

Juvenile Salmonid Dietary Investigation for Three Streams on Joint Base Elmendorf-Richardson, Alaska

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INTRODUCTION

Salmon are an important food source for endangered Cook Inlet belugas, and spawn in five waterways on Joint Base Elmendorf-Richardson (JBER). Not much is known about the health and abundance of salmon rearing in JBER waters. This study investigated the diets of juvenile coho salmon rearing in three of these waterways: Otter Creek, South Fork Chester Creek, and Sixmile Creek. Coho are the most abundant salmon rearing in each of these streams; Otter Lake and Sixmile Lake also support populations of sockeye salmon.

Juvenile salmon are subject to variation in foraging performance that can affect their survival and abundance (Kennedy et al. 2008). If they do not consume sufficient prey they are likely to have reduced fitness that can lead to expenditures of more energy to obtain food (Giacomini et al. 2013), a lengthening of the time they are susceptible to size-dependent predation (Sogard 1997), the adoption of riskier behaviors to obtain food that leaves them more susceptible to predation (Biro et al. 2003), or starvation (Kennedy et al. 2008). Documenting coho prey diversity, quantity and origin will provide useful baseline data for future investigations into the fitness and overall condition of coho rearing in these systems.

OBJECTIVE

The main objective of this study was to document the type and quantity of food that juvenile coho are consuming in South Fork Chester, Sixmile, and Otter creeks within JBER. The study was designed to investigate changes in coho prey preferences in each of these streams from May through September.

METHODS

Identifying stream study reaches

In 2015, Schoofs and Zonneville (2016) performed assessments of physical habitat, benthic macroinvertebrates and fish in JBER streams, including South Fork Chester, Otter and Sixmile Creeks. As part of their study, they caught coho in all streams with a backpack electrofisher. We chose stream reaches that were easily accessible and either in or adjacent to their study reaches that yielded the highest density of coho. Refinement of the study reaches was done in the field while investigating suitable habitat for rearing coho. A map of the three study reaches is shown in Figure 1.



Figure 1. Study reaches on Sixmile, Otter, and South Fork Chester Creeks.

Measuring continuous water temperature

Prior to sampling, we deployed temperature loggers near the top and the bottom of each reach. We used Onset Hobo Water Temperature Pro v2 Data Loggers, set to collect temperature measurements every hour. They were deployed using ¼ inch coated cable attached using u-bolts to either rebar pounded into the stream bottom or looped around riparian trees. Data loggers were checked during each fish collection event (about every five weeks), to make sure that they were in the water and not buried by sediment. Loggers were retrieved on the last sampling day in September from each stream. Data were downloaded, checked for errors, and converted to daily means for all days with 24 measurements. Guidance for minimum data standards and protocols came from Mauger et al. (2014).

Coho field sampling

Juvenile coho were caught using minnow traps baited with commercially cured salmon roe monthly from May through September (Table 1). Traps used were 16.5 x 8.5 inches, with one-inch openings and ¼ inch steel wire mesh. Traps were attached to riparian vegetation with nylon cord. Each trap was numbered and labelled with the ADFG Fish Resource Permit number and contact information and affiliation of the Principal Investigator. Trap locations were marked with flagging tape. The deployment time for each trap was recorded on a data sheet (Appendix C).

Minnow traps were placed in pools, along undercut banks, and in backwater habitats likely to contain juvenile coho salmon. Traps were checked on a regular basis depending on catch rates, typically anywhere from 20 minutes to two hours. Fish from each trap were identified and enumerated by species. All captured fish were removed from the traps and placed in a five gallon (holding) bucket filled with aerated stream water. All non-target species were removed from the holding bucket and placed in a second five gallon (recovery) bucket with aerated stream water. Minnow traps were redeployed until the target number of 100 coho, of which 30 were 56mm fork length or longer, were captured or catch rates approached zero.

Coho were removed from the holding bucket, no more than five at a time, with an aquarium net and placed in a small container with a buffered 70 mg/L solution of MS-222. The solution was made by pre-weighing 70 mg of MS-222 in the lab, and placing the powder in a one-liter insulated Nalgene container that was then filled with stream water. The pH of the resulting solution was measured with pH paper and adjusted to circumneutral with a small amount of sodium bicarbonate, if necessary. Once coho began to lose their equilibrium, they were measured (fork length) and weighed (Figure 2). Prior research helped us set a minimum fork length size of 56 mm for gastric lavage. If the coho had a fork length of 56 mm or longer, we removed its stomach contents by holding the fish, head down, over a plastic funnel leading into an open Whirl-Pak, and flushing it with 20 ml of stream water from a syringe with a 7cm (1.7mm diameter) catheter (Figure 3). The fish was then visually inspected and any remaining debris was removed with an additional stream water rinse and was then placed into the recovery bucket. Approximately 50 ml of 95% ethanol was added to the whirl-pak, along with an identifying label, and tightly closed. This procedure was then repeated for all anesthetized fish, 56 mm in length or greater, until the contents of 30 stomachs were collected. Each anesthetized coho less than 56 mm in length was measured and weighed and placed into the recovery bucket. Once fish processing was complete, coho were returned to the stream, spread throughout the sampling reach.



Figure 2. A juvenile coho being measured (fork length = 63mm) and weighed on the bank of Otter Creek in September, 2017



Figure 3. Gastric lavage being performed on a juvenile coho on the bank of Otter Creek in September 2017.

Invertebrate drift field sampling

At each sampling event, two drift nets (0.3 x 0.3m, 350 μ m mesh) were deployed side-by-side in the thalweg at the upstream end of the sampling reach for 20 to 60 minutes. Drift samples were always collected in the morning while the minnow traps were soaking. Drift nets were secured in the stream using rebar, and they were deployed to capture all drifting debris and organisms between the streambed and surface. Deployment time, depth and stream velocity were recorded. Velocity was measured with a Marsh-McBirney flow meter at a mid-water depth at each of the net mouths (Figure 4). Contents of the nets were transferred to a Nalgene bottle and preserved with 70% ethanol.



Figure 4. Measuring depth and stream velocity at the mouth of a driftnet deployed in South Fork Chester Creek, June 2017.

Lab methods for coho stomach contents

Stomach contents from each coho were emptied into a Petri dish and sorted by taxon. Each aquatic taxon (orders Ephemeroptera, Plecoptera, Trichoptera, Diptera, Coleoptera, Hemiptera, and Collembola) was identified to the lowest practical level, typically genus or family, using standard taxonomic keys (Merritt et al. 2008, Wiggins 2000, and Stewart and Oswood 2006) for organisms (or organism parts) that were identifiable under a Leica MZ6 dissecting scope. Taxa that originated from the terrestrial environment and aquatic non-insects were enumerated and identified at higher levels using standard taxonomic keys (Marshall 2006, Thorp and Covich 2010, Collet 2008, and Cole 1969). For intact organisms, body length was measured to the nearest 0.1 mm for those <2mm long and to the nearest 0.5 mm for all others. For partial organisms, estimates of body length were made, if possible. If accurate length estimates were not possible, partially digested larger organisms (e.g., some teleosts and Oligochaeta) were desiccated in a drying oven and weighed to the nearest 0.1 mg. For the final analysis,

we ended up with 31 prey categories (see Table 2 and Appendix A). Life stage information (e.g., larva, pupa, adult) was merged for each category. We categorized prey organisms based on their origin: organisms originating from the stream (e.g., Chironomidae, Trichoptera), organisms originating from the terrestrial environment (e.g., Aranae, Terrestrial Hemiptera), organisms originating from a marine environment (salmon eggs), and organisms of unknown origin (e.g., Nematoda, Oligochaeta, some Diptera). Plant material found in stomach contents was recorded but not included in the analysis.

Lab methods for invertebrate drift samples

Drift samples were subsampled in the lab to reach a fixed count of 300 organisms using a Caton grid sampler, enumerated and identified to the lowest practical level, following the same taxonomic guidance used for the prey taxa. All information from the drift sample processing is stored in an MS Excel spreadsheet.

Coho prey data analysis

Lengths were converted to biomass (mg) using length-mass coefficients obtained from Bob Wisseman with Aquatic Biology Associates, Inc. For some taxa (e.g., Oligochaeta), dry weights were measured in the lab. Biomasses were summed to obtain a total biomass for each prey taxon in each fish stomach. Prey taxa were grouped into higher taxonomic levels for further data analysis. (See Appendix A) Taxonomic groupings also took into consideration whether the organisms originated in aquatic or terrestrial habitats.

Three metrics were calculated for all taxa at two grouping levels: by site and date (n = 13) and by sites only (n = 3). Percent frequency of occurrence (%O) is the number of fish stomachs a prey taxon occurred in divided by the total number of fish stomachs. All fish were used in the denominator for %O, which included 14 fish with empty stomachs. Percent by number (%N) is the total count for a prey taxon divided by the total count of all prey organisms. Percent by mass (%M) is the total mass for a prey taxon divided by the total biomass of all prey organisms. We also calculated the index of relative importance (IRI) for each prey taxon in each group as $IRI = \%O \times (\%N + \%M)$ (Cailliet et al. 1986; Eidam et al. 2016). The IRI was converted to a percentage as the IRI/total IRI for each group.

Invertebrate drift data analysis

Taxa abundance in each 300-organism pick was mathematically extrapolated (based on the number of grids subsampled) to represent the complete drift sample. Organism density was calculated using the following formula (count/m³):

$$\text{Drift density (organisms/m}^3\text{)} = \frac{(N)(100)}{(t)(W)(H)(V)(3600\text{s/h})},$$

where N represents the taxon abundance in the sample; t is the number of hours the net was deployed in the stream; W is the combined width of the nets in meters; H is the mean height of the water column in the net mouth in meters; and V is the water velocity at the net mouth in meters per second.

Invertebrate drift data can be found in Appendix B.

Prey taxa found in coho stomachs were compared to drift samples from the same site and date using the Jaccard dissimilarity coefficient. Prey taxa counts were summed across all fish stomachs and life stages for each site and date. For the drift samples, the densities of taxa were summed across life stages

for each site and date. The Jaccard dissimilarity coefficient is the proportion of combined abundance that is not shared (McCune and Grace 2002):

$$JD_{ih} = \frac{2 \sum_{j=1}^p |a_{ij} - a_{hj}|}{\sum_{j=1}^p a_{ij} + \sum_{j=1}^p a_{hj} + \sum_{j=1}^p |a_{ij} - a_{hj}|}$$

where a_{ij} is the abundance of species j in sample unit i (one site and date) and there are a total of p species in the drift sample and stomach samples being compared. Jaccard dissimilarities were calculated using abundances based on the same taxonomic groupings used for the metrics.

RESULTS

Water temperature

Stream temperatures in South Fork Chester Creek were much colder than temperatures in Otter and Sixmile Creeks (Figure 5). Mean daily temperatures peaked in July above 20°C for both Sixmile and Otter Creeks, while South Fork Chester Creek remained below 10°C throughout the summer. Sites on both Otter and Sixmile Creeks were situated below relatively large lakes that discharge warm water in the summertime, while the stable cold temperatures in South Fork Chester Creek indicate groundwater inputs within or above the sampled reach.

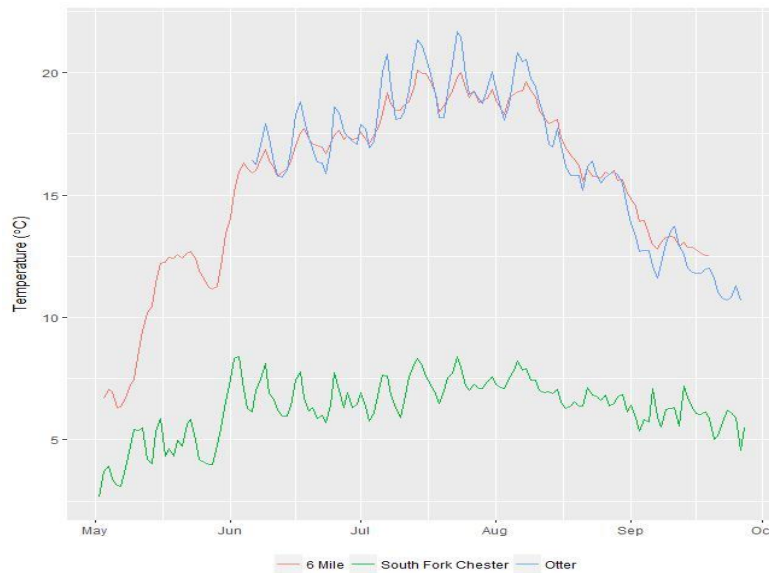


Figure 5. Daily mean stream temperatures calculated from hourly logged temperatures at the three sites: S.F. Chester, Sixmile, and Otter Creeks.

Coho trapping rates and size comparisons

Coho trapping proved to be difficult during the first week of May. In 70 trap hours on South Fork Chester Creek, we caught a total of just 22 juvenile coho, of which 9 were large enough for gastric lavage

(≥ 56 mm, FL) (Table 1). In Sixmile Creek, we caught no coho, despite leaving the minnow traps in overnight, for a total of 325 trap hours. We were unable to sample Otter Creek during the first week of May due to JBER activities that closed the range.

Trapping rates increased dramatically in subsequent sampling visits. In total, we caught 381 coho in Sixmile Creek, of which 120 were lavaged; 396 coho in Otter Creek, of which 116 were lavaged; and 337 coho in S.F. Chester Creek, of which 102 were lavaged (Table 1). Catch rates tended to speed up throughout the summer, with our fastest catch rate occurring in Otter Creek in September (11.5 coho per trap hour). Our slowest catch rates (with the exception of Sixmile Creek in May when we caught no coho) occurred in S.F. Chester Creek, ranging from 0.3 coho per trap hour in May to 2.5 coho per trap hour in September.

| Table 1. Coho caught, lavaged, trap hours and catch rates for each sampling event at the three JBER stream sites. | | | | | | | | | | | | | | |
|---|---------------|--------------|---------------|---------------|---------------|--------------|---------------|---------------|---------------|--------------------|--------------|---------------|---------------|---------------|
| | Sixmile Creek | | | | | Otter Creek | | | | S.F. Chester Creek | | | | |
| | 5/2/ 2017 | 6/8/ 2017 | 7/14/ 2017 | 8/24/ 2017 | 9/20/ 2017 | 6/6/ 2017 | 7/13/ 2017 | 8/23/ 2017 | 9/26/ 2017 | 5/1/ 2017 | 6/7/ 2017 | 7/12/ 2017 | 8/22/ 2017 | 9/28/ 2017 |
| Coho caught | 0 | 81 | 101 | 126 | 109 | 96 | 109 | 105 | 113 | 22 | 51 | 66 | 116 | 98 |
| Coho lavaged | 0 | 30 | 30 | 30 | 30 | 25 | 30 | 30 | 31 | 9 | 30 | 10 | 23 | 30 |
| Trap hours | 325 | 56 | 29.5 | 22.5 | 11 | 38.2 | 54.8 | 34.7 | 8.7 | 70 | 63.2 | 84 | 62.7 | 38.7 |
| Catch rate (coho/ trap hr) | 0 | 1.4 | 3.4 | 5.6 | 9.9 | 2.5 | 2 | 3 | 13 | 0.3 | 0.8 | 0.8 | 1.9 | 2.5 |

We caught coho smolts, based on their silvery appearance, in Sixmile and Otter Creeks throughout the summer and into September. In Sixmile Creek, they comprised 51% of the total catch in June, 32% in July, 24% in August, and 36% in September. In Otter Creek, smolts comprised 5% of the catch in June, 8% in July, 13% of the catch in August, and 15% in September. We caught coho smolts in S.F. Chester Creek in June (4% of catch) and July (6% of catch). Coho tended to smolt when they reached a fork length of 80mm and a weight of over 5 grams.

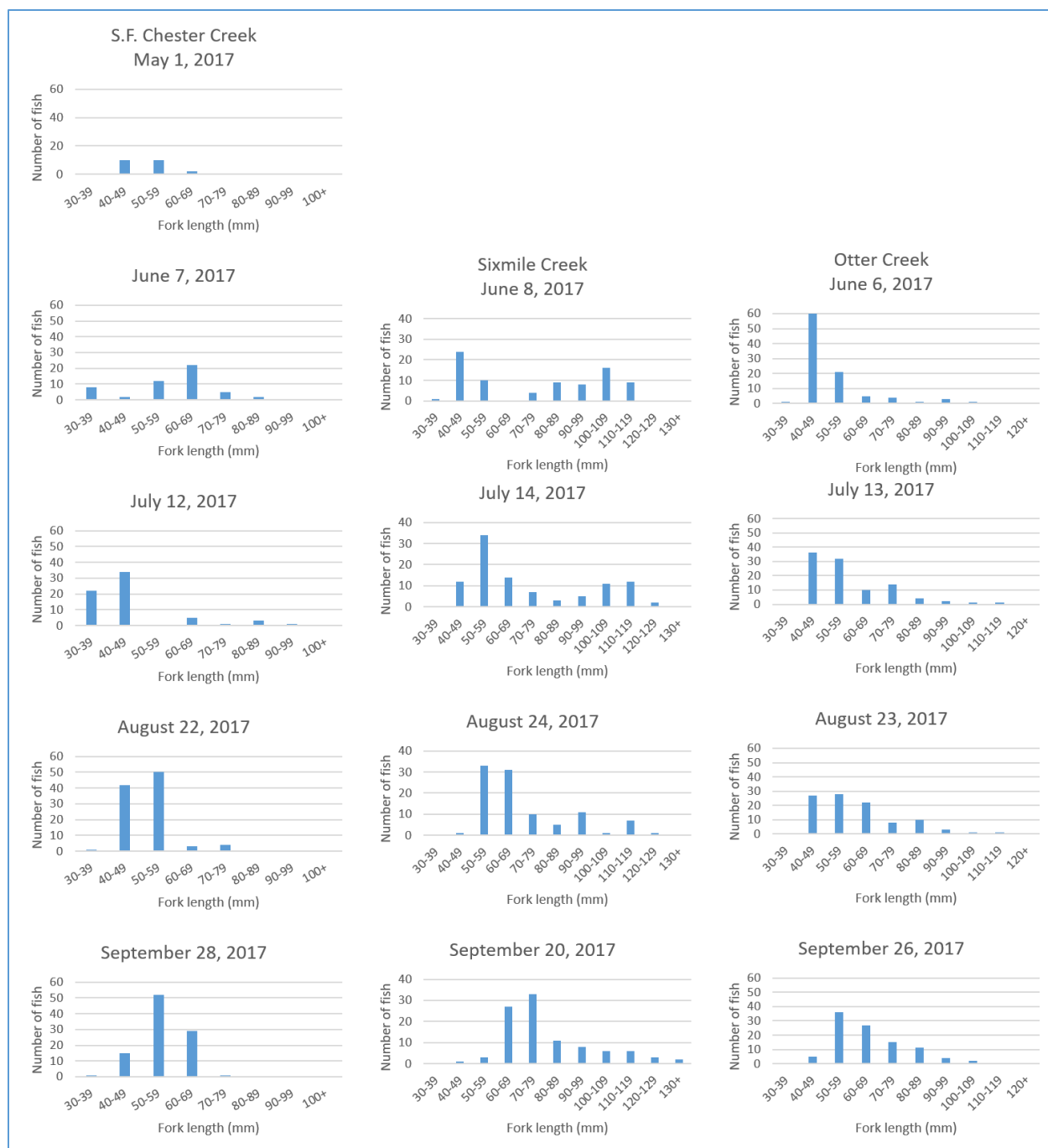


Figure 6. Coho fork length frequencies by date at each of the three sites: S.F. Chester, Sixmile, and Otter Creeks.

Coho prey diversity

Stomach contents from the three streams included invertebrates from 24 different orders, along with fish (teleosts), and plant material. Most coho had a variety of prey items in their stomachs. The average coho had organisms from at least four of the 31 prey categories in its stomach. Prey diversity varied seasonally by site, with Sixmile Creek coho averaging 3.3 different taxa groups in June, 3.8 in July, 4.6 in August, and 3.6 in September. The prey diversity in Otter Creek increased throughout the summer and

fall, starting with an average of 3.0 in June and ending with an average of 4.9 in September. Prey diversity was highest in S.F. Chester Creek, which ranged in monthly average from 4.6 in May to 7.2 in August.

Over 59% of the 4690 prey items identified were members of the order Diptera, which includes taxa that originate in both aquatic and terrestrial habitats. Diptera in the aquatic family Chironomidae alone accounted for more than 42% of the prey items identified, and were by far the most prolific prey item, found in over 77% of the coho stomachs. The next most common prey item, found in over 60% of coho stomachs, were non-Chironomid aquatic Dipterans, including the families Simuliidae, Tipulidae, Ceratopogonidae, Psychodidae, Empididae, Culicidae, Dixidae, Dolichopodidae, and Ephydriidae. Beyond these top two prey taxa groups, which were important prey items in all three streams, prey taxa importance varied between sites (Table 2).

Coho prey taxa by site

In Sixmile Creek, chironomids comprised 51.6% of all prey organisms identified and had a %IRI of 59.9. Teleosts, primarily three-spine stickleback, comprised the most biomass in stomach contents (59.9%), but were found in only 5.9% of coho stomachs. The Amphipod *Hyalella sp.* was also an important prey item for coho in Sixmile Creek, found in 31.9% of stomachs, with a %IRI of 10.3. The other important taxa group in Sixmile Creek was the broad non-chironomid aquatic Diptera group, which was found in 47.1% of stomachs, and had a %IRI of 9.4.

Chironomids were even more prevalent in coho stomachs from Otter Creek, with a frequency of 84.5% and a %IRI of 63.2. Non-Chironomid aquatic Diptera was another important prey group, found in 61.2% of stomachs, with a %IRI of 15.2. Salmon eggs comprised the largest biomass in coho stomachs (37%), but were only found in 6.9% of stomachs.

Prey taxa were more evenly distributed in S.F. Chester Creek coho stomachs, with Chironomids, Non-Chironomid aquatic Dipterans, terrestrial Hemipterans, and Ephemeropterans all found in over half the stomachs investigated. Salmon eggs comprised the largest biomass in S.F. Chester coho (16.1%), but were only found in 2.9% of stomachs, resulting in a low %IRI of 0.5. Caddisflies (Trichoptera) were commonly found as prey items in all three streams, ranging from 29.4% frequency in Sixmile Creek to 43.1% in Otter Creek, with corresponding %IRIs of 7.2 and 8.2. Prey percent frequency, number, biomass and IRI can all be found in Table 1.

Table 2. Juvenile coho prey group statistics for 31 prey groups. % Frequency = percent of coho stomachs prey taxa group was found; % Number = percentage of the total prey organism count; % Mass = percentage of the biomass of Coho stomach contents; %IRI = percentage of the Index of Relative Importance of each taxa group.

| Prey group | Sixmile Creek | | | | Otter Creek | | | | South Fork Chester Creek | | | |
|---------------------------|---------------|-------|--------|-------|-------------|-------|--------|-------|--------------------------|-------|--------|-------|
| | % Freq | % No. | % Mass | % IRI | % Freq | % No. | % Mass | % IRI | % Freq | % No. | % Mass | % IRI |
| Chironomidae | 68.1 | 51.6 | 1.1 | 59.9 | 84.5 | 56.6 | 2.8 | 63.2 | 82.4 | 25.6 | 3.3 | 26.4 |
| Non-Chiro Aquatic Diptera | 47.1 | 10.2 | 1.7 | 9.4 | 61.2 | 15.9 | 3.7 | 15.2 | 73.5 | 13.0 | 10.8 | 19.4 |
| Terrestrial Hemiptera | 9.2 | 1.9 | 0.2 | 0.3 | 18.1 | 1.7 | 2.9 | 1.0 | 61.8 | 12.1 | 9.1 | 14.6 |
| Ephemeroptera | 15.1 | 2.1 | 0.3 | 0.6 | 20.7 | 2.8 | 0.8 | 0.9 | 51.0 | 10.8 | 12.7 | 13.3 |
| Amphipoda | 31.9 | 7.5 | 11.7 | 10.3 | NA | NA | NA | NA | NA | NA | NA | NA |
| Trichoptera | 29.4 | 3.7 | 11.0 | 7.2 | 43.1 | 5.5 | 9.5 | 8.2 | 37.3 | 3.7 | 14.8 | 7.7 |
| Teleost | 5.9 | 1.4 | 59.9 | 6.0 | 0.9 | 0.1 | 12.8 | 0.1 | 3.9 | 0.4 | 5.8 | 0.3 |
| Terrestrial Diptera | 12.6 | 1.5 | 0.2 | 0.4 | 25.9 | 2.6 | 0.9 | 1.1 | 42.2 | 7.7 | 2.5 | 4.8 |
| Plecoptera | 5.9 | 0.6 | 0.1 | 0.1 | 28.4 | 4.5 | 0.7 | 1.9 | 39.2 | 4.5 | 4.0 | 3.7 |
| Salmon egg | 1.7 | 0.9 | 8.1 | 0.3 | 6.9 | 0.7 | 37.0 | 3.3 | 2.9 | 0.2 | 16.1 | 0.5 |
| Aquatic Collembola | 9.2 | 1.2 | 0.0 | 0.2 | 6.9 | 0.6 | 0.0 | 0.0 | 35.3 | 7.3 | 0.2 | 2.9 |
| Nematoda | 24.4 | 5.0 | 0.7 | 2.3 | 16.4 | 1.5 | 0.4 | 0.4 | 4.9 | 0.4 | 0.2 | 0.0 |
| Coleoptera | 3.4 | 0.3 | 0.9 | 0.1 | 9.5 | 0.7 | 1.6 | 0.3 | 28.4 | 3.3 | 2.5 | 1.8 |
| Oligochaeta | 1.7 | 0.2 | 0.0 | 0.0 | 15.5 | 1.3 | 6.4 | 1.5 | 2.9 | 0.2 | 1.2 | 0.0 |
| Acari | 21.8 | 3.8 | 0.1 | 1.4 | 6.9 | 0.5 | 0.0 | 0.0 | 9.8 | 0.7 | 0.1 | 0.1 |
| Araneae | 7.6 | 0.9 | 0.9 | 0.2 | 19.8 | 1.8 | 3.0 | 1.2 | 25.5 | 2.3 | 2.4 | 1.3 |
| Hymenoptera | 7.6 | 0.9 | 1.0 | 0.2 | 9.5 | 0.7 | 0.8 | 0.2 | 20.6 | 2.3 | 2.6 | 1.1 |
| Lepidoptera | NA | NA | NA | NA | 6.0 | 0.4 | 10.1 | 0.8 | 9.8 | 0.7 | 8.8 | 1.0 |
| Terrestrial Collembola | 10.9 | 1.1 | 0.0 | 0.2 | 8.6 | 0.7 | 0.1 | 0.1 | 18.6 | 3.6 | 0.4 | 0.8 |
| Aquatic Gastropoda | 11.8 | 2.1 | 0.7 | 0.6 | 9.5 | 0.8 | 1.0 | 0.2 | NA | NA | NA | NA |
| Terrestrial Gastropoda | 1.7 | 0.2 | 0.6 | 0.0 | 4.3 | 0.5 | 5.4 | 0.3 | 2.0 | 0.1 | 1.7 | 0.0 |
| Hirudinida | 10.1 | 1.1 | 0.2 | 0.2 | 0.9 | 0.1 | 0.0 | 0.0 | 1.0 | 0.1 | 0.0 | 0.0 |
| Aquatic Coleoptera | 4.2 | 0.4 | 0.2 | 0.0 | NA | NA | NA | NA | 4.9 | 0.3 | 0.5 | 0.0 |
| Aquatic Hemiptera | 3.4 | 0.4 | 0.2 | 0.0 | NA | NA | NA | NA | NA | NA | NA | NA |
| Psocoptera | NA | NA | NA | NA | 0.9 | 0.1 | 0.0 | 0.0 | 3.9 | 0.4 | 0.2 | 0.0 |
| Bivalvia | 3.4 | 0.3 | 0.0 | 0.0 | 0.9 | 0.1 | 0.0 | 0.0 | NA | NA | NA | NA |
| Ostracoda | 2.5 | 0.2 | 0.0 | 0.0 | NA | NA | NA | NA | NA | NA | NA | NA |
| Thysanoptera | NA | NA | NA | NA | NA | NA | NA | NA | 2.9 | 0.2 | 0.0 | 0.0 |
| Neuroptera | 0.8 | 0.2 | 0.2 | 0.0 | NA | NA | NA | NA | NA | NA | NA | NA |
| Lithobiomorpha | 0.8 | 0.1 | 0.0 | 0.0 | NA | NA | NA | NA | 1.0 | 0.1 | 0.2 | 0.0 |
| Copepoda | 0.8 | 0.1 | 0.0 | 0.0 | NA | NA | NA | NA | NA | NA | NA | NA |

Coho prey taxa by site and month

Dominant prey taxa groups varied throughout the growing season (Figures 7 and 8). In Sixmile Creek, Amphipod consumption declined throughout the summer, but still remained an important part of the coho diet. Salmon eggs showed up in Sixmile coho stomachs in August, but were not found in any stomachs in September. Salmon eggs in Otter and S.F. Chester Creeks appeared in coho stomachs only in September. When salmon eggs were present, they were found in less than 26% of the stomachs sampled but made up 28-69% of the total prey biomass. Three-spine sticklebacks were found only in Sixmile coho stomachs in August and September, and in less than 14% of stomachs sampled. Yet in September, they accounted for over 80% of the total prey biomass in the pooled stomachs from Sixmile that month. The sole teleost from Otter Creek stomachs was a stickleback found in August, and accounted for over 50% of the pooled biomass from the 30 coho stomachs sampled that month. Partially digested teleosts, possibly three-spined sticklebacks, were found in S.F. Chester Creek coho in

June and again in one stomach in August. In Sixmile Creek in July, Trichoptera accounted for over 50% of the pooled prey biomass that month, while accounting for around 10% in the other three months. Trichoptera were an important prey taxon for S.F. Chester Creek coho in May, found in 8 out of 9 stomachs and accounting for 70% of the pooled prey biomass that month. S.F. Chester Creek coho displayed the most variation in insect prey throughout the sampling period, with peaks of >75% frequency of terrestrial Dipterans and terrestrial Hemipterans in September and lows of <23% of those same taxa in May.

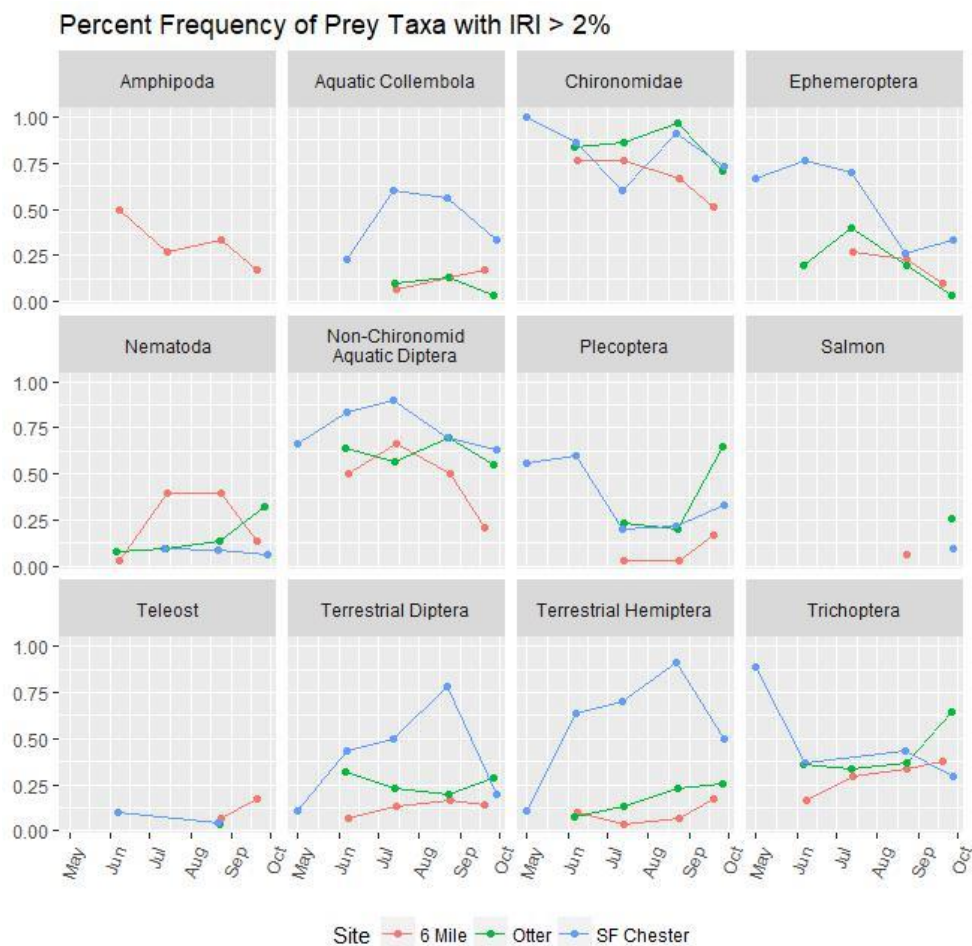


Figure 7. Percent frequency of prey taxa by site and month with a %IRI > 2 for at least one of the three streams.

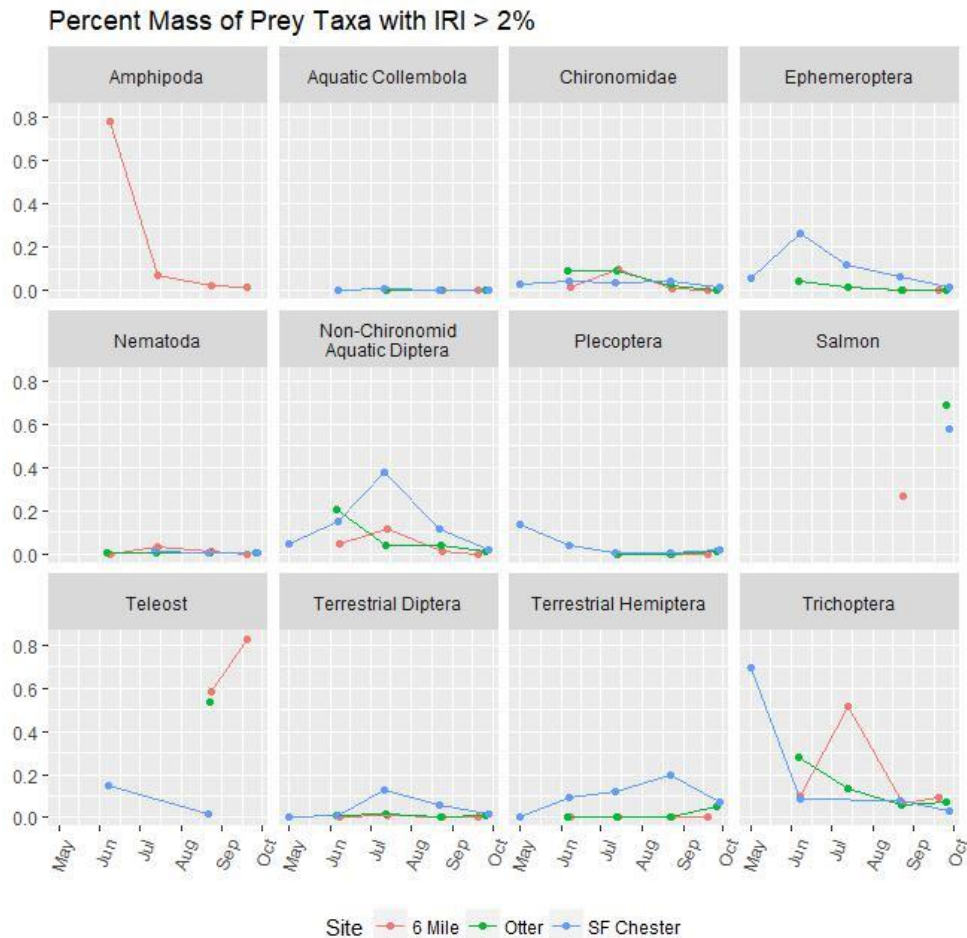


Figure 8. Percent biomass of prey taxa by site and month with a %IRI > 2 for at least one of the three streams.

Coho prey taxa by origin

Based on total counts, coho relied mostly on prey taxa of aquatic origin in all three streams for every month (Figure 9). The biomass of the prey species by origin shows different trends (Figure 10). In Sixmile Creek, aquatic biomass was always much greater than the terrestrial biomass. In Otter Creek, terrestrial biomass was greater than the aquatic biomass from July through September. In S.F. Chester Creek, terrestrial was greater than aquatic biomass in August and September. The marine inputs from the relatively few salmon eggs that were found in coho stomachs from Otter and S.F. Chester Creeks in September contributed more prey biomass than aquatic and terrestrial prey organisms combined (Figure 10).

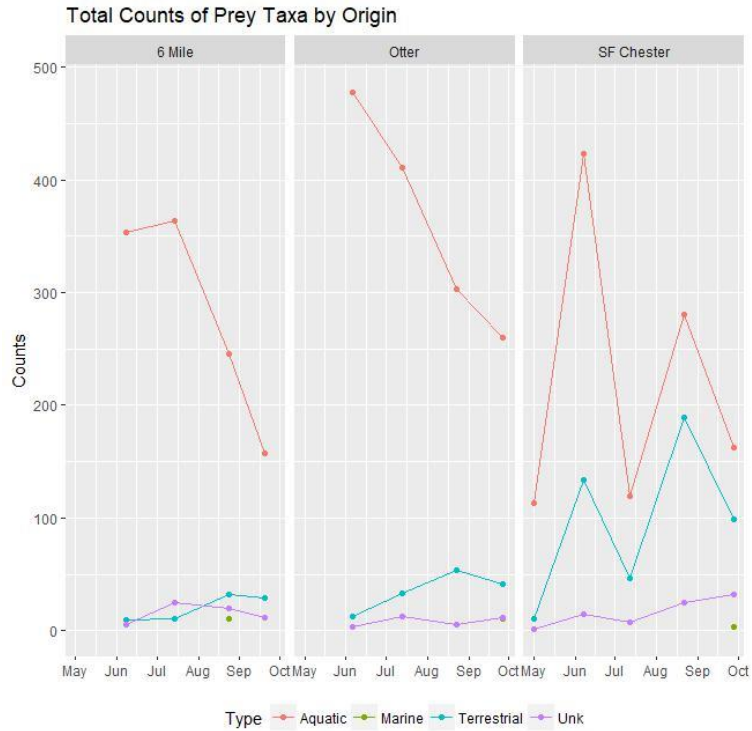


Figure 9. Total counts of coho prey items by stream and month based on origin of taxa.

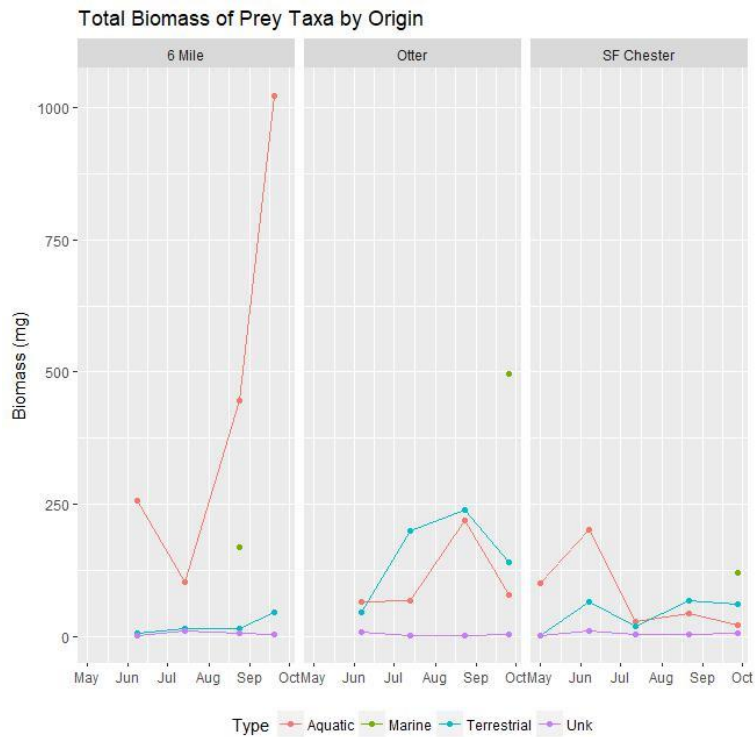


Figure 10. Total biomass of coho prey items by stream and month based on origin of taxa.

Drift taxa compared to prey taxa

The number of potential prey organisms drifting in each of the three streams showed substantial monthly variation. In S.F. Chester Creek, Invertebrate drift started at 1224 organisms/m³ in May, peaked at 1966 organisms/m³ in July, before dropping below 330 organisms/m³ in August and September. Invertebrate drift in Sixmile Creek followed a similar pattern, with 1440 organisms/m³ in June, peaking at 1698 organisms/m³ in July, dropping to 827 organisms/m³ in September. Otter Creek drift started at 1191 organisms/m³ in June, peaked at 1669 organisms/m³ in August, before dropping to 155 organisms/m³ in September (Figure 11).

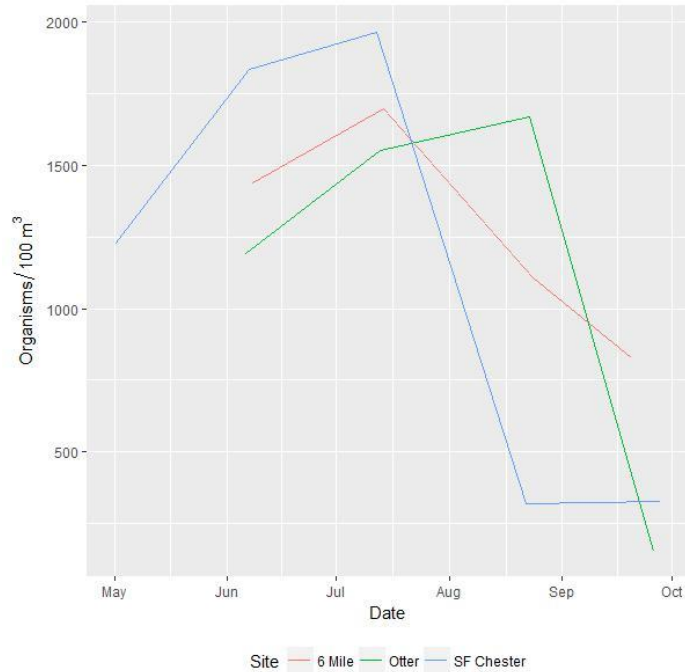


Figure 11. Invertebrate drift rates in the three streams by month

Drifting invertebrates most closely mirrored prey organisms in the June Otter Creek sampling event, where prey organisms were 84% similar to organisms found in the drift. Generally, dissimilarities between prey taxa and drifting organisms increased from summer to fall in all three streams (Figure 12). More detailed invertebrate drift data can be found in Appendix B.

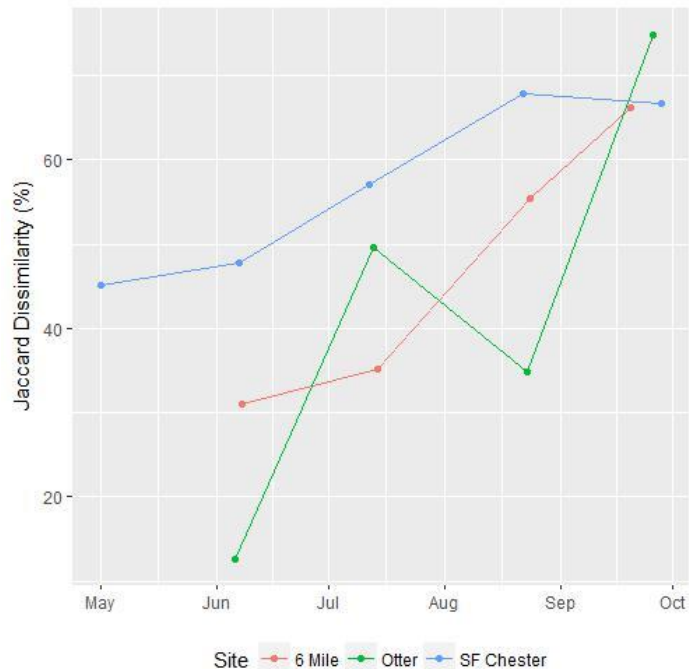


Figure 12. Jaccard Dissimilarity (%) between drift invertebrates and prey organisms.

DISCUSSION

The diet of juvenile coho in Sixmile, Otter, and S.F. Chester Creeks on JBER varied based on the availability of the resources in these three systems. The stream reach we sampled in Sixmile Creek had a variety of habitats, and included slow, deep sections with abundant submerged aquatic vegetation that were not present in Otter and S.F. Chester Creeks. Three-spined sticklebacks (*Gasterosteus aculeatus*) and the side-swimming Amphipod *Hyalella sp.* made up 70% of the biomass found in juvenile coho stomachs in Sixmile Creek, and are typical inhabitants of these deep, heavily vegetated habitats (Gerking 1994, Thorpe & Covich 2010). Amphipods were not found in drift or coho stomach samples from either of the other two streams. Sticklebacks were present in Otter Creek, occasionally showing up in the minnow traps (and in one coho stomach). Unidentified fish were present in coho stomachs in S.F. Chester Creek that may have been sticklebacks. The spike in total biomass found in Sixmile coho stomachs in September (Figure 9) can be largely attributed to *G. aculeatus* appearing in the stomachs of just four coho, all larger smolt. These teleosts may be important food resources for coho smolt as they grow in length and gain weight before moving into the estuary (Daly, et al. 2009, Keeley & Grant 2001).

Chironomids were the most abundant food source for coho in all three streams. They were found in over 75% of all stomachs and comprised more than 42% of all identified prey organisms. Yet, because of their diminutive size, they accounted for less than 5% of the total prey biomass. They were the most important taxa group (as indicated by IRI) in Otter and Sixmile Creeks by wide margins. They were also the most important prey taxa in S.F. Chester Creek, although other insect orders were almost equally important. The colder temperatures in S.F. Chester Creek increase dissolved oxygen concentrations and provide for more suitable conditions for sensitive aquatic taxa, like Ephemeroptera and Plecoptera.

Other differences in habitat, like substrate size and stream morphology, may also help explain the occurrence of these taxa.

Higher temperatures may also help explain differences in the higher abundance of Nematoda found in Otter and Sixmile coho stomachs. Relative to those from the colder S.F. Chester Creek. Nematoda are parasites commonly found in aquatic invertebrates, but it is unclear as to whether the Nematoda in the coho stomach samples were consumed as individuals or were in the bodies of other prey organisms. Nematoda are not uncommonly found in aquatic invertebrates (personal observation). Not much is known about the role of temperature on the rate of Nematoda infections on aquatic invertebrates, but data from this study suggest that higher temperatures may be directly related to infection rates. The fate of the Nematoda in the coho stomachs is another question for consideration. Are the nematodes passed through the gut, or do they migrate out of the coho digestive tract and into muscle tissue?

Results of this study also illustrate the well documented importance of terrestrial invertebrates to coho diets in certain systems (Wipfli 1997, Rine et al. 2016). While prey of aquatic origin were always more abundant in coho diets in all three creeks, prey of terrestrial origin often dominated the biomass in Otter and S.F. Chester Creeks. Terrestrial Hemipterans, in particular, appear to be important prey taxa in S.F. Chester Creek, where their overall %IRI was 14.6. These data emphasize the importance of healthy riparian habitat to coho diets.

CONCLUSION AND RECOMMENDATIONS FOR IMPROVEMENTS

This study provides a preliminary investigation into the diets of coho in Sixmile, Otter, and S.F. Chester Creeks on JBER. Fork length frequencies demonstrated that juvenile cohorts were increasing in size throughout the summer, while stomach content analysis demonstrated that coho were preying on available taxa in the different systems. Additional analysis of this extensive dataset could include a look at other prey metrics including preferred prey size, the dietary differences between smolt and pre-smolt coho, and bioenergetics modeling. Recommended future research on coho diets in these three streams include:

1. investigating coho diets in other parts of Otter and Sixmile Creeks, focusing on the inter-tidal portions of these systems in the Eagle River Flats area;
2. investigating where Sixmile juvenile coho are spending time in winter and spring, and what they are eating;
3. investigating how long coho smolt are staying in Otter and Sixmile Creeks, with emphasis on assessing the importance of piscivory prior to out-migration;
4. using bioenergetics modeling to determine whether or not food supply is limiting coho growth in JBER streams.

An improvement on this study could be made by increasing the time drift nets were deployed in the streams to more accurately describe invertebrate drift composition and densities. A better attempt to standardize fish trap soaking times would allow for a more valid comparison of catch rates in the different streams.

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| Appendix A. Prey Item Frequency | | Sixmile Creek | | | | | Otter Creek | | | | | S.F. Chester Creek | | | | |
|---------------------------------|---|---------------|-----------|-----------|-----------|--|-------------|-----------|-----------|-----------|--|--------------------|----------|-----------|-----------|-----------|
| | | 6/8/2017 | 7/14/2017 | 8/24/2017 | 9/20/2017 | | 6/6/2017 | 7/13/2017 | 8/23/2017 | 9/26/2017 | | 5/1/2017 | 6/7/2017 | 7/12/2017 | 8/22/2017 | 9/28/2017 |
| | # of Coho stomachs sampled | 30 | 30 | 30 | 30 | | 25 | 30 | 30 | 31 | | 9 | 30 | 10 | 23 | 30 |
| | Empty stomachs | 1 | 1 | | 1 | | 1 | 3 | | | | | | 1 | | |
| Aquatic | | | | | | | | | | | | | | | | |
| Aquatic Coleoptera | | | | | | | | | | | | | | | | |
| | Halipilidae | | 2 | 1 | 2 | | | | | | | | | | 3 | |
| | Hydrophilidae | | | | | | | | | | | | | | 2 | |
| Aquatic Hemiptera | | | | | | | | | | | | | | | | |
| | Corixidae | | | | 4 | | | | | | | | | | | |
| | Gerridae | | | | 1 | | | | | | | | | | | |
| Ephemeroptera | | | | | | | | | | | | | | | | |
| | Ameletidae <i>Ameletus sp.</i> | | | | | | | | | | | 2 | | | | |
| | Baetidae | | | | | | | | | | | | | | | |
| | <i>Baetis bicaudatus</i> | | | | | | | | | | | 5 | 22 | 7 | 3 | 6 |
| | <i>Baetis tricaudatus</i> | | 8 | 8 | 3 | | 5 | 12 | 6 | 1 | | | | | | |
| | Ephemerellidae <i>Drunella doddsi</i> | | | | | | | | | | | | 3 | | 1 | 7 |
| | Heptageniidae | | | | | | | | | | | 1 | | | | 4 |
| | <i>Cinygmula sp.</i> | | | | | | | | | | | | 10 | 3 | 3 | 2 |
| | <i>Epeorus longimanus</i> | | | | | | | | | | | | 2 | | 1 | 2 |
| Plecoptera | | | | | | | | | | | | | | | | 1 |
| | Capniidae | | | | | | | | | | | | | | | 3 |
| | Chloroperlidae | | | | | | | | | | | | 8 | 2 | 1 | 1 |
| | Leuctridae | | | | | | | | | | | 1 | 5 | | 1 | |
| | Nemouridae | | | | | | | | 1 | | | 3 | | | | |
| | <i>Zapada sp.</i> | | 1 | 1 | 5 | | | 7 | 5 | 20 | | 4 | 14 | 1 | 3 | 9 |
| | Perlodidae | | | | | | | | | | | | | | 1 | |
| | <i>Isoperla sp.</i> | | | | | | | | | | | | 2 | | | |
| Trichoptera | | 6 | 6 | 9 | 8 | | 4 | 4 | 8 | 2 | | 5 | | | 2 | |
| | Brachycentridae <i>Brachycentrus sp.</i> | | | | | | | | | | | | | | 1 | |
| | Glossosomatidae <i>Glossosoma sp.</i> | | | | | | | | | | | | | | 4 | 5 |
| | Hydropsychidae <i>Hydropsychidae sp.</i> | | 1 | 2 | 3 | | 5 | 6 | 3 | 11 | | | | | | |
| | Hydroptilidae <i>Stactobiella sp.</i> | | | 1 | | | | | | | | | | | | |
| | Leptoceridae <i>Ceraclea sp.</i> | | | | | | | | | 7 | | | | | | |
| | Limnephilidae | 4 | 3 | 1 | 1 | | | 5 | | 3 | | 8 | 4 | | | 3 |
| | <i>Ecclisomyia sp.</i> | | | | | | | | | | | | | | 3 | 1 |
| | <i>Psychoglypha sp.</i> | | 1 | 1 | | | | | | | | | | | | |
| | Rhyacophilidae <i>Rhyacophila sp.</i> | | | | | | | | | | | 4 | | | 2 | |
| Chironomidae | | 16 | 15 | 15 | 14 | | 12 | 13 | 23 | 5 | | 20 | | 3 | 14 | 3 |
| | Chironominae | 13 | 17 | 4 | 1 | | 1 | 3 | 2 | 1 | | 4 | 1 | | 1 | 4 |
| | Diametinae | | 5 | | | | | 1 | | | | 2 | | 3 | 1 | 2 |
| | Orthoclaudiinae | 7 | 20 | 9 | 3 | | 20 | 24 | 21 | 22 | | 9 | 10 | 5 | 19 | 19 |
| | Prodiamesinae | | | | | | | | | | | | | | 1 | |
| | Tanypodinae | 9 | 16 | 7 | 1 | | 13 | 20 | 5 | 4 | | 1 | 18 | 3 | 3 | 3 |
| Non-Chironomid Aquatic Diptera | | | | | | | | | | | | | | | | |
| | Ephydriidae | | | | | | | | | 1 | | | | | | |
| | Ceratopogonidae | 13 | 10 | 6 | | | 12 | 2 | 8 | 9 | | 3 | 12 | | 9 | 4 |
| | Culicidae | 1 | | | | | | | | | | | 1 | 1 | | |
| | Dixidae <i>Dixa sp.</i> | | | | | | | | | | | 2 | 2 | | 1 | |
| | Dolichopodidae | | 1 | | | | 1 | | | | | | | | | |
| | Empididae | | 5 | 2 | 2 | | 3 | 3 | 1 | | | | 1 | 3 | 8 | |
| | <i>Chelifera/Metachela sp.</i> | 2 | 6 | 2 | 1 | | 2 | | 1 | | | 2 | 7 | 4 | 3 | 1 |
| | <i>Oreogeton sp.</i> | | | | | | | | | | | | 2 | | 1 | |
| | Psychodidae <i>Pericoma/Telmatoscopus sp.</i> | | 1 | 1 | 1 | | | 3 | 1 | 1 | | | 1 | | 1 | 12 |
| | Simuliidae | 4 | 16 | 7 | 2 | | 12 | 13 | 15 | 8 | | 2 | 11 | 5 | 8 | 8 |
| | Tipulidae | | | 1 | 1 | | | 1 | 2 | | | | 13 | | 2 | 1 |
| | <i>Dicranota sp.</i> | | 2 | 1 | | | | 2 | 3 | 1 | | 1 | 7 | | 2 | 1 |
| | <i>Hesperoconopa sp.</i> | | | | | | | | | | | | 2 | | | |
| | <i>Molophilus sp.</i> | | | | | | | | | | | | | | 1 | 1 |
| | <i>Tipula sp.</i> | | | | | | | | 2 | | | | | | | |
| Acari | | 1 | 1 | 1 | 1 | | | | 1 | | | | | 1 | 3 | 1 |
| | Sarcoptiformes | 2 | | 1 | | | 1 | 2 | 1 | 1 | | | | | 1 | 2 |
| | Trombidiformes | | 1 | | | | | | | | | | | | | |
| | <i>Arrenurus sp.</i> | | | | | | | | | 1 | | | | | | |
| | <i>Hygrobatas sp.</i> | 4 | 6 | 4 | 2 | | | | | 1 | | | | | | |
| | <i>Lebertia sp.</i> | | 2 | | | | | | | | | | | | | 1 |
| | <i>Sperchon sp.</i> | 1 | 1 | 1 | | | | 1 | | | | | 1 | | 1 | |
| Amphipoda | | | | | | | | | | | | | | | | |
| | Crangonyctidae | | | | 1 | | | | | | | | | | | |
| | Hyalellidae <i>Hyalella sp.</i> | 18 | 9 | 11 | 4 | | | | | | | | | | | |
| Aquatic Collembola | | | | | | | | | | | | | | | | |
| | Poduridae | | | | 1 | | | | 1 | 1 | | | | | | |
| | Sminthuridae | | 2 | 4 | 5 | | | 3 | 3 | | | 7 | 6 | 13 | 10 | |
| Aquatic Gastropoda | | 7 | 1 | 3 | 5 | | | 1 | 2 | | | | | | | |
| | Lymnaeidae | | 1 | 2 | | | | | | | | | | | | |
| | Physidae | | 1 | 3 | | | | | | | | | | | | |
| | Planorbidae | 1 | 1 | 1 | 2 | | | 2 | 1 | | | | | | | |
| | Valvatidae <i>Valvata sp.</i> | | | 1 | | | | 1 | 3 | | | | | | | |
| Bivalvia | | 1 | 1 | 2 | | | | | | 1 | | | | | | |
| | Sphaeriidae | | | | | | | | | | | | | | | |
| Copepoda | | 1 | | | | | | | | | | | | | | |
| Ostracoda | | | 1 | | 2 | | | | | | | | | | | |
| Hirudinida | | 3 | | 8 | 1 | | | 1 | | | | | | | | |
| | Piscicolidae | | | | | | | | | | | | 1 | | | |
| Teleostei | | | | | 1 | | | | | | | | 4 | | 1 | |
| | <i>Gasterosteus aculeatus</i> | | | 2 | 4 | | | | 1 | | | | | | | |
| | <i>Oncorhynchus sp.</i> | | | 2 | | | | | | 8 | | | | | | 3 |

| Appendix B. Invertebrate drift density (orgs/100m ³) | | Sixmile Creek | | | | Otter Creek | | | | S.F. Chester Creek | | | | |
|--|---|---------------|-----------|-----------|-----------|-------------|-----------|-----------|-----------|--------------------|----------|-----------|-----------|-----------|
| | | 6/8/2017 | 7/14/2017 | 8/24/2017 | 9/20/2017 | 6/6/2017 | 7/13/2017 | 8/23/2017 | 9/26/2017 | 5/1/2017 | 6/7/2017 | 7/12/2017 | 8/22/2017 | 9/28/2017 |
| Aquatic | | | | | | | | | | | | | | |
| Aquatic Coleoptera | | | | | | | | | | | | | | |
| | Halplidae | 4.7 | | | | | | | | | | | | |
| | Hydrophilidae | | | | | | | | | | | | | |
| Aquatic Hemiptera | | | | | | | | | | | | | | |
| | Corixidae | | | | | | | | | | | | | |
| | Gerridae | | | | | | | | | | | | | |
| Ephemeroptera | | | | | | | | 4.9 | | | | | | |
| | Ameletidae <i>Ameletus sp.</i> | | | | | | | | | 4 | | | | |
| | Baetidae | | | | | | | | | | | | | |
| | <i>Baetis bicaudatus</i> | 4.7 | | | | | | | | 398.4 | 446.4 | 82.7 | 5.1 | 57.7 |
| | <i>Baetis tricaudatus</i> | 9.3 | 14.1 | 23.8 | 7.6 | 38.1 | 164.5 | 34.5 | | | | | | |
| | Ephemerellidae | | | | | | | | | | | 11.8 | | |
| | <i>Drunella doddsi</i> | | | | | | | | | | | | 1.3 | 2.2 |
| | Heptageniidae | | | | | | | | | | 14.2 | | | |
| | <i>Cinygmula sp.</i> | | | | | | | | | 44.3 | 63.8 | 41.3 | 1.3 | 13.1 |
| | <i>Epeorus longimanus</i> | | | | | | | | | 8 | | 5.9 | | 3.3 |
| Plecoptera | | | | | | | | | | | | 5.9 | 3.8 | |
| | Capniidae | | | | | | | | | | | | | 4.4 |
| | Chloroperlidae | | | | | | | | | | 14.2 | 5.9 | | 1.1 |
| | <i>Plumiperla sp.</i> | | | | | | | | | | 7.1 | | | |
| | Leuctridae <i>Paraleuctra sp.</i> | | | | | | | | | 4 | | | | |
| | Nemouridae <i>Zapada sp.</i> | 4.7 | 18.8 | 11.9 | 22.8 | | 48.4 | 24.6 | 8.5 | 68.4 | 120.5 | 5.9 | 6.4 | 16.3 |
| | Perlodidae | | | 3 | | | | | | | | | | 1.1 |
| | <i>Isoperla sp.</i> | | | | | | | | | | | | | |
| Trichoptera | | 9.3 | | 3 | | | | 34.5 | | | 14.2 | | | |
| | Brachycentridae <i>Brachycentrus sp.</i> | 4.7 | | 3 | 2.5 | | | | 1.1 | | | | | |
| | Glossosomatidae <i>Glossosoma sp.</i> | | | | | | | | | | | | | 1.1 |
| | Hydropsychidae | | 9.4 | 6 | 15.2 | 3.8 | 14.5 | 4.9 | 4.3 | | | | | |
| | <i>Hydropsyche sp.</i> | 4.7 | | | | | | | | | | | | |
| | Hydroptilidae <i>Stactobiella sp.</i> | | | | | | | | | | | | | |
| | Leptoceridae | | | | | | | | | | | | | |
| | <i>Ceraclea sp.</i> | | | | | | | 9.8 | 5.3 | | | | | |
| | <i>Trienodes sp.</i> | 9.3 | | 3 | | | | | | | | | | |
| | Limnephilidae | 14 | | 11.9 | 2.5 | 30.4 | | 4.9 | 1.1 | 12 | | 23.6 | 35.8 | 63.2 |
| | <i>Chyranda sp.</i> | | | | | | | | | | | 5.9 | | |
| | <i>Eccisomyia sp.</i> | | | | | | | | | | | 17.7 | 7.7 | 3.3 |
| | <i>Limnephilus sp.</i> | 4.7 | | | 10.2 | | | | | | | | | |
| | <i>Nemotaulius hostilis</i> | | | 6 | | | | | | | | | | |
| | <i>Onocosmoecus sp.</i> | 14 | 4.7 | | | | | | | | 113.4 | 23.6 | | |
| | <i>Psychoglypha sp.</i> | | | | | | | | | | | | | 1.1 |
| | <i>Rhyacophilidae Rhyacophila sp.</i> | 4.7 | | | | | | | | 8 | 14.2 | 11.8 | | 2.2 |
| Chironomidae | | 270.2 | 511.3 | 393.1 | 111.6 | 258.8 | 362.9 | 728.6 | 5.4 | 442.7 | 42.5 | 525.5 | 61.4 | 12 |
| | Chironominae | | | | | | 24.2 | | 2.1 | | 318.9 | 147.6 | 1.3 | 9.8 |
| | Diamesinae | | | 6 | 27.9 | | 4.8 | | | | 28.3 | 5.9 | 5.1 | 1.1 |
| | Orthocladiinae | 624.3 | 323.7 | 175.7 | 66 | 376.8 | 193.5 | 265.8 | 10.6 | | 283.4 | 271.6 | | 13.1 |
| | Prodiamesinae | | | | | | | | | | | | | |
| | Tanytopodinae | 102.5 | 23.5 | 23.8 | 20.3 | 64.7 | 111.3 | 14.8 | | | 49.6 | 5.9 | | 1.1 |
| Non-Chironomid Aquatic Diptera | | | | | | 3.8 | | | | 4 | | | | 1.1 |
| | Ephydriidae | | | | | | | | | | | | | |
| | Ceratopogonidae | 9.3 | 4.7 | | 2.5 | 7.6 | 4.8 | | | | | 17.7 | 1.3 | |
| | Culicidae | 3.8 | | | | | | | | | | | | |
| | Dixidae <i>Dixa sp.</i> | | | | | | | | | | | | | |
| | Dolichopodidae | | | | | | | | | | | 5.9 | | |
| | Empididae | | 4.7 | | | | 4.8 | | | | | | | 1.1 |
| | <i>Chelifera/Metachela sp.</i> | 4.7 | | | | | | 4.9 | | 8 | 21.3 | 5.9 | | 1.1 |
| | <i>Oreogeton sp.</i> | | | | | | | | | | 7.1 | | | |
| | Psychodidae <i>Pericoma/Telmatoscopus sp.</i> | 14 | 56.3 | 3 | 12.7 | | 19.4 | 9.8 | 2.1 | 44.3 | 7.1 | 53.1 | 14.1 | 19.6 |
| | Simuliidae | 125.9 | 389.3 | 175.7 | 357.9 | 315.9 | 280.5 | 211.7 | 93.7 | 64.4 | 113.4 | 76.8 | 28.2 | 38.1 |
| | Tipulidae | | | | | | | 4.9 | | | 7.1 | | 1.3 | |
| | <i>Dicranota sp.</i> | | | | | | | | | | | | | 1.1 |
| | <i>Hesperoconopa sp.</i> | | | | | | | | | | | | | |
| | <i>Molophilus sp.</i> | | | | | | | | | | | | | |
| | <i>Tipula sp.</i> | | | | | | | | | | | | | |
| Acari | | 4.7 | 4.7 | 3 | 2.5 | | | | | 8 | | 11.8 | 5.1 | |
| | Sarcoptiformes | | 9.4 | | 10.2 | 3.8 | 120.9 | 49.2 | 4.3 | 8 | 28.3 | 88.6 | 14.1 | |
| | Trombidiformes | | | | | | | | | | | | | |
| | <i>Arrenurus sp.</i> | | 4.7 | | | 3.8 | | 4.9 | | | | | | |
| | <i>Hygrobatas sp.</i> | | | 3 | | | | | | | | 35.4 | 9 | |
| | <i>Lebertia sp.</i> | 4.7 | | | | | | | | | 7.1 | 17.7 | 42.2 | 14.2 |
| | <i>Sperchon sp.</i> | 14 | 4.7 | | | 7.6 | | | | 20.1 | 14.2 | 29.5 | 23 | 5.4 |
| Amphipoda | | 14 | | | | | | | | | | | | |
| | Crangonyctidae | | | | | | | | | | | | | |
| | Hyalellidae <i>Hyalella sp.</i> | | | 3 | 2.5 | | | | | | | | | |
| Aquatic Collembola | | | | | | | | | | | | | | |
| | Poduridae | | | | | | 4.8 | | 1.1 | | | | | 3.3 |
| | Sminthuridae | | | 3 | 5.1 | 7.6 | | 4.9 | | | | | 2.6 | |
| Aquatic Gastropoda | | | | | | | | | | | | | | |
| | Lymnaeidae | 4.7 | 4.7 | 3 | | | | 19.7 | | | | | | |
| | Physidae | | | | | | | 4.9 | | | | | | |
| | Planorbidae | | 75 | 74.4 | 43.1 | 7.6 | 4.8 | 19.7 | 2.1 | | | | | |
| | Valvatidae <i>Valvata sp.</i> | | | | | | 4.8 | | | | | | | |

| Appendix B. Invertebrate drift density (orgs/100m ³) | | Sixmile Creek | | | | Otter Creek | | | | S.F. Chester Creek | | | | |
|--|-------------------------------|---------------|-----------|-----------|-----------|-------------|-----------|-----------|-----------|--------------------|----------|-----------|-----------|-----------|
| cont. | | 6/8/2017 | 7/14/2017 | 8/24/2017 | 9/20/2017 | 6/6/2017 | 7/13/2017 | 8/23/2017 | 9/26/2017 | 5/1/2017 | 6/7/2017 | 7/12/2017 | 8/22/2017 | 9/28/2017 |
| Bivalvia | Sphaeriidae | | 61 | | 20.3 | | 9.7 | 73.8 | 1.1 | | | | | |
| | Copepoda | 9.3 | 4.7 | 3 | | | | | | | | | 1.3 | |
| | Ostracoda | | 9.4 | | | | 24.2 | 9.8 | | 24.1 | 7.1 | 47.2 | 6.4 | |
| | Cnidaria | 4.7 | | 11.9 | 7.6 | 30.4 | 48.4 | 29.5 | | | | | | |
| | Turbellaria | | | | | | | | | | 21.3 | 41.3 | 2.6 | 2.2 |
| | Hirudinida | | | | | | | | | | | | | |
| | Piscicolidae | | | | | | | | | | | | | |
| | Teleostei | | | | | | | | | | | | | |
| | <i>Gasterosteus aculeatus</i> | | | 74.4 | | | | | | | | | | |
| | <i>Oncorhynchus sp.</i> | | | | | | | | | | | | | |
| Terrestrial | | | | | | | | | | | | | | |
| | Coleoptera | | | | | | | | | | | | 1.3 | |
| | Carabidae | | | | | | | | | | | | | |
| | Curculionidae | | | | | | 9.7 | | | | | | | |
| | Latridiidae | | | | | | | | 2.1 | | | | | |
| | Nitidulidae | | | | | | 4.8 | | | | | | | 1.1 |
| | Ptiliidae | | | | | | | | 1.1 | | | | | |
| | Scarabaeidae | | | | | | | | | | | | | |
| | Staphylinidae* | 4.7 | | | | | | | | | | 11.8 | | 5.4 |
| | Terrestrial Diptera | | | | | | | | | | | | | 2.2 |
| | Brachycera | | | | | | | | | | 7.1 | 5.9 | | 1.1 |
| | Muscidae | | | | | | | | | | | | | |
| | Nematocera | | | | | | 24.2 | | | | 7.1 | | | |
| | Bibionidae | | | | | | | | | | | | | 2.2 |
| | Mycetophilidae | | | | | | | | | | | 11.8 | | |
| | Terrestrial Hemiptera | 18.6 | 4.7 | 6 | 2.5 | | | | 1.1 | | | | 6.4 | |
| | Auchenorrhyncha | | | | | | | | | | | | | |
| | Cercopidae | | | | | | | | | | | | | |
| | Cicadellidae | | | 3 | | | | | | | | 11.8 | | |
| | Cixiidae | | | | | | | | | | | | | |
| | Delphacidae | | | | 2.5 | | | 4.9 | 1.1 | | | 5.9 | 1.3 | |
| | Heteroptera | | | | | | | | | | | | | |
| | Acanthosomatidae | | | | 1.1 | | | | | | | | | 1.1 |
| | Miridae | | | | | | | | | | 7.1 | | | |
| | Sternorrhyncha | | | | | | | | | | | | | |
| | Aphididae | 4.7 | 4.7 | 6 | | | 14.5 | | | 36.2 | 35.4 | 70.8 | 2.6 | 4.4 |
| | Coccoidea | | | | | | | | | | | | | |
| | Psyllidae | | | | | | | | | | | | | |
| | Hymenoptera | | | | | | | 4.9 | | | | | | |
| | Apocrita | 9.3 | | 3 | 2.5 | | 19.4 | | 1.1 | | | 47.2 | 5.1 | |
| | Formicidae | | | | | | | | | | | | | |
| | Symphyta | | | | | | 9.7 | 14.8 | | | | 23.6 | 1.3 | 2.2 |
| | Cimbicidae | | | | | | | | | | | | | |
| | Thysanoptera | 9.3 | | | | | | | | 4 | | 5.9 | | |
| | Lepidoptera | | | | | | | | | | | 5.9 | | 1.1 |
| | Lithobiomorpha | | | | | | | | | | | | | |
| | Neuroptera | | | | | | | | | | | | | |
| | Psocoptera | | | | | | | 4.9 | | | | | | |
| | Arachnida | | | 3 | | | | | 1.1 | | | 11.8 | 5.1 | 2.2 |
| | Araneae | | | | 2.5 | | 4.8 | 4.9 | 1.1 | 4 | | 11.8 | 1.3 | 3.3 |
| | Terrestrial Collembola | 4.7 | 9.4 | 20.8 | 7.6 | | 4.8 | 9.8 | | 8 | | 53.1 | 14.1 | 1.1 |
| | Terrestrial Gastropoda | | | 6 | 2.5 | | | | | | | | | 1.1 |
| Uncertain origin | | | | | | | | | | | | | | |
| | Nematoda | | 9.4 | | | | 4.8 | | | | | 11.8 | 1.3 | 2.2 |
| | Oligochaeta | | 14.1 | 3 | 27.9 | 22.8 | 4.8 | 4.9 | 3.2 | | 14.2 | 41.3 | | |
| Total | | 44244.9 | 44511.1 | 44049.4 | 43798.1 | 44075.5 | 44481.7 | 44594.1 | 43158.7 | 44078.9 | 44728.6 | 44887.8 | 43289.2 | 43331.1 |

*Some may be aquatic in origin

[illegible]

| Summary report of fish collection activity. | | | | | | | | | | | | | | |
|--|------------|-----------|--------------------|---------------------------------|--------------------|-------------|---|------------------------|---------|------------|---------------------------------|--------------------|-----------------------|----------------------|
| The area biologist was contacted on: TIME/DATE | | | | | | | | | | | | | | |
| Location ID (optional) | Latitude | Longitude | Datum | Coordinate determination method | Name of water body | Date | Observer name (first name, middle initial, last name) | Fish collection method | Species | Life stage | Length (mm) No estimates/ranges | Length (mm) method | Weight (g) | Sex |
| | | | | | | | | | | | | | | Additional count (1) |
| | | | | | | | | | | | | | | Disposition (1) |
| | | | | | | | | | | | | | | Disposition (2) |
| | | | | | | | | | | | | | | Comments |
| 61.18982 | -140.71121 | WGSS/GPS | S.F. Chester Creek | 5/1/2017 | Daniel L. Bogan | Minnow Trap | coho salmon | juvenile | 56 | Fork | 1.6 | Unknown | measured and released | gastric |
| 61.18982 | -140.71121 | WGSS/GPS | S.F. Chester Creek | 5/1/2017 | Daniel L. Bogan | Minnow Trap | coho salmon | juvenile | 59 | Fork | 2.0 | Unknown | measured and released | gastric |
| 61.18982 | -140.71121 | WGSS/GPS | S.F. Chester Creek | 5/1/2017 | Daniel L. Bogan | Minnow Trap | coho salmon | juvenile | 56 | Fork | 1.6 | Unknown | measured and released | gastric |
| 61.18982 | -140.71121 | WGSS/GPS | S.F. Chester Creek | 5/1/2017 | Daniel L. Bogan | Minnow Trap | coho salmon | juvenile | 57 | Fork | 1.6 | Unknown | measured and released | gastric |
| 61.18982 | -140.71121 | WGSS/GPS | S.F. Chester Creek | 5/1/2017 | Daniel L. Bogan | Minnow Trap | coho salmon | juvenile | 56 | Fork | 1.5 | Unknown | measured and released | gastric |
| 61.18982 | -140.71121 | WGSS/GPS | S.F. Chester Creek | 5/1/2017 | Daniel L. Bogan | Minnow Trap | coho salmon | juvenile | 57 | Fork | 1.6 | Unknown | measured and released | gastric |
| 61.18982 | -140.71121 | WGSS/GPS | S.F. Chester Creek | 5/1/2017 | Daniel L. Bogan | Minnow Trap | coho salmon | juvenile | 63 | Fork | 2.5 | Unknown | measured and released | gastric |
| 61.18982 | -140.71121 | WGSS/GPS | S.F. Chester Creek | 5/1/2017 | Daniel L. Bogan | Minnow Trap | coho salmon | juvenile | 56 | Fork | 1.8 | Unknown | measured and released | gastric |
| 61.18982 | -140.71121 | WGSS/GPS | S.F. Chester Creek | 5/1/2017 | Daniel L. Bogan | Minnow Trap | coho salmon | juvenile | 64 | Fork | 2.4 | Unknown | measured and released | gastric |
| 61.18982 | -140.71121 | WGSS/GPS | S.F. Chester Creek | 5/1/2017 | Daniel L. Bogan | Minnow Trap | coho salmon | juvenile | 44 | Fork | 1.0 | Unknown | measured and released | |
| 61.18982 | -140.71121 | WGSS/GPS | S.F. Chester Creek | 5/1/2017 | Daniel L. Bogan | Minnow Trap | coho salmon | juvenile | 48 | Fork | 1.0 | Unknown | measured and released | |
| 61.18982 | -140.71121 | WGSS/GPS | S.F. Chester Creek | 5/1/2017 | Daniel L. Bogan | Minnow Trap | coho salmon | juvenile | 46 | Fork | 0.9 | Unknown | measured and released | |
| 61.18982 | -140.71121 | WGSS/GPS | S.F. Chester Creek | 5/1/2017 | Daniel L. Bogan | Minnow Trap | coho salmon | juvenile | 44 | Fork | 0.7 | Unknown | measured and released | |
| 61.18982 | -140.71121 | WGSS/GPS | S.F. Chester Creek | 5/1/2017 | Daniel L. Bogan | Minnow Trap | coho salmon | juvenile | 48 | Fork | 0.9 | Unknown | measured and released | |
| 61.18982 | -140.71121 | WGSS/GPS | S.F. Chester Creek | 5/1/2017 | Daniel L. Bogan | Minnow Trap | coho salmon | juvenile | 52 | Fork | 1.3 | Unknown | measured and released | |
| 61.18982 | -140.71121 | WGSS/GPS | S.F. Chester Creek | 5/1/2017 | Daniel L. Bogan | Minnow Trap | coho salmon | juvenile | 43 | Fork | 0.6 | Unknown | measured and released | |
| 61.18982 | -140.71121 | WGSS/GPS | S.F. Chester Creek | 5/1/2017 | Daniel L. Bogan | Minnow Trap | coho salmon | juvenile | 52 | Fork | 1.1 | Unknown | measured and released | |
| 61.18982 | -140.71121 | WGSS/GPS | S.F. Chester Creek | 5/1/2017 | Daniel L. Bogan | Minnow Trap | coho salmon | juvenile | 46 | Fork | 0.9 | Unknown | measured and released | |
| 61.18982 | -140.71121 | WGSS/GPS | S.F. Chester Creek | 5/1/2017 | Daniel L. Bogan | Minnow Trap | coho salmon | juvenile | 46 | Fork | 0.9 | Unknown | measured and released | |
| 61.18982 | -140.71121 | WGSS/GPS | S.F. Chester Creek | 5/1/2017 | Daniel L. Bogan | Minnow Trap | coho salmon | juvenile | 52 | Fork | 1.5 | Unknown | measured and released | |
| 61.18982 | -140.71121 | WGSS/GPS | S.F. Chester Creek | 5/1/2017 | Daniel L. Bogan | Minnow Trap | coho salmon | juvenile | 49 | Fork | 1.0 | Unknown | measured and released | |
| 61.18982 | -140.71121 | WGSS/GPS | S.F. Chester Creek | 5/1/2017 | Daniel L. Bogan | Minnow Trap | coho salmon | juvenile | Unknown | | Unknown | | 1 DIED and released | 1 dead shrew in trap |
| 61.29175 | -140.81900 | WGSS/GPS | 6 Mile Creek | 5/2/2017 | Daniel L. Bogan | Minnow Trap | Dolly Varden | juvenile | Unknown | | Unknown | | 12 DIED and released | |
| 61.29175 | -140.81900 | WGSS/GPS | 6 Mile Creek | 5/2/2017 | Daniel L. Bogan | Minnow Trap | rainbow trout | juvenile | Unknown | | Unknown | | 25 DIED and released | |
| 61.29175 | -140.81900 | WGSS/GPS | 6 Mile Creek | 5/2/2017 | D | | | | | | | | | |

| | | | | | | | | | | | | | | | |
|----------|------------|------|-----|--------------|-----------|-----------------|-------------|------------------------|----------------|-----|------|------|---------|-----------------------|----------------|
| 61.29175 | -149.81990 | WGS8 | GPS | 6 Mile Creek | 7/14/2017 | Daniel L. Bogan | Minnow Trap | coho salmon | juvenile | 58 | Fork | 2.2 | Unknown | measured and released | |
| 61.29175 | -149.81990 | WGS8 | GPS | 6 Mile Creek | 7/14/2017 | Daniel L. Bogan | Minnow Trap | coho salmon | juvenile | 57 | Fork | 2.2 | Unknown | measured and released | |
| 61.29175 | -149.81990 | WGS8 | GPS | 6 Mile Creek | 7/14/2017 | Daniel L. Bogan | Minnow Trap | coho salmon | juvenile | 70 | Fork | 3.7 | Unknown | measured and released | |
| 61.29175 | -149.81990 | WGS8 | GPS | 6 Mile Creek | 7/14/2017 | Daniel L. Bogan | Minnow Trap | coho salmon | smolt | 91 | Fork | 8.2 | Unknown | measured and released | |
| 61.29175 | -149.81990 | WGS8 | GPS | 6 Mile Creek | 7/14/2017 | Daniel L. Bogan | Minnow Trap | coho salmon | juvenile | 61 | Fork | 2.7 | Unknown | measured and released | |
| 61.29175 | -149.81990 | WGS8 | GPS | 6 Mile Creek | 7/14/2017 | Daniel L. Bogan | Minnow Trap | coho salmon | juvenile | 51 | Fork | 1.4 | Unknown | measured and released | |
| 61.29175 | -149.81990 | WGS8 | GPS | 6 Mile Creek | 7/14/2017 | Daniel L. Bogan | Minnow Trap | coho salmon | juvenile | 50 | Fork | 1.2 | Unknown | measured and released | |
| 61.29175 | -149.81990 | WGS8 | GPS | 6 Mile Creek | 7/14/2017 | Daniel L. Bogan | Minnow Trap | coho salmon | smolt | 103 | Fork | 11.3 | Unknown | measured and released | |
| 61.29175 | -149.81990 | WGS8 | GPS | 6 Mile Creek | 7/14/2017 | Daniel L. Bogan | Minnow Trap | coho salmon | juvenile | 73 | Fork | 4.8 | Unknown | measured and released | |
| 61.29175 | -149.81990 | WGS8 | GPS | 6 Mile Creek | 7/14/2017 | Daniel L. Bogan | Minnow Trap | coho salmon | juvenile | 58 | Fork | 2.1 | Unknown | measured and released | |
| 61.29175 | -149.81990 | WGS8 | GPS | 6 Mile Creek | 7/14/2017 | Daniel L. Bogan | Minnow Trap | coho salmon | juvenile | 70 | Fork | 4.0 | Unknown | measured and released | |
| 61.29175 | -149.81990 | WGS8 | GPS | 6 Mile Creek | 7/14/2017 | Daniel L. Bogan | Minnow Trap | coho salmon | juvenile | 56 | Fork | 1.7 | Unknown | measured and released | |
| 61.29175 | -149.81990 | WGS8 | GPS | 6 Mile Creek | 7/14/2017 | Daniel L. Bogan | Minnow Trap | coho salmon | juvenile | 52 | Fork | 1.5 | Unknown | measured and released | |
| 61.29175 | -149.81990 | WGS8 | GPS | 6 Mile Creek | 7/14/2017 | Daniel L. Bogan | Minnow Trap | coho salmon | juvenile | 58 | Fork | 1.9 | Unknown | measured and released | |
| 61.29175 | -149.81990 | WGS8 | GPS | 6 Mile Creek | 7/14/2017 | Daniel L. Bogan | Minnow Trap | coho salmon | juvenile | 53 | Fork | 1.6 | Unknown | measured and released | |
| 61.29175 | -149.81990 | WGS8 | GPS | 6 Mile Creek | 7/14/2017 | Daniel L. Bogan | Minnow Trap | rainbow trout | juvenile | | | | Unknown | ID'd and released | |
| 61.29175 | -149.81990 | WGS8 | GPS | 6 Mile Creek | 7/14/2017 | Daniel L. Bogan | Minnow Trap | threespine stickleback | juvenile/adult | | | | Unknown | ID'd and released | |
| 61.29001 | -149.71838 | WGS8 | MAP | Otter Creek | 7/13/2017 | Daniel L. Bogan | Minnow Trap | coho salmon | juvenile | 58 | Fork | 1.9 | Unknown | measured and released | gastric lavage |
| 61.29001 | -149.71838 | WGS8 | MAP | Otter Creek | 7/13/2017 | Daniel L. Bogan | Minnow Trap | coho salmon | juvenile | 59 | Fork | 2.3 | Unknown | measured and released | gastric lavage |
| 61.29001 | -149.71838 | WGS8 | MAP | Otter Creek | 7/13/2017 | Daniel L. Bogan | Minnow Trap | coho salmon | juvenile | 76 | Fork | 4.9 | Unknown | measured and released | gastric lavage |
| 61.29001 | -149.71838 | WGS8 | MAP | Otter Creek | 7/13/2017 | Daniel L. Bogan | Minnow Trap | coho salmon | juvenile | 79 | Fork | 5.8 | Unknown | measured and released | gastric lavage |
| 61.29001 | -149.71838 | WGS8 | MAP | Otter Creek | 7/13/2017 | Daniel L. Bogan | Minnow Trap | coho salmon | juvenile | 56 | Fork | 2.0 | Unknown | measured and released | gastric lavage |
| 61.29001 | -149.71838 | WGS8 | MAP | Otter Creek | 7/13/2017 | Daniel L. Bogan | Minnow Trap | coho salmon | juvenile | 67 | Fork | 3.4 | Unknown | measured and released | gastric lavage |
| 61.29001 | -149.71838 | WGS8 | MAP | Otter Creek | 7/13/2017 | Daniel L. Bogan | Minnow Trap | coho salmon | juvenile | 58 | Fork | 2.5 | Unknown | measured and released | gastric lavage |
| 61.29001 | -149.71838 | WGS8 | MAP | Otter Creek | 7/13/2017 | Daniel L. Bogan | Minnow Trap | coho salmon | juvenile | 73 | Fork | 4.7 | Unknown | measured and released | gastric lavage |
| 61.29001 | -149.71838 | WGS8 | MAP | Otter Creek | 7/13/2017 | Daniel L. Bogan | Minnow Trap | coho salmon | smolt | 89 | Fork | 7.9 | Unknown | measured and released | gastric lavage |
| 61.29001 | -149.71838 | WGS8 | MAP | Otter Creek | 7/13/2017 | Daniel L. Bogan | Minnow Trap | coho salmon | juvenile | 67 | Fork | 3.4 | Unknown | measured and released | gastric lavage |
| 61.29001 | -149.71838 | WGS8 | MAP | Otter Creek | 7/13/2017 | Daniel L. Bogan | Minnow Trap | coho salmon | smolt | 88 | Fork | 7.9 | Unknown | measured and released | gastric lavage |
| 61.29001 | -149.71838 | WGS8 | MAP | Otter Creek | 7/13/2017 | Daniel L. Bogan | Minnow Trap | coho salmon | juvenile | 63 | Fork | 2.8 | Unknown | measured and released | |

[illegible]

[illegible]

[illegible]

[illegible]