# A RELIABLE FINDING OF *PLEUROGRAMMUS AZONUS* (HEXAGRAMMIDAE) OFF THE COAST OF KAMCHATKA WITH NOTES ON THE PERMANENCE OF ITS HABITATION IN THE NORTHERN PART OF DISTRIBUTION RANGE

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Received September, 13 2024

Revised October, 14 2024

Accepted October, 17 2024

*Pleurogrammus azonus* was reliably found off the coast of Kamchatka. A morphological description of a specimen caught in Kronotsky Bay is given in comparison with representatives of the species from other parts of its distribution range. *P. azonus* can be encountered in the waters of the Sea of Okhotsk near Kamchatka in both spring-summer and winter periods, which implies the presence of a permanent local aggregation, strongly dependent on recruitment from more southern areas it inhabits. In catches, it is represented by fish of 24−35 cm fork length, which may exceed the closely related *P. monopterygius* by population size. *P. azonus* entered the waters off the Pacific coast of Kamchatka presumably due to migrations of individual adults from nearby areas on the Sea of Okhotsk side of the peninsula, as well as Shumshu and Paramushir islands.

*Keywords*: *Pleurogrammus azonus*, Hexagrammidae, morphology, distribution, Pacific waters of Kamchatka.

**DOI:** 10.31857/S00428752250202e9

## INTRODUCTION

Until now, it was believed that the only representative of the genus Pleurogrammus from the Terpugidae family (Hexagrammidae), P. monopterygius (Pallas, 1810), lives off the coast of Kamchatka Peninsula (Taranets, 1937; Andriashev, 1954; Rutenberg, 1962; Lindberg and Krasyukova, 1987; Borets, 1997, 2000; Sheiko and Fedorov, 2000; Fedorov, 2000; Parin et al.,

2002; Parin et al., 2014). Another species close to it, P. azonus Jordan et Metz, 1913, has a low-boreal habitat type and inhabits the waters of the Japanese, southern Okhotsk, and northern Yellow Seas. Along the Pacific coast, it is observed mainly from the Southern Kuriles to Hokkaido Island (Rutenberg, 1962; Lindberg and Krasyukova, 1987; Shinohara, 1994; Nakabo, 2002; Mecklenburg and Eschmeyer, 2003). The northernmost captures of single adult P. azonus individuals in the Sea of Okhotsk were reliably recorded in the Tauiskaya Bay (Chereshnev et al., 2012, 2013a, 2013b), and pelagic juveniles near the Kashevarov bank (Melnikov, 1996). In oceanic waters, this species has occasionally been observed as far as Onekotan Island, including the Fourth Kuril Strait (Tokranov, 1998; Dudnik and Zolotov, 2000). Despite the fact that the ranges of P. monopterygius and P. azonus partially overlap in the Kuril Ridge, the mass occurrence of their adult individuals is separated by a gap. Bussol (Dudnik and Zolotov, 2000), therefore, the second of them is almost not observed north of the island of Simushir.

It is characteristic that until recently P. azonus did not appear in ichthyological lists based on the results of bottom trawling surveys off the coast of Kamchatka (Tokranov and Polutov, 1984; Borets, 1997; Chetvergov et al., 2003; Savin et al., 2011). However, a number of recent studies have shown the presence of this species off both coasts of the peninsula (Terentyev et al., 2013; Varkentin et al., 2019; Matveev and Varkentin, 2022). However, these publications do not provide any evidence of reliable captures of P. azonus, as there are no morphological descriptions and photographs of captured individuals.

During accounting work at the Pacific coast of Kamchatka in June-July 2022, an atypical representative of the greenling family was found in Kronotsky Bay. Preliminary examination showed that the caught specimen belongs to *P. azonus* . Furthermore, paying special attention to species identification of greenlings during recent monitoring studies of the bottom fish fishery, we identified the actual presence of *P. azonus* off Western Kamchatka. Thus, the purpose of our work

is to present reliable data on the habitat of *P. azonus* in Kamchatka waters with a morphological description of the specimen from Kronotsky Bay.

## MATERIALS AND METHODS

The material consisted of the results of a bottom trawl survey (83 stations) carried out in June-July 2022 off the Pacific coast of Kamchatka on the fishing vessel "MRTK-316" and MRTK [1]"Engineer Martynov". The research covered the waters of Kronotsky Bay and the northern part of Avachinsky Bay, as well as the southeastern tip of the peninsula. The depth of trawling varied within 26-210 m. A single specimen of *P. azonus* with a Smith fork length ( *FL* ) of 336 mm was caught at coordinates 54°18′ N, 160°43′ E in a bathymetric range of 78-80 m.

To establish the values of meristic and plastic characteristics for accurate species identification of the captured specimen, we applied the scheme from Rutenberg's work (1962). Measurements were performed on fresh material. The following feature designations are used in the text: *D* , *A* , *P* , *V* – dorsal, anal, pectoral (and number of rays in them), and pelvic fins, respectively; *r.br.* – number of gill rays, *sp.br.* – number of gill rakers on the 1st gill arch, *pc* – number of pyloric caeca. For comparison of plastic and meristic characteristics of the studied specimen from Kronotsky Bay, we used the measurement results of *P. azonus* specimens from the Sea of Japan (Posyet Bay) and the Sea of Okhotsk (Tauysk Bay) (Rutenberg, 1962; Chereshnev et al., 2013a, 2013b).

Additionally, data obtained during the monitoring of Danish seine fishing off the west coast of Kamchatka in May-June 2023 and January-February 2024 were used. In 2023, work was conducted at fish processing enterprises located in the village of Ozernovsky and in the village of

[1]MRTK - small stern trawler.

Ustyevoye, where small-tonnage vessels of the MRS-150 type delivered their catches [2]. Danish seines of two designs were used as fishing gear: 95.2/24.5 and 84/18 m. In total, results of 27 hauls from depths of 25-100 m were analyzed during the specified period. In 2024, studies were conducted on the floating base "Viktor Gavrilov," where STR-type vessels delivered fish [3], equipped with a 49.4/46 m Danish seine. Results of 51 hauls from depths of 60-124 m were processed.

## RESULTS

### *Pleurogrammus azonus* Jordan et Metz, 1913

(Fig. 1)

Description . *D* 49, *A* I 28, *P* 23, *r.br.* 6, *sp.br.* 6 + 16 = 22, *pc* 36. Body compressed laterally, symmetrical. Caudal peduncle elongated (fits 8.4 times into *FL* ) and low (contained 2.2 times in its own length and 4.0 times in the greatest body depth). Scales small, ctenoid. Head conical in shape, large, 4.4 times in *FL* . Supraorbital tentacles present. Two pairs of nostrils, with the anterior ones larger than the posterior ones. Interorbital space slightly convex, fits 3.5 times in head length. Mouth terminal, snout rounded. Posterior edge of upper jaw reaches the vertical of the anterior edge of the orbit.

The beginning of the dorsal fin base is located slightly behind the vertical of the end of the gill cover, its length fits 1.6 times in *FL* . The first ray of *A* is unsegmented, short, and almost hidden in the skin. The remaining 28 rays are unbranched and segmented. Pectoral fin slightly elongated, its base wide. The beginning of *V* is located behind the bases of *P* . The length of *V* is contained 8.0 times in *FL* . The ends of paired and some unpaired fins are located at the same level

[2]MRS - small fishing seiner.
[3]STR - refrigerated seiner-trawler.

( *V* under *P* and *A* under *D* ). Caudal fin with a deep notch. Its lower and upper lobes are of equal length.

The seismosensory system consists of five lateral lines, all paired. The first pair on the occiput is not connected, beginning from the vertical of the posterior edges of the orbits. On the caudal peduncle, the left and right lines converge behind *D* (Fig. 2). The second pair runs almost through the entire body: from the upper edge of the gill cover to the middle of *C* , forming a bend at the end of the base of *D* . The third lateral line begins from the middle of *P* and ends above the last rays of *A* . The fourth and fifth pairs are located on the ventral side. On the caudal peduncle, a convergence of the fifth and first pairs of lines is noted.

Coloration . The upper part of the body is brownish-olive, the sides are light. Fins are dark with a greenish tint. The lower part of the head and belly are creamy white. The body is covered with irregularly shaped spots. In the caudal part, three transverse bands of varying width are slightly discernible, fading on the belly and not reaching the anal fin (Fig. 1).

Comparative notes . The values of most morphological features of the specimen found in Kronotsky Bay do not exceed the limits of variability known for *P. azonus* from Posyet Bay and Tauisk Bay (Table 1). Some differences are apparently due to the limited comparative material.

**Table 1.** Plastic and meristic characteristics of specimens *Pleurogrammus azonus* from different parts of the range

| Character | Kronotsky Bay (our data) $n = 1$ | Posyet Bay (Rutenberg, 1962) $n = 35$ | Tauiskaya Bay (Chereshnev et al., 2013a, 2013b) $n = 2$ |
|---|---|---|---|
| *TL* , mm | 353 | | 298, 385* |
| *FL* , mm | 336 | 275–461 | 278, 365 |
| *SL* , mm | 314 | | 262, 334 |
| | | In % *FL* | |
| *aD* | 25.3 | 23.9–26.5 | 25.0, 24.4 |
| *hD* | 8.9 | 9.0–10.8 | 10.3, 9.0 |

| | | | |
|---|---|---|---|
| *lD* | 61.0 | 51.8–61.2 | 58.2, 58.0 |
| *aA* | 54.5 | 49.8–55.5 | 53.2, 53.1 |
| *hA* | 7.7 | 7.6–9.5 | 7.2, 7.7 |
| *lA* | 31.5 | 27.9–31.1 | 30.5, 30.1 |
| *lP* | 17.5 | 17.0–19.6 | 21.2, 23.3 |
| *lV* | 12.5 | 11.4–13.5 | 11.9, 12.1 |
| *H* | 21.4 | 19.2–23.0 | 21.9, 23.0 |
| *h* | 5.3 | 4.9–5.5 | 4.9, 5.2 |
| *lcp* | 11.9 | 11.1–12.8 | 12.2, 11.5 |
| *c* | 22.6 | 22.7–25.3 | 25.2, 24.2 |
| | | In % *c* | |
| *ao* | 37.5 | 36.2–40.5 | 37.1, 37.2 |
| *io* | 30.5 | 28.6–34.0 | 31.4, 31.6 |
| *o* | 16.7 | 15.1–17.6 | 16.5, 16.9 |
| *lmx* | 40.3 | 33.4–40.7 | 34.9, 36.0 |
| *lmd* | 47.2 | 41.8–48.0 | 41.7, 42.5 |
| | | Meristic characteristics | |
| *D* | 49 | 48–52 | 51, 50 |
| *A* | 28 (29) | 27–31 | 27 (28), 27 (28) |
| *P* | 23 | 22–25 | 24, 24 |
| *pc* | 36 | 35–40 | 39** |
| *r.br.* | 6 | | 6, 6 |
| *sp.br.* | 22 | 22–25 | 24, 24 |
| *sp.br.s.* | 6 | 6–8 | 7, 6 |
| *sp.br.i.* | 16 | 15–17 | 17, 18 |
| *squ.ll* $_{3\text{-}5}$ | 10 | 10–11 | 11 and 11, 10 and 11 |

**Note.** *TL* , *SL* , *FL* - total, standard, and Smith length respectively; *aD* - antedorsal distance; *hD* , *lD* - maximum dorsal fin height and length of its base; *aA* - anteanal distance; *hA* , *lA* - anal fin height and length of its base; *lP* , *lV* - pectoral and pelvic fin lengths; *H* - maximum body height; *h* , *lcp* - height and length of caudal peduncle; *c* , *ao* - head and snout lengths; *io* - interorbital distance; *o* - horizontal eye diameter; *lmx* , *lmd* - upper and lower jaw lengths; *D* , *A* , *P* - number of rays in dorsal, anal, and pectoral fins respectively; *pc* - number of pyloric caeca; *r.br.* - number of branchiostegal rays; *sp.br.* , *sp.br.s.* , *sp.br.i.* - number of gill rakers on the first gill arch: total, upper and lower parts respectively; *squ.ll* $_{3\text{-}5}$ - number of scales in oblique row between third and fifth lateral lines (for specimens from Tauy Bay, values are given for left and right sides of body). * In the column before the comma, values are given according to: Chereshnev et al., 2013b, after - according to: Chereshnev et al., 2013a; ** according to: Chereshnev et al., 2013a.

The similarity between *P. azonus* and *P. monopterygius* was previously noted, as the values of most of their morphometric characteristics overlap (Rutenberg, 1962; Lindberg, Krasyukova,

1987; Chereshnev et al., 2013a). The authors emphasized that the first species differs distinctly from the second by its more elongated body, different structure of lateral lines, low dorsal fin height, and its even contour. Differences are also characteristic in fish coloration: specimens of *P. azonus* are predominantly monotone, while *P. monopterygius* has five broad transverse black bands on the body. However, not every listed characteristic is constant and may vary. At the same time, the main distinguishing feature of *P. azonus* , which allows reliable identification of both juveniles and adult fish, is recognized (Rutenberg, 1962; Lindberg, Krasyukova, 1987; Ilinsky, 2007) as a different topography of the first pair of lateral lines on the caudal peduncle. In this species, the left and right lines converge behind the dorsal fin, whereas in *P. monopterygius* they diverge, forming an oval-shaped curve. In our specimen from Kronotsky Gulf, the interval between the lateral lines of the first pair on the caudal peduncle narrows (Fig. 2). Thus, there is no doubt that the discovered specimen belongs to *P. azonus* .

## DISCUSSION

The studied species is considered a bottom-pelagic representative of the greenling family that inhabits most of its life in the shelf zone and adjacent areas of the continental slope (Rutenberg, 1962; Vdovin, 1998). Its juveniles spend their first year of life in the epipelagic zone, moving away from the shores to considerable distances (Shimomura, Fukataki, 1957; Gorbunova, 1962; Nagasawa et al., 1996; Dudnik, Zolotov, 2000). In this regard, the Sea of Okhotsk waters play a significant role in their feeding. During the summer-autumn period, juveniles are distributed throughout the southwestern part of this water body, including areas located above the deep-water basin. In some years, the feeding area in the Sea of Okhotsk may be limited to coordinates 54°–56°N and 150°–155°E, capturing adjacent waters on the Pacific side of the Kuril Islands. In this case, populations of *P. azonus* of "local" and Japan Sea origin mix. Notably, the spawning grounds

of the latter are located near Hokkaido Island and Southwestern Sakhalin (Melnikov, 1996; Shuntov, 1996; Dudnik, Zolotov, 2000; Merzlyakov, Temnykh, 2002; Melnikov, Loboda, 2003).

Two main factors are distinguished that significantly influence the distribution area of *P. azonus* juveniles: the initial number of individuals in different reproduction areas during the spring period and oceanological conditions in the Sea of Okhotsk (Melnikov, Loboda, 2003). It is quite possible that high abundance and favorable hydrological conditions contributed to the bottom settlement of some fish near the northern Kuril Islands, which was noted in the 1980-1990s (Tokranov, 1998; Dudnik, Zolotov, 2000). However, further research in this area did not reveal the presence of *P. azonus* . It was also not recorded near the shores of Kamchatka (Borets, 1997; Fedorov, 2000; Sheiko, Fedorov, 2000; Chetvergov et al., 2003; Savin et al., 2011).

Based on literature data, the first record of *P. azonus* in the Kamchatka waters of the Sea of Okhotsk was registered in July 2012 during a bottom trawl survey on the research vessel "Professor Probatov" (Terentyev et al., 2013). Subsequently, this species was recorded almost annually (Matveev, Varkentin, 2022). However, as noted above, there is no evidence confirming these catches during the specified period. According to our materials, *P. azonus* started to be observed off the western coast of Kamchatka from May-June 2018, when during monitoring of Danish seine fishing for saffron cod *Eleginus gracilis* , Pacific cod *Gadus macrocephalus* and flounders (Pleuronectidae) north of Cape Lopatka, several specimens of this species were recorded (Fig. 1b). All of them possessed characteristics typical for *P. azonus* : even contour of the dorsal fin, light belly, absence of distinct black transverse stripes on the body, uniform coloration on the sides, and species-specific topography of lateral lines. However, determining the exact number of specimens found in 2018 is not possible, as due to certain difficulties in distinguishing species of the genus *Pleurogrammus* , some caught specimens were partially misidentified. Studies conducted in May-June 2023 and January-February 2024 showed that the aforementioned findings were not accidental

- during these periods *P. azonus* was among the bycatch species (Fig. 1c). Its specimens were found in a significantly large water area - between 51° and 56°N (Fig. 3). Thus, our data confirm the actual presence of *P. azonus* in the Kamchatka waters of the Sea of Okhotsk.

During monitoring work among all species of the greenling family, *P. azonus* was not dominant either in frequency of occurrence or in the number of individuals encountered. The most numerous was *Hexagrammos stelleri* (Table 2). However, this circumstance is not unique, as this species is considered the most numerous among all greenlings inhabiting the western coast of Kamchatka (Chetvergov, 2000; Zolotov, 2012; Kurbanov, 2022). Characteristically, the frequency of occurrence of *P. azonus* corresponded to that of *P. monopterygius* , only in winter it was higher. Nevertheless, the number of caught specimens of the first species in spring and summer exceeded that of the second by almost three times (69 and 22 specimens respectively).

**Table 2.** Some quantitative indicators of the occurrence of species from the greenling family (Hexagrammidae) off the western coast of Kamchatka in 2023 and 2024 according to Danish seine catch data

| Indicator | *Pleurogrammus azonus* | *P. monopterygius* | *Hexagrammos lagocephalus* | *H. stelleri* |
|---|---|---|---|---|
| May-June 2023 (27 hauls) | | | | |
| Frequency of occurrence, % | 40.7 | 40.7 | 7.4 | 66.7 |
| Smith length, cm | 24-35 | 21-30 | 45-48 | 17-39 |
| Depths, m | 30-90 | 30-70 | 100 | 25-54 |
| Total number of specimens | 69 | 22 | 3 | 271 |
| January-February 2024 (51 hauls) | | | | |
| Frequency of occurrence, % | 7.8 | 3.9 | 3.9 | 49.0 |
| Smith length, cm | 27-35 | 27-32 | 25-31 | 21-37 |
| Depths, m | 94-105 | 95-106 | 96-106 | 66-110 |
| Total number of specimens | 4 | 4 | 6 | 356 |

During all observation periods, the size of specimens ( *FL* ) *P. azonus* varied within 24-35 cm (Table 2). Note that this species transitions to a bottom-dwelling lifestyle when reaching a body

length [4]of 20-25 cm (Fadeev, 2005), however, there have been cases of catches in the pelagic zone of fish *FL* > 25 cm (Vdovin, 1998; Melnikov, Loboda, 2003). If we assume that our findings of *P. azonus* off Western Kamchatka in summer may be the result of catches in the water column while lifting the fishing gear aboard the vessel, this does not explain the discovery of specimens in January-February, as the feeding period of the species in the Sea of Okhotsk ends in October-November due to deteriorating suitable oceanological conditions (Melnikov, 1996; Dudnik, Zolotov, 2000; Melnikov, Loboda, 2003). In our opinion, the repeated discovery of *P. azonus* in Kamchatka waters is due to the presence of a local ("resident") group highly dependent on recruits from more southern regions. Probably, its formation was facilitated by the rapid growth of the species population near the Southern Kurils, as well as in adjacent waters near Southwestern Sakhalin and Hokkaido Island in the late 1990s-early 2000s. The increase in abundance of *P. azonus* during this period was recorded based on epipelagic survey results (Melnikov, 1996; Melnikov, Loboda, 2003) and reflected in model calculations (Zolotov, Fatykhov, 2016). Additionally, in recent years, there have been multiple cases of catching young-of-the-year *P. azonus* on the Sea of Okhotsk side of Paramushir Island during Danish seine fishing for flounders (personal communication from R.N. Fatykhov, Sakhalin branch of the Russian Research Institute of Fisheries and Oceanography).

According to Chereshnev et al. (2013a, 2013b), the main reason for detecting *P. azonus* in the Taui Bay of the Sea of Okhotsk is also the increase in its abundance. It is characteristic that the first specimen they recorded was a post-spawning female (VI-II stage of gonad maturity), which gave grounds for the authors to assume spawning occurrence. Given that the waters off the western

[4]The author does not specify the length type.

coast of Kamchatka are significantly warmer than the northern part of the Sea of Okhotsk (Shuntov, 2001), there is no doubt about the possibility of this species reproducing in the studied area.

Earlier records of captures of *P. azonus* off the Pacific coast of Kamchatka (Varkentin et al., 2019) raise questions. According to these authors, the species was found during bottom trawl survey in 2002. However, in the paper by Zolotov and Dubinina (2013), who also used the results of these surveys, *P. azonus* is absent from the list of ichthyofauna of Pacific waters of Kamchatka. It is impossible to determine which of these publications contains an error. Nevertheless, the results of subsequent Danish seine and trawl surveys did not confirm the presence of *P. azonus* (Terentiev, 2011; Terentiev, Malykh, 2012; Varkentin et al., 2019). Thus, our capture of this species in Kronotsky Gulf (Fig. 1a) is the first documented case for the Pacific waters of the peninsula. The penetration of *P. azonus* into this water area can probably be explained by migratory activity of individual adult specimens from areas located near South-Western Kamchatka and from the Sea of Okhotsk side of Shumshu and Paramushir Islands. Based on fish tagging results, the average radius of individual activity of mature *P. azonus* is 60 km, with a maximum of 660 km (Vdovin, 1998). The distance from the southernmost part of Western Kamchatka (51°-52°N) to Kronotsky Gulf is ~540-612 km, which fits well within the species' migration capabilities. Additionally, according to one of the authors of this article, in 2021, a recreational fisherman caught an adult greenling specimen in the southern part of Avacha Gulf near Cape Opasny, whose external features fully matched *P. azonus* (specimen not preserved, identification was made from a photograph). Thus, the expansion of this species' range to the Pacific coast of Kamchatka probably began earlier. At the same time, the presence of a complete life cycle of *P. azonus* in Kamchatka waters remains to be established in the future.

FUNDING

The work was funded by the budget of the All-Russian Research Institute of Fisheries and Oceanography. No additional grants were received for conducting or supervising this specific research.

## COMPLIANCE WITH ETHICAL STANDARDS

The work was conducted in accordance with Federal Law No. 498-FZ dated 27.12.2018 (amended on 24.07.2023) "On Responsible Treatment of Animals and Amendments to Certain Legislative Acts of the Russian Federation". Material collection and processing did not contradict international standards for animal treatment, corresponding to Directive 2010/63/EU of the European Parliament and Council of the European Union dated 22.09.2010 on the protection of animals used for scientific purposes (https://ruslasa.ru/wp-content/uploads/2017/06/Directive_201063_rus.pdf).

## CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

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FIGURE CAPTIONS

**Fig. 1.** Specimens of *Pleurogrammus azonus* from Kamchatka waters: a – *TL* 35.3 cm, 2022, Kronotsky Gulf; b, c – *FL* 24.0 and 35.4 cm, 2018 and 2023, western coast of Kamchatka.

**Fig. 2.** Topography of the first pair of lateral lines ( $ll_1$ ) on the caudal peduncle of *Pleurogrammus azonus* from Kronotsky Gulf: *C* , *D* – caudal and dorsal fins.

**Fig. 3.** Capture locations of *Pleurogrammus azonus* near the Kamchatka coast: ( ★ ) – July 2022, ( ● ) – May–June 2023, ( ● ) – January–February 2024; *1* – Kronotsky Gulf, *2* – Cape Lopatka; (---) – isobaths.