

Joint US and CA Mixed-stock Chum Fisheries Sampling Design and Analysis 2013-2014

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Abstract

We conducted Genetic Stock Identification (GSI) of Chum salmon migrating to natal streams through Johnstone Strait (Statistical Areas 12 and 13) east coast of Vancouver Island (Statistical Area 14, 18 and 29) and through the San Juan Islands (Statistical Area 7 and 7A) for 2013 and 2014 using analyses of microsatellite variation. Variation at 14 microsatellites was surveyed for 4565 Chum salmon harvested in Canadian fisheries (Area 12, 14, 18, 29) and 1267 Chum salmon harvested in U.S. fisheries (Area 7-7A). In addition, 847 fish were run from the Fraser River Albion test fishery to test the assignment accuracy of the stock specific catch.

The analysis of chum salmon sampled in the commercial and test fisheries in Johnstone Strait were mainly from Canadian populations (99.8% to 89.9%) comprised largely of Fraser River (53.7% to 15.2%), Strait of Georgia West (65.7% to 6.9%) and Strait of Georgia East (43.9% to 5.6%). The analysis of Chum salmon caught in commercial fisheries in the San Juan Islands were from both Canadian and U.S. origin stocks. Weekly samples from Area 7A were comprised largely of Canadian Fraser River origin fish (99.3% to 68.4%) and samples from Area 7 comprised slightly lower proportion of Canadian fish (98.9% to 84.1%).

Analysis of chum salmon from the Albion test fishery were analyzed from scale samples collected in 1998-2000 to test use of a ratio method for determining basin-wide escapement estimate where the escapement to genetically distinct Chilliwack river population is considered known.

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Introduction

In order to facilitate management responses to Southern Chum stock strength, in accordance with Annex IV, Chapter 6 of the Pacific Salmon Treaty (Treaty) it is necessary to provide the catch composition in fisheries targeting Southern origin Chum salmon (*Oncorhynchus keta*). This is the second and third year of a four year proposed project to sample and provide Genetic Stock Identification (GSI) on key mixed stock fisheries within Canada and the US, duplicating annual sample collections as closely as possible over the four years to obtain uniform coverage. The main fisheries targeted were Johnstone Strait purse seine and gill net commercial and test fisheries (Figure 1), as well as the US commercial purse seine and gill net fisheries occurring in the areas described as San Juan Islands/Point Roberts (SJI/PR) Fishery Management Areas 7 and 7A. The Strait of Juan de Fuca (SJDF) Fishery Management Areas 4B, 5 and 6C is a targeted area but was not sampled 2013-2014 (Figure 2). Both Canadian and US Chum salmon populations were grouped into genetically distinguishable groups and must be evaluated for concordance with existing Canadian Conservation Units and Evolutionary Significant Units for conservation management purposes. The GSI work is part of the information required for accurate post-season run reconstructions which are essential in evaluating whether management actions were consistent with meeting overall objectives and Treaty obligations. Run reconstructions are also important in monitoring the productivity of stocks and assessing the adequacy of current escapement targets and both pre-season forecasting and in-season run assessment techniques. Without this knowledge, managing to achieve Treaty obligations would be difficult and severely limits the assessment of factors influencing stock productivity, which appear to have fluctuated widely in recent years.

The Chum stock specific data collected in these mixed stock areas will provide the information, deemed necessary by the PSC Joint Chum Technical Committee (Chum TC) and the PSC Southern Panel, to develop management options addressing conservation of stocks of

concern while focusing fisheries on stocks of significant abundance. It will also provide a bilaterally agreed method to determine the catch composition on all mixed stock Chum fisheries in Johnstone Strait, US areas 7 and 7A and other border area fisheries in accordance with Annex IV, Chapter 6 of the Treaty.

Materials and Methods

Collection of DNA Samples and Laboratory Analysis

Tissue samples were collected from 2331 adult Chum salmon in 2013 captured in test and commercial fisheries from British Columbia Statistical Areas 12, 13, 14, 18, 29 from Gillnet and Seine fisheries between September 16 and October 29. In 2014, 2234 adult Chum samples were collected between September 15 and October 23. There were 846 Chum salmon captured in commercial fisheries from Washington State Statistical Areas 7 and 7A between October 12 and November 05 2013, and 421 adult Chum salmon from the same Statistical Areas captured between September 24 to October 14, 2014.

No fish were sampled in 2013 or 2014 from the Strait of Juan de Fuca (US Areas 4B, 5, and 6C) as originally planned. Caudal punches were taken from sampled fish by sticking caudal punches on Whatman paper to air dry and DNA was extracted as described by Withler et al. (2000). A duplicate set of tissues were collected in Canadian waters, available to be analyzed by the U.S. lab.

In Canadian waters the Johnstone Strait Purse Seine Test Fishery was sampled on a weekly basis over a period of 7 weeks. In each week, samples were collected over a 4 day period with approximately 50 fish sampled spread out over the 5-6 sets made each day. A total of 200 tissue samples per week were taken across all weeks except the last week where only 99 samples were collected. The catch during the first opening was evenly distributed between Area 12 and Area 13 and 250 random samples were taken from vessels fishing in both areas. Vessels were sampled as they were encountered at the offload location and 25-30 fish were randomly sampled per vessel. The second commercial purse seine fishery occurred on October 22 and 23 and a majority of the catch was assigned to Area 13. All samples taken from that fishery came from vessels fishing in Area 13 and were collected following the same sampling

requirement as the first fishery. A total of 100 tissue samples were collected off a variety of vessels during the offload processing of that catch. The Area 18/19 Chum purse seine test fishery was sampled over the duration of the test fishery in 2013 and 2014 but not analyzed. The Area 29 Gulf limited effort Purse Seine Fishery which occurred on the 27 of October provided 88 tissue samples from a total estimated catch of 114 chum by three vessels. Table 1 summarizes all sample collections by fishery in Canadian waters.

In U.S. waters the chum directed fishery was sampled weekly in Washington Catch Management Areas 7 & 7A (San Juan Islands and Point Roberts). Catch Area 7 was split into East and West geographies with a goal of collecting 200 samples by week and area. 7, 7A fisheries began on October 12 and continued until November 05. Table 1 summarizes sample collections from both gillnet and purse seine gears for Areas 7 & 7A.

Once chum salmon genomic DNA was available, surveys of variation at the following 14 microsatellite loci were conducted: *Ots3* (Banks et al. 1999), *Oke3* (Buchholz et al. 2001), *Oki2* (Smith et al. 1998), *Oki100* (Beacham et al. 2008b), *Ots103* (Nelson and Beacham 1999), *Omm1070* (Rexroad et al. 2001), *Omy 1011* (Spies et al. 2005), *One101*, *One102*, *One104*, *One111*, and *One114* (Olsen et al. 2000), *Ssa419* (Cairney et al. 2000), and *OtsG68* (Williamson et al. 2002). Microsatellites were size fractionated in an Applied Biosystems (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.

In general, polymerase chain (PCR) reactions were conducted in 10 µl volumes consisting of 0.06 units of Taq polymerase, 1µl of 30ng DNA, 1.5-2.5mM MgCl₂, 1mM 10x buffer, 0.8mM dNTP's, 0.006-0.065µM of labeled forward primer (depending on the locus), 0.4µM unlabeled forward primer, 0.4µM unlabeled reverse primer, and deionized H₂O. PCR was completed on an MJResearch™ DNA Engine™ PCT-200 or a DNA Engine Tetrad™ PCT-225.

The amplification profile involved one cycle of 2 min @ 92°C, 30 cycles of 15 sec @ 92°C, 15 sec @ 52-60°C (depending on the locus) and 30 sec @ 72°C, and a final extension for 10 min @ 72°C. Specific PCR conditions for a particular locus could vary from this general outline. Further information on laboratory equipment and techniques is available at the Molecular Genetics Laboratory website at <http://www.pac.dfo-mpo.gc.ca/science/facilities-installations/pbs-sbp/mgl-lgm>.

Baseline Populations

The baseline survey consisted of microsatellite analysis of chum salmon from 130 locations within Canada and the southern US (Table 2). Fourteen regional groupings of populations were identified based on genetic stock structure and the ability to accurately estimate known mixtures on of these groupings (DFO unpublished data). All annual baseline samples available for a specific sample location were combined to estimate population allele frequencies, as was recommended by Waples (1990).

Estimation of Stock Composition

Analysis of fishery samples was conducted with a Bayesian procedure (BAYES) as outlined by Pella and Masuda (2001). Each locus was assumed to be in Hardy-Weinberg equilibrium, and expected genotypic frequencies were determined from the observed allele frequencies and used as model inputs. For BAYES, the initial FORTRAN-based computer program as outlined by Pella and Masuda (2001) required large amounts of computer analytical time when applied to stock identification problems with a baseline as comprehensive as employed in the current study. Given this limitation, a new version of the program was developed by our laboratory as a C-based program which is available from the Molecular Genetics Laboratory website (Neaves et al. 2005). In the analysis, ten 20,000-iteration Monte Carlo Markov chains of estimated stock compositions were produced, with initial starting values

for each chain set at 0.90 for a particular population which was different for each chain.

Estimated stock compositions were considered to have converged when the shrink factor was < 1.2 for the 10 chains (Pella and Masuda 2001). The last 1,000 iterations from each of the 10 chains were then combined, and for each fish the probability of originating from each population in the baseline was determined. These individual probabilities were summed over all fish in the sample, and divided by the number of fish sampled to provide the point estimate of stock composition. Standard deviations of estimated stock compositions were determined from the last 1,000 iterations from each of the 10 chains incorporated in the analysis.

Results and Discussion

A total of three commercial and two test fisheries were sampled across five different statistical areas in Canadian waters for a total of 4565 tissue samples collected in 2013-2014. In U.S. waters seven commercial fisheries were sampled across four different management areas (Table 1). A total of 1,267 tissue samples were collected and analyzed over all the fisheries sampled in 2013 and 2014.

The southern British Columbia/Washington Chum salmon baseline consisting of fourteen microsatellite markers, a subset of the Pacific Rim baseline for Chum salmon ranging from Japan, across the North Pacific (including the Yukon River) to the southern range limit of Chum salmon in the Columbia River (Beacham et al. 2008; Beacham et al. 2008b) was used to determine the compositions of the fishery samples taken in 2013 and 2014 (Table 2).

Samples collected from the Canadian Area 12 test fishery consisted of Canadian origin fish (99.7% to 92.9%; Table 3 and Table 4) predominantly from the Fraser River and Strait of Georgia (east and west sides). Samples collected from Area 12 and Area 13 commercial fisheries were also Canadian origin fish (99.7% to 96.6%; Table 3 and Table 4) predominantly from the Fraser River and Strait of Georgia (east and west sides). Area 14 and Area 18-19 were collected but not run in 2013 and 2014. The Area 29, Albion test fishery using historical scales were used to assign to Chilliwack/non-Chilliwack populations from samples collected in 1997-2000 (Table 7). Estimates of basin-wide chum salmon escapements for the Fraser River would be possible if the Chilliwack escapement could be determined accurately.

Samples collected from commercial fisheries in U.S. Area 7A also were also largely Canadian origin fish (91.9% to 17.0%; Table 5 and Table 6) again predominately Fraser River and Strait of Georgia stocks. Stock compositions in Area 7A for both gear types tended to stay fairly high to Canadian populations throughout the sample time period. There was only one sample taken during the first week of November that demonstrated a drop in the composition of

Canadian stock but that may be reflective of the small sample size (Table 5). The US Area 7 samples demonstrated much more variation in the composition of Canadian and US populations across time (Table 5 and Table 6) but were always dominated by Canadian stocks with larger contributions of Georgia Strait stocks than the Area 7A samples. Catch composition for Area 7 can further be broken down into o Area 7 east and Area 7 west as found in Figure 2, but has not been done at this time.

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Tables

Table 1. Sample size of tissue collections for DNA analysis for Chum salmon directed fisheries in 2013 and 2014.

Canadian Waters			US Waters		
Year	Fishery	# Samples	Year	Fishery	# Samples
2013	Area 12 Purse Seine Comm	371	2013	Area 7 Gillnet	11
2013	Area 12 Purse Seine Test	1329	2013	Area 7 Purse Seine	300
2013	Area 13 Purse Seine Comm	631	2013	Area 7 Purse Seine	101
2014	Area 12 Purse Seine Comm	366	2013	Area 7A Gillnet	304
2014	Area 12 Purse Seine Test	1234	2013	Area 7A Purse Seine	130
2014	Area 13 Purse Seine Comm	634	2014	Area 7 Gillnet	6
			2014	Area 7 Purse Seine	285
			2014	Area 7A Purse Seine	130
Totals		4565			1267

Table 2. Sample size of historical scale collections for DNA analysis for Chum salmon sample in the Fraser River by year.

1997	1998	1999	2000
242(0)	200(0)	241(0)	164(0)

Table 2. Baseline of 130 sample sites/populations by regional genetic groups used to estimate stock composition of Chum salmon from southern British Columbia and Washington State in 2013-2014 fisheries.

Region	Populations
Johnstone Strait	Heydon Cr, Klinaklini R, Ahta R, Viner Sound, Waump Cr, Nimpkish R, Kakweiken R, Glendale Cr, Ahnuhati Cr, Mackenzie Sound, Phillips R, Viner/Scott Cove
Strait of Georgia East	Tzoonie Cr, Cheakamus R, Sliammon R, Mamquam R, Wortley Cr, Squamish R, Indian R, Theodosia R, Southgate R, Algard Cr, Orford R, Shovelnose R, Mashiter Cr, Stawamus R, Homathko R, Kwalate Cr, Lang Cr, Deserted Cr, Myrtle Cr, Snake Cr, Anderson Cr
Strait of Georgia West	Goldstream R, Cowichan R, Nanaimo R, Chemainus R, Puntledge R, Qualicum R, Little Qualicum R, Campbell R, Cold Cr, Englishman R
West Coast Vancouver Island	Smith Cr, Kirby Cr, Demaniel R, Nitinat R, Hathaway Cr, Petattum Cr, Goodspeed, R, Cayeghle Cr, Colonial R, Sugsaw, Cr, Nahmint R, Hoiss Cr, Black Cr, Parks R, Tsowwin_R, Kaouk R, Sucwoa R, Canton R, Little Toquart R, Tranquil Cr, Salmon Cr, Bedwell R, Warner Bay, Burman Cr, Sooke R
Fraser River	Silverdale Cr, Squakum Cr, Wahleach Cr, Chilliwack R, Chehalis R, Stave R, Alouette R, Vedder R, Harrison R, Inch Cr, Lower Lillooet R, Norrish-Worth Cr, North Alouette R, Widgeon Slough, Kawkawa Cr, Blaney Cr, Chilqua Cr, Serpentine R, Kanaka Cr, Worth Cr, Hopedale Cr, Hicks Cr, Harrison Lake, Peach Cr, Sweltzer Cr, Nathan Cr, McIntyre Cr, Street Cr, Railroad, Cr, Collum Cr
North Puget Sound	Skagit R, County Line Cr, Grant Cr, Siberia Cr, Skykomish R, Snohomish R, Stillaguamish R, Sauk R
South Puget Sound	Kennedy Cr, Minter Cr, Nisqually R, Mill Cr, Skookum Cr, Puyallup R, South Prairie Cr
Juan de Fuca/ Hood Canal Summer	Salmon R, Big Quilcene R
Coastal Washington	Ellsworth Cr, Bitter Cr, Quinault R, Satsop R
Nooksack	Nooksack R
Tulalip	Tulalip R
Central Puget Sound	Green R, Grovers Cr
Juan de Fuca/ Hood Canal Fall	Elwha R, Hoodspout, Spencer Cr, Big Mission Cr, Dewatto R, Hamma Hamma R, Big Beef Cr

Table 3. Estimated percentage stock composition of Chum salmon caught in Area 12 -13 Seine Test Fishery (Double Bay and Blinkhorn Light combined) by Statistical Week, 2013. Stock compositions were estimated using 14 microsatellite loci and the baseline outlined in Table 1. Sample size and the number of fish sampled that did not amplify in parentheses. Standard error of the estimated stock composition is in parentheses.

Year	2013		2013		2013		2013		2013		2013		2013		2013		2013					
JualianDate	259-262		266-272		276		273-278		276-277		280-283		287-290		294		296-300		295		301-302	
Gear	seine		seine		seine		seine		seine		seine		seine		seine		seine		seine		seine	
Stat Area	12		12		12		12		13		12		12		12		12		13		12	
Fishery Type	test		test		Comm		test		comm		test		test		comm		test		comm		test	
Dates	Sep16-Sep19		Sep23-Sep29		-Oct03		Sep30-Oct05		Oct03-Oct04		Oct07-Oct10		Oct14-Oct17		-Oct21		Oct23-Oct27		-Oct22		Oct28-Oct29	
Sample Size	200(0)		246(4)		217(2)		88(2)		271(8)		195(4)		197(1)		148(2)		287(8)		337(13)		78(0)	
Region	Estim.	SE	Estim.	SE	Estim.	SE	Estim.	SE	Estim.	SE	Estim.	SE	Estim.	SE	Estim.	SE	Estim.	SE	Estim.	SE	Estim.	SE
Johnstone Strait	0.8	(1.2)	0.3	(1.2)	11.1	(5.4)	10.0	(11.0)	6.4	(4.8)	0.8	(1.6)	0.3	(0.6)	16.7	(6.7)	5.0	(5.4)	10.6	(4.4)	0.3	(1.4)
Strait of Georgia East (F)	38.2	(6.0)	37.6	(5.6)	17.4	(6.2)	18.3	(9.7)	25.4	(7.2)	36.0	(6.2)	43.9	(6.3)	20.1	(7.8)	20.1	(5.5)	22.6	(6.0)	24.3	(9.8)
Strait of Georgia West (F)	6.9	(5.5)	11.0	(4.9)	31.5	(6.2)	28.5	(9.0)	29.7	(6.7)	36.8	(6.4)	35.0	(6.7)	32.6	(10.8)	40.4	(5.5)	43.0	(6.4)	55.7	(10.7)
Fraser River (F)	51.5	(4.6)	49.0	(4.4)	39.2	(4.6)	41.2	(7.5)	37.4	(4.5)	20.2	(4.0)	20.2	(4.3)	16.4	(6.4)	27.3	(3.6)	19.6	(3.3)	15.2	(5.6)
West Coast Vancouver I (F)	1.2	(2.0)	1.9	(1.2)	0.2	(0.6)	0.3	(1.1)	0.6	(1.1)	3.8	(2.3)	0.2	(0.6)	0.3	(0.8)	0.3	(0.7)	0.7	(1.0)	0.8	(2.0)
Puget Sound North (F)	0.1	(0.5)	0.1	(0.4)	0.3	(1.1)	0.3	(1.3)	0.3	(0.8)	1.4	(2.4)	0.2	(0.7)	12.7	(4.5)	1.8	(2.0)	3.3	(2.0)	0.6	(1.9)
Puget Sound Centre (F)	0.0	(0.1)	0.0	(0.1)	0.0	(0.1)	0.1	(0.5)	0.0	(0.1)	0.8	(1.1)	0.0	(0.1)	0.1	(0.3)	0.8	(1.2)	0.0	(0.2)	0.1	(0.6)
Puget Sound South (F-W)	0.0	(0.2)	0.0	(0.1)	0.1	(0.3)	1.1	(1.8)	0.1	(0.4)	0.1	(0.3)	0.0	(0.2)	0.2	(0.8)	1.9	(1.4)	0.0	(0.1)	0.1	(0.7)
Hood Canal (S)	0.0	(0.1)	0.0	(0.1)	0.0	(0.1)	0.0	(0.2)	0.0	(0.0)	0.0	(0.1)	0.0	(0.1)	0.0	(0.1)	0.0	(0.2)	0.0	(0.1)	0.0	(0.2)
Hood Canal (F)	1.3	(1.0)	0.0	(0.2)	0.1	(0.4)	0.2	(0.7)	0.2	(0.7)	0.1	(0.4)	0.1	(0.4)	1.1	(1.4)	2.4	(1.9)	0.1	(0.3)	2.9	(3.0)
Juan de Fuca (F)	0.0	(0.2)	0.0	(0.1)	0.0	(0.2)	0.0	(0.2)	0.0	(0.1)	0.0	(0.1)	0.0	(0.3)	0.0	(0.3)	0.1	(0.3)	0.0	(0.0)	0.0	(0.2)
Coastal Washington (F)	0.0	(0.1)	0.0	(0.1)	0.0	(0.1)	0.0	(0.2)	0.0	(0.1)	0.0	(0.1)	0.0	(0.2)	0.0	(0.2)	0.0	(0.1)	0.0	(0.1)	0.1	(0.6)

Table 4. Estimated percentage stock composition of Chum salmon caught in Area Area 12 -13 Seine Test Fishery (Double Bay and Blinkhorn Light combined) by Statistical Week, 2014. Stock compositions were estimated using 14 microsatellite loci and the baseline outlined in Table 1. Sample size and the number of fish sampled that did not amplify in parentheses. Standard error of the estimated stock composition is in parentheses.

Year	2014		2014		2014		2014		2014		2014		2014		2014		2014		2014		2014		2014			
JualianDate	258-261		266-269		272-276		281-283		287-288		295-297		299-300		280		280		280		294		294-296		294-296	
Gear	seine		seine		seine		seine		seine		seine		seine		seine		seine		seine		seine		seine		seine	
Stat Area	12		12		12		12		12		12		12		12		13		12+13		12		13		12+13	
Fishery Type	test		test		test		test		test		test		test		Comm		Comm		Comm		Comm		Comm		Comm	
Dates	Sep15-Sep18		Sep23-Sep26		Sep29-Oct3		Oct8-Oct10		Oct14-Oct15		Oct22-Oct24		Oct26-Oct27		-Oct07		-Oct07		-Oct07		-Oct21		Oct 21-23		Oct 21-23	
Sample Size	188(0)		191(0)		192(0)		191(1)		192(0)		192(0)		180(0)		266(0)		233(1)		499(1)		100(0)		391(9)		491(9)	
Region	Estim.	SE	Estim.	SE	Estim.	SE	Estim.	SE	Estim.	SE	Estim.	SE	Estim.	SE	Estim.	SE	Estim.	SE	Estim.	SE	Estim.	SE	Estim.	SE	Estim.	SE
Johnstone Strait	1.1	(2.6)	2.0	(2.0)	1.2	(2.5)	0.7	(2.0)	0.4	(1.1)	8.5	(6.1)	5.9	(2.6)	0.9	(2.1)	1.6	(3.2)	1.5	(2.7)	0.2	(0.7)	6.9	(4.8)	2.5	(3.4)
Strait of Georgia East (F)	31.5	(6.2)	23.5	(6.0)	28.3	(7.1)	24.8	(5.4)	14.6	(5.9)	18.7	(7.7)	30.0	(7.0)	13.0	(4.9)	15.3	(5.4)	18.7	(3.9)	5.6	(6.7)	15.5	(5.2)	19.7	(4.5)
Strait of Georgia West (F)	19.9	(6.4)	19.8	(6.1)	28.4	(7.0)	27.4	(5.7)	45.5	(6.5)	35.7	(7.3)	18.8	(6.9)	36.6	(5.5)	35.4	(6.3)	32.7	(4.3)	65.7	(8.3)	35.1	(5.1)	38.8	(5.0)
Fraser River (F)	46.2	(5.0)	53.7	(4.7)	36.0	(5.0)	44.5	(4.8)	31.9	(4.6)	21.4	(4.6)	34.0	(5.3)	47.7	(4.0)	45.7	(4.4)	45.3	(3.1)	19.5	(6.1)	39.1	(3.6)	34.9	(3.1)
West Coast Vancouver I (F)	0.3	(0.8)	0.6	(1.1)	3.8	(2.9)	0.3	(0.9)	1.9	(2.0)	2.9	(3.0)	1.2	(1.8)	0.2	(0.6)	0.3	(0.8)	0.2	(0.4)	0.8	(1.7)	0.3	(0.6)	0.3	(0.5)
Puget Sound North (F)	0.4	(1.2)	0.1	(0.4)	0.6	(1.5)	0.6	(1.2)	0.3	(0.8)	7.2	(6.6)	4.5	(4.2)	0.6	(1.4)	1.1	(2.1)	0.7	(1.4)	5.4	(5.5)	0.3	(0.7)	1.7	(1.6)
Puget Sound Centre (F)	0.1	(0.3)	0.0	(0.2)	1.1	(1.1)	0.8	(0.9)	2.0	(1.3)	0.0	(0.2)	0.1	(0.3)	0.6	(0.8)	0.1	(0.3)	0.1	(0.3)	0.0	(0.3)	0.8	(0.5)	0.6	(0.4)
Puget Sound South (F-W)	0.3	(0.8)	0.0	(0.2)	0.5	(0.8)	0.2	(0.6)	0.1	(0.4)	1.7	(1.2)	0.1	(0.4)	0.3	(0.6)	0.5	(1.0)	0.6	(0.8)	0.2	(0.7)	0.2	(0.4)	0.2	(0.4)
Hood Canal (S)	0.0	(0.1)	0.2	(0.4)	0.0	(0.1)	0.0	(0.1)	0.0	(0.1)	0.0	(0.1)	0.0	(0.1)	0.0	(0.1)	0.0	(0.1)	0.0	(0.0)	0.0	(0.1)	0.0	(0.1)	0.0	(0.0)
Hood Canal (F)	0.2	(0.6)	0.0	(0.3)	0.1	(0.4)	0.7	(1.0)	3.3	(1.7)	3.9	(2.0)	5.4	(2.2)	0.0	(0.2)	0.1	(0.4)	0.1	(0.3)	2.5	(3.0)	1.6	(1.1)	1.3	(1.1)
Juan de Fuca (F)	0.0	(0.2)	0.0	(0.1)	0.0	(0.2)	0.0	(0.1)	0.0	(0.3)	0.0	(0.1)	0.1	(0.4)	0.0	(0.1)	0.0	(0.1)	0.0	(0.0)	0.0	(0.2)	0.0	(0.1)	0.0	(0.0)
Coastal Washington (F)	0.0	(0.1)	0.0	(0.1)	0.0	(0.1)	0.0	(0.1)	0.0	(0.1)	0.0	(0.2)	0.0	(0.1)	0.0	(0.1)	0.0	(0.1)	0.0	(0.1)	0.0	(0.2)	0.0	(0.1)	0.0	(0.1)

Table 5. Estimated percentage stock composition of Chum salmon caught in Area 7A Commercial Fisheries by gear, date in 2013. Stock compositions were estimated using 14 microsatellite loci and the baseline outlined in Table 1. Sample size and the number of fish sampled that did not amplify in parentheses. Standard error of the estimated stock composition is in parentheses.

Year	2013		2013		2013		2013		2013		2013		2013		2013					
JualianDate	285		285		285		288		288-291		288		288-291		295		308		309	
Gear	gill		seine		seine		gill		gill		seine		seine		gill		gill		seine	
Stat Area	7A		7A		7		7A		7		7A		7		7A		7A		7	
Fishery Type	comm		comm		comm		comm		comm		comm		comm		comm		comm		comm	
Dates	-Oct12		-Oct12		-Oct12		-Oct15		Oct15-Oct18		-Oct15		Oct15-Oct18		-Oct22		-Nov04		-Nov05	
Sample Size	63(0)		42(0)		88(0)		29(0)		11(0)		87(0)		219(0)		101(0)		101(0)		101(0)	
Region	Estim.	SE	Estim.	SE	Estim.	SE	Estim.	SE	Estim.	SE	Estim.	SE	Estim.	SE	Estim.	SE	Estim.	SE	Estim.	SE
Johnstone Strait	0.2	(0.9)	0.1	(1.0)	3.6	(6.1)	0.5	(3.0)	0.3	(3.7)	0.2	(1.0)	4.8	(4.7)	12.8	(5.6)	1.6	(3.9)	2.4	(5.2)
Strait of Georgia East (F)	3.0	(4.5)	1.3	(3.0)	15.7	(8.4)	1.1	(3.6)	71.8	(21.4)	5.5	(4.4)	11.2	(5.5)	7.3	(6.3)	11.9	(6.3)	2.1	(3.7)
Strait of Georgia West (F)	15.0	(7.2)	1.0	(3.3)	14.2	(6.6)	31.4	(12.8)	1.2	(5.6)	1.4	(2.9)	14.5	(5.2)	3.5	(5.2)	37.6	(8.5)	41.9	(8.8)
Fraser River (F)	79.8	(7.3)	89.7	(7.3)	61.7	(7.7)	56.0	(11.8)	20.6	(18.2)	91.4	(4.9)	51.9	(5.7)	69.8	(6.5)	17.0	(6.7)	33.4	(7.6)
West Coast Vancouver I (1.3	(2.3)	2.1	(4.4)	2.9	(3.9)	0.4	(2.1)	5.5	(10.4)	0.4	(1.3)	15.7	(4.8)	0.5	(1.4)	0.2	(0.9)	4.3	(3.4)
Puget Sound North (F)	0.5	(1.8)	5.3	(6.2)	1.9	(3.4)	6.4	(8.8)	0.3	(3.0)	1.0	(2.4)	1.7	(3.1)	4.7	(5.4)	29.4	(6.7)	15.5	(8.1)
Puget Sound Centre (F)	0.0	(0.3)	0.0	(0.6)	0.0	(0.3)	0.0	(0.7)	0.0	(1.2)	0.0	(0.3)	0.0	(0.1)	0.3	(0.7)	0.1	(0.5)	0.0	(0.2)
Puget Sound South (F-W)	0.0	(0.4)	0.1	(0.7)	0.0	(0.4)	0.1	(0.9)	0.0	(2.1)	0.0	(0.4)	0.0	(0.2)	1.0	(1.2)	1.4	(1.8)	0.1	(0.6)
Hood Canal (S)	0.0	(0.2)	0.0	(0.3)	0.0	(0.2)	0.0	(0.4)	0.0	(0.9)	0.0	(0.2)	0.0	(0.1)	0.0	(0.1)	0.0	(0.1)	0.0	(0.1)
Hood Canal (F)	0.2	(0.9)	0.3	(1.4)	0.0	(0.4)	4.1	(5.4)	0.2	(2.7)	0.1	(0.6)	0.1	(0.4)	0.1	(0.4)	0.7	(2.2)	0.3	(1.1)
Juan de Fuca (F)	0.0	(0.2)	0.0	(0.2)	0.0	(0.1)	0.0	(0.3)	0.0	(0.6)	0.1	(0.5)	0.0	(0.1)	0.0	(0.2)	0.0	(0.2)	0.0	(0.2)
Coastal Washington (F)	0.0	(0.3)	0.1	(0.7)	0.0	(0.2)	0.0	(0.6)	0.0	(1.8)	0.0	(0.3)	0.1	(0.3)	0.1	(0.4)	0.0	(0.2)	0.0	(0.3)

Table 6. Estimated percentage stock composition of Chum salmon caught in Area 7 Commercial Fisheries by gear, date in 2014. Stock compositions were estimated using 14 microsatellite loci and the baseline outlined in Table 1. Sample size and the number of fish sampled that did not amplify in parentheses. Standard error of the estimated stock composition is in parentheses.

Year	2014		2014		2014		2014		2014		2014		2014	
JualianDate	284		287		284		267-270		273		284		285	
Gear	seine		seine		gill		seine		seine		seine		seine	
Stat Area	Area7A_PS		Area7A_PS		Area7GN		Area7PS		Area7PS		Area7PS		Area7PS	
Fishery Type	StatWk41		StatWk42		StatWk41		StatWk39		StatWk40		StatWk41		StatWk42	
Dates	Oct11		Oct14		Oct11		Sep24-Sep27		Sep30		Oct11		Oct12	
Sample Size	63(5)		58(0)		6(0)		36(0)		3(0)		51(0)		189(0)	
Region	Estim.	SE	Estim.	SE	Estim.	SE	Estim.	SE	Estim.	SE	Estim.	SE	Estim.	SE
Johnstone Strait	0.4	(1.5)	1.0	(3.3)	1.3	(8.4)	0.3	(1.7)	2.1	(10.8)	0.3	(1.4)	2.2	(4.1)
Strait of Georgia East (F)	1.8	(3.2)	3.0	(5.2)	5.4	(12.7)	27.6	(10.5)	4.1	(14.2)	5.5	(6.3)	4.4	(3.7)
Strait of Georgia West (F)	1.3	(2.9)	10.8	(6.8)	19.5	(24.5)	2.4	(5.4)	2.4	(10.0)	22.8	(9.1)	35.7	(6.5)
Fraser River (F)	91.9	(6.2)	74.4	(9.3)	45.0	(28.2)	66.3	(11.4)	84.5	(25.9)	67.3	(8.8)	56.2	(5.3)
West Coast Vancouver I (F)	0.5	(1.7)	3.6	(4.1)	1.9	(9.1)	0.5	(2.2)	3.3	(14.0)	2.6	(4.6)	0.5	(1.2)
Puget Sound North (F)	3.5	(5.2)	6.3	(6.9)	24.4	(27.5)	1.4	(4.2)	1.2	(8.3)	0.6	(2.3)	0.8	(1.7)
Puget Sound Centre (F)	0.0	(0.3)	0.0	(0.4)	0.1	(2.5)	0.3	(1.5)	1.4	(7.5)	0.1	(0.7)	0.0	(0.2)
Puget Sound South (F-W)	0.4	(1.3)	0.6	(2.0)	2.2	(8.3)	0.4	(1.7)	0.6	(6.8)	0.7	(1.7)	0.1	(0.4)
Hood Canal (S)	0.0	(0.3)	0.0	(0.2)	0.0	(1.8)	0.0	(0.3)	0.0	(2.4)	0.0	(0.2)	0.0	(0.2)
Hood Canal (F)	0.1	(0.8)	0.4	(1.7)	0.1	(3.8)	0.7	(2.3)	0.1	(6.3)	0.1	(0.7)	0.1	(0.3)
Juan de Fuca (F)	0.0	(0.1)	0.0	(0.2)	0.0	(1.3)	0.1	(0.8)	0.3	(3.6)	0.0	(0.2)	0.0	(0.1)
Coastal Washington (F)	0.0	(0.4)	0.0	(0.3)	0.0	(2.3)	0.0	(0.5)	0.0	(3.9)	0.0	(0.5)	0.0	(0.2)

Table 7. Estimated percentage stock composition of Chum salmon caught in the Albion test fishery years 1998, 1999, and 2000. Stock compositions were estimated using 14 microsatellite loci and the Fraser baseline only.

Year	1997		1998		1999		2000	
JualianDate	274-324		257-327		260-327		271-325	
Gear	gill		gill		gill		gill	
Stat Area	Area29		Area29		Area29		Area29	
Fishery Type	AlbionTest		AlbionTest		AlbionTest		AlbionTest	
Dates	Oct1-Nov20		Sep14-Nov23		Sep17-Nov24		Sep28-Nov21	
Sample Size	242(0)		200(0)		241(0)		164(0)	
Region	Estim.	SE	Estim.	SE	Estim.	SE	Estim.	SE
Fraser River (F)	99.2	(1.6)	95.3	(4.6)	89.8	(4.8)	87.5	(7.2)
Chilliwack River (F)	0.8	(1.6)	4.7	(4.6)	10.2	(4.8)	12.5	(7.2)

Figures

Figure 1. Map of Statistical Areas outlining Chum salmon fishing locations in southern British Columbia

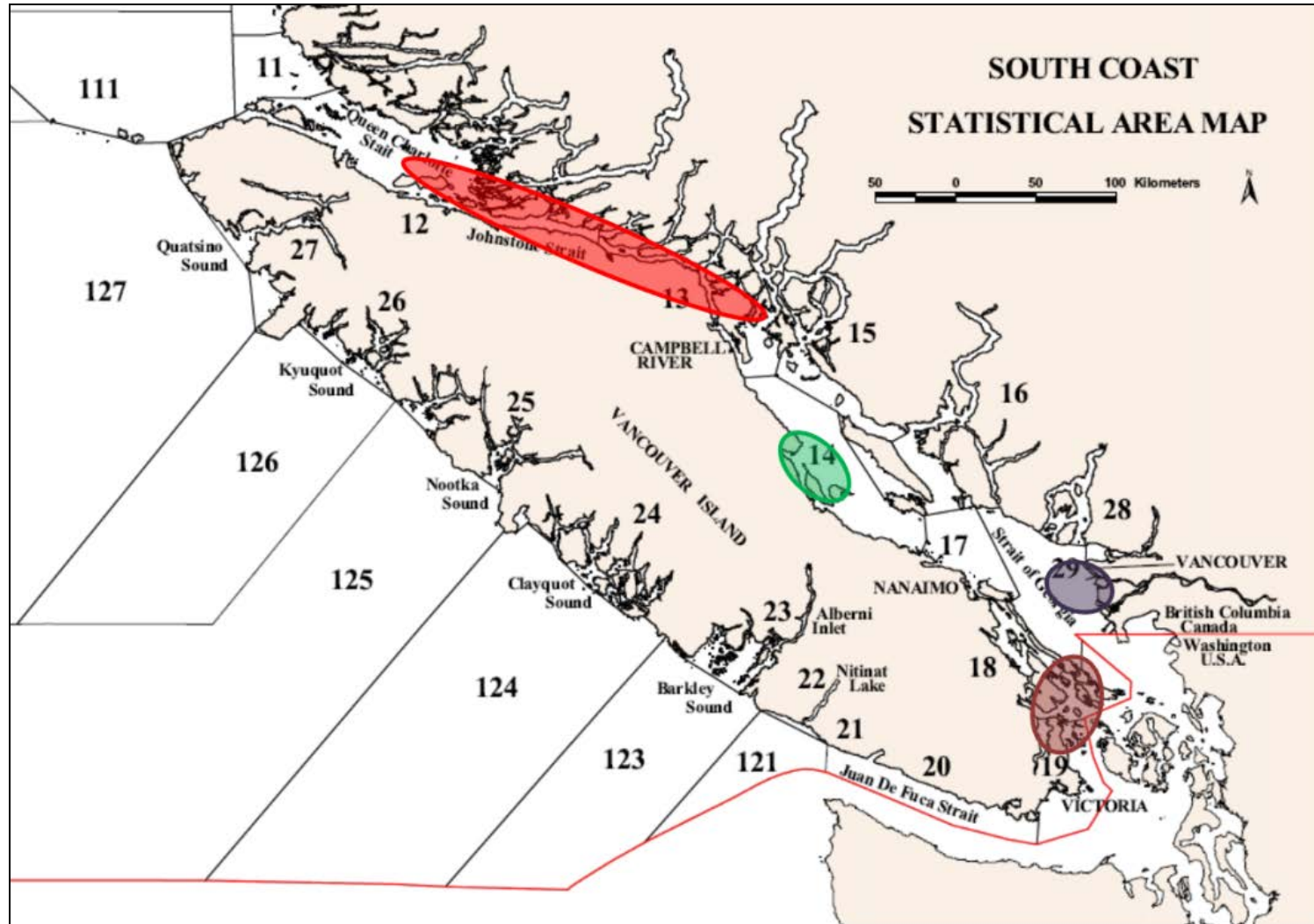


Figure 2. Map of Statistical Areas outlining Chum salmon fishing locations in Puget Sound

