Distribution and Migration of Pink Salmon Juveniles in the Coastal Waters of Eastern Hokkaido, Okhotsk Sea

Daisei Ando[1], **Yasuyuki Miyakoshi**[1], **Mitsuhiro Nagata**[1],
Makoto Fujiwara[1], **Noboru Hoshino**[1], and **Hiroki Asami**[2]
[1]Hokkaido Fish Hatchery, Eniwa, Hokkaido 061-1433, Japan
[2]Hokkaido Central Fisheries Experimental Station, Yoichi, Hokkaido 046-8555, Japan

Keywords: Abundance, pink salmon, migration, surface seawater temperature

Pink salmon is considered to be specialized species of Pacific salmon, because they have a rigid two-year anadromous life cycle, a short freshwater residence, and two genetically isolated broodlines in North America and Asia. The geographical distribution of adult pink salmon migrating upstream in Japan includes part of the Pacific coast of northern Honshu and the Sea of Japan coast of Hokkaido; however, the main spawning grounds are located in rivers of the Okhotsk Sea coast of eastern Hokkaido. In Japan, pink salmon fry are produced by stock enhancement programs. Although the number of fry released in Hokkaido has been similar over the past 15 years, i.e., approximately 140 million fish, the commercial harvest of pink salmon has a unique biennial abundance cycle. Unfortunately, the exact cause of this fluctuation is unknown, because of the lack of information about Hokkaido pink salmon biology in relation to ocean conditions. Moreover, to elucidate the ecology of pink salmon in terms of growth and abundance, information about their distribution and offshore migration during early sea life is important, because high mortality is often suggested to occur soon after juveniles enter the ocean (Manzer and Shepard 1962; Parker 1968). In 2002, we began to investigate the distribution and migration patterns of juvenile pink salmon in the coastal waters of Abashiri on the Okhotsk Sea coast of eastern Hokkaido. Twelve study sites were established, including four at 1 km from shore (10–15 m depth), four at 4 km (20–30 m depth), and four at 7 km (30–40 m; Fig. 1). At each study site, two boats were used to tow a trawl net (8-m wide × 5-m deep net mouth; 5-mm mesh) along the 1–2 m surface layer for 2,000 m, at approximately 4–6 km/h during daylight. Nine seasonal surveys were carried out, approximately every ten days, from late April to mid July in 2002 and 2003. Surface seawater temperature (SST) was measured, and zooplankton was collected with a 0.45-m NORPAC net (0.33-mm mesh), towed vertically from the bottom to the surface at each study site. A beach seine (2-m wide × 13-m long; 3-mm mesh) was also used in shallow nearshore water in May and June 2003, at the same time that seasonal surveys were carried out and SSTs were measured. Fork length of up to 100 pink salmon juveniles from a single study site was measured in the laboratory. Data were analyzed for each offshore line (1-, 4-, and 7-km line) by calculating average values for the four sites. The number of pink salmon juveniles collected from each line during each seasonal survey was totaled, and SST was denoted by the average value for all twelve study sites.

Although SST during the two-year survey period at the trawl net study sites ranged from 2.2–14.9°C, the SSTs in May 2003 were much

Fig. 1. Locations of study sites for trawling (A, B, C, D) and beach seine sampling (E) in Abashiri, the Okhotsk Sea.

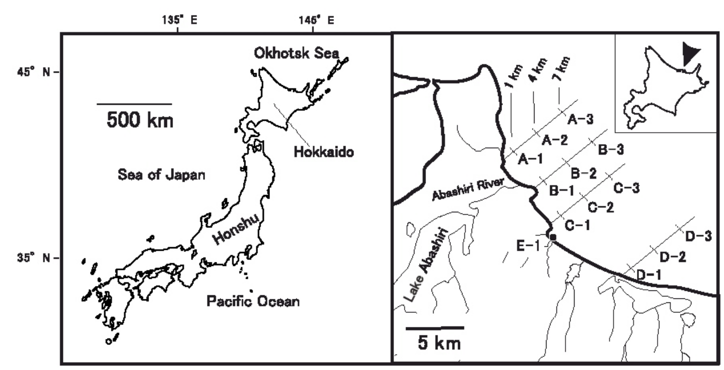
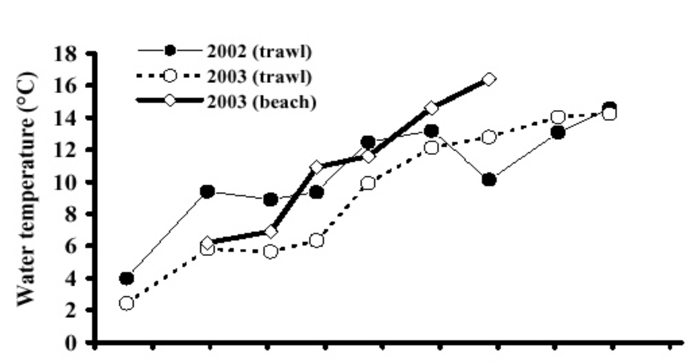


Fig. 2. Surface seawater temperature at offshore trawl (mean of 12 sites) and beach sites in shallow waters of Abashiri coast from late April to mid July 2002 and 2003.



All correspondence should be addressed to D. Ando.
e-mail: andod@fishexp.pref.hokkaido.jp

lower (5.3–6.8°C) than in 2002 (8.2–9.7°C; Fig. 2). An estimated 21,868 and 4,729 pink salmon juveniles in 2002 and 2003, respectively, were collected by trawling; however, a remarkable difference was observed in the annual timing and patterns of offshore migrations (Fig. 3). In 2002, juveniles began to migrate offshore in late May. The exodus began at the 1-km line, and then shifted to the offshore (4-km and 7-km) lines. Interestingly, juveniles captured offshore were larger than those captured near the shore in 2002. In June 2002, juveniles captured offshore were significantly longer (approximately 10–12 mm at 4 km; 11–20 mm at 7 km) than those captured at the 1-km line, indicating that the migration of pink salmon juveniles might be size dependent (Fig. 4). In contrast, catches of pink salmon juveniles by trawling along the coast were lower in May 2003 than in 2002. In late May 2003, however, pink salmon juveniles were caught near the shore by beach seine, prior to their offshore migration. The beach SST was 10.9°C, whereas the offshore SST was low (6.3°C) at that time. Offshore migration of juveniles in 2003 began in early June, and the exodus from the 1-, 4-, and 7-km lines occurred rapidly at the same time without size-dependent migration (Figs. 3 and 4). Most pink salmon juveniles left Abashiri coastal waters when they were 80-mm long; the SST was over 14°C at this time. In July, all juveniles had migrated offshore, prior to attaining a length of 100 mm. The maximum biomass of zooplankton in the ambient water was in May, and decreased rapidly thereafter. In 2002 the biomass of zooplankton from mid May to late May, when the majority of juveniles were collected on the 1-km line, ranged from 824 to 1688 mg/m^3. Although changes in zooplankton biomass in May 2003 were large (571–2383 mg/m^3), the biomass in early June, when the majority of fish were collected, was low (421–530 mg/m^3) at each line.

Distribution and migration of pink salmon juveniles should be strongly related to SST; however, their subsequent survival may be related to zooplankton biomass just after entry in the ocean. Kobayashi (1968) reported that downstream migration of pink salmon fry occurred from early May to late May in a river on the Okhotsk Sea coast of Hokkaido. Therefore, the coastal environment in May must have an important influence on the survival of fry. Healey (1980) investigated the ecology of pink salmon juveniles in British Columbia in relation to their feeding conditions, and he suggested that the movement of pink juveniles away from the beaches in late May is not associated with poor conditions. However, movements in late June and early July may be a response to poor feeding conditions. On the other hand, Willette (2001) reported that low macrozooplankton density led to dispersion of juveniles from shallow near shore habitats. We will investigate pink salmon ecology, including their prey, in the future.

Fig. 3. Seasonal catch of pink salmon juveniles by trawl at 1-, 4-, and 7-km offshore survey lines and by beach seine in the shallow waters of Abashiri coast from late April to mid July 2002 and 2003.

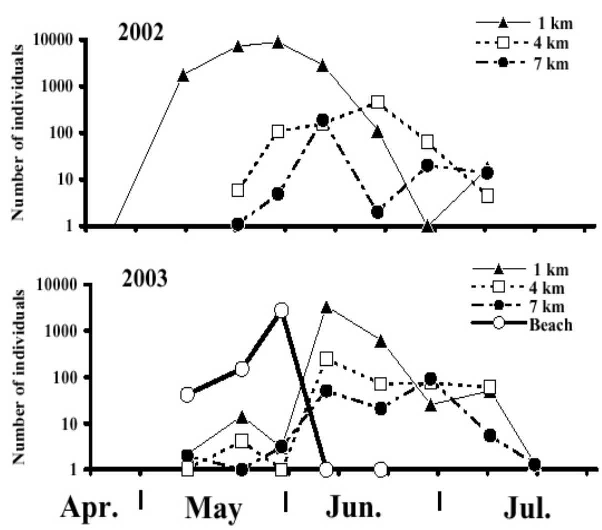
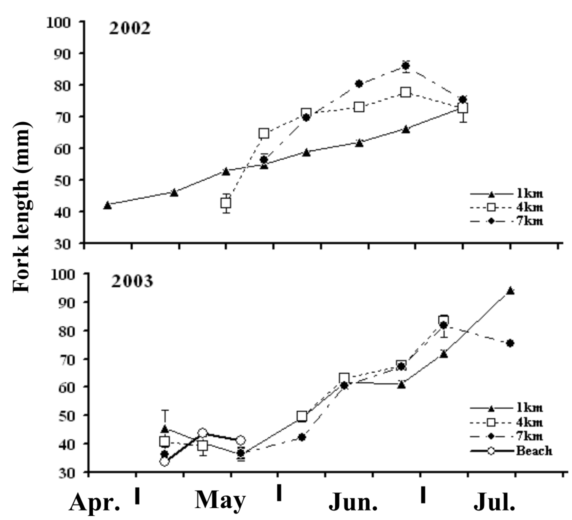


Fig. 4. Average length (±SE) of pink salmon juveniles captured by trawl at 1-, 4-, and 7-km offshore trawl survey lines and by beach seine in shallow waters of Abashiri coast.



REFERENCES

Healey, M.C. 1980. The ecology of juvenile salmon in Georgia Strait, British Columbia. *In* Salmonid ecosystems of the North Pacific. *Edited by* W.J. McNeil and D.C. Himsworth. Oregon State University Press, Corvallis, Oreg. pp. 203–229.

Kobayashi, T. 1968. A note of the seaward migration of pink salmon fry. Sci. Rep. Hokkaido Salmon Hatchery 22: 1–5. (In Japanese with English abstract)

Manzer, J.I., and M.P. Shepard. 1962. Marine survival, distribution and migration of pink salmon (*Oncorhynchus gorbuscha*) off the British Columbia coast. *In* Symposium on pink salmon. *Edited by* N.J. Wilimovsky. University of British Columbia, Vancouver, B.C. pp. 113–122.

Parker, R.R. 1968. Marine mortality schedules of pink salmon of the Bella Coola River, central British Columbia. J. Fish. Res. Board Can. 25: 757–794.

Willette, T.M. 2001. Foraging behaviour of juvenile pink salmon (*Oncorhynchus gorbuscha*) and size-dependent predation risk. Fish. Oceanogr. 10 (Suppl. 1): 110–131.