Interactions of Wild and Hatchery Pink Salmon and Chum Salmon in Prince William Sound and Southeast Alaska

Progress Report for 2014

For Alaska Department of Fish and Game
Contract IHP-13-013

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ABSTRACT

This is the third in a series of annual reports on data collection and analysis for studies of hatchery-wild interactions of Pink Salmon in Prince William Sound (PWS), Chum Salmon in PWS, and summer run Chum Salmon in Southeast Alaska (SEAK). This work was performed by the Prince William Sound Science Center under contract to Alaska Department of Fish & Game. The SEAK portion was further subcontracted to Sitka Sound Science Center. Hatchery Pink Salmon and Chum in Alaska have thermally marked otoliths which were used to determine hatchery or wild origin through samples collected at sea and in streams. As in 2013, ocean sampling was conducted at nine stations near the entrances to PWS in 2014. Otoliths from 1,515 Pink Salmon and 947 Chum Salmon were analyzed for thermal marks indicating hatchery or wild origin. The overall 2014 proportion of hatchery fish across all ocean stations was 86% for Pink Salmon and 51% for Chum Salmon. The proportions of hatchery fish in the ocean sampling varied by station and time. Stream studies were conducted in 2014 for two major purposes: an analysis of straying of hatchery-origin spawners into natural populations in all study streams; and an investigation of the relative survival of hatchery-origin and wild-origin offspring following natural spawning in 10 of the study streams. In 2014 field sampling on the spawning grounds, 33,574 individual fish of both species were sampled during repeated visits to 64 streams for both studies combined. Otoliths were collected from all specimens for identification of possible hatchery origin. Fractions of hatchery Pink Salmon were estimated for 27 PWS spawning populations and hatchery fractions of Chum Salmon were estimated for 17 PWS and 32 SEAK streams. Fractions in each case were estimated by stream, then by district (PWS) or Sub-region (SEAK), and then by region. Estimated region-wide hatchery fractions in spawning streams were 0.15 for PWS Pink Salmon, 0.03 for PWS Chum Salmon, and 0.05 for SEAK Chum Salmon. PWS Pink Salmon hatchery fractions ranged 0.0 to 0.91 across all study streams. Pink Salmon hatchery fractions tended to be greater in districts with hatcheries, such as the Eshamy District (0.87) and the Southwestern District (0.29). PWS Chum Salmon stream hatchery fractions were all less than 0.12, except Cabin Creek where the hatchery fraction was 0.80. Hatchery fractions in 32 SEAK Chum Salmon streams were similarly mostly low (0.0 to 0.15), except in Fish (0.72) and Sawmill creeks (0.19). Using information from both ocean sampling and field sampling programs, as well as data from the commercial fisheries, an estimated 49.7 million Pink Salmon entered PWS in 2014 of which an estimated 7 million were wild fish and 42.8 million were hatchery fish. An estimated 2.4 million Chum Salmon entered PWS in 2014 of which 1.2 million were wild fish and 1.2 million were hatchery fish.

INTRODUCTION

Prince William Sound Science Center (PWSSC) and its sub-contracting partner Sitka Sound Science Center (SSSC) are engaged in scientific data collection and analysis services requested under the State of Alaska contract IHP-13-013 entitled "Interactions of Wild and Hatchery Pink and Chum Salmon in Prince William Sound and Southeast Alaska". This is the third annual report, focusing on the results of 2014 data collection and analysis.

The plans and intentions of this contracted research are guided by two documents: 1) the ADF&G RFP 2013-1100-1020, dated May 7, 2012 entitled "Interactions of Wild and Hatchery Pink and Chum Salmon in Prince William Sound and Southeast Alaska and 2) the PWSSC proposal for the project, dated June 29, 2012. The overarching purposes of this research, as stated in the RFP, are to:

- Estimate the proportion of the annual runs of Pink and Chum Salmon in Prince William Sound (PWS) comprised of first-generation offspring of hatchery salmon.
- Determine the extent and annual variability in straying of hatchery Pink Salmon in PWS and Chum Salmon in PWS and Southeast Alaska (SEAK), and
- Assess the impact on fitness (productivity) of wild Pink and Chum Salmon stocks due to straying of hatchery Pinks and Chum Salmon.

The 2014 field research was organized into three major activities:

- Ocean sampling near PWS to estimate hatchery fractions of runs
- Adult sampling in streams to estimate the hatchery fractions of spawning salmon and to collect DNA samples; and
- Sampling of alevins from the gravel in two experimental streams for collecting DNA tissues for the fitness studies.

Adult sampling was further subdivided into PWS and SEAK activities. The first (2014) spring sampling of alevins in streams for fitness studies followed the first summer sampling of their parents (2013). The methods in this report reflect guidance in the RFP, some refinements made following the 2012 preliminary field season and 2013 full season (Knudsen et al. 2013, Knudsen et al. 2015)., and changes made as a result of consultation with the Science Panel in November 2012 and December 2103. A complete, revised 2014 field sampling protocol is found in Appendices A-E.

This report includes summaries of sample collection during 2014 for estimating hatchery fractions and for the DNA-based fitness studies. DNA samples from the latter were delivered to the ADF&G Gene Conservation Lab and the subsequent analysis will be reported later. This report includes analysis of hatchery proportions of Pink Salmon and Chum Salmon from the ocean sampling and analysis of hatchery fractions by stream, district or sub region; and region. It also includes estimates of the total run sizes of wild and hatchery-origin Pink Salmon and Chum Salmon for both PWS and SEAK. Last, sampling activities alevins from the gravel in Fish and Stockdale creeks in spring of 2014, for part of the fitness study, is reported here.

PWS OCEAN SAMPLING 2014

Authors - Michele Buckhorn, Peter Rand, Eric Knudsen, and David Bernard

INTRODUCTION

The purpose of the ocean fishery is to intercept salmon at the entrances of Prince William Sound to better estimate the proportion of hatchery to wild salmon throughout the Sound. Commercial fishery samples target hatchery fish and do not represent the true ratio of wild to hatchery fish in Prince William Sound. Sampling over 2013, 2014, and 2015 will provide information on interannual variation while within-season sampling provides near real-time run size on a bi-weekly basis. The results of the PWS ocean sampling are also expected to contribute in part to the estimation of the following (see section below):

- number of wild salmon spawning in the wild;
- number of hatchery salmon spawning in the wild (hatchery strays);
- production of hatchery salmon (including hatchery strays); and
- production of wild salmon (excluding hatchery strays).

METHODS

Fish Collection Methods

The ocean sampling fishing portion of the work during the 2014 field season was conducted aboard a contracted 32’ commercial fishing vessel named the F/V Rebound operated by Brad Reynolds, M.S. The sampling season for ocean run Pink Salmon and Chum Salmon occurred from May 15 to August 30, 2014. With only slight modifications from 2013 (to improve catchability), fishing occurred at nine systematically selected stations, three of which were spaced approximately equidistant across Hinchinbrook Entrance (named Hinchinbrook stations H01, H02, and H03) and the remaining six (named Montague stations M01, M02, M03, M04, M05, and M06) across the entrances[1] to PWS just west of Montague Island (Figure 1).

The vessel made sets beginning in the area of each fixed station (Figure 1) using a 200 fathom drift gillnet consisting of four panels with differential ($4^{3/8}$, $4^{3/4}$, $5^{1/8}$, and $5^{1/2}$ inch) stretch mesh. All nine stations were fished over a 2-day period (labeled by TRIP ID) and the catch was delivered to personnel at PWSSC. There were normally two sampling trips per week. This was repeated for the entire fishing season with the exception of days not fished due to rough weather. Sets were planned to be a maximum of one hour using the entire 200 fathoms of net with adjustments to decrease these maximums in the case of large catches, vessel traffic, weather, or the presence of marine mammals. If the full 200 fathoms were not used after fishing all stations, then the net was reversed on the reel for the next round of fishing. Date, time, latitude and longitude were recorded in the database at: 1) the start and end of any periods of net setting; 2)

[1] M01 and M02 in Montague Strait, M03 and MO4 in Latouche Passage, M05 off Point Erlington, and MO6 in Prince of Wales Passage.

the beginning and end of any drift; and 3) the start and end of any net retrieval. Other data recorded included weather and tide state.

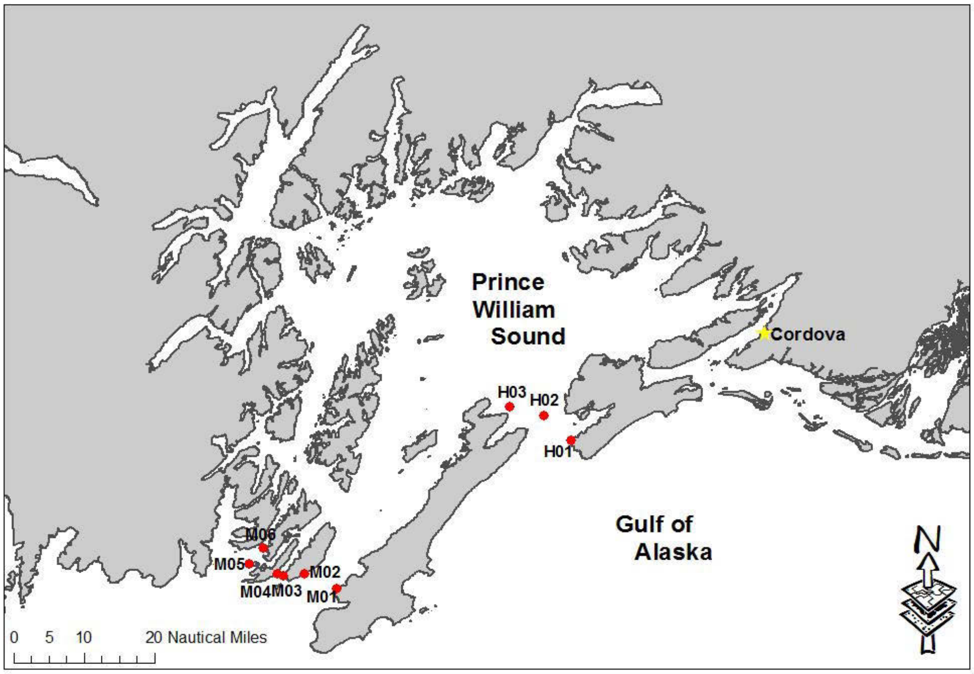

Figure 1. Ocean sampling stations in Montague Strait and Hinchinbrook Entrance.

Once the net was retrieved, fish were removed from the net and total catch recorded. The catch retained from each station (up to 20 per species from Hinchinbrook stations; 10 per species from Montague stations) was tagged with a color-coded Floy tag, bled in the field, and put on ice. Catches that exceeded the maximum sample number per station were systematically subsampled to acquire the appropriate sample size. Chum and Pink samples beyond the maximum sample number were retained if it was determined they would not survive release. The same occurred for species of salmon that were not part of this study. All specimens retained were processed and the otoliths and data turned over to ADF&G (see Appendix A for complete fishing protocols).

SAMPLE PROCESSING METHODS

Fish were delivered to PWSSC personnel and separated by station and species. The following fish morphometric data were collected to accompany the otolith extraction: total length (TL), standard length (SL), mid-eye socket to hypural bone length (MEH), total weight (TW), gonad weight (GW), and sex (S). Otoliths were extracted by making a horizontal cut from just above the eye straight back towards the posterior of the cranium. Otoliths were placed in individual cells in labeled trays provided by ADF&G (see Appendix A for complete sampling protocols).

Fish in good condition were gutted and returned to ice to be sold under the ADF&G commercial fishing permit. Fish that were not in sellable condition were disposed of at sea.

Otoliths were read by the ADF&G lab in Cordova following their standard procedures. ADF&G personnel supplied the otolith reading results back to PWSSC and they were incorporated into the project database.

DATA ANALYSIS

The objectives of the ocean sampling in 2013 and 2014 included estimating the fractions of hatchery fish in each run of Pink Salmon and Chum Salmon to PWS. The hatchery fractions and their variances were estimated at the trip within station, station, and entire Sound levels for each species, Because hatchery fraction estimates calculated from trip to trip were based on different total catches at each station, there was a need to first weight the fractions by the relative catch per unit of effort at each station on each trip.

Catch per Unit of Effort

All total catches were adjusted for comparability based on a standard unit of fishing effort: net fathoms times time fished. Fishing at each station on each day was characterized by setting the net, drifting it, sometimes adjusting the length of net, then retrieving it, and sometimes re-deploying and retrieving again. The expression below accounted for the simplest situation (one deployment, one drift, and one retrieval) or the more complex situation of multiple adjustments and drifts within one fishing event at a station (referred to later as one complete haul per station). A simplifying assumption is that, during deployment or retrieval, the net is fishing 50% of the deployment or retrieval time duration, even though the deployment or retrieval may not be exactly linear. Catch per unit of effort (CPUE) was calculated as:

$$\boldsymbol{CPUE} = \boldsymbol{C_s} /(((\boldsymbol{DS}_1 - \boldsymbol{SB})/2) * \boldsymbol{L}_1) + \sum_{\boldsymbol{d}=1}^{\boldsymbol{n}} (((\boldsymbol{DE_d} - \boldsymbol{DS_d}) * \boldsymbol{L_d})) +$$

$$\sum_{\boldsymbol{d}=1}^{\boldsymbol{n}} (((\boldsymbol{L_d} * (\boldsymbol{DS_d} - \boldsymbol{DE}_{\boldsymbol{d}-1})) + (((\boldsymbol{L}_{\boldsymbol{d}-1} - \boldsymbol{L_d}) * ((\boldsymbol{DS_d} - \boldsymbol{DE}_{\boldsymbol{d}-1})/2))) + (((\boldsymbol{RE} - \boldsymbol{DE}_{\boldsymbol{d}=\boldsymbol{n}})/2) * \boldsymbol{L}_{\boldsymbol{d}=\boldsymbol{n}})$$

Where C_s = number caught per date and station, L = fathoms of net, SB = set begin time, DS = drift start time, DE = drift end time, RE = retrieve end time, and ***d*** = drift number. The first term in the equation is the catch by species. The second term calculates the effort for the first deployment interval only (net length*time/2). The first summation calculates effort for one or more drifts in a given haul (i.e., station and date). The second summation calculates effort for any other intermediate deployments or retrievals. It accounts for the amount of net already out plus or minus 50% of the change in net length. The last term calculates effort during the final retrieval.

Estimates of Hatchery Fraction

There were 29 two-day fishing trips in 2014. Not all scheduled trips resulted in samples. There were four types of outcomes for the 29 scheduled trips for 9 stations (261 possible combinations) in 2014:

Outcome:	Comment:	Frequency:	Adjustment:
1. Target species caught, origin determined for all or some of the catch	Determination for only “some” due to subsampling large catches	183 for Chum Salmon 177 for Pink Salmon	None

2. Target species caught, origin determined for none of the catch	One target species caught, unable to determine origin from otolith	0 for Chum Salmon 0 for pink salmon	Exclude Trip – Most Calculations
3. No target species caught	CPUE = 0	66 for Chum Salmon 72 for Pink Salmon	Exclude Trip – Most Calculations
4. No fishing	Weather	12	Exclude Trip – All Calculations

Because there were catches of each species on almost every trip, the data were not truncated for extended gaps in catch as it was in 2013 (Knudsen et al. 2015).

Trip Within Station

The fraction of hatchery fish in a catch from a specific trip at a specific station was estimated as

$$\hat{p}_{st} = \frac{z_{st}}{m_{st}} \qquad (1)$$

where ***s*** is a specific station, t is a specific trip (date), $\boldsymbol{m_{st}}$ is the number sampled in the catch at station ***s*** during trip ***t*** of the target species for which origin was determined, and $\boldsymbol{z_{st}}$ is the number within $\boldsymbol{m_{st}}$ determined to be of hatchery origin.

By Station

Sample estimates of hatchery fractions for specific stations were weighted when combined to produce unbiased estimates of hatchery fractions for specific stations. Ideally weights would be based on numbers of pink (or chum) salmon (***N***) passing near each station during a trip in relation to all the pink (or chum) salmon passing during the season:

$$W_{st} = \frac{\lambda_{st} N_{st}}{\sum_{t'=1}^{T_s} \lambda_{st'} N_{st'}} \qquad (2)$$

where ***t′*** represents trips to station ***s*** during the season including trip ***t***, and $\boldsymbol{\lambda_{st}}$ = 1 if the trip ***t*** to station ***s*** resulted in outcome 1 or $\boldsymbol{\lambda_{st}}$ = 0 otherwise. $\boldsymbol{T_s}$For 2014, $\boldsymbol{T_s}$ is the number of scheduled trips, 29. Because values of the ***N***s are unknown, catch per unit of effort (***CPUE***) was used as a surrogate. Note that catch ***C*** is a function of fishing effort (***E***), catchability (***q***), and abundance such that ***C*** = ***qEN***, which makes ***N*** = ***CPUE*** (1/***q***). Substitution into the equation above provides estimated weights in terms of catch per unit of effort:

$$\hat{W}_{st} = \frac{\lambda_{st} CPUE_{st}(1/q_s)}{\sum_{t'=1}^{T_s} \lambda_{st'} CPUE_{st'}(1/q_s)} = \frac{\lambda_{st} CPUE_{st}}{\sum_{t'=1}^{T_s} \lambda_{st'} CPUE_{st'}} \qquad (3)$$

so long as the catchability is the same during all trips at station ***s***. Fishing protocols at each station were standardized over the duration of ocean fishing to reduce variability in catchability, however, catch is a stochastic process even if catchability is a constant (see Appendix A). For these reasons surrogate weights add some uncertainty to estimated fractions, so weights were labeled $\hat{W}_{st}$ instead of W_{st}. The estimate for the fraction of hatchery fish at a specific station for the season was calculated as

$$\hat{p}_s = \sum_{t=1}^{T_s} \hat{W}_{st} \hat{p}_{st} . \quad (4)$$

Equation 4 is an unbiased estimator for a proportion estimated with random sampling without replacement through a two-stage design for each station. In our project, fish comprised the subsampling (second) stage and trips the first sampling stage.

For the Sound

The estimated mean fraction of hatchery-produced salmon of the target species in the overall PWS run for 2014 was calculated as the weighted average of the estimated fractions for stations:

$$\hat{\bar{p}} = \sum_{s=H01}^{H01 \cdots M06} \hat{W}_s \hat{p}_s . \quad (5)$$

Here the weights were based on the estimated mean CPUE for each station:

$$\hat{W}_s = \frac{\overline{CPUE}_s}{\sum_{s'=H01}^{H01 \ldots M06} \overline{CPUE}_{s'}} \quad (6)$$

$$\overline{CPUE}_s = \frac{\sum_{t=1}^{T_s} \omega_{st} CPUE_{st}}{\sum_{t=1}^{T_s} \omega_{st}} \quad (7)$$

where $\omega_{st} = 1$ if results during trip ***t*** to station ***s*** had outcomes 1, 2, or 3, and $\omega_{st} = 0$ if outcome 4.[2] Note that Equations 6 and 7 can be modified to estimate the hatchery fraction for any possible combination of stations (say Hinchinbrook stations vs. Montague Stations).

Estimated Variance of Hatchery Fraction

By Station

The variance of a parameter estimated through a two-stage sampling design is the variance of the expected value of the parameter across first-stage units plus the expected value of variances of the parameter within first-stage units (Cochran 1977). By this rule estimated variance for the proportion $\hat{p}_s$ in our study became:

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[2] Two different multipliers, λ and ω, are required because CPUE = 0 (outcome 3) provides no information on the fraction of hatchery fish in the catch, but does provide information on the appropriate weight to be used to estimate the fraction for the entire PWS.

$$v(\hat{p}_s) = \hat{S}_{1s}^2 + \frac{\sum_{t=1}^{T_s} \lambda_{st} \hat{S}_{2st}^2}{\sum_{t=1}^{T_s} \lambda_{st}} \tag{8}$$

where $\hat{S}_{1s}^2$ represents the variance of the expected value of the parameter across first-stage units, and the right-most term in Equation 8 the expected value of variances within first-stage units. Equation 8 was adapted from the standard mathematic framework in Thompson (1992). The variance $\hat{S}_{2st}^2$ represents the variance of our parameter from the samples taken at station ***s*** during trip ***t***. Because of the weighting involved in our study, the product $\hat{W}_{st}\hat{p}_{st}$ was treated as a single parameter for expressing variance, making $\hat{S}_{2st}^2$ the variance of the product of two variates. Following procedures in Goodman (1960), variance for such a product was approximated as:

$$\hat{S}_{2st}^2 = v(\hat{W}_{st})\hat{p}_{st}^2 + \hat{W}_{st}^2 v(\hat{p}_{st}) - v(\hat{W}_{st})v(\hat{p}_{st}) \tag{9}$$

where variance for $\hat{p}_{st}$ was estimated as the variance of a binomial proportion:

$$v(\hat{p}_{st}) = \begin{bmatrix} \dfrac{\hat{p}_{st}(1-\hat{p}_{st})}{m_{st}-1} & \text{if } m_{st} \geq 2; \\ \hat{p}_{st}(1-\hat{p}_{st}) & \text{if } m_{st} = 1; \end{bmatrix} \tag{10}$$

(the alternative formulations simplify calculations at the expense of negligible bias in results). Variance for $\hat{W}_{st}$ was approximated as:

$$v(\hat{W}_{st}) \cong v(CPUE_{st}) \left(\frac{\sum_{t',t'\neq t} CPUE_{st'}}{\left(\sum_{t'} CPUE_{st'}\right)^2} \right)^2 + \left(-\frac{CPUE_{st}}{\left(\sum_{t'} CPUE_{st'}\right)^2} \right)^2 \sum_{t',t'\neq t} v(CPUE_{st'}) \,. \tag{11}$$[3]

The derivation of Equation 11 the equation for $v(CPUE_{st})$ can be found in Appendix B.

While the processes and procedures we used to select samples of individual fish (second-stage sampling units) arguably mimicked random selection, the scheduling of trips (first-stage sampling units) was decidedly not random, but systematic. Under such systematic selection no exact estimate of variance for our first-stage units is possible—only an approximate variance could be calculated. Wolter (1985) concluded that under most conditions the sum of the squared differences between sequential statistics is the most robust estimator of variance for systematic sampling. With adaption of this estimator for our study,

$$\hat{S}_{1s}^2 \cong \frac{\sum_{t=2}^{T_s} \lambda_{st}\lambda_{s(t-1)} (\hat{W}_{st}\hat{p}_{st} - \hat{W}_{s(t-1)}\hat{p}_{s(t-1)})^2}{2\left(\sum_{t=1}^{T_s} \lambda_{st}\lambda_{s(t-1)}\right)\left(\sum_{t=2}^{T_s} \lambda_{st}\lambda_{s(t-1)} - 1\right)} \tag{12}$$

[3] Note that in approximating the variance for a specific trip t, a summation over subscript t' indicates a sum over all trips in a station including trip t; the summation with configuration t', $t' \neq t$ indicates a sum over all trips excluding trip t.

was used to approximate variance of the expected value of the parameter across first-stage units. Here again the multipliers λ were used to adjust for missing data.

For the Sound

Estimated variance for the fraction of hatchery-produced salmon of the target species estimated for the Sound as a whole was approximated by again weighting with CPUE. The approximated variance for the Sound is the variance of the sum across stations of products:

$$v(\hat{p}) = v\left(\sum_{s=H01}^{H01 \cdots M06} \hat{W}_s \hat{p}_s\right) \quad (13)$$

Application of the delta method to Equation 13 provided an approximate variance for $\hat{p}$:

$$v(\hat{p}) \cong \sum_{s=H01}^{H01 \ldots M06} [\hat{W}_s^2 v(\hat{p}_s) + \left(\frac{\hat{p}_s - \hat{p}}{\sum_{s'} \overline{CPUE}_{s'}}\right)^2 v(\overline{CPUE}_s)] \quad (14)$$

Derivation of Equation 14 and of variance for $\overline{CPUE}_s$ is described in Appendix B. That formulation adapted for missing data is

$$v(\overline{CPUE}_s) = \frac{\sum_{t=1}^{T_s} \omega_{st} v(CPUE_{st})}{\left(\sum_{t=1}^{T_s} \omega_{st}\right)^2}. \quad (15)$$

Statistics for any combination of stations can be calculated by restricting weights only to the stations in those combinations. Weights used in the combination must sum to 1 over the number of stations used in the combination. Regardless, the general assumption is that catchability of the target species is the same for all stations included in the combination.

RESULTS

OCEAN SALMON SAMPLING

A total of 12,607 salmon were caught in the ocean test fishery in 2014. Fishing all nine stations occurred over a two (sometimes three) day period throughout the season, so for analysis and graphic purposes each fishing period is defined as a "Trip" with Trip 1 beginning May 15, 2014 and ending with Trip 29 on August 30, 2014. Pink Salmon were the most numerous salmon caught (9,400), followed by Sockeye Salmon (1,644), Chum Salmon (1,198), and then Coho Salmon (355). Ten Chinook Salmon were caught and nine released alive. Further results are focused only on Chum Salmon and Pink Salmon. Similarly to 2013, Chum Salmon entered early in the 2014 season and in lower numbers than Pink Salmon (Figure 2). Chum Salmon was the first species caught at the beginning of the season and they were caught fairly consistently for the entirety of the season, but started to decline by June 24 (TRIP 20). Pink Salmon started showing up in the catch on June 2 (TRIP 17). Pink Salmon trended upward until the first peak on July 5 (957, TRIP 21). Another peak occurred on August 5 (841, TRIP 23) and then trended downward until fishing ceased (Figure 2).

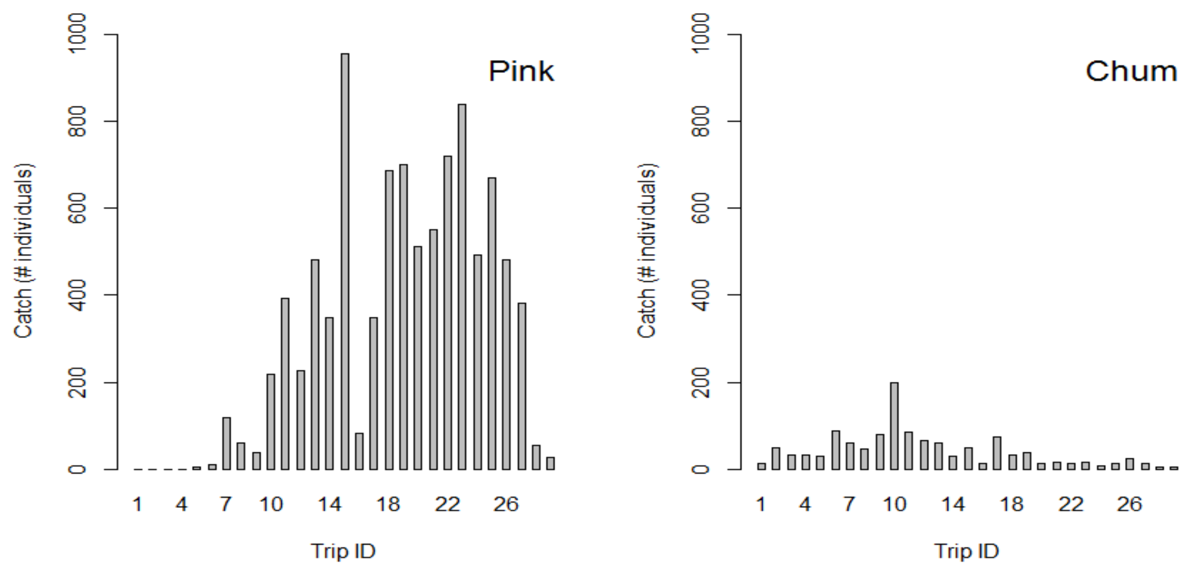

Figure 2. Total Pink Salmon (left) and Chum Salmon (right) caught at all stations by TRIP ID. Trips were evenly spaced with Trip 1 on May 15 and Trip 29 on August 30, 2014.

The station with the highest catch of Pink Salmon (2,257) was M02 while the fewest Pink Salmon (127) were caught at H01 (Figure 3). The station with the highest Chum Salmon catch was H03 (255) and the lowest catch (27) was at H02 which was approximately in the center of the large Hinchinbrook Entrance.

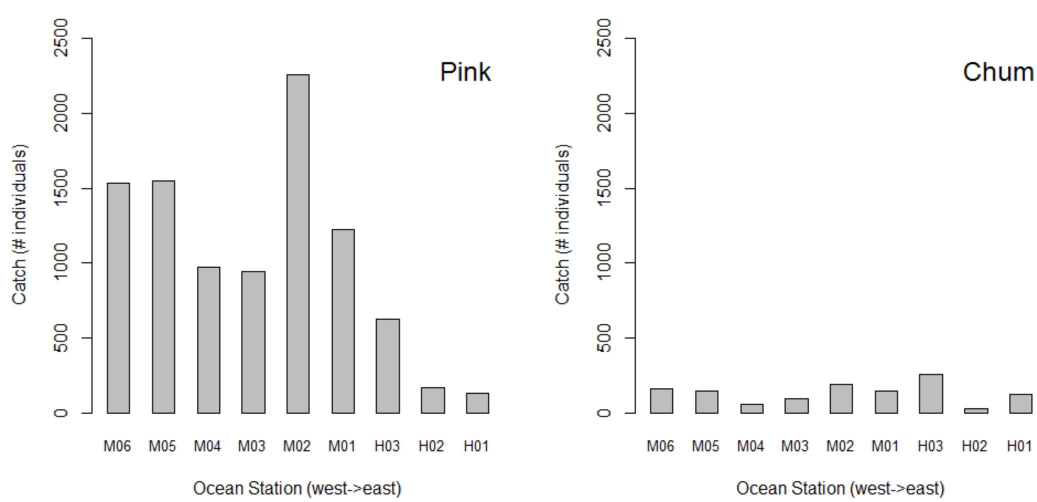

Figure 3. Total Pink Salmon (left) and Chum Salmon (right) caught by station from May 15to August 30, 2014 (H=Hinchinbrook, M=Montague).

Mean CPUE (fish caught per hour per fathom of net length) by station for Pink Salmon ranged from 0.02 (H01) to 0.32 (M02) and for Chum Salmon ranged from 0.004 (H02) to 0.04 (H03) (Figure 4).

Extraneous factors that had an impact on fishing included fog, whales (humpback, orca, grey), Dall's porpoises, sea lions, seals, otters, sport fisher vessels, tankers and/or tugs, rip tides, wind, and flotsam. The vessel captain actively watched for and avoided all such factors which at times either completely prevented a set or limited the set time and/or net fathoms set. The vessel captain also attached whale pingers to the net which he reported may have reduced close encounters with whales in 2014 compared to 2013.

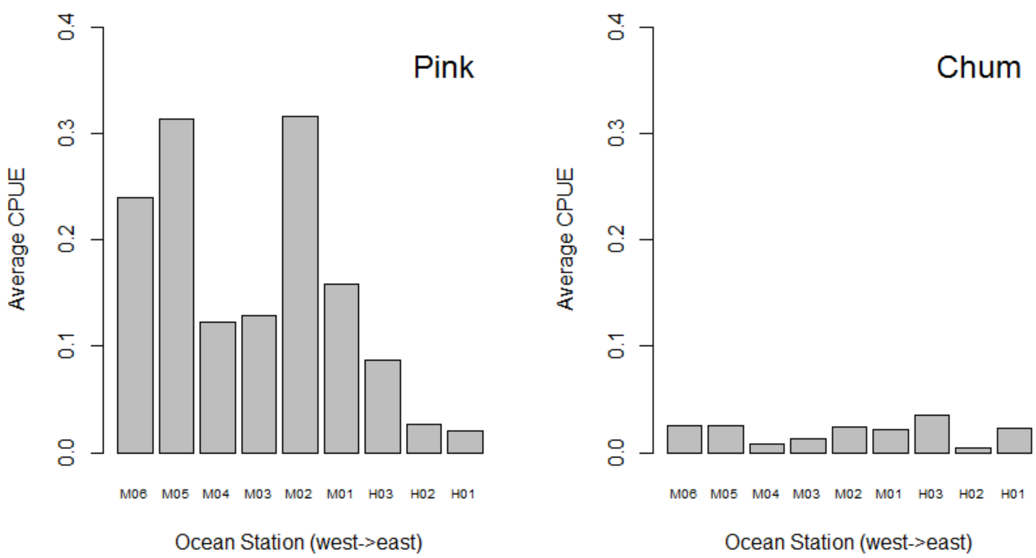

Figure 4. Mean CPUE for Pink Salmon (left) and Chum Salmon (right) by station from May 15 to August 30, 2014 (H=Hinchinbrook, M=Montague).

OCEAN SALMON PROCESSING

A total of 2,523 Pink Salmon and Chum Salmon were processed for weight-length measurements and otoliths extracted, including 1,615 Pink Salmon and 908 Chum Salmon. Mean standard lengths (and SDs) for Pink Salmon and Chum Salmon were 469 ± 27 and 578 ± 41, respectively in millimeters.

The processed Pink Salmon were 60% male while Chum Salmon had close to 50/50 sex ratios (Table 1). Both wild and hatchery Pink Salmon at all stations exhibited greater proportions of males than females (Figure 5). Even though one panel on the net was changed to a smaller mesh size in 2014 compared to 2013, Pink Salmon in the catch were still 60% male. Hatchery Chum Salmon tended to have a higher proportion of female fish in the run than did wild fish (Figure 5). Wild Chum Salmon showed more variability across ocean stations, with most of the sex ratios close to parity, although three stations (M03,M02, H02) exhibited sex ratios tending toward males (Figure 5).

Table 1. Sex ratios by total number and percentage.

Species Common Name	Metric	Female	Male	Unknown	Grand Total
Chum Salmon	count	496	411	1	908
	percent	54.63%	45.26%	0.11%	
Pink Salmon	count	640	973	2	1615
	percent	39.63%	60.25%	0.12%	

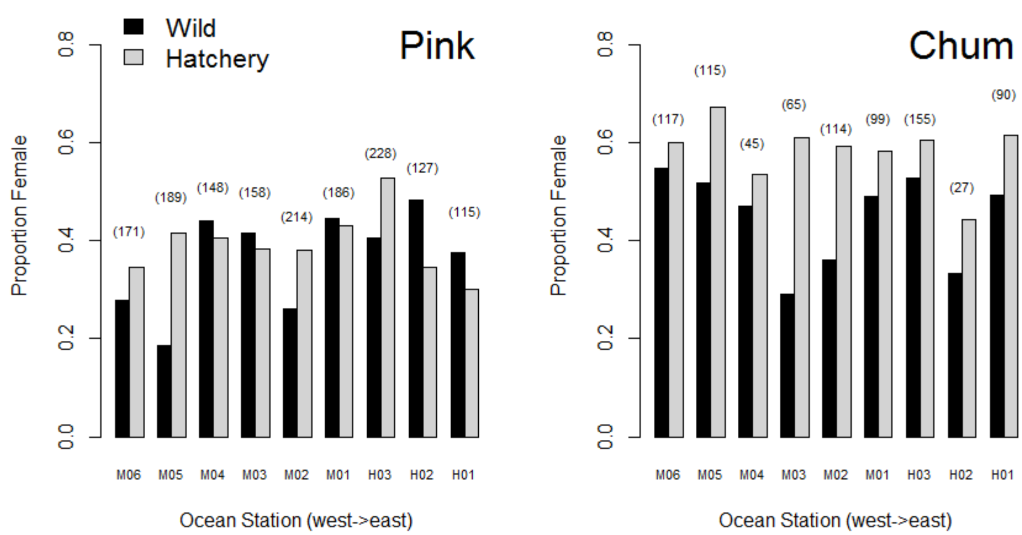

Figure 5. Proportion of female Pink Salmon (left) and Chum Salmon (right) by origin (wild and hatchery) and by ocean station. Numbers in parentheses are the sample size over the entire season at each station.

OCEAN HATCHERY FRACTIONS

The Pink Salmon run passing through the Hinchinbrook stations (H01-H03) generally exhibited a lower proportion of hatchery fish compared to the Montague stations (M01-M06, Figure 6). The wild proportion of the Pink Salmon run appeared to be highest during the middle of the season (Figure 6). Hatchery-origin Chum Salmon predominated in the run early in the season while higher proportions of wild Chum Salmon entered later in the season (Figure 7).

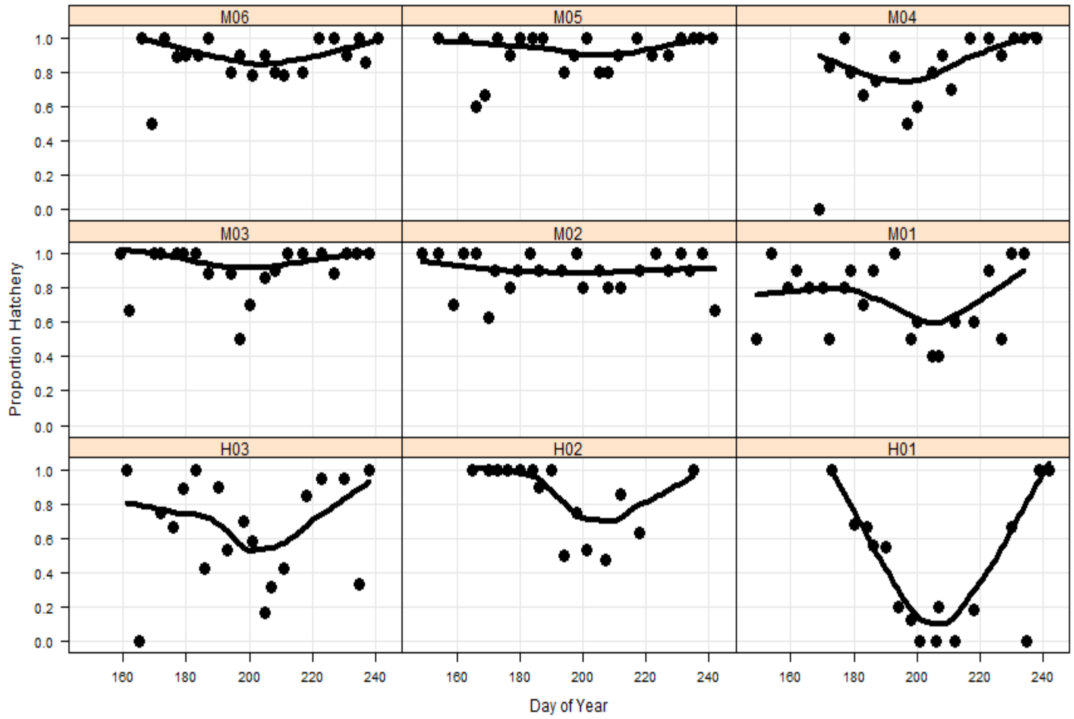

Figure 6. Pink Salmon unweighted hatchery proportion by day of year, from May 15 to August 30, 2014, and Station ID (M = Montague, H = Hinchinbrook). Data are fit to a loess smooth regression for illustrative purposes.

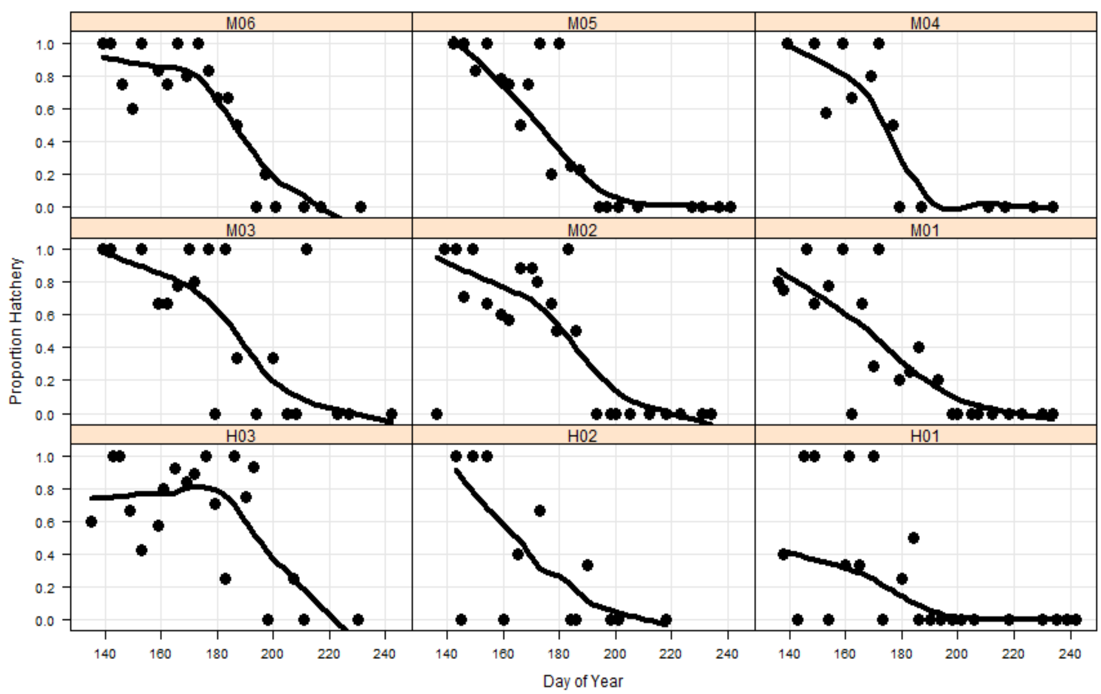

Figure 7. Chum Salmon unweighted hatchery proportions by day of year, from May 15 to August 30, 2014, and Station ID (M = Montague, H = Hinchinbrook). Data are fit to a loess smooth regression for illustrative purposes.

The 2014 weighted hatchery proportions calculated for Pink Salmon and Chum Salmon for all Prince William Sound entrances combined were 0.86 (SE = 0.03) and 0.51 (SE = 0.03), respectively. Pink Salmon hatchery proportions ranged from 0.35 (SE = 0.14) at station H01 to 0.97 (SE = 0.04) at M01 (Figure 8). Chum Salmon hatchery proportions ranged from 0.016 (SE = 0.005) at H01 to 0.896 (SE = 0.07) at H03 (Figure 8). The estimated relative proportion of hatchery Pink Salmon entering PWS was greater in 2014 than in 2013 while the reverse was the case for Chum Salmon (Figure 8). These differences, however, were not statistically tested.

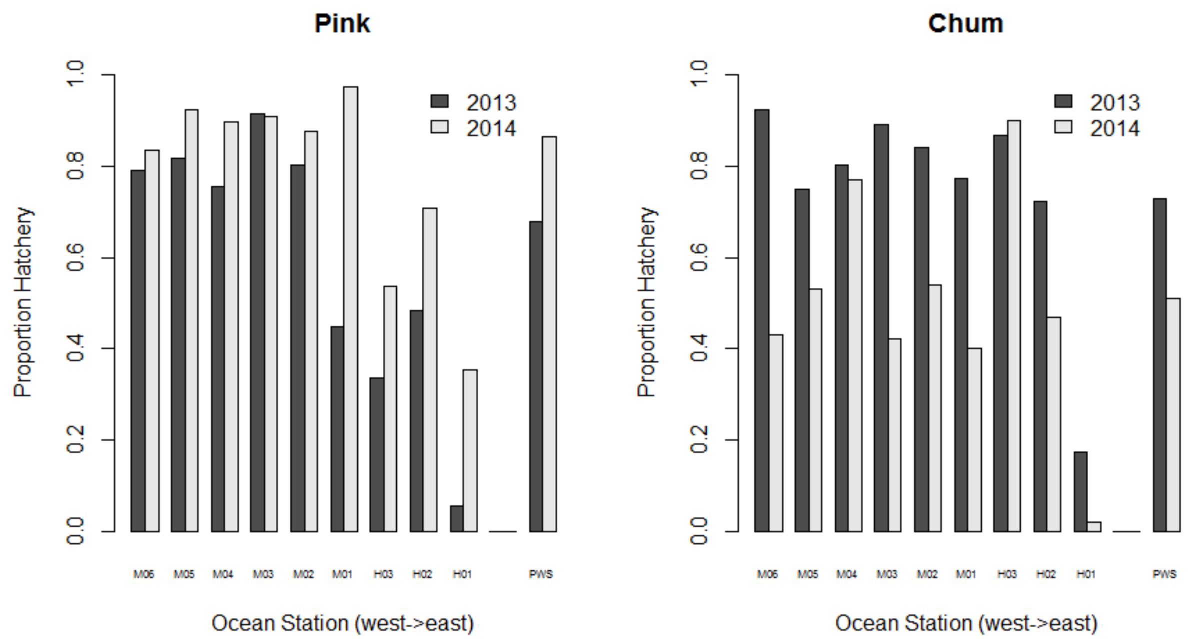

Figure 8. Weighted hatchery proportions of Pink Salmon (left) and Chum Salmon (right) by individual station. The right-most bar for each species represents the aggregate hatchery fraction for Prince William Sound runs. Data are provided for both 2013 and 2014.

The overall proportion of hatchery-origin Pink Salmon entering PWS was apparently greater in 2014 (0.86) than in 2013 (0.68). The overall proportion of hatchery-origin Chum Salmon entering PWS was apparently less in 2014 (0.51) than in 2013 (0.72). These hatchery proportion estimates are affected by the relative run sizes of both hatchery and wild fish. For example, the 2013 wild Pink Salmon run was the largest on record until then (Botz et al. 2014), which helps to explain the lower relative proportion of hatchery fish entering the Sound in 2013.

Pink Salmon hatchery proportions indicate more hatchery fish are entering PWS at the Montague Strait stations than at the Hinchinbrook Entrance stations (Figure 8) and the hatchery-specific origin is variable by station (Figure 9). The Solomon Gulch Hatchery was the single largest contributor to Pink Salmon hatchery fish across most stations. (Figure 9). There was an apparent overall greater hatchery proportion for Pink Salmon across all stations in 2014 than in 2013 (Knudsen et al. 2015).

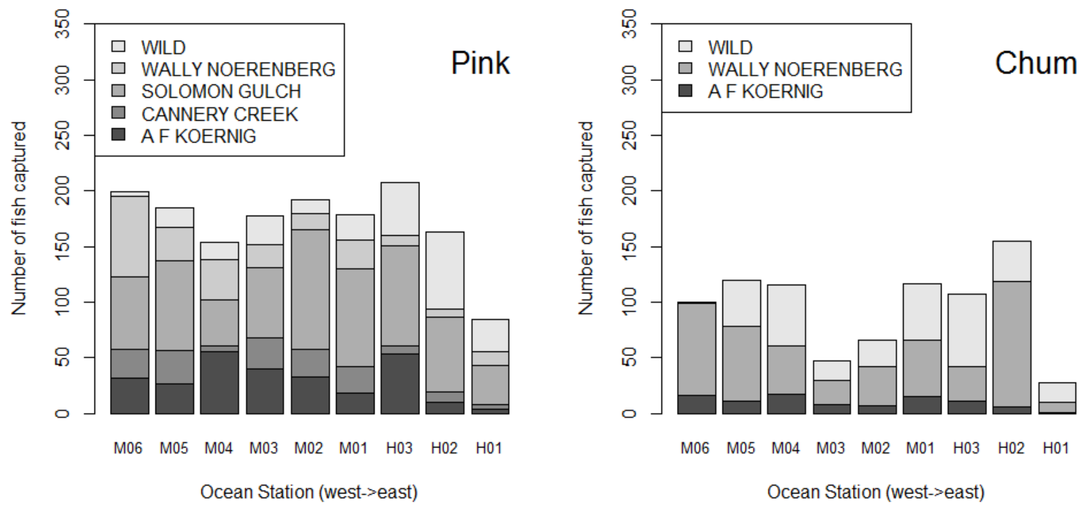

Figure 9. Number of Pink Salmon (left) and Chum Salmon (right) by station during 2014, apportioned by origin. Note these numbers represent processed fish and are not corrected for CPUE.

Chum Salmon hatchery proportions were variable by ocean sampling stations for 2014 (Figure 9) and, for most stations, exhibited lower hatchery proportions than 2013 (Figure 8 and Knudsen et al. 2015). Most of the hatchery Chum Salmon originated from Wally Noerenberg Hatchery (Figure 9).

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SAMPLING ADULT SALMON IN STREAMS

Authors –Ben Adams, Kristen Gorman, Eric Knudsen, David Bernard, and Victoria O'Connell

BACKGROUND

Based on the original RFP from ADF&G, there were two primary purposes for sampling adult Pink Salmon and/or Chum Salmon in streams: 1) to further assess the degree and the range of interannual variability in the fraction of the spawning population composed of hatchery strays; and 2) determine the effects of hatchery fish spawning with wild populations on the fitness of wild populations. The former was to be determined by collecting otoliths from spawned out adults. The otoliths were examined in the ADF&G laboratories to determine whether the individuals were of hatchery or wild origin. This resulted in estimates of the percent of hatchery fish for each stream. The latter was to be accomplished by collecting tissues for DNA analysis from adults in a subset of the same streams, referred to here as "fitness" streams. The DNA pedigree "markers" of these parents were to be used to identify either their pre-emergent offspring collected the following spring, or progeny returning to the streams as adults, so that relative reproductive success of hatchery- and natural-origin fish could be estimated for both males and females.

METHODS

Data collection for this study required repeated sampling of 32 streams throughout PWS and 32 streams throughout SEAK (Figures 12 and 13) with only slight variations for improvement of the methods used in 2013 (Knudsen et al. 2015). The field effort was divided into two major activities: the PWS stream sampling was accomplished by field crews from PWSSC while the stream sampling in SEAK was subcontracted to the SSSC. Final 2013 stream selection was made based on information provided in the RFP combined with some preliminary evaluations of some streams and discussions with ADF&G staff and the Science Panel, and those same streams were sampled in 2014.

In PWS, otoliths were collected for the hatchery fraction analysis from Pink Salmon adults in 28 of the 32 streams and Chum Salmon otoliths were collected from 18 of the streams (Figure 12). Each PWS stream was sampled during a minimum of three visits per stream. In SEAK, otoliths were collected from Chum Salmon (only) in all 32 streams during at least two, and often more, stream visits (Figure 13). For the fitness studies, DNA tissues were collected along with the otoliths from adult Pink Salmon in six of the PWS streams and from Chum Salmon in four of the SEAK streams (Figures 12 and 13).

The experimental design elucidated in the RFP for the hatchery fraction analysis called for collecting a target of 384 otolith samples for each species in each study stream, with the sampling spread roughly evenly across the run timing and throughout the salmon-accessible stream length. Because it is extremely difficult to predict the timing and abundance of salmon that will eventually enter the stream, and because it is logistically impossible to arrive at each stream exactly at the best times to sample, we implemented a strategy for "oversampling" whenever possible during the early visits to each stream. This was to create a higher likelihood of achieving the target of 384 in cases where the early visits coincided with the peak availability of adults to sample and subsequent visits yielded fewer than the required samples. The outcomes of this process are described below.

The RFP originally specified that fitness study streams have sampling targets of 500 individuals in high-stray-rate streams and 1,000 individuals in streams with lower stray rates. Subsequent discussions with ADF&G Gene Conservation Laboratory staff and the Science Panel in late 2013 indicated the importance of exceeding the sampling targets from these streams. Therefore, a strategy of maximizing the number of samples from fitness streams was implemented by making every effort to sample the fitness streams at least every third day in 2014.

OVERALL FIELD SAMPLING STRATEGY – PRINCE WILLIAM SOUND

Streams were sampled in PWS (Figure 12) by five crews that were directly employed, or contracted, by PWSSC. A four-person crew visited the majority of streams in PWS working off a contracted, live-aboard vessel, the ***Cathy G***. This team was primarily responsible for sampling the straying analysis streams, although the team occasionally sampled pedigree streams if needed. A second vessel-based crew of three people worked off the ***Auklet*** primarily on pedigree streams located on Montague and Knight Islands. Similarly the ***Auklet*** crew occasionally sampled straying analysis streams on Montague, Hinchinbrook, and Bainbridge Islands, in addition to Bainbridge Creek in Whale Bay. During the 2014 season, a three-person camping crew operated out of Paddy Bay to complete pedigree sampling at Paddy and Erb Creeks. This crew maintained a camp for nearly six weeks and transported themselves via skiff between Paddy and Ewan Bays. A three- to four-person crew was based in Cordova and sampled Hartney Creek regularly, in addition to later season sampling at Spring Creek located in Simpson Bay. This crew also sampled Humpback Creek two times during the season to collect additional samples for ADF&G's stock structure analysis of Pink Salmon. The crew also visited the upper and lower Coghill River over a two-day period in early September 2014. Lastly, a five-person crew sampled Sheep Creek and Spring Creek in Simpson Bay through a contract with Texas A&M University (TAMU) that operates a summer field course camp in Alice Cove.

The ***Cathy G***, Cordova, and TAMU crews were trained at the PWSSC from July 14 to 17. This included safety, CPR, and firearms training, as well as training and planning for field sampling, tablet use, and data entry. The sampling protocols were refined and finalized during this period. The ***Cathy G*** departed Cordova on July 18 and continued traversing PWS so as to maximize the stream sampling depending on the availability of fish to sample. The ***Cathy G*** crew sampled streams continuously until returning to Cordova on September 20 with brief port calls over August 2-3, 22-24, and September 15-16 for refueling, resupply, and crew breaks. Transit between strategic anchorages usually occurred in the evenings. The ***Cathy G*** was accompanied by a high-speed landing craft that could often quickly access multiple sampling streams from the same anchorage. Attempts were made to steer stream visits to the streams where Pink Salmon and Chum Salmon were most abundant by using ADF&G in-season aerial survey information. However, the field crew quickly assessed the status of run timing as they proceeded and mostly relied on their own observations to guide their deployment for sampling.

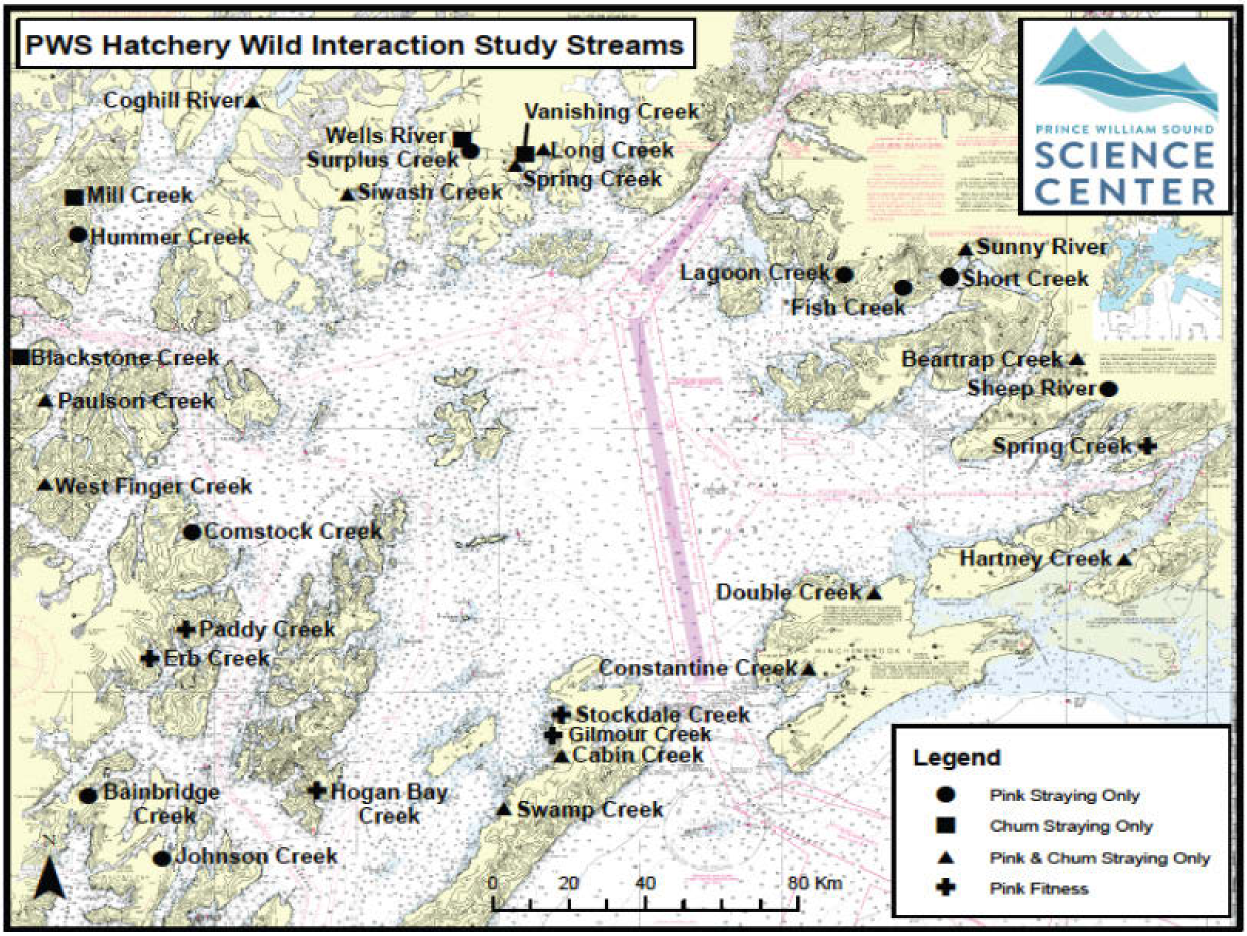

Figure 12. PWS streams sampled for Pink Salmon and Chum Salmon otoliths and DNA tissues.

A second training session was held in Cordova from July 18 through August 2 for the ***Auklet*** and camping crews and again included safety, CPR, and firearms training, as well as training and planning for field sampling, tablet use, and data entry mainly. The ***Auklet*** left Cordova on August 3, 2014, and returned from the field on September 15 with a brief port call on August 24-25. The ***Auklet*** crew was primarily responsible for sampling pedigree streams at Stockdale, Gilmour, and Hogan Bay Creeks on Montague and Knight islands. The Paddy Bay camping crew deployed with the Cathy G on August 4-5. The camp set-up required teams from both the ***Cathy G*** and Paddy camp to assist with hauling gear and getting organized. The Paddy camp started sampling at their study streams on August 7, and finished sampling on September 13 and arrived back in Cordova on September 15 with the ***Auklet*** crew.

For each sampling team, after arriving at study streams, the crew leader would indicate where to begin and how to focus spawn-out and carcass collection depending on system size and tide stage. The crew leaders decided whether all crew members would collect in the same area together, or disperse in order to leapfrog up/downstream for the sake of efficiency. Leaders would also review the target species and collection goals. Crews were additionally equipped with shotguns and VHF radios for safety.

Depending on the size of the stream system and the tide stage, crew leaders decided whether sampling would begin at the upper reaches or in the lower intertidal zone. All efforts were made to sample and survey as much of the stream length as possible, accounting for factors such as incoming tide, deep water, strong current, impassable barriers, and bears. After determining the start location of the survey, the responsible crew member marked the latitude and longitude waypoint on the tablet and all crew members began target species collection.

Sample collection success at any given processing area depended on carcass abundance and sampling goals. At times, collection at a fitness stream took considerably longer due to fish condition because many of the targeted fish had been preyed upon based on the presence of predation marks and/or still-full gonads. After collecting a sufficient number of carcasses at the processing area, the latitude and longitude of the processing area was marked on the tablet.

On straying-only streams, carcasses were aligned in rows of twelve by eight, which mimicked the rows and columns of the 96-well otolith trays. On fitness study streams, carcasses were aligned in rows of eight by six, again, mimicking the deep well plates (DWP). The popular cutting technique for accessing both heart tissue and otoliths was to place the fish on a cutting board positioned upright with its ventral side on the board. First, the head would be removed from the body with a vertical cut just posterior of the gill plate. This cut would typically expose tissue of the bulbous arteriosus, a piece of which was removed and placed in the DWP plate. The head would then be placed on the cutting board with cut down on the board so that the head was positioned vertically. A vertical cut just dorsal of the eye would expose the brain cavity where otoliths could be easily removed and placed in either DWP plates with the corresponding heart tissue for pedigree or stock structure streams, or in otolith only trays for staying streams. (See Appendix D for specific stream sampling protocols.)

The last phase of stream sampling was to perform a fish survey to establish a rough index of the abundance of fish at the time of the sampling visit. When fish sampling was close to completion, two or more crew members conducted both a live and dead estimate of all Pink Salmon and Chum Salmon throughout the system. If multiple people were counting the same species, estimates were discussed at the end of the survey and averaged to produce a final count. When the survey was complete, a crew member called for a pick-up by the charter operator and shotguns were unloaded.

The PWS field crews coordinated regularly with the project manager and necessary scheduling adjustments were made. All teams backed up data on their laptop computer each night, in addition to a secondary external drive. Data were uploaded to the host database whenever internet access was available. For the vessel-based, Cordova and TAMU crews, data upload occurred nearly nightly if not every 2-3 nights due to the generally available internet connections found throughout PWS and in Cordova. The Paddy Bay camping crew did not transmit data until the end of the season as they did not have reliable internet coverage. Between the tablets, laptop computers, external drive backup, and regular data upload to the host database, the likelihood of data being lost was very low and no data were lost in 2014.

After completion of quality control review, the straying-only otoliths were delivered to the Cordova ADF&G office for processing on October 9, 2014. Similarly, fitness stream otoliths and tissues were delivered to ADF&G's Gene Conservation Laboratory in Anchorage on November 17, 2014 where otoliths were to be extracted and shipped back to the Cordova ADF&G office for processing. Electronic data delivery to ADF&G followed the quality control review so that otolith and DNA results could be matched to the field observation data.

Overall Field Sampling Strategy – Southeast Alaska

The Sitka Sound Science Center (SSSC) coordinated sampling of 32 Chum Salmon streams across Southeast Alaska in 2014. Four of these steams were intensively studied fitness streams and 28 streams were sampled for otolith, length, and sex only, all to be used in the hatchery fraction analysis (Figure 13).

SSSC employed 15 field personnel on a total of five field crews in 2014. Field crews were comprised of three vessel-based crews, a crew based in Juneau, and a crew based in Tenakee Springs. The Tenakee Springs crew was subcontracted; the other four crews were composed of seasonal employees of the SSSC.

The 28 otolith-only streams were sampled by the vessel-based crews aboard the ***M/V Surveyor*** and ***M/V Bear***, which sampled the southern and northern portions of Southeast Alaska respectively. The crew based in Tenakee Springs sampled three otolith-only streams in their vicinity. The Juneau-based crew was tasked with sampling two fitness streams: Sawmill and Fish Creek. The ***M/V Nepenthe*** crew sampled the other two fitness streams, Admiralty and Prospect Creek, and occasionally helped the Juneau crew in sampling Fish Creek.

Field training was held between July 17 and 21 for the SSSC seasonal employees. Training included project orientation and goals, field safety, salmon identification, biological sampling techniques, and tablet use for data entry. The Tenakee subcontractors with prior experience did not attend training in Sitka but received the project protocol in advance of sampling and were instructed on data entry and field methods by the SSSC project coordinator. On July 22, the four SSSC crews departed Sitka to begin sampling. The ***M/V Bear*** stopped in Tenakee Arm on July 24, where they delivered supplies to the Tenakee Springs crew.

Hatchery Fraction, Otolith-Only Stream Sampling

The vessel-based otolith-only crews made 2-4 visits to each of the 28 streams in 2014. The ***M/V Bear*** crew surveyed much of the northern portion of the study area, including streams on Baranof, Admiralty, and Chichagof Islands. The ***M/V Surveyor*** crew focused on the southern portion of the study area, including streams on the mainland as well as Admiralty, Kuiu, and Revillagigedo Islands. Both vessels had skiffs for beach access and the ***M/V Surveyor*** crew was also equipped with a jet boat for travelling up the larger Southern area rivers and traversing long tide flats. Both vessels carried three SSSC field crew members as well as their own three-person crew. One or two vessel crewmembers accompanied SSSC personnel into the field to serve as bear protection for each otolith-only stream visit.

The two primary goals of routing vessels to visit these 28 streams were:

- To visit each stream a minimum of two times allowing sampling along the entire length of the anadromous reach, and
- To structure visits so that they coincide with both the early and late stages of the run.

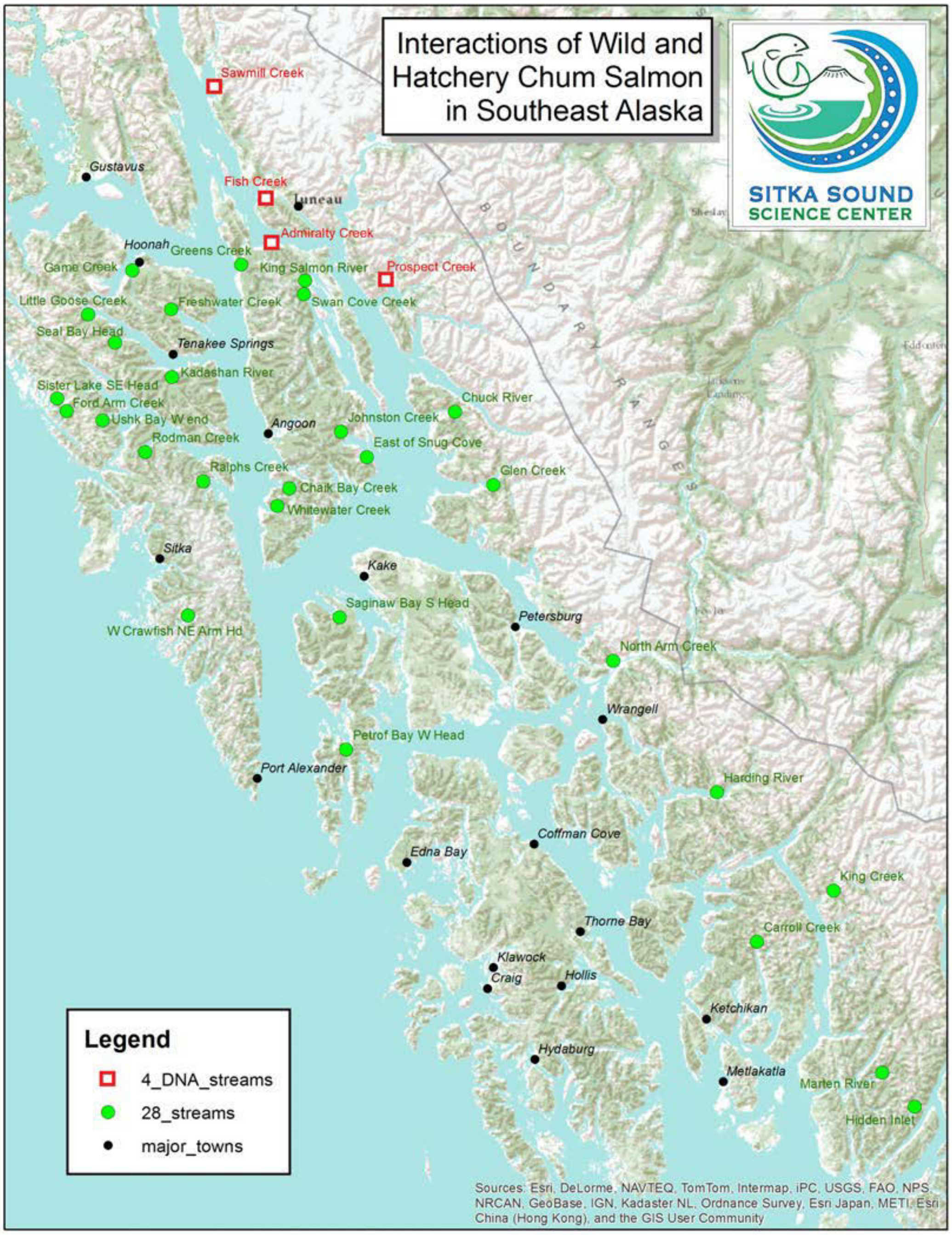

Figure 13. SEAK streams that were sampled for otoliths (green dots) and DNA tissues, and scales (red dots).

Stream visit itineraries were created for both the northern and southern otolith-only crews to best meet these goals. They took into account historical run timing, data from 2013, distance between streams, and potential weather issues. The SSSC otolith-only field crew leaders knew that it would be very likely their schedule would change due to run timing and weather. Thus, after each stream visit, crew leaders would report to SSSC project coordinators the numbers of live/dead fish seen, samples collected, water conditions, and other observations. This information, as well as information from ADF&G aerial and foot surveys, high water events, and other weather-related issues were the basis for in-season schedule changes. Most transit between streams occurred in the evenings. Travel days were scheduled when stream-to-stream distances required over ten hours in transit. Each vessel had occasional resupply days in various ports.

The northern crew sampled 15 streams, with support from the Southern crew co-sampling three streams, the Tenakee Springs crew co-sampling three streams, and the Juneau-based crew, along with a volunteer in Hoonah who took supplementary samples on two streams. Many of the streams in the northern portion of southeast are within close enough proximity that mid-season changes could occur without difficulty.

The southern crew sampled 14 streams with support from the Northern crew co-sampling three streams, the SSSC project coordinator, and ADF&G foot survey crews who took supplementary samples on three streams, and the vessel-based pedigree crew who took supplementary samples on one stream. Many of the streams in the southern portion are larger and much farther apart than those in the northern portion (Figure 13). This, when coupled with bad weather, made for slightly fewer visits on the southern portion of southeast.

The Tenakee Springs crew sampled four otolith-only study streams: Little Goose Creek, Seal Bay Head, Kadashan River, and Freshwater Creek. They furnished a skiff that was used for day-trips to each location.

Fitness Stream Sampling

Fitness stream crews were instructed to maintain a schedule of re-visiting each creek no more than three days apart. The fitness crews maintained this regimen throughout the season, and only deviated from it during high water events when the streams were unsafe to work in.

The Juneau crew sampled Fish Creek via the Douglas road system, with occasional support from the vessel-based pedigree crew and volunteers from ADF&G. They also sampled Sawmill Creek using an ADF&G skiff. Crews often sampled the same creek two days in a row, covering different areas of the creek more thoroughly each day.

The vessel-based pedigree crew sampled Admiralty and Prospect creeks. The frequency of visits to these streams was kept at three days with the exception of high water events. Crews generally spent two days on each creek visit, covering different areas more thoroughly each day.

Technicians would frequently rotate from one crew to another to bolster the sampling effort. This was especially true on the fitness crews. When in port, the ***M/V Nepenthe*** crewmembers would often accompany the Juneau crew to Fish Creek. Fitness crews also made additional, supplementary visits to creeks that were not initially on their schedule, such as Game Creek, Freshwater Creek, and the Chuck River.

Communication and Data Transfer

The SSSC project coordinator communicated daily with the vessel crews using Delorme InReach, satellite-based texting devices. Satellite or cell phone check-ins occurred when longer conversations were needed. The fitness crews had regular phone access in or near Juneau and the Tenakee area contractors communicated via email and phone. The Juneau-based fitness crew and Tenakee Springs crew transmitted their stream survey data regularly from their respective home bases. The vessel based crews were able to transmit surveys when within cell phone service.

The SSSC field crews returned to Sitka between August 31st and September 2nd for gear storage and debriefing. The Tenakee Springs subcontractors were debriefed by phone.

SPECIFIC BIOLOGICAL SAMPLING METHODS

Every effort was made to use consistent field methodologies throughout the data collection in both regions. Detailed specific methodological protocols were developed to guide 2014 field data collection (Appendices C-D). The protocols were developed primarily from previous practices established within ADF&G, modified as necessary to facilitate the current study and improved slightly from experience in 2013. The protocols included specific methods for biological sampling including techniques for collecting post-spawned adult salmon, extracting otoliths, measuring lengths, determining sex, collecting tissues for DNA analysis, and, for the southeast Chum Salmon fitness streams, collecting scale samples for aging. Consistent methods and collection trays were used throughout the study. All otoliths, DNA tissue samples, and scales were sent to the respective ADF&G labs for processing.

All field data were collected on-site using tablet computers running an Android application developed specifically for collecting data on this project (developed under a subcontract to Finsight LLC of Juneau). Guidance for the use of the field tablet application for data collection was integrated into the protocols. A more rigorous process of field and post-field quality control was implemented in 2014. All otolith and DNA samples were checked for completeness and accuracy at the end of each sample tray row, before leaving a processing area, and at the end of the day. Data errors were immediately corrected in the tablet or on the laptop.

A project SQL database was also established in 2013 and modified for the 2014 season by Finsight LLC. Field data was backed up nightly on laptop computers and then uploaded to the host database from the laptops whenever the crews had access to the internet. The survey data were imported nightly from the tablets to laptop computers where they were run through a series of quality assurance checks on a custom laptop application.

HATCHERY FRACTION DATA ANALYSIS

As in 2013, the objectives of the field sampling in 2014 on the spawning grounds of PWS and Southeast included estimates for the fractions of hatchery fish in each spawning population of Pink Salmon and Chum Salmon that year. Sampling followed a stratified, two-stage design in which districts are strata, streams are first-stage sampling units, and fish the second-stage units. Streams included in the study were chosen randomly with probability proportional to their size, based on the 25-year average of spawning abundance indices generated from aerial surveys by ADF&G over years 1986 through 2010 (see Piston and Heinl 2011 and Botz et al. 2014). The number of streams to sample was allocated across PWS districts and SEAK subregions proportional to run size (summed abundance indices) according to procedures in Cochran (1972). Streams to be sampled within a district were selected with probability according to run size (again abundance indices) with replacement. Each sampled stream was visited three to seven times from late July through late September in PWS and two to five times from late July to end of August in Southeast. The number of dead and live salmon of each species was usually counted in the stream during each visit, and samples from dead or moribund salmon were taken during each visit. An otolith was excised from each sampled salmon, and its origin (hatchery or wild) was determined later after sampling had finished.

Estimated Fractions and Estimated Variances

By the District (PWS) or Sub-region (Southeast)

From Thompson (1992, p. 132), an unbiased estimate of the population total τ from any multi-stage sampling design in which the first-stage units (here streams) were chosen proportional to their size with replacement is

$$\tau = \frac{1}{n}\sum_{i=1}^{n}\frac{\tau_i}{\pi_i}, \qquad \pi_i = \frac{M_i}{M}, \quad \text{and} \quad \tau_i = M_i\bar{y}_i, \qquad \text{(1a, 1b, 1c)}$$

where in this study τ is an unbiased estimate of the number of hatchery fish on the spawning grounds in a district (PWS)[4], ***n*** is the number of first-stage units visited in that district, π_i is the relative size of the ***i***th stream among all streams in the district[5], M_i is the number of second-stage units (hatchery and wild spawning fish) in ***i***th stream in that district, ***M*** is the number of spawning fish in the district, τ_i is the estimated number of hatchery salmon on the spawning grounds in the ***i***th stream, and $\bar{y}_i$ is the estimated fraction of hatchery fish on the spawning ground of the ***i***th stream. However, the objective of our field study is not to estimate the total number of hatchery-produced chum or pink salmon on the spawning ground, but to estimate the mean hatchery fraction of the spawning population across all streams. The estimated mean fraction over all streams $\bar{q}$ is found by dividing the estimated number of salmon of hatchery origin in the spawning population (here τ) by the spawning abundance ***M*** of the target species in the district:

$$\bar{q} = \tau / M = \frac{1}{M}\frac{1}{n}\sum_{i=1}^{n}\frac{M_i\bar{y}_i}{M_i/M} = \frac{1}{n}\sum_{i=1}^{n}\bar{y}_i . \qquad (2)$$

[4]This section of the report is ostensibly a description of equations germane to the study in PWS. However, these equations are relevant to the study in SEAK involving Chum Salmon and were used to estimate the hatchery fraction only with sub-regions as strata.

[5] Identifiers τ, y, and q are estimates, while identifiers π, M, and n are actual values.

Thompson (1992) provides the following equation for estimating the variance for the population total under these circumstances:

$$v(\tau) = \frac{1}{n(n-1)} \sum_{i=1}^{n} \left(\frac{\tau_i}{\pi_i} - \tau \right)^2 . \tag{3}$$

Dividing the above equation by the square of the number on the spawning grounds within the district (***M***) provides the estimated variance for the estimated fraction of hatchery fish in the population:

$$v(\overline{q}) = v(\tau)/M^2 = \frac{1}{M^2} \frac{1}{n(n-1)} \sum_{i=1}^{n} \left(\frac{\tau_i}{\pi_i} - \tau \right)^2 = \frac{1}{n(n-1)} \left(\sum_{i=1}^{n} \overline{y}_i^2 - \frac{\left(\sum_{i=1}^{n} \overline{y}_i \right)^2}{n} \right). \tag{4}$$

By the Stream

Part of the sampling design described above is that a single sample of m_i salmon is drawn randomly from each of the ***n*** streams in a district[6]. Each fish in the sample is scored with a "1" if it's a hatchery fish, or a "0" if otherwise. The sum of these m_i recordings is divided by m_i to produce $\overline{y}_i$ for that stream. However, streams in our study were visited several times each to account for changes in the hatchery fraction in the stream over the season. A quasi-random sample from the spawning population was drawn during each visit to estimate the hatchery fraction during that visit. The term quasi-random is used because we assumed that natural forces were sufficient to have distributed hatchery fish evenly among the spawning population such that the sample was representative of the spawning population at the time of the visit. Under these circumstances, the weighted average for the ***i***th stream across visits is:

$$\overline{y}_i \equiv \overline{q}_i = \sum_{v=1}^{V_i} w_{iv} q_{iv} \text{ , where } w_{iv} = \frac{C_{iv}}{\sum_{v'=1}^{V_i} C_{iv'}} \text{ and } q_{iv} = \frac{\sum_{j=1}^{m_{iv}} y_{ijv}}{m_{iv}} \text{ , and} \tag{5a, 5b, 5c}$$

where ***v*** denotes a visit, V_i is the number of visits to the ***i***th stream, C_{iv} the number of dead/live salmon counted during a visit, m_{iv} the number of fish of the target species sampled in a visit, and y_{ijv} is the result of sampling a fish (y_{ijv} = 1 if the fish is of hatchery origin, 0 otherwise). The estimated mean fraction across visits is an unbiased estimate for the mean hatchery fraction for the stream.

From Thompson (1992) the variance of the $\overline{y}_i$ is implied in Equation 4 when first-stage units are selected with a probability according to their size and second-stage units are selected randomly. While first-stage units were so selected in our study, second-stage units were not strictly selected randomly. Nevertheless, several factors ameliorate the need to explicitly consider the variance for $\overline{y}_i$:

[6] Identifier *w* , *v*, *V*, *C*, and *m* are actual values.

1. the frequent visits to streams;
2. the large number of fish sampled during the season;
3. weights were based on actual counts;
4. the effect of random (quasi) sampling in the design; and
5. fractions were often unchanging across visits (often near zero).

For these reasons Equation 4 as written was used to express uncertainty in estimated hatchery fractions for the spawning populations in the districts.

For the Sound

Equations above are germane to any population sampled according to a two-stage design, a population that in our situation is the spawning population in a district of PWS. Given that there are 9 such districts in the Sound[7], there are potentially 9 populations per species. An unbiased estimate of the hatchery fraction for a species across all districts is

$$\hat{q} = \sum_{h=221}^{221,\ldots,229} W_h \overline{q}_h \text{ , where } W_h = \frac{A_h}{\sum_{h'=221}^{221,\ldots,229} A_{h'}} \text{ , and} \qquad (6a, 6b)$$

where $\boldsymbol{h}$ denotes stratum (district), A_h the aerial abundance index by ADFG for stratum (district) $\boldsymbol{h}$ in 2013, and $\overline{q}_h \equiv \overline{q}$ in Equation 2 (the specific district is now explicitly identified), and $\hat{q}$ is the estimated fraction of hatchery fish across the entire Sound. The estimated variance for the estimated sound-wide fraction $\hat{q}$ is

$$v(\hat{q}) = \sum_{h=221}^{221,\ldots,229} W_h^2 v(\overline{q}_h) \text{ .} \qquad (7)$$

The calculations described above were first explicitly framed in Excel. Subsequently, these calculations were implemented in R (R Core Team 2014) for repetitious analytical runs.

RESULTS

Overall, the stream sampling was successful relative to the goals of the project, as described further below. About 30,600 individual fish were sampled from all PWS and SEAK streams and species combined in 2014. Many streams were sampled beyond their targets and others were below the targets. Conditions of fish availability and weather were generally less conducive to sampling success in 2014 than in 2013 when about 33,500 individuals were sampled. In both regions, conditions in mid-August and late-September were at times difficult due to extreme rainfall and stream levels that made streams too dangerous to work in. These conditions likely also affected fish availability and may be why some of the target sampling was not met for certain streams. Further, Pink Salmon run sizes were smaller in 2014 than 2013. While sampling was somewhat reduced on the straying study streams in 2014, sample numbers were mostly greater for the fitness streams due to increased number of sampling visits to those streams.

[7] There are only 8 districts in regards to chum salmon in that District 229 (the Unakwik District) has virtually no chum salmon spawning in the district.

PWS STREAM SAMPLING RESULTS

Pink Salmon were observed in all streams sampled across PWS, where the general pattern of Pink Salmon running into streams was earlier in the season in northeast PWS and later for the southwest portions of PWS. Streams such as Bainbridge Creek had large numbers of Pink Salmon by the end of July, while other streams such as Swamp Creek did not start running until mid-August. Sunny River exhibited strong runs in mid to late September, while all other Pink runs had finished by this time.

Pink Salmon Hatchery Fraction Sampling

Across all 28 streams sampled for Pink Salmon otoliths (Figure 12), 17,595 pairs of otoliths were taken; reaching or exceeding the sampling goal in 22 streams (Table 2). Oversampling, as described in the general methods, occurred during the peak of the Pink Salmon run at most streams. The least productive streams for Pink Salmon samples were Double (46.6% of the goal), Hartney (60.9%), Long (52.3%), Spring (fitness, 30.2%), and Surplus (61.7%) creeks. The results for Spring Creek (fitness) are surprising since this stream was chosen as a fitness stream and therefore considered to have a high probability of Pink Salmon spawning so as to obtain genetic and otolith samples. Some stream sampling may have suffered from intense rains in early August that likely washed out a considerable number of fish before being sampled. Further, this was known as a year of lower Pink Salmon returns in PWS in general, especially as compared with 2013 which was a record year (Botz et al. 2014). The number of samples varied per stream visit (Appendix F). Foot survey-based live and dead counts were made on most stream surveys (Appendix F) and the dead counts were later used to weight the hatchery fraction estimates per visit.

Chum Salmon Hatchery Fraction Sampling

The presence of Chum Salmon was observed at every PWS stream visited except Short, Surplus, and Johnson Creeks, while very low numbers of Chum were observed at Blackstone, Tebenkof, Paddy, Hogan, Stockdale, Gilmour and Swamp Creeks (Table 3). Overall, Chum Salmon runs in PWS range from mid-July to late-September, but not every district’s streams share the same run timing. For instance, Sunny River in eastern PWS, produced a late Chum run, which seemingly began in late August and ended in late-September, whereas, Beartrap Creek, also in eastern PWS had a large run from late-July to early-August.

Table 2. Summary of sampling and hatchery fractions by stream for PWS Pink Salmon in 2014 (2013 fractions shown for comparison). Target sample size per stream was 384 for estimating the hatchery fraction. Counts of live and dead salmon were taken during each visit and dead counts were used to weight the hatchery fraction for each visit to produce a weighted average fraction for each stream.

Stream name	AWC code	Samples collected 2014	Number of stream visits 2014	Average weighted hatchery fraction 2013	Average weighted hatchery fraction 2014
Hartney C	221-10-10020	234	9	0.024	0.072
Spring (fitness)	221-20-10200	151	16	0.031	0.040
Sheep R	221-20-10360	468	4	0.000	0.013
Beartrap R	221-30-10480	511	4	0.024	0.001
Sunny R	221-40-10875	470	6	<0.001	0.022
Short C	221-40-10880	416	4	0.006	0.081
Fish C	221-40-10890	459	3	<0.001	0.054
Lagoon C	221-40-10990	472	4	0.016	0.077
Long C	222-10-12140	201	5	0.070	0.415
Spring C	222-10-12170	473	4	0.002	0.017
Surplus C	222-20-12338	237	5	0.010	0.294
Siwash R	222-20-12640	526	5	0.098	0.367
Coghill R	223-30-13220	464	7	0.018	0.099
Hummer C	224-10-14240	483	3	0.020	0.197
Paulson C	224-10-14550	494	3	0.058	0.005
W. Finger C	224-40-14850	517	3	0.025	<0.001
Comstock C	225-20-15040	560	5	0.868	0.899
Paddy C	226-20-16010	1,158	19	0.154	0.595
Erb C	226-20-16040	1,909	20	0.113	0.228
Bainbridge C	226-20-16300	575	4	0.174	0.000
Hogan Bay	226-30-16810	2,651	15	0.640	0.915
Johnson C	226-40-16269	555	4	0.370	0.712
Swamp C	227-20-17390	388	5	0.063	0.125
Cabin C	227-20-17464	455	6	0.103	0.321
Gilmour C	227-20-17480	670	13	NA	0.557[a]
Stockdale C	227-20-17520	1,551	17	0.163	0.735
Double C	228-40-18310	179	4	0.002	0.048
Constantine C	228-60-18150	368	5	0.000	0.023

[a] Data collected and hatchery fraction calculated at the stream level but Gilmour Creek was not included in the district or PWS-wide hatchery fraction estimations because it was not part of the original hatchery fraction experimental design.

A total of 4,577 Chum Salmon samples were taken with sampling goals reached or exceeded in 8 out of 18 streams (Figure 12). The least productive streams for Chum Salmon samples were Blackstone Creek (0.3% of the sampling goal), Cabin Creek (6.3%), Coghill River (28.1%), Long (12.2%), Paulson (12.5%), Siwash (2.1%), Spring (15.9%), and Swamp (0%) creeks. Because Blackstone Creek had such low numbers of Chum Salmon, we also surveyed nearby Tebenkof Creek which helped by adding 34 samples (see Appendix G for more details). We combined Tebenkof Chum Salmon samples into those from Blackstone for the hatchery fraction analysis. Oversampling was possible in many Chum Salmon systems such as Beartrap Creek, Sunny River, and Mill Creek. The number of Chum samples varied per stream visit (Appendix G). Foot survey-based live and dead counts were made on most stream surveys (Appendix G) and the dead counts were later used to weight the hatchery fraction estimates per visit. See Appendix H for more details on the sampling of each PWS stream.

Table 3. Summary of sampling and hatchery fractions by stream for PWS Chum Salmon in 2014 (2013 fractions shown for comparison). Target sample size per stream was 384 for estimating the hatchery fraction. Counts of live and dead salmon were taken during each visit and dead counts were used to weight the hatchery fraction for each visit to produce a weighted average fraction for each stream.

Stream name	**AWC code**	**Samples taken 2014**	**Number of stream visits 2014**	**Average weighted hatchery fraction 2013**	**Average weighted hatchery fraction 2014**
Hartney C	221-10-10020	395	9	0.005	0.034
Beartrap R	221-30-10480	656	4	0.005	0.051
Sunny R	221-40-10875	506	6	0.001	0.038
Long C	222-10-12140	47	5	0.261	0.058
Vanishing C	222-10-12157	422	4	0.045	0.025
Spring C	222-10-12170	61	4	0.022	0.000
Wells R	222-20-12340	455	5	0.021	0.065
Siwash R	222-20-12640	8	5	0.049	0.120
Coghill R	223-30-13220	108	7	0.049	0.000
Mill C	224-10-14210	519	4	0.042	0.003
Tebenkoff	224-10-14500	34	2	NA	See Blackstone
Blackstone C	224-10-14510	1	4	0.093	0.000
Paulson C	224-10-14550	48	3	0.056	0.043
W. Finger C	224-40-14850	348	3	0.017	0.015
Swamp	227-20-17390	0	5	0.601	NA
Cabin C	227-20-17464	24	6	0.965	0.803
Double C	228-40-18310	489	4	0.040	0.001
Constantine C	228-60-18150	456	5	0.005	0.000

a Samples from Tebenkof Creek were combined under neighboring Blackstone Creek for the analyses described below.

PWS Pink Salmon Fitness Sampling

Overall, sampling was successful at five of the six selected Pink Salmon fitness study streams in PWS (Table 4). Spring Creek was an anomaly as there were abundant fish there in 2013 but very few in 2014. We believe this reflects the generally lower PWS run sizes for Pink Salmon in 2014. Early in the runs, we observed many Pink Salmon that had been depredated by bears and gulls on fitness streams, which rendered these fish useless for genetics/parentage work. However, once the fish started running in earnest, certainly by mid-August, depredation by bears became less of an issue for sampling. Successful sampling of five of the six fitness streams can be attributed to a high return of Pinks and success in bracketing the peak of the run with sampling times (see Appendix H for more details on the sampling of each PWS stream).

Table 4. Total Pink Salmon DNA and otolith samples collected in Prince William Sound during July through September 2014.

Stream name	AWC code	Total collected	Visits
Erb Creek	226-20-16040	1,909	20
Gilmour Creek	227-20-17480	670	13
Hogan Creek	226-30-16810	2,651	15
Paddy Creek	226-20-16010	1,158	19
Spring Creek	221-20-10200	151	16
Stockdale Creek	227-20-17520	1,551	17
	Total	8,090	100

PWS STREAM HATCHERY FRACTION RESULTS

Pink Salmon and Chum Salmon hatchery fractions in the natural spawning streams were analyzed at the level of study stream, district, and then PWS-wide.

PWS Pink Salmon Hatchery Fractions

At the stream level (n = 28), fractions of hatchery Pink Salmon ranged from 0 to 0.92 in 2014 (Table 2, Figure 14). Hatchery Pink Salmon were not detected at Bainbridge or West Finger Creeks in 2014. However, the highest fraction of hatchery Pink Salmon in 2014 was detected at Hogan Bay and Comstock creeks (0.92 and 0.90, respectively). Other study streams with notable hatchery fractions of Pink Salmon were Stockdale, Johnson, Paddy and Gilmour Creeks (0.74, 0.71, 0.60, and 0.56, respectively). Long, Cabin, Siwash, and Surplus Creeks had intermediate fractions of hatchery Pink Salmon in 2014 (0.42, 0.37, 0.32, and 0.29, respectively). All other study streams had lower hatchery fractions (< 0.23). Some 2014 fractions of hatchery Pink Salmon by study stream varied from those observed in 2013 with many apparently higher in 2014 (Table 2).

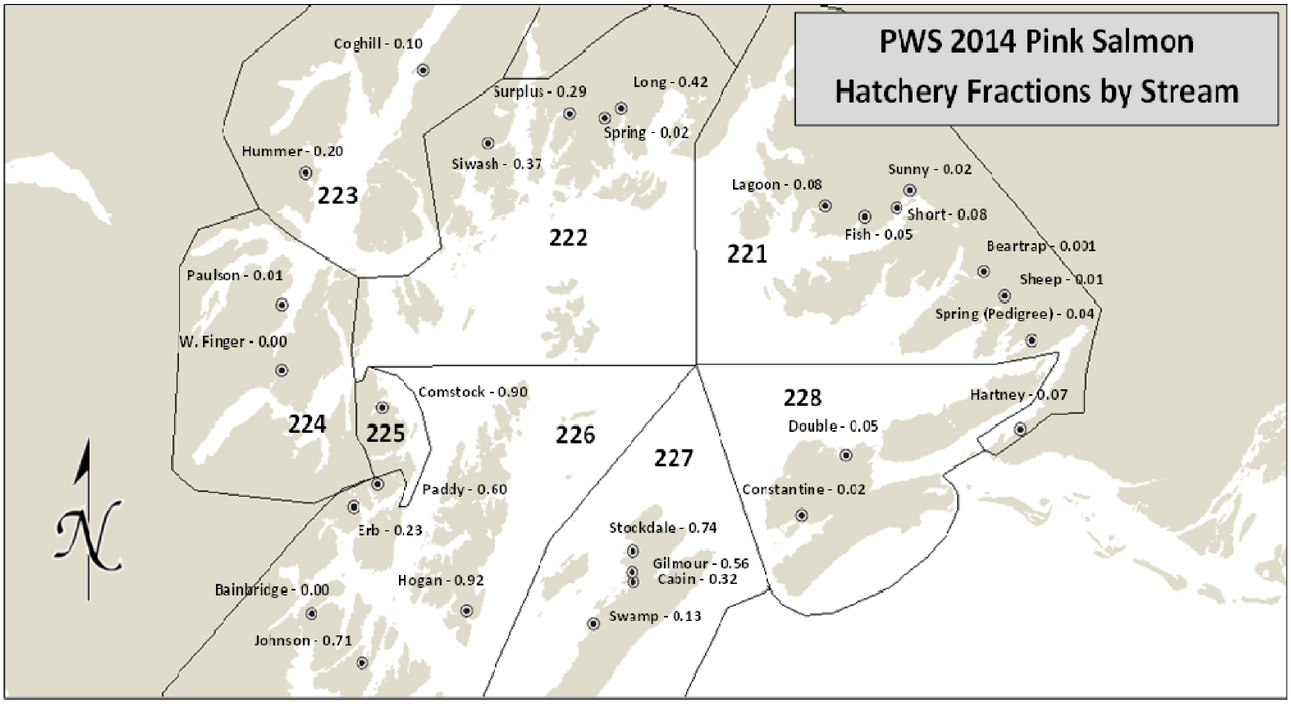

Figure 14. PWS Pink Salmon weighted hatchery fractions by stream in 2014. Black lines represent district borders.

The Eshamy management district had the highest fraction of hatchery Pink Salmon (Table 5) in PWS in 2014, likely due to the fact that Comstock Creek is the only study stream in this district and it had one of the highest hatchery fractions. The Southwestern and Montague districts had the second and third highest fractions of hatchery Pink Salmon (0.49 and 0.39, respectively).

Table 5. Estimated PWS Pink Salmon district-wide stream 2013 and 2014 hatchery fractions and the 2014 standard errors (n=27 as Gilmour Creek was excluded from district and sound-wide analyses). The 2014 aerial survey fraction for each district was used to weight the contribution of each district to the overall fraction estimate.

District	2013 Estimated hatchery fraction	2014 Estimated hatchery fraction	2014 Estimated SE	Number of streams sampled	2014 Aerial survey fraction for district
Eastern (221)	0.013	0.045	0.019	8	0.303
Northern (222)	0.045	0.273	0.089	4	0.133
Coghill (223)	0.018	0.099	NA	1	0.097
Northwestern (224)	0.034	0.067	0.065	3	0.082
Eshamy (225)	0.868	0.899	NA	1	0.004
Southwestern (226)	0.290	0.490	0.166	5	0.087
Montague (227)	0.110	0.394	0.180	3	0.086
Southeastern (228)	0.001	0.036	0.012	2	0.208
Overall	0.044	0.148	0.071	27	1.000

The Northern district had an intermediate fraction of hatchery fish (0.27). All other districts had hatchery fractions < 0.10. All districts except Eshamy (represented by one stream) exhibited apparently greater hatchery fractions in 2014 than 2013 (Table 5). For the entire PWS region in 2014, the fraction of hatchery Pink Salmon in all spawning streams was calculated to be 0.15 ± 0.071. This hatchery fraction estimate was greater than it was in 2013 (0.04 ± 0.029) although the difference was not statistically tested.

PWS Chum Salmon Hatchery Fractions

At the stream level (n = 16), hatchery fractions of PWS Chum Salmon ranged from 0 to 0.80 in 2014 (Table 3, Figure 15). Hatchery Chum Salmon were not detected at Blackstone, Coghill, Constantine, or Spring Creeks. Cabin Creek had the highest Chum Salmon hatchery fraction among all study streams in 2014 (0.80). All other study streams had lower hatchery fractions (< 0.12). Hatchery fractions of Chum Salmon by study stream in 2014 varied from those observed in 2013 but with no discernable pattern as for some streams hatchery fractions increased while, for others, hatchery fractions decreased (Table 3).

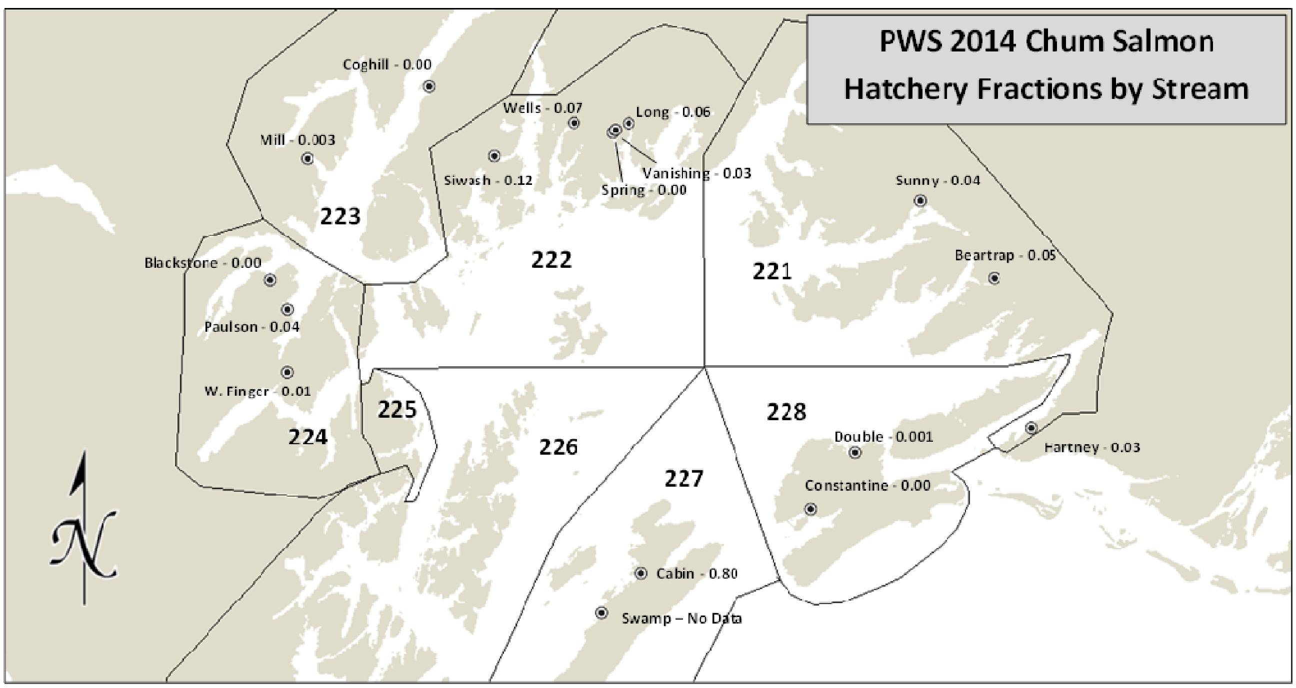

Figure 15. PWS Chum salmon hatchery fractions by stream in 2014. Black lines represent district borders.

Based on estimated hatchery fractions across management districts in PWS, the Montague management district had the highest fraction of hatchery Chum Salmon in 2014 (Table 6). Both Cabin and Swamp Creeks are in the Montague management district and these streams had the highest fractions of hatchery Chum Salmon among all study streams in 2014. The Coghill management district had the lowest fraction of hatchery Chum Salmon in PWS during 2014 (0.00). All but two districts (Montague and Eastern) apparently had lower Chum Salmon hatchery fractions in 2014 than in 2013 (Table 6). For the entire PWS region in 2014, the fraction of hatchery Chum Salmon in spawning streams was estimated to be 0.032, very similar to the 0.028 estimate for 2013.

Table 6. Estimated 2013 and 2014 PWS Chum Salmon district -wide and overall stream hatchery fractions and standard error for 2014. The aerial survey fraction for each district was used to weight the contribution of each district to the overall fraction estimate.

District	2013 Estimated hatchery fraction	2014 Estimated hatchery fraction	2014 Estimated SE	Number of streams sampled	Aerial survey fraction for district
Eastern (221)	0.004	0.041	0.005	3	0.561
Northern (222)	0.080	0.054	0.020	5	0.166
Coghill (223)	0.049	0.000	NA	1	0.057
Northwestern (224)	0.052	0.015	0.010	4	0.030
Montague (227)	0.783	0.803	NA	1	0.000
Southeastern (228)	0.022	<0.001	<0.001	2	0.181
Overall	0.028	0.032	0.009	16	0.995[a]

[a] This does not sum exactly to 1.0 because two minor districts with no study streams in 2014 were not included.

SOUTHEAST ALASKA STREAM SAMPLING RESULTS

SSSC field crews were highly efficient in the 2014 season, conducting 146 stream visits in 43 days, as compared to 90 stream visits in 2013. The vessel captains and crew leaders were experienced in navigating the project areas and crews were transported to and from the field with considerably less difficulty than in 2013. In-season communication between field crews and project coordinators regarding sample numbers, field logistics, and other pertinent topics were discussed at length throughout the project, leading to multiple schedule revisions while maintaining proper visit timing as a priority. Additionally, extra visits were conducted by the project coordinator accompanying ADF&G on their foot surveys on the King Salmon River, Hidden Inlet, and Carroll Creek. Sitka-based SSSC personnel also conducted two visits to West Crawfish, sparing the ***M/V Bear*** from having to travel there. Project coordinators also maintained good communication with ADF&G Area Management Biologists, with whom fish numbers and stream conditions were discussed on multiple occasions. Despite the enhanced efficiency, the 2014 field season saw historically high rainfall and low Chum Salmon returns, both of which greatly affected our success in accessing creeks and collecting samples.

For most Southeast streams sampled in 2014, Chum Salmon numbers were quite low. On many creeks, peak live/dead counts were significantly lower in 2014 than in 2013, even with extra visits. Lower counts were especially noticeable on Johnston Creek, Chaik Bay Creek, Sister Lake SE Head, Rodman Creek, and Sawmill Creek where we observed thousands fewer fish than in 2013. During our second visit to Glen Creek, the crew could not find even a trace of a Chum Salmon, live or dead in the stream. On some streams we have now seen very low numbers of chum two years in a row. This is especially true on the Marten River, Saginaw Bay S Head, Greens Creek, and Glen Creek where we have yet to see over 200 Chum Salmon, live or dead, in the river during any visit in either year. On many occasions there never appeared to be a strong concentration of spawning fish, but rather a collection of small groups lingering in pools throughout the stream.

Four major high water events occurred around July 26-29, August 9-12, August 15-17, and August 29-September 1. These events created dangerous conditions in which we were unable to safely wade in the streams. Crews would often be forced to turn around early due to rising water, or were completely unable to walk a stream. On several occasions, after flood conditions had subsided, crews reported that previously existing log jams and gravel bars had been washed away and there was new downed timber and re-routed river channels. During the high water events when the crews could safely negotiate the streams, the water would often be deep with low visibility, preventing the crews from conducting accurate live/dead counts from the bank. Carcasses were scarce and snagging was usually not possible in these conditions.

During many stream visits, samplers observed mostly live, pre-spawned, Chum Salmon but rarely any spawned out fish or carcasses. A likely explanation was that the frequent, high water events were washing many carcasses and post-spawned salmon out of the streams and preventing them from accumulating. See Appendix J for details of surveys on each Southeast stream.

Chum Salmon Hatchery Fraction Sampling

Chum Salmon were sampled for otoliths in 32 streams across Southeast Alaska (Figure 8) with four of these streams also used for genetics/fitness sampling. SSSC field crews visited the 28 otolith-only streams 2-5 times each from July 22-September 2. They also visited the fitness streams many more times each (see below) and collected otoliths for the straying study at all 32 streams. Field crews collected 8,251 pairs of otoliths across all Southeast Alaska streams (see Appendix I for a listing of each Southeast stream survey). We exceeded ADF&G's otolith sampling goal of 384 at six of the streams (Table 7).

Chum Salmon Fitness Sampling

We sampled four Southeast Alaska streams for Chum Salmon DNA tissue samples as well as otoliths: Admiralty, Fish, Prospect, and Sawmill creeks. We also collected scale samples from a subset of Chum Salmon in each of these streams for aging (Table 8). A total of 3,480 otolith samples, 3,477 tissue samples, and 1,074 sets of scales were collected at these four streams. All four of the fitness streams were visited every 3 days, except during several high water events (Table 8).

Each stream visit consisted of 1-2 days of sampling. Crews were able to cover the entire anadromous stretch over the course of each visit except in high water events. On Fish Creek, the crew would occasionally not reach the upper extent due to a high volume of carcasses in the lower sections.

Table 7. Summary of sampling and hatchery fractions by stream for SEAK Chum Salmon. Target sample size per stream was 384 for estimating the hatchery fraction. Counts of live and dead salmon were taken during each visit and dead counts were used to weight the hatchery fraction for each visit to produce a weighted average fraction for each stream.

Stream name	AWC code	Samples taken 2014	Number of stream visits 2014	Average weighted hatchery fraction 2013	Average weighted hatchery fraction 2014
Hidden Inlet	101-11-11010	228	4	0.063	0.062
Marten River	101-30-10600	19	2	0.047	0.091
Carroll Creek	101-45-10780	378	3	0.044	0.027
King Creek	101-71-10040-2006	205	2	0.084	0.023
Harding River	107-40-10490	194	2	0.167	0.050
North Arm Creek	108-40-10150-2007	259	3	0.043	0.031
Saginaw Bay S Head	109-44-10370	19	2	0.007	0.149
Petrof Bay W Head	109-62-10240	389	2	0.000	0.004
Johnston Creek	110-23-10100	24	2	0.026	0.000
East of Snug Cove	110-23-10210	13	2	0.000	0.000
Chuck River	110-32-10090	89	4	0.013	0.070
Glen Creek	110-34-10060	3	2	0.014	0.000
Swan Cove Creek	111-16-10450	95	2	0.029	0.000
King Salmon River	111-17-10100	290	3	0.028	0.002
Prospect Creek	111-33-10100	457	15	0.241	0.040
Admiralty Creek	111-41-10050	250	16	0.047	0.036
Fish Creek - Douglas	111-50-10690	2631	19	0.728	0.719
Ralphs Creek	112-21-10060	297	3	0.007	0.000
Kadashan River	112-42-10250	17	4	0.000	0.028
Seal Bay Head	112-46-10070	348	5	0.004	0.034
Little Goose Creek	112-48-10190	15	2	0.000	0.000
Freshwater Creek	112-50-10300	107	5	0.018	0.020
Greens Creek	112-65-10240	1	3	0.000	0.000
Chaik Bay Creek	112-80-10280	53	4	0.004	0.000
Whitewater Creek	112-90-10140	46	3	0.041	0.144
W Crawfish NE Arm Hea	113-32-10050	442	2	0.019	0.009
Rodman Creek	113-54-10070	116	3	0.011	0.007
Ushk Bay W End	113-56-10030	70	3	0.008	0.079
Sister Lake SE Head	113-72-10040-2025	528	2	0.015	0.022
Ford Arm Creek	113-73-10030	414	2	0.023	0.012
Game Creek	114-31-10130	120	5	0.036	0.000
Sawmill Creek	115-20-10520	121	13	0.465	0.193

Table 8. Total Chum Salmon DNA and otolith samples collected in SEAK during July and August 2014.

Stream Name	AWC Number	Total Otoliths	Total DNA samples	Total scale samples	Visits
Admiralty Creek	111-41-10050	260	260	236	16
Fish Creek	111-50-10690	2623	2622	396	19
Prospect Creek	111-33-10100	473	471	315	15
Sawmill Creek	115-20-10520	124	124	123	13

Spawning was first seen on Fish Creek, on July 21 and crews began collecting samples July 23. Fish Creek had the largest run of the pedigree streams. The runs on Admiralty and Prospect Creeks were much slower to start and weaker in overall numbers. Sawmill Creek had a very small run. Crews visited Sawmill Creek 13 times between July 22 and August 27 and the peak count was 153 Chum Salmon. Overall, less than 200 total Chum Salmon were observed in Sawmill Creek in 2014. See Appendix J for details of surveys on all Southeast fitness streams.

SOUTHEAST STREAM HATCHERY FRACTION RESULTS

Chum Salmon Hatchery Fractions

At the stream level (n = 32), hatchery fractions of Chum Salmon in SE Alaska ranged from 0 to 0.72 in 2014 (Table 7, Figure 16). No hatchery Chum Salmon were detected at Chaik Bay, East of Snug Cove, Game, Glen, Greens, Johnston, Little Goose, or Swan Cove Creeks. The highest fraction of hatchery Chum Salmon in 2014 was detected at Fish Creek (0.72). All other study streams had lower hatchery fractions (< 0.20) in 2014. Among all the SEAK Chum Salmon streams, 17 streams apparently had somewhat lower fractions, while nine streams had apparently higher hatchery fractions, in 2014 as compared with 2013 (Table 7). Of note, six Chum Salmon study streams had effectively the same hatchery fractions, while three of these had no measureable hatchery fraction detected in either year.

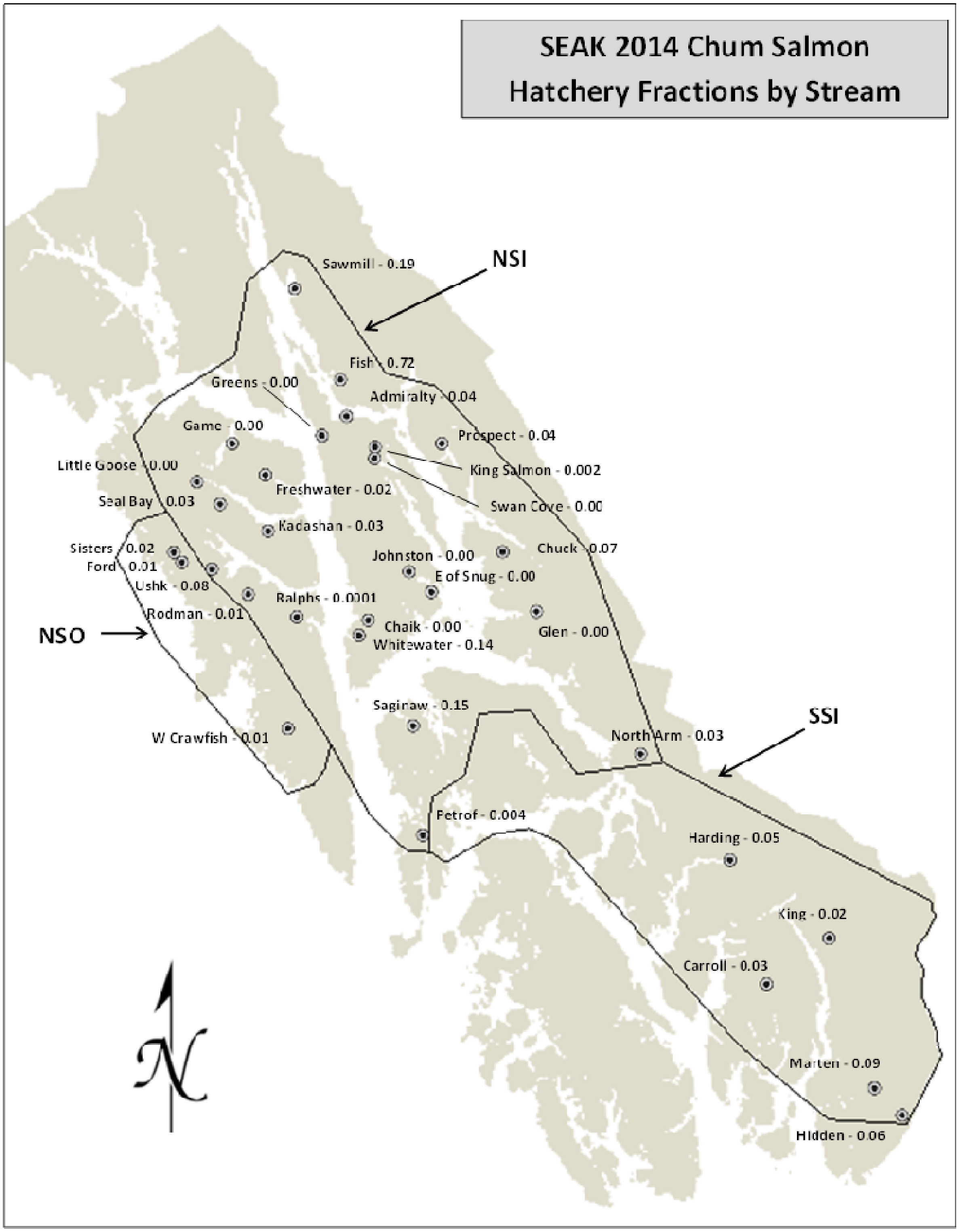

Figure 16. SEAK Chum salmon hatchery proportions by stream in 2014. Black lines represent district borders.

Estimated fractions of hatchery Chum Salmon in spawning populations in 2014, and their associated variance, across SEAK management sub-regions are reported in Table 10. Based on these results, the Northern Southeast Inside had the highest fraction of hatchery Chum Salmon. Fish Creek, which had the highest hatchery fraction of all study streams for Chum Salmon, is located within the Northern Southeast Inside sub-region. The overall 2014 fraction of hatchery Chum Salmon in SEAK study streams was estimated to be 0.054, which was only slightly lower than the 2013 estimate (Table 10).

Table 10. Estimated SEAK Chum Salmon subregion-wide and overall stream hatchery fractions in 2013 and 2014 and standard error for 2014. The aerial survey fraction (S. Heinl, pers. comm.) for each district in 2014 was used to weight the contribution of each district to the overall SEAK fraction estimate.

District	2013 Estimated hatchery fraction	2014 Estimated hatchery fraction	2014 Estimated SE	Number of streams sampled	Aerial survey fraction for district
Northern Southeast Outside	0.019	0.014	0.004	3	0.138
Northern Southeast Inside	0.074	0.065	0.031	24	0.592
Southern Southeast	0.081	0.051	0.012	5	0.270
Overall	0.072	0.054	0.024	32	1.000

DISCUSSION

The overall hatchery fractions in the study streams were 0.15 for PWS Pink Salmon, 0.03 for PWS Chum Salmon, and 0.05 for SEAK for Chum Salmon in 2014. In comparison, the 2014 estimates were higher than in 2013 for PWS Pink Salmon (0.04), but similar between years for both PWS Chum Salmon (0.03 in 2013) and SEAK Chum Salmon (0.07 in 2013). The apparently higher PWS Pink Salmon hatchery fractions in 2014 are probably attributable to the reduced even-year wild Pink Salmon run relative to the record run size of 2013 which increased the relative proportion of hatchery fish. Hatchery fractions varied by species, region, and management unit (Tables 5, 6, and 10), but were generally low for a majority of the streams. A few individual streams exhibited high hatchery fractions, some exhibited medium fractions, but many streams had low or no hatchery strays (Tables 2, 3 and 7). As in 2013, the hatchery fractions for 2014 generally reflect the same patterns of higher hatchery fractions in streams closer to hatcheries than in more distant streams, as reported in Brenner et al (2012) for PWS Pink Salmon and Chum Salmon and Piston and Heinl (2012) and for Chum Salmon in SEAK (compare Figures 14-16 to results in Brenner et al. 2012 and Piston and Heinl 2012). The intention when hatchery release sites were established was to locate them away from important wild stocks (see http://www.adfg.alaska.gov/index.cfm?adfg=fishingHatcheriesResearch.main). This was to protect wild populations from overharvest, but it also serves to limit high hatchery stray fractions to a few local streams thereby minimizing potential negative effects on the overall PWS or SEAK spawning populations. Results from the ongoing hatchery-wild fitness studies should advance understanding of the effects of relative high proportions of hatchery-origin spawners in some local populations. These studies were repeated in 2015 for a third year of the hatchery fraction analysis.

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RUN SIZE AND SPAWNING ABUNDANCE

David R. Bernard, Eric Knudsen, Michele Buckhorn, Kristen Gorman, and Ben Adams

Abundances of spawning Pink Salmon and Chum Salmon in both Prince William Sound (PWS) and Chum Salmon in Southeast Alaska (SEAK) are not estimated, but indexed with aerial surveys designed to provide information for in-season management of common property fisheries. Those fish counted from the air are either the progeny of fish that spawned a generation ago in the same streams, or were spawned in hatcheries and have strayed onto the spawning grounds. Because every hatchery-produced Chum Salmon and Pink Salmon in PWS and Chum Salmon in SEAK have thermally marked otoliths, the processes described above from the ocean and stream sampling in 2014 now allows estimates the hatchery fraction of the spawning populations, as described in the foregoing sections. While knowledge of the hatchery fraction of the spawning abundance is of great interest in its own right, that statistic, along with others, can be used to estimate total run size and spawning abundance as well.

Spawning abundance over a large geographic area can be estimated independent of aerial surveys with knowledge of:

- catches;
- the fraction of the total run comprised of hatchery salmon; and
- the fraction of escapement comprised of hatchery fish.

Current ADF&G catch sampling programs provide the needed knowledge on catches for both wild and hatchery-produced fish in PWS. These catch sampling programs for the common property fishery can also provide estimates on the fraction of the run comprised of hatchery fish if both wild and hatchery salmon have the same harvest rate in that fishery. However, because some fishermen tend to concentrate on catching hatchery salmon in the common property fishery, thereby preventing unbiased sampling of the hatchery-wild ratio in the commercial fishery, ocean sampling is needed to get the statistic for the run before the run is fished. The stream sampling in this study has provided the last bulleted statistic: the fraction of natural escapement comprised of hatchery fish.

Ocean sampling was originally thought to be unnecessary in SEAK because catches of Chum Salmon in common property fisheries there are incidental to catches of Pink Salmon, the targeted species. Also, ocean sampling was impractical in Southeast Alaska due to the many ocean entrances. However, when we attempted the run size estimates for SEAK, it became clear that there was high uncertainty about estimating the overall proportion of hatchery fish in the catch because, while some fisheries are well-sampled, others are not. Therefore, estimates of total run size were not possible for Southeast Alaska Chum Salmon in this study.

METHODS

This section describes calculations of estimators for run size and spawning abundance for Pink Salmon and Chum Salmon in PWS. Methods for calculating approximate variances for estimates are also given. These methods were predicated on independent stream, ocean, and catch sampling programs to deliver statistics for input.

ESTIMATORS

Notation and definition of variables:

R_H is the size of the run of hatchery fish;

R_W is the size of the run of wild fish;

S_H is the number of hatchery strays that survive the fishery (end up spawning);

S_W is the number of wild fish that end up spawning;

C_W is the "catch" of wild fish (in the common property fishery, in cost recovery, and rack return);

C_H is the "catch" of hatchery fish (in the common property fishery, in cost recovery, and rack return);

p is the fraction of the run comprised of hatchery fish; and

q is the fraction of the spawning population comprised of hatchery strays.

Note that by definition:

$$q = \frac{S_H}{S_W + S_H} \quad \text{or} \quad \frac{S_W}{S_H} = \frac{R_W - C_W}{R_H - C_H} = \frac{1-q}{q} = b \,, \tag{1}$$

where ***q*** can be estimated from stream sampling, and ***b*** is a redefined variable solely a function of stream sampling. Also note that by definition

$$p = \frac{R_H}{R_W + R_H} \quad \text{or} \quad \frac{R_W}{R_H} = \frac{1-p}{p} = a \,, \tag{2}$$

where ***p*** can be estimated from ocean sampling, and ***a*** is a redefined variable solely a function of ocean sampling. Equation 2 can be rearranged such that $R_W = aR_H$. When this relationship is plugged into Equation 1 and solved for R_H, the result is

$$R_H = \frac{C_W - bC_H}{a - b} \,. \tag{3}$$

Using the relationship $R_W = aR_H$ in the context of Equation 3,

$$R_W = aR_H = \frac{a(C_W - bC_H)}{a - b} \,. \tag{4}$$

Further relationships involving catch and spawning abundance are

$$S_W = R_W - C_W = \frac{a(C_W - bC_H)}{a - b} - C_W \tag{5}$$

$$S_H = R_H - C_H = \frac{C_W - bC_H}{a - b} - C_H \qquad (6)$$

$$R = R_W + R_H = \frac{(1+a)(C_W - bC_H)}{a - b} \qquad (7)$$

$$S = R - C = \frac{(1+a)(C_W - bC_H)}{a - b} - C \qquad (8)$$

Substitution of estimates including statistics from ocean sampling ($\hat{p} \to p$), field sampling ($\hat{q} \to q$), and catch sampling ($\hat{C}_W \to C_W$ and $\hat{C}_H \to C_H$) changes Equations 3 – 5 into estimators of run size and spawning abundance.

VARIANCES

By the delta method an approximate variance of a non-linear function of variables g[**X**] where **X** is the vector [$\boldsymbol{x}_1$, $\boldsymbol{x}_2$, … $\boldsymbol{x}_n$] can be approximated with the non-quadratic terms in a Taylor series expansion of g[**X**] as follows:

$$v(g[\mathbf{X}]) \cong \sum_i v(x_i)\left(\frac{\partial g}{\partial x_i}\right)^2 + 2\sum_{i<j}\sum Cov(x_i, x_j)\left(\frac{\partial g}{\partial x_i}\right)\left(\frac{\partial g}{\partial x_j}\right).$$

In our study there are several non-linear functions (Equations 3–8) with variables $\hat{p}$, $\hat{q}$, $\hat{C}_W$, and $\hat{C}_H$. These variables serve as the x_i for the delta method. In that the stream, ocean, and catch sampling were conducted independently, covariances among statistics from those programs are zero with one possible exception. Some covariances do exist between $\hat{C}_W$, and $\hat{C}_H$ depending on how the catch sampling was conducted. At this time we have no information on a possible covariance so we have chosen to ignore the possibility. The consequence will be to slightly inflate our approximations of variance.

The first step in approximating variances for the right-hand sides of Equations 3 – 8 is to approximate variances for $\hat{a}$ and $\hat{b}$. First derivatives are

$$\frac{\partial \hat{a}}{\partial \hat{p}} = -\hat{p}^{-2} \qquad \text{and} \qquad \frac{\partial \hat{b}}{\partial \hat{q}} = -\hat{q}^{-2}.$$

The approximate variances are therefore

$$v(\hat{a}) \cong \frac{v(\hat{p})}{\hat{p}^4} \qquad \text{and} \qquad v(\hat{b}) \cong \frac{v(\hat{q})}{\hat{q}^4}.$$

The next steps were to apply the delta method to Equations 3 – 8 to get approximate variances for run size and spawning abundance. The next series of equations is just such an application.

Approximate variance for Equation 3:

$$\boldsymbol{v}(\hat{\boldsymbol{R}}_{\boldsymbol{H}}) \cong \boldsymbol{v}(\hat{\boldsymbol{a}})\left(\frac{\partial \hat{\boldsymbol{R}}_{\boldsymbol{H}}}{\partial \hat{\boldsymbol{a}}}\right)^2 + \boldsymbol{v}(\hat{\boldsymbol{b}})\left(\frac{\partial \hat{\boldsymbol{R}}_{\boldsymbol{H}}}{\partial \hat{\boldsymbol{b}}}\right)^2 + \boldsymbol{v}(\hat{\boldsymbol{C}}_{\boldsymbol{W}})\left(\frac{\partial \hat{\boldsymbol{R}}_{\boldsymbol{H}}}{\partial \hat{\boldsymbol{C}}_{\boldsymbol{W}}}\right)^2 + \boldsymbol{v}(\hat{\boldsymbol{C}}_{\boldsymbol{H}})\left(\frac{\partial \hat{\boldsymbol{R}}_{\boldsymbol{H}}}{\partial \hat{\boldsymbol{C}}_{\boldsymbol{H}}}\right)^2$$

Derivatives: $\frac{\partial \hat{R}_H}{\partial \hat{a}} = -\frac{\hat{R}_H}{\hat{a}-\hat{b}}$ $\quad \frac{\partial \hat{R}_H}{\partial \hat{b}} = \frac{\hat{C}_W - \hat{a}\hat{C}_H}{(\hat{a}-\hat{b})^2}$ $\quad \frac{\partial \hat{R}_H}{\partial \hat{C}_W} = \frac{1}{\hat{a}-\hat{b}}$ $\quad \frac{\partial \hat{R}_H}{\partial \hat{C}_H} = -\frac{\hat{b}}{\hat{a}-\hat{b}}$

Approximate variance for Equation 4:

$$\boldsymbol{v}(\hat{\boldsymbol{R}}_{\boldsymbol{W}}) \cong \boldsymbol{v}(\hat{\boldsymbol{a}})\left(\frac{\partial \hat{\boldsymbol{R}}_{\boldsymbol{W}}}{\partial \hat{\boldsymbol{a}}}\right)^2 + \boldsymbol{v}(\hat{\boldsymbol{b}})\left(\frac{\partial \hat{\boldsymbol{R}}_{\boldsymbol{W}}}{\partial \hat{\boldsymbol{b}}}\right)^2 + \boldsymbol{v}(\hat{\boldsymbol{C}}_{\boldsymbol{W}})\left(\frac{\partial \hat{\boldsymbol{R}}_{\boldsymbol{W}}}{\partial \hat{\boldsymbol{C}}_{\boldsymbol{W}}}\right)^2 + \boldsymbol{v}(\hat{\boldsymbol{C}}_{\boldsymbol{H}})\left(\frac{\partial \hat{\boldsymbol{R}}_{\boldsymbol{W}}}{\partial \hat{\boldsymbol{C}}_{\boldsymbol{H}}}\right)^2$$

Derivatives: $\frac{\partial \hat{R}_W}{\partial \hat{a}} = -\hat{b}\frac{\partial \hat{R}_H}{\partial \hat{a}}$ $\quad \frac{\partial \hat{R}_W}{\partial \hat{b}} = \hat{a}\frac{\partial \hat{R}_H}{\partial \hat{b}}$ $\quad \frac{\partial \hat{R}_W}{\partial \hat{C}_W} = \hat{a}\frac{\partial \hat{R}_H}{\partial \hat{C}_W}$ $\quad \frac{\partial \hat{R}_w}{\partial \hat{C}_H} = \hat{a}\frac{\partial \hat{R}_H}{\partial \hat{C}_H}$

Approximate variance for Equation 5:

$$\boldsymbol{v}(\hat{\boldsymbol{S}}_{\boldsymbol{W}}) \cong \boldsymbol{v}(\hat{\boldsymbol{a}})\left(\frac{\partial \hat{\boldsymbol{S}}_{\boldsymbol{W}}}{\partial \hat{\boldsymbol{a}}}\right)^2 + \boldsymbol{v}(\hat{\boldsymbol{b}})\left(\frac{\partial \hat{\boldsymbol{S}}_{\boldsymbol{W}}}{\partial \hat{\boldsymbol{b}}}\right)^2 + \boldsymbol{v}(\hat{\boldsymbol{C}}_{\boldsymbol{W}})\left(\frac{\partial \hat{\boldsymbol{S}}_{\boldsymbol{W}}}{\partial \hat{\boldsymbol{C}}_{\boldsymbol{W}}}\right)^2 + \boldsymbol{v}(\hat{\boldsymbol{C}}_{\boldsymbol{H}})\left(\frac{\partial \hat{\boldsymbol{S}}_{\boldsymbol{W}}}{\partial \hat{\boldsymbol{C}}_{\boldsymbol{H}}}\right)^2$$

Derivatives: $\frac{\partial \hat{S}_W}{\partial \hat{a}} = \frac{\partial \hat{R}_W}{\partial \hat{a}}$ $\quad \frac{\partial \hat{S}_W}{\partial \hat{b}} = \frac{\partial \hat{R}_W}{\partial \hat{b}}$ $\quad \frac{\partial \hat{S}_W}{\partial \hat{C}_W} = \frac{\partial \hat{R}_W}{\partial \hat{C}_W} - 1$ $\quad \frac{\partial \hat{S}_W}{\partial \hat{C}_H} = \frac{\partial \hat{R}_W}{\partial \hat{C}_H}$

Approximate variance for Equation 6:

$$\boldsymbol{v}(\hat{\boldsymbol{S}}_{\boldsymbol{H}}) \cong \boldsymbol{v}(\hat{\boldsymbol{a}})\left(\frac{\partial \hat{\boldsymbol{S}}_{\boldsymbol{H}}}{\partial \hat{\boldsymbol{a}}}\right)^2 + \boldsymbol{v}(\hat{\boldsymbol{b}})\left(\frac{\partial \hat{\boldsymbol{S}}_{\boldsymbol{H}}}{\partial \hat{\boldsymbol{b}}}\right)^2 + \boldsymbol{v}(\hat{\boldsymbol{C}}_{\boldsymbol{W}})\left(\frac{\partial \hat{\boldsymbol{S}}_{\boldsymbol{H}}}{\partial \hat{\boldsymbol{C}}_{\boldsymbol{W}}}\right)^2 + \boldsymbol{v}(\hat{\boldsymbol{C}}_{\boldsymbol{H}})\left(\frac{\partial \hat{\boldsymbol{S}}_{\boldsymbol{H}}}{\partial \hat{\boldsymbol{C}}_{\boldsymbol{H}}}\right)^2$$

Derivatives: $\frac{\partial \hat{S}_H}{\partial \hat{a}} = \frac{\partial \hat{R}_H}{\partial \hat{a}}$ $\quad \frac{\partial \hat{S}_H}{\partial \hat{b}} = \frac{\partial \hat{R}_H}{\partial \hat{b}}$ $\quad \frac{\partial \hat{S}_H}{\partial \hat{C}_W} = \frac{\partial \hat{R}_H}{\partial \hat{C}_W}$ $\quad \frac{\partial \hat{S}_H}{\partial \hat{C}_H} = \frac{\partial \hat{R}_H}{\partial \hat{C}_H} - 1$

Approximate variance for Equation 7:

$$v(\hat{R}) \cong v(\hat{a})\left(\frac{\partial \hat{R}}{\partial \hat{a}}\right)^2 + v(\hat{b})\left(\frac{\partial \hat{R}}{\partial \hat{b}}\right)^2 + v(\hat{C}_W)\left(\frac{\partial \hat{R}}{\partial \hat{C}_W}\right)^2 + v(\hat{C}_H)\left(\frac{\partial \hat{R}}{\partial \hat{C}_h}\right)^2$$

Derivatives: $\frac{\partial \hat{R}}{\partial \hat{a}} = \frac{\partial \hat{R}_H}{\partial \hat{a}} + \frac{\partial \hat{R}_W}{\partial \hat{a}}$ $\quad \frac{\partial \hat{R}}{\partial \hat{b}} = \frac{\partial \hat{R}_H}{\partial \hat{b}} + \frac{\partial \hat{R}_W}{\partial \hat{b}}$ $\quad \frac{\partial \hat{R}}{\partial \hat{C}_W} = \frac{1+\hat{a}}{\hat{a}-\hat{b}}$

$$\frac{\partial \hat{R}}{\partial \hat{C}_H} = -\frac{(1+\hat{a})\hat{b}}{\hat{a}-\hat{b}}$$

Approximate variance for Equation 8: since the total catch C here is a constant (known supposedly without error), $v(\hat{S}) = v(\hat{R})$.

Equations 3 – 8, their approximate variances, and the accompanying derivatives at first glance appear daunting. However, the calculations were adapted to a spreadsheet. Only eight numbers are needed as input to estimate spawning abundance and run size.

RESULTS

The eight numbers mentioned in the previous section for PWS Pink Salmon in 2014 are:

	p	q	C_W	C_H
Estimate→	0.860	0.1263213	1,829,629	42,016,103
Variance→	0.0008705	0.00556882	940000000	940000000

and for PWS Chum Salmon in 2014 they are:

	p	q	C_W	C_H
Estimate→	0.511	0.0510841	250,731	1,178,892
Variance→	0.0008591	0.00004470	940000000	940000000

where p, q, C_W, and C_H are estimates from ocean, stream, and catch sampling programs[8]. Variances for $\hat{C}_W$ and $\hat{C}_H$ are not available at this writing, so their variances were roughly estimated to be 940,000,000 which one would expect from a catch of 4,000,000 with 1,000 fish sampled randomly from it to determine the hatchery fraction[9].

The total 2014 run size ($\hat{R}$) of Pink Salmon in PWS was estimated to be 49.7 million while the total PWS Chum Salmon run was about 2.4 million (Table 10). The overall run size of PWS Pink Salmon was about 50% lower in 2014 than in 2013. The Pink Salmon hatchery run was about 39% lower in 2014, while the wild run was about 79% lower in 2014. This corresponds to expectations of generally larger Pink Salmon runs in odd years and the expectation that most of the even-odd-year differences would occur in the wild run since hatchery production is relatively stable from year to year.

PWS Chum Salmon total run size was also roughly 42% lower in 2014 than 2013 although the majority of the difference was apparently in hatchery returns which were about 59% lower in 2014 (Table 10). The PWS Chum Salmon spawning escapements were approximately the same in 2013 and 2014.

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[8] Note the "^" are missing from the identifiers.

[9] HINT: Hardly affects precision of estimates at all.

Table 10. PWS run size estimates for 2013 and 2014 and variances for 2014 (The 2013 estimates are derived in Knudsen et al. 2015).

	PWS Pink Salmon				PWS Chum Salmon			
Factor	2013 run size estimates	2014 run size estimates	Approx 2014 SE	Approx 2014 CV (%)	2013 run size estimates	2014 run size estimates	Approx 2014 SE	Approx 2014 CV (%)
$\hat{R}_H$	69,888,190	42,757,968	254,551	0.60	3,007,859	1,228,703	33,305	2.71
$\hat{R}_W$	33,096,875	6,960,599	1,746,836	25.10	1,141,130	1,175,997	148,703	12.64
$\hat{S}_W$	15,698,160	5,130,971	1,747,118	34.05	894,113	925,267	152,167	16.45
$\hat{S}_H$	701,618	741,864	252,608	34.05	50,568	49,811	8,192	16.45
$\hat{R}$	102,985,065	49,718,567	1,494,717	3.01	4,148,989	2,404,700	151,494	6.30
$\hat{S}$	16,399,778	5,872,835	1,494,717	25.45	944,681	975,077	151,494	15.54

DISCUSSION

The HWI Study's 2014 estimate for PWS Pink Salmon spawning abundance (about 5.9 million, from $\hat{S}_W + \hat{S}_H$) is approximately 2.6 times larger than ADF&G's estimate of 2.3 million fish (T. Sheridan, pers. comm.). ADF&G's estimate was based on an aerial survey index expanded through area-under-the-curve methodology, which takes several assumptions into consideration, including stream life, observer efficiency, and a proportion of PWS streams flown as estimated in Bue et al. (1998). Possible reasons for this difference can include inaccurate assumptions being used for ADF&G's expansion, and imprecise aerial survey indices due to reduced survey effort (T. Sheridan, pers. comm.). Budget limitations and poor weather have negatively impacted the PWS pink and chum salmon aerial survey program in recent years, leading to fewer surveys being flown, and increasing duration between surveys (T. Sheridan, pers. comm.). As reported in Wiese et al. (2015), PWS aerial survey observational conditions in 2014 were among the worst on record for the PWS aerial survey program; poor weather conditions resulted in fewer streams flown during August 2014 than any month of August since 1981. Bue et al. (1998) documented that the accuracy and precision of area-under-the-curve estimates decreased as the interval between surveys increased. Further, PWS area-under-the-curve methodology resulted in the majority of Montague District escapement to be excluded from postseason analyses, as only 17 of 33 streams in the district were flown often enough (≥ 3 surveys) in 2014 to use with area-under-the-curve methodology (Wiese et al. 2015). ADF&G believes that 2014 PWS aerial survey pink and chum salmon escapement indices are likely an underestimate of escapement, and represent a minimum count (T. Sheridan, pers. comm.).

Another statistic of interest, from values in the table above, is the estimated Sound-wide harvest rate of wild fish ($\hat{C}_W / \hat{R}_W$) which is 26.3% for PWS Pink Salmon and 21.3% for PWS Chum Salmon in 2014. These results compare to 2013 observations, when the estimated Sound-wide harvest rate of wild fish $(\hat{C}_w/\hat{R}_w)$ was 52.6% for PWS Pink Salmon and 21.6% for PWS Chum Salmon. Low Chum Salmon values for both years likely speak to the fact that most PWS fisheries do not target, and are not managed for, wild Chum Salmon (Fair et al. 2008). Lower wild Pink Salmon harvest rates in 2014 are likely due in part to a relatively conservative management approach in the face of below average escapements, combined with uncertainty resulting from an inability to fly surveys (T. Sheridan, pers. comm.). Late season management in 2014 included a 10-day Sound-wide closure during the traditional peak of the Pink Salmon purse seine fishery to ensure that escapement goals were made, and subsequent fishing opportunity was limited with regards to time and area (Wiese et al. 2015).

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HATCHERY-WILD ALEVIN SAMPLING 2014

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INTRODUCTION

The overarching purpose of sampling salmon alevins in March and April, 2014 was to assess the relative feasibility and costs of collecting offspring from the previous year's spawners for survival comparisons between hatchery- and natural-origin progeny for both males and females. Although the ultimate comparison of the relative survival between the two groups will be made when the offspring return to the streams as adults, assessing the relative survival at the alevin stage will help to reveal whether any differences in survival occur before or after the alevin stage. The origins of the two alevin groups from each stream will be determined by their DNA "fingerprints" corresponding to their parents' DNA. Samples were to be systematically collected from a designated proportion of the total spawning area from where adult DNA tissues were collected the previous summer.

OBJECTIVES

The 2014 sampling for Chum Salmon in Fish Creek on Douglas Island, and Pink Salmon in Stockdale Creek on Montague Island was conducted to evaluate a) the field sampling techniques, b) the relative success of capturing alevins, and c) the number of individual alevins required to successfully determine relative survival rates.

METHODS

Our goal in sampling alevins was to collect 1-25 fry in at least 250 redd samples in each stream by hydraulic sampling ("fry-pumping") in March and early April. The reason for collecting a large number of alevins is because only some of the parents were sampled for genetic tissue, and there may be many other alevins of unknown parentage mixed with those whose parentage can be identified. Specific, pre-season alevin sampling protocols are described in the Appendix E. The methods below are a better reflection of how the 2014 sampling was conducted.

SELECTING SAMPLE LOCATIONS

Sites were sampled with a standard redd pump sampler to collect alevins (Figure 17). Sampling was distributed approximately in proportion to spawning distribution in the previous summer. Because some sample sites produced no target alevins, we knew we would need to "oversample" so the target of 250 positive samples can be attained. However, we did not know in advance what proportion of samples would be positive. Therefore, we initially sampled throughout the entire spawning reach of each stream to assess the relative distribution and success rate. After passing through the stream reach once, we determined how many more positive samples would be required and approximately how they should be distributed throughout the stream to make another representative pass through the stream.

At each sampling location, the sampling net hoop was placed over the substrate wherever it was possible to get a reasonable "seal" of the bottom ring of the net to prevent escape of alevins under the bottom of the ring. If the net did not lay flat on the substrate, it was moved slightly until it sat as flat as possible.

The location of each sample was recorded with GPS coordinates, using the position averaging feature to get a better position. Some samples that were in close proximity were recorded with the same GPS fix. Sample sites were numbered sequentially in chronological order.

PUMPING TO COLLECT ALEVINS

At each sample site, one or two team members worked the 0.5-m net frame down into the substrate as far as practical so that alevins could not escape underneath the frame during pumping (Figure 9). The codend of the net was on the downstream flow side of the net frame.

With the 1½-in gas-powered water pump running, the injector probe was submerged into multiple locations within the net frame, to 12-24 inches deep whenever possible, repeating this action until all possible fry had been released. The amount of time the substrate was probed with pumped water from start to end was recorded. Pumping continued until no fry were observed or it was thought that the 25 targeted alevin were likely in the codend.

Figure 17. Redd pumping on Stockdale Creek, April, 2014.

If alevins were observed on the surface within the net frame, they were scooped with a dip-net and retained in a water-filled container. After pumping, the net frame was removed and all materials were washed into the codend. The contents of the codend were emptied into a round container or on hard surface to reveal the alevins. All alevins from one pump sample were kept separate from any other sample.

Alevin Samples

All alevins from each sample site were sorted and counted by species and recorded. All non-target species, and excess target species, were released alive into the stream whenever possible. Up to 25 of the target species (if available in the sample) were retained for genetic analysis in sample-specific, pre-labeled, ethanol-filled vials (Isopropanol/Methanol/Ethanol - EtOH). The vials contained 4:1 EtOH to fish tissue. The date, stream, and sample number were written on a small, write-in-the-rain sample label and placed inside the bottle. The sample number corresponded to the last four digits from the vial's bar code. The number of fish was written on the outside of the bottle. The sample vial number was recorded on the data sheet, being certain that the vial number is associated with the GPS data for the same pump sample.

Field Approach – Fish Creek (Douglas Island)

Chum Salmon alevin were sampled in Fish Creek on Douglas Island near Juneau March 25-31, 2014. The weather was dry with temperatures ranging between about 18 and 36 degrees F daily. The stream was low and clear. Much thick shelf ice remained along the margins and across the entire stream in some places, especially in treed areas, making sampling some locations impossible. Thinner, new ice was broken when necessary.

To help distribute the sampling throughout the known spawning areas, sampling was apportioned among ten stream reaches. Sampling began in section 4 which corresponds to the area near the footbridge, which was the site of the most intensive spawning the previous summer. Relatively few alevins were captured. Sampling then progressed downstream into the intertidal zone to the downstream-most Chum Salmon spawning observed in summer 2013. Only one Chum Salmon alevin was captured in the intertidal zone.

Sampling was then conducted in the uppermost section where spawning was observed the previous summer. As we progressed downstream from there, success rates improved. We continued to sample where possible, skipping short areas with thick ice. In several areas, very large rock substrate prevented us from digging very deep, however we continued to sample in all accessible areas until we had thoroughly sampled the entire stream. On the final day, we sampled in section 4 once again, which was the area where the most spawning activity occurred the previous summer.

FIELD APPROACH – STOCKDALE CREEK

Pink Salmon alevin were sampled using hydraulic pumping in Stockdale Creek in Prince William Sound April 3-6, 2014. The sampling crew traveled to the study site aboard the ***M/V Babkin***, which anchored in Stockdale Harbor, Montague Island as a live-aboard vessel for the week. The crew and sampling gear were transported daily by zodiac to the mouth of the study stream. Stream flow was low in comparison to flows observed during the previous summer's sampling of adult spawners.

The stream was broken into four recognizable sections, starting from the mouth: 1) the lower intertidal flat, 2) the high-tide gravel bar, 3) the under-ice reach, and 4) the upper uncovered reach. The ice-covered section was 215 of the 700 total meters of the study area. The first three days were used to sample all sections of the stream except those covered in heavy ice. The fourth day was used to break as much of the ice as possible and sample in those areas to more fully represent the study area. The crew used a pry bar to break ice where possible (ice thickness < 15cm) in order to spread samples throughout the spawning grounds of the stream.

The first sample site was located approximately 200m upstream of the uppermost processing area from the previous summer's DNA/otolith sampling. Two teams were distributed about 30m apart, one downstream from the other, pumping anywhere from 1-3m apart across the entire streambed (all depths). Landmarks were set where the downstream team began allowing the upstream team to 'leapfrog' beyond the other team as the landmark was reached. In areas where there was a high density of alevins, the digs would be closer to 1m apart, whereas in low density areas, digs were 3m or greater apart. A variety of 'dry pumps' were also attempted above the waterline of the stream yielding a variety of positive samples, usually within 3m from the stream's edge.

Each dig site was pumped for an average of 60 seconds. Digs were terminated early if a large number of alevins were seen in the net in order to avoid unneeded destruction of the redd. Two redds were pumped until alevins stopped emerging from the gravel to get an idea of how many alevin could potentially be captured at one pump site (the highest density produced was 444 alevin emerging in one 154 sec pump).

RESULTS

RESULTS – FISH CREEK (DOUGLAS ISLAND)

We conducted 774 sample attempts throughout the anadromous reach in Fish Creek from March 25 - 31. In total, we collected 69 positive samples (Table 11). The total number of Chum Salmon alevins captured ranged between 1 and 69 for all positive samples. Pink Salmon alevin were frequently caught as well and were present in 136 sample attempts. The total number of Chum Salmon alevin caught in all positive samples was 757 and the total number of Pink Salmon caught was 569. In general, positive samples were obtained in small clusters spread out across the stream in areas of finer substrate. On many occasions we would have relatively high sampling success in very small areas followed by no success over long stream reaches. We had the highest sampling success in areas of finer substrate midway along the reach where spawning was seen the previous summer (Table 12). Many dead alevin and decomposing eggs were flushed out of the gravel throughout the stream.

Table 11. Sampling success of alevins on Fish Creek in March 2014. Sample attempts represent one sampling event in a specific location and positive samples represents the occasions when we captured live Chum Salmon alevin. Percentages of successful sampling attempts are noted as well as total Chum Salmon and Pink Salmon alevins for all positive samples within that section. Average pump time (duration of sampling event) is noted in seconds.

Section #	# of sample attempts	positive samples	% positive samples	Average pump time (sec)	Total Chum Salmon caught	Total Pink Salmon caught
1	42	1	2.4%	56.6	1	4
2	30	0	0.0%	78.5	0	0
3	110	6	5.5%	106.5	61	1
4	65	9	13.9%	77.8	85	39
5	144	9	6.3%	83.9	92	2
6	103	3	2.9%	81.7	33	15
7	77	16	20.8%	77.4	215	141
8	59	12	20.3%	91	101	8
9	121	12	9.9%	84.9	162	53
10	32	1	3.1%	86.5	7	1

Table 12. Total Chum Salmon and Pink Salmon alevins captured by section over the 6 days of sampling Fish Creek in 2014. Pumping time for each positive sample is recorded in seconds. This table shows the 69 positive samples obtained out of 774 sampling attempts. Sculpin presence and intertidal influence was also noted as was the coordinates for each positive sample collected.

Section #	Date	# Chum Salmon caught	# Pink Salmon caught	Pump time (sec)	Intertidal	Lat	Long
1	26-Mar	1	4	55	yes	58.33067	-134.59495
3	25-Mar	20		118	no	58.33070	-134.59495
3	25-Mar	19		108	no	58.33054	-134.59542
3	25-Mar	4		150	no	58.33050	-134.59550
3	25-Mar	2		113	no	58.33047	-134.59544
3	25-Mar	15		126	no	58.33051	-134.59555
3	26-Mar	1	1	220	no	58.33073	-134.59464
4	25-Mar	10	8	40	no	58.33074	-134.59459
4	25-Mar	1		99	no	58.33070	-134.59451
4	25-Mar	1	7	138	no	58.33074	-134.59448
4	25-Mar	9	13	120	no	58.33056	-134.59440
4	25-Mar	2	3	82	no	58.33024	-134.59716
4	25-Mar	1	3	110	no	58.33150	-134.60043
4	31-Mar	9	1	59	no	58.32914	-134.58458
4	31-Mar	51	4	59	no	58.32918	-134.58492
4	31-Mar	1		70	no	58.32908	-134.58479
5	29-Mar	6	1	75	no	58.32901	-134.58498
5	29-Mar	46		158	no	58.32909	-134.58443
5	29-Mar	1		65	no	58.32909	-134.58443
5	29-Mar	3		90	no	58.32913	-134.58401
5	29-Mar	18		85	no	58.32913	-134.58401

5	30-Mar	2		100	no	58.32913	-134.58401
5	31-Mar	2		110	no	58.32913	-134.58401
5	30-Mar	6		95	no	58.32918	-134.58392
5	31-Mar	8	1	74	no	58.32940	-134.58287
6	29-Mar	26		80	no	58.32921	-134.58189
6	29-Mar	3	15	91	no	58.32889	-134.58541
6	29-Mar	4		81	no	58.32896	-134.58557
7	28-Mar	23		60	no	58.32896	-134.58557
7	28-Mar	11		30	no	58.32896	-134.58557
7	28-Mar	7		40	no	58.32896	-134.58557
7	28-Mar	23		45	no	58.32896	-134.58557
7	28-Mar	4		45	no	58.32896	-134.58557
7	28-Mar	3	25	47	no	58.32896	-134.58557
7	28-Mar	1		80	no	58.32895	-134.58574
7	28-Mar	23	9	82	no	58.32895	-134.58574
7	28-Mar	32	67	95	no	58.32895	-134.58574
7	28-Mar	1	2	49	no	58.32895	-134.58574
7	28-Mar	1		83	no	58.32844	-134.58805
7	28-Mar	12	33	83	no	58.32844	-134.58805
7	28-Mar	65	5	61	no	58.32844	-134.58805
7	28-Mar	5		82	no	58.32844	-134.58805
7	28-Mar	3		40	no	58.32844	-134.58805
7	28-Mar	1		74	no	58.32844	-134.58805
8	28-Mar	1		87	no	58.32844	-134.58805
8	28-Mar	1		70	no	58.32854	-134.58744
8	28-Mar	3		100	no	58.32854	-134.58744
8	28-Mar	21		54	no	58.32861	-134.58821
8	28-Mar	2		98	no	58.32878	-134.58839
8	28-Mar	1		90	no	58.32854	-134.58744
8	28-Mar	5		62	no	58.32854	-134.58744
8	28-Mar	1		287	no	58.32878	-134.58839
8	28-Mar	58	7	73	no	58.32878	-134.58839
8	28-Mar	2		127	no	58.32949	-134.58878
8	28-Mar	5		120	no	58.32878	-134.58839
8	28-Mar	1	1	57	no	58.32949	-134.58878
9	27-Mar	7		81	no	58.32949	-134.58878
9	27-Mar	14	30	120	no	58.33000	-134.59072
9	27-Mar	1		138	no	58.33311	-134.57350
9	27-Mar	18		73	no	58.33311	-134.57350
9	27-Mar	69		74	no	58.33311	-134.57350
9	27-Mar	27		76	no	58.33311	-134.57350
9	27-Mar	13	5	92	no	58.33026	-134.59175
9	27-Mar	1	4	62	no	58.33055	-134.59339
9	27-Mar	4	10	75	no	58.33050	-134.59321
9	27-Mar	1	2	90	no	58.33060	-134.59346
9	27-Mar	1	2	104	no	58.33059	-134.59375
9	27-Mar	5		60	no	58.33059	-134.59375
10	27-Mar	6	1	95	no	58.33059	-134.59375

RESULTS – STOCKDALE CREEK

Sampling for Pink Salmon alevins at Stockdale Creek during April 3-6 was successful, yielding the goal of 250 positive samples out of 520 sample attempts (Tables 13, 14). The total number of Pink Salmon alevin captured for positive samples during normal pump times ranged between 1 and 132 alevin. The highest density produced was 444 alevin emerging in one 154 sec pump when a redd was pumped until no more fry were seen emerging. Samples were spread throughout the spawning area with distinct regions of low and high alevin densities. Very few positive samples were collected in the lower intertidal flat (Section 1) where substrate was very fine grained and muddy. The majority of successful positive digs fell within the gravel bar region

(Section 2) of the stream that is centered around the highest tide line with a mix of gravel and cobble. A large portion of positive samples also came from natural and man-made holes in the ice within the ~215m reach of stream covered in thick snow and ice (Section 3). A small number of positive samples were found in the upper uncovered reach where substrate was a mix of cobble, small gravel and some larger rocks (Section 4). Overall, the success rate of positive digs was 48% throughout the 700 m study area. Stream flow was low in comparison to summer sampling.

Table 13. Sampling success of alevins at Stockdale Creek in April 2014.

Section #	# of sample attempts	positive samples	% positive samples	Average pump time (sec)	Total Chum Salmon caught	Total Pink Salmon caught
1	98	11	11.2%	66.1	0	67
2	200	141	70.5%	55.5	0	3,216
3	142	67	47.2%	71.0	0	801
4	80	31	38.8%	101.8	0	145

Table 14. Total Pink Salmon alevins caught over four days of sampling at Stockdale Creek in April 2014. Table represents the 250 positive Pink Salmon alevin samples by stream section and location.

Section #	Date	# Chum Salmon caught	# Pink Salmon caught	Pump time (sec)	Intertidal?	Latitude	Longitude
1	4/4/2014	0	53	58	Yes	60.30490	-147.18373
1	4/4/2014	0	3	30	Yes	60.30490	-147.18373
1	4/4/2014	0	1	65	Yes	60.30490	-147.18373
1	4/4/2014	0	1	63	Yes	60.30490	-147.18373
1	4/4/2014	0	1	88	Yes	60.30458	-147.18339
1	4/4/2014	0	2	75	Yes	60.30458	-147.18339
1	4/4/2014	0	1	80	Yes	60.30458	-147.18339
1	4/4/2014	0	1	55	Yes	60.30446	-147.18311
1	4/4/2014	0	1	88	Yes	60.30446	-147.18311
1	4/4/2014	0	2	82	Yes	60.30446	-147.18311
1	4/4/2014	0	1	82	Yes	60.30446	-147.18311
2	4/4/2014	0	5	32	Yes	60.30418	-147.18304
2	4/4/2014	0	2	40	Yes	60.30418	-147.18304
2	4/4/2014	0	5	36	Yes	60.30418	-147.18304
2	4/4/2014	0	3	70	Yes	60.30418	-147.18304
2	4/4/2014	0	4	63	Yes	60.30418	-147.18304
2	4/4/2014	0	1	83	Yes	60.30418	-147.18304
2	4/4/2014	0	3	90		60.30410	-147.18350
2	4/4/2014	0	13	65	Yes	60.30418	-147.18304
2	4/4/2014	0	3	83		60.30410	-147.18350
2	4/4/2014	0	3	65	Yes	60.30418	-147.18304

2	4/4/2014	0	1	61		60.30410	-147.18350
2	4/4/2014	0	3	56		60.30410	-147.18350
2	4/4/2014	0	4	78	Yes	60.30418	-147.18304
2	4/4/2014	0	2	72	Yes	60.30418	-147.18304
2	4/4/2014	0	112	30	Yes	60.30418	-147.18304
2	4/4/2014	0	23	54		60.30410	-147.18350
2	4/5/2014	0	1	30		60.30404	-147.18342
2	4/5/2014	0	8	33		60.30390	-147.18343
2	4/5/2014	0	4	45		60.30390	-147.18343
2	4/5/2014	0	1	56		60.30404	-147.18342
2	4/5/2014	0	2	37		60.30390	-147.18343
2	4/5/2014	0	2	47		60.30404	-147.18342
2	4/5/2014	0	4	48		60.30390	-147.18343
2	4/5/2014	0	3	30		60.30404	-147.18342
2	4/5/2014	0	122	48		60.30390	-147.18343
2	4/5/2014	0	3	52		60.30404	-147.18342
2	4/5/2014	0	1	55		60.30404	-147.18342
2	4/5/2014	0	2	44		60.30384	-147.18345
2	4/5/2014	0	1	54		60.30404	-147.18342
2	4/5/2014	0	15	44		60.30384	-147.18345
2	4/5/2014	0	20	50		60.30398	-147.18345
2	4/5/2014	0	1	50		60.30384	-147.18345
2	4/5/2014	0	41	180		60.30406	-147.18357
2	4/5/2014	0	1	66		60.30384	-147.18359
2	4/5/2014	0	2	120		60.30406	-147.18357
2	4/5/2014	0	2	44		60.30384	-147.18341
2	4/5/2014	0	40	60		60.30384	-147.18341
2	4/5/2014	0	5	42		60.30397	-147.18347
2	4/5/2014	0	47	21		60.30384	-147.18341
2	4/5/2014	0	127	87		60.30397	-147.18347
2	4/5/2014	0	15	46		60.30384	-147.18341
2	4/5/2014	0	20	15		60.30397	-147.18347
2	4/5/2014	0	132	43		60.30384	-147.18341
2	4/5/2014	0	7	45		60.30397	-147.18347
2	4/5/2014	0	3	48		60.30376	-147.18337
2	4/5/2014	0	2	90		60.30401	-147.18337
2	4/5/2014	0	6	34		60.30376	-147.18337
2	4/5/2014	0	15	59		60.30395	-147.18347
2	4/5/2014	0	7	68		60.30395	-147.18347
2	4/5/2014	0	2	32		60.30376	-147.18337
2	4/5/2014	0	49	9		60.30395	-147.18347
2	4/5/2014	0	5	6		60.30376	-147.18337
2	4/5/2014	0	1	12		60.30376	-147.18337
2	4/5/2014	0	5	58		60.30395	-147.18347
2	4/5/2014	0	4	50		60.30376	-147.18337

2	4/5/2014	0	62	12	60.30376	-147.18337
2	4/5/2014	0	1	32	60.30384	-147.18352
2	4/5/2014	0	25	29	60.30395	-147.18347
2	4/5/2014	0	2	74	60.30389	-147.18346
2	4/5/2014	0	16	16	60.30389	-147.18346
2	4/5/2014	0	25	7	60.30389	-147.18346
2	4/5/2014	0	56	32	60.30370	-147.18338
2	4/5/2014	0	64	12	60.30370	-147.18338
2	4/5/2014	0	23	60	60.30370	-147.18338
2	4/5/2014	0	2	42	60.30368	-147.18335
2	4/5/2014	0	52	6	60.30368	-147.18335
2	4/5/2014	0	3	60	60.30370	-147.18338
2	4/5/2014	0	62	6	60.30368	-147.18335
2	4/5/2014	0	10	8	60.30370	-147.18338
2	4/5/2014	0	82	10	60.30368	-147.18335
2	4/5/2014	0	8	50	60.30370	-147.18338
2	4/5/2014	0	26	22	60.30370	-147.18338
2	4/5/2014	0	9	20	60.30368	-147.18335
2	4/5/2014	0	21	38	60.30368	-147.18335
2	4/5/2014	0	2	48	60.30368	-147.18335
2	4/5/2014	0	46	12	60.30368	-147.18335
2	4/5/2014	0	16	24	60.30368	-147.18335
2	4/5/2014	0	10	47	60.30368	-147.18335
2	4/5/2014	0	37	4	60.30368	-147.18335
2	4/5/2014	0	20	17	60.30368	-147.18332
2	4/5/2014	0	4	55	60.30366	-147.18342
2	4/5/2014	0	33	33	60.30368	-147.18332
2	4/5/2014	0	3	63	60.30368	-147.18332
2	4/5/2014	0	4	43	60.30368	-147.18332
2	4/5/2014	0	88	40	60.30366	-147.18342
2	4/5/2014	0	13	12	60.30366	-147.18342
2	4/5/2014	0	6	38	60.30366	-147.18342
2	4/5/2014	0	7	24	60.30368	-147.18332
2	4/5/2014	0	1	39	60.30351	-147.18317
2	4/5/2014	0	1	80	60.30354	-147.18313
2	4/5/2014	0	2	N/A	60.30354	-147.18313
2	4/5/2014	0	3	55	60.30351	-147.18317
2	4/5/2014	0	1	20	60.30354	-147.18313
2	4/5/2014	0	1	43	60.30354	-147.18313
2	4/5/2014	0	3	65	60.30351	-147.18311
2	4/5/2014	0	24	67	60.30354	-147.18313
2	4/5/2014	0	1	66	60.30351	-147.18311
2	4/5/2014	0	5	52	60.30354	-147.18313
2	4/5/2014	0	3	83	60.30351	-147.18311
2	4/5/2014	0	8	50	60.30354	-147.18313

2	4/5/2014	0	40	35	60.30342	-147.18307
2	4/5/2014	0	1	65	60.30342	-147.18307
2	4/5/2014	0	1	62	60.30354	-147.18313
2	4/5/2014	0	1	78	60.30342	-147.18307
2	4/5/2014	0	2	52	60.30351	-147.18317
2	4/5/2014	0	6	65	60.30329	-147.18315
2	4/5/2014	0	3	35	60.30319	-147.18317
2	4/5/2014	0	58	54	60.30348	-147.18341
2	4/5/2014	0	39	40	60.30319	-147.18317
2	4/5/2014	0	55	15	60.30325	-147.18323
2	4/5/2014	0	38	17	60.30325	-147.18323
2	4/5/2014	0	22	40	60.30319	-147.18317
2	4/5/2014	0	35	59	60.30325	-147.18323
2	4/5/2014	0	106	43	60.30319	-147.18317
2	4/5/2014	0	8	36	60.30313	-147.18314
2	4/5/2014	0	26	10	60.30325	-147.18323
2	4/5/2014	0	1	10	60.30325	-147.18323
2	4/5/2014	0	22	27	60.30313	-147.18314
2	4/5/2014	0	2	30	60.30314	-147.18306
2	4/5/2014	0	4	38	60.30314	-147.18306
2	4/5/2014	0	65	31	60.30314	-147.18306
2	4/5/2014	0	1	60	60.30303	-147.18303
2	4/5/2014	0	4	42	60.30303	-147.18303
2	4/5/2014	0	4	35	60.30314	-147.18306
2	4/5/2014	0	28	50	60.30303	-147.18303
2	4/6/2014	0	444	154	60.30379	-147.18349
2	4/6/2014	0	293	316	60.30393	-147.18350
2	4/6/2014	0	1	167	60.30393	-147.18350
2	4/6/2014	0	1	93	60.30369	-147.18330
2	4/6/2014	0	4	120	60.30410	-147.18309
2	4/6/2014	0	4	103	60.30369	-147.18330
2	4/6/2014	0	5	86	60.30407	-147.18315
2	4/6/2014	0	28	43	60.30388	-147.18338
2	4/6/2014	0	12	3	60.30388	-147.18338
2	4/6/2014	0	2	103	60.30410	-147.18309
2	4/6/2014	0	1	157	60.30410	-147.18309
2	4/6/2014	0	6	36	60.30388	-147.18338
2	4/6/2014	0	1	47	60.30388	-147.18338
2	4/6/2014	0	16	40	60.30390	-147.18338
2	4/6/2014	0	10	15	60.30399	-147.18339
2	4/6/2014	0	9	60	60.30399	-147.18339
3	4/3/2014	0	2	90	60.30168	-147.18150
3	4/3/2014	0	1	N/A	60.30168	-147.18150
3	4/3/2014	0	24	100	60.30213	-147.18203
3	4/3/2014	0	3	120	60.30213	-147.18203

3	4/3/2014	0	22	66	60.30175	-147.18158
3	4/3/2014	0	118	53	60.30213	-147.18203
3	4/3/2014	0	2	113	60.30175	-147.18158
3	4/3/2014	0	17	56	60.30175	-147.18158
3	4/3/2014	0	1	120	60.30213	-147.18203
3	4/3/2014	0	1	80	60.30213	-147.18203
3	4/3/2014	0	4	75	60.30213	-147.18203
3	4/3/2014	0	1	120	60.30204	-147.18174
3	4/3/2014	0	1	100	60.30213	-147.18203
3	4/3/2014	0	1	75	60.30204	-147.18174
3	4/3/2014	0	10	135	60.30204	-147.18174
3	4/3/2014	0	16	81	60.30204	-147.18174
3	4/3/2014	0	1	93	60.30204	-147.18174
3	4/3/2014	0	1	74	60.30204	-147.18174
3	4/3/2014	0	15	71	60.30204	-147.18174
3	4/3/2014	0	1	130	60.30213	-147.18203
3	4/6/2014	0	2	55	60.30236	-147.18217
3	4/6/2014	0	1	38	60.30236	-147.18217
3	4/6/2014	0	1	60	60.30236	-147.18217
3	4/6/2014	0	45	35	60.30226	-147.18201
3	4/6/2014	0	72	15	60.30226	-147.18201
3	4/6/2014	0	8	40	60.30226	-147.18201
3	4/6/2014	0	2	45	60.30226	-147.18201
3	4/6/2014	0	29	38	60.30236	-147.18217
3	4/6/2014	0	2	76	60.30236	-147.18217
3	4/6/2014	0	2	50	60.30236	-147.18217
3	4/6/2014	0	4	40	60.30226	-147.18201
3	4/6/2014	0	2	63	60.30236	-147.18217
3	4/6/2014	0	6	42	60.30222	-147.18213
3	4/6/2014	0	45	42	60.30228	-147.18208
3	4/6/2014	0	57	51	60.30228	-147.18208
3	4/6/2014	0	5	74	60.30222	-147.18213
3	4/6/2014	0	1	40	60.30228	-147.18208
3	4/6/2014	0	2	79	60.30226	-147.18201
3	4/6/2014	0	1	67	60.30226	-147.18201
3	4/6/2014	0	7	62	60.30226	-147.18201
3	4/6/2014	0	3	54	60.30217	-147.18200
3	4/6/2014	0	1	65	60.30226	-147.18201
3	4/6/2014	0	3	55	60.30217	-147.18200
3	4/6/2014	0	1	58	60.30217	-147.18200
3	4/6/2014	0	10	63	60.30226	-147.18201
3	4/6/2014	0	3	69	60.30226	-147.18201
3	4/6/2014	0	25	29	60.30217	-147.18200
3	4/6/2014	0	2	65	60.30226	-147.18201
3	4/6/2014	0	1	79	60.30226	-147.18201

3	4/6/2014	0	1	42	60.30232	-147.18214
3	4/6/2014	0	1	70	60.30232	-147.18214
3	4/6/2014	0	1	48	60.30217	-147.18200
3	4/6/2014	0	1	42	60.30217	-147.18200
3	4/6/2014	0	1	40	60.30217	-147.18200
3	4/6/2014	0	1	52	60.30250	-147.18246
3	4/6/2014	0	1	54	60.30217	-147.18200
3	4/6/2014	0	3	66	60.30217	-147.18200
3	4/6/2014	0	2	76	60.30250	-147.18246
3	4/6/2014	0	1	67	60.30217	-147.18200
3	4/6/2014	0	4	63	60.30217	-147.18200
3	4/6/2014	0	84	105	60.30275	-147.18266
3	4/6/2014	0	80	31	60.30257	-147.18242
3	4/6/2014	0	1	10	60.30257	-147.18242
3	4/6/2014	0	1	75	60.30257	-147.18242
3	4/6/2014	0	26	75	60.30275	-147.18266
3	4/6/2014	0	2	55	60.30257	-147.18242
3	4/6/2014	0	2	63	60.30275	-147.18309
4	4/3/2014	0	20	90	60.30036	-147.18121
4	4/3/2014	0	4	120	60.30036	-147.18121
4	4/3/2014	0	1	90	60.30036	-147.18121
4	4/3/2014	0	1	120	60.30036	-147.18121
4	4/3/2014	0	45	110	60.30036	-147.18121
4	4/3/2014	0	1	85	60.30036	-147.18121
4	4/3/2014	0	2	120	60.30062	-147.18119
4	4/3/2014	0	2	90	60.30062	-147.18119
4	4/3/2014	0	1	94	60.30098	-147.18115
4	4/3/2014	0	1	90	60.30098	-147.18115
4	4/3/2014	0	1	135	60.30124	-147.18108
4	4/3/2014	0	3	153	60.30098	-147.18115
4	4/3/2014	0	26	130	60.30098	-147.18115
4	4/3/2014	0	2	160	60.30124	-147.18108
4	4/3/2014	0	1	124	60.30124	-147.18108
4	4/3/2014	0	2	90	60.30098	-147.18115
4	4/3/2014	0	14	114	60.30098	-147.18115
4	4/3/2014	0	1	77	60.30124	-147.18108
4	4/3/2014	0	2	90	60.30098	-147.18115
4	4/3/2014	0	1	120	60.30136	-147.18104
4	4/3/2014	0	2	132	60.30098	-147.18115
4	4/3/2014	0	1	62	60.30136	-147.18104
4	4/3/2014	0	1	40	60.30136	-147.18104
4	4/3/2014	0	1	74	60.30136	-147.18104
4	4/3/2014	0	1	90	60.30136	-147.18104
4	4/3/2014	0	1	93	60.30136	-147.18104
4	4/3/2014	0	2	104	60.30152	-147.18124

4	4/3/2014	0	1	91		60.30136	-147.18104
4	4/3/2014	0	1	103		60.30152	-147.18124
4	4/3/2014	0	1	124		60.30152	-147.18124
4	4/3/2014	0	2	76		60.30152	-147.18124