Migration and Homing Behavior of Chum Salmon Tagged in the Okhotsk Sea, Eastern Hokkaido

Hayato Saneyoshi¹, Yousuke Koshino¹, Ryoutarou Ishida¹, Itsuki Tatsuoka², Hokuto Shirakawa²,
Yasuyuki Miyakoshi³, and Kazushi Miyashita²

¹Salmon and Freshwater Fisheries Research Institute, Hokkaido Research Organization, 3-373
Kitakashiwagi, Eniwa, Hokkaido 061-1433, Japan

²Field Science Center for Northern Biosphere, Hokkaido University, 20-5 Benten Hakodate, Hokkaido 040-0051,
Japan

³Fisheries Research Department Planning and Coordination Division Hokkaido Research Organization, 238
Hamanaka Yoichi, Hokkaido 046-8555, Japan

Keywords: migration, archival tag, chum salmon, tagging, water temperature

Chum salmon (*Oncorhynchus keta*) are one of the most important species for commercial fisheries in Hokkaido in northern Japan. The Okhotsk coast in eastern Hokkaido is the principal area of salmon production in Japan. Commercial catches of chum salmon have been supported by intensive hatchery programs (Miyakoshi et al. 2013). In Hokkaido, returning chum salmon are fished in coastal waters mainly via set nets that are operated from September to December. Recently, coastal sea water temperatures in autumn have been higher than the historic mean. In years with high coastal sea water temperatures ($> 20^{\circ}\text{C}$), it has been frequently observed that the peak timing of chum salmon landing was delayed and exploitation rates by coastal set net fisheries were low. In addition, high water temperatures might affect the distribution of chum salmon in coastal areas and the number of fish caught by each set net. In order to determine the effects of sea water temperature on commercial landings, the responses of migrating chum salmon to sea water temperature needs to be elucidated.

To understand migration routes, depths, and temperatures experienced by returning chum salmon in the Okhotsk Sea, we caught chum salmon in the coastal waters, applied archival tags to them, and released them in late August or early September from 2016 to 2018. We report the outcomes of the tagging experiment for chum salmon in the Okhotsk Sea.

From 5 to 7 September 2016, 28 to 30 August 2017 and 28 to 31 August 2018, tagging experiments for chum salmon were conducted in the Okhotsk Sea from the research vessel *Hokuyo maru* (237 tonnes, Wakkanai Fisheries Research Institute, Hokkaido Research Organization). At a total of 8 or 9 sites in each year, we visually counted the number of chum salmon and fished for chum salmon at night (Fig. 1). At each site, fishing lights were used, and chum salmon that appeared were fished with a lure with raw bait (a slice of squid or Pacific saury) on the hook. The captured chum salmon were anesthetized, tagged with an archival tag on the base of the dorsal fin, and measured for fork length and weight. After recovery from anesthesia, the tagged fish were released into the sea. At the fishing sites, the vertical distributions of the sea water temperature and salinity were measured using CTD (Seabird SBE9plus, Sea-Bird Electronics, Inc., Bellevue, WA, USA).

Fig. 1. Map of the sites where the fishing for chum salmon was conducted in the Okhotsk Sea in 2016 (○), 2017 (●), and 2018 (△).

After release, recaptured tagged fish in Japan were reported by the fishermen's cooperative associations when they were caught in commercial fisheries or by the Kitami Region Salmon Enhancement Program Association. Tagged fish were also recaptured by the weirs that are installed in the rivers for broodstock collection and recaptures by anglers in Russia were reported through researchers in Russia and Japan.

In the years 2016, 2017, and 2018, there were a total of 14, 14 and 10 chum salmon tagged and released from the research vessel, respectively. Many chum salmon were counted and caught at sites west of the Kitami-Yamato Bank (approximately 80 km north of Cape Notoro) in 2016 and 2017, and at sites northwest of the Kitami-Yamato Bank (approximately 90 km northeast of Cape Hinode) in 2017 and 2018. At the sites where many chum salmon were counted or caught, the sea water temperatures were 15–18°C at the surface layer, 5–15°C at a depth of 15 m, and < 2°C at depths > 50 m.

Of the tagged chum salmon that were released, there were a total of six, two and one fish that were recaptured in 2016, 2017, and 2018, respectively. Many tagged fish were recaptured at the Okhotsk coast, Hokkaido, except the fish that was tagged in 2018, which was recaptured in the southwestern region of Sakhalin Island, Russia. In 2018, the recaptured fish was released on 29 August at site approximately 100 km southeast of Cape Soya. The tagged fish was recaptured on 18 September. In our study, the migration from the Sea of Okhotsk in Hokkaido through the Soya Strait was confirmed for the first time.

Some of the tagged fish migrated diurnally between the surface layer and a depth of 200 m. During daylight hours the tagged fish preferred sea water temperatures of 1°C at a depth of 200 m. In 2018, the tagged fish which were recaptured in the southwestern region of Sakhalin Island swam a depth of 150 m with a sea water temperature of 3°C without rising to the sea surface for four days. This may be a behaviour that allows the fish to regulate their cavity temperature (Azumaya and Ishida 2005). Our study suggests that sea water temperatures are affecting salmon behavior in the coastal areas.

In the Okhotsk Sea off the coast of the Shiretoko Peninsula and Abashiri region, biotelemetry studies were conducted on chum salmon in the 1980s (Soeda et al. 1985; 1987; Shimamura et al. 1987; Yoza et al. 1985). In their papers, many findings on migratory behavior of chum salmon were reported. We observed many migratory behaviors of chum salmon in our study that were similar to the findings of previous studies. However, our study also showed a new migration route and a migratory behavior. Because the sea water temperatures around Hokkaido in autumn have been higher in recent years, the monitoring of chum salmon behavior relative to the climate changes is important.

REFERENCES

- Azumaya, T., and Y. Ishida. 2005. Mechanism of body cavity temperature regulation of chum salmon (*Oncorhynchus keta*) during homing migration in the North Pacific Ocean. *Fish. Oceanogr.* 14: 81–96.
- Miyakoshi, Y., M. Nagata, S. Kitada, and M. Kaeriyama. 2013. Current enhancement program of chum salmon in Hokkaido, Japan. *Rev. Fish. Sci.* 94: 311–323.
- Shimamura, T., K. Yoza, E. Hasegawa, M. Furuta, and H. Soeda. 1987. On the swimming behavior of chum salmon in early migratory season off the coast of Abashiri, Hokkaido. *Nippon Suisan Gakkaishi* 53: 411–415.
- Soeda, H., K. Yoza, T. Shimamura, E. Hasegawa, and K. Yoshihara. 1985. On the vertical moving behavior of chum salmon in early migratory season off the coast of Shiretoko Peninsula. *Nippon Suisan Gakkaishi* 51: 1425–1429.
- Soeda, H., K. Yoza, T. Shimamura, and E. Hasegawa. 1987. On the swimming behavior of chum salmon in early migratory season off the coast of Hokkaido, Okhotsk Sea. *Nippon Suisan Gakkaishi*. 57: 1827–1833.
- Yoza, K., H. Soeda, T. Shimamura, E. Hasegawa, and K. Yoshihara. 1985. On the horizontal swimming behavior of chum salmon in early migratory season of the coast of Shiretoko Peninsula. *Nippon Suisan Gakkaishi*. 51: 1419–1423.