Distribution and Habitat Utilization of Juvenile Spring Chinook Salmon in the Metolius River Basin, Oregon: 2003 Progress Report

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February 2003

EXECUTIVE SUMMARY

This study was initiated in conjunction with plans to reestablish passage of anadromous fish species through the Pelton Round Butte Hydroelectric Project (Project) in Central Oregon (Ratliff et al. 2001). This study is aimed at investigating the seasonal (spring, summer, and fall) distribution and habitat use of juvenile chinook salmon released into the Metolius river basin. The Metolius River and its tributaries were historically the main spawning ground for spring chinook salmon in the middle Deschutes Basin (Nehlsen 1995).

Characterization and quantification of habitat capacity were identified as uncertainties to be addressed as part of reintroduction efforts (Ratliff et al. 2001). Recent approaches to characterizing habitat quality and quantity in the Metolius Basin, such as HABRATE (Burke et al. In Press), have in large part been based on data collected in other river systems, which may or may not be accurate when applied to the unique ecological setting of the Metolius Basin. The primary goal of this research is to provide managers with data on fish distribution and habitat associations collected by observations in the Metolius Basin.

Preliminary results from the 2002 field season indicate that there was a significant difference in juvenile chinook salmon densities among study sections in 2002. The greatest densities and numbers of juvenile chinook salmon were found in summer and fall in upper Lake Creek. The lowest number and density of juvenile chinook salmon were observed in fall in Heising Spring. Very few juvenile chinook salmon were observed in any season in the large pool habitats of the mainstem Metolius River. Juvenile chinook were, on average, largest in the Metolius Headwaters, and smallest in Heising Spring. Condition factors (length / weight^3, a measure used to reflect the nutritional state or "well-being" of an individual fish [Busacker et al. 1990]) were comparable among all study sections. Invertebrate drift sampling in fall indicated that there was a significant difference among study sections in drift abundance, but not in drift biomass.

At this point, in winter of 2003, we have finished with the first year's data collection, are in the process of data exploration and preliminary analysis of those data, and are preparing for the upcoming second year of field work.

CHINOOK FRY RELEASES

In 2002, approximately 55,000 chinook fry raised in hatchboxes in the Metolius Basin (Schulz 2002) were released into the Metolius River and its tributaries. In 2003, approximately 140,000 chinook fry were reared at the Round Butte Hatchery, and were transported and released on February 5 and 6. In both years, the chinook fry were released in five locations around the basin (Table 1).

Table 1. Approximate number of chinook fry released into the Metolius basin in 2002 and 2003.

Release Location	Metolius Headwaters	Spring Creek	Heising Spring	Canyon Creek	Lake Creek	Estimated Totals
2002 releases (+/- 400)	12,800	11,000	10,400	10,400	10,400	54,300
2003 releases	36,504	14,678	14,748	36,574	37,213	139,217

We hope that increasing initial population levels will allow us to investigate density-dependent differences in distribution and habitat use between years.

STUDY SITES

Six stream sections in the Metolius Basin (Figure 1) were examined to approach the goals of this study. Two study sections were located in the mainstem of the Metolius River, and four were located in tributaries - Lake Creek, Canyon Creek, Spring Creek, and Heising Spring. Each of these tributaries exhibits a unique combination of temperatures and habitat availability (Table 2).

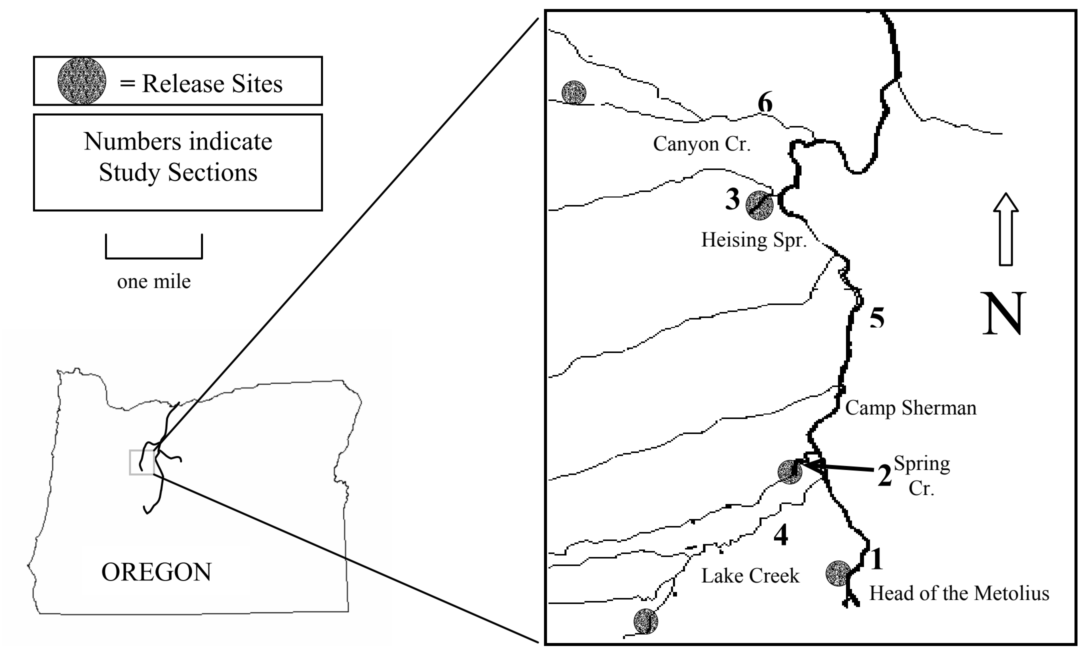

Figure 1. The upper Metolius River Basin and study sections: 1) Head of the Metolius (Metolius Springs), 2) Spring Creek, 3) Heising Spring, 4) Lake Creek, 5) Mainstem Metolius, 6) Canyon Creek.

Table 2. Study sections and physical attributes.

Section #	Stream	Habitat	Summer Maximum Temperature (2002)
1	Metolius Headwaters	Riffle	(13°C)
2	Spring Creek	Riffle	(11° C)
3	Heising Spring	Riffle	(8° C)
4	Lake Creek	Pool / Riffle	(24° C)
5	Mainstem Metolius	Pool / Riffle	(13° C)
6	Canyon Creek	Pool / Riffle	(11° C)

A total of 26 sites were selected for study: Three each in Spring Creek and Heising Spring, and five each in Lake Creek, Canyon Creek, the Metolius Mainstem, and the Metolius Headwaters. Sites ranged from 50m to 120m in length.

STUDY GOALS

The first two years of this study, 2002 and 2003, will involve conducting field observations of juvenile chinook salmon in the Metolius Basin. Our goals are to assess the effects of habitat availability and water temperature on the distribution of juvenile chinook salmon. e will compare distribution in areas with different habitat availability, temperatures, and flow regimes. We also will investigate the role of food availability and other biotic influences on juvenile chinook. In 2003, we have increased the number of chinook fry released into the study sites in an attempt to observe density-dependent effects on distribution and habitat use. The second goal for this study is to develop an approach for habitat capacity models based on the data collected in the first two years of the study.

STUDY OBJECTIVES

Objective 1) Examine the patterns of distribution and habitat utilization by juvenile chinook salmon in relation to:

a. Physical habitat variables and multiple spatial scales.
b. Water temperature differences within and between study sections.
c. Differences in initial population releases between study years.

Objective 2) Investigate the relative differences in growth and condition of juvenile chinook salmon rearing in different temperatures and habitat availability.

Objective 3) Determine the relative resources available to juvenile chinook salmon in areas with different temperatures and habitat availabilities.

METHODS

Habitat Surveys

Habitat surveys were conducted on each of the selected study sites prior to snorkeling efforts. Sites were delineated by major habitat units (riffle or pool). Lengths, widths, maximum depths, pool tail crests, and average depths (for riffles) were measured and recorded. Sketches were drawn of each site, noting the location of each of the habitat units and subunits.

Subunits in riffles were identified by their formative feature: large woody debris, boulder, bank alcove, overhanging vegetation or emergent vegetation. We recorded the length, width, maximum and average depths, and substrate type of each subunit. We also recorded the location of each subunit: bank, mid-channel, or backwater (off-channel).

Seasonal discharge (flow) measurements were taken at each of the sections at each of the seasons, using a Marsh-McBurney Flo-Mate electronic flow meter.

Snorkel Surveys

Snorkeling surveys were conducted on each of the sites at three times during the year: spring (May), summer (June/July) and fall (September). Divers made a single pass of the site, moving from the bottom of each unit upstream to the top. Most sites were surveyed using two divers, one moving up each bank. Some larger units in the mainstem Metolius River were surveyed using three or four divers. A sub-sample of sites (4 in spring, 8 in summer and fall) were re-snorkeled at night. Night diving was always conducted at least 48 hours before or after day snorkeling to allow for the fish to resettle.

All fish were identified by species and size (under 200 mm or over 200 mm) and their locations were recorded. Locations for the fish were recorded as one of the following: main channel or main channel edge (within 0.5 m of the bank) within a habitat unit, or within a subunit. Each diver wrote his observations on a cuff made from 20 cm PVC pipe and transferred to a data sheet after the dive was over.

Temperature

Temperature was recorded by placing temperature data loggers (Optic StowAways™ by Onset) into each of the study sites. The loggers were deployed on May 25, 2002, and were pulled on October 2, 2002. Water temperatures were also taken during each snorkel survey using a handheld thermometer.

Fish Collection

Juvenile chinook salmon were captured for measurement during the week of August 26–30. Fish were collected from each of the study sections near release sites, except for the Metolius mainstem where there were no direct releases. The goal of these sampling efforts was to investigate differences in growth and condition between study sections. Fish were captured by either diver hand netting or diver-directed seine netting. After capture, the fish were anesthetized, weighed, measured, and placed in a recovery bucket of clean water. After recovery, fish were returned to the site of capture.

Invertebrate Drift Sampling

Invertebrate drift samples were taken from each of the six study sections on September 24 and 25. The goal of these sampling efforts was to determine the amount of drifting food available to fish, either as total number of invertebrates or total biomass, and investigate any differences between study sections. The drift samples were taken from the same areas from which fish were collected for measurement in early September.

Four samples were taken in three of the sections each evening using 0.3m by 0.3m drift nets placed randomly in the main channel current. Sampling began at 7:00 p.m. and lasted for 20 minutes. Samples were placed into Whirl-Pak™ bags and taken to Corvallis for processing. Processing involved sorting and counting individual invertebrates from the drift samples using a dissecting microscope. For large samples, a subsample (1/2) was taken and processed. For those samples, the resulting data was doubled to represent the entire sample. After sorting, the invertebrates were placed into drying cups and placed in a drying oven for 48 hours at 60°C. Samples were weighed immediately after removal from the drying oven.

PRELIMINARY RESULTS

The following results are preliminary, and reflect work up to February 2003. The task of data exploration and statistical analysis are a continuing and ongoing process. The results presented here are primarily from fish collection, invertebrate drift sampling, and fish observations at the section and site spatial scales.

Site Densities

Results of all site densities calculations across all seasons displayed in Figure 2. Results from ANOVA tests on density data (all sites and seasons included) indicate that there is a significant differences in density among sections (p = .01). On average, the highest densities and the greatest total number of juvenile chinook salmon were found in summer and fall in upper Lake Creek, sites LK-4 and LK- 5. The lowest density and number of juvenile chinook salmon were found in Heising Spring during fall surveys.

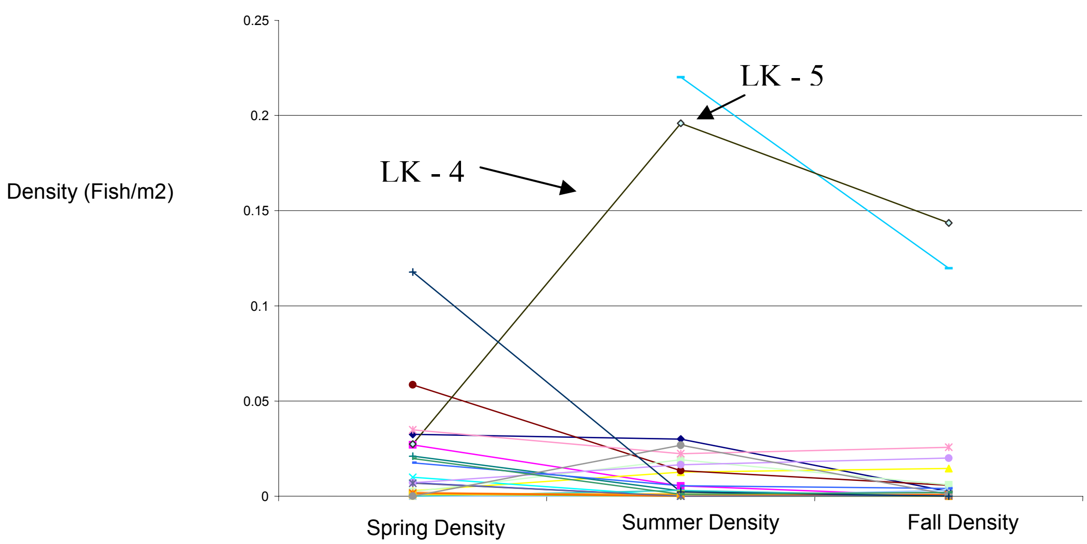

Figure 2. Juvenile chinook densities for all sites and all seasons.

The highest densities and number of juvenile chinook salmon in the Metolius River were observed in the uppermost sites of the Metolius Headwaters study section, closest to the release site. Contrary to what we had expected, very few juvenile chinook salmon were observed in the large pools of the mainstem Metolius River. Longitudinal density patterns are displayed in Figures 3 and 4.

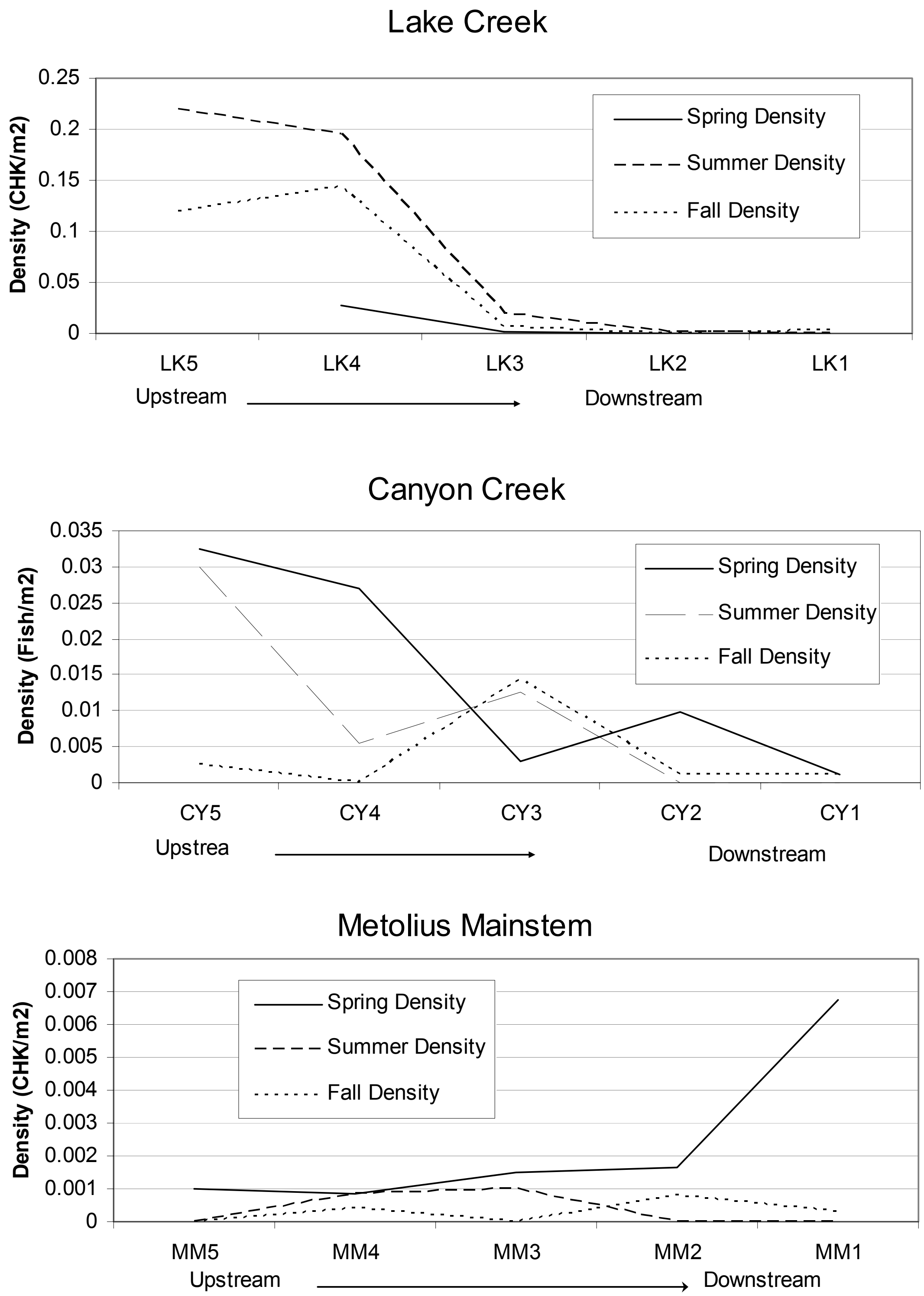

Figure 3. Seasonal juvenile chinook salmon densities in the Lake Creek, Canyon Creek, and Metolius River mainstem study sections of the Metolius River Basin, 2002. Y-axes are not to the same scale. For comparison of densities, see Figure 2.

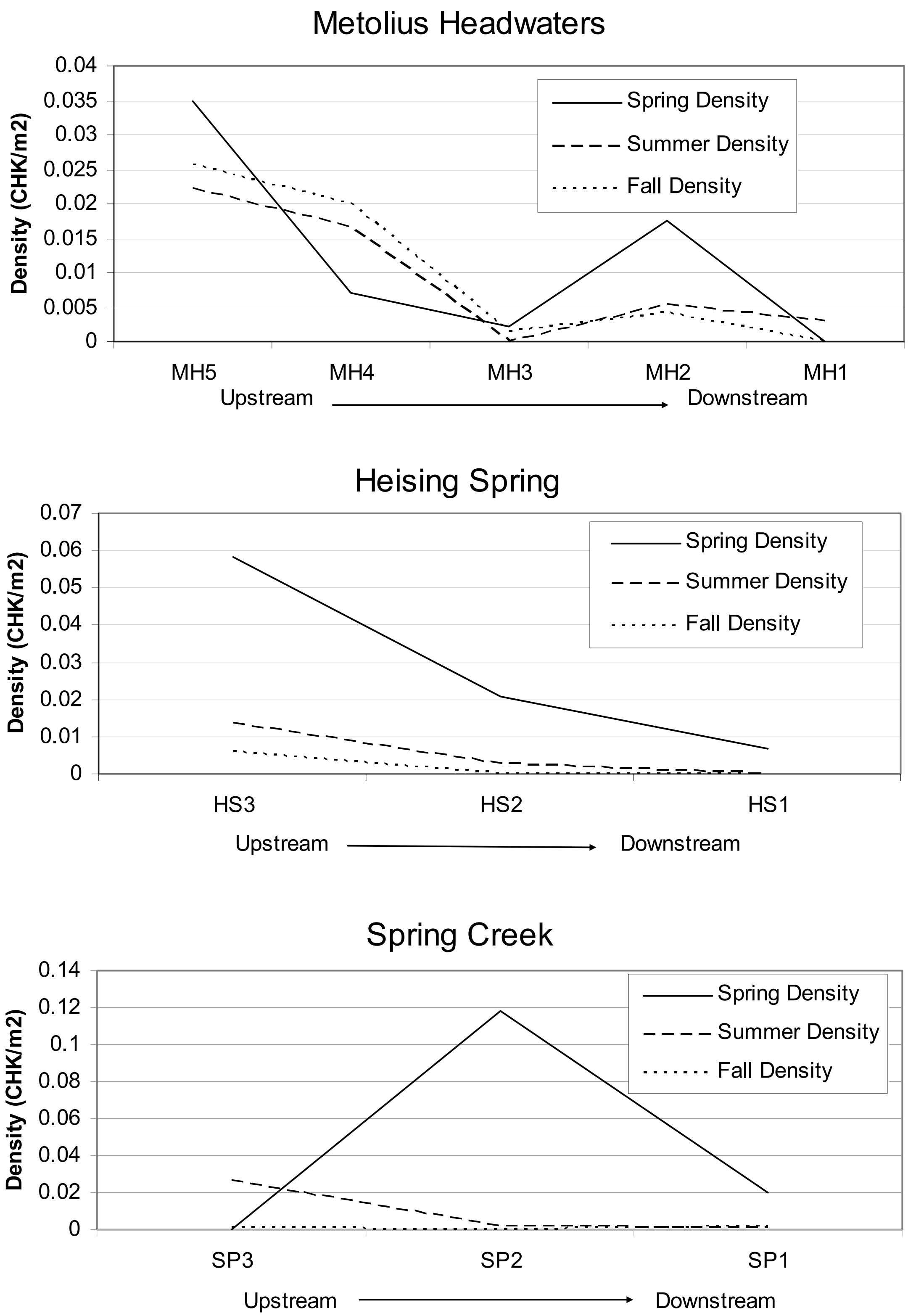

Figure 4. Seasonal juvenile chinook salmon densities in the Metolius River headwaters, Heising Spring, and Spring Creek study sections of the Metolius River Basin, 2002. Y-axes are not to the same scale. For comparison of densities, see Figure 2.

Water Temperature

Water temperature data is presented in Table 3. Sites are arranged in the table for warmest to the coldest. The warmest sites were located in upper Lake Creek, and the coldest study sites were located in Heising Spring.

Table 3. 2002 temperature data from sites in the Metolius Basin. *Hobo was placed on 6/25. Data from 5/23 – 6/25 is "borrowed" from nearest site (LK-4) for comparison purposes.

Site #	Average Temp	Max Temp (Date)	Cum Average Temp	Cum Max Temp
LK – 5*	Warmest	23.86 (7/12)	2196 *	2467*
LK – 4	10.47	23.74 (7/13)	2174	2417
LK – 2	14.55	21.79 (7/13)	1921	2217
MH – 2	9.71	13.54 (7/13)	1281	1632
MH – 1	9.59	13.33 (7/13)	1265	1607
MH - 5	9.49	11.49 (7/13)	1253	1401
MM – 5	9.42	13.31 (7/13)	1243	1541
MM – 4	9.4	13.28 (7/10)	1241	1523
MH - 4	9.4	11.46 (7/13)	1241	1441
MM – 2	9.29	13.32 (7/13)	1226	1533
MH - 3	9.24	11.67 (6/28)	1219	1434
MM – 1	9.2	13.23 (7/13)	1214	1527
MM – 3	9.19	13.18 (7/13)	1213	1510
LK – 1	8.9	12.23 (6/1)	1175	1273
SP – 3	8.73	11.16 (6/4)	1152	1243
SP – 2	7.42	10.16 (5/24)	979	1134
SP – 1	7.19	8.39 (5/29 – 6/5)	950	1035
CY – 1	6.83	11.41 (7/13)	902	1155
CY – 2	6.76	12.1 (8/14)	893	1192
CY – 3	6.33	10.71 (7/13)	836	1072
CY – 4	6.09	10.08 (7/13)	804	1008
CY - 5	6.03	9.6 (7/13)	796	968
HS – 1	Coldest	7.73 (5/30)	781	880
HS – 2	5.79	6.98 (6/1)	764	847
LK – 3	------	DATA	MISSING	-----
HS – 3	-----	DATA	MISSING	-----

Fish Collection

Juvenile chinook salmon data is presented in Table 4, and box-and-whisker plots are presented in Figure 5. We were able to collect our target of 20 fish in four sections: Spring Creek, Lake Creek, Canyon Creek, and Metolius headwaters. We were able to capture only 6 fish from Heising Spring, because that was as many as we could locate. We captured only 3 fish from the Metolius mainstem study section; because they were difficult to locate and proved difficult to capture due to the size and depth of the river.

Table 4. Results of fish collection in the Metolius Basin on August 26 – 29, 2002. Study sections are arranged from lowest to highest (left to right) for each metric.
* Small sample sizes due to lack of fish numbers / difficulty in capture.

	lowest	→				**highest**
Fork Length						
N = 93	Heising	Lake	Canyon	Spring	Mainstem	Headwaters
n	6*	21	21	22	3*	20
mean	68.5	75.6	79.9	83.2	85.3	95.9
max	73.0	82.0	89.0	96.0	92.0	105.0
min	64.0	63.0	70.0	71.0	76.0	86.0
st .dev	2.9	5.4	4.6	5.7	8.3	5.3
Weight						
N = 93	Heising	Lake	Canyon	Spring	Mainstem	Headwaters
n	6*	21	21	22	3*	20
mean	3.3	5.2	6.0	6.6	7.0	10.6
max	4.2	6.5	7.9	10.6	8.7	16.4
min	2.6	3.0	3.8	3.9	4.8	7.0
st .dev	0.5	0.9	1.1	1.5	2.0	2.6
Condition Factor (Fk. Length / Weight^3)						
N = 93	Heising	Mainstem	Spring	Canyon	Headwaters	Lake
n	6*	3*	22	21	20	21
mean	1.03E-05	1.10E-05	1.13E-05	1.16E-05	1.19E-05	1.20E-05
max	1.34E-05	1.12E-05	1.25E-05	1.23E-05	1.50E-05	1.42E-05
min	8.48E-06	1.09E-05	1.04E-05	1.11E-05	1.06E-05	9.77E-06
st .dev	1.66E-06	1.22E-07	6.23E-07	3.84E-07	1.30E-06	9.87E-07

Results from a nonparametric Kruskal-Wallace ANOVA tests indicate that there were statistically significant differences between the sections in fork length ($p < .0001$), weight ($p < .0001$), and condition factor ($p = .0029$). Although a standard one-way ANOVA gave the same significance results, we chose to use a nonparametric ANOVA test because of the non-equality of variances between study sections.

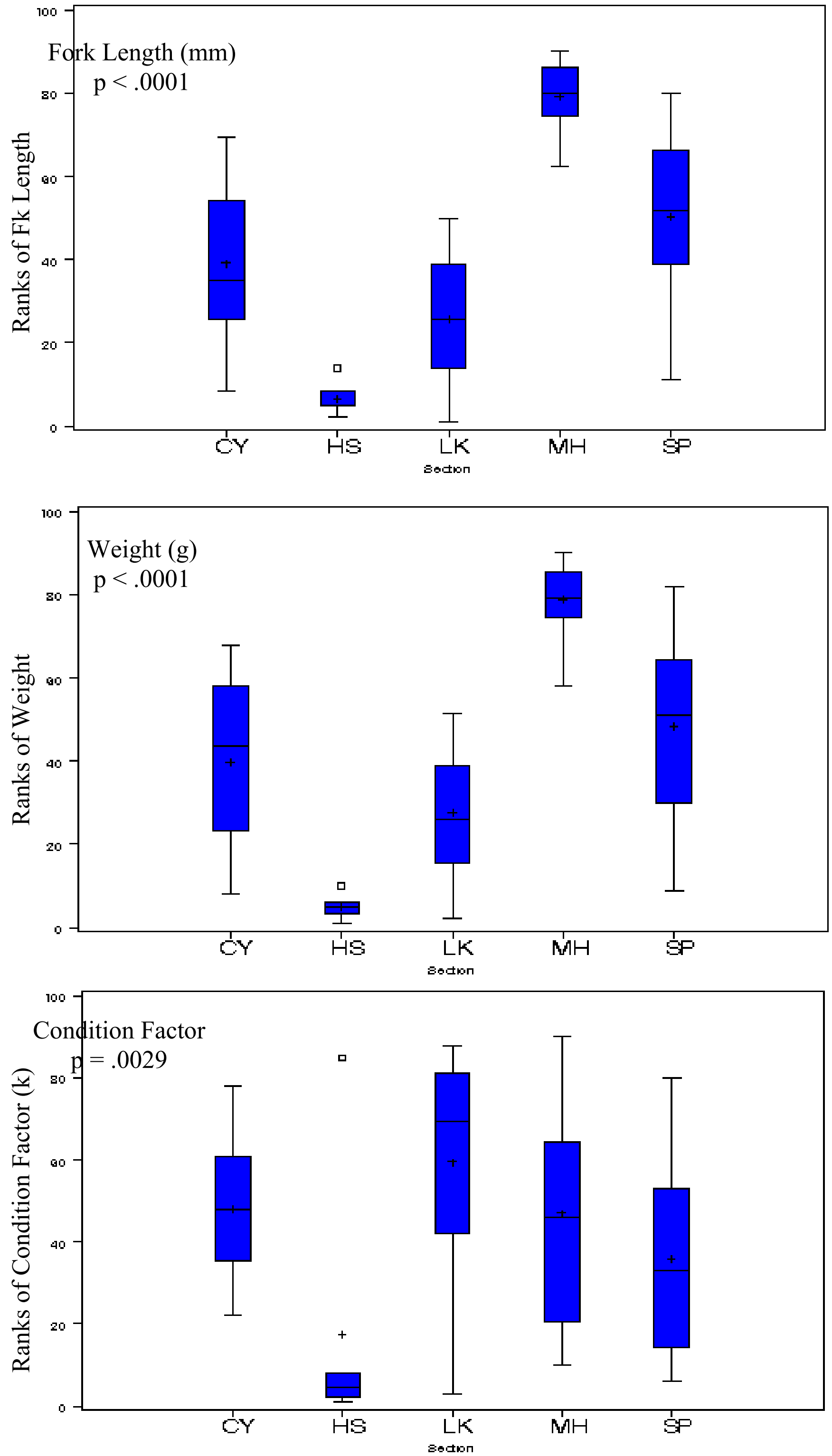

Figure 5. Box-and-Whisker plots from a nonparametric Kruskal-Wallace analysis of variance of juvenile chinook salmon collected in the Metolius River Basin August 26-28, 2002. Study sections are Canyon Creek (CY), Heising Spring (HS), Lake Creek (LK), Metolius Headwaters (MH), and Spring Creek (SP). The Metolius mainstem section is not included in these plots.

Correlation matrices (Figure 6) were generated for parametric size and condition data using Tukey's studentized range HSD (Honest Significant Difference) procedure for means comparisons.

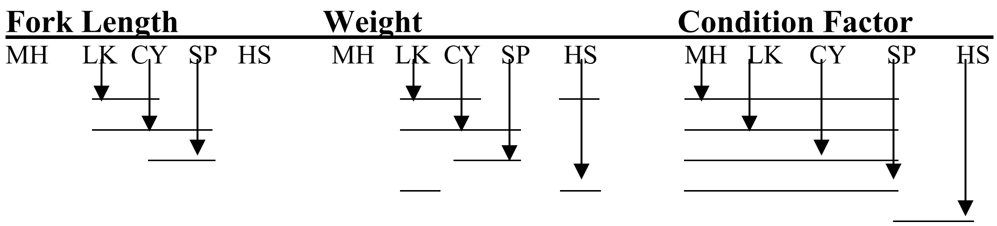

Figure 6. Correlation matrices of size and condition factors from fish collection data in the Metolius Basin, 2002, using Tukey's HSD procedure of means comparison. Arrows indicate section of interest, and lines indicate the lack of statistically significant differences. Example: For length, Lake Creek (LK) is not statistically different from Canyon Creek (CY); Canyon Creek is not statistically different from Lake Creek and Spring Creek; Spring Creek is not statistically different from Canyon Creek.

Invertebrate Drift Sampling

We used a drift density calculation (Smock 1996) to account for differences in drift velocity and depth, and allow for comparison between samples. The formula expresses the amount of invertebrates drifting per 100 m^2 of water:

$$\text{Drift Density} = \frac{(N)100}{(t)(W)(H)(V)(3600\ s/h)}$$

where N represents the number (or biomass) of invertebrates in the sample, *t* is the time the net was in the water (in hours), W is net width, H is height of water in net, V is the velocity of water at the net mouth (m/s).

Box-and-whisker plots are presented in Figures 6 and 7. The results of a nonparametric Kruskal-Wallace ANOVA test indicates that there is a significant difference between sections in abundance count drift density ($p = .008$), but that there was no evidence of a significant difference in biomass drift density ($p = .21$). Correlations for invertebrate data were tested using Tukey's Studentized range procedure indicated that none of the study sections were significantly different from any of the other study sections.

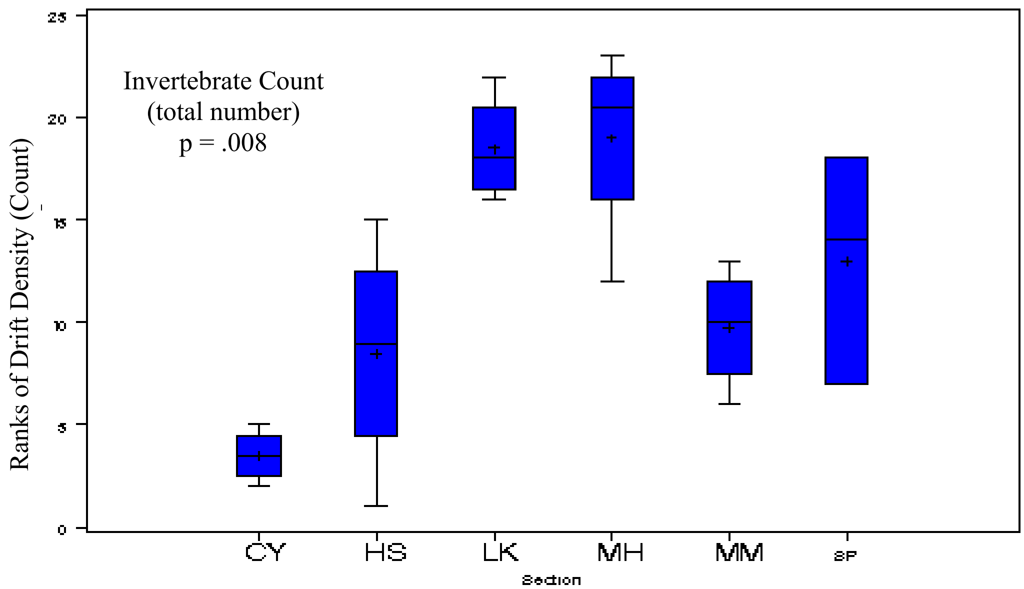

Figure 6. Box-and-whisker plot resulting from nonparametric ANOVA test of invertebrate counts collected by drift net sampling in the Metolius Basin on September 24 and 25, 2002. Four drift samples were collected from each study section. Study sections are Canyon Creek (CY), Heising Spring (HS), Lake Creek (LK), Metolius Headwaters (MH), Metolius Mainstem (MM), and Spring Creek (SP).

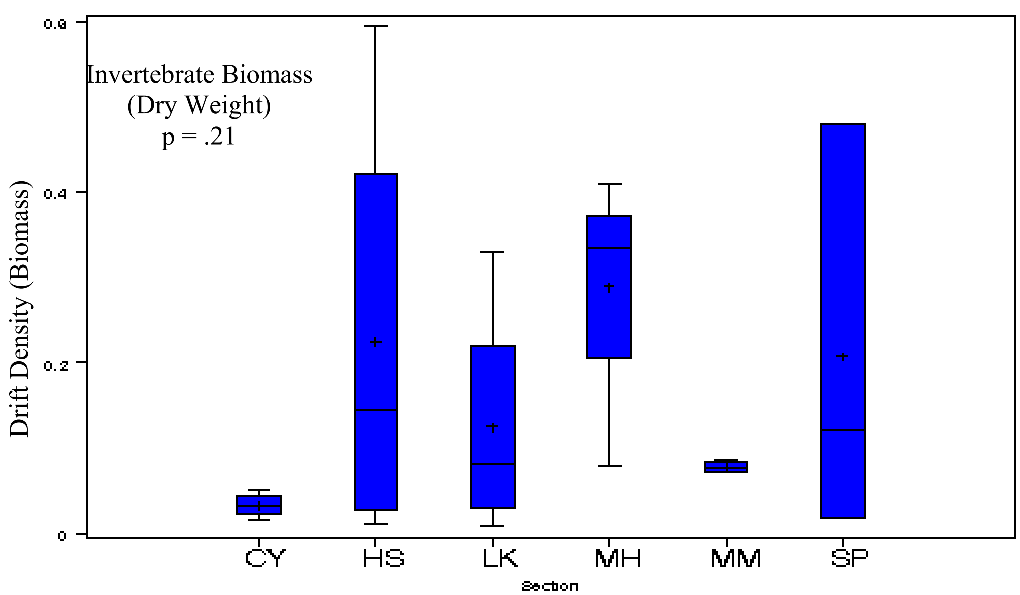

Figure 7. Box-and-whisker plot resulting from a nonparametric ANOVA test of invertebrate biomass collected by drift net sampling in the Metolius Basin on September 24 and 25, 2002. Four drift samples were collected from each study section. Study sections are Canyon Creek (CY), Heising Spring (HS), Lake Creek (LK), Metolius Headwaters (MH), Metolius Mainstem (MM), and Spring Creek (SP).

Late Fall Snorkel Sampling

On November 27, 2002, snorkeling efforts were made in areas where we had seen large groups of chinook during the fall sampling season. These dives were made to determine the presence or absence of juvenile chinook salmon in these areas. One diver surveyed the sites MH- 4 and LK-4. No juvenile chinook salmon were seen in MH – 4, but five were seen in Lake Creek. These findings suggest that Lake Creek may also provide over wintering habitat for juvenile chinook salmon.

DISCUSSION

Temperature

Results indicate that water temperature seems to play a role in the distribution of juvenile chinook salmon. The two warmest study sections, Lake Creek and the Metolius Headwaters, had the highest densities and number of fish. The coldest study section, Heising Spring had the lowest density of chinook salmon in the fall sampling period.

Invertebrate Drift

Analysis of invertebrate drift suggests that drift density (abundance) may correlate with the highest densities and numbers of fish. This pattern is seen in the Metolius Headwaters and Lake Creek study sections, but we are unable at this time to present any statistical analyses that support this claim. Drift density (biomass) did not correlate well with any other metric. The fact that there were large hatches of adult mayflies on Spring Creek and Heising Spring during the sampling period may have influenced the biomass results. There is some concern because we sampled only for one 20 minute period out of the entire year – we cannot be sure that the observed patterns remain constant throughout the seasons.

Growth and Condition Factors

Length and weight of juvenile chinook salmon differed significantly within the basin (Figure 5), particularly in the Metolius Headwaters study section, where juvenile chinook salmon collected were significantly larger in weight and length than those from any other section. Condition factor data showed no significant difference between all study sections except Heising Spring, which was significantly different from all other study sections. This may be attributable to low water temperatures, but these findings are suspect due to low sample size (6 fish).

Upper Lake Creek

Upper Lake Creek seems to be a "hot spot" for juvenile chinook rearing, because summer and fall densities in LK-4 and LK-5 were an order of magnitude greater than any other study site. Our results suggest that there may be a correlation between fish density and numerical drift density or temperature, but we are unable at this time to present any statistical analyses that support this claim. We will intensify our focus on these sites to determine if these patterns reappear in 2003. There also may be value in splitting Lake Creek into two study sections (upper and lower) for analysis.

There is concern that these results may be influenced due to our fish release design. Even though Lake Creek appears to be a good location for summer rearing of juvenile chinook salmon, if there is limited spawning of adults chinook salmon under natural conditions, there will be a limited number of juvenile chinook that will be able to use the habitat.

PLANS FOR 2003

In 2003 we will repeat the sampling efforts of 2002. In response to the preliminary results from 2002, we will focus more intently on Lake Creek. We will add snorkeling sites on Lake Creek and Canyon Creek to get a clearer picture of the longitudinal distribution of the juvenile chinook.

In addition, we will collect fish for growth measurements twice during the year, in spring and in fall, and are looking into the use of PIT (passive integrated transponder) tags, implanting them during spring fish collection to try and quantify movement within and between study sections. We also will be collecting drift samples twice a year, again in spring and fall, to determine if the relative differences in food availability are constant between seasons.

GOALS FOR 2003

1) Continue analysis of 2002 data.
2) Complete the second year of field data collection.
3) Summarize data collected in 2003 and compare to 2002 data.
4) Make presentation of results at Oregon AFS Meeting in winter 2004.
5) Make presentation of results at a national or regional conference (North Amer. Benthological Society, West. Div. AFS, or National AFS).
6) Present results from 2003 and study plan for 2004 at PGE Spring Workshop.
7) Begin work on the second goal of the study, which is developing approaches to habitat quality and capacity models.

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