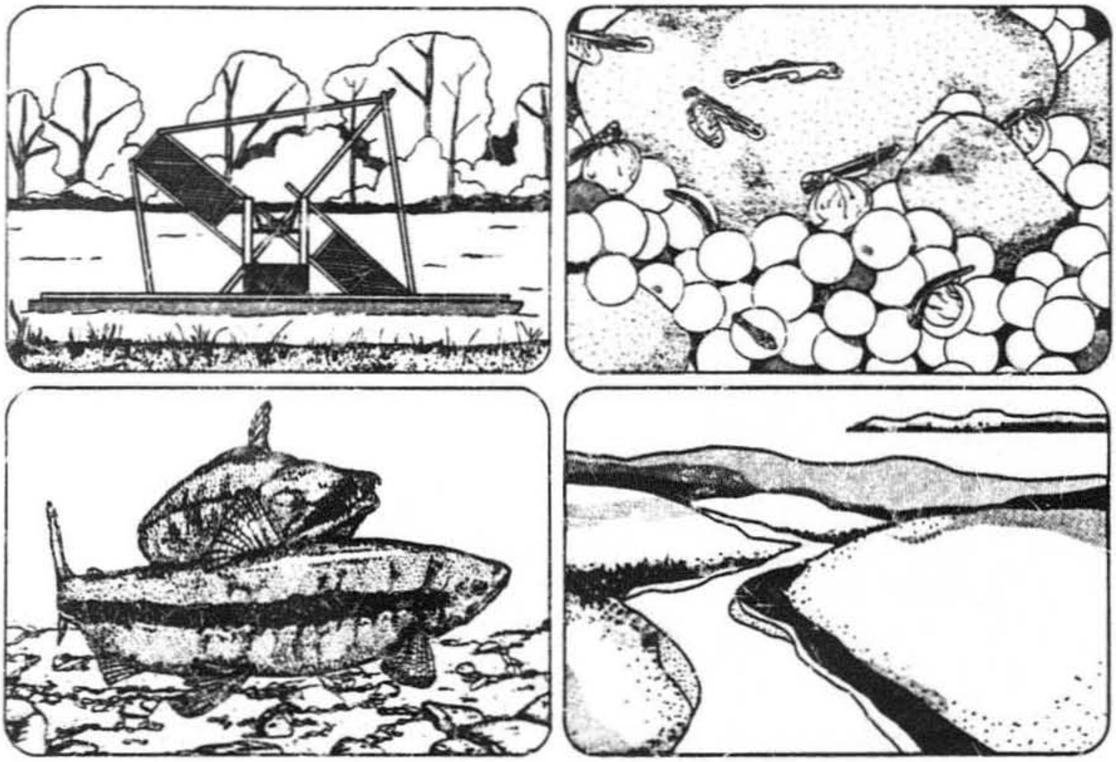

ALASKA DEPARTMENT OF FISH AND GAME
SUSITNA HYDRO AQUATIC STUDIES

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AQUATIC HABITAT AND INSTREAM FLOW INVESTIGATIONS (MAY-OCTOBER 1983)

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May 6, 1984

EVALUATIONS OF SALMON SPAWNING HABITAT UTILIZATION IN TRIBUTARIES OF THE MIDDLE SUSITNA RIVER

1984 Report No. 3, Chapter 9

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ABSTRACT

Spawning habitat utilization criteria (water depth and velocity, substrate composition, and surface and intragravel water temperatures) were collected at active chinook salmon spawning sites in tributaries of the middle reach of the Susitna River. These data were used to develop suitability criteria curves for use in evaluating habitat usability in tributary habitat of the middle Susitna River.

Suitability criteria curves were also developed for coho and pink salmon using literature information and professional judgment of biologists familiar with Susitna River stocks.

These curves only represent the utilization of hydraulic and related components of middle Susitna River tributary habitat.

GLOSSARY

Availability Data - Data collected, or synthesized by a computer model, which represents the environmental condition present for the organism to select for life stage activity.

Best Curve - utilization curve, usually with grouped increments, which represents the distribution with the least variability, lowest level of irregular fluctuations, minimal peakedness, and minimal coefficient of variation.

Cell - The surface area (surrounding each vertical between adjacent verticals and transects) which is assumed to have the same habitat characteristics as the vertical at the center of the cell.

Curve Types - See spawning habitat curve types.

Data Types - See availability data, utilization data, measured data, observed data, synthetic data, predicted data and forecast.

Discharge - Water volume passing a fixed point per unit time. Specifically refers to mainstem habitat.

Fish Curve - Generic name applied to suitability/preference/utilization curves for fish; see also habitat curve.

Glossary (continued)

Flow - Water volume passing a fixed point, per unit time. Specifically referring to non-mainstem habitats.

Habitat - The physical conditions which are needed to support life processes for a particular species and life stage.

Habitat Component - One element of the total spectrum of elements (physical and chemical conditions) needed to support the life functions of a particular species and life stage.

Habitat Curve - Generic name applied to suitability/preference/ utilization curves; see also fish curve.

Minimal Coefficient of Variation - (i.e. the sample standard deviation divided by the sample mean) for the frequency counts.

Minimal Irregular Fluctuations _ Grouped values should continually increase to the maximum grouped value, then continually decrease Baldridge and Amos (1982), as defined by a series of four indices proposed by Baldridge and Amos (1982).

Minimal Peakedness - Meaning a minimal difference between the maximum grouped value (i.e. increment) and the increments immediately below and above the maximum, as defined by a peakedness index.

Glossary (continued)

Minimal Sample Variance - that is minimal variability of the frequency counts denotes a "best curve".

Peakedness Index - A measure of the difference between the maximum grouped value or increment (e.g. in a scaled frequency histogram plot) and the increments to either side of the maximum grouped value or increment. The index ranges from zero, indicating no peak, to two, indicating a maximum peak.

Preference - An apparent behavioral selection for a particular habitat component value as indicated by observed or measured data.

Preference Curve - A utilization curve modified to account for selection of a particular value within the available range of habitat conditions. Can be calculated by dividing the utilized values by values of available habitat in each increment or, when available habitat data are not available, by professional judgement. The x and y axes are established in the same manner as the utilization curves.

Scaled Frequency - The label for the y-axis indicating data which has been standardized to the 0 - 1 scale.

Spawning Habitat Curve Types - See: utilization curve, preference curve, suitability criteria curve, habitat curve, fish curve.

Glossary (continued)

Suitability - How well a particular habitat condition meets the life stage needs of a particular species.

Suitability Criteria Curve - A preference curve, modified by additional information, e.g. observations, professional judgement, field and literature data, etc., to represent the suitability of habitat for a particular species and life stage over the range of habitat components expected to be encountered. This is the curve used to calculate weighted usable area (also suitability index curve and weighted habitat criteria). The x and y axes are established in the same manner as the utilization curves.

Suitability Curve - See: suitability criteria curve.

Suitability Index - The label for the y-axis indicating standardization to the 0 - 1 scale for a suitability curve. Can also be used to indicate a value determined from a suitability curve.

Utilization Curve - Habitat data (depth, velocity, substrate, etc.), collected during life stage activity (i.e. spawning, rearing, etc), plotted to show distribution of actual field measurements. Scale of the increments on the x-axis corresponds to the accuracy of the measuring device, and can be grouped in combination of increments to smooth the distribution. Scale on the y-axis is standardized to a 0 to 1 scale by setting the largest increment to 1 and dividing each increment by this maximum to assign a proportional value.

Glossary (continued)

Utilization Data - Data collected at an active life stage site, (e.g. depth, velocity and substrate data collected at an active salmon redd).

Vertical - The point on a transect where a measurement is made (the measurement is perpendicular to the horizontal plane defined by the water surface).

Weighted Usable Area (WUA) - An index of the capacity of a site to support the species and life stage being considered. WUA is expressed as square feet (ft^2) or percentage (%) of wetted surface habitat area predicted to be available per 1,000 linear feet of habitat reach at a given flow.

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1.0 INTRODUCTION

This chapter is an evaluation of velocity, depth, and substrate characteristics used for spawning by chinook salmon in tributary habitat. Three tributaries: Indian River, Portage and Cheechako Creeks (Figure 9-1) were studied. Tributary habitat in the middle reach of the Susitna River is the primary spawning area for chinook, coho and pink salmon. Chum salmon spawning is equally divided between tributary and slough habitat (ADF&G 1983b).

Tributary habitat is not anticipated to be affected by the operation of the proposed Susitna Hydroelectric Project. Velocity, depth, and substrate characteristics presently associated with tributary spawning may occur in mainstem or side channel habitat areas under with project flows. It is therefore important to identify the range of hydraulic conditions utilized by tributary spawners to determine if velocity, depth, and substrate conditions are among the habitat components presently limiting spawning in other habitat types which are influenced by mainstem discharge. The information in this chapter can be used to identify the range of hydraulic and related conditions that would be acceptable for spawning by this stock of species and life phase at other locations. This information does not indicate spawning will occur at a location if these conditions are present; rather, it indicates it could occur if other required conditions and essential life phase requirements were also available at a site.

Reprogramming of FY84 study plan priorities required that minimal time be spent on this study; therefore, only utilization data were collected.

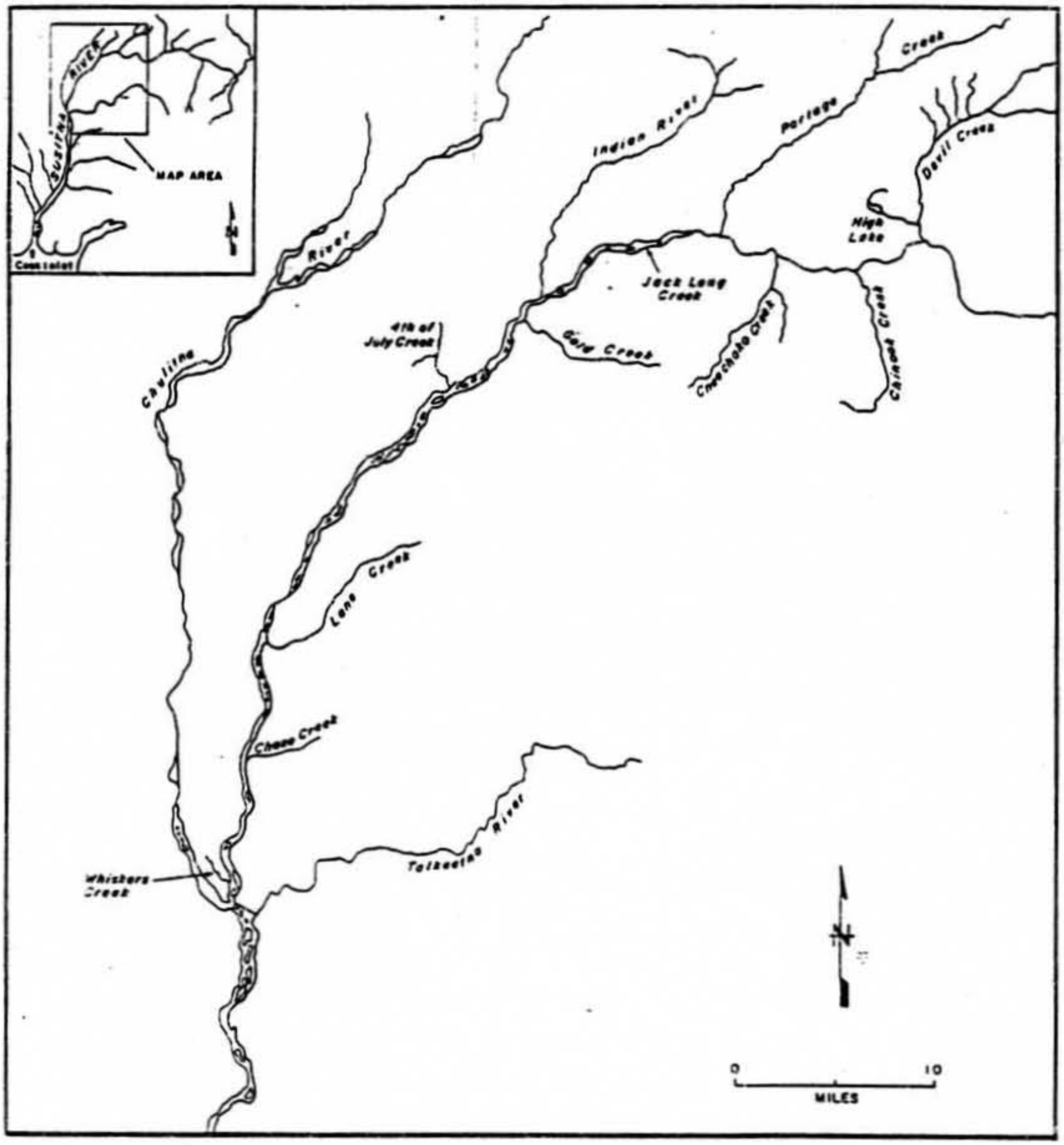

Figure 9-1 Tributaries surveyed for spawning chinook salmon.

It was not possible to obtain availability data which are required to insure that the full range of habitat conditions are evaluated.

The only species for which spawning habitat utilization data were collected in tributary habitat is chinook salmon. Chum salmon spawning in tributaries and sloughs occurred at the same time. Budget reductions during FY84 eliminated the expanded crews necessary to collect data in both habitat types. A low escapement of coho and pink salmon during 1983 and budgetary restrictions also prevented data collection for these species. Thus, coho and pink salmon suitability curves for tributary spawning were synthesized using literature information and professional judgement. Curves were not developed for chum salmon spawning in tributaries (see Chapter 7 for chum salmon suitability criteria developed for sloughs and side channels).

2.0 METHODS

2.1 Site Selection

Tributaries, in the middle reach of the Susitna River, known to support chinook salmon spawning (Figure 9-1), were surveyed by foot and helicopter by Alaska Department of Fish & Game (ADF&G) personnel from the Aquatic Habitat and Instream Flow, and Adult Anadromous programs to determine when spawning salmon were present. The two primary tributaries which supported spawning by chinook salmon were Portage Creek and Indian River. Small numbers of salmon (less than 25) were also seen in nine other streams. Due to the large numbers of fish present in Portage Creek and Indian River, data collection was concentrated in these two tributaries.

Specific sites within the tributaries (Figures 9-2 and 9-3) were selected by flying over the stream in a helicopter to locate areas where high concentrations of fish were present and access conditions were adequate.

2.2 Field Data Collection

After suitable spawning reaches were selected, field crews were deployed. Crews observed spawning behavior from the streamside in order to determine active spawning behavior, using criteria established by Estes et al. (1981) and Wilson et al. (1981). After an active spawning site was established, depth and velocity were measured at the upstream end of the redd using a March-McBirney flow meter and topsetting wading rod. Substrate was evaluated by visual assessment as described in

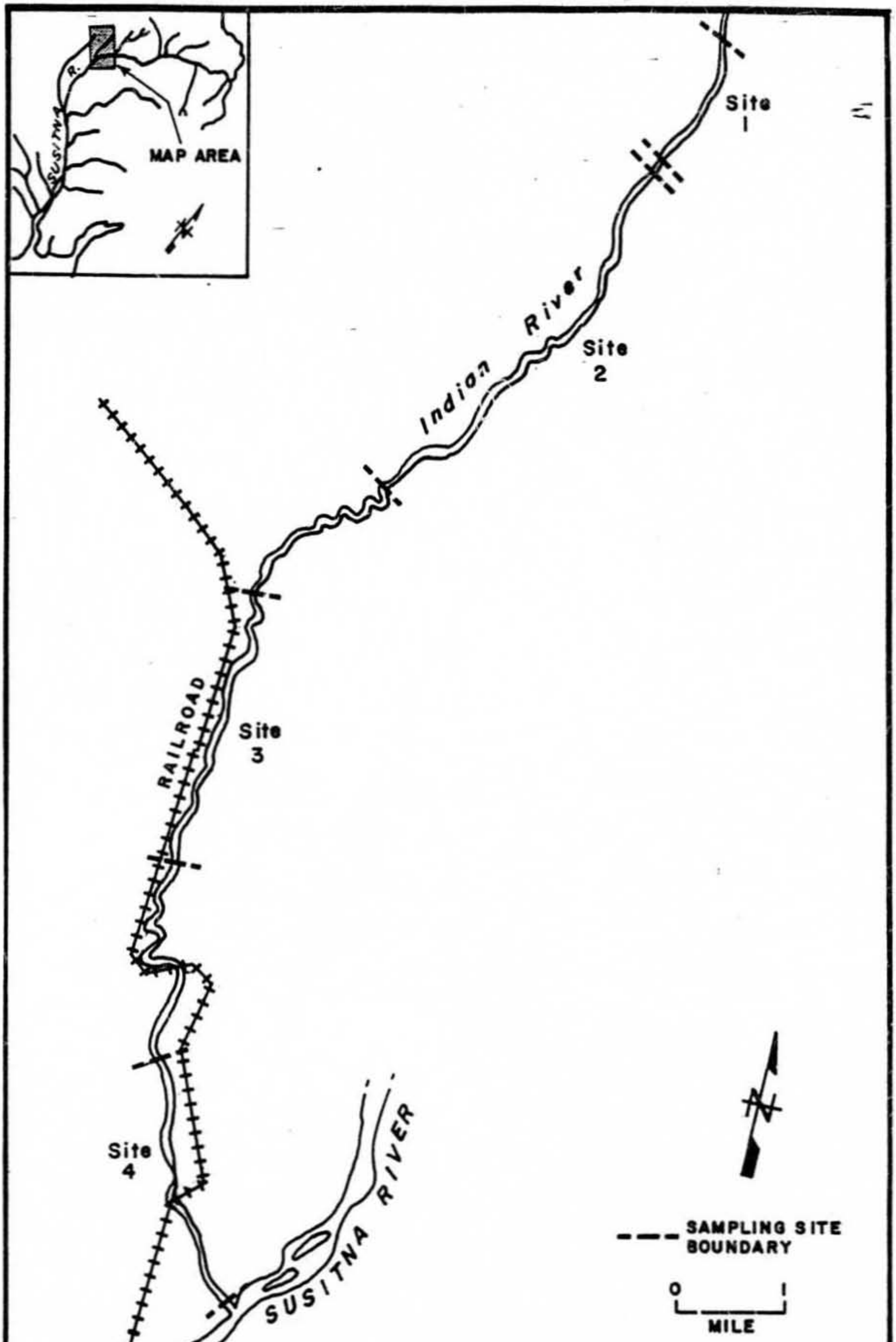

Figure 9-2 Chinook salmon redd sampling site on Indian River.

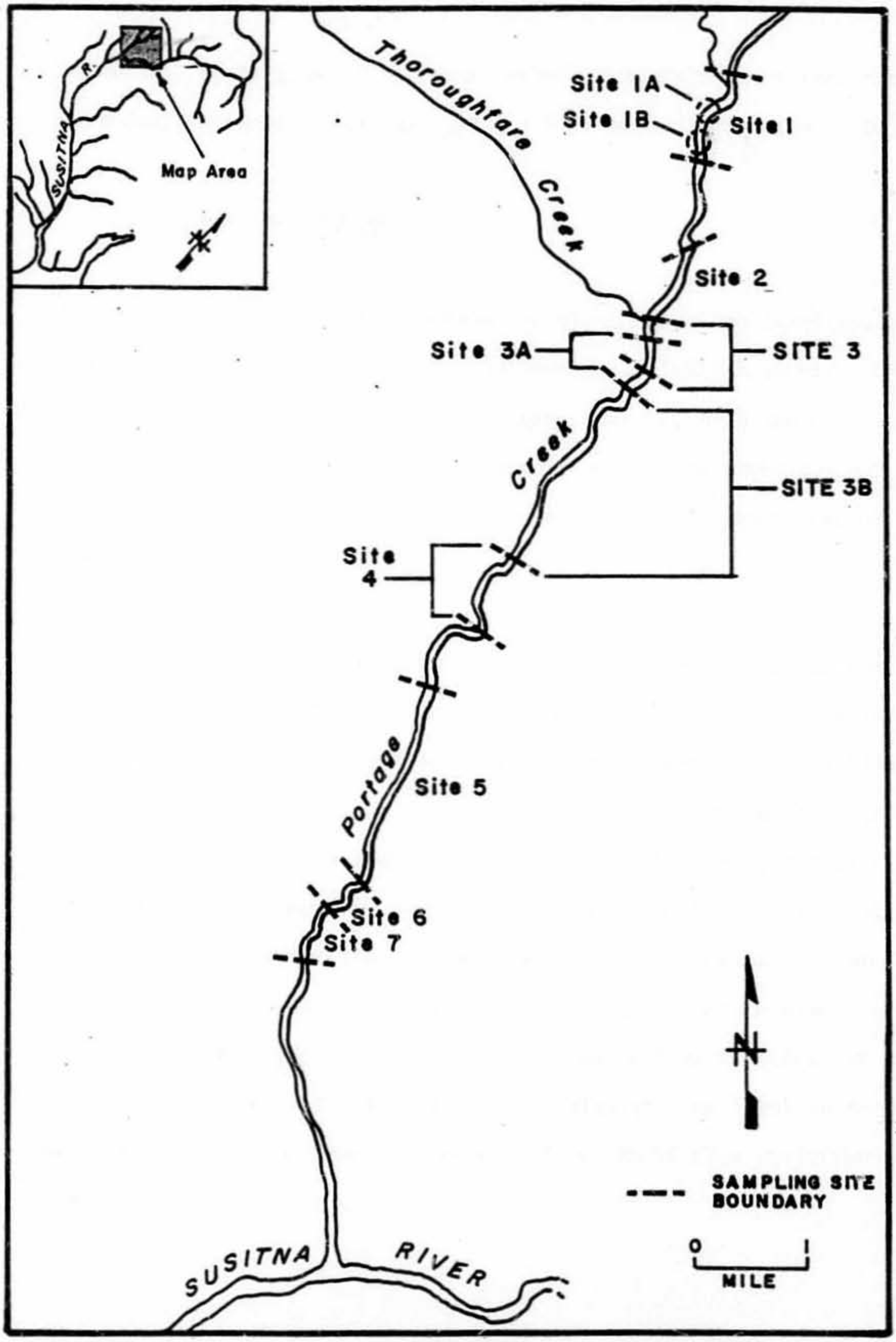

Figure 9-3 Chinook salmon redd sampling site on Portage Creek.

Chapter 7. Surface and intragravel water temperatures were measured in the deposition area of the redd using a Digi-Sense temperature probe.

2.3 Analytical Approach

The primary objective of this portion of the study is the development of weighted habitat criteria for use in habitat evaluation models. These criteria, denoted as suitability criteria curves, were developed for hydraulic and related habitat components which are important to the spawning life stage of the salmon species using the tributaries of the middle Susitna River.

The suitability index represents the relative value as habitat for use in spawning by adult salmon. This index is scaled from 0 to 1, with "1" denoting optimum habitat suitability and "0" denoting no suitability. Index values are plotted on the y-axis against the appropriate habitat component values on the x-axis, forming suitability index curves. The index values correspond to particular levels of each habitat component and, if deemed appropriate, can be combined with a hydraulic model to "weight" each cell in the model in terms of the relative usability of each cell as spawning habitat. The weighted cell usabilities can then be summed for the entire site at each particular flow level to produce Weighted Usable Area (WUA) values as a function of flow variation (see Chapter 7).

Development of suitability indices for each important spawning habitat criteria for each adult salmon species, followed a systematic approach to evaluate the relative importance of each habitat component.

The first step in development of the suitability index curves involves the evaluation of utilization data, that is habitat values at redds utilized by salmon species in the macrohabitat sites of interest in the middle Susitna River. The utilization data is plotted as frequent histograms. The data are standardized by dividing the frequency in each increment of the appropriate habitat component by the frequency in the increment with the highest occurrence; this standardization achieves a 0 to 1 scaling for frequency on the y-axis. These scaled frequency histograms represent utilization curves. The original magnitude of the increments for the frequency analysis corresponds to the measuring/recording accuracy for the particular habitat component of interest. Accordingly, the depth and velocity scaled frequency histograms are initially divided into 0.1 ft and 0.1 ft/sec increments, respectively. The substrate histograms are divided into one set of discrete substrate-class increments (e.g. silt, silt-sand, sand, etc.).

Additional scaled frequency histograms were developed for depth and velocity increments of size 0.2 ft and ft/sec and 0.3 ft and ft/sec in order select the distribution with least variability. There is more than one combination of possible histograms with increment sizes of 0.2 and 0.3, dependent upon the starting value of the increment. Accordingly a total series of six scaled histograms were developed for each variable (i.e. depth and velocity), the histograms are summarized in Table 9-1.

Table 9-1. Summary of histograms used for the selection of best utilization curve.

Histogram	Increment Size	Increment Starting Value
1	0.1	0.0
2	0.2	0.0
3	0.2	0.1
4	0.3	0.0
5	0.3	0.1
6	0.3	0.2

Histogram 1, above, is often equivalent to histogram 2 in that only the first increment is different (i.e. histogram 1 defines all values equal to 0.0 as one increment, while histogram 2 groups these values with values less than or equal to 0.1). The curves developed by these plots were judged in terms of the following criteria:

1. minimal sample variance, that is minimal variability of the frequency counts denotes a "best curve".

2. minimal coefficient of variation (i.e. the sample standard deviation divided by the sample mean) for the frequency counts.

3. minimal irregular fluctuations, "meaning grouped values should continually increase to the maximum grouped value, then continually decrease" (Baldridge and Amos 1981), as defined by a series of four indices proposed by Baldridge and Amos (1981).

4. minimal peakedness, meaning a minimal difference between the maximum grouped value (i.e. increment) and the increments immediately below and above the maximum, as defined by a peakedness index described below.

The first three criteria above are the same as those proposed by Baldridge and Amos (1981). The fourth criteria is proposed as a method of quantifying a characteristic of the utilization curves, which had in previous studies of this type been used to subjectively evaluate the curves (Amos, personal communication). Note the subjective evaluation of curves would occur if the first three criteria failed to indicate one "best" curve.

The four criteria were more or less weighted equally when evaluating the curve. The exceptions being, that the irregular fluctuation criteria was weighted most strongly, while the coefficient of variation was only used as a deciding factor between curves which were otherwise indistinguishable. Peakedness was intermediate in importance between irregular fluctuations and coefficient of variation.

The first criteria (i.e. minimal variance) is utilized in only those instances when the difference between variances is statistically significant. Levene's W test for homogeneity of variance (Brown and Forsythe 1974; Glaser 1983) was executed to evaluate the similarity of the variance of frequency counts between the six or seven scaled frequency histograms. The test is a robust test (i.e. it is to dependent upon a normal distribution assumption). The hypotheses tested are:

H_0: All variances are equal;

H_a: At least one of the variances are different.

If the null hypotheses (i.e. H_0) is rejected then individual pairs of variances are compared utilizing the ratio of the larger variance value to the smaller value forming an F statistic which can be evaluated for statistical significance using standard F tables (Dixon and Massey 1969). The hypotheses involved are:

H_0: One of the six variances is the same as one particular variance of the other five or six.

H_a: One of the six variances is not the same as one particular variance of the other five or six.

A series of fifteen possible pairwise comparisons can be made. However, the comparisons between the histograms with the smaller variance values are those of primary interest (except in cases of violation of the third criteria above, i.e. minimal irregular fluctuations).

The third criteria above (i.e. minimal irregular fluctuations) is evaluated using a series of four indices:

1. Number of irregular fluctuations.

2. Total magnitude of irregular fluctuations.

3. Maximum individual irregular fluctuations.
4. And, average fluctuation.

These indices are computed by the formulas defined in Baldridge and Amos (1981). The best curve should have small values for all four indices.

The minimal irregular fluctuation criteria sometimes led to rejection of the minimal variance curve. Rejection of minimal variance curves due to this criteria involved professional judgment as to the tradeoffs involved. This tradeoff generally involved choosing between a non-smooth curve with many increments and a smooth curve with fewer increments (often with a higher variance). A non-smooth curve with many increments is indicative of low numbers of observations (i.e. frequencies).

The peakedness criteria was evaluated using a peakedness index defined as:

$$\text{Index} = \frac{(-F_{(m-1)} + 2(F_{(m)}) - F_{(m+1)})}{(F_{(m-1)} + F_{(m)} + F_{(m+1)})}$$

where,

$F_{(m-1)}$ represents the frequency of the increment immediately below the maximum increment;

$F_{(m)}$ represents the frequency of the maximum increment; and

$F_{(m+1)}$ represents the frequency of the increment immediately above the maximum increment.

A modification of the above formula is implemented in cases where the peak occurs in the first or last increment of the curve, in this case the formula used is:

$$\text{Index} = \frac{F_{(m)} - F_{(x)}}{F_{(m)} + F_{(x)}}$$

where,

$F_{(x)} = F_{(m+1)}$ when $F_{(m)}$ is first increment of the curve,

or

$F_{(x)} = F_{(m-1)}$ when $F_{(m)}$ is last increment of the curve.

This index has a range of 0, indicating a flat peak, to 2 indicating a maximum peak. Generally, the lower the index the better the curve.

This criteria was established primarily as a method of quantifying (and therefore allowing for repeatability) a subjective criteria which had been previously used to evaluate curves which could not otherwise be distinguished. The criteria of minimal peakedness was only applied when the resulting best curve did not seriously violate the minimal irregular fluctuation criteria. Peakedness indices were evaluated to be "distinguishable" when they differed by $\pm$ 10% from each other. Specific decisions made during the selection of the "best" utilization curves is presented more fully in the appropriate results section.

The second step in developing the habitat suitability criteria curves would ideally be to compare the utilization data to the habitat present at the time the utilization data was collected. This would indicate if certain ranges of the habitat present were not used even though present and thus allow the adjustment of the criteria accordingly. However, due to time and manpower limitations do to reestablishment of priorities this could not be done.

The final step in the development of suitability criteria curves is consideration of the habitat values of increments outside of the range of the field data collected but within the range of predictions that habitat evaluations to be made. This refinement of the curves involves evaluation of additional field observations, previously published information on the species/life stage, and professional judgement.

The analytic approach to developing suitability index factors as described above generally describes the procedures which have been implemented during the development of suitability curves for depth, velocity, and substrate habitat components for adult chinook salmon the tributaries of the middle Susitna River.

Suitability curves for coho and pink salmon were developed from previously published criteria information on the species/life stage, and professional judgment of biologists familiar with the spawning phase of these species in the Susitna River drainage.

3.0 RESULTS

Water depth and velocity, substrate composition, and surface and intragravel water temperatures were measured at 265 active chinook salmon redds in tributaries of the Susitna River upstream of Talkeetna. The majority of the measurements were made in Portage Creek (136) and Indian River (125). Table 9-2 tabulates the tributaries surveyed and number of measurements made per tributary. Table 9-3 tabulates the dates, number of measurements and specific site where measurements were made. Field data are presented in Appendix 9-A.

Depths used by spawning chinook ranges from 0.6 ft to 2.8 ft with the majority of measurements made at 1.5 ft depth. Velocities ranged from 0.4 ft/sec to 4.4 ft/sec with the most observations made at 2.0 ft/sec. Substrate composition at redds ranged from large gravel (1-3 inches) to boulder (10 inches or larger). The majority consisted of rubble (3-5 inch) type substrate. Surface water temperatures ranged from 7.8° to 13.6°C; and intragravel temperatures ranged from 7.7° to 14.5°C. Plots of the depth, velocity and substrate data are presented in Figures 9-4 through 9-6.

Table 9-2. Tributaries surveyed for spawning chinook salmon, 1983

TRIBUTARIES SURVEYED BY ADF&G	RIVER MILE	PEAK COUNTS[1]	NO. REDD MEASUREMENTS
Whiskers Creek	101.4	3	0
Chase Creek	106.9	15	0
Slash Creek	111.2	0	0
Gash Creek	111.6	0	0
Lane Creek	113.6	12	0
Upper McKenzie Creek	116.2	0	0
Little Portage Creek	117.7	0	0
Deadhorse Creek	120.8	0	0
Fifth of July Creek	123.7	0	0
Skull Creek	124.7	0	0
Sherman Creek	130.8	0	0
Fourth of July Creek	131.0	6	0
Gold Creek	136.7	23	0
Indian River	138.6	1,193	125
Jack Long Creek	144.5	6	0
Portage Creek	148.9	3,140	136
Chinook Creek	156.8	8	0
Cheechako Creek	152.5	25	2
Devil Creek	161.0	1	0

1 from Barrett et al. 1984

Table 9-3. Table of sampling sites for chinook salmon spawning habitat data, 1983..

TRIBUTARY	SITE	DATE	TRM	# REDDS
Portage Creek	1	7/24	13.1	9
	1A	7/29	13.0	7
	1B	7/29	12.5	7
	2	7/24	11.2	4
	3	7/25	10.9	14
	3A	7/29	10.2-10.8	24
	3B	7/30	8.0-10.2	25
	4	7/25	7.9	4
	5	7/27	6.4	18
	6	7/28	4.4	1
	7	7/28	3.3	23
				TOTAL 136
Indian River	1	7/26	14.7-16.2	29
	2	7/28	10.0-14.4	34
	3	7/29	4.9-7.8	27
	4	7/28	0.0-2.7	35
				TOTAL 125
Cheechako Creek	1	8/5	0.0-0.5	2
				GRAND TOTAL 263

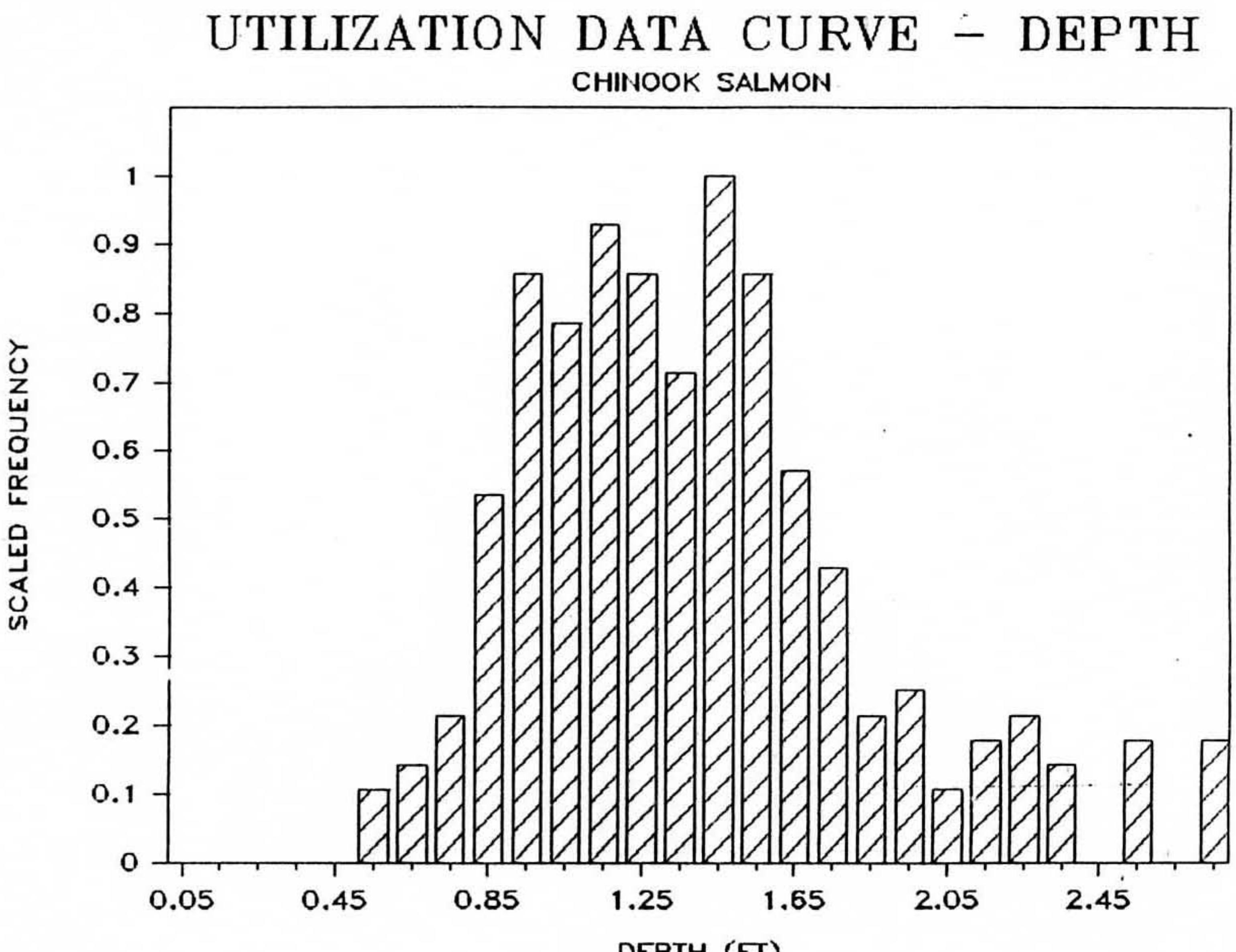

Figure 9-4 Plots of depth utilization data collected at chinook salmon redds.

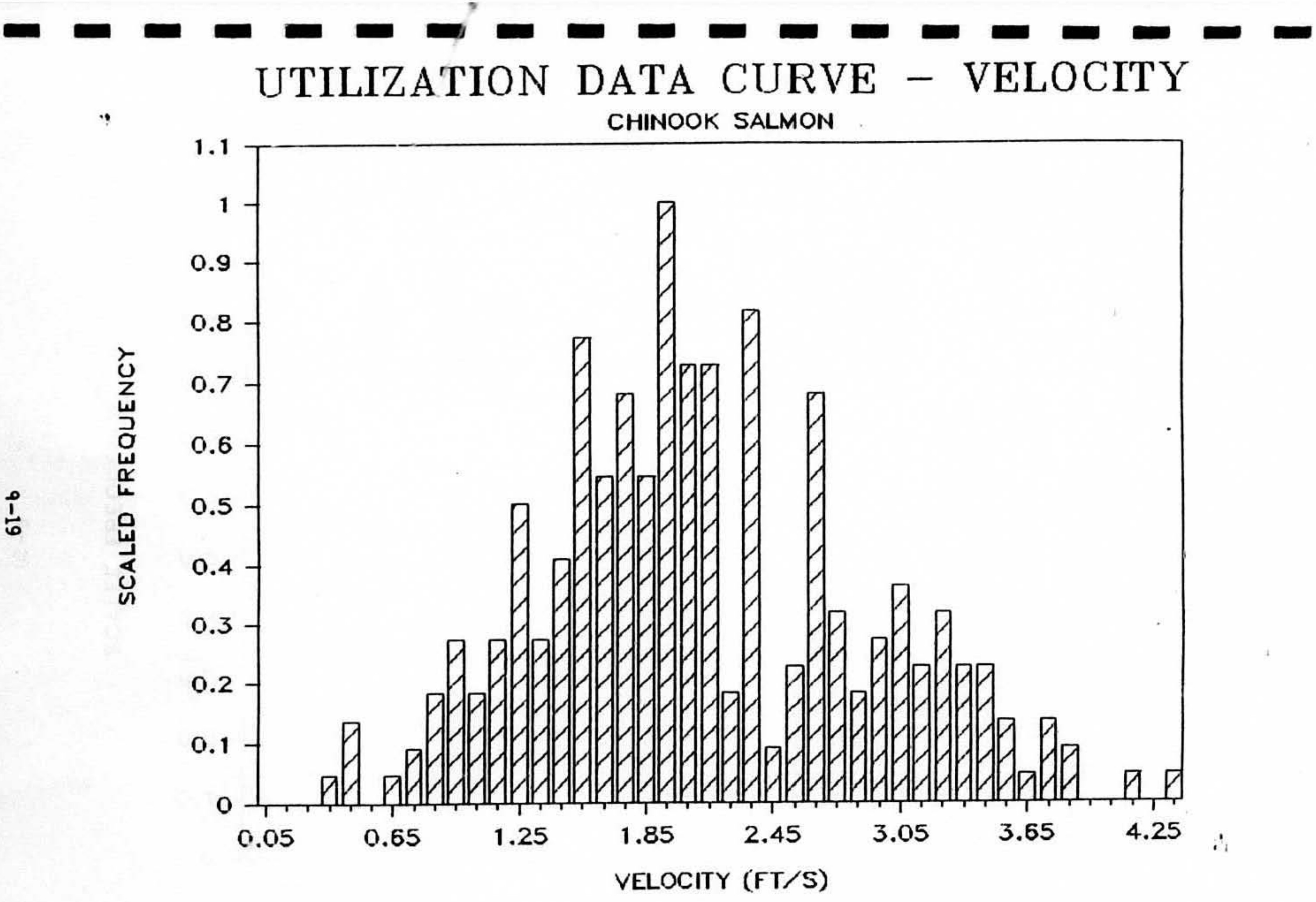

Figure 9-5 Plots of velocity utilization data collected at chinook salmon redds.

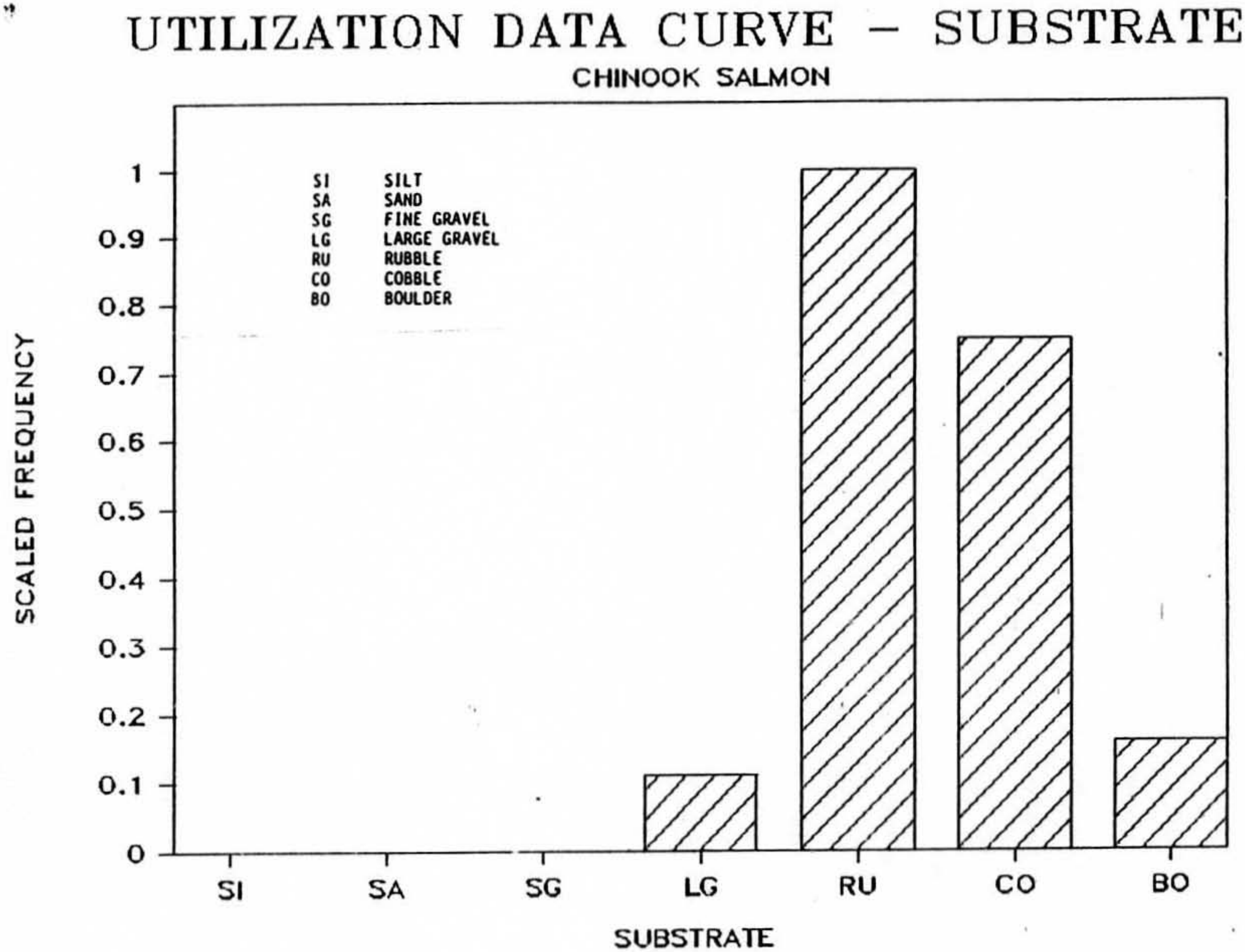

Figure 9-6 Plots of substrate utilization data collected at chinook salmon redds.

Depth measurements at chinook salmon redds were grouped into six incremental groupings as described in the analytical approach section (Section 2.3). These groupings were plotted as histograms, and are shown in Figure 9-7. Table 9-4 summarizes the statistics used to determine which of the six histograms to choose as the "best" utilization curve. The statistically minimal variance curve is the histogram labelled A (see Appendix Table 9-B-1). However, histogram A had large indices of irregular fluctuations, and accordingly was not chosen as the best curve. Histograms B through F were not distinguishable in terms of the minimal variance criteria. While the minimal irregular fluctuation criteria indicated that histograms C and E were the next most likely candidates for the best utilization curve. Of these two histograms curve E had the lowest distinguishable peakedness index and was accordingly chosen as the best utilization curve (Figure 9-8).

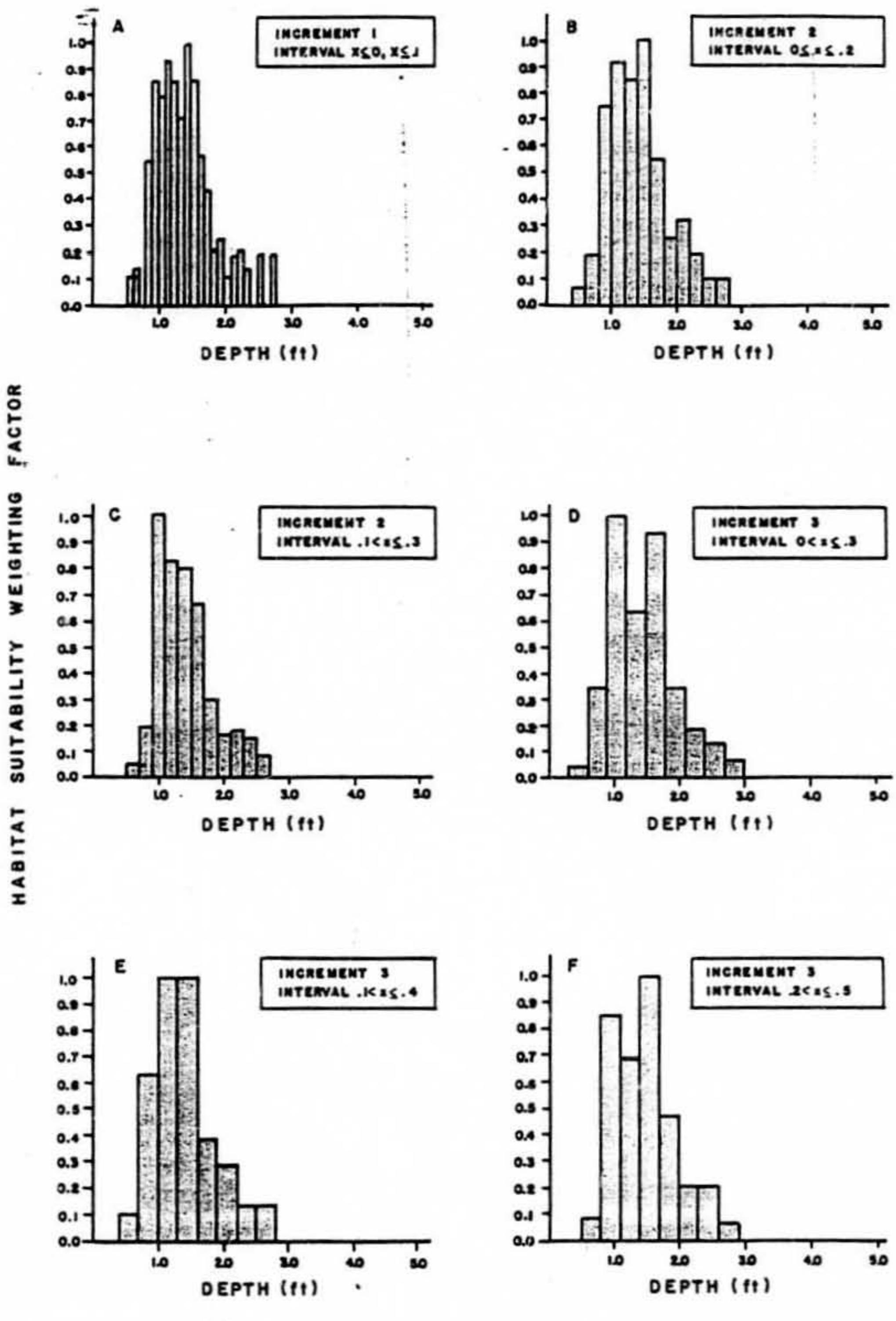

Figure 9-7 Incremental distribution of depths measured at chinook salmon redds.

Table 9-4. Summary of statistics on various incremental groupings for chinook salmon utilization depth histograms.

HISTOGRAM LABEL	A	B	C	D	E	F
INCREMENT SIZE	0.1	0.2	0.2	0.3	0.3	0.3
INCREMENT START	0.0	0.0	0.1	0.0	0.1	0.2
VARIANCE	87.5	353.5	440.1	682.0	727.0	632.0
COEFFICIENT OF VARIATION	0.81	0.85	0.87	0.89	0.81	0.76
IRREGULAR FLUCTUATIONS						
Magnitude	22	6	1	22	0	11
Number	8	2	1	1	0	1
Mean	2.75	3.00	1.00	22.00	---	11.00
Maximum	5	4	1	22	---	11
PEAKEDNESS	0.17	0.26	0.49	0.52	0.33	0.38

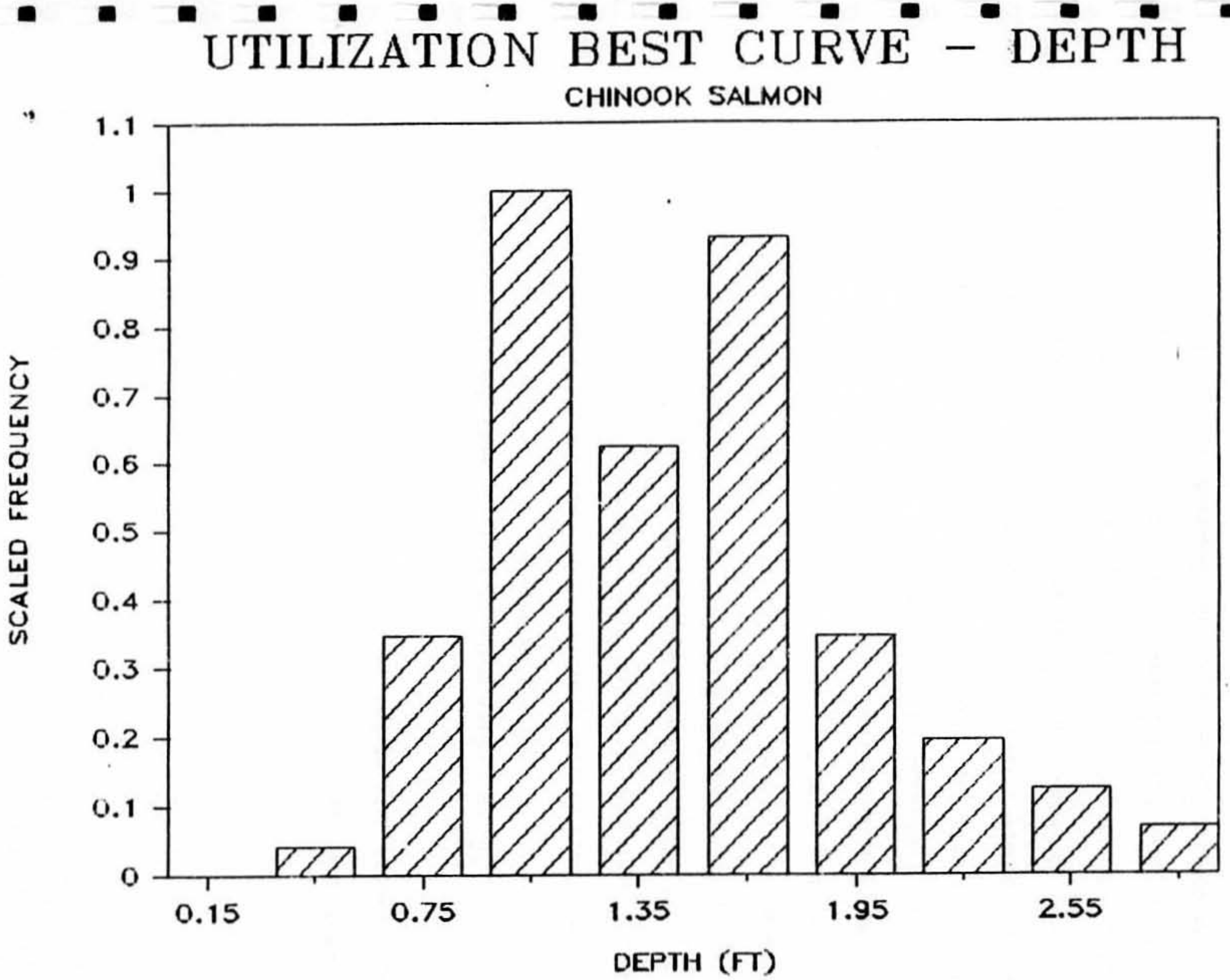

Figure 9-8 Best chinook salmon depth utilization curve.

Velocity measurements at chinook salmon redds were grouped into six incremental groupings as described in the analytical approach section (Section 2.3). These groupings were plotted as histograms, and are shown in Figure 9.9. Table 9.5 summarizes the statistics used to determine which of the six histograms to choose as the "best" utilization curve. The statistically minimal variance curve is the histogram labelled A (see Appendix Table 9-B-2). However, histogram A had large indices of irregular fluctuations, and accordingly was not chosen as the best curve. Histograms B and C both had a variance which were statistically less than the variance for histogram E, but were not distinguishable from each other or from histograms D and F. While the minimal irregular fluctuation criteria indicated that histograms D and F were the next most likely candidates for the best utilization curve, with histogram F having slightly lower values of irregular fluctuation indices. These two histograms were not distinguishable in terms of either peakedness, variance, or coefficient of variation. Accordingly, the slightly lower value for irregular fluctuation led to selection of histogram F as the best utilization curve (Figure 9-10).

Incremental plots of substrate are not appropriate because substrate data are not continuous. Plots of substrate data are presented in Figure 9-6.

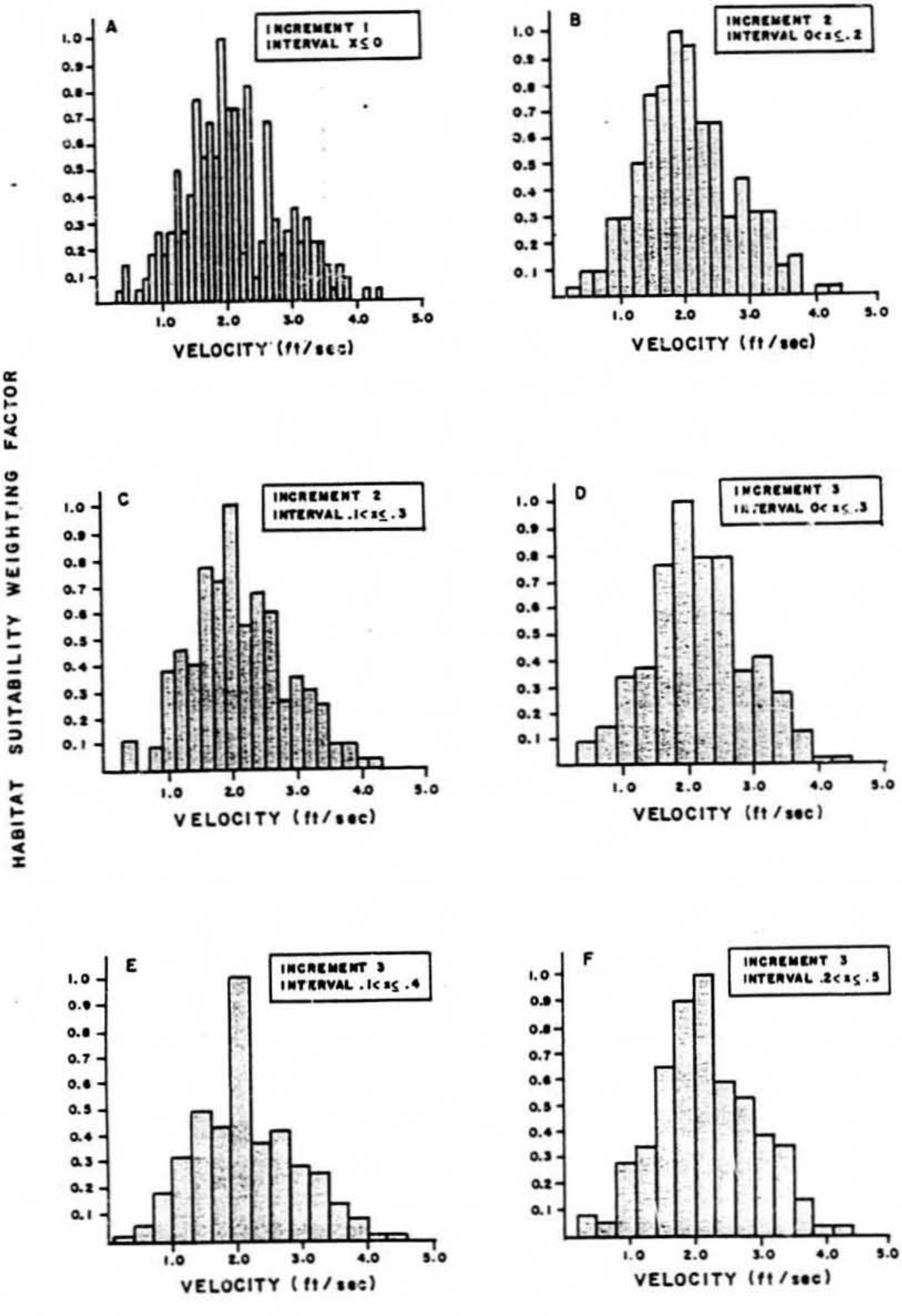

Figure 9-9 Incremental distribution of velocities measured at chinook salmon redds.

Table 9-5. Summary of statistics on various incremental groupings for chinook salmon utilization velocity histograms.

HISTOGRAM LABEL	A	B	C	D	E	F
INCREMENT SIZE	0.1	0.2	0.2	0.3	0.3	0.3
INCREMENT START	0.0	0.0	0.1	0.0	0.1	0.2
VARIANCE	33.8	116.3	117.8	224.8	284.2	236.8
COEFFICIENT OF VARIATION	0.90	0.85	0.82	0.83	0.95	0.81
IRREGULAR FLUCTUATIONS						
Magnitude	55	7	16	3	7	1
Number	14	3	5	1	2	1
Mean	3.93	2.33	3.20	3.00	3.50	1.00
Maximum	14	5	5	3	4	1
PEAKEDNESS	0.32	0.10	0.34	0.19	0.67	0.20

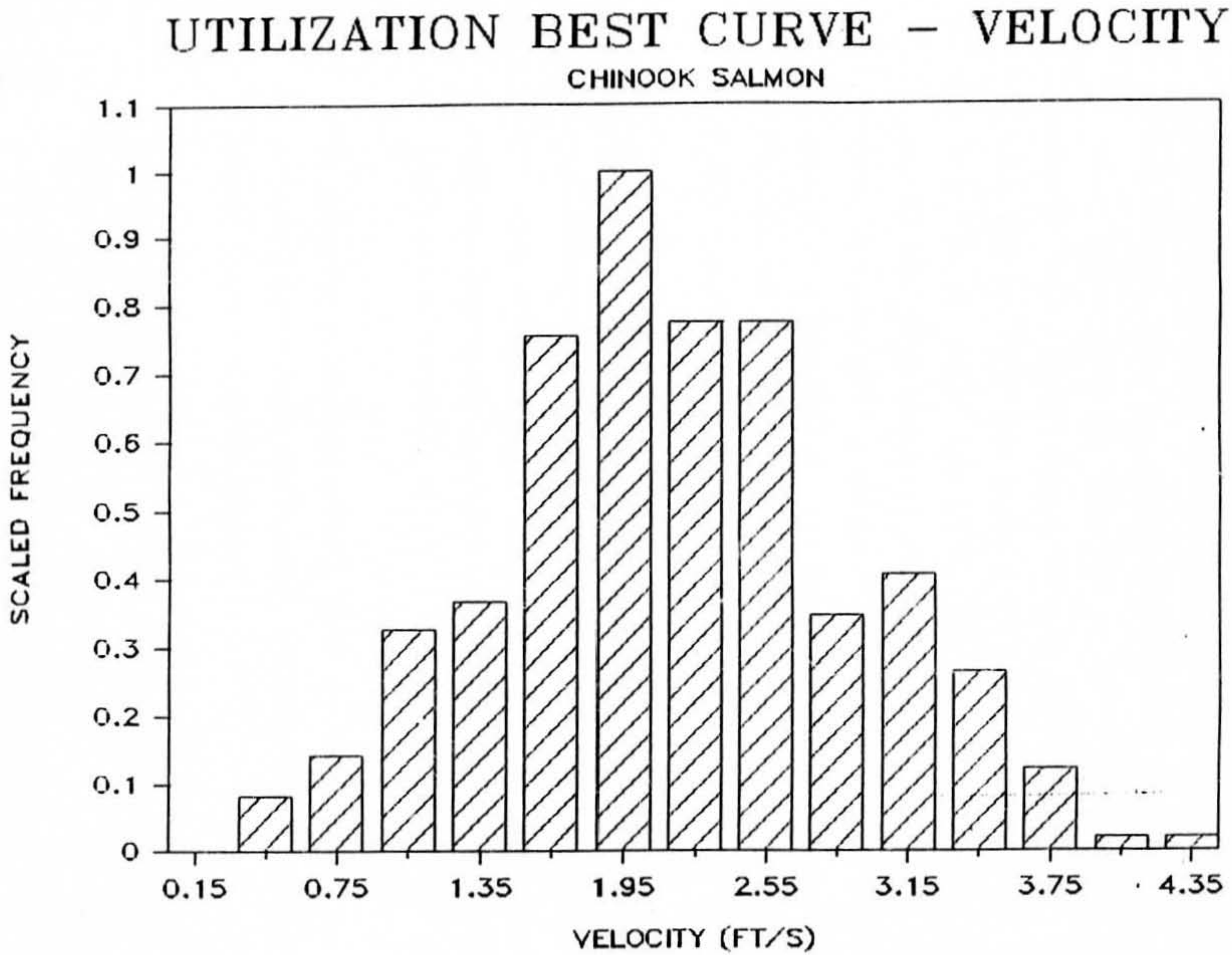

Figure 9-10 Best chinook salmon velocity utilization curve.

The depth suitability curve for chinook salmon spawning was developed by using the selected best utilization curve (histogram E, Figure 9-8). This curve was used as a basis to establish the coordinates for the shallow depths up to the 1.0 point on the suitability axis (i.e. y-axis). The 0.4 depth increment had a scaled frequency of 0.0, therefore, this was established as the 0.0 point on the suitability index scale. The peak ranged from 1.0 to 1.6 on the best utilization curve, this was smoothed to develop the suitability curve with the peak at 1.0 and an inflection point of the 0.8 ft depth 0.7 suitability point. It was determined that depths greater than 1.5 ft would not limit spawning; therefore, the suitability factor of 1.0 was extended out to a depth of 8 ft to indicate this trend.

The velocity utilization curve for chinook salmon spawning was developed in a similar manner. The best utilization curve (histogram F, Figure 9-10) was selected as a basis to start from. This curve was smoothed to indicate a peak between 1.8 and 2.8 ft/sec, tapering to a suitability index of 0.0 at 5.0 and 0.0 ft/sec.

The substrate suitability criteria curve was based largely on the utilization data, slight modifications were made based on professional judgment in order to smooth the curve.

The final chinook salmon suitability criteria curve are presented in Figure 9-11 through 9-13.

PRELIMINARY DRAFT

INTERNAL REVIEW ONLY 3/15/84

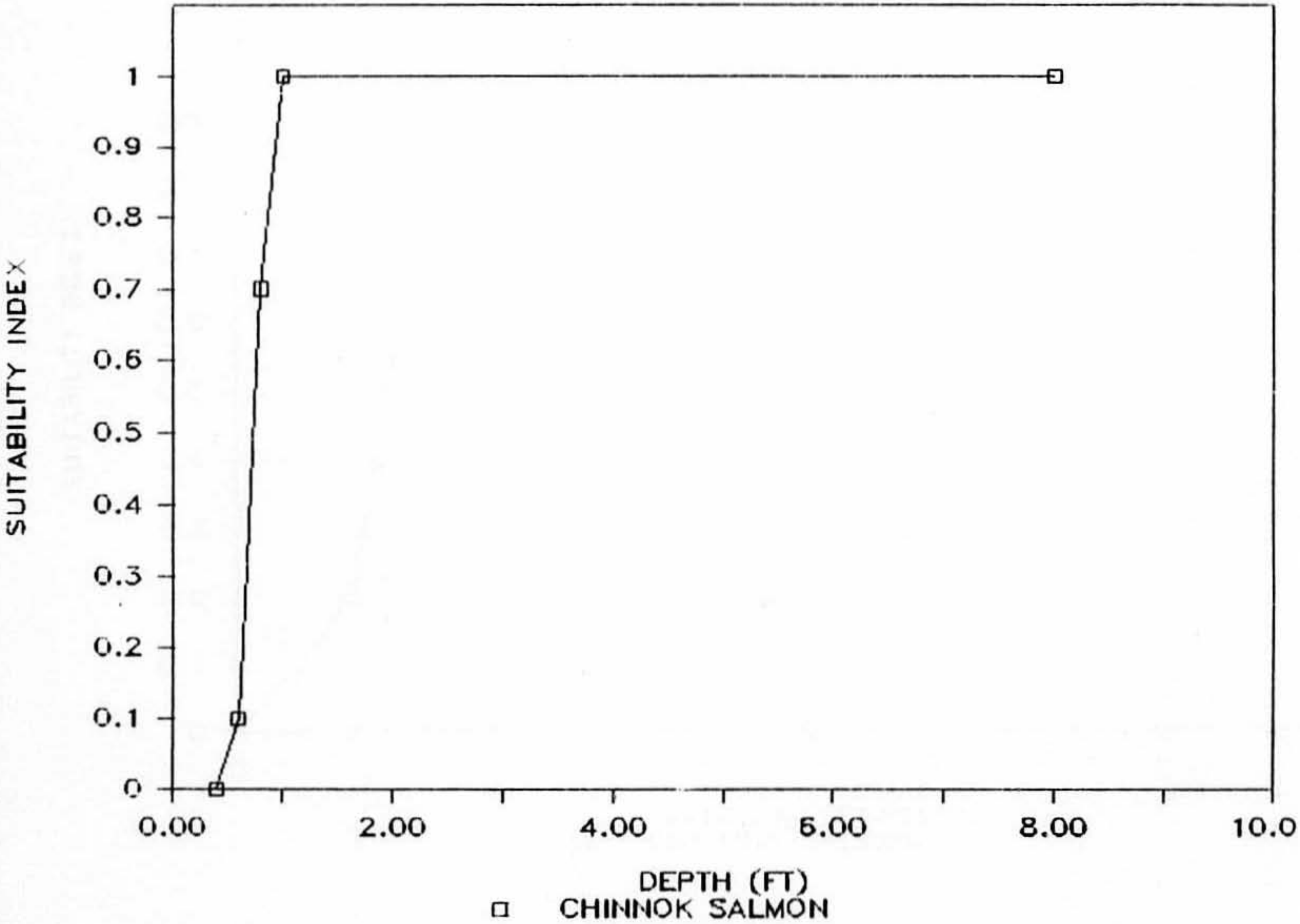

Figure 9-11 Chinook salmon spawning depth suitability criteria curve.

PRELIMINARY DRAFT
INTERNAL REVIEW ONLY 3/15/84

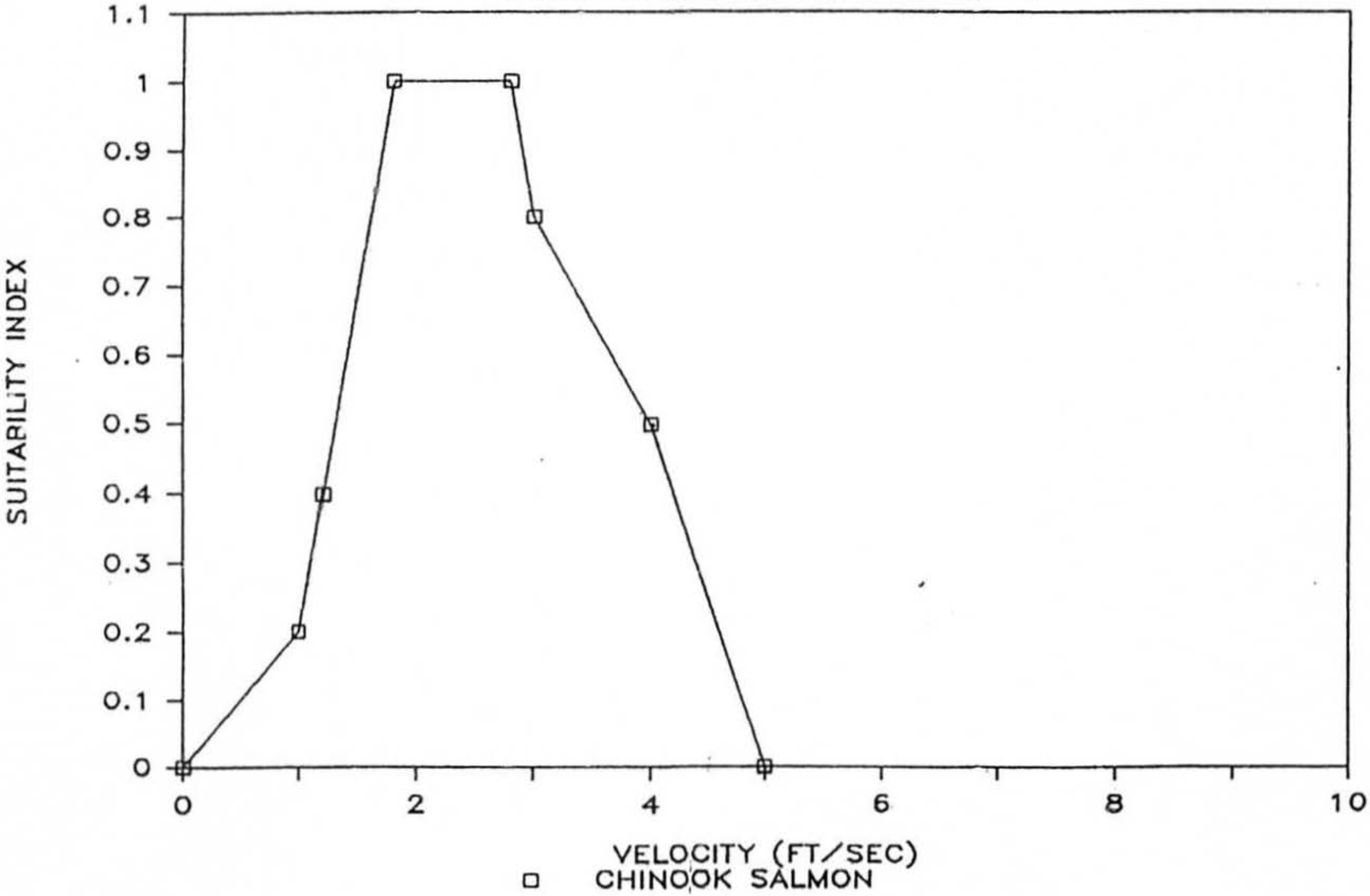

Figure 9-12 Chinook salmon spawning velocity suitability criteria curve.

PRELIMINARY DRAFT

INTERNAL REVIEW ONLY 3/15/84

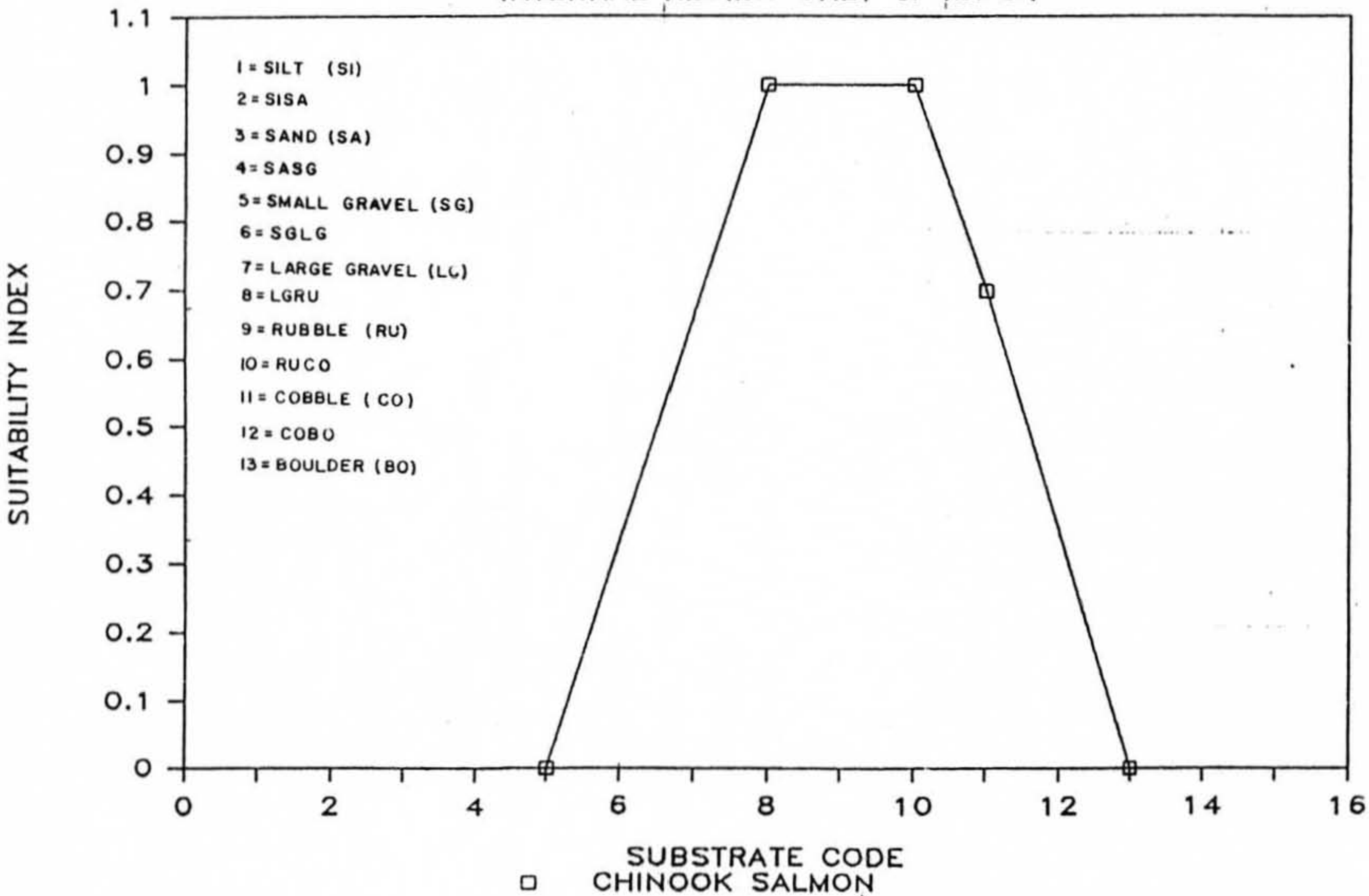

Figure 9-13 Chinook salmon spawning substrate suitability criteria curve.

The coho salmon spawning curves were developed using information from McMahon (1983) and Wilson et al. (1981). McMahon states that a minimum depth of 15 cm; a range of velocities from 21 to 70 cm/sec; and preferred substrate of "gravel and small rubble with low amounts of fine" are required for spawning by coho salmon. The Terror Lake Hydroelectric Study Team (Wilson et al.) developed suitability criteria for coho spawning. These curves were used as a basis for the Susitna River suitability criteria curves. The curves for depth, velocity, and substrate from Wilson et al. were modified to reflect observations of biologists familiar with Susitna River stocks. A modification to the depth curve was to expand the peak suitability to 8.0 ft. Depths greater than 0.8 ft are not considered to limit spawning in Susitna River habitats. The substrate curve was modified to reflect classification codes developed for this study. The coho salmon spawning suitability criteria curves are presented in Figures 9-14 through 9-16.

Pink salmon spawning curves were developed using literature information from Estes et. al. 1981, Wilson et. al. 1981, and Krueger 1981.

Terror Lake curves (Wilson et al. 1981) were the primary source of data used. Differences between Susitna criteria curves and the Terror Lake curves include: an extension of the depth suitability index of 1.0 to a depth of 8.0 ft; and slight changes in the substrate curve to include smaller substrate sizes (i.e. a 0.0 suitability index at substrate code 2 instead of 3).

The resulting Susitna River tributary habitat pink salmon spawning suitability criteria curves are presented in Figures 9-17 through 9-19.

PRELIMINARY DRAFT

INTERNAL REVIEW ONLY 3/15/84

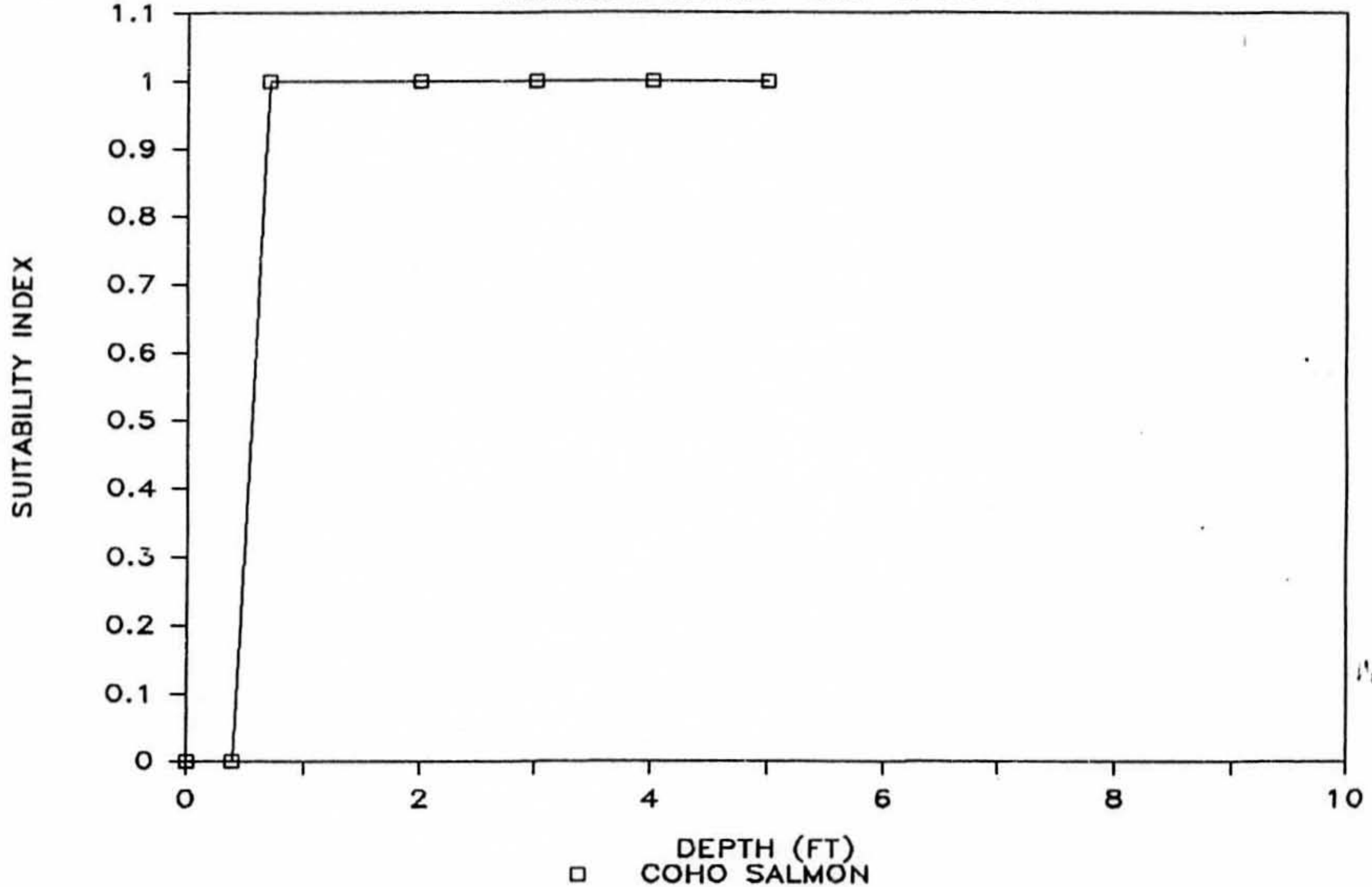

Figure 9-14 Coho salmon spawning depth suitability criteria curve.

PRELIMINARY DRAFT

INTERNAL REVIEW ONLY 3/15/84

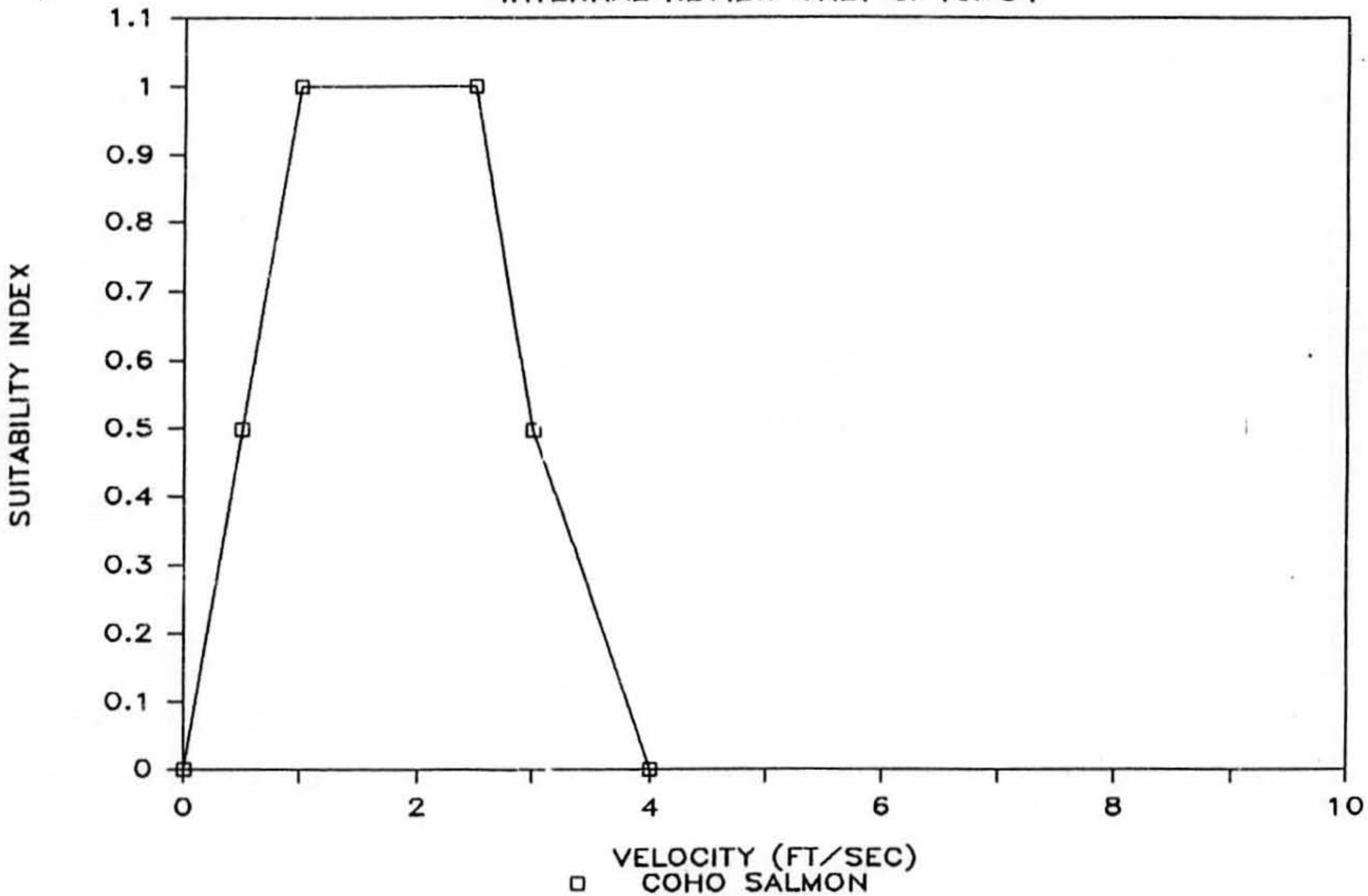

Figure 9-15 Coho salmon spawning velocity suitability criteria curve.

PRELIMINARY DRAFT

INTERNAL REVIEW ONLY 3/15/84

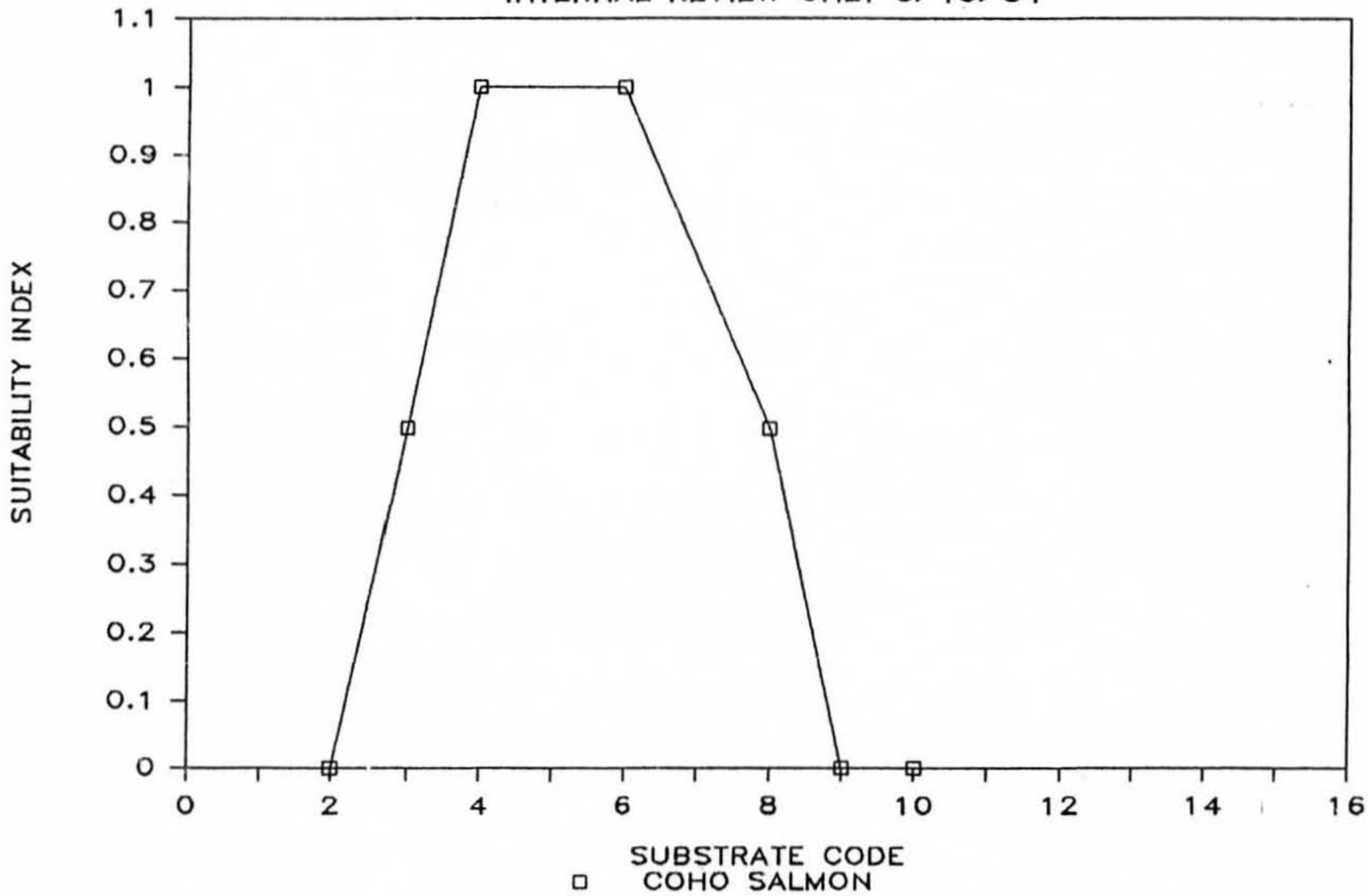

Figure 9-16 Coho salmon spawning substrate suitability criteria curve.

PRELIMINARY DRAFT

INTERNAL REVIEW ONLY 3/15/84

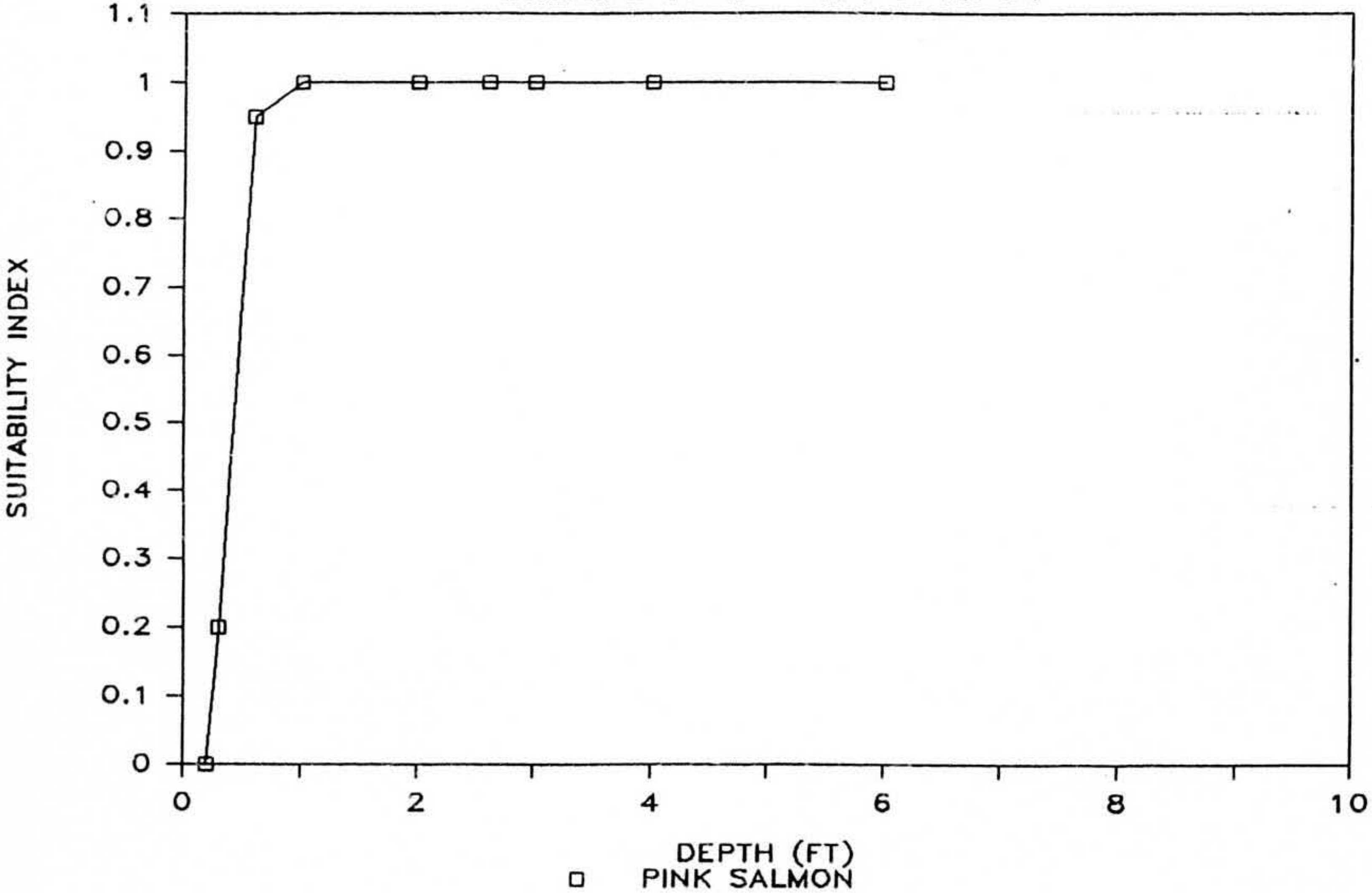

Figure 9-17 Pink salmon spawning depth suitability criteria curve.

PRELIMINARY DRAFT

INTERNAL REVIEW ONLY 3/15/84

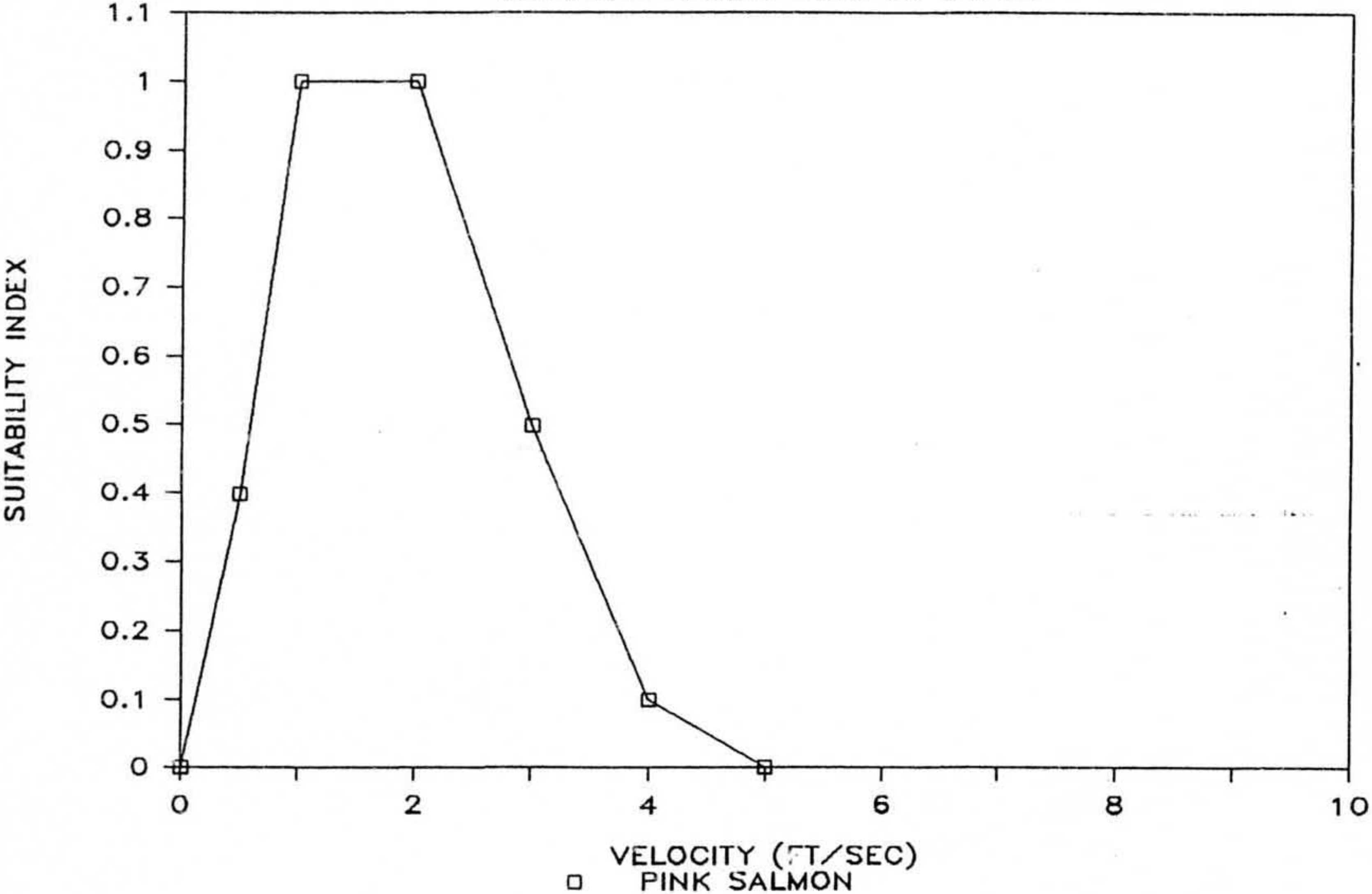

Figure 9-18 Pink salmon spawning velocity suitability criteria curve.

PRELIMINARY DRAFT

INTERNAL REVIEW ONLY 3/15/84

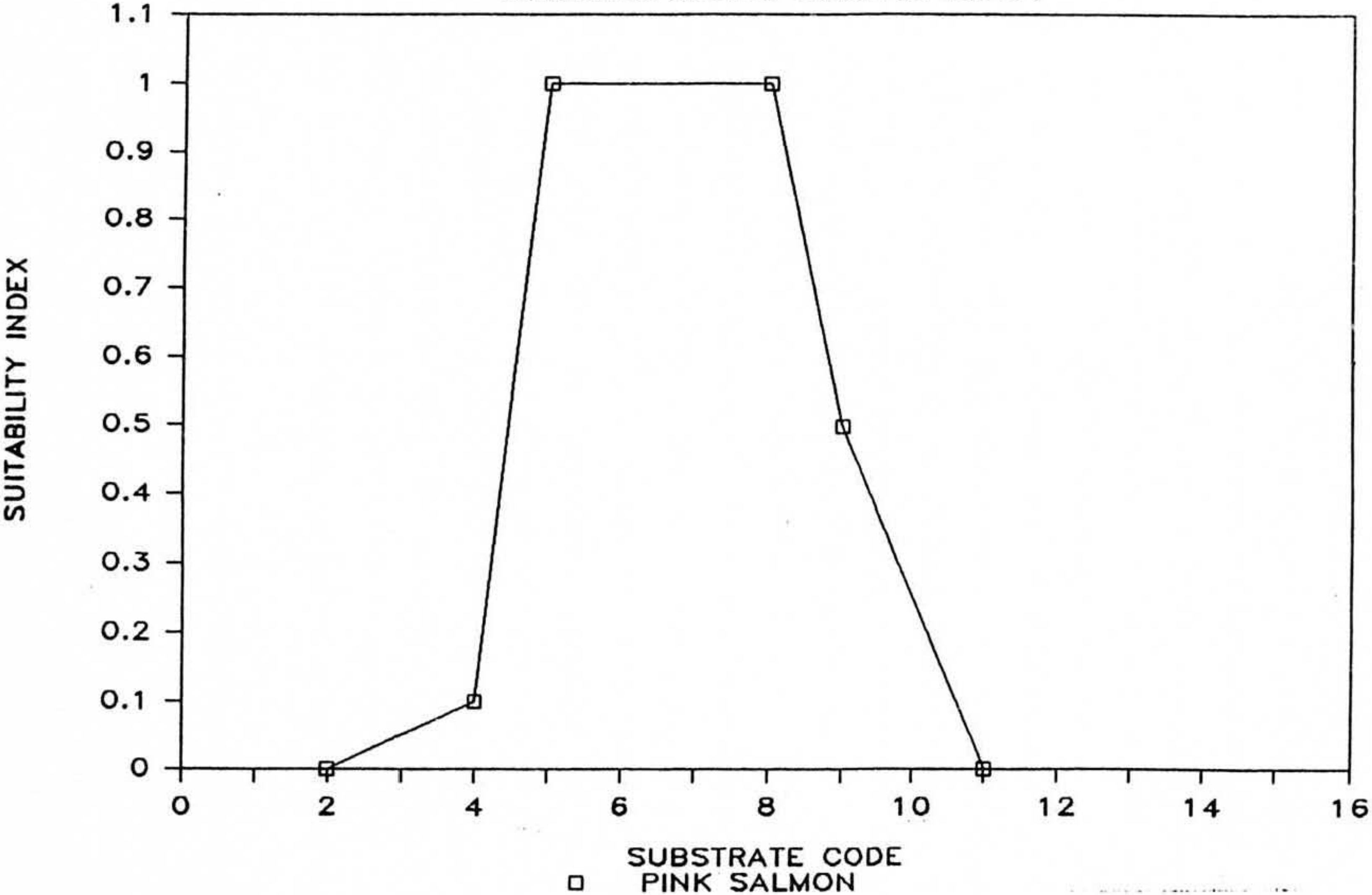

Figure 9-19 Pink salmon spawning substrate suitability criteria curve.

4.0 DISCUSSION

The habitat suitability criteria presented in this report for chinook, coho, and pink salmon are intended to represent the major hydraulic habitat components which are utilized for spawning in tributary habitat by Susitna River stocks of salmon. The curves represent three major hydraulically related habitat components associated with spawning for chinook, coho, and pink salmon (water depth and velocity, and substrate composition). There may however be other habitat components not delineated by the curves which, in themselves, can limit spawning. Use of these curves outside the Susitna River drainage or in different habitat types where spawning by these species has not been observed should therefore be limited to defining a range of hydraulic conditions capable of supporting spawning. For example, the hydraulic conditions for spawning for chinook salmon, as outlined by the curves, can occur within the mainstem and side channels of the Susitna River. However, chinook salmon have not been observed spawning in these areas. Therefore, other habitat factors or life phase requirements must be considered as limiting spawning in these areas. These additional factors include, but are not limited to, substrate embeddedness; surface and intragravel water temperatures; various aspects of water chemistry and intragravel flow; and passage, incubation, or rearing limitations.

In summary, use of these curves in association with hydraulic models to assess usable habitat is appropriate for the tributary habitat. However, application of these curves outside of the specified habitat, although it may indicate usable habitat as it applies to river hydraulics, would not be germane unless it could be proven that other habitat factors were also suitable.

It is important to note that the chinook salmon suitability curves are supported by utilization field data. Habitat availability data were not collected due to budget and manpower limitations; thus it is not known if the full range of available habitat was sampled. Consequently, fish preferences could not be considered when developing the chinook suitability criteria curves. The coho and pink salmon curves are based entirely on literature and professional judgment because of resource reductions. It would, therefore, be appropriate to validate these curves with additional Susitna River drainage field data if they are to be used in predictive habitat models.

5.0 CONTRIBUTORS

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APPENDIX 9-A
Chinook Salmon Spawning Habitat Data

Table 9-A-1 Chinook salmon spawning habitat data.

LOCATION	DATE	DEPTH (FT)	WATER VELOCITY (FT/S)	SUBSTRATE		WATER TEMPERATURE (C)		REDD NO.
				PRIMARY	SECONDARY	INTRAGRAVEL	SURFACE	
4TH OF JULY CREEK 200 FT ABOVE Q SITE	830804	1.70	1.10	RUBBLE	COBBLE	13.2	13.2	1
INDIAN RIVER	830727	1.70	1.90	COBBLE	RUBBLE	9.8	9.8	1
INDIAN RIVER	830727	.80	2.50	RUBBLE	COBBLE	9.5	9.8	2
INDIAN RIVER	830727	1.20	2.40	COBBLE	RUBBLE	8.4	9.9	3
INDIAN RIVER	830727	1.30	2.40	COBBLE	RUBBLE	8.8	9.9	4
INDIAN RIVER	830727	1.30	1.80	RUBBLE	COBBLE	9.6	9.9	5
INDIAN RIVER	830727	1.00	.70	RUBBLE	COBBLE	9.1	9.9	6
INDIAN RIVER	830727	1.60	2.10	COBBLE	RUBBLE	9.6	9.9	7
INDIAN RIVER	830727	1.30	3.30	RUBBLE	COBBLE	9.6	9.9	8
INDIAN RIVER	830727	1.00	3.20	RUBBLE	COBBLE		9.9	9
INDIAN RIVER	830727	1.60	4.10	RUBBLE	COBBLE		9.9	10
INDIAN RIVER	830727	1.20	.50	RUBBLE	LARGE GRAVEL		10.0	11
INDIAN RIVER	830727	1.30	2.00	RUBBLE	COBBLE		10.0	12
INDIAN RIVER	830727	1.30	1.80	RUBBLE	LARGE GRAVEL		10.1	13
INDIAN RIVER	830727	1.60	2.60	RUBBLE	COBBLE		10.1	14
INDIAN RIVER	830727	.70	.50	COBBLE	RUBBLE		10.1	15
INDIAN RIVER	830727	1.10	3.20	RUBBLE	COBBLE		10.3	16
INDIAN RIVER	830727	1.50	3.00	COBBLE	RUBBLE		10.3	17
INDIAN RIVER	830727	1.20	2.33	COBBLE	RUBBLE		10.3	18
INDIAN RIVER	830727	.90	2.00	RUBBLE	COBBLE		10.3	19
INDIAN RIVER	830727	1.00	3.00	RUBBLE	COBBLE		10.4	20
INDIAN RIVER	830727	1.50	2.20	COBBLE	RUBBLE		10.4	21
INDIAN RIVER	830727	2.50	3.80	COBBLE	RUBBLE		10.5	22
INDIAN RIVER	830727	1.80	2.70	RUBBLE	COBBLE		10.5	23
INDIAN RIVER	830727	1.50	3.00	RUBBLE	COBBLE		10.5	24

Table 9-A-1 Continued

LOCATION	DATE	DEPTH (FT)	WATER VELO-CITY (FT/S)	SUBSTRATE		WATER TEMPERATURE (C)		REDD NO.
				PRIMARY	SECONDARY	INTRAGRAVEL	SURFACE	
INDIAN RIVER	830727	1.60	3.50	RUBBLE	COBBLE		10.5	25
INDIAN RIVER	830727	1.80	1.50	RUBBLE	COBBLE		10.7	26
INDIAN RIVER	830727	1.10	1.60	COBBLE	RUBBLE		10.8	27
INDIAN RIVER	830727	1.60	1.10	COBBLE	RUBBLE		10.[illegible]	28
INDIAN RIVER	830727	1.50	3.00	RUBBLE	COBBLE		11.0	29
INDIAN RIVER	830728	1.20	3.20	RUBBLE	COBBLE	10.2	10.2	1
INDIAN RIVER	830728	1.80	1.40	COBBLE	RUBBLE			1
INDIAN RIVER	830728	2.00	3.20	RUBBLE	LARGE GRAVEL	10.2	10.2	2
INDIAN RIVER	830728	1.70	1.80	COBBLE	RUBBLE			2
INDIAN RIVER	830728	1.00	1.80	COBBLE	RUBBLE	10.5	10.6	3
INDIAN RIVER	830728	2.00	2.40	BOULDER	COBBLE			3
INDIAN RIVER	830728	1.40	1.70	RUBBLE	COBBLE	10.3	10.6	4
INDIAN RIVER	830728	.90	2.60	COBBLE	RUBBLE			4
INDIAN RIVER	830728	1.60	1.70	RUBBLE	LARGE GRAVEL	10.7	10.8	5
INDIAN RIVER	830728	1.20	.75	RUBBLE	COBBLE			5
INDIAN RIVER	830728	1.50	1.30	RUBBLE	LARGE GRAVEL	10.7	10.8	6
INDIAN RIVER	830728	1.30	2.40	RUBBLE	COBBLE			6
INDIAN RIVER	830728	1.00	2.00	RUBBLE	COBBLE	10.9	11.0	7
INDIAN RIVER	830728	1.60	2.40	RUBBLE	COBBLE			7
INDIAN RIVER	830728	1.00	1.60	RUBBLE	LARGE GRAVEL	11.1	11.0	8
INDIAN RIVER	830728	1.50	2.60	BOULDER	COBBLE			8
INDIAN RIVER	830728	.90	2.50	RUBBLE	LARGE GRAVEL	11.0	11.1	9
INDIAN RIVER	830728	1.30	.95	RUBBLE	LARGE GRAVEL			9
INDIAN RIVER	830728	1.30	2.50	RUBBLE	LARGE GRAVEL	11.1	11.1	10
INDIAN RIVER	830728	1.10	2.60	RUBBLE	LARGE GRAVEL			10

Table 9-A-1 Continued

LOCATION	DATE	DEPTH (FT)	WATER VELO-CITY (FT/S)	SUBSTRATE PRIMARY	SUBSTRATE SECONDARY	WATER TEMPERATURE (C) INTRAGRAVEL	WATER TEMPERATURE (C) SURFACE	REDD NO.
INDIAN RIVER	830728	1.10	2.60	RUBBLE	COBBLE	10.6	11.1	11
INDIAN RIVER	830728	1.20	2.40	RUBBLE	LARGE GRAVEL			11
INDIAN RIVER	830728	.90	.90	RUBBLE	LARGE GRAVEL	9.2	11.4	12
INDIAN RIVER	830728	1.10	3.25	RUBBLE	LARGE GRAVEL			12
INDIAN RIVER	830728	1.30	1.40	COBBLE	RUBBLE	10.3	11.3	13
INDIAN RIVER	830728	1.50	3.40	COBBLE	RUBBLE			13
INDIAN RIVER	830728	1.50	1.70	COBBLE	RUBBLE	10.8	11.5	14
INDIAN RIVER	830728	2.40	3.10	BOULDER	COBBLE			14
INDIAN RIVER	830728	1.50	2.40	RUBBLE	LARGE GRAVEL	10.2	11.6	15
INDIAN RIVER	830728	1.60	3.40	BOULDER	COBBLE			15
INDIAN RIVER	830728	.60	1.10	RUBBLE	LARGE GRAVEL	11.5	11.7	16
INDIAN RIVER	830728	1.20	1.70	COBBLE	RUBBLE			16
INDIAN RIVER	830728	1.30	2.40	RUBBLE	LARGE GRAVEL	11.6	11.6	17
INDIAN RIVER	830728	1.50	2.35	COBBLE	RUBBLE			17
INDIAN RIVER	830728	1.00	1.50	RUBBLE	COBBLE	11.6	11.7	18
INDIAN RIVER	830728	1.30	2.40	COBBLE	RUBBLE			18
INDIAN RIVER	830728	1.50	1.80	COBBLE	RUBBLE	11.5	11.7	19
INDIAN RIVER	830728	1.00	2.90	RUBBLE	COBBLE			19
INDIAN RIVER	830728	2.10	3.10	COBBLE	RUBBLE	10.9	11.7	20
INDIAN RIVER	830728	1.20	1.40	RUBBLE	LARGE GRAVEL			20
INDIAN RIVER	830728	.90	1.90	RUBBLE	LARGE GRAVEL	11.7	11.7	21
INDIAN RIVER	830728	.60	2.40	RUBBLE	LARGE GRAVEL			21
INDIAN RIVER	830728	1.40	2.00	RUBBLE	LARGE GRAVEL	11.7	11.8	22
INDIAN RIVER	830728	1.20	2.20	LARGE GRAVEL	RUBBLE			22
INDIAN RIVER	830728	1.00	2.30	RUBBLE	LARGE GRAVEL	11.8	11.8	23
INDIAN RIVER	830728	1.00	2.45	RUBBLE	COBBLE			23

Table 9-A-1 Continued

LOCATION	DATE	DEPTH (FT)	WATER VELOCITY (FT/S)	SUBSTRATE		WATER TEMPERATURE (C)		REDD NO.
				PRIMARY	SECONDARY	INTRAGRAVEL	SURFACE	
INDIAN RIVER	830728	1.00	1.70	RUBBLE	LARGE GRAVEL	11.9	11.8	24
INDIAN RIVER	830728	.90	3.70	RUBBLE	COBBLE			24
INDIAN RIVER	830728	1.30	2.40	RUBBLE	LARGE GRAVEL	11.9	11.8	25
INDIAN RIVER	830728	.90	1.90	COBBLE	RUBBLE			25
INDIAN RIVER	830728	1.00	2.30	RUBBLE	LARGE GRAVEL	11.7	11.8	26
INDIAN RIVER	830728	1.90	1.55	RUBBLE	COBBLE			26
INDIAN RIVER	830728	1.30	2.60	RUBBLE	COBBLE	11.8	11.8	27
INDIAN RIVER	830728	1.50	1.30	COBBLE	RUBBLE			27
INDIAN RIVER	830728	1.50	2.70	RUBBLE	COBBLE	11.8	11.8	28
INDIAN RIVER	830728	1.10	1.70	COBBLE	RUBBLE			28
INDIAN RIVER	830728	1.30	3.30	RUBBLE	COBBLE	11.8	11.7	29
INDIAN RIVER	830728	1.00	3.20	COBBLE	RUBBLE			29
INDIAN RIVER	830728	1.50	2.40	RUBBLE	LARGE GRAVEL	11.8	11.8	30
INDIAN RIVER	830728	1.70	1.50	LARGE GRAVEL	RUBBLE			30
INDIAN RIVER	830728	1.60	2.20	RUBBLE	LARGE GRAVEL	11.6	11.5	31
INDIAN RIVER	830728	1.10	2.20	COBBLE	RUBBLE			31
INDIAN RIVER	830728	1.80	2.70	COBBLE	RUBBLE	11.5	11.5	32
INDIAN RIVER	830728	.90	2.00	RUBBLE	COBBLE			32
INDIAN RIVER	830728	1.40	1.80	RUBBLE	LARGE GRAVEL	11.7	11.4	33
INDIAN RIVER	830728	1.70	3.00	BOULDER	COBBLE			33
INDIAN RIVER	830728	1.50	2.20	RUBBLE	COBBLE	11.6	11.4	34
INDIAN RIVER	830728	1.10	2.10	BOULDER	RUBBLE			34
INDIAN RIVER	830728	.80	1.00	RUBBLE	COBBLE			35
INDIAN RIVER	830729	.70	1.55	COBBLE	RUBBLE			1
INDIAN RIVER	830729	1.60	2.45	BOULDER	COBBLE			2

Table 9-A-1 Continued

LOCATION	DATE	DEPTH (FT)	WATER VELO-CITY (FT/S)	SUBSTRATE		WATER TEMPERATURE (C)		REDD NO.
				PRIMARY	SECONDARY	INTRAGRAVEL	SURFACE	
INDIAN RIVER	830729	1.45	3.80	BOULDER	COBBLE			3
INDIAN RIVER	830729	.90	2.80	COBBLE	BOULDER			4
INDIAN RIVER	830729	1.10	1.25	BOULDER	COBBLE			5
INDIAN RIVER	830729	.90	2.00	COBBLE	RUBBLE			6
INDIAN RIVER	830729	1.40	1.80	COBBLE	BOULDER			7
INDIAN RIVER	830729	1.30	3.10	COBBLE	RUBBLE			8
INDIAN RIVER	830729	.80	1.30	COBBLE	RUBBLE			9
INDIAN RIVER	830729	1.80	2.85	BOULDER	COBBLE			10
INDIAN RIVER	830729	1.00	3.50	RUBBLE	COBBLE			11
INDIAN RIVER	830729	.90	1.90	BOULDER	COBBLE			12
INDIAN RIVER	830729	1.00	3.50	RUBBLE	COBBLE			13
INDIAN RIVER	830729	1.00	2.30	COBBLE	RUBBLE			14
INDIAN RIVER	830729	1.20	3.20	BOULDER	COBBLE			15
INDIAN RIVER	830729	1.00	2.50	COBBLE	BOULDER			16
INDIAN RIVER	830729	1.10	2.15	RUBBLE	COBBLE			17
INDIAN RIVER	830729	1.10	2.10	COBBLE	RUBBLE			18
INDIAN RIVER	830729	.85	1.95	COBBLE	RUBBLE			19
INDIAN RIVER	830729	1.00	2.10	BOULDER	COBBLE			20
INDIAN RIVER	830729	.80	2.20	RUBBLE	COBBLE			21
INDIAN RIVER	830729	1.20	2.10	BOULDER	COBBLE			22
INDIAN RIVER	830729	.80	2.40	COBBLE	RUBBLE			23
INDIAN RIVER	830729	1.20	2.70	BOULDER	COBBLE			24
INDIAN RIVER	830729	1.20	2.10	COBBLE	RUBBLE			25
INDIAN RIVER	830729	1.10	2.20	COBBLE	RUBBLE			26
INDIAN RIVER	830729	1.50	2.60	COBBLE	RUBBLE			27

Table 9-A-1 Continued

LOCATION	DATE	DEPTH (FT)	WATER VELOCITY (FT/S)	SUBSTRATE PRIMARY	SUBSTRATE SECONDARY	WATER TEMPERATURE (C) INTRAGRAVEL	WATER TEMPERATURE (C) SURFACE	REDD NO.
PORTAGE CREEK	830724	1.50	2.10	RUBBLE	LARGE GRAVEL	7.7	7.8	1
PORTAGE CREEK	830724	1.10	1.80	LARGE GRAVEL	RUBBLE	9.9	10.1	1
PORTAGE CREEK	830724	.80	1.10	COBBLE	LARGE GRAVEL	11.2	11.3	1
PORTAGE CREEK	830724	1.70	2.20	RUBBLE	LARGE GRAVEL	7.9	7.9	2
PORTAGE CREEK	830724	1.40	1.30	RUBBLE	COBBLE	9.2	10.2	2
PORTAGE CREEK	830724	1.10	2.10	RUBBLE	LARGE GRAVEL	11.3	11.3	2
PORTAGE CREEK	830724	1.80	2.20	COBBLE	LARGE-GRAVEL	7.7	8.0	3
PORTAGE CREEK	830724	1.40	2.20	RUBBLE	COBBLE	10.4	10.5	3
PORTAGE CREEK	830724	1.90	3.30	RUBBLE	LARGE GRAVEL	11.3	11.3	3
PORTAGE CREEK	830724	2.10	1.20	LARGE GRAVEL	RUBBLE	7.8	8.0	4
PORTAGE CREEK	830724	1.00	1.00	COBBLE	RUBBLE	9.6	10.6	4
PORTAGE CREEK	830724	2.00	3.00	RUBBLE	COBBLE	11.3	11.3	4
PORTAGE CREEK	830724	1.40	1.60	LARGE GRAVEL	RUBBLE	7.8	8.0	5
PORTAGE CREEK	830724	1.70	1.80	LARGE GRAVEL	RUBBLE	8.1	8.3	6
PORTAGE CREEK	830724	2.70	1.55	RUBBLE	LARGE GRAVEL	8.3	9.0	7
PORTAGE CREEK	830724	2.70	1.70	RUBBLE	LARGE GRAVEL	9.1	9.4	8
PORTAGE CREEK	830724	1.40	2.90	RUBBLE	LARGE GRAVEL	9.0	9.6	9
PORTAGE CREEK	830725	1.40	2.00	COBBLE	RUBBLE	9.0	9.3	1
PORTAGE CREEK	830725	1.00	1.60	RUBBLE	COBBLE	9.0	9.4	2
PORTAGE CREEK	830725	1.30	2.00	RUBBLE	COBBLE	8.7	9.5	3
PORTAGE CREEK	830725	1.40	1.50	RUBBLE	COBBLE	9.4	9.5	4
PORTAGE CREEK	830725	1.70	1.70	RUBBLE	LARGE GRAVEL	10.0	10.0	5
PORTAGE CREEK	830725	1.80	1.30	COBBLE	RUBBLE	10.1	10.4	6
PORTAGE CREEK	830725	2.00	2.10	COBBLE	RUBBLE	9.7	10.1	7
PORTAGE CREEK	830725	1.70	1.50	RUBBLE	COBBLE	9.5	9.7	8

Table 9-A-1 Continued

LOCATION	DATE	DEPTH (FT)	WATER VELO-CITY (FT/S)	SUBSTRATE		WATER TEMPERATURE (C)		REDD NO.
				PRIMARY	SECONDARY	INTRAGRAVEL	SURFACE	
PORTAGE CREEK	830725	2.30	2.40	COBBLE	RUBBLE	8.4	9.7	9
PORTAGE CREEK	830725	2.20	2.00	COBBLE	RUBBLE	9.6	9.9	10
PORTAGE CREEK	830725	1.10	2.10	COBBLE	RUBBLE	10.4	10.5	11
PORTAGE CREEK	830725	1.00	1.00	RUBBLE	LARGE GRAVEL			12
PORTAGE CREEK	830725	1.50	1.80	COBBLE	RUBBLE			13
PORTAGE CREEK	830725	1.30	2.60	LARGE GRAVEL	RUBBLE			14
PORTAGE CREEK	830727	2.50	1.58	COBBLE	LARGE GRAVEL	9.6	10.0	1
PORTAGE CREEK	830727	1.70	1.90	COBBLE	RUBBLE	9.4	10.1	2
PORTAGE CREEK	830727	2.50	3.35	COBBLE	RUBBLE	9.6	10.2	3
PORTAGE CREEK	830727	2.30	2.00	COBBLE	RUBBLE	10.0	10.2	4
PORTAGE CREEK	830727	.90	1.90	RUBBLE	LARGE GRAVEL	9.9	10.3	5
PORTAGE CREEK	830727	2.00	1.30	COBBLE	LARGE GRAVEL	10.5	10.7	6
PORTAGE CREEK	830727	1.50	1.20	RUBBLE	LARGE GRAVEL	8.9	10.7	7
PORTAGE CREEK	830727	1.40	1.40	COBBLE	RUBBLE	10.5	10.7	8
PORTAGE CREEK	830727	1.60	2.10	RUBBLE	LARGE GRAVEL	10.6	10.7	9
PORTAGE CREEK	830727	1.50	1.30	RUBBLE	SMALL GRAVEL	10.7	10.7	10
PORTAGE CREEK	830727	1.30	2.60	COBBLE	RUBBLE	10..	10.9	11
PORTAGE CREEK	830727	1.90	2.00	COBBLE	LARGE GRAVEL	11..	11.3	12
PORTAGE CREEK	830727	1.80	2.70	COBBLE	RUBBLE	11.2	11.4	13
PORTAGE CREEK	830727	1.70	2.10	RUBBLE	LARGE GRAVEL	10.7	11.4	14
PORTAGE CREEK	830727	1.60	1.90	COBBLE	LARGE GRAVEL	11.3	11.5	15
PORTAGE CREEK	830727	1.50	1.70	RUBBLE	LARGE GRAVEL	11.2	11.6	16
PORTAGE CREEK	830727	1.30	2.70	RUBBLE	LARGE GRAVEL	11.6	11.8	17
PORTAGE CREEK	830727	1.40	1.60	RUBBLE	LARGE GRAVEL	12.0	12.2	18

Table 9-A-1 Continued

LOCATION	DATE	DEPTH (FT)	WATER VELO-CITY (FT/S)	SUBSTRATE PRIMARY	SUBSTRATE SECONDARY	WATER TEMPERATURE (C) INTRAGRAVEL	WATER TEMPERATURE (C) SURFACE	REDD NO.
PORTAGE CREEK	830728	1.90	3.60	COBBLE	RUBBLE	11.3	11.5	1
PORTAGE CREEK	830728	1.70	3.70	COBBLE	RUBBLE	11.9	11.9	2
PORTAGE CREEK	830728	1.50	2.20	RUBBLE	COBBLE	10.5	12.3	3
PORTAGE CREEK	830728	2.20	2.10	RUBBLE	LARGE GRAVEL	12.1	12.1	4
PORTAGE CREEK	830728	1.80	3.10	RUBBLE	LARGE GRAVEL	12.2	12.2	5
PORTAGE CREEK	830728	1.30	1.60	LARGE GRAVEL	RUBBLE	11.5	12.2	6
PORTAGE CREEK	830728	1.30	2.10	RUBBLE	LARGE GRAVEL	11.3	12.2	7
PORTAGE CREEK	830728	2.30	2.00	RUBBLE	COBBLE	11.7	12.3	8
PORTAGE CREEK	830728	2.30	1.30	RUBBLE	LARGE GRAVEL	11.2	12.3	9
PORTAGE CREEK	830728	2.40	2.90	RUBBLE	LARGE GRAVEL	12.3	12.4	10
PORTAGE CREEK	830728	1.20	.80	COBBLE	LARGE GRAVEL	13.0	13.1	11
PORTAGE CREEK	830728	1.90	1.97	COBBLE	LARGE GRAVEL	13.0	13.1	12
PORTAGE CREEK	830728	1.80	2.90	RUBBLE	LARGE GRAVEL	13.2	13.1	13
PORTAGE CREEK	830728	1.80	1.60	RUBBLE	LARGE GRAVEL	11.7	13.1	14
PORTAGE CREEK	830728	1.90	1.40	RUBBLE	LARGE GRAVEL	12.5	13.2	15
PORTAGE CREEK	830728	2.20	1.20	RUBBLE	LARGE GRAVEL	13.3	13.1	16
PORTAGE CREEK	830728	1.70	.90	RUBBLE	LARGE GRAVEL	13.3	13.2	17
PORTAGE CREEK	830728	1.20	.90	LARGE GRAVEL	COBBLE	13.2	13.2	18
PORTAGE CREEK	830728	1.50	.90	LARGE GRAVEL	COBBLE	13.0	13.2	19
PORTAGE CREEK	830728	1.40	.50	RUBBLE	LARGE GRAVEL	11.9	13.3	20
PORTAGE CREEK	830728	1.10	.40	LARGE GRAVEL	RUBBLE	13.3	13.3	21
PORTAGE CREEK	830728	1.60	2.60	RUBBLE	COBBLE	10.6	13.6	22
PORTAGE CREEK	830728	1.20	2.00	LARGE GRAVEL	COBBLE	13.6	13.6	23
PORTAGE CREEK	830728	2.10	2.60	RUBBLE	COBBLE	14.5	13.6	24
PORTAGE CREEK	830729	1.20	1.29	RUBBLE	LARGE GRAVEL	9.0	9.6	1

Table 9-A-1 Continued

LOCATION	DATE	DEPTH (FT)	WATER VELO-CITY (FT/S)	SUBSTRATE PRIMARY	SUBSTRATE SECONDARY	WATER TEMPERATURE (C) INTRAGRAVEL	WATER TEMPERATURE (C) SURFACE	REDD NO.
PORTAGE CREEK	830729	1.60	3.40	COBBLE	LARGE GRAVEL	9.2	9.1	1
PORTAGE CREEK	830729	2.40	1.54	RUBBLE	LARGE GRAVEL	9.3	10.0	2
PORTAGE CREEK	830729	1.60	3.10	COBBLE	BOULDER	9.9	9.9	2
PORTAGE CREEK	830729	2.50	1.83	RUBBLE	LARGE GRAVEL	9.7	10.1	3
PORTAGE CREEK	830729	1.40	1.50	COBBLE	LARGE GRAVEL	10.1	10.1	3
PORTAGE CREEK	830729	2.30	1.54	COBBLE	LARGE GRAVEL	9.5	10.[illegible]	4
PORTAGE CREEK	830729	1.70	2.20	RUBBLE	LARGE GRAVEL	8.2	9.1	4
PORTAGE CREEK	830729	1.10	1.11	LARGE GRAVEL	RUBBLE	10.3	10.3	5
PORTAGE CREEK	830729	2.00	2.70	COBBLE	RUBBLE	10.5	10.5	5
PORTAGE CREEK	830729	1.40	2.10	RUBBLE	LARGE GRAVEL	12.0	12.1	6
PORTAGE CREEK	830729	1.50	1.40	RUBBLE	LARGE GRAVEL	10.7	10.1	6
PORTAGE CREEK	830729	1.60	1.47	RUBBLE	COBBLE	11.6	12.1	7
PORTAGE CREEK	830729	1.00	1.60	RUBBLE	LARGE GRAVEL	10.4	10.9	7
PORTAGE CREEK	830729	1.10	1.58	COBBLE	LARGE GRAVEL	11.8	12.2	8
PORTAGE CREEK	830729	1.50	1.70	RUBBLE	LARGE GRAVEL	10.9	11.0	8
PORTAGE CREEK	830729	1.40	2.10	RUBBLE	COBBLE	12.1	12.5	9
PORTAGE CREEK	830729	1.10	1.80	RUBBLE	LARGE GRAVEL	10.9	10.9	9
PORTAGE CREEK	830729	1.70	1.96	COBBLE	RUBBLE	12.3	12.5	10
PORTAGE CREEK	830729	.60	1.20	RUBBLE	LARGE GRAVEL	10.4	10.7	10
PORTAGE CREEK	830729	1.40	1.51	RUBBLE	LARGE GRAVEL	12.5	12.5	11
PORTAGE CREEK	830729	1.10	1.80	COBBLE	RUBBLE	11.4	11.1	11
PORTAGE CREEK	830729	1.60	2.20	RUBBLE	LARGE GRAVEL	11.8	12.5	12
PORTAGE CREEK	830729	1.00	2.80	COBBLE	RUBBLE	11.1	11.4	12
PORTAGE CREEK	830729	1.60	1.96	COBBLE	RUBBLE	11.7	12.6	13
PORTAGE CREEK	830729	1.10	1.90	RUBBLE	LARGE GRAVEL	11.0	11.3	13
PORTAGE CREEK	830729	1.60	1.92	RUBBLE	LARGE GRAVEL	12.6	12.6	14

Table 9-A-1 Continued

LOCATION	DATE	DEPTH (FT)	WATER VELO-CITY (FT/S)	SUBSTRATE PRIMARY	SUBSTRATE SECONDARY	WATER TEMPERATURE (C) INTRAGRAVEL	WATER TEMPERATURE (C) SURFACE	REDD NO.
PORTAGE CREEK	830729	1.30	2.20	RUBBLE	LARGE GRAVEL	11.2	11.3	14
PORTAGE CREEK	830729	1.20	3.74	RUBBLE	LARGE GRAVEL	12.5	12.6	15
PORTAGE CREEK	830729	1.20	1.70	COBBLE	RUBBLE	11.6	11.5	15
PORTAGE CREEK	830729	1.40	1.70	COBBLE	RUBBLE	11.8	11.7	16
PORTAGE CREEK	830729	1.50	1.90	BOULDER	RUBBLE	11.7	11.7	17
PORTAGE CREEK	830729	1.80	3.00	BOULDER	COBBLE	11.7	11.7	18
PORTAGE CREEK	830729	.70	1.90	COBBLE	RUBBLE	9.6	11.1	19
PORTAGE CREEK	830729	1.10	2.20	RUBBLE	LARGE GRAVEL	10.7	10.9	20
PORTAGE CREEK	830729	1.60	1.20	LARGE GRAVEL	SMALL GRAVEL	11.7	12.6	21
PORTAGE CREEK	830729	1.30	1.00	COBBLE	RUBBLE	12.6	12.2	22
PORTAGE CREEK	830729	2.50	2.50	RUBBLE	LARGE GRAVEL	13.0	12.9	23
PORTAGE CREEK	830729	2.70	1.50	RUBBLE	LARGE GRAVEL	13.0	12.9	24
PORTAGE CREEK	830730	1.50	2.00	BOULDER	RUBBLE	8.9	8.9	1
PORTAGE CREEK	830730	1.60	1.25	BOULDER	COBBLE	9.3	9.0	2
PORTAGE CREEK	830730	.90	2.00	COBBLE	RUBBLE	9.2	9.0	3
PORTAGE CREEK	830730	1.20	2.80	RUBBLE	LARGE GRAVEL	9.2	9.1	4
PORTAGE CREEK	830730	1.00	1.50	COBBLE	RUBBLE	9.4	9.4	5
PORTAGE CREEK	830730	.70	2.60	BOULDER	COBBLE	9.4	9.5	6
PORTAGE CREEK	830730	1.20	2.00	RUBBLE	LARGE GRAVEL	9.6	9.6	7
PORTAGE CREEK	830730	1.20	2.90	COBBLE	RUBBLE	9.8	9.7	8
PORTAGE CREEK	830730	1.40	2.00	RUBBLE	LARGE GRAVEL	10.1	10.0	9
PORTAGE CREEK	830730	2.30	3.40	COBBLE	RUBBLE	9.7	9.8	10
PORTAGE CREEK	830730	1.20	1.80	COBBLE	RUBBLE	9.9	10.0	11
PORTAGE CREEK	830730	2.70	3.00	COBBLE	RUBBLE	10.0	9.9	12
PORTAGE CREEK	830730	1.60	2.40	COBBLE	RUBBLE	10.0	9.8	13

Table 9-A-1 Continued

LOCATION	DATE	DEPTH (FT)	WATER VELO- CITY (FT/S)	SUBSTRATE PRIMARY	SUBSTRATE SECONDARY	WATER TEMPERATURE (C) INTRAGRAVEL	WATER TEMPERATURE (C) SURFACE	REDI NO.
PORTAGE CREEK	830730	2.00	2.90	COBBLE	RUBBLE	9.9	9.9	14
PORTAGE CREEK	830730	1.20	2.60	COBBLE	LARGE GRAVEL	10.0	9.9	15
PORTAGE CREEK	830730	2.20	3.30	COBBLE	LARGE GRAVEL	9.9	9.8	16
PORTAGE CREEK	830730	2.40	3.40	COBBLE	RUBBLE	9.7	9.6	17
PORTAGE CREEK	830730	1.60	2.60	BOULDER	COBBLE	9.9	9.6	18
PORTAGE CREEK	830730	1.30	1.80	COBBLE	RUBBLE	9.9	9.7	19
PORTAGE CREEK	830730	1.20	1.80	RUBBLE	LARGE GRAVEL	9.6	9.6	20
PORTAGE CREEK	830730	1.40	4.30	COBBLE	RUBBLE	9.8	9.7	21
PORTAGE CREEK	830730	1.60	1.90	COBBLE	RUBBLE	9.7	9.7	22
PORTAGE CREEK	830730	1.70	2.30	COBBLE	RUBBLE	9.7	9.6	23
PORTAGE CREEK	830730	1.20	2.60	COBBLE	RUBBLE	9.5	9.3	24
PORTAGE CREEK	830730	2.70	1.55	RUBBLE	LARGE GRAVEL	9.6	9.3	25
CHEECHAKO CREEK	830805	2.20	1.00	COBBLE	LARGE GRAVEL	11.9	11.7	1
CHEECHAKO CREEK	830805	.90	2.40	LARGE GRAVEL	RUBBLE	11.4	11.3	2

APPENDIX 9-B
Summary of variance statistics and tests for various groupings for chinook salmon utilization histograms

Table 9-B-1 Summary of variance statistics and tests for various groupings for chinook salmon utilization depth histograms..

HISTOGRAM LABEL	INCREMENT SIZE	INCREMENT START	VARIANCE	df
A	0.1	0.0	87.5336	22
B	0.2	0.0	353.5379	11
C	0.2	0.1	440.0909	10
D	0.3	0.0	682.0278	8
E	0.3	0.1	726.9821	7
F	0.3	0.2	632.4107	7

LEVENE'S TEST

F STATISTIC	df	PROB
5.990000	5,65	0.0001

PAIRWISE COMPARISONS

PAIR	df	F VALUE	PROB
A,B	11,22	4.038882	0.0026
A,C	10,22	5.027680	0.0008
A,D	8,22	7.791611	0.0001
A,E	7,22	8.305178	0.0001
A,F	7,22	7.224777	0.0002
B,C	10,11	1.244820	0.3600
B,D	8,11	1.929150	0.1500
B,E	7,11	2.056306	0.1400
B,F	7,11	1.788806	0.1900
C,D	8,10	1.549743	0.2500
C,E	7,10	1.651891	0.2300
C,F	7,10	1.437000	0.2900
D,E	7,8	1.065913	0.4600
D,F	8,7	1.078457	0.4700
E,F	7,7	1.149541	0.4300

Table 9-B-2 Summary of variance statistics and tests for various groupings for chinook salmon utilization velocity histograms.

HISTOGRAM LABEL	INCREMENT SIZE	INCREMENT START	VARIANCE	df
A	0.1	0.0	33.7549	40
B	0.2	0.0	116.3476	20
C	0.2	0.1	117.7763	19
D	0.3	0.0	244.8407	13
E	0.3	0.1	284.2381	14
F	0.3	0.2	236.8407	13

LEVENE'S TEST

F STATISTIC	df	PROB
5.300000	5,119	0.0002

PAIRWISE COMPARISONS

PAIR	df	F VALUE	PROB
A,B	20,40	3.446836	0.0004
A,C	19,40	3.489162	0.0004
A,D	13,40	7.253486	0.0000
A,E	14,40	8.420647	0.0000
A,F	13,40	7.016484	0.0000
B,C	19,20	1.012280	0.4900
B,D	13,20	2.104390	0.0650
B,E	14,20	2.443008	0.0330
B,F	13,20	2.035630	0.0740
C,D	13,19	2.078862	0.0720
C,E	14,19	2.413373	0.0380
C,F	13,19	2.010937	0.0810
D,E	14,13	1.160910	0.4000
D,F	13,13	1.033778	0.4800
E,F	14,13	1.200124	0.3700