

History and Use of Allozyme Baselines for Pacific Rim Chum Salmon

by

Penelope A. Crane¹, Christine M. Kondzela², and Lisa W. Seeb¹

¹*Alaska Department of Fish and Game, 333 Raspberry Road, Anchorage, AK, USA 99518*

²*National Marine Fisheries Service, Auke Bay Laboratory, 11305 Glacier Highway, Juneau, AK, USA 99801*

Submitted to the
NORTH PACIFIC ANADROMOUS FISH COMMISSION
BY THE
UNITED STATES OF AMERICA

October, 2001

This document may be cited as:

Crane, P. A., C. M. Kondzela, and L. W. Seeb. 2001. History and Use of Allozyme Baselines for Pacific Rim Chum Salmon. (NPAFC Doc. 561) 17 pages. Alaska Department of Fish and Game, 333 Raspberry Road, Anchorage, AK, USA 99518.

History of Allozyme Baseline for Pacific Rim Chum Salmon

Genetic stock identification (GSI) studies for chum salmon (*Oncorhynchus keta*) requiring a Pacific Rim-wide database began in the mid 1980s with an interest in identifying the origin of illegally harvested chum salmon in the high seas and incidentally-caught chum salmon in high-seas driftnet fisheries for flying squid (*Ommastrephes bartrami*) (Seeb and Seeb 1986; Winans et al. 1989; Smouse et al. 1990). Agencies using protein electrophoresis to estimate genetic population structure in chum salmon began efforts early in their research programs to collect information on a common set of allozyme loci and to standardize alleles scored. These efforts evolved into an informal coastwide GSI consortium with a goal to standardize allozyme data for Pacific salmon to facilitate data sharing and the creation of large databases for application to complex fisheries.

In the early 1990s, large data sets of allele frequency information for chum salmon from Washington, British Columbia, Alaska, Canada, Russia, and Japan were completed. These data were collected by Washington Department of Fish and Wildlife (WDFW), National Marine Fisheries Service (NMFS)-Seattle, NMFS-Auke Bay Laboratory, Alaska Department of Fish and Game (ADF&G), and US Fish and Wildlife Service (USFWS), with collaborators from Kamchatka Branch of Pacific Research Institute of Fisheries and Oceanography (KoTINRO) and Fisheries Agency of Japan. Data were collected to describe population structure within regions and to create baselines for fishery applications; data sources are Kondzela et al. (1994), Phelps et al. (1994), Seeb and Crane (1999a), Wilmot et al. (1994), and Winans et al. (1994).

The first application of these data for genetic stock identification was to estimate the origin of chum salmon harvested in fisheries occurring off the south Alaska Peninsula in June (Seeb and Crane 1999b). Researchers from contributing agencies met in Anchorage, AK, to finalize allele standardization and to discuss control of bias through pooling populations or using populations representative of a region. Preliminary analyses of the mixture samples suggested that Asia and western Alaska were the largest contributors to the fishery; therefore, most of the available data for these areas were included in the baseline. Southeast Alaska, British Columbia, and Washington were small contributors; therefore, only populations representative of these regions were used. Preliminary stock groups that could be identified in mixtures were selected from heterogeneity and multidimensional scaling analyses and were refined using simulation studies of artificial mixtures created 100% from a single stock group under study (Seeb and Crane 1999b). Contribution estimates to south Alaska Peninsula fisheries for chum were presented for the following groups: Japan, Russia, Northwestern Alaska summer, Fall Yukon, Alaska Peninsula/Kodiak Island, British Columbia, and Washington (Seeb and Crane 1999b); the baseline used data for 20 allozyme loci from 164 collections of chum salmon.

As new population data have become available, researchers have independently updated the original baseline used by Seeb and Crane (1999b). Wilmot et al. (1995) added new data from Asia; this baseline was used to estimate the origin of chum salmon sampled from the Bering Sea Trawl fishery for walleye pollock (*Theragra chalcogramma*) (Wilmot et al. 1995; Wilmot et al. 1996, Wilmot et al. 1998), high seas testfisheries (Urawa et al. 1997; Urawa et al. 1998; Winans et al. 1998; Urawa et al. 2000), and confiscated fishery samples from illegal fishing (Wilmot et al. 1999; Wilmot et al. 2000). Seeb et al. (1997) added new Alaskan data and estimated the stock

contribution of Japan, Northern Russia, China/Southern Russia, Northwest Alaska summer, Fall Yukon, Alaska Peninsula/Kodiak Island, Susitna River, Prince William Sound, Southeast Alaska/Northern British Columbia, and Southern British Columbia/Washington to commercial catches from the south Alaska Peninsula (Seeb et al. 1997; Crane and Seeb 2000).

Future Allozyme Baselines for Chum Salmon

Collections of chum salmon assayed for genetic variation at allozyme loci are summarized in Table 1. The source of the data is listed, as well as the use of the collection in a Pacific Rim-wide baseline. These data have been standardized at 20 loci (Table 2).

Current GSI studies for chum salmon are focusing on estimating the distribution and migration routes of chum salmon in the North Pacific Ocean, Gulf of Alaska, and Bering Sea. Genetic baselines used in previous studies are sufficient for identifying continent of origin and large geographic aggregates, but creation of a new baseline with the new population data available and more loci will aid in finer regional estimates and estimate precision, increasing the power of studies looking at changes in migration and distribution due to climate change or changes in carrying capacity (e.g., NMFS 1995). In 2001, participating laboratories plan to meet to update the baseline with new population information and re-evaluate the stock groupings that can be analyzed in mixtures following the methods of Teel et al. (1999).

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Table 1. Collections of chum salmon assayed for genetic variation at allozyme loci, data source, and if the collection has been used in a baseline for genetic stock identification of Pacific Rim chum salmon (1=Seeb and Crane 1999a, 2=Wilmot et al. 1995, 3=Seeb et al. 1997).

Geographic Area	Population	N	Source	Baseline
Alaska				
Kotzebue Sound	Sikusuilq Hatchery 1989	100	NMFS-ABL unpublished	
	Sikusuilq Hatchery 1991	100	Seeb and Crane 1999a	1,2,3
	Sikusuilq Hatchery 1993	100	Seeb and Crane 1999a	1,2,3
	Noatak River 1991	100	Seeb and Crane 1999a	1,2,3
	Kelly Lake 1991	100	Seeb and Crane 1999a	1,2,3
	Salmon River 1991	106	Seeb and Crane 1999a	1,2,3
	Selby Slough 1994	100	Seeb et al. 1997	3
Norton Sound	Pilgrim River 1994	90	Seeb and Crane 1999a	1,2,3
	Snake River 1992	47	Seeb and Crane 1999a	1,2,3
	Snake River 1993	35	Seeb and Crane 1999a	1,2,3
	Snake River 1994	24	Seeb et al. 1997	3
	Snake River 1995	58	Seeb et al. 1997	3
	Nome River 1991	27	Seeb and Crane 1999a	1,2,3
	Nome River 1992	13	Seeb and Crane 1999a	1,2,3
	Nome River 1993	53	Seeb and Crane 1999a	1,2,3
	Nome River 1994	32	Seeb et al. 1997	3
	Nome River 1995	50	Seeb et al. 1997	3
	Solomon River 1995	65	Seeb et al. 1997	3
	Fish River 1994	100	Seeb and Crane 1999a	1,2,3
	Kwiniuk River 1994	100	Seeb and Crane 1999a	1,2,3
	Unalakleet River 1992	100	Seeb and Crane 1999a	1,2,3
Yukon River	W. Fk. Andreafsky River 1993	100	Seeb and Crane 1999a	1,2,3
	E. Fk. Andreafsky River 1993	100	Seeb and Crane 1999a	1,2,3
	Andreafsky River 1987	150	Wilmot et al. 1994	
	Chulinak River 1989	100	Wilmot et al. 1994	
	Innoko River 1993	88	Seeb and Crane 1999a	1,2,3
	Anvik/Beaver Creek 1992	100	Seeb and Crane 1999a	1,2,3
	Anvik/Beaver Creek 1993	100	Seeb and Crane 1999a	1,2,3
	Anvik/Yellow River 1992	100	Seeb and Crane 1999a	1,2,3
	Anvik/Swift River 1992	100	Seeb and Crane 1999a	1,2,3
	Anvik/Swift River 1993	100	Seeb and Crane 1999a	1,2,3
	Anvik/Canyon Creek 1993	50	Seeb and Crane 1999a	1,2,3
	Anvik/Otter Creek 1993	100	Seeb and Crane 1999a	1,2,3
	Rodo River 1989	78	Wilmot et al. 1994	
	Kaltag River 1992	100	USFWS unpublished	
	Nulato River Mainstem 1987	61	Wilmot et al. 1994	
	Nulato River, South Fork 1987	71	Wilmot et al. 1994	
	Nulato River, North Fork 1988	50	Wilmot et al. 1994	
	Nulato River 1994	100	Seeb et al. 1997	3
	Koyukuk (early) 1996	100	USFWS unpublished	
	Koyukuk (late) 1996	100	USFWS unpublished	
	Koyukuk/Gisasa River 1989	97	Wilmot et al. 1994	
Koyukuk/Gisasa River 1994	100	Seeb et al. 1997	3	
Koyukuk/Huslia River 1993	100	Seeb and Crane 1999a	1,2,3	
Koyukuk/Dakli River 1992	100	USFWS unpublished		
Koyukuk/Clear Creek 1995	100	Seeb et al. 1997	3	

Geographic Area	Population	N	Source	Baseline
	Koyukuk/Henshaw Creek 1987	43	Wilmot et al. 1994	
	Koyukuk/Henshaw Creek 1995	62	Seeb et al. 1997	3
	Koyukuk/Jim River 1987	101	Wilmot et al. 1994	
	South Fork Koyukuk River late 1995	100	Seeb et al. 1997	3
	Koyukuk River, early 1990	75	Wilmot et al. 1994	
	Koyukuk River, late 1990	75	Wilmot et al. 1994	
	Melozitna River 1994	100	Seeb et al. 1997	3
	Tozitna River 1989	85	Wilmot et al. 1994	
	Tozitna River 1992	71	USFWS unpublished	
	Chena River 1992	86	Seeb and Crane 1999a	1,2,3
	Chena River 1994	100	Seeb et al. 1997	3
	Salcha River 1988	50	Wilmot et al. 1994	
	Salcha River 1989	50	Wilmot et al. 1994	
	Salcha River 1992	100	Seeb and Crane 1999a	1,2,3
	Salcha River 1994	100	Seeb et al. 1997	3
	Toklat River 1987	135	Wilmot et al. 1994	
	Toklat River 1990	75	Wilmot et al. 1994	
	Toklat River 1991	60	Seeb and Crane 1999a	1,2,3
	Toklat River 1992	155	Seeb and Crane 1999a	1,2,3
	Toklat River 1993	200	Seeb et al. 1997	3
	Toklat River site a 1994	100	Sarafin 1995	3
	Toklat River site b 1994	100	Sarafin 1995	3
	Toklat/Geiger Creek 1994	100	Sarafin 1995	3
	Toklat/Sushana River 1994	100	Sarafin 1995	3
	Tanana River (mainstem) 1992	97	Seeb and Crane 1999a	1,2,3
	Tanana River (mainstem) 1993	100	Seeb and Crane 1999a	1,2,3
	Bluff Cabin Slough 1987	135	Wilmot et al. 1994	
	Bluff Cabin Slough 1992	100	Seeb and Crane 1999a	1,2,3
	Delta River 1987	135	Wilmot et al. 1994	
	Delta River 1990	75	Wilmot et al. 1994	
	Delta River 1991	100	Seeb and Crane 1999a	1,2,3
	Delta River 1992	100	Seeb and Crane 1999a	1,2,3
	Delta River 1994	100	Seeb et al. 1997	3
	Chandalar River 1987	150	Wilmot et al. 1994	
	Chandalar River 1988	73	Wilmot et al. 1994	
	Chandalar River 1989	75	Wilmot et al. 1994	
	Sheenjek River 1987	135	Wilmot et al. 1994	
	Sheenjek River 1988	80	Wilmot et al. 1994	
	Sheenjek River 1989	80	Wilmot et al. 1994	
	Sheenjek River 1992	100	Seeb and Crane 1999a	1,2,3
	Sheenjek River 1993	64	Seeb and Crane 1999a	1,2,3
	Black River 1995	96	USFWS unpublished	
Kuskokwim River	Kwethluk River 1989	77	Wilmot et al. 1994	
	Kwethluk River 1994	100	Seeb and Crane 1999a	1,2,3
	Kasigluk River 1994	70	Seeb et al. 1997	3
	Kisaralik River 1994	100	Seeb et al. 1997	3
	Tuluksak River 1993	100	Seeb and Crane 1999a	1,2,3
	Aniak River 1989	75	Wilmot et al. 1994	
	Aniak River 1992	100	Seeb and Crane 1999a	1,2,3
	Hokokuk River 1995	48	Seeb et al. 1997	3
	Oskawalik River 1994	58	Seeb et al. 1997	3
	George River 1996	100	Seeb et al. 1997	3

Geographic Area	Population	N	Source	Baseline
	Kogrukluk River 1992	75	Seeb and Crane 1999a	1,2,3
	Kogrukluk River 1993	50	Seeb and Crane 1999a	1,2,3
	Stoney River early	100	Seeb et al. 1997	3
	Stoney River late	56	Seeb et al. 1997	3
	Tatlawiksuk River 1994	100	Seeb and Crane 1999a	1,2,3
	Nunsatuk River 1994	100	Seeb et al. 1997	3
	4th of July Creek 1994	100	Seeb and Crane 1999a	1,2,3
	Kuskokwim River at McGrath 1994	100	Seeb et al. 1997	3
	South Fork Kuskokwim-late 1995	100	Seeb et al. 1997	3
	Big River 1996	100	Seeb et al. 1997	3
Kanektok River	Kanektok River 1989	75	Wilmot et al. 1994	
	Kanektok River 1993	39	Seeb and Crane 1999a	1,2,3
	Kanektok River 1994	100	Seeb et al. 1997	3
Goodnews River	Goodnews River Site 1 1989	50	Wilmot et al. 1994	
	Goodnews River Site 2 1989	50	Wilmot et al. 1994	
	Goodnews River 1991	100	Seeb and Crane 1999a	1,2,3
Bristol Bay	Togiak River 1987	98	Wilmot et al. 1994	
	Togiak River 1993	100	Seeb and Crane 1999a	1,2,3
	Togiak River 1994	100	Seeb and Crane 1999a	1,2,3
	Nushagak River 1987	87	Wilmot et al. 1994	
	Upper Nushagak River 1992	53	Seeb and Crane 1999a	1,2,3
	Upper Nushagak River 1993	50	Seeb and Crane 1999a	1,2,3
	Mulchatna River 1994	100	Seeb and Crane 1999a	1,2,3
	Stuyahok River 1992	31	Seeb and Crane 1999a	1,2,3
	Stuyahok River 1993	57	Seeb and Crane 1999a	1,2,3
	Alagnak River 1987	100	Wilmot et al. 1994	
	Alagnak River 1992	84	Seeb and Crane 1999a	1,2,3
	Naknek River 1988	75	Wilmot et al. 1994	
	Naknek/Big Creek 1993	80	Seeb and Crane 1999a	1,2,3
	Gertrude Creek 1987	100	Wilmot et al. 1994	
	Egegik Bay/Whale Mountain Creek 1993	98	Seeb and Crane 1999a	1,2,3
	Mother Goose	1987	Wilmot et al. 1994	
	Ugashik Bay/Pumice Creek 1993	100	Seeb and Crane 1999a	1,2,3
North Alaska Peninsula	Meshik River 1989	75	Wilmot et al. 1994	
	Meshik/Plenty Bear Creek 1993	93	Seeb and Crane 1999a	1,2,3
	Meshik/Braided Creek 1992	78	Seeb and Crane 1999a	1,2,3
	Wiggly Creek 1993	100	Seeb et al. 1997	3
	Herendeen 1987	100	Wilmot et al. 1994	
	Lawrence Valley Creek 1992	100	Seeb and Crane 1999a	1,2,3
	Nelson/Sapsuck 1987	100	Wilmot et al. 1994	
	Moffitt Creek 1996	100	Seeb et al. 1997	3
	Joshua Green River 1992	80	Seeb and Crane 1999a	1,2,3
	Joshua Green River 1994	100	Seeb et al. 1997	3
	Frosty Creek 1992	100	Seeb and Crane 1999a	1,2,3
	Alligator Hole 1996	100	Seeb et al. 1997	3
	Trader's Cove Creek 1992	100	Seeb and Crane 1999a	1,2,3
	St. Catherine's Cove 1992	80	Seeb and Crane 1999a	1,2,3
	Peterson Lagoon 1992	86	Seeb and Crane 1999a	1,2,3
South Alaska Peninsula	Little John Lagoon 1992	87	Seeb and Crane 1999a	1,2,3
	Sandy Cove 1996	100	Seeb et al. 1997	3
	Russell Creek 1992	100	Seeb and Crane 1999a	1,2,3

Geographic Area	Population	N	Source	Baseline
	Russell Creek 1993	100	Seeb et al. 1997	3
	Delta Creek 1996	100	Seeb et al. 1997	3
	Belkofski River 1992	87	Seeb and Crane 1999a	1,2,3
	Volcano Bay 1992	64	Seeb et al. 1997	3
	Volcano Bay 1996	42	Seeb et al. 1997	3
	Ruby's Lagoon 1996	100	Seeb et al. 1997	3
	Canoe Bay 1992	100	Seeb and Crane 1999a	1,2,3
	Zachary Bay 1992	80	Seeb et al. 1997	3
	Coleman Creek 1996	100	Seeb et al. 1997	3
	Foster Creek 1992	100	Seeb et al. 1997	3
	Chichigof Bay 1996	100	Seeb et al. 1997	3
	Stepovak Bay 1992	50	Seeb et al. 1997	3
	Stepovak River 1993	100	Seeb and Crane 1999a	1,2,3
	Ivanoff River 1993	94	Seeb and Crane 1999a	1,2,3
	Portage Creek 1993	100	Seeb et al. 1997	3
	North Fork River 1993	72	Seeb et al. 1997	3
	North Fork Creek 1993	100	Seeb et al. 1997	3
	Main Creek	92	Seeb et al. 1997	3
	Chiginigak River 1993	75	Seeb and Crane 1999a	1,2,3
	Wide Bay 1993	100	Seeb and Crane 1999a	1,2,3
	E. Bear Bay Creek 1993	100	Seeb et al. 1997	3
	Alagoshak River 1993	95	Seeb and Crane 1999a	1,2,3
	Gull Cape Creek 1993	100	Seeb et al. 1997	3
	Big River 1993	100	Seeb and Crane 1999a	1,2,3
	McNeil River 1994	60	Seeb et al. 1997	3
	McNeil River 1996	49	Seeb et al. 1997	3
Kodiak Island	American River 1992	100	Seeb et al. 1997	3
	American River 1995	45	Seeb et al. 1997	3
	Dog Bay 1992	100	Seeb et al. 1997	3
	Big Sukhoi Creek 1992	100	Seeb and Crane 1999a	1,2,3
	Sturgeon River 1992	71	Seeb and Crane 1999a	1,2,3
	Kitoi Hatchery 1993	100	Seeb et al. 1997	3
	Uganik River 1992	100	Seeb et al. 1997	3
	Kizhuyak 1989	50	NMFS-ABL unpublished	
	Kizhuyak River 1992	88	Seeb and Crane 1999a	1,2,3
Upper Cook Inlet	Little Susitna 1989	40	NMFS-ABL unpublished	
	Little Susitna 1990	39	NMFS-ABL unpublished	
	Yentna/Lake Creek 1996	100	Seeb et al. 1997	3
	Susitna/Chunilna River 1993	87	Seeb and Crane 1999a	1,2,3
	Susitna/Slough 11 1996	100	Seeb et al. 1997	3
	Susitna/Talkeetna River 1995	50	Seeb et al. 1997	3
Prince William Sound	WHN Hatchery 1992	92	Seeb and Crane 1999a	1,2,3
	Wells River 1996	100	Seeb et al. 1997	3
	Olsen Creek 1992	100	Seeb et al. 1997	3
	Olsen Creek 1995	100	Seeb et al. 1997	3
	Olsen Bay Creek 1992	100	NMFS-ABL unpublished	
	Olsen Bay Creek 1997	50	NMFS-ABL unpublished	
	Constantine Creek 1994	100	Seeb et al. 1997	3
	Keta Creek 1992	100	Seeb et al. 1997	3
Southeast Alaska-wild	Alsek River, lower river slough, 2000	100	NMFS-ABL unpublished	
	Lynn Brothers 1988	50	Kondzela et al. 1994	
	Well's Bridge 2000	50	NMFS-ABL unpublished	

Geographic Area	Population	N	Source	Baseline
Well's Bridge 1991		40	NMFS-ABL unpublished	
Herman Creek 1987		100	Kondzela et al. 1994	1,2,3
Herman Creek 1990		59	Kondzela et al. 1994	1,2,3
Sawmill Creek 1993		20	NMFS-ABL unpublished	
Eagle River 1997		54	NMFS-ABL unpublished	
Taku River, lower river slough, 2000		45	NMFS-ABL unpublished	
Sawmill Creek 1993		80	NMFS-ABL unpublished	
Lace River 1995		25	NMFS-ABL unpublished	
Donkey Creek 1986		100	Kondzela et al. 1994	
Donkey Creek 1990		62	Kondzela et al. 1994	
Pybus Bay East 1989		65	Kondzela et al. 1994	
Gambier Bay SW 1989		27	Kondzela et al. 1994	
Gambier Bay SW 1990		40	Kondzela et al. 1994	
Eliza Harbor 1989		61	Kondzela et al. 1994	
Chaik Bay 1995		100	NMFS-ABL unpublished	
Hood Bay, N arm, E head, 1992		110	NMFS-ABL unpublished	
Hood Bay, N arm, E head, 1991		8	NMFS-ABL unpublished	
Greens Creek 1995		100	NMFS-ABL unpublished	
Humpback Creek 1994		102	NMFS-ABL unpublished	
Spasski Creek 1992		94	NMFS-ABL unpublished	
Spasski Creek 1991		51	NMFS-ABL unpublished	
Saltery River 1992		48	NMFS-ABL unpublished	
Saltery River 1991		53	NMFS-ABL unpublished	
Black Bay, N head, 1992		100	NMFS-ABL unpublished	
Black Bay, N head, 1991		100	NMFS-ABL unpublished	
Ford Arm, E head, 1994		9	NMFS-ABL unpublished	
Ushk Bay 1992		101	NMFS-ABL unpublished	
Ushk Bay 1991		45	NMFS-ABL unpublished	
Kennel Creek 1995		100	NMFS-ABL unpublished	
Long Bay 1992		103	NMFS-ABL unpublished	
Long Bay 1991		66	NMFS-ABL unpublished	
Lover's Cove Creek 1987		100	Kondzela et al. 1994	
Lover's Cove Creek 1990		31	Kondzela et al. 1994	
Saook Bay 1994		103	NMFS-ABL unpublished	
W. Crawfish Inlet 1994		50	NMFS-ABL unpublished	
W. Crawfish Inlet 1993		55	NMFS-ABL unpublished	
Whale Bay, head of Great Arm, 1993		100	NMFS-ABL unpublished	
Irish Creek 1986		98	Kondzela et al. 1994	
Elena Bay 1989		61	Kondzela et al. 1994	
Saginaw Creek 1995		97	NMFS-ABL unpublished	
Port Camden 1995		100	NMFS-ABL unpublished	
No Name Bay 1995		84	NMFS-ABL unpublished	
Port Beauclerc, S arm E, 1995		60	NMFS-ABL unpublished	
Gail Creek 1995		40	NMFS-ABL unpublished	
North Arm Creek 1987		81	Kondzela et al. 1994	
Harding River 1986		95	Kondzela et al. 1994	1,2,3
Kugel Creek 1986		104	Kondzela et al. 1994	1,2,3
Aiken Creek 1986		100	Kondzela et al. 1994	
Disappearance Creek 1986		100	Kondzela et al. 1994	1,2,3
Disappearance Creek 1988		100	Kondzela et al. 1994	1,2,3
Disappearance Creek 1998		100	NMFS-ABL unpublished	
Lagoon Creek 1986		102	Kondzela et al. 1994	1,2,3

Geographic Area	Population	N	Source	Baseline
	Old Tom Creek 1986	100	Kondzela et al. 1994	1,2,3
	Old Tom Creek 1988	53	Kondzela et al. 1994	1,2,3
	Old Tom Creek 1998	42	NMFS-ABL unpublished	
	Cabin Creek 1986	103	Kondzela et al. 1994	1,2,3
	Karta River 1986	100	Kondzela et al. 1994	
	Coco Harbor 1987	100	Kondzela et al. 1994	
	Coco Harbor 1998	100	NMFS-ABL unpublished	
	Breezy Bay 1986	100	Kondzela et al. 1994	
	Breezy Bay 1987	100	Kondzela et al. 1994	
	Breezy Bay 1988	54	Kondzela et al. 1994	
	Port Real Marina 1986	100	Kondzela et al. 1994	1,2,3
	Port Real Marina 1988	48	Kondzela et al. 1994	1,2,3
	Port Real Marina 1998	58	NMFS-ABL unpublished	
	Cruz Cove 1986	84	Kondzela et al. 1994	
	Cruz Cove 1987	56	Kondzela et al. 1994	
	Cruz Cove 1988	54	Kondzela et al. 1994	
	Cruz Cove 1998	64	NMFS-ABL unpublished	
	Token Creek 1986	101	Kondzela et al. 1994	
	Fish Creek 1986	100	Kondzela et al. 1994	1,2,3
	Fish Creek 1987	50	Kondzela et al. 1994	1,2,3
	Fish Creek 1988	52	Kondzela et al. 1994	1,2,3
	Tombstone River 1986	98	Kondzela et al. 1994	1,2,3
	Marten River 1986	105	Kondzela et al. 1994	1,2,3
	Keta River 1986	101	Kondzela et al. 1994	1,2,3
	Blossom River 1986	101	Kondzela et al. 1994	1,2,3
	Wilson River 1986	103	Kondzela et al. 1994	1,2,3
	Traitor River	100	Kondzela et al. 1994	
	Carroll River 1986	100	Kondzela et al. 1994	
	Portage Creek 1986	111	Kondzela et al. 1994	
	Portage Creek 1988	63	Kondzela et al. 1994	
	King Creek 1986	100	Kondzela et al. 1994	
	King Creek 1988	52	Kondzela et al. 1994	
	Klahini River 1986	102	Kondzela et al. 1994	
	Eulachon Creek 1986	90	Kondzela et al. 1994	
	Grant Creek 1986	127	Kondzela et al. 1994	
	Herman River 1986	100	Kondzela et al. 1994	
Southeast Alaska-hatchery	Gastineau Hatchery 1997	100	NMFS-ABL unpublished	
	Gastineau Hatchery 1998	200	NMFS-ABL unpublished	
	Sheep Creek Hatchery 1997	100	NMFS-ABL unpublished	
	Hidden Falls Hatchery 1997	150	NMFS-ABL unpublished	
	Medvejie Hatchery 1997	150	NMFS-ABL unpublished	
	Neets Bay Hatchery (summer) 1997	150	NMFS-ABL unpublished	
	Neets Bay Hatchery (fall) 1997	150	NMFS-ABL unpublished	
Canada				
Arctic	Peel River 1998	38	NMFS-ABL unpublished	
Yukon River	Fishing Branch 1987	129	Wilmot et al. 1994	
	Fishing Branch 1989	50	Wilmot et al. 1994	
	Fishing Branch 1992	100	USFWS unpublished	3
	Fishing Branch 1994	100	Seeb et al. 1997	3
	Big Creek 1987	70	Wilmot et al. 1994	
	Big Creek 1992	100	USFWS unpublished	3
	Big Creek 1995	100	Seeb et al. 1997	3

Geographic Area	Population	N	Source	Baseline
	Minto Slough 1989	100	Wilmot et al. 1994	
	Tatchun 1987	75	Wilmot et al. 1994	
	Tatchun 1992	98	USFWS unpublished	
	Pelly River 1993	84	Seeb et al. 1997	3
	Kluane River 1987	135	Wilmot et al. 1994	3
	Kluane River 1992	100	USFWS unpublished	3
	Donjek River 1994	74	Seeb et al. 1997	3
	Teslin River 1989	95	Wilmot et al. 1994	3
	Teslin River 1992	100	USFWS unpublished	3
British Columbia				
Queen Charlotte Islands	Awun River 1989	75	Kondzela et al. 1994	
	Mace Creek 1989	100	Kondzela et al. 1994	
	Peel Creek 1989	75	Kondzela et al. 1994	
	Tasu Creek 1989	100	Kondzela et al. 1994	
	Lagins Creek 1989	91	Kondzela et al. 1994	
	Deena River 1989	82	Kondzela et al. 1994	
	Pallant Creek 1988	100	Kondzela et al. 1994	1,2,3
	Lagoon Creek 1989	83	Kondzela et al. 1994	1,2,3
	Salmon River 1989	57	Kondzela et al. 1994	
	Sedgewick Creek 1989	74	Kondzela et al. 1994	1,2,3
	Bag Harbor Creek 1989	89	Kondzela et al. 1994	1,2,3
	Surprise Creek 1989	85	Kondzela et al. 1994	1,2,3
Northern British Columbia	Kshwan River 1988	88	Kondzela et al. 1994	1,2,3
	Kitsault River 1988	95	Kondzela et al. 1994	1,2,3
	Stagoo Creek 1988	75	Kondzela et al. 1994	1,2,3
	Stagoo Creek 1989	53	Kondzela et al. 1994	1,2,3
	Khutzeymateen River 1988	94	Kondzela et al. 1994	
	Toon River 1988	98	Kondzela et al. 1994	
	Ecstall River 1988	99	Kondzela et al. 1994	
	Kitimat River 1988	92	Kondzela et al. 1994	1,2,3
	Kitimat River 1989	100	Kondzela et al. 1994	1,2,3
	Mussel River 1989	31	Kondzela et al. 1994	1,2,3
	Neekas Creek 1989	54	Kondzela et al. 1994	
	Klownik Creek 1989	100	Kondzela et al. 1994	
	Nekite Channel 1989	100	Kondzela et al. 1994	1,2,3
	Nekite River 1989	97	Kondzela et al. 1994	1,2,3
Georgia Strait	Nanaimo River	100	Phelps et al. 1994	1,2,3
	Cowichan River	100	Phelps et al. 1994	1,2,3
	Chemainus River	100	Phelps et al. 1994	1,2,3
	Goldstream river	100	Phelps et al. 1994	1,2,3
	Big Qualicum FH	200	Phelps et al. 1994	1,2,3
	Little Qualicum	100	Phelps et al. 1994	1,2,3
	Puntledge FH	100	Phelps et al. 1994	1,2,3
	Cheakamus River	100	Phelps et al. 1994	
	Indian Arm	100	Phelps et al. 1994	
	Mamquam River	100	Phelps et al. 1994	
	Tzoonie River	100	Phelps et al. 1994	
	Sliammon FH	100	Phelps et al. 1994	
Fraser River	Alouette River	100	Phelps et al. 1994	1,2,3
	Stave River	100	Phelps et al. 1994	1,2,3
	Chilliwack-Vedder FH	100	Phelps et al. 1994	1,2,3
	Chehalis at Harrison FH	100	Phelps et al. 1994	1,2,3

Geographic Area	Population	N	Source	Baseline
	Inch Creek FH	100	Phelps et al. 1994	
	Weaver River	100	Phelps et al. 1994	1,2,3
	Chehalis FH	100	Phelps et al. 1994	1,2,3
	Harrison River	100	Phelps et al. 1994	1,2,3
	Squakum Creek	100	Phelps et al. 1994	1,2,3
	Wahleach Creek	100	Phelps et al. 1994	1,2,3
WCVI	Nitinat River and FH	380	Phelps et al. 1994	1,2,3
	Nahmint River	100	Phelps et al. 1994	1,2,3
	Sarita River	127	Phelps et al. 1994	1,2,3
Strait of Juan de Fuca	Sooke River	100	Phelps et al. 1994	
Washington				
Strait of Juan de Fuca	Deep Creek	100	Phelps et al. 1994	
	Lyre River	100	Phelps et al. 1994	
	Pysht River	255	Phelps et al. 1994	
	Salmon Creek	50	Phelps et al. 1994	
	Snow Creek	50	Phelps et al. 1994	
	Jimmycomelately Creek	100	Phelps et al. 1994	
Northern Puget Sound	Squire Creek	140	Phelps et al. 1994	
	Jim Creek	151	Phelps et al. 1994	
	Fortson Creek	211	Phelps et al. 1994	
	N.F. Stillaguamish River	140	Phelps et al. 1994	
	Skagit River	100	Phelps et al. 1994	
	Illabot Creek	98	Phelps et al. 1994	1,2,3
	Dan Creek	153	Phelps et al. 1994	1,2,3
	Finney Creek	41	Phelps et al. 1994	
	Samish FH	100	Phelps et al. 1994	
	Thomas Creek	101	Phelps et al. 1994	
	Bob Smith Creek	100	Phelps et al. 1994	
	Nooksack River	36	Phelps et al. 1994	
	Kendall FH	200	Phelps et al. 1994	
	Maple Creek	100	Phelps et al. 1994	
	Chuckanut Creek	35	Phelps et al. 1994	
	Schoolhouse Slough	100	Phelps et al. 1994	
	Wallace River	144	Phelps et al. 1994	
	Skykomish River	200	Phelps et al. 1994	
Southern Puget Sound	Swift Creek	250	Phelps et al. 1994	
	Perry Creek	350	Phelps et al. 1994	
	Elson Creek	350	Phelps et al. 1994	
	Carbon River	150	Phelps et al. 1994	
	Fennel Creek	100	Phelps et al. 1994	
	Skookum Creek	100	Phelps et al. 1994	
	Little Creek	51	Phelps et al. 1994	
	Reitdorf Creek	50	Phelps et al. 1994	
	Upper Skookum Creek	100	Phelps et al. 1994	
	Sherwood, Rocky, Coulter Cks,	106	Phelps et al. 1994	
	Mill Creek	179	Phelps et al. 1994	1,2,3
	Kennedy Creek	200	Phelps et al. 1994	
	Goldsborough Creek	200	Phelps et al. 1994	
	Chico Creek	196	Phelps et al. 1994	
	Gorst Creek	100	Phelps et al. 1994	
	Johns Creek FH	100	Phelps et al. 1994	
	Sherwood Creek	100	Phelps et al. 1994	

Geographic Area	Population	N	Source	Baseline	
Hood Canal	Coulter Creek FH	100	Phelps et al. 1994		
	Blackjack Creek	100	Phelps et al. 1994		
	Chambers Creek FH	100	Phelps et al. 1994		
	Nisqually River	300	Phelps et al. 1994		
	Big Mission Creek	67	Phelps et al. 1994		
	Little Mission Creek	53	Phelps et al. 1994		
	Big Beef Creek	100	Phelps et al. 1994		
	Dewatto River	263	Phelps et al. 1994		
	Tahuya River	83	Phelps et al. 1994		
	Enetai FH	100	Phelps et al. 1994		
	Hood Canal FH	450	Phelps et al. 1994	1,2,3	
	Lilliwaup Creek	100	Phelps et al. 1994		
	Walcott FH	100	Phelps et al. 1994		
	McKernan FH	100	Phelps et al. 1994		
	Big Quilcene FH	100	Phelps et al. 1994		
Coastal, Columbia River	Hamma Hamma River	186	Phelps et al. 1994		
	Dosewallips River	105	Phelps et al. 1994		
	Satsop River	100	Phelps et al. 1994		
	Wynoochee River	22	Phelps et al. 1994		
	Stevens Creek	100	Phelps et al. 1994		
	Ellsworth Creek	100	Phelps et al. 1994		
	Bitter Creek	100	Phelps et al. 1994		
	Hamilton Creek	100	Phelps et al. 1994		
	Grays River	100	Phelps et al. 1994		
	Coal Creek	100	Phelps et al. 1994		
	Hatcheries in other areas	Minter Creek FH	100	Phelps et al. 1994	
		Lower Elwah FH	100	Phelps et al. 1994	
		Tulalip FH GM	197	Phelps et al. 1994	
		Keta Creek FH	150	Phelps et al. 1994	
		Bellingham Maritime FH	100	Phelps et al. 1994	1,2,3
Hamma Hamma River		37	Phelps et al. 1994		
Quilcene Bay & FH		240	Phelps et al. 1994		
Lilliwaup Creek	120	Phelps et al. 1994			
Japan Honshu	Gakko River 1989	39	Winans et al. 1994	1,2,3	
	Gakko River 1994	40	Urawa unpublished		
	Gakko River 1997	46	Urawa unpublished		
	Miomote River 1989	100	Winans et al. 1994	1,2,3	
	Tsugaruishi River 1989	100	Winans et al. 1994	1,2,3	
	Tsugaruishi 1991	40	NMFS-ABL unpublished		
	Ohkawa River 1989	100	Winans et al. 1994	1,2,3	
	Kido River 1994	80	Urawa unpublished		
	Koizumi River 1996	80	Urawa unpublished		
	Naruse River 1995	80	Urawa unpublished		
	Katagishi 1991	40	NMFS-ABL unpublished		
	Katagishi River 1995	79	Urawa unpublished		
	Hei River 1996	46	Urawa unpublished		
	Orikasa River 1996	80	Urawa unpublished		
	Tedori River 1994	40	Urawa unpublished		
	Sho River 1994	80	Urawa unpublished		
	Kurobe River 1996	80	Urawa unpublished		
	Uono River 1995	80	Urawa unpublished		

Geographic Area	Population	N	Source	Baseline
Hokkaido	Teshio River 1987	97	Winans et al. 1994	1,2,3
	Chitose River 1989	100	Winans et al. 1994	1,2,3
	Chitose River 1990	80	Winans et al. 1994	1,2,3
	Tokachi River 1989	100	Winans et al. 1994	1,2,3
	Tokachi River 1990	80	Winans et al. 1994	1,2,3
	Kushiro River 1989	100	Winans et al. 1994	1,2,3
	Nishibetsu River 1989	100	Winans et al. 1994	1,2,3
	Shari River 1989	100	Winans et al. 1994	1,2,3
	Tokushibetsu River 1987	42	Winans et al. 1994	1,2,3
	Yurrapu River 1997	80	Urawa unpublished	
	Yurrapu River 1997	80	Urawa unpublished	
	Yurrapu River 1997	80	Urawa unpublished	
	Shikiu Riuver 1991	80	Urawa unpublished	
	Abashiri River 1998	80	Urawa unpublished	
	Yubetsu River 1992	80	Urawa unpublished	
	Masuhoro River 1987	80	Urawa unpublished	
	Yurrapu River 1989	100	Urawa unpublished	
	Tokoro River 1988	100	Urawa unpublished	
	Shibetsu River 1988	100	Urawa unpublished	
	China			
Amur River	Heilong River	50	Wilmot et al. 1995	2,3
	Suifen (Dongning Hatchery)	25	Wilmot et al. 1995	2
	Amur River 1997	58	ADF&G unpublished	
Russia				
Kuril Islands	Reidova River, Kuril Is. 1998	77	ADF&G unpublished	
	Reidova Bay 1998	76	ADF&G unpublished	
	Kons Bay 1998	35	ADF&G unpublished	
Premorye	Ryzanovka 1994	51	Wilmot et al. 1995	2,3
	Avakumovka 1994	35	Wilmot et al. 1995	2
	Narva 1994	18	Wilmot et al. 1995	2
Sakhalin Island	Kalininka 1994	49	Wilmot et al. 1995	2,3
	Naiba River 1995	100	Wilmot et al. 1995	2,3
	Udarnitsa 1994	98	Wilmot et al. 1995	2,3
	Tym River 1995	56	NMFS-ABL unpublished	
Anadyr River	Anadyr River 1991	104	Winans et al. 1994	1,2,3
	Anadyr River 1991	90	Wilmot et al. 1994	1,2
	Kanchalan River 1991	79	Wilmot et al. 1994	1,2,3
Northern Russia	Korf Bay 1991	18	Winans et al. 1994	1,2
	Ossora River 1990	40	Winans et al. 1994	
	Ossora 1996	40	NMFS-ABL unpublished	
	Nerpichi Lake 1991	40	Winans et al. 1994	1,2,3
	Kamchatka River 1990	80	Winans et al. 1994	1,2,3
	Kamchatka River 1991	40	Winans et al. 1994	1,2,3
	Adrianovka River 1991	36	Winans et al. 1994	
	Avacha River 1990	32	Winans et al. 1994	
	Avacha Bay 1991	26	Winans et al. 1994	
	Utka River 1991	79	Winans et al. 1994	1,2,3
	Kikchik River 1991	40	Winans et al. 1994	1,2,3
	Pymta River 1990	80	Winans et al. 1994	1,2,3
	Pymta River 1991	79	Winans et al. 1994	1,2,3
Pymta 1993	60	NMFS-ABL unpublished		
Kol River 1990	93	Winans et al. 1994	1,2,3	

Geographic Area	Population	N	Source	Baseline
Vorovskaia River 1991		40	Winans et al. 1994	
Vororskaya 1993		146	NMFS-ABL unpublished	
Hairusova River 1990		154	Winans et al. 1994	1,2,3
Harusova 1990		164	NMFS-ABL unpublished	
Harusova 1993		48	NMFS-ABL unpublished	
Gizhiginskaya Bay 1989		80	Winans et al. 1994	
Tumani River 1991		66	Winans et al. 1994	1,2,3
Tauy River 1990		57	Winans et al. 1994	
Magadan 1991		80	Wilmot et al. 1994	
Ola River 1990		80	Winans et al. 1994	1,2,3
Ola River 1991		80	Winans et al. 1994	1,2,3
Bolshaya River 1997		99	ADF&G unpublished	
Paratunka River 1998		100	ADF&G unpublished	
Bistraya River 1998		70	ADF&G unpublished	
Ozerki Hatchery 1998, Bistraya Broodstock		50	ADF&G unpublished	
Palana River 1998		98	ADF&G unpublished	
Oklan 1993		77	NMFS-ABL unpublished	
Penzhina 1993		50	NMFS-ABL unpublished	
Belaya 1993		40	NMFS-ABL unpublished	

Table 2. Loci and alleles pooled for Pacific Rim baseline for chum salmon.

Locus	Allele								
	1	2	3	4	5	6	7	8	9
sAAT-1,2*	100/113	120/125	65		84/80/95				
mAAT-1*	-100	-120/-110	-70						
mAH-3*	100/140	124	115						
ALAT*	100/fast	93	78						
ESTD*	100	91	110						
G3PDH-2*	100/132	90							
GPI-B1,2*	100	fast	40						
GPI-A*	100	slow	fast						
mIDHP-1*	100	60	140	20	85				
sIDHP-2*	100/65	35	85	25	20	110	28		45
LDH-A1*	100	50	110/0						
LDH-B2*	100/60	fast							
sMDH-A1*	100	200	400	10					
sMDH-B1,2*	100/110	72/85/95	50/20	fast>110					
mMEP-2*	100/75	122							
sMEP-1*	100	90							
MPI*	100	94/91/95	110	80/86		74			
PEPA*	100	90	113						
PEPB-1*	-100	-146	-126	-127	-72/-50				
PGDH*	100	88/84	104/106/110	95					