Identification of Two Ecological Forms of Chum Salmon by Analyzing Microstructure of Otoliths

Elena Akinicheva, Igor Izergin, and **Vladimir Volobuev**
Magadan Scientific Research Institute of Fisheries and Oceanography (MagadanNIRO)
36/10 Portovaya St., Magadan 685000, Russia

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We analyzed otoliths (sagitta) of chum salmon caught in 2002 in the Taui River, the largest river of the Taui Gulf on the continental coast of the Sea of Okhotsk. While conducting biological analyses, we sampled otoliths from 818 individuals of chum salmon caught with a drag seine during controlled test fishing. Otoliths were removed during biological analysis and stored dried until processing. Some otoliths were rejected due to indistinct micro-increments (aberrant otoliths). Thermoplastic cement (Buehler, USA) was used to prepare sections. Sections were polished with "Mark-52" polisher (USA) using aluminum oxide abrasive paper disks with different particle sizes (Struers, Copenhagen/Denmark). Otoliths were sectioned along the center of growth, polished, and examined under a microscope. Sections were turned over when necessary and polished from the other side. Sections were examined with a Galen-3 microscope in transmitted light with magnifications 10x10, 10x20, 10x40, 10x100.

Analysis of otolith patterns of chum during anadromous migration permits not only division of the entire population into hatchery released and wild fishes, but also identification of local groups within wild populations.

For this purpose the most descriptive information is the analysis of otolith patterns formed during fresh-water ontogenesis up until the switch to exogenous feeding.

Based on analysis of otolith sections (sagitta) made along the sagittal plane through the core, we divided chum population of Taui River into two groups – group A and group B. Group A is characterized by a large number of similarly grouped increments (Fig. 1) with high optical brightness in transmitted light. Group B consists of individuals with otolith zone, corresponding to embryonic period, characterized by different combinations of hyaline and opaque rings. Groups of increments in their otoliths are characterized by diffuseness and lower optical brightness. Only eye pigmentation and hatching rings can be distinctly identified (Fig. 2).

Statistical analysis of biological characteristics of individuals of both groups showed distinct differences in weight and linear parameters (Figs. 3 and 4)..

Analysis of age and sex composition of both groups of chum salmon showed a significant difference between them. Males prevailed in group A (53.4%), females – in group B (51.6%) (Fig. 5).

As you can see from Fig. 6, both groups are represented by fish of three ages, however the relative number of fishes in each age group is different.

Group A is characterized by an almost even distribution of fishes by ages with a slightly larger quantity of the oldest fish. At the same time, group B is characterized by significant differentiation with a peak number of individuals at the age of 3 (48.96%) and a minimum number of fish at the age of 5 (11.34).

Fig. 1. Otolith pattern No. 1 - otolith of individual belonging to group A.

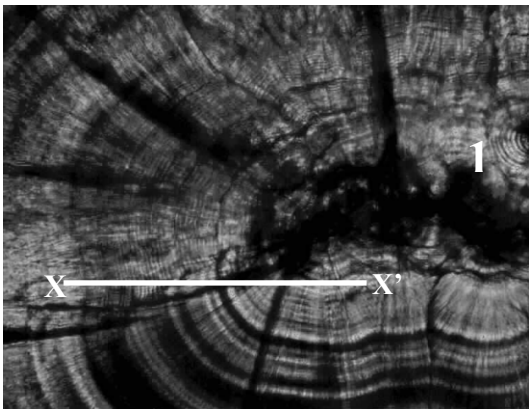
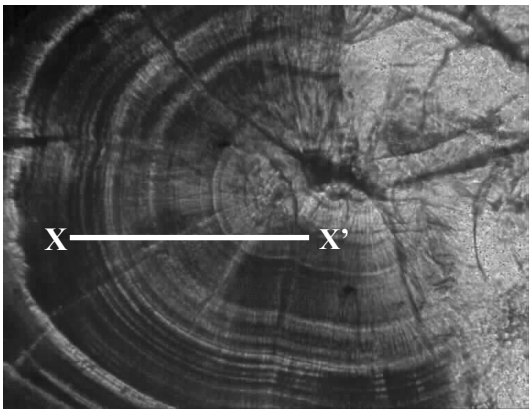


Fig. 2. Otolith pattern No. 2 – otolith of individual belonging to group B.



All correspondence should be addressed to E. Akinicheva.
e-mail: otolith@magadanniro.ru

Fig. 3. Fork length of chum in groups A and B caught in Taui River.

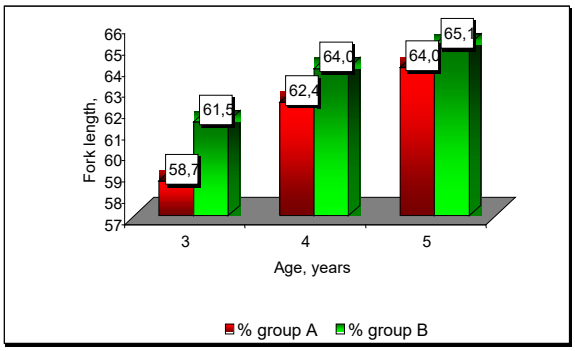


Fig. 4. Weight of chum salmon in groups A and B caught in Taui River.

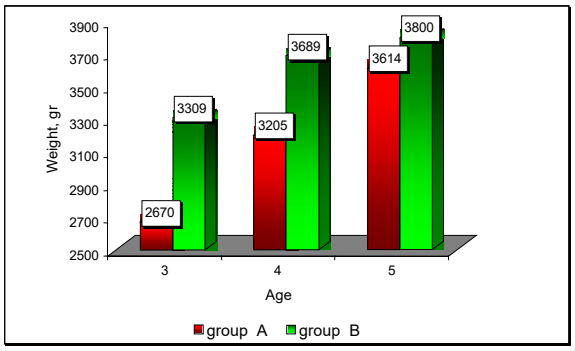


Fig. 5. Sex composition in groups A and B.

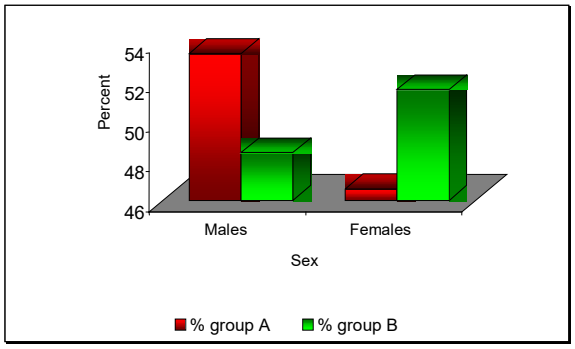
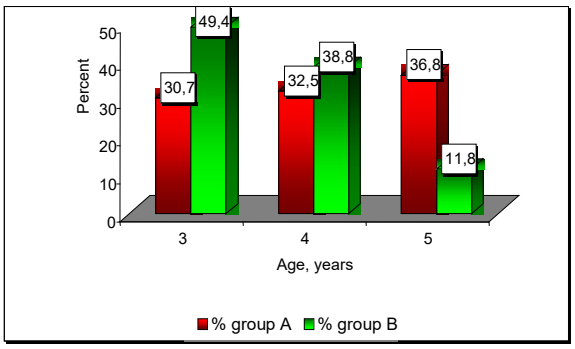


Fig. 6. Age composition of chum salmon in groups A and B.



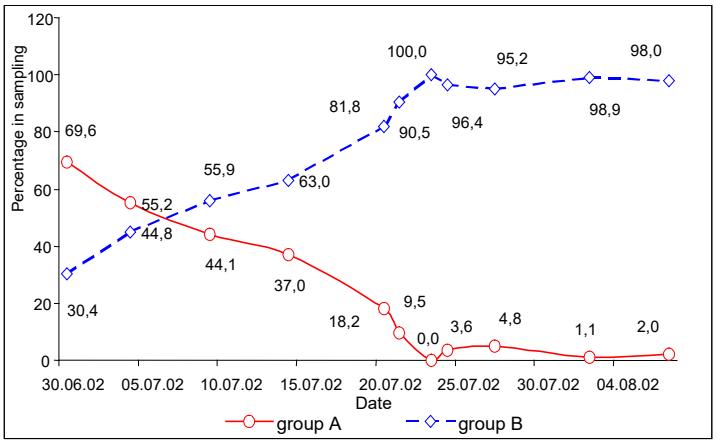
Differences in groups A and B were apparent not only for morphological parameters but also for spawning dynamics. Fish of group A prevailed in the beginning of spawning (69.57%). Then the proportion of fish in both groups became equal. By the middle of spawning, the proportion of fish in group A declined to a minimum and remained at that level until the end of anadromous migration (Fig. 7).

The preceding data support the assumption that two groups of chum salmon, differentiated by otolith microstructure, belong to different ecological forms. Based on previous studies of chum salmon of Taui River (Volobuev 1983; Mednikov 1988; Volobuev 1990, 2001), these groups of chum salmon can be classified as early (group A) and late (group B) forms.

Differences in visualization of increments are caused by the fact that these ecological forms reproduce at different types of spawning grounds: early chum salmon are spawning in river channels, and the late form of chum salmon reproduces in spring-fed grounds (Volobuev 1990). Hydrological conditions of spawning grounds determine differences in length of a time period required for embryonic and larval development. High water temperature of the spawning grounds of the early form of chum salmon in summertime (9–13°C) was the reason for higher rate of development in the early stages of embryogenesis. This is very different from the late form of chum salmon which reproduces in spawning grounds with water temperature ranging from 7 to 8°C.

Analysis of microstructure of otoliths divides chum salmon populations into ecological forms. Large numbers of similarly grouped increments with high optical brightness on otolith section of individuals indicate that they belong to the early form of chum salmon. Chum salmon individuals belonging to a certain ecological form can be identified by applying the above method at any stage of ontogenesis.

Fig. 7. Spawning dynamics in both groups of chum salmon in Taui River.



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