Overview of Juvenile Salmon Research in Japan from 2001 to 2005

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Major mortalities of chum and pink salmon may occur during the initial coastal life. Accordingly, their coastal life history studies are important to understand the survival mechanisms. The purpose of the investigation for the early sea life of juvenile salmon is to clarify mechanisms controlling population dynamics of the fishes.

Research on juvenile salmon in coastal waters began in 1967 in Japan. Since a historical review concerning the studies of the early ocean life of juvenile Pacific salmon in Japan was done by Mayama and Ishida (2003), the recent studies including ongoing ones are introduced in this paper.

There are several organizations conducting juvenile salmon surveys in Japan. The National Salmon Resources Center initiated a monitoring program at seven coastal areas around Hokkaido in the spring of 1994. The Hokkaido Fish Hatchery and the Iwate Prefectural Fisheries Technology Center researched at the Abashiri coast and the Touni Bay, respectively (Fig. 1).

After leaving Japanese coastal waters, Japanese chum salmon juveniles dwell in the Okhotsk Sea from summer to autumn (Urawa et al. 2001; Urawa 2004). To investigate the distribution of salmon juveniles in the Okhotsk Sea, Japan-Russia cooperative juvenile salmon surveys were conducted in the autumn of 2000 and 2002 (Fig. 2). In addition, small-scale surveys were carried out within the Japanese exclusive economic zone (EEZ) of the Okhotsk Sea in October 2004 and 2005 (Fig. 2).

According to a rise of sea surface temperature (SST), CPUEs of juvenile chum salmon and zooplankton wet weights increased, but the CPUEs decreased when SST increased over 12–14ºC at the four stations of Ishikari Shari, Shiraoi and Shibetsu. Zooplankton wet weights decreased above 10ºC at the three stations of Ishikari Shari and Shiraoi. Zooplankton biomass was more abundant in the Pacific coasts of Hokkaido than in the Japan Sea and Okhotsk Sea coasts. These observations suggest that juvenile chum salmon migrated after a decrease of prey organisms (Seki 2005).

Fig. 1. Map showing monitoring stations around the northern Japan.

Fig. 2. Map showing sampling stations in the Okhotsk Sea in 2002, 2004 and 2005.

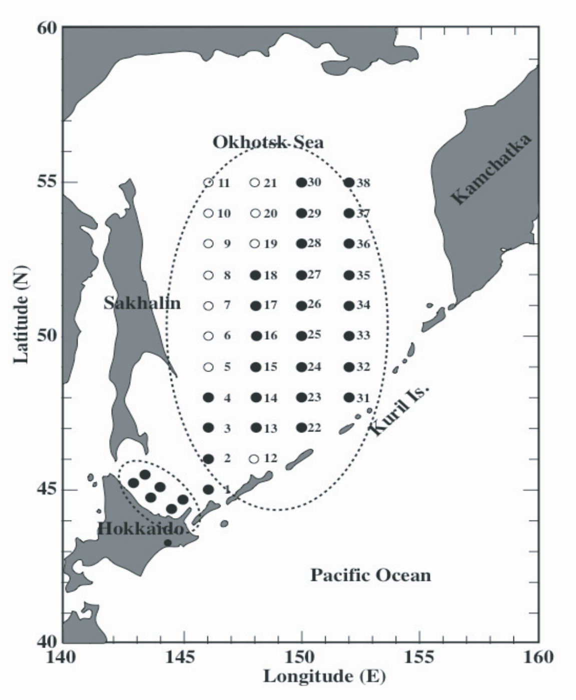

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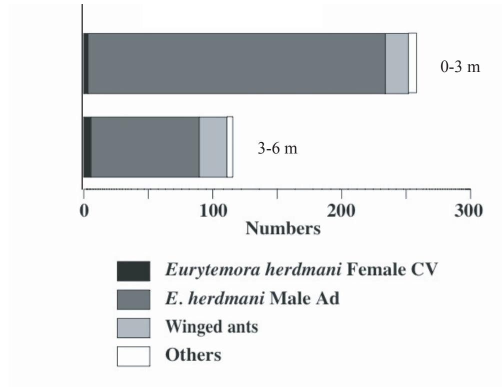
Table 1. Plan for number (x10³) of otolith-marked sallmon released from Japanese hatcheries, 1999–2007.

Released year	Chum	Pink	Masu	Sockeye
1999	3,958			
2000	14,503	985		
2001	19,030	2,820		
2002	40,747	2,572	33	
2003	65,199	2,980	30	
2004	64,783	3,078	32	
2005	72,345	1,373	1,567	
2006	123,475	2,200	2,198	200
2007	129,118	3,380	1,708	25

Fig. 3. Compositions of stomach content of juvenile chum salmon captured at two layers of 0–3 m and 3–6 m in the coastal waters near Shibetsu on 27 June, 2001.



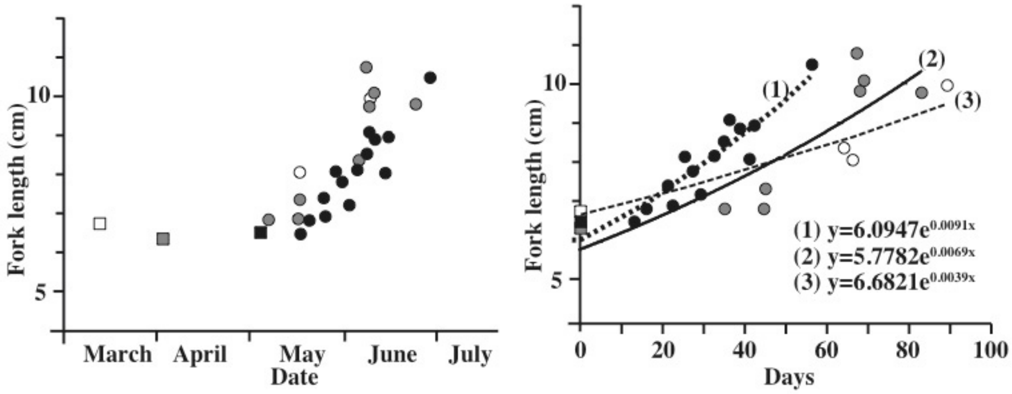
Zooplankton wet weight formed more than two peaks in three of five years from 1998 to 2002 in Shibetsu coastal waters, although in general the peak of zooplankton wet weight is once during spring in the coastal waters of Hokkaido. The zooplankton wet weight in 2001 exceeded three or four times than that of the other four years in Shibetsu (Seki et al. 2006). These results suggest that long-term coastal environment monitoring are necessary in each coastal areas.

Three zooplankton species of *Acartia longiremis*, *Pseudocalanus* spp. and *Evadne nordmanii* were dominated in the coastal waters off Shibetsu from spring to early summer. These three species had different distribution. Namely, *A. longiremis* was distributed near shore, *Pseudocalanus* spp. were distributed off shore and lower layer and *E. nordmanii* increased in late season and was distributed in upper zone. It seemed that the species avoided the duplications of the distribution to each other. Figure 3 shows stomach content compositions of juvenile chum salmon captured at the different layers of 0–3 m and 3–6 m in the coastal waters near Shibetsu. Three items of *Eurytemora herdmani* copepodite stage 4 female, adult male and winged ants were dominated in the stomach. Mainly, *E. herdmani* adult male occupied more than 75%. Number of stomach contents of juvenile chum salmon in the upper layer was two times more than that in the lower layer, due to difference in the distribution patterns of *E. herdmani* adult males. These results suggest that estimates of prey biomass have to consider both the distribution characteristics of prey organisms and fish.

The releasing of otolith marked fish started in 1999 in Japan. Only four million chum salmon fry were released in the first year. The number of otolith mark releases increased every year, and 128 million fishes of chum, pink, masu and sockeye salmon were released in the spring of 2006 (Table 1). Otolith marked chum salmon juveniles were captured in the wide area of the Pacific coast of Hokkaido. Because many fishes were captured in the west side of the released river mouth during the inital period, the migration of chum salmon juveniles might be affected by the current (in particular, Oyashio). Figure 4 shows temporal changes in fork length (left) and computed growth rates (right) of three different released groups of otolith marked chum salmon released in the Shizunai River in 2005. Although three groups were released every 20–30 days each other, the fork length of three groups were almost similar when released. When the growth rate was compared among the groups, the last released group grew much faster than other groups.

Chum salmon, pink salmon and arabesque greenling were dominated among fish captured by trawls in the Okhotsk Sea on October 14–27, 2002. A genetic analysis showed that the regional stock composition estimates of juvenile chum salmon was 37.6% Japan, 6.6% Sakhalin, 0.6% Premorye, 4.2% Amur River, and 49.7% northern Russian stocks (Urawa et al. 2004). The estimated stock composition was apparently different among the catching locations. The percentage of Japanese stocks was high in southern water, but low in northern water. The northern Russian stocks showed the opposite trends in their distribution. Sakhalin and Amur River stocks appeared in the western water. A similar result was obtained in 2000 (Urawa et al. 2006) and 2003 (Urawa et al. 2007). Nineteen otolith marked chum salmon released from three Japanese (Chitose, Shizunai and Ichani in Hokkaido) and three Russian (Bereznykovsky and Sokolovsky in Sakhalin, and Ozerki in western Kamchatka) hatcheries were found in the Okhotsk Sea (Urawa et al. 2004). Japanese marked fish (n = 14) were widely distributed in the waters south of 53ºN. It was confirmed for the first time that Japanese chum salmon juveniles migrate even from the Pacific coast (Shizunai Hatchery) to the Okhotsk Sea. Four otolith marked fish released from two hatcheries in southern Sakhalin were caught in the western water near the island.

Fig. 4. Temporal changes in fork length (left) of otolith marked chum salmon released in the Shizunai River on 11 March (white), 1 April (gray) and 3 May (black) in 2005, and computed instantaneous growth rate of each group (right).



In summary, major mortalities of salmon may occur during the initial coastal life. The previous studies indicate that Asian juvenile salmon are abundantly distributed in the Okhotsk Sea during summer and fall in the first year of ocean life. The early life history studies in the coastal waters and the Okhotsk Sea are important to understand the survival mechanisms of salmon. To clarify mechanisms controlling population dynamics of juvenile salmon, we focus on the following research items:

- Feeding, growth, and survival of juvenile salmon;
- Seasonal distribution and migration of juvenile salmon; and
- Monitoring of ocean environments such as surface water temperature, salinity, primary production, and prey organisms.

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