KLAMATH RIVER FISHERIES ASSESSMENT PROGRAM

U. S. FISH & WILDLIFE SERVICE

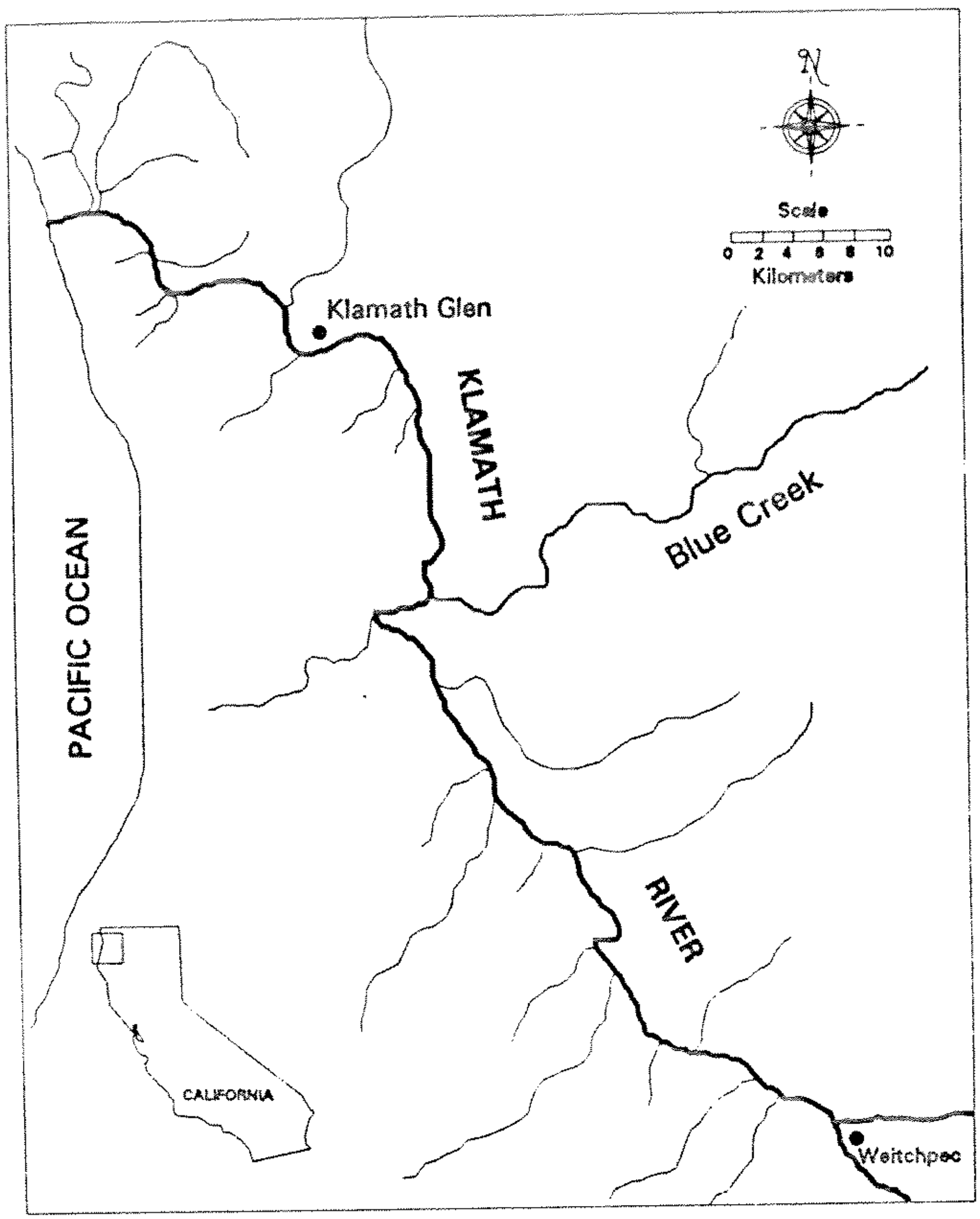
DEPARTMENT OF THE INTERIOR

INVESTIGATIONS ON BLUE CREEK

Annual Progress Report FY 1990 and 1991

November 1992

Coastal California Fishery Resource Office
Arcata, California
Region 1



PROGRESS REPORT FOR
INVESTIGATIONS ON BLUE CREEK
FY 1990-1991

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Funded by:

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DISCLAIMER

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PHASE II
SCOTT RIVER GRANITIC SEDIMENT STUDY
FRENCH CREEK SUBBASIN EROSION CONTROL ASSESSMENT

by

U.S.D.A. SOIL CONSERVATION SERVICE

for the

SISKIYOU RESOURCE CONSERVATION DISTRICT
ETNA, CALIFORNIA

ABSTRACT

The extent of the decomposed granitic sand sediment problem in the Scott River watershed of Siskiyou County was first examined in the study entitled "Scott River Basin Granitic Sediment Study" completed in 1990. The Phase I report indicated that 23.3 percent of the annual total erosion within the Scott River Basin originated from the French Creek watershed.

This is "Phase II" of that study, an examination of erosion sites producing decomposed granitic sediment within the French Creek subbasin. Data was collected by intensive ground surveys of significant erosion areas during the summer of 1990. The French Creek subbasin encompasses approximately 21,500 acres, of which approximately 14,500 acres have soils which are derived from granitic and dioritic parent materials. The report focuses on five main aspects of the problem: 1) identification of erosion areas called stations; 2) prescription of erosion control practices for each station; 3) estimation of the cost of treatment; 4) selection of priority reaches (groups of stations); 5) discussion on possible funding sources for installation of erosion control practices.

There were 903 identified erosion stations which were grouped into 162 reaches. Reaches are groups of stations which are in proximity to each other and inter-related such as road surfaces, cutbanks, and fillslopes. Using criteria of proximity to stream courses and a cost factor, 38 priority reaches were recommended for erosion control treatments. It was estimated that the priority sites could be treated for a cost of $436,924.00 and would treat approximately 73 percent of the reaches with a high probability of adding sediment to stream courses..

Various sources of California State and Federal funds for completion of erosion control practices are discussed. Funding, availability, qualifications and purpose for the identified sources varies annually.

PROGRESS REPORT FOR
INVESTIGATIONS ON BLUE CREEK
FY 1990 and 1991

ABSTRACT

The U.S. Fish and Wildlife Service, Coastal California Fishery Resource Office in Arcata, CA, was funded to investigate chinook salmon spawning use, juvenile salmonid outmigration and characterize habitats in Blue Creek, Klamath Basin, Ca. Investigations that began in October 1988 have continued to date, with this reporting period covering Oct 1989 through Sept 1991. Adult chinook spawner escapements were addressed by surveys of redds and carcasses, and radio telemetry. Spawner numbers were very low both years, with only 86 redds observed in fall/winter 1989-90 and 26 redds in fall/winter 1990-91. Telemetry of migrating spawners was used in both years (19 fish in 1990 and 17 in 1991) to locate remote spawning areas. Virtually all of the mainstem, and most of the tributary spawning habitat (27.8 kilometers (km) of channel) were classified into five types of channel. A total of 29.1 km of channel were also habitat-typed. Emigrating juvenile salmonids were trapped at river kilometer (rkm) 1.8 with a rotary-screw type trap. The trapping periods were April to August both years, with 77 and 69 trapping days respectively. Peak emigrations were during high flows the week of May 19 for both years. A juvenile weir was operated 28 and 36 days respectively in 1990 and 1991. For 1990, a total of 4,914 chinook, 2,916 steelhead, and 250 coho salmon were captured in the rotary trap. An additional 2,414 chinook, 1,349 steelhead and 98 coho were caught in the weir. Rotary trap catches in 1991 were 1,397 chinook, 1,491 steelhead, and 59 coho. Weir catches in 1991 were 3,073 chinook, 1,487 steelhead, and 144 coho. Expanded numbers of emigrating chinook were 32,000 for 1990 and 12,500 for 1991. Chinook were marked with coded wire tags (3,308 and 3,055 respectively in 1990 and 1991) and released, with other juvenile fish, into Blue Creek. Densities of rearing chinook averaged .025 fish/sq meter for all reaches, with a range of 0 to .063. Temperatures varied from 4.0 to 19.4 ^{0}C and flows ranged from 61 cfs, in October, 1989 to 4,300 cfs in April, 1991.

PROGRESS REPORT FOR
INVESTIGATIONS ON BLUE CREEK

October 1989 - October 1991

INTRODUCTION

The Klamath River basin, including Blue Creek, a major tributary to the lower Klamath River, has historically supported large runs of chinook salmon (Oncorhynchus tshawytscha) and steelhead trout (O. mykiss). The basin has been altered substantially during the past century and particularly during the last four decades. During this period, anadromous salmonid fishery resources have severely declined. Losses, including the quantity and quality of instream habitat and the population size of salmon and steelhead, have coincided with expanded logging and fishing operations, construction of roads and dams, water export, mining, and other development (U.S. Dept. of Interior, 1985).

In response to problems associated with the anadromous fishery resources of the basin, Congress enacted P.L. 99-552, the Klamath River Fish and Wildlife Restoration Act of 1986. This legislation authorized the Secretary of Interior to restore anadromous salmonid stocks to historic levels in the Klamath River basin. This action and subsequent restoration efforts have initiated interest in the Blue Creek anadromous salmonid stocks, particularly fall chinook salmon.

In a 1979 report detailing the status of anadromous stocks within the Hoopa Valley Reservation, the U.S. Fish and Wildlife Service (USFWS) found Blue Creek to have "the greatest potential to support anadromous fish of any tributary on the reservation" (USFWS, 1979). Concerns were raised about the restoration program's proposed actions for Blue Creek. Specifically, are there adequate population levels to allow Blue Creek to be considered a broodstock source, and what can be done to rebuild habitat and populations to historic levels?

With these questions in mind, the USFWS Coastal California Fisheries Resource Office in Arcata, California (CCFRO - Arcata) submitted a five year study proposal in 1989 to the Klamath River Basin Fisheries Task Force to evaluate the status of fall chinook and their habitat in Blue Creek. Work has been ongoing since that time with the final report and recommendations proposed to be funded in FY 1993. To date the study has gathered information on adult spawner escapement, juvenile outmigration characteristics, available spawning habitat, juvenile rearing habitat, general habitat and channel characteristics, stream discharge, and temperature regime. Emigrating juvenile chinook have been marked with coded-wire tags each year.

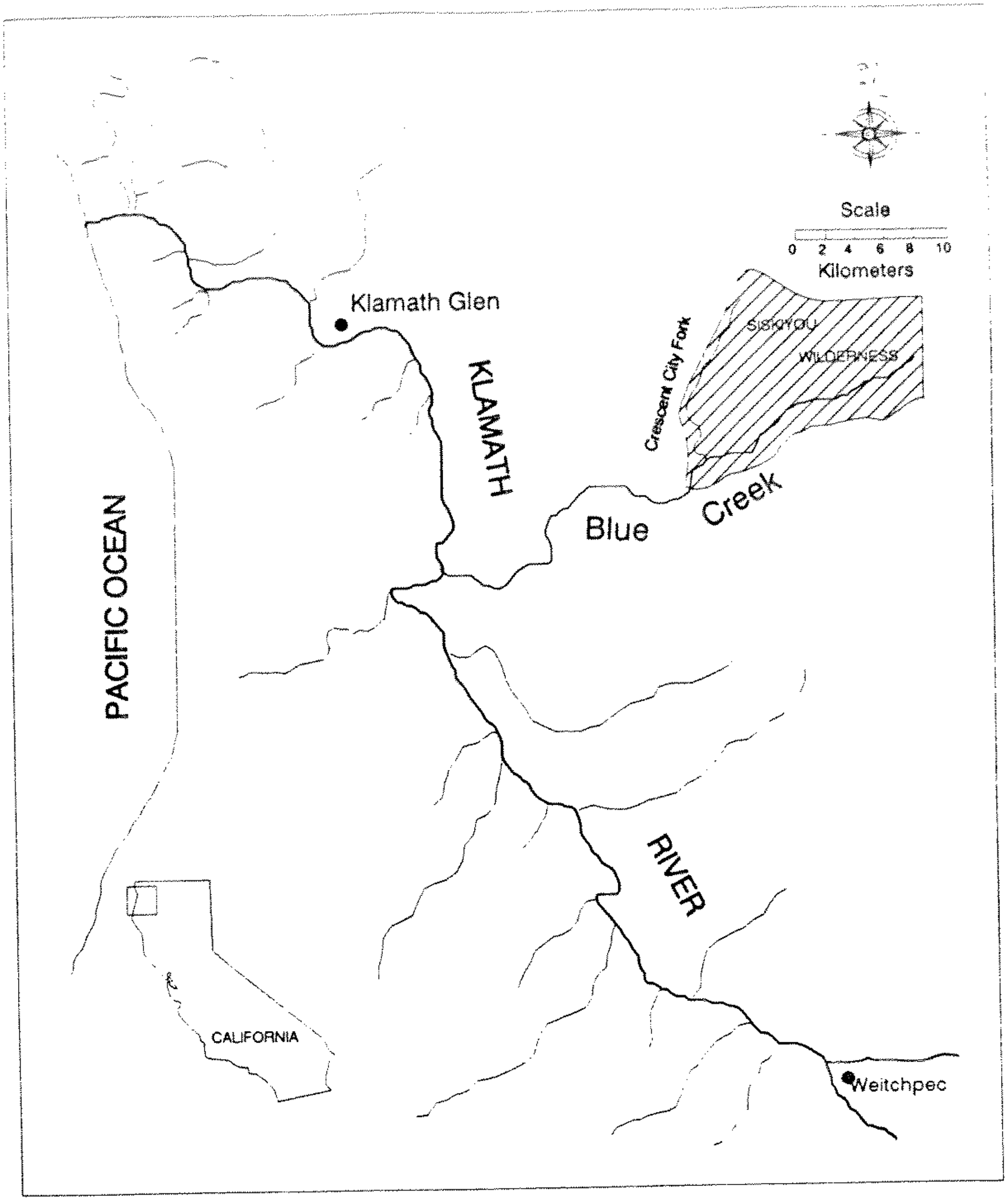


FIGURE 1. Lower Klamath River Basin with Blue Creek.

STUDY AREA

Blue Creek is a fourth-order stream which enters the Klamath River at river kilometer (rkm) 26.4 (Figure 1). The creek drains 329 square kilometers and is the largest tributary to the Klamath River below Weitchpec (rkm 64). It is noted for its clear water, sufficient summer flows, and large chinook salmon (Waterman, 1920). The drainage is steep and mountainous with historically moderate to dense timber growth of coastal redwood (Sequoia sempervirens), incense cedar (Libocedrus decurrens), Port Orford cedar (Chamaecyparis lawsoniana), Douglas fir (Pseudodtsuga menziesii), tanoak (Lithocarpus densiflora), and madrone (Arbutus menziesii). Riparian species include alder (Alnus sp.), willow (Salix sp.), California laurel (Umbellularia californica), and big leaf maple (Acer macrophyllum).

The Blue Creek watershed is underlain by four major rock types of the Coastal Range and Klamath Mountains provinces. Proceeding upstream from the mouth, Blue Creek flows through sandstone and shale of the Franciscan Complex; ultramafic rocks (serpentinized peridotite) of the Josephine Ophiolite; slate, metagraywacke, and greenstone of the Galice Formation; and an assemblage of diverse rock types (mostly metasedimentary) of the Western Paleozoic and Triassic Belt (Wagner and Saucedo, 1987). The streambed substrate is generally composed of small and large cobble, with many bedrock controls. Sparsely vegetated flood terraces, dating from the December, 1964 flood, are dominant features below rkm 4.4. Stream gradient averages 1.4% in the lower 23 km.

Blue Creek originates at about 1500 m elevation and flows south-westerly 37 kms to its confluence with the Klamath River. The elevation at the mouth is 12 m. Annual precipitation is approximately 200 centimeters (cm) in the headwaters of the Blue Creek drainage with about 75% of it occurring during five months of the year (November - March) (U.S. Weather Bureau, 1974). Precipitation runs off quickly, producing rapid fluctuations in discharge and high bedload movement. USGS water discharge records indicate large flow variations ranging from a low of 43 cubic feet per second (cfs) on November 1, 1965 to 33,000 cfs on March 2, 1972 (USFWS, 1979).

Three tributaries to Blue Creek have been identified as important to anadromous salmonid spawning and rearing. These include West Fork, Nickowitz Creek, and Crescent City Fork, which is the largest and flattest tributary accessible to anadromous fish. These three streams comprise 41% of the area of the entire basin, but only Crescent City Fork (58.7 square km) is widely used by both salmon and steelhead. A fourth tributary, Slide Creek, has a steep gradient and landslides in the vicinity of the mouth, but may provide access to steelhead during some high flow events. During the summers of 1989 and 1990, the California Department of Fish and Game (CDFG) and California Conservation Corps. (CCC) constructed stream habitat enhancement structures on the West Fork of Blue Creek. These log and boulder structures were designed for enhancement of coho salmon and steelhead spawning habitat (C. Harral, personal communication).

A natural barrier to fish movements on the mainstem of Blue Creek is located approximately 1.0 km below the confluence of the East Fork. This barrier consists of a very steep boulder-jammed gorge at rkm 23.6. Below the barrier, three species of anadromous salmonids are present: chinook salmon (Oncorhynchus tshawytscha), coho salmon (O. kisutch) and steelhead trout (O. Mykiss). The mainstem and East Fork of Blue Creek above the barrier (rkm 23.6) were planted with steelhead, rainbow trout, and eastern brook trout (Salvelinus fontinalis) during the 1930's and 40's (CDFG files, Eureka). Hereinafter, Blue Creek discussions are restricted to the lower 23 km of stream accessible to anadromous salmonids.

As with many of the tributaries to the lower Klamath River, extensive timber harvesting has occurred along portions of Blue Creek. Since the early 1960's, many areas on the West Fork of Blue Creek and lower 12 km of the mainstem have been clearcut. Timber has been removed from sections adjacent to the stream and along the upper slopes. Mature redwoods and hardwood trees provided a dense riparian canopy before the floods in 1955 and 1964 (F.Erickson, pers. comm.). Simpson Timber Company owns the land surrounding the lower 12.8 km of Blue Creek and logging continues in this portion of the watershed. Upstream of Simpson Timber Company property at about rkm 12.9, the creek runs through National Forest lands including the Siskiyou Wilderness of the Six Rivers National Forest above about rkm 13.7. National Forest lands are mostly forested below elevations of about 1400 meters (m).

An arterial logging road parallels Blue Creek at an elevation of about 240 m above the creek, from rkm 3.2 to 9.6. Little used roads branch off this maintained road and provide streamside access at rkm 2.0, 3.2, 8.0, and 12.5. No road access to the watershed above rkm 12.5 is available due to its inclusion in the Siskiyou Wilderness Area. USFWS personnel have accessed Blue Creek rkm 12.5 to 23.6 by wading upstream. During FY 1990, a portion of an old trail was cleared by CCC crews that provided access to the upper portions of Blue Creek and Crescent City Fork.

MATERIALS and METHODS

Salmonid Habitat Investigations

Discharge

The stream gaging station was established in 1989 at rkm 3.2, and was described in a previous report (USFWS, 1990). A staff gage and crest gage have been maintained throughout the study. A stage discharge table has been prepared for the site. Gages were read daily during the period of spring/summer juvenile trapping, and the crest gage was read every few weeks throughout the winter. A top-setting rod and Price AA flow meter were used to measure stream discharge.

The former USGS gauge site at rkm 5.0 was not used because the channel there had apparently been greatly changed by deposition of coarse sediments since the gauge was removed in Sept, 1978.

Temperature

A Ryan Tempmentor thermograph with a remote probe was maintained at rkm 3.2. Readings were made at two hour intervals and averaged for each 24 hour period. The thermograph was deployed throughout both years. During FY 1990, the thermograph suffered problems with water leaking into the watertight case and damage to the remote probe wire from animals chewing through the cable. Both events led to a loss of data for nearly the entire year. A maximum-minimum thermometer was used to monitor water temperature extremes during the juvenile trapping season from early April to mid-July in both years. Air and water temperatures were also monitored with a hand-held thermometer at irregular intervals during surveys.

Rearing Habitat

Juvenile salmonid rearing habitat was assessed during late spring of 1989, preceding emergence of fry. Due to spring rains and high water conditions in late spring of 1990, no data on rearing habitat were collected above rkm 19.5.

Rearing habitat reaches were quantified between the mouth and 19.5 rkm. A physical measurement of the substrate was recorded for 100 m of every 500 m (20%) downstream from the starting point at rkm 19.5 (Figure 2). Within each 500 m reach the following physical parameters were measured: mean width, mean depth, maximum depth, habitat types present, dominant habitat type, percent instream cover, dominant cover type, substrate composition, and quantity and quality of rearing habitat available for young of the year (YOY) and juvenile salmonids. Underwater observations consisted of snorkeling 100 m of every 1000 m (10%) of the stream. The snorkel surveys identified and counted all salmonids to species, apparent age, and location within the wetted channel (edge, intermediate, or thalweg).

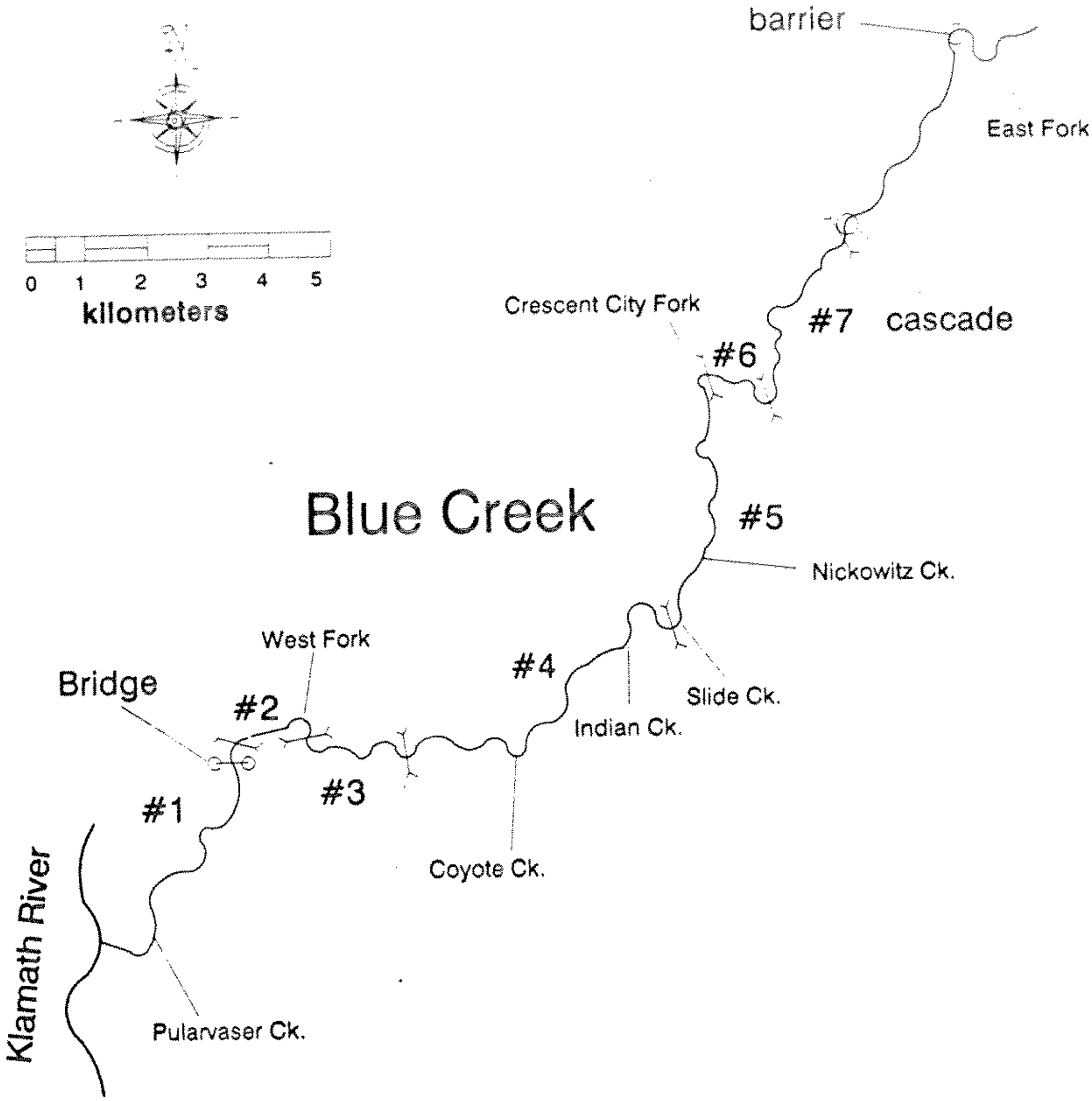


FIGURE 2. Blue Creek rearing habitat reaches.

Densities of chinook and steelhead were derived from only those areas that were sampled by underwater counts (10.5%). No attempt was made to calibrate diver counts by electroshocking due to the large size and depth of the stream.

The location of observed salmonids within the stream channel was broken down into three classifications; edgewater, intermediate, and thalweg. Within each classification, numbers of each species and approximate age were recorded; chinook young of the year (YOY), chinook 1+, steelhead YOY, steelhead 1+, steelhead 2+, and coho.

Spawning Habitat

Spawning habitat availability estimates were made during FY 1989 and FY 1990 in the mainstem of Blue Creek and the Crescent City Fork. Spawning habitat was measured at locations expected to be sites for chinook redds by field personnel familiar with depths and velocities preferred by chinook at pool/riffle exchanges, runs, and deep riffles. One to three transects were established (upper, middle, and lower) within each site and along these transects three to five cells were established. In each cell, water depths were measured to the nearest 0.1 m and substrate composition was ocularly estimated into the following categories; > 15 cm, 8-15 cm, 3.5-8 cm, 0.5-3.5 cm, < 0.5 cm. Surface area considered suitable for chinook spawning was calculated in square meters (m^2).

Habitat Classification

Habitat classification in the mainstem of Blue Creek was completed from the mouth to rkm 19.5 by October, 1990. Habitats were also classified for the lowest 5.4 km of Crescent City Fork in August, 1991. All habitat typing efforts utilized methods modified from Bisson et al (1982) and Decker (1986) in 1988 and 1989, and by McCain et al (1990) in 1990 and 1991. All habitat units were classified into one of 24 specific habitat types (Appendix A). Each specific type was derived from one of three general types; pools, riffles, or flat water. The length of each unit was measured, with the minimum length equal to or greater than the width of the wetted channel. In 1990 and 1991, methods were identical to 1989 except: physical measurements were recorded every fifth different type to insure all 24 types would be included in a stratified random sampling scheme derived from Hankin and Reeves (1989). This was done to obtain physical information on a subsample of the specific types. Additional physical measurements were recorded for, at a minimum, every fifth general habitat type encountered (pool, riffle, flat water). Total surface area was calculated by using the mean length and the mean width for each habitat type unit multiplied by the total number of each specific habitat unit recorded, and then summed for all habitat units.

Channel classification

Channel types were designated on Blue Creek mainstem to rkm 23.6 and to rkm 5.0 on Crescent City Fork in 1989-1990 using the stream classification system developed by Rosgen (1985). That system incorporates the following channel features: gradient, valley confinement, channel entrenchment, sinuosity, and dominant substrate composition (Appendix B).

Adult Chinook Salmon Investigations

Chinook Salmon Spawning Surveys

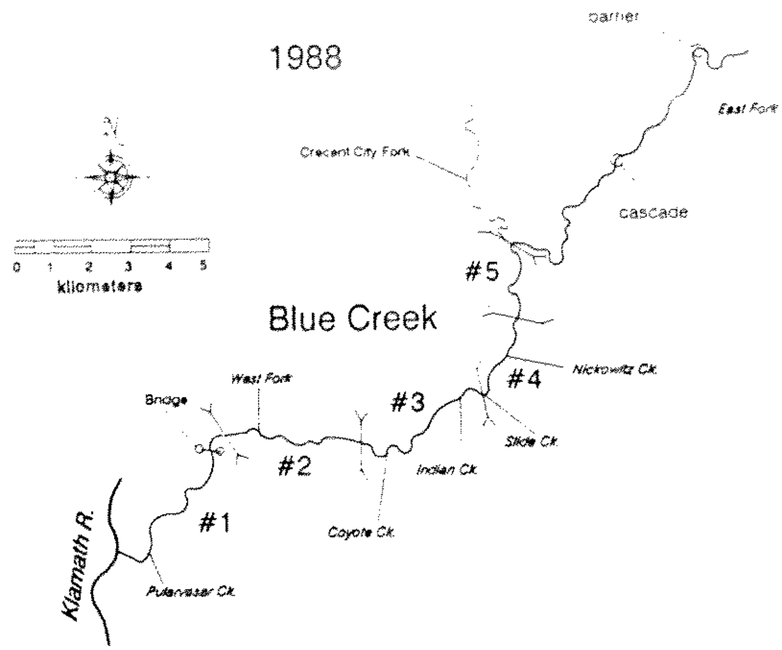
Surveys of chinook redds, carcasses, and live adults occurred in fall and winter to determine spawner numbers, spawning areas and distribution. Due to limited access points, the lower 19.8 km was broken into six reaches. Reaches 4 and 5 of FY 89 surveys were combined to form Reach 4 in FY 90 and 91. The lower 3.2 km of Crescent City Fork (Reach 5), and 3.2 km of the main channel above the confluence with Crescent City Fork (Reach 6), were added in FY90 and FY91 to cover additional spawning areas (Figure 3). Attempts were made to survey the six reaches on a monthly schedule with a two person crew in each reach. Crews wore diving suits and each carried a flow meter and top-setting rod.

Locations of fall chinook redds were recorded on maps. Redds were measured for length, width, pit and mound depth to the nearest 0.1 m, pit and mound velocity (feet per second), and substrate composition was ocularly estimated. Fish presence was also recorded. Habitat units defined by Bisson, et al (1982) and modified by Decker (1986), Appendix A, were described for all redd locations.

Salmonid carcasses were classified to species, sexed if possible, and examined for fin clips, animal predation, and percent reproductively spent. Fork length and scale samples were collected and recorded.

Direct underwater observations were conducted in conjunction with redd, carcass, and radio tag application and tracking. Fish were identified to species, development, and locations were recorded.

Radiotelemetry was used to gather information on spawning locations and the distribution of spawners throughout the watershed. Direct observations of all spawning areas were difficult due to limited access and frequent high waters. The use of radiotelemetry allowed the tracking of spawners by road and by air during some high flows. Air tracking was provided by the USCG helicopter, McKinleyville Group, at the Arcata Airport. The radiotelemetry equipment, two receivers (Model 2000 and 2000B), twenty tags (ten internal and ten external Model five) and two antenna loops (Air and Ground, <60 Mhz), were purchased from Advanced Telemetry Systems, Inc. (ATS).



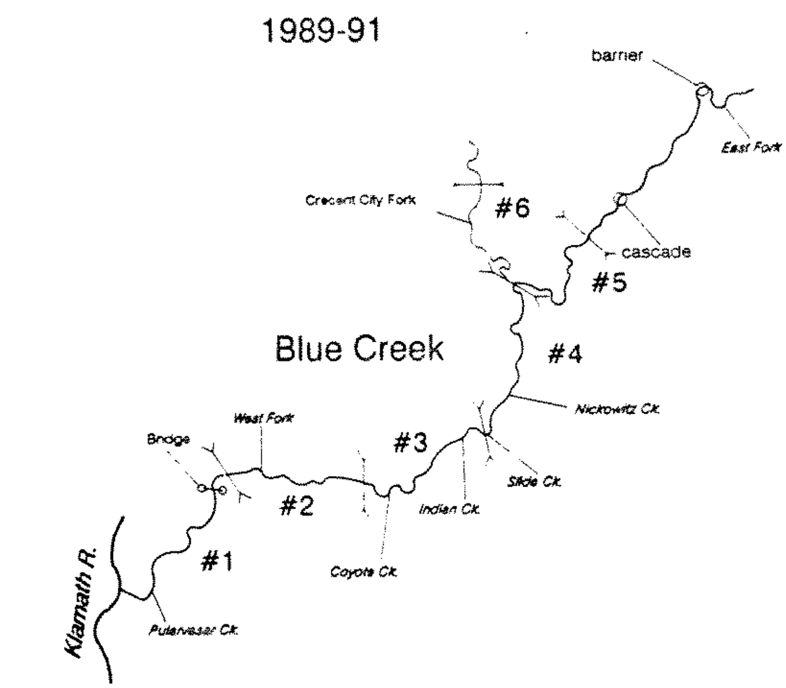


FIGURE 3. Chinook redd survey reaches, Blue Creek, 1988, 1989-91.

The receiver unit was able to detect tags from a height of 150 m to 300 m above the stream in the helicopter. Road and stream tracking was conducted from five roadside over-looks and by wading along the stream. The receiver was able to detect tags on the average 1 km from roads. Bounce of radio signals around bedrock gave confusing directional information.

Snorkel surveys to determine when chinook entered Blue Creek and to identify potential trapping and tag application sites began in October. These surveys were confined to the lower 5 km of the stream and continued into November. When a sufficient concentration of adults were found, tagging operations began.

Adults were captured in deep pools with the use of gillnets, (two 30.5 m long, with 0.13 m and 0.18 m stretch mesh sizes), a rubber raft, PVC holding tubes, and a fish cradle. Pools containing adult fish were located, a gill net was stretched across mid-pool, and three or four workers in wet suits would herd the fish toward the net. As fish were caught, workers promptly removed each fish and placed then into individual holding tubes (0.20 diam. x 0.91 meter long). External tags were wired next to the dorsal fin (Figure 4.a). Internal tags were inserted down the esophagus into the stomach with the use of a short section of 3/4" PVC tubing (Figure 4.b). Sex, length, scales, physical condition, date of tagging and location were recorded. Tagged fish were released nearby.

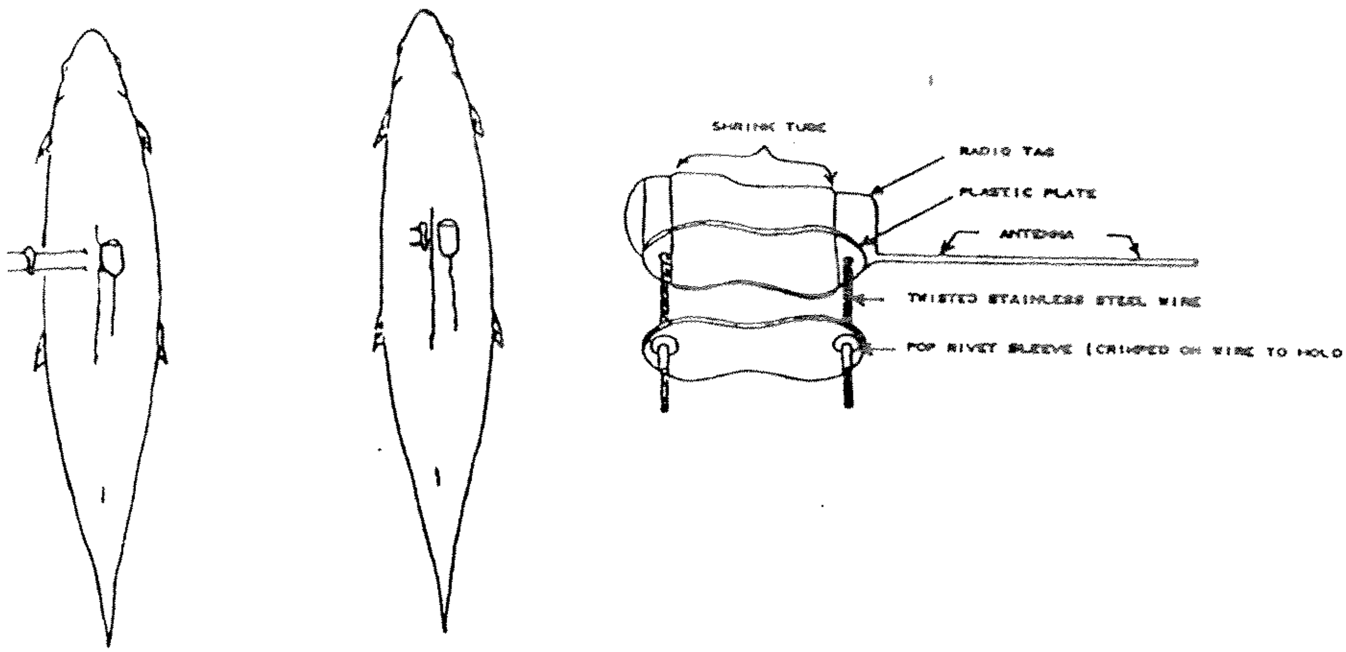
Radio tracking was done weekly, either by driving and walking or by helicopter. Five overlooks were established along the road to monitor the lower 12.5 km of the creek, (Figure 5). Helicopter access allowed tracking over entire Blue Creek watershed and portions of the mainstem Klamath River, but was limited by weather conditions.

Juvenile Salmonid Investigations

Juvenile Trapping

A rotary screw trap (Figure 6) with a 2.44 m diameter cone was utilized to trap emigrating juvenile salmonids at rkm 1.8. Operation of the rotary-screw trap commenced on April 11, 1990 and continued through August 3. In 1991, the rotary screw trap was operated from April 12 to August 12. The trap was generally operated 5 days (4 nights) per week, Monday through Friday. A trapping day was defined from the time the trap was set or checked, typically morning or early afternoon, to the next morning. This time period encompassed the night when salmonids generally emigrate.

(a)



(b)

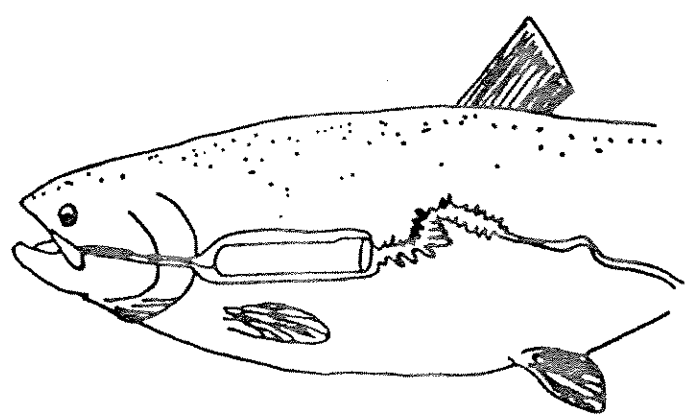


FIGURE 4. Radio tag placement (a) externally and (b) internally.

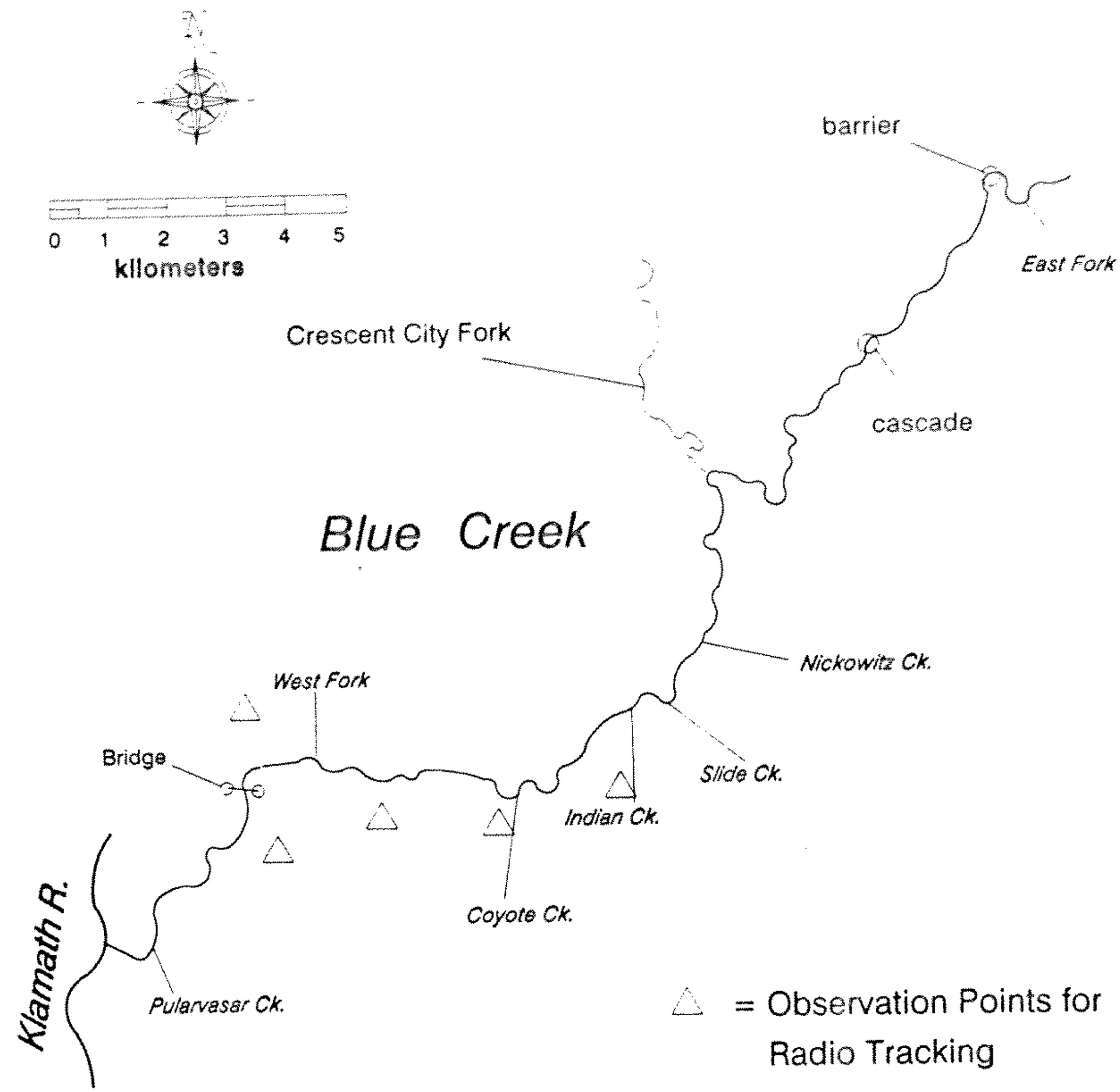


FIGURE 5. Radio-tracking areas.

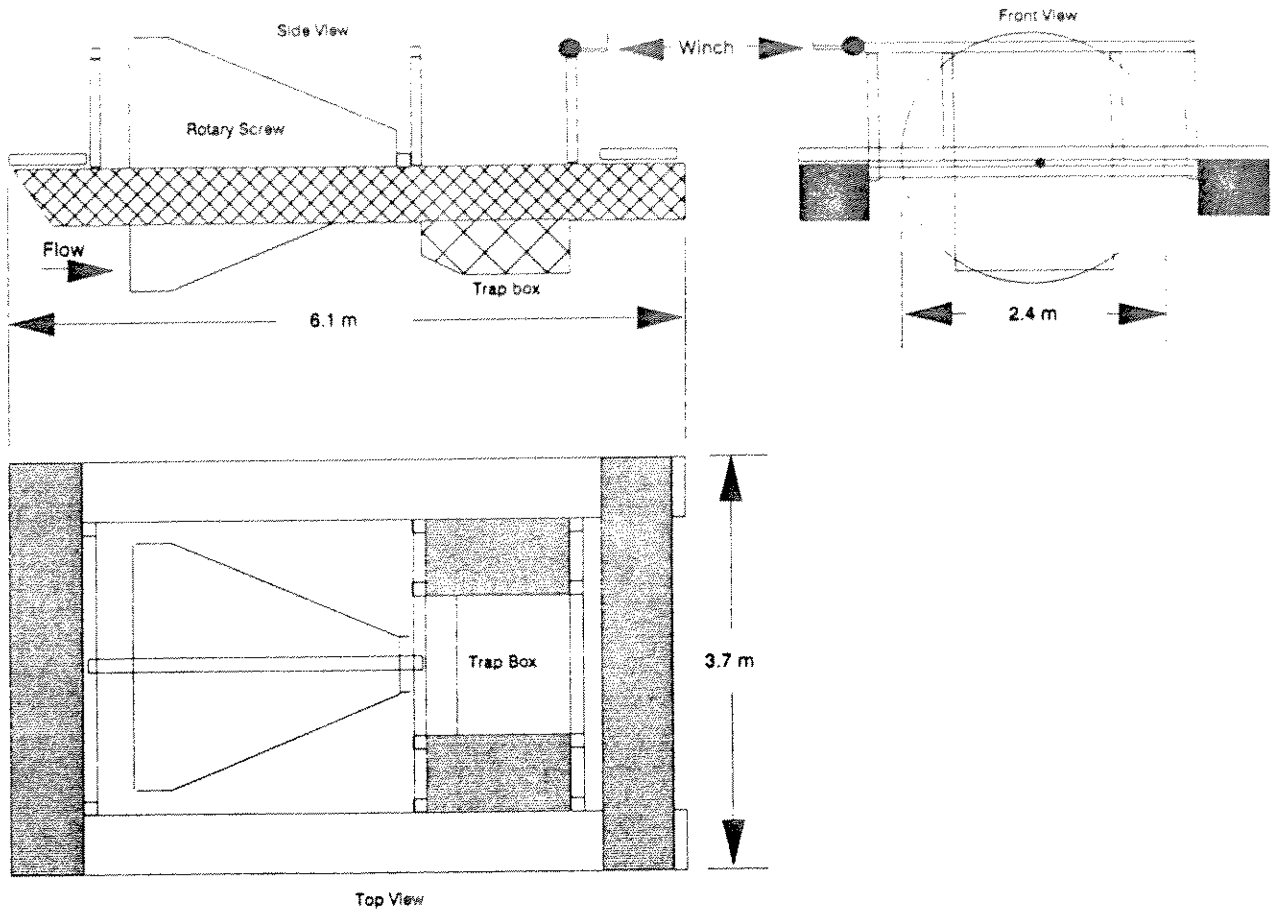


FIGURE 6. Views of the rotary screw trap used on Blue Creek.

The juvenile salmonid sampling index was determined by dividing the estimated discharge by the volume of water sampled by the screw trap. To determine the volume of water, velocity measurements were measured at the left, center, and right positions immediately in front of the cone with a Price AA current meter. These velocity measurements along with the submerged area of the cone were used to calculate the volume sampled. Daily abundance indexes for each species and developmental stage were estimated by multiplying the number of fish captured by the sampling index. Weekly abundance indexes were estimated by summing the daily index values for that week and dividing the sum by the proportion of the week that was sampled. Comparisons of magnitude and timing of the juvenile emigration were based on the juvenile indexes.

A weir consisting of a frame net (1.5 m x 3 m, 0.48 cm delta mesh) and hardware cloth (0.64 cm width mesh) panels (1.2-1.5 m x 3 m) was installed immediately downstream of the rotary-screw trap in the tail-out of the pool. This was operated from April 12 to July 25, 1990. In 1991, the weir was operated from May 16 to July 26. The operation of the weir was dependent on flow and at times only a portion of the stream was trapped. The weir was operated to collect additional chinook for coded wire tagging.

All salmonids collected were identified to species and enumerated. Steelhead were categorized into three developmental stages: young of year (YOY), parr, and smolt. Coho were categorized into two developmental stages: YOY/Parr and smolt. Fork length (mm) and displacement (ml) were measured on a subsample (up to 30) of all categories of salmonids captured. Steelhead age classes were determined by length frequency analysis. Scale samples were collected when time permitted. Displacements and scale samples were collected but these data are not presented in this report. As time permits these data will be analyzed.

Length comparisons between chinook captured in the screw trap and weir were done using a two-group ANOVA (Statgraphics software). For 1990, t-tests (n=12), comparing weekly lengths of chinook captured in the weir and screw trap were done at the 99.6% level of significance (alpha = 0.004) so that an overall 95% level of confidence was maintained. For 1991, t-tests (n=11), comparing weekly lengths of chinook captured in the weir and screw trap were done at the 99.5% level of significance (alpha = 0.005) so that an overall 95% level of confidence was maintained. Comparisons of length statistics for steelhead and coho captured in the screw trap and weir were not conducted. Larger steelhead and coho were able to swim out of the frame net leading to a biased sample in the weir.

RESULTS and DISCUSSIONS

Salmonid Habitat Investigations

Channel Classification

Blue Creek was divided into ten reaches differentiated by changes in channel type. Four channel types were identified on the mainstem of Blue Creek and a fifth type on the Crescent City Fork in 1989. Stream surveys identified three of the four major channel types: C, low gradient, open valley bottom, and a wide floodplain; B, moderate gradient, narrow valley bottom, and an active floodplain; A, steep gradient, narrow bottom valley, and no floodplain. Mainstem channel types C1, B2, B3, A2, totaled 7.2, 6.9, 7.4, and 1.3 km respectively. Five km of Crescent City Fork were classified as B1 (Figure 7).

Habitat Classification

Habitat inventory began in 1988 and continued through 1990 on the mainstem Blue Creek. Habitat inventory of Crescent City Fork was done in August 1991. Habitat inventory of West Fork was done by CDFG.

Blue Creek:
A total of 466 main channel and 78 side channel habitat units were identified and recorded between the barrier (rkm 23.6) and the mouth. Total main channel length was measured at 23.67 km. Total surface area excluding side channels was estimated at 3.41 km^2. Mean width for each habitat type not measured in 1988 was represented by substituting the mean width for that type within that channel reach. No volume measurements or estimates were derived due to a lack of depth measurements for each habitat unit in 1988, 1989, and 1990.

Habitat types ranked by the percent of total number of units were: low gradient riffles, 25%; high gradient riffles, 15%; runs, 14%; and lateral scour bedrock pools, 10%. Habitat types were also ranked by percent of total surface area: low gradient riffles, 31%; runs, 12%; lateral scour bedrock pools, 12%; glides, 11.5%; and high gradient riffles, 8% (Tables 1 and 2).

Habitat substrate composition varied within the three general habitat types sampled (riffles, flatwater, and pools). Riffles had a greater percentage of boulders and cobble with less gravel, sand, and fines. Flatwater had more gravel, sand, and fines than riffles. Pools had twice the amounts of gravel, sand, and fines as that found in flatwater. Percent embeddedness varied from pools, flatwater, and riffles. Pools had 3.6 times the embeddedness of riffles and 1.5 times that of flatwater habitat types.

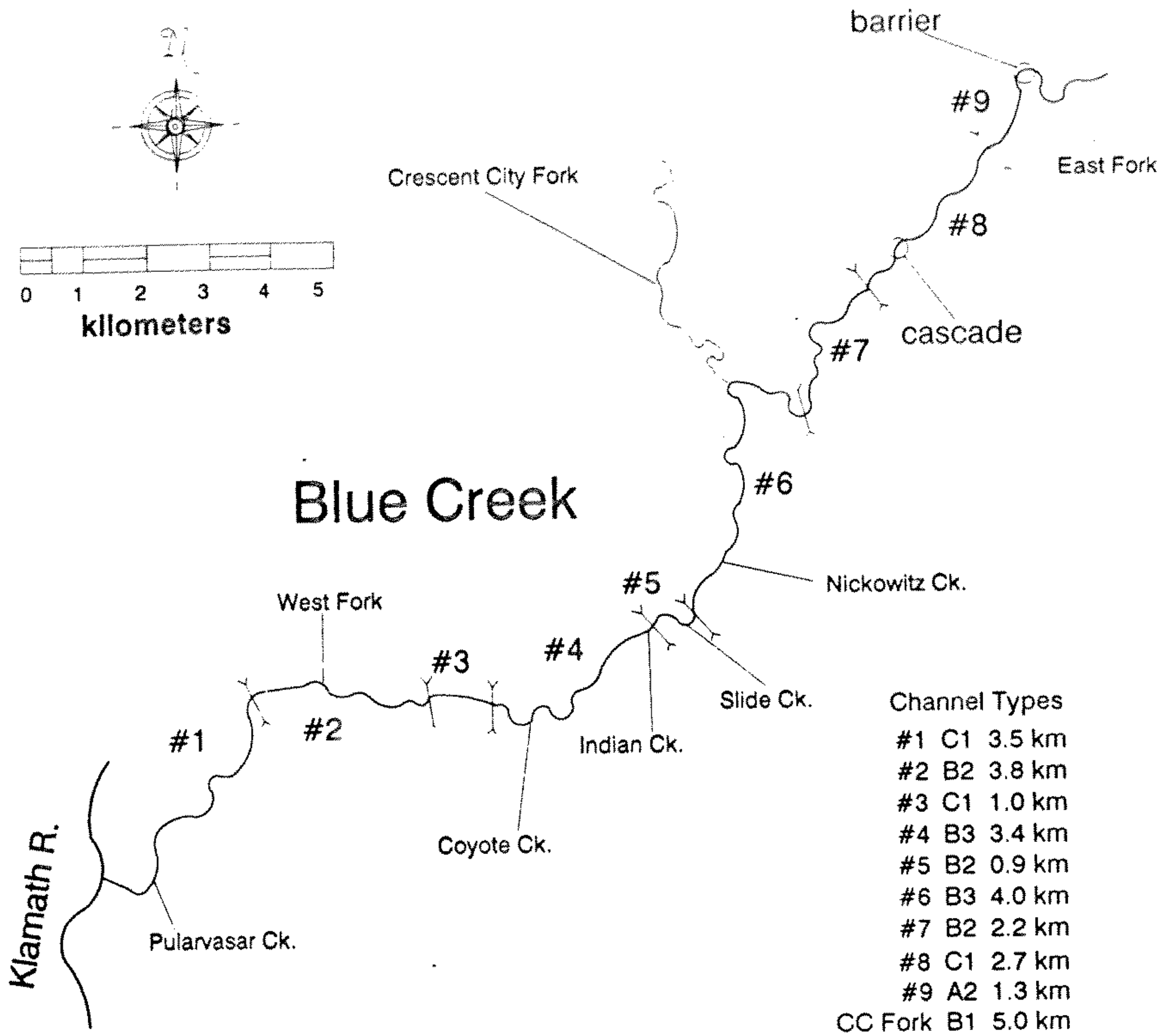


FIGURE 7. Blue Creek and Crescent City Fork channel types according to Rosgen's criteria (Rosgen 1985).

TABLE 1. Blue Creek habitat typing summary.

Main Channel

	HABITAT UNITS PRESENT	# OF HAB UNITS PRESENT	% OF TOTAL PRESENT	SAMPLED UNITS	MEAN LENGTH	MEAN WIDTH	TOTAL LENGTH	MEAN DEPTH	MAX DEPTH	AREA (m2)
RIFFLE										
	LGR 1	117	25.1	26	58.9	14.4	6888.6	0.3	0.7	105757.9
	HGR 2	70	15.0	11	32.5	12.3	2272.4	0.4	0.7	28181.0
	CAS 3	8	1.7	1	21.2	12.6	169.5	0.4	2.3	2590.7
TOTAL		195	41.8	38						136529.6
POOL										
	PLP 9	1	0.2	n/s	51.0	13.3	51.0	n/s	n/s	687.3
	LaLog 10	1	0.2	1	3.5	10.0	3.5	0.9	1.0	35.0
	LaRw 11	1	0.2	1	20.5	12.1	20.5	0.9	1.5	248.0
	LaBk 12	48	10.3	15	59.4	13.2	2850.5	1.0	2.2	40960.0
	MCP 17	13	2.8	5	89.9	16.0	1169.0	1.1	2.4	19209.6
	CCP 19	3	0.6	n/s	90.0	22.0	270.0	n/s	n/s	4043.4
	LaBo 20	34	7.3	11	40.3	12.9	1371.0	0.8	1.7	18977.5
	CRP 22	1	0.2	n/s	30.0	13.3	30.0	n/s	n/s	399.0
	STP 23	6	1.3	2	37.2	12.8	223.5	0.8	1.1	2996.5
TOTAL		108	23.2	35						87556.3
FLATWATER										
	GLD 14	33	7.1	9	71.8	15.8	2368.0	0.5	1.0	39279.0
	RUN 15	63	13.5	14	49.6	12.6	3124.8	0.4	0.7	41700.4
	SRN 16	21	4.5	5	66.7	11.5	1401.0	0.5	0.8	17823.5
	POW 21	46	9.9	10	31.6	12.0	1455.3	0.5	0.9	18272.3
TOTAL		163	35.0	38						117075.2
TOTALS		466		111			23668.6			341161.1

Side Channel

	HABITAT UNITS PRESENT	# OF HAB UNITS PRESENT	% OF TOTAL PRESENT	SAMPLED UNITS	MEAN LENGTH	MEAN WIDTH	TOTAL LENGTH	MEAN DEPTH	MAX DEPTH	AREA (m2)
RIFFLE										
	LGR 1	29	37.2	2	74.8	6.6	2168.0	0.2	0.5	14636.6
	HGR 2	8	10.3	2	22.2	6.0	177.5	0.2	0.3	972.0
	CAS 3	1	1.3	n/s	6.0	4.6	6.0	n/s	n/s	27.6
TOTAL		38	48.7	4						15636.2
POOL										
	SCP 4	6	7.7	1	40.0	6.8	240.0	0.6	0.8	1625.0
	BwBo 5	6	7.7	n/s	12.4	5.4	74.5	n/s	n/s	509.6
	PLP 9	1	1.3	1	10.5	11.0	10.5	0.7	1.1	115.5
	LaBk 12	1	1.3	n/s	11.0	6.0	11.0	n/s	n/s	66.0
	LaBo 20	2	2.6	1	5.8	5.8	11.5	0.4	0.8	71.8
TOTAL		16	20.5	3						2387.9
FLATWATER										
	GLD 14	1	1.3	n/s	17.0	4.0	17.0	n/s	n/s	68.0
	RUN 15	6	7.7	1	15.2	5.2	91.5	0.3	0.5	472.9
	SRN 16	3	3.8	n/s	28.7	10.3	86.0	n/s	n/s	990.0
	EGW 18	12	15.4	5	11.3	5.3	135.4	0.3	0.6	823.3
	POW 21	2	2.6	n/s	23.0	6.1	46.0	n/s	n/s	278.8
TOTAL		24	30.8	6						2633.0
TOTALS		78		13			3074.9			20657.1

TABLE 2. Blue Creek habitat typing cover and substrate summary.

Main Channel

	HAB UNITS PRESENT	# OF HAB TYPE PRESENT	# OF HAB UNITS SAMPLED	% OF HAB UNITS SAMPLED	MEAN % SHADE	MEAN % COVER	MEAN % FINES	MEAN % SAND	MEAN % GRAVEL	MEAN % COBBLE	MEAN % BOULDER	MEAN % BEDROCK	MEAN % EMBED	MEAN % EXP SUB
RIFFLE														
	LGR 1	117	26	22.2	16	36	2	12	19	35	31	1	22	18
	HGR 2	70	11	15.7	20	51	1	7	14	27	49	1	15	28
	CAS 3	8	1	12.5	10	100	0	0	0	0	20	80	0	20
TOTAL		195	38	19.5										
POOL														
	PLP 9	1	n/s	n/s	n/s	n/s	n/s	n/s	n/s	n/s	n/s	n/s	n/s	n/s
	LsLog 10	1	1	100.0	5	35	0	10	15	25	45	5	15	20
	LsRw 11	1	1	100.0	0	27	5	15	25	45	10	0	30	0
	LsBk 12	48	15	31.3	20	19	6	24	25	19	18	8	50	2
	MCP 17	13	5	38.5	25	14	14	42	13	16	12	3	82	0
	CCP 19	3	n/s	n/s	n/s	n/s	n/s	n/s	n/s	n/s	n/s	n/s	n/s	n/s
	LsBo 20	34	11	32.4	21	21	4	16	16	27	37	0	43	11
	CRP 22	1	n/s	n/s	n/s	n/s	n/s	n/s	n/s	n/s	n/s	n/s	n/s	n/s
	STP 23	6	2	33.3	42	22	5	28	10	18	40	0	38	12
TOTAL		108	35	32.4										
FLATWATER														
	GLD 14	33	9	27.3	11	7	3	12	21	33	25	5	36	3
	RUN 15	63	14	22.2	10	20	3	14	22	35	25	1	33	5
	SRN 16	21	5	23.8	22	29	2	14	9	30	45	0	22	10
	POW 21	46	10	21.7	16	26	3	16	17	28	34	2	24	9
TOTAL		163	38	23.3										
TOTALS		466	111	23.8										

Side Channel

	HAB UNITS PRESENT	# OF HAB TYPES PRESENT	# OF HAB UNITS SAMPLED	% OF HAB UNITS SAMPLED	MEAN % SHADE	MEAN % COVER	MEAN % FINES	MEAN % SAND	MEAN % GRAVEL	MEAN % COBBLE	MEAN % BOULDER	MEAN % BEDROCK	MEAN % EMBED	MEAN % EXP SUB
RIFFLE														
	LGR 1	29	2	6.9	65	25	0	8	28	30	35	0	10	22
	HGR 2	8	2	25.0	60	35	0	2	15	28	55	0	2	30
	CAS 3	1	n/s	n/s	n/s	n/s	n/s	n/s	n/s	n/s	n/s	n/s	n/s	n/s
TOTAL		38	4	10.5										
POOL														
	SCP 4	6	1	16.7	25	10	10	30	10	20	30	0	40	3
	BwBo 5	6	n/s	n/s	n/s	n/s	n/s	n/s	n/s	n/s	n/s	n/s	n/s	n/s
	PLP 9	1	1	100.0	0	20	0	30	5	15	40	10	25	5
	LsBk 12	1	n/s	n/s	n/s	n/s	n/s	n/s	n/s	n/s	n/s	n/s	n/s	n/s
	LsBo 20	2	1	50.0	80	25	0	60	5	10	25	0	50	5
TOTAL		16	3	18.8										
FLATWATER														
	GLD 14	1	n/s	n/s	n/s	n/s	n/s	n/s	n/s	n/s	n/s	n/s	n/s	n/s
	RUN 15	6	1	16.7	10	35	0	0	10	45	45	0	0	5
	SRN 16	3	n/s	n/s	n/s	n/s	n/s	n/s	n/s	n/s	n/s	n/s	n/s	n/s
	EDW 18	12	5	41.7	40	18	10	33	22	8	19	8	59	9
	POW 21	2	n/s	n/s	n/s	n/s	n/s	n/s	n/s	n/s	n/s	n/s	n/s	n/s
TOTAL		24	6	25.0										
TOTALS		78	13	16.7										

Crescent City Fork:
Habitat inventory for Crescent City Fork was completed from the mouth to rkm 5.5 in August 1991. A total of 133 main channel and 11 side channel habitat units were identified and recorded. Total length of the main channel was 5.48 km and the side channels was 0.43 km. Total area and volume for main channel was 49,819 m^2 and 28,352 m^3. Total area and volume for the side channels were 1,558 m^2 and 506 m^3, respectively.

Habitat types ranked by the most numerous in percent of the total habitat units were: low gradient riffles (30%), lateral scour bedrock pools (25%), runs (10%), high gradient riffles (10%), backwater pools (6%), and all others were each less than (5%). Habitat types ranked by the most numerous in total percent of surface area were: low gradient riffles (47%), lateral scour bedrock pool (15%), runs (10%), high gradient riffles (10%), and all others were each less than 5% (Tables 3 and 4).

Spawning Habitat

Estimated spawning habitat in the mainstem of Blue Creek totaled 19,603 m^2 based on all measurements of estimated optimum spawning areas for each habitat unit. Optimal substrate size for chinook spawning ranges from 0.5 cm to 15.0 cm (Briggs 1953; Reiser and Bjornn 1979). Redds and spawners were sometimes observed in areas considered less than optimum, so this total is conservative.

A large proportion (50%) of the available spawning habitat is located in the lower 3 km of Blue Creek. This portion of the mainstem is characterized by a wide, shallow and braided channel with extensive alluvial gravel deposits. The channel was typed as C1. Unfortunately, the extensive alluvial deposits which provide optimal size substrate for spawning are highly mobile during high winter flows. Another section of C1 channel type between rkm 7.3 to 8.3 contains a significant portion (10%) of the available gravel. The remainder of the available gravels are widely distributed throughout the mainstem. In 1990 and 1991 most redds were observed upstream of rkm 3.0 (Figure 8).

Embeddedness within all the habitat units varied from a high of 82% in main channel pools to a low of 15% in lateral scour log- formed pools.

Based on chinook redd size information collected during the fall 1988 and fall 1989 an estimate was made of the potential number of chinook spawning pairs that could be accommodated. The average redd size of fall-run chinook in Blue Creek was 8.5 m^2. We estimated the area required per pair of spawning chinook by doubling the average redd size to allow for redd separation. Blue Creek could support at least 1,153 chinook spawning pairs, using the estimate of 17.0 m^2 per spawning pair.

TABLE 3. Habitat typing summary for the Crescent City Fork tributary of Blue Creek by channel type (all units measured in meters).

Main Channel

	HABITAT UNITS PRESENT	# OF HABITAT UNITS	% OF TOTAL PRESENT	TOTAL LENGTH	MEAN LENGTH	MEAN WIDTH	MEAN DEPTH	MAX DEPTH	AREA (m2)	VOLUME (m3)
RIFFLE										
	LGR 1	40	30.1	2557.5	63.9	9.2	0.4	0.9	23605.7	9206.2
	HGR 2	13	9.8	536.5	41.3	8.9	0.5	0.9	4748.0	2136.6
	CAS 3	2	1.5	35.5	17.8	6.0	0.7	0.9	213.0	138.5
TOTAL		55	41.4	3129.5					28566.8	11481.3
POOL										
	BwBo 5	8	6.0	147.0	18.4	11.2	0.8	1.5	1644.9	1283.0
	LaBk 12	33	24.8	845.5	25.6	8.7	1.0	2.2	7313.6	7459.8
	MCP 17	6	4.5	179.5	29.9	8.3	1.1	3.4	1480.9	1673.4
	LaBo 20	3	2.3	71.5	23.8	11.7	1.0	1.6	834.4	809.4
	CRP 22	1	0.8	37.0	37.0	10.0	1.5	2.5	370.0	555.0
	STP 23	3	2.3	108.0	36.0	8.8	0.7	1.3	953.6	696.2
TOTAL		54	40.6	1388.5					12597.4	12476.8
FLATWATER										
	GLD 14	1	0.8	55.0	55.0	7.0	0.6	1.0	385.0	231.0
	RUN 15	14	10.5	552.5	39.5	9.1	0.5	1.0	5011.2	2405.4
	SRN 16	2	1.5	134.0	67.0	8.3	0.4	0.7	1105.5	442.2
	POW 21	6	4.5	181.0	30.2	10.2	0.6	1.0	1840.8	1159.7
	BRS 24	1	0.8	39.0	39.0	8.0	0.5	0.7	312.0	156.0
TOTAL		24	18.1	961.5					8654.4	4394.2
TOTALS		133		5479.5					49818.6	28352.4

Side Channel

	HABITAT UNITS PRESENT	# OF HABITAT UNITS	% OF TOTAL PRESENT	TOTAL LENGTH	MEAN LENGTH	MEAN WIDTH	MEAN DEPTH	MAX DEPTH	AREA (m2)	VOLUME (m3)
RIFFLE										
	LGR 1	5	45.5	270.0	54.0	3.6	0.2	0.5	972.0	233.3
	HGR 2	3	27.3	84.0	28.0	2.3	0.2	1.5	195.7	45.0
TOTAL		8	72.7							
POOL										
	DPL 13	1	9.1	30.0	30.0	9.0	0.4	0.6	270.0	108.0
	CCP 19	1	9.1	30.0	30.0	4.0	1.0	0.6	120.0	120.0
TOTAL		2	18.2							
FLATWATER										
	RUN 15	1	9.1	20.0	20.0	4.0	0.4	0.5	80.0	32.0
TOTAL		1	9.1							
TOTALS		11		414.0					1557.7	506.3

TABLE 4. Habitat typing cover and substrate for Crescent City Fork tributary of Blue Creek.

Main Channel

	HAB UNITS PRESENT	# OF HAB TYPE PRESENT	# OF HAB UNITS SAMPLED	% OF HAB UNITS SAMPLED	MEAN % SHADE	MEAN % COVER	MEAN % FINES	MEAN % SAND	MEAN % GRAVEL	MEAN % COBBLE	MEAN % BOULDER	MEAN % BEDROCK	MEAN % EMBED	MEAN % EXP SUB
RIFFLE														
	LOR 1	40	9	22.5	32.2	63.4	0.3	8.0	13.3	29.4	45.0	3.9	28.9	32.2
	HOR 2	13	3	23.1	56.7	54.7	0.0	5.0	6.7	26.7	60.0	1.7	18.3	50.0
	CAS 3	2	2	100.0	32.5	85.5	0.0	6.5	8.5	25.0	60.0	0.0	25.0	50.0
TOTAL		55	14	25.5										
POOL														
	BwBo 5	8	3	37.5	46.7	64.7	1.7	10.0	16.7	21.7	45.0	5.0	28.3	16.7
	LaBk 12	33	8	24.2	33.3	78.3	6.3	12.5	17.5	24.4	27.5	13.1	39.4	4.8
	MCP 17	6	2	33.3	20.0	90.0	5.0	15.0	25.0	15.0	30.0	10.0	47.5	2.5
	LaBo 20	3	1	33.3	5.0	99.0	2.0	8.0	35.0	10.0	40.0	5.0	55.0	25.0
	CRP 22	1	1	100.0	50.0	85.0	5.0	15.0	20.0	30.0	15.0	15.0	50.0	1.0
	STP 23	3	2	66.7	20.0	96.5	0.0	7.5	10.0	17.5	40.0	25.0	17.5	32.5
TOTAL		54	17	31.5										
FLATWATER														
	GLD 14	1	1	100.0	15.0	75.0	5.0	15.0	20.0	40.0	15.0	5.0	50.0	5.0
	RUN 15	14	6	42.9	40.8	60.3	3.0	10.3	19.2	22.5	42.5	5.0	37.5	10.8
	SRN 16	2	2	100.0	40.0	92.5	2.5	10.0	15.0	25.0	47.5	0.0	30.0	22.5
	POW 21	6	2	33.3	30.0	79.5	2.5	10.0	15.0	22.5	47.5	2.5	30.0	27.6
	BRS 24	1	1	100.0	40.0	65.0	0.0	5.0	10.0	5.0	10.0	70.0	0.0	50.0
TOTAL		24	12	50.0										
TOTALS		133	43	32.3										

Side Channel

	HAB UNITS PRESENT	# OF HAB TYPE PRESENT	# OF HAB UNITS SAMPLED	% OF HAB UNITS SAMPLED	MEAN % SHADE	MEAN % COVER	MEAN % FINES	MEAN % SAND	MEAN % GRAVEL	MEAN % COBBLE	MEAN % BOULDER	MEAN % BEDROCK	MEAN % EMBED	MEAN % EXP SUB
RIFFLE														
	LOR 1	5	4	80.0	95.0	65.0	2.5	7.5	12.5	33.8	43.8	0.0	22.5	30.0
	HOR 2	3	2	66.7	100.0	60.0	0.0	2.5	7.5	30.0	60.0	0.0	10.0	57.5
TOTAL		8	6											
POOL														
	DPL 13	1	1	100.0	100.0	70.0	50.0	20.0	20.0	0.0	10.0	0.0	100.0	10.0
	CCP 19	1	1	100.0	10.0	56.0	5.0	10.0	20.0	25.0	35.0	5.0	35.0	0.0
TOTAL		2	2	100.0										
FLATWATER														
	RUN 15	1	1	100.0	80.0	65.0	5.0	10.0	25.0	20.0	40.0	0.0	40.0	5.0
TOTAL		11	9	81.8										

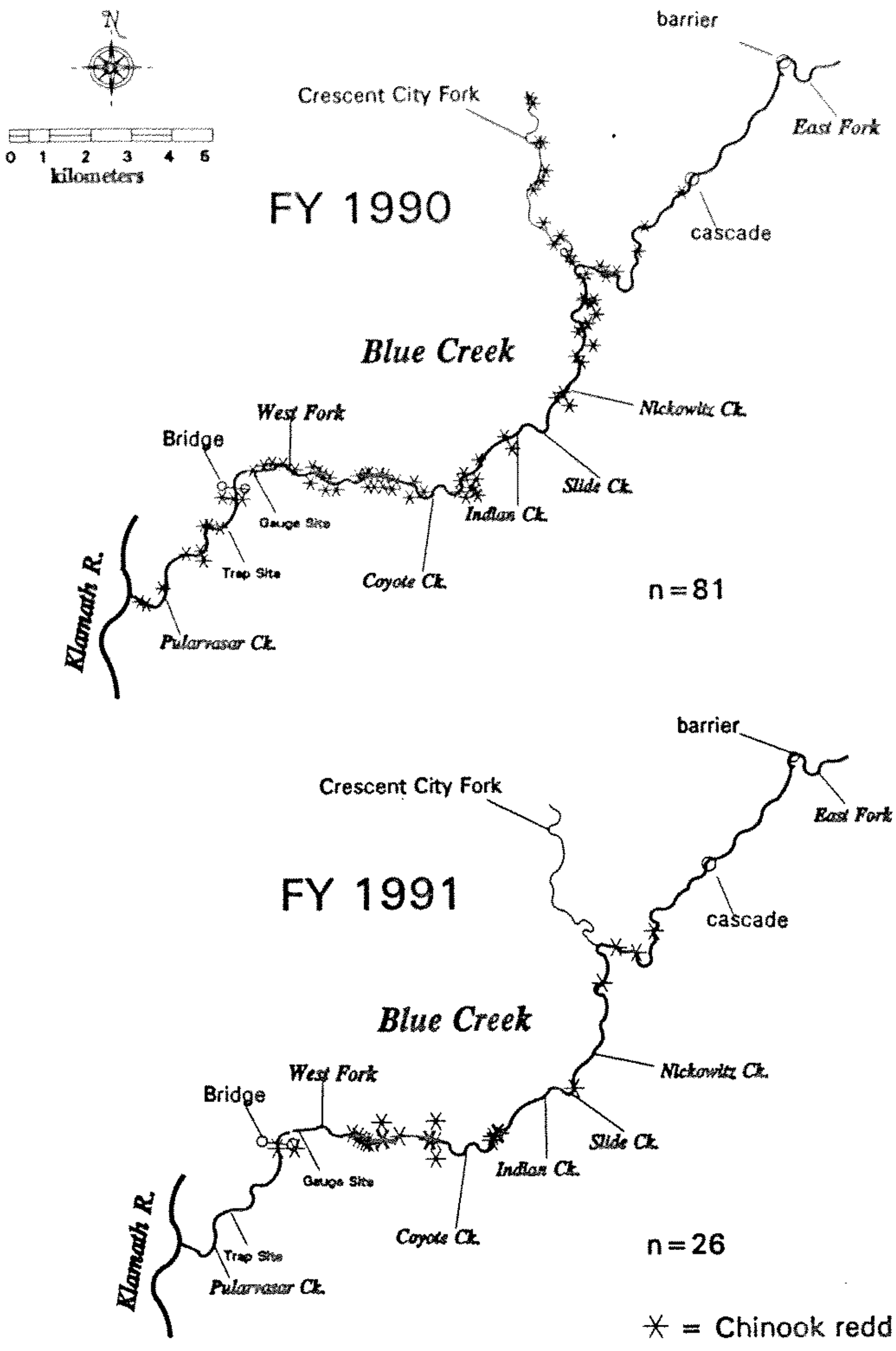


FIGURE 8. Chinook redd location, fall 1989, 1990.

Rearing Habitat

A total area of 123,600 m^2 was sampled by walking 20% of all the anadromous fish habitat. Based on this sample, the total expanded rearing habitat area for 7 reaches was 618,000 m^2. Based on underwater observations of about 10% of the total stream, 28% was used by rearing chinook and 54% by rearing steelhead (Figure 9).

Rearing fish used general habitat types (edgewater, thalweg, and intermediate) in varying amounts depending on species and age class (Figure 10). Only the 2+ and 1+ steelhead were found in the thalweg, while both chinook and steelhead YOY mainly inhabited edges. Dominate fish in the intermediate areas were older steelhead (1+ and 2+). The few coho observed were not in the thalweg.

Underwater observations were also used to calculate densities of rearing fish for each age and species in each reach, Figure 11. Chinook densities ranged from 0 in reach 6 to .063 fish/m^2 in reach 3. Average density of chinook within all 7 reaches was .025 fish/m^2. This average was similar to other average densities observed from the Scott, Salmon, Shasta, and mid-Klamath sub basin tributaries .029 fish/m^2 reported by the USFS (West et al.1989).

Juvenile salmonids were observed at the heads of pools and at the bottoms of riffles during the low flow and warmer temperature period. No specific cool-water refuges were located.

Temperature

FY 1990

The maximum-minimum thermometer was deployed with the screw trap beginning in April and provided data into August (Figure 12). Only median data are plotted because averages cannot be calculated from the daily ranges recorded. Data for August to October were provided from the replaced thermograph (Figure 13). Temperatures decreased briefly at the end of May due to storm events.

FY 1991

Temperature data were collected throughout the year by using a thermograph (Figure 13). A few days data were lost in early February when batteries were changed. Data from August into October were lost due to operator error. The seasonal low occurred in December at 4.0 °C. Temperatures in mid-January increased due to rain.

Discharge

Drought conditions have occurred in the entire Klamath basin since bout 1986. Measured minimum flows in Blue Creek for the two years

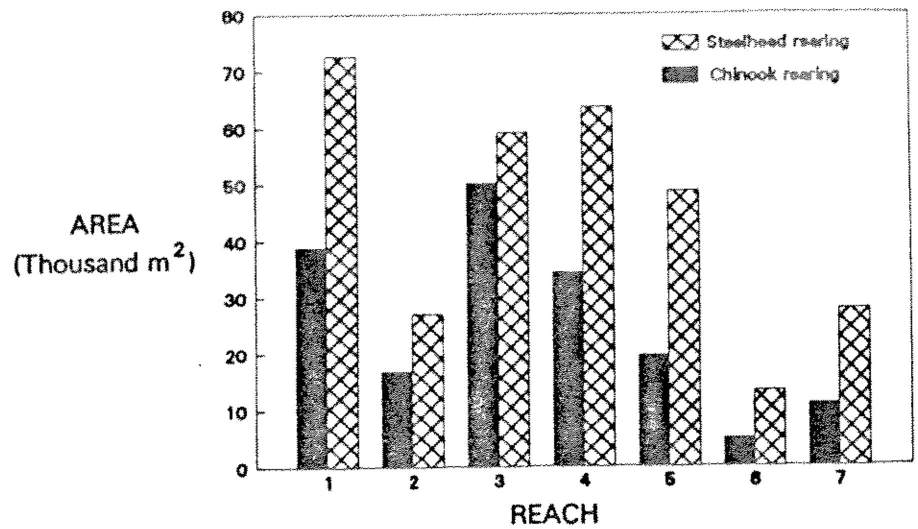


FIGURE 9. Area of rearing habitats by reach and species.

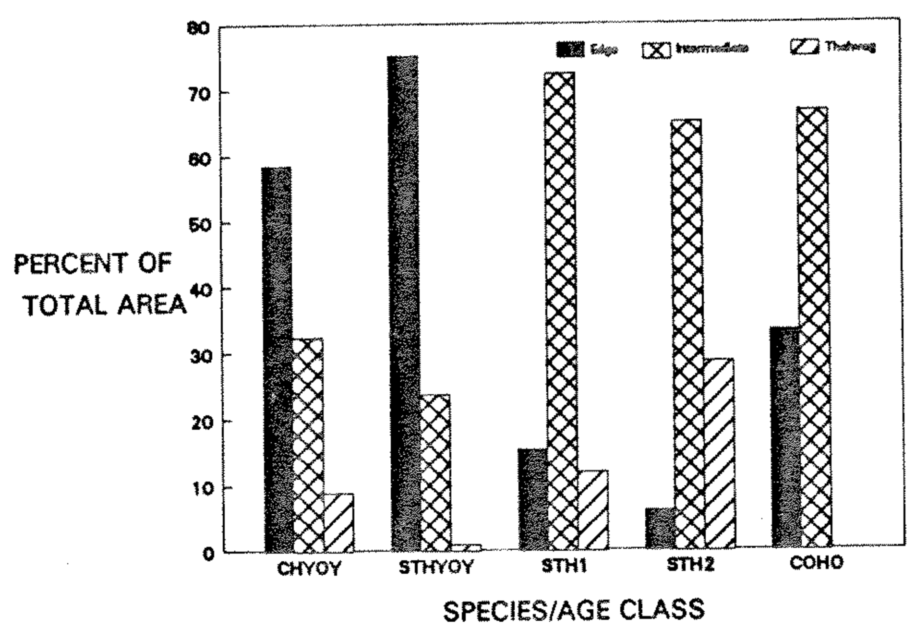


FIGURE 10. Percent of general habitat type used by species for each age class (CHYOY = chinook young-of-year, STHYOY = steelhead young-of-year, STH1 = 1+ Steelhead, STH2 = 2+ Steelhead).

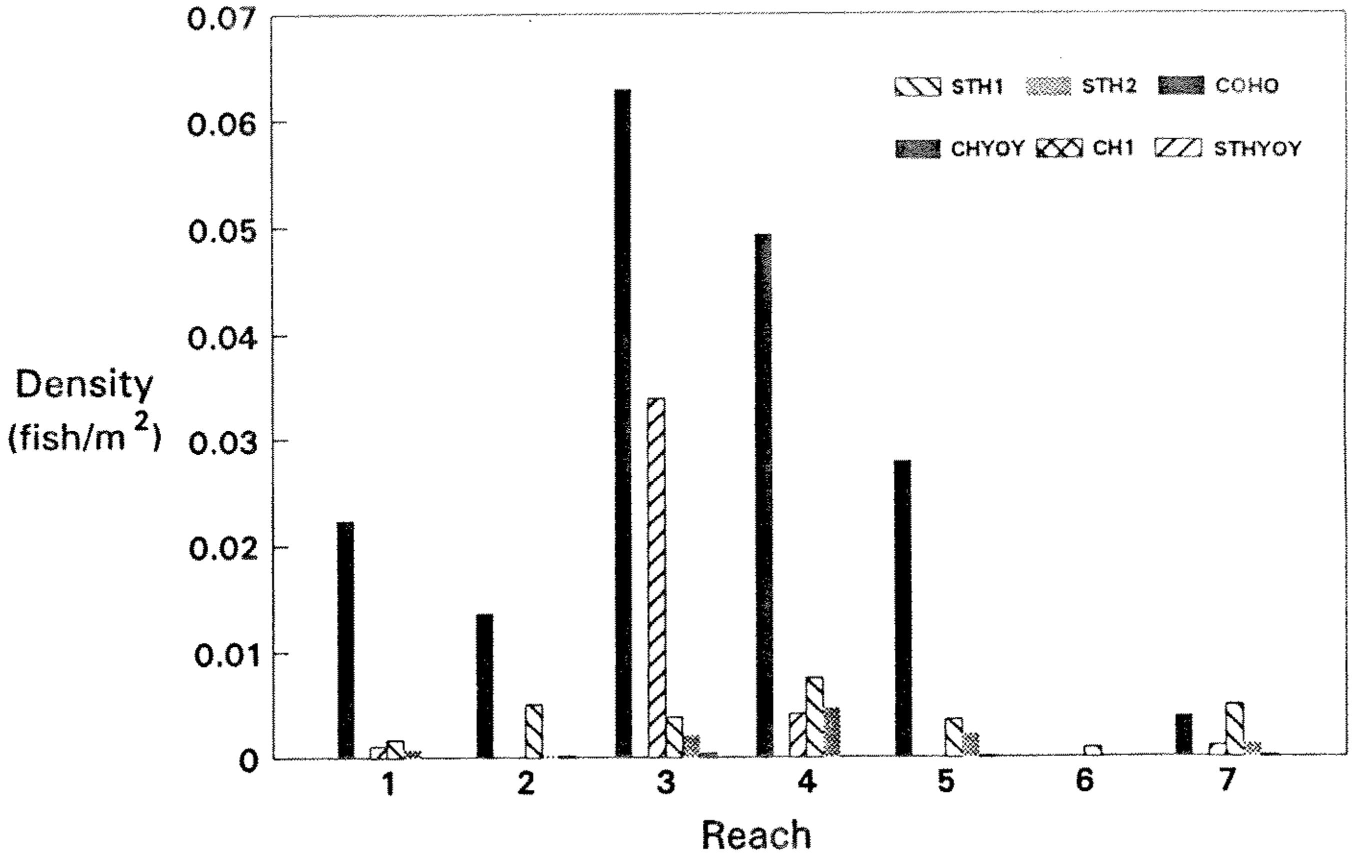


FIGURE 11. Densities of fish observed by reach, species, and age-class (CHYOY = chinook young-of-year, STHYOY = steelhead young-of-year, CH1 = 1 + chinook, STH1 = 1 + steelhead, STH2 = 2 + steelhead).

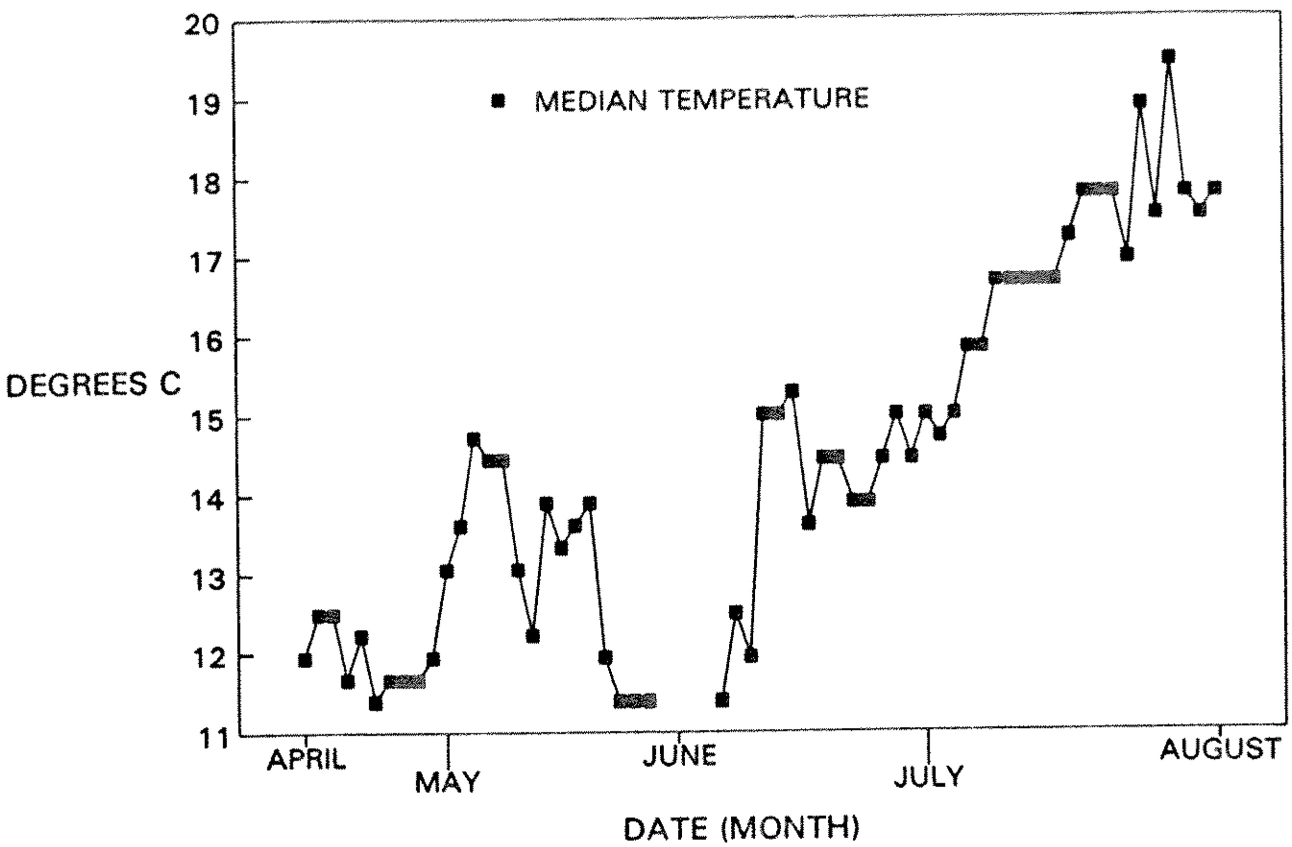


FIGURE 12. Blue Creek daily median temperature, April-August 1990.

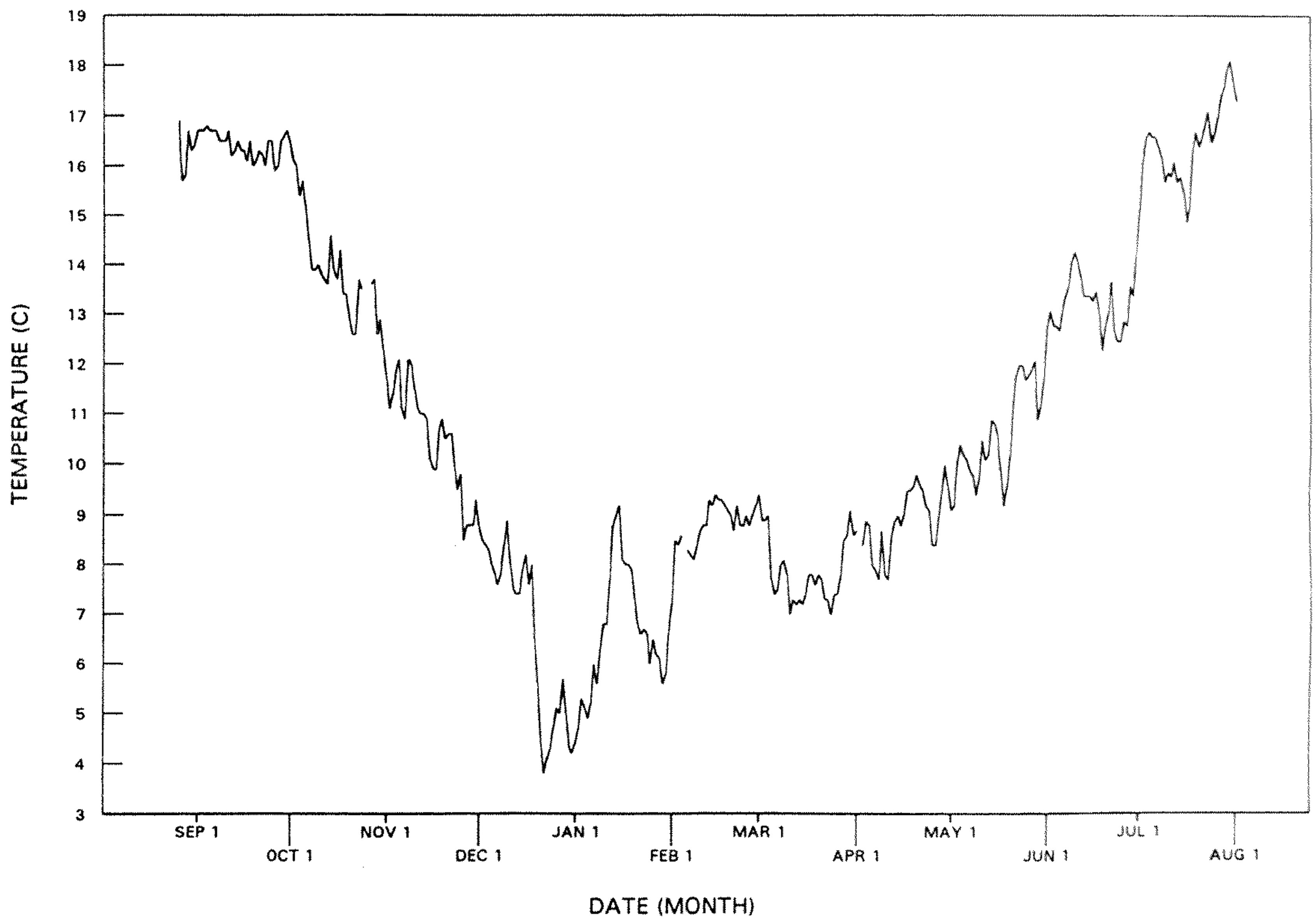


FIGURE 13. Blue Creek daily average temperatures, September 1990 - August 1991.

were 61 cfs, Oct. 3, 1989, and 65 cfs, on Sept. 10, 1990 (Figures 14 and 15). Maximum flows were estimated from crest gage heights and were 2,870 cfs on June 4, 1990, and 4,303 cfs on April 11, 1991 (Figures 16 and 17).

Adult Chinook Salmon Investigations

Radiotelemetry

FY 1990

Radio-tag application began on October 23, 1989 and concluded on November 28, 1989. Nineteen radio-tags were applied to adult fall run chinook in Blue Creek. Nine tags were applied externally and ten applied internally. One external tag was used twice. All tags were applied in Blue Creek from rkm 3.5 to 5.0. No immediate mortalities resulted from tag application procedures. Eighteen tags remained on the fish throughout the spawning season and yielded suitable results. Two of the first tags were lost. One external tag was incorrectly crimped and fell off within a few hours of application and the first internal tag applied was recovered downstream a few weeks later. We suspect that this tag was regurgitated by the fish.

Tagged fish were tracked by helicopter on seven occasions and by road and stream ten times between October 27, 1989 to December 29, 1989 (Appendix C). During aerial observations, several passes along the stream had to be made to determine locations since many tags were in close proximity.

Three tagged fish moved downstream after application, 14 moved upstream, and two remained in the vicinity where the tags were applied. Two of the fish which moved downstream ended up in the mainstem Klamath River, of which one was recovered after the fish was caught in an Indian gillnet, 1.6 km downstream of the mouth of Blue Creek. The other tag was located in the same location in the Klamath River, but was not recovered. The third downward moving fish remained in Blue Creek and was observed excavating a redd 1.5 km below the tag site three days after tag application. Of the 14 fish which moved upstream, one traveled approximately 13.5 km upstream into the Crescent City Fork, two moved 6.5 to 8.0 km upstream, eight moved 3.0 to 5.0 km upstream, and three remained within one km of the tagging site (Appendix C).

Some tagged fish were observed and photographed after tagging by snorkeling and surface observations. Two externally tagged fish were observed on redds, one just three days after tag application. Externally tagged fish were observed schooling with other chinook and steelhead. Internal radio tags were only obvious in the fish with external marks.

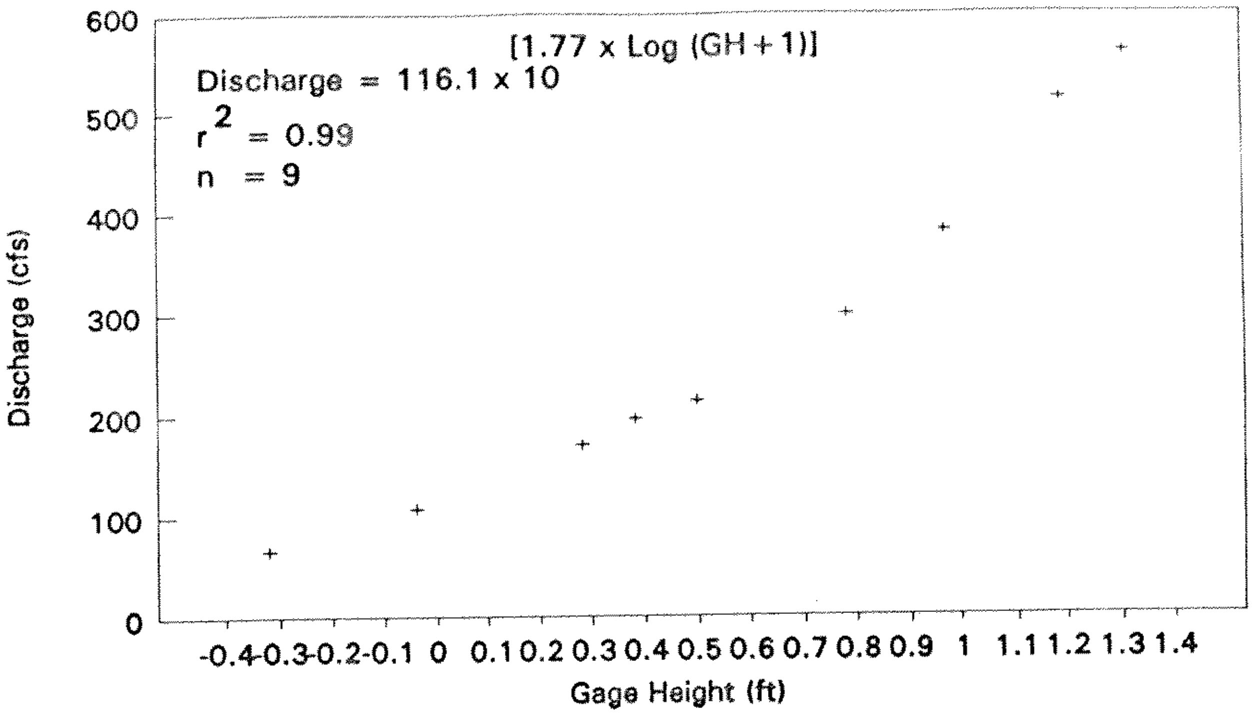


Figure 14. Gage height-discharge relationship, Blue Creek 1990.

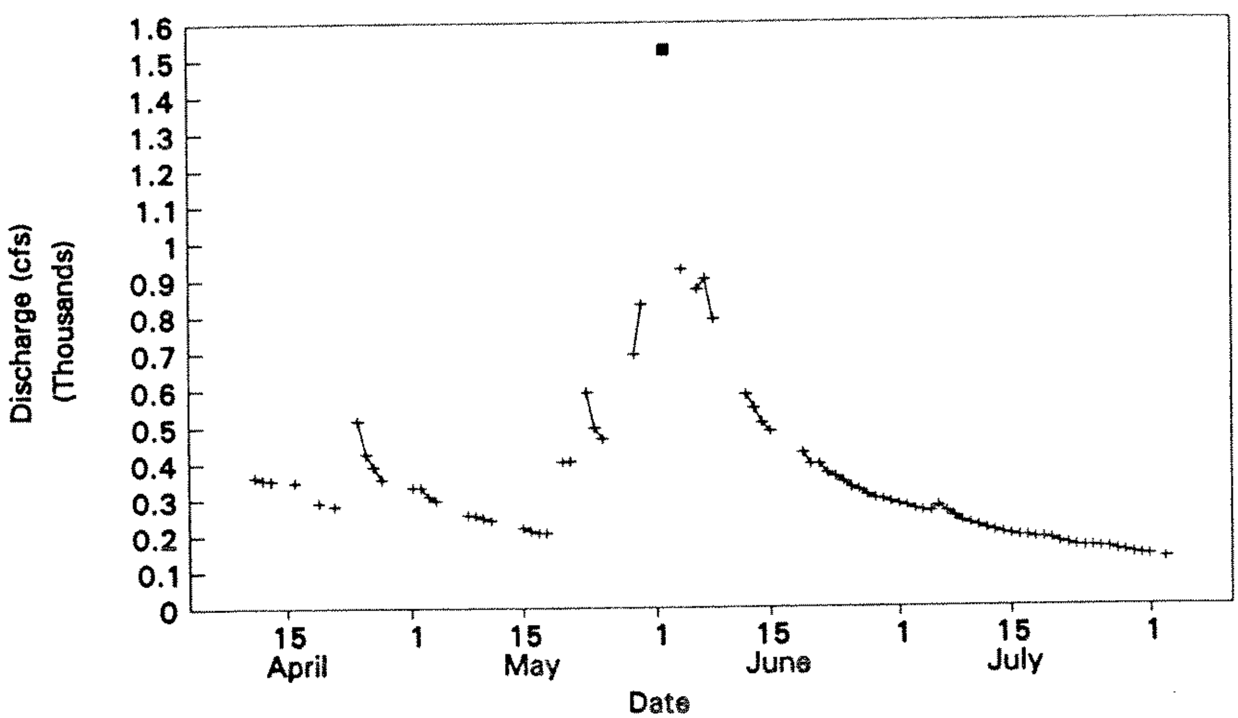


Figure 15. Estimated discharge (cfs) of Blue Creek during 1990 juvenile trapping season (■ is peak discharge).

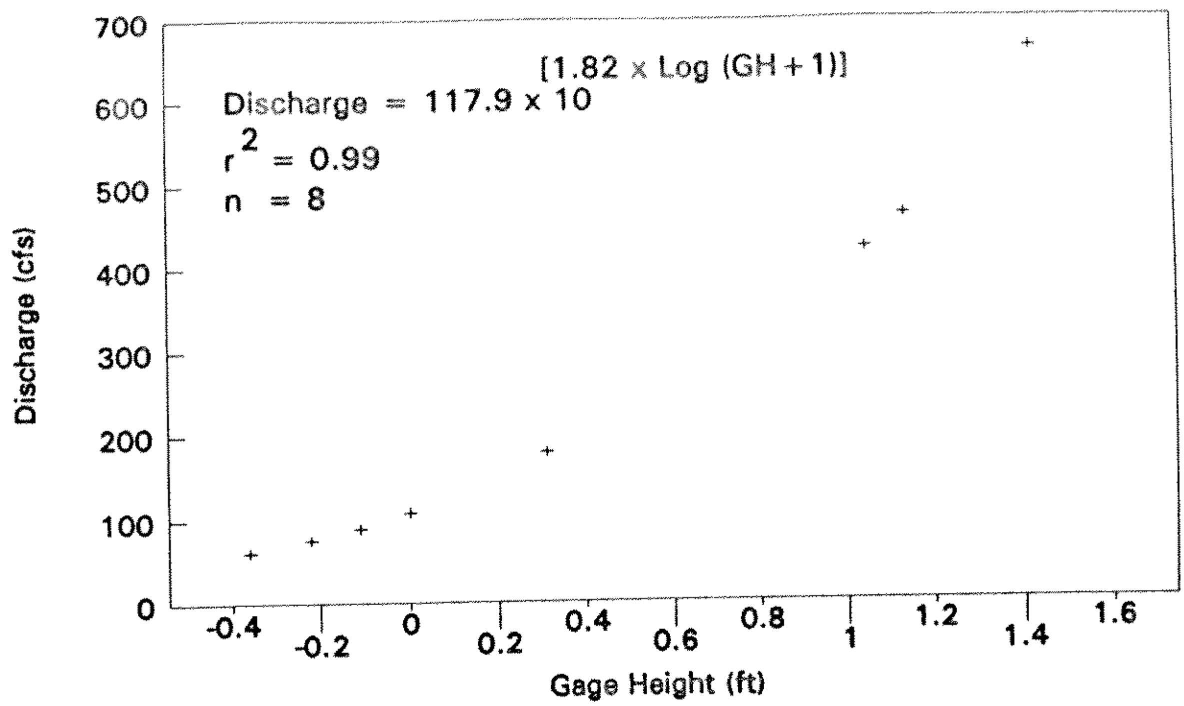


FIGURE 16. Gage height-discharge relationship, Blue Creek 1991.

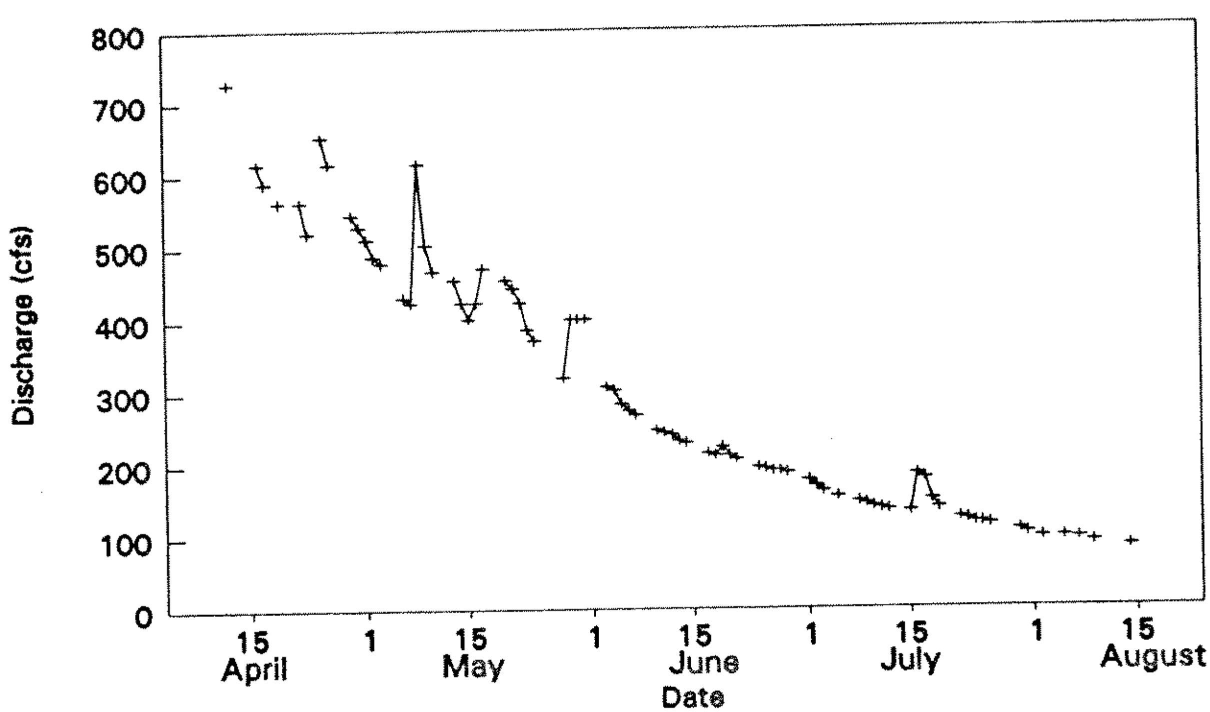


FIGURE 17. Estimated discharge (cfs) of Blue Creek during 1991 juvenile trapping.

Tag recovery was incomplete due to predation and difficulty in finding the tag after it dropped off or out of the fish. One tag was assumed to be inside a redd and others not recovered were assumed to be buried in the streambed. Fourteen tags were recovered at the conclusion of the chinook spawning season.

FY 1991

Seventeen tags were applied to spawners in Nov. 1-20, at rkm 2.0 to 4.8 (Appendix C). Five tags were external and 12 internal. All but one of the tagged fish were followed for at least three subsequent visits. Nine tags were recovered after spawning.

One fish returned to the Klamath River and was not located again. Distances travelled upstream varied from 0 to 11.2 rkm (average 3.2) with four fish not moving at all. The longest time that a tag was followed was 65 days. No tagged fish were observed in Crescent City Fork.

Redd, Carcass, and Live Adult Surveys

FY 1990

Redd Counts:

Redd surveys conducted during FY 90 located a total of 74 redds on mainstem Blue Creek and 12 on Crescent City Fork (Figure 8). Five redds on the mainstem were possibly formed by either several pairs or multiple attempts by one spawning pair. All redds were assumed to be fall run chinook, although a single adult coho was observed each year. Redds were tallied by both reach and habitat type in percent (Figure 18). Tail-outs of bedrock lateral-scour pools were most commonly used in the Blue Creek. The average surface area for each of the 50 measured redds on the mainstem of Blue Creek was 8.5 m^2, and 5.2 m^2 for the four measured redds on Crescent City Fork. Total areas of measured redds on both Blue Creek and Crescent City Fork came to 425.5 m^2 and 20.8 m^2, respectively. Additionally, expanded total areas for unmeasured redds, 19 in Blue Creek and 8 in Crescent City Fork, based on measured averages, were 587.2 m^2 and 62.3 m^2, respectively. Redd surveys were conducted through Reach 7. Because of few numbers of adult salmon, only six percent of the total available spawning gravel was used.

Lateral scour bedrock pools had a mean of 50% embeddedness yet supported over 30% of the units that redds were found in 1988, 1989, 1990, and 1991 (Figure 8). Spawners were able to place redds at pool tail-outs despite the apparently moderate to high amounts of sands and silts.

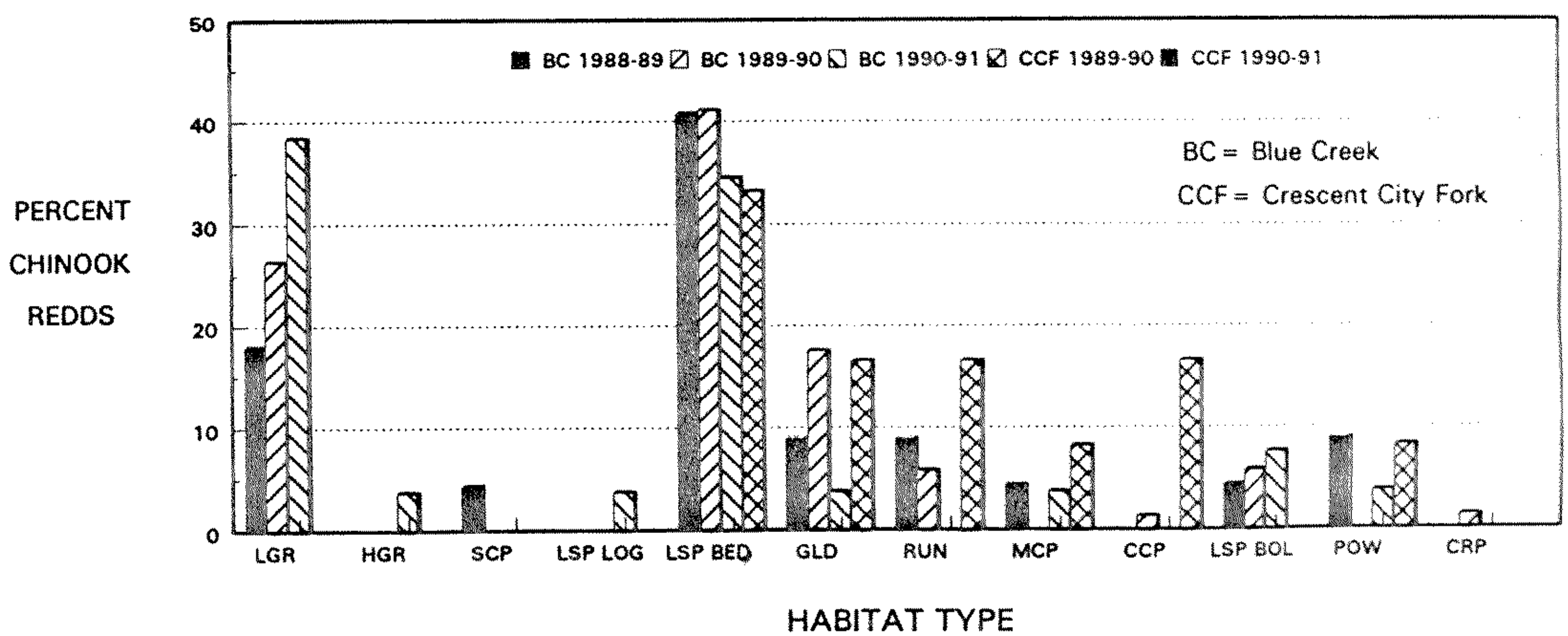


FIGURE 18. Chinook redds by habitat type in percent, 1988-1991.

Spawning activity occurred in two time periods which coincided with two storms that encouraged upstream migration in late October and early December (Tables 5 and 6).

Carcass Counts:

Carcass surveys recorded ten chinook and one coho (Table 7). Poor recovery of carcasses was mainly due to predation by black bears (Ursus americanus), river otters (Lutra canadensis), and raccoons (Procyon lotor). Black bears were active during both night and day, and were encountered during surveys on several occasions. No mark and recapture efforts of carcasses were attempted due to low numbers.

Live Counts:

Snorkel surveys identified times of entry for adult chinook into Blue Creek, located groups of chinook for tagging, and confirmed locations of externally tagged chinook (Table 9). Water visibility sometimes limited counting and identification of chinook and other salmonids. Incomplete counts of adults prevented estimates of the spawning population. On October 16, 1989 four chinook and one steelhead were observed at rkm 3.2 and one chinook and two steelhead were seen at rkm 3.5, indicating that the flows were adequate for entry of adult chinook into Blue Creek in early October. Only juvenile salmonids were observed within the West Fork tributary during underwater observations of adult chinook.

FY 1991

Redd Counts:

Redd surveys were conducted seven times from November 8 to December 18, 1990, and a total of 26 redds were located on the mainstem of Blue Creek and none on Crescent City Fork (Figure 8 and Table 10). Only one survey of all 6 sections was completed due to lack of suitable stream conditions and access. The lower 4 sections were surveyed twice and the lower 2 sections were surveyed three times. The estimated spawning area used was 330 square meters (Table 10), which is 2% of the total estimated available.

Carcass Counts:

Chinook carcass surveys recovered only 5 partial carcasses (Table 8). Few carcasses were seen due to the lack of extensive surveying and predation.

Live Counts:

Snorkel surveys identified entry times for fall run chinook, located groups of chinook for radio-tagging, and confirmed locations of radio-tagged chinook (Table 9). On October 17, 1990,

TABLE 5. Chinook Redd Data, Blue Creek, fall 1989.

Date	Rkm	Habitat Type	Length (m)	Width (m)	Area (m2)	Pit Depth (m)	Mound Depth (m)	Fish Present
11-08-89	13.4	12	1.5	1.3	2.0	0.4	0.2	0
11-08-89	13.4	12	2.0	1.5	3.0	0.6	0.4	0
11-08-89	13.8	12	5.0	5.6	28.0			0
11-08-89	14.5	12	4.5	2.5	11.3	0.4	0.1	0
11-08-89	14.5	12	5.0	2.5	12.5	0.6	0.35	0
11-08-89	14.5	12	2.5	1.2	3.0	0.5	0.35	0
11-08-89	15.1	20	2.5	1.5	3.8	0.6	0.2	1
11-08-89	15.8	20	2.5	1.0	2.5	0.6	0.25	0
11-09-89	8.8	12	3.2	1.6	5.1	0.4	0.2	1
11-09-89	8.8	12	6.5	3.8	24.7	0.5	0.35	0
11-09-89	8.2	20	5.6	2.4	13.4	0.35	0.15	0
11-09-89	8.2	15	5.0	2.8	14.0	0.5	0.2	0
11-09-89	8.0	12	4.0	2.0	8.0	0.3	0.15	0
11-09-89	8.0	12	3.0	2.0	6.0	0.65	0.35	0
11-09-89	5.3	1	2.0	1.2	2.4	0.5	0.25	0
11-09-89	7.7	15	1.9	1.0	1.9	0.4	0.25	1
11-09-89	7.7	12	4.7	2.0	9.4	0.35	0.15	2
11-09-89	6.4	1	3.9	1.5	5.9	0.4	0.15	2
11-09-89	6.4	1	4.0	2.5	10.0	0.45	0.05	1
11-09-89	6.4	15	4.0	1.8	7.2	0.35	0.1	1
11-09-89	6.3							1
11-09-89	5.8	20	4.3	3.1	13.3	0.6	0.2	0
11-09-89	5.2	1	3.4	1.6	5.4	0.45	0.15	0
11-09-89	5.2	1	2.5	1.5	3.8	0.4	0.1	0
11-09-89	5.2	1						0
11-09-89	5.0	14						0
11-09-89	4.7	14						0
11-09-89	4.7	14						0
11-09-89	4.3	1						0
12-01-89	1.9	14	2.8	1.4	3.9	0.55	0.2	1
12-01-89	1.8	1	3.0	1.5	4.5	0.65	0.2	0
12-01-89	1.7	1	4.1	1.5	6.2	0.6	0.35	0
12-01-89	1.4	1	1.8	1.1	2.0	0.6	0.25	0
12-01-89	1.4	1	0.9	0.8	0.7	0.4	0.2	0
12-04-89	6.4	1						0
12-04-89	5.8	1						0
12-04-89	5.6	1						1
12-04-89	5.2	1						0
12-06-89	1.3	22						0
12-06-89	0.8	15						0
12-06-89	0.4	14						0
12-06-89	0.4	14						0

TABLE 5. Chinook Redd Data, Blue Creek, fall 1989 (continued).

12-07-89	2.9	14	3.8	2.0	7.6	0.5	0.4	0
12-07-89	2.9	14	3.3	1.5	5.0	0.55	0.45	2
12-07-89	2.9	1	3.2	1.8	5.8	0.5	0.4	0
12-13-89	15.9	19						0
12-13-89	15.1	12						0
12-13-89	13.8	1	2.0	0.9	1.8	0.65	0.3	1
12-13-89	13.5	12	3.0	2.0	6.0	0.55	0.35	1
12-13-89	14.5	12	7.5	3.6	27.0	0.7	0.3	3
12-13-89	16.7	12	3.5	2.2	7.7	0.55	0.3	0
12-13-89	16.3	12	5.0	6.0	30.0	0.5	0.2	0
12-13-89	16.3	12						0
12-13-89	16.3	12	2.5	2.5	6.3	0.65	0.3	0
12-14-89	11.3	12	4.5	2.1	9.5	1.2	0.8	1
12-14-89	11.3	12	3.5	2.0	7.0	1	0.8	2
12-14-89	10.6	12	3.0	1.8	5.4	1.1	0.75	1
12-14-89	10.5	1	3.5	2.3	8.1	0.7	0.3	0
12-14-89	10.5	12	3.2	1.7	5.4	0.55	0.35	1
12-14-89	10.5	12	4.0	1.8	7.2	0.5	0.25	1
12-14-89	10.3	14						0
12-14-89	10.3	14	3.0	1.7	5.1	0.65	0.4	0
12-14-89	10.1	12	5.0	3.6	18.0	0.4	0.25	0
12-14-89	10.3	12	4.0	3.0	12.0	0.8	0.45	1
12-14-89	10.3	14	4.6	3.6	16.6	0.65	0.4	0
12-14-89	10.3	14	3.0	2.8	8.4	0.7	0.4	0
12-21-89	18.7	12	4.0	1.7	6.8	0.9	0.4	2
12-21-89	18.2	12						0
12-21-89	17.5	12	3.3	1.6	5.3	0.6	0.2	0

Total Redds= 69

TABLE 6. Crescent City Fork Redds, Blue Creek, fall 1989-90.

Date	Rkm	Habitat Type	Length (m)	Width (m)	Area (m2)	Pit Depth (m)	Mound Depth (m)
12-13-89	0.3	12	3.7	1.8	6.7	0.8	0.5
12-13-89	0.5	12	3.0	1.0	3.0	0.6	0.4
12-13-89	0.7	17	3.5	2.6	9.1	0.8	0.4
12-13-89	0.8	12	2.0	1.0	2.0	0.5	0.3
01-05-90	1.2	20					
01-05-90	1.5	20					
01-05-90	1.6	15					
01-05-90	1.7	21					
01-05-90	2.0	15					
01-05-90	2.1	12					
01-05-90	2.9	14					
01-05-90	3.0	14					

Total Redds= 12

TABLE 7. Chinook carcass surveys, Blue Creek, fall 1989.

DATE	RKM	LENGTH	SEX	CONDITION	REACH	% SPENT	COMMENTS
11-09-89	8.2	62	F	fresh	2	100	
11-09-89	7.7	55	F	fresh	2	100	
11-09-89	6.3	61	F	fresh	2	100	
12-13-89	CCF 1.6	–	F	decayed	6	–	Not recovered
12-14-89	10.3	–	F	fresh	3	100	No head
12-14-89	4.5	88	F	fresh	1	100	
12-14-89	9.6	–	F	fresh	3	–	Not recovered
12-15-89	5.0	77	M	fresh	2	100	
12-15-89	5.0	86	F	fresh	2	95	
12-15-89	5.2	95	F	fresh	2	100	

Total Carcasses = 10 (CCF = Crescent City Fork)

TABLE 8. Chinook carcass surveys, Blue Creek, fall 1990.

DATE	RKM	LENGTH	SEX	CONDITION	REACH	% SPENT	COMMENTS
11-16-90	10.5	–	–	fresh	3	–	Not recovered
11-28-90	5.1	–	–	decayed	2	–	Head and skin
11-30-90	5.1	–	F	fresh	2	–	Skin and eggs
12-03-90	11.4	90	F	fresh	3	100	Predated
12-18-90	6.3	92	F	fresh	2	100	
Total Carcasses=5							

TABLE 9. Adult Live Counts, Blue Creek, fall 1990.

DATE	REACH	CHINOOK	COHO	STEELHEAD 1/2 POUNDERS	STEELHEAD ADULTS
11-08-90	1	6	0	4	0
11-13-90	2	8	0	6	0
11-16-90	3	11	0	3	0
11-16-90	4	1	1	0	0
11-28-90	1	4	0	0	0
11-28-90	2	18	0	0	0
12-03-90	3	8	0	1	0
12-03-90	4	16	1	2	0
12-04-90	5	4	0	0	0
12-04-90	6	0	0	0	0
12-18-90	1	0	0	0	0
12-18-90	2	8	0	3	0

TABLE 10. Chinook Redd Data, Blue Creek, fall 1990.

Date	Rkm	Habitat Type	Length (m)	Width (m)	Area (m2)	Pit Depth(m)	Mound Depth(m)	Pit Velocity (ft/sec)	Mound Velocity (ft/sec)	# of Fish Present	Redd Age
11-13-90	6.3	20	6.2	3.5	21.7	0.55	0.15	1.46	2.00	0	recent
11-13-90	6.4	1	3.6	2.0	7.2	0.55	0.24	1.65	2.96	0	recent
11-16-90	8.0	12	3.7	1.4	5.2	0.60	0.40			0	recent
11-16-90	8.0	12	3.5	1.5	5.3	0.50	0.10			0	recent
11-16-90	10.4	1	2.2	1.2	2.6	0.70	0.30			0	1 wk
11-16-90	10.4	12	4.0	2.0	8.0	0.70	0.40			0	1 wk
11-16-90	15.4	12	9.5	4.5	42.8	0.65	0.23	0.75	1.60	0	recent
11-28-90	3.2	14	3.5	2.0	7.0	0.40	0.15	1.10	1.32	3	1 wk
11-28-90	6.4	1	3.0	1.5	4.5	0.18	0.18	0.58	2.05	0	1 wk
11-28-90	6.4	1	4.5	1.5	6.8	0.43	0.18	1.45	2.80	0	1 wk
11-28-90	5.6	1	3.6	1.5	5.4	0.52	0.43	1.88	2.50	2	1 wk
11-28-90	5.1	2	3.5	2.0	7.0	0.34	0.12	0.58	1.80	0	1 wk
12-03-90	11.3	12	6.5	3.3	21.5	0.73	0.43	1.35	2.71	2	recent
12-03-90	11.3	12	4.4	2.4	10.6	0.94	0.61	2.15	2.40	2	recent
12-03-90	8.0	10	5.0	5.9	29.5	0.70	0.09	1.55	2.55	1	1 wk
12-03-90	12.9	21	4.0	2.0	8.0	0.65	0.50			0	1-2 wks
12-04-90	16.5	12	4.0	3.0	12.0	0.50	0.20			0	2-3 wks
12-04-90	16.6	12	6.0	6.0	36.0	0.90	0.30			1	1 wk
12-04-90	17.5	12	4.0	2.0	8.0	0.65	0.35			0	1-2 wks
12-18-90	3.2	17	4.5	2.8	12.6	0.30	0.20			0	
12-18-90	8.0	1	5.5	4.0	22.0	1.45	0.35			1	1-2 wks
12-18-90	7.9	1	3.2	3.5	11.2	0.52	0.49			0	1-2 wks
12-18-90	7.7	1	4.0	2.5	10.0	0.65	0.40			1	1-2 wks
12-18-90	6.4	20	6.0	3.0	18.0	0.80	0.60			1	2 wks
12-18-90	6.1	1	3.3	1.5	5.0	0.55	0.35			1	1-2 wks
12-18-90	5.6	1	3.7	3.0	11.1	0.40	0.20			1	2 wks

Total Redds = 26

one chinook jack was observed at rkm 5.0 and one adult chinook at rkm 4.0, indicating that flows were sufficient for entry of fall-run chinook into Blue Creek. Due to poor stream conditions, access, and low survey numbers, only 84 adult chinook, 2 coho, and 19 half-pound steelhead were observed.

Juvenile Salmonid Investigations

Chinook Salmon - 1990

A total of 4,914 juvenile chinook were captured by the screw trap in 77 days of trapping during the juvenile monitoring operation in 1990 (Table 11). Chinook were captured throughout the entire sampling period. Weekly catches ranged from a low of 52, during the first week of trapping, to 706, which occurred during the week of June 24.

A total of 2,414 juvenile chinook were captured in the weir in 28 days of trapping (Table 12). Weekly chinook catches in the weir ranged from a high of 363 during the week of April 15 to a low of 10 during the week of July 22. No comparisons of weekly catches between the screw trap and weir are warranted because equal effort between the two methods was not expended. Due to high flows, only a portion of the stream was trapped with the weir on 8 of the 28 days.

The juvenile chinook index for the period from April 8 through August 4 was estimated to be 32,017 (Table 13). Based on index values, the juvenile chinook emigration peaked during the week of May 20 (Figure 19). This peak coincided with a storm event that increased the stream discharge from 205 cfs on May 18 to 590 cfs on May 23 (Figure 15). This trend is similar to that observed in 1989 when increases in emigration coincided with increases in discharge. The low index value for the week of June 3 may be the result of another storm event that increased the stream discharge to 1,525 cfs on June 2-3. Only 9 chinook were captured during two nights of trapping during this week. Due to the high flows the trap was moved out of the main flow and may have under-sampled the numbers of juvenile salmonids emigrating past the trap site. By June 8 stream discharge had decreased to levels at which the trap could be effectively operated on Blue Creek. From June 8 to the end of the trapping operation, 43% of all counted juvenile chinook emigrated from Blue Creek. Ninety-five percent of the juvenile chinook that emigrated from Blue Creek during trapping operations did so by the week of July 15. Although a significant number of chinook were captured during the final week of trapping, it is believed that the majority of the chinook had already left the system.

Juvenile trapping was discontinued on August 3 due to other aspects of the Blue Creek project requiring all available personnel. Based on the numbers of chinook captured during the last week of sampling, it appears that juvenile chinook continuously emigrate

Table 11. Weekly juvenile salmonid catches by the screw trap, Blue Creek 1990.

Week	# Days Sampled	Chinook	Steelhead					Coho	
			YOY	1+ Parr	1+ Smolt	2+ Parr	2+ Smolt	YOY/Parr	1+ Smolt
04/08/90	3	52	0	114	11	2	117	1	17
04/15/90	3	75	0	427	35	5	103	1	61
04/22/90	4	168	0	330	4	0	24	2	25
04/29/90	4	248	0	355	9	0	58	0	47
05/06/90	4	191	0	130	8	0	19	0	29
05/13/90	4	214	4	92	2	0	17	0	17
05/20/90	3	460	6	82	4	0	1	1	13
05/27/90	1	20	0	5	1	0	0	1	0
06/03/90	2	9	1	4	0	0	0	0	0
06/10/90	4	470	26	50	4	0	0	0	2
06/17/90	5	294	22	46	6	0	0	3	0
06/24/90	7	706	41	58	10	0	0	8	0
07/01/90	7	474	27	39	11	1	1	1	0
07/08/90	7	480	36	42	13	0	0	7	0
07/15/90	7	491	103	31	4	0	0	9	0
07/22/90	7	404	149	60	2	1	1	5	0
07/29/90	5	158	151	54	2	0	0	0	0
Total	**77**	**4,914**	**566**	**1,919**	**126**	**9**	**341**	**39**	**211**

Table 12. Weekly juvenile salmonid catches by the weir, Blue Creek 1990.

Week	# Days Sampled	Chinook	Steelhead YOY	Steelhead 1+ Parr	Steelhead 1+ Smolt	Steelhead 2+ Parr	Steelhead 2+ Smolt	Coho YOY/Parr	Coho 1+ Smolt
04/08/90	1	36	0	24	2	0	10	0	3
04/15/90	1	363	0	63	1	0	2	0	17
04/22/90	1	191	0	51	1	0	2	0	16
04/29/90	1	87	0	36	0	0	0	0	13
05/06/90	2	317	0	77	0	0	1	0	4
05/13/90	3	806	234	129	0	1	3	3	21
05/20/90	1	85	145	0	0	0	0	1	0
05/27/90	0	0	0	0	0	0	0	0	0
06/03/90	0	0	0	0	0	0	0	0	0
06/10/90	2	67	165	0	0	0	0	0	0
06/17/90	4	75	80	7	0	0	0	3	0
06/24/90	3	218	76	2	4	0	0	10	0
07/01/90	1	97	23	2	0	0	0	0	0
07/08/90	3	44	28	4	1	0	0	1	0
07/15/90	3	18	89	2	0	0	0	6	0
07/22/90	2	10	83	1	0	0	0	0	0
07/29/90	0	0	0	0	0	0	0	0	0
Total	28	2,414	923	398	9	1	18	24	74

Table 13. Weekly juvenile salmonid abundance indexes, Blue Creek 1990.

Week	Chinook	Steelhead					Coho	
		YOY	1+ Parr	1+ Smolt	2+ Parr	2+ Smolt	YOY/Parr	1+ Smolt
04/08/90	452	0	977	96	21	1,014	8	147
04/15/90	482	0	2,667	218	32	655	8	347
04/22/90	1,252	0	2,481	29	0	186	15	197
04/29/90	1,282	0	1,852	49	0	303	0	243
05/06/90	937	0	646	40	0	96	0	142
05/13/90	1,259	25	551	12	0	103	0	104
05/20/90	11,006	136	1,898	99	0	33	10	328
05/27/90	1,288	0	322	64	0	0	64	0
06/03/90	249	28	109	0	0	0	0	0
06/10/90	4,131	235	440	34	0	0	0	18
06/17/90	1,600	138	279	32	0	0	19	0
06/24/90	2,381	139	192	33	0	0	27	0
07/01/90	1,402	80	118	33	0	2	2	0
07/08/90	1,286	100	118	38	0	0	19	0
07/15/90	1,446	317	95	12	3	0	26	0
07/22/90	1,131	416	169	6	3	2	14	0
07/29/90	433	472	161	7	0	0	0	0
Total	**32,017**	**2,086**	**13,076**	**803**	**59**	**2,395**	**213**	**1,527**

from Blue Creek, at least through August and probably throughout the fall. Because of this, the index of 32,000 should only be viewed as an indirect measure of the magnitude of juvenile production for the period of the year beginning April 8 through August 4.

Mean length of juvenile chinook captured in the screw trap remained relatively constant during the weeks of April 15 to June 3 (Figure 20), ranging from 54.3 mm during the week of May 13 to 58.0 mm during the week of June 3 (Table 14). During the remainder of the trapping season, mean fork length increased to a maximum of 89.8 mm during the last week of trapping. Mean length of juvenile chinook captured in the weir ranged from a low of 44.2 mm during the week of April 15 to a high of 80.0 mm during the week of July 8 (Table 14). Mean fork length of juvenile chinook captured in the weir was generally less than that of chinook captured in the screw trap (Figure 20). There was a significant difference in mean fork lengths of chinook captured in the weir and screw traps ($F=129$; $df_n=1$, $df_d=2873$; $p=0.00$) and a significant difference between weeks ($F=694$; $df_n=11$, $df_d=2873$; $p=0.00$). There was a significant difference the length of chinook captured in the two trap types in 7 of the 12 comparisons, with the length of chinook captured in the screw trap being greater in all 7 occasions (Table 14). The greater length of chinook captured in the screw trap may be due to larger fish emigrating in the swifter current in which the screw trap is placed making them more susceptible to capture.

Steelhead - 1990

Three age classes (YOY, 1+, and 2+) of steelhead were captured in the screw trap. A total of 566 YOY, 2,045 1+, and 350 2+ steelhead were captured in the screw trap during the 1990 trapping season (Table 11). Steelhead were captured throughout the entire juvenile trapping period, but individual age classes or developmental stages (parr/smolt) were not captured during all weeks. A total of 923 YOY, 407 1+, and 19 2+ steelhead were captured in the weir during the trapping season.

YOY steelhead were first captured in the screw trap during the week of May 13, when four were captured. YOY steelhead captured at this time had recently emerged, based on the presence of a yolk sac. Peak catch of YOY steelhead (151) occurred during the last week of trapping. The YOY steelhead abundance index for the 1990 juvenile trapping season was 2,086 (Table 13). The majority of the YOY steelhead (58%) emigrated from Blue Creek during the last three weeks of trapping, July 15 through August 4 (Figure 21).

A total of 923 YOY steelhead were captured in the weir during the trapping season. The first capture of YOY steelhead, the week of May 13, coincided with the first capture of YOY steelhead in the screw trap.

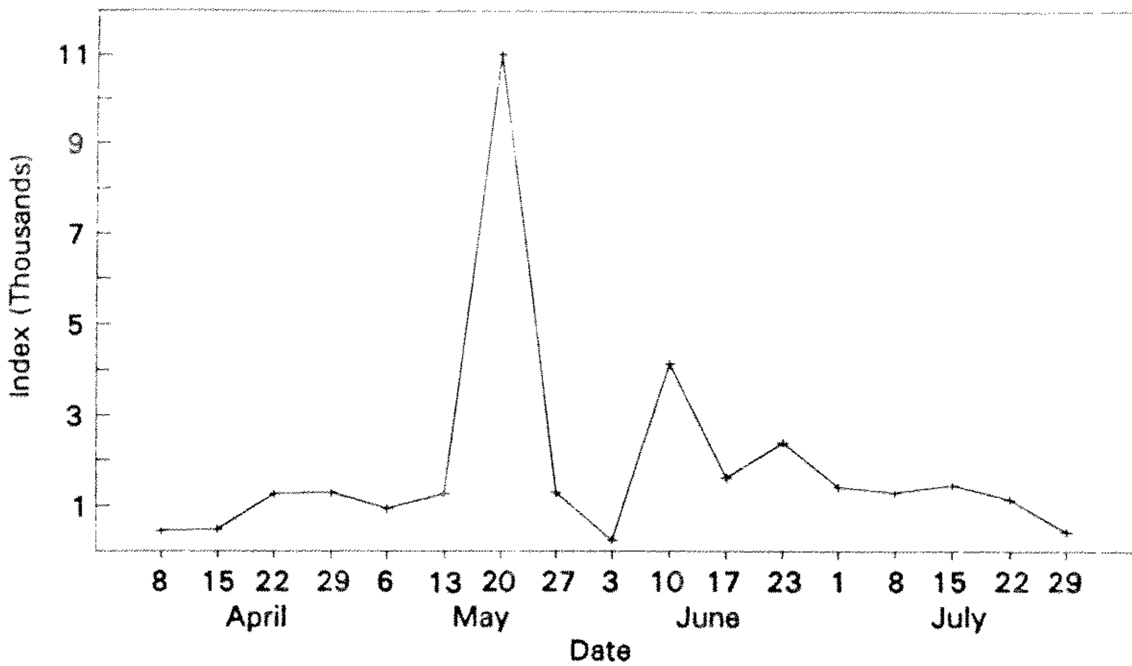


FIGURE 19. Weekly chinook index, Blue Creek 1990.

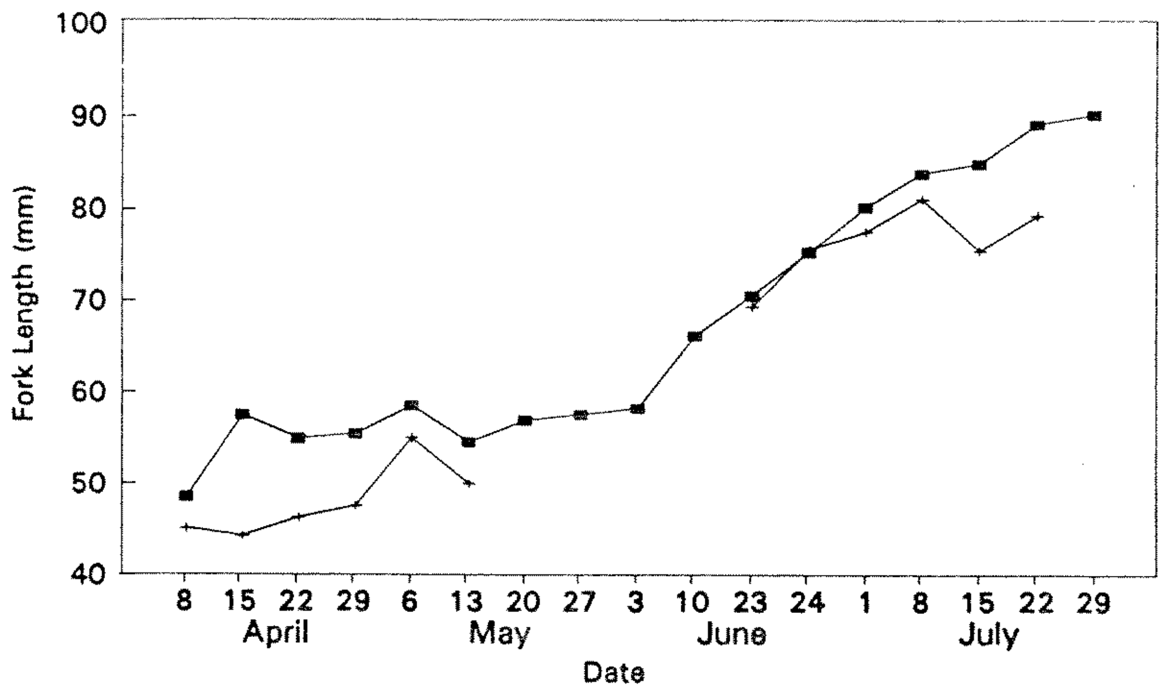


FIGURE 20. Weekly mean fork length of chinook salmon captured in screw trap (■) and weir (+) during 1990 juvenile trapping on Blue Creek.

Table 14. Weekly mean fork length (mm), standard deviation (s), and sample size (n) of chinook captured in the screw trap and weir during 1990 juvenile trapping on Blue Creek.

	Screw Trap			Weir			p – value for significant difference
Week	Mean	s	n	Mean	s	n	
04/08/90	48.5	6.06	51	45.0	5.83	36	0.0085
04/15/90	57.3	7.41	43	44.2	9.21	52	0.0000
04/22/90	54.7	6.42	166	46.2	5.86	50	0.0000
04/29/90	55.3	6.69	191	47.4	8.74	50	0.0000
05/06/90	58.3	6.58	168	54.8	6.48	125	0.0000
05/13/90	54.3	7.79	167	49.9	10.13	150	0.0000
05/20/90	56.7	7.21	139				
05/27/90	57.3	11.12	20				
06/03/90	58.0	13.65	9				
06/10/90	65.9	8.94	200				
06/17/90	70.3	11.20	86	69.1	10.62	75	0.4851
06/24/90	75.0	9.40	289	75.3	8.46	150	0.7639
07/01/90	79.9	8.22	200	77.2	8.86	50	0.0415
07/08/90	83.5	7.44	273	80.8	7.61	39	0.0327
07/15/90	84.5	7.91	229	75.2	8.56	18	0.0000
07/22/90	88.8	6.38	218	79.0	10.22	10	0.0000
07/29/90	89.8	6.77	124				

Mean fork length of YOY steelhead captured in the screw trap increased throughout the trapping season (Figure 22), ranging from 33.3 mm during the week of May 13 to 56.1 mm during the last week of trapping, July 29 (Table 15).

A total of 2,045 1+ steelhead were captured in the screw trap (Table 11). Of these, 1,919 (94%) were classified as parr. Age 1+ steelhead were captured during each week of trapping. Peak catch of 1+ steelhead (427 parr and 35 smolts) occurred during the week of April 15. The 1+ steelhead abundance index was 13,879 (13,076 parr and 803 smolts) for the 1990 juvenile trapping season (Table 13). Based on the 1+ steelhead index, the majority of 1+ steelhead (52%) emigrated from Blue Creek during April 15 to May 5 and peaked during the week of April 15 (Figure 21). A secondary peak (index of 1,898) occurred during the week of May 20.

A total of 407 age 1+ steelhead were captured in the weir during 1990 (Table 12). The majority of these (98%) were classified as parr. This percentage of the parr developmental stage is similar to that observed for age 1+ steelhead captured in the screw trap.

Mean fork length of 1+ steelhead parr captured in the screw trap gradually increased throughout the trapping season (Figure 22) ranging from 92.3 mm during the first week of trapping and increasing to 127.2 mm during the last week of trapping (Table 15). Mean fork length of 1+ smolts also gradually increased throughout the trapping season and was in all cases greater than the mean fork length of 1+ parr (Figure 22). Mean fork length of 1+ smolts ranged from 101.2 mm during the first week of trapping to 156.7 mm during the week of July 22.

A total of 350 2+ steelhead were captured in the screw trap (Table 11). Peak weekly catch of 2+ steelhead, 119, occurred during the first week of trapping. Thirty-nine (11%) of the 2+ steelhead were classified as parr. Age 2+ steelhead were captured during the first seven weeks of trapping (April 8 to May 20) and infrequently after the week of May 20. The 2+ steelhead abundance index for the 1990 trapping season was 2,454 (Table 13). Based on the abundance index, the majority (90%) of the 2+ steelhead captured during the 1990 trapping season emigrated from Blue Creek from April 8 to May 5 (Figure 21).

Only 19 age 2+ steelhead were captured in the weir in 1990 (Table 12). Eighteen of these (95%) were classified as smolts. The majority of age 2+ steelhead were captured during the first three weeks of trapping with the weir.

Mean fork length of 2+ steelhead smolts captured in the screw trap ranged from 169.1 mm during the week of May 13 to 187.5 mm during the week of April 15 (Table 15). Mean fork length of age 2+ steelhead smolts generally decreased throughout the early portion of the trapping season (Figure 22). This trend of decreasing

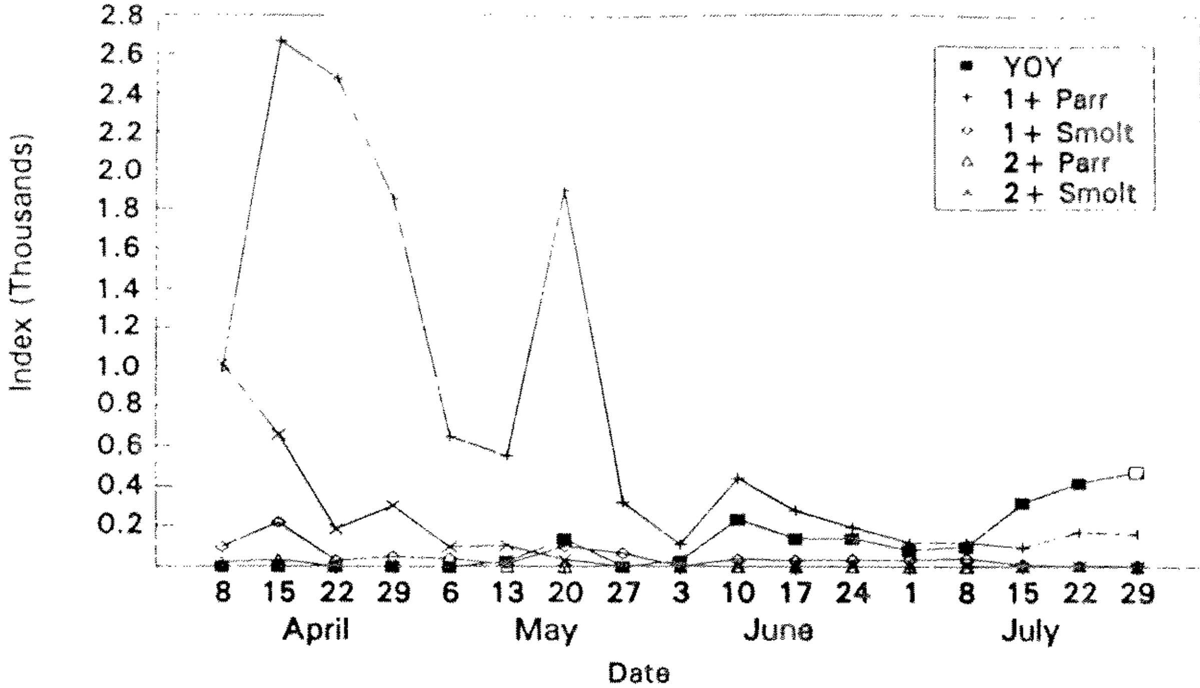


FIGURE 21. Weekly steelhead index, Blue Creek 1990.

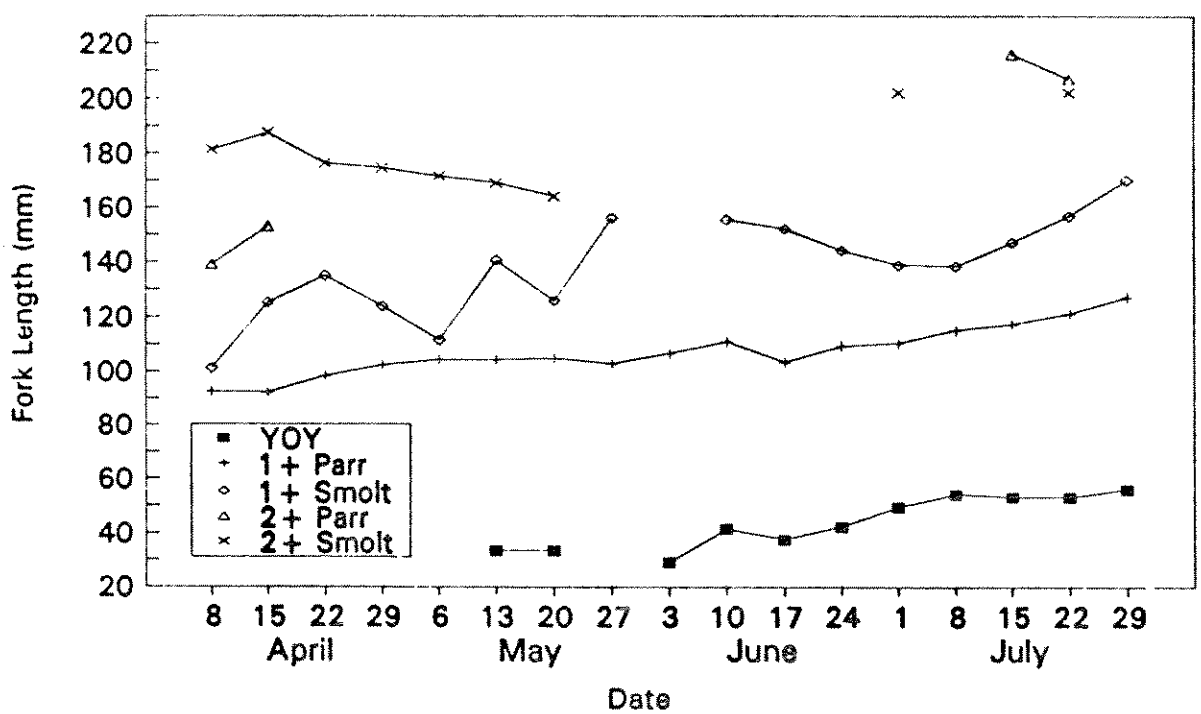


FIGURE 22. Weekly mean fork length of steelhead captured in the screw trap during 1990 juvenile trapping on Blue Creek.

Table 15. Weekly mean fork length (mm), standard deviation (s), and sample size (n) of steelhead captured in the screw trap during 1990 juvenile trapping on Blue Creek.

	YOY (0+)			1+ Parr			1+ Smolt			2+ Parr			2+ Smolt		
Week	Mean	s	n	Mean	s	n	Mean	s	n	Mean	s	n	Mean	s	n
04/08/90			0	92.3	13.80	47	101.2	7.66	5	139.0		1	181.3	16.92	53
04/15/90			0	92.1	15.90	83	125.3	15.56	4	153.0		1	187.5	29.18	12
04/22/90			0	98.5	15.17	221	135.0	17.51	4			0	176.3	11.63	26
04/29/90			0	102.4	13.17	162	124.0	15.12	5			0	174.7	10.86	31
05/06/90			0	104.3	16.13	127	111.6	14.20	8			0	171.4	13.18	19
05/13/90	33.5	1.73	4	104.3	14.39	91	140.5	9.19	2			0	169.1	9.46	17
05/20/90	33.3	0.77	6	104.8	13.62	79	126.0	15.13	3			0	164.0		1
05/27/90			0	102.8	14.34	5	156.0		1			0			0
06/03/90	29.0		1	106.5	5.57	4			0			0			0
06/10/90	41.4	4.78	26	110.8	17.75	50	155.3	14.89	4			0			0
06/17/90	37.5	8.23	17	103.3	17.79	29	152.0	19.80	2			0			0
06/24/90	42.3	11.35	41	109.4	14.02	69	144.1	22.49	10			0			0
07/01/90	49.6	10.66	32	110.5	12.35	40	138.7	24.38	14			0	202.0		1
07/08/90	54.2	8.53	28	115.1	12.69	43	138.4	14.65	14			0			0
07/15/90	53.3	8.68	88	117.5	19.55	31	147.0	9.85	3	216.0		1			0
07/22/90	53.1	8.01	108	121.1	17.75	56	156.7	10.69	3	207.0		1	202.0		1
07/29/90	56.1	6.89	74	127.2	18.39	61	170.0		1			0			0

length over time was also observed during the 1989 trapping season.

Due to the high number of 1+ and 2+ steelhead captured during the first week of trapping, it is obvious that the steelhead emigration had commenced some time before trapping began. Because of this, abundance indexes presented are not intended to reflect the entire production of age 1+ and 2+ steelhead but only the emigration of steelhead observed during the trapping period.

Coho Salmon - 1990

Two age classes of coho salmon, YOY and 1+, were captured during the 1990 trapping operation. A total of 250 coho salmon (39 YOY and 211 1+ smolts) were captured in the screw trap (Table 11). Ninety-eight coho (24 YOY/parr and 74 smolts) were captured in the weir during 1990.

YOY coho were captured throughout most of the trapping season with a peak weekly catch of nine occurring during the week of July 15 (Table 11). The coho YOY abundance index for the 1990 trapping season was 213 (Table 13). Based on the abundance index, a peak of YOY coho immigration occurred during the week of May 27 (Figure 23). Smaller peaks in abundance occurred during the weeks of June 24 and July 15.

Mean fork length of YOY coho captured in the screw trap ranged from 53.0 mm during the first week of trapping, April 8, to 70.3 mm during the last week of trapping, July 22 (Table 16). Mean fork length of YOY coho was variable, probably due to the small sample sizes, but appeared to generally increase throughout the trapping season (Figure 24).

Age 1+ coho were predominately captured in the screw trap during the early part of the trapping operation with the peak weekly catch of 61 occurring during the week of April 15 (Table 11). The 1+ coho abundance index for the 1990 trapping season was 1,527 (Table 13). Based on the abundance index, the majority of the 1+ coho (99%) emigrated from Blue Creek by the week of May 20 with peaks occurring during the weeks of April 15 and May 20 (Figure 23). As with the 1+ and 2+ steelhead, 1990 trapping was apparently initiated after the 1+ coho smolt emigration began and the index of abundance is only indicative of the trapping period.

The majority of the 1+ coho smolts captured in the weir occurred during the first six weeks of trapping and coincided with their capture in the screw trap (Table 12).

Chinook Salmon - 1991

A total of 1,397 juvenile chinook salmon were captured by the screw trap in 69 days of trapping during the 1991 juvenile salmonid monitoring effort (Table 17). Chinook were captured during all

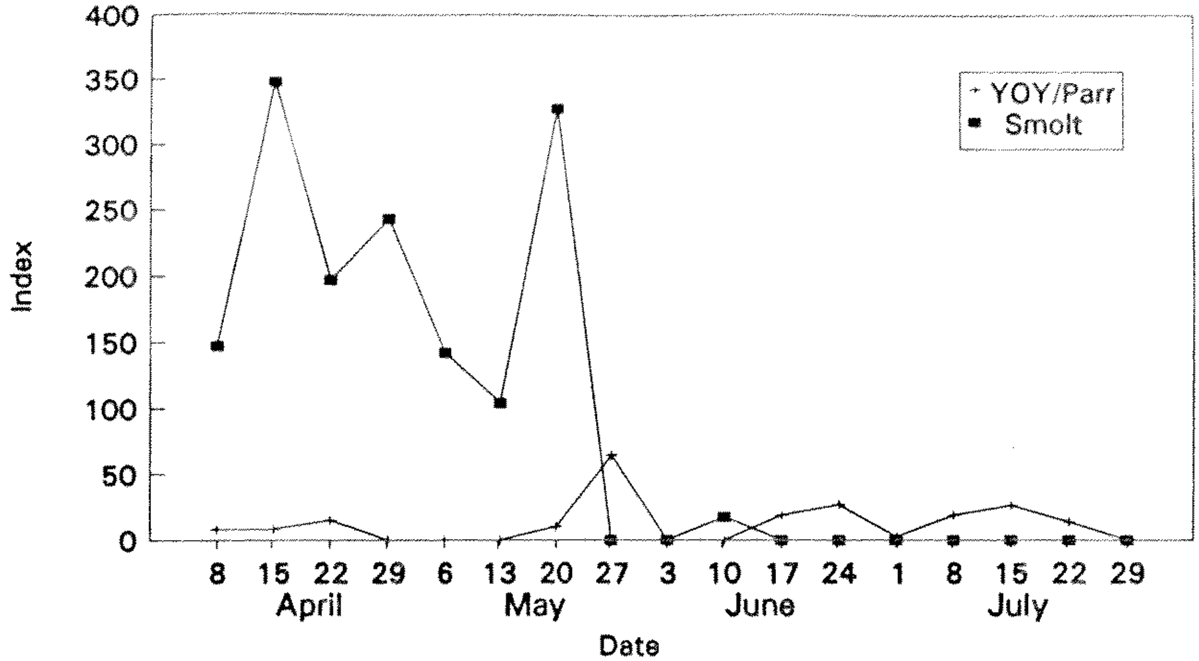


FIGURE 23. Weekly coho index, Blue Creek 1990.

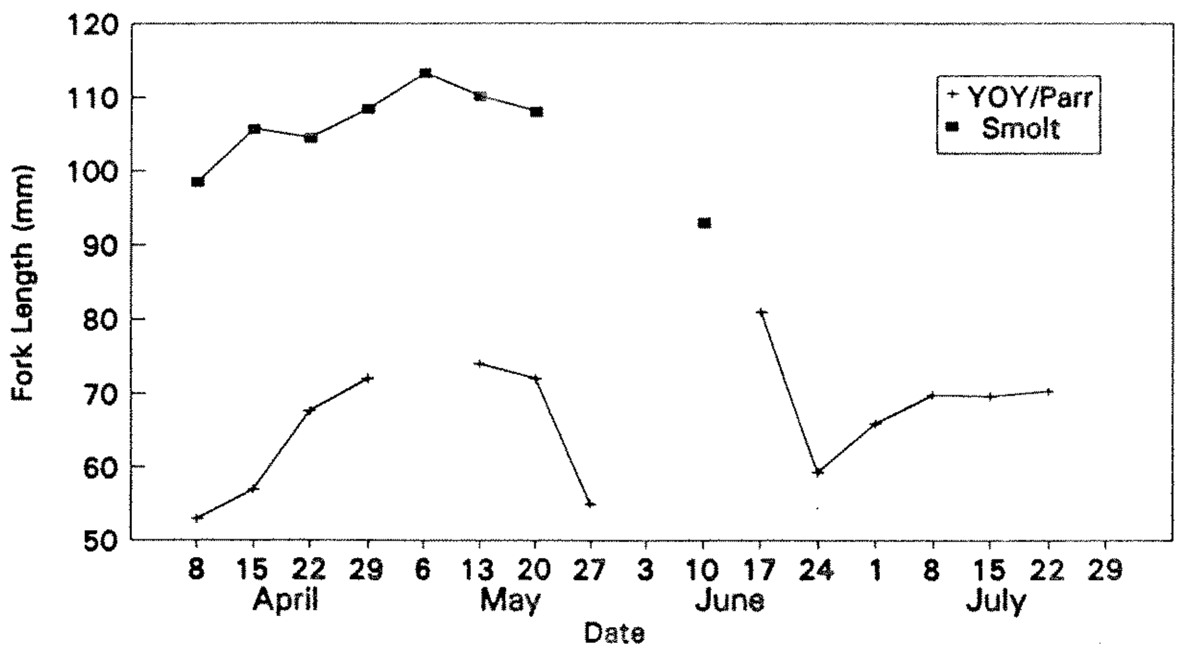


FIGURE 24. Weekly mean fork length of coho salmon captured in the screw trap during 1990 juvenile trapping on Blue Creek.

Table 16. Weekly mean fork length (mm), standard deviation (s), and sample size (n) of coho salmon captured in the screw trap during 1990 juvenile trapping on Blue Creek.

	YOY/Parr			Smolt		
Week	Mean	s	n	Mean	s	n
04/08/90	53.0	0.00	1	98.5	12.47	18
04/15/90	57.0	0.00	1	105.6	8.22	27
04/22/90	67.7	22.30	3	104.4	9.36	56
04/29/90	72.0	0.00	1	108.4	7.59	46
05/06/90			0	113.3	10.96	29
05/13/90	74.0	0.00	1	110.1	8.02	16
05/20/90	72.0	0.00	1	108.0	6.06	13
05/27/90	55.0	0.00	1			0
06/03/90			0			0
06/10/90			0	93.0	4.24	2
06/17/90	81.0	15.59	3			0
06/24/90	59.3	8.38	8			0
07/01/90	66.0	2.83	2			0
07/08/90	69.8	5.59	5			0
07/15/90	69.6	4.76	11			0
07/22/90	70.3	4.46	6			0

Table 17. Weekly juvenile salmonid catches by the screw trap, Blue Creek 1991.

	# Days		Steelhead					Coho	
Week	Sampled	Chinook	YOY	1+ Parr	1+ Smolt	2+ Parr	2+ Smolt	YOY/Parr	1+ Smolt
04/07/91	1	6	0	3	0	0	2	2	0
04/14/91	4	3	0	28	0	0	21	5	2
04/21/91	3	29	0	23	0	0	8	0	1
04/28/91	4	43	0	20	0	0	14	1	3
05/05/91	4	79	0	97	3	1	19	2	1
05/12/91	4	83	0	33	3	0	15	7	1
05/19/91	4	309	1	49	1	2	12	10	1
05/26/91	3	116	2	9	0	0	2	1	0
06/02/91	4	132	9	8	4	0	1	6	2
06/09/91	4	102	14	8	5	0	0	0	0
06/16/91	4	117	4	5	1	0	0	2	1
06/23/91	4	72	6	1	0	0	0	1	0
06/30/91	4	73	154	7	0	0	0	2	0
07/07/91	4	148	309	6	3	0	0	1	0
07/14/91	4	41	230	2	3	0	0	4	0
07/21/91	4	16	42	0	1	0	0	1	0
07/28/91	4	21	24	1	0	0	0	1	0
08/04/91	4	5	55	0	0	0	0	0	0
08/11/91	2	2	13	0	0	0	0	1	0
Total	69	1,397	863	300	24	3	94	47	12

weeks of trapping and weekly catches ranged from a low of 2 during the week of August 11 to a high of 309 during the week of May 19.

The weir was operated for 36 days in 1991 and 3,073 juvenile chinook were captured (Table 18). Weekly catches by the weir ranged from a low of 4 during the week of July 21 to a high of 643 during the week of June 2.

The juvenile chinook abundance index for the 1991 trapping effort was 12,505 (Table 19). Based on index values, the juvenile chinook emigration peaked during the week of May 19 (Figure 25). The timing of this peak is the same as that observed in 1990 and also coincided with a storm event which increased stream discharge (Figure 17). Virtually all of the juvenile chinook (97%) emigrated from Blue Creek by the end of the week of July 14. This is similar to what was observed in 1990. The index for 1991 from April 7 through July 28 (the same period the 1990 index was based on), was 12,428. This is substantially smaller (39%) than the index in 1990. The low production of juvenile chinook in 1991 (1990 brood) is indicative of the lower spawning escapement in 1990. A total of 26 redds were observed during surveys in 1990 (producing juveniles that emigrated during 1991) while 86 were observed in 1989. Spawning in 1990 (as measured by redd counts) was only 31% of that observed in 1989, possibly leading to the poor juvenile chinook production observed in 1991.

Mean length of juvenile chinook captured in the screw trap during the 1991 monitoring effort generally increased throughout the season, ranging from 38.3 mm, during the week of April 14, to 87.4 mm, during the week of August 4 (Table 19 and Figure 26). Mean length of juvenile chinook captured in the weir ranged from 52.7 mm, during the week of May 15, to 85.0 mm during the week of July 21 (Table 20). Mean length of chinook captured in the weir generally increased throughout the time when the weir was operated (Figure 26). There was a significant difference in mean length of juvenile chinook captured by trap type (screw trap or weir) ($F=6.939$; $df_n=1$, $df_d=1726$; $p=0.0085$) and a significant difference between weeks ($F=121.6$; $df_n=10$, $df_d=1726$; $p=0.00$). There was a significant difference in mean length of chinook captured in the two trap types in 4 of the 11 weeks compared (Table 20). The mean length of chinook captured in the weir was significantly greater during the week of May 12 ($p=0.00$) while the mean length of chinook captured in the screw trap was significantly greater during the weeks of May 19 ($p=0.00$), June 23 ($p=0.0008$), and June 30 ($p=0.0002$). Trapping with the screw trap in 1991 appears to have been less selective for larger chinook as indicated in 1990 by fewer significant differences in weekly mean length of chinook captured in each trap type.

Table 18. Weekly juvenile salmonid catches by the weir, Blue Creek 1991.

Week	# Days Sampled	Chinook	Steelhead					Coho	
			YOY	1+ Parr	1+ Smolt	2+ Parr	2+ Smolt	YOY/Parr	1+ Smolt
04/07/91	0	0	0	0	0	0	0	0	0
04/14/91	0	0	0	0	0	0	0	0	0
04/21/91	0	0	0	0	0	0	0	0	0
04/28/91	0	0	0	0	0	0	0	0	0
05/05/91	0	0	0	0	0	0	0	0	0
05/12/91	2	330	0	18	0	0	0	27	15
05/19/91	2	496	36	9	0	0	0	5	0
05/26/91	1	270	4	14	0	0	1	11	0
06/02/91	3	643	77	0	0	0	0	26	0
06/09/91	4	358	124	4	0	0	1	13	0
06/16/91	4	579	53	0	0	0	0	21	0
06/23/91	4	69	31	0	0	0	0	5	0
06/30/91	4	21	181	1	0	0	0	3	0
07/07/91	4	247	444	2	0	0	2	9	0
07/14/91	4	56	454	4	0	0	0	9	0
07/21/91	4	4	31	0	0	0	0	0	0
07/28/91	0	0	0	0	0	0	0	0	0
08/04/91	0	0	0	0	0	0	0	0	0
08/11/91	0	0	0	0	0	0	0	0	0
Total	36	3,073	1,435	52	0	0	4	129	15

Table 19. Weekly juvenile salmonid indexes, Blue Creek 1991.

Week	Chinook	Steelhead					Coho	
		YOY	1+ Parr	1+ Smolt	2+ Parr	2+ Smolt	YOY/Parr	1+ Smolt
04/07/91	249	0	125	0	0	83	83	0
04/14/91	33	0	306	0	0	229	43	32
04/21/91	432	0	346	0	0	120	0	15
04/28/91	491	0	226	0	0	159	11	33
05/05/91	796	0	956	29	10	184	21	10
05/12/91	856	0	349	31	0	157	74	10
05/19/91	2,830	9	453	9	18	110	92	9
05/26/91	1,492	26	117	0	0	26	13	0
06/02/91	1,124	76	66	32	0	8	53	16
06/09/91	783	109	61	38	0	0	0	0
06/16/91	843	29	36	7	0	0	15	7
06/23/91	509	42	7	0	0	0	7	0
06/30/91	482	1,017	46	0	0	0	13	0
07/07/91	942	1,967	38	19	0	0	6	0
07/14/91	298	1,672	14	21	0	0	29	0
07/21/91	103	269	0	6	0	0	7	0
07/28/91	165	192	8	0	0	0	8	0
08/04/91	47	518	0	0	0	0	0	0
08/11/91	30	195	0	0	0	8	15	0
Total	12,505	6,124	3,154	194	29	1,076	489	132

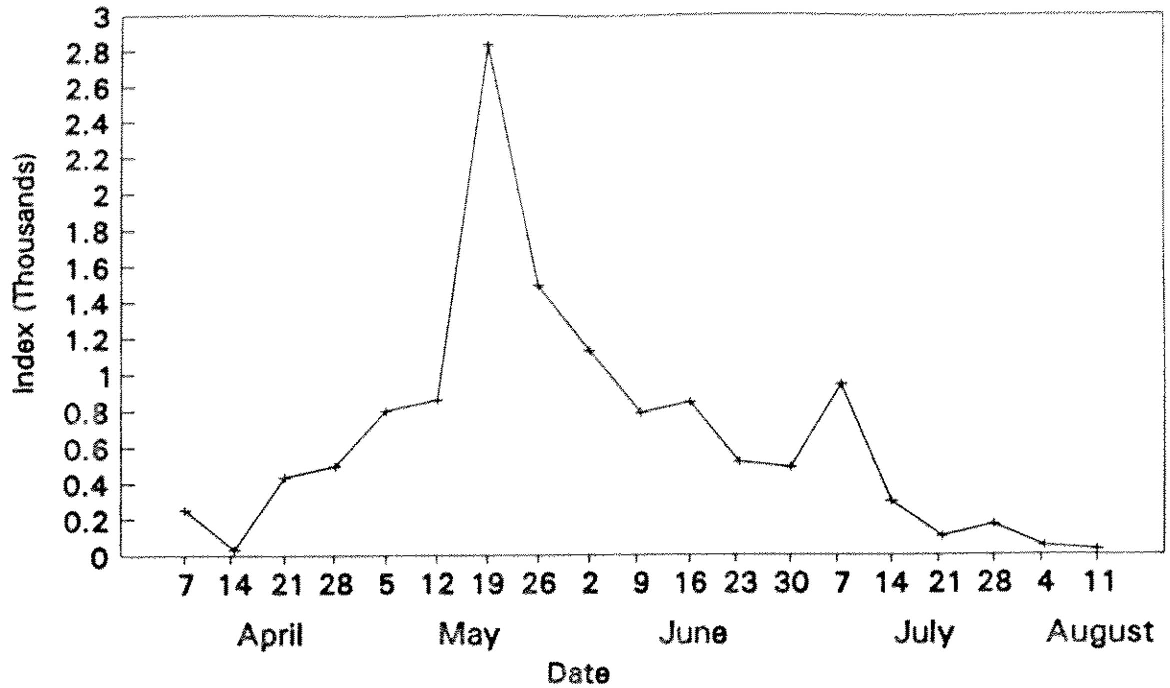


FIGURE 25. Weekly chinook index, Blue Creek 1991.

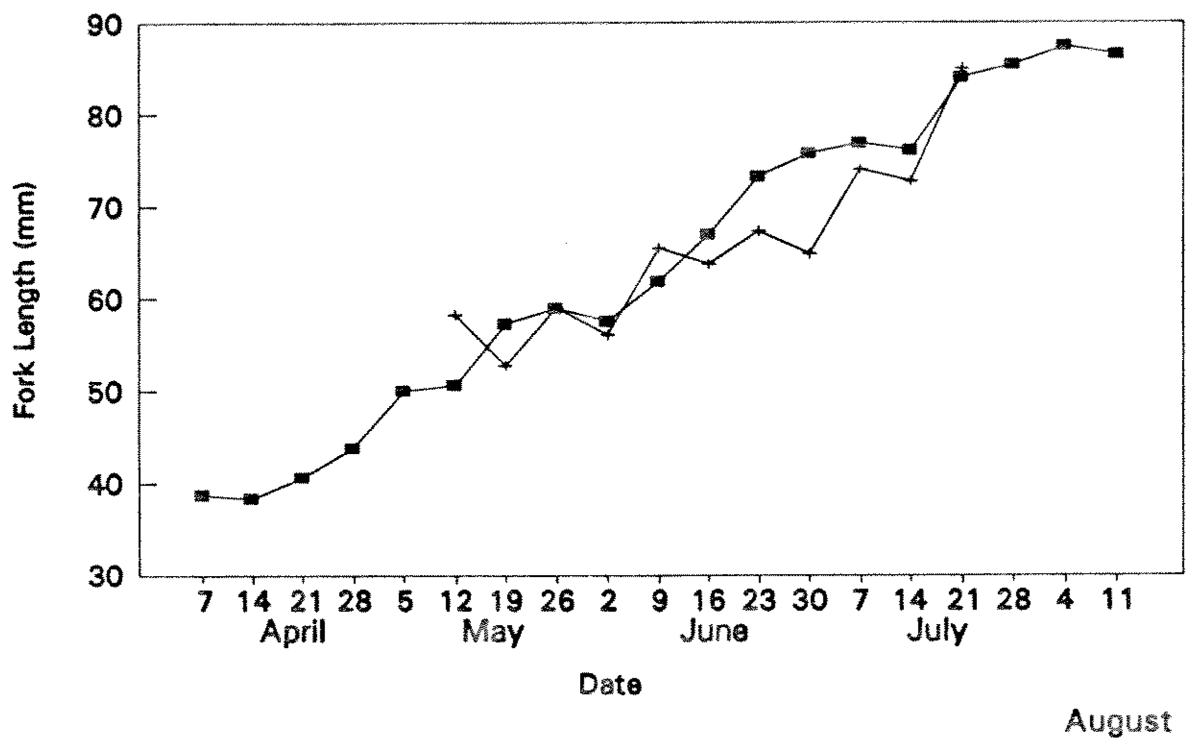


FIGURE 26. Weekly mean fork length of chinook salmon captured in the screw trap (▪) and weir (+) during 1991 juvenile trapping on Blue Creek.

Table 20. Weekly mean fork length (mm), standard deviation (s), and sample size (n) of chinook captured in the screw trap and weir during 1991 juvenile trapping on Blue Creek.

Week	Screw Trap			Weir			p - value for significant difference
	Mean	s	n	Mean	s	n	
04/07/91	38.7	1.86	6			0	
04/14/91	38.3	1.53	3			0	
04/21/91	40.6	4.08	29			0	
04/28/91	43.7	8.65	43			0	
05/05/91	50.0	8.55	80			0	
05/12/91	50.6	8.99	82	58.2	8.93	103	0.0000
05/19/91	57.2	7.68	196	52.7	6.92	82	0.0000
05/26/91	58.9	8.00	83	59	8.99	41	0.9396
06/02/91	57.5	7.78	113	56	7.84	92	0.1903
06/09/91	61.8	12.01	102	65.5	9.21	120	0.0097
06/16/91	66.9	11.49	96	63.7	8.72	122	0.0179
06/23/91	73.2	10.26	65	67.3	7.19	50	0.0008
06/30/91	75.7	11.01	53	64.8	9.28	21	0.0002
07/07/91	76.8	9.35	117	74	9.69	83	0.0423
07/14/91	76.0	8.61	41	72.7	7.54	56	0.0472
07/21/91	84.0	6.19	16	85	7.39	4	0.7831
07/28/91	85.4	7.19	21			0	
08/04/91	87.4	5.13	5			0	
08/11/91	86.5	6.36	2			0	

Steelhead - 1991

A total of 1,284 steelhead were captured in the screw trap during juvenile monitoring operations on Blue Creek in 1991 (Table 14).

Steelhead were captured during all weeks of trapping although individual age classes or developmental stages were not captured during all weeks. The weir caught 1,491 steelhead during 1991 trapping operations (Table 18).

The screw trap caught 863 YOY steelhead in 1991. The first capture of YOY occurred during the week of May 19 (Table 17). Once YOY steelhead were first captured, weekly screw trap catches of YOY steelhead ranged from 1, during the week of May 19, to 309 during the week of July 7. The YOY steelhead index for the 1991 trapping season was 6,124 (Table 19). The majority of the YOY steelhead (76%) emigrated from Blue Creek during the weeks June 30 to July 14 with the peak occurring during the week of July 7 (Figure 27).

The weir captured 1,435 YOY steelhead during 1991. YOY steelhead were first captured during the week of May 19 (Table 18). While YOY steelhead were present, weekly weir catches ranged from 4, during the week of May 26, to 454, during the week of July 14.

Mean fork length of YOY steelhead captured in the screw trap in 1991 ranged from 30.0 mm, during the week of May 26, to 63.8 mm, during the week of August 11 (Table 21). The mean fork length of YOY steelhead gradually increased throughout the trapping season (Figure 28).

There were 324 age 1+ steelhead captured in the screw trap in 1991 (Table 17). The majority of these (93%) were classified as parr. Age 1+ steelhead were captured in the screw trap during all but the last two weeks of trapping. Weekly catch of 1+ steelhead parr in the screw trap ranged from 0 (weeks of July 21, August 4, and August 11) to 97 during the week of May 5. The weekly screw trap catch of 1+ steelhead smolts ranged from 0, occurring frequently throughout the trapping season, to 5, during the week of June 9. The 1991 age 1+ steelhead abundance index was 3,348 (3,154 parr and 194 smolts) (Table 19). The majority of the 1+ steelhead parr (91%) emigrated from Blue Creek by the week of May 26 with a peak occurring during the week of May 5 (Figure 27). The majority of the 1+ steelhead smolts (72%) emigrated from Blue Creek by the week of June 9 with a moderate peak occurring during the week of June 9.

Fifty-two 1+ steelhead were captured in the weir during 1991 trapping operations on Blue Creek (Table 18). All of these were classified as parr. The peak weekly catch (18) occurred during the week of May 12 which is the first week the weir was operated in 1991.

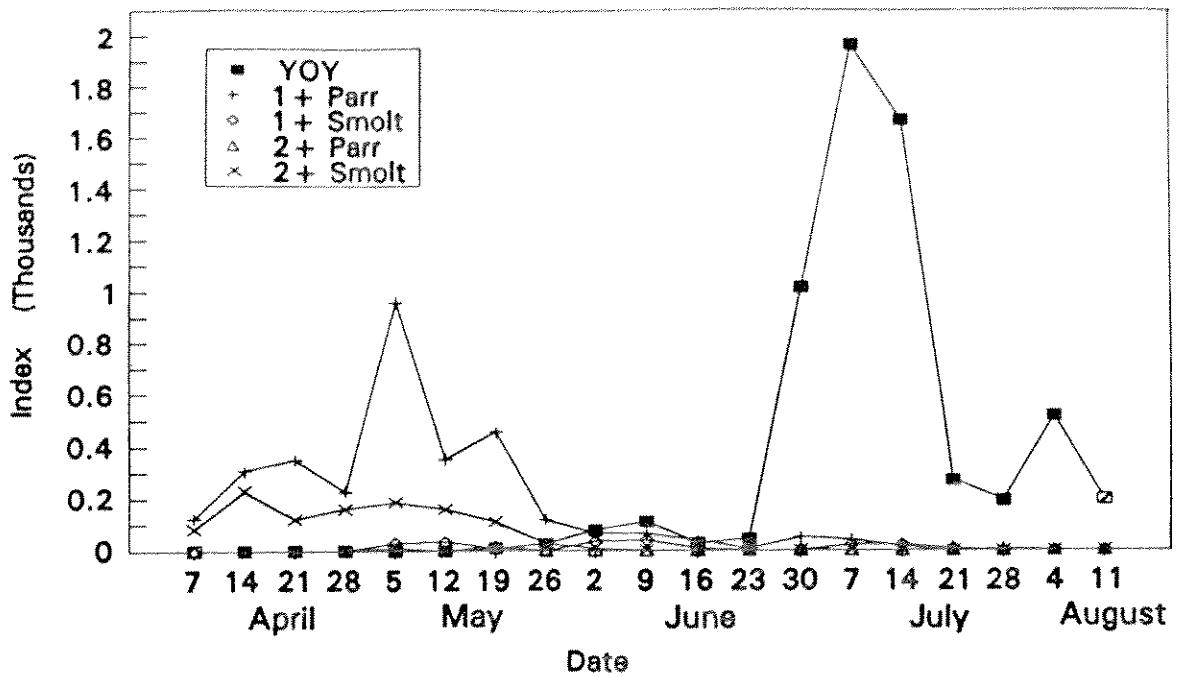


FIGURE 27. Weekly steelhead index, Blue Creek 1991.

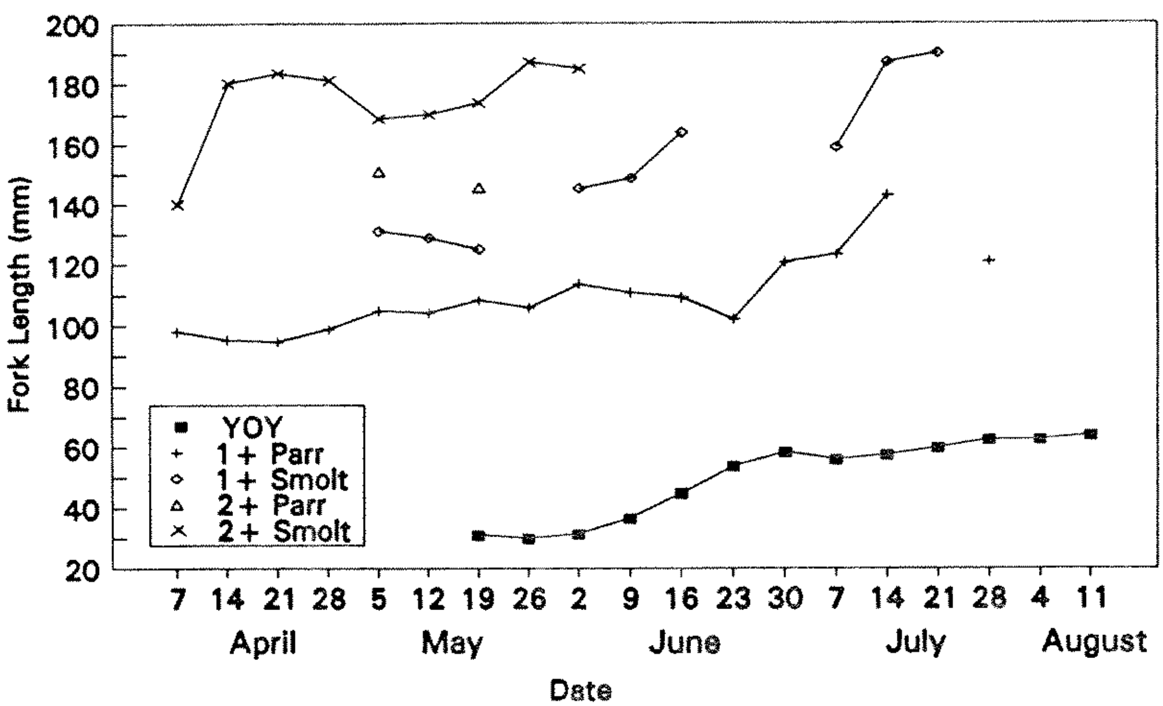


FIGURE 28. Weekly mean fork length of steelhead captured in the screw trap during 1991 juvenile trapping on Blue Creek.

Table 21. Weekly mean fork length (mm), standard deviation (s), and sample size (n) of steelhead captured in the screw trap during 1991 juvenile trapping on Blue Creek.

Week	YOY (0+)			1+ Parr			1+ Smolt			2+ Parr			2+ Smolt		
	Mean	s	n	Mean	s	n	Mean	s	n	Mean	s	n	Mean	s	n
04/07/91			0	98.0	26.06	3			0			0	140.0		1
04/14/91			0	95.4	10.76	28			0			0	180.3	15.54	21
04/21/91			0	94.7	15.76	23			0			0	183.5	15.85	8
04/28/91			0	98.9	16.05	20			0			0	181.2	11.92	14
05/05/91			0	104.8	14.10	94	131.0	8.54	3	151.0		1	168.7	19.24	19
05/12/91			0	104.2	13.49	33	128.7	6.43	3			0	170.0	19.13	15
05/19/91	31.0		1	108.2	13.12	49	125.0		1	145.5	4.95	2	173.8	11.85	12
05/26/91	30.0	1.73	3	105.9	13.23	9			0			0	187.0	14.14	2
06/02/91	31.4	5.22	9	113.6	13.96	8	145.3	10.11	4			0	185.0		1
06/09/91	36.5	7.21	14	110.8	17.80	8	148.6	17.34	5			0			0
06/16/91	44.8	3.40	4	109.2	19.40	5	164.0		1			0			0
06/23/91	53.8	6.15	6	102.0		1			0			0			0
06/30/91	58.3	6.55	70	120.7	13.41	6			0			0			0
07/07/91	55.9	5.30	100	123.3	12.85	6	159.0	7.94	3			0			0
07/14/91	57.4	6.95	84	143.0	38.18	2	187.0	13.43	3			0			0
07/21/91	59.8	5.96	42			0	190.0		1			0			0
07/28/91	62.6	4.04	24	121.0		1						0			0
08/04/91	62.6	6.36	45			0						0			0
08/11/91	63.8	6.69	13			0						0			0

Mean fork length of 1+ steelhead parr captured in the screw trap ranged from 94.7 mm, during the week of April 21, to 143.0 mm, during the week of July 14 (Table 21). Mean length of 1+ parr remained relatively constant from the beginning of trapping through the week of June 23 (Figure 28) ranging from 94.7 mm to 113.6 mm. Mean length of 1+ parr increased after the week of June 23 to a maximum of 143.0 mm. Mean length of 1+ steelhead smolts ranged from 128.7 mm, during the week of May 12, to 187.0 mm, during the week of July 14 (Table 21). Mean length of 1+ smolts generally increased throughout the trapping season (Figure 28).

Screw trap captures of age 2+ steelhead totalled 97 (3 parr and 94 smolts) during 1991 juvenile monitoring operations (Table 17). Virtually all 2+ steelhead were captured during April and May with the peak weekly catch of 21 occurring during the week of April 14. No 2+ steelhead were captured in the screw trap after the week of June 2. The 1991 2+ steelhead abundance index was 1,105 (29 parr and 1,076 smolts) (Table 19). The peak of the 2+ steelhead emigration occurred during the week of April 14 with all 2+ steelhead having left Blue Creek by the week of June 9 (Figure 27).

Four 2+ steelhead were captured in the weir during 1991 trapping (Table 18). All were classified as smolts. The low catch of 2+ steelhead in the weir can be attributed to the ability of larger fish to evade capture in the weir.

Mean fork length of 2+ steelhead smolts ranged from 168.7 mm, during the week of May 5, to 187.0 mm, during the week of May 26 (Table 21). Mean length of 2+ steelhead smolts remained fairly constant from April 14 to May 5, decreased during the week of May 5, then increased to its peak during the week of May 26 (Figure 28).

Coho Salmon - 1991

A total of 59 coho salmon (47 YOY/parr and 12 1+ smolt) were captured in the screw trap in 1991 (Table 17). Although the weekly catch of coho was generally low (compared to that of other salmonid species) they were captured in the screw trap during all but two weeks of trapping. The catch of coho in the weir during 1991 was 144 (129 YOY/parr and 15 smolts).

The weekly catch of YOY/parr coho in the screw trap ranged from 0, occurring during three weeks, to 10, during the week of May 19 (Table 17). The YOY/parr coho abundance index for 1991 was 489 (Table 19). The majority of the YOY/parr coho (80%) emigrated from Blue Creek by the week of June 2 with the peak occurring during the week of May 19 (Figure 29). A minor peak occurred after this period, during the week of July 14, with an index value of 29.

The weir caught 129 YOY/parr coho during 1991. The catch ranged from 0, during the last week of weir operation, to 27, during the week of May 5 (first week of trap operation) (Table 18).

Mean length of YOY/parr coho captured in the screw trap ranged from 37.0 mm, during the week of April 7, to 80.5 mm, during the week of July 14 (Table 22). The mean length of YOY/parr generally increased throughout the trapping season although the large mean lengths during the weeks of April 28 and May 5 distort this trend (Figure 30).

The screw trap captured 12 1+ coho smolts in 1991 (Table 17). Catches ranged from 0, occurring frequently, to a peak of 3 occurring during the week of April 8. No 1+ coho were captured after the week of June 16. The 1+ coho smolt abundance index for 1991 was 132 (Table 19). The 1+ coho smolt emigration had two peaks, during the weeks of April 14 and April 28, and was over by the week of June 16 (Figure 29).

Fifteen 1+ coho smolts were captured in the weir in 1991 (Table 18). All of them were captured during the week of May 12. This was the first week in which the weir was in operation.

Mean length of 1+ coho smolts captured in the screw trap ranged from 104.0 mm, during the week of June 2, to 124.0 mm, during the week of May 28 (Table 22). Mean length of 1+ coho smolts did not show any clear trend, although this is to be expected with so few samples (Figure 30).

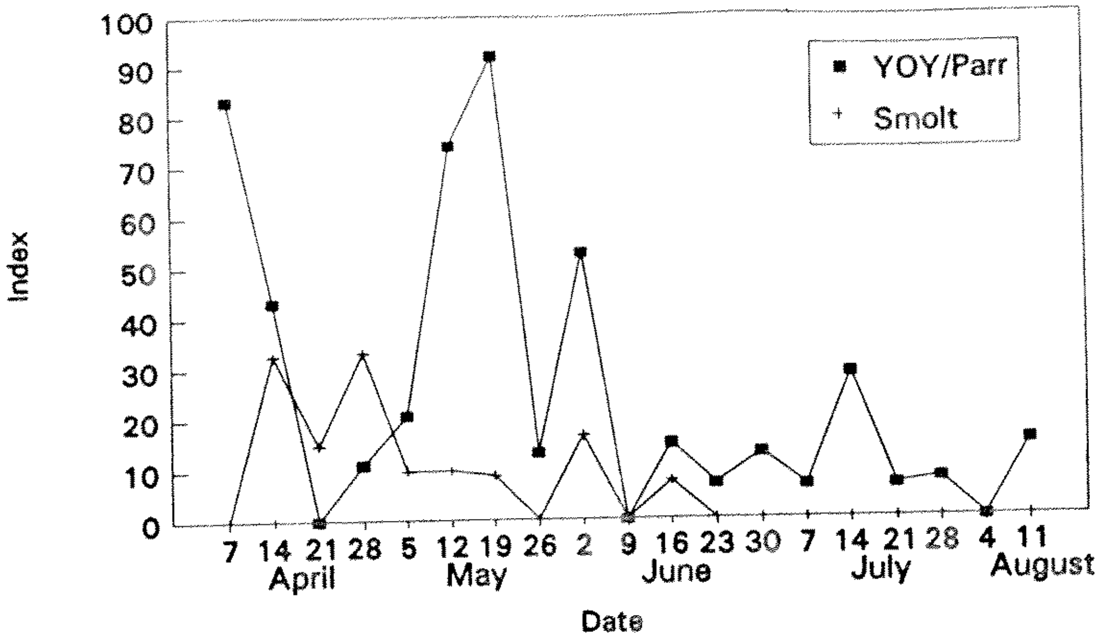


FIGURE 29. Weekly coho index, Blue Creek 1991.

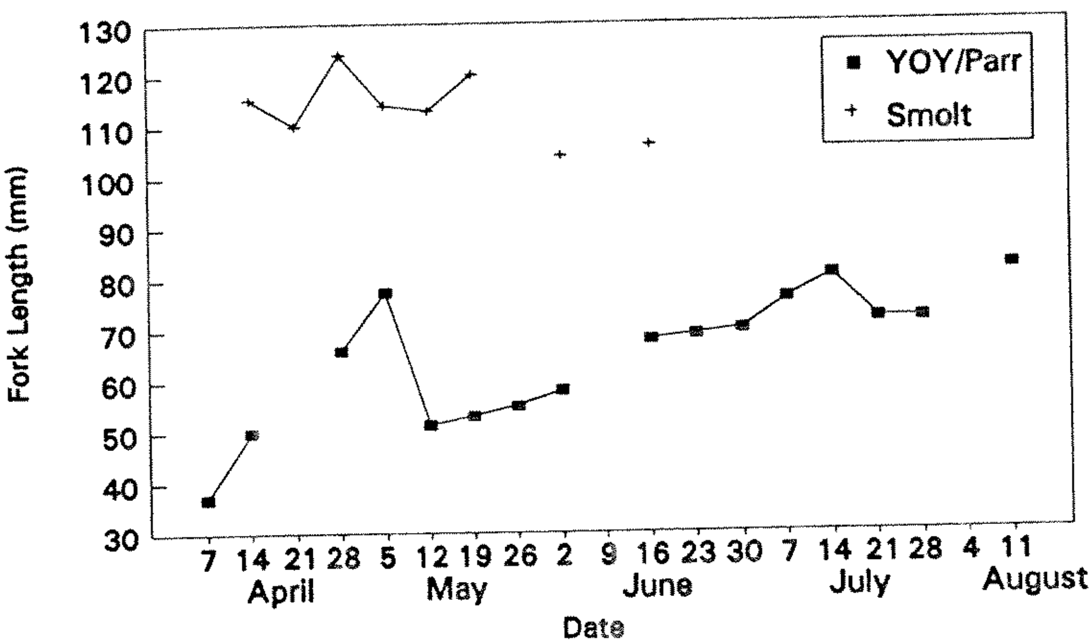


FIGURE 30. Weekly fork length of coho salmon captured in the screw trap during 1991 juvenile trapping on Blue Creek.

Table 22. Weekly mean fork length (mm), standard deviation (s), and sample size (n), of coho salmon captured in the screw trap during 1991 juvenile trapping on Blue Creek.

	YOY/Parr			Smolt		
Week	Mean	s	n	Mean	s	n
04/07/91	37.0	0.00	2			
04/14/91	50.0	9.83	4	115.3	4.73	3
04/21/91			0	110.0		1
04/28/91	66.0		1	124.0	2.00	3
05/05/91	77.5	3.54	2	114.0		1
05/12/91	51.3	19.20	7	113.0		1
05/19/91	53.1	10.10	10	120.0		1
05/26/91	55.0		1			
06/02/91	58.0	6.32	6	104.0	15.56	2
06/09/91			0			
06/16/91	68.0	1.41	2	106.0		1
06/23/91	69.0		1			
06/30/91	70.0	7.07	2			
07/07/91	76.0		1			
07/14/91	80.5	4.12	4			
07/21/91	72.0		1			
07/28/91	72.0		1			
08/04/91			0			
08/11/91	82.0		1			

Summary

Continuing investigations of salmon and habitats have further defined the areas and times of fall chinook spawning. The anadromous reaches of Blue Creek and Crescent City Fork have been classified into five channel types, based on gradient, valley bottom width, and presence of active floodplains. Anadromous habitats have been further delineated into 466 main channel and 78 side-channel units, according to a standard scheme of 24 habitat types. Pool structures were mostly boulder/bedrock, with little large woody material noted.

Numbers of returning adult fall-run chinook were very low in both 1989-1990 and 1990-1991. Based on the total estimated area of suitable spawning habitat, only 6% of the maximum potential number of redds were seen in 1990, and 2% in 1991. Spawning and rearing habitats in Blue Creek appeared suitable for survival and should support a larger spawning population. Continued harvest of this stock should be of concern if recovery of the population is expected in a reasonable period. Ocean and in-river harvest of this stock should be closely examined for effects on escapement. In addition, the continued take of these fish for artificial propagation may contribute to the insufficient escapement of spawners to Blue Creek.

Radio-telemetry of adult spawners proved to be a useful, although time consuming method to locate remote areas of spawning activity, especially when high flows prevented wading surveys. The lower 5 km of Crescent City Fork were discovered by telemetry to be accessible to spawning chinook.

Emigrating juvenile salmonids were trapped in both spring 1990 and 1991, using both a rotary-screw trap and weir. Larger fish were caught by the rotary-screw trap than the weir. Calculated indexes for total chinook juveniles are 32,000 for 1990 and 12,500 for 1991, compared with an estimated 51,100 in 1989. Numbers of chinook that were coded-wire tagged were similar for 1990 (3,308) and 1991 (3,055), but less than 1989 (10,452).

Water levels continued to be relatively low and temperatures were warm each summer, although no specific problems were noted with either rearing or spawning fish. Low flows in late summer and early fall may have delayed immigration of spawners, but no barriers were noted after fish began moving upstream. In summer and early fall, water from Blue Creek continued to provide a cool-water refuge at the confluence to spawners migrating in the Klamath River. Temperatures in Blue Creek from July to October ranged from 16-19°C, while average summer Klamath River temperatures were 18-26°C. Flows from Blue Creek over those months ranged from about 100 to 60 cfs, which represent 2 to 3% of the Klamath River flows during those times.

Investigations are projected to continue for FY92 and FY93. Counts will be made of chinook redds and also emigrating juvenile salmonids. Emigrating chinook will be marked with coded-wire tags, in order to assess the contribution of Blue Creek stocks to the fishery. Stage and temperatures will also be monitored. Based on observed use of specific habitats, and general knowledge of stream restoration methods, proposals may be made for projects to restore riparian and aquatic habitats.

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PERSONAL COMMUNICATIONS

Erickson, F., USFWS, Arcata, Ca.

Harral, C. California Department of Fish and Game, Redding, Ca.

Appendix A. Habitat types and descriptions.

HABITAT TYPE		DESCRIPTION
0	Dry Channel (DRY)	
1	Low Gradient Riffle (LGR)	Shallow reaches with swiftly flowing, turbulent water with some partially exposed substrate. Gradient <4%, substrate is usually cobble dominated.
2	High Gradient Riffle (HGR)	Steep reaches of moderately deep, swift, and very turbulent water. Amount of exposed substrate is relatively high. Gradient is >4%, and substrate is boulder dominated.
3	Cascade (CAS)	The steepest riffle habitat, consisting of alternating small waterfalls and shallow pools. Substrate is usually bedrock and boulders.
4	Secondary Channel Pool (SCP)	Pools formed outside of the average wetted channel width. During summer, these pools will dry up or have very little flow. Mainly associated with gravel bars may contain sand and substrates.
5	Backwater Pool (BwBo) Boulder Formed	Found along channel margins and caused by eddies around obstructions such as boulders, rootwads, or woody material. These pools are usually shallow and are dominated by fine grain substrates. Current velocities are quite low.
6	Backwater Pool (BwRw) Root Wad Formed	
7	Backwater Pool (BwLog) Log Formed	
8	Trench/Chute (TRC)	Channel cross sections typically U-shaped with bedrock or coarse grained bottom flanked by bedrock walls. Current velocities are swift and the direction of flow is uniform. May be pool-like.

9	Plunge Pool (PLP)	Found where stream passes over a complete or nearly complete channel obstruction and drops steeply into the streambed below, scouring out a depression; often large and deep. Substrate size is highly variable.
10	Lateral Scour Pool (LsLog) Log Formed	Formed by flow impinging against a streambank or against a partial channel obstruction. The associated scour is generally confined to <60% of wetted channel width. Channel obstructions include root-wads, woody material, boulders and bedrock.
11	Lateral Scour Pool (LsRw) Root-wad Formed	
12	Lateral Scour Pool (LsBk) Bedrock Formed	
13	Dammed Pool (DPL)	Water impounded from a complete or nearly complete channel blockage (log jams, rock landslides or beaver dams). Substrates tend toward smaller sized gravels and sand.
14	Glides (GLD)	A wide uniform channel bottom. Flow with low to moderate velocities, lacking pronounced turbulence. Substrate usually consists of cobble, gravel and sand.
15	Run (RUN)	Swiftly flowing reaches with little surface agitation and no major flow obstructions. Often appears as flooded riffles. Typical substrates are gravel, cobble and boulders.
16	Step Run (STR)	A sequence of runs separated by short riffle steps. Substrates are usually cobble and boulder dominated.
17	Mid-Channel Pool (MCP)	Large pools formed by mid-channel scour. The scour hole encompasses more than 60% of the wetted channel. Water velocity is slow, and the substrate is highly variable.
18	Edgewater (EGW)	Quiet, shallow area found along

the margins of the stream, typically associated with riffles. Water velocity is low and sometimes lacking. Substrates vary from cobbles to boulders.

19 Channel Confluence Pool (CCP) Large pools formed at the confluence of two or more channels. Scour can be due to plunges, lateral obstructions or scour at the channel intersections. Velocity and turbulence are usually greater than those in other pool types.

20 Lateral Scour Pool (LsBo) Boulder Formed — Formed by flow impinging that create a partial channel obstruction. The associated scour is confined to <60% of wetted channel width.

21 Pocket Water (POW) — A section of swift flowing stream containing numerous boulders or other large obstructions which create eddies or scour holes (pockets) behind the obstructions.

22 Corner Pool (CRP) — Lateral Scour Pools formed at a bend in the channel. These pools are common in lowland valley bottoms where stream banks consist of alluvium and lack hard obstructions.

23 Step Pool (STP) — A series of pools separated by short riffles or cascades. Generally found in high gradient, confined mountain streams dominated by boulder substrate.

24 Bedrock Sheet (BRS) — A thin sheet of water flowing over a smooth bedrock surface. Gradients are highly variable.

Appendix B. Channel classification as described by Rosgen 1985.

Stream Type	Gradient (%)	Dominant Particle Size of Channel Materials	Channel Entrenchment Valley Confinement
A1	4-10	Bedrock	Very deep; very well confined
A1-a	10+	Same as A1	
A2	4-10	Large & small boulders w/mixed cobbles	Same as A1
A2-a	10+	Same as A2	
A3	4-10	Small boulders, cobbles, coarse gravels, some sand.	Same as A1
A3-a	10+	Same as A3	
A4	4-10	Predominantly gravel, sand, and some silts.	Same as A1
A4-a	10+	Same as A4	
A5	4-10	Silt and/or clay bed and bank materials.	Same as A1
A5-a	10+	Same as A5	

B1-1	1.5-4.0	Bedrock bed:banks are cobble, gravel, some sand.	Shallow entrenchment; moderate confinement
B1	2.5-4.0 (X=3.5)	Predominately small boulders and very large cobble.	Moderate entrenchment; moderate confinement
B2	1.5-2.5 (X=2.0)	Large cobble mixed w/small boulders and coarse gravels	Moderate entrenchment; moderate confinement
B3	1.5-4.0 (X=2.5)	Cobble bed w/mixture of gravel and sand. Some small boulders	Moderate entrenchment; well confined
B4	1.5-4.0 (X=2.0)	Very coarse gravel w/cobbles, sand and finer materials	Deeply entrenched; well
B5	1.5-4.0 (X=2.5)	Silt / clay	Deeply entrenched; well confined.
B6	1.5-4.0	Gravel w/few cobbles and w/noncohesive sand and finer soil.	Deeply entrenched; slightly confined

Stream type	Gradient (%)	Dominant Particle Size of Channel Materials	Channel Entrenchment Valley Confinement
C1-1	1.5 or less (X=1.0)	Bedrock bed, gravel sand or finer banks.	Shallow entrench-ment; partially confined.
C1	1.0-1.5 (X= 1.3)	Cobble, coarse gravel bed, gravel, sand banks.	Moderate entrench-ment; well confined.
C2	0.3-1.0 (X=0.6)	Large cobble bed w/mixture of small boulders and coarse gravel.	Moderate entrench-ment; well confined.
C3	0.5-1.0 (X=0.8)	Gravel bed w/mixture of small cobble and sand.	Moderate entrench-ment; slightly confined.
C4	0.1-0.5 (X=0.3)	Sand bed w/mixture of gravel and silt. No bed armor.	Moderate entrench-ment; slightly confined.
C5	0.1 or less (X=0.05)	Silt clay w/mixture of medium to fine sand, no bed armor.	Moderate entrench-ment; slightly confined.
C6	0.1 or less (X=0.05))	Sand bed w/mixture of silt and some gravel.	Deeply entrenched; unconfined.

D1	1.0 or greater (X=2.5)	Cobble bed w/mixture of coarse gravel, sand, and small boulders.	Slightly entrenched; no confinement.
D2	1.0 or less (X=1.0)	Sand bed w/mixture of small to medium gravel and silt.	Slightly entrenched; no confinement.
F1	1.0 or less	Bedrock bed w/few boulders, cobble and gravel.	Total confinement.
F3	1.0 or less	Cobble/gravel bed with locations of sand in depositional sites.	Same as F1
F4	1.0 or less	Sand bed with smaller amounts of silt and gravel.	Same as F1
F5	1.0 or less	Silt/clay bed and banks with smaller amounts of sand.	Same as F1

APPENDIX C.

Chinook Radio Telemetry, Blue Creek, Fall 1989-90.

FREQUENCY (20 TAGS TOTAL)	0.012	0.020	0.032	0.040	0.052
SEX	M	M	M	M	F
FORK LENGTH (cm)	88	75	97	68	84
SCALES	YES	YES	YES	YES	YES
TAG TYPE (I=INTERNAL, E=EXTERNAL)	I	I	I	I	I
DATE APPLIED	11-14-89	10-23-89	11-14-89	11-28-89	11-14-89
RKM (TAG APPLIED)	4.8	3.2	4.8	5.0	4.8
DATE RECOVERED	01-03-90	11-14-89	12-12-89	01-03-90	12-15-89
RKM (TAG RECOVERED)	7.2	2.1	0.8	2.7	3.2
DATE OF UPPER MOST MOVEMENT	11-29-89	11-14-89	12-01-89	12-11-89	11-29-89
RKM (FURTHEST UPSTREAM)	6.4	2.9	7.2	8.0	7.4
# OF DAYS DEPLOYED	50	22	29	36	32

Chinook radio telemetry by ground and helicopter, Blue Creek, Fall 1989-90.

GROUND TRACKING

DATE (RKM)	FREQUENCY	0.012	0.020	0.032	0.040	0.052
10-27-89		E	N/A	E	E	E
10-31-89		E	3.0	E	E	E
11-06-89		E	2.4	E	E	E
11-13-89		E	2.0	E	E	E
11-16-89		4.3	D	N/A	E	N/A
11-21-89		5.1	D	4.5	E	4.8
12-01-89		10.1	D	7.2	4.5	7.2
12-04-89		7.9	D	N/A	7.4	7.1
12-07-89		N/A	D	N/A	6.8	3.2
12-14-89		N/A	D	D	5.9	3.0
12-20-89		N/A	D	D	2.4	D

HELICOPTER TRACKING

DATE (RKM)	FREQUENCY	0.012	0.020	0.032	0.040	0.052
10-26-89		E	A	E	E	E
11-03-89		E	2.9	E	E	E
11-14-89		E	2.1	E	E	E
11-29-89		6.8	D	N/A	5.0	7.4
12-11-89		6.4	D	0.9	8.0	3.4
12-21-89		N/A	D	D	2.9	D
12-29-89		7.2	D	D	2.9	D

Chinook Radio Telemetry, Blue Creek, Fall 1989-90 (continued).

0.062	0.072	0.082	0.092	0.102	0.120	0.132	0.140
F	M	F	F	M	F	F	F
61	83	79	91	69	91	98	86
YES	YES	YES	YES	YES	YES	YES	YES
I	I	I	I	I	E	I	E
10-24-89	11-28-89	11-14-89	11-28-89	10-31-89	11-14-89	10-31-89	11-28-89
3.2	5.0	4.8	5.0	3.2	4.8	3.2	5.0
N/A	12-19-89	12-19-89	12-20-89	1-90	01-03-90	7-05-90	1-03-90
N/A	4.0	5.3	8.8	N/A	3.7	4.5	8.2
12-01-89	12-11-89	12-11-89	12-14-89	12-01-89	11-29-89	12-11-89	12-11-89
7.4	8.8	6.4	10.6	3.2	4.8	11.6	8.0
N/A	23	37	24	125	50	247	39

Chinook radio telemetry by ground and by helicopter, Blue Creek, Fall 1989-90 (continued).

0.062	0.072	0.082	0.092	0.102	0.120	0.132	0.140
3.0	E	E	E	E	B	E	E
2.9	E	B	E	E	B	E	E
6.8	E	E	E	N/A	E	3.0	E
N/A	E	E	E	N/A	E	3.0	E
N/A	E	4.3	E	B	N/A	N/A	F
6.4	E	5.2	E	B	4.3	7.2	F
7.4	4.3	4.8	4.2	B	4.3	9.6	5.0
7.4	4.3	5.5	4.8	B	4.3	N/A	5.5
6.4	7.2	4.8	9.6	B	3.5	10.4	N/A
C	4.3	5.3	10.6	B	3.8	11.2	8.0
C	D	D	8.8	B	N/A	10.4	8.0

0.062	0.072	0.082	0.092	0.102	0.120	0.132	0.140
A	E	E	E	A	E	A	E
7.2	E	E	E	N/A	E	3.0	E
N/A	E	E	E	0.0	E	4.3	E
N/A	4.0	5.5	N/A	B	4.8	10.9	4.8
6.4	8.8	6.4	10.4	B	4.3	11.6	8.0
C	D	D	D	B	N/A	9.6	8.0
C	D	D	D	B	3.2	9.6	7.2

Chinook Radio Telemetry, Blue Creek, Fall 1989-90 (continued).

0.162	0.190	0.200	0.242	0.250	0.260
F	UNK	F	M	UNK	F
84	76	81	79	64	74
YES	YES	YES	YES	YES	YES
E	I	E	I	I	I
11-28-89	10-24-89	11-14-89	11-14-89	11-14-89	10-24-89
5.0	3.2	4.8	4.8	4.8	3.2
12-19-89	N/A	12-15-89	N/A	N/A	N/A
2.9	5.2	N/A	N/A	N/A	N/A
11-29-89	12-07-89	12-01-89	12-04-89	12-07-89	N/A
3.5	CCF 1.6	5.5	4.8	8.0	N/A
23	N/A	31	N/A	N/A	N/A

Chinook radio telemetry by ground and by helicopter, Blue Creek, Fall 1989-90 (continued).

0.162	0.190	0.200	0.242	0.250	0.260
E	3.0	E	E	E	N/A
E	2.4	E	E	E	B
E	4.8	E	E	E	B
E	5.0	E	E	E	B
E	N/A	N/A	4.3	N/A	B
E	4.8	4.8	4.6	4.8	B
2.9	N/A	5.5	4.5	7.2	B
N/A	N/A	5.2	4.8	7.9	B
2.9	CCF 1.6	N/A	4.5	8.0	B
2.1	C	5.2	4.6	8.0	B
D	C	D	4.5	7.9	B

0.162	0.190	0.200	0.242	0.250	0.260
E	A	E	E	E	A
E	3.0	E	E	E	0.0
E	4.8	E	E	E	B
3.5	CCF 1.6	N/A	N/A	N/A	B
3.2	N/A	N/A	4.8	8.0	B
D	C	D	4.5	7.9	B
D	C	D	4.8	8.0	B

Chinook Radio Telemetry, Blue Creek, Fall 1990-91.

FREQUENCY (17 TAGS TOTAL)	0.012	0.020	0.032	0.040	0.052
SEX	F	M	F	M	F
FORK LENGTH (cm)	85.0	90.0	79.0	74.0	86.0
SCALE SAMPLE	YES	YES	YES	YES	YES
TAG TYPE (I=INTERNAL, E=EXTERNAL)	I	I	I	I	I
DATE APPLIED	11-06-90	11-06-90	11-06-90	11-06-90	11-06-90
RKM (TAG APPLIED)	2.0	2.0	2.0	2.0	2.0
DATE RECOVERED	N/A	N/A	01-10-91	12-13-90	N/A
RKM (TAG RECOVERED)	N/A	N/A	3.7	2.9	N/A
DATE OF UPPER MOST MOVEMENT	11-19-90	11-06-90	12-05-90	11-26-90	11-06-90
RKM (FURTHEST UPSTREAM)	5.0	2.0	6.4	8.2	2.0
# OF DAYS DEPLOYED	N/A	N/A	65.0	20.0	N/A

Chinook radio telemetry tracking by ground and by helicopter, Blue Creek, Fall 1990-91.

GROUND TRACKING

DATE (RKM)	FREQUENCY	0.012	0.020	0.032	0.040	0.052
11-02-90		E	E	E	E	E
11-06-90		E	E	E	E	E
11-08-90		3.2	0.0	0.0	1.8	1.8
11-14-90		4.5	B	0.0	N/A	1.8
11-19-90		5.0	B	0.0	7.9	1.6
11-26-90		5.0	B	5.6	8.2	1.6
12-05-90		5.0	B	6.4	N/A	1.4
12-06-90		N/A	N/A	6.4	2.9	N/A
12-11-90		5.0	N/A	6.1	2.9	1.4
12-13-90		N/A	B	5.6	D	N/A
12-17-90		5.0	B	5.6	D	1.4
01-09-91		4.5	B	3.7	D	1.4
01-10-91		4.5	B	D	D	1.4

HELICOPTER TRACKING

DATE (RKM)	FREQUENCY	0.012	0.020	0.032	0.040	0.052
01-04-91		4.5	B	4.0	N/A	1.4

Chinook Radio Telemetry, Blue Creek, Fall 1990-91 (continued).

0.072	0.082	0.092	0.102	0.120	0.132	0.140	0.162
F	F	F	M	F	F	M	F
88.0	85.0	79.0	58.0	70.0	78.0	85.0	85.0
YES	YES	N/A	YES	YES	YES	YES	YES
I	I	I	I	E	I	E	E
11-06-90	11-09-90	11-20-90	11-20-90	11-02-90	11-20-90	11-01-90	11-01-90
2.0	3.5	2.0	1.6	4.8	1.6	3.5	3.5
12-13-90	11-30-90	N/A	N/A	N/A	12-13-90	11-08-90	11-02-90
1.6	4.0	N/A	N/A	N/A	3.0	1.8	3.5
11-06-90	11-14-90	12-17-90	01-04-91	12-05-90	12-05-90	11-01-90	11-01-90
2.0	4.0	6.4	6.4	16.0	5.6	3.5	3.5
37.0	21.0	N/A	51.0	N/A	23.0	7.0	1.0

Chinook radio tracking by ground and by helicopter, Blue Creek, Fall 1990-91(continued).

0.072	0.082	0.092	0.102	0.120	0.132	0.140	0.162
E	E	E	E	4.8	E	3.2	3.5
E	E	E	E	5.1	E	2.6	D
1.6	E	E	E	5.1	E	1.8	D
1.6	4.0	E	E	9.6	E	D	D
1.6	4.0	E	E	N/A	E	D	D
1.6	4.0	3.2	5.6	N/A	1.8	D	D
1.4	D	6.1	5.6	16.0	5.6	D	D
N/A	D	N/A	5.6	N/A	N/A	D	D
1.6	D	6.1	5.3	N/A	2.7	D	D
D	D	N/A	N/A	N/A	D	D	D
D	D	6.4	5.3	N/A	D	D	D
D	D	6.4	5.5	12.5	D	D	D
D	D	6.4	5.5	12.5	D	D	D

0.072	0.082	0.092	0.102	0.120	0.132	0.140	0.162
D	D	6.4	6.4	12.5	D	D	D

Chinook Radio Telemetry, Blue Creek, Fall 1990-91 (continued).

0.180	0.200	0.212	0.272
F	F	M	F
84.0	84.0	68.0	87
YES	YES	YES	YES
I	E	E	I
11-14-90	11-02-90	11-01-90	11-09-90
5.0	5.0	3.5	3.5
12-14-90	N/A	N/A	11-30-90
6.4	N/A	N/A	5.1
12-05-90	11-08-90	11-19-90	11-19-90
6.9	6.4	11.2	5.1
30.0	N/A	N/A	21

Chinook radio tracking by ground and by helicopter, Blue Creek, Fall 1990-91 (continued).

0.180	0.200	0.212	0.272	
E	E	4.8	E	
E	N/A	N/A	E	
E	6.4	N/A	E	
E	6.4	9.6	4.5	
5.0	6.1	11.2	5.1	
6.4	5.6	11.2	5.1	A= No reception due to bad antenna cable.
6.9	6.4	N/A	D	B= Below mouth of Blue Creek in Klamath River.
6.4	6.4	N/A	D	C= Tag not recovered.
6.4	6.4	11.2	D	D= Tag recovered.
N/A	N/A	N/A	D	E= Tag not deployed.
D	6.4	11.2	D	F= Tag fell off, recovered at same location and redeployed.
D	6.4	11.0	D	
D	6.4	11.0	D	
0.180	0.200	0.212	0.272	
D	6.4	11.0	D	