IDAHO HABITAT EVALUATION

FOR OFF-SITE MITIGATION RECORD

Annual Report 1987

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EXECUTIVE SUMMARY

The Idaho Department of Fish and Game has been monitoring and evaluating existing and proposed habitat improvement projects for steelhead (Salmo gairdneri) and chinook salmon (Oncorhynchus tshawytscha) in the the Clearwater and Salmon River drainages over the last four years. Projects included in the evaluation (Figure 1) are funded by, or proposed for funding by, the Bonneville Power Administration (BPA) under the Northwest Power Planning Act as off-site mitigation for downstream hydropower development on the Snake and Columbia rivers. This monitoring project is also funded under the same authority (Fish and Wildlife Program, Northwest Power Planning Council).

A mitigation record is being developed to use increased smolt production at full seeding as the best measure of benefit from a habitat enhancement project. Determination of full benefit from a project depends on presence of adequate numbers of fish to document actual increases in fish production. The depressed nature of upriver anadromous stocks have precluded attainment of full benefit of any habitat project in Idaho. Partial benefit will be credited to the mitigation record in the interim period of run restoration.

According to the BPA Work Plan, project implementors have the primary responsibility for measuring physical habitat and estimating habitat change. To date, Idaho habitat projects have been implemented primarily by the U.S. Forest Service (USFS). The Shoshone-Bannock Tribes (SBT) have sponsored three projects (Bear Valley Mine, Yankee Fork, and the proposed East Fork Salmon River projects). IDFG implemented two barrier-removal projects (Johnson Creek and Boulder Creek) that the USFS was unable to sponsor at that time. The role of IDFG in physical habitat monitoring is primarily to link habitat quality and habitat change to changes in actual, or potential, fish production.

Estimation of anadromous fish response to BPA habitat projects in Idaho is generally the responsibility of IDFG. However, the SBT have primary responsibility for the three projects that they have sponsored. IDFG and SBT have worked jointly to ensure that data collected by both entities are compatible.

Approaches to monitor habitat projects and document a record of credit were developed in 1984-1985. The IDFG monitoring and evaluation approach consists of three basic, integrated levels: general monitoring, standing crop evaluations, and intensive studies. Annual general monitoring of anadromous fish densities in a small number of sections for each project will be used to follow population trends and define seeding levels. For most projects, standing crop production estimates of parr will be used to estimate smolt production by factoring appropriate survival rates from parr to smolt. Intensive studies will determine Parr-to-smolt survival rates and provide other basic information that is needed for evaluation of the Fish and Wildlife Program.

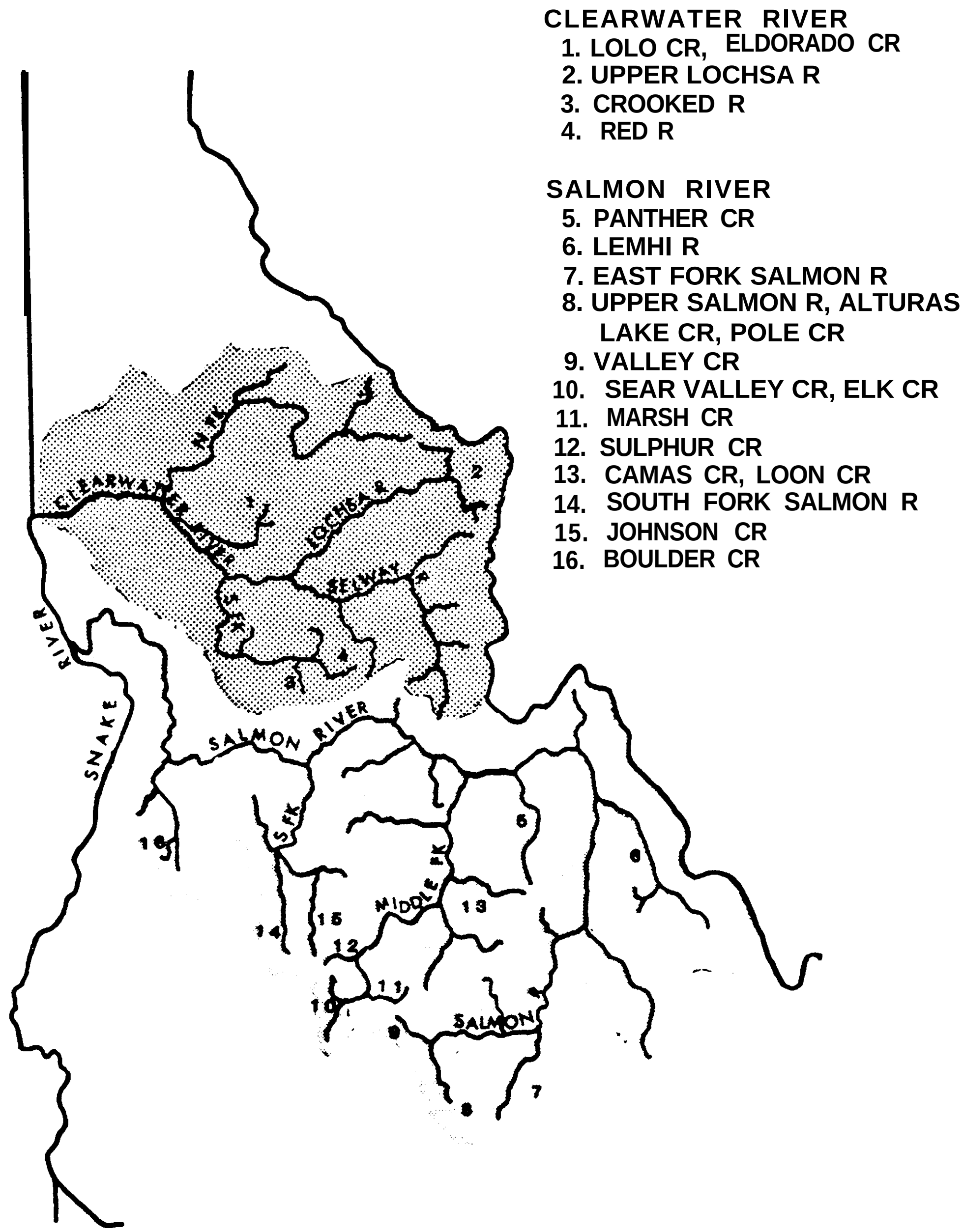

Figure 1. BPA habitat project areas in Clearwater River and Salmon River drainages.

The relationship of general level studies to intensive studies is depicted in Figure 2. Data compartments depicted by square boxes will be components of both general and intensive level evaluations. The general monitoring studies will be confined to these types of data.

Intensive level studies will include information collected by general monitoring and will add quantitative assessments through weir counts of adult escapements and smolt production.

Data collected through other management activity and research will complement the monitoring and evaluation data base. These data compartments are depicted in Figure 2 by hexagons. Integration of these data components will assist in defining realistic estimates of smolt production and adult production.

General monitoring and evaluation of BPA habitat projects during 1984-1987 document the depressed status of wild and natural steelhead and chinook populations (Petrosky and Holubetz, Part I). Population levels have improved from the early 198Os, and parr densities of wild chinook increased 2.6 fold from 1984 to 1987 in the monitoring sections.

A parallel IDFG-funded monitoring program was established in 1985 to index anadromous fish abundance in the remainder of the Clearwater, Salmon, and Snake River subbasins in Idaho. General monitoring data indicate that potential chinook production is higher in low-gradient habitats, whereas steelhead production is optimal in steeper stream reaches. Increased sedimentation reduces production potential for both species (Petrosky and Holubetz, Part I; Welsh, Part II).

Benefits (parr production) attributed to implemented BPA habitat projects through 1987 have been relatively small due to depressed populations and lag time in habitat response. To date, none of the four instream structure projects have produced major benefits. Additions of new increments of habitat through barrier removal (Welsh, Part II; Holubetz and Petrosky, Parts V and VI), or development of off-channel rearing ponds appear among the most effective ways to increase production potential. The potential benefits are also high for sediment-reduction projects in the Idaho Batholith. Production efficiency can be increased in various life stages by significant decreases in sediment. These changes in production efficiency will yield significant benefits at all seeding levels. In some cases, such as the Bear Valley Creek drainage, success of BPA-funded projects to reduce sediment depends on concurrent land management improvements (Petrosky and Holubetz, Part I - Appendix C).

There are a number of suitable techniques for monitoring changes in sediment levels (Torquemada and Platts, Part III). Results from most of the techniques correlated strongly. A two-step sampling design was recommended for general inventories using ocular surface monitoring techniques (first step) combined with more intensive methods such as measured embeddedness at a subsample of locations (second step) to provide estimates with increased precision at relatively low cost.

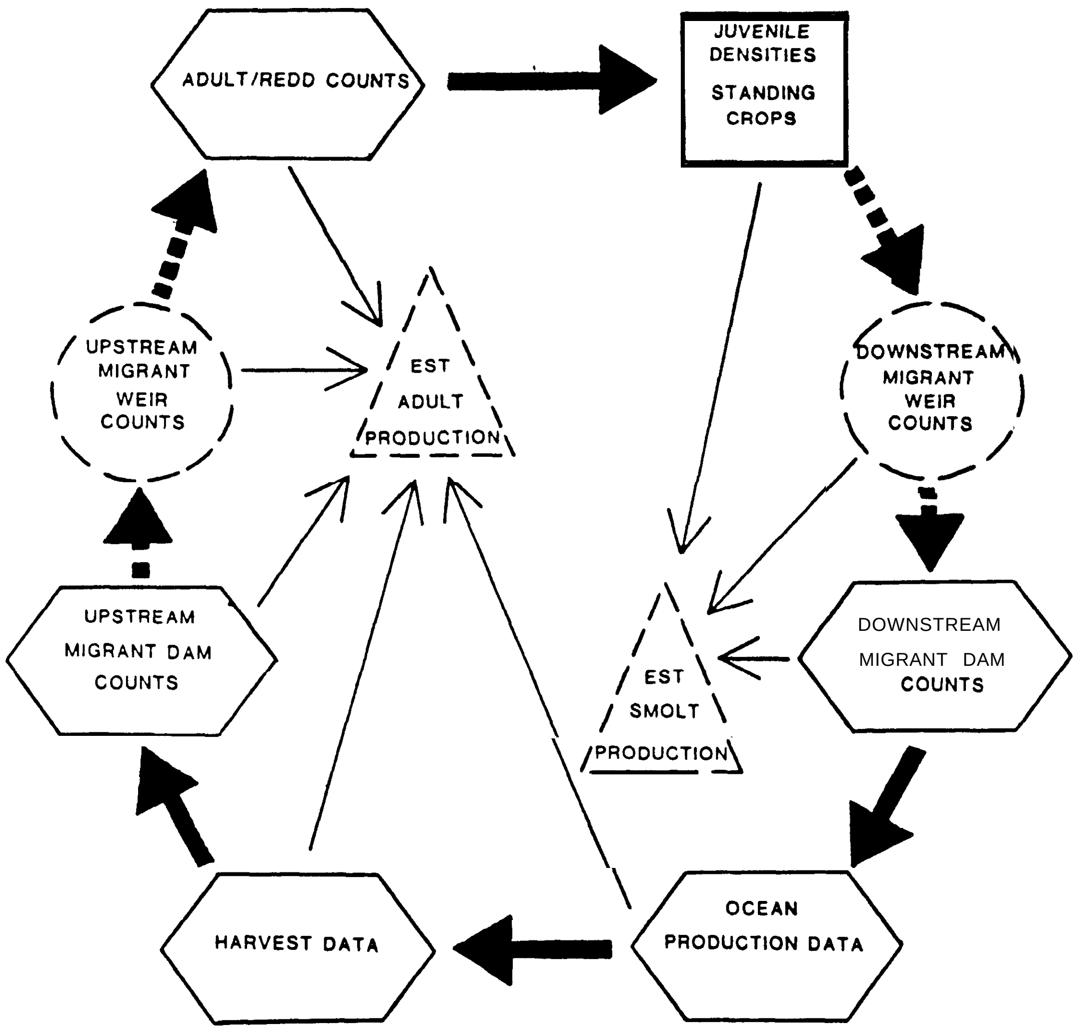

Figure 2. Relationships of major data compartments to estimated production of smolts and adults. General evaluation and monitoring will link (chinook) redd counts and juvenile densities or standing crops. Intensive studies will link actual spawning escapements, redd counts, juvenile densities, and downstream migrants.

Standardization of sediment variables is needed particularly at the general inventory level to make data from different sources compatible, Additional work is needed to define effects of sediment level changes on all life stages of anadromous fish.

Intensive studies were begun in 1987 in the upper Salmon River and Crooked River (South Fork Clearwater River tributary) to determine quantitatively the relationships between spawning escapement, parr product ion, and smolt production (Kiefer and Apperson, Part IV). The studies incorporate data from general monitoring and rely on weirs to trap adults and juvenile migrants. PIT tags (passive integrated transponder) are being inserted into juvenile fish to determine parr-to-smelt survival rates. They will also provide other basic information such as smolt. migration timing, effects of flow, spill and bypass on smolt survival, upstream migration timing, etc. PIT tags can provide a major key to extrapolating survival rates between fish populations in streams with different stocks, habitat types, flow regime, and sediment levels.

A physical habitat and fish population data base is being developed for every BPA habitat project in Idaho to develop the record of credit for off-site' mitigation. These data combined with data from other Idaho streams will serve to monitor progress of the Fish and Wildlife Program.

Success of the entire Fish and Wildlife Program will be determined ultimately by the restoration of runs that are affected by hydropower operation, particularly the runs of depressed upriver stocks, Successful on-site mitigation to increase passage survival through improved flows and bypass systems is essential to the success of off-site mitigation projects implemented in Idaho.

Part I

Subproject I

IDAHO HABITAT EVALUATION FOR OFF-SITE MITIGATION RECORD

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INTRODUCTION

The Idaho Department of Fish and Game (IDFG) has been conducting an evaluation of proposed and existing habitat improvement projects for steelhead (Salmo gairdneri) and chinook salmon (Oncorhynchus tshawytscha) in the Clearwater River and Salmon River drainages over the last four years. Projects included in the evaluation are funded by or proposed for funding by the Bonneville Power Administration (BPA) under the Northwest Power Planning Act as off-site mitigation for downstream hydropower development on the Snake and Columbia rivers. This evaluation project is also funded under the same authority (Fish and Wildlife Program, Northwest Power Planning Council).

A mitigation record is being developed to use increased smolt production (i.e., yield) at full seeding as the best measure of benefit from a habitat enhancement project. Determination of full benefit from a project depends on completion or maturation of the project and presence of adequate numbers of fish to document actual increases in fish production. The depressed nature of upriver anadromous stocks have precluded measuring full benefits of any habitat project in Idaho. Partial benefit will be credited to the mitigation record in the interim period of run restoration.

According to the BPA Work Plan (BPA 1985), project implementors have the major responsibility for measuring physical habitat and estimating habitat change. To date Idaho habitat projects have been implemented primarily by the U.S. Forest Service (USFS). The Shoshone-Bannock Tribes (SBT) have sponsored three projects (Bear Valley Mine, Yankee Fork, and the proposed East Fork Salmon River projects). IDFG implemented two barrier removal projects (Johnson Creek and Boulder Creek) that the USFS was unable to sponsor at that time. The role of IDFG in physical habitat monitoring is primarily to link habitat quality or habitat change to changes in actual and potential fish production.

Estimation of anadromous fish response to BPA habitat projects in Idaho is generally the responsibility of IDFG (BPA 1985). However, the SBT have primary responsibility for developing the mitigation record for the three projects that they have sponsored.

Approaches to monitor habitat projects and document a record of credit were developed in 1984-1985 (Petrosky and Holubetz 1985, 1986). The IDFG evaluation approach consists of three basic, integrated levels: general monitoring, standing crop evaluations, and intensive studies. Annual general monitoring of anadromous fish densities in a small number of sections for each project will be used to follow population trends and define seeding levels. For most projects, standing crop estimate of parr will be used to estimate smolt production by factoring appropriate survival rates from Parr-to-smolt stages. Intensive studies (Kiefer and Apperson 1988) will determine parr-to-smelt survival rates and provide other basic biological information that is needed for evaluation of the Fish and Wildlife Program.

A physical habitat and fish population data base is being developed for every BPA habitat project in Idaho. The data will be integrated at each level of evaluation. Compatibility of data is also needed between Idaho and other agencies and tribes in the Columbia River Basin.

The schedule of BPA habitat project implementation and IDFG general monitoring-evaluation activities from 1983-1987 is presented in Table 1. A full mitigation record will be made as three conditions can be met: (1) the habitat project is completed or at full maturation; (2) the fish population affected is observed at full seeding, or a full seeding level has been determined for the affected habitat type; and (3) the appropriate survival rates from late summer parr state to smolt stage have been determined from the intensive monitoring studies.

After a habitat enhancement project has been implemented and prior to the time that the aforementioned conditions have been met, IDFG will construct a partial mitigation record based on estimated increases in parr production. At a later time, the interim parr responses can be converted to estimated smolt yields. Monitoring data will be essential to establish trends and estimate partial benefits during the years that project evaluations are not conducted (Figure 1).

In 1987 the general monitoring and evaluation project focused on five areas : (1) general density monitoring, (2) anadromous fish introductions above treated passage barriers, (3) investigations into rearing potential for chinook and steelhead, (4) measurement of physical habitat variables for all general monitoring sections, and (5) participation in a study to compare the performance of commonly used sediment variables for use in habitat project evaluations (Torquemada and Platts 1988).

METHODS

Physical Habitat Monitoring

Monitoring sections were established in 1984-1987 in all BPA habitat project areas and other streams to provide an annual index of anadromous fish abundance in different habitat types anti drainages. The section boundaries were defined at breaks between habitat types; most sections included at least one riffle-pool sequence. Streams, project reaches (strata), and sections were cross-referenced to the Environmental Protection Agency (EPA) reach numbering system.

Physical habitat variables were standardized and measured at least one time in each of the 121 established monitoring sections and in most other sections used in habitat project evaluations. In 1987 IDFG incorporated this list of variables into a parallel monitoring program being conducted in addition to this BPA-funded program (Appendix A-23). IDFG has encouraged other agencies and tribes to incorporate this standardized variable list into their monitoring programs.

Table 1. Schedule of BPA project implementation (I) and evaluation activities (P = pretreatment evaluation, M = monitoring, and E = posttreatment evaluation) in Idaho, 1983-1987.

Project	Project type[a]	1983	1984	1985	1986	1987
Lolo Creek	IS	I	I,P,E	E	M	M
Eldorado Creek	PA		I,P	I,M	E	M
Upper Lochsa River	IS	I	I,E	M	M	M
Crooked Fork Creek	PA		I,P	I,P	E	E
Colt Creek	PA				I	M
Crooked River	PA		I,P	M	E	M
	IS		I,P	I,P,M	E	M
	BC		P	I,P	E	M
	OC		I,M	I,M	I,E	I,M
Red River	BC	I	I,M	M	M	M
	IS	I,M	I,M	I,M	E	M
	RR					
Meadow Creek	PA					I,M
Panther Creek	SP		P	M	M	M
Pine Creek	PA					I,M
Lemhi River	IF			P	M	M
Upper Salmon River	IF		P	P	M	P
	RR		M	P	M	P
Alturas Lake Creek	IF		P	M	M	P
Pole Creek	PA	I	M	M	M	M
	RR		M	P	M	P
Valley Creek	RR			P	M	M
Bear Valley Creek	SP		I,P	I,P	I,M	M
	RR		M	P	P	M
Elk Creek	RR		M	P	P	M
Marsh Creek	RR		M	P	M	M
Knapp Creek	PA		M	P	M	I,M
Camas Creek	RR		M	M	M	M
	BC		M	M	M	M
Johnson Creek	PA		I,P	I,E	I,E	E
South Fork tributaries	PA				I,M	M
Boulder Creek	PA		P	I,P	E	M
Loon Creek	CO			M	M	M
Sulphur Creek	CO		M	M	P	M
South Fork Salmon	CO		M	M	M	M

[a]BC=bank-channel rehabilitation, CO=control stream, IF=improved flows, IS=instream structure, OC=off-channel developments, PA=passage, RR=riparian revegetation, and SP=sedimentation and pollution control.

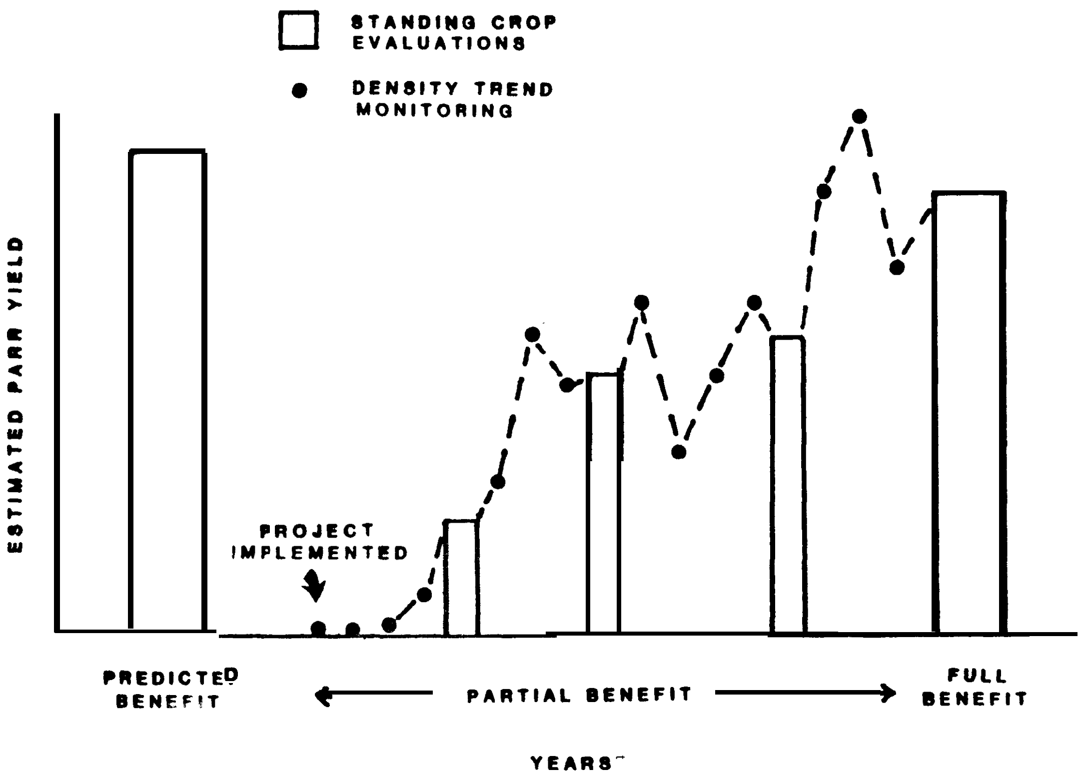

Figure 1 Hypothetical schedule for estimating partial and full benefits of a project (in terms of parr) from monitoring and evaluation programs.

Physical habitat data were collected for the sections according to the transect method derived primarily from Platts et al, (1983). The standardized variables are: channel type (Rosgen 1985), section length (measured midstream), percent gradient, width, depth, percent habitat type (pool, run, pocket water, riffle, and backwater) as described by Shepard (1983), and percent substrate composition (sand, gravel, rubble, boulder, and bedrock) as defined by Torquemada and Platts (1988). Transects were established systematically (usually 10 or 20-m intervals). Stream width was measured at each transect. At the quarter, half, and three-quarter point of each transect, we classified habitat, measured depth, and visually estimated substrate composition. Physical habitat data were summarized as section means.

More detailed physical habitat data were collected in several project streams in 1984-1987 to complement the common habitat data base. In 1985 IDFG cooperated in pretreatment and problem identification inventory of riparian and aquatic habitat conditions of headwater streams of the upper Salmon River and Middle Fork Salmon River (OEA 1987a,b). In 1986 IDFG expanded this inventory into Sulphur Creek, an adjacent wilderness stream that is ungrazed by cattle or sheep (Petrosky and Holubetz 1987). Pretreatment physical habitat data were collected in 1984-1986 in sections of Red River, Crooked River, Bear Valley Creek, and Elk Creek through subcontract with the Intermountain Forest and Range Experiment Station (IFRES) (Torquemada and Platts 1985; Platts et al. 1986, 1987).

Physical habitat data collected during 1984-1987 were summarized by channel type. Because this variable simultaneously categorizes several morphological characteristics, we used it as a primary classification to compare composition of habitat types and substrate within and between streams and to investigate chinook and steelhead rearing potential and population response to sedimentation.

Because several BPA habitat projects are designed to reduce sediment, and biologists have not agreed on the best sediment monitoring techniques, IDFG subcontracted with IFRES in 1987 to investigate the performance of several commonly used sediment variables in Idaho Batholith streams (Torquemada and Platts 1988). IDFG cooperated in this study by conducting observer bias tests for classification of habitat type, estimates of substrate composition, and ratings of embeddedness class and dominant particle. A pair of IDFG observers independently and simultaneously rated habitat at the same 33 locations in each of 6 different stream sections. Observers 1 and 2 rated sections in the Salmon River, Frenchman Creek, Bear Valley, and the South Fork Salmon River in September 1987; Observer 1 and a third observer did the ratings for Red River and Crooked River,

The physical habitat data base will be used in conjunction with data collected by project implementors to develop the mitigation record for BPA habitat projects. Quantity and quality of habitat added and improved will be estimated using standardized variables. Actual and potential production of steelhead and chinook parr attributable to each project will be estimated using relationships developed from this data base.

Density Monitoring

In 1984-1987 IDFG established a total of 121 monitoring sections to index the annual abundance of juvenile rainbow-steelhead and chinook in BPA habitat project streams. These data, and data from a parallel IDFG-funded monitoring program, will be used to index annual trends in abundance, estimate rearing potential in different habitats and develop relationships between adult escapements and juvenile fish densities (Appendix A-23). Mitigation benefits will be determined in part from density trends and habitat-fish relationships developed from this data base.

Because most anadromous production streams in Idaho are very clear and have low conductivity, snorkeling counts by trained observers are usually preferred over estimates obtained from electrofishing. In larger streams, electrofishing techniques are neither practical or reliable for juvenile fish. Density estimates were obtained by snorkeling counts for all sections, except those in the highly conductive and slightly turbid Lemhi River during 1984-1987. In 1986 IDFG calibrated population estimates obtained by snorkeling with removal-type population estimates (Seber and LeCren 1967; Zippen 1958) in streams of different conductivity and water clarity (Petrosky and Holubetz 1987). Census methods and fish population field forms are presented in Petrosky and Holubetz (1986).

Comparisons of snorkel counts and electrofishing estimates in typical Idaho anadromous streams (Petrosky and Holubetz 1987) demonstrated that direct observations are an excellent method of censusing salmon and steelhead parr populations. Hankin and Reeves (in press) presented similar evidence for western Oregon streams.

We summarized rainbow-steelhead and chinook parr densities by year, production type (wild or natural), and channel type. Wild chinook populations monitored under the BPA program were exclusively in the Middle Fork Salmon River tributaries. Wild steelhead were in the Middle Fork and and South Fork Salmon River drainages. All other BPA monitoring streams were classified as natural production areas, managed with varying degrees of outplanting (Appendices A-23 to A-25).

Anadromous Fish Introductions

The 1984-1987 steelhead and chinook releases into BPA project and monitoring streams are summarized in Appendices A-24 to A-25. Chinook fry stocking in 1987 was designed to establish populations above barrier-removal projects and to evaluate chinook rearing potential in different habitats in Johnson Creek and in the upper Lochsa River.

Steelhead Rearing Potential

Preliminary inferences to steelhead rearing potential in different habitats were drawn from annual monitoring of parr densities in selected streams with relatively strong escapements and in streams that received large out-plants of hatchery spawners and/or fry. The selected streams (tributaries to the lower Salmon River and Snake River) had parr densities higher than most other Idaho streams. Evidence that the streams were generally underescaped in 1984-1987 was provided in part by counts of natural adult steelhead past Rapid River Hatchery weir in 1983-1986 that averaged only 39% of the 1968-1972 escapements. Releases of hatchery spawners and fry were of a magnitude to expect full seeding in some years for Eldorado Creek, Crooked River, the upper Lemhi River, and possibly upper Panther Creek (Appendices A-24 to A-25).

Rainbow-steelhead parr densities in the selected monitoring sections were summarized by channel type, year, and by the maximum density observed during the period. We considered the maximum observed densities for these selected streams to be a conservative estimate of steelhead rearing potential. Means and standard errors were calculated for the maximum observed densities by channel type and by classes of percent gradient, percent pool and run, and percent surface sand.

Chinook Rearing Potential

Inferences to chinook rearing potential. were drawn from annual monitoring of parr densities and from fry outplants specifically designed to test carrying capacity in different habitats.

A subset of the highest densities observed in established monitoring sections during 1984-1987 was created for C-channels and B-channels. We considered most of the sections in this subset underseeded and believe the maximum observed densities represented conservative estimates of rearing potential.

Chinook fry stocking in 1987 was designed to establish populations and to estimate rearing potential in portions of Johnson Creek and upper Lochsa River tributaries, Crooked Fork, White Sand, and Big Flat creeks. Johnson Creek and tributaries, Rock Creek and Sand Creek, were stocked by helicopter with a total. of 118,424 summer chinook fry. Results of the Johnson Creek investigations are reported in Welsh (1988). Five sites in the upper Lochsa River were stocked on May 7-8, 1987 with Rapid River spring chinook fry (average 414/pound) by helicopter or truck.

The five stocking sites in the upper Lochsa River tributaries selected represented a range of stream size, gradient and channel type in nondegraded habitat (Figure 2). We allocated 600,000 chinook fry to the sites. Each site received more or less fry than another based on its stream width. A site estimated to be 20-m wide would receive four times the number of fry stocked in a 5-m wide site (Table 2). Based on an

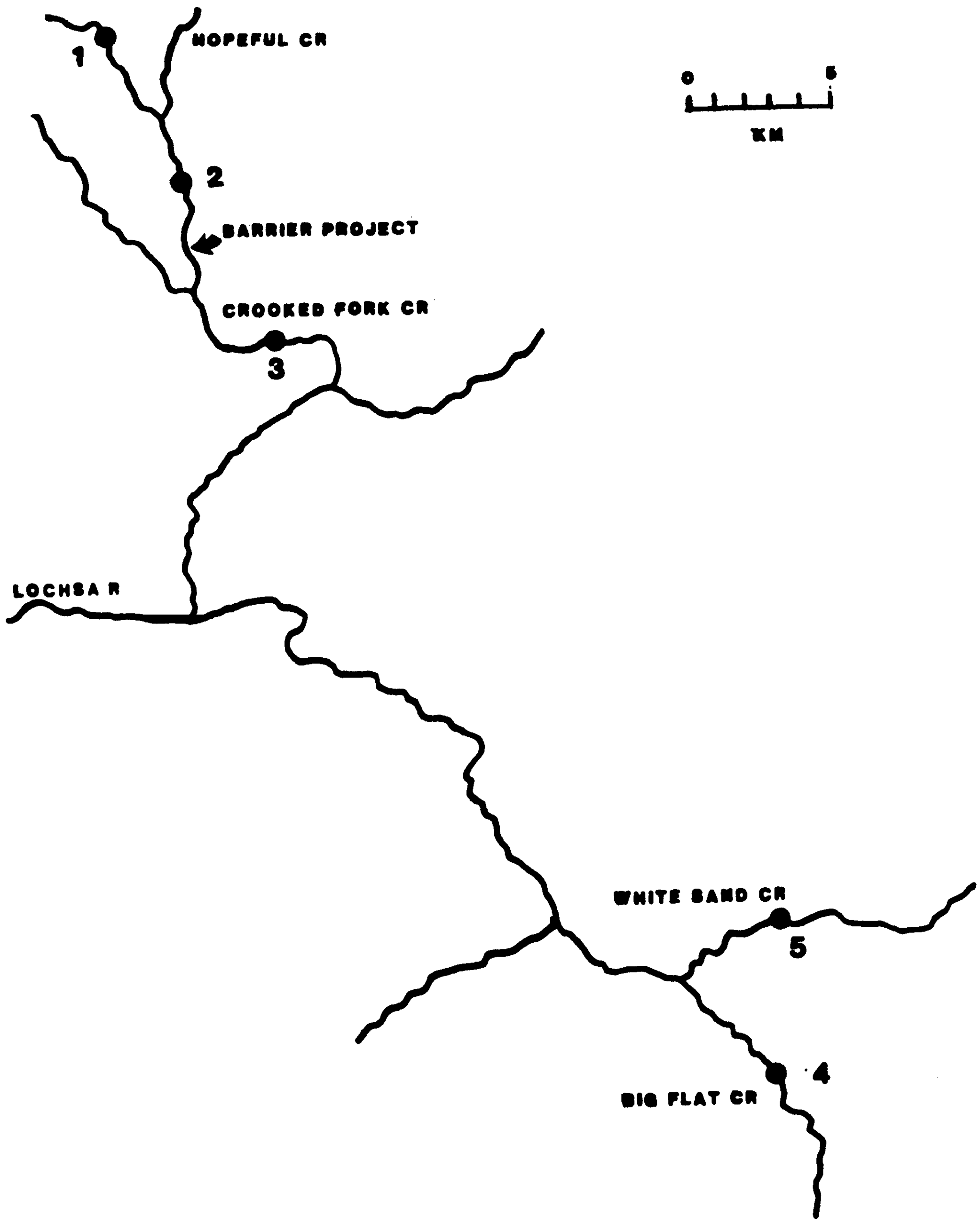

Figure 2. Chinook fry stocking sites, upper Lochsa River tributaries, 1987.

Table 2. Chinook fry stocking summary, rearing potential investigations, upper Lochsa River, 1987.

Stream, stocking site	Estimated[a] width	Chinook fry stocking			
		Number	Number/lb.	Date	Method
Crooked Fork Creek					
1.	5.4	58,800	400	5/7/87	helicopter
2.	9.7	105,630	400	5/7/87	helicopter
3.	17.0	185,120	400	5/7/87	truck
Big Flat Creek					
4.	9.0	98,000	434	5/8/87	helicopter
White Sand Creek[b]					
5.	14.0	152,450	434	5/8/87	helicopter

[a]Estimated from past data and aerial inspection (4/27/87),
[b]An additional 50,000 fry were stocked near the mouth of White Sand Creek.

initial expectation of 15% fry-to-parr survival (Petrosky and Holubetz 1987), the stocking rate would seed 1.63 km of stream at an average density of 100 parr/100 m^2. The only site with substantial natural production before stocking was the lower site (3) on Crooked Fork Creek.

We systematically established sections at 0.5 km intervals beginning at each stocking site and extending 1.0 km upstream and 3.0 km downstream. We measured habitat variables and estimated fish densities during August 10-20, 1987. Two sites (upper Crooked Fork Creek and White Sand Creek) were also sampled May 27-28, three weeks after stocking.

Systematic stratified sampling (Scheaffer et al. 1979) was used to estimate the total abundance and fry-to-parr survival for all sites except Site 3 where natural spawning occurred. Strata were defined *a priori* as: U1 (0.25 to 1.25 km upstream of the site), D1 (0.25 upstream to 1.25 km downstream of the site), D2 (1.25 to 2.25 km downstream), and D3 (2.25 to 3.25 km downstream). Each stratum contained two sections, except for D1 which contained three. Dispersal of fry outside the 4.5-km study area would make estimates of total abundance and fry-to-parr survival conservative.

Chinook Reproductive Curves

Columbia River Basin system planning documents (NPPC 1986) assume smolt carrying capacity of rearing habitat to be a density-dependent relationship in the form of a Beverton-Holt function (Ricker 1975). As redd densities increase, smolt (or parr) densities increase to an asymptote (carrying capacity).

Densities of age 0 chinook from Salmon River streams in 1984-1987 were compared to densities of redds in IDFG spawning ground survey reaches. The comparison was limited to low gradient (C-channel) reaches that have a predominance of age 52 (age 5, two years in freshwater, three years in saltwater) spawners (Table 3). We classified the stream reaches by average percent surface sand measured in the monitoring sections (<30%, 30-40%, and >40%). Linear and Beverton-Holt regressions were fitted to the data.

Chinook Egg-to-Parr Survival

Total abundance estimates of age 0 chinook and redd counts in upper Salmon River and Middle Fork Salmon River streams were used as the basis to estimate and compare egg-to-parr survival rates in streams with different sediment levels. IDFG estimated total parr abundance for the upper Salmon River, Valley Creek, Marsh Creek drainage, and Elk Creek in 1985 (1984 brood year); and for Elk Creek in 1986 and 1987. SBT provided comparable data for Bear Valley Creek (BY 1983-1985) and Herd Creek (BY 198%1986). All populations included in the analysis have a predominance of age 52 spawners. Fecundity was assumed to be 5,900 (1981-1984 average, Sawtooth Hatchery). Redd counts were assumed to

Table 3. Reaches and sections of the Salmon River and tributaries used to develop chinook reproduction curves, brood years 1983-1986.

Sediment class	Stream	Spawning ground survey reach upstream/downstream	Mean percent sand	Density monitoring sections
<30%	Salmon River	headwaters/diversion	19.7	8A, 8B, 9A, 9B, 10A, 10B
		diversion/R.S. bridge	17.2	5B, 6A, 6B, 7A, 7B
		R.S. bridge/Sawtooth weir	17.2	3A, 3B, 4A, 4B, 5A
	Alturas Lake Cr.	Alpine Cr./Alturas Lake	29.0	1A, 2A
		Cabin Cr. Bridge/mouth	10.0	3
	Pole Creek	headwaters/diversion	16.0	1A, 1B, 2A, 2B
		diversion/mouth	20.5	3A, 3B
	Valley Creek	Trap Cr./Stanley Lake Cr.	26.0	3A, 3B
	E. Fk. Salmon R.	weir/Herd Cr.	15.0	5
		Herd Cr./mouth	5.0	8
	Marsh Creek	airstrip/Cape Horn Cr.	23.7	4B, 5A, 6A
	Knapp Creek	beaver ponds/mouth	27.0	1A
	Cape Horn Creek	Banner Cr./mouth	13.5	1A, 2B
	Beaver Creek	Bear Cr./ bridge	8.0	1A, 3B
	Loon Creek	Cabin Cr./steep canyon	23.5	1,2
	Camas Creek	Castle Cr./Hammer Cr.	9.0	1,2
30-401	Bear Valley Cr.	mine/Elk Cr.	35.7	3A, 5A, BIG-MEADOW
	Sulphur Creek	Sulphur Cr. Ranch/lower	33.0	4A, 4B
>40%	Valley Creek	Stanley Lake Cr./mouth	46.0	1B
	Bear Valley Cr.	Elk Cr./Fir Cr.	57.0	2A, 2B
	Elk Creek	West Fork Elk Cr./Bearskin Cr.	45.0	2A, 2B
		Bearskin Cr./Bear Valley Cr.	46.0	1A, 1B

represent either 1.0 redd/female (Bjornn 1978) or 1.5 redds/female (Ortmann 1968). Sediment levels were summarized as percent surface sand in C-channels based on OEA (1978a,b) and SBT data for Herd Creek.

Partial Project Benefits

Partial project benefits were estimated in l-984-1987 according to the project-specific approaches in Petrosky and Holubetz (1986) and Appendix B. The interim benefits are expressed in terms of parr production until reliable estimates of parr-to-smolt survival rates can be attained from the intensive smolt monitoring studies (Kiefer and Apperson 1988).

RESULTS

Physical Habitat Monitoring

Monitoring sections established in C-channels were generally lower in gradient and contained more pool and run and less pocket water habitat than the B-channel sections (Table 4). Sand and gravel made up a larger percentage of the substrate in the depositional C-channels than the confined B-channels. None of the sections or streams were bedrock dominated.

Sediment levels varied widely between streams (Table 4). The mean surface sand ranged from 6% to 66% in C-channel sections (Hayden Creek and Eldorado Creek, respectively) and from 0% to 30% in B-channel sections (Alturas Lake Creek and Red River, respectively). Lolo Creek, Bear Valley Creek, Elk Creek, and the South Fork Salmon River and tributar ies also had comparatively high sediment levels.

Variation and bias of habitat data collected by different observers were investigated in six C-channel stream sections in conjunction with a more comprehensive sediment study by IFRES (Torquemada and Plants 1988). Experienced observers generally gave similar ratings to habitat type substrate composition, embeddedness class, and dominant particle, but with indications of observer bias for some variables

The observers gave similar ratings to percent pool and run combined, but the separation of pool from run was subject to observer bias (Table 5). Observer 1 consistently rated a higher percentage of pool and lower percentage of run than either observer 2 or 3. Percentage of riffle was rated similarly. Unlike the IFRES team (Torquemada and Platts 1988), IDFG observers did not rate any pocket water in the six C-channel sections.

The observers gave similar ratings to percent substrate composition without significant observer bias (Table 5). Percentages assigned to each substrate class (averaged for the section) varied at most by 7% for sand, 11% for gravel, and 6% for rubble. Very little boulder and no bedrock substrates were present in the sections.

Table 4. Summary of physical habitat variables measured in monitoring sections, Clear-water River and Salmon River subbasins, 1984-1987.

Subbasin, stream	Channel type	Number sections	Mean % gradient	Mean width(m)	Mean percent habitat type[a]					Mean percent substrate[b]				
					Pool	Run	PW	RIF	BU	S	G	R	B	BR
Clearwater Subbasin														
Lolo Creek	C	4	1.1	12.3	11	83	0	6	0	38	28	23	11	0
	B	2	1.2	16.3	0	100	0	0	0	6	19	66	10	0
Eldorado Creek	C	2	0.8	7.4	24	67	0	9	0	66	24	8	1	0
	B	2	2.0	6.7	4	26	24	46	0	23	18	44	14	0
Crooked Fork Creek	B	6	1.6	11.6	26	38	10	26	0	6	22	42	30	0
Colt Creek	B	1	1.7	5.5	0	33	67	0	0	1	10	22	67	0
	C	5	0.6	10.5	30	60	0	10	0	29	37	31	3	0
Crooked River	B	2	1.6	8.0	25	42	0	33	0	10	41	34	15	0
Red River	C	5	0.3	11.5	40	43	0	17	0	36	39	22	2	0
	B	2	1.2	9.4	20	20	60	0	0	30	13	25	32	0
Meadow Creek	C	1	0.6	7.2	0	42	0	58	0	22	39	39	0	0
	B	1	1.6	8.0	25	0	50	25	0	23	18	23	35	0
Salmon Subbasin														
Panther Creek	C	4	1.2	7.6	23	33	4	38	0	15	46	31	7	0
	B	2	0.8	18.2	0	54	6	38	4	11	37	44	9	0
Pine Creek	B	2	4.6	4.4	25	25	25	25	0	22	32	38	9	0
Lemhi River	C	3	1.4	8.6	15	65	19	0	0	18	62	19	0	0
Hayden Creek	C	1	1.4	7.4	33	20	0	47	0	6	92	2	0	0
	B	2	2.4	9.8	0	50	21	29	0	3	28	48	21	0
East Fork Salmon River	C	4	0.9	15.0	6	86	0	8	0	8	44	42	7	0
Salmon River	C	8	1.4	11.9	20	53	8	17	2	18	29	44	8	0
	B	1	2.5	23.7	0	60	40	0	0	13	16	31	40	0
Alturas Lake Creek	C	3	0.4	7.9	15	51	2	32	0	24	64	30	0	0
	B	1	1.0	8.4	0	27	70	3	0	0	39	46	15	0
Pole Creek	C	4	0.6	4.1	29	35	1	35	0	14	66	19	2	0
Valley Creek	C	3	1.5	13.0	23	53	0	22	0	33	29	35	3	0
	B	1	1.8	6.3	0	72	16	11	0	24	20	35	22	0

Table 4. Continued.

Subbasin, stream	Channel type	Number sections	Mean % gradient	Mean width (m)	Mean percent habitat type[a]					Mean percent substrate[b]				
					Pool	Run	PW	RIF	BW	S	G	R	B	BR
Salmon Subbasin (cont.)														
Bear Valley Creek	C	5	1.0	14.4	27	64	0	4	5	46	32	20	2	0
	B	1	1.5	21.9	0	40	60	0	0	22	3	10	56	0
Elk Creek	C	5	1.6	12.6	37	49	0	12	2	49	42	9	0	0
Marsh Creek	C	3	1.3	8.5	29	32	0	39	0	23	59	16	1	0
	B	2	2.2	19.0	44	20	0	36	0	10	26	37	26	0
Knapp Creek	C	2	1.0	5.7	16	58	0	26	0	25	39	36	0	0
Cape Horn Creek	C	2	1.2	7.5	10	43	0	47	0	14	56	28	0	0
Beaver Creek	C	2	1.2	12.8	20	46	0	34	0	8	34	48	11	0
Sulphur Creek	C	2	0.7	10.4	62	9	0	29	0	35	57	8	0	0
	B	1	3.0	10.2	33	0	67	0	0	21	11	32	36	0
Camas Creek	C	2	0.2	17.1	6	72	0	15	6	9	55	35	1	0
	B	1	0.8	9.1	0	33	58	8	0	4	45	25	26	0
Loon Creek	C	2	0.2	18.0	75	8	0	17	0	24	60	12	2	4
	B	1	1.4	18.4	0	0	100	0	0	-	-	-	-	-
South Fork Salmon River	C	3	0.4	17.4	24	64	0	11	0	45	28	29	1	0
Dollar Creek	B	1	3.3	6.2	25	33	0	42	0	26	15	34	25	0
Johnson Creek	C	5	0.3	7.1	46	42	0	13	0	39	54	7	0	0
	B	3	1.3	14.3	17	16	67	0	0	12	16	23	50	0
Boulder Creek	C	1	0.6	5.0	93	7	0	0	0	42	30	27	1	0
	B	3	2.3	9.7	2	34	54	10	0	9	22	37	32	0
Little Salmon River	B	2	1.3	16.1	6	70	22	3	0	4	8	32	56	0
MEAN	C	81	0.9	11.3	27	52	2	18	1	29	42	25	4	0
	B	40	2.0	11.6	11	37	33	19	0	12	23	37	28	0

[a]Habitat types: PW = pocket water; RIF = riffle; BW = backwater.
[b]Substrates: S = sand; G = gravel; R = rubble; B = boulder; BR = bedrock.

Table 5. Summary of observer bias tests, comparing estimates or percentage of rating by 2 observers who independently rated the same 33 locations in 6 stream sections, 1987.

Variable	Observers:	Salmon R.		Frenchmans Cr.		Bear Valley Cr.		S. Fk. Salmon		Red R.		Crooked R.	
		1	2	1	2	1	2	1	2	1	3	1	3
% Habitat type													
Pool		9	0	70	55	18	6	15	6	64	24	67	15
Run		61	64	9	30	79	91	76	79	18	58	15	58
Pocket water		0	0	0	0	0	0	0	0	0	0	0	0
Riffle		30	36	15	12	3	3	9	15	18	18	18	27
Backwater		0	0	6	3	0	0	0	0	0	0	0	0
% Substrate													
Sand		7	6	44	48	56	49	34	36	26	21	28	33
Gravel		61	65	56	52	35	41	54	45	54	59	60	49
Rubble		32	29	0	0	6	7	12	19	20	20	12	18
Boulder		0	0	0	0	3	3	0	0	0	0	0	0
Bedrock		0	0	0	0	0	0	0	0	0	0	0	0
% Embeddedness class													
<5%		79	85	9	30	9	18	9	12	42	21	15	13
5-25%		15	9	21	12	9	6	21	12	24	58	30	33
25-50%		6	6	3	9	3	18	6	9	15	9	27	30
50-75%		0	0	15	9	21	18	9	24	6	6	12	9
>75%		0	0	52	39	58	39	55	42	12	6	15	12
% Dominate particle													
Fine sand		0	0	24	33	18	27	21	24	9	12	12	12
Coarse sand		0	0	6	9	39	21	0	0	3	0	0	3
Gravel		82	97	70	58	36	45	67	58	73	82	85	76
Riffle		18	3	0	0	0	0	12	18	15	6	3	9
Boulder		0	0	0	0	6	6	0	0	0	0	0	0
Bedrock		0	0	0	0	0	0	0	0	0	0	0	0

Ratings of embeddedness class varied between observers (Table 5). Observer 1 tended to assign higher class values than Observer 2.

Ratings of percent dominant particle agreed moderately well between the observers, with no apparent bias (Table 5). Ratings of dominant particle varied more than comparable ratings of substrate composition, however.

The three sediment variables investigated for observer bias have applicability for general stream inventories because estimates can be made efficiently. However, the variable percent substrate composition contains more information than embeddedness class or percent dominant particle. Torquemada and Platts (1988) found high correlation between most sediment variables investigated in their study. For general inventories in the Idaho Batholith, they recommended use of the variables percent substrate composition, percent embeddedness (ocular), and substrate score (Crouse et al. 1981).

Density Monitoring

Parr densities of wild steelhead and chinook in established monitoring sections indicate depressed population status during the period 1984-1987 (Table 6). Average parr densities of wild steelhead populations (Middle Fork Salmon River and South Fork Salmon River) were lower than in natural production areas (Appendix A). Mean densities of wild chinook (Middle Fork Salmon River) increased 2.6 fold from 1984 to 1987 in the monitoring section. Wild steelhead and chinook parr densities in the highly sedimented Bear Valley Creek and Elk Creek drainages have remained very low, especially compared to similar wild production streams with less sediment (Appendix A).

Densities of natural juvenile steelhead and chinook in established monitoring sections varied by stream and year (Appendix A). Outplanted hatchery chinook accounted for increased densities above barrier removal projects in Eldorado Creek, Crooked Fork Creek, Johnson Creek, Boulder Creek, and Panther Creek (a proposed BPA project stream). Conversely, the trapping of chinook adults for Sawtooth Hatchery accounted for a decrease in natural production above the weir (upper Salmon River, Alturas Lake Creek, and Pole Creek). Large outplants of excess Dworshak NFH spawners in 1985 probably fully seeded Eldorado Creek and Crooked River with yearling steelhead in 1986. Large outplants of steelhead adults and fry into the upper Lemhi River and upper Panther Creek may have resulted in full seeding. No other monitoring streams were considered to be at rearing potential in 1984-1987.

Channel type influenced parr densities, even at the currently depressed population levels (Table 6). Chinook densities averaged three times higher in the C-channels compared to B-channels, whereas rainbow-steelhead parr densities averaged 2.3 times greater in the B-channel sections.

Table 6. Rainbow-steelhead and chinook parr densities (mean number/l00 m2) in established BPA monitoring sections, summarized by wild versus natural production and by channel type, Clearwater and Salmon River drainages, 1984-1987.

Species, age	Year	Wild		Natural		Combined
		C-channel	B-channel	C-channel	B-channel	
Rainbow-steelhead						
Age >1	1984	0.2	3.2	1.6	1.5	1.4
	1985	0.5	3.4	3.5	4.6	2.7
	1986	0.8	3.1	5.3	7.0	3.7
	1987	0.6	1.6	4.6	5.9	3.9
	Mean	0.5	2.8	3.8	4.8	2.9
	Rearing potential[a]	15.0	20.0	15.0	20.0	17.5
Chinook						
Age 0	1984	5.2	3.2	17.9	1.2	10.9
	1985	9.4	4.0	16.7	8.6	12.4
	1986	14.0	5.9	19.0	5.9	13.9
	1987	18.4	2.9	22.2	10.9	17.8
	Mean	11.8	4.0	19.0	6.6	13.8
	Rearing potential[a]	108.0	67.0	108.0	67.0	88.0

[a]Authors' expectation for nondegraded streams based on literature for Idaho streams, monitoring and evaluation data, and results of chinook fry and outplanting study, upper Lochsa River, 1987.

Steelhead Rearing Potential

Rainbow-steelhead parr densities in selected streams with above average seeding ranged from 0 to 44.6/100 m^2 in 1984-1987 (Table 7). Lowest densities in the subset were observed in the highly sedimented Eldorado Creek. The Lemhi River, a fertile stream, and some lower Salmon River and Snake River tributaries had the highest densities.

Although most streams were underseeded, some relationships existed between the maximum observed parr density for a section and habitat variables (Table 8, Figure 3). B-channels tended to rear more rainbow-steelhead parr than C-channels. Maximum parr density increased with gradient and decreased with sediment. No simple relationship was apparent between maximum parr density and the percent of habitat classified as pool and run.

Chinook Rearing Potential

The highest chinook parr densities observed during 1984-1987 in established monitoring sections have been in C-channels (Table 9). Both the C and B-channel sections in this data subset had characteristics similar to the average for all monitoring sections. However, three C-channel sections with the higher densities had sediment levels at least as high as 40% surface sand. These sections were in supplemented streams (Appendix A-25). The subset also included sections from wild chinook production streams (Cape Horn, Marsh, and Loon creeks).

Chinook fry stocking in upper Lochsa River tributaries fully seeded stream reaches in the vicinity of the stocking sites. We summarized chinook parr densities by location and habitat to estimate summer rearing potential and fry-to-parr survival. Chinook fry dispersed slightly in the first three weeks after stocking in Crooked Fork and White Sand creeks (Table 10). Fry were present at high density only within 1.0 km of the stocking sites in late May. At the higher gradient site (Crooked Fork Creek, Site l), dispersal was primarily downstream. In low gradient (White Sand Creek, Site 5), fry dispersed slightly upstream. Based on mean density in late May (257/100 m^2 and 283/100 m^2 for sites 1 and 5, respectively), approximately 62% of the fry survived the first three weeks after stocking.

By August 1987 chinook parr had dispersed substantially, primarily downstream from the stocking sites (Table 11). Density within 2 km downstream of the sites averaged 93.1/100 m^2 (range = 26.6 to 228.41100 m^2). Density upstream and greater than 2 km downstream of the sites averaged 35.0/100 m^2 and 53.8/100 m^2, respectively. A major storm system and cold weather during August 13-15 may have influenced distribution at some sites. Major emigration of summer chinook parr was associated with this storm in Johnson Creek (Welsh 1988).

Table 7. Rainbow-steelhead parr density (number/100 m^2) by channel type in established monitoring sections of selected Idaho streams with above-average seeding, 1984-1987.

Channel type	Primary means of seeding[a]	Drainage, stream	Program[b]	Section	1984	1985	1986	1987	Observed maximum
C	N	**Salmon River**							
		Boulder Creek	BPA	1	6.3	3.7	6.8	15.6	15.6
		Slate Creek	RES	5	-	4.4	6.1	13.4	13.4
				MEAN	6.3	4.0	6.4	14.5	14.5
	H	**Clearwater River**							
		Eldorado Creek[c]	BPA	2M	o	0	0	1.3	1.3
			BPA	2LG	o	0	4.3	1.8	4.3
		Crooked River[d]	BPA	II-Treatment 2		1.5	13.7	19.6	19.6
			BPA	II-Control 2	-	2.6	14.0	9.5	14.0
			BPA	III-Natural	3.1	-	3.5	9.0	9.0
			BPA	IV-Meander 1	-	0.4	6.1	11.0	11.0
			BPA	IV-Meander 2	1.2	1.1	7.7	9.4	9.4
		Salmon River							
		Panther Creek[e]	BPA	M01	4.3	8.4	13.3	14.8	14.8
			BPA	PC10	4.3	-	-	2.0	4.3
			BPA	PC9	7.1	-	12.5	7.7	12.5
		Lemhi River	BPA	LEM-1A	-	44.6	15.8	20.8	44.6
			BPA	LEM-2B	-	20.0	21.5	19.8	21.5
			BPA	LEM-3A	-	15.9	12.7	8.2	15.9
				MEAN	2.9	9.4	10.4	10.4	14.0
				C-channel mean	3.3	8.6	9.9	10.9	14.1
B	N	**Salmon River**							
		Boulder Creek	BPA	2	2.7	7.5	5.3	8.8	8.8
			BPA	3	8.1	13.3	-	15.5	15.5
			BPA	5	4.9	16.8	24.1	20.9	24.1
		Little Salmon River	BPA	1	-	13.2	9.8	7.6	13.2
			BPA	2	-	10.1	14.8	7.3	14.8
		Hazard Creek	IDFG	HAZ-1	-	12.2	13.1	15.6	15.6
		Rapid River	IDFG	RAP-1	-	7.9	3.5	8.7	8.7
			IDFG	RAP-2	-	9.8	15.4	14.8	15.4

Table 7. Continued.

Channel type	Primary means of seeding[a]	Drainage, stream	Program[b]	Section	1984	1985	1986	1987	Observed maximum
		Slate Creek	RES	1	-	4.5	8.2	5.6	8.2
			RES	2	-	4.6	6.6	3.2	6.6
			RES	3	-	5.1	5.2	5.6	5.6
			RES	4	-	45.4	20.7	7.4	45.4
		Whitebird Creek	RES	1	-	-	25.5	1.9	25.5
			RES	2	-	19.5	29.2	16.2	29.2
			RES	3	-	28.5	31.6	26.0	31.6
			RES	4	-	19.4	7.2	3.8	19.4
		Snake River							
		Captain John Creek	IDFG	1	-	11.0	23.4	11.2	23.4
			IDFG	2	-	15.6	30.0	13.3	30.0
		Wolf Creek	IDFG	1	-	19.5	8.9	12.2	19.5
			IDFG	1	-	24.6	37.8	41.8	41.8
			IDFG	2	-	7.0	9.0	5.6	9.0
		Granite Creek	IDFG	1	-	19.4	15.2	12.7	19.4
			IDFG	2	-	22.5	9.7	8.7	22.5
			IDFG	3	-	14.0	15.2	13.0	15.2
				MEAN	5.2	15.3	16.1	12.0	19.5
B	H	Clearwater River							
		Eldorado Creek[c]	BPA	1HG	0	0	11.1	7.9	11.1
			BPA	1B	5.1	5.3	8.7	7.5	8.7
		Crooked River[d]	BPA	I-Sill Log A	0.2	1.5	5.9	7.0	7.0
			BPA	I-Control 1	0.7	0.5	5.7	2.9	5.7
				MEAN	1.5	1.8	7.8	6.3	8.1
				B-channel mean	3.1	13.3	14.8	11.2	17.9

[a] N=natural escapement; H=hatchery adult and fry outplants.
[b] BPA=BPA habitat monitoring and evaluation' IDFG=IDFG fishery management (unpublished data); RES=IDFG fishery research (Rohrer, IDFG, personal communication)
[c] High sediment levels; sections 2M, 2LG, and 2HG upstream of barrier-removal project.
[d] Channelized by dredge mining.
[e] Upstream of mine pollution.

Table 8. Maximum density (number/100 m^2) of rainbow-steelhead parr and habitat summaries in established monitoring sections of selected Idaho streams with above-average seeding, 1984-1987.

Channel type	Stream	Section	Observed maximum density	Percent gradient	Width (m)	Mean % habitat[a] Pool	Run	PW	RIF	BU	Mean % substrate[b] S	G	R	B	BR
C	Lemhi River	LEM-1A	44.6	1.1	6.9	33	40	0	27	0	13	79	8	0	0
	Lemhi River	LEM-2B	21.5	1.4	8.3	13	73	0	13	0	28	56	15	0	0
	Crooked River	II-Treatment 2	19.6	0.9	9.1	60	40	0	0	0	33	25	35	7	0
	Lemhi River	LEM-3A	15.9	1.6	9.9	13	52	0	35	0	0	83	17	0	0
	Boulder Creek	1	15.6	0.6	5.0	93	7	0	0	0	42	30	27	1	0
	Panther Creek	MO1	14.8	1.8	6.5	12	42	25	21	0	9	55	27	9	0
	Crooked River	II-Control 2	14.0	0.9	9.9	0	83	0	17	0	22	41	36	2	0
	Slate Creek	5	13.4	0.5	2.7	67	28	6	0	0	38	61	1	0	0
	Panther Creek	PC9	12.5	1.9	6.3	7	20	0	73	0	13	22	48	16	0
	Crooked River	IV-Meander 1	11.0	0.3	9.0	47	40	0	13	0	40	40	20	0	0
	Crooked River	IV-Meander 2	9.4	0.3	12.9	61	33	0	6	0	37	37	25	1	0
	Crooked River	I I I-Natural	9.0	0.5	8.9	67	15	0	18	0	28	60	12	0	0
	Panther Creek	PC10	4.3	0.6	4.1	47	53	0	0	0	36	64	0	0	0
	Eldorado Creek	2LG	4.3	1.0	8.9	27	67	0	7	0	33	49	16	2	0
	Eldorado Creek	2M	1.3	0.5	6.0	22	67	0	11	0	100	0	0	0	0
		Mean	14.1	0.9	7.6	38	44	2	16	0	31	47	19	3	0
B	Slate Creek	4	45.4	2.5	10.5	13	27	60	0	0	6	15	24	56	0
	Sheep Creek	1	41.8	10.0	6.8	20	20	60	0	0	1	24	23	52	0
	Whitebird Creek	3	31.6	4.0	5.5	7	13	80	0	0	1	18	51	31	0
	Captain John Cr.	2	30.0		3.6	44	33	0	22	0					
	Whitebird Creek	2	29.2	3.5	5.3	0	7	87	7	0	0	15	44	41	0
	Whitebird Creek	1	25.5		8.9	20	0	80	0	0	1	9	45	46	0
	Boulder Creek	5	24.1	1.6	8.6	7	60	20	13	0	9	32	45	14	0
	Captain John Cr.	1	23.4		3.2	25	33	0	25	0					
	Granite Creek	2	22.5	8.6	7.8	17	0	83	0	0	0	2	8	90	0
	Wolf Creek	1	19.5	4.9	4.7	13	20	13	53	0	2	33	54	11	0
	Granite Creek	1	19.4	9.5	9.0	20	0	80	0	0	0	11	32	57	0
	Whitebird Creek	4	19.4	1.0	6.2	47	13	40	0	0	13	56	22	13	0
	Hazard Creek	HAZ- 1	15.6	o-7	14.3	17	67	8	8	0	1	13	28	58	0
	Boulder Creek	3	15.5	3.2	12.2	0	8	75	17	0	10	18	42	30	0

Table 8. Continued.

Channel type	Stream	Section	Observed maximum density	Percent gradient	Width (m)	Mean % habitat[a] Pool	Run	PW	RIF	BW	Mean % substrate[b] S	G	R	B	BR
B	Rapid River	RAP-2	15.4	1.3	13.9	33	25	42	0	0	7	24	35	34	0
	Granite Creek	3	15.2	5.8	7.2	0	40	60	0	0	0	13	30	57	0
	Little Salmon R.	2	14.8	1.4	12.6	11	72	11	6	0	3	5	31	61	0
	Little Salmon R.	1	13.2	1.2	19.6	0	67	33	0	0	5	10	34	50	0
	Eldorado Creek	IHG	11.0	1.6	7.0	7	53	20	20	0	38	12	28	21	0
	Sheep Creek	2	9.0	6.5	6.0	0	0	100	0	0	1	15	44	39	0
	Boulder Creek	2	8.8	2.2	8.2	0	33	67	0	0	8	16	23	53	0
	Rapid River	RAP-l	8.7	2.1	6.4	0	100	0	0	0	2	36	42	19	0
	Eldorado Creek	1B	8.7	2.5	6.4	0	0	27	73	0	8	25	59	7	0
	Slate Creek	1	8.2	2.5	13.6	7	20	67	7	0	4	20	47	29	0
	Crooked River	I-Sill Log A	7.0	1.8	8.4	50	42	8	0	0	11	49	32	8	0
	Slate Creek	2	6.6	1.0	13.6	0	27	73	0	0	4	20	42	34	0
	Crooked River	I-Control 1	5.7	1.2	7.6	0	42	58	0	0	10	32	36	22	0
	Slate Creek	3	5.6	5.0	5.6	7	20	67	7	0	2	25	32	41	0
		Mean	17.9	3.7	8.7	13	0	47	0	0	6	21	36	37	0

[a]PW=pocket water; RIF=riffle; BW=backwater.
[b]S=sand; G=gravel; R=rubble; B=boulder; BR=bedrock.

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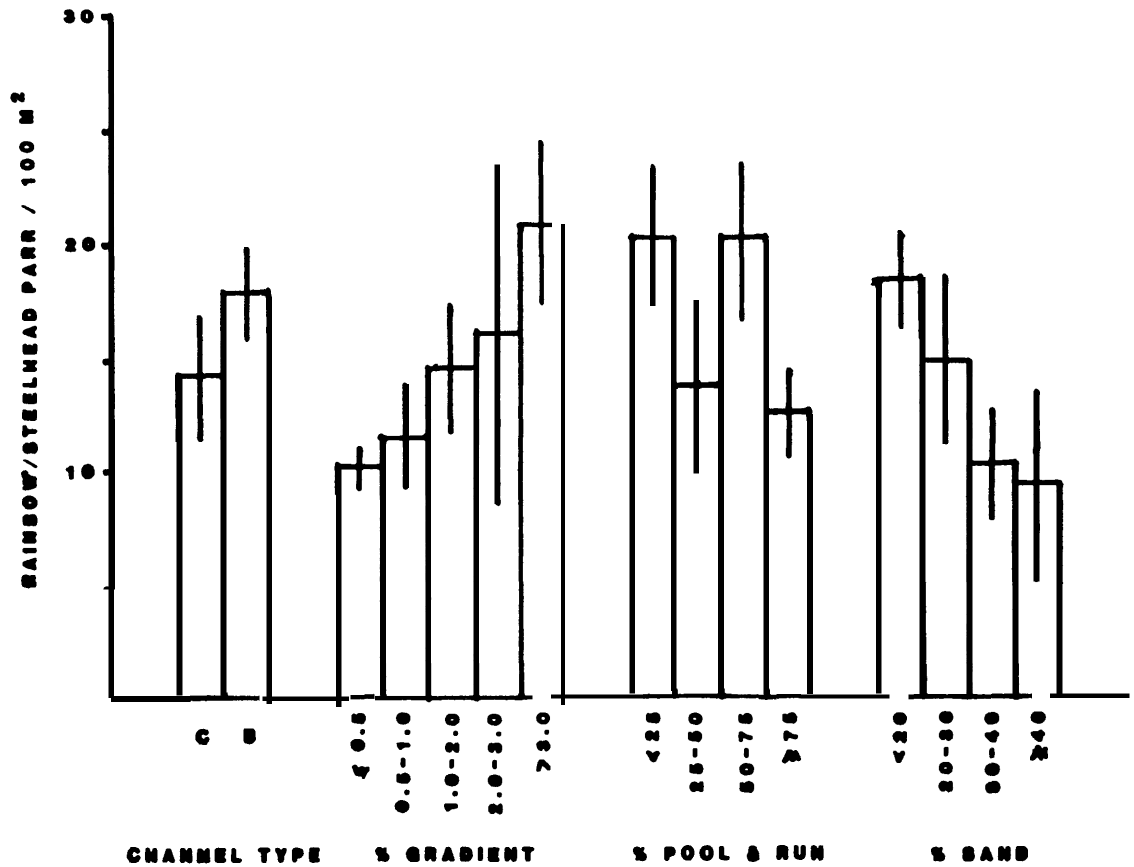

Figure 3. Maximum observed density of rainbow-steelhead parr in established monitoring sections of selected Idaho streams summarized by channel type and classes of percent gradient, percent pool and run, and percent sand, 1984-1985. Vertical bars represent ± SE.

Table 9. Subset of highest observed chinook parr density (number/100 m^2) and habitat summaries in established monitoring sections, summarized by channel type and means of seeding, 1984-1987.

Channel type	Primary[a] means of seeding	Stream	Section	Year	Density	Percent gradient	Width (m)	Mean % habitat type[b] Pool	Run	PW	RIF	BW	Mean % substrate[c] S	G	R	B	BR
C	N	Salmon River	8A	1984	97.4	0.5	9.0	67	20	0	13	0	18	30	39	12	0
		Cape Horn Creek	2B	1987	96.8	1.0	7.5	20	33	0	47	0	19	46	35	0	0
		Salmon River	7B	1984	94.7	0.5	6.9	25	75	0	0	0	26	29	42	3	0
		Crooked River	IV-Meander 1	1986	93.4	0.3	9.0	47	40	0	13	0	40	40	20	0	0
		S. Fk. Salmon R.	Stolle 2	1987	91.5	0.4	11.6	33	50	0	17	0	59	30	15	0	0
		Crooked River	II-Control 2	1985	90.2	0.9	9.9	0	83	0	17	0	22	41	36	2	0
		Marsh Creek	5A	1987	89.3	1.5	11.2	42	25	0	33	0	14	63	23	1	0
		Salmon River	3BRA	1987	88.8	0.6	28.0	16	44	0	26	14	23	49	25	3	0
		Red River	I-Millers	1987	88.4	0.3	3.5	64	18	0	18	0	26	53	21	0	0
		Alturas Lake Cr.	3	1984	81.9	0.4	9.0	24	36	6	33	0	7	54	39	0	0
	H	Eldorado Creek	2M	1987	160.9	0.5	6.0	22	67	0	11	0	100	0	0	0	0
		Eldorado Creek	2M	1986	111.6						.	.			.	.	
			Mean		98.7	0.6	10.1	33	45	0	21	l	32	39	27	2	0
	N	Red River	II-Treatment 2	1985	75.4	1.2	9.0	40	40	20	0	0	33	18	23	26	0
		Red River	II-Treatment 2	1987	48.1						.	.			.	.	
		Boulder Creek	5	1987	40.9	1.6	8.6	7	60	20	13	0	9	32	45	14	0
		Red River	II-Control 2	1985	39.9	1.2	9.8	0	0	100	0	0	26	8	27	38	0
		Crooked River	I-Sill Log A	1985	31.9	1.8	8.4	50	42	0	8	0	11	49	32	8	0
		Loon Creek	LNM- 1	1986	25.4						.	.			.	.	
		Boulder Creek	3	1987	20.2	3.2	12.2	0	8	75	17	0	10	18	42	30	0
		Red River	II-Treatment 2	1986	19.3						.	.			.	.	
		Boulder Creek	5	1986	18.1						.	.			.	.	
		Crooked River	I-Sill Log A	1986	17.8						.	.			.	.	
	H	Crooked Fork Cr.	2A	1987	57.0	2.4	4.7	20	30	20	30	0	8	22	32	39	0
		Crooked Fork Cr.	2A	1986	24.2						.	.			.	.	
			Mean		34.8	1.9	8.8	20	30	39	11	0	16	24	34	26	0

[a]N=natural (or wild) escapement; H=hatchery fry outplants.
[b]PU=pocket water; RIF=riffle; BW=backwater.
[c]S=sand; G=gravel; R=rubble; B=boulder; BR=bedrock.

Table 10. Summary of chinook fry density (number/100 m^2) three weeks after stocking near two sites, upper Lochsa River, May 1987.

Stream, stocking site	1987 date	Stratum	Section[a]	Density	Channel type	Percent gradient	Mean width (m)	Percent pool, run[b]	Percent sand[b]
Crooked Fork Creek									
1.	5/28	Ul	0.5U	0[c]	B	5.4	3.6	25	5
		Dl	0.5D	505.6	C	0.8	5.1	78	11
			0.OD	865.3	C	1.2	5.6	67	15
		D2	1.0D	68.4	B	1.7	5.0	47	8
			1.5D	86.5	C	2.8	6.1	60	11
			2.0D	15.5	B	2.5	5.4		
White Sand Creek									
5.	5/27	U1	1.0U	1.8	C	0.1	13.6	87	73
			0.5U	592.0	C	0.2	12.5	100	40
		Dl	0.OD	764.2	C	0.1	14.0	92	33
			0.5D	53.3	C	0.1	11.2	100	73
			l.OD	1.5	C	0.1	10.5	100	26

[a] 1.OU=1 km upstream of stocking site; 0.OD=stocking site; 1.OD=1 km downstream of stocking site, etc.
[b] August 1987 data.
[c] Passage block for juvenile chinook located at downstream end of section.

Table 11. Summary of chinook parr density (number/100 m^2) 13 to 15 weeks after stocking near 5 sites, upper Lochsa River, August 1987.

Stream, stocking site	1987 date	Stratum	Section[a]	Density	Channel type	Percent gradient	Mean width (m)	Percent Pool, run	Percent sand
Crooked Fk. Cr.									
1.	8/10-12	U1	1.0U	0[b]	B				
			0.5U	0[b]	B	5.4	2.4	25	5
		D1	0.0D	224.8	C	0.8	3.1	78	11
			0.5D	228.4	C	1.2	3.4	67	15
			l.0D	89.0	B	1.7	2.9	47	8
		D2	1.5D	109.1	C	2.8	4.4	60	11
			2.0D						
		D3	2.5D	97.4	C	1.2	4.2	56	6
			3.0D	57.0	B	2.3	4.7	50	7
2.	8/13-14[c]	U1	1.0U	4.6	C	0.5	8.3	83	8
			0.5U	7.3	C	1.1	9.7	83	18
		Dl	0.0D	35.3	C	0.8	6.3	92	6
			0.5D	78.1	B	1.7	7.8	66	3
			l.0D	71.5	B	1.4	8.8	58	10
		D2	1.5D	44.9	B	1.6	8.2	42	2
			2.00	57.3	B	1.6	7.4	83	5
		D3	2.5D	53.1	B	1.2	11.5	67	10
			3.0D	44.2	B	2.3	8.4	8	0
3.[d]	8/11	U1	1.0U	29.2	B	0.7	16.0	87	1
			0.5U	37.5	B	2.1	24.8	75	4
		Dl	0.0D	87.8	B	0.7	14.5	75	2
			0.5U	94.1	C	0.6	13.6	92	4
			l.0D	26.6	B	2.7	20.4	42	1
		D2	1.5D	89.5	B	0.7	14.2	100	5
			2.0D	64.6	B	0.9	17.2	58	6
		D3	2.5D	39.0	B	1.1	22.9	75	4
			3.0D	49.9	B	1.0	14.7	93	5
Big Flat Cr.									
4.	8/19[c]	U1	1.00	36.1	C	0.2	6.1	67	22
			0.5U	88.8	C	0.1	5.0	100	21
		D1	0.0D	66.6	C	0.4	6.1	50	25
			0.5D	73.2	C	0.1	7.8	100	25
			l.0D	76.4	C	0.1	7.6	100	16
		D2	1.5D	65.5	C	0.1	9.0	100	28
			2.0D	68.9	C	0.2	6.4	100	22
		D3	2.5D	74.2	C	0.3	8.3	100	17
			3.0D	65.8	C	0.4	7.8	67	25

Table 11. Continued.

Stream, stocking site	1987 date	Stratum	Section[a]	Density	Channel type	Percent gradient	Mean width (m)	Percent pool, run	Percent sand
White Sand Cr.									
5.	8/18[c]	U2[e]	2.5U	12.8	C	0.1	9.8	75	4
			2.0U	53.0	C	0.1	10.7	100	16
			1.5U	41.7	C	0.6	9.5	100	43
		U1	1.00	36.8	C	0.1	12.0	87	73
			0.5u	106.8	C	0.2	10.2	100	40
		D1	0.0D	86.6	C	0.1	11.0	92	33
			0.50	138.5	C	0.1	12.7	100	73
			1.0D	125.0	C	0.1	11.1	100	26
		D2	1.5D	114.3	C	0.4	10.6	100	10
			2.0D	64.5	B	0.7	10.2	83	4
		D3	2.5D	33.1	B	0.6	81.	0	1
			3.0D	23.9	B	0.8	10.9	67	5

[a]1.00=1 km upstream of stocking site; 0.0D=stocking site; 1.0D=1 km downstream of stocking site, etc.
[b]Upstream of passage block for juvenile chinook.
[c]Sampled after major storm and cold weather on 8/13-15. Major emigration of chinook from summer rearing areas associated with this storm in Johnson Creek (Welsh, personal communication).
[d]Includes chinook production from natural spawning.
[e]Extra sections sampled to determine upstream range of dispersal.

In Crooked Fork, Big Flat, and White Sand creeks, August density within 2 km downstream of the sites was related to channel type (Figure 4). C-channels supported a density of chinook parr (107.6/100 m^2) that averaged 60% higher than the B-channel density (67.41100 m^2). No simple relationship was apparent between density and percent gradient, percent pool and run, or percent sand.

The systematic stratified sampling design produced moderately precise but conservative estimates of chinook parr abundance and survival (Table 12). Bounds on the error of estimation (±2 SE) averaged 22% of the estimated totals for sites 1, 2, 4, and 5. Total abundance was not estimated for Site 3 because natural spawning occurred in this area. Estimated chinook fry-to-parr survival (May to August) averaged 24% for the four sites. Survival estimates *were* conservative because some parr dispersed outside the study areas.

Chinook Reproduction Curves

In general, chinook parr density correlated directly with redd density for the 1983-1986 brood years in the Salmon River drainage (Table 13, Figure 5). The highest redd density observed in the period was 12.5/hectare in Sulphur Creek (a wild production stream) in 1986; redd density averaged 1.8/hectare for all reaches. By contrast, the 1960-1969 average redd density for the Marsh Creek drainage was 18.7/hectare.

Chinook parr densities observed in 1984-1987 (BY 1983-1986) varied considerably, but ranged and averaged higher in the less-sedimented reaches (Table 13).

A linear regression fit moderately well (r^2=0.56) to chinook parr density and redd density data for C-channel stream reaches with less than 30% sand (Table 13). Linear relationships were weak to nonexistent for data from sediment classes 30-40% and >40%, The regression slopes decreased as sediment levels increased. Poor fit of linear regressions for higher sediment classes probably resulted from small sample size and low, variable survival rates in highly sedimented streams.

Beverton-Holt functions did not fit data from any of the three sediment classes or combined data (Table 13) because redd densities were too low to effect a definable density-dependent response in parr survival.

Results from the 1987 upper Lochsa releases of chinook fry suggest a Beverton-Holt asymptote of approximately 108 parr/100 m^2 for C-channels (Figure 4). Extrapolation of the linear relationship of parr to redd density to this asymptote roughly approximates the shape of a Beverton-Holt function (Figure 6). Parr density data have not been collected in Idaho streams for the mid to high range of chinook redd densities to define this relationship. With more empirical data and applied research, it should be possible to shape spawning escapement objectives from this data base. However, such relationships will be conservative unless they also account for juveniles that emerged from the major spawning areas but reared downstream.

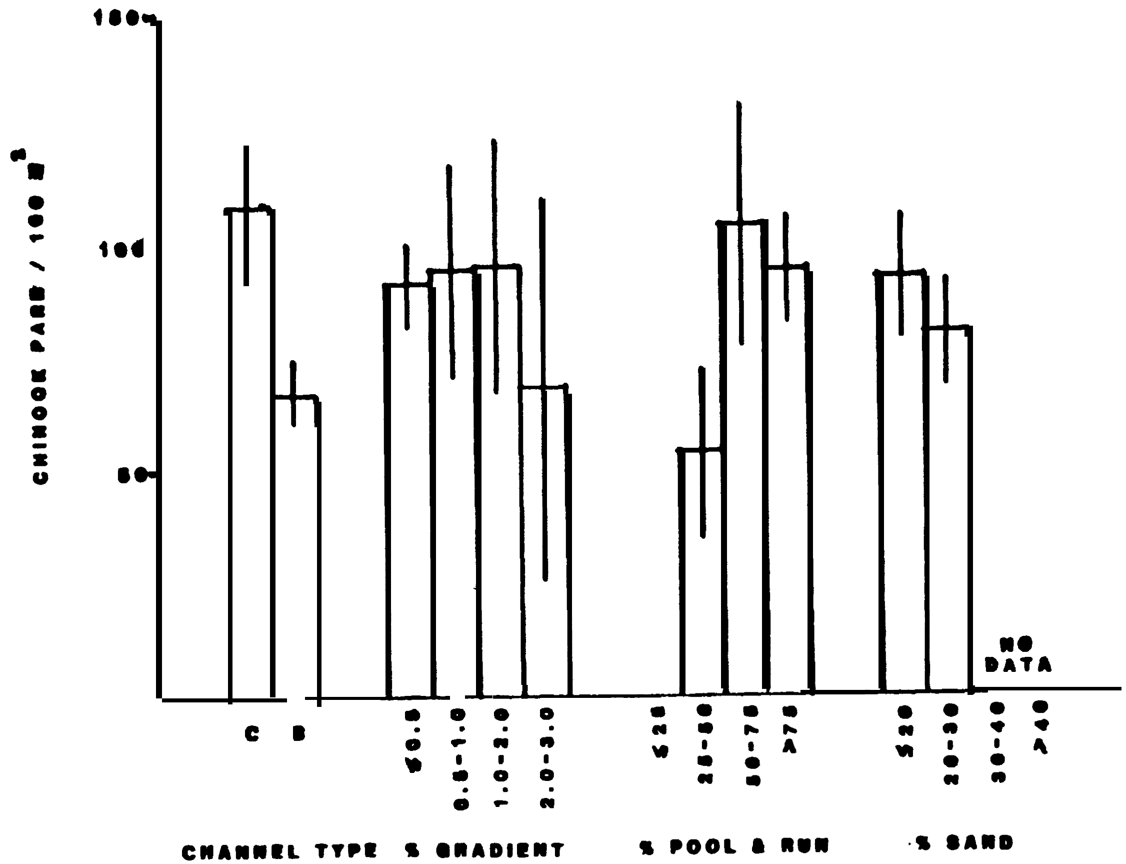

Figure 4. Chinook parr density near five stocking sites (within 2 km downstream of site) summarized by channel type and classes of percent gradient, pool and run, and percent sand, Crooked Fork, White Sand, and Big Flat creeks, August, 1987. Vertical bars represent ± SE.

Table 12. Total abundance and fry-to-Parr survival estimates for age 0 chinook, four stocking sites, upper Lochsa River, August 1987.

Stream, stocking site	Stratum	Stratum area (m^2)	Number of sections	Total abundance ±2 SE	% of number stocked
Crooked Fork Creek					
1.	U1	2,400	2	0+0	0
	D1	4,700	3	8,494±4,179	14.4
	D2-3	8,870	3	7,712±2,659	13.1
	Total	15,970	8	16,206±4,953	27.6[a]
2.	U1	9,000	2	529±219	0.5
	Dl	11,450	3	7,099±2,911	6.7
	D2	7,800	2	3,914±896	3.7
	D3	9,950	2	4,820±835	4.6
	Total	38,200	9	16,362±3,166	15.5[a]
Big Flat Creek					
4.	U1	5,600	2	3,423±2,793	3.5
	D1	10,750	3	7,850±592	8.0
	D2	7,700	2	5,145±239	5.2
	D3	8,050	2	5,688±647	5.8
	Total	32,100	9	22,106±2,937	22.6[a]
White Sand Creek					
5.	U2	15,000	3	5,481±3,399	3.6
	U1	11,100	2	7,668±6,800	5.0
	D1	17,400	3	20,115±5,051	13.2
	D2	10,400	2	9,144±4,880	6.0
	D3	9,500	2	2,656±812	1.7
	Total	63,400	12	45,064±10,382	29.6″

[a]Conservative estimate of fry-to-parr survival.

Table 13. Coefficients for linear and Beverton-Holt relationships fitted to chinook redd density and parr density data, Salmon River drainage, 1983-1986 brood years,

Variable	Sediment class <30%	30-40%	>40%	Combined
Sample size	45	8	15	68
P (redds/ha) mean (range)	1.8(0-8.9)	2.8(0-12.5)	1.2(0-2.6)	1.8(0-12.5)
R (parr/100 m^2) mean (range)	17.5(0-81.9)	13.0(0.6-44.2)	4.3(0.1-21.9)	14.1(0-81.9)
Linear regression				
a	4.62	8.12	12.05	5.15
b	7.19	1.74	-5.89	4.93
r^2	0.56	0.21	0.37	0.36
Beverton-Holt[a]				
β	0.0873	0.4100	-0.7374	0.6501
α	0.0141	0.0046	2.1778	-0.0031
r^2	0.12	co.01	0.10	co.01

[a] $\frac{P}{R} = \beta + \alpha P$ (Ricker 1975).

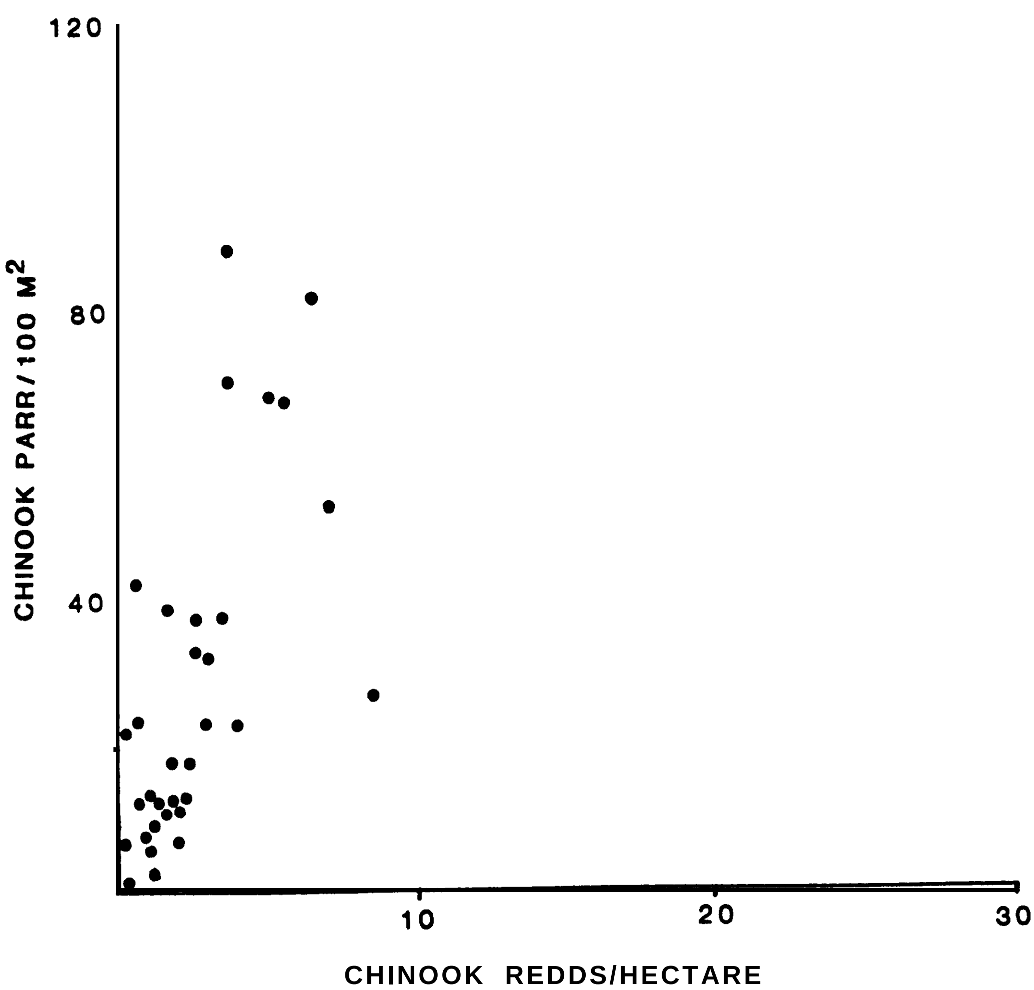

Figure 5. Relationships between chinook redd density and chinook parr density, C-channel streams with low sediment (<30% surface sand), Salmon River drainage, 1983-1986 brood years.

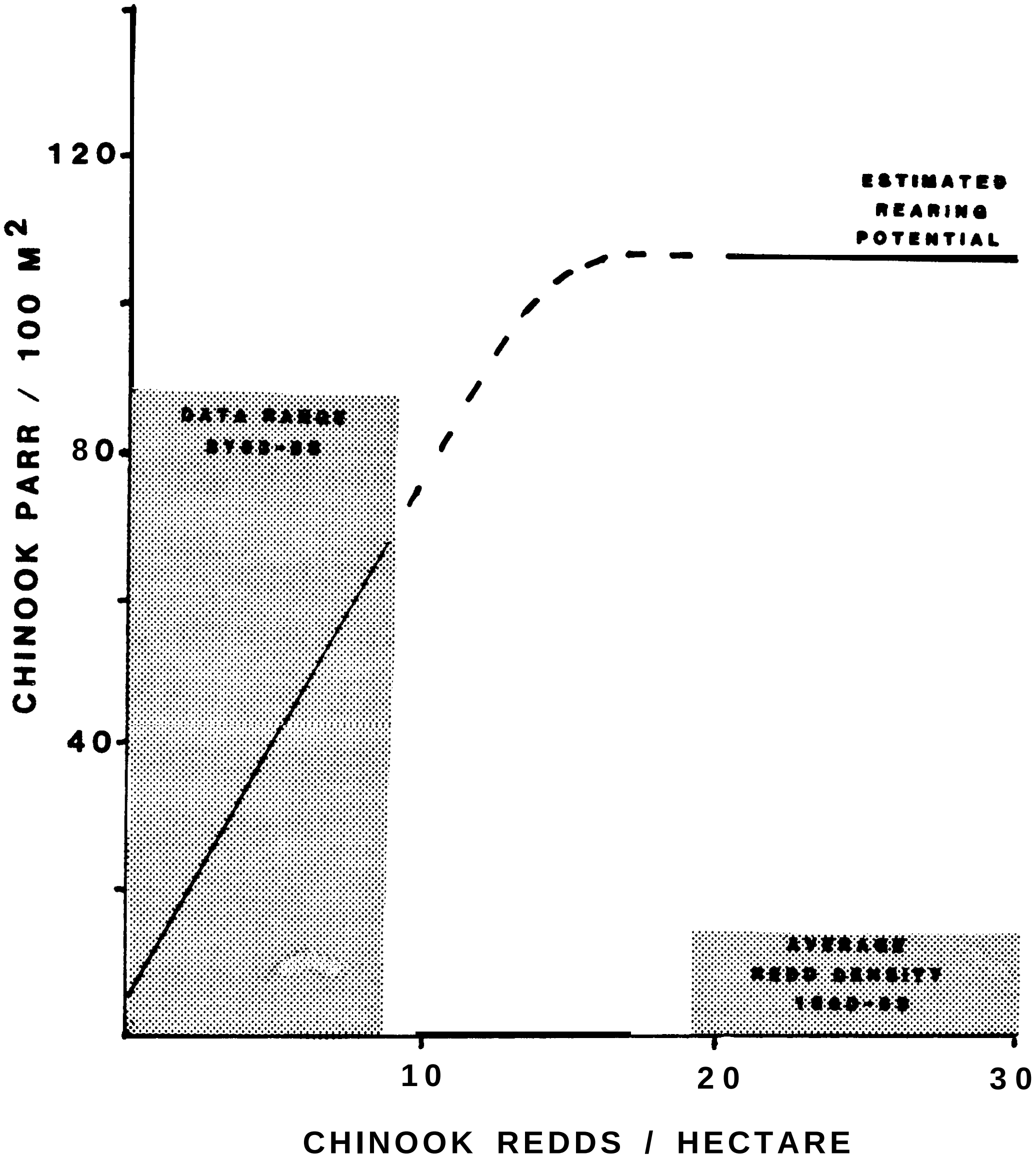

Figure 6. Hypothetical chinook reproduction curve for C-channel streams with low sediment (<30% surface sand), Salmon River drainage. Linear regression was fitted to redd density and parr density data, 1983-1986 brood years. Horizontal line represents mean parr density for well-seeded C-channel sections, upper Lochsa River tributaries, 1987.

Chinook Egg-to-Parr Survival

Estimates of egg-to-Parr survival for chinook (calculations based on 1.5 redds/female) ranged from 1.2% in Elk Creek (1987) and Bear Valley Creek (1986) to 74% in Valley Creek (1985) (Table 14). Estimates averaged 29% for Marsh Creek and the upper Salmon River and 13% for Herd Creek. The extremely high survival estimate for Valley Creek was an apparent outlier and may indicate that the 1984 redd count underestimated total redds.

Estimated egg-to-Parr survival for chinook was inversely related to sediment level (Figure 7). Estimated survival in the two most sedimented streams (Bear Valley and Elk creeks) averaged only 12% of survival in the two cleanest streams (Marsh Creek and Salmon River). Correlation coefficients between percent survival and percent surface sand were -0.65 and -0.97 for data that included and excluded the Valley Creek estimate, respectively.

Partial Project Benefits

Numbers of steelhead and chinook parr attributed to implemented projects from 1984-1987 are presented in Tables 15 and 16 according to approaches in Appendix B. Analysis of trends from density monitoring data will be used to estimate benefits in nonevaluation years (Figure 1).

Largest benefits (number of parr produced) accrued to date have been from barrier-removal projects where fish have been available for introductions. Total benefits from off-channel developments have been relatively small, due primarily to the small area involved (Tables 17 and 18). Off-channel developments in Crooked River have shown good potential for rearing high densities of chinook. We have not detected major increases in steelhead or chinook parr densities from any of the four instream structure projects implemented in Idaho, although the Lolo Creek project apparently resulted in a slight increase in steelhead rearing potential. Success of some BPA-funded projects will depend on concurrent land management improvements. BPA sediment reduction projects in the Bear Valley Creek drainage will likely be ineffective unless accompanied by improvements in cattle grazing management and revegetation (Appendix C).

DISCUSSION

Success of the entire Fish and Wildlife Program will be determined ultimately by the restoration of runs that are affected by hydropower operation, particularly the runs of depressed upriver stocks. Successful on-site mitigation to increase passage survival through improved flows and bypass systems is essential to the success of off-site mitigation projects, including those listed in Measure 703(c). The aforementioned improvements are also essential to evaluation of the full benefit of habitat enhancement in Idaho (Tables 15 to 18).

Table 14. Estimated survival from egg-to-Parr for chinook populations with a predominance of 5_2 spawners, Salmon River drainage.

Stream	Reach	Brood year	IDFG redd count	Summer total abundance	Percent survival[a] 1 redd/ female	1.5 redds/ female	Percent[b] surface sand
Marsh Creek	drainage	1984	61	77,913	21.6	32.5	17.8
Valley Creek	main stem	1984	21	61,126	49.3	74.0	30.2
Salmon River	above Valley Cr.	1984	76	76,102	17.0	25.5	19.8
Elk Creek	main stem	1984	27	6,559	4.1	6.2	49.2
		1985	28	1,885	1.1	1.7	49.2
		1986	55	2,581	0.8	1.2	49.2
Bear Valley Cr.	main stem	1983	56	18,100[c]	5.5	8.2	47.5
		1984	55	4,814[c]	1.5	2.2	47.5
		1985	134	6,274[c]	0.8	1.2	47.5
Herd Creek	main stem	1985	9[d]	9,274[d]	8.7	13.0	34.1[d]
		1986	31[d]	37,444[d]	9.1	13.6	34.1[d]

[a]Assumes 5,900 eggs per female (1981-1984 average, Sawtooth Hatchery) and either 1.0 redds/female (Bjornn 1978), or 1.5 redds/female (Ortmann 1968).
[b]OEA (1987 a,b) data for C-channels.
[c]Shoshone-Bannock Tribes data (Konopacky et al. 1986; Richards and Cernera 1987).
[d]Shoshone-Bannock Tribes data (Richards, personal communication).

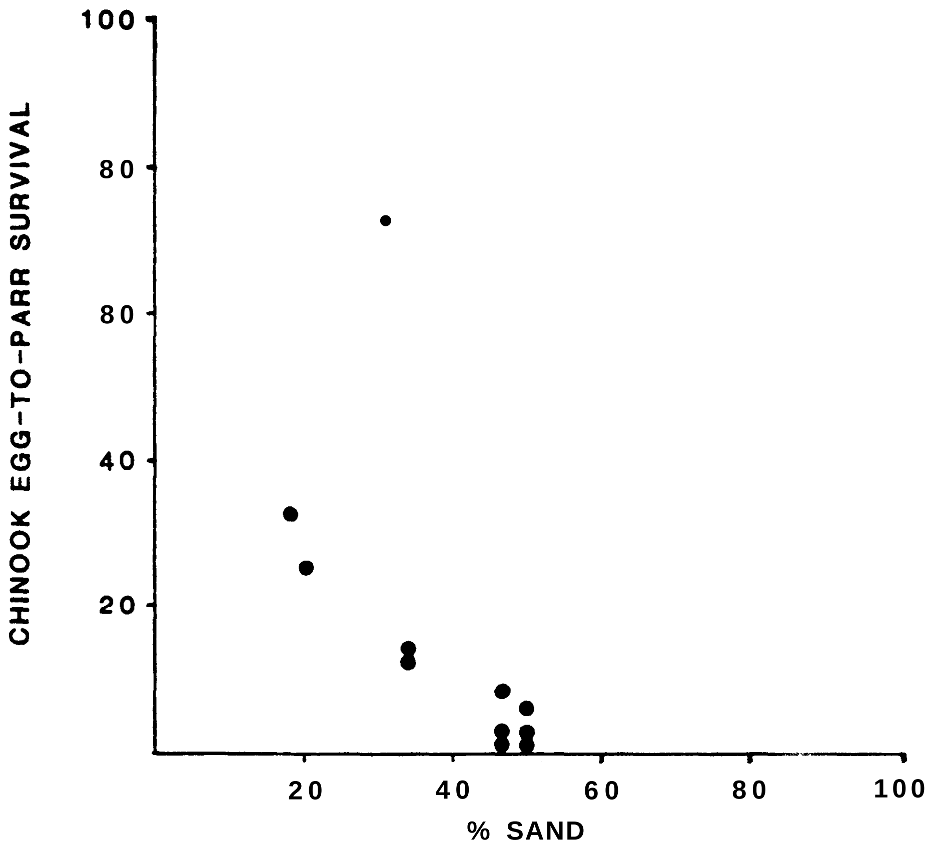

Figure 7. Estimated egg-to-Parr survival for chinook populations compared to percent surface sand (C-channels), Salmon River drainage. Survival estimates based on assumptions of 1.5 redds/female and fecundity of 5,900. Open circle represents Valley Creek estimate, an apparent outlier.

Table 15. Standing crops of steelhead parr attributed as benefits of implemented projects, 1984-1987. Project benefits in nonelevation years (PB) will be estimated at a later time from monitoring and evaluation data.

Project type, stream	Year implemented	Steelhead parr standing crop 1984	1985	1986	1987	1988
Barrier Removal - Complete						
Eldorado Creek	1984- 1985	-	0	7,310	PB	
Pine Creek	1987	-	-	-	PB	
Barrier Removal - Partial[a]						
Crooked Fork Creek	1984- 1985	-	PB/f	505/f	154/f	
Crooked River (culvert)	1984	-	PB/f	2,750/f	PB/f	
Pole Creek (screen)	1983	0	376/f	PB/f	PB/f	
South Fork tributaries	1986	-	-	-	-	
Off-Channel Developments						
Crooked River	1984- 1985	-	0	69	PB	
Red River	1985	-	-	1	PB	
Instream Structures						
Lolo Creek	1983- 1984	PB	2,752	PB	PB	
Upper Lochsa River	1983- 1984	0	PB	PB	PB	
Crooked River	1984- 1985	-	PB	0	PB	
Red River	1983- 1985	-	PB	0	PB	

[a] Benefits from partial barrier-removal projects to be calculated as a fraction (l/f) of standing crop based on analysis of preproject potential.

Table 16. Standing crops of age 0 chinook attributed as benefits of implemented projects, 1984-1987. Project benefits in nonevaluation years (PB) will be estimated at a later time from monitoring and evaluation data.

Project type, stream	Year implemented	Age 0 chinook standing crop				
		1984	1985	1986	1987	1988
Barrier Removal - Complete						
Eldorado Creek	1984- 1985	-	0	30,319	PB	
Crooked Fork Creek	1984- 1985	-	-	17,588	32,571	
Johnson Creek	1984- 1985	-	PB	23,711	17,700	
Boulder Creek	1985	-	-	28,112	0	
Meadow Creek	1987	-	-	-	-	
Knapp Creek	1987	-	-	-	-	
Barrier Removal - Partial[a]						
Crooked River (culvert)	1984	-	PB/f	7,413/f	PB/f	
Pole Creek (screen)	1983	0	0	0	0	
Off-Channel Developments						
Crooked River	1984-1985	-	12	739	PB	
Red River	1985	-	-	215	PB	
Instream Structures						
Lolo Creek	1983- 1984	PB	0	PB	PB	
Upper Lochsa River	1983- 1984	0	PB	PB	PB	
Crooked River	1984- 1985	-	PB	0	PB	
Red River	1983- 1985	-	PB	0	PB	

[a]Benefits from partial barrier-removed projects to be calculated as a fraction (l/f) of standing crop based on analysis of preproject potential.

Table 17. Change in steelhead parr density and stream area (hectares) attributed to implemented projects from project evaluations, 1984-1987.

Project type, stream	Year implemented	Steelhead Parr/100 m^2 (hectares) 1984	1985	1986	1987	1988
Barrier Removal - Complete						
Eldorado Creek	1984-1985	-		4,4(13.8)	-	-
Pine Creek	1987			0	-	-
Barrier Removal - Partial[a]						
Crooked Fork Creek	1984-1985	-		0.2(11.2)	0.1(11.2)	
Crooked River (culvert)	1984			5.7(5.3)		
Pole Creek (screen)	1983		1.0(2.9)	-	(2.9)	
South Fork tributaries	1986			0		
Off-Channel Developments						
Crooked River	1984-1985	-	0.0(0.02)	8.2(0.08)	-	
Red River	1985			0.2(0.05)	-	
Instream Structures						
Lolo Creek	1983-1984	-	1.8(15.3)		-	
Upper Lochsa River	1983-1984	0.0(12.5)		0		
Crooked River	1984-1985	-		0.0(5.3)	-	
Red River	1983-1985	-		0.0(7.5)		

[a]Benefits from partial barrier-removal projects to be calculated as a fraction of standing crop based on analysis of preproject potential.

Table 18. Change in chinook density and stream area (hectares) attributed to implemented projects from project evaluations, 1984-1987.

Project type, stream	Year implemented	Age 0 chinook/100 m^2 (hectares)				
		1984	1985	1986	1987	1988
Barrier Removal - Complete						
Eldorado Creek	1984-1985	-		27.1 (13.8)	- (13.8)	
Crooked Fork Creek	1984- 1985	-		21.1 (11.2)	29.1(11.2)	
Johnson Creek	1984- 1985	-		7.4 (34.7)	- (34.7)	
Boulder Creek	1985			28.9 (9.7)	0 (9.7)	
Barrier Removal - Partial[a]						
Crooked River (culvert)	1984			16.4 (5.3)	-	
Pole Creek (screen)	1983		0.0 (2.4)	-	0 (2.4)	
Off-Channel Developments						
Crooked River	1984- 1985	-	6.7 (0.02)	88.0 (0.08)	-	
Red River	1985			44.0 (0.05)	-	
Instream Structures						
Lolo Creek	1983- 1984	-	0.0 (15.3)	-		
Upper Lochsa River	1983- 1984	0.0 (12.5)	-			
Crooked River	1984- 1985	-		0.0 (5.3)	-	
Red River	1983-1985	-		0.0 (7.5)	-	

[a]Benefits from partial barrier-removal to be calculated as a fraction of standing crop based on analysis of preproject potential.

During the period of run restoration, most anadromous populations in Idaho will exhibit a wide range of seeding levels. The current underseeded conditions and the expected trend for increasing steelhead and salmon escapements as main stem passage conditions improve preclude a simple "before and after" comparison of populations to estimate benefits from habitat projects.

The IDFG general evaluation approach relies heavily on monitoring population trends to define full-seeding levels and separation of those parts of "final" densities or standing crops due to specific enhancement activities (Figure 1, Appendix B). Intensive production studies relating spawning escapements, standing crops of juveniles, and smolt yields (Kiefer and Apperson 1988) will be integrated with the survey approach of the general evaluations. A common data base will be needed to apply results from a small number of intensive studies across a broad range of habitats and stocks. Monitoring will assist in applying knowledge gained over time, as well as over a broad range of habitat types, and is essential to estimating partial benefits prior to the project reaching full maturation and/or the parr densities reaching full seeding.

IDFG initiated a parallel monitoring program in 1985 that annually monitors anadromous fish densities in streams unaffected by BPA habitat projects. The physical habitat and fish population data bases from the BPA and non-BPA monitoring programs are compatible and together provide important empirical information on the status of wild and natural anadromous stocks. Further management emphasis is needed to integrate data from these monitoring programs with other information from land management activities, redd counts, dam counts of adults and smolts, main stem flow conditions, and ocean, downriver, and tributary harvest.

The data base being developed in Idaho through general and intensive monitoring programs will not only determine the effectiveness of individual habitat enhancement projects but will also contribute to the determination of the effectiveness of major elements of the Fish and Wildlife Program as described below.

Section 203	Program goals for anadromous fish
Section 303	Water budget and migrant survival
Section 403	Downstream migrant passage
Section 503	Ocean survival, harvest management, and escapement objectives
Section 703	Wild, natural, and hatchery propagation Integration of natural and hatchery propagation

Evaluation and monitoring data will provide a scientific basis for informed decisions. Planners, managers, researchers, and administrators will utilize a common data base to improve their ability to effectively perform their tasks.

A data collection system using standardized formats that would assimilate physical habitat- data, juvenile density data, and spawning escapement data from all sources (fish and wildlife agencies, tribes, land management agencies, and private entities) into a common data base should be implemented for the entire Columbia River Basin. This data base would better serve fisheries managers, land managers, and planners than the present data collection process.

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LITERATURE CITED

Andrews, J. and L.B. Everson. 1988. Middle Fork and upper Salmon River habitat improvement implementation plan, FY 1988-1992. Department of Energy, Bonneville Power Administration, Division of Fish and Wildlife.

Bjornn, T.C. 1978. Survival, production, and yield of trout and chinook salmon in the Lemhi River, Idaho. University of Idaho, Forest, Wildlife and Range Experiment Station Bulletin 27, Moscow, Idaho.

Crouse, M.R., C.A. Callahan, K.W. Maleug, and S.C. Dominguez. 1981. Effects of fine sediments on growth of juvenile coho salmon in laboratory streams. Transactions of the American Fisheries Society 110:281-286,

Hankin, D.G. and G.H. Reeves. In press. Estimating total fish abundance and total habitat area in small streams based on visual estimation methods. Canadian Journal of Fisheries and Aquatic Sciences.

Kiefer, R.B. and K. Apperson. 1988. Intensive evaluation and monitoring of chinook salmon and steelhead trout production, Crooked River and Salmon River sites. Part IV in Idaho Department of Fish and Game. 1988. Idaho habitat evaluation of off-site mitigation record. Annual Report, fiscal year 1987. Department of Energy, Bonneville Power Administration, Division of Fish and Wildlife.

Konopacky, R.C., P.J. Cernera, E.C. Bowles, and J.M. Montgomery. 1986. Salmon River habitat enhancement. Annual Report, fiscal year 1984. Department of Energy, Bonneville Power Administration, Division of Fish and Wildlife.

Northwest Power Planning Council (NPPC). 1986. Columbia River Basin Fishery Planning Model-technical discussion paper. Northwest Power Planning Council.

OEA (OEA Research). 1987a. Middle Fork of the Salmon River, aquatic and riparian area inventory. Final report. Department of Energy, Bonneville Power Administration, Division of Fish and Wildlife.

OEA (OEA Research). 1987b. Upper Salmon River, aquatic and riparian area inventory. Final report. Department of Energy, Bonneville Power Administration, Division of Fish and Wildlife.

Ortmann, D.W. 1968. Salmon and steelhead investigations, Job 1, South Fork of the Salmon River, salmon and steelhead harvest and escapement studies. Federal Aid to Fish Restoration, Job Completion Report, Project F-49-4-6. Idaho Department of Fish and Game.

Petrosky, C.E. and T.B. Holubetz. 1985. Idaho habitat evaluation for off-site mitigation record. Annual report, fiscal year 1984. Department of Energy, Bonneville Power Administration, Division of Fish and Wildlife.

Petrosky, C.E. and T.B. Holubetz. 1986. Idaho habitat evaluation for off-site mitigation record. Annual report, fiscal year 1985. Department of Energy, Bonneville Power Administration, Division of Fish and Wildlife.

Petrosky, C.E. and T.B. Holubetz. 1987. Evaluation and monitoring of Idaho habitat enhancement and anadromous fish natural production. Annual report, fiscal year 1986, Department of Energy, Bonneville Power Administration, Division of Fish and Wildlife,

Platts, W.S., M. McHenry, and R. Torquemada. 1986. Evaluations of fish habitat enhancement projects in Crooked River, Red River, and Bear Valley Creek. Progress Report 2 in Petrosky, C.E., and T.B. Holubetz. 1986. Idaho habitat evaluation for off-site mitigation record. Department of Energy, Bonneville Power Administration, Division of Fish and Wildlife.

Platts, W.S., M. McHenry, and R. Torquemada. 1987. Aquatic and riparian habitat conditions of the Bear Valley area, 1986. Progress report in Petrosky, C.E., and T.B. Holubetz. 1987. Evaluation and monitoring of Idaho habitat enhancement and anadromous fish natural production. Annual report, fiscal year 1986. Department of Energy, Bonneville Power Administration, Division of Fish and Wildlife.

Platts, W.S., N.F. Megahan, and G.W. Minshall. 1983. Methods for evaluating stream, riparian, and biotic conditions, General technical report INT-138. U. S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station, Ogden, Utah.

Richards, C. and P.J. Cernera. 1987. Salmon River habitat enhancement. Annual report, fiscal year 1986. Department of Energy, Bonneville Power Administration, Division of Fish and Wildlife.

Ricker, W.E. 1975. Computation and interpretation of biological statistics of fish populations. Fisheries Research Board of Canada. 34:123-128.

Rosgen, D.L. 1985. A stream classification system. North America Riparian Conference, Tucson, Arizona, April 16-18, 1985.

Scheaffer, R.L., W. Mendenhall, and L. Ott. 1979. Elementary survey sampling, second edition, Duxbury Press,

Seber, G.A.F. and E.D. LeCren. 1967. Estimating population parameters from catches large relative to the population. Journal of Animal Ecology 36:631-643.

Shepard, B.B. 1983. Evaluation of a combined methodology for estimating fish abundance and lotic habitat in mountain streams of Idaho. Master's thesis, University of Idaho, Moscow, Idaho.

Torquemada, R.J., and W.S. Platts. 1984. Evaluation of fish habitat enhancement project s in Crooked River, Red River, and Bear Valley Creek. Progress Report I, in Petrosky, C.E., and T.B. Holubetz. 1985. Idaho habitat evaluation for off-site mitigation record. Annual report, fiscal year 1984. Department of Energy, Bonneville Power Administration, Division of Fish and Wildlife.

Torquemada, R.J., and W.S. Platts. 1988. A comparison of sediment monitoring techniques of potential use in sediment/fish population relationships. Part 111 in Idaho Department of Fish and Game. 1988. Idaho habitat evaluation for off-site mitigation record. Annual report, fiscal year 1987. Department of Energy, Bonneville Power Administration, Division of Fish and Wildlife.

Welsh, T.L. 1988. Development of chinook fry outplanting strategies for supplementat ion of depressed stocks and evaluation of Johnson Creek fish passage improvement projects. Part II in Idaho Department of Fish and Game. 1988. Idaho habitat evaluation for off-site mitigation record. Annual Report, fiscal year 1987. Department of Energy, Bonneville Power Administration, Division of Fish and Wildlife.

Zippen, C. 1958. The removal method of population estimation. Journal of Wildlife Management. 22:82-90.

APPENDIX A

Appendix A-l. Annual trends in density (number/100 m^2) of yearling-and-older rainbow-steelhead and age 0 chinook in established monitoring sections, Lolo Creek. Sections are listed sequentially, upstream to downstream. Time of implementation is indicated by a (/); evaluation years are indicated by shading.

Species, age	Treatment[a]	Section	1983	1984	1985	1986	1987	1988
Rainbow-steelhead								
Age >1	IS	8303	- /	4.4	3.6	2.4	8.0	
	C	RUN 1U	-	3.9	2.5	1.4	4.0	
	C	RUN 7U	-	·	6.9	2.2	11.3	
	IS	8360	- /	5.4	6.3	1.3	7.0	
	IS	DS 6	-	/	1.0	14.2	7.1	
	C	RUN 6D	-	2.5	0.4	9.9	0.5	
		Mean	-	4.0	3.4	5.2	6.3	
Chinook								
Age 0	IS	8303	- /	6.3	25.2	38.3	58.3	
	C	RUN 1U	-	0	7.1	70.7	33.2	
	C	RUN 7U	-		0.2	1.1	4.1	
	IS	8360	- /	0.9	0.6	0.4	9.7	
	IS	DS 6	-	/	0.7	1.0	9.0	
	C	RUN 6D	-	0	0	0	0	
		Mean	-	1.8	5.6	18.6	19.0	

[a]IS=Instream structure; C=control.

Appendix A-2. Annual trends in density (number/100 m^2) of yearling-and-older rainbow-steelhead and age 0 chinook in established monitoring sections, Eldorado Creek. Sections are listed sequentially, upstream to downstream. Time of implementation is indicated by a slash (/); evaluation years are indicated by shading.

Species, age	Location[a]	Section	1983	1984	1985[b]	1986[c]	1987[c]	1988
Rainbow-steelhead								
Age >l	AU	2M		/	0	0	1.3	
	AL	1HG		0 /	0	11.1	7.9	
	AL	2LG		0 /	0	4.3	1.8	
	B	1B		5.1	5.3	8.7	7.5	
		Mean		1.7	1.3	6.0	4.6	
Chinook								
Age 0	AU	2M		/	0	111.6	160.9	
	AL	1HG		0 /	0	2.6	11.3	
	AL	2LG		0 /	0	61.4	2.0	
	B	1B		0	0	2.0	1.3	
		Mean		0	0	44.4	43.9	

[a] AU=above barriers, upper meadow; AL=above barriers, lower meadow; B=below barriers.
[b] Adult steelhead outplanted.
[c] Chinook fry introductions.

Appendix A-3. Annual trends in density (number/100 m^2) of yearling-and-older rainbow-steelhead and age 0 chinook in established monitoring sections, Crooked Fork Creek. Sections are listed sequentially, upstream to downstream. Time of implementation is indicated by a slash (/); evaluation years are indicated by shading.

Species, age	Location[a]	Section	1983	1984	1985	1986[c]	1987[c]	1988
Rainbow-steelhead								
Age ≥1	A	1A		0	0 /	0	0.2	
	A	2A		0.1	0 /	0	0	
	A	3A		0	0 /	0	0	
	A	4A		0	0 /	0.4	0	
	B	1B	5.3	5.3	0.8	0.5	1.6	
	B	2B	4.8	5.0	1.8	2.0	1.8	
		Mean	1.7[b]	1.7	0.4	0.5	0.6	
Chinook								
Age 0		1A		0	0 /	12.3	1.5	
		2A		0	0 /	24.2	57.0	
		3A		0	0 /	6.4	15.5	
		4A		0	0 /	5.2	10.6	
	B	1B	4.3	2.9	0.4	2.3	15.0	
	B	2B	8.6	3.8	0.5	5.8	2.9	
		Mean	2.2[b]	1.1	0.2	9.4	17.1	

[a] A=above barriers; B=below barriers.
[b] Densities above barriers assumed to be zero.
[c] Chinook fry introductions.

Appendix A-4 Annual trends in density (number/100 m^2) of yearling-and-older rainbow-steelhead and age 0 chinook in established monitoring sections, Crooked River. Sections are listed sequentially, upstream to downstream. Time of implementation is indicated by a slash (/); evaluation years are indicated by shading.

Species age	Reach, treatment[a]	Section	1983	1984	1985	1986	1987	1988
Rainbow-steel head								
Age >1	I,IS	Sill Log A		0.2 /	1.5	5.9	7.0	
	I,C	Control 1		0.7	0.5	5.7	2.9	
	II,IS	Treatment 2			1.5 /	13.7	19.6	
	II,C	Control 2			2.6	14.0	9.5	
	III,U	Natural	1.2	3.1		3.5	9.0	
	IV,U	Meander 1			0.4	6.1	11.0	
	IV,U	Meander 2	0.2	0.7	0.1	5.3	6.5	
		Mean	0.7	1.2	1.1	7.7	9.4	
Chinook								
Age 0	I,IS	Sill Log A		0 /	31.9	17.8	5.2	
	I,C	Control 1		0	9.7	12.2	0.8	
	II,IS	Treatment 2			52.4 /	21.9	1.7	
	II,C	Control 2			90.2	29.8	0.4	
	III,U	Natural	19.5	32.2		57.8	22.3	
	IV,U	Meander 1			91.9	93.4	12.5	
	IV,U	Meander 2	4.2	3.8	40.7	50.1	18.3	
		Mean	11.8	9.0	52.8	40.4	8.7	

[a]IS=instream structure; C=control; U=undetermined treatment.

Appendix A-5. Annual trends in density (number/100 m^2) of yearling-and-older rainbow-steelhead and age 0 chinook in established monitoring sections, Red River. Sections are listed sequentially, upstream to downstream. Time of implementation is indicated by a slash (/); evaluation years are indicated by shading.

Species, age	Reach, treatment[a]	Section	1983	1984		1985	1986	1987	1988
Rainbow-steelhead									
Age ≥1	I	Millers						0	
	II,IS	Treatment 2	·		/	2.3	2.2	3.1	
	II,C	Control 2				1.1	1.3	1.7	
	IV,C	Control 2	3.9	2.7		1.1	3.5	4.5	
	IV,IS	Treatment 2	1.8	1.6	/	0.8	1.6	3.3	
	V,C	Control 2				0.4	19.1	7.9	
	V,BSR	Treatment 2	·		/	0.5	11.4	5.4	
		Mean	2.8	2.2		1.0	6.5	3.7	
Chinook									
Age 0	I	Millers						88.4	
	II,IS	Treatment 2	·		/	75.4	19.3	48.1	
	II,C	Control 2				39.9	4.1	16.5	
	IV,C	Control 2	11.7	9.8		77.8	34.3	46.6	
	IV,IS	Treatment 2	15.1	17.0	/	60.2	39.7	47.4	
	V,C	Control 2				7.2	49.4	11.9	
	V,BSR	Treatment 2	·		/	8.0	15.1	9.5	
		Mean	13.4	13.4		44.8	27.3	38.3	

[a]IS=instream structure; C=control; BSR=bank stabilization, riparian revegetation.

Appendix A-6. Annual trends in density (number/100 m^2) of yearling-and-older rainbow-steelhead and age 0 chinook in established monitoring sections, Panther Creek. Sections are listed sequentially, upstream to downstream. Time of implementation is indicated by a slash (/); evaluation years are indicated by shading.

Species, age	Location[a]	Section	1983	1984	1985[b]	1986[c]	1987	1988
Rainbow-steelhead								
Age <1	A	MO1	-	4.3	8.4	13.3	14.8	
	A	PC10	-	4.3	·	·	2.0	
	A	PC9	-	7.1		12.5	7.7	
	B1,A2	PC6	-	1.1	1.0	2.5	3.8	
	B1,B2	PC4	-	0	+	0.2	0.1	
	B1,B2	PC1	-	1.0	0.7	0.8	1.3	
		Mean		3.0	2.0	5.7	5.0	
Chinook								
Age 0	A	MO1		0	0	0	0.3	
	A	PC10	·	0	·		0	
	A	PC9		0	·	0	56.2	
	B1,A2	PC6		+	0	0	3.2	
	B1,B2	PC4		0	0	0	1.0	
	B1,B2	PC1		0	0	0	0.1	
		Mean	-	+	0	0	10.1	

[a] A=above mine effluent; B1=below Blackbird Creek; A2=above Big Deer Creek; B2=below Big Deer Creek.
[b] Engineering feasibility, habitat assessment only.
[c] Adult chinook outplanted.

Appendix A-7. Annual trends in density (number/100 m^2) of yearling-and-older rainbow-steelhead and age 0 chinook in established monitoring sections, Lemhi River. Sections are listed sequentially, upstream to downstream. Time of implementation is indicated by a slash (/); evaluation years are indicated by shading.

Species, age	Location[a]	Section	1983	1984	1985[b]	1986	1987	1988
Rainbow-steelhead								
Age >l	Big Springs Cr.	LEM-1A	-	-	44.6	15.8	20.8	
	Lemhi R.	LEM-2B	-	-	20.0	21.5	19.8	
	Lemhi R.	LEM-3A	-	-	15.9	12.7	8.2	
	Bear Valley Cr.	HC-1B	-	-	1.0	0.3	0.4	
	Hayden Cr.	HC-2B	-	-	0	0.2	0	
	Hayden Cr.	HC-3B	-	-	0.5	4.1	0.9	
		Mean	-	-	13.7	9.1	8.4	
Chinook								
Age 0	Big Springs Cr.	LEM-1A	-	-	0.5	0.7	4.9	
	Lemhi R.	LEM-2B	-	-	1.4	5.0	30.9	
	Lemhi R.	LEM-3A	-	-	1.7	1.1	14.9	
	Bear Valley Cr.	HC-1B	-	-	0	0	0	
	Hayden Cr.	HC-2B	-	-	14.4	0	0	
	Hayden Cr.	HC-3B	-	-	7.3	0	0	
		Mean	-	-	4.2	1.1	8.4	

[a] All sections located above dewatered area.
[b] Engineering feasibility, habitat assessment only.

Appendix A-8. Annual trends in density (number/100 m^2) of yearling-and-older rainbow-steelhead and age 0 chinook in established monitoring sections, East Fork Salmon River. Sections are listed sequentially, upstream to downstream. Time of implementation is indicated by a slash (/); evaluation years are indicated by shading.

Species, age	Location[a]	Section	1983	1984	1985[b]	1986[b]	1987[b]	1988
Rainbow-steelhead								
Age >l	AW	2			0.2	1.5	0.2	
	AW	3			0	0.7	0.8	
	BW	5			1.2	1.4	2.4	
	BW	8			6.2	2.6	2.0	
		Mean			1.9	1.6	1.4	
Chinook								
Age 0	AW	2	.	.	0	0.3	0.1	
	AW	3	.	.	0	6.5	0.4	
	BW	5	.	.	6.0	10.5	23.8	
	BW	8	.	.	21.0	1.3	3.7	
		Mean	-	-	5.2	4.7	7.0	

[a] AW=above East Fork weir; BW=below weir.
[b] Pretreatment evaluation by Shoshone-Bannock Tribes.

Appendix A-9. Annual trends in density (number/100 m^2) of yearling-and-older rainbow-steelhead and age 0 chinook in established monitoring sections, upper Salmon River. Sections are listed sequentially, upstream to downstream. Time of implementation is indicated by a slash (/); evaluation years are indicated by shading.

Species, age	Location[a]	Section[b]	1983	1984	1985	1986	1987	1988
Rainbow-steelhead								
Age 21	AD	10A	-	0	10.9	15.9	20.4	
	AD	9A	-	0.2	3.9	11.1	10.0	
	AD	8B	-	0	0.8	0.6	0.3	
	AD	8A	-	1.9	0.4	1.2	1.1	
	BD	7B	-	0.2	0.8	0.2	1.2	
	BD	7A	-	1.4	1.2	0.5	0	
	BD	6A	-		0.1	0	0	
	BW	3BRA	-		8.2	3.7	3.3	
	BW	2B	-		2.0	1.1	3.1	
		Mean	-	0.8	3.1	3.8	4.4	
Chinook								
Age 0	AD	10A	-	28.1	7.1	3.4	0.4	
	AD	9A	-	53.2	12.8	6.0	7.7	
	AD	8B	-	12.9	1.2	7.6	2.2	
	AD	8A	-	97.4	1.4	16.9	18.9	
	BD	7B	-	94.7	10.8	1.7	36.0	
	BD	7A	-	41.2	17.4	20.2	7.0	
	BD	6A	-		0	0.4	0.2	
	BW	3BRA	-	·	32.2	70.6	88.8	
	BW	2B		·	2.2	4.1	5.8	
		Mean	-	54.0	9.4	14.5	18.6	

[a] AD=above irrigation diversion; BD-below diversion; BW=below Sawtooth Hatchery weir.
[b] Sections 10A, 9A, 8B, 8A, and 7A were initially numbered in 1984 as 1, 2, 3, 4, 5, and 6, respectively.

Appendix A-10. Annual trends in density (number/100 m2) of yearling-and-older rainbow-steelhead and age 0 chinook in established monitoring sections, Alturas Lake Creek. Sections are listed sequentially, upstream to downstream. Time of implementation is indicated by a slash (/); evaluation years are indicated by shading.

Species, age	Location[a]	Section	1983	1984	1985	1986	1987	1988
Rainbow-steelhead								
Age >1	A,L	1A		0	0.1	0	0	
	A,L	2A		0	0	0	0	
	A	2		0.5	-	1.0	3.5	
	B	3		0.5	0.8	0.3	1.5	
		Mean		0.2	0.3	0.3	1.2	
Chinook								
Age 0	A,L	1A		0.1	0	0	0	
	A,L	2A		1.2	0	0.1	0.1	
	A	2		6.8	-	5.7	1.2	
	B	3		81.9	12.5	12.3	38.9	
		Mean		22.5	4.2	4.5	9.8	

[a] A=above irrigation diversion; B=below diversion; L=above Alturas Lake.

Appendix A-11. Annual trends in density (number/100 m^2) of yearling-and-older rainbow-steelhead and age 0 chinook in established monitoring sections, Pole Creek. Sections are listed sequentially, upstream to downstream. Time of implementation is indicated by a slash (/); evaluation years are indicated by shading.

Species, age	Location[a]	Section[b]	1983	1984	1985[c]	1986	1988
Rainbow-steelhead							
Age ≥1	A	38	/	0	0	0.2	0
	A	3A	- /	0	0	0	0.3
	B	2B		0	0	0.3	10.4
	B	2A	-	0.8	3.2	3.6	2.7
		Mean		0.2	0.8	1.0	3.4
Chinook							
Age 0	A	38	- /	0	0	0	0
	A	3A	/	0	0	0	0
	B	2B		45.2	0	0	0.9
	B	2A	-	15.5	0	0.3	0.8
		Mean		15.2	0	0.1	0.4

[a] A=above irrigation diversion screen; B=below irrigation diversion screen.
[b] Sections 3B, 3A, 2B, and 2A were initially numbered in 1984 as 1, 2, 3, and 4, respectively.
[c] Habitat inventory and problem identification, not an evaluation of BPA screening project.

Appendix A- 12. Annual trends in density (number/100 m^2) of yearling-and-older rainbow-steelhead and age 0 chinook in established monitoring sections, Valley Creek. Sections are listed sequentially, upstream to downstream. Time of implementation is indicated by a slash (/); evaluation years are indicated by shading.

Species, age	Section	1983	1984	1985[a]	1986	1987	1988
Rainbow-steelhead							
Age >l	6B			0.2	0.3	0.7	
	3B			2.8	0.9	0.3	
	3A			3.5	0.7	0.6	
	1B			1.3	0.5	0.1	
	Mean			1.9	0.6	0.4	
Chinook							
Age 0	6B			5.4	0	5.0	
	3B			38.6	0.7	30.4	
	3A			45.5	3.5	47.6	
	1B			15.1	21.9	2.5	
	Mean			26.1	6.5	21.4	

[a]Habitat inventory and problem identification.

Appendix A-13. Annual trends in density (number/100 m^2) of yearling-and-older rainbow-steelhead and age 0 chinook in established monitoring sections, Bear Valley Creek. Sections are listed sequentially, upstream to downstream. Time of implementation is indicated by a slash (/); evaluation years are indicated by shading.

Species, age	Location[a]	Section[b]	1983	1984[c]	[illegible][c,d]	1986[c]	1987[c]	1988
Rainbow-steelhead								
Age ≥1	AM	9B		0	0	0	0	
	BM	5A	-	0	0 /	0	0.1	
	BM	3A	-	0.2	0 /	0.8	0.3	
	BE	2A	-	t	0.1 /	0.1	0	
	BE	2B		t	0 /	0	0	
	BE	1A	-	1.1	0 /	3.3	1.7	
		Mean		0.2	t	0.7	0.4	
Chinook								
Age 0	AM	9B	-	5.9	0	0	2.2	
	BM	5A	-	5.4	0.2 /	4.1	1.3	
	BM	3A	-	2.0	1.0 /	4.7	7.7	
	BE	2A	-	4.7	1.9 /	3.0	0.9	
	BE	2B	-	1.3	0 /	0.3	0	
	BE	1A	-	3.2	0.2 /	0.5	1.2	
		Mean		3.8	0.6	2.1	2.2	

[a] AM=above mining area; BM-below mining area; BE--below mining area and Elk Creek.
[b] Sections 2A and 2B were initially numbered by IDFG in 1984 as sections 4 and 5; all other sections established by Shoshone-Bannock Tribes.
[c] Pretreatment and posttreatment evaluation by Shoshone-Bannock Tribes for "point-source" sediment reduction project.
[d] Habitat inventory and problem identification.

Appendix A-14. Annual trends in density (number/100 m^2) of yearling-and-older rainbow-steelhead and age 0 chinook in established monitoring sections, Elk Creek. Sections are listed sequentially, upstream to downstream, Time of implementation is indicated by a slash (/); evaluation years are indicated by shading.

Species, age	Location[a]	Section[b]	1983	1984	1985[c]	1986	1987	1988
Rainbow-steelhead								
Age >_1	A	2A		0	0	+	0	
	A	2B			1.1	0.2	0	
	B	1A			0.4	0	0	
	B	1B		+	1.4	0.6	0	
	BC	1B		+	0	-	0	
		Mean		+	0.6	0.2	0	
Chinook								
Age 0	A	2A		0.5	0.5	0.9	0	
	A	2B			6.1	2.6	3.8	
	B	1A			2.8	0.1	0.1	
	B	1B		7.7	1.0	2.9	0.1	
	BC	1B			0.2	-	0	
		Mean		4.1	2.1	1.6	0.8	

[a] A=above Bearskin Creek confluence; B=below Bearskin Creek; BC=Bearskin Creek,
[b] Sections 2A and 1B were initially numbered in 1984 as 1 and 2, respectively.
[c] Habitat inventory and problem identification.

Appendix A-15. Annual trends in density (number/100 m^2) of yearling-and-older rainbow-steelhead and age 0 chinook in established monitoring sections, Marsh Creek drainage. Sections are listed sequentially, upstream to downstream. Time of implementation is indicated by a slash (/); evaluation years are indicated by shading.

Species, age	Location[a]	Section[b]	1983	1984	1985[c]	1986	1987	1988
Rainbow-steelhead								
Age >1	KN,M	2B			0.6	0.3	0	
	KN,M	1A	0.2		1.0	0.7	3.5	
	MA,M	6A	0.4		0	0.5	0.7	
	MA,M	5A			0.4	1.2	1.5	
	MA,M	4B	1.3	1.0	1.3	1.2	1.7	
	CH,M	2B			0.2	0.5	0	
	CH,M	1A			0	0.6	0.9	
	BV,M	3B			1.2	2.1	0.7	
	BV,M	1A			1.4	0	0.1	
	MA,C	1B			1.5	1.6	0.3	
	MA,C	1A			1.7	0.2	1.0	
		Mean	0.6	1.0	0.8	0.8	0.9	
Chinook								
Age 0	KN,M	2B			0.4	0	0.1	
	KN,M	1A	16.9		23.6	7.2	10.4	
	MA,M	6A	25.9		9.7	8.3	36.0	
	MA,M	5A			35.7	45.4	89.3	
	MA,M	4B	21.6	17.9	22.2	26.2	34.0	
	CH,M	2B			48.0	12.6	96.8	
	CH,M	1A			25.0	14.5	39.4	
	BV,M	3B			10.8	28.6	5.9	
	BV,M	1A	-		12.9	7.2	0.5	
	MA,C	1B			10.6	1.7	0.2	
	MA,C	1A			5.4	0	6.5	
		Mean	21.5	17.9	17.7	13.8	29.0	

[a] Locations: KN=Knapp Creek; MA=Marsh Creek; CH=Capehorn Creek; BV=Beaver Creek.
Habitat: M=meadow; C=canyon.

[b] Section 4B, Marsh Creek, was initially numbered in 1984 as 1.

[c] Habitat inventory and problem identification.

Appendix A-16. Annual trends in density (number/100 m^2) of yearling-and-older rainbow-steelhead and age 0 chinook in established monitoring sections, Sulphur Creek. Sections are listed sequentially, upstream to downstream. Time of implementation is indicated by a slash (/); evaluation years are indicated by shading.

Species, age	Section	1983	1984	1985	1986	1987	1988
Rainbow-steelhead							
Age ≥1	4B		0	1.0	1.1	0.2	
	4A			0	0.2	3.2	
	3A				3.0	1.9	
	Mean		0	0.5	1.4	1.8	
Chinook							
Age 0	4B		9.2	18.1	62.6	18.8	
	4A			0.1	25.8	39.3	
	3A				8.1	3.6	
	Mean		9.2	9.1	32.2	20.6	

Appendix A-17. Annual trends in density (number/100 m^2) of yearling-and-older rainbow-steelhead and age 0 chinook in established monitoring sections, Camas Creek and Loon Creek (control stream). Sections are listed sequentially, upstream to downstream. Time of implementation is indicated by a slash (/); evaluation years are indicated by shading.

Species, age	Location,[a] habitat	Section	1983	1984	1985	1986	1987[b]	1988
Rainbow-steelhead								
Age >_1	C,DM	1	0.4	0.8	1.9	4.6	.	
	C,DM	2		2.5	1.0	0.4	.	
	C,C	CAM- 1			16.8	1.8	.	
	L,CM	1			1.7	4.0	.	
	L,CM	2			1.4	4.0	.	
	L,C	LNM- 1			0.2	9.1	.	
		Mean	0.4	1.6	3.8	4.0	.	
Chinook								
Age 0	C,DM	1	2.5	0.8	3.0	10.0	.	
	C,DM	2	.	1.3	3.6	5.2	.	
	L,C	CAM- 1			2.1	0.2	.	
	L,CM	1		.	3.3	19.8	.	
	L,CM	2			3.3	44.8	.	
	L,C	LNM- 1			1.7	25.4	.	
		Mean	2.5	1.0	2.8	17.7	.	

[a]Stream: C=Camas Creek; L=Loon Creek. Habitat: DM=degraded meadow; C=canyon; CM=control meadow.
[b]Sampled after downstream migration of parr (8/28).

Appendix A-18. Annual trends in density (number/100 m^2) of yearling-and-older rainbow-steelhead and age 0 chinook in established monitoring sections, South Fork Salmon River. Sections are listed sequentially, upstream to downstream. Time of implementation is indicated by a slash (/); evaluation years are indicated by shading.

Species, age	Stream	Section	1983	1984	1985	1986	1987	1988
Rainbow-steelhead								
Age ≥ 1	South Fork	Stolle-1	.	0.2	1.1	1.0	1.1	
	South Fork	Stolle-2	.	.	0	0.1	0	
	South Fork	Poverty	.	.	.		0	
	Dollar Creek	1				1.9	3.3	
		Mean		0.2	0.6	1.0	1.1	
Chinook								
Age 0	South Fork	Stolle-1	.	14.6	75.0	19.0	51.7	
	South Fork	Stolle-2	.	.	7.5	19.7	91.5	
	South Fork	Poverty	.	.	.		2.1	
	Dollar Creek	1				0	0	
		Mean		14.6	41.2	12.9	36.3	

Appendix A-19 Annual trends in density (number/100 m^2) of yearling-and-older rainbow-steelhead and age 0 chinook in established monitoring sections, Johnson Creek and tributaries. Sections are listed sequentially, upstream to downstream. Time of implementation is indicated by a slash (/); evaluation years are indicated by shading.

Species, age	Stream, habitat[a]	Section	1983	1984[b]		1985[c]	1986[c]	1987[c]	1988
Rainbow-steelhead									
Age ≥1	J,MA	M1	-	0.6	/	0	0.3		
	J,MA	M2		0.2	/	0	0.5		
	J,MA	M3	-	0.8	/	0	0.3		
	S,MA	M2		0	/	0	-		
	R,MA	M1		0	/	0	0		
	J,CA	PW1A	-	0.5	/	0.2	0.1		
	J,CA	PW3A	-	8.1	/	·	9.3		
	J,CB	PW3B	-	3.1			0.7		
		Mean	-	1.7		+	1.6		
Chinook									
Age 0	J,MA	M1	-	0	/	2.8	17.4		
	J,MA	M2	-	0	/	0.3	21.3		
	J,MA	M3		0	/	1.6	5.2		
	S,MA	M2	-	0	/	8.0			
	R,MA	M1		0	/	4.0	15.8		
	J,CA	PW1A		0	/	0.8	1.0		
	J,CA	PW3A	-	0	/	·	13.6		
	J,CB	PW3B	-	0			3		
		Mean		0		2.9	10.6		

[a] Stream: J=Johnson Creek; S=Sand Creek; R=Rock Creek. Habitat: MA=meadow above barriers; CA=canyon above barriers; CB=canyon below barriers.
[b] Pretreatment survey.
[c] Success of chinook introductions evaluated through subcontract (Welsh 1988).

Appendix A-20. Annual trends in density (number/100 m^2) of yearling-and-older rainbow-steelhead and age 0 chinook in established monitoring sections, Boulder Creek and Little Salmon River. Sections are listed sequentially, upstream to downstream. Time of implementation is indicated by a slash (/); evaluation years are indicated by shading.

Species, age	Stream	Location[a]	Section	1983	1984	1985[b]	1986	1987	1988
Rainbow-steelhead									
Age ≥1	Boulder Cr.	A	1		6.3	3.7 /	6.8	15.6	
	Boulder Cr.	A	2		2.7	7.5 /	5.3	8.8	
	Boulder Cr.	B	3		8.1	13.3		15.5	
	Boulder Cr.	B	5		4.9	16.8	24.1	20.9	
	Little Salmon R.	B	1			13.2	9.8	7.6	
	Little Salmon R.	B	2	-	-	10.1	14.8	7.3	
			Mean		5.5	10.8	12.2	12.6	
Chinook									
Age 0	Boulder Cr.	A			0	0.4 /	3.7	0	
	Boulder Cr.	A	2		0	0 /	0	0	
	Boulder Cr.	B	3		2.5	3.9		20.2	
	Boulder Cr.	B	5		1.8	4.2	18.1	40.9	
	Little Salmon R.	B	1	-	-	0.1	0.1	1.8	
	Little Salmon R.	B	2	-	-	1.3	2.8	3.5	
			Mean		1.1	1.7	4.9	11.1	

[a] A=above Boulder Creek barrier; B=below barriers.
[b] Chinook fry introduction.

Appendix A-21. Rainbow-steelhead and chinook parr density (number/100 m^2) in monitoring sections established in 1987, Colt, Meadow, and Pine creeks.

Species, age	Stream	Section	1987
Rainbow-steelhead			
Age ≥l	Colt Creek	BRIDGE	0
	Meadow Creek	GRAZED-l	15.0
		MILEPOST-2	11.6
	Pine Creek	SAWMILL	0.5
		BRIDGE	8.0
		Mean	7.0
Chinook			
Age 0	Colt Creek[a]	BRIDGE	
	Meadow Creek	GRAZED-l	0
		MILEPOST-2	0
	Pine Creek[a]	SAWMILL	
		BRIDGE	
		Mean	0

[a]No plans for chinook introductions.

Appendix A-22. Steelhead and chinook production type for BPA project and monitoring streams, and channel type of established monitoring sections, Clearwater and Salmon River drainages.

Drainage, stream	Production type[a] W=wild; N=natural steelhead	chinook	C-channel	B-channel
Clearwater R. Subbasin				
Lolo Creek	N	N	8303; Run 1U; Run 7U; 8360	OS-6; Run 60
Eldorado Creek	N	N	2M; 2LG	1HG; 1B
Crooked Fork Creek	N	N		1A; 2A; 3A; 4A; 1B; 2B
Colt Creek	N			BRIDGE
Crooked River	N	N	II-Treatment 2; II-Control; III-Natural; IV-Meander 1; IV Meander II	I-Sill Log A; I-Control 1
Red River	N	N	I-Millers; IV-Control 2; IV-Treatment 2; V-Control 2; V-Treatment 2	II-Treatment 2; II-Control 2
Meadow Creek	N	N	GRAZED- 1	MILEPOST-2
Salmon River Subbasin				
Panther Creek	N	N	MO1; PC10, PC9; PC6	PC4; PC1
Pine Creek	N			SAWMILL; BRIDGE
Lemhi River	N	N	LEM-1A; LEM-2B; LEM-3A; HC-1B	HC-2B; HC-3B
East Fk. Salmon River	N	N	2; 3; 5; 8	
Salmon River	N	N	10A; 9A; 8B; 8A; 7B; 7A; 6A; 3BRA	2B
Alturas Lake Creek	N	N	1A; 2A; 3	2
Pole Creek	N	N	3B; 3A; 2B; 2A	
Valley Creek	N	N	3B; 3A; 1B	6B
Bear Valley Creek	U	W	9B; 5A; 3A; 2A; 2B	1A
Elk Creek	W	W	2A; 2B; 1A; 1B; Bearskin-1B	
Marsh Creek	U	U	6A; 5A; 4B; Knapp-2B, 1A; Cape Horn 2B; 1A; Beaver-3B, 1A	1B; 1A
Sulphur Creek	U	U	4B; 4A	3A
Camas Creek	U	U	1, 2	CAM-1
Loon Creek	U	U	1, 2	LNM-1
South Fork Salmon River	U	N	Stolle-1; Stolle-2; Poverty	Dollar-1
Johnson Creek	U	N	Ml; M2; M3; Sand-HZ; Rock-M1	PW1A; PW3A; PW3B
Boulder Creek	N	N	1	2, 3, 5
Little Salmon River	N	N		1, 2

[a]IDFG (1985) definition: wild fish-maintained through natural production with no hatchery supplementation, often the indigenous stock; natural fish-progeny of hatchery fish which have reproduced in natural environments.

Appendix A-23. IDFG anadromous fish density monitoring sections in Idaho drainages, summarized by monitoring program, production type, and channel type.

Subbasin drainage	Main stem or tributary	Production type[a] steelhead	Production type[a] chinook	Program[b]	C-channel	B-channel	Total
Clearwater River							
Lower and Middle Forks	main stem	N	N		0	0	0
Clearwater River	tributary	N	N	BPA	6	4	10
		N	N	IDFG	0	1	1
Lochsa River	main stem	N	N	IDFG	0	2	2
	tributary	N	N	BPA	0	7	7
		N	N	IDFG	0	1	1
Selway River	main stem	W	N[c]	IDFG	2	9	11
	tributary	W	N[c]	IDFG	3	8	11
S. Fk. Clearwater R.	main stem	N	N	IDFG	1	0	1
	tributary	N	N	BPA	11	5	16
		N	N	IDFG	3	1	4
				Subbasin Total	26	38	64
Salmon River							
Lower Salmon River	main stem				0	0	0
to Vinegar Creek	tributary	N	N	BPA	1	5	6
		N	N	IDFG	1	11	12
Salmon River Canyon	main stem				0	0	0
(Vinegar to Corn Cr.)	tributary	W	W	IDFG	2	10	12
S. Fk. Salmon River	main stem	W	N	BPA	3	0	3
		W	N	IDFG	2	12	14
	tributary	W	N	BPA	5	4	9
		W	W,N	IDFG	5	3	8
Y. Fk. Salmon River	main stem	W	W	IDFG	2	27	29
	tributary	W	W	BPA	25	6	31
		W	W	IDFG	2	14	16
Salmon River (Corn Cr.	main stem				0	0	0
to Pahsimeroi)	tributary	N	N	BPA	8	6	14
		N	N	IDFG	3	1	4
Salmon R. (Pahsimeroi	main stem	N	N	BPA	8	1	9
River to headwaters)		N	N	IDFG	1	0	1
	tributary	N	N	BPA	14	2	16
		N	N	IDFG	1	1	2
				Subbasin Total	83	103	186
Snake River	main stem	N	N	IDFG	0	0	0
	tributary	N	N	IDFG	0	8	0
				Subbasin Total	0	8	0
				Idaho Total	109	149	258

[a]IDFG (1985) definitions: wild fish = maintained through natural production with no hatchery supplementation, often the indigenous stock; natural fish = progeny of hatchery fish that have reproduced in natural environments.
[b]BPA-funded monitoring program initiated in 1984; IDFG-funded program in 1985.
[c]Natural population established with wild fish transfers and hatchery fish introductions; managed as wild.

Appendix A-24. Summary of hatchery steelhead releases (in thousands) into natural production areas for BPA habitat project and monitoring streams, 1984-1987.

Stream	Race[a]	Size	1984	1985	1986	1987
Lolo Creek	SB	egg	0	0	0	0
		fry	0	0	0	0
		smolt	0	0	0	0
		adult	0	0	0	0
Eldorado Creek	SB	egg	0	0	0	0
		fry	0	0	0	0
		smolt	0	121	197	0
		adult	0	1.15	0.15	0
Crooked Fork Cr.	SB	egg	0	0	0	0
		fry	0	0	0	0
		smolt	0	0	0	0
		adult	0	0	0	0
Colt Creek	SB	egg	0	0	0	0
		fry	0	0	0	0
		smolt	0	0	0	0
		adult	0	0	0	0
Crooked River	SB	egg	0	0	0	0
		fry	0	0	88	0
		smolt	34	42	141	159
		adult	0	1.73	0	5.2
Red River	SB	egg	0	731	0	0
		fry	0	0	0	0
		smolt	74	80	0	0
		adult	0	0	0	0
Meadow Creek	SB	egg	0	0	0	770
		fry	0	0	0	0
		smolt	0	0	0	0
		adult	0	0	0	0
Panther Creek	SA	egg	0	0	0	0
		fry	305	485	625	378
		smolt	0	208	246	300
		adult	0.68	0.15	0.12	0
Pine Creek	SA	egg	0	0	0	0
		fry	25	0	0	0
		smolt	0	0	0	0
		adult	0	0	0	0
Lemhi River	SA	egg	0	0	0	0
		fry	270	923	718	185
		smolt	0	0	0	0
		adult	4.28	0.87	0.68	1.01
E. Fk. Salmon R.	SB	egg	0	0	0	0
		fry	0	19	789	0
		smolt	426	270	495	485
		adult	0	0	0.42	0.06

Appendix A-24. Continued.

Stream	Race[a]	Size	1984	1985	1986	1987
Upper Salmon R,	SA	egg	0	0	0	0
		fry	0	503	533	0
		smolt	724	786	637	688
		adult	2.66	0	0	0
Alturas Lake Cr.	SA	egg	0	0	0	0
		fry	0	32	300	175
		smolt	0	0	0	0
		adult	0	0	0	0
Pole Creek	SA	egg	0	0	0	0
		fry	318	488	349	189
		smolt	0	0	0	0
		adult	0	0	0	0
Valley Creek	SA	egg	0	0	0	0
		fry	215	173	0	142
		smolt	0	0	0	0
		adult	1.55	0.10	0.52	0
Boulder Creek	SA	egg	0	0	0	0
		fry	149	0	27	0
		smolt	0	0	0	0
		adult	0	0	0	0
Little Salmon R.	SA	egg	0	0	0	0
		fry	0	82	126	0
		smolt	0	0	0	0
		adult	0	0	0	0

[a] SA=A-run steelhead; SB=B-run steelhead.

Appendix A-25. Summary of hatchery chinook releases (in thousands) into natural production areas for BPA habitat project and monitoring streams, 1984-1987.

Stream	Race[a]	Size	1984	1985	1986	1987
Lolo Creek	SP	egg	0	0	0	0
		fry	0	0	0	133
		smolt	0	0	0	0
		adult	0	0	0	0
Eldorado Creek	SP	egg	0	0	0	0
		fry	0	0	270	119
		smolt	0	0	0	0
		adult	0	0	0	0
Crooked Fork Cr.	SP	egg	0	0	0	0
		fry	0	0	200	349
		smolt	0	0	0	0
		adult	0	0	0	0
Crooked River	SP	egg	0	0	0	50
		fry	0	0	350	0
		smolt	0	0	0	479
		adult	0	0	0	0
Red River	SP	egg	0	0	0	331
		fry	0	0	0	0
		smolt	0	80	137	195
		adult	0	0	0	0
Meadow Creek	SP	egg	0	0	0	0
		fry	0	0	0	0
		smolt	0	0	0	0
		adult	0	0	0	0
Panther Creek	SP	egg	0	0	0	137
		fry	0	0	0	0
		smolt	0	0	0	0
		adult	0	0	3.38	0
Lemhi River	SP	egg	0	0	0	0
		fry	0	0	1	0
		smolt	0	0	0	0
		adult	0	0	0.02	0
E. Fk. Salmon R.	SP	egg	0	0	0	0
		fry	0	0	1	0
		smolt	0	0	109	195
		adult	0	0	0	0
Upper Salmon R.	SP	egg	0	0	0	0
		fry	0	0	0	0
		smolt	231	420	348	1,185
		adult	0	0	0	0.01
Alturas Lake Cr.	SP	egg	0	0	0	0
		fry	0	0	0	0
		smolt	0	0	0	0
		adult	0	0	0	0

Appendix A-25. Continued.

Stream	Race[a]	Size	1984	1985	1986	1987
Pole Creek	SP	egg	0	0	0	0
		fry	0	0	0	0
		smolt	0	0	0	0
		adult	0	0	0	0
Valley Creek	SP	egg	0	0	0	0
		fry	0	0	0	0
		smolt	0	0	0	0
		adult	0	0	0	0
5. Fk. Salmon R.	SU	egg	0	0	3	0
		fry	0	0	0	0
		smolt	270	564	970	958
		adult	0	0	0	0
Dollar Creek	SU	egg	0	0	0	0
		fry	0	0	0	0
		smolt	0	0	0	0
		adult	0	0	0	0
Johnson Creek	SU	egg	0	0	0	0
		fry	0	51	178	118
		smolt	0	0	0	0
		adult	0	0	0	0
Boulder Creek	SP	egg	0	0	0	140
		fry	0	0	101	0
		smolt	0	0	0	0
		adult	0	0	0	0
Little Salmon R.	SP	egg	0	0	0	0
		fry	0	0	0	0
		smolt	0	0	0	0
		adult	0	0	0	0

[a] SP=spring chinook; SU=summer chinook

APPENDIX B

Appendix B-l. Proposed definition of mitigation benefits for implemented projects on Lolo Creek.

Project type: Instream structures

Year implemented: 1983-1984

Sponsor: Clearwater National Forest

	Species benefited	
Enhancement	B-run steelhead	Spring chinook
Production type	natural	natural
Hectares enhanced	15.3	15.3

Production constraints: High sediment levels

Definition of benefits: Statistical comparison of steelhead and chinook parr densities in treated and untreated sections will be done at 3 to 5-year intervals to determine the difference in densities. The differences in parr densities will be factored by Parr-to-smolt survival rates derived from the intensive studies.

Evaluations were conducted in 1984 and 1985 at relatively low parr abundance. The 1985 evaluation determined that sections with structures supported a slightly higher rainbow-steelhead parr density (1.81100 m^2) than untreated sections. No difference in density was evident for chinook.

Appendix B-Z. Proposed definition of mitigation benefits for implemented project in Eldorado Creek.

Project type: Passage barriers

Year implemented: 1984-1985

Sponsor: Clearwater National Forest

Enhancement	Species benefited B-run steelhead	Spring chinook
Production type	natural	natural
Hectares added	13.8	13.8

Production constraints: High sediment levels

Definition of benefit: Complete passage barriers to adults of both species were removed. Benefits will be determined from estimated numbers of parr reared above the project at 3 to 5-year intervals. Parr abundance will be factored by Parr-to-smolt survival rates determined from intensive studies.

Total abundance of steelhead parr above the project was estimated in August 1985 following an outplant of 1,150 Dworshak National Fish Hatchery adult steelhead in 1984. An estimated 7,310 yearling steelhead were present above the project in 1985, and additional parr were produced downstream of the project.

Total abundance of chinook parr above the project was estimated in August 1985 following an outplant of 199,000 Rapid chinook fry in April-May. August 1985 abundance totaled 30,300 (15% survival). Most of the area was underseeded as evidenced by decreases in abundance away from stocking sites.

Appendix B-3. Proposed definition of mitigation benefits for implemented projects on upper Lochsa River.

Project type: Instream structures (lower White Sand and Crooked Fork creeks)

Year implemented: 1983-1984

Sponsor: Clearwater National Forest

Enhancement	Species benefited	
	B-run steelhead	Spring chinook
Production type	natural	natural
Hectares enhanced	12.5	12.5

Production constraints:

Definition of benefit: Statistical comparisons of steelhead and chinook parr densities in treated and untreated sections will be done at a future date for a sample of remaining structures. Differences in parr densities will be factored by Parr-to-smolt survival rates from the intensive studies.

An evaluation was conducted in 1984 at low parr abundance for both species. Little habitat change was observed, and no difference in densities for either species was detected between treated and untreated sections. A high rate of structure failure occurred the first year after implementation. No definable benefits are anticipated from this project.

Appendix B-4. Proposed definition of mitigation benefits for implemented projects on Crooked Fork Creek.

Project type: Passage barriers

Years implemented: 1984-1985

Sponsor: Clearwater National Forest

Enhancement	Species benefited	
	B-run steelhead	Spring chinook
Production type	natural	natural
Hectares added	11.2	11.2

Production constraints:

Definition of benefits: Passage barriers to adults of both species were removed. Benefits will be determined from estimated numbers of parr reared above the project at 3 to 5-year intervals. Parr abundance will be factored by Parr-to-smolt survival rates determined from intensive studies.

As of 1987 steelhead fry have not been allocated for introductions into upper Crooked Fork Creek. The estimated 500 rainbow-steelhead parr reared above the project in 1986.

Total abundance of chinook parr above the project was estimated in August 1986 and August 1987 following fry outplants of 156,200 in May 1986 and 164,400 in May 1987. Estimated parr abundance was 17,600 and 32,600 in 1986 and 1987, respectively. Most of the area was underseeded in both years as evidenced by decreases in abundance from stocking sites.

Appendix B-5. Proposed definition of mitigation benefits for implemented project on Colt Creek.

Project type: Passage barriers

Year implemented: 1986

Sponsor: Clearwater National Forest

Enhancement	Species benefited	
	B-run steelhead	Spring chinook
Production type	natural	natural
Hectares added	6.4	0

Production constraints: Gradient judged too steep to achieve chinook passage.

Definition of benefits: Passage barriers to adult steelhead were removed. Benefits will be determined from estimated numbers of steelhead parr reared above the barriers at 3-5 year intervals (after introductions begin). Parr abundance will be factored by Parr-to-smolt survival rates determined from intensive studies.

As of 1987 steelhead fry have not been allocated for introductions into Colt Creek. No rainbow-steelhead parr were observed in a single monitoring section in 1987.

Appendix B-6. Proposed definition of mitigation benefits for implemented projects in Crooked River.

Project type: Passage barrier (culvert)

Year implemented: 1984

Sponsor: Nez Perce National Forest

Enhancement	Species benefited	
	B-run steelhead	Spring chinook
Production type	natural	natural
Hectares added	13.3	9.1

Production constraints: Channelized (treated with structures in 1985), lack of riparian vegetation for 6.1 km upstream of barrier culvert.

Definition of benefits: A partial barrier to adult steelhead and chinook was removed by replacement of a culvert with a bridge. Benefits will be determined annually from estimated numbers of parr reared above the project. A fraction of this production will be the mitigation benefit. Smolt production will be estimated directly by the intensive study.

Total abundance of rainbow-steelhead parr for the 6.1 km between the project and the confluence of the East Fork and West Fork was 2,750 in 1986 and 2,347 in 1987. Chinook parr abundance for this reach was 7,413 and 1,483, respectively.

Appendix B-6. Continued.

Project type: Instream structures, riparian revegetation

Years implemented: 1984-1985

Sponsor: Nez Perce National Forest

Enhancement	Species benefited	
	B-run steelhead	Spring chinook
Production type	natural	natural
Hectares enhanced	7.3	7.3

Production constraints: Channelized, lack of riparian vegetation.

Definition of benefits: Statistical comparisons of steelhead and chinook parr densities in treated and untreated sections will be done at 3 to 5-year intervals to determine the difference in densities. The intensive study in Crooked River will provide direct estimates of parr-to-smolt survival rates.

An evaluation was conducted in July and August 1986 at a fully seeded condition for yearling steelhead, and moderate seeding levels for chinook. Alteration of habitat by the structures had occurred riparian conditions had not yet improved. No difference in densities could be attributed to the instream structure project.

Appendix B-6. Continued.

Project type: Off-channel developments

Years implemented: 1984-1987

Sponsor: Nez Perce National Forest

Enhancement	Species benefited: B-run steelhead	Spring chinook
Production type	natural	natural
Hectares added	No data	No data

Production constraints: Pond and side channel habitat will primarily benefit chinook.

Definition of benefits: The total abundance of steelhead and chinook parr in connected ponds and side-channels will be considered mitigation benefits. Parr-to-smolt survival rates will be estimated directly in the intensive study.

An evaluation of off-channel rearing densities was conducted in 1986. The 0.08 hectares added to Crooked River through 1985 reared an estimated 69 rainbow-steelhead parr (8/100 m^2) and 739 chinook parr (88/100 m^2).

Appendix B-7. Proposed definition of mitigation benefits for implemented projects in Red River.

Project type: Instream structures

Years implemented: 1984-1985

Sponsor: Nez Perce National Forest

Enhancement	Species benefited	
	B-run steelhead	Spring chinook
Production type	natural	natural
Hectares enhanced	7.5	7.5

Definitions of benefits: Statistical comparisons of steelhead and chinook parr densities in treated and untreated sections will be done at 3 to 5-year intervals to determine the difference in densities. The differences in densities will be factored by Parr-to-smolt survival rates derived from the intensive studies.

An evaluation was conducted in July and August 1986 at moderately low steelhead and chinook parr abundance. No difference in densities could be attributed to the instream structure project.

Appendix B-7. Continued.

Project type: Off-channel developments

Year implemented: 1985

Sponsor: Nez Perce National Forest

Enhancement	Species benefited: B-run steelhead	Species benefited: Spring chinook
Production type	natural	natural
Hectares added	0.02	0.02

Production constraints: Limited opportunity for side-channel/pond development.

Definition of benefits: The total abundance of steelhead and chinook parr in off-channel production areas will be considered mitigation benefits. Parr-to-smolt survival rates will be derived from the intensive studies.

Numbers of steelhead and chinook parr estimated in the 0.02 hectares added by 1986 totaled only 1 and 215, respectively.

Appendix B-8. Proposed definition of mitigation benefits for implemented project in Pine Creek.

Project type : Passage barrier

Year implemented: 1987

Sponsor: Nez Perce National Forest

Enhancement	Species benefited A-run steelhead
Production type	natural
Hectares added	6.9

Production constraints:

Definition of benefits: A barrier. to adult steelhead was removed by this project. Benefits will be estimated from total abundance of parr reared above the barrier. Parr- to- smolt survival rates will be determined from the intensive studies.

Appendix B-9. Proposed definition of mitigation benefit8 for implemented project in Pole Creek.

Project type: Diversion screen

Year implemented: 1983-1984

Sponsor: Sawtooth National Forest

	Species benefited	
Enhancement	B-run steelhead	Spring chinook
Production type	natural	natural
Hectares affected	4.2	4.2

Production constraints: Juvenile steelhead upstream passage is impeded.

Definition of benefits: An unscreened irrigation diversion was screened . The proportion of the steelhead and chinook parr reared upstream of the diversion that are screened from the ditch and returned to Pole Creek will be considered as mitigation benefits. The upper Salmon River intensive study will determine this proportion during PIT tag operations and directly estimate parr-to-smolt survival.

Estimated total abundance of rainbow-steelhead parr upstream of the diversion was 420 in 1985 and 63 in 1987. Chinook have not been available for introduction upstream of the diversion.

Appendix B-10. Proposed definition of mitigation benefits for implemented project, Bear Valley and Elk creeks.

Project type: Sediment reduction, riparian revegetation

Year implemented: 1987 - ongoing

Sponsor: Boise National Forest

Enhancement	Species benefited Middle Fork Salmon River (B-run) steelhead	Spring chinook
Production type	wild	wild
Hectares enhanced	0	0

Production constraints: High sediment levels, streambank degradation

Definition of benefits: The Bear Valley and Elk Creek project will attempt to significantly reduce sediment from point and nonpoint sources in the drainage, and complement anticipated grazing management improvements. Benefits will be estimated based on: (a) measured changes in sediment and on fish-sediment relationships, and (b) relative changes in efficiency (survival) from egg deposition to parr production. Parr-to-smolt survival rates will be applied based on the intensive studies.

Only a minor amount of work was accomplished in 1987. Recovery of the aquatic habitat is expected to be a slow process and hinges on improved grazing management by the USFS (Appendix C).

Appendix B-11. Proposed definition of mitigation benefits for implemented project, Knapp Creek.

Project type: Passage barrier (diversion structure)

Year implemented: 1987

Sponsor: Challis National Forest

Enhancement	Species benefited Spring chinook
Production type	wild
Hectares added	8.0

Production constraints:

Definition of benefits: An irrigation diversion that completely blocked adult chinook passage was modified. Benefits will be estimated from total abundance of chinook parr reared above the barriers. Parr-to-smolt survival rates will be applied based on the intensive studies.

Appendix B-12. Proposed definition of mitigation benefits for implemented project, Johnson Creek.

Project type: Passage barrier

Year implemented: 1984-1986

Sponsor: Idaho Department of Fish and Game

Enhancement	Species benefited Summer chinook
Production type	natural
Hectares added	50.0

Production constraints: High sediment levels in portions of drainage.

Definition of benefits: Natural rock barriers that completely blocked adult chinook passage were modified. Benefits will be estimated from total abundance of chinook parr reared above the barriers. Parr-to-smolt survival rates will be applied based on the intensive studies.

A total of 186,000 and 118,424 summer chinook fry were stocked into the upper Johnson Creek drainage in 1986 and 1987. Total abundance of parr from these plants were estimated at 23,700 and 17,700 for the two years, respectively. Fry stocking did not fully seed the drainage either year.

Appendix B-l?. Proposed definition of mitigation benefits for implemented project , South Fork Salmon River tributaries (Dollar Creek).

Project type: Passage barrier (partial)

Year implemented: 1986

Sponsor: Boise National Forest

	Species benefited	
Enhancement	South Fork Salmon River (B-run) steelhead	Spring chinook
Production type	wild	natural
Hectares added	6.8	5.4

Production constraints: High sediment levels

Definition of benefits: Debris jam barriers that partially blocked passage were selectively removed. Benefits will be estimated based on a yet-to-be-determined fraction of the total parr abundance for each species. Parr-to-smolt survival rates will be applied from intensive studies.

Appendix B-14. Proposed definition of mitigation benefits for implemented project, Boulder Creek.

Project type: Passage barrier

Year implemented: 1985

Sponsor: Idaho Department of Fish and Game

Enhancement	Species benefited spring chinook
Production type	natural
Hectares added	10.2

Production constraints:

Definition of benefits: A barrier falls that was a nearly complete block to adult chinook was modified. Benefits will be based on total chinook parr abundance. Parr-to-smolt survival rates will be applied from intensive studies.

An estimated total of 28,100 chinook parr were reared in 1986 from a May release of 99,900 fry. The area above the project was underseeded in 1986.

APPENDIX C

BEAR VALLEY CREEK AND ELK CREEK

Project 84-24

Implementation Plan (FY 1988-1992)

The BPA Middle Fork and upper Salmon River Habitat Improvement Implementation Plan for FY 1988-1992 (Andrews and Everson 1988) outlines Phase II plans to implement habitat restoration projects in Bear Valley Creek and Elk Creek drainage. Objectives of Project 84-24 in the drainage are to reduce the impact of sediment loading from USFS lands through streambank stabilization and erosion control structures, and to revegetate riparian areas to abate sedimentation of aquatic habitat.

Project 84-24 activities will be in addition to BPA Project 83.359 which was implemented by the Shoshone-Bannock Tribes in 1984 to reduce the sediment recruitment from an unstable dredge mined area in upper Bear Valley Creek.

The BPA Implementation Plan was developed based on the assumption that improvements in grazing management would accompany the BPA projects. The Plan notes that the USFS has an ongoing process for improving the management of livestock grazing and road maintenance, and that BPA expenditures are not substitutions for USFS responsibility. A grazing allotment review is scheduled to occur in 1991.

Habitat Problem Definition

Phase I of Project 84-24 consisted of problem definition and inventory of aquatic and riparian habitat conditions in 1985 in the upper Salmon and Middle Fork Salmon rivers (OEA 1987a,b). The Bear Valley Creek and Elk Creek drainages were identified as damaged by cattle grazing and had the highest sediment levels of the drainages inventoried.

Sediment levels in Bear Valley and Elk creeks have increased since a 1941 inventory by the Bureau of Commercial Fisheries (1941 data provided by J. Sedell, Pacific Northwest Research Station, USFS, Corvallis, OR). Bear Valley Creek sediment levels increased from 29% surface sand in 1941 to 40% in 1985 (OEA 1987a). Elk Creek sediment levels increased from 41% to 49% during the same period. By contrast, sediment levels in adjacent Sulphur Creek which was not extensively cattle grazed averaged 27% surface sand in both 1941 and 1986 (Petrosky and Holubetz 1987).

The OEA (1987a,b) study clearly linked decreases in streambank stability to cattle grazing in riparian zones. Streambanks associated with wet community types were inherently more stable than drier sites. Stability decreased significantly for all community types where grazed by cattle. Controlled sheep grazing did not significantly reduce streambank stability.

In addition to streambank sloughing induced by grazing, OEA (1987a,b) identified several other erosion problems in the study area: recreation, improper use of rip-rap, mining (particularly in Bear Valley Creek), irrigation diversions, roads and bridges, natural sources, and ephemeral drainages. However, the inventory results indicated that cattle grazing probably had the largest effects on sedimentation.

For each habitat section, OEA (1987a,b) categorized the cumulative percentage of streambank upstream that was managed for cattle grazing into four classes: 0-25%, 26-50%, 51-75%, and 76-100%. Statistical comparisons were made between sediment levels (percent surface sand) and cumulative cattle use upstream of a seciton. Surface sand in ungrazed or lightly grazed (with 25% or less of streambanks upstream managed for cattle) averaged 21% and 17% for the upper Salmon and Middle Fork drainages, respectively. As cattle use increased, sediment levels increased significantly to levels higher than 30% surface sand.

IDFG physical habitat data from C-channels unaffected by cattle grazing in the Batholith supports the baseline sediment values from the OEA inventory. A set of "control" streams and sections was established to compare physical and fish density conditions in the Bear Valley Creek and Elk Creek drainage to similar, undisturbed streams. Control streams contained wild chinook and steelhead. Other criteria were that the streams were located in ungrazed, undeveloped Batholith watersheds with low-gradient, C-channels. The control streams were: Sulphur, Loon, Cape Horn, Beaver, Knapp, Chamberlain, and West Fork Chamberlain creeks. Surface sand in established monitoring sections averaged 51% in the Bear Valley Creek and Elk Creek drainage and 20% in the control streams (Appendix C-l).

During 1984-1987, wild chinook and rainbow-steelhead parr densities averaged more than ten times higher in the control streams than in the Bear Valley Creek and Elk Creek drainage (Appendix C-l). High sediment levels have been linked to decreased egg-to-Parr survival for chinook in Salmon River tributaries (Table 14; Figure 7). Degraded riparian vegetation, altered channel morphology, and reduced streambank and instream cover were also associated with high sediment levels and extremely depressed anadromous fish population in Bear Valley and Elk creeks.

Habitat Restoration Objectives

For effective restoration of Bear Valley and Elk creeks, objectives should be established for instream sediment level and riparian vegetation. These objectives should be established for both the BPA Fish and Wildlife Program projects and the Forest. Service land management activities. Without such common objectives, both the BPA program and the improved land management could be ineffective in achieving the intended restoration of the highly important anadromous fish habitat in Bear Valley Creek drainage,

Appendix C-l. Percent surface sand and density of wild chinook and rainbow-steelhead parr in established monitoring sections, Bear Valley Creek and Elk Creek drainage and control drainages, 1984-1987.

Location	Stream	Section	Percent sand	Chinook Parr/100 m^2					Rainbow-steelhead Parr/100 m^2				
				1984	1985	1986	1987	Mean	1984	1985	1986	1987	Mean
Bear Valley & Elk	Bear Valley Cr.	2A	43	4.7	1.9	3.0	0.9	2.6	0.1	0.1	0.1	0	0.08
		2B	71	1.3	0	0.3	0	0.4	0	0	0	0	0
		3A	25	2.0	1.0	4.7	7.7	3.8	0.2	0	0.8	0.1	0.28
		5A	28	5.4	0.2	4.1	1.3	2.8	0	0	0	0	0
		9B	55	5.9	0	0	2.2	2.0	0	0	0	0	0
	Elk Cr.	1A	44		0.4	0	0.1	0.2		0.4	0	0	0.13
		1B	63	0	1.4	0.6	0.1	0.5	0.1	1.4	0.6	0	0.52
		2A	53	0	0	0	0	0	0	0	0.1	0	0.02
		2B	37		1.1	0.2	3.8	1.7		1.1	0.2	0	0.43
	Bearskin Cr.	1B	84		0		0	0		0		0	0
		MEAN	50.6	2.8	0.6	1.4	1.6	1.6	0.06	0.3	0.2	0.01	0.14
Controls	Chamberlain Cr., W. Fk.	CHA-2	22		43.8	68.2	38.0	50.0		8.8	16.2	7.9	11.0
	Chamberlain Cr.	CHA-4	21				10.2	10.2				4.7	4.7
	Knapp Cr.	1A	23		23.6	7.2	10.4	13.7		1.1	0.7	3.5	1.8
	Beaver Cr.	1A	5		12.9	7.2	0.5	6.9		1.3	0	0.1	0.5
		3B	11		10.8	28.6	5.9	15.1		1.2	2.1	0.7	1.3
	Cape Horn Cr.	2B	19		49.0	10.7	96.8	52.2		0.2	0	0	0.1
		1A	8		34.7	14.5	39.4	29.5		0.1	0.6	0.9	0.5
	Sulphur Cr.	4A	40		0.1	25.8	39.9	21.9		0	0.3	3.2	1.2
		4B	30	9.2	18.1	62.6	18.8	27.2	0	1.0	1.0	0.2	0.6
	Loon Cr.	1	28		3.3	19.8		11.6	-	1.7	4.1		2.9
		2	19		3.3	44.8		24.0	-	1.4	3.9		2.6
		MEAN	20.5	9.2	20.0	28.9	28.9	21.8	0	1.7	2.9	2.4	1.8

PART II

DEVELOPMENT OF CHINOOK SALMON FRY OUTPLANTING STRATEGIES FOR SUPPLEMENTATION OF DEPRESSED STOCKS

AND

EVALUATION OF THE JOHNSON CREEK FISH PASSAGE IMPROVEMENT PROJECTS

FINAL REPORT

SUBMITTED TO
IDAHO DEPARTMENT OF FISH AND GAME
BOISE, IDAHO

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June 12, 1988

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ABSTRACT

We stocked summer chinook salmon fry in upper Johnson Creek drainage during three years, 1985-1987. The number of salmon fry stocked during the three years was 20,000, 186,000 and 105,000 respectively. Snorkel counts and electrofishing collections revealed that brook trout comprised over 96% of the standing fish crop in the upper Johnson Creek drainage prior to the first stocking of salmon fry on August 2, 1985. By autumn of 1987, after three years of chinook salmon fry introduct ions, brook trout comprised only 10% of the standing crop in study site in the upper Johnson Creek drainage,

We removed or relocated *over* 3,200 brook trout during the three field seasons. Salmon fry production was compared in the brook trout reduction (treatment) sites and adjacent control sites. More salmon fry reared in the control sites than in the treatment sites in eight out of nine replicates of the study.

Densities of salmon fry stocked via helicopter in early May of 1986 and 1987, remained high at the stocking sites. Fry moved up and downstream 2-3 km during the summer and fall growth period. Fry densities deminished sequentially according to distance from the stocking site.

We stocked salmon fry at geometrically progressive increases from 0.3 to 4.8 fry/m square. Rearing densities were positively correlated with stocking densities. Salmon fry growth was negatively correlated with the combined densities of salmon fry and brook trout and percent sand in the substrate.

Predation by brook trout on salmon fry was insignificant. We saw only two instances of brook trout preying on salmon fry in snorkel surveys covering 140 km of stream channel during three study years. We saw no salmon fry in examinations of brook trout stomachs,

Common mergansers preyed heavily on salmon and brook trout in two of the three study streams during 1987. Snorkel counts subsequent to merganser sightings were about 50% lower than pre-merganser counts. Mergansers not only consume the entire carcass of salmon and brook trout, at time they eat only the heads, skins, and some of the internal organs. While mergansers were present in the study sites, surviving fish remained concealed in mats of vegetation and undercut banks,

In early August of 1987, salmon fry disappeared from the lower helicopter stocking site in upper Johnson Creek. Because of the early emigration of salmon fry, we were unable to estimate total production and survival of salmon fry in 1987. At the upper helicopter stocking site in Tyndall Meadows, salmon fry survival was estimated at 14.5% in June of 1987, and 9.0% in August of 1987.

Upper Johnson Creek drainage should be stocked with salmon fry at the rate of 0.4 to 1.0 salmon/m square, Sand substrates will rear autumn-age-0 salmon to a length of 80-85 mm at an average rearing density of 0.4 fry/m square. Gravel substrates will rear salmon fry to the same length (80-85 mm) at 0.8 to 1.0 fry/m square. Upper Johnson Creek drainage is capable of rearing about 375,000 salmon fry to an autumn-age-0 length of 80-85 mm. Overseeding of salmon rearing areas will result in higher fry mortality and slower growth.

We saw no returning jack salmon from the 1985 fry stocking In upper Johnson Creek. No jumping activity was noted at the barriers in mid-Johnson Creek. We have seen adult salmon and salmon and steelhead redds in upper Johnson Creek so we assume the barrier improvement projects were successful.

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Bruce Holubetz assisted with data collection during the 1986 field season. Charlie Petrosky made valuable suggestions for the 1987 field work and assisted with collection of physical data in the study sites. Paul Abbott from the McCall Summer Chinook Salmon Hatchery and Rudy Ringe from the University of Idaho assisted in the salmon fry stocking operation in the upper Johnson Creek drainage.

I appreciate the help of my wife Leslie in data collection and her moral support and positive reinforcement during the snorkeling of over 140 km of cold mountain streams.

INTRODUCTION

I compared natural production and survival to autumn-age-0 summer-run chinook salmon fry (Oncorhynchus tshawyscha) stocked at different densities in upper Johnson Creek drainage, Idaho (Figure 1). The study was designed to determine the relationship between salmon fry stocking densities, timing and methods of stocking, and survival and produc tion of autumn-age-0 salmon fry. I also estimated natural production potential and summer chinook escapement necessary to fully seed the upper Johnson Creek drainage. Additionally, in the third and final year of the study, we used both underwater and stream bank observers to assess the effectiveness of the fish passage improvement projects funded by Bonneville Power Administration in middle Johnson Creek.

Native stocks of chinook, salmon, steelhead trout (Salmo gairdneri), and introduced brook trout (Salvelinus fontinalis) coexist in numerous tributaries of the Salmon River drainage in central Idaho (Petrosky and Holubetz, 1985). Under-seeding of anadromous fish spawning areas in the drainage during the past decade may have allowed non-anadromous species such as brook trout, to make further intrusions into anadromous fish production areas. It was unknown whether expansion of brook trout populations would depress salmon production because no studies have been done on sympatric populations of chinook salmon and brook trout.

In addition to development of strategies for outplanting of chinook salmon fry to supplement depressed runs, I investigated potential competition between brook trout and chinook salmon. I determined whether the presence of brook trout reduced the survival or density of stocked salmon fry. By making multiple passes with electrofishing gear, we removed as many brook trout as possible from some sites, while addjacent sites served as controls. Weekly snorkel counts and bi-weekly electrofishing samples were used to compare densities and growth of salmon fry at various population levels of salmon fry and brook trout. During the snorkel counts, I made observations of fish predation by brook trout and mergansers (Mergus merganser).

OBJECTIVES:

1. Estimate the density (fish/m square) and abundance and survival of summer age-0 chinook salmon fry fry stocked In portions of upper Johnson Creek drainage.

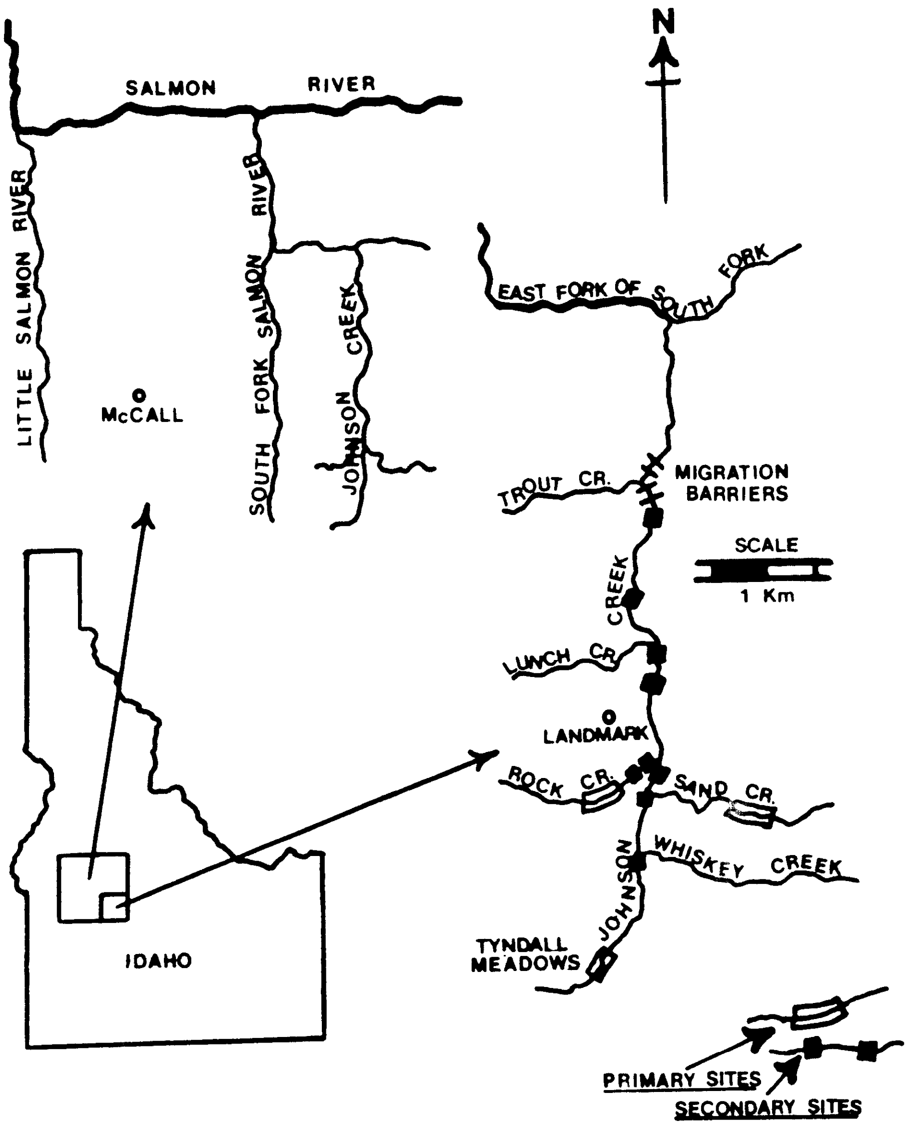
2. Relate salmon production to habitat types, according to substrate, gradient, and pool-riffle-run habitat.

3. Estimate salmon carrying capacity within the various habitat types and the number of adult salmon necessary for full seeding in Johnson Creek upstream from the barriers.

4. Compare salmon growth and condition factors in brook. trout removal sites and in control sites. Compare growth to rearing densities in all primary study sites (Figure 1).

5. Relate growth and condition factors of stocked salmon fry in the upper Johnson Creek drainage to their wild cohorts in lower Johnson Creek and the upper South Fork Salmon River drainage.

6. Relate salmon fry growth to water temperatures in upper Johnson



CHINOOK SALMON - BROOK TROUT COMPETITION.
JOHNSON **CREEK DRAINAGE, IDAHO. 1985-1988.**

Figure 1. Location map of the Johnson Creek study area in central Idaho.

Creek and upper South Fork Salmon River.

7. Observe any evidence of brook trout predation on salmon fry during the snorkel surveys and incidence of salmon fry in gut contents of the larger brook trout.

8. Evaluate the effectiveness of the barrier improvement projects for fish passage (Figure 1) in middle Johnson Creek and provide recommendations for additional corrective action if necessary.

DESCRIPTION OF THE STUDY AREA:

Johnson Creek is the largest tributary of the East Fork, of the South Fork Salmon River. Historically, the South Fork Salmon River was one of the largest contributors of summer-run chinook salmon In the Columbia River drainage (Mallet, 1974). The study area in upper Johnson Creek drainage is predominately high alpine meadow at elevations in excess of 2,090 m above MSL. Precipatation falls mainly as snow between October and May with snow accumulations of 3-4 m being common.

Soils in upper Johnson Creek are geologically young and easily erodable (Platts and Torquemada, 1985). The drainage lies in a geologic formation known as the Idaho Batholith. Upper Johnson Creek has a long history of livestock overgrazing beginning in the late 1800's. In 1920, the upper Johnson Creek allotment came under USDA Forest Service administration and the number of grazing sheep was reduced to 5,000 from previously uncontrolled levels. In 1961, the allotment was converted to a 500 cow (and calf) grazing operation (Platts and Torquemada, 1985). The effects of over-use of the meadows by livestock is plainly evident, even to the casual observer. The riparian vegetation and stream banks are heavily trampled, resulting in a loss of overhead cover as the banks fall into the stream channel. Surface sand over the substrate in the primary study sites, Sand and Rock creeks and Tyndall Meadows, was 25%, 90%, and 48% respectively (Appendix 1).

Some long-time residents of the Johnson Creek area saw dense concentrations of salmon spawners during the 1920's in the headwater meadows of Johnson Creek and its tributaries, particularly Sand Creek. Only infrequent sightings of salmon spawners have been reported during the past three decades. Apparently, a land slide deposited large boulders in the steep section of middle Johnson Creek. The Idaho Department of Fish and Game has drilled and blasted selected boulders to improve fish passage (Holubetz and Petrosky, 1988) Lower Johnson Creek, downstream from the barriers, provides spawning and rearing areas for chinook salmon and steelhead trout. Prior to stocking of upper Johnson Creek with chinook salmon fry in August of 1985, brook trout comprised 96.4% of the fish collected in electrofishing samples in Tyndall Meadows and Rock. and Sand creeks. The remainder of the fish in the samples was about equally divided between rainbow-steelhead trout and longnose dace (Rhinichthys cataractae). Of interest is the fact that the other resident species of fish inhabiting lower Johnson Creek have not been collected or seen in upper Johnson Creek and its tributaries in nearly 140 km of snorkel surveys during the three years of this research. The downstream resident species include whitefish (Prosopium williamsoni), cutthroat trout (Salmo clarki), bulltrout (Salvelinus malma), and cottids (Cottus sp.). Obviously, the barriers have prevented most resident fish species from colonizing the headwaters of Johnson Creek drainage.

METHODS:

Field work on this project began In June of 1985. Earlier data on fish species and physical habitat in upper Johnson Creek had been gathered in 1984 by Petrosky and Holubetz (1985). I established primary study sites in Tyndall Meadows on the headwaters of Johnson Creek and on Rock and Sand creeks, the two largest tributaries of upper Johnson Creek (Figure 2). Some of the monitoring sites established by Petrosky and Holubetz (1985) were retained for this work and designated as supplemental sites. The primary function of the supplemental sites was to serve as indicators of drainage-wide changes in fish populations in areas that brook trout had not been removed by electrofishing.

In 1985, I marked 14 sites 100 m in length in lower Tyndall Meadows. By making multiple passes with an electrofisher in the middle 800 m, I removed as many brook trout as possible. The lower 300 m and upper 400 m served as controls. We collected length and weight measurements on brook trout removed from the treatment sites. In 1985, I duplicated the brook trout removal procedures on 800 m of Rock Creek and 500 M of Sand Creek. Adjacent sites served as controls. On August 2-3, 1985, we stocked all the primary study sites with summer chinook salmon fry at sequential densities of 30-60-120-120-60-30 fry/100 m sq. of wetted substrate. The fry were reared at the Idaho Department of Fish and Game's McCall Summer Chinook Salmon Hatchery. Rearing areas in main Johnson Creek from Tyndall Meadows downstream to Landmark (Figure 2) received fry that were in excess of the needs of the primary study sites. We conducted weekly snorkel counts between 1000 and 1800 hours to determine rearing densities. Fish were collected bi-weekly by electrofishing and measured to the nearest mm and weighed on a triple-beam-balance to the nearest 0.01 gm.

On May 9, 1986, personnel from the Idaho Department of Fish an? Game stocked 176,000 salmon fry in upper Johnson Creek drainage (Figure 3). The USDA Forest Service (William Platts, pers. com.) suggested that I move the primary study sites in lower Tyndall Meadows to upper Tyndall Meadows in a grazing study area. The grazing study consisted of three stream sites, each 184 m long with the middle site fenced to exclude livestock. The USFS had collected fish population and channel measurements on all three sites annually since 1975. We removed brook trout from the upper and lower sites (treatment) and the fenced site served as the control. We duplicated the brook trout removal operation on treatment sites on Rock and Sand Creeks. On June 30-July 1, 1986, we stocked 10,000 salmon fry in the primary study sites at Tyndall Meadows, Rock and Sand creeks. Sand Creek received salmon fry at the rate of 30 fry/l00 m sq., Tyndall Meadows at 60 fry 100 m sq., and Rock Creek at 120 fry/100 m sq.

On May 5, 1987, we stocked 34,500 salmon fry from the McCall Salmon Hatchery in Tyndall Meadows 200 m upstream from the USFS grazing study and 55,500 fry in Johnson Creek at its confluence with Sand Creek (Figure 4). Because the winter of 1986-87 was a near record low precipitation year in central Idaho, stream flows were abnormally low in June of 1987, and we were able to remove brook trout earlier than in 1985 and 1986. In addition, the brook trout populations were much reduced from the 1985-86 levels. We were able to stock salmon in the brook trout removal (treatment) sites and control sites on June 12, 1967, three weeks earlier than in 1986 (Figure 4). We stocked a total of 105,300 salmon fry via helicopter and truck during 1987. Rock Creek

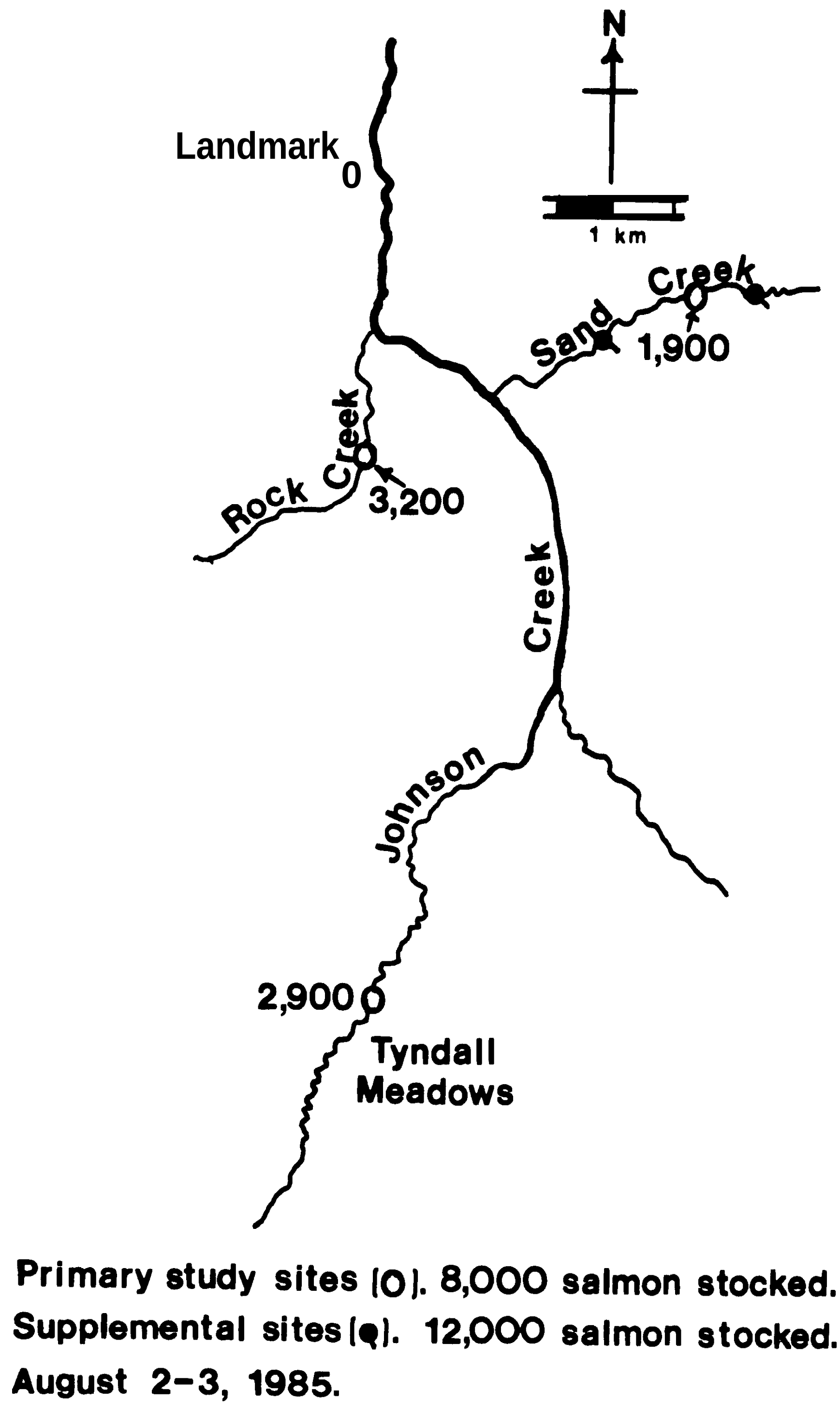


Figure 2. Primary and supplemental study sites in upper Johnson Creek drainage, and number, location, and date of salmon fry stocking, 1985.

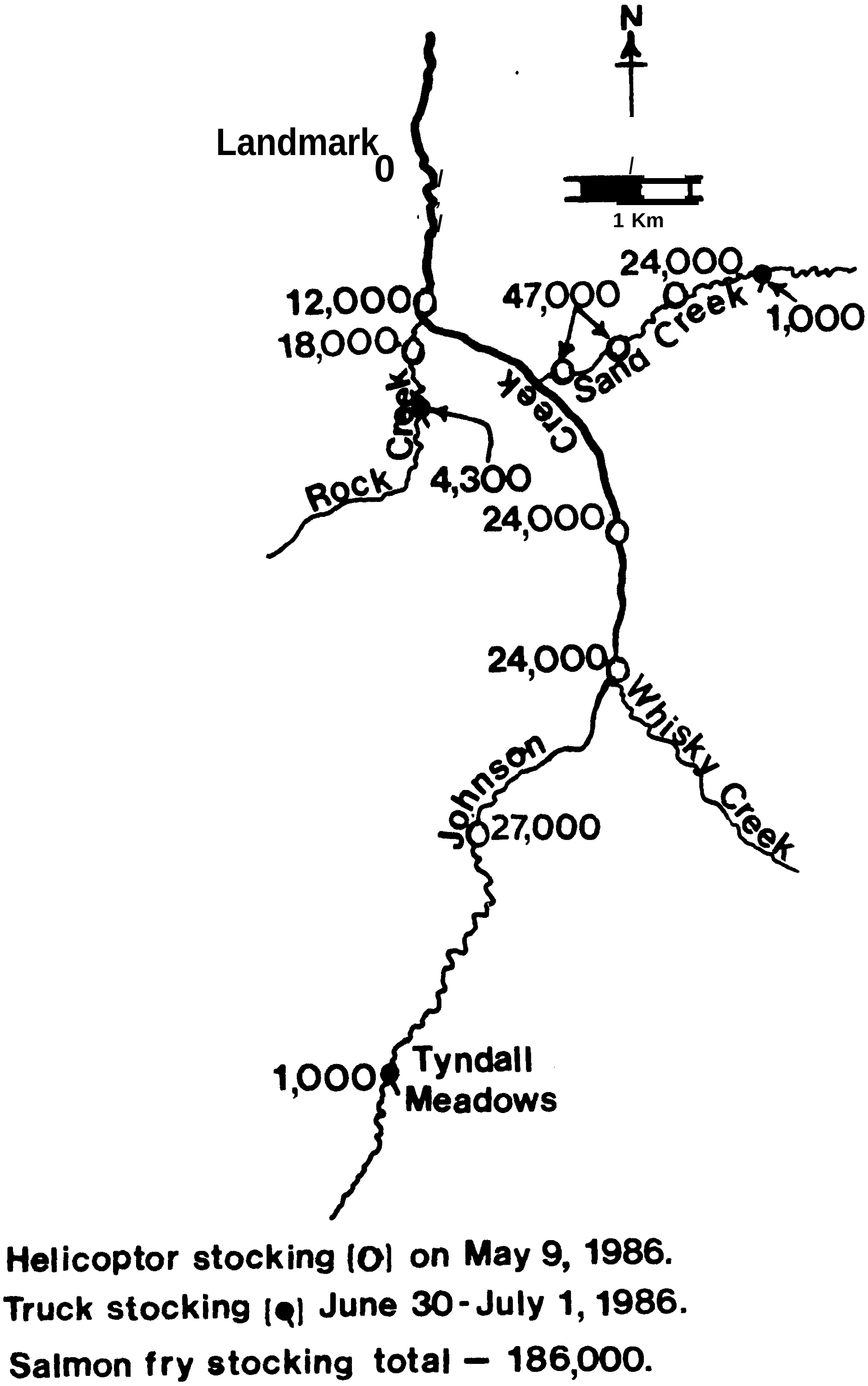


Figure 3. Primary and supplemental study sites in upper Johnson Creek drainage, and number, location, and date of salmon fry stocking, 1986.

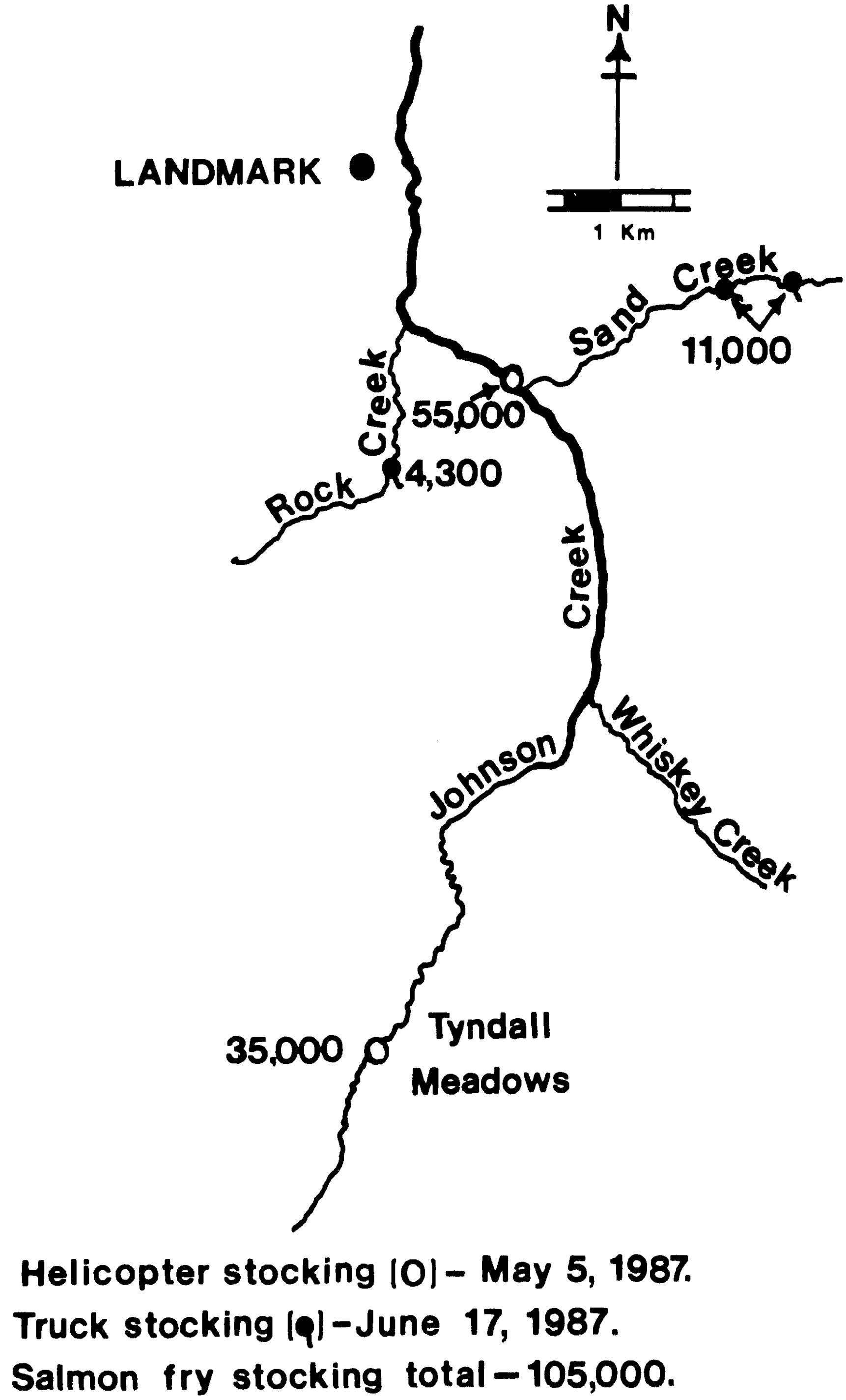


Figure 4 Primary and supplemental study sites in upper Johnson Creek drainage, and number, location, and date of salmon fry stocking, 1987.

was stocked at 120 fry/100 M sq, Sand Creek at 240 fry/100 m sq, and Tyndall Meadows (helicopter stocking) was designated as the highest stocking density (480 fry/l00 m sq.) because we released all the fish at one site.

The 1987 salmon fry stocking methods were Identical to the 1986 operation with two exceptions. We stocked only two sites In Johnson Creek in 1987, one at the head of the Tyndall Meadows grazing study and the other at the confluence of Sand and Johnson creeks. Also, in 1987, wc increased the stocking densities from 30-60-120 fry/100 m square, to 120-240-480 fry/100 m square. Rock Creek was stocked at the lowest density In 1987 (same as in 1986), Sand Creek the intermediate density, and Tyndall Meadows the highest density.

During the salmon fry stocking operations, we used both stream bank and underwater observations to record the behavior of salmon fry and predation by brook trout immediately after the fry were stocked. In addition, we noted all fish predation seen during the weekly snorkel counts and examined the gut contents of 2-year-old and older brook trout removed from the brook trout reduction sites.

Stocked salmon fry migrate upstream and downstream during the rearing season. At both the Tyndall Meadows and mouth of Sand Creek helicopter stocking sites, we established snorkel areas at 0.5 km intervals 3 km downstream and 1.5 km upstream from the two stocking sites, Each snorkel site was at least 40 m in length. We measured the physical habitat using the methods of Petrosky and Holubetz (1965) (Appendix 2). I snorkeled the Tyndall Meadows movement study sites on June 24 and August 15, 1987. On August 15-17, 1987, we conducted a systematic snorkel population survey of Rock and Sand Creek plus all of the supplemental snorkel sites on main Johnson Creek.

I calculated average rearing densities from the weekly snorkel counts during the rearing season. I also snorkeled the supplemental sites bi-weekly to assess drainage wide changes in fish populations. Bi-weekly electrofishing samples provided growth statistics in the primary study sites. I compared fish numbers in early morning and afternoon snorkel surveys with electrofishing captures In the study sites in Tyndall Meadows. To compare growth of stocked salmon fry with that of wild salmon fry, I collected fry from Stolle Meadows on the South Fork Salmon River.

Thermometers recorded daily maximumum and minimum water temperatures on upper Johnson Creek and upper South Fork Salmon River In Stolle Meadows. Streambank and snorkel surveys were conducted to assess the effectiveness of the fish passage improvement projects in middle Johnson Creek. I determined the alkalinity and pH and estimated the flow in all three study streams during the 1987 field season,

I measured upper Johnson Creek drainage stream lengths on USFS maps and estimated average widths from field measurements to arrive at a total rearing area estimate in upper Johnson Creek drainage above the barriers,

During the snorkel counts in the three primary study sites, I noted the number of mergansers In the sites and counted and photographed dead salmon fry and brook trout. I compared fish numbers pre-and-post-merganser sightings in the snorkel areas.

From 1985 through 1987, in the upper Johnson Creek study area, we snorkeled 139,535 m (86.7 miles), classified over 148,000 fish as to species and age class, removed OF relocated over 3,200 brook trout, and weighed and measured 6,414 fish.

FINDINGS:

Brook Trout Population:

Brook trout densities during the 1985 electrofishing removal operations ranged from 0.3 to 0.5 fish m sq. and 1.67 to 5.46 gm/m sq. In upper Johnson Creek drainage (Table). We were not able to remove all brook trout in three passes with the electrofisher so those densities are slight under-estimates of true densities.

From 1985 through 1987, we killed or relocated about 3,200 brook. trout in the upper Johnson Creek drainage (Figure 5). In 1985, the Brook trout population age structure ranged from fry to 3-years-plus fish. The largest brook trout I saw in electrofishing collections was 200 mm total length while the average length was less than 100 mm.

1985 Results:

Because of the late summer stock ing time In 1985 (August 2-3), most of the salmon drifted downstream in milling schools immediately after release in the study sites. ToG few salmon fry remained in the primary study sites to draw conclusions regarding growth and survival However, it was interesting to note that more salmon fry remained in the control sites than in the brook trout removal (treatment) sites. During the 1985 fry stocking operation, a brief rainstorm put the stocked salmon fry into a feeding frenzy, apparently in the belief that food pellets rather than rain drops were falling on the water surface, The principle conclusion of the 1985 work was that salmon fry out-plantings, designed to restore or supplement natural production, should not be made in late summer and probably should be timed to coincide with the emergence of natural salmon fry at the temperature regime of that particular location.

1986 and 1987 Results:

The salmon fry stocked from a helicopter in early May, 1986-87, were released near the normal timing of peak emergence from the gravel at the elevation and temperature regime of the study area (Welsh unpublished). Most of the fry remained near the release sites and moved inshore, behaving similarly to salmon fry immediately after emergence from the gravel (Welsh, 1963). Many salmon fry released from the fish truck into the three primary study sites in late June, 1986, and m1 d-June, 1987, also remained near the stocking sties during the summer growth period. Large numbers of salmon fry occupied all of the study sites throughout the 1986 and 1987 field season.

We recorded dramatic changes in fish populations in upper Johnson Creek from 1985 through 1987. (Figure 6). Salmon proportions increased from 12% of the fish in snorkel sites In 1985 to 89% in 1987. Trout numbers were inversely proportional to the number of salmon fry in the counts. The decline in brook trout, from a maximum count of 280 fish in a site on Rock Creek (Petrosky and Holubetz, 1985), continued through 1987 as salmon fry numbers escalated (Figure 7).

The brook trout population declined, regardless of whether brook trout had been removed from the sites. We removed no brook- trout from the two supplemental sites at the mouth of Sand Creek and at the mouth of Whiskey Creek, yet brook trout had nearly disappeared from both snorkel sites by 1987 (Figure 8).

Table 1. Total catch of brook trout and longnose dace and fish densities In g/m square In electrofishing operations In upper Johnson Creek drainage, 1985.

Site identification		Date 1985	Area m sq.	Total catch of brook trout & dace	Number of passes & electrofisher type
Tyndall Meadows	0D-2D	7-30	552	64 brook trout	2 passes Smith-Root
	2D-3D	7-30	276	26 brook trout	1 pass Smith-Root
	3D-4D	7-16	276	41 brook trout	1 pass Smith-Root
	3D-4D	7-17	276	86 brook trout	4 passes Georator
	4D-6D	7-21	552	183 brook trout 5 dace	4 passes Smith-Root
	6D-7D	7-26	276	130 brook trout 6 dace	3 passes Smith-Root
Rock Creek	12D-13D	7-31	184	62 brook trout 1 dace	1 pass Smith-Root
	13D-15D	7-29	368	51 brook trout 3 dace	2 passes Smith-Root
	l3D-15D	7-31	368	71 brook trout	2 passes Smith-Root
	l6D-l7D	7-18	184	99 brook trout 2 dace	4 passes Smith-Root
	17D-18D	7-18	184	101 brook trout 11 dace	4 passes Smith-Root
	18D-19D	7-22	184	61 brook trout 4 dace	3 passes Smith-Root
	19D-20D	7-22	184	91 brook trout 6 dace	3 passes Smith-Root
Sand Creek	1D-2D	7-18	317	40 brook trout	4 passes Georator
	2D-3D	7-19	276	45 brook trout	3 passes Smith-Root
	3D-4D	7-23	276	40 brook trout	4 passes Georator
	4D-5D	7-23	276	68 brook trout	4 passes Georator

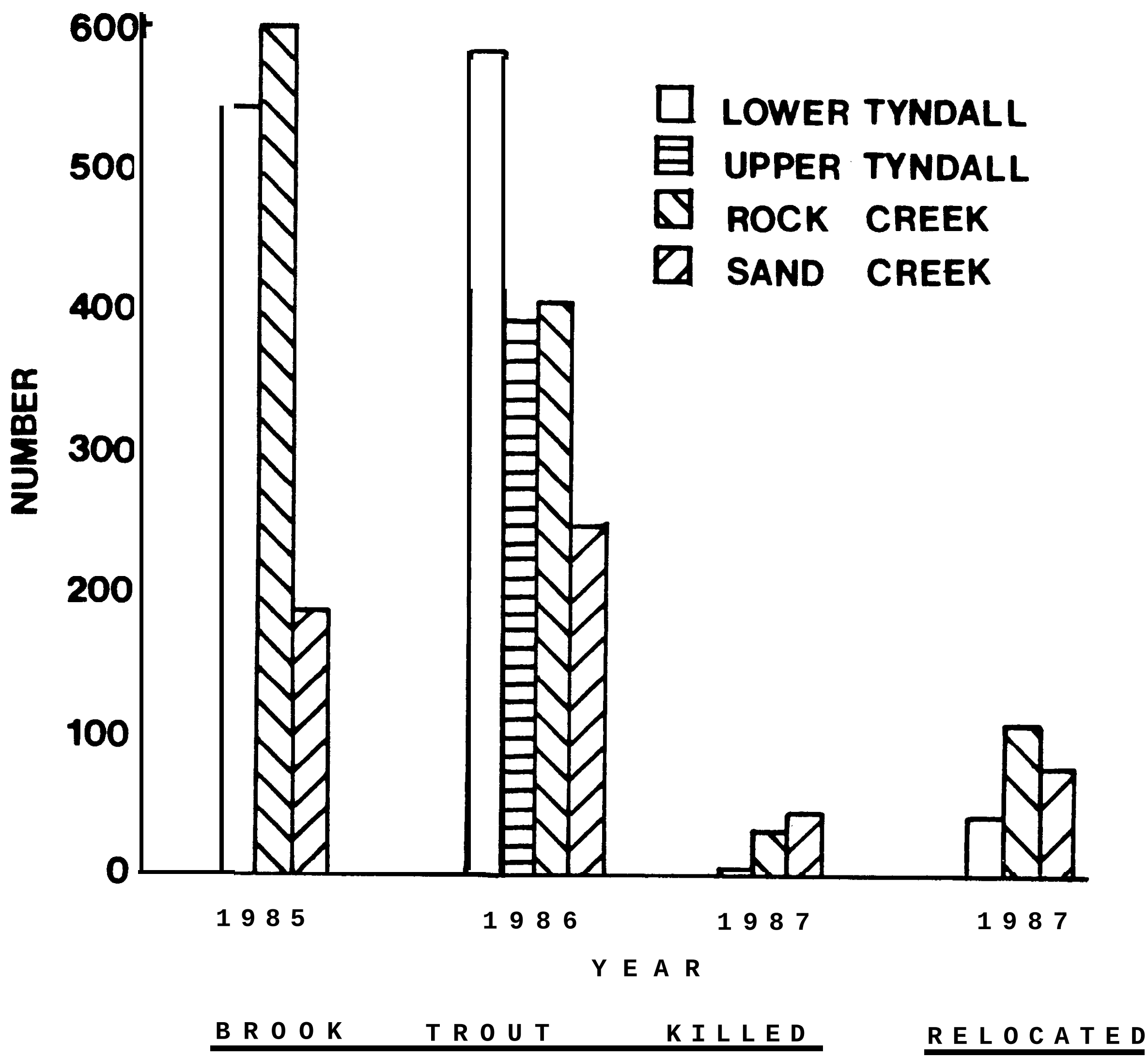


Figure 5. Numbers of brook trout killed and relocated in upper Johnson Creek drainage, 19854987.

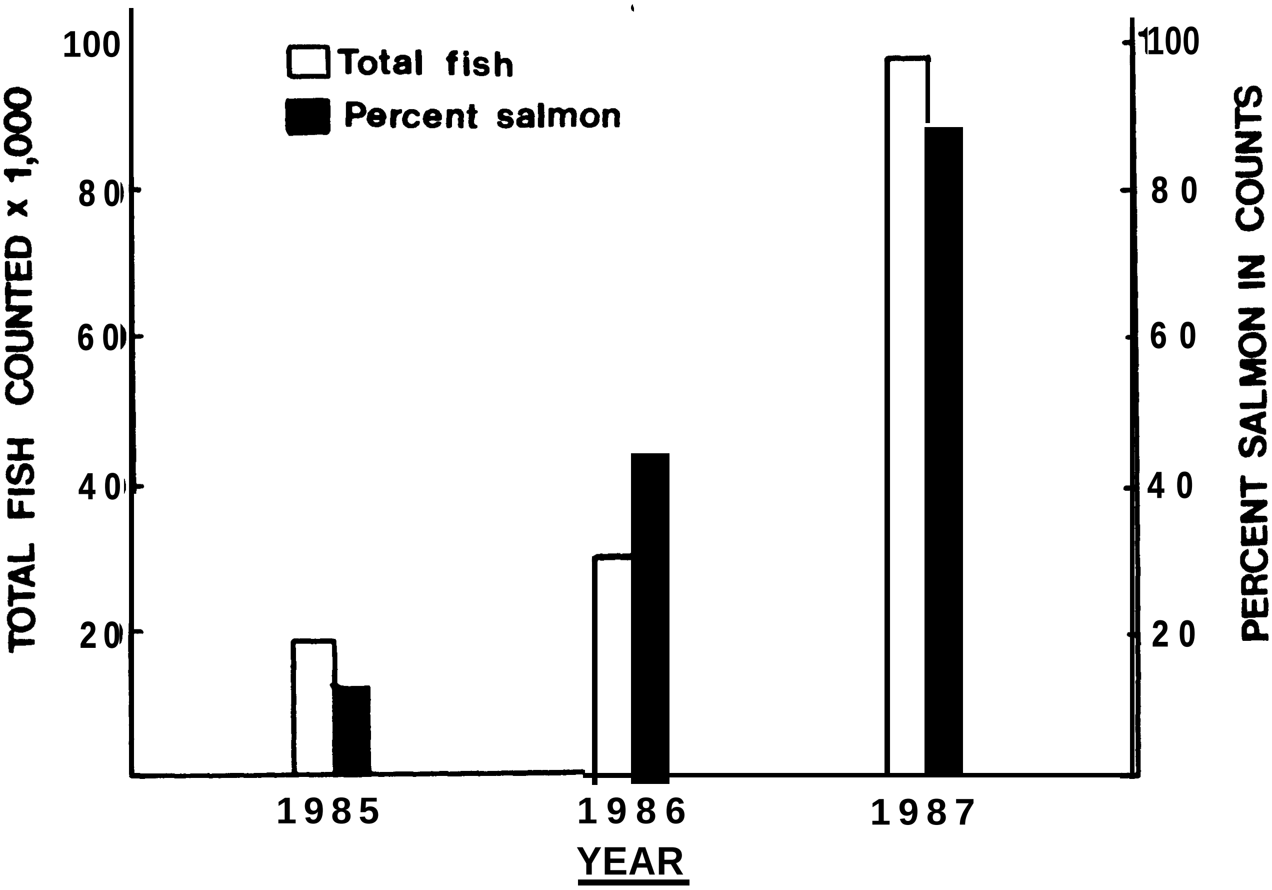


Figure 6. Total fish counted in snorkel surveys and percent salmon in upper Johnson Creek drainage study sites, 1985-1987.

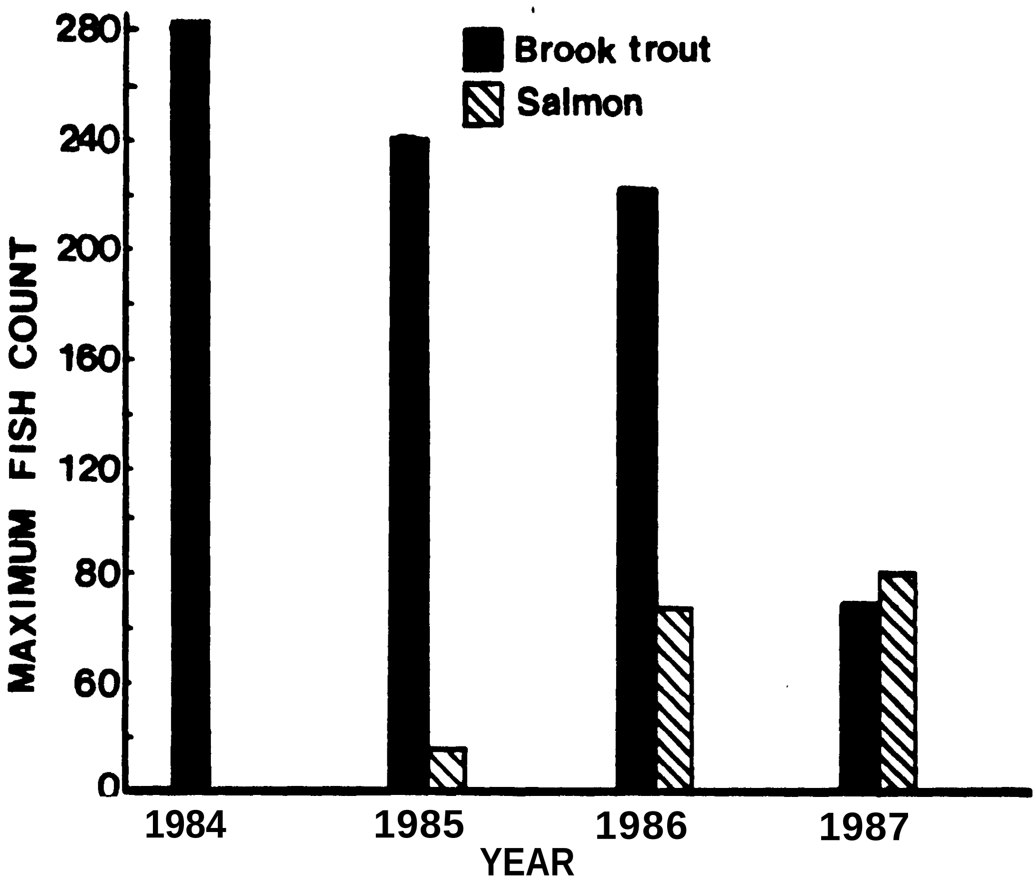


Figure 7. Maximum number of salmon and brook trout counted in a supplemental study site 92 m in length on lower Rock Creek, 1984-1987.

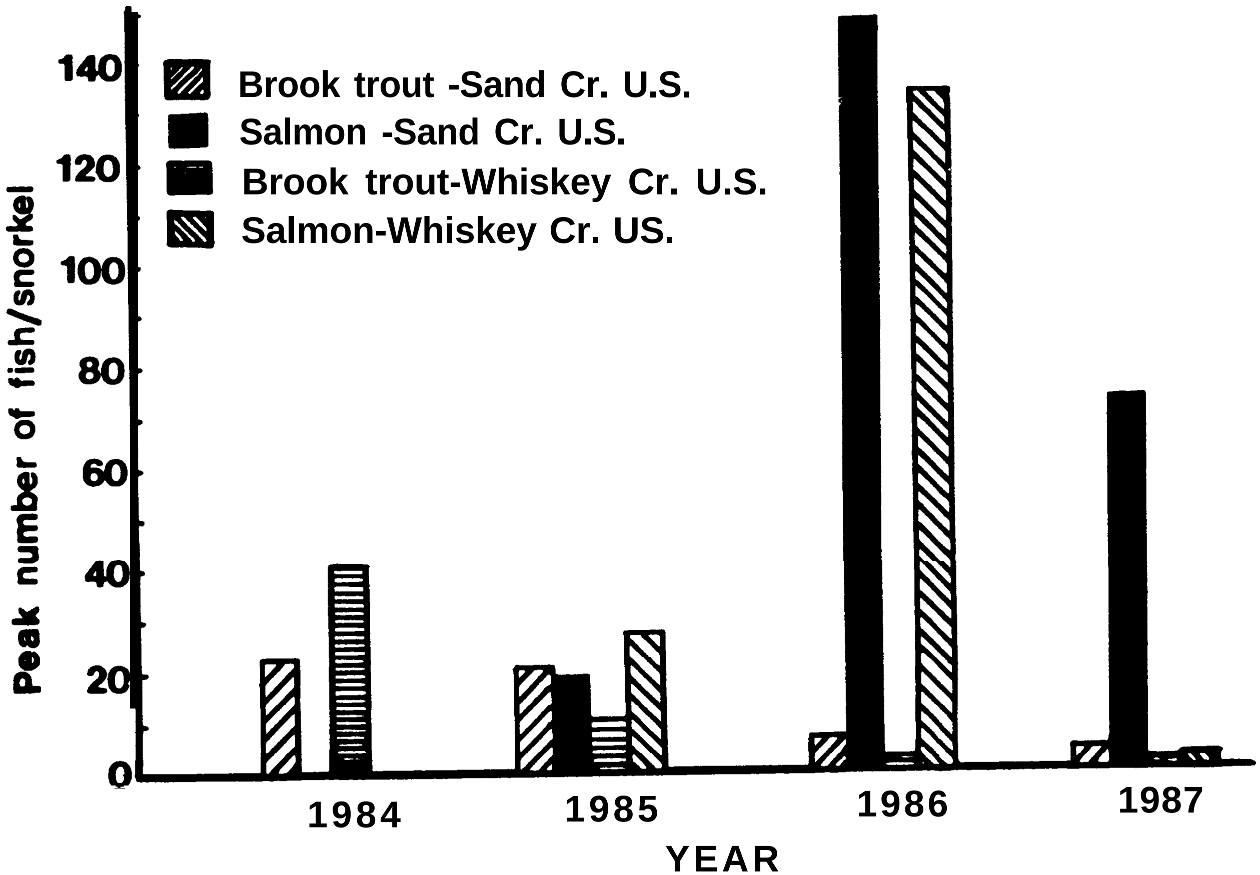


Figure 8. Peak number of salmon and brook trout in two supplemental study sites, each 92 m in length, in upper Johnson Creek, one at the mouth of Sand Creek and the other at the mouth of Whiskey Creek, 1984-1987.

The proportion of salmon fry In the snorkel counts increased in all study sites from 1985 to 1987 (Figure 9). Salmon proportions were higher in non-brook, trout-removal 5ites on main Johnson Creek than In the primary study s tes 1n 1986. However, that was because main Johnson Creek recei ed heavier stocking of salmon fry in 1986 than in either 1985 or 1987

Brook trout did not appear in the lower portion of upper Johnson Creek (airfield site) until early July of 1985 (Figure 10). Because of the barriers on middle Johnson Creek) those brook trout appearing In the airfield site M0ved downstream from upper Johnson Creek or adjacent tributaries. Brook trout numbers in the airfield site peaked sharply in mid-August and declined precipitously in early September, The same trend was apparent in three supplemental snorkel sites downstream from the airfield sites. In contrast, salmon fry reared In the airfield site from late June through August, 1986.

Salmon fry numbers in the three Tyndall Meadows study sites declined progressively from a high of nearly 5,000 fish on May 12, 1987, to about 1,800 fish by August 11, 1987. Salmon fry numbers declined rapidly in mid-August, 1987, and remained in the 100-200 level from late August to early October (Table 2).

Salmon fry stocked via helicopter May 5, 1987, moved both upstream and downstream from the Tyndall Meadows stocking site (Figure 11). On the snorkel survey of June 24, 1987, movement was about equally divided upstream and downstream from the release site, However, by August 15, 1987, nearly all salmon fry had disappeared from the downstream sites and more salmon fry had moved upstream. Salmon fry survival from time of stocking until June 24, 1987, ignoring emigration from the study sites, was estimated to be 14.5%; survival to August 15, 1987, was estimated to be 9.0% (Appendix 3).

Because of the unexpected late summer upstream movement of salmon fry, I established an additional snorkel site 2.0 km upstream from the stocking site in Tyndall Meadows. On October 3, 1987, salmon fry densities were 0.25 fish/m sq. at the additional site (Figure 11). The snorkel sites were covered by breakable ice during the October counts.

On August 15, 1987, we snorkeled the sites upstream and downstream from the helicopter stocking site at the mouth of Sand Creek. Ail the salmon fry and brook trout had disappeared from all sites. On July 6, 1987, I counted 228 salmon fry, nine brook trout, two rainbow trout, and 41 dace at the mouth of Sand Creek. stocking site. Fish numbers continually declined at the site until August 5, 1987, when I saw no salmon fry, four brook trout fry, and one rainbow trout fry. In contrast, in 1986, there was little emigration of salmon fry from the snorkel sites until the end of September. Because of the early movement of salmon from upper Johnson Creek, we were unable to estimate total survival of the salmon fry stocked in upper Johnson Creek. drainage in 1987.

We saw large discrepancies in snorkel counts between early morning (9:00 a.m) and afternoon (2:00 p.m.) in Tyndall Meadows (Figure 12). Brook trout remain concealed in mats of vegetation (Fontinalis) and holes in the streambank until mid-morning. Chinook salmon fry congregate in large schools in early morning and split into smaller schools by mid-morning. We had close agreement between both snorkel counts, three passes with the electrofisher and the population estimate for salmon fry at site 3 In Tyndall Meadows (Figure 12). However, we had large differences in the four estimates for Brook trout. Some of the differences in snorkel counts for sites 1 and 2 may be due to the counts being two days apart. The afternoon counts were done August 2 and the morning counts August 4, 1987. We saw major reductions in both

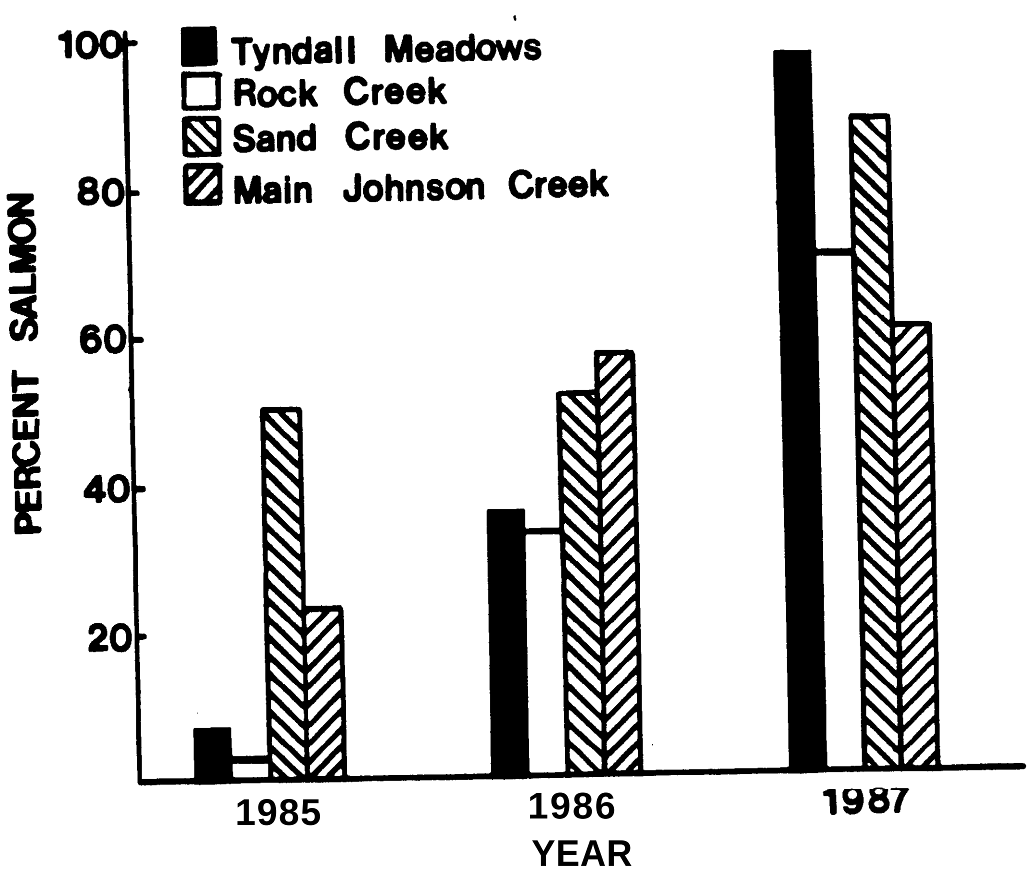


Figure 9. Percent salmon fry in all snorkel study sites in upper Jonhson Creek drainage, 1985-1987.

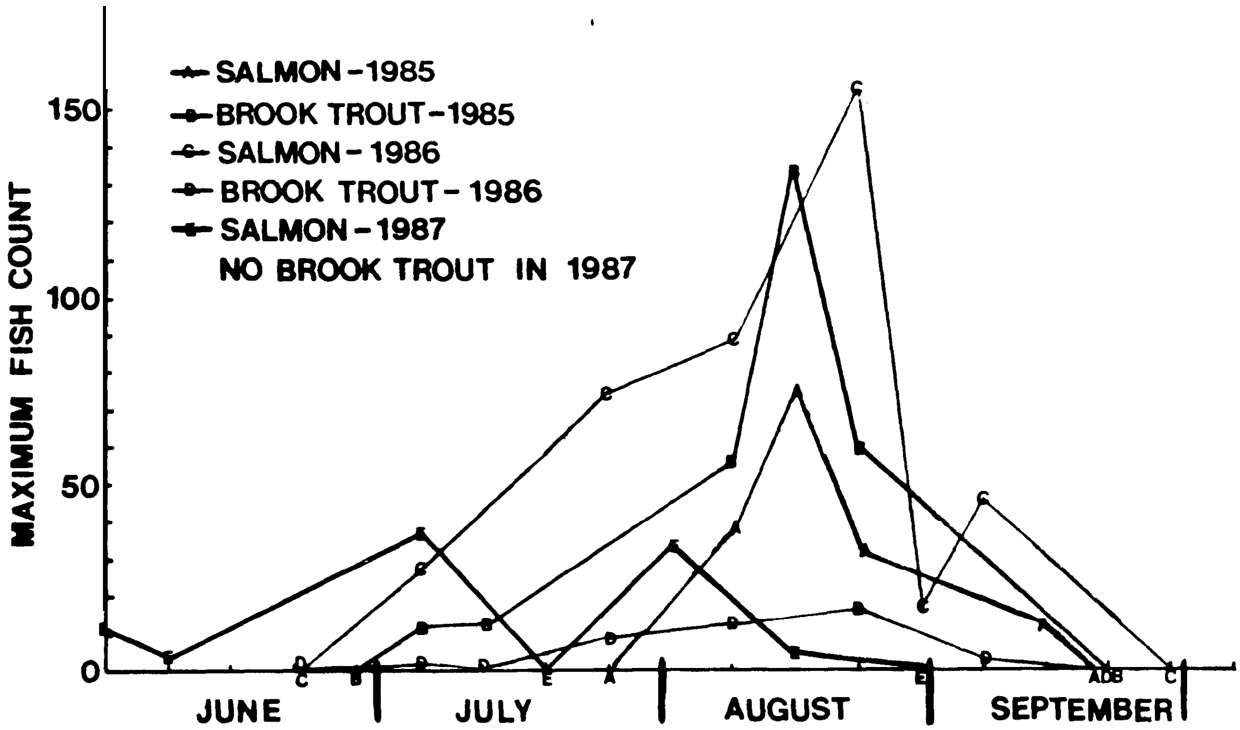


Figure 10. Maximum number of salmon fry and brook trout counted in a 270 m long supplemental study site in upper Johnson Creek upstream from the mouth of Rock Creek.

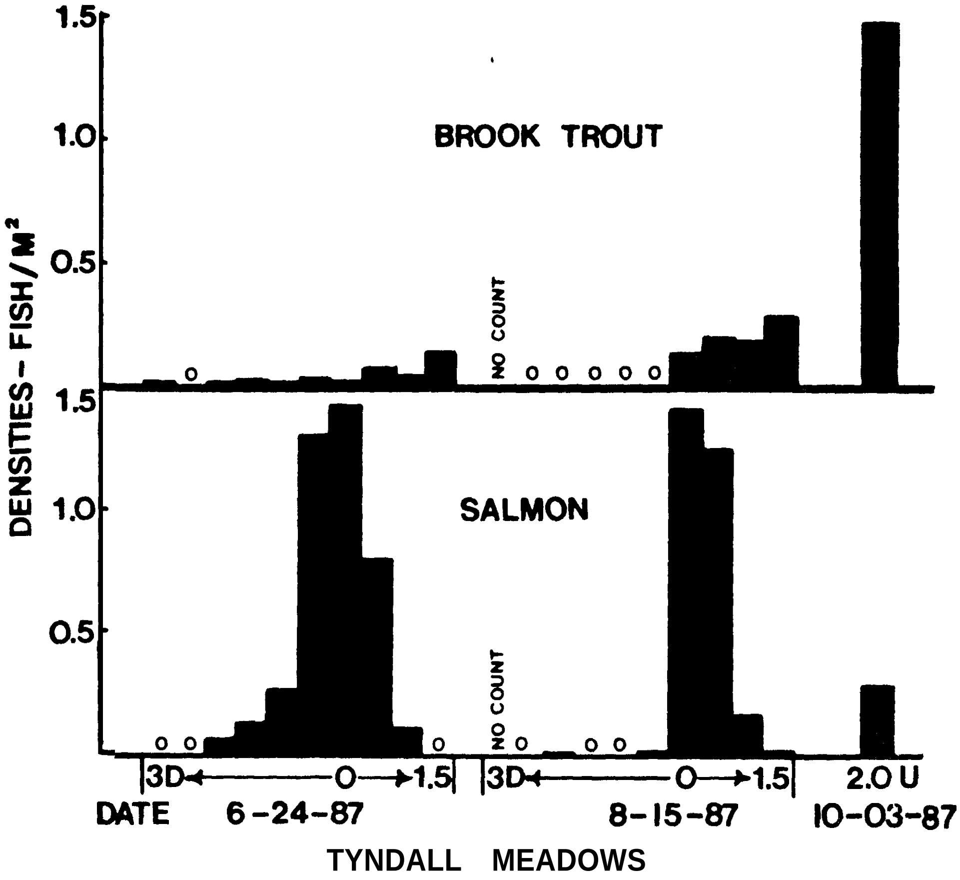


Figure 11. Number of salmon fry and brook trout in snorkel sites at 0.5 km intervals 2 km upstream and 3 km downstream from the stocking sites sites, designated as 0, June 14 and August 15, 1987.

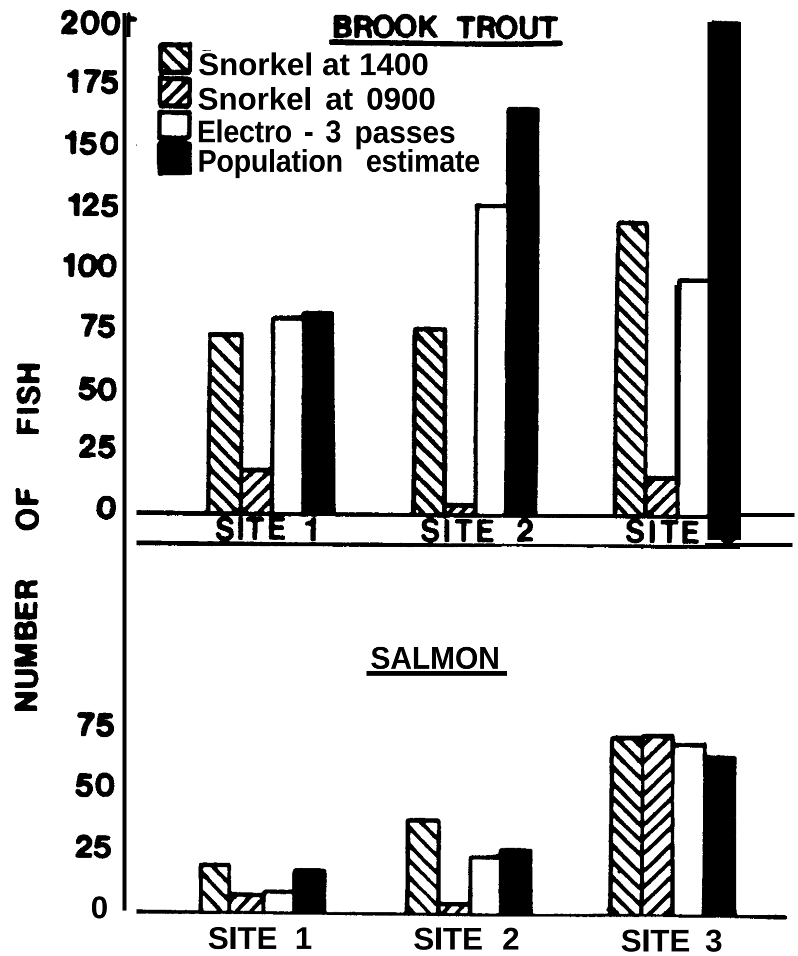


Figure 12. Numbers of salmon fry and brook trout in early morning and afternoon snorkel counts, three passes with an electrofisher and the maximum likelihood population estimation method (VanDeventer and Platts 1983), Tyndall Meadows, August 2-4, 1987.

the chinook salmon and brook trout counts beginning the first week of August, 1987. At site 3 in Tyndall Meadows, all data were gathered August 4, 1987.

On September 10, 1987, water in Tyndall Meadows had a pH of 7.2 and alkalinity (expressed as calcium carbonate) of 90 ppm. On September 11, 1987, Rock and Sand creeks had pH and alkalinity levels of 7.2 and 90 ppm and 7.2 and 50 ppm respectively. Flow estimates on October 29, 1987 in Tyndall Meadow and Rock and Sand creeks In the primary study sites were 1.2, 0.7 and 1.2 cfs respectively. The 1987 discharges In the Johnson Creek drainage were near record lows.

Salmon fry growth was inversely proportional to rearing densities (Figure 13). In 1987, salmon growth, at an average rearing density of 0.3 fish/m sq. in Rock Creek, was nearly equal to salmon growth of 0.5 fish/m sq. in Sand Creek. However, salmon growth at an average density of 1.7 fish/m sq. in Tyndall Meadows was slower than the other two sites. In fact, salmon fry lost weight during late July-early August. The salmon fry were adding a little length but losing weight during that period. Average weights of salmon fry did not increase until mid-August when rearing densities declined (Table 2).

Length of chinook salmon fry at the end of the summer growth period was dependant on rearing densities and the proportion of sand in the substrate (Figure 14). For 1986 and 1987, I compared salmon length at the end of the growth season to the combined rearing densities of salmon fry and brook trout and percent surface sand over the substrate. Rock *Creek* has the highest proportion of surface sand (90%) and Sand Creek the lowest (25%) with Tyndall Meadows intermediate (46%). A multiple regression analysis yielded an R sq. of .93 (Figure 14). Independant variables (density and sand) are significant at alpha=.025 in axplaining variation in growth. As shown In Figure 14, all but one of the Sand Creek data points (least sand) lie above the regression line. The one data point below the line has the most amount of sand (37%) of the six sites in Sand Creek. All of the data points for Rock Creek (most sand) fall below the regression line.

On August 25, 1987, wild salmon fry in Stolle meadows on the South Fork of the Salmon River averaged 66.8 mm in lengtt and 2.87 gm in weight. On the same day in Sand Creek in upper Johnson Creek drainage, salmon fry averaged 81.9 mm in length and 5.41 gm In weight. Both sites are in predominately gravel substrates. I was unable to obtain accurate snorkel counts because of the abundance of mats of underwater vegetation (Fontinalis) In the study site in Stolle Meadows. However, I suspect that the combined fish densities, conside ring all the species that are present in Stolle Meadows, is significantly higher In Stolle Meadows in upper South Fork Salmon River than In Sand Creek in upper Johnson Creek.

Maximum-minimum water temperatures follow a similar pattern in Stolle Meadows and upper Johnson Creek (Figure 15). In general, the absolute maximum temperature in 1987 was slightly higher In upper Johnson Creek than in Stolle Meadows (22.5 vs 21 degrees C) but the average maximum was higher in Stolle Meadows for most of the summer and fall salmon fry growth period. However, the average minimum temperature was lower in Stolle Meadows during the same period. In a series of spot water temperature readings during the 1985 field season, it appears that Rock Creek\ has the highest heat budget of the three primary study sites, Tyndall Meadows intermediate, and Sand Creek the coolest (Table 3). The heat budget follows the elevational pattern, (about 150 m total difference) with Rock Creek lowest and Sand Creeb highest. The study area on Rock Creek is nearly devoid of riparian vegetation which promotes the high mid-summer water temperatures.

Table 2. Snorkel counts of fish In the three 184 M long study sites In Tyndall Meadows, May 12 to October 3, 1987.

Date 1987	Brook Trout Fry	1+	2+	3+	Salmon Fry	1+	Other
May 12		7	2		4,897	1	
May 22		7	2	1	3,957		
Jun 1		10		1	3,010		
Jun 6		17	16	2	2,389		1 rainbow trout
Jun 13		7	8	-	2,005		
Jun 20	7	32	9	5	3,100	2	
Jun 28	3	44	37	10	3,492	2	
Jul 7	2	41	46	8	2,544	2	
Jul 14	1	37	26	11	2,218	2	
Jul 21	1	59	21	5	2,154		
Jul 29	7	73	48	10	2,082		1 dead salmon fry
Aug 5	7	54	39	8	1,748	1	
Aug 11	10	58	51	6	1,835	3	1 rainbow trout
Aug 15	11	53	25	3	882	4	
Aug 26	2	3	4		238		
Aug 31	3	1			52		
Sep 10					209		
Sep 14					257		
Sep 23		2			107		
Oct 3		1			179		

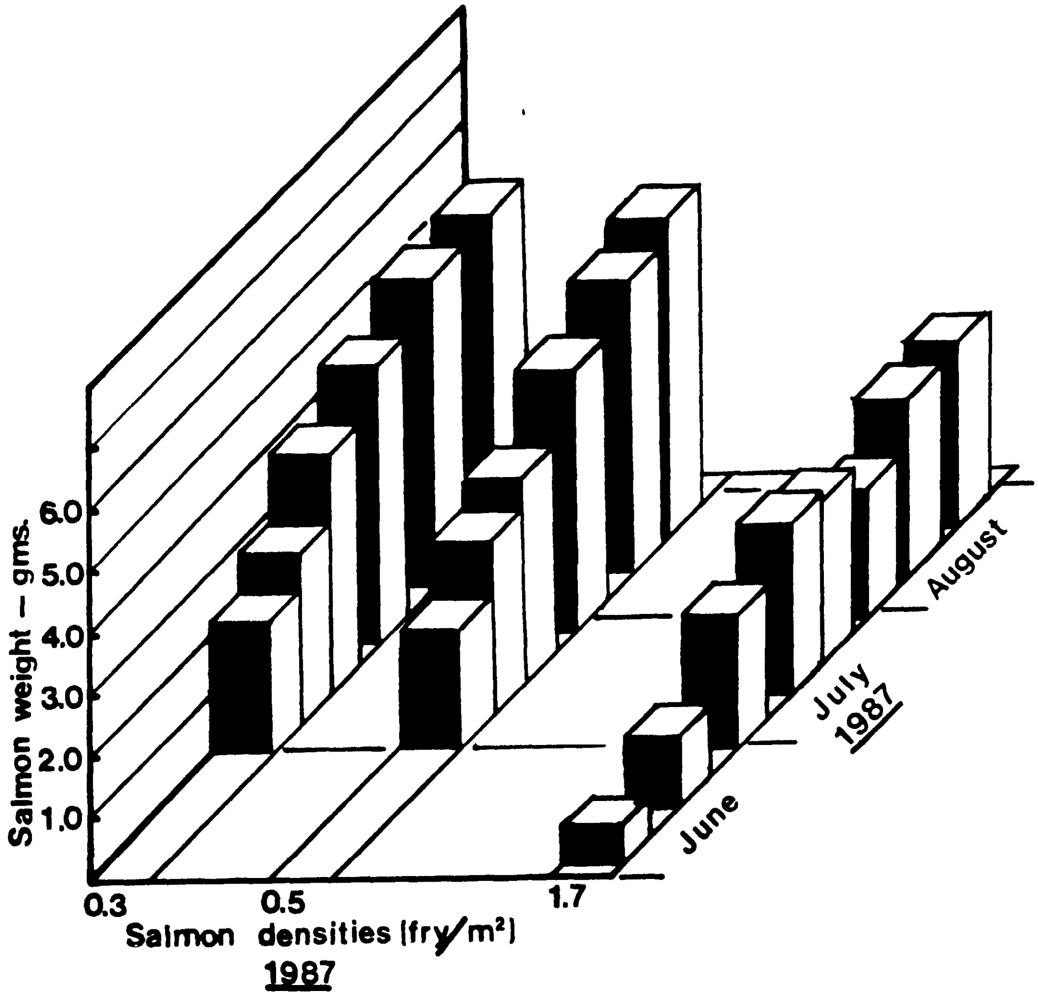


Figure 13. Relationship between salmon weight and salmon rearing densities in upper Johnson Creek drainage, June-August, 1987.

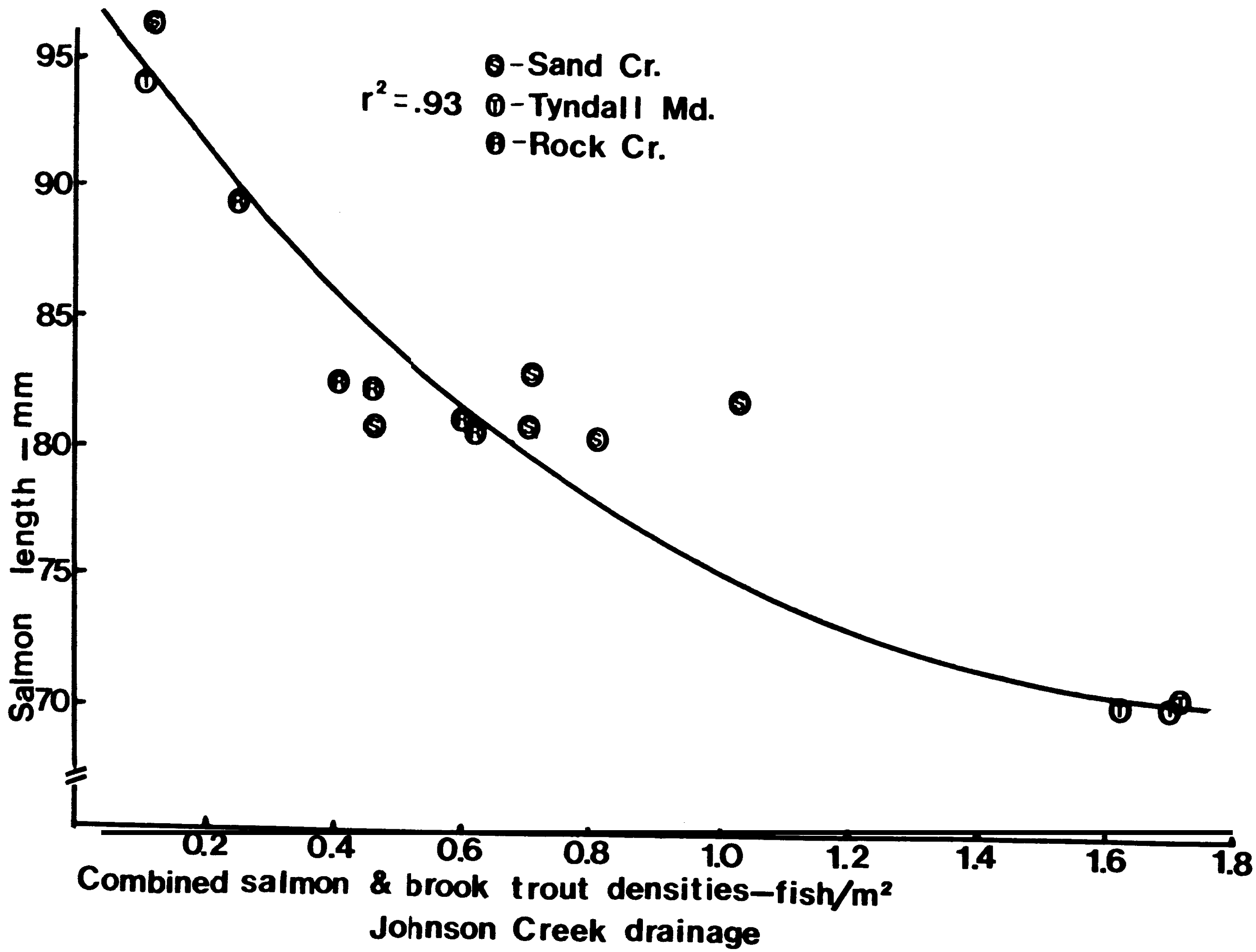


Figure 14. Multiple regression analysis of salmon fry length on the average combined densities of salmon and brook trout during the rearing season and sand in the substrate, upper Johnson Creek drainage, 1986-1987.

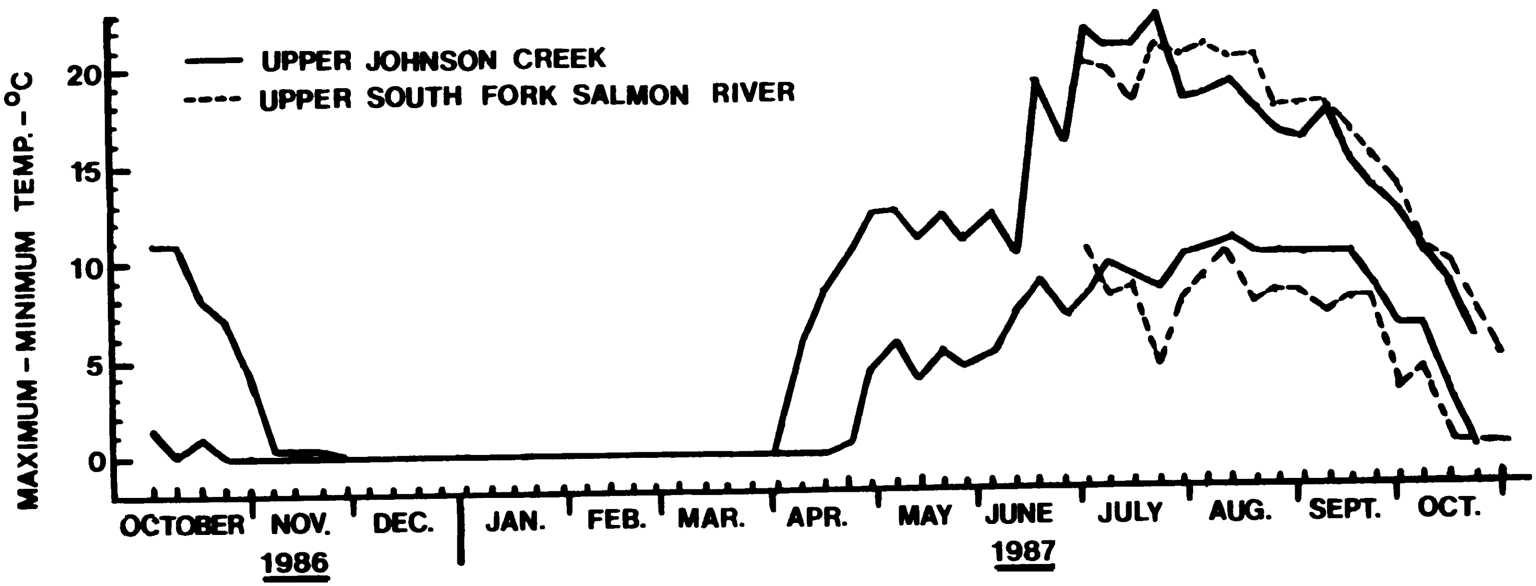


Figure 15. Maximum-minimum water temperatures in upper Johnson Creek and upper South Fork Salmon River, 1986-1987.

Table 3. Spot checks of water temperatures in Rock and Sand creeks and upper Johnson Creek In Tyndall Meadows, Landmark, and the confluence of Johnson Creek and Rock Creek, June 27 to October 18, 1985.

Date 1985	Time	Location	Temp deg. C	Date 1985	Time	Location	Temp. deg. C
06-27	1400	Tyndall	7	09-12	1400	Tyndall	7
07-14	1430	Rock Cr.	14	09-12	1645	Sand Cr.	6
07-14	1430*	Rock Cr.	16	09-16	1400	Rock Cr.	9
07-18	1450	Sand Cr.	16	09-16	1610	Tyndall	9
07-18	1530	Rock Cr.	19	09-18	1310	Rock Cr.	7
07-21	1305	Rock Cr.	18	09-18	1500	Tyndall	6
07-21	1640	Rock, Cr.	21	09-19	1250	Rock Cr.	6
07-22	1350	Rock Cr.	18	09-19	1330	Sand Cr.	4
07-23	0900	Rock Cr.	15	09-19	1340	Landmark	5
07-23	1600	Sand Cr.	18	09-23	1245	Landmark	6
07-23	1630	Tyndall	20	09-23	1430	Tyndall	8
07-26	1500	Sand Cr.	17	09-23	1650	Rock Cr.	9
07-26	1535	Rock Cr.	20	09-27	1245	Landmark	6
07-26	1700	Tyndall	20	09-27	1255	Sand Cr.	6
08-02	1200	Rock Cr.	17	09-30	1030	Rock Cr.	2
08-02	1430	Tyndall	12	09-30	1030	Confluence	1
08-05	1300	Rock Cr.	19	10-06	1300	Rock Cr.	6
08-08	1000	Sand Cr.	11	10-06	1300	Confluence	5
08-10	1200	Landmark	11	10-06	1330	Tyndall	6
08-11	0910	Rock Cr.	8	10-11	1120	Landmark	1
08-11	0925	Tyndall	8	10-11	1300	Sand Cr.	1
08-30	0900	Rock Cr.	11	10-11	1345	Rock Cr.	2
08-30	1245	Sand Cr.	14	10-11	1345	Confluence	1
09-03	1600	Tyndall	17	10-18	1300	Rock Cr.	4
09-04	1650	Rock Cr.	9	10-18	1300	Confluence	3

* Water temperatures taken at the same time with the cooler water 7 m downstream. A submerged spring cooled the stream temperature.

In nine replicates of brook trout reductions (treatment) and comparisons of salmon rearing densities in adjacent control sites, more salmon reared in the control sites during eight of the nine tests (Figure 16). In the one site where salmon densities were greater in the treatment areas than in the controls, the differences were slight.

We saw no evidence of brook trout predation on salmon fry in 1985, other than during fry stocking. I snorkeled Rock Creek while salmon were being stocked on August 2, 1985, and saw a salmon fry taken by a length-group-3 brook trout. In Tyndall Meadows, on the same day, I saw a length-group-2 brook trout capture a salmon fry. I saw no further evidence of brook. trout preying on salmon fry during the 1985 snorkel counts or in brook. trout gut content examinations. In 1986, we saw no predation by brook trout on salmon fry or salmon fry in brook trout gut examinations. One length-group-2 female brook trout captured on a small tributary of Rock Crek on June 23, 1986, had 21 brook trout fry in her gut. She was in a pool beneath an elevated culvert; emerging brook trout fry tumbling through the shallow water in the culvert and falling into the pool were easy prey. We found one dace in the gut of a length-group-3 brook trout in Rock Creek in 1986.

On June 29, 1987, in the second 200-m site on Rock Creek, I saw a length-group-3 brook trout with a live salmon fry crosswise in his jaws. After a couple of minutes, the brook trout swam to an undercut bank and I was unable to make further observations. On July 8, 1987, at the same locat ion on Rock Creek, I saw a length-group-3 brook trout capture a salmon fry. While conducting a snorkel count, I was herding a large school of salmon fry in front of me. The school turned at a shallow riffle and started back towards me single-file downstream. The brook trout darted from concealment in an undercut bank and took, the lead salmon head-first at less than arms length from my face. The location was identical with the previous weeks predation obervation and it was very likely the same brook trout predator. On Rock Creek July 1, 1987, a 140 mm long brook trout had the tail of a partially digested 90 mm long rainbow trout protruding from his mouth. In Tyndall Meadows in 1987, during a snorkel count, I saw a 3-year-old brook trout swallowing a salmon fry I had killed earlier during electrofishing.

On July 29, 1987, I sighted a merganser brood (one adult and six chicks) mid-way through the six 200-m long snorkel sites. On the lower 200 m snorkel transect, I counted only three live and two dead brook trout. On the second site, I counted four live salmon, 15 dead salmon and five live Brook trout. The mergansers skirted around me and moved downstream. In the four transects upstream from where the mergansers were sighted, I saw a total of 679 salmon fry and 400 brook trout.

On September 11, 1987, in a snorkel survey in the primary study sites in Sand Creek, I had seen only eight live salmon fry and nine live and two dead brook trout in the lower 600 m of stream. As I rounded a meander and was about to enter the largest pool in the Sand Creek study sites, I encountered nine grown mergansers. On the bottom of the pool, I counted 20 dead brook trout and six dead salmon fry. Some of the salmon fry were headless. Most of the brook trout were headless and stripped of their skin. The testes and ovaries were missing from the spawning-age brook trout. Upstream from the pool containing the dead fish and mergansers, I counted 542 live and no dead salmon fry and 49 live and no dead brook trout in 700 m of channel.

On September 23, 1987, I encountered four adult mergansers in the lower 200 m site on Sand Creek. The pool inhabited by the mergansers contained 27 dead salmon fry and four dead brook trout. I saw no live

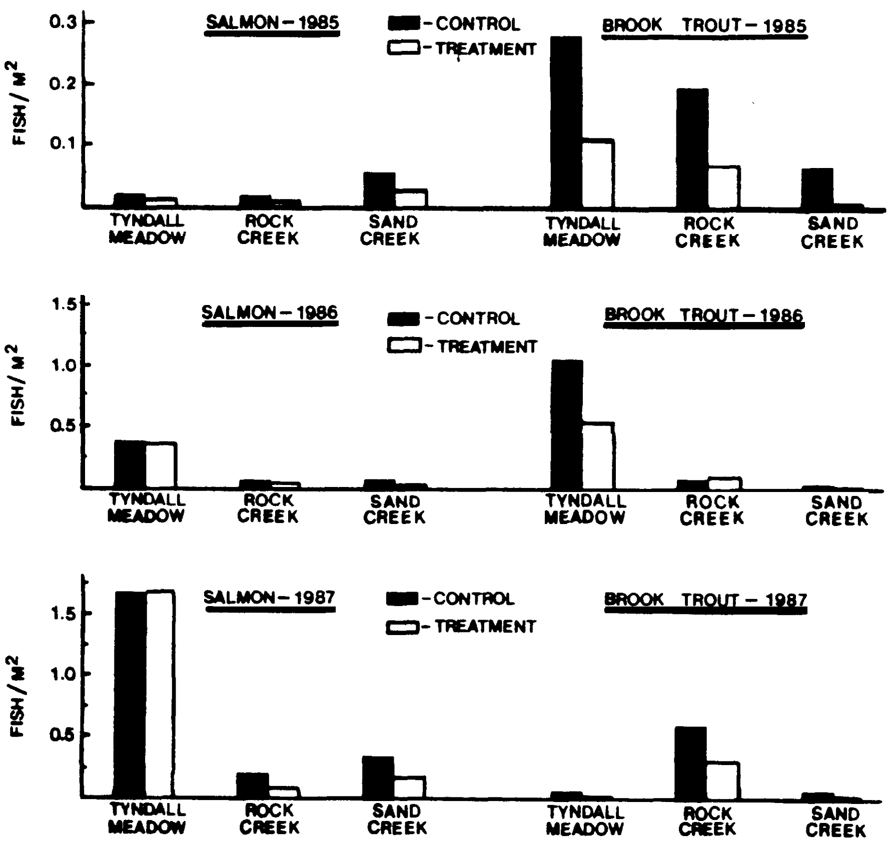


Figure 16. Average rearing densities of salmon fry and brook trout in brook trout reduction sites (treatment) and control sites in the primary study sites on Rock and Sand creeks and in Tyndall Meadows, 1985-1987.

fish in either of the lower 200-m transects. The upper 500 m of study sites contained near normal numbers of salmon and brook trout. In counts subsequent to the merganser sightings on Rock and Sand creeks, the snorkel count totals were about 50% lower than the pre-sighting counts. Apparently, the surviving fish were concealed in underwater vegetation and holes in the bank when I was snorkeling while mergansers were present.

One-year-salt (three-year-old) salmon from the 1985 stocking of 20,000 fry were expected to return to upper Johnson Creek in 1987. We snorkeled resting pool5 below the barriers during the summer of 1987. I also positioned streambank observers near the barriers to record the number of salmon jumps, location, and success or failure of the jump. We saw no salmon in the snorkel surveys nor in observations from the streambanks. No adult salmon or redds were observed during our snorkeling and electrofishing during the 1987 field season on upper Johnson Creek upstream from the barriers.

DISCUSSION:

COMPETITION:

Larkin (1956) stated that "Interspecific competition would only occur when by chance two species with close habits were both abundant in relation to a limited environmental resource they both required".

Because of similarities in timing of spawning and emergence as well as habitat preferences of chinook salmon and brook: trout, competition between the two species is nearly intraspecific in nature. Both species are fall spawners and the fry emerge from the gravel the following spring. Newly emerging fry of both species seek inundated sedges in shallow, slow-moving water on the margins of stream banks. As the fry of both species grow, they move offshore into deeper water. Both species prefer lentic habitats in lotic environments (Everest, 1967, and Cunjak, 1984).

Competition between brook trout and chinook salmon is most intense in the early growth phase following emergence from the gravel. Chinook salmon have a 50% size advantage over brook trout and they emerge six weeks earlier in the spring. Brown (1946) proved that larger brown trout (Salmo trutta) have higher survival and better growth than smaller brown trout fry. The growth of subyearling brook trout declined after emergence of rainbow trout fry (Rose, 1986) and the displacement of brook trout may have been due to excessive overwinter mortality as a result of the growth reduction in the brook trout population.

West and Larkin (1987) found evidence of size-selective mortality of juvenile sockeye salmon (<u>Oncorhynchys rhynchus *nerka*</u> > in Babine lake, British Columbia. They state, "Initial size differences of <1 mm fork length may have profound implications for growth and survival of individuals within cohorts of juvenile sockeyes". They declared, unequivocally, that there is a size selective mortality of fish that were relatively small at the time of emergence. They presumed that the proximate causes of sockeye fry mortalities were size related, such as as parasitism and disease. Sockeye salmon fry are particularly vulnerable to infestations of parasitic cestodes during the early growth phase, from about 34 to 40 mm (West and Larkin (1987). The faster the fry grow through that length phase, the less vulnerable they are to mortality from cestodes.

In sympatry, brook trout are restricted to the very headwaters of tributaries, above the upstream lmits of salmon spawning. Salmon fry move upstream into the headwaters but in fewer numbers (Figure 11). At 2 km upstream from the Tundall Meadows stocking site, salmon densities were only 15% of the density at the stocking site. However, Brook trout densities were ten-fold greater than at the salmon stocking site. In work done beyond the scope of this study, I found that the salmon competing against Brook trout 2 km upstream from the stocking site at Tyndall Meadows were twice as heavy as those competing against their cohorts at the stocking site. Therefore, it is apparent that salmon are able to compete successfully with brook trout throughout the rearing areas in the upper Johnson Creek drainage.

No data are available but I suspect that the brook trout population expanded during the 1930-40's, In the absence of competition from salmon fry, following the blockage of adult salmon at the barriers in mid-Johnson Creek, . In some lotic environments in the Salmon River drainage, we find dense populations of brook trout above barriers that have excluded chinook salmon. Those areas include Cold Meadows near Chamberlain Basin (Welsh, unpubli shed) and upper Johnson Creek;. When salmon are present, brook trout are largely restricted to the very headwaters of small tributaries such as the upper end of Elk Creek.. in the Middle Fork of the Salmon River drainage (Welsh, unpublished).

From 1984 through 1987, I documented the exodus of brook. trout from the lower portions of Sand and Rock Creeks and Tyndall Meadows, except the very headwaters. We removed over 3,000 brook trout from the primary study sites in Rock. and Sand creeks and Tyndall Meadows. With the use of USDA Forest Service maps, I measured stream length and estimated channel width from field measurements. With these methods, I arrived at an estimate of 500,000 sq. m of rearing area in the upper Johnson Creek. drainage above the barriers. If we assume that the brook trout densities of 0.3 to 0.5 fish/m sq. I observed In the electrofishing samples are a reasonable estimate of true drainage wide densities, the rearing areas In upper Johnson Creek had a 1985 standing crop of 150,000 to 250,000 brook trout. Therefore, the brook trout removal operation would have accounted for only 1.2 to 2% of the decline In the brook trout population and competition from chinook salmon would most likely account for the remainder of the decline (88%). The dominance of the chinook salmon population transpired regardless of whether we removed brook trout and irrespective of salmon stocking rates.

PREDATION:

Larger brook trout prey on all four species of fish (chinook salmon, rainbow trout, longnose dace and brook trout) in the upper Johnson Creek drainage. At times other than during salmon fry stocking, we were able to document brook trout predation on salmon fry in only two instances. We examined the gut contents of over 2,000 brook trout and found fish remains in three of them. I saw a brook trout pick up a dead salmon fry I had killed during electrofishing, Undoubtedly, brook trout feed on dead and dying fish that have succumbed to natural pathogens. In upper Johnson Creek drainage during the three years of field investigations, predation by Brook trout on chinook salmon fry was an insignificant agent of mortality in the salmon population.

Avian predatores such an the common merganser are a major source of chinook salmon mortalities in rearing areas. Wood (1987) estimated that merganser ducklings consumption of fish ranged from 80% of body weight for ducklings at 10 d of age to 40% of body weight at 40 d of age l Merganser broods consumed between 82,000 and 131,000 coho salmon (Oncorhynchus kisutch) in the Big Qualicum River from early June to late August. That estimate is equivalent to 24-65% of the observed wild smolt production from the Big Qualicum River, assuming those fry consumed would have survived to the smolt stage.

Predation by merganser broods resulted in significant reductions in both salmon fry and brook trout in study sites in Rock Creek and Sand Creek during late summer and early fall of 1987. Merganser predation and a reduction in rearing densities probably would have resulted in better growth of survivors in overstocked areas such as Tyndall Meadows. However, I saw no mergansers in Tyndall Meadows; they preyed on fish in Rock and Sand creeks in study sites that were stocked at or near optimum densities. The killing of salmon and brook trout by mergansers and the consumption of the heads, skin and gonads, adds epidermal and mesentary fat which sustains the birds during their fall and winter southward migration, When we estimate fish loss to merganser predation, consumption plus waste equals the total loss rather than consumption alone.

ANGLING PRESSURE:

We made informal note of angling pressure in the upper Johnson Creek drainage during the three field seasons. We saw no more than a couple dozen anglers and those we interviewed had paused in their travel to make a few casts and had caught no fish. One party makes an annual foray to Sand Creek during the July 4th holiday but for the most part, upper Johnson Creek is not a destination fishing area. During the big game hunting season, a few hunters also do some fishing in streams adjacent to their camps.

SALMON PRODUCTION IN BROOK TROUT REMOVAL AREAS:

More salmon fry reared in the control areas than in brook trout reduction (treatment) areas in eight out of nine replicates during the 1985-1987 freld seasons. Salmon fry in mountain meadow environments rear in schools and may be attracted to brook trout, In 1985, I snorkeled during the salmon stocking operation and saw milling schools of salmon srifting downstream through the brook trout removal sites and schooling with brook trout in the contol sites.

SALMON FRY SUPPLEMENTATION:

We should be seeding the rearing areas in upper Johnson Creek drainage with salmon fry at a rate ranging from 0.4 to 1.0 fry/m sq. The seeding rates are dependant on the quality of the substrate. Sand substrates will rear autumn-age-0 chinook salmon to a length of 80-85 mm at a rearing density of 0.4 fry/m sq. Gravel substrates will rear salmon fry to the same length (80-85 mm) at 0.8 to 1.0 fry/m sq. Overseeding of salmon fry, whether from natural spawning or hatchery outplanting programs, will result in higher fry mortality rates, higher overwinter mortality rates, and reduced smolt size. Population reductions because of reduced smolt size will not be extracted until predators take their toll during the seaward migration.

Using the estimate of 500,000 sq. M of salmon rearing in the upper Johnson Creek drainage refered to earlier, and an intermediate density of 0.75 salmon/m sq., the upper drainage is capable of rearing about 375,000 salmon fry to an autumn-age-0 length of 80-85 mm.

Of course we have no estimate of the average fecundity of female chinook that may return to upper Johnson Creek to spawn nor of egg-to emergent fry survival in the drainage. For the sake of discussion, if one can assume a fecundity of 5,000 eggs/female and 50% egg-to-emergent fry survival, upper Johnson Creek and its tributaries would be fully seeded with 150 salmon redds. However, a certain proportion of emergent fry drift considerable distances downstream. Those early emigrants would seed middle Johnson Creek between the lower and upper spawning areas. Therefore, I would probably add a factor of 50 redds to account for early downstream drift to seed middle Johnson Creek. Under the above assumptions, upper Johnson Creek would be optimally seeded with 200 salmon redds annually.

Fry stocked in early May in flat gradient stream channels, will move 2-3 km upstream and downstream during the rearing season. However, they tend to remain near the stocking site In very dense numbers which increases intraspecific competition and reduces survival, Salmon fry outplantlng operations should strive for a wrde scatter of small numbers of fry rather than release of large numbers of fry in one or two locations. Dispersal of fry during the stocking operation would duplicate natural conditions where each riffle in the spawning area contains one or two redds, resulting in a more equal distribution of fry. On May 12, 1987, nine days after salmon fry were stocked in Tyndall Meadows, nearly 5,000 fry still remained near the stocking site in an area capable of rearing only about 1,000 fry to an autumn-age-0 size of 82-84 mm.

SALMON FRY GROWTH US DENSITY:

In a study of stream residence time, size, and migration patterns of Juvenile chinook. salon from a tributary of the Rakaia River, New Zealand, Unwin (1986), found no evidence of decreased egg to fry survival as ova deposition increased. His findings suggest that availability of spawning gravel was not a limiting factor, Unwin (1986) further stated that his findings, “supported Hopi ins (1981) who concluded from his analysis of the 1973-75 seasons that large initial fish numbers may not show commensurately high values of production”. “This relative decrease in fingerling production suggests that intraspecific competition for rearing habitat has a limiting effect on the population.“. “Fingerling from the 1975 and 1976 brood grew rather more slowly than those from the 1973 and 1974 broods which is consistent with increased competition for habitat and food at higher population densities,” I suspect that in most salmon producing areas in the Salmon River drainage, Idaho, rearing capabilities rather than spawning availabilty are limiting salmon fry production.

We have seen large differences in the size of chinook. salmon smolts in the Columbia River drainage for at least the past 30 years. In an egg-to-migrant survival study of spring chinook salmon in the Yakima River, Washington for the 1957-61 brooks, Major and Mighell (1969) stated, “Length frequency polygons of down-stream migrating spring chinook salmon show that the modal length increased from 120 mm in 1959 and 1960 to 125 mm in 1961, 130 mm in 1962, and 135 mm in 1963”. “Present data are inadequate to explain the reason for the increase in modal length.” I plotted the same regression line of Figure 14 for the Yakima River salmon length data for the 1957-1961 broods (Figure 17), The scale on the Y axis is the same but the range is different to account for the larger salmon smolts in the Yakima River. On the X axis of Figure 17, I have substituted redds for fish densities but the relative scale is identical. The upper four data points fall close to the regression line. However the data point for the observed smolt

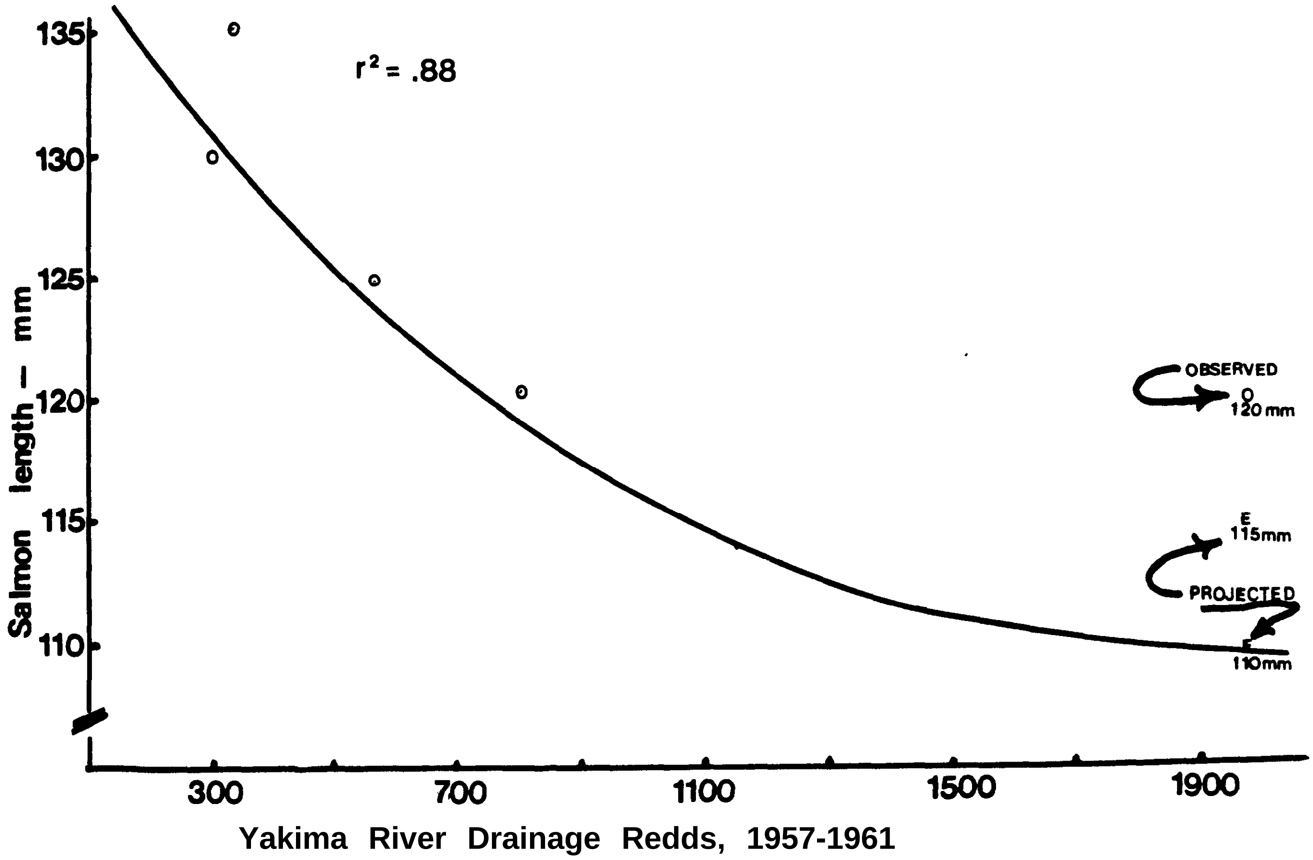


Figure 17. Observed and projected average lengths of Yakima River drainage salmon smolts, 1957-1961, as compared to the number of brood year redds redds.

length of 120 mm at about 1,900 redds lies far above the line. Major and Mighell (op cit.), further state that reduced flows over Easton Dam during the incubation season resulted in the loss of 30 to 50% of the 1967 eggs. In view of the fact that I recorded autumn-age-0 salmon length differences of 30% depending on rearing densities, smolts from the 1957 brood year may have been closer to 110 mm in length, had redd dessication not occured. In that event , the 1957 smolt length would have fallen on the regression line and the calculated R sq. value would be 0.88 (Figure 17).

BARRIER REMOVAL EVALUATION:

Our failure to observe one-salt jack salmon at the barriers or in our snorkel surveys is probably due to the small number of salmon fry (20,000) stocked In 1985 and poor fry survival because of the late summer release (August 2-3). A stocking of 20,000 salmon fry would equal the production from 8-10 redds. Realistically, we should not have expected more than a dozen Jack salmon from the salmon fry stocked in 1985, even with good survival. We saw one adult salmon above the barriers and one false salmon redd in the snorkel site at the mouth of Sand Creek in 1986. In 1987 we saw three steelhead redds in upper Johnson Creek;. Therefore, we can assume that the barriers are passable to adult salmon and steelhead but we do not know the degree of difficulty in passage,

SUMMATION:

When salmon spawning areas are under-escaped, compensation for under-seeding result5 in higher fry growth and survival during the rearing season. Conversly, following over-escapement, intraspecific competition causes reduced survival and undersized fry at the end of the rearing season. Smaller fry may suffer higher overwinter mortality (Welsh, in progress) and smaller smolts undoubtedly sustain higher losses due to predation during their seaward migration. Chapman et al (in print) observed juvenile trout predation directed almost exclusively towards small wild chinook salmon a5 the wild salmon co-mingled with larger downstream drifting hatchery reared salmon.

Compensation for underseeding (larger fry and higher survival) and penalties for overseeding (smaller fry and higher mortality) of spawning and nursery areas stabilizes fresh water production and moderates fluctuations in natural populations of chinook salmon.

LITERATURE CITED

Brown, M. E., 1946. The growth of brown trout (Salmo trutta). Journ. Exp. Biol. 22:118-129.

Cunjak, R. A., and J. M. Green. 1984. Species dominance by brook trout and rainbow trout in a simulated stream environment. Transactions of the American Fisheries Society. 113:737-743.

Everest, F. E., 1967. Habitat selection and spatial interaction of Juvenile chinook salmon and steelhead trout in two Idaho streams. PhD dissertation. University of Idaho, Moscow.

Holubetz, 1. B., and C. E. Petrosky, 1988. Idaho habitat evaluation for offsite mitigation record. Idaho Department of Fish and Game. Boise, Idaho. Annual report to Bonneville Power Administration.

Larkin, F. A., 1956. Interspecific competition and population control in freshwater fish. Journals of the Fisheries Research Board of Canada. 13(3).

Mallet, J., 1974. Long range planning for salmon and steelhead in Idaho. Job 2. Inventory of salmon and steelhead resources, habitat, use and demands. Idaho Department of Fish and Game. Boise, Idaho.

Major, R. L. and J. L. Mighell, 1969. Egg -to-migrant survival of spring chinook. salmon (Oncorhynchus tshawytscha) in the Yakima River, Washington. Bureau of Commercial Fisheries Bulletin: Vol. 67. No. 2.

Petrosky, C. E., and T. B. Holubetz, 1985. Idaho habitat evaluation for offsite mitigation record. Idaho Department of Fish and Game. Boise, Idaho. Annual report to Bonneville Power Administration.

Platts, W. S., and K. Torquemada. 1986. The effects of livestock grazing on the aquatic environment, streamside environment and fisheries in a high mountain meadow in the Idaho Batholith. USDA Forest Service. Intermountain Forest and Range Experiment Station. Boise, Idaho.

Rose, G. A., 1986. Growth decline in subyearling brook trout (Salvelinus fontinalis) after emergence of rainbow trout (Salmo gairdneri). Canadian Journal of Fisheries and Aquatic Sciences. 43:187-193.

Unwin, M. J., 1966. Stream residence time, size characteristics, and migration patterns of Juvenile chinook salmon (Oncorhynchus tshawytscha) from a tributary of the Rakaia River, New Zealand. New Zealand Journal of Marine and Freshwater Research. 1986. Vol. 20:231-252.

VanDeventer, J., and W. S. Platts, 1983. A computer software system for entering, managing, and analyzing fish capture data from streams. Research Note INP-353. Intermountain Research Station. USDA Forest Service. Ogden, Utah.

LITERATURE CITED (Continued)

Water, T. F., 1983. Replacement of Brook trout by brown trout over 35 years In a Minnesota stream: Prodution and abundance. Transactions of the American Fisheries Society. 112:137-146.

Welsh T. L., 1963. Reintroduction of chinook salmon into the Selway River drainage, Idaho. Progress report. Idaho Department of Fish and Game, Boise, Idaho.

West, C. J., and P. A. Larkin, 1987. Evidence for size-selective mortality of Juvenile sockeye salmon (Oncorhynchus rhynchus nerka) in Babine Lake, British Columbia. Canadian Journal of Fisheries and Aquatic Sciences. 44:712--721.

Wood, C. C., 1987. Predation of Juvenile Pacific salmon by the common merganser (Met-gus merganser) on eastern Vancouver Island. II: Predation of stream-resident Juvenile salmon by merganser broods. Canadian Journal of Fisheries and Aquatic Sciences. 44:950-959.

Appendix 1. Habitat data in the primary study sites in the upper Johnson Creek drainage, 1987.

SAND CREEK

Site length m	area m sq.	Habitat* type %	Mean depth m	Mean width m	Substrate sand %	gravel %	rubble %	boulder %
209	796	1--57 2--17 3--0 4--26	0.33	3.8	37	63		
173	692	1--59 2--08 3-- 0 4--33	0.32	4.0	25	75		
193	618	1--42 2--25 3--0 4--33	0.31	3.1	26	74		
226	610	1--50 2--12 3- 0 4--38	0.32	2.7	19	81		
260	936	1--61 2--08 3--0 4--31	0.36	3.6	20	80		

* 1 = Pool; 2 = Run; 3 = Pocket Water; 4 = Riffle. Habitat data for Tyndall Meadows taken from Platts and Torquemada, 1985.

Appendix 1. Habitat data in primary study sites in the upper Johnson Creek drainage, 1987.

ROCK CREEK

Site length m	area m sq.	Habitat* type %	Mean depth m	Mean width m	Substrate sand %	gravel %	rubble %	boulder %
170	397	1--15 2--59 3-- 0 4--26	0.31	2.3	92	07		01
187	449	1--15 2--57 3--0 4--28	0.29	2.4	94	06		
190	532	1--25 2--56 3--0 4--19	0.31	2.8	93	07		
180	396	1--14 2--32 7-- 0 L-54	0.20	2.2	88	11	01	
198	554	1--52 2--27 3--0 4--21	0.37	2.8	90	09	01	
189	662	1--40 2--42 1-- 0 4--31	0.41	3.5	90	08	<1	<1

* 1 = Pool; 2 = Run; 3 = Pocket Water; 4 = Riffle.

Appendix 2. Habitat data upstream and downstream from the salmon fry stocking sites in Johnson Creek at Tyndall Meadows and at the mouth of Sand Creek, 1987.

JOHNSON CREEK AT TYNDALL MEHDOWS

Strat.	Sect.	Type+	% Grade	Mean width (m)	Habitat type Pool %	Run %	Riffle %	Percent Substrate** Snd. %	Grav. %	Rub. %	Bdr %
U 2	U 2.0	C	0.2	1.9	50		50	63	32	05	
	U 1.5	C	0.05	2.0	57	29	14	85	15		
U 1	U 1.0	C	0.1	2.0	50	50		62	38		
	U 0.5	C	0.1								
	D 0.0	C	0.3	2.4	04	71	25	78	22		
D2	D 0.5	C	0.1	2.2	17	6 1	22	92	08		
	D 1.0	C	0.1	2.2	11	72	17	92	08		
	D 1.5	C	0.1	2.9	56	33	22	95	05		
	D 2.0	C	0.05	5.5	40	60		95	05		
D3	D 2.5	C	0.1	4.2		46	54	72	28		
	D 3.0	C	0.1	4.6	33	33	34	96	04		

JOHNSON CREEK AT MOUTH OF SAND CREEK

Strat.	Sect.	Type+	% Grade	Mean width (m)	Pool %	Run %	Riffle %	Snd. %	Grav. %	Rub. %	Bdr %
U 1	U 1.0	C	0.6	7.4	08	54	38	35	48	17	
	U 0.5	C	0.1	7.9	11	72	17	26	69	05	
	D 0.0	C	0.4	7.4	100			26	56	18	
D2	D 0.5	C	0.4	7.9	04	63	33	17	45	37	02
	D 1.0	C	0.2	10.2	14	61	25	25	62	13	
D3	D 1.5	C	0.4	10.5	43	28	19	14	78	08	
	D 2.0	C	0.2	9.9	57	43		26	69	05	
D 4	D 2.5	C	0.1	12.1	22	56	22	56	44		
	D 3.0	C	0.1	11.9	17	50	33	33	67		

* Channel type C is a meandered channel (Petrosky and Holubetz, 1985).
** Sand=<4.75 mm; gravel=4.75-76 mm; rubble= 76-305 mm; boulder=':305 mm

Appendix 3. Standing crop and survival estimates of chinook salmon fry June 24, 1987, from fry stocked by helicopter in Tyndall Meadows May 5, 1987.

Strata	Section*	Fry Number/ 100 m sq.	Actual fry number	Adjusted*+ fry number
U-l	1.5U	2.5	3	2.8
	1.0u	0.0	0	0.0
	n = 2			
	N = 18			
	fpc = .89***	Variance = 65	Pop. est. = 25 + or - 48	
D-l	0.5u	82	107	112
	0.0D	140	236	191
	0.5D	135	148	183
	n = 7			
	N = 26			
	fpc = .88	Variance = 374,973	Pop. est. = 4,212 + or - 1,224	
D-2	1.0D	43.6	48	75
	1.5D	8.6	20	15
	n = 1			
	N = 15			
	fpc = .87	Variance = 176,175	Pop. est. = 675 + or - 839	
D-3	2.0D	4.5	10	11
	2.5D	0.0	0	0
	3.0D	0.0	0	0
	n= 3			
	N = 29			
	fpc = .90	Variance = 15,264	Pop. est. = 106 + or - 247	

TOTAL POPULATION ESTIMATE = 5,018 t or - 1,505 where bound on estimate is equal to 2 x the square root of the variance.

TOTAL SURVIVAL ESTIMATE = 14.5% of the 34,500 stocked fry.

* Section denotes distance in km upstream and downstream from the stocking site designated as 0.0.
** Weighted average
*** Finite population correction factor.

Appendix 3 (Cont). Standing crop and survival estimate of chinook salmon fry August 15, 1987, from fry stocked by helicopter May 5, 1987.

Strata	Section*	Fry Number/ 100 m sq.	Actual fry number	Adjusted*+ fry number
U-l	1.5u	3.3	4	4
	1.0u	16.0	16	16
	n= 3			
	N = 18			
	fpc = .89***	Variance = 10,381	Pop. est. = 180 + or - 204	
	0.5U	1.5	2	2
D-1	0.0U	139.3	234	132
	0.5D	148.2	163	202
	n = 3			
	N :: 26			
	fpc = .88	Variance = 2,042,241	Pop. est. = 2,912 + or - 2,858	
D-2	1.0D	NO FISH COUNTED		
	1.50	NO FISH COUNTED		
D-3	2.0D	0.0	0	0
	2.5D	0.3	1	1
	3.0D	MARKERS WERE MISSING (NO COUNT)		
	n= 2			
	N= 20			
	fpc = .90	Variance = 90	Pop. est. = 10 + or - 5	

TOTAL POPULATION ESTIMATE = 3,102 + or - 2,866 where bound on estimate 15 equal to 2 x the square root of the variance.

TOTAL SURVIVAL ESTIMATE = 9.0% of the stocked fry.

l Section denotes distance in km upstream and downstream from the stocking site designated as 0.0.
** Weighted average
*** Finite population correction factor.

A COMPARISON OF SEDIMENT MONITORING TECHNIQUES OF POTENTIAL USE IN SEDIMENT / FISH POPULATION RELATIONSHIPS

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INTRODUCTION

For over 65 years, biologists have investigated the relationships between streambottom substrate quality and salmonid reproduction (Harrison 1923). Intensive field and laboratory evaluation of substrate composition, particularly fine sediment of various sizes, has continued on for over thirty years (see reviews by Iwamoto et al. 1978, Chapman and McCleod 1987). Recently the importance, extent, and implications of sediment and water quality impacts to aquatic biota have come to the forefront, especially as they pertain to forest practices (Bauer 1985, Brown 1985).

The literature has shown that increasing fine sediments in stream channel substrate can reduce salmonid fish populations, Increases in fine sediment in the channel reduce geometric mean particle size, gravel permeability, and lead to lower dissolved oxygen levels in intergravel water. These changes can reduce survival of chinook salmon in the egg to alevin emergence stage. No threshold values or criteria have been confirmed by sound field data relating fish response (rearing and incubation) to selected sediment values. Thus, if fine sediments within the channel increase or decrease from one level to another, managing agencies do not have the information needed to determine if fish or habitat response to these changes will be significant enough to cause concern.

This study was designed to improve our ability to quantitatively and qualitatively measure streambottom substrate. This study will also evaluate several habitat measurements with potential for evaluating fish-sediment response.

Large accelerated increases in sediment loads delivered to streams can create intolerable changes within the stream channel and in turn be detrimental to salmonid spawning and rearing (Platts et al. in prep.). Problems confound the analysis of stream response to increased or decreased sediment loads, however, and especially how this relates to fish populations, Most of the information being used by biologists comes from the results of laboratory analysis, which may not relate to actual stream conditions.

Other basic difficulties occur in establishing criteria for measuring fish response. Adams and Beschta (1980) noted that spatial variability in Oregon) stream substrate compositions may prohibit a simple characterization of gravel bed quality (by coring) within a given area. They found that fine sediments in channels varied greatly over time and space. This variability, and especially bias in study designs and methods of measurement, have led different authors to different conclusions. At this time the issues of what, where, when, and how to measure are being debated.

We conducted this study to evaluate several commonly used measurement techniques, attempting to determine the observer bias and variables that relate to or predict fish response. This report outlines the study areas, design, and procedures used to determine which variables are the most representative for predicting the response of fish populations to sediment. The precision and accuracy of these variables and relationships among the variables are assessed.

OBJECTIVES

1. Compare the most commonly used methods (in Idaho) for monitoring sediments:

   Surface substrate composition - ocular transect method (Platts et al. 1983)

   Surface substrate composition - Idaho Department of Fish and Game (IDFG) ocular method (Petrosky and Holubetz 1986)

   Surface embeddedness - ocular transect method, and measured hoop method (Kelley and Dettman 1980, Burns 1984, Burns and Edwards 1985)

   Subsurface sediment composition - Core sampling (McNeil and Ahnell 1964)

   Substrate score - (Crouse et al. 1981, Shepard et al. 1983)

   Spawning gravel indices: Fredle, Geometric mean diameter (Lotspeich and Everest 1981, Platts et al. 1979)

   Photographic analysis - (Hamilton and Bergersen 1984, Chapman et al. 1986).

2. Determine the relationships between the variables in objective 1 by habitat type and by stream reach, giving analysis capability over a large geographical area of the Idaho batholith.

3. Determine the degree of observer bias affecting the estimated measurement techniques.

4. Determine the relationships between the variables in objective 1 and fish population densities, by each habitat type and channel reach.

STUDY AREA

The study sites were located within a broad geographic area of central Idaho known for sediment problems because of inherent soil instability derived from Idaho batholith granitics (figure 1) Forest Service and IDFG biologists selected six sites representing a range of sedimentation levels and stream sizes (table 1). Criteria for selecting sites included availability of past sediment information and known use by chinook salmon. All sites were established in C-type channels (Rosgen 1985).

Table 1. Study sites and their respective data base.

Site	Previous data (years)	Avg width (m)	Sediment level[1]
1. N.F. Red River	3	4.6	high
2. Crooked River	3	10.5	low
3. S.F. Salmon-Poverty	20	33.0	mid
4. Bear Valley-Big Meadow	10	7.6	high
5. Salmon River 3BRA	2	23.7	low
6. Frenchman Creek	13	3.8	mid

[1] Sediment levels based on ocular surface "fines" estimates from past inventories. Low = <15% ; Mid = 15-30% ; High > 30%.

STUDY DESIGN

Sites consisted of 100 meter stream reaches, with 33 transects systematically placed perpendicular to the main stream flow at 3 meter intervals after establishing a randomly selected middle transect location (figure 2). We identified and mapped microhabitat types within each site following the terminology of Bisson et al. (1981). Microhabitat was also determined independently at the time of data collection. We measured all surface ocular attributes for reach and habitat inventory along the transect line, as well as a random hoop embeddedness sample point. Variables measured only under specific habitat criteria such as cobble embeddedness (wintering juvenile chinook salmon), and gravel core samples (chinook spawning areas) were measured under those conditions only, without regard to transect lines.

STUDY AREAS

Clearwater River Drainage
1. Crooked River
2. N.F. Red River

South Fork Salmon River Drainage
3. Poverty

Middle Fork Salmon River Drainage
4, Bear Valley Cr. (Big Meadows)

Salmon River Drainage
5. Salmon River - 3BRA
6. Frenchman Cr. (lower)

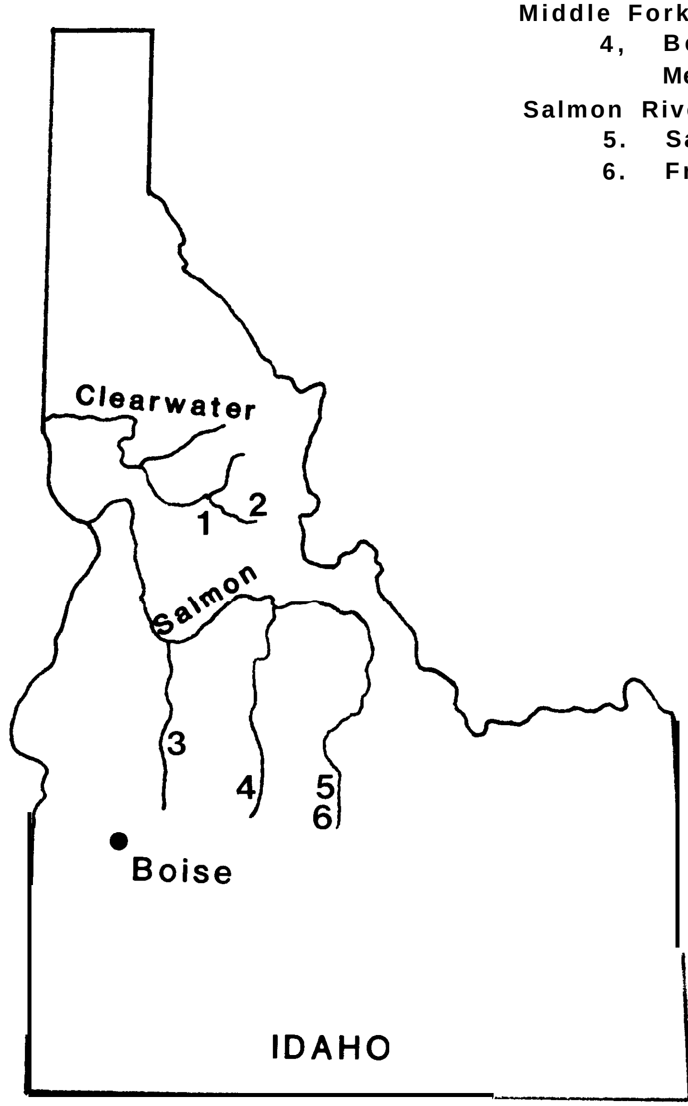


Figure 1. General location of study areas.

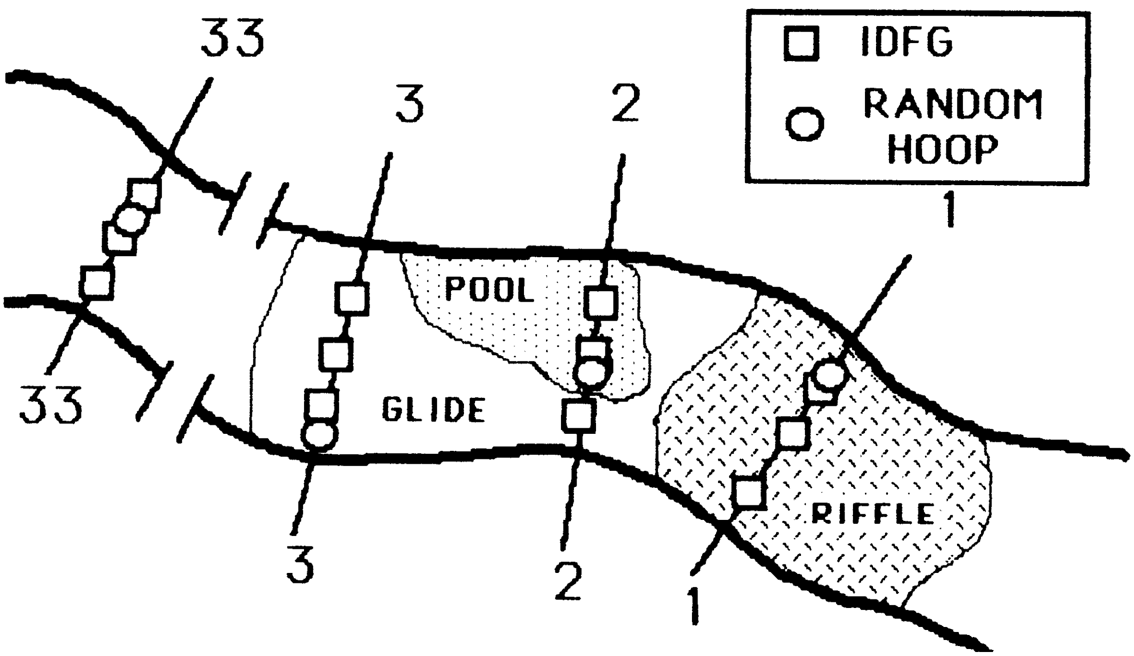


Figure 2. Schematic of study site design for 100 meter sites.

METHODS

Habitat Mapping

Study sites were mapped using a Hewlett-Packard Electronic Distance Measurer (EDM) and mapping techniques described in Platts et al. (1987). Bearings and distances were measured for the entire waterline, transect stakes, and habitat types (i.e. various types of pools, riffles, and glides).

Habitat Classification

An aquatic habitat type classification following (and intermediate to) those of Bisson et al. (1981) and Platts et al. (1983) was used to categorize fish habitat within the study sites. We identified five categories based on relative differences in depth, velocity, gradient, and channel morphology according to the following criteria:

Riffles - Portions of the stream with fast water velocity, relatively shallow depth, turbulent water surface and steep gradient (>2%).

Pools - Areas of the stream with slow water velocity, relatively deeper depths, and gradients less than one percent.

Glides - Areas possessing attributes of both riffles and pools, being intermediate in depth and velocity. Flow pattern is laminar, with little turbulence.

Pocket Water - Consisted of areas of the stream flowing around or through protruding stream channel substrate or obstructions such as logs. These areas formed small, shallow microniches with characteristics of riffles, pools and glides at different water levels. Because of influence of water level, and difficulties in distinguishing between different categories of pocket water (e.g. pocket pools and pocket glides) further breakdown of this category was abandoned.

Backwater - The only further breakdown of the pool category, backwater areas were synonymous with secondary channel pools of Bisson et al. (1981). These areas occurred along the stream margins and were usually associated with gravel bars or the confluence of intermittent tributaries. Though connected to the stream, most backwater areas exhibit little or no flow, and are influenced by water level changes.

Surface Substrate Composition and Embeddedness

Channel surface substrate materials were ocularly classified using the method described in Platts et al. 1983. The dominant substrate size category was determined for each 0.3 meter section of stream width along each transect line using the following particle size classification:

Class	Size
Boulder	>305 mm
Cobble	76.1 - 305mm
Gravel	6.4 - 76mm
Large fines	0.84 - 6.3mm
Small fines	<0.83mm

The individual 0.3 meter classifications were totaled and percentage composition determined by dividing by the transect stream width. Separate estimates of surface sediment composition were made for each microhabitat type, allowing comparisons of each type to other variables. We used reference sediment samples encased in epoxy resin to help classify the smaller size classes.

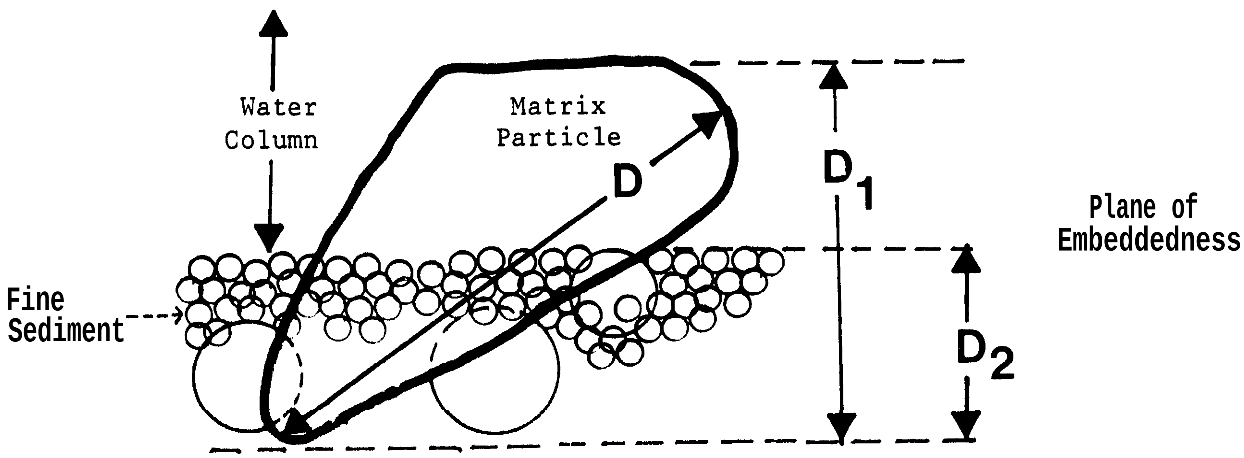
IDFG Surface Methodology

The Idaho Department of Fish and Game developed a modification of the surface transect approach, dubbed the "Quick and Dirty" (Q & D) technique (Petrosky and Holubetz 1986). Ocular estimates were taken at the 1/4, 1/2, and 3/4 points along 10 transects spaced at 10 meter intervals. At these three points along each transect line, substrate size composition and embeddedness were estimated for a 0.3 square meter cell. Particle size classification is the same as that used for the surface transect method, however, fines were lumped together into the category of Sand. The Q & D method was applied at each transect for comparison with the surface transect approach, Additionally, a subset of eleven preselected transects was used to correspond with the intensity of sampling generally used in IDFG habitat inventories.

Embeddedness

Surface sediment embeddedness was measured using the Cobble Embeddedness method [also known as the Hoop Method (Kelley and Dettman 1980, Burns 1984, Burns and Edwards 1985)], a modified embeddedness measurement, and an ocular estimate method (modified from Platts et al. 1983).

The hoop method involved measuring the longest diameter of a cobble size substrate particle perpendicular to the streambed, and the distance that this particle is embedded by fine material (figure 3). At least one hundred substrate particles of a



percent embeddedness for each rock $= \left(\frac{D_2}{D_1}\right) \times 100.$

Mean embeddedness = Sum of all individual percentages divided by number of rocks.

Figure 3. Measurement to determine particle embeddedness for cobble and random hoop techniques (from Burns and Edwards 1985).

specific size range are selected from a 60 cm wire hoop thrown in an area that meets specific criteria selected to approximate the requirements of overwintering juvenile chinook salmon:

Depth: 15 - 45 cm

Velocity (at 0.6 depth): 0.24 - 0.67 m/sec

Substrate Size: 4.5 - 30 cm

Once the 60 cm hoop sample was selected, free matrix (unembedded) particles were lifted from the hoop, measured for D (figure 3), and discarded. Matrix (embedded) particles were subsequently removed and measured using a plexiglass measuring frame. All particles within the designated size range were measured until the hoop contained only particles outside the criteria or ones exposed after the removal of embedded material, Subsequent hoops were sampled as needed to reach the 100 rock sample size, however all matrix particles were measured in the last hoop to avoid bias against the most heavily embedded particles (Burns and Edwards 1985).

We modified the Cobble Embeddedness technique to assess its usefulness as an indicator of overall stream embeddedness, A 30cm hoop sample point was selected from each transect by generating a random number between O-100 from a hand held calculator and using this number as a percent of stream width. We collected water depth, velocity at 0.6 depth, and ocular estimates of substrate composition, score, and embeddedness at this sample point before measuring the rocks. Minimum particle size for analysis was lowered to approximately 1 cm -- the minimum effective size that could be grasped and measured by a gloved hand.

A third measure of embeddedness used was a ocular estimate surface substrate embeddedness (Platts ocular method). Embeddedness of gravel and larger particles was visually estimated to the nearest 10 percent for each 0.3 meter section of stream width and determined for each microhabitat intercepted by the transect line. Using this method, substrate material less than 6.3mm is 100 percent embedded by definition,

We attempted to use photographic methods (Hamilton and Bergersen 1984, Chapman et al. 1986) to validate ocular methods in a subsample of transects at three sites. Poor photo quality caused by several factors (such as glare, depth, and poor lighting) prevented the use of these slides as a validation tool,

<u>Observer bias</u>

We tested observer bias in ocular surface sediment composition and embeddedness estimates by having four observers independently measure 10 transects over a 30 meter stream section.

Measurement bias and repeatability of the hoop embeddedness technique was determined from a reference sample of one hundred rocks collected from the sample areas. These test rocks were numbered and a hypothetical embeddedness line drawn to simulate stream embeddedness by fine material. Four observers measured the set of rocks twice, with at least a two day break between trials.

Subsurface Sediment Analysis

Within each study site, channel subsurface sediment was sampled using a 300cm diameter McNeil-type core tube. All material within the tube was collected to a depth of 30 cm where possible, to approximate the depth at which chinook egg pockets are found. We collected up to 20 cores per site from selected locations meeting habitat criteria suitable for spawning chinook salmon (Reiser and Bjornn 1980). Before coring, crews determined depth, velocity, substrate composition (ocular estimate) and substrate score at the core location.

Sediment samples were processed in the Sediment Laboratory at the Boise Forestry Sciences building for particle size analysis. In the lab, all samples were oven dried, reduced into representative subsamples (one-half sample volume) using a Gilson mechanical splitter, and shaken through a series of U.S.A Standard Testing Sieves with mesh openings measuring 75 mm, 25 mm, 9.5 mm. 6.3 mm. 4.75 mm, 0.85 mm, and 0.25 mm. The sediment retained and passing through sieves of each size class were weighed and converted to percentage of sample.

Several descriptors of spawning gravel have been developed for salmonids (eg. Fredle, Geometric Mean Diameter), which have been related to egg to emergent alevin survival. These descriptors were determined for pre- and post- spawning conditions found in chinook salmon natal areas.

A total of 23 salmon redd cores were collected during the study. The number of redds encountered within the study areas ranged from 0 at Bear Valley to 10 redds from the SFSR Poverty site. We processed these redd core samples in the same manner as samples taken from spawning areas prior to spawning.

Substrate score

Substrate score (Crouse et al. 1981, Shepard et al. 1983) was determined for each IDFG, hoop, and core sample point within each site. Substrate score is the sum of the ranks of dominant and subdominant sediment particle categories along with the substrate embeddedness category (table 2).

Table 2. Substrate size and embeddedness categories for determining substrate score (from Shepard et al. 1983).

Particle Size		Embeddedness	
Rank	Category	Rank	Category
1	Silt/Detritus	1	Completely
2	Sand <2.0mm	2	3/4
3	Large Fines (206.3mm)	3	1/2
4	Gravel (6.4-64mm)	4	1/4
5	Cobble (64.1-256mm)	5	Unembedded

Fish Populations

Fish numbers and size class were visually estimated by IDFG crews using the snorkeling technique (Petrosky and Holubetz 1986). Fish observed were tallied on hand-drawn stream habitat maps and density estimates calculated by habitat type from maps prepared from the habitat mapping data. The presence of non-game species were noted but not tallied.

RESULTS

Habitat Classification

Stream habitat composition was similar using the three techniques (table 3). Mapping generally yielded higher estimates of glide and less pocket water than transect or IDFG point estimates. These differences may be due to higher flows encountered during the mapping period, which took place 4-8 weeks before surface data collection.

The surface ocular techniques differed somewhat in identification of habitat. Surface transect estimates of habitat type consistently had higher distributions of pool and stream margin habitats (i.e. pocket and backwater) than IDFG estimates taken at the 1/4, 1/2, and 3/4 points (table 3). The IDFG method typically estimated higher amounts of glide habitat, more commonly found in the center of the channel due to channel flow dynamics. This conclusion is supported by the results of four independent observers (figure 4).

Table 3. Habitat composition (percentage) as determined by mapping, surface transect, and IDFG surface point estimates.

Habitat/Technique	BV	CR	LF	Site1 NR	PV	SM	SS
Pool							
Map	34.1	11.2	40.0	51.2		6.3	14.3
Transect	29.4	24.3	69.0	44.7	34.3	5.7	25.4
IDFG[2]	27.3	29.3	59.6	41.4	28.3	2.0	25.3
IDFG II	24.2	21.2	63.6	33.3	33.3	0	27.3
Riffle							
Map	6.4	33.5	16.5	32.0		54.1	43.5
Transect	4.1	19.8	11.2	29.8	16.1	45.6	36.6
IDFG	6.1	20.2	16.2	27.3	14.1	48.5	36.4
IDFG II	3.0	21.2	6.1	21.2	12.1	45.5	42.4
Glide							
Map	52.1	42.5	43.6	15.2		38.5	33.0
Transect	47.5	29.2	19.8	22.6	38.9	43.2	28.0
IDFG	55.6	30.3	24.2	29.3	57.6	45.5	37.4
IDFG II	57.6	39.4	30.3	45.5	54.5	54.5	30.3
Backwater							
Map	5.1	10.2	0.0	1.6		0.0	5.9
Transect	4.8	5.3	0.0	0.3	0.9	0.0	1.2
IDFG	5.1	0.0	0.0	0.0	0.0	0.0	0.0
IDFG II	3.0	0.0	0.0	0.0	0.0	0.0	0.0
Pocketwater							
Map	2.3	2.6	0.0	0.0		1.2	3.3
Transect	14.3	21.3	0.0	2.6	9.9	5.5	8.8
IDFG	6.1	20.2	0.0	2.0	0.0	0.0	1.0
IDFG II	12.1	21.2	0.0	0.0	0.0	0.0	0.0

[1]/ Site: BV = Bear Valley CR = Crooked River LF = Lower Frenchman Cr. NR = N.F. Red River PV = Poverty, SFSR SM = Salmon River, Main SS = Salmon River, Side.

[2]/ IDFG = All transects (99 points). IDFG II = Selected transects (33 points.

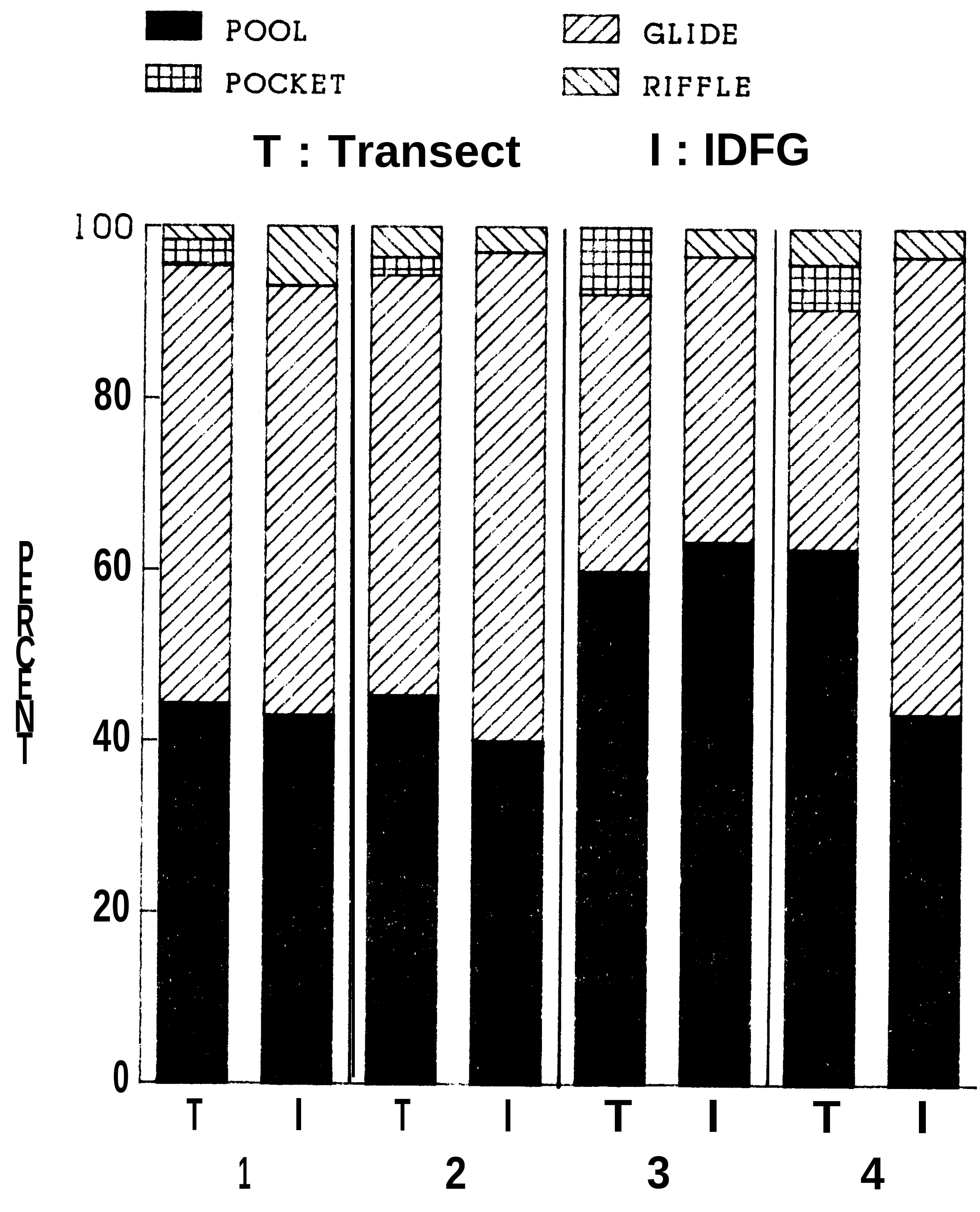


Figure 4. Differences in classification of aquatic habitat types by four observers (Bear Valley Creek).

Table 4. Surface sediment composition results by study site. IDFG is the Idaho Dept. Fish and Game point estimates on all transects, IDFG 11 is a subsample of 11 transects.

	Surface transects			IDFG			IDFG 11		
Habitat/Variable	**N**	**X**	**S.D.**	**N**	**X**	**S.D.**	**N**	**X**	**S.D.**
Bear Valley									
Stream Width	33	21.5	5.2	--	--	--	--	--	--
Score	--	--	--	99	9.13	2.28	33	8.91	2.24
Boulder %	33	5.9	6.6	99	5.8	17.9	33	5.2	15.2
Rubble %	33	13.9	12.4	99	12.2	15.3	33	10.2	13.7
Gravel %	33	30.1	19.8	99	26.8	26.9	33	28.0	24.9
Lg. Fines %	33	38.4	15.3	--	--	--	--	--	--
Sm. Fines %	33	11.8	8.6	--			--	--	--
Sand %	33	50.1	16.8	99	55.3	32.1	33	56.7	30.1
Imbeddedness %	33	76.3	11.0	99	71.7	21.7	33	73.0	20.7
Crooked River									
Stream Width	33	28.9	7.6	--	--	--	--	--	--
Score	--	--	--	99	12.03	2.15	33	12.09	2.49
Boulder %	33	1.7	3.8	99	2.0	9.2	33	4.6	15.0
Rubble %	33	46.7	15.8	99	48.4	22.7	33	49.6	23.5
Gravel %	33	38.9	14.9	99	33.2	19.8	33	30.0	18.4
Lg. Fines %	33	6.9	6.9	--	--	--	--	--	--
Sm. Fines %	33	5.8	7.6	--	--	--	--	--	--
Sand %	33	12.7	10.0	99	16.5	21.3	33	15.9	22.2
Imbeddedness %	33	43.8	14.5	99	52.4	24.0	33	38.8	25.8
Loner Frenchman Creek									
Stream Width	33	10.5	3.6	--	--	--	--	--	--
Score	--	--	--	99	8.95	2.36	33	8.5	2.5
Boulder %	33	0.0	0.0	99	0.0	0.0	33	0.0	0.0
Rubble %	33	0.0	0.0	99	0.0	0.0	33	0.0	0.0
Gravel %	33	59.2	26.1	99	63.9	34.8	33	60.5	36.4
Lg. Fines %	33	23.6	17.8		--	--	--	--	--
Sm. Fines %	33	17.1	16.7	--	--	--	--	--	--
Sand %	33	40.8	26.1	99	35.9	34.9	33	39.2	36.7
Imbeddedness %	33	62.0	20.0	99	58.5	26.6	33	63.6	24.1

Table 4, (Continuation)

Habitat/Variable	Surf ace Transects N	X	S.D.	IDFG N	X	S.D.	IDFG 11 N	X	S.D.
North Pork Red River									
Stream Width	33	10.1	3.2	--	--	--	--	--	--
Score	--	--	--	99	11.45	2.60	33	11.7	2.53
Boulder %	33	0.0	0.0	99	0.0	0.0	33	0.0	0.0
Rubble %	33	43.7	21.9	99	38.0	27.8	33	39.7	28.6
Gravel %	33	37.2	16.6	99	37.8	22.7	33	39.1	24.6
Lg. Fines %	33	10.9	13.1	--	--	--	--	--	--
Sm. Fines %	33	8.1	11.3	--	--	--	--	--	--
Sand %	33	19.1	18.9	99	24.4	28.0	33	21.2	27.0
Imbeddedness %	33	42.6	19.5	99	41.4	27.3	33	37.9	28.0
Poverty									
Stream Width	33	99.7	12.1	--	--	--	--	--	--
Score	--	--	--	99	11.33	2.08	33	11.39	1.92
Boulder %	33	0.5	1.0	99	0.5	5.0	33	1.5	8.7
Rubble %	33	41.9	9.7	99	38.2	28.8	33	34.7	22.4
Gravel %	33	49.7	11.3	99	43.0	22.5	33	42.7	21.1
Lg. Fines %	33	5.1	3.9	--	--	--	--	--	--
Sm. Fines %	33	2.7	2.4	--	--	--	--	--	--
Sand %	33	7.9	4.7	99	20.3	20.8	33	21.1	20.4
Imbeddedness %	33	46.3	11.0	99	43.0	22.0	33	44.2	21.4
Salmon River 3BRA Main Channel									
Stream Width	33	38.1	4.8	--	--	--	--	--	--
Score	--	--	--	99	13.09	1.52	33	13.30	1.34
Boulder %	33	0.0	0.0	99	0.0	0.0	33	0.0	0.0
Rubble %	33	74.8	10.8	99	84.4	22.0	33	88.4	23.4
Gravel %	33	22.9	8.7	99	29.0	18.8	33	27.8	15.8
Lg. Fines %	33	1.5	2.9	--	--	--	--	--	--
Sm. Fines %	33	0.8	2.1	--	--	--	--	--	--
Sand %	33	2.3	4.2	99	8.5	15.3	33	8.1	16.0
Imbeddedness %	33	20.3	9.7	99	22.5	18.1	33	19.7	17.0

Table 4, Continuation.

	Surface transects			m			IDFG 11		
Habitat/Variable	N	X	S.D.	N	X	S.D.	N	X	S.D.
Salmon River 3BRA- Side Channel									
Stream Width	33	32.1	8.3	--	--	--	--	--	--
Score	--	--	--	99	10.42	2.89	33	10.52	2.66
Boulder %	33	1.6	3.7	99	2.0	11.3	33	2.9	16.5
Rubble %	33	33.8	21.5	99	32.3	30.1	33	33.3	31.4
Gravel %	33	47.5	15.1	99	43.4	28.8	33	40.8	28.2
Lg. Fines %	33	5.2	6.7	--	--	--	--	--	--
Sm. Fines %	33	12.3	10.2	--	--	--	--	--	--
Sand %	33	17.4	12.2	99	22.3	33.0	33	23.0	30.5
Imbeddedness %	33	41.1	20.4	99	56.5	23.9	33	56.7	22.3
Salmon River 3BRA- Back									
Stream Width	7	19.0	6.98	--	--	--	(only 7 transects sampled)		
Score	--	--	--	21	6.0	2.59			
Boulder %	7	5.2	7.0	21	3.8	17.5			
Rubble %	7	3.2	8.0	21	8.1	24.2			
Gravel %	7	2.1	3.6	21	5.7	9.5			
Lg. Fines %	7	3.8	3.5	--	--	--			
Sm. Fines %	7	85.7	16.2	--	--	--			
Sand %	7	89.5	16.1	21	82.4	29.2			
Imbeddedness %	7	85.0	19.1	21	91.0	15.5			

Differences in Observer interpretation of habitat class was apparent but not consistent (figure 4). The four observers in our study split in classification of habitat by surface transect while 3 of 4 generally agreed on habitat classification. An independent observer bias test conducted by IDFG crews indicated considerable disagreement between observers, particularly in distinguishing between pool and glide (Charlie Petrosky-Personal Communication).

Surface Composition

Streambed surface substrate composition by site and habitat is presented in appendix 1. When disregarding habitat classification influence, reach attributes were consistent among monitoring techniques (Table 4). We found no significant differences between percentage sand estimates by technique for each reach (figure 5), except for the Poverty site (t= -3.42, P<.01). Two possible reasons for this are stream size, and differences due to incomplete sorting of the Poverty study site sediments. The surface transect approach assigns the sample segment to a dominant size class. Theoretically, significant amounts of another size category can be overlooked using this method if subdominant throughout the site. Also, since Poverty has the largest stream width of the 7 sites (33m), there may be a difference due to inadequate coverage by the 0.3 meter sample frame used in the IDFG technique. About three percent of the stream width along the transect line was sampled using a frame of this size, compared to a medium sized stream such as Bear Valley Creek (14%), or a small site such as the N.F. Red River (30%).

It was clear from our observer bias test, that three of the four observers had experience in stream sampling techniques (figure 6). Observer number 4 was a mid-season replacement on our field crew, with no biological or hydrological experience. The overall ANOVA was significant (P<.01) between observers but not between techniques for percentage sand estimates. A Student-Newman-Keuls (SNK) test, determined no significant difference between the three observers with training and field experience.

Embeddedness

Ocular embeddedness measurements by site ranged from 20 percent in the Salmon River main channel area to over 75 percent in the Bear Valley - Big Meadows site (see table 4). Within reaches, estimates of embeddedness by ocular techniques were not significantly different, and rankings of relative embeddedness by site were similar using the three methods (table 5). Coefficient of variation comparisons between techniques show a higher degree of variation in the IDFG techniques than surface transect, with little difference between the 11 and 33 transect IDFG sample

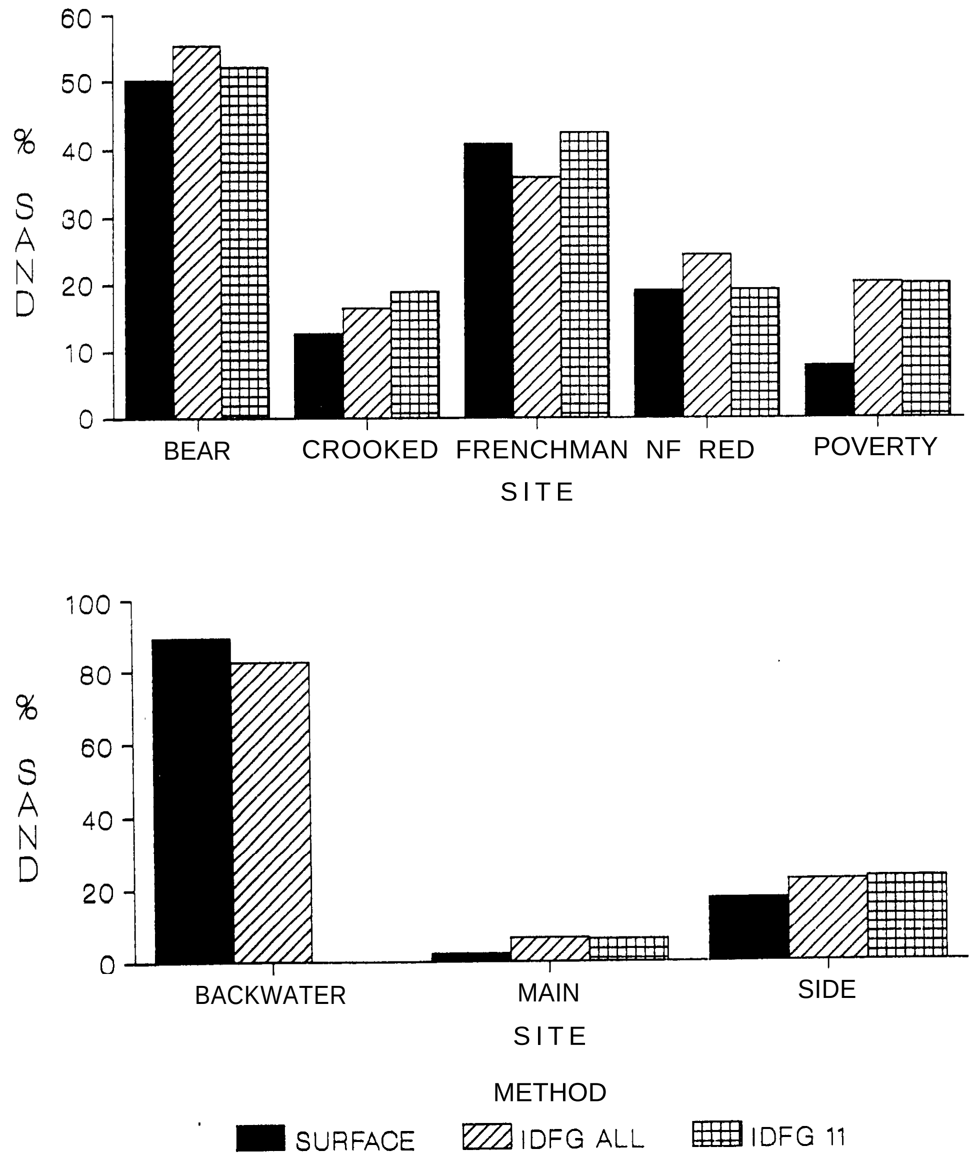


Figure 5. Ocular percentage sand determined by surface transect, IDFG (all transects), and a subsample of 11 transects. Bottom graph is of the three channels of the Salmon River 3BRA study area.

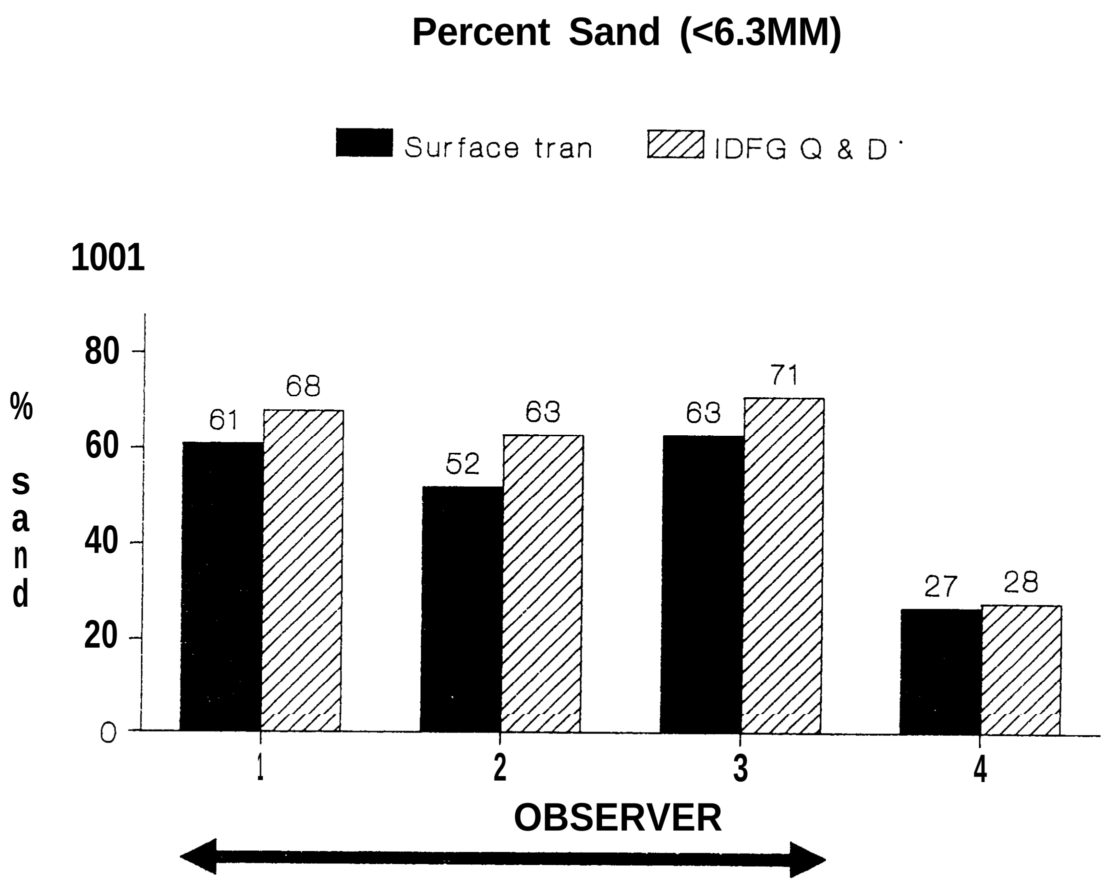


Figure 6. Ocular sand estimates by observer. Arrow indicates observers not significantly different.

size. Interestingly, there was no significant difference between estimates made by the same four observers (including the inexperienced observer 4) or between technique in our observer bias test (figure 7).

Using the 60 cm hoop/Cobble Embeddedness technique and specific depth, velocity and substrate criteria, embeddedness values for each site were considerably lower in four of the seven sites (figure 8). The number of rocks sampled ranged from 104 to 157, taken from one to three hoops per site. Rankings by site differed drastically from rankings based on ocular estimates of overall reach embeddedness (table 5). Lower Frenchman Creek is an extreme example of this disparity. This site had the second highest overall ocular embeddedness ranking (62%) and the second lowest cobble embeddedness level (approx. 16%). Apparently, while a sample of 100 rocks is sufficient to quantify embeddedness levels at a particular location, extrapolation spatially over a site is questionable. These differences were also apparent in randomly sampled 30 cm hoop measurements, however differences were not so pronounced.

A total of 9,406 rocks was measured in random 30 cm hoops covering seven sites (avg. 40 rocks per hoop at 231 transects). Though our random hoop embeddedness measurements Included particle sizes down to 1.0 cm, there were problems associated with locations where surface sand predominated. Hoop embeddedness measurements do not measure amounts of sand, resulting in lower embeddedness levels in situations where substantial amounts of surface sand occurs. Random sample locations would often fall in locations where surface sand exceeded five percent. Under these conditions, unembedded (free matrix) and partially embedded rocks are measured from the hoop while fully embedded rocks and sand particles are disregarded, leading to a lower mean embeddedness estimate than actual. For example, a hoop falling in a slower velocity area common in pool and glide/pool transition zones might have 20 measurable particles covering 30 percent of the sample area, with the other 70 percent of the area in sand. Under this scenario,+ measured particle embeddedness might be 27 percent, failing to consider the impact of excessive sand. To account for this, a weighted random hoop embeddedness value was derived by considering the estimated amount of surface sand at an embeddedness level of 100 percent (figure 9).

Results for random, weighted random, and ocular embeddedness estimates by habitat type is presented in table 6. Habitat type, through differences in depth and velocity, greatly influenced embeddedness levels.

Table 5. Mean embeddedness levels and relative site rankings (1 = highest lowest), with the percent coefficient of variation for each technique.

Variable	SITE						
	Bear Valley	Crooked River	French-man	N.F. Red	Poverty	Salmon River Main	Salmon River Side
Embeddedness							
Surface Transect							
Mean	76	45	62	43	46	20	41
Rank	1	4	2	5	3	7	6
C.V.	14.4	33.1	32.3	45.8	23.8	8.3	8.6
IDFG							
Mean	72	52	59	41	43	23	57
Rank	1	4	2	6	5	7	3
C.V.	30.3	45.8	45.5	65.9	51.2	80.4	42.3
IDFG 11							
Mean	73	39	64	38	44	20	57
Rank	1	5	2	6	4	7	3
C.V.	28.4	66.5	37.9	68.6	48.4	86.3	39.3
Hoop (Ocular)							
Mean	74	44	60	39	50	27	55
Rank	1	5	2	6	4	7	3
C.V.	25.8	58.6	48.7	65.0	38.8	66.9	54.3
Hoop Measured							
Mean	28	30	39	24	34	24	45
Rank	5	4	2	7	3	6	1
C.V.	89.2	56.7	81.9	64.0	44.0	55.7	66.2
Hoop Weighted							
Mean	60	41	60	41	47	30	55
Rank	1	6	2	5	4	7	3
C.V.	46.8	54.6	51.2	67.4	45.2	67.8	54.2
Cobble Emb.							
Mean	37	25	16	15	44	29	49
Rank	3	5	6	7	2	4	1
C.V.	99.7	113.3	145.6	167.8	68.2	95.2	58.7

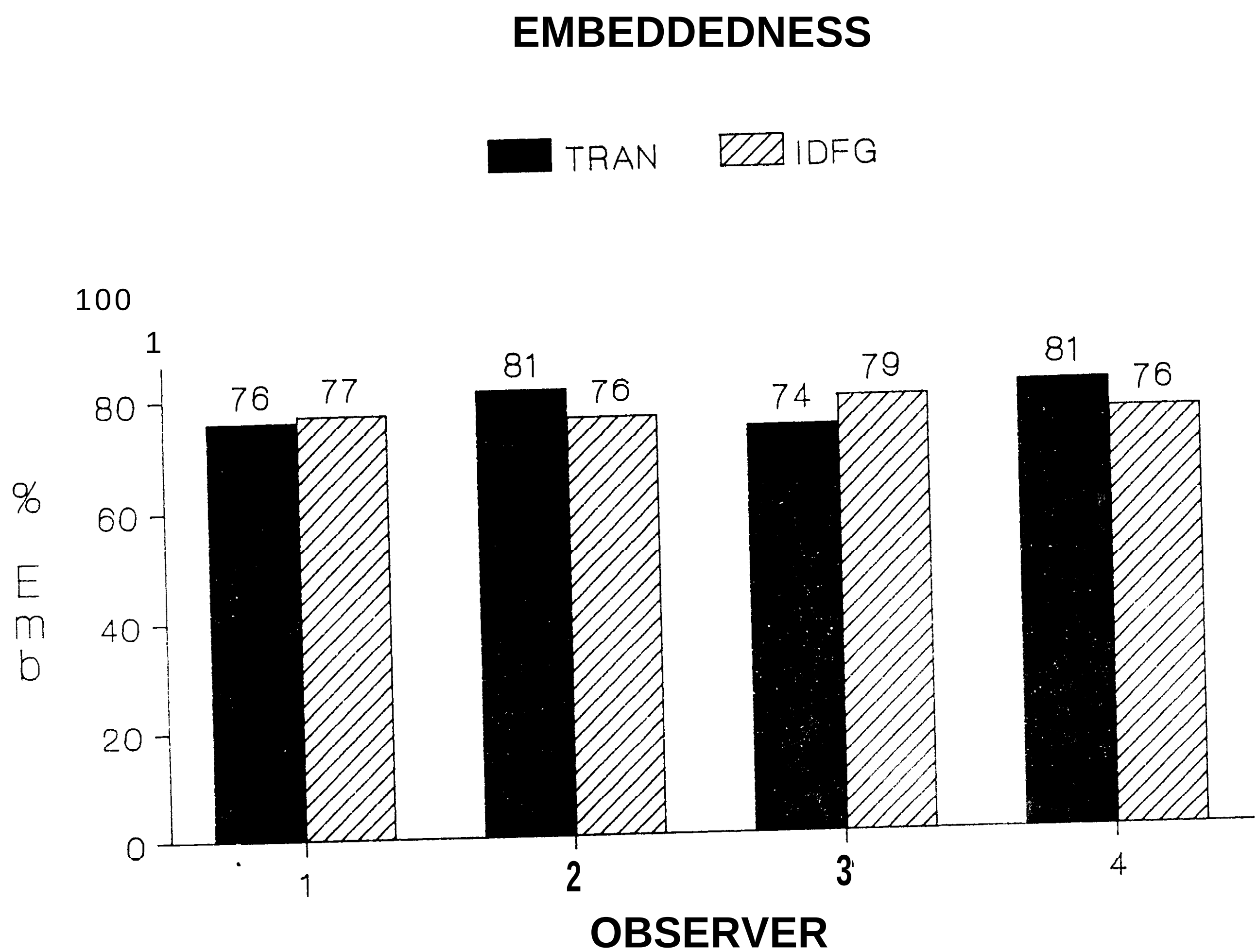


Figure 7. Ocular embeddedness percentage estimates by observer.

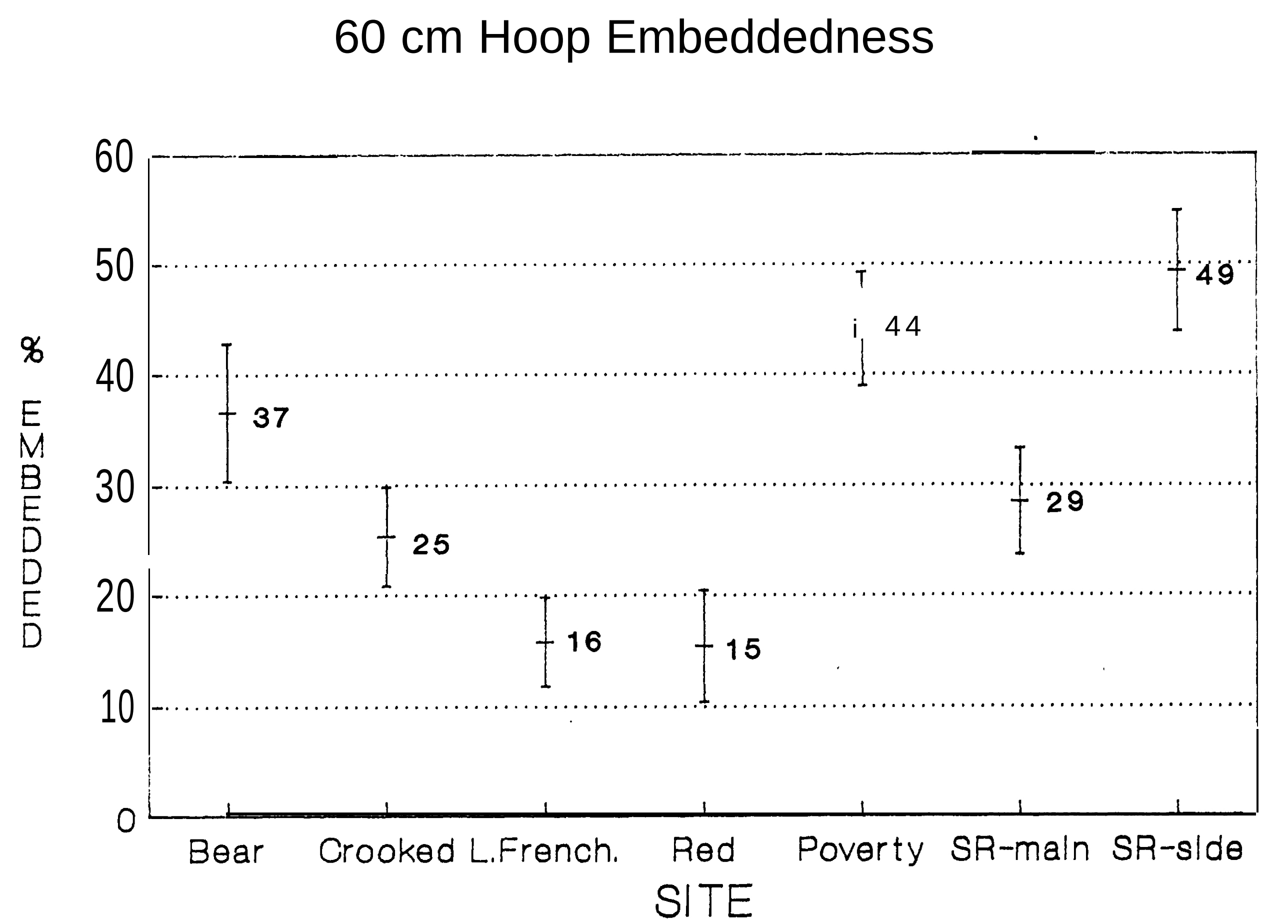
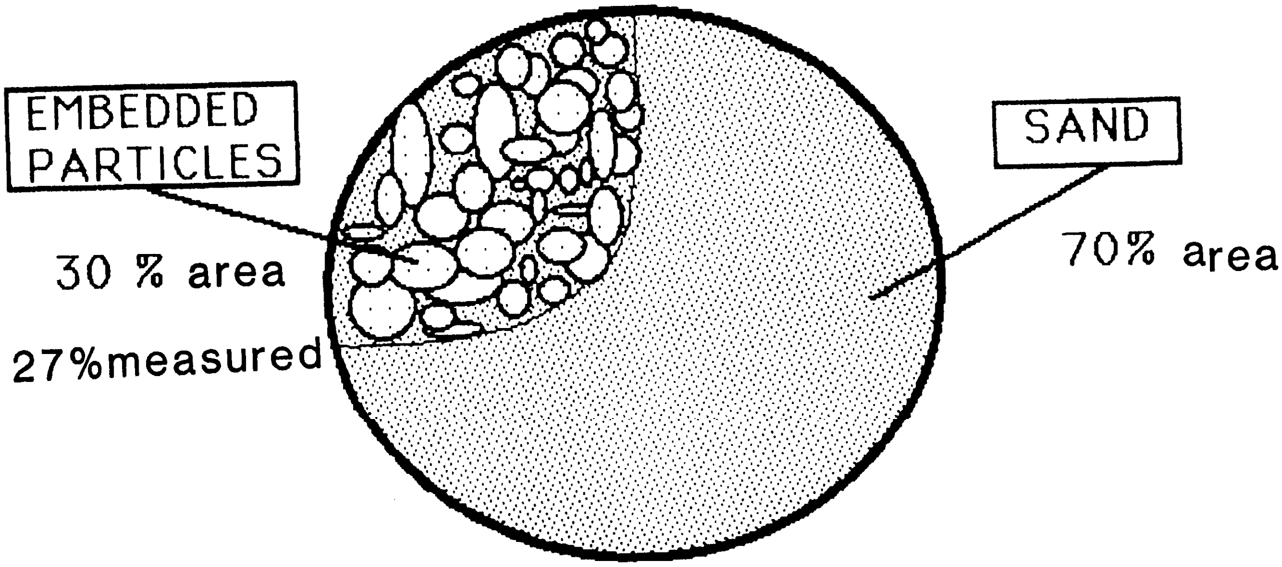


Figure 8. Mean cobble embeddedness, and 95% Confidence Interval for all sites.



Weighted Embeddedness = (Area Sand)*100
(1-Area Sand)*meas. embed.

Example: (.70*100)+(.30*27)m78%

Figure 9. Hypothetical random hoop sample in a low velocity habitat.

Table 6. Random hoop embeddedness results by habitat type, combined sites.

VARIABLE		HABITAT TYPE Pool n=72	Glide n=87	Pocket water n=l8	Riffle n=51	Back-water n=3
Stream depth (m)	Mean	0.27	0.27	0.08	0.21	0.10
	S.E.	0.02	0.01	0.01	0.02	0.07
Velocity (m/s)	Mean	0.12	0.36	0.06	0.59	0.00
	S.E.	0.02	0.02	0.02	0.04	0.00
Random hoop emb (%)	Mean	43.8	27.3	38.1	20.6	38.3
	S.E.	3.22	1.91	4.19	2.13	31.14
Weighted R. hoop (%)	Mean	62.4	43.1	50.5	30.7	95.8
	S.E.	3.21	2.68	4.50	3.00	4.25
Ocular Embedded (%)	Mean	64.4	48.4	56.7	27.5	96.7
	S.E.	2.89	2.86	4.57	2.76	3.33
Substrate Score	Mean	9.0	10.9	11.0	12.5	5.0
	S.E.	0.31	0.28	0.44	0.23	1.00
Free Matrix (%)	Mean	34.1	49.6	29.0	57.2	58.7
	S.E.	3.22	2.70	3.77	2.96	30.14

Both random and weighted random hoop embeddedness (measured) was significantly related to ocular embeddedness estimates made at the hoop sample location, however a stronger relationship existed for weighted random embeddedness (figure 10). The relationship was significant for all habitat types (figure 11-12). Random hoop embeddedness (weighted) was also significantly related to ocular embeddedness levels by site, whereas unweighted random hoop embeddedness was not (table 7).

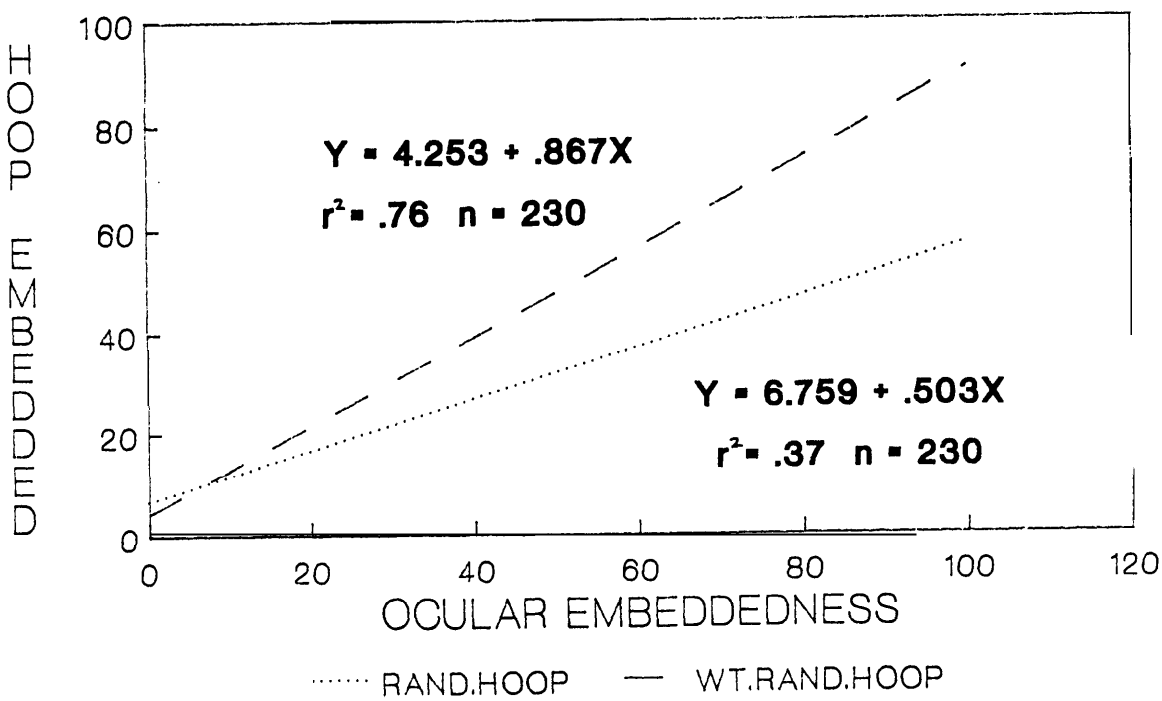
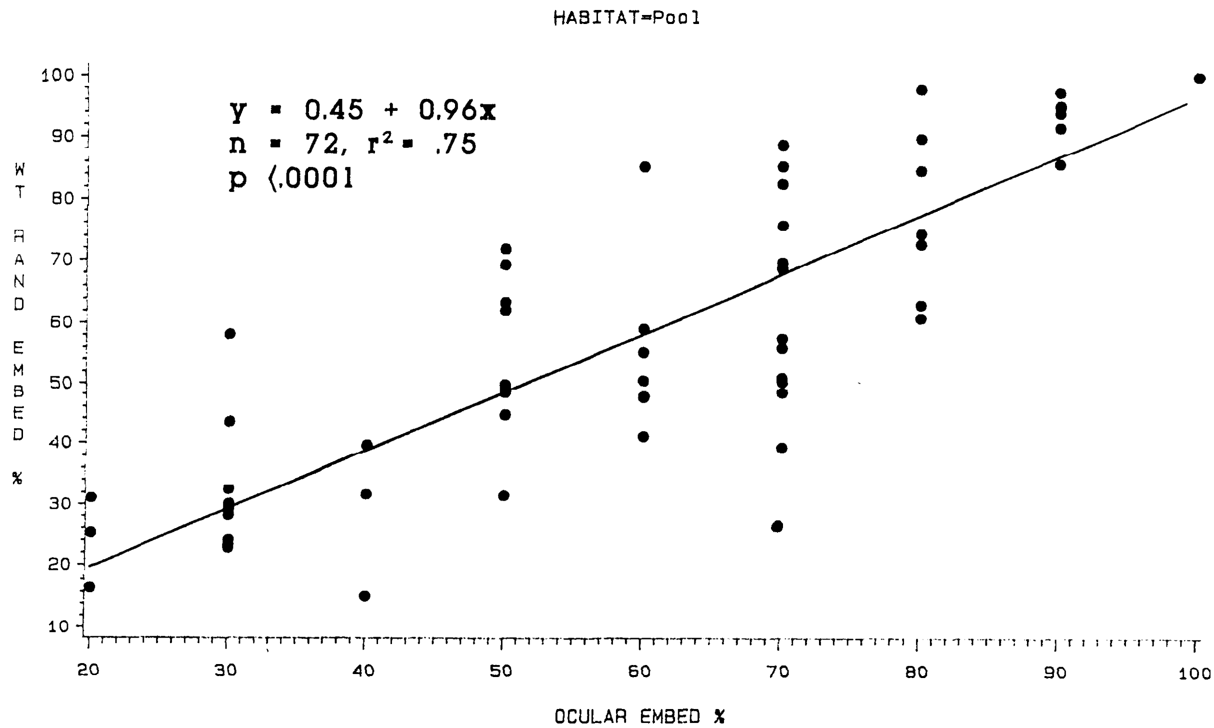


Figure 10. Relationship between ocular embeddedness and random hoop embeddedness.



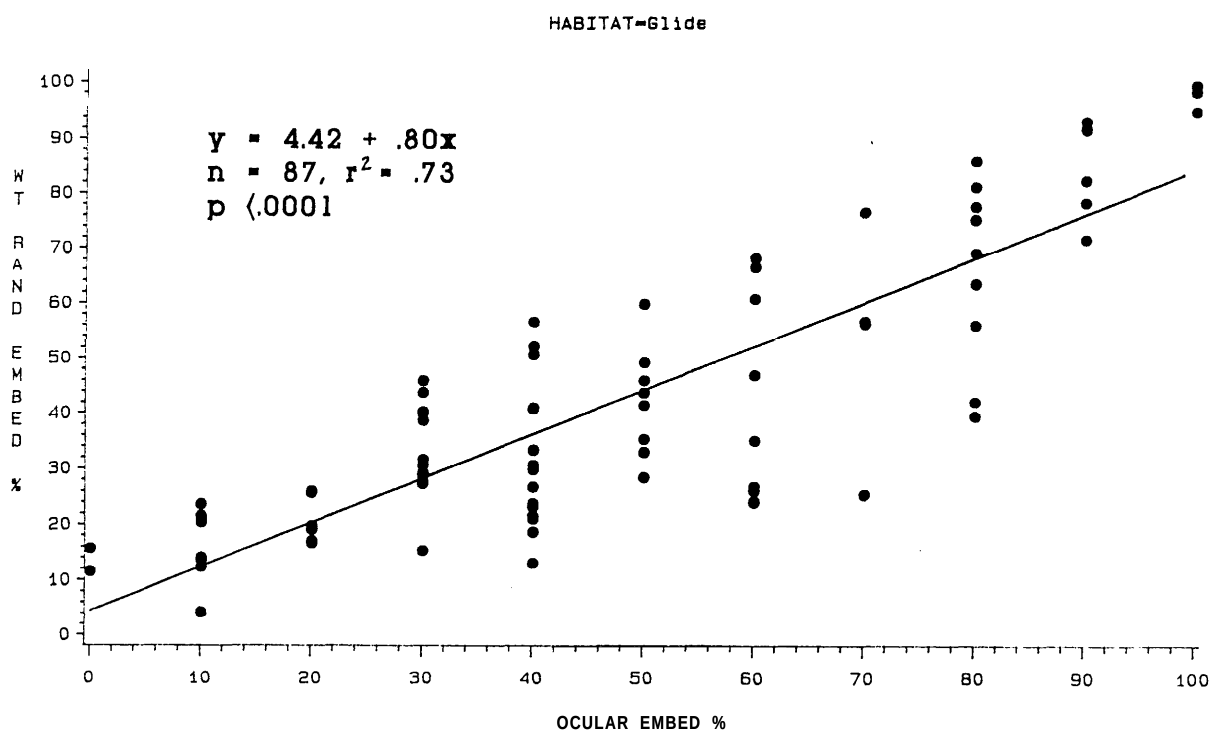


Figure 11. **Ocular and weighted random hoop embeddedness relationships for pool and glide habitats.**

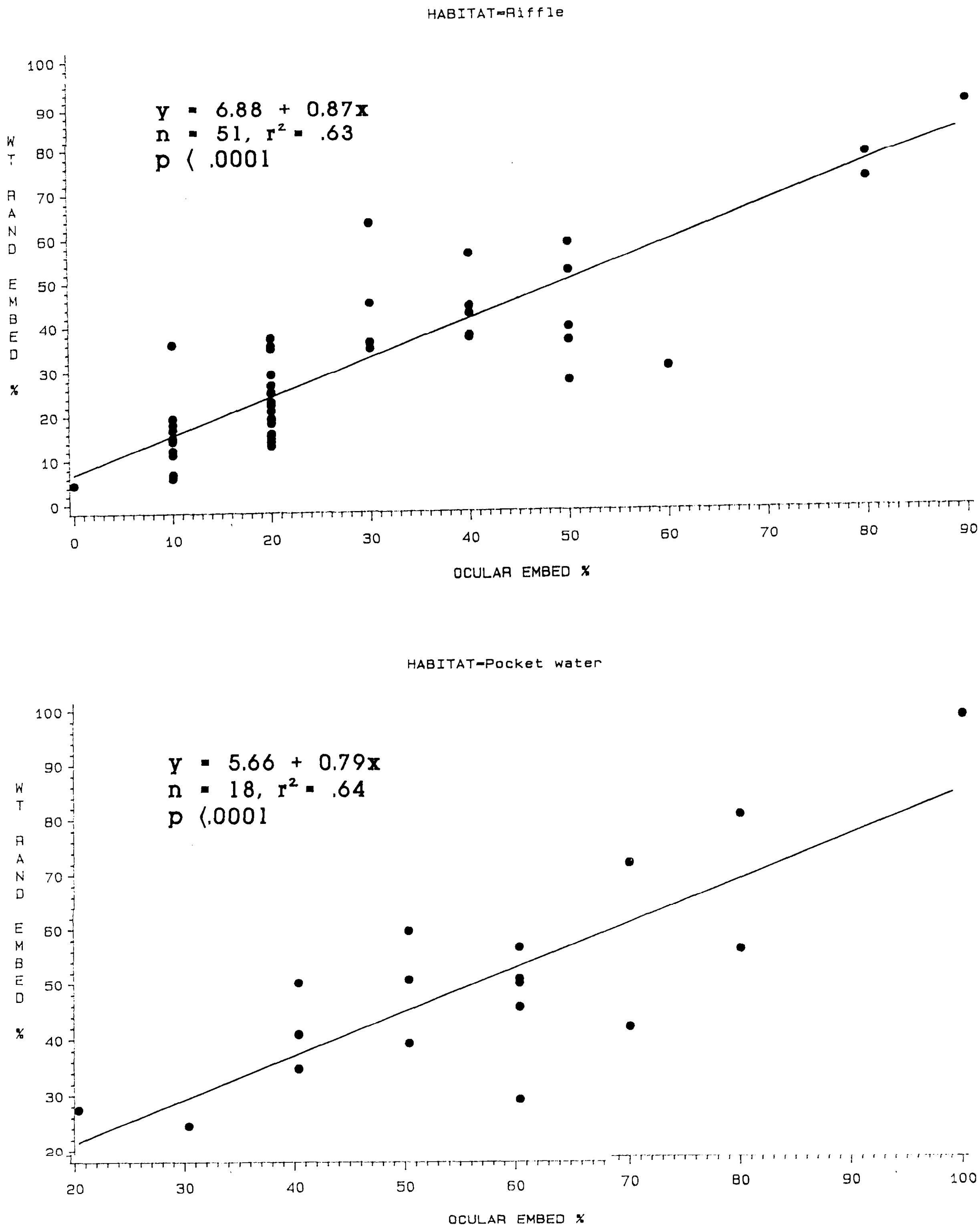


Figure 12. Ocular and weighted random hoop embeddedness relationships for riffle and pocket water.

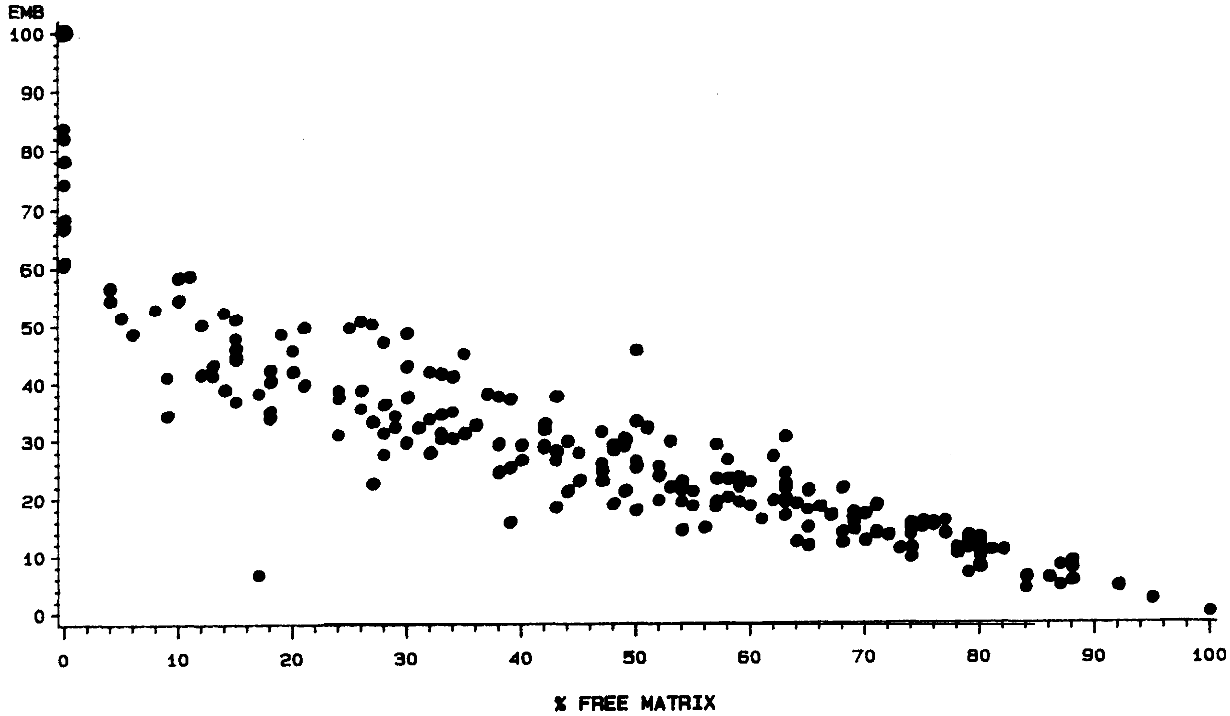
Table 7. Pearson correlation coefficient and significance levels for ocular and measured embeddedness means by site (n=7).

	Surface Transect Ocular	IDFG Ocular	Random Hoop Ocular	Random Measured Embed.	Random Weighted Embed.	Cobble Embed.
Surface Transect	1. 00[1]/ 0.002/					
IDFG Ocular	0.908 0.004	1.00 0.00				
Random Hoop	0.933 0.002	0.951 0.001	1.00 0.00			
Random Measured	0.195 0.675	0.455 0.305	0.451 0.309	1.00 0.00		
Random Weighted	0.857 0.013	0.909 0.004	0.951 0.001	0.640 0.122	1.00 0.00	
Cobble Embedded	-0.029 0.950	0.174 0.708	0.283 0.538	0.461 0.298	0.218 0.639	1.00 0.00

1/ - Correlation Coefficient
2/ - Prob > |R| under Ho: Rho=0

Free Matrix (percentage of unembedded particles in sample) was significantly correlated to both cobble embeddedness (r = -0.90, n=7, p<0.01) and random (unweighted) embeddedness (r = -0.86, n=231, p<0.01). Though also related to weighted random embeddedness the relationship was weaker but significant (r = -0.58, n=231, p<0.01). Figure 13 illustrates the differences in the two relationships. The larger amount of scatter exhibited by the weighted hoop plot is due to influence of sand on the embeddedness level, a factor not considered in free matrix percentage.

In our tests of measurement error between observers, we found no significant differences between observers (p>F = 0.68), overall measurements (p>F = 0.37), or repeated trials by observers (p>F =0.53).



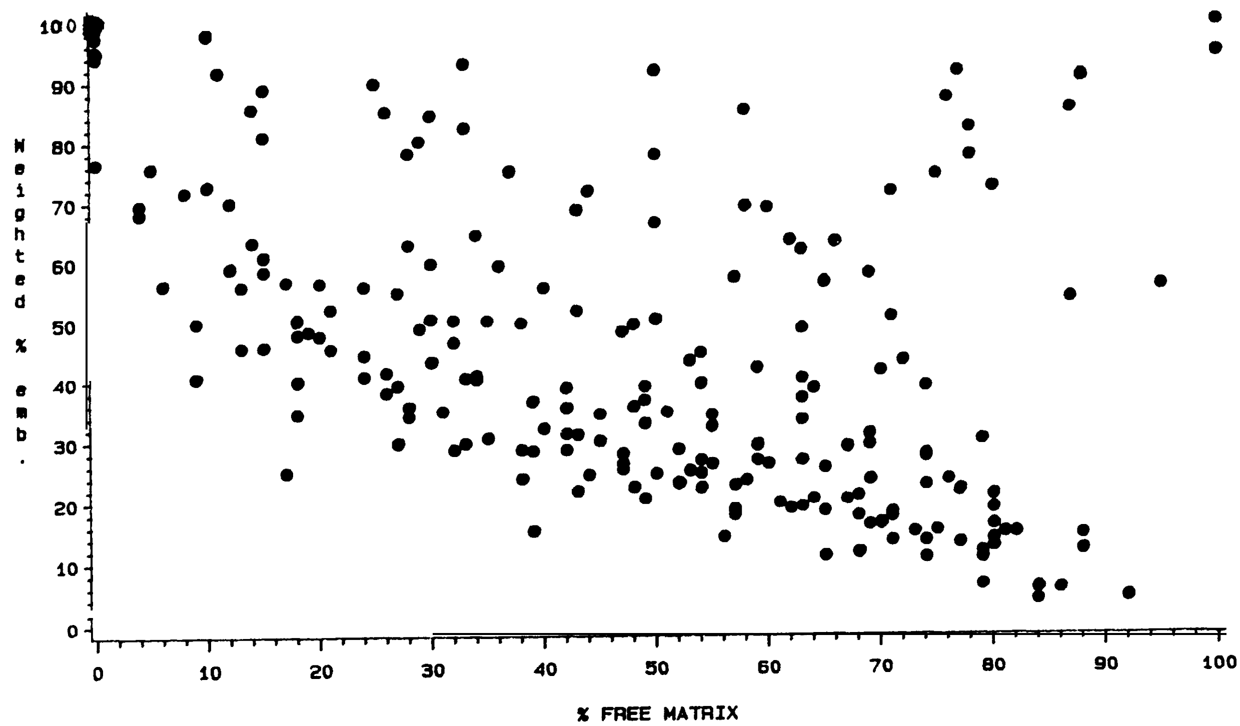


Figure 13. Free matrix percentage versus random hoop (top), and weighted random hoop (bottom) embeddedness.

Subsurface Sediment

Over 2.8 metric tons of core sample material were dry sieved for particle analysis from a total of over 5.7 metric tons sampled. We collected a total of 99 cores from the six areas before the onset of chinook spawning activity. Unfortunately, low water conditions and a poor spawner escapement to the sites severely limited the number of redds available for post-spawning core samples. Highest numbers of redds and redd pocket cores occurred in the SFSR Poverty site (n=10), while the Bear Valley site and vicinity contained no redds or adult chinook salmon. A total of 23 redds was sampled.

The cleansing effect that redd construction causes is evident in both percentage fine material and geometric mean particle size. Redd construction decreased the percentage of fine sediment (< 6.3mm) from 3.7% to 13.6% percent (in actual percent measurements) at each site (figure 14). This elimination of fine material effectively increased the geometric mean particle size and Fredle Index at each study area (figure 15). Figure 16 illustrates these differences through a comparison of the cumulative particle size distribution within the Poverty site, where the most spawning activity took place. These changes are consistent with the findings reported in Everest et al. 1987,

Subsurface core data and surface ocular data relationships were generally weak, and differed between pre-spawning vs. post-spawning comparisons (table 8). In samples taken from undisturbed areas prior to spawning, surface sand was significantly related ($p<0.05$) only to subsurface sediment less than 4.7mm. Ocular embeddedness estimates were significantly related to material less 9.5, 6.3, and 4.7mm at the $p<0.05$ level, while substrate score was the most significantly related surface ocular measurement ($p<0.01$). All correlations between surface and subsurface measurements had r values below 0.29 (absolute value). In contrast, all post-spawning redd core and surface ocular relationships were insignificant, with the exception of percentage surface sand and subsurface material less than 0.85mm. All within-type (i.e. surf ace vs surface and core vs core variables) comparisons were highly correlated and significant ($p<0.01$).

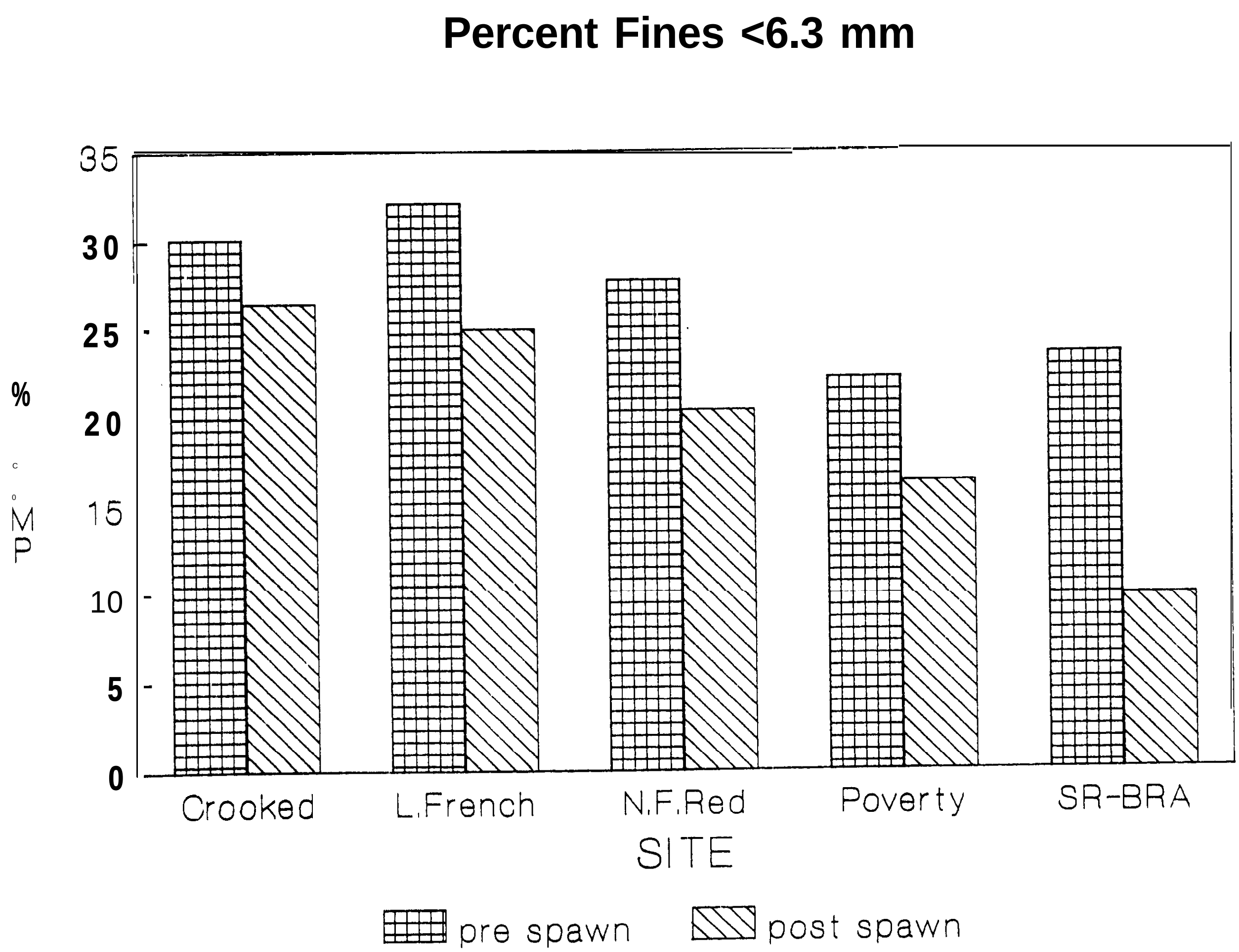


Figure 14. Fine sediment levels from core samples taken before and after chinook salmon spawning activity.

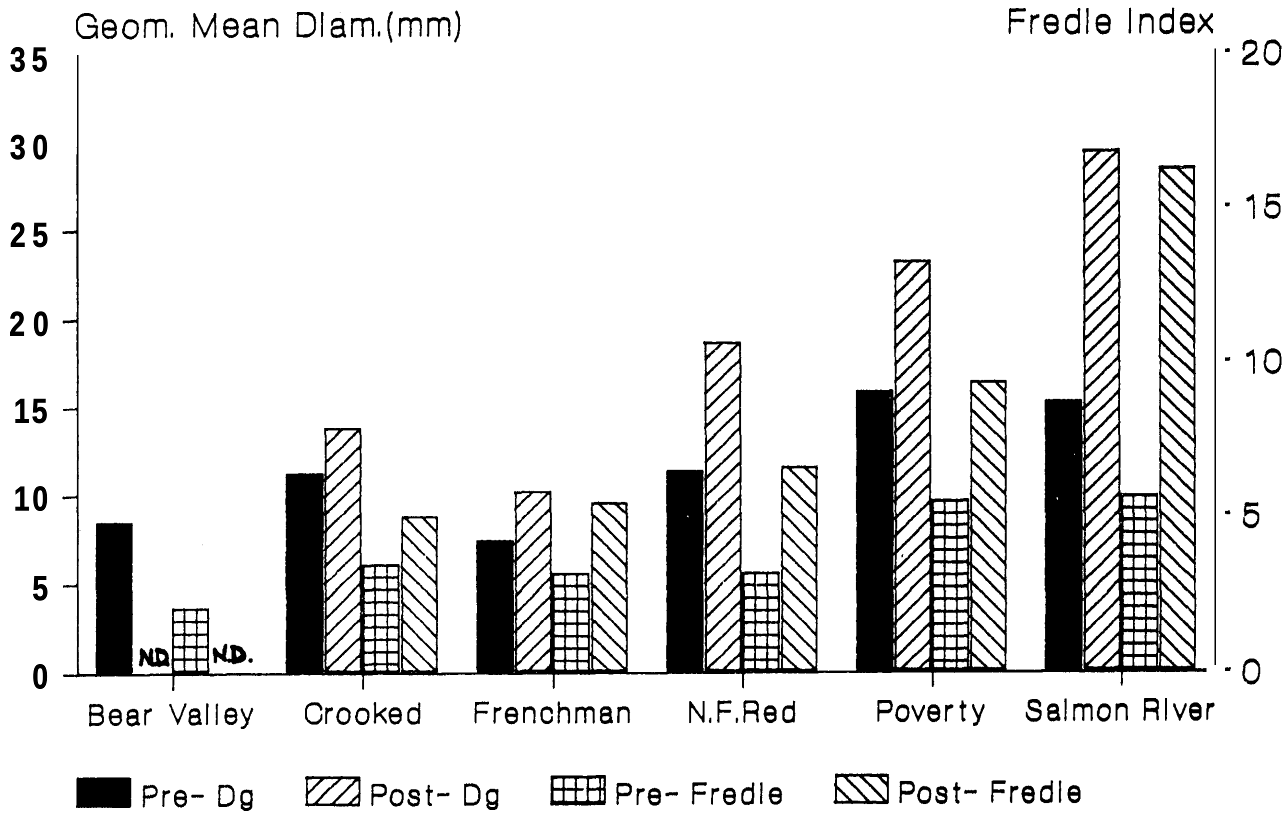


Figure 15. Geometric mean particle size and Fredle index from core samples taken before and after chinook salmon spawning activity.

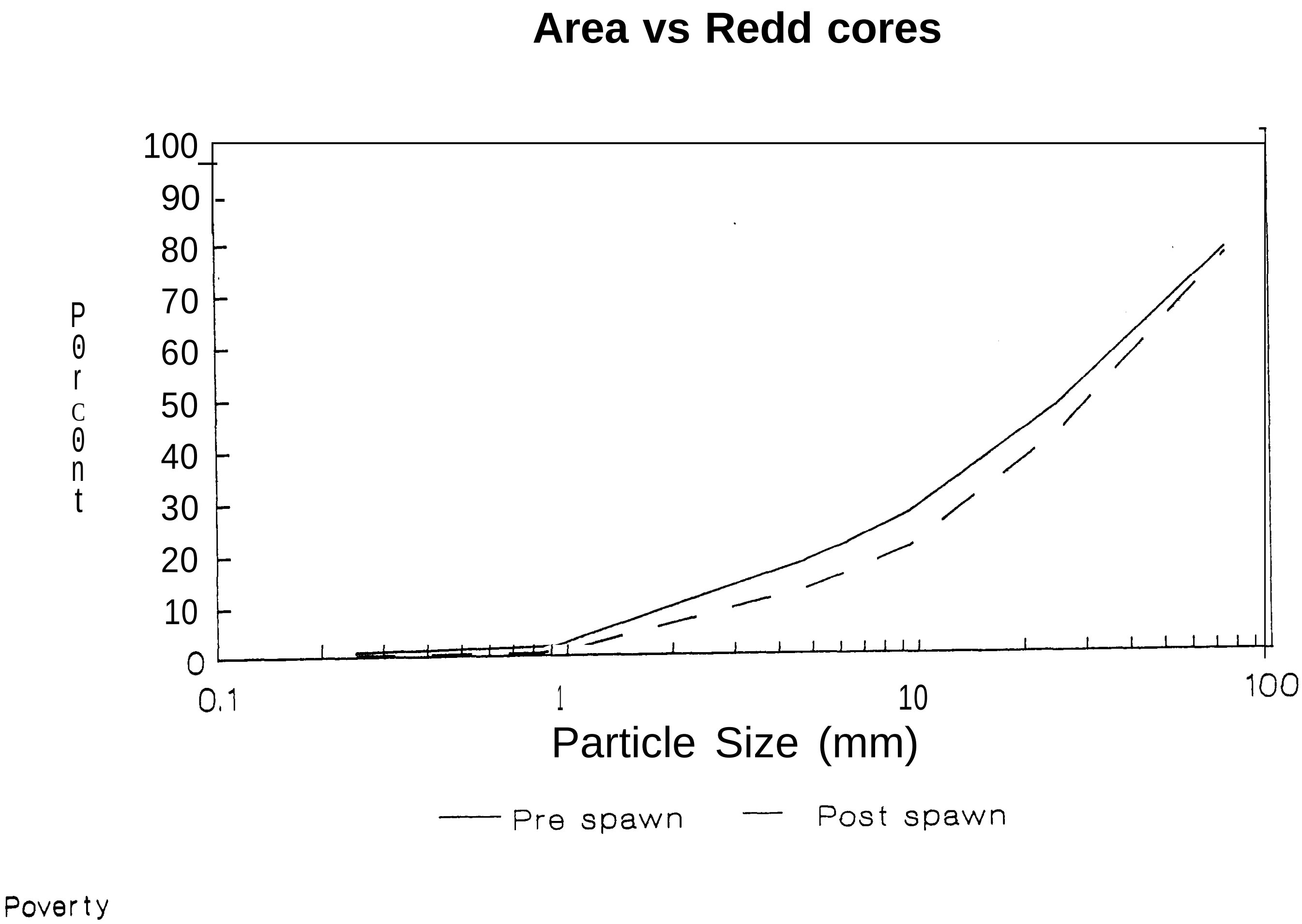


Figure 16. Cumulative distribution of particle size from core samples taken before and after chinook salmon spawning activity.

Table 8. Correlation matrix for ocular surface and subsurface measurements - all sites.

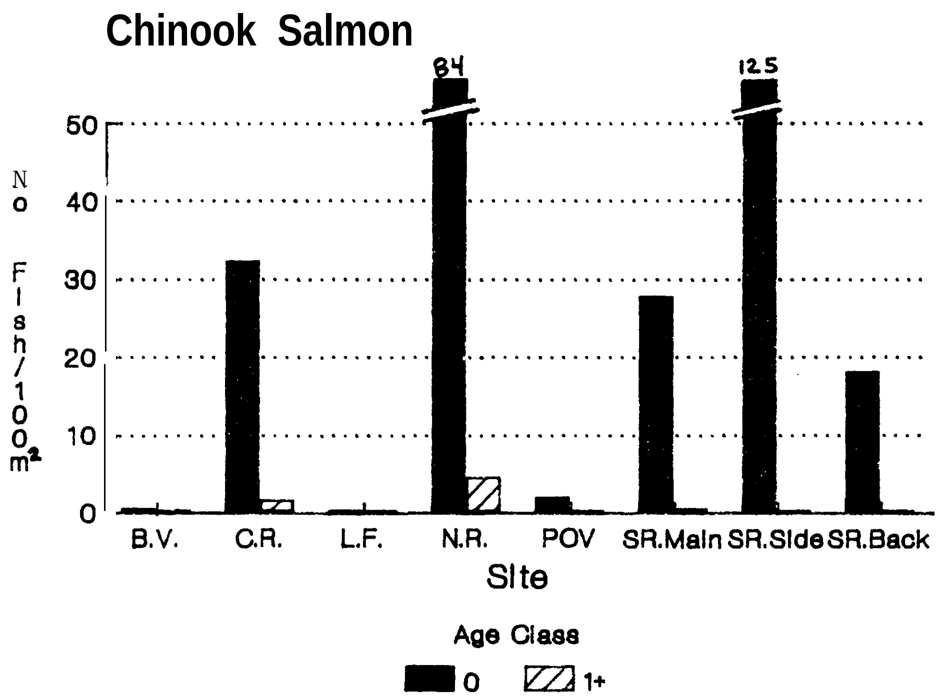
	Ocular			Subsurface			
	% Sand	% Emb	Score	<LT9.5	<6.3	<4.7	<.85
Pre Spawning (n=99)							
Ocular							
% Sand	1.0						
% Embedded	.56**	1.0					
Score	-.59**	-.74**	1.0				
Subsurface							
%LT 9.5mm	.13	.22*	-.27**	1.0			
%LT 6.3mm	.18	.25*	-.29**	.97**	1.0		
%LT 4.7mm	.21*	.24*	-.28**	.94**	.99**	1.0	
%LT .85mm	.14	.05	-.28**	.31**	.33**	.34**	1.0
Post Spawning (n=23)							
Ocular							
% Sand	1.0						
% Embedded	.90**	1.0					
Score	-.86**	-.92**	1.0				
Subsurface							
%LT 9.5mm	.21	.28	0.38	1.0			
%LT 6.3mm	.17	.24	-.31	.98**	1.0		
%LT 4.7mm	.14	.22	0.28	.96**	.99**	1.0	
%LT .85mm	.44*	.39	0.36	.61**	.63**	.63**	1.0

*/ Significant at $p<0.05$
**/ Significant at $p<0.01$

Fish Populations

Several factors precluded the development of specific models that relate sediment conditions to summer fish rearing density. The small number of sample sites, variations in seeding levels among sites, differences in habitat classification among and between crews (agencies), and time lapse between mapping, monitoring and snorkeling all confound the statistical interpretation of sediment / fish relationships. Efforts of this sort will require future studies incorporating a large number of randomly chosen sites, covering a wide range of habitat types and fully seeded areas (or areas adjusted using fish collected off-site).

Figure 17 illustrates the disparity in fish densities among sites. Chinook and rainbow/steelhead numbers were highly variable, ranging from 0 to 124 fish per 100 square meters. We could find no significant correlations between surface sediment conditions and fish density at the site level.



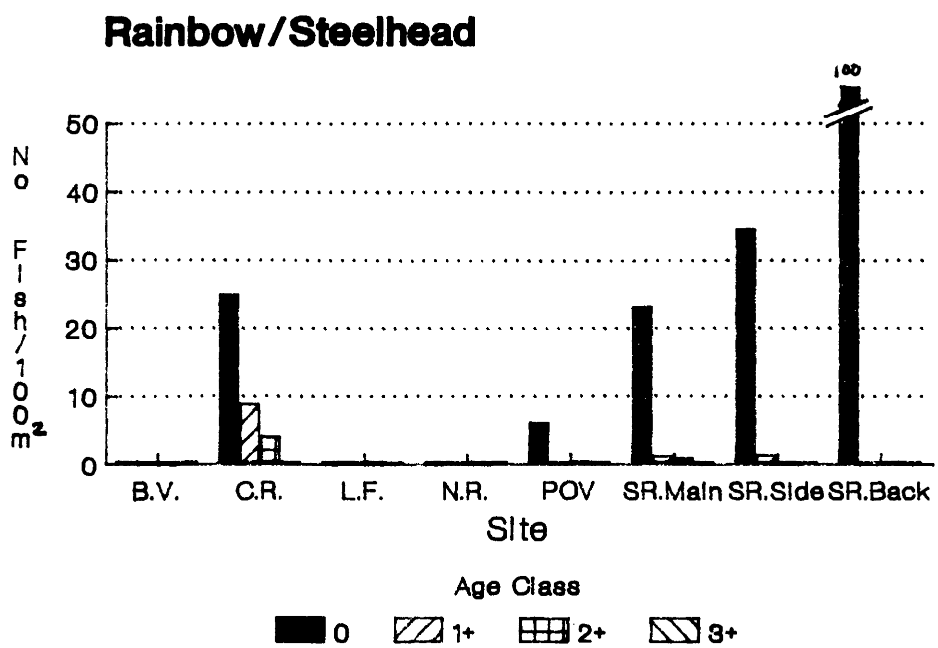


Figure 17. Chinook salmon and rainbow/steelhead trout Densities (number per 100 square meters) by site.

DISCUSSION

The results illustrate the need for careful deliberation in choosing an appropriate technique or techniques for evaluating streambed sediment conditions. For general inventories, a well planned sampling design using ocular surf ace monitoring techniques (first stage) combined with more intensive methods such as measured embeddedness at a subsample of locations (second stage) I could provide estimates of increased precision at a relatively low cost. For intensive evaluations of pre- and post-project conditions, more intensive techniques applied to an adequate sample size would be required. The methods studied varied in labor intensity, costs, equipment needed, and time required, but had a common denominator in the need for training and "practice runs" before application.

Surface ocular methods are the quickest and least costly to implement, and lend themselves well to general surveys or extensive inventory efforts. Observer and sampling bias, however, may be significant if trained, experienced field personnel are unavailable. These techniques have been successfully used in time trend studies where the same observer has estimated conditions over time (Platts et al. in prep.). Both surface transect and IDFG techniques adequately measured conditions within a stream reach, however, adjustments for targeting specific habitat types (e.g. stream margins, debris or backwater pools) or large streams are necessary. Substrate score provided the quickest and easiest assessment of surface condition, and should be included as a variable when using either approach.

The results show that the measured cobble embeddedness technique can be modified to determine reach and specific habitat conditions, and is related to surface parameters such as ocular embeddedness and substrate score. Random embeddedness hoops can be weighted to reflect the surface conditions found in habitat types not currently sampled. Hoop embeddedness techniques were intermediate between surface and subsurface techniques in cost and time required. A surrogate embeddedness measurement, Free Matrix Percentage (Burns 1984, Burns and Edwards 1985), shows promise as a quicker (and less costly) approach to monitoring embeddedness conditions.

Subsurface core samples proved to be the most expensive and time consuming technique evaluated. Samples typically weighed over 50 kilograms, approaching the physical limits of field equipment and crew. The ability of the female chinook salmon to alter the quality and composition of streambottom substrate was apparent at all locations where they occurred. This supports the contentions of Chapman and McCleod (1987), that extrapolations of relationships determined from non redd areas, and using laboratory controlled substrate should be avoided, unless adequate correction factors can be developed on site. Given the costs, equipment and processing requirements of this technique, core sampling of subsurface material should be undertaken only when spawning gravel condition has been deemed to be limiting fish populations.

Ideally, substrate evaluations should be carried out by a well financed, adequately trained and supervised crew using the techniques dictated by the needs of the management agency. In reality, evaluations are often undertaken without regard to information requirements, adequate funding, or availability of expertise. We hope that this document will result in careful consideration of these requirements before selecting a technique,

ACKNOWLEDGEMENTS

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REFERENCES

Adams, J. N.; Beschta, R. L. 1980. Gravel bed composition in Oregon coastal streams. Canadian Journal of Fishery and Aquatic Sciences. 37: 1514-1521.

Bauer, S.B. 1985. Evaluation of nonpoint source impacts on water quality from forest practices in Idaho: relation to water quality standards. In: Perspective on nonpoint source pollution: Proceedings of a national conference; 1985 May 19-22; Kansas City, MO. Washington, DC: U.S. Environmental Protection Agency: 455-458

Bisson, P.A.; Nielsen, J.L.; Palmason, R.A.; Grove, L.E. 1981. A System of naming habitat types in small streams, with examples of habitat utilization by salmonids during low streamflow. In: N. Armantrout, ed. Symposium on Acquisition and Utilization of Aquatic Habitat Inventory Information. Portland, Oregon, October 28-30, 1981.

Brown, G.W. 1985. Controlling nonpoint source pollution from silvicultural operations: what we know and don't know. In: Perspectives on nonpoint source pollution: Proceedings of a national conference; 1985 May 19-22; Kansas City, MO. EPA 440/5-85-001. Washington, DC: U.S. Environmental Protection Agency: 332-333.

Burns, D. C. 1984. An inventory of embeddedness of salmonid habitat in the South Fork Salmon River drainage, Idaho, Unpublished paper on file at: U.S. Department of Agriculture, Forest Service, Payette National Forest, McCall, ID

Burns, D.C.; Edwards, R.E. 1985. Embeddedness of salmonid habitat of selected streams on the Payette National Forest. Unpublished paper, Payette National Forest, McCall, ID.

Chapman, D.W.; McCleod, K.P. 1987, Development of Criteria for fine sediment in the Northern Rockies Ecoregion. Final Report. EPA 910/9-87-162. U.S. Environmental Protection Agency, Region 10.

Chapman, D.W.; Weitkamp, D.E.: Welsh, T.L.; Dell M.B,; Shadt T.H. 1986. Effects of river flow on the distribution of chinook salmon redds. Transactions of the American Fisheries Society 115(4):537-547.

Crouse, M.R.; Callahan C.A.: Maleug K.W.; Dominguez S.E. 1981, Effects of fine sediments on growth of juvenile coho salmon in laboratory streams. Transactions of the American Fisheries Society 110:281-286.

Everest, F.H.; Beschta, R.L.; Scrivener, J.C.; Koski, K.V.;

Sedell, J.R.; Cederholm, C.J. 1987. Fine sediment and salmonid production: a paradox. In: Streamside management: forestry and fishery interactions: Proceedings of a symposium; 1986 February 12-14; Seattle, WA. Seattle, WA: University of Washington, College of Forest Resources, Institute of Forest Resources: 98-142.

Hamilton, K.: Bergesen, E.P. 1984. Methods to estimate aquatic habitat variables. Unpublished Report. Colorado Cooperative Fishery Research Unit, Colorado State University, Ft. Collins, CO.

Harrison, C.W. 1923. Planting eyed salmon and trout eggs. Transactions of the American Fisheries Society. 52: 191-200.

Iwamoto, R.N.: Salo, E.O.; Madej, M.A.; McComas, R.L. 1978. Sediment and water quality: a review of the literature including a suggested approach for water quality criteria. EPA 910/g-78-048. Seattle, WA: U.S. Environmental Protection Agency, Region X. 151 p.

Kelley, D. W.; Dettman, D. H. 1980. Relationships between streamflow, rearing habitat, substrate conditions, and juvenile steelhead populations in Lagunitas Creek, Marin County, 1979. Unpublished paper on fine at: Marin County Water District.

Lotspeich, F.D.; Everest, F.H. 1981. A new method for reporting and interpreting textural composition of spawning gravel. Res. Note PNW-369. U.S. Department of Agriculture, Forest Service,Pacific Northwest Forest and Range Experiment Station.

McNeil, W.J.; W.H. Ahnell. 1964. Success of pink salmon spawning relative to size of spawning bed materials. U.S. Fish and Wildlife Service, Special Scientific Report - Fisheries 469. 15 p.

Petrosky, C. E.; Holubetz, T. B. 1986. Idaho habitat evaluation for off-site mitigation record, annual report 1985. USDOE Bonneville Power Administration Contract No. DE-AI79-84BP13381, Project No. 83-7.

Platts, W.S.; Armour, C.; and 11 others. 1987. Methods for evaluating riparian habitats with applications to management. Gen. Tech. Rep. INT-221. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Research Station. 177 p.

Platts, W. S.; Megahan, W. F.; Minshall, G. W. 1983. Methods for evaluating stream, riparian, and biotic conditions. Gen. Tech. Rep. INT-138. Ogden, UT: U. S. Department of Agriculture, Intermountain Forest and Range Experiment Station.

Platts, W.S.; Shirazi, M.A.; Lewis, D.H. 1979. Sediment particle sizes used by salmon for spawning with methods for evaluation.

U.S. Environmental Protection Agency. EPA-600/3-79-043.

Platts, W. S.; Torquemada, R.J.; McHenry, M.L. Salmon spawning area response to large increases in sediment delivery, South Fork Salmon River, Idaho. Proposed for publication in Transactions of the American Fisheries Society. (in preparation).

Reiser, D.W.; Bjornn, T.C. 1979. Influence of forest and rangeland management on anadromous fish habitat in Western North America: habitat requirements of anadromous salmonids. Gen. Tech. Rep. PNW-96. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station.

Rosgen, D.L. 1985. A Stream Classification system. North American Riparian Conference. Tucson, Arizona, April 16-18, 1985.

Shepard, B.B.; Leathe, S.A.; Weaver, T.M.; Enk, M.D. 1984. Monitoring levels of fine sediment within tributaries to Flathead Lake and impacts of fine sediment on bull trout recruitment. In: Wild Trout III Symposium. Yellowstone National Park, WY: 24-25 September 1984.

APPENDIX I. SURFACE OCULAR RESULTS BY HABITAT AND SITE USING TRANSECT AND IDFG METHODS

BEAR VALLEY CREEK

Habitat/Variable	.rface Transects N	X	S.D.	IDFG N	X	S.D.	IDFG II N	X	S.D.
Pool:									
Score	--	--	--	27	8.85	2.33	8	8.13	1.55
Boulder %	20	15.8	29.4	27	6.3	21.2	8	0.0	0.0
Rubble%	20	16.0	20.2	27	8.5	11.6	8	10.0	16.0
Gravel %	20	18.9	24.5	27	24.4	31.5	8	26.9	30.6
Lg. Fines %	20	36.5	27.1	--	--	--	--	--	--
Sm. Fines %	20	12.8	11.5	--	--	--	--	--	--
Sand %	20	49.3	32.3	27	60.7	35.9	8	63.1	35.0
Imbeddedness %	20	76.2	16.6	27	75.9	23.4	8	01.3	18.9
Riffle:									
Score	--	--	--	6	8.83	2.23	1	8.0	0.0
Boulder %	5	20.0	44.7	6	0.0	0.0	1	0.0	0.0
Rubble%	5	23.3	43.5	6	5.8	2.0	1	5.0	0.0
Gravel %	5	47.3	43.4	6	45.8	32.8	1	55.0	0.0
Lg. Fines %	5	9.4	13.3	--	--	--	--	--	--
Sm. Fines %	5	0.0	0.0	--	--	--	--	--	--
Sand %	5	9.4	13.3	6	48.3	33.4	1	40.0	0.0
Imbeddedness %	5	53.4	12.5	6	60.0	26.1	1	70.0	0.0
Glide:									
Score	--	--	--	55	9.45	2.32	19	9.3	2.62
Boulder %	32	4.5	7.0	55	6.6	18.6	19	7.9	19.2
Rubble%	32	15.8	13.3	55	15.0	16.2	19	12.1	15.8
Gravel %	32	34.9	22.9	55	27.4	23.3	19	24.5	21.1
Lg. Fines %	32	38.4	22.8	--	--	--	--	--	--
Sm. Fines %	32	6.3	11.0	--	--	--	--	--	--
Sand %	32	44.7	24.7	55	51.1	30.8	19	55.5	31.3
Imbeddedness %	32	73.8	13.1	55	69.1	20.6	19	70.5	22.7
Pocket Water:									
Score	--	--	--	6	9.5	0.84	4	9.75	0.50
Boulder %	27	3.3	13.1	6	3.3	8.2	4	5.0	10.0
Rubble%	27	5.6	16.5	6	19.2	24.6	4	5.0	10.0
Gravel %	27	33.2	41.8	6	30.8	32.6	4	45.0	31.1
Lg. Fines %	27	35.9	36.9	--	--	--	--	--	--
Sm. Fines t	27	21.9	32.8	--	--	--	--	--	--
Sand %	27	57.8	40.1	6	46.7	12.1	4	45.0	12.9
Imbeddedness %	27	80.2	17.6	6	68.3	11.7	4	62.5	5.0
Back Hater:									
Score	--	--	--	5	7.0	2.24	1	6.0	0.0
Boulder %	4	0.0	0.0	5	4.0	8.9	1	0.0	0.0
Rubble%	4	1.8	3.6	5	0.0	0.0	1	0.0	0.0
Gravel %	4	7.5	15.0	5	5.0	7.1	1	10.0	0.0
Lg. Fines %	4	46.1	34.8	--	--	--	--	--	--
Sm. Fines %	4	44.6	37.2	--	--	--	--	--	--
Sand %	4	90.7	14.2	5	91.0	15.2	1	90.0	0.0
Imbeddedness %	4	97.3	4.9	5	96.0	8.9	1	100.0	0.0

CROOKED RIVER

Habitat/Variable	Surface Transects N	Surface Transects X	Surface Transects S.D.	IDFG N	IDFG X	IDFG S.D.	IDFG II N	IDFG II X	IDFG II S.D.
Pool:									
Score	--	--	--	29	11.14	2.33	7	11.29	2.63
Boulder %	24	2.3	10.2	29	1.9	10.2	7	7.9	20.8
Rubble%	24	32.0	29.5	29	52.8	26.6	7	57.9	28.7
Gravel %	24	32.4	19.7	29	22.1	16.8	7	11.4	6.3
Lg. Fines %	24	12.5	17.3	--	--	--	--	--	--
Sm. Fines %	24	20.8	24.3	--	--	--	--	--	--
Sand %	24	33.3	32.5	29	23.3	27.5	7	22.9	26.7
Imbeddedness %	24	62.9	17.5	29	52.4	24.0	7	51.4	24.1
Riffle:									
Score	--	--	--	20	13.45	1.00	6	13.50	0.84
Boulder %	15	0.6	1.6	20	1.0	4.5	6	0.0	0.0
Rubble%	15	42.4	24.4	20	40.0	16.9	6	44.2	13.9
Gravel %	15	56.0	25.7	20	53.3	18.5	6	50.8	10.7
Lg. Fines %	15	0.9	2.0	--	--	--	--	--	--
Sm. Fines %	15	0.0	0.0	--	--	--	--	--	--
Sand %	15	0.9	2.0	20	5.8	6.1	6	5.0	7.7
Imbeddedness %	15	23.1	9.5	20	19.5	14.7	6	16.7	15.1
Glide:									
Score	--	--	--	30	12.07	2.49	13	11.92	3.21
Boulder %	26	2.0	5.7	30	4.0	12.8	13	7.3	18.6
Rubble%	26	47.4	23.6	30	47.3	22.0	13	45.0	25.0
Gravel %	26	41.8	21.6	30	31.7	16.5	13	30.0	14.4
Lg. Fines %	26	6.4	12.7	--	--	--	--	--	--
Sm. Fines %	26	2.4	10.7	--	--	--	--	--	--
Sand %	26	8.8	15.8	30	17.0	23.6	13	17.7	28.5
Imbeddedness %	26	36.9	15.6	30	37.3	25.2	13	39.2	29.6
Pocket Water:									
Score	--	--	--	20	11.85	1.39	7	12.00	1.53
Boulder %	35	0.0	0.0	20	0.0	0.0	7	0.0	0.0
Rubble%	35	54.4	37.2	20	52.0	21.4	7	54.3	22.8
Gravel %	35	37.5	35.8	20	31.5	15.1	7	30.7	20.5
Lg. Fines %	35	5.3	19.0	--	--	--	--	--	--
Sm. Fines %	35	2.9	16.9	--	--	--	--	--	--
Sand %	35	8.1	24.8	20	16.5	12.3	7	15.0	7.6
Imbeddedness %	35	44.5	17.5	20	46.0	15.4	7	44.3	18.1
Back Water:									
Score	--	--	--						
Boulder %	7	4.4	7.6						
Rubble%	7	21.8	14.0	(No back water in sample)					
Gravel %	7	36.1	24.1						
Lg. Fines %	7	18.9	28.4						
Sm. Fines %	7	18.7	31.2						
Sand %	7	37.6	37.3						
Imbeddedness %	7	68.4	18.2						

LOWER FRENCHMAN CREEK

Habitat/Variable	Surface Transects			IDFG			IDFG II		
	N	X	S.D.	N	X	S.D.	N	X	S.D.
Pool:									
Score	--	--	--	59	7.98	2.29	21	7.76	2.55
Boulder %	30	0.0	0.0	59	0.0	0.0	21	0.0	0.0
Rubble%	30	0.0	0.0	59	0.1	0.7	21	0.0	0.0
Gravel %	30	52.1	31.5	59	52.0	36.8	21	51.2	38.8
Lg. Fines %	30	25.7	22.8	--	--	--	--	--	--
Sm. Fines %	30	22.2	25.5	--	--	--	--	--	--
Sand %	30	47.9	31.5	59	47.1	36.9	21	48.8	38.8
Imbeddedness %	30	72.2	15.2	59	72.1	20.1	21	74.3	18.6
Riffle:									
Score	--	--	--	16	11.19	1.68	2	10.00	1.41
Boulder %	9	0.0	0.0	16	0.0	0.0	2	0.0	0.0
Rubble%	3	0.0	0.0	16	0.3	1.3	2	2.5	3.5
Gravel %	9	92.5	18.9	16	82.5	24.2	2	75.0	21.2
Lg. Fines %	9	0.0	0.0	--	--	--	--	--	--
Sm. Fines %	9	1.5	18.9	--	--	--	--	--	--
Sand %	9	7.5	18.9	16	17.2	24.4	2	22.5	24.7
Imbeddedness %	9	27.3	18.5	16	25.6	21.9	2	30.0	14.1
Glide:									
Score	--	--	--	24	9.83	1.43	10	9.30	1.83
Boulder I	16	0.0	0.0	24	0.0	0.0	10	0.0	0.0
Rubble%	16	0.0	0.0	24	0.2	1.0	10	0.5	1.6
Gravel %	16	73.4	32.2	24	79.0	23.3	10	77.0	27.8
Lg. Fines %	16	12.6	16.0	--	--	--	--	--	--
Sm. Fines %	16	14.0	27.7	--	--	--	--	--	--
Sand %	16	26.6	32.2	24	20.8	24.1	10	22.5	28.2
Imbeddedness %	16	49.0	15.4	24	46.9	17.9	10	48.0	22.0

N.F. RED RIVER

Habitat/Variable	Surface Transects N	Surface Transects X	Surface Transects S.D.	IDFG N	IDFG X	IDFG S.D.	IDFG II N	IDFG II X	IDFG II S.D.
Pool:									
Score	--	--	--	41	10.29	2.80	11	11.00	2.79
Boulder %	25	0.0	0.0	41	0.0	0.0	11	0.0	0.0
Rubble%	25	26.4	28.5	41	33.7	29.8	11	37.3	31.3
Gravel %	25	29.3	24.8	41	32.0	22.2	11	35.9	24.3
Lg. Fines %	25	19.8	25.2	--	--	--	--	--	--
Sm. Fines %	25	24.5	31.3	--	--	--	--	--	--
Sand %	25	44.3	36.0	41	34.9	33.3	11	26.8	33.8
Imbeddedness %	25	65.9	18.3	41	55.9	26.8	11	47.3	27.2
Riffle:									
Score	--	--	--	27	13.33	1.18	7	13.14	1.57
Boulder %	13	0.0	0.0	27	0.0	0.0	7	0.0	0.0
Rubble%	13	49.9	29.2	27	47.8	25.4	7	47.9	30.5
Gravel %	13	45.0	21.4	27	45.2	22.3	7	47.1	25.8
Lg. Fines %	13	5.1	12.5	--	--	--	--	--	--
Sm. Fines %	13	0.0	0.0	--		--	--	--	--
Sand %	13	5.1	12.5	27	0.0	7.5	7	5.0	5.0
Imbeddedness %	13	21.8	14.8	27	18.2	13.0	7	21.4	14.6
Glide:									
Score	--	--	--	29	11.52	2.16	15	11.53	2.56
Boulder %	15	0.0	0.0	23	0.0	0.0	15	0.0	0.0
Rubble%	15	43.3	21.0	29	36.9	24.9	15	37.7	27.0
Gravel %	15	49.0	23.6	29	38.6	21.6	15	37.7	25.1
Lg. Fines %	15	6.6	13.8	--	--	--	--	--	--
Sm. Fines %	15	1.1	4.3	--	--	--	--	--	--
Sand %	15	7.7	13.9	29	24.5	23.2	15	24.7	25.8
Imbeddedness %	15	35.2	12.9	29	41.0	22.7	15	38.7	26.7
Pocket Water:									
Score	--	--	--	2	9.00	4.24			
Boulder %	5	0.0	0.0	2	0.0	0.0			
Rubble%	5	10.0	22.4	2	10.0	7.1		(No pocket water)	
Gravel %	5	73.3	25.3	2	45.0	42.4			
Lg. Fines %	5	16.7	23.6	--	--	--			
Sm. Fines %	5	0.0	0.0	--	--	--			
Sand %	5	16.7	23.6	2	45.0	49.5			
Imbeddedness %	6	52.6	11.0	2	65.0	35.4			

POVERTY - S.F. SALMON RIVER

Habitat/Variable	Surface Transects N	Surface Transects X	Surface Transects S.D.	IDFG N	IDFG X	IDFG S.D.	IDFG II N	IDFG II X	IDFG II S.D.
Pool:									
Score	--	--	--	28	10.82	2.13	11	10.73	2.20
Boulder %	31	0.3	1.0	28	0.0	0.0	11	0.0	0.0
Rubble%	31	43.5	19.8	28	36.4	31.5	11	35.5	24.0
Gravel %	31	41.2	20.6	28	35.9	22.9	11	35.5	24.1
Lg. Fines %	31	7.0	6.7	--	--	--	--	--	--
Sm. Fines %	31	8.0	11.9	--	--	--	--	--	--
Sand %	31	15.0	15.1	28	27.7	24.7	11	29.1	27.5
Imbeddedness %	31	57.1	13.9	28	47.1	22.4	11	49.1	24.3
Riffle:									
Score	--	--	--	14	11.86	1.70	4	10.75	1.71
Boulder %	21	0.2	0.9	14	0.0	0.0	4	0.0	0.0
Rubble%	21	42.4	24.2	14	30.7	21.6	4	20.0	18.7
Gravel %	21	53.2	24.0	14	53.9	13.6	4	58.8	8.5
Lg. Fines %	21	2.7	7.5	--	--	--	--	--	--
Sm. Fines %	21	1.6	7.3	--	--	--	--	--	--
Sand %	21	4.2	10.0	14	15.4	17.3	4	21.3	14.4
Imbeddedness %	21	27.1	8.2	14	34.3	15.1	4	37.5	9.6
Glide:									
Score	--	--	--	57	11.46	2.12	18	11.94	1.70
Boulder %	33	0.7	2.0	57	0.9	6.6	18	2.8	11.8
Rubble%	33	51.0	18.7	57	37.5	25.7	18	37.5	21.9
Gravel %	33	43.1	19.3	57	43.8	23.2	18	43.6	19.7
Lg. Fines %	33	4.3	4.3	--	--	--	--	--	--
Sm. Fines %	33	0.9	1.5	--	--	--	--	--	--
Sand %	33	5.2	4.7	57	17.9	18.4	18	16.1	15.3
Imbeddedness %	33	44.6	14.7	57	43.2	22.9	18	42.8	21.6
Pocket Water:									
Score	--	--	--	--	--	--	--	--	--
Boulder %	50	0.0	0.0	--	--	--	--	--	--
Rubble%	50	7.0	15.6	--	--	--	--	--	--
Gravel %	50	77.7	31.0	--	--	--	--	--	--
Lg. Fines %	50	7.0	18.4	--	--	--	--	--	--
Sm. Fines %	50	8.3	22.1	--	--	--	--	--	--
Sand %	50	15.3	30.2	--	--	--	--	--	--
Imbeddedness %	50	44.1	23.9	--	--	--	--	--	--
Back Water:									
Score	--	--	--	--	--	--	--	--	--
Boulder %	5	0.0	0.0	--	--	--	--	--	--
Rubble%	5	8.6	19.2	--	--	--	--	--	--
Gravel %	5	79.4	20.7	--	--	--	--	--	--
Lg. Fines %	5	4.0	8.9	--	--	--	--	--	--
Sm. Fines %	5	8.0	11.0	--	--	--	--	--	--
Sand %	5	12.0	17.9	--	--	--	--	--	--
Imbeddedness %	5	40.2	19.0	--	--	--	--	--	--
Debris:									
Score	--	--	--	--	--	--	--	--	--
Boulder %	1	0.0	0.0	--	--	--	--	--	--
Rubble%	1	0.0	0.0	--	--	--	--	--	--
Gravel %	1	0.0	0.0	--	--	--	--	--	--
Lg. Fines %	1	80.0	0.0	--	--	--	--	--	--
Sm. Fines %	1	20.0	0.0	--	--	--	--	--	--
Sand %	1	100.0	0.0	--	--	--	--	--	--
Imbeddedness %	1	96.0	0.0	--	--	--	--	--	--

SALMON RIVER 3BRA-MAIN CHANNEL

	Surface Transects			IDFG			IDFG II		
Habitat/Variable	N	X	S.D.	N	X	S.D.	N	X	S.D.
Pool:									
Score	--	--	--	2	7.50	2.12			
Boulder %	11	0.0	0.0	2	0.0	0.0		no pool	
Rubble%	11	61.8	31.5	2	30.0	35.4			
Gravel %	11	27.7	24.1	2	12.5	3.5			
Lg. Fines %	11	4.5	8.3	--	--	--			
Sm. Fines %	11	5.9	13.6	--	--	--			
Sand %	11	10.4	14.3	2	57.5	38.9			
Imbeddedness %	11	40.6	18.9	2	80.0	14.1			
Riffle:									
Score	--	--	--	48	13.67	0.81	15	14.07	0.70
Boulder %	20	0.0	0.0	48	0.0	0.0	15	0.0	0.0
Rubble%	20	77.6	16.1	48	72.7	17.6	15	81.7	9.9
Gravel %	20	22.0	14.5	48	24.2	16.2	15	17.0	9.0
Lg. Fines %	20	0.2	1.1	--	--	--	--	--	--
Sm. Fines %	20	0.2	1.1	--	--	--	--	--	--
Sand %	20	0.4	2.1	48	2.9	3.8	15	1.3	2.3
Imbeddedness %	20	11.15	4.3	48	14.4	10.5	15	9.3	7.0
Glide:									
Score	--	--	--	49	12.76	1.49	18	12.72	1.45
Boulder %	26	0.0	0.0	43	0.0	0.0	18	0.0	0.0
Rubble%	26	75.1	20.5	49	57.8	22.2	18	53.6	23.9
Gravel %	26	24.0	20.0	49	34.4	15.9	18	36.4	14.9
Lg. Fines %	26	0.7	1.8	--	--	--	--	--	--
Sm. Fines %	26	0.2	0.9	--	--	--	--	--	--
Sand %	26	0.9	2.4	49	7.9	17.5	18	10.0	20.9
Imbeddedness %	26	24.6	9.3	49	28.2	17.9	18	28.3	18.2
Pocket Water:									
Score	--	--	--						
Boulder %	19	0.0	0.0	--	--	--	--	--	--
Rubble%	19	65.7	38.4	--	--	--	--	--	--
Gravel %	19	26.8	37.3	--	--	--	--	--	--
Lg. Fines %	19	5.3	13.7	--	--	--	--	--	--
Sm. Fines %	19	2.2	6.7	--	--	--	--	--	--
Sand %	19	7.5	19.4	--	--	--	--	--	--
Imbeddedness %	19	39.6	15.2	--	--	--	--	--	--

SALMON RIVER 3BRA-SIDE CHANNEL

Habitat/Variable	Surface Transects N	Surface Transects X	Surface Transects S.D.	IDFG N	IDFG X	IDFG S.D.	IDFG II N	IDFG II X	IDFG II S.D.
Pool:									
Score	--	--	--	25	8.0	2.58	9	8.56	2.13
Boulder %	18	0.0	0.0	25	0.0	0.0	9	0.0	0.0
Rubble%	18	24.6	20.1	25	15.6	28.8	3	16.1	28.9
Gravel %	18	35.2	24.0	25	37.6	33.2	9	43.9	31.9
Lg. Fines %	18	12.8	13.4						
Sm. Fines %	18	30.2	22.8						
Sand %	18	43.0	24.0	25	46.8	37.3	9	40.0	31.2
Imbeddedness %	18	69.7	12.5	25	78.0	16.3	3	75.6	13.3
Riffle:									
Score	--	--	--	36	11.83	2.10	14	12.07	1.59
Boulder %	18	4.1	6.9	36	5.4	18.4	14	6.8	25.4
Rubble%	18	43.9	23.6	36	40.6	28.0	14	44.3	31.6
Gravel %	18	41.5	17.4	36	43.9	25.4	14	42.1	27.9
Lg. Fines %	18	4.1	3.6						
Sm. Fines %	18	6.3	12.3						
Sand %	18	10.5	16.6	36	10.1	22.2	14	6.8	16.0
Imbeddedness %	18	21.4	18.4	36	45.0	20.2	14	44.3	18.3
Glide:									
Score	--	--	--	37	10.76	2.75	10	10.10	3.11
Boulder %	21	0.0	0.0	37	0.0	0.0	10	0.0	0.0
Rubble%	21	30.8	31.5	37	36.5	28.9	10	33.5	28.8
Gravel %	21	52.7	31.5	37	45.3	28.0	10	36.0	27.6
Lg. Fines %	21	2.4	4.5	37	--	--	10	--	--
Sm. Fines %	21	14.2	25.6	37	--	--	10	--	--
Sand %	21	16.5	26.0	37	18.2	30.6	10	30.5	36.2
Imbeddedness %	21	45.4	21.5	37	53.2	22.6	10	57.0	23.1
Pocket Water:									
Score	--	--	--	1	8.0	0.0			
Boulder %	19	0.0	0.0	1	0.0	0.0			
Rubble%	19	42.5	36.7	1	0.0	0.0			
Gravel %	19	44.3	28.0	1	100.0	0.0	(No pocket water)		
Lg. Fines %	19	3.4	11.8						
Sm. Fines %	19	3.2	17.3						
Sand %	19	12.7	21.6	1	0.0	0.0			
Imbeddedness %	19	43.4	25.7	1	50.0	0.0			

Part IV

Subproject II

INTENSIVE EVALUATION AND MONITORING OF CHINOOK SALMON AND STEELHEAD TROUT PRODUCTION, CROOKED RIVER AND UPPER SALMON RIVER SITES

Annual Report 1987

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INTRODUCTION

Work began on the intensive evaluation and monitoring portion of this project in September 1986. The objective is to quantify changes in physical habitat and in chinook salmon Oncorhynchus tshawytscha and steelhead trout Salmo gairdneri smolt production relating to Bonneville Power Administration (BPA) funded habitat improvement projects. It has generally been accepted that habitat improvement projects can lead to increased fish production, and in anadromous populations the change in smolt production would be the best measure of a project's effectiveness. The actual increase in smolt production, however, has never been statistically quantified in the field (Buell 1986). A realistic quantitative approach for Idaho is: (1) to estimate parr production attributable to habitat projects through general monitoring; (2) to quantify relationships between spawning escapement, parr production, and smolt production through intensive monitoring in two typical anadromous stream reaches; and (3) to use the determined Parr-to-smolt survival rates as a basis for BPA mitigation accounting.

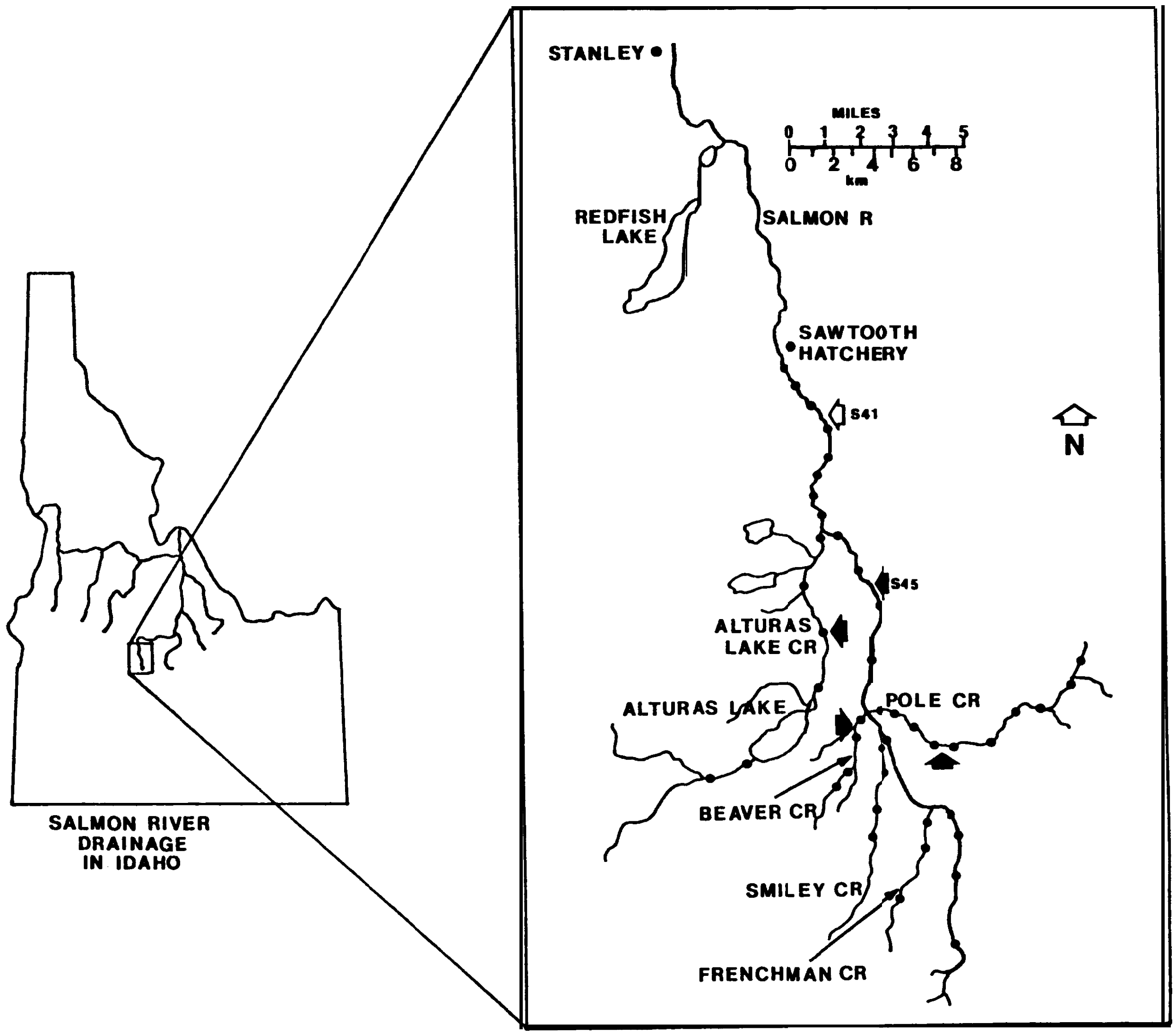
The primary objectives of the intensive evaluation and monitoring portion of this project are: (1) to determine smolt production from two typical anadromous streams reaches: (2) to develop Parr-to-smolt survival rates for wild and natural salmon and steelhead for BPA habitat project mitigation; (3) to determine the mathematical relationship between spawning escapement, parr production, and smolt production; (4) to determine migration characteristics; (5) to determine the most effective methods of supplementing natural anadromous fish production with hatchery production: (6) to determine habitat rearing potential, potential smolt production, and reproductive potential for the two study streams; and (7) to determine which factors limit wild and natural smolt production,

STUDY SITES

Upper Salmon River

The Salmon River originates in the Sawtooth, Smokey, and White Cloud mountains in southcentral Idaho. The upper Salmon River study site is located upstream from the Sawtooth Hatchery at elevations above 1,980 m. Study sections are located throughout the upper basin (Figure 1). The upper river above Sawtooth Fish Hatchery is a major production area for anadromous spring chinook salmon and A-run summer steelhead trout. Resident salmonids in the upper Salmon drainage are native rainbow, cutthroat, and bull trout, mountain whitefish, and non-native brook trout (Mallet 1974).

Historically, sockeye salmon existed in all moraine lakes in the Stanley Basin (Everman 1895). A remnant run of sockeye returns to Redfish Lake, the outlet of which enters the Salmon River approximately 2.7 km downstream from Sawtooth Hatchery. Adult sockeye are still occasionally seen in Alturas Lake Creek (Kent Ball, IDFG, personal communication), but



gure Location of the upper Salmon River study area and sections B• ' Solid arrows indicate irrigation diversions with flow problems.

irrigation diversion that completely dewaters the creek every summer makes adult passage to the lake unlikely (Bowles and Cochnauer 1984). No other sockeye runs are known to exist in the Salmon River drainage above Sawtooth Fish Hatchery.

Nearly pristine water quality and an abundance of high quality spawning gravel and rearing habitat are present throughout much of the upper basin. Water flows at the Sawtooth Hatchery range from lows of 61 to 122 cms from July through April to highs of 396 to 823 cms during May and June.

Livestock grazing and hay production are predominant uses of private land throughout the upper Salmon basin. Grazing in riparian zones has degraded aquatic habitat in localized areas. Water diversions from the river and tributaries have impaired the potential for production of salmon and steelhead in some of the upper Salmon River drainage.

An irrigation diversion (S45) between Alturas Lake Creek and Pole Creek completely dewaters the river for 0.4 km during July and August in an average flow year. Flow diversions from tributary streams vary from partial to complete dewatering. Conversion from flood to overhead sprinkler irrigation has decreased the withdrawal of water from Pole Creek since 1982. BPA funded the construction of a fish screen for the irrigation diversion on Pole Creek in 1983-1984. Steelhead fry have been outplanted into upper Pole Creek every year since 1985 (IDFG, unpublished data). Upper Salmon River chinook salmon have not been available from Sawtooth Fish Hatchery for reintroduction to date.

The Sawtooth Fish Hatchery was constructed in cooperation with the U.S. Fish and Wildlife Service and the U.S. Army Corps of Engineers through the Lower Snake River Compensation Plan. The hatchery program involves trapping adult salmon and steelhead and releasing smolts and other life stages. The hatchery is designed to produce 2.4 million chinook smolts per year. Steelhead eyed eggs are sent to other facilities for rearing, and the smolts are transported back to Sawtooth Hatchery for release. Approximately 700,000 steelhead smolts were released from the hatchery in 1986 (T. Rogers, IDFG, personal communication). At least 33% of the adult salmon and steelhead entering the trap are released upstream of the hatchery to spawn naturally.

Crooked River

The Crooked River originates at an elevation of 2,070 m in the Clearwater Mountains within the Nez Perce National Forest and enters the South Fork Clearwater River at river kilometer 94 at an elevation of 1,140 m (Figure 2). The entire Crooked River drainage is the study site. Salmon and steelhead runs were eliminated historically by construction of the Harpster Dam on the South Fork Clearwater River in 1927. Spring chinook and B-run summer steelhead were re-established in Crooked River following removal of the dam in 1962. Resident salmonids in Crooked River include mountain whitefish, rainbow trout, bull trout, and cutthroat trout (Petrosky and Holubetz 1986).

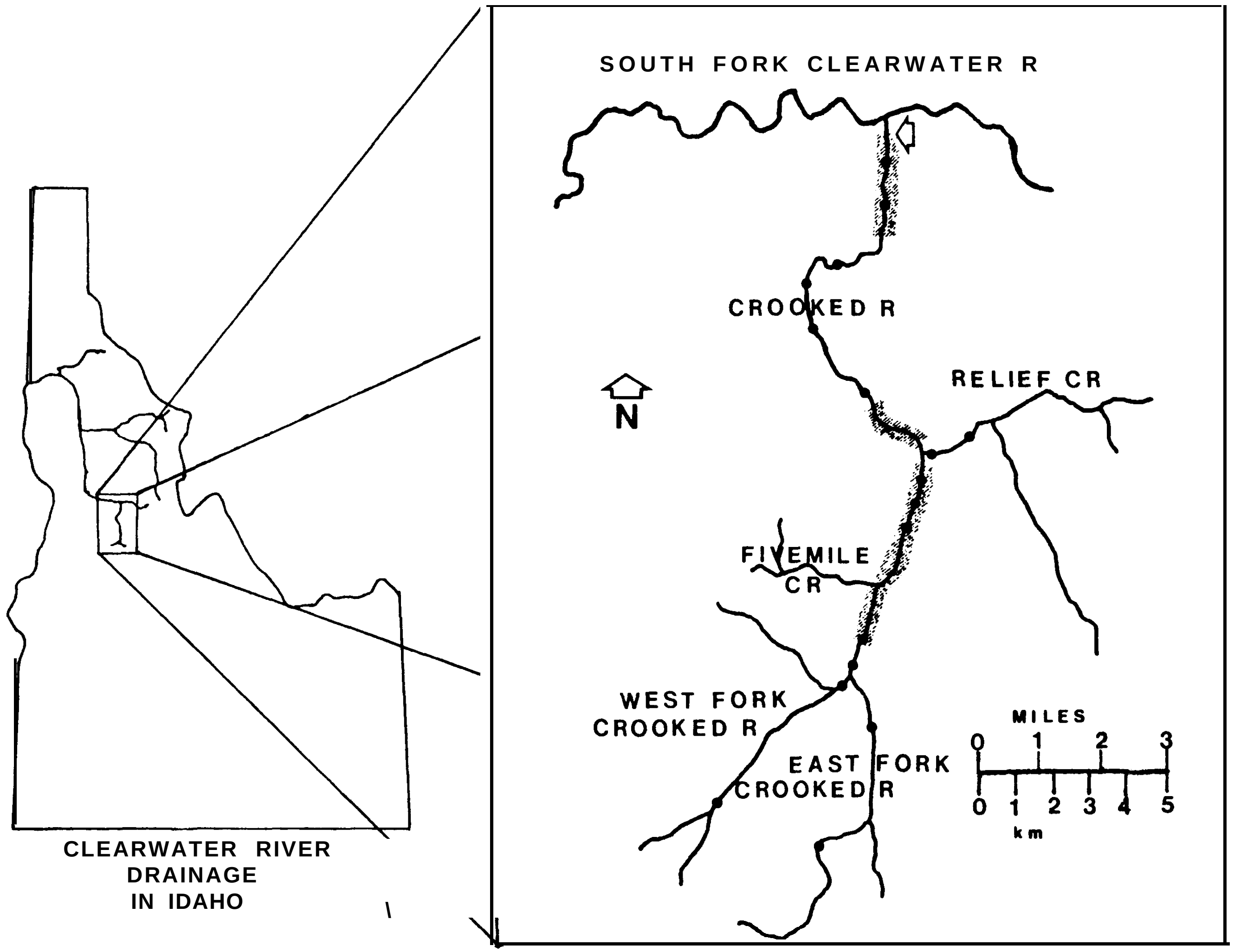


Figure 2. Location of Crooked River, meadows (shaded) degraded by dredging, and study section locations (•). Arrow indicates proposed location of trapping facility.

Dredge mining activities during the 1950s severely degraded habitat within the two meadow reaches of the stream. In the upstream meadow, the stream was forced to the outside of the floodplain, resulting in a straight, high gradient channel. In the lower meadow, dredge tailings have forced the stream into long meanders with many ponds and sloughs. During runoff, juvenile trout and salmon use some of these ponds but are trapped as flow recedes.

Fish density and habitat surveys were initiated in 1984 by IDFG and the Intermountain Forest and Range Experiment Station, USFS, Boise, Idaho (Petrosky and Holubetz 1985). They found that densities of juvenile chinook and steelhead in the two meadow reaches were relatively lower than those in other Idaho streams. Densities of fish in the few pools and the high velocity sections were similar, indicating the lack of a relationship between juvenile density and habitat type. Because chinook parr generally prefer pool habitat over high velocity sections, this lack of a relationship between juvenile density and habitat type indicates that the upper meadow reach was underseeded in 1984.

In 1984, the U.S. Forest Service, with BPA funds, placed a series of log structures, rock and boulder reflectors, organic debris structures, and loose rock weirs within the upper meadow in an effort to compensate for stream gradient and increase the pool to riffle ratio. In addition, banks were stabilized and revegetated, an of f-channel pond was connected with a side channel, and a culvert blocking adult passage was removed (Hair and Stowell 1986). Recent efforts have concentrated on connecting additional ponds in the dredge tailings to the main channel and developing side channels to provide continuous water supply during low flow periods.

MATERIALS AND METHODS

Habitat Evaluations and Fish Densities

We evaluated habitat and estimated fish densities at both study areas in 1987 at the same sections and with the same methodologies used in general monitoring in 1984-1987 (Petrosky and Holubetz 1987). Physical habitat and fish density surveys were conducted on 56 and 57 sections in the upper Salmon River study area, respectively.

In 1987, physical habitat and fish density surveys were conducted on 1 and 8 sections in the Crooked River study area, respectively, as part of the general monitoring portion of this project. Intensive evaluation of Crooked River is scheduled to begin in 1988. The intensive evaluation plan for Crooked River adds 7 additional sections to those that have been established for the general monitoring.

The stream habitat evaluation methodologies used are Petrosky and Holubetz's (1985) modifications of methods derived from Platts et al. (1983). In this method, transects are established at 10-m intervals within a selected stream section, and stream width is measured at each transect. Depth, velocity, substrate composition, embeddedness, and habitat type (i.e., pool, run, riffle, pocket water, or backwater) (Shepard 1983) are measured or determined at the one-quarter, one-half, and three-quarter points of each stream transect. Proportions of sand (<0.5 cm diameter), gravel (0.5-7.4 cm), rubble (7.5-30.4 cm), boulder (>30.5 cm), and bedrock that comprise the substrate are estimated ocularly. Embeddedness is the proportion of surface area of gravel, rubble, and boulder that is surrounded by fine (sand or smaller) sediments . Embeddedness is classified as 0%, 0-5%, 5-25%, 25-50%, 50-75%, 75-100%, and 100%. Stream gradient is measured with a surveyor's transit and stadia rod as the elevation difference between the upper and lower section boundaries divided by channel length. Stream channel type is classified according to Rosgen (1985). All sections are flagged and photographed for future repeated measurements.

Fish abundance by species and length class is estimated by snorkeling a known stream distance through habitat sections (Petrosky and Holubetz 1985, 1986). Total abundance of steelhead and chinook parr are estimated during July-August by stratified sampling.

Tagging and Tag Monitoring

PIT tags were implanted into 2,795 chinook salmon parr and 1,585 steelhead trout parr in the upper Salmon River drainage during August and September, 1987. No PIT tagging was performed in the Crooked River study area in 1987. The National Marine Fisheries Service (NMFS) was contracted to work jointly with IDFG during the first season of PIT tagging so that IDFG personnel could utilize and learn from their experience with PIT tags. In the joint IDFG and NMFS tagging operation, 1,434 chinook salmon and 1,351 steelhead trout (primarily age 2+) were tagged in their summer rearing areas. The remainder were tagged during the fall outmigration. The outmigrating fish were collected in 1 x 1.5 x 0.5-m box traps placed over the bypass pipes of three irrigation diversion fish screens.

Fish to be PIT tagged during the joint IDFG and NMFS operation were collected with a Smith-Root Model 12 electrofisher or seine, depending on which method was most suitable for a particular site. The electrofisher was operated with the following configuration and settings: 30.5-cm diameter anode ring on a 2-m pole, 2.4-m rattail cathode, voltage settings of between 200 to 400 V, and pulse rates of 90/s when fishing in primarily chinook salmon waters and 30/s in primarily steelhead trout waters. Conductivity in the upper Salmon River ranges from 37 to 218 umho/cm (Emmett 1975). Nylon netting tied onto the anode was observed to reduce the incidence of electrical burn marks and fish mortality without a noticeable reduction of capture effectiveness.

Fish to be tagged were anesthetized with MS-222, and the PIT tags were injected into the body cavity using a 12-gauge hypodermic needle and modified syringe. The needle was oriented anteriorly to posteriorly and inserted just off the mid-ventral line about one-quarter of the distance between the end of the pectoral fin and the pelvic girdle. Immediately after the needle entered the body cavity, the needle was rotated and its angle changed so that the bevel of the needle made contact with the inner surface of the body wall, then the tag was inserted. After tagging, tag presence was confirmed using a handheld detection-decoding device (Prentice et al. 1986). NMFS has found that once a functional tag has been successfully implanted in a fish, the tag failure rate has been near 0%. (For a more detailed description of PIT tags, see Appendix A.)

Fork length was measured to the nearest millimeter on all parr that were PIT tagged. Fish weight was measured to the nearest tenth of a gram on 1,389 of the chinook salmon tagged and on 1,398 of the steelhead trout parr tagged. Tagged fish were held in fresh water until fully recovered and then released near their capture site. Perforated plastic trash cans were used to hold fish before being tagged and during recovery. Handheld PIT tag detectors were used to detect the tag codes and send them directly to a portable microcomputer. The microcomputer used a BASIC program supplied by NMFS to organize the tag codes and associated data into data files. These PIT tag data files were downloaded on a daily basis to a personal computer for storage and later analysis.

Of the 1.1% mortality due to perforated organs during tag implantation, handling stress, or overdose of MS-222, almost all fish showed behavioral changes and/or darkening of color almost immediately after tagging. We conducted a 24-h delayed mortality test on one group of 33 chinook salmon and 29 steelhead trout parr that contained fish collected by both electrofishing and seining. These fish were held in one of the perforated plastic trash cans placed in a l-m deep pool of the stream.

Downstream Migrant Trapping

To monitor the movements of juvenile anadromous fish in the upper Salmon River study area, a floating scoop trap with a l-m wide inclined traveling screen was contracted to be built by Midwest Fabrication Inc., Corvallis, Oregon. However, due to delays in design and construction, the trap was not delivered until October 25, 1987 and could not be used to sample the fall 1987 outmigration. The trap was tested for 2 days and performed well.

Box traps made of perforated steel plates were placed on the bypass pipes of three irrigation diversion fish screens to collect migration data during fall 1987. The three irrigation diversions selected for trapping were: the Henslee's diversion on Pole Creek, the Busterback Ranch diversion (S45) located between Alturas Lake Creek and Pole Creek, and S41 diversion located 13.3 km above the Sawtooth Hatchery (Figure 1). A daily trap record was maintained for each trap. All salmon and steelhead parr were scanned for PIT tag presence. All untagged salmon and steelhead parr were anesthetized and tagged with PIT tags using the methods described in the Tagging and Tag Monitoring Section.

Hatchery Supplementation

To begin the evaluation of hatchery supplementation, six pairs of adult chinook salmon were outplanted into Frenchman Creek and 28,000 eyed chinook eggs were buried in artificial redds in Beaver Creek.

On September 4, 1987, six pairs of adult chinook salmon were released into Frenchman Creek at the lower study site. This reach is located within a grazing enclosure which is part of a sediment monitoring study (Torquemada and Platts 1988). Cattle were in this enclosure during the entire time that adult salmon were alive. A picket weir prevented the fish from moving upstream from this area, and beaver ponds discouraged them from moving downstream. The section of stream was walked approximately every other day to monitor the spawning activity.

On October 21, 1987, 28,000 chinook salmon eyed eggs were buried in artificial redds in Beaver Creek. The site selected for this outplant is in Reach 2, 4.5 km above the mouth. The eggs were buried in 14 artificial redds (2,000/redd) according to the directions of White (1980). The total number of eggs buried in Beaver Creek was selected to match the number of eggs deposited into Frenchman Creek by the five females that successfully spawned there (5 females x 5,600 eggs/female-28,000 eggs). The number of eggs/female (5,600) is the average observed at the Sawtooth Hatchery from 1981 to 1984.

Total chinook salmon parr abundance resulting from these two outplants will be estimated in 1988. Since neither stream received natural chinook escapements in 1987, all parr in these streams in 1988 can be attributed to the outplants. Egg-to-Parr survival rates will be calculated and compared for these two outplants. We will also PIT tag parr from these streams in 1988 to obtain Parr-to-smolt survival rates.

The chinook salmon hatchery supplementation evaluation plan for the upper Salmon River study area divides the upper stream basin into eight reaches so that two replicates of four different supplementation methods can be evaluated. The life stages to be outplanted and their respective stream reaches to be planted are as follows: late May fingerlings into Smiley Creek and lower Pole Creek, late August parr into the Salmon River above Highway 75 and lower Alturas Lake Creek, adults into upper Pole Creek and Frenchman Creek, and eyed eggs into Beaver Creek and upper Alturas Lake Creek. The number of fingerlings and parr in each plant will be calculated to equal the number of fish at that stage that would have been produced had the eyed eggs in the previous fall outplants been kept in the Sawtooth Hatchery. For 1988, we will be planting 24,000 fingerlings and 21,500 parr into the respective stream sections. The supplementation plan for Crooked River will be developed before summer 1988, and implementation will begin fall 1988.

Adult Escapement and Redd Counts

Actual escapement numbers for chinook salmon and steelhead trout in the upper Salmon River study area were obtained from Sawtooth Hatchery records. Except for a small percentage of early and late fish in each of the runs, the entire escapement above the hatchery weir consists of the fish collected in the hatchery's trap that are released upstream to spawn naturally. No actual escapement numbers will be available for the Crooked River study area until the trapping facility is completed there in summer 1989.

Chinook salmon redd counts were obtained from the respective Regional Fishery managers (Hall-Griswold and Cochnauer 1987). For the upper Salmon River study area, a one-day peak redd count is made by helicopter over the entire current spawning area during the first week of September. On Crooked River, the redd count is a one-day walking count from Fivemile Creek to Relief Creek during the first week of September.

The number of eggs deposited in the gravel are estimated by dividing the number of redds observed by 1.5 redds/female (Ortmann 1967) and then multiplying this number by the average number of eggs/female. For the upper Salmon River, the numbers for eggs/female are the average numbers observed at the Sawtooth Hatchery. For Crooked River, the number of eggs/female are the average numbers observed at the Red River trapping facility until the Crooked River trapping facility is built in 1989, at which time Crooked River trap numbers will be used.

RESULTS AND DISCUSSION

Fish Densities and Physical Habitat Analysis

Petrosky and Holubetz (1985, 1986) found snorkeling to be an effective method of enumerating fish at both study sites. Observations made by snorkeling can be superior to other methods of enumerating salmonids and determining habitat preferences. Trout and salmon tend to hold their position in the presence of an underwater observer, but electrofishing and seining operations disturb and chase fish out of habitat they have selected (Goldstein 1978; Platts et al. 1983).

The estimates for the total parr populations in the upper Salmon River study area during late summer 1987 were as follows: chinook age 0=65,739 + 30,186, steelhead age 1=14,280 + 3,956, and steelhead age 2+=5,852 ± 2,952. In summer 1985, there were slightly more chinook age 0 (73,548) and approximately one-third fewer steelhead parr (12,579). (In 1985, steelhead age 1 and 2+ were combined.) These changes in chinook and steelhead parr densities may be a result of low water flows that occurred in the upper Salmon River study area during summer 1987. During low flow years, many side and braided channels are completely dewatered, Typically, this type of habitat is where the highest concentrations of age 0 chinook are found, Conversely, during low flows much of the stream is concentrated in deeper runs where the highest densities of steelhead parr are typically found. Another contributing factor to the increase in steelhead parr numbers has been the increase in steelhead fry outplants since 1984 (Table 1).

It appears that during years of low flow in the upper Salmon River study area, the rearing potential for chinook is decreased while it may be increased for steelhead. A compounding problem for chinook in low water years is that with the current rate of irrigation withdrawal, much of the rearing habitat cannot be naturally seeded by chinook because of complete dewatering on Alturas Lake Creek, Beaver Creek, and the upper Salmon River.

The formats for Idaho fish density and physical habitat common data bases were developed by project personnel using DBASE III. These common data bases will make it possible to more easily use and share data collected by different researchers and agencies in Idaho. This project's fish density and physical habitat data from 1985 to 1987 has been entered into these common data bases.

Adult Escapement and Redd Counts

Egg-to-Parr survival rates will be based on adult female escapement numbers when available. Known escapements will be correlated with redd counts for chinook and possibly steelhead. Since 1984, female escapement numbers have been available for the upper Salmon River study area with the operation of the Sawtooth Fish Hatchery weir and trap. On Crooked River, these numbers will not be available until the weir and trap are built in 1989.

Currently, chinook redd counts are one-day peak counts, and on Crooked River the count does not cover the entire spawning area. Steelhead redd counts were begun in Crooked River in 1986.

The data collected (Table 2) enable us to calculate chinook and steelhead egg-to-Parr survival rates in the upper Salmon River study area for brood years 1984 and 1986. Based on adult escapement numbers, the estimated egg-to-Parr survival rate for chinook has changed from 24.0% for brood year 1984 to 6.1% for brood year 1986, while for steelhead the change has been from 0.2% to 1.0% for the same brood years. Based on redd counts for chinook, the estimated egg-to-Parr survival rates are 24.9% for brood year 1984 and 12.9% for brood year 1986. The data for Crooked River (Table 3) are not complete enough at this time to calculate egg-to-Parr survival rates.

Table 1. Parr production from supplementation for upper Salmon River study area.

Chinook Salmon

Brood year	1983	1984	1985	1986	1987
Adult females outplanted	---	---	---	---	6[a]
Average # eggs/female[b]	5,080	6,017	4,530	5,156	5,399
Estimated # eggs deposited	---	---	---	---	26,995
Eyed eggs outplanted	0	0	0	0	28,000
Egg-to-Parr survival rate	---	---	---	---	---
Fry outplanted	0	0	0	0	---
Fry-to-Parr survival rate	---	---	---	---	---
Parr outplanted	0	0	0	0	---
Postrelease parr survival	---	---	---	---	---

Steelhead Trout

Brood year	1983	1984	1985	1986	1987
Adult females outplanted	0	0	0	0	0
Average # eggs/female	---	---	---	---	---
Estimated # eggs deposited	---	---	---	---	---
Eyed eggs outplanted	0	0	0	0	0
Egg-to-Parr survival rate	---	---	---	---	---
Fry outplanted	---	317,500	1,440,880	832,414	717,559
Fry-to-Parr survival rate	---	---	---	---	---
Parr outplanted	0	0	0	0	0
Postrelease parr survival	---	---	---	---	---
Total parr from supplementation	---	---	---	---	---

[a] One of the 6 females died before spawning and was not included in the calculations.
[b] Data obtained from Sawtooth Fish Hatchery.

Table 2. Adult escapement, parr production, and smolt production data for upper Salmon River study area.

Chinook Salmon

Brood year	1983	1984	1985	1986	1987
Female escapement above weir	---	51	171	208	241
Redd count	188	74	83	105	124
Average # eggs/female	5,080	6,017	4,530	5,156	---
Estimated # eggs deposited	955,040	306,867	774,630	1,072,448	---
Total # of parr	---	73,548	---	65,739	---
Egg-to-Parr survival rate	---	24.0%	---	6.1%	---
Estimated Parr-to-smolt survival rate	---	---	---	---	---
Estimated total # of smolts	---	---	---	---	---

Steelhead Trout

Brood year	1983	1984	1985	1986	1987
Female escapement above weir	---	1,293[a]	91	319	379
Redd count	---	---	---	---	---
Average # eggs/female	---	3,969	5,640	4,468	4,854
Estimated # eggs deposited	---	5,131,917	513,240	1,425,292	1,839,666
Total # of parr	---	12,579[c]	---	14,280	---
Egg-to-Parr survival rate	---	0.2%	---	1.0%	---
Estimated Parr-to-smolt survival rate	---	---	---	---	---
Estimated total # of smolts	---	---	---	---	---

[a] Percent of pond mortalities observed at Sawtooth Fish Hatchery subtracted from escapement total.
[b] Includes 1,271 females outplanted from Pahsimeroi Fish Hatchery.
[c] Includes age 2+ steelhead.

Table 3. Adult escapement, parr production, and smolt production data for Crooked River study area.

Chinook Salmon

Brood year	1983	1984	1985	1986	1987
Female escapement above weir	---	---	---	---	---
Redd count[a]	12	22	10	9	17
Average # [b] eggs/female	---	4,432	---	---	4,010
Total d of parr	---	---	---	---	---
Estimated Parr-to-smolt survival rate	---	---	---	---	---
Estimated total # of smolts	---	---	---	---	---

Steelhead Trout

Brood year	1983	1984	1985	1986	1987
Female escapement above weir	---	---	---	---	---
Redd count	---	---	---	---	---
Average #[c] eggs/female	---	---	---	7,053	6,394
Estimated # eggs deposited	---	---	---	---	---
Total # of parr	---	---	---	---	---
Egg-to-Parr survival rate	---	---	---	---	---
Estimated Parr-to-smolt survival rate	---	---	---	---	---
Estimated total # of smolts	---	---	---	---	---

[a] Salmon redd count is a one-day aerial count conducted during the first week in September and only covers the river from the narrows up to Orogrande.

[b] Data from fish trapped at Red River.

[c] Data from Dworshak National Fish Hatchery.

Downstream Migrant Trapping

A large proportion of juvenile chinook salmon and steelhead trout parr have been found to move downstream out of high mountain nursery areas to overwinter (Bjornn 1978). To develop mitigation record based on smolt production, it is necessary to determine what proportion of parr outmigrate from project areas in the fall to overwinter and then determine the Parr-to-smolt survival rates for these fish.

The data collected during fall 1987 from the trap boxes placed over the outlet pipes of three irrigation diversion screens in the upper Salmon River study area indicate that significant migration was occurring when we installed the traps on August 11, and the peak migration occurred between late August and the third week of September (Figures 3, 4, and 5). Because of its location and length of operation, the S41 diversion box trap was determined most representative of the fall 1987 outmigration (Figure 3).

During the period it was operated (8/12/87-9/2/87), the S45 (Busterback) diversion trap sampled the entire stream flow and should have captured most of the outmigrating fish from the upper basin. However, it is possible that significant numbers of fish failed to find the bypass pipe and/or found a way past the diversion screens. In this trap, we captured 306 chinook and 64 steelhead parr, of which 2 chinook and 10 steelhead were recaptures.

We investigated the possibility of estimating population size upstream of S45 based on the box trap catch and total numbers of PIT- tagged parr above this diversion. Both of the chinook recaptured in the S45 box trap had been PIT tagged in Reach 1 of Pole Creek on 8/12/87. The number of days between tagging and recapture were 3 and 18. With only two of 306 chinook being recaptures, an estimate of the total chinook population above the. S45 diversion cannot be made with much precision ($N=117,504 \pm 162,108$; $p \leq 0.05$). Snorkel counts indicate that the point estimate is-much too high (Table 1). This estimate is probably inaccurate due to the following violations of model assumptions: (1) nonrandom distribution of marked fish, and (2) the parr from above Pole Creek do not appear to have migrated down to the S45 diversion in substantial numbers, and (3) the number of recaptures was too small.

Five of the 10 steelhead recaptures in the S45 box trap were tagged at the Pole Creek box trap and the other 5 were from reaches 1 and 2 of Pole Creek. Because the five recaptures from the Pole Creek box trap can be assumed to be actively outmigrating, they should not be included in the population estimates made from these recaptures. The recaptured steelhead from the Pole Creek box trap took an average of 8.2 days to get to S45, with a range of 4 to 12 days.

The five steelhead recaptures from reaches 1 and 2 of Pole Creek took an average of 7.8 days to get to S45, with a range of 2 to 16 days. The random chance was only 0.01% that all five recaptures would have come from Pole Creek, an area which contained only 25% of the tagged fish upstream

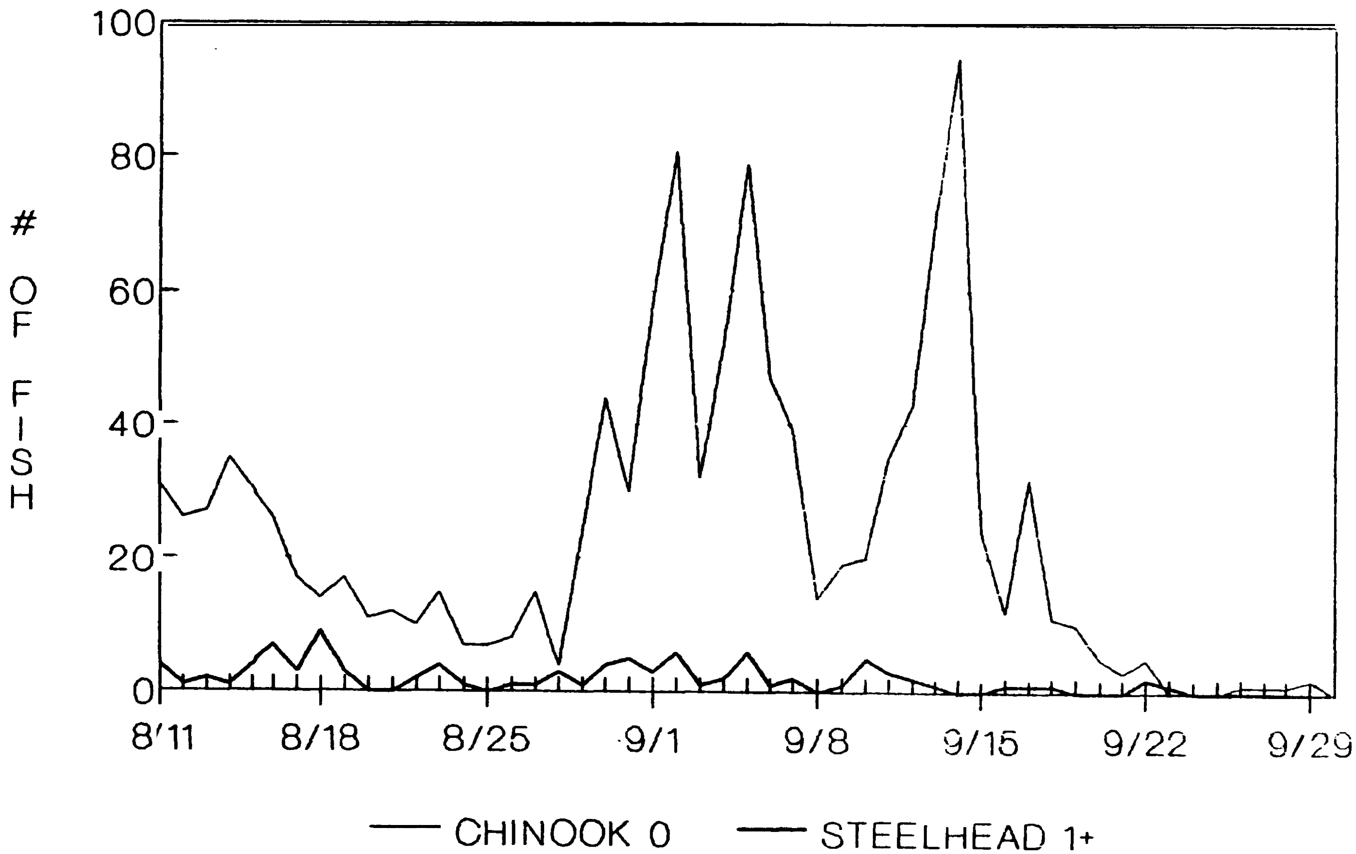


Figure 3. S41 box trap data for chinook and steelhead parr.

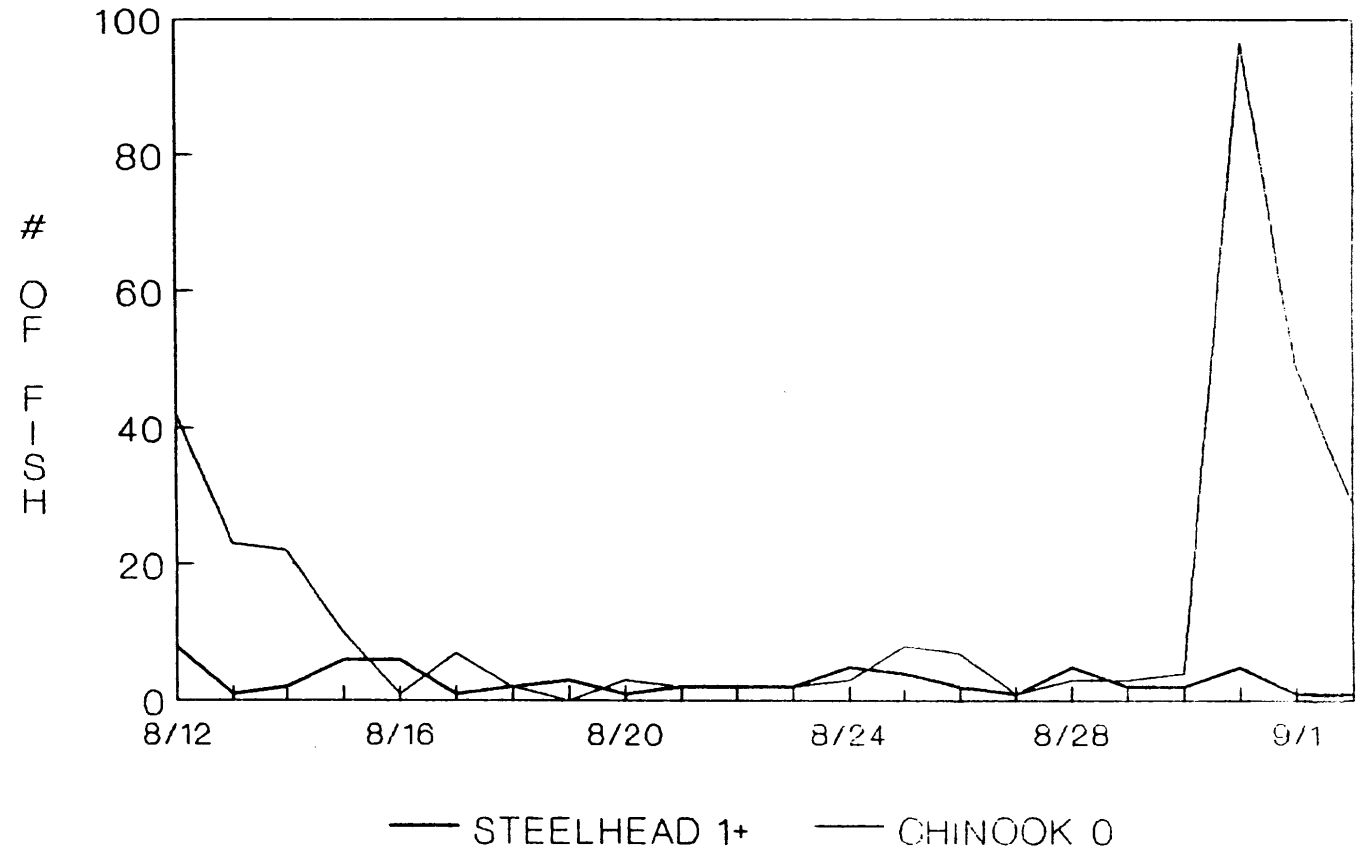


Figure 4. S45 box trap data for chinook and steelhead parr.

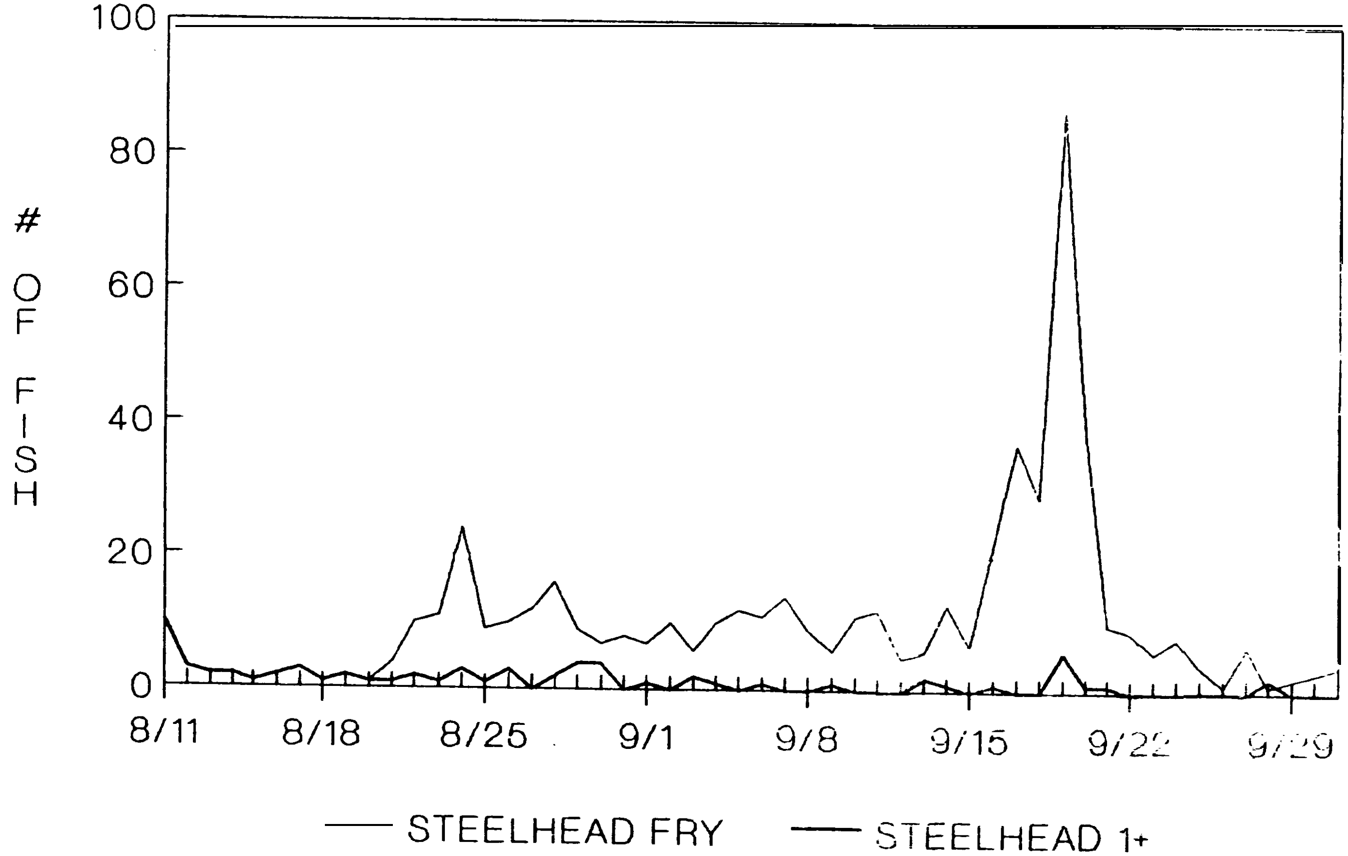


Figure 5 Pole Creek box trap data for steelhead fry and parr.

of S45, This suggests that most of the parr captured during the short sampling period at S45 were from Pole Creek and the Salmon River below Pole Creek. Because of this apparent nonrandom capture in the S45 box trap, we rejected the validity of a population estimate based on these recaptures.

PIT Tagging

PIT tags were selected for this project primarily because fewer tags are required than with traditional methods and the low tagging mortalities found in the NMFS studies. An advantage to using PIT tag technology is the capability to create data files containing large amounts of information in the field with relative ease. To date, these data files have been used by IDFG to provide release files for Columbia River management agencies and to produce length and weight data files from specific locations for university graduate research.

Tests by NMFS have shown that tagged smolts can be automatically recognized at a rate of 97 to 100% by detection-recording devices located within the smolt collection facilities at Lower Granite, Little Goose, and McNary dams. With information collected from individual fish, and with detection of virtually all the tagged smolts passing through the bypass system at these dams, Prentice et al. (1986) estimated that only 5 to 10% of the traditional number of fish are needed to collect statistically valid data. This is extremely useful in research on wild and natural anadromous fish populations, where the large numbers of fish are not easily obtained.

The first field season's overall tagging mortality rate of 3.1% for this project demonstrates that PIT tagging wild and natural chinook salmon and steelhead trout parr can be accomplished in rearing streams with relatively low mortality rates. Use of an electrofisher designed to operate in low conductivity waters effectively collected chinook salmon and steelhead trout parr, with a collection mortality of 2.0%.

The plastic trash cans used to hold fish were found to be somewhat difficult to use because of their tendency to tip over, and two fish were killed when crushed by boulders used to stabilize the containers.

Stream temperature was found to have a significant affect upon both collection and tagging mortalities. Tagging operations conducted when the stream temperature was over 15°C resulted in an overall tagging mortality of 6.7%.

The mortalities associated with using PIT tags to tag wild and natural parr appear to occur during capture and actual tagging of the fish. Our single 24-h delayed mortality test on 33 chinook salmon and 29 steelhead parr resulted in no mortalities. This supports extensive testing on hatchery chinook and steelhead parr by NMFS, which found delayed mortalities to be negligible (Prentice et al. 1986).

The types of information that PIT tags are being used to collect in this study include: Parr-to-smolt survival, smolt-to-adult survival, migration survival, migration timing, and locating overwintering areas. Because data is gathered from individual fish, the information listed above will be correlated with such variables as length, weight, condition, stock, rearing stream, migration characteristics, and method of hatchery supplementation.

Presently, the PIT tag length and weight data enables us to make some observations about the growth of chinook and steelhead parr in the streams sampled (Table 4). For chinook, the growth rate in Pole Creek appears to be greatest of the streams sampled and the growth rate in Alturas Lake Creek may be least of the streams sampled. For steelhead, it appears that the growth rates in Pole and Smiley creeks are greater than in the Salmon River and Alturas Lake Creek; however, the sample size in Alturas Lake Creek was small.

Because they contain no batteries, PIT tags have a virtually unlimited life span that allows for the collection of adult return data. Currently, the only PIT tag adult detection system is located in the fishway at Lower Granite Dam. Hopefully, by 1990 adult detection systems will be installed at Bonneville and McNary dams. Without at least these two additional adult detection systems, important adult migration timing and survival data cannot be collected.

RECOMMENDATIONS

Habitat Evaluation and Fish Densities

We will continue to use Petrosky and Holubetz's (1985) modifications of Platts et al. (1983) stream habitat evaluation methodologies and to use the snorkel methodologies of Petrosky and Holubetz (1985) to estimate total abundance of steelhead and chinook parr during July and August. Parr densities will be monitored annually at each study section, and physical habitat monitoring will be conducted on an alternating basis with each study section being sampled every other year. This decision is based upon the fact that long-term changes in summer parr densities will exhibit much greater variability as compared to physical habitat.

The Idaho common data bases for parr density and physical habitat data will be used to organize and analyze the project's data beginning in winter 1988-1989.

Tagging and Tag Monitoring

With the experience gathered during the 1987 field season, some minor changes will be made in the 1988 fish collecting methods. These changes are intended to lower the mortality rates and make the operation more efficient. The seines have been dyed brownish green in an attempt to

Table 4. Length and weight data for PIT-tagged parr from the upper Salmon River study area, 1987.

Chinook Salmon

	Length				Weight			
	# of fish	mean	min.	max.	# of fish	mean	min.	max.
All fish	1,768	75	52	142[a]	1,389	5.3	1.8	33.1[a]
Pole Creek	218	82	61	99	211	6.9	2.9	11.1
Alturas Lake Cr.	127	72	60	123	127	4.9	2.6	23.8
Smiley Creek	60	75	67	116	60	5.4	3.6	12.8
Salmon River	1,363	74	52	142	991	5.0	1.8	33.1

Steelhead Trout

	Length				Weight			
	# of fish	mean	min.	max.	# of fish	mean	min.	max.
All fish	1,461	130	55[b]	238[c]	1,398	29.4	4.8[b]	166.6[c]
Pole Creek	391	136	82	238	238	33.9	7.6	166.6
Alturas Lake Cr.	6	125	95	138	6	24.8	11.6	31.3
Smiley Creek	131	142	95	198	129	36.8	7.8	90.3
Salmon River	933	126	55	222	901	26.5	4.8	120.0

[a] PIT tags were implanted inadvertently into a few yearling chinook.
[b] PIT tags were implanted into primarily age 2+ steelhead.
[c] May include a few resident rainbow trout.

reduce fish avoidance. The seines will be used whenever possible because they induce a lower mortality rate than electrofishing. Live boxes will be built to eliminate the problems encountered in using the plastic trash cans to hold the fish. PIT tagging operations will cease when the stream temperature exceeds 15°C to avoid the higher mortality rates encountered when tagging at high water temperatures.

One use of the length and weight data collected in our PIT tagging operation will be to determine the effect of fish length, weight, and condition on smolting success by regression analysis. With this information, we will be able to more accurately estimate smolt production in the general monitoring streams by combining length and weight data with parr densities.

A future advantage to using PIT tags in the intensive monitoring is the potential to PIT tag parr in the general monitoring sites and then pair the PIT tag data from the intensive and general monitoring sites. By using PIT tags and pairing the data, we will be able to determine more accurately Parr-to-smolt survival rates and collect migration information from other Idaho streams.

Downstream Migrant Trapping

The scoop trap for the Sawtooth Hatchery weir will be installed and operated beginning March 14, 1988 to collect smolt migration data from the upper Salmon River study area. This trap will be fished continuously until high runoff occurs in mid to late May, reinstalled in June, and fished intermittently until catches increase in August and then fished continuously until migration ceases in late October-early November.

The scoop trap for Crooked River will be purchased and installed by August 15, 1988. For this trap, the USFS has agreed to build a rock weir to concentrate the stream flow. This rock weir will be located at the site where the adult trapping facility is to be built. This trap will be operated beginning August 15, 1988 and fished continuously until the fall migration ceases in late October-early November.

Hatchery Supplementation

In 1988, we will plant 24,000 chinook fingerlings into both Smiley Creek and lower Pole Creek and 21,500 fall parr into both the Salmon River above Highway 75 and lower Alturas Lake Creek. If the fish are available, we will outplant 15 pair of adult chinook salmon into both Frenchman Creek and upper Pole Creek. In October 1988, eyed eggs will be buried in Beaver Creek and upper Alturas Lake Creek to match the number that would have been produced had the adults outplanted been kept in the Sawtooth Hatchery.

Adult Escapement and Redd Counts

In the upper Salmon River study area, we will conduct a one-day peak redd count over the entire spawning habitat during the same period that the fisheries management biologists make their aerial count.

Until the weir is completed on Crooked River, we will use redd counts to estimate the number of eggs deposited. For chinook, we will make a one-day peak redd count over the entire spawning habitat during the same period that the fisheries management biologists make their partial index count. By determining what proportion of the entire count is found in the partial count, we will be able to estimate the number of eggs deposited in past years. For steelhead in the Crooked River, we will make one-day peak counts in those years that water conditions permit until the weir and trap are installed.

LITERATURE CITED

Bjornn, T.C. 1978. Survival, production, and yield of trout and chinook salmon in the Lemhi River, Idaho. University of Idaho, Forest, Wildlife, and Range Experiment Station, Completion Report, Project B-036-IDA, Moscow, Idaho.

Bowles, E.C. and T. Cochnauer. 1984. Potential sockeye salmon production in Alturas Lake Creek drainage, Idaho. Idaho Department of Fish and Game, prepared for U.S. Department of Agriculture, Forest Service, Sawtooth National Forest.

Buell, J.W. 1986. Stream habitat enhancement evaluation workshop: a synthesis of views. U.S. Department of Energy, Bonneville Power Administration, Division of Fish and Wildlife, Portland, Oregon.

Emmett, W.W. 1975. The channels and waters of the upper Salmon River area, Idaho. U.S. Geological Survey Professional Paper 870 - A.

Everman, B.W. 1895. A preliminary report upon salmon investigations in Idaho in 1894. Bulletin U.S. Fish Commission 15:253-28

Goldstein, R.M. 1978. Quantitative comparison of seining and underwater observation for stream fishery surveys. Progressive Fish-Culturist 40(3):108-111.

Hair, D. and R. Stowell. 1986, South Fork Clear-water, River habitat enhancement. Annual Report. Department of Energy, Bonneville Power Administration, Division of Fish and Wildlife, Portland, Oregon.

Hall-Griswold, J. and T. Cochnauer. 1988. Salmon and steelhead investigations, Study 1, Salmon spawning ground survey. Federal Aid in Fish Restoration, Job Performance Report, Project F-73-R-10. Idaho Department of Fish and Game.

Idaho Department of Fish and Game. 1985. Idaho anadromous fish management plan, 1985-1990. Idaho Department of Fish and Game.

Mallet, J. 1974. Long range planning for salmon and steelhead in Idaho. Job 2: Inventory of salmon and steelhead resources, habitat, use, and demand. Job Performance Report, Project F-58-R-1, Idaho Department of Fish and Game.

Ortmann, D.W. 1968. Salmon and steelhead investigations, Job 1, Southfork of the Salmon River, salmon and steelhead harvest and escapement studies. Federal Aid in Fish Restoration, Job Completion Report, Project F-49-4-6. Idaho Department of Fish and Game.

Petrosky, C.E. and T.B. Holubetz. 1985. Idaho habitat evaluation for off-site mitigation record, Annual Report, 1984. Idaho Department of Fish and Game for U.S. Department of Energy, Bonneville Power Administration, Division of Fish and Wildlife, Portland, Oregon.

Petrosky, C.E. and T.B. Holubetz. 1986, Idaho habitat evaluation for off-site mitigation record, Annual Report, 1985. Idaho Department of Fish and Game for U.S. Department of Energy, Bonneville Power Administration, Division of Fish and Wildlife, Portland, Oregon.

Petrosky, C.E. and T.B. Holubetz. 1987. Idaho habitat evaluation for off-site mitigation record, Annual Report, 1986. Idaho Department of Fish and Game for U.S. Department of Energy, Bonneville Power Administration, Division of Fish and Wildlife, Portland, Oregon.

Platts, W.S., W.F. Megahan, and G.W. Minshall. 1983. Methods for evaluating stream, riparian, and biotic conditions. U.S. Department of Agriculture, GTR INT-138.

Prentice, E.F., D.L. Park, T.A. Flag, and C.S. McCutcheon. 1986. A study to determine the biological feasibility of a new tagging system: 1985-1986. National Marine Fisheries Service, Northwest and Alaska Fisheries Center, Seattle, Washington. Bonneville Power Administration Contract Number DE-A179-84BP11982, Project Number 83-319.

Torquemada, R.J. and W.S. Platts. 1988. A comparison of sediment monitoring techniques of potential use in sediment/fish population relationships, Part III in Idaho Department of Fish and Game. 1988. Idaho habitat evaluation for offsite mitigation record, Annual Report, fiscal year 1987. Department of Energy, Bonneville Power Administration, Division of Fish and Wildlife.

White, L.E.. 1980. Evaluation of a new planting device for salmon eggs. The Progressive Fish-Culturist 42(3):177-180.

A P P E N D I X

PIT Tag Technical Information

The passive integrated transponder (PIT) tag was developed by Identification Devices Inc., of Denver, CO., and tested for applicability in fisheries research by the National Marine Fisheries Service (NMFS). Physically, the PIT tag is a silicon computer chip and a copper antenna encapsulated in a glass cylinder 10-mm long and 2.1-mm in diameter. The tag is smooth, leak-proof, and totally biologically inert.

The energy to operate the PIT tag is supplied by a radio-frequency pulse that is produced by the detection system, When a tagged fish passes through this radio-frequency pulse, the microprocessor chip in the tag is energized by electromagnetic energy. The energized microprocessor chip then transmits its unique 10 digit alphanumeric code which is received and decoded by the detection system. With this 10 digit alphanumeric code system, there are about 32 billion possible code combinations. Because the PIT tag is passive until energized by a detector, it has for all practical purposes an unlimited life span and can be recycled.

NMFS studies have found the glass encapsulated version of the PIT tag highly reliable in tagging fish as small as 3 g (65 mm) with a tag retention rate of higher than 99% (Prentice et al. 1986). To implant the PIT tag, a 12-gauge needle and modified hypodermic syringe are used to inject the tag into the peritoneal cavity of the fish. On juvenile fish, the tag is inserted just off the mid-ventral line about one-quarter of the distance between the end of the pectoral fin and the pelvic girdle. Immediately after the needle enters the body cavity, the needle angle is changed so that the needle is in contact with the inner surface of the body wall and the tag is implanted. After tagging, tag presence can be confirmed using a handheld detection-decoding device. Of the few fish that die due to perforated organs during tag implantation, almost all will show behavioral changes and/or darkening of color almost immediately after tagging. NMFS has found that once a functional tag has been successfully implanted in a fish, the tag failure rate has been 0%.

Currently, there are three different basic detector systems being used with PIT tags. The first is a small 6-inch square detector used to send a tagged fish's identification code directly to a computer data collection system during large-scaled tagging operation, such as those at a hatchery. The second is a handheld detector that is primarily used in the field. The handheld detector sounds a tone when a reading is completed and displays the code on a liquid crystal display until it is reset. The handheld detector can store over 1,300 tag codes, or it can feed the codes directly into a computer. The third detector system which is installable at fish ladders, weirs, smolt bypass systems, or other sites is a series of 18-inch maximum diameter pipes with detector loops built in. This system is automatic and interfaces with a computer on site that is connected to a power interruption protection unit. Currently, this type of detector system is installed in the smolt bypass systems at Lower Granite, Little Goose, and McNary dams. Plans have been made to have detection systems operating in the adult fish ladders on several of the Columbia Basin dams in the next several years.

Tests by NMFS have shown that tagged smolts can be automatically recognized at a rate of 97-100% by detection-recording devices located within the smolt collection facilities at hydroelectric dams. With information being collected for each individual fish and with detection of virtually all the tagged smolts passing through the bypass system, NMFS has estimated that only 5-10% of the traditional number of tagged or marked fish are needed to collect statistically valid information (Prentice et al. 1986).

Part V

Subproject II

JOHNSON CREEK

PASSAGE BARRIER REMOVAL

Final Report

Prepared by

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and

C.E. Petrosky, Staff Biologist

IDAHO DEPARTMENT OF FISH AND GAME

Prepared for

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Contract No. DE-AI79-84BP13381
Project 83-7

December 1988

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INTRODUCTION

The Columbia River Basin Fish and Wildlife Program, Section 703(c), calls for enhancement of salmon habitat by modifying natural impediments to migration in the South Fork Salmon River and tributaries. In 1983, Idaho Department of Fish and Game (IDFG) identified the natural barriers in Johnson Creek downstream from Landmark as being one of the most effective habitat enhancement measures in Idaho. The U.S. Forest Service was contacted and they indicated that they were not interested in implementing the proposed project. The Forest Service was supportive of Idaho Department of Fish and Game implementing this project,

The IDFG submitted a project proposal to BPA in 1984 to remove the barriers to salmon migration in Johnson Creek.

Johnson Creek supports runs of summer steelhead and summer chinook. Adult steelhead apparently could pass these barriers during most flows, but the upper basin produced few juvenile steelhead. Adult chinook were blocked from the upper drainage during low flows of late summer. In most years, chinook spawning and rearing were restricted to the lower end of Johnson Creek. Known passage by adult chinook to the upper meadow prior to the project consists of seine samples of juvenile chinook near Rock Creek in 1976, observations of a single chinook redd near Rock Creek in 1983, and five chinook redds in the upper meadow in 1960 (Petrosky and Holubetz 1985). A sheepherder also reported that salmon were very numerous in Sand Creek in the early 1930s.

Resident salmonids of Johnson Creek include rainbow trout, bull trout, brook trout, and mountain whitefish (Mallet 1974) and cutthroat trout. Brook trout dominated the fish community in the upper meadow.

The upper basin of Johnson Creek has received less development than many other South Fork Salmon River watersheds. Roads follow the entire main stem of Johnson Creek and some of the upper tributaries (e.g., Sand Creek, Whiskey Creek, and lower Rock Creek). Livestock grazing has degraded riparian habitat and sedimentation is high in parts of the upper basin.

Objectives of the BPA-funded project in Johnson Creek were to: (1) modify the natural barriers to allow passage by adult chinook into the upper basin, (2) establish summer chinook in habitat made available by the barrier removal project, (3) improve passage conditions for wild steelhead, and (4) increase natural production of anadromous fish consistent with IDFG (1985) Anadromous Fish Management Plan for Subbasin SA-3.

METHODS

In the fall of 1983, Terry Holubetz, Staff Fishery Biologist, and Phil Jeppson, Engineer, walked the Johnson Creek canyon from Burnt Log Creek to Park Creek. Four natural rock barriers were located in this section of the stream (Figure 1). Field drawings of the barriers were constructed, and vertical drop and width measurements were taken. The field data were used to develop cost estimates and a conceptual approach to providing passage.

A technique of selectively removing large boulders and portions of boulders was determined to be the best approach. Selective drilling and blasting of individual rocks to create lower overpours, jumping pools, and escape avenues above the falls were the means selected to alleviate the problems caused by the rock falls. Two Pionjar Model 120 drills were used on this project. Integral bit-type drill steel in 2-,4-, and 6-foot lengths was employed. Although none of the rocks to be removed required holes to be drilled in excess of 4 feet, the location of some of the holes required the use of 6-foot steel to obtain a 4-foot hole. The blasting agent was 40% strength dynamite in l-inch-diameter sticks, Electric detonators were used in delay, with the maximum delay being 5 milliseconds. In the fall of 1984, a consulting engineer, Department biologist, and a contract crew of driller/blasters were employed to remove rock from Barriers 1, 2, 3, and 4 (Figure 1). Additional modifications were completed on these barriers in the summer of 1985 using the same techniques. In the spring 1986, a low level helicopter survey of Johnson Creek steelhead spawning activity revealed an additional barrier (5) near the mouth of Pid Creek. In the fall of 1986, the drilling and blasting of large boulders and bedrock at the barrier and the movement of some large (car-sized) boulders from the embankments to the lower end of the pool downstream from Barrier 5 were accomplished. This technique was used to successfully reduce the vertical drop at this barrier and to improve the jumping pool downstream from the drop.

RESULTS

All migration barriers in Johnson Creek were modified to provide passage for chinook salmon and steelhead during the period 1984-1986. These barriers were total migration blocks to chinook salmon and partial blocks to steelhead when the project was initiated.

Barriers 1, 2, 3, and 4 were modified in 1984 and 1985 as illustrated in Figures 2 through 5. Barrier 5 was modified in 1986 as illustrated in Figure 6.

A total of 68 stream kilometers and 436,000 m^2 of rearing habitat was made accessible to summer chinook above the barriers (Table 1). In addition, 3 km of Johnson Creek immediately below the barriers will be seeded by upstream spawning realized by the project.

In 1986, snorkel surveys were conducted in Johnson Creek, and an adult chinook salmon was observed upstream from Barrier 4 and downstream from Barrier 5. This was the only adult chinook observed above the barriers during the years 1984 through 1987.

The barriers were not as much of an impediment to steelhead migration, and steelhead redds were observed in the vicinity of the mouth of Sand Creek in 1986 and 1987.

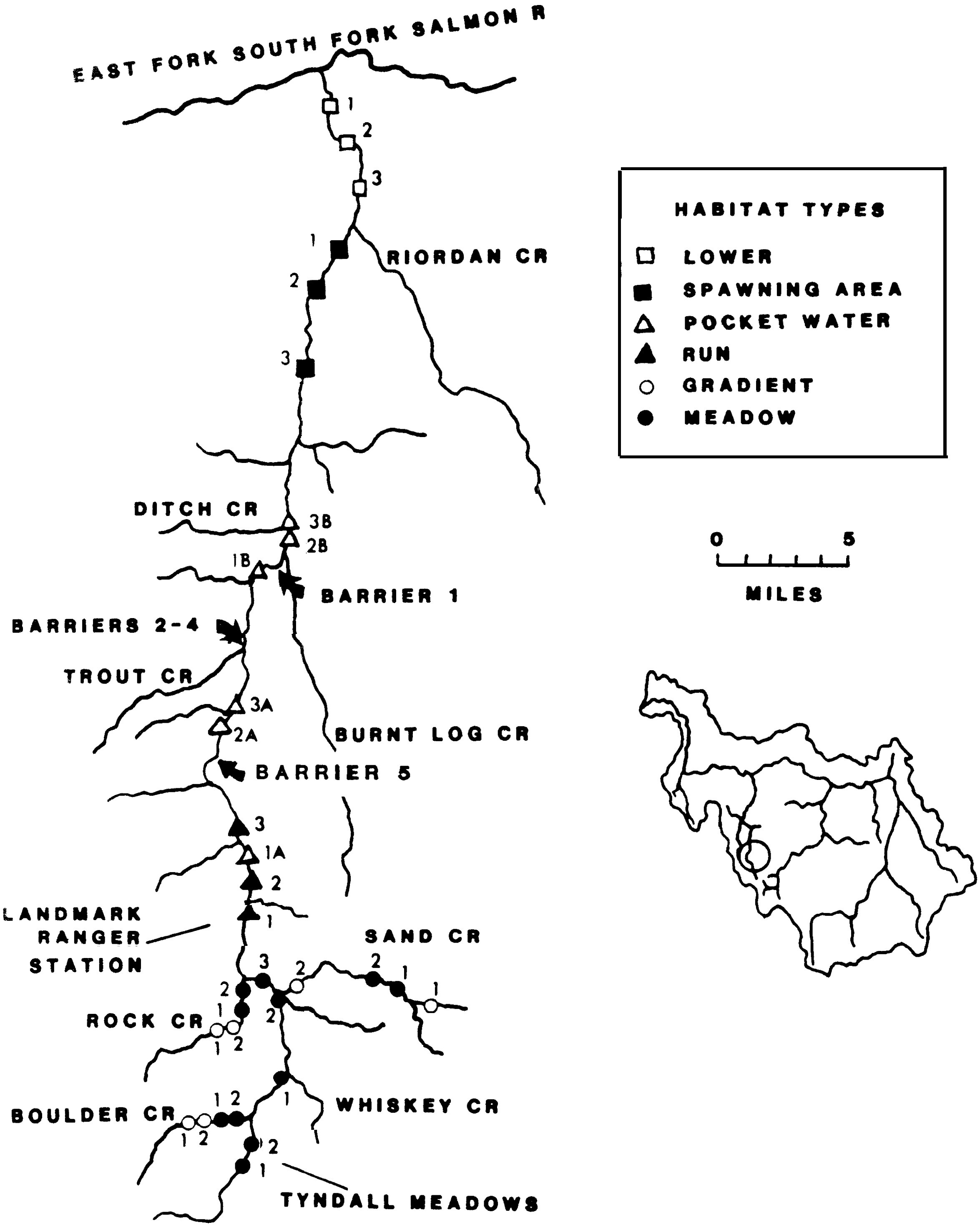


Figure 1. Location of 1984-1986 barrier removal project on Johnson Creek and established monitoring sections.

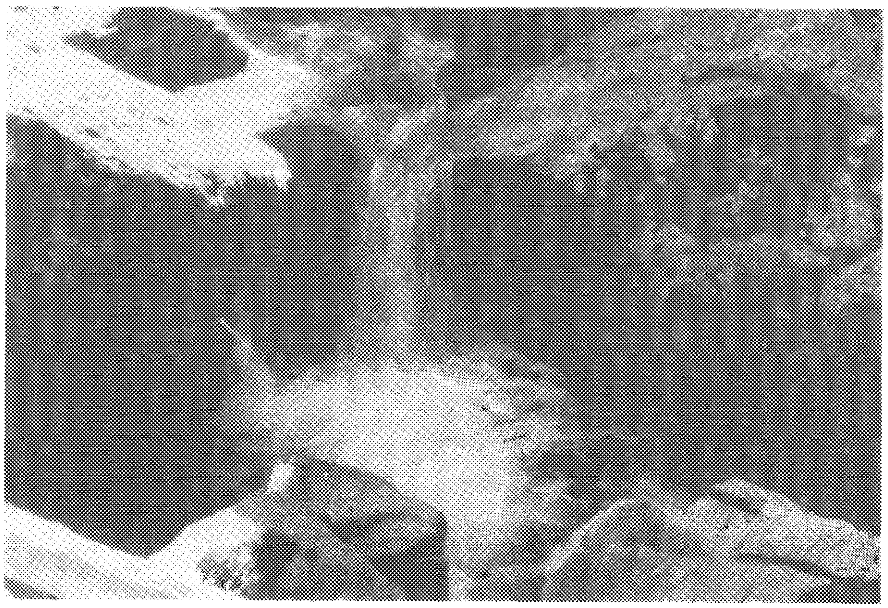


Figure 2. Barrier 1, Johnson Creek. Shaded area indicates rock removed by project.

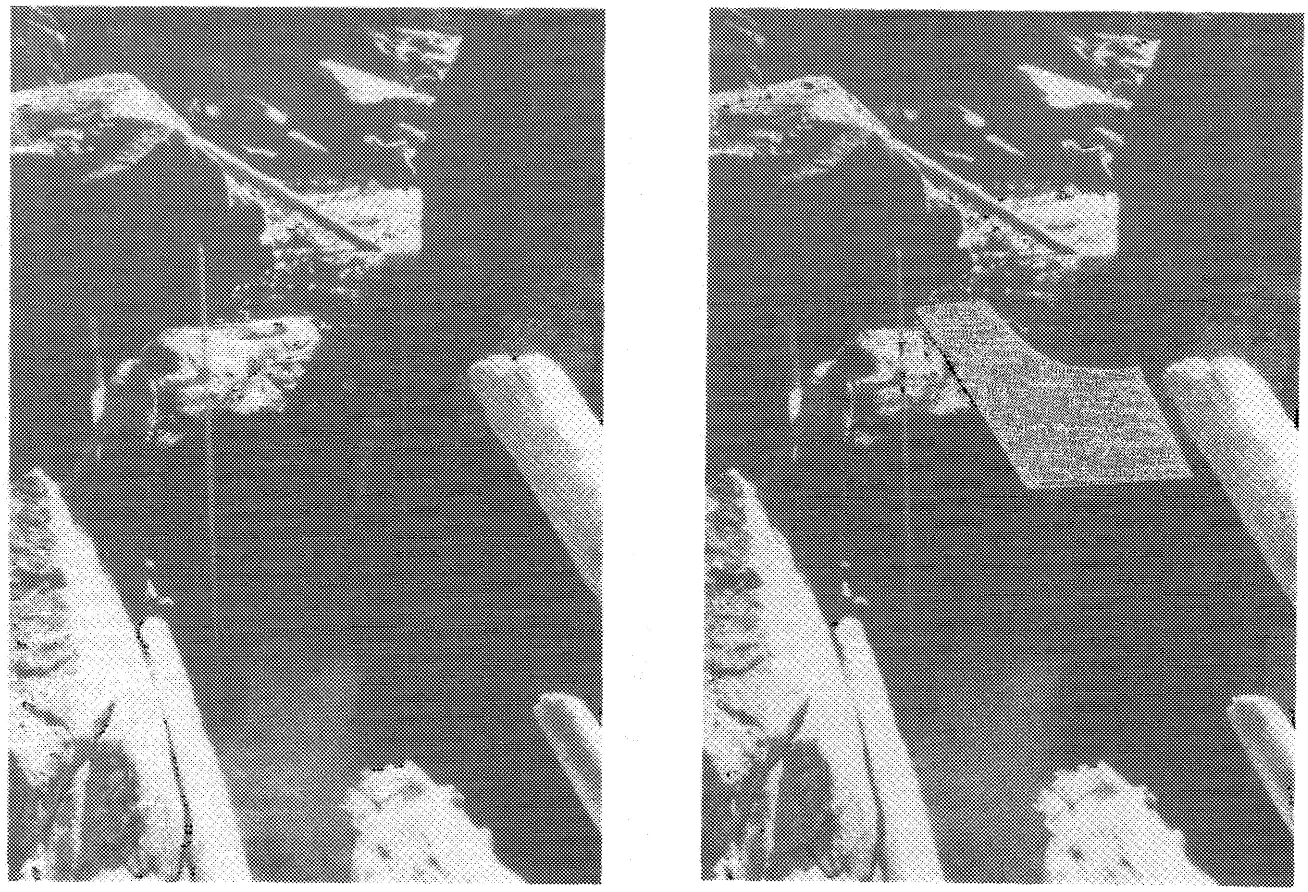


Figure 5. Barrier 2, Johnson Creek, Shaded area indicates rock removed by project.

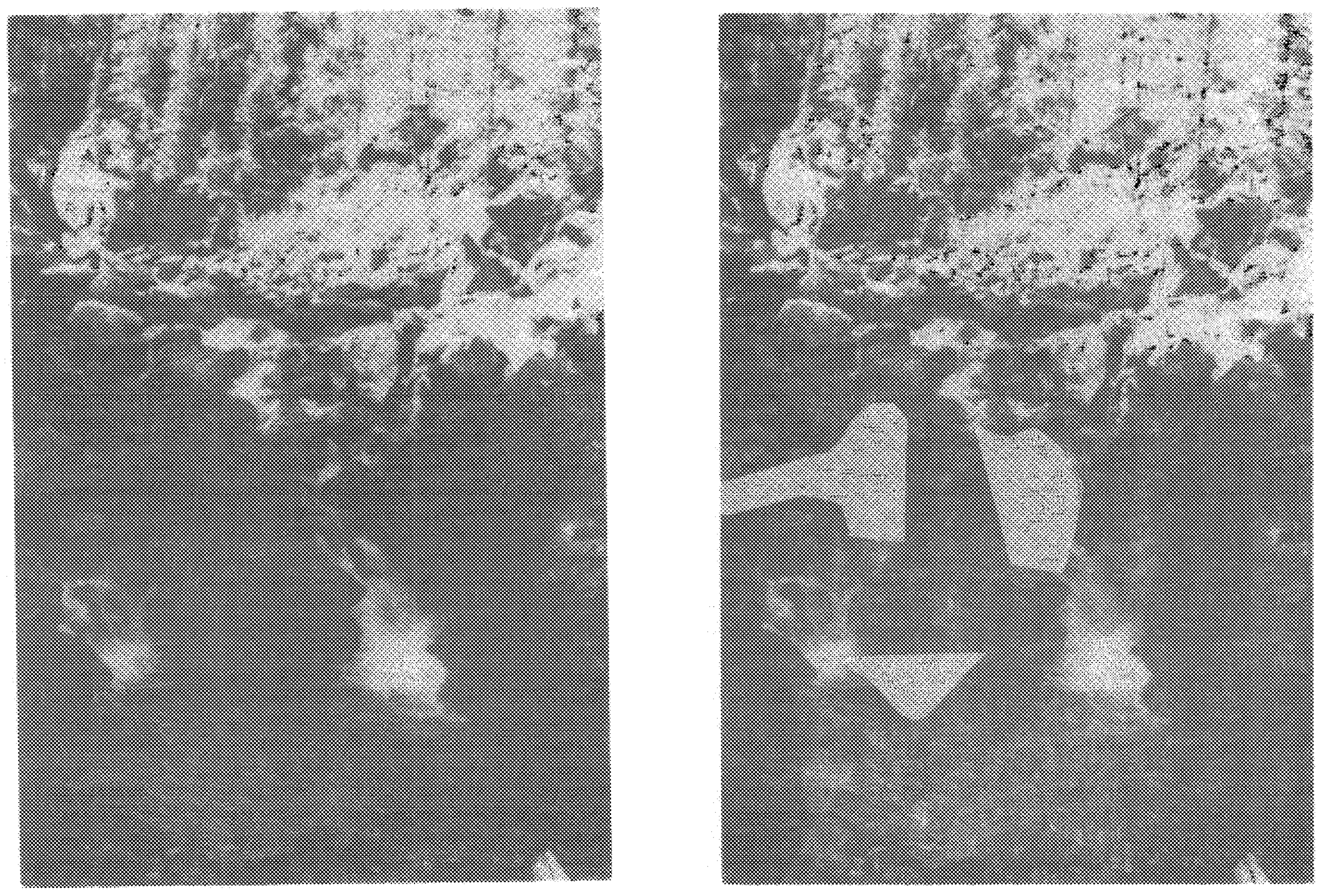
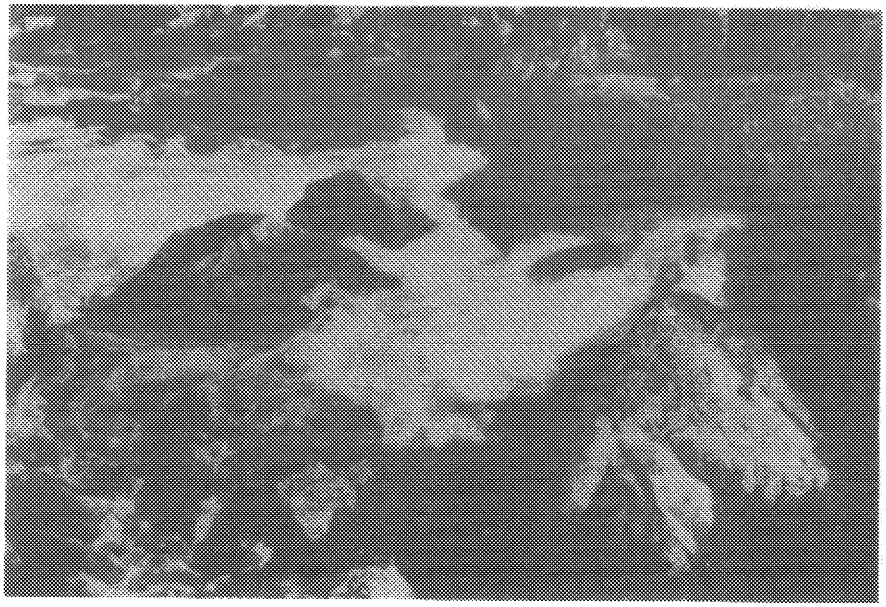


Figure 4. Barrier 3, Johnson Creek. Shaded area indicates rock removed by project.



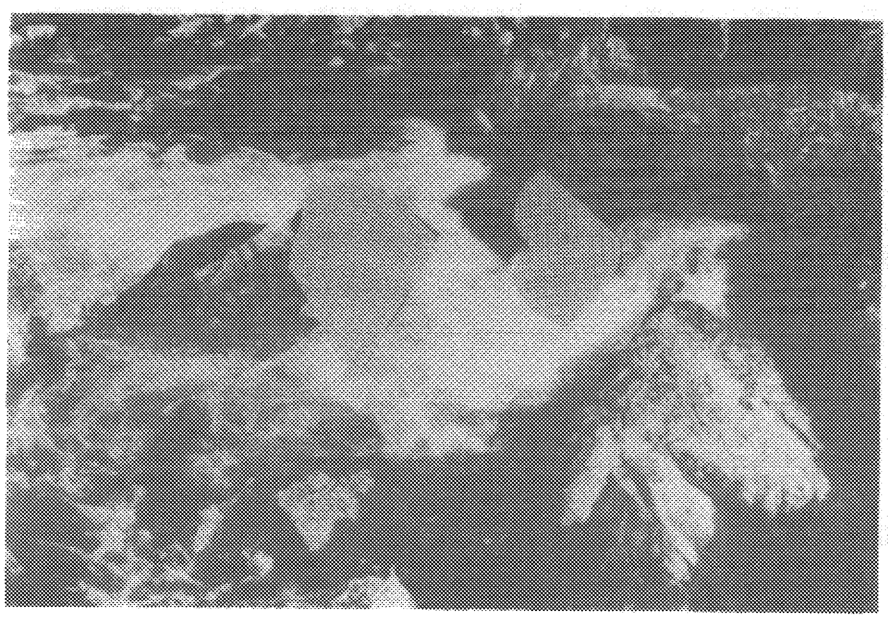


Figure 5. Barrier 4, Johnson Creek. Shaded area indicates rock removed by project.

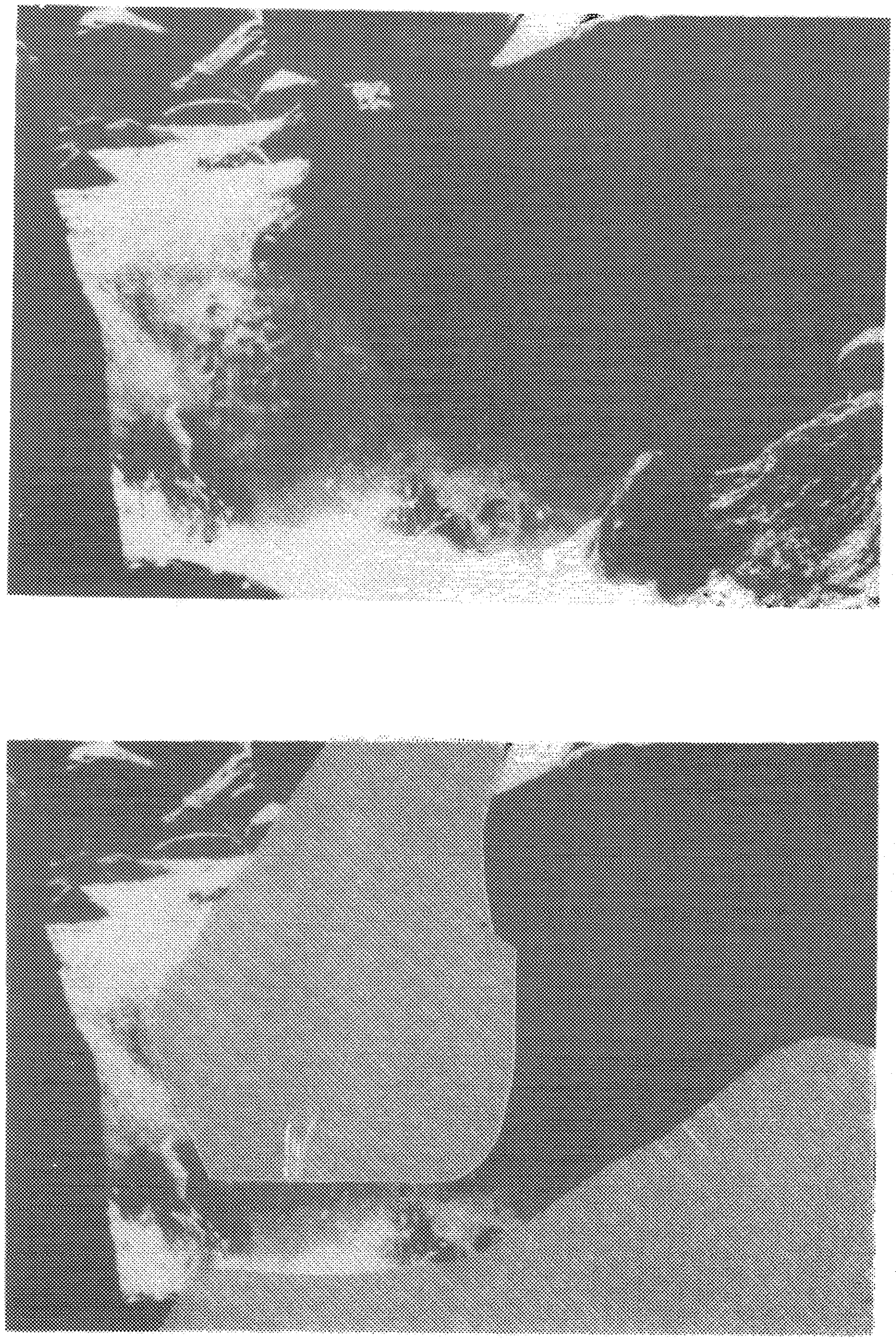


Figure 6. Barrier 5, Johnson Creek. Shaded area indicates rock removed by project.

Table 1. Projected effects of passage improvement project on Johnson Creek.

CONTRACT NUMBER: DE-AI79-84BP13381
PROJECT NUMBER: 83-7
PROJECT NAME: SUBPROJECT II. HABITAT PASSAGE
SUBBASIN NAME: SALMON RIVER
LOCATION: STATE: IDAHO
TYPE OF PROJECT: INSTREAM ___ PASSAGE X PONDS ___
PUBLISHED IN:
CONTRACTOR: IDAHO DEPARTMENT OF FISH AN0 GAME TYPE: FEDERAL ___ STATE X TRIBE ___ PRIVATE ___
PROJ. LEADER: TERRY HOLUBETZ
EPA STREAM SEG./MILE CODE: 1706020804700/MILE 16.5
STREAM ORDER:
BEGINNING DATE: 1984
COMPLETION DATE: 1986
PRESENT STATUS: COMPLETE
PROJECT LIFE (YEARS): 50+

RELATED PROJECT NUMBERS:
STREAM(S): JOHNSON CREEK
TARGET SPECIES: SUMMER CHINOOK
COUNTY: VALLEY

HABITAT DESCRIPTION	PRE-PROJECT CONDITIONS	POST-PROJ. CONDITIONS	PREDICTED CHANGE	ACTUAL CHANGE	POTENTIAL SUMMER CHINOOK FISH PRODUCED PER UNIT OF HABITAT PARR/ML PREDICTED	ACTUAL
SPAWNING AREA (SQ. M.)						
REARING AREA (SQ. M.)	0	436,000	436,000	436,000	0.54	
TOTAL USABLE AREA (SQ. M.)	0	436,000	436,000	436,000	0.54	
STREAM LENGTH (MILES)	0	42.7	42.7	42.7		
POOL/RIFFLE RATIO			0			
PONDS (NO. & TOTAL ACREAGE)			0			
SIDE CHANNELS (SQ. M.)			0			
RIPARIAN			0			
AREA (ACRES)			0			
STREAM LENGTH (MILES)			0			
DOWNSTREAM IMPACT (MILES)	0	2	2	2	0.37	
WATER TEMP. (DEG. C.)						
SEDIMENT						

FISH PRODUCTION (NUMBERS)

*SEE ATTACHED STOCK ASSESSMENT OF COLUMBIA RIVER ANADROMOUS SALMONIDS

	SPECIES	CODE*				
JUVENILE:	SUMMER CHINOOK		0	248,000	248,000	
SMOLT:						
ADULT:						

Stocking of chinook salmon fry from the South Fork Salmon River stock at McCall Hatchery into upper Johnson Creek has established salmon populations above the barriers (Table 2) and has afforded an opportunity to assess the rearing potential of the area.

Studies by Welsh (1988) in 1985-1987 provided an estimate of rearing potential for upper Johnson Creek of 375,000 chinook parr. Idaho Department of Fish and Game has estimated the rearing potential of upper Johnson Creek (above the barriers) to be 236,000 chinook parr. The 3 km immediately below the barriers would rear an additional 12,000 parr due to seeding from spawning areas opened by the project. This potential will not be realized unless significant improvements in downstream migrant survival are also provided by the Fish and Wildlife Program and harvest management in the Pacific Ocean and Columbia River is conducted in a manner that allows adequate spawning escapements to return to upper Johnson Creek.

Total cost of this project was $19,162.

DISCUSSION

The capability to naturally produce approximately one-quarter million smolts annually at a cost of approximately $19,000 is believed to be an extremely cost-effective enhancement measure,

If grazing, timbering, and other land management activities are conducted in a manner that reduces sediment input to upper Johnson Creek, the future rearing potential could be considerably increased over the present level. This type of improvement could increase the mitigation level of this project over time.

Some maintenance and monitoring of passage conditions will be required in the future. Large boulders could move and create new migration barriers in the vicinity of Barriers 2 through 4 in future years. Idaho Department of Fish and Game will monitor the condition of the improvements annually.

The summer chinook salmon population will be managed for natural production in Johnson Creek, with some hatchery supplementation occurring when needed. Upper Johnson Creek will be stocked with fry from the McCall Hatchery until natural spawning of adults seed the area adequately.

The summer steelhead population will be managed for wild production, and no hatchery supplementation of steelhead will occur in upper Johnson Creek. Because steelhead were able to ascend the barriers into upper Johnson Creek prior to the implementation of the BPA project, no mitigation credit can be assigned to this project for steelhead.

Table 2 Numbers of summer chinook fry stocked into Johnson Creek drainage above the barrier removal project, 1984-1988.

Year	Number of fry	Number of parr (August)	Percent survival
1984	0	0	
1985	50,744		
1986	178,606	23,711	13.4
1987	118,424	17,700	15.0
1988	366,800		

LITERATURE CITED

Idaho Department of Fish and Game. 1985. Idaho Anadromous Fish Management Plan, 1985-1990. Boise, Idaho.

Welsh, T.L. 1988. Evaluation of the Johnson Creek fish passage improvement projects, Part II, in Idaho Department of Fish and Game. 1988, Idaho habitat evaluation for off-site mitigation record. Annual report, fiscal year 1987. Department of Energy, Bonneville Power Administration, Division of Fish and Wildlife.

Part VI

Subproject II

BOULDER CREEK

PASSAGE BARRIER REMOVAL

Final Report

Prepared by

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IDAHO DEPARTMENT OF FISH AND GAME

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Contract No. DE-AI79-84BP13381
Project 83-7

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Appendix B-12. Proposed definition of mitigation benefits for implemented project, Johnson Creek.

Project type: Passage barrier

Year implemented: 1984-1986

Sponsor: Idaho Department of Fish and Game

Enhancement	Species benefited Summer chinook
Production type	natural
Hectares added	50.0

Production constraints: High sediment levels in portions of drainage.

Definition of benefits: Natural rock barriers that completely blocked adult chinook passage were modified. Benefits will be estimated from total abundance of chinook parr reared above the barriers. Parr-to-smolt survival rates will be applied based on the intensive studies.

A total of 186,000 and 118,424 summer chinook fry were stocked into the upper Johnson Creek drainage in 1986 and 1987. Total abundance of parr from these plants were estimated at 23,700 and 17,700 for the two years, respectively. Fry stocking did not fully seed the drainage either year.

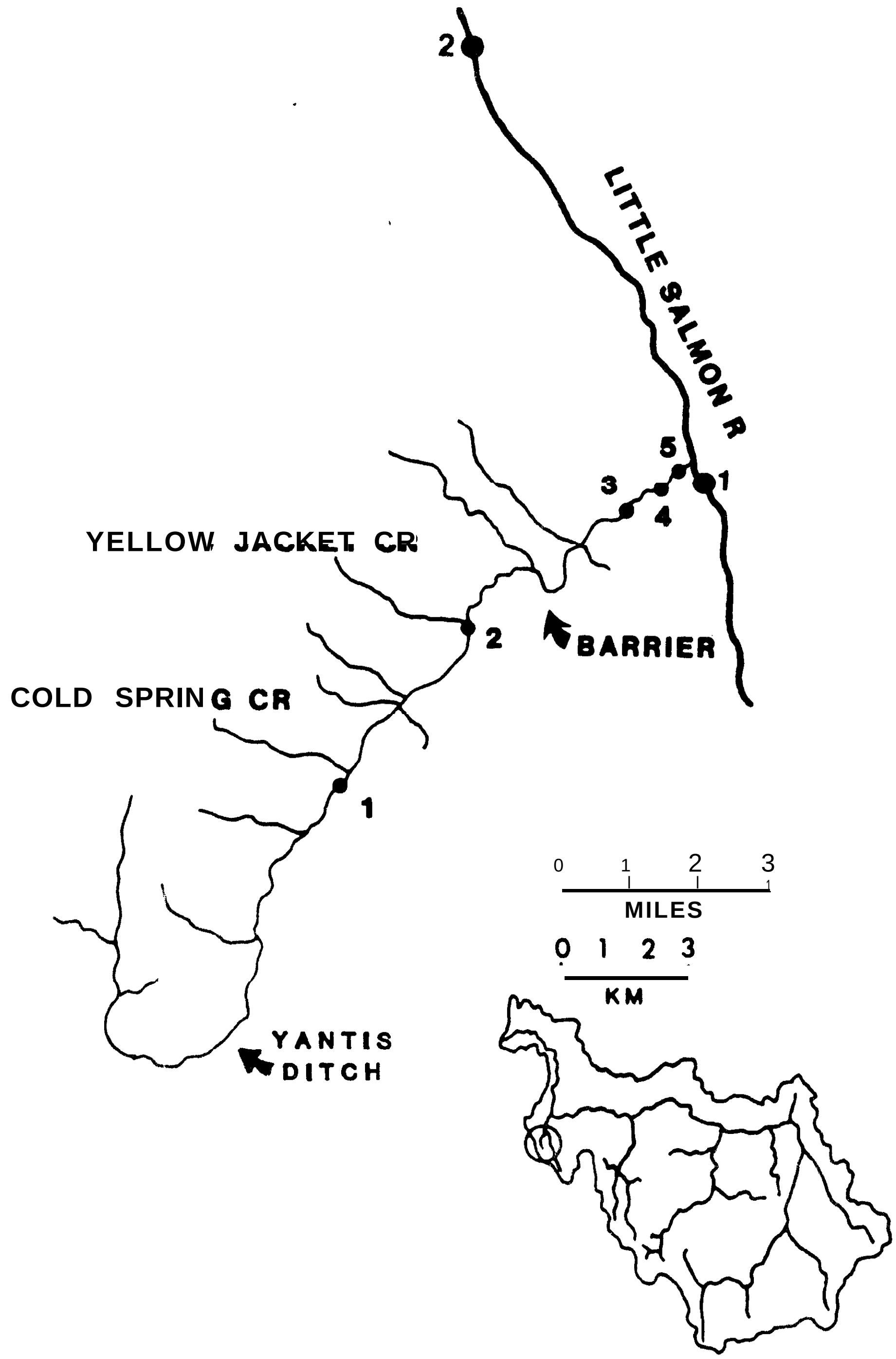

Figure [illegible]. Location of 1985 barrier removal project on Boulder Creek and established monitoring sections.

falls by removing portions of the solid granite sill to provide a "stair stepping' of two drops of about 1.2 to 1.5 m, with adequate jumping pools below each drop.

In September 1985, supplies were packed by horses into the Boulder Creek Canyon and a camp was set up approximately 500 m downstream from the barrier at one of the few flat places in the area. The drills, powder, and related equipment were dropped at the site by helicopter sling. Under the supervision of an IDFG engineer and a IDFG fisheries biologist, a contract blasting crew was directed to drill and blast portions of the solid granite ledge that formed the salmon migration barrier. Repeated drilling and shooting removed rock in smaller pieces from the ledge and prevented any excessive build up of large rock in the jumping pool below the waterfall.

A small basin was blasted in the downstream face of the ledge on the south bank of Boulder Creek. This basin has a depth of 0.4 m to 1.0 m, depending on flow, and is designed to provide a place for upstream migrants to land and make a secondary jump of approximately 0.3 to 1.0 m to complete their ascent of the waterfall.

The top of the northern half of the ledge was drilled and blasted. The removal of this rock was intended to lower the headwater pool elevation and thereby decrease the height of the waterfall.

To evaluate project effectiveness, IDFG biologists have observed salmon activity both above and below the waterfall.

Fry were taken from Rapid River Hatchery and stocked into upper Boulder Creek to establish the salmon population and to determine the rearing capacity of the habitat.

RESULTS

The drilling and blasting created a step in the face of the falls and lowered the height of the falls by approximately 0.2 m. Both effects of the project implementation should assist upstream migrating salmon. No blockage of upstream migration of adult salmon has been observed since the modifications were completed.

Modifications of the waterfall are illustrated in Figure 2. These modifications should allow salmon to pass this area in all flow conditions. Boulder Creek upstream of the barrier contains approximately 10.2 hectares of salmon habitat (Table 1).

This habitat is estimated to have a capacity to annually rear approximately 60,800 parr (Table 1). When the passage and harvest problems are resolved in the Snake 'and Columbia rivers, this project will yield approximately 60,800 parr annually, or approximately 40,700 smolts.

The numbers of fry and eyed eggs stocked and the estimated number of parr produced are provided in Table 2.

The total cost of this project was $6,900.

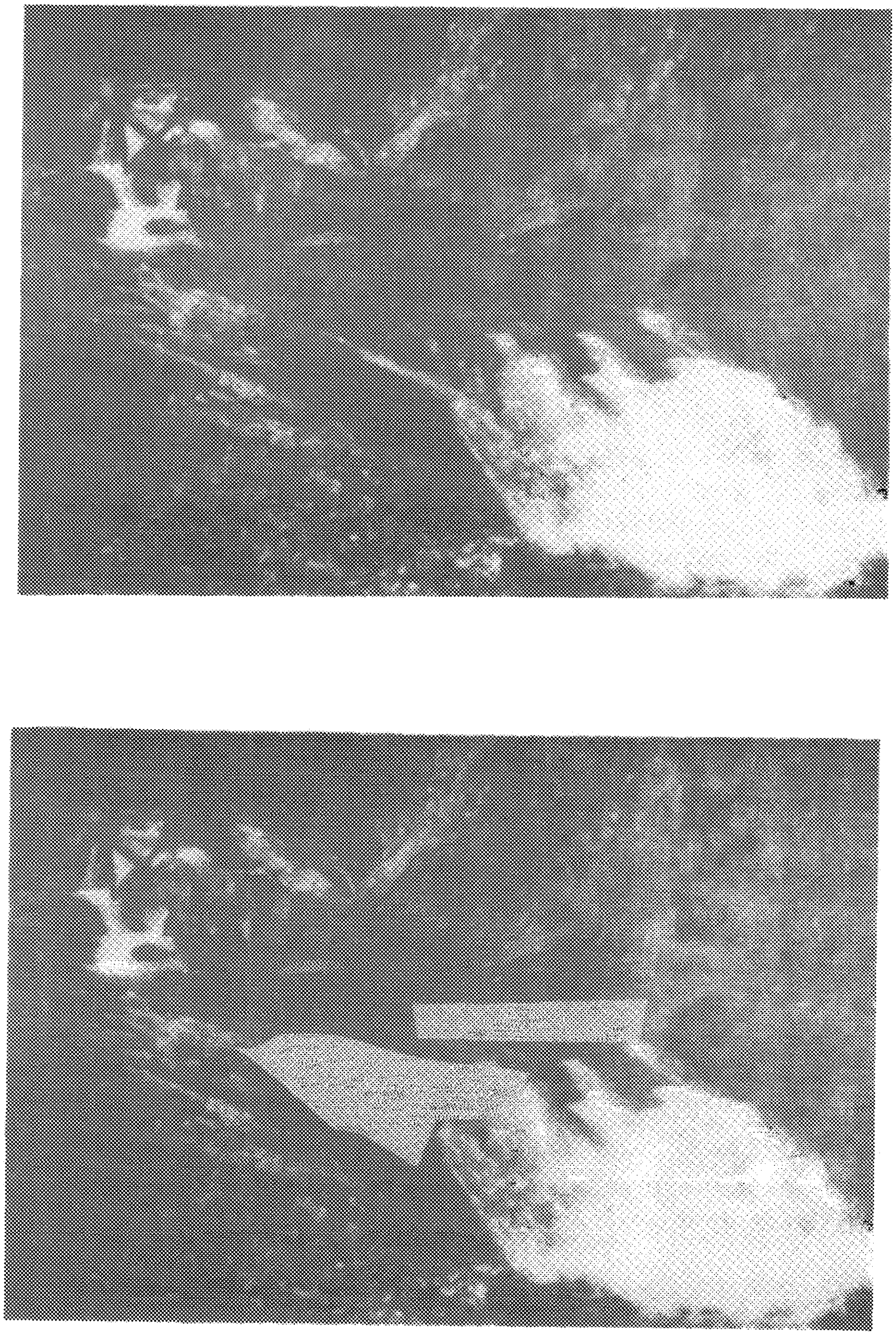

Figure 2. Passage barrier, Boulder Creek. Shaded area indicates rock removed by project.

Table 1. Projected effects of passage improvement project on Boulder Creek.

CONTRACT NUMBER: DE-AI79-84BP13381
PROJECT NUMBER: 83-7
PROJECT NAME: SUBPROJECT II. HABITAT PASSAGE
SUBBASIN NAME: SALMON RIVER
LOCATION: STATE: IDAHO
TYPE OF PROJECT: INSTREAM ___ PASSAGE X PONDS ___

RELATED PROJECT NUMBERS:
STREAM(S): BOULDER CREEK
TARGET SPECIES: SPRING CHINOOK
COUNTY: ADAMS

PUBLISHED IN:
CONTRACTOR: IDAHO DEPARTMENT OF FISH AND GAME TYPE: FEDERAL ___ STATE X TRIBE ___ PRIVATE ___
PROJ. LEADER: TERRY HOLUBETZ
EPA STREAM SEG./MILE CODE: 1706021000900/MILE 3.0
STREAM ORDER:
BEGINNING DATE: 1984
COMPLETION DATE: 1986
PRESENT STATUS: COMPLETE
PROJECT LIFE (YEARS): 50+

HABITAT DESCRIPTION	CONDITIONS	CONDITIONS	CHANGE	CHANGE	POTENTIAL FISH PRODUCED PER UNIT OF HABITAT PREDICTED	ACTUAL
SPAWNING AREA (SQ. M.)	0					
REARING AREA (SQ. M.)	0	108,000	108,000	108,000	0.56	
TOTAL USABLE AREA (SQ. M.)	0	108,000	108,000	108,000	0.56	
STREAM LENGTH (MILES)	0	12	12	12		
POOL/RIFFLE RATIO			0	0		
PONDS (NO. & TOTAL ACREAGE)			0	0		
SIDE CHANNELS (SQ. M.)			0	0		
RIPARIAN			0	0		
AREA (ACRES)			0	0		
STREAM LENGTH (MILES)			0	0		
DOWNSTREAM IMPACT (MILES)			0	0		
WATER TEMP. (DEG. C.)			0	0		
SEDIMENT			0	0		

FISH PRODUCTION (NUMBERS)

*SEE ATTACHED STOCK ASSESSMENT OF COLUMBIA RIVER ANADROMOUS SALMONIDS

	SPECIES	CODE*				
JUVENILE:	SPRING CHINOOK		0	60,800	60,800	
SMOLT:						
ADULT:						

Table 2. Numbers of spring chinook fry and eyed eggs stocked into Boulder Creek above the barrier removal project, 1984-1988.

Year	Stage stocked	Number stocked	Number of parr (August)	Percent survival
1984		0	0	-
1985		0	0	
1986	fry	99,900	28,112	28.1
1987		0	0	
1988	eyed eggs[a]	0	1,560	1.1

[a]Stocked October 1987, according to conventional shovel method (White 1980).

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DISCUSSION

Steelhead were not blocked by the waterfall and therefore no additional steelhead production potential will be realized through the implementation of this project.

When the full salmon production potential of Boulder Creek is realized, 60,800 parr should be credited to the BPA mitigation record. Until passage/flow improvements have been made, it will require hatchery supplementation to realize the full mitigation potential of this project.

Boulder Creek is managed by IDFG for natural production with outplanting of appropriate fish stocks to assist the population when there is inadequate natural spawning.

An annual yield potential of approximately 60,000 spring chinook salmon parr for a one-time cost of approximately $6,900 is an extremely cost-effective enhancement measure. No maintenance is anticipated for this project.

LITERATURE CITED

Idaho Department of Fish and Game. 1985. Idaho Anadromous Fish Management Plan, 1985-1990. Boise, Idaho.

White, L.E. 1980. Evaluation of a new planting device for salmon eggs. The Progressive Fish-Culturist 42(3):177-180.