Composition Changes in Retinal Pigments According to Habitat of Chum and Pink Salmon

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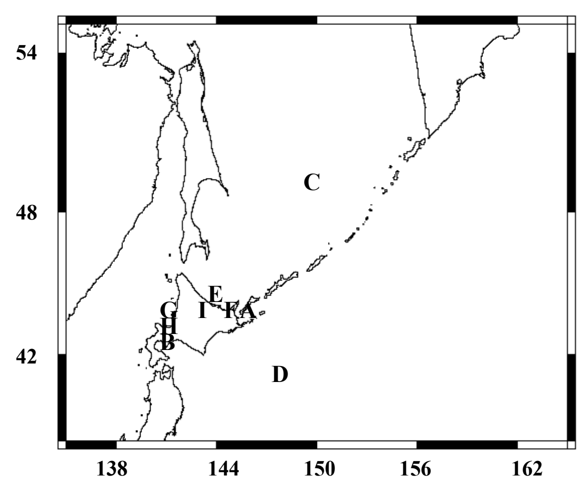
In order to investigate changes in the composition of retinal pigments according to habitats of chum (*Oncorhynchus keta*) and pink (*O. gorbuscha*) salmon, their rhodopsin ratio was analyzed by sampling individual fish before release from the hatchery, during the feeding and homing migration, and after return to their natal river. The ratio in both species increased gradually in sea water. However, the ratio decreased after return to their natal river. Moreover, the ratio in chum salmon was always slightly higher than that in pink salmon in sea water. The difference per individual in the ratio was largest in the case of individuals caught with a set net during the homing migration.

Visual pigments consist of a chromophoric group with a specific protein, opsin, in a lipoprotein complex. Various kinds of pigments with different absorption spectra are distributed over the whole animal kingdom, although opsin differs interspecifically. Spectral sensitivity in scotopic conditions can be analysed by measuring the absorption spectrum of visual pigment located in the outer segments of the rods. Photosensitive visual pigments are classified into rhodopsin, a vitamin A_1-based pigment, and porphyropsin, a vitamin A_2-based pigment. Most marine fishes have rhodopsin, while most freshwater fishes have porphyropsin. The absorption spectrum of visual pigment that each fish has is closely related to the light condition in the fish's environment. For example, the λmax (wavelength of peak absorbance) of a fish living in the deep sea is shifted to the short wavelengths compared with that of a coastal species. Some fishes have both visual pigments in the retina. The proportions of these two visual pigments can change with differing habitat. For examples, the dominant retinal pigment of ayu (*Plecoglossus altivelis*) changes from rhodopsin in sea water to porphyropsin in fresh water (Hasegawa and Miyaguchi 1997). In pink and chum salmon, the λmax of rhodopsin is 503 nm and the λmax of porphyropsin is 527 nm. Our objective was to examine whether the composition of visual pigment in chum and pink salmon changes by habitat, as in the ayu.

The life stages of pink and chum salmon investigated in this report ranged from eyed egg to spawning adult. Individuals before release were produced in hatcheries at Chitose and at the Kitami branch office of the National Salmon Resources Center. Juveniles after release were caught in coastal areas of Shibetsu and Shiraoi with a small round-haul net, a pair trawl net, and a set net. Young chum and pink salmon were caught in the Sea of Okhotsk with a trawl net (Hasegawa et al. 2002). Individuals during their feeding or homing migration were caught in the North Pacific Ocean with a drift gillnet. Spawning individuals were caught in the coastal areas of Shari and Atsuta with a set net, as well as in the Shari, Tokoro, and Chitose rivers. The locations of sampling areas are shown in Fig. 1.

Fig. 1. Research area for the composition of visual pigments. A—offshore Shibetsu, B—offshore Shiraoi, C—Sea of Okhotsk, D—North Pacific Ocean, E—Tokoro R., F—Shari R. and set net, G—Atsuta, H; Chitose, I—Kitami.



Retinal and 3-dehydroretinal, which are the chromophores of visual pigment, were analyzed by essentially the same method as Suzuki and Makino-Tasaka (1983). An example of the chromatogram of chum salmon just before release is shown in Fig. 2.

The changes in visual pigment composition in chum and pink salmon are shown in Fig. 3. After being released, chum and pink salmon move to the offshore habitat. In connection with this migration, their rhodopsin ratio increases gradually. However, for chum and pink salmon returning to the coast for spawning, an increase in porphyropsin was observed. The rhodopsin ratio for chum salmon was always higher than that of pink salmon in the sea life stage. Visual pigment composition of individuals returning to their natal river is reversed, and porphyropsin is highest. Moreover, the rhodopsin ratio of pink salmon is

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always higher than that of chum salmon in fresh water. Based on other knowledge about the relation between the spectral sensitivity of fishes and their habitat depth (Kobayashi 1962), the selection depth of chum salmon in the sea is deeper than that of pink salmon. It is supposed that the selection depth of chum salmon in fresh water is shallower than that of pink salmon. The difference between species in selection depth may be the most important consideration when determining the abundance of these two species in the ocean.

Furthermore, the difference per individual in visual pigment composition (standard deviation of the rhodopsin ratio) of both species was largest for caught by set net when they returned to the coast for spawning (life stage E, Fig. 3). It is thought that the rhodopsin ratio decreases just before salmon ascend the river to spawn, and higher values are maintained in fish that go further south. Individuals on a homing migration may be contained by capture in a set net. The abundance of the resources of local origin may be correctly estimated using the differences in rhodopsin ratios of individuals between catches in each set net laid along the northern coast of Japan.

Fig. 2. Example of the chromatogram of a hatchery chum salmon just before release. 1—11-cis-retinaloxime, 2—11-cis-3-dehydroretinaloxime, 3—all-trans-retinaloxime, 4—all-trans-3-dehydroretinaloxime.

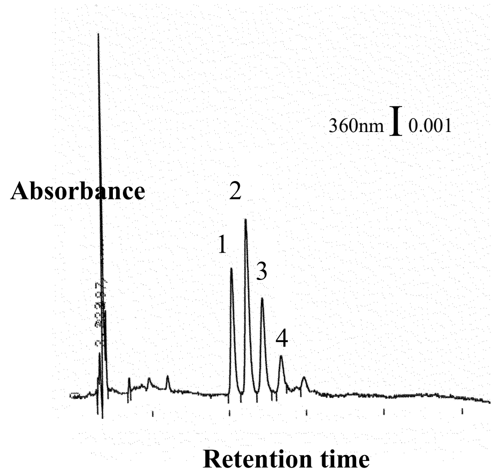
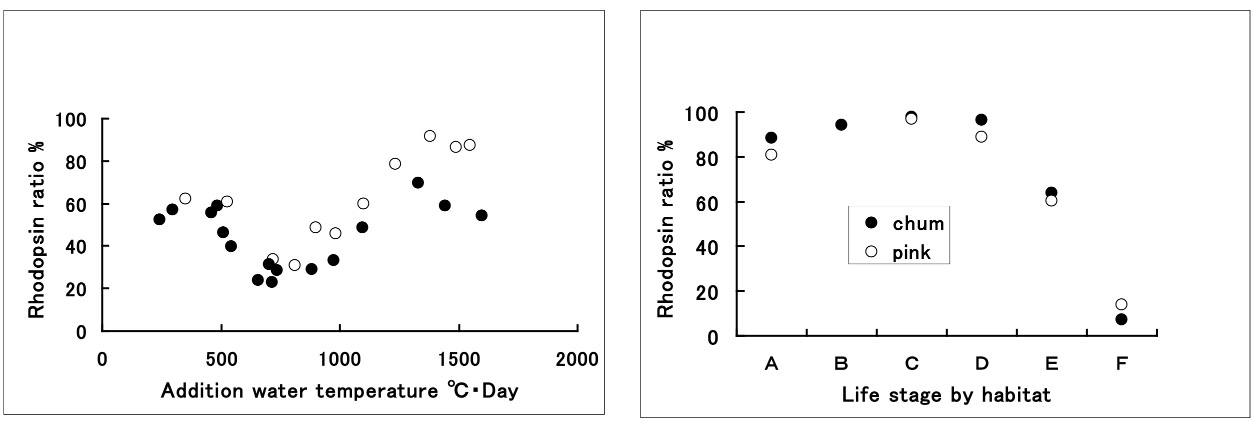


Fig. 3. Composition changes in retinal pigments in the hatchery (left view) and after release (right view). A—Japan coast after release, B—migrating north (maybe Honshu origin), C—in the Sea of Okhotsk before winter, D—during feeding or homing migration (caught by drift gillnet in the North Pacific Ocean), E—during homing migration (caught by set net), F—in river before spawning.



REFERENCES

Hasegawa, E.I., and D. Miyaguchi. 1997. Changes in scotopic spectral sensitivity of Ayu *Plecoglossus altivelis*. Fish. Sci. 63: 509–513.

Hasegawa, E.I., T. Saito, and J. Seki. 2002. Composition changes in retinal pigments according to habitat of chum and pink salmon. J. Fish Biol. 61: 1305–1308.

Kobayashi, H. 1962. A comparative study on electroretinogram in fish, with special reference to ecological aspects. J. Shimonoseki Coll. Fish. 11: 407–538.

Suzuki, T., and M. Makino-Tasaka. 1983. Analysis of retinal and 3-dehydroretinal in the retina by high-pressure liquid chromatography. Analyt. Biochem. 129: 111–119.