Genetic Stock Identification of Juvenile Chum Salmon Caught in the Okhotsk Sea During the Fall of 2003

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Juvenile chum salmon (*Oncorhynchus keta*) are abundantly distributed in the Okhotsk Sea during the fall season (Ueno 1997; Melnikov et al. 1999a, 1999b; Lapko and Glebov 2001; Volvenko 2003). The first genetic stock identification (GSI) study suggested that the Japanese stock was dominant among juvenile chum salmon caught in the southern Okhotsk Sea (45–49ºN, 145–152ºE) in October 1993 (Urawa et al. 1998, 2001). On the other hand, Russian stocks were dominant in the southwestern water (46–51ºN, 146–150ºE) in October 2000 (Urawa et al. 2006). Urawa et al. (2004) estimated the stock origins of juvenile chum salmon caught in the wide areas of the Okhotsk Sea (45–55ºN and 146–152ºE) in October 2002 using allozyme and otolith marks, and confirmed that the stock composition was different among the sampling locations.

In the present study, the origins of juvenile chum salmon caught in the Okhotsk Sea during the fall of 2003 were estimated by using allozyme and microsatellite DNA variations. A total of 361 juvenile chum salmon (age 0.0) was caught at eight stations (51–55ºN and 148–155ºE) by a surface trawl net of a Russian research vessel between September 27 and October 17, 2003 (Table 1). Tissue samples (heart, liver and muscle) were collected from each fish, and frozen on board.

Samples were examined for protein electrophoretic variation on horizontal starch gels using standard procedures described by Aebersold et al. (1987). Alleles were compared and standardized for 20 polymorphic loci. We used an Asian baseline data set (43 stocks/20 loci) reported by Winans et al. (1994), Wilmot et al. (1998) and Urawa et al. (2006). Estimates of stock contributions were made with a conditional maximum likelihood algorithm using the Statistics Program for Analyzing Mixtures (SPAM version 3.7, Debevec et al. 2000). Standard deviations and 90% confidence intervals were estimated by 1,000 bootstrap resamplings of the baseline and mixture samples. Estimates were made to individual stocks and then pooled to regional stock groups: Japan, Sakhalin, Premorye, Amur River, and northern Russia (Magadan/Kamchatka/Anadyre).

Table 1. Juvenile chum salmon caught in the Okhotsk Sea in the fall of 2003 for genetic stock identification.

Station	Latitude	Longitude	Date	Number of samples
1	51°31'N	155°00'E	Sep-27-2003	50
2	51°01'N	152°00'E	Sep-29-2003	50
3	51°00'N	149°00'E	Sep-30-2003	50
4	52°59'N	148°02'E	Oct-06-2003	36
5	52°53'N	152°00'E	Oct-07-2003	44
6	55°00'N	147°59'E	Oct-13-2003	50
7	55°01'N	151°57'E	Oct-15-2003	30
8	55°00'N	155°00'E	Oct-17-2003	51
Total				361

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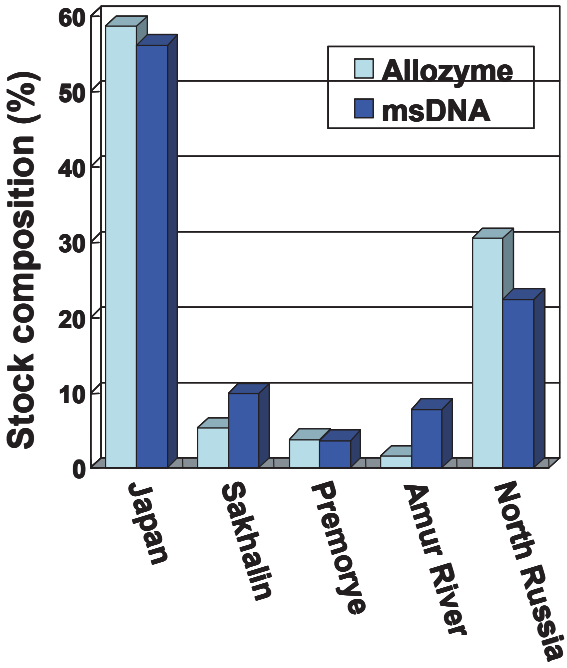
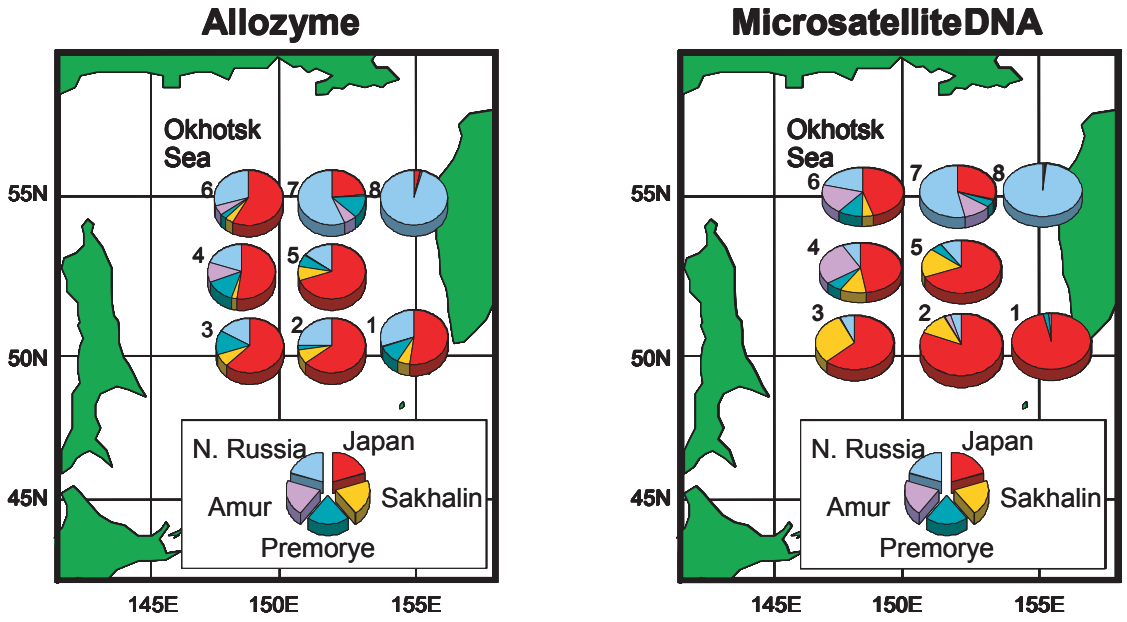
Fig 1. A comparison of regional stock composition (%) of total mixtures of juvenile chum salmon estimated by allozyme and microsatellite (ms) DNA analyses. Both analyses showed that the Japanese stock was predominant in the Okhotsk Sea in the fall of 2003.



In addition, surveys of variation at 13 microsatellite loci were conducted: *Ots3, Oke3, Oki2, Oki100, Omy 1011, One101, One102, One103, One104, One111, One114, Ssa419,* and *OtsG68* (Beacham et al. 2004). Genotypic frequencies were determined for each locus in each sample and SPAM version 3.7 was used to estimate stock composition of the mixed-stock samples. Analysis of the mixed-stock sample was conducted with a baseline of 25 Russian populations and 26 Japanese populations (Beacham et al. unpublished data).

Both allozyme and microsatellite DNA analyses showed similar estimates of stock composition for all juvenile chum salmon samples: 59% and 56% for Japan, 5% and 10% for Sakhalin, 4% and 4% for Premorye, 2% and 8% for Amur River, and 31% and 22% for northern Russia stocks, respectively (Fig. 1). The estimated stock composition was different among the sampling locations (Fig. 2). Japanese chum salmon were predominant in southern waters, while northern Russian stock (mainly western Kamchatka) was predominant in the northeastern waters. In comparison with the 2002 results (Urawa et al. 2004), the distribution of Japanese and Russian stocks shifted to the northern water in the fall of 2003, maybe because of warmer water temperatures in 2003. Thus, the distribution pattern of juvenile chum salmon within the Okhotsk Sea may be different among years. It is highly important to continue the monitoring program for juvenile salmon in the Okhotsk Sea including accurate stock identifications in order to understand the population status and dynamics of Asian chum salmon.

Fig 2. Regional stock composition (%) of juvenile chum salmon estimated by allozyme and microsatellite DNA analyses. The stock composition was different among the sampling locations: the Japanese stock was predominant in the southern waters and the northern Russia (west Kamchatka) stock dominated in the northeastern waters.



REFERENCES

Aebersold, P.B., G.A. Winans, D.J. Teel, G.B. Milner, and F.M. Utter. 1987. Manual for starch gel electrophoresis: a method for the detection of genetic variation. NOAA Tech. Rep. NMFS No. 61.

Beacham T.D., K.D. Le, and J.R. Candy. 2004. Population structure and stock identification of chum salmon (*Oncorhynchus keta*) based upon microsatellite analysis. N. Pac. Anadr. Fish Comm. Tech. Rep. 5: 31–33.

Debevec, E.M., R.B. Gates, M. Masuda, J. Pella, J. Reynolds, and L.W. Seeb. 2000. SPAM (version 3.2): statistics program for analyzing mixtures. J. Hered. 91: 509–511.

Lapko, V.V., and I.I. Glebov. 2001. Distribution and abundance of Pacific salmon in the southern Okhotsk Sea in summer-fall 2000. NPAFC Doc. 522. 14 pp. (Available at http://www.npafc.org).

Melnikov, I.V., A.N. Starovoitov, E.N. Ilyinsky, and I.I. Glebov. 1999a. Interannual variability of Pacific salmon distribution in the southern Okhotsk Sea during summer of 1998 and 1999. NPAFC Doc. 432. 12 pp. (Available at http://www.npafc.org).

Melnikov, I.V., V.I. Radchenko, and A.N. Starovoitov. 1999b. Pacific salmon distribution in the southern Okhotsk Sea during autumn of 1998 and pink salmon catch forecast for 1999 fishery season. NPAFC Doc. 433. 10 pp. (Available at http://www.npafc.org).

Ueno, Y. 1997. Distribution, migration, and abundance estimation of Asian juvenile salmon. NPAFC Doc. 270. 17 pp. (Available at http://www.npafc.org).

Urawa, S., Y. Ueno, Y. Ishida, S. Takagi, G. Winans, and N. Davis. 1998. Genetic stock identification of young chum salmon in the North Pacific Ocean and adjacent seas. NPAFC Doc. 336. 9 pp. (Available at http://www.npafc.org).

Urawa, S., Y. Ueno, Y. Ishida, L.W. Seeb, P.A. Crane, S. Abe, and N.D. Davis. 2001. A migration model of Japanese chum salmon during early ocean life. N. Pac. Anadr. Fish Comm. Tech. Rep. 2: 1–2.

Urawa, S., J. Seki, M. Kawana, T. Saito, P.A. Crane, L. Seeb, K. Gorbatenko, and M. Fukuwaka. 2004. Juvenile chum salmon in the Okhotsk Sea: their origins estimated by genetic and otolith marks. N. Pac. Anadr. Fish Comm. Tech. Rep. 5: 87–88.

Urawa, S., J. Seki, M. Kawana, T. Saito, P.A. Crane, L.W. Seeb, M. Fukuwaka, and E. Akinicheva. 2006. Origins of juvenile chum salmon caught in the southwestern Okhotsk Sea during the fall of 2000. Bull. Nat. Salmon Resources Center, 8: 9–16.

Volvenko, I.V. 2003. Knowledge base and catalogue of salmons abundance in the Okhotsk Sea. NPAFC Doc. 731. 69 pp. (Available at http://www.npafc.org).

Wilmot, R.L., C.M. Kondzela, C.M. Guthrie, and M.S. Masuda. 1998. Genetic stock identification of chum salmon harvested incidentally in the 1994 and 1995 Bering Sea trawl fishery. N. Pac. Anadr. Fish Comm. Bull. 1: 285–299.

Winans, G.A., P.B. Aebersold, S. Urawa, and N.V. Varnavskaya. 1994. Determining continent of origin of chum salmon (*Oncorhynchus keta*) using genetic stock identification techniques: status of allozyme baseline in Asia. Can. J. Fish. Aquat. Sci. 51 (Suppl. 1): 95–113.