Salmon stock identification using DNA technology

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Final Report, September 2011

A project funded by the Northern Boundary Restoration and Enhancement Fund 2010-2011.

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Abstract

Chinook salmon (*Oncorhynchus tshawytscha*) from 24 populations in northern British Columbia were surveyed for variation at 97 (96 nuclear, 1 mitochondrial) single nucleotide polymorphism (SNP) loci that included the suite (75 SNPs) incorporated in the Genetic Analysis of Pacific Salmon (GAPS) shared database. Observed heterozygosity ranged from 0.00 to 0.49, with the distribution of genotypes of the 96 nuclear SNPs in Hardy-Wienberg equilibrium. The average F_{ST} value was 0.064 among nuclear SNPs, with individual locus values ranging from 0.000 (*IKAROS-250*) to 0.306 (*ZNF330-181*). A regional population structure was observed, with populations clustering into geographic regions. The most distinctive regions were those incorporating populations from the Nass River and Central/North Coast. For the present, a combined microsatellite and SNP approach may be a practical approach to incorporating the power of both classes of markers in stock identification applications.

Introduction

Single nucleotide polymorphisms (SNPs) have been suggested as an alternative to microsatellites for salmon stock identification. The benefits of applying SNPs relative to microsatellites were suggested to be ease of data standardization among laboratories, high throughput, high among population diversity, lower genotyping errors, and lower cost of analysis per individual (Smith et al. 2005a, b). SNPs generally display only two alleles, and thus individual SNPs will be generally less powerful than individual microsatellites in stock identification applications. The lesser power of individual SNPs relative to microsatellites can be compensated by simply adding more SNPs to a GSI application so that equivalency in accuracy and precision of estimated stock compositions is obtained. Once the number of SNPs is determined, then evaluation of which technique produces the most cost effective method of stock identification can be conducted within individual laboratories. As a first step, it is necessary to develop a baseline for SNP variation for possible subsequent applications for estimation of stock composition in mixed-stock fishery samples. Accordingly, a proposal was developed to survey SNP variation in Chinook salmon (*Oncorhynchus tshawytscha*) populations in northern British Columbia.

The objectives of the current study, outlined in the project proposal, were:

1) For the 12 populations from northern British Columbia currently included in the analysis, the additional 24 SNPs included in the GAPS recommended set of 75 SNPs will be surveyed, as well as the 10 new SNPs developed in the MGL.
2) Ten new populations will be included in the survey, with these new populations being surveyed at the 75 GAPS SNPs, the additional 10 SNPs developed by the MGL, and the 10 SNPs from the initial survey that were not included in the GAPS list. Transboundary river populations would be a major emphasis in the survey.

The current report will outline the results of the survey of variation for 97 SNPs in 24 populations of Chinook salmon from northern British Columbia.

Methods

Collection of DNA samples and laboratory analysis

The sampling sites or populations surveyed in each geographic region are outlined in Table 1. The geographic locations of the populations listed in Table 1 are indicated in Figure 1. Tissue samples were collected from mature Chinook salmon in these populations, preserved in 95% ethanol, and sent to the Molecular Genetics Laboratory at the Pacific Biological Station. DNA was extracted from the tissue samples using a variety of methods, including a chelex resin protocol outlined by Small et al. (1998), a Qiagen 96-well Dneasy® procedure, or a Promega Wizard SV96 Genomic DNA Purification system. Once extracted DNA was available,

In general, PCR DNA amplifications were conducted using DNA Engine Cycler Tetrad2 (BioRad, Hercules, CA) in 6µl volumes consisting of 0.15 units of Taq polymerase, 1µl of extracted DNA, 1x PCR buffer (Qiagen, Mississauga, Ontario), 60µM each nucleotide, 0.40µM of each primer, and deionized H_2O. The thermal cycling profile involved one cycle of 15 minutes at 95°C, followed by 30 – 40 cycles of 20 seconds at 94°C, 30-60 seconds at 47 - 65°C and 30-60 seconds at 68 - 72°C (depending on the locus). Variation was analyzed at 95 nuclear and 1 mitochondrial SNPs, with primer and probe sequences outlined by Smith et al. (2005b, c, d), Smith et al. (2007), Campbell and Narum (2008), and Miller et al. (2008). The listing of all SNPs surveyed is outlined in Table 2. After PCR amplification, the plates (384-well) were read on an ABI

Prism 7900HT Sequence Detection System by one individual using Sequence Detection software from ABI. One SNP, *Ots_CI_A1*, required analysis on the automated sequencer, as it was an insertion or deletion, and as such a size variant. Repeatability of genotyping was evaluated by repeat PCR analysis and scoring of genotypes, with discrepancies in scoring observed in three genotypes of 21,408 genotypes scored across all loci evaluated, for a genotyping error rate of 0.01%. One SNP, C3N3, was mitochondrial in origin, and as such was not included in heterozygosity and Hardy-Weinberg equilibrium distribution analyses.

Data analysis

All annual samples available for a location were combined to estimate population allele frequencies, as was recommended by Waples (1990). Each population at each locus was tested for departure from Hardy-Weinberg equilibrium by using the software FSTAT version 2.9.3.2 (Goudet 1995). Critical significance levels for simultaneous tests were evaluated using Bonferroni adjustment (0.05/24=0.0021; Rice 1989). Weir and Cockerham's (1984) F_{st} estimates for each locus over all populations were calculated with FSTAT. The significance ($P<0.05$) of the multilocus F_{st} value over all samples was determined by jackknifing over loci. Cavalli-Sforza and Edwards (CSE) (1967) chord distance was used to estimate genetic distances among all populations. An unrooted neighbor-joining tree based upon CSE was generated using NJPLOT (Perriere and Gouy 1996).

Results and Discussion

Variation within populations

Two SNPs, *Ots_IKAROS-250* and *Ots_ZP3B_1* were observed to be monomorphic in all 24 populations surveyed (Table 2, 3). Other loci displayed very low frequency variation among all populations, with the frequency of variant alleles < 0.03 across populations (*Ots_CH97077-179R, Ots_CYP17, Ots_E9-BAC*). Private alleles were observed only at *Ots_CYP17* (Cranberry River population, relative frequency 0.01) (Table 3). The mean expected heterozygosity across all populations for the heterozygous SNPs surveyed ranged from 0.001 (*Ots_CYP17*) to 0.489 (*Ots_SWS1OP-182)*.

Genotypic disequilibrium was detected at specific pairs of SNP loci. The two SNPs at *Ots_FGF6* (*Ots_FGF6A, Ots_FGF6*) were significantly linked, as were the two SNPs at *Ots_HSP90B* (*Ots_HSP90B-100, Ots_HSP90B-385)*. Significant disequilibrium was also detected between *Ots_LWSop-638* and *Ots_OPLW173_1*, as well as between *Ots_CI-ISOT-Y* and *Ots_ETIF1A*.

Variation among populations

The average F_{ST} value was 0.064 among nuclear SNPs, with individual locus values ranging from 0.000 (*IKAROS-250*) to 0.306 (*ZNF330-181*) (Table 2). There were 17 SNPs where the observed F_{ST} value was greater than 0.15 (Table 2), and these would be the SNPs that would be the most useful in stock composition analysis. These SNPs were: *Ots_CH113457-40R, Ots_CI-GCSH-R-R, Ots_ENDORB1-486, Ots_ETIF1A, Ots_FARSLA-220, Ots_HSP90B-100, Ots_MHC1, Ots_MHC2, Ots_MYOD-364, Ots_NOD1, Ots_NRAMP-321, Ots_RAG3, Ots_RFC2-558, Ots_TAPBP, Ots_U202-161, Ots_U211-85,* and *Ots_ZNF330-181*.

The dendrogram analysis indicated that populations were arranged on a geographic basis, with groups corresponding to geographical regions, namely the North and Central coastal region, Skeena River, Nass River, Stikine River, and Taku River (Figure 1). The most distinctive regions were those incorporating populations from the Nass River and Central/North Coast.

Mixed-stock analysis

One important aspect of conducting the survey of SNP variation was the power of individual loci for genetic stock identification of mixed-stock samples. An analysis of the power of individual loci for stock identification in 60 British Columbia populations of Chinook salmon, including the 24 surveyed in the current study, has been outlined by Beacham et al. (in review). In that study, the 10 most powerful SNPs evaluated were: *Ots_FARSLA-220, Ots_MHC2, Ots_RFC2-558, Ots_u211-85, Ots_hnRNPL-533, Ots_U07-25-325, Ots_NRAMP-321, Ots_PGK-54, Ots_RAG3,* and *Ots_P450.* Individual F_{ST} values for these 10 loci were: 0.155, 0.264, 0.169, 0.124, 0.086, 0.027, 0.119, 0.044, 0.136, and 0.045, respectively (Table 2). Three of the loci (*Ots_U07-25-325, Ots_PGK-54, Ots_P450)* displayed F_{ST} values < 0.05, which indicated that these loci displayed greater difference among the 36 other populations surveyed by Beacham et al. (in review) than among the 24 populations surveyed in the current study. The SNP with the greatest observed differentiation in the current survey (*Ots_ZNF330-18*, F_{ST}=0.306), displayed less differentiation among populations when 60 populations were evaluated (F_{ST}= 0.189). Larger scale surveys of variation are valuable in order to evaluate the power of individual loci for population differentiation.

Accurate and precise regional estimates of stock compositions are generally the easiest to produce, followed in difficulty by population-specific estimates, with assignment of individuals to specific populations the more difficult problem. If population-level estimates of stock composition are required for some regions, then at least 180 SNPs of the average quality evaluated in the study would be required to provide population-specific accuracy and precision comparable to microsatellites (Beacham et al. in review). SNP arrays containing 100-200 loci were also estimated to be required to meet management standards for fine-scale resolution of Columbia River Chinook salmon (Hess et al. 2011). For the present, the combined microsatellite and SNP approach outlined by Narum et al. (2008) and Hess et al. (2011) may be a practical approach to incorporating the power of both classes of markers.

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Table 1. Regions, populations within regions, year of sampling, and sample sizes available in the survey of SNPs for 24 Chinook salmon populations in northern British Columbia.

Region	Population	Year	N
Central/North Coast	Wannock	1996	95
	Kitlope	2004, 2006	95
	Chuckwalla	2000, 2001, 2005	95
	Atnarko	1996	95
	Upper Dean	1996	95
	Kateen	2005	95
Skeena River	Lower Kitsumkalum	2001	95
	Bulkley	1999	95
	Morice	1995, 1996	95
	Bear	1991, 1995, 2005	80
	Sustut	2001	95
Nass River	Tseax	2002, 2006	95
	Cranberry	1997	79
	Damdochax	1997	95
	Kwinageese	1997	95
Stikine River	Christina	2002	95
	Craig	2001	95
	Verrett	2007	94
	Shakes	2001	95
	Little Tahltan	2004	95
Taku River	Little Tatsamenie	2005, 2007	190
	Nahlin	2006	95
	Nakina	2005	95
	Dudidontu	2005, 2006	95

Table 2. An index of genetic differentiation F_{ST} (SD in parentheses), expected heterozygosity (H_e), observed heterozygosity (H_o), and percent significant Hardy-Weinberg equilibrium tests for 96 nuclear SNPs (HWE, n=24 tests) among 24 Chinook salmon (*Oncorhynchus tshawytscha*) populations.

Locus	F_{ST}	H_e	H_o	HWE
Ots_ALDB1-122	0.062 (0.027)	0.136	0.130	0.0
Ots_ALDB-177M	0.050 (0.018)	0.253	0.255	0.0
Ots_ARF-188	0.014 (0.004)	0.019	0.019	0.0
Ots_ASNRS-60	0.037 (0.017)	0.412	0.414	4.2
Ots_ASPAT-196	0.048 (0.027)	0.011	0.010	0.0
Ots_CD59_2	0.026 (0.009)	0.441	0.432	0.0
Ots_CD63	0.023 (0.009)	0.474	0.466	0.0
Ots_CH113242-216	0.083 (0.026)	0.343	0.334	0.0
Ots_CH113457-40R	0.114 (0.028)	0.390	0.391	0.0
Ots_CH123048-521	0.045 (0.011)	0.333	0.342	0.0
Ots_CH128757-61R	0.070 (0.016)	0.366	0.363	0.0
Ots_CH94857-232R	0.028 (0.015)	0.346	0.337	0.0
Ots_CH94903-99R	0.014 (0.006)	0.433	0.439	0.0
Ots_CH96222-525	0.018 (0.006)	0.299	0.289	0.0
Ots_CH96500-180	0.073 (0.019)	0.421	0.421	0.0
Ots_CH96899-357R	0.084 (0.026)	0.409	0.401	0.0
Ots_CH97077-179R	0.012 (0.004)	0.004	0.004	0.0
Ots_CI_A1_ID	0.036 (0.021)	0.465	0.760	0.0
Ots_CI-1363-W	0.053 (0.016)	0.367	0.377	0.0
Ots_CI-1740-R	0.030 (0.010)	0.477	0.461	0.0
*Ots_CI-1803-K_*	0.078 (0.030)	0.291	0.281	0.0
Ots_CI-CIRPA-2-2	0.023 (0.009)	0.407	0.401	0.0
Ots_CI-GCSH-R-R	0.125 (0.066)	0.254	0.244	0.0
Ots_CI-ISOT-Y	0.048 (0.012)	0.149	0.148	4.2
*Ots_CI-OSTM1-1_*	0.025 (0.012)	0.390	0.384	0.0
*Ots_CI-PEMT-Y_*	0.060 (0.020)	0.470	0.382	4.2
*Ots_CI-PHOS-R_*	0.084 (0.042)	0.132	0.152	0.0
*Ots_CI-THIO-1_*	0.038 (0.020)	0.477	0.477	0.0
Ots_CMYC526	0.073 (0.022)	0.162	0.154	0.0
Ots_COX1-241	0.048 (0.013)	0.390	0.375	4.2
Ots_CYP17	0.001 (0.001)	0.001	0.000	0.0
Ots_E2-275	0.075 (0.028)	0.457	0.464	0.0
Ots_E9-BAC	0.013 (0.009)	0.003	0.001	0.0
Ots_ENDORB1-486	0.102 (0.024)	0.436	0.445	0.0
Ots_EP-529	0.019 (0.006)	0.042	0.042	0.0
Ots_ETIF1A	0.132 (0.039)	0.415	0.400	4.2
Ots_FARSLA-220	0.155 (0.045)	0.404	0.384	0.0
Ots_FGF6A	0.013 (0.005)	0.389	0.381	0.0
Ots_FGF6B	0.037 (0.012)	0.312	0.306	0.0
Ots_GDH-81X	0.038 (0.015)	0.437	0.432	0.0

Ots_GH2_1	0.043 (0.016)	0.172	0.165	0.0
Ots_GNRH-271	0.079 (0.020)	0.163	0.156	0.0
Ots_GPDH-338	0.035 (0.010)	0.057	0.055	0.0
Ots_GPH-318	0.018 (0.011)	0.248	0.256	0.0
Ots_GST-375	0.045 (0.011)	0.131	0.131	0.0
Ots_GTH2B-550	0.019 (0.006)	0.484	0.468	4.2
Ots_HGFA-446	0.012 (0.004)	0.017	0.016	0.0
Ots_hnRNPL-533	0.086 (0.019)	0.444	0.418	4.2
Ots_HSP90B-100	0.127 (0.049)	0.439	0.423	4.2
Ots_HSP90B-385	0.060 (0.016)	0.205	0.205	0.0
Ots_IGF-I-1-76	0.037 (0.015)	0.369	0.358	0.0
Ots_IKAROS-250	0.000 (0.000)	0.000	0.000	0.0
Ots_IL-11	0.050 (0.016)	0.448	0.435	4.2
Ots_IL8R-CS	0.054 (0.015)	0.451	0.453	0.0
Ots_LWSop-638	0.048 (0.016)	0.076	0.075	0.0
Ots_MHC1	0.167 (0.041)	0.404	0.413	0.0
Ots_MHC2	0.264 (0.054)	0.179	0.177	4.2
Ots_MYBP-85	0.073 (0.025)	0.326	0.320	0.0
Ots_MYC-366	0.020 (0.008)	0.151	0.150	0.0
Ots_MYO1-384	0.021 (0.006)	0.084	0.081	0.0
Ots_MYOD-364	0.122 (0.031)	0.346	0.337	0.0
Ots_NKEF-192	0.051 (0.020)	0.384	0.388	0.0
Ots_NOD1	0.141 (0.030)	0.421	0.410	0.0
Ots_NRAMP-321	0.119 (0.031)	0.282	0.291	0.0
Ots_OPLW173_1	0.047 (0.015)	0.075	0.076	0.0
Ots_OTS311-101X	0.025 (0.008)	0.146	0.142	0.0
Ots_P450	0.045 (0.014)	0.478	0.483	0.0
Ots_P53	0.041 (0.019)	0.472	0.447	0.0
Ots_PGK-54	0.044 (0.013)	0.164	0.162	0.0
Ots_PRL2	0.040 (0.015)	0.475	0.461	4.2
Ots_RAG3	0.136 (0.034)	0.423	0.419	0.0
Ots_RFC2-558	0.169 (0.089)	0.183	0.168	4.2
Ots_S7-1	0.029 (0.010)	0.483	0.482	4.2
Ots_SCLKF2R2-135	0.057 (0.014)	0.473	0.470	0.0
Ots_SERPC1-209	0.043 (0.015)	0.082	0.077	0.0
Ots_SL	0.023 (0.008)	0.424	0.424	0.0
Ots_SWS1OP-182	0.023 (0.009)	0.489	0.493	4.2
Ots_TAPBP	0.139 (0.031)	0.243	0.242	4.2
Ots_TCL1	0.046 (0.021)	0.478	0.458	4.2
Ots_TGFB1	0.033 (0.011)	0.424	0.419	0.0
Ots_TLR3	0.038 (0.016)	0.476	0.475	0.0
Ots_TNSF	0.052 (0.023)	0.452	0.443	0.0
Ots_u07-07-161	0.051 (0.027)	0.397	0.410	4.2
Ots_u07-17-373	0.015 (0.006)	0.070	0.066	0.0
Ots_u07-18-378	0.084 (0.035)	0.069	0.069	0.0
Ots_u07-25-325	0.027 (0.010)	0.298	0.300	0.0

Ots_u07-49-290	0.021 (0.009)	0.362	0.346	4.2
Ots_u07-53-133	0.048 (0.018)	0.375	0.365	0.0
Ots_U07-57-120	0.081 (0.027)	0.440	0.427	4.2
Ots_U202-161	0.138 (0.036)	0.404	0.398	4.2
Ots_U211-85	0.124 (0.026)	0.273	0.285	0.0
Ots_U212-158	0.012 (0.004)	0.159	0.164	0.0
Ots_U4-92	0.054 (0.021)	0.074	0.075	0.0
Ots_U6-75	0.034 (0.012)	0.305	0.313	0.0
Ots_ZNF330-181	0.306 (0.202)	0.048	0.033	0.0
Ots_ZP3B_1	0.000 (0.000)	0.000	0.000	0.0
Ots_ZR-575	0.041 (0.014)	0.442	0.394	0.0
Total	0.064 (0.005)	0.299	0.297	

Table 3. Sample sizes and allele frequencies of 97 SNPs in 24 populations of Chinook salmon in northern British Columbia. Allele frequencies derived from the VIC labelled primer are indicated.

Population	ALDB1-122		ALDB-177M		ARF-188		ASNRS-60		ASPAT-196		C3N3	
Atnarko	91	0.03	90	0.31	93	0.01	89	0.62	94	0.00	84	0.46
Chuckwalla	94	0.09	90	0.23	92	0.04	92	0.76	94	0.02	72	0.36
Kateen	93	0.06	94	0.11	95	0.00	84	0.57	94	0.00	91	0.63
Kitlope	94	0.08	94	0.20	95	0.00	95	0.74	95	0.00	93	0.44
Upper Dean	92	0.11	93	0.28	95	0.00	94	0.60	95	0.01	92	0.22
Wannock	95	0.23	95	0.22	93	0.00	95	0.95	95	0.00	94	0.79
Bear	78	0.02	74	0.09	64	0.03	73	0.73	66	0.02	47	0.51
Bulkley	95	0.01	95	0.39	94	0.03	95	0.48	95	0.00	94	0.57
Lower Kalum	95	0.14	94	0.14	95	0.02	94	0.74	95	0.00	74	0.43
Morice	90	0.02	83	0.14	91	0.04	87	0.67	92	0.00	69	0.71
Sustut	93	0.02	95	0.13	95	0.02	95	0.84	95	0.07	89	0.82
Cranberry	66	0.03	77	0.12	78	0.00	73	0.73	79	0.01	71	0.35
Damdochax	85	0.01	81	0.20	81	0.00	80	0.71	69	0.00	84	0.31
Kwinageese	94	0.00	86	0.20	91	0.00	85	0.76	82	0.00	85	0.29
Tseax	71	0.04	84	0.19	91	0.00	91	0.81	82	0.00	92	0.27
Christina	93	0.04	93	0.06	93	0.03	88	0.66	94	0.00	87	0.80
Craig	94	0.03	93	0.15	95	0.03	93	0.67	95	0.00	92	0.91
Little Tahltan	94	0.05	94	0.06	95	0.00	95	0.64	95	0.00	87	0.77
Shakes	91	0.07	94	0.07	94	0.00	91	0.64	95	0.00	91	0.75
Verrett	94	0.05	93	0.11	94	0.01	94	0.64	94	0.00	89	0.78
Dudidontu	95	0.05	94	0.09	93	0.00	93	0.63	95	0.00	89	0.98
Little Tatsamenie	94	0.07	95	0.07	189	0.00	182	0.71	95	0.00	155	0.85
Nahlin	94	0.05	94	0.13	94	0.00	95	0.63	93	0.00	84	0.90
Nakina	94	0.04	95	0.08	94	0.00	92	0.66	95	0.00	90	0.88

Population	CD59_2		CD63		CH113242-216		CH113457-40R		CH123048-521		CH128757-61R	
Atnarko	93	0.77	93	0.41	93	0.23	93	0.61	94	0.14	94	0.84
Chuckwalla	89	0.60	83	0.58	91	0.33	90	0.48	88	0.14	92	0.59
Kateen	94	0.55	94	0.46	93	0.15	94	0.47	94	0.19	94	0.67
Kitlope	95	0.46	93	0.50	95	0.36	93	0.68	95	0.17	95	0.68
Upper Dean	91	0.55	92	0.35	91	0.34	93	0.60	91	0.13	95	0.90
Wannock	94	0.56	95	0.32	95	0.54	92	0.55	95	0.37	95	0.92
Bear	67	0.69	68	0.38	79	0.14	74	0.26	76	0.20	78	0.76
Bulkley_Early	94	0.67	94	0.21	94	0.20	94	0.46	95	0.05	94	0.73
Lower Kalum	93	0.67	91	0.34	95	0.28	94	0.29	94	0.14	95	0.78
Morice	90	0.71	86	0.44	89	0.25	91	0.21	85	0.11	88	0.68
Sustut	94	0.62	90	0.29	94	0.06	93	0.27	94	0.31	93	0.55
Cranberry	71	0.85	70	0.43	77	0.08	73	0.22	73	0.21	77	0.63
Damdochax	85	0.72	67	0.44	85	0.02	86	0.26	91	0.11	86	0.57
Kwinageese	87	0.64	81	0.31	94	0.04	92	0.23	92	0.16	88	0.50
Tseax	75	0.71	77	0.51	71	0.11	72	0.19	73	0.25	68	0.51
Christina	89	0.59	94	0.44	89	0.32	92	0.20	92	0.40	92	0.80
Craig	92	0.63	90	0.47	91	0.36	93	0.22	92	0.30	95	0.88
Little Tahltan	95	0.63	95	0.39	94	0.40	95	0.25	95	0.35	95	0.75
Shakes	94	0.70	87	0.40	89	0.30	93	0.27	92	0.27	94	0.82
Verrett	91	0.55	94	0.51	93	0.37	93	0.25	94	0.30	94	0.84
Dudidontu	95	0.74	87	0.36	95	0.22	95	0.13	94	0.27	95	0.85
Little Tatsamenie	93	0.75	88	0.44	94	0.35	94	0.25	93	0.24	95	0.77
Nahlin	92	0.64	92	0.46	90	0.26	91	0.18	90	0.26	94	0.80
Nakina	91	0.70	95	0.46	93	0.25	94	0.21	93	0.32	94	0.75

Table 3 continued

Population	CH94857-232R		CH94903-99R		CH96222-525		CH96500-180		CH96899-357R		CH97077-179R	
Atnarko	93	0.20	94	0.28	95	0.77	92	0.37	93	0.07	94	1.00
Chuckwalla	94	0.12	93	0.23	93	0.86	90	0.60	93	0.08	93	0.98
Kateen	93	0.24	94	0.27	93	0.82	95	0.46	93	0.11	93	0.98
Kitlope	94	0.28	95	0.26	94	0.77	95	0.41	94	0.10	95	0.99
Upper Dean	93	0.24	91	0.27	94	0.86	93	0.57	95	0.08	95	1.00
Wannock	95	0.02	95	0.47	94	0.84	87	0.54	94	0.32	95	1.00
Bear	79	0.23	79	0.37	78	0.87	65	0.80	79	0.42	79	1.00
Bulkley	94	0.23	95	0.20	95	0.70	94	0.81	94	0.23	95	1.00
Lower Kalum	95	0.29	95	0.40	94	0.86	95	0.54	95	0.31	95	1.00
Morice	92	0.15	83	0.32	93	0.89	85	0.55	84	0.39	93	1.00
Sustut	94	0.18	94	0.34	93	0.85	94	0.60	93	0.39	93	1.00
Cranberry	76	0.18	74	0.24	76	0.92	71	0.74	78	0.51	78	1.00
Damdochax	93	0.19	85	0.31	90	0.81	80	0.66	90	0.33	95	1.00
Kwinageese	90	0.22	88	0.32	94	0.85	91	0.64	92	0.40	95	1.00
Tseax	74	0.30	70	0.31	74	0.93	74	0.84	70	0.44	74	1.00
Christina	94	0.26	92	0.34	92	0.78	91	0.79	93	0.39	94	1.00
Craig	95	0.30	92	0.35	93	0.78	94	0.80	92	0.42	95	1.00
Little Tahltan	95	0.24	95	0.37	94	0.77	95	0.78	94	0.46	95	1.00
Shakes	93	0.30	92	0.36	94	0.77	93	0.69	93	0.42	95	1.00
Verrett	94	0.23	94	0.31	93	0.76	94	0.79	94	0.43	94	1.00
Dudidontu	95	0.41	95	0.44	95	0.73	95	0.74	95	0.42	95	1.00
Little Tatsamenie	94	0.19	93	0.38	94	0.80	93	0.68	95	0.44	94	1.00
Nahlin	94	0.30	93	0.33	93	0.76	91	0.68	94	0.43	94	1.00
Nakina	92	0.26	93	0.34	94	0.74	92	0.65	93	0.43	93	1.00

Population	CI_A1		CI-1363-W		CI-1740-R		CI-1803-K		CI-CIRPA-2-2		CI-GCSH-R-R	
Atnarko	89	0.39	93	0.18	92	0.32	94	0.50	93	0.41	93	0.76
Chuckwalla	74	0.43	92	0.17	92	0.34	91	0.76	90	0.43	92	0.71
Kateen	89	0.47	95	0.16	95	0.43	94	0.81	95	0.38	95	0.79
Kitlope	93	0.44	93	0.23	95	0.53	94	0.76	95	0.41	94	0.68
Upper Dean	89	0.34	94	0.25	93	0.45	93	0.84	92	0.30	91	0.75
Wannock	94	0.50	94	0.02	94	0.50	94	0.54	95	0.48	95	0.36
Bear	70	0.38	76	0.23	73	0.41	60	0.85	67	0.22	57	0.89
Bulkleyy	86	0.39	94	0.42	94	0.41	94	0.58	95	0.19	94	0.98
Lower Kalum	91	0.54	95	0.22	95	0.33	94	0.89	94	0.30	90	0.71
Morice	72	0.38	87	0.23	89	0.50	86	0.87	81	0.25	87	0.89
Sustut	94	0.10	95	0.43	95	0.29	95	0.92	95	0.25	87	0.94
Cranberry	61	0.39	77	0.12	77	0.64	77	0.92	74	0.24	78	0.88
Damdochax	65	0.38	78	0.21	81	0.63	78	0.87	74	0.26	78	0.88
Kwinageese	79	0.39	91	0.15	89	0.57	83	0.84	80	0.29	92	0.92
Tseax	91	0.44	85	0.25	82	0.36	77	0.79	82	0.32	83	0.84
Christina	85	0.36	91	0.34	95	0.42	92	0.82	92	0.29	87	0.78
Craig	94	0.34	91	0.25	94	0.38	94	0.80	92	0.24	92	0.80
Little Tahltan	93	0.41	68	0.41	74	0.43	79	0.82	87	0.30	76	0.91
Shakes	88	0.36	91	0.41	89	0.34	90	0.88	91	0.26	93	0.91
Verrett	91	0.35	93	0.22	93	0.34	94	0.85	94	0.25	93	0.81
Dudidontu	94	0.39	93	0.38	93	0.39	94	0.85	95	0.23	93	0.89
Little Tatsamenie	95	0.43	95	0.32	95	0.46	95	0.88	94	0.20	93	0.91
Nahlin	94	0.41	93	0.38	94	0.51	92	0.84	95	0.28	91	0.93
Nakina	94	0.62	93	0.34	93	0.43	93	0.88	95	0.27	95	0.95

Table 3 continued

Population	CI-ISOT-Y		CI-OSTM1-1		CI-PEMT-Y		CI-PHOS-R		CI-THIO-1		CMYC526	
Atnarko	92	0.98	95	0.35	94	0.58	95	0.01	95	0.60	94	0.97
Chuckwalla	90	0.85	93	0.26	89	0.49	84	0.20	90	0.59	87	1.00
Kateen	95	0.97	95	0.32	95	0.43	95	0.12	95	0.59	95	0.93
Kitlope	94	0.91	95	0.32	95	0.37	94	0.15	95	0.52	95	0.87
Upper Dean	92	0.98	90	0.30	91	0.57	93	0.04	94	0.40	92	0.95
Wannock	95	1.00	93	0.48	95	0.21	94	0.35	94	0.74	94	0.97
Bear	61	0.91	68	0.23	76	0.52	64	0.04	78	0.59	56	0.92
Bulkley_Early	92	0.99	94	0.11	91	0.65	93	0.00	95	0.66	95	0.72
Lower Kalum	95	0.95	95	0.32	93	0.53	95	0.03	95	0.54	95	0.94
Morice	85	0.89	88	0.28	84	0.60	87	0.01	83	0.63	89	0.93
Sustut	95	0.78	95	0.17	95	0.46	94	0.01	95	0.23	93	0.97
Cranberry	78	0.99	71	0.27	75	0.26	77	0.04	73	0.64	77	0.89
Damdochax	86	0.99	84	0.27	78	0.24	83	0.07	82	0.66	77	0.82
Kwinageese	88	0.99	90	0.16	84	0.33	87	0.05	89	0.65	87	0.75
Tseax	79	0.99	90	0.17	90	0.44	94	0.03	93	0.51	92	0.70
Christina	93	0.88	94	0.28	89	0.57	87	0.10	93	0.54	89	0.96
Craig	94	0.87	94	0.37	91	0.66	91	0.08	95	0.58	92	0.90
Little Tahltan	74	0.88	76	0.29	89	0.53	87	0.09	85	0.48	95	0.94
Shakes	93	0.85	92	0.29	88	0.61	91	0.09	91	0.51	92	0.92
Verrett	93	0.87	92	0.30	90	0.60	92	0.03	94	0.52	94	0.88
Dudidontu	94	0.85	95	0.24	94	0.51	95	0.03	93	0.44	94	0.95
Little Tatsamenie	95	0.86	94	0.23	94	0.55	95	0.07	95	0.55	188	0.96
Nahlin	94	0.89	93	0.32	91	0.62	91	0.10	87	0.53	93	0.96
Nakina	95	0.83	94	0.28	91	0.60	94	0.13	93	0.49	94	0.92

Population	COX1-241		CYP17		E2-275		E9-BAC		ENDORB1-486		EP-529	
Atnarko	93	0.60	94	0.00	93	0.51	95	0.00	93	0.23	95	0.96
Chuckwalla	89	0.74	95	0.00	85	0.51	92	0.00	93	0.34	95	1.00
Kateen	93	0.72	95	0.00	95	0.61	94	0.00	90	0.19	95	0.99
Kitlope	95	0.66	95	0.00	95	0.51	95	0.00	95	0.27	95	0.97
Upper Dean	90	0.54	95	0.00	91	0.42	95	0.00	94	0.45	95	0.99
Wannock	95	0.66	95	0.00	95	0.77	95	0.00	91	0.25	95	0.98
Bear	61	0.73	56	0.00	66	0.36	55	0.00	76	0.54	79	1.00
Bulkley	95	0.78	95	0.00	95	0.75	95	0.00	87	0.43	95	1.00
Lowr Kalum	95	0.61	95	0.00	94	0.55	95	0.00	95	0.37	95	0.99
Morice	87	0.81	94	0.00	81	0.49	94	0.00	83	0.46	94	1.00
Sustut	95	0.61	94	0.00	95	0.46	95	0.00	89	0.58	94	0.94
Cranberry	78	0.72	78	0.01	74	0.34	79	0.00	68	0.67	79	0.99
Damdochax	72	0.56	91	0.00	68	0.32	80	0.01	75	0.68	91	0.99
Kwinageese	81	0.73	92	0.00	87	0.32	90	0.02	90	0.73	95	1.00
Tseax	85	0.54	91	0.00	93	0.35	95	0.00	65	0.72	79	0.99
Christina	93	0.88	94	0.00	87	0.45	95	0.00	92	0.32	93	0.97
Craig	95	0.89	95	0.00	92	0.29	95	0.00	89	0.24	95	0.93
Little Tahltan	95	0.81	95	0.00	94	0.42	95	0.00	89	0.31	94	0.97
Shakes	87	0.70	92	0.00	89	0.36	92	0.00	88	0.39	95	0.93
Verrett	93	0.89	91	0.00	94	0.18	94	0.00	94	0.23	94	0.98
Dudidontu	95	0.67	95	0.00	94	0.39	94	0.00	94	0.40	95	0.99
Little Tatsamenie	94	0.79	189	0.00	187	0.33	190	0.00	93	0.56	94	0.97
Nahlin	93	0.72	95	0.00	93	0.37	94	0.00	95	0.27	95	0.98
Nakina	94	0.78	95	0.00	95	0.32	95	0.00	90	0.39	94	0.95

Table 3 continued

Population	ETIF1A		FARSLA-220		FGF6A		FGF6B		GDH-81X		GH2_1	
Atnarko	89	0.56	92	0.56	94	0.31	94	0.74	95	0.24	95	0.03
Chuckwalla	91	0.36	91	0.64	86	0.33	92	0.66	90	0.34	93	0.09
Kateen	92	0.35	93	0.58	95	0.38	95	0.75	95	0.30	95	0.07
Kitlope	95	0.63	94	0.75	95	0.29	95	0.67	95	0.29	94	0.07
Upper Dean	95	0.68	93	0.44	92	0.32	94	0.78	93	0.44	95	0.03
Wannock	94	0.85	95	0.84	95	0.39	94	0.79	95	0.19	95	0.00
Bear	76	0.33	61	0.31	53	0.19	79	0.73	78	0.36	78	0.10
Bulkley	95	0.48	95	0.32	95	0.38	95	0.88	94	0.27	95	0.05
Lower Kalum	94	0.71	95	0.41	95	0.27	95	0.64	95	0.29	95	0.08
Morice	86	0.33	91	0.25	91	0.21	83	0.73	93	0.27	88	0.16
Sustut	95	0.16	95	0.41	94	0.31	95	0.82	94	0.37	95	0.09
Cranberry	69	0.29	77	0.42	77	0.23	73	0.91	76	0.52	72	0.21
Damdochax	77	0.33	69	0.40	81	0.17	92	0.95	87	0.57	87	0.23
Kwinageese	85	0.32	87	0.43	83	0.24	92	0.96	90	0.59	91	0.27
Tseax	94	0.19	85	0.47	94	0.22	76	0.91	72	0.42	76	0.11
Christina	92	0.29	92	0.35	92	0.24	92	0.85	92	0.26	94	0.11
Craig	93	0.30	94	0.31	93	0.23	94	0.84	93	0.29	95	0.15
Little Tahltan	94	0.26	95	0.16	93	0.26	95	0.80	95	0.30	95	0.08
Shakes	91	0.32	93	0.15	90	0.20	91	0.76	92	0.34	94	0.10
Verrett	94	0.31	94	0.20	94	0.30	94	0.83	94	0.29	94	0.11
Dudidontu	94	0.26	94	0.16	94	0.28	95	0.77	95	0.29	95	0.02
Little Tatsamenie	190	0.52	95	0.15	190	0.22	93	0.77	94	0.37	93	0.08
Nahlin	93	0.22	94	0.24	95	0.26	95	0.82	95	0.39	94	0.07
Nakina	95	0.24	95	0.17	93	0.23	93	0.76	92	0.36	92	0.08

Population	GNRH-271		GPDH-338		GPH-318		GST-375		GTH2B-550	
Atnarko	93	0.03	94	0.03	94	0.13	95	0.02	93	0.48
Chuckwalla	91	0.02	93	0.05	92	0.13	90	0.04	89	0.63
Kateen	94	0.11	94	0.11	94	0.15	94	0.06	95	0.70
Kitlope	95	0.14	91	0.12	93	0.17	95	0.02	95	0.71
Upper Dean	94	0.08	93	0.10	94	0.11	92	0.10	93	0.52
Wannock	95	0.03	94	0.00	95	0.14	94	0.00	95	0.68
Bear	45	0.13	63	0.01	78	0.19	77	0.06	53	0.56
Bulkleyy	91	0.00	95	0.00	95	0.15	95	0.01	95	0.52
Lower Kalum	95	0.05	94	0.01	95	0.22	95	0.04	95	0.64
Morice	92	0.03	91	0.00	88	0.33	88	0.05	85	0.59
Sustut	95	0.01	95	0.00	95	0.20	95	0.00	95	0.56
Cranberry	77	0.02	77	0.03	73	0.18	77	0.03	72	0.44
Damdochax	72	0.04	87	0.00	75	0.12	92	0.03	70	0.46
Kwinageese	78	0.01	94	0.00	90	0.18	92	0.05	81	0.46
Tseax	91	0.01	93	0.01	84	0.08	75	0.05	94	0.48
Christina	92	0.21	94	0.02	93	0.11	92	0.15	91	0.57
Craig	95	0.16	94	0.02	95	0.09	95	0.16	88	0.51
Little Tahltan	94	0.16	94	0.04	95	0.12	95	0.15	95	0.56
Shakes	93	0.22	94	0.03	92	0.14	90	0.16	90	0.57
Verrett	92	0.13	94	0.05	94	0.08	94	0.11	94	0.44
Dudidontu	95	0.11	94	0.04	95	0.18	95	0.12	94	0.53
Little Tatsamenie	187	0.27	189	0.01	93	0.10	93	0.20	190	0.62
Nahlin	94	0.20	95	0.03	93	0.14	94	0.08	94	0.57
Nakina	93	0.17	95	0.04	95	0.12	94	0.10	94	0.57

Table 3 continued

Population	HGFA-446		HNRNPL-533		HSP90B-100		HSP90B-385		IGF-I-1-76		IKAROS-250	
Atnarko	92	0.00	91	0.55	94	0.59	93	0.26	93	0.27	94	0.00
Chuckwalla	95	0.04	87	0.34	91	0.85	91	0.29	89	0.17	95	0.00
Kateen	94	0.04	90	0.39	92	0.60	94	0.19	95	0.16	95	0.00
Kitlope	95	0.00	91	0.38	92	0.65	94	0.20	95	0.15	95	0.00
Upper Dean	94	0.00	92	0.42	93	0.56	91	0.18	94	0.16	95	0.00
Wannock	95	0.00	95	0.34	95	0.94	95	0.32	95	0.02	95	0.00
Bear	69	0.00	64	0.65	65	0.32	67	0.19	53	0.21	65	0.00
Bulkley	95	0.00	95	0.54	95	0.22	95	0.01	95	0.39	95	0.00
Lower Kalum	95	0.00	94	0.65	94	0.47	95	0.16	94	0.16	95	0.00
Morice	90	0.00	89	0.62	89	0.31	88	0.04	91	0.21	93	0.00
Sustut	95	0.00	94	0.57	95	0.45	94	0.18	95	0.38	95	0.00
Cranberry	79	0.01	78	0.53	73	0.50	77	0.08	77	0.34	77	0.00
Damdochax	74	0.00	78	0.54	78	0.47	71	0.06	76	0.32	89	0.00
Kwinageese	91	0.00	81	0.53	84	0.35	90	0.08	81	0.36	94	0.00
Tseax	94	0.00	84	0.73	85	0.39	76	0.10	92	0.37	93	0.00
Christina	92	0.03	90	0.77	91	0.42	92	0.05	90	0.27	92	0.00
Craig	95	0.02	95	0.55	94	0.53	95	0.06	95	0.24	95	0.00
Little Tahltan	95	0.01	95	0.82	95	0.34	95	0.07	95	0.27	95	0.00
Shakes	93	0.03	92	0.72	90	0.37	95	0.07	91	0.27	94	0.00
Verrett	94	0.01	94	0.54	91	0.52	94	0.09	92	0.22	94	0.00
Dudidontu	95	0.01	94	0.74	95	0.21	95	0.08	95	0.37	94	0.00
Little Tatsamenie	189	0.01	95	0.80	95	0.29	95	0.09	188	0.27	188	0.00
Nahlin	95	0.01	93	0.74	94	0.33	94	0.06	94	0.33	94	0.00
Nakina	93	0.01	95	0.76	95	0.37	95	0.08	94	0.26	95	0.00

Population	IL-11		IL8R-CS		LWSOP-638		MHC1		MHC2		MYBP-85	
Atnarko	94	0.48	93	0.25	94	0.00	94	0.26	94	0.57	93	0.20
Chuckwalla	86	0.55	90	0.49	92	0.07	92	0.30	88	0.29	94	0.28
Kateen	94	0.41	91	0.43	95	0.10	93	0.31	92	0.38	93	0.25
Kitlope	95	0.45	95	0.32	95	0.15	95	0.21	93	0.53	95	0.21
Upper Dean	93	0.42	95	0.18	95	0.01	91	0.42	90	0.26	93	0.28
Wannock	95	0.61	95	0.15	95	0.00	95	0.54	93	0.31	94	0.43
Bear	64	0.36	73	0.26	61	0.02	67	0.63	71	0.01	79	0.11
Bulkley	94	0.41	94	0.19	95	0.00	95	0.95	95	0.01	95	0.19
Lower Kalum	93	0.42	95	0.42	95	0.03	95	0.66	92	0.36	95	0.23
Morice	84	0.46	89	0.40	92	0.00	90	0.74	93	0.00	89	0.17
Sustut	94	0.46	94	0.33	95	0.16	94	0.84	95	0.03	93	0.01
Cranberry	72	0.24	76	0.46	79	0.07	77	0.84	79	0.03	77	0.01
Damdochax	61	0.25	81	0.30	76	0.01	86	0.83	82	0.01	92	0.00
Kwinageese	77	0.16	84	0.32	84	0.01	92	0.84	92	0.02	91	0.05
Tseax	81	0.17	85	0.53	94	0.02	95	0.86	93	0.14	76	0.42
Christina	92	0.38	91	0.46	94	0.07	91	0.47	94	0.04	92	0.22
Craig	94	0.21	94	0.42	92	0.03	93	0.46	95	0.11	92	0.31
Little Tahltan	95	0.41	94	0.56	95	0.06	94	0.55	95	0.01	94	0.35
Shakes	92	0.36	92	0.55	94	0.02	90	0.54	94	0.03	88	0.29
Verrett	94	0.24	94	0.50	92	0.05	94	0.40	94	0.06	93	0.26
Dudidontu	95	0.39	93	0.44	94	0.02	93	0.63	93	0.09	95	0.37
Little Tatsamenie	95	0.46	93	0.45	188	0.02	190	0.61	188	0.01	95	0.27
Nahlin	94	0.48	95	0.48	93	0.04	95	0.57	93	0.03	94	0.26
Nakina	94	0.37	94	0.43	95	0.04	95	0.58	95	0.01	91	0.28

Table 3 continued

Population	MYC-366		MYO1-384		MYOD-364		NKEF-192		NOD1		NRAMP-321	
Atnarko	94	0.94	94	0.12	93	0.92	94	0.19	94	0.86	89	0.46
Chuckwalla	92	0.98	93	0.04	90	0.73	89	0.25	91	0.82	93	0.40
Kateen	92	0.92	94	0.05	94	0.83	94	0.30	94	0.79	89	0.39
Kitlope	95	0.92	95	0.05	94	0.72	95	0.23	94	0.81	94	0.18
Upper Dean	91	0.87	94	0.11	94	0.89	92	0.20	92	0.84	92	0.32
Wannock	94	0.93	95	0.11	95	0.66	95	0.01	95	0.89	95	0.54
Bear	78	0.90	72	0.03	70	0.82	63	0.23	75	0.54	71	0.04
Bulkley	94	0.96	95	0.09	94	0.94	95	0.33	95	0.48	95	0.09
Lower Kalum	95	0.97	95	0.04	94	0.74	95	0.28	95	0.65	94	0.08
Morice	94	1.00	90	0.00	89	0.75	84	0.39	85	0.62	92	0.06
Sustut	94	0.99	94	0.09	95	0.39	94	0.45	95	0.63	95	0.02
Cranberry	78	0.83	79	0.06	76	0.46	77	0.21	74	0.39	79	0.15
Damdochax	93	0.89	82	0.00	77	0.45	76	0.14	85	0.31	79	0.06
Kwinageese	95	0.95	88	0.02	85	0.48	81	0.21	89	0.28	88	0.05
Tseax	75	0.92	86	0.02	88	0.53	89	0.11	91	0.27	87	0.14
Christina	91	0.89	93	0.04	93	0.86	89	0.37	93	0.62	90	0.18
Craig	94	0.90	94	0.02	94	0.76	92	0.37	89	0.68	94	0.22
Little Tahltan	95	0.91	95	0.02	95	0.87	94	0.38	94	0.44	94	0.17
Shakes	94	0.89	92	0.02	93	0.85	91	0.29	89	0.44	94	0.19
Verrett	94	0.88	94	0.04	93	0.68	94	0.36	94	0.59	93	0.35
Dudidontu	95	0.89	95	0.04	94	0.80	95	0.36	95	0.54	93	0.18
Little Tatsamenie	94	0.85	95	0.03	95	0.75	94	0.37	188	0.40	94	0.19
Nahlin	94	0.90	95	0.02	94	0.86	95	0.32	95	0.54	95	0.18
Nakina	93	0.92	95	0.04	95	0.81	95	0.40	95	0.43	92	0.15

Population	OPLW173_1		OTS311-101X		P450		P53		PGK-54		PRL2	
Atnarko	92	0.00	94	0.01	94	0.46	93	0.51	94	0.14	89	0.44
Chuckwalla	91	0.06	92	0.08	92	0.43	95	0.44	92	0.10	90	0.53
Kateen	95	0.10	93	0.08	94	0.44	86	0.48	95	0.07	94	0.52
Kitlope	95	0.15	95	0.03	95	0.52	94	0.47	92	0.05	95	0.59
Upper Dean	94	0.01	95	0.07	94	0.51	94	0.45	93	0.25	90	0.54
Wannock	95	0.00	95	0.06	93	0.45	94	0.14	94	0.12	95	0.46
Bear	76	0.01	65	0.07	75	0.49	58	0.38	76	0.13	77	0.49
Bulkley	94	0.00	95	0.05	95	0.48	94	0.37	94	0.22	95	0.67
Lower Kalum	95	0.03	94	0.11	95	0.67	95	0.52	95	0.21	86	0.66
Morice	89	0.00	85	0.19	83	0.52	90	0.47	92	0.09	83	0.56
Sustut	93	0.16	95	0.12	95	0.68	95	0.21	95	0.05	95	0.61
Cranberry	77	0.06	77	0.04	74	0.52	76	0.43	76	0.08	79	0.68
Damdochax	93	0.01	74	0.03	73	0.60	80	0.38	80	0.00	76	0.70
Kwinageese	93	0.01	89	0.03	87	0.62	88	0.31	84	0.01	78	0.68
Tseax	74	0.02	90	0.01	80	0.71	92	0.43	79	0.13	85	0.84
Christina	92	0.08	94	0.15	93	0.33	90	0.58	92	0.06	88	0.52
Craig	95	0.05	95	0.07	94	0.38	94	0.54	95	0.03	93	0.55
Little Tahltan	94	0.06	95	0.13	93	0.41	93	0.49	92	0.12	95	0.46
Shakes	93	0.01	93	0.11	91	0.42	94	0.48	92	0.12	92	0.48
Verrett	93	0.05	94	0.06	94	0.27	93	0.61	93	0.02	94	0.47
Dudidontu	94	0.02	94	0.09	95	0.39	93	0.45	95	0.06	94	0.51
Little Tatsamenie	93	0.01	94	0.14	190	0.36	180	0.39	190	0.05	190	0.44
Nahlin	94	0.05	92	0.09	94	0.45	93	0.37	95	0.05	95	0.39
Nakina	92	0.04	95	0.14	94	0.42	94	0.50	95	0.10	95	0.43

Table 3 continued

Population	RAG3		RFC2-558		S7-1		SCLKF2R2-135		SERPC1-209		SL	
Atnarko	94	0.49	94	0.91	94	0.48	93	0.73	92	0.83	94	0.28
Chuckwalla	90	0.51	92	0.85	87	0.50	90	0.53	88	0.84	91	0.26
Kateen	95	0.46	95	0.67	94	0.44	95	0.59	93	0.94	94	0.45
Kitlope	95	0.47	95	0.72	95	0.54	95	0.67	95	0.95	95	0.38
Upper Dean	92	0.41	95	0.82	91	0.60	94	0.73	93	0.96	92	0.23
Wannock	95	0.33	95	0.39	95	0.61	95	0.60	95	1.00	95	0.13
Bear	70	0.50	74	0.90	71	0.48	64	0.66	77	0.95	71	0.37
Bulkley	94	0.61	95	0.99	95	0.66	95	0.41	94	0.99	95	0.43
Lower Kalum	95	0.61	94	0.89	95	0.63	95	0.64	95	0.96	95	0.30
Morice	83	0.49	92	0.93	89	0.56	87	0.56	90	0.99	87	0.23
Sustut	95	0.55	94	0.96	95	0.41	94	0.74	95	0.99	95	0.30
Cranberry	76	0.51	78	0.95	75	0.28	71	0.57	79	0.99	76	0.21
Damdochax	78	0.44	80	0.96	61	0.27	75	0.60	94	1.00	78	0.25
Kwinageese	85	0.46	93	1.00	78	0.33	85	0.49	93	1.00	80	0.21
Tseax	82	0.49	79	0.91	79	0.49	81	0.44	82	1.00	83	0.40
Christina	91	0.79	91	0.92	92	0.41	85	0.45	92	0.96	88	0.36
Craig	90	0.64	91	0.86	95	0.50	92	0.47	95	0.96	93	0.37
Little Tahltan	95	0.81	94	0.90	95	0.46	95	0.47	95	0.92	95	0.34
Shakes	92	0.78	94	0.93	93	0.52	93	0.47	95	0.91	90	0.36
Verrett	94	0.73	93	0.81	94	0.46	93	0.39	94	0.98	94	0.36
Dudidontu	95	0.88	94	0.95	94	0.40	94	0.43	95	0.94	94	0.40
Little Tatsamenie	189	0.91	190	0.94	190	0.45	190	0.35	95	0.96	190	0.37
Nahlin	95	0.86	94	0.97	94	0.45	93	0.46	92	0.96	94	0.34
Nakina	95	0.84	94	0.93	94	0.48	95	0.39	93	0.95	94	0.31

Population	SWS1OP-182		TAPBP		TCL1		TGFB1		TLR3		TNSF	
Atnarko	94	0.59	94	0.11	93	0.44	92	0.36	93	0.39	93	0.45
Chuckwalla	91	0.41	94	0.04	90	0.44	92	0.12	91	0.53	91	0.60
Kateen	87	0.60	93	0.23	94	0.35	94	0.32	94	0.44	93	0.65
Kitlope	95	0.45	95	0.23	94	0.53	94	0.26	94	0.41	95	0.54
Upper Dean	91	0.48	94	0.06	92	0.54	94	0.28	94	0.64	92	0.54
Wannock	94	0.31	95	0.00	95	0.18	95	0.16	95	0.28	95	0.27
Bear	63	0.52	72	0.34	49	0.49	70	0.24	58	0.31	73	0.57
Bulkley	95	0.33	95	0.10	95	0.54	95	0.39	95	0.42	95	0.66
Lower Kalum	95	0.63	94	0.14	85	0.62	95	0.20	95	0.42	93	0.65
Morice	82	0.46	87	0.30	86	0.69	86	0.23	86	0.30	87	0.41
Sustut	94	0.57	95	0.17	95	0.72	94	0.39	95	0.31	95	0.51
Cranberry	72	0.51	72	0.44	69	0.38	77	0.40	77	0.54	75	0.83
Damdochax	72	0.49	68	0.50	57	0.39	67	0.43	82	0.46	74	0.75
Kwinageese	83	0.53	81	0.42	71	0.38	82	0.40	91	0.45	81	0.73
Tseax	82	0.57	80	0.26	79	0.54	90	0.47	90	0.73	80	0.64
Christina	91	0.47	94	0.05	89	0.51	91	0.34	92	0.52	88	0.66
Craig	94	0.49	95	0.19	94	0.48	94	0.31	93	0.38	94	0.57
Little Tahltan	95	0.58	93	0.08	93	0.50	95	0.35	95	0.47	95	0.68
Shakes	91	0.45	94	0.06	94	0.57	94	0.26	95	0.53	87	0.60
Verrett	93	0.50	94	0.19	93	0.42	94	0.46	93	0.43	92	0.65
Dudidontu	94	0.63	95	0.03	91	0.54	94	0.38	93	0.46	95	0.71
Little Tatsamenie	182	0.53	190	0.03	187	0.58	94	0.31	95	0.51	189	0.69
Nahlin	94	0.49	93	0.04	89	0.54	94	0.37	95	0.39	94	0.61
Nakina	94	0.60	95	0.04	94	0.54	95	0.33	93	0.42	94	0.66

Table 3 continued

Population	u07-07-161		u07-17-373		u07-18-378		u07-25-325		u07-49-290		u07-53-133	
Atnarko	94	0.23	93	0.09	93	0.14	93	0.80	94	0.80	91	0.33
Chuckwalla	92	0.24	90	0.02	94	0.11	80	0.93	90	0.72	89	0.41
Kateen	94	0.31	95	0.04	94	0.04	94	0.78	93	0.67	92	0.43
Kitlope	95	0.23	95	0.05	95	0.09	95	0.89	95	0.70	95	0.39
Upper Dean	92	0.22	94	0.05	95	0.23	93	0.85	92	0.78	93	0.23
Wannock	95	0.60	94	0.11	94	0.03	95	0.95	94	0.80	92	0.29
Bear	59	0.31	56	0.04	59	0.03	52	0.83	72	0.74	56	0.31
Bulkley	94	0.26	95	0.01	95	0.00	94	0.88	95	0.87	95	0.28
Lower Kalum	94	0.34	87	0.03	95	0.05	94	0.80	94	0.82	95	0.31
Morice	86	0.36	87	0.01	89	0.01	75	0.83	85	0.71	76	0.20
Sustut	94	0.33	59	0.00	95	0.02	95	0.87	95	0.58	93	0.29
Cranberry	73	0.25	74	0.02	79	0.01	74	0.86	77	0.78	76	0.07
Damdochax	68	0.24	64	0.01	72	0.00	58	0.75	68	0.74	66	0.02
Kwinageese	75	0.37	78	0.01	84	0.01	63	0.79	88	0.77	75	0.09
Tseax	91	0.60	77	0.00	94	0.01	94	0.71	86	0.90	84	0.10
Christina	92	0.23	93	0.04	93	0.01	86	0.81	91	0.82	90	0.26
Craig	92	0.23	94	0.03	94	0.06	91	0.76	93	0.81	93	0.26
Little Tahltan	95	0.19	95	0.06	95	0.01	95	0.75	94	0.74	94	0.26
Shakes	92	0.29	92	0.04	95	0.00	89	0.79	89	0.79	95	0.34
Verrett	94	0.20	94	0.06	94	0.07	94	0.88	94	0.77	94	0.25
Dudidontu	95	0.26	95	0.03	95	0.00	92	0.73	95	0.69	94	0.36
Little Tatsamenie	95	0.24	95	0.04	95	0.02	95	0.66	94	0.69	93	0.38
Nahlin	95	0.27	95	0.07	94	0.01	93	0.82	95	0.73	93	0.31
Nakina	95	0.28	94	0.05	95	0.01	94	0.77	94	0.73	94	0.36

Population	U07-57-120		U202-161		U211-85		U212-158		U4-92		U6-75	
Atnarko	93	0.66	90	0.58	92	0.46	94	0.08	93	0.05	93	0.12
Chuckwalla	90	0.67	89	0.62	88	0.51	92	0.08	92	0.08	92	0.11
Kateen	92	0.64	93	0.47	94	0.32	95	0.12	94	0.07	93	0.11
Kitlope	95	0.68	95	0.47	95	0.41	94	0.13	95	0.04	93	0.17
Upper Dean	93	0.71	92	0.71	90	0.37	92	0.12	94	0.02	91	0.06
Wannock	94	0.94	92	0.78	95	0.38	94	0.03	95	0.02	95	0.03
Bear	75	0.59	53	0.18	71	0.16	67	0.16	57	0.00	60	0.23
Bulkley	95	0.63	95	0.51	95	0.16	94	0.14	95	0.09	94	0.33
Lower Kalum	95	0.61	94	0.39	95	0.15	94	0.08	94	0.01	94	0.17
Morice	83	0.61	87	0.34	90	0.08	93	0.04	89	0.00	88	0.19
Sustut	95	0.62	95	0.22	95	0.02	93	0.03	95	0.00	95	0.07
Cranberry	77	0.69	77	0.13	76	0.07	74	0.07	76	0.02	78	0.25
Damdochax	71	0.73	77	0.16	83	0.05	84	0.15	71	0.00	85	0.17
Kwinageese	78	0.83	87	0.15	90	0.05	90	0.12	81	0.00	90	0.20
Tseax	81	0.81	77	0.31	84	0.28	84	0.10	74	0.00	84	0.28
Christina	94	0.52	88	0.38	89	0.16	94	0.06	93	0.06	92	0.26
Craig	93	0.48	95	0.45	92	0.10	93	0.08	94	0.15	93	0.20
Little Tahltan	94	0.54	95	0.33	94	0.14	92	0.06	95	0.03	95	0.29
Shakes	94	0.42	92	0.32	95	0.12	93	0.08	95	0.04	91	0.28
Verrett	93	0.48	93	0.45	94	0.13	92	0.13	94	0.19	93	0.24
Dudidontu	94	0.49	94	0.18	95	0.16	93	0.06	95	0.01	93	0.28
Little Tatsamenie	95	0.41	189	0.17	189	0.10	188	0.05	189	0.04	190	0.24
Nahlin	94	0.34	95	0.31	91	0.12	91	0.07	94	0.02	95	0.17
Nakina	94	0.46	94	0.23	94	0.11	95	0.08	95	0.03	95	0.24

Table 3 continued

Population	ZNF330-181		ZP3B_1		ZR-575	
Atnarko	93	0.03	95	0.00	89	0.32
Chuckwalla	95	0.00	92	0.00	91	0.23
Kateen	95	0.00	94	0.00	93	0.25
Kitlope	95	0.00	94	0.00	92	0.28
Upper Dean	94	0.00	94	0.00	92	0.27
Wannock	95	0.00	94	0.00	92	0.57
Bear	72	0.44	71	0.00	66	0.35
Bulkley	95	0.02	94	0.00	85	0.49
Lower Kalum	95	0.04	93	0.00	95	0.21
Morice	93	0.00	93	0.00	83	0.39
Sustut	95	0.01	94	0.00	91	0.60
Cranberry	76	0.01	78	0.00	66	0.38
Damdochax	89	0.01	93	0.00	85	0.29
Kwinageese	92	0.01	93	0.00	82	0.44
Tseax	88	0.01	80	0.00	79	0.27
Christina	91	0.00	95	0.00	83	0.30
Craig	94	0.01	93	0.00	92	0.41
Little Tahltan	95	0.03	95	0.00	84	0.38
Shakes	93	0.03	95	0.00	88	0.44
Verrett	94	0.01	93	0.00	92	0.30
Dudidontu	92	0.02	95	0.00	94	0.30
Little Tatsamenie	190	0.02	93	0.00	90	0.31
Nahlin	93	0.06	95	0.00	91	0.40
Nakina	95	0.04	91	0.00	86	0.42

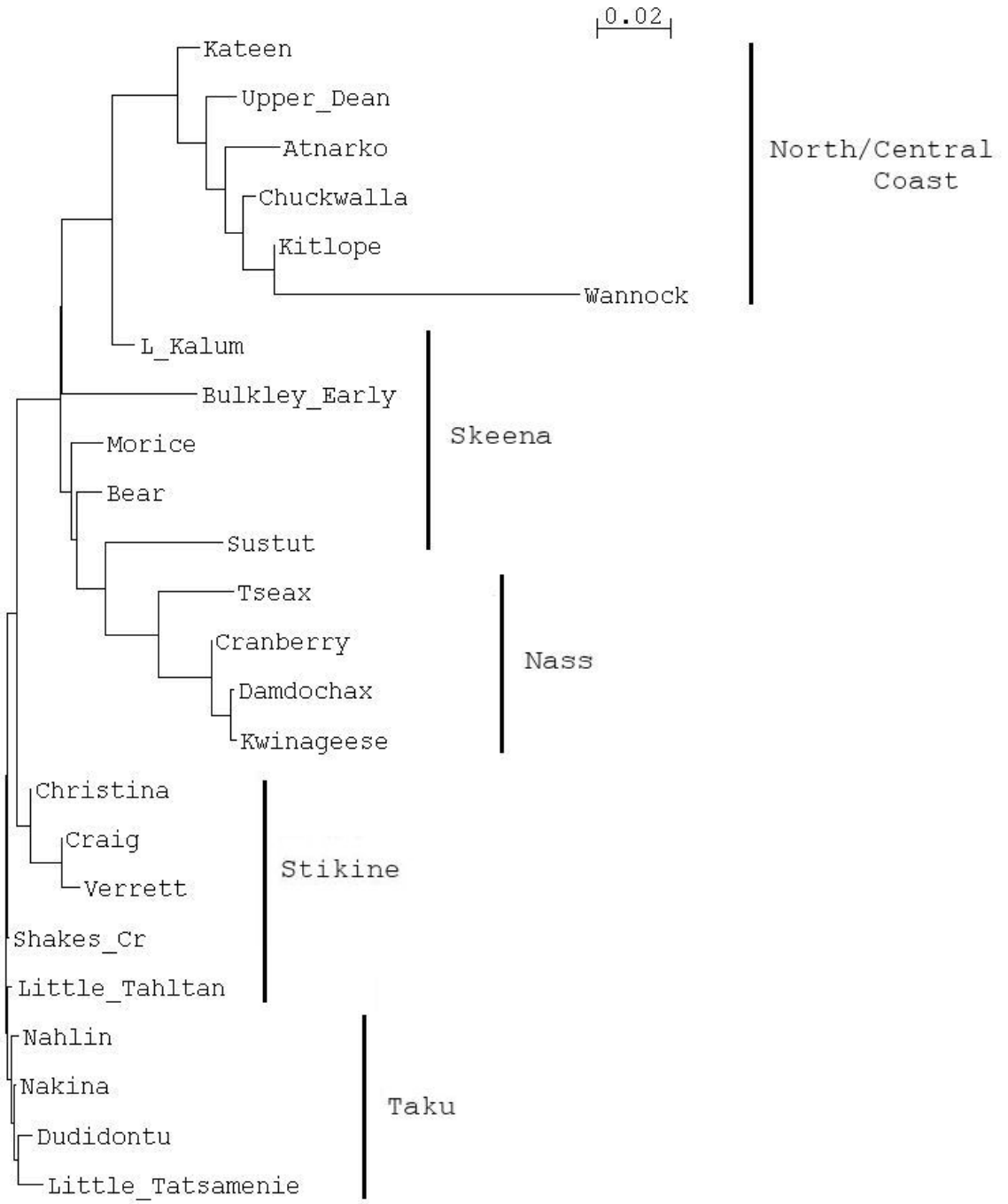

Figure 1. Neighbour-joining dendrogram of Cavalli-Sforza and Edwards (1967) chord distance for 24 northern British Columbia populations of Chinook salmon (*Oncorhynchus tshawytscha*) surveyed at 96 SNPs.