Chum Salmon stock identification in southern British Columbia and Puget Sound using microsatellites, with an assessment of the baseline expansion for additional 53 populations.

John R. Candy, K. Le, C. Wallace, and Terry D. Beacham

Fisheries and Oceans Canada

Pacific Biological Station

3190 Hammond Bay Road

Nanaimo, British Columbia

Canada V9T 6N7

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Abstract

Chum Salmon (*Oncorhynchus keta*) from 53 populations in southern British Columbia and Puget Sound were surveyed for variation at 28 microsatellite loci as part of a baseline expansion for microsatellites. Previously, 20 populations were analyzed for a SNP and microsatellite baseline comparison in 2014. Significant genetic differentiation was observed among Chum Salmon populations sampled in the different geographic regions surveyed. The F_{ST} value over all populations and loci was 0.012 (SD=0.001), with individual locus values ranging from 0.004 (*Omm1070, One102*) to 0.039 (*Oki100*). Populations clustered into geographic regions. Microsatellites with larger numbers of alleles were 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 48.8%, although estimates of individual populations ranged from 0.0% for the Tsouwwin River population to 100.0% for the Salmon River population in Hood Canal. The average regional accuracy of estimates of stock composition of the single-population samples was 85.2%, with estimates of individual populations ranging from 10.3% for the Demamiel Creek population to 100.0% for the Salmon River population in Hood Canal. Standard deviations about stock composition estimates were higher for population-specific estimates compared with regional estimates of stock composition, and the utilization of baselines with larger numbers of microsatellites for estimation of stock composition resulted in estimates with higher precision (lower standard deviations). Increased numbers of sampled fish per population also resulted in estimates of stock composition with higher precision.

Introduction

Microsatellites have been applied previously to estimate stock compositions in mixed-stock Chum Salmon fishery samples in southern British Columbia and Washington. These estimates were based upon 14 microsatellites as outlined by Beacham et al. (2009). These microsatellites had previously been standardized between DFO and 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 by DFO were used to provide estimates of stock composition in fisheries in Washington and British Columbia by Kirby (2008, 2011, Grant Kirby, Northwest Indian Fisheries Commission), with estimates provided by 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.

Staff at the Molecular Genetics Laboratory at the Pacific Biological Station in Nanaimo subsequently investigated over 100 additional microsatellites for finer population-specific or region-specific resolution, and up to 14 new microsatellites were chosen for subsequent evaluation. It is necessary to develop a baseline for microsatellite variation for possible subsequent applications for estimation of stock composition in mixed-stock fishery samples. Accordingly, an initial baseline was developed to survey microsatellite variation in Chum Salmon populations in southern British Columbia and Washington (Beacham et al. 2009). The next phase of the microsatellite baseline project was to increase the number of microsatellites in the baseline so that a common set of markers could be employed in studies concerning genetic stock identification of Chum Salmon.

A considerable baseline for stock ID analysis existed for the original 14 microsatellites in British Columbia and Washington (Beacham et al. 2009). In the current project, a standard set of 10 populations both from southern British Columbia and Washington was initially chosen as the standard reference populations. The approach for the microsatellite component of the project had two aspects. The first aspect 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 approach was to survey the additional 14 microsatellites for the reference populations chosen for evaluation in the study, so that an evaluation of the utility of specific microsatellites can be conducted (Beacham et al. 2014, report to the Southern Fund). This initial set of 20 reference populations were also run on a set of SNP markers to compare the accuracy and precision of the 28 microsatellites and a set of new SNP markers developed by Washing Department of Fish and Wildlife (WDFW).

The Southern Endowment Fund continued to supported surveys of microsatellite variation in

southern British Columbia and Washington Chum Salmon that were in addition to those reported by Beacham et al. (2009, 2014) and provide funding to increase the total numbers population surveyed. The current report will outline the results of the survey of variation for 28 microsatellites in the original 20 populations of Chum Salmon, plus an additional 53 populations from southern British Columbia and Washington.

Methods and Materials

Collection of DNA samples and laboratory analysis

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 H_2O. 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 16,786 Chum Salmon from 73 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) F_{ST} 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. When ONCOR was used to estimate stock compositions, 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 ten 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,* and *OtsG85.* Finally, four loci (set 3) were added (*Bhms176, Ots104, Ots21esuf,* and *Ssa408*), found to be out of Hardy-Weinberg equilibrium but were added to the set of 24 loci because they provide additional resolution in estimates of stock composition (Beacham et al. 2014).

Results and Discussion

Population structure

The report follows the three groupings of loci outlined in Beacham et al. (2014). The three sets of loci were identified as: the original 14 loci (set 1), plus the 10 new loci (set 2) in Hardy-Weinberg equilibrium (HWE), plus the remaining 4 loci (set 3) out of HWE. For the remaining four loci (set 3) Beacham et al (2014) reported large allelles (up to 700 bp) were observed at two loci (*Ssa408, Ots104*), and analysis of degraded tissue may have resulted in large allele "dropout", and thus lower levels of heterozygosity than expected. Null alleles may have accounted for genotypes at the other two loci (*Bhms176, Ots21esfu*) not being in Hardy-Weinberg equilibrium. Significant genetic differentiation was observed among Chum Salmon populations sampled in the different geographic regions surveyed. The F_{ST} value over all populations and loci was 0.012 (SD=0.001), with individual locus values ranging from 0.004 (*Omm1070, One102*) to 0.039 (*Oki100*) (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 Creek) 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* (92 alleles) (Table 4). Microsatellites with larger numbers of alleles were 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 73 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. However the simulated baseline of 300 fish per population does not always increase the accuracy of the estimate (Table 9 and Table 10). Other factors such as degree of genetic separation between populations, along with sample size, will play an important role in determining accuracy of an individual population.

ONCOR simulations incorporating estimation of stock composition of single-population samples was conducted for the original set of 14 microsatellites as outlined by Beacham et al. (2009) (Set 1, Table 5), adding ten new microsatellites to the original suite of 14 microsatellites (Set 2, Table 6), and finally adding four addition loci to the previous set (Set 3, Table 7). 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 more loci to the suite of microsatellites used for estimation of stock composition improved estimates of stock composition, regardless of whether the loci were in Hardy-Weinberg equilibrium or not (Table 8, Table 9). Standardizing to a population sample size of 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)(Table 6).

The results from the simulations involving 28 loci will be reviewed in some detail. The average accuracy of estimates of stock composition of the single-population samples was 48.8% (Table 8), although estimates of individual populations ranged from 0.0% for the Tsouwwin Creek population on the west coast of Vancouver Island to 100.0% for the Salmon River population in Hood Canal. 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=17, Table 1).

Regional estimates of stock composition, derived from the 12 regions defined in Table 1, were, as expected, higher than those for populations. The average regional accuracy of estimates of stock composition of the single-population samples was 85.2%, with estimates of individual populations ranging from 10.3% for the Demaniel Creek, a west coast of Vancouver Island population to 100.0% for the Salmon River population in Hood Canal (Table 9). 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 3.5% for the 14-locus baseline, 2.8% for the 24-locus baseline, and 2.5% for the 28-locus baseline (Tables 5, 6, 7). Corresponding values for the regional estimates of stock composition were 3.1%, 2.6%, and 2.3%, respectively. With population sample size standardized to 300 individuals per population, average standard deviations for population-specific estimates were 3.5%, 2.8%, and 2.5%, respectively.

Corresponding standard deviations of regional estimates of stock composition in the standardized 300 individuals per population baseline were 2.6%, 1.9%, and 1.7%, respectively. As expected, standard deviations about the estimates were higher for population-specific estimates compared with regional estimates of stock composition, and the utilization of baselines with larger numbers of microsatellites for estimation of stock composition resulted in estimates with higher precision (lower standard deviations). Increased numbers of sampled fish per population also resulted in estimates of stock composition with higher precision.

Stock compositions were estimated for mixtures of 200 fish containing individuals from four of the 20 populations in the baseline with the baseline population sample size at observed levels (Table 10) and with baseline sample size standardized to 300 fish per population (Table 11). Regional estimates of stock composition were typically within 2% of actual values, except when populations from North Puget Sound dominated the mixtures causing some allocation loss to east coast of Vancouver Island. Standardization of baseline samples sizes to 300 fish per population generally improved estimates of stock composition.

Literature Cited

Banks, M. A., M. S. Blouin, B. A. Baldwin, V. K. Rashbrook, H. A. Fitzgerald, S. M. Blankenship, and D. Hedgecock. 1999. Isolation and inheritance of novel microsatellites in chinook salmon (*Oncorhynchus tshawytscha*). Journal of Heredity 90: 281-288.

Beacham, T. D., J. R. Candy, C. Wallace, S. Urawa, S. Sato, N. V. Varnavskaya, K. D. Le, and M. Wetklo. 2009. Microsatellite stock identification of Chum Salmon on a Pacific Rim basis. North American Journal of Fisheries Management 29: 1757-1776.

Beacham, T. D., N. V. Varnavskaya, K. D. Le, and M. Wetklo. 2008. Determination of population structure and stock identification of Chum Salmon (*Oncorhynchus keta*) in Russia, determined with microsatellites. Fishery Bulletin 106: 245-256.

Beacham, T. D., M. Wetklo, D. K. Hawkins, and S. F. Young. 2005. Development of a standardized suite of microsatellite loci to be used in the establishment of a Chum Salmon baseline for southern British Columbia and Washington. Final report to Southern Boundary Restoration and Enhancement Fund.

Beacham, T. D., K. Le, C. Wallace, and John R. Candy 2014. Chum Salmon stock identification in southern British Columbia and Puget Sound using microsatellites. Final report to Southern Boundary Restoration and Enhancement Fund.

Buchholz, W. G., S. J. Miller, and W. J. Spearman. 2001. Isolation and characterization of Chum Salmon microsatellite loci and use across species. Animal Genetics 32: 160-165.

Cairney, M., J. B. Taggart, and B. Hoyheim. 2000. Characterization of microsatellite and minisatellite loci in Atlantic salmon (*Salmo salar* L.) and cross-species amplification in other salmonids. Molecular Ecology 9: 2175-2178.

Debevec, E. M., R. B. Gates, M. Masuda, J. Pella, J. M. Reynolds, and L. W. Seeb. 2000. SPAM (Version 3.2): Statistics program for analyzing mixtures. Journal of Heredity 91: 509-510.

Govoroun, M., F. Le Gac, and Y. Guiguen. 2006. Generation of a large scale repertoire of Expressed Sequence Tags (ESTs) from normalised rainbow trout cDNA libraries. BMC Genomics Aug 3;7:196.

Goudet, J. 1995. FSTAT A program for IBM PC compatibles to calculate Weir and Cockerham's (1984) estimators of F-statistics (version 1.2). Journal of Heredity 86: 485-486.

Kalinowski, S. T., K. R. Manlove, and M. L. Taper. 2007. ONCOR a computer program for genetic stock identification. Montana State University, Bozeman. Available: www.montana.edu.

Kirby, G. 2008. Southern study area chum stock distribution assessment in Washington San Juan Islands – Pt. Roberts and in British Columbia Southern Gulf Fisheries. PSC Southern Boundary Restoration & Enhancement Fund 2007 Final Report.

Kirby, G. 2011. Southern study area chum stock distribution assessment in Washington San Juan Islands – Pt. Roberts and in British Columbia Southern Gulf Fisheries. PSC Southern Boundary Restoration & Enhancement Fund 2010 Final Report.

Nelson, R. J., and T. D. Beacham. 1999. Isolation and cross species amplification of microsatellite loci useful for study of Pacific salmon. Animal Genetics 30: 228-229.

Olsen, J. B., S. L. Wilson, E. J. Kretschmer, K. C. Jones, and J. E. Seeb. 2000. Characterization of 14 tetranucleotide microsatellite loci derived from sockeye salmon. Molecular Ecology 9: 2185-2187.

Rannala, B., and J. L. Mountain. 1997. Detecting immigration by using multilocus genotypes. Proceedings of the National Academy of Science USA 94: 9197-9201.

Rexroad, C. E., R. L. Coleman, A. M. Martin, W. K. Hershberger, and J. Killefer. 2001. Thirty-five polymorphic microsatellite markers for rainbow trout (*Oncorhynchus mykiss*). Animal Genetics 32: 317-319.

Rexroad C.E, and Y. Palti. 2003. Development of Ninety-Seven Polymorphic Microsatellite Markers for rainbow trout (Oncorhynchus mykiss). *Transactions of the American Fisheries Society* **132:**1214-1221.

Rexroad, C. E. 3rd, Y. Lee, J. W. Keele, S. Karamycheva, G. Brown, B. Koop, S. A. Gahr, Y. Palti, and J. Quackenbush. 2003. Cytogenet sequence analysis of a rainbow trout cDNA library and creation of a gene. Genome Res 102 (1-4): 347-354.

Small, M. P., T. D. Beacham, R. E. Withler, and R. J. Nelson. 1998. Discriminating coho salmon (*Oncorhynchus kisutch*) populations within the Fraser River, British Columbia using microsatellite DNA markers. Molecular Ecology 7: 141-155.

Smith, C. T., B. F. Koop, and R. J. Nelson. 1998. Isolation and characterization of coho salmon (*Oncorhynchus kisutch*) microsatellites and their use in other salmonids. Molecular Ecology 7: 1613-1621.

Spies, I. B., D. J. Brasier, P. T. L. O'Reilly, T. R. Seamons, and P. Bentzen. 2005. Development and characterization of novel tetra-, tri-, and dinucleotide microsatellite markers in rainbow trout (*Oncorhynchus mykiss*). Molecular Ecology Notes 5: 278-281.

Weir, B.S., and C. C. Cockerham. 1984. Estimating F-statistics for the analysis of population structure. Evolution 38: 1358-1370.

Williamson, K. S., J. F. Cordes, and B. P. May. 2002. Characterization of microsatellite loci in chinook salmon (*Oncorhynchus tshawytscha*) and cross-species amplification in other salmonids. Molecular Ecology Notes 2: 17-19.

Wright, J. J., K. P. Lubieniecki, J. W. Park, S. H. S. Ng, R. H. Devlin, J. Leong, B. F. Koop, and W. S. Davidson. 2007. Sixteen Type 1 polymorphic microsatellite markers from Chinook salmon (*Oncorhynchus tshawytscha*) expressed sequence tags. Animal Genetics 39: 84–92

Table 1. Chum Salmon spawning locations, sample collection years, and total number of fish sampled (N) for 20 previously analyzed (bold) and 53 new populations in 12 geographic areas in southern British Columbia and Washington. N is the average sample size over all loci scored.

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

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 ºC/60s	68ºC/60s	35
Bhms313a	50 ºC/60s	68ºC/60s	45
Ca368462	50 ºC/60s	72ºC/60s	40
Cr373404	47ºC/60s	68ºC/60s	35
Oke3	62 ºC/45s	72 ºC/45s	38
Oki100	50 ºC/60s	72ºC/60s	33
Oki2	47 ºC/60s	72ºC/60s	33
Omm1070	65 ºC/60s	72ºC/60s	40
Omm1080	50 ºC/60s	68ºC/60s	35
Omm1105	48 ºC/60s	68ºC/60s	40
Omm1134	50ºC/60s	72ºC/60s	45
Omm1276	38 ºC/60s	64ºC/60s	45
Omy1011	50 ºC/30s	72ºC/30s	35
One101	52 ºC/60s	68ºC/60s	28
One102	52 ºC/60s	72ºC/60s	33
One104	52 ºC/30s	70ºC/30s	40
One111	52 ºC/30s	68ºC/60s	30
One114	47 ºC/30s	68ºC/60s	33
Ots1	48 ºC/60s	64ºC/60s	45
Ots103	61 ºC/60s	72ºC/60s	28
Ots104	47 ºC/60s	68ºC/60s	45
Ots21e	55 ºC/60s	68ºC/60s	35
Ots23e	58ºC/60s	68ºC/60s	30
Ots3	48ºC/60s	72ºC/60s	40
OtsG68	50ºC/60s	72ºC/60s	37
OtsG85	50 ºC/60s	68ºC/60s	40
Ssa408	48 ºC/60s	68ºC/60s	45
Ssa419	57 ºC/30s	68ºC/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 a set of 10 new microsatellites in Hardy-Weinberg equilibrium, and Set 3 is a set of four new microsatellites considered out of Hardy-Weinberg equilibrium.

Locus	N	Ho	He	Fst
Set 1				
Oke3	14,880	0.719	0.736	0.031(0.022)
Oki100	14,219	0.864	0.799	0.039(0.035)
Ots3	14,488	0.825	0.711	0.011(0.008)
Oki2	13,698	0.899	0.813	0.029(0.025)
Omy1011	14,104	0.874	0.873	0.008(0.007)
One104	14,644	0.952	0.933	0.009(0.009)
Ots103	13,805	0.956	0.943	0.008(0.007)
Ssa419	14,675	0.825	0.805	0.010(0.008)
One101	13,840	0.875	0.915	0.011(0.010)
Omm1070	13,573	0.953	0.96	0.004(0.004)
One114	14,013	0.923	0.909	0.008(0.008)
One102	14,265	0.911	0.923	0.004(0.004)
OtsG68	14,138	0.97	0.961	0.008(0.008)
One111	13,830	0.945	0.961	0.010(0.009)
Set 2				
Ots23esfu	13,875	0.806	0.693	0.014(0.01)
OtsG85	14,609	0.888	0.873	0.009(0.008)
Cr373404	14,771	0.846	0.837	0.010(0.009)
Omm1134	14,727	0.846	0.845	0.014(0.012)
Ots1	14,621	0.753	0.875	0.015(0.012)
Bhms313a	14,704	0.717	0.693	0.008(0.006)
Omm1105	14,432	0.933	0.949	0.005(0.005)
Ca368462	14,707	0.948	0.942	0.012(0.011)
Omm1276	14,105	0.938	0.967	0.011(0.010)
Omm1080	12,523	0.966	0.977	0.004(0.004)
Set 3				
Bhms176	14,501	0.903	0.919*	0.015(0.014)
Ssa408	12,874	0.841	0.896*	0.016(0.014)
Ots104	11,720	0.936	0.938*	0.010(0.009)
Ots21esfu	14,252	0.938	0.948*	0.008(0.008)
All				0.012(0.001)

* 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 73 populations listed in Table 1. The region designation includes the sum of percentage allocations to all populations in the region as outlined in Table 1. Simulations for each locus individually were conducted with SPAM with a 73-population baseline, 150 fish in the mixture sample, and 100 resamplings in the mixture sample and baseline samples.

Locus	Number	Population		Region	
	of alleles	Estimate	SD	Estimate	SD
Set 1					
oke3	24	34	21	55	19
oki100	29	49	17	65	14
ots3	30	40	20	58	18
oki2	30	49	16	66	13
omy1011	30	45	17	62	14
one104	37	54	14	68	12
ots103	44	55	13	70	11
ssa419	36	41	19	56	17
One101	45	58	13	72	11
omm1070	48	51	13	62	12
one114	41	52	14	66	12
one102	43	45	16	57	15
otsg68	64	60	11	71	10
one111	92	68	10	79	8
Set 2					
Ots23e	22	42	18	58	17
Otsg85	27	45	16	60	15
Cr373404	31	53	17	68	13
Omm1134	43	53	17	69	14
Ots1	56	57	16	71	13
Bhms313a	55	60	14	71	12
Omm1105	61	60	12	71	11
Ca368462	60	65	11	78	9
Omm1276	75	64	11	76	9
Omm1080	82	60	10	68	10
Set 3					
Bhms176	45	57	14	74	11
Ssa408	66	63	13	74	11
Ots104	79	61	12	71	11
Ots21e	84	68	10	81	8

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 73 populations (20 originally analyzed and 53 new) with observed individual population sample sizes as outlined in Table 1 and with a simulated baseline where population sample sizes have been standardized to 300 individuals per population.

		Observed Baseline				Simulated Baseline			
		% Population		% Region		% Population		% Region	
Region	Population	Estimate	SD	Estimate	SD	Estimate	SD	Estimate	SD
Johnstone Strait	Viner_Sound	97.1	1.3	97.3	1.2	96.5	1.3	96.6	1.3
	Nimpkish	94.3	2.2	94.4	2.1	89.1	2.8	89.2	2.8
Southern mainland	Heydon	77.2	4.3	83.6	4.0	73.3	4.2	79.7	3.7
	Southgate	86.2	2.8	90.8	2.8	95.5	1.8	96.7	1.5
	Shovelnose	42.6	4.7	63.3	5.2	82.2	3.9	87.5	3.6
	Phillips	39.1	6.4	56.2	5.8	68.4	5.0	77.9	4.7
	Lang	52.5	5.5	67.3	5.0	70.4	5.5	78.9	5.0
	Cheakamus	25.8	4.2	49.0	5.8	83.5	3.4	86.6	3.5
	Myrtle	8.1	2.4	68.1	5.6	85.9	3.0	91.1	2.7
	Anderson	13.7	3.1	55.1	6.1	86.8	3.3	91.5	2.9
	Snake_Bay	39.8	5.3	64.6	5.4	74.7	4.2	81.5	3.8
East Coast Vancouver Island	Goldstream	57.3	6.1	88.0	3.8	59.9	5.3	82.9	3.8
	Cowichan	61.2	5.6	90.2	3.5	58.4	5.8	85.4	3.5
	Nanaimo	49.9	5.9	89.1	3.3	62.3	4.2	83.9	4.1
	Puntledge	61.4	6.4	90.7	3.7	59.0	5.3	84.9	4.1
	Qualicum	51.3	7.3	91.9	3.2	48.9	4.7	83.6	4.3
	Little Qualicum	60.4	5.7	93.9	2.7	61.0	4.4	87.0	3.4
	Campbell	39.1	6.4	85.0	4.1	58.4	6.0	83.5	4.4
	Englishman	12.2	4.3	82.7	4.7	63.6	4.6	77.4	5.0
West Coast Vancouver Island	Demamiel	8.3	2.3	10.6	2.6	86.2	3.1	87.8	2.9
	Hoiss	1.8	1.2	97.3	1.3	91.0	2.5	95.4	1.7
	Black_WCVI	0.4	0.6	89.2	2.9	86.0	3.4	91.2	3.0
	Parks	0.2	0.4	93.6	2.8	90.3	2.6	94.7	1.8
	Nitinat	84.4	3.7	96.5	1.6	85.1	3.9	95.0	2.1
	Kaouk	16.1	3.0	95.7	1.8	90.2	2.7	96.5	1.6
	Sucwoa	52.0	6.4	96.8	1.4	73.9	4.8	95.4	1.7
	Canton	61.8	5.9	97.2	1.4	71.6	4.1	94.8	1.9
	Burman	0.5	0.8	97.3	1.5	88.8	2.9	93.5	2.1
	Sooke	2.2	1.5	75.6	3.9	85.9	3.1	89.9	2.8
	Tsouwwin	0.1	0.2	81.8	3.3	89.8	2.6	93.4	2.2
Fraser River	Silverdale	29.6	7.0	93.5	2.9	49.1	5.5	88.8	3.9
	Squawkum	66.9	7.1	96.7	1.4	51.4	5.2	93.1	2.2
	Chilliwack	28.9	5.2	96.8	1.6	69.1	4.6	94.1	2.2
	Alouette	1.2	1.0	58.0	4.7	90.4	2.6	93.1	2.3
	Harrison	43.5	5.4	88.3	3.6	71.8	4.7	88.0	3.1
	Inch	82.9	3.8	96.3	1.8	80.8	4.5	93.5	2.2
	Widgeon_Slough	26.3	6.4	94.8	2.2	57.6	6.2	90.8	3.3
	Kawkawa	57.7	3.8	96.1	1.7	80.7	3.4	94.0	2.1
	Blaney	47.8	6.2	95.4	2.1	61.5	4.9	90.9	3.3
	Kanaka	45.0	6.8	96.5	1.6	56.5	5.1	91.9	2.8
	Hopedale_Slough	57.4	5.8	97.8	1.4	71.0	4.0	95.2	2.0
Tulalip	Tulalip	97.1	1.3	97.1	1.3	94.1	2.1	94.1	2.1
North Puget Sound	**Nooksack**	68.9	4.3	79.2	4.1	81.7	3.5	86.0	3.5
	County_Line	34.1	4.4	63.6	5.0	83.1	3.1	88.3	3.2
	Grant	19.9	3.9	60.4	5.5	81.2	3.7	88.4	3.0
	Siberia	8.4	2.5	79.6	4.2	83.0	3.1	88.4	2.9
	Skykomish	3.5	2.2	78.0	4.0	69.2	3.7	83.5	3.5
	Snohomish	34.5	5.2	80.8	4.0	67.4	4.5	85.4	3.7
	Stillaguamish	54.7	5.8	82.6	3.9	69.5	5.2	83.7	4.0
	Sauk	11.4	2.8	80.5	4.4	79.8	3.8	88.3	2.8
	Skagit	1.0	1.1	80.1	4.1	74.8	4.7	84.0	3.9
South Puget Sound	**Kennedy**	87.6	3.5	96.2	1.6	93.1	2.5	96.9	1.3
	Minter	87.1	2.9	96.9	1.5	97.3	1.2	98.6	0.8
	Nisqually	73.4	3.8	88.2	2.7	90.6	2.6	94.4	2.2
	Skookum/Mill	51.3	4.7	80.1	3.5	91.0	2.4	93.8	2.1
	Puyallup	90.7	2.6	97.6	1.3	93.9	2.0	97.6	1.1
	SPrairie_W	30.3	4.2	34.6	4.4	85.2	2.8	85.9	2.8
Hood Canal	Salmon_Hood	99.4	0.6	99.5	0.4	99.8	0.3	99.8	0.3
	Big_Quilcene	97.9	1.1	98.2	1.0	98.9	0.7	99.1	0.6
	Hoodsport	73.3	3.9	87.5	3.5	90.4	2.9	94.7	1.9
	Lilliwaup	69.8	4.0	88.2	2.7	89.6	2.6	95.0	1.9
	Spencer	13.7	3.2	54.3	4.3	92.0	2.4	95.8	1.8
	Big_Mission	6.6	2.3	71.8	4.4	90.7	2.5	94.5	1.8
	Dewatto	1.4	1.4	71.5	4.4	86.5	3.3	93.0	2.3
	Hamma_Hamma	6.3	2.4	63.0	4.4	88.1	2.8	93.3	2.1
	Big_Beef	36.0	4.8	75.0	4.4	85.0	3.0	93.2	2.1
Central Puget Sound	GreenR_Hatchery	50.0	4.7	88.1	2.6	89.8	2.8	94.5	1.7
	Grovers/Chico	78.5	3.7	93.1	2.4	88.9	3.2	95.5	1.7
Juan_de_Fuca	Elwha	44.2	4.5	44.2	4.5	85.1	3.3	85.1	3.3
Coastal Washington	Ellsworth_Cr	37.7	4.4	95.1	1.7	92.9	2.2	98.0	1.0
	Bitter_Cr	71.8	4.0	93.5	2.3	91.5	2.7	96.9	1.3
	Quinault	89.0	2.5	96.2	1.5	95.8	1.6	98.0	1.0
	Satsop	69.6	3.6	92.0	2.0	92.6	2.2	97.8	1.1

Table 6. Mean accuracy and standard deviation of estimated stock compositions of single-population samples of 200 fish for the original suite of 24 microsatellites as outlined by Beacham et al. (2009) (Set 1 and 2 of Table 3) estimated from ONCOR over 73 populations (20 originally analyzed and 53 new) with observed individual population sample sizes as outlined in Table 1 and with a simulated baseline where population sample sizes have been standardized to 300 individuals per population.

		Observed Baseline				Simulated Baseline			
		% Population		% Region		% Population		% Region	
Region	Population	Estimate	SD	Estimate	SD	Estimate	SD	Estimate	SD
Johnstone Strait	Viner_Sound	98.2	0.9	98.3	0.9	98.0	1.1	98.1	1.1
	Nimpkish	96.9	1.3	96.9	1.3	93.3	1.9	93.3	1.9
Southern mainland	Heydon	75.2	3.5	82.8	3.7	80.2	3.3	85.2	2.9
	Southgate	88.0	2.7	92.7	2.2	96.0	1.5	97.2	1.3
	Shovelnose	47.1	4.2	61.4	4.6	83.2	3.2	87.4	2.8
	Phillips	34.4	4.7	50.2	5.3	69.1	3.9	75.5	3.8
	Lang	51.7	5.0	59.6	4.6	71.0	4.4	78.2	3.9
	Cheakamus	25.3	3.6	47.5	4.8	85.6	2.9	89.0	2.8
	Myrtle	3.3	1.5	53.0	4.7	90.5	2.4	93.4	1.9
	Anderson	16.9	3.2	57.9	4.0	93.2	2.0	95.8	1.5
	Snake_Bay	45.1	4.6	65.4	5.2	80.0	3.4	86.2	3.2
East Coast Vancouver Island	Goldstream	60.0	4.6	91.2	2.6	66.5	4.5	85.7	3.4
	Cowichan	60.8	4.3	93.9	2.3	61.2	4.5	85.1	3.4
	Nanaimo	47.4	5.1	93.4	2.7	64.3	5.3	87.2	3.1
	Puntledge	63.6	5.3	94.6	2.2	57.9	4.8	86.7	3.2
	Qualicum	49.3	6.5	94.5	2.3	58.3	4.6	90.6	3.0
	Little Qualicum	51.4	5.2	96.0	1.6	63.3	4.7	90.5	3.0
	Campbell	41.3	5.2	89.2	3.4	60.7	4.6	84.0	3.5
	Englishman	11.6	3.2	87.5	3.7	67.0	3.7	85.2	3.0
West Coast Vancouver Island	Demamiel	8.4	2.2	11.4	2.7	88.4	2.6	89.4	2.5
	Hoiss	0.1	0.2	98.8	0.8	94.7	1.8	97.9	0.9
	Black_WCVI	0.3	0.4	94.0	2.0	93.4	2.0	96.5	1.3
	Parks	0.1	0.2	95.4	2.1	93.6	1.8	96.7	1.4
	Nitinat	89.0	3.2	98.1	1.0	88.5	2.8	96.5	1.4
	Kaouk	7.6	2.5	95.1	2.1	90.4	2.5	96.9	1.3
	Sucwoa	60.4	5.3	98.3	0.9	76.0	4.0	97.8	1.1
	Canton	66.5	4.5	98.8	0.9	76.2	3.9	97.5	1.3
	Burman	0.1	0.3	99.0	0.7	93.4	1.9	96.9	1.3
	Sooke	2.7	1.5	60.2	5.0	91.6	2.4	93.4	2.1
	Tsouwwin	0.0	0.1	79.5	3.9	93.4	1.9	95.6	1.5
Fraser River	Silverdale	35.9	5.9	95.7	2.1	55.9	5.0	90.4	2.9
	Squawkum	71.2	5.2	97.9	1.2	54.3	4.4	94.0	1.9
	Chilliwack	29.1	4.2	98.3	1.0	73.2	3.6	95.1	1.7
	Alouette	2.1	1.2	76.7	4.0	92.1	2.0	95.2	1.6
	Harrison	41.6	4.7	92.5	2.5	76.1	3.8	92.0	2.6
	Inch	83.4	3.3	97.0	1.4	82.4	3.8	94.3	2.2
	Widgeon_Slough	31.4	5.3	96.8	1.7	63.4	3.8	91.9	2.2
	Kawkawa	60.3	4.1	97.9	1.1	83.3	3.2	96.2	1.5
	Blaney	51.8	5.3	97.5	1.3	71.5	4.0	94.3	2.2
	Kanaka	61.5	5.3	97.6	1.3	72.6	3.9	93.4	1.8
	Hopedale_Slough	56.7	4.8	98.6	1.0	68.6	4.0	96.2	1.6
Tulalip	Tulalip	99.1	0.6	99.1	0.6	97.4	1.2	97.4	1.2
North Puget Sound	**Nooksack**	73.7	3.6	82.4	3.6	87.3	2.8	91.7	2.4
	County_Line	35.5	4.0	77.7	3.8	83.4	2.9	90.4	2.6
	Grant	17.3	3.5	67.2	4.0	83.0	3.5	90.5	2.4
	Siberia	6.8	2.3	86.2	3.6	83.9	3.0	91.5	2.0
	Skykomish	2.4	1.6	79.1	4.1	78.0	3.6	88.2	2.9
	Snohomish	45.7	4.6	84.3	3.5	73.0	4.1	86.0	3.1
	Stillaguamish	61.9	4.5	82.6	3.5	68.2	4.3	82.8	4.1
	Sauk	6.7	2.2	76.7	3.8	86.3	2.9	92.8	2.2
	Skagit	3.6	1.7	80.2	3.4	82.3	3.5	91.1	2.5
South Puget Sound	**Kennedy**	88.8	2.7	97.5	1.2	95.7	1.8	98.8	0.8
	Minter	90.9	2.4	98.4	1.0	97.9	1.1	99.0	0.6
	Nisqually	82.8	3.3	92.5	2.2	96.8	1.5	97.6	1.2
	Skookum/Mill	54.8	3.8	85.1	2.7	93.7	2.0	96.1	1.5
	Puyallup	95.1	1.9	98.4	1.0	98.4	0.9	99.3	0.6
	SPrairie_W	31.0	4.1	32.5	4.2	91.2	2.2	91.4	2.2
Hood Canal	Salmon_Hood	100.0	0.1	100.0	0.1	99.9	0.2	99.9	0.2
	Big_Quilcene	99.0	0.7	99.2	0.7	99.8	0.3	99.8	0.3
	Hoodsport	73.6	3.6	90.3	2.5	95.5	1.7	97.8	1.1
	Lilliwaup	77.9	3.7	93.5	2.1	92.0	2.1	97.0	1.3
	Spencer	10.8	2.3	53.4	4.1	95.2	1.7	97.2	1.2
	Big_Mission	2.7	1.4	74.4	4.1	91.7	2.2	95.3	1.7
	Dewatto	3.4	1.6	75.5	3.6	90.8	1.8	95.4	1.4
	Hamma_Hamma	8.3	2.2	45.9	4.3	94.3	1.8	96.4	1.4
	Big_Beef	43.0	4.6	81.8	3.3	91.8	2.5	96.6	1.6
Central Puget Sound	GreenR_Hatchery	45.5	4.5	90.9	2.3	92.5	2.3	95.6	1.6
	Grovers/Chico	82.5	3.0	96.5	1.4	94.9	1.7	98.3	1.0
Juan_de_Fuca	Elwha	36.7	4.3	36.7	4.3	89.3	2.7	89.3	2.7
Coastal Washington	Ellsworth_Cr	41.9	3.9	95.3	1.7	96.8	1.4	98.8	0.8
	Bitter_Cr	85.2	2.7	96.7	1.5	96.5	1.4	98.9	0.6
	Quinault	94.6	1.7	97.9	1.0	98.5	0.9	99.2	0.7
	Satsop	82.8	3.3	94.9	2.0	97.3	1.2	98.9	0.6

Table 7. Mean accuracy and standard deviation of estimated stock compositions of single-population samples of 200 fish for the original suite of 28 microsatellites as outlined by Beacham et al. (2009) (Set 1, 2 and 3 of Table 3) estimated from ONCOR over 73 populations (20 originally analyzed and 53 new) with observed individual population sample sizes as outlined in Table 1 and with a simulated baseline where population sample sizes have been standardized to 300 individuals per population.

		Observed Baseline				Simulated Baseline			
		% Population		% Region		% Population		% Region	
Region	Population	Estimate	SD	Estimate	SD	Estimate	SD	Estimate	SD
Johnstone Strait	Viner_Sound	98.8	0.7	98.9	0.7	98.6	0.8	98.6	0.8
	Nimpkish	98.0	1.1	98.0	1.1	94.9	1.7	94.9	1.7
Southern mainland	Heydon	78.0	3.7	85.3	3.3	82.5	3.7	87.7	3.0
	Southgate	89.8	2.7	93.5	2.6	96.2	1.4	97.4	1.1
	Shovelnose	50.4	3.8	61.8	4.0	84.4	3.2	88.3	3.0
	Phillips	39.4	4.7	53.0	5.0	72.8	4.2	79.0	3.8
	Lang	57.1	4.4	62.9	4.2	76.2	3.8	80.9	3.8
	Cheakamus	26.6	3.4	45.8	4.7	86.1	2.8	89.4	2.5
	Myrtle	4.6	1.9	55.1	4.6	93.6	1.9	95.8	1.6
	Anderson	19.2	2.9	52.3	4.7	93.7	1.8	96.1	1.5
	Snake_Bay	52.4	4.7	66.8	4.8	83.7	3.0	88.8	2.9
East Coast Vancouver Island	Goldstream	64.0	4.9	93.1	2.4	67.9	4.0	87.7	2.6
	Cowichan	74.6	4.2	96.5	1.5	74.9	3.6	90.4	2.4
	Nanaimo	45.7	4.7	94.9	2.2	72.6	4.0	90.9	2.7
	Puntledge	67.3	5.0	96.4	1.6	62.9	4.6	89.1	2.8
	Qualicum	51.7	4.9	96.0	1.8	56.5	4.5	88.6	3.0
	Little Qualicum	58.0	4.8	97.6	1.4	68.6	4.3	91.1	2.2
	Campbell	42.1	4.9	92.5	2.7	65.4	4.3	88.8	2.8
	Englishman	9.8	3.5	91.1	2.8	68.5	3.9	87.0	3.3
West Coast Vancouver Island	Demamiel	7.6	2.1	10.3	2.6	92.3	2.2	93.1	2.1
	Hoiss	0.1	0.2	99.4	0.5	95.5	1.7	98.5	0.9
	Black_WCVI	0.2	0.3	93.1	2.1	96.4	1.4	97.8	1.0
	Parks	0.5	0.6	98.1	1.2	95.5	1.6	97.8	1.2
	Nitinat	91.2	2.4	98.7	0.8	93.0	2.2	98.1	0.9
	Kaouk	7.4	2.1	96.3	1.8	91.9	2.2	97.2	1.3
	Sucwoa	65.7	4.3	98.6	0.8	84.9	2.8	97.7	1.0
	Canton	70.8	4.5	99.1	0.7	85.1	3.0	97.9	1.1
	Burman	0.1	0.3	99.0	0.8	94.7	1.7	97.5	1.0
	Sooke	5.1	1.8	58.8	4.7	92.9	2.1	94.9	1.8
	Tsouwwin	0.0	0.1	73.5	3.6	95.1	1.9	96.7	1.4
Fraser River	Silverdale	37.9	5.2	97.4	1.4	62.3	4.2	93.9	2.4
	Squawkum	72.7	5.2	98.7	0.9	56.9	4.1	96.0	1.4
	Chilliwack	30.9	4.6	99.3	0.6	79.5	3.4	97.9	1.1
	Alouette	2.3	1.3	86.0	3.2	93.0	1.9	95.7	1.6
	Harrison	39.8	4.4	96.8	1.4	76.4	3.6	94.8	1.6
	Inch	84.2	3.5	97.9	1.2	85.7	3.1	96.3	1.3
	Widgeon_Slough	34.5	4.8	98.0	1.0	63.7	4.4	95.1	1.9
	Kawkawa	61.3	3.8	99.1	0.7	87.2	3.0	97.9	1.0
	Blaney	58.1	4.7	98.4	1.0	71.5	3.9	95.7	1.5
	Kanaka	66.8	4.6	98.1	1.1	70.4	4.0	94.8	2.0
	Hopedale_Slough	61.0	4.7	99.2	0.7	77.6	3.5	98.5	0.9
Tulalip	Tulalip	99.4	0.6	99.4	0.6	97.8	0.9	97.8	0.9
North Puget Sound	**Nooksack**	77.4	3.6	86.3	2.9	90.6	2.4	94.3	1.8
	County_Line	35.9	4.8	83.1	3.5	85.2	3.0	92.9	2.2
	Grant	18.2	3.3	72.5	3.8	89.6	2.4	93.9	2.0
	Siberia	7.4	2.1	88.1	3.0	90.3	2.5	95.4	1.9
	Skykomish	4.1	1.9	78.0	3.7	80.8	3.5	90.7	2.4
	Snohomish	45.4	5.1	85.9	2.9	75.0	4.4	87.4	2.9
	Stillaguamish	63.5	5.0	83.8	3.6	72.0	4.2	86.9	3.2
	Sauk	7.5	2.3	80.8	3.3	88.1	2.7	94.3	1.9
	Skagit	5.1	1.9	78.7	3.7	84.8	3.1	91.8	2.2
South Puget Sound	**Kennedy**	90.6	2.3	98.2	1.1	96.2	1.5	99.0	0.7
	Minter	90.8	2.3	98.7	1.0	98.6	1.0	99.3	0.6
	Nisqually	87.1	2.8	94.5	1.9	97.4	1.1	97.8	1.0
	Skookum/Mill	57.3	4.3	87.9	3.0	95.3	1.6	97.3	1.3
	Puyallup	97.2	1.3	98.9	0.7	98.7	0.8	99.1	0.6
	SPrairie_W	37.3	4.2	38.2	4.3	94.2	1.8	94.2	1.8
Hood Canal	Salmon_Hood	100.0	0.1	100.0	0.1	100.0	0.1	100.0	0.1
	Big_Quilcene	99.4	0.5	99.6	0.4	99.9	0.2	99.9	0.2
	Hoodsport	74.4	3.6	91.4	2.5	92.6	2.0	97.2	1.3
	Lilliwaup	81.3	2.9	94.5	1.8	95.1	1.7	98.1	1.0
	Spencer	9.0	2.8	53.5	3.7	96.2	1.4	98.2	0.9
	Big_Mission	2.0	1.3	72.9	3.6	94.9	1.7	97.3	1.1
	Dewatto	3.4	1.5	78.7	3.5	91.3	2.3	95.8	1.5
	Hamma_Hamma	7.7	2.1	43.1	4.1	95.6	1.6	97.2	1.4
	Big_Beef	49.5	3.7	85.3	3.2	91.0	2.4	97.0	1.4
Central Puget Sound	GreenR_Hatchery	49.7	4.0	94.1	1.9	94.4	2.0	97.2	1.3
	Grovers/Chico	86.0	2.9	97.1	1.4	95.0	1.9	98.4	1.0
Juan_de_Fuca	Elwha	41.0	4.3	41.0	4.3	90.5	2.3	90.5	2.3
Coastal Washington	Ellsworth_Cr	41.7	3.6	94.9	1.5	97.3	1.2	98.9	0.8
	Bitter_Cr	88.0	2.5	97.5	1.2	98.2	1.1	99.3	0.6
	Quinault	96.4	1.5	98.6	0.9	98.8	0.8	99.2	0.6
	Satsop	85.7	2.6	95.9	1.5	98.2	1.0	99.1	0.7

Table 8. Population percentage accuracy of estimated stock compositions of single-population samples of 200 fish for a suite of 14, 24, and 28 microsatellites (Set 1, Set 2, and Set 3 of Table 3) estimated from ONCOR over 73 populations with observed baseline sample sizes.

		Number of microsatellites		
Region	Population	14	24	28
Johnstone Strait	Viner_Sound	97.1	98.2	98.8
	Nimpkish	94.3	96.9	98.0
Southern mainland	Heydon	77.2	75.2	78.0
	Southgate	86.2	88.0	89.8
	Shovelnose	42.6	47.1	50.4
	Phillips	39.1	34.4	39.4
	Lang	52.5	51.7	57.1
	Cheakamus	25.8	25.3	26.6
	Myrtle	8.1	3.3	4.6
	Anderson	13.7	16.9	19.2
	Snake_Bay	39.8	45.1	52.4
East Coast Vancouver Island	Goldstream	57.3	60.0	64.0
	Cowichan	61.2	60.8	74.6
	Nanaimo	49.9	47.4	45.7
	Puntledge	61.4	63.6	67.3
	Qualicum	51.3	49.3	51.7
	Little Qualicum	60.4	51.4	58.0
	Campbell	39.1	41.3	42.1
	Englishman	12.2	11.6	9.8
West Coast Vancouver Island	Demamiel	8.3	8.4	7.6
	Hoiss	1.8	0.1	0.1
	Black_WCVI	0.4	0.3	0.2
	Parks	0.2	0.1	0.5
	Nitinat	84.4	89.0	91.2
	Kaouk	16.1	7.6	7.4
	Sucwoa	52.0	60.4	65.7
	Canton	61.8	66.5	70.8
	Burman	0.5	0.1	0.1
	Sooke	2.2	2.7	5.1
	Tsouwwin	0.1	0.0	0.0
Fraser River	Silverdale	29.6	35.9	37.9
	Squawkum	66.9	71.2	72.7
	Chilliwack	28.9	29.1	30.9
	Alouette	1.2	2.1	2.3
	Harrison	43.5	41.6	39.8
	Inch	82.9	83.4	84.2
	Widgeon_Slough	26.3	31.4	34.5
	Kawkawa	57.7	60.3	61.3
	Blaney	47.8	51.8	58.1
	Kanaka	45.0	61.5	66.8
	Hopedale_Slough	57.4	56.7	61.0
Tulalip	Tulalip	97.1	99.1	99.4
North Puget Sound	**Nooksack**	68.9	73.7	77.4
	County_Line	34.1	35.5	35.9
	Grant	19.9	17.3	18.2
	Siberia	8.4	6.8	7.4
	Skykomish	3.5	2.4	4.1
	Snohomish	34.5	45.7	45.4
	Stillaguamish	54.7	61.9	63.5
	Sauk	11.4	6.7	7.5
	Skagit	1.0	3.6	5.1
South Puget Sound	**Kennedy**	87.6	88.8	90.6
	Minter	87.1	90.9	90.8
	Nisqually	73.4	82.8	87.1
	Skookum/Mill	51.3	54.8	57.3
	Puyallup	90.7	95.1	97.2
	SPrairie_W	30.3	31.0	37.3
Hood Canal	Salmon_Hood	99.4	100.0	100.0
	Big_Quilcene	97.9	99.0	99.4
	Hoodsport	73.3	73.6	74.4
	Lilliwaup	69.8	77.9	81.3
	Spencer	13.7	10.8	9.0
	Big_Mission	6.6	2.7	2.0
	Dewatto	1.4	3.4	3.4
	Hamma_Hamma	6.3	8.3	7.7
	Big_Beef	36.0	43.0	49.5
Central Puget Sound	GreenR_Hatchery	50.0	45.5	49.7
	Grovers/Chico	78.5	82.5	86.0
Juan_de_Fuca	Elwha	44.2	36.7	41.0
Coastal Washington	Ellsworth_Cr	37.7	41.9	41.7
	Bitter_Cr	71.8	85.2	88.0
	Quinault	89.0	94.6	96.4
	Satsop	69.6	82.8	85.7
Mean		**45.0**	**46.7**	**48.8**

Table 9. Regional percentage accuracy of estimated stock compositions of single-population samples of 200 fish for a suite of 14, 24, and 28 microsatellites (Set 1, Set 2, and Set 3 of Table 3) estimated from ONCOR over 20 populations with observed baseline sample sizes.

		Number of microsatellites		
Region	Population	14	24	28
Johnstone Strait	Viner_Sound	97.3	98.3	98.9
	Nimpkish	94.4	96.9	98.0
Southern mainland	Heydon	83.6	82.8	85.3
	Southgate	90.8	92.7	93.5
	Shovelnose	63.3	61.4	61.8
	Phillips	56.2	50.2	53.0
	Lang	67.3	59.6	62.9
	Cheakamus	49.0	47.5	45.8
	Myrtle	68.1	53.0	55.1
	Anderson	55.1	57.9	52.3
	Snake_Bay	64.6	65.4	66.8
East Coast Vancouver Island	Goldstream	88.0	91.2	93.1
	Cowichan	90.2	93.9	96.5
	Nanaimo	89.1	93.4	94.9
	Puntledge	90.7	94.6	96.4
	Qualicum	91.9	94.5	96.0
	Little Qualicum	93.9	96.0	97.6
	Campbell	85.0	89.2	92.5
	Englishman	82.7	87.5	91.1
West Coast Vancouver Island	Demamiel	10.6	11.4	10.3
	Hoiss	97.3	98.8	99.4
	Black_WCVI	89.2	94.0	93.1
	Parks	93.6	95.4	98.1
	Nitinat	96.5	98.1	98.7
	Kaouk	95.7	95.1	96.3
	Sucwoa	96.8	98.3	98.6
	Canton	97.2	98.8	99.1
	Burman	97.3	99.0	99.0
	Sooke	75.6	60.2	58.8
	Tsouwwin	81.8	79.5	73.5
Fraser River	Silverdale	93.5	95.7	97.4
	Squawkum	96.7	97.9	98.7
	Chilliwack	96.8	98.3	99.3
	Alouette	58.0	76.7	86.0
	Harrison	88.3	92.5	96.8
	Inch	96.3	97.0	97.9
	Widgeon_Slough	94.8	96.8	98.0
	Kawkawa	96.1	97.9	99.1
	Blaney	95.4	97.5	98.4
	Kanaka	96.5	97.6	98.1
	Hopedale_Slough	97.8	98.6	99.2
Tulalip	Tulalip	97.1	99.1	99.4
North Puget Sound	**Nooksack**	79.2	82.4	86.3
	County_Line	63.6	77.7	83.1
	Grant	60.4	67.2	72.5
	Siberia	79.6	86.2	88.1
	Skykomish	78.0	79.1	78.0
	Snohomish	80.8	84.3	85.9
	Stillaguamish	82.6	82.6	83.8
	Sauk	80.5	76.7	80.8
	Skagit	80.1	80.2	78.7
South Puget Sound	**Kennedy**	96.2	97.5	98.2
	Minter	96.9	98.4	98.7
	Nisqually	88.2	92.5	94.5
	Skookum/Mill	80.1	85.1	87.9
	Puyallup	97.6	98.4	98.9
	SPrairie_W	34.6	32.5	38.2
Hood Canal	Salmon_Hood	99.5	100.0	100.0
	Big_Quilcene	98.2	99.2	99.6
	Hoodsport	87.5	90.3	91.4
	Lilliwaup	88.2	93.5	94.5
	Spencer	54.3	53.4	53.5
	Big_Mission	71.8	74.4	72.9
	Dewatto	71.5	75.5	78.7
	Hamma_Hamma	63.0	45.9	43.1
	Big_Beef	75.0	81.8	85.3
Central Puget Sound	GreenR_Hatchery	88.1	90.9	94.1
	Grovers/Chico	93.1	96.5	97.1
Juan_de_Fuca	Elwha	44.2	36.7	41.0
Coastal Washington	Ellsworth_Cr	95.1	95.3	94.9
	Bitter_Cr	93.5	96.7	97.5
	Quinault	96.2	97.9	98.6
	Satsop	92.0	94.9	95.9
Mean		**82.6**	**83.9**	**85.2**

Table 10. Percentage estimated stock compositions from mixture simulations (four populations 200 fish/mixture) in ONCOR for Chum Salmon populations genotyped with 28 microsatellite loci. Mixture percentages were estimated to population and to region.

Population	Value	Avg	SD	Value	Avg	SD	Value	Avg	SD	Value	Avg	SD	Value	Avg	SD
Alouette	0	0.0	0.1	0	0.0	0.0	0	0.0	0.1	0	0.0	0.0	0	0.0	0.1
Anderson	0	0.0	0.1	0	0.0	0.1	0	0.0	0.0	0	0.0	0.1	0	0.0	0.1
Big_Beef	0	0.0	0.1	0	0.0	0.1	0	0.0	0.1	0	0.0	0.1	0	0.0	0.1
Big_Mission	0	0.0	0.1	0	0.0	0.1	0	0.0	0.0	0	0.0	0.1	0	0.0	0.0
Big_Quilcene	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
Bitter	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
Black_WCVI	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
Blaney	0	0.2	0.4	0	0.2	0.4	0	0.2	0.4	0	0.3	0.5	0	0.2	0.4
Burman	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
Campbell	0	1.9	1.6	0	1.1	1.1	0	2.3	1.7	0	1.1	1.2	0	3.2	2.3
Canton	0	0.0	0.1	0	0.0	0.1	0	0.0	0.1	0	0.0	0.1	0	0.0	0.1
Cheakamus	0	0.1	0.2	0	0.0	0.1	0	0.1	0.2	0	0.0	0.2	0	0.1	0.2
Chilliwack	0	0.1	0.2	0	0.0	0.1	0	0.1	0.2	0	0.1	0.3	0	0.0	0.1
County_Line	0	0.0	0.1	0	0.0	0.1	0	0.1	0.3	0	0.1	0.2	0	0.1	0.2
Cowichan	0	0.8	1.0	0	0.4	0.6	0	1.1	1.2	0	0.6	0.8	0	1.0	1.3
Demamiel	0	0.0	0.1	0	0.0	0.1	0	0.0	0.0	0	0.0	0.1	0	0.0	0.1
Dewatto	0	0.0	0.1	0	0.0	0.1	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
Ellsworth	0	0.0	0.0	0	0.0	0.1	0	0.0	0.0	0	0.0	0.0	0	0.0	0.1
Elwha	0	0.0	0.1	0	0.1	0.2	0	0.0	0.1	0	0.0	0.1	0	0.0	0.1
Englishman	0	0.3	0.4	0	0.1	0.3	0	0.2	0.4	0	0.2	0.4	0	0.6	0.8
Goldstream	0	1.6	1.5	0	0.9	0.9	0	3.2	2.0	0	0.9	1.0	0	2.0	1.5
Grant	0	0.0	0.1	0	0.0	0.1	0	0.1	0.1	0	0.0	0.1	0	0.0	0.1
GreenR_Hatchery	0	0.0	0.1	0	0.0	0.1	0	0.0	0.1	0	0.0	0.1	0	0.0	0.1
Grovers/Chico	0	0.0	0.1	0	0.0	0.1	0	0.0	0.1	0	0.0	0.1	0	0.0	0.0
Hamma_Hamma	0	0.0	0.1	0	0.0	0.0	0	0.0	0.0	0	0.0	0.1	0	0.0	0.0
Harrison	0	0.6	0.8	0	0.4	0.6	0	0.5	0.7	0	1.5	1.3	0	0.2	0.4
Heydon	0	0.1	0.3	0	0.1	0.2	0	0.1	0.3	0	0.1	0.3	0	0.1	0.3
Hoiss	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.1	0	0.0	0.0
Hoodsport	0	0.1	0.2	0	0.0	0.1	0	0.0	0.1	0	0.0	0.1	0	0.0	0.1
Hopedale_Slough	0	0.1	0.2	0	0.1	0.2	0	0.1	0.2	0	0.1	0.3	0	0.1	0.2
Inch	20	16.2	1.7	10	8.0	1.1	10	8.1	1.3	60	49.7	2.8	10	7.9	1.2
Kanaka	0	0.6	0.7	0	0.3	0.4	0	0.4	0.7	0	1.2	1.2	0	0.3	0.4
Kaouk	0	0.0	0.1	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
Kawkawa	0	0.1	0.2	0	0.0	0.1	0	0.1	0.2	0	0.1	0.2	0	0.0	0.1
Kennedy	0	0.0	0.1	0	0.1	0.2	0	0.0	0.1	0	0.0	0.1	0	0.0	0.1
Lang	0	0.3	0.5	0	0.2	0.4	0	0.3	0.4	0	0.2	0.4	0	0.7	0.8
Lilliwaup	0	0.0	0.1	0	0.0	0.1	0	0.0	0.1	0	0.0	0.1	0	0.0	0.1
Little Qualicum	0	1.5	1.4	0	0.6	0.8	0	0.9	1.0	0	0.8	0.9	0	4.1	2.2
Minter	0	0.0	0.1	0	0.0	0.1	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
Myrtle	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
Nanaimo	0	0.8	1.0	0	0.5	0.6	0	0.9	1.1	0	0.7	0.9	0	1.5	1.4
Nimpkish	0	0.1	0.3	0	0.1	0.2	0	0.1	0.3	0	0.1	0.2	0	0.1	0.3
Nisqually	0	0.3	0.4	0	0.9	0.8	0	0.2	0.4	0	0.2	0.3	0	0.2	0.4
Nitinat	0	0.0	0.1	0	0.0	0.1	0	0.0	0.1	0	0.0	0.1	0	0.0	0.1
Nooksack	20	14.2	1.8	10	6.9	1.2	60	45.6	2.9	10	7.0	1.1	10	6.7	1.1
Parks	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
Phillips	0	0.3	0.4	0	0.2	0.4	0	0.2	0.5	0	0.2	0.3	0	0.4	0.7
Puntledge	20	13.4	2.4	10	6.8	1.5	10	7.5	2.1	10	6.7	1.8	60	40.6	3.7
Puyallup	20	19.0	0.7	60	57.9	1.0	10	9.3	0.5	10	9.4	0.6	10	9.4	0.6
Qualicum	0	2.6	2.1	0	1.1	1.1	0	1.3	1.5	0	1.0	1.1	0	7.1	3.0
Quinault	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
Salmon_Hood	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
Satsop	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.1	0	0.0	0.1
Sauk	0	0.0	0.1	0	0.0	0.1	0	0.0	0.1	0	0.0	0.1	0	0.0	0.1
Shovelnose	0	0.1	0.2	0	0.1	0.2	0	0.1	0.2	0	0.1	0.2	0	0.1	0.3
Siberia	0	0.0	0.0	0	0.0	0.1	0	0.0	0.1	0	0.0	0.1	0	0.0	0.1
Silverdale	0	0.5	0.8	0	0.3	0.5	0	0.6	0.8	0	1.2	1.3	0	0.4	0.6
Skagit	0	0.0	0.1	0	0.1	0.1	0	0.0	0.1	0	0.0	0.1	0	0.0	0.1
Skookum/Mill	0	0.0	0.1	0	0.0	0.1	0	0.0	0.0	0	0.0	0.1	0	0.0	0.0
Skykomish	0	0.1	0.2	0	0.1	0.2	0	0.1	0.3	0	0.1	0.2	0	0.1	0.2
Snake_Bay	0	0.1	0.3	0	0.1	0.2	0	0.1	0.3	0	0.1	0.2	0	0.2	0.3
Snohomish	0	0.3	0.5	0	0.3	0.5	0	0.7	0.8	0	0.3	0.4	0	0.3	0.6
Sooke	0	0.0	0.1	0	0.0	0.0	0	0.0	0.1	0	0.0	0.1	0	0.0	0.0
Southgate	0	0.0	0.1	0	0.0	0.1	0	0.0	0.1	0	0.0	0.1	0	0.0	0.1
Spencer	0	0.0	0.1	0	0.0	0.0	0	0.0	0.1	0	0.0	0.1	0	0.0	0.1
SPrairie_W	0	0.0	0.1	0	0.0	0.1	0	0.0	0.1	0	0.0	0.1	0	0.0	0.1
Squawkum	0	1.4	1.5	0	0.8	0.9	0	1.0	1.1	0	3.9	2.2	0	0.8	1.0
Stillaguamish	0	1.5	1.2	0	0.9	0.9	0	4.0	2.0	0	0.7	0.8	0	0.8	0.8
Sucwoa	0	0.0	0.1	0	0.0	0.1	0	0.0	0.1	0	0.0	0.1	0	0.0	0.1
Tsouwwin	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
Tulalip	20	19.8	0.4	10	9.9	0.4	10	9.8	0.4	10	9.9	0.3	10	9.8	0.4
Viner_Sound	0	0.0	0.1	0	0.0	0.1	0	0.0	0.1	0	0.0	0.1	0	0.0	0.1
Widgeon_Slough	0	0.5	0.7	0	0.3	0.6	0	0.5	0.7	0	1.3	1.2	0	0.4	0.7
Regions															
Johnstone Strait	0	0.1	0.3	0	0.1	0.3	0	0.2	0.3	0	0.1	0.2	0	0.1	0.3
Southern Mainland	0	1.1	0.8	0	0.7	0.7	0	0.9	0.9	0	0.7	0.7	0	1.7	1.3
East Coast Vancouver Island	20	22.9	1.9	10	11.5	1.4	10	17.4	2.5	10	12.0	1.6	60	60.1	1.9
West Coast Vancouver Island	0	0.1	0.2	0	0.1	0.2	0	0.1	0.2	0	0.1	0.2	0	0.1	0.2
Fraser	20	20.2	1.3	10	10.4	0.9	10	11.4	1.2	60	59.3	1.5	10	10.4	1.0
Tulalip	20	19.8	0.4	10	9.9	0.4	10	9.8	0.4	10	9.9	0.3	10	9.8	0.4
North Puget Sound	20	16.2	1.6	10	8.3	1.2	60	50.6	2.3	10	8.2	1.2	10	8.1	1.1
South Puget Sound	20	19.4	0.6	60	58.9	0.7	10	9.6	0.5	10	9.6	0.5	10	9.6	0.4
Hood Canal	0	0.1	0.3	0	0.1	0.2	0	0.1	0.2	0	0.1	0.2	0	0.1	0.2
Juan de Fuca	0	0.0	0.1	0	0.1	0.2	0	0.0	0.1	0	0.0	0.1	0	0.0	0.1
Coastal Washington	0	0.0	0.0	0	0.0	0.1	0	0.0	0.0	0	0.0	0.1	0	0.0	0.1
Central Puget Sound	0	0.0	0.1	0	0.1	0.2	0	0.0	0.1	0	0.0	0.1	0	0.0	0.1

Table 11. Percentage estimated stock compositions from mixture simulations (four populations 200 fish/mixture) in ONCOR for Chum Salmon populations genotyped with 28 microsatelite loci with population sample sizes standardized to 300 fish per population. Mixture percentages were estimated to population and to region.

Population	Value	Avg	SD	Value	Avg	SD	Value	Avg	SD	Value	Avg	SD	Value	Avg	SD
Alouette	0	0.1	0.2	0	0.1	0.2	0	0.1	0.2	0	0.1	0.3	0	0.1	0.1
Anderson	0	0.1	0.2	0	0.0	0.2	0	0.1	0.2	0	0.0	0.1	0	0.1	0.3
Big_Beef	0	0.1	0.3	0	0.1	0.2	0	0.1	0.2	0	0.1	0.2	0	0.0	0.1
Big_Mission	0	0.1	0.2	0	0.1	0.2	0	0.0	0.1	0	0.0	0.1	0	0.1	0.2
Big_Quilcene	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
Bitter	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.1	0	0.0	0.0
Black_WCVI	0	0.0	0.1	0	0.0	0.1	0	0.1	0.1	0	0.0	0.1	0	0.0	0.1
Blaney	0	0.2	0.4	0	0.1	0.3	0	0.2	0.4	0	0.4	0.6	0	0.2	0.4
Burman	0	0.0	0.1	0	0.0	0.1	0	0.0	0.1	0	0.1	0.2	0	0.0	0.2
Campbell	0	1.4	1.3	0	0.5	0.6	0	1.1	1.0	0	0.9	0.9	0	3.0	1.7
Canton	0	0.0	0.1	0	0.0	0.1	0	0.0	0.1	0	0.0	0.1	0	0.0	0.1
Cheakamus	0	0.1	0.3	0	0.2	0.3	0	0.2	0.3	0	0.1	0.3	0	0.2	0.3
Chilliwack	0	0.2	0.3	0	0.1	0.2	0	0.1	0.2	0	0.2	0.4	0	0.1	0.3
County_Line	0	0.2	0.4	0	0.1	0.2	0	0.4	0.6	0	0.2	0.4	0	0.1	0.2
Cowichan	0	0.8	0.9	0	0.3	0.6	0	0.7	0.8	0	0.8	0.9	0	1.4	1.2
Demamiel	0	0.0	0.1	0	0.0	0.2	0	0.1	0.2	0	0.1	0.2	0	0.1	0.2
Dewatto	0	0.1	0.2	0	0.0	0.1	0	0.0	0.1	0	0.0	0.1	0	0.1	0.1
Ellsworth	0	0.0	0.0	0	0.0	0.1	0	0.0	0.0	0	0.0	0.1	0	0.0	0.1
Elwha	0	0.2	0.4	0	0.1	0.2	0	0.2	0.3	0	0.1	0.3	0	0.2	0.4
Englishman	0	0.7	0.9	0	0.4	0.5	0	0.5	0.7	0	0.4	0.6	0	2.0	1.4
Goldstream	0	0.6	0.8	0	0.3	0.5	0	0.6	0.8	0	0.6	0.8	0	1.5	1.2
Grant	0	0.1	0.3	0	0.1	0.2	0	0.1	0.3	0	0.2	0.3	0	0.1	0.2
GreenR_Hatchery	0	0.0	0.1	0	0.0	0.1	0	0.0	0.1	0	0.0	0.1	0	0.0	0.1
Grovers/Chico	0	0.0	0.1	0	0.0	0.1	0	0.0	0.0	0	0.0	0.1	0	0.0	0.1
Hamma_Hamma	0	0.1	0.2	0	0.1	0.2	0	0.0	0.1	0	0.1	0.1	0	0.0	0.1
Harrison	0	0.6	0.8	0	0.3	0.5	0	0.4	0.5	0	1.3	1.1	0	0.4	0.6
Heydon	0	0.4	0.5	0	0.2	0.4	0	0.2	0.4	0	0.4	0.6	0	0.6	0.8
Hoiss	0	0.0	0.1	0	0.0	0.1	0	0.0	0.1	0	0.0	0.1	0	0.0	0.1
Hoodsport	0	0.1	0.2	0	0.0	0.2	0	0.0	0.1	0	0.1	0.2	0	0.0	0.1
Hopedale_Slough	0	0.1	0.2	0	0.1	0.2	0	0.1	0.3	0	0.1	0.3	0	0.1	0.2
Inch	20	16.4	1.5	10	8.1	1.0	10	8.2	1.2	60	50.6	2.5	10	7.8	1.1
Kanaka	0	0.6	0.8	0	0.2	0.4	0	0.4	0.5	0	0.9	1.0	0	0.5	0.7
Kaouk	0	0.0	0.1	0	0.0	0.1	0	0.0	0.0	0	0.0	0.1	0	0.1	0.2
Kawkawa	0	0.1	0.3	0	0.1	0.2	0	0.1	0.2	0	0.1	0.2	0	0.0	0.2
Kennedy	0	0.0	0.1	0	0.0	0.1	0	0.0	0.1	0	0.0	0.1	0	0.0	0.1
Lang	0	0.6	0.8	0	0.4	0.5	0	0.4	0.6	0	0.3	0.5	0	1.9	1.3
Lilliwaup	0	0.0	0.1	0	0.1	0.2	0	0.0	0.1	0	0.0	0.1	0	0.0	0.1
Little Qualicum	0	0.9	0.9	0	0.6	0.7	0	0.5	0.6	0	0.5	0.7	0	2.6	1.8
Minter	0	0.0	0.1	0	0.0	0.0	0	0.0	0.0	0	0.0	0.1	0	0.0	0.0
Myrtle	0	0.1	0.1	0	0.0	0.1	0	0.0	0.1	0	0.0	0.1	0	0.1	0.2
Nanaimo	0	0.6	0.7	0	0.3	0.6	0	0.5	0.7	0	0.7	0.8	0	1.6	1.2
Nimpkish	0	0.1	0.3	0	0.1	0.1	0	0.1	0.2	0	0.0	0.1	0	0.1	0.3
Nisqually	0	0.1	0.2	0	0.2	0.3	0	0.1	0.2	0	0.1	0.2	0	0.1	0.2
Nitinat	0	0.0	0.1	0	0.0	0.1	0	0.0	0.1	0	0.0	0.1	0	0.0	0.1
Nooksack	20	17.3	1.3	10	8.4	1.1	60	53.3	1.9	10	8.5	0.9	10	8.7	1.0
Parks	0	0.0	0.1	0	0.0	0.1	0	0.0	0.1	0	0.0	0.1	0	0.0	0.1
Phillips	0	0.4	0.6	0	0.3	0.5	0	0.4	0.6	0	0.3	0.5	0	0.9	0.9
Puntledge	20	12.4	2.0	10	5.9	1.4	10	6.7	1.5	10	5.9	1.5	60	37.3	3.6
Puyallup	20	19.5	0.5	60	58.9	0.7	10	9.7	0.4	10	9.6	0.4	10	9.6	0.4
Qualicum	0	1.6	1.1	0	1.0	1.1	0	1.0	0.9	0	0.9	0.9	0	5.0	2.0
Quinault	0	0.0	0.0	0	0.0	0.0	0	0.0	0.1	0	0.0	0.1	0	0.0	0.1
Salmon_Hood	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
Satsop	0	0.0	0.1	0	0.0	0.0	0	0.0	0.1	0	0.0	0.1	0	0.0	0.1
Sauk	0	0.1	0.2	0	0.1	0.2	0	0.1	0.3	0	0.1	0.2	0	0.1	0.3
Shovelnose	0	0.2	0.4	0	0.1	0.3	0	0.2	0.4	0	0.2	0.4	0	0.4	0.6
Siberia	0	0.1	0.2	0	0.1	0.2	0	0.1	0.2	0	0.1	0.2	0	0.1	0.3
Silverdale	0	0.6	0.8	0	0.3	0.4	0	0.4	0.7	0	1.1	1.1	0	0.4	0.6
Skagit	0	0.1	0.3	0	0.1	0.2	0	0.2	0.4	0	0.1	0.2	0	0.1	0.3
Skookum/Mill	0	0.0	0.1	0	0.0	0.1	0	0.0	0.1	0	0.0	0.1	0	0.0	0.1
Skykomish	0	0.2	0.4	0	0.2	0.4	0	0.2	0.4	0	0.2	0.3	0	0.2	0.4
Snake_Bay	0	0.2	0.3	0	0.2	0.3	0	0.1	0.3	0	0.1	0.2	0	0.4	0.6
Snohomish	0	0.5	0.6	0	0.3	0.5	0	0.6	0.7	0	0.3	0.4	0	0.5	0.7
Sooke	0	0.1	0.2	0	0.0	0.2	0	0.1	0.2	0	0.1	0.2	0	0.1	0.2
Southgate	0	0.0	0.1	0	0.0	0.1	0	0.0	0.1	0	0.1	0.2	0	0.0	0.1
Spencer	0	0.0	0.1	0	0.0	0.1	0	0.0	0.1	0	0.0	0.1	0	0.1	0.2
SPrairie_W	0	0.1	0.2	0	0.1	0.1	0	0.0	0.2	0	0.1	0.2	0	0.1	0.2
Squawkum	0	0.5	0.7	0	0.4	0.6	0	0.5	0.7	0	1.9	1.4	0	0.6	0.8
Stillaguamish	0	0.5	0.7	0	0.4	0.6	0	0.9	1.0	0	0.4	0.6	0	0.6	0.7
Sucwoa	0	0.1	0.2	0	0.0	0.1	0	0.0	0.1	0	0.1	0.2	0	0.1	0.1
Tsouwwin	0	0.0	0.1	0	0.0	0.1	0	0.0	0.1	0	0.0	0.1	0	0.0	0.1
Tulalip	20	19.3	0.5	10	9.5	0.5	10	9.5	0.5	10	9.6	0.5	10	9.5	0.5
Viner_Sound	0	0.0	0.1	0	0.0	0.1	0	0.0	0.1	0	0.0	0.1	0	0.0	0.1
Widgeon_Slough	0	0.4	0.6	0	0.3	0.5	0	0.4	0.6	0	0.9	0.9	0	0.3	0.5
Regions															
Johnstone Strait	0	0.2	0.3	0	0.1	0.2	0	0.1	0.2	0	0.1	0.2	0	0.1	0.3
Southern Mainland	0	2.0	1.2	0	1.4	0.9	0	1.5	1.1	0	1.5	1.1	0	4.4	1.8
East Coast Vancouver Island	20	19.1	1.7	10	9.4	1.4	10	11.5	1.8	10	10.6	1.4	60	54.3	2.2
West Coast Vancouver Island	0	0.3	0.4	0	0.3	0.4	0	0.3	0.4	0	0.4	0.4	0	0.4	0.5
Fraser	20	19.7	1.3	10	10.0	1.0	10	10.9	1.2	60	57.6	1.6	10	10.6	1.2
Tulalip	20	19.3	0.5	10	9.5	0.5	10	9.5	0.5	10	9.6	0.5	10	9.5	0.5
North Puget Sound	20	19.1	1.3	10	9.7	1.3	60	55.8	1.7	10	10.0	1.0	10	10.4	1.4
South Puget Sound	20	19.6	0.5	60	59.2	0.6	10	9.8	0.4	10	9.8	0.4	10	9.8	0.4
Hood Canal	0	0.5	0.4	0	0.4	0.5	0	0.3	0.3	0	0.3	0.4	0	0.3	0.4
Juan de Fuca	0	0.2	0.4	0	0.1	0.2	0	0.2	0.3	0	0.1	0.3	0	0.2	0.4
Coastal Washington	0	0.0	0.1	0	0.0	0.1	0	0.0	0.1	0	0.0	0.1	0	0.0	0.1
Central Puget Sound	0	0.0	0.1	0	0.1	0.2	0	0.0	0.1	0	0.0	0.1	0	0.0	0.1

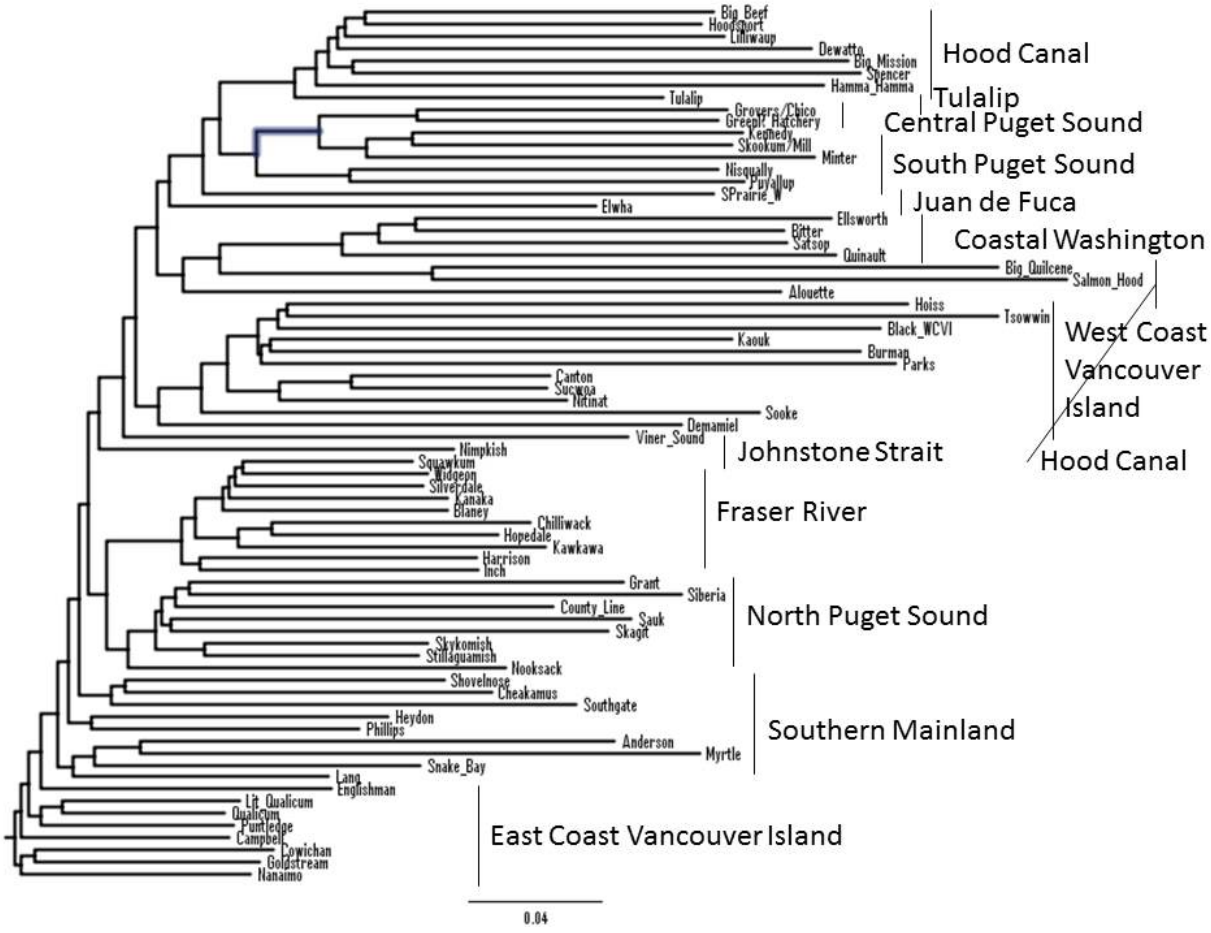

Figure 1: Neighbour-joining dendrogram of Cavalli-Sforza and Edwards (1967) chord distance for 73 southern British Columbia and Puget Sound populations of Chum Salmon (*Oncorhynchus keta*) surveyed at 28 microsatellites.

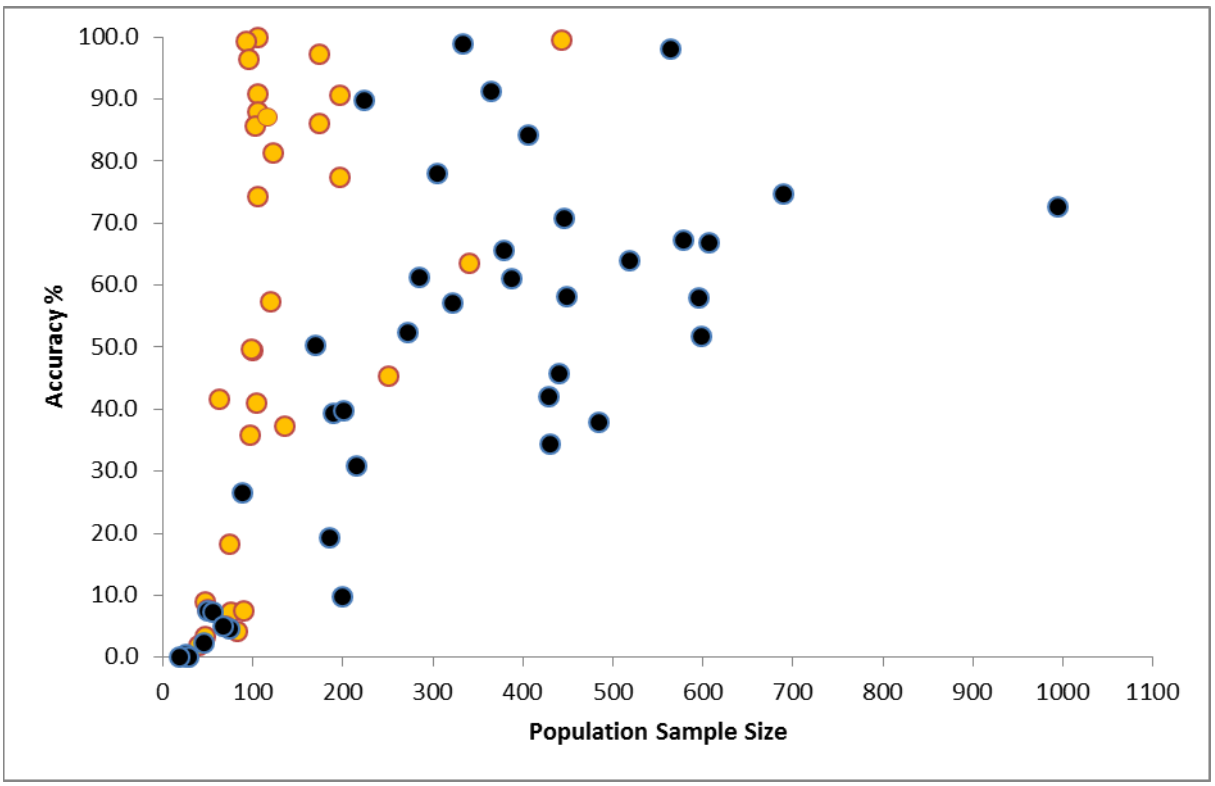

Figure 2. Relationship between the number of Chum Salmon surveyed for microsatellite variation in a specific population and the accuracy obtained for estimated population percentage of simulated single-population mixtures for 73 populations of Chum Salmon. Orange denotes Washington populations and blue denotes British Columbia populations.