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# Status Report for Genetic Stock Identification Studies of Pacific Rim Sockeye Salmon

by

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## ABSTRACT

Sockeye salmon populations from the Pacific Rim form mixed-stock aggregations during their ocean residency. Identification of sockeye salmon harvested from these mixtures has been an ongoing challenge for management agencies. Classification methods based on environmentally mediated traits such as scale pattern analysis or parasite load are only marginally useful. Substantial allozyme baselines have been constructed and genetic stock identification methods based on these baselines have been used successfully. We report on the progress of integrating these baselines. The current allozyme baseline will eventually include allozyme data for as many as 51 loci from over 40,380 individuals from 280 sites ranging across the Pacific Rim from Washington State to Russia.


## INTRODUCTION

Sockeye salmon (*Oncorhynchus nerka)* from North America and Asia migrate into the North Pacific Ocean generally spending two to three years in the ocean before returning to their natal streams to spawn (Burgner 1991). The salmon form aggregations composed of numerous stocks during their ocean residency and freshwater migrations. Identification of stock compositions in mixtures of sockeye salmon caught in international waters, in the U.S. Exclusive Economic Zone, and in the major river systems leading to spawning tributaries, has been an ongoing challenge for fisheries biologists and management agencies throughout the Pacific Rim.

In Alaska, migrating sockeye salmon are harvested in fisheries including Bristol Bay, Alaska Peninsula, Kodiak Island, Cook Inlet, and Southeast Alaska. In addition, sockeye salmon have been harvested by foreign fishing vessels fishing illegally in international waters of the North Pacific (Wilmot et al. 1999, 2000). Identifying stock composition of fish within these legal and illegal fisheries is important to manage the fisheries, assess the effects of the fisheries on conservation, and to provide forensic information to law enforcement agencies.

Identifying stock compositions of mixed fisheries of sockeye salmon has been attempted with age and parasite composition analyses and genetic analyses. Age composition analyses have limited resolving power because of a lack of differences among stocks (Wilmot et al. 1999). Parasite composition data are limited by lack of differences especially within regions and by potential distribution changes in parasites since some studies were done 40 years ago (Wilmot et al. 1999). Although genetic data consisting of microsatellite, mtDNA, and minisatellite markers have been used to characterize the population genetic structure of sockeye salmon (Beacham et al. 1995; Seeb et al. 1998; Allendorf and Seeb 2000), only allozyme marker data exist from all areas of the Pacific Rim (Guthrie et al. 1994; Varnavskaya et al. 1994; Wood et al. 1994; Winans et al. 1996; Seeb et al. 2000). Allozymes have been used to successfully identify components of mixtures using genetic stock identification (GSI) methods in Cook Inlet, Alaska (Grant et al. 1980; Seeb et al. 2000). A limited set of allozyme loci has also been successfully used in GSI to identify the origin of sockeye salmon originating from throughout the Pacific Rim (Wilmot et al. 1999, 2000; Guthrie et al. 2000). Standardization of additional allozyme alleles and subsequent statistical analysis to determine reporting groups are needed to increase the power and assess the accuracy of the allozyme data to identify stock compositions of mixed fisheries throughout the Pacific Rim.

Developing a comprehensive for allozyme database from the North Pacific requires cooperation among all the laboratories collecting data on sockeye salmon. This database is in the process of being standardized among laboratories and will be maintained by National Marine Fisheries Service (NMFS; Auke Bay Lab (ABL), Juneau. We anticipate that it will eventually include allozyme data for as many as 51 loci from over 40,380 individuals from 280 sites ranging across the Pacific Rim from Washington State to Russia (Table 1). Data have been collected by the ABL, the NMFS Northwest Fisheries Science Center (NWFSC), Seattle, the Alaska Department of Fish and Game (ADF&G; Gene Conservation Lab (GCL), Anchorage); United

States Fish and Wildlife Service (USFWS; Alaska Fish and Wildlife Research Center (AFWRC), Anchorage); the Canadian Department of Fisheries and Oceans (CDFO; Pacific Biological Station (PBS), Nanaimo); and with assistance from the Pacific Research Institute of Fisheries and Oceanography in Kamchatka, Russia (Table 1). Additional data collection is ongoing by the GCL.

## PROGRESS TO DATE

Baseline Collections:

To date, the majority of collections have been analyzed (Table 1) using 51 loci (Table 2). Fifty-two additional sockeye salmon collections from Western Alaska and the Alaska Peninsula will be analyzed by the GCL (Table 1) by the fall of 2002.

Allele Standardization Within and Among Laboratories:

Alleles have been standardized within each participating laboratory, and standardization among laboratories is in progress. The ABL has completed standardization of allozyme alleles between itself and the AFWRC and PBS laboratories. The GCL and ABL have initiated standardization among remaining laboratories, and progress for each allele is presented in Table 3. First priority is aimed at alleles appearing at a frequency at or above 0.05 within any single collection. Alleles will be pooled for statistical analyses under two conditions: 1) if mobility differences are not replicable within or among laboratories or 2) if differences in mobility are minor and differentiation among alleles would to too complex. NWFSC has submitted samples to GCL for some alleles (Table 3), and laboratory analysis of these samples is pending.

Statistical Analyses:

After allozyme alleles have been standardized across laboratories, reporting groups will be delineated and simulations conducted to assess the accuracy and precision of the stock composition estimates following the methods of Teel et al. (1999).

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Table 1. Collection sites, data sources, and sample sizes for collected for allozyme tissue collections of anadromous sockeye salmon from Pacific Rim. Sites ordered alphabetically within regions or drainages which are ordered from West to East. Sources followed by an asterisk (*) indicate that the tissue collection has been made, but allozyme data collection is pending.

| Site | Source | N | Site | Source | N |
|---|---|---|---|---|---|
| **Japan** | | | | | |
| Abira River | 12 | 80 | | | |
| **Russia** | | | | | |
| Belia River | 5 | 90 | Kamchatka River | 5 | 80 |
| Bistraya River | 3 | 56 | Kamchatka River Early | 3 | 80 |
| Bolshaya River | 3 | 28 | Kamchatka River Late | 3 | 119 |
| Dvn-Yurta River | 5 | 91 | Kitilgina River Early | 3 | 28 |
| Etamink Bay | 12 | 50 | Kronoka Lake | 12 | 100 |
| Hairusova River | 5 | 150 | Kuril Lake | 5 | 249 |
| Hapiza River Early | 3 | 100 | North River | 12 | 53 |
| Hapiza River Late | 3 | 81 | Yelovka River | 5 | 110 |
| Irurup Island | 12 | 60 | | | |
| **Norton Sound** | | | | | |
| Salmon Lake | 3* | 100 | | | |
| **Kuskokwim Delta** | | | | | |
| Goodnews Weir | 1,3 | 174 | Kagati River | 1 | 50 |
| Stoney River | 1 | 75 | Kanektok River | 1 | 50 |
| **Togiak River** | | | | | |
| Gechiak Lake | 3* | 100 | Togiak River | 1 | 50 |
| Togiak Lake | 3* | 100 | | | |
| **Wood River** | | | | | |
| Agulowok River | 3* | 100 | Lake Kulik | 3* | 102 |
| Agulukpak River | 3* | 100 | Lynx Creek | 3* | 100 |
| Bear Creek | 3* | 150 | Pick Creek | 3* | 100 |
| Happy Creek | 3* | 107 | Wood River | 1 | 50 |

Table 1. continued.

| Site | Source | N | Site | Source | N |
|---|---|---|---|---|---|
| **Nushagak River** | | | | | |
| Allen River | 3* | 100 | Mulchatna River B | 3* | 65 |
| Allen River Beach | 3* | 100 | Nushagak River | 1 | 50 |
| Igushik River | 1 | 50 | Nuyakuk Lake (North Shore) | 3 | 100 |
| King Salmon River | 3* | 100 | Nuyakuk Lake (South Shore) | 3* | 100 |
| Klutapuk Creek | 3* | 100 | Nuyakuk River | 3* | 100 |
| Kogrukluk River | 3* | 100 | Stuyahok River | 3* | 100 |
| Koktuli River | 3 | 100 | Tikchik River | 3* | 100 |
| Lake Chauekuktuli (north shore) | 3* | 100 | Upper Nushagak River | 3* | 100 |
| Mulchatna River A | 3* | 100 | | | |
| **Kvichak River** | | | | | |
| Battle Creek | 1,3* | 150 | Knutson Bay | 3* | 100 |
| Bear Creek | 3* | 100 | Knutson Creek | 1 | 50 |
| Belinda Creek | 1 | 50 | Kulik Creek | 1,3* | 151 |
| Chinkelyes Creek | 3 | 98 | Lower Talarik Creek | 1,3 | 220 |
| Copper River | 1,2 | 101 | Moraine Creek | 3* | 100 |
| Dennis Creek | 3* | 100 | Nick N Creek | 3* | 100 |
| Dream Creek | 3* | 103 | Newhalen River | 1 | 50 |
| Finger Beach | 3 | 100 | Southeast Creek | 3* | 100 |
| Fuel Dump Island Beach | 2,3 | 148 | Tazimina River | 3* | 150 |
| Gibraltar Creek | 1,2 | 109 | Tommy Creek | 3* | 100 |
| Gibraltar River | 3 | 100 | Triangle Island | 3* | 100 |
| Iliamna River | 1,2 | 109 | Woody Island | 2,3* | 151 |
| Kijik Lake | 3 | 151 | | | |
| **Naknek River** | | | | | |
| American River | 3* | 100 | Margot Creek | 1,3* | 150 |
| Headwater Creek | 3* | 100 | Upatree Creek | 1,3 | 150 |
| Idavain Creek | 3 | 100 | | | |
| **Egegik River** | | | | | |
| Bear Creek | 1 | 50 | Featherly Creek | 1,3* | 150 |
| Becharof Creek | 3 | 100 | Franks Creek | 1 | 50 |
| Bible Creek | 1 | 50 | Kejulik River | 1,3* | 150 |
| Cabin Creek | 3 | 100 | Ruth River | 1,3* | 150 |
| Cleo Creek | 3* | 100 | | | |

Table 1. continued.

| Site | Source | N | Site | Source | N |
|---|---|---|---|---|---|
| **Ugashik River** | | | | | |
| Black Creek | 1 | 50 | Ugashik Narrows | 1,3 | 150 |
| Deer Creek | 1,3* | 150 | Ugashik Creek | 1,3* | 149 |
| Outlet Stream | 1,3 | 150 | | | |
| **Northern Alaska Peninsula** | | | | | |
| Bear River Late | 3 | 100 | Nelson River | 3* | 100 |
| Bear River Early | 1,3 | 175 | Ocean River | 3* | 100 |
| Hoodoo Lake (Sapsuk Lake) | 1,3 | 150 | Sandy Lake | 3 | 100 |
| Landlocked Creek | 3* | 72 | Willie Creek | 3* | 81 |
| **Aleutian Islands** | | | | | |
| Summer Bay Lake | 3 | 100 | | | |
| **Southern Alaska Peninsula** | | | | | |
| Alec River | 3 | 100 | Chignik River | 3 | 100 |
| Big Springs | 3 | 100 | Clark River October | 3 | 100 |
| Black Lake | 3 | 100 | Clark River September | 3 | 100 |
| Boulevard Creek | 3 | 100 | Fan Creek | 3 | 100 |
| Broad Creek | 3 | 100 | Hatchery Beach October | 3 | 100 |
| Chiaktuak Creek August | 3 | 100 | Hatchery Beach September | 3 | 100 |
| Chiaktuak Creek October | 3 | 50 | Orzinski Creek | 3 | 100 |
| Chiaktuak Creek September | 3 | 94 | West Fork | 3 | 100 |
| **Kodiak/Afognak Islands** | | | | | |
| Afognak Lake | 3 | 80 | Saltery Lake | 3 | 200 |
| Ayakulik River weir | 3 | 100 | Thumb River (lower) Late | 3 | 100 |
| Little Kitoi Lake | 3 | 100 | Thumb River (upper) Early | 3 | 100 |
| Little River Lake | 3 | 100 | Uganik Lake | 3 | 100 |
| Malina Creek | 3 | 80 | Upper Station (lower) Late | 3 | 100 |
| O'Malley River | 3 | 100 | Upper Station (upper) Early | 3 | 200 |
| Paul's Lake | 3 | 70 | Frazer Lake | 11 | 223 |
| Portage Lake | 3 | 100 | | | |
| **Western Cook Inlet** | | | | | |
| Beluga River | 4 | 100 | McArthur River | 4 | 100 |
| Chilligan River | 4 | 150 | Packers Lake | 4 | 200 |
| Coal Creek | 4 | 200 | Wolverine Creek | 4 | 100 |
| Crescent Lake | 4 | 250 | | | |

Table 1. continued.

| Site | Source | N | Site | Source | N |
|---|---|---|---|---|---|
| **Susitna River** | | | | | |
| Birch Creek | 4 | 100 | Red Shirt Lake | 4 | 34 |
| Byers Lake | 4 | 100 | Shell Lake | 4 | 200 |
| Chelatna Lake | 4 | 200 | Stephan Lake | 4 | 150 |
| Hewitt and Whiskey lakes | 4 | 100 | Susitna River sloughs | 4 | 156 |
| Judd Lake | 4 | 200 | Talkeetna River sloughs | 4 | 79 |
| Larson Creek | 4 | 200 | Trinity and Movie lakes | 4 | 200 |
| Mama and Papa Bear lakes | 4 | 50 | West Fork Yentna River | 4 | 200 |
| **Knik Arm** | | | | | |
| Big Lake | 4 | 95 | Jim Creek | 4 | 100 |
| Cottonwood Creek | 4 | 100 | Nancy Lake | 4 | 100 |
| Fish Creek | 4 | 300 | Sixmile Creek. | 4 | 100 |
| **North East Cook Inlet** | | | | | |
| Bishop Creek | 4 | 100 | Swanson River | 4 | 100 |
| Daniels Lake | 4 | 200 | | | |
| **Kenai River** | | | | | |
| Bear Creek | 3* | 100 | Ptarmigan Creek | 4 | 200 |
| Btwn Kenai/Skilak lakes site 1 | 4 | 100 | Quartz Creek | 4 | 200 |
| Btwn Kenai/Skilak lakes site 2 | 4 | 100 | Railroad Creek | 4 | 100 |
| Btwn Kenai/Skilak lakes site 3 | 4 | 150 | Russian River Weir Early | 4 | 100 |
| Btwn Kenai/Skilak lakes site 4 | 4 | 50 | Russian River Weir Late | 4 | 200 |
| Btwn Kenai/Skilak lakes site 5 | 4 | 100 | Russian River Below Falls | 4 | 100 |
| Btwn Kenai/Siklak lakes site 6 | 4 | 299 | Russian Lake Upper, Shore | 3* | 100 |
| Goat Creek | 3* | 100 | Russian Lake Upper, Outlet | 3* | 100 |
| Hidden Creek | 4 | 200 | Skilak Lake Outlet | 4 | 800 |
| Johnson Creek | 4 | 88 | Tern Lake | 4 | 150 |
| Moose Creek | 4 | 200 | | | |
| **Kasilof River** | | | | | |
| Bear Creek | 4 | 200 | Seepage Creek | 4 | 100 |
| Glacier Flats Creek | 4 | 300 | Tustumena Lake site 1 | 4 | 50 |
| Moose Creek | 4 | 200 | Tustumena Lake site 2 | 4 | 50 |
| Nikolai Creek | 4 | 200 | Tustumena Lake site 3 | 4 | 27 |

Table 1. continued.

| Site | Source | N | Site | Source | N |
|---|---|---|---|---|---|
| **South Kenai Peninsula** | | | | | |
| Delight River | 3 | 71 | English Bay | 3 | 300 |
| **Western Prince William Sound** | | | | | |
| Coghill Lake | 3 | 300 | Main Bay Hatchery Eshamy | 3 | 250 |
| Eshamy Lake | 3 | 100 | Main Bay Hatchery Eyak | 3 | 150 |
| Main Bay Hatchery Coghill | 3 | 400 | | | |
| **Eastern Prince William Sound** | | | | | |
| Bering Lake | 3 | 50 | Eyak Lake | 3 | 180 |
| Cordova | 3 | 31 | McKinley Lake | 3 | 100 |
| Erb Creek | 3 | 100 | Miners Lake | 3 | 100 |
| **Copper River** | | | | | |
| Gulkana Hatchery Broodstock | 3 | 16 | | | |
| **Southeastern Alaska** | | | | | |
| Alecks Lake | 5,6 | 154 | Luck Lake | 6 | 213 |
| Auke Lake | 5,6 | 216 | McDonald Lake | 5,6 | 407 |
| Benzeman Lake | 5 | 187 | Naha River | 5,6 | 384 |
| Chilkat Lake | 6 | 245 | Old Situk River | 5 | 106 |
| Chilkoot Lake | 6 | 137 | Red Bay Lake | 5,6 | 173 |
| Crescent Lake | 5,6 | 193 | Redfish Lake | 5 | 100 |
| East Alsek River | 5,6 | 178 | Redoubt Lake Beaches | 5 | 92 |
| Eva Lake | 5 | 100 | Redoubt Lake Outlet | 5 | 116 |
| Ford Arm Lake | 5 | 100 | Salmon Bay Lake | 5,6 | 258 |
| Hugh Smith Lake | 5,6 | 301 | Sitkoh Lake | 6 | 197 |
| Karta River | 5,6 | 302 | Situk Lake | 5,6 | 198 |
| Kegan Lake | 6 | 287 | Speel Lake | 5,6 | 200 |
| Klakas Lake | 6 | 159 | Steep Creek | 5,6 | 131 |
| Kook Lake | 5 | 100 | Tahltan Lake | 5,7 | 500 |
| Kutlaku Lake | 5,6 | 100 | Thoms Lake | 5,6 | 235 |
| Lace River | 5 | 59 | Upper Taku River | 6 | 421 |
| Little Tatsamenie Lake | 5,6,7 | 362 | Windfall Lake | 6 | 73 |
| Little Trapper | 5,6 | 308 | Yehring Creek | 6 | 217 |
| Lower Taku River | 6 | 80 | | | |

Table 1. continued.

| Site | Source | N | Site | Source | N |
|---|---|---|---|---|---|
| **British Columbia** | | | | | |
| Alastair Lake | 7,8 | 350 | Morrison River | 7,8 | 100 |
| Bear Lake | 7,8 | 152 | Nanika River | 7,8 | 126 |
| Bonney Lake | 7,8 | 280 | Owikeno Lake | 7,8 | 300 |
| Bowser Lake | 7,8 | 262 | Pierre Creek | 7,8,9 | 433 |
| Damdochax Lake | 7,8 | 299 | Pinkut River Channel | 7 | 1049 |
| Fulton River Channel | 7 | 1192 | Sustat River | 7 | 93 |
| Johnson Creek | 7 | 60 | Swan Lake | 7,8 | 100 |
| Kimsquit Lake | 7,8 | 100 | Tenas Lake | 7,8 | 100 |
| Klukshu Lake | 7 | 76 | Williams Creek | 7,8 | 279 |
| McDonnell Lake | 7,8 | 162 | | | |
| **Frasier River** | | | | | |
| Adams River | 7,8 | 100 | Middle River | 7 | 90 |
| Birkenhead River | 7 | 250 | Nadina Channel | 7 | 98 |
| Chilko Lake | 7 | 99 | Narrows Creek | 7 | 368 |
| Dust Creek | 7 | 101 | Shale Creek | 7 | 130 |
| Gates Channel | 7 | 99 | Shuswap River | 7,9 | 342 |
| Gluskie Creek | 7 | 42 | Stellako River | 7 | 100 |
| Horsefly River | 7,8 | 100 | Weaver Channel | 7 | 100 |
| Long Lake | 7 | 284 | | | |
| **Washington** | | | | | |
| Baker Lake | 9 | 80 | Okanagan River | 7,8,9 | 133 |
| Cedar River | 9 | 100 | Ozette Lake | 9 | 34 |
| Lake Washington | 9 | 100 | Quinault River | 10 | 93 |

Sources:
1 - W. J. Spearman, USFWS, Anchorage, AK (personal communication)
2 - Varnavskaya et al. (1994)
3 – Gene Conservation Lab, ADF&G, Anchorage, AK (unpublished data)
4 - Seeb et al. (2000)
5 - C. M. Guthrie, NMFS, Juneau, AK (unpublished data)
6 - Guthrie et al. (1994)
7 - Wood et al. (1994)
8 - C. Wood, CDFO, Nanaimo, BC (personal communication)
9 - Winans et al. (1996)
10 - G. A. Winans, NMFS, Seattle, WA (unpublished data)
11- F. Bowers, ADF&G, Dutch Harbor, AK (personal communication)
12 – Winans and Urawa (2000)

Table 2. Stain protocols used by ADF&G to resolve enzyme coding loci in Alaska sockeye salmon samples. Enzyme nomenclature follows Shaklee et al. (1990), and locus abbreviations are given.

| Enzyme or Protein | Enzyme Number | Locus | Tissue | Buffer |
|---|---|---|---|---|
| Aspartate aminotransferase | 2.6.1.1 | *sAAT-1,2** | H | ACE 7.2 |
| | | *sAAT-3** | E | TBCL |
| | | *mAAT-1** | H | ACE 7.2 |
| | | *mAAT-2** | L | ACE 7.0 |
| Aconitate hydratase | 4.2.1.3 | *mAH-1,2** | H | ACE 7.2 |
| | | *mAH-4** | H | ACE 7.2 |
| | | *sAH** | L | ACE 7.0 |
| Alanine aminotransferase | 2.6.1.2 | *ALAT** | M | KG |
| Creatine kinase | 2.7.3.2 | *CK-A2** | M | TBCLE |
| | | *CK-B** | E | ACE 7.0 |
| | | *CK-C1** | E | ACE 7.0 |
| | | *CK-C2** | E | ACE 7.0 |
| Formalin dehydrogenease | 1.2.1.1 | *FDHG** | L | TBE |
| Glyceraldehyde-3-phosphate | 1.2.1.12 | *GAPDH-2** | H | ACE 7.0 |
| Glycerol-3-phosphate dehydrogenase | 1.1.1.8 | *G3PDH-1,2** | M | ACE 7.0 |
| | | *G3PDH-3** | H | ACE 7.0 |
| | | *G3PDH-4** | H | ACE 7.0 |
| Glucose-6-phosphate isomerase | 5.3.19 | *GPI-B1,2** | M | TBCLE |
| | | *GPI-A** | M | TBCLE |
| L-Idditol dehydrogenase | 1.1.1.14 | *IDDH-1** | L | TBCL |
| | | *IDDH-2** | L | TBCL |

Table 2. continued.

| Enzyme or Protein | Enzyme Number | Locus | Tissue | Buffer |
|---|---|---|---|---|
| Isocitrate dehydrogenase (NADP+) | 1.1.1.42 | *mIDHP-1** | H | ACE 7.0 |
| | | *mIDHP-2** | H | ACE 7.0 |
| | | *sIDHP-1** | L | ACE 7.0 |
| | | *SIDHP-2** | L | ACE 7.0 |
| L-Lactate dehydrogenase | 1.1.1.27 | *LDHA-2** | M | ACE 7.0 |
| | | *LDHB-1** | M | TBCLE |
| | | *LDHB-2** | L | TBE |
| Malate dehydrogenase | 1.1.1.37 | *sMDH-A1,2** | H | ACN 7.0 |
| | | *sMDH-B1,2** | H | ACN 7.0 |
| Malic enzyme (NADP+) | 1.1.1.40 | *mMEP-1** | M | ACN 7.0 |
| Mannose-6-phosphate isomerase | 5.3.1.8 | *MPI** | L | TBE |
| Dipeptidase | 3.4.13.18 | *PEPA** | M | TBCL |
| Tripeptide aminopeptidase | 3.4.11.4 | *PEPB-1** | H | TBE |
| Peptidase-C | 3.4.-.- | *PEPC** | E | KG |
| Proline dipeptidase | 3.4.13.9 | *PEPD-2** | H | TBE |
| Peptidase-LT | 3.4.-.- | *PEPLT** | M | TBCLE |
| Phosphogluconate dehydrogenase | 1.1.1.44 | *PGDH** | L | ACE 7.0 |
| Phosphoglucomutase | 5.4.2.2 | *PGM-1** | H | ACE 7.2 |
| | | *PGM-2** | M | TBCLE |
| Superoxide dismutase | 1.15.1.1 | *sSOD-1** | L | TBE |
| Triose-phosphate isomerase | 5.3.1.1 | *TPI-1,2** | E | KG |
| | | *TPI-3** | E | KG |
| | | *TPI-4** | E | KG |

Table 3. Status of allozyme loci and variant alleles under standardization for a Pacific Rim sockeye salmon database. Loci previously used in mixed-stock analyses of seized vessels (Wilmot et al. 1999, 2000) and loci where incomplete data exist for British Columbia (B.C.) and Washington (WA) are indicated. Status notation: 1 – allele standardized between the GCL and the ABL; 2 – Allele did not meet minimum allele frequency criteria and was not standardized; 3 – Further investigation needed to standardize between GCL and ABL. Standardization between GCL and ABL and NWFSC is pending further investigation. Alleles for which samples have been sent from NWFSC to GCL are indicated with a carrot (^) after the allele in the status column.

| Locus | Previously used | Incomplete B.C. / WA | Allele | Status |
|---|---|---|---|---|
| *mAAT-1** | X | | -83 | 1 |
| *mAAT-2** | | | -73 | 1 |
| | | | -129 | pooled w/*100 |
| | | | -191 | 2 |
| *sAAT-1,2** | X | | 77 | 1 |
| | | | 122 | 1 |
| *sAAT-3** | | | 117 | 3 |
| *mAH-1,2** | | X | 75 | 3 |
| | | | 133 | 1 |
| | | | 65 | 3 |
| | | | 111 | 3 |
| *mAH-4** | | | 81 | 1 |
| | | | 114 | 1 |
| | | | 84 | pooled w/*81 |
| *sAH** | | | 117 | 1 |
| | | | 83 | 1 |
| | | | 75 | pooled w/*83 |
| | | | 65 | 3 |
| | | | 125 | 1 |

Table 3. continued

| Locus | Previously used | Incomplete B.C. / WA | Allele | Status |
|---|---|---|---|---|
| *ALAT** | X | | 91 | 1 |
| | | | 108 | 1 |
| | | | 86 | 2 |
| | | | 95 | 1 |
| *CK-A2** | | X | 125 | 2 |
| | | | 86 | 2 |
| *CK-B** | | | 102 | 2 |
| *CK-C1** | | | 78 | 2 |
| | | | 135 | 2^ |
| *CK-C2** | | X | 90 | 2 |
| *FDH** | | X | 108 | pooled w/*100 |
| | | | 128 | 2 |
| | | | 54 | 2 |
| *G3PDH-1,2** | | | -150 | 1^ |
| | | | -175 | pooled w/*150 |
| | | | 0 | 1 |
| | | | -213 | 1 |
| *G3PDH-3** | | | | |
| *G3PDH-4** | | | 108 | 1 |
| | | | 88 | pooled w/*100 |
| | | | 76 | 1 |
| *GAPDH-2** | | X | 50 | 3 |
| | | | 208 | 3 |
| *GPI-B1,2** | X | | 132 | 1 |
| | | | 143 | 1 |
| | | | -100 | 1 |

Table 3. continued

| Locus | Previously used | Incomplete B.C. / WA | Allele | Status |
|---|---|---|---|---|
| *GPI-A** | | X | 94 | pooled w/*86 |
| | | | 107 | 1 |
| | | | 86 | 1 |
| *mIDHP-1** | | | 33 | 1 |
| | | | 77 | pooled w/*33^ |
| *mIDHP-2** | | | | |
| *sIDHP-1** | X | | 72 | 1 |
| | | | 84 | 1^ |
| | | | 61 | 1 |
| | | | 118 | 1 |
| | | | 94 | pooled w/*100 |
| *sIDHP-2** | X | | 125 | 1 |
| | | | 92 | 2 |
| | | | 75 | 3 |
| | | | 115 | pooled w/*100 |
| | | | 143 | 1 |
| *LDH-A2** | | | 150 | 3^ |
| *LDH-B1** | X | | 123 | 3 |
| | | | 80 | 3 |
| *LDH-B2** | X | | 110 | 1 |
| | | | 85 | 2 |
| | | | 105 | 2 |
| *PEPA** | | | 106 | 1^ |
| | | | 92 | 2 |
| | | | 88 | 3 |
| *PEPB-1** | | | 130 | 1 |
| | | | 163 | pooled w/*130 |

Table 3. continued

| Locus | Previously used | Incomplete B.C. / WA | Allele | Status |
|---|---|---|---|---|
| *PEPC** | | | 105 | 1 |
| | | | 97 | 2 |
| *PEPD-2** | | X | 113 | 1 |
| | | | 94 | 2 |
| | | | 107 | pooled w/*113 |
| *PEPLT** | | | 88 | 1^ |
| | | | 114 | 3 |
| *sMDH-A1,2** | X | | 64 | 1 |
| | | | 46 | 1 |
| | | | 147 | 1 |
| *sMDH-B1,2** | X | | 65 | 1 |
| | | | 120 | 3^ |
| | | | 60 | 1 |
| | | | 116 | 3 |
| | | | 131 | 3 |
| | | | 105 | 2 |
| | | | 123 | 3 |
| | | | 128 | 3 |
| *mMEP-1** | | | 125 | 1 |
| | | | 80 | pooled w/*100 |
| | | | 58 | 1 |
| *MPI** | X | | 105 | 1 |
| | | | 91 | 1 |
| | | | 107 | pooled w/*105 |
| | | | 96 | 1 |
| *PGDH** | | | 90 | 1 |
| | | | 86 | pooled w/*90 |
| | | | 107 | 1 |

Table 3. continued

| Locus | Previously used | Incomplete B.C. / WA | Allele | Status |
|---|---|---|---|---|
| *PGM-1** | X | | null | 1 |
| | | | -180 | 1 |
| | | | -80 | 1 |
| *PGM-2** | X | | 136 | 1 |
| | | | 186 | 1 |
| | | | 57 | 1 |
| *sSOD-1** | X | | 160 | 2 |
| | | | 48 | 1 |
| | | | 75 | 1 |
| *TPI-1,2** | | X | 54 | 3 |
| | | | -173 | 3 |
| | | | -82 | 3 |
| *TPI-3** | | X | 110 | 2 |
| | | | 98 | 3 |
| *TPI-4** | | X | 106 | 3 |
| | | | 97 | 3 |
| | | | 105 | pooled w/*106^ |
| | | | 107 | pooled w/*106 |