June 1985

# IDAHO HABITAT EVALUATION FOR OFFSITE MITIGATION RECORD

Annual Report FY 1984

DOE/BP-13381-1

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# IDAHO HABITAT EVALUATION
# FOR OFFSITE MITIGATION RECORD

Annual Report FY 1984

by

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DIVISION OF FISH AND WILDLIFE

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# INTRODUCTION

In 1984 Idaho Department of Fish and Game (IDFG) undertook an evaluation of existing and proposed habitat improvement projects for anadromous fish in the Clearwater River and Salmon River drainages. Projects included in the evaluation are funded by, or are proposed for funding by, Bonneville Power Administration (BPA) under the Northwest Power Planning Act.

The Clearwater River and Salmon River drainages (Fig. 1) account for virtually all of Idaho's wild and natural production of summer steelhead and spring and summer chinook salmon, as well as a remnant run of sockeye salmon. Approximately 5,687 miles of streams were once available to anadromous fish in Idaho, of which some 40% was lost due to dam construction in Idaho on the Snake River and the North Fork of the Clearwater River (Mallet 1974).

Although much of the habitat still available to steelhead and salmon is high quality, man's activity in Idaho has degraded many streams. Sedimentation has increased with widespread logging, roadbuilding, and associated activities. Intensive livestock grazing near streams has removed riparian vegetation, changed stream morphology, and eroded soils. Mining has had profound effects in parts of the drainages, through stream channel alterations, discharge of toxic effluents, and increased sedimentation. Irrigation withdrawals have reduced flows and increased water temperatures, often to critical levels for steelhead and salmon during summer.

Presently, public agencies, including U.S. Forest Service (USFS), U.S. Fish and Wildlife Service (USFWS), Idaho Department of Fish and Game, and the Shoshone-Bannock and Nez Perce Tribes are cooperatively working on solutions to habitat problems for protection, enhancement, and mitigation of anadromous fish throughout the Clearwater River and Salmon River basins. Although it is generally accepted that habitat projects do increase juvenile production, actual increases and relative benefits have seldom been quantified in the field. These are required so that a record of credit for offsite mitigation on Columbia River tributaries can be established to compensate for losses due to the federal hydropower development system on the Snake and Columbia Rivers.

Habitat enhancement projects are intended to either increase the amount of habitat, or increase the carrying capacity of existing (usually, degraded) habitat, or both. Migration barriers, such as waterfalls, culverts, and water diversions, can be modified to make available habitat that is not being used, or is underutilized, by anadromous fish. BPA has funded, or funding has been proposed for, a number of these projects in Idaho: on Eldorado Creek, Crooked Fork Creek, Crooked River, the upper Salmon River, Alturas Lake Creek, Pole

Creek, Johnson Creek, and Boulder Creek (Fig. 1). Juvenile rearing habitat can also be added by connecting off-channel ponds to streams as on Crooked River. Control of toxic discharge from mining areas (Panther Creek) can eliminate partial blocks to anadromous fish passage and bring polluted stream reaches back into production. The amount of sediment entering streams from major "point-sources" such as mines can be reduced (Bear Valley Creek) to increase juvenile survival and carrying capacity. The carrying capacity of streams potentially can be increased by strategic placement of instream structures to reduce sedimentation, increase quality of rearing habitat for juvenile salmonids, and increase hiding or spawning habitat for adults (Lo10 Creek, Crooked Fork Creek, White Sand Creek, Crooked River, Red River). High velocities in channelized reaches can be reduced to more optimal levels for rearing juvenile salmonids by reconstructing stream channels to simulate more natural conditions (Crooked River). Finally, riparian zones may be managed to reduce sedimentation and stabilize streambanks to increase carrying capacity by a variety of techniques, including livestock fencing, revegetation, and bank revetments.

Objectives of this evaluation are: 1) document physical changes in habitat; 2) measure changes in steelhead and chinook production attributable to habitat enhancement projects; 3) measure changes in standing crops of resident fish species due to enhancement; and 4) determine project effectiveness, including relative costs and benefits, to establish the record of credit for mitigation and to guide future management actions.

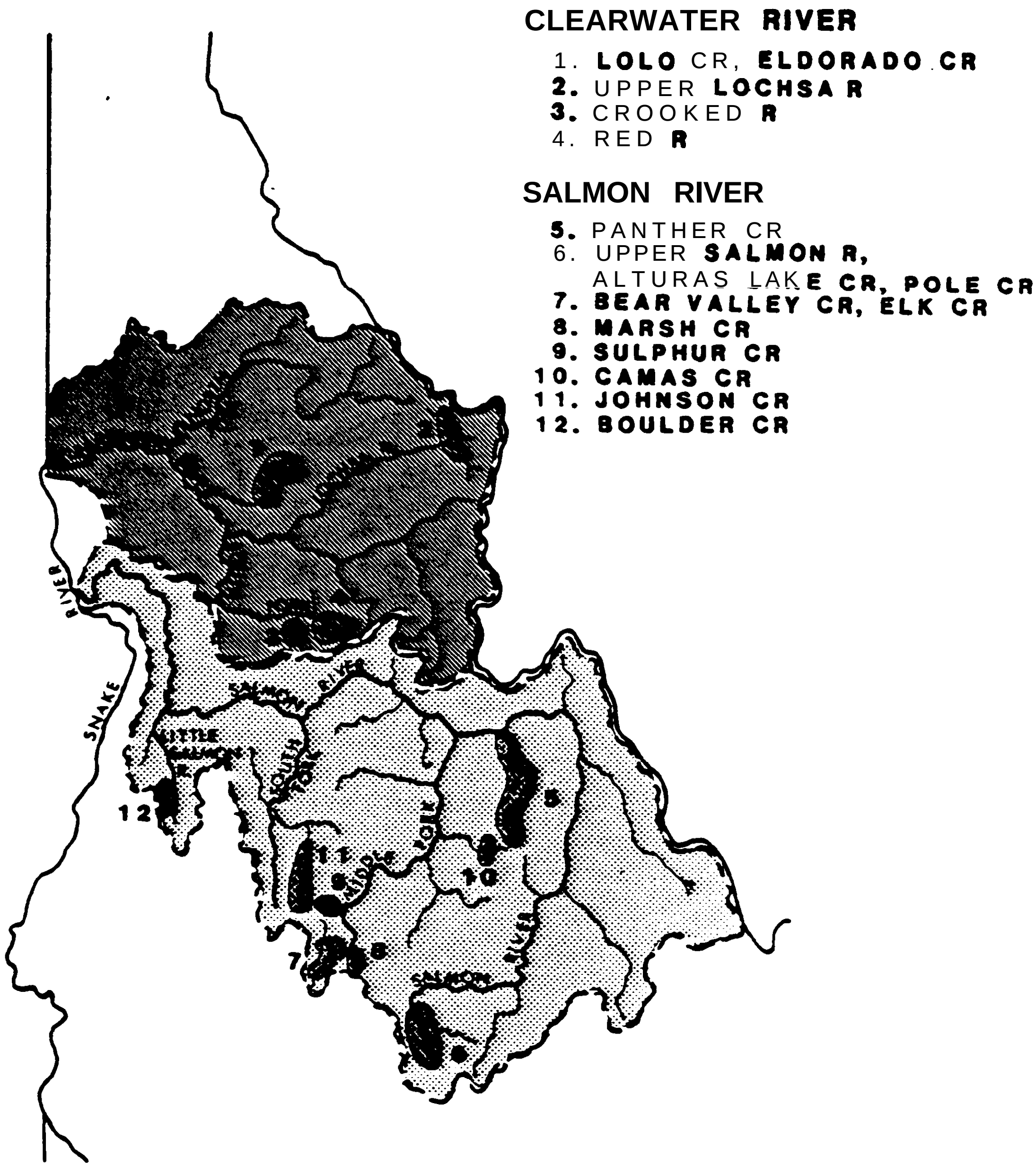


Figure 1. Project areas in Clearwater River and Salmon River drainages, Idaho.

# METHODS AND MATERIALS

## Evaluation Approach

Ideally, habitat enhancement measures for anadromous fish should be evaluated in terms of the number of smolts produced in excess of a stream system's smolt-producing capacity prior to enhancement. Actual smolt production is, however, difficult and costly to determine on an extensive basis and normally requires a means of enumerating emigrants. Therefore, as an index of smolt production, we have begun to monitor juvenile production in terms of densities of steelhead and salmon during summer. Monitoring juvenile production will provide a better measure of the benefits from habitat enhancement than would the subsequent return of adults because: 1) ocean harvest and the Columbia River fisheries limit steelhead and salmon escapements to Idaho; 2) specific origins of adult fish cannot be assigned in these mixed stock fisheries; and 3) juvenile production is a more direct measure of qualitative and quantitative changes in habitat at full seeding.

A number of factors must be developed to determine final benefits from increased juvenile standing crops in terms of increased smolt yields and adult returns. Extensive survey approaches were developed in 1984 to monitor increases in juvenile abundance that can be attributed to specific enhancement activities. IDFG plans to initiate a limited number of intensive studies of survival, production, and yield (e.g., Bjornn 1978) to develop factors relating juvenile standing crop to smolt yield (Table 1). Survival factors from smolt to adult will be available from ongoing migration studies in the Snake and Columbia Rivers and from increased ability to estimate catch and escapement of adults. Survival rates should increase from present low levels as passage problems at the dams are mitigated. Dollar values for adult fish have not been determined for Idaho stocks, but will increase with time as escapement objectives can be met and larger proportions of the production can be harvested.

Partial benefits from habitat enhancement will begin to accrue as smolt production increases in response to the projects. Full benefits will not be realized until smolt survival rates increase and stabilize, and escapements increase to a level that available habitat can be fully seeded. Important, possibly intangible benefits will accrue immediately from enhancement activity that assists critically depressed wild stocks.

Table 1. Hypothetical example of estimated benefits of habitat enhancement projects.

| Parameter | Hypothetical value |
|---|---|
| SMOLT YIELD FROM PROJECT | |
| 1. Estimated increase in juvenile density (summer)[a] | 20/100 $yd^2$ |
| 2. Area enhanced [a] | x 100,000 $yd^2$ |
| 3. Estimated increase in juvenile standing crop (summer) within project area [a] | 20,000 |
| 4. Estimated increase in juvenile standing crop (summer) in downstream areas due to enhancement [ab] | + 10,000 |
| 5. Total increase in juvenile standing crop | 30,000 |
| 6. Survival factor (juvenile to smolt) [b] | x 80% |
| 7 OUTPUT - - Annual smolt yield | 24,000 |
| DOLLAR BENEFITS FROM PROJECT | |
| 7. Annual smolt yield | 24,000 |
| 8. Survival factor (smolt-to-adult) | X 10% |
| 9. Total increase in adult production | 240 |
| 10. Dollar value/adult (catch/escapement factor) | x $ 50 |
| 11. Value of increased adult production | $1,200 |
| 11. OUTPUT --Total annual benefits | $ 1,200 |

[a]Determined from field sampling--BPA habitat enhancement monitoring.
[b]Determined from intensive survival, production, and yield studies.

The final determination of benefits from habitat enhancement projects should be made based on demonstrated biological responses under conditions of full seeding. Overfishing and low survival rates for migrants at the Snake and Columbia River dams have prevented full seeding in recent years. Densities that constitute full seeding remain undefined for most streams, however, because biologists in Idaho generally did not begin to measure rearing densities until after stocks declined drastically in the early 1970's. Defining full-seeding levels, or carrying capacity, should be possible as escapements to Idaho return to pre-1970's levels. Currently, steelhead are recovering faster than are spring and summer chinook.

Steelhead returns to Idaho suffered serious declines in the early 1970's due largely to cumulative smolt mortality after construction of the lower Snake River dams, Ice Harbor, Lower Monumental, Little Goose, and Lower Granite. The number of adult steelhead passing Ice Harbor Dam into Idaho shows an incomplete recovery beginning in the late 1970's (Fig. 2). Because steelhead spawn during spring, when water can be high and turbid, consistent yearly records of numbers of spawners are lacking for individual streams. Consequently, determination of numerical spawner-juvenile relationships for individual streams is difficult. For the upper Clearwater River in general, escapement of spawners has begun to return gradually to pre-1970's levels (Fig. 3). Middle Fork Salmon River stocks went through a similar decline during the 1970's and escapements now represent about 40% of levels in 1971. Because recovery in numbers of steelhead spawners is incomplete, we are not yet able to satisfactorily judge what constitutes juvenile steelhead carrying capacity on a stream-by-stream basis.

Chinook salmon suffered greater mortality due to construction of dams on the Columbia River and lower Snake River and more extensive overfishing in downriver areas and in the Pacific Ocean, and have shown less recovery than steelhead (Fig. 2). Because chinook spawn during a low-water period in late summer, their yearly spawning trends can be followed for individual streams. Redd counts in the Salmon River drainage still represent less than 20% of those during the 1960's and continue to vary considerably from year to year (Table 2). Comparable long-term records do not exist for Clearwater River streams because, until the mid-1960's, these runs were not fully re-established after their depletion in the 1920's by passage problems at Lewiston Dam. Because of continued low escapements of chinook, it is unlikely that they are fully seeding habitat, except on a rare and localized basis.

Full seeding is important to evaluate benefits from a habitat enhancement project whether the objective is to add rearing habitat or to increase the carrying capacity. Benefits measured from less-than-full-seeding conditions may underestimate true benefits where rearing habitat is added (e.g., barrier

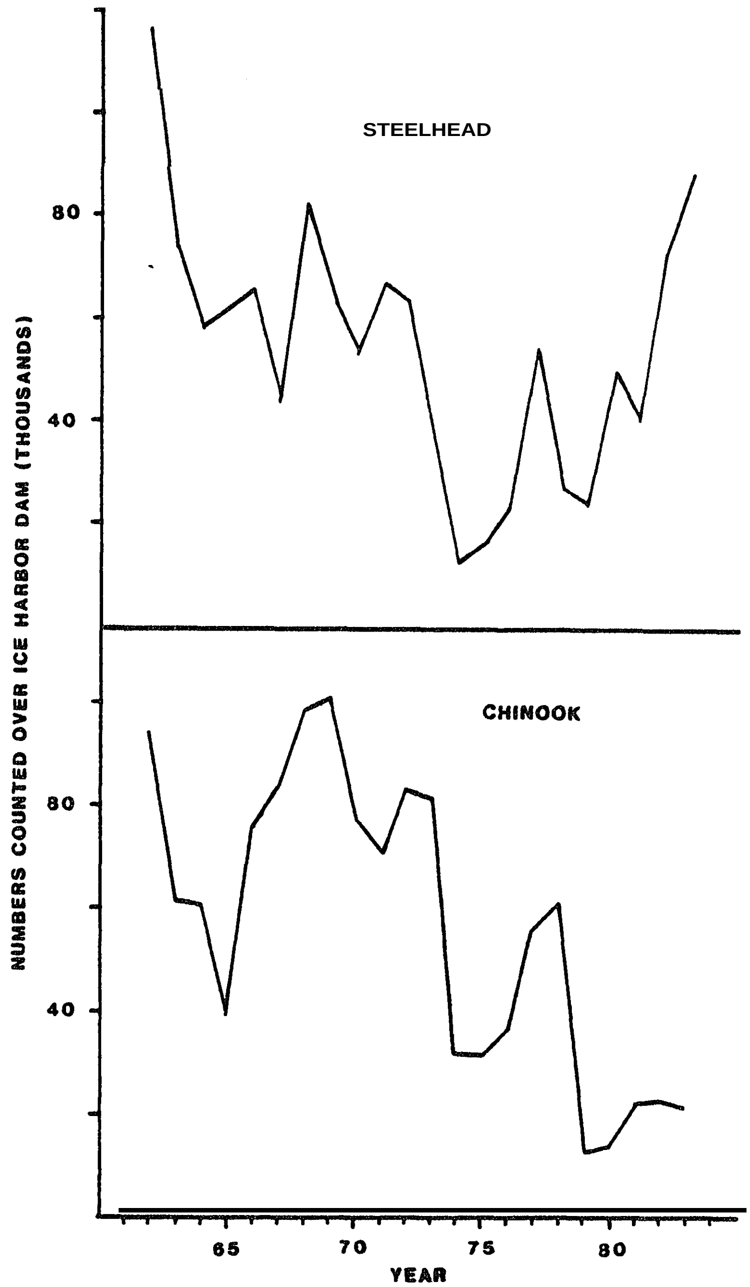


Figure 2. Number of adult steelhead and chinook passing Ice Harbor Dam into Idaho, 1962-84.

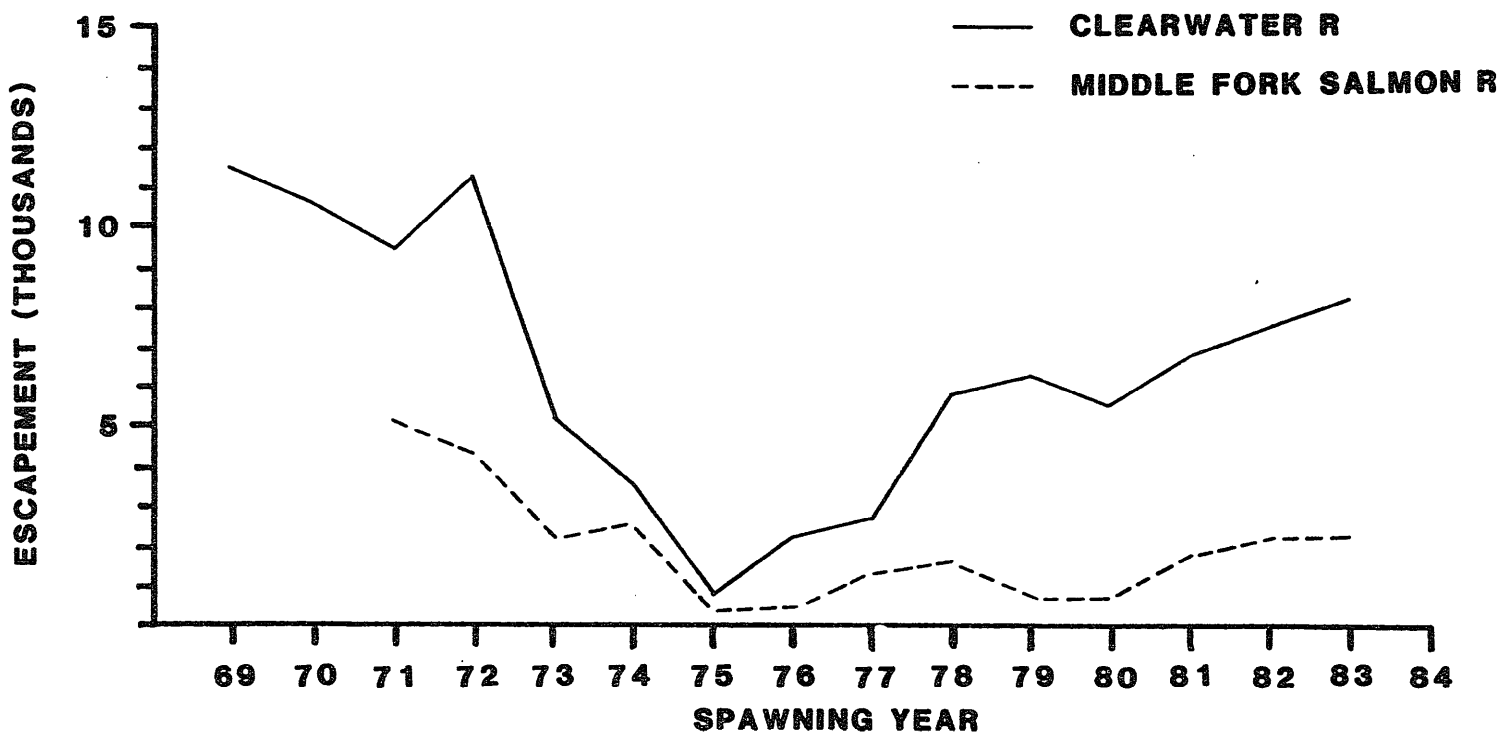


Figure 3. Estimated number of steelhead from wild and natural production escaping to upper Clearwater River (Lukens 1984) and to Middle Fork Salmon River (Thurow 1983), 1969-83.

Table 2. Chinook salmon redd counts in established trend areas during the 1960's compared to 1982-84 counts (Pollard 1983; IDFG file records).

| Drainage and stream | 1960-69 average | 1982 | 1983 | 1984 | 1982-84 average | % of 1960-69 average |
|---|---|---|---|---|---|---|
| Clearwater River | | | | | | |
| Crooked Fork Creek | 32[a] | 34 | 7 | 28 | 23 | 72% |
| South Fork Clearwater River | | | | | | |
| Crooked River | --[b] | 2 | 12 | 22 | 12 | |
| Red River | --[b] | 159 | 204 | 177 | 180 | |
| Salmon River | | | | | | |
| Upper Salmon River | 658 | 42[c] | 161[c] | 76[c] | 93 | 14% |
| Alturas Lake Creek | 81 | 9[c] | 27[c] | 3[c] | 13 | 16% |
| Middle Fork Salmon River | | | | | | |
| Bear Valley Creek | 479 | 39 | 56 | 55 | 50 | 10% |
| Elk Creek | 422 | 9 | 38 | 27 | 25 | 6% |
| Marsh Creek drainage | 445 | 40 | 33 | 60 | 44 | 10% |
| Camas Creek | 208[d] | 33 | 38 | 11 | 27 | 13% |
| Sulphur Creek | 152 | 3 | 8 | 0 | 4 | 2% |
| South Fork Salmon River | | | | | | |
| Upper South Fork | 1,082 | 111[e] | 185[e] | 165[e] | 154 | 14% |
| Johnson Creek | 251 | 37 | 63 | 17 | 39 | 16% |

[a] 1965-69 average.
[b] Chinook salmon not yet reestablished.
[c] Reduced by trapping adults at Sawtooth Hatchery: 111 females in 1982; 179 in 1983; and 187 in 1984.
[d] 1961-69 average.
[e] Reduced by trapping adults near Cabin Creek: 147 females in 1982; 180 in 1983; and 353 in 1984.

removal) and be ambiguous where attempts are made to increase carrying capacity.

Where rearing habitat is added and carrying capacity is reached, measured increases in juvenile steelhead and chinook densities (apparent benefits) will approximate true benefits (Fig. 4A). If carrying capacity is not reached, true benefits will be underestimated by measured increases in juvenile fish densities (Fig. 4B). Representative stream sections will be sampled before and after treatment to determine extent of use of a stream reach by anadromous fish. Control reaches (eg., below a barrier) will also be sampled to follow annual trends in density, but these-data likely will not be used in final calculations of benefits. Benefits will be calculated from the increase in density from pre-treatment (usually, zero) to post-treatment at full seeding.

Where the project objective is to increase carrying capacity, we expect that measured benefits will also approximate true benefits when full seeding occurs (Fig. 4C). Otherwise, densities of juvenile salmonids may bear little relationship to the quality of habitat, and thus measured "benefits" would be misleading (Fig. 4D). Without full seeding by steelhead and chinook, we cannot determine whether a differential in densities between treated and untreated sections indicates only habitat preferences or true increases in rearing potential. Conversely, without full seeding, a lack of differential densities does not necessarily imply that rearing potential was not changed by habitat enhancement. At full-seeding, intra-specific competition for food and space will force juveniles to distribute, thus assuring that juvenile densities will reflect rearing potential. At full-seeding, benefits will be calculated from differences between post-treatment densities and densities in control sections. Pre-treatment data will be necessary to establish comparative baselines for control and post-treatment sections.

There will be three basic phases to IDFG evaluation of habitat enhancement projects. A pre-treatment phase will consist of estimates of anadromous fish densities and measurements of physical habitat in sections or reaches to be treated and in control sections. The second phase will consist of estimation of partial benefits at lower seeding levels and annual monitoring of trend sections until juvenile densities approach carrying capacity. Hypothetically, carrying capacity for a stream reach can be estimated as the level at which juvenile fish densities stabilize while adult escapements continue to increase (Fig. 5). Adult escapements will be monitored by spawning ground surveys for chinook and estimated escapements to a drainage for steelhead. Final project evaluation will occur in the third phase, at full seeding. Post-treatment evaluations will include estimates of juvenile fish densities and measurements of physical habitat in treated and untreated sections.

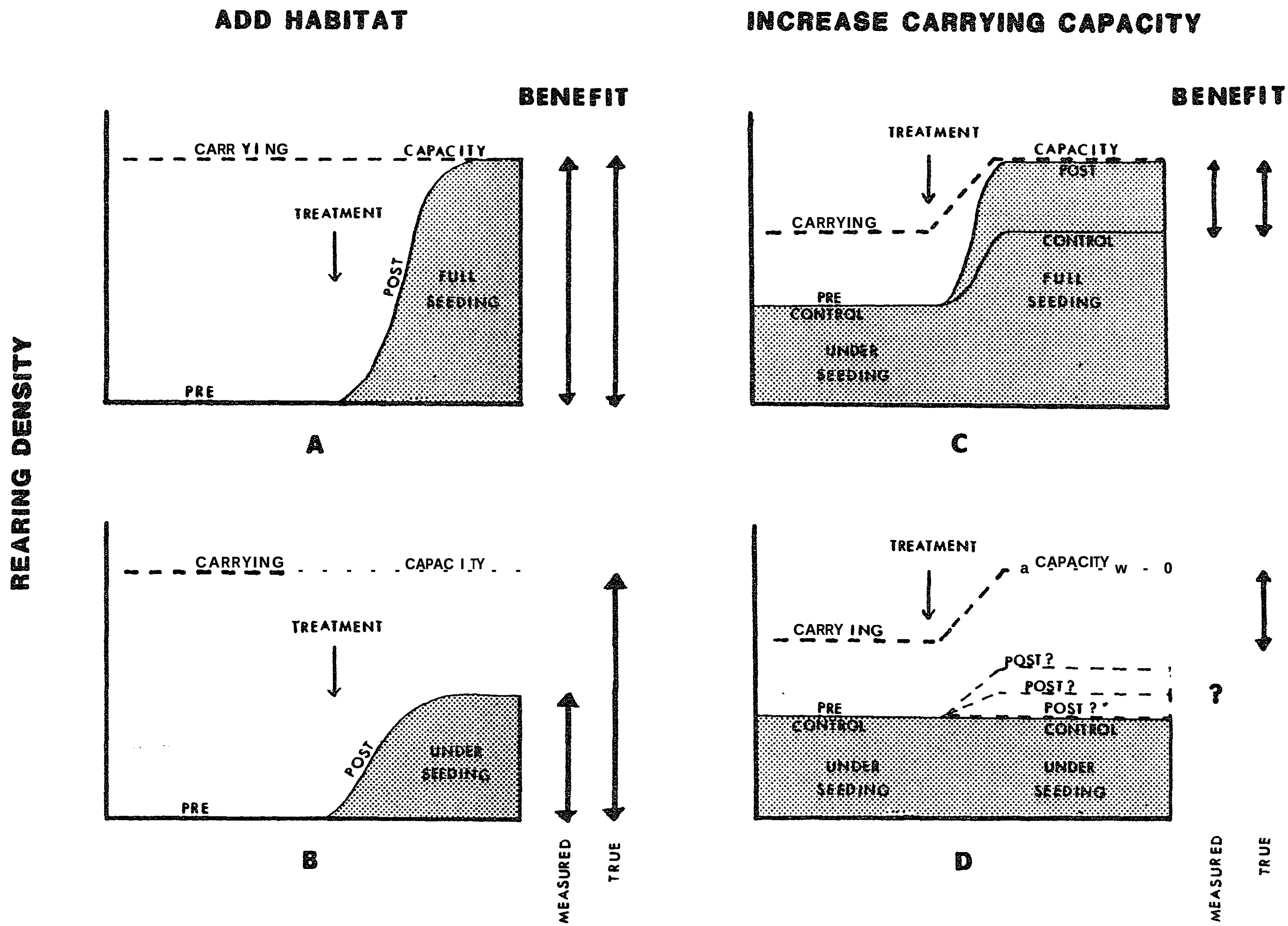


Figure 4. Expected measured and true benefits from projects that add habitat under conditions of full seeding (A) and partial seeding (B), and from projects that increase carrying capacity under conditions of full seeding (C) and partial seeding (D).

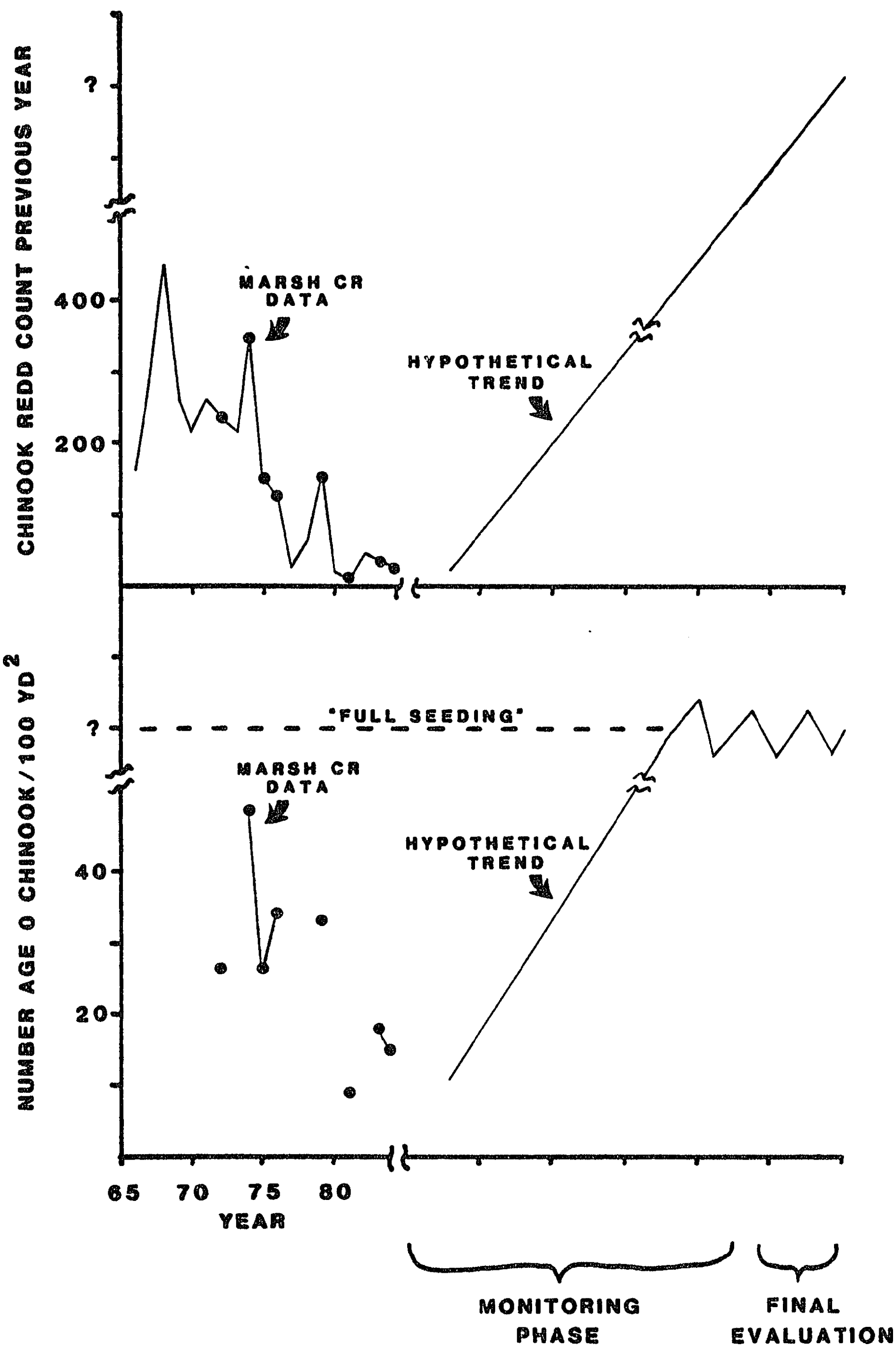


Figure 5. Phases of IDFG evaluation showing recent decline in chinook escapements and summer densities in Marsh Creek, and expected response of densities to future increased escapements.

Difficulty of quantifying benefits for mitigation purposes will vary from project to project. Easiest to quantify will be those projects that add a new increment of production potential, such as barrier removals. Where complete barriers are removed, benefits can be calculated simply from the final estimates of numbers of anadromous fish reared at full seeding; where partial barriers are removed, some downward adjustment of estimated benefits based on pre-treatment potential will be needed.

Localized increases in carrying capacity (eg., instream structures, riparian fencing) will also be relatively easy to measure. For these projects which improve rearing habitat locally, the benefits can be measured at full seeding from the increase in density relative to untreated sections.

It will be difficult and costly to estimate benefits for some types of general land treatments such as road paving, cutbank seeding, and other projects designed to decrease sedimentation, especially where a minor facet of a multifaceted problem is treated. Costs of evaluation could easily exceed projected benefits for such projects.

In some cases, stocking the habitat with hatchery steelhead and chinook will be required to establish a run or to estimate full-seeding density. Stocks to be used will be compatible with IDFG (1984) Anadromous Fish Management Plan. Number of fish stocked will necessarily depend on hatchery fish availability.

The alternative to estimating final benefits at full seeding--projecting potential benefits from current depressed seeding levels--is not acceptable to IDFG. We do not consider existing models reliable enough to accurately predict potential benefits that could be used to develop a mitigation record. Development and verification of reliable habitat-standing crop models should be possible as seeding levels increase and as the appropriate data is accumulated. But most importantly, no benefits would be realized by increasing potential of the habitat to rear fish unless juvenile production also increases.

## Methods

In 1984 IDFG began evaluation of existing and proposed BPA-funded enhancement projects for anadromous salmonid habitat in the state. The first phase of evaluation included identification of how benefits will be measured as seeding levels increase. We wanted to develop a flexible evaluation approach in which intensity of sampling effort for the projects could vary with time because: 1) lag time for responses of habitat and fish populations will vary among projects; 2) intensive studies repeated every year cannot be justified for most projects at current low seeding levels; and 3) in many cases, once basic sample designs are established and seeding levels increase, the number of sample sections can be increased to gain precision in post-treatment evaluations.

In July-August 1984 we primarily collected pre-treatment and control information on fish densities and physical habitat (Table 3) to set the stage for evaluation. For a few projects implemented in 1983 (instream structures in Lolo Creek, Crooked Fork Creek, and White Sand Creek, and improvement of an irrigation diversion in Pole Creek), we could measure only post-treatment and control conditions.

In 1984 we also sampled in a number of potential project areas before specific enhancement activity was proposed. We intended data from this limited sampling in project streams (Elk Creek, Marsh Creek, and Camas Creek) and in possible control streams (Sulphur Creek, South Fork Salmon River) to help put into perspective current seeding levels and interpret future trends. Once enhancement proposals become more specific, we can establish appropriate sampling designs for these streams.

Sections were established to be monitored in 1984 and future years. For each habitat type identified (eg., pocket water, meandering meadow, run habitat with or without instream structures, etc.) we established a minimum of two sections that were usually 100-yards long. Upper and lower ends of each section were either flagged with surveyors tape or staked and photographed to facilitate future sampling. We estimated fish abundance and densities and measured physical habitat variables in the sections in July-August, 1984.

Fish abundance by species and age group or length class in the sections was estimated in 1984 from snorkeling observations. Depending on the size of stream and crew availability, from one to three observers snorkeled slowly upstream (Fig. 6), counting numbers of age 0 and age I+ chinook, and numbers of trout, whitefish, and other species by one-inch length class. The final crew member recorded the counts and other observations (ie., approximate fish distributions, associations with structures, and presence of adult chinook).

We calculated fish densities (number/100 $yd^2$) by species and age group for each section. Young-of-year and yearling chinook did not overlap in length and could be readily distinguished visually. Lengths of age groups for other species, however, overlapped considerably. Steelhead and resident rainbow trout, which were visually indistinguishable, were separated into four

Table 3. Pre-treatment, control, and post-treatment measurements taken 1984 to evaluate current and proposed habitat enhancement projects in Idaho.

| Drainage and stream | Habitat improvement project | Year implemented | 1984 evaluation activity density (D), habitat (H) pre | control | post |
|---|---|---|---|---|---|
| Clearwater River | | | | | |
| Lo10 Cr | instream structures | 1983 | | D H | D H |
| | | 1984 | D H | D H | |
| Eldorado Cr | passage | 1984 | D | D | |
| upper Lochsa R | instream structures | 1983 | | D H | D H |
| | passage | 1984 | D | D | |
| South Fork Clearwater River | | | | | |
| Crooked R | passage | 1984 | D H | D H | |
| | instream structures | 1984 | D H | D H | |
| | channel changes | -- | D H | D H | |
| Red R | bank stabilization | 1983 | | | |
| | bank stabilizationa | 1984 | | | |
| | instream structures | 1984 | D H | D H | |
| Salmon River | | | | | |
| Panther Cr | reduce pollution | -- | D H | D H | |
| upper Salmon R | passage | -- | D H | D H | |
| Alturas Lake Cr | passage | -- | D H | D H | |
| Pole Cr | passage | 1983 | | D H | D H |

Table 3. continued.

| Drainage and stream | Habitat improvement project | Year implemented | 1984 evaluation activity density (D), habitat (H) pre | control | post |
|---|---|---|---|---|---|
| Middle Fork Salmon River | | | | | |
| Bear Valley Cr | reduce sediment[b] | -- | D H | D H | |
| | riparian | -- | D H | D H | |
| Elk Cr | riparian | -- | D H | D H | |
| Marsh Cr | riparian | -- | D H | D H | |
| Camas Cr | riparian | -- | D | | |
| South Fork Salmon River | | | | | |
| Johnson Cr | passage | 1984 | D H | D H | |
| Other tributaries | passage | -- | | | |
| Little Salmon River | | | | | |
| Boulder Creek | passage | (1985) | D | D | |

[a] IDFG personnel not informed in time to evaluate project.
[b] Cooperative study with Shoshone-Bannock Tribe.

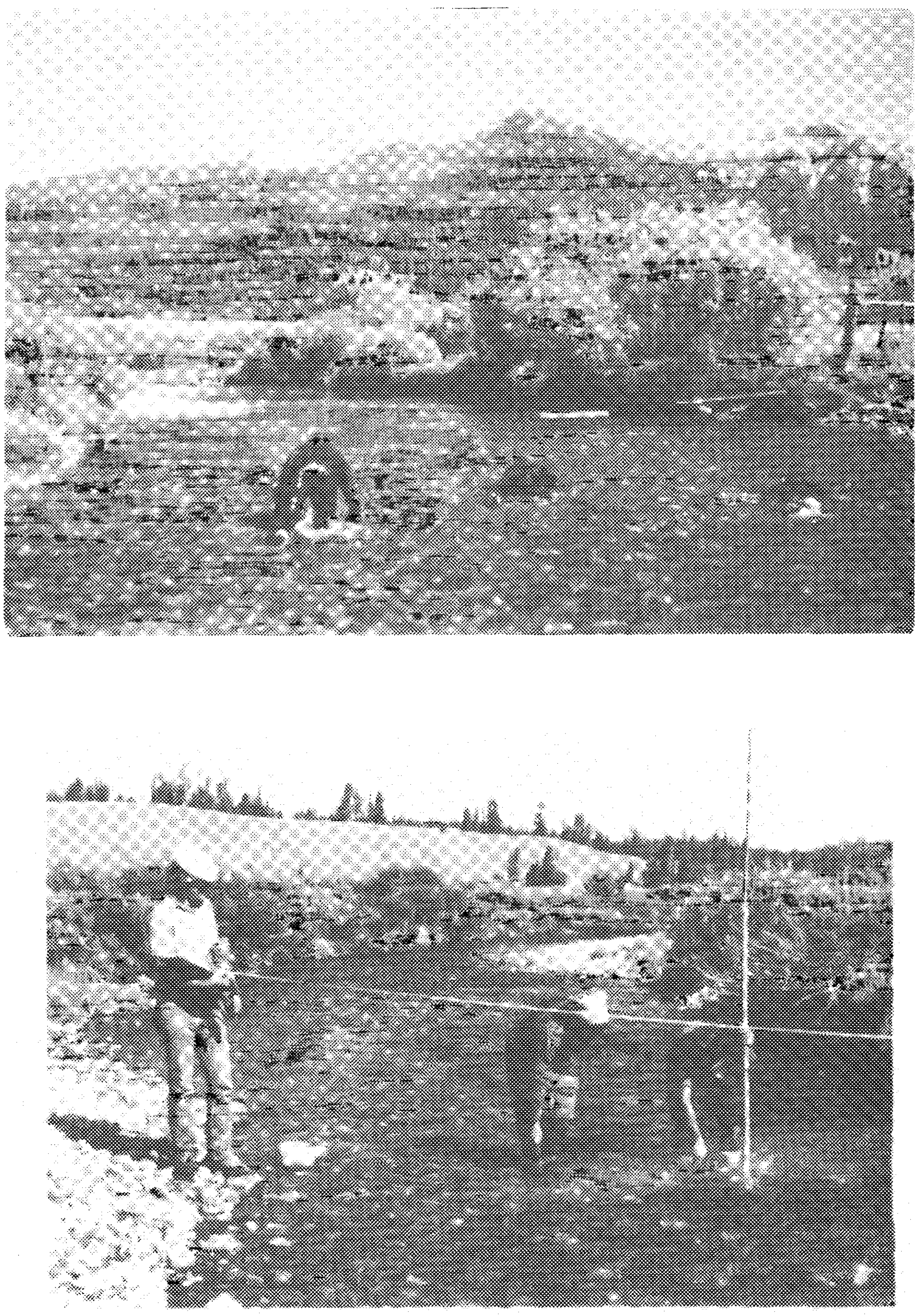

Figure 6. Three observers snorkeling a section of the upper Salmon River (upper photo) and measuring width, velocity, depth, substrate composition, and embeddedness (lower photo).

age-groups based on length-frequency analysis by Thurow (1983). For most streams in July-August, young-of-year rainbow-steelhead were less than two-inches long; ages I, II, and III-and-older corresponded to respective length-classes 3"-5", 6"-8", and 9"-and-longer. In Lolo Creek and Eldorado Creek, which we sampled in early July, age groups were considered to be one inch shorter. In summaries for nonanadromous species, we separated observed lengths only into young-of-year and yearling-and-older age groups.

Physical habitat was measured to determine present (usually, pre-treatment or control) conditions, and to eventually document changes due to enhancement projects and relate biological responses to physical changes. The basic procedure was the transect method described by Platts et al. (1983).

The most intensive habitat measurements in 1984 were carried out by Platts' team (Intermountain Forest and Range Experiment Station, USFS, Boise, Idaho) for sections in Crooked River, Red River, and Bear Valley Creek. USFS personnel established and staked transects for future reference, and measured pre-treatment habitat conditions. Measurements of various morphologic, hydrologic, and riparian variables were taken at locations of one-quarter, one-half, and three-quarters of the stream width on evenly spaced (lo-foot) transects (Torquemada and Platts 1984); the USFS habitat report for 1984 is appended.

In 1984 IDFG adapted Platts et al. (1983) habitat methodology into a quicker survey technique to be used more extensively. We used evenly spaced (30-foot) transects, similar to USFS methods, but did not stake each transect for future repeated measurements. We measured width, depth, velocity, substrate composition and embeddedness (Fig. 6) and typed habitat into pool, run, riffle, or pocket water at approximate locations of one-quarter, one-half, and three-quarters of the stream width (Fig. 7). Widths were measured to O.l-foot precision, and included measurement of undercut banks. Depths were measured to O.l-foot precision 'at the three locations on each transect. Velocities, when taken, were measured (Marsh-McBirney, Model 201) at 0.6 depth to the nearest 0.1 foot/second. Percentage substrate composition by area was estimated visually for an approximate 1 $yd^2$ area at the three locations on each transect. Substrate classes were sand (less than 0.2' diameter), gravel (0.2"-2.9") rubble (3.0"-11.9"), and boulder (12" and larger). Occular estimates of embeddedness (amount of surface area of larger particles surrounded by sediment) were classed as less than 5%, 5-25%, 25-50%, 50-75%, and >75% (Platts et al. 1983).

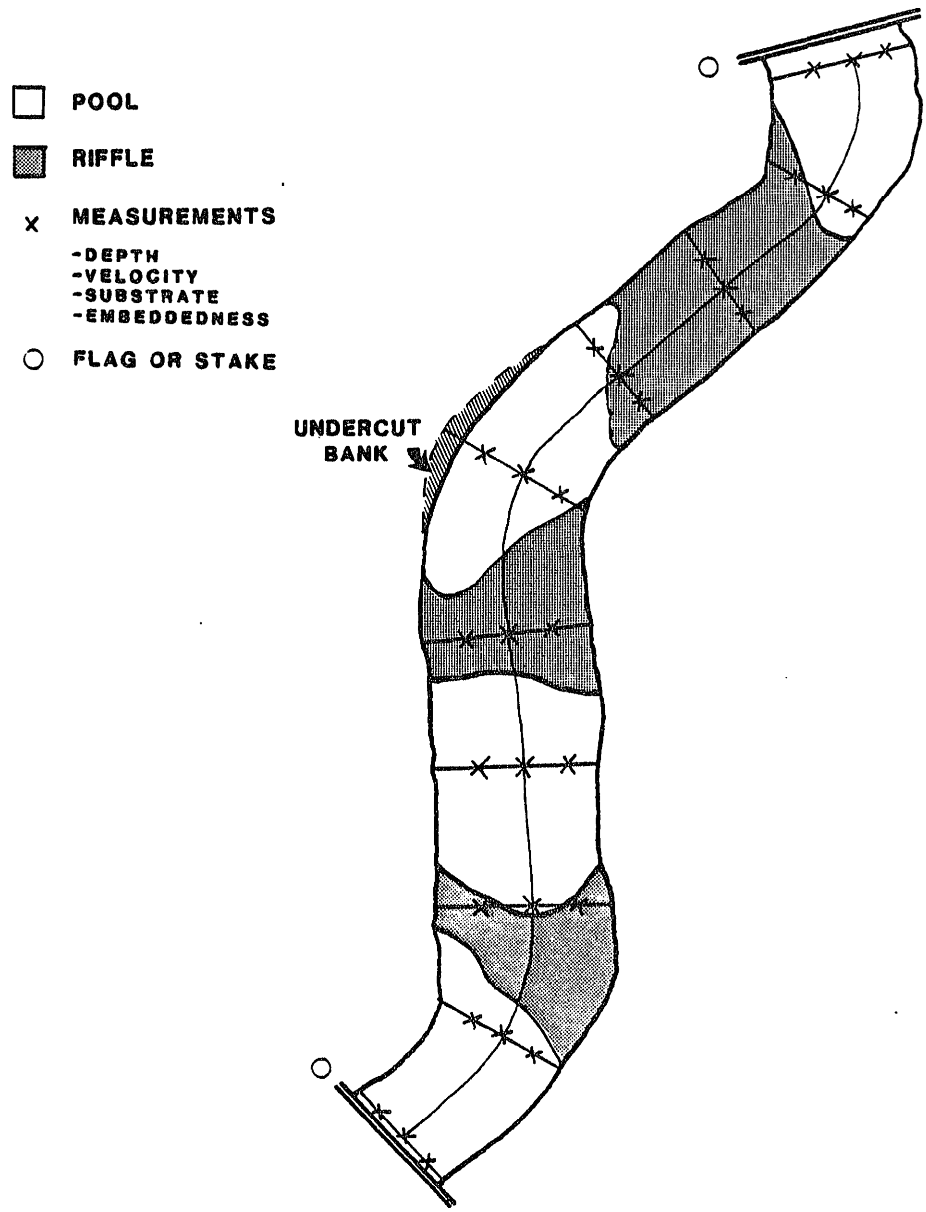


Figure 7. Transect method used to measure physical habitat and type habitat in 1984. Transects were spaced at equal intervals as measured from midstream. Habitat in this example would be typed 63% pool (19/30 measurements) and 37% riffle.

The IDFG evaluation team in 1984 was:

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## CLEARWATER RIVER

### Lolo Creek

Lolo Creek, 42-miles long, enters the Clearwater River above Greer at river mile 54. The upper 18 miles of stream, including the project area, lie within the Clearwater National Forest (Fig. 8). The lower stream runs through an area of mixed ownership which includes private, state, Nez Perce tribal and U.S. Bureau of Land Management interests. Within the Forest boundaries, Lolo Creek drains a watershed of about 73,000 acres (Espinosa 1984). Lo10 Creek drops 3,940 feet from its source to its confluence with the Clearwater River (1.8% average gradient). Within the project area, gradient is a more moderate 1.0%.

Lolo Creek is a major producer of anadromous fish for the lower Clearwater River. Summer steelhead and spring chinook spawn and rear in the stream. Both species have been stocked extensively in the system. A partial migration barrier upstream from Eldorado Creek was removed by USFS blasting projects in 1974 and 1978 to allow more complete utilization of the upper area. In recent years, juvenile rainbow-steelhead trout have dominated the fish community of upper Lolo Creek. Juvenile rainbow-steelhead made up 71% of all fish observed in population surveys during 1975-79 (Espinosa 1984); juvenile chinook made up 21%.

Nonanadromous salmonids reported in Lo10 Creek are rainbow trout, cutthroat trout, brook trout, and mountain whitefish (Mallet 1974). Sculpin also occur in the project area of Lo10 Creek,

Lo10 Creek has been degraded by excessive sedimentation from such timber management activities as road construction and riparian harvesting. To a lesser degree, placer mining for gold has also introduced sediment to the system. Most of the habitat degradation on Forest lands occurred during the 1950's and 60's. Espinosa and Branch (1979) found no significant improvements, and some declines, in habitat quality in the project area since 1974.

Espinosa (1984) identified several factors as potentially limiting to anadromous fish production in Lo10 Creek. Pool/riffle structure, pool quality, and habitat diversity, including bank cover and instream organic debris, were rated suboptimal. Sedimentation was rated excessive in both spawning and rearing habitats.

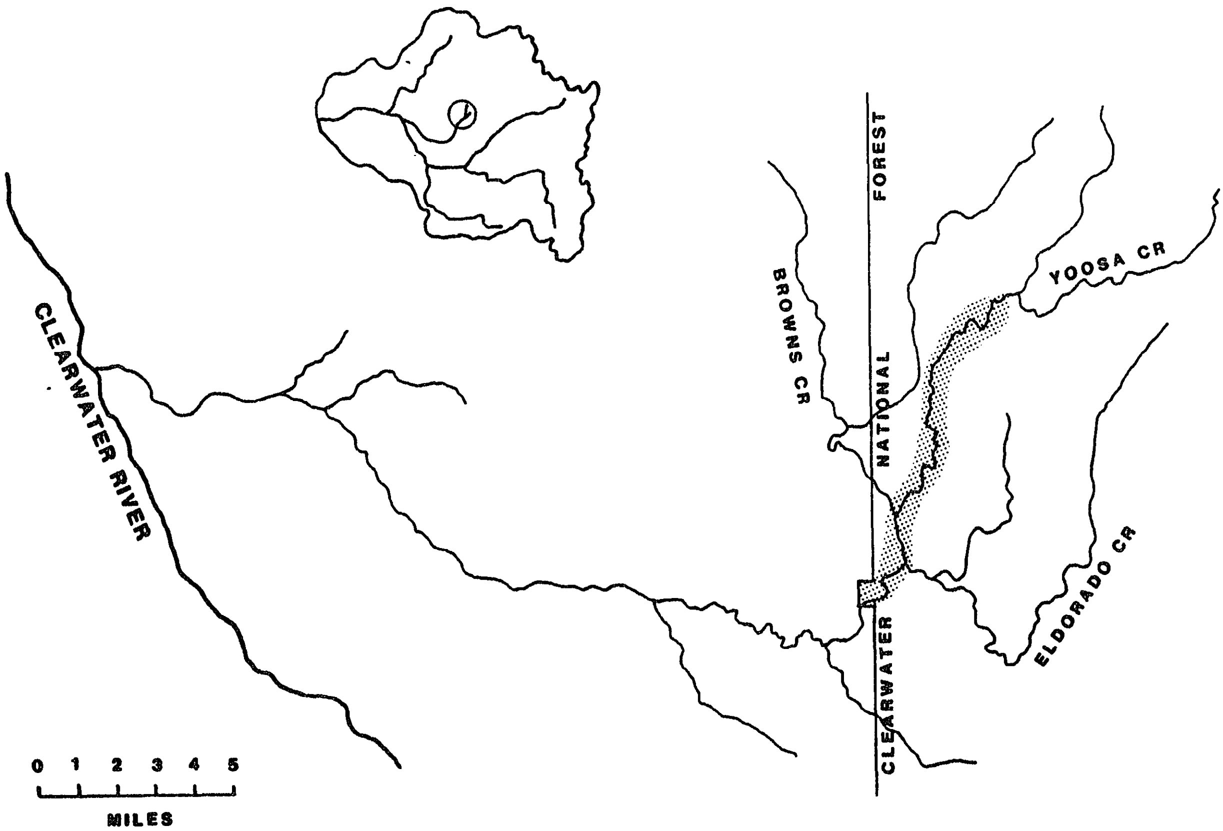



Figure 8. Location of habitat enhancement project (shaded) on Lolo Creek.

A BPA-funded habitat enhancement project was implemented in 1983 and continued in 1984. Objectives of the project were: 1) increase rearing potential for juvenile steelhead and chinook; 2) increase pool frequency and quality; 3) increase hiding and resting cover for adult spawners; 4) reduce instream sediment loads through increased scour capability; and 5) increase natural production of steelhead and chinook, consistent with IDFG (1984) Anadromous Fish Management Plan for subbasin CL-3.

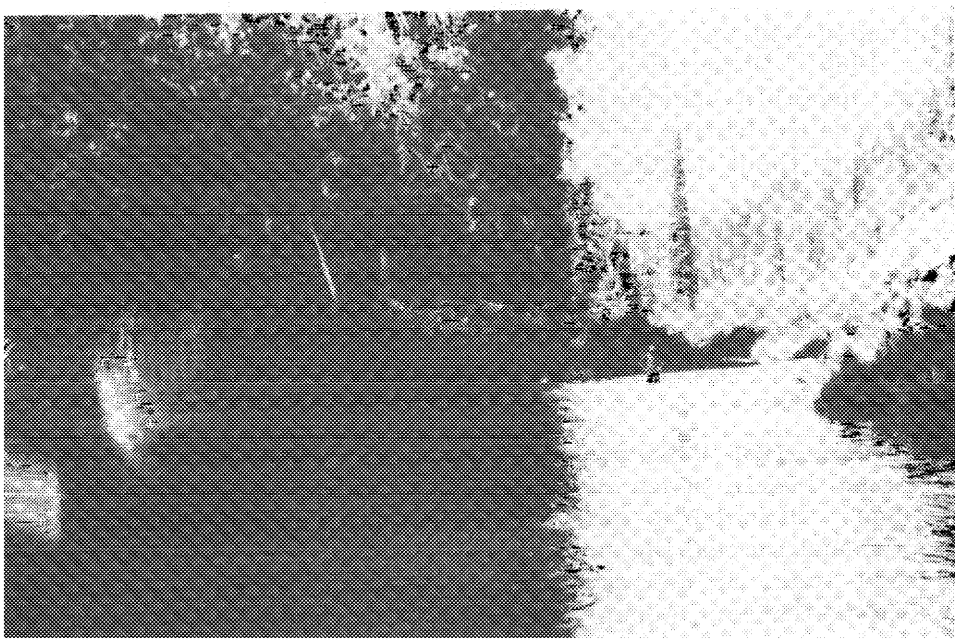
## 1983 Habitat Enhancement Project

During summer 1983 USFS project personnel installed 145 structures in Lo10 Creek in an 8-mile reach between Yoosa Creek and Browns Creek confluences (Espinosa 1984). Structures were intended to diversify habitat primarily by creating pools and increasing pool quality and cover. In run habitat, 9 K-dams, 29 sill logs, 35 deflector logs, and 15 root wads (cedar stumps) were placed to form pools (or deepen runs), enhance cover for juvenile anadromous fish, and reduce sedimentation. Fifty-three boulder clusters (133 boulders) were placed in riffles to create pocket water habitat, provide cover for juvenile salmonids, and reduce sedimentation. In addition, USFS installed 3 bank-cover devices to increase overhead cover, and constructed a pool below a natural deflector.

IDFG evaluation of the project began in 1984, one year after structure installation. To simplify the evaluation, we grouped the instream stuctures into four types: 1) log weirs (K-dams and sill logs), which were placed perpendicular to the flow in run habitat; 2) deflector logs, placed diagonally in run habitat; 3) root wads, placed in runs, generally in slow water; and 4) boulder clusters, placed in riffles. Untreated runs and untreated riffles, interspersed between structure reaches served as controls for comparing abundance of juvenile salmonids. Figures 9-11 illustrate an example of each type of section.

Before sampling, we randomly selected six treatment sections of each structure-type (24 sections), using the numbers that USFS had assigned to the structures. For example, number 1 was the uppermost structure, a K-dam; number 60 was the structure furthest downstream, a sill log. Numbered structures totaled less than the 145 installed because several structures of the same type had been applied consecutively and numbered as reaches.

Only a few untreated runs and riffles were suitable as controls because some of the better habitat (in USFS judgement) was left untreated in 1983. Potential control runs and riffles were identified by USFS project personnel



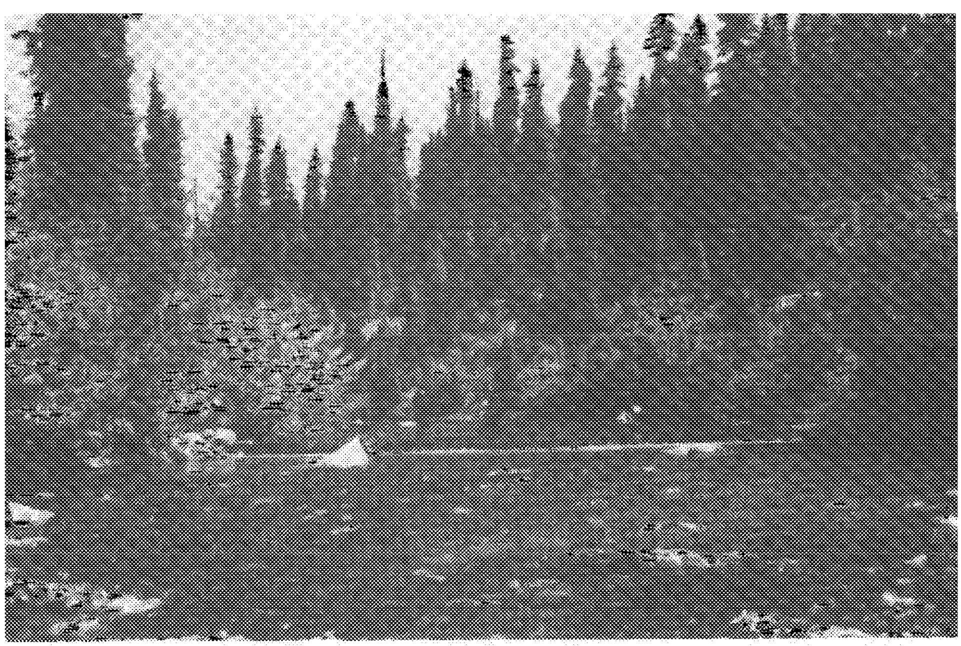


Figure 9. Untreated run habitat (upper photo) and sill Pog (Power photo), Lolo Creek, July 6984.

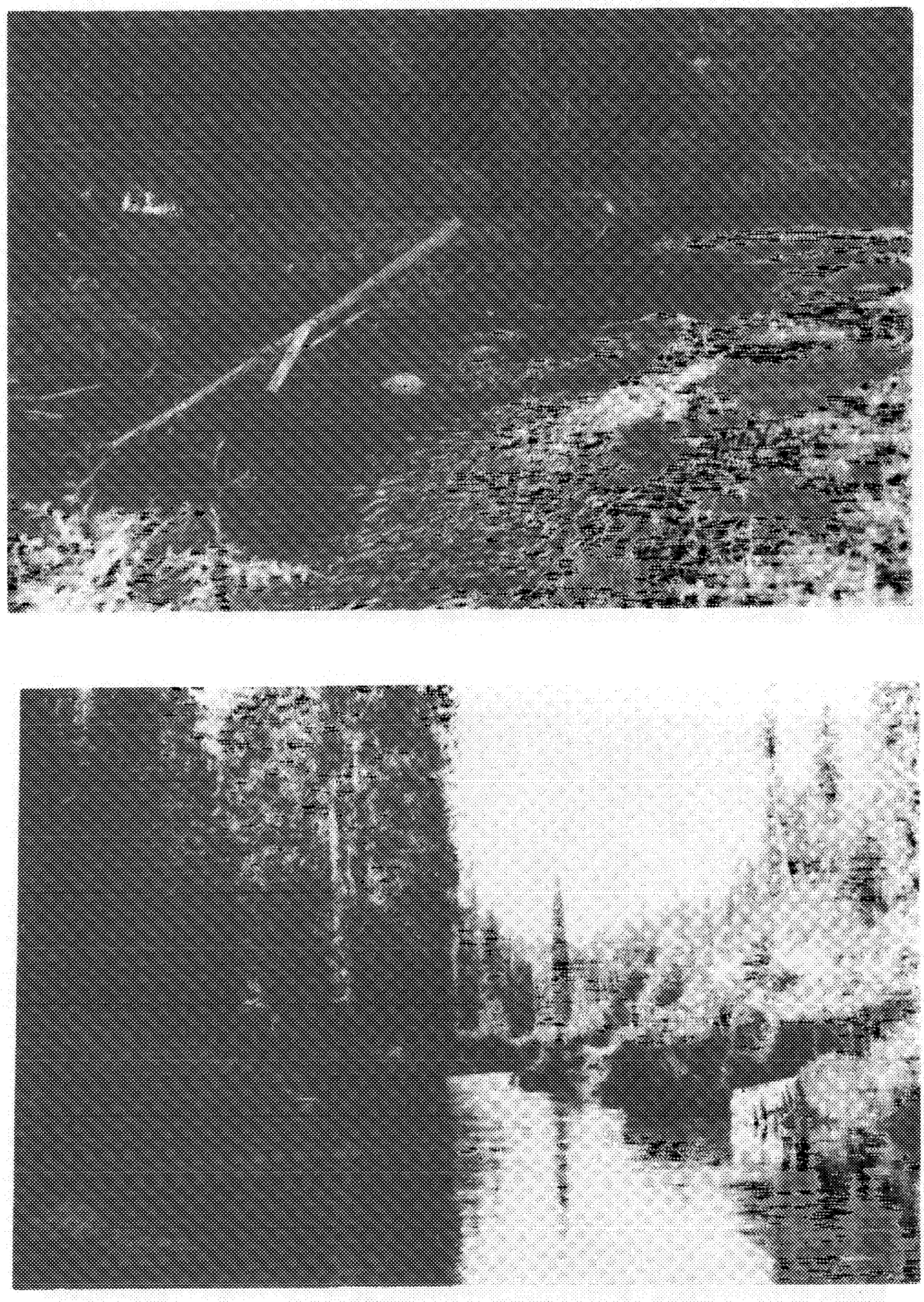
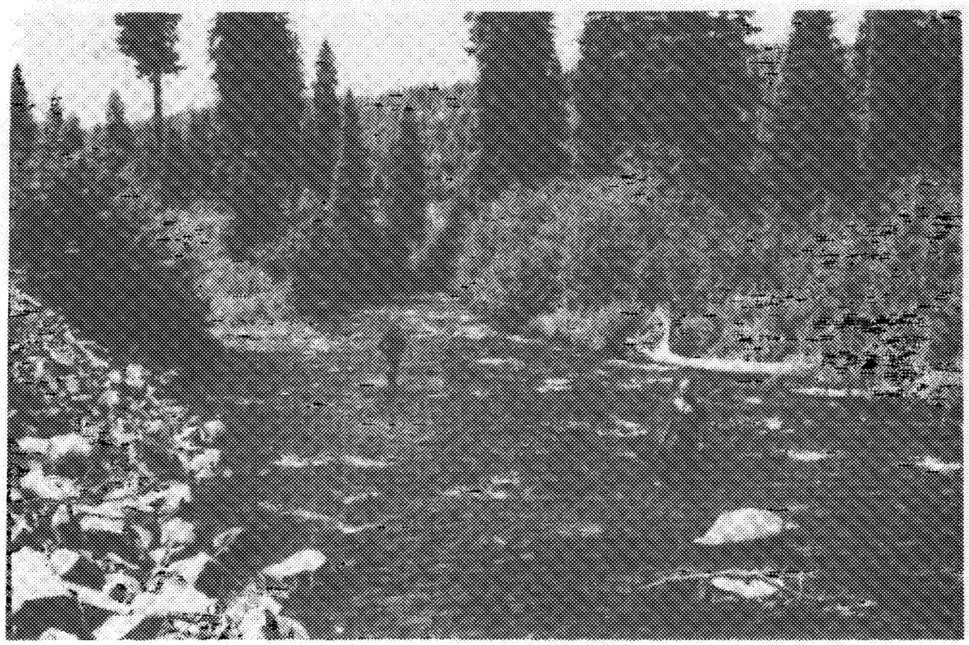


Figure 16. Deflector log (upper photo) and root wads (lower photo) in run habitat, Lolo Creek, July 1984,



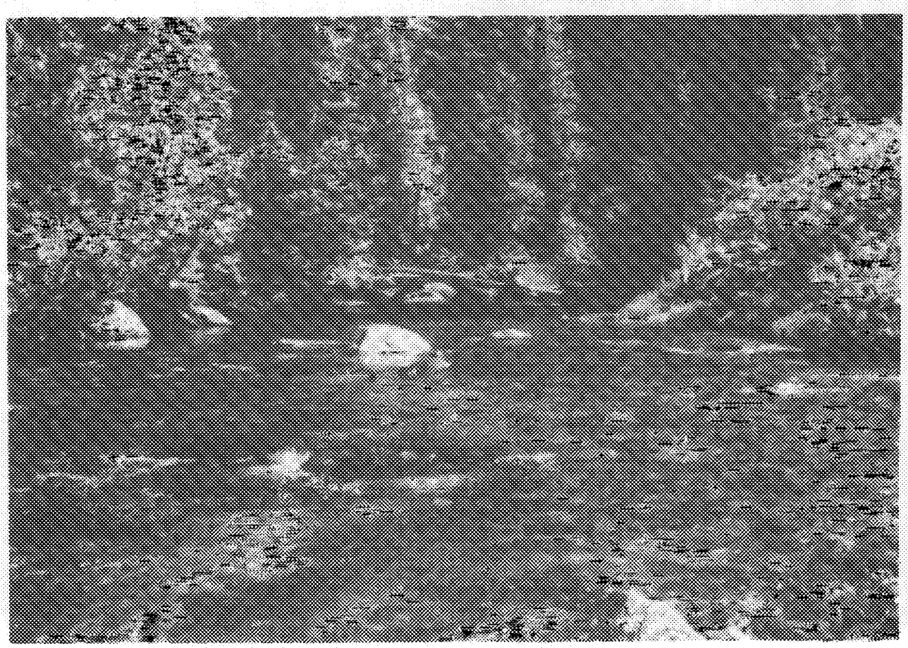


Figure 11 Untreated riffle (upper photo) and boulder cluster (lower photo), Lolo Creek, July 1984.

as reaches that would have been treated in 1983, except that access was limited for backhoes and/or front-end loaders. We selected six each of these runs and riffles, numbering them consecutively from upstream (ie., run l-6 and riffle l-6).

Because of time and scheduling constraints, we snorkeled only three of each section-type (18 sections) during July 10-13, 1984 (Fig. 12). We classified yearling rainbow-steelhead to be 2"-4" long during early July; age II fish were about 5"-7" long. Young-of-year rainbow-steelhead had not yet emerged by the time we sampled Lo10 Creek.

We determined the length of each section, but measured widths and took habitat measurements on only seven (Table 4). Thus, we can presently determine linear densities (number/100 yd) for all sections, but area1 densities (number/100 $yd^2$) for just seven (Tables 5 and 6). In general rainbow-steelhead (areal) densities were fairly high relative to those in many other Idaho streams in 1984 (Appendix Al), but chinook densities were relatively low (Appendix A2).

Differences in linear densities (number/100 yd) of age I and age II rainbow-steelhead and age 0 chinook between treated and untreated sections in July 1984 were evaluated by a one-way classification analysis of variance. Confidence intervals (+ 2SE) reported for section-type means were determined from the pooled (all sections) variance.

Yearling steelhead make up the majority of the subsequent year's outmigrating smolts from Idaho streams. In early July 1984, yearling rainbow-steelhead were no more abundant in sections with structures than in untreated sections. There was no significant ($p<0.05$) difference ($F=0.00$; $p=0.95$) in linear densities, nor was there any apparent, nonsignificant difference (Fig. 13). Future evaluations for yearling rainbow-steelhead should include larger sample size, a survey in early and late summer to account for changing habitat and habitat requirements (i.e., depths, velocities), and repeated surveys as seeding levels increase.

Abundance of age II rainbow-steelhead apparently did increase in response to the habitat enhanced by some structures. Although not statistically significant ($F=2.18$; $p=0.l2$) age II fish tended to be most abundant in sections treated with log weirs and deflector logs and least abundant in untreated runs and root-wad sections with slow water (Fig. 13). If this apparent difference does represent a true difference (for current seeding levels, in early summer), statistical significance can be established by increasing sample size in future evaluations.

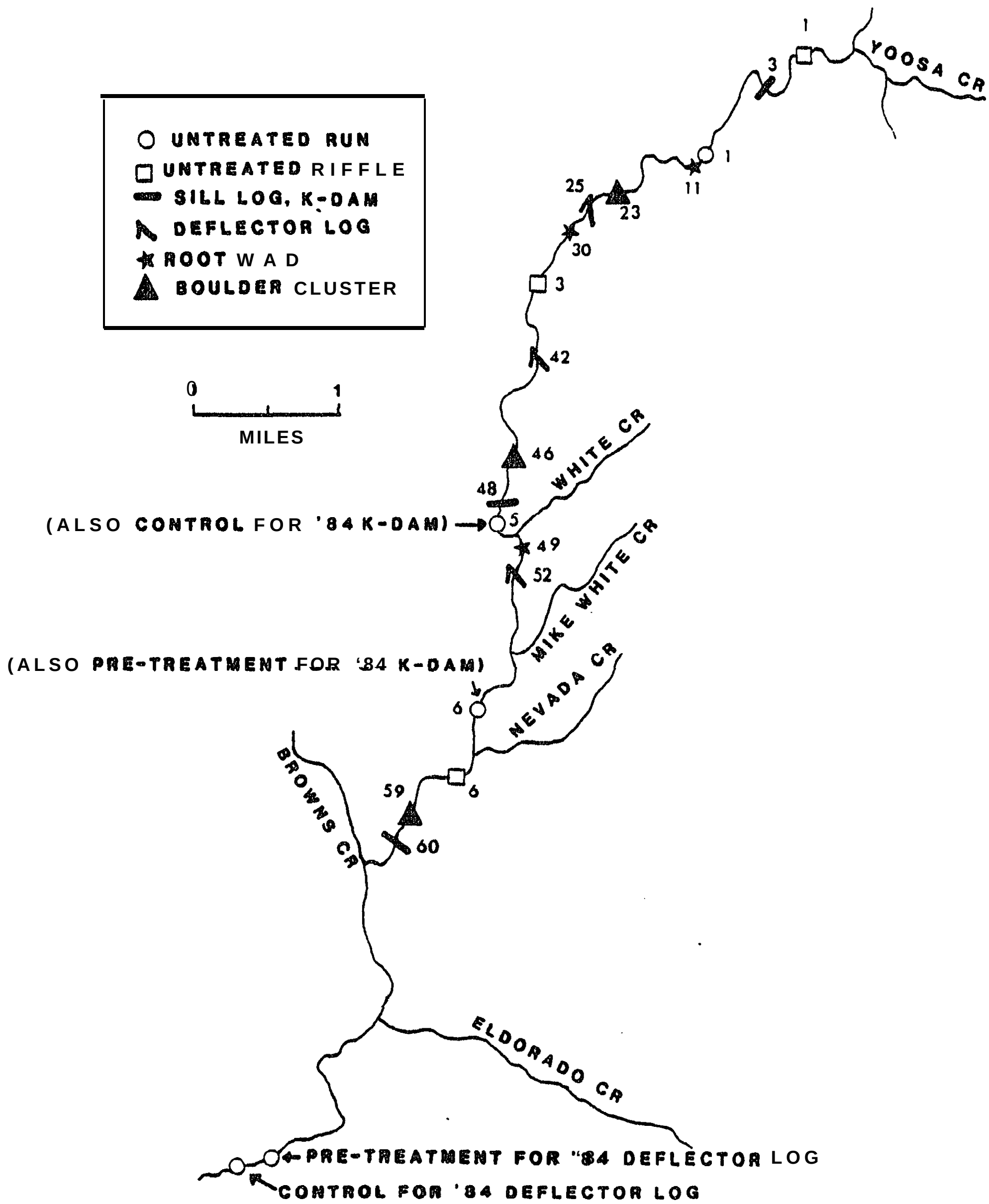



Figure 12. Lolo Creek sections sampled July 10-13, 1984.

Table 4. Sections sampled in Lo10 Creek to assess the 1983 habitat enhancement project, July 10-13, 1984.

| 1983 treatment | Section | Habitat type | Miles above USFS boundary | Length (yd) | Mean width + 2SE (yd) | Area ($yd^2$) |
|---|---|---|---|---|---|---|
| Untreated | 1 | run | 11.2 | 23.3 | -- | -- |
| | 5 | run | 6.8 | 25.0 | 16.2 + 0.5 | 406 |
| | 6 | run | 4.9 | 38.3 | 11.0 + 1.0 | 422 |
| Sill log, K-dam | 3 | run | 11.0 | 15.0 | -- | -- |
| | 48 | run | 6.9 | 29.0 | 17.6 ± 1.4 | 510 |
| | 60 | run | 3.6 | 18.0 | -- | -- |
| Deflector log | 25 | run | 9.4 | 20.0 | 12.7 ± 0.4 | 253 |
| | 42 | run | 7.9 | 25.0 | -- | -- |
| | 52 | run | 6.2 | 18.0 | -- | -- |
| Root wad | 11 | run | 10.1 | 42.0 | -- | -- |
| | 30 | run | 8.8 | 30.0 | 18.3 ± 2.5 | 549 |
| | 49 | run | 6.4 | 35.0 | -- | -- |
| Untreated | 1 | riffle | 10.2 | 16.7 | -- | -- |
| | 3 | riffle | 8.6 | 23.3 | 12.8 ± 1.3 | 298 |
| | 6 | riffle | 4.1 | 18.0 | -- | -- |
| Boulder cluster | 23 | riffle | 9.5 | 30.0 | -- | -- |
| | 45 | riffle | 7.0 | 30.0 | 12.0 ± 1.1 | 360 |
| | 59 | riffle | 3.7 | 19.7 | -- | -- |

Table 5. Number of trout, salmon, and whitefish (number/100 $yd^2$) counted in Lolo Creek sections that were initially run habitat, July 10-13, 1984.

| | Untreated run | | | 1983 sill log or K-dam | | | 1983 deflector log | | | 1983 root wad | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| age | 1 | 5 | 6 | 3 | 48 | 60 | 25 | 42 | 52 | 11 | 30 | 49 |
| **Rainbow-steelhead** | | | | | | | | | | | | |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| I | 10 | 16 (3.9) | 41 (9.7) | 13 | 15 (2.9) | 20 | 16 (6.3) | 27 | 15 | 4 | 14 (2.6) | 63 |
| II | 1 | 2 (0.5) | 9 (2.1) | 8 | 5 (1.0) | 9 | 6 (2.4) | 9 | 9 | 0 | 1 (0.2) | 13 |
| ≥III | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Chinook | 0 | 0 | 16 (3.8) | 30 | | | | | | | | |
| 0 | 0 | 0 | | 3 | 2 | | | | | | 69(12.6) | 61 |
| 14 | | | 0 | | 0 (0.4) | 5 2 | 0 (0.4) | 28 | 0 | 0 | 0 | 0 |
| **Whitefish** | | | | | | | | | | | | |
| 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| ≥I | 8 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Table 6. Number of trout, salmon, and whitefish (number / 100 $yd^2$) counted in Lolo Creek sections that were initially riffle habitat, July 10-13, 1984.

| Species, age | Untreated riffle | | | 1983 boulder clust | | |
|---|---|---|---|---|---|---|
| | 1 | 3 | 6 | 23 | 45 | 59 |
| Rainbow-steelhead | | | | | | |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| I | 15 | 11 (3.7) | 30 | 22 | 17 (4.7) | 25 |
| II | 7 | 4 (1.3) | 6 | 7 | 10 (2.8) | 7 |
| ≥III | 0 | 0 | 0 | 0 | 2 (0.6) | 1 |
| Chinook | | | | | | |
| 0 | 0 | 0 | 1 | - | 6 (1.7) | - |
| I+ | 0 | 0 | 0 | - | 2 (0.6) | - |
| Whitefish | | | | | | |
| 0 | - | - | - | - | - | - |
| ≥I | - | - | - | - | - | - |

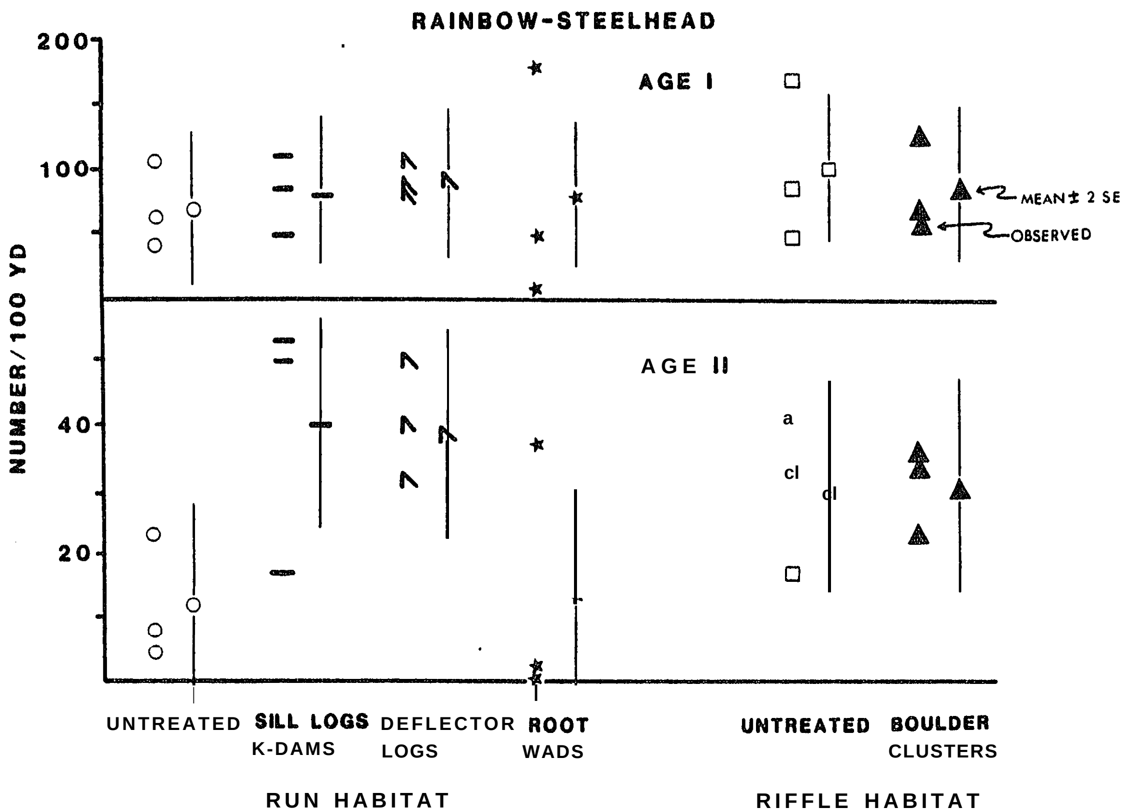



Figure 13. Number of age I and age II rainbow-steelhead/lOO yd (linear) in treated and untreated sections, Lo10 Creek, July 10-13, 1984.

We observed that median lengths of rainbow-steelhead in sections treated with sill logs, K-dams, deflector logs, and boulder clusters were one-inch longer than median lengths in untreated sections or sections containing root wads (Fig. 14). Juvenile rainbow-steelhead did associate with structures where they existed. In July, about 70% of rainbow-steelhead in treated sections were associated with the structures or habitat altered by structures.

Evaluation results for age 0 chinook in July 1984 are inconclusive. There was no significant difference ($F=1.69$; $p=0.21$) in linear densities between treated and untreated sections in July (Fig. 15).

Young chinook were schooled inshore during early July and used backwaters and submerged streamside vegetation for cover. Few chinook occupied riffle habitat in early July. They used sections with structures, but much of what appeared to be good habitat--in both treated and untreated sections--was unoccupied. Because of their small size and preference for shallows in early July, only 40% of the chinook were associated with nearby structures.

We snorkeled several sections on August 11, 1984 to look for adult chinook and to qualitatively observe use of structures by juvenile salmonids. Pools created below K-dams or sill logs were adequate to hide adult chinook, but we saw none. USFS personnel have observed adult chinook using these structures for cover. In August, juvenile rainbow-steelhead used habitat created by structures and were associated with pools below log weirs, boulder clusters, and deflector logs. Juvenile chinook appeared to be more associated with structures in August than they were in July. Juvenile chinook commonly used habitat modified by structures, such as eddies below log weirs, runs deepened by deflector logs, and debris trapped earlier by a deflector log, even though much of the log was then dry. Juvenile chinook were absent from a slow root-wad section (49) that they had used in July.

Physical habitat data from seven sections (untreated runs 5 and 6, untreated riffle 3, K-dam 48, deflector log 25, root wad 30, and boulder cluster 45) in early July 1984, indicate that Lolo Creek should be a good rearing stream for both steelhead and chinook except for the high sediment levels. Sand made up a third of the substrate (by area) and most of the larger substrate was more than 50% embedded (Fig. 16).

Some structures clearly have altered habitat in Lolo Creek, but because no physical measurements exist for the sites before 1984, we cannot measure the actual change for the 1983 project. Log weirs impound water upstream and create plunge pools downstream. Suitable spawning gravel has accumulated immediately above the sills and at tail-outs of the plunge pools; silt and sand have settled in upstream impoundments. Deflector logs have deepened runs and some have accumulated spawning gravel near them. Root wads have

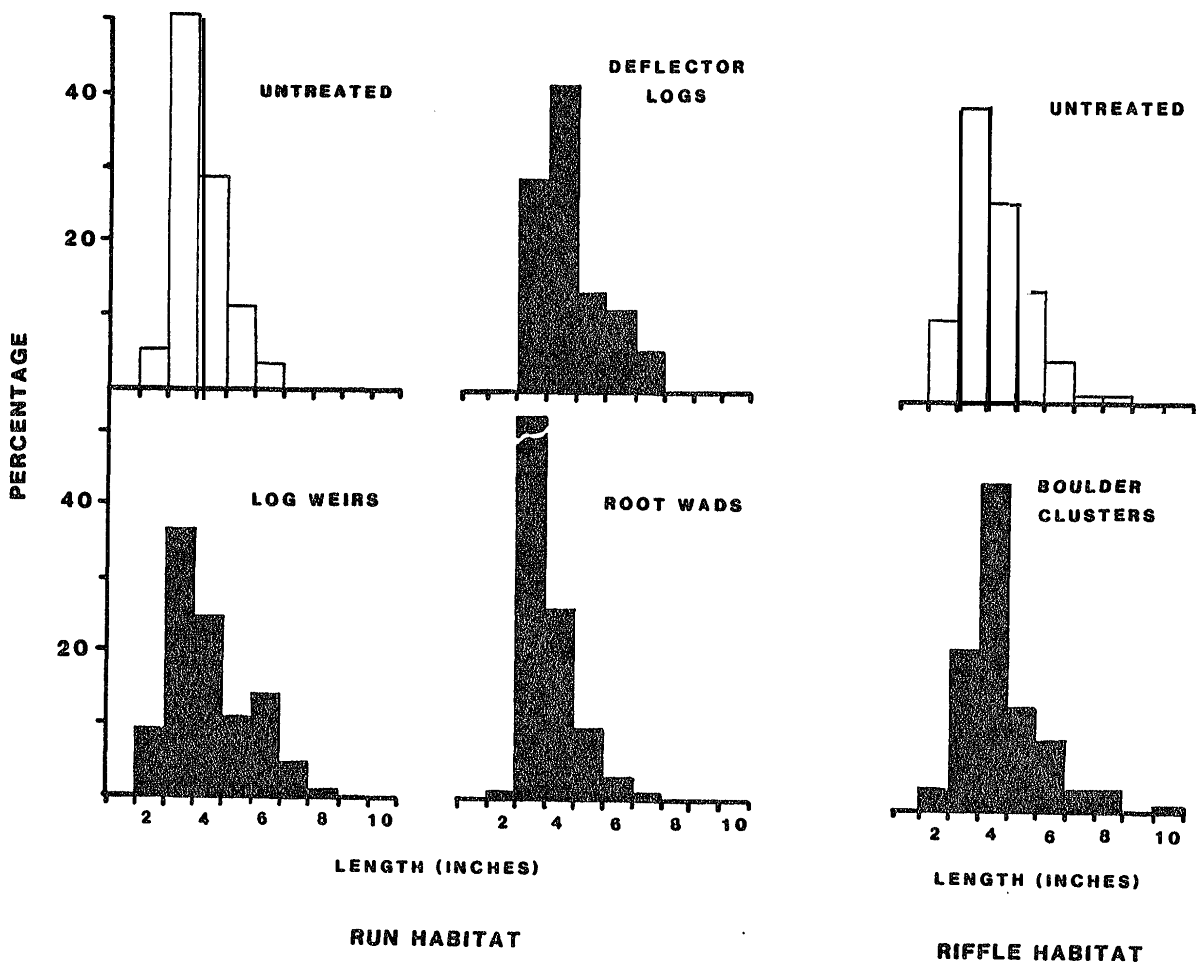



Figure 14. Percentage length-frequency distributions of rainbow-steelhead observed in treated and untreated sections, Lolo Creek, July 10-13, 1984.

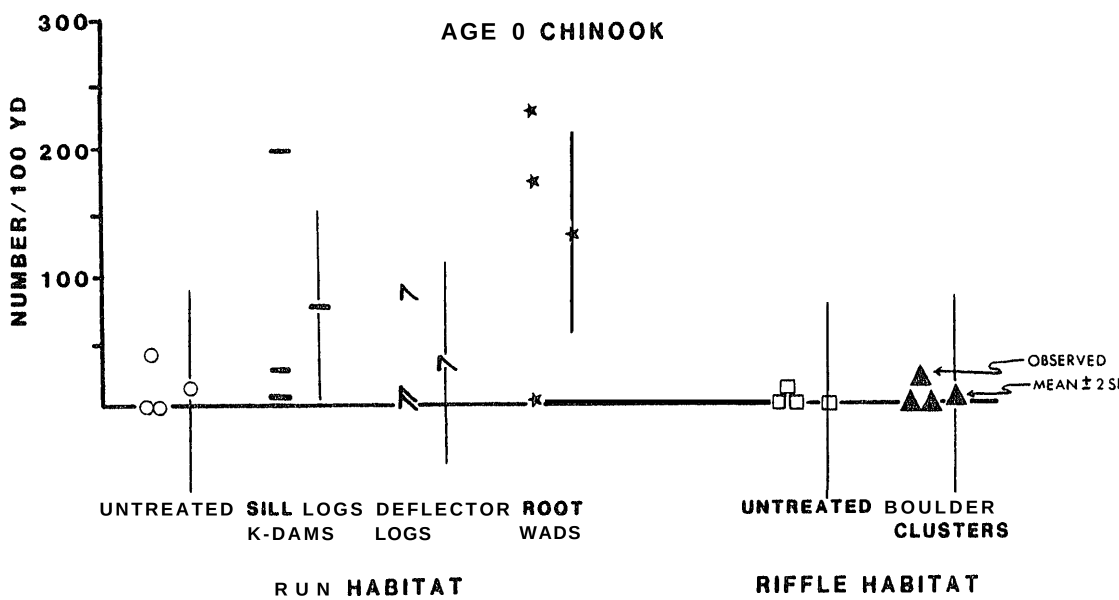



Figure 15. Number of age 0 chinook/100 yd (linear) in treated and untreated sections, Lolo Creek, July 10-13, 1984.

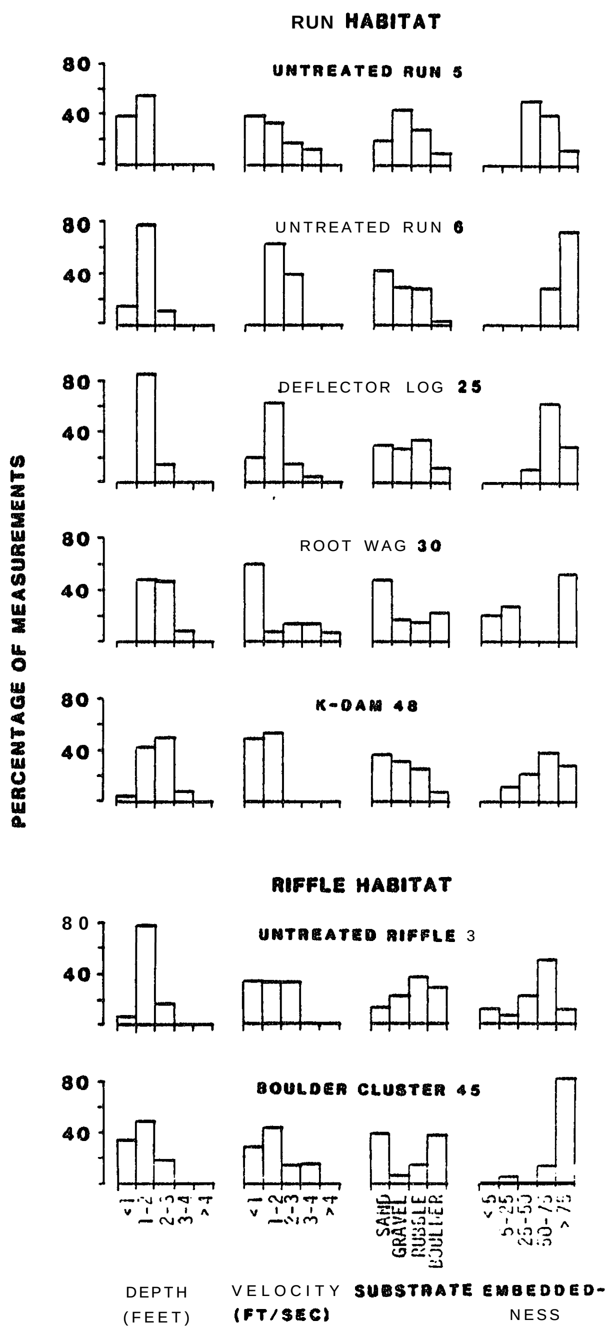



Figure 16. Summary of physical habitat measurements in sections treated during 1983 and in untreated sections, Lo10 Creek, July 10-13, 1984.

apparently not changed the habitat much; in slow runs and pools, some have silted in. Sand has settled downstream from boulders placed in riffles and substrate above and adjacent to boulders appears to have been cleansed. In general, the physical habitat now appears more diverse. Continued, more intensive sampling is needed to evaluate these physical changes in terms of increased abundance of juvenile fish.

## 1984 Habitat Enhancement Project

USFS project personnel installed an additional 256 structures during summer 1984 within the same reach enhanced in 1983 (Yoosa Creek to Browns Creek) and extending down to the Forest boundary (Fig. 8). Most stuctures were boulder placements (193) and deflector logs (30). USFS also installed 7 K-dams, 4 sill logs, 7 boulder weirs, 7 root wads, and 8 bank-cover devices, and removed two debris jams in the vicinity of Nevada Creek.

IDFG evaluation for the 1984 project began as a pre-treatment in 1984, before structures were installed. Part of the evaluation will be incorporated with the sampling program set up for the 1983 project because, for the most part, similar structures were applied in similar ways both years. Snorkeling surveys will be continued for sections containing weirs (log and boulder), deflector logs, root wads, and boulder clusters, as well as for untreated runs and untreated riffles. In addition we established four sections to specifically evaluate the 1984 project. These sections consist of a pre-treatment for a 1984 K-dam paired with a similar control section, and a pre-treatment for a 1984 deflector log paired with another control section (Fig. 12). The K-dam was installed in a low-energy meadow site, whereas the the deflector log was a streamside tree that was dropped and anchored in a relatively high-energy run. With these paired sections, a site-specific change in habitat can be measured. Evaluation of fish response to the 1984 project will be incorporated with the 1983 project evaluation.

We snorkeled these four additional sections during July 10-13, 1984, along with the evaluation of the 1983 project. We measured length and mean width of each section to determine section area (Table 7). We measured the physical habitat variables depth, velocity, substrate composition, and embeddedness at each site.

In early July, yearling and age II rainbow-steelhead occupied the four sections at varying densities. Densities in the pre-treatment and control sections for the deflector log were more comparable than in the paired sections for the K-dam (Table 8). Only the pre-treatment section for the

Table 7. Sections sampled in Lo10 Creek to assess 1984 habitat enhancement project, July 10-13, 1984.

| 1984 treatment | Section | Habitat type | Miles above USFS boundary | Length (yd) | Mean width + 2SE (yd) | Area ($yd^2$) |
|---|---|---|---|---|---|---|
| Untreated | Control | run | 6.8 | 25.0 | 16.2 ± 0.5 | 406 |
| K-dam | Pre-treatment | run | 4.9 | 38.3 | 11.0 ± 1.0 | 422 |
| Untreated | Control | run | -0.1 | 40.0 | 19.1 + 1.3 | 762 |
| Deflector log | Pre-treatment | run | 0.1 | 40.0 | 16.8 ± 0.6 | 672 |

Table 8. Number of trout, salmon, and whitefish (number/100 yd²) in Lolo Creek pre-treatment and control sections for 1984 habitat enhancement project, July 10-13, 1984.

| Species, age | 1984 K-dam | | 1984 deflector log | |
|---|---|---|---|---|
| | Control | Pre-treatment | Control | Pre-treatment |
| Rainbow-steelhead | | | | |
| 0 | 0 | 0 | 0 | 0 |
| II | 16 (3.9) | 41 (9.7) | 10 (1.3) | 7 (1.0) |
| | 2 (0.5) | 9 (2.1) | 6 (0.8) | (1.0) |
| ≥III | 0 | 0 | 0 | |
| Chinook | | | | |
| | 0 | | 0 | 0 |
| 1+ | 0 | 16 (3.8) | 0 | 0 |
| Whitefish | | | | |
| 0 | 0 | 0 | 0 | 0 |
| ≥I | 0 | 0 | 2 (0.3) | 2 (0.3) |

K-dam contained age 0 chinook. The only mountain whitefish observed in Lolo Creek were in the deflector-log and control sections near the Forest boundary.

Because several deflector logs were placed in high-energy runs in 1984, two additional classes (treated and untreated high-energy runs) should be incorporated into the 1985 evaluation. A sample size of 6 sections per class should be sufficient to detect differences of the magnitude observed in 1984 at the 5% level of significance (type II error = 0.3).

Habitat changes in the K-dam and deflector-log sections should be apparent after the 1985 survey. In 1984 the K-dam section before treatment was similar to its control section, although it was slightly deeper and faster, with more sediment (Fig. 17). The deflector log section was very similar to its control.

Bank-cover devices were constructed at eight locations between Yoosa Creek and Browns Creek confluences in 1984. Although their major purpose is to provide overhead cover for adult chinook and steelhead, some were built above water that appears too shallow in summer to hold adults (Fig. 18). Unless water is successfully deepened beneath these, we do not believe they will provide cover for adult chinook.

## Costs and Benefits

Project costs to date for the Lolo Creek habitat enhancement project are presented in Appendix B.

Based on the 1984 evaluation the instream structures appear to have increased rearing potential in early summer for age II rainbow-steelhead but not for yearlings. Better definition of benefits for rainbow-steelhead at current seeding levels will be obtained in 1985. Benefits for rearing chinook may not become apparent until seeding increases substantially.

Final benefits can be calculated at full seeding from the mean difference in summer densities between treated and untreated sections (Table 1). Full seeding could be assured in Lo10 Creek by hatchery releases of fry and fingerling or excess adults of appropriate stock (IDFG 1984). Estimated longevity of the structures will have to be factored into a determination of final benefits. Habitat changes will be documented primarily to supplement biological data.

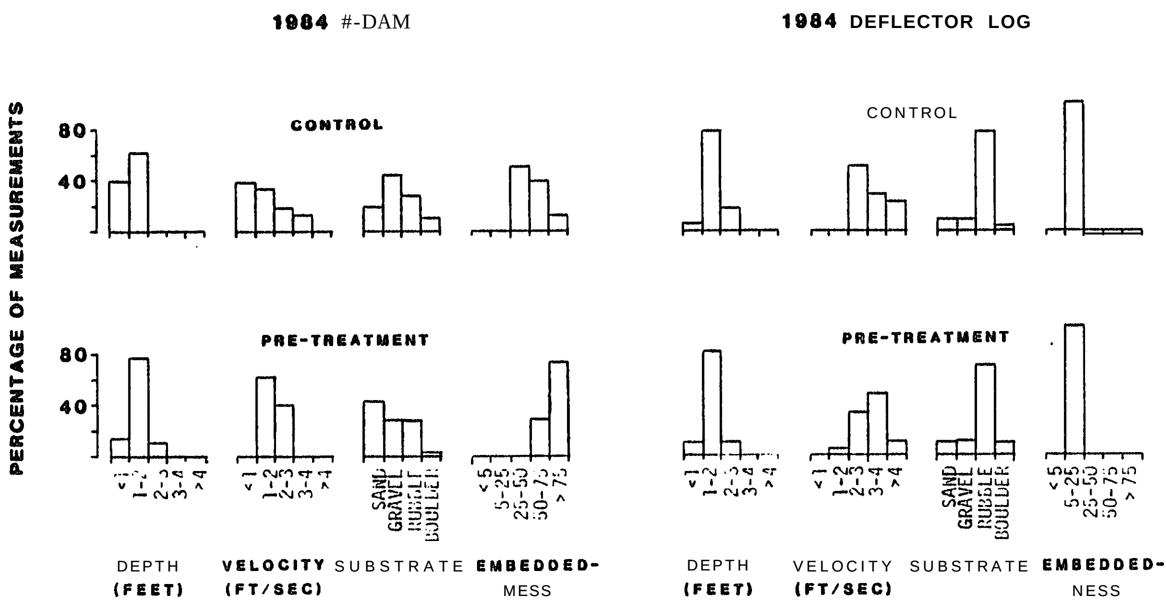



Figure 17. Summary of physical habitat measurements in pre-treatment sections for 1984 project and in control sections, Lolo Creek, July 10-13, 1984.

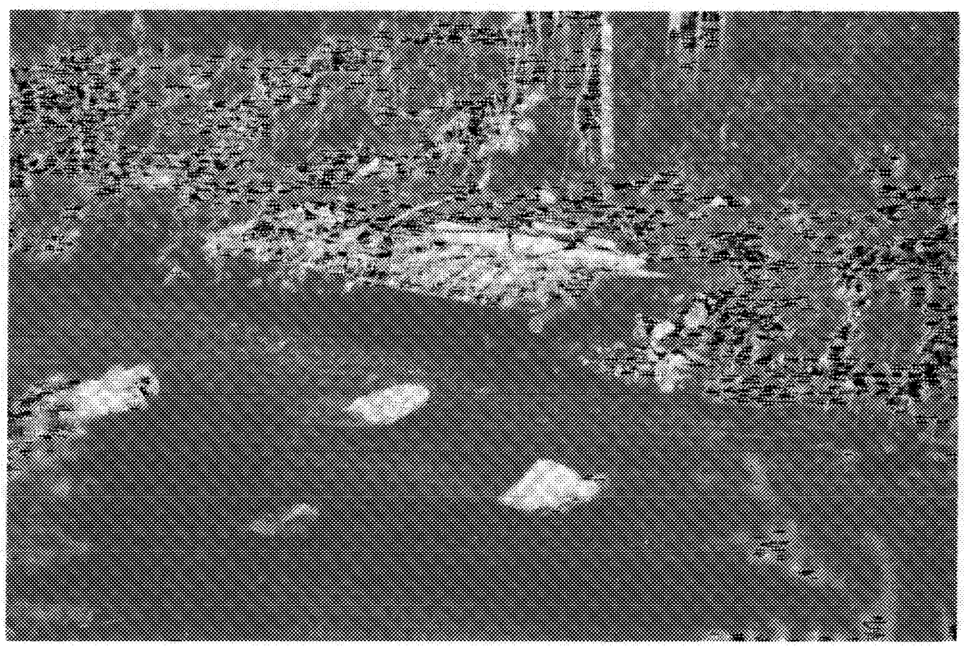


Figure 18. Bank-cover device installed over shallow water, Lolo Creek, September 1984.

## Summary

In 1984 evaluation of the Lo10 Creek enhancement projects (1983 and 1984) indicated possible benefits for larger (age II) rainbow-steelhead, but not for yearlings or for age 0 chinook. Differences in densities of age II rainbow steelhead, if they exist at current seeding levels, can be established statistically by sampling a larger number of sections in future evaluations. More frequent sampling throughout the summer is needed to determine whether more yearling rainbow-steelhead or age 0 chinook use treated sections than untreated at current seeding levels.

## Recommendations

To evaluate increased rearing potential due to structures at current seeding levels, the survey should be repeated in 1985 with an increased number of sections and increased sampling frequency. Two additional classes should be incorporated into the evaluation: high-energy runs with and without deflector logs. In 1985 we plan to sample 48 sections (six sections per class) in early July and late August, provided that juvenile densities are similar to or higher than in 1984. Physical habitat should be measured in treated and untreated sections in the 1985 survey.

After the 1985 evaluation, a few trend sections should be sampled annually to monitor steelhead and chinook densities in the project area and downstream until seeding levels change enough to warrant a follow-up evaluation. Annual chinook spawning ground counts should be established in the project area.

## Eldorado Creek

Eldorado Creek is 16 miles long and enters Lolo Creek at stream mile 26 (Fig. 19). About one mile from its confluence with Lo10 Creek, three natural basalt falls and a boulder constriction adjacent to USFS Road 500 have restricted passage of anadromous fish. Removal of the barriers would bring an estimated 40-50 acres of spawning and rearing habitat into production for steelhead and chinook.

The barriers have been a total block to both steelhead and chinook in recent years. Nez Perce tribal biologists surveyed Eldorado Creek in 1983 (Fuller, et al. 1984) and found cutthroat trout to be the only salmonid above the barriers. Rainbow trout, probably resident, have been reported above the barriers (W. Murphy, USFS, Kamiah, Idaho, personal communication).

Objectives of this project are: 1) provide access for adult steelhead and chinook into spawning and rearing areas of Eldorado Creek; 2) introduce populations of suitable stock into habitat made available by the barrier removal project; and 3) increase natural production of steelhead and chinook, consistent with IDFG (1984) Anadromous Fish Management Plan for subbasin CL-3.

### 1984 Barrier Removal

USFS project personnel began work on barrier removal in September 1984. Barriers at low and high-flow conditions after the 1984 project are shown in Figures 20-23.

Blasting on the upper barrier (number 1), a boulder constriction, was apparently successful. Rock berms were constructed below the jumping pool to maintain water depth. Rocks used in berm construction appeared to be small; stability of berms should be apparent after the 1985 runoff.

Barrier removal on the lower three barriers, natural basalt falls, was not completed in 1984. Drilling in fractured basalt caused bits to stick and jumping pools could not be created with the planned precision. At this time, neither jumping pools nor heights of jump appear adequate to pass anadromous fish on any of the lower three barriers.

USFS will continue to work on barrier removals during 1985. Alternate approaches have not yet been definitely established.

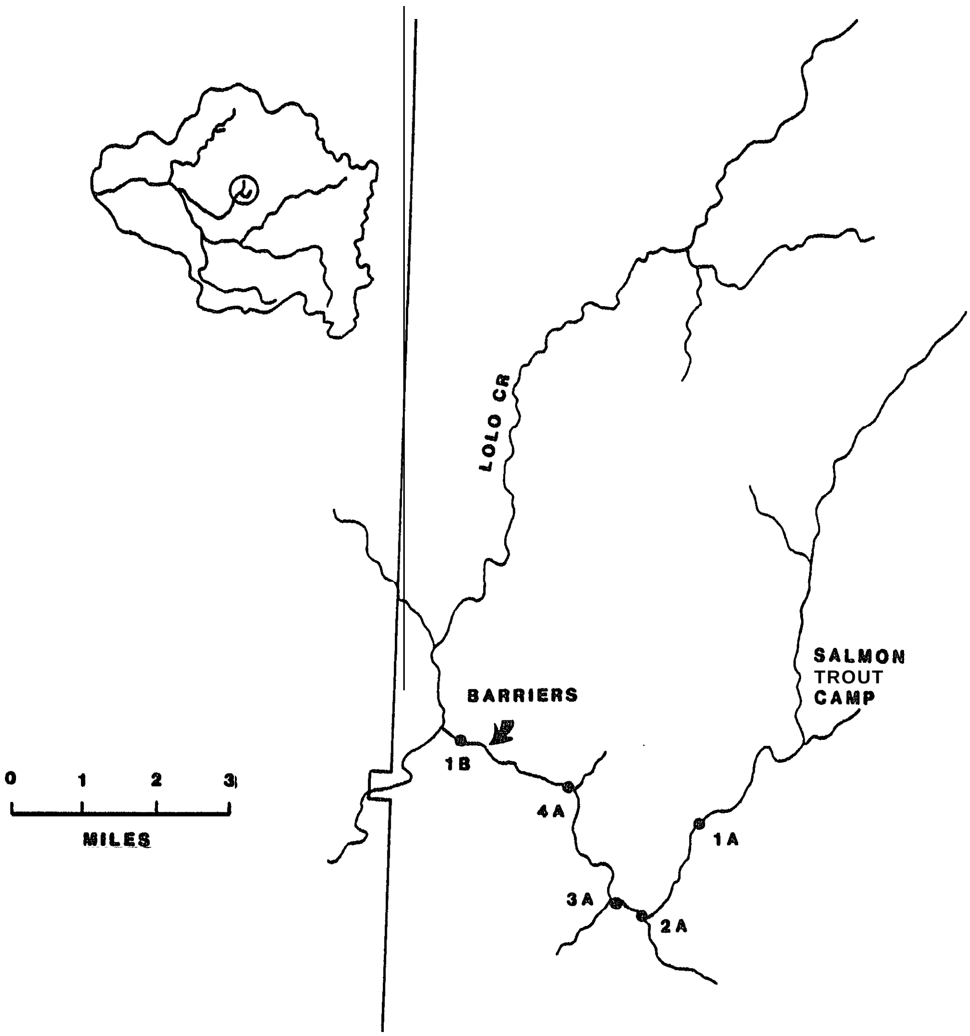



Figure 19. Sections sampled in Eldorado Creek, July 9-13, 1984.

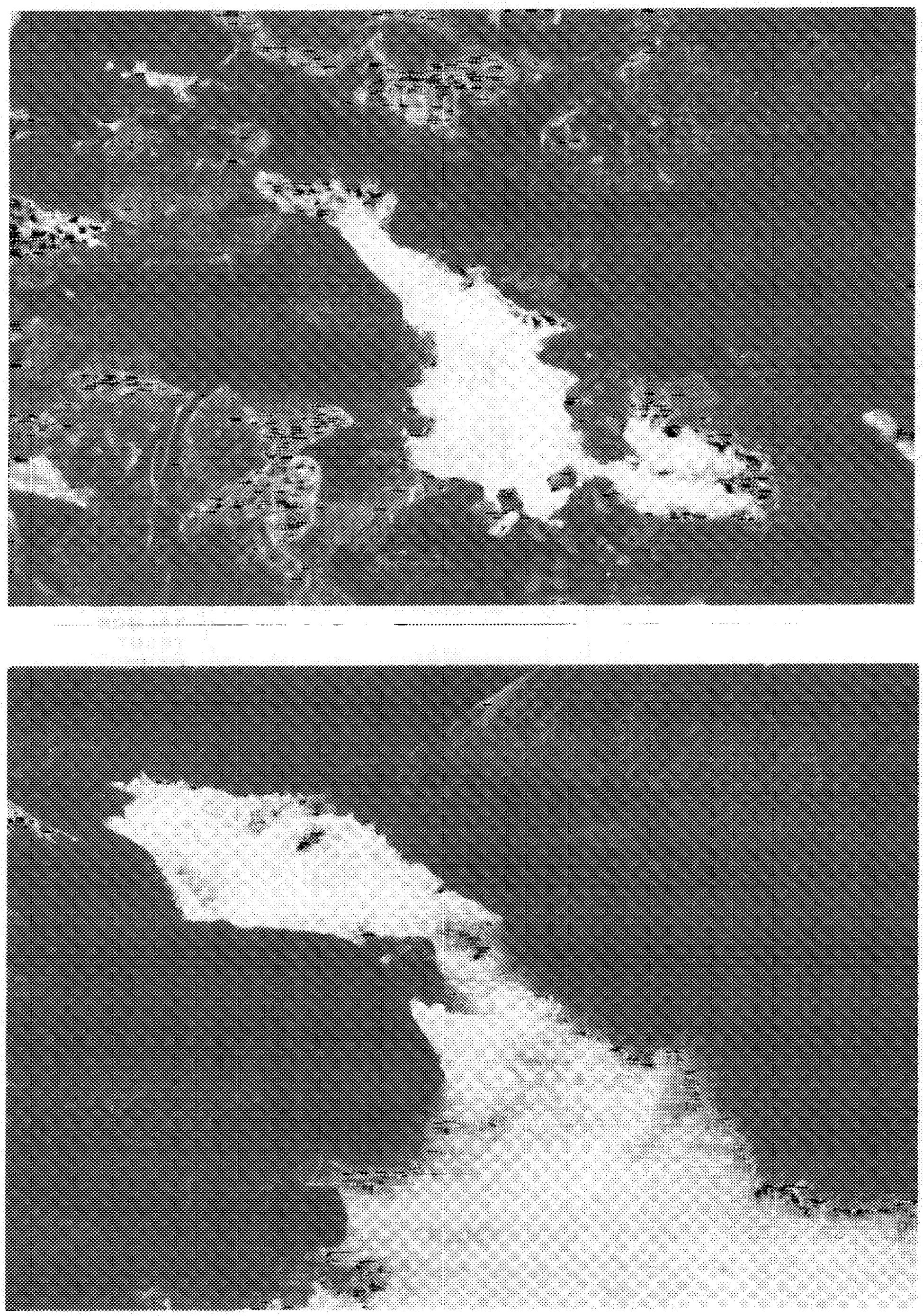


Figure 20. Barrier 1 on Eldorado Creek at low flow in October 1984 (upper photo) and at high flow in May 1985 (lower photo) after 1984 project.

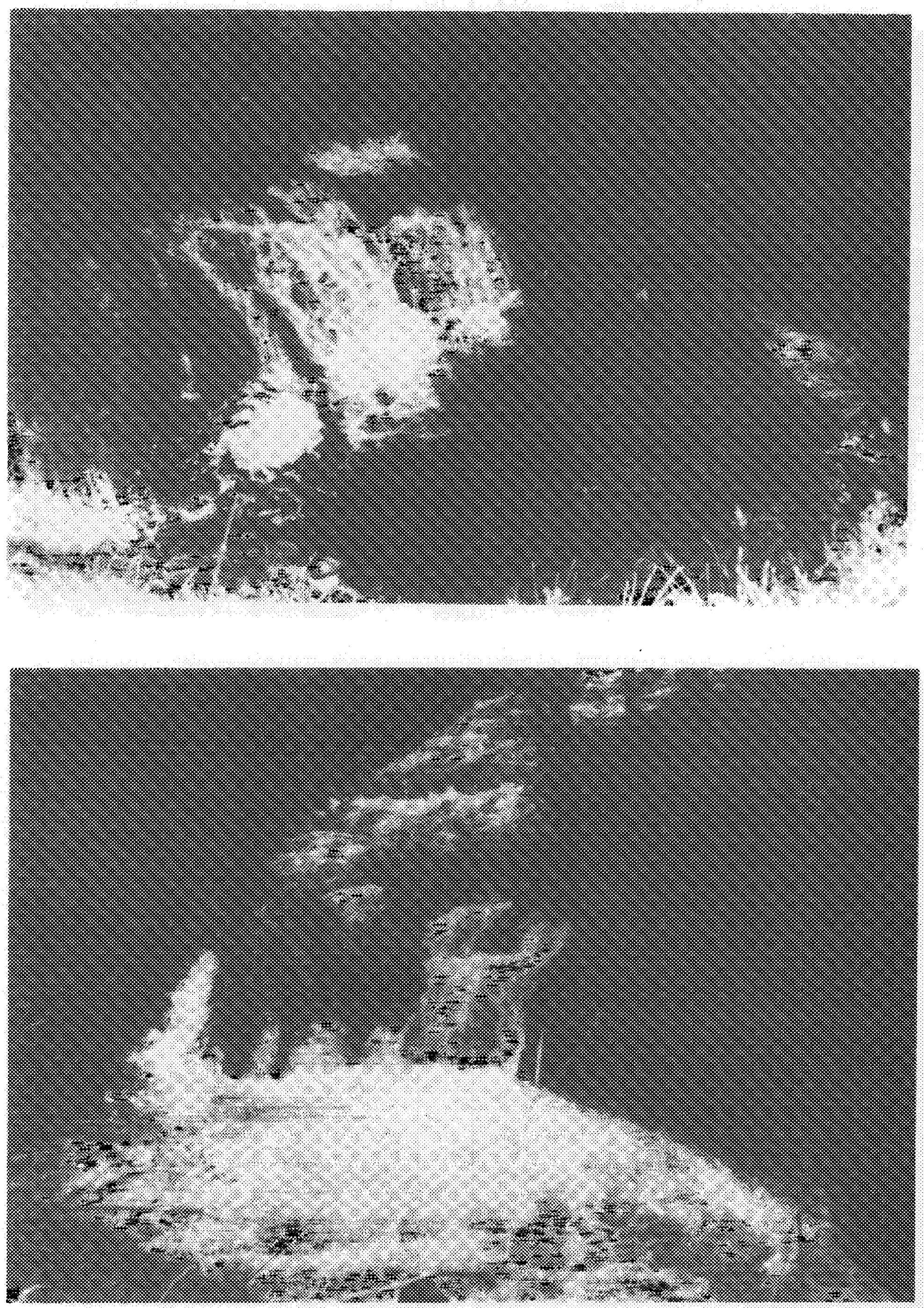


Figure 21. Barrier 2 on Eldorado Creek at low flow in October 1984 (upper photo) and at high flow in May 1985 (lower photo) after 1984 project.

Barrier 3 on Eldorada Creek at low flow in October 1985 (upper photo) and at high flow in May 1985 flower photo) after 1984 project.

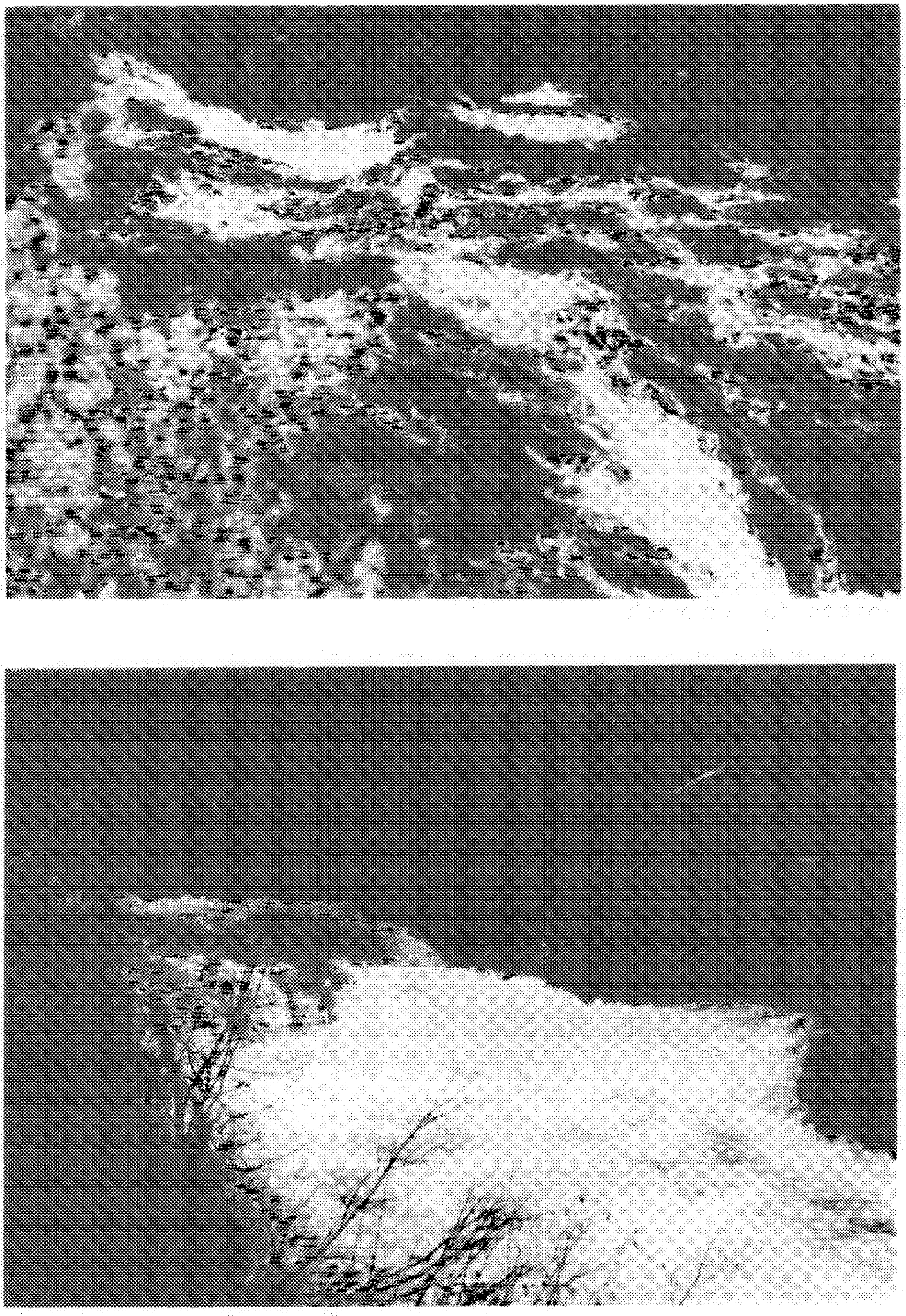


Figure 23. Barrier 4 on Eldorado Creek at low flow in October 1984 (upper photo) and at high flow in May 1985 (lower photo) after 1984 project.

IDFG sampled four sections in Eldorado Creek above the barriers and one section below the barriers (Fig, 19; Table 9) during July 9-13, 1984 before barrier removal work began. The sections above the barriers, each about ZOO-yards long, were located in a moderate gradient (1.2%) reach, typified by either long runs with short riffles or pocket water, A meandering meadow reach above Salmon Trout Camp was not sampled in 1984.

In 1984 only cutthroat trout were observed above the barrier, while juvenile rainbow-steelhead predominated below (Table 10). No chinook were observed in Eldorado Creek sections.

Eldorado Creek above the barriers has good potential to rear both steelhead and chinook. The better steelhead habitat appears to be the 7.5 miles immediately above the barriers. In 1984 an estimated 4,440 ± 1,540 cutthroat trout, excluding fry, reared in this 7.5 miles. We expect that at least as many juvenile steelhead could rear there after barrier removal, and additional steelhead could rear upstream in the slower meadow reach. The best chinook rearing habitat appears to be upstream of Salmon Trout Camp in the slower meadow reach, but the lower 7.5 miles also contains much suitable rearing habitat for chinook.

We did not measure physical habitat in Eldorado Creek sections in 1984. However, sediment levels appeared comparable to those in Lolo Creek.

## Costs and Benefits

Project costs to date are presented in Appendix B.

Final benefits of the barrier removal project can be calculated from estimated standing crops of juvenile steelhead and chinook at full seeding (Table 1). Because the Eldorado Creek barriers completely block anadromous fish runs, all anadromous fish reared above the barriers in the future can be considered benefits from the project.

## Summary

USFS personnel encountered problems with the Eldorado Creek barrier

Table 9. Sections sampled in Eldorado Creek to assess 1984 barrier removal project, July 9-13, 1984. Section areas based on a width of 10 yd, measured at the confluence.

| Section | Length (yd) | Width | Approximate area ($yd^2$) | % habitat type Pool/ run | Riffle | Pocket water |
|---|---|---|---|---|---|---|
| Above barriers | | | | | | |
| 1A | 240 | -- | 2,400 | 33 | 4 | 63 |
| 2A | 183 | -- | 1,830 | 57 | 43 | 0 |
| 3A | 233 | -- | 2,330 | 87 | 13 | 0 |
| 4A | 187 | -- | 1,870 | 20 | 40 | 40 |
| Below barriers | | | | | | |
| 1B | 200 | -- | 2,000 | 0 | 0 | 100 |

Table 10. Number of trout, salmon, and whitefish counted in Eldorado Creek sections to assess barrier removal, July 9-13, 1984. Densities (number/100 $yd^2$, in parentheses) calculated from an assumed mean width of 10 yd.

| Species, age | Above barrier 1A | 2A | 3A | 4A | Below barrier 1B |
|---|---|---|---|---|---|
| Rainbow-steelhead | | | | | |
| 0 | 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 | 50 (2.5) |
| II | 0 | 0 | 0 | 0 | 34 (1.7) |
| ≥III | 0 | 0 | 0 | 0 | 2 (0.1) |
| Chinook | | | | | |
| 0 | 0 | 0 | 0 | 0 | 0 |
| I+ | 0 | 0 | 0 | 0 | 0 |
| Cutthroat | | | | | |
| ≥I | 69 (2.9) | 66 (3.6) | 48 (2.1) | 91 (4.9) | 0 |
| Brook | | | | | |
| 0 | 0 | 0 | 0 | 0 | 0 |
| ≥I | 0 | 0 | 0 | 0 | 1 (+) |
| Whitefish | | | | | |
| 0 | 0 | 0 | 0 | 0 | 0 |
| ≥I | 0 | 0 | 0 | 0 | 6 (0.3) |

removal in 1984. These problems should be corrected by late-summer 1985. IDFG fish surveys found no evidence of anadromous fish above the barriers in 1984. Once the barriers are successfully modified to pass adult steelhead and chinook, we expect significant benefits for both species.

Artificial seeding of Eldorado Creek with summer steelhead and spring chinook will be required initially to establish runs.

## Recommendations

Annual surveys of juvenile fish densities in trend sections of Eldorado Creek should be initiated once barrier removals appear to be complete and juvenile steelhead and chinook are introduced above the barriers. Steelhead should be stocked above the barrier in 1985. Chinook should be stocked as available. Future fish abundance surveys need to be expanded to include two sections in the meandering meadow habitat above Salmon Trout Camp. An annual spawning ground survey for chinook should be established as adults return from initial introductions.

## Upper Lochsa River

The Lochsa River is formed by the confluence of Crooked Fork Creek and White Sand Creek (Fig. 24). Each major tributary is about 24-miles long and drains about 150,000 acres of the Bitterroot Mountains (Espinosa 1984). Crooked Fork Creek watershed is owned by USFS (77%) and Plum Creek Timber Company (23%). White Sand Creek watershed is owned primarily by USFS (98%); this tributary originates in the Selway-Bitterroot Wilderness Area. The two streams have similar channel gradients (1%) and flows (160-170 cfs, base; 3,000 cfs, peak). The project area includes USFS-owned portions of Crooked Fork Creek and White Sand Creek outside of the Wilderness Area.

Crooked Fork Creek and White Sand Creek are major producers of summer steelhead and spring chinook for the Lochsa River. Within their systems, they contain the bulk of the remaining high quality spawning and rearing habitat for anadromous fish on the Clearwater National Forest. The long-term ability to restore and maintain anadromous fish runs to the upper Lochsa River depends on maintenance and enhancement of spawning and rearing habitat in these two systems. Records of densities of juvenile rainbow-steelhead and chinook for Crooked Fork Creek and White Sand Creek go back to 1975, when steelhead run size was lowest in recent history (Graham 1977; Mabbott 1982). Densities of age 0 and yearling rainbow-steelhead have increased in Crooked Fork Creek since 1975-76; age II rainbow-steelhead and age 0 chinook densities have not changed markedly (Fig. 25-26).

Other, nonanadromous salmonids in the upper Lochsa River system are rainbow trout, cutthroat trout, bull trout, brook trout, and mountain whitefish (Mallet 1974).

Extensive timber harvesting and road construction has occurred during the past two decades, primarily in the lower half of Crooked Fork Creek watershed and its subdrainage Brushy Fork Creek (Espinosa 1984). Only the lower three miles of White Sand Creek drainage have been developed extensively. A series of seven natural barriers blocks salmon passage and partially blocks steelhead passage to high-quality rearing habitat in upper Crooked Fork Creek. No migration barriers exist in White Sand Creek within the project area.

USFS habitat surveys on Crooked Fork Creek in 1979 and White Sand Creek in 1971 suggested that some potential limiting factors to fish production were suboptimum levels of pool quality, bank cover, pool/riffle structure, and habitat diversity (Espinosa 1984). The surveys also suggested that suitable spawning habitat might be limiting in Crooked Fork Creek. In 1981, USFS fish abundance surveys on Crooked Fork Creek above the barriers found age I

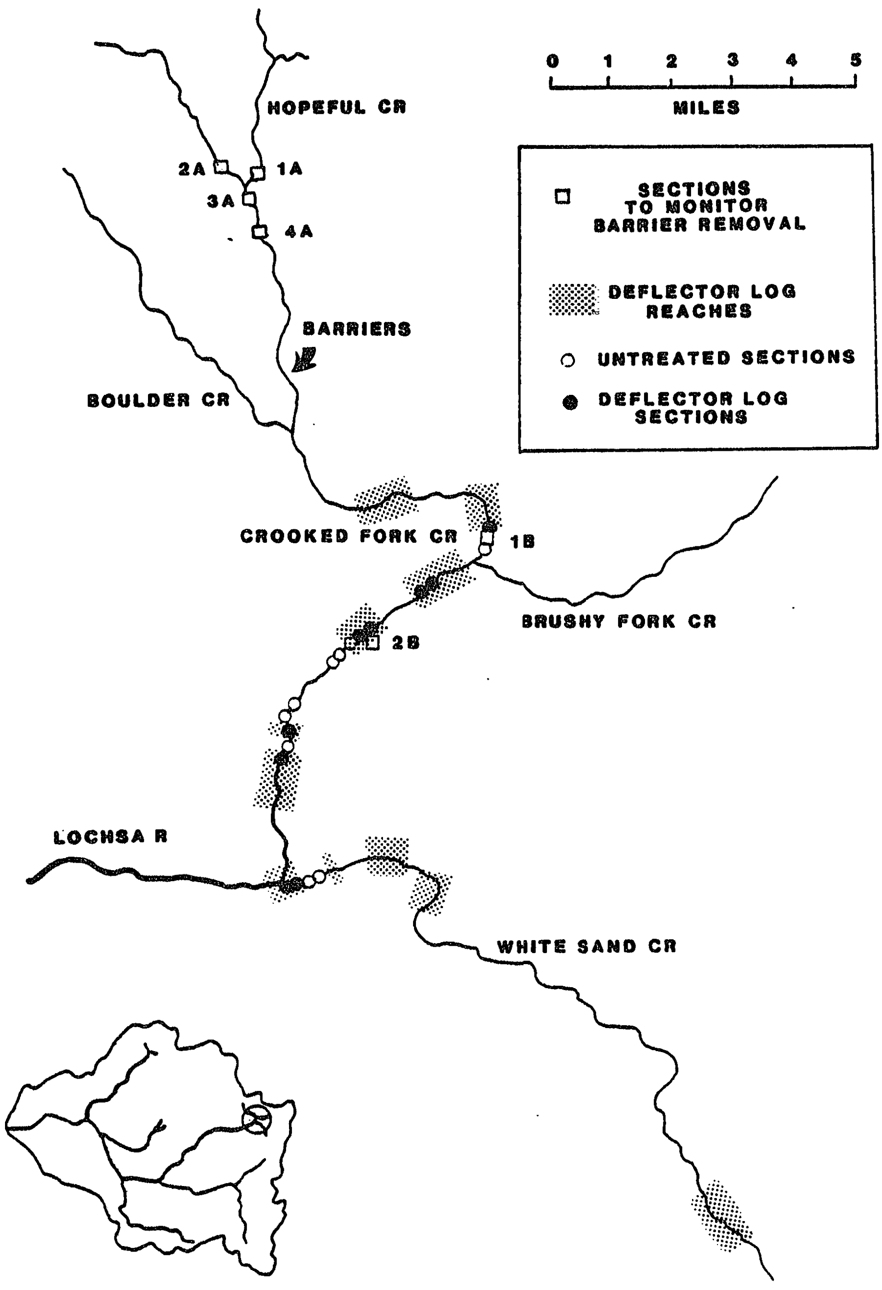



Figure 24 Crooked Fork Creek and White Sand Creek habitat enhancement projects and sample sections, upper Lochsa River.

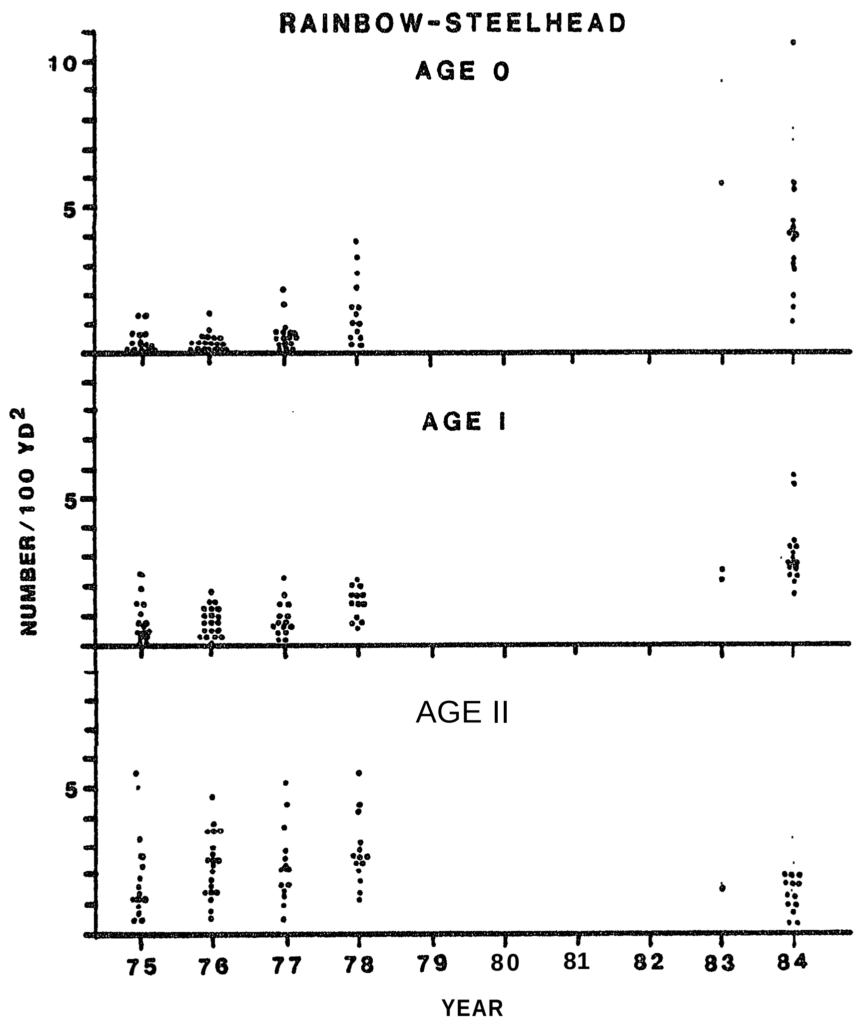



Figure 25. Densities of juvenile rainbow-steelhead, Crooked Fork Creek, 1975-84.

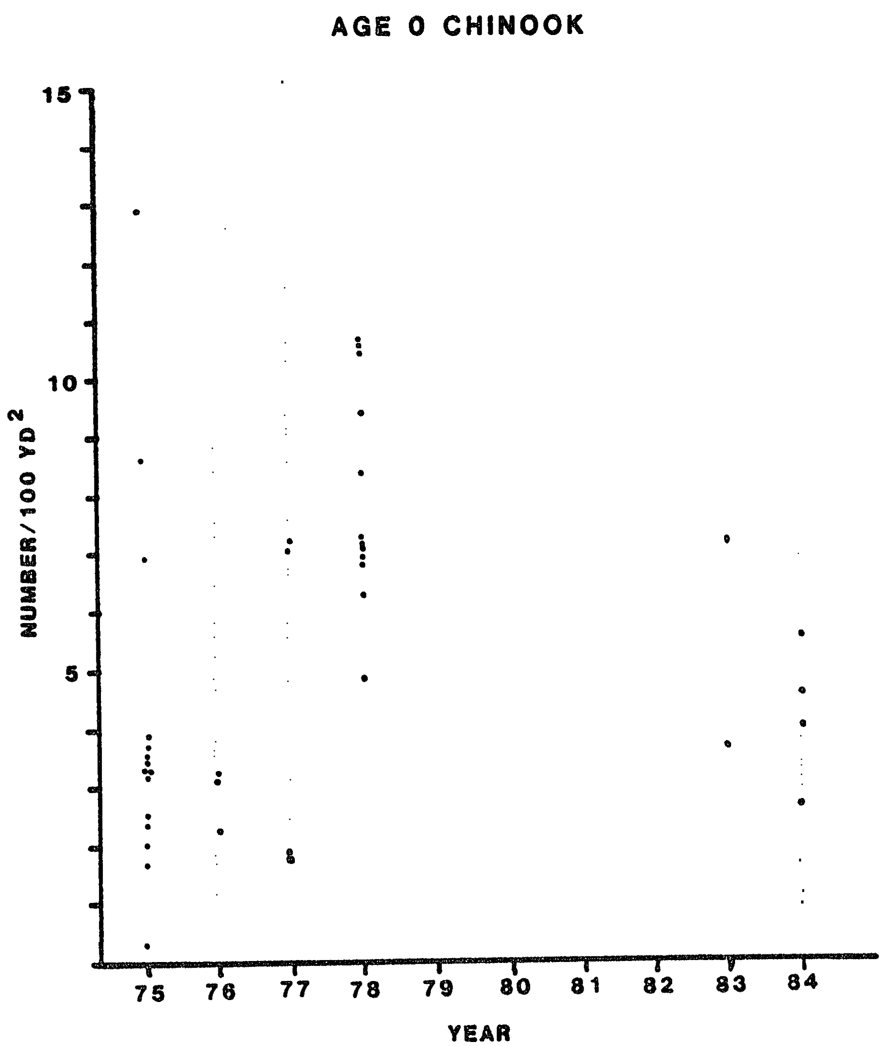



Figure 26. Densities of age 0 chinook, Crooked Fork Creek, 1975-84.

rainbow-steelhead present in low densities (1.4/100 $yd^2$), evidence that a few adult steelhead passed the barriers in 1980 (R. Kramer, USFS, Powell, Idaho, personal communication).

Objectives of instream habitat enhancement projects in Crooked Fork Creek and White Sand Creek were: 1) increase rearing potential for juvenile steelhead and chinook; 2) increase pool frequency and quality; and 3) increase natural production of steelhead and chinook, consistent with IDFG (1984) Anadromous Fish Management Plan for subbasin CL-6.

Objectives of the barrier removal project on Crooked Fork Creek were: 1) provide access for adult steelhead and chinook into spawning and rearing areas of upper Crooked Fork Creek; 2) if necessary, introduce populations of suitable stock into habitat made available by barrier removal; and 3) increase natural production of steelhead and chinook, consistent with IDFG (1984) Anadromous Fish Management Plan for subbasin CL-6.

## 1983 Habitat Enhancement Project

During summer 1983, USFS project personnel installed 118 deflector-log structures in seven reaches of Crooked Fork Creek and 78 structures in five reaches of White Sand Creek (Espinosa 1984). Most (200) structures were riparian conifers which were felled and cabled into place; the rest were "opportunity debris" (naturally fallen logs) which were simply cabled. In Crooked Fork Creek, 5.6 miles were treated with an average number of 30 per mile. In White Sand Creek, 3.4 miles were treated with an average number of 27 per mile. Secondary channels, where they occurred, were identified as highly preferred enhancement sites because of their smaller size and lower flows. Structures were installed only on USFS land.

Severe habitat conditions, which are typical for the drainages, influenced performance of the structures. An ice jam, 'I-feet thick, moved through the project area of Crooked Fork Creek during winter 1983-84. A USFS survey of about half the structures in April 1984 indicated that eight structures had broken from force of the ice (R. Kramer, USFS, Powell, Idaho, personal communication). Generally, these were at a steep angle from the bank and were too rigidly secured to pivot. On average, peak runoff flows exceed low flows by 18-fold. Deflector logs tended to pivot with the high flows in May-June 1984 and stayed in the current. By August during low flows, many were "high and dry", resting on the large rubble and boulder substrate. Figure 27 exemplifies these conditions.

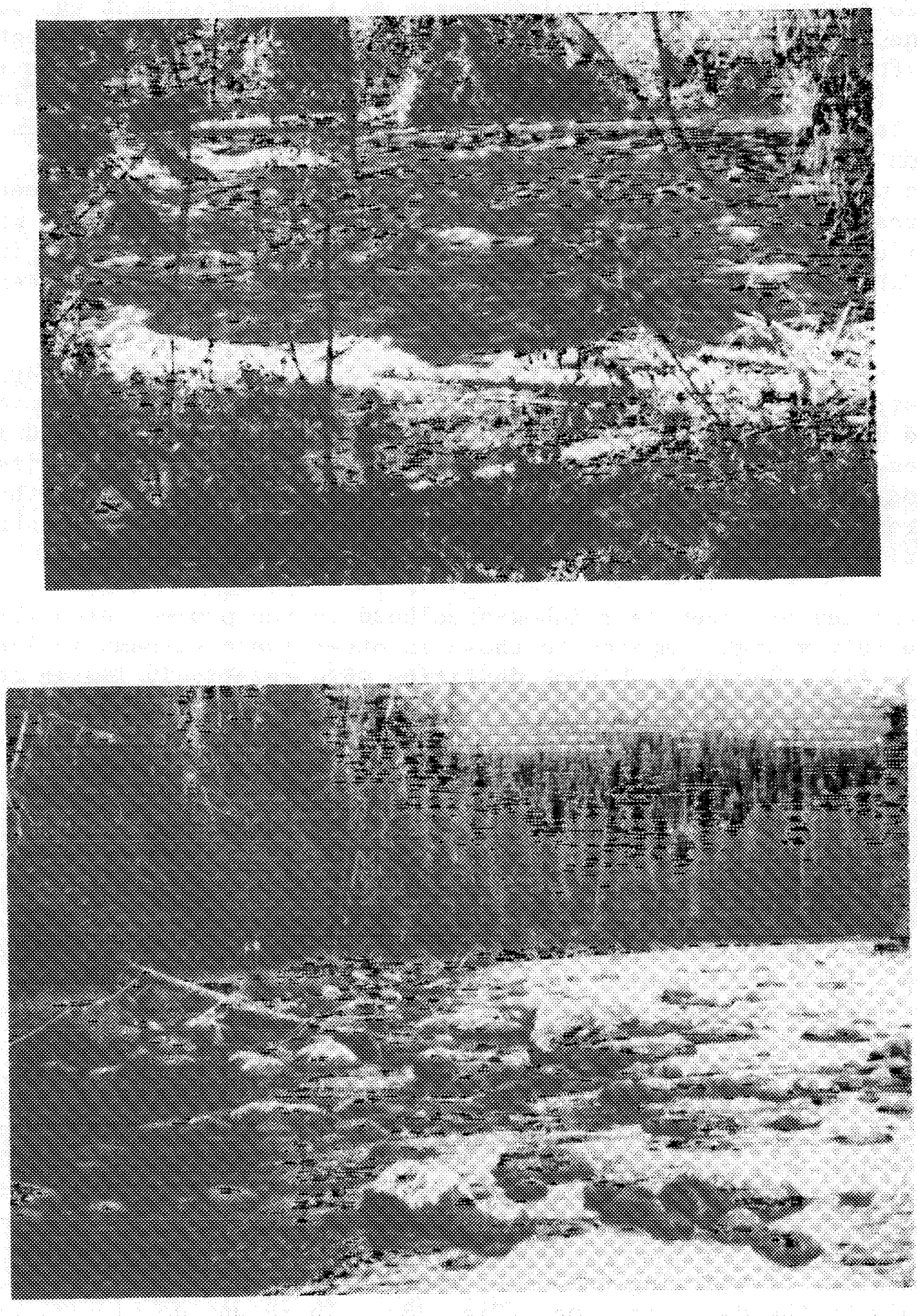


Figure 27. Deflector logs in the current during high flows in June 1984 (upper photo) and "high and dry" during low flow in August 1984 (lower photo).

IDFG assessment of the project began as a post-treatment evaluation in 1984, one year after implementation. We selected seven treated sections in Crooked Fork Creek and two in White Sand Creek near its confluence (Fig. 24). Controls (untreated sections) were selected either on Plum Creek Timber Company land or in unenhanced reaches on USFS land. Seven controls were chosen on Crooked Fork Creek, interspersed among treated sections, and two controls were chosen near treated sections on lower White Sand Creek (Table 11). Treatment sections were limited in length to the area which may have been influenced by the structures; control sections were selected in run habitat which appeared similar to runs where deflector logs had been installed in 1983.

We snorkeled the 18 sections on August 8-9, 1984, recording approximate fish distributions by species and size on a sketch map of the section. We measured lengths and widths of the sections to determine areas and fish densities. We measured depths at lo-foot increments across the stream to plot depth contours to detect possible modification of run habitat by the structures. No additional habitat measurements (eg., velocity, substrate composition, embeddedness) were taken in 1984.

Densities of juvenile rainbow-steelhead in the project area (Tables 12, 13) were fairly high compared to those in other Idaho streams in 1984 (Appendix Al). Juvenile chinook densities were relatively low in comparison (Appendix A2).

Differences in densities between treated and untreated sections were assessed statistically using a one-way classification. Because significant trends in density occurred from upstream to downstream locations, the variable "miles upstream from confluence" was used as a covariate to reduce the variance and increase power of the models to detect differences. Statistical tests were conducted at the 5% level. Confidence intervals (+ 2SE) reported for section-type means were determined from the pooled (all sections) variance. Fish distribution and depth contour maps enabled us to qualitatively determine associations of juvenile anadromous fish with structures or habitat modified by the structures.

Age 0 rainbow-steelhead were not more abundant in sections treated with deflector logs than in control sections (Fig. 28). Rather, they were significantly ($F=6.38$; $p=0.02$) more abundant in control sections. Their higher mean abundance in controls apparently reflects high abundance in three sections (controls 4, 5, and 9), and not an avoidance of treated sections.

Densities of yearling and older rainbow-steelhead were not influenced measurably by the deflector logs (Fig. 28). There was no significant ($F=0.91$; $p=0.35$) nor apparent difference in mean density of yearlings between treated

Table 11. Sections sampled in Crooked Fork Creek (CF) and White Sand Creek (WS) to assess 1983 deflector log applications, August 8-9, 1984.

| Treatment and stream | Section | Channel type: Main (M) or Secondary (S) | Miles above con-fluence | Length (yd) | Mean width +2SE (yd) | Area ($yd^2$) |
|---|---|---|---|---|---|---|
| Untreated | | | | | | |
| WS | 1 | M | 0.6 | 60.0 | 46.7 | 2,800 |
| WS | 2 | M | 0.6 | 46.7 | 40.0 | 1,867 |
| CF | 3 | M | 2.5 | 71.4 | 27.9 ± 3.5 | 2,000 |
| CF | 4 | M | 3.0 | 41.7 | 20.3 ± 1.4 | 847 |
| CF | 5 | M | 3.5 | 33.3 | 26.8 ± 2.5 | 892 |
| CF | 6 | S | 4.7 | 43.3 | 21.9 ± 2.7 | 949 |
| CF | 7 | S | 4.7 | 40.7 | 17.2 ± 0.3 | 699 |
| CF | 8 | M | 5.1 | 28.3 | 29.2 ± 4.5 | 826 |
| CF | 9 | M | 7.6 | 40.0 | 19.6 ± 0.6 | 783 |
| Deflector log | | | | | | |
| WS | 1 | M | 0.2 | 60.0 | 46.7 | 2,800 |
| WS | 2 | M | 0.2 | 53.3 | 46.7 | 2,491 |
| CF | 3 | M | 2.2 | 40.0 | 29.2 ± 3.5 | 1,166 |
| CF | 4 | M | 2.9 | 33.3 | 34.4 ± 0.9 | 1,147 |
| CF | 5 | M | 5.1 | 20.0 | 23.1 ± 0.4 | 462 |
| CF | 6 | M | 5.1 | 20.0 | 21.8 ± 1.1 | 435 |
| CF | 7 | S | 6.7 | 41.7 | 14.6 ± 1.7 | 608 |
| CF | 8 | S | 6.7 | 30.0 | 13.7 ± 1.4 | 410 |
| CF | 9 | M | 7.8 | 38.0 | 26.5 ± 0.5 | 1,008 |

Table 12. Number of trout, salmon, and whitefish (number/loo yd²) counted in untreated sections to assess 1983 deflector log appl icat ions, Crooked Fork and White Sand Creeks, August 8-9, 1984.

| Species, age | Untreated sect ions | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| **Rainbow-steelhead** | | | | | | | | | |
| 0 | 7 (0.2) | 13 (0.7) | 88 (2.4) | 30 (3.5) | 20 (2.2) | 23 (2.4) | 28 (4.0) | 35 (4.2) | 83 (10.6) |
| I | (0.2) | 8 (0.4) | | 17 (2.0) | 4 (0.4) | 9 (0.9) | 40 (5.7) | 22 (2.7) | 26 (3.3) |
| II | | | 47 (2.4) | [illegible] | | | | | 25 (3.2) |
| ≥III | 6 | 0 | 2 (0.1) | 1 (0.1) | 0 | 0 | 0 (1.4) | 0 (1.5) | 0 |
| | 0 | | | | | | | | |
| **Chinook** | | | | | | | | | |
| 0 | 1 (+) | 3 (0.1) | 34 (1.7) | 47 (5.5) | 17 (1.9) | 66 (7.0) | 18 (2.6) | 33 (4.0) | 9 (1.1) |
| I+ | 0 | 0 | 1 (+) | 3 (0.4) | 0 | 0 | 0 | 0 | 0 |
| **Cutthroat** | | | | | | | | | |
| ≥I | 0 | 0 | 3 (0.2) | 3 (0.4) | 0 | 0 | 0 | 1 (0.1) | 1 (0.1) |
| **Bull** | | | | | | | | | |
| 0 | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| ≥I | 0 | 8 | 1 (+) | 0 | 0 | 1 (0.1) | 1 (0.1) | 0 | 0 |
| **Whitefish** | | | | | | | | | |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | | | 0 |
| ≥I | 0 | 0 | 2 (0.1) | 14 (1.7) | 0 | 0 | 8 | 0 | 0 |

Table 13. Number of trout, salmon, and whitefish (number/100 yd²) counted in sections treated with deflector logs during 1983 habitat enhancement project, August 8-9, 1984.

| Species, age | Deflector- log sections | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| **Rainbow-steelhead** | | | | | | | | | |
| 0 | 8 (0.3) | 4 (0.2) | 12 (1.0) | 22 (1.9) | 18 (3.9) | 13 (3.0) | 17 (2.8) | 15 (3.7) | 58 (5.8) |
| I | 11 (0.4) | 10 (0.4) | 27 (2.3) | 28 (2.4) | 8 (1.7) | 13 (3.0) | 32 (5.3) | 13 (3.2) | |
| II | 7 (0.2) | 13 (0.5) | 14 (1.2) | 14 (1.2) | 1 (0.2) | 4 (0.9) | 11 (1.8) | 8 (2.0) | 20 (2.0) |
| ≥III | 0 | 1 (+) | 1 (0.1) | 0 | 0 | 1 (0.2) | 0 | 0 | 8 (0.2) |
| **Chinook** | | | | | | | | | |
| 0 | 1 (+) | 2 (0.1) | 38 (3.3) | 11 (1.0) | 16 (3.5) | 17 (3.9) | 18 (3.0) | 19 (4.6) | 31 (3.1) |
| I+ | 1 (+) | 0 | 0 | 0 | 0 | 1 (0.2) | 0 | 0 | 0 |
| **Cutthroat** | | | | | | | | | |
| ≥I | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Bull** | | | | | | | | | |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| ≥I | 0 | 0 | 2 (0.2) | 0 | (0.2) | (0.2) | | 0 | 0 |
| **Whitefish** | | | | | | | | | |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | | 0 | 0 |
| ≥I | 0 | 0 | 0 | 0 | 0 | 0 | 8 | 0 | 0 |

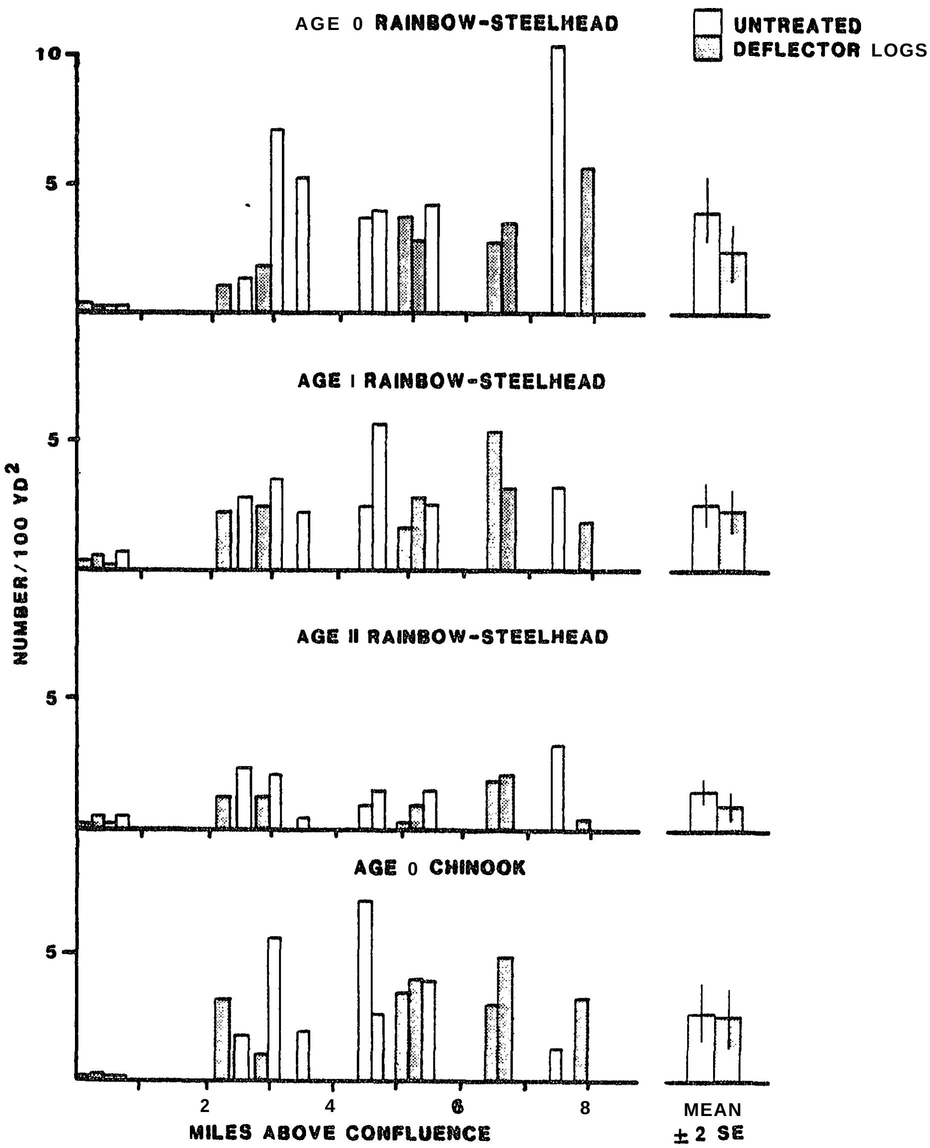



Figure 28. Densities of juvenile rainbow-steelhead and chinook in sections treated with deflector logs during 1983 and in untreated sections, Crooked Fork Creek and White Sand Creek, August 8-9, 1984.

and untreated sections. Similarly, age II rainbow-steelhead showed no tendency ($F=2.25$; $p=0.15$) to be more abundant in sections treated with deflector logs than in untreated sections.

Rainbow-steelhead selected habitat on the basis of size. Fry tended to be in shoals less than one-foot deep; yearlings and older fish generally occupied depths from one to three feet (Figs. 29, 30). No group demonstrated strong association with the deflector logs. Unlike the situation in Lolo Creek, there was no apparent change in size distribution of rainbow-steelhead between treated and untreated sections (Fig. 31).

Age 0 chinook densities also were largely unaffected ($F=0.22$; $p=0.64$) by deflector log applications (Fig. 28). They tended to select habitat that was intermediate in depth to that of rainbow-steelhead fry and yearlings (Fig. 29, 30).

Deflector logs in Crooked Fork Creek and White Sand Creek did not modify summer rearing habitat much, if at all. The depth contour maps (Fig. 30) indicate that treatment 7, in a secondary channel, may have accumulated substrate above and created a run below; treatments 5, 8 and 9 might have deflected enough stream energy to deepen run habitat downstream. These conditions were not visually apparent during the August 1984 survey, however. Depths of runs were not increased greatly. No accumulations of suitable spawning gravel due to log applications were evident. The rubble and boulder substrate was apparently too large to be influenced by deflector logs. But this large substrate already provided good holding cover for larger rainbow-steelhead. Possible minor changes in summer rearing habitat from deflector logs would not have been evident because we did not sample these sites before treatment in 1983.

## 1984 Barrier Removal

USFS personnel modified the barriers during August-September 1984 by blasting. Presently, barriers require additional modification to consistantly pass anadromous fish (A. Espinosa, USFS, Orofino, Idaho, personal communication).

We toured the site from the air on October 2, 1984. Because of the project's remoteness, we have not inspected it from the ground.

IDFG sampled four sections above the barrier on Crooked Fork Creek and the tributary Hopeful Creek during July 23-24, 1984 (Fig. 24). During August

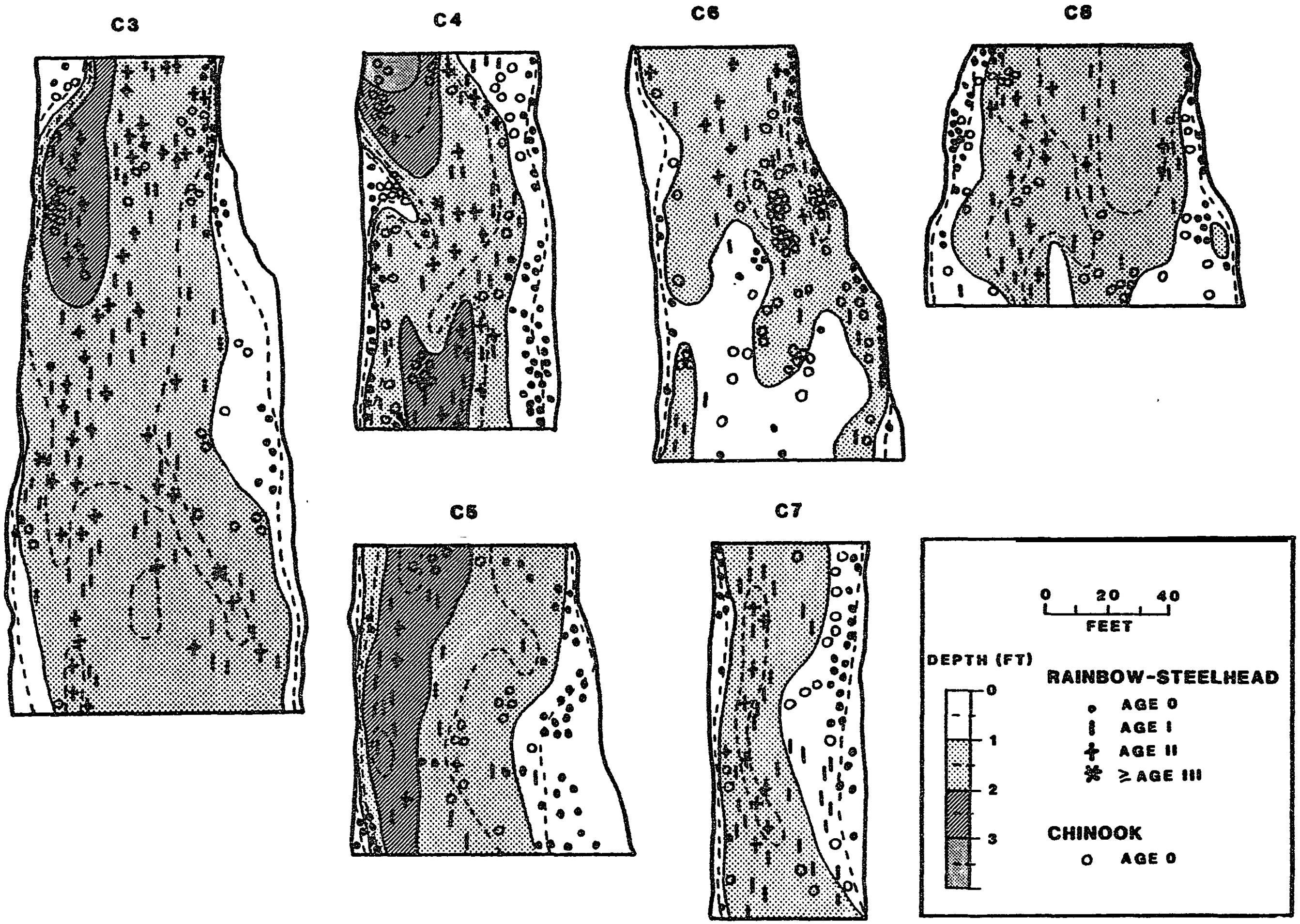



Figure 29 Approximate distributions of juvenile rainbow-steelhead and chinook in untreated sections, Crooked Fork Creek, August 8-9, 1984.

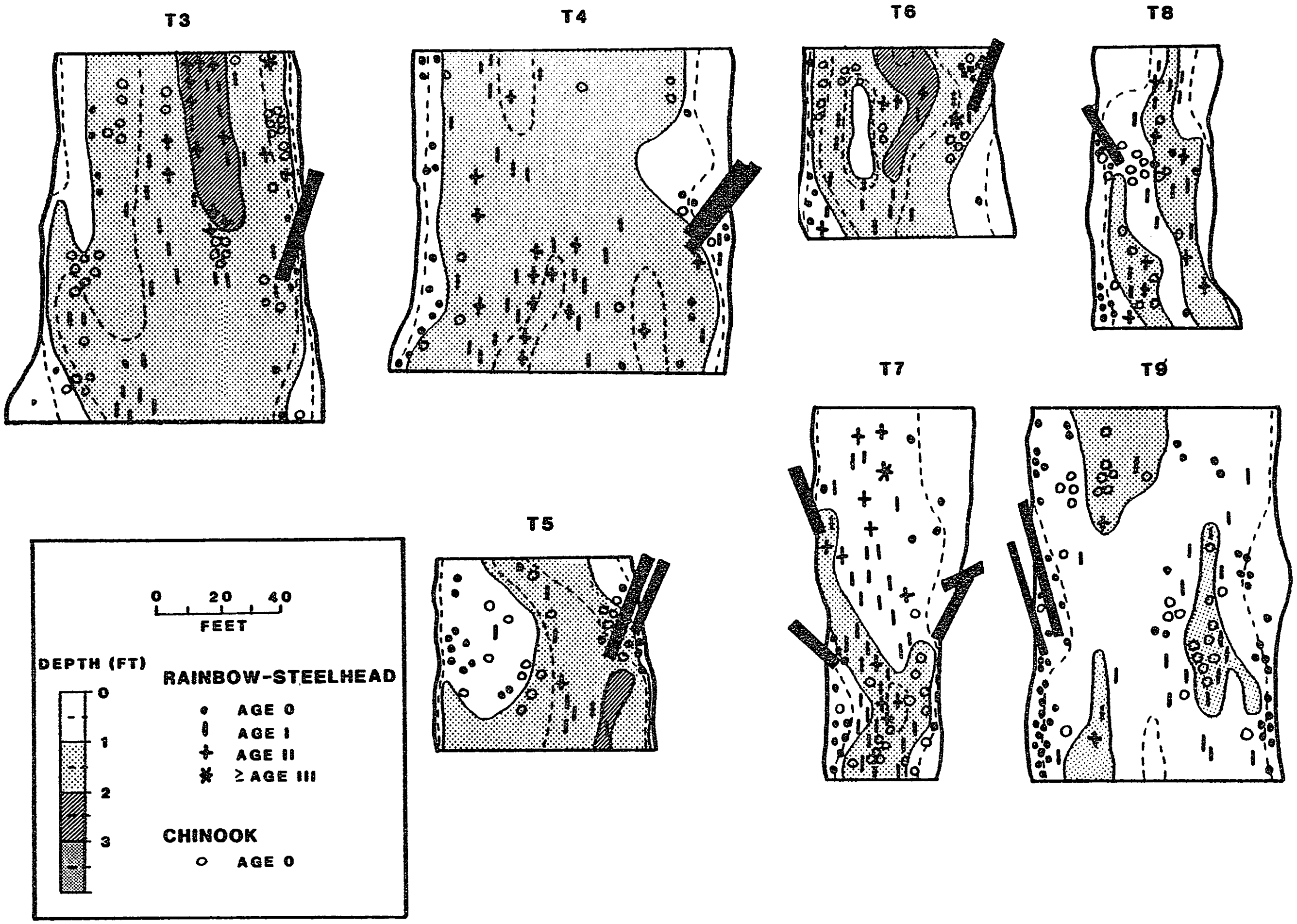



Figure 30 Approximate distributions of juvenile rainbow-steelhead and chinook in sections treated with deflector logs, Crooked Fork Creek, August 8-9, 1984. Deflector logs were in the water in sections T3, T4, T5, and T7 (upstream log only).

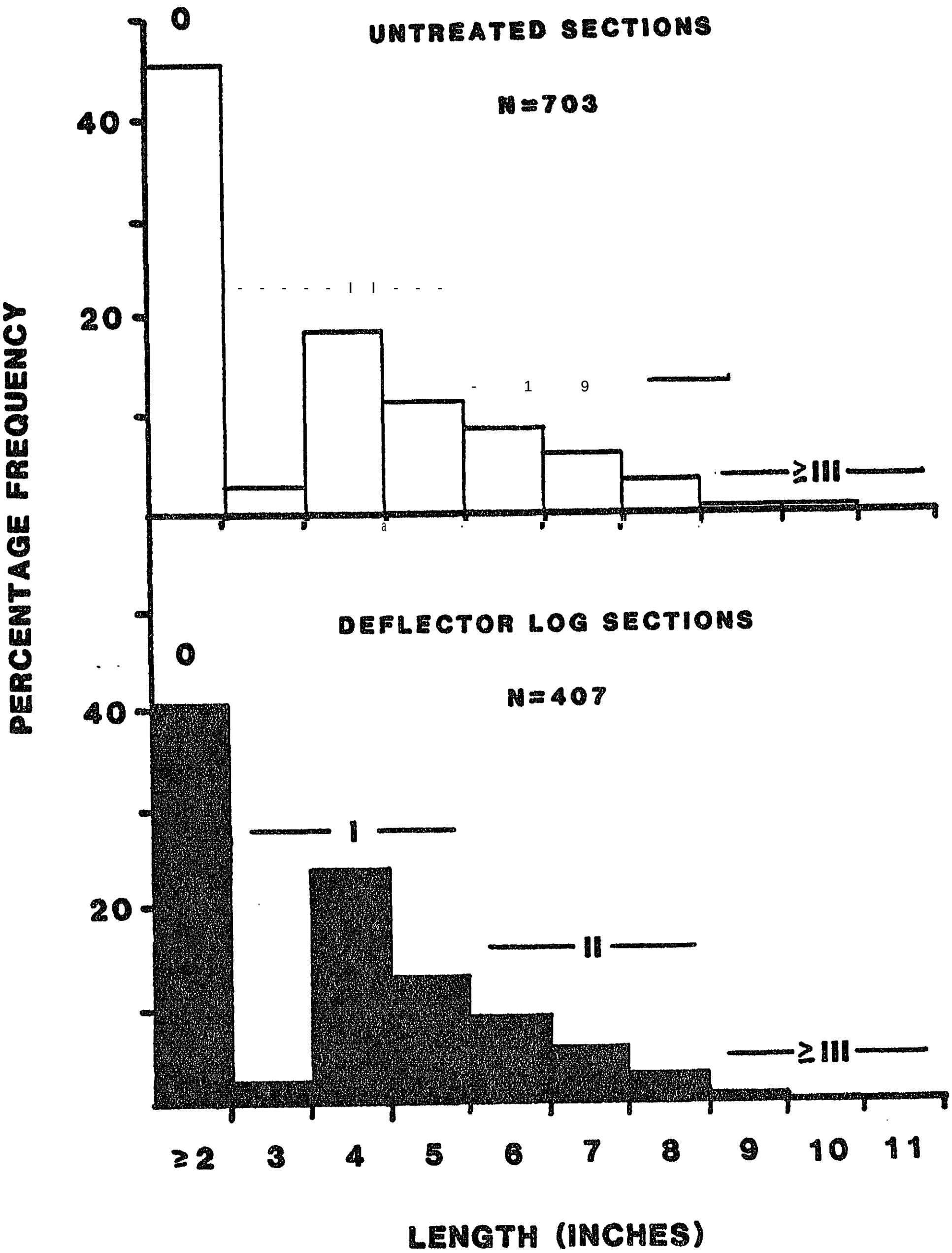



Figure 31. Percentage length-frequency distributions of rainbow-steelhead observed in treated and untreated sections, Crooked Fork Creek and White Sand Creek, August 8-9, 1984.

8-9, 1984 we established two sections on Crooked Fork Creek below the barriers that had been sampled previously by USFWS in 1983 (Fishery Assistance Office, USFWS, Ahsahka, Idaho, unpublished data). We snorkeled the sections and measured section lengths and widths (Table 14). No other physical habitat measurements (depth, velocity, substrate composition, embeddedness) were taken in 1984.

In 1984, primarily cutthroat trout occupied sections above the barriers while juvenile rainbow-steelhead and chinook predominated below (Table 15). Only one rainbow-steelhead, 8-inches long, and no chinook were observed above the barriers. Few cutthroat trout were observed in sections below the barriers.

Crooked Fork Creek and Hopeful Creek above the barriers have good potential to rear both steelhead and chinook. Habitat is primarily pocket water interspersed with runs and pools. Artificial seeding of chinook and possibly steelhead will be required initially to establish a run.

## Costs and Benefits

Project costs to date for deflector log applications and barrier removal projects are presented in Appendix B.

Final benefits from deflector log applications can be calculated from any increased rearing potential measured in treated sections, at full seeding (Table 1). Chinook, and probably steelhead, did not fully seed available habitat in 1984. Under-seeding could mask any true increases in rearing potential. However, because existing run habitat appeared mostly unaltered, we think that any benefits from deflector-log applications were minor.

Final benefits from the barrier removal project in upper Crooked Fork Creek can be calculated from estimated standing crops of steelhead and chinook, at full seeding (Table 1). The 1984 and previous surveys above the barriers found no evidence of use by chinook and only occasional use by small numbers of steelhead. Once the barriers are successfully modified we expect significant benefits for both species. All future use of the upper area by chinook and most use by steelhead can be considered benefits from barrier removal.

Table 14. Sections sampled in Crooked Fork Creek and Hopeful Creek to assess 1984 barrier removal project, July-August, 1984,

| Section | Length (yd) | Mean width + 2SE (yd) | Area ($yd^2$) | % habitat type Pool | Run | Riffle | Pocket water |
|---|---|---|---|---|---|---|---|
| Above barriers | | | | | | | |
| 1A | 200 | 7.4 + 0.6 | 1,480 | 6.7 | 23.2 | 0 | 70.0 |
| 2A | 200 | 5.0 + 0.6 | 1,000 | 10.0 | 30.0 | 10.0 | 50.0 |
| 3A | 200 | 9.7 + 1.3 | 1,941 | 0 | 10.0 | 10.0 | 80.0 |
| 4A | 200 | 12.0 + 0.8 | 2,393 | 0 | 0 | 0 | 100 |
| Below barriers | | | | | | | |
| 1B | 200 | 17.3 | 3,464 | 0 | 66.7 | 33.3 | 0 |
| 2B | 180 | 20.1 | 3,614 | 67.4 | 0 | 32.6 | 0 |

Table 15. Number of trout, salmon, and whitefish (number/100 $yd^2$) counted in Crooked Fork Creek and Hopeful Creek sections to assess barrier removal project, July-August 1984.

| Species, age | Above barriers 1A | 2A | 3A | 4A | Below barriers 1B | 2B |
|---|---|---|---|---|---|---|
| **Rainbow-steelhead** | | | | | | |
| 0 | 0 | 0 | 0 | 0 | 264 (7.6) | 104 (2.9) |
| | 0 | 0 | 0 | 0 | 78 (2.3) | 83 (2.3) |
| II | 0 | 1 (0.1) | 0 | 0 | 69 (2.0) | 62 (1.7) |
| ≥III | 0 | 0 | 0 | 0 | 5 (0.1) | 6 (0.2) |
| **Chinook** | | | | | | |
| 0 | 0 | 0 | 0 | 0 | 83 (2.4) | 114 (3.2) |
| 1+ | 0 | 0 | 0 | 0 | 0 | 3 (0.1) |
| **Cutthroat** | | | | | | |
| >1 | 52 (3.5) | 62 (6.2) | 70 (3.6) | 48 (2.0) | 4 (0.1) | 6 (0.2) |
| **Bull** | | | | | | |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| >1 | 1 (0.1) | 0 | 0 | 0 | 2 (0.1) | 0 |
| **Whitefish** | | | | | | |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| <1 | 0 | 0 | 0 | 0 | 4 (0.1) | 46 (1.3) |

## Summary

Deflector-log applications in Crooked Fork Creek and White Sand Creek in 1983 apparently did not modify the habitat much or increase densities of juvenile rainbow-steelhead or chinook. High-energy streams with large substrate do not appear suited for this type of instream structure.

The barriers on Upper Crooked Fork Creek were modified by blasting in 1984, but require additional work in 1985. The 1984 and previous surveys above the barriers found no use by chinook and only occasional use by small numbers of steelhead. Once barriers are successfully modified, we expect significant benefits for both species.

Artificial seeding of Crooked Fork Creek above the barriers with spring chinook will be required initially to establish a run. Summer steelhead might seed the area naturally.

## Recommendations

Fish abundance surveys and habitat measurements should be repeated for deflector-log applications as escapements increase to verify or refute the lack of benefits that we found in 1984. We recommend no further applications of deflector logs in Crooked Fork Creek and White Sand Creek.

Trend sections in Crooked Fork Creek above and below the barriers should be sampled annually until full-seeding is reached. Sections should be established downstream in the Lochsa River to follow annual trends in the river system. Steelhead and chinook should be stocked above the barriers in 1985.

## SOUTH FORK CLEARWATER RIVER

### Crooked River

Crooked River, 17-miles long, enters the South Fork Clearwater River at river mile 58.4 (Fig. 32). The stream lies within the Nez Perce National Forest. The streambed was dredge mined for gold during the 1950's, and mining claims underlie much of the stream and surrounding area. The stream runs through two highly degraded meadow reaches. Presently, the BPA-funded habitat enhancement project addresses problems only in the upper meadow (Reach 1).

Crooked River supports runs of summer steelhead and spring chinook which were re-established in the 1960's following removal of Harpster Dam on the South Fork Clearwater River in 1962. Crooked River has potential to support much larger runs of steelhead and chinook than it does presently. Because of its high-quality water, habitat potential, and location in the South Fork drainage, IDFG (1984) has identified Crooked River as an important production stream in their Anadromous Fish Management Plan.

Salmonids identified in Crooked River in a 1983 survey of the two degraded meadows by USFWS, in decreasing order of abundance, were juvenile chinook, mountain whitefish, rainbow-steelhead, bull trout, and cutthroat trout (Fishery Assistance Office, USFWS, Ahsahka, Idaho, unpublished data). Nearly all juvenile chinook and whitefish were found in the lower meadow. Dace and sculpin also occur in Crooked River.

Dredge mining for gold in the streambed severely degraded Crooked River during the 1950's. In the upper meadow (Reach 1), dredge tailings forced the stream to the outside of the meadow, resulting in a relatively straight, high-gradient channel (Fig. 33). In the lower meadow (Reach 2), tailings were piled perpendicular to the general stream course, forcing the stream into unnaturally long, slow meanders (Fig. 33). Ground water flows through and around tailings piles in both meadows creating many off-channel ponds and sloughs. During runoff, juvenile trout and salmon use some of these ponds and are trapped as flow recedes. Compounding problems in Reach 1, a culvert at a road crossing has partially blocked adult steelhead passage at high flows, adult chinook passage at low flows, and juvenile steelhead and chinook passage at all flows (Stowell 1984a).

A BPA-funded habitat enhancement project was implemented in 1984 for Reach 1, following planning stages in 1983. Objectives of the project were:

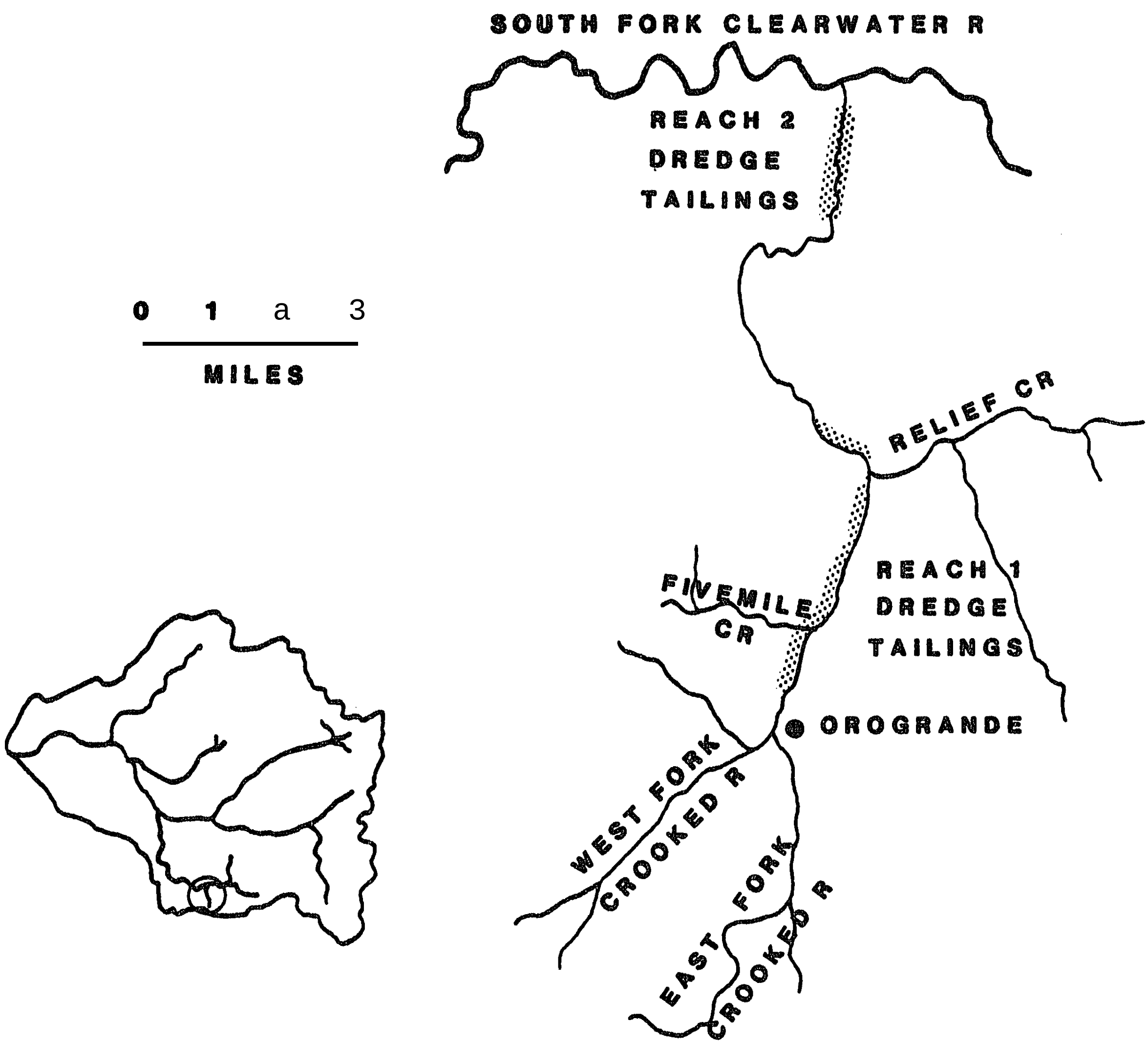



Figure 32. Location of meadows degraded by dredge tailings (shaded), Crooked River.

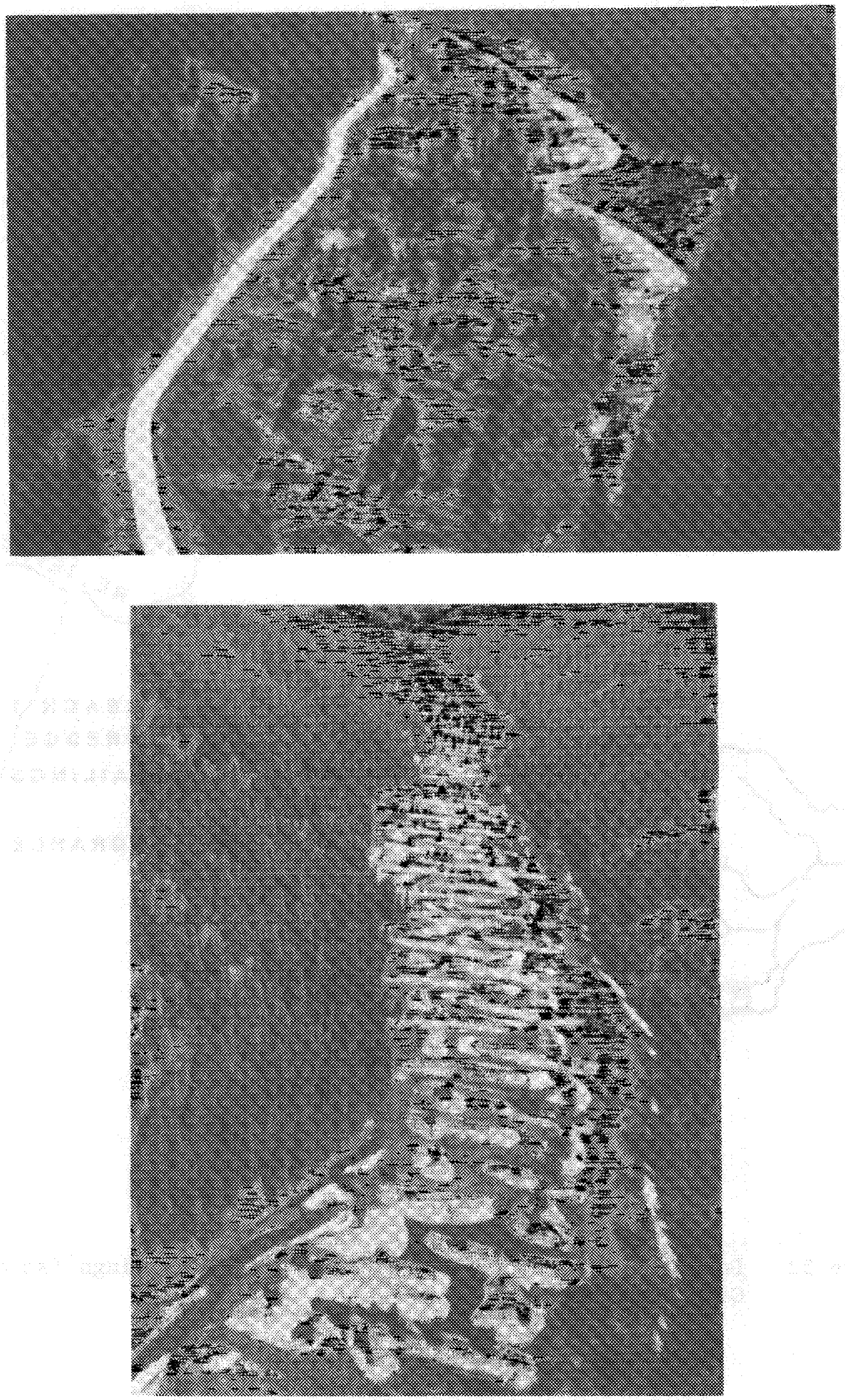


Figure 33. Crooked River channelized and forced to outside of upper meadow by tailings (upper photo), and forced into long meanders around tailings in lower meadow (lower photo).

1) improve passage to the upper meadow by juvenile and adult steelhead and chinook; 2) increase carrying capacity of the stream in the upper meadow; 3) connect off-channel ponds to Crooked River to provide additional rearing habitat; 4) gain information that can be used to rehabilitate other dredge-mined streams such as Yankee Fork, Newsome Creek, and American River; and 5) increase natural production of steelhead and chinook, consistent with IDFG (1984) Anadromous Fish Management Plan for subbasin CL-4.

## 1984 Habitat Enhancement Project

During summer 1984 USFS project personnel treated two reaches of the upper meadow in Crooked River primarily with log structures, and two reaches primarily with boulders (Fig. 34). In all, USFS installed 18 log weirs, 4 log deflectors, and anchored 23 organic debris structures primarily in "Sill Log Reaches A and B". USFS placed boulders randomly (59), and constructed rock-and-boulder deflectors (15), loose rock weirs (22), and boulder weirs (9) primarily in "Boulder Reaches A and B". In addition the project team connected an off-channel pond with a side-channel, built a bank cover device and a Hewitt ramp, treated a debris jam, stabilized cutbanks, and planted grass seed and streamside shrubs (D. Hair, USFS, Elk City, Idaho, personal communication). Two reaches of this high-gradient channelized stream were left untreated to allow for evaluation. The future channels of two additional sections to be reconstructed into meanders were identified, but construction did not proceed in 1984.

During September-October 1984, USFS replaced the culvert which had reduced fish passage with a bridge.

IDFG evaluation of the project began in 1984 as a pre-treatment for combinations of 1984 log structures, combinations of 1984 boulder placements and structures, and 1985 channel reconstructions. We met with USFS project personnel in June 1984 to select sections slated for treatment with logs and boulders and for rechannelizing, and reserved control (untreated) sections for evaluation. We selected eight sections (Fig. 34), two of each type to provide for replication in future statistical comparisons. Sections were 100-yards long, except for the pre-treatment for channel reconstruction B, which was 67-yards long and confined on the upper end by an existing (non-BPA) K-dam (Table 16).

We snorkeled the eight sections during July 16-19, 1984 and measured section lengths. W. S. Platts' team (Intermountain Forest and Range

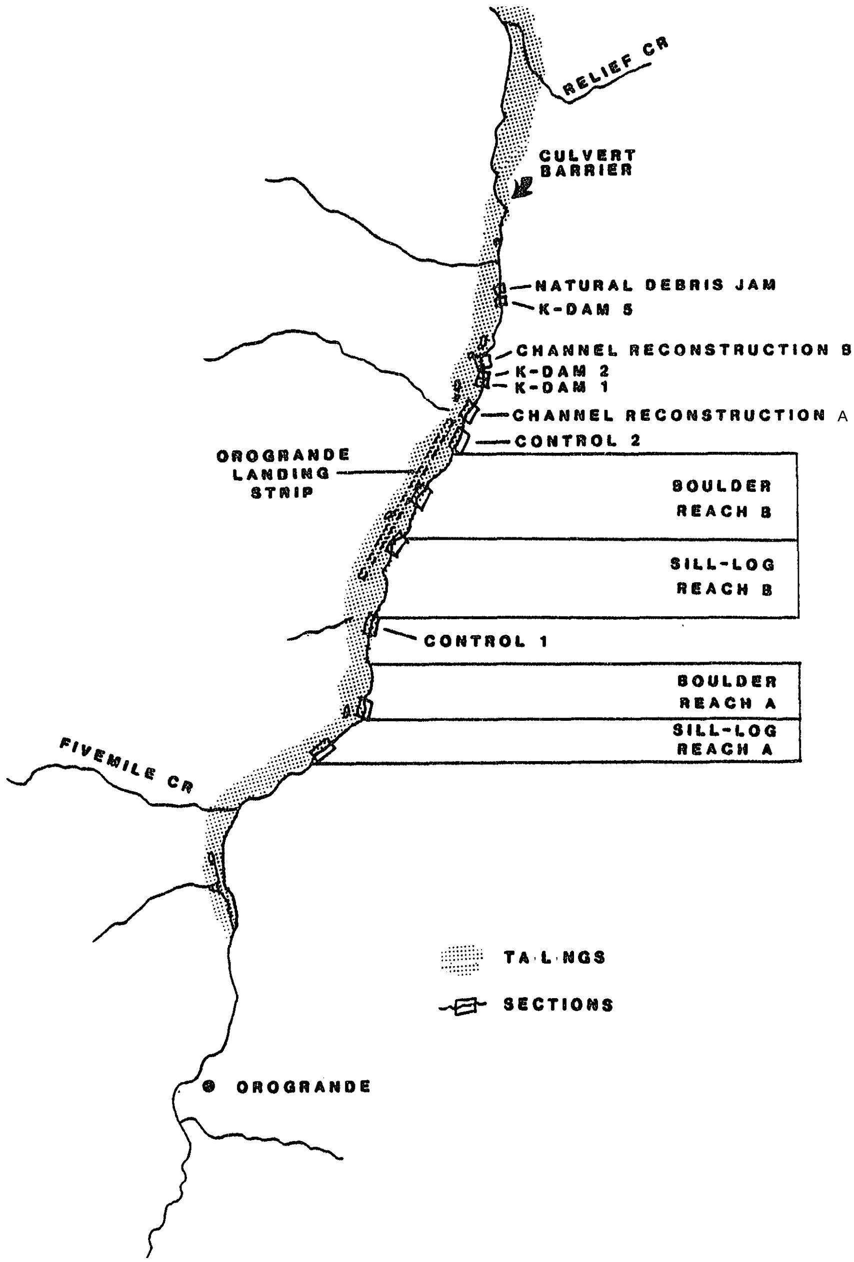



Figure 34. Sections sampled in Reach 1, Crooked River, July 16-19, 1984.

Table 16. Sections sampled in upper meadow (Reach 1) of Crooked River to evaluate 1984 and 1985 habitat enhancement projects, July 16-19, 1984.

| Treatment | Section | Length (yd) | Mean width (yd) | Area ($yd^2$) |
|---|---|---|---|---|
| Untreated | 1 | 100 | 11.9 | 1,187 |
| | 2 | 100 | 11.4 | 1,137 |
| Sill log | A | 100 | 10.2 | 1,023 |
| (pre-treatment) | B | 100 | 8.0 | 803 |
| Boulder | A | 100 | 10.6 | 1,060 |
| (pre-treatment) | B | 100 | 10.2 | 1,023 |
| Channel change | A | 100 | 9.2 | 920 |
| (pre-treatment) | B | 67 | 10.4 | 695 |

Table 17. Additional sections sampled in Crooked River, July 16-19, 1984.

| Locaton and section | Length (yd) | Mean width ± 2SE (yd) | Area ($yd^2$) | % habitat type: Pool | Run | Riffle | Pocket water |
|---|---|---|---|---|---|---|---|
| Reach 1 | | | | | | | |
| Debris jam | 37 | 12.0 ± 1.0 | 444 | 83.3 | 0 | 16.7 | 0 |
| K-dam 1 | 29 | 10.9 | 312 | 50 | 0 | 50 | 0 |
| K-dam 2 | 35 | 10.9 | 382 | 50 | 0 | 50 | 0 |
| K-dam 3 | 33 | 10.9 ± 0.6 | 362 | 46.7 | 0 | 53.3 | 0 |
| Reach 2 | | | | | | | |
| "Non-degraded" | 120 | 11.5 ± 5.1 | 1,379 | 0 | 82.0 | 18.0 | 0 |
| "Forced meander'* | 113 | 14.1 ± 4.9 | 1,593 | 61.1 | 33.3 | 5.6 | 0 |

Experiment Station, USFS, Boise, Idaho) measured physical habitat during September 1984 (Appendix C).

We sampled six additional sections during July 16-19, 1984, four in Reach 1 and two in Reach 2 (Table 17). In Reach 1, we sampled short sections at three (non-BPA) K-dams, built earlier by USFS, and at a natural debris jam (Fig. 34) because together they represented most of the limited pool habitat present in Reach 1. These data were intended to supplement the above evaluation. In Reach 2, we sampled two sections, a relatively nondegraded section and a "forced-meander" section, both of which had been established in 1983 by USFWS, to follow downstream trends in fish density. We snorkeled these six sections, determined fish densities, and took physical habitat measurements (depth, velocity, substrate composition, and embeddedness).

In pre-treatment and control sections for 1984-85 projects, densities of juvenile rainbow-steelhead and chinook (Table 18) were generally lower than in other Idaho streams in 1984 (Appendix Al, A2). No more than six rainbow-steelhead, all ages combined, were found in any l00-yard section. Age 0 chinook were absent from all the sections except one, where 14 were schooled in a shallows with flooded vegetation.

During the July 1984 surveys, quality of rearing habitat in the upper meadow appeared to be highest in the natural debris jam section, intermediate in existing non-BPA K-dam sections, and lowest in the high-velocity pre-treatment and control sections. The debris jam was located in one of the few areas where gradient lessened and a natural meander had formed; the existing K-dams formed only small plunge-pools downstream and no pool or run upstream because of the stream's high gradient.

Hypothetically, we expected juvenile rainbow-steelhead and chinook densities to reflect our judgement of habitat quality, but generally they did not. Except for a number of age I+ chinook that used the natural debris jam, densities in sections containing pools (Table 19) were not much higher than in high-velocity sections established to evaluate the habitat enhancement project (Table 18). The lack of an apparent relationship between juvenile densities and habitat quality indicates under-seeding in the upper meadow in 1984. As passage improves following culvert removal, seeding levels will increase and densities should begin to represent habitat quality.

Highest fish densities estimated for Crooked River in 1984 occurred in the lower meadow (Table 20). Rainbow-steelhead densities in lower Crooked River were relatively low compared with those in other Idaho streams in 1984 (Appendix Al). In the 'non-degraded' section, juvenile chinook density (24.8/100 yd2) was comparable to densities in Red River, but in the "forced-meander" section, juvenile chinook density (2.9/100 yd2) was several

Table 18. Number of trout, salmon, and whitefish (number/100 yd²) counted in upper meadow (Reach 1) control and pre-treatment sections, Crooked River, July 16-19, 1984.

| Species, age | Control 1 | Control 2 | Sill log reach A | Sill log reach B | Boulder reach A | Boulder reach B | Channel reconstruction A | Channel reconstruction B |
|---|---|---|---|---|---|---|---|---|
| Rainbow-steelhead | | | | | | | | |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| I | 3 (0.3) | 0 | 0 | 0 | 0 | 1 (0.1) | 0 | 0 |
| II | 2 (0.2) | 1 (0.1) | 2 (0.2) | 4 (0.5) | 3 (0.3) | 2 (0.2) | 0 | 0 |
| ≥III | 1 (0.1) | 0 | 0 | 1 (0.1) | 1 (0.1) | 0 | 0 | 0 |
| Chinook | | | | | | | | |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 14 (1.5) | 0 |
| I+ | 4 (0.3) | 0 | 0 | 1 (0.1) | 2 (0.2) | 1 (0.1) | 1 (0.1) | 0 |
| Cutthroat | | | | | | | | |
| ≥I | 1 (0.1) | 0 | 4 (0.4) | 0 | 1 (0.1) | 4 (0.4) | 2 (0.2) | 0 |
| Brook | | | | | | | | |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| ≥I | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Bull | | | | | | | | |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| ≥I | 0 | 2 (0.2) | 0 | 1 (0.1) | 0 | 0 | 0 | 0 |
| Whitefish | | | | | | | | |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| ≥I | 6 (0.5) | 5 (0.5) | 1 (0.1) | 4 (0.4) | 4 (0.4) | 2 (0.2) | 2 (0.2) | 0 |

Table 19. Number of trout, salmon, and whitefish (number/100 $yd^2$) counted in upper meadow sections that contained pool habitat, Crooked River, July 16-19, 1984.

| Species, age | Natural debris jam | K-dam 1 | K-dam 2 | K-dam 5 |
|---|---|---|---|---|
| Rainbow-steelhead | | | | |
| 0 | 0 | 0 | 1 (0.3) | 0 |
| I | 0 | 0 | 1 (0.3) | 0 |
| II | 2 (0.5) | 1 (0.3) | 0 | 0 |
| >III | 0 | 2 (0.6) | 0 | 0 |
| Chinook | | | | |
| 0 | 3 (0.7) | 0 | 0 | 0 |
| I+ | 16 (3.6) | 1 (0.3) | 1 (0.3) | 5 (1.4) |
| Cutthroat | | | | |
| ≥I | 6 (1.4) | 0 | 4 (1.1) | 2 (0.6) |
| Brook | | | | |
| 0 | 0 | 0 | 0 | 0 |
| ≥I | 0 | 0 | 0 | 1 (0.3) |
| Bull | | | | |
| 0 | 0 | 0 | 0 | 0 |
| ≥I | 2 (0.5) | 2 (0.6) | 0 | 1 (0.3) |
| Whitefish | | | | |
| 0 | 0 | 0 | 0 | 0 |
| >1 | 3 (0.7) | 2 (0.6) | 3 (0.8) | 0 |

Table 20. Number of trout, salmon, and whitefish (number/l00 yd2) counted in lower meadow sect ions, Crooked River, August 23, 1983 (USFWS, unpublished data) and July 19, 1984.

| Species, age | "Non-degraded" 1983 | "Non-degraded" 1984 | "Forced meander" 1983 | "Forced meander" 1984 |
|---|---|---|---|---|
| Ra i nbow-stee l head | | | | |
| 0 | 5 (0.4) | 2 (0.2) | 3 (0.2) | 0 |
| I | 4 (0.3) | 12 (0.9) | 1 (0.1) | a (0.5) |
| II | 4 (0.3) | 12 (0.9) | 2 (0.1) | 2 (0.1) |
| >1 I I | | | 0 | 0 |
| Ch i nook | | | 55 (3.5) | |
| 0 | 225 (16.3) | 37; (26.9) | 7 (0.4) | 51 (3.2) |
| I+ | 45 (3.3) | (0.4) | . | 2 (0.1) |
| Cutthroat | | | | |
| >1 | 3 (0.2) | 0 | 0 | 1 (0.1) |
| Brook | | | | |
| 0 | | 0 | 0 | 0 |
| >1 | 0 | 0 | 0 | 0 |
| Bul l | | | | |
| 0 | 0 | 0 | 0 | 0 |
| $\geq$I | 4 (0.3) | 2 (0.2) | 2 (0.1) | 0 |
| Whitefish | | | | |
| 0 | 19 (1.4) | 0 | 22 (1.4) | 0 |
| >1 | 63 (4.6) | 22 (1.6) | 109 (6.8) | 27 (1.7) |

times lower. In general, abundance of all species except whitefish in the two lower meadow sections was similar to that in 1983.

We snorkeled one off-channel pond in Reach 1 and two backwater sloughs in Reach 2 during July 1984. Juvenile rainbow-steelhead and cutthroat trout were trapped in the Reach 1 pond; about 100 age 0 chinook were trapped in one of the Reach 2 sloughs. We were able to dig a small, temporary access channel from the latter slough.

We revisited Crooked River on September 6 and October 4, 1984, after structure installation. Habitat was changed markedly in enhanced reaches (Fig. 35). Although pools were excavated above and below weirs during construction, some natural digging and sorting of gravel was already apparent by September. Debris tied into weirs (Fig. 35) has added cover for juvenile salmonids. Adult chinook spawned on gravel sorted by an earlier non-BPA K-dam, and in newly sorted gravel. Adult chinook also used the Hewitt ramp pool for cover (R. Lindland, IDFG, Lewiston, Idaho, personal communication). The connecting channel between the off-channel pond and Crooked River, however, was shallow in September and nearly dry in October because water was being lost through intra-gravel seepage (Fig. 36) as the water table dropped below the bottom of the ditch.

Both the structure installation and culvert removal added silt to the stream below. We expect that the silt will be flushed during spring runoff.

Presently, our major concerns for the 1984-85 habitat enhancement project are the stability of structures and their effectiveness in increasing production. Relatively small rocks were used in some of the deflectors and as fill on weirs. Although designed differently than those in the present project, the five existing non-BPA K-dams show signs of deterioration. All show bank erosion where sills are buried and one has washed out under the sill. Stability of the 1984 structures will begin to become apparent after spring runoff.

## Costs and Benefits

Project costs to date are summarized in Appendix B.

Final benefits from the Crooked River project can be determined from increased rearing potential, estimated at full seeding (Table 1). An intensive production, survival, and yield study in Crooked River would

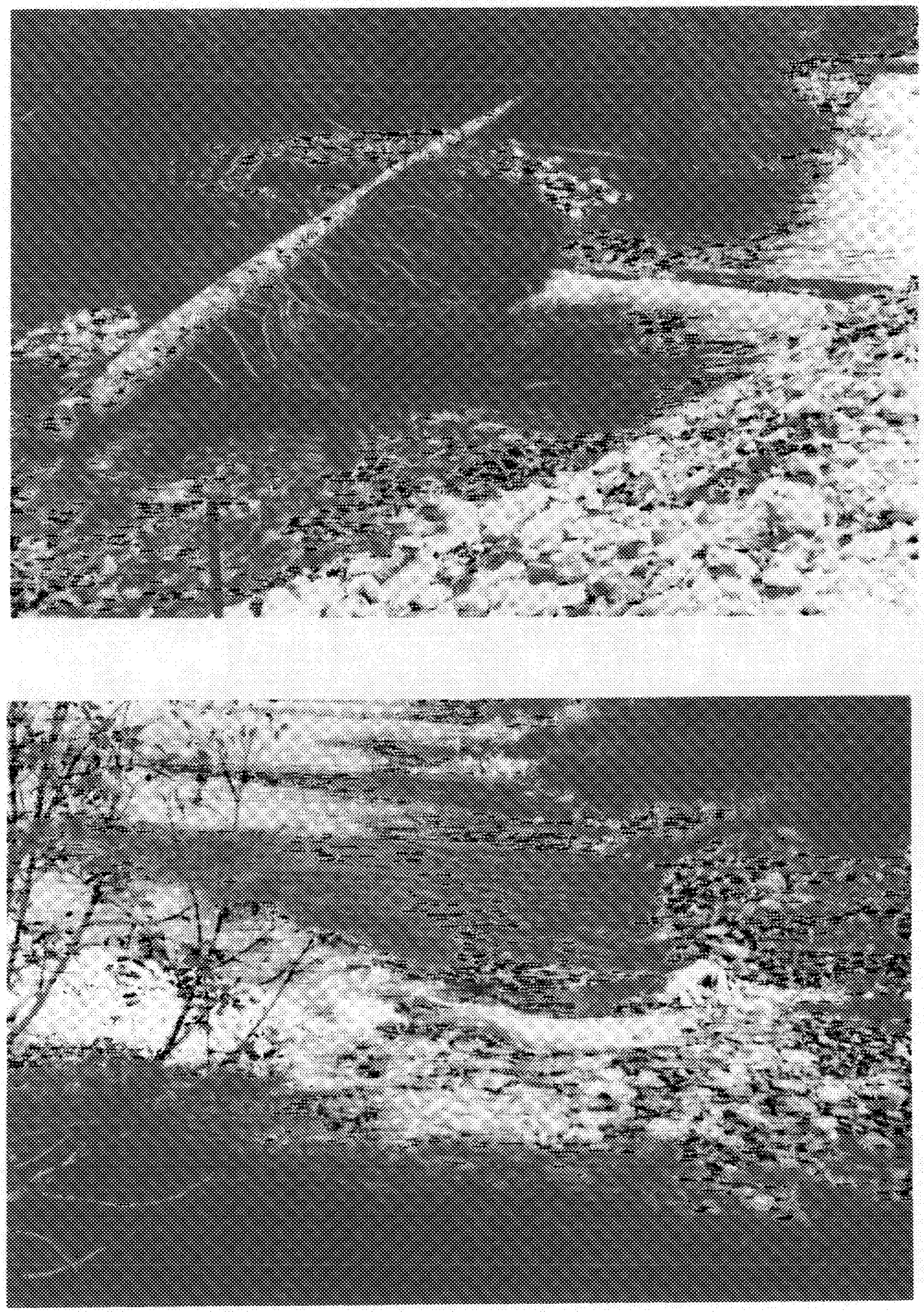


Figure 35. Conifer tied into log weir (upper photo) and loose rock weir (lower photo), Crooked River, September 1984.

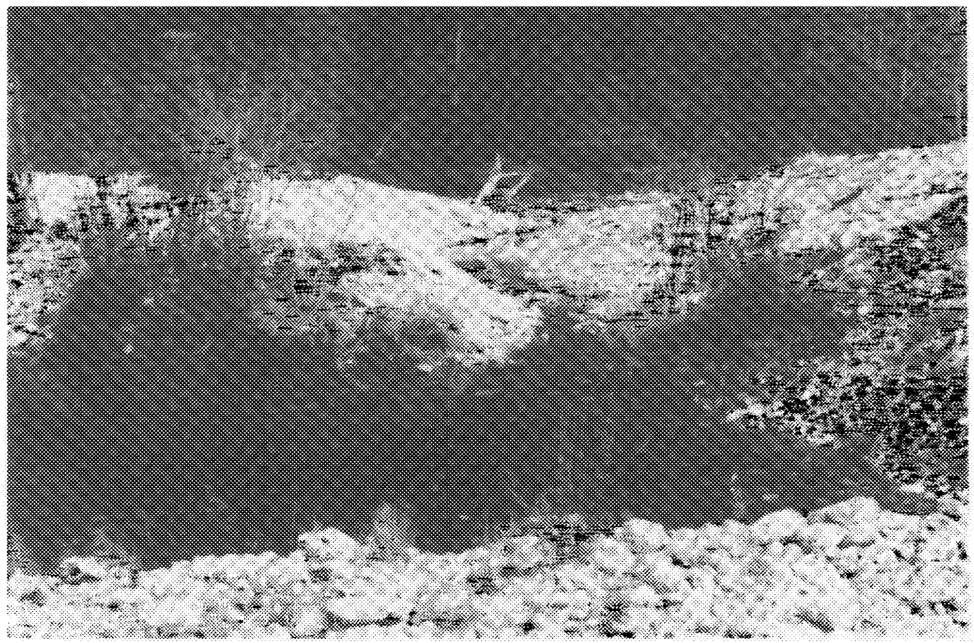


Figure 36 Off-channel pond connected to Crooked River, September 1984

directly provide factors relating spawner abundance, summer standing crop, and yield of migrants and smolts.

Because the Crooked River habitat enhancement project has several facets, benefits will have to calculated in different ways for the different subprojects. Increases in juvenile steelhead and chinook densities in control sections of Reach I should be considered the result of improved passage due to culvert removal and increasing escapements. Additional benefits from instream structures and channel reconstructions, which are intended to increase carrying capacity, can be calculated from the differences in density between treated and control sections at full seeding. Benefits from connecting off-channel ponds (habitat additions) can be estimated from the numbers of fish using these areas which have access to Crooked River, at full seeding.

As with the Red River project, we doubt that benefits can be assigned specifically to such subprojects as bank stabilization, grass and shrub plantings, except as they influence treated sections directly. Benefits from increases in adult cover and possibly improvements in spawning habitat may also be difficult to quantify.

## Summary

Habitat enhancement subprojects completed for the upper meadow on Crooked River in 1984 include log and boulder instream structures, connection of an off-channel pond, and culvert removal. Reconstruction of stream channels is slated for 1985. Maintenance may be required for instream structures and modifications of the connecting channel must be made to maintain the connection year-around.

IDFG evaluation program was established in 1984. Densities of juvenile anadromous fish appeared to be below carrying capacity in the degraded upper meadow habitat. Chinook densities in the lower meadow were higher than in upstream sections, and more comparable to densities in Red River. Juvenile rainbow-steelhead and chinook used off-channel ponds and were stranded after flow receded.

## Recommendations

Because juvenile salmonids do use the off-channel ponds, sloughs, and sidechannels when they are are accessible, high priority should be given to developing these types of habitat in future enhancement projects. Channel modifications are recommended for future work in Crooked River.

Sections established in Reach 1 in 1984 should be sampled in 1985. Additional sections below the culvert and in Reach 2 can be established as future enhancement plans are formulated.

Because extensive rehabilitation is being planned and because the information gathered here may be applicable to a number of other dredge-mined streams, a weir with capability to enumerate upstream and downstream migrants should be constructed near the mouth of Crooked River. An intensive survival, production, and yield study should be conducted in Crooked River.

## Red River

The confluence of Red River with American River near Elk City forms the South Fork of the Clearwater River (Fig. 37). Ownership of the 19 miles of Red River within the project area is about half private and half federal (Nez Perce National Forest). Man's activity has altered fish habitat in Red River. Reaches of the river have been dredged for gold and channelized. Logging and road construction have introduced sediment streamwide. Grazing in riparian zones has led to loss of riparian cover, streambank destabilization, and sedimentation.

Red River supports runs of summer steelhead and spring chinook. Anadromous runs were restored to Red River in the 1960's following removal of Harpster Dam on the South Fork of the Clearwater River in 1962. Chinook returns to Red River in recent years have been among the strongest in the state, aided by the establishment of an adult trapping facility and juvenile rearing pond at Red River Ranger Station.

In addition to anadromous fish, Red River supports several native resident species: cutthroat trout, bull trout, mountain whitefish, northern squawfish, bridgelip sucker, longnose and speckled dace, and sculpin (Torquemada and Platts 1984). Brook trout have also become established in the Red River drainage.

USFS project personnel identified five reaches with different characteristics in Red River (Fig. 37) and rated habitat with respect to opportunity for improvement (Stowell 198433). Reaches rated highest with respect to potential improvement were II, IV, and V. Grazing on private land in Reaches I, III, and V has degraded riparian meadow habitat. Tailings from past dredge-mining operations have channelized the stream in Reach IV. Sedimentation from logging, road construction, and grazing is excessive throughout all reaches.

Primary objectives of the BPA-funded habitat enhancement project for Red River were: 1) protect the riparian zone from continued grazing impacts through streamside fencing; 2) reverse the degradation of cover by re-establishing hardwood vegetation; 3) increase in-channel cover for fish through installation of stream structures; and 4) increase natural production of steelhead and chinook, consistent with IDFG (1984) Anadromous Fish Management Plan for subbasin CL-4.

Secondary objectives were: 1) increase quantity and quality of spawning and rearing habitat for fish; and 2) provide examples of riparian area

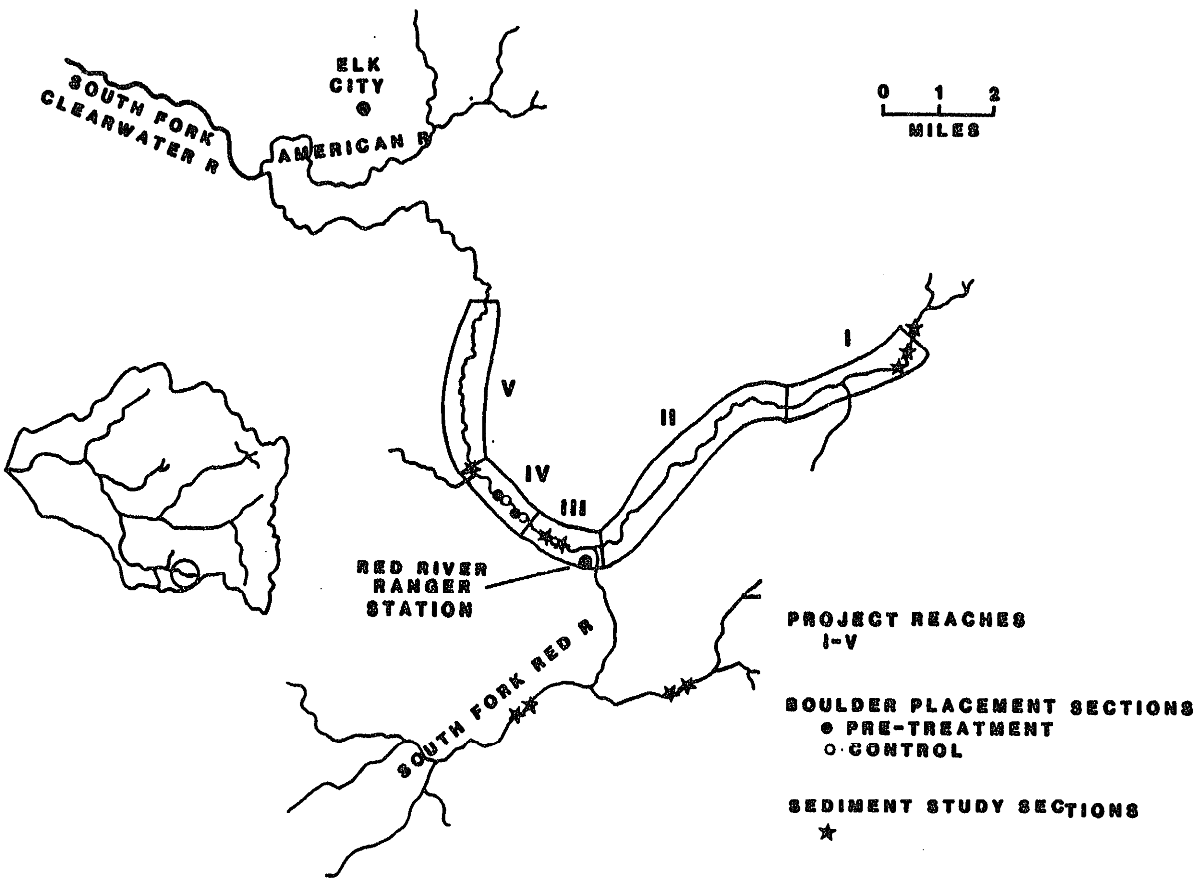



Figure 37. Red River habitat enhancement project and sections sampled to evaluate boulder placements. Locations of sections for USFS sediment study are also shown.

management techniques compatible with grazing of private pastures which may be utilized by other landowners in the future.

## 1983 Habitat Enhancement Project

During summer 1983 USFS project personnel primarily planned future enhancement activities. Most enhancement activity in 1983 occurred in Reach IV (Stowell 1984b). In this reach USFS built a sediment trap/cover, placed 9 trees in the stream as deflectors and to provide cover, used logs to stabilize banks, planted conifer seedlings, deciduous seedlings and grass seed, and moved boulders and began placing them in the stream as cover. In other reaches, USFS placed 2 trees in the stream, planted deciduous seedlings, and grass seed, constructed a.jack-leg fence, and built 5 K-dams.

Evaluation of habitat enhancement activities was begun in 1983 by W. S. Platts' team (Intermountain Forest and Range Experiment Station (IFRES), USFS, Boise, Idaho) as pre-treatment and control surveys of fish populations and habitat to measure effectiveness of boulder placements in Reach IV. Results of this pre-treatment evaluation are reported in Torquemada and Platts (1984) and partially excerpted in the following section.

## 1984 Habitat Enhancement Project

In 1984 USFS project personnel treated the five reaches of Red River with a variety of techniques (D. Hair, USFS, Elk City, Idaho, personal communication). Most of the treatments can be grouped according to intended, sometimes overlapping effects: localized improvements in rearing potential or streamwide increases in carrying capacity (Fig. 38).

Because treatments are diverse and lean heavily toward reduction of sediment from various sources and locations, evaluation of the habitat enhancement project as a whole will be difficult. Cover-enhancement methods which can be evaluated specifically include boulder placements, weirs and other structure installations, and riparian fencing. Control sections established to evaluate site-specific changes can also be used to determine streamwide trends in physical habitat and juvenile fish density.

To assess site-specific changes in density due to boulder placements in Reach IV, IDFG snorkeled four 200-yard sections, consisting of two

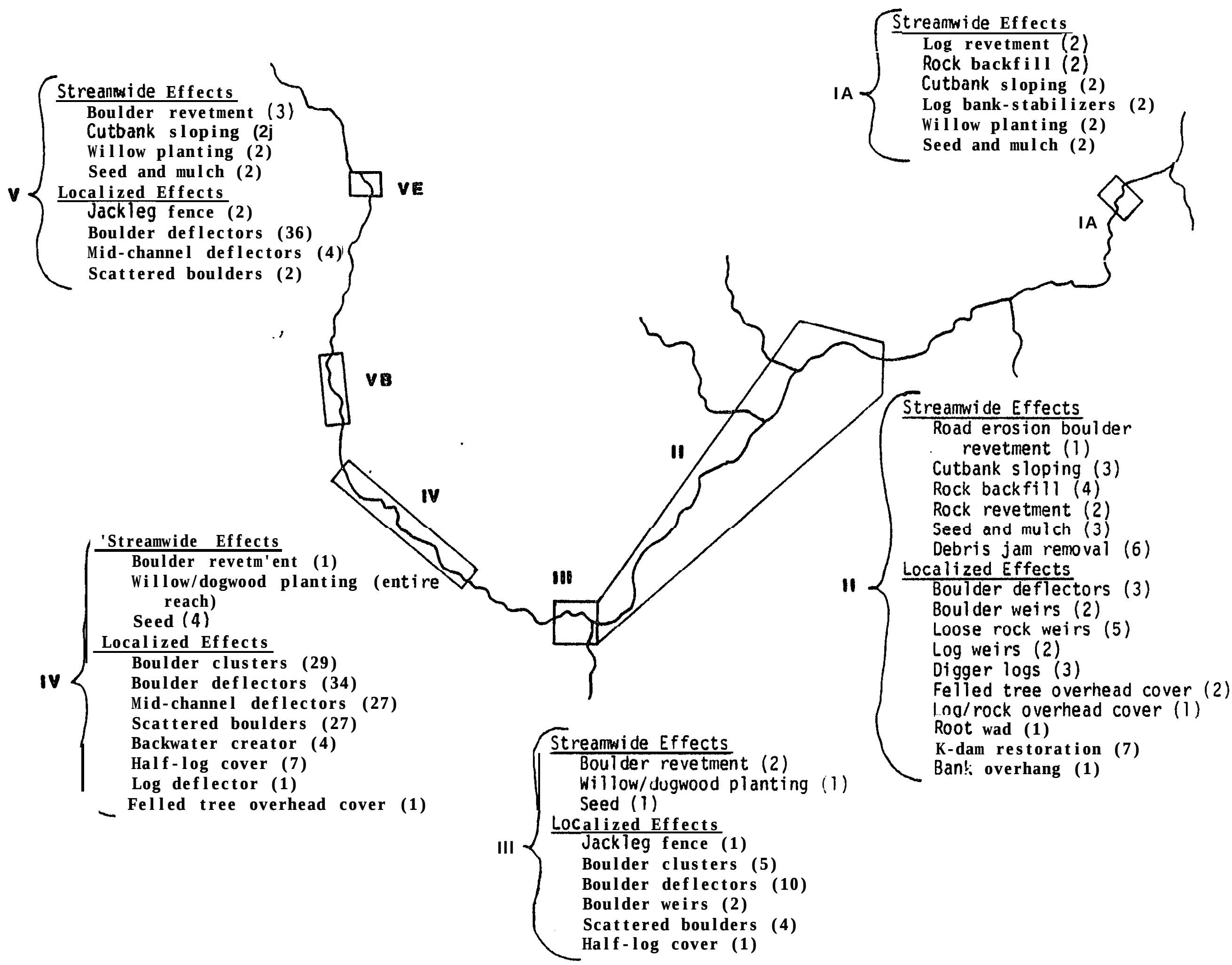



Figure 38. Habitat enhancement activities grouped by their expected primary effects (number of sites treated in parentheses), Reaches I-V, Red River, 1984.

pre-treatments and two controls (Fig. 37), in July and August 1984. One pair of these pre-treatment and control sections was established and sampled by IFRES in 1983. IFRES measured habitat in the four sections during August-September 1984 (Appendix C).

In July and August 1984, densities of juvenile rainbow-steelhead in Reach IV sections of Red River (Table 21) tended to be lower than in many other Idaho streams (Appendix Al). Densities of age 0 chinook were comparable to those in the headwaters of the Middle Fork Salmon River (Appendix A2). Except for fewer rainbow-steelhead fry and more large whitefish in 1984, densities of most species and ages were comparable to those in 1983 (Table 22). The large number of fry in 1983 resulted from hatchery releases upstream.

Evaluation of effectiveness of boulder placements can begin in 1985. Boulders were placed in the lower treatment section after we sampled in July 1984; boulders have not yet been placed in the upper treatment section. In July 1984, we also had an opportunity to observe fish distributions near a few boulders placed in 1983. Most of these boulders were scattered in relatively slow run habitat (Fig. 39). They did not appear to speed the flow markedly or to attract many juvenile rainbow-steelhead or chinook. Largest concentrations of age 0 chinook in July were in backwaters.

IDFG evaluation of other structures and riparian fencing was not started in 1984. Agreements were not obtained with private landowners to lease and fence riparian habitat in 1984. We plan to add sections in Reach II to evaluate structures. As agreements procede to fence riparian zones on private land, we will add pre-treatment and control sections to analyze these localized effects. Sections now being sampled for the USFS sediment study can also be incorporated into future evaluations.

## Costs and Benefits

Project costs to date are presented in Appendix B.

Benefits from instream structure installation and from riparian fencing can be calculated based on measured increases in juvenile densities in treated sections compared to controls, at full seeding (Table 1).

Other types of habitat enhancement techniques applied in 1983-84, including revegetation and bank stabilization, will be difficult to evaluate specifically, except as they influence habitat locally. We can document streamwide trends in physical habitat and juvenile densities in future years

Table 21. Number of trout, salmon, and whitefish (number/100 $yd^2$) counted in Red River sections, July 18, 1984 (lower sections) and August 7, 1984 (upper sections).

| Species, age | Upper, Reach IV | | Lower, Reach IV | |
|---|---|---|---|---|
| | Control | Pre-treatment | Control | Pre-treatment |
| Rainbow-steelhead | | | | |
| 0 | 0 | 9 (0.3) | | 1 (+) |
| I | 34 (1.2) | | | |
| II | 10 (0.3) | 28 (1.1) | 18 (0.7) | 25 (0.9) |
| ≥III | 2 (0.1) | 17 (0.3) | 1 (+) | 12 (0.4) |
| Chinook | | | | |
| 0 | 407 (14.1) | 78; (29.9) | 213 (8.2) | 411 (14.2) |
| I+ | 10 (0.3) | (0.3) | 22 (0.8) | 25 (0.9) |
| Cutthroat | | | | |
| ≥I | 0 | 1 (+) | 2 (0.1) | 3 (0.1) |
| Brook | | 0 | | |
| 0 | 0 | 2 | 0 | 0 |
| ≥I | 1 (+) | (0.1) | 1 (+) | 2 (0.1) |
| Bull | 0 | | | |
| 0 | 0 | 0 | 0 | 0 |
| ≥I | | 1 (+) | 0 | 2 (0.1) |
| Whitefish | | | | |
| 0 | 5 (0.2) | 2 (0.1) | 0 | 0 |
| ≥I | 28 (1.0) | 27 (1.0) | 124 (4.8) | 74 (2.6) |

Table 22. Number of trout, salmon, and whitefish (number/100 $yd^2$) estimated by electrofishing July 27, 1983 (Torquemada and Platts 1984) and by snorkeling July 18, 1984 in lower control and pre-treatment sections, Red River.

| Species, age | Control | | Pre-treatment | |
|---|---|---|---|---|
| | 1983 | 1984 | 1983 | 1984 |
| Rainbow-steelhead | | | | |
| 0 | 164 (6.3) | 0 | 200 (6.9) | 1 (+) |
| I | 55 (2.1) | 42 (1.6) | 39 (1.3) | 25 (0.9) |
| II | 30 (1.2) | 18 (0.7) | 5 (0.2) | 12 (0.4) |
| ≥III | -- | 1 (+) | -- | |
| Chinook | | | | |
| 0 | 255 (9.8) | 213 (8.2) | 365 (12.6) | 411 (14.2) |
| I+ | 1 (+) | 22 (0.8) | 1 (+) | 25 (0.9) |
| Cutthroat | | | | |
| ≥I | 6 (0.2) | 2 (0.1) | 10 (0.3) | 3 (0.1) |
| Brook | | | | |
| 0 | 0 | 0 | 0 | 0 |
| ≥I | 0 | 1 (+) | 1 (+) | 2 (0.1) |
| Bull | | | | |
| 0 | 0 | 0 | 0 | |
| >I | 1 (+) | 0 | 0 | 02 (0.1) |
| Whitefish | | | | |
| 0 | 0 | 0 | 0 | 0 |
| ≥I | 17 (0.7) | 124 (4.8) | 19 (0.7) | 74 (2.6) |

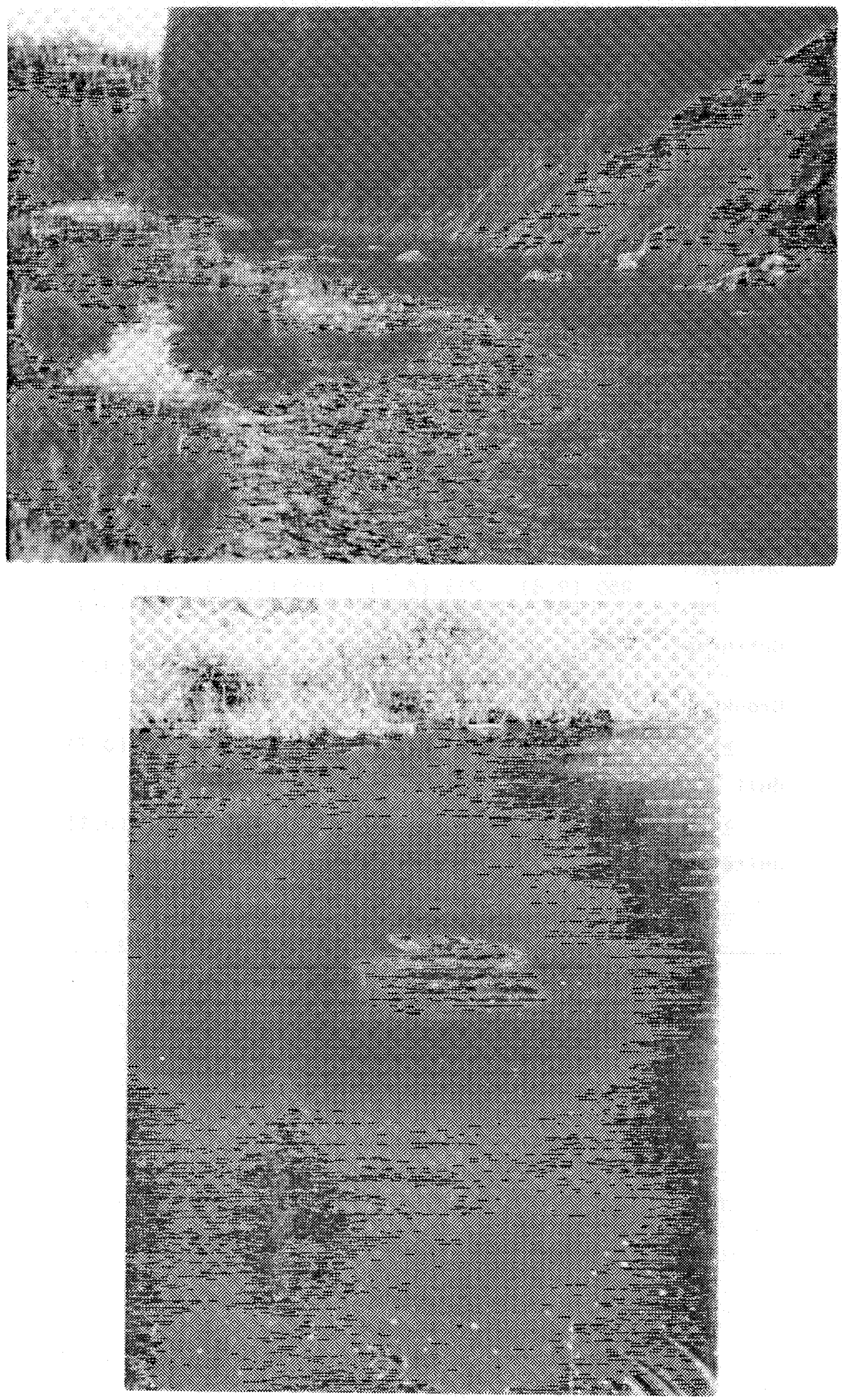


Figure 39. Boulder placements in Reach IV, Red River, 1984. Age 0 chinook primarily used backwaters in late July (upper photo, left) Many boulders were placed in slow run habitat (lower photo).

by adding sections in all reaches. Habitat in sections upstream of the enhancement area in Red River and South Fork of Red River probably will not change markedly; we may be able to use sections in these reaches as "controls". Because Red River now has the strongest chinook runs in the South Fork Clearwater River system, other nearby streams in the drainage might not serve well as controls. Some relationship, such as increased efficiency of recruitment from spawning, might be derived from annual trends in chinook redd counts and juvenile densities and from intensive work in other streams. However, it is still uncertain whether sediment models or other habitat measurements will provide the basis to separate streamwide benefits from this enhancement project from those of other enhancement projects and from other trends.

## Summary

IDFG evaluation of the Red River habitat enhancement project began in 1984 as a pre-treatment for boulder placements. IDFG will continue to sample fish populations in control and treated sections after boulders are placed. USFS Intermountain Forest and Range Experiment Station (IFRES) personnel will conduct habitat measurements in these sections before and after enhancement.

Other evaluations are planned by IDFG to determine localized effects from instream structure placements in Reach II and from riparian fencing on private land which is being negotiated. Enhancement activities in Red River are more diverse than in other BPA-funded projects. Site-specific benefits of some of these activities can be measured statistically. Benefits from many activities will not be localized, and we anticipate difficulty in assigning benefits to these subprojects.

Definite approaches to separating streamwide increases in juvenile rearing from increases due to expected increasing spawner escapements and from other changes in the watershed have not been determined. Sampling physical habitat conditions and juvenile fish densities in a larger number of sections and reaches, and continuation of annual chinook redd counts during the period that escapements increase might provide a basis for separating streamwide effects of some types of enhancement activity.

## Recommendations

Sections established to evaluate boulder placements need to be surveyed after treatment as escapements increase. Control and treatment sections should be established to determine localized changes in densities due to other instream structures and riparian fencing.

Streamwide trends in juvenile fish density should be monitored annually during the period that escapements increase. Sections should be added in reaches upstream and downstream from the habitat enhancement project area.

## SALMON RIVER

### Panther Creek

Panther Creek, 43-miles long, enters the Salmon River at river mile 203 near Shoup (Fig. 40). Panther Creek lies within the Salmon National Forest and drains a watershed of about 340,000 acres. The watershed ranges in elevation from 3,300 to 10,000 feet and contains nearly 100 miles of rearing streams. Cobalt and copper ore have been mined at Blackbird Mine near Cobalt. Access to rearing habitat has been partially blocked by effluent from the mining area which has entered Panther Creek via Blackbird Creek and Big Deer Creek since at least the early 1950's.

Panther Creek supported substantial runs of steelhead and chinook before being damaged by pollution from mining. Steelhead still use the drainage to a reduced degree. As many as 2,000 chinook may have spawned in the drainage historically (Corley 1967). The last known spawning by chinook in Panther Creek occurred in 1962. However an IDFG conservation officer observed a pair of adult chinook holding below Beaver Creek bridge in 1983 (M. Reingold, IDFG, Salmon, Idaho, personal communication). Since 1979 IDFG has released adult spawner steelhead and steelhead fry into Panther Creek.upstream of Blackbird Creek confluence. Chinook fry had been stocked in the Panther Creek drainage in the late 1970's.

In 1967 IDFG personnel electrofished four sections in Panther Creek between Porphyry Creek and Napias Creek and one section in Blackbird Creek (Corley 1967). Rainbow-steelhead dominated the fish populations, followed by whitefish, brook trout, dace, and sculpin. No fish were found in Panther Creek just downstream from Blackbird Creek confluence. Mallet (1974) also reported cutthroat trout, bull trout, and chinook in the drainage.

Effluents from the mining area have long affected fish populations in Panther Creek. These effluents resulted in acidic waters high in sediment and the heavy metals cobalt, iron, manganese, lead, and zinc (Platts, et al. 1979). Significant fish kills occurred in 1954 when acid was released from Blackbird Mine (Corley 1967). Between 1954 and 1967, numerous reports exist of black sediment deposition. Corley found no invertebrates in 5 benthos samples from Panther Creek just downstream from Blackbird Creek; in 1967 field experiments, both cutthroat trout eyed-eggs and juvenile (3-inches long) rainbow trout suffered increased short-term (7 and 3 days, respectively) mortality downstream from Blackbird Creek compared to upstream locations.

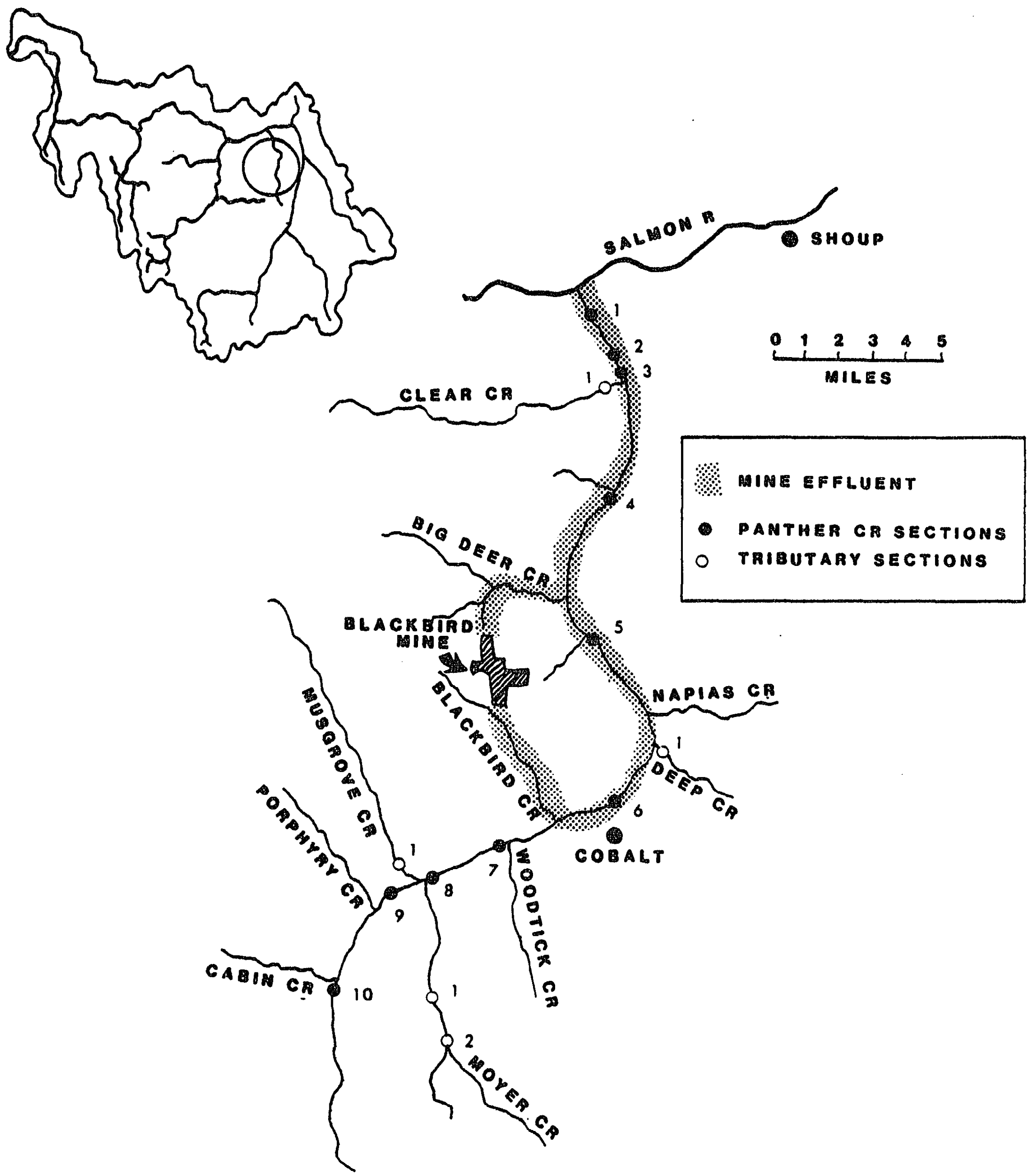



Figure 40. Reaches receiving mine effluent and sections sampled in Panther Creek and tributaries, August 1984.

IDFG conducted further live-box tests in 1977 (5 days) with juvenile steelhead and in 1984 (6 days) with juvenile chinook in relation to mining effluents from Blackbird Creek and Big Deer Creek (M. Reingold, IDFG, Salmon, Idaho, personal communication). In April 1977, juvenile steelhead suffered increased mortality downstream from the two polluted tributaries (Fig. 41). Juvenile chinook mortality also increased below Blackbird Creek in May 1984 (Fig. 41; Table 23); unfortunately, the live box below Big Deer Creek disappeared before the test was completed.

Objectives of the Panther Creek habitat enhancement project are: 1) develop a means to eliminate or control toxic discharges into Panther Creek; 2) restore anadromous fish populations in the Panther Creek drainage; and 3) increase natural production of steelhead and salmon, consistant with IDFG (1984) Anadromous Fish Management Plan for subbasin SA-6.

## 1984 Evaluation

Alternative approaches to controlling toxic discharges from Blackbird Mine area will be defined through BPA contract. This contract for determining feasible alternatives was awarded to Bechtel Corporation in 1984.

IDFG surveyed fish populations in Panther Creek and tributary sections during August 15-17, 1984 to determine pre-treatment conditions before pollution clean-up. We snorkeled sections, measured section lengths and widths (Table 24), and determined fish densities by species and age group. Bechtel Corporation measured physical habitat in the sections and took water chemistry samples in the drainage in 1984.

Densities of juvenile rainbow-steelhead in reaches of Panther Creek and tributaries that were not recieving mine effluent (Tables 25, 26) were comparable to those in many other Idaho streams in 1984 (Appendix Al). We observed only three age 0 chinook in the drainage; these may have been fish that were released after the 1984 live-box tests.

Several influences of mining effluent were evident during the August 1984 survey. In Panther Creek, juvenile rainbow-steelhead densities were lower downstream than upstream from Blackbird Creek confluence (Table 25; Fig. 42). We saw no fish of any species in section 4 downstream from Big Deer Creek confluence. Substrate in sections recieving effluent, particularly section 4, was coated with a grey slime and the water was milky in color. We observed only one mountain whitefish in the polluted reach and it was immediately upstream from Big Deer Creek; in other streams surveyed (eg., Johnson Creek,

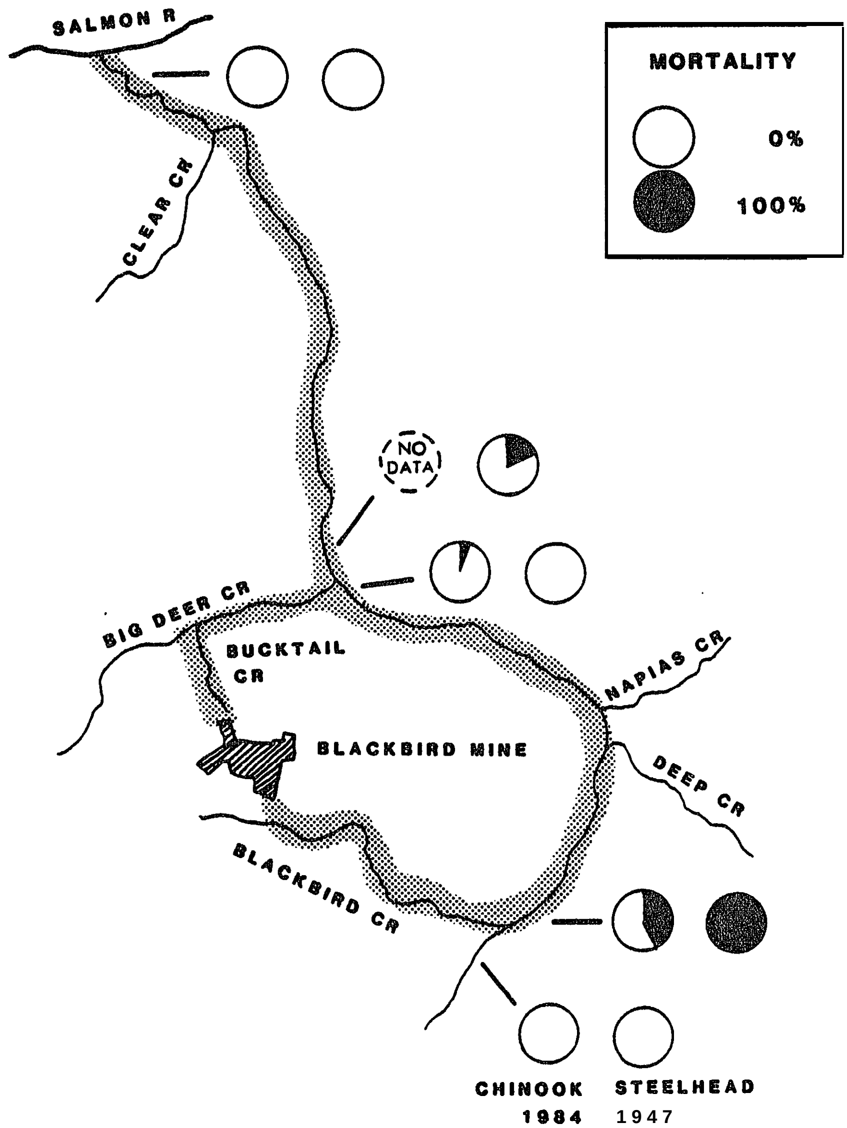



Figure 41. Percentage mortality of juvenile chinook (left circle) in a 6-day live box test, May 1984 and of juvenile steelhead (right circle) in a S-day live box test, April 1977, Panther Creek in vicinity of Blackbird Mine effluents (Gard and Reingold, unpublished manuscript).

Table 23. Results of live-box tests in Panther Creek using juvenile chinook salmon, May 8-14, 1984 (Gard and Reingold, unpublished manuscript).

| Location | Cumulative number dead after day | | | | | | Percent mortality[a] | Temperature (C) on day | | | | | | Mean temperature (C) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | | 1 | 2 | 3 | 4 | 5 | 6 | |
| 0.8 miles above Blackbird Creek | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 5 | 3 | 8 | 8 | 5 | 6 | 5.8 |
| 0.6 miles below Blackbird Creek | 0 | 0 | 0 | 0 | 6 | 8 | 40 | 5 | 3 | 8 | 8 | 6 | 6 | 6.0 |
| 11.7 miles below Blackbird Creek (above Big Deer Creek) | 0 | 0 | 0 | 0 | 0 | 1 | 5 | 6 | 9 | 11 | 11 | 7 | 5 | 8.2 |
| 12.1 miles below Blackbird Creek (below Big Deer Creek) | 0 | -- | -- | -- | -- | -- | --[b] | 6 | 9 | -- | -- | -- | -- | -- |
| 23.8 miles below Blackbird Creek | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 10 | 8 | 12 | 8 | 9 | 9 | 9.3 |

[a] Initial number of 20 fish per live box.
[b] Live box disappeared on second day.

Table 24. Sections sampled in Panther Creek and tributaries, August 15-17, 1984.

| Stream | Location and section | Length (yd) | Mean width ± 2SE (yd) | Area ($yd^2$) |
|---|---|---|---|---|
| Panther | Above Blackbird Cr. | | | |
| | 10 | 100 | 5.3 ± 1.3 | 532 |
| | 9 | 100 | 6.2 ± 1.0 | 621 |
| | 8 | 100 | 9.0 ± 0.8 | 900 |
| | 7 | 100 | 8.6 ± 0.9 | 859 |
| Panther | Below Blackbird Cr. | | | |
| | 6 | 100 | 15.1 ± 2.3 | 1,506 |
| | 5 | 100 | 21.0 ± 1.0 | 2,105 |
| Panther | Below Big Deer Cr. | | | |
| | 4 | 100 | 26.9 ± 1.8 | 2,691 |
| | 3 | 100 | 23.6 ± 3.8 | 2,359 |
| | 2 | 100 | 23.5 ± 1.4 | 2,351 |
| | 1 | 100 | 20.0 ± 1.2 | 1,997 |
| Musgrove | Above Blackbird Cr. | | | |
| | 1 | 100 | 5.2 ± 1.4 | 525 |
| Moyer | Above Blackbird Cr. | | | |
| | 1 | 100 | 4.7 ± 1.5 | 474 |
| | 2' | 200 | 7.3 ± 1.0 | 1,457 |
| Deep | Below Blackbird Cr. | | | |
| | 1 | 100 | 4.5 ± 0.9 | 450 |
| Clear | Below Big Deer Cr. | | | |
| | 1 | 200 | 6.9 ± 0.6 | 1,386 |

Table 25. Number of trout, salmon, and whitefish (number/100 yd²) counted in Panther Creek sections, August 15-17, 1984.

| Species, age | Above Blackbird Creek | | | | Below Blackbird Creek | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Below Big Deer Creek | | | |
| | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 |
| Rainbow-steelhead | | | 0 | 0 | 0 | | 0 | 0 | | |
| 0 | 21 (3.9) | 12 (1.9) | 18 | 22 | 2 | 0 | 0 | 0 | 4 | 0 |
| I | 17 (3.2) | 22 (3.5) | (2.0) | (2.6) | (0.1) | 9 (0.4) | | | 4 (0.2) | 7 (0.4) |
| II | 2 (0.4) | 13 (2.1) | | 21 (2.4) | 7 (0.5) | 13 (0.6) | 0 | 3 (0.1) | (0.2) | (0.3) |
| ≥III | 0 | 2 (0.3) | 15 (1.7) | 1 (0.1) | 4 (0.3) | 0 | 0 | 1 (+) | 3 (0.1) | 8 (0.1) |
| | | | 2 (0.2) | | | | | | | |
| Chinook | | | | | | | | | | |
| | 0 | 0 | 0 | 0 | 1 (0.1) | 0 | 0 | 0 | 0 | 2 (0.1) |
| I+ | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Cutthroat ≥I | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 (0.1) | 0 |
| Brook | | | | | | | | | 0 | |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| ≥I | 2 (0.4) | 1 (0.2) | 0 | 0 | 3 (0.2) | 0 | 0 | 0 | | 0 |
| Bull | | | | | | | | | | |
| 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| ≥I | 8 | 0 | 0 | 2 (0.2) | 1 (0.1) | 0 | 0 | 0 | 0 | 0 |
| Hatchery rainbow | 0 | 0 | 12 (1.3) | 5 (0.6) | 0 | 0 | 0 | 0 | 0 | 0 |
| Whitefish | | | | | | | | | 0 | |
| 0 | 3 (0.6) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| ≥I | 6 (1.1) | 10 (1.6) | 6 (0.7) | 1 (0.1) | 0 | 1 (+) | 0 | 0 | | 0 |

Table 26. Number of trout, salmon, and whitefish (number/100 $yd^2$) counted in Panther Creek tributary sections, August 15-17, 1984.

| Species, age | Musgrove Cr. | Moyer Cr. | | Deep Cr. | Clear Cr. |
|---|---|---|---|---|---|
| | 1 | 2 | 1 | 1 | 1 |
| **Rainbow-steelhead** | | | | | |
| 0 | 2 (0.4) | 0 | 1 (0.1) | 0 | 42 (3.0) |
| I | 10 (1.9) | 3 (0.6) | 34 (2.3) | 5 (1.1) | 56 (4.0) |
| II | 8 (1.5) | 1 (0.2) | 16 (1.1) | 6 (1.3) | 34 (2.5) |
| ≥III | 1 (0.2) | 0 | 3 (0.2) | 7 (1.6) | 6 (0.4) |
| **Chinook** | | | | | |
| 0 | 0 | 0 | 0 | 0 | 0 |
| I+ | 0 | 0 | 0 | 0 | 0 |
| **Cutthroat** | | | | | |
| ≥I | 0 | 0 | 0 | 0 | 3 (0.2) |
| **Brook** | | | | | |
| 0 | 0 | 0 | 0 | 0 | 0 |
| ≥I | 5 (1.0) | 0 | 0 | 0 | 0 |
| **Bull** | | | | | |
| 0 | 0 | 0 | 0 | 0 | 0 |
| ≥I | 0 | 1 (0.2) | 6 (0.4) | 1 (0.2) | 4 (0.3) |
| **Whitefish** | | | | | |
| 0 | 0 | 0 | 0 | 0 | 0 |
| ≥I | 0 | 0 | 0 | 0 | 0 |

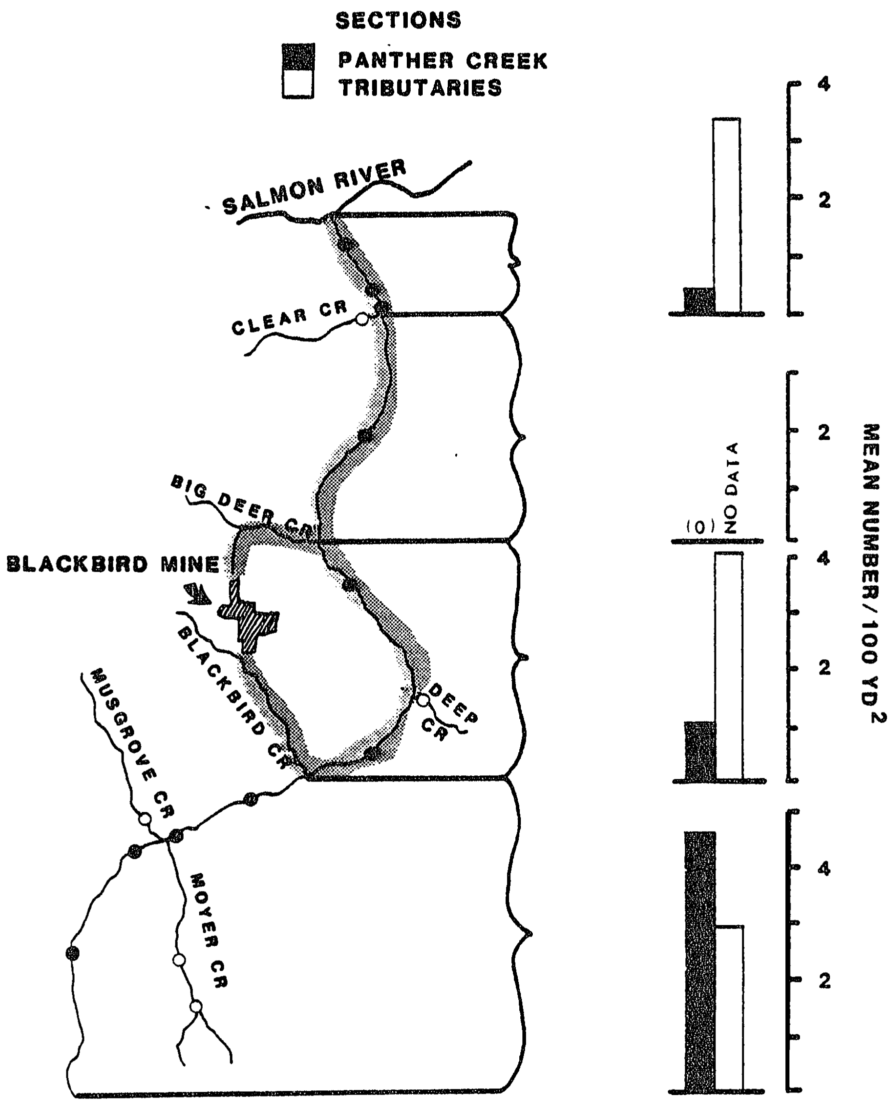



Figure 42 Densities of age I-and-older rainbow-steelhead in Panther Creek and tributary sections relative to Blackbird Mine effluent, August 15-17, 1984.

Bear Valley Creek) this larger, deeper downstream habitat was preferred by whitefish. Based on fish distributions, pollution in Panther Creek appears most severe below Big Deer Creek. Pollutant levels may be higher in Big Deer Creek than Blackbird Creek, or the cumulative effect from pollution in both 'streams may explain this fish distribution pattern.

Rainbow-steelhead observed in Panther Creek and tributaries are apparently a mixture of resident and anadromous stocks. Steelhead have been introduced recently in the upper drainage and the present anadromous population is supported primarily by stocking. Many rainbow-steelhead had a relatively deep body and large spots more typical in appearance of resident rainbow trout stocks. Separation of resident from anadromous stocks may be possible by otolith nuclei measurements (McKern, et al. 1974; Rybock, et al., 1975). Such separation will be necessary to assess the amount of steelhead production after pollution clean-up.

Several benefits to steelhead, chinook and resident fish will occur from controlling toxic discharges into Panther Creek. Densities of rainbow-steelhead should increase substantially in the 25 miles now receiving effluent. Improved access for adult steelhead will increase steelhead rearing potential in the upper drainage of Panther Creek. Both the mainstem Panther Creek and tributaries would provide excellent chinook rearing habitat after pollution sources are reduced. A 5-mile meadow reach above Moyer Creek provides especially good potential for chinook. However, we observed considerable organic sediment deposited in meadow sections 9 and 10 during August 1984. Above this meadow, the headwaters reach of Panther Creek contains numerous short meadow sections with excellent habitat quality that we did not sample in 1984.

## Costs and Benefits

Cost of the problem identification and feasibility phase of pollution clean-up through 1984 is presented in Appendix B.

Final benefits of the project can be determined from estimated standing crops of juvenile steelhead and chinook in the drainage upstream and within the present polluted reach, at full seeding (Table 1). Based on the current assessment that anadromous populations are not self-sustaining, all anadromous fish reared in the drainage could be considered benefits of pollution control. This assessment requires better definition in future evaluations.

## Summary

Distributions and densities of fish in Panther Creek during the August 1984 survey reflected pollution conditions. Densities of rainbow-steelhead in tributaries and upstream of effluent reaches in Panther Creek were comparable to other streams in Idaho; densities in polluted reaches were much lower. Apparently, both resident and anadromous stocks of rainbow-steelhead now inhabit Panther Creek drainage above the mine effluent; anadromous stocks are sustained primarily by stocking. Chinook were essentially missing from the drainage in 1984.

Benefits from pollution clean-up at the Blackbird Mine area will be high for both steelhead and chinook.

## Recommendations

Trend sections should be sampled annually to monitor seeding levels. Complete surveys need to be conducted after pollution control is initiated; at least two additional sections should be established near the headwaters. Samples of rainbow-steelhead otoliths from stocked and unstacked portions of the upper drainage should be taken to determine the ratio of anadromous to resident rainbow before and after pollution control. Spawning ground surveys for chinook should be reestablished.

## Upper Salmon River

The Salmon River, 410-miles long, has its source in the Sawtooth Mountains within the Idaho Batholith, a region with highly erodible soils. The upper river above Stanley (Fig. 43) lies primarily within the Sawtooth National Recreation Area which was created in 1972 to assure the "preservation and protection of the natural, scenic, historic, pastoral, and fish and wildlife values". The upper river flows through a relatively flat basin. Flow diversions for irrigation restrict anadromous fish use to parts of the basin and grazing in riparian zones has degraded aquatic habitat.

The upper Salmon River system is a major production area for spring chinook salmon. To a lesser degree the upper basin produces summer steelhead. A remnant run of sockeye salmon rears in Redfish Lake. Anadromous fish runs to the upper Salmon River were reduced in the early 1900's by construction of Sunbeam Dam downstream from Stanley. The dam, which was a barrier to anadromous fish at high flows, was breached in 1934. The upper Salmon River was not restocked extensively in the years following the dam removal (M. Reingold, IDFG, Salmon, Idaho, personal communication). Compensation for spring chinook in the Salmon River drainage led to recent construction of the Sawtooth Hatchery near Stanley under the Lower Snake River Compensation Plan. A brood stock development program, involving trapping of adults and release of smolts, has been in operation since 1981 (Partridge 1984).

Native resident salmonids in the upper Salmon River drainage are rainbow trout, cutthroat trout, bull trout, and mountain whitefish (Mallet 1974). Non-native brook trout have also become established.

An irrigation diversion on the Salmon River between the confluences of Alturas Lake Creek and Pole Creek dewaters the stream for about one-quarter mile during late summer in dry years. Passage for adult chinook is restricted during these years and rearing habitat is reduced for juvenile steelhead and chinook. A ladder was constructed on the diversion structure in 1981. Informal arrangements had been made with a private caretaker to check the ladder and to open it if adult chinook were beginning to concentrate in the dewatered area (M. Reingold, IDFG, Salmon, Idaho, personal communication).

USFS is currently working on feasible solutions to passage restrictions for adult chinook at the irrigation diversion using BPA funds. Two possible alternatives are to purchase enough of the water right to assure passage during all years and/or to construct a fishway channel to pass fish around the dewatered stream reach.

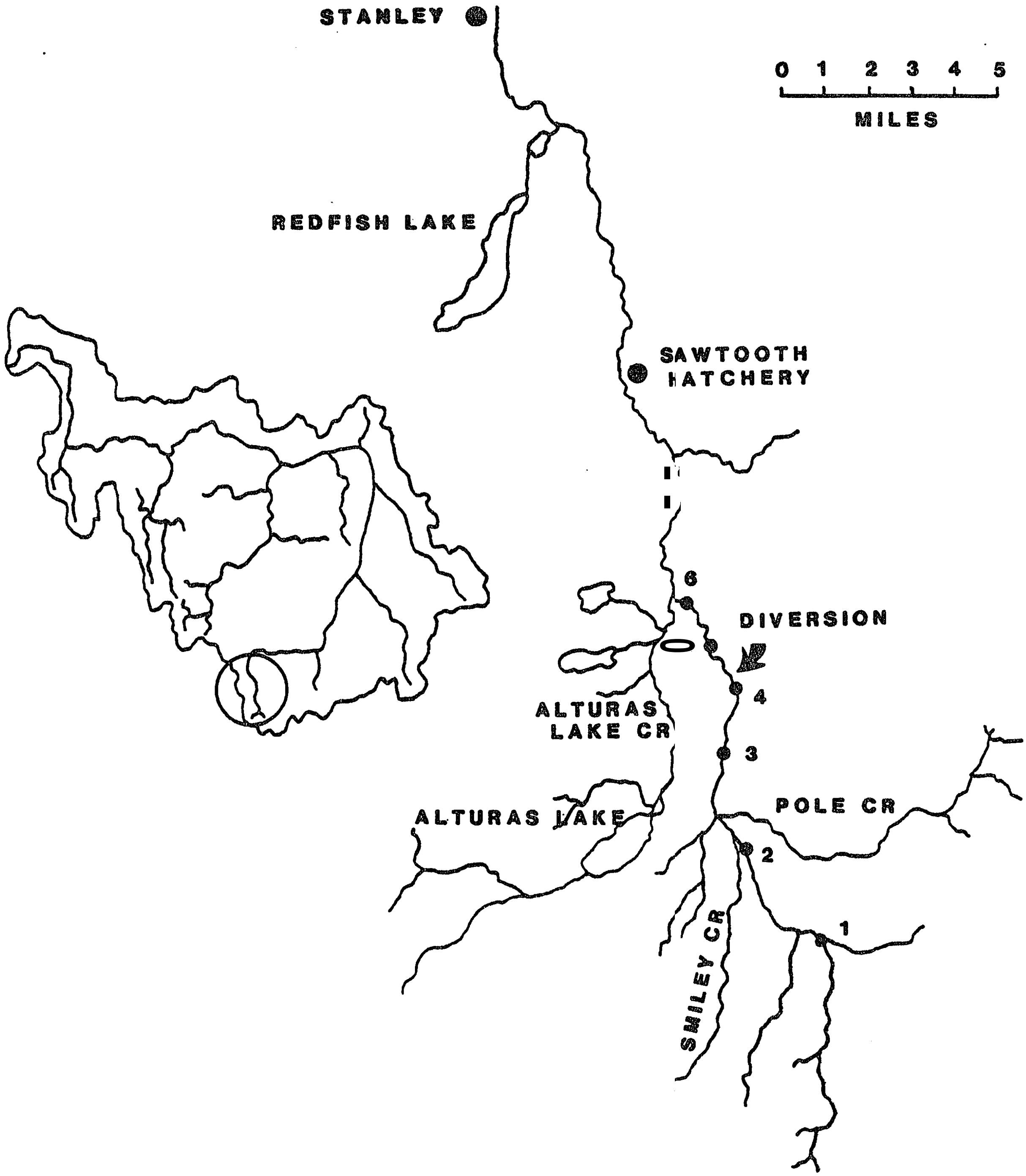



Figure 43 Location of irrigation diversion and sections sampled in upper Salmon River, 1984.

Objectives of the project are: 1) secure passage for anadromous fish at the water diversion; 2) if possible, improve instream flows downstream from the diversion; and 3) increase natural production of anadromous fish in the upper Salmon River, consistent with IDFG (1984) Anadromous Fish Management Plan for subbasin SA-11.

## 1984 Survey

Before remedial measures are implemented, IDFG surveyed sections of the upper Salmon River in 1984 to determine fish distribution and densities and document current physical habitat conditions. We established six sections on the upper Salmon River between the confluence of Alturas Lake Creek and U.S. Highway 93 bridge near Galena Summit (Fig. 43). We snorkeled the sections during August 20-21, 1984, measured section lengths, widths (Table 27), and physical habitat, and determined fish densities by species and age group.

Densities of juvenile rainbow-steelhead (Table 28) in the upper Salmon River sections were low relative to those in other streams surveyed in 1984 (Appendix Al). Juvenile rainbow-steelhead were found above and below the irrigation diversion in 1984 (Fig. 44). Rainbow-steelhead fry were found only in sections 1 and 2, upstream from Smiley Creek confluence (Table 28).

Age 0 chinook densities in the upper Salmon River (Table 28) were the highest observed in Idaho in 1984 (Appendix A2). To our knowledge, densities of 80/100 yd2 in two sections represent the highest densities of age 0 chinook from natural production documented for Idaho streams. These localized high densities resulted from a spawning escapement that was 24% of the 1960-69 average based on redd counts in established trend areas. However, because much of the available habitat was not utilized, it is doubtful that these high densities represented full seeding. High densities in 1984 occurred above and below the irrigation diversion (Fig. 44).

During the August 1984 survey, the irrigation diversion did not completely dewater the upper Salmon River and fish passage for juveniles and adults was not a problem. The high densities of juvenile chinook upstream of the diversion and in lower Pole Creek indicate that adult chinook passed through in 1983. Complete dewatering by the diversion occurs only in dry years; 1983 and 1984 were relatively high-water years.

Although livestock damage was evident in several reaches in 1984, aquatic habitat in general was relatively high quality. Depths and velocities were

Table 27. Sections sampled in upper Salmon River, August 20-21, 1984.

| Location and section | Length (yd) | Mean width ± 2SE (yd) | Area ($yd^2$) | % habitat type: Pool | Run | Riffle | Pocket water |
|---|---|---|---|---|---|---|---|
| Above diversion | | | | | | | |
| 1 | 100 | 4.6 ± 1.2 | 457 | 26.7 | 60.0 | 13.3 | 0 |
| 2 | 200 | 6.2 ± 0.7 | 1,231 | 0 | 63.3 | 36.7 | 0 |
| 3 | 100 | 12.4 ± 1.0 | 1,237 | 0 | 44.4 | 55.6 | 0 |
| 4 | 97 | 11.4 ± 0.5 | 1,108 | 30.0 | 36.7 | 33.3 | 0 |
| Below diversion | | | | | | | |
| 5 | 100 | 8.7 ± 1.4 | 871 | 40.0 | 20.0 | 40.0 | 0 |
| 6 | 100 | 13.1 ± 1.8 | 1,305 | 36.7 | 30.0 | 33.3 | 0 |

**Table 28. Number of trout, salmon, and whitefish (number/100 $yd^2$) counted in upper Salmon River sections, August 20-21, 1984.**

| Species, age | Above diversion: 1 | 2 | 3 | 4 | Below diversion: 5 | 6 |
|---|---|---|---|---|---|---|
| Rainbow-steelhead | | | 0 | | | |
| 0 | 25 (5.5) | 4 (0.3) | 0 | 0 | 0 | 0 |
| | 0 | | | | | 7 (0.5) |
| II | 0 | 01 (0.1) | 0 | 93 (0.3) (0.8) | 01 (0.1) | 7 (0.5) |
| ≥III | 0 | 1 (0.1) | 0 | 6 (0.5) | 1 (0.1) | 2 (0.2) |
| Chinook | | | | | | |
| 0 | 105 (23.5) | 548 (44.5) | 134 (10.8) | 903 (81.5) | 690 (79.2) | 450 (34.5) |
| I+ | 8 (1.8) | 5 (0.4) | 0 | 0 | 3 (0.3) | 10 (0.8) |
| Brook | | | | | | |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| >I | 2 (0.4) | 2 (0.2) | 0 | 0 | 0 | 0 |
| Hatchery rainbow | 0 | 0 | 0 | 0 | 0 | 5 (0.4) |
| Whitefish | | | | | | |
| 0 | 1 (0.2) | 5 (0.4) | 0 | 168 (15.2) | 5 (0.6) | 1 (0.1) |
| >I | 4 (0.9) | 12 (1.0) | 2 (0.2) | 50 (4.5) | 14 (1.6) | 51 (3.9) |

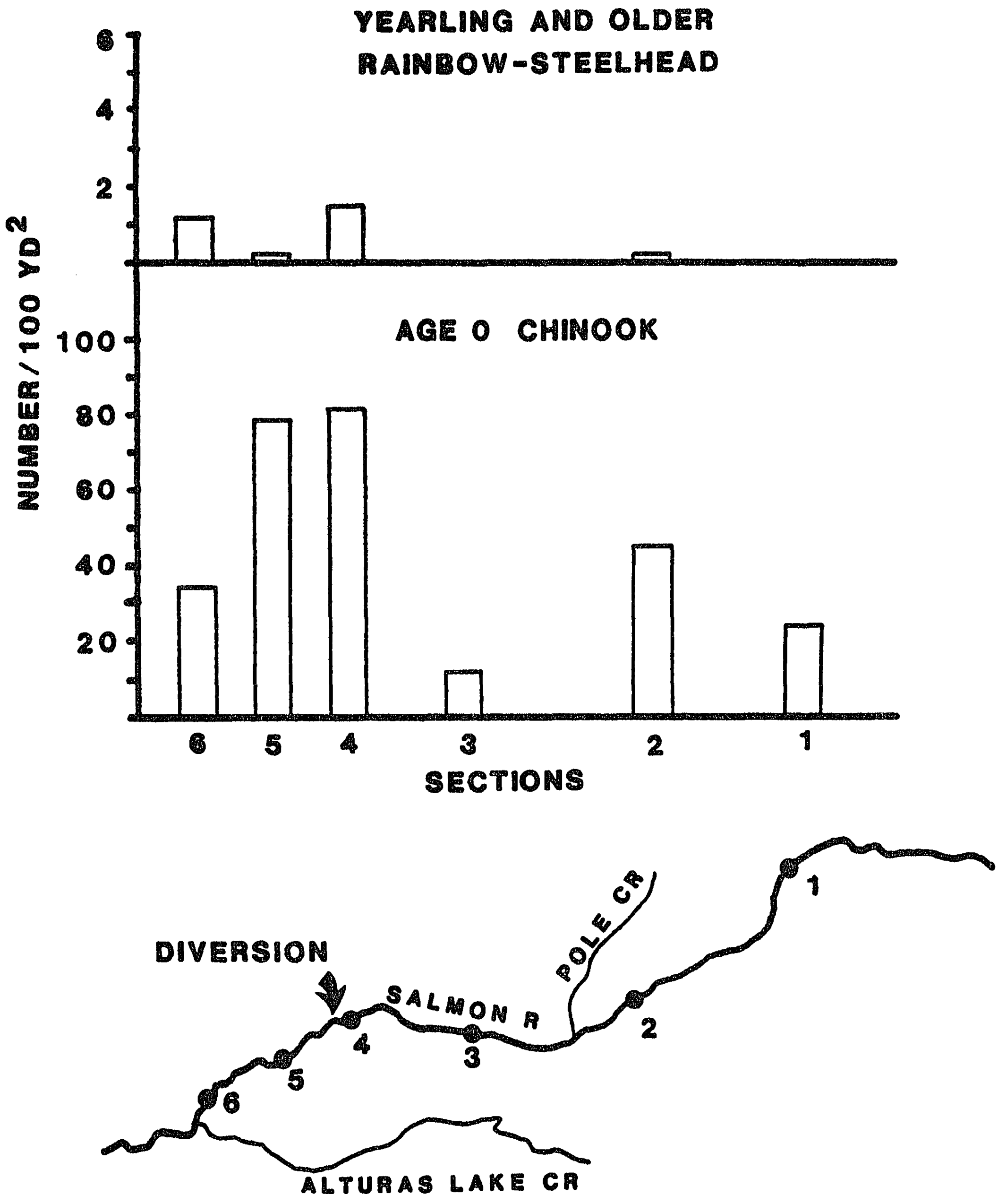



Figure 44. Distribution and densities of juvenile rainbow-steelhead and chinook in upper Salmon River relative to irrigation diversion, August 20-21, 1984.

moderate in most sections (Fig. 45). Sand made up less than 25% of the substrate by area; embeddedness was relatively low in sections 1, 2, and 5.

## Costs and Benefits

Costs of the feasibility study to date are presented in Appendix B.

Primary benefits of the project to allow passage past the irrigation diversion will be for chinook production during dry years. Much high-quality habitat exists upstream of the diversion that could be seeded by chinook during critical low-water years. Steelhead adults can pass the diversion site under current conditions. Project benefits can be calculated at full seeding from the estimated number of age 0 chinook produced above the diversion during low-water years (Table 1), The frequency of complete dewatering in past years can be determined from IDFG file records and factored into the calculation of benefits from passage improvement. Additional benefits for steelhead and chinook may occur downstream from improved stream flows during summer; these could be estimated in future years from an instraem flow study.

## Summary

USFS is formulating feasible alternatives to resolve dewatering problems at an irrigation diversion on the upper Salmon River which blocks adult chinook passage in dry years. An IDFG fish survey found high densities of age 0 chinook above and below the diversion in 1984. Passage was apparently not a problem during 1983 and 1984. Much of the habitat in the upper Salmon River is high quality, but some portions are being degraded by grazing practices. Once passage for adult chinook is secured we expect significant benefits for chinook during critical low-water years.

## Recommendations

Fish densities and distributions should be monitored annually in upper Salmon River sections established in 1984. Sections should be added in 1985 on the Salmon River between Alturas Lake Creek confluence and Sawtooth Hatchery to follow annual density trends downstream. An additional spawning

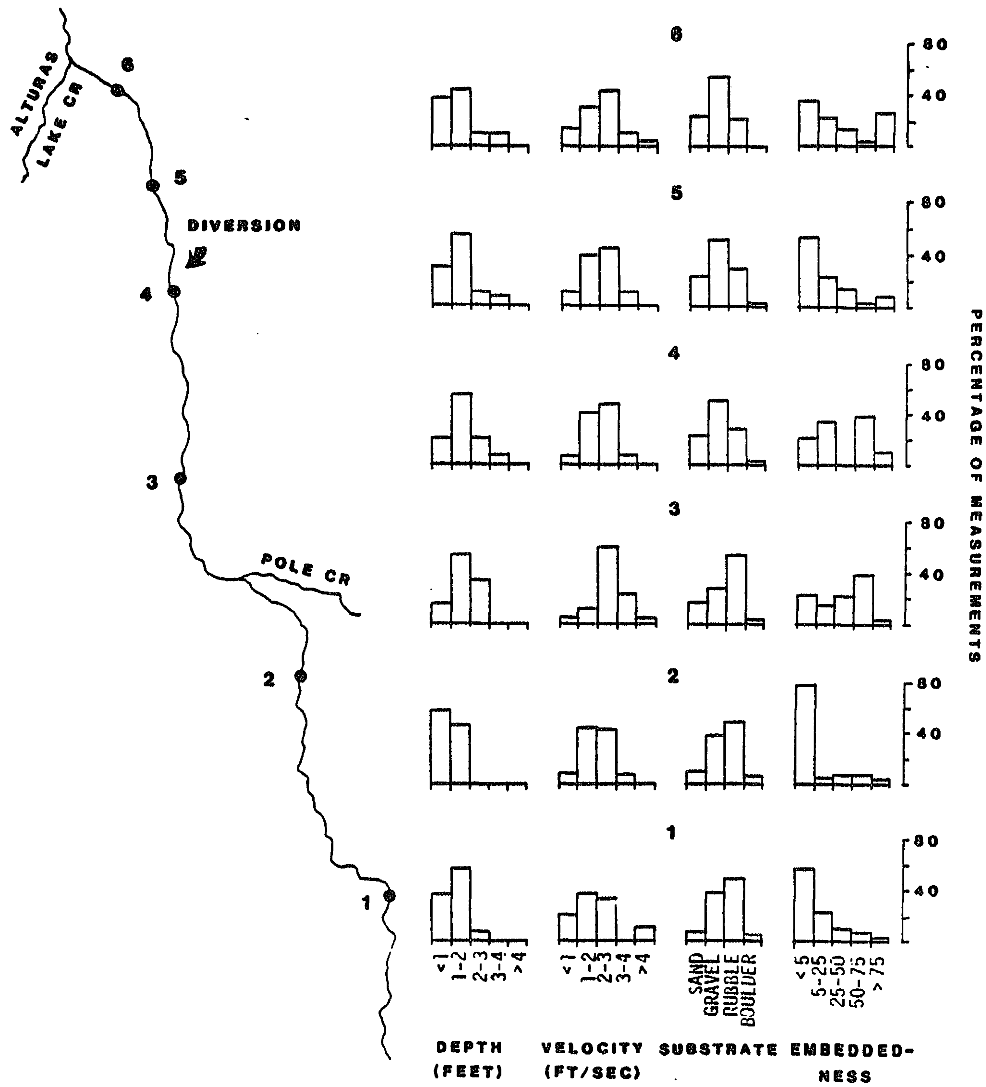



Figure 45. Summary of physical habitat measurements in upper Salmon River sections, August 20-21, 1984.

ground survey to monitor annual trends in number of chinook redds should be established upstream of the irrigation diversion in 1985.

## Alturas Lake Creek[a]

Alturas Lake Creek is a tributary to the upper Salmon River and originates at 8960 feet elevation in the Sawtooth National Recreation Area. From its source, the stream courses in a general north-easterly direction dropping 2130 feet in 15.5 miles (137 feet/mile) to its confluence with the Salmon River (Fig. 46). The stream passes through two natural lakes, Alturas Lake (838 acres) and Perkins Lake (51 acres), which receive moderate recreational use during the summer season. Below the lakes, four main tributaries and subsurface seepage enter the stream; above the lakes, only Alpine Creek contributes substantially to is volume. An irrigation diversion below the lakes completely dewaters the stream during most years limiting use of the stream by anadromous fish.

Historically, spring chinook spawned and reared in Alturas Lake Creek above and below the lakes and in Alpine Creek up to its barrier 1.5 miles upstream. Some use of Alturas Lake Creek by summer steelhead also occurred. Sockeye salmon spawned in the upper drainage and reared in Alturas Lake.

Resident salmonids in Alturas Lake Creek are rainbow trout, cutthroat trout, bull trout, brook trout, and mountain whitefish (Mallet 1974); kokanee have been stocked in Alturas Lake. Several species of cyprinids and catastomids occur in the two lakes and in the stream near the outlets.

Approximately 4.8 miles upstream from the mouth of Alturas Lake Creek, an irrigation diversion dam (Figure 46) usually diverts all flow after the first week of July. Most of the potential chinook spawning habitat and more than 80% of the suitable rearing habitat exists upstream from the diversion (H. Forsgren, USFS, Hailey, Idaho, personal communication). The stream is dewatered for 1.6 miles below this diversion during the largest part of the chinook spawning season. Vat Creek and subsurface flows do provide sufficient water to the lower portions of Alturas Lake Creek for fair spawning and rearing conditions in most years. In addition to reducing chinook and steelhead production potential, the diversion eliminated a sockeye run which probably exceeded 4500 in escapement.

USFS is investigating two approaches to resolve the instream flow problem in Alturas Lake Creek (Forsgren 1984a). The first involves the construction of an outlet control structure on Alturas Lake to store spring runoff water for release into the creek during late summer and early fall to accommodate

[a]Contributed by S. Rubrecht, USFWS, Ahsahka, Idaho.

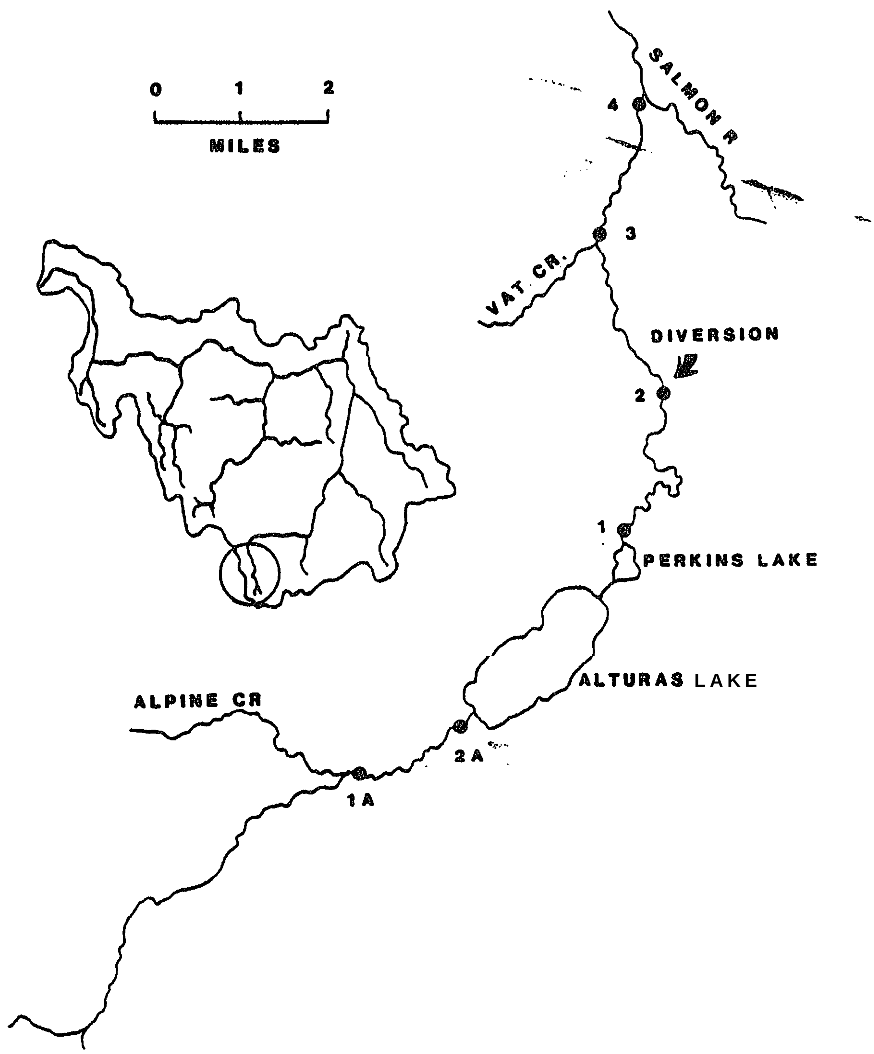



Figure 46. Location of irrigation diversion and sections sampled in Alturas Lake Creek, 1984.

upstream migrating and spawning chinook. In conjunction with this structure, a fish screen and fish ladder would be necessary at the diversion. The second approach would be the acquisition of the water right or a portion of that right held on Alturas Lake Creek for instream flows.

Objectives of the project are 1) secure passage of adult chinook and sockeye into the upper stream; 2) restore production potential of Alturas Lake Creek for chinook and sockeye; and 3) increase natural production of anadromous fish, consistant with IDFG (1984) Anadromous Fish Management Plan for subbasin SA-11.

## 1984 Survey

Before any remedial action is implemented on Alturas Lake Creek, IDFG conducted a precondition survey in 1984 which included a determination of juvenile steelhead and chinook distributions and densities and a habitat inventory. Six sample sections were established on Alturas Lake Creek: 2 below the diversion, 2 between the diversion and the lakes, and 2 above the lakes (Fig. 46). During August 18-19, 1984 we snorkeled sections, measured section lengths, widths (Table 29), and physical habitat, and determined fish densities by species and age group.

Rainbow-steelhead were present only in the lower sections 2, 3, and 4 (Table 30; Fig. 47). Densities of juvenile rainbow-steelhead were lower than in most other Idaho streams in 1984 (Appendix Al).

Age 0 chinook were present in all sections, but in much lower densities upstream of the diversion (Table 30; Fig. 47). Density of age 0 chinook in section 3 near Vat Creek confluence was among the highest observed for Idaho streams in 1984 (Appendix A2).

The only locations that either sockeye or kokanee were observed were section 1A, above Alturas Lake, and section 1, downstream from Perkins Lake (Table 30). High densities of brook trout were observed in the meadow section (3) near Vat Creek confluence. In section 1, downstream from Perkins Lake, we observed high densities of squawfish, suckers, and chubs.

In mid-August 1984 when Alturas Lake Creek was inventoried, the diversion served as a total block to upstream migration. The stream was almost completely dewatered below the diversion (Fig. 48). Age 0 chinook were observed in sections 1, 2, lA, and 2A above the diversion but in low densities. These fish were probably progeny from a few adults that returned

Table 29. Sections sampled in Alturas Lake Creek, August 18-19, 1984.

| Location and section | Length (yd) | Mean width + 2SE (yd) | Area ($yd^2$) | % habitat type | | | |
|---|---|---|---|---|---|---|---|
| | | | | Pool | Run | Riffle | Pocket water |
| Above diversion and Alturas Lake | | | | | | | |
| 1A | 100 | 8.3 ± 0.9 | 825 | 63.3 | 3.3 | 33.3 | 0 |
| 2A | 100 | 8.0 ± 0.9 | 797 | 85.2 | 0 | 14.8 | 0 |
| Above diversion | | | | | | | |
| 1 | 100 | 23.7 ± 1.4 | 2,367 | 0 | 100 | 0 | 0 |
| 2 | 91 | 12.3 4 1.8 | 1,230 | 0 | 11.1 | 44.4 | 44.4 |
| Below diversion | | | | | | | |
| 3 | 200 | 9.0 ± 1.3 | 1,807 | 0 | 71.7 | 28.3 | 0 |
| 4 | 100 | 18.5 ± 2.2 | 1,680 | 0 | 66.7 | 33.3 | 0 |

Table 30. Number of trout, salmon, and whitefish (number/100 $yd^2$) counted in Alturas Lake Creek sections, August 18-19, 1984.

| Species, age | Above Alturas Lake | | Below Alturas Lake | | | |
|---|---|---|---|---|---|---|
| | Above diversion | | | | Below diversion | |
| | 1A | 2A | 1 | 2 | 3 | 4 |
| Rainbow-steelhead | | | | | | |
| 0 | 0 | 0 | 0 | 0 | 0 | 3 (0.2) |
| | 0 | 0 | 0 | 0 | 0 | 0 |
| II | 0 | 0 | 0 | 4 (0.3) | 7 (0.4) | 8 (0.5) |
| ≥III | 0 | 0 | 0 | 1 (0.1) | 0 | 0 |
| Chinook | | | | | | |
| 0 | 1 (0.1) | 8 (1.0) | 2 (0.1) | 70 (5.7) | 1237 (68.5) | 176 (10.5) |
| I+ | 0 | 0 | 1 (+) | 5 (0.4) | 66 (3.7) | 8 (0.5) |
| Kokanee | | | | | | |
| 0 | 0 | 0 | 1 (+) | 0 | 0 | 0 |
| >I | 7 (0.9) | 0 | 0 | 0 | 0 | 0 |
| Brook | | | | | | |
| 0 | 4 (0.5) | 0 | 0 | 0 | 0 | 0 |
| ≥I | 20 (2.4) | 22 (2.4) | 8 (0.3) | 15 (1.2) | 221 (12.2) | 46 (2.7) |
| Hatchery rainbow | 0 | 0 | 0 | 0 | 0 | 1 (0.1) |
| Whitefish | | | | | | |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| ≥I | 0 | 2 (0.3) | 9 (0.4) | 8 (0.7) | 22 (1.2) | 27 (1.6) |

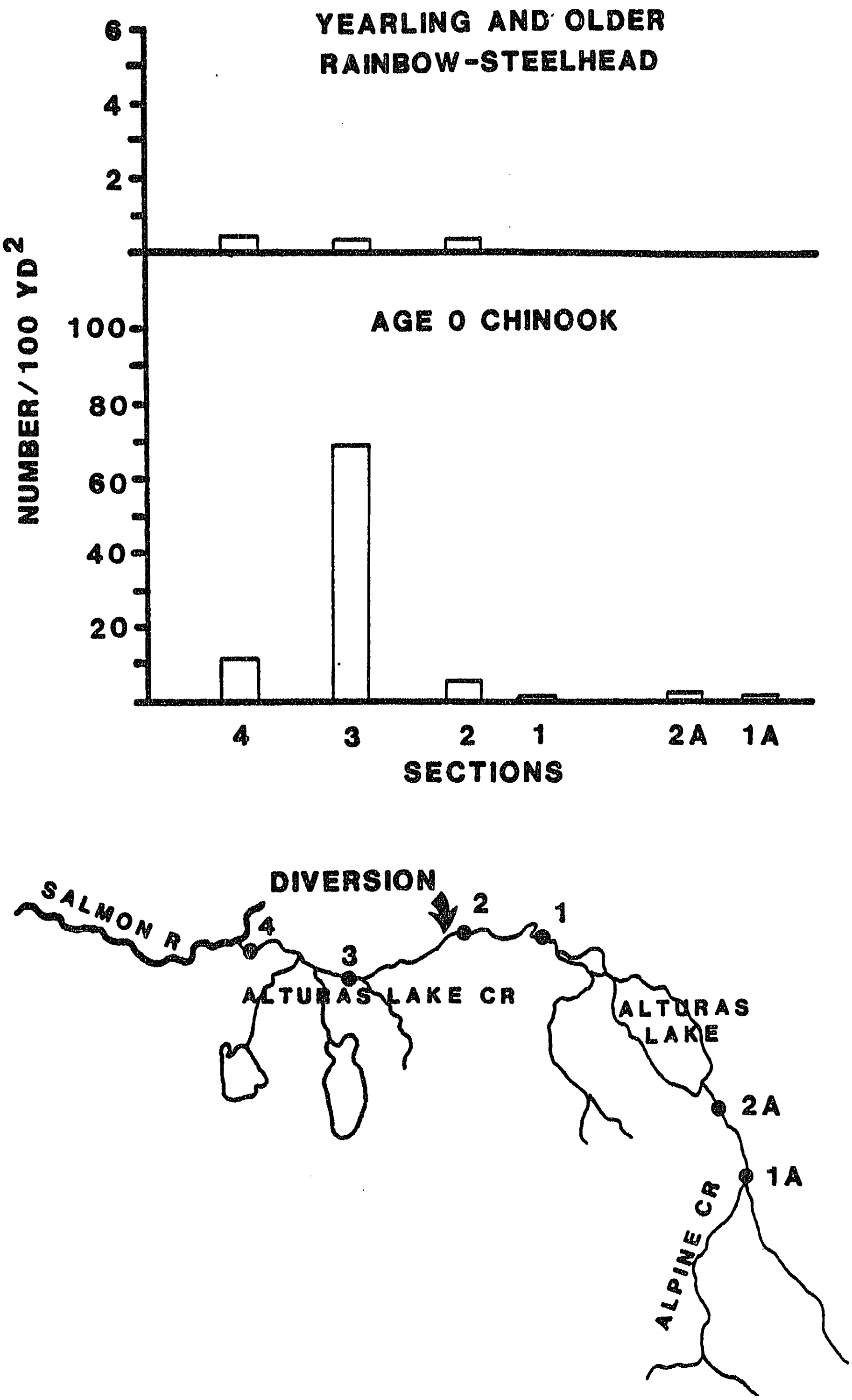
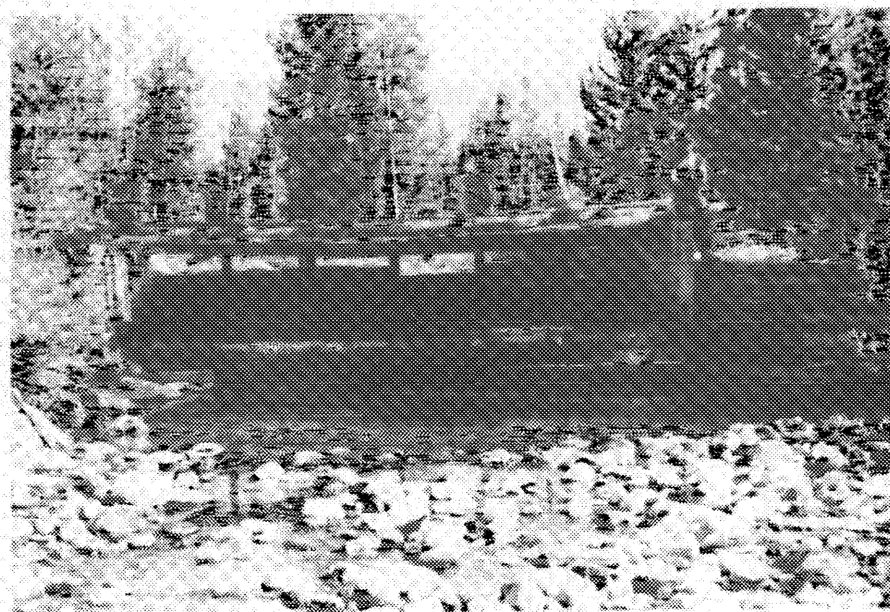



Figure 47. Distribution and densities of juvenile rainbow-steelhead and chinook in Alturas Lake Creek relative to irrigation diversion, August 18-19, 1984.



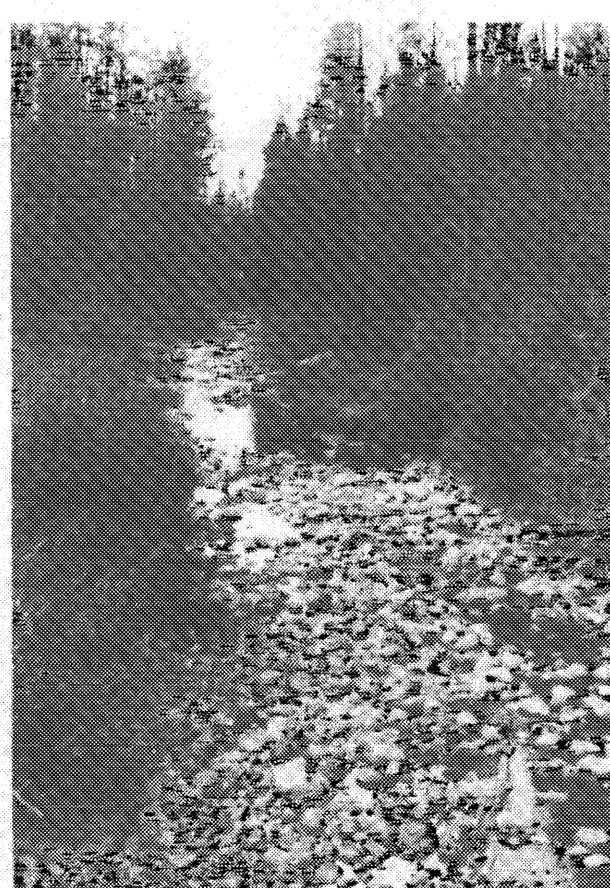


Figure 48. Irrigation diversion dam on Alturas Lake Creek (upper photo) and dewatering downstream from diversion (lower photo), August 1984.

early in 1983 before complete flow diversion occurred. Presence of any age 0 chinook above Alturas Lake was surprising in view of recent depressed spawning escapements and the irrigation diversion.

Physical habitat varied considerably among the six sections in Alturas Lake Creek in 1984 (Fig. 49). Section 4 near the mouth and section 2 above the diversion were similar in terms of their relatively high velocities, large substrate, and low embeddedness. Section 1 below Perkins Lake was a highly sedimented flat run. Habitat measurements in sections 1A and 2A above Alturas Lake most closely resemble those in section 3 near Vat Creek which supported the stream's highest density of age 0 chinook in 1984. In general, habitat quality in Alturas Lake Creek was high and comparable to that in the upper Salmon River (Fig. 45).

Estimates of the numbers of age 0 chinook rearing in the three zones of Alturas Lake Creek during 1984 were made based on densities in the sections and amount of rearing habitat in each zone. In the lower 3.2 miles below the irrigation diversion that maintained a flow in 1984, an estimated 26,501 (216,384) age 0 chinook were present during August; in the 1.6 miles below the diversion that was dewatered another 13,000 chinook could have reared, given adequate flows (assuming similar density). Between the diversion and Perkins Lake, an estimated 2,402 (+4,468) age 0 chinook reared in 1984. In the 6.7 miles of available habitat above Alturas Lake, only 134 (+181) age 0 chinook were estimated to be present during August 1984. Precision of standing crop estimates can be improved in future years when full seeding is approached by adding more sections and stratifying habitat into general types and increasing the number of sections sampled. However, it is clear that the high-quality habitat upstream of the diversion was underseeded in 1984.

Restoration of the spring chinook run in Alturas Lake Creek above the lakes could be difficult if these fish are of a unique stock. Alturas and Perkins Lakes present an unusual migratory route for adult chinook and smolts which are spawned above the lakes. Under present conditions, adults returning to that portion of the stream must not only return early enough to pass the diversion dam before flow is diverted, but must also find their way through two natural lakes. Apparently, this group is wild in origin and was not supplemented by past stocking above the lakes. If chinook returning to the upper reach of Alturas Lake Creek are unique, seeding of this prime habitat may also be impeded due to current hatchery operations on the Salmon River. Since 1981, Sawtooth Fish Hatchery has attempted to capture a major portion of chinook adults returning to the upper Salmon River system. In 1983, approximately 400 adults escaped capture before the hatchery weir was operational on July 20 (T. Rogers, IDFG, Sawtooth Fish Hatchery, personal communication). An additional 78 male and 19 female adults were released above the weir following capture. In 1984 an unknown number of adults passed

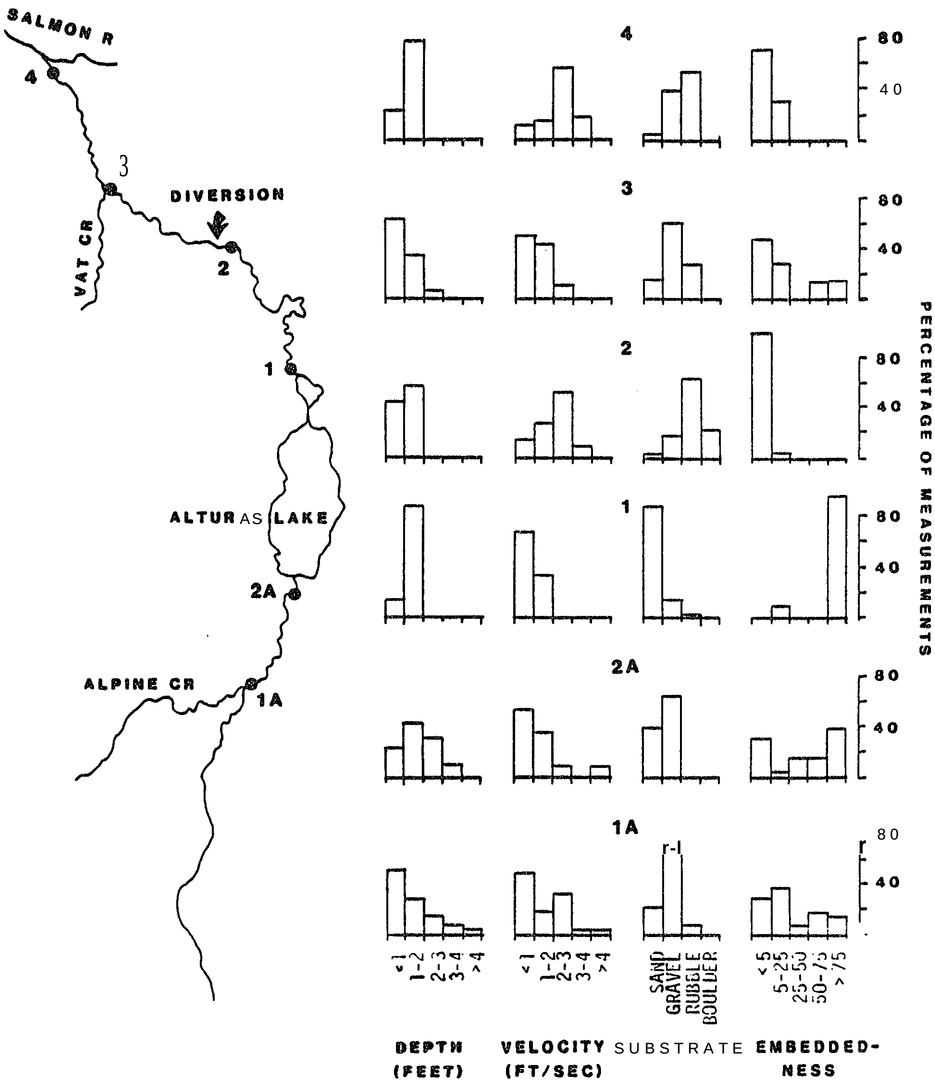



Figure 49. Summary of physical habitat measurements in Alturas Lake Creek sections, August 18-19, 1984.

before the weir was operational and only 140 male and 65 female adults were released after the hatchery weir was operational. Because their release occurred after July 11 and flow diversion began the first week in July, it is doubtful that any of those released adults continued upstream to spawn above Alturas Lake. If successful spawning occurred above the lakes in 1984, it will be detected by snorkel surveys in 1985.

## Costs and Benefits

Costs of the feasibility study through 1984 are presented in Appendix B.

Resolution of the instream flow problems and a screen at the diversion would benefit chinook production in three ways. Better passage would allow for seeding of high-quality habitat upstream of the diversion. Final benefits from a resolution of the chinook passage problem in Alturas Lake Creek can be determined from standing crops of juvenile chinook reared above the diversion, at full seeding (Table 1). Higher instream flows would increase the quantity and quality of rearing habitat downstream from the diversion during summer and early fall for chinook; these benefits could be determined from an instream flow study. Screening the diversion would save a portion of juvenile chinook migrants from entrainment in the irrigation network; the proportion saved could be estimated in future years by mark-recapture experiments.

Benefits for steelhead would be derived from improved instream flows downstream of the diversion and from a fish screen at the diversion. These benefits can be calculated in the same manner as for chinook. Adult steelhead can pass the diversion under current conditions.

Improved passage conditions at the diversion would also allow for reestablishment of sockeye in Alturas Lake of which the entire run could be counted as a benefit of the project. Smolt yields of sockeye should be enumerated directly: an upstream and downstream migrant counting facility incorporated into the design of a modified irrigation diversion structure would allow for direct enumeration of sockeye as well as chinook and steelhead.

## Summary

Currently, USFS is developing alternatives to solve the adult chinook passage problem due to dewatering at the Alturas Lake Creek irrigation diversion. An IDFG fish survey in 1984 found high densities of age 0 chinook below the diversion and low densities above. Very few age 0 chinook were seen above Alturas Lake in Alturas Lake Creek. Habitat is generally high quality above the diversion. Once passage problems are resolved, we expect large benefits for chinook and sockeye. Benefits would also occur for juvenile chinook and steelhead from screening the diversion and from late-summer flow augmentation to the 1.6 miles of stream below the diversion. Restoration of chinook runs above the lakes could be difficult if these few remaining fish represent a unique stock.

## Recommendations

Fish densities and distributions should be monitored annually in Alturas Lake Creek sections established in 1984. Two additional reaches should be added to annual chinook spawning ground surveys, one between the irrigation diversion and Perkins Lake and one above Alturas Lake.

Sockeye should be reintroduced into Alturas Lake. Special consideration should be given to sustaining the remnant wild spring chinook run above Alturas Lake.

An upstream and downstream migrant counting facility should be incorporated into the design of the modified irrigation diversion structure to evaluate production enhancement of chinook, sockeye, and steelhead.

## Pole Creek

Pole Creek, g-miles long, enters the Salmon River near its headwaters at river mile 392 (Fig. 50). Pole Creek lies entirely within the Sawtooth National Recreation Area. The stream in its lower three miles below an irrigation diversion flows through private, irrigated land. Habitat for spawning and rearing of anadromous fish is high quality. However, irrigation withdrawals before 1982 had dewatered the mouth of the stream, and partially dewatered the lower 3.5 miles, during summer.

Summer steelhead and spring chinook were essentially eliminated from Pole Creek above the irrigation withdrawals. After anadromous fish runs are restored, Pole Creek should be an important producer of steelhead and chinook for the upper Salmon River drainage. Aquatic habitat surveys by IDFG and USFS suggest that the three miles of stream immediately above the diversion could support about 560 steelhead spawners and 940 chinook spawners (Forsgren 198433).

In addition to its potential for producing anadromous fish, Pole Creek reportedly supports a popular fishery for resident trout (Forsgren 1984b).

The abstracted water rights in Pole Creek (65.6 cfs) exceeded the total instream flow throughout most of the irrigation season before 1982 (Forsgren 1984b). Irrigation water was withdrawn from seven points along the stream, leaving the mouth of Pole Creek dewatered. In 1982 the mode of irrigation was changed from "flood" to "overhead sprinkler". The new irrigation system requires only 12-18 cfs drawn from one point, and leaves enough water instream to reestablish steelhead and chinook in Pole Creek.

Screening of juvenile steelhead and chinook from the new single diversion was an important part of anadromous fish restoration in Pole Creek. Preliminary estimates suggested that about 25% of all juvenile steelhead and chinook could die in an unscreened diversion network (Forsgren 198433). With support of IDFG, the Sawtooth National Forest entered into an agreement with BPA in 1983 to screen the Pole Creek diversion. USFS contracted IDFG to design, construct, and install the screen.

Project objectives are: 1) reestablish steelhead and chinook runs to Pole Creek; 2) screen downstream migrating juvenile steelhead and chinook from the irrigation diversion; and 3) increase natural production of anadromous fish in Pole Creek, consistent with IDFG (1984) Anadromous Fish Management Plan for subbasin SA-11.

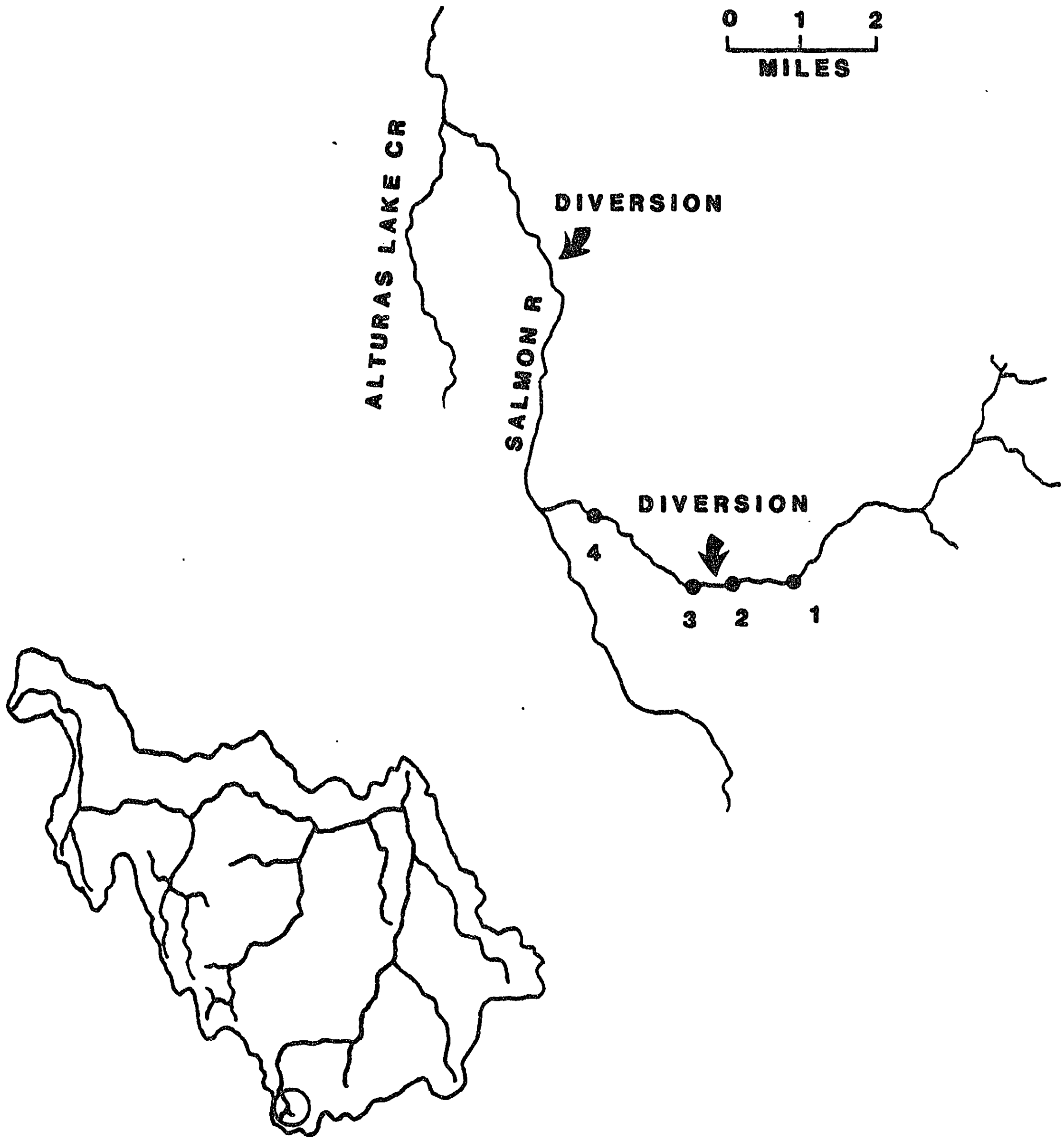



Figure 50. Location of irrigation diversion and sections sampled in Pole Creek, 1984.

Table 31. Sections sampled in Pole Creek, August 18, 1984.

| Location and section | Length (yd) | Mean width ± 2SE (yd) | Area ($yd^2$) | % habitat type: Pool | Run | Riffle | Pocket water |
|---|---|---|---|---|---|---|---|
| Above diversion | | | | | | | |
| 1 | 100 | 5.1 ± 0.4 | 511 | 43.3 | 16.7 | 40.0 | 0 |
| 2 | 100 | 5.0 ± 0.6 | 500 | 43.3 | 30.0 | 26.7 | 0 |
| Below diversion | | | | | | | |
| 3 | 100 | 5.5 ± 0.6 | 547 | 20.0 | 30.0 | 50.0 | 0 |
| 4 | 100 | 5.5 ± 0.5 | 552 | 0 | 55.6 | 44.4 | 0 |

**Table 32. Number of trout, salmon, and whitefish (number/100 $yd^2$) counted in Pole Creek sections, August 18, 1984.**

| Species, age | Above diversion 1 | Above diversion 2 | Below diversion 3 | Below diversion 4 |
|---|---|---|---|---|
| Rainbow-steelhead | | | | |
| 0 | 0 | 0 | 0 | 0 |
| | 0 | 0 | 0 | 0 |
| II | 0 | 0 | 0 | 3 (0.5) |
| ≥III | 0 | 0 | 0 | 1 (0.2) |
| Chinook | | | | |
| 0 | 0 | 0 | 207 (37.8) | 72 (13.0) |
| I+ | 0 | 0 | 1 (0.2) | 1 (0.2) |
| Brook | | | | |
| 0 | 0 | 0 | 0 | 0 |
| ≥I | 0 | 4 (0.8) | 0 | 6 (1.1) |
| Whitefish | | | | |
| 0 | 0 | 0 | 0 | 0 |
| ≥I | 0 | 0 | 1 (0.2) | 4 (0.7) |

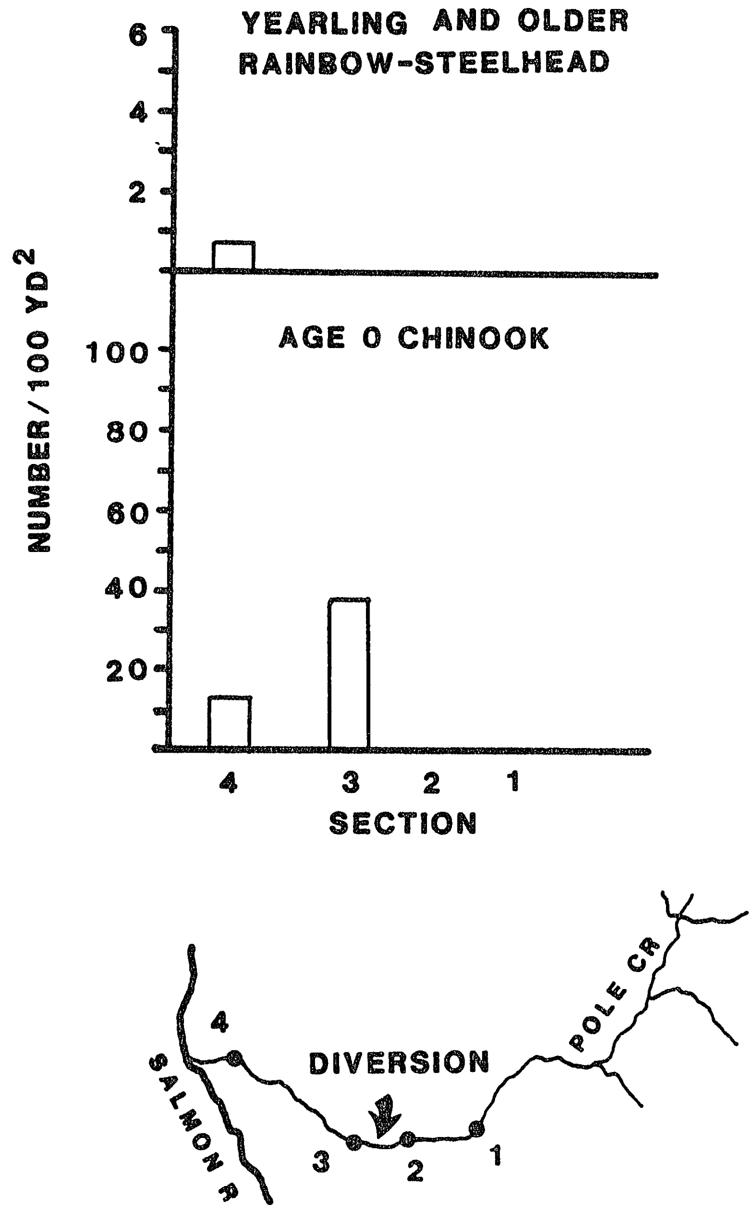



Figure 51. Distribution and densities of juvenile rainbow-steelhead and chinook in Pole Creek relative to irrigation diversion, August 18, 1984.

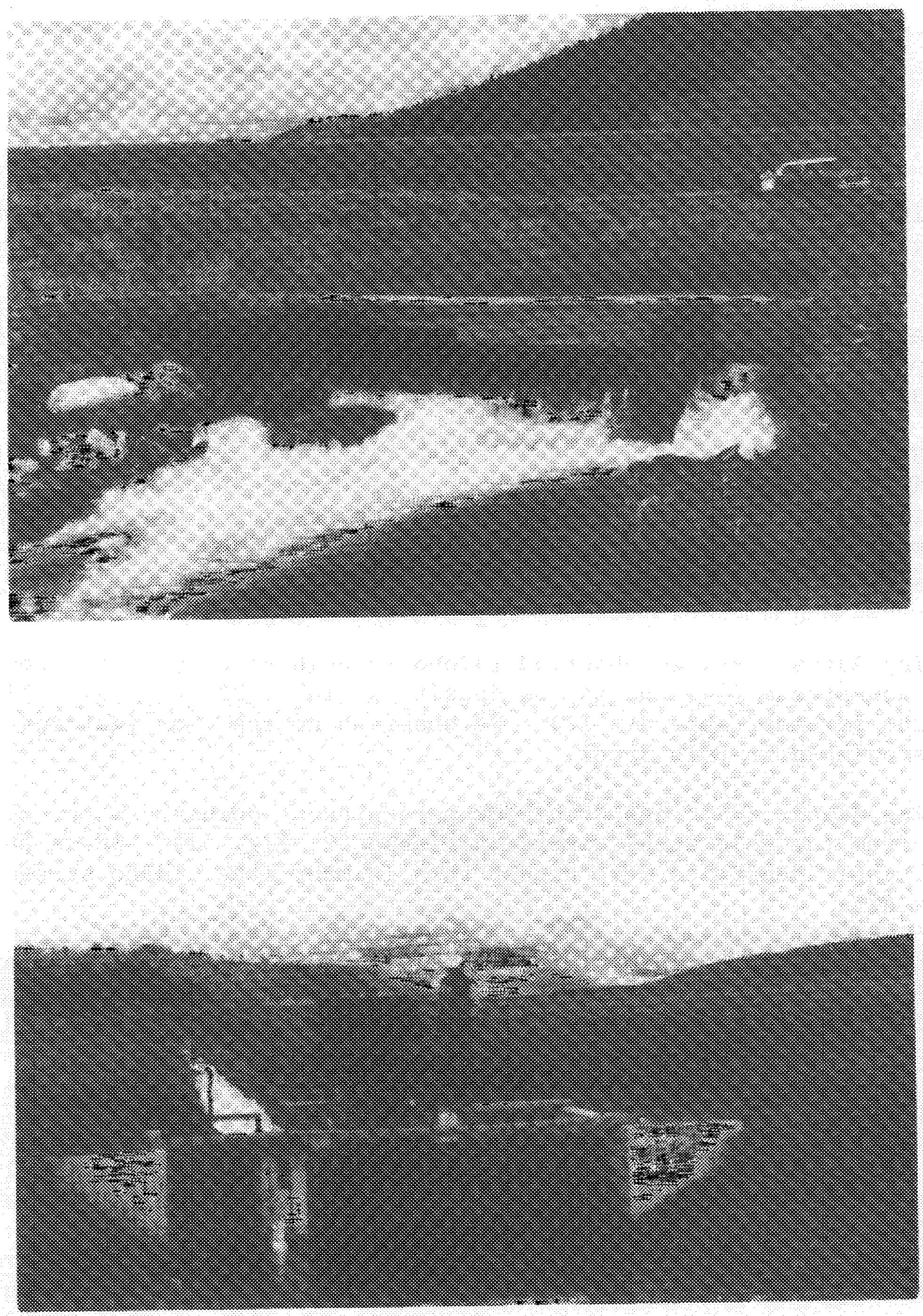


Figure 52. Diversion structure (upper photo) and BPA-funded fish screen (lower photo), Pole Creek, August 1984.

1983 Screening Project

During summer 1983 IDFG engineering personnel surveyed the diversion site and designed the screen. A single rotary drum-screen, powered by a paddle wheel, was designed for use beginning in the 1984 irrigation season. Arrangements were made with the water right holder to delay construction until after the 1983 irrigation season to avoid interference with his water supply. IDFG completed concrete work and backfilling during September 1983. The screen was first installed and operated during the 1984 irrigation season.

IDFG began evaluation of restoration of anadromous fish in Pole Creek and of the diversion screen in 1984 after the screen was in place. We sampled four sections on Pole Creek, two above and two below the diversion (Fig. SO), and inspected the diversion structure on August 18, 1984. We snorkeled sections, measured section lengths and widths (Table 31), and physical habitat, and determined fish densities by species and age group.

During August 1984 we observed rainbow-steelhead only in the section furthest downstream (4), and at low densities (Table 32; Fig. 51) relative to other Idaho streams (Appendix Al). We observed no age 0 or yearling rainbow-steelhead in Pole Creek.

During August 1984, age 0 chinook were present downstream but not upstream from the Pole Creek diversion (Table 32; Fig, 51). Where chinook occurred, their densities were higher than in many other Idaho streams in 1984 (Appendix A2).

During our inspection on August 18, 1984 irrigation water was not being withdrawn and the drum screen (Fig. 52) was not in operation. The screen should effectively prevent entrainment of all fish larger than fry which can swim through the screen.

Fish passage at the diversion structure (Fig. 52) was a problem in 1983 and 1984. Based on the lack of age 0 chinook upstream from the diversion dam in 1984, we assume that adult chinook did not pass the structure in 1983. In our judgement, adult chinook would have had problems passing the diversion in August 1984 because water was shallow below the fishway and dam. We saw no adult chinook anywhere in Pole Creek by snorkeling and no adults or redds from the air on August 21, 1984. High velocities blocked upstream movements of juvenile fish at the diversion dam. On August 18, 1984 we observed 259 age 0 chinook in the pool downstream of the dam but only brook trout in the pool upstream.

We temporarily modified the fishway at the diversion on August 18, 1984 by moving boulders and rubble to create a deeper jumping pool for adult chinook. Annual inspection of the facility to ensure proper condition for upstream passage of adults should be required.

Aquatic habitat in Pole Creek appeared to be of excellent quality for spawning and rearing by steelhead and particularly by chinook. Depths and velocities in Pole Creek sections were generally comparable to those observed in upper Salmon River sections (Fig. 53 and 45). Sand made up less than 20% of the substrate by area; embeddedness was low.

## Costs and Benefits

Costs of the Pole Creek screening projects are presented in Appendix B.

We expect large benefits to both steelhead and chinook from a restoration of anadromous fish runs to Pole Creek. Overall benefits from restoration can be measured, at full seeding, from the estimated numbers of both species rearing streamwide (Table 1). Benefits from the BPA-funded screening project alone can be estimated in future years by mark-recapture estimates of the fraction of the overall population saved from entrainment in the irrigation diversion network.

## Summary

The fish screen installed by IDFG for the 1984 irrigation season appears to be effective for all fish except fry. In 1984 the diversion dam was an impediment to upstream passage of adult chinook and juvenile steelhead and chinook. IDFG fish surveys found no evidence of anadromous fish above the diversion dam in 1984. Therefore, no benefits can be attributed to the screening project in 1984. Once the upstream passage problem is remedied, and juvenile steelhead and chinook are distributed into the area, we expect significant benefits for both species. Habitat quality in upper Pole Creek is excellent.

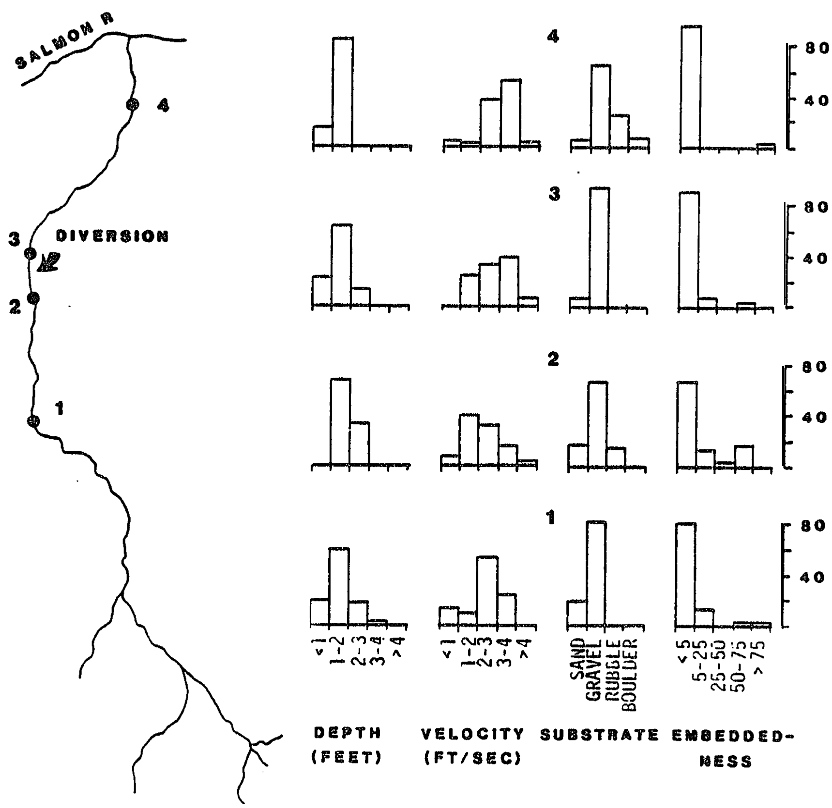



Figure 53 Summary of physical habitat measurements in Pole Creek sections, August 18, 1984.

## Recommendations

Fish densities and distributions should be monitored annually in the Pole Creek sections established in 1984. Final benefits can be estimated at full seeding by a more intensive survey. Spawning ground surveys should be initiated in Pole Creek above and below the diversion. Upstream passage problems at the diversion dam must be remedied. Steelhead should be stocked in Pole Creek in 1985. Chinook should be introduced above the diversion as allowed by fish availability.

## MIDDLE FORK SALMON RIVER

### Bear Valley Creek

Bear Valley Creek, 37-miles long, and Marsh Creek form the Middle Fork Salmon River (Fig. 54). Both streams flow from high, flat basins in the Idaho Batholith, a mountainous region with unstable, sandy soils. Bear Valley Creek lies within the Challis National Forest and is an important traditional fishing area for the Shoshone-Bannock Tribe. Bear Valley Creek has been severely degraded by sedimentation from dredge mining and heavy livestock use.

Bear Valley Creek supported a sizeable run of spring chinook before the mid-1970's. To a lesser degree summer steelhead spawned and reared in this meadow stream. Production of both species is currently depressed by low escapements.

Resident salmonids in Bear Valley Creek include rainbow trout, cutthroat trout, bull trout (Mallet 1974), and brook trout. Sculpin also inhabit Bear Valley Creek.

During 1955-59, dredge mining for placer deposits in upper Bear Valley Creek (Fig. 54) induced catastrophic sedimentation of important chinook spawning and rearing areas. The stream was diverted around the mining area through canals dug into the depositional bottom lands. Instability of canals resulted in canal breaching and channel scouring. In 1969 the major canal system was filled in and the stream was allowed to find its own channel. Sediment from the dredge mining area continues to enter Bear Valley Creek and degrade aquatic habitat downstream. Platts (1968) estimated that extensive, heavy livestock use of the meadow could be as large a source, or larger, of sedimentation to the stream.

The Shoshone-Bannock Tribe undertook a BPA-funded project in 1984 to reduce the "point-source" sedimentation from the mining area. To better define the other sedimentation problems on Bear Valley Creek and other upper basin streams of the Middle Fork and minastem Salmon River, USFS and contractors will begin to identify habitat problems in 1985, under BPA funding.

Objectives of the 1984 project were: 1) determine a feasible means to reduce sedimentation from the mining area; 2) restore anadromous fish populations in Bear Valley Creek; and 3) increase production of wild

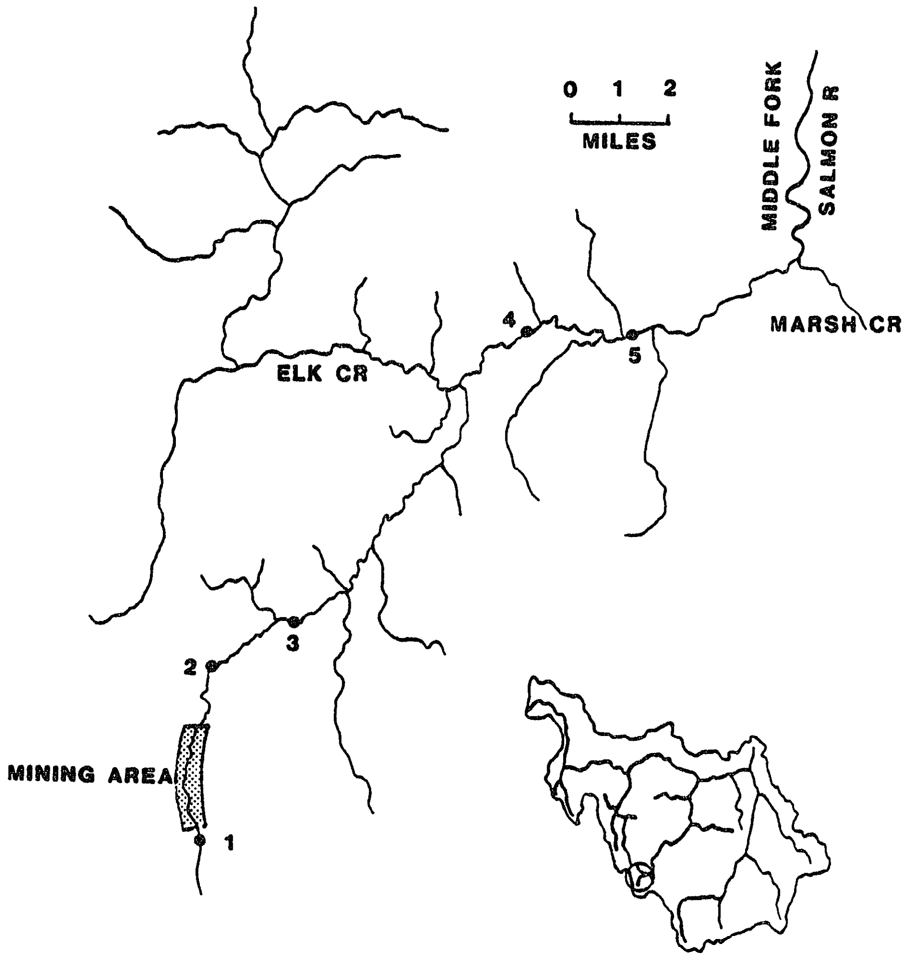



Figure 54. Sections sampled in joint Shoshone-Bannock and IDFG survey of Bear Valley Creek, 1984.

anadromous fish in Bear Valley Creek, consistent with IDFG (1984) Anadromous Fish Management Plan for subbasin SA-5.

## 1984 Project

In 1984 the Shoshone-Bannock Tribe contracted a consulting firm, James M. Montgomery Consulting Engineers, Inc., to draw up alternative solutions to reduce sedimentation from the mining operation.

Two studies were funded by BPA in Bear Valley Creek in 1984 before corrective measures were implemented on sediment reduction from the mine. The primary study was conducted by the Shoshone-Bannock Tribe. The Shoshone-Bannock Tribe and IDFG also jointly conducted a survey in 1984 to determine fish distributions and densities and to tie future habitat changes to an existing USFS data base. Tribal biologists surveyed the upper three sections (Fig. 54; Table 33) on September 5, 1984; IDFG surveyed the lower two on July 31, 1984. A USFS Intermountain Forest and Range Experiment Station team (IFRES) measured habitat conditions in Bear Valley Creek sections (Appendix C).

Densities of juvenile rainbow-steelhead in Bear Valley Creek (Table 34) were low relative to other Idaho streams sampled in 1984, but similar to other headwater streams to the Middle Fork and main Salmon River (Appendix Al). The only Bear Valley Creek section with a significant number of rainbow-steelhead fry was section 4 in Poker Meadows.

Age 0 chinook densities (Table 34) were also low in 1984 compared to other headwater streams (Appendix A2), ranging from about 1.0 to 3.9/100 $yd^2$. In August 1984 age 0 chinook primarily used side channels, backwaters, and beaver runs; few were in the main channel. The lower densities in upstream sections may have been partially the result of the late sampling date (September 5). Juvenile chinook in the Salmon River drainage typically begin to emigrate from summer rearing areas at this time of year.

## Costs and Benefits

Costs of the feasibility study to date are presented in Appendix B.

Table 33. Sections sampled in Bear Valley Creek by IDFG (sections 4 and 5), July 31, 1984 and by Shoshone-Bannock Tribe (sections 1-3), September 5, 1984.

| Section | Length (yd) | Mean width (yd) | Area ($yd^2$) |
|---|---|---|---|
| 1 | 200 | 3.8 | 762 |
| 2 | 200 | 9.2 | 1,848 |
| 3 | 200 | 9.7 | 2,128 |
| 4 | 200 | 37.2 | 7,440 |
| 5 | 200 | 34.2 | 6,847 |

Table 34. Number of trout, salmon, and whitefish (number/100 $yd^2$) counted in Bear Valley Creek sections by IDFG (sections 4 and 5), July 31, 1984 and by Shoshone-Bannock tribe (sections 1-3), September 5, 1984.

| Species, age | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| Rainbow-steelhead | | | | | |
| 0 | 0 | 0 | 2 (0.1) | 152 (2.0) | 6 (0.1) |
| I | 1 (0.1) | 0 | 0 | 3 (+) | 1 (+) |
| II | 0 | 0 | 0 | 0 | 2 (+) |
| >III | 0 | 0 | 0 | 0 | 1 (+) |
| Chinook | | | | | |
| 0 | 30 (3.9) | 13 (0.7) | 10 (0.5) | 292 (3.9) | 73 (1.1) |
| I+ | 0 | 0 | 0 | 1 (+) | 1 (+) |
| Cutthroat | | | | | |
| >I | 0 | 0 | 0 | 0 | 1 (+) |
| Brook | | | | | |
| 0 | 0 | 0 | 0 | 0 | 0 |
| >I | 1 (0.1) | 0 | 0 | 1 (+) | 0 |
| Bull | | | | | |
| 0 | 0 | 0 | 0 | 0 | 0 |
| >I | 2 (0.3) | 0 | 0 | 0 | 0 |
| Whitefish | | | | | |
| 0 | 0 | 0 | 2 (0.1) | 107 (1.4) | 73 (1.1) |
| >I | 1 (0.1) | 0 | 1 (+) | 82 (1.1) | 18 (0.3) |

We expect significant benefits primarily for chinook and secondarily for steelhead from the sediment reduction project. Benefits from the project may be difficult to estimate, however. The difficulty lies in two major areas: 1) escapements and seeding will be changing during implementation; and 2) contributions of sediment from mining, grazing, logging, and natural sources may also be changing during implementation. We believe that the degraded habitat is now underseeded by juvenile steelhead and chinook and that densities would increase with increased escapements, even without sediment reduction. We can readily measure trends in densities, escapements (for chinook only), and habitat conditions. The increase in carrying capacity due to sediment reduction resulting from the BPA project may be separable from these other trends by stratifying the stream into reaches and documenting the different responses of physical habitat and fish populations. Trends in juvenile densities measured for other headwater streams such as Sulphur Creek with parallel, increasing escapements and different sediment levels and sources should also be useful in analysis of benefits.

## Summary

A BPA-funded project to determine alternatives to reduce sedimentation from a dredge mine area to Bear Valley Creek was implemented in 1984. A joint IDFG and Shoshone-Bannock Tribe fish survey in 1984 found low densities of juvenile rainbow-steelhead and chinook. USFS measured physical habitat in sections in 1984. Major benefits should accrue from the sediment reduction project, but may be difficult to measure.

Definition of other major sources of sedimentation, including livestock grazing, will be addressed in a BPA-funded inventory of habitat problems in 1985.

## Recommendations

We will establish 24 sections on Bear Valley Creek and 30 sections on Bear Valley Creek tributaries as part of the problem-identification project in 1985. Sections established in 1984 should be incorporated into the 1985 habitat'inventory. USFS and a contractor will collect physical habitat data for the habitat inventory. The Shoshone-Bannock Tribe and IDFG will collect fish density data. Sampling in Elk Creek and other tributaries of Bear Valley

Creek should be accomplished in a manner that compliments sampling on main Bear Valley Creek.

## Elk Creek

Elk Creek, 22-miles long, is the largest tributary to Bear Valley Creek (Fig. 55). Elk Creek enters Bear Valley Creek 11 miles from the mouth. Sedimentation in Elk Creek has been increased above natural levels by logging and livestock grazing and by mass erosion in the Bearskin Creek watershed.

Elk Creek, like Bear Valley Creek, supported a substantial run of spring chinook before the mid-1970's. Summer steelhead also spawned and reared in Elk Creek. Currently, both species are at a depressed level.

Resident salmonids in Elk Creek are rainbow trout, cutthroat trout, bull trout, mountain whitefish (Mallet 1974), and brook trout. Sculpin also occur in Elk Creek.

Aquatic habitat in much of the Elk Creek drainage is degraded. Bearskin Creek and lower Elk Creek have been most affected by sedimentation, upper Elk Creek the least (Konopacky 1984). Stream banks have collapsed in reaches where livestock graze the riparian zones.

Before implementing any habitat enhancement projects in Elk Creek, USFS and contractors will begin a "problem identification" study in 1985 under BPA funding. In Elk Creek and other Middle Fork and main Salmon River tributaries, general habitat reaches will be classified and sections will be established to measure physical habitat conditions and fish densities before enhancement.

The major objective of habitat enhancement projects in Elk Creek will be to increase production of wild anadromous fish, consistent with IDFG (1984) Anadromous Fish Management Plan for subbasin SA-5.

### 1984 Survey

Before habitat enhancement measures are implemented, IDFG conducted a survey in Elk Creek in 1984. We used two previously sampled sections on Elk Creek (Table 35). The upper section in Corduroy Meadows, from the mouth of Porter Creek downstream (Fig. 55), was established outside an experimental cattle exclosure used by W. S. Platts (Intermountain Forest and Range Experiment Station, Boise, Idaho) to measure grazing impacts. The lower section had been surveyed in 1983 by Fishery Assistance Office, USFWS,

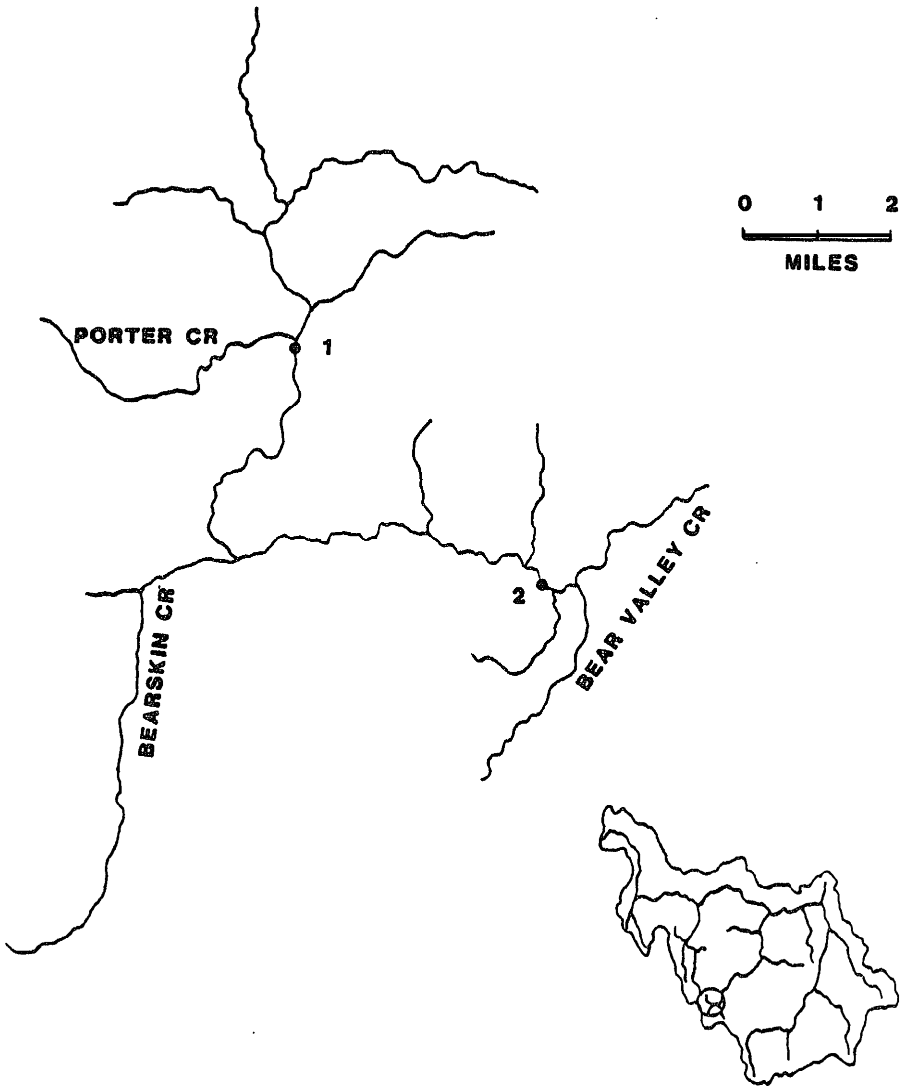



Figure 55. Sections sampled in Elk Creek, 1984.

Table 35. Sections sampled in Elk Creek, August 1, 1984.

| Section | Length (yd) | Mean width (yd) | Area ($yd^2$) |
|---|---|---|---|
| 1 | 200 | 10.6 | 2,113 |
| 2 | 200 | 18.5 | 3,697 |

Table 36. Number of trout, salmon, and whitefish (number/100 $yd^2$) counted in Elk Creek sections, August 1,1984.

| Species, age | 1 | 2 |
|---|---|---|
| Rainbow-steelhead | | |
| 0 | 1 (+) | 18 (0.5) |
| I | 0 | 0 |
| II | 0 | 1 (+) |
| ≥III | 0 | 0 |
| Chinook | | |
| 0 | 10 (0.4) | 218 (6.4) |
| I+ | 0 | 3 (0.1) |
| Cutthroat | | |
| ≥I | 0 | 1 (+) |
| Bull | | |
| 0 | 0 | 0 |
| ≥I | 0 | 1 (+) |
| Whitefish | | |
| 0 | 0 | 238 (6.4) |
| ≥I | 4 (0.2) | 79 (2.1) |

Ahsahka, Idaho. We snorkeled the sections on August 1, 1984. We measured physical habitat only for the lower section and USFS measured physical habitat on the upper section.

We observed very few juvenile rainbow-steelhead in Elk Creek sections in 1984 (Table 36; Appendix Al). A low density of fry was observed in the lower section near Bear Valley Creek; we saw only one rainbow-steelhead larger than a young-of-year.

Age 0 chinook were present at low densities in both Elk Creek sections in 1984 (Table 36). Densities in Elk Creek were generally lower than in comparable meadow streams in the headwaters of the Middle Fork Salmon River and Salmon River (Appendix A2).

Physical habitat measurements for the lower section (Fig. 56) indicate a high degree of sedimentation. We observed the upper section to be relatively less degraded than the lower, but stream bank destabilization due to grazing was evident.

## Summary

Habitat problems in Elk Creek will be identified by USFS and contractor in a BPA-funded inventory in 1985. An IDFG fish survey in 1984 found low densities of juvenile rainbow-steelhead and age 0 chinook.

## Recommendations

Elk Creek fish populations should be monitored annually until habitat enhancement projects are initiated. Twenty-eight sections will be sampled in Elk Creek as part of the problem-identification survey in 1985. Final sampling designs should be formulated after plans for habitat enhancement projects become more specific.

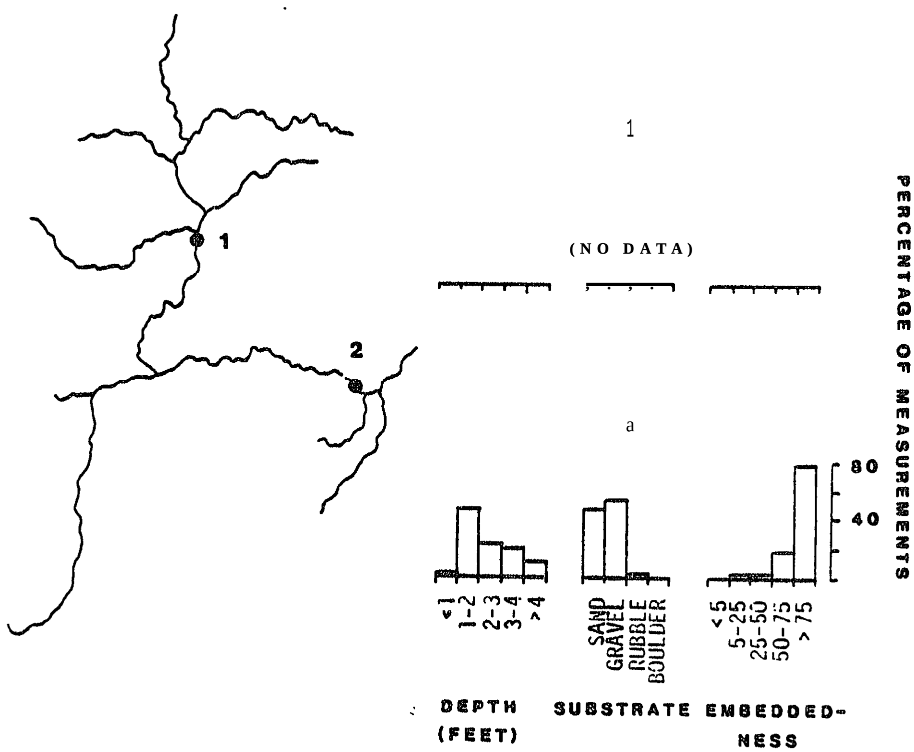



Figure 56. Summary of physical habitat measurements in Elk Creek section, August 1, 1984.

## Marsh Creek

Marsh Creek is 14.5 miles long and rises from springs in a relatively flat, high-elevation basin within the Challis National Forest. The confluence of Marsh Creek with Bear Valley Creek forms the Middle Fork Salmon River (Fig. 57), which historically is the most important producer of anadromous fish in Idaho. Habitat in Marsh Creek, while in better condition than that in Bear Valley Creek, has been degraded by livestock grazing in riparian zones.

Marsh Creek is most important as a production stream for spring chinook, secondarily for summer steelhead. Anadromous fish populations in Marsh Creek have been studied longer and more intensively than in other Middle Fork Salmon River tributaries. Juvenile rainbow-steelhead densities have been generally low in this meadow stream, ranging from 0.2 to 2.0/100 $yd^2$ in the mid-1970's (Sekulich 1980) and 0.4 to 0.9/100 $yd^2$ in 1982 (Thurow 1983). During the 1970's and 80's age 0 chinook densities have correlated strongly with the adult escapements the previous year (Fig. 58). Highest mean densities (48.0/100 $yd^2$) occurred in 1974 for Marsh Creek and its tributary Knapp Creek, following the highest chinook redd count on record since the mid-1960's (Table 37); lowest mean densities (9.7/100 $yd^2$) occurred in 1981 after the lowest redd count on record. The high positive correlation ($r=0.90$) between juvenile density and spawning escapement through this period suggests that summer carrying capacity for age 0 chinook in Marsh Creek is at least 50/100 $yd^2$. From stocking experiments in the Marsh Creek tributary Cape Horn Creek, Sekulich (1980) set the upper limit of chinook carrying capacity during summer at about 100/100 $yd^2$. Most juvenile steelhead and chinook leave the upper meadow of Marsh Creek to winter downstream. Counts of age 0 chinook emigrants at a weir located just upstream from the mouth of Cape Horn Creek are also positively correlated to redd counts and to summer densities (T. Bjornn, Idaho Cooperative Fishery Research Unit, University of Idaho, Moscow, Idaho, personal communication).

Nonanadromous salmonids in Marsh Creek include resident rainbow trout, cutthroat trout, bull trout, mountain whitefish (Mallet 1974), and brook trout. Sculpin also inhabit Marsh Creek.

Livestock grazing in riparian zones has degraded aquatic habitat throughout much of the meadow habitat in Marsh Creek and tributaries. Streambanks have become unstable and sediment loads have increased due to grazing. No specific project was planned for Marsh Creek in 1984. Habitat problems will be defined on a streamwide basis in Marsh Creek and other upper Middle Fork Salmon River and upper Salmon River tributaries during 1985 by USFS and a contractor, under BPA funding.

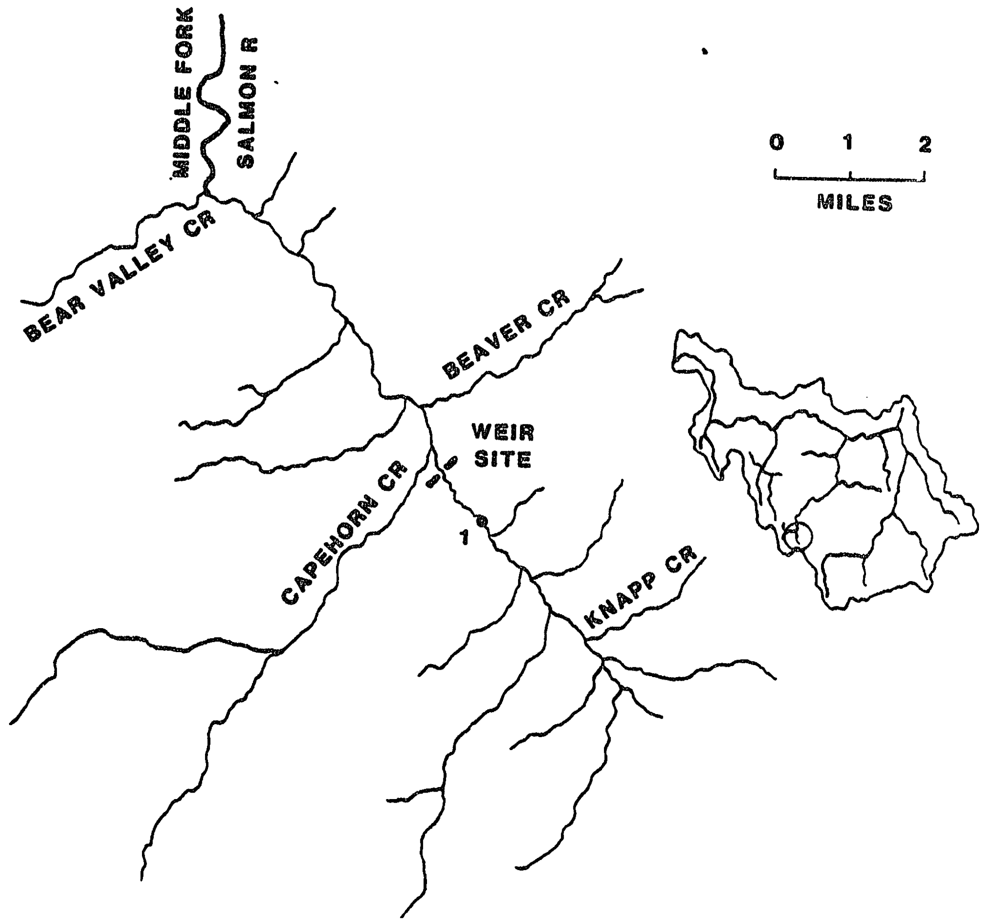



Figure 57   Section sampled in Marsh Creek, 1984

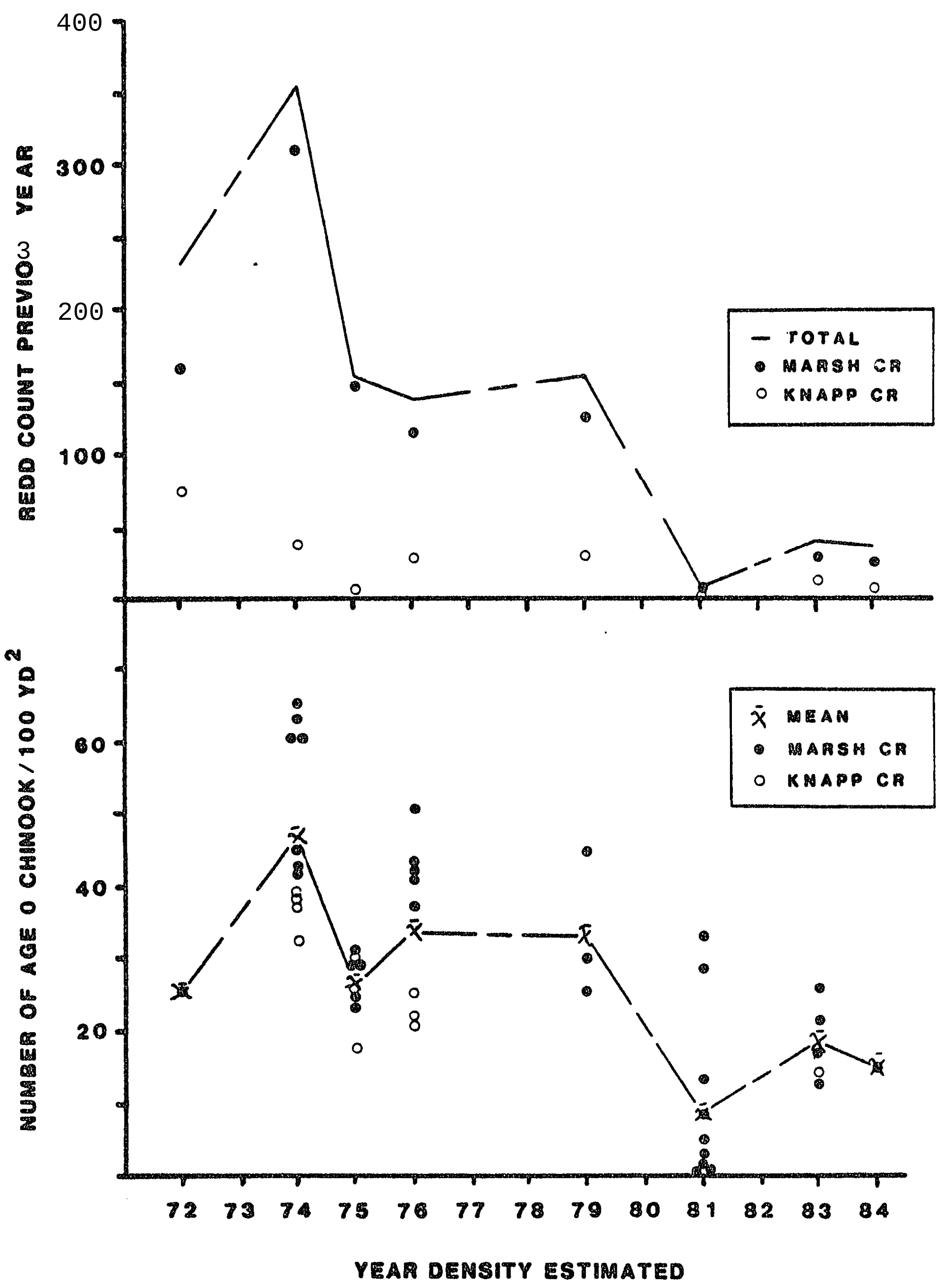



Figure 58. Relationship of age 0 chinook density to redd count the previous year, Marsh Creek and tributary Knapp Creek, 1972-84.

Table 37. Summary of age 0 chinook densities and adult redd counts, Marsh Creek, 1972-84.

| Year density estimated | Mean number age 0 chinook/100 $yd^2$ | | | Redd count previous year | | |
|---|---|---|---|---|---|---|
| | Marsh Cr | Knapp Cr | Combined | Marsh Cr | Knapp Cr | Total |
| 1972[a] | 26.5 | -- | 26.5 | 161 | 73 | 234 |
| 1974[b] | 53.6 | 36.9 | 48.0 | 314 | 37 | 351 |
| 1975[b] | 27.4 | 24.5 | 26.4 | 148 | 7 | 155 |
| 1976[b] | 39.4 | 23.1 | 34.0 | 115 | 24 | 139 |
| 1979[c] | 33.4 | -- | 33.4 | 126 | 28 | 154 |
| 1981[d] | 9.7 | -- | 9.7 | 7 | 0 | 7 |
| 1983" | 19.4 | 14.1 | 18.3 | 28 | 10 | 38 |
| 1984[f] | 15.0 | -- | 15.0 | 15 | 6 | 19 |

[a]Stuehrenberg (1975).
[b]Sekulich (1980).
[c]R. Konopacky, Shoshone-Bannock Tribe, Fort Hall, Idaho, personal communication.
[d]T. Bjornn, Idaho Cooperative Fishery Unit, University of Idaho, Moscow, Idaho, personal communication.
[e]USFWS, Fishery Assistance Office, Ahsahka, Idaho, unpublished data.
[f]Present study.

The major objective of habitat enhancement projects in Marsh Creek will be to increase production of wild anadromous fish, consistent with IDFG (1984) Anadromous Fish Management Plan for subbasin SA-5.

## 1984 Survey

Before action is taken to enhance Marsh Creek habitat, IDFG established one section on Marsh Creek (Fig. 57) in 1984 to follow future annual trends in fish density and habitat conditions. Part of this section had been sampled in 1983 by USFWS, Fishery Assistance Office, Ahsahka, Idaho. We snorkeled the section on August 21, 1984, measured section length, width, and physical habitat, and determined fish densities by species and age group.

Rainbow-steelhead density in 1984 (Table 38) was relatively low compared to other streams surveyed in Idaho (Appendix Al). Rainbow-steelhead fry were present in the section in 1984 but not in 1983.

Age 0 chinook density in Marsh Creek in 1984 (Table 38) was depressed from previous years (Fig. 58), but comparable to densities in other major rearing streams in 1984 which also have depressed escapements (eg., Sulpher Creek, South Fork Salmon River; Appendix A2).

Livestock grazing on Marsh Creek had destabilized streambanks at the section and increased sedimentation. Sedimentation was much less severe in Marsh Creek than in nearby Bear Valley Creek or Elk Creek. Sand made up 22% of the substrate by area in the section and embeddedness was fairly low (Fig. 59).

## Summary

A BPA-funded program to define habitat problems in Marsh Creek prior to implementation is scheduled for 1985. An IDFG fish survey in 1984 found relatively low densities of juvenile rainbow-steelhead and age 0 chinook. Habitat is being degraded by grazing activity.

Table 38. Number of trout, salmon, and whitefish (number/100 $yd^2$) counted in Marsh Creek section, September 11, 1983 (USFWS, unpublished data) and August 21, 1984.

| Species, age | 1983 | 1984 |
|---|---|---|
| Rainbow-steelhead | | |
| 0 | 0 | 33 (1.4) |
| I | 21 (0.9) | 10 (0.4) |
| II | 4 (0.2) | 8 (0.3) |
| 2111 | 0 | 2 (0.1) |
| Chinook | | |
| 0 | 441 (18.1) | 364 (15.0) |
| I+ | 1 (+) | 23 (1.0) |
| Cutthroat | | |
| ≥I | 0 | 2 (0.1) |
| Brook | | |
| 0 | 0 | 21 (0.9) |
| ≥I | 38 (1.6) | 37 (1.5) |
| Whitefish | | |
| 0 | 19 (0.8) | 6 (0.2) |
| ≥I | 2 (0.1) | 27 (1.1) |

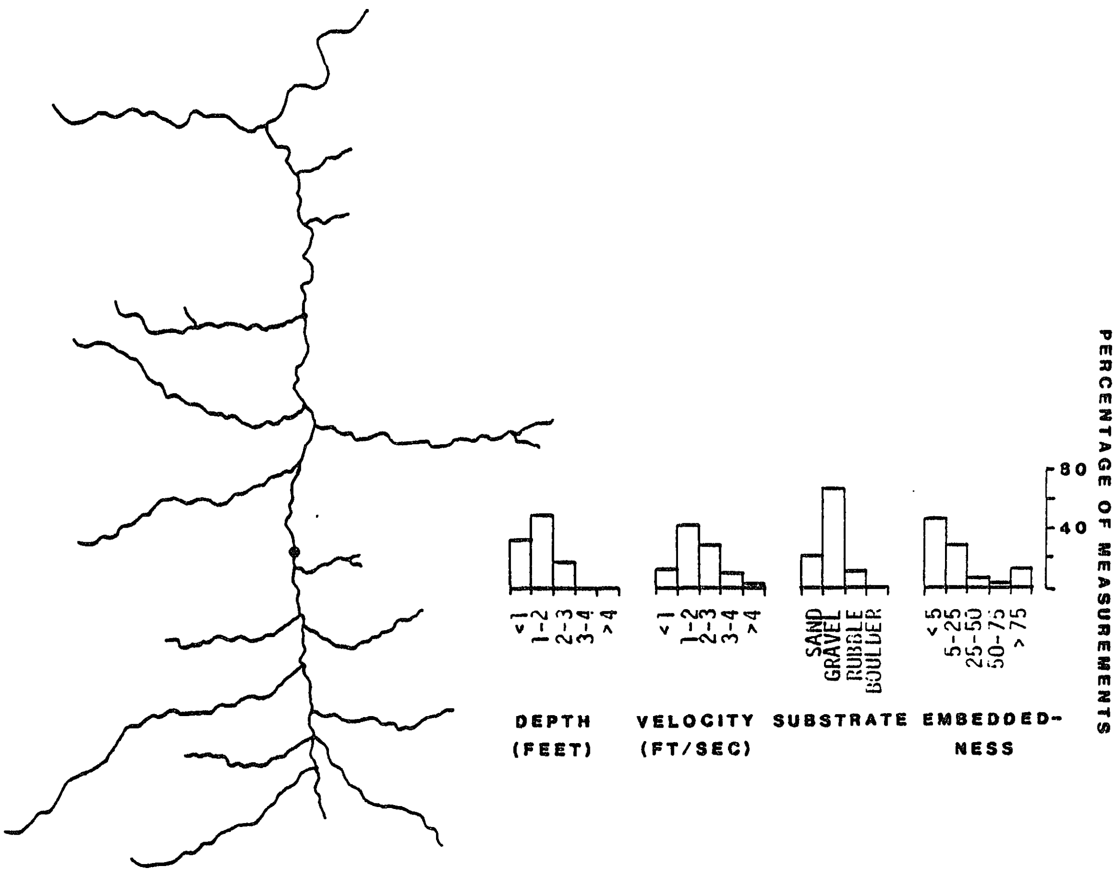



Figure 59. Summary of physical habitat measurements in Marsh Creek section, August 21, 1984.

## Recommendations

Fish populations in Marsh Creek should be monitored until habitat enhancement projects are implemented. We will establish 16 sections in Marsh Creek and 26 sections in Marsh Creek tributaries as part of the problem-identification project in 1985. Final sampling designs should be formulated as plans for habitat enhancement become more specific.

# Sulphur Creek

Sulphur Creek is 19 miles long and enters the Middle Fork Salmon River 94 miles from the mouth (Fig. 60). Sulphur Creek lies entirely within the Frank Church River of No Return Wilderness Area and is accessible only by trail or by an airstrip at Parker Ranch. Most of the meadow habitat in Sulpher Creek is essentially pristine.

Spring chinook and summer steelhead runs in Sulphur Creek have gone through the same declines seen in other Idaho streams; in the reach established to count chinook redds, no redds or adult chinook were seen in 1984. These downward trends in Sulphur Creek reflect the escapement problems associated with migration mortality on the Columbia and lower Snake Rivers and overfishing more clearly than in streams with obvious habitat problems.

Nonanadromous salmonids reported in Sulphur Creek are rainbow trout, cutthroat trout, and mountain whitefish (Mallet 1974). Apparently, brook trout have not become established (Simpson and Wallace 1978).

No BPA-funded projects are slated for Sulphur Creek. However, its high-quality habitat and the established chinook spawning ground counts make Sulphur Creek a good "control" stream for comparison with other, degraded Middle Fork and upper Salmon River tributary streams which will have BPA projects.

## 1984 Survey

In 1984 IDFG established one section in Sulphur Creek near the landing strip at Parker Ranch (Fig. 59). We snorkeled the section on July 24, 1984. Other than determining section length (245 yd) and mean width (11 yd), we did not measure physical habitat in 1984.

No juvenile rainbow-steelhead were observed in the Sulphur Creek in 1984 (Table 39).

Age 0 chinook density (Table 39) in Sulphur Creek was low compared to similar streams in the headwaters of the Middle Fork Salmon River and Salmon River. Age 0 chinook primarily used side channels, backwaters, and beaver runs; few were in the main channel in late July.

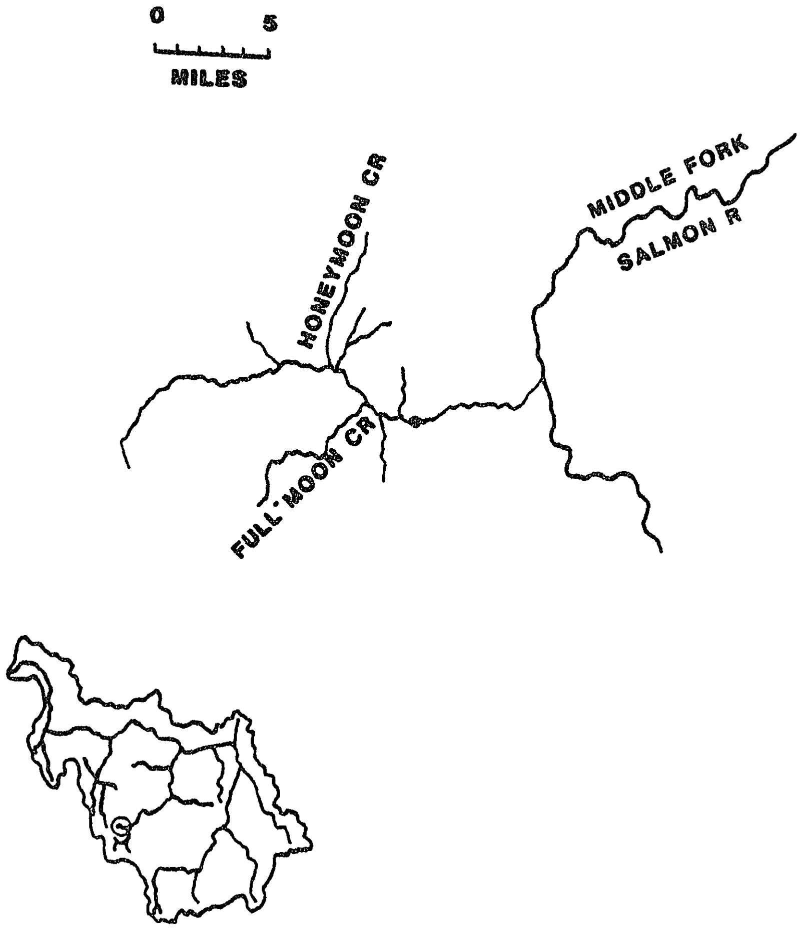



Figure 60. Section sampled in Sulphur Creek, 1984.

Table 39. Number of trout, salmon, and whitefish (number/100 $yd^2$) counted in Sulphur Creek section, July 24, 1984.

| Species, age | 1 |
|---|---|
| Rainbow-steelhead | |
| 0 | 0 |
| I | 0 |
| II | 0 |
| ≥III | 0 |
| Chinook | |
| 0 | 207 (7.7) |
| I+ | 0 |
| Cutthroat | |
| ≥I | 3 (0.1) |

## Summary

No BPA project is planned for Sulphur Creek. IDFG established one section on Sulphur Creek in 1984 to serve as a control for BPA projects on degraded streams. A 1984 fish survey by IDFG found no juvenile rainbow-steelhead and a low density ($7.7/100\ yd^2$) of age 0 chinook.

## Recommendations

Another section should be established in Sulphur Creek and both should be surveyed annually to determine trends in juvenile density. Physical habitat should be measured in both sections.

## Camas Creek

Camas Creek, 38-miles long, is a major tributary to the Middle Fork Salmon River, entering the Middle Fork 35 miles above its mouth (Fig. 61). Compared to the infertile upper Middle Fork and Salmon River tributaries of the batholith, Camas Creek is moderately productive in terms of water chemistry. Camas Creek in its lower 12 miles flows through a steep canyon; the stream in the upper section has less gradient and more meanders. Road access is limited to Meyers Cove in the upper section. Past agricultural practices at Meyers Cove have degraded and destabilized aquatic habitat. Presently this area is managed by USFS.

Camas Creek supported sizable summer steelhead and chinook runs before the 1970's. Gebhards (1959) estimated that the potential capacity of the stream exceeded 5 ,200 chinook females. Both steelhead and chinook spawn and rear in the mainstem and tributaries. The stream at Meyers Cove is an important spawning area for both species.

Resident salmonids in Camas Creek include rainbow trout, cutthroat trout, bull trout, and mountain whitefish (Mallet 1974).

Habitat quality of Camas Creek at Meyers Cove has been reduced by past land management and the influence of runoff events. Intensive agricultural use, including crop production, livestock grazing, and irrigation, has negatively influenced channel stability. Natural flow events compounded and further intensified unstable conditions (B. May, USFS, Salmon, Idaho, personal communication).

No BPA-funded activities were planned for Camas Creek in 1984. A potential USFS project at Meyers Cove will be in the feasibility stage through 1985. The potential project's objective would be: 1) improve riparian and instream conditions in the area to increase steelhead and chinook spawning and rearing potential; and 2) increase production of wild anadromous fish, consistant with IDFG (1984) Anadromous Fish Management Plan for subbasin SA-5.

### 1984 Sampling

Before any projects are implemented, IDFG surveyed fish populations in Camas Creek at Meyers Cove in 1984. We established two sections, one of which had been sampled by Fishery Assistance Office, USFWS, Ahsahka, Idaho, in 1983.

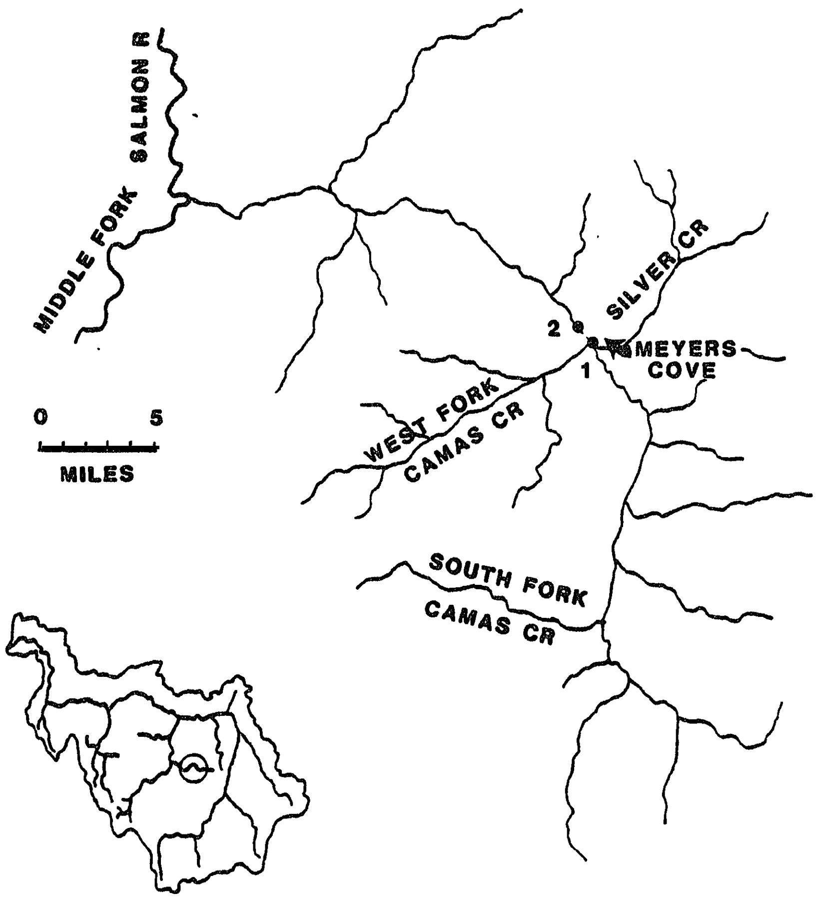



Figure 61. Sections sampled in Camas Creek, 1984.

On August 16, 1984 we snorkeled the two sections. Visibility was limited by a milky-blue tint to the water. Aside from determining section lengths and widths (Table 40), we did not measure physical habitat in 1984.

Densities of juvenile rainbow-steelhead in Camas Creek were low relative to other streams surveyed in 1984 (Table 41; Appendix Al). We observed a higher density of fry and age II rainbow-steelhead in 1984 than in 1983 (Table 42).

Densities of age 0 chinook were also relatively low in Camas Creek (Table 41; Appendix A2). Fewer juvenile chinook were observed in 1984 than in 1983 (Table 42). Four adult chinook and three chinook redds were observed in section 1 on August 16, 1984.

## Costs and Benefits

BPA funds have been spent only on feasibility studies in Camas Creek through 1984 (Appendix B).

Benefits from habitat enhancement at Meyers Cove will probably be difficult to define. Annual trends in habitat conditions can be determined readily. However, visibility is marginal for snorkeling observations in Camas Creek. Of all streams surveyed in 1984, we have the least confidence of our snorkeling counts in Camas Creek because of limited visibility. Because snorkeling counts can be expected to be highly variable, any potential increases in density due to habitat enhancement may have to be large before they could be detected. Because of its large size, Camas Creek does not lend itself easily to other methods of population estimation such as electrofishing. Control sections for the Meyers Cove project area could be established upstream or in Loon Creek which has similar physical characteristics and water chemistry.

## Summary

A BPA-funded project has been proposed for Camas Creek at Meyers Cove to improve riparian and instream conditions to increase spawning and rearing conditions for steelhead and chinook. In 1984 juvenile rainbow-steelhead and chinook densities were low. Visibility was a problem during the snorkeling

Table 40. Sections sampled in Camas Creek, August 16, 1984.

| Section | Length (yd) | Mean width ± 2SE (yd) | Area ($yd^2$) |
|---|---|---|---|
| 1 | 240 | 19.0 ± 4.2 | 4,563 |
| 2 | 100 | 14.2 ± 1.7 | 1,419 |

Table 41. Number of trout, salmon, and whitefish (number/100 $yd^2$) counted in Camas Creek sections, August 16, 1984.

| Species, age | 1 | 2 |
|---|---|---|
| Rainbow-steelhead | | |
| 0 | 51 (1.1) | 12 (0.8) |
| I | 8 (0.2) | 16 (1.1) |
| II | 24 (0.5) | 3 (0.2) |
| 2111 | 1 (+) | 0 |
| Chinook | | |
| 0 | 30 (0.7) | 15 (1.1) |
| I+ | 2 (+) | 0 |
| Cutthroat | | |
| >I | 3 (0.1) | 0 |
| Brook | | |
| 0 | 0 | 0 |
| >I | 1 (+) | 1 (0.1) |
| Whitefish | | |
| 0 | 3 (0.1) | 0 |
| >I | 1 (+) . | 0 |

Table 42. Number of trout, salmon, and whitefish (number/100 $yd^2$) counted in Camas Creek section 1, September 9, 1983 (USFWS, unpublished data) and August 16, 1984.

| Species, age | 1983 | 1984 |
|---|---|---|
| Rainbow-steelhead | | |
| 0 | 20 (0.4) | 51 (1.1) |
| I | 6 (0.2) | 8 (0.2) |
| II | 6 (0.2) | 24 (0.5) |
| >III | 2 (+) | 1 (+) |
| Chinook | | |
| 0 | 90 (2.1) | 30 (0.7) |
| I+ | 0 | 2 (+) |
| Cutthroat | | |
| >I | 0 | 3 (0.1) |
| Bull | | |
| 0 | 0 | 0 |
| >I | 2 (+) | 1 (+) |
| Whitefish | | |
| 0 | 6 (0.2) | 3 (0.1) |
| >I | 7 (0.2) | 1 (+) |

survey, and benefits from habitat enhancement at Meyers Cove could be difficult to define.

## Recommendations

Sections established in 1984 should be snorkeled annually if a BPA project is implemented. Control sections need to be established, either upstream in Camas Creek or in a similar., modeately productive stream such as Loon Creek.

# SOUTH FORK SALMON RIVER

## Mainstem South Fork Salmon River

The South Fork Salmon River is a major tributary which enters the Salmon River at river mile 133 (Fig. 62). The South Fork Salmon River contains about 183 miles of stream available to anadromous fish in a 1,270-$mi^2$ watershed. The fragile, steep slopes of the watershed are primarily granitic bedrock. Mass erosion in the South Fork drainage began to occur during the 1950's following soil disturbances from logging and road construction (Platts and Megahan 1975). Major storm events in 1962, 1964, and 1965 accelerated erosion rates tremendously, particularly from logging roads.

Erosion severely affected runs of summer steelhead and summer chinook in the South Fork Salmon River (Platts and Partridge 1978). The summer chinook run, historically Idaho's largest salmon run, began to decline before migration mortality at Columbia and Snake River dams reduced other stocks in the 1970's (Fig. 63). During the early 1970's (1971, 72, and 74), when escapements were only about 20% of earlier levels, age 0 chinook densities in South Fork tributaries ranged from about 1 to 34/100 yd2 (Platts and Partridge 1978). A further reduction in adult chinook returns occurred in 1974 which paralleled declines in other Idaho production streams. Since 1980 IDFG has trapped adult chinook for spawn-taking, and reared juveniles at McCall Hatchery for' their release back into the South Fork as smolts. Sockeye salmon reportedly once used the drainage but have not been seen during extensive spawning ground surveys since I.955 (Mallet 1974).

Nonanadromous salmonids native to the South Fork Salmon River drainage include cutthroat trout, bull trout, and mountain whitefish (Platts and Megahan 1975). Brook trout have become established widely throughout the drainage. Sculpin, dace, and sucker also inhabit the drainage.

Habitat conditions in the South Fork Salmon River improved steadily since sediment production from surface erosion declined and sediment was transported from the system (Platts and Megahan 1975). Largely responsible for the decreasing erosion rates was a moratorium placed on logging and road construction in the mid-1960's. However, another mass erosion event occured on August 30, 1984.

No BPA-funded habitat enhancement project was planned for the South Fork Salmon River in 1984. The established spawning ground surveys for summer

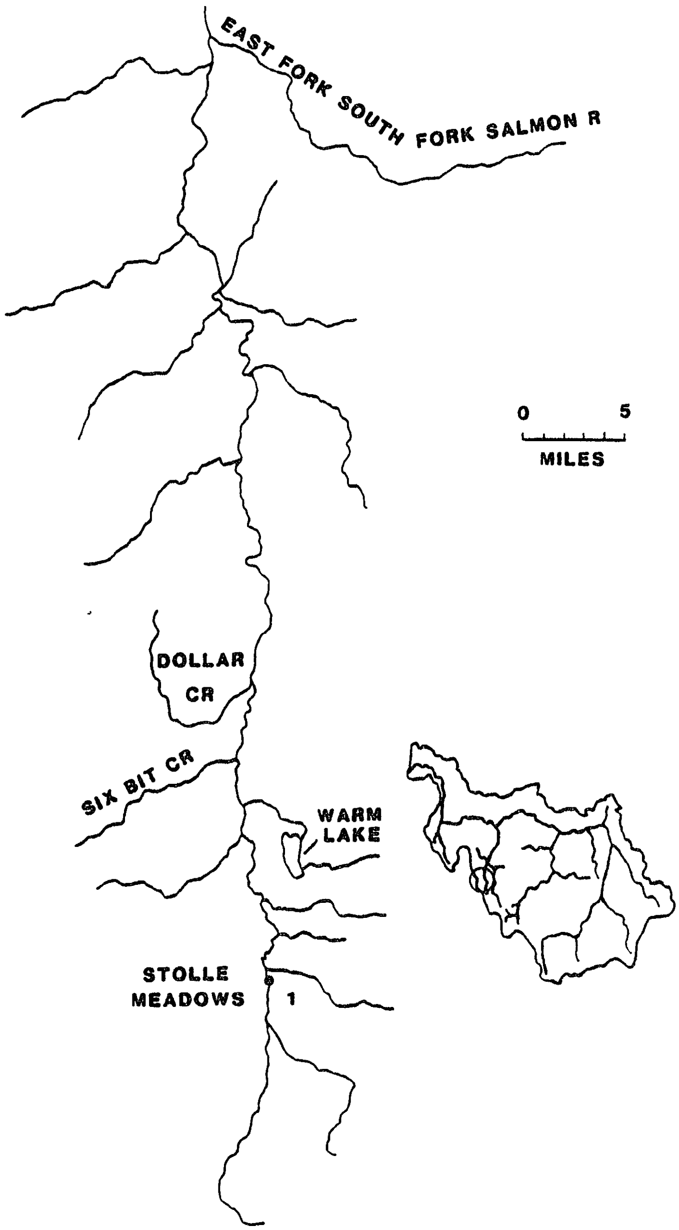



Figure 62. Section sampled in upper South Fork Salmon River, 1984.

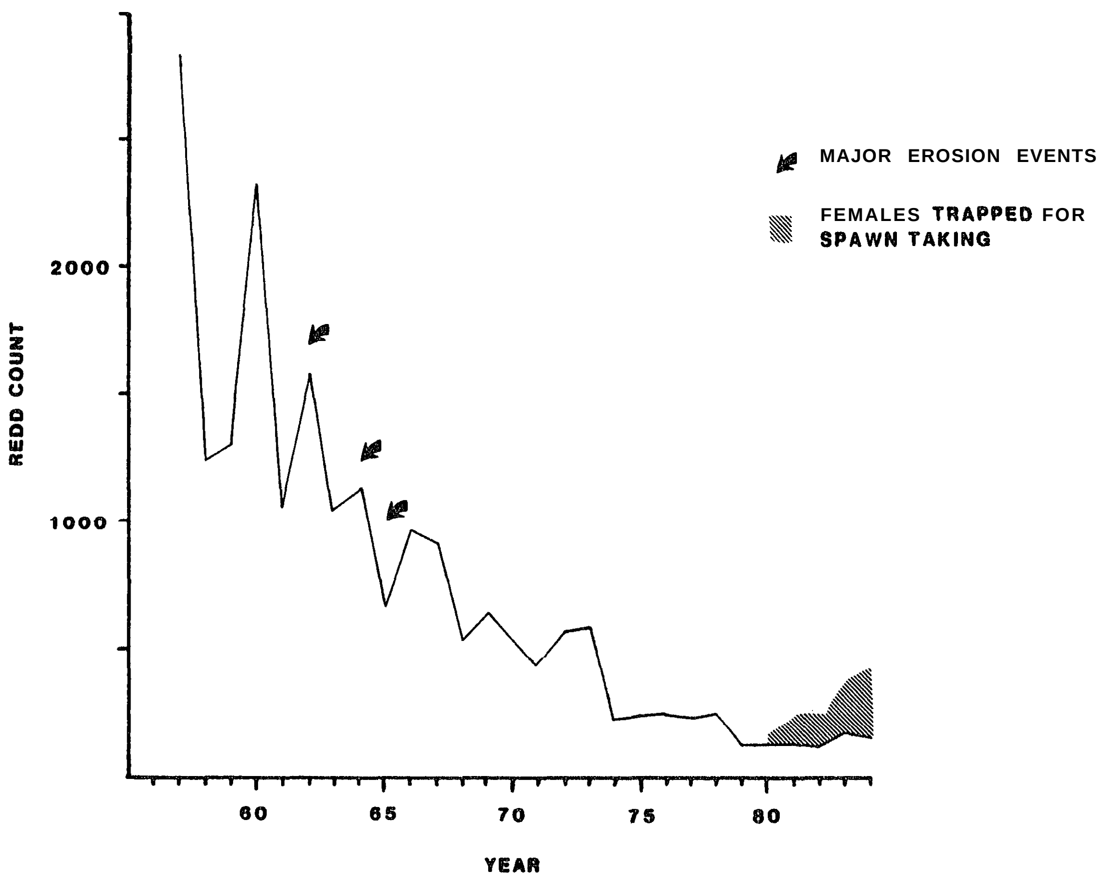



Figure 63. Summer chinook redd counts in established trend area, South Fork Salmon River, 1957-84.

chinook and ongoing studies of sedimentation by USFS make the upper portions of the South Fork a good "control" stream for comparison with other streams for which BPA projects are planned.

## 1984 Survey

In 1984 IDFG established one section on the South Fork Salmon River at Stolle Meadows (Fig. 62); downstream sections were also sampled in 1984 for a study of steelhead status in the South Fork drainage (pers. comm. R. Thurow, IDFG, McCall). The section at Stolle Meadows, 200-yards long, was established upstream from an exclosure used by USFS to measure grazing impacts on aquatic habitat and monitor sediment levels. We snorkeled the section on August 29, 1984; no habitat measurements were taken.

Few (0.1/100 yd2) juvenile rainbow-steelhead were observed in the section in 1984 (Table 43; Appendix Al).

Age 0 chinook were present at low densities (12.2/100 yd2; Table 43), similar to those of depressed stocks in other Idaho streams in 1984 (Appendix A2).

## Summary

No BPA project is currently planned for the Stolle Meadows reach of South Fork Salmon River. IDFG established one section at Stolle Meadows in 1984 to serve as a control for BPA projects on other streams. A 1984 IDFG fish survey found low densities of juvenile rainbow-steelhead and age 0 chinook.

## Recommendations

At least one more section should be established on South Fork Salmon River in 1985. Sections should be surveyed annually to determine trends in juvenile densities. Downstream sections surveyed in 1984 by Thurow (IDFG, McCall, Idaho) could be incorporated into the monitoring program.

Table 43. Number of trout, salmon, and whitefish (number/100 yd2) counted in Stolle Meadows section, South Fork Salmon River, August 29, 1984.

| Species, age | 1 |
|---|---|
| Rainbow-steelhead | |
| 0 | 0 |
| I | 4 (0.2) |
| II | 0 |
| 2111 | 0 |
| Chinook | |
| 0 | 196 (12.2) |
| I+ | 7 (0.4) |
| Bull | |
| 0 | 0 |
| >I | 1 (+) |
| Whitefish | |
| 0 | 11 (0.7) |
| >I | 20 (1.2) |

## Johnson Creek

Johnson Creek is 38-miles long and enters the East Fork of the South Fork Salmon River 14 miles from the mouth (Fig. 64). Johnson Creek flows through the Idaho batholith. The steep slopes of the watershed are extremely vulnerable to erosion from land disturbing activities. However, the Johnson Creek watershed has been less disturbed than many other parts of the South Fork Salmon River drainage. Gradient in the lower 28 miles of Johnson Creek alternates between moderate and steep. The headwaters is in a flat, high-elevation basin containing about 20 miles of high-quality spawning and rearing habitat. A series of three barriers (numbers 2-4) downstream from the mouth of Trout Creek and another barrier (number 1) between Halfway Creek and Ditch Creek (Fig. 64) prevent adult chinook from seeding this habitat in most years. All barriers were caused by natural rock slides combined with high stream gradient, and consisted of large boulders that had fallen into the stream.

Johnson Creek supports runs of summer steelhead and summer chinook. Adult steelhead apparently can pass these barriers during high flows. Adult chinook are blocked from the upper drainage during low flows of late summer. In most years chinook spawning and rearing is restricted to the lower end of Johnson Creek. Known passage by adult chinook to the upper meadow consist of seine samples of juvenile chinook near Rock Creek in 1976 (Holubetz, unpublished data) and observations of a single chinook redd near Rock Creek in 1983 (D. Corley, USFS, Boise, Idaho, personal communication) and five chinook redds in the upper meadow in 1960 (M. Richards, IDFG, Boise, Idaho, personal communication).

Resident salmonids of Johnson Creek include rainbow trout, bull trout, brook trout; mountain whitefish (Mallet 1974), and cutthroat trout. Brook trout dominate 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 minstem of Johnson Creek and some of the upper tributaries (eg., Sand Creek, Whiskey Creek, and lower Rock Creek), but few timber sales have occured in the upper basin. Livestock grazing has degraded riparian habitat in parts of the upper meadow of Johnson Creek. Condition of aquatic habitat appears to be comparable to that in existing chinook production streams of the headwaters of the Middle Fork and mainstem Salmon Rivers.

Objectives of the BPA-funded project in Johnson Creek are: 1) modify the natural barriers to allow passage by adult chinook into the upper basin; 2)

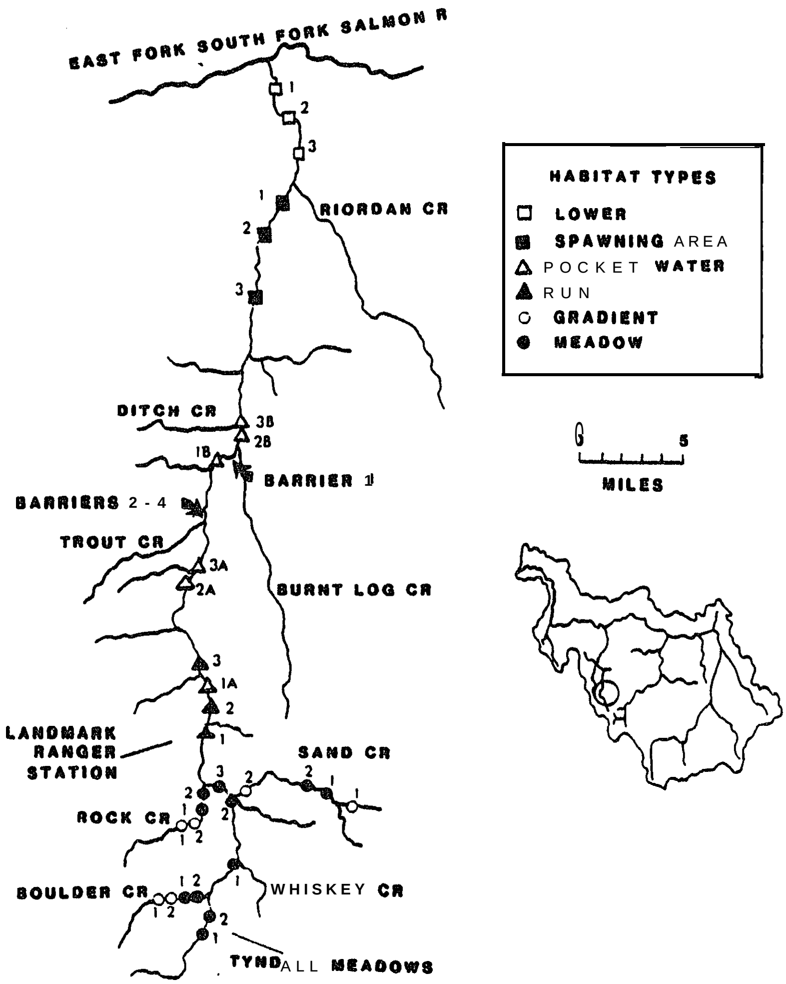



Figure 64. Sections sampled in Johnson Creek, 1984.

establish summer chinook in habitat made available by the barrier removal project; and 3) increase natural production of anadromous fish, consistent with IDFG (1984) Anadromous Fish Management Plan for subbasin SA-3.

## 1984 Barrier Removal

The Johnson Creek barrier removal project was planned for late-August or September 1984. Problems with completing the Environmental Assessment delayed IDFG action on the project until October 1984.

During October 15-20, 1984 IDFG personnel and a consulting fisheries engineer modified the barriers. Individual rocks were selectively drilled and blasted to create lower overpours, deeper jumping pools, and escape avenues above the falls (Fisher 1984). Ice and snow during this period caused some of the 1984 work to be extremely difficult.

Barrier 1 (Fig. 65) consisted of two falls about 4 feet in height with no jumping pool in between. It was caused by large rounded boulders being wedged together and creating thin overpours over the boulders. The stream was spread out over several falls with none providing adequate water for fish passage. Corrective drilling and blasting concentrated half the flow in the area of the blasts with the falls being reduced to two 2-foot falls with an adequate jumping pool between them.

Barrier 2 (Fig. 66) was at the base of a large active rock slide area downstream from the mouth of Trout Creek confluence in a steep-walled canyon. The barrier consisted of a large rock fall that created an island at low flow with half the flow on each side of the boulder island. Falls were about 8-feet high with inadequate jumping pools below. Corrective measures concentrated all flow to the left bank and created a 2.5-foot and a 3-foot falls with a jumping pool in between.

Barrier 3 (Fig. 67) was about 150 yards upstream of barrier 2. The stream was split into two 7-foot falls with most flow on the left bank. The falls on the right was modified to provide a series of small cataracts and pools that is expected to pass adult fish. The left bank falls was lowered by about one foot and an escape pool was provided at the top of the falls.

Barrier 4 (Fig. 68), just below the mouth of Trout Creek, was rendered inaccessible by ice covered boulders. This barrier was not a total passage block. Ice and cold weather prevented any work on this falls in October 1984.

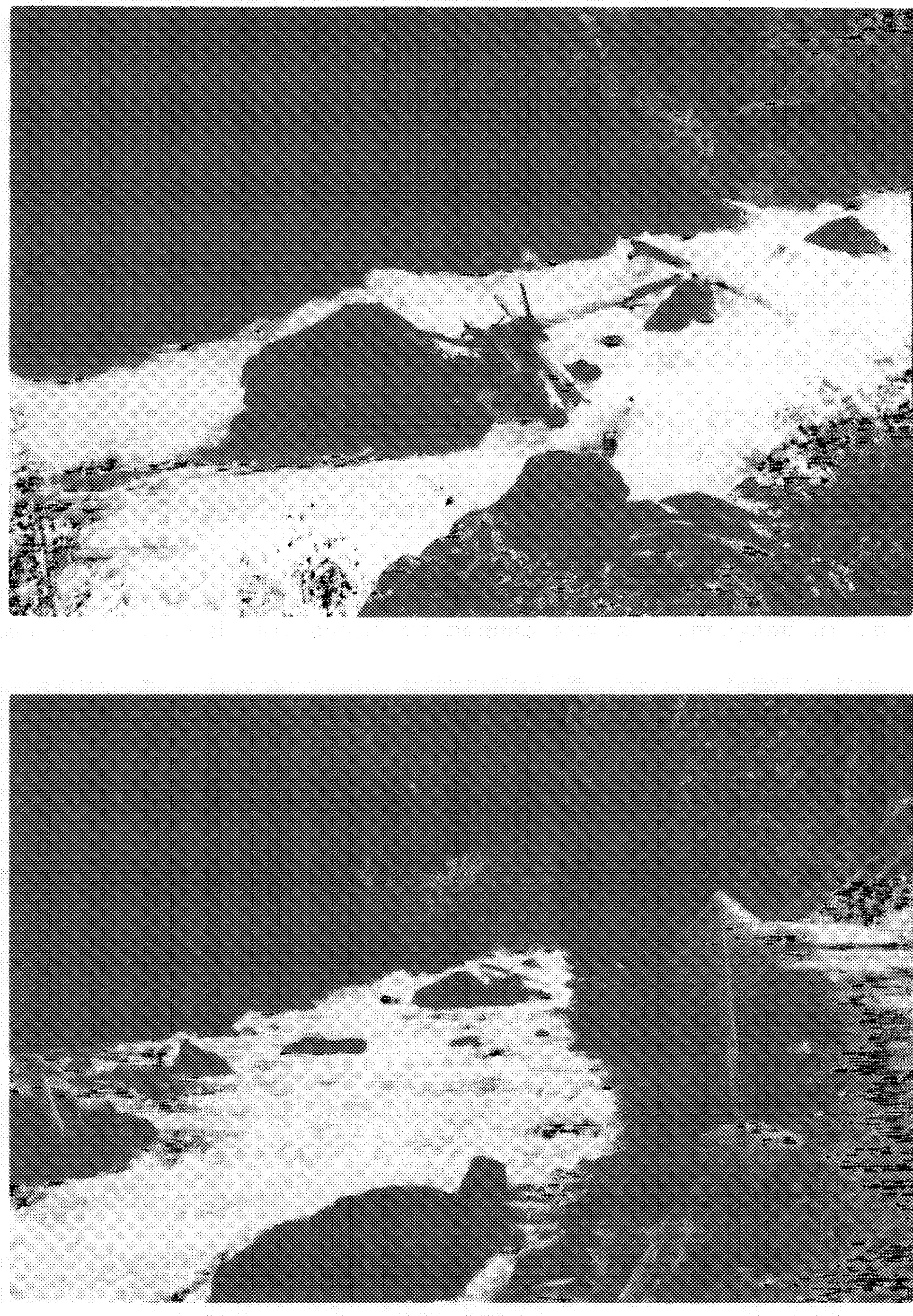
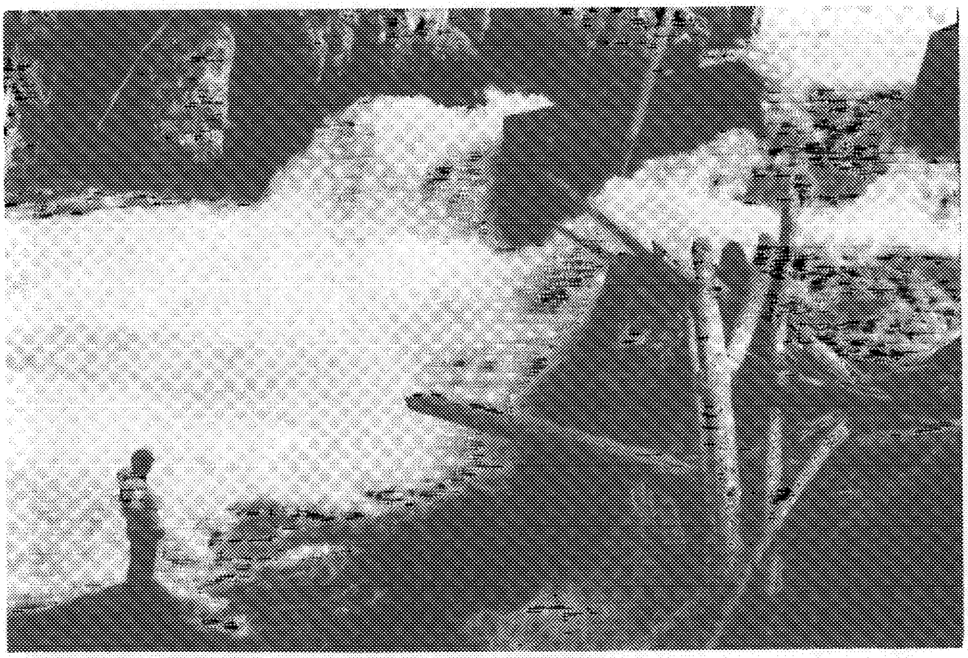


Figure 65   Barrier 1 on Johnson Creek at high flow in June 1984.



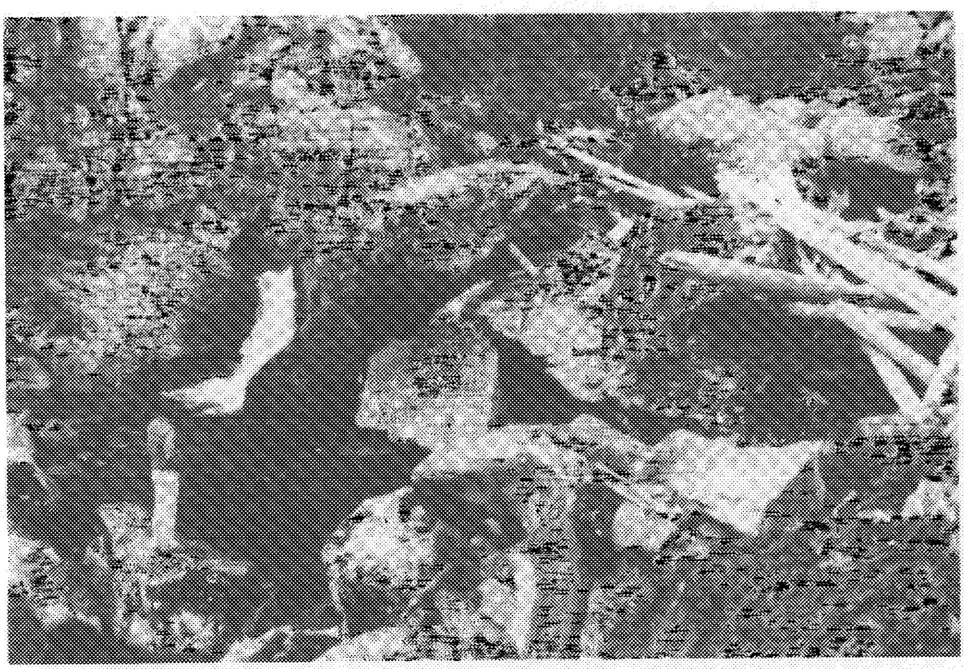
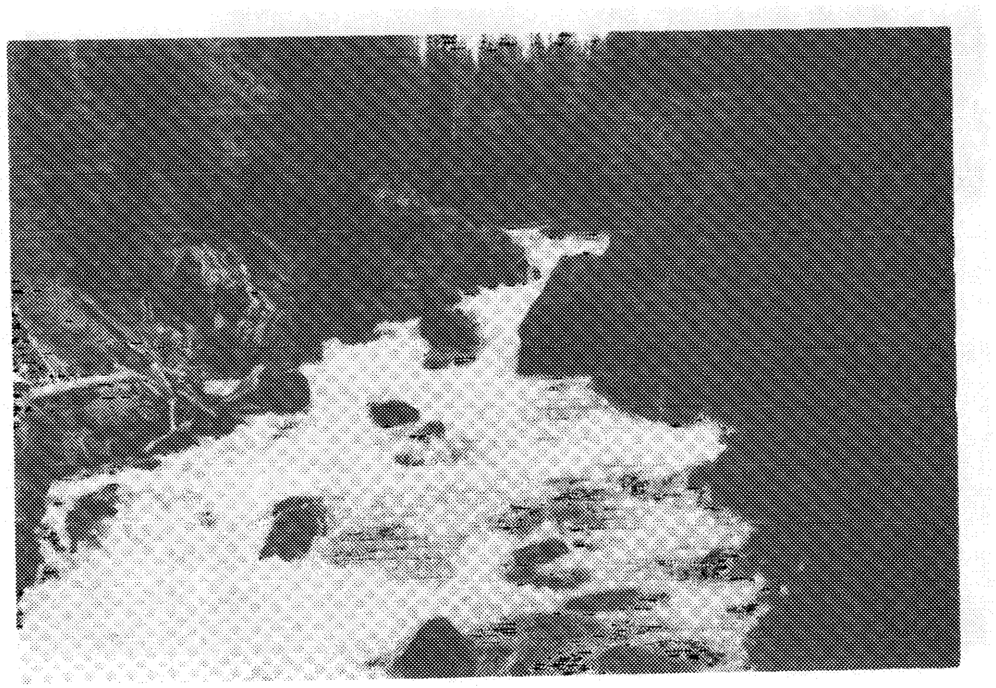


Figure 66. Barrier 2 on Johnson Creek at high flow in June 1984 (upper photo) and at low flow in September 1984 (lower photo).



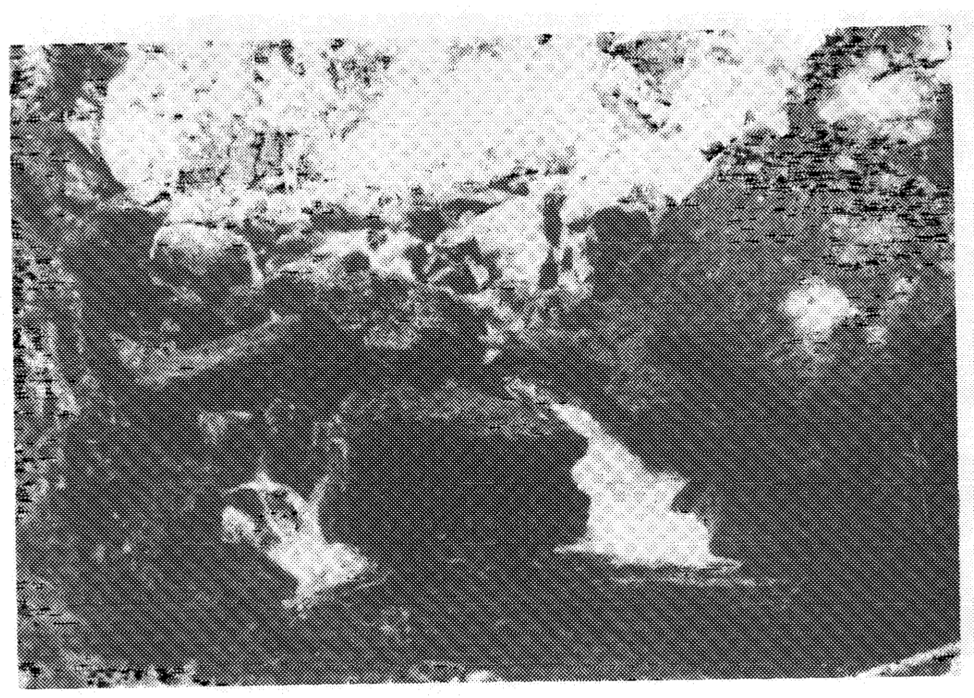


Figure 67. Barrier 3 on Johnson Creek at high flow in June 1984 (upper photo) and at low flow in September 1984 (lower photo).

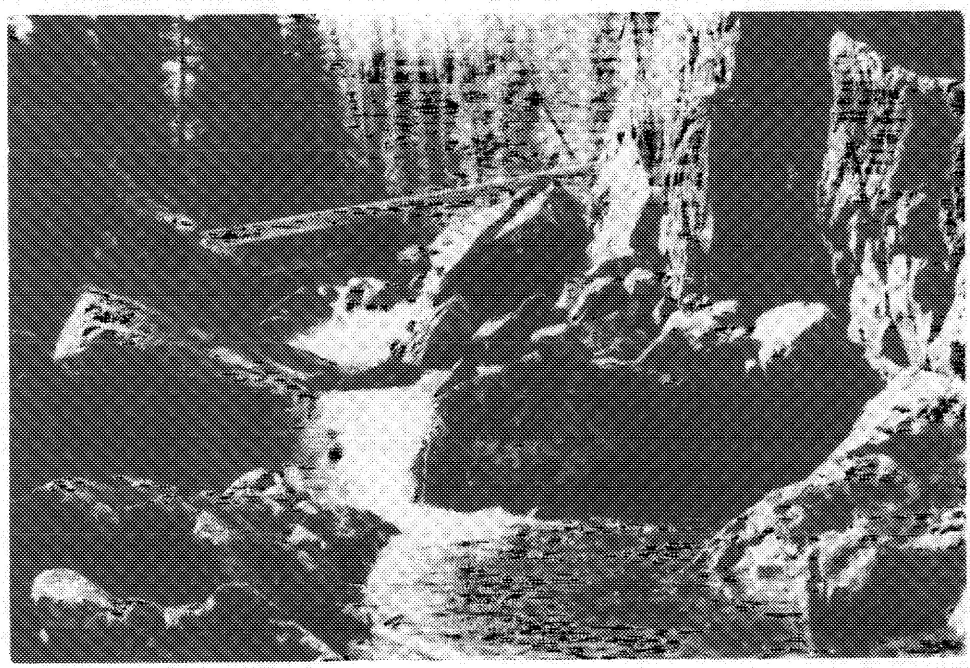


Figure 68. Barrier 4 on Johnson Creek at low flow in September 1984.

Upstream passage by adult chinook may be possible after the 1984 barrier removal depending on effects of high flow on rock removed. The barriers will require periodic inspections to assure continued passage by anadromous fish.

IDFG evaluation of the barrier removal project on Johnson Creek began as a pre-treatment survey of fish distributions and densities and habitat in 1984. We selected sections according to major habitat type. For the upper basin, we distinguished between meandering meadow habitat and habitat with moderate gradient (Fig. 64). For Johnson Creek between the upper basin and barriers 2-4 we identified moderate-gradient run habitat and steeper-gradient pocket water. Below barriers 2-4 to Ditch Creek we identified only pocket water habitat. Below Ditch Creek, sampling was done by Thurow (IDFG, McCall, Idaho) as part of a survey of steelhead in the South Fork Salmon River; major habitat types identified were the primary spawning area and the lower reach of stream.

We selected at least two sections of each available habitat type throughout most of Johnson Creek (Fig. 64). We snorkeled the sections during July 25-27, 1984. We measured section lengths, widths, (Tables 44, 45), and physical habitat.

Juvenile rainbow-steelhead were present above and below the barriers (Tables 46, 47). Their densities in the upper basin sections were lower than in other Idaho streams in 1984 (Appendix Al). Relatively higher densities of juvenile rainbow-steelhead were observed in the higher gradient sections both above and below the barriers.

Age 0 chinook were not observed above the barriers in 1984 (Tables 46, 47). Juvenile chinook were observed only in lower sections of Johnson Creek in the primary spawning area. Densities in the lower sections were comparable to densities of spring chinook in the Middle Fork Salmon River tributaries in 1984 (Appendix A2).

Quality of habitat varied considerably among locations in Johnson Creek drainage in 1984. The upper basin contains much high-quality rearing habitat for juvenile chinook. However, both "meadow" sections and "gradient" sections in the headwaters of Johnson Creek (Tyndall Meadows and above Whiskey Creek) and in Boulder Creek contained high levels of sediment (Fig. 69). Sand was less prevalent and embeddedness was lower in the Johnson Creek reach between Whiskey Creek and Landmark Ranger Station and in Sand Creek and Rock Creek. Both of these tributaries had abundant, clean spawning gravels. We saw little potential spawning habitat in "pocket water" or "run" sections between Landmark Ranger Station and Ditch Creek confluence but this reach does provide good rearing potential for juvenile steelhead and chinook.

Table 44. Sections sampled in Johnson Creek, July 25-27, 1984.

| Location and section | Length (yd) | Mean width ± 2SE (yd) | Area ($yd^2$) | % habitat type | | | |
|---|---|---|---|---|---|---|---|
| | | | | Pool | Run | Riffle | Pocket water |
| Headwaters | | | | | | | |
| Tyndall 1 | 100 | 4.7 ± 0.4 | 472 | 100 | 0 | 0 | 0 |
| Tyndall 2 | 100 | 5.5 ± 1.0 | 554 | 100 | 0 | 0 | 0 |
| Above barriers | | | | | | | |
| Meadow 1 | 100 | 8.0 ± 2.0 | 799 | 70.0 | 0 | 30.0 | 0 |
| Meadow 2 | 100 | 7.5 ± 1.3 | 753 | 30.0 | 60.0 | 10.0 | 0 |
| Meadow 3 | 200 | 9.5 ± 2.1 | 1,892 | 0 | 73.3 | 26.7 | 0 |
| Run 1 | 140 | 13.3 ± 1.0 | 1,862 | 0 | 90.5 | 0 | 9.5 |
| Run 2 | 67 | 14.8 ± 2.4 | 987 | 0 | 0 | 0 | 100 |
| Run 3 | 47 | 17.6 ± 6.2 | 823 | 46.7 | 46.7 | 6.7 | 0 |
| PW 1A | 100 | 19.0 ± 1.4 | 1,900 | 0 | 0 | 0 | 100 |
| PW 2A | 74 | 14.4 ± 1.2 | 1,066 | 0 | 0 | 0 | 100 |
| PW 3A | 54 | 11.1 ± 1.1 | 599 | 0 | 0 | 0 | 100 |
| Below barriers | | | | | | | |
| PW 1B | 43 | 17.7 ± 3.5 | 766 | 52.4 | 0 | 23.8 | 23.8 |
| PW 2B | 56 | 14.3 ± 1.0 | 811 | 0 | 0 | 0 | 100 |
| PW 3B | 163 | 12.4 ± 1.3 | 2,025 | 22.2 | 0 | 8.3 | 69.4 |
| Spawn area 1 | 100 | 30.5 ± 1.7 | 3,050 | -- | -- | a- | -- |
| Spawn area 2 | 129 | 32.6 ± 3.5 | 4,202 | -- | -- | -- | -- |
| Spawn area 3 | 91 | 26.3 ± 3.9 | 2,393 | -- | -- | -- | -- |
| Lower 1 | 83 | 21.4 ± 1.6 | 1,768 | a- | -- | -- | -- |
| Lower 2 | 87 | 23.7 ± 0.8 | 2,052 | -- | -- | -- | -- |
| Lower 3 | 80 | 23.4 ± 2.5 | 1,879 | -- | -- | -- | -- |

Table 45. Sections sampled in Johnson Creek tributaries, July 25-27, 1984.

| Stream and section | Length (yd) | Mean width ± 2SE (yd) | Area ($yd^2$) | % habitat type | | | |
|---|---|---|---|---|---|---|---|
| | | | | Pool | Run | Riffle | Pocket water |
| Boulder Creek | | | | | | | |
| Gradient 1 | 93 | 4.9 ± 0.5 | 454 | 10.0 | 50.0 | 40.0 | 0 |
| Gradient 2 | 97 | 4.6 ± 1.0 | 449 | 16.7 | 43.3 | 30.0 | 10.0 |
| Meadow 1 | 100 | 4.1 ± 0.6 | 412 | 30.0 | 70.0 | 0 | 0 |
| Meadow 2 | 100 | 4.5 ± 0.7 | 446 | 23.3 | 76.7 | 0 | 0 |
| Rock Creek | | | | | | | |
| Gradient 1 | 100 | 3.4 ± 0.6 | 339 | 16.7 | 20.0 | 33.3 | 30.0 |
| Gradient 2 | 100 | 4.1 ± 0.7 | 409 | 0 | 43.3 | 0 | 56.7 |
| Meadow 1 | 100 | 4.5 ± 0.8 | 446 | 80.0 | 20.0 | 0 | 0 |
| Meadow 2 | 100 | 4.9 ± 0.7 | 492 | 90.0 | 10.0 | 0 | 0 |
| Sand Creek | | | | | | | |
| Gradient 1 | 100 | 4.8 ± 0.6 | 481 | 10.0 | 33.3 | 13.3 | 43.3 |
| Gradient 2 | 100 | 7.0 ± 1.3 | 704 | 20.0 | 50.0 | 13.3 | 16.7 |
| Meadow 1 | 100 | 4.9 ± 0.7 | 490 | 50.0 | 50.0 | 0 | 0 |
| Meadow 2 | 100 | 4.8 ± 0.7 | 476 | 80.0 | 20.0 | 0 | 0 |

Table 46. Number of trout, salmon, and whitefish (number/100 yd²) counted in Johnson Creek sections above and below barriers, July 25-27, 1984.

| Species, age | Above barriers | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Tyndall Meadow | | Meadow | | | Run | | | Pocket water | | |
| | 1 | 2 | 1 | 2 | 3 | 1 | 2 | 3 | 1A | 2A | 3A |
| Rainbow-steelhead | | | | | | | | | | | |
| | | 0 | | | 0 | | | | 0 | 0 | 0 |
| 0 | 0 | 0 | 3 (0.4) | 1 (0.1) | 10 (0.5) | 0 (+) | 3 (0.3) | 0 | 0 | 37 (3.5) | 23 (3.8) |
| II | 0 | 0 | 1 (0.1) | 1 (0.1) | 3 (0.2) | 0 | 6 (0.6) | 2 (0.2) | 8 (0.4) | | 14 (2.3) |
| ≥III | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 24 (2.3) | 4 (0.7) |
| | | | | | | | | | | 3 (0.3) | |
| Chinook | | | | | | | | | | | |
| | 0 | | | | | 0 | | | 0 | | 0 |
| 0+ | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Cutthroat | | | | | | | | | | | |
| ≥I | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 (0.1) | 1 (0.1) | 0 |
| Brook | | | | | | | | | | | |
| 0 | 79 (16.7) | 3 (0.5) | 43 (5.41 | 22 (2.9) | 3 (0.2) | 15 (0.8) | 0 | 0 | 0 | 0 | 0 |
| ≥I | 36 (7.6) | 14 (2.5) | 35 (4.4) | 54 (7.2) | 47 (2.5) | 19 (1.0) | 6 (0.6) | 1 (0.1) | 4 (0.2) | 8 (0.8) | 0 |
| Bull | | | | | | | | | | | |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| ≥I | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Whitefish | | | | | | | | | | | |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| ≥I | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Table 46. continued.

| Species, age | Below barriers | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Pocket water | | | Spawning area | | | Lower | | |
| | 1B | 2B | 3B | 1 | 2 | 3 | 1 | 2 | 3 |
| Rainbow-steelhead | | | | | | | | | |
| | | | | | | | 0 | | |
| 0 | 3 (0.41 | 0 | 1 (+) | 0 | 0 | 0[a] | 19 | P[a] | 0 |
| II | 21 (2.3) | 9 (1.1) | 26 (1.3) | 0 | 0 | 0 | 21 (1.2) | 33 (1.6) | 26 (1.4) |
| | | | 25 (1.2) | 0 | | | | | 17 (0.9) |
| ≥III | 0 | 0 | 3 (0.1) | 0 | 0 | 0 | 1 (0.1) | 4 (0.2) | 2 (0.1) |
| Chinook | | | | | | | | | |
| | | | 0 | | | | | | |
| 0 | 0 | 0 | 0 | 570 (1.9) | 62 (1.5) | 09 (0.4) | 71 (0.4) | 168 2 (8.2) | 12; (6.8) |
| I+ | 0 | 0 | | | 0 | | (0.1) | (0.1) | (0.1) |
| Cutthroat | | | | | | | | | |
| ≥I | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 (0.1) |
| Brook | | | | | | | | | |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| ≥I | 0 | 0 | 1 (+) | 0 | 0 | 0 | 0 | 0 | 0 |
| Bull | | | | | | | | | |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| ≥I | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 (0.1) | 0 |
| Whitefish | | | | | | | | | |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| ≥I | 0 | 2 (0.2) | 5 (0.21 | 32 (1.0) | 26 (0.6) | 3 (0.1) | 8 (0.5) | 9 (0.4) | 10 (0.5) |

[a] Present, abundance not estimated.

Table 47. Number of trout, salmon, and whitefish (number/100 yd²) counted in Johnson Creek tributary sections, July 25-27, 1984.

| Species, age | Boulder Creek | | | | Rock Creek | | | | Sand Creek | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Gradient | | Meadow | | Gradient | | Meadow | | Gradient | | Meadow | |
| | | 2 | | 2 | 1 | 2 | 1 | 2 | 1 | 2 | | 2 |
| Rainbow-steelhead[a] | | | | | | | | | | | | |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 ([illegible]) | 0 | 0 |
| I | 0 | 1 (0.2) | 0 | 0 | 0 | 1 (0.2) | 0 | 0 | 2 (0.4) | 8 ([illegible]) | 0 | 0 |
| II | 0 | 1 (0.2) | 0 | 0 | 0 | 1 (0.2) | 0 | 0 | 2 (0.4) | 3 (0.3) | 0 | 0 |
| ≥III | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Chinook | | | | | | | | | | | | |
| 0 | 0 | 0 | 3 | 5 | 0 | 0 | 0 | 0 | 0 | 3 | 3 | 0 |
| I+ | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Brook | | | | | | | | | | | | |
| 0 | 0 | 0 | 3 (0.7) | 24 (5.4) | 0 | 0 | 280(62.8) | 270(56.3) | 0 | 10 (1.4) | 0 | 0 |
| ≥I | 0 | 4 (0.9) | 3 (0.7) | 4 (0.9) | 5 (1.5) | 19 (4.6) | 66(14.8) | 70(14.2) | 35 (7.3) | 38 (5.4) | 29 (5.9) | 2 (0.4) |
| Whitefish | | | | | | | | | | | | |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| ≥I | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

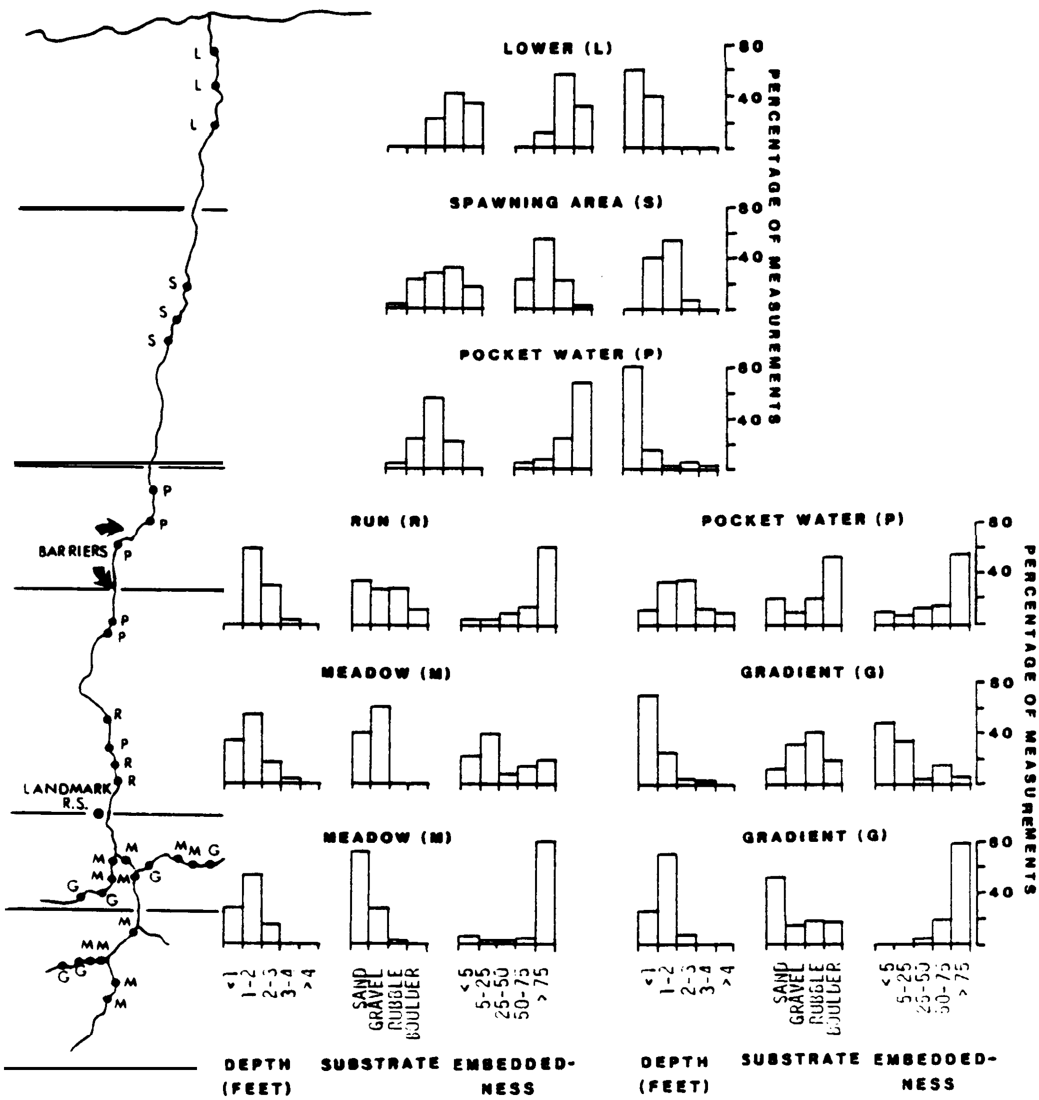



Figure 69. Summary of physical habitat measurements in Johnson Creek sections, July 25-27, 1984.

Significant benefits will occur for summer chinook from the Johnson Creek barrier removal project. Adequate spawning habitat exists in the upper basin, particularly Sand Creek and Rock Creek, to naturally seed at least part of the system above Landmark Ranger Station. Where sediment levels are high (Johnson Creek at Tyndall Meadows and Boulder Creek), supplementation with hatchery fish may be required to fully seed habitat.

Initial stocking of the upper basin with hatchery-reared summer chinook (South Fork Salmon River stock) will be required to establish a run. Chinook fry may be available for this purpose in 1985. Highest priority should be given to stocking Sand Creek because of its low sediment levels and relatively small population of brook trout. Habitat in Rock Creek is similar in quality but competition and predation from the dense brook trout population might reduce survival of stocked juvenile chinook.

## Costs and Benefits

Project costs of barrier removal are presented in Appendix B.

We expect significant benefits for summer chinook from the barrier removal project. Final benefits can be determined from estimated standing crops of juvenile chinook, at full seeding (Table 1). We have no evidence at this time that the barriers restricted steelhead passage.

## Summary

In 1984 IDFG modified natural rock barriers which had blocked passage of adult summer chinook into upper Johnson Creek and tributaries. An IDFG fish survey in 1984 before the barrier removal project was implemented found juvenile rainbow-steelhead above and below the barriers and age 0 chinook only below the barriers. Highest quality habitat observed in the upper basin was in tributaries Sand Creek and Rock Creek. Highest priority should be given to stocking Sand Creek.

## Recommendations

Annual sampling of Johnson Creek trend sections should be initiated in the first year that juvenile summer chinook are available for stocking and continued until full seeding is reached. Chinook spawning ground survey reaches should be established in the upper basin after adult chinook return from the introductions. Barriers should be inspected annually to assure continued passage by adult chinook. Every effort should be made to stock upper Johnson Creek with summer chinook juveniles in the summer of 1985.

# LITTLE SALMON RIVER

## Boulder Creek

Boulder Creek, 16-miles long, enters the Little Salmon River at river mile 16 (Fig. 70). About four miles above the mouth of Boulder Creek, a 9-foot-high natural rock falls partially blocks upstream passage by adult chinook.

Boulder Creek presently supports spawning and rearing of summer steelhead and spring chinook. Steelhead apparently can pass the falls but chinook cannot pass the falls every year. Habitat in the 12 miles above the barrier is relatively high quality and would support considerable numbers of juvenile chinook.

Nonanadromous salmonids present in Boulder Creek include rainbow trout, bull trout, brook trout, and mountain whitefish (Mallet 1974).

A BPA-funded project is planned for 1985 to modify the falls to allow passage of adult chinook under all flow conditions. This IDFG project would use explosives to lower the height of the falls by removing portions of the solid granite sill to provide a "stairstepping" of two drops of about 4 to 5 feet with adequate jumping pools below each drop.

Objectives of the project are: 1) provide assured access for chinook to the upper 12 miles of Boulder Creek; and 2) increase natural production of chinook, consistant with IDFG (1984) Anadromous Fish Management Plan for subbasin SA-1.

### 1984 Survey

In 1984 IDFG sampled sections of Boulder Creek above and below the barrier before the project was initiated. We established 2 sections above and 3 sections below the barrier (Fig. 70) and snorkeled the sections on August 28, 1984. Other than determining section length and width (Table 48), we did not measure physical habitat in 1984.

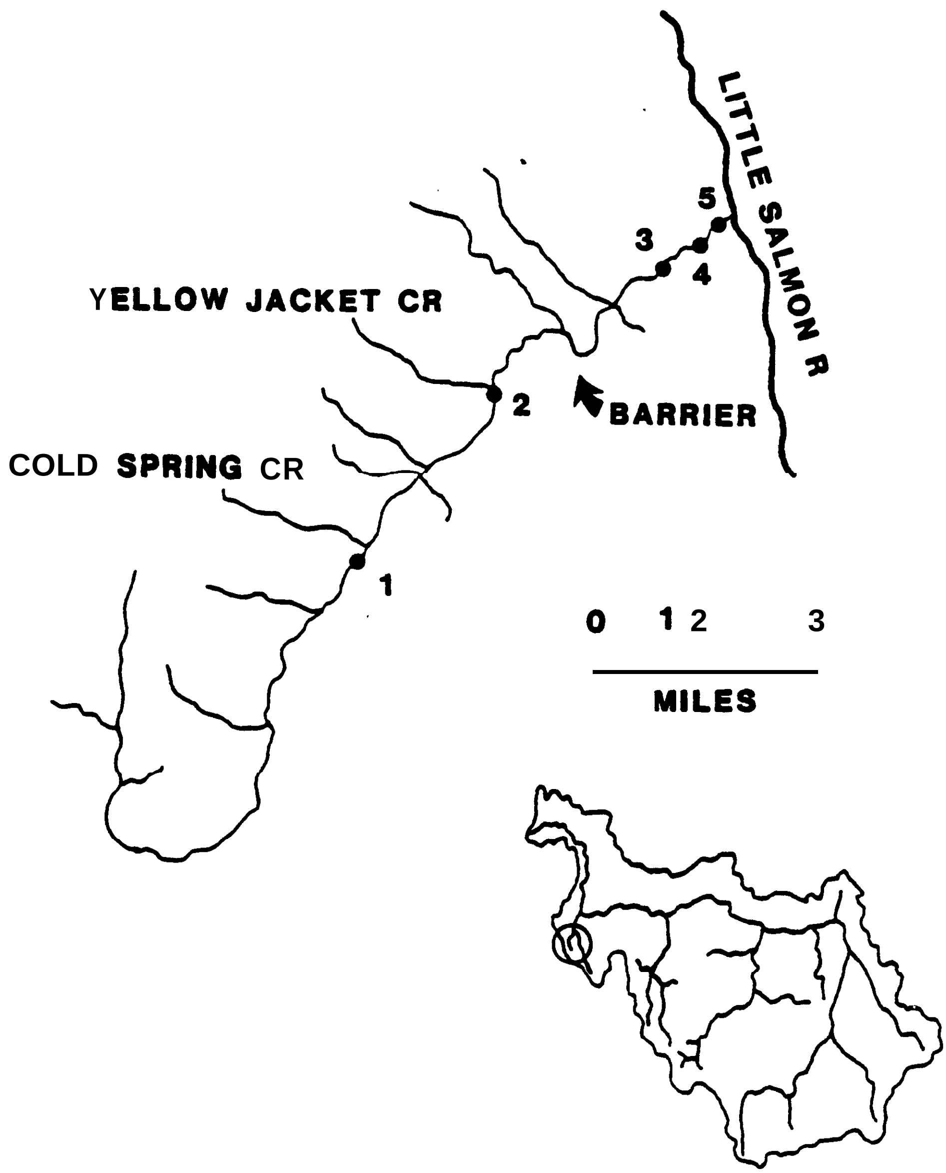



Figure 70. Sections sampled in Boulder Creek, 1984.

Table 48. Sections sampled in Boulder Creek, August 28, 1984.

| Location and section | Length (yd) | Approximate width (yd) | Area ($yd^2$) |
|---|---|---|---|
| Above barrier | | | |
| 1 | 100 | 7 | 700 |
| 2 | 100. | 8 | 800 |
| Below barrier | | | |
| 3 | 100 | 14 | 1,400 |
| 4 | 100 | 14 | 1,400 |
| 5 | 300 | 14 | 4,200 |

**Table 49. Number of trout, salmon, and whitefish (number/100 $yd^2$) counted in Boulder Creek sections, August 28, 1984.**

| Species, age | Above barrier | | Below barrier | | |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 |
| **Rainbow-steelhead** | | | | | |
| 0 | 7 (1.0) | 0 | 15 (1.7) | 20 (1.4) | 42 (1.0) |
| | 32 (4.6) | 10 (1.2) | 59 (4.2) | 43 (3.1) | 107 (2.5) |
| II | 4 (0.6) | 7 (0.9) | 35 (2.5) | 26 (1.9) | 57 (1.4) |
| ≥III | 1 (0.1) | 2 (0.2) | 1 (0.1) | 1 (0.1) | 10 (0.2) |
| **Chinook** | | | | | |
| 0 | 0 | 0 | 17 (1.2) | 30 (2.1) | 64 (1.5) |
| I+ | 0 | 0 | 0 | 0 | 0 |
| **Brook** | | | | | |
| 0 | 0 | 0 | 0 | 0 | 1 (+) |
| ≥I | 31 (4.4) | 0 | 0 | 0 | 1 (+) |
| **Hatchery rainbow** | 2 (0.3) | 2 (0.2) | 0 | 0 | 2 (+) |
| **Whitefish** | | | | | |
| 0 | 0 | 0 | 0 | 0 | 0 |
| ≥I | 0 | 0 | 6 (0.4) | 6 (0.4) | 13 (0.3) |

Densities of juvenile rainbow-steelhead were comparable in sections above and below the barrier falls (Table 49). Densities of yearling and age II rainbow-steelhead were high compared to other streams surveyed in 1984 (Appendix Al); fry were present in most sections but were not highly abundant in 1984.

Age 0 chinook were present in sections below but not above the Boulder Creek barrier falls in 1984 (Table 49). Densities below the barrier were low relative to other Idaho streams in 1984 (Appendix A2).

## Costs and Benefits

No BPA funds have been spent for implementation on Boulder Creek through 1984 (Appendix B).

The barrier removal project should yield significant benefits for chinook. The 12 miles of stream above the falls has a moderate gradient with run/riffle or pocket water habitat being prevalent. This reach also contains about one mile of meandering meadow habitat which appears to be excellent chinook rearing habitat. Final benefits can be determined at full seeding from the estimated numbers of age 0 chinook reared above the barrier (Table 1). We have no evidence at this time that the falls are a barrier to steelhead.

## Summary

A BPA-funded barrier removal project is planned for Boulder Creek in 1985. An IDFG fish survey in 1984 found relatively high densities of juvenile rainbow-steelhead above and below the barrier. Age 0 chinook were not present in sections above the barrier. Significant benefits are expected for chinook from this project.

## Recommendations

Annual sampling of Boulder Creek trend sections should be initiated the first year after barrier removal. Two sections should be established in the upper part of Boulder Creek, upstream from section 1. Juvenile chinook should be stocked into upper Boulder Creek in 1986. A chinook spawning ground reach should be established as adults begin to return from introductions.

# RESULTS AND DISCUSSION

## Project Evaluations

IDFG evaluation of benefits from habitat enhancement projects relies on monitoring population trends to define full-seeding levels and separation of those parts of final densities due to specific enhancement actions. With our extensive survey approach we have emphasized changes in rearing habitat more than changes in spawning habitat because rearing habitat appears to be the limiting factor in most project areas.

Intensive studies of survival, production, and yield in a few streams should provide further insight into the question of whether spawning or rearing habitat is limiting, as well as define the relative importance of summer and winter rearing habitat. In the Lemhi River system, Idaho, the amount of suitable winter habitat influenced the migration of juvenile steelhead from upstream areas (Bjornn 1978). However, these migrants found suitable winter habitat elsewhere in the Lemhi River, where they remained an additional year before migrating seaward as smolts. Juvenile chinook in high-elevation streams in Idaho typically migrate from summer rearing areas and winter downstream before emigrating as smolts. The focus of these extensive evaluations could be shifted if intensive studies determine that the "bottleneck" to smolt production occurs after the summer rearing period.

Hypothetically, steelhead and chinook populations can show two types of benefit from habitat enhancement projects. One benefit can occur from increased numbers of fish reared within the enhanced stream reach. The other can occur from additional fish drifting to downstream rearing areas. At this time no attempt is being made to assess this second type of benefit. Potential for defining this second type of benefit will probably be available from the intensive studies.

It was not possible to define the level of enhancement for any BPA project in 1984.

Evaluations for all projects except three were in the pre-treatment phase during 1984. Because full benefits cannot be defined at current low seeding levels, projects must be monitored until full-seeding is approached.

We obtained post-treatment information for three projects in 1984: Lolo Creek instream structures; upper Lochsa River instram structures; and screening of the irrigation diversion on Pole Creek. Of the three, only the Lo10 Creek project exhibited any apparent benefits; these apparent benefits were not conclusively determined in 1984. The Lolo Creek project requires a follow-up evaluation in 1985. The Pole Creek project requires better passage for adult chinook at the irrigation diversion.

There appears to be a large differential in potential for benefits among projects. Some projects stand out because they have potentially higher benefits, more easily defined benefits, or both. In general, these projects are barrier removals, connection of off-channel rearing ponds, channel reconstructions in channelized stream reaches, and probably riparian revegetation. In 1984 we had indications that some applications of instream structures may not produce any significant benefits.

Implementation of several projects was delayed in 1984. Fencing of riparian habitat in Red River was stopped by the lack of a land management agreement in negotiations with a private landowner. Delays in completing an Environmental Assessment caused the Boulder Creek barrier removal project to be scheduled for 1985, one year later than planned. The Environmental Assessment process delayed the Johnson Creek barrier removal project until October 1984 when cold weather prevented its completion. Barrier removal projects in Eldorado Creek and Crooked Fork Creek were not completed in 1984 due to technical problems with drilling. Barrier removal projects on South Fork Salmon River tributaries (Dollar Creek, Six Bit Creek) were delayed indefinitely by environmental concern over the possible contribution of silt to the South Fork which might result from these projects.

In general the methodology used in 1984 appeared to be suitable and adequate to gain the information needed to eventually assign benefits to most projects. Snorkeling was an acceptable method to estimate juvenile fish densities in all streams except CAmas Creek where turbid water limited visibility. Section gradient should be added to the physical habitat parameters estimated in 1984.

The approaches developed in 1984 will be adequate to establish a mitigation record for all passage improvement projects, including those implemented or proposed for Eldorado Creek, Crooked Fork Creek, Crooked River, Panther Creek, upper Salmon River, Alturas Lake Creek, Pole Creek, Johnson Creek, and Boulder Creek. Site-specific improvements in (summer) rearing potential from instream structure projects in Lolo Creek, upper Lochsa River, Crooked River, and Red River and from riparian projects can also be defined by extensive surveys. These types of projects constitute the majority of habitat enhancement projects in Idaho.

Detection of subtle streamwide effects from some types of projects, including sediment reduction, will be difficult without development of habitat models from more intensive sampling in a few streams. Potential to estimate efficiency of recruitment at various levels of sedimentation exists in headwater streams of the Salmon and Middle Fork Salmon Rivers. Where high implementation costs justify more intensive studies, as in Bear Valley Creek, efficiency of recruitment can be estimated fairly precisely for chinook during a period that sedimentation decreases. Precise estimates of spawner escapements, juvenile standing crops, and smolt yields of steelhead and chinook will also be obtained from intensive studies planned for the upper Salmon River. To estimate recruitment efficiency from habitat changes in other streams, a common methodology for extensive surveys and more intensive studies will be needed.

## Habitat Requirements

For benefits to accrue from a project, some factor limiting production of juvenile steelhead or chinook must be modified. We believe that the current low seeding rates of both species--due to low adult escapements--primarily limit production in most Idaho streams. Barrier removal projects and efforts to increase carrying capacity will have limited success until escapements increase.

Given adequate escapements, habitat factors which will set limits to anadromous fish populations are not well-defined. Habitat enhancement projects must address several habitat factors in the absence of certain knowledge of which factor(s) represents the "bottleneck" to anadromous fish production. The exception to the above generalization is removal of a migration barrier where access to habitat obviously sets the primary limit to production.

Spring-spawning steelhead and fall-spawning chinook have similar requirements for clean spawning gravel in riffles. At some imprecisely defined levels of sedimentation, survival to emergence of steelhead and chinook embryos drops rapidly. Some evidence indicates that chinook, because of their larger size at emergence, are more affected by fine sediments than are steelhead (Bjornn 1966; Tappel and Bjornn 1983). Both species are able to clean sediment from the redds by their spawning behavior.

Juvenile fish of both species gradually move into faster, deeper water as they grow larger. Overlap in habitat use between the two species and between different age groups of steelhead is limited by relatively discrete inter- and intra-specific size groups (Everest and Chapman 1972).

To some extent, summer rearing habitat can be defined in terms of optimal depths and velocities (Bovee 1978). Yearling and older steelhead use habitat that is faster and deeper than that preferred by either age 0 steelhead or age 0 chinook. In Middle Fork Salmon River tributaries, Thurow (1983) found higher densities of yearling and older rainbow-steelhead in pocket water rather than meadow habitats. In our 1984 survey, we also observed higher densities of yearling and older rainbow-steelhead in higher-velocity sections in Lolo Creek, lower Eldorado Creek, upper Lochsa River, upper Panther Creek, lower Johnson Creek, and Boulder Creek. Age 0 rainbow-steelhead schooled in backwaters and shoals, gradually moving offshore during summer.

Like rainbow-steelhead fry, age 0 chinook also move offshore during summer into habitat of moderate depth and velocity. In mid-July 1984, as flows were receding, we observed schools of age 0 chinook using shoals, backwaters with water exchange, and stream edges with flooded grassy vegetation in Lolo Creek, Crooked River', and Red River. in late July, in Bear Valley Creek and Sulphur Creek, they also selected braided channels and beaver runs more so than midstream habitat.

By mid-August 1984 we observed increasingly more use of midstream habitat by age 0 chinook. The relatively high juvenile chinook densities in parts of the upper Salmon River drainage in August 1984 allowed us to tentatively investigate relationships between their density and depth-velocity combinations in some sections where available habitat appeared to be utilized. Although carrying capacity in the upper Salmon River drainage was probably higher than the densities we observed, there was a direct, high correlation ($r=0.93$) between juvenile chinook density and the percentage of habitat measurements having both moderate depths and moderate velocities (Table 50; Fig. 71). Development and verification of habitat models to account for variation in rearing potential should become possible as seeding levels increase, and aid in final evaluations of benefits.

Sediment affects rearing habitat of both steelhead and chinook. In Middle Fork Salmon River tributaries (Marsh Creek, Bearskin Creek, Elk Creek), larger trout occupied only those areas with rubble, boulders, and/or vegetation mats because these types of structure offered forms of cover during periods of cold water (Konopacky 1984); highly sedimented reaches were not selected by larger trout. Age 0 chinook do rear in highly sedimented streams such as Bearskin Creek. Fine sediment effects on chinook rearing appear to be more subtle than on trout. Growth rate of age 0 chinook was lower and the time of fall migration was earlier in sedimented streams than in comparable streams with less sediment (Konopacky 1984). Influences of sediment on

Table 50. Relationship of chinook densities to percentage of habitat measurements having both moderate depth and moderate velocity (Bovee 1978), upper Salmon River and tributaries, August 18-21, 1984.

| Stream | Section | Number of age 0 chinook/100 $yd^2$ | % of measurements with moderate depth[a] and moderate velocity[b] |
|---|---|---|---|
| | | Available habitat used[c] | |
| Salmon R | 2 | 44.5 | 25.0 |
| | 3 | 10.8 | 0 |
| | 4 | 81.5 | 30.0 |
| | 5 | 79.2 | 33.3 |
| | 6 | 34.5 | 20.0 |
| Alturas | 3 | 68.5 | 35.0 |
| Lake Cr | 4 | 10.5 | 7.4 |
| Pole Cr | 3 | 37.8 | 23.3 |
| | 4 | 13.0 | 3.7 |
| | | Available habitat not used[c] | |
| Salmon R | 1 | 23.5 | 36.7 |
| Alturas | 1A | 0.1 | 26.7 |
| Lake Cr | 2A | 1.0 | 66.7 |
| | 1 | 0.1 | 73.3 |
| | 2 | 5.7 | 11.1 |
| Pole Cr | 1 | 0 | 20.0 |
| | 2 | 0 | 43.3 |

[a]0.5 through 3.0 feet.
[b]0.5 through 2.0 feet/second.
[c]Based on field observations.

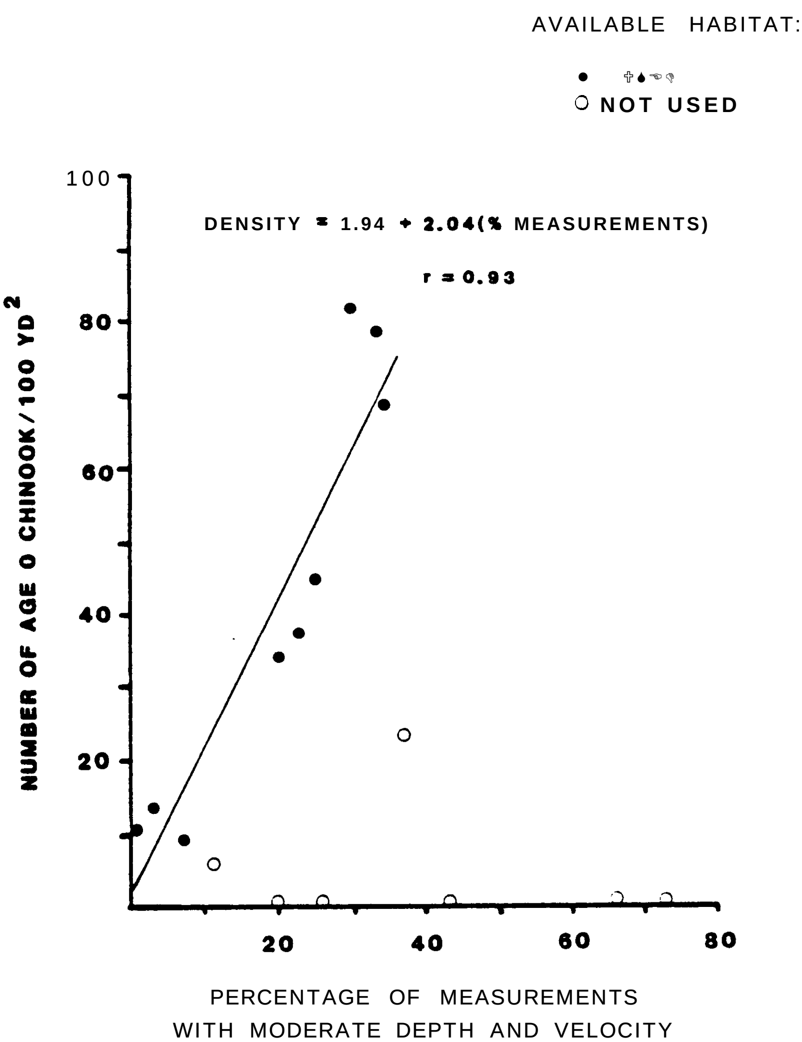



Figure 71. Relationship of age 0 chinook densities to percentage of habitat with both moderate depth (0.5-3.0 feet) and velocity (0.5-2.0 feet/second), upper Salmon River and tributaries, August 18-21, 1984. A determination of use of available habitat was based on field observations.

carrying capacity of Idaho streams are not entirely clear because most studies have been conducted during the recent period of low escapements.

## Conclusions

Although it is recognized that the other fish and wildlife agencies and tribes will provide input to the direction of this program, IDFG will set priorities of BPA-funded habitat enhancement projects primarily according to the potential for increasing juvenile steelhead and salmon production and to a lesser degree by the likelyhood of quantifying these increases. Quantification of benefits is required by the Northwest Power Planning Act to mitigate for losses due to federal hydropower development on the Snake and Columbia Rivers.

Barrier removal projects or other habitat additions such as additional channel construction and off-channel pond construction have definite, easily defined benefits and generally low costs. These types of projects, though limited in number, will continue to receive high priority from IDFG.

Emphasis in 1985 habitat work should be on high-yield projects such as barrier removals, stream channel reconstruction, and connection of off-channel rearing ponds. Emphasis should also be placed on riparian revegetation projects. Implementation of additional instream structure projects should be deferred until the 1985 evaluation is completed on Lolo Creek, Red River, and Crooked River projects.

Beginning in 1985, additional streams should be sampled as controls for riparian revegetation projects in tributaries to upper Salmon and Middle Fork Salmon Rivers. Additional chinook spawning ground surveys should be established in new production areas opened by BPA barrier removal projects.

Commitment must be obtained to continue evaluation of BPA habitat enhancement projects from now to the time that full seeding occurs.

## LITERATURE CITED


Bjornn, T. C. 1966. Steelhead trout production studies. Job Number 3, Project F-49-R-4, Idaho Department of Fish and Game.

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.

Bovee, K. D. 1978. Probability of use criteria for the family salmonidae. Cooperative Instream Flow Group. Energy Land Use Team, Office of Biological Services. Paper number 4. FWS/OBS-78/07. U. S. Department of Interior, Fish and Wildlife Service.

Corley, D. R. 1967. Biological sampling of Panther Creek above and below the introduction of mining wastes. Idaho Department of Fish and Game.

Espinosa, A. 1984. Lolo, Crooked Fork and White Sands Creeks habitat improvement. Annual Report 1983. in Natural Propagation and Habitat Improvement, Volume III - Idaho, Final and Annual Reports 1982/83. Department of Energy, Bonneville Power Administration, Division of Fish and Wildlife.

Espinosa, F. A., Jr. and C. D. Branch. 1979. Lo10 Creek fisheries monitoring program. Progress Report: 1974-79. Clearwater National Forest, Processed Report. 43 p.

Everest, F. H. and D. W. Chapman. 1972. Habitat selection and spacial interaction by juvenile chinook salmon and steelhead in two Idaho streams. Journal of the Fisheries Research Board of Canada 29:91-100.

Fisher, J. G. 1984. Drilling and blasting selected migration barriers, Johnson Creek, Valley County, Idaho. Completion Report to Idaho Department of Fish and Game. J. G. Fisher and Associates, Anchorage, Alaska. (unpublished manuscript).

Forsgren, H. 1984a. Alturas Lake Creek flow augmentation. Annual Report 1983. in Natural Propagation and Habitat Improvement, Volume III - Idaho, Final and Annual Reports 1982/83. Department of Energy, Bonneville Power Administration, Division of Fish and Wildlife.

Forsgren, H. 1984b. Pole Creek irrigation diversion screening. Annual Report 1983. in Natural Propagation and Habitat Improvement, Volume III - Idaho, Fianl and Annual Reports 1982/83. Department of Energy, Bonneville Power Administration, Division of Fish and Wildlife.

Fuller, R. K., J. H. Johnson, and M. A. Bear. 1984. A biological and physical inventory of the streams within the lower Clearwater River basin, Idaho. Annual Report 1983. in Natural Propagation and Habitat Improvement, Volume III - Idaho, Final and Annual Reports 1982/83. Department of Energy, Bonneville Power Administration, Division of Fish and Wildlife.

Gard, B. and M. Reingold. 1984. Panther Creek live box tests, May 1984. Idaho Department of Fish and Game. (unpublished manuscript).

Gebhards, S. V. 1959. Preliminary Planning Report - Salmon River. Columbia River Fisheries Development Program. Idaho Department of Fish and Game.

Graham, P. J. 1977. Juvenile steelhead trout densities in the Lochsa and Selway River drainages. Master's thesis. University of Idaho, Moscow, Idaho.

IDFG (Idaho Department of Fish and Game). 1984. Idaho Anadromous Fish Management Plan, 1984-1990. Draft. Idaho Department of Fish and Game.

Konopacky, R. C. 1984. Sedimentation and productivity in salmonid streams. Ph.D. disseration. University of Idaho, Moscow, Idaho.

Lukens, J. R. 1984. River and Streams Investigations, Clearwater River steelhead investigations. Federal Aid in Fish Restoration, Job Performance Report, Project F-73-R-5, Idaho Department of Fish and Game.

Mabbott, L. B. 1982. Density and habitat of wild and introduce juvenile steelhead trout in the Lochsa River drainage, Idaho. Master's thesis. University of Idaho, Moscow, Idaho.

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.

McKern, J. L., H. F. Horton, and K. V. Koski. 1974. Development of steelhead trout (Salmo gairneri) otoliths and their use for age analysis and for separating summer from winter races and wild from hatchery stocks. Journal of the Fisheries Research Board of Canada 31:1420-1426.

Partridge, F. E. 1984. Fish hatchery evaluations - Idaho, October 1982 to September 1983. Prepared for Lower Snake River Compensation Plan Office. Idaho Department of Fish and Game.

Platts, W. S. 1968. Bear Valley Creek preliminary aquatic survey. U. S. Department of Agriculture, Forest Service.

Platts, W. S., S. B. Martin, and E. R. J. Primbs. 1979. Water quality in an Idaho stream degraded by acid mine waters. General Technical Report INT 67. U. S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station, Ogden, Utah.

Platts, W. S. and W. F. Megahan. 1975. Time trends in riverbed sediment composition in salmon and steelhead spawning areas: South Fork Salmon River, Idaho. Transactions of the 40th North American Wildlife and Natural Resources Conference, 1975.

Platts, W. S., W. 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.

Platts, W. S. and F. E. Partridge. 1978. Rearing of chinook salmon in tributaries of the South Fork Salmon River, Idaho. Research Paper INT-205. U. S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station, Ogden, Utah.

Pollard, H. A., II. 1983. Salmon and Steelhead Investigations. Study II, Job Number I: Salmon spawning ground surveys. Job Performance Report. Idaho Department of Fish and Game.

Rybock, J. T., H. F. Horton, and J. T. Fessler. 1975. Use of otoliths to separate juvenile steelhead trout from juvenile rainbow trout. Fishery Bulletin 73:654-659.

Sekulich, P. T. 1980. The carrying capacity of infertile streams for rearing juvenile chinook salmon. Ph.D. dissertation. University of Idaho, Moscow, Idaho.

Simpson, J. C. and R. L. Wallace. 1978. Fishes of Idaho. University Press of Idaho, Moscow, Idaho. 237 pages.

Stowell, R. 1984a. Crooked River passage improvement. Annual Report 1983. in Natural Propagation and Habitat Improvement, Volume III - Idaho, Final and Annual Reports 1982/83. Department of Energy, Bonneville Power Administration, Division of Fish and Wildlife.

Stowell, R. 1984b. Red River Habitat Improvement. Annual Report 1983. in Natural Propagation and Habitat Improvement, Volume III - Idaho, Final and Annual Reports 1982/83. Department of Energy, Bonneville Power Administration, Division of Fish and Wildlife.

Stuehrenberg, L. C. 1975. The effects of granitic sand on the distribution and abundance of salmonids in Idaho streams. Master's thesis. University of Idaho, Moscow, Idaho.

Tappe1, P. D. and T. C. Bjornn. 1983. A new method of relating size of spawning gravel to salmonid embryo survival. North American Journal of Fisheries Management 3:123-135.

Thurow, R. 1983. River and Stream Investigations, Middle Fork Salmon River fisheries investigations. Job Performance Report, Project F-73-R-5, Idaho Department of Fish and Game.

Torquemada, R. J. and W. S. Platts. 1984. Evaluation of fisheries enhancement projects on Red River, Nez Perce National Forest. Progress Report 1, FY 1983 - Pretreatment Inventory. U. S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station, Boise, Idaho.

Simpson, J. C. and R. L. Wallace. 1978. Fishes of Idaho. University Press of Idaho, Moscow, Idaho. 237 pages.

Stowell, R. 1984a. Crooked River passage improvement. Annual Report 1983. in Natural Propagation and Habitat Improvement, Volume III - Idaho, Final and Annual Reports 1982/83. Department of Energy, Bonneville Power Administration, Division of Fish and Wildlife.

Stowell, R. 1984b. Red River Habitat Improvement. Annual Report 1983. in Natural Propagation and Habitat Improvement, Volume III - Idaho, Final and Annual Reports 1982/83. Department of Energy, Bonneville Power Administration, Division of Fish and Wildlife.

Stuehrenberg, L. C. 1975. The effects of granitic sand on the distribution and abundance of salmonids in Idaho streams. Master's thesis. University of Idaho, Moscow, Idaho.

Tappel, P. D. and T. C. Bjornn. 1983. A new method of relating size of spawning gravel to salmonid embryo survival. North American Journal of Fisheries Management 3:123-135.

Thurow, R. 1983. River and Stream Investigations, Middle Fork Salmon River fisheries investigations. Job Performance Report, Project F-73-R-5, Idaho Department of Fish and Game.

Torquemada, R. J. and W. S. Platts. 1984. Evaluation of fisheries enhancement projects on Red River, Nez Perce National Forest. Progress Report 1, FY 1983 - Pretreatment Inventory. U. S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station, Boise, Idaho.

# APPENDIX A

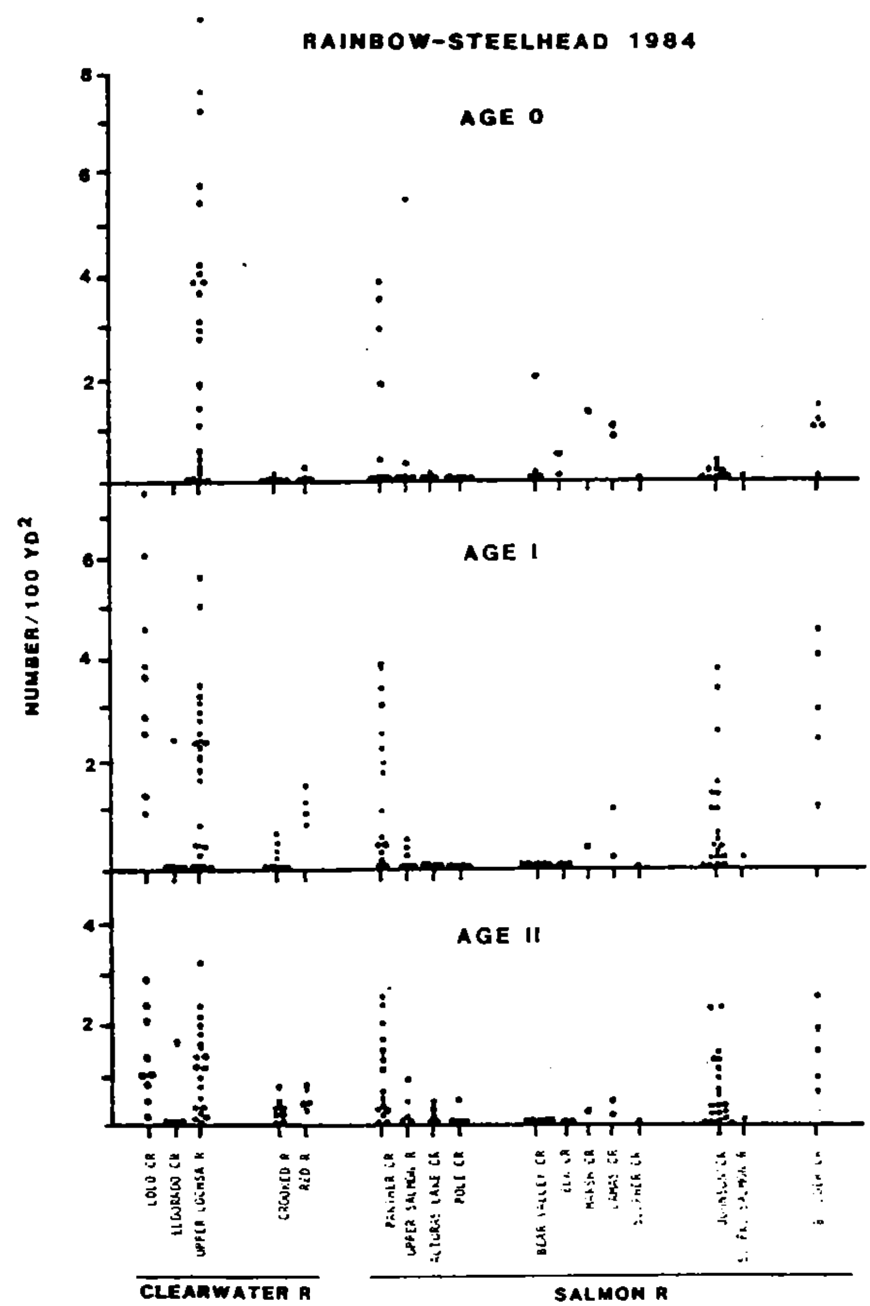



Figure A1. Densities of juvenile rainbow-steelhead in Clearwater River and Salmon River drainages, July-August 1984.

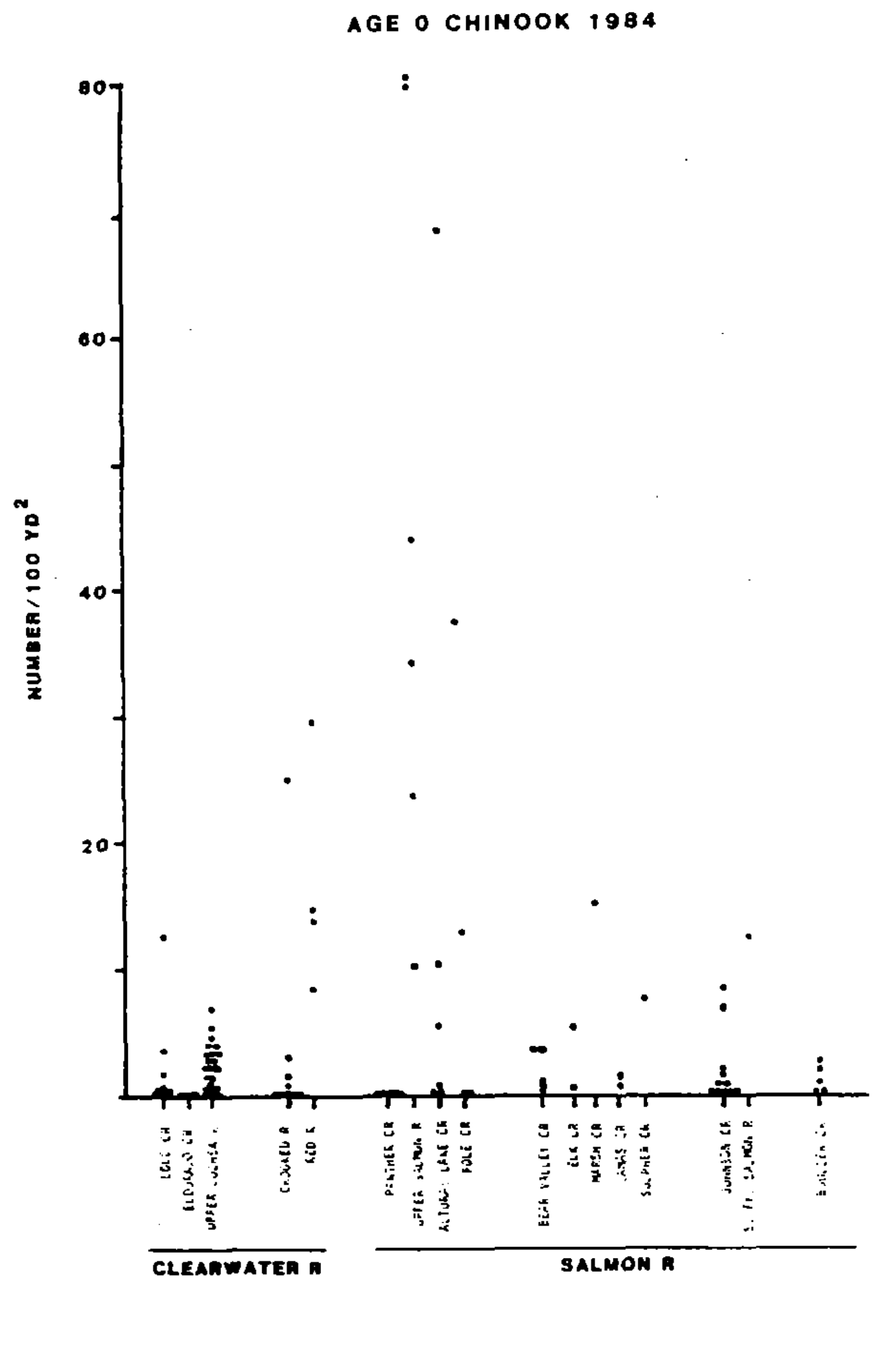



Figure A2. Densities of age 0 chinook in Clearwater River and Salmon River drainages, July-August 1984.

APPENDIX B

Table B1. Budget summary for BPA habitat enhancement projects, Idaho, 1983-1984.

| Drainage and Project | Proposed budget | Costs through 1984 |
|---|---|---|
| Clearwater River | | |
| *Lolo Creek* | | |
| instream structures (83-522, 84-6) | 95,153 | 66,109 |
| Eldorado Creek | | |
| barrier removal (84-6) | 17,668 | 17,668 |
| Upper Lochsa River | | |
| instream structures (83-522) | 28,927 | 28,927 |
| barrier removal (84-6) | 20,006 | 20,006 |
| Crooked River | | |
| passage (83-522) | 22,985 | 42,131 |
| habitat (84-5) | 181,507 | 72,189 |
| Red River | | |
| habitat (83-501, 84-5) | 255,045 | 163,796 |
| Maintenance | 15,000 | 6,231 |
| Salmon River | | |
| Panther Creek | | |
| pollution control (84-29) | 198,679 | 80,000 |
| Alturas Lake Creek | | |
| passage (83-415) | 39,000 | 0 |
| Pole Creek | | |
| passage (83-416) | 29,725 | 29,725 |
| Upper Middle Fork and Salmon Rivers | | |
| riparian revegetation (84-24) | 125,400 | 4,204 |
| Bear Valley Creek | | |
| sediment reduction (83-359) | 590,466 | 133,409 |
| Camas Creek (Meyer Cove) | | |
| riparian revegetation (84-23) | 4,699 | 0 |
| Johnson Creek | | |
| barrier removal (83-07) | 75,600 | 19,143 |
| Boulder Creek | | |
| barrier removal (83-07) | 26,113 | 0 |
| IDFG project evaluations (83-07) | 149,000 | 124,200 |

# APPENDIX C

# EVALUATION OF FISH HABITAT ENHANCEMENT PROJECTS IN CROOKED RIVER, RED RIVER, AND BEAR VALLEY CREEK

Progress Report 1

to

Terry Holubetz
Idaho Department of Fish and Game

Richard J. Torquemada
William S. Platts

Intermountain Forest and Range Experiment Station
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ABSTRACT

In order to evaluate stream rehabilitation and enhancement projects in central and northern Idaho, ten study sites were established to document aquatic habitat conditions and study the effectiveness of various instream and riparian habitat improvement techniques. These sites were located in three river drainages; the Crooked and Red Rivers in the Nezperce National Forest; and Bear Valley Creek in the Boise National Forest. Habitat condition variables representing critical components for successful salmonid populations were measured at each site prior to project completion.

## INTRODUCTION

To improve stocks of anadromous fish within the Columbia Basin, and in accordance with the Congressional mandate to protect, mitigate and enhance fish populations impacted by dams and the development of hydro-electric power in the Pacific Northwest (Pacific Northwest Electric Power Planning and Conservation Act of 1980), several stream enhancement projects are currently underway in the National Forests of Idaho. These projects are funded by the Bonneville Power Administration, with the overall goal of stream rehabilitation and enhancement to increase anadromous salmonid production within Idaho. This report covers studies underway in three areas of Idaho to evaluate enhancement efforts. The Red River, a tributary to the South Fork of the Clearwater River (SFCR); Crooked River, also a tributary of the SFCR; and Bear Valley Creek, a major tributory of the Middle Fork of the Salmon River are the areas of study. These areas were historically major producers of chinook salmon and steelhead trout.

The stream habitat enhancement and rehabilitation projects fall into three major types: Instream structures of different shapes and kinds (e.g. log K-dams, boulder clusters, cabled tree deflectors, and riprap); Rechannelization to provide sinuosity and approximate pre-development conditions; and riparian revegetation planting to improve riparian habitats.

Each area has its own specific project goal and methods, with Crooked River testing an assortment of rehabilitation projects.

## OBJECTIVES

As part of this overall enhancement effort, fisheries biologists from the Intermountain Forest and Range Experiment Station and Idaho Department of Fish and Game are documenting pre- and post-treatment conditions on selected reaches within the study areas. This evaluation program is designed to:

1. Document pre-treatment stream, streambank, and riparian habitat conditions;

2. Follow trends in stream habitat conditions and fish population reaction to enhancement efforts, and;

3. Evaluate the overall effectiveness of enhancement techniques and projects to the aquatic ecosystem.

## STUDY AREA

The Crooked and Red River study areas were selected to document and study projects initiated by biologists from the Nezperce National Forest. Bear Valley study areas were selected by Idaho Department of Fish and Game.

Red and Crooked Rivers

Red River and Crooked River (Figures 1-3), drain an area of approximately 90,800 and 44,914 acres respectively. Ecologically, these areas lie within the Cedar/Hemlock/Douglas fir section of Bailey's Columbia Forest Province (Bailey 1980). These areas are characterized by a mixed coniferous forest consisting of Englemann spruce, grand fir, Douglas fir, lodgepole pine, subalpine fir, ponderosa pine, and larch. Hardwoods found along riparian areas include red alder, willow, dogwood, and Rocky Mountain maple.

Climate of these study areas consist of fairly severe winters, and summers which are characterized by hot days and cool nights. Precipitation exhibits a strong orographic effect, with amounts ranging from 25 inches below 5,000 feet to 45 inches above 6,000 feet. Snowfall represents 83 percent of the precipitation and total runoff, with the highest runoff occurring during the May snowmelt period.

Bear Valley

Bear Valley Creek, located in the Rocky Mountain Forest Province (Bailey 1980), has its source in weakly glaciated granitic uplands of the Idaho batholith. A structural depression within the batholith, Bear Valley has been filled with alluvium derived from the surrounding uplands, resulting in a meandering, low gradient stream. The two study sites are located near the transitional area where the Bear Valley channel becomes steeper and the valley floor narrower as it approaches its confluence with Marsh Creek to form the Middle Fork of the Salmon River (Figure 4).

Climatic conditions in Bear Valley are among the severest in Idaho. Precipitation averages 48 inches annually, with approximately 75 percent of this falling as snow. Winters are long and cold, with the January mean temperature 0°F. Summer weather is normally warm and dry, but subject to occasional intense convectional storms, and snow can fall during any given month.

## METHODS

We documented habitat conditions in all three study areas using the intensive transect line methodology developed by Platts and others (1983). The basic study design and variables collected differed between sites slightly, due to project time and budget constraints. All fish population sampling was conducted by Idaho Fish and Game Department personnel and is not included in this progress report. The size of each study area was selected on the basis of type of structures analyzed and project goals. Wooden or rebar stakes were placed on each streambank at ten-foot intervals, measured from midstream and perpendicular to the stream flow to mark all transects. All habitat variables were measured along this transect line (Table 1) for repeatability in proceeding years.

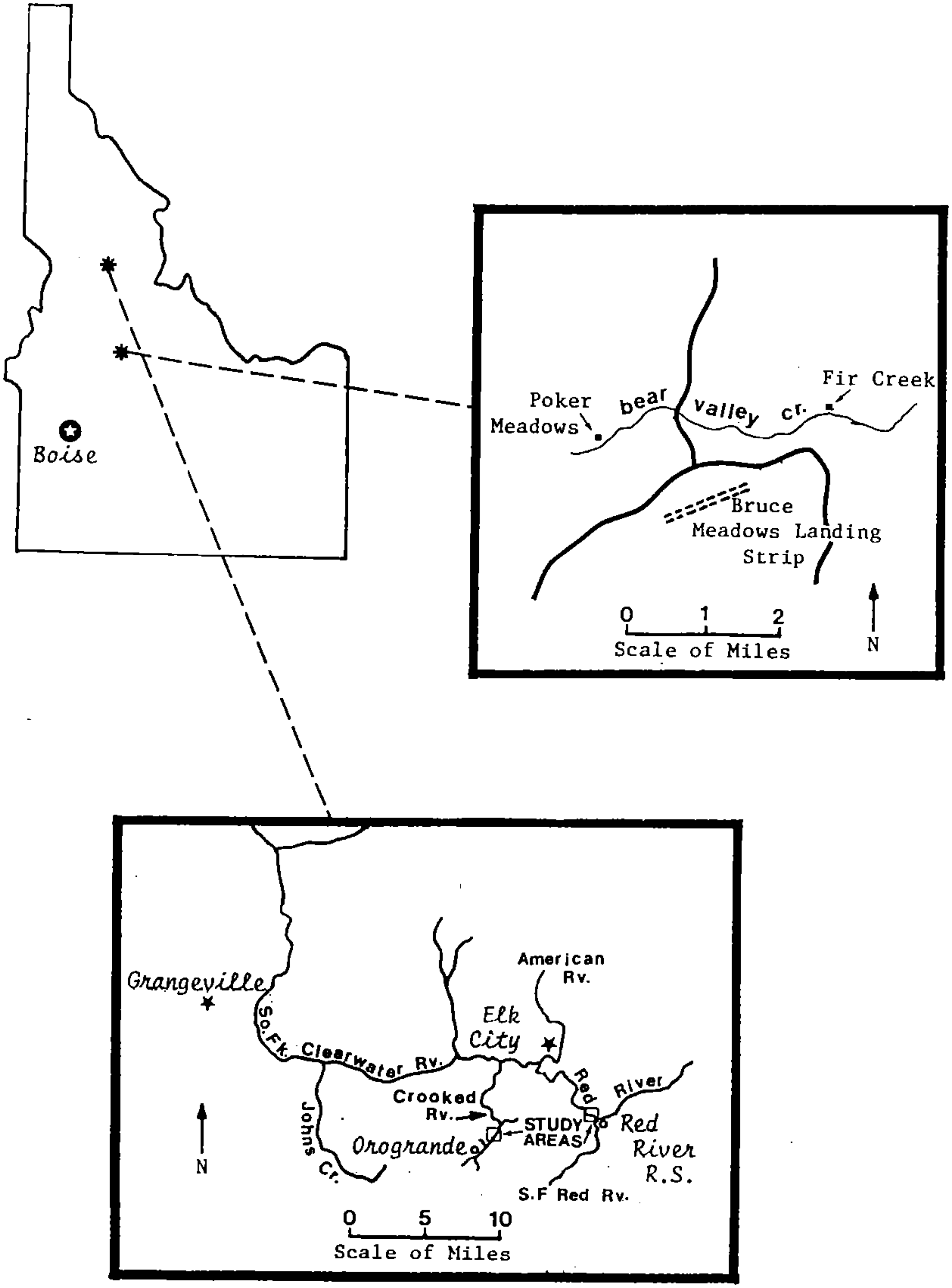


Figure 1.--Location of rehab study areas, Nezperce and Boise National Forests, Idaho.

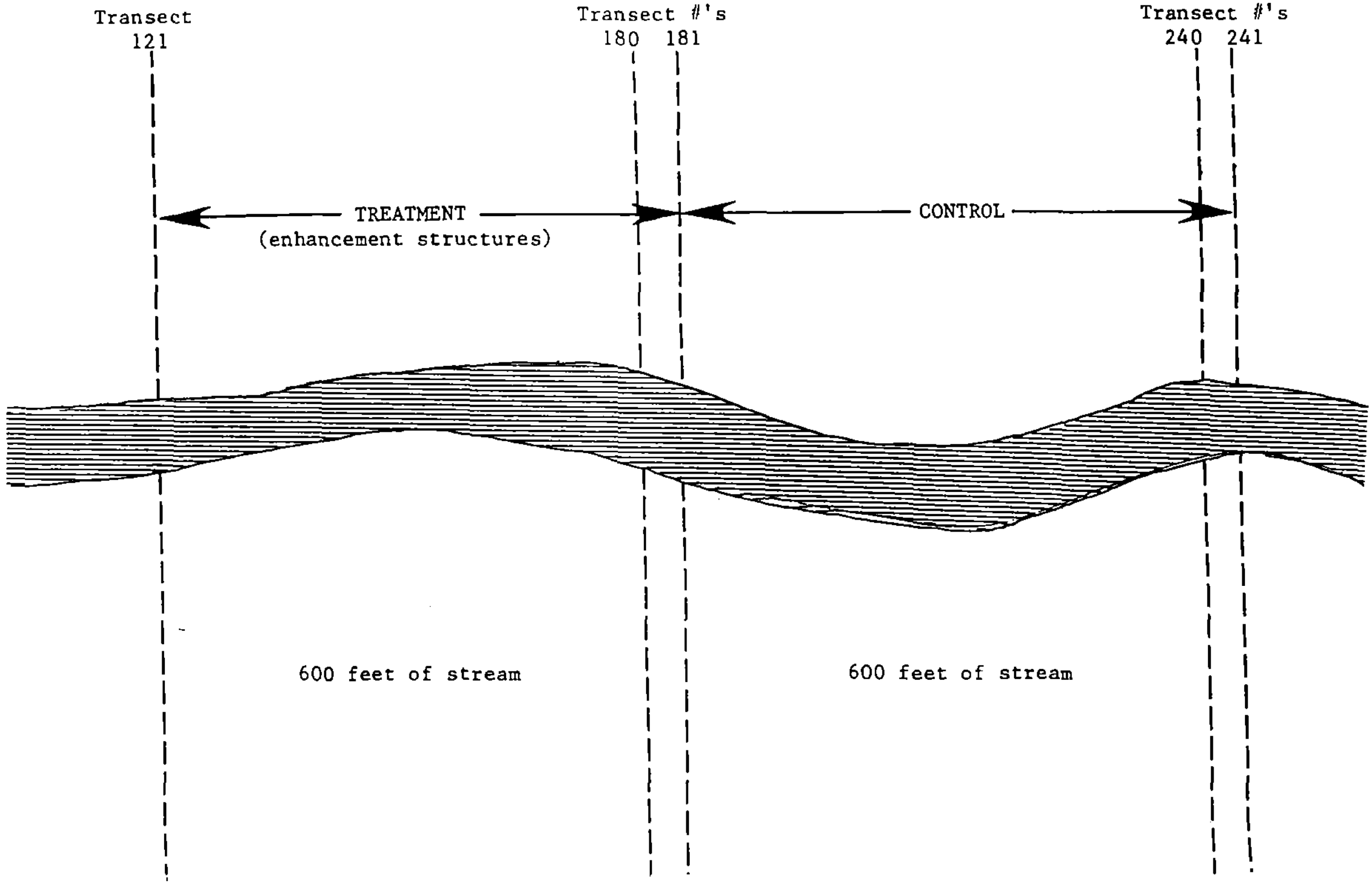


Figure 2.--Location and design of the Upper Red River study area, Nezperce National Forest, Idaho.

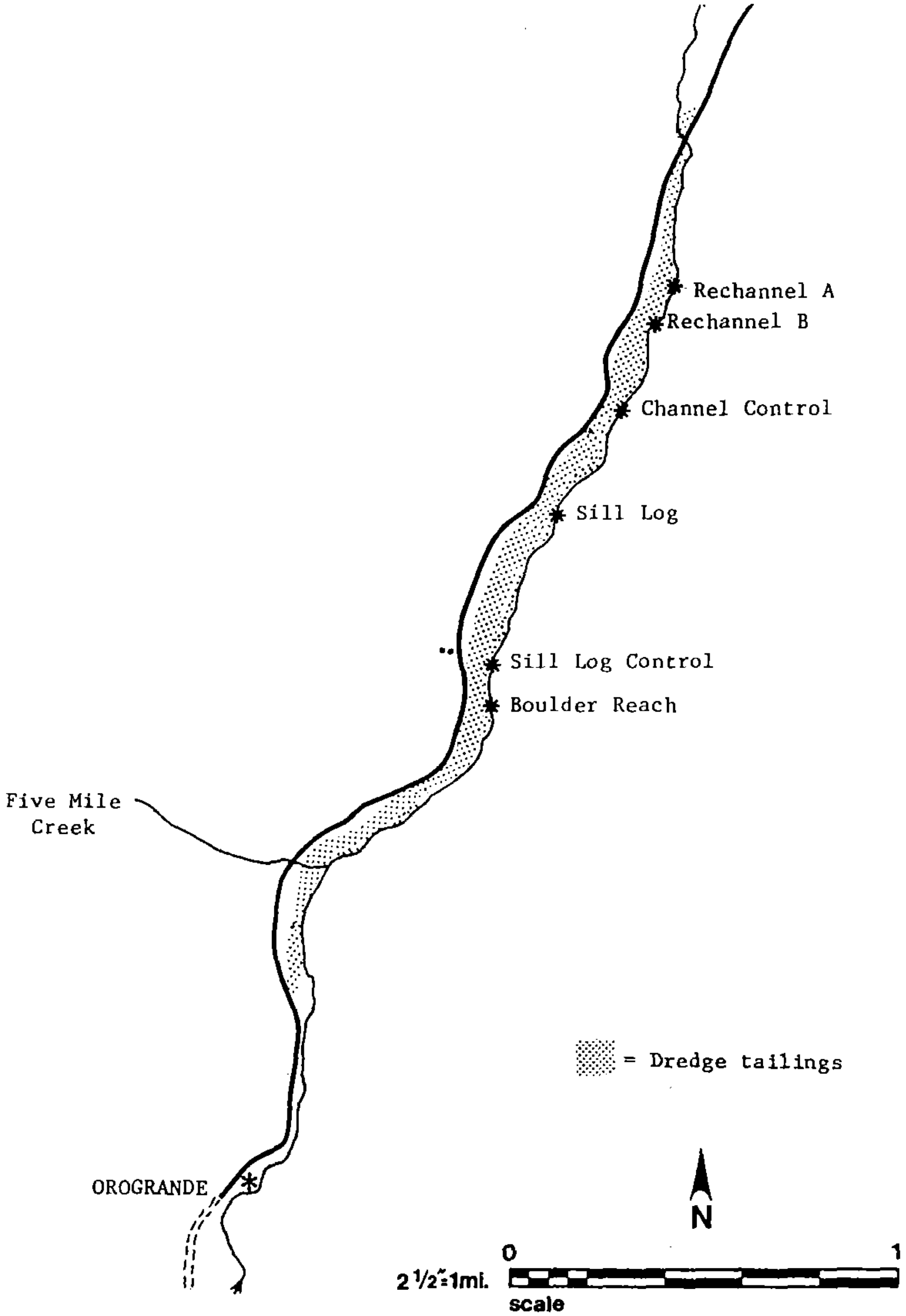


Figure 3.--Location of Crooked River study sites, Nezperce National Forest, Idaho.

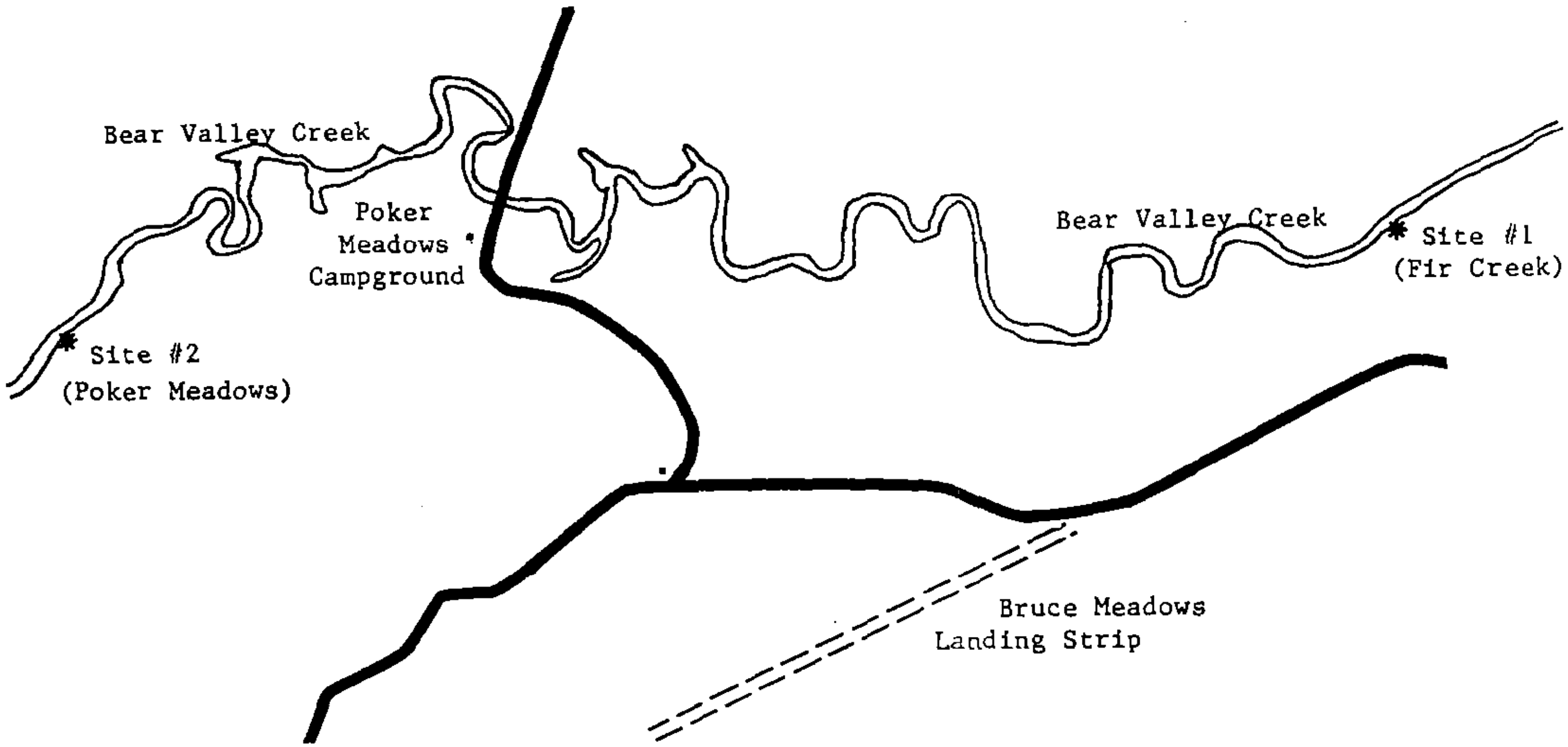


Figure 4.-- The Poker Meadows and Fir Creek study sites, Bear Valley area, Idaho.

Table 1.--Habitat conditions measured at enhancement study areas during the 1984 field season.

| Variable | Bear Valley[1] | Crooked River[2] | Upper Red |
|---|---|---|---|
| **Geomorphic/Aquatic** | | | |
| Stream width and depth | x | x | x |
| Pool quantity and quality | x | x | x |
| Riffle quantity | x | x | x |
| Substrate surface materials | x | x | x |
| Substrate particle embeddedness | x | x | x |
| Instream vegetative cover | x | x | x |
| Streamshore depth and undercuts | x | x | x |
| Bank angle | x | x | x |
| Solar input | x | x | |
| **Riparian** | | | |
| Streamside habitat type | x | x | x |
| Streambank stability | x | x | x |
| Overhanging vegetation | x | x | x |
| Streambank alteration | x | x | x |
| **Hydrologic** | | | |
| Stream profile | | x | 3 |
| Stream gradient | | x | 3 |
| Stream velocity | | x | 3 |
| **Biological** | | | |
| Fish species composition and age | 4 | 4 | 4 |
| Fish population estimates | | | |
| Fish standing crop and biomass | | | |

[1] 2 sites: Poker Meadows and Fir Creek
[2] 6 sites: Rechannel (2), Control (2), Logsill, Boulder
[3] To be collected in July, 1985.
[4] All fish population data collected by Idaho Department of Fish and Game in 1984.

A brief description of the procedures used in this study follows. More detailed descriptions can be found in Platts and others (1983), Platts and others (in press), and Ray and Megahan (1979). Some of our variables are rated or ranked according to categories given in appendix A.

Habitat condition variables were statistically analyzed using one-way analysis of variance for continuous data, and a chi square contingency test (SAS Institute 1982), for categorical data (Appendix A).

Water Column

Stream width is the horizontal distance along the transect line from shore to shore along the existing water surface, measured to the nearest foot. We measured stream depth as the sum of three vertical water height readings taken at one-fourth, one-half and three-fourths the stream width. This total (measured to the nearest tenth of feet) is then divided by four to account for the zero depths at the stream shore.

Pool and riffle widths were measured to the nearest foot at each transect, then totals were converted to percentages for each study area. Pool quality and feature were determined for each transect using categorical scales developed by Platts and others (1983) (Appendix A).

Solar input was measured using a Solarpathfinder[R] to determine actual btu's striking the surface along the transect line using the method of Platts and others (in prep).

Streambanks

Streambank angle was measured with a clinometer and the average of both banks was recorded. Undercut banks were measured to the nearest tenth of feet when encountered, along with the immediate streamshore depth at the undercuts. The average of both banks were taken.

Streambottom

Surface sediments were classified using an ocular technique. The amount of each substrate class (Table 2) was measured to the nearest foot along the wetted stream bottom. Embeddedness or the "gasket effect" of fine particles surrounding gravel and larger substrate was determined. The amount of instream vegetation was also recorded to the nearest foot.

Table 2.--Classification of stream substrate channel materials by particle size.

| Particle diameter size | | Sediment classification |
|---|---|---|
| Millimeters | Inches | |
| 304.8 and over | 12 and over | Boulder |
| 76.1 to 304.7 | 3 to 11.9 | Rubble |
| 4.75 to 76.0 | 0.19 to 2.9 | Gravel |
| 0.83 to 4.74 | 0.033 to 0.18 | Coarse sediment |
| 0.83 or less | 0.033 and less | Fine sediment (sandy) |

Riparian

Riparian variables describe the streambanks ability to resist erosion and provide necessary shade and cover components of fish habitat. We rated habitat type, bank cover stability and streamside cover according to tables developed by Platts and others (1983) (Appendix A). The amount of overhanging vegetation was measured to the nearest tenth of feet.

Hydraulic Geometry

We collected profiles and hydraulic measurements at the Crooked River sites, using a sag tape procedure as described by Platts and others (1983) and Ray and Megahan (1979). This technique utilizes engineer's level, flow meter and a tension-mounted metal tape to accurately measure streambanks, channel bottom, and water column characteristics. Cross sections were later plotted by a computer using programs developed by the USFS Regional Office (R2 Cross) and Intermountain Station (sagtape). Due to a change over in computer systems, cross sections will be presented in future reports.

## RESULTS

Results for this first year of habitat documentation vary with stream size, location and project goals. The Crooked and Red River study design allows for statistical comparison to determine pretreatment difference between and among sites. The Bear Valley areas, however, due to their distance apart and presence of a larger creek in the immediate vicinity of the Bear Valley-Fir site, do not allow realistic comparisons to be made.

Bear Valley - Fir Creek site

The Fir Creek site had better habitat overall, with better banks (smaller bank angles, larger and deeper undercuts, more stability and cover, less alteration) than those of the Poker Meadows site. Water column was about equal, with the exception of the amount and quality of pools in Fir Creek being much greater. The substrate composition reflects the disparity in the amount of pools. The Fir Creek site, with over 99 percent pool area, has a high percentage of fine sediments (34.5% total surface fines, Figure 5).

The Fir Creek site had moderate streambank alteration, with most of this being contributed to natural erosion. It is difficult to distinguish between natural and artificial bank alteration. If the alteration is new and can be contributed to recent sheer or trampling stress by animals, it is classified as artificial. If the alteration is questionable or too old to determine its cause, it is classified as natural.

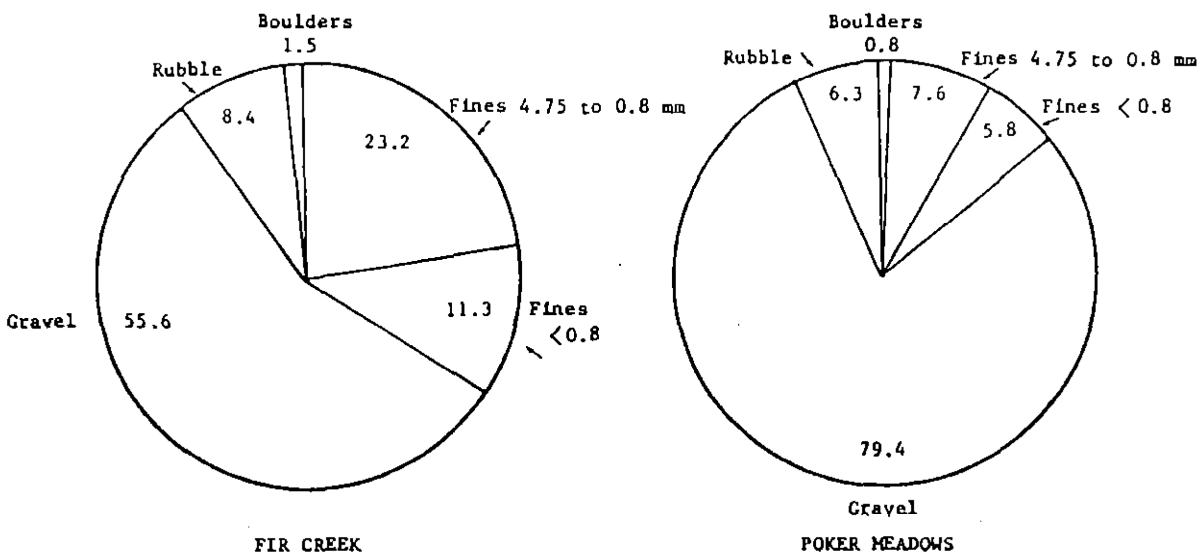


Figure 5.--Surface substrate composition, Bear Valley areas, 1984.

## Bear Valley-Poker Meadows

The Poker Meadow site was wider and shallower, with more riffle area and lower quality pools (Table 3). Streambanks and the adjacent riparian area conditions were generally not as good as those of the Fir Creek area. Bank angle was greater, with smaller undercuts and less bank water depth. Surface substrates are predominately gravel, with less than 14 percent in the fine sediment category.

The streambank alteration was high in Poker Meadows, with a third of this alteration being contributed to artificial causes. Stream cover rating reflected grassy species dominance and lower habitat type ratings (less stability) reflected the streambank erosion. Total alteration at this site was similar to levels found in the Upper Red River site which has experienced severe dredge mining impacts, however, two-thirds of Poker Meadows bank damage is attributed to natural causes.

## Upper Red River

Analysis of aquatic habitat revealed fairly homogenous conditions in the Upper Red River study area (Table 4). Stream width, pool quality, bank angle, surface gravel, surface rubble, and overhanging vegetation were the only variables found to be significantly different between sites (Figure 6). Stream width averaged almost four feet less over the lower section, primarily due to the presence of a low revegetating bar that was mostly exposed during the sampling period. Other water column variables were similar in each site. Red River within the study area is predominately pool (two-thirds to three quarters) and averages about one foot deep. Pool quality differed between sites, with site one (lower, treatment) having less pool area, but deeper pools. The control area is dominated by a large run/pool area[1].

Results from the upper site are very similar to those found in the lower site in 1983. Since the similar treatments are being administered in both areas, it will be interesting to follow the trends in each site, testing the replicability of effects of boulder placement.

## Crooked River

The six study sites on Crooked River were set up to test a number of enhancement techniques. These six sites fall into two areas of emphasis - the upper three sites (Boulder Reach, Log Sill Reach, and Control) testing instream structures, and the lower three (Rechannel A, B, and Control) looking at the effects of rechannelization.

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[1] In our method of classification, slow to medium velocity runs are grouped in the "pool" category.

Table 3.--Summary of 1984 geomorphic/aquatic analysis means, standard deviation and 95 percent confidence intervals for Fir Creek and Poker Meadows, Bear Valley Creek, Idaho.

| | Fir Creek Site | | | Poker Meadows Site | | |
|---|---|---|---|---|---|---|
| Variable | Mean | S.D.[1/] | C.I.[2/] | Mean | S.D. | C.I. |
| **Water Column** | | | | | | |
| Stream width (feet) | 102.7 | 6.9 | 99.7 -105.7 | 111.5 | 11.2 | 106.7-116.3 |
| Stream depth (feet) | 1.48 | 0.11 | 1.43- 1.53 | 0.98 | 0.23 | 0.88- 1.08 |
| Riffle width (percent) | 0.1 | 0.7 | 0 - 1.5 | 12.2 | 15.5 | 5.5 - 18.9 |
| Pool width (percent) | 99.9 | 0.7 | 98.5 -101.3 | 87.8 | 15.5 | 81.1 - 94.5 |
| Pool feature[3/] | 5.0 | 0 | - | 5.0 | 0 | - |
| Pool quality rating[3/] | 5.0 | 0 | - | 3.5 | 0.6 | 3.2 - 3.8 |
| **Streambanks** | | | | | | |
| Bank angle (degrees) | 73.6 | 29.7 | 60.9 - 86.3 | 104.9 | 42.6 | 86.7 -123.1 |
| Bank undercut (feet) | 0.54 | 0.31 | 0.41- 0.67 | 0.35 | 0.38 | 0.19- 0.51 |
| Bank water depth (feet) | 0.58 | 0.33 | 0.44- 0.72 | 0.37 | 0.35 | 0.22- 0.52 |
| **Channel** | | | | | | |
| Fines 4.75 - 0.8 mm (percent) | 23.2 | 8.7 | 19.5 - 26.9 | 7.6 | 5.3 | 5.3 - 9.9 |
| Fines 0.8 mm (percent) | 11.3 | 3.8 | 9.7 - 12.9 | 5.8 | 5.3 | 3.5 - 8.1 |
| Gravel (percent) | 55.6 | 11.1 | 50.8 - 60.4 | 79.4 | 12.3 | 74.1 - 84.7 |
| Rubble (percent) | 8.4 | 6.6 | 5.6 - 11.2 | 6.3 | 5.9 | 3.8 - 8.8 |
| Boulder (percent) | 1.5 | 1.8 | 0.7 - 2.3 | 0.8 | 1.5 | 0.1 - 1.5 |
| Substrate embeddedness[3/] | 2.0 | 0.2 | 1.9 - 2.1 | 2.0 | 0.3 | 1.9 - 2.1 |
| Instream veg. cover (feet) | 54.5 | 9.0 | 50.6 - 58.4 | 17.0 | 17.3 | 9.6 - 24.4 |
| **Riparian** | | | | | | |
| Habitat type[3/] | 17.5 | 2.7 | 15.7 - 19.3 | 13.3 | 4.3 | 11.5 - 15.1 |
| Bank cover stability[3/] | 4.0 | 0 | - | 3.4 | 0.6 | 3.1 - 3.7 |
| Stream cover[3/] | 2.3 | 0.5 | 2.1 - 2.5 | 1.9 | 0.4 | 1.7 - 2.1 |
| Bank alteration (percent) | | | | | | |
| Natural | 20.0 | 7.8 | 16.7 - 23.3 | 28.1 | 9.9 | 23.9 - 32.3 |
| Artificial | 6.6 | 7.5 | 3.3 - 9.7 | 14.5 | 10.8 | 9.9 - 19.1 |
| Total | 26.6 | | | 42.6 | | |
| Vegetative overhang (feet) | 0.32 | 0.23 | 0.22- 0.42 | 0.36 | 0.28 | 0.24- 0.48 |

[1/] S.D. = Standard deviation
[2/] C.I. = 95 percent confidence interval
[3/] Categorical variables, tables found in appendix A.

Table 4.--Summary of pretreatment geomorphic/aquatic analysis means, standard deviation and confidence intervals for the Upper Red River study area, Idaho, 1984.

| | Site 1 (treatment) | | | Site 2 (control) | | | |
|---|---|---|---|---|---|---|---|
| Variable | Mean | S.D.[1/] | C.I.[2/] | Mean | S.D. | C.I. | Significance |
| Water Column | | | | | | | |
| Stream width (feet) | 39.3 | 6.9 | 37.6 - 41.0 | 43.1 | 5.9 | 41.6 - 44.6 | 0.01 |
| Stream depth (feet) | 1.04 | 0.49 | 0.92 - 1.16 | 1.0 | 0.41 | 0.90- 1.10 | N.S. |
| Riffle width (percent) | 34.3 | 32.8 | 26.0 - 42.6 | 25.3 | 30.3 | 17.6 - 33.0 | N.S. |
| Pool width (percent) | 65.7 | 32.8 | 57.4 - 74.0 | 74.7 | 30.3 | 67.0 - 82.4 | N.S. |
| Pool feature[3/] | 5.0 | 0.6 | 4.8 - 5.2 | 5.0 | 0 | 5.0 - 5.0 | N.S. |
| Pool quality rating[3/] | 3.3 | 1.2 | 3.0 - 3.6 | 3.6 | 0.9 | 3.4 - 3.8 | 0.01 |
| Streambanks | | | | | | | |
| Bank angle (degrees) | 122 | 27.3 | 115.1 -128.9 | 112 | 27.2 | 105.1 -118.9 | 0.05 |
| Bank undercut (feet) | 0.18 | 0.27 | 0.11- 0.25 | 0.19 | 0.24 | 0.13- 0.25 | N.S. |
| Bank water depth (feet) | 0.20 | 0.30 | 0.12- 0.28 | 0.20 | 0.26 | 0.13- 0.27 | N.S. |
| Channel | | | | | | | |
| Fines 4.75 - 0.8 mm (percent) | 8.9 | 11.1 | 6.1 - 11.7 | 10.0 | 8.8 | 7.8 - 12.2 | N.S. |
| Fines 0.8 mm (percent) | 5.5 | 8.4 | 3.4 - 7.6 | 8.6 | 9.1 | 6.3 - 10.9 | N.S. |
| Gravel (percent) | 21.0 | 12.9 | 17.7 - 24.3 | 27.7 | 9.2 | 25.4 - 30.0 | 0.01 |
| Rubble (percent) | 62.7 | 15.3 | 58.8 - 66.6 | 52.7 | 14.8 | 49.0 - 56.4 | 0.01 |
| Boulder (percent) | 1.9 | 7.0 | 0.1 - 3.7 | 1.0 | 2.0 | 0.5 - 1.5 | N.S. |
| Substrate embeddedness[3/] | 2.5 | 0.8 | 2.3 - 2.7 | 2.3 | 0.7 | 2.1 - 2.5 | N.S. |
| Instream veg. cover (feet) | 1.2 | 1.5 | 0.8 - 1.6 | 0.5 | 0.9 | 0.3 - 0.7 | 0.01 |
| Riparian | | | | | | | |
| Habitat type[3/] | 9.1 | 11.6 | 8.7 - 9.5 | 9.3 | 1.6 | 8.9 - 9.7 | N.S. |
| Bank cover stability[3/] | 3.4 | 0.6 | 3.2 - 3.6 | 3.4 | 0.7 | 3.2 - 3.6 | N.S. |
| Stream cover[3/] | 1.9 | 0.3 | 1.8 - 2.0 | 1.8 | 0.4 | 1.7 - 1.9 | N.S. |
| Bank alteration (percent) | | | | | | | |
| Natural | 1.2 | 2.5 | 0.6 - 1.8 | 2.8 | 2.4 | 2.2 - 3.4 | 0.01 |
| Artificial | 47.8 | 7.3 | 46.0 - 49.6 | 49.6 | 9.8 | 47.1 - 52.1 | N.S. |
| Vegetative overhang (feet) | 0.61 | 0.64 | 0.44- 0.77 | 0.27 | 0.28 | 0.20- 0.34 | 0.01 |

[1/] S.D. = Standard deviation
[2/] C.I. = 95 percent confidence interval
[3/] Categorical variables, tables found in appendix A.

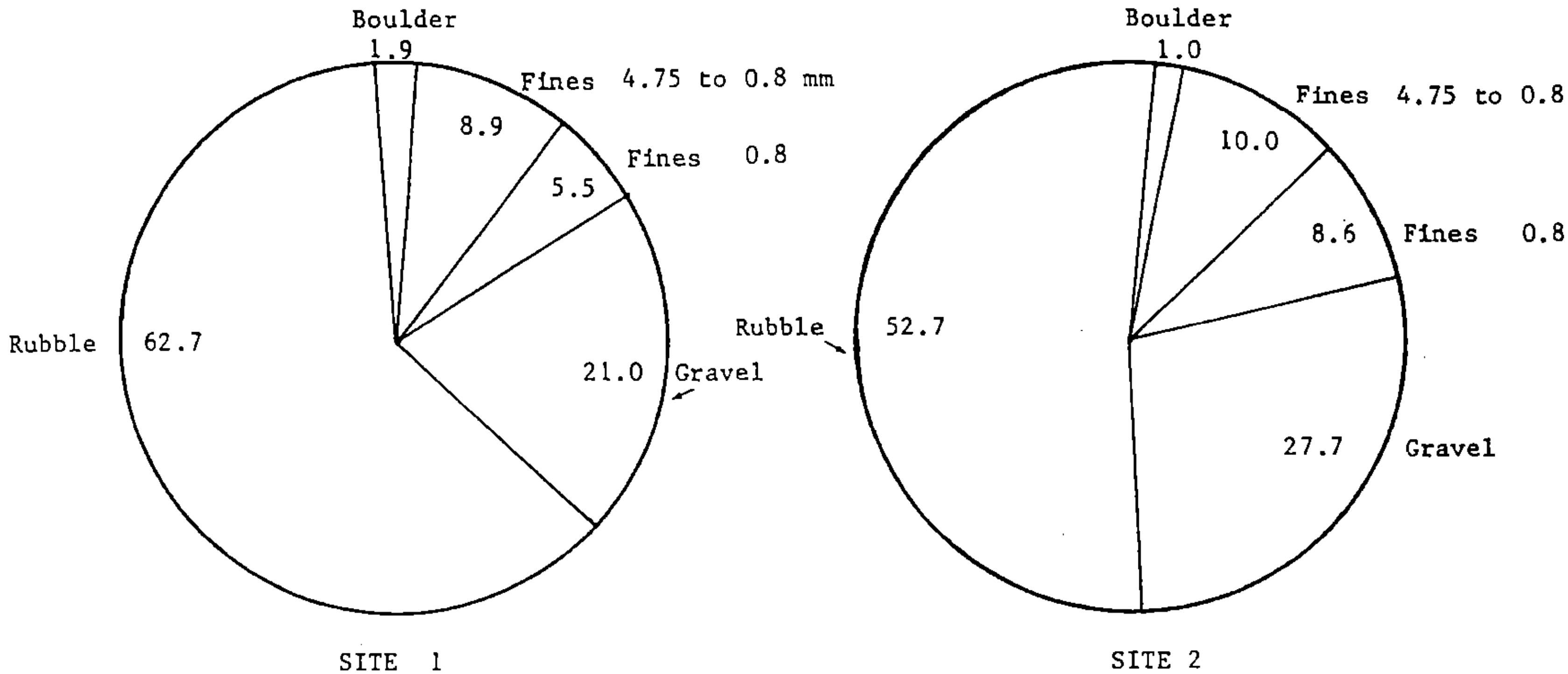


Figure 6.--Surface substrate composition (percent) of the Upper Red River study area, 1984.

Analysis of this area revealed the overall poor quality of aquatic and riparian habitat, especially salmonid rearing habitat, in this severely degraded section of Crooked River (Table 5-6). The river in this area is predominately straight, swift and shallow, possessing a large amount of riffle (Figure 7) especially in the upper sites where dredging and the presence of a small aircraft runway has resulted in a channel with little sinousity. In the upper four sites, pool form consists mainly of small pocket water stretches behind boulders and along the banks. The lower two reaches are beyond the influence of the runway, and had more pools because of the slight meanders and old K-dam structures still intact from previous rehabilitation efforts.

Bank angle averaged about 127 degrees overall, with the only significant difference found in the Log Sill stretch. Since the left bank (facing downstream) was formed by a similar process (dredging) throughout the study area, tailing piles had similar angle readings throughout each site, and differences between sites were influenced to a greater extent by situations found along the right bank where the river was up against natural conditions. The influence of these "dredge banks" is also noticeable in undercut and bank water depth. In our comparisons of channel study sites, Rechannel B had a significantly larger average undercut, while in the instream structure study area, both undercut and bank water depth were significantly different in the Log Sill Reach only.

Streambottom variables were similar throughout the six sites. The study area substrates, in order of relative abundance, are rubble, gravel, boulder and fine sediment (Figure 8). The amount of fine sediment is extremely low, primarily due to the higher water velocities and relatively small amount of pool created by mining activities. This is also evident in the very high substrate embeddedness ratings, indicating a low "gasket effect" on gravel and larger particle sizes. Significant differences are found in the amount of rubble and gravel in Rechannel B relative to the Channel Control; and in boulder, rubble and gravel in the Log Sill and Boulder sites. The amount of instream vegetation was low throughout the area, but the upper sites were slightly higher than the lower three sites.

We usually estimate streambank alteration in two categories, naturally caused and artificially caused. Due to the severity of past land use activities (mining), we lumped all streambank damage into one category in Crooked River. Alteration levels were high throughout the study area, with most streambank damage evident on the left bank. The unstable rubble and boulder composition of the bank has largely prevented the establishment of significant overhanging vegetation or even the formation of streambank soils and undercut banks.

Table 5.--Aquatic structural and riparian results, lower three Crooked River channel study sites, Nezperce N.F., Idaho, 1984.

| | RECHANNEL A | | | | RECHANNEL B | | | | Channel control | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Variable | Mean | S.D.[1/] | C.I.[2/] | Sign.[3/] | Mean | S.D. | C.I. | Sign. | Mean | S.D. | C.D. |
| Water Column | | | | | | | | | | | |
| Stream width (feet) | 31.3 | 3.8 | 30.0 - 32.6 | <0.05 | 27.6 | 3.6 | 26.3 - 28.9 | <0.01 | 34.1 | 7.4 | 31.5 - 36.7 |
| Stream depth (feet) | 0.61 | 0.36 | 0.48- 0.74 | N.S. | 0.88 | 0.41 | 0.73- 1.03 | <0.01 | 0.63 | 0.20 | 0.56- 0.70 |
| Riffle width (percent) | 57.9 | 38.8 | 44.0 - 71.8 | <0.01 | 65.6 | 35.3 | 53.0 - 78.2 | N.S. | 79.7 | 11.2 | 75.7 - 83.7 |
| Pool width (percent) | 42.1 | 38.8 | 28.2 - 56.0 | <0.01 | 34.4 | 35.3 | 21.8 - 47.0 | N.S. | 20.3 | 11.2 | 16.3 - 24.3 |
| Pool feature[4/] | 5.7 | 1.2 | 5.2 - 6.2 | - | 6.1 | 1.2 | 5.7 - 6.5 | - | 6.0 | 1.0 | 5.6 - 6.4 |
| Pool quality rating[4/] | 2.9 | 1.4 | 2.4 - 3.4 | - | 2.3 | 1.8 | 1.6 - 3.0 | - | 1.8 | 1.0 | 1.4 - 2.2 |
| Streambanks | | | | | | | | | | | |
| Bank angle (degrees) | 121 | 30.3 | 110.2 -131.8 | N.S. | 133 | 29.9 | 122.3 -143.7 | N.S. | 127 | 29.7 | 116.4 -137.6 |
| Bank undercut (feet) | 0.17 | 0.25 | 0.08- 0.26 | N.S. | 0.41 | 0.57 | 0.20- 0.62 | <0.01 | 0.14 | 0.25 | 0.05- 0.23 |
| Bank water depth (feet) | 0.25 | 0.36 | 0.12- 0.38 | N.S. | 0.29 | 0.48 | 0.12- 0.46 | N.S. | 0.12 | 0.20 | 0.05- 0.19 |
| Channel | | | | | | | | | | | |
| Fines 4.75 - 0.8 mm[5/] | 0.8 | 1.6 | 0 - 1.8 | N.S. | 1.2 | 2.4 | 0.4 - 2.0 | N.S. | 1.7 | 2.9 | 0.6 - 2.8 |
| Fines 0.8 mm[5/] | 0.9 | 2.7 | 0.3 - 1.5 | N.S. | 0.5 | 2.4 | 0 - 1.4 | N.S. | 1.8 | 3.1 | 0.8 - 2.8 |
| Gravel[5/] | 20.9 | 10.6 | 17.1 - 24.7 | N.S. | 23.8 | 13.0 | 19.1 - 28.5 | <0.05 | 17.8 | 9.6 | 14.4 - 21.2 |
| Rubble[5/] | 74.0 | 11.5 | 69.9 - 78.1 | N.S. | 64.2 | 17.8 | 57.8 - 70.6 | <0.05 | 71.8 | 9.2 | 68.5 - 75.1 |
| Boulder[5/] | 3.9 | 4.3 | 2.4 - 5.4 | N.S. | 10.3 | 12.0 | 6.0 - 14.6 | N.S. | 7.0 | 6.3 | 4.8 - 9.2 |
| Substrate embeddedness[4/] | 4.1 | 0.7 | 3.8 - 4.4 | - | 4.7 | 0.5 | 4.5 - 4.9 | - | 4.3 | 0.6 | 4.1 - 4.5 |
| Instream veg. cover (feet) | 0.4 | 0.5 | 0.2 - 0.6 | N.S. | 0.3 | 0.8 | 0.03- 0.6 | N.S. | 0.5 | 0.9 | 0.2 - 0.8 |
| Riparian | | | | | | | | | | | |
| Habitat type[4/] | 10.8 | 3.3 | 9.6 - 12.0 | - | 10.5 | 2.2 | 9.7 - 11.3 | - | 10.8 | 3.5 | 9.5 - 12.1 |
| Bank cover stability[4/] | 3.3 | 0.5 | 3.1 - 3.5 | - | 2.8 | 0.7 | 2.6 - 3.0 | - | 2.7 | 0.7 | 2.4 - 3.0 |
| Stream cover[4/] | 1.9 | 0.7 | 1.6 - 2.2 | - | 1.7 | 0.7 | 1.4 - 2.0 | - | 1.8 | 0.7 | 1.5 - 2.1 |
| Bank alteration (percent) | | | | | | | | | | | |
| Artificial | 51.9 | 17.9 | 45.5 - 58.3 | <0.05 | 58.1 | 17.4 | 51.9 - 64.3 | N.S. | 60.8 | 13.4 | 56.0 - 65.6 |
| Vegetative overhang (feet) | 0.14 | 0.31 | 0.03- 0.25 | N.S. | 0.09 | 0.27 | 0 - 0.19 | N.S. | 0.19 | 0.29 | 0.09- 0.29 |

1/ S.D. = Standard deviation
2/ C.I. = 95 percent confidence interval
3/ Sign. = Significance compard to channel control.
4/ Categorical variables, tables found in appendix A.
5/ Substrate means are shown in percent.

Table 6.--Aquatic structural and riparian results for the upper three Crooked River channel study sites, Nezperce N.F., Idaho, 1984.

| | LOG SILL | | | | LOG SILL CONTROL | | | BOULDER REACH | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Variable | Mean | S.D.[1] | C.I.[2] | Sign.[3] | Mean | S.D. | C.I. | Mean | S.D. | C.D. | Sign. |
| **Water Column** | | | | | | | | | | | |
| Stream width (feet) | 24.1 | 2.5 | 23.2 - 25.0 | <0.01 | 35.6 | 7.7 | 32.8 - 38.4 | 31.8 | 4.1 | 30.3 - 33.3 | <0.01 |
| Stream depth (feet) | 0.84 | 0.11 | 0.80- 0.88 | <0.01 | 0.64 | 0.20 | 0.57- 0.71 | 0.75 | 0.15 | 0.70- 0.80 | <0.01 |
| Riffle width (percent) | 85.5 | 6.5 | 83.2 - 87.8 | <0.01 | 75.4 | 14.9 | 70.1 - 80.7 | 87.8 | 6.1 | 85.6 - 90.0 | <0.01 |
| Pool width (percent) | 14.5 | 6.5 | 12.2 - 16.8 | <0.01 | 24.6 | 14.9 | 19.3 - 29.9 | 12.2 | 6.1 | 10.0 - 14.4 | <0.01 |
| Pool feature[4] | 4.4 | 2.0 | 3.6 - 5.2 | | 5.3 | 1.2 | 4.9 - 5.7 | 6.1 | 1.6 | 5.5 - 6.7 | |
| Pool quality rating[4] | 1.2 | 0.4 | 1.0 - 1.4 | | 1.4 | 0.6 | 1.2 - 1.6 | 1.1 | 0.3 | 1.0 - 1.2 | |
| **Streambanks** | | | | | | | | | | | |
| Bank angle (degrees) | 114 | 23.9 | 105.4-122.6 | <0.01 | 134 | 19.7 | 126.9-141.1 | 136 | 29.9 | 125.3-146.7 | N.S. |
| Bank undercut (feet) | 0.14 | 0.16 | 0.08- 0.20 | <0.05 | 0.05 | 0.09 | 0.02- 0.08 | 0.09 | 0.20 | 0.03- 0.15 | N.S. |
| Bank water depth (feet) | 0.31 | 0.39 | 0.17- 0.45 | <0.05 | 0.06 | 0.15 | 0.01- 0.11 | 0.08 | 0.22 | 0.00- 0.16 | N.S. |
| **Channel** | | | | | | | | | | | |
| Fines 4.75 - 0.8 mm[5] | 1.8 | 2.6 | 9.98- 2.6 | N.S. | 2.5 | 4.3 | 1.8 - 3.2 | 0.9 | 2.4 | 0.1 - 1.7 | N.S. |
| Fines 0.8 mm[5] | 0.9 | 2.3 | 0 - 1.8 | N.S. | 1.0 | 2.0 | 0 - 2.5 | 1.1 | 2.2 | 0.3 - 1.9 | N.S. |
| Gravel[5] | 11.3 | 6.8 | 8.9 - 13.7 | <0.05 | 15.3 | 8.8 | 12.1 - 18.5 | 3.3 | 2.8 | 2.3 - 4.3 | <0.01 |
| Rubble[5] | 80.1 | 9.1 | 76.9 - 83.3 | <0.01 | 69.5 | 11.8 | 65.3 - 73.7 | 81.1 | 9.7 | 77.6 - 84.6 | <0.01 |
| Boulder[5] | 5.9 | 7.0 | 3.4 - 8.4 | <0.01 | 11.6 | 5.8 | 9.5 - 13.7 | 13.7 | 9.8 | 10.2 - 17.2 | N.S. |
| Substrate embeddedness[4] | 4.5 | 0.5 | 4.3 - 4.7 | | 4.5 | 0.6 | 4.3 - 4.7 | 4.7 | 0.5 | 4.5 - 4.9 | |
| Instream veg. cover (feet) | 1.0 | 1.9 | 0.1 - 1.9 | N.S. | 0.7 | 1.8 | 0.1 - 1.4 | 0.8 | 2.2 | 0.0 - 1.6 | N.S. |
| **Riparian** | | | | | | | | | | | |
| Habitat type[4] | 12.7 | 2.8 | 11.7 - 13.7 | | 10.3 | 3.9 | 8.8 - 11.8 | 10.9 | 4.0 | 9.4 - 12.4 | |
| Bank cover stability[4] | 3.4 | 0.8 | 3.1 - 3.7 | | 3.0 | 0.7 | 2.7 - 3.3 | 2.8 | 0.7 | 2.5 - 3.1 | |
| Stream cover[4] | 2.1 | 0.3 | 2.0 - 2.2 | | 1.9 | 0.7 | 1.6 - 2.2 | 2.0 | 0.6 | 1.8 - 2.2 | |
| Bank alteration (percent) | | | | | | | | | | | |
| Artificial | 46.7 | 5.8 | 44.6 - 48.8 | <0.05 | 52.4 | 7.3 | 49.8 - 55.0 | 65.3 | 16.5 | 59.4 - 71.2 | <0.01 |
| Vegetative overhang (feet) | 0.17 | 0.37 | 0.04 - 0.30 | N.S. | 0.23 | 0.30 | 0.12 - 0.34 | 0.13 | 0.23 | 0.05 - 0.21 | N.S. |

[1] S.D. = Standard deviation
[2] C.I. = 95 percent confidence interval
[3] Sign. = Significance compard to channel control.
[4] Categorical variables, tables found in appendix A.
[5] Substrate means are shown in percent.

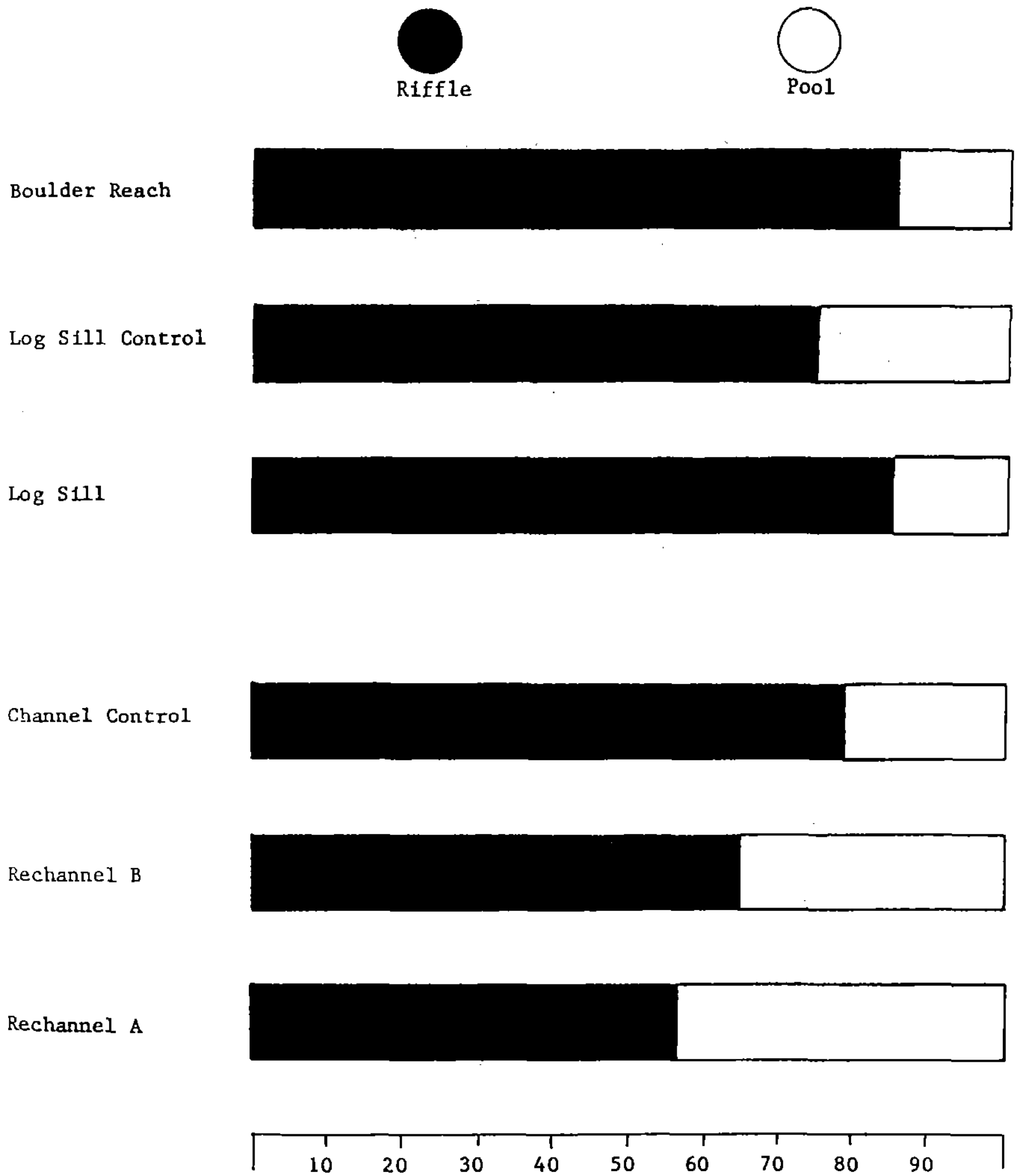


*Figure 7.--Pool and riffle percentage of the Crooked River study area sites, 1984.*

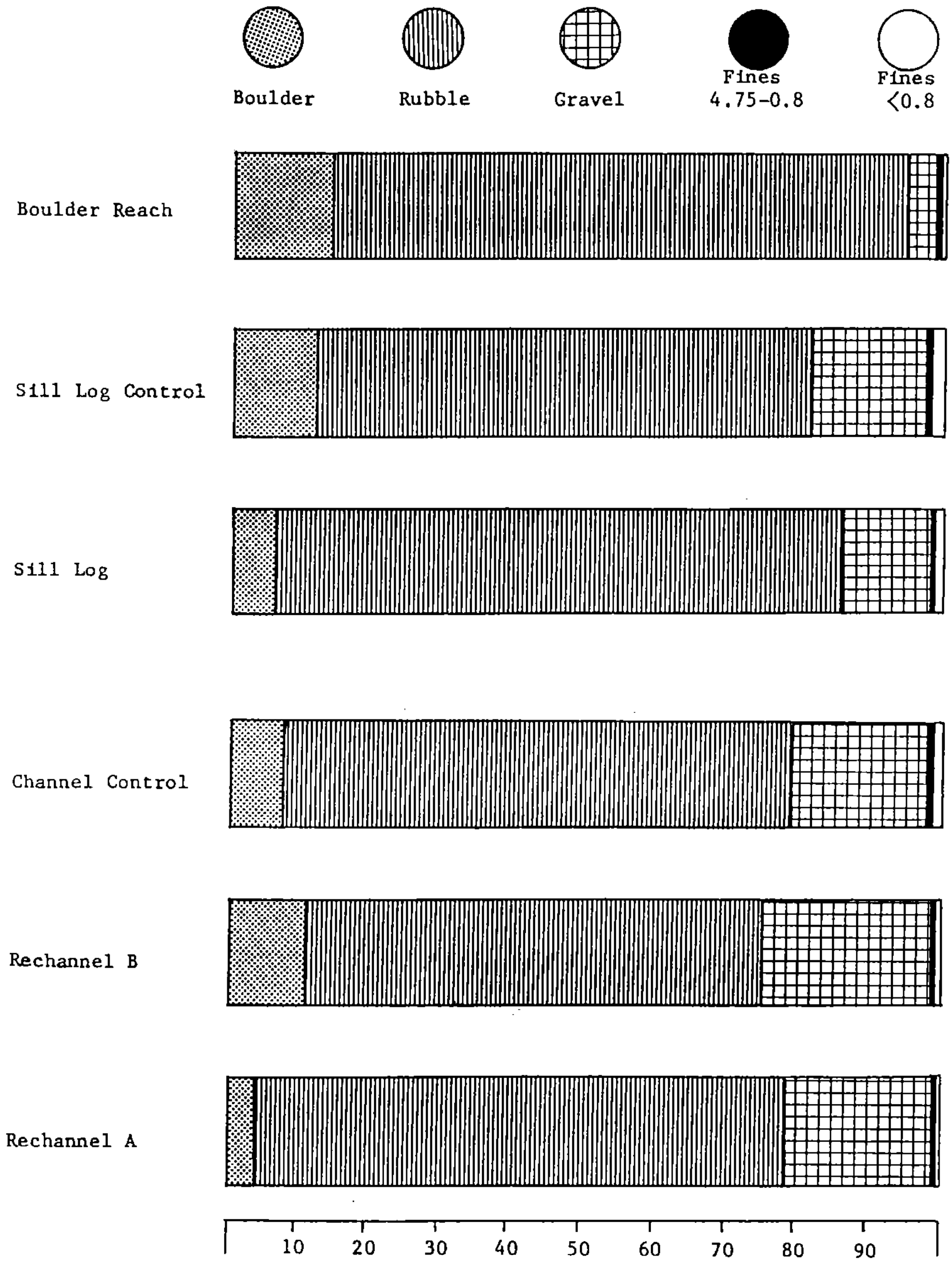


Figure 8.--Surface substrate composition of the Crooked River study area sites, 1984.

## RECOMMENDATIONS

This report documents initial conditions in the Crooked River, Upper Red River, and Lower Bear Valley areas. Further study will be required to evaluate the impacts and long-term dependability of the rehabiliation and enhancement projects installed in 1984. Recommendations for 1985 are as follows:

1. Evaluate the Crooked River rehabilitation and enhancement structures after one year in place (summer 1985).

2. Evaluate the affects of instream enhancement projects in the Lower Red River area after one year in place (summer 1985).

3. After completion of the rechannelizing project on Crooked River, set up new study sites and document aquatic habitat conditions (late summer 1985).

4. Assess aquatic habitat conditions on selected areas of Bear Valley as needed.

## LITERATURE CITED

Bailey, R. G. 1980. Description of the ecoregions of the United States. U.S. Department of Agriculture, Miscellaneous Publication No. 1391, 77 p.

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, 70 p.

Platts, W. S. and others. In preparation. Methods for evaluating riparian conditions. U. S. Department of Agriculture, Forest Service, GTR Intermountain Forest and Range Experiment Station. Ogden, UT.

Ray, G. A., and W. F. Megahan. 1978. Measuring cross sections using a sag tap: a generalized procedure. U.S. Department of Agriculture, GTR INT-47, 12 p.

SAS Institute Inc. SAS User's Guide: Statistics, 1982 Edition. Cary, NC: SAS Institute Inc., 1982. 584 p.

Original document's pages misnumbered--no page 25, 26, 27, or 28

APPENDIX A: Tables used to measure categorical-type habitat variables (from Platts and others 1983).

Table A-1.--Key to pool quality rating.

| | | Pool Rating |
|---|---|---|
| 1A | If the pool maximum diameter is within 10% of the average stream width of the study site[1/]....Go to 2 | |
| 1B | If the maximum pool diameter exceeds the average stream width of the study site by 10% or more....................................Go to 3 | |
| 1C | If the maximum pool diameter is less than the average stream width of the study site by 10% or more.......................................Go to 4 | |
| 2A | If the pool is less than 2 feet in depth........Go to 5 | |
| 2B | If the pool is more than 2 feet in depth........Go to 3 | |
| 3A | If the pool is over 3 feet in depth or the pool is over 2 feet in depth and has abundant fish cover[2/]........ | Rate 5 |
| 3B | If the pool is less than 2 feet in depth, or if the pool is between 2 and 3 feet and the pool lacks fish cover........................................ | Rate 4 |
| 4A | If the pool is over 2 feet with intermediate or better cover............................................ | Rate 3 |
| 4B | If the pool is less than 2 feet in depth but pool cover for fish is intermediate or better................. | Rate 2 |
| 4C | If the pool is less than 2 feet in depth and pool cover is classified as exposed.......................... | Rate 1 |
| 5A | If the pool has intermediate to abundant cover........... | Rate 3 |
| 5B | If the pool has exposed cover conditions................. | Rate 2 |

1/ A study area is the entire 1200-foot stream reach.

2/ (a) If cover is rated abundant, the pool has excellent in-stream cover and the perimeter has a fish cover.

(b) If cover is rated intermediate, the pool has moderate in-stream cover and one-half of the pool perimeter has fish cover.

(c) If the cover is rated exposed, the pool has poor in-stream cover and less than one-fourth of the pool perimeter has fish cover.

Table A-2--Embeddedness rating for channel materials (gravel, rubble, and boulder).

| Rating | Rating Description |
|---|---|
| 5 | The gravel, rubble, and boulder particles have less than 5 percent of their perimeter (surface) covered by fine sediment. |
| 4 | The gravel, rubble, and boulder particles have between 5 to 25 percent of their perimeter (surface) covered by fine sediment. |
| 3 | The gravel, rubble, and boulder particles have between 25 and 50 percent of their perimeter (surface) covered by fine sediment. |
| 2 | The gravel, rubble, and boulder particles have between 50 and 75 percent of their perimeter (surface) covered by fine sediment. |
| 1 | The gravel, rubble, and boulder particles have over 75 percent of their perimeter (surface) covered by fine sediment. |

Surface area incorporates the entire substrate particle. The underside and edge of the substrate especially provide the bulk of habitat for most aquatic insects.

Table A-3.--Streamside cover rating.

| Rating | Streambank Cover |
|---|---|
| 4 (tree) | The dominant vegetation influencing the streamside and/or water environment is of tree form. |
| 3 (brush) | The dominant vegetation influencing the streamside and/or water environment is brush. |
| 2 (grass) | The dominant vegetation influencing the streamside and/or water environment is grass or grasslike. |
| 1 (exposed) | Over 50 percent of the streambanks have no vegetation and the dominant material is soil, rock, bridge materials, road materials, culverts, mine tailings, etc. |

Table A-4.--Streamside cover as it relates to maintaining stability.

| Rating | Environment Conditions |
|---|---|
| 4 (Excellent) | Over 80 percent of the streambank surfaces covered by vegetation in vigorous condition or by boulder and rubble. These materials prevent water flows from eroding the streambanks. |
| 3 (Good) | 50 to 79 percent of the streambank surfaces are covered by vegetation or by gravel or larger material. These materials significantly buffer the banks allowing only minor damage. |
| 2 (Fair) | 25 to 49 percent of the streambank surfaces are covered by vegetation or by gravel or larger material. The streambank cover has some but only limited ability to inhibit erosion. |
| 1 (Poor) | Less than 25 percent of the streambank surfaces are covered by vegetation or by gravel or larger materials. This cover provides little or no control over erosion and such banks are usually damaged each year by high water flows. |

Table 5. Number of trout, salmon, and whitefish (number/100 $yd^2$) counted in Lolo Creek sections that were initially run habitat, July 10-13, 1984.

| Species, | Untreated run | | | 1983 sill log or K-dam | | | 1983 deflector log | | | 1983 root wad | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| age | 1 | 5 | 6 | 3 | 48 | 60 | 25 | 42 | 52 | 11 | 30 | 49 |
| Rainbow-steelhead | | | | | | | | | | | | |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| I | 10 | 16 (3.9) | 41 (9.7) | 13 | 15 (2.9) | 20 | 16 (6.3) | 27 | 15 | 4 | 14 (2.6) | 63 |
| II | 1 | 2 (0.5) | 9 (2.1) | 8 | 5 (1.0) | 9 | 6 (2.4) | 9 | 9 | 0 | 1 (0.2) | 13 |
| ≥III | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Chinook | | | | | | | | | | | | |
| 0 | 0 | 0 | 16 (3.8) | 30 | 2 (0.4) | 5 | 1 (0.4) | 23 | 1 | 1 | 69(12.6) | 61 |
| I+ | 0 | 0 | 0 | 3 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 |
| Whitefish | | | | | | | | | | | | |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| ≥I | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Table A-6.--Streamside habitat type rating.

| Rating | Streambank Material | | Rating | Streambank Material | |
|---|---|---|---|---|---|
| | Dominant | Subdominant | | Dominant | Subdominant |
| 1 | fines | fines | 13 | boulder | tree |
| 2 | fines | gravel | 13 | boulder | sod |
| 2 | fines | grass | 13 | boulder | brush |
| 2 | fines | rubble | 12 | root | fines |
| 3 | fines | boulder | 13 | root | gravel |
| 3 | fines | root* | 12 | root | grass |
| 3 | fines | tree** | 13 | root | rubble |
| 3 | fines | sod*** | 13 | root | boulder |
| 3 | fines | brush | 13 | root | root |
| 4 | gravel | fines | 14 | root | tree |
| 5 | gravel | gravel | 13 | root | sod |
| 6 | gravel | grass | 14 | root | brush |
| 6 | gravel | rubble | 12 | tree | fines |
| 7 | gravel | boulder | 13 | tree | gravel |
| 8 | gravel | root | 13 | tree | grass |
| 8 | gravel | tree | 13 | tree | rubble |
| 7 | gravel | sod | 13 | tree | boulder |
| 8 | gravel | brush | 14 | tree | root |
| 8 | grass | fines | 14 | tree | tree |
| 9 | grass | gravel | 14 | tree | sod |
| 9 | grass | grass | 14 | tree | brush |
| 9 | grass | rubble | 12 | sod | fines |
| 9 | grass | boulder | 13 | sod | gravel |
| 11 | grass | root | 14 | sod | grass |
| 12 | grass | tree | 15 | sod | rubble |
| 13 | grass | sod | 16 | sod | boulder |
| 17 | grass | brush | 18 | sod | root |
| 8 | rubble | fines | 18 | sod | tree |
| 9 | rubble | gravel | 17 | sod | sod |
| 9 | rubble | grass | 19 | sod | brush |
| 10 | rubble | rubble | 17 | brush | fines |
| 10 | rubble | boulder | 20 | brush | gravel |
| 11 | rubble | root | 20 | brush | grass |
| 11 | rubble | tree | 21 | brush | rubble |
| 11 | rubble | sod | 22 | brush | boulder |
| 12 | rubble | brush | 23 | brush | root |
| 11 | boulder | fines | 23 | brush | tree |
| 12 | boulder | gravel | 24 | brush | sod |
| 12 | boulder | grass | 23 | brush | brush |
| 12 | boulder | rubble | | | |
| 12 | boulder | boulder | | | |
| 13 | boulder | root | | | |

* Should include only substantial roots, e.e. brush or tree roots.

** Downfall logs included.

*** Sod has an extensive root mass and is more stable than grass or grass tufts.

Table A-7.--Streambank soil alteration rating.

| Rating | Description |
| --- | --- |
| 100% to 76% | Streambanks intercepted by the transect line are severely altered. Less than 25% of the streambank is in a stable condition. Over 75% of the streambank is false, broken down or eroding. A bank previously altered is now classified as a false bank that has gained some stability, and cover is still rated as altered. Alteration is rated as natural, artificial or a combination of both. |
| 75% to 51% | Streambanks are receiving major alteration along the transect line. Less than 50% of the streambank is in a stable condition. Over 50% of the streambank is false, broken down, or eroding. A false bank that may have gained stability and cover is still rated as altered. Alteration is rated as natural, artificial or a combination of both. |
| 50% to 25% | Streambanks are receiving only moderate alteration along the transect line. At least 50% of the streambank is in a natural stable condition. Less than 50% of the streambank is false, broken down, or eroding. False banks are rated as altered. Alteration is rated as natural, artificial or a combination of both. |
| 24% to 1% | Streambanks are stable but receiving some light alteration along the transect line. Less than 25% of the streambank is receiving any kind of stress and if stress is being received, it is very light. Less than 25% of the streambank is false, broken down, or eroding. Alteration is rated as natural, artificial or a combination of both. |
| 0% | Streambanks are stable and receiving no alteration from water flows, animal use, or other factors. |

Appendix B. Velocity and Flow Measurements: Crooked River sites.

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In lieu of sag tape channel cross sections which will be provided in a future report, a hydrologic data summary was also conducted on five transects within each study site in the Crooked River area. Stream gradient, stream width, depth and velocity measurements were taken at approximately 20 points across five systematically sampled transects (table B-1).

Gradients averaged slightly over 1 percent overall, ranging from 0.89 percent to 1.58 percent (table B-2). Average stream depth for the area ranged from 0.6 to 1.1 feet, and mean velocities ranged from 1.15 to 1.85 feet per second. There did not appear to be any trend in hydrologic variables measured, and although all sites were sampled during the same period, estimated flows calculated for each site varied widely. One possible explanation for this variation in flow may be differences in the amount of groundwater recharge and discharge within the highly permeable dredge tailings of the area. The large amount of variation in flow between transects (table B-1), may also be attributable to bias from sampling techniques.

A more detailed, sag tape cross section analysis is needed to determine the individual influences of each sample transect. With this analysis, the changes associated with stream enhancement projects should also become evident.

Table B-1.--Transect summaries by study site, Crooked River study area.

| Site/Transect | n[1] | Width (feet) | Avg. Depth (feet) | Avg. Velocity[2] (ft/sec) | Flow CFS) |
|---|---|---|---|---|---|
| Rechannel A | | | | | |
| T 5 | 20 | 33 | 0.5 | 2.55 | 50 |
| T 10 | 21 | 35 | 1.4 | 0.60 | 29 |
| T 15 | 19 | 31 | 0.6 | 1.60 | 30 |
| T 20 | 22 | 35 | 0.6 | 1.65 | 35 |
| T 25 | 18 | 29 | 0.8 | 1.80 | 42 |
| | | | | Mean | 37.2 |
| Rechannel B | | | | | |
| T 5 | 19 | 26 | 0.9 | 0.70 | 16 |
| T 10 | 22 | 29 | 0.8 | 1.55 | 36 |
| T 15 | 19 | 25 | 2.6 | 0.40 | 26 |
| T 20 | 20 | 32 | 0.7 | 1.45 | 32 |
| T 25 | 18 | 27 | 0.7 | 1.70 | 32 |
| | | | | Mean | 28.4 |
| Channel Control | | | | | |
| T 5 | 19 | 20 | 0.8 | 1.95 | 31 |
| T 10 | 22 | 41 | 0.7 | 1.80 | 52 |
| T 15 | 26 | 36 | 0.7 | 2.00 | 50 |
| T 20 | 23 | 42 | 0.7 | 1.85 | 54 |
| T 25 | 21 | 31 | 0.8 | 1.25 | 31 |
| | | | | Mean | 43.6 |
| Log Sill | | | | | |
| T 5 | 20 | 22 | 0.7 | 2.35 | 36 |
| T 10 | 24 | 26 | 0.7 | 2.05 | 37 |
| T 15 | 21 | 23 | 1.0 | 1.20 | 28 |
| T 20 | 17 | 21 | 0.8 | 1.75 | 29 |
| T 25 | 20 | 28 | 0.7 | 1.80 | 35 |
| | | | | Mean | 33.0 |
| Log Sill Control | | | | | |
| T 5 | 21 | 44 | 0.8 | 1.10 | 39 |
| T 10 | 15 | 40 | 0.6 | 1.95 | 47 |
| T 15 | 24 | 40 | 0.7 | 1.15 | 32 |
| T 20 | 17 | 27 | 0.8 | 1.70 | 37 |
| T 25 | 21 | 28 | 0.8 | 1.70 | 38 |
| | | | | Mean | 38.6 |
| Boulder Reach A | | | | | |
| T 5 | 37 | 35 | 0.7 | 1.40 | 34 |
| T 10 | 29 | 28 | 0.7 | 1.70 | 33 |
| T 15 | 23 | 24 | 0.6 | 1.45 | 21 |
| T 20 | 26 | 28 | 0.5 | 0.90 | 13 |
| T 25 | 18 | 33 | 0.6 | 1.55 | 31 |
| | | | | Mean | 26.4 |

[1] Sample size of each transect.

[2] To the nearest .05 ft/second.

Table B-2.--Average of hydrologic parameters measured in Crooked River study sties, 08/06/84 (averages based on five transect samples).

| Site | Average Velocity (ft/sec) | Average Depth (feet) | Estimated Flow CFS) | Gradient (percent) |
|---|---|---|---|---|
| Boulder Reach A | 1.40 | 0.6 | 26 | 1.10 |
| Sill Log Control | 1.50 | 0.7 | 39 | 1.36 |
| Sill Log | 1.85 | 0.8 | 33 | 0.89 |
| Channel Control | 1.75 | 0.7 | 44 | 1.37 |
| Rechannel B | 1.15 | 1.1 | 28 | 1.58 |
| Rechannel A | 1.65 | 0.8 | 37 | 0.89 |