Monitoring Juvenile Salmon and Resident Fish within the Matanuska-Susitna Basin

ARRI
Aquatic Restoration & Research Institute

Hannah Ramage, Jeffrey C. Davis, and Gay A. Davis
Aquatic Restoration and Research Institute
P.O. Box 923 Talkeetna, AK 99676
(907) 733 5432 arri@arrialaska.org
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1.0 Summary

This report presents 2013 fish monitoring data from thirteen streams within the Matanuska-Susitna Borough. Streams representing three geomorphic classification types (lake-stream complex, upland and wetland) were sampled in spring, summer and fall for juvenile salmon and resident fish using baited minnow traps. Water temperature was measured using data loggers and point water quality measures were taken during every fish sampling event for pH, dissolved oxygen, specific conductivity and turbidity. Fish metrics such as juvenile salmon relative abundance, condition factor and instantaneous growth, resident to anadromous abundance ratios and stickleback abundance were calculated. This study's methods are a part of a monitoring program initiated in 2010 and 2011 (Miller et al 2011) and will be continued in 2014. Monitoring data will be augmented with intermittent sampling at a sub-set of streams beginning in 2008.

Fish communities were not distributed evenly among stream classification types. Chinook salmon were found primarily in upland streams and Dolly Varden were captured solely in upland streams. Juvenile coho salmon were found at all sampling locations, but average abundances was lowest in upland streams and highest in wetland streams. Overall, both juvenile coho and Chinook salmon abundances were lower than previous years; however condition factors and growth rates were consistent with past studies. Water quality also differed among stream types. Lake-stream complexes were generally warmer with the highest seasonal maximum temperature, over 40% of days over 20°C, and the highest average cumulative degree-days. Upland streams were coldest with the lowest average degree-days and lowest maximum temperatures. Upland streams also had higher average oxygen levels than any other stream type. In general, stream temperatures for every stream type were higher than previous years.

2.0 Introduction

The sport and commercial salmon harvest is a major part of the Southcentral Alaska and the Matanuska-Susitna Borough economy. Salmon abundance depends, in part, on their survival and growth during their fresh-water residency, which can be for the first two to three years. Juvenile salmon growth and survival is influenced by the quality and quantity of their fresh water habitat. Public support for the protection of water quality in Alaska is largely through desire to protect commercial and recreational salmon fisheries. The importance of water quality and physical habitat has been recognized by the Mat-Su salmon Partnership as critical in the strategy for the protection of salmon (Smith and Speed 2013). While water quality and habitat condition are important for rearing juvenile salmon survival and growth, and salmon production depends, in part, on their survival and growth during fresh-water residency. Alaska does not have a monitoring program in place to measure changes in the abundance of rearing juvenile salmon or tools to evaluate differences in salmon abundance to changes in water quality or physical habitat. The implementation of a long term monitoring program for juvenile salmon is necessary to track changes in salmon distribution, relative abundance, and growth and to determine if changes over time are due to changing water quality or habitat conditions.

The use of biological indicators is an integral part of many states' water quality standards. However, Alaska's water quality standards do not include biocriteria or measures of juvenile salmon abundance to assess water quality (ADEC 2011). The concept of biocriteria is not new, and many states began developing biological assessment programs in the late 1980s and early 1990s after a new body of knowledge supported that biotic monitoring of water quality avoids many of the limitations related to measures of compliance with water quality standards (Davis and Simon 1995). Direct measures and evaluation of the condition of the living system are necessary to accurately assess the condition of aquatic resources (Karr and Chu 1999).

The health of the biotic community integrates the effects of different environmental stressors, such as increased sediment loading, direct habitat alterations, temperature fluctuations, and changes in flow regime. For example, the effects of suspended sediment on juvenile salmon are greater at higher temperatures. The influence of high water temperatures on salmon is modified by acclimation and available food resources. The use of biocriteria in regulatory programs therefore provides a more comprehensive and effective monitoring strategy than simply monitoring for changes in physical chemistry or habitat (Barbour et al 2000). Furthermore, biological integrity has become an important focus within the EPA for assessing the condition of our nation's surface waters, and documenting the success of aquatic resource protection (USEPA 1990).

Long term monitoring of juvenile salmon abundance and condition can be used to evaluate the effectiveness of the Strategic Action Plan of the Mat-Su Basin Habitat Partnership. The updated 2013 Strategic Action Plan has identified water quality monitoring as an objective in order to track the changes in Mat-Su water bodies. Included in that objective is a strategic action to support biological monitoring (Smith and Speed 2013). This study supports that action by providing critical long term population and condition data that allows for direct evaluation of water quality changes.

Juvenile coho, Chinook, and sockeye salmon spend from 1 to 3 years rearing in freshwater lakes and streams prior to migrating to the ocean as smolt. Monitoring juvenile salmon abundance provides a direct evaluation of water quality changes in rearing habitats including increasing water temperatures, and other physical and biotic impacts such as reduced instream flow, habitat modification, and the proliferation of invasive northern pike. Biological monitoring provides a demonstration of the effects of changes in water quality or habitat conditions on the fish community. Demonstrating the effects of habitat loss on salmon relative abundance can promote public support of land management decisions that will avoid or minimize habitat loss. For example, we can measure changes to wetland area within a watershed, however, we must also show how water volume, water quality and physical habitat affect impact fish abundance. Without this documentation of these habitat changes affecting fish abundance it is difficult to get support for land managers to protect these areas through existing regulations, new regulations, land management decisions, or land purchases. Similarly, we can monitor changes to water quality or flow volume, however, before we can gain the public and political support to deny a water use permit application we need to show a direct connection to decreased salmon abundance.

The goal of ARRI's monitoring program is to develop consistent methods to evaluate changes in juvenile salmon distribution and abundance and evaluate these changes relative to changes in physical, chemical, and biological habitat characteristics. Sampling was initiated in 2010 and 2011. Sampling methods were refined and evaluated in the report covering these sampling years (Miller et al. 2011) and sampling results are augmented by results from other previous monitoring studies across the Mat-Su basin (Table 1). This report details the results from 2013, the first year of a two additional years of monitoring water quality using fish community metrics in thirteen Mat-Su streams (Table 2). This report provides 2013 sampling results of juvenile coho and Chinook salmon distribution, relative abundance, condition, and growth; additional fish community metrics including resident to anadromous fish and stickleback and sculpin abundance; and water quality measures. Fish community metrics and water quality from 2008 through 2014 will be discussed in the final report upon conclusion of this study in 2014.

Table 1. Mat-Su Basin sites sampled 2008-2013

Site Name	Latitude	Longitude	Years Sampled
Buddy Creek	62.1341	-150.0059	2008, 2009, 2010, 2011
Caswell Creek	61.9475	-150.0557	2010, 2011, 2013
Chijuk Creek	62.0798	-150.5839	2009, 2010
Chijuk Trib.	62.0956	-150.5371	2008, 2009, 2010, 2013
Colter Creek	61.6537	-149.4988	2008, 2009, 2010, 2011, 2013
Cottonwood Creek 1	61.6244	-149.2855	2011, 2012
Cottonwood Creek 2	61.3648	-149.1754	2011, 2012
Cottonwood Creek 3	61.5748	-149.4079	2010, 2011, 2012, 2013
Cottonwood Creek 4	61.5249	-149.5295	2010, 2011, 2012
Deception Creek	61.7639	-150.0293	2008, 2009, 2010
Grey's Creek	61.8969	-150.0773	2008, 2011
Iron Creek North	61.8345	-149.8352	2008, 2009, 2010, 2011, 2013
Iron Creek South	61.8359	-149.8439	2008, 2009, 2010, 2011, 2013
Meadow Creek 1	61.5917	-149.6666	2010, 2011, 2012
Meadow Creek 2	61.5691	-149.6702	2011, 2012, 2013
Meadow Creek 3	61.5626	-149.8260	2010, 2011, 2012
Nancy Creek	61.6709	-149.9850	2008, 2009, 2010, 2013
Queer Creek	62.1926	-150.2175	2008, 2009, 2010, 2011, 2013
Sawmill Creek	62.2432	-150.2507	2008,
Swiftwater Creek	61.6497	-149.5125	2008, 2009, 2010, 2011, 2013
Trapper Creek	62.2656	-150.1816	2008, 2009
Wasilla Creek 1	61.6614	-149.1885	2011, 2012
Wasilla Creek 2	61.6139	-149.2416	2011, 2012
Wasilla Creek 3	61.3526	-149.1509	2010, 2011, 2012
Wasilla Creek 4	61.3405	-149.1888	2010, 2011, 2012, 2013
Whiskers Creek	62.3812	-150.1712	2008, 2009, 2010
Wiggle Creek	62.3624	-150.1184	2008, 2009, 2010, 2013

3.0 Methods

3.1 Sampling Locations

Sampling was conducted in thirteen streams within the Matanuska-Susitna Basin in 2013 (Table 2 and Figure 1). Three unique stream types were represented among the thirteen sites; four lake-stream complexes, five upland streams and four wetland streams. Lake-stream complexes included Caswell Creek, Cottonwood Creek, Nancy Creek, Question Creek; upland streams included Colter Creek, Iron Creek North, Iron Creek South, Swiftwater Creek, Wasilla Creek; and the wetland streams were Chijuk Tributary, Meadow Creek, Queer Creek and Wiggle Creek (Table 2, Figure 1).

Table 2. Sampling sites with stream type, coordinates and location description

Site name	Latitude	Longitude	Type	Location
Caswell Creek	61.94748	-150.05572	Lake-stream	At Parks Hwy crossing
Cottonwood Creek	61.57481	-149.41104	Lake-stream	Old Matanuska Road crossing
Nancy Creek	61.67087	-149.98495	Lake-stream	Parks Hwy crossing
Question Creek	62.22190	-150.08833	Lake-stream	Talkeetna Spur Rd crossing
Colter Creek	61.65369	-149.49881	Upland	Softwind Road crossing
Iron Creek North	61.83450	-149.83515	Upland	Willer Kash Road, North Fork
Iron Creek South	61.83594	-149.84396	Upland	Willer Kash Road, South Fork
Swiftwater Creek	61.64970	-149.51254	Upland	Softwind Road crossing
Wasilla Creek	61.56721	-149.31371	Upland	Parks HWY and Hyer Rd
Chijuk Tributary	62.09563	-150.53712	Wetland	Oilwell Rd crossing
Meadow Creek	61.57641	-149.72868	Wetland	Parks Hwy and Big Lake Rd
Queer Creek	62.19256	-150.21750	Wetland	West of Parks Hwy
Wiggle Creek	62.36242	-150.11835	Wetland	Talkeetna Chase Trail

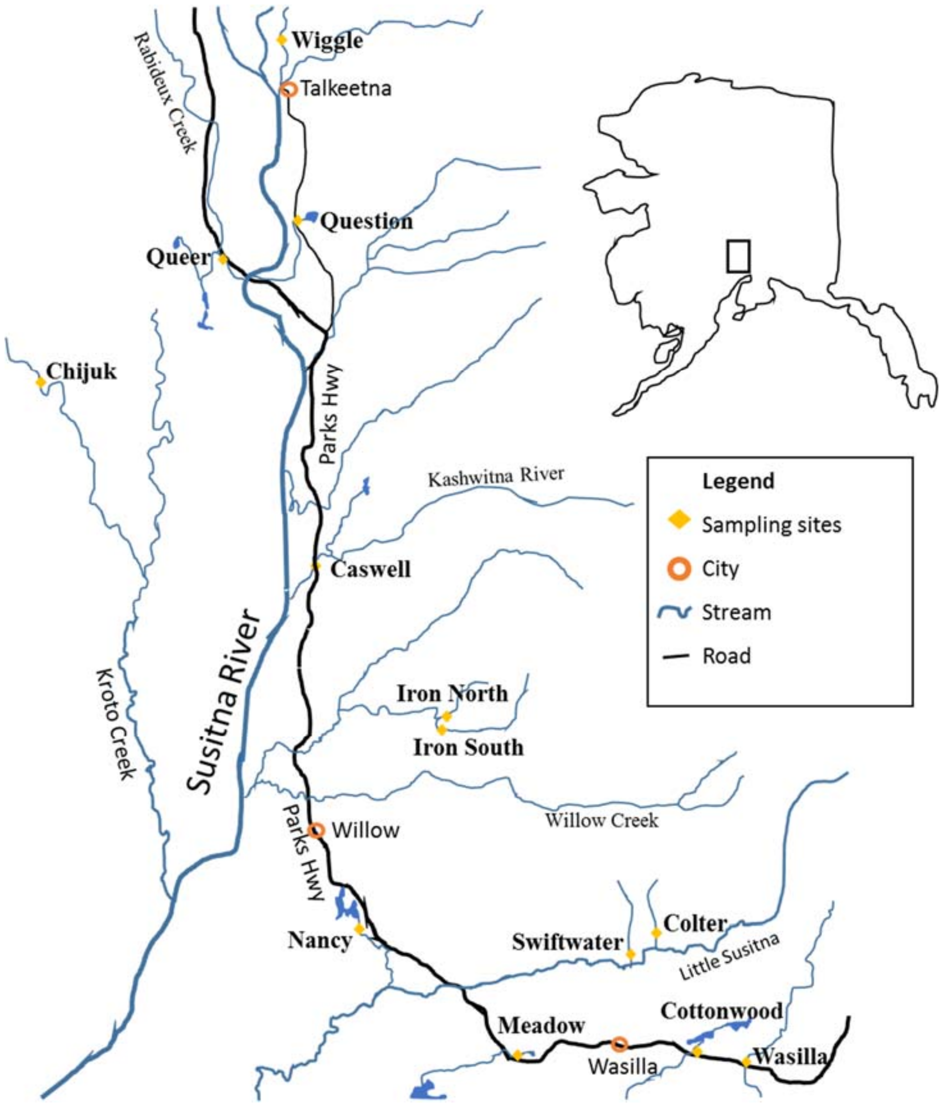

Figure 1: Map of sampling sites

3.2 Sampling Schedule

Measures of fish communities were completed three times in 2013 at each of the thirteen sampling sites in order to investigate seasonal rearing abundance and distribution. Sampling in the spring occurred between June 4 and 27. Sampling in the summer occurred between July 16 and 30 and fall sampling occurred between September 3 and 17. There were at least 30 days between sampling events at every site. Congruent with fish sampling, water quality parameters and temperature were measured at each site spring, summer and fall.

3.3 Measures of Fish Community

Fish sampling was conducted using Gee minnow traps (1/4 inch mesh, Memphis Net and Twine). Twenty traps were baited with salmon roe enclosed in perforated whirl-pak bags and placed within a 200 m stream reach. Traps were selectively placed in slower moving water and ideally protected by cover from overhanging banks or woody debris. A separation distance of approximately 10 m was maintained between traps. The traps were left to soak for 20 to 24 hours. Captured fish were transferred from the traps to plastic buckets filled with stream water and anesthetized using MS222. All fish were identified to species and all salmon were measured to fork length (FL), and weighed to the nearest 10^{-2} grams (Scout Pro Scale). Each trap was evaluated separately providing 20 replicate catch per unit trap (CPUT) values per sampling reach.

Fish community metrics were calculated for each sampling location to allow for comparisons among sites. Average catch per unit trap (CPUT) was calculated for all species individually in order to determine relative abundances among sites. CPUT averages were further used to calculate ratios of juvenile salmon to resident fish species. Length and weight data were used to determine condition factor for each juvenile salmon using the formula:

$$\left(\frac{W}{L^3}\right)10{,}000$$

where W is weight in grams and L is fork length in millimeters. Length frequency distributions were used to determine coho and Chinook age classes. Growth rates for young of year (YOY) coho and Chinook salmon were calculated using the difference of medians between July and September samples divided by days between sampling events. Instantaneous growth was calculated using the formula:

$$\left(\frac{\ln(L2) - \ln(L1)}{t}\right)100$$

where L2 is the median length of YOY in fall sample, L1 is the median length of YOY in summer sample and t is days between sampling events.

3.4 Water Quality Measures

Stream temperature was collected at each site with an Onset Pro V2 Data logger and recorded every 30 minutes from May through September. Other water quality parameters were measured before fish traps were placed at each site. Turbidity (NTU) was measured using a LaMotte 2020we/wi meter. Specific Conductivity (µS/cm), pH and temperature were measured using a YSI model 63 handheld meter. Dissolved Oxygen (mg/L and percent saturation) and temperature were measured using a YSI 550A handheld meter. Temperature (°C) was calculated as the average between the two handheld meters. Water velocity (cfs) was measured using a Swoffer Model 3000 current meter and stream discharge calculated as the sum of component sections.

4.0 Results

4.1 Fish Distribution

Eleven fish species were collected during 2013 sampling. Species included juvenile coho salmon (*Onchorynchus kisutch*), and Chinook salmon (*Onchorynchus tshawytscha*), Dolly Varden char (*Salvelinus malma*), rainbow trout (*O. mykiss*), three-spine stickleback (*Gasterosteus aculeatus*), nine-spine stickleback (*Pungituis pungitius*), burbot (*Lota lota*), slimy sculpin (*Cottus cognatus*), lamprey (*Lethenteron camtschaticum)*, longnose sucker (*Castostomus catostomus)*, and northern pike (*Esox lucius)*. Figure 2 shows the average catch per unit trap among all sites for all species except three and nine-spine stickleback.

Juvenile coho salmon were observed in all thirteen sampling locations during all three seasons with the exception of Nancy creek in the summer and fall. Juvenile Chinook salmon were only observed in four of thirteen streams, Colter, Swiftwater and Wasilla creeks during all three seasons and in Queer creek in the spring and summer. Rainbow trout were observed in ten of thirteen streams. They were observed in all three seasons in Colter, Cottonwood, Meadow, Iron North, Iron South, and Question creeks. Rainbow trout were observed seasonally in Swiftwater (fall), Caswell (spring), Chijuk (summer and fall) and Queer creeks (summer and fall). Dolly Varden were observed in only five streams, Colter, Swiftwater, Wasilla, Iron North, and Iron South creeks during all three seasons. Sculpin had a wide distribution, found at all sites except Nancy Creek. Sticklebacks were observed in Caswell, Chijuk, Cottonwood, Meadow, Nancy, Queer, Question and Wiggle creeks during all three seasons and in Swiftwater Creek in the fall. Arctic lamprey were captured in small numbers in Caswell, Meadow, Question and Wiggle creeks primarily in the spring. Low numbers of longnose sucker were captured at Caswell, Cottonwood, Nancy and Queer creeks in the spring and summer. A total of 6 juvenile northern pike were captured in Nancy Creek in the summer.

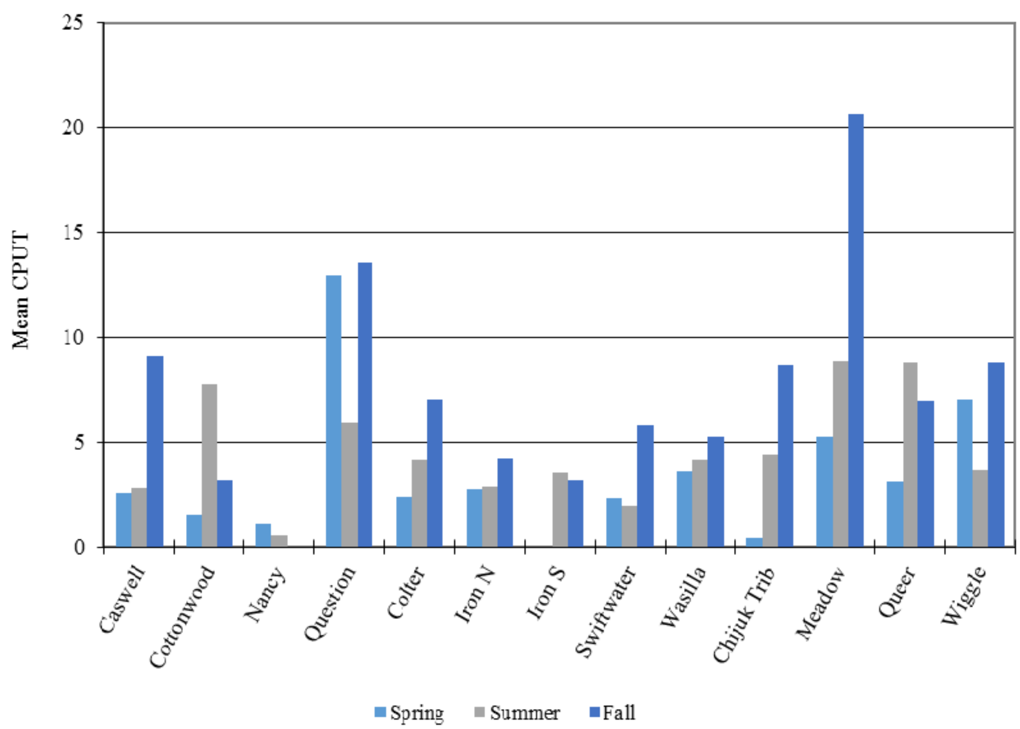

Figure 2: Average relative abundance (catch per unit trap) for all species combined (excluding stickleback) for all sites sampled in all three seasons. *Iron S was not sampled in the spring.

4.2 Relative Abundance

All abundance data (CPUT) for each site in every season can be found in Tables, 3, 4 and 5.

Coho salmon

Juvenile coho salmon were present in all sampling locations and all seasons; however, at Nancy Creek, were present only during the spring (Figure 3). Average CPUT ranged from 0.00 to15.10 among streams and seasons. In the spring, coho salmon were most abundant in Question Creek with 11.95 CPUT and least abundant in Chijuk Tributary with 0.35 CPUT. In the summer coho salmon were most abundant in Queer Creek with 7.10 CPUT and least abundant in Nancy Creek with 0.00 CPUT. In the fall, coho salmon were most abundant in Meadow Creek with 15.10 CPUT and least abundant in Nancy Creek with 0.00 CPUT. On average, upland streams had the lowest abundance in all three seasons.

Chinook salmon

Chinook salmon were absent from lake-stream complexes and found in only one wetland stream. The highest abundances of Chinook salmon were observed in upland streams. However, Chinook salmon were absent from the North and South Tributaries of Iron Creek (tributaries to Little Willow Creek), where they have traditionally been found (Miller et al. 2011). Relative abundances of juvenile Chinook salmon are shown in Figure 4. Chinook salmon abundances were highly variable among streams sampled but not among seasons. The highest Chinook salmon abundance was observed in Wasilla Creek in the fall with a CPUT of 0.74, which is considerably lower than coho abundances and previous measures of Wasilla Creek CPUT.

Resident salmonids

Dolly Varden were found in all upland streams but not in other stream types. The range in relative abundance of Dolly Varden was less than other species of salmonids. The highest abundance in both spring and summer was observed in Colter Creek (spring 1.50, summer 1.50 CPUT). The highest relative abundance in the fall was observed in Swiftwater Creek with a CPUT of 3.0. Rainbow trout were observed in all stream types, but were not captured in Nancy, Wasilla or Wiggle creeks, during any season. They were also observed in all seasons but had higher average CPUT in the fall compared to other seasons. Meadow Creek had the highest average abundance in the fall with 4.20 CPUT. There are only four streams where both Rainbow trout and Dolly Varden were captured in the same sampling event; Colter, Iron North, Iron South and Swiftwater creeks. These four streams also had the four lowest salmon to resident salmonid ratios. Figure 5 shows anadromous juvenile salmon (coho and Chinook) abundances relative to resident salmonid abundances (Dolly Varden and rainbow trout).

Resident non-salmonids

Stickleback were not found in any upland stream site during any season, but were present in all lake-stream complexes and wetland streams (Figure 6). Sculpin abundances relative to anadromous juvenile salmon abundances are shown in Figure 7. Sculpin were present in all sampling locations.

Table 3: Average CPUT for each species and every site sampled in spring 2013. *Iron S was not sampled.

Site	Stream Type	coho	Chinook	Dolly Varden	rainbow trout	sculpin	lamprey	longnose sucker	northern pike	stickleback
Cottonwood	L/S	0.45	0.00	0.00	0.40	0.65	0.00	0.05	0.00	2.65
Nancy	L/S	1.00	0.00	0.00	0.00	0.00	0.00	0.10	0.00	66.95
Caswell	L/S	2.45	0.00	0.00	0.05	0.05	0.05	0.00	0.00	37.50
Question	L/S	11.95	0.00	0.00	0.55	0.00	0.45	0.00	0.00	4.15
Iron N	US	0.75	0.00	1.40	0.55	0.05	0.00	0.00	0.00	0.00
Iron S*	US	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Colter	US	0.65	0.05	1.50	0.05	0.15	0.00	0.00	0.00	0.00
Swiftwater	US	0.70	0.05	1.30	0.00	0.25	0.00	0.00	0.00	0.00
Wasilla	US	1.75	0.55	0.80	0.00	0.50	0.00	0.00	0.00	0.00
Queer	WS	2.25	0.15	0.00	0.00	0.65	0.00	0.05	0.00	9.15
Chijuk Trib.	WS	0.35	0.00	0.00	0.00	0.10	0.00	0.00	0.00	2.15
Wiggle	WS	6.95	0.00	0.00	0.00	0.05	0.05	0.00	0.00	62.10
Meadow	WS	2.25	0.00	0.00	1.10	0.65	1.25	0.00	0.00	7.95
Maximum		11.95	0.55	1.50	1.10	0.65	1.25	0.10	0.00	66.95
Minimum		0.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 4: Average CPUT for each species at each site sampled in summer 2013

Site	Stream Type	coho	Chinook	Dolly Varden	rainbow trout	sculpin	lamprey	longnose sucker	northern pike	stickleback
Caswell	L/S	2.75	0.00	0.00	0.00	0.00	0.00	0.05	0.00	41.80
Cottonwood	L/S	4.79	0.00	0.00	2.68	0.32	0.00	0.00	0.00	9.32
Nancy	L/S	0.00	0.00	0.00	0.00	0.05	0.00	0.20	0.30	36.35
Question	L/S	5.00	0.00	0.00	0.90	0.00	0.00	0.00	0.00	3.95
Colter	US	2.20	0.25	1.50	0.05	0.15	0.00	0.00	0.00	0.00
Iron N	US	0.65	0.00	1.35	0.85	0.00	0.00	0.00	0.00	0.00
Iron S	US	2.00	0.00	0.65	0.60	0.30	0.00	0.00	0.00	0.00
Swiftwater	US	0.65	0.20	0.90	0.00	0.20	0.00	0.00	0.00	0.00
Wasilla	US	3.11	0.39	0.17	0.00	0.50	0.00	0.00	0.00	0.00
Chijuk Trib	WS	3.95	0.00	0.00	0.25	0.20	0.00	0.00	0.00	14.15
Meadow	WS	6.20	0.00	0.00	1.90	0.65	0.10	0.00	0.00	22.55
Queer	WS	7.10	0.10	0.00	0.10	1.45	0.00	0.05	0.00	17.90
Wiggle	WS	3.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00	70.45
Maximum		7.10	0.39	1.65	2.68	1.45	0.10	0.20	0.30	70.45
Minimum		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 5: Average CPUT for each species at each site sampled in fall 2013

Site	Stream Type	coho	Chinook	Dolly Varden	rainbow trout	sculpin	lamprey	longnose sucker	northern pike	stickleback
Caswell	L/S	9.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	13.80
Cottonwood	L/S	1.20	0.00	0.00	1.90	0.10	0.00	0.00	0.00	1.00
Nancy	L/S	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	26.75
Question	L/S	12.55	0.00	0.00	0.85	0.15	0.00	0.00	0.00	4.15
Colter	US	4.10	0.60	1.85	0.05	0.40	0.00	0.00	0.00	0.00
Iron N	US	0.50	0.00	1.35	2.30	0.10	0.00	0.00	0.00	0.00
Iron S	US	0.47	0.00	0.89	1.68	0.11	0.00	0.00	0.00	0.00
Swiftwater	US	1.56	0.72	3.00	0.06	0.50	0.00	0.00	0.00	0.11
Wasilla	US	2.79	0.74	0.32	0.00	1.42	0.00	0.00	0.00	0.00
Chijuk Trib.	WS	7.20	0.00	0.00	1.40	0.10	0.00	0.00	0.00	5.35
Meadow	WS	15.10	0.00	0.00	4.20	1.30	0.05	0.00	0.00	84.30
Queer	WS	6.89	0.00	0.00	0.05	0.00	0.00	0.00	0.00	0.63
Wiggle	WS	8.80	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.65
Maximum		15.10	0.74	3.00	4.20	1.42	0.05	0.00	0.00	84.30
Minimum		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

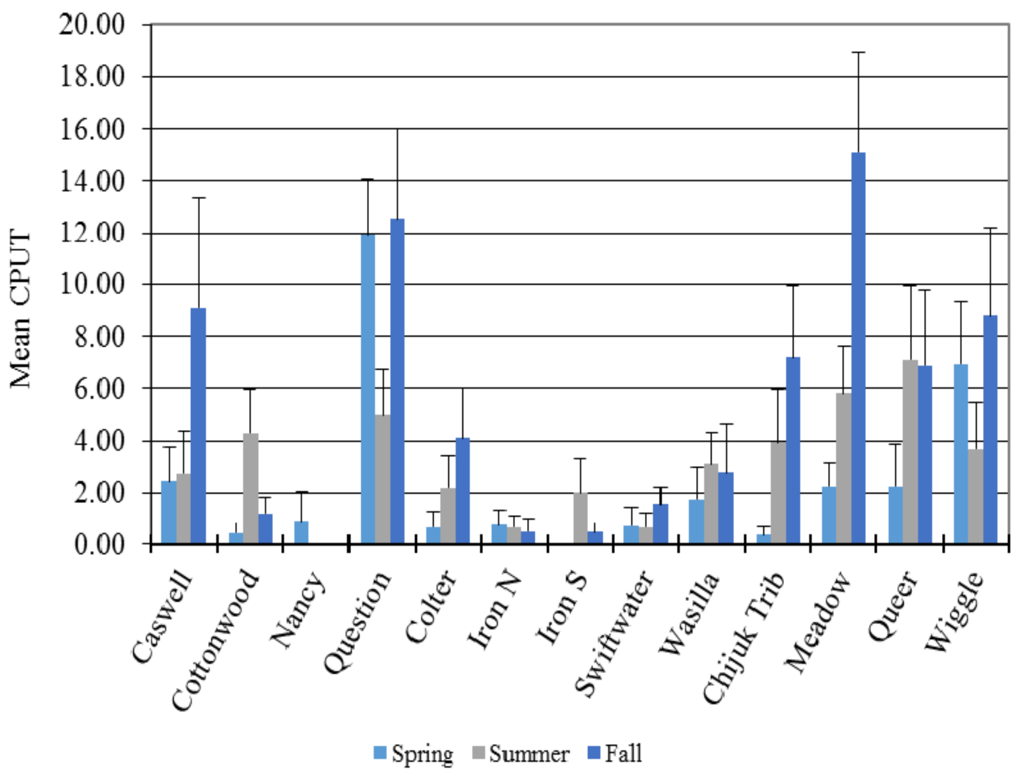

Figure 3: Average relative abundance of juvenile coho salmon (catch per unit trap) for all thirteen sampled sites in all three seasons. *Iron S was not sampled in spring 2013.

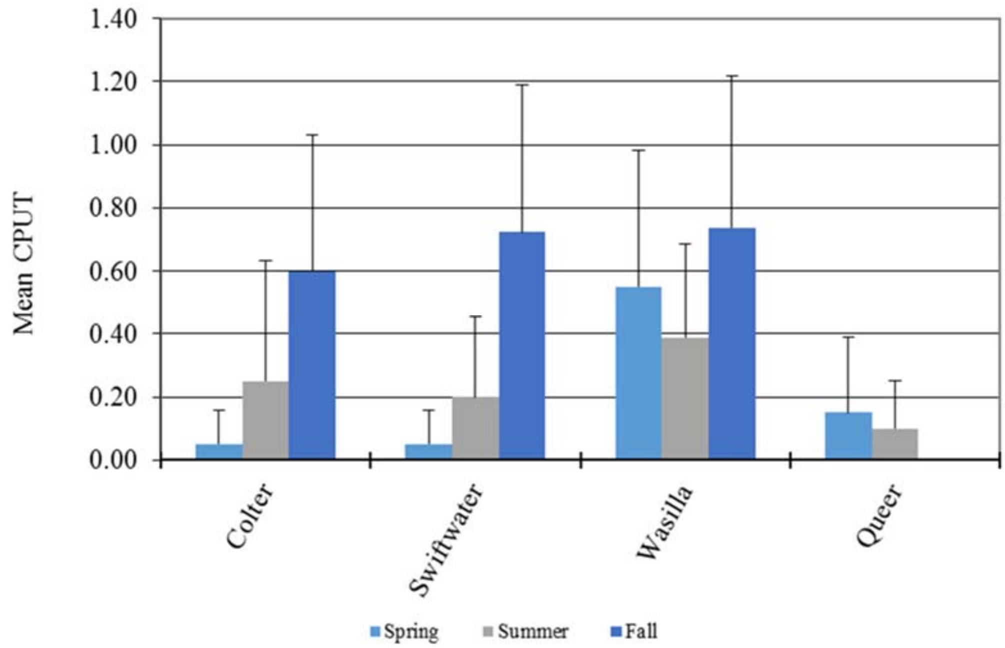

Figure 4: Relative abundance of juvenile Chinook salmon (mean catch per unit trap) for all thirteen sites in all three seasons. *Sites not shown had 0.00 CPUT for all three seasons.

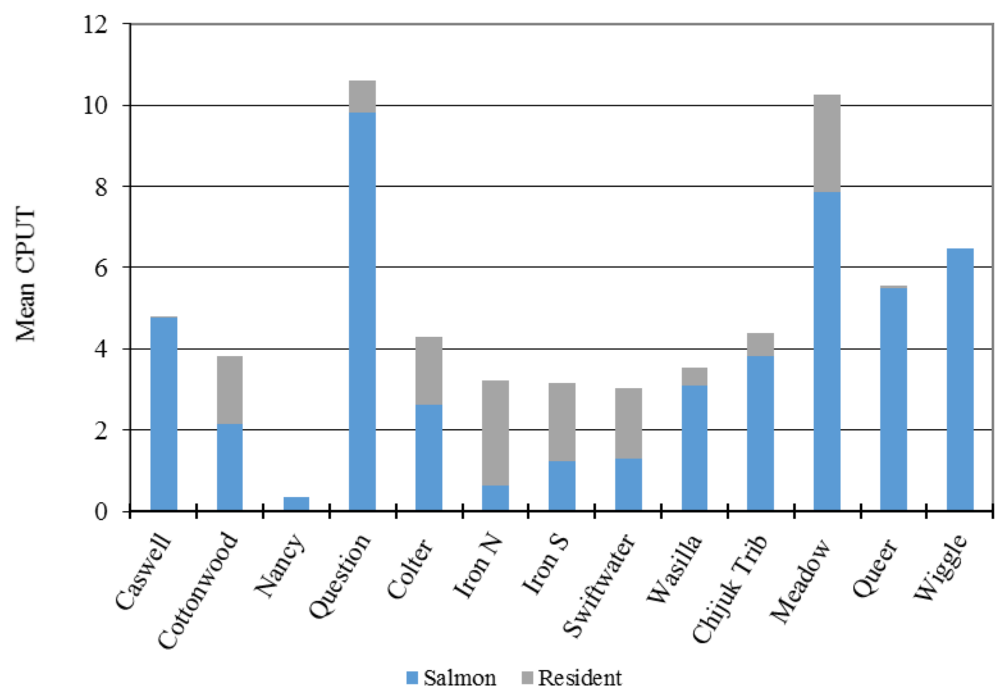

Figure 5: Average yearly relative abundances (mean catch per unit trap) of anadromous juvenile salmon and resident salmonids.

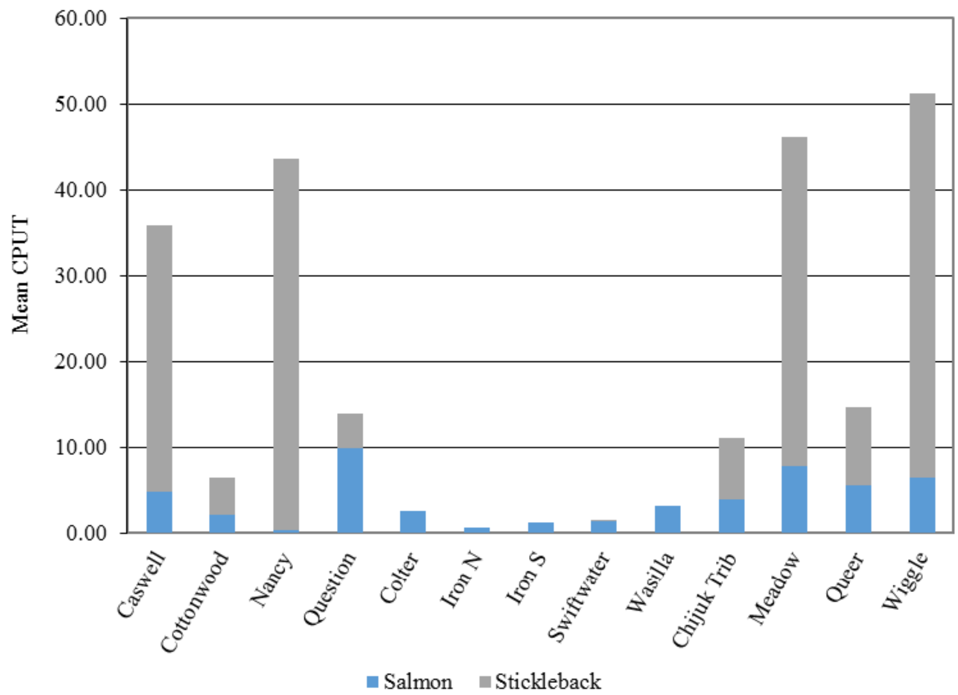

Figure 6: Average yearly relative abundances (mean catch per unit trap) of anadromous juvenile salmon and stickleback.

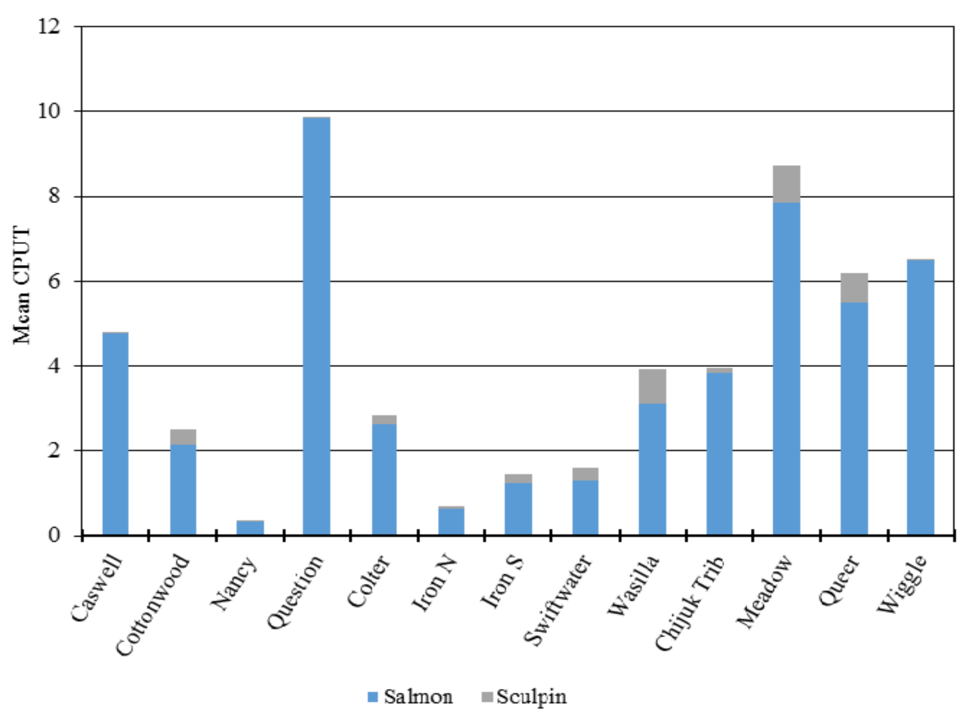

Figure 7: Average yearly mean abundances (catch per unit trap) of anadromous juvenile salmon and sculpin.

4.3 Salmon Condition

Average condition factors for coho salmon are shown in Figure 8. Spring condition factors ranged from 0.087 in Swiftwater Creek to 0.109 in Caswell Creek. In the summer, condition factors were generally higher than in the spring with a low of 0.101 at Meadow Creek and a high of 0.109 at Swiftwater Creek. Fall coho salmon condition factors were generally lower than in the summer with a low of 0.0952 at Meadow Creek and a high of 0.104 at Question Creek. Coho summer and fall condition factors decreased as relative abundance increased with the exception of Question and Wiggle creeks which had high relative abundance and high fall condition factors.

Condition factors for Chinook salmon could only be calculated for Wasilla Creek. All other sites where Chinook were observed had too few fish to determine their average condition. Wasilla Creek had a low condition factor of 0.103 and a high of 0.112.

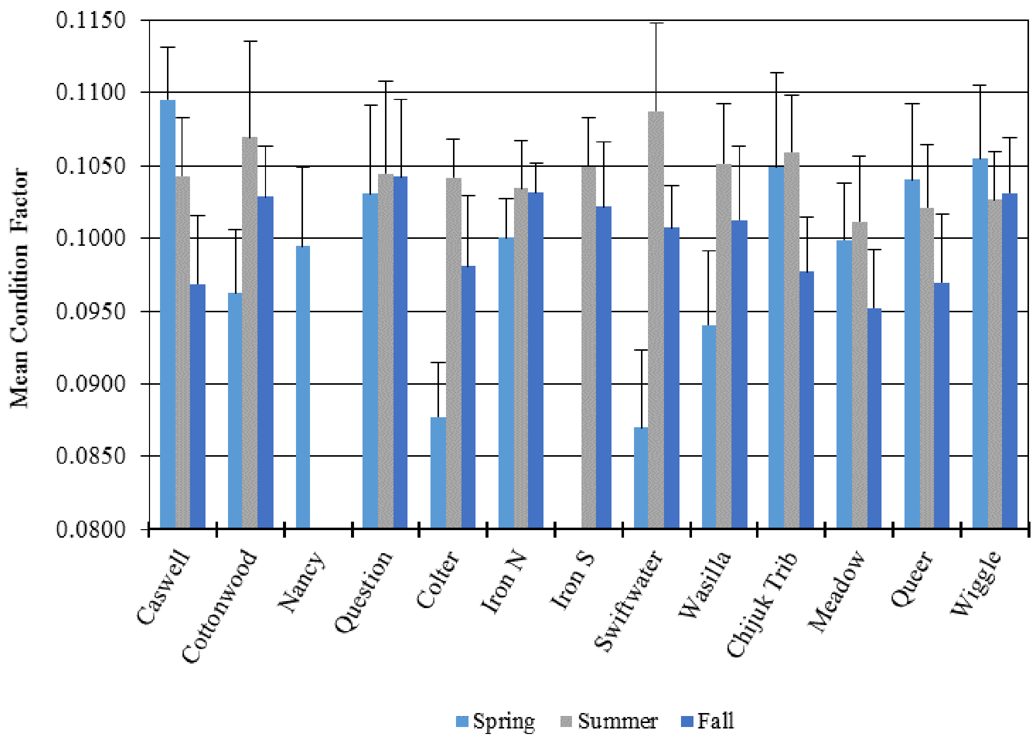

Figure 8: Mean condition factor (mm/g^3) of juvenile coho salmon for all sites sampled in every season. *Iron S was not sampled in spring 2013 **condition factors for Nancy Creek in summer and fall were not calculated because no coho salmon were captured.

4.4 Growth Rates

Instantaneous growth rates for coho salmon are shown in Table 6. Growth rates were calculated for YOY (young of year) coho in seven sample sites using median fork lengths and weights from summer to fall. Fork length frequency distributions were used to determine the YOY age class (Figure 9). Some sites (Colter, Iron N, Iron S, Nancy, Swiftwater and Wiggle creeks) had no distinct bimodal fork length distribution or too few fish resulting in the inability to determine age class. This prevented growth rates from being calculated for those sites. Instantaneous growth rates were only calculated for YOY Chinook salmon in Wasilla Creek due to low fish numbers in 2013 at all other sites. Rates for Chinook salmon at Wasilla Creek were 0.53 (mm/mm/day) and 1.71 (g/g/day) for length and weight respectively.

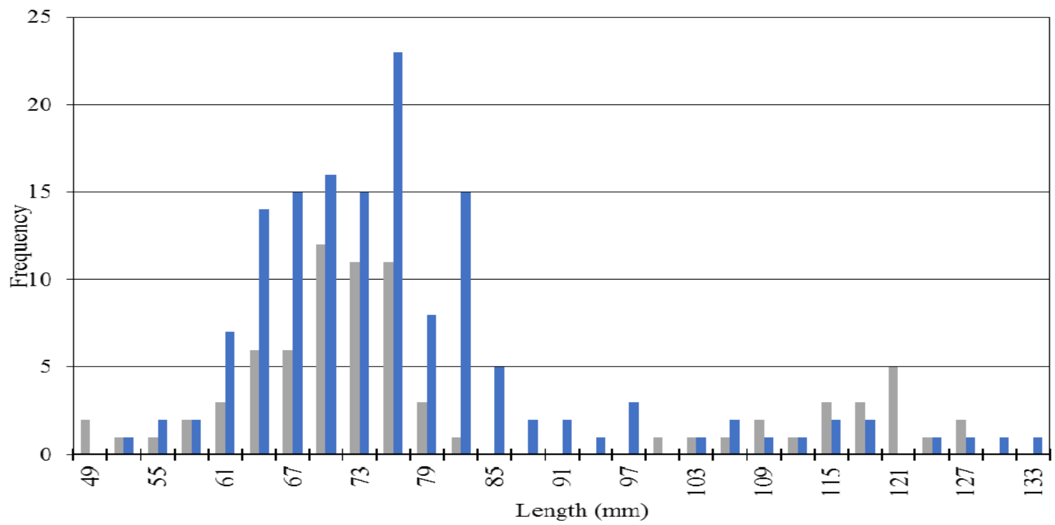

Figure 9: Example of juvenile coho salmon length frequency distribution used to determine YOY age class. Example is from Chijuk Tributary in summer and fall. The distribution is bimodal showing two distinct age classes.

Table 6: Instantaneous growth rates for YOY coho salmon. Growth rates were calculating using median fork length and weights. *Growth rate could not be calculated due to low coho salmon numbers or lack of distinguishable YOY age class in length frequency distribution.

Site Name	Instantaneous growth rate (mm/mm/day)	Instantaneous growth rate (g/g/day)
Caswell	0.15	0.36
Chijuk Trib.	0.06	0.01
Colter	*	*
Cottonwood	0.34	0.89
Iron N	*	*
Iron S	*	*
Meadow	0.30	0.73
Nancy	*	*
Queer	0.26	0.58
Question	0.33	1.13
Swiftwater	*	*
Wasilla	0.34	1.07
Wiggle	*	*

4.5 Water Quality

pH

Stream water pH ranged from 5.21 to 9.82 among the 13 sampled sites (Table7). Seasonally, spring samples had lower pH values than summer and fall with an average of 7.16 (standard deviation (σ) =1.14). Fall samples had generally higher pH values then summer with an average of 7.64 (σ =0.83). Wetland streams had the lowest average pH values in every season with a yearly average of 6.71 (σ=0.82). There was no strong difference in pH for any season between upland streams and lake-stream complexes.

Specific Conductivity

Specific Conductivity values ranged from 19.00 to 257.50µS/cm among the 13 sampled sites (Figure 10). There was no strong seasonal variation in specific conductivity. Overall, there also were no strong differences in specific conductivity among stream types. As seen in Figure 10, Cottonwood, Wasilla and Meadow creeks had the three highest conductivities and each is a different stream type (lake-stream, upland, and wetland respectively); however, all three flow through urban and commercially developed watersheds.

Dissolved Oxygen

Dissolved oxygen (DO) as percent saturation ranged from 61.0 to 107.3% and concentrations from 6.77 to 13.21mg/L among all 13 sampled sites (Figure 11). There was no strong difference in average DO across seasons; however, DO was different among stream types. Upland streams were saturated with oxygen and had the highest average DO% and DO mg/L for every season sampled with a yearly average of 101% saturation (σ=6.72) and 11.58 mg/L (σ=1.54). Wetland streams had the lowest yearly average with 88.14% saturation (σ=12.26) and average concentration of 8.66 mg/L (σ=1.23).

Turbidity

Stream water turbidity ranged from 0.13 to 12.98 NTU among all sampled sites and seasons. Overall, turbidity did not vary among seasons with only slightly higher turbidity values in the spring with an average of 2.88 (σ=3.71). Wasilla Creek had the highest yearly average with 7.76 NTU. The next highest turbidity was Chijuk Tributary with a yearly average of 3.58 NTU. Upland streams had higher turbidy than any other stream type with a yearly average of 3.55NTU (σ=3.6) due to high turbidity in Wasilla Creek and Swiftwater Creek in the spring.

Temperature

Temperature data for each site can be found in Table 8. Lake-stream complexes had the highest season maximum temperatures averaging 24.5°C (σ=1.74) Lake-stream complexes also had the highest percentage of days over 20°C with an average of 35.6% (σ=10.86) and the lowest percentage of days in the optimal temperature range (32.7%). As seen in Figure 12 none of the upland streams had any days over 20°C. Wetland streams had the highest percentage of days in the optimal temperature range with an average of 39.1%

(σ=6.46). Of all the stream types, upland streams had the lowest average cumulative degree days for every month June through September.

Table 7: Water quality measures for all sites in the spring, summer and fall. *Iron Creek South was not sampled in the spring. **Temperature is an average of two YSI handheld meters

	Caswell Creek	**Cottonwood Creek**	**Nancy Creek**	**Question Creek**	**Colter Creek**	**Iron Creek North**	**Iron Creek South***	**Swiftwater Creek**	**Wasilla Creek**	**Chijuk Tributary**	**Meadow Creek**	**Queer Creek**	**Wiggle Creek**
Spring	**6/24**	**6/5**	**6/12**	**6/14**	**6/3**	**6/19**	**N/A**	**6/3**	**6/12**	**6/17**	**6/5**	**6/18**	**6/26**
Stream type	L	L	L	L	U	U	U	U	U	W	W	W	W
pH	6.6	8.1	7.5	7.1	6.9	6.8	N/A	7.1	9.8	7.6	7.3	5.2	5.9
Spec Cond (µS/cm)	41.5	208.1	76.6	53.6	39.1	51.5	N/A	32.5	154.4	37.6	180.6	19.0	69.2
DO (% Saturation)	73.5	107.3	81.4	97.1	104.5	96.7	N/A	102.9	80.1	84.5	105.1	92.2	83.7
DO (mg/l)	7.2	10.7	7.1	8.4	13.2	8.6	N/A	13.2	8.2	7.5	11.0	7.5	7.7
Turbidity (NTU)	0.6	2.7	1.0	0.4	3.3	0.4	N/A	7.1	13.0	3.0	1.0	0.7	1.6
Discharge (cfs)	5.2	25.7	49.1	10.7	30.7	7.2	N/A	38.0	60.7	10.1	21.8	11.6	8.5
Temperature (°C)**	16.5	15.5	20.7	20.7	5.5	13.8	N/A	5.5	12.7	19.5	13.8	24.9	18.3
Summer	**7/23**	**7/16**	**7/18**	**7/29**	**7/15**	**7/22**	**7/22**	**7/15**	**7/16**	**7/24**	**7/17**	**7/24**	**7/29**
pH	6.7	8.4	7.4	7.1	7.5	6.4	7.1	7.6	8.0	6.8	7.8	6.3	6.7
Spec Cond (µS/cm)	41.7	220.8	N/A	58.6	54.7	56.8	60.1	55.3	219.7	45.6	196.3	39.5	69.2

	Caswell Creek	Cottonwood Creek	Nancy Creek	Question Creek	Colter Creek	Iron Creek North	Iron Creek South*	Swiftwater Creek	Wasilla Creek	Chijuk Tributary	Meadow Creek	Queer Creek	Wiggle Creek
DO (% Saturation)	87.1	105.8	103.1	92.2	103.7	105.5	103.0	102.1	106.2	95.5	101.4	102.9	82.7
DO (mg/l)	8.1	9.6	9.4	8.0	11.5	12.2	10.9	11.4	11.6	8.9	9.8	9.4	7.8
Turbidity (NTU)	3.3	1.7	1.9	1.4	1.4	2.9	1.8	0.8	1.5	5.2	2.0	6.1	2.3
Discharge (cfs)	5.5	18.0	5.3	9.6	4.0	3.7	5.2	6.6	22.7	0.1	15.4	0.2	N/A
Temperature (°C)**	18.7	20.7	20.0	22.2	10.7	9.4	12.9	10.5	11.5	19.0	16.9	20.0	19.6
Fall	**9/11**	**9/2**	**9/4**	**9/10**	**9/3**	**9/16**	**9/16**	**9/3**	**9/2**	**9/9**	**9/4**	**9/11**	**9/12**
pH	6.8	8.4	7.8	8.2	8.3	7.4	7.7	8.1	8.8	7.5	5.9	N/A	6.7
SpecCond (µS/cm)	35.6	257.5	112.0	66.5	61.9	41.9	43.7	59.3	133.5	30.0	N/A	N/A	40.9
DO (% Saturation)	80.4	92.3	86.2	94.9	105.5	104.6	99.7	105.3	98.9	80.0	82.6	86.1	61.0
DO (mg/l)	8.7	9.5	8.8	9.9	12.0	13.1	12.7	12.1	11.4	9.0	9.0	9.7	6.8
Turbidity (NTU)	0.5	0.4	0.1	1.5	1.8	1.4	3.2	2.4	8.9	2.6	0.6	1.3	1.8
Discharge (cfs)	40.8	29.5	22.5	14.7	16.2	26.0	21.1	22.7	55.7	16.9	23.8	N/A	N/A
Temperature (°C)**	11.8	14.3	14.2	12.9	9.7	5.6	5.7	9.3	9.0	9.6	11.9	10.2	10.5

Table 8: Temperature metrics calculated from measurements recorded by Onset Pro V2 Data logger. *Optimal temperature is defined as >10°C and <16.8°C

Site Name	Caswell Creek	Cottonwood Creek	Nancy Creek	Question Creek	Colter Creek	Iron Creek North	Iron Creek South	Swiftwater Creek	Wasilla Creek	Chijuk Tributary	Meadow Creek	Queer Creek	Wiggle Creek
Seasonal Maximum Temperature	22.0	26.1	25.2	24.7	15.9	13.4	17.7	15.4	17.1	20.1	22.0	24.6	22.5
Percent Days over 20°C	19.4	41.2	41.8	40.2	0.0	0.0	0.0	0.0	0.0	2.3	10.4	22.4	15.7
Percent Optimal Temperature Days*	51.0	26.0	30.9	22.7	35.2	26.2	47.6	33.6	35.9	39.1	44.8	42.4	30.1
June Cumulative Degree Days	108.3	582.8	368.6	557.7	218.0	105.4	125.3	212.9	320.3	436.8	475.0	529.6	496.7
July Cumulative Degree Days	548.1	618.6	621.3	626.6	334.7	293.4	355.0	318.3	359.7	487.5	507.1	518.0	535.4
August Cumulative Degree Days	479.1	530.7	532.6	572.4	319.3	282.5	326.1	304.5	314.7	427.3	437.3	446.7	463.9
September Cumulative Degree Days	301.8	338.3	343.5	343.0	197.9	192.4	190.8	188.8	200.6	229.3	266.6	274.9	243.5

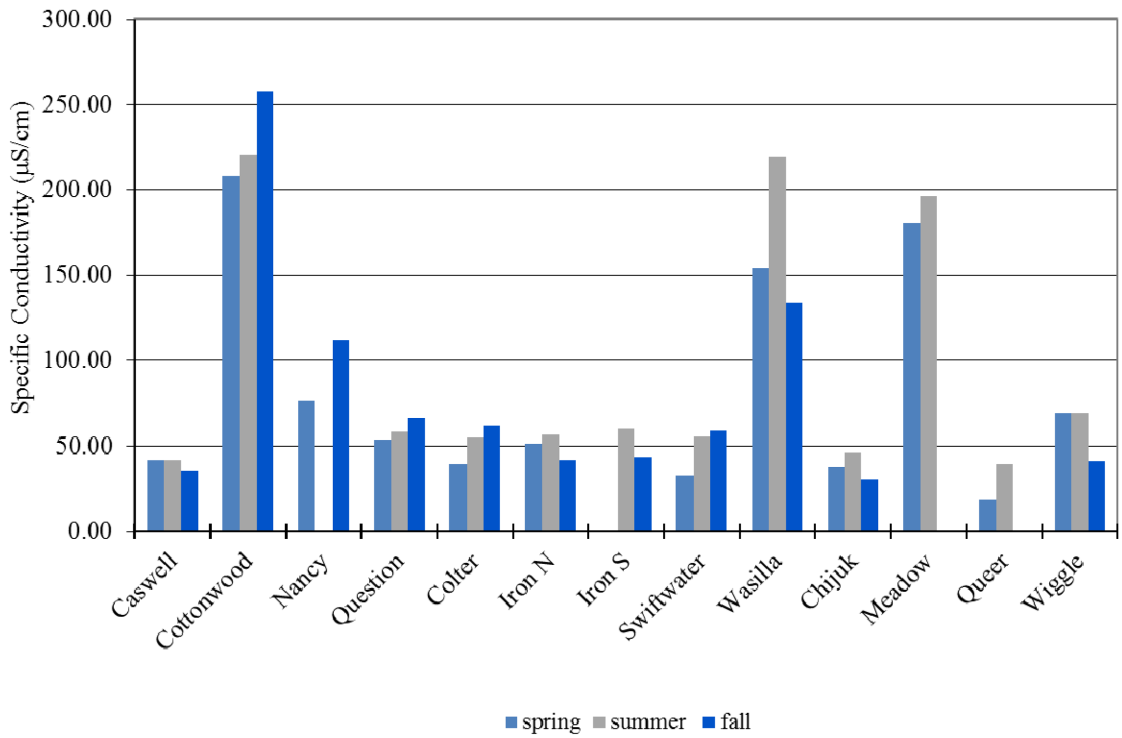

Figure 10: Specific Conductivity for all sites sampled for all three seasons. *Iron South was not sampled in the spring.

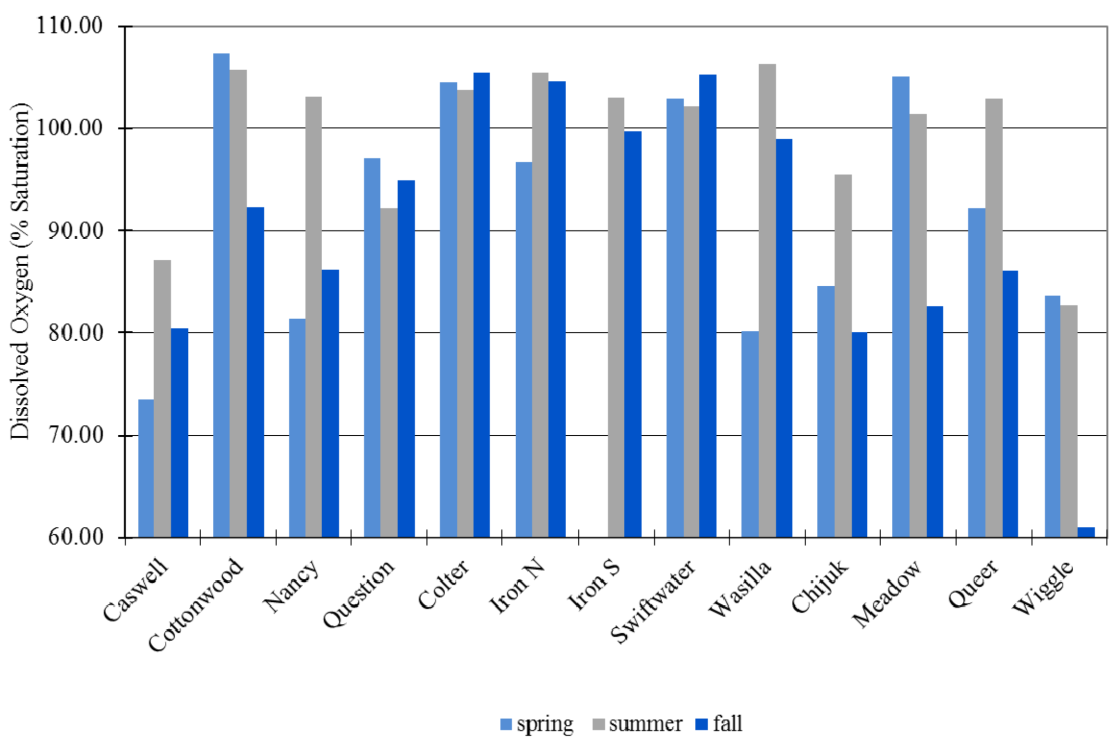

Figure 11: Dissolved Oxygen (% saturation) for all sites sampled in all three season. *Iron South was not sampled in the spring.

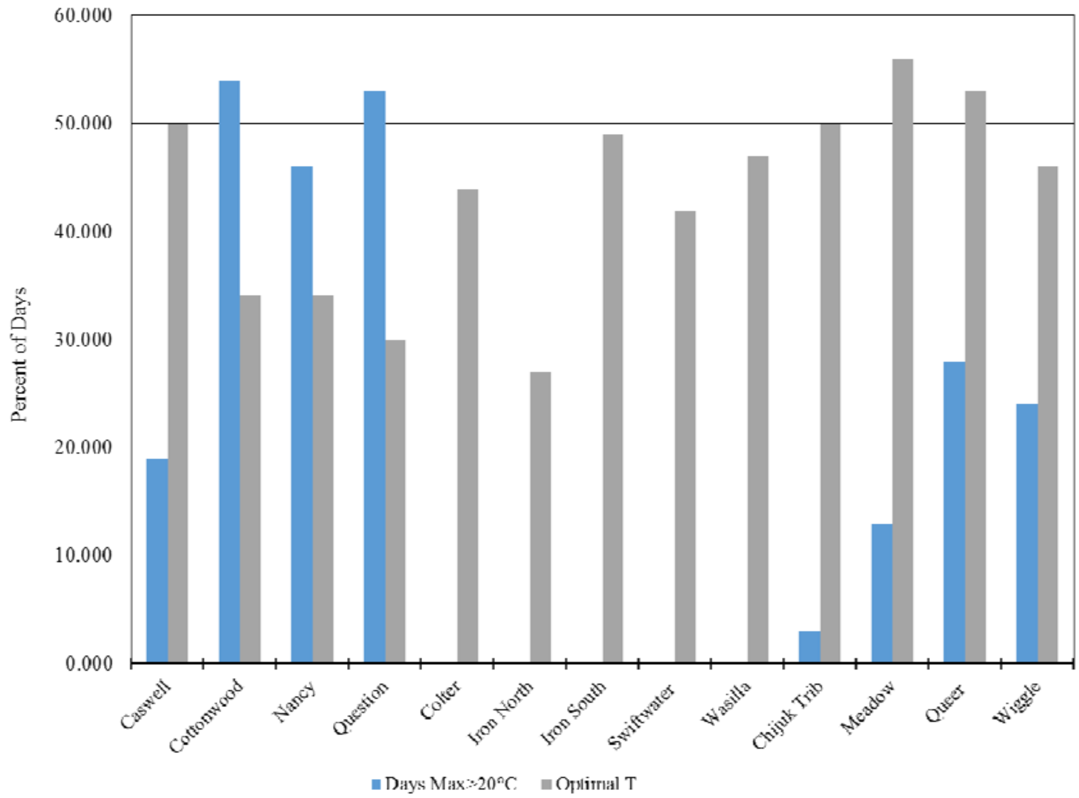

Figure 12: For each stream the percentage of totals days that maximum temperature exceeded 20°C and the percentage of total days in an optimal temperature range (between 10 and 16.8°C).

5.0 Discussion

This investigation of juvenile Pacific salmon abundance and condition among 13 sites in the Matanuska Susitna Valley reveals distinct differences among stream classification types and an overall decrease in abundance compared to previous years. Upland streams were generally colder with the lowest average degree-days, lowest maximum temperature and no days above 20°C. They also had higher average oxygen levels than any other stream type. Juvenile Chinook salmon, although not captured in any great abundance in 2013, were almost exclusively found in upland streams. In contrast, upland streams had the lowest abundance of coho salmon compared to wetland streams and lake-stream complexes. Stickleback were not captured in upland streams but were found in great abundance in the other stream types. Dolly Varden were found solely in upland streams.

Wetland streams had slightly lower average pH values and dissolved oxygen than lake-stream complexes. Lake-stream complexes were generally warmer with the highest seasonal maximum temperatures, highest percentage of days over 20°C and the highest average cumulative degree-days in July, August and September. Coho salmon abundances were higher on average in wetland streams. Both wetland and lake-stream complexes supported high abundances of stickleback.

Condition factors for coho and Chinook salmon have remained fairly consistent with past years' studies. Every stream sampled in summer 2013 had average coho salmon condition factors above 0.10 mm/g^3. In the fall 2013, only four of the streams dropped slightly below 0.10. These averages are similar to those found in 2010 and 2011 (Miller et al 2011). Condition factors tended to be negatively correlated with relative abundance and were useful for identifying productive stream systems.

Abundances in fall 2013 compared to past juvenile salmon monitoring studies in these streams indicate that both coho and Chinook salmon abundances have decreased significantly from previous years' study. Chinook salmon were not captured in five streams where they had been captured in previous years including; Caswell, Iron North, Iron South, Queer, and Wiggle Creeks and were mainly restricted to upland streams in 2013. In addition, coho salmon abundances have declined in those same streams as well as in Colter, Cottonwood, Nancy, Swiftwater, Wasilla creeks.

Lower relative abundance of juvenile salmon could be partially attributed to low adult returns for both Chinook and coho salmon in the Susitna drainage in 2012. The Deshka River barely met escapement goals for Chinook salmon in 2012 with 14,096 fish counted. The Little Susitna River Chinook fishery was closed due to extremely low catch rates on June 15th 2012. Similarly coho salmon escapement goals (10,100-17,700 fish) were not met on the Little Susitna in 2012, and have not been met since 2008 (Shields and Dupuis 2013).

Fall flooding, in addition to low adult Chinook salmon escapement in 2012 may have been an additional cause of low salmon abundance and limited distribution relative to previous years. Several rivers in the Mat-Su reached 100 year flood stage, including the Talkeetna River and Wasilla Creek. The Little Susitna River reached 200 year flood stage (USGS 2013). High bed tractive forces associated with these floods have the potential to increase bedload movement and scour eggs from redds.

Previous years' data also suggests that aside from flood effects, low abundances are a part of a more long term decline in numbers (Figures 13 and 14). In conjunction with declining abundances are warmer temperatures in streams of every geomorphic classification type.

Nancy Creek at the outlet of Nancy Lake contained invasive northern pike and had the warmest water temperatures among all sampling locations. Juvenile coho salmon were present only in spring Nancy Creek samples and were absent in the summer and fall. This is a decrease from previous years. In 2008, average coho salmon CPUT was 5.5, 4.1 in 2009, then dropped to 1.3 in 2010. There were no resident salmonids captured in any season in Nancy Creek. Nancy Creek was the only stream in which northern pike were captured, suggesting predation as the cause for the decline in Nancy Lake coho and resident salmonids relative abundance. Nancy logged more than 40% of days over 20°C and had a maximum stream temperature of 25.2°C which is approaching the lethal temperature for rearing coho salmon (Ritcher and Kolmes 2005).

Stream temperature is a crucial variable controlling aquatic systems due to its effect on stream primary production and metabolic rates of aquatic organisms. Stream temperature is understood to be highly influential in the health and abundance of salmon (Richter and Kolmes 2005). Nancy Creek as well as several other streams had high maximum yearly temperatures and high cumulative monthly temperatures compared to previous years (Miller et al 2011). Although there is a slight positive correlation between maximum stream temperature and summer coho salmon abundance in 2013 among streams sampled (r =0.56) a more thorough temporal investigation spanning several years is needed in order to determine if temperature is positively correlated with abundance or condition of juvenile salmon within streams and stream types.

Juvenile salmon and water quality monitoring appears to provide a useful index of the health of salmon communities within Mat-Su streams. Differences in the relative abundance of salmon, resident fish, and water quality must account for natural differences among stream types. However, they also appear to be an effective indicator of annual trends and declines associated with predation. Differences in relative abundance among years was reflected in the decrease in the distribution of salmon species particularly Chinook juveniles. Proposed development projects must consider this variability when using short-term measures of relative abundance to evaluate habitat quality.

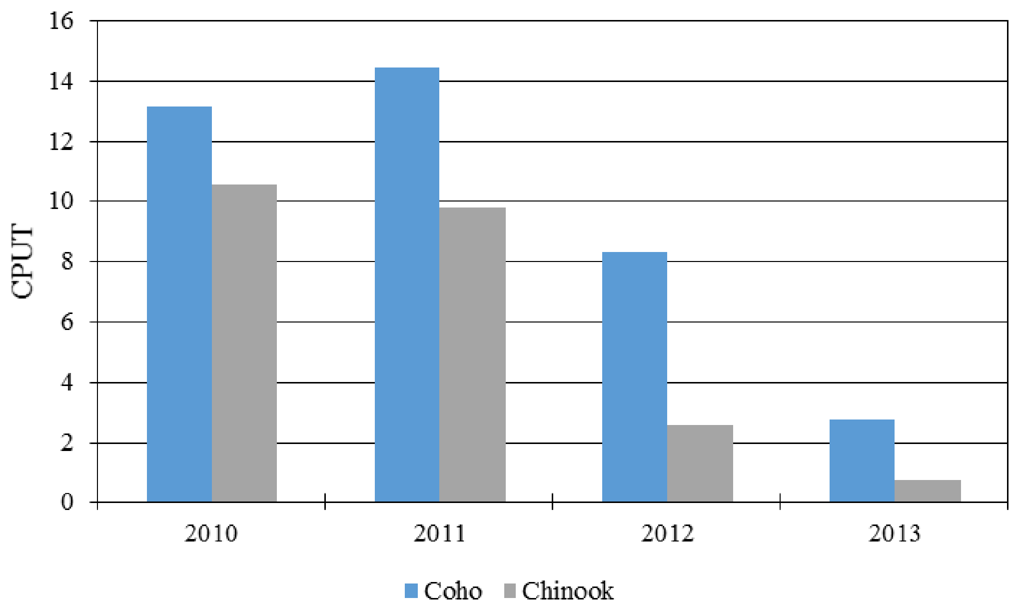

Figure 13: Catch per Unit Trap for Wasilla Creek for juvenile coho and Chinook salmon from 2010 to 2013 in the fall.

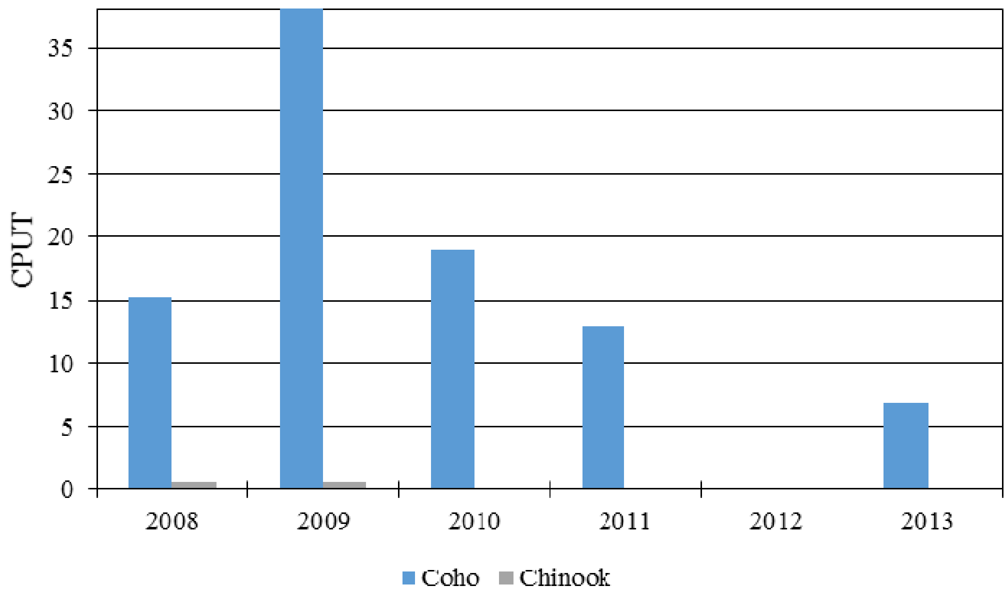

Figure 14: Catch per Unit Trap for Queer Creek for juvenile coho and Chinook salmon from 2008 to 2013 in the fall. *No sampling was conducted in 2012

References

Alaska Department of Environmental Conservation. 2011. 18 AAC 70, Water Quality Standards. Juneau, Alaska

Barbour, M.T., W.F. Swietlik, S.K. Jackson, D.L. Courtemanch, S. P.Davies, and C.O. Yoder. 2000. Measuring the attainment of biological integrity in the USA: A critical element of ecological integrity. Hydrobiologia 422/423:453-464.

Davis, J.C., G.A. Davis, and L.R. Jensen. 2013. Matanuska-Susitna Stormwater Assessment: 2011-2012. Final Report for the Alaska Department of Environmental Conservation. Aquatic Restoration and Research Institute, Talkeetna, Alaska.

Davis, W.S. & T.P. Simon (eds). 1995. Biological Assessment and Criteria: Tools for Water Resource Planning and Decision Making. Lewis Publishers, Boca Raton, F L, 415 pp.

Karr, J. R. and E. W. Chu. 1999. Restoring Life in Running Waters: Better Biological Monitoring. Journal of Water, Air and Soil Pollution. 116:666-667

Miller, E.M., J.C. Davis, and G.A. Davis. 2011. Monitoring juvenile salmon and resident fish with the Matanuska-Susitna Basin. Final Report for the Mat-Su Basin Salmon Habitat Partnership. Aquatic Restoration and Research Institute, Talkeetna, AK.

Richter, A. and S.A. Kolmes. 2005. Maximum temperature limits for Chinook, Coho and chum salmon and steelhead trout in the Pacific Northwest. Reviews in Fisheries Science 13, 1: 23-49.

Shields, P. and A. Dupuis. 2013. Upper Cook Inlet Commercial Fisheries Annual Management Report, 2012. Fishery Management Report No. 12-21. Alaska Department of Fish and Game. Pdf accessed 14 May 2013. <http://www.adfg.alaska.gov/fedaidpdfs/fmr13-21.pdf>

Smith, C. and J. Speed (eds). 2013. Conserving Salmon in the Mat-Su Basin: The Strategic Action Plan of the Mat-Su Salmon Habitat Partnership 2013 update. Web. 20 April 2014 <http://www.matsusalmon.org/wp-content/uploads/2012/10/2013-Strategic-Action-Plan.pdf>

USEPA, 1990. Biological Criteria: National Program Guidance for Surface Waters. EPA 440-5-90-004. Office of Water Regulations and Standards, U.S. Environmental Protection Agency, Washington, DC, 87 pp.

U.S. Geological Survey, 2013, Water-resources data for the United States, Water Year 2012: U.S. Geological Survey Water-Data Report WDR-US-2012, site 15292780, pdf accessed 14 May 2013. <http://wdr.water.usgs.gov/wy2012/pdfs/15292780.2012.pdf>