

## Coastal Residence of Juvenile Chum Salmon and Their Adult Returns to the Ishikari River, Hokkaido

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Based on coastal and river catch sizes, the number of chum salmon returning to Hokkaido rivers draining into the Sea of Japan (SJ) region have fluctuated at levels lower than fish returning to rivers draining into the Pacific Ocean and the Sea of Okhotsk. The Ishikari River stock is one of the largest in the SJ region; ~30 million otolith-marked chum fry are released annually from the Chitose Hatchery, which is the only hatchery producing chum salmon fry in the river. Despite the constant number of fry released from the Chitose hatchery, there are large fluctuations in the return of adults to both the Ishikari River (river catch) and SJ region (coastal catch and river catch) stocks.

Improving the number of adult returns to the SJ region would contribute to developing effective strategies for recovering salmon stocks in the region. The early period of marine residence is a critical period for juvenile salmon survival (e.g., Bax 1983; Fukuwaka and Suzuki 2000; Saito et al 2011). Identification of factors that affect juvenile survival during periods of coastal residence is essential for developing salmon propagation techniques aimed towards improved survival of released fish.

We analyzed data for juvenile chum salmon caught in surface trawl surveys conducted in March–July during 2003–2009 in the coastal waters off Atsuta, which is located on the coast near the mouth of the Ishikari River. Atsuta is on the main northward migration route of juveniles originating from the Ishikari River (Mayama and Ishida 2003). Catch per unit effort for otolith-marked juveniles was positively correlated with the return rates of adult salmon to the Ishikari River, suggesting that the abundance of marked fish recaptured at Atsuta is an indicator of survival during early marine residence.

Based on samples obtained from the trawl surveys, we investigated daily growth, sea entry timing, and days of residence in the river and in the sea for three groups of mark-recaptured juvenile chum salmon released at different times (mid-March, late-March, and mid-April) by analyzing otolith daily growth increments. The earlier the fish were released, the earlier they entered the sea; early-released fish spent protracted periods in both the river and the sea. The daily growth of chum salmon after entering the sea was unaffected by the date of entry into the sea. However, adult return rates differed among juveniles released at different times. Chum salmon in the late-March release group had the highest return rate of adults. In the coastal waters off Atsuta, the temperature at 3-m depth during the peak period when juvenile chum salmon appear ranges from 7° to 10°C. The date when water temperatures first warmed to 7°C following the winter period varied by about 20 days from 2003 through 2009. The number of the adult chum salmon returning to the river was negatively related to the number of days after March 1 that water temperatures were below 7°C off Atsuta. Thus, appropriate timing of the seaward migration is an essential component of improved juvenile survival.

The combined effects of seaward migration timing and temperature conditions in the coastal ocean probably strongly affect the survival of Ishikari River juvenile chum salmon.

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