Influence of Water Salinity on the Physiological Status and Distribution of Juvenile Chum Salmon in the Estuary of the Ola River of the Northeast Coast of the Okhotsk Sea

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Identification of individual fishes by their specific features, natural or artificial markers, is the basis for differentiating between individual populations and fish groups in mixed stocks. The significant number of thermally marked fish released from the Ola Salmon Hatchery gives us an opportunity to conduct a large-scale research of various salmon stocks on the basis of their identification at any stage of their life cycle.

One of factors contributing to survivability of juvenile salmon during their migration from fresh water to the ocean is their ability to adapt to increasing water salinity. Osmoregulatory mechanisms of juvenile chum salmon begin to form during the freshwater period at the presmolt stage and reaches a significant level of development at the smolt stage prior to their migration into the ocean. Results of the work performed in 2003–2005 have indicated that juvenile salmon in the Ola River estuary (Fig. 1) mix with wild fish beginning from the middle of June. The stock abundance dynamics during seaward migration is influenced by habitat conditions. The analysis of different hydrological and hydro chemical parameters allowed us to determine that the main abiotic factor from which the distribution of juvenile salmon depended was water salinity. The dynamics of changes in catch volumes in the estuary represents distributional pattern for chum fry from the time of their seaward migration until their subsequent journey to the coastal regions of the ocean.

During July significant numbers of juvenile salmon were found in the pre-estuary part of the river and also in the estuary of the Ola River in the areas of oligohaline and mesohaline types (Fig. 2). Such distribution is connected with the active migrations of juvenile salmon during the period of high growth rate and gradual adaptation to the conditions of increased salinity and the influence of great quantity of hatchery-released salmon. The otolith microstructure analysis allowed us to differentiate hatchery released juvenile salmon in the mixed aggregation and also their distribution regularity in the estuary (Fig. 3). Hatchery juveniles were found in the inner part of the estuary in small numbers. To get into the north-western and north-eastern parts of the estuary water area, juvenile chum salmon have to migrate for long distances through the head tide zones. We believe hatchery-released salmon

Fig 1. Survey stations within the Ola River estuary.

Fig 2. Average number of juvenile salmon caught in the Ola River estuary in July.

Fig 3. Distribution of otolith-marked salmon juveniles in the Ola River estuary in July.
increase of the number of young erythrocyte forms, either polychromatophil or basophil. Such a large quantity of young erythrocytes and blast forms indicates the erythropoiesis increase.

Thus, in the process of adaptive reactions to increasing water salinity, new erythrocyte production increases along with a decrease in volume unit. This fact, from our point of view, can be explained by the intensive degeneration of the old erythrocyte forms which have not adapted to the changed concentration of ions inside the fish body when entering salt water and great quantity of degenerated erythrocyte data received from the blood smears of juvenile salmon from the areas of variable salinities also supports the above. Additional proof of intensive degeneration of adult erythrocytes of juvenile salmon is the results of our osmotic erythrocyte resistance investigation. This parameter’s evaluation was carried out with the help of being able to determine the sodium chloride solution concentration under which the osmotic erythrocytes’ cover is being degenerated, e.g. we observed hemolysis.

We took solution concentration into account, under which the process of hemolysis began, e.g. some part of erythrocytes degenerated, and also the concentration under which all erythrocytes entirely degenerated. Figure 6 shows that juvenile chum salmon erythrocytes from different areas with sea salinity started to degenerate under the sodium chloride solution concentration of 0.5% and entirely degenerated under the sodium chloride solution concentration of 0.42 %, while erythrocytes of freshwater salmon could tolerate a greater concentration of the solution. According to these results we can come to the conclusion that osmotic erythrocyte resistance in juvenile salmon from brackish water areas is lower.

The hematologic indexes, characterizing the immune system and determining compensatory body abilities, are the structural elements of fish white blood cells—lymphocytes (they are responsible for the humoral immunity and antibodies production), neutrophils (represented by juvenile neutrophils and segmented neutrophils) and monocytes which are responsible for phagocytal functions at different stages of the immunal reaction in fish. When going from freshwater areas into the brackish areas, some portion of lymphocytes decrease while some portions of monocytes and juvenile neutrophils increase (Fig. 7). Such types of responses of immune system are typical for juvenile salmon, during the evolutionary process. Under stress-factors, we see changes in the metabolism and respiratory systems, which help fish to survive in a given stress situation, but at the same time these changes can cause illnesses within fish. In this connection we can explain the increase of some forms of juvenile neutrophils and segmented neutrophils as they take part in the phagocytosis on the first stage of the adaptive reaction of fish and that is why
they are consumed in the first place.

Under continuing stress, which can be observed when fish are in the zone of increased salinity for a long time, the accumulation of suboxidal products in the location of the inflammation occur, and become the reason for juvenile neutrophils and segmented neutrophils becoming less active and their place being taken by monocytes. Thus, monocytes are being activated at the second stage of phagocytosis, and that is why they exist in great numbers in the blood of juvenile chum salmon from the areas with different salinity and practically are not seen in smoltificated juvenile salmon from the areas with high salinity (Fig. 7).

To reveal the regularity of the blood elements of wild and hatchery born salmon we conducted a two stage experiment: 1) under the conditions of hypoxia in fresh water; and 2) under the conditions of increased water salinity. Equal quantities of wild juvenile salmon, found in Ustye, and hatchery-born salmon were placed into equal concentration of fresh water. For two days salmon hatchlings were contained in such conditions without additional aeration. Diurnal temperature oscillations were varied from 5°C to 12°C, oxygen from 3.3 to 4.0 mg/l. After that, all the hatchings were placed into concentrations of sea water with the following parameters: salinity = 13.4‰, oxygen = 4.4 mg/l, temperature = 12.3°C. Hematologic tests were conducted at the beginning of the experiment as a background (22 June 2004), after two days of oxygen starvation (24 June 2004) and after keeping the hatchings in salt water (26 June 2004). Hematologic changes of red blood cell dynamics are shown on the diagram (Fig. 8).

Comparing the background of red blood parameters of wild and hatchery born juvenile salmon showed that wild fish have a higher number of erythrocytes, basophilocytes and polychromatophiles; existence of the blast cells is noted. Juvenile hatchery raised salmon have the highest concentration of mature erythrocytes of 93.5%. After two days of starvation and lack of additional airiation (24 June 2004) both wild and hatchery raised salmon had a decrease in the quantity of erythrocytes. Thus, physiological reaction of both wild and hatchery raised salmon was the same, e.g. the activation of erythropoiesis occurred. After remaining in salt water, the effect on the organs of the hematosis response of wild and hatchery-raised salmon was totally different. While the mature erythrocyte portion of wild salmon remained the same, hatchery-raised salmon stopped producing juvenile forms of erythrocytes and “red” blood cells consisted mainly of mature, the oldest erythrocytes. Such a correlation of erythrocyte forms is the index of inconsistency of the ability of the body to adapt. After the influence of salt water the white blood cell index of “wild” juvenile salmon slightly changed, but thrombocyte quantity increased two-fold which is a normal adaptive reaction to salinity increase. Juvenile neutrophils of hatchery raised salmon abruptly increased, while thrombocytes portions decreased by five times. In the course of the experiment the removal was noted only within hatchery raised salmon at 33%.