Interactions of Wild and Hatchery Chum Salmon in Southeast Alaska

Report for 2023

For Alaska Department of Fish and Game Contract CT 160001756

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January 22, 2023

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ABSTRACT

The Sitka Sound Science Center, under contract by the Alaska Department of Fish & Game (ADF&G), conducted data collection for an investigation of the impact on fitness (productivity) of wild Chum Salmon due to straying of hatchery Chum Salmon. This is the seventh in a series of annual progress reports on data collection and analysis. During the 2023 field season, we sampled 6,650 individual Chum Salmon carcasses and tagged 283 live Chum Salmon for mark/recapture analysis during repeated visits to the spawning grounds of one Northern Southeast Alaskan stream, Fish Creek (AWC 111-50-10690). This stream has been sampled for this research since 2013. The relative reproductive success (RRS) for each fish will be analyzed through DNA extraction from collected tissue samples of carcasses and live Chum Salmon. Otoliths were collected from individual carcasses to assess the natal origins (hatchery versus wild) of Chum Salmon. Scales were collected to determine the age of both carcasses and tagged Chum Salmon during this study. Through mark/recapture analysis, we estimated the unstratified proportion sampled was 40% in Fish Creek with an estimated run size of 17,451 salmon. The majority (83.3%) of Chum Salmon sampled were of hatchery origin. The average lengths of returning Chum Salmon on Fish Creek in 2023 were small compared to the average size of both males and females observed over the past decade of surveys on this stream.

INTRODUCTION

The Alaska Department of Fish & Game (ADF&G), along with private-non-profit hatchery corporations, have engaged in research studies addressing concerns about straying and the genetic and ecological interactions between hatchery and wild salmon. These concerns relate to the value of hatchery-origin and wild stocks to Alaska salmon fisheries and the state mandate that hatchery production be compatible with sustainable productivity of wild stocks. The Hatchery-Wild Interactions Project began in 2011 to address these concerns. Initially, ADF&G convened a science panel that prioritized three major questions in Southeast Alaska:

1) What is the genetic stock structure of Chum Salmon (*Oncorhynchus keta*) in Southeast Alaska (SEAK)?
2) What is the extent and annual variability in straying of hatchery Chum Salmon in SEAK?
3) What is the impact on fitness (productivity) of wild Chum Salmon due to straying of hatchery Chum Salmon?

The first two objectives were addressed by tissue sampling from spawned out Pink and Chum Salmon in 64 streams across Prince William Sound and Southeast Alaska between 2013 and 2015. Estimates of the percent of hatchery-origin salmon for each stream, district, and regional spawning population over three years are now complete (Knudsen et al. 2016; Knudsen et al. 2021). The Sitka Sound Science Center (SSSC) was contracted by the ADF&G to collect genetic and life history samples from post-spawned summer Chum Salmon in the Northern Southeast region of Alaska beginning in 2017 to address the third objective. This report details the field summary and survey findings of one fitness stream for the 2023 field season. Similar studies of Pink Salmon in Prince William Sound were managed by the Prince William Sound Science Center and results reported elsewhere. The raw data are available and were submitted via the Hatchery Wild Application.

METHODS

Daily surveys of the study stream were intended to obtain samples for pedigree analysis and estimate the proportion sampled. Samples collected from each fish included otoliths, tissue samples for DNA analysis, scales, and meristic observations from post-spawned Chum Salmon. Crew also conducted a mark-recapture study to produce escapement estimates that could be used to estimate the proportion of the run that is sampled. Daily surveys were conducted in one study stream, Fish Creek (AWC 111-50-10690, in Southeast Alaska (Figure 1). Each day, the crew also recorded the count of live fish, dead fish, and previously sampled fish. The crew also recorded weekly live counts of Pink Salmon and documented any other Pacific salmon species observed.

Logistical Strategy

SSSC was contracted to sample Chum Salmon throughout the entire run in Fish Creek, on Douglas Island, SEAK (Figure 1). Sampling focused on post-spawned summer Chum Salmon between July 21 through August 27, 2023.

Figure 1. Location of Fish Creek (AWC 111-50-10690) sampled by the SSSC field crew in 2023.

A six-person field crew was employed and supervised by two permanent staff from SSSC who functioned as Project Coordinators. The field crew was split into two teams to maximize sampling coverage on Fish Creek, each with a crew lead and two technicians. Crew leaders were given responsibility to maximize efficiency and achieve sampling goals when Project Coordinators were not present. Five days prior to mobilization, crews were trained in Sitka, Alaska. Training included field sampling procedures, bear, CPR and basic first aid, tablet use, and data entry and quality control. Once in Juneau, the crew was trained for an additional two days in water safety skills and additional sampling procedures. Refer to Appendix A for further information on improved sampling efficiency through training procedures.

<u>Pedigree Stream Sampling Methods and Execution</u>

The study plan called for surveying the stream from tidewater to the highest extent of salmon migration. The starting location was determined by crew leaders, depending on tide stage, stream turbidity, flow, and carcass density. The crew would split into two teams, with one team starting in the lower intertidal zone, while the other starting in the upper stream reach. Both teams would survey towards one another, meeting in the middle. On days where high flow prevented a crew from completing a full survey stretch of the study stream, sampling would concentrate in accessible areas of high Chum Salmon carcass density. Crew members began targeting Chum Salmon collection after locating GPS points for the survey. After collecting a satisfactory amount of Chum Salmon carcasses, the latitude and longitude of the processing area was marked on a tablet and sampling began. All efforts were made to sample the entire study stream length when conducting surveys for pedigree analysis, accounting for factors such as carcass availability, the tide stage, and bears. On days where tagging was scheduled, the crew starting at the intertidal zone would perform a pedigree survey in the first half of the stream then switch over to tagging efforts, while the crew starting at the upper stream would cover the remaining pedigree survey.

Carcasses were sampled as they were encountered. While the initial goal was to sample 100% of carcasses, high density of returns led to a modified sampling strategy. In locations where large numbers of carcasses were observed, carcasses were haphazardly subsampled to allow time for processing carcasses in other sections of the stream. Subsample goals were set each day depending on the density of carcasses, determined by the Project Coordinators and crew leads.

Carcass sampling was intended to determine the sex, size, age, origin, and pedigree. For each carcass the sex, length (mm) from mid-eye to hypural plate (MEHL), and body depth (mm) was recorded. Four scales were collected for age analysis, both sagittal otoliths removed to determine origin, and cardiac tissue (bulbus arteriosus) sampled for pedigree analysis. In addition, the carcass recovery date and condition were recorded. Each carcass was examined for the presence of tags (opercular fin punches and Floy tags) associated with the mark-recapture analysis (described below). Carcasses were aligned in rows of eight by six, mimicking the 48 deep well plates (DWP) samples were stored in. Once collected, otoliths, tissue samples, and recovered Floy tags if present, were stored in high concentration ethanol. When the survey was complete and both teams met up, a crew member marked the GPS end location of the survey, combined the count numbers from each team into a final total, and made any additional comments. A quality control review of the collected data was conducted after every survey, comparing collected tablet data to otolith and DNA samples in the DWP, then electronically delivered to ADF&G once reviewed (Appendix A).

<u>Proportion of Run Sampled Methods and Execution</u>

A mark-recapture study was incorporated into the sampling to provide precise estimates of Chum Salmon run size and estimate the proportion of the run sampled for pedigree analysis. The
The mark-recapture study consisted of periodic sampling of live Chum Salmon entering Fish Creek, double marking them, and releasing them. The recapture phase coincided with carcass sampling. For mark-recapture surveys, efforts were made to maximize the number of live Chum Salmon tagged, with efforts dependent on the density of untagged pre-spawn summer Chum Salmon, stream flow and turbidity, and the ability to complete a full pedigree survey on that same day.

The tagging of pre-spawn Chum Salmon was conducted over a period of approximately four weeks. Tagging began on July 22 and was conducted every other day until August 21. All marking ceased the third week of August due to the incoming fall chum run and to allow all tagged salmon sufficient time to spawn. Live fish for tagging and release were captured at a fixed location using beach seines, dip nets, and by hand. Release locations were far enough upstream to minimize the number of probing fish that might emigrate the stream after tagging.

Captured chum salmon were processed similarly to the methods described above for pedigree analysis, with a few exceptions. Once captured, fish were given uniquely numbered Floy tags and unique opercular punches that corresponded to the week of release. The date of tagging, tissue samples (axillary process) for genetic analysis, two scales, sex, spawning state, and length were taken for each fish, and released back into the stream. Lengths of tagged fish were recorded at tip-of-snout to fork-of-tail (SFL) to minimize handling. The lengths of subsequent recaptures were recorded as MEHL. The lengths of all tagged and released fish were converted to MEHL using a linear regression of the MEHL on SFL for the recaptures. Release data were recorded in the field using the HWI computer application. A "Survey Type" field distinguished release samples from recapture samples. A quality control review of the collected data was conducted after every survey, comparing collected tablet data to Floy tag numbers and DNA samples in the DWP, then electronically delivered to ADF&G once reviewed (Appendix A).

1.1 Estimation of the Proportion Sampled

The proportion of the run sampled for each of the streams was calculated using the ratio of the number of unique samples collected to the estimated run size. The number of unique samples (N_u) is the sum of the number of tagged fish released and the observed number of unmarked carcasses. Run s $\hat{N}$ (   ) was estimated using Chapman's modification of the Peterson estimate:

$$\hat{N} = \left(\frac{(M+1)(C+1)}{R+1}\right) + 1 \qquad \text{equation 1}$$

Where M = is the total number of marks released, C is the number of carcasses inspected, and R is the number of recaptured fish. The variance estimator is given by:

$$V_{\hat{N}} = \frac{(M+1)(C+1)(M-R)(C-R)}{(R+1)^2(R+2)} \qquad \text{equation 2}$$

The proportion of the population sampled (P) is estimated as:

$$P = \frac{N_u}{\hat{N}} \qquad \text{equation 3}$$

Where N_u is the number of unique samples collected from the stream. The 95% confidence interval for the run size was estimated as

$$C.I. = 1.96 * \sqrt{V_{\hat{N}}} \qquad \text{equation 4}$$

There are several important assumptions underlying the Peterson estimator that must be examined to understand the potential for bias in the estimates. Specifically, these include:

1) Marking does not affect the catchability of a fish. This includes no mortality

associated with handling.

2) Fish do not lose marks between sampling events.
3) Recruitment and death of fish cannot occur between sampling events.

These assumptions were met in our study by holding marked fish briefly to ensure they recovered from the marking event. Fish were double marked to determine if the fish lost marks, and finally, marking and recovery occurred throughout the run which minimizes the possibility for recruitment into the stream during the study. There is some potential for emigration from the study, but we located our marking area above the high tide line to minimize any marking of fish probing the system. Removal by predators is another source of emigration, but our carcass surveys also examined areas along stream banks.

In addition, it is important that at least one of these three criteria are also met to minimize bias:

1. Every fish has an equal probability of being marked and released alive during the first sampling event.
2. Every fish has an equal probability of being captured during the second sampling event.
3. Marked fish mix completely with unmarked fish between sampling events.

The criteria were examined by analyzing the proportion of males and females and the size distributions of fish collected in the marking and recovery events. Comparisons of the proportion of males and females employed Chi-square analysis of the proportion of Marked and Recaptured fractions of the data set. Rejection of the null hypothesis led to the conclusion samples were biased with result to sex in the recovery data (Failure of criterion 2). Comparisons of the sex ratios in the Captured and Recaptured fractions that rejected the null hypothesis led to the conclusion that sampling was biased in the marking event (Failure of criterion 1). Comparisons of the ratios in the Marked and Captured fractions were used to examine criterion 3. A similar process was used to compare lengths relative to criteria 1 through 3 with Chi-square analysis, comparing the proportion of small versus large fish. Critical values for hypothesis testing relied on α = 0.05.

Stratified estimates of the proportion sampled were calculated as:

$$\text{C.I.} = 1.96 * \frac{\sum N_u}{\sum \hat{N}} \qquad \text{equation 5}$$

RESULTS

Survey timing and coverage:

The study stream was surveyed throughout the 37-day field season in 2023, yielding an unprecedented number of samples for pedigree analysis. Sampling lasted from July 21 to August 28 for Fish Creek. Fish Creek had 34 unique stream visits. Crew members recorded lengths, identified sex, and collected DNA tissue samples, scales, and otoliths (carcasses only) from over 6,933 samples representing 6,650 chum carcasses and 283 live Chum Salmon (Table 1). Compared with an average of 1,160 carcass samples collected annually from 2013 and 2022, 2023 was clearly an above average year for sampling numbers.

Table 1. Starting and ending dates from Chum Salmon stream surveys and gross counts of live chum, dead chum sampled, live chum sampled, the number of otolith samples collected (including 1 missing), and the number of scale samples (carcass and mark/recapture surveys combined) collected in 2023.

	Start Date	End Date	Cumulative Live Observed	Number carcasses sampled	Number live fish sampled	Number otolith samples	Number scale samples
Fish Creek	7/21/2023	8/28/2023	39,502	6,650	283	6,602	6,775

Live chum counts in Fish Creek had a somewhat bimodal distribution, while the number of Chum Salmon samples had a more uniform distribution pattern (Figure 2). Peak live counts were the highest during the last week of July, with 2,865 live Chum Salmon observed on July 27. Live counts declined in the following week, but reached a secondary maximum of 2,153 live fish counted on August 4. The highest number of dead fish was 3,452 Chum Salmon observed on August 9. The peak number of samples collected did not correspond to the peak number of dead fish observed in the stream due to the extremely high number of carcasses. Starting on July 30, crews began to subsample carcasses after determining that they could not keep up with total carcass numbers. Crew leads set a goal of subsampling at least 10% of total carcasses encountered on the creek each day, which was achieved for every survey except August 5 (7% subsampled) and Aug 9 (8% subsampled). This translated into crews collecting between 130-420 samples each survey day from July 30 to August 23. Although total dead counts dropped by late August and crews no longer had to deliberately subsample from available caracasses by August 26, the state of decomposition of remaining carcasses in the stream prevented crews from sampling 100% of dead fish in the final week of the field season.

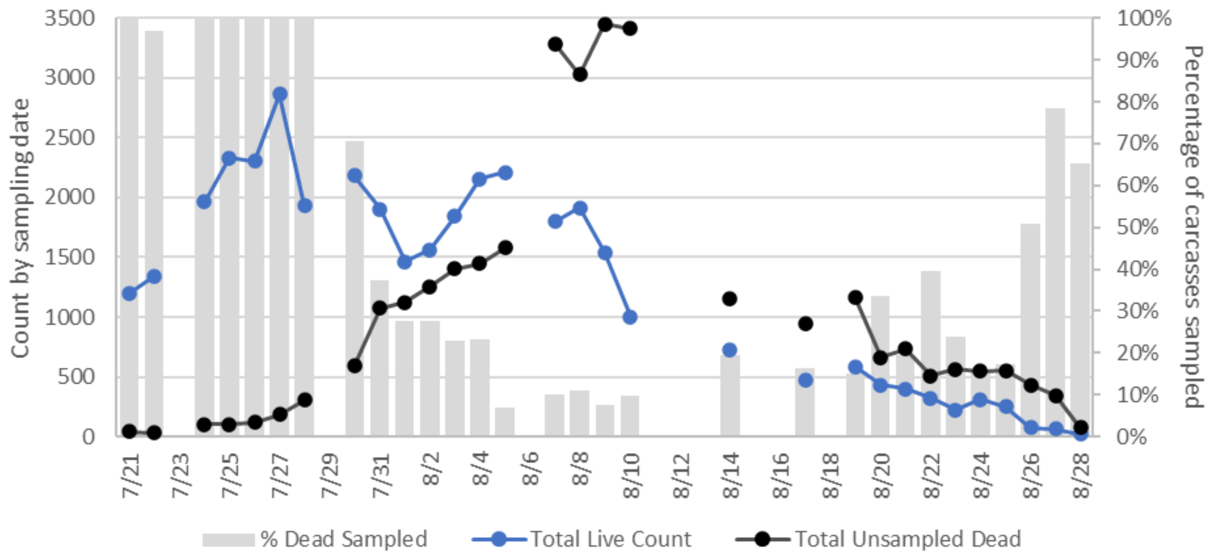

Figure 2. Daily counts of live and dead Chum Salmon on Fish Creek by survey date. Gray bars indicate the percentage of previously-unsampled carcasses that were sampled by survey date.

Weather was relatively mild for the majority of the 2023 field season, with a few poor weather days leading to canceled surveys in mid-August. Three carcass surveys were modified due to logistical constraints (July 23, August 11, August 15), and three surveys were canceled (August 12, August 13, August 16) due to high water. The terrain and nature of Fish Creek, with it being the main drainage for a large portion of North Douglas Island, led to major flooding episodes that made surveying impossible during high precipitation events.

Sex Ratio:

The sex ratio of sampled Chum Salmon differed between carcass surveys and mark/recapture surveys for the 2023 field season. Sex ratios were skewed towards female for carcass sampling. In Fish Creek, 60.2% of chum carcasses were female, 39.6% male, and <1% sex unknown. It was observed that a higher percentage of male salmon were present at the beginning of the survey season. The sex ratios in Fish Creek observed in 2023 fall within the range documented in this stream since 2013 (Figure 3; average 56.8% female). For the mark/recapture analysis, sex ratios were evenly distributed between males and females in 2023. In Fish Creek, 49.5% of the tagged Chum Salmon were female and 50.5% were male.

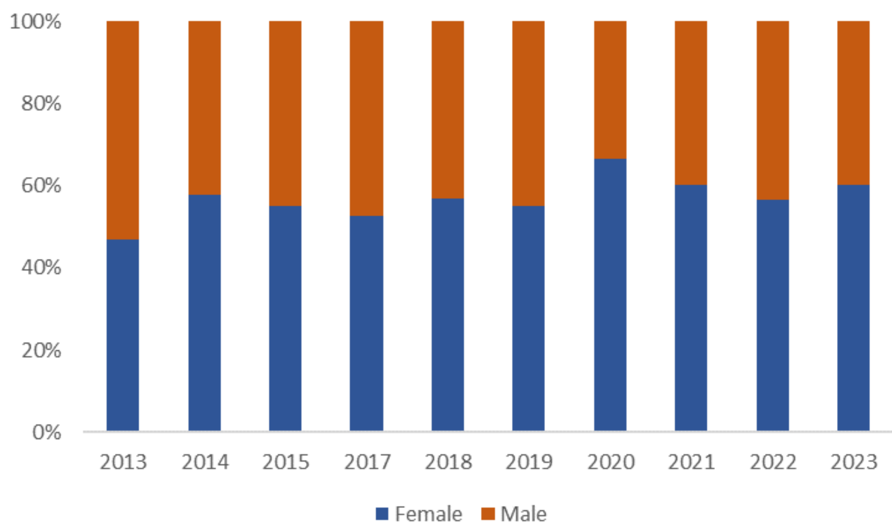

Figure 3. Sex ratio of carcasses surveyed in Fish Creek 2013-2023 by percent of total fish sampled.

Size:

Two types of length measurements were taken for the 2023 season. The length from mid-eye to hypural plate (MEHL) was used to measure chum carcasses, while the length from the snout to the caudal fork (SFL) was used to measure live Chum Salmon. SFL measurements for all fish were corrected to MEHL by regressing the MEHL observed for the recaptured fish on their SFL ($r^2 = 0.704$, $p < 0.001$) recorded at tagging. The resulting model was applied to all tagged fish (Table 2). Comparing the average corrected MEHL of tagged live chum to the average MEHL of carcasses, live females were smaller than carcass females, while live males were larger than carcass males for Fish Creek. For both live and carcass sampled surveys, males had a greater average length than females.

Table 2. Live Chum Salmon lengths by sex compared to carcass survey Chum Salmon lengths by sex for each survey stream. Standard errors for each value are in parentheses.

Stream	Average Female Carcass Survey MEHL (SE)	Average Male Carcass Survey MEHL (SE)	Average Female Tagging Survey Corrected MEHL (SE)	Average Male Tagging Survey Corrected MEHL (SE)
Fish Creek	483.7 (±0.44)	487.7 (±0.68)	476.7 (±1.95)	496.6 (±2.44)

Age:

Scales were collected from both chum carcasses and live chum, providing information on the age structure of the runs. Age data was received from the DIPAC fish aging lab in Juneau. Carcass and tagged live Chum Salmon scale loss rate for Fish Creek was 2.3% and 2.5%, respectively. This loss rate combines carcasses that were too decomposed to gather salvageable scales, as well as scales that were sampled but were unreadable due to inadequate preservation in the field. The higher level of scale loss seen for tagged live Chum Salmon could be attributed to the lower number of scales taken for each sample, two, compared to the four scales taken for Chum Salmon carcasses. The lower number of scales collected for live chum was a result of minimizing the amount of time Chum Salmon were out of the water, along with the increased difficulty of collecting scales from live fish.

The age distribution of Chum Salmon carcasses in relation to sex was analyzed. Fish Creek females averaged 4.1 years while males averaged 4.0 years. Tagged Chum Salmon averaged 4.0 years for both males and females (Figure 4). When comparing age classes, less than 1% of all Chum Salmon carcass samples were 6 years old, 11.7% were 5 years old, 78.7% were 4 years old, and 9.4% were 3 years old. For tagged live Chum Salmon, 9.4% were 5 years old, 78.3% were 4 years old, and 12.3% were 3 years old.

The lengths of four year old pedigree sampled and tagged live Chum Salmon in 2023 were below average for both males and females when compared with the past ten years of sampling data for Fish Creek (Figure 5).

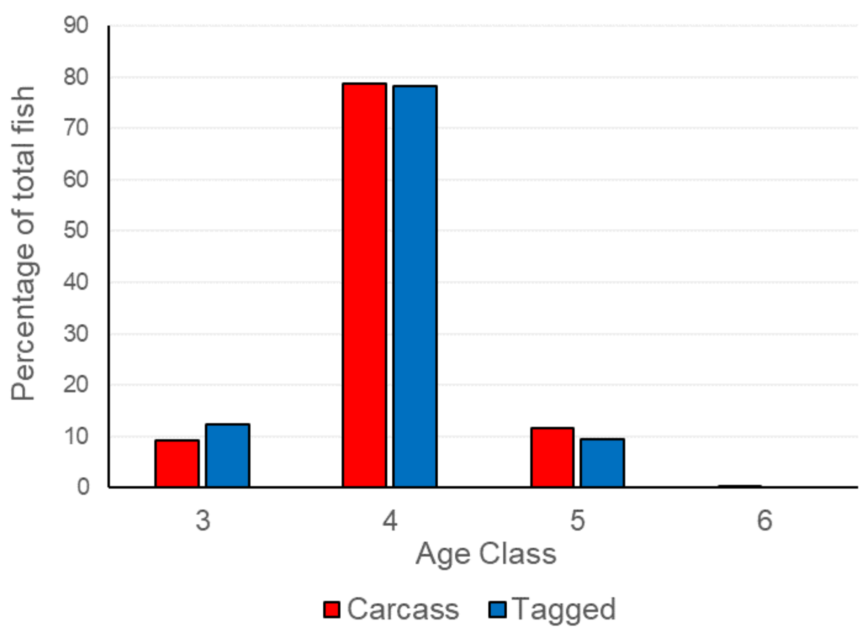

Figure 4. Age distribution of Chum Salmon carcasses counted or tagged in 2023, by percentage of totals in each category.

Figure 5. Average length of four year old Chum Salmon carcasses surveyed on Fish Creek from 2013 to 2023, by sex. Error bars represent standard error for that sampling year.

Origin:

Otolith samples (N=6933) were submitted to the ADF&G Mark Tag and Aging Lab at the end of the field season, with data reported back to SSSC on January 8, 2024. Otolith reads indicated that 83.3% of sampled Chum Salmon were of hatchery origin, with the vast majority originating from the Douglas Island Pink and Chum, Inc. (DIPAC) hatchery in Juneau (Table 4).

Table 4. Origin data of sampled Chum Salmon on Fish Creek in 2023

Otolith mark ID	Count	percent of total fish sampled
Deep Inlet	1	0.01%
DIPAC	5748	82.91%
Hidden Falls	23	0.33%
Sheldon Jackson	1	0.01%
Thomas Bay	1	0.01%
NA (non-hatchery origin)	1159	16.72%

Proportion of Run Sampled:

Marking began on the second day of sampling in each creek and ended approximately one week before the end of sampling (Figure 6). Protocols called for tagging to be conducted every other day until the beginning of the last week of August. Fish were to be captured at fixed locations ("staging areas") using beach seines or dip nets. These locations were located near or just beyond the tidal influence. The use of a newly designed beach seine assisted in the capturing of Chum Salmon, though most fish were caught by dip net. Catchability was highest for fish intending to spawn in the lower spawning area reach. Table 5 summarizes the number of tagged fish released (M in equation 1), the number of recaptures (R in equation 1) and the number of carcasses examined for tags (C in equation 1).

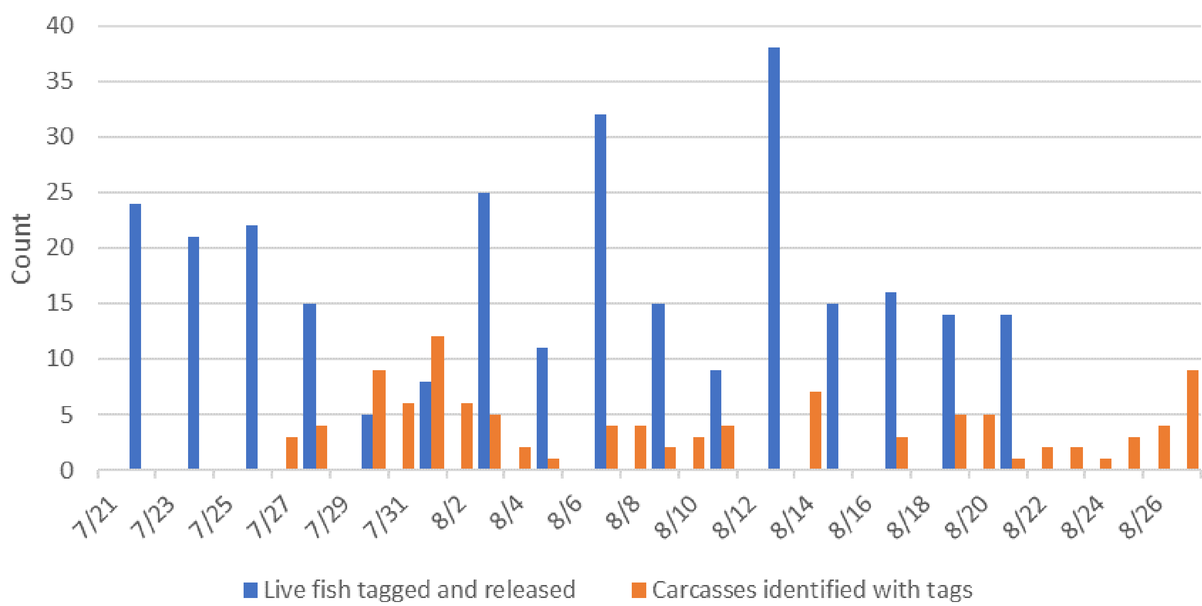

Figure 6. Counts of tags deployed and recovered, by date. Note that tagging of live fish occurred every other day from July 22 to August 21

Table 5. Marks released (M), recaptures (R) and the number of carcasses inspected (C) in Fish Creek. Recaptures include all fish with mutilated opercula. Percent lost tags is the percentage of R for which no Floy tag was observed. Fish with unknown sex or size not measured are included in totals.

	M	R	% Lost Tags	C
Total	283	107	1.9	6,650
Males	140	64	2	4,003
Females	143	43	0	2,632
<= 485 mm	138	55	0	3,226
>485 mm	144	50	1.0	3,218

Examination of the sex ratios observed in the different fractions indicated the presence of bias with respect to sex in the Fish Creek sample as indicated by the rejection of the null hypothesis for the comparison of the sex ratios in M vs. R (second sampling event) and M vs. C (Table 6). Thus, the probability of sampling a given sex varied between the mark/release period and the capture/recapture period. Similarly, analysis of the lengths indicated evidence of some unknown size bias in Fish Creek during the capture/recapture phase. Consequently, population estimates were made for all the fish combined in each stream and broken down by sex and size. Fish were partitioned into size classes "small" (<= 485 mm) or "large" (> 485 mm) based on the median length observed for all sample types (Table 7).

Table 6. Results of $\chi 2$ testing on length frequency distributions in different fractions of the mark-recapture data sets for each stream. M is the marked and released fraction, R is the recaptured fraction and C is the fraction representing the second sampling event.

Comparison	M vs. R	C vs. R	M vs. C	Conclusion
Sex Bias	**Reject H_0**	Accept H_0	**Reject H_0**	Bias in the first event, bias in the second event
Size Bias	Accept H_0	**Reject H_0**	Accept H_0	

The estimated proportion sampled in Fish Creek ranged minimally in relation to sex bias. Estimated run sizes, the number of unique samples, and the 95% confidence intervals for the proportion sampled are given in Table 6. Unstratified and stratified estimates regarding sex bias for the proportion sampled were 40%. The estimated run size was 17,490 salmon. Stratified estimates for run size and the percentage of the un sampled was equal to the estimates made without stratification.

Stratified estimates of the percentage of the run sampled regarding size (using the proportion of "small" fish to "large") for Fish Creek varied minimally compared to estimates made without stratification (less than 2%). Comparing the estimated proportion sampled stratified by sex versus by size varied by 3%. Comparing sex versus size bias of stratified samples were nearly equal in Fish Creek.

Table 7. Run size estimates, the number of unique samples, and the estimated percentage of the run sampled in Fish Creek. Stratified estimates do not include unknown sex specimens.

Stream	$\hat{N}$	$V_{\hat{N}}$	N_u	Percent sampled	95% CI of percent sampled
Fish Creek - total	17,490	1,710,885	6,933	39.6	34.5-46.4
female	8,617	1,126,750	2,775	32.0	25.9-42.5
male	8,686	606,097	4143	47.7	41.0-57.9
sex stratified	17,703	1,732,847	6918	40.0	34.8-47.0
size <= 485 mm	8,010	660,446	3,364	42.0	35.0 - 52.4
size >485 mm	9,152	1,027,681	3,362	36.7	30.1 - 46.9
size stratified	17,162	1,688,127	6,726	39.2	34.1 - 46.0

DISCUSSION

For the 2023 season, Chum Salmon returns throughout Southeast Alaska were well above average. Preliminary estimates from ADF&G suggest the 2023 commercial harvest in Southeast Alaska was 15.5 million Chum Salmon, a 55% increase compared to the ten-year average for SE Alaska (~10 million salmon) (Information Services Section, Division of Commercial Fisheries 2023). This was over 6 million more Chum Salmon estimated compared to 2022 (~9.4 million fish). Coincidently, the numbers of live chum observed in our surveys were above our ten-year average for Fish Creek.

An above average number of carcass and tagging samples were collected compared to the average number of samples collected between 2013 and 2022. Comparing the 10-year average to 2023, there was a 473% increase in the number of carcasses sampled. Comparing the 2-year average to 2023, there was a 31% increase in the number of live Chum Salmon tagged at Fish Creek. The increased number of samples collected may have resulted from a combination of increased Chum Salmon returns in SE Alaska as well as an increase in crew size assigned to Fish Creek relative to prior sampling years. As mentioned above, little effort had to be made to locate chum carcasses for sampling, as incredibly high concentrations of carcasses were found throughout the extent of the stream. This in turn made tagging efforts easier as chum salmon returned in high concentrations. Unlike previous years, sampling efforts targeted only a single stream to maximize the number of samples taken in this last field season. Crew sizes in the past consisted of a single crew lead and 3 fishery technicians. In 2023, the crew consisted of two crew leads, each with a team of two fishery technicians. The two project coordinators periodically joined sampling efforts for approximately 50% of the season. Having an increased crew presence at Fish Creek resulted in an increased efficiency in sample gathering.

From our first two years of mark/recapture sampling, we learned that Chum Salmon do not gather in large numbers in staging areas before moving upstream, making capturing and subsequent tagging in large numbers difficult. Using a newly designed beach seine net with a deep middle pocket was moderately effective in capturing salmon. The beach seine net was most useful when deployed downstream on congregating Chum Salmon, acting as a barrier for crew to use dip nets to land the fish. Overall, the crew heavily relied on dip netting to sample salmon for marking and release.

Despite conscious effort to minimize sampling bias when tagging, biases were present for mark/recapture sampling. We hypothesize that these sex and size ratio biases are mostly a result of sex-specific differences in run return timing. Male spawners tend to move into freshwater first to compete for spawning territory before females arrive (Auld et al. 2019). Indeed, our crew observed that the majority of encountered fish were males at the beginning of tagging, but there was a distinct change in the proportion of males versus females present during the midpoint of the field season. However, these biases did not materially affect the estimated run size or estimated sampling fraction. Additionally, despite the need to repeatedly subsample carasses throughout this field season, estimates of the sampling fraction (~40%) were consistent with previous years when run sizes were much smaller.

Unlike previous years, weather was not a major hindrance to sampling efforts. Only a few poor weather days led to canceled or modified surveys, with only three surveys canceled in mid-August and three surveys modified throughout the sampling season. The terrain and nature of Fish Creek, with it being the main drainage for a large portion of North Douglas Island, led to major flooding episodes that made surveying impossible during high precipitation events. When modifying a survey effort, the crew assessed the water level and flow of the stream that day and determined sampling could be done but only in specific sections of the stream. In sections where the crew determined the survey was too unsafe, they walked along the edge of the stream if possible or went back up the trail until they encountered favorable conditions again.

Chum Salmon in Fish Creek in 2023 were small compared to prior survey years. The smaller than average size of fish was distinct enough in the field (Figure 7) to cause returning field crew from prior project years to initially hypothesize that they were observing younger than average fish. However, after age analysis was completed, the mean age of return was approximately four years for both male and female fish, comparable to prior sampling years. The notable decrease in size of both male and female Chum Salmon in Fish Creek over the course of this study warrants further consideration.

Figure 7. Chum Salmon prepared to be processed at Fish Creek in 2023. The male carcass in the upper left row was identified by crew leads as the ‘typical’ size of a male surveyed in prior years, whereas all other fish pictured are representative of the average male Chum Salmon encountered in Fish Creek in 2023.

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Appendix A: Sampling Equipment & Data Quality Improvements

Most sampling equipment worked well in 2023. We had issues using the seine nets for the mark-recapture study due to a lack of adequate staging areas where Chum Salmon were gathering in sufficient numbers. We also had issues with clickers freezing from rust. Despite these equipment setbacks, crew members felt well prepared and satisfied with the equipment used in the field.

Communication between field crew and project coordinators was effective and frequent. The use of cell phones allowed crews to remain in contact with the SSSC project coordinators and field support staff throughout the season. Sample numbers, field logistics, schedule revisions, field crew requests, and other challenges were discussed throughout the season. The project coordinators also maintained communication with ADF&G Area Management Biologists in Juneau with updates on fish numbers, as well as stream and sampling conditions. Updates were also communicated to ADF&G project supervisors and the HWI science panel.

The laptop application allowed for easy review of all field data and data were submitted after returning to base. Prior to data transmission, the laptop application prompted a complete review of the samples collected and required the identification of milestone cells (missing otolith, last specimen, etc.). Once these checks were complete, the surveys were transmitted to the Hatchery-Wild Database via the internet. Data was backed up on multiple storage devices daily by field crew. The Hatchery-Wild Database was critical to acquisition of error-free data and was used by project personnel throughout the season to produce reports, conduct data checks, and confirm survey transmission. The database was also used during the season to conduct final quality assurance checks prior to delivering otolith and DNA tissue samples to the ADF&G Mark, Tag, and Age Lab in Anchorage and scales to the Douglas Island Pink & Chum lab in Juneau.