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STATE/FEDERAL RESOURCE DAMAGE ASSESSMENT
DATA SUMMARY REPORT

Project Title:	INJURY TO DOLLY VARDEN AND CUTTHROAT TROUT IN PRINCE WILLIAM SOUND
Study ID Number:	Fish/Shellfish Study Number 5
Lead Agency:	State of Alaska, ADF&G; Sport Fish Division
Principal Investigator:	Kelly Hepler, Fishery Biologist
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LITIGATION SENSITIVE / ATTORNEY WORK PRODUCT

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EXECUTIVE SUMMARY

Populations of Dolly Varden and cutthroat trout in Prince William Sound were studied during the spring and summer of 1989, 1990, and 1991 as part of a plan to assess potential injury due to the Exxon Valdez oil spill. These potential impacts were measured through differences in survival and growth rates of the Dolly Varden and the cutthroat trout that spent the winter in lacustrine watersheds that issued into oiled and non-oiled parts of Prince William Sound. Weirs were constructed above tidal influence on five streams; three streams issued into oiled estuaries and two into estuaries not exposed to crude oil. Fish migrating past weirs were counted and measured for fork length, scales and otoliths were collected from a sample of fish, and a large portion of the fish were tagged with individually numbered Floy tags. Since trout and Dolly Varden were in freshwater when the oil spill occurred in 1989, fish were sampled before any potential exposure to an oiled marine environment.

There was a highly significant difference between the growth of cutthroat trout from an oiled site and control sites, but not for Dolly Varden. Cutthroat trout from Eshamy Bay, an oiled site, grew 71% slower than fish from control sites. There was no inherent difference in mean length-at-age of fish of either species between control and treatment populations in 1989. Therefore, significant differences in growth between control and oiled sites can be attributed to some external disturbance such as exposure to oil. There were also significant differences in the mortality rates of Dolly Varden and cutthroat trout from oiled and control sites. Dolly Varden from Rocky Bay, an oiled site, had a 12% higher mortality than fish from control sites. Cutthroat trout from Eshamy Bay, an oiled site, had a 65% higher mortality than fish from control sites. The possible sources of variation, such as tag loss or fishing mortality, were not found to be significant and therefore differences in mortality between control and oiled sites can be attributed to some external disturbance such as oil exposure.

OBJECTIVES

The goal of this study was to compare the survival rates, and growth rates of cutthroat trout *Oncorhynchus clarki* (hereafter referred to as trout) and Dolly Varden *Salvelinus malma* differentially affected by the oil spill in Prince William Sound (PWS). A map of the study is presented in Figure 1. During 1991, the specific objectives of this project were:

1. to test the hypothesis that there is no difference in annual survival rates of Dolly Varden and cutthroat trout between treatment and control groups during 1990-91 (the test will be done given a level of significance of $\alpha = 0.05$.);

2. to test the hypothesis that there is no difference in annual growth rates of Dolly Varden and cutthroat trout between treatment and control groups during 1990-91 (the test will be done given a level of significance of $\alpha = 0.05$.);

3. to identify potential alternative methods and strategies for restoration of lost use, populations, or habitat where injury is identified (to be accomplished upon completion of this project).

To accomplish these objectives, the following tasks were performed:

1. estimate annual survival rates from fish that were tagged in 1990 for each of the study stocks using abundance data collected at the weirs; and,

2. estimate mean length of previously tagged emigrating trout from each study stream (the estimates will be ± 10 mm of their true values 90% of the time).

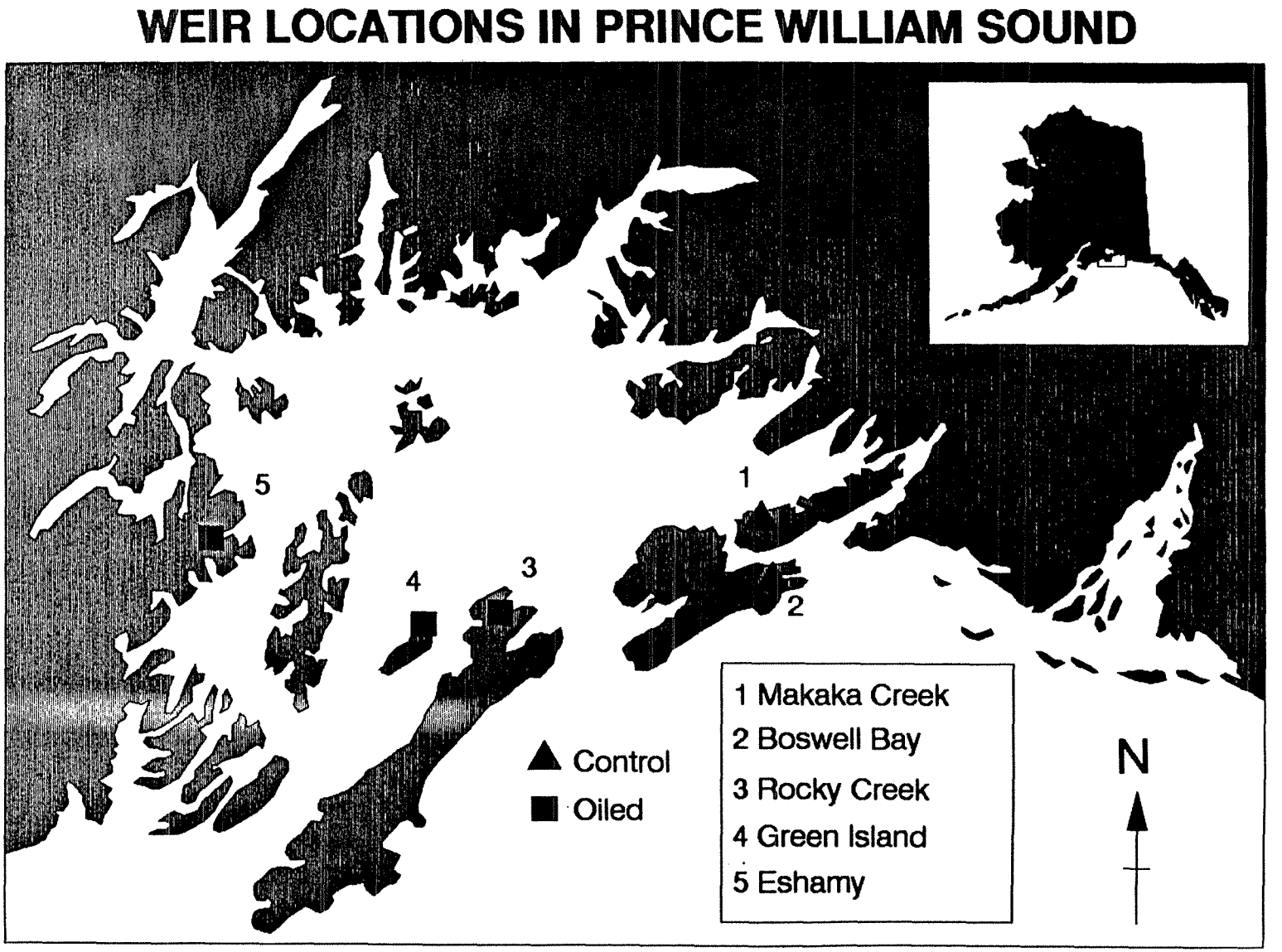

Figure 1. Locations of weirs in Prince William Sound, 1991.

INTRODUCTION

This report constitutes a status summary that evaluates the effects of the Exxon Valdez oil spill on Dolly Varden and trout in PWS following the third year of study. Study results from 1990 showed there was a significant difference in growth of cutthroat trout from Eshamy Bay, an oiled site, and control sites and a significant difference in survival for both cutthroat trout and Dolly Varden from oiled and control sites between 1989 and 1990 (Hepler et al 1990).

The experimental design for this program was based upon the model developed by Armstrong (1970, 1974, 1984) and Armstrong and Morrow (1980) to explain the migratory behavior of anadromous Dolly Varden. This model identifies two patterns of life history: fish that were spawned in lacustrine watersheds and fish that were spawned in fluvial watersheds. For both groups, juvenile Dolly Varden remain in their natal stream for up to four years. During their last spring of freshwater residence, they smolt to sea. During late summer or early fall, fish that were spawned in lacustrine watersheds return to their natal stream to overwinter in the freshwater lake. During the spring, they again emigrate into marine waters and annually return to their natal lake system during late summer or early fall to spawn and overwinter. Fish that were spawned in fluvial watersheds exhibit a more complex migration. Upon smolting, juvenile Dolly Varden search for a lake system to overwinter. These fish then behave in the same manner as do fish that originate in a lacustrine watershed except that they return to their natal stream to spawn and then return to their selected lake system to overwinter. The migratory habits of anadromous cutthroat trout are similar to those of Dolly Varden, however, trout spawn in the spring. (Armstrong 1981, Johnston 1981, Jones 1982).

By sampling overwintering Dolly Varden and trout as they emigrated to PWS in 1990, survival and growth rates over the intervening summer when these fish were at risk were measured. During the summer, both Dolly Varden and trout utilize near-shore and estuarine waters for feeding (Armstrong 1967, Morrow 1980, Jones 1982). Of all the waters exposed to oil, these were the most severely contaminated. Because of the fidelity of Dolly Varden and trout to return annually to the same lake to overwinter all survivors could be sampled.

METHODS

Populations of overwintering fish from five lacustrine watersheds were divided in two groups according to the exposure of their estuaries to oil. The control groups (no exposure to oil) were in lakes connected to the ocean through Makaka Creek and through

Boswell Creek. The oiled groups were in lakes connected to the ocean through Rocky Bay Creek, Green Island Creek and Eshamy Creek. Rocky Bay had less exposure to oil than the other two oiled sites (Damage Assessment Geoprocessing Group 1990).

Weirs were installed on all these creeks before the emigration began in the spring of 1990 and the spring of 1991. The weirs were constructed with inclined aluminum panels and contained free-moving vertical rods spaced at 2 cm intervals. Each panel measured 2.0 meters long and 1.0 meter high. The panels rested against wooden tripods spaced approximately 2 m apart. Each weir completely blocked the stream and directed emigrating fish into a holding pen.

All emigrating Dolly Varden and trout captured at the weir were counted, measured (fork length) to the nearest mm, and passed over the weir. They were not anesthetized. Every captured fish of both species greater than 200 mm was tagged with an individually numbered Floy tag and in 1991 the right ventral fin was clipped. The tag was inserted between the finrays at the base of the dorsal fin approximately 15 mm foreword of the posterior end of the fin on the left side. Tagged fish were retained for five minutes to cull any immediate mortalities from handling. A summary of the number of each species tagged in 1990 and 1991 and number of recaptures in 1990 is found in Table 1.

Scales were collected from a random sample of trout. In an effort to reduce destructive sampling, sagittal otoliths were only collected from Dolly Varden that were weir mortalities . Scales were collected from the left side of the fish approximately two rows above the lateral line and on the diagonal row downward from the posterior insertion of the dorsal fin as described in Clutter and Whitesel (1956). Otoliths were stored in a 1:1 solution of water and glycerine for 24 hours prior to the reading to increase clarity (Barber and McFarlane 1987). Age was determined by examination of otoliths using a Nikon model SMZ-1B scope with a fiber-optic lighting system following techniques outlined by Jearld (1983).

The proportional age composition of the sample of the emigration was estimated for each study group. Letting p_h equal the estimated proportion of age group h in the group:

$$V(\hat{p}_h) = \frac{\hat{p}_h(1-\hat{p}_h)}{n-1}$$

where n is the sample size.

Table 1. Numbers of fish recaptured and tagged at weirs on five streams in Prince William Sound, 1991.

CUTTHROAT TROUT

Site	Fish Tagged in 1990	Fish Recaptured in 1991	Fish Not Recaptured	Fish Tagged in 1991
BOSWELL	1,375	508	867	1,128
MAKAKA	841	253	588	2,814
Total Control	2,216	761	1,455	3,942
ROCKY	29	0	29	0
GREEN*	20	1	19	10
ESHAMY*	233	27	207	151
Total Oiled	282	28	255	161
TOTAL	2,498	789	1,710	4,103

* In 1991 weir washed out for three days at these sites.

DOLLY VARDEN

Site	Fish Tagged in 1990	Fish Recaptured in 1991	Fish Not Recaptured	Fish Tagged in 1991
BOSWELL	7,027	1,341	5,686	1,803
MAKAKA	12,669	2,299	10,370	11,861
Total Control	24,696	1,117	16,056	23,664
ROCKY	15,962	2,624	13,338	6,007
GREEN*	1,651	118	1,533	570
ESHAMY*	4,344	261	4,128	663
Total Oiled	21,957	3,003	18,999	7,240
TOTAL	46,653	4,120	35,055	30,904

* In 1991 weir washed out for three days at these sites.

Tissue samples were collected from the livers, kidneys and hearts of approximately 10 immigrating Dolly Varden at the weir sites during the fall of 1991. These samples were collected for analysis of mixed function oxidase induced enzyme systems (MFO). All samples were stored in 10% buffered formalin and sent to the School of Veterinarian Medicine at University of California, Davis for analysis.

Comparison of Growth Rates

Growth of individual fish was calculated as the difference between length at time of recovery and length at time of release. A few impossible values (eg. -100 mm, +260 mm) were calculated and considered to be recording errors. For each site, a box plot was constructed and all observations more than 1.5 interquartiles away from the box edge were deleted from the growth analysis.

Analysis of variance was used to test the hypothesis that fish from oiled areas grew at the same rate as fish from control areas. Because small fish generally grow faster than large fish, length at tagging was included in the ANOVA model as a blocking variable for Dolly Varden and as a covariate for trout. This different approach took advantage of the low correlation between the dependent variable (growth) and the independent variable (tagging length in 1990) for Dolly Varden ($r = -0.34$) and the high correlation for trout ($r = -0.77$) (Cox 1957).

Dolly Varden:

The exploratory data analysis procedure eliminated 428 observations or 6.6% of the growth values for Dolly Varden (Figure 2). The final ANOVA for Dolly Varden was a randomized block design with a nested treatment arrangement. Fish were separated into two blocks: small fish ($\leq$ 270 mm) and large ($>$ 270 mm). Blocks were defined through an inspection of growth rates (Figure 3). The ANOVA model was:

$$\text{growth} = \mu + \text{length} + \text{tmt} + \text{length*tmt} + \text{site(tmt)} + \text{error}$$

where:

growth = length in 1991 - length in 1990 (measured in mm)
length = blocking variable; small or large
tmt = treatment; oiled or control area
site = overwintering lake system

The analysis was done using the SAS GLM procedure specifying the error term to be site(tmt) when testing the effect of treatment (SAS 1985).

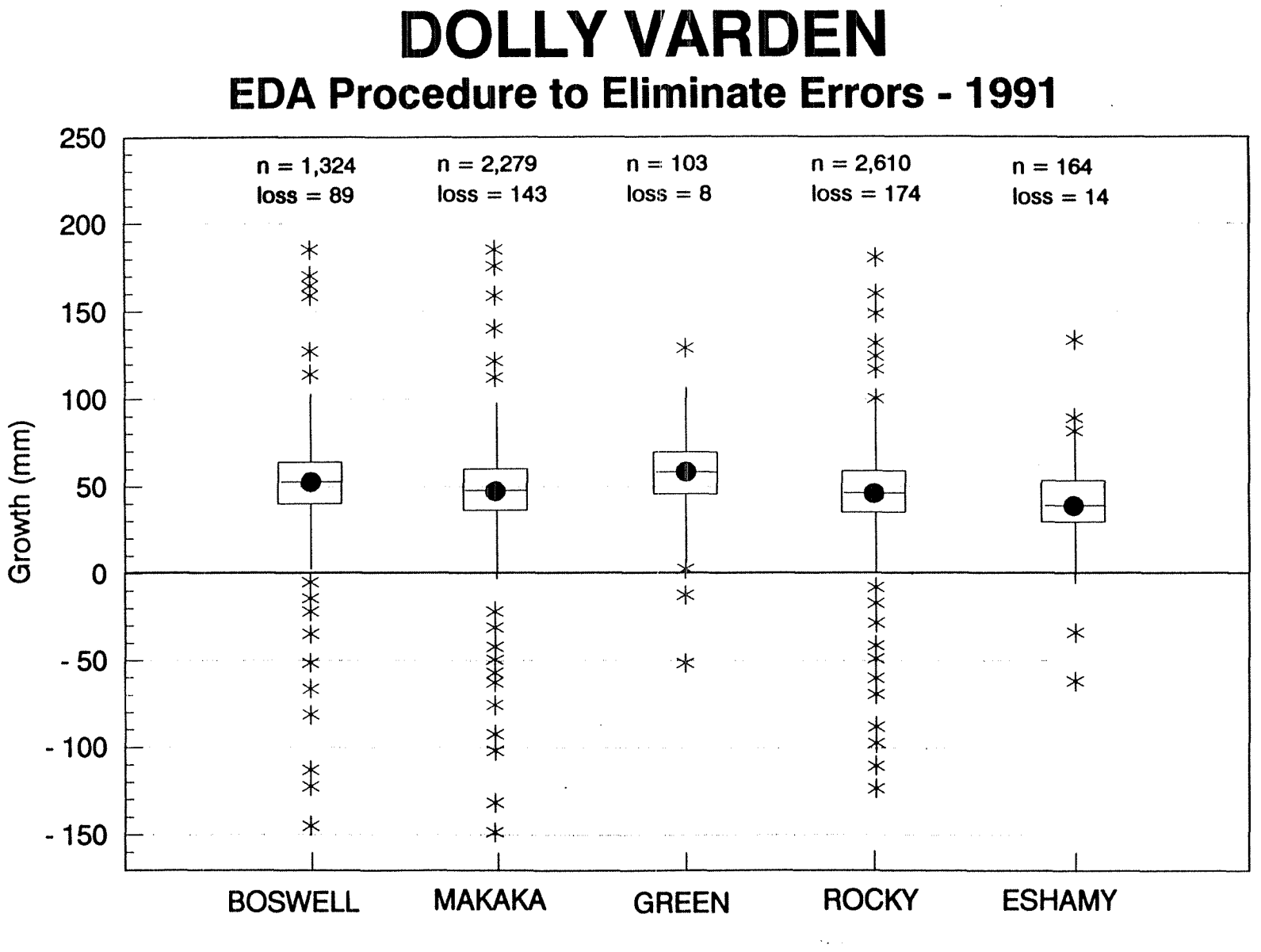

Figure 2. Exploratory data analysis (EDA) procedures used to eliminate recording errors in the Dolly Varden growth data, 1991.

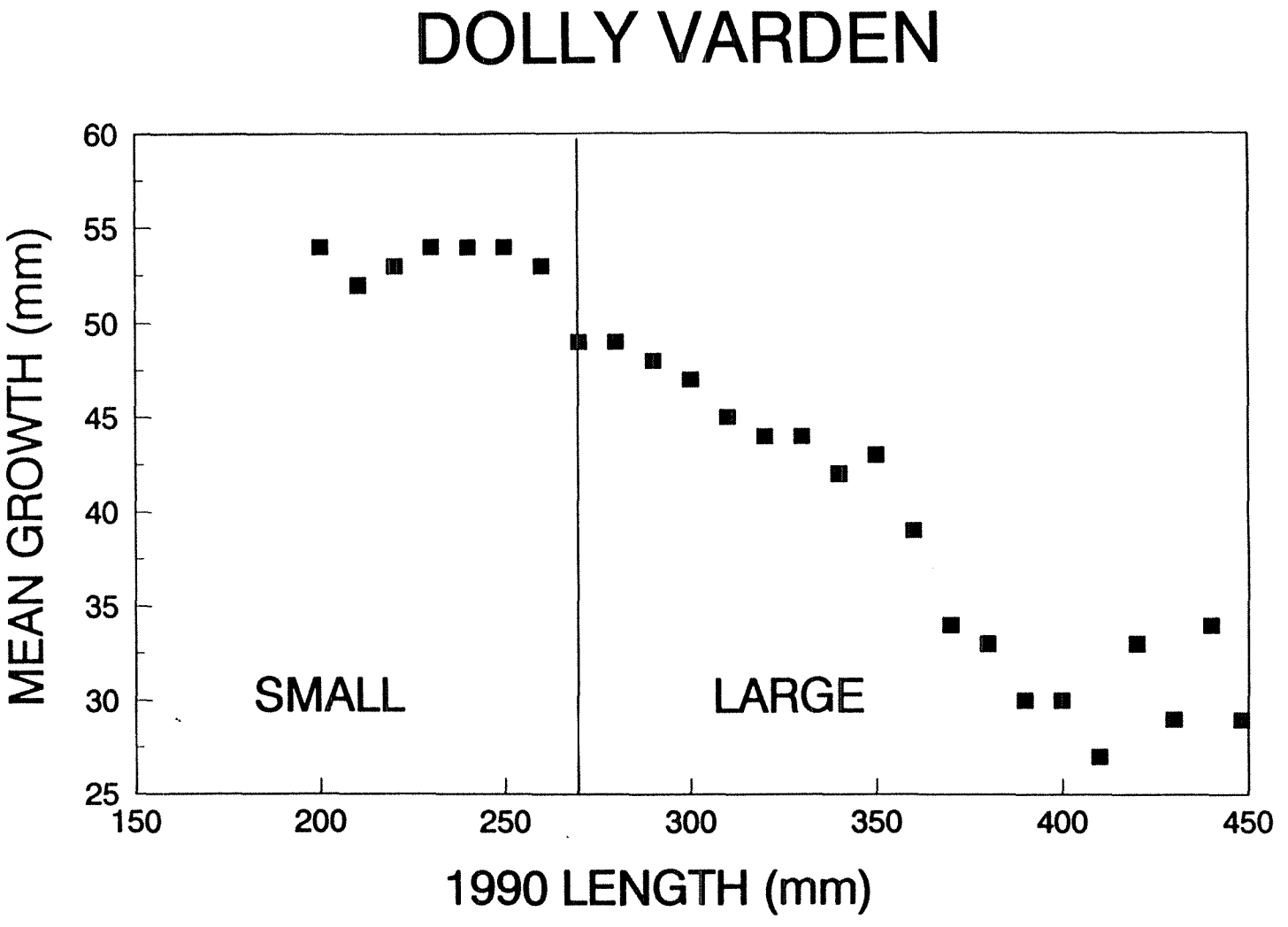

Figure 3. Plot of the mean growth of Dolly Varden (y) versus the length at tagging (x), 1991.

Cutthroat Trout:

The exploratory data analysis procedure eliminated 18 observations or 2% of the growth values from the trout database (Figure 4). The specific design for trout was a mixed model:

$$\text{growth} = \mu + \text{length} + \text{site} + \text{error}$$

where:
growth = length in 1991 - length in 1990 (measured in mm)
length = length in 1990
site = overwintering lake system

Rocky Bay and Green Island were not used in the analysis of growth because their sample sizes were small and would be rare event sampling. The analysis was done using SAS GLM procedure. Pairwise comparisons were then done to test for growth differences between sites from oiled and non-oiled areas.

Comparison of Survival Rates

Survival rate was calculated as the percent of fish tagged in 1990 that were recovered in 1991. A contrast within a multinomial analysis of variance (Woodward et al. 1990) was used to test the hypothesis that fish from oiled areas have the same survival rate as fish from control areas. The dependent variable was recapture (0,1) and the independent variable was site.

Dolly Varden:

Rocky Bay was the only oiled site included in the analysis since the weirs washed out for three days at Green Island and Eshamy creeks, during the middle of the emigration, and there was no way to predict the number of tagged fish that could have been missed at these two sites.

Cutthroat Trout:

Eshamy Creek was used in the analysis, even though the weir washed out for three days, because the wash-out occurred ten days before the initiation of emigration (Figure 5). Rocky Bay and Green Island were not used in the analysis of survival for cutthroat trout because their sample sizes were so small.

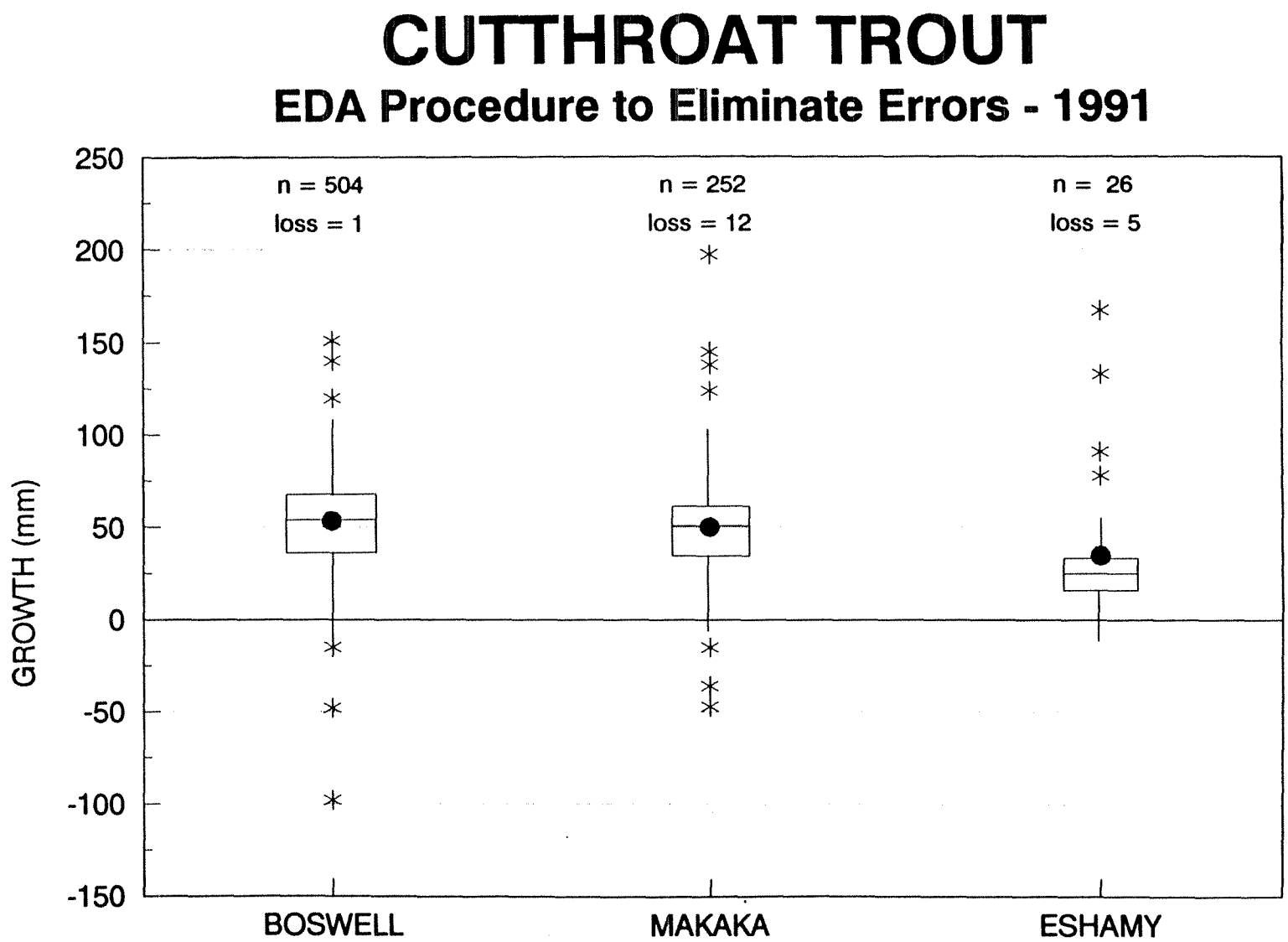

Figure 4. Exploratory data analysis (EDA) procedures used to eliminate recording errors in the cutthroat trout growth data, 1991.

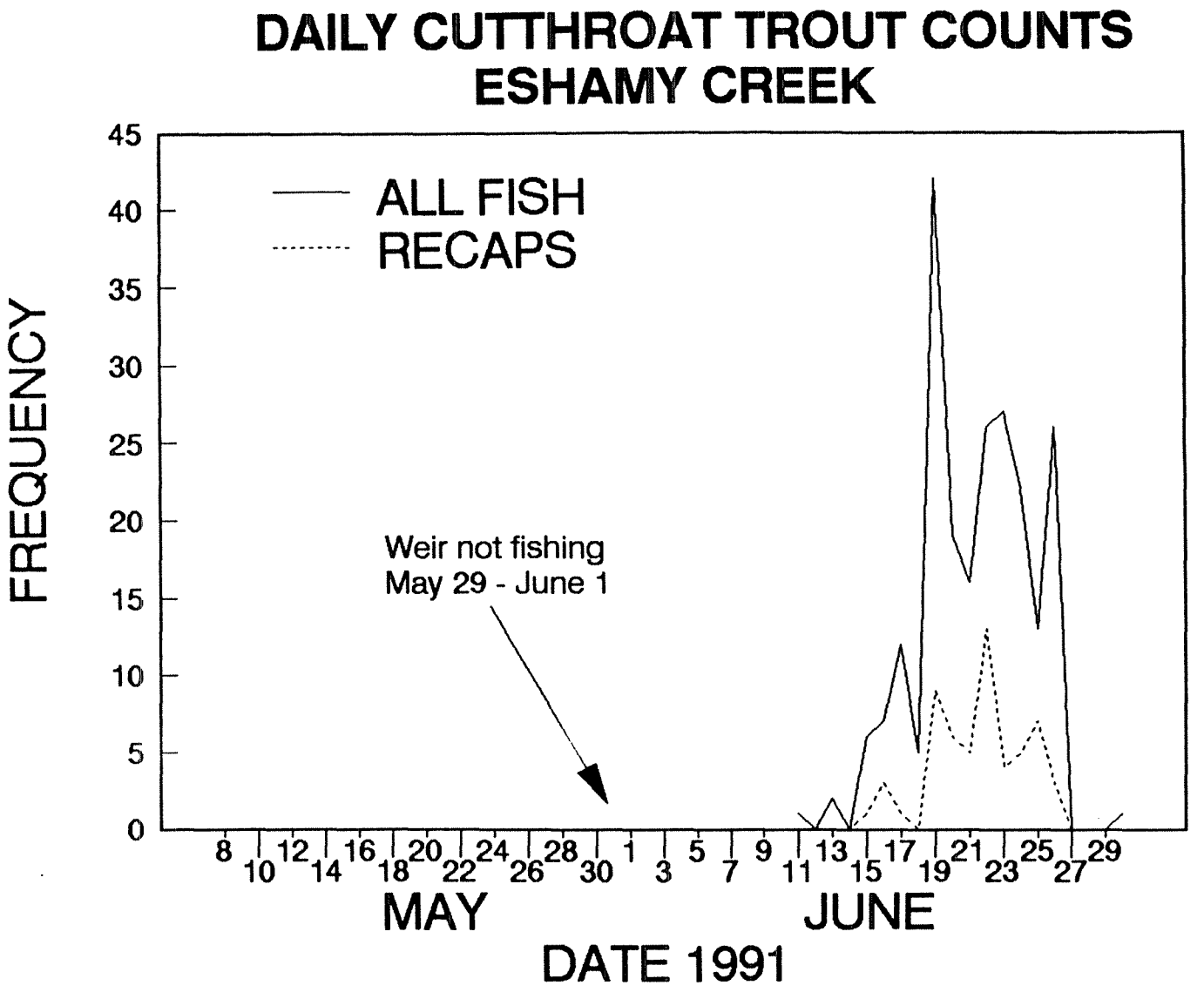

Figure 5. Daily weir counts for cutthroat trout, Eshamy Creek, 1991.

STUDY RESULTS

Comparison of Growth Rates

Dolly Varden:

All growth measurements were within previously reported ranges (Heiser 1965). The analysis of variance showed no significant differences in the growth of Dolly Varden from oiled and control areas ($P = 0.50$; Table 2 and Figures 6 and 7).

Cutthroat Trout:

The ANOVA showed a significant difference in growth between the three sites ($P < 0.001$; Table 3a). Pairwise comparisons with least squares means showed a significant difference between the oiled site and the two control sites (both *p*-values < 0.001) but no significant difference between the two control sites ($P = 0.06$; Table 3b). Eshamy Bay, the oiled site had significantly less growth than the two control sites (Figure 8).

Comparison of Survival Rates

Dolly Varden:

The contrast within the multinomial analysis of variance showed there was a significant difference in the survival rate of Dolly Varden from Rocky Bay, and oiled site, and control areas (Pearson Chi-square, $P < 0.001$; Table 4). The Pearson residuals showed that Dolly Varden from the oiled site had a survival rate less than expected, and fish from control areas had a greater survival rate than expected (Figure 9).

Cutthroat Trout:

The contrast within the multinomial ANOVA showed there was a significant difference in the survival rate of trout from Eshamy Bay, an oiled site, and the control sites (Pearson Chi-square, $P < 0.001$; Table 5). The Pearson residuals showed that trout from the oiled site had a survival rate less than expected, and fish from control areas had a greater survival rate than expected (Figure 10).

Mean length by sex and age groups and age and sex composition for each study group are presented in Appendix Tables 1 and 2 for trout.

Tissue samples collected in 1990 were sent to University of California, Davis, School of Veterinary Medicine for analysis. Tissue samples have been analyzed but the final results were not available for inclusion in this report.

Table 2. Analysis of variance for growth of Dolly Varden, Prince William Sound, 1991.

Source	df	Type I SS	F	P>F
Block	1	128,595		
Treatment	1	4,111	0.50	0.50
Site (treatment)	7	58,007		
Error	6,042	1,336,441		
Total	6,051	1,527,154		

Table 3a. Analysis of variance for growth of cutthroat trout, Prince William Sound, 1991.

SOURCE	df	Type III SS	F	P>F
Site	2	4,907	14.97	<0.001
Length 90	1	167,447		
Error	743	121,757		
Total	746	294,111		

Table 3b. Pairwise comparison of least-square means for cutthroat trout, Prince William Sound, 1991.

	Makaka	Eshamy
Boswell	0.062	0.0001
Makaka		0.0001

Table 4. Multinomial analysis of variance for survival rates of Dolly Varden, Prince William Sound, 1991.

Site	Observed Proportions	ML Predicted Proportions	N
BOSWELL	0.1908	0.1776	7,027
MAKAKA	0.1815	0.1742	12,669
ROCKY	0.1644	0.1759	15,962

PEARSON CHI-SQUARE = 27.660
DF = 1
P < 0.001

Table 5. Multinomial analysis of variance for survival rates of cutthroat trout, Prince William Sound, 1991.

Site	Observed Proportions	ML Predicted Proportions	N
BOSWELL	0.3695	0.3517	1,375
MAKAKA	0.3008	0.2754	841
ESHAMY	0.1159	0.3136	233

PEARSON CHI-SQUARE = 46.923
DF = 1
P = < 0.001

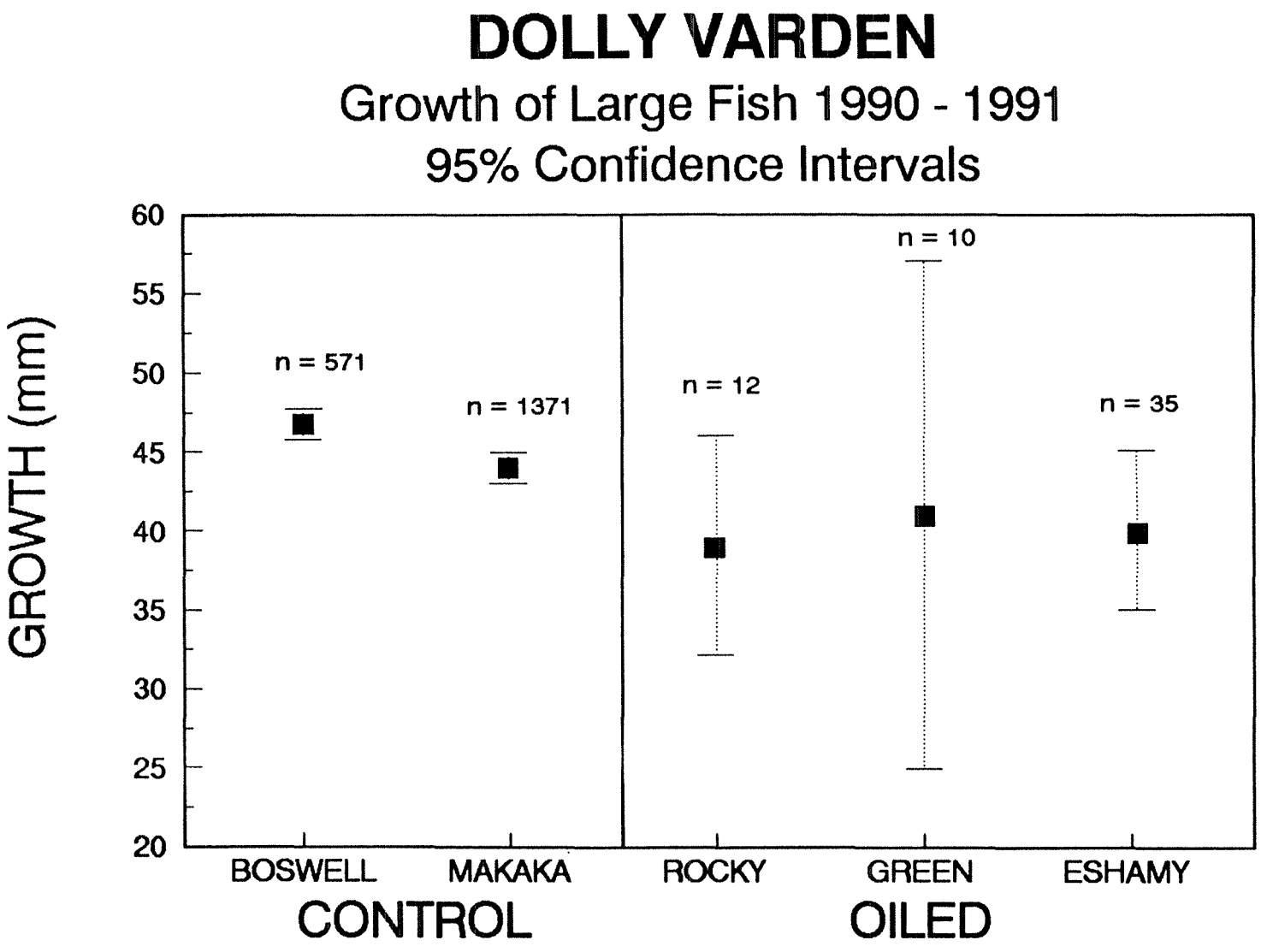

Figure 6. Means and 95% confidence intervals for growth of large (> 270 mm FL) Dolly Varden, 1991.

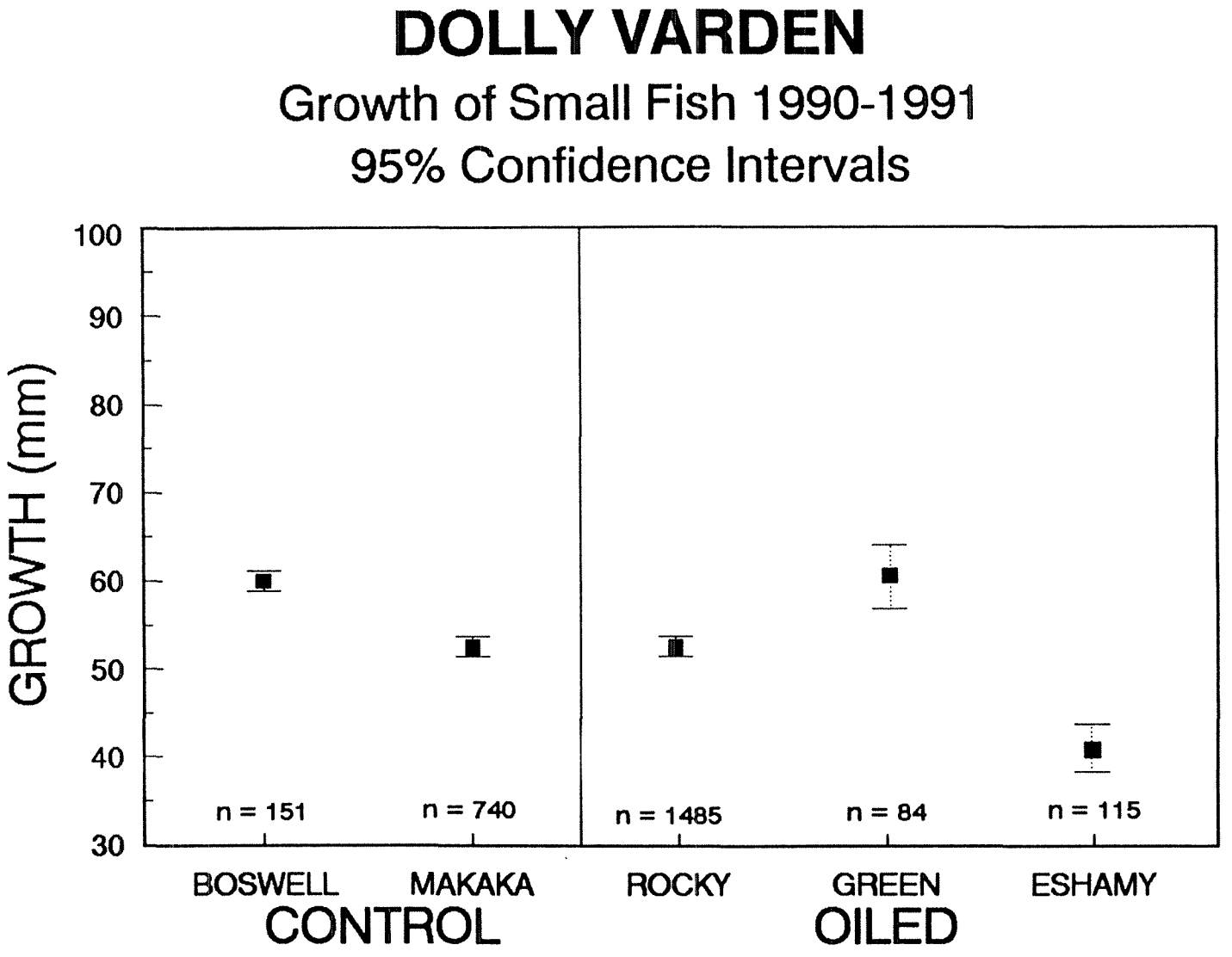

Figure 7. Means and 95% confidence intervals for growth of small (≤ 270 mm FL) Dolly Varden, 1991.

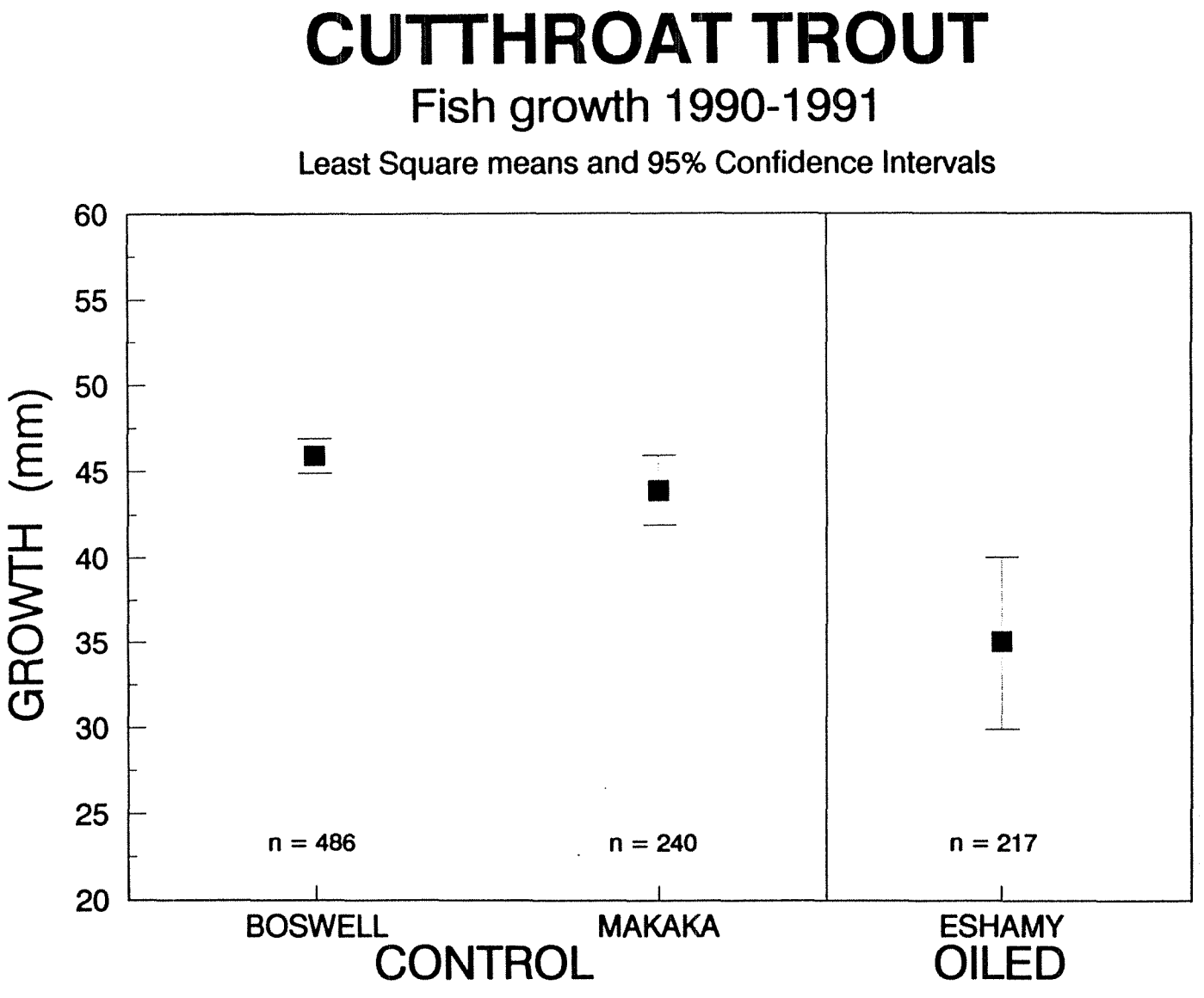

Figure 8. Least-square means and 95% confidence intervals for cutthroat trout growth, 1991.

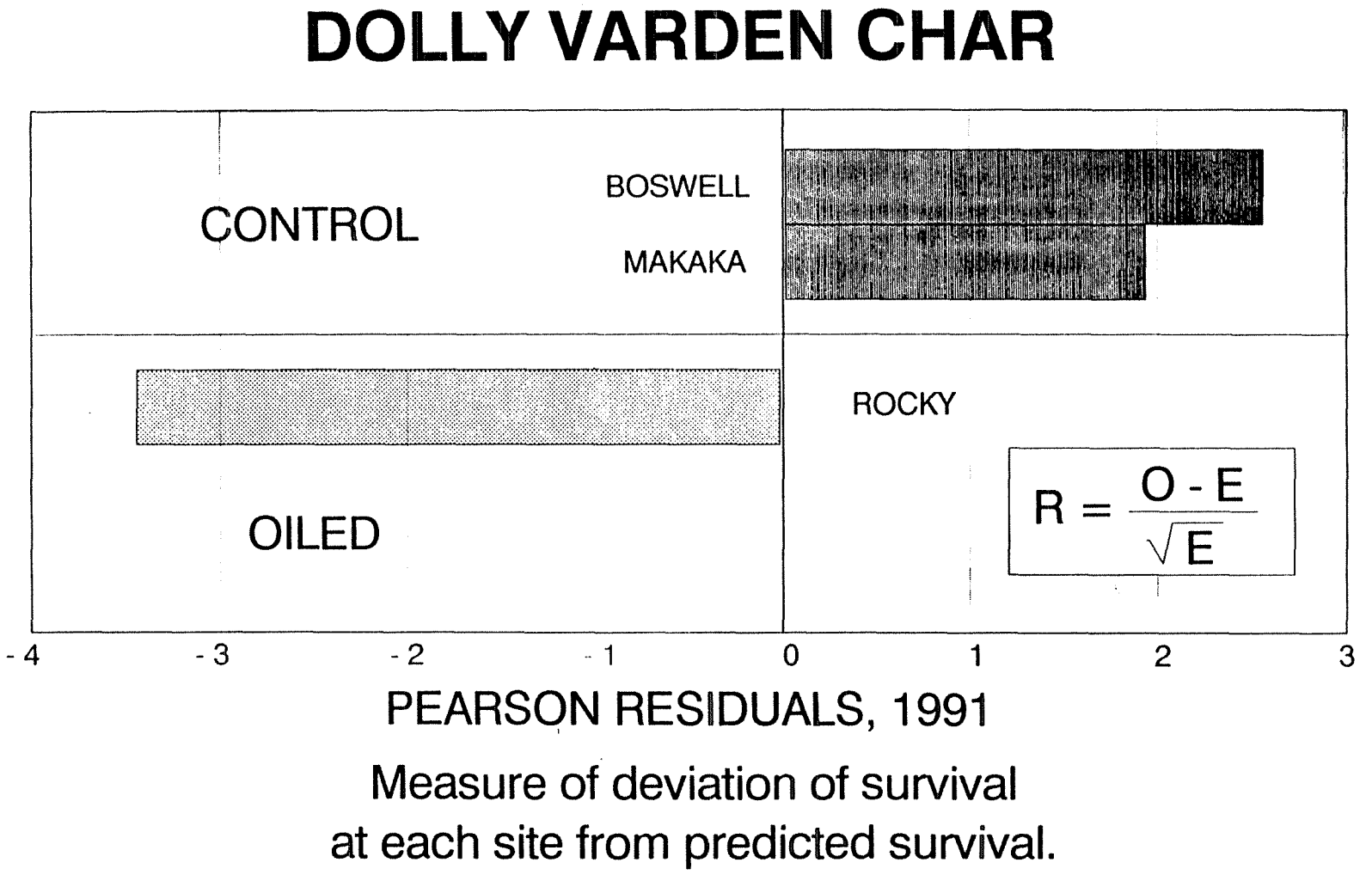

Figure 9. Pearson residuals for analysis of survival of Dolly Varden, 1991.

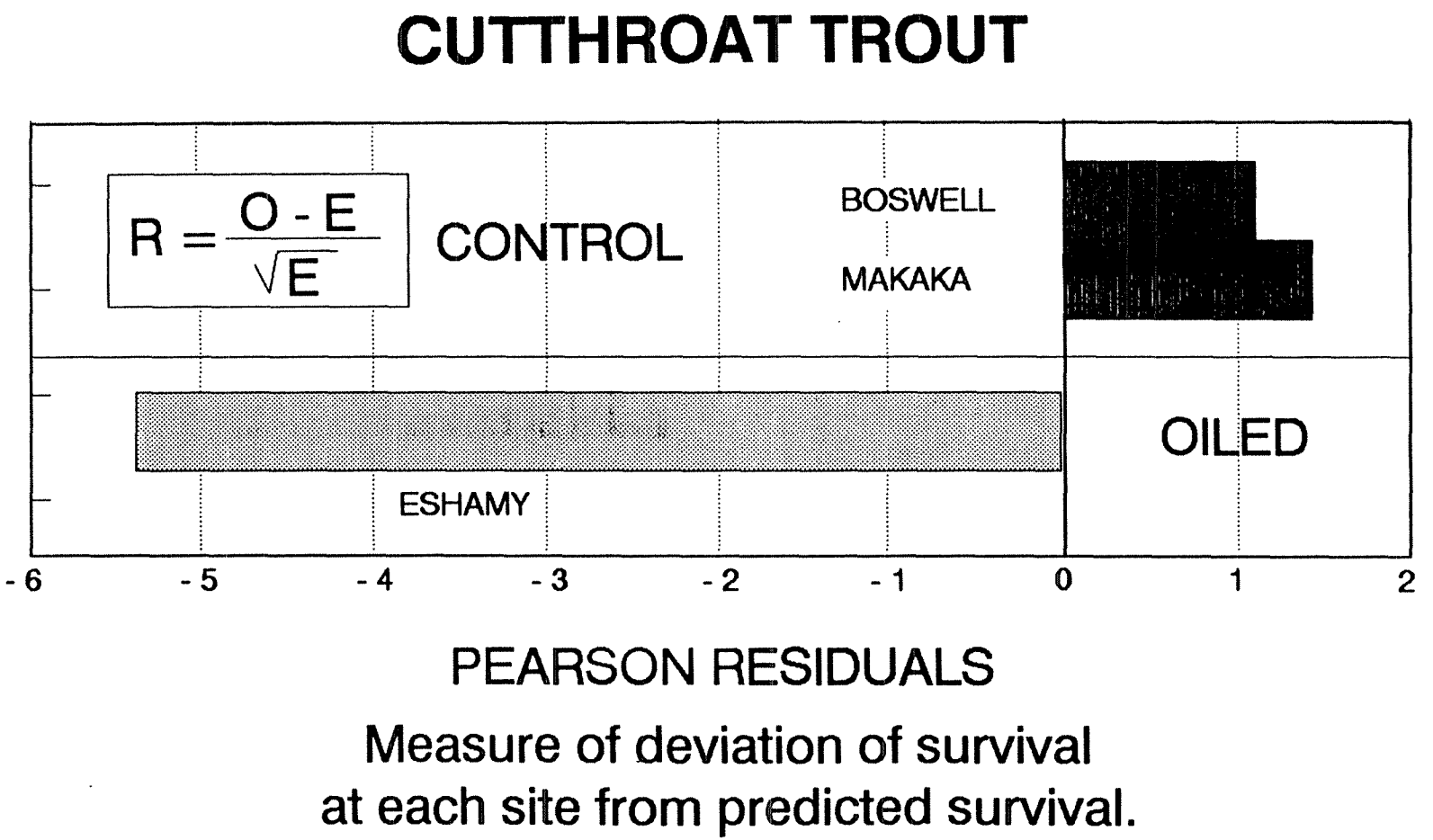

Figure 10. Pearson residuals for analysis of survival of cutthroat trout, 1991.

STATUS OF INJURY ASSESSMENT

Emigrating salmonids, especially Dolly Varden, are sensitive to oil exposure as they undergo the physiological changes associated with the transition of moving from freshwater into marine waters (Moles et al. 1979). Bioassays have shown that the presence of crude oil in low concentrations can affect their migratory behavior and survival of the prey of these species. High concentrations may directly impair growth and survival rates of both Dolly Varden and trout (Malins and Hodgins 1981). Since both Dolly Varden and trout commonly live to 8 years (Morrow 1980), the potential exists for both short-term and long-term effects from exposure to oil. Study of these species is crucial in that they represent the only finfish species in the assessment program whose adult life stage inhabit the most oil-affected areas (the near-shore waters) for extensive periods of time. A measurable, detrimental impact on these anadromous stocks of trout and Dolly Varden may result in a loss in opportunity for the recreational fisheries supported by these stocks. The status of recreational fisheries will be investigated through an ongoing postal survey (Mills 1989).

Comparison of Growth Rates

There was a highly significant difference in the growth of trout from an oiled site and control sites. Trout from Eshamy Creek, an oiled site, grew 71% slower than fish from control sites. It should also be noted that the least squares means of growth were very similar for the control sites (47 mm for Boswell Bay and 44 mm for Makaka Creek). This is another indication that trout from control sites probably were exposed to similar environmental conditions and the natural variability between undisturbed sites is small.

There was not a significant difference in the growth of Dolly Varden from control and oiled sites.

There was not a significant difference in mean-length-at-age of Dolly Varden among oiled and control groups in 1989 which indicates that fish of the same size grow at the same rate regardless of their overwintering location (Hepler et al 1989). Since overwintering populations of Dolly Varden and trout are composed of many different genetic stocks (Armstrong 1965) and the ambient climates in the experimental areas of PWS are similar, differences in mean growth rates were not expected. This was further supported by examining the mean growth patterns between 1990 and 1991. In 1991, mean growth values for both control and oiled study sites were consistently lower for trout and Dolly Varden than reported in 1990. This would indicate that fish from both control and oiled sites were exposed to similar climatic changes. Therefore, significant differences in average growth rates between control and oiled sites can be attributed to some external disturbance such as exposure to oil.

Comparison of Survival Rates

There were significant differences in the mortality rates of Dolly Varden and trout from an oiled site and control sites. Dolly Varden from Rocky Bay, an oiled site, had a 12% higher mortality rate than fish from control sites. Cutthroat trout from Eshamy Creek, an oiled site, had a 65% higher mortality rate than fish from control areas. It was necessary to account for any possible sources of variation in order to show that the differences in the mortality rates could be attributed to exposure to oil. The possible sources of variation include: differential fishing mortality, tag loss, weir washout, and migratory behavior. The two possible sources of fishing mortality are from the commercial and sport fisheries. It was concluded that fishing mortality was not significant in either fishery. A high proportion of the commercial catch was examined by Commercial Fisheries Division at the major canneries in PWS in 1990 and no tagged fish were recovered. The greatest opportunity for commercial interception of tagged fish is in the gill net fishery that operates in the Eshamy Subdistrict. The mesh size used in the gill nets is large enough that trout and Dolly Varden rarely become entangled. This was evidenced by the fact that only 12 tags were voluntarily turned in by gill netters in 1990. The creel survey that was conducted in 1989 did not recover any tagged fish so Division of Sport Fish did not operate a creel survey in PWS in 1990. Anglers did voluntarily turn in 20 tagged fish during 1990. Ninety percent of these fish were originally tagged in control sites. Tag loss was less than 3% for both trout and Dolly Varden, therefore, tag loss was a not significant source of variation. The integrity of the weirs was maintained throughout the emigration for Dolly Varden and trout at the control sites and at Rocky Bay, an oiled site, which meant that all the emigrating fish were examined for tags. The weir was maintained at Eshamy Creek, an oiled site, throughout the emigration of trout which meant that all emigrating trout were examined for tags.

Another possible source of variation is that tagged fish did not return to the original site of tagging and overwintered in another location. Over 90% tagged Dolly Varden and trout were recaptured at their original tagging location (Figures 11, 12, 13, and 14). This high degree of homing supports the assumption that Dolly Varden and trout in PWS exhibit migratory behavior similar to that reported by Armstrong and Morrow (1980) and Jones (1982) and support the original experimental design. In addition, there is a substantial amount of literature to support that Dolly Varden and trout spawn in their natal streams (Armstrong 1967, Armstrong and Winslow 1968, Johnston 1981, Jones 1982, Campton and Utter 1987, Trotter 1989, and Sonnichsen in press). The strong homing tendency supports the theory that fish of spawning size tagged in 1990 will return to their natal stream or their original tagging site in 1991.

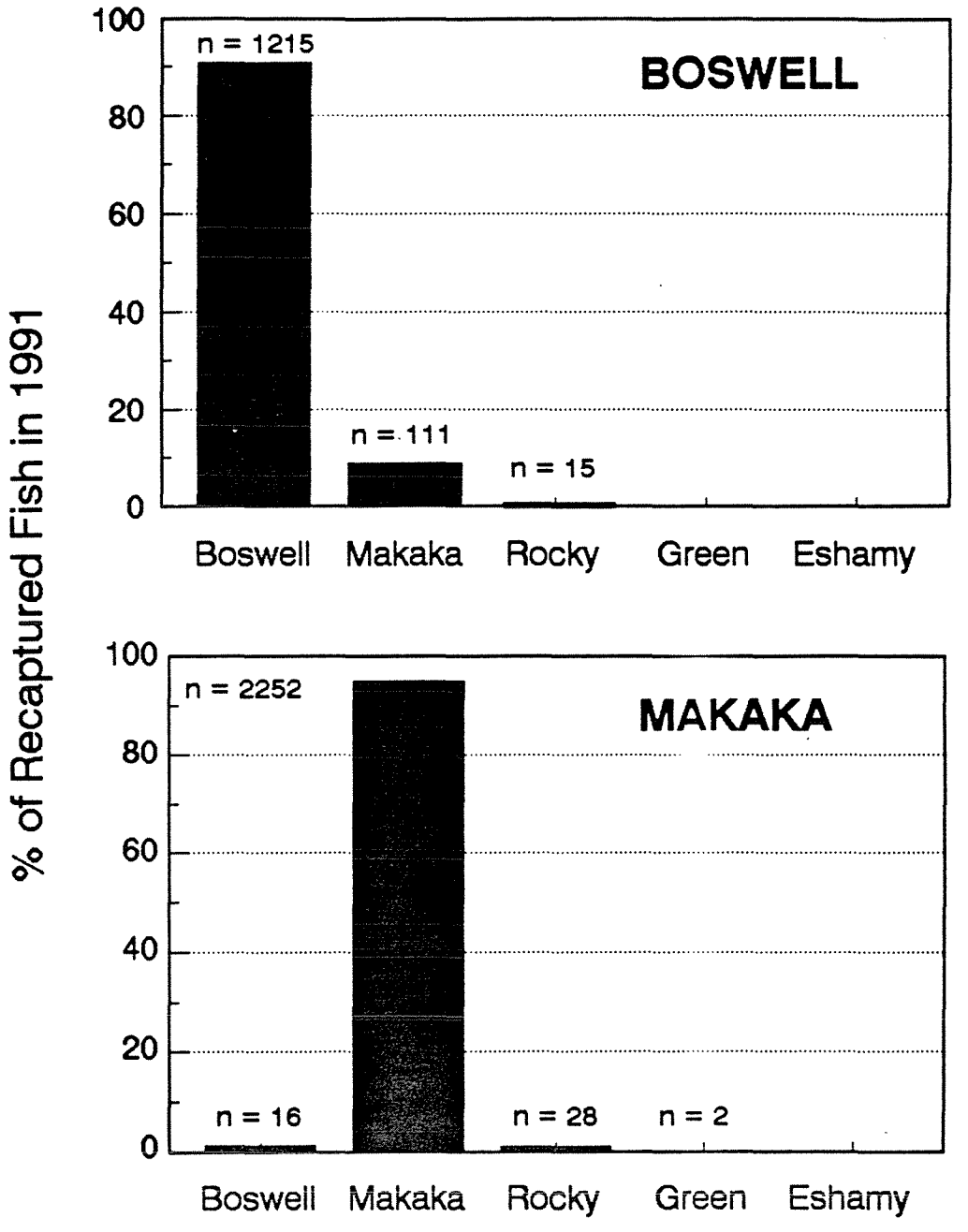

Figure 11. Locations of recaptured Dolly Varden from control sites in 1991.

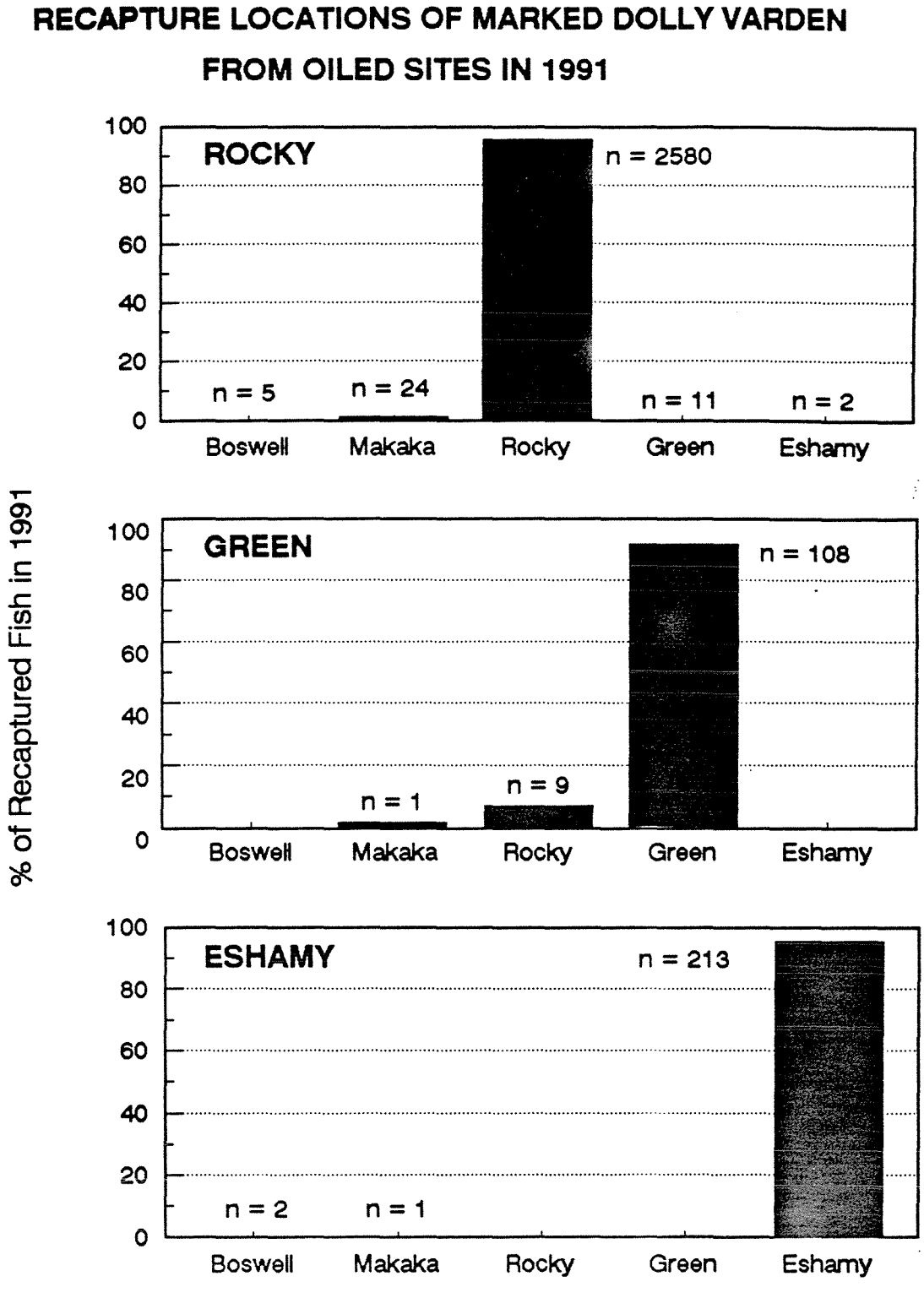

Figure 12. Locations of recaptured Dolly Varden from oiled sites in 1991.

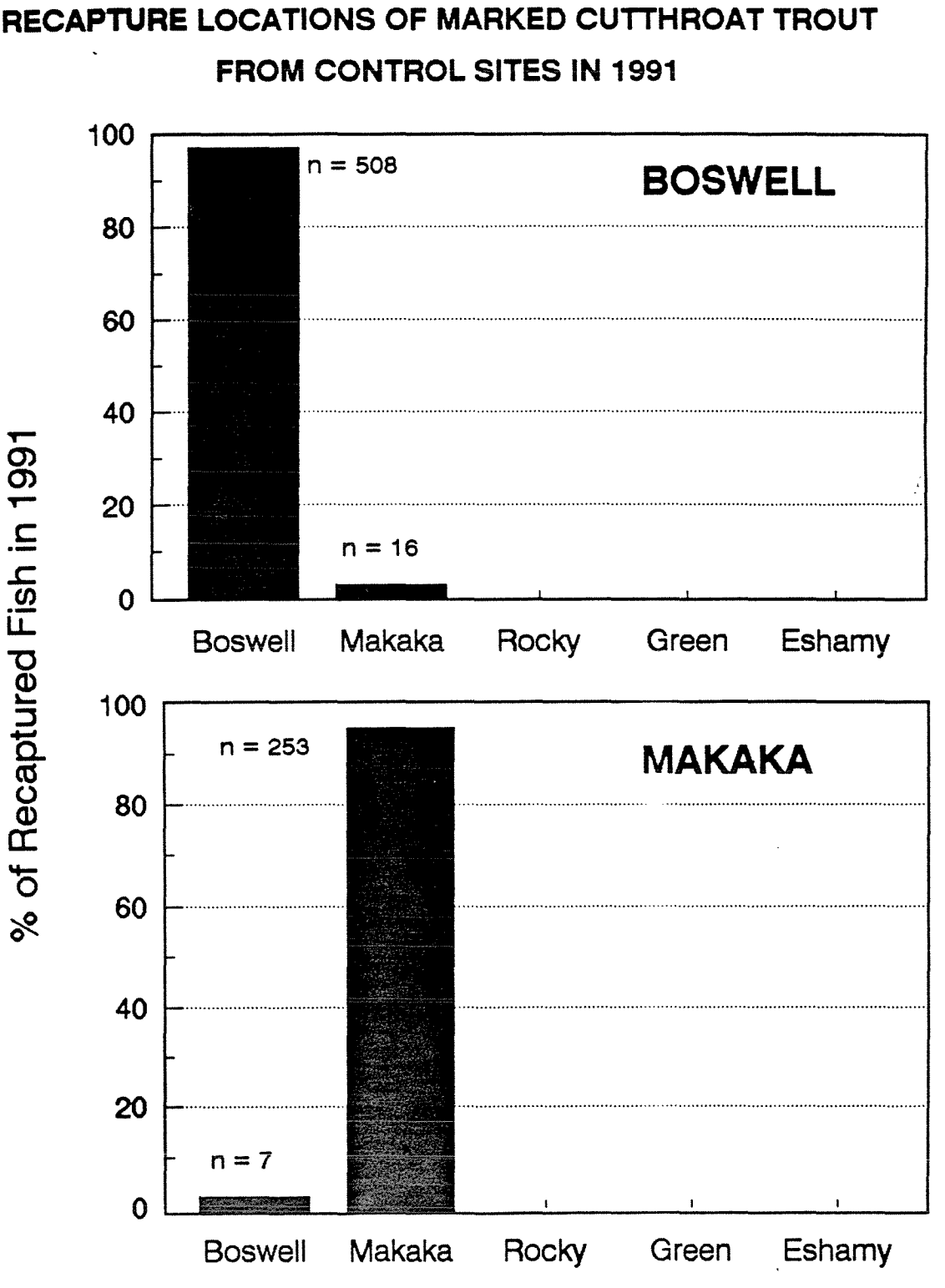

Figure 13. Locations of recaptured cutthroat trout from control sites in 1991.

RECAPTURE LOCATIONS OF MARKED CUTTHROAT TROUT FROM OILED SITES IN 1991

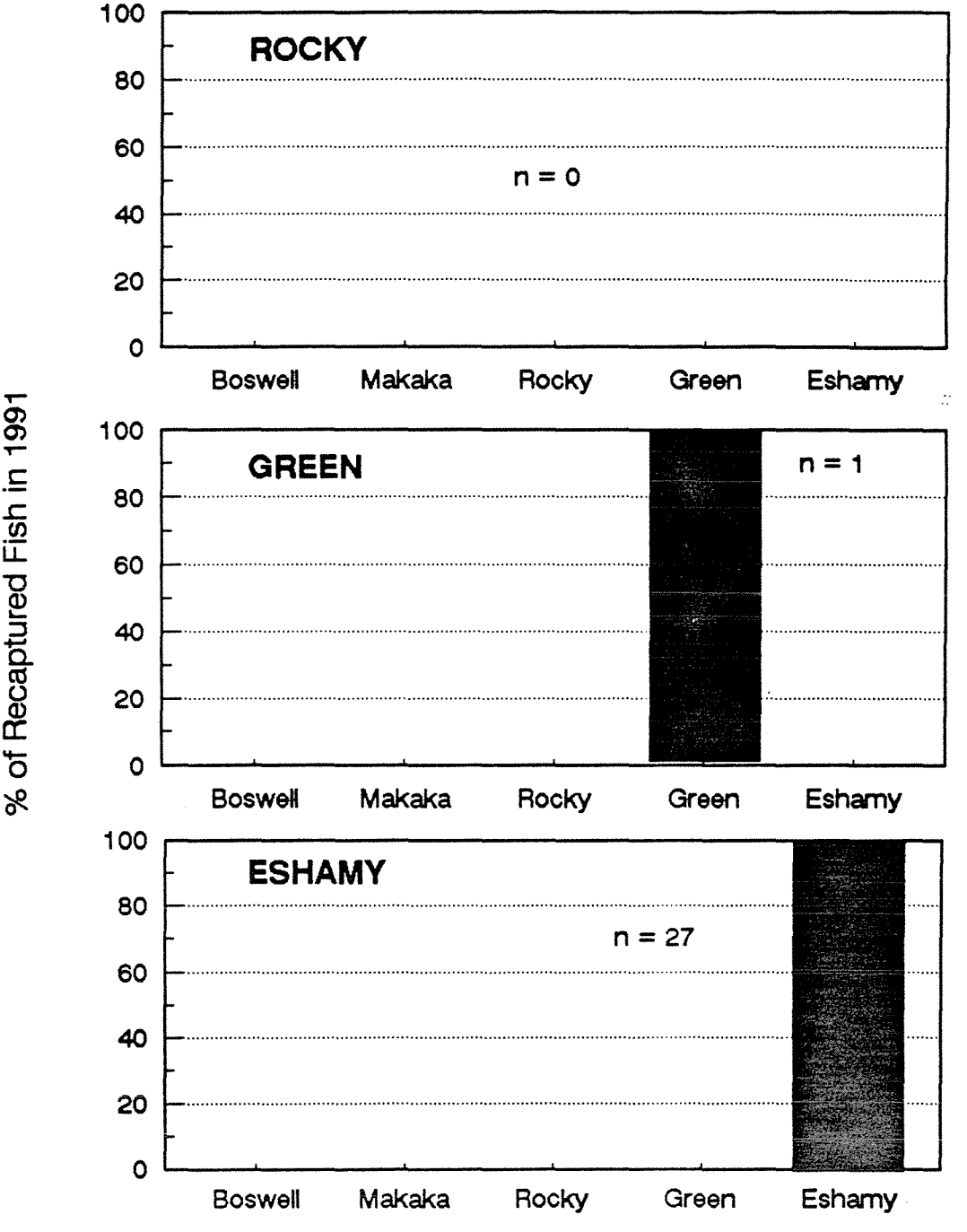

Figure 14. Locations of recaptured cutthroat trout from oiled sites in 1991.

Overall, there was highly significant difference in the growth of trout from oiled and control sites. There was not a significant difference in the growth rates of Dolly Varden from oiled and control sites. There was also a significant difference in the mortality rates of Dolly Varden and trout from an oiled site and control sites. Cutthroat trout from Eshamy Creek, an oiled site, had a 65% higher mortality rate than fish from control areas. Dolly Varden from Rocky Bay, an oiled site, had a 12% higher mortality rate than fish from control sites. The possible sources of variation were not found to be significant and therefore differences in mortality between control and oiled sites can be attributed to some external disturbance such as oil exposure.

RESTORATION ALTERNATIVES

We strongly recommend that the Dolly Varden\cutthroat trout project continue as a monitoring program through Oil Year 4. This project will verify whether the initial damage inflicted on these resources as a result of EVOS has persisted. The degree to which these populations remain affected by oil pollution provides a quantitative indication of ecosystem recovery. The Dolly Varden\cutthroat Damage Assessment Project was designed to measure the effects of oil on growth and survival of these two species. The project has conclusively documented damage to these species in the year following EVOS that has resulted in the overall loss of opportunities for recreational anglers in PWS. Dolly Varden and cutthroat trout are both important components of the recreational fisheries in PWS and these fisheries offer a diverse and often unique range of angling opportunities. The Division of Sport Fish recommends replacing lost recreational opportunities by directing human use. Implementation of the objective will be carried out through the development of a special management plan which will provide for responsible and orderly development of fisheries which will protect the biological integrity of wild stocks and provide recreational benefit to all users. The Division of Sport Fish of Alaska Department of Fish and Game, already has an ongoing restoration project, which was approved by the Restoration Work Group, that will provide some of the necessary elements for development of this special management plan.

A monitoring program through Oil Year 4 will provide two necessary pieces of information for the development of our restoration strategy: 1) persistence of injury; and 2) development of a model to predict population dynamics given changes in survival, growth, and fishing mortality. We have documented significant reductions in growth and survival for the period 1989 to 1990 and we have nearly conclusive evidence that injury to oiled stocks persisted between 1990 and 1991. Data collected in the spring of 1992 will, without a doubt, allow us to estimate differences in growth between 1991 and 1992 and survival between 1990 and 1991. If the populations are censused as they were in 1989, we will also measure differences in survival between 1991 and 1992. These data will

provide important information on the persistence of oil and an important gauge by which to evaluate restoration alternatives for human use.

This project would also provide logistical support for a proposed restoration science study proposal entitled "Assessment of Genetic Stock Structure of Salmonids for Restoration Planning and Monitoring".

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Appendix

Appendix Table 1. Mean length, in millimeters, by sex and age group of cutthroat trout sampled from weirs in Prince William Sound, 1991.

	Age Group						
	2	3	4	5	6	7	TOTAL
Boswell*							
Female							
Average		230	352	348	364	391	348
SE		11.0	19.3	14.6	10.1		11.9
Sample Size		2	4	5	6	1	19
Male							
Average	221	282	317	350	343	370	335
SE		23.1	9.3	7.4	20.3	17.8	7.0
Sample Size	1	3	8	17	5	4	38
All							
Average	221	249	292	339	343	365	318
SE		7.0	6.5	4.7	8.7	10.6	4.2
Sample Size	1	15	43	54	23	8	146
Makaka*							
Female							
Average				332			332
SE				17.5			17.5
Sample Size				2			2
Male							
Average							
SE							
Sample Size							
All							
Average		273	321	341	341	378	333
SE		17.2	5.0	3.8	7.4	11.5	3.2
Sample Size		7	49	61	23	5	146

(continued)

Appendix Table 1. Mean length, in millimeters, by sex and age group of cutthroat trout sampled from weirs in Prince William Sound, 1991. (continued)

	Age Group						
	2	3	4	5	6	7	TOTAL
Rocky							
All							
Average							
SE							
Sample Size							
Green							
All							
Average		222	230	312		328	240
SE		6.3	5.5				11.7
Sample Size		8	2	1		1	12
Eshamy							
Female							
Average		267	295	344	342	345	333
SE		3.0	17.0	6.8	5.3	13.7	5.1
Sample Size		2	8	15	21	5	51
Male							
Average		242	276	324	330	358	312
SE		21.1	20.5	11.4	10.4	11.6	8.3
Sample Size		4	10	19	8	6	47
All							
Average		250	278	329	339	352	319
SE		14.4	12.0	7.2	4.8	8.6	4.9
Sample Size		6	21	36	29	11	103

(continued)

Appendix Table 1. Mean length, in millimeters, by sex and age group of cutthroat trout sampled from weirs in Prince William Sound, 1991. (continued)

	Age Group						
	2	3	4	5	6	7	TOTAL
All sites*							
Female							
Average		249	314	343	347	353	336
SE		11.7	14.9	5.6	4.9	13.5	4.7
Sample Size		4	12	23	27	6	73
Male							
Average	221	259	295	336	335	380	333
SE		16.4	12.8	7.2	9.7	9.2	5.6
Sample Size	1	7	18	36	13	11	86
All							
Average	221	248	301	337	341	360	321
SE		5.7	4.3	2.3	3.9	5.9	2.4
Sample Size	1	36	115	153	75	25	408

* 2 cutthroat trout at age 8 yrs (1 female, 1 unsexed) from Boswell Creek and 1 cutthroat trout at age 9 yrs (unsexed) from Makaka Creek were not included in this table.

Appendix Table 2. Age and sex composition of cutthroat trout sampled at weir sites in Prince William Sound, 1991.

	Age Group						
	2	3	4	5	6	7	TOTAL
Boswell*							
Female							
Sample Number		2	4	5	6	1	19
% of Sample		11	21	26	32	5	95
SE		.72	.96	1.04	1.10	.53	
Male							
Sample Number	1	3	8	17	5	4	38
% of Sample	3	8	21	45	13	11	100
SE	.26	.44	67	.82	.56	.50	
All							
Sample Number	1	15	43	54	23	8	144
% of Sample	1	10	29	37	16	5	98
SE	.07	.25	.38	.40	.30	.19	
Makaka*							
Female							
Sample Number				2			2
% of Sample				100			100
SE				.00			
Male							
Sample Number							
% of Sample							
SE							
All							
Sample Number		7	49	61	23	5	145
% of Sample		5	34	42	16	3	100
SE		.18	.39	.41	.30	.15	
Rocky							
All							
Sample Number							
% of Sample							
SE							

(continued)

Appendix Table 2. Age and sex composition of cutthroat trout sampled at weir sites in Prince William Sound, 1991. (continued)

	Age Group						
	2	3	4	5	6	7	TOTAL
Green							
All							
Sample Number		8	2	1		1	12
% of Sample		67	17	8		8	100
SE		1.42	1.12	.83		.83	
Eshamy							
Female							
Sample Number		2	8	15	21	5	51
% of Sample		4	16	29	41	10	100
SE		.27	.51	.64	.70	.42	
Male							
Sample Number		4	10	19	8	6	47
% of Sample		8	21	40	17	13	100
SE		.41	.60	.72	.55	.49	
All							
Sample Number		6	21	36	29	11	103
% of Sample		6	20	35	28	11	100
SE		.23	.40	.47	.45	.31	
All Sites							
Female							
Sample Number		4	12	23	27	6	72
% of Sample		5	16	32	37	8	98
SE		.27	.44	.55	.57	.32	
Male							
Sample Number	1	7	18	36	13	11	86
% of Sample	1	.8	21	42	15	13	100
SE	.12	.30	.44	.54	.39	.36	
All							
Sample Number	1	36	115	153	75	25	405
% of Sample	1	9	28	38	18	6	100
SE	.02	.14	.22	.24	.19	.12	

* 2 cutthroat trout at age 8 yrs (1 female, 1 unsexed) from Boswell Creek and 1 cutthroat trout at age 9 yrs (unsexed) from Makaka Creek were not included in this table.