Exxon Valdez Oil Spill
Restoration Project Final Report

Cutthroat Trout and Dolly Varden Rehabilitation in Western Prince William Sound

Restoration Project 98043B
Final Report

Dan Gillikin

USDA Forest Service
Glacier Ranger District
POB 129
Girdwood, Alaska 99587

December 2000

Exxon Valdez Oil Spill
Restoration Project Final Report

Cutthroat Trout and Dolly Varden Rehabilitation in Western Prince William Sound

Restoration Project 98043B
Final Report

Dan Gillikin

USDA Forest Service
Glacier Ranger District
POB 129
Girdwood, Alaska 99587

December 2000

Cutthroat Trout and Dolly Varden
Rehabilitation in Western Prince William Sound
Restoration Project 98043B
Final Report

Study History: In 1989 the oil tanker *Exxon Valdez* ran aground on Bligh Reef spilling millions of gallons of crude oil into Prince William Sound (PWS). The oil spill damage assessment identified related injuries to cutthroat trout (*Onchorynchus clarki*) and Dolly Varden (*Salvelinus malma*) in Prince William Sound. In an attempt to mitigate these impacts to cutthroat trout and Dolly Varden, the Forest Service installed habitat improvement structures to increase habitat suitability (EVOS project 95043B). Competition with juvenile coho salmon (*Oncorhynchus kisutch*) is believed to limit cutthroat trout production. Concerns are that certain types of habitat enhancements may increase coho salmon densities, and consequently increase competitive stress on cutthroat trout. This report summarizes a four-year study that monitored the response of these species to habitat improvements.

Abstract: This study monitored habitat improvement projects over a four-year period to evaluate their effects on cutthroat trout and Dolly Varden abundance. In 1995 a total of 63-habitat improvement structures were installed in Prince William Sound at four different project locations. The enhancement project (95043B) was intended to improve cutthroat trout and Dolly Varden habitat. Interspecific competition with juvenile coho salmon is believed to limit cutthroat trout production. Concerns were raised that habitat enhancements may increase coho salmon populations, thereby increasing competitive stress on cutthroat trout populations. The abundance of juvenile cutthroat trout, Dolly Varden and coho salmon were annually monitored using standard mark recapture techniques. However, bias in population estimates precluded their use in the final analysis; catch per unit effort information was used instead. We found that at only two locations, Otter Creek and Red Creek , could the increase in cutthroat trout and coho salmon abundance respectively, be attributed to the improvement work done in 1995. No significant negative trends in abundance for the three species were observed at any of the project locations. Stream enhancements such as cross-logs and particularly boulder clusters seemed to benefit cutthroat trout more than other types of improvements monitored in our study.

Key Words: Catch per unit effort, coho salmon, cutthroat trout, Dolly Varden, *Exxon Valdez*, *Onchorynchus clarki*, *Oncorhynchus kisutch*, Prince William Sound, *Salvelinus malma*.

Project Data: *Description*- Mark-recapture, CPUE, length frequency and distribution, Modified Hankin and Reeves (1988) stream surveys. *Format*- Excel and Access. *Custodian*- Cliff Fox, Glacier Ranger District, USDA Forest Service, P.O. Box 129, Girdwood, Alaska 99587, PH. (907) 783-3242, Fax (907) 783-2094, Email: cfox02@fs.fed.us. *Availability*- Upon written request.

Citation: Gillikin, D. 2000. Cutthroat trout and Dolly Varden Rehabilitation in Western Prince William Sound, *Exxon Valdez* Oil Spill Restoration Project Final Report (Restoration Project 98043B), U.S. Forest Service, Glacier Ranger District, Girdwood, Alaska.

TABLE OF CONTENTS

LISTS OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

EXECUTIVE SUMMARY

During the 1995 field season, USFS, Glacier Ranger District Fisheries crews installed a total of 63 habitat improvement structures at Otter Lake, Gunboat Lakes, Red Creek and Billy's Hole to improve cutthroat trout and Dolly Varden rearing habitat in Prince William Sound. The abundance of juvenile cutthroat trout, Dolly Varden and coho salmon were annually monitored using standard mark recapture techniques, however biases in population estimates precluded their use in the final analysis. Nonparametric test on catch per unit effort data were used instead. Stream habitat at each project site was surveyed prior to and then again after structure installation for comparison.

Results of this study indicate that juvenile cutthroat trout abundance increased significantly at two of the four locations but at only one location, Otter Creek, was the increase clearly attributed to the improvement work. Dolly Varden abundance increased at only one location, Otter Creek, but no relationship to the improvement work was indicated. Coho salmon abundance increased at Red and Otter creek, however, only at Red Creek could we demonstrate a link to the improvement work. No significant negative trends in abundance for the three species were observed at any of the project locations.

The results of this study suggests that certain types of improvements may have been more beneficial to cutthroat trout than coho salmon or Dolly Varden. At two project locations the work consisted primarily of adding small woody debris to the stream to increase cover habitat; here trapping data indicated no significant changes to cutthroat trout abundance. At the other two locations, more cross-log and boulder cluster structures were installed, affecting the channel morphology to a greater degree than cover structures. At these two locations, we observed significant positive trends in total cutthroat trout abundance.

INTRODUCTION

In 1989 the oil tanker *Exxon Valdez* ran aground on Bligh Reef spilling millions of gallons of crude oil into Prince William Sound (PWS). The oil spill damage assessment identified oil spill related injuries to cutthroat trout *(Oncorhynchus clarki)* and Dolly Varden *(Salvelinus malma)* populations among other species in Prince William Sound (PWS). Information collected in 1989-1991 by the Natural Resources Damage Assessment (NRDA) study, documented lower growth rates for cutthroat trout and Dolly Varden in oiled areas than in unoiled areas. Mortality rates for anadromous Dolly Varden in oiled areas were significantly higher than rates from sites in the non-oiled areas of eastern PWS (EVOS Trustee Council 1994a,1994b). The reduced growth rates persisted into 1991 when studies were discontinued. It is unknown if growth rates have since returned to normal.

The cutthroat trout populations found in PWS are at the northern extent of the species' North American range (Morrow, 1980). Species inhabiting the extreme limits of their habitat exhibit higher sensitivities to environmental stresses than the same species well within their normal range. Little is known of the genetic diversity, distribution, or life histories of cutthroat trout in PWS. The cutthroat trout stocks known to exist within PWS are few in number and appear to be discrete populations with limited interbreeding. It is highly possible that there have been unique genetic adaptations in these populations due to local conditions and their relative isolation from other stocks. Several stocks of cutthroat trout within PWS appear to be anadromous and have a limited home range within streams (Heggenes et al., 1991). Both adults and subadults of anadromous populations migrate to the ocean for summer feeding (Trotter 1989; Hepler et al. 1993). Emigration to saltwater occurs in early May through July (Hepler et al. 1993). They return to freshwater in July through November, peaking in September and October (Trotter 1989; Wedemeyer 1993).

In an attempt to mitigate impacts to cutthroat trout and Dolly Varden, the Forest Service installed habitat improvement structures to increase habitat suitability (EVOS project 95043B). It is uncertain what effect habitat manipulation had on these species. Competition with juvenile coho salmon *(Oncorhynchus kisutch)* is believed to limit cutthroat trout production in quality rearing habitat (Glova and Mason 1976). A concern was raised that certain types of habitat enhancements may increase coho salmon densities, and consequently increase competitive stress on cutthroat trout. Additional information is needed to assist managers in making decisions for future fisheries enhancement work that may affect cutthroat trout in PWS.

OBJECTIVES

The objectives of this project are to monitor and document the responses of cutthroat trout, Dolly Varden and coho salmon to modifications made to their habitat by enhancement activities. Specifically they are:

1. Estimate the relative abundance of juvenile cutthroat trout, Dolly Varden and coho salmon throughout the project locations.

2. Estimate the relative abundance of the three species at the habitat improvements.

3. Evaluate the effects that structures have on aquatic habitats.

4. Summarize findings on the effectiveness of the habitat structures installed in 1995.

METHODS

Study Area. The study took place at four different locations in Western PWS (Appendix A).

Billy's Hole is located on the west side of Long Bay (North). This location has 21 enhancement sites throughout 327 m of stream located in the southwestern corner of Billy's Hole Lake.

Gunboat Lakes are north of Eshamy Bay. The project locations are in two reaches, separated by a small lake. Six enhancement sites are located throughout reach two, which is 226 m in length. Three enhancement sites are located throughout reach three, which is 62 m in length, terminating at a 6 m waterfall, assumed to be a barrier to upstream migration.

Otter Creek is located on the east side of Knight Island, in the western tributary of Otter Lake; eight enhancement sites are located throughout 296 m of stream, terminating at a 3 m waterfall, assumed to be a barrier to upstream migration.

Red Creek on the east side of Esther Passage was the final location. The project is located in the east fork of Red Creek, a tributary to Red Lake. Ten enhancement sites are located throughout 456 m of stream, terminating at a 4 m waterfall, assumed to be a barrier to upstream migration.

Sampling. Fisheries data were collected during 1995, 1996, 1997 and 1998 on an annual basis. Stream surveys were conducted before and after structure installation was complete. Using a modified version of Hankin and Reeves (1988) methodology, all stream surveys were conducted by the same pair of observers. This method included stratification of habitat by macrohabitat type (Appendix B). Three types of enhancement structures were installed: cross-logs, treetops and boulder clusters. Structure "sites" mentioned in this report may include more than one improvement structure within close proximity to each other. The percent of change to macro habitats was evaluated by comparing the types and frequency of habitat units, including total area and cover, in 1995 before the enhancement projects were started and again after the enhancement work in 1995 and 1996.

Post enhancement stream surveys were used to determine the proper sampling distribution to trap fish in a stratified random design. Trapping effort was conducted proportional to the availability of slow and fast water habitats found at each location. For example, if slow water habitats comprised 30 percent of the available habitat within a reach, 30 percent of the trapping effort was randomly placed in slow water habitats. Trapping effectiveness varies between fast and slow water habitat types. To compensate for this it was assumed that a single minnow trap could effectively trap a 10 m^2 area of slow water habitat, and a linear 3 m segment of fast water habitat. The streams were stratified based on these segment lengths and a proportional number of segments were selected at random for both slow and fast water types, without replacement. This assumption was based on past trapping efforts and conversations with other biologists in the Region; the ratio of traps in slow and fast water habitat types was maintained from year to year. The exception to this was Billy's Hole where initial sampling indicated that cutthroat trout densities were too low to be sampled accurately using the proposed mark - recapture design. Instead, trapping was conducted in a systematic manner to maximize capture for cutthroat trout throughout the project area.

Baited G-Type minnow traps were set in the morning and allowed to soak for approximately 90 -180 minutes. Traps were pulled and the fish were sedated, identified, measured and a small hole punched into the caudal fin. Fish were returned to the trapping location and allowed to mingle back into the general population overnight. This procedure was repeated over a three-day period. For the purposes of our study, we assumed that all fish captured were juveniles of that species.

Analysis. Bailey's modification of the Lincoln-Petersen model (described in Kohler and Hubert, 1993) was used to estimate the populations of coho, cutthroat trout and Dolly Varden juveniles at each project location. A coefficient of variation (CV) was calculated for each population estimate. Sampling from 1995 to 1998 consistently produced population estimates for cutthroat trout with a CV value of greater than 0.20, which is generally inadequate and indicates low precision of the estimates (Kohler and Hubert, 1993). This was due primarily to the low numbers of recaptured cutthroat trout, presumably due to trap avoidance (shyness).

Due to the bias observed in the mark-recapture population estimates, this set of data was abandoned for the final analysis. Catch–per-unit effort (CPUE) information for the three species was collected during the entire project for each project location at individual trapping sites. Recaptured fish were not included in any of the calculations to minimize bias due to trap shyness. The number and locations of individual traps at a project site were consistent for a given year. This allowed for annual pooling of the total effort and number of unique fish of a particular species at each trap. The individual CPUE calculations for each trap were used as a measure of relative abundance.

Hypotheses. The primary hypothesis for this project, as stated in the project proposal was that the number of cutthroat trout at the project locations would not change due to the habitat improvements made in 1995. To answer this hypothesis with the given data set, a restatement is required. The restated primary hypothesis (H_o) is; the habitat improvement will not have benefited juvenile cutthroat trout, Dolly Varden or coho salmon. The specific hypotheses (H_{1-3}) to this for each of the three species at each project site over the duration of the project are:

H_1 = There is no significant difference in relative fish abundance between structure and non-structure sites.

H_2 = The relative fish abundance will not increase significantly during 1995 - 1998.
H_3 = Macrohabitats will not change due to the improvement work done in 1995.

Statistical Tests. Descriptive statistics revealed that the CPUE data sets did not have a normal distribution and were right skewed. This was due to the numerous zero CPUE values for a particular species at a given trap. Different transformations were applied in an attempt to normalize the data. However, most of the data sets still failed normality test, suggesting the use of nonparametric testing procedures would be appropriate. A transformation of the LN (CPUE+ 1) was applied to the data to linearize the distribution for nonparametric analysis.

A Mann-Whitney test on the rank sums of the transformed data was tested for significant differences between structure and non-structure locations from 1995 to 1998 by ($p<0.05$). Scatter plots were then constructed with the two data sets for each year, location and species, the sample size (n) being equal to the total number of traps fished at a given location. A notched box plot indicating the combined median and a regression line with 95% confidence intervals (CI) were added to each plot. Slopes of the regression lines were considered significant when only one possible sign, within the 95% CI was possible; this, along with the mean CPUE for each group, was used to determine significant use and trends at structure or non-structure sites.

Changes in total abundance were tested for significance ($p<0.05$) using a Kruskal-Wallis one-way analysis of variance on ranks for each project location between years. Associated scatter plots were constructed in the same manner as the plots between structure and non-structure sites. Where significant differences between years and significant slopes were identified, the sign was used to predict a trend in total abundance.

RESULTS

The following describes the distribution of species throughout the various project locations over the entire study period. Gunboat Lakes is shown as two reaches due to separation by a small lake.

Billy's Hole. Two juvenile cutthroat trout were captured in 1995 and only 1 in 1996 at this location, although adult fish were annually observed in the lake. The upstream limits of all fish species distribution were not identified for Billy's Hole. Cutthroat trout were present in 0% to 25% of the habitat units surveyed. Coho salmon and Dolly Varden were found in all habitat types, with Dolly Varden being observed in 50% to 100% of the units, and coho salmon in 75% to 100% of the habitat units surveyed.

Gunboat Lakes, Reach Two. Cutthroat trout were present in all habitat types for all years with the exception of 1997, when none were observed. The upstream limits of distribution were the same for cutthroat trout, coho salmon and Dolly Varden, not varying by more than 145 m from the upper lake. Cutthroat trout were found in 0% to 73% of the habitat units surveyed. Coho salmon were present in all habitat types throughout the study and found in 67% to 100% of the surveyed habitat units. Dolly Varden were also present in all habitat types and observed in 0% to 91% of the surveyed habitat units.

Gunboat Lakes, Reach Three. Cutthroat trout were present in all habitat types throughout the study. The upstream limits of distribution did not vary more than 34 m downstream of the barrier. Cutthroat trout were observed in 50% to 100% of the surveyed habitat units. Coho salmon and Dolly Varden had very similar distribution and both were present in all habitat types throughout the study. The upstream limits of distribution did not vary more than 28 m below the barrier for both coho and Dolly Varden. Coho salmon were found in 0% to 100%, and Dolly Varden in 0% to 75% of the habitat units surveyed.

Otter Creek. Cutthroat trout, coho salmon and Dolly Varden were present in all habitat types. The upstream limits of distribution did not vary by more than 65 m below the barrier for cutthroat trout, which were found in 0% to 80% of surveyed habitat units. The upstream limits for coho salmon and Dolly Varden did not vary more than 117 m downstream of the barrier. Coho salmon were found in 44% to 100%, and Dolly Varden were found in 83% to 100% of the habitat units surveyed.

Red Creek. Cutthroat trout, coho salmon and Dolly Varden were present in all habitat types for all years. The upstream limits of distribution did not vary more than 92 m below the barrier to fish migration for both cutthroat trout and Dolly Varden. Distribution was varied within the study area, with cutthroat trout observed in 35% to 68%, and Dolly Varden in 50% to 100% of surveyed habitat units. The coho salmon upstream limits of distribution varied as much as 351 m downstream of the barrier and were observed in 16% to 79% of the habitat units surveyed.

Table 1 summarizes the raw (not transformed) CPUE (fish/hr.) information for each project site by year. Each value is an average for that years trapping and excludes recaptured fish in its calculation.

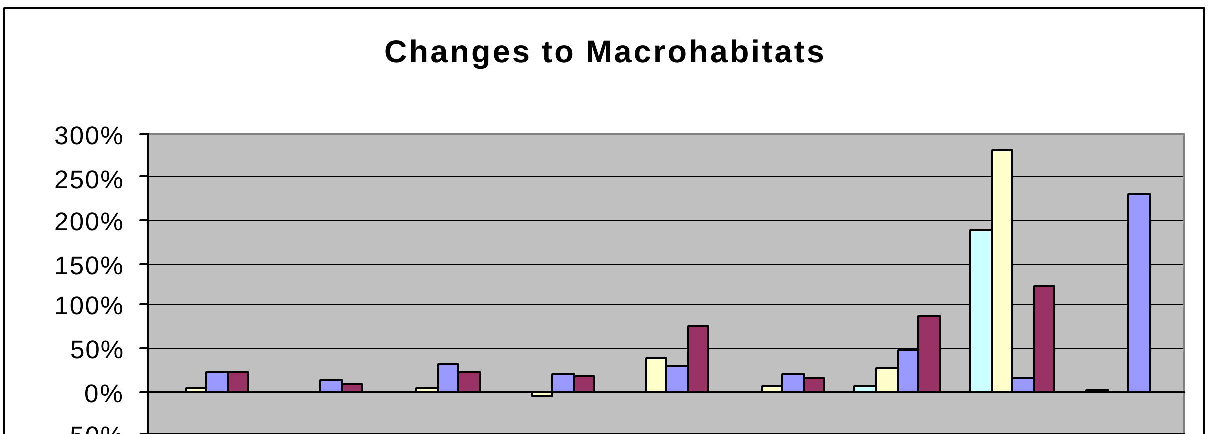
Table 1. Summary of CPUE. Coho salmon (CO); Cutthroat trout (CT); Dolly Varden Char (DV).

Year	Billy's			Gunboat			Otter Ck.			Red Ck.		
	CO	CT	DV	CO	CT	DV	CO	CT	DV	CO	CT	DV
1995	1.464	0.071	3.536	0.915	0.389	0.325	0.139	0.034	0.261	0.035	0.107	0.326
1996	1.691	0.007	0.745	0.534	0.310	0.894	0.504	0.034	0.579	0.355	0.058	0.179
1997	1.230	0.000	1.560	0.858	0.479	0.435	0.858	0.116	0.524	0.630	0.271	0.657
1998	2.421	0.000	2.685	1.459	0.394	0.466	1.402	0.089	1.052	0.524	0.250	0.331

Changes to macro habitats after enhancement activities are provided in (Appendix C) and summarized in Figure 1. All but two of the original 63 structures installed in 1995 were regularly maintained and remained functional throughout the study.

Improvements at Billy's Hole were primarily cover type structures installed in small pool habitats. Gunboat Lake enhancements also focused primarily on adding small woody debris as cover structure with only three cross log structures installed. Red and Otter Creek enhancement involved larger changes to the overall channel morphology by adding more cross-log structures to the stream than at the other two locations. Otter Creek also had the most rockwork performed, mostly in turbulent habitat types.

Figure 1. Summary of Changes to Macrohabitats. Number of Habitat Units (# Units); Pocket Pools (Pools); Turbulent Units (Turb); Non-Turbulent (Nturb); Slow Water Habitat types (Slow); Large Woody Debris (LWD); Small Woody Debris (SWD); Rocks (RS). Percentages represent the amount of changes to stream habitat after the installation of improvement structures.



	# Units	Area	Pools	Turb	Nturb	Slow	LWD	SWD	RS
Billy's	0%	0%	0%	0%	0%	0%	7%	188%	3%
Gun	5%	1%	6%	-5%	40%	8%	28%	281%	0%
Otter	23%	15%	33%	21%	30%	21%	49%	16%	230%
Red	23%	9%	24%	18%	75%	17%	87%	123%	0%

Tables 2, 3 and 4 summarize the results of the Mann-Whitney and Kruskal-Wallis test for significance and the descriptive statistics for each species and group at a given project location. Probability = (*p*), shaded values indicate significance ($p = < 0.05$). Groups are; non-structure locations (NST), structure locations (YST) and all locations (ALL). Sample size = (*n*); Median (MED); Mean (MEA), shaded values indicate a significantly higher mean value. Upper confidence interval of the mean (UCI); Lower confidence interval of the mean (LCI). The possible signs of the slope of the regression line at a 95% confidence interval (Sign 95%), shaded values indicate a significant trend.

Gunboat Lakes had a significantly higher mean value for coho salmon at the structure locations but no significant increase in the overall abundance (Table 2). Cutthroat trout abundance appeared not to have significantly changed in any group. Dolly Varden abundance was significantly higher at non-structure locations but no trend was apparent (Appendix D).

Table 2. Summary of Gunboat Lakes CPUE Statistics.

Species	*p*	Groups	*n*	MED	MEA	UCI	LCI	Sign 95%
CO	< 0.001	NST	204	0.193	0.279	0.329	0.228	+,-,0
	< 0.001	YST	114	0.367	0.453	0.541	0.365	+,-,0
	< 0.001	ALL	318	0.264	0.341	0.387	0.295	+,-,0
CT	0.087	NST	204	0	0.057	0.075	0.039	+,-,0
	0.087	YST	114	0	0.046	0.075	0.017	+,-,0
	0.267	ALL	318	0	0.053	0.069	0.038	+,-,0
DV	0.031	NST	204	0	0.116	0.152	0.080	+,-,0
	0.031	YST	114	0	0.080	0.123	0.037	+,-,0
	< 0.001	ALL	318	0	0.103	0.131	0.075	+,-,0

Otter Creek had a significantly higher mean value for coho salmon at the non-structure locations with a significant increase in all groups (Table 3). Cutthroat trout abundance significantly increased overall and at the structure locations. Total Dolly Varden abundance increased during 1995-1998, but no significant use at structure or non-structure sites was indicated (Appendix E).

Table 3. Summary of Otter Creek CPUE Statistics.

Species	*p*	Groups	*n*	MED	MEA	UCI	LCI	Sign 95%
CO	0.004	NST	113	0.358	0.574	0.688	0.461	+
	0.004	YST	135	0.224	0.312	0.371	0.254	+
	< 0.001	ALL	248	0.271	0.432	0.494	0.369	+
CT	0.036	NST	113	0	0.045	0.062	0.028	+,-,0
	0.036	YST	135	0	0.081	0.104	0.059	+
	< 0.001	ALL	248	0	0.064	0.079	0.050	+
DV	0.529	NST	113	0.300	0.395	0.468	0.321	+,-,0
	0.529	YST	135	0.363	0.363	0.482	0.351	+,0
	< 0.001	ALL	248	0.315	0.407	0.455	0.358	+

Red Creek had a significantly higher mean value for coho salmon at the structure locations with an increase in all groups (Table 4). Cutthroat trout abundance changed significantly overall without indicating significant use between structure or non-structure sites. Dolly Varden trends overall, and for structure or non-structure sites could not be identified (Appendix F).

Table 4. Summary of Red Creek CPUE Statistics.

Species	*p*	Groups	*n*	MED	MEA	UCI	LCI	Sign 95%
CO	0.008	NST	247	0	0.207	0.252	0.161	+
	0.008	YST	143	0	0.295	0.362	0.228	+
	< 0.001	ALL	390	0	0.239	0.277	0.201	+
CT	0.514	NST	247	0	0.133	0.161	0.105	+
	0.514	YST	143	0	0.124	0.162	0.087	+,0
	< 0.001	ALL	390	0	0.130	0.152	0.107	+
DV	0.429	NST	247	0	0.207	0.254	0.160	+,-,0
	0.429	YST	143	0	0.245	0.309	0.181	+,-,0
	< 0.001	ALL	390	0	0.221	0.259	0.183	+,-,0

In summary, at the structure locations for Gunboat and Red Creek, coho abundance was significantly greater than at non-structure sites, while cutthroat trout abundance for any group was not significant. At Otter Creek, coho salmon abundance was predominant at non-structure locations while cutthroat trout exhibited a significantly higher abundance at the structure sites. Dolly Varden overall abundance increased only at Otter Creek. A greater abundance of Dolly Varden was indicated at Gunboat Lakes for non-structure sites, but no trend was identified. None of the species indicated a significant negative trend at any location for any group.

At Billy's Hole, the distribution and relative abundance of cutthroat trout generally did not change throughout the study. Cutthroat were present in only two of the four years of the study and found in very low numbers. Coho salmon and Dolly Varden also showed little change in distribution and relative abundance, although both species were present throughout the entire study. The habitat improvement work appears to have not significantly benefited any of the species at Billy's Hole during this study.

Results at the other three study locations were mixed; each was addressed separately by accepting or rejecting the restated primary hypotheses (H_o) and each specific hypothesis (H_{1-3}). In tables 5,6 and 7 any rejection of H_1 also indicates where greater abundance was observed (structure or non-structure sites). All of the study sites showed changes to macrohabitat due to the improvement work that endured throughout the life of the project; therefore, we rejected the null hypotheses H_3 at each project location (Appendix C). To reject H_o we must reject H_{1-3} and observe the significantly greater abundance at the structure sites, and in the overall abundance, for a particular species.

At Gunboat Lakes we accepted H_o for each species and concluded that the enhancement work was of no benefit to coho salmon, cutthroat trout or Dolly Varden (Table 5). The data suggest that coho were redistributed within the stream and that little or no change occurred in total abundance for any of the three species in our study at this location (Table 2, Appendix D).

Table 5. Gunboat Lakes Hypotheses Summary.

Hypothesis	***Coho***	***Cutthroat***	***Dolly Varden***
H_1	Reject (Structure Site)	Accept	Reject (Non-Structure Site)
H_2	Accept	Accept	Accept
H_3	Reject	Reject	Reject
H_o	Accept	Accept	Accept

At Otter Creek, a positive trend in total abundance is apparent for all species. However only the increase in cutthroat trout abundance appears to be related to the improvement work, therefore we reject H_o for cutthroat trout. Coho abundance was significantly less at the structure sites and Dolly Varden showed no significant preference; therefore, we must accept H_o for both species (Table 6). The data also clearly indicate a significant positive trend for cutthroat at only the structure locations, a unique occurrence in our study. Additionally this was the only location where coho salmon abundance was greater at the non-structure sites, suggesting a possible interaction between coho salmon and cutthroat trout at this location. (Table 3, Appendix E).

Table 6. Otter Creek Hypotheses Summary.

Hypothesis	***Coho***	***Cutthroat***	***Dolly Varden***
H_1	Reject (Non-Structure Site)	Reject (Structure Site)	Accept
H_2	Reject	Reject	Reject
H_3	Reject	Reject	Reject
H_o	Accept	Reject	Accept

At Red Creek, a significant positive trend in overall abundance for cutthroat trout is evident but no significant use of structure verses non-structures sites could be determined. Dolly Varden showed no significant increase overall, or a preference for structure or non-structure sites. This leads us to acceptance of H_o for cutthroat trout and Dolly Varden (Table 7). Coho exhibited a significant increase overall and significantly higher use at structure sites, allowing us to reject H_o and conclude that the improvement work did benefit coho salmon (Table 4, Appendix F).

Table 7. Red Creek Hypotheses Summary.

Hypothesis	***Coho***	***Cutthroat***	***Dolly Varden***
H_1	Reject (Structure Site)	Accept	Accept
H_2	Reject	Reject	Accept
H_3	Reject	Reject	Reject
H_o	Reject	Accept	Accept

DISCUSSION

In summary we find that juvenile cutthroat trout abundance increased at two of the four locations but at only one location, Otter Creek, could the increase be attributed to the improvement work. Dolly Varden abundance increased at only one location, again Otter Creek, but no relationship to the improvement work was indicated. Coho salmon abundance increased at Red and Otter Creek, however, only at Red Creek could we demonstrate a link to the improvement work. In general, no significant negative trends in total abundance were observed at any of the project location for any of the species in our study.

The differing results at the four project locations could be due to a variety of factors. One factor may be in the way the data are represented. Given the observed asymmetrical distribution in the various data sets there is a suggestion that there are sub-populations not accounted for in our groupings. For example: if cutthroat trout prefer a particular macrohabitat type and sampling focused on only those types we would expect to see a more normal distribution possibly strengthening our results. A cluster analysis of the various habitat components and associated abundance may reveal these sub-populations.

Natural cycles in populations or interspecific competition may be another factor in the varying results. There is some evidence of competition between cutthroat trout and coho salmon in our study. At Otter Creek, we observed a significant use of non-structure sites by coho and a corresponding significant use of structure sites by cutthroat trout; this was the only such occurrence in our study. At the other two sites, where coho showed significant use at the structure locations, we observed no significant use by cutthroat trout.

Certain types of improvements may have been more beneficial to cutthroat trout than other types. The data suggest that this may be the case. Gunboat Lakes and Billy's Hole showed no significant changes in cutthroat trout abundance. The work at these locations consisted primarily of the addition of small woody debris to increase cover, which results in very little alteration to the overall stream channel morphology. The work at Red and Otter Creek however involved alterations that modified the channel morphology to a greater degree; and at these locations, we did observe significant positive trends in cutthroat trout abundance.

CONCLUSIONS

Otter Creek was the only location where we could demonstrate that the stream enhancement work completed in 1995 benefited cutthroat trout. Dolly Varden appeared to have not benefited at any of the study locations. Stream enhancements appeared to benefit coho salmon at only Red Creek. We did not observe any significant negative trends in total abundance at any of the project locations for coho salmon, cutthroat trout or Dolly Varden.

A possible competitive interaction between coho salmon and cutthroat trout was observed at Otter Lake. Our study was not designed to verify this observation, however, our data does contain some evidence to support it. Exploration of the available data sets may also identify sub-populations that could result in a more normal distribution than we observed. However, it was felt that given the scale of the possible groupings (habitat units), and determining an underling relationship between macro habitats and fish distribution would require extensive reworking of the data sets and could possibly introduce more error into our results. Sampling proved problematic throughout our study due to “trap shyness” and small population sizes of cutthroat trout, similar projects should consider these difficulties and be designed accordingly.

Red Creek, Otter Creek, Billy’s Hole, and Gunboat Lake were selected as enhancement opportunities in part due to their lack of habitat complexity. So in general, the improvements at these locations focused on increasing that complexity. However, the treatments at Billy’s Hole and Gunboat Lakes did not greatly alter the complexity of the habitats but rather focused on increasing cover. Because we observed no significant negative trends for any of the species during our study we assume the enhancement work at least did not have a detrimental effect. Enhancement structures such as cross-logs and rockwork appeared to be of more benefit to cutthroat trout than other types of enhancements. Although our sample size is limited, it may be that structures that increase habitat complexity may provide a greater benefit than cover type structures for cutthroat trout. To achieve maximum benefits for cutthroat trout, future enhancement work may want to focus on those types of improvements that increase total complexity of the stream.

ACKNOWLEDGMENTS

Glacier Ranger District Fisheries Crew, Will Frost, Beth Kitto, Mike Spink, Dan Young, Jed Jankowski, Lynette Halladay and Gretchen Fitzgerald. The Glacier Ranger District also wishes to thank Karen Murphy, Rob Spangler and Ken Holbrook for their assistance and guidance throughout the project.

LITERATURE CITED

Exxon Valdez Oil Spill Trustee Council. November 1994. *Exxon Valdez* Oil Spill Restoration Plan. Anchorage, Alaska.

Exxon Valdez Oil Spill Trustee Council. September 1994. Final Environmental Impact Statement for the *Exxon Valdez* Oil Spill Restoration Plan. Anchorage, Alaska.

Glova, G.J., and J.C. Mason. 1976. Interactive ecology of juvenile salmon and trout in streams. Fish Res. Board Can. MS Rep. Ser. No. 1391. 24pp.

Hankin, D.G., and G.H. Reeves. 1988. Estimating total fish abundance and total habitat area in streams based on visual estimation methods. Canadian Journal of Fisheries Aquatic Sciences. (45: 834-844).

Heggenes, J., T.G. Northcote, and A. Peter. 1991. Seasonal Habitat Selection and Preferences by Cutthroat Trout (*Oncorhynchus clarki*) in a Small Coastal Stream. Canadian Journal of Fisheries and Aquatic Sciences. (48:1364-1370).

Hepler, K., P.A. Hansen, and D.R. Bernard. 1993. Impact of Oil Spilled from the *Exxon Valdez* on Survival and Growth of Dolly Varden and Cutthroat Trout in Prince William Sound, Alaska. Alaska Department of Fish and Game. 32pp.

Kohler, C.C., and W. A. Hubert. 1993. Inland fisheries management in North America Fisheries Society. Bethesda, Maryland.

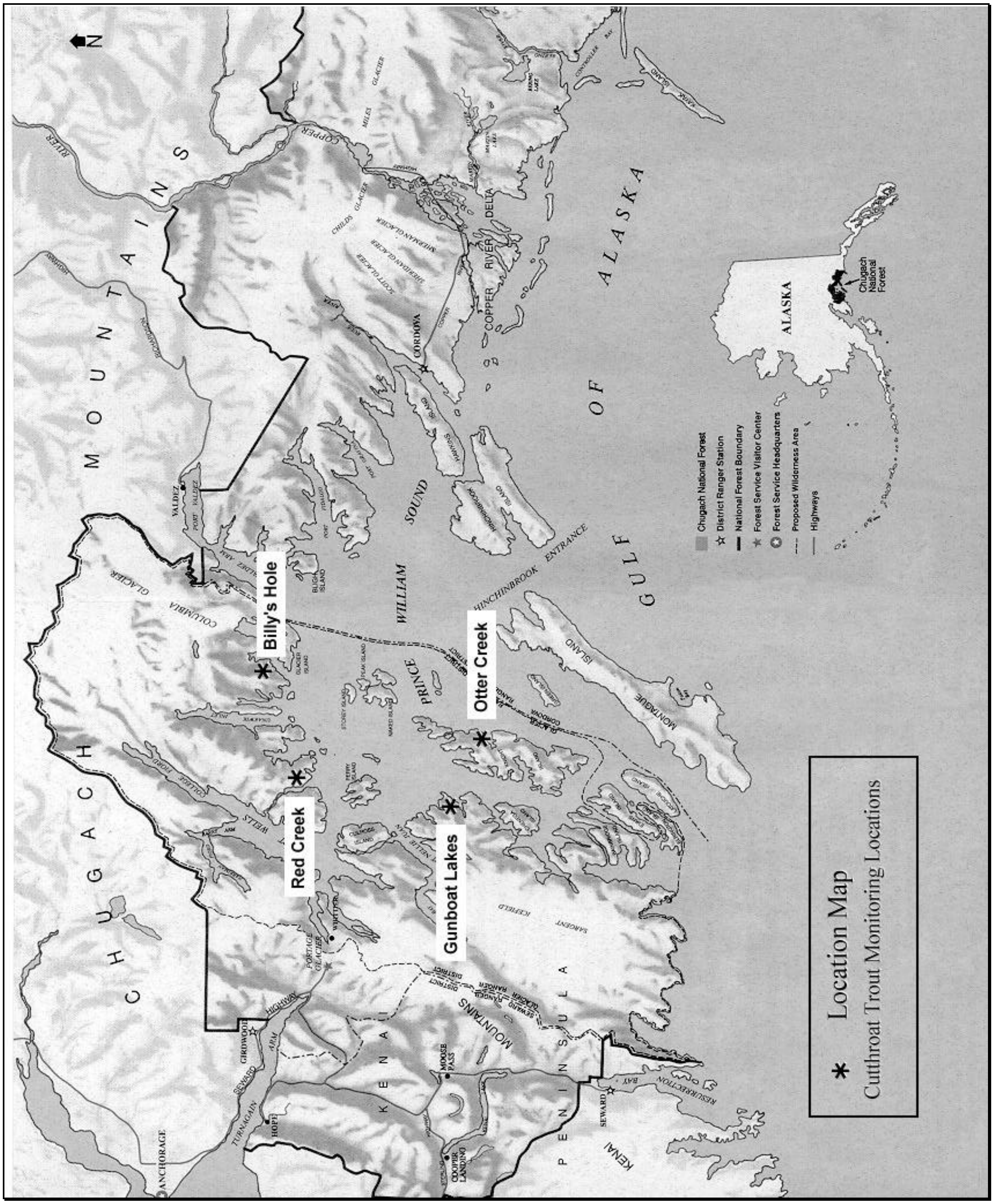
Morrow, J.E. 1980. The freshwater fishes of Alaska. Alaska Northwest Publishing Co. Anchorage, Alaska. 248 pages.

Trotter, P.C. 1989. Coastal Cutthroat Trout: A Life History Compendium. Transactions of the American Fisheries Society (118:463-473).

Wedemeyer, K. 1993. Cutthroat Trout in Prince William Sound. U.S. Forest Service report, Girdwood, Alaska. 4pp.

APPENDICES

Appendix A. Cutthroat Trout Project Location Map.



Appendix B. Description of Habitat Classification Technique.

- Fast Water Habitat Types
  - Turbulent
    - Turbulent (Rapid)
    - High Gradient Riffle
    - Low Gradient Riffle
  - Non-Turbulent
    - Runs
    - Glides
- Slow Water Habitat Types
  - Dammed
    - Main
    - Backwater
  - Scoured
    - Lateral
    - Mid-Scour

VARIABLE CATEGORY	***DESCRIPTION***
Fast Water Habitat type: Subdivided into Turbulent and Non-Turbulent Types	Includes Turbulent, High and Low gradient riffles, Runs, Glides, and associated pocket pools.
Slow Water Habitat Types: Subdivided into Dammed and Scoured type pools.	Includes Main and Backwater Dammed pools; Scoured pools of 3 types (lateral, mid and plunge) and the source that caused the pools such as woody debris, boulders, bedrock, tributaries etc.
Length, Width, Depth: Based on actual measurement of the particular habitat unit.	Measured for each habitat unit observed.
The Type and Percent of available cover: Based on an estimation of the percent observed within a particular habitat unit.	Cover types include: Large and Small Woody Debris, root wads, overhanging vegetation, undercut banks, rocks or boulders, beaver dams, aquatic vegetation.
Substrate composition: Based on an estimation of the percent observed within a particular habitat unit.	Silt, sand, gravel, small cobble, large cobble
Gradient: Measured with clineometer.	Measured for each habitat unit observed.

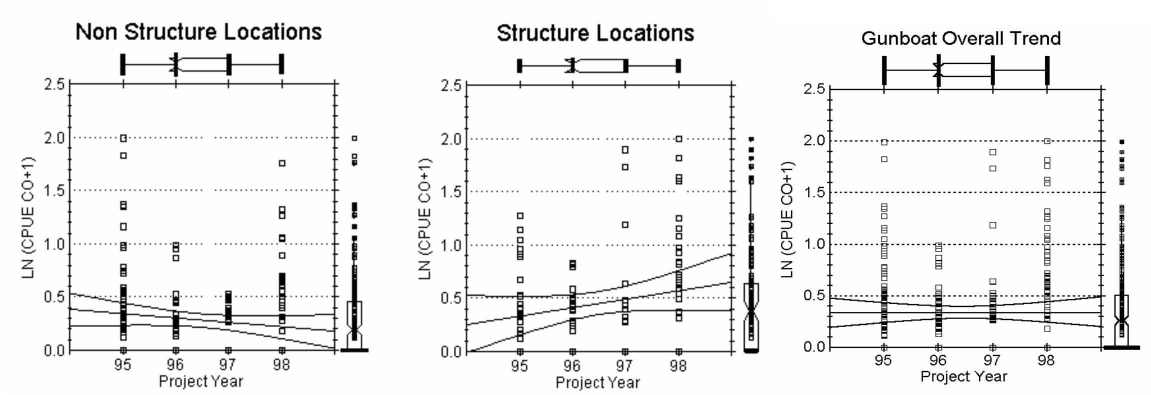
Appendix C. Summary of Habitat Surveys.

Habitat Units (HU); Pocket Pools (PP); Turbulent Units (Turb); Non-Turbulent (Nturb); Large Woody Debris (LWD); Small Woody Debris (SWD); Rocks (RS). Measurements before structure installation (Pre); Measurements after installation of structure (Post).

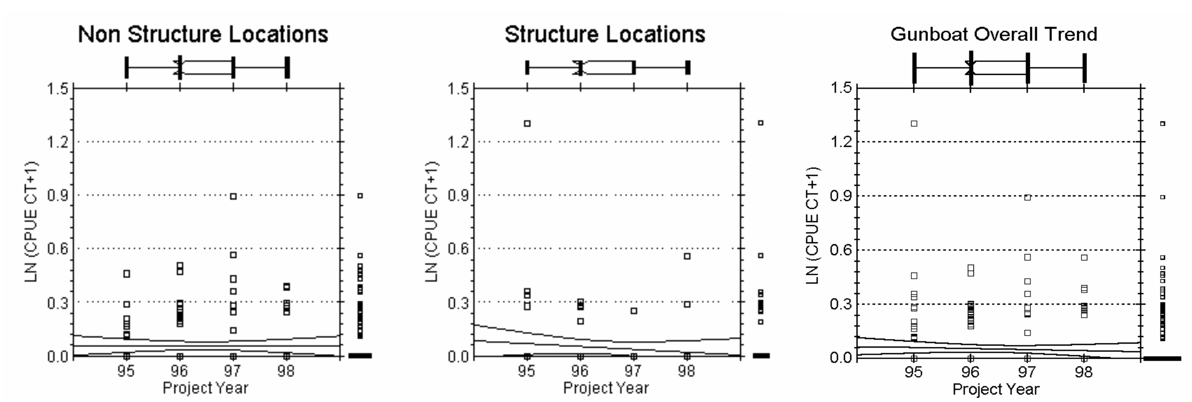
Loc.		***# of HU***	***H.U. m^2***	***# of PP***	***# of Turb***	***# of Nturb***	***# of Slow***	***LWD m^2***	***SWD m^2***	***RS m^2***
Otter	Pre.	43	1456	24	19	10	14	95	901	7
Creek	Post	53	1675	32	23	13	17	141	1045	22
	Diff.	10	220	8	4	3	3	46	144	15
	% Inc.	23%	15%	33%	21%	30%	21%	49%	16%	230%
Red	Pre.	44	1872	21	17	4	23	65	147	63
Creek	Post	54	2044	26	20	7	27	122	327	63
	Diff.	10	171	5	3	3	4	57	180	0
	% Inc.	23%	9%	24%	18%	75%	17%	87%	123%	0%
Gun	Pre.	38	2825	16	21	5	12	118	77	293
Boat	Post	40	2843	17	20	7	13	152	293	293
	Diff.	2	18	1	-1	2	1	34	216	0
	% Inc.	5%	1%	6%	-5%	40%	8%	28%	281%	0%
Billy's	Pre.	64	8875	41	33	8	23	329	346	58
Hole	Post	64	8875	41	33	8	23	352	994	60
	Diff.	0	0	0	0	0	0	23	648	2
	% Inc.	0%	0%	0%	0%	0%	0%	7%	188%	3%
Total		51%	25%	63%	34%	145%	47%	171%	608%	233%

Appendix D. Scatter Plots of Gunboat Lakes CPUE.

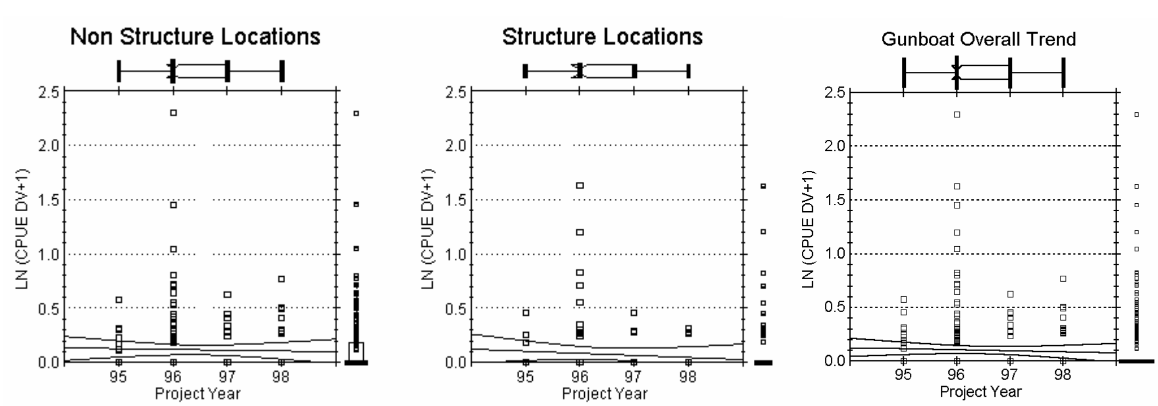
Coho Salmon Plots



Cutthroat Trout Plots

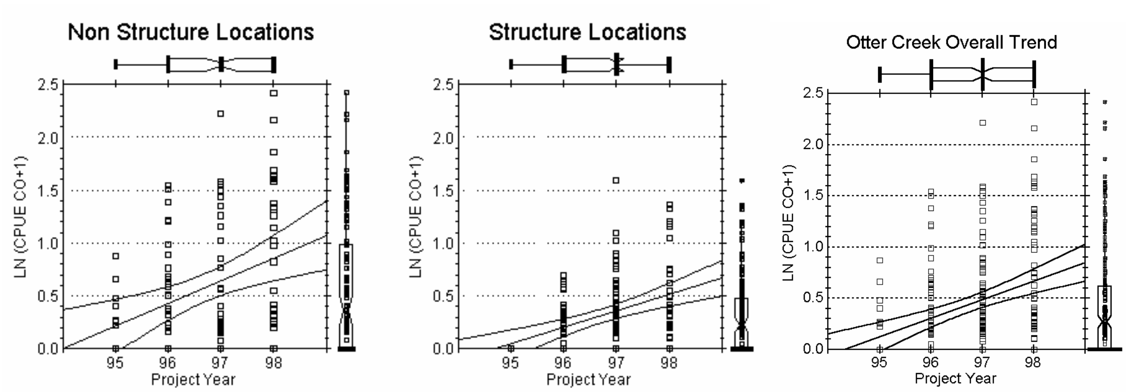


Dolly Varden Plots

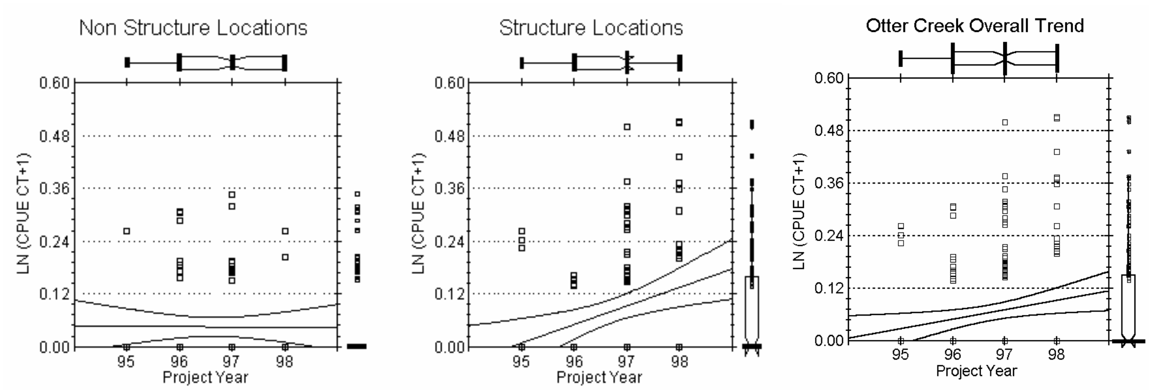


Appendix E. Scatter Plots of Otter Creek CPUE.

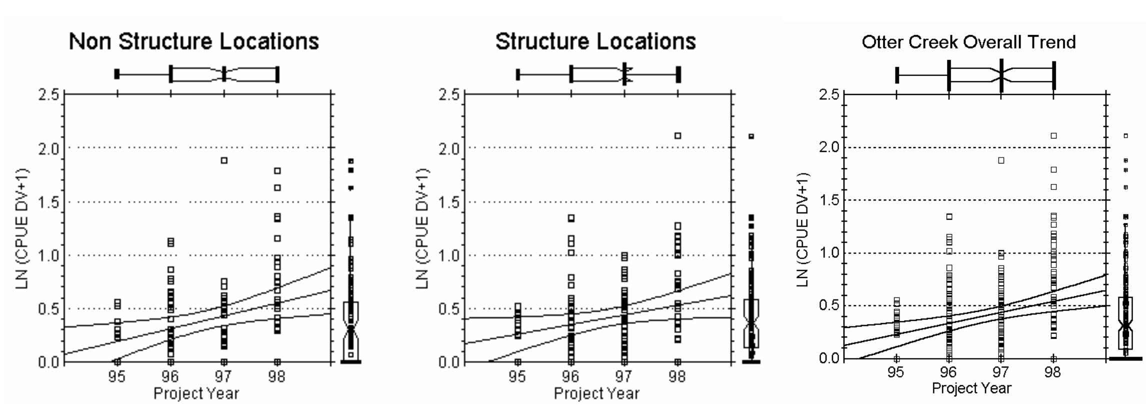
<u>Coho Salmon Plots</u>



<u>Cutthroat Trout Plots</u>

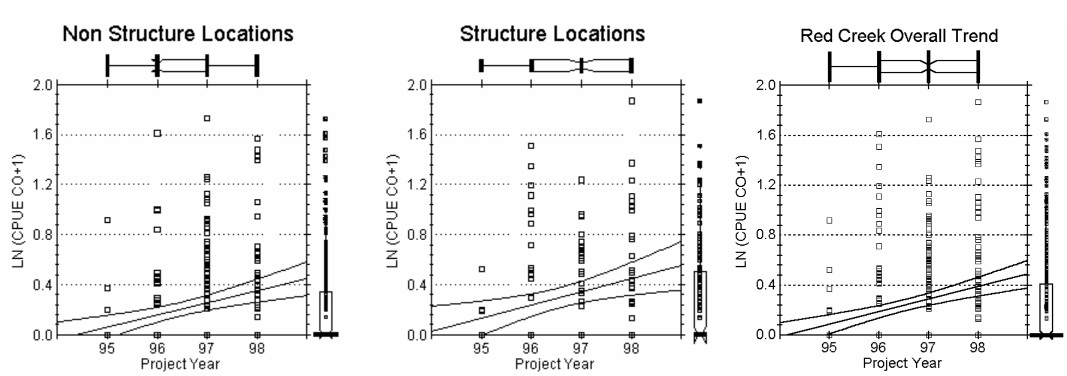


<u>Dolly Varden Plots</u>

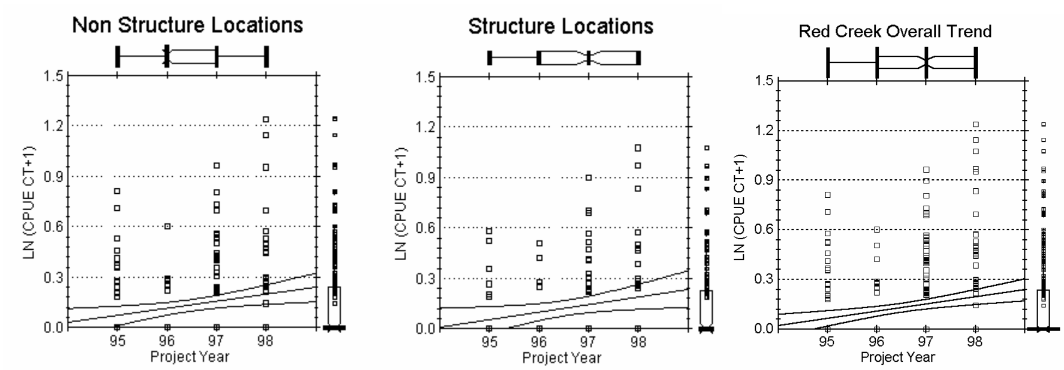


Appendix F. Scatter Plots of Red Creek CPUE.

Coho Salmon Plots



Cutthroat Trout Plots



Dolly Varden Plots