Statistical Analyses of Aquatic Habitat Variables in the Tongass National Forest

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***Abstract**: Watershed assessments on the Tongass National Forest make frequent use of natural ranges of variation for select stream attributes published by Bryant et al in 2004 to evaluate the condition of aquatic habitat. An expansion of the original dataset presented an opportunity to repeat these analyses and provide updated statistics. A recent publication by Woodsmith et al. (2005) offered additional metrics that could be efficiently analyzed during this effort. Our study evaluated data from 262 reaches in four process groups (Paustian 1992), stratified by management history following Bryant et al. (2004) published methodology. We find that the increase in sample size produces better separation between treatments and increases the discriminating power of these data; we recommend periodic statistical updates as more data is collected.*

Introduction: Metrics based on stream channel morphological characteristics are commonly used to evaluate the effects of land management activities on aquatic habitat and salmon abundance (Kershner et al. 2004). In the Pacific Northwest, considerable effort has gone into the collection and analysis of channel morphology data (Kaufmann et al. 1999, Larsen et al. 2004, Woodsmith et al. 2005). While the details vary, the general approach has been to identify measurable parameters that are sensitive to disturbance and use these parameters to compare managed (primarily timber harvest and road building but may include agriculture or urbanization) and unmanaged (reference or natural) systems or to track trends over time. Refinements of these methodologies focus on the analysis and minimization of sources of variability in the measurement process (Roper et al. 2002, Whitacre et al. 2007).

In southeast Alaska, this work includes a series of papers by Murphy et.al. (1986, 1989) comparing salmonid habitat in harvested and buffered harvest reaches to unmanaged reaches, focusing on the role of woody debris in pool creation and habitat complexity. A decade later, the synthesis document, Anadromous Fish Habitat Assessment (USFS 1995) commonly referred to as the AFHA report, introduced the concept of fish habitat objectives (variously referred to as habitat variable) and presented a suite of habitat metrics for gauging stream health. Metrics were derived from stream habitat data collected during Channel Type Verification (CTV) and basin-wide surveys for three variables of interest: large woody debris (scaled to reach area); percent pool area; and stream width-to-depth ratio. These metrics were calculated for unmanaged channels only. Following closely on this report Coghill (1996) used a similar data set to evaluate the discriminating power of the data and produced estimates of samples sizes needed to detect the effects of management on aquatic systems. Bryant et al. (2004) evaluated a set of 132 stream reaches and compared metrics from managed and unmanaged reaches for eight variables of interest. A concurrent research effort, the channel condition assessment (Woodsmith 2005) used a set of 66 streams and compared metrics for five variables. The conclusions for both papers alluded to the idea that larger sample sizes could increase the discriminating power of the data as would attempts to control the variability in the channel morphology metrics.

In southeast Alaska, statistics derived from surveys in reference reaches are the basis of fish habitat objectives (USFS, 1995) used to evaluate the condition of managed systems relative to natural system variability. We began this exercise with the following hypothesis: By using previously published analytical techniques with an expanded data set we can increase the statistical power of the comparisons.

Methods: The methods for the statistical analysis follow those in Bryant et al. (2004). Stream habitat survey data were filtered to remove obvious outliers, then stratified by process group, channel type (Paustian 1992) and watershed management history. Means and quartiles were derived and summarized for ten variables (Table 1). Individual variables were log-transformed and differences between unmanaged and managed reaches were evaluated using one-way t-tests.

Table 1 – Data collection methods and equations used to calculate the ten habitat response variables from field surveys.

Habitat response variable	Equation	Data Collection Methods
Width-to-depth ratio (WD) [b]	Bankfull width / mean bankfull depth	Bankfull width Bankfull depth (∑ depths within bankfull / n+1) averaged for the reach
Total Large Wood pieces / meter (TLWD/M)	Total Pieces / meters surveyed	Total count of large wood pieces >1 m long and 0.1m in diameter. Total length of stream surveyed
Total Key pieces Large Wood/meter (TKWD/M)	Total Key pieces / meters surveyed	Total count of key large wood pieces Key piece size based on average channel bed width of stream surveyed. Total length of stream surveyed
Pools/Km (POOL/KM)	Total number of Pools / meters surveyed * 1000	Total count of pools Total length of stream surveyed
Pool Spacing (POOL SPACE)	(Length of stream surveyed / channel bed width) / total number of pools	Total length of stream surveyed Average channel bed width (width of active channel bed from bottom of bank to bottom of bank averaged for the reach) Total number of pools
Residual Pool Depth/Channel Bed width (RPD/CBW)	Average of all pool residual depth / average channel bed width	Residual Pool depth = maximum pool depth – pool tail depth Average channel bed width
D50	Median particle size	Measure intermediate diameter of 100 pebbles
Pool Length/meter (PLNGTH/M)	Total pool length / total length of stream surveyed	Sum of all pool lengths Total length of stream surveyed
Relative Submergence (REL_SUBMRG)	Mean bankfull depth / D50	Bankfull depth (∑ depths within bankfull / n+1) averaged for the reach Measure intermediate diameter of 100 pebbles

Pool Size (POOL_SIZE)	Average residual pool depth / average bankfull depth	Residual pool depth = max. depth – pool tail depth reach average Bankfull depth (∑ depths within bankfull / n+1) averaged for the reach

Data Sources. All data were collected by trained field crews using defined protocols set out in the Alaska Region Aquatic Habitat Management Handbook (USFS 2001) or in project specific protocols. Data were collected between 1993 and 2005 during a variety of projects including: Channel Condition Assessment (Woodsmith et al. 2005); Resident Fish Management Indicator Species (MIS) (Aho 2000); Coho MIS (Bryant 2003); Case Study Watershed (Thompson, 2004); Buffer Effectiveness (USFS unpublished); and surveys in preparation for timber harvest projects. These surveys were collated for entry into the forthcoming National Resource Information System (NRIS) water module. Differences in survey design and protocols were addressed during data entry and resulted in not all surveys containing all variables of interest.

Each survey represents a unique reach (though not necessarily a unique stream). Channel types were verified in the field and compared to the corporate GIS streams layer. A site was classified as managed if there were any harvest units adjacent to or upslope of the surveyed reach. Harvest status was determined in GIS for all sites where the location was verified. Overlays of hydrologic unit and timber harvest boundaries were combined, and upslope harvest was verified manually before status was assigned. Roads alone did not put a reach into the managed category. Where the location was not specifically known, e.g. only the stream mouth was identified, harvest condition was inferred from textual references. The dataset was then filtered to remove sites where the data was significantly incomplete (e.g. no bankfull width or channel type), or where the survey length was less than 60 meters.

Results

Table 2 compares mean values of each statistic in managed and unmanaged reaches stratified by process group. Three habitat measures differ significantly at the $\alpha = 0.05$ level and several others are significant at the $\alpha = 0.10$ level. Complete tables showing quartiles for all variables are presented as Appendix A.

Table 2. – Results of t-test for habitat variables by process group and harvest status. Habitat variables are abbreviated as noted in Table 1 above. The abbreviation N_N stands for the number of samples in the unmanaged group, the abbreviation N_H for the number of samples in the managed group. The direction of difference between treatments is indicated by upward-pointing ↑ (the value for the harvested group > that of the unharvested group) and downward-pointing ↓ arrows (the value for the harvested group < that for the unharvested group).

Habitat Measure	Direction	Flood Plain (FP)			Moderate Gradient Mixed Control (MM)			Moderate/Low Gradient Contained (MC/LC)		
		N_N	N_Y	P-value	N_N	N_Y	P-value	N_N	N_Y	P-value
WD	↑	43	28	**0.03**	42	30	0.19	18	20	**0.02**

TLWD/M	↓	44	79	0.59	41	34	0.52	11	12	0.45
TKWD/M	↓	41	69	< **0.01**	42	27	**0.05**	13	6	0.15
POOLS/KM	↓	52	82	**0.01**	49	38	0.66	20	21	**0.05**
POOL SPACE	↑	52	79	0.12	47	36	0.86	20	21	0.11
RPD/CBW	↓	48	32	0.08	41	28	0.24	19	20	0.23
D50	↓	43	32	0.59	44	28	0.66	15	16	0.13
PLNGTH/M	↓	32	24	0.66	41	29	0.25	19	17	0.73
REL_ SUBMRG	↓	41	28	0.49	40	27	0.42	15	16	0.73
POOL SIZE	↑	41	30	0.08	37	29	0.39	17	19	0.19

Statistical Power:
The concept of statistical power is useful to illustrate the magnitude of effect detectable by an experimental design (Peterman 1990). The statistical power of a test is “the probability of rejecting the null hypothesis when it is false and the alternative hypothesis is correct” (Sokal 1997). Statistical power is a function of variation structure, sample size, type I error rates (i.e., alpha), and the alternative hypothesis (e.g., a one-sided or two-sided test). An increase in sample size, a reduction in the variation structure, an increase in alpha, or a less restrictive alternative hypothesis all allow us to better discriminate between treatments.

Table 3 addresses the question; “How much confidence do we have to detect changes of different magnitudes?” The three effects sizes shown, 80%, 50% and 20%, may be thought of as grossly visible change; barely perceptible change; and fine resolution change (Cohen 1988). Table 3 shows that we are becoming reasonably confident of our ability to quantitatively depict gross changes (80% or more) for most variables in all process groups, and that we have a better than average chance of correctly identifying barely perceptible change (50% or more), especially in the measures deemed significant in the t-test. This ability to identify some changes in the barely perceptible range is an improvement over the earlier statistical effort. The difference in statistical power across process groups reflects our current sampling focus towards low gradient alluvial channels.

Table_3. Statistical power for the t-tests shown in C_2 (alpha=0.05, Cohen’s effect sizes, 20%, 50%, and 80% are percent of one std. deviation).

Habitat Measure	Flood Plain (FP)			Moderate Gradient Mixed Control (MM)			Moderate/Low Gradient Contained (MC/LC)		
	20%	50%	80%	20%	50%	80%	20%	50%	80%
WD	0.21	0.68	0.96	0.21	0.68	0.96	0.15	0.45	0.78
TLWD/M	0.30	0.87	0.99	0.22	0.70	0.96	0.12	0.33	0.60
TKWD/M	0.28	0.84	0.99	0.21	0.67	0.95	0.11	0.29	0.53
POOLS/KM	0.31	0.90	0.99	0.24	0.75	0.98	0.16	0.48	0.82
PL SPC	0.31	0.89	0.99	0.23	0.74	0.98	0.16	0.48	0.82
RPD/CBW	0.22	0.72	0.97	0.21	0.67	0.95	0.15	0.46	0.80
D50	0.22	0.70	0.96	0.21	0.68	0.96	0.14	0.40	0.72
PLNGTH/M	0.18	0.58	0.90	0.21	0.67	0.95	0.15	0.43	0.76

REL_SUBMRG	0.21	0.67	0.95	0.20	0.66	0.95	0.14	0.40	0.72
POOL SIZE	0.21	0.68	0.96	0.20	0.64	0.94	0.14	0.40	0.76

Discussion
This exercise was a statistical analysis of existing data following a published methodology. As such it was intended to demonstrate that aquatic data collection continues to have value and to provide a stepping-off point for further work. This document is intended to provide a framework and bibliography for the statistics to further enable their use as an analysis tool. The following section discusses measurement variation, the individual variables and recommendations for the next round of analysis.

Summary Description of Individual Variables
The process of channel evaluation where a single set of data is compared to the regional quartiles has a qualitative component. While we can quantify the departure of the individual channel from the regional mean it is not always clear if values greater or less than the mean are more desirable. What we think of as best for channel functionality may not be the best for fish habitat and vise versa. In most cases we follow the philosophy that a stable complex channel that effectively dissipates stream energy and maximizes habitat diversity within its watershed context is the desired condition.

Generally speaking, these statistics are a suite of tools to aid professional judgment in the channel analysis decision process. The following describes the individual variables in more detail and suggests (in table 4) a rating system. Though not all variables are equal in statistical significance, we support the idea that the entire suite of variables in conjunction with spatial information providing an ecological context for the reach be used to tell the story and assess the trend of the study site.

Width-to-Depth Ratio (WD): The width-to-depth ratio is an indicator of channel stability (Rosgen 1996). In the Floodplain channels we see significant increases in WD following disturbance. An increase in WD is a widening and/or shallowing of the channel. This can have several causes including sediment overburden from mass movement, bank erosion or exposure of floodplain sediments working through the system; or decreases in stream complexity that changes local stream power. Alternatively a decrease in WD may indicate that, through loss of grade controls the channel is becoming entrenched. In both cases, significant departure from the mean is cause for further analysis

Large Woody Debris: Large Woody Debris (LWD) plays important roles in channel function and fish habitat creation. In pristine alluvial channels, LWD obstructions function to dissipate stream energy and are associated with a majority of the pool habitat units (Smith and Buffington 1993) as well as producing local variability in bankfull width (Robison and Beschta 1990). Large wood (LWD) and key pieces (a subset of LWD) are influenced by changes in their supply and mobilization. Riparian harvest can lead to a LWD minimum as instream (legacy) wood decays before the young growth can contribute material of functional size to the stream (Murphy 1989). Lack of LWD In some channels we qualitatively observe a change in LWD species composition as alder (usually red alder *Alnus rubra*) becomes more common. In other cases we have measured increases in gross LWD but decreases in key pieces reflecting changes in supply.

Pool measures: A suite of pool metrics is used to evaluate the quantity and quality of fish habitat as well as to evaluate channel complexity and stability. In alluvial channels a functional and complex reach that balances cover (pools) with spawning gravels (riffles) is generally thought to maximize production such that "the most productive streams are those with alternating pools and riffles about equal in area. A pool to riffle ratio of 1:1 provides optimum food and cover conditions…" (Groot and Margolis 1991). After disturbance there tends to be fewer and shallower pools. We do not measure pool to riffle ratio directly but approximate it with the Pool length per meter variable below.

- Pool frequency is one of the best explanatory variables in the suite. It is correlated with LWD/KWD in alluvial channels.
- Pool Spacing adds the component of width to the frequency calculation (Length Of Survey/Channel Bed Width / Poolcount). This variable is similar to the pool density variable published by Woodsmith (2005)
- Pool Length per meter of channel: Otherwise known as % pools
- Pool Size (Woodsmith 2005): is defined as the ratio of average residual pool depth to average bankfull depth and is a measure of pool quality
- Average Residual Pool Depth / Channel Bed Width is a measure of pool quality scaled to channel size.

Substrate: D50, median particle size, is a commonly collected measure of substrate and one with the least statistical power overall. It suffers from significant sampling and measurement variance, and is probably biased away from fine particles. We treat D50 as a characterizing variable and expect to revisit this variable and stratify by geology.
Relative submergence – the ratio of flow depth to grain size (Buffington 2002) depicts the relationship between stream power and substrate in pool formation. This variable was advocated by Woodsmith (2005) and will continue to be explored.

Table 4. Interpretation criteria for specific variables

Habitat Variable	**< 25th Percentile**	**> 25th and < 75th**	**> 75th**
WD	Fair	Good	Fair
TLWD/M	Fair	Good	Excellent
TKWD/M	Fair	Good	Excellent
POOLS/KM	Fair	Good	Excellent
POOL SPACE	Excellent	Good	Fair
RPD/CBW	Fair	Good	Excellent
D50	Fair	Good	Fair
PLNGTH/M	Fair	Good	Fair
REL_SUBMRG	Fair	Good	Fair
POOL_SIZE	Fair	Good	Excellent

Given the wide range of values naturally occurring on the landscape, it is difficult to assign a specific meaning to any quantitative variable. Instead, individual reach values are compared to the regional ranges and where values tend to fall toward the tails of the distribution (outside the inter-quartile range) they are flagged as potential areas of concern (Bauer & Ralph 2001, Casipit et al 2000).

Potential sources of variation:
Critics of using habitat survey data consistently note that the high degree of variation in the numbers diminishes our ability to detect change. This variation comes from a variety of sources and has been addressed in the literature by several authors (Roper et al. 2002, Whitacre 2007). Roper breaks variation into several components; environmental heterogeneity, sampling variance and measurement error.
Environmental heterogeneity - Southeast Alaska’s highly dissected landscape, diverse geological and glacial history and variety of management practices points to significant differences in sites accounting for variation among streams. Paustian’s (1992) channel types effectively account for differences in basin size and stream power but do not completely separate out differences in parental geology. Extreme differences (e.g. the presence of a few sand-bed channels) were removed as outliers. Improving our ability to spatially stratify monitoring sites is a primary goal for the next statistical run.
Sampling variance (where and what to measure) – A well-defined protocol helps to minimize sampling variance by applying clear standards to each measurement variable. Repeat surveys performed in 2002 showed that some variables, width-to-depth ratio specifically, showed unacceptable levels of variation. Focusing on specific areas of concern in our training will minimize this problem.
Measurement Error (the ability to make consistent measurements) - In most cases, a clearly designed protocol complemented by a standardized training package acts to minimize measurement error. The use of specific tools or templates such as the ‘gravelometer’ and measuring tapes helps minimize the effects of “eyeballing” measurements. Finally, emphasis on data quality (rather than quantity) promotes a methodical data collection philosophy and better data.

Recommendations
While this exercise demonstrates that increasing sample size can begin to overcome the high natural range of variability to discern differences between unmanaged and managed aquatic systems, it should not be considered a final product. Improvements in data management will allow easier manipulation of the data than this exercise experienced. Several specific recommendations for improving the usability of these metrics follow.

Stratification: This exercise separated the data by hydrologic process and management history in a basic manner. Management history may be refined by separating harvest effects into direct, un-buffered riparian harvest, and indirect buffered upslope harvest. This separation would better reflect current management practices. Physical stratification of watersheds by ecological subsection (Nowacki et al 2001) to reflect differences in terrane origin and glacial history will more accurately depict sediment source and transport functions. For un-buffered harvest there is evidence that time since harvest affects the woody debris component with woody debris minimums being reached 70 years after harvest (Murphy 1989).

This exercise also separated the surveys by process group and by channel type. To increase statistical power we should increase the sample sizes in several channel types to reflect changes in forest management. Specifically, the small sample size for several foot-slope channel types limits the strength of conclusions that can be drawn from the data. Expansion of the dataset in HC2 and AF1 channel types (Paustian 1992) is in line with the current timber focus on hillslope units.

Statistics-on-the-fly. The integration of habitat data with an accurate spatial depiction of land use management in a single database is the next step for these data. We require the ability to generate statistics-on-the-fly for a stratifiable set.
Randomization of the sample set: A significant criticism with the current Tongass approach to aquatic habitat monitoring is the site selection. Considerable access constraints limit the realistic use of a simple random sample design, however a modified sample (access-weighted) might be feasible.

Investigation of outliers: Statistically outliers are often thrown out of the set so that they don't overwhelmingly influence the data. In this exercise several reaches were thrown out for exactly this reason. In at least one case, real data produced values several orders of magnitude from the sample mean. This points to the need to investigate the reason for the anomaly and improve our stratification.

Sample length: Wide ranges in sample length are statistically problematic but were not dealt with during this exercise except to note their range. Survey data in this set comes in a variety of reach lengths ranging from a few tens of meters to several kilometers Increasing sample length tends to skew variables towards median values while surveys that are overly short may not capture enough repeating channel units to adequately represent the true condition of the channel.. Further statistical exercises of this nature would benefit from narrowing the ranges of sample length. It is recommended that a minimum survey length of 20 channel bedwidths be measured (Smith and Buffington 1993, USFS 1997, Woodsmith 2005) with a minimum sample length of 100 meters. At the other end of the spectrum are the surveys where the entire channel was measured.

Training reaches: To further minimize unintended variability in data collection we recommend the creation of a set of training reaches where permanently monumented reaches be established. The resurvey data from these reaches will assist in training and in quantifying measurement error.

Multivariate Analysis: In conceptualizing these data the question arises – "Do we see natural channels that have high scores (excellent ratings) for all metrics?" In all likelihood the answer is no, the mythical perfect channel does not exist. This question though, allows that the current analytical method may be overly reductionist and may benefit from multivariate analytical techniques. Preliminary analysis of such techniques produced the following bivariate plot of pools vs wood comparing managed and unmanaged channels.

Amendments to the survey protocol:

1. Streamline Tier II survey data collection to only acquire the data needed to compute the fish habitat objectives. This would eliminate side-channel data collection from the Tier II survey except for noting their intersection with the main channel. Side channel habitat survey would still be nested at the Tier III or IV level.
2. Update substrate classes to use those measurable using the gravelometer. This change allies us well with the currently defunct attempt at a national protocol.
3. Sample length should be set near the value of twenty times the average channel bed width, with a minimum of 100 meters if no special circumstances exist.
4. Quality control: establish training streams where repeat analyses can be conducted to train new crews and help quantify observer variability.
5. Monumented cross-sections: Add a recommendation to monument and GPS cross-sections in case we need to find them again.

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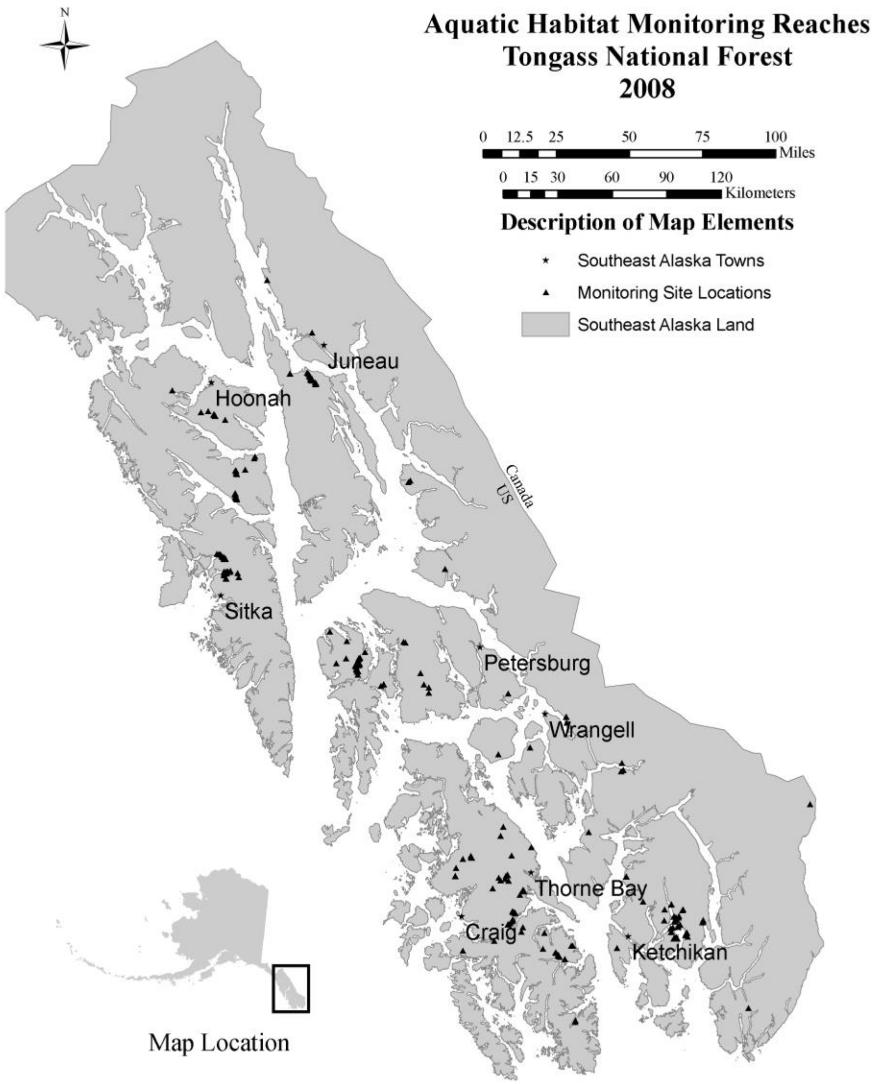
Appendix A_1 quartiles for stream reach samples from undisturbed channels

Habitat Attribute	Percentiles	Process Group=FP	Process Group=MM	Process Group=MC/LC	Process Group=HC*	Channel Type=FP3	Channel Type=FP4	Channel Type=FP5*	Channel Type=MM1
WD	25	16.5	10.4	9.2	8.3	10.9	18.5	23.1	10.2
	50	19.3	15.3	14.5	11.1	14.9	20.2	27.2	14.2
	75	26.7	22.4	21.0	13.0	19.0	32.8	43.6	22.0
TLWD/M	25	0.26	0.27	0.20	0.23	0.24	0.31	0.15	0.27
	50	0.36	0.38	0.28	0.34	0.40	0.37	0.17	0.38
	75	0.50	0.50	0.42	0.48	0.55	0.50	0.46	0.51
TKWD/M	25	0.04	0.05	0.05	0.07	0.10	0.06	0.02	0.06
	50	0.10	0.12	0.07	0.08	0.17	0.11	0.03	0.12
	75	0.15	0.14	0.09	0.27	0.25	0.15	0.08	0.14
POOLS/KM	25	30	40	30	50	30	30	10	50
	50	45	60	50	60	40	40	20	60
	75	70	70	60	100	70	60	25	70
POOL SPACE	25	1.4	2.8	2.2	2.4	2.2	1.3	1.7	2.8
	50	2.2	4.0	3.7	3.4	3.2	1.8	2.7	4.0
	75	3.5	5.8	4.8	5.7	5.1	2.2	3.2	5.8
RPD/CBW	25	0.04	0.06	0.04	0.06	0.06	0.04	0.03	0.07
	50	0.05	0.08	0.07	0.08	0.07	0.04	0.03	0.08
	75	0.06	0.10	0.08	0.09	0.09	0.05	0.03	0.10
D50	25	17	27	38	36	22	15	17	26
	50	24	35	88	93	27	19	20	35
	75	39	56	158	135	39	34	53	53
PLNGTH/M	25	0.34	0.28	0.20	0.17	0.35	0.38	0.18	0.38
	50	0.51	0.42	0.32	0.28	0.58	0.54	0.42	0.54
	75	0.69	0.47	0.51	0.44	0.69	0.70	0.44	0.70
REL_SUBMRG	25	12.0	5.0	4.2	3.3	10.6	26.5	11.4	5.0
	50	24.2	7.6	8.1	4.8	14.0	36.9	25.8	7.1
	75	37.5	13.6	20.7	11.4	23.1	49.4	52.2	12.4
POOL_SIZE	25	0.65	0.83	0.48	0.43	0.67	0.68	0.58	0.83
	50	0.84	1.16	0.72	0.59	1.14	0.84	0.65	1.25
	75	1.23	1.78	0.92	1.02	1.58	0.94	0.95	1.91

Appendix A_2 quartiles for stream reach samples from disturbed channels

Habitat Attribute	Percentiles	Process Group=FP	Process Group=MM	Process Group=MC/ LC	Process Group=HC*	Channel Type=FP3*	Channel Type=FP4	Channel Type=FP5*	Channel Type=MM1
WD	25	18.3	11.9	8.1	1.5	13.7	20.1	31.5	12.8
	50	27.8	17.3	21.4	5.0	18.8	27.8	38.6	16.7
	75	39.0	25.2	44.7	7.9	22.2	36.3	66.4	22.8
TLWD/M	25	0.21	0.28	0.13	0.24	0.30	0.21	0.10	0.36
	50	0.40	0.38	0.16	0.27	0.46	0.49	0.32	0.46
	75	0.61	0.51	0.49	0.44	0.59	0.61	0.61	0.57
TKWD/M	25	0.01	0.02	0.02	0.02	0.03	0.01	0.00	0.06
	50	0.03	0.07	0.03	0.03	0.06	0.03	0.01	0.10
	75	0.09	0.12	0.05	0.03	0.13	0.09	0.03	0.14
POOLS/KM	25	20	40	10	60	40	30	10	50
	50	30	65	30	70	50	40	20	70
	75	50	90	40	80	70	50	25	90
POOL SPACE	25	1.6	2.7	3.2	3.6	2.6	1.5	1.4	2.7
	50	2.4	4.0	3.9	6.2	4.2	2.0	2.2	3.9
	75	4.1	5.1	4.7	12.6	6.7	2.4	3.1	5.1
RPD/CBW	25	0.03	0.05	0.04	0.06	0.06	0.04	0.03	0.05
	50	0.04	0.06	0.06	0.07	0.07	0.04	0.03	0.08
	75	0.05	0.10	0.07	0.18	0.08	0.04	0.03	0.11
D50	25	17	25	34	93	16	22	18	24
	50	27	34	53	119	27	26	27	31
	75	40	51	106	1000	37	38	50	47
PLNGTH/M	25	0.39	0.29	0.26	0.03	0.39	0.47	0.32	0.29
	50	0.54	0.35	0.30	0.12	0.50	0.60	0.51	0.34
	75	0.60	0.45	0.61	0.58	0.55	0.87	0.57	0.50
REL_SUBMRG	25	12.8	3.9	5.8	1.3	6.7	17.7	12.9	3.8
	50	19.9	7.1	10.0	8.6	11.7	24.4	26.6	7.2
	75	29.7	11.4	22.8	10.3	14.6	40.4	30.9	11.4
POOL_SIZE	25	1.08	0.86	0.37	0.26	1.11	0.71	1.05	0.87
	50	1.09	1.21	0.76	0.27	1.35	0.99	1.21	1.35
	75	1.54	1.62	1.64	0.34	1.61	1.30	1.32	1.79


Aquatic Habitat Monitoring Reaches
Tongass National Forest
2008
N
0 12.5 25 50 75 100
Miles
0 15 30 60 90 120
Kilometers
Description of Map Elements
Southeast Alaska Towns
Monitoring Site Locations
Southeast Alaska Land
Juneau
Hoonah
Sitka
Petersburg
Wrangell
Thorne Bay
Craig
Ketchikan
Canada
US
Map Location