Coastal Seawater Temperature during Early Ocean Life of Chum Salmon Measured by Satellite Remote Sensing and Its Effect on Their Return Rates in Eastern Hokkaido

Yasuyuki Miyakoshi[1], Mitsuhiro Nagata[1], Makoto Fujiwara[1], Atsushi Matsuoka[2], and **Sei-ichi Saitoh[2]**

[1]*Hokkaido Fish Hatchery, Kitakashiwagi 3-373, Eniwa, Hokkaido 061-1433, Japan*
[2]*Laboratory of Marine Environment and Resource Sensing, Graduate School of Fisheries Sciences, Hokkaido University, 3-1-1 Minato-cho, Hakodate, Hokkaido 041-8611, Japan*

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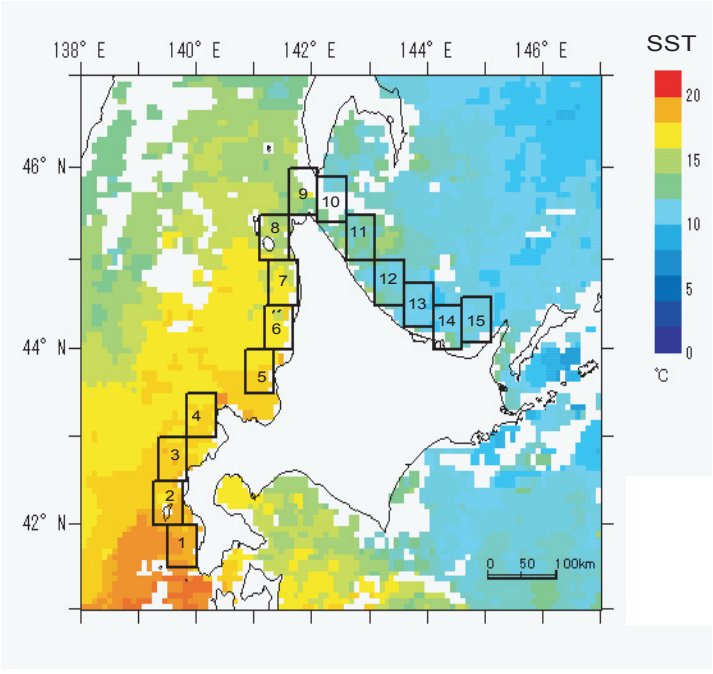
Many chum salmon populations are currently maintained by hatchery program in Japan. Egg-to-fry survival is improved by the hatchery technologies, and the early marine phase is thought as a critical period for hatchery-reared chum salmon when the mortality is highly variable. Recent researches in the Abashiri Bay, eastern Hokkaido, reported that the distribution of juvenile chum salmon shortly after ocean entry was strongly affected by coastal environmental conditions (Nagata et al. 2005; Miyakoshi et al. 2007), and ocean conditions greatly varied among years (Sawada et al. 2007). We hypothesized that coastal seawater temperature affected the distribution and survival of juvenile chum salmon in this region. The satellite remote sensing has been developed as an effective tool in oceanography research (Laurs and Polovina 2000). We began a study using the satellite remote sensing to analyze the relationship between coastal sea surface temperature (SST) and return rates of chum salmon stocked along the coast of the Okhotsk Sea, eastern Hokkaido.

The AVHRR/NOAA data (spatial resolution: 9 km, eight-day composite) distributed by NASA JPL PO-DAAC PATHFINDER database were used to measure SST in the coastal areas. The maximum SST were extracted from 9 coastal boxes (0.5° × 0.5°), consecutively spaced at 0.5° latitudinal intervals between 41.5°N and 46.0°N in the coastal waters of the Sea of Japan and 6 boxes, consecutively spaced at 0.5° longitudinal intervals between 142°E and 145°E in the coastal waters of the Okhotsk Sea (Fig. 1). Each box covers an area within approximately 40 km of the coastline. The SST data from eleventh eight-day period (mean from 22 to 29 March) to twenty-sixth period (mean from 20 to 27 July) from 1991 to 2001 were processed. Using the periodical maximum SST in 1997 (low survival year) and 2001 (high survival year), isopleths of coastal SST were drawn (Fig. 2). To evaluate the timing of release from hatcheries, the Sea of Japan and the Okhotsk Sea coasts were divided into three geographical regions, respectively, and numbers of juvenile chum salmon released were totaled by each region. Dates of beginning, end, and 50% of total fish stocked were plotted on the isopleths of coastal SST. Using the SST in the east coast (No. 13–15 in Fig. 1) of the Okhotsk Sea, the relationship between SST and return rate was analyzed by the simple linear regression.

Fig. 1. Locations of coastal areas (0.5° × 0.5°) where sea surface temperature data were extracted from satellite data.

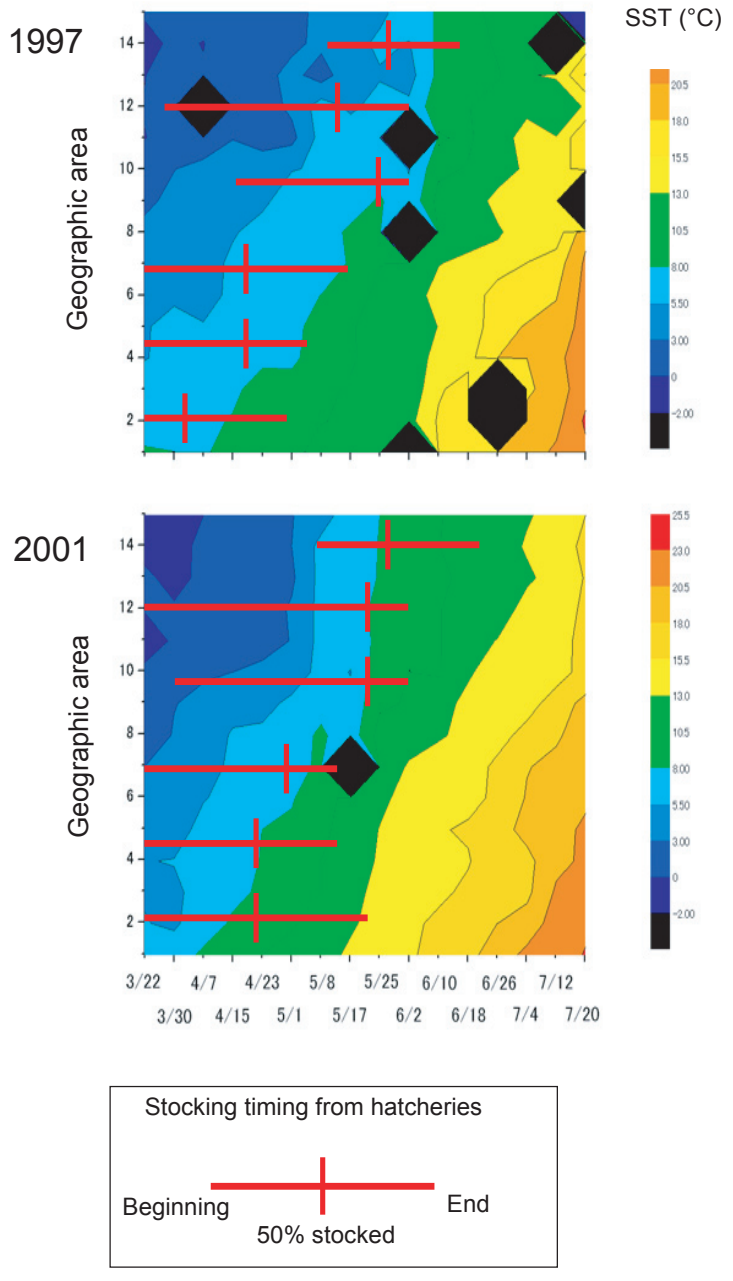


By comparing the coastal SSTs in 1997 and 2001, coastal SST in the Okhotsk Sea was lower (< 8°C) and did not reach the optimum SST range (8–13°C) for residence of juvenile chum salmon by late May in 1997, while the coastal SST exceeded 8°C by late May in 2001 (Fig. 2). The timing of juvenile chum salmon stocked from hatcheries was earlier in 1997 when SST was lower. The discrepancy in the timings of stocking and optimum coastal SST period may affect the return rate of chum salmon stocked in the two years. By analyzing the SST and return rates of chum salmon stocked in 1991–2001, the relationship between timing of SST first

All correspondence should be addressed to Y. Miyakoshi.
e-mail: miyakoshiy@fishexp.pref.hokkaido.jp

reaching the optimum range (8–13°C) and return rate was negatively significant ($R^2 = 0.46$, $P < 0.05$); i.e., the earlier the period of coastal SST first reaching the optimum range for chum salmon, the higher the return rate. This study suggests that the timing of optimum temperature range in coastal areas is an important factor affecting the survival of chum salmon stocked from hatcheries in the eastern region of the Okhotsk coast on Hokkaido, while other factors, e.g., fish size, stocking timing, and environmental conditions in the high seas, would also affect the return rate. This study also showed that a portion of hatchery-reared chum salmon was stocked too early when coastal SST was unfavorable, and reducing such ineffective stocking is important to conduct the hatchery programs efficiently.

Fig. 2. Isopleths of coastal sea surface temperature of the Sea of Japan and Okhotsk Sea along the coasts of Hokkaido in 1997 and 2001. Green areas in the isopleths indicate the optimum temperature range for residence of juvenile chum salmon in the coastal waters.



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