Improvement of stocking techniques related to ocean conditions to recover late-run chum salmon being adaptable to warming coastal water

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INTRODUCTION

While early-run chum salmon in Hokkaido remarkably increased since 1980s, late-run chum salmon spawning (mid November ～) did not (Fig.1). However, in recent years when coastal water temperature becomes warmer in September, early-run chum salmon began to decrease or fluctuate. To compensate the reduction of salmon run in the warming water, recovery of late-run chum salmon would be needed. Juveniles from late-rum chum tend to be released in rivers later than early-run.

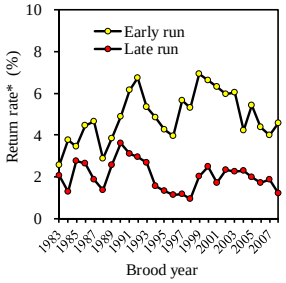
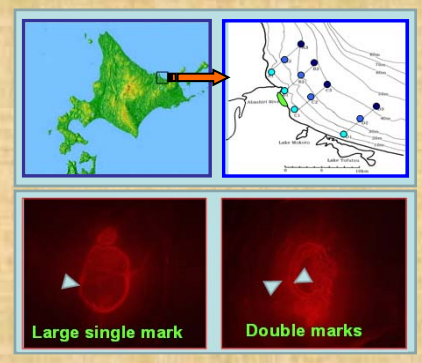


Fig. 1 Changes in return rates of early and late run chum salmon in Hokkaido. * Return rate was estimated as the number of adults returned 4 years later devided by the number of released juveniles ; released number for each run was estimated by multiplying the total number to the ratio of eggs-number artificially-spawned.

OBJECTIVES

We hypothesize that late releasing causes high mortality induced by mismatch to coastal ocean conditions in early life. We surveyed to testify this hypothesis in the Abashiri coast of the Okhotsk Sea.

METHODS



A total of 34 million juveniles are stocked in the Abashiri River every year. Over 30 % of them contains late-run chum fertilized after November 10th. Some of eyed eggs from late-run in 2003 and 2004 were otolith-marked in 200ppm ALC solution with different day degrees before hatching (Table 1). ALC-marked juveniles (0.7-0.9 million, ~5cm fork length) were stocked in mid May (early release) and late May (late release) 2004 - 2005 (Table 1). Salmon juveniles were captured by a surface trawl net toward along 1-2m surface layer for 1-2km at 4-6km/hr during daytime at the interval of 10 days from late April to early July from 1km to 7 km offshore of the Abashiri coastal water. Seawater temperature at each study site were measured with STD.

The weir was installed near the mouth of the Abashiri River to collect brood stock for artificial propagation. Ca. 500 fish (F to M is 1 to 1) out of the returned adults were randomly collected at the intervals of 10 days from early October to early December in 2007 to 2009. After measuring FL and BW, otolith and scale were taken to determine age and to detect ALC-marks.

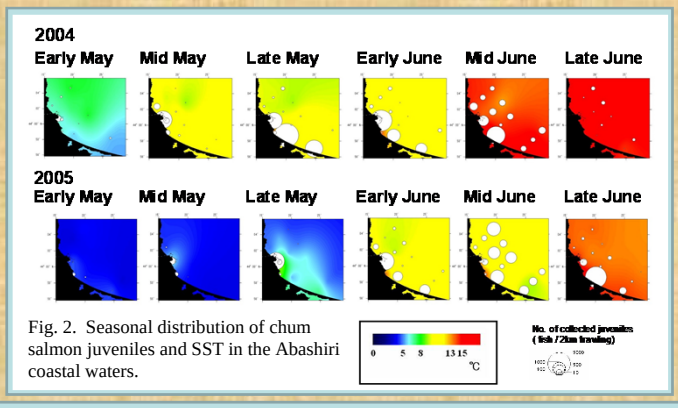


Fig. 2. Seasonal distribution of chum salmon juveniles and SST in the Abashiri coastal waters.

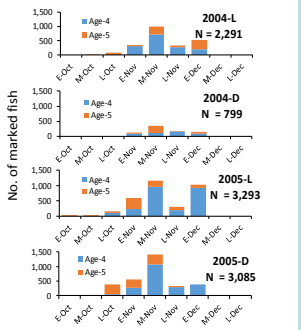


Fig. 3. Seasonal changes in the marked fish (4- and 5-year-old) of each group.

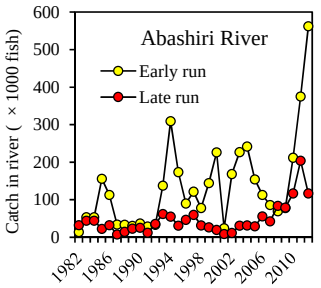


Fig. 4 Changes in the number of adults as brood stock captured in the Abashiri River.

Table 1 Date, number and fish size of arizaline complexone (ALC)- marked chum salmon juveniles stocked in the Abashiri River 2004 and 2005. Number of recaptured fish shows the total number captured in the 1-7km offcoast. Recapture rate was computed as the ratio (%) of number of recaptured juveniles to the number of stocked marked-juveniles.

Group	Date of Fertilization	Date of Release	ALC Marks[*1]	Stocked number of marked fish	Mean fork length (mm)[*2]	Mean body weight (g)[*2]	Number of recaptured fish	Recapture rate (%)
2004-E	15 Nov. 2003	16 May 2004	L	886,000	46.79[b]	0.90[b]	379	0.043
2004-L	15 Nov. 2003	30 May 2004	D	671,000	47.90[a]	0.97[a]	88	0.013
2005-E	15 Nov. 2004	15 May 2005	L	810,000	47.27[ab]	0.80[c]	275	0.034
2005-L	15 Nov. 2004	31 May 2005	D	842,000	47.94[a]	0.82[c]	236	0.028

[*1] L and D represent single large ALC-banding and double ALC-banding marks, respectively.
[*2] The values not sharing a common small letter among different groups are significantly different in FL and BW (P<0.05).

Table 2 Return rates of each group released in 2004 and 2005. Return rate was computed as the ratio (%) of the total number of 4- and 5-year-old marked adults to the number of releaed marked juveniles.

	2004-E	2004-L	2005-E	2005-L
No. of released juveniles (a)	886000	671000	810000	842000
No. of returned adults (b)	2291	799	3293	3085
No. of age 4 adults	1496	461	2409	2074
No. of age 5 adults	795	338	884	1011
Return rate to river (b x 100 / a)	0.259	0.119	0.407	0.366

RESULTS & CONCLUSIONS

• Elevation of SST in the Abashiri coastal waters was earlier in 2004 than in 2005. While juvenile chum salmon expanded to mainly 1 km off coast when SST reached to 8 C, most juveniles disappeared in the coast when SST was over 13 C (Fig. 2). Marked juveniles of 2004-E, 2005-E, and 2005-L (Table 1) were recaptured in the 1km off coast for one month, but 2004-L were recaptured there only for tow 10-days.

•There were differences in recapture rates in 1-7km off coast between groups, especially 2004-L was the lowest (Table 1). Specific growth rate of juveniles recaptured 1km off coast was highest in 2005-L followed by 2004-E, 2004L and 2005-E. While average fish size in 1 km off coast before offshore migration was over 60 mm in fork length for 2004-E, 2005-E and 2005-L, 2004-L did not reach to 60 mm in fork length maybe because they stayed in the coastal waters only for ca. 20 days due to over 13 C in late June .

•Return timing of marked adults for every group was ranged from late October to early December, peaks of return was in mid November, consistent with the fertilization date (15 November) of their parents (Fig. 3). Return rate in 2005-E was the highest, followed by 2005-L, 2004-E. 2004-L with the lowest recapture rate during early marine phase was the lowest in the 4 groups (Table 2).

•Offshore movement of chum salmon juveniles after downstream migration is dependent on seawater temperature, especially water mass over 13 C accelerates their passive movement to offshore. Delayed release may cause higher mortality.

•The results strongly support our recommendation that hatchery juveniles should be released within 7 - 11 ℃ in SST in the Abashiri Coast (Nagata et al., 2007. NPAFC Bull.), but release with larger juveniles might be effective near the 11 ℃ to recover late-run chum salmon being adaptable to warming seawater. Fortunately late run chum has been gradually recovered in the Abashiri River (Fig.4)

******** ACKNOWLEDGMENTS *********

We deeply appreciate staff of the Abashiri Fisheries Cooperative Association, the Abashiri City Science Center, the East Branch of Fisheries Technical Guidance Office and the Kitami Salmon Enhancement Programs Association for supporting coastal and beach fishing survey, ALC mass-marking and fish production. The Fisheries and Forestry of Hokkaido Government provided financial support for sampling.