THE OREGON PLAN *for Salmon and Watersheds*

Aquatic Habitat in Oregon Coastal Streams: Winter, 1999 – 2001

Report Number: OPSW-ODFW-2004-05

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Winter, 1999 – 2001

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Executive Summary

We compared summer and winter aquatic habitat conditions to determine patterns of seasonal habitat dynamics for coho salmon (*Oncorhynchus kisutch*). Winter sites corresponded to summer sites, facilitating a direct comparison between seasons on a site specific and regional scale. The data sets included 128 sites selected from the Oregon Plan habitat sites (OPHS) surveyed in the summers of 1999 and 2000 and surveyed again in the winters of 2000 and 2001.

We found significant differences among geomorphic, hydrologic, and physical habitat variables measured along identical reaches in streams between winter and summer. Increases in water volume corresponded with increased deep pool density, secondary channel habitats, and wood density. These differences highlight the importance of high winter flows in terms of their contribution towards essential habitat for coho survival and reproduction. Differences among habitat variables from consecutive winters were minimal, indicating that any differences in habitat variables may be a result of variation in annual precipitation. Moreover, minimal differences in habitat variables were observed between Basin and OPHS surveys, also leading to the suggestion that OPHS surveys, conducted during the summer may provide important baseline information on habitat variables within and among watersheds. Habitat quality, as measured by benchmarks, was shown to be independent of land ownership but not independent of monitoring area.

This investigation allowed us to quantify seasonal changes in summer-to-winter habitat dynamics in coastal Oregon streams. Future research could involve the addition of juvenile salmon surveys with habitat surveys to determine any significant associations between fish density and habitat quality. Furthermore, habitat variables measured during the summer might be used to determine winter habitat conditions (i.e. and thus quality), after accounting for variation in annual precipitation. Attribute means and estimates of variation, measured at identical sites in summer and winter over the long-term, may be beneficial when linking summer to winter habitat variables and ultimately to fish density estimates, thereby increasing sample size and predictability.

Introduction

Coho salmon (*Oncorhynchus kisutch*) historically were distributed from northern Japan across the Bering Sea to Alaska, and south through all coastal areas to California (Sandercock 1991). In Oregon, they are found in many of the tributaries of the Lower Columbia and Willamette Rivers, as well as in most coastal streams south to the Rogue River (Atkinson et al. 1967). Juvenile Coho Salmon spend one summer and winter in freshwater habitats (Nickelson 2001) before migrating to the ocean; they occupy pool habitats during their first summer following emergence (Sandercock 1991). Reproductive success and overwinter survival likely are closely associated with habitat quantity and quality (Nickelson 2001). Slow-water habitats such as secondary channels, backwater pools, alcoves, and dammed beaver pools may provide refugia during high winter discharges (Solazzi et al. 2000). Woody debris slows water velocity, increases habitat complexity, stores sediments and provides food for coho (Bustard and Narver 1975). This report provides an evaluation of variables used to measure current winter habitat conditions for juvenile coho salmon in western Oregon coastal streams and compares consecutive years of winter data and paired data from summer and winter sites. The objectives of this study were to:

1. Quantify significant changes, if any, in stream habitat variables from summer to winter.

2. Quantify any significant changes in stream habitat variables during consecutive winter seasons.

3. Determine if Oregon Plan Habitat Survey (OPHS) data might be more representative of a larger geographic area than census data from selected watersheds (basin surveys).

4. Assess habitat quality and determine if habitat indices are independent of land ownership and monitoring area.

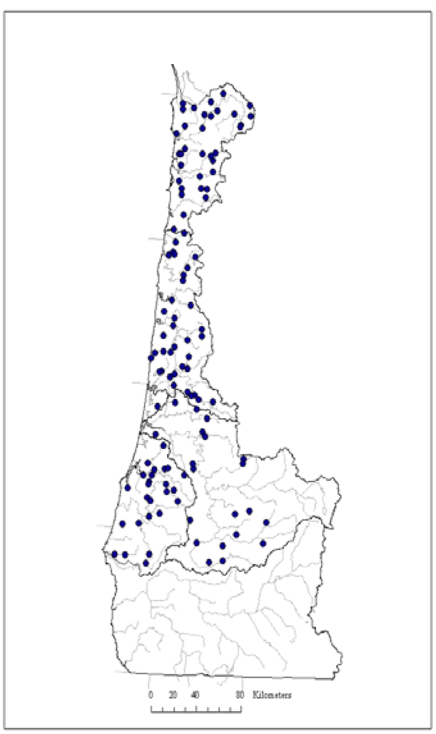

Figure 1. Winter/summer habitat survey sites, 1999 – 2001.

Methods

Juvenile coho salmon summer and winter habitat data were obtained as part of Oregon Plan Habitat Surveys (OPHS) and basin surveys, both of which are designed to assess aquatic habitat in streams contained within watersheds of western Oregon draining into the Pacific Ocean south of the Columbia River (Figure 1). Survey sites were selected within the currently known distribution of coho salmon using a random tessellation stratified (RTS) design that best represents habitat conditions with the monitoring area and reduces sample variance (Flitcroft et al. 2002).

Habitat surveys involved the collection of stream characteristics (geomorphic, hydrologic, and physical) through direct observation and measurement (Moore, et al. 1997) (Table 1). Basin surveys varied in length from 0.5–5.0 kilometers. Habitat variables were collected from the stream mouth to its headwaters, whereas OPHS were either 500 – 1000 m collected at a randomly selected location of stream. A paired t-test was used to determine significant differences in habitat variables between summer and winter sites (Zar 1999).

Paired sites were randomly selected from the North Coast, Mid-Coast, Mid-South Coast, and Umpqua monitoring areas. Annual surveys were conducted on 11 winter sites in 2000 and 2001 (9% of total sites). A paired t-test was used to determine significant differences among habitat variables (Zar 1999). Winter basin survey data (n = 67), collected from 1991 – 1999, was compared against OPHS data, collected in 2000 and 2001. These data were not randomly selected and, therefore, were not intended to represent all coho streams, although they have been assumed in the past to typify coastal stream conditions. A two-sample t-test assuming unequal variances was used to determine any significant differences (Zar 1999:136). Finally, benchmark habitat quality values were calculated at each survey site (Flitcroft et al. 2002). Sites were characterized as low-, moderate-, or high-quality winter habitat based on the number of benchmarks that each site contained (Table 2); sites were sorted and summarized to monitoring area and land ownership. Habitat quality and the associated benchmarks were assessed with respect to land ownership. In this case, a x^2 test (Zar 1999) was used to determine if land use practices associated with ownership were independent of habitat quality or monitoring area. All tests were considered significant at $p \leq 0.05$.

Table 1. Habitat variables measures in 128 western Oregon coastal streams, 1991 – 2001 (after Moore et al. 1997).

Variable	Dimension
Geomorphic (15)	
Primary Channel Length	m
Primary Channel Area	m^2
Secondary Channel Length	m
Secondary Channel Area	m^2
Secondary Channel Area %	%
Active Channel Width	m
Wetted Width	m
Channel Entrenchment	m
Number of Units	#
Unit Density	#/100 m
% Fine	%
% Gravel	%
% Bedrock	%
% Riffle Fine	%
% Riffle Gravel	%
Hydrologic (10)	
Number of Pools	#
Pool Area	%
Scour Pool Depth	m
Scour Pool Area	%
Percent Slow Water	%
Riffle Depth	m
Density Deep Pools	#/km
Residual Pool Depth	m
Pool Width/Depth Ratio	#
Physical (10)	
Number of Wood Pieces	#
Wood Volume	m^3
Wood Density	#/100 m
Wood Volume Density	#/100 m
Key Wood Pieces	#
Key Wood Pieces Density	#/100 m
Wood Jams	#
Wood Jam Density	#/100 m
Number of Beaver Dams	#/site

Results and Discussion

There were 128 paired sites, taken during both summer and winter, from which to conduct habitat analyses. Fifty sites were surveyed in summer, 1999 and resurveyed in winter, 2000. Seventy-eight sites were surveyed in summer, 2000, and again the following winter, 2001 (Table 3).

Table 2. Winter/summer habitat benchmarks for sites surveyed during summer and winter 1999-2001.

Habitat Quality Benchmarks	
Summer	Winter
>35% Pool Area	>40% Pool Area
< 12% Fines in Riffles	>4 deep (1m) Pools/km
≥ 35% Gravel in Riffles	>5% Slow Water Units
> 20 Pieces Large Woody Debris/100m	>20 Pieces Large Woody Debris/100m
>70% Shade	>4 Wood Jams/km
>150 Riparian Conifers/305m	> 75% Secondary Channels

Table 3. Significant habitat variables (geomorphic, hydrologic, and physical) measured in 128 western Oregon coastal streams between summer and winter, 1999 – 2001.

Variable	Summer (Mean ± S. E.)	Winter (Mean ± S. E.)	t-value	p – value [1]
Geomorphic (7)				
Primary Channel Length (m)	962.1 ± 14.5	907.9 ± 16.3	4.1	0.00
Primary Channel Area (m^2)	5,714.3 ± 468.6	7,525.0 ± 606.5	-6.3	0.00
Secondary Channel Length (m)	79.5 ± 10.1	126.5 ± 14.2	-5.2	0.00
Secondary Channel Area (m^2)	259.5 ± 58.0	453.7 ± 80.0	-4.8	0.00
Secondary Channel Area (%)	3.7 ± 0.5	5.6 ± 0.8	-2.7	0.00
Wetted Width (m)	5.0 ± 0.3	6.6 ± 0.4	-7.0	0.00
Number of Units (#)	50.0 ± 1.6	44.7 ± 2.6	2.0	0.05
Hydrologic (6)				
Pool Area (%)	43.0 ± 2.0	32.6 ± 1.7	7.9	0.00
Scour Pool Area (%)	37.9 ± 1.8	27.6 ± 1.5	7.8	0.00
Scour Pool Depth (m)	0.7 ± 0.1	0.9 ± 0.1	-9.5	0.00
Riffle Depth (m)	0.2 ± 0.1	0.3 ± 0.1	-12.6	0.00
Density Deep Pools ($^{\#}$/km)	2.6 ± 0.3	4.6 ± 0.4	-4.2	0.00
Residual Pool Depth (m)	0.56 ± 0.02	0.6 ± 0.02	-1.95	0.01
Physical (1)				
Wood Density ($^{\#}$/100 m)	12.7 ± 1.1	14.4 ± 0.9	-2.1	0.03

[1] Significant at $p \leq 0.05$.

Sample sites encompassed 4 monitoring areas: North Coast (n = 37), Mid-Coast (n = 38), Mid-South Coast (n = 30), and Umpqua (n = 23). Proportionally, more geomorphic (channel length and area) and hydrologic (pool, riffle depth, density and area) variables were significantly different between summer and winter than physical variables (i. e., woody debris). Two-thirds of hydrologic variables were significantly different between summer and winter (6 of 10 variables).

Winter vs. Summer Habitat Surveys

Whereas primary channel length significantly decreased in winter (p = 0.00), off-channel or secondary channel habitat (expressed as area and length) increased in winter (Table 3). Mean secondary channel area for the combined winter data was 454 m^2 while the summer had 260 m^2. Secondary channel area and the total number of units increased from summer to winter (p = 0.08 and p = 0.05, respectively).

Pool and scour pool areas significantly decreased in winter (p = 0.00). The percent of pool, as habitat area, was significantly higher in summer, which may be attributed to an increase in water volume and speed, resulting in rapids and glides, or because smaller pools were not observable during winter flows. Scour pool depth and area was higher in summer than winter (p = 0.00), although scour pool depth was higher in winter (p = 0.00). However, the number of deep pools (> 1.0 m) increased from 2.6 pools/km in the summer to 4.6 deep pools/km in winter. Wood density (the number of wood pieces per 100 meters) was significantly greater in the winter (14.4 pieces/100m) than in the summer (12.7 pieces/100m) (p = 0.03).

By monitoring area, the North Coast had the highest mean secondary channel area (823 m^2). The proportion of secondary channel habitat was highest in the North Coast monitoring area. Sites in the Mid-South Coast had more percent pool area and the highest mean percent of slow water habitats (Appendix A). In contrast, the Mid-Coast had the highest mean density of key wood pieces and wood volume. In summary, increases in water volume resulted in corresponding geomorphic, hydrologic and physical effects within the streams, primarily in terms of increased deep pool density, secondary channel habitats, and wood density.

Winter Surveys

We found few significant differences in stream variables measured during consecutive winters. Eleven sites surveyed in winter 2000, and again in 2001 showed only significant difference in secondary channel area (p = 0.05), mean scour pool depth (p = 0.01), and deep pool density (p = 0.04) (Table 4). These significant differences likely could be attributed to annual variations in winter precipitation patterns. Rainfall across all coastal basins was typical in 2000, but approximately 50% of the long-term average in 2001. Yet only 1 geomorphic variable and 2 hydrologic variables significantly changed.

Winter Basin Surveys (1991 – 1999) vs. Winter Oregon Plan Surveys (2000 – 2001)

About 419 km (419,134 m) of basin surveys were completed from 1991 – 1999. Oregon Plan winter surveys totaled 16 km (16,216 m). Only 2 geomorphic variables and 1 hydrologic variable was significantly different between basin and OPHS. Thus, surveys may be representative of winter habitat on a large regional scale (Table 5), although differences may exist at a smaller spatial scale.

Table 4. Significant differences in habitat variables (geomorphic and hydrologic) measured across 11 western Oregon coastal streams between successive winters, 2000 and 2001.

Variable	Winter, 2000 (Mean ± S. E.)	Winter, 2001 (Mean ± S. E.)	t-value	p – value [1]
Geomorphic (1)				
Secondary Channel Length (m)	469.1 ± 141.7	184.7 ± 84.7	2.2	0.05
Hydrologic (2)				
Scour Pool Depth (m)	0.9 ± 0.1	0.8 ± 0.1	3.5	0.01
Density Deep Pools (#/km)	6.6 ± 1.8	3.3 ± 1.2	2.3	0.04

[1] Significant at $p \leq 0.05$.

Table 5. Significant differences in habitat variables (geomorphic and hydrologic) measured across 252 Basin and 128 Oregon Plan Surveys throughout western Oregon coastal streams. Results are means (± 1 S.E.) and t-values based on a two-sample t-test, assuming unequal variances (Zar, 1999:136).

Variable	Basin Survey (Mean ± S. E.)	Oregon Plan (Mean ± S. E.)	t-value	p – value [1]
Geomorphic (2)				
Primary Channel Area	14,837.9 ± 2,045.2	7,525.0 ± 606.5	3.6	0.001
% Gravel	27.5 ± 0.8	30.8 ± 1.3	-3.5	0.03
Hydrologic (1)				
Pool Area	27.7 ± 1.3	32.6 ± 1.7	-3.4	0.03

[1] Significant at $p \leq 0.05$.

Winter Habitat Quality Benchmarks –Monitoring Areas and Land Ownership

Habitat quality was not independent of monitoring area ($x^2_{0.05, 6} = 21.61$, $p > 0.05$), but was independent of land ownership ($x^2_{0.05, 6} = 10.62$, $p \leq 0.05$). Of the 128 winter sites, 42 sites (33%) had low quality winter habitat (0 -1 benchmark), 61 sites (48%) had moderate habitat (2 -3 benchmarks) and 25 sites (19%) had high quality habitat (4 – 6 benchmarks) (Table 6). North Coast sites had the greatest percent of high quality winter habitat sites (35%) followed by the Mid-Coast (23%). Considerably fewer sites with high quality habitat were found in the Umpqua region (4%) and the Mid-South region (6%). There were fewer high quality winter habitat sites in the North Coast than expected, and fewer high quality winter habitat sites in the Mid-South Coast than expected. There were more moderate quality sites than expected, and the Umpqua monitoring area contained more low quality sites and fewer high quality sites than expected.

Winter habitat within state-owned land contained the highest percentage of moderate and high quality winter habitat (Table 7). Private non-industrial lands contained the lowest amount of high quality habitat and the highest amount of low quality habitat. Again, most lands contained low-to-moderate habitat quality. Juvenile coho

Table 6. The percentage of winter habitat sites (n = 128) with low, moderate and high quality winter habitat according to monitoring area. Sample sizes are listed in parentheses.

	Habitat Quality		
Monitoring Area	Low	Moderate	High
North Coast (n = 37)	30% (11)	35% (13)	35% (13)
Mid-Coast (n = 38)	24% (9)	53% (20)	24% (9)
Mid-South Coast (n = 30)	27% (8)	67% (20)	7% (2)
Umpqua (n = 23)	61% (14)	35% (8)	4% (1)

salmon tend to be distributed in the lower reaches of the streams, where the gradient is low and the channel has the potential to be unconstrained. Land ownership in these lower stream reaches is predominantly private individuals or industrial. Upper reaches of streams tend to be higher gradient and forested with predominantly public ownership (federal and state). From the information, in terms of monitoring area and land ownership, habitat quality where juvenile coho salmon tend to be distributed likely is lower than would be expected given a random distribution.

Table 7. The percentage of winter habitat sites (n = 128) with low, moderate and high quality winter habitat based on land ownership. Sample sizes are listed in parentheses.

	Habitat Quality		
Land ownership	Low	Moderate	High
Private Forest – Industry (n = 42)	33% (14)	45% (19)	21% (9)
Private Non-Industrial (n = 28)	46% (13)	46% (13)	7% (2)
State (n = 18)	11% (2)	50% (9)	39% (7)
Federal (n = 38)	32% (12)	53% (20)	16% (6)
Other (n = 2)	50% (1)	0% (0)	50% (1)

Conclusions and Recommendations

Coho salmon reside in different habitat types at different stages of their life cycle. Fry emerge from February to early June (Moring and Lantz 1975) and actively feed in the spring. During this early life state, salmon reside in backwater pools and stream margins (Mundie 1969, Nickelson et al. 1992). Juvenile coho salmon benefit from slow water refugium during the high-velocity winter flows and streams with increased secondary channels, dammed/beaver pools, and backwater habitat (along with other beneficial variables such as high amounts of gravel, wood) are more productive for juvenile salmonids (Nickelson et al. 1992, Solazzi et al. 2000). Juvenile salmonid survival may likely depend more on adequate shelter areas for rest and cover than for food (Mason 1976).

We examined preliminary data between summer and winter aquatic habitat conditions. Seasonal changes in the abundance and distribution of habitat may seem apparent, but this investigation allowed us to quantify summer and winter habitat dynamics in coastal Oregon streams. We found significant differences among geomorphic, hydrologic, and physical habitat variables measured along identical reaches in streams during winter and summer. These differences highlight the importance of high winter flows in contributing and maintaining essential habitat for coho survival and reproduction. Differences among habitat variables from consecutive winters were minimal, leading to the suggestion that any differences in habitat variables may be a result of variation in annual precipitation. Moreover, minimal differences in habitat variables between Basin and OPH surveys also indicate that OPH surveys, conducted during the summer may provide important baseline information on habitat variables within and among watersheds. Finally, habitat quality benchmarks were independent of land ownership but not independent of monitoring area.

Future research could involve the comparison of juvenile salmon surveys with the habitat datasets to determine any significant associations of fish density to habitat quality. Habitat variables measured during the summer might be used to determine winter habitat conditions (i.e. and thus quality). Habitat attribute means and estimates of variations measured at identical sites in summer and winter over the long-term may have the benefit of linking summer to winter habitat variables and ultimately to fish density estimates, thereby increasing sample size and predictability.

Literature Cited

Atkinson, C. E., J. H. Rose, and T. O. Duncan. 1967. Pacific salmon in the United States, p. 43 -233. In: Salmon of the North Pacific Ocean. Part IV: spawning populations of North Pacific salmon Int. North Pac. Fish. Comm. Bull 23

Bustard, D. R., and D.W. Narver. 1975. Aspects of winter ecology of juvenile coho salmon (*Oncorhynchus kisutch*) and steelhead trout (*Salmo gairdneri*). Journal Fisheries Research Board of Canada 32:667-680.

Flitcroft, R. L., K. K. Jones, K. E. M. Reis and B. A. Thom. 2002. Year 200 stream habitat conditions in western Oregon. Monitoring Program Report Number OPSW-ODFW-2001-05, Oregon Department of Fish and Wildlife, Portland.

Jones, K. K., and K. M. S. Moore. 2002. Habitat Assessment in Coastal Basins in Oregon: Implications for Coho Salmon Production and Habitat Restoration. Pages 329 – 340 *in* E. E. Knudsen, C. R. Steward, D. D. MacDonald, J. E. Williams, and D. W. Reiser, editors. Sustainable Fisheries Management: Pacific Salmon. Lewis Publishers, Inc. New York. 724 pp.

Mason, J. C. 1976. Response of under yearling coho salmon to supplemental feeding in a natural stream. Journal of Wildlife Management 40:775-788.

Moore, K. M. S., K. K. Jones and J. M. Dambacher. 1997. Methods for Stream Habitat Surveys. Oregon Department of Fish and Wildlife Information report 97-4, Portland, OR.

Moring, J. R., and R. L. Lantz. 1975. The Alsea watershed study: Effects of logging on the aquatic resources of three headwater streams of the Alsea River, Oregon. Part 1 – Biological Studies. Oregon Department of Fish and Wildlife, Fishery Research Report Number 9, Corvallis.

Mundie, J. H. 1969. Ecological implications of diet of juvenile coho in streams. Pages 135-152 *in* T. G. Northcote, editor, Symposium on salmon and trout in streams. H. R. Macmillan Lectures in Fisheries. University of British Columbia, Vancouver, B.C.

Nickelson, T. E., J. D. Rodgers, S. L. Johnson, and M. F. Solazzi. 1992. Seasonal changes in habitat use by juvenile coho salmon (*Oncorhynchus kisutch*) in Oregon coastal streams. Canadian Journal of Fisheries and Aquatic Sciences 49:783-789.

Nickelson, Thomas E. 2001. Population Assessment: Oregon Coast Coho Salmon ESU. Northwest Region Research and Monitoring Program. ODFW Information Report 2001-02. 47 pp.

Sandercock, F. K. 1991. Life History of Coho Salmon (*Oncorhynchus kisutch*). Pages 397 – 435 *in* C. Groot and L. Margolis, editors, Pacific Salmon – Life Histories. University of British Columbia, Vancouver, B.C.

Solazzi, M. F., T. E. Nickelson, S. L. Johnson, and J. D. Rodgers. 2000. Effects of increasing winter rearing habitat on abundance of salmonids in two coastal Oregon streams. Canadian Journal of Fisheries and Aquatic Sciences 57: 906-914.

Zar, J. H. 1984. Biostatistical Analysis. 2nd Edition. Prentice-Hall, Englewood Cliffs, New Jersey, 663 pp.

Appendix A. Significant habitat variables measured in 128 western Oregon coastal streams, by monitoring area, between summer and winter, 1999 – 2001.

Variable	North Coast (n =37)		Mid-Coast (n = 38)		Mid-South Coast (n = 30)		Umpqua (n = 23)	
	Summer (Mean ± S. E.)	Winter (Mean ± S. E.)	Summer (Mean ± S. E.)	Winter (Mean ± S. E.)	Summer (Mean ± S. E.)	Winter (Mean ± S. E.)	Summer (Mean ± S. E.)	Winter (Mean ± S. E.)
Geomorphic (7)								
Primary Channel Length (m)	917.6 ± 29.7	874.8 ± 32.9	973.4 ± 25.4	936.1 ± 29.6	971.7 ± 35.1	867.3 ± 36.6	1,002.4 ± 20.6	967.7 ± 24.4
Primary Channel Area (m^2)	5,385.0 ± 852.9	7,883.4 ± 950.4	5,683.2 ± 760.3	6,748.7 ± 855.6	6,208.2 ± 1,334.4	8,179.0 ± 1,960.1	5,651.9 ± 640.3	7,378.0 ± 846.6
Secondary Channel Length (m)	104.4 ± 25.4	194.2 ± 35.7	84.7 ± 19.6	136.8 ± 26.4	74.3 ± 12.2	74.2 ± 14.1	37.8 ± 10.4	68.8 ± 11.3
Secondary Channel Area (m^2)	442.9 ± 169.8	823.1 ± 205.2	238.8 ± 90.0	430.9 ± 159.7	176.7 ± 53.5	203.2 ± 58.1	106.7 ± 26.0	224.1 ± 46.1
Secondary Channel Area (%)	5.6 ± 1.3	7.9 ± 1.3	3.6 ± 0.8	7.3 ± 2.1	3.2 ± 0.5	2.9 ± 0.6	1.6 ± 0.4	2.8 ± 0.6
Wetted Width (m)	5.1 ± 0.7	7.2 ± 0.8	5.2 ± 0.7	6.2 ± 0.7	4.3 ± 0.6	6.4 ± 0.9	5.1 ± 0.5	6.5 ± 0.7
Number of Units (#)	44.5 ± 2.5	40.2 ± 2.7	54.3 ± 2.6	52.5 ± 7.5	53.2 ± 4.2	41.3 ± 3.5	47.0 ± 2.6	43.4 ± 2.7
Hydrologic (6)								
Pool Area (%)	39.2 ± 3.5	32.0 ± 3.0	42.4 ± 3.5	29.5 ± 3.1	49.7 ± 4.9	36.1 ± 4.3	41.2 ± 4.3	34.0 ± 3.6
Scour Pool Area (%)	35.3 ± 3.2	27.6 ± 2.7	39.2 ± 3.2	24.6 ± 2.6	42.5 ± 4.6	29.8 ± 3.7	34.2 ± 3.3	29.9 ± 3.3
Scour Pool Depth (m)	0.7 ± 0.0	0.9 ± 0.0	0.6 ± 0.0	0.8 ± 0.0	0.7 ± 0.1	0.9 ± 0.1	0.7 ± 0.0	0.9 ± 0.1
Riffle Depth (m)	0.2 ± 0.0	0.3 ± 0.0	0.1 ± 0.0	0.3 ± 0.0	0.1 ± 0.0	0.3 ± 0.0	0.1 ± 0.0	0.3 ± 0.0
Density Deep Pools (#/km)	2.8 ± 0.5	5.1 ± 0.7	1.6 ± 0.3	4.2 ± 0.8	3.5 ± 0.9	5.0 ± 1.0	2.4 ± 0.6	4.0 ± 0.8
Residual Pool Depth (m)	0.5 ± 0.0	0.6 ± 0.0	0.5 ± 0.0	0.6 ± 0.0	0.7 ± 0.1	0.6 ± 0.0	0.6 ± 0.0	0.6 ± 0.0
Physical (1)								
Wood Density (m)	18.9 + 3.0	17.4 + 1.8	12.1 + 1.3	15.9 ± 1.9	10.2 ± 1.3	12.9 ± 1.7	6.8 ± 1.0	8.9 ± 1.1