INTERACTIONS OF WILD AND HATCHERY PINK SALMON AND CHUM SALMON IN PRINCE WILLIAM SOUND AND SOUTHEAST ALASKA

Final Progress Report for 2013

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

Authors:
Eric Knudsen, Michele Buckhorn, Kristen Gorman, Dan Crowther, Katie Froning, and Megan Roberts
Prince William Sound Science Center
P.O. Box 705
Cordova, AK 99574

Laurinda Marcello, Ben Adams, and Victoria O'Connell
Sitka Sound Science Center
834 Lincoln St., Suite 200
Sitka, AK 99835

David R. Bernard
D.R. Bernard Consulting, LLC
2481 NW 87th Avenue
Ankeny, IA 50023-8829

December 9, 2015

TABLE OF CONTENTS

ABSTRACT

This is the second 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 fish have thermal-marked otoliths which were used to determine hatchery or wild origin through samples collected at sea and in streams. Ocean sampling was conducted in 2013 at nine stations near the entrances to PWS. Otoliths from 1,515 Pink Salmon and 947 Chum Salmon were analyzed for thermal marks indicating hatchery or wild origin. The overall proportion of hatchery fish across all ocean stations was 67.9% for Pink Salmon and 72.8% for Chum Salmon. Stream studies were conducted in 2013 for two major purposes: an analysis of the proportion of hatchery-origin spawners in natural populations in all study streams; and an investigation of the relative survival of hatchery-origin and wild-origin offspring following natural spawning. During 2013 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 4.3% for PWS Pink Salmon, 5.4% for PWS Chum Salmon, and 7.2% for SEAK Chum Salmon. Most PWS Pink Salmon stream hatchery proportions were relatively low (0.0 to 0.18) but were higher in localized areas, such as the Eshamy District (0.87) and the Southwestern District (0.27). The same pattern was observed for PWS Chum Salmon where the majority of the 17 study streams exhibited hatchery fractions ranging from 0.0 to 0.18, except in the Montague District where the average hatchery fraction was 0.82. Hatchery fractions in 32 SEAK Chum Salmon streams were similarly mostly low (0.0 to 0.16), except in Sawmill Creek (0.50) and Fish Creek (0.66). Using information from both ocean sampling and field sampling programs, an estimated 103.0 million Pink Salmon entered PWS in 2013 of which approximately 33.1 million were wild fish and 69.9 million were hatchery fish. An estimated 4.1 million Chum Salmon entered PWS in 2013 of which about 1.1 million were wild fish and 3.0 million were hatchery fish.

INTRODUCTION

Prince William Sound Science Center (PWSSC) and its sub-contracting partner Sitka Sound Science Center (SSSC) are engaged in the 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".

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 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 2013 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
- Testing of juvenile sampling methods.

Adult sampling was further subdivided into PWS and SEAK activities. Because the first spring sampling of alevins in streams for the survival studies must follow the first summer sampling of their parents, the first full spring sampling occurred in March 2014 and will be reported in next year's annual report. However, this report includes a summary of some initial testing of spring sampling techniques conducted in March of 2013. The methods in this report reflect both the RFP and some refinements made following the 2012 preliminary field season, as well as consultation with the Science Panel in November 2012.

This report includes summaries of sample collection during 2013 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, a summary of initial testing of methods for sampling alevins from the gravel for part of the fitness study is reported here.

PWS OCEAN SAMPLING

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 proportions of hatchery and wild Pink and Chum Salmon in annual runs to the Sound. Commercial fisheries target hatchery fish and therefore their catches do not represent the true ratio of wild to hatchery fish in Prince William Sound. Sampling over the next several years 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, results of which are described in a subsequent chapter:

- 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

The ocean sampling fishing portion of the work during the 2013 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 25 to August 29, 2013. 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 using a 200-fathom drift gillnet consisting of four panels with different (4 ¾ , 5, $5^{1/8}$, and 5 $^{3/8}$ -inch) stretch mesh. All nine stations were fished over a 2-day period (a trip) and then the catch was delivered to personnel at PWSSC. There were normally two sampling trips per week. This was repeated for the entire season with the exception of days the vessel was experiencing mechanical difficulties or weather delays. 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

---

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

longitude were recorded in the database at: 1) the start and end of any periods of net setting, 2) the beginning and end of any drift, 3) the start and end of any net retrieval. Other data recorded included weather and tide state.

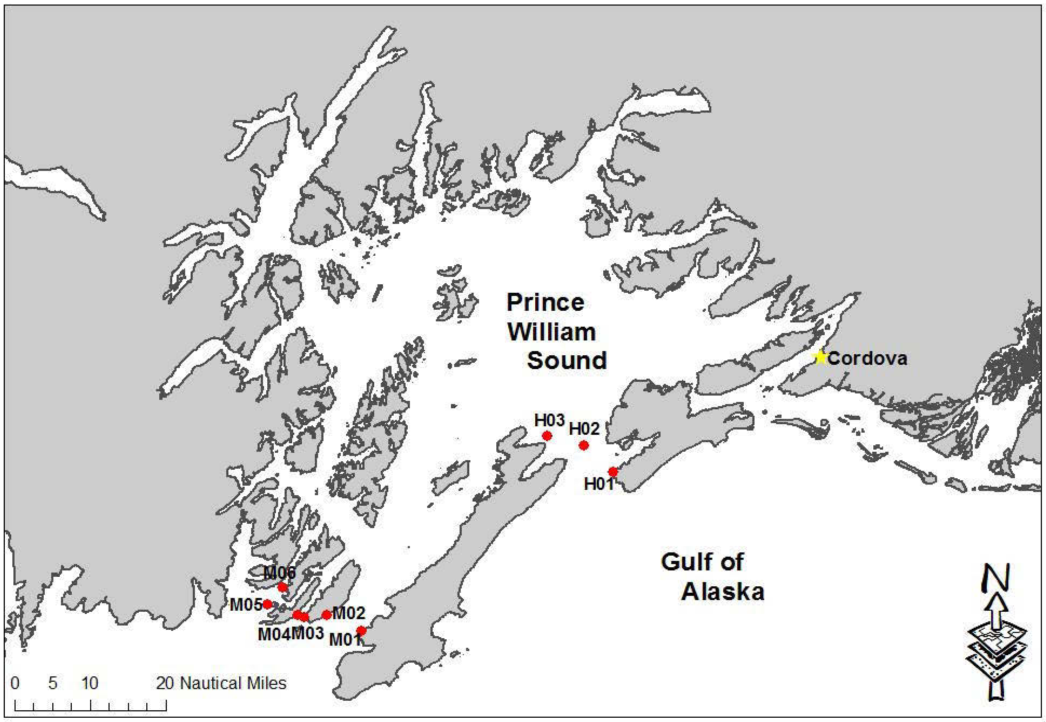

Figure 1. Ocean sampling stations in Montague Strait and Hinchinbrook Entrance.

Once the net was retrieved, fish were removed from the net and total catch recorded. The catch retained from each station (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 number. 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

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), 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 and they were incorporated into the project database.

DATA ANALYSIS

The objectives of the ocean sampling in 2013 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 samples used to estimate a hatchery fraction for a trip were not selected randomly from the passing population, average fractions for a trip were weighted averages with weights calculated from the standardized catch per unit of effort at each station on each trip.

Catch per Unit of Effort

All catches were adjusted for comparability based on a standard unit of fishing effort: net fathoms multiplied by 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 $\boldsymbol{d}$ = drift number. The first term in the equation is the catch by species. The second term represents the effort for the first deployment interval only (net length*time/2). The first summation represents effort for one or more drifts in a given haul (i.e., station and date). The second summation represents 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 represents effort during the final retrieval.

Estimates of Hatchery Fraction

There were 27 two-day fishing trips in 2013. There were four types of outcomes for the 27 scheduled trips for 9 stations (243 possible combinations) in 2013. Not all scheduled trips resulted in samples. There were four types of outcomes for the 27 scheduled trips for 9 stations (243 possible combinations) in 2013:

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	158 for Chum Salmon 170 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	74 for Chum Salmon 62 for Pink Salmon	Exclude Trip – Most Calculations
4. No fishing	Weather	11	Exclude Trip – All Calculations

Because outcomes 2 and 3 were prevalent whenever passage of the target species was nil (late in the study for Chum Salmon and early for Pink Salmon), the data set was truncated after trip 15 (=T_s) for Chum Salmon and before trip 13 (T_s=27-12) for Pink Salmon. Dummy variables representing the four outcomes were included in equations described in the following sections as adjustments to sample sizes for missing data.

Trip Within Station

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

$$\hat{p}_{st} = \frac{z_{st}}{m_{st}} \tag{1}$$

where ***s*** is a specific station, t is a specific trip (date), 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 z_{st} is the number within 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:

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

where ***t′*** represents trips to station ***s*** during the season including trip ***t***, and λ_{st} = 1 if the trip ***t*** to station ***s*** resulted in outcome 1 or λ_{st} = 0 otherwise. Remember that T_s = 15 for Chum Salmon and 15 for Pink Salmon. 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:

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

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 2013 was calculated as the weighted average of the estimated fractions for stations:

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

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 ω_{st} = 1 if results during trip ***t*** to station ***s*** had outcomes 1, 2, or 3, and ω_{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).

---

[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.

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:

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

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:

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

(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 derivations 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

[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´* ≠ *t* indicates a sum over all trips excluding trip *t*.

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,

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

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 is described in Appendix B. The derivation 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

A total of 5,691 salmon were caught in the ocean fishery during 2013. Pink Salmon were the most numerous salmon caught (3,458), followed by Chum Salmon (1,305), Sockeye salmon (655), and then Coho salmon (272). Seven Chinook Salmon were caught and released. Further results are focused only on Chum Salmon and Pink Salmon. Chum Salmon were the first species caught at the beginning of the season and were caught fairly consistently until declining in early to mid-July (Trip 12, Figure 2). Although they decreased dramatically after Trip 16, they were still caught every trip the entire season. Pink Salmon started showing up in the catch on June 1st

(Trip 3) with catches trending upward until the first peak on July 18th (Trip 16). Another peak occurred on July 30th (Trip 19) and then catches trended downward until fishing ceased on August 29th.

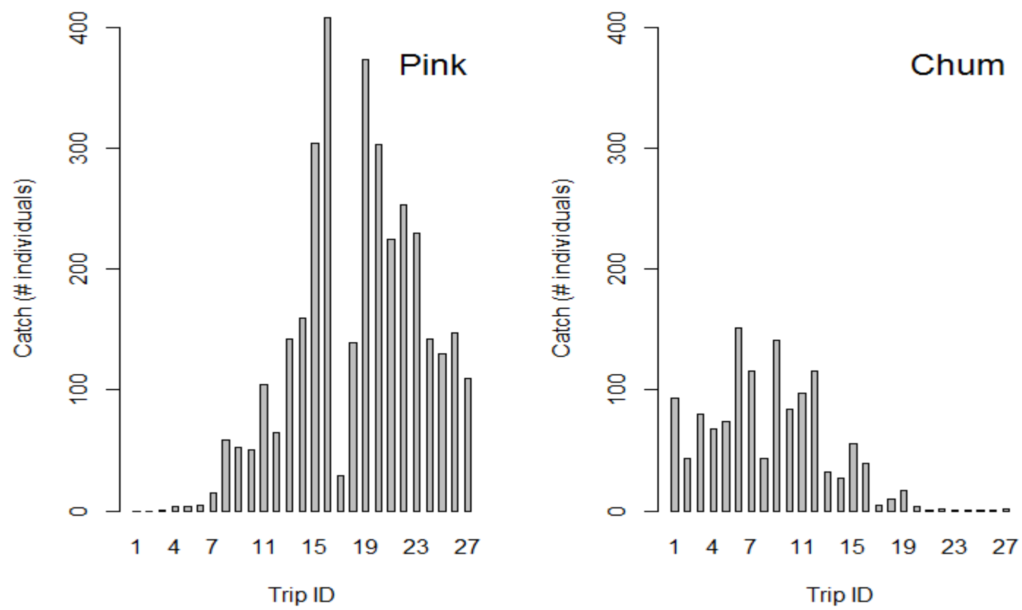

Figure 2. Total catch (in number of individuals) for each species by trip. Trips were evenly spaced with Trip 1 on May 25 and Trip 27 on August 29, 2013.

Mean CPUE of Pink Salmon ranged from 0.01 at the beginning of the season (June 1st, Trip 3) and peaked at 0.97 (August 17th, Trip 24) (Figure 3). Mean CPUE of Chum Salmon was much lower than Pink Salmon for the entire season ranging from 0.01 (towards the end of the season) and peaking at 0.27 (June 13th, Trip 6; Figure 3). Both species had the lowest CPUE at station H02 (Pink: 0.01; Chum: 0.02) and the highest at station M05 (Pink: 0.61; Chum: 0.17; Figure 4).

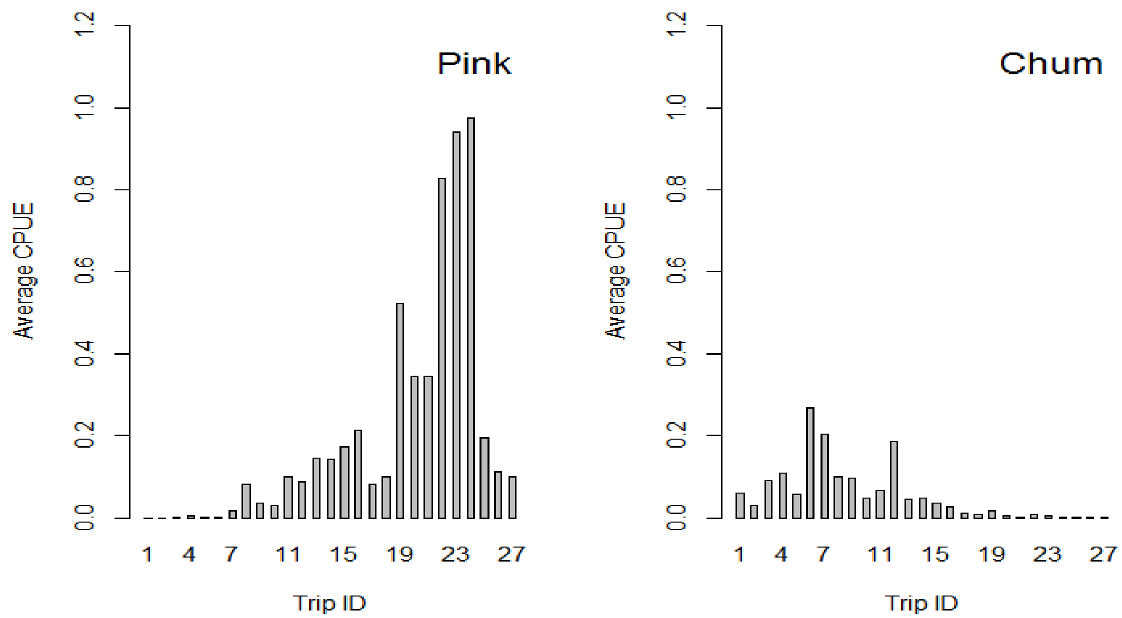

Figure 3. Mean CPUE of Pink and Chum Salmon by Trip ID. Trips were evenly spaced with Trip 1 on May 25 and Trip 27 on August 29, 2013.

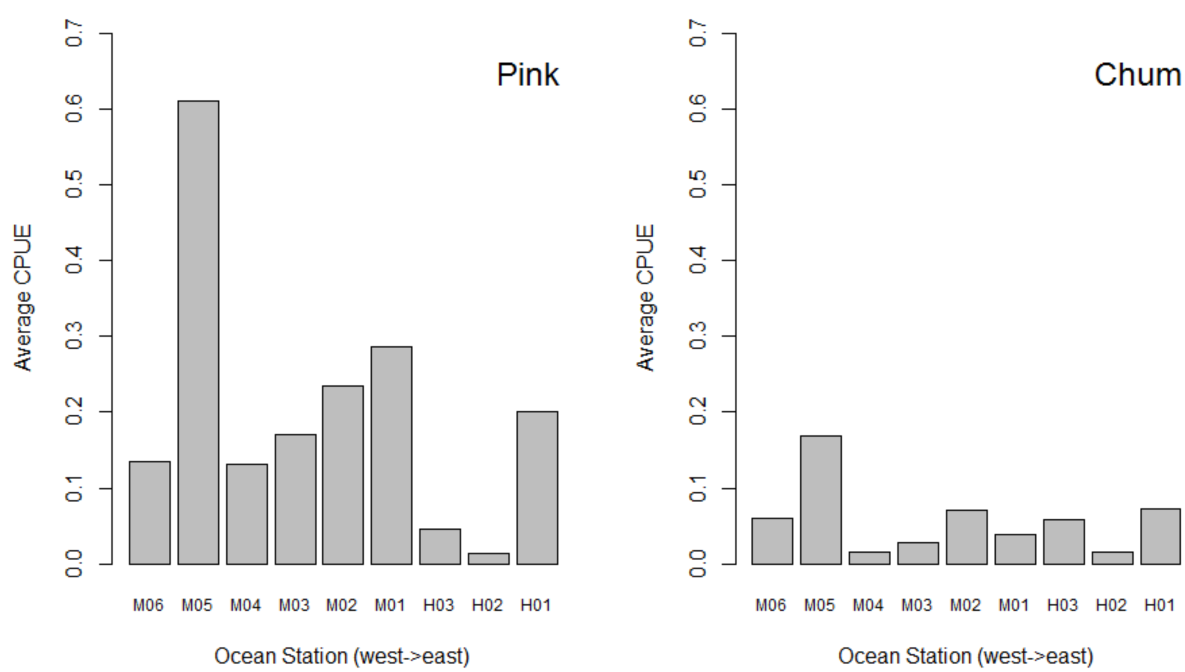

Figure 4. Mean CPUE of Pink and Chum Salmon by Station ID.

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 (Table 1). These factors either completely prevented a set or limited the time and fathoms set. The vessel captain would actively watch for and avoid all such factors, with the exception of a few encounters with sport fishing vessels. They either were not accustomed to seeing a gillnetter in those locations or just not paying attention to the buoys, resulting in some close encounters with the net.

OCEAN SALMON PROCESSING RESULTS

A total of 1,515 Pink Salmon and 947 Chum Salmon were processed for weight-length measurements and otoliths were extracted. Mean standard lengths for Pink Salmon and Chum Salmon were 461 mm ± 27 SD and 582 mm ± 36 SD, respectively.

The Pink Salmon processed from the ocean stations were highly skewed toward males, while the run of Chum Salmon was closer to a 50:50 sex ratio (Table 2, Figure 5).

Table 1. Frequency of factors that prevented complete sets at each station from May 25-August 29, 2013. Each cell number is representative of occurrences, not number of individual factors at a time (e.g. under seiners there could be 9-20+ seiners per occurrence). Encounters with flotsam often occurred in conjunction with a rip tide.

Station	Fog	Whales	Orcas	Dolphins	Sea Lions or Seals	Otters	Tanker and/ or Tug	Sport fishers	Seiners and/or Tenders	Wind	Flotsam
H01	4	8	1		1		2	3	1	1	
H02	2	1	3		1		3	1			1
H03	2	11	1					2		1	
M01	5	9	1	2				2		2	
M02	3	4		1				2	1	1	
M03	1					2		1		5	
M04	1	1								1	2
M05	5	4	1		4			2	8		3
M06	3	1						3	6		6
Total	**26**	**39**	**7**	**3**	**6**	**2**	**5**	**16**	**16**	**11**	**12**

Table 2. Sex ratios by total number and percentage of salmon processed from the ocean sampling.

Common Name	Count/Percent	Female	Male	Unknown
Chum Salmon	Count	509	430	8
	Percent	53.75	45.41	0.84
Pink Salmon	Count	420	1086	11
	Percent	27.69	71.59	0.73

Hatchery fish of both species generally exhibited greater proportions of females than did wild fish at most stations (Figure 5). Exceptions to this trend were at Station H03 for Pink Salmon and Stations H01, H03 and M06 for Chum Salmon. The greatest discrepancy in the sex ratio of wild and hatchery runs were observed for Chum Salmon at a few stations at the Montague Entrance (M01,M02, and M03, Figure 5).

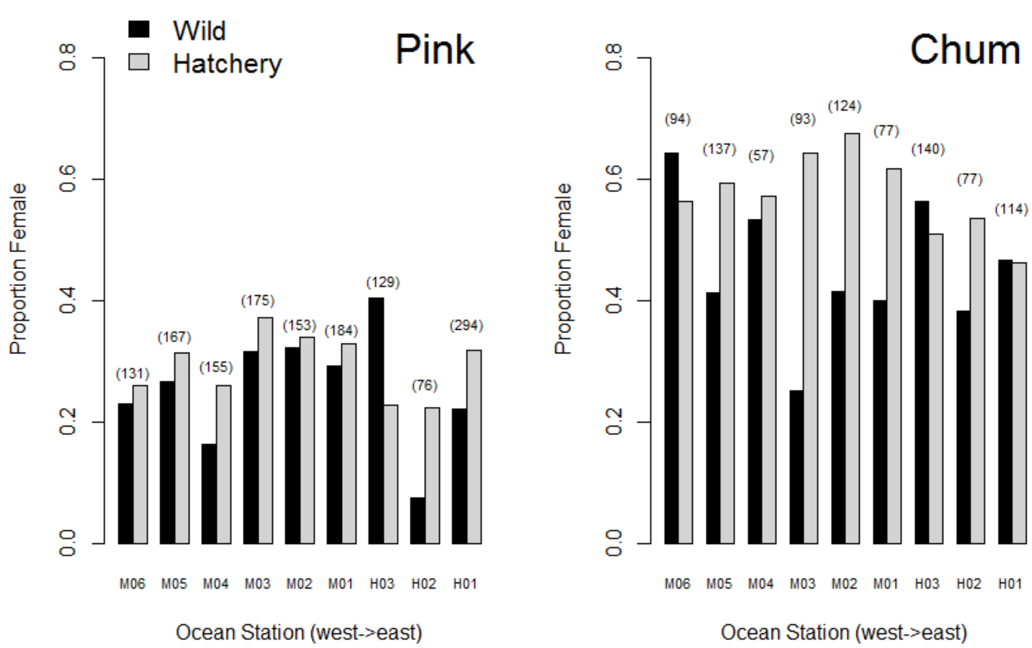

Figure 5. Sex ratio of salmon captured at ocean stations during 2013. Figures in parentheses above the bars are the sample sizes over the entire season.

The proportions of hatchery and wild Pink Salmon and Chum salmon varied by trip and station (Figures 6 and 7). The station H1 (eastern-most station) showed a consistently low proportion of hatchery fish throughout the entire season for both species (Figures 6 and 7). The early run of Pink Salmon was predominately wild while hatchery fish were more abundant later in the season (Figure 6). The temporal pattern at each station for Chum Salmon was less clear, but the general trend was a decreasing proportion of hatchery fish in the late run (Figure 7).

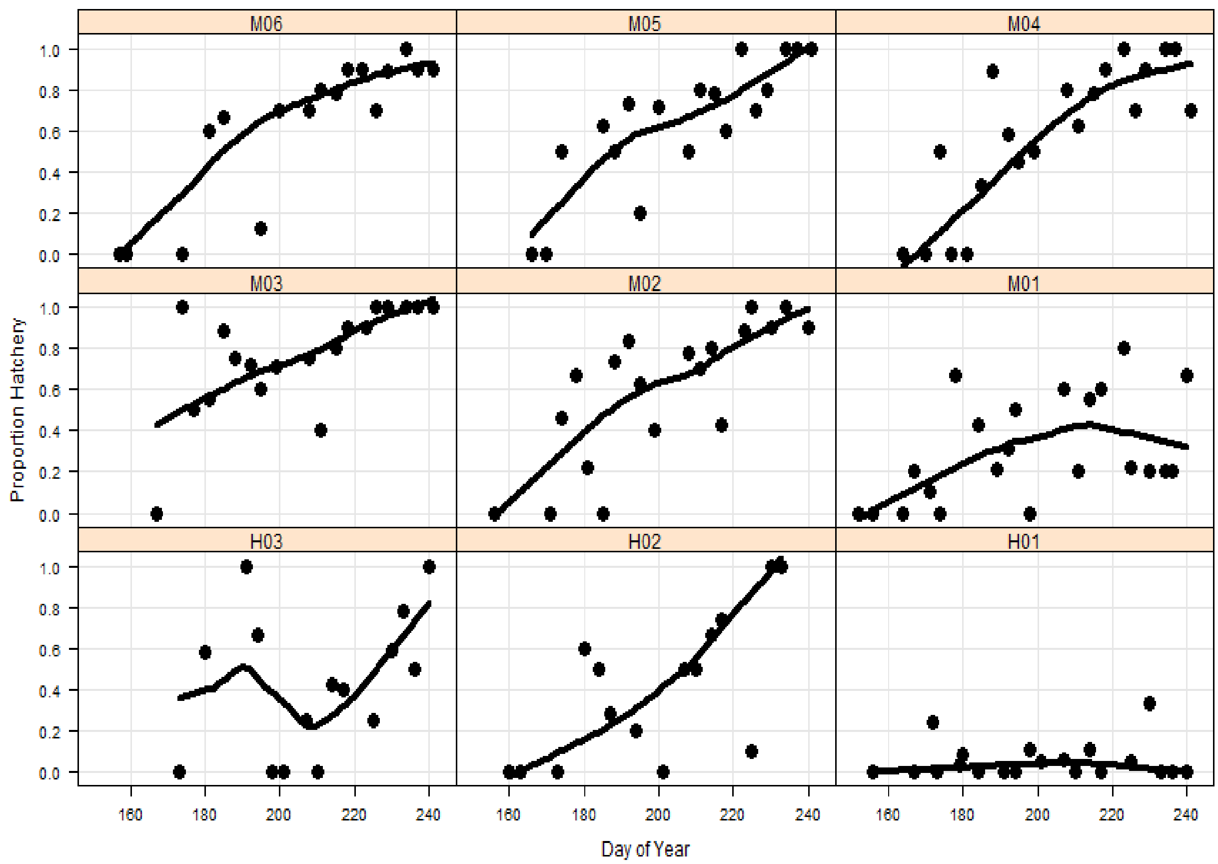

Figure 6. Proportion of the Pink Salmon run that was of hatchery origin over the season from May 25 to August 29, 2013, by ocean station. Data are fit to a loess smooth regression for illustrative purposes.

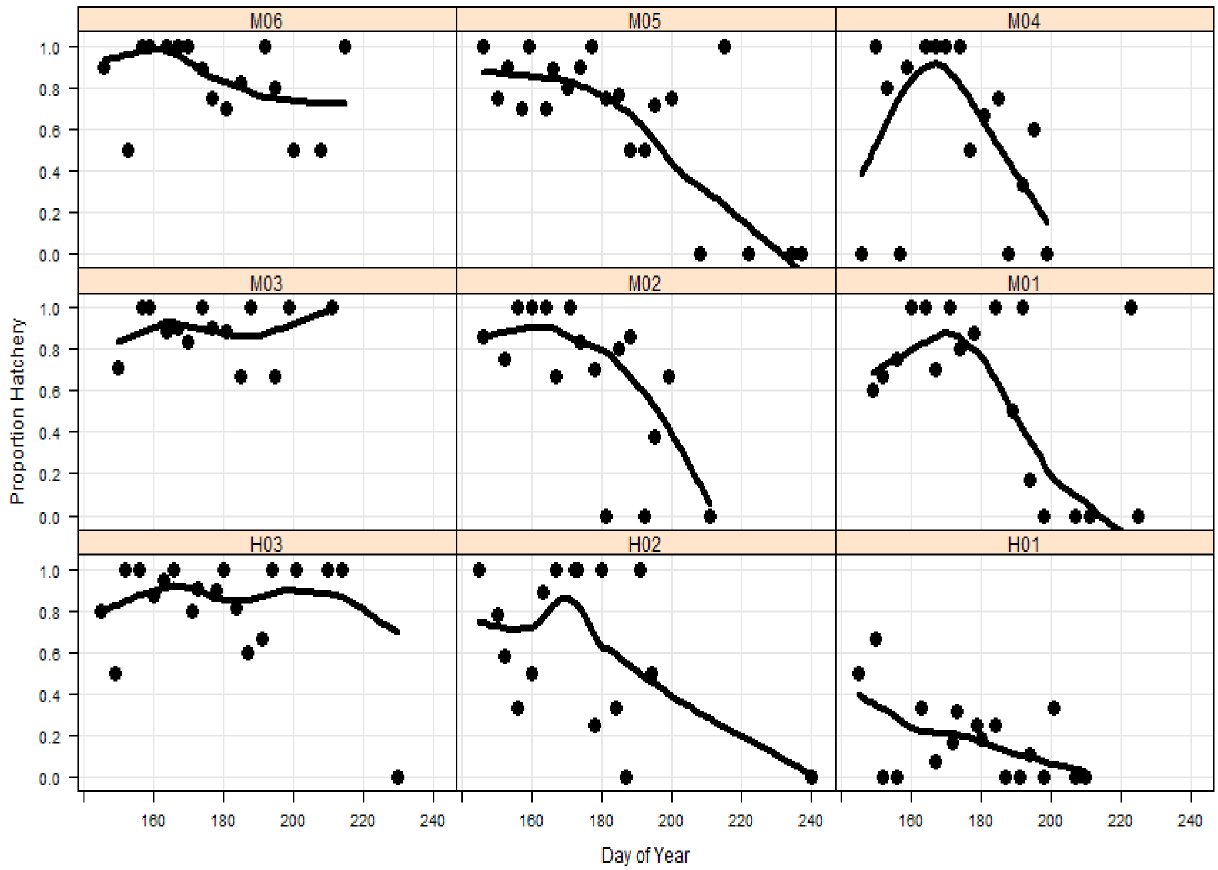

Figure 7. Proportion of the Chum Salmon run that was of hatchery origin over the season by ocean station. Data are fit to a loess smooth regression for illustrative purposes.

The weighted hatchery proportions calculated for Pink Salmon and Chum Salmon for all Prince William Sound entrances combined in 2013 was 0.679 (SE =0.016) and 0.728 (SE=0.018), respectively. Pink Salmon hatchery proportions ranged from 0.054 (SE=0.014) at H01 to 0.916 (SE=0.038) at M03. Chum Salmon hatchery proportions ranged from 0.174 (SE=0.014) at H01 to 0.924 (SE=0.055) at M06 (Figure 8).

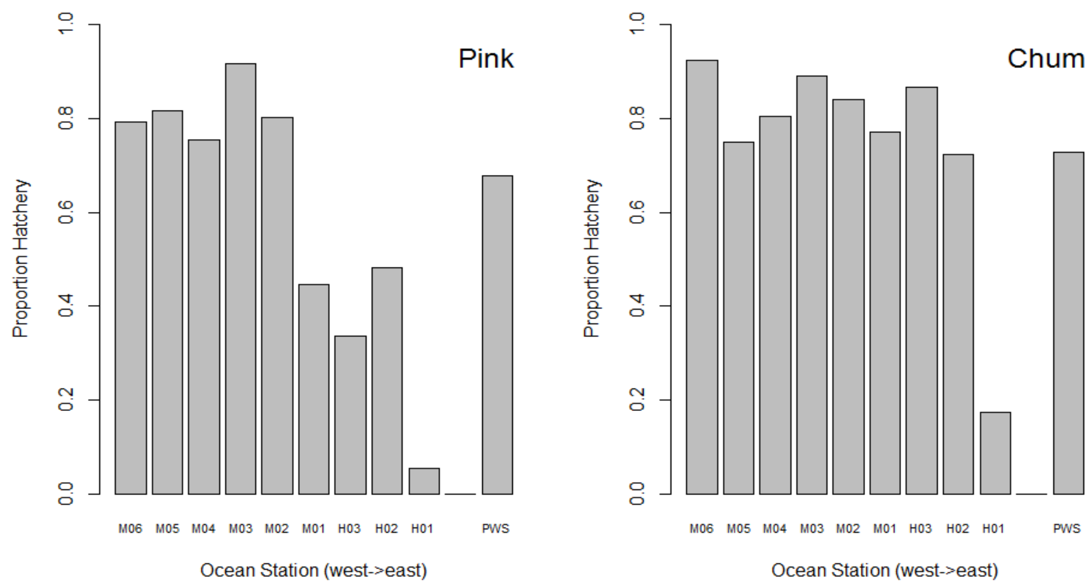

Figure 8. Weighted hatchery proportions of Pink Salmon and Chum Salmon by individual station calculated for the entire season. The right bar in each plot represents the weighted proportion of hatchery fish for the entire run for each species in Prince William Sound.

There was a clear pattern in both species of hatchery fish entering the Sound predominately across the western-most Montague entrances, while most wild fish entered via the eastern-most stations located in Hinchinbrook entrance, most dramatically evident for Pink Salmon (Figures 9 and 10). This may be explained by the fact that most hatchery production occurs in the western portion of the Sound.

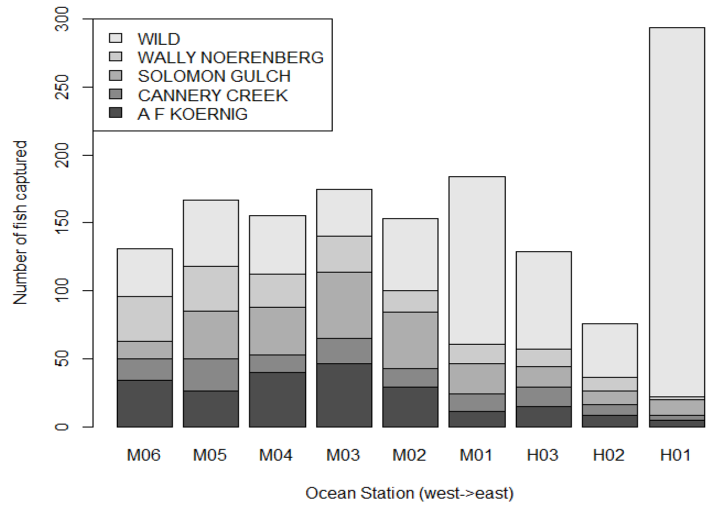

Figure 9. Pink Salmon hatchery-wild proportion of processed fish by station and by hatchery. It should be noted these proportions are not weighted by CPUE.

.

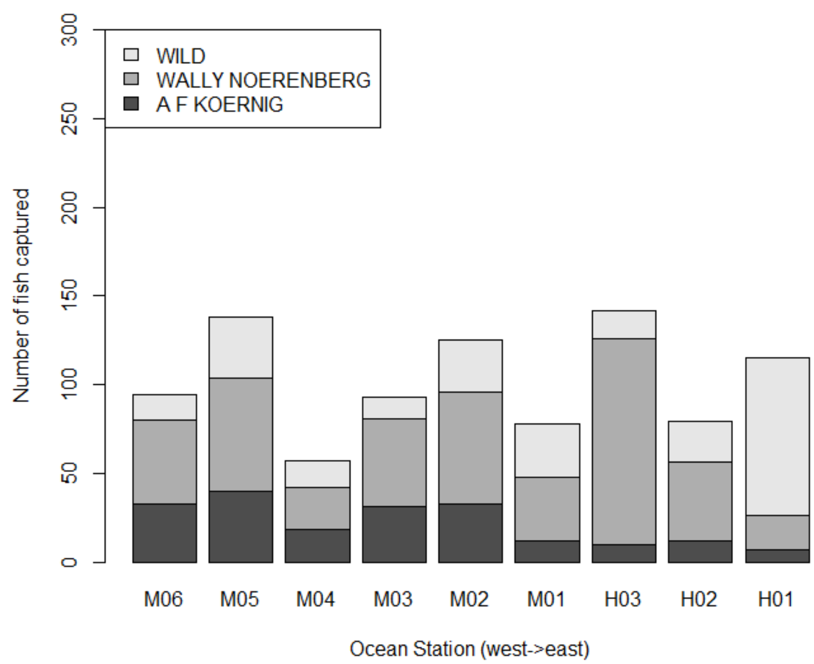

Figure 10. Chum Salmon hatchery-wild proportion of processed fish by station and by hatchery. It should be noted these proportions are not weighted by CPUE.

REFERENCES

Cochran, W. G. 1977. Sampling techniques. John Wiley & Sons, New York.

Goodman, L. A. 1960. On the exact variance of a products. Journal of the American Statistical Association 55:708-713.

Thompson, S. K. 1992. Sampling. John Wiley & Sons, New York.

Wolter, K. M. 1985. Introduction to variance estimation. Springer-Verlag, New York.

ADULT SAMPLING IN STREAMS

Authors – Eric Knudsen, Kristen Gorman, Ben Adams, David Bernard, Laurinda Marcello, Dan Crowther, Katie Froning, , Megan Roberts, 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 hatchery fractions; 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 the spawning population composed of hatchery strays into 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

To implement the data collection for this study required repeatedly sampling 31 streams throughout PWS and 32 streams throughout SEAK (Figures 11 and 12). 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 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.
In PWS, otoliths were collected for the hatchery fraction analysis from Pink Salmon adults in 27 of the 31 streams and Chum Salmon otoliths were collected from 17 of the streams (Figure 11). Each PWS stream was sampled during a minimum of three visits per species. In SEAK, otoliths were collected from summer-run Chum Salmon (only) in all 32 streams during a minimum of two stream visits (Figure 12). For the fitness studies, DNA tissues were collected with the otoliths from adult Pink Salmon in six of the streams in PWS and from Chum Salmon in four of the streams in SEAK (Figures 11 and 12).

The experimental design elucidated in the RFP for the straying analysis called for collecting 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 384 goal 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.

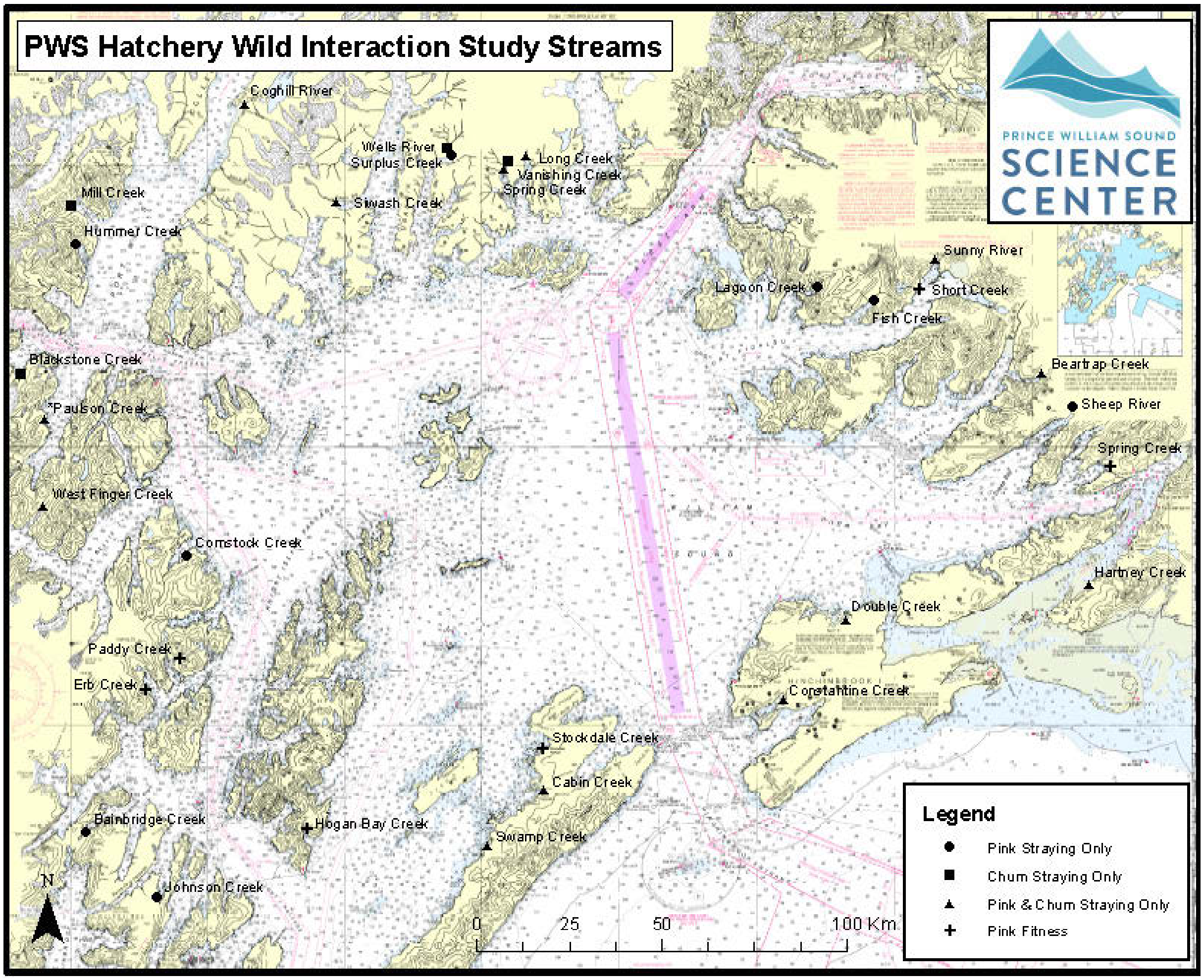

Figure 11. PWS streams sampled for Pink Salmon and Chum Salmon otoliths and DNA tissues.

The RFP specified that fitness study streams have sampling targets of 500 individuals in streams with high fractions of hatchery strays and 1,000 individuals in streams with low fractions. Subsequent discussions with ADF&G Gene Conservation Laboratory staff indicated the importance of exceeding the sampling targets from these streams. Observed spawning areas in the fitness study streams were mapped so that samplers could return to those areas in March of 2014 to collect pre-emergent fry. The maps were also to be used to calculate the total area of spawning to enable calculation of the 1,000 fry sampling cells.

Every effort was made to use consistent field methodologies throughout the data collection in both regions. Detailed, specific methodological protocols were developed to guide field data collection (Appendices B-D). A project SQL database was established and all field data was collected and entered via handheld tablets running an Android application developed specifically for this project (developed under a subcontract to Finsight LLC of Juneau). Field data were backed up on laptop computers and then uploaded to the host database from the laptops whenever the crews had access to the internet. A process of quality control was implemented and data errors corrected.

OVERALL FIELD SAMPLING STRATEGY – PRINCE WILLIAM SOUND

Streams were sampled in PWS by two crews employed by PWSSC. The majority of streams were visited by a 4-6-person crew based on a contracted, live-aboard vessel, the Cathy G. A second, 4-person crew based in Cordova visited the four streams closest to Cordova during the peak of the season.

Crews went through a training period in Cordova July 10-16 including safety, CPR, and firearms training, as well as training and planning for the field sampling, spawning area mapping, 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 25. The vessel made four 2-day intermediary stops in Cordova 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 which 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.

After disembarkation from the charter vessel and approaching the stream, the crew leader and/or assistant 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 equipped with shotguns and VHF radios.

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. In streams sampled only to estimate the fraction of hatchery salmon in the population, carcasses were aligned in rows of twelve by eight, which mimicked the rows and columns of otolith trays. On fitness study streams, carcasses were aligned in rows of eight by six, again mimicking the style of the deep well plate (dwp). The popular cutting technique for accessing otoliths was to use only one horizontal slice off the top of the head. Successfully accessing heart tissue for fitness sampling was easily achievable with the same knife used for exposing otoliths, with one horizontal cut, below the preopercular margin.

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 Pink Salmon and Chum Salmon throughout the system. If multiple people were counting the same species and morbidity status, 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 protocol and scheduling adjustments were made. Data were uploaded to the host database whenever internet access was available.

All otolith and DNA samples were checked by the field leader for completeness and data errors were later corrected in the database. The straying-only otoliths were delivered to the Cordova ADF&G office for processing. Fitness stream otoliths and tissues were shipped to ADF&G's Gene Conservation Laboratory in Anchorage where the otoliths were extracted and the dwps were shipped back to the Cordova ADF&G office for processing. Electronic data delivery to ADF&G followed the quality 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 summer-run Chum Salmon in 32 streams across Southeast Alaska in 2013, including four intensively-studied fitness streams and 28 straying-only streams (Figure 12).

The SSSC had 13 field personnel on four field teams – two vessel-based teams, a Tenakee Springs area team, and a fitness stream team based in Juneau. The Tenakee samplers were subcontractors and all other field crew were employees of SSSC. The two vessels, M/V Surveyor and M/V Bear are Sitka-based bear guiding platforms, well equipped for extended trips and with much experience navigating Southeast Alaska and working on salmon streams.

Crew training was held between July 15 and 19 for the ten SSSC seasonal employees. Training included project orientation and goals, field safety, salmon identification, biological sampling techniques, and tablet use and data entry. The experienced subcontractors did not attend training in Sitka but received the project protocol in advance of sampling and were instructed on tablet use. On July 19, the two vessels departed Sitka for their first streams and the fitness crew traveled by ferry to Juneau. These three crews all returned to Sitka for clean-up and debriefings on August 26. The Tenakee Springs subcontractors were debriefed by phone.

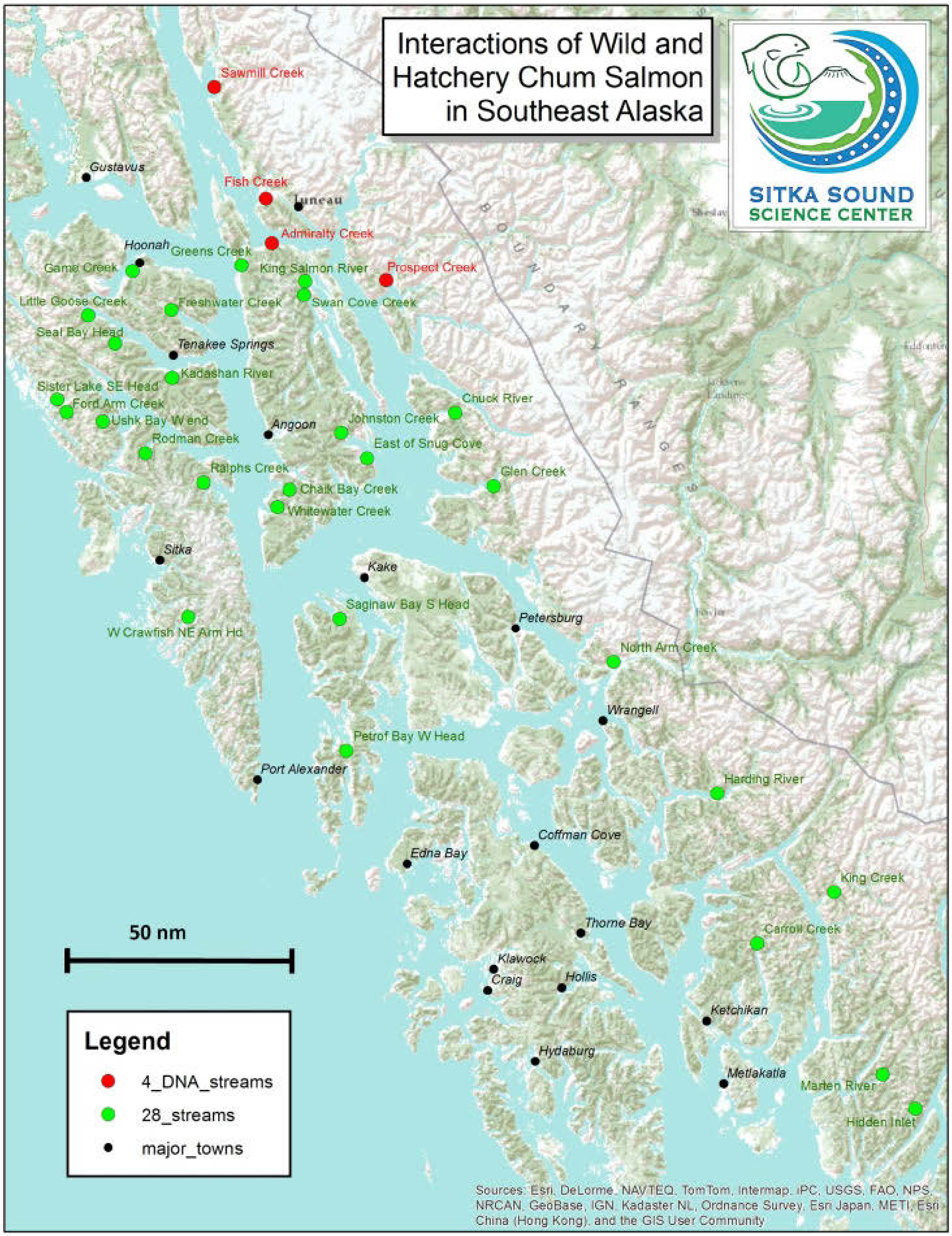

Figure 12. SEAK streams that were sampled for otoliths, DNA tissues, and scales.

The vessel-based crews made at least two visits per stream to 22 of the 23 otolith-only streams with the exception of Harding River. Harding River was deemed too hazardous to safely sample after the first field visit there (ADF&G was notified of this).

The M/V Bear surveyed much of the northern portion of the study area. The M/V Surveyor focused on southern SEAK mid-season, but also covered northern areas in the beginning and end of the season. Both vessels had skiffs for beach access and the M/V Surveyor was also equipped with a jet boat for access on larger, southern streams. Each vessel typically carried three SSSC field crew members. Both vessels had their own three-person crew and sent two personnel into the field to serve as bear protection daily.

We based each crew's stream schedule on historic run timing data with transit between streams usually occurring in the evenings. Day time travel was scheduled when stream-to-stream distances required over ten hours in transit. Each vessel had occasional resupply days in various ports built into their schedule. Contingency days were also built into the schedule to allow for bad weather or to allow crews to make additional visits to streams with low sample numbers. Several in-season schedule adjustments were made to adjust for Chum Salmon run timing.

The subcontractors sampled four Tenakee Springs area straying-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. .

The fitness crew surveyed Fish, Sawmill, Admiralty, and Prospect creeks. They made three multi-day visits to each stream, except Admiralty Creek which was surveyed four times. In addition to collecting otoliths and length and sex data, Chum Salmon tissue samples were also taken. Chum Salmon were sub-sampled for scale samples as well. The fitness crew mapped spawning areas within these four creeks throughout the field season.

The logistical approach for each fitness stream varied:

- Fish Creek is road accessible and was surveyed on day trips from Juneau.
- Sawmill Creek was accessed on day-trips with ADF&G's Boston whaler from Echo Cove at the north end of the road in Juneau.
- Prospect Creek is near DIPAC's Port Snettisham facility. Our crew flew to Port Snettisham via Ward Air. The crew lodged at DIPAC's bunkhouse and their staff transported our crews to and from Prospect Creek each day.
- Admiralty Creek has a USFS cabin on the lower river. Our crew generally flew in to Admiralty Cove from Port Snettisham or from Juneau via Ward Air. They hiked to different sections of the creek each day from the USFS cabin. Return trips to Juneau were provided by Island Images Water Taxi and Ward Air.

We gathered Chum Salmon spawn-outs and carcasses by hand, snagging live, post-spawned fish with hook-and-line, and/or using a gaff pole to extract carcasses or post-spawned live fish from the streams.

The SEAK coordinator communicated with the vessel crews using near-daily satellite phone check-ins and occasional longer conversations when they were in port or cell phone range. The fitness crew had regular phone access in Juneau and at Port Snettisham. The Tenakee area contractors communicated via email and phone.

All field data were collected on-site using tablet computers. The survey data were imported nightly when possible from the tablets to laptop computers. Data were then transmitted to the main database when an internet connection was available. The fitness crew uploaded their stream surveys regularly from Juneau. The northern crew was able to transmit surveys a few times in-season while in port. However, the crew aboard the M/V Surveyor and the Tenakee Springs contractors were unable to transmit in-season and had to deliver their tablets to the SSSC main office for data transmission.

All otolith samples were delivered to the SSSC office and checked by the coordinator for completeness. The samples were then delivered to the ADF&G Mark Tag Age Laboratory (MTA Lab) in Juneau. Fitness stream otoliths, tissues, and scales were checked by the field crew leader in Juneau and delivered directly to the MTA lab. The MTA Lab retained otoliths and scales and later shipped the DNA tissues to Anchorage's Gene Conservation Laboratory. Data issues were identified and fixes were made to the data made by the project manager. Electronic data delivery to ADF&G followed the quality review.

SPECIFIC BIOLOGICAL SAMPLING METHODS

The specific methods for biological sampling included techniques for collecting fish, extracting otoliths, measuring lengths, determining sex, and, for the fitness streams, collecting tissues for DNA analysis. The protocols for sampling Southeast Chum Salmon also included methods for sampling scales for aging. Otolith, DNA tissue samples, and scales were sent to the respective ADF&G labs for processing.

Detailed stream sampling protocols were prepared for standardization and consistency among all field crews (see Appendices C and D). The protocols were developed primarily from previous practices established within ADF&G, modified as necessary to facilitate the current study. Guidance for the use of the field tablet application for data collection was integrated into the protocols.

MAPPING OF FITNESS STREAM SPAWNING AREAS

A technique for mapping the spawning areas in fitness study streams was developed specifically for this study and is described in the protocols (Appendix E). The techniques are generally designed to determine the boundaries of observed spawning on each visit and integrate those observations over successive stream visits so that, ultimately, the outer boundaries of all the combined spawning areas are spatially delineated. This was accomplished by a combination of GPS fixes and on-the-ground distances and bearings, relative to known landmarks. The data was used in a GIS environment to plot the spawning areas. The total area of all possible spawning within a given stream was calculated to provide a basis for estimating the spacing for sampling alevins from the gravel in the spring.

We mapped the spawning areas in most of the fitness study streams using the techniques described in Appendix E. However, several on-site factors led to modifications of the prescribed methods. In several of the streams, we found two conditions that led to modifying the protocol somewhat. One was that spawning was so ubiquitous within a stream that simply measuring the boundaries of most of the submerged stream area delineated the total spawning boundaries and there was no need for re-mapping on more than one visit (e.g. Sawmill Creek and Spring Creek). The other was that spawning sometimes occurred in many small patches spread through a relatively large area of poor spawning habitat consisting mainly of large substrate (cobbles and boulders, e.g., Fish Creek, Douglas Island). Rather than measure every one of the numerous small patches, we measured the outer wetted boundary of all the patches. In these cases, it will be impossible to sample for alevins in the cobble/boulder substrate and technicians will necessarily need to sample in the spawning patches.

ESTIMATING STRAY FRACTIONS

The objectives of the field sampling in 2013 on the spawning grounds of PWS and SEAK 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. 2014d). The number of streams to sample in 2013 was allocated across PWS districts 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 SEAK. The number of dead and live salmon of each species was usually counted in the stream section surveyed 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

[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.

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:

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

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:

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

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 $\bar{y}_i$ 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:

---

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

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

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

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 $\bar{y}_i$ 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 $\bar{y}_i$:

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

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

where ***h*** denotes stratum (district), A_h the aerial abundance index by ADFG for stratum (district) ***h*** in 2013, and $\bar{q}_h \equiv \bar{q}$ 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

[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.

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

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 project goals, as described further below. A total of 33,574 individual fish were sampled from all streams and species combined. Fair weather and lower than normal precipitation, combined with large runs in some locations, likely contributed to the successful sampling. Conversely, low water and high stream temperatures contributed to later-than-normal spawning as well as some pre-spawning mortality in many Southeast streams, decreasing sampling opportunity in some systems.

PWS Stream Sampling Results

PWS Pink Salmon Sampling

Pink Salmon were observed in all streams sampled across PWS. 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 Fish Creek exhibited strong runs in late July, but other runs, such as Comstock Creek, did not begin until late-August.

Across all 27 streams sampled for Pink Salmon otoliths (Figure 11), 17,063 otoliths were taken, reaching or exceeding the sampling goal in 24 streams (Table 3). Notably, two of the least productive streams for Pink Salmon samples were in Long Bay, at Long Creek (211 samples, 55% of the sampling goal) and Spring Creek (205 samples, 53% of the goal). These two streams had later runs which made logistical planning difficult as the season was closing. During the last two visits we could not avoid positive low tides at these streams (penultimate visit was +13 feet). We tried to plan stream visits to match expected run timing by using ADF&G historical run timing and 2013 aerial survey data. Oversampling occurred during the peak of the Pink Salmon run at most streams. However, unproductive visits at Paddy (see ***Fitness*** section), Long, and Spring creeks were unavoidable given environmental and logistical issues. The number of samples varied per stream visit (Appendix G). Foot survey-based live and dead counts were made on most stream surveys (Appendix G).

Table 3. Summary of sampling and hatchery fractions by stream for PWS Pink Salmon in 2013. Target sample size per stream was 384 for estimating the hatchery fraction. Counts of live and dead salmon were taken during each visit and the dead counts were used to weight the hatchery fraction of salmon sampled each visit to produce a weighted average fraction for each stream. Area under the curve indices for 2013 (Steve Moffitt, pers. comm.) are shown to illustrate the relative sizes of spawning populations.

Stream name	AWC code	Samples taken	Number of stream visits	Area under curve index 2013	Average weighted hatchery fraction
Hartney C	221-10-10020	518	9	48,538	0.024
Spring	221-20-10200	205	4	13,398	0.031
Sheep R	221-20-10360	766	3	104,328	0.000
Beartrap R	221-30-10480	500	4	94,250	0.024
Sunny R	221-40-10875	395	4	22,063	<0.001
Short C	221-40-10880	1,459	6	6,934	0.006
Fish C	221-40-10890	535	4	78,281	<0.001
Lagoon C	221-40-10990	619	4	60,784	0.016
Long C	222-10-12140	211	5	17,047	0.070
Spring C	222-10-12170	1480	7	12,485	0.002
Surplus C	222-20-12338	634	5	9,724	0.010
Siwash R	222-20-12640	517	4	16,148	0.098
Coghill R	223-30-13220	626	3	548,047	0.018
Hummer C	224-10-14240	421	4	12,994	0.020
Paulson C	224-10-14550	610	4	21,589	0.058
W. Finger C	224-40-14850	484	4	37,343	0.025
Comstock C	225-20-15040	672	5	15	0.868
Paddy C	226-20-16010	125	5	6,211	0.154
Erb C	226-20-16040	637	6	11,123	0.113
Bainbridge C	226-20-16300	539	3	41,141	0.174
Hogan Bay	226-30-16810	828	7	20,478	0.640
Johnson Cr	226-40-16269	627	4	52,757	0.370
Swamp C	227-20-17390	640	4	108,359	0.063
Cabin C	227-20-17464	486	3	31,897	0.103
Stockdale C	227-20-17520	1199	5	1,809	0.163
Double C	228-40-18310	824	5	37,692	0.002
Constantine C	228-60-18150	506	3	170,833	0.000

PWS Chum Salmon Sampling

The presence of Chum Salmon was observed at every PWS stream visited except Comstock and Erb creeks. There were no live Chum Salmon observed at Blackstone Creek throughout the entire season; only two carcasses were sampled there. In general, Chum Salmon runs in southern PWS streams, including Swamp, Cabin, Double and Constantine, ran strongly from late July and early August to mid-August. Northwest streams, such as Coghill River and Mill Creek, produced Chum Salmon runs from mid-July to early and mid-August. Overall, Chum Salmon runs in PWS range from mid-July to late-September, but not every region's streams share the same run timing. For instance, Beartrap Creek, in eastern PWS, had a large run from late-July to early-August whereas Sunny River, also in eastern PWS, produced a late Chum Salmon run, which apparently began in late August and ended in late September.

Table 4. Summary of sampling and hatchery fractions by stream for PWS 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 the dead counts were used to weight the hatchery fraction of salmon sampled each visit to produce a weighted average fraction for each stream. Area under the curve indices (Steve Moffitt, pers. comm.) are shown to illustrate the relative sizes of spawning populations.

Stream name	AWC code	Samples taken	Number of stream visits	Area under curve index 2013	Average weighted hatchery fraction
Hartney C	221-10-10020	717	8	3,186	0.005
Beartrap R	221-30-10480	639	3	22,714	0.005
Sunny R	221-40-10875	359	5	2,705	0.001
Long C	222-10-12140	479	5	3,532	0.261
Vanishing C	222-10-12157	457	4	2,577	0.045
Spring C	222-10-12170	279	5	1,409	0.022
Wells R	222-20-12340	665	4	18,093	0.021
Siwash R	222-20-12640	309	4	4,141	0.049
Coghill R	223-30-13220	124	3	5,456	0.049
Mill C	224-10-14210	434	4	2,353	0.042
Blackstone C	224-10-14510	2	4	230	0.093
Paulson C	224-10-14550	23	4	360	0.056
W. Finger C	224-40-14850	179	4	1,835	0.017
Swamp	227-20-17390	46	3	274	0.601
Cabin C	227-20-17464	326	3	548	0.965
Double C	228-40-18310	431	3	1,357	0.040
Constantine C	228-60-18150	515	3	15,552	0.005

A total of 5,984 Chum Salmon samples were taken with sampling goals reached or exceeded in eight out of 17 streams (Figure 11), The least productive streams for Chum Salmon samples were Blackstone Creek (two specimens, 0.5% of goal), Paulson Creek (23 specimens, 6%) and Swamp Creek (46 specimens, 12%). These are all historically low-producing systems. Blackstone Creek failed to produce any semblance of a Chum Salmon run over the course of five visits between late July and late September. We also surveyed other nearby streams, including Tebenkof Creek, with very little success of sampling Chum Salmon (see Appendix H for more details). Sampling at Coghill River was also relatively unsuccessful (124 specimens, 33%). Based on the 2013 cumulative Chum Salmon count at the ADF&G Coghill River weir, we suspect the run started in early July and peaked in mid-July. Our sample dates were 8/9/2013, 9/5/2013, and 9/19/2013, so much of our effort at Coghill might have been too late to achieve the sampling goal (see Appendix I for more details). Oversampling was possible at many Chum Salmon systems such as Beartrap Creek, Constantine Creek, and Wells River, where the runs were strong and steady during each sampling trip, and Hartney Creek, where sampling was frequent due to ease of access, the number of Chum Salmon samples varied per stream visit (Appendix H). Foot survey-based live and dead counts were made on most stream surveys (Appendix H).

PWS Pink Salmon Fitness Sampling

Overall, sampling was successful at a majority of the six selected Pink Salmon fitness study streams in PWS. We sampled 5,679 fish, or 126% of the total goal of 4,500 samples (Table 5). Sampling success, relative to the goals, ranged from 25% of the goal in Paddy Creek up to 166% in Hogan Bay Creek. Paddy Creek (125 samples exhibited a very small return of Pink Salmon this year. For instance, there were never more than 75 live and 430 dead Pink Salmon observed at Paddy Creek, and no active spawning was seen. Dead Pink Salmon observed at Paddy were clearly preyed upon prior to spawning or too degraded to sample. Successful sampling of five of the six fitness streams likely resulted from a high return of Pink Salmon and success in bracketing the peak of the run with sampling times (Appendix I has more details on sampling of each PWS stream).

Table 5. Total Pink Salmon DNA and otolith samples collected in Prince William Sound during July through September 2013.

Stream name	AWC code	Sampling goal	Total collected	Percent	Visits
Erb Creek	226-20-16040	500	637	127%	6
Hogan Creek	226-30-16810	500	828	166%	7
Paddy Creek	226-20-16010	500	125	25%	5
Short Creek	221-40-10880	1000	1459	146%	6
Spring Creek	221-20-10200	1000	1431	143%	6
Stockdale Creek	227-20-17520	1000	1199	120%	6
	Total	4500	5679	126%	

PWS STREAM HATCHERY FRACTION RESULTS

Pink Salmon Hatchery Fractions

At the individual stream level (n = 27), Pink Salmon hatchery fractions ranged from 0 to 0.87 in 2013 (Table 3, Figure 13). No hatchery Pink Salmon were detected at Constantine Creek or Sheep River. The highest hatchery fraction of Pink Salmon in 2013 was detected at Comstock Creek (0.87). Other study streams with notable hatchery fractions of Pink Salmon were Hogan Bay and Johnson creeks (0.64 and 0.37, respectively). All other study streams had lower hatchery fractions (< 0.17).

Hatchery Pink Salmon fractions in 2013, and their associated variances were estimated across PWS management districts (Table 6). Based on these results, the Eshamy management district in PWS had the highest fraction of hatchery Pink Salmon. This was because Comstock Creek, which had the highest hatchery Pink Salmon fraction of all study streams, is the only study stream in this district. The Southwestern and Montague districts had the second and third highest hatchery fractions (0.29 and 0.11, respectively). All other districts had hatchery fractions < 0.05. For the entire PWS region in 2013, the overall fraction of hatchery Pink Salmon in spawning streams was calculated to be 0.044 (SE = 0.029).

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

District	Estimated hatchery fraction	Estimated SE	Number of streams sampled	2013 Aerial survey fraction for district
Eastern (221)	0.013	0.004	8	0.270
Northern (222)	0.045	0.023	4	0.070
Coghill (223)	0.018	NA	1	0.137
Northwestern (224)	0.034	0.012	3	0.043
Eshamy (225)	0.868	NA	1	0.003
Southwestern (226)	0.290	0.098	5	0.074
Montague (227)	0.110	0.029	3	0.088
Southeastern (228)	0.001	0.001	2	0.314
Overall	0.044	0.029	27	1.000

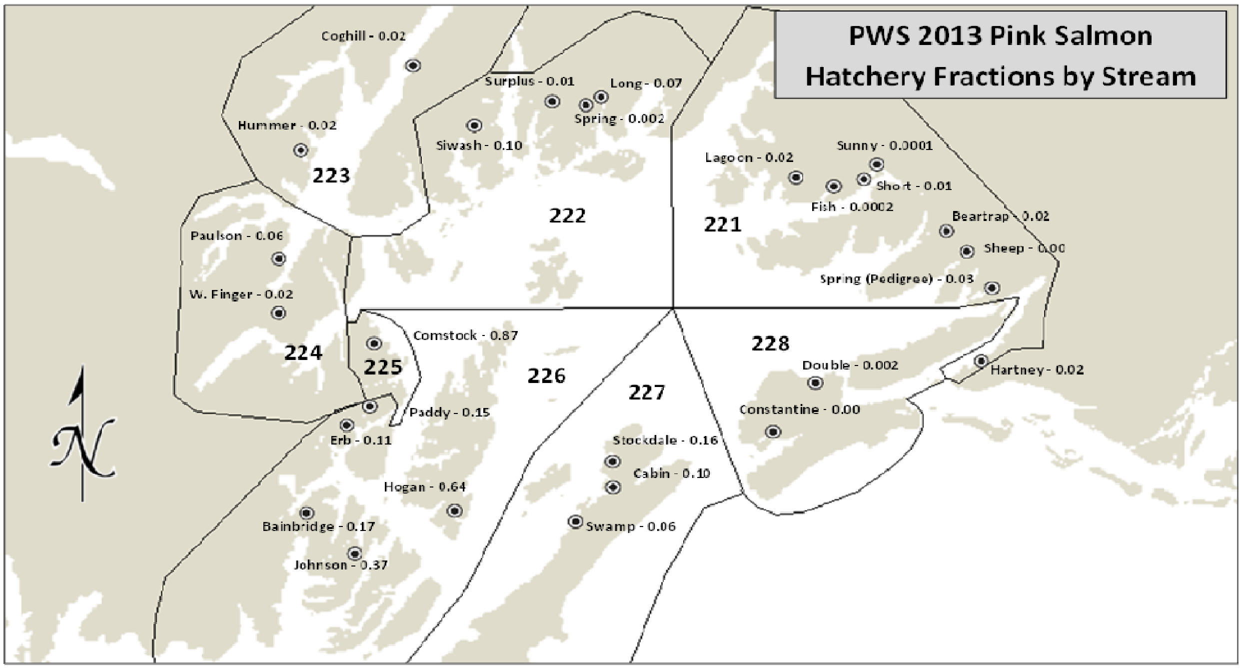

Figure 13. PWS Pink Salmon hatchery fractions by stream in 2013. Black lines represent district borders.

Chum Salmon Hatchery Fractions

For the entire PWS region in 2013, the overall fraction of hatchery Chum Salmon in spawning streams was calculated to be 0.028 (SE = 0.025) (Table 7). The Montague management district had the highest fraction of hatchery Chum Salmon due to the fact that Cabin and Swamp Creeks, which had the highest hatchery Chum Salmon fractions of all study streams, are in this district. All other districts had hatchery fractions < 0.09 (Table 7). At the stream level (n = 17), hatchery fractions for Chum Salmon in PWS ranged from 0.001 to 0.97 in 2013 (Table 4, Figure 14). Sunny River had the lowest fraction of hatchery Chum Salmon in 2013 (0.002), while Cabin, Swamp, and Long creeks had the highest fractions (0.96, 0.60, and 0.26, respectively). All other study streams had lower fractions of hatchery fish (< 0.09).

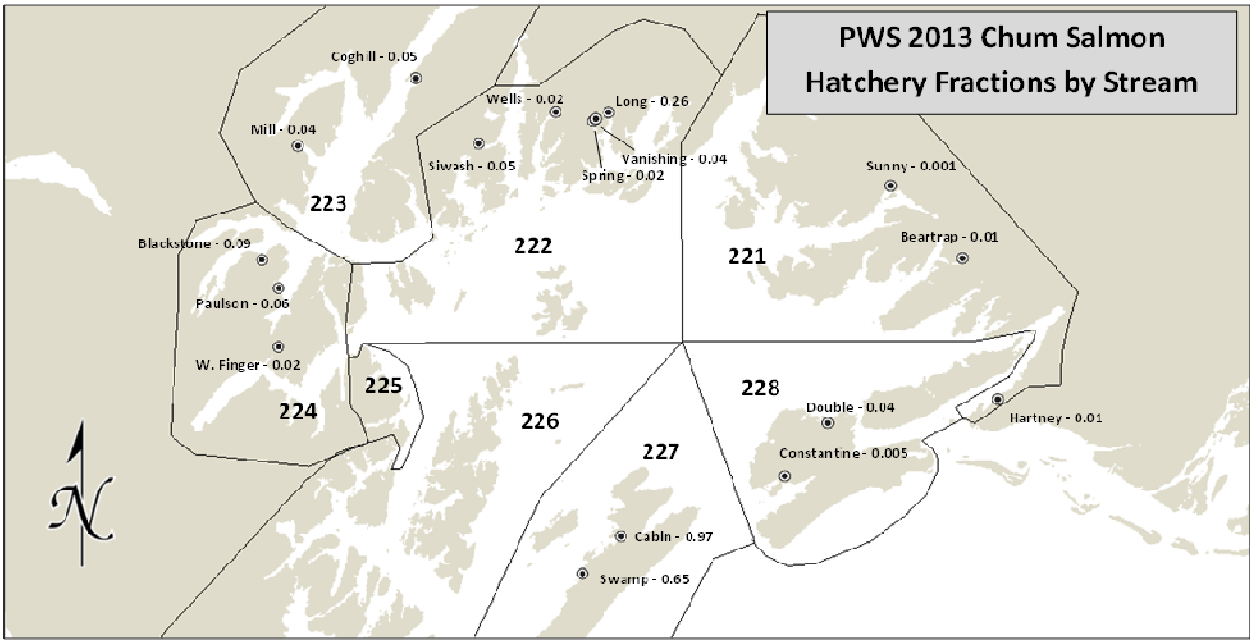

Figure 14. PWS Chum Salmon hatchery fractions by stream in 2013. Black lines represent district borders.

Table 7. Estimated 2013 PWS Chum Salmon district -wide and overall stream hatchery fractions and their standard errors. The 2013 aerial survey fraction for each district was used to weight the contribution of each district to the overall fraction estimate.

District	Estimated hatchery fraction	Estimated SE	Number of streams sampled	2013 Aerial survey fraction for district
Eastern (221)	0.004	0.001	3	0.577
Northern (222)	0.080	0.046	5	0.164
Coghill (223)	0.049	NA	1	0.055
Northwestern (224)	0.052	0.016	4	0.023
Montague (227)	0.783	0.182	2	0.006
Southeastern (228)	0.022	0.017	2	0.173
Overall	0.028	0.025	17	1.000

Southeast Alaska Stream Sampling Results

Southeast Chum Salmon Hatchery Fraction Sampling

Chum Salmon were sampled for otoliths in 32 streams across Southeast Alaska (Figure 12). SSSC field crews visited 27 of the 28 hatchery fraction study streams at least two times each. We visited the Harding River only once due to significant safety concerns. We met or exceeded ADF&G's otolith sampling goals at 11 of 28 otolith-only streams (Table 8). Field crews collected a total of 10,527 pairs of otoliths across all Southeast Alaska streams (see Appendix J for a listing of each stream survey). We were unable to meet sampling goals in some of these streams for several reasons. Not unexpectedly, it was difficult to correctly time our stream visits with the run timing for all streams, especially mid-season when there were peak runs occurring throughout several areas of Southeast Alaska simultaneously. Also, the extraordinarily dry and warm summer delayed some Chum Salmon moving upstream due to low water. Lastly, in 2013 we had limited access to upriver areas of several of the longer rivers in the study (particularly Game Creek, Kadashan River, and Marten River) and may have missed opportunities to sample Chum Salmon in those cases (see Appendix K for summaries of sampling at each stream).

In general, 2013 Southeast Alaska Chum Salmon runs occurred between late July and late August with wide variation in the timing and duration of runs among streams. We first observed large numbers of Chum Salmon in late July at Ralphs Creek, located on Baranof Island inside waters. Swan Cove Creek, Seal Bay Head, and Chuck River/Sylvia Creek also had post-spawned Chum Salmon available starting in late July. As the season progressed into early August, Chum Salmon runs were next seen across many streams along northern Southeast inside waters. Runs into mid-to-late August, were present in some southern Southeast Alaska streams, south Chichagof Island and Baranof Island outside waters, and in Petrof Bay on Kuiu Island. Some indications of relative run timing can be inferred from the rough estimates of Chum Salmon live and dead counts (Appendix J).

Southeast Chum Salmon Fitness Sampling

We sampled four Southeast Alaska streams for Chum Salmon DNA tissue samples, in addition to otoliths: Admiralty, Fish, Prospect, and Sawmill creeks. We also collected scale samples from a subset of Chum Salmon in each stream for aging. Tissue sampling goals were met in Fish Creek and scale sampling goals were met in all fitness streams except for Sawmill Creek (Table 9). A total of 2,114 otolith samples, 1,998 tissue samples or tags[8], and 859 sets of scales were collected at these four streams. All four of the fitness streams were visited on at least three multi-day visits (Table 9).

[8] Just prior to our field season, ADF&G Gene Conservation Lab representatives collected tissue samples from a group of Chum Salmon in Fish Creek and tagged the fish with individually identifiable Floy tags some of which SSSC crews recovered later.

Table 8. 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 the dead counts were used to weight the hatchery fraction of salmon sampled each visit to produce a weighted average fraction for each stream. Aerial survey indices (Steve Heinl, pers. comm.) are shown to illustrate the relative sizes of spawning populations.

Stream name	AWC code	Samples taken	Stream visits	Aerial index 2013	Average weighted hatchery fraction
Hidden Inlet	101-11-11010	289	2	1,300	0.063
Marten River	101-30-10600	111	2	8,000	0.047
Carroll Creek	101-45-10780	228	2	2,000	0.044
King Creek	101-71-10040-2006	342	2	5,000	0.084
Harding River	107-40-10490	7	1	3,500	0.167
North Arm Creek	108-40-10150-2007	453	2	1,981	0.043
Saginaw Bay S Head	109-44-10370	104	2	1,500	0.007
Petrof Bay W Head	109-62-10240	475	2	858	0.000
Johnston Creek	110-23-10100	130	4	1,200	0.026
East of Snug Cove	110-23-10210	183	3	1,417	0.000
Chuck River	110-32-10090	453	2	7,100	0.013
Glen Creek	110-34-10060	148	2	1,900	0.014
Swan Cove Creek	111-16-10450	205	2	600	0.029
King Salmon River	111-17-10100	293	2	4,000	0.028
Prospect Creek	111-33-10100	485	3	700	0.241
Admiralty Creek	111-41-10050	421	4	1,700	0.047
Fish Creek	111-50-10690	767	3	125	0.728
Ralphs Creek	112-21-10060	456	2	9,300	0.007
Kadashan River	112-42-10250	64	4	21,000	0.000
Seal Bay Head	112-46-10070	480	2	22,200	0.004
Little Goose Creek	112-48-10190	140	2	8,100	0.000
Freshwater Creek	112-50-10300	172	2	6,000	0.018
Greens Creek	112-65-10240	70	2	1,810	0.000
Chaik Bay Creek	112-80-10280	600	3	19,500	0.004
Whitewater Creek	112-90-10140	235	3	2,300	0.041
W Crawfish NE Arm Hd	113-32-10050	768	2	4,200	0.019
Rodman Creek	113-54-10070	478	3	15,300	0.011
Ushk Bay W End	113-56-10030	492	4	2,000	0.008
Sister Lake SE Head	113-72-10040-2025	600	2	8,300	0.015
Ford Arm Creek	113-73-10030	408	2	1,320	0.023
Game Creek	114-31-10130	29	2	15,500	0.036
Sawmill Creek	115-20-10520	441	3	1,845	0.465

Table 9. Total Chum Salmon DNA and otolith samples collected in SEAK during July and August 2013.

Stream Name	AWC Number	Sampling Goal	Total Otoliths	Percent	Total DNA tissues	Total scale samples	Visits
Prospect Creek	111-33-10100	1000	485	49	483	234	3
Admiralty Creek	111-41-10050	1000	421	42	408	258	4
Fish Creek	111-50-10690	500	767	153	764	278	3
Sawmill Creek	115-20-10520	500	441	88	343	89	3

A mistimed stream visit played the largest role in falling short of sample goals in Sawmill Creek. Chum Salmon in Sawmill Creek spawned within a short temporal window and it now appears the peak run occurred sometime near August 2. Our first visit on July 23 was too early (many chum were spawning) and our second visit on August 9-10 was too late in the run to sample these fish immediately after spawning. The carcasses were significantly degraded on the 9th and 10th so we were unable to obtain enough tissue and scale samples (only 343 of 500 tissue samples and 89 of 200 scale samples were obtained).

We also fell short of DNA tissue sampling goals at Admiralty and Prospect Creeks, collecting 408 and 483 of the 1,000 requested tissue samples respectively. Both of these streams appeared to have fairly small Chum Salmon runs with peak counts of fewer than 1,000 live and dead for Prospect Creek, and around 500 for Admiralty Creek. Chum Salmon runs in both locations may also be extended over several weeks. The combination of these factors meant that relatively few Chum Salmon were available to sample on any given stream visit. Rough live and dead counts were made during most surveys on the SEAK fitness streams (Appendix J).

SOUTHEAST STREAM HATCHERY FRACTION RESULTS

Chum Salmon Hatchery Fractions

For SEAK in 2013, the overall fraction of hatchery Chum Salmon was calculated to be 0.07 (SE = 0.028) (Table 10). Hatchery Chum Salmon fractions across management sub-regions in SEAK in 2013 ranged from 0.019 to 0.081 (Table 10). The Northern Southeast Inside and Southern Southeast sub-regions had the highest and similar average weighted fractions of hatchery Chum Salmon. Fish and Sawmill Creeks, which had the highest hatchery fractions of all study streams for Chum Salmon, are located in the Northern Southeast Inside sub-region but so were many other streams with very low hatchery fractions, greatly reducing the sub-region average fraction relative to those two streams.

At the stream level (n = 32), hatchery fractions for Chum Salmon in SEAK ranged from 0 to 0.73 in 2013 (Table 8, Figure 15). No hatchery Chum Salmon were detected at East of Snug Cove, Greens Creek, Kadashan River, Little Goose Creek, or Petrof Bay West Head. The three highest SEAK stream hatchery fractions of Chum Salmon in 2013 were at Fish Creek (0.73), Sawmill Creek (0.46), and Prospect Creek (0.24). All other study streams had hatchery fractions < 0.17 (Table 8).

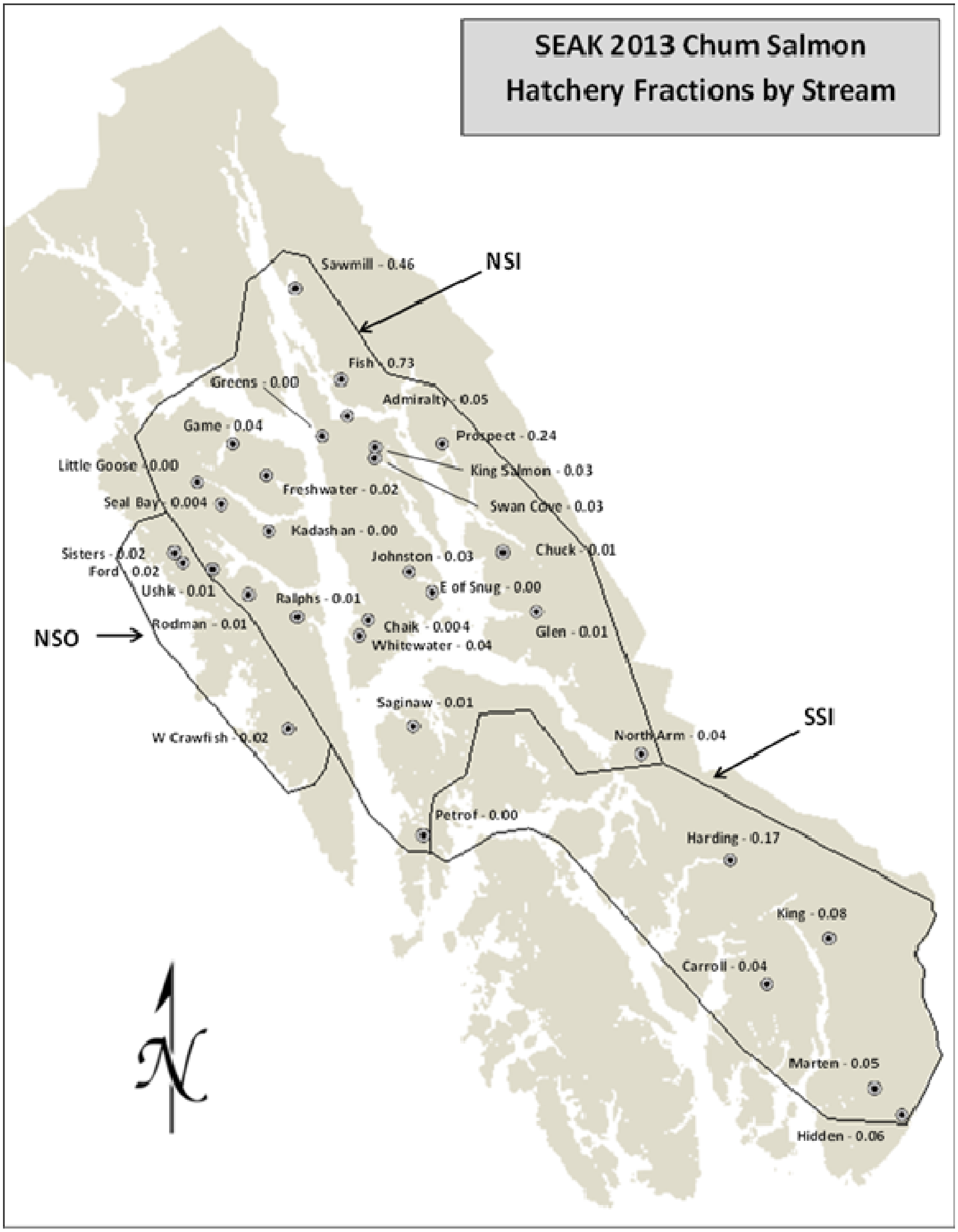

Figure 15. SEAK Chum Salmon hatchery fractions by stream in 2013. Black lines represent sub-region borders (NSI = Northern Southeast Inside, NSO = Northern Southeast Inside, and SSE = Southern Southeast sub-regions).

Table 10. Estimated 2013 SEAK Chum Salmon stream hatchery fractions by sub-region and for SEAK overall. The 2013 aerial survey fraction for each sub-region was used to weight the contribution of each sub-region to the overall fraction estimate.

Sub-region	Estimated hatchery fraction	Estimated SE	Number of streams sampled	Aerial survey fraction for sub-regions
Northern Southeast Outside	0.019	0.002	3	0.113
Northern Southeast Inside	0.074	0.035	24	0.618
Southern Southeast	0.081	0.022	5	0.269
Overall	0.072	0.028	32	1.000

FITNESS STREAM SPAWNING AREA MAPPING

Spawning areas were successfully mapped at most of the fitness study streams in 2013. Stockdale Creek in PWS was never directly mapped because weather delays prevented the crew from accessing the stream at the end of the season. However, we recorded the upper and lower extent of spawning, which was fairly uniform throughout the sampled spawning length, and we have sufficient information on the average wetted width to enable generation of an estimated map.

The maps resulting from the mapping protocol, sometimes modified as described under Methods above, were to be used to 1) determine the specific location of the areas to be sampled for alevins in the spring and 2) form the basis for determining the total spawning area to subdivide into the prescribed 1,000 sampling cells. Each spawning area has associated data including GPS fixes, physical location descriptions, a landmark description, distances and bearings to the spawning area, and a set of photographs to help guide the spring samplers to the spawning area. An example of the spawning area maps is shown in Figure 16.

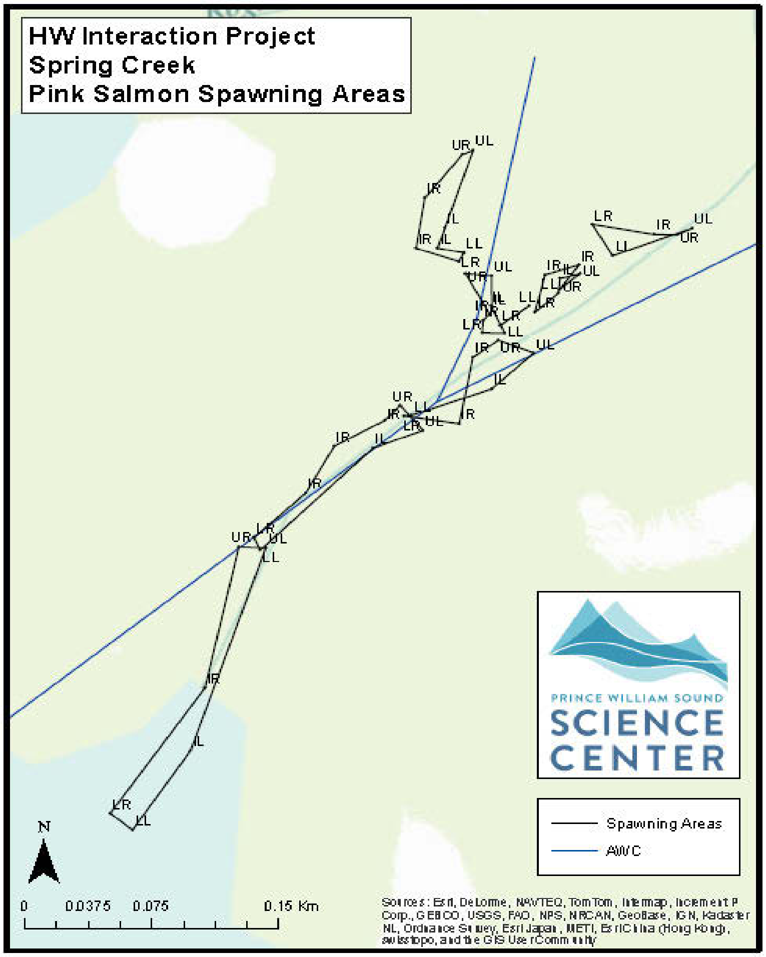

Figure 16. An example of the spawning area maps being developed for each fitness study stream's spawning areas.

DISCUSSION

Estimated region-wide fractions of hatchery strays on the spawning grounds were relatively low in PWS for Pink Salmon (0.04) and Chum Salmon (0.03) and in SEAK for Chum Salmon (0.07). Fractions varied by species and management unit (Tables 6, 7, and 10). In individual streams, a few exhibited high hatchery fractions, some exhibited medium hatchery fractions, but a majority of streams had low or no hatchery strays (Tables 3, 4 and 8). Results for 2013 generally reflect the same patterns of higher 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) for summer run Chum Salmon in SEAK (compare Figures 13-15 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. Studies reported here have been repeated in 2014 and 2015 (Knudsen et al. 2015).

REFERENCES

Botz, J., T. Sheridan, A. Wiese, S. Moffitt, R. Brenner. 2014. 2013 Prince William Sound area finfish management report. Alaska Department of Fish and Game, Fishery Management Report No, 14-43, Anchorage.

Brenner, R. E., S. D. Moffitt, and W. S. Grant. 2012. Straying of hatchery salmon in Prince William Sound, Alaska. Environmental Biology of Fish 94:179-195.

Cochran, W. G. 1977. Sampling techniques. John Wiley & Sons, New York.

Knudsen, E., M. Buckhorn, K. Gorman, P. Rand, M. Roberts, B. Adams, V. O’Connell, D. Bernard. 2015. Interactions of Wild and Hatchery Pink Salmon and Chum Salmon in Prince William Sound and Southeast Alaska. Final Progress Report for 2014, For Alaska Department of Fish and Game Contract IHP-13-013, Cordova, Prince William Sound Science Center, Alaska.

Piston, A. W. and S. C. Heinl. 2011. Chum salmon stock status and escapement goals in Southeast Alaska. Alaska Department of Fish & Game, Special Publication Number 11-21, Anchorage.

Piston, A. W., and S. C. Heinl. 2012. Hatchery Chum Salmon Straying Studies in Southeast Alaska, 2008–2010. Alaska Department of Fish and Game, Fishery Manuscript Series No. 12-01, Anchorage.

R Core Team (2014). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL http://www.R-project.org/.

Thompson, S. K. 1992. Sampling. John Wiley & Sons, New York.

RUN SIZE AND SPAWNING ABUNDANCE

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

Abundances of spawning Pink Salmon and Chum Salmon in both Prince William Sound (PWS) and Chum Salmon in Southeast Alaska (SEAK) are not directly estimated. Rather, they are 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 2013 allowed estimates of the spawning populations' hatchery fractions, 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 spawning 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, the fishing fleet tends to concentrate effort near hatcheries on the more abundant hatchery returns. The effect of this is the proportion of hatchery fish in the harvest is not a good indicator of the proportion of the total return so 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 the run size estimates were attempted 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.

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, in cost recovery, and rack return);

C_H is the "catch" of hatchery fish (in the common property, 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

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

$$S_H = R_H - C_H = \frac{C_W - bC_H}{a-b} - C_H \tag{6}$$

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

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

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 [$\mathbf{x}_1$, $\mathbf{x}_2$, … $\mathbf{x}_n$] 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

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

The approximate variances are therefore

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

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 2013 are:

	p	q	C_W	C_H
Estimate→	0.679	0.0427822	17,398,715	69,186,572
Variance→	0.0002688	0.00063916	940000000	940000000

and for PWS Chum Salmon in 2013 are:

	p	q	C_W	C_H
Estimate→	0.725	0.0535296	247,017	2,957,291
Variance→	0.0003604	0.00119162	940000000	940000000

where ***p***, ***q***, $\boldsymbol{C_W}$, and $\boldsymbol{C_H}$ are estimates from ocean, stream, and catch sampling programs[9]. 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[10].

The estimates and variances from the numbers provided above are:

	PWS Pink Salmon			PWS Chum Salmon		
Factor	**Estimate**	**Approx SE**	**Approx CV (%)**	**Estimate**	**Approx SE**	**Approx CV (%)**
$\hat{R}_H$	69,888,190	117,844	0.17	3,007,859	32,004	1.06
$\hat{R}_W$	33,096,875	2,541,682	7.68	1,141,130	111,661	9.79
$\hat{S}_W$	15,698,160	2,541,874	16.19	894,113	115,972	12.97
$\hat{S}_H$	701,618	113,607	16.19	50,568	6,559	12.97
$\hat{R}$	102,985,065	2,428,481	2.36	4,148,989	113,337	2.73
$\hat{S}$	16,399,778	2,428,481	14.81	944,681	113,337	12.00

[9] Note the "^" are missing from the identifiers.
[10] HINT: Hardly affects precision of estimates at all.

DISCUSSION

Our 2013 estimate for PWS Pink Salmon spawning abundance (about 16.4 million, from $\hat{S}_W + \hat{S}_H$) is approximately 1.2 times larger than ADF&G's estimate of 13.4 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 the 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 Salmon and Chum Salmon aerial survey program in recent years, leading to fewer surveys being flown, and increasing duration between surveys (T. Sheridan, Pers. Comm.). Fewer aerial surveys were flown in 2013 than any year since 1976 due in part to poor weather conditions in late August and early September (Botz et al. 2014). Bue et al. (1998) documented that the accuracy and precision of area-under-the-curve estimates decreased as the interval between surveys increased. Another statistic of interest not in the table above is the estimated Sound-wide harvest rate of wild fish $(\hat{C}_W / \hat{R}_W)$ which is 52.6% for PWS Pink Salmon in 2013 and 21.6% for PWS Chum Salmon in 2013. The low chum salmon harvest rate likely speaks to the fact that most PWS fisheries do not target, and are not managed for, wild chum salmon (Fair et al. 2008).Otherwise, a record wild stock Pink Salmon run combined with record hatchery Pink Salmon returns warranted a liberal fishery management approach by ADF&G in 2013, resulting in significant time and area opportunity for commercial harvest throughout PWS.

REFERENCES

Botz, J., T. Sheridan, A. Wiese, S. Moffitt, and R. Brenner. 2014. 2013 Prince William Sound area finfish management report. Alaska Department of Fish and Game, Fishery Management Report No. 14-43, Anchorage.

Bue, B. G., S. M. Fried, S. Sharr, D. G. Sharp, J. A. Wilcock, and H. J. Geiger. 1998. Estimating salmon escapement using area under the curve, aerial observer efficiency, and stream-life estimates: The Prince William Sound pink salmon example. North Pacific Anadromous Fish Commission Bulletin No. 1: 240–250.

Fair, L. F., S. D. Moffitt, M. J. Evenson, and J. Erickson. 2008. Escapement goal review of Copper and Bering rivers, and Prince William Sound Pacific salmon stocks, 2008. Alaska Department of Fish and Game, Fishery Manuscript No. 08–02, Anchorage.

FRY SAMPLING IN STREAMS

Authors: Laurinda Marcello, Eric Knudsen

INTRODUCTION

As part of the Hatchery/Wild Interaction Project there are ten intensively-sampled fitness study streams that will be sampled through 2015. Six Prince William Sound streams will be sampled every summer for DNA tissues from post-spawned Pink Salmon and four SEAK streams will be sampled for DNA tissues from Chum Salmon. These same streams will be re-sampled in March and April of the following year to collect pre-emergent alevins that will be used in a parentage analysis by ADF&G's Gene Conservation Lab to compare relative survival between wild, hatchery, and hatchery x wild offspring.

Full spring collections begin at all ten streams in 2014. To prepare for that full spring sampling effort, we conducted preliminary reconnaissance in March 2013 and tried various hydraulic pump set-ups, examined project protocols (see Appendix F), and tested collection methods of alevin at Fish Creek near Juneau.

METHODS

All activities described here occurred on March 19-20, 2013 at Fish Creek in Juneau, AK (AWC number 111-50-10690). Fish Creek was largely frozen over and had low water levels during our visit. Much of the area where chum Salmon had spawned the previous summer was dewatered and the substrate was frozen solid.

Our primary goals were to test equipment, pumping methods, and protocols for alevin collection. We attempted collection of Chum Salmon alevin at 14 within-stream sites. All sites were on the downstream side of the walking trail's bridge. Most sites sampled were in watered stream channels, but we also attempted to sample a few dewatered sites where fish spawned during the previous summer (as far as the frozen and dry conditions would allow). We used two different hydraulic pumps (Briggs & Stratton model unknown; Honda 1.5-inch portable water pump, model WX15AX2) and various probes to extrude alevin from the creek's substrate.

The end of the pump's intake hose was submerged in the stream and water travels through the pump and outtake hose to the probe. The probe was contained within a cylindrical metal and mesh basket to capture the alevins. Once the probe was inserted into the gravel, we checked the sample basket frequently for live alevin. In general, pumping times lasted between 3 and 5 minutes per sample site. The alevin, if any, of each pump site were then transferred from the cod-end of the mesh into a plastic tub for identification by species and disposition. Chum Salmon alevin were then collected, up to 25 per sample site, and preserved in ethanol. The preserved alevin were personally delivered to the ADF&G Gene Conservation Lab in Anchorage.

RESULTS

Of the 14 sites we sampled, only three sites contained live fish. We found a total of 107 Chum Salmon and retained a total of 42 Chum Salmon from three sites for the ADF&G Gene Conservation Lab. All other Chum Salmon alevin, save 5 mortalities, were returned to the creek live. Additionally, we identified and released 23 Pink salmon alevin. A summary of results, by species, date, and disposition are listed in the table below.

Dewatered sites were impossible to sample if the substrate was frozen more than 1-2 inches. We were able to partly sample several dewatered sites that were close to the water's edge although we only found a few dead and decaying alevins in those sites.

Species	**Disposition**	**19-Mar**	**20-Mar**	**Totals by Disposition and Species**	
Pink Salmon	G - genetic samples taken	0	0	G	0
	ID - ID'ed and released	0	23	ID	23
	M - unintended mortality	0	0	M	0
	All dispositions	**0**	**23**	**Total Pink salmon alevin**	**23**
Chum Salmon	G - genetic samples taken	17	25	G	42
	ID - ID'ed and released	0	60	ID	60
	M - unintended mortality	0	5	M	5
	All dispositions	**17**	**90**	**Total Chum Salmon alevin**	**107**
				Total of all collections	**130**