Spawning of the Sea Raven *Hemitripterus villosus* in Peter the Great Bay, Sea of Japan

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Abstract—The spawning habits of the sea raven *Hemitripterus villosus* were investigated by scuba diving at shallow rocky bottom sites around Bolshoi Pelis Island (Peter the Great Bay, Sea of Japan). Spawning occurs in September, when the surface water temperature drops. The optimum spawning temperature is 17–18°C. The fish density in nest sites reaches 120/300 m². The mean individual fecundity is about 10000 eggs. Over 35% of the egg masses of *H. villosus* are eaten by echinoderms, primarily *Patiria pectinifera* and *Strongylocentrotus nudus*. Since fecundity is relatively low and parents do not take care of the egg masses, predation can strongly affect the abundance of this species.

Key words: sea raven, fish ecology, spawning, predation, Sea of Japan, marine reserve.

The sea raven *Hemitripterus villosus* (Pallas, 1814) is common in the Sea of Japan and in the Yellow, Okhotsk, and Bering seas [4]. Although it has a wide distribution, this species is neither abundant nor commercially important. Little information is available on the biology and spawning of *H. villosus* [1, 7–10].

*H. villosus* is a common element of the ichthyofauna of Peter the Great Bay. It occurs throughout the Far East Marine Reserve, and, in 1978, a large spawning site of this species was found at the northern end of Bolshoi Pelis Island [5]. Further investigations have shown that this spawning site is used by sea ravens every year [1, 2] and it is the largest in the reserve area and, possibly, in Peter the Great Bay.

The aim of the present research was to investigate the characteristic spawning habits of the sea raven *H. villosus* in Peter the Great Bay (time of spawning, abiotic conditions, behavior, and interactions with other animals) and to use these data for a comprehensive description of the biota of the marine reserve.

RESULTS AND DISCUSSION

From the second half to the end of August (80% of observations) and, in some years, to mid-September, fish were encountered around the spawning sites on sandy and silty-sandy substrates at depths of 7 to 25 m. Generally, about 90% of the fish were females, but sometimes the percentage of males increased to as high as about 50%.

The spawning site at Bolshoi Pelis Island is a gently sloping rocky-bottom area 0.7 to 1.9 m deep and 3–5 m wide, extending for 50–60 m from the innermost part of the bay along the left entrance cape. Thus, the spawning site area is 300 m². To a depth of 2 m, the bottom consists of 8–30 cm boulders; below 2 m, the boulders are 30–60 cm; the bottom descends fairly steeply to 6–12 m. The bay is open southwestward, and a stone ridge protects it against strong westerly and northerly storms.

Spawning females had a mean total body length of 429.1 ± 50.9 mm (from 350 to 505 mm, n = 38) and a weight of 1833.0 ± 736.7 g (680–3250 g). The mean weight of eggs per female was 554.25 ± 196.8 g; the gonadosomatic index (GSI) was 33.4 ± 7.1 (26.15 to 45.4). The number of eggs per female was 10207 ± 6884 (3913–25000).

Migration to the spawning site and egg deposition began in late August (see figure). At the spawning site, females were encountered either singly or in groups (3 ± 1, n = 327 specimens). The mean distance between individual fish and groups was 5.7 ± 4.6 m (n = 86 mea-
The number of sea raven egg masses damaged by various predatory animals at the nest site of Bolshoi Pelis Island in September–October 1997–1998

<table>
<thead>
<tr>
<th>Species</th>
<th>Percentage of damaged egg masses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patiria pectinifera</td>
<td>17.5</td>
</tr>
<tr>
<td>Strongylocentrotus nudus</td>
<td>16.89</td>
</tr>
<tr>
<td>Aphelasterias japonica</td>
<td>0.46</td>
</tr>
<tr>
<td>Asterias amurensis</td>
<td>0.15</td>
</tr>
<tr>
<td>Lysastrosoma anthosticta</td>
<td>0.15</td>
</tr>
<tr>
<td>Undamaged egg masses</td>
<td>64.85</td>
</tr>
</tbody>
</table>

Note: We examined 657 egg masses.

The egg masses rapidly formed lumps (usually trapezium-shaped), measuring $8.5 \times 3.0 \times 3.5$ cm$^3$. The egg laying process was comparatively long; females remained immobile for 30 min or more. Unfortunately, in no case were we able to observe the whole process.

The mean egg mass weight was $34.6 \pm 16.0$ g (6.7–73.0 g, n = 52), and the number of eggs in each egg mass was $605.2 \pm 279.5$ (50–1260). Egg size varied from 3.9 to 4.75 mm. By the end of the spawning period, the density of egg masses at this nest site had reached $13/m^2$ (3.0–20.0/m$^2$). In other areas along the reserve coast, on large boulders and on a monolithic rock, egg mass density was lower. Three to four egg masses were observed close to one another, apparently deposited by the same female. They were most often located among concretions of the mussel *Crenomytilus grayanus* at depths of 3 to 5 m.

Judging by individual size and coloration, females stayed at the nesting site for 1 to 2 days. During storms, females occasionally migrated into the bay to depths of 4–12.0 m, returning after the weather had improved. Decreased transparency of the water produced no changes in the spawning process. At night, the fish were not active, but stayed at the nest site. Like the white-edged rockfish *Sebastes taczanowskii* [3], some individuals of *H. villosus* were seen with the overgrown hydroid *Obelia longissima*; on some days, these fish made up 10% of the total number of specimens at the spawning site.

Immediately after spawning, the egg masses began to be eaten by various animals, usually the starfish *Patiria pectinifera* and the sea urchin *Strongylocentrotus nudus*, which damaged more than 1/3 of the egg masses (see table). We often observed that the same egg mass was eaten by several sea urchins or shared between sea urchins and starfishes. Egg masses hidden deep among stones were less accessible to predators. In this study, we did not see the white-edged rockfish *Sebastes taczanowskii* eating *H. villosus* egg masses, as has been noted previously [1, 2], but we repeatedly observed small groups of white-edged rockfish and the rockfish *S. minor* surrounding female sea ravens approaching the spawning site. Other fishes inhabiting the spawning site were indifferent to *H. villosus*.

Spawning intensity in *H. villosus* gradually decreased by late September, and spawning ceased by early October (see figure). Throughout the period of spawning observations, females did not take care of or guard the egg masses, nor did they feed.

Our investigations show that, like Irish lords of the genus *Hemilepidotus* (family Cottidae), which exhibit a similar mode of life [6], *H. villosus* spawns during the fall in the upper subtidal area. Spawning fish were smaller than fish from the coast of Kamchatka [7], but their fecundity was almost the same. In all cases, spawning occurred on a stony substrate, as opposed to the fish from Hokkaido, which deposit eggs among polychaete tubes [8]. The latter circumstance may be an...