Assessment of Anadromous Fish Stocks in Blue Creek, Lower Klamath River, California, 1994-1996

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Habitat Assessment and Biological Monitoring Division
Technical Report No. 4
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Abstract

The Yurok Tribal Fisheries Program (YTFP) continued long-term monitoring of anadromous salmonid populations in Blue Creek, a fourth order lower Klamath River tributary, during fiscal years 1995-1996. This project monitored juvenile outmigrants with a rotary screw trap and assessed adult escapement and spawning activity during the fall months via direct observation. The resulting information provided a means of assessing the population trends of Blue Creek salmonids as well as enhancing knowledge of the life history of these unique fish populations.

Peak weekly counts of adult chinook in lower Blue Creek increased annually during the project period, totaling 57 adults in 1994, 275 fish in 1995, and 801 adults in 1996. No adult coho salmon were observed during fall 1994 surveys, while YTFP documented weekly peak counts of four adult coho in 1995 and 33 adult coho on consecutive weeks in 1996. The peak immigration and spawning period of Blue Creek coho likely occurred after high flows necessitated the cessation of surveys during each year. Small numbers of adult steelhead were observed each year during fall surveys, with larger numbers of steelhead half-pounders and adult cutthroat trout routinely documented throughout the survey periods. YTFP documented 117 chinook redds and one coho redd during 1995, and 89 chinook redds and two coho redds were observed in 1996. A total of 24 chinook carcasses were located during 1995 surveys, as well as one coho and one steelhead half-pounder carcass and three carcass remnants from an indeterminable species of adult salmonid. During 1996 surveys, 31 chinook and one coho carcass were located.

An estimated 3,937 (+/- 551) chinook fingerlings emigrated past the lower Blue Creek trapping site during 88 days of outmigrant sampling in 1995. An overall assessment of juvenile chinook emigration in 1995 is not possible as an indeterminable number of chinook fry and fingerlings emigrated prior to the deployment of outmigrant traps in mid-May. During 1996, an estimated 106,377 (+/- 23,863) chinook juveniles emigrated past the trap site between mid-March and the end of September. In addition, a total of 6,379 young-of-the year (YOY) and 55 age 1+ and older steelhead were captured during 1995, while 1996 trapping efforts resulted in the capture of 1,398 YOY and 559 age 1+ and older steelhead. Juvenile coho capture numbers were low during both years, with only one YOY coho sampled in 1995 while in 1996 70 YOY and 3 yearling coho were sampled. No cutthroat trout emigrants were captured in 1995 and only seven cutthroat were captured during the 1996 trapping season. Due to low capture numbers of yearling and older steelhead, coho, and cutthroat trout, no emigration estimates were possible for these species.

The information generated during this project has resulted in the formulation of restoration and management recommendations for specific portions of Blue Creek. These recommendations will aid in protecting and enhancing the unique fisheries resources in this basin. In addition, several recommendations are presented for refining the project methodologies to improve and/or expand the trend assessment data collected in this long-term monitoring effort.

1.0 Introduction

Historically the Klamath River Basin contained bountiful anadromous fish runs, supporting indigenous peoples throughout the region. Anthropogenic activities over the last 150 years, coupled with natural events, have resulted in substantial declines in these fish populations and widespread reduction and degradation of associated habitat. Concern over diminishing runs resulted in the 1997 listing of Klamath Basin coho salmon (*Oncorhynchus kisutch*) as threatened under the Endangered Species Act (ESA), with similar status proposed for Klamath steelhead (*O. mykiss*) populations. In addition, populations of chinook salmon (*O. tshawytscha*) and coastal cutthroat trout (*O. clarki clarki*) have been petitioned for ESA listing due to concerns over declining population numbers.

The lower Klamath sub-basin, encompassing all tributaries downstream of the Trinity River confluence, has been subjected to substantial timber harvest and related road construction over the last 60 years. These activities, occurring in a region with steep, naturally erodible terrain and high annual rainfall, have contributed to widespread streambed sedimentation and associated habitat degradation and native fish run declines throughout the sub-basin.

Blue Creek is the largest and most pristine tributary to the lower Klamath, and correspondingly supports the largest anadromous fish populations in the sub-basin. Out of concern over the proposed collection of broodstock for lower Klamath small-scale rearing projects, the U.S. Fish & Wildlife Service (USFWS) initiated a five year program in 1988 to evaluate the status of Blue Creek chinook populations (Longenbaugh and Chan 1994). Following its formation in 1994, the Yurok Tribal Fisheries Program (YTFP) assumed responsibility for all monitoring and assessment activities throughout the lower Klamath sub-basin.

During the fiscal years 1995-1996, YTFP was funded by the Klamath River Basin Fisheries Task Force to continue long-term monitoring of Blue Creek anadromous salmonid populations. This project, using outmigrant trapping methods and direct observation, continued juvenile emigration monitoring and substantially expanded adult spawning assessment efforts initiated by USFWS. The resulting information provided a means of assessing the population trends of Blue Creek salmonids as well as enhancing knowledge of the life history of unique Blue Creek fish populations. In addition, this project resulted in the ability to assess Blue Creek's contribution to the overall Klamath Basin chinook salmon run size. Continuation of this monitoring effort will allow for ongoing assessment of long-term population trends and further enhance understanding of the magnitude and importance of Blue Creek's fish runs in the Klamath Basin.

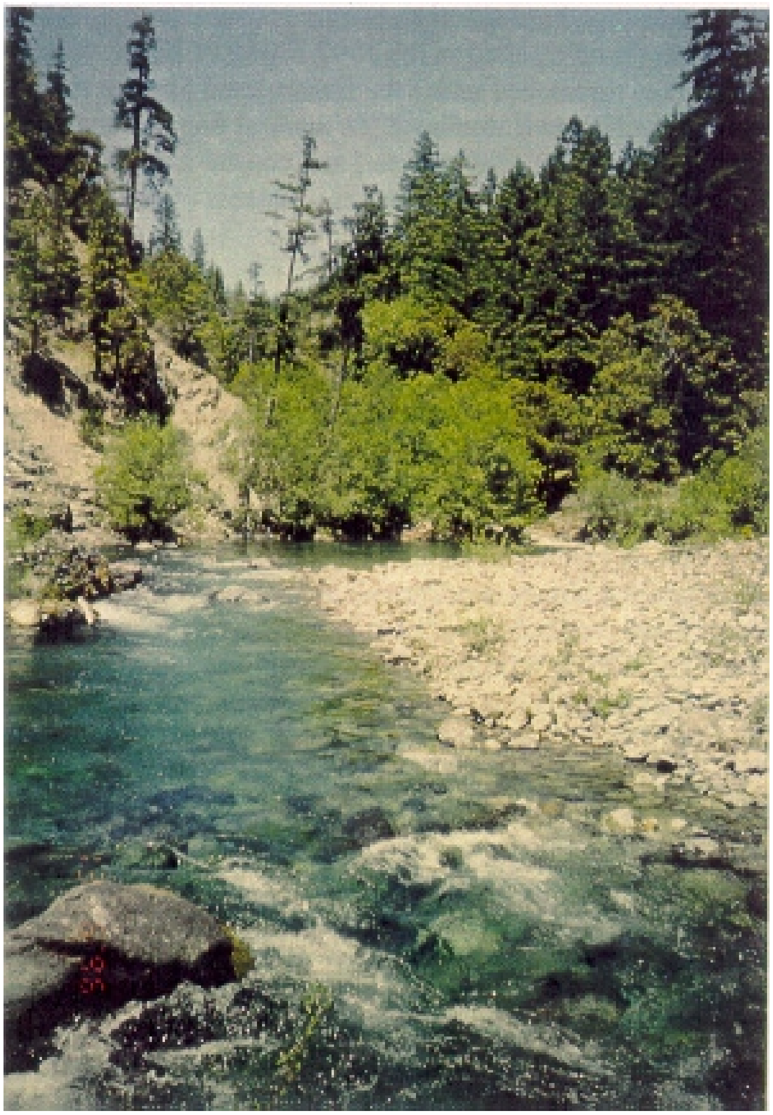

Plate 1. Mainstem Blue Creek immediately downstream of the Crescent City Fork confluence pool, lower Klamath River, California, 1996.

2.0 Study Area

Blue Creek is a fourth order drainage that enters the lower Klamath River at river mile (rm) 16.1 (Figure 1). The headwaters originate in the Elk Valley area of the Siskiyou Wilderness, at an elevation of 4,800 feet. The stream flows southwesterly 23 miles to its confluence with the Klamath River at an elevation of 40 feet. The watershed drains 81,296 acres (127 square miles) and is the largest tributary to the Klamath River downstream of the Trinity River confluence at Weitchpec (rm 40). The drainage is steep and mountainous with moderate to high channel confinement present throughout the basin.

Blue Creek was historically vegetated with moderate to dense timber stands comprised mostly of coastal redwood (*Sequoia sempervirens*), Douglas fir (*Psuedotsuga menziesii*), Port Orford cedar (*Chamaecyparis lawsoniana*), incense cedar (*Libocedrus decurrens*), tanoak (*Lithocarpus densiflora*), and madrone (*Arbutus menziesii*). Dominant riparian species include alder (*Alnus* sp.), willow (*Salix* sp.), California laurel (*Umbellularia californica*), and big leaf maple (*Acer macrophyllum*).

Four major rock types of the Coastal Range and Klamath Mountains provinces underlie the Blue Creek watershed. Proceeding upstream from the mouth, Blue Creek flows through (1) sandstone and shale of the Franciscan Complex, (2) ultramafic rocks (serpentinized peridotite) of the Josephine Ophiolite (3) slate, metagraywacke, and greenstone of the Galice Formation and (4) an assemblage of diverse rock types (mostly metasedimentary) of the Western Paleozoic and Triassic Belt (Wagner and Saucedo 1987, as cited in Chan and Longenbaugh 1994). The streambed substrate is typically dominated by small and large cobble with numerous bedrock and boulder control points.

The Blue Creek watershed has the highest level of precipitation in the Klamath Basin, with annual rainfall averaging approximately 100 inches in the headwaters, 75% of which occurs between November and March (Helley and LaMarche 1973). Stream discharge data collected in lower Blue Creek by the U.S. Geological Survey (USGS) for the period 1965-1978 indicate large seasonal flow variations. Stream flows over this period ranged from 43 cubic feet per second (cfs) on November 1, 1965 to 33,000 cfs on March 2, 1972 (USGS, unpublished data). The extreme flood event of December 22, 1964, although outside the period of record, was estimated at 48,000 cfs (Chan and Longenbaugh 1994). The recurrence interval of this flood event, based on geomorphic evidence as well as radiocarbon analysis and tree ring counts of material entrained in historic Blue Creek flood deposits, is estimated to be at least 100 years (Helley and LaMarche 1973).

Three tributaries to Blue Creek have been identified as having importance to anadromous salmonid spawning and rearing. These include West Fork Blue Creek, Nickowitz Creek, and Crescent City Fork Blue Creek, which is the largest and lowest gradient tributary accessible to anadromous fish (Figure 2). These three tributaries comprise 41% of the entire watershed area, but only the Crescent City Fork is extensively utilized by both salmon and steelhead. Smaller numbers of salmon have previously been documented spawning in the lower one mile of the West Fork (Longenbaugh and Chan 1994), with more extensive utilization by steelhead likely. To date, only a small number of juvenile and adult salmon have been observed in Nickowitz Creek, but juvenile steelhead have

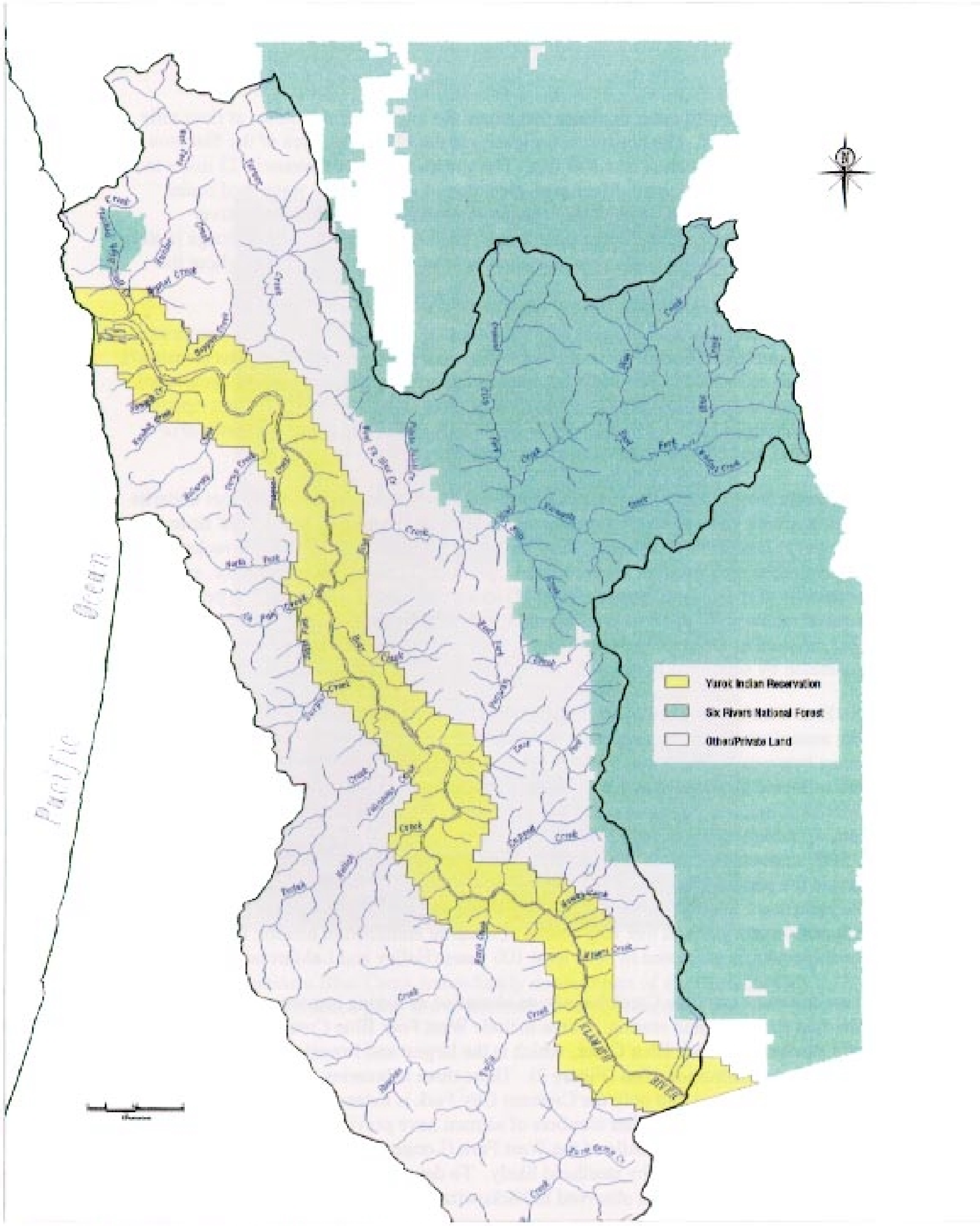

Figure 1. Location of lower Klamath River Tributaries
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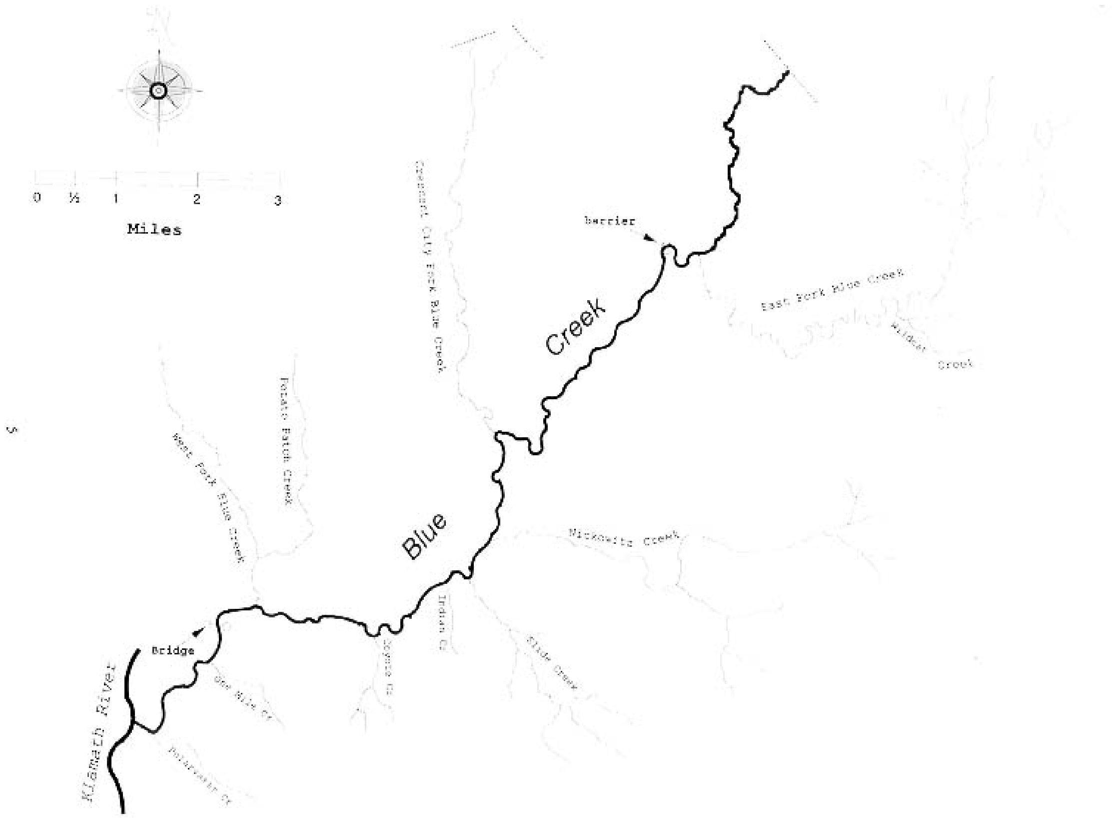


Figure 2. Blue Creek drainage, lower Klamath River, California.

been observed throughout the basin (Hayden 1998; Voight and Gale 1998; YTFP preliminary data 1997). A fourth tributary, Slide Creek, has a steep gradient and slides near its mouth, but provides access to steelhead during winter flow events.

A natural barrier on the mainstem of Blue Creek is located approximately 0.25 miles below the confluence of the East Fork (rm 15) (Figure 2). This barrier, consisting of a very steep boulder jammed gorge, results in a complete blockage of upstream anadromous migration (Gale 1997a). Below the barrier, four species of anadromous salmonids are present: chinook salmon, coho salmon, steelhead trout, and coastal cutthroat trout. Resident rainbow trout are the only species currently present upstream of the anadromous barrier, although brook trout (*Salvelinus fontinalis)* were stocked in upper reaches at an undocumented point earlier in the century (Gale 1997a). Hereinafter, Blue Creek discussions are restricted to the lower 15 miles of stream accessible to anadromous salmonids.

As with many of the tributaries to the lower Klamath River, widespread timber harvesting has occurred along portions of Blue Creek. Since the early 1960's, extensive road networks have been constructed and timber has been removed throughout virtually all of the West Fork drainage and lower eight miles of the mainstem. Simpson Timber Company owns the land surrounding the lower 8.1 miles of Blue Creek and logging continues to date in this portion of the watershed (Figure 3).

Upstream of Simpson property, the creek runs through Six Rivers National Forest (SRNF) land. The majority of this portion of the Blue Creek basin is located in the Siskiyou Wilderness Area (Figure 3). Federally owned portions of the watershed which were not included in the Siskiyou Wilderness Area include: Slide Creek, Nickowitz Creek, portions of the Crescent City Fork, and virtually all of the East Fork (the lower one mile is included). The majority of these “non-wilderness” holdings are classified as Late Successional Reserve (LSR) under the President’s Forest Plan (Option 9). The only exception is the portions of the Crescent City Fork not included in the Siskiyou Wilderness, which are classified as Matrix land. LSR’s are areas primarily composed of old growth forest that are set aside from active timber harvesting to “assure the viability of threatened and at-risk species” (FEMAT 1993). The Matrix, defined as all land outside of the Reserves and “Congressionally Withdrawn Areas” (i.e. Wilderness Areas), is subject to timber harvest activities (FEMAT 1993).

An arterial logging road parallels the southern side of Blue Creek several hundred feet above the creek, from rm 2.1 to 6.0 (Figure 3). This main road (Simpson Road #B-10) crosses Blue Creek at river mile 2.1, providing the only bridge crossing in the basin. This bridge is typically in place from April through October, and once removed, access to the majority of the Blue Creek basin is limited. Little used roads branch off this maintained road, providing additional streamside access at rms 1.4, 5.6, and 8.1 (Figure 3).

Road access into the federally owned portion of the watershed (above rm 8.1) is very limited. A few old logging spur roads in the upper half of the Crescent City Fork provide vehicle access to within a half mile of the stream channel, and the USFS road #13N45 provides access (via Orleans and the “G-O” road) to within 1.5 miles of the mainstem

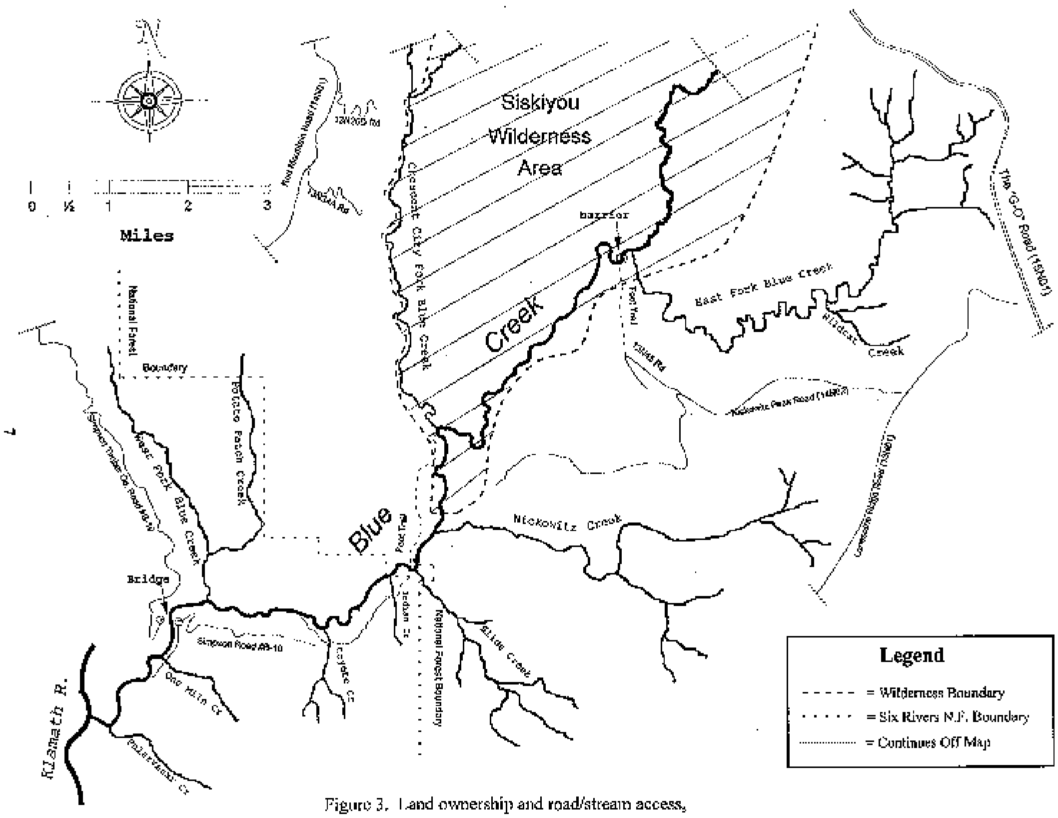


Figure 3. Land ownership and road/stream access,
Blue Creek, lower Klamath River, California, 1995-1996.

anadromous barrier (Figure 3). Foot access to the stream channel from these roads is difficult due to steep terrain and dense vegetation. Use of these access points typically requires an overnight campout, as well as requiring survey crews to exit the channel via the Simpson road network beginning at rm 8.1.

Plate 2. View of lower Blue Creek from Simpson Road #B-10, lower Klamath River, California, 1996

3.0 Methods & Materials

3.1 Stream Discharge Monitoring

Stream discharge in lower Blue Creek was monitored in conjunction with 1995 outmigrant trapping. A staff gage, located at rm 2.3, was read daily throughout the trapping season (Figure 4). Daily stream discharge was estimated from these gage readings using the following gage height-discharge relationship:

$$Q = 117.3 \times 10^{(1.77 \times \text{Log GH}+1)}, r^2 = 0.97$$

This relationship was established at the same site by USFWS in 1993 (Longenbaugh and Chan 1994). The staff gage was dislodged during high flows in winter 1995-1996, resulting in an inability to estimate discharge during 1996.

3.2 Water Temperature Monitoring

Water temperature monitoring occurred in Blue Creek during 1995 and 1996. Temperature recorders were placed inside perforated PVC tubes and then secured inside mesh covered cement blocks. The cement blocks were secured to an anchor (usually a tree) using 1/8" galvanized steel aircraft cable. Recorders were set to record the water temperature (°F) every thirty minutes, and were placed in an area such as riffle or fast flowing run to provide adequate water flushing. They were checked and downloaded regularly throughout the season. The downloaded data was analyzed using dBase software.

<u>1995</u>

An Onset Stow Away Temperature logger (model # STEB08-05+37ºC) was used to record water temperatures during 1995. This data recorder was placed upstream from the Simpson Road # B10 bridge (rm 2.1) in a fast flowing run (Figure 4). This logger recorded from 20 Apr through 26 Dec 1995.

<u>1996</u>

Onset Optic Stow Away temperature loggers (model #WTA08-05+37 ºC) were used to monitor Blue Creek at four different locations during 1996 (Figure 4):

- Lower Blue Creek at Simpson Road # B-10 Bridge (1 Jan through 16 Sep 1996).
- Upper Blue Creek approximately 100 feet upstream of the Crescent City Fork confluence (24 Jul through 24 Oct 1996).
- Crescent City Fork approximately 30 feet upstream of mouth (23 Jul through 28 Oct 1996).
- Nickowitz Creek approximately 50 feet upstream of mouth (24 Jul through 28 Oct 1996).

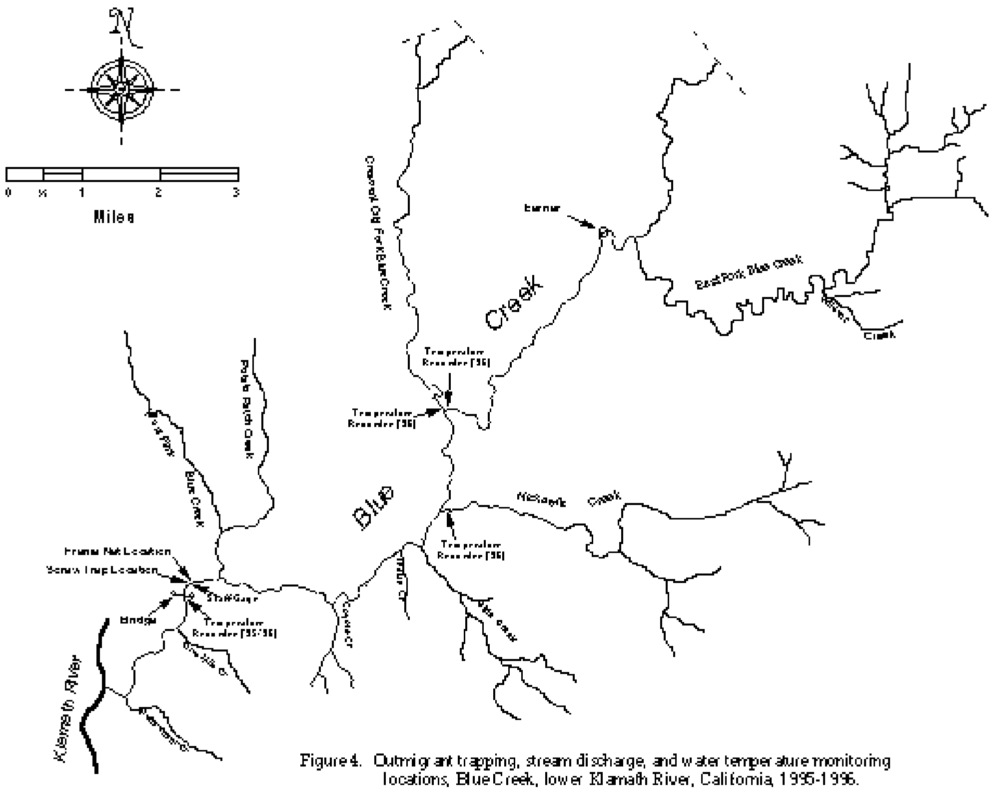


Figure 4. Outmigrant trapping, stream discharge, and water temperature monitoring locations, Blue Creek, lower Klamath River, California, 1995-1996.

3.3 Fall Spawning Surveys

The Yurok Tribal Fisheries Program conducted both snorkel surveys and streamside foot surveys to assess salmonid spawning activity during 1994, 1995, and 1996. Blue Creek fall spawning surveys were initiated in September 1994 in the lower 10.3 miles of the drainage, and expanded in subsequent years to cover additional spawning areas. Spawning survey data collection methods remained consistent between years.

3.3.1 Equipment

Data collection utilized two different methodologies: direct observation via mask and snorkel and streamside foot surveys. Snorkel surveys required the use of a full 7mm neoprene wetsuit, dive hood, gloves, and mask and snorkel. Streamside foot surveyors wore neoprene chest waders, polarized glasses, and rain gear when necessary. All crews wore felt-soled stream boots for added traction on wet, slippery surfaces, and carried waistpack dry bags containing data collection kits.

3.3.2 Snorkel Survey Methods

The U.S. Fish and Wildlife Service (USFWS) began performing fall Blue Creek spawning surveys in 1988. Initially USFWS performed bi-weekly surveys of four separate stream reaches of lower Blue Creek to collect trend data on adult spawning escapement, habitat utilization, run composition, and the timing and duration of fall spawning runs. Consistent bi-weekly "index" surveys were attempted by USFWS for these lower four reaches in 1988-92 (excluding 1989). USFWS conducted sporadic surveys of portions of the upper basin and significant tributaries, but comprehensive basin-wide surveys were never performed.

To maintain this trend data, YTFP surveyed four "index" reaches covering the lower 10.3 miles of Blue Creek each week during the 1994-1996 project period. For consistency and logistical reasons, reaches #1-4 (Figures 5-6) were based on reaches established by USFWS during their 1989-1993 surveys. In general, YTFP performed surveys of reaches #1-4 once a week, as stream conditions allowed, during the fall spawning season. The fall survey season was initiated typically in September prior to the arrival of late-fall running chinook and continued until heavy rains commenced and flow conditions became unsafe and/or unsuitable for surveying. Reach delineations are as follows (Figures 5-6):

- **Reach #1**:
  From the confluence with the Klamath River upstream to the Simpson road #B-10 bridge crossing, (total length: 2.1 miles).
- **Reach #2**:
  Upstream from the Blue Creek Bridge to the "B-10X" road access at river mile 5.6 (total length: 3.5 miles).
- **Reach #3:**
  Between the "B-10X" road access and the Slide Creek confluence pool, 8.1 miles from the mouth (total length: 2.5 miles).
- **Reach #4**:
  Between the Slide Creek confluence pool and the mouth of the Crescent City Fork (total length: 2.2 miles)

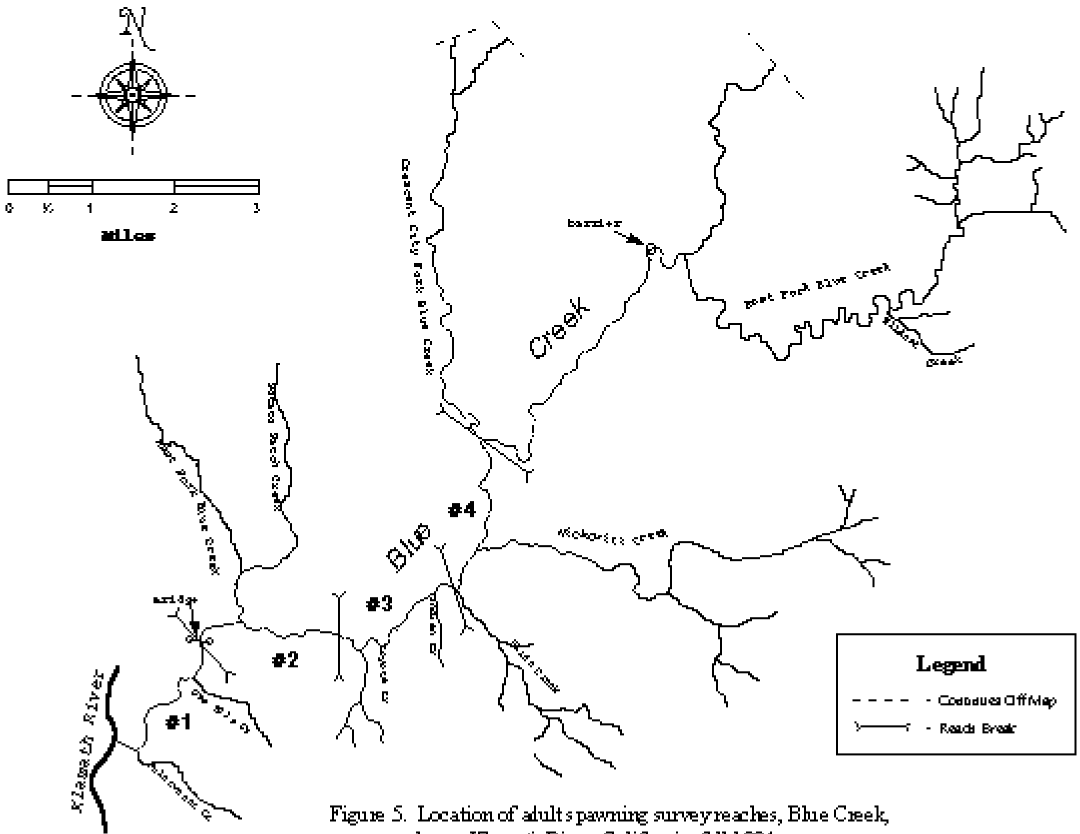


Figure 5. Location of adult spawning survey reaches, Blue Creek, lower Klamath River, California, fall 1994.

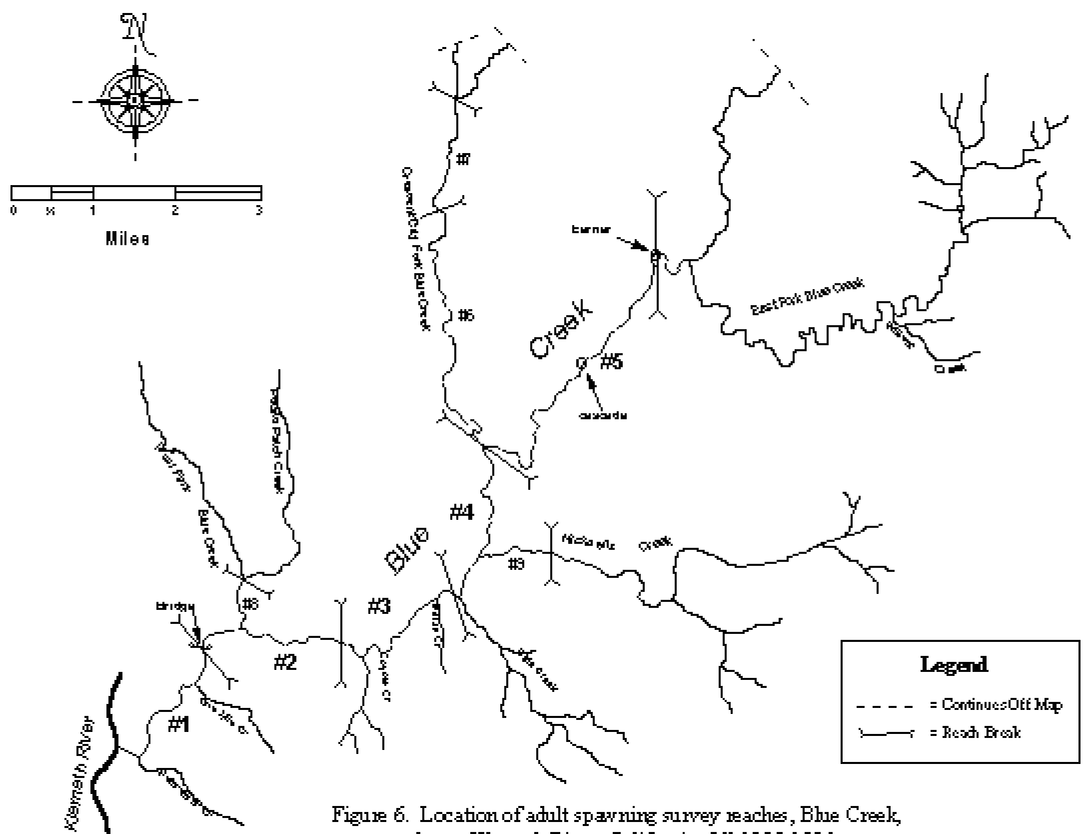


Figure 6. Location of adult spawning survey reaches, Blue Creek, lower Klamath River, California, fall 1995-1996.

To provide comprehensive basin-wide coverage, YTFP expanded spawning survey efforts in 1995 and 1996 to include an additional 13.1 miles of the Blue Creek drainage. These reaches included the upper portion of the mainstem (between reach #4 and the anadromous barrier), Crescent City Fork, Nickowitz Creek and West Fork Blue Creek (Figure 5). Reach delineations of these expanded survey areas were based on previously observed habitat utilization, newly established stream access, and the amount of stream that could potentially be surveyed in one day. These reaches were occasionally surveyed in 1995, and surveyed bi-weekly in 1996. Surveys of the West Fork and Nickowitz Creeks commenced after summer low-flow barriers abated with fall rains, and were performed on a "time-permitting basis" after the "index" reaches had been finished for that week. Surveys of the remote upper reaches (#5-7) required crews to hike and camp overnight in the field. Delineations of reaches #5-9 are as follows:

- **Reach #5**:
  The upper mainstem of Blue Creek, from the Crescent City Fork (CCF) confluence to the anadromous barrier (total length: 4.25 miles).
- **Reach #6**:
  The lower portion of the CCF, between the mouth and the U.S. Forest Service (USFS) Road # 13N34A trail access (total length: 3.5 miles).
- **Reach #7**:
  The upper portion of the CCF, between the USFS Road #13N26D trail access and the USFS Road # 13N34A trail access (total length: 1.9 miles).
- **Reach #8**:
  The lower portion of West Fork Blue Creek, from the Potato Patch Creek confluence to the mouth (total length: 0.85 miles).
- **Reach #9**:
  Lower portion of Nickowitz Creek, upstream from its confluence with Blue Creek (total length: 0.75-1.0 miles).

Snorkel survey crews, consisting of two to three divers, swam downstream in parallel lanes and collected data on redds, live fish, carcasses, and other biological observations (test redds, predators, etc.). In an attempt to provide comparable counts and maximum coverage of the stream channel, additional crewmembers surveyed at times of increased flows and/or reduced water visibility. When heavy rain created unsuitable snorkeling conditions, surveys were postponed until conditions improved. In order to maximize consistency between surveys, crews followed specific protocols. These protocols were as follows:

1) ***Redds***. Each identified "area" of redd construction was assigned a location number ("R-#") and its geographical location marked on a topographic map. Multiple redds in one location would be counted and described separately in the notes but grouped together under one location number on the map. Each new area of redd construction was flagged at the downstream extent of the disturbed substrate to prevent double counting between surveys. Pertinent data such as overall redd dimensions (length x width), depth of the mound (or "tail-spill") and pit, and other site-specific observations such as fish presence,

habitat type, construction stage, and redd age, were recorded in a field notebook.

2) ***Live Fish Sightings***. In addition to adult chinook salmon, YTFP also collected biological data on any other adult salmonids observed. Data collection protocols for live fish were essentially the same as for redds. Each fish sighting was assigned a location number ("F-#") and corresponding site location on the survey map. For each site, the number of each species observed and the habitat type was recorded. In addition, crews would record the age class (adult vs. jack), sex, and relative condition of observed fish, as well as the presence of any clips, marks, or scars. Factors such as fluctuating stream-flow and water visibility, large schools of fish, and/or swiftly darting fish frequently limited collection of some of the above data.

3) ***Carcasses***. The location of each carcass sighting was assigned a corresponding number ("C-#") on the survey map as they were encountered during a survey. In addition, the following biological data for each carcass was recorded: species, sex, fork length, estimated % "spent", the relative condition, and any identifying clips, marks or scars. A scale sample was collected from each carcass when feasible. Finally, a piece of flagging with the date was attached to the carcass so that it would not be recounted on a later date. When discovering an adipose fin-clipped carcass, crews removed the head for coded-wire tag retrieval.

3.3.3 Streamside Survey Methods

Streamside foot surveys were conducted when stream conditions prevented direct observation of fall spawners. Although infrequent, foot surveys were typically performed in areas still accessible when high flows washed out the Blue Creek bridge (i.e. lower reach #2 and upper reach #1). Foot surveys were also conducted on reaches #8 and #9 when stream conditions did not allow for snorkel counts. Crewmembers on each bank walked downstream looking for any signs of anadromous spawning activity. When encountered, redds were approached slowly to determine if fish were present. Redds, carcasses and other data were measured and recorded utilizing the same methodology as the snorkel surveys.

3.4 Juvenile Salmonid Trapping

Outmigrant traps were operated in 1995 and 1996 in order to monitor juvenile salmonid emigration. Trap locations were chosen based on stream access, hydraulics, as well as proximity to recent USFWS outmigrant trapping efforts. In general, traps were operated 24 hours a day, seven days a week, although trapping effort (days sampled) varied between years.

1995

Two frame nets were deployed side by side in a pool tailout located at rm 2.3 (Figure 4). These traps were installed on 5 May 1995 after receding spring flows allowed safe access to the stream. A rotary screw trap was later purchased because of concerns over the frame nets' low trapping efficiency and inability to capture and retain older age class fish. This trap was installed downstream of the frame nets at rm 2.2 on 21 Jul 1995. The frame nets and rotary screw trap were operated simultaneously until 8 Aug 1995, when the frame nets were removed for the season. The screw trap continued operation until it was pulled for the season on 28 Sep 1995.

1996

The rotary screw trap was deployed at rm 2.2 on 19 Mar and was operated continuously until 1 Oct 1996, except for downtime due to high flows and/or required repairs. Frame nets were not utilized in Blue Creek during 1996.

3.4.1 Equipment

Frame Net

Each frame net measured 10' x 5' at the mouth opening and tapered 28 ft. to a 10" x 9" cod end. Two live boxes were attached at the cod end of each net with an interconnecting nylon mesh sleeve between the two boxes. Weir panels were used to increase trapping efficiency by deflecting a greater proportion of the flow and the fish into trap. Panels were constructed with 1" x 4" wood frames and ¼" hardware cloth. The panels were secured with steel fence posts in a V-shape with the apex facing downstream.

Rotary Screw Trap

The rotary screw trap (manufactured by E.G. Solutions, Inc., Corvallis, Oregon) is equipped with a five-foot diameter cone, and is supported by two aluminum-covered foam pontoons (Plate 3). Water enters the upstream end of the trapping cone and strikes the angled internal screw, rotating the screw assembly and perforated stainless steel cone. As the assembly rotates, fish are trapped within the chambers formed by the screw and are moved rearward into the live box. Floating leaves and detritus are removed via a rotating drum screen at the rear of the live box.

The screw trap was placed in the main thalweg to maximize the quantity of stream flow sampled. The trap was secured in position by 3/8" steel cable attached to anchor points (logs or trees) on each bank. Repositioning occurred throughout the season in response to changing flow conditions.

3.4.2 Biological Sampling

YTFP personnel checked the traps in the morning hours to minimize holding and temperature-induced stress. Captured fish were removed from live boxes in small batches (20-30 fish) and transferred to five-gallon buckets, with water replenished every 10 minutes. In 1995, fish captured in the screw trap and the frame nets were kept separate. All captured salmonids were anaesthetized with tricane methanesulfonate (MS

222) and identified to species and age class. YTFP measured fork lengths from a random sample of up to thirty fish of each species, as well as inspecting all captured salmonids for marks (see Marking section). All non-salmonid species were identified and tallied on a daily basis.

Scales were collected from selected steelhead and cutthroat trout to facilitate age class differentiation of each species. Scales were taken from just below the dorsal fin on both sides of the fish and placed in wax paper-lined coin envelopes. Each sample was mounted and analyzed using methods described in Jearld (1983).

3.4.3 Outmigration Estimates

Mark-recapture methods were used to estimate trapping efficiencies throughout the 1995 and 1996 trapping seasons. These efficiencies allow for expansion of captured chinook numbers to estimate the total number of emigrants during both seasons. Kennan et al. (1994) and Polos (1997) note that the following assumptions are made when conducting such a mark-recapture experiment: (1) Marked fish continue their migration downstream after release, (2) Handling fish will not affect their behavior, (3) Marked and unmarked fish are evenly distributed when they migrate past the trapping site and exhibit similar behavior (equal capture probability), (4) Fish do not lose their marks prior to passing through the trap site, (5) All marks are observed and recorded, and (6) Mortality of marked fish is minimal.

Outmigration estimates were only calculated for chinook salmon. Age 1+ and older steelhead were marked throughout both trapping periods, but sample sizes failed to yield adequate recapture numbers. Because of the low number of coho and cutthroat emigrants captured throughout both trapping seasons, these species were not marked.

<u>Marking</u>

During 1995, YTFP marked juvenile chinook with dye (early season) and fin-clips (late season). Bismarck Brown Y, a biological stain (Mundie and Traber 1983), was utilized to dye fish. Juvenile chinook were immersed in an aerated 0.021 g/l solution of Bismarck Brown Y for 15 to 30 minutes. Dyed fish are typically recognizable for up to three days (Polos 1997). The addition of fin clipping created a diversity of marks and alleviated concerns over the low retention time of the stain. Surgical scissors were used to remove the tips of select fins. The use of different fin clips enabled the tracking of marked fish from discrete marking periods, thereby increasing the reliability of trap efficiency estimates. Partial fin clipping was the sole mark-recapture method used in 1996.

After marked fish had recovered from anesthesia, they were carried upstream in buckets and released 1/4 mile upstream of the trap. This facilitated equal dispersal with non-marked fish prior to passing the trap site. All recaptures and unmarked fish were released 1/8 mile downstream of the trap.

<u>Efficiency- Based Estimates</u>

All marked and recaptured fish were categorized by mark type and assigned to discrete marking periods. Marking periods in 1995 were separated by a weekly mark change. In

1996, marking periods were based on changing flow conditions and/or trap position. In the event flow and/or trap position did not change significantly, a weekly period was used until such changes occurred. Trap efficiency estimates for each marking period were calculated using the following formula:

$$E = R/M * 100$$

Where: M = number of fish marked from a given marking period
R = number of fish recaptured from a given marking period

The total number of emigrants in a given period was estimated using the following formula:

$$N = C/E$$

Where: C = number of unmarked fish captured in a given marking period
E = estimated trapping efficiency for a given marking period

Variances for estimates from each marking period were calculated using the bootstrap method (Efron and Tibshirani 1986) with 1,000 iterations (M. Solazzi, personal communication; Thedinga et al. 1994). The estimates and variances from each of the individual marking periods were summed to achieve overall values for the trapping season.

Plate 3. Rotary screw trap deployed at river mile 2.2, Blue Creek, lower Klamath River, California, 1996.

Plate 4. YTFP staff with retrieved chinook carcass, Blue Creek, lower Klamath River, California, 1997.

Plate 5. YTFP staff retrieving fish captured in the rotary screw trap, Blue Creek, lower Klamath River, California, 1997.

4.0 Results & Discussion

4.1 Stream Discharge

Stream discharge declined steadily during the 1995 trapping season, with the exception of two sharp peaks following rain events in mid-June (Figure 7). Discharge ranged from 676 cfs on 9 May (the first day gage readings were taken) to a low of 143 cfs on 16 Aug (the last day gage readings were consistently recorded) (Figure 7). The two flow peaks on 15 Jun and 19 Jun were estimated at 830 and 840 cfs, respectively. Based on a gage reading taken on 28 Sep, prior to the onset of fall rains, the flow was estimated at 128 cfs. It is unknown how significantly the stream channel may have changed adjacent to the staff gage since USFWS last calibrated their gage-discharge relationship in 1993. Therefore, the validity of using this relationship for 1995 gage height readings is not known.

The staff gage was dislodged during high flows in winter 1995-1996, and consequently no discharge estimates were made during the 1996 trapping season. A flow measurement of 62.6 cfs was taken on 3 Oct 1996, prior to the onset of fall rains. USFWS estimated annual minimum flows of 32-74 cfs between 1988-1993 (Chan and Longenbaugh 1994; Gilroy et al. 1992; Longenbaugh and Chan 1994; Stern and Noble 1990).

4.2 Water Temperature

<u>1995</u>

Water temperature was monitored in lower Blue Creek from 20 Apr-26 Dec 1995. The lowest stream temperatures during this period were recorded in late April and December, with the lowest daily average temperature occurring on 24-25 Dec (45.1°F) (Figure 8). The season high temperatures occurred during July and August, when daily average temperatures were routinely over 60°F (Figure 8). The maximum recorded temperature of 68.7°F was measured on 4 Aug, with a similar peak temperature (68.1°F) observed on 16 Jul 1995.

<u>1996</u>

Water temperature was monitored in lower Blue Creek from 1 Jan until 16 Sep 1996. September 16 was the last date the lower Blue Creek recorder was downloaded; this recorder was subsequently lost on/around 1 Jan 1997 during the “New Years Flood”. Water temperature was also monitored in upper Blue Creek (above the Crescent City Fork mouth), lower Nickowitz Creek, and lower Crescent City Fork Blue Creek from late July through late October.

The lowest recorded temperatures in lower Blue Creek occurred in late February and late March, while seasonal high temperatures were recorded during July and August (Figure 9). The minimum recorded temperature in lower Blue Creek (42.8°F) occurred on 26 Feb, while the highest recorded temperature (69.0°F) was observed on 30 Jul 1996 (Figure 9). The average daily temperature fluctuation during July and August was 7.7°F,

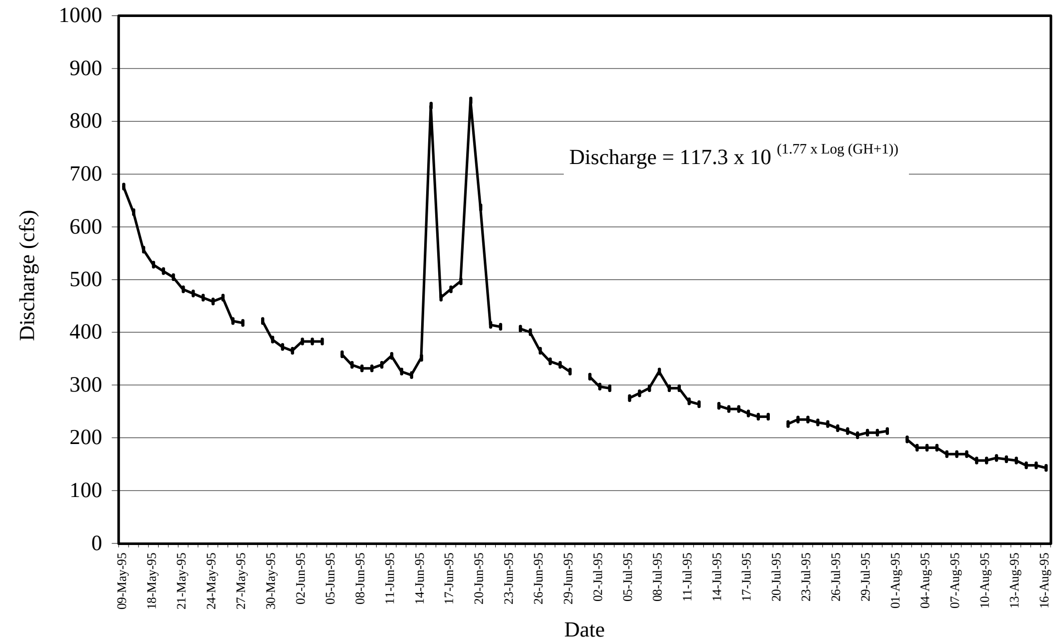


Figure 7. Estimated daily discharge during the 1995 outmigrant trapping season, Blue Creek, lower Klamath River, California, 1995.

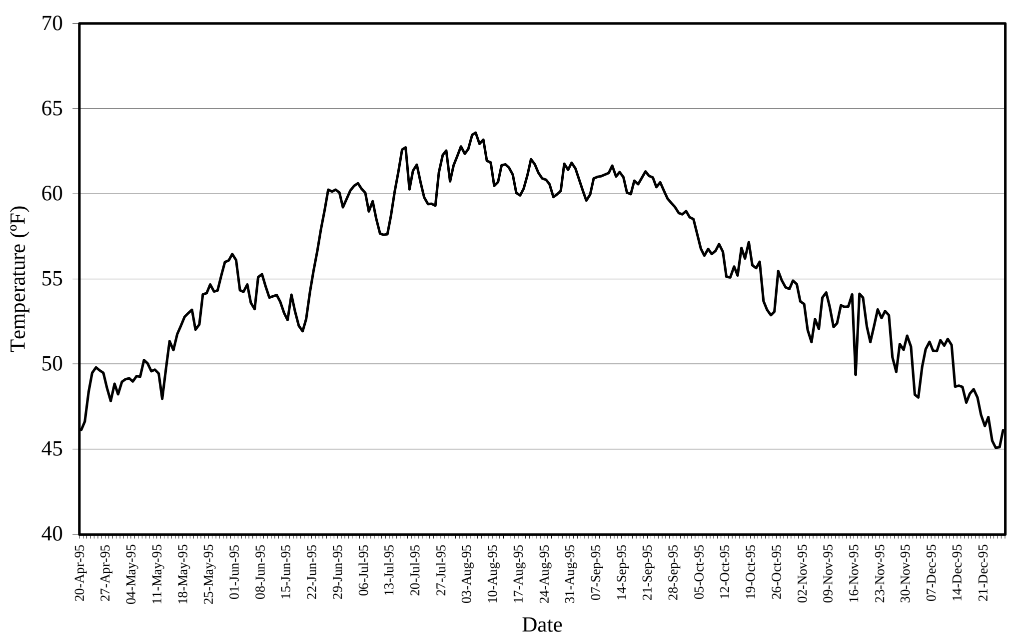


Figure 8. Average daily water temperature, lower Blue Creek, lower Klamath River, California, Apr-Dec, 1995.

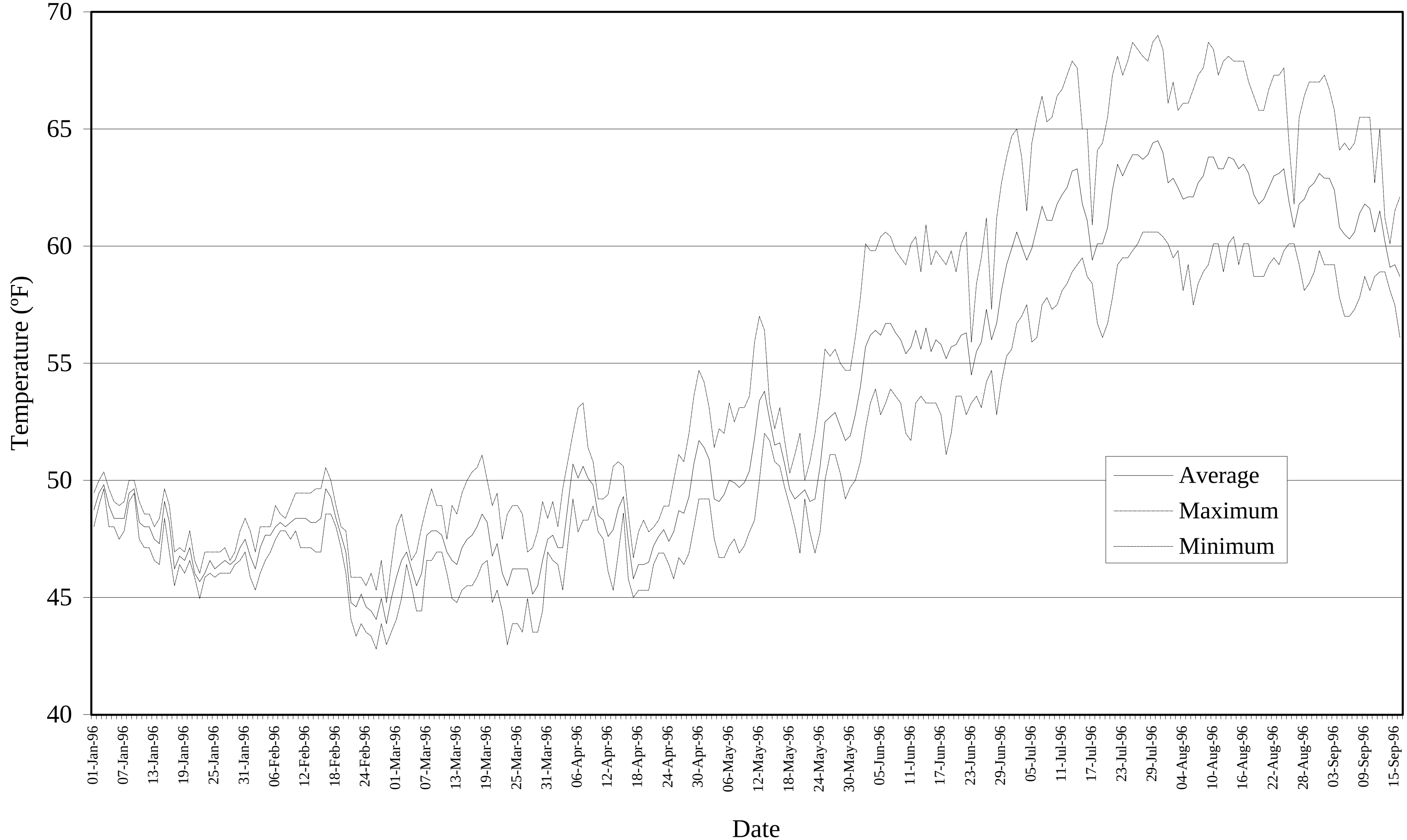


Figure 9. Daily average, maximum, and minimum water temperature, lower Blue Creek, lower Klamath River, California, Jan-Sept, 1996.

while this average fluctuation was only 1.5°F during January and February (Figure 9). Average daily water temperature in lower Blue Creek during 1995 and 1996 did not appear to vary substantially (Figures 8-9).

Average daily temperature in upper Blue Creek was similar to conditions in the lower portion of the drainage, although upper Blue Creek was on average 1.6°F cooler during the time period that both recorders were in operation (Figure 10). Nickowitz Creek and the Crescent City Fork exhibited very similar temperature regimes during the monitoring period, with both of these drainages on average being 3.6°F cooler than temperatures in upper Blue Creek (Figure 10).

4.3 Fall Spawning Surveys

<u>1994</u>

Surveys were conducted on reaches #1-4 for a total of four weeks during 1994 (Table 1). Snorkel surveys commenced the week of 11 Oct 1994 and continued each week through 9 Nov 1994. Although limited, this effort was the first instance when YTFP surveyed all four Blue Creek index reaches at least twice during the course of the spawning season. Surveys ended in mid-November after sustained high flows washed out the Blue Creek Bridge and created hazardous survey conditions.

<u>1995</u>

The fall survey season began the week of 28 Sep and continued for 10 weeks to 29 Nov 1995 (Table 2). Surveys concluded when heavy rains and high flows prevented the continuation of spawning surveys. In general, reaches #1-4 were surveyed each week during the 1995 fall spawning season, except during the third week when reaches #2 and #3 were not surveyed due to Simpson Timber Co. aerial spraying closure.

Due to the remote location and rugged terrain, surveys of reaches #5-9 were performed on a periodic basis as survey conditions, access, and time permitted. Reach #5 was surveyed once on 26 Oct, and again later in the season on 29 Nov 1995. YTFP completed two spawning surveys of reach #6 during November. Reach #7 was surveyed only once in 1995, while YTFP personnel performed four surveys of reach #8 and two surveys of reach #9.

<u>1996</u>

YTFP performed 8 weeks of spawning surveys in the Blue Creek basin during the 1996 fall season (Table 3). Surveys began during the week of 9 Sep and concluded the week of 13 Nov 1996 when high flows prevented further surveys.

Early-September surveys were conducted in order to document the time of first entry into Blue Creek. Since these preliminary surveys observed low chinook abundance, subsequent surveys were completed on a biweekly basis until 9 Oct 1996. After this date, index reaches were surveyed weekly for the remainder of the season. YTFP surveyed

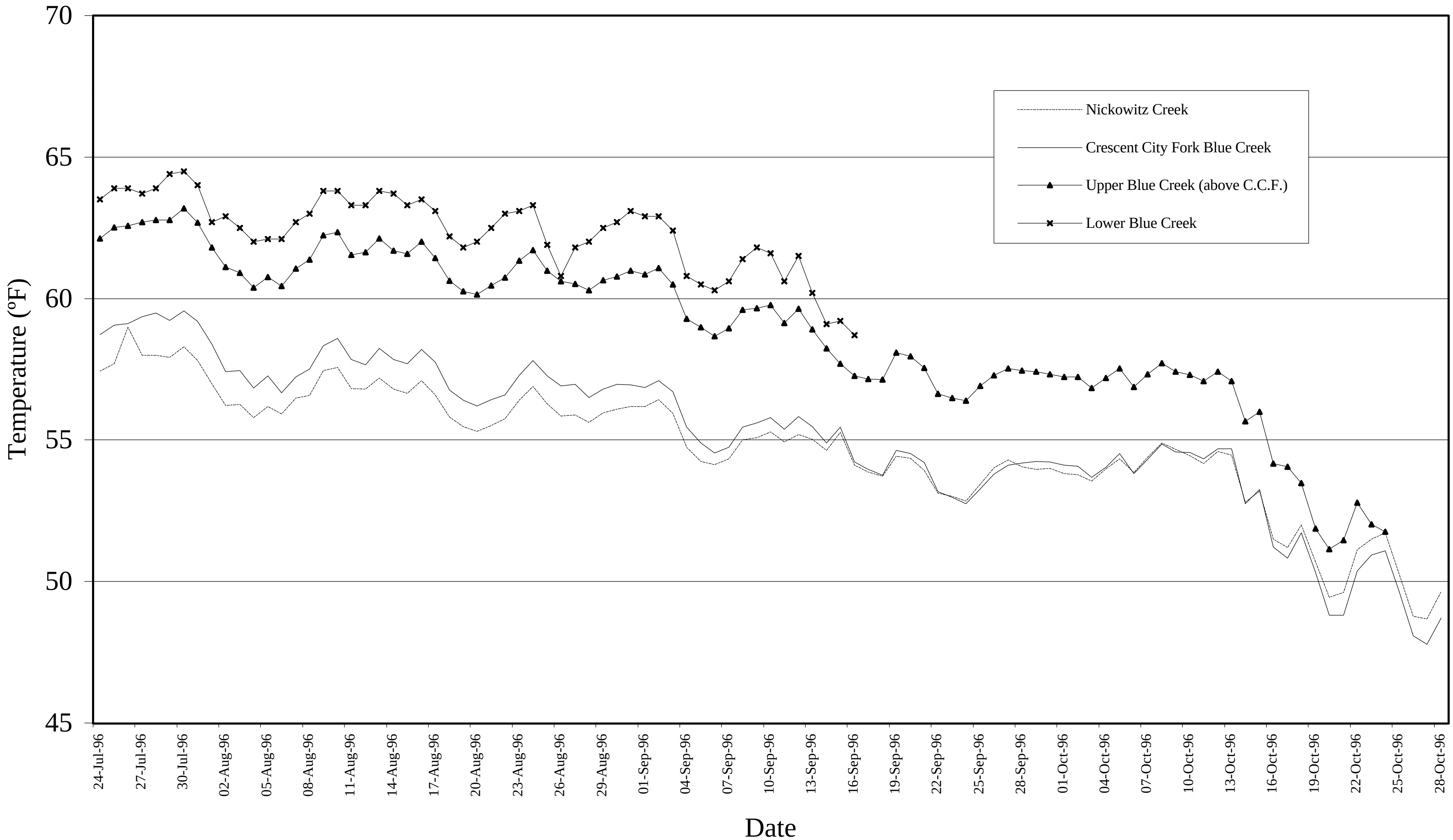


Figure 10. Average daily water temperature, Blue Creek and selected tributaries, lower Klamath River, California, July-Oct, 1996.

Table 1. Summary of adult salmonids, redds, and carcasses observed by reach during snorkel surveys, Blue Creek, lower Klamath River, California, 1994.

		Chinook			Steelhead		Adult	Unidentified	Chinook	
Date	Reach	Adult	Jack	Coho	1/2 Pounder	Adult	Cutthroat	Adult Salmonid	Redds	Carcassses
10/19/94	1	0	0	0	0	1	0	0	0	0
10/19/94	2	1	0	0	0	0	0	0	0	1
10/18/94	3	0	0	0	0	1	0	0	0	0
10/18/94	4	0	0	0	1	0	0	0	0	0
	Total:	1	0	0	1	2	0	0	0	1
10/26/94	1-2	- Surveys cancelled due to high flows -								
10/25/94	3	0	0	0	5	0	0	0	0	0
10/27/94	4	- Survey cancelled due to high flows -								
	Total:	0	0	0	5	0	0	0	0	0
11/3/94	1	14	0	0	0	2	0	0	0	0
11/3/94	2	16	0	0	12	3	0	1	2	1
11/2/94	3	4	0	0	7	1	0	0	0	0
11/2/94	4	21	0	0	5	2	0	0	1	1
	Total:	55	0	0	24	8	0	1	3	2
11/9/94	1-2	- Surveys cancelled due to high flows -								
11/8/94	3	23	0	0	1	2	0	0	0	0
11/8/94	4	14	1	0	3	3	0	0	0	0
	Total:	37	1	0	4	5	0	0	0	0

Table 2. Summary of adult salmonids, redds, and carcasses observed by reach during snorkel surveys, Blue Creek, lower Klamath River, California, 1995.

		Chinook			Steelhead		Adult	Unidentified	Chinook	
Date	Reach	Adult	Jack	Coho	1/2 Pounder	Adult	Cutthroat	Adult Salmonid	Redds	Carcasses
9/25/95	1	3	0	0	2	1	1	0	0	2
9/26/95	2	3	0	0	0	3	0	0	0	0
9/27/95	3	2	0	0	4	1	1	0	0	0
9/28/95	4	1	0	0	2	0	0	0	0	0
	Total:	9	0	0	8	5	2	0	0	2
10/2/95	1	1	0	0	6	2	1	0	0	1
10/3/95	2	1	0	0	3	0	3	1	0	0
10/4/95	3	1	0	0	4	1	0	0	0	0
10/4/95	4	7	1	0	4	1	1	0	0	0
	Total:	10	1	0	17	4	5	1	0	1
10/12/95	1	5	0	0	0	0	5	0	0	1
10/11/95	2-3	- Surveys cancelled due to Simpson herbicide spraying/road closures -								
10/10/95	4	7	0	0	2	0	1	0	0	0
	Total:	12	0	0	2	0	6	0	0	1
10/17/95	1	0	0	0	5	0	0	1	0	0
10/17/95	2	10	0	0	3	4	0	0	0	1
10/16/95	3	4	0	0	8	0	1	0	0	0
10/16/95	4	9	0	0	4	0	3	0	2	0
10/18/95	8	0	0	0	0	0	0	0	0	0
	Total:	23	0	0	20	4	4	1	2	1
10/24/95	1	1	0	0	2	0	0	0	0	0
10/24/95	2	5	0	0	1	0	7	0	6	1
10/23/95	3	8	0	0	5	0	1	0	0	0
10/23/95	4	8	2	0	0	0	1	0	3	0
10/26/95	5	1	0	0	0	0	0	0	2	0
	Total:	22	2	0	8	0	9	0	11	1
10/31/95	1	7	0	0	0	0	1	0	2	0
10/31/95	2	37	1	0	7	1	2	0	13	1
10/30/95	3	9	0	0	1	0	1	0	4	0
10/30/95	4	15	0	0	0	0	0	0	3	1
11/2/95	6	1	0	0	0	0	0	0	2	0
	Total:	68	1	0	8	1	4	0	24	2
11/7/95	1	4	0	0	0	1	1	0	0	0
11/7/95	2	44	1	0	0	0	5	0	12	4
11/6/95	3	5	0	0	5	0	3	2	0	0
11/6/95	4	20	1	0	0	2	1	0	2	0
11/9/95	8	0	0	0	0	0	0	0	0	0
	Total:	73	2	0	5	3	10	2	14	4
11/13/95	1	7	0	0	2	0	0	0	0	0
11/14/95	2	162	21	0	3	1	3	0	5	2
11/13/95	3	34	0	0	3	0	5	0	0	1
11/15/95	4	47	4	0	2	0	0	0	2	0
11/15/95	9	0	0	0	0	0	0	0	0	0
	Total:	250	25	0	10	1	8	0	7	3
11/21/95	1	50	8	0	4	1	2	0	2	0
11/22/95	2	110	0	0	4	0	1	0	15	5
11/21/95	3	16	0	1	1	0	2	0	5	1
11/22/95	4	74	10	0	1	3	0	0	4	0
11/20/95	6	9	5	0	0	0	0	0	10	0
11/20/95	7	0	0	0	0	0	0	0	0	0
11/20/95	8	7	1	0	0	0	0	0	3	0
	Total:	266	24	1	10	4	5	0	39	6
11/28/95	1	31	2	0	0	0	0	0	1	0
11/28/95	2	140	6	1	0	0	2	3	8	3
11/27/95	3	6	0	0	2	0	2	0	0	0
11/27/95	4	28	0	0	0	1	0	1	0	2
11/29/95	5	20	4	2	1	0	0	0	10	1
11/29/95	8	11	0	0	0	0	0	0	2	0
	Total:	236	12	3	3	1	4	4	21	6
12/28/95	9	0	0	0	0	0	0	0	0	0
	Total:	0	0	0	0	0	0	0	0	0

TABLE 2.

YUROK TRIBAL FISHERIES PROGRAM

Salmonid Live Count Reach Descriptions, Blue Creek, Fall 1995.

Reach Descriptions:

Reach #1: Simpson Bridge Crossing to Blue Creek Mouth (2.1 miles)
Reach #2: B10X Road Access to Simpson Bridge Crossing (3.5 miles)
Reach #3: Slide Creek Confluence to B10X Road Access (2.5 miles)
Reach #4: Crescent City Fork Confluence to Slide Creek Confluence (2.2 miles)
Reach #5: Mainstem Blue Creek from Barrier to Crescent City Fork Confluence (4.25 miles)
Reach #6: Crescent City Fork from Road #13N34A Access to Mouth (3.5 miles)
Reach #7: Crescent City Fork from Road #13N26D Access to Road #13N34A Access (1.85 miles)
Reach #8: West Fork Blue Creek from Potato Patch Creek confluence to Mouth (0.85 miles)
Reach #9: Nickowitz Creek above Mouth (1.0 miles)

Table 3. Summary of adult salmonids, redds, and carcasses observed by reach during snorkel surveys, Blue Creek, lower Klamath River, California, 1996.

		Chinook		Coho		Steelhead		Adult	Unidentified	Chinook	
Date	Reach	Adult	Jack	Adult	Jack	1/2 Pounder	Adult	Cutthroat	Adult Salmonid	New Redds	Carcasses
9/9/96	1	0	0	0	0	52	2	21	0	0	0
9/10/96	2	1	0	0	0	6	2	7	0	0	0
9/12/96	3	0	0	0	0	2	0	3	0	0	0
9/13/96	4	0	1	0	0	2	0	1	0	0	0
	Total:	1	1	0	0	62	4	32	0	0	0
9/23/96	1	0	0	0	0	17	1	14	0	0	0
9/24/96	2	2	1	0	0	7	0	2	0	0	0
9/25/96	3	1	1	0	0	1	0	3	0	0	0
9/26/96	4	2	0	0	0	3	0	2	0	0	0
	Total:	5	2	0	0	28	1	21	0	0	0
10/11/96	1	0	0	0	0	10	3	8	0	0	1(+1 coho)
10/11/96	2	4	0	0	0	4	0	1	0	1	0
10/11/96	3	1	1	0	0	0	0	6	1	0	0
10/10/96	4	0	0	0	0	4	0	4	0	0	0
10/9/96	6	1	1	0	0	1	0	0	0	0	0
	Total:	6	2	0	0	19	3	19	1	1	2
10/18/96	1-2	- Surveys cancelled due to heavy rains/poor water visibility -									
10/17/96	3	0	1	0	0	7	0	0	0	0	0
10/17/96	4	0	0	0	0	0	2	2	0	0	0
10/17/96	5	0	0	0	0	0	0	0	0	0	0
10/16/96	8	0	0	0	0	3	0	1	0	0	0
	Total:	0	1	0	0	10	2	3	0	0	0
10/23/96	1	5	0	0	0	8	0	4	0	0	0
10/23/96	2	10	0	2	0	5	1	8	0	1	0
10/22/96	3	6	0	0	0	2	1	2	0	0	0
10/22/96	4	6	1	0	0	3	0	3	0	1	0
10/25/96	6	7	2	1	0	1	0	0	0	0	0
10/24/96	8	- Survey cancelled due to heavy rains/poor water visibility -									
	Total:	34	3	3	0	19	2	17	0	2	0
10/30/96	1	30	3	1	0	8	1	4	1	0	0
10/30/96	2	445	24	18	0	16	0	0	0	2	0
10/29/96	3	78	0	0	0	6	3	3	0	2	0
10/29/96	4	64	12	4	0	1	0	3	1	0	0
11/1/96	5	63	9	1	0	0	0	0	1	3	0
11/1/96	8	0	0	0	0	0	0	0	0	0	0
11/1/96	9	0	0	0	0	0	0	0	0	0	0
	Total:	680	48	24	0	31	4	10	3	7	0
11/8/96	1	17	1	0	0	3	0	4	0	1	0
11/8/96	2	512	42	12	1	2	1	8	1	11	1
11/7/96	3	95	10	6	0	8	1	8	0	1	1
11/7/96	4	74	6	10	0	2	0	6	0	3	1
11/6/96	6	17	4	5	2	0	0	0	0	10	0
11/6/96	7	8	1	0	0	0	0	0	0	6	0
	Total:	723	64	33	3	15	2	26	1	32	3
11/13/96	1	15	0	1	0	4	1	7	0	2	0
11/13/96	2	579	27	17	0	2	0	9	0	9	0
11/12/96	3	72	3	3	0	7	1	0	0	3	0
11/12/96	4	95	10	12	0	3	0	3	0	5	0
11/15/96	5	46	5	0	0	0	0	0	0	22	0
11/14/96	8	0	0	0	0	0	0	0	0	0	0
	Total:	807	45	33	0	16	2	19	0	41	0

Reach Descriptions:

Reach #1: Simpson Bridge Crossing to Blue Creek Mouth (2.1 miles)
Reach #2: B10X Road Access to Simpson Bridge Crossing (3.5 miles)
Reach #3: Slide Creek Confluence to B10X Road Access (2.5 miles)
Reach #4: Crescent City Fork Confluence to Slide Creek Confluence (2.2 miles)
Reach #5: Mainstem Blue Creek from Barrier to Crescent City Fork Confluence (4.25 miles)
Reach #6: Crescent City Fork from Road #13N34A Trail Access to Mouth (3.5 miles)
Reach #7: Crescent City Fork from Road #13N26D Trail Access to Road #13N34A Trail Access (1.85 miles)
Reach #8: West Fork Blue Creek from Potato Patch Creek confluence to Mouth (0.85 miles)
Reach #9: Nickowitz Creek above Mouth (1.0 miles)

reaches #5 and #6 on an alternating biweekly basis beginning on the week of 16 Oct 1996. Thus, each reach was surveyed twice a month on alternating weeks. Reach #7 was surveyed once during the week of 6 Nov 1996; four surveys of reach #8 were performed beginning the week of 16 Oct, and ending the week of 13 Nov 1996; and reach #9 was surveyed once on 1 Nov 1996.

4.3.1 Live Fish Counts

4.3.1.1 Chinook salmon

<u>Synopsis</u>

Blue Creek supports a unique population of late-fall run chinook salmon that is genetically distinct from other Klamath River chinook stocks (Gall et al. 1990). This native chinook stock is a major component of the wild chinook population in the lower Klamath River basin. YTFP documented peak weekly counts in lower Blue Creek of 57 chinook in 1994 and 275 chinook in 1995. In 1996, a peak weekly count of 801 chinook was documented in lower Blue Creek. Late-fall chinook began to enter Blue Creek in September, with peak entry occurring in November after fall rains had begun. Chinook likely continued to immigrate through December. Based on the timing of peak redd counts, the peak spawning period was likely in late-November of 1995 and 1996, but may have extended into December.

<u>Abundance Observations</u>

1994: Initial surveys of reaches #1-4 commenced in October of 1994, and found only a single adult chinook salmon. Subsequent surveys found no chinook in lower Blue Creek until the beginning of November. In 1994, YTFP observed a peak count of 55 fall-chinook occupying reaches #1-4 (Table 1). Surveys in 1994 were restricted by previously mentioned factors, thus limiting the amount of biological data collected on chinook salmon. Thus no distinct distribution trends were observed, but as seen in 1995-1996, chinook salmon were most abundant in reaches #2-4 in early November.

1995-1996: A total of 9 adult chinook salmon were seen in reaches #1-4 during the earliest survey week of 28 Sep 1995 (Table 2). In 1996, a total of 6 adult chinook salmon and 3 jack chinook were found in reaches #1-4 by the end of September (Table 3). The presence of adult chinook in Blue Creek during initial surveys suggest that fall-chinook began migrating upstream in early September, prior to the typical start of fall spawning surveys.

Peak counts of fall-run chinook differed substantially between the 1995 and 1996 survey seasons. The 1995 peak chinook count (reaches #1-4) was 250 adults and 25 jacks during a 3-day period from 13-15 Nov 1995 (Figure 11). The 1996 weekly peak count in reaches #1-4 was 761 adults and 40 jacks observed 13-15 Nov 1996 (Figure 12). Peak counts during both 1995 and 1996 occurred during mid-November. Although 1996 peak counts were higher than in previous years (Figure 13), subsequent surveys were cancelled due to high flows, and thus this peak count may be conservative since fresh chinook

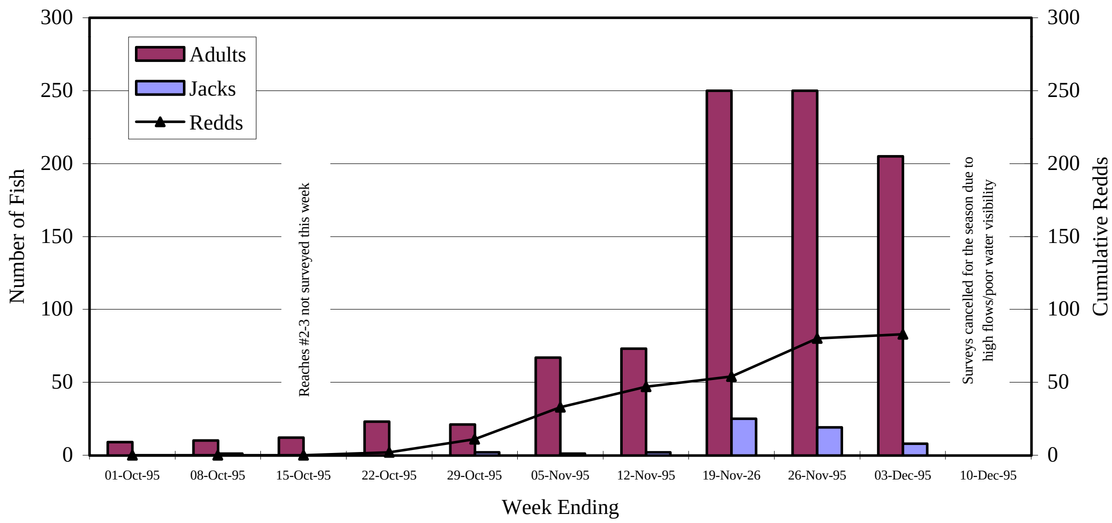


Figure 11. Total number of chinook salmon observed weekly and cumulative number of observed redds in reaches #1-4, Blue Creek, lower Klamath River, California, 1995.

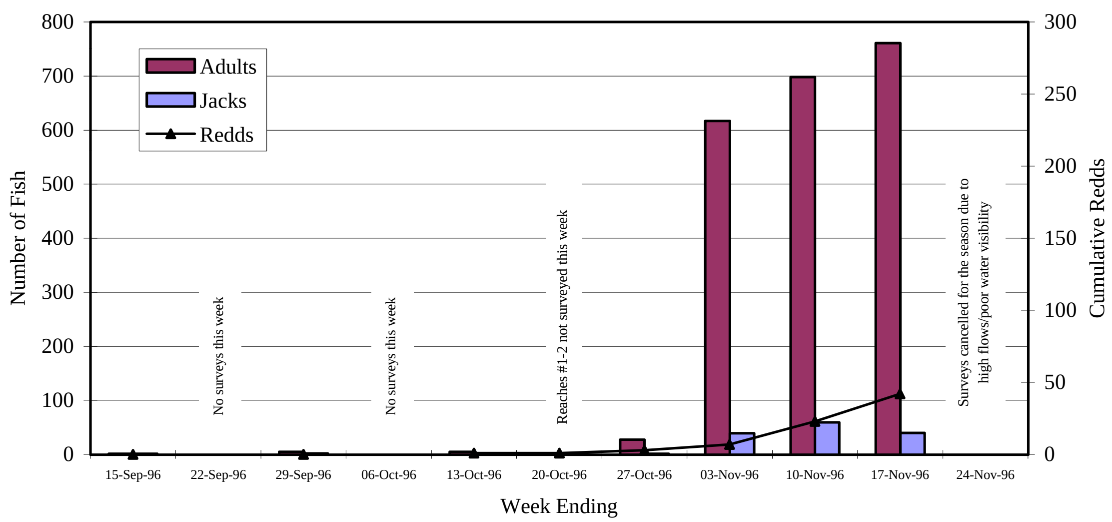


Figure 12. Total number of chinook salmon observed weekly and cumulative number of observed redds in reaches #1-4, Blue Creek, Lower Klamath River, California, 1996.

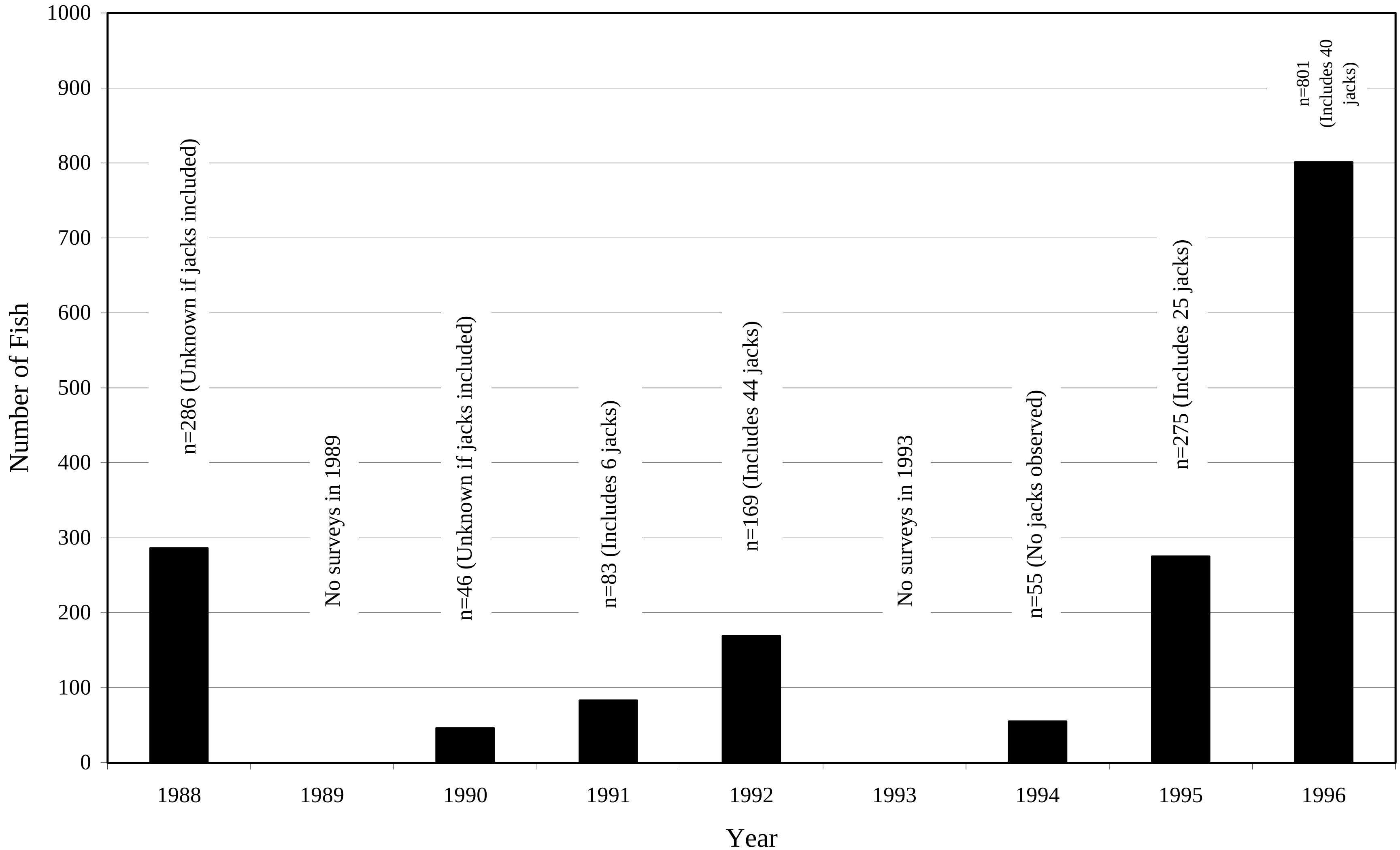


Figure 13. Annual peak counts of late-fall run chinook in reaches #1-4, Blue Creek, lower Klamath River, California, 1988-1996.

likely continued to enter Blue Creek into December. Furthermore, weekly peak countsshould not be considered absolute estimates of chinook escapement, because (1) fresh or “bright” fish were continuously observed throughout both the 1995 and 1996 survey seasons; (2) upper reaches were not surveyed weekly; (3) predation and mortality rates were unmeasurable; and (4) there was no means to assess what proportion of the total fish present during a given survey were counted by divers.

Adult chinook relative abundance in reaches #1-4 steadily increased as the 1995 and 1996 spawning seasons progressed, with significant numbers first seen in the beginning of November in both years (Figures 11-12). These increases coincided with substantial rainfall events. It appears that increased stream discharge facilitated chinook immigration into Blue Creek from the Klamath River.

The abundance of jack chinook remained relatively constant throughout each survey season, although a slight increase in jack numbers was observed in November 1995 and 1996. During early season surveys, jack chinook numbers were low, usually only a few present in the lower four reaches. The late-season increase in jack abundance occurred with the influx of adult chinook that also entered reaches #1-4 during mid-November (Figures 11-12). During the 1995 and 1996 survey seasons, 6.9% and 7.3% respectively of the chinook observed were jacks. Shaw et al. (1997) noted that the contribution of jacks to total Klamath River fall chinook runs vary from year to year, but their migrational patterns generally coincide with the adult migration.

Abundance Trends

The abundance of late fall-run chinook in lower Blue Creek has fluctuated substantially during 1988-1996 (Figure 13). Prior to 1994, adult chinook abundances in reaches #1-4 ranged from a peak count of 286 fish in 1988 to a low of 46 adult chinook in 1990. YTFP survey efforts in 1994 and 1995 estimated a peak chinook abundance of 57 and 275, fish respectively (Figure 13). Survey data from 1996 showed a distinct increase from previous years, with a peak count of 801 chinook observed. No live fish surveys were conducted during the 1989 and 1993 seasons.

Habitat Utilization

YTFP observed seasonal trends in fall-chinook habitat utilization. During the early surveys conducted in 1995 and 1996 (September-October), chinook salmon were not abundant and appeared to be evenly distributed throughout the lower four reaches. Beginning with the early November influx, however, chinook salmon were found to be most abundant in reach #2 in both years (Figures 14-15), where large congregations of adults and jacks were observed occupying the numerous deep pools and swift run and pocket-water habitats. Reach #1, with significantly less pool habitat than reach #2, appears to be mainly a migrational corridor. Although we observed spawning in all Survey reaches, chinook showed a distinct preference for the spawning habitat present in reach #2, based on numbers of live fish, redds and carcasses seen each year.

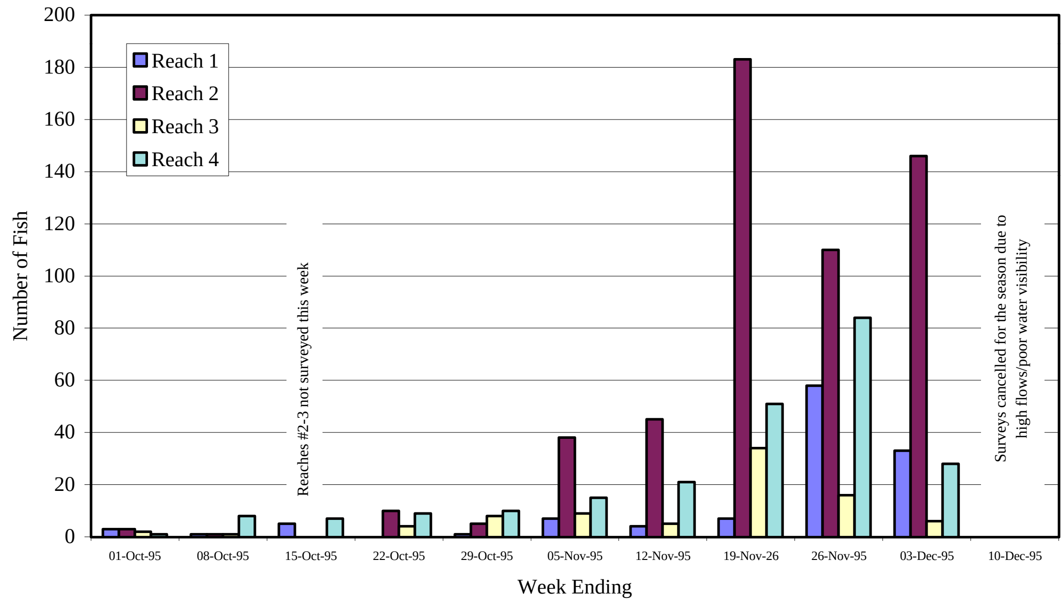


Figure 14. Number of chinook salmon observed weekly in reaches #1-4, Blue Creek, lower Klamath River, California, 1995.

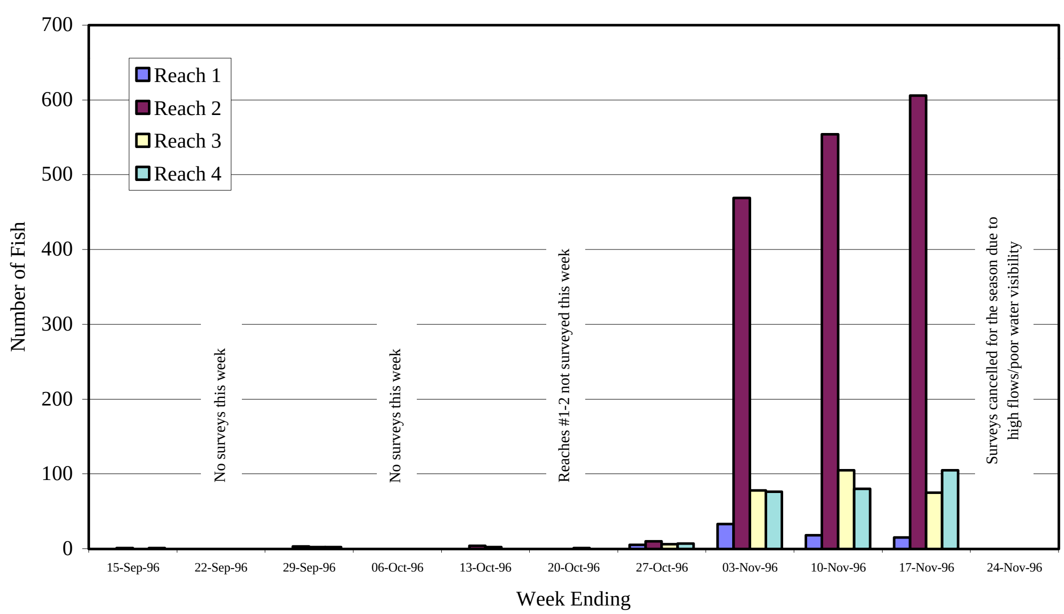


Figure 15. Number of chinook salmon observed weekly in reaches #1-4, Blue Creek, lower Klamath River, California, 1996.

Qualitative snorkel observations showed that Blue Creek chinook salmon preferred different habitats at different times during the spawning season. In general, large congregations of chinook were observed schooling in the numerous deep pool habitats in lower Blue Creek early in the spawning season. Later in the season, chinook were seen more often utilizing runs and spawning areas than in pool holding habitats. It should be noted, however, that the 1996 surveys ended before large numbers of schooling fish in lower Blue Creek pools dispersed and/or spawned.

Klamath Basin Contribution

Although YTFP surveys did not attempt to estimate the overall Blue Creek fall-chinook run size, peak counts suggest that the Blue Creek run is a substantial portion of the wild chinook population in the Klamath River Basin. Klamath Basin cooperative spawning ground surveys conducted by the US Forest Service (USFS), California Department of Fish and Game (CDFG), Americorps and others in 1995 and 1996 (Americorps et al. 1995-1996) attempted to estimate the total fall-chinook run-size of Klamath River tributaries upstream of the Trinity River confluence at Weitchpec.

Comparison with these run size estimates showed that Blue Creek contributed relatively small numbers of chinook to the Klamath Basin. YTFP surveys observed a 1995 peak count of 275 late-fall chinook (Figure 13). In 1996 YTFP observed a peak count of 801 chinook in Blue Creek (Figure 13). Excluding the lower Klamath, Trinity River Basin, and Bogus Creek (consists primarily of Iron Gate Hatchery strays), the Klamath basin wild fall-chinook run size estimate was 35,924 fish in 1995 and 21,428 fish in 1996 (Figure 16). Blue Creek chinook comprised 0.8% of this total basin estimate in 1995 and 3.7% in 1996. As previously mentioned, the peak counts generated by YTFP should be considered as very conservative estimates of actual Blue Creek escapements. Consequently, any estimates of basinwide contribution should also be considered very conservative.

When compared to non-hatchery enhanced tributaries of similar drainage area, however, Blue Creek contributed a much more significant proportion to the wild chinook run size. If estimates from Red Cap and Camp Creeks (small scale rearing-enhanced tributaries), and the Shasta, Scott and Salmon Rivers (substantially larger tributaries) are also excluded, the Klamath tributary wild chinook escapement totaled 2,461 in 1995 and 2,724 in 1996 (Figure 17). When these estimates are compared with YTFP peak counts from the same years, Blue Creek wild chinook contributed 11.2% and 29.4%, respectively.

4.3.1.2 Coho Salmon

Synopsis

The Blue Creek basin supports a viable population of native coho salmon. The Crescent City Fork provides ideal spawning and rearing habitat for coho salmon and appears to be more heavily utilized by coho salmon than other areas of the basin. The Blue Creek coho

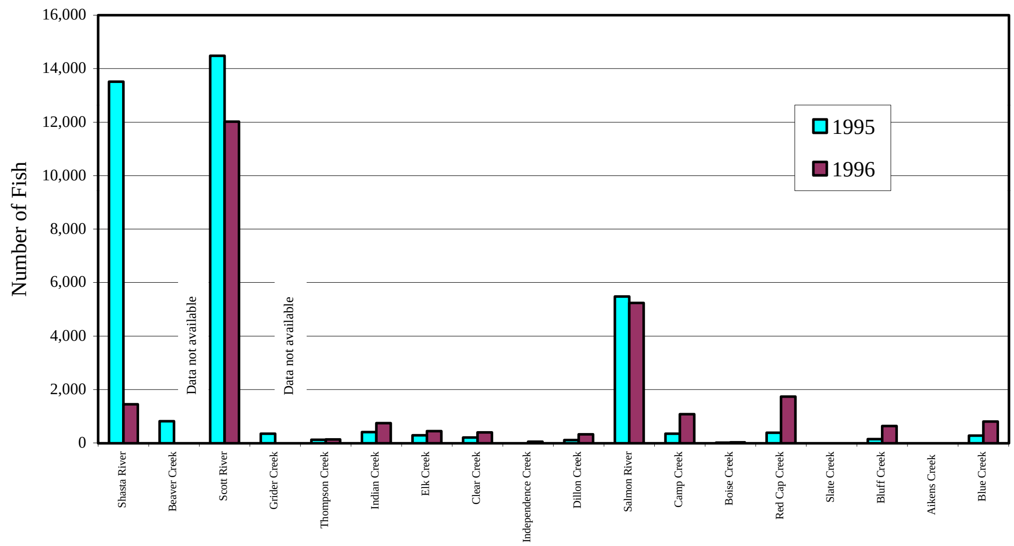


Figure 16. Estimated fall chinook escapment in surveyed Klamath River tributaries, 1995-1996.

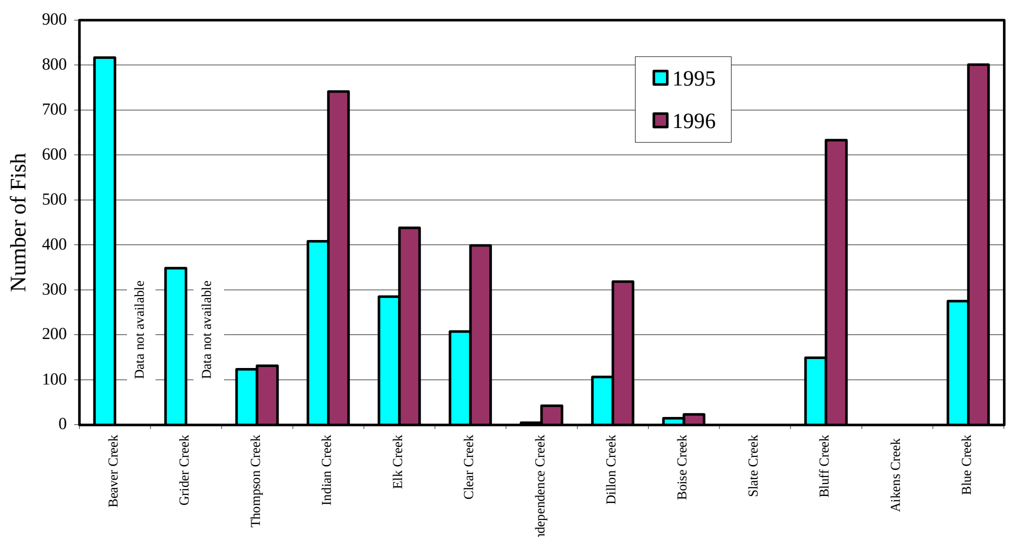


Figure 17. Estimated fall chinook escapment in non-hatchery enhanced Klamath River tributaries of similar drainage area, 1995-1996.

stock is an important genetic refuge for wild coho populations in the lower Klamath River basin.

YTFP documented weekly peak counts of four adult coho in 1995 and 33 adult coho on consecutive weeks in 1996. YTFP observed coho migrating into Blue Creek over a broad period from October through the end of surveys in November, but coho likely continue to enter into January. The peak spawning period of coho salmon was not observed, but probably occurs in December or early-January.

Abundance Observations

1994: Surveys during 1994 found no adult coho in any of the four lower index reaches (Table 1). Although no adult coho were seen, surveys concluded 8 Nov 1994, prior to the usual November/December entry time of coho salmon in California streams (Shapovalov and Taft 1954; Hassler 1987).

Summer and fall snorkel surveys performed on reaches #1-4 in 1995 found juvenile coho salmon rearing in low abundance. In addition, surveys of the Crescent City Fork (reaches # 6-7), revealed juvenile coho in relatively high abundance. During these surveys, YTFP observed numerous young-of-the-year (YOY) coho from the previous fall/winter coho run, documenting that wild coho successfully spawned in Blue Creek during the 1994 spawning season.

1995: A peak weekly count of three adult coho salmon was observed during 27-29 Nov 1995 (Table 2). A total of four adult coho were seen in Blue Creek during the 1995 survey season (Table 2). Because heavy fall rains did not occur until the end of November, YTFP was able to extend fall spawning surveys into the early portion of the coho salmon migration period, allowing a rough estimation of the time of first entry.

YTFP first observed adult coho in Blue Creek on 21 Nov 1995. This roughly coincided with the arrival of the main portion of the late-fall chinook run, which entered lower Blue Creek during the previous week (Table 2). These coho were observed holding with large numbers of chinook, suggesting that early coho may migrate upstream in sympatric schools with late fall-run chinook.

1996: YTFP observed the largest abundance of adult coho salmon over the course of the 3-year survey period during 1996. The first coho observed in 1996 was a fresh carcass located in lower reach #1 on 11 Oct 1996. Live adult coho were observed occupying reach #2 on 23 Oct 1996 (Table 3). An additional adult coho was also seen on 24 Oct 1996 in upper reach #6, over 12 miles from the mouth of Blue Creek. Coho salmon wait for freshets before entering rivers, so a delay in fall rain may postpone river entry and, potentially, spawn timing as well (Wietkamp et al. 1995). It appears that early fall rains in early/mid-October influenced the initial entry of the 1996 coho run.

As in 1995, the first observations of coho in 1996 roughly coincided with the arrival of large numbers of late-fall chinook in lower Blue Creek. Heavy rains on 18 Oct 1996 preceded the arrival of this main influx chinook. Relatively large numbers of adult coho continued to be observed in lower Blue Creek for the remainder of the 1996 season

(Table 3). YTFP observations and USFWS data suggest that coho enter Blue Creek over a broad period beginning in early October and extending into January. Wietkamp et al. (1995) also reported a broad entry period for lower Klamath River coho from late August to mid-January.

For most coho stocks, the spawning migration takes place over three months or more (Sandercock 1991). Due to the onset of heavy rains in late November – early December of each season, YTFP was unable to estimate the total duration of the coho spawning run during the project period. Future late-season surveys for spawning coho salmon could focus on the Crescent City Fork, which, due to its smaller size and relatively pristine conditions, is more suited for surveying during heavy rains and is utilized more extensively by coho salmon than other areas of the basin

The 1996 coho salmon run was substantially greater than observed in previous years. In November of 1996, a peak weekly count of 33 coho was documented on two consecutive weeks, compared to four fish observed in 1995 and no fish in 1994 (Tables 1-3). These peak counts coincided with the highest weekly counts for chinook during the same year. Higher relative numbers of coho correlates well with the observation that the overall chinook run size in 1996 was significantly larger than in recent years. Mention should be made again, however, that peak weekly counts should be considered conservative estimates of relative coho run size, not actual escapement estimates.

Abundance Trends

Abundance estimates of annual Blue Creek coho runs are currently limited by a lack of knowledge about the main portion of their spawning season. In addition, the small number of adult coho seen during snorkel surveys by USFWS and YTFP obscure population trends.

Observations of coho escapement in the Klamath and Trinity Rivers suggest an annual increase in regional coho run sizes from 1994-1996. Hatchery return data from Iron Gate Hatchery and Trinity River escapement data from the Willow Creek weir showed a yearly increase in coho escapement beginning in 1994. Iron Gate hatchery coho returns increased from 172 fish in 1994 to 3,546 fish in 1996 (Zuspan 1997). Willow Creek weir data showed an increase in coho escapement from a low of 239 fish in 1994 to 33,047 adult coho in 1996 (Aguilar et al. 1996a, 1996b; Pisano 1998). Although overall run sizes increased in the Klamath and Trinity Rivers from 1994-1996, a majority of returning coho were of hatchery origin, thus these increases should not be considered an indication of the recovery of self-sustaining coho populations.

Habitat Utilization

YTFP personnel typically observed the first adult coho salmon in mid-November. In 1995, coho were observed in reaches #2-3 and upper basin reach #5 (Table 2). Sandercock (1991) reported that earlier migrating coho spawn farther upstream within a basin than later entering fish, which migrate in a more advanced state of sexual maturity. Briggs (1953) also noticed a tendency for coho that migrate early to move further upstream than later migrating fish. This could explain early season observations of coho in the upper basin, and their low abundance in lower Blue Creek in 1995. YTFP observations in 1996 also support Sandercock's assertions. Early arriving adult coho were seen in the Crescent City Fork and upper mainstem Blue Creek. As the season progressed, coho occupied lower reaches #1-4 more extensively than upper basin reaches, suggesting heavier utilization of spawning habitat in lower reaches by later arriving coho. Actual spawning habitat utilization by coho cannot be determined from 1995-1996 surveys since unknown numbers of fish could have immigrated and/or dispersed into the upper basin following the end of the survey season.

Qualitative snorkel surveys of the Crescent City Fork (CCF) in 1995 and 1996 documented the highest abundance and greatest densities of rearing juvenile coho salmon in Blue Creek. Within the CCF, juvenile coho were more abundant in upper sections than in the lower surveyed section. The CCF provides excellent spawning and rearing habitat for coho salmon. Its relatively low gradient channel profile, abundant spawning habitat, dense mixed-coniferous riparian canopy, abundant in-stream large woody debris, and numerous off-channel habitats provide ideal conditions for year-round utilization by coho salmon (YTFP 1997 habitat mapping data).

<u>Klamath Basin Contribution</u>

Attempts to quantify wild coho runs in Klamath River tributaries are hindered by the late-fall/winter run timing of coho. Currently, efforts to estimate annual basin-wide wild coho run sizes are not made for this reason. Run size and escapement information is currently limited to harvest, hatchery return, and weir count data from the mainstem Klamath and Trinity Rivers. However, no quantifiable distinction between hatchery, naturalized, and wild run sizes has been attempted. In addition, since no data is available on Klamath river sport harvest or escapement into Klamath River tributaries, actual Blue Creek contributions to annual basin-wide coho runs cannot be reliably estimated.

In spite of this, inferences about the relative importance of Blue Creek wild coho stocks can be made. Apparently, there is little natural production from the Klamath River coho stock, which is heavily influenced by hatcheries (Wietkamp et al. 1995). Heavy basin-wide hatchery production, including historic non-native plantings in many tributaries, has threatened the genetic integrity of native Klamath River coho stocks. Recently, NMFS listed wild coho populations in the Klamath Basin as threatened under the Endangered Species Act. Although the lower 1/3 of the Blue Creek watershed has been heavily logged, the majority of the upper basin and Crescent City Fork is either preserved as part of the Siskiyou Wilderness Area or currently set aside as a Late Successional Reserve (Figure 3). Compared to other lower Klamath River tributaries, Blue Creek provides the highest quality and quantity of anadromous habitat for coho salmon. Furthermore, there has been no documented influence from hatchery-origin coho salmon. For these reasons, the Blue Creek wild coho stock represents an important genetic stronghold for native coho stocks in the lower Klamath River Basin.

4.3.1.3 Steelhead Trout

Synopsis

The Blue Creek basin provides ideal spawning and rearing habitat for steelhead trout. CDFG described Blue Creek as "the best steelhead producing stream in the entire Klamath Basin" (O'Brien 1973). Steelhead trout appear to have the widest distribution of any anadromous salmonid in the basin. In general, they are distributed farther upstream and occupy a greater variety of habitats than other anadromous salmonids in Blue Creek. Blue Creek appears to be utilized year-round by adult steelhead. The basin supports a substantial run of winter steelhead and may support a remnant population of summer steelhead. The low numbers of summer steelhead observed in 1996-1997, however, raise doubt whether a reproductively viable population exists (Gale 1996, 1997b).

YTFP observed low numbers of adult steelhead during the 3-year project period, making run timing, duration and magnitude trends hard to determine, though trends in half-pounder abundance were observed during 1995 and 1996. Snorkel survey observations documented winter steelhead present in Blue Creek from September through May, with peak spawning probably occurring in February or March (Voight 1997).

Abundance Observations

YTFP fall spawning surveys did not occur during the peak winter steelhead spawning period in February-March (Busby et al. 1996; Voight 1997). Consequently, we were unable to determine the magnitude or duration of the winter steelhead run. 1995 and 1996 fall snorkel surveys (Tables 2-3, Figures 18-19) and 1996-1997 summer dives (Gale 1996, 1997b) have consistently documented low numbers of adult steelhead during the summer and fall months. These observations suggest that adult steelhead utilize Blue Creek year-round, rather than only during the winter spawning season.

1994: A peak weekly count of 8 adult steelhead and 24 half-pounders were documented in reaches #1-4 during the week of 2 Nov 1994 (Table 1). This peak count for adult and sub-adult steelhead coincided with the peak weekly count of chinook in 1994. Steelhead appear to have migrated into lower Blue Creek with the main portion of the chinook run following the onset of fall rains.

The large influx of half-pounders may be indicative of freshwater re-entry to over-winter in Blue Creek. Immature "half-pounders" return to freshwater after only 2-4 months in the ocean, generally over-winter in freshwater, then outmigrate again the following spring (Busby et al. 1996). The half-pounder life history trait is only reported in Northern California and Southern Oregon systems. However, it has been suggested by Cramer et al. (1995) that Klamath River Basin half-pounders may actually be reproductively active. YTFP did not document any half-pounders spawning in Blue Creek, but observations of half-pounders feeding downstream of spawning chinook salmon were documented. Considering the early-November timing of the 1994 peak count, and the lower basin concentrations of fish, this influx of adult and sub-adult steelhead was probably comprised of winter run fish.

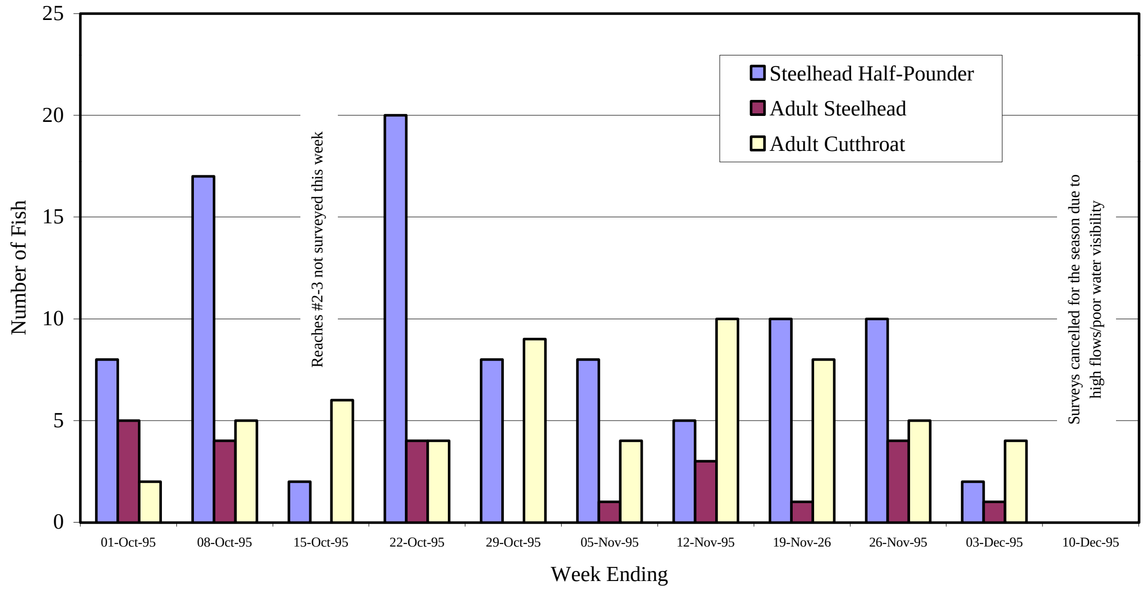


Figure 18. Total number of adult steelhead, half-pounders, and adult cutthroat observed by week in reaches #1-4, Blue Creek, lower Klamath River, California, 1995.

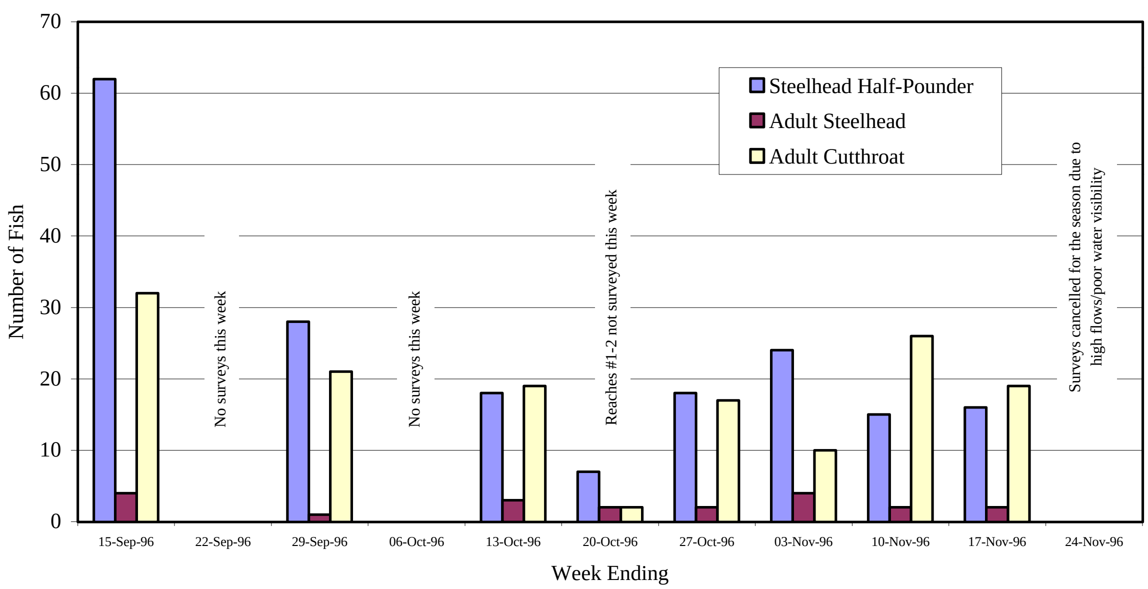


Figure 19. Total number of adult steelhead, half-pounders, and adult cutthroat observed by week in reaches #1-4, Blue Creek, lower Klamath River, California, 1996.

1995-1996: Total weekly counts of adult steelhead in reaches #1-4 were also low throughout the 1995 and 1996 survey seasons (Figures 18-19). In 1995 and 1996 half-pounders were typically more numerous than adult steelhead. YTFP documented a weekly peak count of five adult steelhead the first week of 1995 surveys and 20 half-pounders during the week of 22 Oct 1995 (Table 2, Figure 18). A weekly peak count of four adult steelhead was documented twice during 1996, while 62 half-pounders were seen the first week of 1996 surveys (Table 3, Figure 19).

Because we observed low numbers of adult steelhead throughout the surveys, and no dives were conducted during peak spawning months, conclusions about run timing, size, or spawning activity are not possible.

Although YTFP is unable to identify the exact run timing of summer and winter-run steelhead, snorkel counts and qualitative observations provide some evidence to differentiate the timing of the two runs. Busby et al. (1996) reported that Klamath River summer steelhead migrate to freshwater spawning grounds from April to October, with peak spawning occurring in January. Fall snorkel surveys typically began in September, and found adult steelhead occupying lower Blue Creek. In addition, summer snorkel surveys have documented the presence of adult steelhead in Blue Creek in low abundance during July and August (Gale 1996; Gale 1997b), suggesting that Blue Creek may support a small population of summer steelhead.

Based on fall 1995-1996 and winter 1997 snorkel surveys, winter-run steelhead are believed to enter Blue Creek from September until May, with peak spawning probably occurring in February or March. Snorkel surveys of reach #4 were performed from February-May, 1997. During this time winter steelhead were observed in highest abundance on 23 Feb. 1997 and were seen spawning into late May (Voight 1997). The presence of “fresh/bright” fish in May might also be evidence of summer steelhead immigration. “Dark/stream colored” fish which appeared to have already spawned and were possibly “runbacks” were also observed in late May.

Abundance Trends

We documented adult steelhead in low abundance throughout the summer and fall months, but no other temporal or spatial abundance trends were recognized. We observed fluctuations in steelhead half-pounder abundance, however, that coincided with abundance fluctuations of other anadromous salmonids. In 1994, the weekly peak count of half-pounders in lower Blue Creek coincided with the weekly peak count of chinook salmon for that year (Table 1). Surveys performed in 1996 found a distinct increase in the abundance of half-pounders compared to the previous two years, and this increase coincided with similar observations of Blue Creek chinook and coho salmon runs.

In addition, the observed half-pounder migration trends are similar to past findings. Kessner and Barnhart (1969) reported that half-pounders were primarily caught (at “Blake riffle”, about 8 miles downstream of Blue Creek) in the early part of the 1967 and 1968 steelhead runs, while larger, adults were caught later in the run. We documented peak counts of half-pounders in October and September of 1995 and 1996, respectively, during the early period of the winter steelhead immigration (Figures 18-19).

Habitat Utilization

Although fall surveys were unable to document the extent of steelhead spawning habitat utilization, juvenile salmonid surveys in 1995-1997 found steelhead well distributed throughout Blue Creek. Blue Creek apparently supports a large population of steelhead trout that extensively utilize anadromous habitat.

Our observations of juvenile steelhead distribution suggest that adults spawn in all Blue Creek tributaries with anadromous access. Many smaller intermittent tributaries with limited spawning habitat were also found to support steelhead/rainbow trout fry (Gale 1997a; Voight and Gale 1998), suggesting that non-natal rearing may be occurring in the Blue Creek basin.

4.3.1.4 Coastal Cutthroat Trout

Synopsis

Blue Creek supports a small population of coastal cutthroat trout. Mature sea-run or anadromous cutthroat trout begin to enter Blue Creek in July and may continue their immigration into the winter months. Peak migration likely occurs in August and September, but may vary from year to year. No cutthroat trout were observed in lower Blue Creek during 1994 surveys. Divers observed a peak count of 10 adult cutthroat in index reaches #1-4 during the week of 6 Nov 1995, and 32 fish the first week of surveys starting on 9 Sep 1996. The lack of data from winter/spring months restricts inferences about run timing, size, and spawning activity/behavior.

Abundance Observations

In 1994, no adult cutthroat were documented during spawning surveys (Table 1). We observed a peak weekly count of 10 adult cutthroat trout during the week of 12 Nov 1995 (Figure 18). In 1996, we documented substantial numbers of adult cutthroat in lower Blue Creek compared to previous years. A peak weekly count of 32 adult cutthroat trout was seen during the week of 15 Sep 1996 (Figure 19). This increase in cutthroat abundance coincided with relative increases for other Blue Creek salmonid species in 1996.

During early season surveys, YTFP divers observed low numbers of adult chinook, making cutthroat trout counts more accurate. After the arrival of large numbers of fall chinook later in the season, divers may have overlooked cutthroat trout. Consequently, early season counts should be considered more reliable than late season surveys. In addition, degraded survey conditions in late-November may have also negatively biased cutthroat trout counts.

The timing of freshwater entry into specific streams is consistent from year to year, but entry time varies from stream to stream (Trotter 1989). Johnston and Mercer (1976) suggested that the distance from salt water to the spawning site is a controlling factor, which influences the timing of upstream migrations to spawning sites. Because Blue Creek is relatively close (Klamath rm 16.0) to the ocean, coastal cutthroat stocks may be considered an “early-entering” run. Johnston (1981) documented the migratory duration of “early -entering” cutthroat trout from July through November, with the peak in September and October.

Coastal cutthroat trout display extreme variations in their life history patterns. Among coastal populations, there are three basic life history forms: an anadromous form, a potamodromous form and a non-migratory form that resides in small streams and headwater tributaries (Trotter 1989).

YTFP is currently unable to determine if potamodromous or resident cutthroat trout utilize the Blue Creek basin. Resident coastal cutthroat trout may inhabit portions of the Blue Creek drainage, but the extent of their utilization is minimal. In most lower Klamath River tributaries, resident coastal cutthroat trout are typically the only species present upstream of anadromous barriers (Voight and Gale 1998). Blue Creek appears to be the exception to this observation. Gale (1997a) found only resident rainbow trout populations above anadromous barriers in upper Blue Creek.

Qualitative snorkel observations suggest that the anadromous form dominates the coastal cutthroat trout population in the Blue Creek basin. Divers observed numerous large (16-20 in.) silvery cutthroat in Blue Creek during late-summer and fall surveys, strengthening the inference that sea-run cutthroat adults return to Blue Creek during this time of the year.

Due to the lack of complete year-round surveys, it is unclear how extensively sea-run cutthroat trout utilize Blue Creek as over-wintering and/or spawning habitat. Outmigrant trapping efforts in 1995 and 1996 captured few juvenile cutthroat trout, suggesting minimal use of Blue Creek spawning habitat. Year round dives are needed to better understand cutthroat trout utilization of Blue Creek.

4.3.2 Redd Surveys

<u>Synopsis</u>

Chinook salmon utilize most areas of the basin, with a distinct preference observed for spawning habitat in reach #2. Surveys conducted in 1994 found only three chinook redds prior to the end of surveys. In 1995, YTFP discovered 117 chinook redds and one coho redd during surveys of reaches #1-9. Reach #2 contained 50.4% of the redds seen in 1995. Surveys conducted in 1996 found 89 redds in reaches #1-9, of which two appeared to have been constructed by coho. 29% of the redds observed in 1996 were located in reach #2. Based on weekly redd counts, the peak chinook spawning period was likely in late-November of 1995, with 1996 surveys apparently ending before peak spawning occurred in late November – early December.

<u>Survey Limitations</u>

Redd data collection was limited at times because of variable survey conditions and diver experience. Freshly constructed redds were easily identified and counted during the beginning of the survey season because they sharply contrasted with the surrounding algae covered substrate (Plate 6). Later in the fall when smaller substrate had been flipped by high flows, redd identification and quantification was more difficult. High flows also flattened out redd mounds and filled in redd pits, making older redds and superimposed redds nearly indistinguishable. Our identification of temporal and spatial trends in redd construction was restricted because upper reaches were not surveyed on a weekly basis. Additionally, since chinook likely continued to spawn after the end of surveys, the actual number of redds constructed was undetermined.

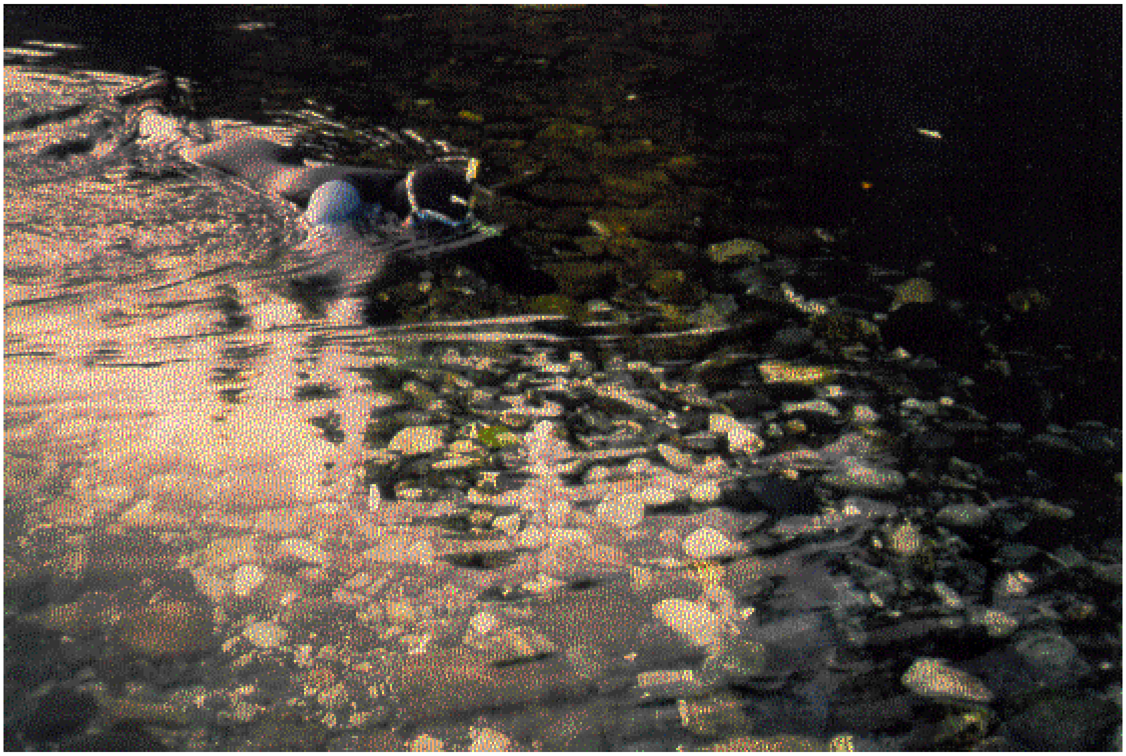


Plate 6. YTFP snorkeler observing freshly constructed chinook redd, Blue Creek, lower Klamath River, California, 1995.

Abundance Observations

YTFP performed redd surveys in conjunction with live fish and carcass counts. Redd counts provided information on salmon spawning distribution and habitat utilization as well as the timing and duration of the spawning season. Additionally, redd counts provided a rough estimate of annual chinook spawning activity in Blue Creek.

1994: Spawning surveys were limited in scope and duration during 1994 because of early fall rains and sustained high flow conditions. High flows early in the season flipped stream substrate, making redds difficult to distinguish and quantify. Although numerous adult chinook were noted in lower Blue Creek by the end of the survey season, only three chinook redds were observed during 1994 (Table 1). The magnitude of chinook redd construction and extent of habitat utilization was undetermined because surveys concluded in early-November, prior to the peak spawning period of chinook salmon.

1995: We enumerated 117 chinook redds during 1995 spawning surveys (Figure 20). Surveys of reaches #1-4 counted 89 chinook redds constructed by 3 Dec 1995, 76% of the basin-wide total observed in 1995 (Table 4). A peak count of 26 redds was observed during the week ending 25 Nov 1995 (Figure 21).

During 1995 surveys, YTFP documented 11 chinook redds in reach #5 and 12 chinook redds in reach #6 (Table 5). A single coho redd was also found in reach # 5 on 29 Nov 1995. Five chinook redds were identified in reach #8 (West Fork) in November 1995 (Table 5). No redds were seen in reaches #7 and #9 during 1995 surveys. Redd counts in 1995 were the highest observed during the 3 year project period, but the total number was likely higher since chinook appeared to continue spawning at least into December.

1996: Spawning surveys documented 83 redds in the Blue Creek basin during 1996 (Figure 22). A total of 43 chinook redds had been identified in reaches #1-4 by the conclusion of surveys on 13 Nov 1996 (Table 6). Two of the redds found in reach #4 may have been constructed by coho salmon. An additional redd was also documented in reach #1 during a bankside carcass survey on 19 Dec 1996 (Table 6). A peak weekly count of 19 redds were observed in reaches #1-4 the last week of surveys which concluded on 17 Nov 1996 (Figure 23).

YTFP also found 24 redds in reach #5 during 1996 (Table 7). Surveys of the Crescent City Fork documented 10 redds in reach #6 and 6 redds in reach #7 (Table 8). One of the redds recorded in reach #6 may have been constructed by coho, which were nearby at the time of the survey. As was the case in 1995, chinook likely spawned throughout December, and thus the actual number of redds constructed in 1996 was undetermined.

Temporal Trends

1994: The low number of redds observed in 1994 made temporal trends indistinguishable. However, it appears that spawning was delayed in 1994 until substantial numbers of adult chinook had entered Blue Creek. No redds were found until early-November, during the same week as the peak weekly count of chinook salmon in 1994. Because surveys ended by the week of 8 Nov 1994, neither the peak period of chinook spawning activity, nor the total duration of the spawning run were determined for 1994.

1995: Fresh redds were first documented in lower Blue Creek on 16 Oct 1995, prior to the arrival of the main influx of the chinook run (Table 2). Subsequent surveys observed two peaks in redd construction: the first peak was observed the week of 4 Nov 1995 and the second was documented the week of 25 Nov 1995 (Figure 21). These peaks occurred after the main influx of chinook arrived. The second peak may have been influenced by the timing of upper basin surveys, which likely represented more than one week of redd construction. The peak chinook spawning period appeared to be ongoing in late November 1995 when high flows ended surveys.

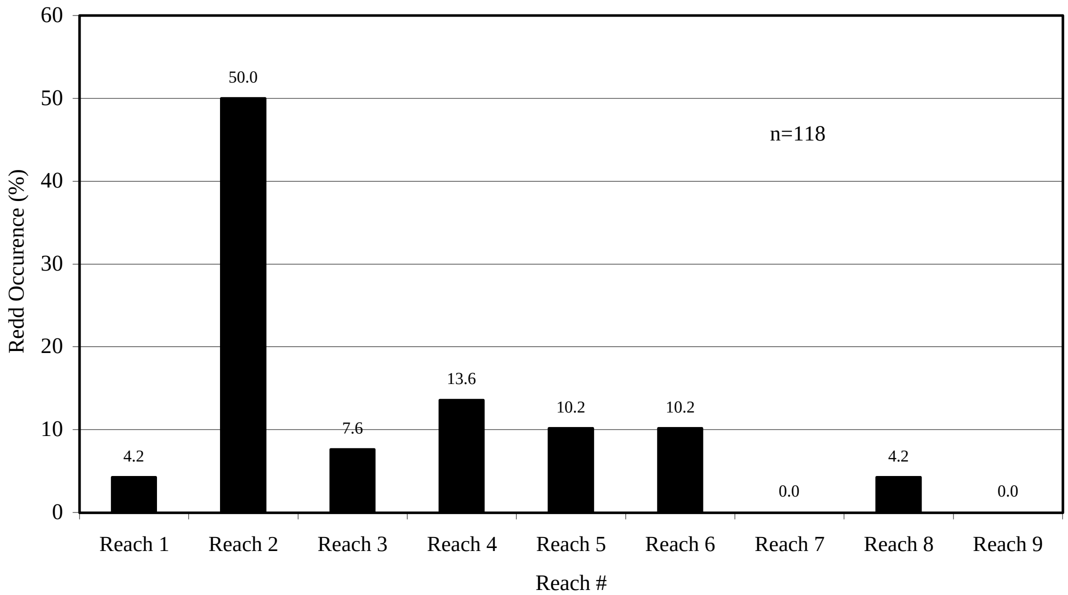


Figure 20. Percent occurrence by reach of observed salmon redds, Blue Creek, lower Klamath River, California, fall 1995.

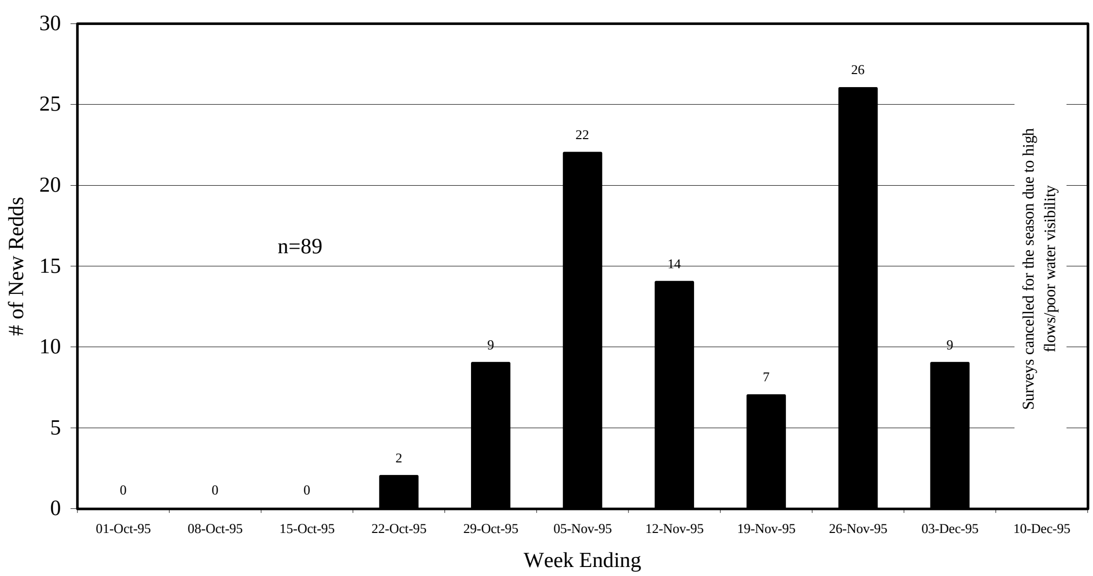


Figure 21. Number of new salmon redds observed in reaches #1-4 by week, Blue Creek, lower Klamath River, California, 1995.

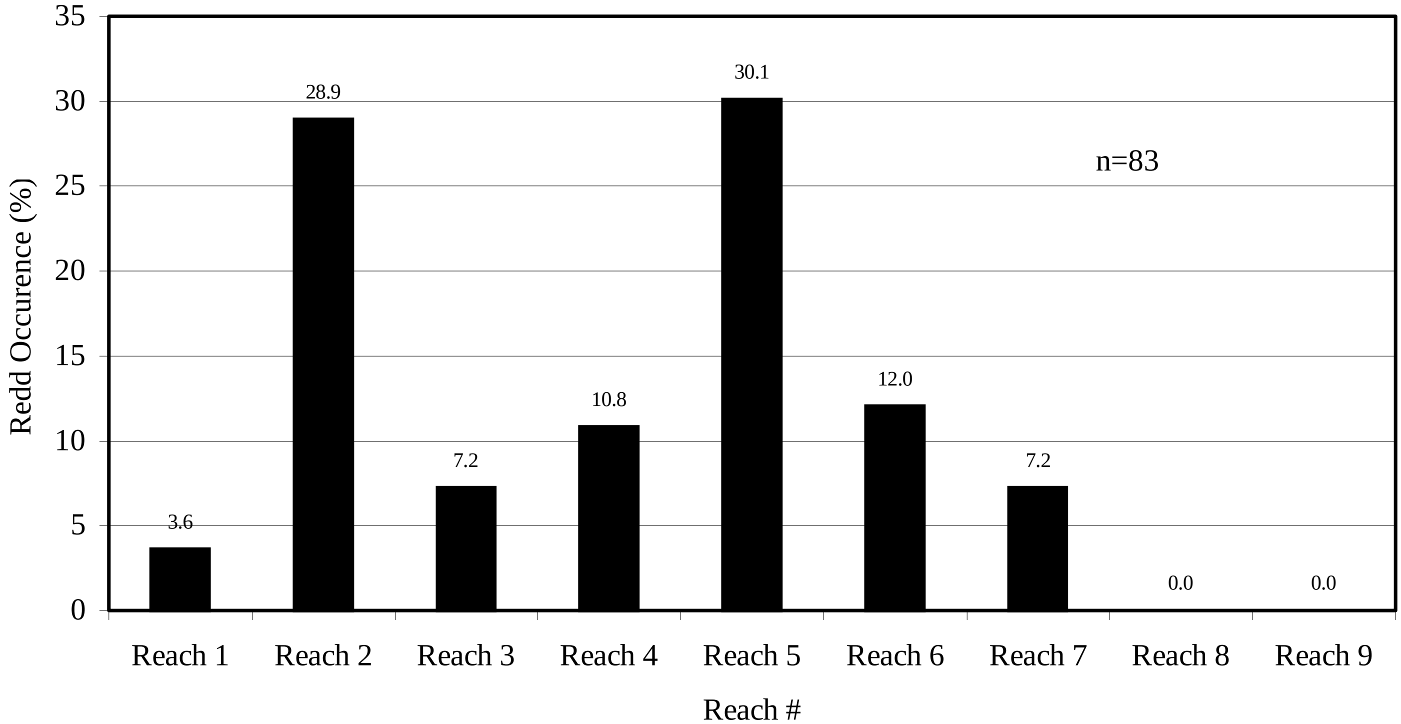


Figure 22. Percent occurrence by reach of observed salmon redds, Blue Creek, lower Klamath River, California, fall 1996.

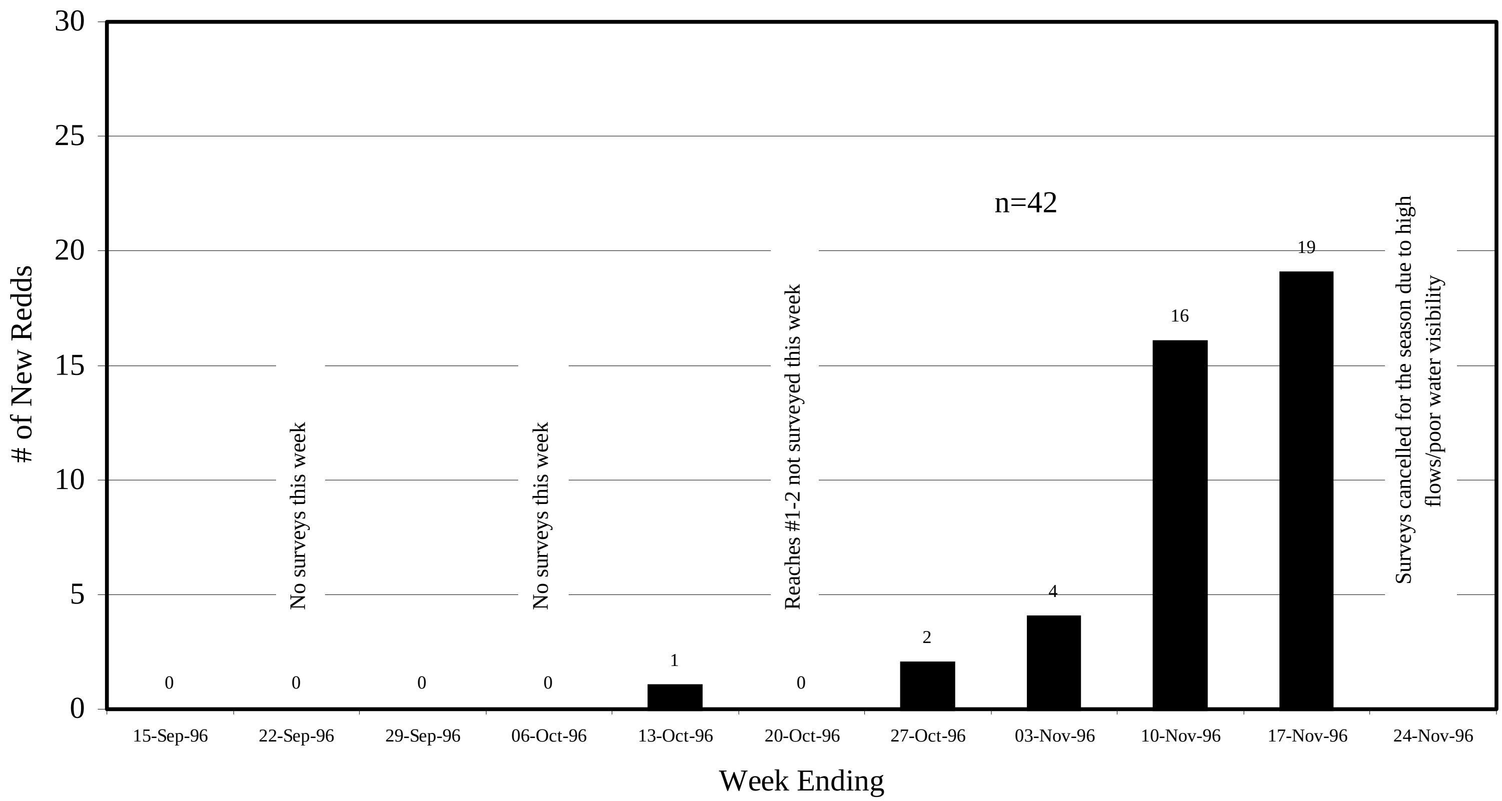


Figure 23. Number of new salmon redds observed in reaches #1-4 by week, Blue Creek, lower Klamath River, California, 1996.

Table 4. Summary of salmonid redds observed during spawning surveys, lower Blue Creek, lower Klamath River, California, fall 1995.

Date	Reach	Location (rm)	Habitat Type	Length (ft)	Width (ft)	Area (ft^2)	Pit Depth (ft)	Mound Depth (ft)	Fish Present	Comments
10/16/95	4	11.9	LSP	7	5	35	NR	NR		Located in "Pitcher Plant Pool"
10/16/95	4	11.9	LSP	7	7	49	NR	NR		Located in "Pitcher Plant Pool"
10/23/95	4	11.9	LSP	12	4	48	0.18	0.13	2 Adult Chinook	Located in "Pitcher Plant Pool"
10/23/95	4	11.4	RUN	10	4	40	0.16	0.13	1 Chinook Jack	Located in "Grand Pool" side-channel
10/23/95	4	11.4	RUN	12	4	48	0.14	0.7		Located in "Grand Pool" side-channel
10/24/95	2	4.9	RUN	7	2.5	17.5	1.8	1.2		Located in "Redd City"
10/24/95	2	4.9	RUN	6	2.5	15	1.6	1		Located in "Redd City"
10/24/95	2	4.9	RUN	10	2.5	25	1.5	1		Located in "Redd City"
10/24/95	2	4.0	RUN	4	3	12	1.7	1.1		Located in "New Redd City"
10/24/95	2	4.0	RUN	4	3	12	1.6	0.9		Located in "New Redd City"
10/24/95	2	3.3	NR	13	3	39	2.4	2		
10/30/95	3	10.0	RUN	10	4	40	0.2	0.15		In fast step-run
10/30/95	3	9.1	MCP	8	4	32	0.12	0.12		In shallow MCP tail-out
10/30/95	3	8.7	NR	15	8	120	0.22	0.85	1 Female Chinook	
10/30/95	3	8.5	LSP	11	6	66	0.14	0.82		In LSP-boulder pool tail-out
10/30/95	4	11.4	RUN	8	5	40	NR	NR	5 Adult Chinook	Located in "Grand Pool" side-channel
10/30/95	4	11.4	RUN	30	5	150	NR	NR	5 Adult Chinook	Located in "Grand Pool" side-channel
10/30/95	4	11.4	RUN	9	4	36	NR	NR	5 Adult Chinook	Located in "Grand Pool" side-channel
10/31/95	1	1.2	NR	15	5	75	NR	NR	5 Adult Chinook	
10/31/95	1	1.1	NR	20	5	100	NR	NR	5 Adult Chinook	
10/31/95	2	5.2	NR	10	4	40	NR	NR	1 Adult Chinook	
10/31/95	2	4.9	RUN	NR	NR	NR	NR	NR	1 Adult Chinook	Located in "Redd City"
10/31/95	2	4.9	RUN	NR	NR	NR	NR	NR	1 Adult Chinook	Located in "Redd City"
10/31/95	2	4.9	RUN	NR	NR	NR	NR	NR	1 Adult Chinook	Located in "Redd City"
10/31/95	2	4.6	NR	NR	NR	NR	NR	NR		
10/31/95	2	4.6	NR	NR	NR	NR	NR	NR		
10/31/95	2	4.0	RUN	19	5	95	NR	NR	1 Adult Chinook	Located in "New Redd City"
10/31/95	2	3.6	NR	NR	NR	NR	NR	NR	1 Adult Chinook	2 more adult chinook in area
10/31/95	2	3.6	NR	NR	NR	NR	NR	NR	1 Adult Chinook	
10/31/95	2	3.6	NR	NR	NR	NR	NR	NR	1 Adult Chinook	
10/31/95	2	3.3	NR	NR	NR	NR	NR	NR		
10/31/95	2	3.3	NR	NR	NR	NR	NR	NR		
10/31/95	2	3.0	NR	6	4	24	NR	NR		
11/06/95	4	9.8	NR	12	8	96	2.5	1.5		Upstream of older redd
11/06/95	4	9.1	NR	14	6	84	1.33	1		Between two older redds
11/07/95	2	5.2	RUN	29	4	112	1.33	0.67		Right margin of run
11/07/95	2	4.9	RUN	11	8	88	2	1.5		Located in "Redd City"
11/07/95	2	4.9	RUN	16	10	160	2.5	0.83		Located in "Redd City"
11/07/95	2	4.9	RUN	18	8	144	2	0.83		Located in "Redd City"
11/07/95	2	4.9	RUN	16	8	134	1.67	0.5		Located in "Redd City"
11/07/95	2	4.9	RUN	12	6	72	1.67	0.67		Located in "Redd City"
11/07/95	2	4.9	RUN	10	6	60	2	0.67		Located in "Redd City"
11/07/95	2	4.3	NR	12	4	48	2	1	1 Female Chinook	Pit was trench-like
11/07/95	2	4.1	RUN	12	6	36	1	0.25		Located in "New Redd City"
11/07/95	2	4.1	RUN	16	8	128	1	.5-.75		Located in "New Redd City"
11/07/95	2	4.1	RUN	10	4	40	1.5	0.67	2 Adult Chinook	Located in "New Redd City"
11/07/95	2	2.2	NR	15	13	165	1.5-2	0.67	1 Female Chinook	

Table 4 (Cont). Summary of salmonid redds observed during spawning surveys, lower Blue Creek, lower Klamath River, California, fall 1995.

Date	Reach	Location (rm)	Habitat Type	Length (ft)	Width (ft)	Area (ft^2)	Pit Depth (ft)	Mound Depth (ft)	Fish Present	Comments
11/14/95	2	4.9	RUN	14	6	84	2	1		Located in "Redd City"
11/14/95	2	4.9	RUN	11	5	3	1.5	0.67		Located in "Redd City"
11/14/95	2	4.1	NR	16	6	96	1.17	0.42	1 Female Chinook	Located in "New Redd City"
11/14/95	2	4.1	NR	10	4	40	1.67	0.67	1 Female Chinook	Located in "New Redd City"
11/14/95	2	2.9	RUN	20	9	180	3.00	1.00	3 Female Chinook	Large excavation
11/15/95	4	9.8	RUN	14	5	90	2.17	0.83	2 Adult Chinook	
11/15/95	4	9.1	RUN	20	8	160	2.5	0.67	2 Adult Chinook	
11/21/95	1	1.5	RUN	24	5	120	2	1-1.5	1 Female Chinook	Female chinook "working it"
11/21/95	1	1.3	NR	40	15	600	2	1-1.5	1 Female Chinook	Female chinook on redd
11/21/95	3	6.5	NR	18	NR	-	0.5	0.5		
11/21/95	3	6.5	LSP	10	4	40	1	0.5	1 Adult Chk nearby in run	Redd in tail-out
11/21/95	3	5.9	RUN	20	NR	-	1.08	0.58	1 Adult Chinook	CHK on redd
11/21/95	3	5.7	LSP	15	NR	-	1	1	1 Adult Chinook in Pool	Redd in tail-out
11/21/95	3	5.7	LSP	20	NR	-	1	0.67	1 Adult Chinook in Pool	Redd in tail-out
11/22/95	2	5.5	RUN	12	8	96	1	0.42	2 Adult Chk nearby in Pool	
11/22/95	2	4.9	RUN	15	8	120	1	0.5	2 Adult Chk nearby in Pool	Located in "Redd City"
11/22/95	2	4.9	RUN	8	4	32	1	0.5	2 Adult Chk nearby in Pool	Located in "Redd City"
11/22/95	2	4.9	RUN	10	6	60	1.5	0.5	2 Adult Chk nearby in Pool	Located in "Redd City"
11/22/95	2	4.9	RUN	5	3	15	NR	NR	2 Adult Chk nearby in Pool	Located in "Redd City"
11/22/95	2	4.1	RUN	10	4	40	1	0.5	14 Adult Chk nearby in Pool	Located in "New Redd City"
11/22/95	2	4.0	RUN	15	10	150	1.5	0.83	14 Adult Chk nearby in Pool	Located in "New Redd City"
11/22/95	2	4.0	RUN	16	6	96	1	0.5	14 Adult Chk nearby in Pool	Located in "New Redd City"
11/22/95	2	4.0	RUN	18	6	108	1	1	14 Adult Chk nearby in Pool	Located in "New Redd City"
11/22/95	2	3.8	NR	12	4	48	4	0.5		
11/22/95	2	3.8	NR	12	6	72	4	0.33		
11/22/95	2	3.5	NR	16	10	160	1.25	1	3 Adult Chk nearby in Pool	
11/22/95	2	3.2	NR	7	4	28	2.5	1.83	3 Adult Chk nearby in Pool	
11/22/95	2	3.0	NR	10	6	60	2.5	1.83		
11/22/95	2	2.4	NR	15	5	75	1.5	0.5		
11/22/95	4	9.9	NR	25	25	625	2	1		Pit 10ft wider than mound. May be >1 redd
11/22/95	4	9.2	NR	40	8	320	2	0.5	1 Female Chinook	
11/22/95	4	9.2	NR	11	4	44	3	1.5	1 Female Chinook	
11/22/95	4	8.9	CCP	18	4	72	NR	NR	4 Adult Chinook in Pool	Deep redd - Located in Slide Creek confluence pool
11/28/95	1	2.0	RUN	4	4	16	0.5	1.5	3 Adult Chk & 2 Jacks	
11/28/95	2	4.9	RUN	NR	NR	NR	NR	NR	1 Female Chinook	Located in "Redd City"
11/28/95	2	4.9	RUN	NR	NR	NR	NR	NR	1 Female Chinook	Located in "Redd City"
11/28/95	2	4.4	RUN	12	4	48	3	2	3 Adult Chinook	
11/28/95	2	4.1	RUN	NR	NR	NR	NR	NR	1 Adult Chinook	Located in "New Redd City"
11/28/95	2	4.1	RUN	NR	NR	NR	NR	NR	1 Adult Chinook	Located in "New Redd City"
11/28/95	2	4.1	RUN	NR	NR	NR	NR	NR	1 Adult Chinook	Located in "New Redd City"
11/28/95	2	4.1	RUN	NR	NR	NR	NR	NR	1 Adult Chinook	Located in "New Redd City"
11/28/95	2	2.2	NR	NR	NR	NR	NR	NR	1 Female Chinook	

Total Redds: 54 chinook and 35 undetermined

LSP = lateral scour pool CCP = channel confluence pool
MCP = mid-channel pool NR = not recorded

Table 5. Summary of salmonid redds observed during spawning surveys, West Fork & upper Blue Creek, lower Klamath River, California, fall 1995.

Date	Reach	Location (rm)	Habitat Type	Length (ft)	Width (ft)	Area (ft^2)	Pit Depth (ft)	Mound Depth (ft)	Fish Present	Comments
10/26/95	5	11.1	LSP	5	3	15	0.8	0.6	None Observed	
10/26/95	5	10.9	RUN	17	8	136	1.5	0.8	None Observed	Big redd, large substrate moved
11/2/95	6	17.4	LSP	5	3	15	3.0	1.0	1 Adult Chinook D/S in next pool	In tailout of shallow pool
11/2/95	6	17.4	LSP	11	5	55	ND	ND	1 Adult Chinook	Fish holding on redd in tailout of shallow pool
11/20/95	6	13.7	RUN	10	5	50	0.7	0.4	None Observed	Located in the Middle of 120' Run
11/20/95	6	13.4	POW	18	6.5	117	2.0	2.0	1 Female Chinook	Fish holding in near vicinity of redd
11/20/95	6	13.3	ND	8	4	32	1.2	1.0	None Observed	
11/20/95	6	11.5	RUN	18	5	90	1.7	1.3	None Observed	
11/20/95	6	11.4	RUN	5	3	15	1.0	0.5	None Observed	
11/2095	6	11.3	RUN	13	4	52	1.4	1.0	None Observed	
11/20/95	6	11.0	ND	4	2	8	1.0	0.8	Chinook Jack holding nearby	
11/20/95	6	10.9	ND	4	2	8	1.0	0.7	None Observed	
11/20/95	6	10.7	MCP	8	2.5	20	1.0	1.0	3 Female Chk & 3 Jacks in Pool	Located in "Crescent City Fork Gorge Pool" tailout
11/20/95	6	10.6	ND	8	2.5	20	1.0	1.0	None Observed	
11/20/95	8	3.8	RUN	15	8	120	ND	ND	4 Adult Chinook & 1 Jack	Adjacent to CCC Habitat Structure
11/20/95	8	3.8	RUN	15	8	120	ND	ND	4 Adult Chinook & 1 Jack	Adjacent to CCC Habitat Structure
11/2095	8	3.9	RUN	6	4	24	12.0	6.0	1 Male Chinook	
11/29/95	5	13.7	RUN	15	6	90	2.5	1.5	1 Female Chinook & 1 Jack	
11/29/95	5	13.4	RUN	10	4	40	3.0	1.0	1 Female Chinook	
11/29/95	5	13.0	RUN	8	4	32	2.5	1.0	None Observed	
11/29/95	5	12.8	RUN	12	6	72	2.0	1.0	3 Adult Chk immed. U/S in LSP	
11/29/95	5	11.6	LSP	20	10	200	2.0	1.0	5 Adult Chk & 2 Jacks in Pool	"Redd Complex", likely 2-4 Redds
11/29/95	5	11.2	LSP	8	3	24	3.0	2.0	1 Male Coho	
11/29/95	5	10.6	RUN	10	6	60	2.0	1.0	1 Female Chinook	
11/29/95	8	4.1	RUN	8	4	32	2.0	4.0	5 Adult Chinook	
11/29/95	8	4.1	ND	15	5	75	2.0	ND	3 Adult Chinook	

Total Redds: 17 chinook, 1 coho and 10 undetermined

LSP = lateral scour pool MCP = mid-channel pool POW = pocketwater
U/S = upsteam D/S = downstream ND = not determined

Table 6. Summary of salmonid redds observed during spawning surveys, lower Blue Creek, lower Klamath River, California, fall 1996.

Date	Reach	Location (rm)	Habitat Type	Length (ft)	Width (ft)	Area (ft^2)	Pit Depth (ft)	Mound Depth (ft)	Fish Present	Comments
10/11/96	2	4.9	RUN	15	8	120	1.5	0.5	None Observed	Located in "Redd City"
10/22/96	4	9.9	RUN	5	4	20	1.5	1.0	Chinook pair D/S in pool	Located immediately U/S of the "Pitcher Plant Pool"
10/23/96	2	4.9	RUN	9	3	27	1.5	1.0	None Observed	Located in "Redd City"
10/29/96	3	6.0	LSP	20	16	320	1.5	1.0	1 Female Chinook	Large Cobble Substrate
10/29/96	3	6.7	RUN	10	5	50	1.0	0.5	None Observed	Large Cobble Substrate
10/30/96	2	4.1	LGR	10	5	50	0.75	0.5	1 Chinook Jack	Located in "New Redd City"
10/30/96	2	4.2	RUN	15	5	75	1.0	0.5	None Observed	Located in "New Redd City"
11/7/96	3	5.9	RUN	20	12	240	1.5	1.0	None Observed	Large cobble substrate
11/7/96	4	9.2	RUN	16	6	96	2.0	0.25	None Observed	In Run D/S of the "Grand Hole"
11/7/96	4	9.7	LSP	8	3	24	1.0	0.5	1 Adult Chinook & 4 Adult Coho	In "Pitcher Plant Pool" tailout - Possible coho redd
11/7/96	4	9.7	LSP	16	7	112	1.33	0.67	1 Adult Chinook & 4 Adult Coho	In "Pitcher Plant Pool" tailout - Possible coho redd
11/8/96	1	1.3	RUN	10	4	40	1.0	0.5	None Observed	Above road washout
11/8/96	2	5.6	RUN	9	5	45	3.0	2.0	1 Female & 1 Male Chinook	
11/8/96	2	3.3	LSP	9	5	45	2.0	1.0	48 Adult & 1 Jack Chinook (in pool)	Located in tailout of West Fork confluence pool
11/8/96	2	3.3	LSP	10	4	40	2.0	1.0	48 Adult & 1 Jack Chinook (in pool)	Located in tailout of West Fork confluence pool
11/8/96	2	3.4	RUN	11	5	55	1.67	1	None Observed	
11/8/96	2	4.1	RUN	12	5	60	1	0.33	None Observed	Located in "New Redd City"
11/8/96	2	4.9	RUN	20	7	140	2.5	1.5	None Observed	Located in "Redd City"
11/8/96	2	4.9	RUN	16	8	128	1.5	0.67	None Observed	Located in "Redd City"
11/8/96	2	4.9	RUN	10	6	60	1.5	1.0	None Observed	Located in "Redd City"
11/8/96	2	4.9	RUN	27	7	189	1.0	0.33	None Observed	Located in "Redd City"
11/8/96	2	5.3	RUN	9	4	36	1.33	0.67	None Observed	
11/8/96	2	5.4	RUN	16	8	128	1.5	0.33	None Observed	
11/8/96	2	5.5	RUN	20	8	160	1.0	0.5	Two Female Chinook	One spawned out male carcass also located
11/12/96	3	5.9	RUN	8	4	32	1.0	0.67	None Observed	
11/12/96	3	6.9	RUN	7	3	21	0.75	0.5	None Observed	
11/12/96	3	7.0	LGR	6	3	18	1.0	0.5	1 Female & 1 Male Chinook	
11/12/96	4	8.2	CCP	14	6	84	7.0	5.0	1 Female Chinook on redd + 5 more in pool	In Slide Cr. confluence pool tailout. Same location as 1995
11/12/96	4	9.1	RUN	18	6	108	1.5	0.5	None Observed	Top of run above Slide Creek confluence
11/12/96	4	9.2	RUN	16	4	64	2.0	0.5	2 Female & 1 Jack Chinook	Located in run exiting the "Grand Hole"
11/12/96	4	9.2	RUN	16	6	96	3.0	2.0	2 Female & 1 Jack Chinook	Located in run exiting the "Grand Hole"
11/12/96	4	9.9	RUN	16	8	128	2.5	1.5	2 Male Chinook	Located in the Second run above the "Pitcher Plant Pool"
11/13/96	1	1.3	RUN	6	5	30	0.75	0.67	None Observed	Located above road washout
11/13/96	1	1.3	RUN	10	6	60	1.0	0.67	None Observed	Located adjacent to road washout
11/13/96	2	3.3	LSP	11	6	66	1.5	1.0	None Observed	
11/13/96	2	3.3	LSP	13	6	78	2.0	1.33	None Observed	
11/13/96	2	4.0	RUN	16	10	160	2.0	1.0	1 Female Chinook	Located in "New Redd City"
11/13/96	2	4.0	RUN	9	6	54	2.0	0.5	1 Female Chinook	Located in "New Redd City"
11/13/96	2	4.1	RUN	9	5	45	1.5	1.0	None Observed	Located in "New Redd City"
11/13/96	2	4.1	RUN	13	7	91	2.0	1.0	None Observed	Located in "New Redd City"
11/13/96	2	4.1	RUN	12	6	72	1.0	0.67	None Observed	Located in "New Redd City"
11/13/96	2	4.1	RUN	12	6	72	1.0	0.5	None Observed	Located in "New Redd City"
11/13/96	2	4.1	RUN	10	3	30	1.0	0.5	None Observed	Located in "New Redd City"
12/19/96	1	1.7	RUN	15	6	90	2	0.67	None Observed	Located in side channel below bridge

Total Redds: 14 chinook and 30 undetermined

LSP = lateral scour pool   CCP = channel confluence pool   LGR = low gradient riffle
U/S = upsteam   D/S = downstream   ND = not determined

Table 7. Summary of salmonid redds observed during spawning surveys, Crescent City Fork Blue Creek, lower Klamath River, California, fall 1996.

Date	Reach	Location (rm)	Habitat Type	Length (ft)	Width (ft)	Area (ft^2)	Pit Depth (ft)	Mound Depth (ft)	Fish Present	Comments
11/6/96	6	10.9	RUN	16	8	128	0.75	0.25	1 Female Chinook	
11/6/96	6	10.9	RUN	7	6	42	2.25	1.0	1 Female Chinook	
11/6/96	6	11.4	LSP	12	6	72	1.0	0.33	1 Female Chinook	Located in pool tailout
11/6/96	6	12.4	LSP	15	3	45	4.5	4.0	1 Female Chinook	Located in "deep water" in pool head
11/6/96	6	13.0	LSP	12	6	72	1.5	0.5	3 Chinook & 3 Coho Adults, + 2 Coho Jacks	Located in "Pete's Cave Pool" - Possible coho redd
11/6/96	6	13.1	LSP	16	6	96	2.0	1.0	1 Female & 1 Jack Chinook	
11/6/96	6	13.1	LSP	4	4	16	0.67	0.5	1 Female & 1 Jack Chinook	
11/6/96	6	13.3	RUN	9	4	36	2.0	1.0	1 Female Chinook	
11/6/96	6	13.7	RUN	15	5	75	1.25	0.67	1 Female & 1 Male Chinook	Ad-clipped female chinook in pool immediately U/S
11/6/96	6	13.7	RUN	7	4	28	1.0	0.67	1 Female & 1 Male Chinook	
11/6/96	7	13.9	LSP	8	8	64	1.67	1.0	1 Female & 1 Male Chinook	Redd in progress - located in tailout
11/6/96	7	14.0	LSP	10	5	50	1.67	1.0	1 Female Chinook w/ ad-clip	Redd in progress - located in tailout
11/6/96	7	14.2	MCP	8	3	24	1.0	0.33	1 Female & 1 Jack Chinook	Located in pool tailout
11/6/96	7	14.4	MCP	15	3	45	1.5	1.0	1 Female Chinook	Fish had gill net scar
11/6/96	7	14.4	MCP	12	6	72	1.5	1.0	1 Female & 1 Male Chinook	Fish actively digging redd - Male had an ad-clip
11/6/96	7	14.4	LSP	12	5	60	3.0	0.5	1 Female Chinook	Fish had an ad-clip

Total Redds: k and 1 undetermined

LSP = lateral scour pool MCP = mid-channel pool U/S = upsteam

Table 8. Summary of salmonid redds observed during spawning surveys, upper Blue Creek, lower Klamath River, California, fall 1996.

Date	Reach	Location (rm)	Habitat Type	Length (ft)	Width (ft)	Area (ft^2)	Pit Depth (ft)	Mound Depth (ft)	Fish Present	Comments
11/1/96	5	11.3	LSP	25	15	375	1.5	1.0	1 Female & 1 Jack Chinook	2-3 redds in "complex" - Dimensions are overall
11/1/96	5	11.9	LSP	11	3	33	2.0	1.0	2 Female & 1 Male Chinook in Pool	Same location as redd from 1995
11/15/96	5	10.5	LSP	14	6	84	1.33	0.5	2 Female and 2 Male Chinook - 2 w/ ad-clip	Located in first pool U/S of Crescent City Fork confluence
11/15/96	5	10.5	LSP	13	5	65	1.0	0.25	2 Female and 2 Male Chinook - 2 w/ ad-clip	Located in first pool U/S of Crescent City Fork confluence
11/15/96	5	10.6	LSP	16	6	96	2	0.67	None Observed	Located in pool tailout
11/15/96	5	10.7	LSP	10	4	40	1.5	0.67	1 Adult Chinook	Located in pool tailout
11/15/96	5	11.3	LSP	17	8	136	2	1	3 Adult Chinook in pool - 1 w/ ad-clip	Located in pool tailout
11/15/96	5	11.3	LSP	12	5	60	1.5	0.5	3 Adult Chinook in pool - 1 w/ ad-clip	Located in pool tailout
11/15/96	5	11.5	LSP	ND	ND	ND	ND	ND	1 Female & 1 Male Chinook	Located in pool tailout
11/15/96	5	11.7	RUN	13	4	52	4.0	2.5	1 Female & 1 Male Chinook	
11/15/96	5	11.8	LSP	23	8	ND	3.0	0.5	2 Female Chinook	Located in pool tailout
11/15/96	5	11.8	LSP	22	4	88	4.0	2.5	2 Female Chinook	Located in pool tailout
11/15/96	5	11.9	LSP	13	4	ND	1.5	1.0	7 Chinook adults in pool	Located in pool tailout
11/15/96	5	11.9	LSP	10	4	40	1.75	1.0	1 Jill Chinook on redd & 7 adults in pool	Located in pool tailout
11/15/96	5	12.2	LSP	21	10	ND	2.25	0.5	2 Female and 2 Male Chinook	Black bear & cub on bank watching fish/redd
11/15/96	5	12.3	RUN	20	8	160	2.33	1.33	2 Adult Chinook	
11/15/96	5	12.3	RUN	12	5	ND	2.0	1.33	2 Adult Chinook	
11/15/96	5	12.3	RUN	10	6	60	2.5	1.5	2 Adult Chinook	
11/15/96	5	12.6	LSP	15	5	ND	3.0	2.0	12 Adult Chinook in pool	Located in tailout of the "Cascade Pool"
11/15/96	5	12.8	LSP	8	4	32	1.5	0.5	None Observed	Same location as redd from 1995
11/15/96	5	13.0	LSP	20	12	ND	1.0	0.33	1 Female Chinook	Pool tailout is a "redd complex"
11/15/96	5	13.0	LSP	10	5	50	0.75	0.25	1 Female Chinook	Pool tailout is a "redd complex"
11/15/96	5	13.1	RUN	23	5	ND	1.25	0.5	1 Female Chinook	
11/15/96	5	13.6	RUN	16	8	128	1.5	0.33	1 Female Chinook	Located adjacent to campsite

Total Redds: k and 2 undetermined

LSP = lateral scour pool U/S = upsteam ND = not determined

1996: The first chinook redds were seen in reach #1 on 11 Oct 1996, although additional redds were not documented until late-October (Table 3). Spawning activity increased during subsequent weeks, with the peak weekly count of 19 redds in reaches #1-4 observed during week of 16 Nov1996 (Figure 23). This peak redd count coincided with the peak weekly count of chinook spawners. The total duration of the 1996 spawning season was undetermined because surveys ended the week of 16 Nov1996, but based on 1995 observations likely extended into December.

Intra-basin Run/Spawn Timing: Survey data indicated differential spawning times for chinook salmon in the lower versus upper Blue Creek basin. During late-season surveys of the Crescent City Fork and upper Blue Creek in 1996, most chinook were observed actively constructing redds (Tables 7-8). At that same time large congregations of unspawned chinook were holding in lower Blue Creek, with relatively little spawning activity seen. These observations may be related to the stage of sexual maturity when chinook salmon enter Blue Creek. Early-entering chinook may be less sexually mature than later-entering fish. Early-entering chinook likely migrate to the upper basin and Crescent City Fork to hold until they become fully ripe. Late-entering chinook may be more sexually mature when entering Blue Creek. Consequently, they spawn lower in the basin than early-entering chinook. This pattern of differential spawning time between lower and upper basin chinook is similar to observations made for coho salmon by Sandercock (1991).

Klamath Basin Comparison: Barnhart (1994) classified Blue Creek chinook as a late-spawning population. YTFP observations of Blue Creek chinook runs support this conclusion. In general, chinook salmon began entering Blue Creek in September, and fresh fish continued to be observed in late-November. Spawning typically began in late-October and continued beyond November, with peak spawning typically seen in late-November. Chinook likely continue spawning throughout December in the Blue Creek basin, but high flows prematurely ended surveys all three years during the project period.

Blue Creek late-fall chinook display distinctly different run-timing patterns from other Klamath River chinook populations. Barnhart (1994) stated that fall chinook in the upper Klamath River basin spawn earlier in the year than lower basin populations. The USFWS reported peak redd counts in October for mainstem spawning chinook populations in the upper Klamath River during 1993-1996 (Shaw et al. 1997).

There may be a genetic basis for the reported differential run timing of lower and upper Klamath basin chinook stocks. Gall et al. (1990) concluded that the Blue Creek chinook stock is genetically identical to Smith River chinook salmon, while being relatively distant from Klamath-Trinity stocks. Snyder (1931) reported that “Blue Creekers” resemble the fish of Smith River in size, as well as in color, character of snout and other peculiarities associated with maturity. The Smith River fish, like the “Blue Creekers”, enter the river late in the season, are relatively mature, and have but a short distance to migrate to their spawning grounds (Snyder 1931).

Spatial Trends

YTFP spawning surveys have documented late-fall chinook utilizing the lower Blue Creek basin more extensively than the upper basin. The location of chinook redds was mapped for 1995 and 1996 (Figures 24-25). Intra-basin comparisons showed that 79.6% of the observed redds in 1995 were located in lower basin reaches #1-4 and reach #8 (Figure 20). The remaining 20.4% of the observed redds in 1995 were documented in the combined upper basin reaches #5-7 (Figure 20). Comparisons of redd distribution in 1996 showed that 50.5 % and 49.5 % of the observed redds were observed in the lower and upper basins respectively (Figure 22).

It is interesting to note that the upper basin was utilized more extensively in 1996 than in 1995. This is most apparent from reach #5 redd counts. 10.2% of the 118 redds seen in 1995 were located in reach #5 (Figure 21). In 1996, 30.1% of the 83 redds seen were constructed in reach #5 (Figure 22). This observed distribution was likely biased by the large number of unspawned lower basin chinook present at the end of 1996 surveys. More extensive survey efforts of upper Blue Creek in 1996 also likely influenced these spatial observations. The large numbers of fall chinook observed in Blue Creek in 1996 may also have played a role in this observation. Available spawning habitat in lower Blue Creek may have been insufficient for the substantially larger numbers of chinook seen in 1996. Thus, chinook may have dispersed to upper reaches where spawning habitat was not as extensively utilized.

We observed a distinct preference for spawning habitat in reach #2. 1995 surveys found that 50% of the documented chinook redds were located in reach #2 (Figures 20, 24). 1996 data indicated that 28.8% of the redds were located in reach #2 (Figures 22, 25). This was slightly lower than the percentage of redds found in reach #5, but still shows that chinook actively selected reach #2 over other lower Blue Creek reaches. Again however, the temporal difference in spawning time between lower and upper basin chinook as well as the early conclusion of 1996 surveys likely biased this observation.

Specific areas of reach #2 were consistently utilized by spawning chinook both 1995 and 1996. We identified two major areas of heavy redd construction that YTFP divers labeled "Redd City" and New Redd City" (Figures 24-25). In 1995, 33.9% (n=20) and 27.1% (n=16) of the redds observed in reach #2 were documented in "Redd City" and "New Redd City", respectively (Table 4). Redd surveys in 1996 found 24% (n=6) of reach #2 redds in "Redd City" and 40% (n=10) in "New Redd City" (Table 6). Both of these areas were classified as "run" habitat types with minimally embedded cobble and gravel spawning substrates, ideal for chinook redd construction (McCain et al. 1990).

Qualitative diver observations may provide evidence for why this preference exists. Large numbers of schooling chinook were seen in reach #2 pools. It appears that fall-run chinook utilize the numerous deep pools as holding habitat prior to spawning or upstream dispersal. In addition, reach #2 appears to contain the largest amount and highest quality spawning habitat in lower Blue Creek. The habitat composition of Blue Creek may also influence fall chinook habitat selection. YTFP is currently conducting an anadromous habitat survey of the entire Blue Creek basin. Once completed, the overall habitat composition of Blue Creek will be better understood.

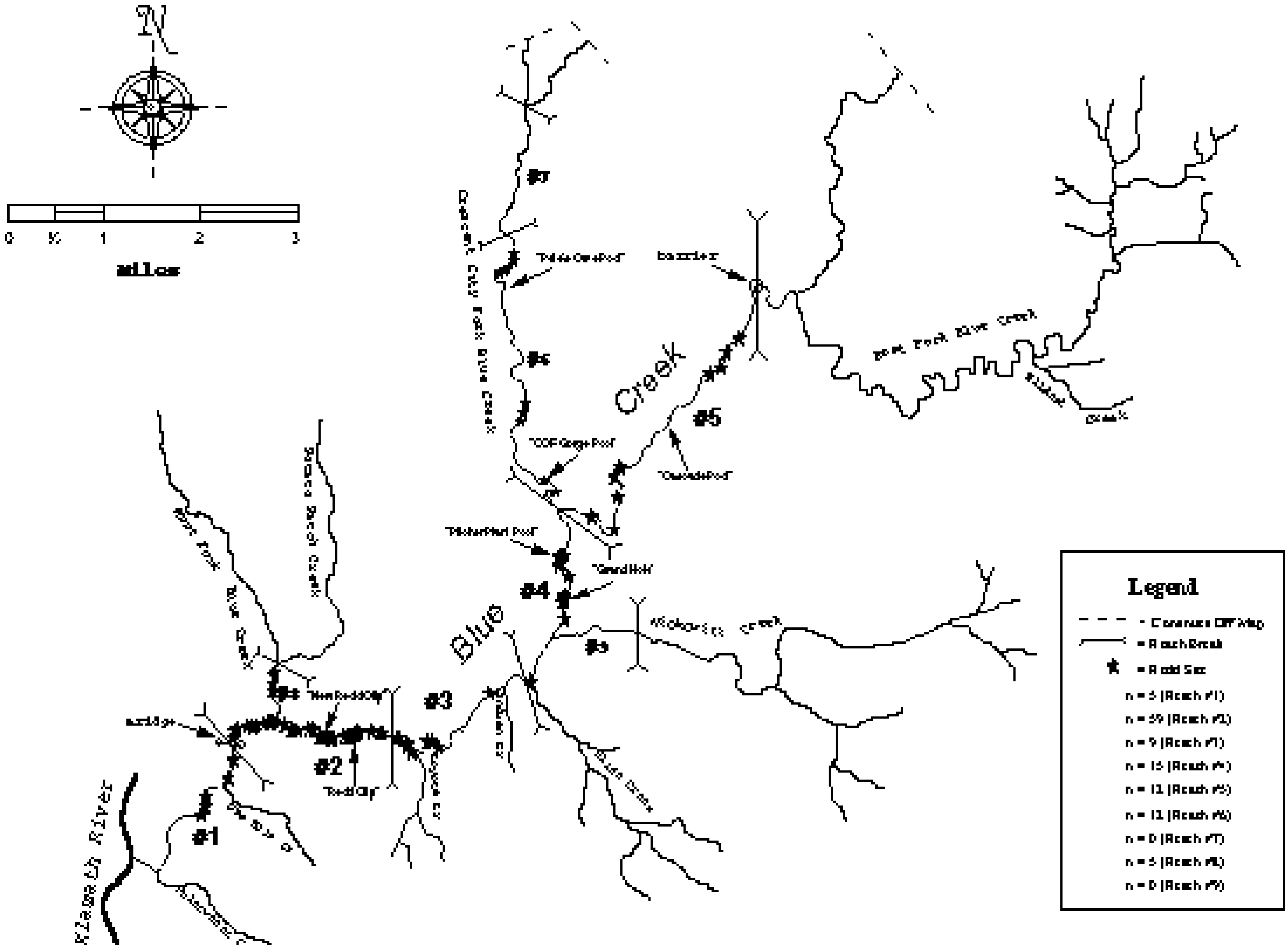


Figure 24. Location of chinook salmon redds observed in Blue Creek, lower Klamath River, California, Fall 1995.

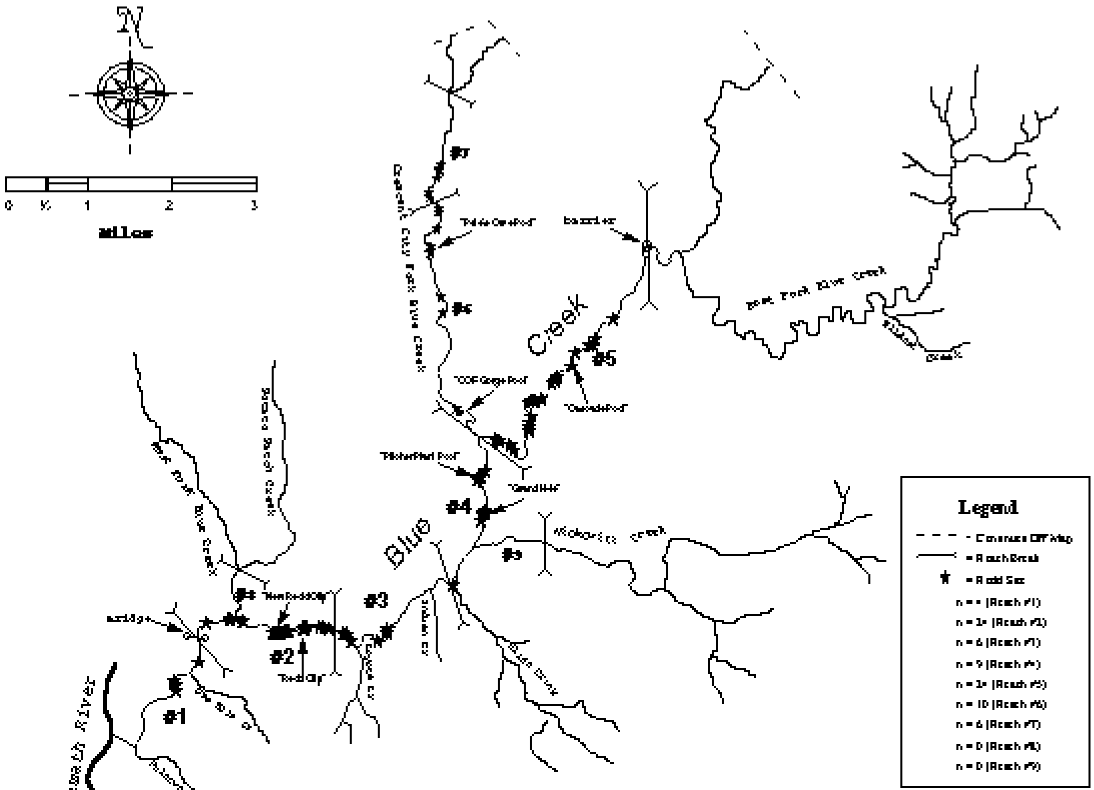


Figure 25. Location of chinook salmon redds observed in Blue Creek, lower Klamath River, California Fall 1996.

Throughout 1995 and 1996 chinook redds were consistently constructed in run habitat types. In 1995, 81.0% (n=64) of the observed chinook redds in reaches #1-8 (where habitat type was documented) were constructed in run habitats. During 1996, an estimated 55.4% (n=46) of the observed redds in reaches #1-8 were constructed in run habitats. Chinook may select higher velocity run habitat to facilitate subgravel flow through their redds. Chinook have large eggs with a small surface-to-volume ratio, and subsequently are more sensitive to reduced oxygen levels and require a more certain level of subgravel irrigation (Healy 1991). The apparent preference for spawning areas with high subgravel flow may explain their tendency to aggregate in particular locations for spawning and to ignore other, superficially similar, areas (Vronskiy 1972).

The decline in run utilization from 1995 to 1996 is the result of a significant shift in spawning habitat selection in the upper reaches (Figure 26). Chinook spawners showed a definite preference for run habitat in the lower basin during both years (Figure 26). Upper basin spawners, however, selected run habitat twice as often as pool tailouts in 1995 yet chose pool tailouts three times as often as runs in 1996 (Figure 26). The large number of unspawned lower basin fish at the time surveys were halted likely biased the observed basinwide habitat usage in favor of upper basin spawners. As previously noted, most fish observed in the upper reaches (#5-7) during the final 1996 surveys were actively spawning while lower basin fish (#1-4) were primarily holding/schooling prior to initiating spawning.

4.3.3 Carcass Surveys

<u>Synopsis</u>

In 1994, two chinook carcasses were found in reach #2 and one was located in reach #4, with no other carcasses seen. 1995 snorkel surveys found 23 chinook carcasses in reaches #1-4 and a single carcass in reach #5 (Table 9). In addition, a single coho carcass and one steelhead half-pounder carcass were discovered in lower reach #1, and three unidentified carcasses were found during 1995. A total of 31 chinook carcasses were found in reaches #1-4 during 1996 surveys (Table 10). YTFP also discovered a single coho salmon carcass in lower reach #1 in 1996. Analysis of chinook scales collected in 1995 and 1996 indicated that most carcasses were 3 and 4-year-old fish. No trends were distinguished in the ratio of male to female carcasses found.

<u>Temporal & Spatial Trends</u>

1994: We documented a total of three carcasses in 1994 (Table 1). The first carcass was found in reach #2 on 10 Oct 1994 and another on 3 Nov 1994. One carcass was also found in the reach #4 “Grand Hole” (Figure 24-25) on 2 Nov 1994. The low number of recovered carcasses was probably due in part to the fact that many unspawned chinook still occupied reaches #1-4 by the conclusion of 1994 surveys.

1995-1996: YTFP found early season carcasses in reach #1 during both 1995 and 1996. YTFP discovered two unspawned chinook carcasses on 25 Sept 1995 in reach #1.

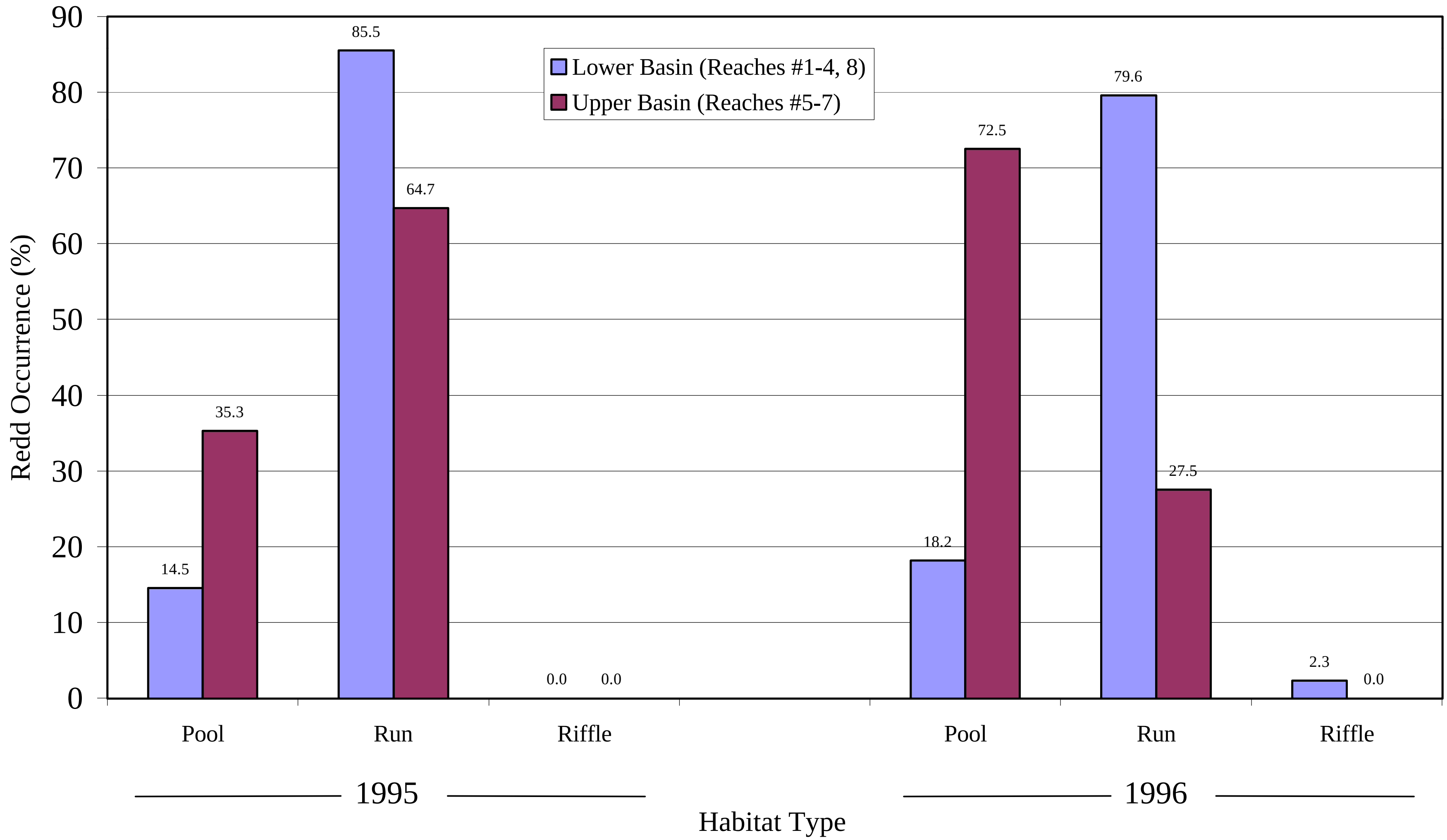


Figure 26. Percent occurrence by habitat type of observed chinook salmon redds, Blue Creek, lower Klamath River, California, 1995-1996.

Table 9. Summary of salmonid carcasses collected during spawning surveys, Blue Creek, lower Klamath River, California, fall 1995.

Date	Reach	Location (rm)	Species	Length (mm)	Sex	Age	Condition	%Spent	Comments
9/25/95	1	0.6	Chinook	~750	F	ND	decayed	ND	Appeared unspawned
9/25/95	1	1.6	Chinook	~750	F	ND	fresh	ND	Appeared unspawned
10/2/95	1	0.6	Chinook	-	-	ND	depredated	-	Head and part of spine only
10/12/95	1	1.9	Chinook	-	-	ND	depredated	-	Head and body separated
10/17/95	1	0.3	Coho	673	F	3	fresh	0	Close to ripe
10/17/95	1	0.3	Steelhead	343	ND	ND	fresh	-	Half-pounder w/ gill net scar
10/17/95	2	3.2	Chinook	-	M	ND	depredated	-	Head and bones
10/24/95	2	3.2	Chinook (?)	-	-	-	depredated	-	Pieces at bottom of pool
10/30/95	4	9.3	Chinook (?)	-	-	-	depredated	-	Spine only
10/31/95	2	3.0	Chinook (?)	-	-	-	depredated	-	Back half of carcass at bottom of pool
11/7/95	2	2.9	Chinook	483	M	2	fresh	-	Jack - Still had milt
11/7/95	2	3.1	Chinook	-	-	-	depredated	-	Head at bottom of pool
11/7/95	2	3.2	Chinook	~100	M	ND	depredated	-	Head and body separated on bottom of pool
11/7/95	2	5.4	Chinook	787	M	ND	decayed	100	Totally spawned out
11/13/95	3	6.5	Chinook	940	F	4	fresh	25	Bear or otter kill
11/14/95	2	4.8	Chinook	820	F	4	fresh	100	Body and fins heavily abraded
11/14/95	2	4.2	Chinook	790	F	4	fresh	100	Ad-clipped - CWT recovered
11/22/95	2	4.8	Chinook	597	M	3	fresh	50	
11/22/95	2	4.7	Chinook	711	F	3	fresh	100	
11/22/95	2	4.7	Chinook	673	M	3	fresh	-	
11/22/95	2	4.7	Chinook	610	M	3	fresh	-	
11/22/95	2	4.5	Chinook	813	M	4	fresh	-	
11/22/95	2	4.4	Chinook	483	M	2	fresh	-	Jack
11/27/95	4	8.4	Chinook	-	-	-	decayed	-	On bottom of pool
11/27/95	4	8.8	Chinook	800	F	ND	fresh	100	
11/28/95	2	4.7	Chinook	780	M	3	fresh	50	Gash on head - possibly from bear
11/28/95	2	4.4	Chinook	540	M	2	fresh	0	Gash on head - readily releasing milt
11/28/95	2	3.1	Chinook	730	M	3	fresh	50	Part of head missing
11/29/95	5	12.4	Chinook	930	M	5	fresh	ND	Relatively fresh + intact - some abrasions

Total Carcasses: 24 chinook, 1 coho, 1 steelhead, and 3 undetermined

rm = river mile   ND = not determined

Table 10. Summary of salmonid carcasses collected during spawning surveys, Blue Creek, lower Klamath River, California, fall 1996.

Date	Reach	Location (rm)	Species	Length (mm)	Sex	Age	Condition	%Spent	Comments
10/11/96	1	0.1	Chinook	665	M	ND	Fresh	0	Unspawned - Head/Jaw wound
10/11/96	1	0.1	Coho	670	F	3	Fresh	0	Gill net scar
11/7/96	3	7.8	Chinook	850	F	3	Fresh	0	Abrasions on caudal fin but unspawned
11/7/96	4	9.2	Chinook	-	-	-	Fresh	-	Back half of carcass at bottom of pool
11/8/96	2	5.5	Chinook	710	M	3	Fresh	100	Dark fish with large canine teeth
12/19/96	1	1.5	Chinook	1010	M	4	Decayed	-	Located 300' U/S of One Mile Cr. - Rotten but intact
12/19/96	1	1.9	Chinook	980	M	4	Decayed	100	Located in side channel below bridge - rotting
12/19/96	2	2.1	Chinook	830	F	3	Decayed	100	Totally spawned out
12/19/96	2	2.1	Chinook	790	F	3	Decayed	100	Totally spawned out
12/19/96	2	2.2	Chinook	-	M?	-	Decayed	-	Located on flood terrace - thoroughly rotten
12/19/96	2	2.2	Chinook	880	M	-	Depredated	-	Decapitated and rotten
12/19/96	2	2.2	Chinook	-	-	-	Depredated	-	Partially eaten and rotten
12/19/96	2	2.2	Chinook	800	F	3	Decayed	100	Rotten - located in side channel above bridge
12/19/96	2	2.3	Chinook	860	M	-	Decayed	-	Rotten - located above screw trap pool
12/19/96	2	2.5	Chinook	1020	M	-	Depredated	-	Partially eaten - Head, spine, and tail only
12/19/96	2	2.2	Chinook	1030	M	-	Decayed	-	Rotten - located in side channel above bridge
12/19/96	2	2.3	Chinook	-	F	-	Decayed	-	Rotten and mangled
12/19/96	2	2.3	Chinook	-	M	-	Decayed	-	Rotten and mangled
12/19/96	2	2.3	Chinook	-	-	-	Depredated	-	Back half of carcass
12/19/96	2	2.5	Chinook	830	F	4	Fresh	100	Fins eroded - died recently
12/19/96	2	2.4	Chinook	970	M	-	Decayed	-	Rotten - Located in lower end of fyke pool
12/19/96	2	2.4	Chinook	1030	M	-	Decayed	-	Rotten - Located in lower end of fyke pool
12/19/96	2	2.4	Chinook	880	F	-	Depredated	-	Partially eaten - Head, spine, and tail only
12/19/96	2	2.4	Chinook	850	F	-	Decayed	100	Rotten - Located in lower end of fyke pool
12/19/96	2	2.4	Chinook	890	F	4	Decayed	100	Heavy abrasion/fin erosion from spawning
12/19/96	2	2.4	Chinook	1060	M	-	Decayed	-	Rotten - Located in fyke pool. Big Fish!
12/19/96	2	2.4	Chinook	760	F	-	Decayed	100	Rotten - Located in fyke pool
12/19/96	2	2.5	Chinook	840	F	-	Decayed	100	Fins heavily eroded
12/19/96	2	2.8	Chinook	-	M?	-	Depredated	-	Located on flood terrace - partially eaten/well rotted
12/19/96	2	2.9	Chinook	-	M?	-	Depredated	-	Located on flood terrace - partially eaten/well rotted
12/19/96	2	3.2	Chinook	940	F	4	Fresh	100	Located 300' U/S of West Fork - Heavy abrasion
1/6/97	2	2.2	Chinook	740	F	3	Fresh	100	Heavily abraded tail - fairly fresh

Total Carcasses: 31 chinook and 1 coho

rm = river mile U/S = upstream D/S = downstream ND = Not Determined

Subsequent surveys discovered three additional chinook carcasses, a coho carcass and a half-pounder carcass in reach #1 in early October (Table 9). Similarly, in 1996 YTFP found an unspawned chinook and a coho carcass near the mouth of Blue Creek during the initial survey of reach #1 (Table 10). The physical condition of carcasses found near the mouth of Blue Creek suggest a possible temperature or harvest related influence for these early mortalities.

Overall, in 1995, YTFP found 7.4% of carcasses in September, 22.2% of the carcasses in October and 70.3% in November. In 1995, fresh carcasses became progressively more numerous as November progressed. The final surveys of 1995 documented a peak weekly carcass count coinciding with the peak weekly counts of live fish in late-November.

The majority of the carcasses observed during 1995 were found in reaches #1-2. Seventy percent (n=17) of the recovered carcasses occurred in reach #2 and 17% (n=6) in reach #1 (Table 9). YTFP found numerous carcasses in reach #2 near “Redd City” and “New Redd City” spawning areas (Figures 24-25). YTFP observed 21% (n=4) of the carcasses found in reach #2 in the vicinity of “Redd City” and 10.5% (n=2) associated with “New Redd City”.

1996 surveys found very low numbers of carcasses. YTFP found 3% of the total carcasses in October and 10% in November (Table 10). Fresh carcasses were discovered during early November surveys in reaches #1-3. Because snorkel surveys ended 16 Nov 1996 due to high flows, further carcass data throughout reaches #1-4 were not collected.

A post-season foot survey conducted between One Mile Creek and the West Fork on 19 Dec 1996 located 26 chinook carcasses, some of which were fresh (Table 10, Figure 6). This count represented 84% of the carcasses seen during 1996. In addition, a foot survey on 6 Jan 1997 found a single fresh chinook carcass in reach #2. Together, these observations supported the inference the Blue Creek late-fall chinook spawn through December and possibly into January.

As in 1995, the majority of carcasses found in 1996 were documented in reaches #1-2 (Table 10). Of the 31 chinook carcasses YTFP documented during 1996 surveys of reaches #1-4, 83.9% occurred in reach #2 and 9.7% occurred in reach #1. No chinook carcasses were documented in reaches #5-9 during 1996 surveys. However, most of the reach #2 carcasses were found during the bank-side foot survey conducted on 19 Dec 1996. Since this survey only covered areas below the West Fork confluence, absolute carcass distribution was unknown in 1996.

Age Composition

Scale analysis data from 1995 and 1996 carcass surveys indicate that the Blue Creek late-fall chinook run was composed primarily of 3 year old fish (Tables 9-10). In 1995, 2 year old chinook comprised 20% (n=3) and three year olds 46.6% (n=7) of the aged carcasses. Four year olds comprised 26.6% (n=4) and 5 year olds 6.6% (n=1) of the aged carcasses documented in 1995. Analysis of scale samples collected in 1996 showed that 3 year olds comprised 58.3% (n=7) and 4 year olds 41.6% (n=5) of the aged carcasses.

These estimates give a rough idea of the 1995 and 1996 age composition, but are likely biased due the small sample size collected. Numerous jacks (2 year old males) were observed in 1996, for instance, but no carcasses were recovered to provide scale samples.

Carcass Predation

YTFP frequently found chinook carcasses that had been killed/scavenged and/or partially consumed by predators. Heavy predation and scavenging likely influenced the low numbers of chinook carcasses recovered by YTFP personnel. Primary predators/scavengers include black bears (*Ursus americanus*), river otters (*Lutra canadensis*), and raccoons (*Procyon lotor*). YTFP personnel also observed the following during surveys: bald eagles (*Haliaeetus leucocephalus*), ospreys (*Pandion haliaetus*), mergansers (*Mergus merganser*) and great blue herons (*Ardea herodias*).

4.4 Outmigrant Trapping

4.4.1 Chinook Salmon

1995

A total of 609 juvenile chinook were captured in the frame net in 80 days of trapping (Table 11). The peak weekly capture occurred during the week ending 4 Jun 1995 (n=129), with a second smaller peak occurring in early July (Table 11). Following its deployment on 20 Jul 1995, a total of 190 juvenile chinook were captured in the rotary screw trap over 29 days of sampling (Table 11). Capture numbers consistently decreased with no peaks observed.

Trap efficiency ranged from a low of 3.6% during the week ending 28 May 1995 to a high of 42.9% during the weeks ending 21 May and 13 Aug 1995 (Table 12). Based on these efficiencies, an estimated 3,937 (+/- 551) chinook fingerlings emigrated past the trap sites during the combined 88 days of sampling (Table 12). Emigration peaked during the week ending 28 May, with additional peaks occurring during July and early August (Figure 27). Emigration peaks did not appear to be related to fluctuations in stream discharge (Figure 29).

Mean length of sampled chinook steadily increased throughout the trapping season, ranging from 51.2 mm during the week ending May 28 to 102.7 mm during the week ending August 20 (Table 13, Figure 30). Juvenile chinook sampled in the rotary screw trap were significantly larger than those captured in the frame net during the three week period of simultaneous operation (Figure 30). Similar size selectivity differences were reported by USFWS for juvenile chinook captured in their frame net and rotary screw trap during the 1989-1993 trapping seasons (Longenbaugh and Chan 1994). Larger fish appeared to have an increased ability to avoid capture in the frame net, particularly under reduced flow conditions. Age 1+ and older steelhead were observed swimming out of the frame net on several occasions during 1995, and it is assumed that chinook increasingly possessed this ability as they grew larger throughout the season. USFWS observed similar retention problems with the frame net during all five years of their Blue Creek

Table 11. Total number of juvenile salmonids captured by week in the frame net and rotary screw trap, Blue Creek, lower Klamath River, California, 1995.

FRAME NET

	# Days		Steelhead		Coho		
Week Ending	Sampled	Chinook	YOY	Parr/Smolt	YOY	Yearling	Cutthroat
5/21/95	5	9	32	2	0	0	0
5/28/95	6	32	83	0	0	0	0
6/4/95	7	129	556	0	0	0	0
6/11/95	7	96	1053	0	0	0	0
6/18/95	5	74	666	0	0	0	0
6/25/95	7	15	506	0	0	0	0
7/2/95	7	74	1003	0	0	0	0
7/9/95	7	89	530	0	0	0	0
7/16/95	7	37	144	5	0	0	0
7/23/95	7	24	775	1	0	0	0
7/30/95	7	22	467	4	0	0	0
8/6/95	6	8	216	1	0	0	0
8/13/95	2	0	16	1	0	0	0
				- Frame Nets Pulled on 8/8/95 -			
Total:	80	609	6,047	14	0	0	0

ROTARY SCREW TRAP

	# Days		Steelhead		Coho		
Week Ending	Sampled	Chinook	YOY	Parr/Smolt	YOY	Yearling	Cutthroat
7/23/95	3	62	54	6	0	0	0
7/30/95	7	51	118	11	0	0	0
8/6/95	6	50	47	10	0	0	0
8/13/95	7	21	22	4	0	0	0
8/20/95	3	6	19	4	0	0	0
				- Trap Pulled Until 9/5/95 -			
9/10/95	1	0	2	1	1	0	0
				- Trap Pulled Until 9/26/95 -			
9/30/95	2	0	70	5	0	0	0
				- Screw Trap Pulled for Season on 9/28/95 -			
Total:	29	190	332	41	1	0	0

Table 12. Mark-recapture trapping efficiency summary for juvenile chinook salmon captured in the frame net and rotary screw trap, Blue Creek, lower Klamath River, California, 1995.

Mark Period	Week Ending	# Days Marked	# Captured	# Marked	# Recaptured	Trap Efficiency (%)	Estimated # Outmigrants	Variance	Standard Deviation
1	5/21/95	5	9	7	3	42.9	21	255	16
2	5/28/95	6	32	28	1	3.6	896	161,714	402
3	6/4/95	7	129	102	30	29.4	439	6,817	83
4	6/11/95	7	96	76	21	27.6	347	6,346	80
5	6/18/95	5	74	65	21	32.3	229	2,917	54
6	6/25/95	7	15	9	3	33.3	45	1,343	37
7	7/2/95	7	74	55	12	21.8	339	13,896	118
8	7/9/95	7	89	77	15	19.5	457	19,874	141
9	7/16/95	7	37	33	8	24.2	152	8,661	93
10	7/23/95	7	86	46	11	23.9	360	18,047	134
11	7/30/95	7	73	60	25	41.7	190	1,323	36
12	8/6/95	6	58	57	8	14.0	413	61,503	248
13	8/13/95	7	21	14	6	42.9	49	999	32
14	8/16/95	3	6	0	0				
	Season Totals:	88	799	629	164		3,937	303,695	551

Table 13. Weekly mean fork length, standard deviation, 95% confidence interval, and sample size of chinook salmon captured in the frame net and rotary screw trap, Blue Creek, lower Klamath River, California, 1995.

	Frame Trap				**Screw Trap**			
Week Ending	Mean F.L.	S.D.	95% C.I.	# Sampled	Mean F.L.	S.D.	95% C.I.	# Sampled
5/21/95	60.8	12.6	7.2	12				
5/28/95	51.2	11.0	3.8	32				
6/4/95	52.9	11.2	1.8	149				
6/11/95	58.2	12.4	2.4	100				
6/18/95	66.5	10.0	2.1	91				
6/25/95	72.94	12.0	5.7	17				
7/2/95	73.83	8.1	1.9	71				
7/9/95	79.13	7.8	1.5	103				
7/16/95	81.67	9.8	2.8	48	Screw Trap Installed 7/20/95			
7/23/95	80.9	7.1	2.7	26	94.3	5.8	1.4	63
7/30/95	86.7	7.5	3.8	15	96.9	5.7	1.2	88
8/6/97	91.6	7.4	4.8	9	95.2	5.0	1.3	60
8/13/95	Frame Trap Pulled 8/8/95				98.8	4.7	2.0	28
8/20/95					102.67	5.9	4.7	6

Trap Fished Intermittently 8/21/95-9/28/95
-No Chinook Captured-

Screw Trap Pulled 9/28/95

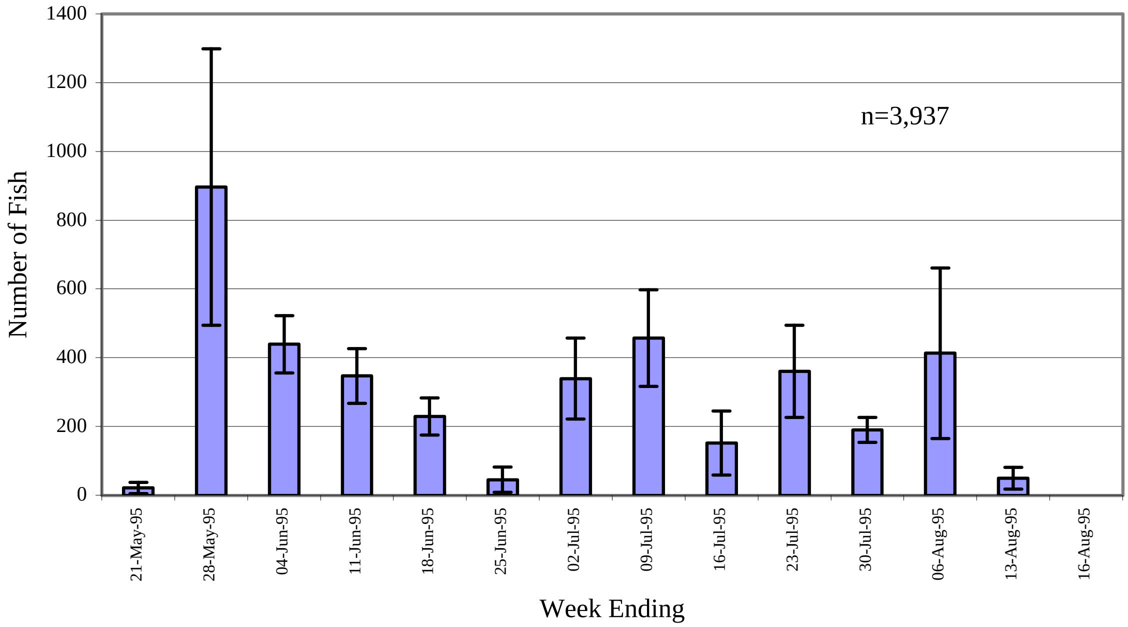


Figure 27. Estimated number of juvenile chinook outmigrants (+/- 1 S.D.), Blue Creek, lower Klamath River, California, 17 May-13 Aug, 1995.

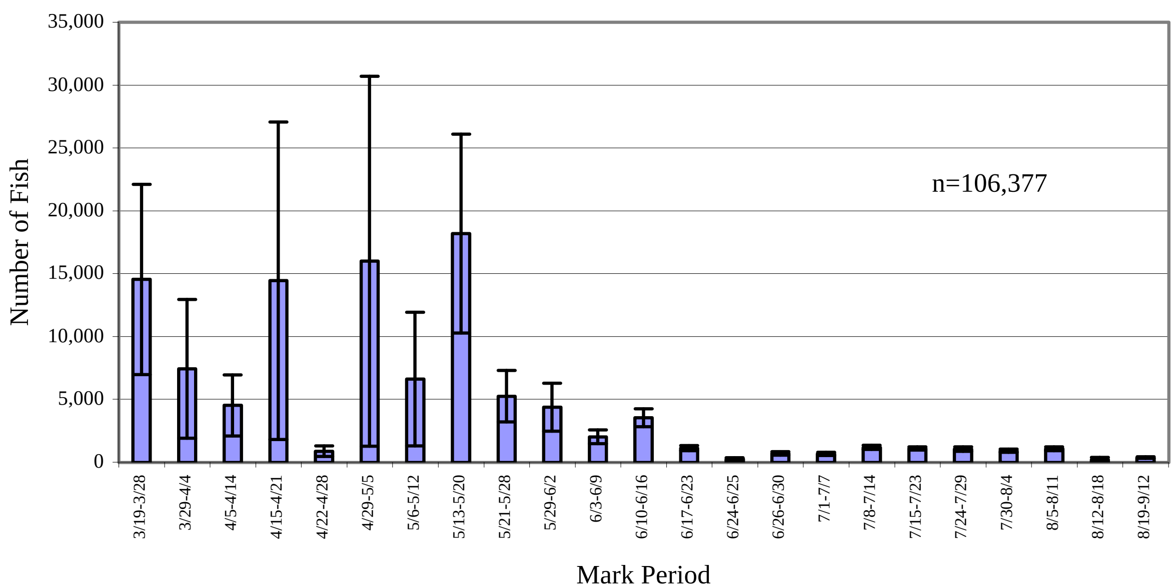


Figure 28. Estimated number of juvenile chinook outmigrants (+/- 1 S.D.), Blue Creek, lower Klamath River, California, 18 Mar-12 Sep, 1996.

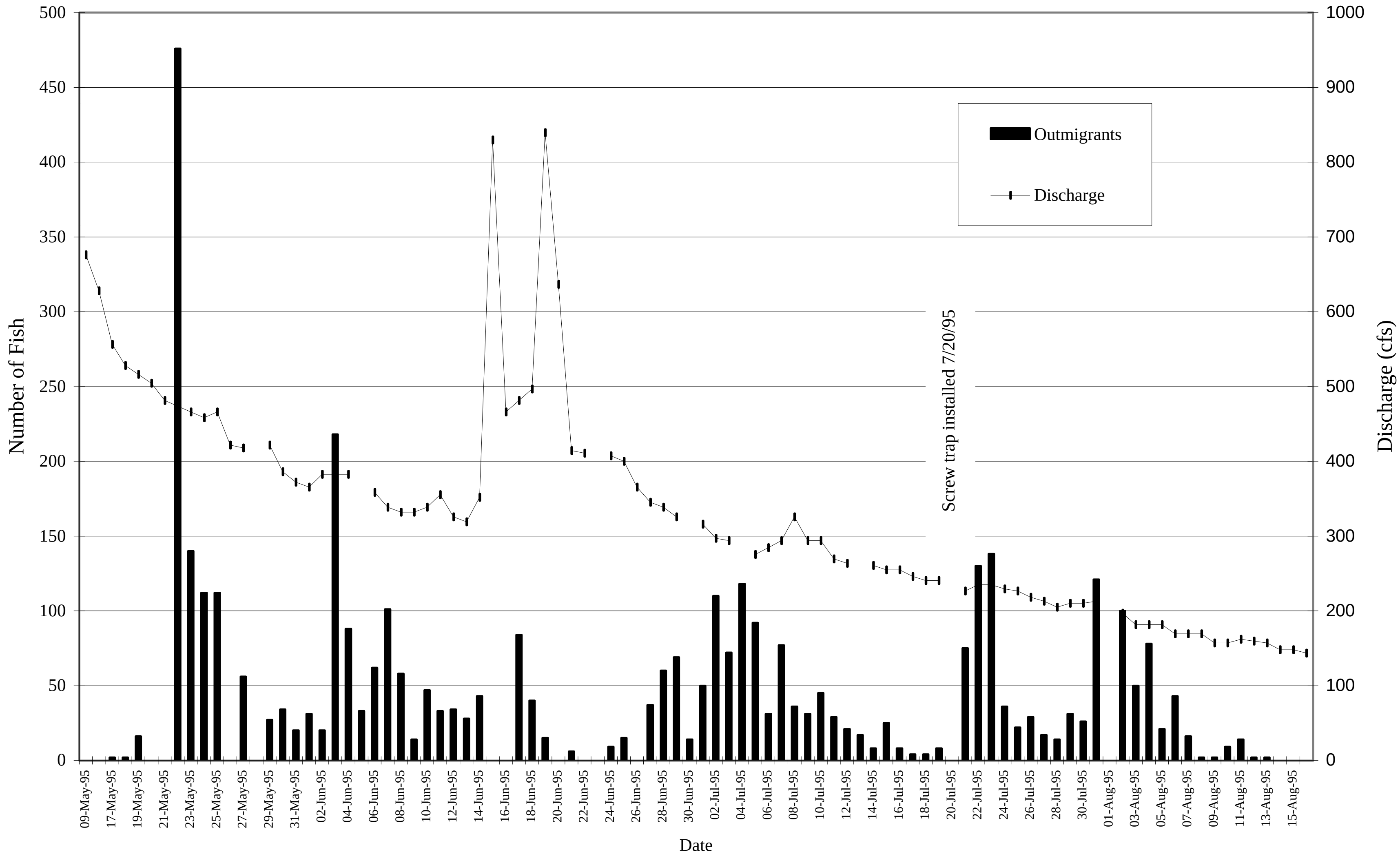


Figure 29. Daily estimated number of chinook salmon emigrants and stream discharge, Blue Creek, lower Klamath River, California, 1995.

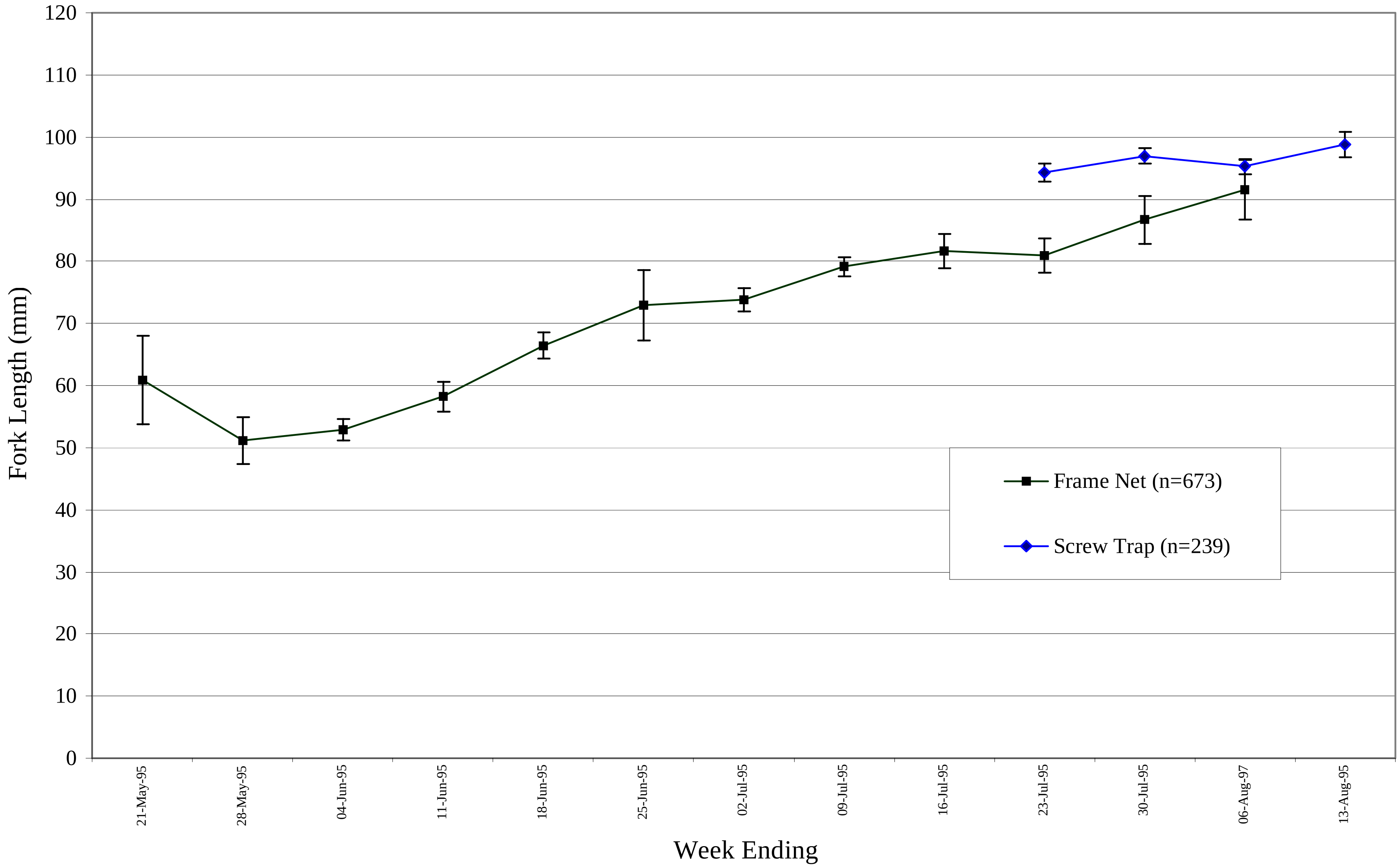


Figure 30. Mean weekly fork length (+/- 95% CI) of juvenile chinook sampled in the frame net and rc
screw trap, Blue Creek, lower Klamath River, California, 1995.

outmigrant trapping effort (Chan and Longenbaugh 1994; Gilroy et al. 1992; Longenbaugh and Chan 1994; Stern and Noble 1990).

1996

A total of 4,931 juvenile chinook were captured in the rotary screw trap during the 1996 trapping season (Table 14). Capture numbers were fairly consistent from mid-March until mid-August, after which a substantial decrease in sampled chinook was observed (Table 14). No distinct peaks in capture numbers were observed during 1996.

Trapping efficiency ranged from a low of 1.7% early in the season to a high of 30.6% during late August-early September (Table 15). Efficiency was consistently <5% from mid-March until mid-May, likely the result of high discharge during the spring months. Beginning with marking period #9 (21-28 May), the trap efficiency steadily increased until marking period 14 (24-25 Jun), after which it remained fairly consistent throughout the remainder of the trapping season (Table 15). The observed increase was attributed to decreasing stream flows and the corresponding ability to reposition the trap closer to the head of the pool. Screw trap positioning that maximizes the percentage of stream flow sampled and/or minimizes the avoidance potential for emigrating salmonids has resulted in a significant increase in trapping efficiency (Kennen et al. 1994; Roper and Scarnecchia 1996).

Based on the calculated trap efficiencies, a total of 106,377 (+/- 23,863) juvenile chinook were estimated to have emigrated past the trap site during the sample period (Table 15, Figure 28). The peak daily emigration occurred on 21 Apr (n=5,957), with smaller peaks observed on 5 May (n=4,873) and 13 May (n=5,610) (Figure 31). An estimated 1,368 chinook emigrated past the trap on the first night of operation (19 Mar), indicating that a substantial amount of emigration had been occurring for an unknown time period prior to the initiation of sampling (Figure 31). In addition, the trap was pulled because of high flows and/or necessary repairs for a total of nine days during the 179 day trapping season (Figure 31). As a result, the quantity of emigrants during these times cannot be reliably estimated.

Mean fork length of sampled chinook remained relatively constant from mid-March through mid-May, ranging from an average of 39.4mm during the week ending 24 Mar to 44.1mm during the week ending 19 May 1996 (Table 16, Figure 32-33). Beginning with the week ending 26 May, the size of captured chinook steadily increased until the week ending 1 Sep, when the average fork length peaked at 102.9mm (Table 16, Figure 32). This sudden change in average size is the result of a shift from fry to fingerling migrants (Healey 1991). Chinook fry migrants typically range from 30-45mm FL and frequently still have a portion of their yolk sac present (Healey 1991). Fingerlings are defined as migrants that have elected to rear within their natal stream prior to seaward migration (Healey 1991). While fingerlings typically emigrate close on the heels of the fry migration, fingerlings are readily distinguished by their larger size (50-120mm FL) (Healey 1991).

During 1996, chinook fry (≤50 mm) comprised 71.7% of the total estimated emigration, while fingerlings constituted the remaining 28.3% (Figure 31). No yearling chinook (age

Table 14. Total number of juvenile salmonids captured by week in the rotary screw trap, Blue Creek, lower Klamath River, California, 1996.

Week Ending	# Days Sampled	Chinook	Steelhead		Coho		Cutthroat
			YOY	Parr/Smolt	YOY	Yearling	
3/23/96	5	226	0	22	0	0	0
3/30/96	6	213	0	34	0	0	0
4/6/96	7	145	1	29	4	1	0
4/13/96	6	134	0	39	5	1	0
4/20/96	7	193	6	45	2	0	1
4/27/96	3	142	3	11	0	0	0
5/4/96	6	203	14	40	2	0	0
5/11/96	6	277	15	54	1	0	0
5/18/96	6	225	43	61	0	0	0
5/25/96	6	171	96	4	1	0	0
6/1/96	7	370	61	15	1	0	0
6/8/96	7	208	79	14	0	1	0
6/15/96	7	362	152	17	0	0	0
6/22/96	7	247	130	19	16	0	0
6/29/96	7	221	91	11	3	0	0
7/6/96	7	143	42	6	5	0	0
7/13/96	7	251	97	15	6	0	1
7/20/96	7	276	129	35	6	0	2
7/27/96	7	225	47	22	5	0	0
8/3/96	7	243	25	4	1	0	1
8/10/96	7	306	76	20	6	0	0
8/17/96	7	37	103	10	1	0	1
8/24/96	7	18	94	7	0	0	0
8/31/96	5	8	16	5	0	0	0
9/6/96	4	75	29	7	3	0	1
9/13/96	7	12	47	12	2	0	0
9/20/96	0	- Trap Not Fished During This Week -					
9/27/96	3	0	2	1	0	0	0
- Trap Pulled on 10/5/97 Due to Low Fish Numbers -							
Total:	168	4,931	1,398	559	70	3	7

Table 15. Mark-recapture trapping efficiency summary for juvenile chinook salmon captured in the rotary screw trap, Blue Creek, lower Klamath River, California, 1996.

Mark Period	Date Range	# of Days Marked	# Captured	# Marked	# Recaptured	Trap Efficiency (%)	Estimated # Outmigrants	Variance	Standard Deviation
1	3/19-3/28	10	404	324	9	2.8	14,544	57,341,810	7,572
2	3/29-4/4	7	127	117	2	1.7	7,430	30,445,530	5,518
3	4/5-4/14	10	222	163	8	4.9	4,523	5,914,724	2,432
4	4/15-4/21	7	269	161	3	1.9	14,436	159,223,900	12,618
5	4/22-4/28	2	31	28	1	3.6	868	177,835	422
6	4/29-5/5	7	292	219	4	1.8	15,987	216,520,800	14,715
7	5/6-5/12	6	245	162	6	3.7	6,615	28,335,800	5,323
8	5/13-5/20	6	180	101	1	1.0	18,180	62,612,610	7,913
9	5/21-5/28	8	288	237	13	5.5	5,250	4,157,761	2,039
10	5/29-6/2	5	278	189	12	6.3	4,379	3,669,767	1,916
11	6/3-6/9	7	192	179	17	9.5	2,022	300,043	548
12	6/10-6/16	7	386	283	31	11.0	3,524	507,147	712
13	6/17-6/23	7	212	191	36	18.8	1,125	43,049	207
14	6/24-6/25	2	51	49	10	20.4	250	11,001	105
15	6/26-6/30	5	172	119	29	24.4	706	19,456	139
16	7/1-7/7	7	155	142	33	23.2	667	15,235	123
17	7/8-7/14	7	274	237	58	24.5	1,179	26,985	164
18	7/15-7/23	9	301	256	71	27.7	1,085	15,991	126
19	7/24-7/29	6	217	159	33	20.8	1,046	34,328	185
20	7/30-8/4	6	245	210	56	26.7	919	13,967	118
21	8/5-8/11	7	246	213	49	23.0	1,069	22,915	151
22	8/12-8/18	7	33	32	5	15.6	211	25,945	161
23	8/19-9/12	15	111	108	33	30.6	363	4,106	64
	Season Totals:	160	4,931	3,879	520	13.4	106,377	569,440,705	23,863

Figure 16. Weekly mean fork length, standard deviation, 95% confidence interval, and sample size of chinook salmon captured in the rotary screw trap, Blue Creek, lower Klamath River, California, 1996.

Week #	Week Ending	Mean Fork Length (mm)	Standard Deviation	95% C.I.	# Sampled
1	24-Mar-98	39.4	3.1	0.5	171
2	31-Mar-98	39.1	2.9	0.5	125
3	07-Apr-98	41.6	3.5	0.7	107
4	14-Apr-98	41.4	4.8	0.8	125
5	21-Apr-98	42.5	5.3	0.9	147
6	28-Apr-98	44.9	6.6	2.4	28
7	05-May-98	43.2	6.0	0.9	178
8	12-May-98	44.7	7.7	1.1	176
9	19-May-98	44.1	7.8	1.5	107
10	26-May-98	51.8	9.9	1.5	171
11	02-Jun-98	56.6	8.9	1.2	201
12	09-Jun-98	56.2	7.3	1.1	156
13	16-Jun-98	63.8	9.4	1.3	190
14	23-Jun-98	65.1	9.4	1.5	148
15	30-Jun-98	71.7	9.3	1.5	154
16	07-Jul-98	77.3	9.9	1.7	127
17	14-Jul-98	79.1	9.0	1.4	160
18	21-Jul-98	82.4	7.5	1.2	163
19	28-Jul-98	85.4	6.5	1.0	164
20	04-Aug-98	87.8	6.1	0.9	161
21	11-Aug-98	87.8	7.2	1.2	146
22	18-Aug-98	90.3	8.5	2.9	33
23	25-Aug-98	96.0	6.3	3.1	16
24	01-Sep-98	102.9	4.9	3.4	8
25	08-Sep-98	99.1	5.7	1.3	76
26	15-Sep-98	96.8	10.6	6.0	12
27	22-Sep-98		No Chinook Captured		
28	29-Sep-98		No Chinook Captured		

Screw Trap Pulled 10/01/96

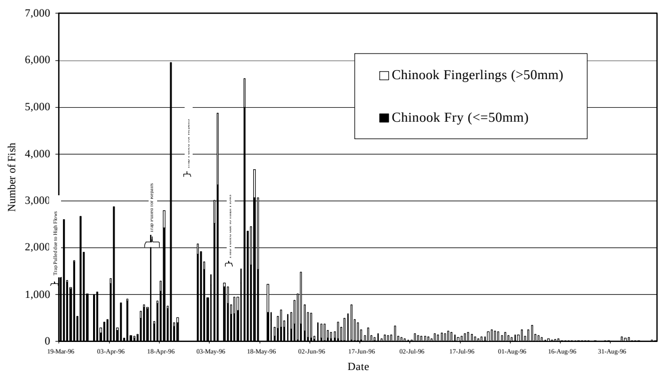


Figure 31. Daily estimated number of emigrant chinook salmon fry and fingerlings, Blue Creek, lower Klamath River, California, 1996.

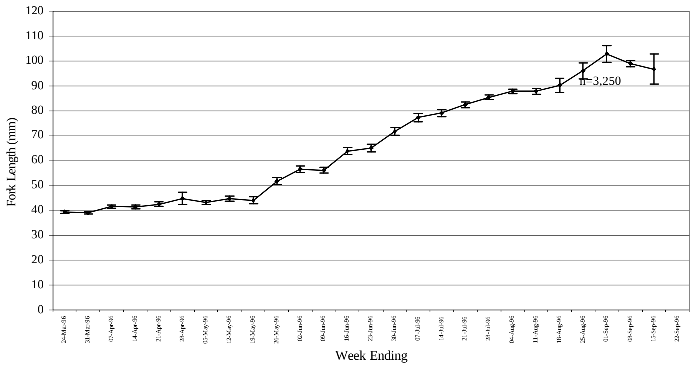


Figure 32. Mean weekly fork length (+/- 95% CI) of juvenile chinook sampled in the rotary screw trap, Blue Creek, lower Klamath River, California, 1996.

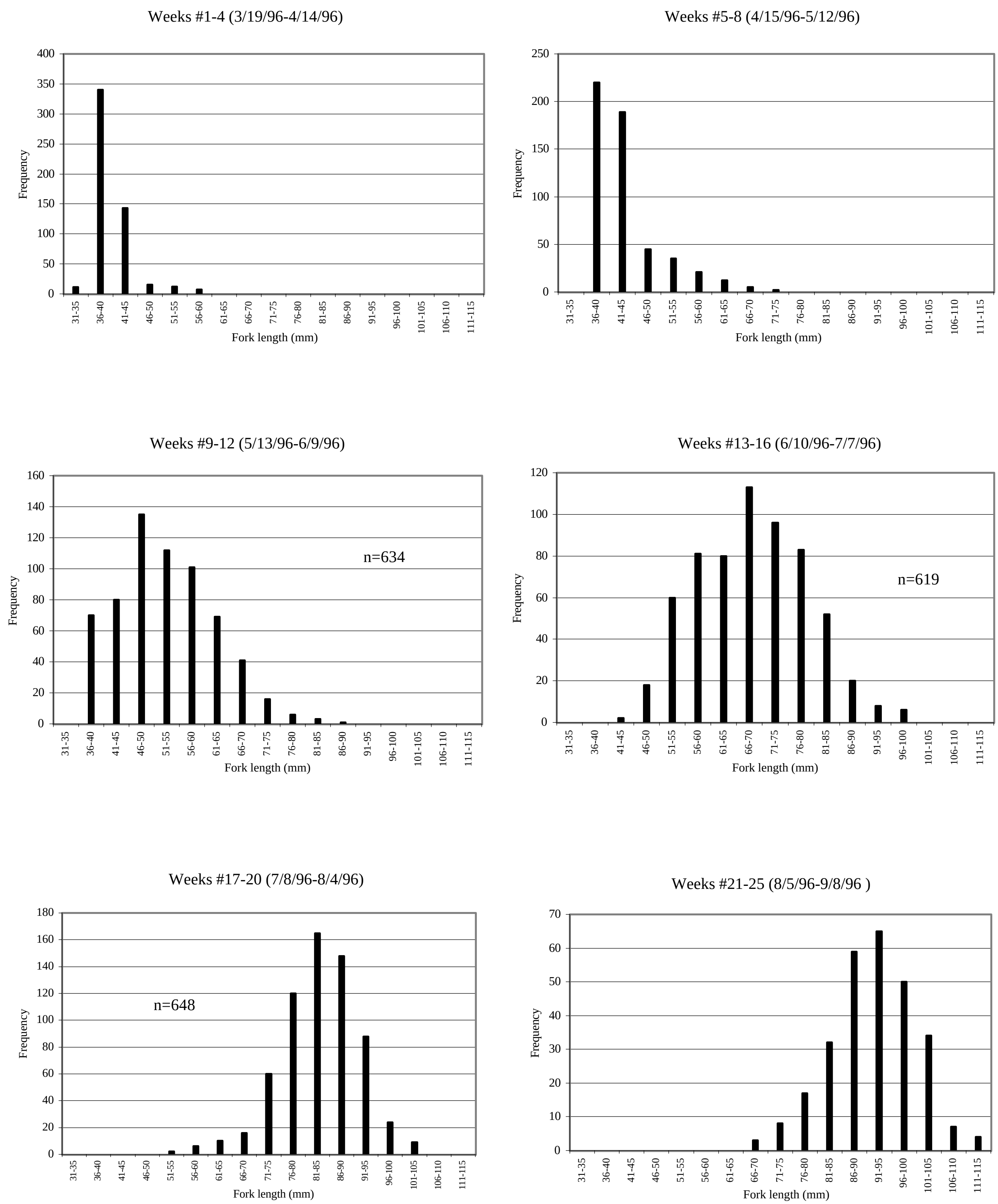


Figure 33. Length-frequency of juvenile chinook sampled in the rotary screw trap, Blue Creek, lower Klamath River, CA, 1996

1+) were captured during 1996. The fry migration began prior to the initiation of 1996 trapping activities, while only a small number of fingerlings were observed during the first month of operation (Figure 31). As a result, the emigration estimate underestimates the actual number of fry outmigrants but likely represents virtually all of the fingerling migration period. Fry were the dominant component of the chinook emigration until mid-May, after which their numbers dropped abruptly and fingerlings dominated the emigrant population for the remainder of the season (Figures 31, 33). Large quantities of fingerlings were first observed in mid-April, and their emigration peaked between mid-May and mid-June (Figure 31). Smaller numbers were consistently captured throughout the remainder of the trapping season, although emigration appeared minimal after the middle of August (Figure 31).

A large downstream movement of chinook fry following emergence is typical of most populations, and is likely a dispersal mechanism that aids in distributing emergent fry throughout the available rearing habitat (Allen and Hassler 1986; Healey 1991). In several British Columbia streams, chinook fry have exhibited a preference to migrate directly to the estuary rather than remaining within their natal stream to rear (Healey 1991). It is unknown what proportion of Blue Creek fry emigrants remain in the lower two miles of the drainage versus migrating directly to the mainstem Klamath and/or estuary. The contribution of emigrant fry to the returning adult spawner population is also unknown, although it is assumed less than that for fingerling outmigrants. Based on tagging studies, it has been suggested that chinook fry remaining in the upper Sacramento River to rear experience a higher survival to smolting than fry that rear in the Delta (Kjelson et al. 1982; Brown 1986, as cited in Healey 1991).

4.4.2 Coho Salmon

<u>1995</u>

During the 1995 trapping season, no juvenile coho were captured in the frame net and only a single coho YOY was sampled in the screw trap (Table 11). The failure to sample a single coho yearling in 1995 can be explained in part by the late deployment and size selectivity bias of the frame net. During their 1989-1993 Blue Creek trapping efforts, USFWS had captured virtually all of the season's coho yearlings by the end of May (Chan and Longenbaugh 1994; Gilroy et al. 1992; Longenbaugh and Chan 1994; Stern and Noble 1990). Since high flows prevented the deployment of the frame net until 17 May 1995, it is likely that most coho yearlings had already emigrated by the installation date. Additionally, USFWS makes repeated mention of the frame net's inefficiency at retaining older age class fish, particularly under waning flow conditions (Chan and Longenbaugh 1994; Gilroy et al. 1992; Longenbaugh and Chan 1994; Stern and Noble 1990). YTFP observed similar retention problems with age 1+ and older steelhead during 1995.

<u>1996</u>

During 1996, a total of 70 YOY and three yearling (age 1+) coho were captured in the rotary screw trap (Table 14). The weekly catch of YOY fish ranged from zero to 16, with the peak capture occurring from late June through early July (Table 14; Figure 34). Two of the three yearlings were captured by mid-April, while the final fish was sampled in early June (Table 14; Figure 34). Coho ordinarily emigrate as age 1+ smolts, with movement of YOY typically attributed to dispersal to less crowded/more preferred rearing habitat (Hassler 1987; Sandercock 1991).

Numerous YOY coho were observed during fall 1995 snorkel surveys in the Crescent City Fork. Barring a high overwinter mortality rate, most of these fish would have emigrated during spring 1996; our infrequent capture of age 1+ smolts, however, suggests only small numbers actually left the system. Although no coho-based trapping efficiency could be calculated due to the small sample size, the chinook-based efficiency ranged between 1.0 and 5.5% during the age 1+ coho emigration period (March-May) (Table 12). Based on these efficiencies, the three captured coho yearlings would be expanded to an emigration estimate of 100-300 fish. It is assumed that the screw trap is less efficient at capturing age 1+ and older fish as larger fish likely have more avoidance potential than chinook YOY. Therefore, it is likely that YTFP's trapping efforts underestimate the extent of yearling coho emigration. Nonetheless juvenile coho appeared to comprise only a small fraction of 1996 Blue Creek salmonid emigrants.

USFWS reported similar coho capture results during their 1989-1993 Blue Creek trapping efforts (Table 17). Direct comparisons between YTFP and USFWS trapping data are not possible because of differences in trapping effort and gear, and unquantifiable differences between trapping efficiencies for each of the given years, but general trend observations can be made.

YTFP's total YOY capture during 1996 does not appear to be significantly different than that reported by USFWS (Table 17). Year-to-year variation is just as likely because of different trap efficiencies or effort than to actual fluctuation in numbers of migrating coho fry. Total yearling captures, however, do appear to be significantly higher for at least the 1989-1990 seasons (Table 17). Despite these increased numbers, juvenile coho still only comprised ≤1% of the total juvenile salmonid capture during 1989-1990 (Longenbaugh and Chan 1994). As a result, it appears that juvenile coho have consistently constituted only a fraction of the total salmonid emigrants from Blue Creek, with no meaningful population trend apparent.

4.4.3 Steelhead

<u>1995</u>

A total of 6,047 young-of-the-year (YOY) and 14 age 1+ and older steelhead were captured in the frame net during the 1995 trapping season (Table 11). Following its deployment on 21 Jul 1995, a total of 332 YOY and 41 age 1+ and older steelhead were sampled in the rotary screw trap (Table 11). Capture of age 0+ steelhead occurred

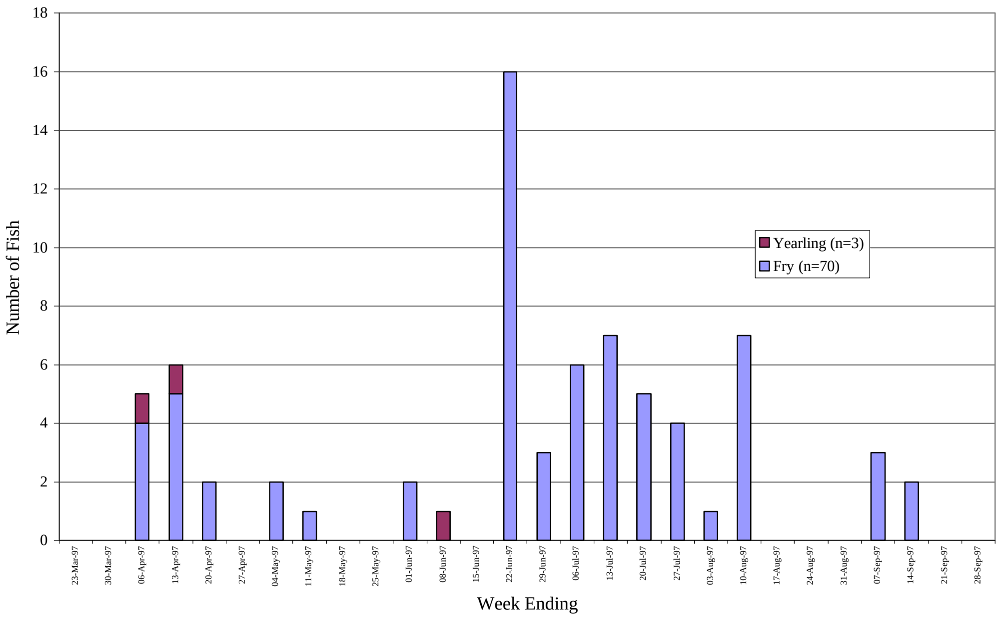


Figure 34. Total number of juvenile coho captured weekly in the rotary screw trap, Blue Creek, lower Klamath River, California, 1996.

Table 17. Summary of juvenile coho captures in the rotary screw trap and frame net, Blue Creek, lower Klamath River, CA, 1989-1993.

	Coho YOY		Coho Yearlings	
Year	Screw Trap	Frame Net	Screw Trap	Frame Net
1989[1]	8	32	90	1
1990[2]	39	24	211	74
1991[2]	47	129	12	15
1992[3]	88	127	11	0
1993[4]	55	48	14	1
1995	1	0	0	0
1996	70	N/A	3	N/A

N/A = Not applicable

Sources:
[1] – Stern and Noble 1990
[2] – Gilroy et al. 1992
[3] – Chan and Longenbaugh 1994
[4] – Longenbaugh and Chan 1994

throughout the trapping season, with peak captures occurring in mid-June and early July (Table 11, Figure 35). Low capture numbers of age 1+ and older fish precludes any assessment of migration timing or peak capture during 1995. In addition, no attempt was made to assess the efficiency of either trap in capturing steelhead parr and smolts due to the low sample size. Based on capture numbers from the rotary screw trap, age 1+ and older steelhead continue to emigrate in low numbers through at least the early fall (Table 11).

The low capture of age 1+ and older steelhead is not necessarily indicative of low migrant numbers during the sampling period, but could be the result of the frame net's inefficiency at capturing and retaining larger juvenile salmonids. USFWS observed similar low capture of parr and smolt steelhead in their frame net(s) during 1989-1993 Blue Creek outmigrant monitoring (Chan and Longenbaugh 1994; Gilroy et al. 1992; Longenbaugh and Chan 1994; Stern and Noble 1990). USFWS speculated that larger fish are able to swim back out of the net, thereby evading capture. YTFP observed juvenile steelhead exiting the frame net on several occasions during 1995.

1996

During 1996, a total of 1,398 YOY and 559 age 1+ and older steelhead were captured in the rotary screw trap (Table 14). The first YOY was observed on April 2, with consistent captures occurring by the end of the month (Table 14, Figure 36). The peak YOY capture occurred during the week ending June 15 (n=152), with smaller peaks occurring from late May through the end of August (Table 14, Figure 36). We continued to capture age 0+ fish through the remainder of the trapping season, although numbers had declined by late September (Table 14, Figure 36).

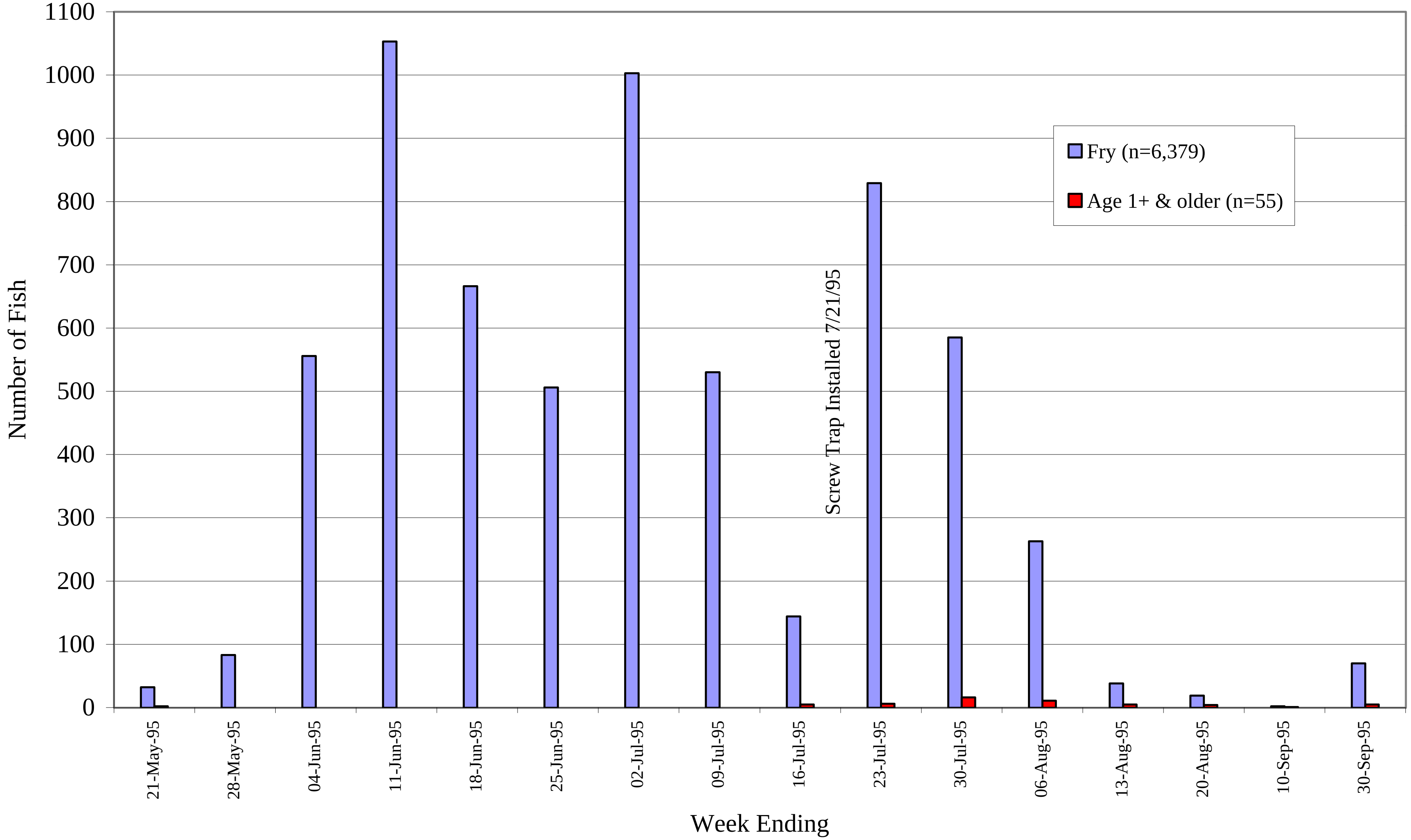


Figure 35. Total number of juvenile steelhead captured weekly in the frame net and rotary screw trap, Blue Creek, lower Klamath River, California, 1995.

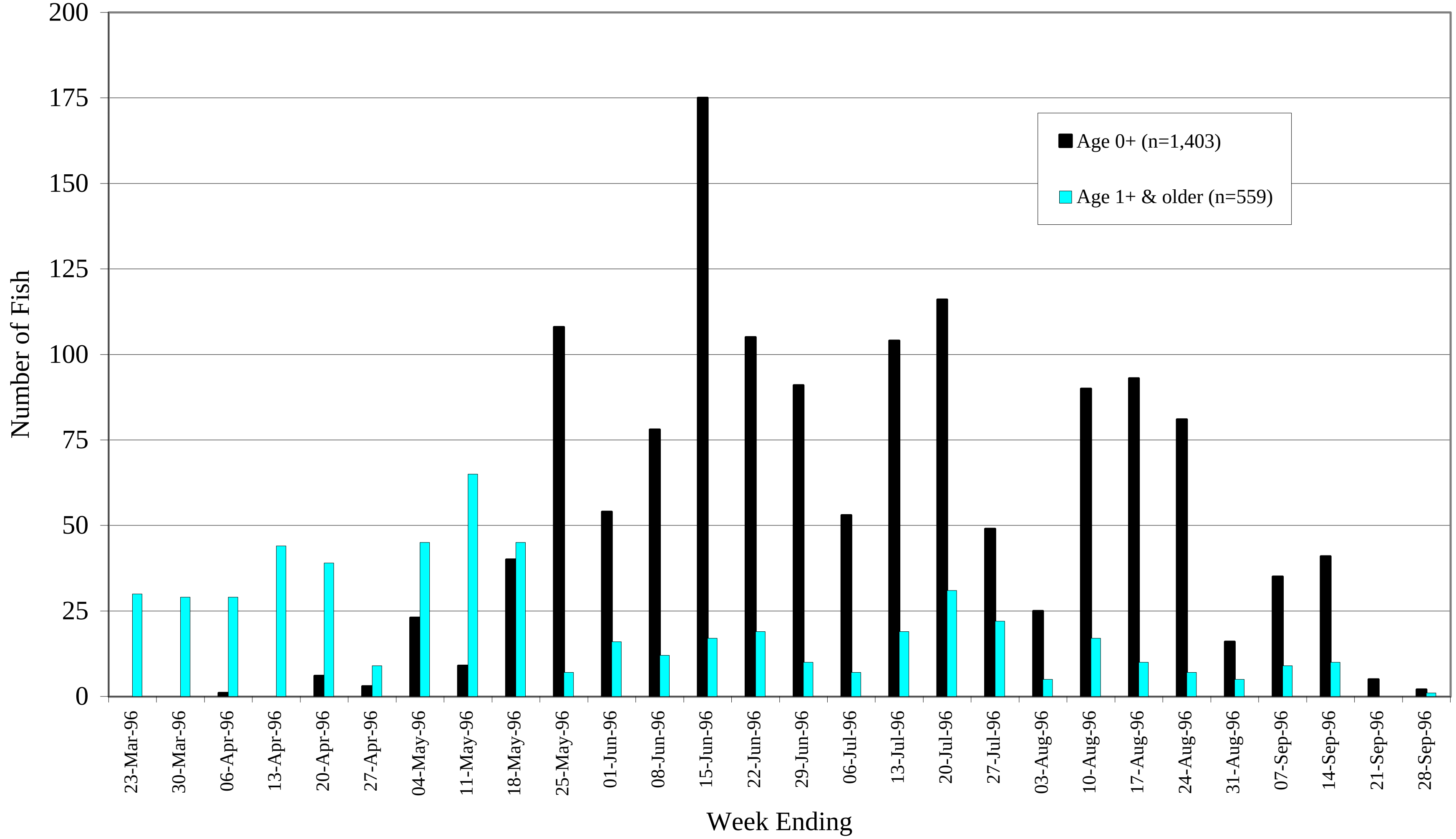


Figure 36. Total number of juvenile steelhead captured weekly in the rotary screw trap, Blue Creek, lower Klamath River, California, 1996.

Age 1+ and older steelhead were captured throughout the trapping season in fairly steady numbers (Table 14, Figure 36). Although age 1+ and older steelhead juveniles were consistently marked and released back upstream, 1996 recapture numbers were insufficient to provide meaningful trap efficiency estimates. Rotary screw trap efficiencies for steelhead parr and smolts have been shown to be significantly less than efficiencies for juvenile salmon species (Thedinga et al. 1994). In particular, trap efficiency for steelhead smolts was almost an order of magnitude less than the efficiency for chinook smolts. This difference was hypothesized to be the result of trap avoidance ability and differences in migratory behavior.

Steelhead trapping efficiencies likely increased as the trap season progressed for two reasons: 1) efficiencies for juvenile chinook progressively increased throughout the summer, and 2) declining streamflows allowed us to reposition the trap closer to the head of the pool where avoidance potential is presumably reduced. Since age 1+ and older capture numbers remained fairly constant throughout the season, this assumed efficiency increase would indicate that peak emigration occurred during the spring months. This peak emigration period would be consistent with peak parr and smolt timing reported by USFWS during their 1989-1993 Blue Creek outmigrant monitoring (Chan and Longenbaugh 1994; Gilroy et al. 1992; Longenbaugh and Chan 1994; Stern and Noble 1990).

Average fork length of sampled YOY steelhead remained fairly constant (30-35mm) from the date of first capture (April 2) through early July (Table 18, Figure 37). Average size then increased significantly each week through early August, before stabilizing and remaining constant (56-61mm) throughout the remainder of the season (Table 18, Figure 37). Virtually all YOY steelhead captured through early July appeared to be recently emergent fry, based on size and morphological characteristics. A similar trend was observed for YOY chinook emigrants (Figure 32), with the different size trends attributed to distinct emigrations of fry and fingerling chinook (Healey 1991).

Since steelhead typically smolt at age 1+ or older (Barnhart 1986), it is likely that these “emigrant” fry were actually dispersing from nearby spawning areas to less crowded/more preferential rearing habitat. The sudden increase in average size is indicative of a sudden change in capture from emergent fry to actively growing (and mobile) YOY. It is unclear why the increasing size trend abruptly stopped in early August.

Besides age 0+, steelhead were captured in three age classes throughout the trapping season, with age 1+ parr comprising the majority of sampled emigrants (Figure 38, Appendix A). Age 1+ and older fish ranged in size from 56-254mm throughout the season, with the majority of the age 3+ emigrants (≈190-260mm) having been captured by the middle of April (Figure 38, Appendix A). Age 1+ and 2+ steelhead continued to be captured throughout the season, although emigrants were dominated by the age 1+ fish, based on length-frequency analysis. The minimum size of sampled age 1+ fish progressively increased throughout the season, ranging from 56mm in March to 91mm during the month of August (Figure 38).

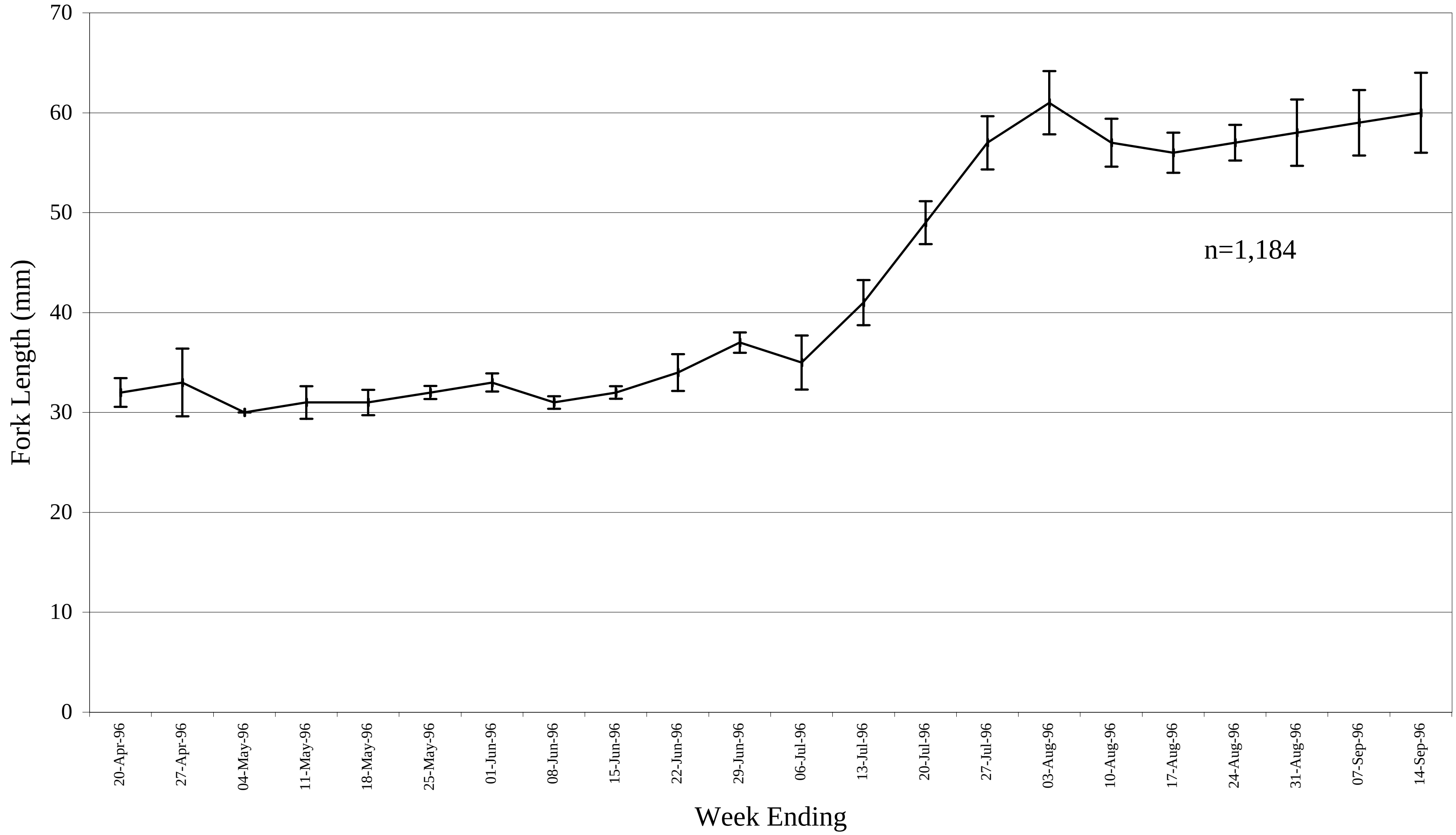


Figure 37. Mean weekly fork length (+/- 95% CI) of age 0+ steelhead sampled in the rotary screw trap, Blue Creek, lower Klamath River, California, 1996.

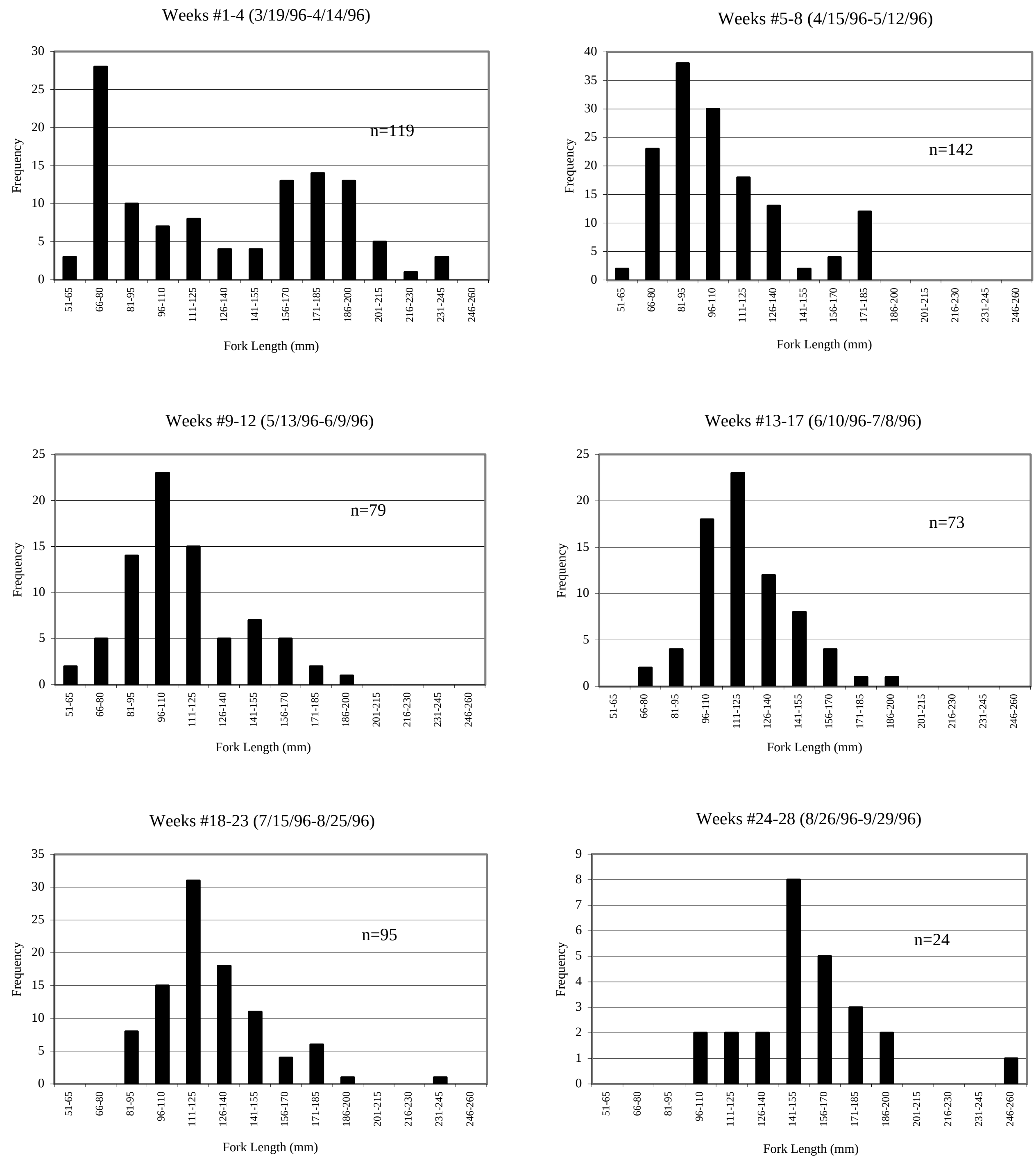


Figure 38. Length-frequency of age 1+ and older steelhead sampled in the rotary screw trap, Blue Creek, lower Klamath River, California, 1996.

Table 18. Weekly mean fork length, standard deviation, 95% confidence interval, and sample size of age 0+ steelhead captured in the rotary screw trap, Blue Creek, lower Klamath River, California, 1996.

Week Ending	Mean FL	S.D.	95% C.I.	# Sampled
4/7/96	30	0	-------	1
4/14/96		No Steelhead Captured		
4/21/96	32	1.79	1.43	6
4/28/96	33	3.46	3.39	4
5/5/96	30	0	-------	2
5/12/96	31	2.49	1.63	9
5/19/96	31	3.19	1.27	24
5/26/96	32	3.41	0.66	101
6/2/96	33	3.26	0.9	51
6/9/96	31	2.55	0.63	63
6/16/96	32	3.66	0.63	131
6/23/96	34	7.35	1.85	61
6/30/96	37	3.87	1.02	55
7/7/96	35	9.35	2.7	46
7/14/96	41	11.75	2.26	104
7/21/96	49	11.64	2.16	111
7/28/96	57	9.49	2.66	49
8/4/96	61	8.05	3.16	25
8/11/96	57	10.72	2.4	77
8/18/96	56	9.85	2	93
8/25/96	57	8.16	1.78	81
9/1/96	58	6.78	3.32	16
9/8/96	59	9.9	3.28	35
9/15/96	60	12.91	4	40
9/22/96		No Steelhead Captured		
9/29/96	82	16	22	2

Screw Trap Pulled 10/01/96

Dambacher (1991) deduced that a steelhead emigration which is dominated by pre-smolt fish is the result of either environmental pressures (i.e. waning streamflows) or, in the cases where downstream rearing conditions are superior to those present in the natal drainage, is a life history adaptation to maximize survival. In cases where downstream rearing areas might result in reduced survival for early emigrants, it would be expected that populations would have adapted to prolong their use of natal drainages until smoltification occurs (Dambacher 1991).

Although quantitative estimates of parr and smolt emigrant numbers were not produced in 1996, it appears that substantial numbers of Blue Creek steelhead outmigrate as presmolts. This is consistent with observations made by USFWS during their 1989-1993 Blue Creek outmigrant trapping efforts (Chan and Longenbaugh 1994; Gilroy et al. 1992; Longenbaugh and Chan 1994; Stern and Noble 1990). The mainstem Klamath is typically hampered by marginal water quality, while Blue Creek contains high quality rearing habitat throughout the year. Consequently, it seems unlikely that Blue Creek populations would have adapted to emigrate as parr in search of improved rearing conditions. This might indicate that environmental pressures such as overseeding of rearing areas and/or competitive interaction with large numbers of juvenile chinook may result in reluctant emigration from the basin.

Alternatively, parr emigrants could be migrating directly to the Klamath estuary. Once in the estuary, they could continue to rear until undergoing smoltification. During electrofishing and seining operations in the estuary in 1996 and 1997, CDFG has captured numerous juvenile salmonids, including steelhead, which bore a fin clip applied by YTFP during mark-recapture experiments (Wallace 1997, 1998). The sampled steelhead have ranged from 101-184mm during the two years of sampling, with the majority of the fish being ≤130mm. While it is unknown whether the clipped fish originated from Blue Creek or from outmigrant traps operated by YTFP in Hunter or McGarvey Creeks (Figure 1), this still indicates that “parr-size” steelhead from lower Klamath tributaries are utilizing the estuary for rearing habitat during the late spring and summer months.

4.4.4 Coastal Cutthroat Trout

No cutthroat trout were captured in either the frame net or the rotary screw trap during the 1995 trapping effort. During 1996, a total of seven cutthroat were captured in the rotary screw trap (Table 14). These fish, ranging in size from 116-455mm, were predominantly sampled during the summer months (Table 19). These low capture numbers are similar to those reported by USFWS during their 1989-1993 outmigrant trapping effort in lower Blue Creek. During this five-year span, no cutthroat were captured in 1989, 1991, or 1993, and only two were captured in 1990 (June) and a total of nine sampled in 1992 (May-July) (Longenbaugh and Chan 1994).

The majority of the 1996 fish were captured during the summer, when large numbers of adult cutthroat are typically observed entering lower Blue Creek (Gale 1996; Gale 1997b). The size and appearance of the trap-sampled fish was similar to diver observations of summertime immigrants, indicating the majority of the captured fish were likely new arrivals rather than outmigrants. Cutthroat trout typically emigrate from natal streams between February and June, with the peak movement in April and May (Lowry 1965; Sumner 1962; Trotter 1997; YTFP Hunter & McGarvey Creek preliminary data 1997).

Consistently low capture numbers since 1989 indicate that few coastal cutthroat trout actually spawn in Blue Creek and its tributaries. While cutthroat are a dominant component of the salmonid community in virtually all lower Klamath tributaries within

Table 19. Length and age summary of coastal cutthroat trout captured in the rotary screw trap, Blue Creek, lower Klamath River, CA, 1996.

Date	Fork Length (mm)	Age
14-Apr-96	116	1+
09-Jul-96	290	2+
17-Jul-96	405	3+
18-Jul-96	122	1+
29-Jul-96	230	1+
15-Aug-96	455	3+
04-Sep-96	234	N/A

N/A = Not Available

their range, only small numbers have been observed within the Blue Creek basin (Hayden 1998; Voight and Gale 1998). Cutthroat populations typically spawn in small drainages or in small tributaries of larger drainages, all of which are typically low gradient and have summer low flows that seldom exceed 10 cfs (Hartman and Gill 1968; Johnston 1982, as cited in Trotter 1997).

The large numbers of adult cutthroat observed every summer and fall in lower Blue Creek are likely seeking refuge from poor river conditions in the mainstem Klamath. Blue Creek is the only significant lower Klamath tributary within the cutthroat's range (downstream of Roaches Creek at rm 31.5) that maintains adequate summer streamflow to provide access to fish wishing to escape inhospitable conditions in the Klamath (Voight and Gale 1998). While homing ability to natal streams appears to be very precise (Trotter 1997), extensive straying has been documented for non-spawning fish seeking overwintering habitat in the vicinity of their natal stream (Giger 1972, as cited in Trotter 1997).

4.4.5 Other Species

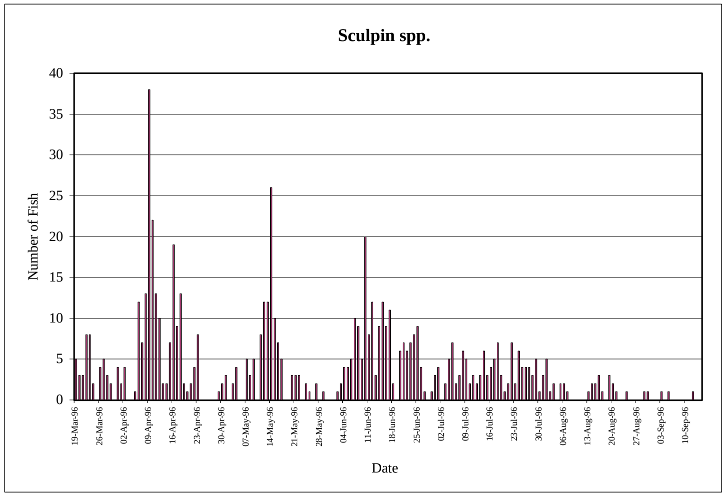
1995

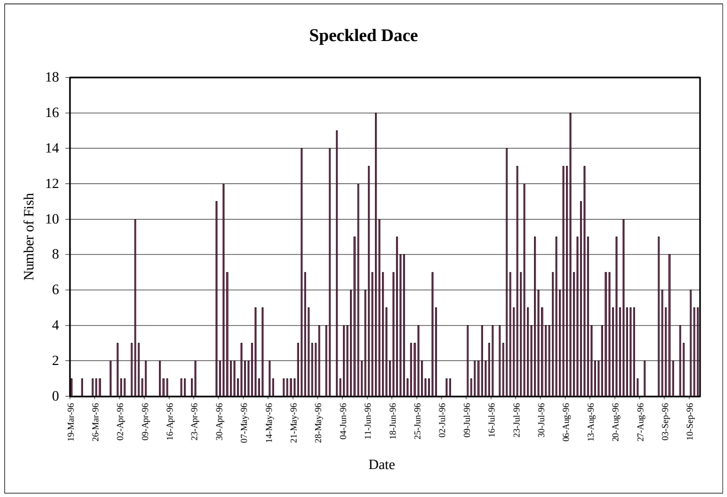
The following non-salmonid species were captured during 1995 outmigrant trapping efforts: sculpin (*Cottus* spp.), speckled dace (*Rhinichthys osculus*), threespine stickleback (*Gasterosteus aculeatus*), Klamath smallscale sucker (*Catostomus rimiculus*), Pacific lamprey adults and ammocoetes (*Lampetra tridentata*), Pacific giant salamander (*Dicamptodon ensatus*), foothill yellow-legged frog (*Rana boyleii*), western toad (*Bufo boreas*), western aquatic garter snake (*Thamnophis couchii*), and crayfish (*Pacifastacus* spp.).

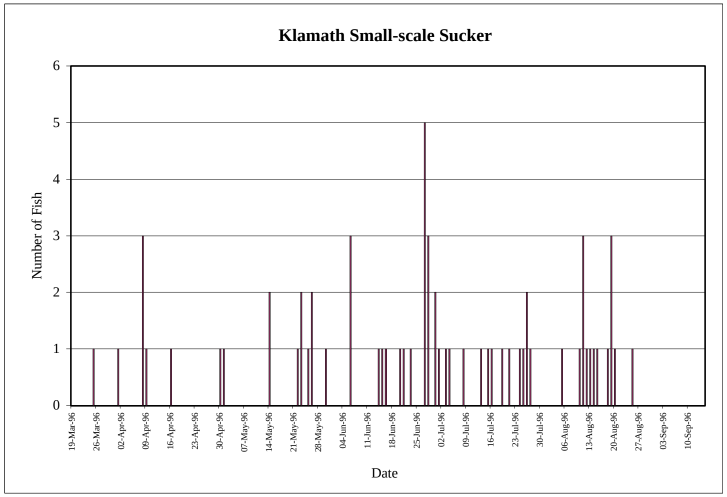
1996

Additional species captured in the rotary screw trap during 1996 included: prickly sculpin *(Cottus asper*), coast-range sculpin *(Cottus aleuticus*), speckled dace, threespine stickleback, Klamath smallscale sucker, Pacific lamprey adults and ammocoetes, foothill yellow-legged frog, and western rattlesnake *(Crotalus viridis*). A daily capture summary for sculpin (both species combined), speckled dace, Klamath smallscale sucker, and threespine stickleback are presented in Figure 39.

Plate 7. Prickly sculpin *(Cottus asper*) captured in the frame net,
Blue Creek, lower Klamath River, California, 1995.







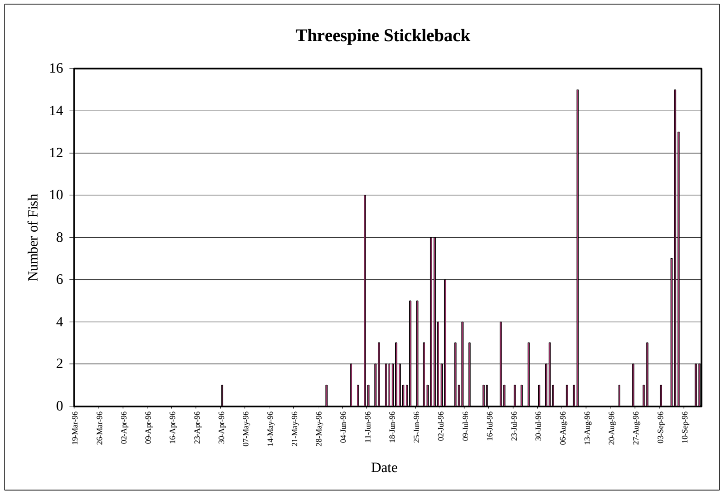


Figure 39. Capture summary for select non-salmonid fish species at the rotary screw trap, Blue Creek, lower Klamath River, California, 1996.

5.0 Recommendations

This project has refined our understanding of the life history periodicity of each anadromous salmonid species present in Blue Creek. In addition, we have identified specific portions of the basin that have particular importance to each of these life history stages. This improved understanding of anadromous salmonids has resulted in the formulation of restoration and management recommendations to protect and enhance the unique aquatic resources in this basin. Additionally, several recommendations have been generated to refine the project methodologies to improve and/or expand the generated trend assessment data.

5.1 Six Rivers National Forest Holdings

The Blue Creek mainstem is an important spawning area for chinook salmon throughout it length (downstream of the anadromous barrier). In addition, both coho and steelhead have been observed spawning in the mainstem at various locations during the course of this project, with more extensive usage presumed during their peak spawning periods. Juveniles of all species have been documented throughout the mainstem.

The Crescent City Fork, located exclusively within the Six Rivers National Forest (SRNF), also provides important spawning and rearing habitat for all anadromous species. In particular, the CCF consistently contained the highest concentration of rearing juvenile coho salmon in the basin. Snorkel surveys conducted by YTFP in fall 1997 (YTFP preliminary data) documented juvenile coho presence in over seven miles of the Crescent City Fork, with their abundance frequently outnumbering that of any other salmonid in upper drainage habitats.

Nickowitz and Slide Creeks, both located within SRNF, appear to be extensively utilized by spawning and rearing steelhead, with at least some limited use of Nickowitz Creek by chinook salmon.

The majority of the SRNF holdings are protected as part of the Siskiyou Wilderness Area (Figure 3), and therefore no management recommendations are necessary for this portion of the drainage. Nickowitz and Slide Creeks as well as the majority of the East Fork are all currently classified as Late Successional Reserve, with no land management activities planned in these areas in the near future. These portions of the drainage contain pristine fish habitat and are essential to the overall water quality in the basin. In order to provide long term connectivity with the remainder of the upper basin, we recommend that all existing roads in the LSR be decommissioned and this area be included into the Siskiyou Wilderness Area.

While the east slope of the Crescent City Fork is protected within the Wilderness Area, the west slope and a large portion of the headwaters are currently managed as Matrix land. Large portions of the timber in this area were previously harvested, and corresponding road networks remain. Given the importance of the CCF to coho salmon, an ESA-listed threatened species, it is not prudent for SRNF to consider any future timber harvesting or road construction within the CCF drainage. Therefore, it is recommended that USFS remove the unprotected portion of the CCF from the Matrix and designate it as an LSR or similar protected designation.

Since the SRNF portion of the Blue Creek basin is extremely remote and the aquatic habitat is relatively pristine, no instream restoration activities are warranted. It is however recommended that all USFS road networks within Blue Creek be inventoried and upgraded or decommissioned as appropriate.

5.2 Simpson Timber Company Holdings

Simpson Timber Company's property extends from Slide Creek downstream to the confluence with the Klamath River (reaches #1-3) (Figures 3, 6). Their property holdings include the West Fork in its entirety as well as the majority of Potato Patch Creek and the lower half-mile of Slide Creek. In addition, smaller tributaries such as Indian, Coyote, One Mile, and Pularvasar Creeks are located within Simpson's property boundaries.

The largest concentration of spawning chinook has consistently been observed in reach #2, with smaller numbers observed annually in reach #3. While spawning is typically limited in reach #1, this reach serves an important function as a migrational corridor between the Klamath River and upstream spawning areas. In addition to chinook, steelhead have been documented spawning in the lower basin and it is assumed that at least small numbers of coho also spawn in this portion of the drainage. The lower basin also contains a large quantity of deep pools and other habitat routinely used by adult salmonids for holding and cover during their migration to upstream reaches. Juveniles of all species utilize the lower three reaches as rearing habitat and an emigration corridor.

The West Fork has limited use in the lower mile by spawning and rearing chinook, with more extensive steelhead usage occurring throughout the majority of the basin. Lower Potato Patch Creek is populated by juvenile steelhead, with limited presence of juvenile chinook documented during summer 1997 (Hayden 1998).

Currently, hillslope and stream bank erosion is the largest threat to anadromous salmonids in lower Blue Creek. Sedimentation of spawning substrate appears minimal in mainstem reaches, presumably due to the flushing ability of Blue Creek's large annual peak flows. The alteration and/or reduction of deep pool habitat resulting from large bedload movement, however, could reduce the value of these reaches as holding and rearing habitat for anadromous salmonids. Long-term channel monitoring is required to determine channel stability in the basin.

In order to reduce the potential of future hillslope erosion, it is recommended that all roads within lower Blue Creek and its tributaries be inventoried to assess failure potential. Once these inventories are completed, all roads should be upgraded or decommissioned as necessary. In order to reduce the potential for stream bank failure, it is recommended that all future timber harvest activities in lower Blue Creek and its tributaries incorporate adequate no-cut stream buffers. These buffers would also aid in maintaining long-term sources of large woody debris for recruitment to the stream channel.

5.3 Project Methodology Refinement

5.3.1 Spawning Surveys

It is recommended that reaches #1-4 be surveyed over a maximum period of 1-2 days. This reduced time frame will aid in minimizing the amount of inter-reach fish movement that might occur between surveys of adjacent reaches. In addition, this will reduce the possibility that adverse weather and/or stream conditions will occur prior to the completion of the index reach dives during a given week. It is also recommended that reaches #5-9 be surveyed on a bi-weekly basis, with all surveys occurring during the same week. This will result in bi-weekly enumeration throughout the chinook portion of the basin. Previous surveys of reaches #5-9 either were sporadic (1995) or were conducted on alternating weeks (1996). While useful in expanding knowledge of fish presence and habitat use throughout these reaches, these surveys did not allow an assessment of total basin fish numbers in conjunction with concurrent reach #1-4 surveys for the same time period.

It is recommended that reach #7 (CCF) be expanded by accessing via the USFS road #14N01C. This expansion will increase the length of reach #7 from 1.85 miles to 3.5 miles and, in conjunction with reach #6, will provide access to virtually all of the anadromous-accessible portion of the CCF drainage. This expansion will allow YTFP to better monitor the distribution of spawning and rearing salmon in the upper portion of this tributary. In addition, it is recommended that YTFP attempt to continue surveys of reaches #6-7 into the winter so as to better enumerate coho during their peak spawning period. These extended surveys may be feasible in some years due to the smaller size of this drainage and its typically clear-flowing water.

In order to continue collecting data on salmonid spawning during years when high flows cause an early cessation of snorkel surveys (i.e. 1996), it is recommended that YTFP attempt to conduct carcass and redd surveys via raft or inflatable kayak until adequate snorkel conditions return. Access via boat would allow surveying over larger and more remote areas than can be covered via bankside surveying.

5.3.2 Outmigrant Trapping

It is recommended that the outmigrant trapping be initiated by mid-February when feasible. This would allow for a complete assessment of chinook emigration, including early fry migrants. In addition, this early start would provide an opportunity to monitor the magnitude of early season steelhead and coho emigration. The planned construction of a more "permanent" bridge by Simpson will improve access to the trap site during the winter months.

The use of a Pan-Jet marker is recommended to increase the diversity of marks while minimizing the potential to overlook marks when checking for recaptured fish. There presently is some concern that crews may occasionally overlook less distinct marks (i.e. pelvic fin clips), particularly on smaller chinook. The use of such a marking device will enhance identification of fish from a given marking period, while reducing the positive bias associated with the failure to document all recaptured fish.

Survival tests of marked fish should be conducted for each species throughout the trapping season. Marked fish should be held in protected pens for 24 hours after marking and prior to release upstream of the trap. These tests would provide a mortality rate for fish subjected to the handling and marking process, providing increased confidence in the generated trapping efficiencies. Previously no such tests have been conducted, resulting in the need to assume a survival rate of 100%.

It is recommended that a more efficient trap be used in order to provide a means of quantifying steelhead and coho emigrants. At present, our screw trap is inefficient during the spring months, capturing inadequate numbers of these species for mark-recapture. A larger screw trap could be employed, although insufficient capture may still occur during high flow periods. In addition, a larger diameter screw trap will be more likely to "bottom out" as flows recede during summer months. An alternative to the rotary traps is the large incline plane traps operated by the Washington Department of Fisheries in several coastal rivers throughout western Washington. These traps sample a substantially larger cross-section of the stream channel than the rotary traps and are considerably more durable. These traps can operate effectively under higher flow and debris-load conditions than the rotary traps, as well as having the adjustment ability to sample a wide range of stream depths. It is expected that such a trap could effectively capture a large percentage of the emigrants of all species and age classes. Such capture numbers would provide the means to generate meaningful trap efficiencies throughout the season for all salmonid emigrants.

5.3.3 Stream Discharge Monitoring

Previous discharge estimates have only been possible during the outmigrant trapping season due to the need to manually check the stream gage on a daily basis. In order to provide discharge estimates throughout the year, as well as more accurately monitor peak flows, it is recommended that a permanent gaging station be installed in lower Blue Creek. Such a station would include an automatic gage height recorder, which not only would eliminate the need to manually check the gage, but also would provide gage readings on a set interval (i.e. hourly). This would minimize the likelihood that short-term peak increases are overlooked.

5.3.4 Water Temperature Monitoring

To effectively monitor water temperature throughout the basin, we recommend that efforts be expanded both temporally and spatially. The lower Blue Creek temperature logger should be operated continuously due to access ease and the ability to maintain and download the recorders throughout the winter. The remaining loggers should be operated from late April until early October in order to monitor temperature throughout the summer period. In addition to the recorders placed in the upper and lower mainstem, CCF, and Nickowitz Creek, loggers should be placed in both Slide Creek and the West Fork. These locations will permit temperature monitoring in all major Blue Creek tributaries with anadromous access.

Plate 8. View of the lower end of the "Blue Creek Gorge", located immediately upstream of the East Fork confluence and approximately 1/2 mile upstream of the anadromous barrier, Blue Creek, lower Klamath River, California, 1996.

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Appendix A. Summary of age, fork length, and capture date of juvenile steelhead captured in the rotary screw trap, Blue Creek, lower Klamath River, California, 1996.

Date	Species	Fork Length (mm)	Age
7/12	Steelhead	58	0+
7/12	Steelhead	58	0+
7/15	Steelhead	54	0+
7/15	Steelhead	54	0+
7/15	Steelhead	56	0+
7/15	Steelhead	58	0+
7/15	Steelhead	59	0+
7/15	Steelhead	65	0+
7/15	Steelhead	65	0+
7/16	Steelhead	54	0+
7/16	Steelhead	63	0+
7/17	Steelhead	54	0+
7/17	Steelhead	55	0+
7/17	Steelhead	55	0+
7/17	Steelhead	58	0+
7/17	Steelhead	60	0+
7/17	Steelhead	60	0+
3/19	Steelhead	95	1+
3/20	Steelhead	99	1+
3/25	Steelhead	86	1+
3/26	Steelhead	84	1+
3/26	Steelhead	89	1+
3/26	Steelhead	97	1+
3/30	Steelhead	87	1+
3/31	Steelhead	84	1+
4/2	Steelhead	112	1+
4/5	Steelhead	100	1+
4/6	Steelhead	106	1+
4/8	Steelhead	96	1+
4/9	Steelhead	118	1+
4/12	Steelhead	84	1+
4/13	Steelhead	86	1+
4/13	Steelhead	95	1+
4/14	Steelhead	85	1+
4/15	Steelhead	98	1+
4/15	Steelhead	98	1+
4/15	Steelhead	125	1+
5/2	Steelhead	118	1+
5/4	Steelhead	116	1+
5/8	Steelhead	101	1+
5/9	Steelhead	105	1+
5/9	Steelhead	108	1+
5/9	Steelhead	114	1+
5/9	Steelhead	114	1+
5/9	Steelhead	116	1+
5/10	Steelhead	110	1+
6/15	Steelhead	119	1+
6/17	Steelhead	114	1+
6/17	Steelhead	117	1+
7/14	Steelhead	87	1+
7/15	Steelhead	115	1+
7/15	Steelhead	121	1+
3/19	Steelhead	185	2+
3/20	Steelhead	139	2+
3/24	Steelhead	150	2+
3/24	Steelhead	151	2+
3/24	Steelhead	167	2+
3/24	Steelhead	195	2+
3/25	Steelhead	121	2+
3/26	Steelhead	167	2+
3/26	Steelhead	200	2+
3/30	Steelhead	202	2+
3/31	Steelhead	172	2+
4/2	Steelhead	180	2+
4/4	Steelhead	195	2+
4/5	Steelhead	182	2+
4/5	Steelhead	192	2+
4/6	Steelhead	133	2+
4/6	Steelhead	153	2+
4/6	Steelhead	167	2+
4/7	Steelhead	174	2+
4/7	Steelhead	180	2+
4/8	Steelhead	189	2+
4/9	Steelhead	163	2+
4/9	Steelhead	174	2+
4/10	Steelhead	173	2+
4/10	Steelhead	176	2+
4/10	Steelhead	181	2+
4/12	Steelhead	160	2+
4/12	Steelhead	166	2+
4/13	Steelhead	160	2+
4/14	Steelhead	158	2+
4/14	Steelhead	198	2+
4/15	Steelhead	163	2+
4/15	Steelhead	186	2+
4/20	Steelhead	178	2+
4/23	Steelhead	190	2+
5/3	Steelhead	131	2+
5/3	Steelhead	132	2+
5/4	Steelhead	140	2+
5/5	Steelhead	149	2+
5/5	Steelhead	176	2+
5/5	Steelhead	185	2+
5/5	Steelhead	205	2+
5/8	Steelhead	135	2+
5/8	Steelhead	172	2+
5/8	Steelhead	181	2+
5/10	Steelhead	166	2+
5/13	Steelhead	166	2+
5/14	Steelhead	156	2+
5/14	Steelhead	169	2+
5/15	Steelhead	184	2+
5/26	Steelhead	165	2+
6/1	Steelhead	153	2+
6/14	Steelhead	141	2+
6/17	Steelhead	136	2+
6/17	Steelhead	140	2+
6/17	Steelhead	168	2+
6/22	Steelhead	162	2+
7/1	Steelhead	198	2+
7/5	Steelhead	150	2+
7/12	Steelhead	174	2+
7/15	Steelhead	137	2+
7/15	Steelhead	181	2+
3/22	Steelhead	198	3+
3/24	Steelhead	232	3+
3/27	Steelhead	195	3+
4/7	Steelhead	192	3+
4/12	Steelhead	204	3+