

Natural reproduction of pink salmon on the Okhotsk coast of Hokkaido, Japan

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INTRODUCTION

In Hokkaido, despite the constant number of hatchery fry releases, the pink salmon catch exhibited a biennial oscillation. Hence, pink salmon have a fixed 2-year life cycle, this oscillation indicates a substantial addition of wild fish. However, most major rivers have weirs to capture hatchery broodstock. We assumed that the rivers with weirs were unsuitable for natural spawning. Then, we investigated the conditions of naturally spawning pink salmon in the Tokoro River system which has a weir in Northeastern Hokkaido, Japan.

METHODS

Visual survey

We visually surveyed three tributaries, the Tokoro-Horonai, Kuma, and Nikoro Stream (Fig. 1 and Table 1). In 2010, we quantified the number of pink salmon and spawning redds once every 10 days from the beginning of August until the beginning of October. Throughout the survey, the weir was not submerged and functioned normally.

The estimated number of naturally spawned eggs

Assuming that one spawning redd contained half of the average female fecundity, which is approximately 1500 eggs, we estimated the total number of spawning eggs in the study areas by multiplying the number of confirmed spawning redds by half of the female average fecundity, i.e., 750 eggs.

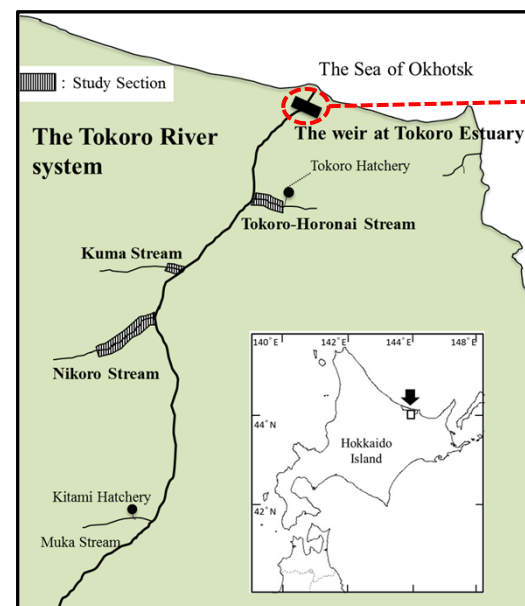


Fig. 1 Location of visual survey sections in three streams and the weir in the Tokoro River in Hokkaido.



The weir at Tokoro Estuary traverses the river completely. This style is common in Hokkaido.

Table 1 Study areas.

Stream	Length (m)	Width (m)	Area (m ²)
Tokoro-Horonai	821	4.2 ± 1.1	3454
Kuma	317	3.1 ± 0.4	998
Nikoro	2290	10.6 ± 2.5	12909
Total	3428		17361

RESULTS

Visual survey

The streams followed similar trends. The number of naturally spawning pink salmon increased in early September, reached a maximum in mid-September, and decreased in late September. In mid-September, there were 1376, 20, and 360 spawning pink salmon in the Tokoro-Horonai, Kuma, and Nikoro Streams, respectively. The number of spawning redds also increased in September. There were 1007, 165, and 773 spawning redds in the Tokoro-Horonai, Kuma, and Nikoro Streams, respectively (Fig. 2). The Tokoro-Horonai River, which is the nearest river to the Tokoro Estuary, had the highest spawning redd density (Fig. 3).

The estimated number of naturally spawned eggs

The estimated numbers of eggs spawned were 755,000, 124,000, and 580,000 in the Tokoro-Horonai, Kuma, and Nikoro Streams, respectively (Table 2).

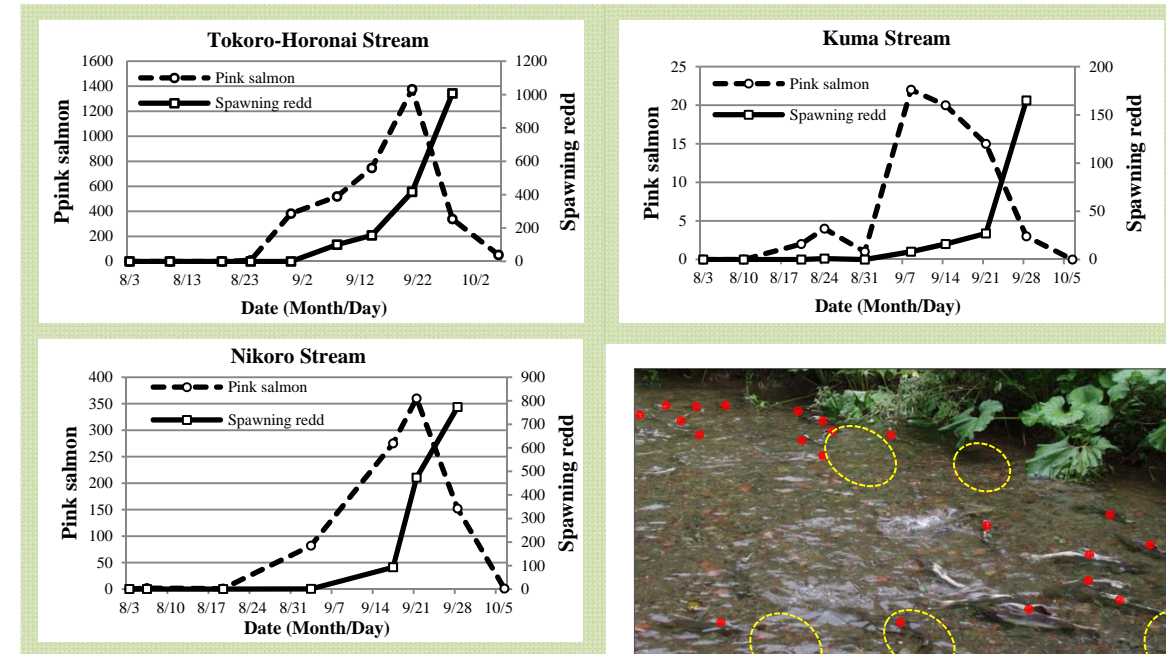
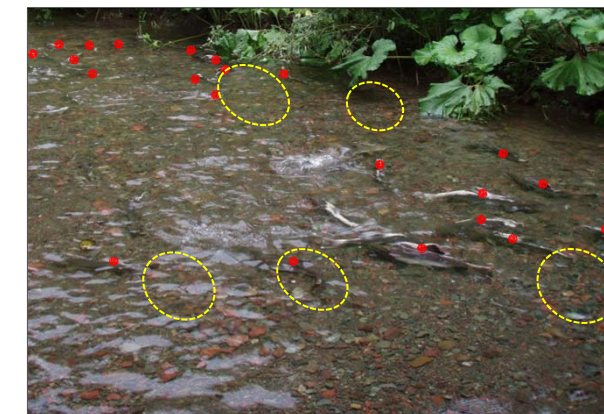


Fig. 2 Number of pink salmon and spawning red in the visual survey sections.



Visual observation at Tokoro-Horonai Stream in 14 September. (Red dot: Pink salmon, Yellow circle: Spawning redd)

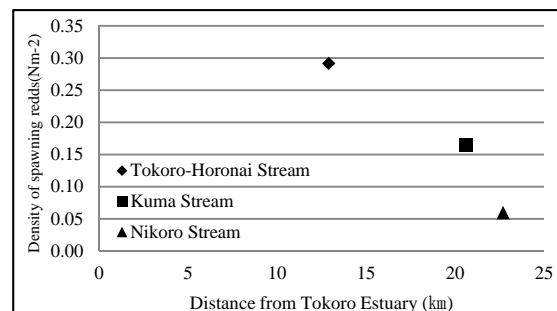


Fig. 3 Relationship between density of spawning redds and distance from Tokoro Estuary.

Table 2 The estimated number of naturally spawned eggs in the Tokoro-Horonai, Kuma, and Nikoro Streams.

Stream	Area (m ²)	Confirmed spawning redds	The estimated number of spawned eggs (thousand)
Tokoro-Horonai	3,454	1,007	755
Kuma	998	165	124
Nikoro	12,909	773	580
Total	17,361	1,945	1,459

CONCLUSION

Weirs couldn't block upstream migration perfectly

Since many pink salmon migrated upstream over the weir, the weir did not block upstream migration completely, although it appeared to functioned normally. We assumed that the weir contained some gaps that the pink salmon were able to pass through, which could have been formed by debris in the water or water pressure.

Natural reproduction exist despite weirs

An estimated 1,459,000 eggs were spawned in the 17,361 m² study area during the investigation, suggesting a very large estimated total number of eggs spawned over the entire 1,930 km² of the Tokoro River.

We think these naturally spawned eggs survive and they contribute to great resources, and cause the biennial oscillation of pink salmon catch in Hokkaido.



The reason for the gaps in the weir could have been caused by the garbage, e.g. fallen leaves, small pieces of trunks and stones in the water and a combination with water pressure.