Stock-Specific Summertime Distribution of Immature Chum Salmon in the Bering Sea as Inferred from SNP Markers

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Chum salmon (*Oncorhynchus keta*) is the most widely distributed salmon species of the North Pacific Rim. Populations of chum salmon from Asia and North America co-mingle in the North Pacific Ocean and Bering Sea. Estimation of stock origins and ocean distribution of chum salmon will provide valuable information to help clarify stock-specific patterns of ocean migration for stock assessment. Many salmon research cruises have been conducted in the summer in the Bering Sea because this area is a major feeding habitat for chum salmon during summer. However, the areas surveyed are limited to the central and southern Bering Sea (52°N to 59°N). Thus, distribution and stock-specific composition of chum salmon in the northern areas of Bering Sea and Arctic Ocean are unclear. In this study, we surveyed chum salmon distribution from the southern Bering Sea to the Arctic Ocean during summer 2009, and we estimated the stock-specific ocean distribution of chum salmon by genetic stock identification (GSI) using single nucleotide polymorphism (SNP) markers.

Cruises were conducted by the research vessel R/V *Hokko maru* in the Chukchi Sea (three stations, 67°53'N-70°05'N, 167°49'W-167°23'W), Bering Strait (two stations, 64°48'N-65°14'N, 169°36'W-168°40'W), northern Bering Sea (10 stations, 59°01'N-63°00'N, 177°28'E-170°05'W), and other areas of Bering Sea (17 stations, 52°30'N-58°23'N, 174°49'E-174°55'W) during July 15-24 and July 30-August 9, 2009. A mid-water trawl (MTN) and a surface trawl (STN) were used to catch fish during the cruises (Morita et al. 2009). The MTN was used in the northern Bering Sea, Bering Strait, and Chukchi Sea, and the STN was used in the other areas of Bering Sea. The MTN is smaller than the STN, and the catch by the STN was 2.7872 times higher than the catch by the MTN (Morita et al. 2009). The CPUE (catch per unit effort) and mean CPUE of chum salmon by MTN were standardized to the CPUE of the STN. Adipose fin samples (N=2,256) were collected and fixed in 100% ethanol. The DNA was extracted from the samples in the laboratory. Each sample was assayed for 32 SNP loci using TaqMan chemistry. The genotyping data were pooled from two or three nearby stations. Because most fish were immature (96%), maturing fish were excluded from the genetic analysis. Stock contributions (Japan, Russia, and North America) of immature fish were estimated using a Bayesian procedure and a SNP baseline dataset developed from 146 populations from the North Pacific Rim.

Table 1. Catch number and mean CPUE of chum salmon caught in four regions during the research cruise of the R/V *Hokko maru* in July-August 2009.

Region	Latitude	Number of stations	Catch No.	Mean CPUE
Chukchi Sea	67°N-70°N	3	4	3.716*
Bering Strait	64°N-65°N	2	3	4.181*
Northern Bering Sea	59°N-63°N	10	1,080	301.018*
Bering Sea (other areas)	52°N-58°N	17	2,817	165.706

*Mean CPUEs are standardized to the catch in a surface trawl.

The chum salmon catch in the northern Bering Sea and other areas of Bering Sea was 1,080 and 2,817, respectively (Table 1). Four chum salmon were caught in the Chukchi Sea and three were caught in the Bering Strait. Mean CPUE of chum salmon in the northern Bering Sea was higher than that in the Bering Strait and Chukchi Sea (Fig. 1). These results suggest that abundance of chum salmon in the northern Bering Sea was higher than in other survey areas. The estimated chum salmon stock composition was 49.2-58.4% Japanese and 27.6-47.0% Russian fish in the northern Bering Sea and 37.9-47.1% Japanese and 50.5-59.7% Russian in the central Bering Sea (56°N-58°N). The stock composition in the southern Bering Sea (52°N-55°N) was 5.3-37.1% Japanese and 55.8-86.9% Russian chum salmon. In the western Bering Sea (53°N-56°N, 175°E), the stock composition was estimated to be 6.3-14.7% Japanese and 84.0-88.9% Russian.

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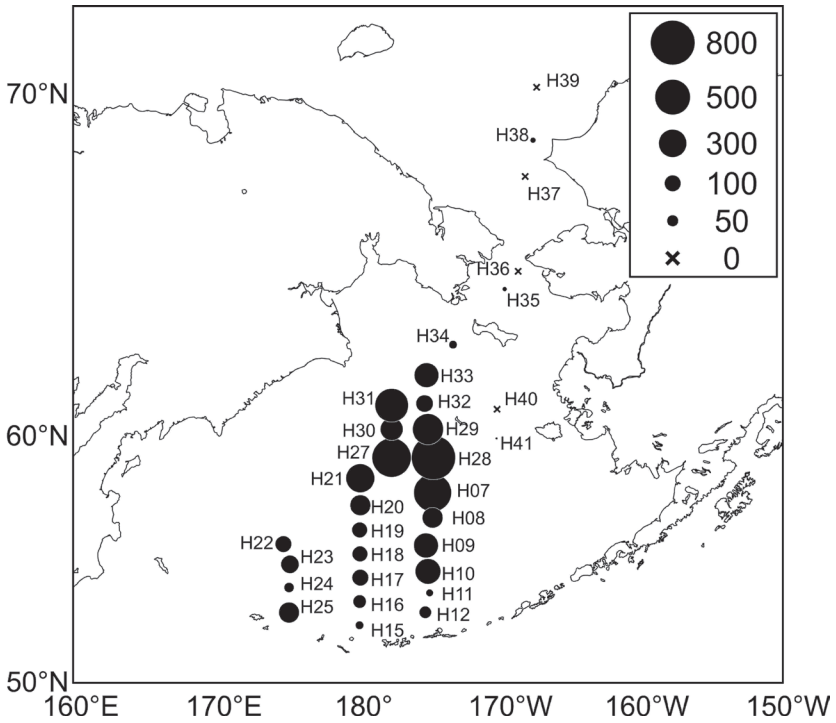

Fig.1. Distribution of chum salmon in the survey areas during summer 2009. Size of the circle indicates the abundance of fish by catch per unit of effort (CPUE). CPUEs are standardized to the catch in a surface trawl.

The percentages of North American stocks were 1.3-15.8% in the Bering Sea survey areas. The CPUEs weighted by GSI estimates indicated that abundance of Japanese stocks increased gradually from southern to northern areas of the Bering Sea, and they predominated in the central and northern Bering Sea. Russian stocks were highly abundant in the northern Bering Sea, and they predominated in the southern and western Bering Sea. North American stocks were less abundant than Asian stocks in the survey areas of the Bering Sea. Sato et al. (2009) and Urawa et al. (2009) indicated that Japanese immature chum salmon were widely distributed in the Bering Sea during summer and particularly predominant in the central Bering Sea. Our results are supported by their data, and our data also indicate that immature Japanese stocks migrate to northern areas (> 60°N) in the Bering Sea during summer. Japanese chum salmon stocks may utilize wide regions of the Bering Sea, including northern waters, as a summer feeding area. A previous study showed that Russian immature chum salmon had a distribution similar to the Japanese stocks in the Bering Sea (Urawa et al. 2009). However, our results indicate that abundance of Russian stocks is higher than Japanese stocks in the southern and western Bering Sea. Recently, the commercial catch of Russian chum salmon has increased, while that of Japanese chum salmon has decreased. Perhaps our results reflect recent abundance trends of Asian chum salmon. We should continue monitoring the stock-specific ocean distribution patterns of Asian chum salmon to provide critical information for stock assessment.

REFERENCES

Morita, K., S. Sato, M. Kato, and J. Yamamoto. 2009. The summer 2009 Japanese salmon research cruise of the R/V *Hokko maru*: exploration of the northern limit of offshore distribution and annual survey in the Bering sea. N. Pac. Anadr. Fish Comm. Doc. 1191. 12 pp. (Available at www.npafc.org).

Sato, S., S. Moriya, T. Azumaya, H. Nagoya, S. Abe, and S. Urawa. 2009. Stock distribution patterns of chum salmon in the Bering Sea and North Pacific Ocean during the summer and fall of 2002–2004. N. Pac. Anadr. Fish Comm. Bull 5: 29–37. (Available at www.npafc.org).

Urawa, S., S. Sato, P.A. Crane, B. Agler, R. Josephson, and T. Azumaya. 2009. Stock-specific ocean distribution and migration of chum salmon in the Bering Sea and North Pacific Ocean. N. Pac. Anadr. Fish Comm. Bull. 5: 131-146. (Available at www.npafc.org).