inlet, and the specimens congregating in the water area off the island of Hokkaido, which is father south, in the summer season tend to migrate to the water area off West Sakhalin at 48° N for overwintering. First, the findings based on the survey results deal with the sexually mature specimens, since the juvenile plain sculpin fish prefer to overwinter along the shelf area (Sen Tok Kim, 2001). In addition, the examples of the other regions also indicate overwintering areas at the depths of $<100$ m in the shelf region at low water temperatures for a certain portion of juvenile plane sculpin fish (Borets, 1997).

Therefore, the question arises whether the tendency for declines in the plain sculpin body size toward the north is a south-to-north size-decline trend common for species in this area as observed in the surveys across the Sea of Japan or an effect of local environmental conditions in the Sea of Japan. Unfortunately, it is considered impossible to ascertain the fact because of discrepancies between the published data. According to the information reported by Tokranov (1988, 2017, and 2018), the maximum size of the plain sculpin fish located in the coastal waters off the Kamchatka Peninsula, i.e., at the north of the species range area, is 70 cm in length. However, this value is considered higher, comprising 85 cm for the opinions of Matveev and Terentiev (2016). In the latter case, the alerting feature is exactly that the maximum size comprising 85 cm in length is reported by the authors indicated above for the great sculpin *M. polyacanthocephalus*, despite this species is considered the largest representative of the family Cottidae, in contrast to the plain sculpin (Tokranov, 1988, 2017; Borets, 1997; Novikov et al., 2002; Fadeev, 2005).

Sen Tok Kim (2001) asserted that overwintering aggregations are typical for the plain-sculpin group inhabiting the Tatar Strait in the area off the island coast. In addition, he indicated that the greatest depth of species habitats there in that time comprised 448 m. Statistics of landings in the post-overwintering period, when a portion of specimens remains in the ovewintering habitats, show that this value comprises no less than 492 m depth. The records made within the surveys for the central marine zone indicate that some plain-sculpin specimens from both the northern and southern water regions are probably capable to move down to depths of 500 meters and deeper.

In addition, the current survey data on the plain sculpin distribution across the water area in the spring and autumn seasons can prove its aggregations in the Tatar Strait area off the Sakhalin Island for overwintering. It is provided by hydrological conditions favorable in this area, since southwestern Sakhalin is under the effects of the Tsushima Warm Current flowing along the Japanese islands (Zuenko, 2008). A hard mode is typical for the Tatar Strait waters off the continental coast, in contrast to the water area off the Sakhalin Island. In the northern region of the strait, a layer of decreased temperature and salinity is formed below the water surface, when the warm season ends. Low salinity in the strait inlet waters is provided by the continental-scale flow rate of water perdominantly by the Amur River. Waters of the subsurface layer indicated above sink toward the seafloor to form a cold underlayer due to the winter convection. It stretches along the continental coast further south up to the southern end of the Tatar Strait. The hydrological regime crossing latitudes over a distance up to the water area of the Peter the Great Bay, where the southern subtropical mode water effects occur, would remain broadly similar.

Bathymetric pattern ranges of the plane-sculpin habitats tend to be widely extended across the water area described above before overwintering due to the mass species retreat to the shelf edge and the upper continental slope for overwintering (Panchenko, 2003). Decreasing the fish density in the shallow water area of the Tatar Strait inlet seems quite reasonable in relation to the summer-to-autumn and spring seasons. However, it should be noted that a decrease in the specific gravity of fish populations at the similar depths in the southern water zone (the Peter the Great Bay) was expressed by estimates at lower grades. In addition, both immature and adult fish inhabited that shallow water area in the transition months closely related to the wintertime as it was indicated above. It was caused by a spawning event. In the northern range area (coastal waters off the Kamchatka Peninsula), the plain sculpin fish spawn in the water area of a 100-m isobath in December to January (Tokranov, 1988; Borets, 1997). With respect to the south, spawning goes on in the shallow water area in the Peter the Great Bay (Panchenko, 2001). Thus, the plain sculpin prespawn specimens, mainly males that apparently arrived first on the spawning grounds, were caught there with nets at one of the marine sites at 6–8 m depths in November to register in bulk quatities. After an interruption in the surveys, the developing plain-sculpin egg clutches guarded by males at this site were discovered during dive cycles. Only fish of this sex were captured with nets at that time. Therefore, not all the adult specimens in the southern species group tend to shift to the offshore marine areas to overwinter. A certain portion of males remains to guard the spawn in the shallow water zone. Plain-sculpin larva hatching after the winter spawning event occurs in April (Sokolovskaya, 1994; Sokolovsky and Sokolovskaya, 2008).

It is scarcely possible for the plain sculpin from the northern species group to spawn in the shallow waters of the Tatar Strait inlet, taking into consideration both a hard hydrological regime in the winter season and a reduced size of species congregations at this site in the autumn and spring seasons compared to the summertime. Therefore, the question arises whether the spawning grounds of fish of the northern speceis group are located in the deep-water zone similar to the northern species range or spawaning events occur in the shallow-water zone off the coast of Southwest Sakhalin, where the hard mode of seawater is softened by the inflow of a warm current. This question requires further survey answers.

## CONCLUSIONS

It has been determined that two plain-sculpin intraspecific groups inhabit the Russian territorial waters in the Sea of Japan. They may be characterized as the northern and southern specific groups by the latitudianl distribution. The northern group specimens can reach 67 cm *TL*, while the sizes in the southern fish group are larger, reaching 75 *TL* cm.

In a summer season, the species groups are separated from each other by a wide water area extending from 45° to 48° N. In addition, the northern species-group nucleus is located in the Tatar Bay inlet, while the southern species group inhabits the Peter the Great Bay. These two regions as opposed to the other water areas are characterized by the extended continental-shelf zones, where the majority of juvenile fish assigned to appropriate groups usually congregates in the warm months. In the summertime, the mature fish also generally tend to be found in the upper slope shelf area, however, at greater depths than that for the juvenile fish. Overall, the southern-group plain sculpin prefers the depths of ≤80 m in the summertime, while the northern group specimens select the shallower depths of ≤60 m.

In the period from fall to spring, the edges of the species groups get closer to the central of the test water area off the continental coastal stretch between 46° and 48° N, where the plain sculpin landings can be occasionally observed. In a cold season, the majority of fish stocks of the southern species group is still congregating in the Peter the Great Bay, shifting to the shelf edge and the continental slope, while some porton of male fish remains at spawning grounds in the coastal zone to springtime to guard egg clutches. The specimens of the nothern group leave the shallow Tatar Strait inlet at massive level to congregate over the winter in the locations of a deep-water area off the mid-coastal zone of the Sakhalin Island.

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## COMPLIANCE WITH ETHICAL STANDARDS

*Conflict of interests*. The authors declare that they have no conflicts of interest.

*Statement on the welfare of animals*. All applicable international, national, and/or institutional guidelines for the care and use of animals were followed.

## REFERENCES

Amaoka, K., Nakaya, K., and Yabe, M., *The Fishes of Northern Japan*, Sapporo: Kita-Nihon Kaiyo Center Co. Ltd., 1995.

Borets, L.A., *Donnye ikhtiotseny rossiiskogo shel'fa dal'nevostochnykh morei: sostav, struktura, elementy funktsionirovaniya i promyslovoe znachenie* (Bottom Ichthyocenes of the Russian Shelf of the Far Eastern Seas: Composition, Structure, Functional Elements and Commercial Value), Vladivostok: TINRO-tsentr, 1997.

Fadeev, N.S., *Spravochnik po biologii i promyslu ryb severozapadnoi chasti Tikhogo okeana* (Handbook of Biology and Fisheries of the Pacific Northwest), Vladivostok: TINRO-tsentr, 2005.

Fedorov, V.V., Chereshnev, I.A., Nazarkin, M.V., et al., *Katalog morskikh i presnovodnykh ryb severnoi chasti Okhotskogo morya* (Catalog of Marine and Freshwater Fishes of the Northern Part of the Sea of Okhotsk), Vladivostok: Dalnauka, 2003.

Kim Sen Tok, Winter Migrations of Shelf Fish to the Continental Slope of the Southwestern Sakhalin, *J. Ichthyol.*, 2001, vol. 41, no. 8, pp. 564–574.

Lindberg, G.U. and Krasyukova, Z.V., *Ryby Yaponskogo morya i sopredel'nykh chastei Okhotskogo i Zheltogo morei* (Fishes of the Sea of Japan and Adjacent Parts of the Sea of Okhotsk and the Yellow Sea), Leningrad: Nauka, 1987, pt. 5.

Matveev, A.A. and Terentiev, D.A., Fisheries, long-term dynamics of biomass, distribution and length composition of mass species of Cottidae on the west coast of Kamchatka, *Issled. Vodn. Biol. Resur. Kamchat. Sev.-Zap. Chasti Tikhogo Okeana*, 2016, no. 41, pp. 17–42. https://doi.org/10.15853/2072-8212.2016.41.17-42

Mecklenburg, C.W., Mecklenburg, T.A., and Thorsteinson, L.K., *Fishes of Alaska*, Bethesda: Am. Fish. Soc., 2002.

Novikov, N.P., Sokolovsky, A.S., Sokolovskaya, T.G., and Yakovlev, Yu.M., *Ryby Primor'ya* (The Fishes of Primorye), Vladivostok: Dal'rybvtuz, 2002.

Panchenko, V.V., Reproduction peculiarities of plain sculpin *Myoxocephalus jaok* in Peter the Great Bay, Sea of Japan, *Russ. J. Mar. Biol.*, 2001, vol. 27, no. 2, pp. 111–112.

Panchenko, V.V., Age and growth of sculpins of the genus *Myoxocephalus* (Cottidae) in Peter the Great Bay (the Sea of Japan), *J. Ichthyol.*, 2002a, vol. 42, no. 7, pp. 516–522.

Panchenko, V.V., Seasonal distribution of sculpins of the genus *Myoxocephalus* (Cottidae) in the coastal zone of Peter the Great Bay (the Sea of Japan), *Ibid.*, 2002b, vol. 42, no. 1, pp. 59–64.

Panchenko, V.V., The seasonal bathymetric distribution of the sculpin *Myoxocephalus jaok* (Cottidae) in the northern part of the Sea of Japan, *Ibid.*, 2003, vol. 43, no. 9, pp. 751–756.

Panchenko, V.V., Size-age composition and dynamics of abundance of threaded sculpin *Gymnocanthus pistilliger* (Cottidae) in Peter the Great Bay (Sea of Japan), *Vopr. Rybolovstva (Problems of fisheries)*, 2013, vol. 14, no. 2 (54), pp. 208–218.

Parin, N.V., Evseenko, S.A., and Vasil'eva, E.D., *Ryby morei Rossii: annotirovannyi katalog* (Fishes of Russian Seas : Annotated Catalogue), Moscow: KMK, 2014.

Sokolovskaya, T.G., Species structure of ichthyoplankton of Peter the Great Bay, Sea of Japan on spring-summer season, Abstr. 45th Arctic Sci. Conf. "Bridges of the Science between North America and the Russian Far East," Book 1, Vladivostok: Dal'nauka, 1994, p. 145.

Sokolovsky, A.S. and Sokolovskaya, T.G., *Atlas ikry, lichinok i mal'kov ryb rossiiskikh vod Yaponskogo morya* (Atlas of Eggs, Larvae and Fry of Fishes in Russian Waters of the Sea of Japan), Vladivostok: Dalnauka, 2008.

Sokolovsky, A.S., Dudarev, V.A., Sokolovskaya, T.G., and Solomatov, S.F., *Ryby rossiiskikh vod Yaponskogo morya: annotirovannyi i illyustrirovannyi katalog* (Sea Fishes of the Russian Waters of the Sea of Japan: Annotated and Illustrated Catalogue), Vladivostok: Dalnauka, 2007.

Solomatov, S.F., The characteristics of marine ichthyofauna of northern Primorye (Sea of Japan), *Izv. Tikhookean. Nauchno-Issled. Inst. Rybn. Khoz. Okeanogr.*, 2004, vol. 138, pp. 205–219.

Tokranov, A.M., Reproduction of mass species of sculpin fishes in Kamchatka waters, *Biol. Morya*, 1988, no. 4, pp. 28–32.

Tokranov, A.M., Sculpins of the genus *Myoxocephalus* (Cottidae) in the waters off Kamchatka and problems of its resources exploitation, *Sb. tr. Vseros. nauch. konf. V Baltiiskii morskoi forum. "Vodnye bioresursy, akvakul'tura i ekologiya vodoemov"* (Proc. All-Russ. Sci. Conf. 5th Baltic Maritime Forum "Aquatic Bioresources, Aquaculture and Ecology of Water Bodies"), Kaliningrad: Kaliningrad. Gos. Tekhn. Univ., 2017, pp. 75–80.

Tokranov, A.M., Feeding patterns of the plain sculpin *Myoxocephalus jaok* (Cuvier, 1829) (Cottidae) and its position in the trophic system of near-Kamchatka waters, 2018, *Mor. Biol. Zh.*, vol. 3, no. 3, pp. 43–56. https://doi.org/10.21072/mbj.2018.03.3.05

Vdovin, A.N., Izmyatinsky, D.V., and Solomatov, S.F., The main results of research of marine coastal complex of ichthyofauna in Primorye, *Izv. Tikhookean. Nauchno-Issled. Inst. Rybn. Khoz. Okeanogr.*, 2004, vol. 138, pp. 168–190.

Zuenko, Yu.I., *Promyslovaya okeanografiya Yaponskogo morya* (Fisheries Oceanography of the Japan Sea), Vladivostok: TINRO-tsentr, 2008.

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