New data on reproduction and early ontogenesis of the antlered sculpin, *Enophrys diceraus*

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Reports on spawning of the antlered sculpin (*Enophrys diceraus)*, its larvae development and timing of their appearance in plankton in Peter the Great Bay were already done earlier (Sokolovsky and Sokolovskaya, 1999; Panchenko, 2005). However, such important aspects of the biology of this species as the timing and conditions of spawning, eggs development and the transition of the pelagic larval stage have not been sufficiently investigated. Our year-round complex ichthyoplanktonic and ichthyological study conducted in 2017–2021 and supplemented investigations with using SCUBA techniques starting from 2019 made it possible to highlight these issues in more detail. The research was carried out on a weekly basis in the Zhitkov Bay located on Russky Island and in the adjacent waters of the Paris Bay.

During the SCUBA diving performed in November–December 2019 and March–May 2020 we found several clutches of antlered sculpin eggs. The period from January to February was not covered by diving operations due to ice conditions. The first two clutches in this area were found on November 29, 2019, while the procreators were spotted in this location during October–November. The determining factor for the onset of spawning was probably the bottom water temperature because we found a clutch of this species at an earlier period in previous years in another area of the Peter the Great Bay. It was discovered during investigations in the Vostok Bay at a depth of 7 m with water temperature of about 3°C on November 22, 1999 (Panchenko, 2005). The clutch was spread over a stone in an irregular oval shape measuring 30x20 cm in size with 3 cm thickness in the middle. Such a large size of the clutch indicated that the eggs were laid by several females. Mature eggs in the gonads of different females of antlered sculpin vary in colour (Sokolovsky, Sokolovskaya, 1999; our data) so in different areas of the clutch the color of eggs laid by different females changed from orange to purple while the eggs diameter varied from 1.7–2.0 to 1.8–2.1 mm. An adult antlered sculpin was spotted near the clutch. Protection of eggs, usually done by males, is a characteristic feature of many species of fish of the Cottidae family (Nikolsky, 1950; Andriyashev, 1954; Gorbunova, 1964; Munehara at al., 1994; Hayakawa, Munehara, 1996; Panchenko, 2001; and others). We found that protection of antlered sculpin eggs was also carried out by males.

In our diving research in the autumn–winter period in Zhitkov Bay and in the adjacent water area, we observed males and females of antlered sculpin species. Some of the males were seen near clutches found at a depth of 6–11 m guarding them (fig. 1). The seabed in the area of the location of spawning grounds of antlered sculpin that we found was muddy. However, the eggs were usually attached to solid surfaces like upper parts of rocks, between stones or on mussel druses, oysters, etc. Only one clutch was found loose on the muddy bottom (fig. 2). It was located near a flooded metal structure on which it was probably deposited but slid off as a result of an unsuccessful placement onto the substrate. A male sculpin was initially found above the clutch but it probably stopped guarding it because of the failed placement of the clutch so we removed the eggs for the subsequent incubation in the aquarium. In springtime, only antlered sculpin males continuing to guard the eggs were found in the area of the spawning grounds.

Fig. 1. Male of the antlered sculpin (in the center) near a clutch of eggs on oysters (on the left)

Fig. 2. Egg clutch that has fallen from the substrate to the muddy bottom

The first clutches of antlered sculpin were found at the end November 2019 at water temperature of 2.3°C. The latest eggs finding was recorded on April 10, 2020 at a depth of 11 m and the bottom layer water temperature of 2.0°C. At this time, it was close to the surface temperature. (fig. 3). Visually, the size of this clutch appeared decreased which was possibly due to the onset of hatching of larvae. We did not find any egg clutches and/or individuals of antlered sculpin in the area of the spawning grounds later than this period, apparently, due to the end of hatching and the protected fish species departure.

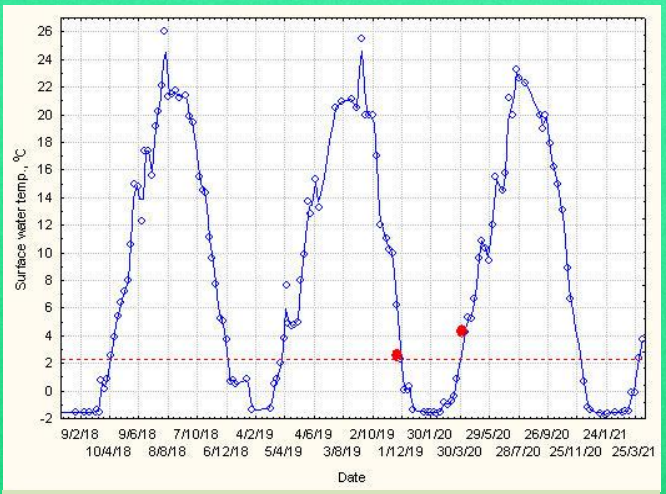

Fig. 3. **S**urface water temperature during the research period

It is known from literary sources that larvae of the antlered sculpin in the Peter the Great Bay appear in ichthyoplankton at the end of April (Sokolovsky, Sokolovskaya, 1999). Our research showed that the onset of hatching may occur much earlier in some years. In 2020 the first antlered sculpin larvae were found at the fish-luring light stations in the Zhitkov Bay already on March 23rd with the bottom water temperature of –0.6°C (+2.4 °C at the surface). Taking into account the cases of finding clutches up to the 10th of April in the current year, the hatching period could have lasted for several weeks. Hatching of larvae of this species in the Peter the Great Bay begins already at a negative water temperature. Apparently, the development of eggs initiates, albeit slowly, in winter (lasting for about 4 months) and it does not stop with the bottom water temperature staying below 0°C (a drop to -1.7°C in January—February was recorded). Such temperature conditions are common in the area from mid-December to the end of March.

In other years, the timing of the onset of larvae appearance at a fish-luring light stations varied from late March to the second decade of May, which, we believe, depends not only on hydrological conditions, but also on the proximity of the developing clutches to plankton collection sites. It is possible that in 2018, when the first larvae having the size approaching the size of transition to bentic life mode were observed only in May, the spawning of the antlered sculpin near the place of collection in the Zhitkov Bay did not happen for some reason.

The earliest prelarvae caught by us had large pinkish-red yolk sacs (the colour of developing eggs) and a body length of 7.8–8.0 mm (*TL*) (fig. 4). According to literature data it is known that hatching occurs at smaller sizes of 6.3–6.5 mm (*SL*) in April–May (Sokolovsky, Sokolovskaya, 1999). The significant disparity in size with the literature data is probably due to the fact that, according to our observations made during the incubation of eggs, the prelarvae are inactive for some time (1–2 days) and do not rise from the bottom before becoming part of the plankton. Also, we measured living species while earlier descriptions were made on fixed material. Hatching from the developing clutch collected by us in winter 2020 under aquarium conditions (SAC of the Primorsky Oceanarium) began on March 2, 2021 at water temperature of about 5°C. Development of eggs under such conditions was obviously significantly accelerated so the live larvae had a body length of about 5.5 mm (*TL*), which would undoubtedly be less in natural conditions.

Fig. 4. Larvae with a body length of 7.8 and 8.0 mm (*TL*)

As shown by the analysis of our catchings, larvae of antlered sculpin usually remain in plankton until the second half of May where surface water temperatures rising to 7–8°C. By this time they reach a body length of 13–14 mm (*TL*) (fig. 5). Larvae of this size already have well-formed fins and show first signs of pigmentation characteristic of bottom settled juvenile fish. In the course of observations of larvae development in aquarium conditions, carried out in the spring of 2017 in the environment of the NSCMB aquarium, it was also noted that already at a length of about 14 mm (*TL*) postlarvae preferred to spend most of their time lying on the bottom of the aquarium only occasionally rising up for picking crustaceans offered as food. Meanwhile, in the paper by A.S. Sokolovsky and T.G. Sokolovskaya (1999) it was reported that the transfer of antlered sculpin to the bentic mode of life happened at a much greater body length (over 20 mm). Considering the fact that the collection of the larvae described in their study was carried out not only at the surface, but also with the help of oblique towing of ichthyoplankton sampler from bottom, one can assume that some already bentic juveniles also got into their catches.

Fig. 5. Larvae with a body length of 13.0 and 14.0 mm (*TL*)