

# **Joint US and CA Juan de Fuca Chum Sampling Program 2016**

## Report to Southern Endowment Fund

Pieter Van Will, John Candy, Carmen McConnell, Lee Kearey

Department of Fisheries and Oceans  
3190 Hammond Bay Road  
Nanaimo, B. C.  
V9T 6N7

and

Bill Patton

Northwest Indian Fisheries Commission  
6730 Martin Way E.  
Olympia WA 98516-5540

Contact: Phone: 250-949-9273

Email: [pieter.vanwill@dfo-mpo.gc.ca](mailto:pieter.vanwill@dfo-mpo.gc.ca)

## **Abstract**

Through the initial work on the ChumGEM reconstruction model, it was very apparent that the diversion of Chum salmon stocks through the southern route (Strait of Juan de Fuca) was a significant gap in our information needed to populate the model. Currently the model structure is available to incorporate this information but the assumptions on the migration pathways being used require investigation and validation.

The purpose of this project was to work towards addressing that data gap by sampling this migration route in both US and Canadian waters to determine:

- The spatial and temporal stock composition of Chum salmon migrating through the Southern Diversion route,
- Provide sampling platform for stock identification, migration rate studies etc.
- Develop time series of Catch per Unit effort data to pair with the Johnstone Strait Test Fishery to determine diversion rate of various Chum populations.

The first year of this multi-year program was initiated in 2016. The program began as planned on September 27<sup>th</sup> and ran until October 31<sup>st</sup>. A total of 104 sets were completed (44 in Canadian waters and 60 in US waters). A total of 1,471 Chum were encountered and 1,024 were sampled for stock id and other biologicals. The catch information demonstrated a later timing than originally expected, also observed in the Johnstone Strait Test Fisheries, with the highest Chum Catch per Unit Effort (CPUE) occurring in week 44. Over the period of the program, Chum CPUE was higher in US waters than in Canadian waters except in the first week.

Stock composition information demonstrated that Canadian stocks dominated the samples early in both US and Canadian fishing areas. In Canadian waters US stocks

increased in composition later in the program and were prevalent throughout the sampling in US waters dominating the mixture after week 41. Stock timing and distribution differences were observed and this new information has improved our understanding of stock composition and timing through the Strait of Juan de Fuca

## **Acknowledgments**

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## Introduction

The Chum Technical Committee (TCChum), in consideration of the requirements of the latest version of Annex IV, Chapter 6 (Chum Annex) of the Pacific Salmon Treaty, has determined that a significant amount of stock assessment work should be undertaken by the parties, in order to provide the level of information necessary for the successful implementation of the Annex.

Part of implementing the strategic plan, the TCChum submitted various proposals over the last few years to target key components of the plan. In 2014 the first phase of the Chum Genetic and Environmental Management model (ChumGEM) was initiated to develop a run reconstruction model for Southern BC and Washington Chum salmon.

Through the initial work on ChumGEM, it was very apparent that the diversion of Chum salmon stocks through the southern route (Strait of Juan de Fuca) was a significant gap in our information needed to populate the model. Currently the model structure is available to incorporate this information but the assumptions on the migration pathways being used required investigation and validation.

The purpose of this project was to work towards addressing that data gap by sampling this migration route in both US and Canadian waters to determine:

- The spatial and temporal stock composition of Chum salmon migrating through the Southern Diversion route,
- Provide sampling platform for stock identification, migration rate studies etc.
- Develop time series of Catch per Unit effort data to pair with the Johnstone Strait Test Fishery to determine diversion rate of various Chum populations.



## Study Area

Juan de Fuca Strait is a partially mixed tidal channel connecting the freshwater catchment basins of the Strait of Georgia and Puget Sound to the continental margin of British Columbia and Washington State (Figure 1). The strait has a maximum depth of 200 m, a width of 25–40 km, a length of 160 km, a surface area of 4068 km<sup>2</sup>, and a volume of 417 km<sup>3</sup> (Thomson, Mihály and Kulikov 2007). In order to evaluate the migration of Chum moving through this Southern Diversion pathway, the area was broken into 4 quadrants (Figure 2) to sample over the duration of the program.

## Materials and Methods

This program entailed 3 components: Vessel operation, catch sampling and sample processing.

### *Charter Vessel Operations and Fish Capture:*

In order to reduce catch selectivity, a Purse Seine vessel was chartered to conduct the sampling to cover the main fall Chum migration time period through the month of October. The dimensions of the seine net used were 225 fathom (1,350 feet; 411m) long and 30 fathoms (180 feet; 55 m; 675 meshes) deep. The charter vessel was to attempt a minimum of 6 sets/day fishing in a quadrant pattern within Juan de Fuca Strait (Figure 2). As this was a pilot program, flexibility in the set location was allowed in order to determine optimum set locations (i.e. the fish maybe predominantly shore-oriented so most of the effective fishing effort would be near-shore). The vessel plan was to fish a total of 4 days per week (2 days in Canadian waters and 2 days in

U.S. waters) over a 6 week period starting the end of September through October (September 27-October 31).

All catches were estimated numerically by following these procedures:

- Once the seine bunt was dried up alongside or at the stern of the vessel fish were sampled by dip-netting or brailing a portion of the catch out of the net.
- Only fish that were required for biological sampling were retained and all other fish were enumerated and released
- The remaining fish were counted by species as they swam out of the bunt over the breast line. Lowering and raising the breast line controlled the speed at which the fish swam out of the net.
- The observer with crew support enumerated all species

An on-board observer trained by DFO was responsible for the collection and recording of all catch data, such as date, time, set location, number of sets, and catch by set and species. All data collected was recorded on paper set logs (examples in Appendix A and B) and then entered into an electronic logbook for real-time data transmission using a satellite system. Data collected from the vessel is available on the DFO website at:

[http://www-ops2.pac.dfo-mpo.gc.ca/fos2\\_Internet/Testfish/rptdtfdparm.cfm?fsub\\_id=228](http://www-ops2.pac.dfo-mpo.gc.ca/fos2_Internet/Testfish/rptdtfdparm.cfm?fsub_id=228).

This satellite system also provided the Vessel Monitoring System (VMS) for real time monitoring of vessel positioning every 15 minutes. That data is available but not included in this report due to the size of the file.

#### *Catch Sampling:*

Once the net was dried up a portion of the catch will be dip-netted/brailed out for sampling. The target samples size was for a maximum of 400 Chum each week (200/ week on the Canadian side and 200/week on the U.S. side). Every attempt was made to sample the catch across sets proportionate to the CPUE. The information collected was:

- Scale samples for age determination based on protocols laid out in (MacLellan et al. 2004).
- Length samples (Post Orbital Fork)
- Sex composition
- Tissue samples for DNA extraction DNA tissue samples will be collected as adipose tissue and mounted on Whatman paper as described in sampling protocols on the MGL website at <http://www.pac.dfo-mpo.gc.ca/science/facilities-installations/pbs-sbp/mgl-lgm/samp-echant/index-eng.html>.

#### *Sample processing:*

##### **Scale samples:**

All scale samples were sent to the Sclerochronology Laboratory of the Pacific Biological Station in Nanaimo for age analysis. Sample preparation and scale age evaluation were completed following methods described in (MacLellan et al. 2015) and (Hudson et al. 2010). Results by fish were provided back and compiled within the database for this program.

##### **Tissue samples for DNA:**

##### **Sample preparation**

All tissue samples were sent to the Molecular Genetic Laboratory of the Pacific Biological Station for DNA extraction and analysis. The sample size (200/strata) was derived from past genetic studies. Simulations from previous Puget Sound Chum genetic stock studies in the 1980s and 1990s using less accurate electrophoresis genetic analyses methods demonstrated large increases in precision when sample size increased from 100 to 200 and a small increase in precision for sample size above 200.

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 MgCl<sub>2</sub>, 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 H<sub>2</sub>O. 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 1). Thirteen 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 estimated when all Monte Carlo Markov chains had converged producing a Gelman-Rubin coefficient  $< 1.2$  (Pella and Masuda 2001). The last 1,000 iterations from each of the 10 chains were 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 also determined from the last 1,000 iterations from each of the 10 Monte Carlo Markov chains incorporated in the analysis.

## Results and Discussion

The program initiated as planned on September 27<sup>th</sup> and ran until October 31<sup>st</sup>. Data has been stratified over each week and by fishing area (see Table 2 for the week assignments).

A total of 104 sets were completed (44 in Canadian fishing areas and 60 in US fishing areas). A total of 1,471 Chum were encountered and 1,024 were sampled for stock id and other biologicals.

### *Set distribution*

Sets were conducted throughout the study area during the duration of the program. As this was the first year of this type of survey in this location, flexibility on set location was provided within a defined area to determine fish utilization and behavior (Figure 2). Set locations were collected on the data sheets as well as through VMS. The GPS coordinates of each of these set locations (Appendix C) were then incorporated into Google Earth and provided in Figures 3-8.

Of the 104 sets conducted only one set was deemed a “non-assessment” set due to a setting malfunction and not included in the analysis. For the 103 assessment sets 42% were within the Canadian fishing areas and 58% were conducted in US waters over the duration of the program. The original plan was to set weekly in both Canadian and US fishing areas, but due to the participation of the sampling platform in commercial fisheries, some weekly coverage in both fishing areas was not achieved.

### *Catch and Effort information*

Catch and effort data is provided in Table 3 for the program. A total of 1,471 Chum, 103 adult Coho and 71 Coho jacks were encountered during the program. Of the catch only 1,024 Chum were retained for sampling and all the other Chum and Coho were released. Chum CPUE peaked during week 44 in both the US and Canadian waters. Chum CPUE tended to be higher in US waters over the duration of the program except week 40 (Figure 9). As this was the first year of this type of sampling it is difficult to draw any conclusions as to what the CPUE

encountered reflects on abundance of Chum salmon moving through this area over the time of the program.

### *Biological Information*

All Chum retained during the project were sampled for a variety of biologicals. 1,024 Chum were sampled over the duration of the project.

### **Sex composition**

The sex composition varied across weeks (Table 4). Male Chum dominated in the first weeks with female Chum composition increasing through the weeks and then dominating in week 45 (Figure 10). This pattern is indicative of chum migration seen in other areas such as the Johnstone Strait Test fishery.

### **Age composition**

Age composition was dominated by 4<sub>1</sub> Chum during the entire program (Table 5). This result is similar to what was observed in the 2016 Johnstone Strait test fishery samples. Female age 31 fish increased in their composition in the later 2 weeks (Figure 11).

### **Length data**

Fish size range from 571mm to 774 mm with the average Male Chum = 637mm and females = 625mm (Table 6). Fish size tended to decline over time for both sexes. A drop in female size during the last week coincides with a strong Age 3 female composition during that period (Figure 12).

### **Stock Composition**

Stock composition of the Chum catch by week and fishing area is provided in Table 7 to the regional and country of origin level. Keep in mind when evaluating the assignment of stock to the samples that sample size targets were not achieved in all weeks and fishing areas.

The samples collected in the Canadian fishing areas tended to be dominated by Canadian stocks with an increase in prevalence of US stocks into the later weeks. In US waters, the Canadian stocks only dominated the samples during the first two weeks with US stocks taking over in week 42 through week 44. Based on this information it appeared that spatially, US stocks tend to favor the “US waters” or the Southern portion of the Study Area and temporally, US stocks increase their prevalence as you get later into October and into November in both US and Canadian fishing areas (Figure 13).

In regards to Canadian composition, Fraser stocks tended to dominate spatially in Canadian waters over the first 3 weeks of the program and in the last 2 weeks Southern BC populations were more dominant. Over the duration of the program, the Southern BC populations were made up primarily of West Coast Vancouver Island stock and Strait of Georgia West stock (Figure 14). West Coast Vancouver Island composition tended to be high in Canadian waters for week 41 through 42 and in US waters in week 41. Strait of Georgia West stock dominated most of the other samples in both time and area for the Southern BC Chum proportion.

The composition of US stocks was a little more variable with Puget Sound North Fall stock comprising a majority in weeks 40 through 42 in Canadian waters with negligible contribution in US waters during the same time (Figure 15). Hood Canal Fall stock dominated in US waters from week 41 till the end and in Canadian waters in weeks 44 and 45. This indicates that there was both temporal and spatial variation within the US populations migrating through the Strait of Juan de Fuca in 2016. Puget Sound North stock appeared to migrate earlier and spatially more in Canadian waters, and Hood Canal Fall populations were more dominant and dispersed in both US and Canadian waters as the season progressed.



## **Conclusion**

The program in 2016 proved to be an effective platform to sample Chum migration moving through the Strait of Juan de Fuca. The program collected valuable stock specific information on spatial distribution and migration timing. Strong differences were observed in the stock composition over weeks and between US and CDN waters. Canadian populations tended to dominate samples on both sides early in the season and US stocks increased in prevalence later in the season

## **Recommendations**

In planning for subsequent years, it is important that sample sizes by strata (week and fishing area) be achieved in order to draw appropriate conclusions regarding temporal and spatial compositions moving through the Strait of Juan de Fuca. It is imperative that we sample on both sides of the border during the same week in order to compare the catch information. Based on the small sample sizes during the first few weeks of the project, we recommend starting the program a few weeks later running for a 6 week period to get better coverage of the migration timing. As the program requires permitting on both sides of the border it will be key to initiate that process well in advance of the start date to ensure all required permits are approved for the fishing activities. In discussion with the skipper it is also recommended that we look at a shallower net (move from a 675mesh to a 475 mesh) to better access sites in the Canadian Fishing areas and spend additional time on site selection.

## Literature Cited

- Hudson, M. J., N. Crosby, F. Canada. Dept. of & R. Oceans. Pacific. 2010. *How to produce quality salmon scale impressions*. Nanaimo, BC: Fisheries and Oceans Canada, Science Branch Pacific Region, Pacific Biological Station.
- MacLellan, S. E., F. Canada. Dept. of, Oceans & S. Pacific Biological. 2004. *Guide for sampling structures used in age determination of Pacific salmon*. Nanaimo, BC Fisheries and Oceans Canada, Stock Assessment Division, Pacific Biological Station.
- MacLellan, S. E., D. C. Gillespie, S. Pacific Biological, F. Canada. Dept. of & R. Oceans. Pacific. 2015. *Chinook salmon (*Oncorhynchus tshawytscha*) scale age determination procedures*. Nanaimo, B.C: Science Branch, Pacific Biological Station, Fisheries & Oceans Canada.
- Neaves, P. I., J. R. Wallace, J. R. Candy & T. D. Beacham. 2005. CBayes:computer program for mixed stock analysis of allelic data.
- Pella, J. & M. Masuda (2001) Bayesian methods for analysis of stock mixtures from genetic characters. *FISHERY BULLETIN*, 99, 151-167.
- Thomson, R. E., S. F. Mihály & E. A. Kulikov (2007) Estuarine versus transient flow regimes in Juan de Fuca Strait. *Journal of Geophysical Research - Oceans*, 112, C09022.
- Waples, R. S. (1990) Temporal Changes of Allele Frequency in Pacific Salmon: Implications for Mixed-Stock Fishery Analysis. *Canadian Journal of Fisheries and Aquatic Sciences*, 47, 968-976.

## Tables

**Table 1.** 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 2016 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, Hoodsport, Spencer Cr, Big Mission Cr, Dewatto R, Hamma Hamma R, Big Beef Cr

**Table 2.** 2016 Date ranges and assigned week numbers

<b>Date Range</b>	<b>Week Number</b>
September 25- October 1	40
October 2 – October 8	41
October 9- October 15	42
October 16 – October 22	43
October 23 – October 29	44
October 30 – November 5	45

**Table 3.** Catch and Effort information for the program in 2016

<b>Week Number/ Fishing Area</b>	<b>Number of Sets</b>	<b>Chum Kept</b>	<b>Chum Released</b>	<b>Coho adult released</b>	<b>Coho Jack released</b>
<b>40</b>					
Canada	5	14	0	19	5
US	8	21	1	10	9
<b>41</b>					
Canada	6	22	0	7	0
US	12	140	8	28	0
<b>42</b>					
Canada	10	36	0	21	0
US	6	51	1	8	0
<b>43</b>					
US	12	185	41	2	3
<b>44</b>					
Canada	12	90	109	2	4
US	22	412	287	4	50
<b>45</b>					
Canada	10	53	0	2	0
<b>Grand Total</b>	<b>103</b>	<b>1,024</b>	<b>447</b>	<b>103</b>	<b>71</b>

**Table 4.** Chum Salmon age composition by sex over time

<b>Week #</b>	<b>Female</b>	<b>Male</b>	<b>Sample Size</b>
40	29%	71%	35
41	41%	59%	165
42	47%	53%	86
43	46%	54%	184
44	50%	50%	503
45	57%	43%	53
<b>Combined</b>	<b>47%</b>	<b>53%</b>	<b>1026</b>

**Table 5.** Chum Salmon age composition by sex over time

<b>Sex/ Week #</b>	<b>Female</b>				<b>Male</b>			
	<b>Age 3</b>	<b>Age 4</b>	<b>Age 5</b>	<b>Total</b>	<b>Age 3</b>	<b>Age 4</b>	<b>Age 5</b>	<b>Total</b>
40	3%	23%	3%	<b>29%</b>	9%	57%	6%	<b>71%</b>
41	5%	35%	1%	<b>41%</b>	6%	47%	5%	<b>59%</b>
42	6%	35%	6%	<b>46%</b>	10%	40%	4%	<b>54%</b>
43	4%	40%	1%	<b>45%</b>	10%	40%	4%	<b>55%</b>
44	11%	38%	1%	<b>51%</b>	11%	37%	2%	<b>49%</b>
45	25%	30%	2%	<b>57%</b>	4%	36%	4%	<b>43%</b>
<b>Combined</b>	<b>9%</b>	<b>37%</b>	<b>2%</b>	<b>47%</b>	<b>9%</b>	<b>40%</b>	<b>3%</b>	<b>53%</b>

**Table 6.** Chum salmon length by sex over time

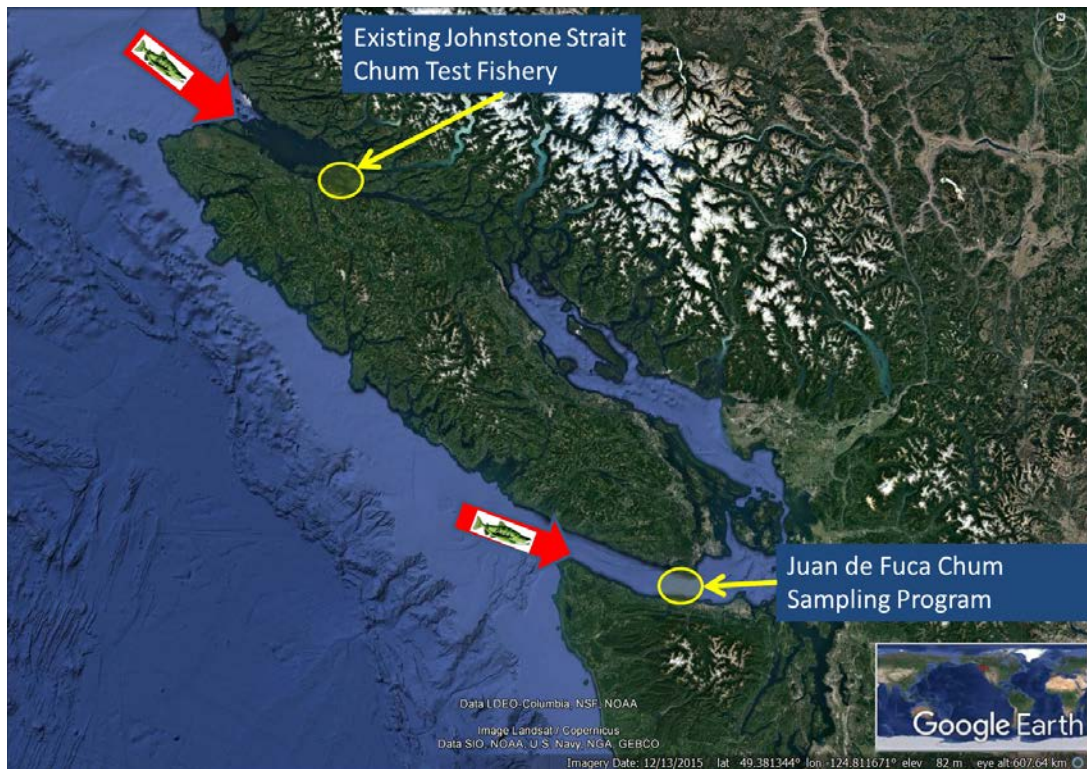
<b>Sex/ Week#</b>	<b>Average Length (mm)</b>	<b>Standard deviation (mm)</b>	<b>Maximum (mm)</b>	<b>Minimum (mm)</b>	<b>Sample Size</b>
<b>Female</b>	<b>625</b>	<b>35</b>	<b>750</b>	<b>521</b>	<b>487</b>
40	647	37	685	564	10
41	632	29	710	555	68
42	642	33	703	553	40
43	630	35	750	550	85
44	621	34	721	521	254
45	605	33	704	541	30
<b>Male</b>	<b>637</b>	<b>41</b>	<b>774</b>	<b>517</b>	<b>539</b>
40	670	36	715	589	25
41	646	40	754	545	97
42	641	44	729	568	46
43	638	43	774	540	99
44	629	40	735	517	249
45	641	38	721	556	23
<b>Combined</b>	<b>631</b>	<b>39</b>	<b>774</b>	<b>517</b>	<b>1026</b>

**Table 7.** Estimated percentage stock composition of Chum salmon caught in the Juan de Fuca sampling program by week and Area (CDN: Canadian waters, US: United States waters) in 2016. Stock compositions were estimated using 14 microsatellite loci and the baseline outlined in Table 1. Number of fish excluded because of their inability to provide sufficient information for genetic stock identification in parentheses beside the sample size. Standard deviation (SD) of the estimated stock composition is in parentheses.

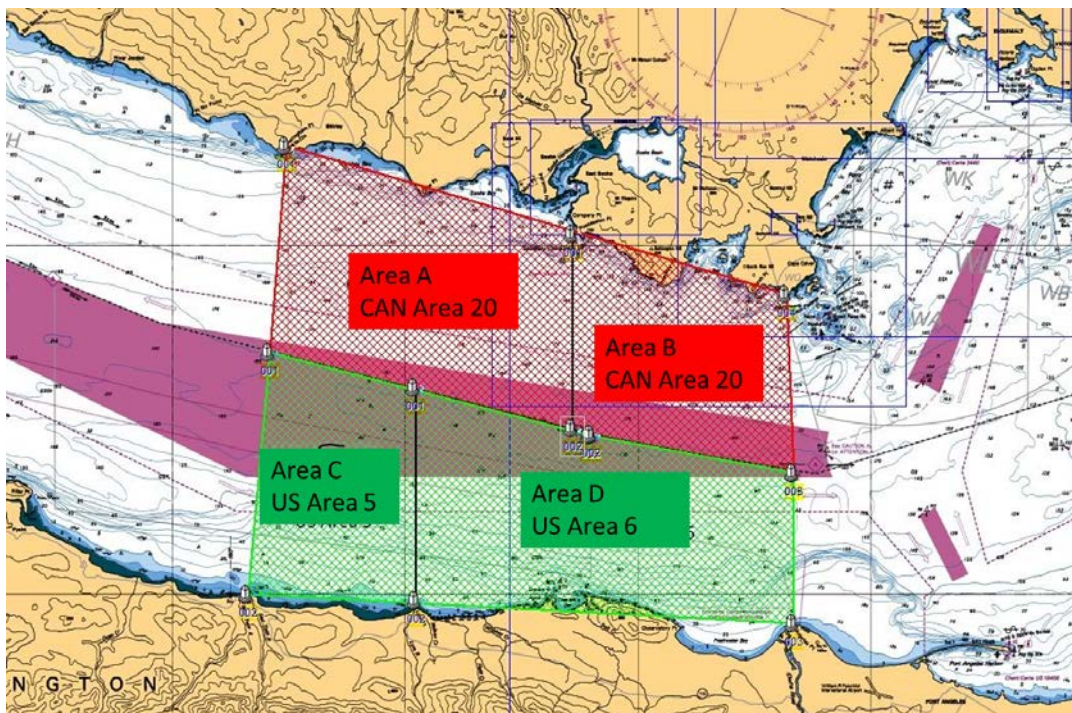
Year	2016		2016		2016		2016		2016		2016		2016		2016		2016		2016	
Julian Date	271-272		272		282		280-282		283-288		283-288		295		297-298		299-303		304-305	
Gear	Seine		Seine		Seine		Seine		Seine		Seine		Seine		Seine		Seine		Seine	
Area	JdeFucaTest-CDN		JdeFucaTest-US		JdeFucaTest-CDN		JdeFucaTest-US		JdeFucaTest-CDN		JdeFucaTest-US		JdeFucaTest-US		JdeFucaTest-CDN		JdeFucaTest-US		JdeFucaTest-CDN	
Week #	Week40		Week40		Week41		Week41		Week42		Week42		Week43		Week44		Week44		Week45	
Sample Dates	Sept27- 28		28-Sep		8-Oct		Oct6-7		Oct9-14		Oct13		Oct21-22		Oct23-24		Oct25-29		Oct30-31	
Sample size	13(0)		22(0)		22(0)		143(0)		36(0)		50(0)		184(0)		90(0)		412(0)		53(0)	
Region	Estimate	SD	Estimate	SD	Estimate	SD	Estimate	SD	Estimate	SD	Estimate	SD	Estimate	SD	Estimate	SD	Estimate	SD	Estimate	SD
Johnstone Strait	0.8	(4.9)	9.3	(9.9)	2.0	(5.4)	0.4	(1.6)	0.6	(2.4)	3.2	(5.0)	1.6	(2.3)	1.7	(4.2)	2.9	(2.3)	1.7	(2.6)
Strait of Georgia East (F)	5.2	(10.4)	14.5	(12.2)	8.9	(11.4)	7.5	(6.0)	3.5	(5.4)	1.4	(3.1)	4.2	(3.9)	8.2	(5.6)	4.4	(2.9)	6.8	(7.5)
Strait of Georgia West (F)	29.5	(15.6)	10.6	(12.5)	3.4	(7.9)	5.6	(6.3)	4.8	(7.3)	26.6	(10.8)	11.5	(4.0)	19.6	(8.6)	10.1	(3.3)	28.2	(8.6)
Fraser River (F)	60.5	(16.6)	36.9	(13.1)	51.7	(15.4)	38.5	(5.2)	58.5	(10.1)	5.3	(6.2)	16.2	(4.1)	31.0	(6.7)	10.7	(2.2)	12.8	(7.0)
West Coast Vancouver I (F)	2.8	(7.5)	8.2	(7.7)	27.2	(12.9)	17.8	(4.2)	31.4	(9.9)	10.5	(6.9)	3.3	(1.9)	4.6	(3.3)	0.8	(0.8)	5.7	(5.4)
North Puget Sound (F)	0.7	(3.5)	0.6	(2.8)	5.2	(8.9)	0.2	(0.9)	0.8	(2.7)	1.1	(3.2)	4.3	(4.3)	0.1	(0.6)	5.1	(2.3)	1.9	(3.8)
Central Puget Sound (F)	0.0	(0.9)	3.7	(6.7)	0.2	(1.4)	4.0	(2.3)	0.0	(0.4)	9.4	(4.8)	4.6	(2.2)	9.6	(4.5)	1.8	(0.9)	0.2	(1.3)
South Puget Sound (F-W)	0.3	(2.8)	4.3	(7.0)	0.9	(3.1)	8.3	(2.8)	0.1	(1.0)	2.5	(4.4)	13.2	(3.2)	3.5	(4.0)	17.3	(2.5)	20.3	(5.9)
Hood Canal (S)	0.0	(0.7)	2.5	(3.9)	0.0	(0.5)	0.0	(0.1)	0.0	(0.5)	0.0	(0.3)	0.0	(0.1)	0.0	(0.2)	0.0	(0.0)	0.0	(0.3)
Hood Canal (F)	0.2	(2.9)	0.4	(2.3)	0.4	(2.5)	17.6	(3.8)	0.2	(1.4)	39.7	(8.6)	34.8	(4.4)	21.3	(5.1)	38.2	(2.9)	22.2	(6.9)
Juan de Fuca (F)	0.0	(1.3)	8.9	(9.1)	0.0	(0.7)	0.0	(0.1)	0.1	(0.9)	0.0	(0.3)	0.0	(0.1)	0.0	(0.1)	0.0	(0.1)	0.0	(0.4)
Coastal Washington (F)	0.0	(1.3)	0.0	(0.9)	0.0	(1.0)	0.0	(0.2)	0.0	(0.6)	0.2	(0.9)	6.3	(2.2)	0.3	(0.9)	8.7	(1.6)	0.2	(1.1)
Country																				
Canada	98.8	(5.9)	79.5	(12.8)	93.2	(9.6)	69.9	(4.5)	98.8	(3.3)	47.0	(8.9)	36.8	(5.2)	65.2	(5.9)	28.9	(3.1)	55.2	(8.2)
US	1.2	(5.9)	20.5	(12.8)	6.8	(9.6)	30.1	(4.5)	1.2	(3.3)	53.0	(9.0)	63.2	(5.2)	34.8	(5.9)	71.1	(3.1)	44.8	(8.2)

\*(F)=Fall run Chum, (S)=Summer run Chum, (F-W)= Fall and winter run Chum

## Figures

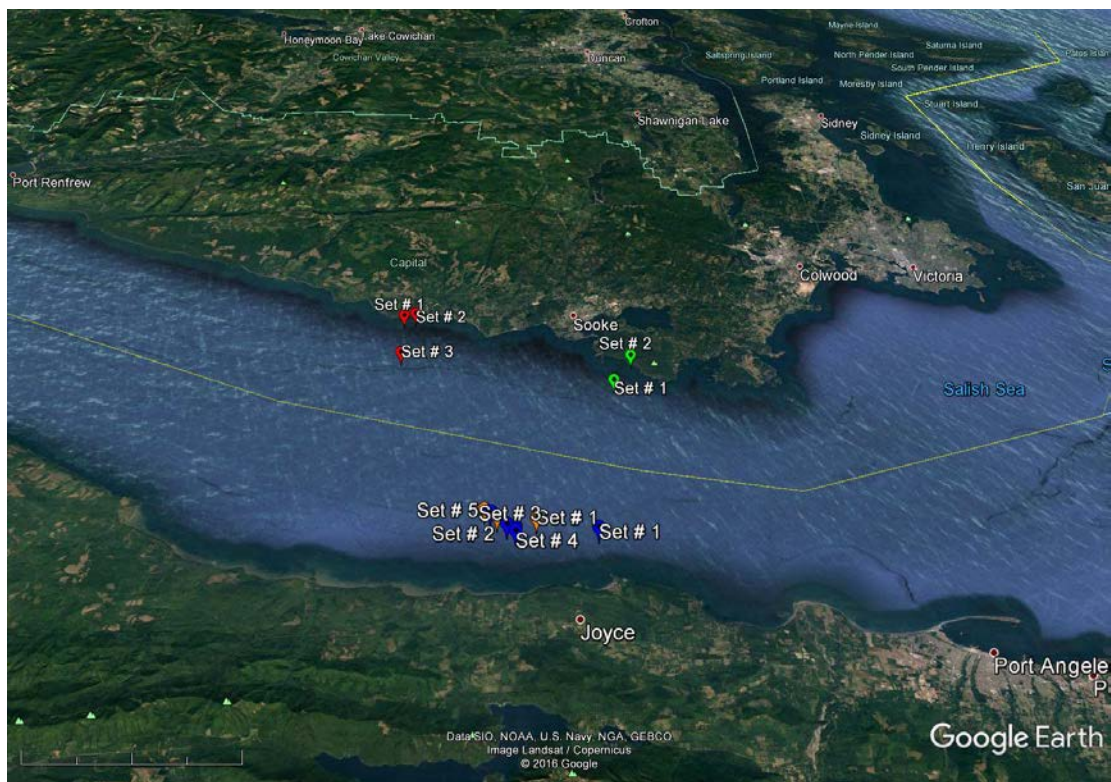


**Figure 1.** Map of migration pathways for Fall Chum returning to Southern BC and Washington State

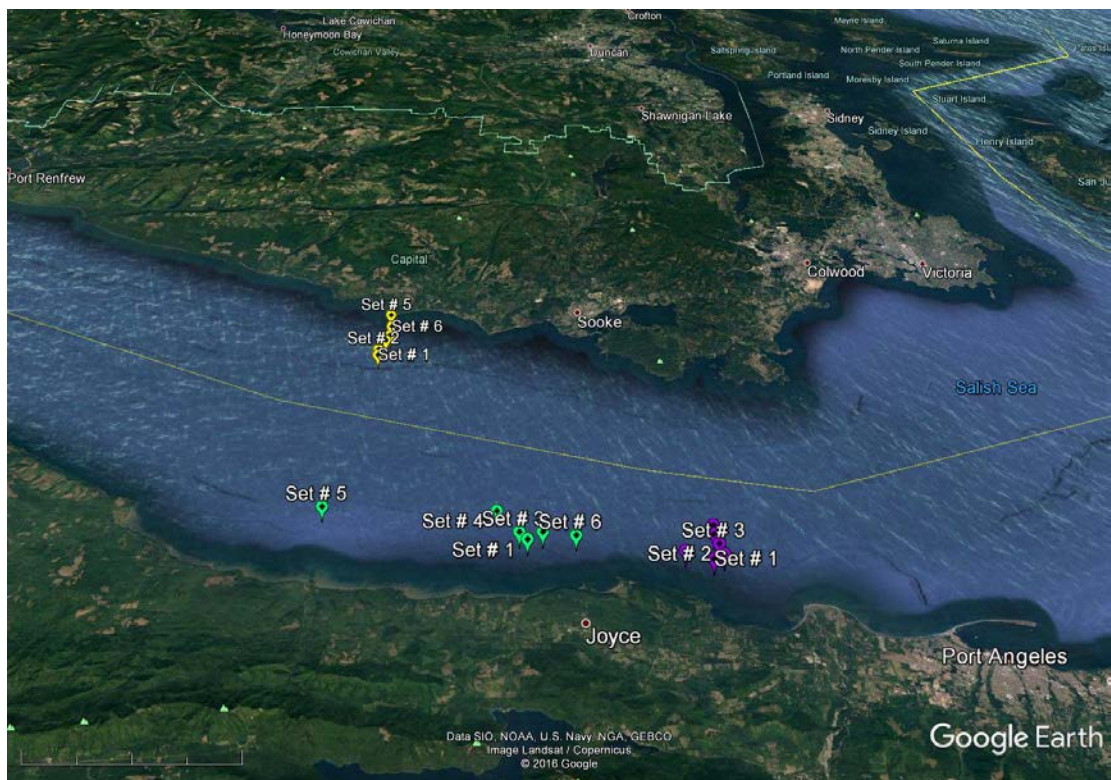


**Figure 2.** Map of fishing quadrants in Juan de Fuca Strait



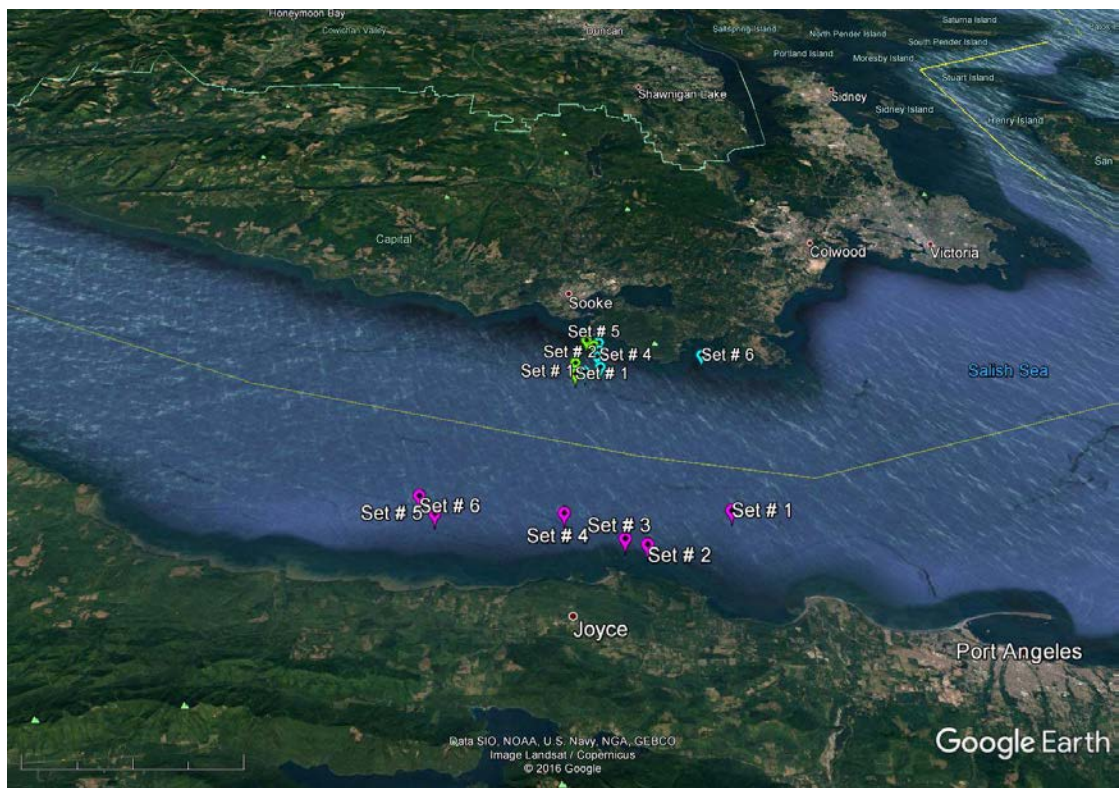


**Figure 3.** Set locations Week 40 (Sept 25-Oct 1)

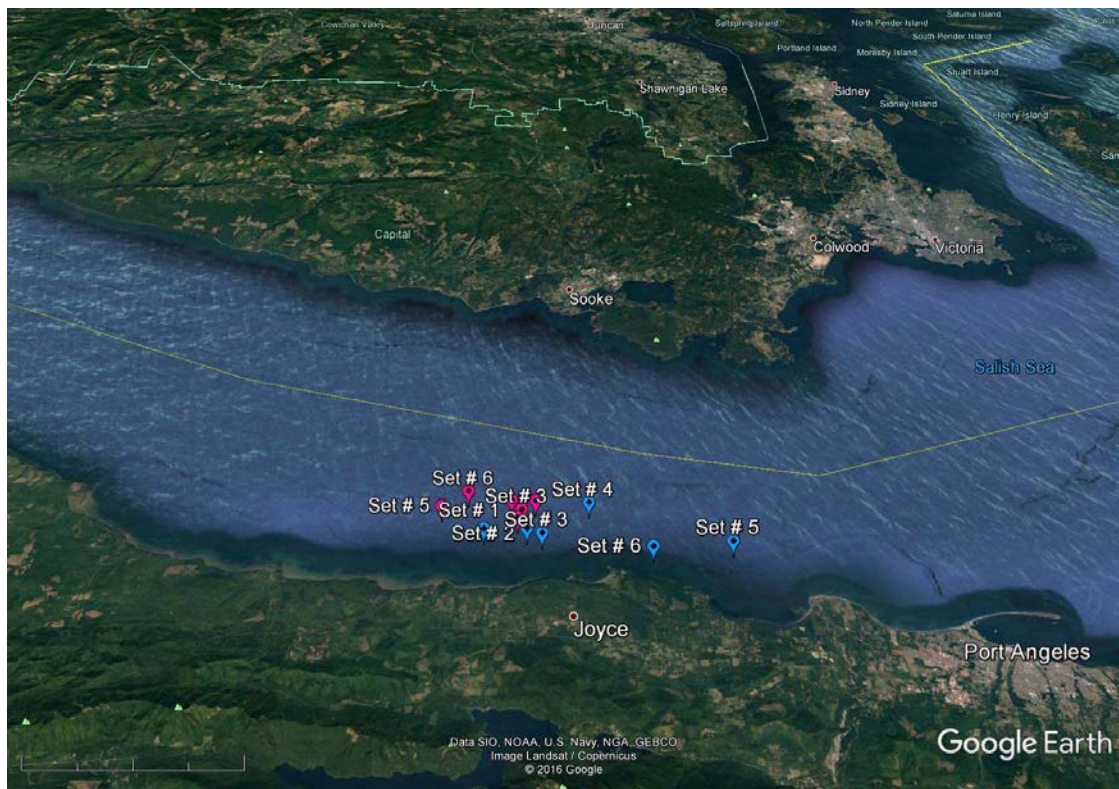


**Figure 4.** Set locations Week 41 (Oct 2-8)



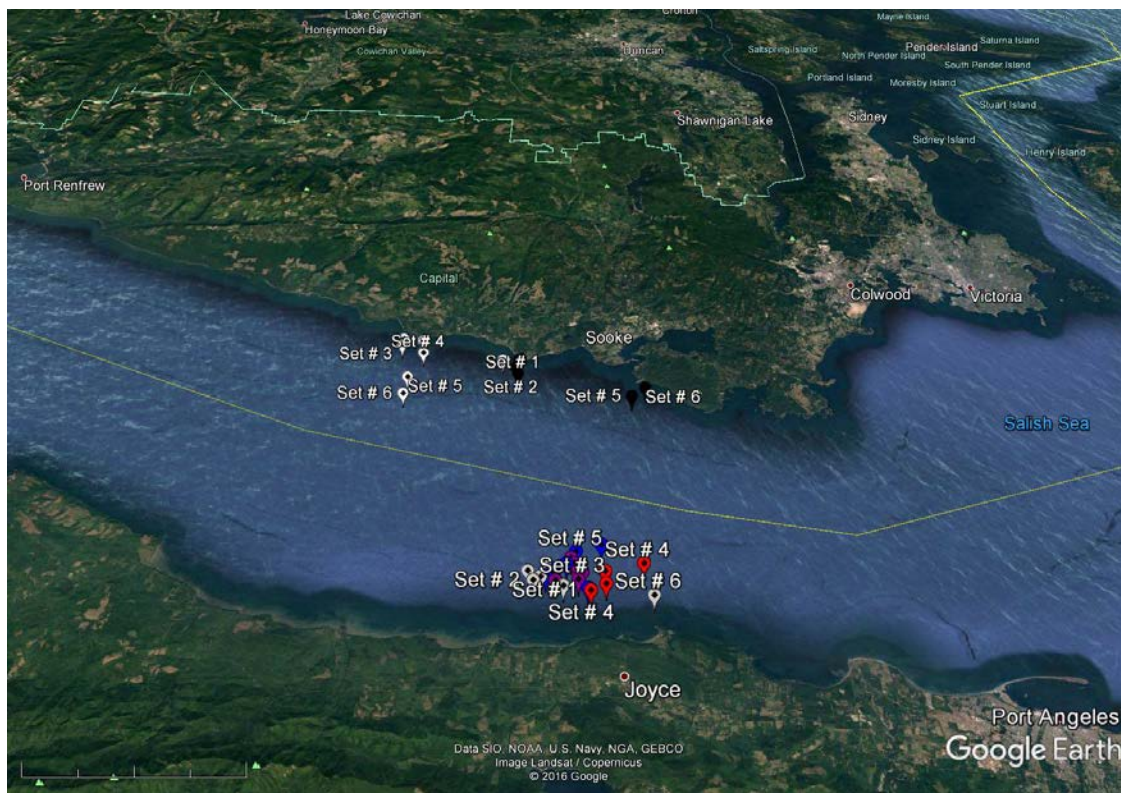


**Figure 5.** Set locations Week 42 (Oct 9-15)

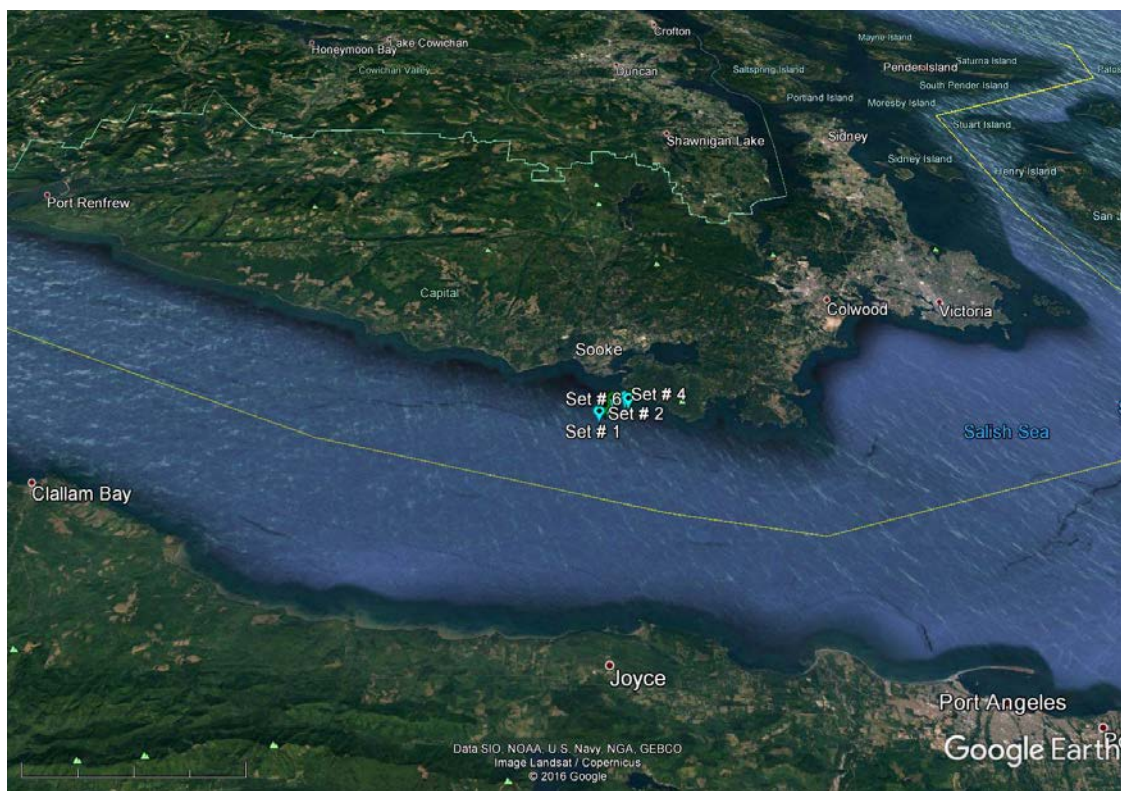


**Figure 6.** Set locations Week 43 (Oct 16-22)

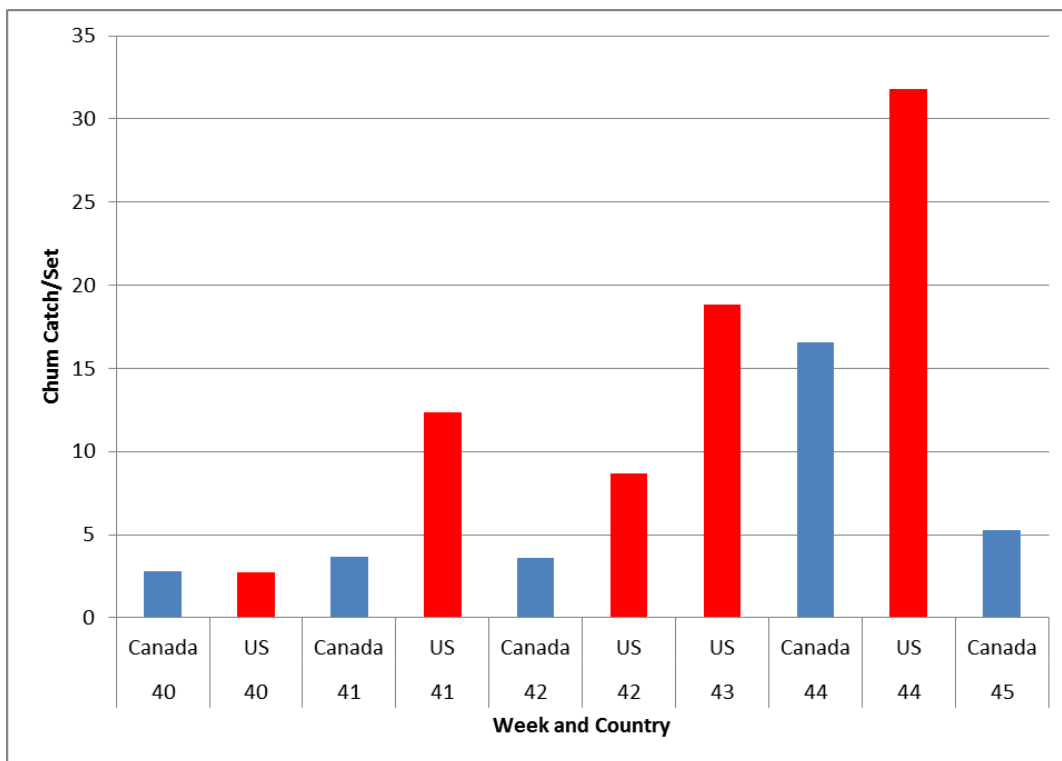




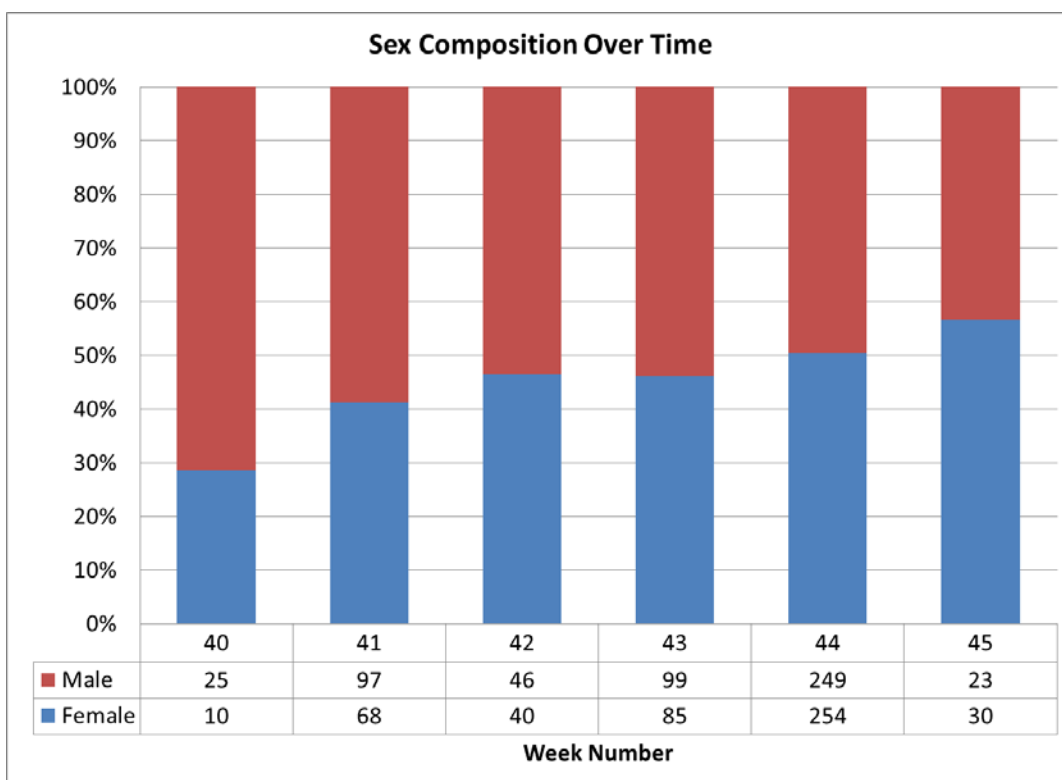
**Figure 7. Set locations Week 44 (Oct 23-29)**



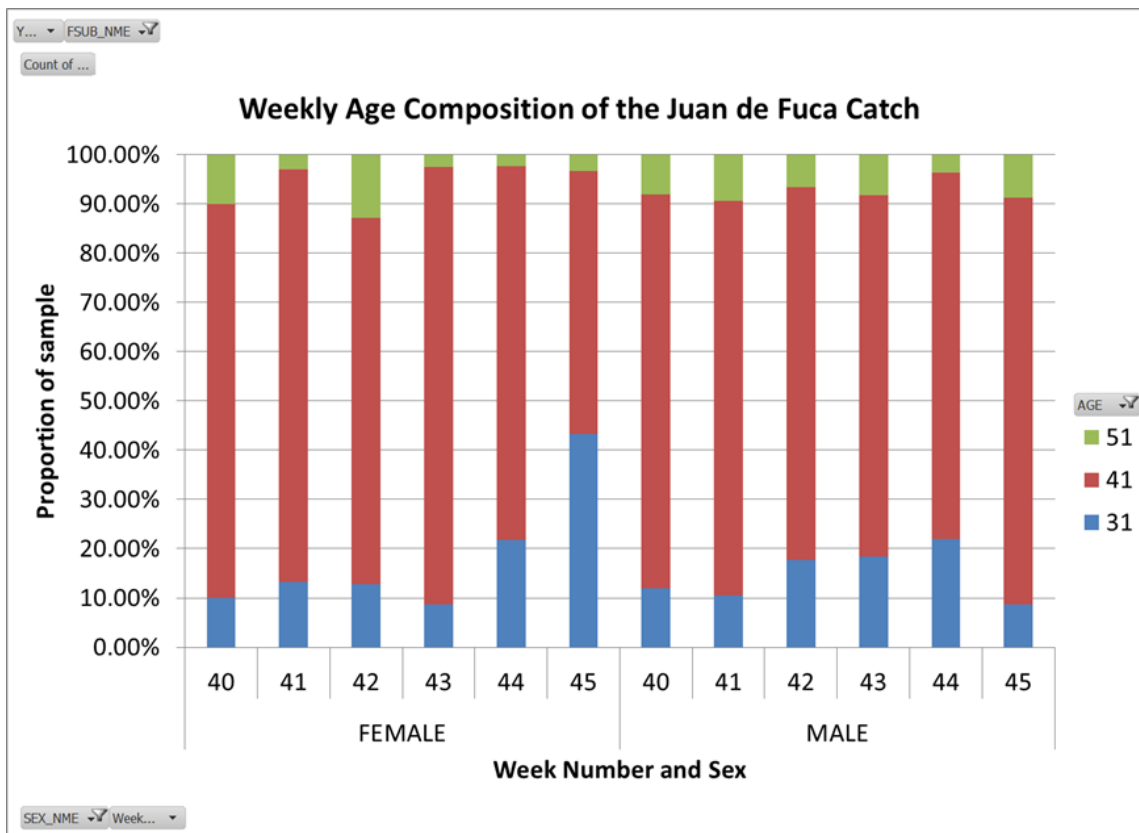
**Figure 8. Set locations Week 45 (Oct 30-Nov 5)**



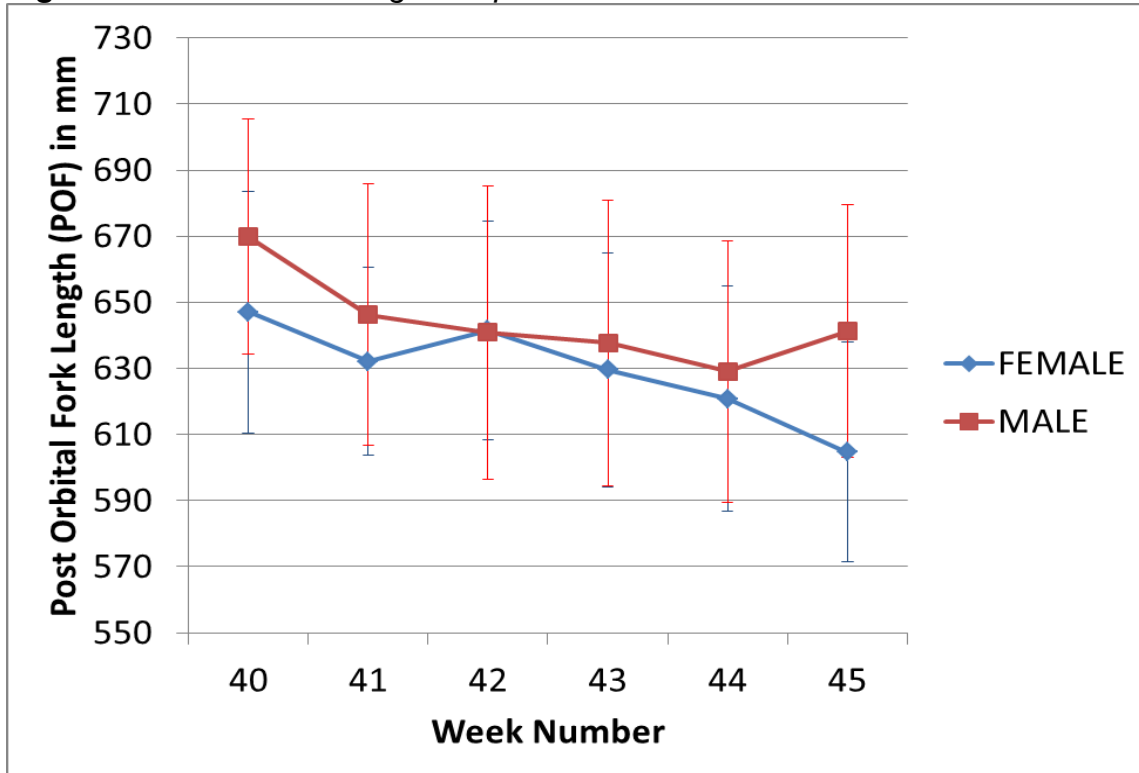
**Figure 9.** CPUE by time and area



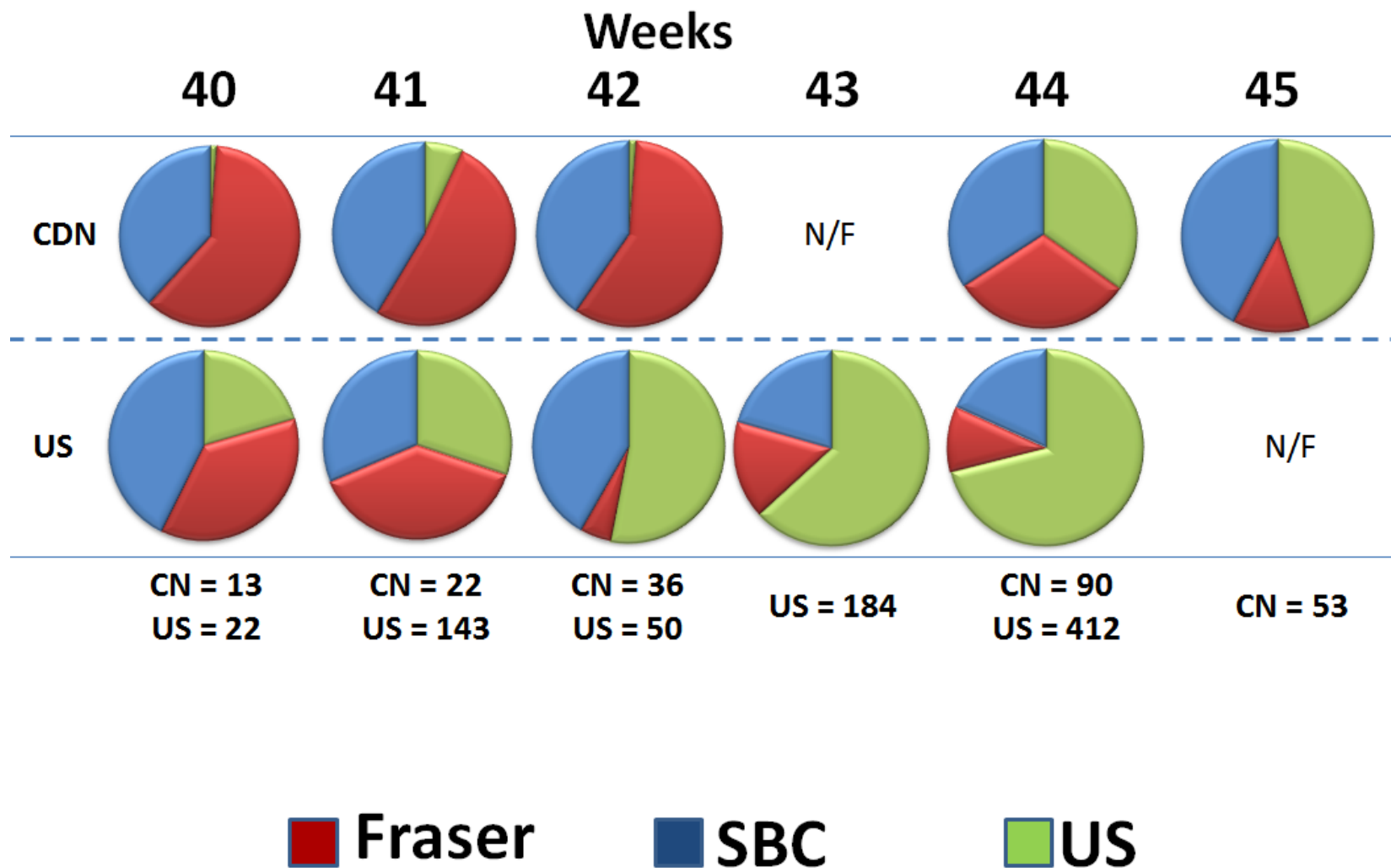
**Figure 10.** Chum salmon sex composition over time (sample size below week #)



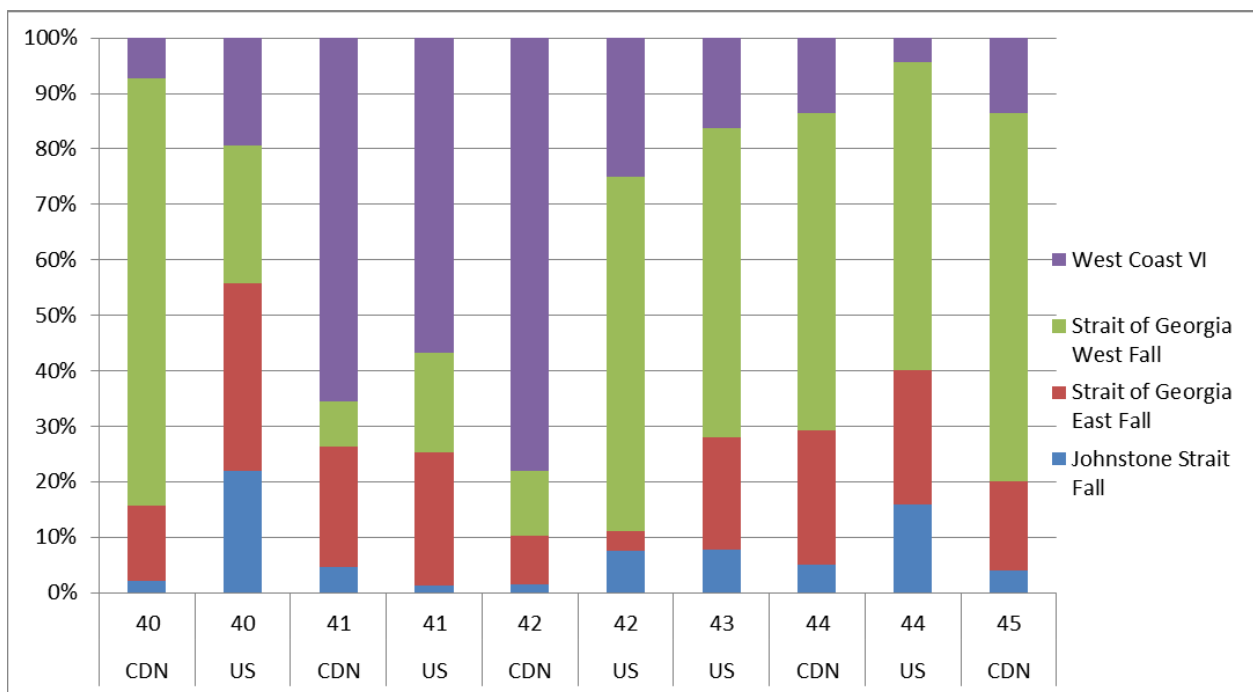
**Figure 11.** Chum salmon age composition over time



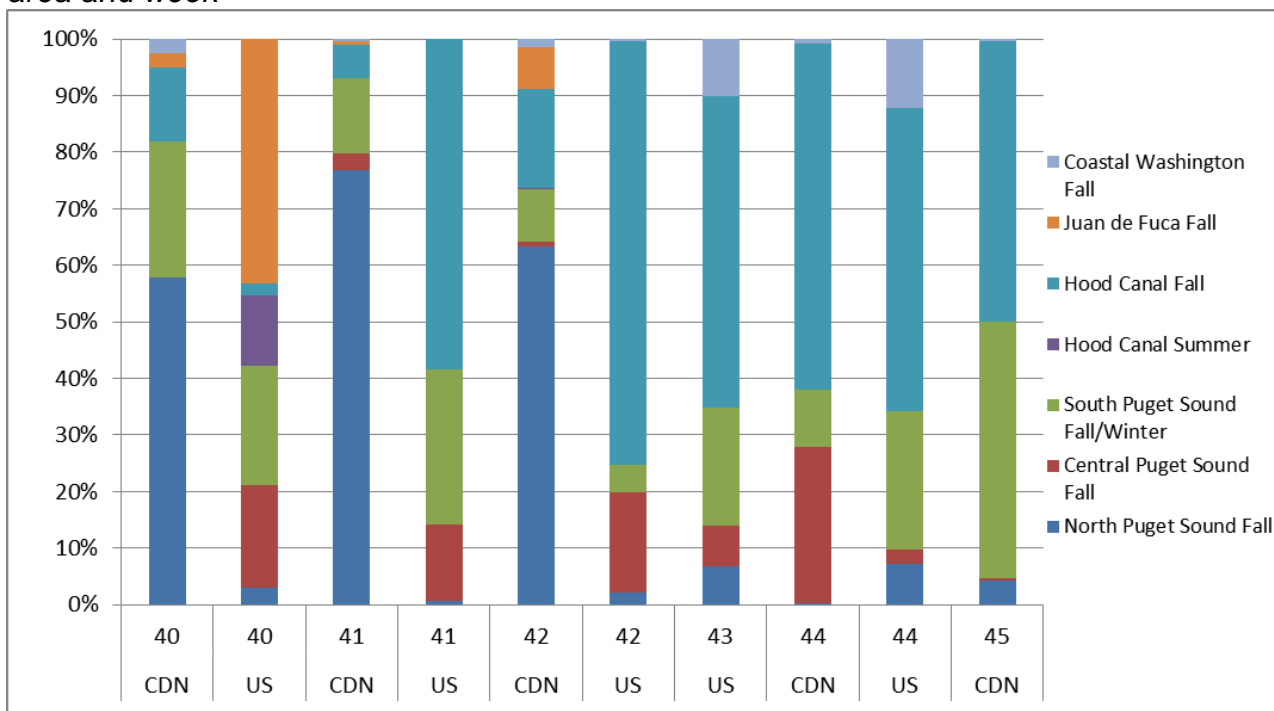
**Figure 12.** Chum salmon length by sex over time (error bars= 1 S.D.)



**Figure 13.** Fraser, Southern BC (SBC) and US Composition of samples across time and between in US and Canadian waters (Sample size is provided below the pie graphs for each week). Week 40 = Sept 25-Oct 1



**Figure 14.** Stock composition of the Southern BC (SBC) component in the samples by area and week



**Figure 15.** Stock composition of the US component in the samples by area and week

## *Appendices*

## Appendix A: Set log example

Chum Seine Test Fishery				Juan de Fuca Strait Area 20				Date (dd/mm/yyyy): ____ / ____ / ____				Page ____ of ____									
Mark Recalma MV "Qualicum Producer"				Blinkhorn - Vessel # 2				Observer:				FOS Trip ID (office use only):									
Set #	Location Name	Time (PST 1845) Start	Close	Tide	Weather		Sockeye (118) Adult	Jack	Coho (115) Adult	Jack/Juv	Pink (108)	Chum (112)	Chinook (124) Adult	Jack	Stlhd (128)	Other (specify)	Set Cond.	Set Type	Bio Data & Set Comments ( # of jumpers and finners, problems with set, ect...)		
					Rain: 0 1 2 3	Kept													Book #	Scale #	to
					% Overcast:														Book #	Scale #	to
					Wind (Dir/kn):	Rel													DNA Sheet #	DNA #	to
					Sea Cond:														Water Temp °C		
					Rain: 0 1 2 3	Kept													Book #	Scale #	to
					% Cloud:														Book #	Scale #	to
					Wind (Dir/kn):	Rel													DNA Sheet #	DNA #	to
					Sea Cond:														Water Temp °C		
					Rain: 0 1 2 3	Kept													Book #	Scale #	to
					% Cloud:														Book #	Scale #	to
					Wind (Dir/kn):	Rel													DNA Sheet #	DNA #	to
					Sea Cond:														Water Temp °C		
					Rain: 0 1 2 3	Kept													Book #	Scale #	to
					% Cloud:														Book #	Scale #	to
					Wind (Dir/kn):	Rel													DNA Sheet #	DNA #	to
					Sea Cond:														Water Temp °C		
					Rain: 0 1 2 3	Kept													Book #	Scale #	to
					% Cloud:														Book #	Scale #	to
					Wind (Dir/kn):	Rel													DNA Sheet #	DNA #	to
					Sea Cond:														Water Temp °C		
DAILY & SET COMMENTS		Assessment Total (set cond 1 & 2 and/or set type 1)																Set Condition:			
		Non-Assessment Total (set cond 0 and/or set type 2)																0 - Bad set or catch not representative			
																	1 - Problem with set but did not affect catch				
																	2 - Good set no problems				
																	Set Type:				
																	1 - Assessment				
																	2 - Non-Assessment				
																	Weather Codes:				
																	Overcast: 0%, 25%, 50%, 75%, 100%				
																	Rain: 0 - none 1 - light 2 - medium 3 - heavy				
																	Sea Cond: calm rippled chop rough				
Total Daily Samples -																					



**CHUM BIOSAMPLE FORM:**

Date: \_\_\_\_/\_\_\_\_/\_\_\_\_

[illegible]

### Appendix C: Set coordinates and time

Latitude	Longitude	TimeBegin	TimeEnd	Latitude	Longitude	TimeBegin	TimeEnd
48°21.96N	123°54.42W	9/27/2016 11:32	9/27/2016 12:10	48°10.18N	123°40.58W	10/21/2016 17:04	10/21/2016 17:17
48°22.09N	123°53.74W	9/27/2016 13:07	9/27/2016 13:36	48°11.88N	123°46.79W	10/22/2016 8:11	10/22/2016 8:31
48°19.74N	123°54.22W	9/27/2016 14:51	9/27/2016 15:22	48°11.85N	123°45.71W	10/22/2016 8:55	10/22/2016 9:14
48°18.2N	123°41.91W	9/28/2016 8:22	9/28/2016 8:52	48°11.53N	123°46.32W	10/22/2016 9:58	10/22/2016 10:19
48°19.58N	123°40.85W	9/28/2016 9:34	9/28/2016 10:17	48°11.21N	123°46.49W	10/22/2016 11:04	10/22/2016 11:26
48°11.28N	123°43.06W	9/29/2016 12:24	9/29/2016 12:54	48°11.65N	123°49.91W	10/22/2016 15:41	10/22/2016 16:06
48°11.42N	123°47.56W	9/29/2016 14:10	9/29/2016 14:36	48°12.23N	123°48.77W	10/22/2016 17:08	10/22/2016 17:30
48°11.29N	123°47.11W	9/29/2016 15:52	9/29/2016 16:22	48°21.72N	123°55.07W	10/23/2016 8:03	10/23/2016 8:03
48°11.15N	123°47.12W	9/29/2016 16:53	9/29/2016 17:21	48°21.83N	123°56.2W	10/23/2016 8:56	10/23/2016 9:16
48°11.94N	123°48.41W	9/29/2016 17:59	9/29/2016 18:24	48°21.49N	123°56.24W	10/23/2016 9:44	10/23/2016 10:05
48°11.64N	123°46.12W	9/30/2016 10:15	9/30/2016 10:39	48°21.07N	123°54.95W	10/23/2016 10:30	10/23/2016 10:53
48°11.72N	123°48.06W	9/30/2016 10:56	9/30/2016 11:22	48°19.77N	123°55.61W	10/23/2016 11:24	10/23/2016 11:46
48°12.03N	123°48.71W	9/30/2016 11:38	9/30/2016 12:08	48°18.93N	123°55.7W	10/23/2016 12:16	10/23/2016 12:37
48°10.85N	123°46.72W	10/6/2016 8:55	10/6/2016 9:17	48°20.7N	123°50.38W	10/23/2016 14:15	10/23/2016 14:42
48°11.14N	123°46.0W	10/6/2016 10:11	10/6/2016 10:37	48°20.0N	123°49.48W	10/24/2016 8:59	10/24/2016 9:20
48°11.14N	123°47.12W	10/6/2016 11:18	10/6/2016 11:41	48°20.33N	123°49.62W	10/24/2016 9:51	10/24/2016 10:09
48°11.98N	123°48.25W	10/6/2016 12:19	10/6/2016 12:38	48°20.71N	123°49.48W	10/24/2016 10:51	10/24/2016 11:06
48°12.16N	123°56.77W	10/6/2016 14:52	10/6/2016 15:15	48°20.76N	123°49.36W	10/24/2016 12:07	10/24/2016 12:19
48°11.01N	123°44.42W	10/6/2016 17:25	10/6/2016 17:48	48°18.88N	123°43.19W	10/24/2016 14:06	10/24/2016 14:25
48°11.4N	123°37.86W	10/7/2016 4:46	10/7/2016 5:05	48°19.31N	123°42.43W	10/24/2016 14:57	10/24/2016 15:17
48°10.41N	123°39.32W	10/7/2016 5:30	10/7/2016 5:55	48°11.36N	123°48.41W	10/25/2016 8:24	10/25/2016 8:43
48°10.1N	123°38.04W	10/7/2016 9:27	10/7/2016 9:47	48°11.02N	123°48.14W	10/25/2016 9:17	10/25/2016 9:40
48°10.28N	123°37.53W	10/7/2016 10:22	10/7/2016 10:44	48°10.83N	123°46.74W	10/25/2016 10:05	10/25/2016 10:28
48°10.68N	123°37.7W	10/7/2016 11:31	10/7/2016 11:51	48°11.15N	123°47.8W	10/25/2016 11:06	10/25/2016 11:28
48°11.06N	123°37.89W	10/7/2016 12:25	10/7/2016 12:44	48°11.52N	123°47.48W	10/25/2016 12:00	10/25/2016 12:18
48°19.45N	123°55.54W	10/8/2016 8:57	10/8/2016 9:17	48°10.53N	123°42.58W	10/25/2016 13:42	10/25/2016 14:06
48°19.78N	123°55.57W	10/8/2016 9:45	10/8/2016 10:05	48°10.68N	123°45.47W	10/26/2016 13:42	10/26/2016 14:01
48°20.29N	123°55.25W	10/8/2016 10:28	10/8/2016 10:49	48°10.92N	123°44.76W	10/26/2016 14:36	10/26/2016 14:54
48°20.57N	123°55.07W	10/8/2016 11:13	10/8/2016 11:36	48°11.37N	123°44.8W	10/26/2016 15:30	10/26/2016 15:48
48°21.79N	123°55.23W	10/8/2016 12:40	10/8/2016 13:00	48°11.68N	123°42.98W	10/26/2016 16:23	10/26/2016 16:39
48°21.1N	123°55.07W	10/8/2016 14:26	10/8/2016 14:55	48°11.19N	123°47.57W	10/28/2016 11:09	10/28/2016 11:27
48°17.68N	123°43.32W	10/9/2016 7:26	10/9/2016 7:47	48°11.45N	123°47.07W	10/28/2016 12:08	10/28/2016 12:26
48°17.9N	123°42.5W	10/9/2016 8:05	10/9/2016 8:25	48°11.64N	123°46.61W	10/28/2016 13:05	10/28/2016 13:25
48°18.45N	123°42.65W	10/9/2016 8:51	10/9/2016 9:08	48°10.76N	123°45.6W	10/28/2016 14:39	10/28/2016 14:56
48°18.77N	123°42.53W	10/9/2016 9:34	10/9/2016 9:53	48°12.09N	123°46.17W	10/28/2016 15:38	10/28/2016 15:59
48°19.19N	123°42.53W	10/9/2016 10:37	10/9/2016 10:56	48°12.36N	123°44.97W	10/28/2016 16:21	10/28/2016 16:50
48°18.52N	123°37.11W	10/9/2016 11:41	10/9/2016 12:04	48°11.65N	123°46.24W	10/29/2016 10:30	10/29/2016 10:48
48°11.54N	123°36.82W	10/13/2016 9:18	10/13/2016 9:36	48°11.32N	123°45.86W	10/29/2016 11:24	10/29/2016 11:43
48°10.28N	123°40.75W	10/13/2016 10:24	10/13/2016 10:46	48°11.07N	123°46.05W	10/29/2016 12:11	10/29/2016 12:35
48°10.49N	123°41.72W	10/13/2016 11:29	10/13/2016 11:50	48°11.02N	123°47.11W	10/29/2016 13:55	10/29/2016 14:49
48°11.45N	123°44.41W	10/13/2016 12:29	10/13/2016 12:50	48°11.31N	123°47.22W	10/29/2016 14:45	10/29/2016 15:06
48°11.43N	123°50.26W	10/13/2016 14:28	10/13/2016 14:51	48°11.85N	123°46.4W	10/29/2016 15:29	10/29/2016 15:50
48°12.12N	123°51.07W	10/13/2016 15:23	10/13/2016 15:48	48°18.54N	123°44.42W	10/30/2016 9:07	10/30/2016 9:31
48°17.55N	123°43.83W	10/14/2016 7:51	10/14/2016 8:09	48°18.89N	123°43.88W	10/30/2016 10:13	10/30/2016 10:37
48°18.11N	123°43.81W	10/14/2016 8:38	10/14/2016 8:56	48°19.29N	123°43.44W	10/30/2016 11:03	10/30/2016 11:44
48°19.02N	123°42.8W	10/14/2016 9:18	10/14/2016 9:53	48°19.23N	123°42.68W	10/30/2016 13:22	10/30/2016 13:45
48°19.31N	123°43.19W	10/14/2016 10:35	10/14/2016 10:55	48°19.29N	123°42.87W	10/30/2016 14:16	10/30/2016 14:38
48°10.82N	123°47.95W	10/21/2016 10:03	10/21/2016 10:29	48°18.54N	123°44.4W	10/30/2016 15:25	10/30/2016 15:47
48°10.82N	123°46.06W	10/21/2016 11:09	10/21/2016 11:32	48°19.26N	123°43.59W	10/31/2016 7:45	10/31/2016 8:03
48°10.66N	123°45.39W	10/21/2016 12:04	10/21/2016 12:27	48°18.88N	123°44.05W	10/31/2016 8:31	10/31/2016 8:55
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48°10.37N	123°37.1W	10/21/2016 15:51	10/21/2016 16:16	48°19.42N	123°42.51W	10/31/2016 9:55	10/31/2016 10:18