Chum Salmon Stock Identification in Southern British Columbia and Puget Sound Using Microsatellites, Assessment of the Baseline Expansion with Additional 11 Populations.

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Abstract

Chum Salmon (*Oncorhynchus keta*) from 84 populations in southern British Columbia and Puget Sound were surveyed for variation at 28 microsatellite loci as part of baseline expansion. As of last year, 73 populations had been analyzed for a microsatellite baseline expansion, in this report we are including 11 new populations. Significant genetic differentiation was observed among Chum Salmon populations sampled in the different geographic regions surveyed. The Fst value over all populations and loci was 0.052 (SD=0.039), with individual locus values ranging from 0.015 (*Ots104*) to 0.16 (*Ssa408*), and populations clustering into geographic regions. Microsatellites with larger numbers of alleles generally provided more accurate estimates of stock composition of single-population samples than did loci with smaller numbers of alleles. The average accuracy of estimates of stock composition of the single-population samples was 42.14%, although estimates of individual populations ranged from 0.06% for the Tsouwwin River in West Coast Vancouver Island to 99.47% for the Salmon River of Hood Canal. The average regional accuracy of estimates of stock composition of the single-population samples was 80.66%, with estimates of individual populations ranging from 10.3% for Big Mission to 99.59% for Salmon River, both in the Hood Canal. Standard deviations of stock composition estimates were higher for population-specific estimates compared to regional estimates, and the use of baselines with more microsatellites for estimation of stock composition (28 vs. 14) resulted in better estimates with higher precision (lower standard deviations). Larger numbers of sampled fish per population also resulted in better estimates of stock composition.

Contents

Introduction

Microsatellites have been traditionally applied to estimate stock compositions in mixed-stock Chum Salmon fishery samples in southern British Columbia and Washington. These estimates were based upon a set of 14 microsatellites, as outlined by Beacham et al. (2009). This set had previously been standardized by Fisheries and Oceans Canada (DFO) and the Washington Department of Fish and Wildlife (WDFW) in a preliminary project funded by the Southern Endowment Fund (Beacham et al. 2005, final report to PSC). Surveys of population genetic variation for these 14 microsatellites were conducted by DFO staff for both British Columbia and Washington populations. The baseline populations surveyed were used to provide estimates of stock composition in fisheries in Washington and British Columbia, including the following sub-regions: Fraser River, East Coast Vancouver Island, West Coast Vancouver Island, southern BC mainland, North Puget Sound, South Puget Sound, Hood Canal, Juan de Fuca Strait, and Coastal Washington.

However, it was necessary to develop a baseline to improve estimation of stock composition in mixed-stock fisheries. Staff at the Molecular Genetics Laboratory at the Pacific Biological Station in Nanaimo investigated more than 100 additional microsatellites in order to obtain finer population-specific or region-specific resolution with the intention of selecting 14 additional microsatellites, in addition to evaluating the 14 existent. In the current project, a standard set of 10 populations both from southern British Columbia and Washington was chosen as the reference. The approach for the microsatellite component of the project had two objectives. The first was to survey the original 14 microsatellites for all new reference samples available so that the baseline can be applied in a timely manner to mixed stock fishery samples. The second was to survey the additional 14 microsatellites for the reference populations chosen for evaluation in the study (Beacham et al. 2014, report to the Southern Fund). The Southern Endowment Fund continued to support surveys of Chum Salmon microsatellite variation in southern British Columbia and Washington additional to those reported by Beacham et al. (2009, 2014) and Candy et al. (2016).

The current report outlines the results of these surveys employing the 28 selected microsatellites in the 73 populations previously addressed by the project (Candy et al. 2016) plus additional 11 populations from southern British Columbia and Washington.

Methods and Materials

Collection of DNA samples and laboratory analyses:

Tissue samples were collected from mature Chum Salmon, generally preserved in 95% ethanol but previously frozen tissue initially collected for allozyme analysis was also accessed in some cases, and sent to the Molecular Genetics Laboratory at the Pacific Biological Station. Populations sampled, year of collection, and number of fish surveyed were outlined in Table 1. 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, surveys of variation at 28 microsatellite loci were conducted: *Ots1, Ots3* (Banks et al. 1999), *Oke3* (Buchholz et al. 2001), *Oki2* (Smith et al. 1998), Oki100 (Beacham et al. 2008b), *Omm1070, Omm1080, Omm1105, Omm1134* (Rexroad et al. 2001), *Omy1011* (Spies et al. 2005), One101, *One102, One104*, *One111*, and *One114* (Olsen et al. 2000), *Ots103, Ots104* (Nelson and Beacham 1999), *Ssa408, Ssa419* (Cairney et al. 2000), *OtsG68*, *OtsG85* (Williamson et al. 2002), Omm1276 (Rexroad and Palti 2003), *Cr373404* (Govoroun et al. 2006), *Ots21esfu, Ots23esfu* (Wright et al. 2007), Bhms176 (B. Hoyheim, Genbank accession number AF256765), *Bhms313a* (B. Hoyheim, Genbank accession number AF257052), and *Ca368462* (Rexroad et al. 2003).

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 H2O. Specific PCR conditions for a particular locus were outlined in Table 2. PCR fragments were initially size fractionated in denaturing polyacrylamide gels using an ABI 377 automated DNA sequencer, and genotypes were scored by Genotyper 2.5 software (Applied Biosystems, Foster City, CA) using an internal lane sizing standard. Later in the study, microsatellites were size fractionated in an ABI 3730 capillary DNA sequencer, and genotypes were scored by GeneMapper software 3.0 (Applied Biosystems, Foster City, CA) using an internal lane sizing standard. Allele scores derived from Genotyper or GeneMapper were verified by either one or two laboratory personnel. Allele identification between the two sequencers were standardized by analyzing approximately 600 individuals on both platforms and converting the sizing in the gel-based data set to match that obtained from the capillary-based set.

Baseline populations

The baseline survey consisted of analysis of 20,401 Chum Salmon from 84 populations from southern British Columbia and Puget Sound (original report 5,450 chum from 20 populations). The sampling sites or populations surveyed in each geographic region are outlined in Table 1. Weir and Cockerham's (1984) Fst estimates for each locus over all populations were calculated with FSTAT version 2.9.3.2 (Goudet 1995).

Estimation of stock composition in single-population samples

Two software packages were utilized in estimation of stock composition of single-population mixtures: Statistical Package for the Analysis of Mixtures software program (SPAM version 3.7) (Debevec et al. 2000) and ONCOR (Kalinowski et al. 2007). SPAM was used to evaluate the accuracy and precision of estimated stock compositions both on a population and regional basis for an individual locus for all 28 loci surveyed. Genotypic frequencies were determined for each locus in each population and were used to estimate stock composition of simulated single-population samples. The Rannala and Mountain (1997) correction to baseline allele frequencies was used for SPAM analyses in order to avoid the occurrence of fish in the mixed sample from a specific population having an allele not observed in the baseline samples from that population. This correction incorporated Bayesian modelling of baseline allele frequency distributions. All loci were considered to be in Hardy-Weinberg equilibrium, and expected genotypic frequencies were determined from the observed allele frequencies. Reported stock compositions for simulated single-population samples are the bootstrap mean estimate of each mixture of 150 fish analyzed, with mean and variance estimates derived from 1000 bootstrap simulations. Each baseline population and simulated single-population sample was sampled with replacement in order to simulate random variation involved in the collection of the baseline and fishery samples. ONCOR was used to estimate stock compositions (known mixtures) in five scenarios of varying regional compositions. In this case the Rannala and Mountain (1997) correction to baseline allele frequencies was again implemented, with precision of the stock compositions calculated by bootstrapping (100 simulations) over observed baseline population sample sizes and a mixture size of 200 fish.

For both SPAM and ONCOR, allocations to individual baseline populations were summed to provide estimates of stock compositions for regional stock groups (Table 1). ONCOR was used to evaluate accuracy of estimated stock compositions both on a population and regional basis for the set of 14 microsatellites (set 1) originally outlined by Beacham et al. (2009). These loci were *Ots3*, *Oke3*, *Oki2*, *Oki100*, *Omm1070*, *Omy1011*, *One101*, *One102*, *One104*, *One111*, *One114*, *Ots103*, *OtsG68*, and *Ssa419*. Next, the new set of 14 additional microsatellites (set 2) outlined in Beacham et al. 2014 added to the original set. These loci were: *Bhms313a, Ca368462, Cr373404, Omm1080, Omm1105, Omm1134, Omm1276, Ots1, Ots23esuf, OtsG85, Bhms176, Ots104, Ots21esuf*, and *Ssa408*. The last four were found to be out of Hardy-Weinberg equilibrium but were added because they provide additional resolution in estimates of stock composition (Beacham et al. 2014).

Results and Discussion

Population structure

Significant genetic differentiation was observed among Chum Salmon populations sampled in the different geographic regions surveyed. The Fst value over all populations and loci was 0.052 (SD=0.039), with individual locus values ranging from 0.015 (Ots104) to 0.16 (Ssa408), Table 3. Dendrogram analysis indicated that there was typically clustering of populations within a geographic region. For example, samples from Hood Canal fall-run populations (Big_Beef, Big_Mission, Dewatto, Hamma_Hamma, Hoodsport, Lilliwaup, Spencer) clustered together and the two Hood Canal summer-run (Big_Quilcene, Salmon_Cr) form a separate cluster. Tulalip, a transplanted Hood Canal fall-run population groups with the other Hood Canal falls but also remains genetically distinctive as portrayed by a long branch-length connected to the base of the Hood Canal fall-run group (Figure 1). A regional clustering of populations is important in order to support regional estimates of stock composition in mixed-stock fishery sampling.

Estimation of stock composition

Substantial variation was observed in the number of alleles at the 28 microsatellite loci surveyed in the study. The fewest number of alleles was observed at *Ots23e* (22 alleles), and the greatest number of alleles observed at *One111* (150 alleles) (Table 4). Microsatellites with larger numbers of alleles generally provided more accurate estimates of stock composition of single-population samples than did loci with smaller numbers of alleles (Table 4).

The effect of baseline population sample size on accuracy of estimated stock compositions for single-population mixtures was evaluated for the 84 populations surveyed. Population-specific accuracy values were determined from the ONCOR simulations involving 28 loci and single-population samples with observed baseline sample sizes as indicated in Table 1. Estimates of population specific accuracy were plotted against observed baseline sample sizes for each of the populations (Table 1), showing substantial variation in accuracy with respect to individual population sample size. The more genetically differentiated Puget Sound populations showed a higher level of accuracy for a given sample size (Figure 2). An average sample size of 300 fish was projected to be required for an accuracy of estimated stock compositions to be in excess of 90% to population consistently (Beacham et al. 2014). Accurate estimation of regional contributions is a less demanding objective. Larger sample sizes were required to obtain the same level of population-specific accuracy compared with region-specific accuracy. Other factors such as degree of genetic separation between populations, along with sample size, play an important role in determining accuracy of assignments to an individual population.

14 vs. 28 Loci

ONCOR simulations incorporating estimation of stock composition of single-population samples were conducted for the original set of 14 microsatellites as outlined by Beacham et al. (2009) (Set 1, Table 3), adding fourteen new microsatellites to the original group (Set 2, Table 3). The simulations were conducted using the observed baseline sample sizes for each population (Table 1), and with population sample size standardized to 300 fish. The simulations indicated that adding 14 more loci to the suite of microsatellites used for estimation of stock composition improved estimates of stock composition in 74% of cases, regardless of whether the loci were in Hardy-Weinberg equilibrium or not (Figures 3 and 4). Standardizing to a population sample size to 300 individuals generally improved accuracy of estimates of stock composition for populations where less than 300 individuals were sampled (eg. Tsouwwin), but decreased accuracy for populations in which more than 300 individuals were sampled (eg. Squawkum).

The results from the simulations involving 14 loci suggest that the average accuracy of estimates of stock composition of the single-population samples was 42.1% (Table 5), with estimates of individual populations ranging from 0.06% in the Tsouwwin Creek population on the west coast of Vancouver Island to 99.47% for the Salmon River population in Hood Canal. The results from the simulations involving 28 loci suggest that the average accuracy of estimates of stock composition of the single-population samples was 45.8% (Table 6), although estimates of individual populations ranged from 0.03% for the Tsouwwin Creek population to 99.98% for the Salmon River population. Lower accuracy of estimated stock compositions was generally observed in those populations with lower numbers of fish sampled for microsatellite variation. For example, the Tsouwwin population displayed the lowest accuracy of population-specific stock composition, and it also had the fewest number of fish surveyed in the population (n=19, Table 1).

Regional estimates of stock composition derived from the 12 regions defined in Table 1, were higher than those of populations, as expected. When using 14 loci, the average regional accuracy of estimates of stock composition of the single-population samples was 80.66%, with estimates of individual populations ranging from 8.54% for Big Missison, a Hood Canal population, to 99.59% for the Salmon River in the same region (Table 5). When using 28 loci, the average regional accuracy of estimates of stock composition of the single-population samples was 82.8%, with estimates of individual populations ranging from 6.89% for Big Missison to 99.99% for the Salmon River (Table 6). Lower regional accuracy of estimated stock compositions was generally observed in those populations with lower numbers of fish sampled for microsatellite variation.

Standard deviations of the population-specific estimates of stock composition declined as the number of loci used in estimation increased. For example, average standard deviations for estimates of specific populations were 3.95% for the 14-locus baseline and 3.1% for the 28-locus baseline (Tables 5 and 6). Corresponding values for the regional estimates of stock composition were 3.05% and 2.17%, 14 and 28 loci respectively, suggesting that increasing the number of microsatellites not only improves assignments but the decreases the uncertainty of the estimates.

The results from the fishery simulations performed with 28 loci to estimate stock compositions using 200 individuals from five of the 84 populations at varying regional proportions (five scenarios) were consistent. The findings suggest that the regional estimates of stock composition were typically within 2% of actual values, except when employing mixtures with a larger (~60%) composition in North Puget Sound, which presented some allocation loss to east coast of Vancouver Island (Tables 7 and 8).

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Figures and Tables

Table 1. Chum Salmon spawning locations, sample collection years, and total number of fish sampled (N) for 73 previously analyzed and 11 new populations (bold) in 12 geographic areas of Southern British Columbia and Washington. N is the average sample size over all loci scored.

#	Region	Population	Years	N 2014	Added 2016	Total
1	Johnstone Strait	Viner_Sound	2002 2003 2006 2008	334		334
2		Nimpkish	2002 2004 2010 2011	564		564
3	Southern mainland	Heydon	1998 2001 2003 2011	305		305
4		Southgate	2003 2004	223		223
5		Shovelnose	2004 2008	170		170
6		Phillips	2004 2006 2008 2011 2012	190		190
7		Lang	2008 2009 2011	322		322
8		Cheakamus	1992 2002 2008	88		88
9		Myrtle	2010 2011	74		74
10		Anderson	2011	185		185
11		Snake_Bay	2010 2011	272		272
12	East Coast Vancouver Island	Goldstream	1991 1992 1997 1999 2011	518		518
13		Cowichan	1997 1999 2000 2010 2011	689		689
14		Nanaimo	1991 1997 2001 2002 2010	440		440
15		Puntledge	1991 2007 2009 2010	579		579
16		Qualicum	1992 2007 2009 2010	598		598
17		Little Qualicum	1991 2007 2009 2010	596		596
18		Campbell	2002 2011	429		429
19		Englishman	2010 2011	200		200
20	West Coast Vancouver Island	Demamiel	1992	50		50
21		Hoiss	2010	27		27
22		Black_WCVI	2010	25		25
23		Parks	2010	26		26
24		Nitinat	1992 2004 2010	365		365
25		Kaouk	2010	56		56
26		Sucwoa	2010 2011 2012	379		379
27		Canton	2010 2011 2012	446		446
28		Burman	2010	29		29
29		Sooke	2011	67		67
30		Tsouwwin	2010	19		19
31	Fraser River	Alouette	1991	46		46
32		**Barnes**	**2012 2013 2014**		**183**	183
33		**Blaney**	2004 2007 2008 2009 2010 2011 **2013**	449	**83**	532
34		Chilliwack	1992 2004	215		215
35		**Coghlan**	**2014**		**25**	25
36		Harrison	2002	201		201
37		**Hopedale_Slough**	2005 2007 2008 2009 2010 2011 **2013 2014**	388	**164**	552
38		**Hunter**	**2012 2013 2014**		**277**	277
39		Inch	2002 2003	406		406
40		Kanaka	2004 2005 2006 2007 2008 2009 2010 2011	607		607
41		**Kawkawa**	2004 2008 2009 2010 2011 **2012 2013 2014**	285	**275**	560
42		**MacIntyre**	**2012 2013 2014**		**200**	200
43		**Railroad**	**2012 2013 2014**		**243**	243
44		Silverdale	2000 2004 2005 2007 2008 2009 2010 2011	484		484
45		**Silverhope**	**2012 2013 2014**		**417**	417
46		Squawkum	2000 2004 2005 2007 2008 2009 2010 2011	994		994
47		**Street**	**2012 2013 2014**		**301**	301
48		**Whonnock**	**2012 2013 2014**		**452**	452
49		Widgeon_Slough	2004 2009 2010 2011	430		430
50		**Worth**	**2012 2013 2014**		**164**	164
51	Tulalip	Tulalip	2003 2009 2010 2012	443		443
52		**Enetai_Fall**	**2014**		**383**	383
53		**McKerman_Fall**	**2014**		**330**	330
54	North Puget Sound	Nooksack	1998 2010 2011	196		196
55		County_Line	1994	97		97
56		Grant	2003	74		74
57		Siberia	1993 2003	76		76
58		Skykomish	2007	82		82
59		Snohomish	2010 2012	250		250
60		Stillaguamish	2010 2012	340		340
61		Sauk	2010 2013	89		89
62		Skagit	2013	70		70
63	South Puget Sound	Kennedy	2003 2010 2011	196		196
64		Minter	2003	106		106
65		Nisqually	2010 2011	116		116
66		Skookum/Mill	2010 2011	119		119
67		Puyallup	2011 2012	174		174
68		**SPrairie_W**	2011 **2014**	135	**118**	253
69	Hood Canal	Salmon_Hood	1997 2000	105		105
70		Big_Quilcene	1994 1997 2000	93		93
71		Hoodsport	2003	106		106
72		Lilliwaup	2002 2010	123		123
73		Spencer	2010	47		47
74		Big_Mission	2010	40		40
75		Dewatto	2010	47		47
76		Hamma_Hamma	2010	50		50
77		Big_Beef	2010 2011	99		99
78	Central Puget Sound	GreenR_Hatchery	2007	98		98
79		Chico/Grovers	2010 2011 2012	174		174
80	Juan_de_Fuca	Elwha	1995	104		104
81	Coastal Washington	Ellsworth_Cr	2000	63		63
82		Bitter_Cr	2000	106		106
83		Quinault	1998	95		95
84		Satsop	1998	103		103
		TOTAL		16786	**3615**	20401

Table 2. Microsatellite loci surveyed in Chum Salmon and their associated annealing and extension temperatures and times (seconds), as well as the number of cycles used in polymerase chain reaction amplifications.

Locus	Annealing	Extension	Cycles
Bhms176	52 °C/60s	68°C/60s	35
Bhms313a	50 °C/60s	68°C/60s	45
Ca368462	50 °C/60s	72°C/60s	40
Cr373404	47°C/60s	68°C/60s	35
Oke3	62 °C/45s	72 °C/45s	38
Oki100	50 °C/60s	72°C/60s	33
Oki2	47 °C/60s	72°C/60s	33
Omm1070	65 °C/60s	72°C/60s	40
Omm1080	50 °C/60s	68°C/60s	35
Omm1105	48 °C/60s	68°C/60s	40
Omm1134	50°C/60s	72°C/60s	45
Omm1276	38 °C/60s	64°C/60s	45
Omy1011	50 °C/30s	72°C/30s	35
One101	52 °C/60s	68°C/60s	28
One102	52 °C/60s	72°C/60s	33
One104	52 °C/30s	70°C/30s	40
One111	52 °C/30s	68°C/60s	30
One114	47 °C/30s	68°C/60s	33
Ots1	48 °C/60s	64°C/60s	45
Ots103	61 °C/60s	72°C/60s	28
Ots104	47 °C/60s	68°C/60s	45
Ots21e	55 °C/60s	68°C/60s	35
Ots23e	58°C/60s	68°C/60s	30
Ots3	48°C/60s	72°C/60s	40
OtsG68	50°C/60s	72°C/60s	37
OtsG85	50 °C/60s	68°C/60s	40
Ssa408	48 °C/60s	68°C/60s	45
Ssa419	57 °C/30s	68°C/60s	33

Table 3. Microsatellite loci surveyed in Chum Salmon, total number of fish scored per locus, as well as expected and observed heterozygosity, and Fst values. Set 1 is the 14 microsatellites outlined by Beacham et al. (2009), Set 2 is composed by 10 new microsatellites in Hardy-Weinberg equilibrium and four out of Hardy-Weinberg equilibrium.

Set	Locus	N	He	Ho	Fst
1	*Ots3*	16592	0.746062	0.734209	0.015887
1	*Oke3*	16921	0.720017	0.678388	0.057819
1	*Oki100*	16136	0.881349	0.834655	0.052981
1	*Oki2*	15750	0.856826	0.807302	0.057801
1	*Omm1070*	15450	0.957182	0.935081	0.02309
1	*Omy1011*	16153	0.886586	0.866403	0.022766
1	*One101*	15780	0.93595	0.91711	0.02013
1	*One102*	16352	0.920586	0.902764	0.01936
1	*One104*	16641	0.94625	0.903311	0.045379
1	*One111*	15750	0.935361	0.917016	0.019614
1	*One114*	15944	0.929106	0.906673	0.024145
1	*Ots103*	15762	0.947282	0.92888	0.019427
1	*Otsg68*	16070	0.96448	0.946049	0.019111
1	*Ssa419*	16724	0.823435	0.794726	0.034866
2	*Bhms176**	16998	0.925399	0.844864	0.087029
2	*Bhms313a*	16987	0.731851	0.694825	0.050593
2	*Ca368462*	17085	0.948101	0.89921	0.051569
2	*Cr373404*	17224	0.849224	0.812877	0.042801
2	*Omm1080*	14291	0.977919	0.91757	0.061714
2	*Omm1105*	16871	0.954535	0.898643	0.058556
2	*Omm1134*	16556	0.833308	0.797294	0.043219
2	*Omm1276*	16486	0.962079	0.900825	0.06367
2	*Ots1*	17031	0.834814	0.797546	0.044644
2	*Ots104**	13546	0.941793	0.796397	0.154387
2	*Ots21e**	16454	0.951391	0.816519	0.141766
2	*Ots23e*	16055	0.748177	0.718717	0.039377
2	*Otsg85*	16413	0.89908	0.878877	0.022472
2	*Ssa408**	15037	0.894214	0.744231	0.167731

* Locus considered out of Hardy-Weinberg equilibrium (Beacham et al. 2014)

Table 4. Number of alleles observed at a locus, as well as mean percentage and standard deviations (SD) of estimated percentage compositions of single-population mixtures of Chum Salmon from the 84 populations listed in Table 1. The region designation includes the sum of percentage allocations to all populations in the region. Simulations for each locus individually were conducted with SPAM with a 84-population baseline, 150 fish in the mixture sample, and 100 resamplings in the mixture sample and baseline samples.

Locus	**Nr. of Alleles**	**Population**		**Region**	
		Estimate	**SD**	**Estimate**	**SD**
Ots3	31	47.8	18.5	56.8	18.0
Bhms176	49	65.0	12.7	71.4	11.1
Bhms313a	62	65.2	12.8	71.0	11.4
Ca368462	60	70.2	10.2	77.3	8.9
Cr373404	33	58.9	15.6	65.5	14.0
Oke3	27	44.3	19.9	51.4	19.7
Oki100	32	56.9	15.8	64.9	13.8
Oki2	57	56.5	15.3	63.6	13.6
Omm1070	69	56.2	12.9	61.7	11.9
Omm1080	83	63.0	10.1	67.4	9.6
Omm1105	71	63.9	11.8	70.5	10.6
Omm1134	47	60.3	15.6	67.0	14.4
Omm1276	76	69.0	10.2	74.1	9.0
Omy1011	46	51.7	15.3	60.9	14.3
One101	61	63.4	12.1	70.3	10.8
One102	73	49.0	15.7	58.1	14.4
One104	53	60.5	12.7	66.7	11.5
One111	150	72.4	9.3	78.4	8.3
One114	60	57.5	13.8	65.7	12.6
Ots1	61	62.1	14.8	68.2	13.2
Ots103	57	61.0	12.2	68.5	10.9
Ots104	83	64.8	11.6	68.6	10.7
Ots21e	86	73.8	9.5	78.2	8.4
Ots23e	22	46.9	17.6	57.0	16.3
Otsg68	70	64.7	11.0	70.5	10.1
Otsg85	27	50.2	15.6	58.8	14.5
Ssa408	68	67.6	12.3	72.3	11.1
Ssa419	73	47.6	18.5	55.1	17.5

Table 5. Mean accuracy and standard deviation of estimated stock compositions of single-population samples of 200 fish for the original suite of 14 microsatellites as outlined by Beacham et al. (2009) (Set 1 of Table 3) estimated from ONCOR over 84 populations (73 originally analyzed and 11 new) with observed individual population sample sizes as outlined in Table 1 and with a simulated baseline population sample sizes standardized to 300 individuals per population.

N	Region	Population	% Population		% Region	
			Estimate	SD	Estimate	SD
1	Johnstone Strait	Viner_Sound	96.93	1.6	97.01	1.54
2		Nimpkish	94.18	2	94.21	2
3	Southern mainland	Heydon	76.91	4.1	83.08	4.39
4		Southgate	86.02	3.01	90.66	3.2
5		Shovelnose	43.51	5.09	62.79	5.88
6		Phillips	38.94	5.08	54.77	5.87
7		Lang	52.94	5.43	66.51	5.31
8		Cheakamus	26.01	3.66	48.93	5.38
9		Myrtle	8.3	2.56	67.39	5.3
10		Anderson	13.12	2.92	55.83	5.69
11		Snake_Bay	40.33	5.09	64.75	5.93
12	East Coast Vancouver Island	Goldstream	57.34	5.34	87.91	3.49
13		Cowichan	60.64	5.76	89.77	3.54
14		Nanaimo	50.74	5.61	88.32	3.8
15		Puntledge	61.96	5.45	90.77	3.61
16		Qualicum	53.13	7.51	91.38	3.08
17		Little Qualicum	60.99	5.6	93.47	2.48
18		Campbell	38.51	6.35	84.74	4.49
19		Englishman	12.05	4.2	81.89	4.72
20	West Coast Vancouver Island	Demamiel	8.43	2.53	10.81	3.01
21		Hoiss	1.34	1.18	97.34	1.43
22		Black_WCVI	0.46	0.54	88.55	3.42
23		Parks	0.36	0.47	93.38	2.54
24		Nitinat	83.98	3.54	96.62	1.52
25		Kaouk	15.04	3.48	95.46	1.81
26		Sucwoa	52.61	6.42	96.38	1.69
27		Canton	60.28	6.47	96.85	1.36
28		Burman	0.46	0.73	96.96	1.52
29		Sooke	2.05	1.22	75.88	4.47
30		Tsouwwin	0.06	0.16	80.85	3.66
31	Fraser River	Alouette	0.95	0.89	60.62	4.95
32		Barnes	21.78	4.6	97.26	1.58
33		Blaney	44.03	5.62	96.14	1.83
34		Chilliwack	24.86	5.23	97.1	1.53
35		Coghlan	0.76	0.82	92.77	2.53
36		Harrison	42.51	5.95	87.73	3.46
37		Hopedale_Slough	51.1	6.62	98.09	1.26
38		Hunter	48.76	5.32	98.08	1.07
39		Inch	80.97	3.64	96.49	1.88
40		Kanaka	40.76	6.81	96.82	1.48
41		Kawkawa	51.35	5.53	97.18	1.48
42		MacIntyre	18.86	5.41	94.86	2.31
43		Railroad	21.7	5.66	97.71	1.34
44		Silverdale	22.61	6.75	94.56	2.56
45		Silverhope	66.89	5.81	98.28	0.93
46		Squawkum	57.08	8.29	97.21	1.4
47		Street	48.8	5.96	97.47	1.39
48		Whonnock	27.79	6.45	95.65	1.87
49		Widgeon_Slough	22.21	6.05	95.28	2.03
50		Worth	34.17	7.36	95.52	2.38
51	Tulalip	Tulalip	96.46	1.62	97.3	1.41
52		Enetai_Fall	55.89	5.72	90.5	3.73
53		McKerman_Fall	49.87	5.63	93.77	2.08
54	North Puget Sound	Nooksack	69.47	5.04	78.41	4.4
55		County_Line	34.73	4.3	63.15	5.1
56		Grant	19.57	4.07	60.13	5.74
57		Siberia	7.9	2.38	79.36	4.11
58		Skykomish	3.06	2.21	76.23	4.22
59		Snohomish	34.29	4.6	80.22	3.96
60		Stillaguamish	54.33	6	81.62	4.02
61		Sauk	11.27	3.12	79.25	4.21
62		Skagit	0.88	1.05	78.53	4.57
63	South Puget Sound	Kennedy	92.1	2.72	96.21	1.76
64		Minter	86.99	3.19	97.04	1.25
65		Nisqually	73.91	3.58	88.19	2.55
66		Skookum/Mill	22.19	3.63	78.48	3.8
67		Puyallup	89.94	2.77	97.07	1.48
68		SPrairie_W	28.59	3.91	32.25	4.43
69	Hood Canal	Salmon_Hood	99.47	0.54	99.59	0.47
70		Big_Quilcene	97.69	1.2	98.01	1.08
71		Hoodsport	63.48	4.27	68.89	4.21
72		Lilliwaup	59.47	4.12	66.79	4.19
73		Spencer	8.58	2.58	19.52	4.1
74		Big_Mission	0.73	0.92	8.54	3.21
75		Dewatto	0.25	0.51	26.99	4.54
76		Hamma_Hamma	3.53	1.61	18.75	4.15
77		Big_Beef	17.91	3.79	29.85	4.83
78	Central Puget Sound	GreenR_Hatchery	67.63	3.73	80.12	3.47
79		Chico/Grovers	55.54	4.23	84.19	2.97
80	Juan_de_Fuca	Elwha	43	3.81	43	3.81
81	Coastal Washington	Ellsworth_Cr	36.8	4.14	94.87	2.03
82		Bitter_Cr	71.48	3.48	93.23	1.84
83		Quinault	88.9	2.46	95.99	1.49
84		Satsop	69.04	3.67	91.85	2.27

Table 6. Mean accuracy and standard deviation of estimated stock compositions of single-population samples of 200 fish for both the original (Beacham et al., 2009) and the new suites of microsatellites (Sets 1 and 2 of Table 3) estimated from ONCOR over 84 populations (73 originally analyzed and 11 new) with observed individual population sample sizes as outlined in Table 1 and with a simulated baseline population sample sizes standardized to 300 individuals per population.

N	Region	Population	% Population		% Region	
			Estimate	SD	Estimate	SD
1	Johnstone Strait	Viner_Sound	98.93	0.67	98.98	0.66
2		Nimpkish	97.57	1.11	97.58	1.11
3	Southern mainland	Heydon	78.4	3.77	85.38	3.3
4		Southgate	89.98	2.34	93.23	2.1
5		Shovelnose	49.86	4.27	61.99	4.53
6		Phillips	39.17	5.03	52.97	5.14
7		Lang	57.27	4.93	62.74	4.96
8		Cheakamus	26.33	3.53	44.78	4.81
9		Myrtle	4.58	1.82	55.07	4.49
10		Anderson	18.99	3.1	51.75	4.78
11		Snake_Bay	51.58	4.24	65.54	4.63
12	East Coast Vancouver Island	Goldstream	63.47	4.09	92.83	2.37
13		Cowichan	73.61	3.38	96.51	1.58
14		Nanaimo	45.83	4.2	94.39	2.31
15		Puntledge	67.54	4.17	96.15	1.73
16		Qualicum	52.82	4.72	95.76	1.91
17		Little Qualicum	57.66	5.28	97.08	1.25
18		Campbell	41.35	4.72	91.88	2.97
19		Englishman	9.41	3.08	90.32	2.63
20	West Coast Vancouver Island	Demamiel	7.73	2.12	10.33	2.42
21		Hoiss	0.05	0.15	99.32	0.54
22		Black_WCVI	0.19	0.28	93.26	2.07
23		Parks	0.56	0.57	98.02	1.09
24		Nitinat	91.48	2.31	98.52	0.93
25		Kaouk	7.57	2.14	96.32	1.5
26		Sucwoa	65.08	4.13	98.6	0.9
27		Canton	70.11	4.88	99.05	0.64
28		Burman	0.08	0.18	99.01	0.69
29		Sooke	4.74	1.79	59.3	4.36
30		Tsouwwin	0.03	0.11	73.77	3.55
31	Fraser River	Alouette	2.1	1.2	87.09	3.07
32		Barnes	22.33	3.44	98.78	0.73
33		Blaney	54.72	5.27	98.65	0.97
34		Chilliwack	24.94	4.71	99.52	0.49
35		Coghlan	0.08	0.19	97.95	1.31
36		Harrison	40.07	5.06	97.01	1.41
37		Hopedale_Slough	52.32	5.16	99.46	0.54
38		Hunter	56.17	4.59	99.53	0.5
39		Inch	82.13	3.68	98.19	1.1
40		Kanaka	63.96	5.06	98.49	0.91
41		Kawkawa	56.67	4.43	99.21	0.62
42		MacIntyre	23.79	4.86	97.71	1.28
43		Railroad	19.99	3.99	99.24	0.65
44		Silverdale	31.95	5.24	97.77	1.15
45		Silverhope	72.93	3.84	99.45	0.54
46		Squawkum	65.76	5.44	98.96	0.86
47		Street	49.41	4.51	99.49	0.55
48		Whonnock	32.23	4.34	98.54	0.96
49		Widgeon_Slough	29.15	4.64	98.41	0.97
50		Worth	46.62	4.77	98.57	0.91
51	Tulalip	Tulalip	99.14	0.73	99.45	0.55
52		Enetai_Fall	65.01	4.26	96.54	1.56
53		McKerman_Fall	49.88	5.47	95.87	1.77
54	North Puget Sound	Nooksack	78.26	3.3	86.85	2.84
55		County_Line	35.56	4.25	82.52	3.42
56		Grant	17.53	3.14	71.75	4.4
57		Siberia	7.34	2.35	87.61	2.74
58		Skykomish	4.18	1.83	78.18	4.05
59		Snohomish	46.34	5.73	85.67	3.19
60		Stillaguamish	64.21	4.68	83.33	3.7
61		Sauk	7.53	2.15	79.57	3.82
62		Skagit	4.57	1.95	76.09	3.95
63	South Puget Sound	Kennedy	96.85	1.37	98.46	0.94
64		Minter	91.68	2.18	98.89	0.73
65		Nisqually	86.33	2.81	93.69	1.94
66		Skookum/Mill	27.23	3.53	86.04	3.43
67		Puyallup	96.87	1.36	98.73	0.79
68		SPrairie_W	37.25	3.49	38	3.44
69	Hood Canal	Salmon_Hood	99.98	0.09	99.99	0.06
70		Big_Quilcene	99.42	0.51	99.53	0.43
71		Hoodsport	47.81	4.36	51.92	4.33
72		Lilliwaup	69.17	4.14	73.74	4.05
73		Spencer	4.62	1.75	18.2	3.61
74		Big_Mission	0.13	0.28	6.89	2.3
75		Dewatto	0.77	0.69	17.33	3.43
76		Hamma_Hamma	5.37	1.83	15.45	3.61
77		Big_Beef	24.02	4.03	31.66	4.26
78	Central Puget Sound	GreenR_Hatchery	78.64	3.05	87.95	2.76
79		Chico/Grovers	53.63	4.28	89.77	2.27
80	Juan_de_Fuca	Elwha	39.86	3.62	39.86	3.62
81	Coastal Washington	Ellsworth_Cr	42.79	4.11	94.61	1.66
82		Bitter_Cr	88.2	2.62	97.37	1.09
83		Quinault	96.13	1.48	98.46	0.9
84		Satsop	85.59	2.94	95.95	1.53

Table 7. Percentage estimated allocations to stock (column "Avg") for known mixtures (column "value") from simulations (five populations 200 fish/mixture) in ONCOR for Chum Salmon populations genotyped with 28 microsatellite loci. We present five scenarios with different regional compositions.

		Scenario1			Scenario2			Scenario3			Scenario4			Scenario5	
Population	**Value**	**Avg**	**SD**	**Value**	**Avg**	**SD**	**Value**	**Avg**	**SD**	**Value**	**Avg**	**SD**	**Value**	**Avg**	**SD**
Alouette	0	0.03	0.1	0	0.04	0.14	0	0.04	0.14	0	0.06	0.15	0	0.04	0.13
Anderson_Cr	0	0.08	0.24	0	0.13	0.31	0	0.11	0.3	0	0.09	0.24	0	0.15	0.37
Barnes_Cr	0	0.1	0.29	0	0.11	0.32	0	0.13	0.34	0	0.13	0.33	0	0.11	0.33
Big_Beef_Cr	0	0.16	0.35	0	0.14	0.32	0	0.1	0.3	0	0.09	0.23	0	0.14	0.33
Big_Mission_Cr	0	0.03	0.11	0	0.07	0.21	0	0.01	0.07	0	0.05	0.16	0	0.04	0.15
Big_Quilcene	0	0.01	0.06	0	0.01	0.06	0	0.01	0.05	0	0.01	0.07	0	0.01	0.07
Bitter_Cr	0	0.03	0.12	0	0.03	0.14	0	0.04	0.13	0	0.04	0.16	0	0.02	0.1
Black_Cr_WCVI	0	0.03	0.16	0	0.01	0.07	0	0.02	0.09	0	0.03	0.1	0	0.03	0.13
Blaney_Cr	0	0.33	0.83	0	0.27	0.56	0	0.46	0.87	0	0.39	0.91	0	0.4	0.98
Burman_R	0	0.02	0.08	0	0.02	0.11	0	0.02	0.13	0	0.01	0.08	0	0.01	0.05
Campbell	0	1.72	2.06	0	0.8	1.17	0	1.63	1.87	0	1.54	1.67	0	2.8	2.86
Canton_R	0	0.09	0.24	0	0.07	0.26	0	0.05	0.18	0	0.04	0.17	0	0.05	0.18
Cheakamus	0	0.21	0.48	0	0.14	0.27	0	0.2	0.4	0	0.18	0.33	0	0.16	0.38
Chico_Cr	0	0.07	0.17	0	0.14	0.26	0	0.05	0.14	0	0.03	0.11	0	0.06	0.15
Chilliwack_R	0	0.2	0.47	0	0.09	0.25	0	0.19	0.39	0	0.24	0.58	0	0.13	0.32
Coghlan	0	0.03	0.12	0	0.02	0.09	0	0.04	0.15	0	0.03	0.13	0	0.01	0.1
County_Line	0	0.28	0.6	0	0.2	0.37	0	0.39	0.64	0	0.4	0.67	0	0.13	0.34
Cowichan_R	0	1.95	2.14	0	1.03	1.64	0	3.17	2.87	0	1.12	1.56	0	1.97	2.12
Demamiel	0	0.05	0.17	0	0.07	0.23	0	0.12	0.3	0	0.06	0.14	0	0.04	0.17
Dewatto_R	0	0.06	0.2	0	0.04	0.13	0	0.04	0.15	0	0.05	0.16	0	0.05	0.16
Ellsworth_Cr	0	0.02	0.09	0	0.01	0.07	0	0.01	0.06	0	0.03	0.14	0	0.03	0.12
Elwha	0	0.14	0.34	0	0.12	0.26	0	0.24	0.45	0	0.17	0.38	0	0.16	0.33
Enetai_Fall	0	0.25	0.54	0	0.24	0.45	0	0.07	0.25	0	0.12	0.3	0	0.18	0.51
Englishman_R	0	0.61	0.89	0	0.42	0.85	0	0.36	0.7	0	0.52	0.86	0	1.46	1.67
Goldstream_R	0	1.54	1.88	0	0.74	1.02	0	3.18	2.68	0	0.82	1.29	0	1.58	1.76
Grant_Cr	0	0.19	0.41	0	0.1	0.24	0	0.43	0.75	0	0.18	0.38	0	0.19	0.38
GreenR_Hatchery	0	0.08	0.22	0	0.18	0.34	0	0.14	0.29	0	0.08	0.21	0	0.08	0.22
Hamma_Hamma_R	0	0.05	0.16	0	0.06	0.2	0	0.06	0.17	0	0.02	0.09	0	0.03	0.11
Harrison	0	1.78	1.89	0	0.91	1.07	0	1.4	1.45	0	4.87	2.71	0	0.87	1.14
Heydon_Cr	0	0.26	0.47	0	0.27	0.59	0	0.35	0.65	0	0.25	0.47	0	0.33	0.65
Hoiss_Cr	0	0.01	0.07	0	0.01	0.06	0	0.02	0.09	0	0.01	0.06	0	0.01	0.07
Hoodsport	0	0.14	0.34	0	0.07	0.19	0	0.11	0.25	0	0.08	0.22	0	0.08	0.2
Hopedale_Slough	0	0.22	0.48	0	0.13	0.31	0	0.5	0.88	0	0.2	0.45	0	0.19	0.46
Hunter_Cr_FR	0	0.07	0.21	0	0.04	0.16	0	0.07	0.2	0	0.12	0.29	0	0.06	0.23
Inch_Cr	20	15.02	2.22	10	7.16	1.68	10	7.88	1.76	60	47.14	3.51	10	7.13	1.55
Kanaka_Cr	0	0.27	0.55	0	0.12	0.34	0	0.17	0.55	0	0.17	0.54	0	0.13	0.37
Kaouk_R	0	0.01	0.05	0	0.02	0.11	0	0.02	0.08	0	0.02	0.08	0	0.02	0.1
Kawkawa_Cr	0	0.18	0.4	0	0.1	0.28	0	0.13	0.38	0	0.24	0.5	0	0.11	0.39
Kennedy_Cr	0	0.11	0.27	0	0.1	0.26	0	0.07	0.21	0	0.09	0.26	0	0.13	0.26
Lang_Cr	0	0.44	0.81	0	0.3	0.56	0	0.3	0.68	0	0.37	0.71	0	1.09	1.37
Lilliwaup_Cr	0	0.1	0.26	0	0.1	0.25	0	0.08	0.2	0	0.05	0.2	0	0.08	0.2
Lit_Qualicum_R	0	0.79	1.16	0	0.6	0.94	0	0.4	0.77	0	0.58	0.94	0	3.08	2.72
MacIntyre_R	0	0.19	0.58	0	0.21	0.6	0	0.35	0.71	0	0.29	0.71	0	0.29	0.78
McKerman_Fall	0	0.21	0.46	0	0.16	0.37	0	0.14	0.29	0	0.1	0.24	0	0.14	0.36
Minter_Cr	0	0.04	0.13	0	0.02	0.12	0	0.06	0.18	0	0.03	0.09	0	0.04	0.13
Myrtle_Cr	0	0.04	0.15	0	0.01	0.06	0	0.04	0.12	0	0.04	0.15	0	0.07	0.2
Nanaimo_R	0	0.96	1.58	0	0.52	0.91	0	1.19	1.67	0	0.66	1.15	0	1.11	1.49
Nimpkish_R	0	0.25	0.5	0	0.13	0.37	0	0.44	0.7	0	0.19	0.42	0	0.28	0.51
Nisqually_R	0	0.98	0.97	0	3.37	1.9	0	0.57	0.74	0	0.69	0.84	0	0.53	0.61
Nitinat_R	0	0.07	0.2	0	0.05	0.17	0	0.02	0.11	0	0.05	0.19	0	0.07	0.21
Nooksack	20	11.99	2.22	10	5.96	1.94	60	40.03	3.53	10	6.07	1.7	10	5.65	1.92
Parks_R	0	0.01	0.08	0	0.02	0.1	0	0.02	0.08	0	0.03	0.14	0	0.03	0.15
Phillips	0	0.4	0.85	0	0.11	0.36	0	0.38	0.79	0	0.22	0.51	0	0.59	0.99
Puntledge_R	20	11.72	3.58	10	5.62	2.55	10	6.08	3.03	10	4.72	2.42	60	36.01	5.61
PuyallupHatch	20	17.25	1.25	60	53.39	2.44	10	8.44	1.05	10	8.35	1.04	10	8.39	0.99
Qualicum_R	0	2.11	2.01	0	1.08	1.51	0	0.95	1.53	0	0.77	1.15	0	8.08	4.67
Quinault	0	0.02	0.08	0	0	0.04	0	0.03	0.17	0	0.02	0.1	0	0.01	0.07
Railroad_Cr	0	0.41	0.71	0	0.25	0.58	0	0.55	0.82	0	0.89	1.18	0	0.23	0.54
Salmon_Cr_Hood	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.04
Satsop	0	0.02	0.09	0	0	0.02	0	0.04	0.17	0	0.01	0.05	0	0.03	0.11
Sauk_R	0	0.08	0.24	0	0.07	0.19	0	0.15	0.31	0	0.07	0.18	0	0.11	0.3
Shovelnose_Cr	0	0.57	0.97	0	0.25	0.51	0	0.36	0.58	0	0.38	0.66	0	0.54	0.87
Siberia_Cr	0	0.11	0.26	0	0.06	0.22	0	0.16	0.36	0	0.05	0.17	0	0.09	0.29
Silverdale_Cr	0	0.55	0.95	0	0.24	0.55	0	0.58	1.35	0	0.7	1.15	0	0.41	0.96
Silverhope_Cr	0	0.11	0.33	0	0.08	0.28	0	0.2	0.54	0	0.15	0.42	0	0.19	0.41
Skagit_R	0	0.21	0.4	0	0.18	0.4	0	0.3	0.51	0	0.09	0.24	0	0.08	0.27
Skookum_Cr_F	0	0.08	0.2	0	0.14	0.29	0	0.05	0.15	0	0.03	0.1	0	0.07	0.19
Skykomish	0	0.26	0.49	0	0.22	0.47	0	0.61	1.04	0	0.17	0.34	0	0.17	0.41
Snake_Bay_Cr	0	0.37	0.6	0	0.16	0.46	0	0.21	0.51	0	0.15	0.35	0	0.7	1.01
Snohomish	0	0.59	0.87	0	0.52	0.81	0	0.81	1.25	0	0.23	0.51	0	0.27	0.61
Sooke_R	0	0.03	0.13	0	0.01	0.06	0	0.01	0.06	0	0.05	0.15	0	0.02	0.08
Southgate	0	0.09	0.24	0	0.05	0.15	0	0.11	0.24	0	0.04	0.15	0	0.07	0.22
Spencer_Cr	0	0.11	0.24	0	0.05	0.18	0	0.05	0.14	0	0.03	0.12	0	0.07	0.18
SPrairie_Cr_W	0	0.14	0.29	0	0.06	0.21	0	0.1	0.29	0	0.09	0.22	0	0.09	0.21
Squawkum_Cr	0	0.72	1.39	0	0.35	0.78	0	0.35	0.75	0	1.23	1.91	0	0.27	0.69
Stillaguamish	0	1.11	1.49	0	0.83	1.21	0	3.1	2.27	0	0.69	0.99	0	0.93	1.39
Street_Cr	0	0.17	0.5	0	0.07	0.26	0	0.1	0.38	0	0.07	0.22	0	0.11	0.4
Sucwoa_R	0	0.09	0.29	0	0.07	0.24	0	0.08	0.3	0	0.04	0.15	0	0.12	0.32
Tsowwin_R	0	0.01	0.06	0	0.01	0.06	0	0	0.02	0	0.01	0.07	0	0.02	0.08
Tulalip	20	18.76	1.32	10	9.58	0.99	10	9.43	1.07	10	9.3	0.79	10	9.17	1.24
Viner_Sound	0	0.1	0.28	0	0.05	0.17	0	0.12	0.36	0	0.03	0.14	0	0.1	0.25
Whonnock	0	0.22	0.47	0	0.24	0.54	0	0.26	0.71	0	0.47	0.97	0	0.36	0.7
Widgeon_Slough	0	0.56	0.95	0	0.25	0.64	0	0.4	0.83	0	0.99	1.38	0	0.63	1.13
Worth_Cr	0	0.52	1.17	0	0.34	0.75	0	0.3	0.63	0	1.09	1.48	0	0.48	1

Table 8. Percentage estimated allocations to region (column “Avg”) for known mixtures (column “value”) from simulations (five regions 200 fish/mixture) in ONCOR for Chum Salmon populations genotyped with 28 microsatellite loci. We present five scenarios with different regional compositions.

		Scenario1			Scenario2			Scenario3			Scenario4			Scenario5	
Region	**Value**	**Avg**	**SD**	**Value**	**Avg**	**SD**	**Value**	**Avg**	**SD**	**Value**	**Avg**	**SD**	**Value**	**Avg**	**SD**
Johnstone_St	0	0.35	0.59	0	0.18	0.39	0	0.56	0.81	0	0.22	0.44	0	0.38	0.57
South_Coast	0	2.47	1.48	0	1.42	1.17	0	2.06	1.36	0	1.73	1.22	0	3.71	2.26
ECVI	20	21.4	2.93	10	10.8	2.4	10	16.95	3.76	10	10.74	2.37	60	56.09	3.65
WCVI	0	0.42	0.51	0	0.37	0.52	0	0.39	0.52	0	0.35	0.38	0	0.43	0.52
Fraser	20	21.69	2.44	10	11.02	1.79	10	14.12	2.65	60	59.47	2.27	10	12.15	2.12
Tulalip	20	19.22	1.3	10	9.98	1.06	10	9.64	1.09	10	9.52	0.79	10	9.49	1.04
North_Puget_Sound	20	14.82	2.52	10	8.13	2.2	60	45.98	3.84	10	7.94	1.93	10	7.62	2.12
South_Puget_Sound	20	18.61	1.12	60	57.08	1.28	10	9.29	0.91	10	9.28	0.88	10	9.25	0.84
Hood_Canal	0	0.65	0.63	0	0.54	0.61	0	0.45	0.55	0	0.38	0.45	0	0.5	0.54
Juan_de_Fuca	0	0.14	0.34	0	0.12	0.26	0	0.24	0.45	0	0.17	0.38	0	0.16	0.33
Coastal_Washingto	0	0.09	0.19	0	0.05	0.16	0	0.13	0.27	0	0.1	0.26	0	0.09	0.19
Central_Sound	0	0.15	0.27	0	0.31	0.44	0	0.18	0.3	0	0.11	0.24	0	0.14	0.26

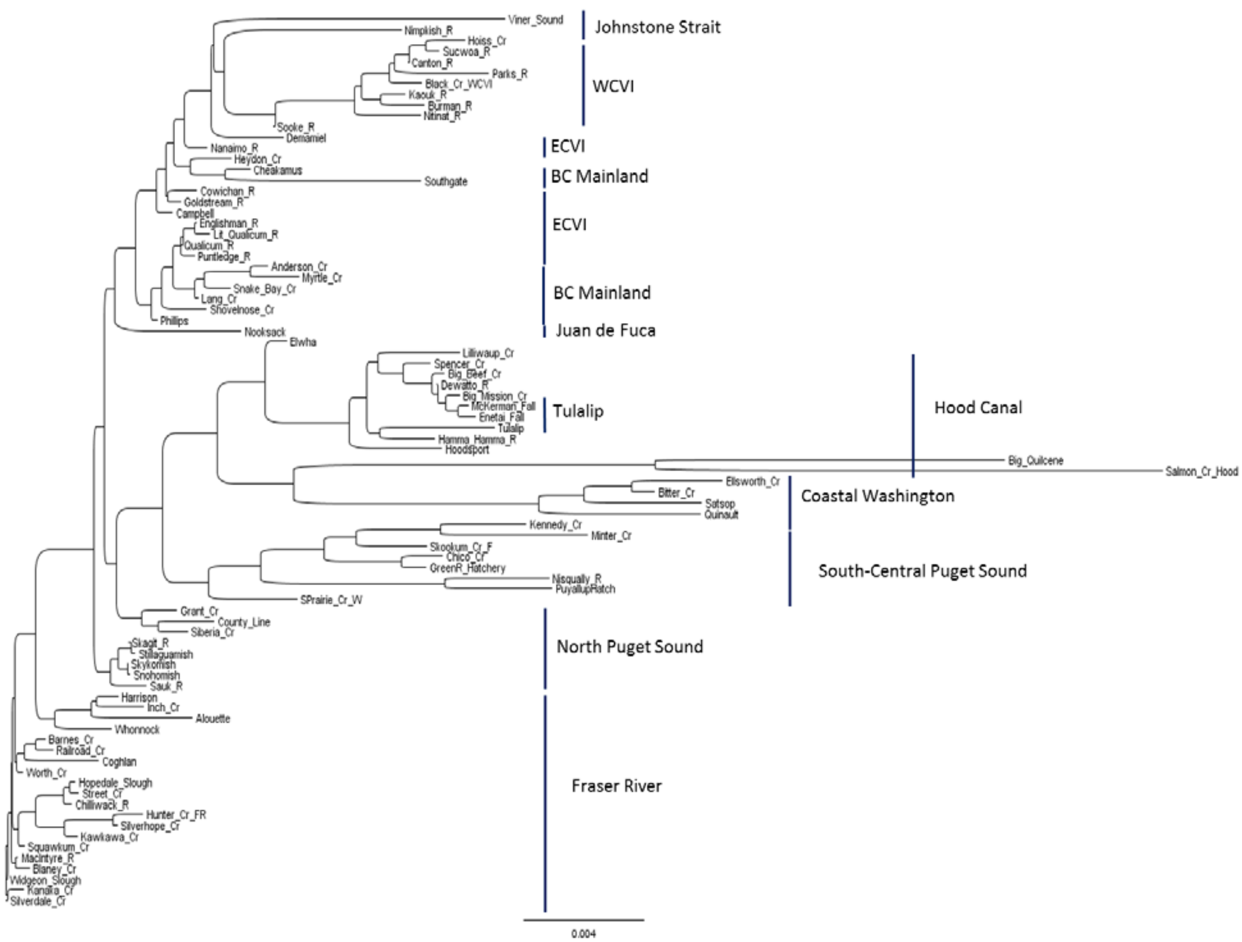

Figure 1. Neighbour-joining dendrogram of Cavalli-Sforza and Edwards (1967) chord distance for 84 southern British Columbia and Puget Sound populations of Chum Salmon (*Oncorhynchus keta*) surveyed at 28 microsatellites.

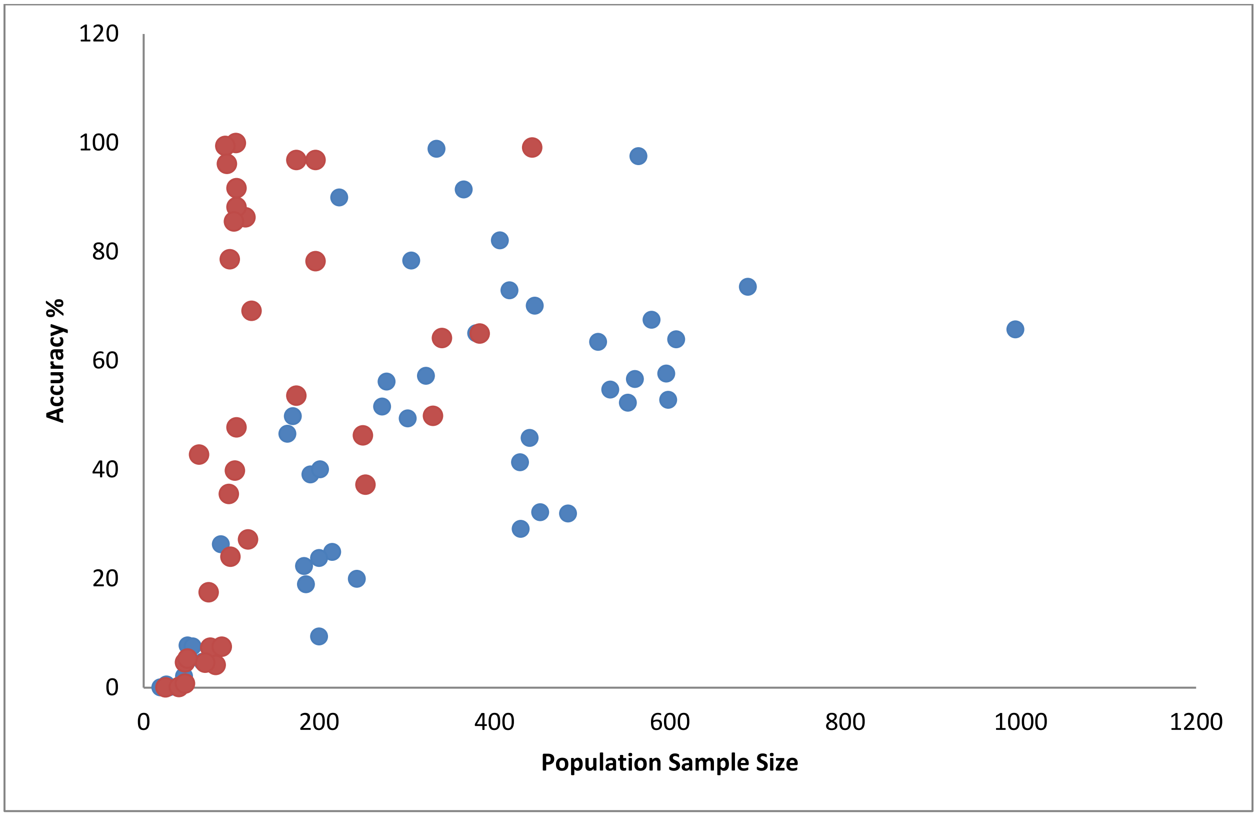

Figure 2. Relationship between the number of Chum Salmon surveyed for microsatellite variation in a specific population and the accuracy obtained for estimated population percentage of simulated single-population mixtures for 84 populations of Chum Salmon. Red denotes Washington populations and blue denote British Columbia populations.

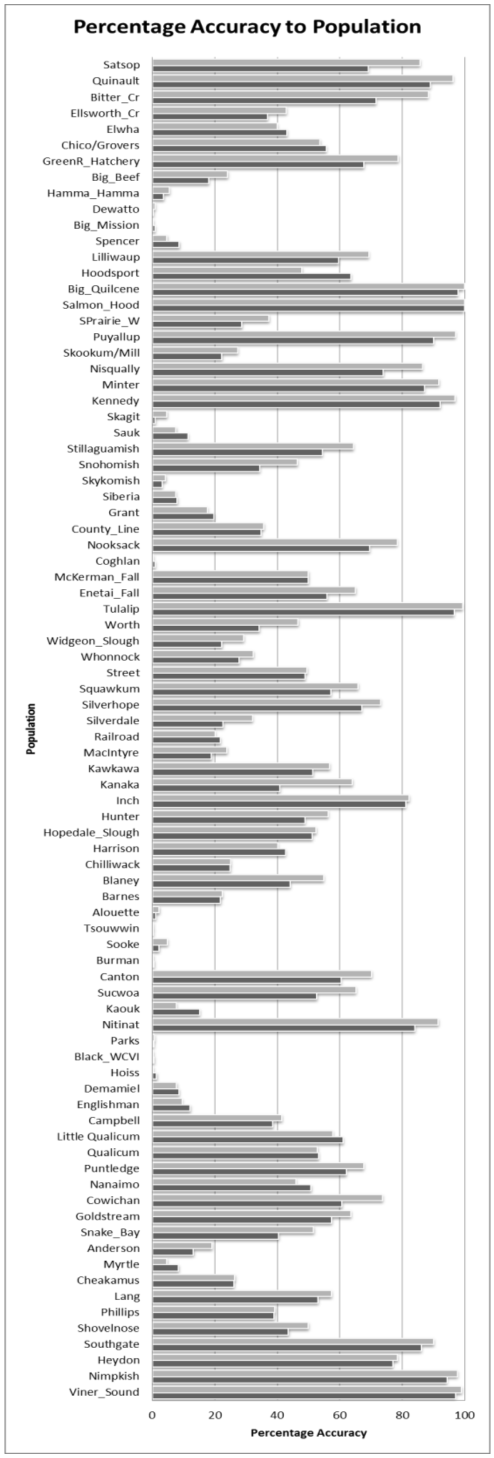

Figure 3. Population percentage accuracy of estimated stock compositions of single-population samples of 200 fish for a suite of 14 (Sets 1, dark grey) and 28 microsatellites (Set 2, light gray) estimated from ONCOR over 84 populations with observed baseline sample sizes.

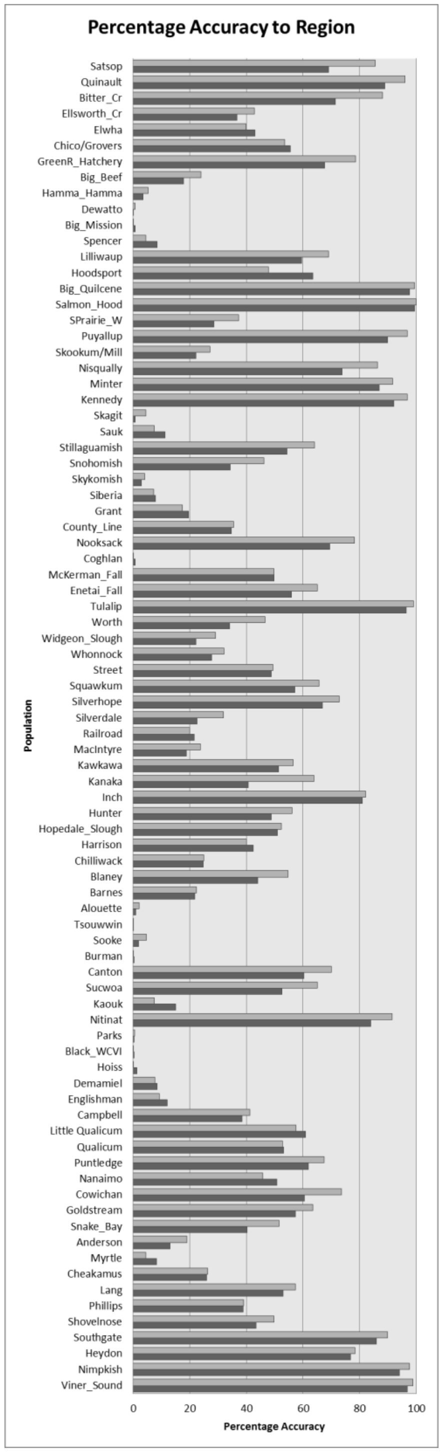

Figure 4. Regional percentage accuracy of estimated stock compositions of single-population samples of 200 fish for a suite of 14 (Sets 1, dark grey) and 28 microsatellites (Set 2, light gray) estimated from ONCOR over 84 populations with observed baseline sample sizes.