ASSESSMENT OF ANADROMOUS SALMONID SPAWNING IN BLUE CREEK, TRIBUTARY TO THE LOWER KLAMATH RIVER, DURING 2010

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Acknowledgments

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1.0 Introduction

The Klamath River Basin historically contained bountiful anadromous fish runs, supporting indigenous peoples throughout the region. Over the last 150 years, anthropogenic activities coupled with natural events have resulted in a widespread reduction and degradation of freshwater salmon habitat causing substantial declines in anadromous salmon runs. The Lower Klamath Sub-basin, which encompasses all tributaries downstream of the Trinity River confluence (river mile (rm) 43.75), has been the site of 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 (Gale and Randolph 2000). Concern over diminishing runs resulted in the 1997 listing of Klamath Basin coho salmon (*Oncorhynchus kisutch*) as threatened under the Endangered Species Act (ESA). Klamath River chinook salmon (*O. tshawytscha*), steelhead (*O. mykiss*) and coastal cutthroat trout (*O. clarki clarki*) populations were also petitioned for ESA listing, and despite the listings being determined "Not Warranted", concern continues to exist over their status and long-term trends.

Blue Creek is the largest and most pristine tributary to the Lower Klamath and supports the largest proportion of anadromous fish populations in the Sub-basin. Monitoring of returning adult Chinook was initiated in 1988 by the United States Fish and Wildlife Service (USFWS) out of concern for the proposed collection of broodstock for small-scale aquaculture activities in the Lower Klamath Sub-basin.The USFWS continued monitoring for five years to evaluate the status of Blue Creek chinook populations (Chan and Longenbaugh 1994). The Yurok Tribal Fisheries Program (YTFP) assumed responsibility of all monitoring and assessment activities throughout the lower Klamath Sub-basin in 1994.The YTFP has continued long-term monitoring of Blue Creek anadromous salmonid populations since 1995 using direct observation snorkel survey methodology initiated by USFWS to assess population trends in Blue Creek.

The primary objectives of this project were to: 1) continue direct observation snorkel surveys and 2) implement mark/recapture techniques using an Area Under the Curve (AUC) methodology to generate an escapement estimate and stream residence times for chinook salmon. The results will contribute to long-term population assessment efforts and provide a means of assessing population trends in Blue Creek, as well as enhance our knowledge of the life history of Blue Creek fish populations. In addition, the results of this project will allow managers to assess Blue Creek's contribution to the overall Klamath Basin chinook salmon run, which is managed for tribal subsistence, commercial, and sport fishing. Continuation of this monitoring effort will further enhance our understanding of the magnitude and importance of Blue Creek's fish runs in the Klamath Basin.

2.0 Study Area

Blue Creek is a fourth order drainage that enters the Lower Klamath River at rm 16.1 (Figure 1). The headwaters originate in the Chimney Rock and 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 43.5). The drainage is steep and mountainous with moderate to high channel confinement present throughout the basin (Gale 2009). 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) between 1965 and 1978 indicate large seasonal flow variations, and records during this period ranged from 43 cubic feet per second (cfs) on November 1, 1965 to 33,000 cfs on March 2, 1972. Flows during the extreme flood event of December 22, 1964, although outside the period of record, were 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).

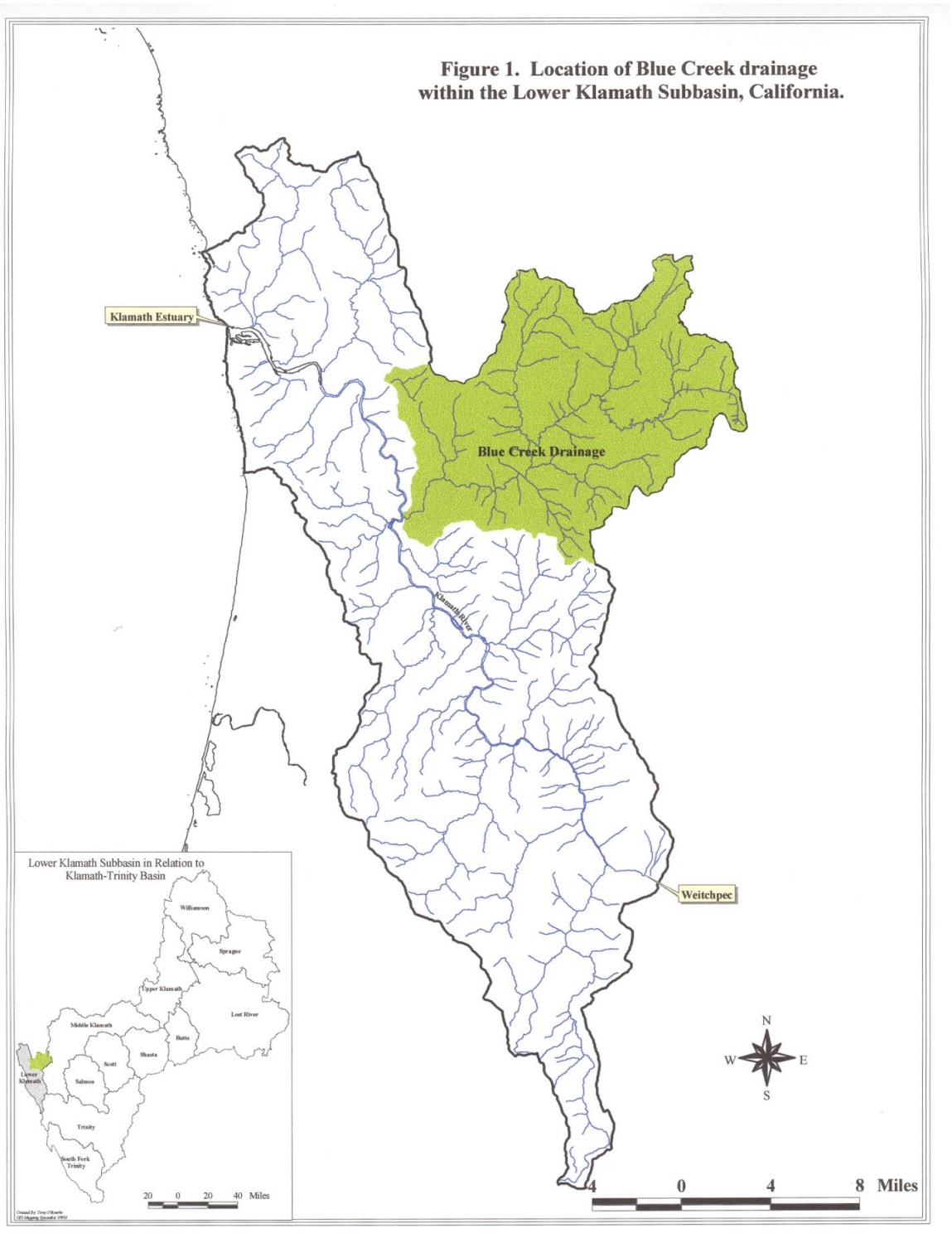
Figure 1. Location of Blue Creek drainage within the Lower Klamath Subbasin, California.
Klamath Estuary
Blue Creek Drainage
Klamath River
Weitchpec
N
W
E
S
4 0 4 8 Miles
Lower Klamath Subbasin in Relation to Klamath-Trinity Basin
Williamson
Sprague
Upper Klamath
Lost River
Middle Klamath
Butte
Shasta
Scott
Lower Klamath
Salmon
Trinity
South Fork Trinity
20 0 20 40 Miles

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A natural barrier on the mainstem of Blue Creek is located at rm 15 approximately 0.25 miles below the confluence of the East Fork (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 the 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.

Three tributaries to Blue Creek have been identified as important for anadromous salmonid spawning and rearing and comprise 41% of the watershed area (West Fork Blue Creek, Nickowitz Creek, and Crescent City Fork Blue Creek). The Crescent City Fork is the largest and lowest gradient tributary accessible to anadromous fish,and and both salmon and steelhead extensively utilize the tributary (Figure 2). Small numbers of salmon have previously been documented spawning in the lowermost mile of the West Fork (Gale et al. 1998; Longenbaugh and Chan 1994), with steelhead extensively utilizing the majority of the tributary (Hayden 1998; Voight and Gale 1998). To date, only a small number of juvenile and adult salmon have been observed in Nickowitz Creek, but juvenile steelhead have been observed extensively throughout the tributary (Hayden 1998; Voight and Gale 1998). A fourth tributary, Slide Creek, has also shown importance for steelhead populations. Slide Creek has a steep gradient near its mouth, but the lower two miles have consistently supported three age classes of juvenile steelhead (YTFP unpublished survey data).

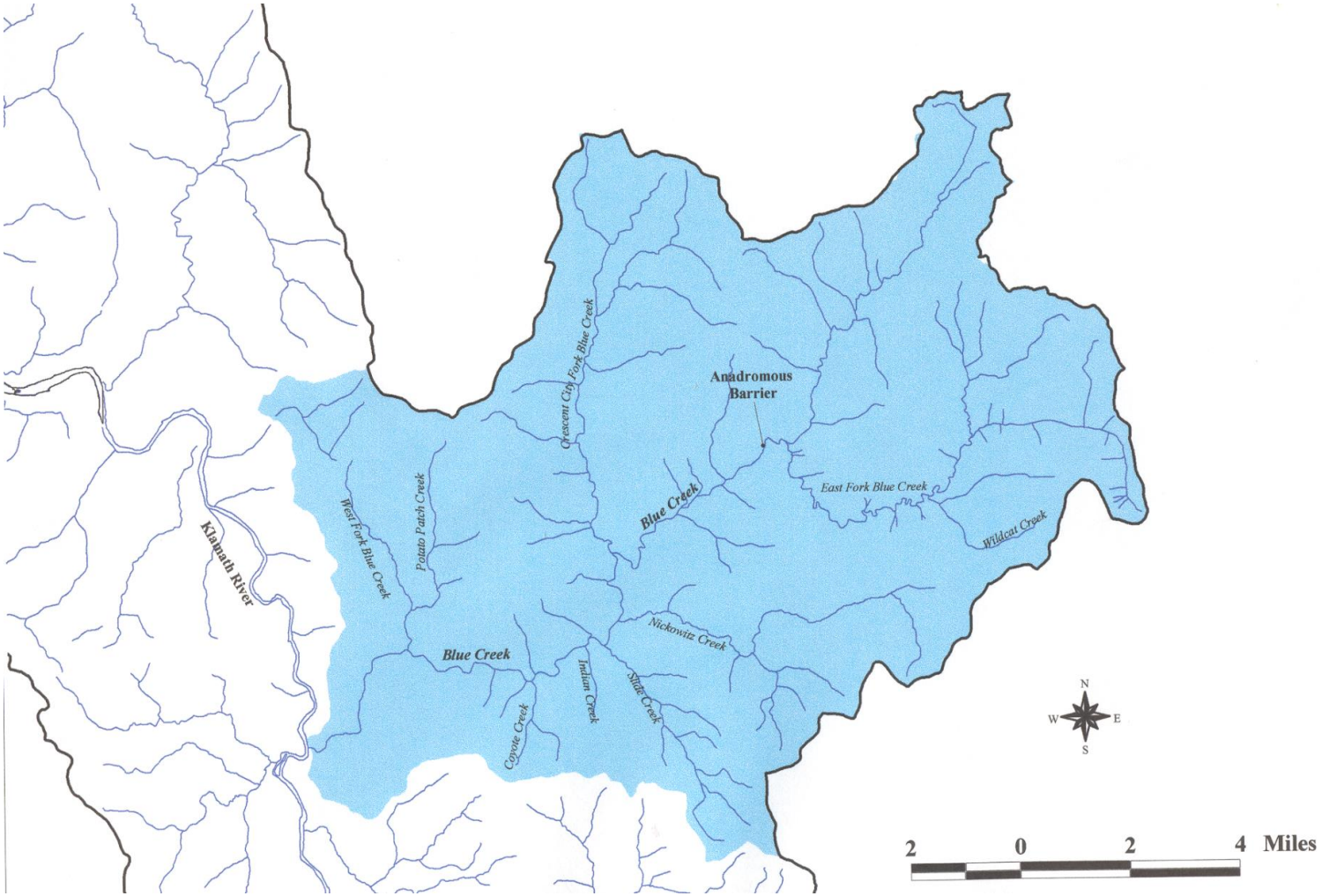

Figure 2. Blue Creek drainage, Lower Klamath River, California.

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*). 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.

The two major landowners of the Blue Creek drainage are Green Diamond Resource Company (GDRC – formerly Simpson Timber Company) and the United States Forest Service (USFS). Green Diamond Resource Company owns the land surrounding the lower 8.1 miles of Blue Creek, and continues to manage their lands for timber production. Upstream of GDRC property, the creek runs through USFS land managed by the Six Rivers National Forest (SRNF), which is almost entirely included in the Siskiyou Wilderness Area. Portions of the Crescent City Fork are not included in the Siskiyou Wilderness and are classified as "Matrix land", which are defined as all land outside of the Reserves and "Congressionally Withdrawn Areas" (i.e. Wilderness Areas) and are subject to timber harvest activities (FEMAT 1993).

Access to Blue Creek is limited in the lower reaches is limited to and regulated by GDRC, and access to the upper drainage is remote and inaccessible in some reaches during winter months. An arterial logging road maintained by GDRC parallels the southern side of Blue Creek several hundred feet above the creek from rm 2.1 to 6.0. This main road (GDRC Road #B-10) crosses Blue Creek at river mile 2.1, providing the only bridge crossing in the basin. Infrequently used roads branch off this maintained road, providing additional vehicle and/or ATV streamside access at rm 1.4, 5.6, and 8.1.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 anadromous barrier. Foot access to the stream channel from these roads is difficult due to steep terrain and dense vegetation. Use of these access points typically require survey crews to exit the channel via the GDRC road network beginning at rm 8.1 or via a foot trail to the South Red Mountain Road (USFS road #13N34).

3.0 Methods & Materials

3.1 Fall Spawning Surveys

The Yurok Tribal Fisheries Program conducted snorkel surveys from early October through mid-November 2010 to assess salmonid spawning activity. Diving in 2010 was limited by precipitation that resulted in unsuitable stream conditions for diving. Spawning survey data collection methods remained consistent throughout the survey period. All surveys were conducted using direct observation (mask and snorkel) techniques until heavy fall/winter rains resulted in ineffective and/or unsafe sampling conditions.

3.1.1 Equipment

All spawning surveys utilized direct observation methodology during snorkel surveys. Snorkel surveys required the use of either a full 7mm neoprene wetsuit or drysuit, dive hood, gloves, and mask/snorkel. Additionally, all crew members wore felt-soled stream boots for added traction on wet, slippery surfaces, and carried waistpack dry bags containing data collection kits. Data collection kits included flagging, a field notebook, markers, underwater camera, reach maps, datasheets, scale envelopes, and a small knife to collect scale samples.

3.1.2 Snorkel Survey Methods

The YTFP assumed responsibility of Blue Creek spawner surveys in 1994. For consistency and logistical reasons, reaches #1-4 were based on reaches established by USFWS during their 1989-1993 snorkel surveys. Surveys between 1994 – 1996 were limited to weekly surveys of the lower four reaches. Between 1995 and 1998, in an effort to provide a more comprehensive basin-wide coverage, YTFP extended spawning survey efforts to include an additional 13.1 miles of the Blue Creek drainage, which included the upper portion of the mainstem (between reach #4 and the anadromous barrier), the Crescent City Fork, Nickowitz Creek and West Fork Blue Creek (Figure 3). Surveys were conducted weekly (weather and flows permitting) in reaches #1-4 during the fall spawning season, which is typically initiated in late September or October prior to the arrival of late-fall chinook and continued until heavy rains commence and flow conditions became unsafe and/or unsuitable for snorkel surveys. Surveys in the upper reaches were typically surveyed bi-weekly after the first fall chinook appeared in Lower Blue Creek (Gale 2009).

YTFP conducted snorkel surveys over seven weeks in 2010, beginning the week of 05-Oct-10 through 17-Nov-10 (Table 1). Surveys in reaches #1 and #2 were conducted weekly with the exceptions of the weeks of 11-Oct-10 and 25-Oct-10 due to high flows and poor water visibility, for a total of five surveys. Surveys in reaches #3 and #4 were conducted for the first three weeks of November 2010, with a total of three surveys each. The upper mainstem Blue Creek (reach #5) and Crescent City Fork (reach #6) were each surveyed once during the season (16-Nov-10). The upper Crescent City Fork (reach #7), the West Fork, and Nickowitz Creek were not surveyed in 2010 due to the short window of suitable weather for diving.

In 2010 the study period for this project was shortened due to an extremely high rainfall season (Figure 3). In past years in order to encompass the majority of the chinook salmon run YTFP has aimed to conduct surveys from early October until as late into December as weather allows, with surveys spanning an average of 10.6 weeks (1999-2009). Surveys in 2010 spanned seven weeks, with surveys occurring during five of these weeks. Ideal conditions for snorkel surveys in Blue Creek exist when stream discharge is between 200 and 500 cfs. Above this range visibility conditions decrease rapidly due to increased turbidity and bubbles curtains, which in combination with increased swimming speed can compromise diver safety and count accuracy. Streamflow estimates during the study period ranged between 75 – 1826 cfs, and 14 inches of rain were recorded. Water temperatures during the survey period ranged between 9.5 – 12.1°C. (Yurok Tribe Environmental Program, Blue Creek Gaging Station unpublished data)

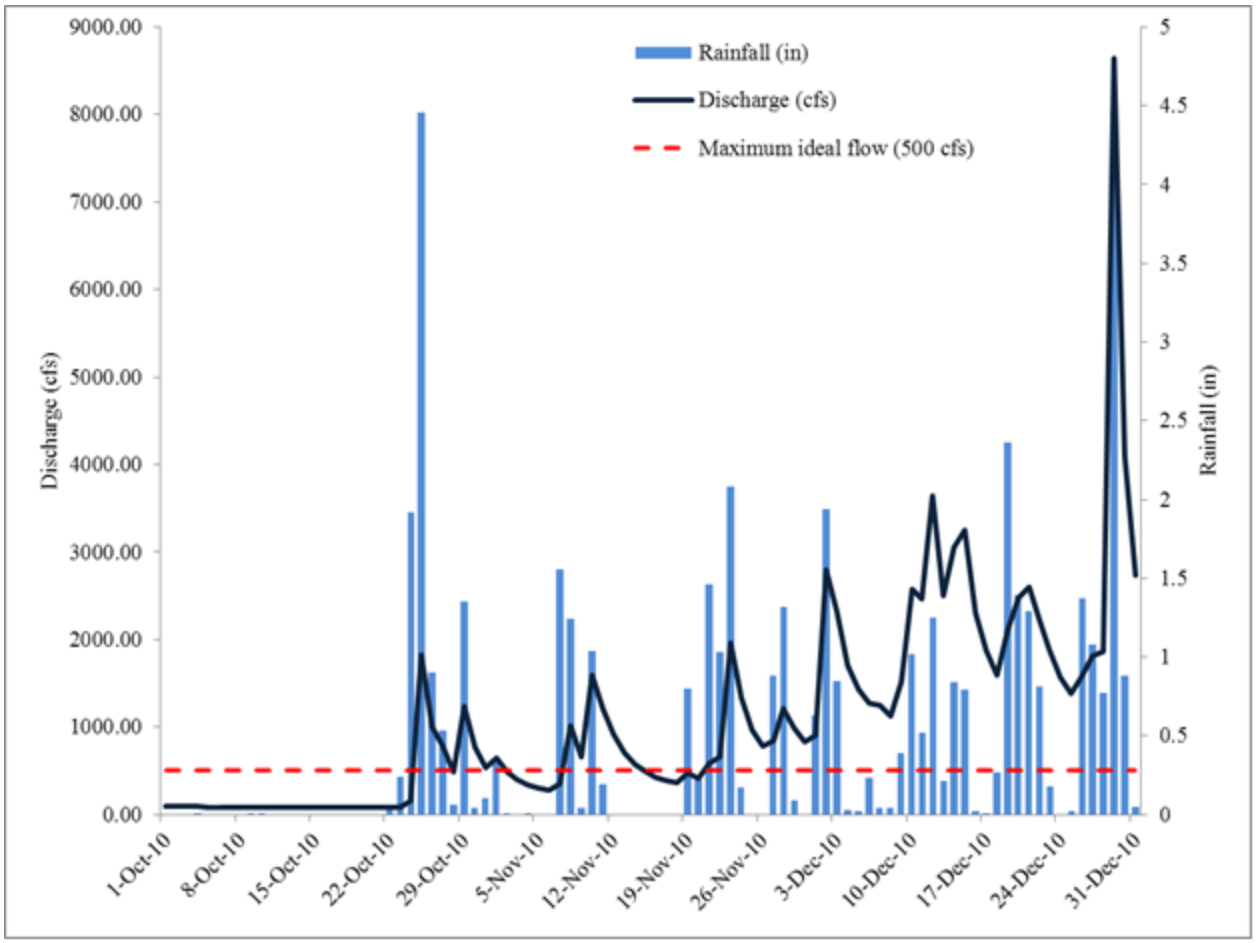

Figure 3. Discharge, precipitation, and maximum ideal flow for snorkel surveys during fall/winter 2010, Blue Creek, Klamath, California.

Snorkel survey crews, consisting of two to four 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 resulted in unsuitable snorkeling conditions, surveys were postponed until conditions improved. In order to maximize consistency between surveys, crews followed specific data collection protocols:

1) ***Redds***. Each identified "area" of redd construction was assigned a location number ("R-#") and its geographical location was 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. 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 recorded the estimated age class (adult vs. jack), sex, and relative condition of observed fish, as well as the presence of any clips, marks, or scars when possible. Oftentimes, factors such as fluctuating stream-flow and water visibility, large schools of fish, and/or swiftly darting fish frequently limited such detailed data collection..

3) ***Carcasses***. The location of each observed carcass 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" or spawned out, the relative condition, and any identifying clips, marks or scars. A scale sample was collected from each carcass when possible. A piece of flagging with the date was attached to each carcass so that it would not be recounted during subsequent surveys. Heads were collected from all adipose-clipped carcasses for coded-wire tag retrieval to determine hatchery origin.

Reach delineations are as follows (Figure 4):

- **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).

- **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 # 13N34A trail access and the USFS Road #14N01C trail access (total length: 3.5 miles).

- **Reach #7b**:

Unnamed tributary to the CCF ("Doctor Rock Creek") – enters the CCF in T13N, R3E, NE ¼ Section 9 (total length: 0.75-1.0 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).

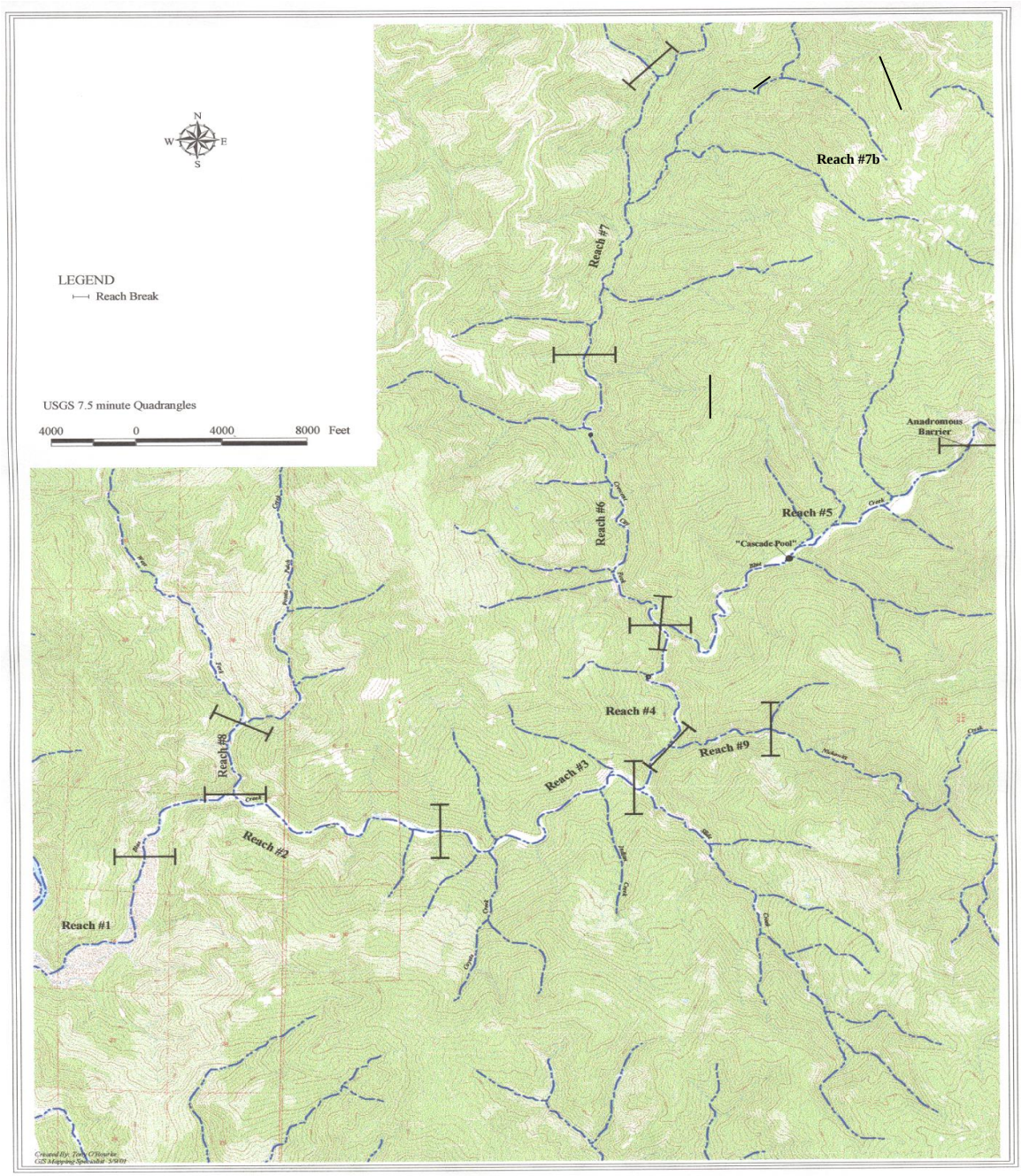

Figure 4. Location of adult spawner survey reaches in Blue Creek, Lower Klamath River, California.

3.2 Salmon Capture and Tagging

Adult salmon were captured to collect age, sex, and length data using either angling gear or a tooth tangle net. Pools in the lower reaches of Blue Creek were targeted due to access and the ability to sample fish prior to their arrival at their spawning grounds. Divers initially snorkeled pools to determine fish abundance, after which time a 3.5" mesh tooth tangle net was deployed in pools selected by divers. Divers herded fish into the nets by swimming upstream from the pool tailout. Captured fish were immediately placed into holding tubes, and when fishing efforts were exhausted, all fish were measured, sexed, tagged, assigned an identifying number and released.

Adult salmonids were tagged with highly visible streamer tags on their dorsal fins to estimate residence times. White 'spaghetti' floy tags were applied to adult salmonids in addition to Hi-Viz Artic Flagging, which included capture/tag date and fish identification number clearly marked on it. Floy tags were inserted through the posterior end of the dorsal fin using a 6" long by 1/8" diameter hollow needle. Hi-Viz Arctic Flagging was then attached to the Floy tag using a square knot, with 4-8"of flagging trailing behind the knot. The color of the flagging was changed weekly, and all tagged fish were marked with a hole punch in the anal fin as a secondary mark.

4.0 Results & Discussion

4.1 Spawning Surveys

The number of chinook observed during the study period varied throughout the study period. During the first two survey weeks no chinook were observed, and in the following week of 1-Nov-10 a peak count of 790 adults and 134 jacks occurred (Table 1, Figure 5). This peak is comparable to peak counts of 1029 in 2009 and 1121 in 2003. The peak was followed by 224 chinook observed in the week of 8-Nov-10, and 1011 in the week of 15-Nov-10 (including fish from reaches 5 and 6, only surveyed once and not included in peak counts).

A peak of 14 adult coho salmon were observed in the week of 15-Nov-10, with 19 total observed over the study period. Adult and half-pounder steelhead were observed regularly throughout the study period, and a peak count of one adult and 93 half-pounders occurred during the first week of surveys (5-Oct-10), though a similar count of five adults and 88 half-pounders occurred in the week of 1-Nov-10. In this same week a peak of three coastal cutthroat trout adults were observed; only four were observed throughout the study period.

Redds were not observed until the final two weeks of surveys, with nine observed the week of 8-Nov-10, and 61 in the week of 15-Nov-10. Reach 2 contained the most redds (n=16), and the number of redds in the remaining reaches ranged from two to 13. Only five carcasses were retrieved during surveys.

Table 1. Summary of adult salmonids, redds, and carcasses observed by reach during snorkel surveys, Blue Creek, Lower Klamath River, California, 2010.

		Chinook		Coho		Steelhead		Adult	New	
Date	Reach	Adult	Jack	Adult	Jack	Adult	1/2 pounder	Cutthroat (>12")	Redds	Carcasses
5-Oct-10	1	0	0	0	0	0	53	1	0	0
5-Oct-10	2	0	0	0	0	1	40	0	0	0
	Total	0	0	0	0	1	93	1	0	0
18-Oct-10	1	0	0	0	0	0	35	0	0	0
18-Oct-10	2	0	0	0	0	0	50	0	0	0
	Total	0	0	0	0	0	85	0	0	0
3-Nov-10	1	139	15	0	0	0	18	1	0	1
4-Nov-10	2	406	24	0	0	0	30	0	0	0
4-Nov-10	3	95	29	0	0	4	25	2	0	0
5-Nov-10	4	150	66	3	0	1	15	0	0	0
	Total	790	134	3	0	5	88	3	0	1
12-Nov-10	1	11	1	2	0	0	0	0	0	0
12-Nov-10	2	62	17	0	0	0	20	1	6	0
12-Nov-10	3	46	9	0	0	0	0	0	3	0
12-Nov-10	4	63	15	0	0	0	0	0	0	0
	Total	182	42	2	0	0	20	1	9	0
17-Nov-10	1	137	3	1	0	0	0	0	8	0
17-Nov-10	2	261	48	3	0	0	0	1	16	1
17-Nov-10	3	155	2	1	0	2	0	0	2	1
17-Nov-10	4	140	38	1	0	3	0	0	11	1
16-Nov-10	5	84	8	1	0	2	0	0	13	0
16-Nov-10	6	114	21	7	0	0	0	0	11	0
	Total	891	120	14	0	7	0	1	61	3
Surveys halted after 17-Nov-10 due to continuous high flows										

Reach #1: Simpson Bridge Crossing to Blue Creek Mouth (2.1 miles)
Reach #2: Simpson Road #B10X Access to Simpson Bridge Crossing (3.5 miles)
Reach #3: Slide Creek Confluence to Simpson Road #B10X Access (2.5 miles)
Reach #4: Crescent City Fork Confluence to Slide Creek Confluence (2.2 miles)
Reach #5: Mainstem reach upstream of Forks
Reach #6: Lower Crescent City Fork Blue Creek

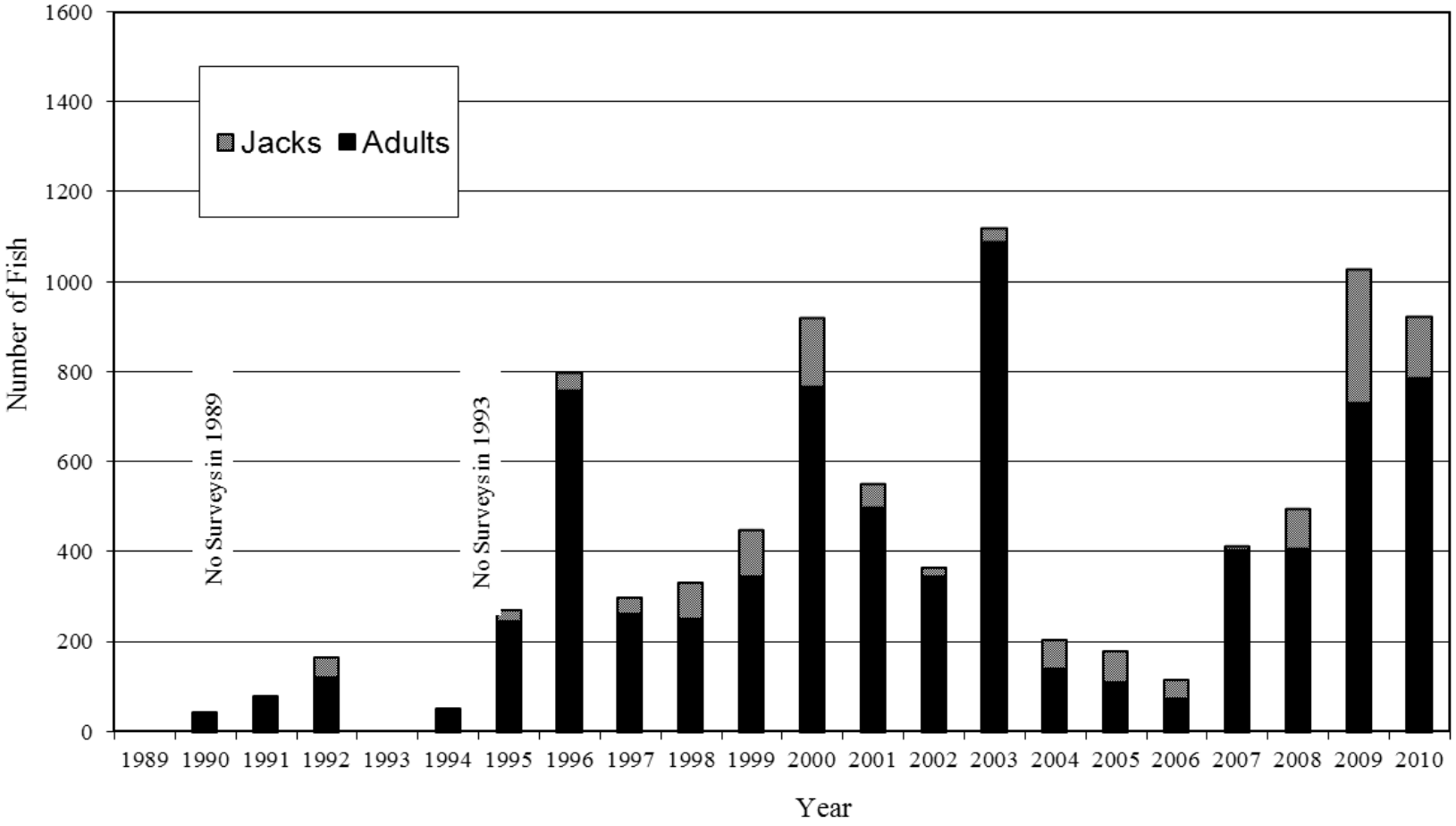

Figure 5. Annual peak counts of late-fall run Chinook salmon in reaches #1 – 4 in Blue Creek between 1989 – 2009.

4.2 Salmon Capture and Tagging

A total of four adult chinook (two male, two female) were captured and tagged during two sampling events in 2010. Fork lengths of tagged fish ranged from 29 to 39.5 inches. Fish were tagged on 27-Oct-10 and 9-Nov-10 in a lower Blue Creek pool located in reach #1. None of these fish were visually recaptured in subsequent snorkel surveys, most likely because of the small sample size marked.

5.0 Conclusion

Estimating salmon escapement in Blue Creek can be a challenging task. During high water years like 2010 it can be difficult to physically capture and visually recapture marked fish due to high flows, turbid water, and the inability to conduct surveys due to flow conditions. Between October 1 and December 31, 46 inches of rain fell on the Blue Creek watershed, resulting in flows up to 8647 cfs and preventing surveys after mid-November. As a result YTFP could not adequately capture and recapture marked fish to determine residence times and no AUC escapement estimate was made for this year.

The YTFP has conducted direct observation snorkel surveys in Blue Creek over the past decade using the Peak Count Method. By successfully applying the AUC method with the snorkel surveys, we are often able to generate an escapement estimate for fall chinook in Blue Creek. In order to accurately estimate adult escapement in Blue Creek in future years, we recommend continuing to study stream residence time as long into the salmon run as weather allows for safe capture and recapture techniques. By collecting multiple years of residence time data, we may be able to calculate a mean residence time for fall-run Chinook in Blue Creek and use those metrics to back-calculate escapement estimates for prior survey years.

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