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Thermal Otolith Mark Recoveries from Salmon in International Waters of the Gulf of Alaska in 2002

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Abstract

This document reports thermal otolith mark recovery data for salmon sampled during the *Oshoro maru* research cruise in the Gulf of Alaska in July 2002. Otoliths collected from 446 chum salmon and 63 pink salmon at seven gillnet stations along the 145°W transect (51°-56°N) were examined for thermal marks. Thermal marks were found on the otoliths of 35 chum salmon (8% of total, n=446 fish). None of the pink salmon otoliths were thermally-marked. Because of the release of duplicate marks only nine of the marked chum salmon (26% of total, n=35 fish) could be identified to both brood year (1999 or 2000) and hatchery of origin. An additional seven fish could be identified to hatchery of origin, and were either brood year 1999 or 2000 fish. In these cases, age determinations or body size data or both could be used to determine the brood year of four fish. Similar to the results of a previous study, thermally-marked Alaska hatchery chum salmon (Prince William Sound, n=2 fish; Southeast Alaska, n=12 fish) were distributed along the entire 145°W transect in July. Samples that could be identified to country or hatchery of origin included the first two reported recoveries of otolith-marked Asian (1 Japan, 1 Russia) hatchery chum salmon from the central Gulf of Alaska. These recoveries corroborate published estimates from genetic stock identification research, indicating that Asian and North American chum salmon intermingle in the central Gulf of Alaska (49-56°N, 145°W) in July. The continent of origin of 18 thermally-marked chum salmon (51% of total, n=35 fish) could not be identified because of duplicate marks released by hatcheries in Russia, Alaska, British Columbia, and Washington. The authors encourage the NPAFC's Ad Hoc Working Group on Salmon Marking to develop a complete repository of digital images or photographs with measurements or voucher specimens of otolith marks. This would increase the accuracy of identification of thermally marked salmon caught in Convention waters where Asian and North American salmon intermingle. The authors also encourage the reporting to NPAFC of all thermally-marked salmon recovered from research vessel catches in the Convention area.

Introduction

Thermal marking of salmon otoliths is a stock identification technique used by North Pacific Rim countries (Canada, Japan, Russian, United States) to mass mark anadromous salmon for research and management (NPAFC 2001; http://npafc.taglab.org/index.asp). Otolith mark recovery experiments have provided significant new stock-specific information on high seas distribution and migration patterns of immature and maturing salmon (e.g., Kawana et al. 1999, 2001; Carlson et al. 2000; Urawa et al. 2000). In this document, we list previously unreported data for otolith-marked salmon recovered during the July 2002 *Oshoro maru* salmon survey in the Gulf of Alaska. The results are compared to previous information from high seas stock identification studies, and significant new information on ocean ranges and migration patterns of salmon is discussed.

Methods

Otolith samples were collected from 480 chum salmon and 85 pink salmon at seven gillnet stations in the central Gulf of Alaska along the 145°W transect (51°-56°N) during the July 2002 salmon research cruise of the *Oshoro maru* (Meguro et al. 2003). To collect the otoliths, the head was removed, the top of the skull was cut off, and both otoliths taken and placed in collecting trays. At a later date the otoliths were divided between a Japanese and a U.S. research lab. In cases where only one otolith was collected, it was retained by the Japanese lab. Samples from 446 chum salmon and 63 pink salmon were available to the U.S. lab and were examined for otolith marks at the Alaska Department of Fish and Game, Division of Commercial Fisheries, Mark, Tag, and Age Laboratory (http://tagotoweb.adfg.state.ak.us/). During shipment, some otoliths came out of their cells in the collecting tray and could not be associated with an individual fish, though the species was known and the sampling station was usually known. Methods used for coding of thermal otolith marks are described by Hagen et al. (2000).

To evaluate whether Gulf of Alaska recoveries of thermally-marked salmon in 2002 provided significant new information on ocean ranges and migration patterns of salmon, we compared our results to information from high seas salmon tagging experiments, as well as to previously published otolith mark recovery and genetic stock identification data (Kawana et al. 1999, 2001; Carlson et al. 2000; Urawa et al. 2000). High seas salmon tag recovery data have been reported annually to the International North Pacific Fisheries Commission (1956-1992) and NPAFC (1993-present), and a database of these recoveries is archived at the School of Aquatic and Fishery Sciences, University of Washington, Seattle.

Results and Discussion

Thermal marks were found on the otoliths of 35 chum salmon (8% of the total, n = 446; Table 1). None of the pink salmon otoliths were thermally-marked. Because of the release of duplicate marks only nine of the marked chum salmon (26% of total, n=35) could be identified to both brood year and hatchery of origin (Table 1, fish nos. 1, 4, 7, 9, 13, 16, 18, 28, and 34). An additional seven fish could be identified to hatchery of origin, and were

either brood year 1999 or 2000 fish (Table 1, fish nos. 3, 5, 14, 21, 23, 26, and 29). In these cases, age determinations or body size data or both were used to determine the brood year of four fish (Table 1, Fish nos. 3, 5, 21, and 23). Similar to the result of Urawa et al. (2000), we found that thermally-marked Alaska hatchery chum salmon (Prince William Sound, n=2 fish; Southeast Alaska, n=12 fish) were distributed at stations along the entire 145°W transect in July (Table 1).

Samples that could be identified to country or hatchery of origin included the first two reported recoveries of otolith-marked Asian (1 Russia, 1 Japan) hatchery chum salmon from the Gulf of Alaska (Fig. 1; Table 1, fish no. 19, Tauy River or Yana River, northern Okhotsk Sea coast, Russia, and fish no. 29, Shizunai River, Hokkaido, Japan). These recoveries corroborate information from genetic stock identification research, which showed that Asian and North American chum salmon intermingle in the central Gulf of Alaska (49-56°N, 145°W) in July (Urawa et al. 2000).

The continent of origin of 18 thermally-marked chum salmon (51% of total, n=35 fish) could not be identified because of duplicate marks released by hatcheries in Russia, Alaska, British Columbia, and Washington (Table 1). Urawa et al. (2001) described efforts by NPAFC's *Ad Hoc* Working Group on Salmon Marking (established in 1998) to compile and coordinate salmon otolith marks in the North Pacific. The working group has developed an international thermal mark database, which is available at http://npafc.taglab.org. We encourage the working group to expand this information to include a repository of digital images or photographs with measurements or voucher specimens of otolith marks. This would improve the accuracy of identification of thermal otolith marks from salmon in Convention waters where Asian and North American salmon intermingle. We also encourage the reporting to NPAFC of all thermally-marked salmon recovered from research vessel catches in the Convention area.

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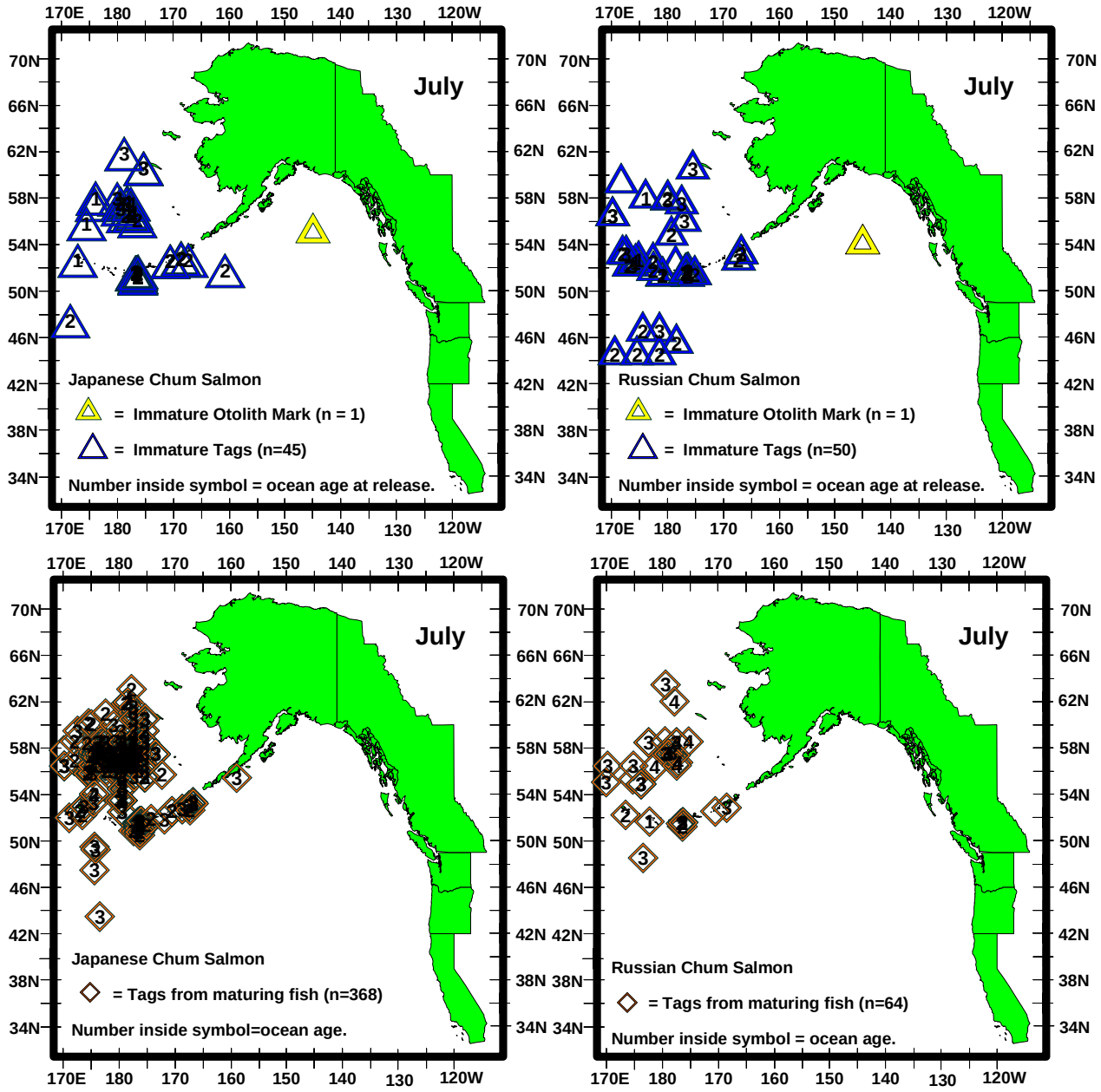

Fig. 1. Maps showing July 2002 Gulf of Alaska recovery locations of an otolith-marked Japanese hatchery chum salmon (top left panel, 1 fish) and an otolith-marked Russian hatchery chum salmon (upper right panel, 1 fish) with respect to information from high seas tagging experiments (1956-2003). The maturity of the Japanese chum salmon was unknown, but for purposes of illustration we assumed that it was an immature fish. The symbols for tags indicate the release locations of tagged immature fish (top panels) and maturing fish (bottom panels) that were later recovered in Japan and Russia. Recoveries of high seas tagged salmon from release locations west of 170°E are not shown.

Table 1. Thermally-marked chum salmon caught during the *Oshoro maru* salmon survey in the central Gulf of Alaska in July 2002. Spec = species; Hatch code = coding structure of thermal marks (Hagen et al. 2000); for example, fish no. 1 carried a Hatch Code of 6H3, which is a band of six rings prior to the hatch mark, and a band of three rings post-hatch. Oto age = age determined from otoliths; N Lat. = degrees and minutes North latitude; W Long. = degrees and minutes West longitude; Wt = whole body weight, Gon Wt = gonad weight; Mat = maturity according to the criteria of Takagi (1961). Some otolith samples were accidentally mixed during shipment, and the exact recovery date, location, and associated biological data could not be determined for these fish. In some of these cases, there were two possible recovery dates and recovery latitudes, which are listed in the table. AK = Alaska, RU = Russia, BC = British Columbia, WA = Washington. WHN = Wally H. Noerenberg Hatchery (Port Chalmers), Prince William Sound, Alaska. All of the other Alaska hatcheries listed are located in southeast Alaska.

Fish no.	Spec	Hatch code	Oto age	Otolith Mark Brood Year 1999 Possibilities	Otolith Mark Brood Year 2000 Possibilities	*Oshoro maru* station code	(yymmdd) Recovery date (JST)	Recovery Location N Lat.	Recovery Location W Long.	Sex	(mm) Fork Length	(g) Body Wt	(g) Gon Wt	Mat	Scale age	Remarks
1	Chum	6H3	0.2	Gastineau Channel99 (AK)	none	G09	020720	5100	14500	M	518	1640	2	IMM	0.2	
2	Chum	5,2H	0.1	Tauy River (RU)	Tauy Bay, Odyan (RU) or WHN00 (AK)	G09 or G10	020720 or 020721	5100 or 5200	14500							
3	Chum	3H	0.2	Port Chalmers99 (AK)	Port Chalmers00 (AK)	G09 or G10	020720 or 020721	5100 or 5200	14500							Age 0.2 confirms BY 99
4	Chum	5H6	0.1	none	Amalga00L (AK)	G09 or G10	020720 or 020721	5100 or 5200	14500							
5	Chum	3,3H	0.2 or 0.1	Hidden Falls99 (AK)	Hidden Falls00 (AK)	G09	020720	5100	14500	F	396	660	5	IMM	0.1	Age 0.1 confirms BY 00

Table 1. (continued)

Fish no.	Spec	Hatch code	Oto age	Otolith Mark Brood Year 1999 Possibilities	Otolith Mark Brood Year 2000 Possibilities	*Oshoro maru* station code	(yymmdd) Recovery date (JST)	Recovery Location N Lat.	Recovery Location W Long.	Sex	(mm) Fork Length	(g) Body Wt	(g) Gon Wt	Mat	Scale age	Remarks
6	Chum	5,2H	0.1	Tauy River (RU)	Tauy Bay, Odyan (RU) or WHN00 (AK)	G09	020720	5100	14500	F	407	820	5	IMM	0.1	
7	Chum	5H6	0.1	none	Amalga00L (AK)	G10	020722	5301	14500	M	481	1460	4	IMM	0.2	
8	Chum	5,2H	0.1	Tauy River (RU)	Tauy Bay, Odyan (RU) or WHN00 (AK)	G10	020722	5301	14500	F	400	700	5	IMM	0.1	
9	Chum	5H6	0.1	none	Amalga00L (AK)	G09 or G10	020721 or 020722	5200 or 5301	14500							
10	Chum	5H	0.1	Ola River (RU), Nitinat River (BC), WHN99 (AK)	Nitinat Lake (BC), Amalga00E (AK)	G09 or G10	020721 or 020722	5200 or 5301	14500							
11	Chum	5H	0.1	Ola River (RU), Nitinat River (BC), WHN99 (AK)	Nitinat Lake (BC), Amalga00E (AK)	G10	020722	5301	14500	F	388	660	5	IMM	0.1	
12	Chum	5H	0.1	Ola River (RU), Nitinat River (BC), WHN99 (AK)	Nitinat Lake (BC), Amalga00E (AK)	G10 or G11	020722 or 020723	5301 or 5400	14500 or 14501							
13	Chum	3,3H	0.2	Hidden Falls99 (AK)	none	G10 or G11	020722 or 020723	5301 or 5400	14500 or 14501							
14	Chum	4,3H	0.2 or 0.1	Deep Inlet99 (AK)	Deep Inlet00 (AK)	G11	020723	5400	14501							

Table 1. (continued)

Fish no.	Spec	Hatch code	Oto age	Otolith Mark Brood Year 1999 Possibilities	Otolith Mark Brood Year 2000 Possibilities	*Oshoro maru* station code	(yymmdd) Recovery date (JST)	Recovery Location N Lat.	Recovery Location W Long.	Sex	(mm) Fork Length	(g) Body Wt	(g) Gon Wt	Mat	Scale age	Remarks
15	Chum	4H	0.1 ??	Hamma Hamma River, Chimacum Creek (WA), Okhotsk Sea (RU)	Hamma Hamma River, Chimacum Creek, Satsop Springs (WA), Okhotsk Sea (RU), Takatz00 (AK)	G11	020723	5400	14501							
16	Chum	5H4	0.1	none	Boat Harbor00 (AK)	G11	020723	5400	14501							
17	Chum	6H	0.2 or 0.1	Yana River (RU), Amalga99E (AK)	Ola River (RU)	G11	020723	5400	14501							
18	Chum	5H4	0.1	none	Boat Harbor00 (AK)	G11	020723	5400	14501							
19	Chum	7H	?	none	Tauy River, Yana River (RU)	G11	020723	5400	14501	F	406	800	5	IMM	0.1	
20	Chum	4H	?	Hamma Hamma River, Chimacum Creek (WA), Okhotsk Sea (RU)	Hamma Hamma River, Chimacum Creek, Satsop Springs (WA), Okhotsk Sea (RU), Takatz00 (AK)	G11	020723	5400	14501	M	524	1660	4	IMM	0.2	
21	Chum	3,3H	0.2 or 0.1	Hidden Falls99 (AK)	Hidden Falls00 (AK)	G12	020724	5500	14459	M	604	2560	4	IMM	0.2	Age 0.2 confirms BY 99
22	Chum	5,2H	0.1	Tauy River (RU)	Tauy Bay, Odyan (RU) or WHN00 (AK)	G12	020724	5500	14459	M	421	800	1	IMM	0.2	Age could be 0.1 (annulus at edge)

Table 1. (continued)

Fish no.	Spec	Hatch code	Oto age	Otolith Mark Brood Year 1999 Possibilities	Otolith Mark Brood Year 2000 Possibilities	*Oshoro maru* station code	(yymmdd) Recovery date (JST)	Recovery Location N Lat.	W Long.	Sex	(mm) Fork Length	(g) Body Wt	(g) Gon Wt	Mat	Scale age	Remarks
23	Chum	3H	0.2	Port Chalmers99 (AK)	Port Chalmers00 (AK)	G12	020724	5500	14459							Age 0.2 confirms BY 99
24	Chum	5H	0.1	Ola River (RU), Nitinat River (BC), or WHN99 (AK)	Nitinat Lake (BC) or Amalga00E (AK)	G12	020724	5500	14459							
25	Chum	5H	0.2	Ola River (RU), Nitinat River (BC), or WHN99 (AK)	Nitinat Lake (BC) or Amalga00E (AK)	G12	020724	5500	14459							
26	Chum	4,3H	0.1	Deep Inlet99 (AK)	Deep Inlet00 (AK)	G12	020724	5500	14459	M	441	940	3	IMM	0.1	
27	Chum	4H	?	Hamma Hamma River, Chimacum Creek (WA) or Okhotsk Sea (RU)	Hamma Hamma River, Chimacum Creek, Satsop Springs (WA), Okhotsk Sea (RU), or Takatz00 (AK)	G12	020724	5500	14459	M	481	1240	2	IMM	0.2	
28	Chum	6H6	0.2	Amalga99L (AK)	none	G12	020724	5500	14459	F	510	1500	16	IMM	0.2	
29	Chum	2,3H	?	Shizunai River (JAPAN)	Shizunai River (JAPAN)	G12	020724	5500	14459							
30	Chum	5H	0.1	Ola River (RU), Nitinat River (BC), or WHN99 (AK)	Nitinat Lake (BC) or Amalga00E (AK)	G13	020724	5600	14500	M	610	2540	8	IMM	0.2	
31	Chum	5H	0.2	Ola River (RU), Nitinat River (BC), or WHN99 (AK)	Nitinat Lake (BC) or Amalga00E (AK)	G12 or G13	020723 or 020724	5500 or 5600	14459 or 14500							

Table 1. (continued)

Fish no.	Spec	Hatch code	Oto age	Otolith Mark Brood Year 1999 Possibilities	Otolith Mark Brood Year 2000 Possibilities	*Oshoro maru* station code	(yymmdd) Recovery date (JST)	Recovery Location N Lat.	Recovery Location W Long.	Sex	(mm) Fork Length	(g) Body Wt	(g) Gon Wt	Mat	Scale age	Remarks
32	Chum	5H	0.1	Ola River (RU), Nitinat River (BC), or WHN99 (AK)	Nitinat Lake (BC) or Amalga00E (AK)	G12 or G13	020723 or 020724	5500 or 5600	14459 or 14500							
33	Chum	5H	0.1	Ola River (RU), Nitinat River (BC), or WHN99 (AK)	Nitinat Lake (BC) or Amalga00E (AK)	G13	020724	5600	14500	F	544	1800	16	IMM	0.2	
34	Chum	6H3	0.2	Gastineau Channel99 (AK)	none	G13	020724	5600	14500							
35	Chum	5H	0.1	Ola River (RU), Nitinat River (BC), or WHN99 (AK)	Nitinat Lake (BC) or Amalga00E (AK)	G13	020724	5600	14500							