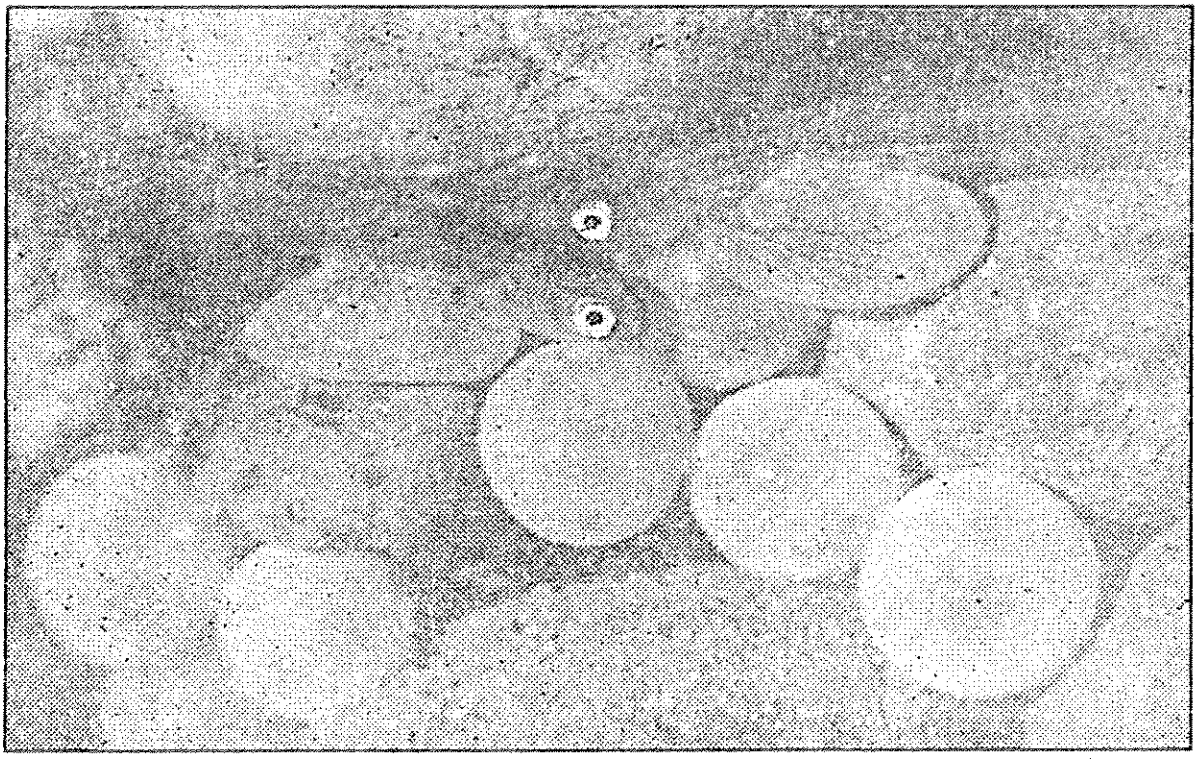
SALMON, SCOTT, AND MID-KLAMATH SUB-BASIN SPAWNING GROUND UTILIZATION SURVEYS 1989/1990 AND 1990/1991



Annual Report for Interagency Agreement 14-16-0001-90532
Submitted January 1992 to the Klamath River Basin Fisheries Task Force.

Annual Report

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SALMON, SCOTT, AND MID-KLAMATH SUB-BASIN SPAWNING GROUND UTILIZATION SURVEYS

1989/1990
and
1990/1991

by
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EXECUTIVE SUMMARY

Salmon, Shasta, Scott, and mid-Klamath River sub-basin tributaries support a major portion of the naturally spawning salmon and steelhead populations of Klamath River Basin. Spawner escapement and habitat use trends may be used to determine the rate which available habitat is presently utilized compared to its potential capacity. Assessment of the spacial and temporal aspects of salmon and steelhead spawning may also provide life history information critical to the maintenance of these populations.

This report summarizes the results of field work completed between October 1, 1989 and September 30, 1990 under an interagency agreement 14-16-0001-90532 between the U.S Department of Agriculture (USDA) and the U.S. Fish and Wildlife Service (USFWS). In addition, results of similar field investigations completed during the previous season (1988/89) are referenced for comparison. Further, results of spawning ground investigations conducted by the USDA for 1990/91 are included to provide three years of trend information.

The purpose of this study was to provide a multi-year assessment of habitat use by salmon and steelhead spawners in the Salmon, Scott, Shasta (Yreka Creek), and mid-Klamath River sub-basin tributaries.

Field crews conducted spawning ground surveys on each study area stream on a two week interval during the salmon (October - December) and steelhead (March - May) spawning period. Surveyors identified and enumerated redds, adult spawners, and carcasses, keeping records by pre-designated stream reach. The habitat type associated with each redd location, including whether the habitat had been enhanced by in-stream structures, was recorded. Redds were marked to avoid duplicate counting and where possible, snorkel surveys were employed to census holding fish. Spawning habitat was quantified during summer low flow conditions for both salmon and steelhead. Habitat specific spawner utilization rates were calculated relative to the availability of a particular habitat type. Biological information was collected from salmon carcasses in a pilot study to test the feasibility of using this type of information to assess escapement age structure of specific streams.

Approximately 67,000 m^2 of suitable salmon and/or steelhead spawning habitat was present under summer base flow conditions during the study period. Roughly 14,000 chinook redds and 45,000 steelhead redds could be accommodated by existing suitable habitat under base flow conditions, disregarding territorial needs of either species. Spawning habitat in Nordheimer, Shackleford/Mill, and Yreka Creeks was not readily accessible to chinook salmon during low fall flows experienced during 1988 through 1991. As a result, only about 49,700 m^2 of spawning habitat, which could accommodate 10,800 redds, was accessible to chinook.

A total of 1,349 chinook redds were counted in all study areas during fall 1989. Chinook spawning began in mid-September in the Salmon sub-basin study areas and concluded by late November in all sub-basins. During 1990 complete chinook salmon counts were performed on eight of the previously (1988 and 1989) censused streams, providing three years of comparable habitat use data. **A total of 577 chinook salmon redds were observed during the fall of 1990.** In general, chinook spawning began in mid-September and concluded by late November for 1988 through 1990 surveys. Redd counts for fall 1990 were dramatically lower in study area steams than previous 1988 and 1989 survey years.

Observations of coho salmon spawning were limited to mid-Klamath River basin tributaries during the study period. Coho fry were observed in several mid-Klamath sub-basin tributaries in the summer of 1989, indicating that at least some successful spawning occurred between December 1988 and March 1989. These streams include: Elk, Indian, Grider, Beaver, China, Independence, and Ti Creeks.

Spring conditions during 1990 and 1991 proved nearly optimal for surveys and may be responsible for the increase in number of steelhead redds observed from 1989. **A total of 1,492 steelhead redds were counted in all study areas during spring 1990.** Complete counts were obtained on five streams previously censused under USFWS contract. **Two hundred thirty-nine steelhead redds were observed during spring 1991 counts.** Habitat types used by steelhead for spawning varied between study areas. Steelhead spawning generally begins in late February and continues into mid-May, presumably extending alevin gravel residence into early July.

A summary of key findings was developed from the results of all study area streams and are listed below:

1) Significant numbers of chinook salmon utilized the mainstem Salmon River for spawning and holding during 1989 and 1990.

2) Adult american shad are present in the lower mainstem Salmon River as late as October.

3) Large numbers of chinook salmon and steelhead were observed immediately downstream from the Oak Bottom weir on the Salmon River during 1989/90 and 1990/91 surveys.

4) An estimated 67,000 m^2 of spawning habitat was present during low flow conditions which could accommodate roughly 14,000 chinook and 47,000 steelhead redds.

5) Significant declines in the number of salmon and steelhead redds observed occurred in most study area streams between 1988/89 and 1990/91.

6) Spring chinook salmon appear to exhibit spacial segregation from fall chinook during spawning within the Salmon River basin.

7) Steelhead spawning in Klamath River tributaries generally extends into May which implies steelhead egg and fry development extends through June.

8) In general, salmon and steelhead exhibited similar spawning habitat use patterns between 1988/89 and 1989/90 surveys.

Recommendations

1) Bio-enhancement objectives should be clearly defined before initiating projects of this nature. Careful consideration must be given to the possible impacts to endemic fish and aquatic species from this enhancement technique.

2) The Klamath Basin Restoration task force and California Department of Fish and Game (CDFG) should reconsider possible adverse impacts to spring-run chinook through introduction of pond reared fall-run chinook in the upper North and South Fork Salmon River and their tributaries. This action may contribute to hybridization between these stock groups.

3) CDFG should consider changing suction dredge operating season for Klamath River tributaries in Siskiyou County (Zone D) to June 15 or July 1 to September 15, to reduce potential impacts to larval steelhead development. The Klamath National Forest and CDFG should strengthen coordination and enforcement of dredge operating permits on Klamath River tributaries. Out-of-season extensions granted to suction dredge operators should be coordinated with existing site specific spawning ground information.

4) CDFG should strongly consider a closure to angling from the Oak Bottom Weir downstream to at least George Geary fishing access during periods of weir operation due to fish concentrations in this vicinity.

5) Expand spawning ground surveys to include tributaries with minimal effects from land management and stocking (eg. Dillon Creek, Clear Creek) to contrast health of remaining wild salmon and steelhead runs.

6) Expand chinook salmon spawning ground surveys to include mainstem Salmon River habitat from Butler Creek upstream to Nordheimer Creek to provide a clearer picture of stock distribution and habitat utilization within this watershed.

7) Complete investigations of spring chinook salmon rearing and spawning habitat use within the Salmon River basin.

8) Integrate stream mapping techniques with spawning ground investigations for the purpose of developing an inventory of persistent spawning beds. This information would aide resource managers and law enforcement personnel in the protection of these critical areas.

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Introduction

The Klamath River system provides habitat for chinook salmon Oncorhynchus tshawytscha, coho salmon O. kisutch, steelhead trout O. mykiss, and other anadromous and non-anadromous species. The upper Klamath system contains salmonid spawning and rearing tributaries of varying size. The Salmon, Scott, and Shasta Subbasins are considered to be important to the maintenance of wild salmonid populations in the Klamath system between Iron Gate dam and the Trinity River (Kier et al. 1991). Smaller tributaries (e.g. Elk, Indian, Grider, and Beaver Creeks) provide habitat conditions which help to maintain basin-wide genetic diversity.

As a result of reported declines in fish production over past decades, Congress enacted the Klamath River Fish and Wildlife Restoration Act (P.L. 99-552) on October 27, 1986. This law authorized the Secretary of Interior to restore anadromous fish populations to optimum levels in the Klamath and Trinity Rivers through a program of fish harvest management and habitat restoration. A Klamath River Fishery Management Council was established to recommend management of fish harvests and a Task Force was established to implement appropriate habitat restoration measures.

The Klamath National Forest conducted investigations of fish habitat condition and utilization in Salmon, Scott, Shasta, and Mid Klamath subbasins under an Interagency Agreement with the U.S. Fish and Wildlife Service in fiscal year 1989. Two reports summarizing the results of field work completed between October 1, 1988 and September 30, 1989 were published in 1990 (West et al. 1990; Olson and West 1990). Field work focused on identification of salmonid spawning and rearing habitat condition and use. Eleven streams (total length 208 km (125 mi)) located in Salmon, Scott, Shasta, and Mid-Klamath subbasins were investigated. Additionally, the performance of ten in-stream structure types was evaluated under the same agreement and the results were reported separately.

Little site specific information was available on habitats being selected by spawners, duration of spawning, overall condition and availability of spawning habitat, and extent of habitat utilization prior to these investigations.

In 1989 the Klamath National Forest proposed to expand rearing and spawning habitat investigations to include anadromous habitat in the mainstem Salmon River and unsurveyed reaches of the North Fork and South Fork Salmon River. Results of work undertaken in FY89 led to the proposed elimination of the Shasta River reach. The current work was funded by another Interagency Agreement

(#14-16-0001-90532) to be undertaken between October 1, 1989 and September 30, 1990. The results of these investigations are summarized in this report. In addition, results of steelhead and salmon spawning ground surveys conducted by the Klamath National Forest, for fall 1990 and spring 1991, are included in this report. An analysis of habitat types associated with spawning habitat during 1990/91 season are not included in this report.

The purpose of this study was to provide a multi-year comparison of spawner use throughout the Salmon, Scott, and mid-Klamath sub-basins. The study area was expanded to encompass a greater percentage of chinook spawning habitat in the Salmon River sub-basin. Specifically, the questions to be answered in this paper are:

a) Were habitats selectively used by chinook, coho, and steelhead spawners during 1989/90? How does this use compare to 1988/89 results?

b) How much suitable spawning habitat is available at base flow levels in each system for each species and how is it distributed? Compare spawning habitat availability during base and spring flow periods.

c) Does distribution of spawners change from year to year?

d) Does distribution of spawners change throughout the spawning period?

e) What is the timing and duration of spawning activities in each system? How do results of 1988/89, 1989/90, and 1990/91 compare?

f) What measures might be employed to increase survival of incubating eggs?

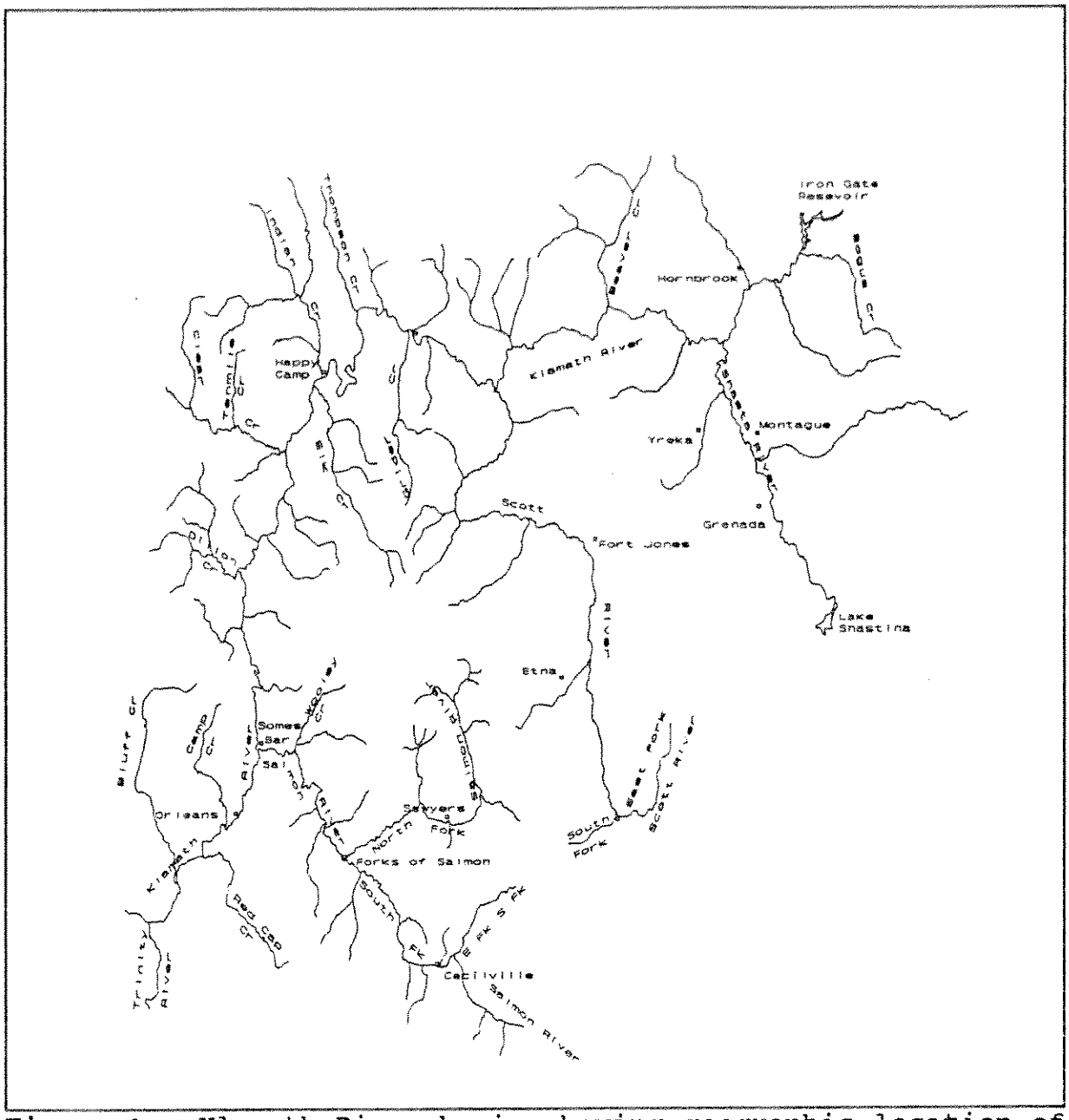

Figure 1. Klamath River basin showing geographic location of study area.

Study Area

The study area includes tributaries located in the Salmon, Scott, and mid-Klamath sub-basins of the Klamath River Basin (Figure 1). Stream reach designations for tributaries and the subject species are summarized in Table 1.

Table 1. Summary of stream reaches and species investigated during 1989/90 spawning ground surveys.

Sub-basin/Tributary	Area Surveyed	Species
Salmon Sub-basin		
South Fork Salmon River	Little S. Fk to Cecil Ck	Steelhead
	Little S. Fk to Forks[1]	Chinook
North Fork Salmon River	Rt. Hand Fk to Whites Gl	Steelhead
	Rt. Hand Fk to Forks[2]	Chinook
Mainstem Salmon River	Forks to Bloomer Falls/ Wooley Ck to Mouth[3]	Chinook
Nordheimer Creek	Granite Ck to Mouth	Chin/Sthd
Scott Sub-basin		
Scott River	Jones Beach to Mouth	Chinook
Shackleford Creek	Mill Ck to Mouth	Chin/Sthd
Shasta Sub-basin		
Yreka Creek	Montague Rd. to Mouth	Steelhead
Mid-Klamath Sub-basin		
Beaver Creek	Grouse Ck to Mouth	Chin/Sthd
Grider Creek	Stones Valley Ck to Mth	Chin/Sthd
Indian Creek	Green Ck to Mouth	Chin/Sthd
Elk Creek	Bear Ck to Mouth	Chin/Sthd

Salmon Subbasin

The Salmon Subbasin ranges from the headwaters of the Salmon River to the Klamath River near Somes Bar. The watershed area is 1943 km^2 (750 mi^2) and nearly all ownership is public, under management of the Klamath National Forest (CH2M Hill 1985). The Salmon River is a federally designated Wild and Scenic River.

[1] Expanded from FY89 survey to include Cecil Ck to Forks, 16 miles

[2] Expanded from FY89 survey to include Whites Gulch to Forks, 15.5 miles.

[3] Fy89 surveys included no mainstem habitat, new reach includes 10.5 miles.

Salmon River

The Salmon River study area includes mainstem habitat from the Klamath River confluence upstream to Forks of Salmon. Mainstem habitat was included for chinook salmon surveys only and excluded the river gorge from Wooley Creek upstream to Nordheimer Creek. Two reaches, from Wooley Creek 6.4 km (4 mi.) to the mouth and Forks of Salmon 7.2 km (4.5 mi.) to Nordheimer Creek were surveyed within this study area during the 1989/90 season.

South Fork Salmon River

The South Fork Salmon study area is located in the upper portion of the basin, from the mouth at Forks of Salmon upstream to the Little South Fork. The study area for chinook salmon was expanded from 1988/89 surveys to include to an additional 29 km (18 mi.) of habitat from the mouth of Cecil Creek to Forks. This addition resulted in a complete census of chinook spawning habitat on the South Fork. The steelhead spawner survey reach remained unchanged and extended 18.3 km (11 mi.) from Little South Fork to Cecil Creek.

North Fork Salmon River

The North Fork Salmon study area extended from the mouth at Forks of Salmon upstream 46.7 km (29 mi.) to the Right Hand Fork within the Marble Mountain Wilderness Area. The study area for chinook salmon was expanded from 1988/89 surveys to include an additional 29 km (18 mi.) of habitat from Whites Gulch to Forks. The study reach for steelhead included 18.3 km (11 mi.) of habitat from Right Hand Fork to Whites Gulch, unchanged from surveys conducted in 1988/89.

Nordheimer Creek

The Nordheimer Creek study area is predominately public land, except for one private parcel located 1.8 km from the mouth. The study area extends from the Salmon River upstream 6.7 km (4 mi.) to Granite Creek and remains unchanged from 1988/89 surveys. The entire area is characterized by a steep gradient channel (2%) well entrenched in a bedrock canyon. A fish ladder provides access to the upper 4.5 km (2.8 mi) of anadromous habitat.

Scott Subbasin

Located between the Shasta and Salmon Subbasins, the Scott Subbasin covers an area of approximately 2072 km^2 (800 mi^2). Land ownership is mainly private. The subbasin ranges from the Scott River headwaters in the Trinity Alps to the confluence of the Scott and Klamath Rivers (CH2M Hill 1985). The Scott River

is federally designated as Wild and Scenic from Meamber Bridge to the mouth. Results of 1989 work indicate that granitic sands negatively influence spawning and rearing habitat throughout the study area.

Scott River

The Scott River study area extends 30 km (18 mi.) from the Klamath upstream to Jones Beach Picnic Area. Spawner surveys were conducted for chinook salmon only within the study area which remained unchanged from 1988/89.

Shackleford/Mill Creeks

The Shackleford/Mill Creek study area extends from the confluence of Shackleford Creek with Scott River upstream about 10 km (6 mi) on Shackleford Creek to a 4 m high waterfall barrier and about 3.3 km (2 mi) upstream on Mill Creek to Quartz Valley School. The entire area is privately owned grazing and timberland. The study area remained unchanged from 1988/89 surveys.

Shasta Subbasin

This subbasin ranges from the headwaters of the Shasta River on Mt.Shasta to the river's confluence with the Klamath and includes the Little Shasta River. The area drained by the watershed totals approximately 1554 km^2 (600 mi^2), and is predominantly privately owned (CH2M Hill 1985).

Yreka Creek

The Yreka Creek study area extends from the Shasta River upstream 4.8 km (3 mi.) to Montague Road. This reach was reduced in length from 1988/89 and censused for steelhead spawning only.

Mid-Klamath Subbasin

This subbasin includes the Klamath River and its major tributaries from Iron Gate Dam to the Salmon River. It has a total area of approximately 3900 km^2 (1,500 mi^2). Ownership is a mixture of public and private holdings (CH2M Hill 1985).

Elk Creek

The Elk Creek watershed covers 254 km^2 (96 mi^2) and is situated entirely within the Klamath National Forest. Approximately 1/3 of the watershed lies within the Marble Mountain Wilderness. The study area extends from the mouth upstream 23.3 km (14 mi.) to Bear Creek and is unchanged from surveys conducted in 1988/89. Surveys were conducted for both chinook salmon and steelhead.

Indian Creek

The Indian Creek drainage basin covers 351 km^2 (135 mi^2) and is located entirely within the Klamath and Siskiyou National Forest boundaries. The study area extends 28.3 km (17 mi) from the mouth of Indian Creek upstream to Greens Creek. The surveys were conducted for chinook salmon and steelhead on the same reaches as in 1988/89.

Grider Creek

The Grider Creek watershed encompasses an area of 113 km^2 (43.6 mi^2), predominantly public land, managed by the Klamath National Forest, however the lower 3 km. of stream is privately owned. The study area extends from the Klamath River upstream 19.8 km (12.3 mi) to Stones Valley. Both chinook salmon and steelhead surveys were conducted on these reaches, unchanged from 1988/89.

Beaver Creek

The Beaver Creek drainage encompasses an area of 316 km^2 (121 mi^2) of mixed ownership lands, 60% of which is publicly owned and managed by the U.S. Forest Service (USFS) or Bureau of Land Management (BLM). The study area extends from the Klamath River upstream 20 km (12 mi.) to Grouse Creek. Both chinook salmon and steelhead surveys were conducted on these reaches, unchanged from 1988/89.

Materials and Methods

Each study area was surveyed during spawning season (chinook salmon: October through December; steelhead: March through mid-May) at biweekly intervals by two-person crews wearing either chest waders, wetsuits, or drysuits. When wading, surveyors wore polarized anglers glasses to aid in locating redds and improve safety. Once each day water and air temperatures were recorded, streamflow was estimated, and weather conditions were noted.

Redds were counted and each was marked by hanging colored flagging on nearby vegetation, adjacent to the redd pott to reduce the likelihood of duplicate counts of the same redd. The habitat type (Appendix A) associated with the redd was identified and recorded. Because spawning often occurs in the transition zone found at the tailout of pools (ie. pool to riffle), secondary habitat associations were also identified when describing spawning habitat preference. Occasionally, spawning areas were associated with "non-typical" habitat types (ie: spawning might be found in tailouts of pools which were not large enough to be classified as a distinct habitat type). On those occasions, spawning habitats were categorized into a major

spawning habitat type based on velocity associated with that area (eg: glide = low velocity spawning areas; run = higher velocity areas). Enhanced habitats were classified according to structure present. Because enhanced deflector and enhanced pocket types occurred together in the field, they were lumped together. Final groupings used for analysis were: low gradient riffle (Type 1); high gradient riffle (Type 2), glide (Types 14, 4, 5, 6, 7, 9, 13, 17, 18, 19, and 22), run (Types 15, 8, 10, 11, 12, 20, and 21), step run (Type 16); enhanced weir, and enhanced deflector/pocket.

Habitat specific spawner "utilization coefficients" were developed using the formula described by Bisson et al. (1982) to "relate the fraction of the population found within a particular habitat type to the relative abundance of that habitat type" in the study area. The formula used is:

$$\text{Utilization} = \frac{\text{habitat specific density} - \text{average total density}}{\text{average total density}}$$

where:

habitat specific density = average density (redds/sq.m.) in the habitat type of interest

average total density = average density (redds/sq.m.) over the entire study area, all habitat types containing spawning areas

Values of this coefficient can range from -1 to positive infinity; a negative value indicates that use of a specific habitat for spawning is less than the average use throughout the reach. A positive value indicates habitat specific spawning use greater than average. A value of zero indicates that the specific habitat is being used in proportion to it's occurrence in the study area. Some reaches were uncountable at times, especially during steelhead spawning, due to adverse viewing conditions.

Biological information was collected from salmon carcasses during spawning ground visits on the mainstem Salmon River, Elk Creek, and Indian Creek. Carcasses were identified to species, sex, and whether it had spawned. In addition, fork length and scales were collected when possible. Individual carcasses were marked with pink flagging tied at the caudal peduncle to avoid duplicate counting. Carcasses were then placed in the same location where originally located.

Results and Discussion

All Study Areas

Approximately 67,000 m^2 of suitable salmon and/or steelhead spawning habitat was present under summer base flow conditions during the study period (Table 2). From 1989 investigations average chinook redd surface area (4.6 m2; n= 520) and average steelhead redd surface area (1.5 m^2; n= 194) were not significantly different (p=0.05) between study areas or between habitat types within study areas (West et al. 1990). Roughly 14,000 chinook redds and 45,000 steelhead redds could be accommodated by existing suitable habitat under base flow conditions, disregarding any territorial needs of either species (Table 2). Spawning habitat in Nordheimer, Shackleford/Mill, and Yreka Creeks was not readily accessible to chinook salmon during low fall flows experienced during 1988 through 1991. As a result, only about 49,700 m^2 of spawning habitat, which could accommodate 10,800 redds, was accessible to chinook.

Table 2. Area (m^2) of available spawning habitat and potential number of redds accommodated on Salmon, Scott, and mid-Klamath sub-basin study streams.

	Spawning Habitat (m^2)		Redds Accommodated	
	Salmon	Steelhead	Salmon	Steelhead
Salmon River	1,500	1,500	330	1,000
N.Fk. Salmon	12,150	12,150	2,600	8,100
S.Fk. Salmon	14,600	14,600	3,200	9,700
Nordheimer Creek	635	635	140	420
Scott River	6,630	6,630	1,440	4,420
Mill/Shackleford	14,925	14,925	3,200	10,000
Yreka Creek	----	270	---	180
Beaver Creek	6,930	8,720	1,500	5,520
Grider Creek	4,500	5,660	980	4,500
Elk Creek	340	340	75	230
Indian Creek	2,400	2,400	520	1,600

1989-90 Field Season - A total of 1,349 chinook redds were counted in all study areas during fall 1989 (Table 3). Chinook spawning began in mid-September in the Salmon subbasin study areas and concluded by late November in all subbasins (Appendix B).

Observations of coho salmon spawning were limited to Elk and Indian Creeks during the 1989/90 study period. Coho fry were observed in several mid-Klamath Basin tributaries in summer of 1989, indicating that at least some successful spawning occurred between December 1988 and March 1989 in these streams as well. These streams include: Grider, Beaver, China, Independence, and Ti Creeks.

A total of 1,492 steelhead redds were counted in all study areas during spring 1990 (Table 4).

Habitat types used by steelhead for spawning varied between study areas (Appendix B); Present available spawning area can accommodate a maximum of 45,000 steelhead redds.

Table 3. Chinook salmon redds observed during fall spawning ground surveys conducted in 1988-1990 on Salmon, Scott, and mid-Klamath River sub-basin tributaries (ns = no survey; p/c = incomplete survey).

	1988	1989	1990
Salmon River	n/s	55	82
N.Fk. Salmon River	49[4]	207	103
S.Fk. Salmon River	334[5]	337	284
Nordheimer Creek	1	21	0
Scott River	804	411	p/c
Beaver Creek	138	9	10
Grider Creek	66	60	6
Elk Creek	97	104	37
Indian Creek	206	145	55

1990-91 Field Season - Complete chinook salmon counts were performed on eight of the previously (1988/89 and 1989/90) censused streams, providing three years of comparable habitat use data. A total of 577 chinook salmon redds were observed during the fall of 1990 (Table 3). This number does not include redds observed during partial counts of the Scott River. Spawning began in late September and concluded by late November. With the exception of Beaver Creek, redd counts were dramatically lower

[4] Partial survey - Right Hand Fork to Whites Gulch

[5] Partial survey - Little South Fork to Cecil Creek

than observed during previous years. For Beaver Creek, 1990 counts reflected the second consecutive year of low chinook use.

Coho salmon remained largely unobserved throughout the study period. However, a few adults were observed holding during late November in mid-Klamath tributaries, Elk and Indian Creeks. Thirteen coho salmon were reported by California Department of Fish and Game (CDFG) personnel operating the Salmon River weir during October, 1990.

Table 4. Steelhead redds observed during spring ground surveys conducted in 1989-1991 on Salmon, Scott, and mid-Klamath River sub-basin tributaries (n/s = no survey).

	1989	1990	1991
S.Fk. Salmon River	49	243	52[6]
N.Fk. Salmon River	16	179	n/s
Nordheimer Creek	37	107	22
Mill/Shackleford	279	511	n/s
Yreka Creek	177	73	103
Beaver Creek	57	57	3
Grider Creek	36	101	7
Elk Creek	66	105	24
Indian Creek	41	116	28

Although spring conditions provided nearly optimal survey conditions, effort was reduced for steelhead redd counts during 1991. Complete counts were obtained on five streams previously censused under a U.S. Fish and Wildlife Service (USFWS) contract (Table 4). Partial counts were obtained on an additional two streams. Two hundred thirty-nine steelhead redds were observed during spring 1991 counts (Table 4).

Further investigations were initiated to determine the incubation period and emergence timing of juvenile chinook salmon and steelhead based on rearing assessments conducted during summer 1989. Results of out-migrant and redd trapping conducted during spring 1991 in the South Fork Salmon River indicate chinook salmon fry may emerge as late as June and steelhead fry as late as July. Concurrent out-migrant investigations on Elk Creek show similar results.

[6] Partial Survey - Blindhorse Creek to East Fork of South Fork Creek.

Salmon Subbasin

Mainstem Salmon River

Results and Discussion

An estimated 1,500 m^2 of suitable salmon and steelhead spawning habitat was observed during the summer 1990 habitat condition survey. This habitat could potentially accommodate approximately 330 chinook redds and 1,000 steelhead redds. Spawning habitat was located in glide, run, low gradient riffle, and step-run habitat types.

Other species, including green sturgeon Acipenser medirostris, dace Cyprinus spp., Pacific lamprey Lampetra tridentata, and suckers Catostomus spp. have been observed in the mainstem, however, their population size and distribution were not assessed during these investigations.

1989-90 Field Season - Fifty-five chinook redds were observed in the two study reaches during fall 1989 (Appendix C). Of the redds observed, 85% occurred in run habitat, which accounted for only 25% of the total estimated spawning area, resulting in a positive utilization coefficient. Eight redds were distributed among the remaining habitat types resulting in negative utilization coefficients for each. Eighty-three percent of the glide habitat utilized by spawners was associated with pools. Of the total run habitat where redds occurred, 40% was associated with pool habitat. Spawning was observed from mid-October through mid-November in mainstem Salmon River. During the early October survey, 59 adult chinook and 410 steelhead were observed holding in pools immediately downstream of the Oak Bottom weir. By mid-October approximately 150 chinook and 750 steelhead were holding in pools below the weir. Late October counts were conducted after the weir was gone and showed 15 chinook and 29 steelhead below the weir.

Sixty adult american shad Alosa sapidissima (including 5 carcasses) were observed in early October. Mid-October counts found 130 shad holding in the lower Salmon River reach, both above and below the Oak Bottom weir.

No Coho salmon spawning was observed, however, small numbers of adult coho have been observed by CDFG personnel while operating the counting weir located at Oak Bottom. Field crews observed no juvenile coho during the summer season in the mainstem.

1990-91 Field Season - An additional 5.5 km (3.4 mi) of mainstem habitat, extending from Wooley Creek to Butler Creek was censused during fall 1990 chinook surveys. Eighty-two chinook redds were

observed in the two mainstem reaches which does not account for 10 km (6.2 mi) of habitat between Butler and Nordheimer Creeks. Nineteen redds were observed in the well confined reach between Wooley and Butler Creeks. Ten redds were located below the Oak Bottom counting weir. One hundred eighteen adult salmon were seen holding below the weir during the mid-October survey. Salmon and steelhead holding downstream from the Oak Bottom weir appear to concentrate in pools located between the weir and George Geary fishing access. Not surprisingly, shore anglers are often concentrated in this vicinity during the fall. Poor visibility (<0.3m) due to turbidity from Wooley Creek prevented crews from adequately assessing adult holding during the late October visit.

Ten adult american shad were observed above the Oak Bottom weir during mid-October surveys. Shad were seen as far upstream as Tripp Point at river kilometer 18 (11.3 mi) during the July adult spring-run chinook census.

No Coho salmon spawning was observed, although 13 adult coho were counted passing the weir by CDFG personnel.

Summary and Conclusion

From these investigations it is clear that large numbers of salmon, steelhead, and shad transit and hold in the lower mainstem Salmon River. In addition, chinook salmon and shad utilize mainstem habitat from Butler Creek to the mouth and Nordheimer Creek to Forks for spawning as well as rearing. Steelhead spawning in the mainstem has not been quantified, however it is believed to be light below Wooley Creek based on sporadic spring observations.
Nine and 17 percent of the redds observed in the Salmon River sub-basin occurred in the mainstem in 1989 and 1990 respectively. This does not account for spawning occurring in 10 km of habitat between Butler Creek and Nordheimer Creek.

Large numbers of chinook salmon and steelhead appear to be holding downstream from the Oak Bottom weir during October which indicates spawners may be temporarily delayed during a critical migration period. In addition, adult steelhead may be subjected to additional sport harvest due to increased vulnerability.

South Fork Salmon River

Results and Discussion

During 1989 surveys an estimated 14,602 m^2 of suitable spawning habitat was available in the study area during low flow conditions which could accommodate a maximum of 3,200 chinook redds and 9,700 steelhead redds.

1989-90 Field Season - A total of 337 chinook redds were counted in the study area during fall 1989 (Appendix D). These observations compare with 334 chinook redds identified during fall 1988 surveys which did not include the lower 29 km (18 mi) of South Fork habitat. Habitats artificially manipulated with in-stream structures (deflector, pocket water) were selectively used by chinook spawners as evidenced by positive utilization coefficients (Appendix D). Natural habitats selected for spawning were low and high gradient riffles and runs. Glides and step-run habitat were used less than average. Of the glides and runs utilized by spawners, 59% and 11% respectively were associated with pool habitat.

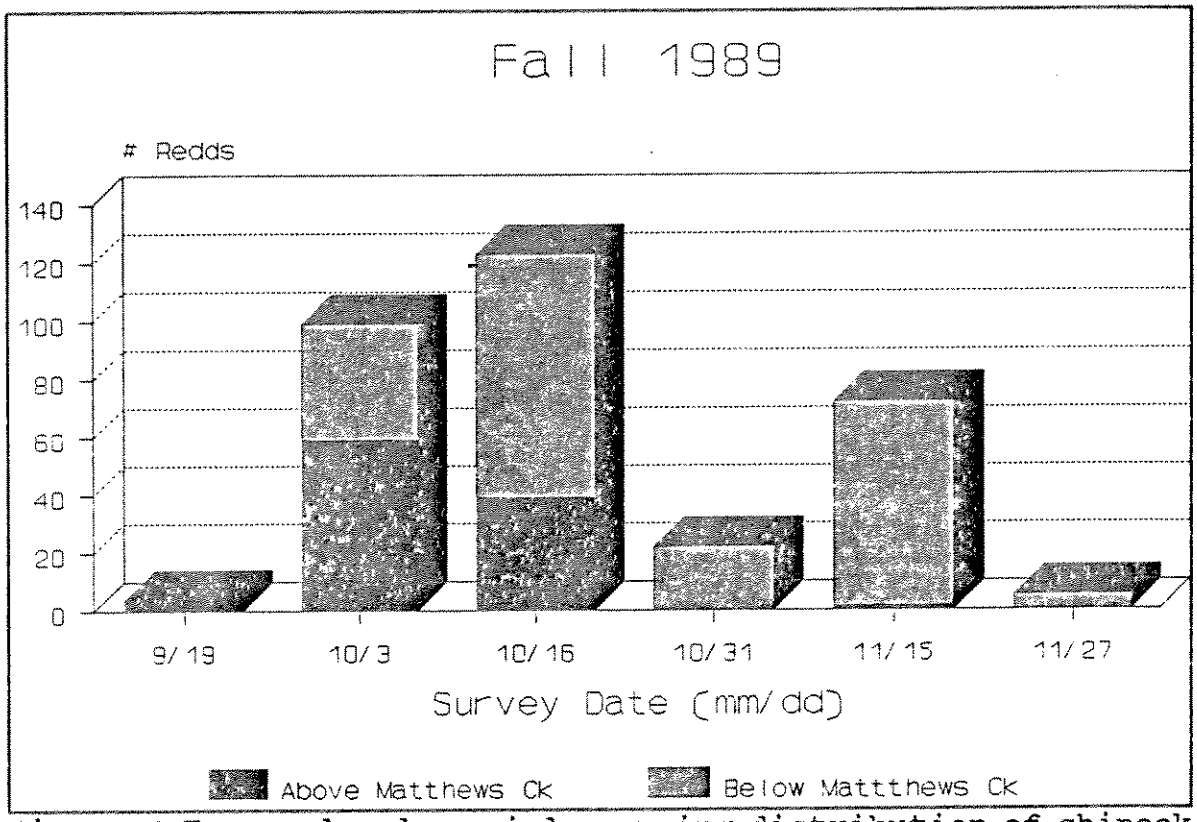

Figure 2 Temporal and spacial spawning distribution of chinook salmon in South Fork Salmon River above and below Matthews Creek during 1989.

Chinook spawning began in late-September, peaked in mid-October and again in mid-November, then concluded in late November. This pattern differs from that observed in fall 1988 and prompted further investigation. When redd counts conducted above and below Matthews Creek are displayed separately a temporal and spacial habitat use pattern becomes apparent (Figure 3) suggesting some separation between spring and fall runs. While an overlap exists between where and when spawners construct redds, it appears that redds constructed above Matthews Creek confluence are predominately of spring-run origin. This pattern was seen again and verified by radio telemetry tagging in fall of 1990 (DesLaurier, personal comm.). Other wild population of spring chinook in California display this pattern which tends to segregate spring and fall-run chinook populations during spawning (Marcotte 1984; CDFG 1990; Campbell and Moyle 1991).

No coho salmon spawning was observed, however, juvenile coho were observed during summer 1990 habitat utilization surveys conducted in the lower South Fork indicating that the study area was used by coho during the contract period.

Two hundred forty-three steelhead redds were observed in the study area during spring 1990 which was significantly higher than the 49 redds censused in 1989 (Table 3). This increase is likely attributed to mild spring weather and absence of high turbid flows, unlike those encountered during 1989, providing nearly ideal redd observation conditions. Habitats artificially manipulated with in-stream structures (weir, deflector, and pocket water) were selectively used by steelhead spawners as evidenced by high positive utilization coefficients (Appendix D). Margin areas associated with runs and high gradient riffle habitats were also selected for spawning. High gradient riffle associated spawning habitat was limited in the study area (only 72 m^2) which may lead to a false impression of that habitat's overall importance. Low gradient riffle, glides, and step runs were used less than average or not at all. Of those habitats utilized by steelhead spawners, 100% of glide, 46% of run, and 9% of low gradient riffle were associate with pool habitat. Spawning habitat utilization was very similar for 1988/89 and 1989/90 seasons. Steelhead spawning began in late February, peaked in early March, and concluded in late April (Appendix D).

1990-91 Field Season - Two hundred eighty-four spring and fall chinook salmon redds were observed in the study area during fall 1990. Spawning began the third week in September and extended through mid-November in the South Fork Salmon River. The 1990 census comprised comparable study reaches and resulted in 53 fewer redds (Table 3). As in 1989, a temporal and spacial overlap was observed between spring and fall chinook spawning (Figure 4). However, habitat above Matthews Creek was almost exclusively utilized by spring chinook.

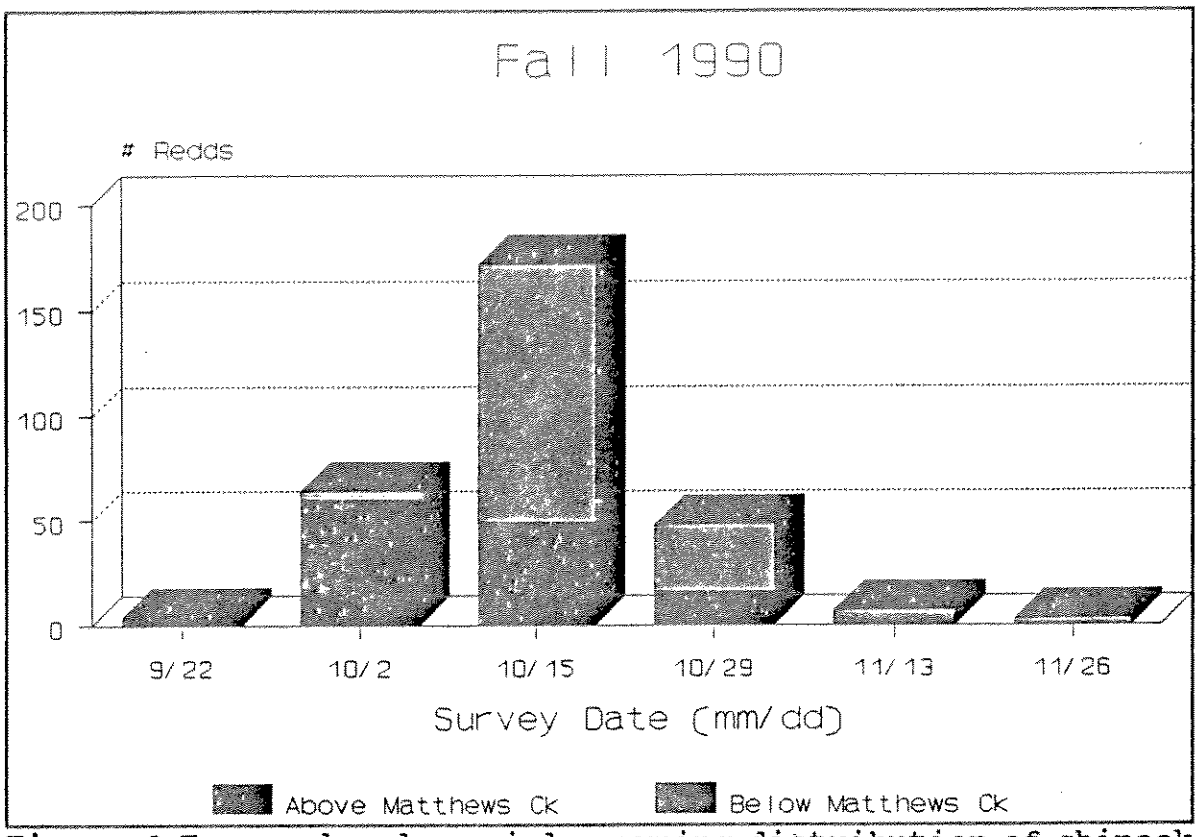

Figure 3 Temporal and spacial spawning distribution of chinook salmon in South Fork Salmon River above and below Matthews Creek during 1990.

Coho spawning was not observed during fall 1990 surveys.

Steelhead surveys were abbreviated from spring 1990 to include 9.7 km (6 mi) reaches from Blind Horse Creek to East Fork. Fifty-two steelhead redds were observed in the study area during spring 1991. Spawning was observed from late February through early May.

Summary and Conclusions

Sixty percent of the redds observed in the Salmon River Basin during fall 1990 occurred in the South Fork Salmon River. In 1989, 54% of the sub-basin redds were observed in the South Fork.

The South Fork Salmon River is utilized by spring-run and fall-run chinook salmon for spawning and rearing. Based in part on flow year, some spacial and temporal separation may exists during spawning between these runs. In general, spring-run salmon appear to utilize habitat farther upstream and spawn

approximately two weeks prior to fall-run chinook. During fall 1989 and 1990 redds occurring above Matthews Creek were predominantly of spring-run origin. **For this reason, barrier modification and bio-enhancement projects which may influence stock mixing should be evaluated carefully prior to implementation.**

Chinook fry may incubate in spawning gravels as late as June 1, and steelhead as late as July 15. Development rates for both the eggs and alevins are dependent on water temperature and time of spawning. **Some instream uses (ie. suction dredging) may impact incubating eggs or fry under the existing (1991) operating season (May 25-September 15). Special exclusionary permits, evaluated on site by site basis, which allow extended out of season operations have an even greater likelihood of negative impacts on emergent success.**

North Fork Salmon River

Results and Discussion

An estimated 12,156 m^2 of suitable salmon and steelhead spawning habitat was available in the study area, which could accommodate about 2,600 chinook redds and 8,100 steelhead redds. Over 87% of the available spawning habitat is associated with glides and runs.

1989-90 Field Season - Chinook spawners used very little glide and no high gradient riffle or step-run habitat. Run and low gradient riffle habitat were used preferentially and accounted for 82% of the total redds observed. Of the glide and run habitat utilized by chinook spawners, 43% and 17% of these habitats respectively were associated with pools.

Two hundred seven chinook redds were counted in the study area during fall 1989 (Appendix E) compared with forty-nine observed in fall 1988. Chinook spawning began in late September, peaked in late September and late October, then concluded in late November.

Coho salmon spawning was not observed. Juvenile coho, however, were observed in the lower North Fork during summer 1990, indicating that the study area was used by coho during the contract period.

One hundred seventy-nine steelhead redds were observed in the study area in spring 1989. Flow and observation conditions similar to those described for South Fork Salmon were encountered on the North Fork resulting in higher counts than obtained in spring 1989. Glide and run habitat accounted for 92% of the available spawning habitat although run habitat was selected for spawning at a level disproportionately higher than its

availability resulting in a positive utilization coefficient. Glides, were not well used, accounting for only 8% of the redds observed. Margin areas of low and high gradient riffles were also selected for spawning as evidenced by positive utilization coefficients. Ninety-three percent of glides and 55% of runs selected by spawners were associated with pool habitat. Spawning was observed beginning in late February, peaking in late March, and extending into early May (Appendix E).

1990-91 Field Season - Results from survey reaches investigated during fall 1990 were comparable to fall 1989. One hundred three spring and fall chinook redds were observed from mid-September through mid-November.

No Coho salmon spawning was observed in the study area.

No steelhead surveys were conducted during spring 1991 on North Fork Salmon River.

Summary and Conclusions

Extension of fall spawning surveys to include the lower reaches of the North Fork Salmon River has accounted for the majority of chinook salmon habitat use in this tributary. On average, 30% of the chinook salmon redds observed in the Salmon River sub-basin occurred in the North Fork during 1989/90 and 1990/91. Chinook utilization of available North Fork habitat appears low, relative to the quantity of habitat available, for both spring and fall runs.

Nordheimer Creek

Results and Discussion

An estimated 634 m^2 of suitable salmon and steelhead spawning habitat was available in the study area (West et al. 1990). This habitat could accommodate a maximum of 140 chinook redds and 424 steelhead redds.

1989-90 Field Season - Twenty-one chinook redds were counted in the study area during fall 1989. Seventeen of these redds were located in run habitat. Most of the spawning (80%) did not occur until mid-November, following an increase in flows. Three of the chinook redds were observed above the fish ladder. Access to the stream was restricted, but not impassable, by low flows over a broad alluvial fan at the mouth of the creek.

No coho salmon spawning was observed and juvenile coho were not seen in summer 1989, indicating that the study area was not used by coho during 1988 and 1989.

One hundred seven steelhead redds were observed in Nordheimer Creek, including 20 above the fish ladder, in spring 1990. Flow and observation conditions similar to those described for South Fork Salmon were encountered on Nordheimer Creek. Spawning habitat associated with runs received the largest use, accounting for 78% of the total redds. Spawning was first observed in late February and concluded in late April. No late spawning was observed in this study area, similar to observations in the South Fork Salmon study area (Appendix F).

1990-91 Field Season - Although habitat was accessible, no chinook salmon redds were observed in the Nordheimer Creek study area.

No coho salmon spawning was observed during fall 1990 surveys.

Twenty-two steelhead redds were observed during spring 1991 surveys conducted from mid-March through early May. Two of these redds occurred above the fish ladder.

Summary and Conclusions

Chinook use of Nordheimer Creek habitat appears to be highly variable and flow dependent. This condition has likely been aggravated by drought conditions encountered since this study began. Nordheimer Creek would seem to favor late run chinook due to accessibility and location in the lower river.

Steelhead use during the past three years also appears to vary, however the run size is relatively large for a small stream. **Introduction of hatchery or pond reared steelhead into this system could jeopardize the endemic run.**

Salmon and steelhead continue to access the upper 4.5 km (2.8mi) of anadromous habitat using the fish ladder constructed in 1987.

Scott Subbasin

Scott River

Results and Discussion

An estimated 6,630 m^2 of suitable salmon and steelhead spawning habitat was available in the study area, which could accommodate a maximum of 1,440 chinook redds and 4,420 steelhead redds (West et al. 1990).

1989-90 Field Season - Crews observed 411 chinook redds in the study area during fall 1989, compared with 804 redds in fall 1988 (Table 3). Although only 25% of the estimated spawning area occurred in run habitat, spawner use was disproportionately high,

accounting for 64% of the total redds observed. Glide, low gradient riffle, high gradient riffle, and step-run habitat had relatively low use, resulting in negative coefficients (Appendix G). Of the glides and runs selected by spawners only 6% and 1% respectively were associated with pools. Chinook spawning began in mid-September and concluded in mid-November.

No coho salmon spawning was observed in the study area during fall 1989 surveys.

1990-91 Field Season - Intensive spawning ground surveys were not conducted on Scott River or its tributaries during fall 1990.

Summary and Conclusions

Historically, spawning likely occurred high in the drainage in the less confined, lower gradient Scott Valley habitat. Much of the higher quality spawning habitat still remains on private land in the upper system. Spawning habitat within USFS boundaries is of generally poor quality and will remain so until the upper watershed conditions improve.

Shackleford/Mill Creeks

Results and Discussion

An estimated 14,925 m^2 of suitable salmon and steelhead spawning habitat was available in the study area (West et al. 1990), which could accommodate a maximum of 3,200 chinook redds and 10,000 steelhead redds.

1989-90 Field Season - No chinook spawning was observed in this study area, due to dewatered conditions at the confluence with Scott River until late December. Chinook spawning has been observed in this study area in previous years when flow conditions permitted access.

No coho spawning was observed in the study area because of the above mentioned fish access problem.

Five hundred eleven steelhead redds were observed during spring 1990 (Appendix H). This is nearly twice the number of steelhead redds observed in spring 1989 (Table 4). Low gradient riffle and run associated spawning habitat was used most extensively by steelhead spawners. High gradient riffle has a relatively high utilization coefficient although only 2% of the redds occurred there. Forty-five percent of the glides utilized by spawners were associated with pools. Spawning was first observed in late February, peaked in March and was completed by early May (Appendix H). Spawning in Mill Creek tended to be more uniform and less concentrated throughout the spawning period.

1990-91 Field Season - As in the previous two years (1988-89) Mill Creek was not accessible to fall-run Chinook salmon due to low flow conditions aggravated by drought. Fall counts were not conducted for this reason. Spring counts of steelhead utilization were not conducted in 1991.

Summary and Conclusions

Mill and Shackleford Creeks continue to provide spawning habitat for large numbers of steelhead despite lack of supporting rearing habitat. This habitat may act as a spawning refuge for displaced steelhead from other areas in the Scott River Basin. Steelhead fry continue to be rescued from dewatered habitat during the summer. These fish are presumably released into the Scott River. The long-term effects of this rescue and release strategy are unknown.

Shasta Subbasin

Yreka Creek

Results and Discussion

An estimated 270 m^2 of suitable spawning habitat was available in the study area, which could accommodate a maximum of 180 steelhead redds. The amount of this spawning habitat suitable for chinook use is variable and limited to the lower reach of stream when flows permit access.

1989-90 Field Season - No chinook spawning was observed in this study area, possibly due to low discharge conditions during the study period. Chinook spawning has been observed in previous years in the lower several kilometers of the study area by employees of CDFG.

No coho spawning was observed in the study area during the spawning habitat assessment study periods.

Seventy-three steelhead redds were observed in the study area in spring 1990. Spawning was first observed in mid March, peaked in April and was completed by early May (Appendix I).

1990-91 Field Season - Fall Chinook surveys were conducted by USFS crews from the Montague Road bridge to the mouth. No Chinook salmon were observed during fall 1990.

Steelhead surveys conducted during the spring of 1991 included habitat from the headwaters to the mouth. These counts were conducted cooperatively by Klamath National Forest and CDFG personnel. One hundred three steelhead redds were observed

during these counts which were conducted from mid-February through March. Of the redds observed, eighty occurred upstream from Montague Road.

Summary and Conclusions

Chinook salmon spawning in Yreka Creek has been variable, which is likely due to the absence of adequate flows during the fall. Yreka Creek continues to support a sizable steelhead run. Unlike steelhead counts throughout the remainder of the sub-basin, redd numbers declined in spring 1990 and experienced an increase in spring 1991 (Table 4). The 1990 results may be explained in part by favorable observation conditions on Yreka Creek in 1990, when the remaining sub-basin streams experienced high flows and turbid runoff. Possible reasons for increased redd numbers in spring 1991 when the other sub-basin study areas experienced substantial decreases are unknown.

Mid-Klamath Subbasin

Elk Creek

Results and Discussion

An estimated 342 m^2 of suitable spawning habitat was available in the study area, which could accommodate a maximum of 76 chinook redds and 228 steelhead redds (West et al. 1990). Eighty-eight percent of the available spawning habitat was associated with glide and high gradient riffle habitats.

1989-90 Field Season - Crews observed 104 chinook redds in the study area during fall 1989, increased slightly from the 97 redds observed in 1988 (Table 3). No redd superimposition was observed, though higher quality gravel beds were crowded with redds. Runs (7% of the available spawning habitat) received disproportionately high use by spawners, accounting for 50% of the redds observed. Glide habitat held 38% of the redds censused but maintained a lower than average redd density. Low and high gradient riffles received little or no use by spawning chinook. Enhanced weir habitat held 11% of the total redds observed in the study area. Chinook spawning began in mid October, peaked in late October, and was completed in the study area by mid-November (Appendix J). As observed in 1988, nearly all of the spawning occurred in the two week period of between late October and early November.

No coho were observed spawning in the study area. Use of the habitat by native-run coho is also supported by presence of juvenile coho during the summer rearing habitat evaluation period.

One hundred five steelhead redds were observed in the study area

in spring 1990 (Appendix J) compared to 66 seen in 1989 (Table 4). This increase is likely attributable to poor observation conditions in spring 1989 rather than a larger run size. Glide and run associated spawning habitat was selected by steelhead spawners. The spawnable habitat provided by enhanced weirs and pocket water in the study area was also selected by steelhead during the study period as evidenced by positive utilization coefficients (Appendix J). Spawning was first observed in early March, peaked in mid-April, and was completed by mid-May.

1990-91 Field Season - Fall 1990 surveys were conducted on reaches comparable to those surveyed in 1988 and 1989. Thirty-seven fall chinook redds were observed during fall 1990. Spawning began in mid-October, peaked in early November, and concluded by late November.

No Coho salmon spawning was observed during these surveys, however one coho carcass was found. Juvenile coho of were captured during out-migrant studies conducted in spring and summer of 1991 by USFS.

Twenty-four steelhead redds were observed during 1991 spring surveys conducted from late February through early May. Observation conditions were nearly ideal due to low spring run-off.

Summary and Conclusions

The number of 1989 fall chinook redds observed was slightly higher than in 1988, however, redd counts for 1990 decreased by nearly 60%. Habitat utilization patterns were not similar between 1988 and 1989. Enhanced weir habitat continued to receive high use by spawners in 1989. The compressed spawning period observed in fall 1988, was apparent again in 1989. The compressed spawning period may be the result of releasing progeny of Iron Gate Hatchery stocks from on-site rearing ponds.

The distribution of spawning among the four reaches investigated does not appear to be static, but changed from year to year (Figure 5). From 1988 to 1990, chinook spawning has been concentrated in the lower three reaches comprising habitat from the mouth to Doolittle Creek.

Fall spawning ground surveys conducted to date have not adequately assessed coho salmon runs in Elk Creek. Juvenile coho salmon continue to be observed despite infrequent adult sightings. Surveys should be conducted from mid-November through January to assess spawning habitat use by adult coho.

The number of steelhead redds observed in spring 1990 increased from 1989, although a substantial decline was recorded in spring 1991. Steelhead habitat utilization during 1989 and 1990 was

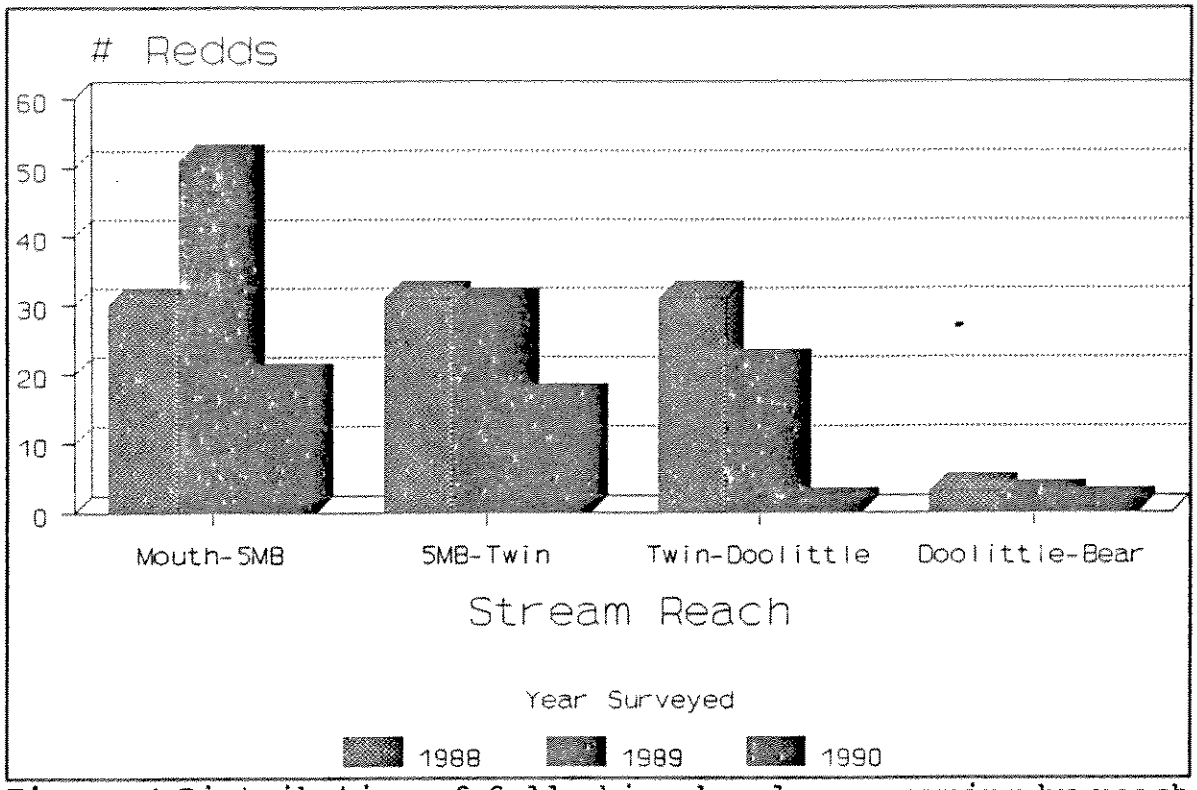

Figure 4 Distribution of fall chinook salmon spawning by reach on Elk Creek, CA 1988-1990.

similar. Steelhead spawning continues to be observed as late as May, suggesting egg and alevin gravel residence may continue through early July.

A sufficient number of chinook salmon carcasses might be recovered from this system to provide information on the age structure of the spawning population.

Indian Creek

Results and Discussion

An estimated 2,400 m^2 of suitable spawning habitat was available in the study area, which could accommodate a maximum of 520 chinook redds and 1,600 steelhead redds (West et al. 1990).

1989-90 Field Season - One hundred forty-five chinook redds were observed in the study area during fall 1989. This count is about 30% less than the 206 redds observed in fall 1988 (Table 3). Crowded spawning areas were evident near rearing ponds operated by CDFG, indicating that some of these fish may be pond returnees. In both 1988 and 1989 low gradient riffles and runs were selected for spawning. In 1989, 64% of the redds were associated with these habitat types. Enhanced deflector/pocket

water associated spawning areas received high chinook use. Conversely, enhanced weir spawning habitat exhibited below average use (Appendix K). Nearly 60% of the redds found in glide habitats occurred where glides were formed by 'pool tailouts'. Fifteen percent of runs utilized by chinook spawners were associated with pools. Chinook spawning began in late September, peaked in late October, and concluded in the study area by mid November (Appendix K).

We observed one coho redd in the study area during fall 1989. Adult coho were observed holding in the study area, however they had not spawned before the end of the study period in late-November. Use of the habitat by endemic coho is supported by presence of juvenile coho during the following summer months.

One hundred sixteen steelhead redds were observed in the study area in spring 1990 (Appendix K) compared to 41 redds observed in 1989 (Figure 4). Observed increases may be attributable to ideal observation conditions experienced in 1990. Run habitat was extensively selected by steelhead spawners. Enhanced weir, deflector, and pocket water habitats were used at or above average. Fifty-five percent of the glide habitat and 32% of the run habitat utilized by spawners was associated with pools. Steelhead spawning was first observed in late February, peaked in mid-April, and was completed by mid-May (Appendix K).

Recovery of fall chinook carcasses on Indian Creek (n>300) were used to describe the length frequency of the 1989 fall chinook salmon run this mid-Klamath tributary. Carcass lengths appear to be well distributed (Figure 6), and the mean carcass fork length (FL) was 73 centimeters (cm). Carcasses less than or equal to 56 cm were assumed to be jacks (USFWS 1990), of which 8 were collected with an average FL of 51 cm. Of the carcasses recovered where sex was identifiable, 1.2 males for each female were recovered. Only one of the female carcasses examined had not spawned.

1990-91 Field Season - Fifty-five chinook redds were observed during fall 1990 surveys. Seventy percent fewer chinook redds were found in 1990 than were observed in fall 1989 on Indian Creek. Reaches surveyed were comparable but visited less frequently than in previous survey years, however we are confident that the results accurately reflect adult habitat use during the spawning period.
No coho redds were found, although adults were observed holding in habitat above South Fork Indian Creek.

Twenty-eight steelhead redds were observed during spring surveys conducted between March and May 1991, a 76% reduction from the number of redds observed the previous year.

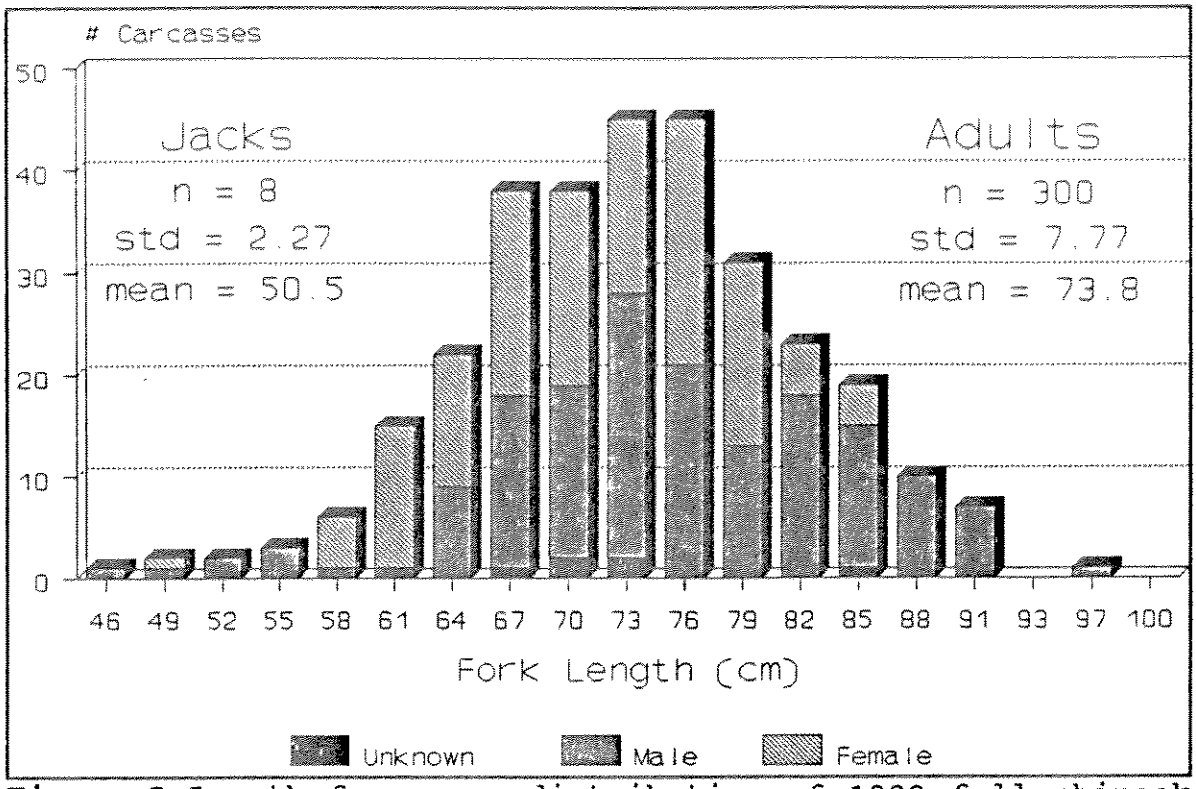

Figure 5 Length frequency distribution of 1989 fall chinook salmon run from carcass recoveries in Indian Creek, CA.

Only 40 fall chinook carcasses were recovered during fall 1990 surveys. Mean carcass fork length was 75 cm (Appendix K). Only one jack salmon was recovered. The sex ratio of carcasses recovered (only where sex was identifiable) was 1 male to 1.5 females. Only one of the females recovered had not spawned.

Summary and Conclusions

The number of fall chinook redds observed in fall 1989 decreased 30% from 1988. As with most of the sub-basin tributaries, the number of redds observed during 1990 was about one third the size of the 1989 census. The spawning period was longer in 1989 than 1988, extending into mid-November. The habitats selected by spawners was similar in 1988 and 1989, however run habitat received higher use in 1989. Chinook use of deflector/pocket water habitat increased between 1988 and 1989.

The distribution of chinook redds is generally concentrated in the lower two reaches which includes habitat from South Fork Indian Creek to the mouth. Most of the adjacent land in these reaches is privately owned including the chinook rearing pond site. The aggradational reach from Ikes Creek to South Fork Indian Creek provides ample spawning habitat. Much of the instream restoration activity undertaken to date has been concentrated on public land located upstream from South Fork

Indian Creek in an attempt to provide habitat higher in the system. No chinook spawning was observed above the confluence of West Branch Creek.

Limited coho spawning was observed in 1988 and 1989. Coho spawning observed to date has occurred upstream from South Fork Indian Creek where the stream is considerably smaller in size. When coho are observed, holding adults and rearing juveniles are usually associated with complex habitat composed of rootwads and/or logs.

Three times more steelhead redds were reported in 1990 than in 1989, probably due to improved observation conditions. During spring 1991 the number of steelhead redds was less than that reported in 1989 even though observation conditions were excellent. Habitats selected by spawners for redd construction were quite similar to those selected in 1989. Interestingly, 20% of the redds observed in spring 1990 were associated with instream structures. **In 1989, 1990, and 1991 steelhead spawning has continued into mid-May, with an average of 10% of the redds constructed at this late time. It is apparent that alevin gravel residence extends through June and possibly into July.**

Indian Creek has yielded large numbers of spawned chinook salmon carcasses in recent years from which survey crews have collected meristic data. These data can be used to determine the age composition of the run and possibly, success of a given cohort given age separation techniques available. As the run develops and more of the pond reared fish are marked it may be possible to evaluate the success of the bio-enhancement program on Indian Creek.

Grider Creek

Results and Discussion

An estimated 5,660 m^2 of suitable steelhead spawning habitat was available in the study area, which could accommodate 3,760 steelhead redds (West et al. 1990). Chinook salmon could only access the lower 9.1 km (5.6 mi) of habitat which provides 4,500 m^2 of spawning area, enough to accommodate a maximum of 980 chinook redds.

1989-90 Field Season - Crews observed 60 chinook redds in the study area during fall 1989, down slightly from fall 1988 (Figure 3). Spawner use of low gradient riffles was highest among habitat types associated where spawning habitat was available. Disproportionately heavy use of low gradient riffle habitat resulted in a very high positive spawner utilization coefficient during this study period. Eighty percent of the redds observed were associated with run and low gradient riffle habitat. Of

these habitats, 34% were associated with pools. Chinook spawning began in late October, peaked in early November, and was completed in the study area by late November (Appendix L).

No coho salmon spawning was observed during fall 1989 surveys.

One hundred-one steelhead redds were observed in the study area in spring 1990 compared to 36 redds in 1989 (Figure 4). As in several of the study area streams, an increase in the number of redds is likely a result of substantially better observation conditions in spring 1990. High, positive utilization coefficients were observed for spawning associated with low and high gradient riffles. However, run and low gradient riffle contained 90% of the observed steelhead redds. None of the spawning habitats utilized during these surveys were associated with pools. Spawning was first observed in late February, peaked in early April, and was completed by early May (Appendix L).

1990-91 Field Season - Fall chinook surveys were conducted using methods similar to those used in previous surveys. Six chinook redds were observed during fall 1990.

Coho salmon were not observed during the study period.

Seven steelhead redds were censused during spring 1991 surveys. As in previous years, snow precluded access to the upper reaches of Grider Creek during peak spawning.

Summary and Conclusions

The number of chinook redds observed by crews during 1988 and 1989 were nearly the same, although only 6 redds (10% of 1989 redds) were found in 1990. Habitat use by spawners still focused on low gradient riffle, however, high gradient riffle did not receive the utilization it received in 1988. Similar to observations on Indian Creek, the chinook spawning period was generally later in 1989 than 1988, extending into late November.

No information on coho salmon spawning was obtained for Grider Creek, although small numbers of rearing juvenile coho have been observed there in summer months.

During spring 1990, nearly 3 times more steelhead redds were observed in Grider than in 1989, again possibly due to more favorable observation conditions. However, 1991 surveys accounted for fewer than 10% of the previous years total redds. Habitats selected by spawners remained unchanged during 1989 and 1990, although the spawning period was more protracted in 1990. The spawning described in 1990 (late February-early May) may be more representative.

Beaver Creek

Results and Discussion

Prior to the debris torrent which occurred in August 1989, an estimated 8,270 m^2 of suitable spawning habitat was available in the study area, which would accommodate a maximum of 5,520 steelhead redds (West et al. 1990). Chinook salmon could only access the lower 12.4 km (7.7 mi) of habitat which provides an estimated 6,930 m^2 of spawning habitat, enough to accommodate 1,500 chinook redds.

1989-90 Field Season - Crews observed a total of 9 chinook redds in the study area during fall 1989. This is a substantial drop from the fall 1988 count of 138 redds. Redds were concentrated in the lower reach of Beaver Creek and were associated with run and enhanced weir habitats. Because of the low numbers of redds observed and unestimated quantity of spawning habitat available, it is not reasonable to display chinook spawner utilization further. Chinook spawning began in late October, and concluded by late November (Appendix M).

No coho salmon spawning was observed during fall 1989 surveys.

Fifty-seven steelhead redds were observed in the study area in spring 1990, the same number of redds observed in 1989. (Appendix M). Run habitat was used extensively by steelhead spawners, accounting for 72% of the redds observed. Low gradient riffle habitat was also utilized by steelhead spawners during the survey period. All of the glides and one third of the runs utilized by spawners were associated with pools. Unlike 1989 results, artificial structures were not used by steelhead spawners in 1990. Spawning was first observed in late February, peaked in early April, and was completed by early May (Appendix M).

1990-91 Field Season - Chinook redd counts were conducted using methods similar to previous surveys (1988 and 1989). Ten chinook redds were observed in fall 1990, all located in the lower reach of Beaver Creek.

No coho spawning was observed during the study period.

Three steelhead redds were observed during surveys conducted during spring 1991.

Summary and Conclusions

Chinook salmon runs in Beaver Creek have declined considerably in recent years. Unlike other streams in the study area, Beaver Creek showed a considerable decline in run size during fall 1989. The limited spawning which occurred in 1989 and 1990 was concentrated near the mouth. Perhaps not coincidentally, 1984

was the last year of chinook salmon rearing pond releases from Beaver Creek. Fall 1988 would have marked the return of 5 year old fish from pond operations. Of greater concern, however, is the fate of the endemic runs which were present prior to pond rearing operations. A significant effort should be made to restore that endemic stock group if enough individuals remain in the system to be used as brood stock. California Department of Fish and Game should investigate this and similar possibilities in the Klamath basin for application of 'wild trout hatchery' principles on a small scale.

As in the case of Grider Creek, no information on coho spawning was obtained, although juvenile coho have been observed in small numbers.

Declines in the number of steelhead redds have been just as dramatic as in other study area streams. Only 3 steelhead redds were observed during spring 1991. Habitat use patterns were not similar during 1989 and 1990 despite the occurrence of nearly the same number of redds. The spawning period during 1990 was more protracted than the previous year, and possibly more representative of a 'typical' season. As in other tributaries investigated, steelhead spawning continues into mid-May, extending alevin gravel residence through June.

Summary

All Study Areas

A summary of key findings was developed from the results of all study area streams and listed below:

1) Significant numbers of chinook salmon utilized the mainstem Salmon River for spawning and holding during 1989 and 1990.

2) Adult american shad are present in the lower mainstem Salmon River as late as October.

3) Large numbers of chinook salmon and steelhead were observed immediately downstream from the Oak Bottom weir on the Salmon River during 1989/90 and 1990/91 surveys.

4) An estimated 67,000 m^2 of spawning habitat was present during low flow conditions which could accommodate roughly 14,000 chinook and 47,000 steelhead redds.

5) Significant declines in the number of salmon and steelhead redds observed occurred in most study area streams from 1988/89 to 1990/91.

6) Spring chinook salmon appear to exhibit spacial segregation

from fall chinook during spawning within the Salmon River basin.

7) Steelhead spawning in Klamath River tributaries generally extends into May which implies steelhead egg and fry development extends through June.

8) In general, salmon and steelhead exhibited similar habitat use patterns between 1988/89 and 1989/90 surveys.

Recommendations

All Study Areas

1) Bio-enhancement objectives should be clearly defined before initiating projects of this nature. Careful consideration must be given to the possible impacts to endemic fish and aquatic species given this enhancement technique.

2) The Klamath Basin Restoration task force and CDFG should reconsider possible adverse impacts to spring-run chinook through introduction of pond reared fall-run chinook in the upper North and South Fork Salmon River and their tributaries. This action may contribute to hybridization between these stock groups.

3) CDFG should consider changing suction dredge operating season for Klamath River tributaries in Siskiyou County (Zone D) to June 15 or July 1 to September 15, to reduce possible impacts to steelhead early life history development. The Klamath National Forest and CDFG should strengthen coordination and enforcement of dredge operating permits on Klamath River tributaries. Out-of-season extensions granted to suction dredge operators should be coordinated with existing site specific spawning ground information.

4) CDFG should strongly consider a closure to angling from the Oak Bottom Weir downstream to at least George Geary fishing access during periods of weir operation due to fish concentrations in this vicinity.

5) Expand spawning ground surveys to include tributaries with minimal effects from land management and stocking (eg. Dillon Creek, Clear Creek) to contrast health of remaining wild salmon and steelhead runs.

6) Expand chinook salmon spawning ground surveys to include mainstem Salmon River habitat from Butler Creek upstream to Nordheimer Creek to provide a clearer picture of stock distribution and habitat utilization within this watershed.

7) Complete investigations of spring chinook salmon rearing and spawning habitat use within the Salmon River basin.

8) Integrate stream mapping techniques with spawning ground investigations for the purpose of developing an inventory of persistent spawning beds. This information would aide resource managers and law enforcement personnel in the protection of these critical areas.

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APPENDIX A. SPAWNING HABITAT CLASSIFICATION

Habitat Types	Number	Abbreviation
Riffles		
Low Gradient Riffle	1	LGR
Low Gradient Riffle/Pool	1/P	LGR/P
High Gradient Riffle	2	HGR
High Gradient Riffle/Pool	2/P	HGR/P
Flat Water		
Glide	14	GLD
Glide/Pool	14/P	GLD/P
Run	15	RUN
Run/Pool	15/P	RUN/P
Pocket water	21	POW
Modified Habitat		
Enhanced Weir	***	WEIR
Enhanced Deflector	***	DEFL
Enhanced Pocket Water	***	EPOW

APPENDIX B. SPAWNING HABITAT USE - ALL STUDY AREAS

Chinook Redd Counts
1989

Stream	Stream #	LGR	HGR	Run	Glide	SRun	Weir	Defl	PCT	Total
Beaver Ck	1	0	0	3	0	0	6	0	0	9
Elk Ck	6	1	0	52	39	0	11	0	1	104
Grider Ck	7	34	0	14	5	0	6	0	1	60
Indian Ck	8	7	0	86	36	0	7	1	8	145
NFk Salmon River	16	30	0	140	37	0	0	0	0	207
Nordheimer Ck	17	3	0	17	1	0	0	0	0	21
SFk Salmon River	19	96	3	203	29	1	1	0	4	337
Scott River	28	47	0	265	88	4	2	0	5	411
Mainstem Salmon River	35	1	0	47	6	1	0	0	0	55

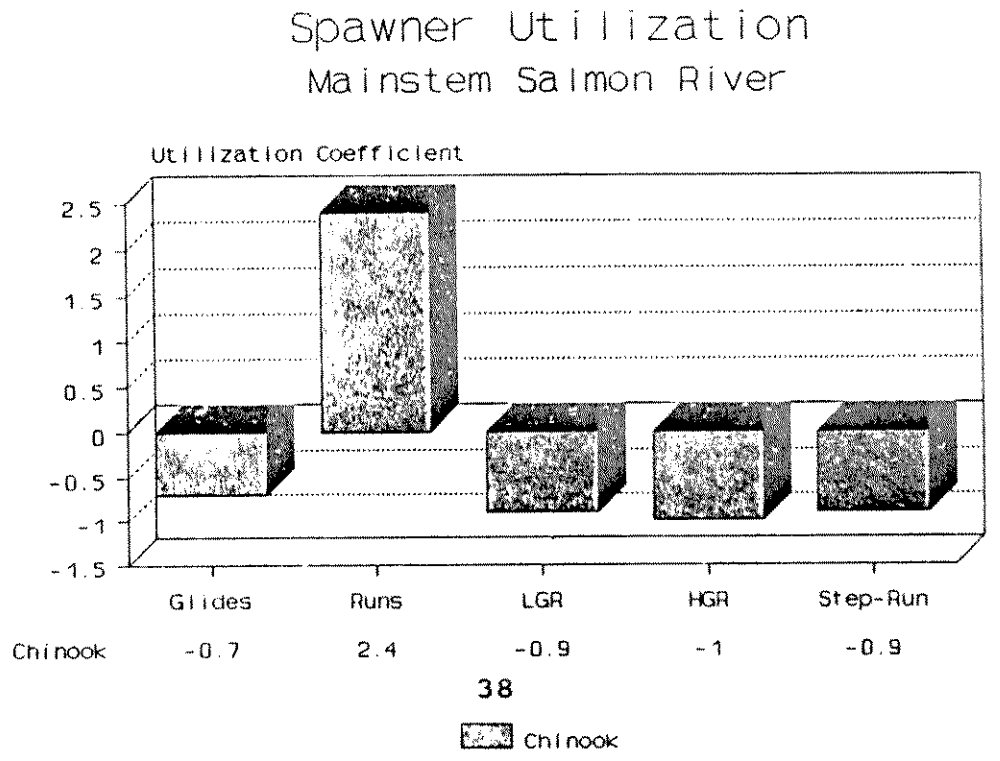
Steelhead Redd Count
1990

Stream	Stream #	LGR	HGR	Run	Glide	SRun	Weir	Defl	PCT	Total
Beaver Ck	1	10	2	41	4	0	0	0	0	57
Elk Ck	6	3	0	58	31	0	7	0	6	105
Grider Ck	7	40	5	51	5	0	0	0	0	101
Indian Ck	8	2	0	69	22	0	8	1	14	116
Shackleford/Mill	15	73	11	416	11	0	0	0	0	511
NFk Salmon River	16	12	2	151	14	0	0	0	0	179
Nordheimer Ck	17	22	3	78	4	0	0	0	0	107
SFk Salmon River	19	43	3	144	4	0	14	6	29	243
Yreka Ck	25	9	0	30	8	0	0	0	0	47

APPENDIX C. SPAWNING HABITAT USE - MAINSTEM SALMON RIVER

Mainstem Salmon River

	Glides	Runs	LGR	HGR	Step-Run	Weir	Defl/POW	Total
Spawning Area	437	328	327	0	196	0	0	1287
% Spawning Area	34%	25%	25%	0%	15%	0%	0%	
Chinook Redds	6	47	1	0	1	0	0	55
Chinook Redd Density	0.0137	0.1433	0.0031	N/A	0.0051	N/A	N/A	0.0427

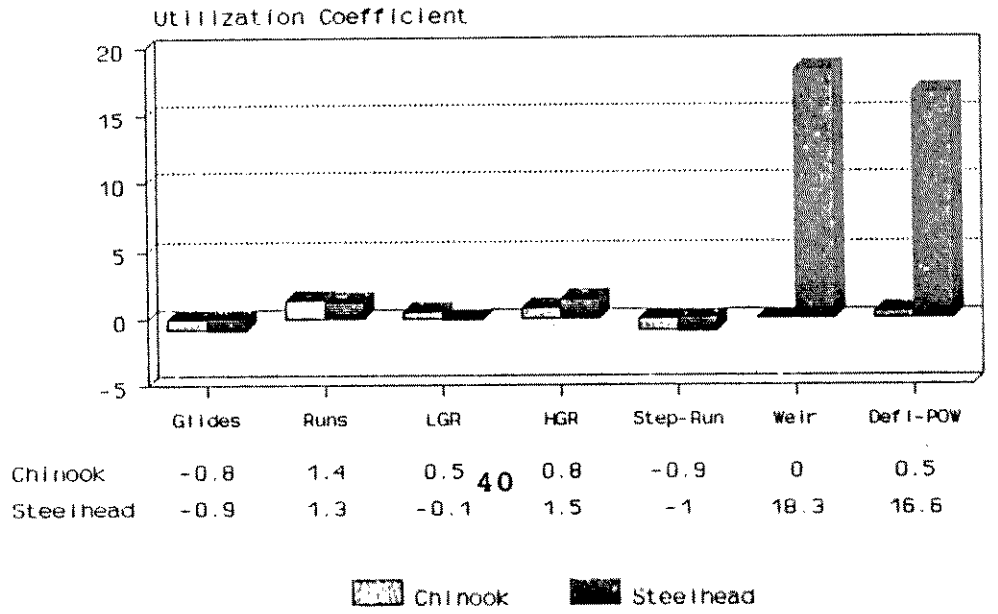


APPENDIX D. SPAWNING HABITAT USE - SOUTH FORK SALMON RIVER

South Fork Salmon River

	Glides	Runs	LGR	HGR	Step-Run	Weir	Defl/POW	Total
Spawning Area	6029	3719	2754	72	1866	44	119	14602
% Spawning Area	41%	25%	19%	0%	13%	0%	1%	
Chinook Redds	29	203	96	3	1	1	4	337
Steelhead Redds	4	144	43	3	0	14	35	243
Chinook Redd Density	0.0048	0.0546	0.0349	0.0419	0.0005	0.0229	0.0335	0.0231
Steelhead Redd Density	0.0007	0.0387	0.0156	0.0419	0.0000	0.3206	0.2932	0.0166

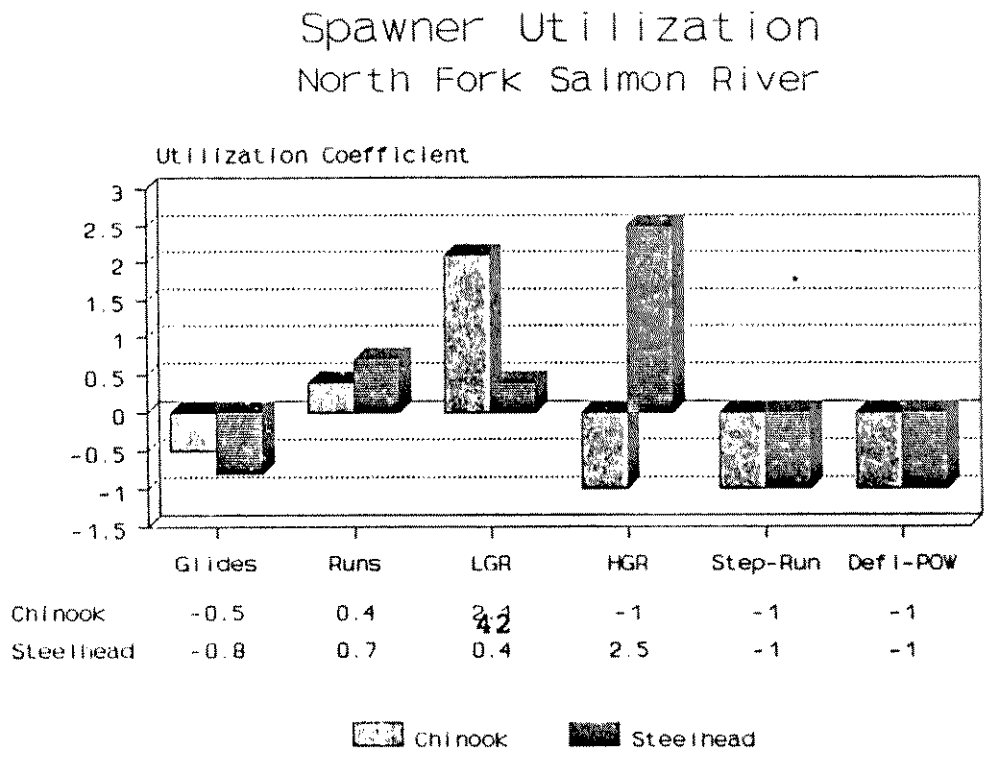
Spawner Utilization
South Fork Salmon River



APPENDIX E. SPAWNING HABITAT USE - NORTH FORK SALMON RIVER

North Fork Salmon River

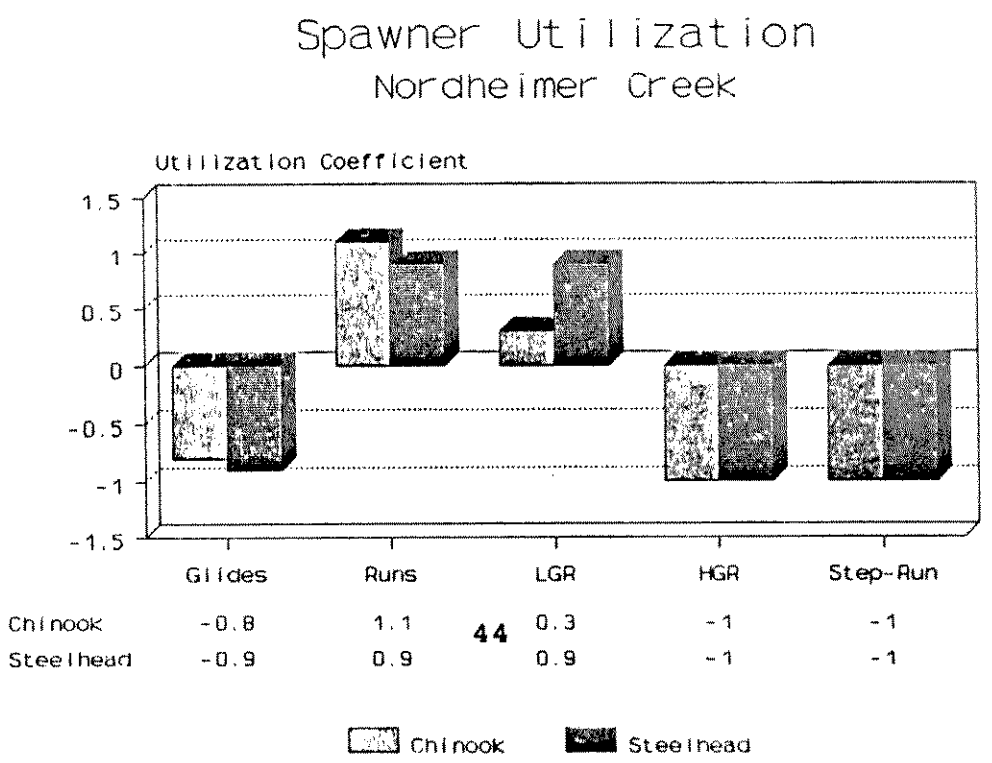
	Glides	Runs	LGR	HGR	Step-Run	Weir	Defl/POW	Total
Spawning Area	4487	6030	568	39	1027	2	2	12156
% Spawning Area	37%	50%	5%	0%	8%	0%	0%	
Chinook Redds	37	140	30	0	0	0	0	207
Steelhead Redds	14	151	12	2	0	0	0	179
Chinook Redd Density	0.0082	0.0232	0.0528	0.0000	0.0000	0.0000	0.0000	0.0170
Steelhead Redd Density	0.0031	0.0250	0.0211	0.0513	0.0000	0.0000	0.0000	0.0147



APPENDIX F. SPAWNING HABITAT USE - NORDHEIMER CREEK

Nordheimer Creek

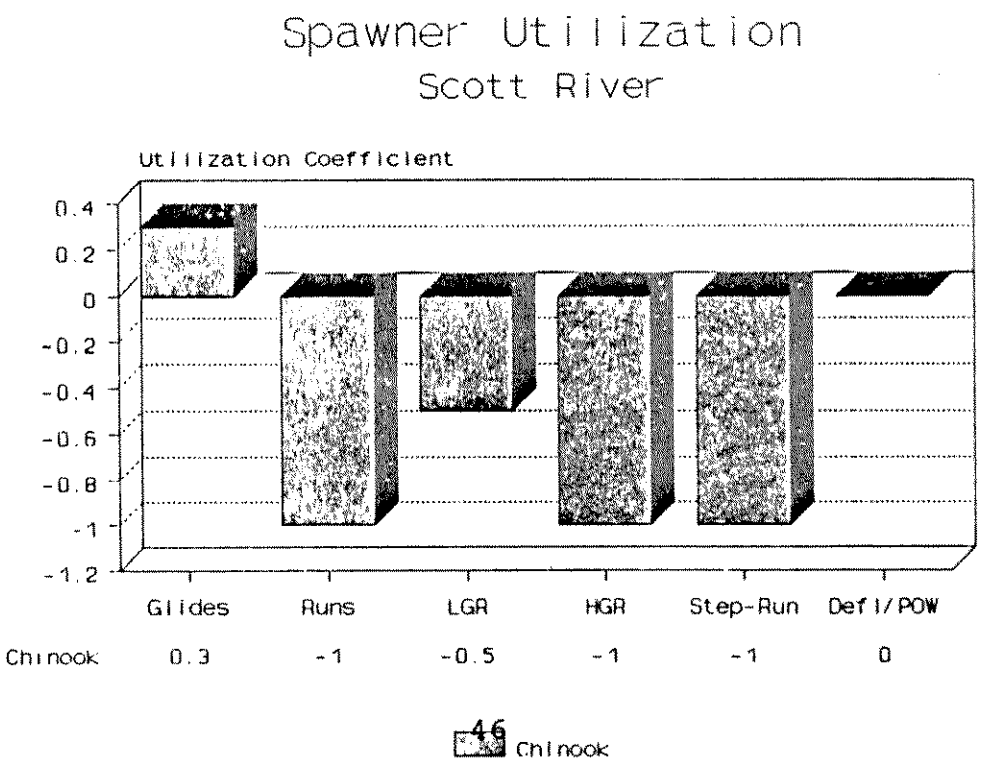
	Glides	Runs	LGR	HGR	Step-Run	Weir	Defl/POW	Total
Spawning Area	173	245	70	0	145	0	0	634
% Spawning Area	27%	39%	11%	0%	23%	0%	0%	
Chinook Redds	1	17	3	0	0	0	0	21
Steelhead Redds	4	78	22	3	0	0	0	107
Chinook Redd Density	0.0058	0.0693	0.0427	N/A	0.0000	N/A	N/A	0.0331
Steelhead Redd Density	0.0231	0.3179	0.3128	N/A	0.0000	N/A	N/A	0.1687



APPENDIX G. SPAWNING HABITAT USE - SCOTT RIVER

Scott River

	Glides	Runs	LGR	HGR	Step-Run	Weir	Defl/POW	Total
Spawning Area	3854	1626	1020	8	122	0	0	6630
% Spawning Area	58%	25%	15%	0%	2%	0%	0%	
Chinook Redds	88	265	47	0	4	2	5	411
Chinook Redd Density	0.0228	0.1630	0.0461	0.0000	0.0329	N/A	N/A	0.0620

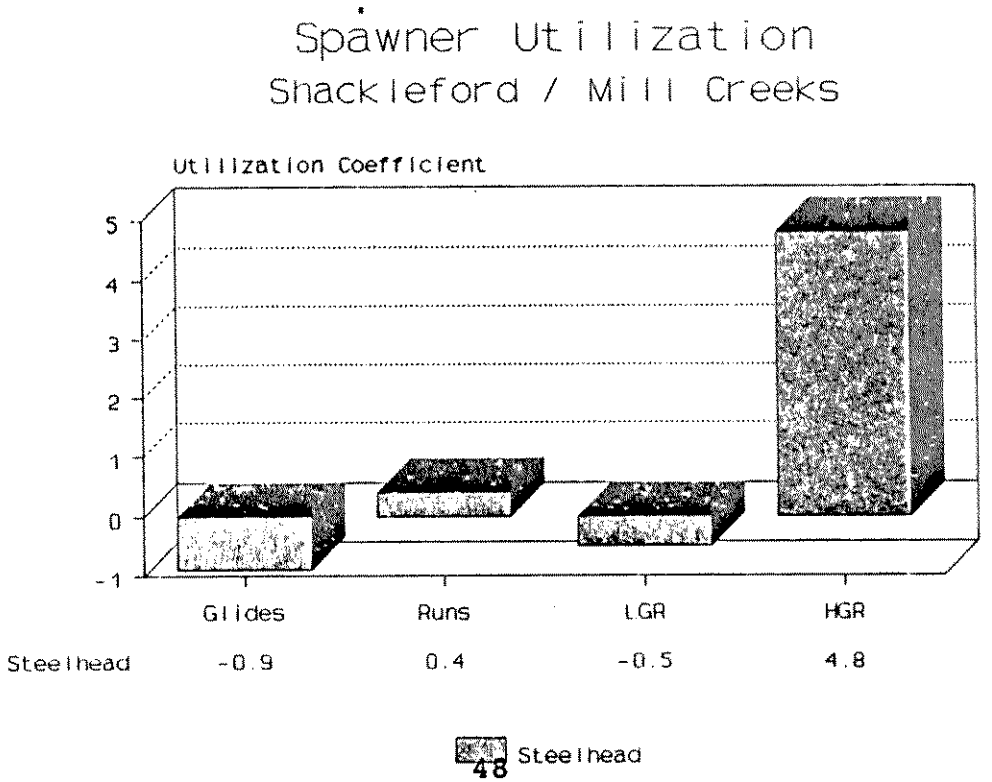


1989-90

APPENDIX H. SPAWNING HABITAT USE - SHACKLEFORD/MILL CREEKS

Shackleford / Mill Creeks

	Glides	Runs	LGR	HGR	Step-Run	Weir	Defl/POW	Total
Spawning Area	2511	8385	3973	56	0	0	0	14925
PERCENT Spawning Area	17%	56%	27%	0%	0%	0%	0%	
Steelhead Redds	11	416	73	11	0	0	0	511
Steelhead Redd Density	0.0044	0.0496	0.0184	0.1973	N/A	N/A	N/A	0.0342

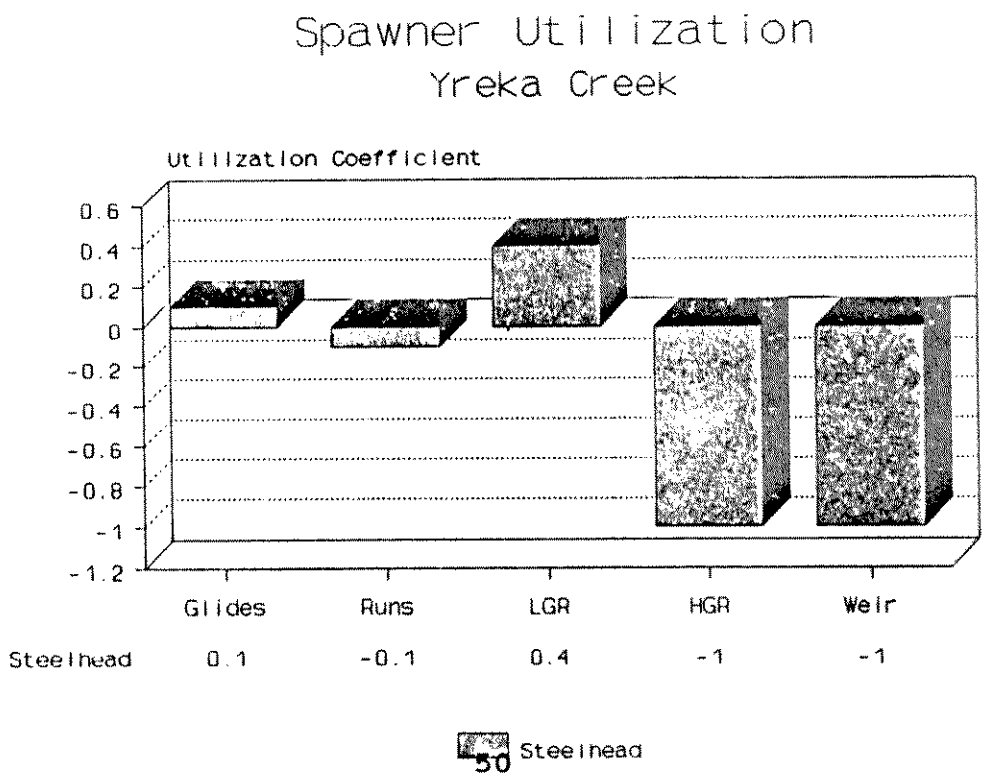


1989-90

APPENDIX I. SPAWNING HABITAT USE - YREKA CREEK

Yreka Creek

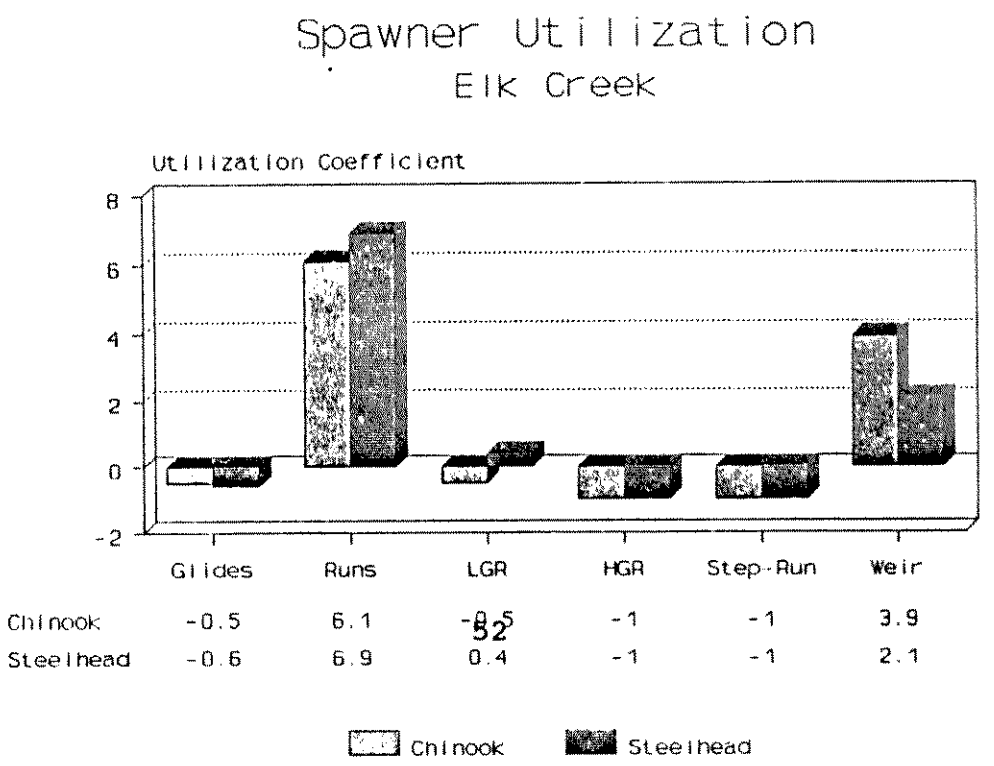
	Glides	Runs	LGR	HGR	Step-Run	Weir	Defl/POW	Total
Spawning Area	41	190	37	0	0	1	0	269
% Spawning Area	15%	71%	14%	0%	0%	0%	0%	
Steelhead Redds	8	30	9	0	0	0	0	47
Steelhead Redd Density	0.1962	0.1577	0.2428	N/A	N/A	0.0000	N/A	0.1747



APPENDIX J. SPAWNING HABITAT USE - ELK CREEK

Elk Creek

	Glides	Runs	LGR	HGR	Step-Run	Weir	Defl/POW	Total
Spawning Area	174	18	5	55	1	6	0	259
% Spawning Area	67%	7%	2%	21%	0%	2%	0%	
Chinook Redds	39	52	1	0	0	11	1	104
Steelhead Redds	31	58	3	0	0	7	6	105
Chinook Redd Density	0.2245	2.8705	0.1957	0.0000	0.0000	1.9734	N/A	0.4020
Steelhead Redd Density	0.1784	3.2017	0.5871	0.0000	0.0000	1.2558	N/A	0.4058

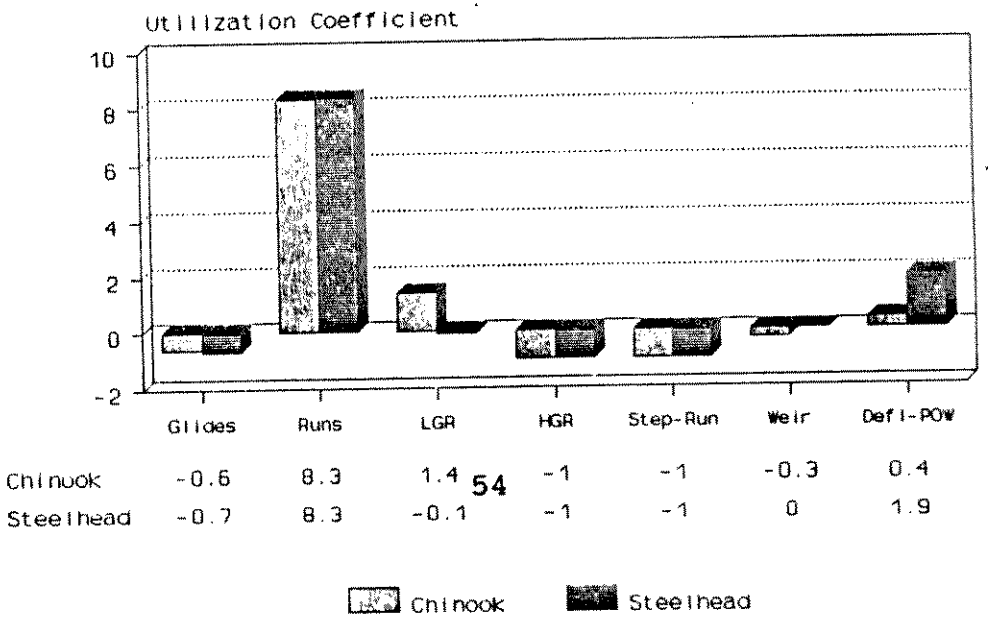


APPENDIX K. SPAWNING HABITAT USE - INDIAN CREEK

Indian Creek

	Glides	Runs	LGR	HGR	Step-Run	Weir	Defl/POW	Total
Spawning Area	1543	154	48	9	387	166	107	2413
% Spawning Area	64%	6%	2%	0%	16%	7%	4%	
Chinook Redds	36	86	7	0	0	7	9	145
Steelhead Redds	22	69	2	0	0	8	15	116
Chinook Redd Density	0.0233	0.5577	0.1449	0.0000	0.0000	0.0422	0.0842	0.0601
Steelhead Redd Density	0.0143	0.4474	0.0414	0.0000	0.0000	0.0482	0.1404	0.0481

Spawner Utilization
Indian Creek

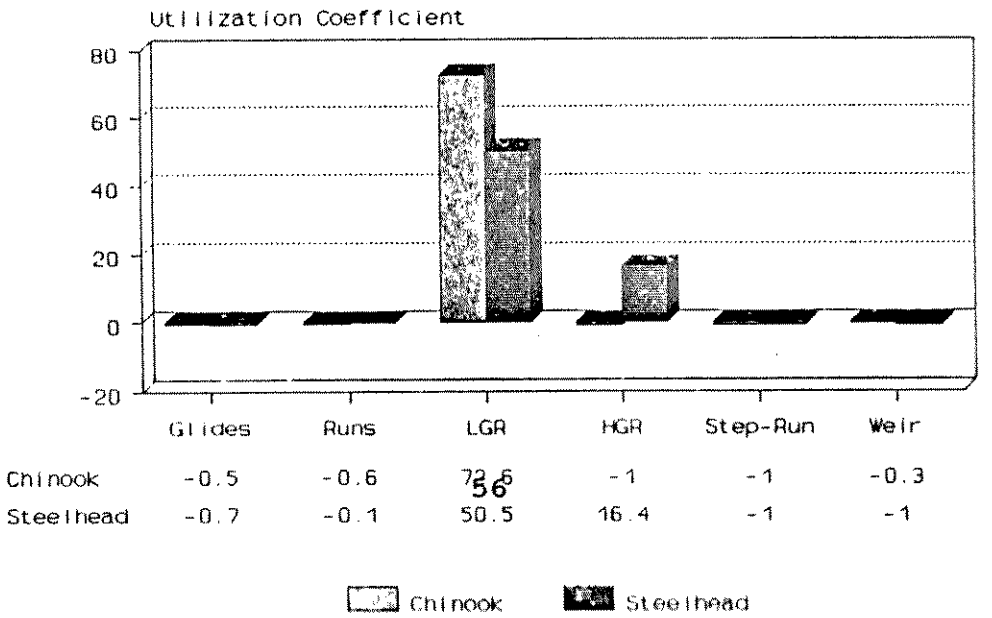


APPENDIX L. SPAWNING HABITAT USE - GRIDER CREEK

Grider Creek

	Glides	Runs	LGR	HGR	Step-Run	Weir	Defl/POW	Total
Spawning Area	890	3287	44	16	663	762	0	5663
% Spawning Area	16%	58%	1%	0%	12%	13%	0%	
Chinook Redds	5	14	34	0	0	6	1	60
Steelhead Redds	5	51	40	5	0	0	0	101
Chinook Redd Density	0.0056	0.0043	0.7804	0.0000	0.0000	0.0079	N/A	0.0106
Steelhead Redd Density	0.0056	0.0155	0.9181	0.3111	0.0000	0.0000	N/A	0.0178

Spawner Utilization
Grider Creek



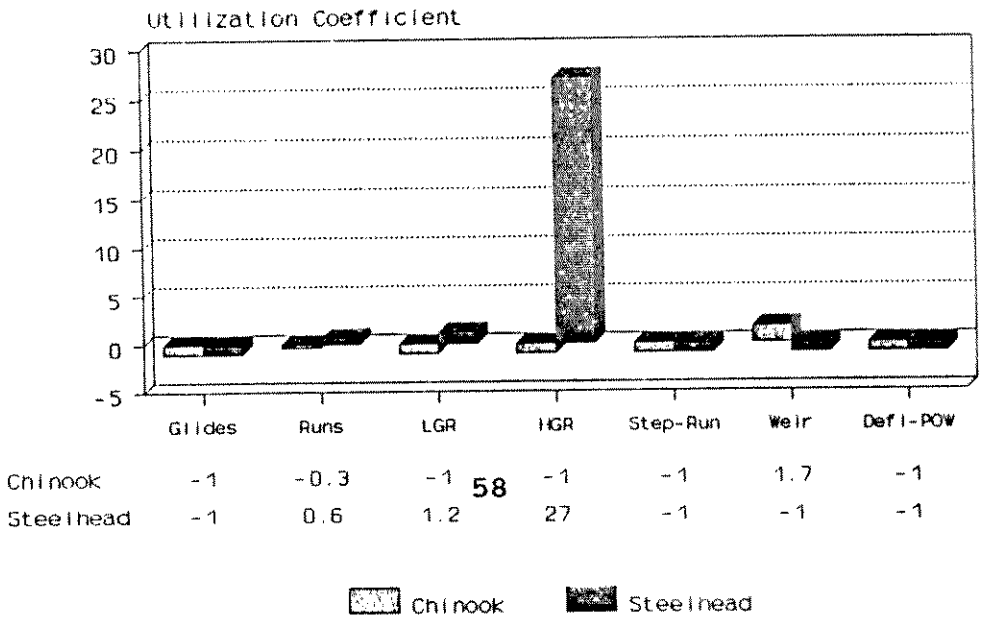
APPENDIX M. SPAWNING HABITAT USE - BEAVER CREEK

Beaver Creek

	Glides	Runs	LGR	HGR	Step-Run	Weir	Defl/POW	Total
Spawning Area	1173	3718	640	10	562	2001	57	8161
% Spawning Area	14%	46%	8%	0%	7%	25%	1%	
Chinook Redds	0	3	0	0	0	6	0	9
Steelhead Redds	4	41	10	2	0	0	0	57
Chinook Redd Density	0000.0	0.0008	0.0000	0.0000	0.0000	0.0030	0.0000	0.0011
Steelhead Redd Density	0.0034	0.0110	0.0156	0.1957	0.0000	0.0000	0.0000	0.0070

Spawner Utilization

Beaver Creek



APPENDIX N. SUMMARY OF EXPENDITURES

Summary of Expenditures

Budget Activity	USFWS Funded	USFS Contribution	Project Total
Salary	91,347	12,000	103,347
Transportation	22,902	3,660	26,562
Equipment	8,930	15,200[7]	24,130
Total	$123,179	$30,860	$154,039

[7] Includes overhead, data processing, printing,and facilities.