Chinook Salmon Spawning Study
Russian River Fall 2002-2007

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INTRODUCTION

Chinook salmon in the Russian River basin were considered nearly extinct in the 1980s but in recent years have been found in increasing numbers. The Sonoma County Water Agency (Agency) began conducting Chinook salmon spawning surveys during fall 2002 to address concerns that reduced water releases from Coyote Valley Dam at Lake Mendocino may impact migrating and spawning Chinook salmon (Cook 2003). Releases were curtailed from the lake during fall 2002, 2004, and 2007 due to below normal rainfall and low levels in the lake. In other years water releases from Lake Mendocino were normal and were not expected to affect spawning salmon. Water releases from Lake Mendocino, along with rainfall runoff, provide most of the flows in the upper Russian River during the fall season when adult Chinook salmon migrate upstream to spawn.

The purpose of this study was to determine the distribution and abundance of Chinook salmon spawning sites in 2007 and compare results among previous study years. This study includes spawning surveys for Chinook salmon from 2002 to 2007, except 2005 due to poor field conditions. Background information on the natural history of Chinook salmon presented in previous annual reports (Cook 2003 and 2004) has been incorporated into this report.

Life History

Russian River Chinook salmon follow the fall-run life history pattern, which is an adaptation to avoid summer high water temperatures. Fall-run adult salmon migrate from the ocean to spawn in rivers and large tributaries in late summer and fall. Spawning occurs within a few days or weeks of arriving at a spawning ground. Adults create a nest, called a redd, by digging a shallow depression in the streambed with their caudal (tail) fin. Females deposit between 2,000 and 17,000 eggs that settle into the rocky substrate of the redd. Redds are usually located at the head of riffles with large gravel to cobble substrate to ensure oxygenated water flows to the eggs. Adults die soon after spawning. Eggs hatch within 4 to 6 weeks and young salmon emerge from the substrate in spring and move downstream within a few months. Young Chinook salmon may rear in the mainstem of rivers or estuaries during spring before water temperatures increase in the summer. Young salmon are called smolts while they are acclimating to salinity in preparation for the ocean. The smolt process occurs during the first year usually during spring or summer. Once accustomed to saltwater, smolts head out to the ocean where they spend between 1 to 5 years maturing before returning to their natal stream to spawn and complete their lifecycle.

Historic Runs

The historic occurrence of Chinook salmon in the Russian River is debated; however, the scant available historic sources suggest that Chinook salmon were uncommon in the river. Steiner (1996) compiled several sources from the late-1800s and early-1900s that suggested there were few Chinook salmon in the Russian River. Moyle (2002) indicated that Chinook salmon "disappeared with the advent of agriculture and water projects in the basin." Stocking attempts began as early as 1881 with 15,000 Chinook salmon planted in the mainstem without success

(USACOE 1982; Steiner 1996). Heavy planting in Dry Creek, starting in the 1980s, did not establish a viable run (Steiner 1996). Hatchery fish were primarily from Sacramento River and Klamath River stocks (Myers et al. 1998, cited in Moyle 2002).

The first attempt at a population estimate was in the early 1960s at 500 spawning adults and an additional 2,000 "salmon" taken by fishermen; however, this estimate "involved no field work" and "were made by men who are familiar with the [river]" (CDFG 1965). The reference to "salmon" presumably includes both Chinook salmon and coho salmon. By 1982 Chinook salmon were considered "not currently established in the Russian River" except for occasional observations "possibly a vestige of prior attempts at establishing a viable population" (USACOE 1982). Also, by the 1990s Steiner (1996) concluded that there were currently few hatchery or wild Chinook salmon in the Russian River basin.

Rigorous field studies of Russian River Chinook salmon did not begin until the late 1990s (Chase et al. 2000). Recent observations indicate that Chinook salmon numbers are higher than historic accounts (Chase et al. 2000, 2001, 2002, 2003, and 2004). Recent genetic studies indicate that Chinook salmon in the Russian River are a unique wild run and not hatchery stock from outside the basin (Hedgecock et al. 2002).

METHODS

This study consisted of redd surveys in the upper Russian River basin and video monitoring of migrating adult Chinook salmon conducted as part of the Agency's Mirabel Inflatable Dam/Wohler Pool Fish Sampling Program. The inflatable dam and video monitoring was located near the downstream end of the redd study area. The upstream migration of Chinook salmon recorded by video monitoring was used to coordinate the timing of redd surveys.

Underwater Video Monitoring

Underwater video cameras were used to document the number of Chinook salmon in the Russian River during the fall migration (see Chase et al. 2003 and Chase et al. 2004 for detailed descriptions of methods). Chinook salmon redd surveys were initiated after video monitoring indicted a peak in adult Chinook salmon migration. Cameras were installed at 2 fish ladders located at the Agency's inflatable dam near Wohler Road Bridge, 12 km downstream of the Dry Creek confluence with the Russian River. Time-lapse cameras recorded the upstream migration of adult Chinook salmon. Video monitoring was conducted continuously, 24 hours a day, from August to late November or December annually. The video monitoring ended when heavy rainfall required the deflation of the dam. Adults migrating to spawning habitat in tributaries below the video monitoring station would not have been documented by our monitoring. For example, Chinook salmon are known to spawn in Austin Creek, located near the Russian River Estuary and below our monitoring station (David Hines, NOAA Fisheries, unpublished data).

Redd Surveys

Chinook salmon redd surveys in the Russian River were conducted during fall 2002 to 2007 in the upper Russian River and Dry Creek. The study area included approximately 114 km of the Russian River mainstem from Riverfront Park (40 rkm) located south of Healdsburg upstream to the East and West Forks of the Russian River (154 rkm) near Ukiah. River kilometers (rkm) are

linear river distances and are measured from the river at the Pacific Ocean or creek mouth (0 rkm) upstream. In 2003, the study area was expanded to include 22 rkm of Dry Creek below Warm Springs Dam at Lake Sonoma. Surveys in 2005 were incomplete due to poor conditions for surveying (Cook 2006) and results are not included in this report. Intense rainfall during the 2005 Chinook salmon migration caused high river flows and excessive turbidity that resulted in poor visibility for detecting redds. The Russian River and Dry Creek study area was sectioned into 6 reaches based on gradient and surrounding topography, including:

- Lower Healdsburg reach (Riverfront Park to Dry Creek confluence),
- Upper Healdsburg reach (Dry Creek confluence to Alexander Valley Road bridge),
- Alexander Valley reach (Alexander Valley Road bridge to Big Sulphur Creek confluence),
- Canyon reach (Big Sulphur Creek confluence to Highway 101 bridge near Hopland),
- Ukiah reach (Highway 101 bridge near Hopland to East and West Forks confluence), and
- Dry Creek reach (Russian River confluence to Warm Springs Dam).

The upper end of the Ukiah reach is at the East and West Forks near the City of Ukiah. Upstream of this reach approximately 1.5 rkm on the East Fork is Coyote Dam and Lake Mendocino. This small river section provides marginal spawning habitat for Chinook salmon (Sean White pers. obs.) and was not surveyed. The West Fork was also not surveyed for Chinook salmon redds due to restricted access and poor kayaking conditions (i.e., narrow channel with shallow depths and an abundance of downed trees and brush) that prohibited surveying along most of the reach. However, the West Fork is utilized by spawning Chinook salmon. Since the completion of the Mumford Dam Fish Passage project in 2003, migrating adult Chinook salmon have been observed annually passing the restoration site (Sean White, Sonoma County Water Agency, unpublished data). Mumford dam is located in Redwood Valley approximately 12 rkm upstream of the Forks confluence.

The Dry Creek study reach terminates at Warm Springs Dam and is located approximately 22 rkm upstream of the confluence with the Russian River. Dry Creek is the second largest tributary of the Russian River and the confluence is located downstream of Healdsburg approximately 2 km. As the name suggests, historically Dry Creek was “dry” during the late summer and early fall prior to the rainy season. Beginning in the early 1980s, flows in Dry Creek were maintained by releases at Warm Springs Dam and are substantially higher than natural flows during the fall Chinook salmon migration period.

Surveys were conducted to determine the distribution and abundance of Chinook salmon redds and spawning habitat used. The study area was surveyed once in November and/or December during each survey year. A crew of 2 or 3 biologists would survey a reach by kayak and visually search for redds along the streambed. Coordinates of observed redds were recorded using a global positioning system (GPS). Habitat characteristics of spawning sites (i.e., substrate size, water depth, and velocity, etc) were qualitatively described. Field surveys were conducted by David Cook, David Manning, Shawn Chase, Craig Lauridsen, Justin Smith, Rob Fortner, and Nick Carll.

The number of redds counted during surveys likely underestimated the true number of redds deposited during the annual spawning period. This underestimate is likely due to the single-pass survey method and difficulty in occasionally distinguishing individual redds. As mentioned

above, redd surveys were conducted after video monitoring indicated a peak in migration activity; however, additional redds could have been deposited after our single-pass survey of the study area. Identification of individual redds was difficult at high density spawning grounds because some redds were covered or obscured by overlapping redds. Also, Chinook salmon likely spawned in large tributaries outside of the study area.

RESULTS

Camera Monitoring of Adult Migration

Migration to the upper Russian River basin usually begins in August to early September when a few adult Chinook salmon are detected, but most migration activity occurs in October to mid-November (Figure 1). During fall 2007, a total of 1959 adults were recorded at the camera station (Chase unpublished data). Fall Chinook salmon numbers have been as high as 6081 adults in 2003 (Chase et al. 2004). The first recorded Chinook salmon in 2007 was on September 28. During 1999 to 2006 first arrivals ranged from 20 August to 16 September. Fall Chinook salmon migration continued through the end of our underwater camera monitoring in early December of each study year.

Most Chinook salmon migration activity occurs during 3 or 4 movement events annually and is usually related to fall rains, increases in river flows, and cooler water temperatures. Typically, adult Chinook salmon begin migrating in late summer when river flows are low and then migration activity peaks with rising river flows during the cool fall rainy season. During the low rainfall year of 2007, late summer flows in the river ranged from 80 cubic feet per second (cfs) on 19 August to 165 cfs on 11 September (Figure 2). During late-summer 2006, with normal rainfall, flows ranged from 130 to 175 cfs. Peak daily migration activity in 2007 occurred on 4 events, including 29 October, 8 and 16 November, and 8 December. River flows during these peak periods ranged from 248 cfs to 685 cfs. During the 9 years of migration monitoring, the largest one-day peak observation was on 7 November 2002 with 2,213 Chinook salmon, or 41% of the observed fish for the season. This event corresponded with a river flow increase that reached 689 cfs the day following the peak migration. During 2007, there was a succession of increasing peak migration events beginning with 32 Chinook salmon on 29 October and ending with the largest one-day migration event on 8 December with 289 Chinook salmon at a river flow of 685 cfs (Figure 2).

Redd Distribution and Abundance

The locations of Chinook salmon redds in the Russian River and Dry Creek were similar during the years of study (Figures 3 through 10). There were few redds observed in the Lower Healdsburg reach compared to upstream reaches and most redds in this reach were found near the upstream end near the confluence with Dry Creek. Redds in the Upper Healdsburg reach were clustered in the center and upstream end of the reach. In Alexander Valley, redds were clustered in the center of the reach. Redds were distributed throughout both the Canyon and Ukiah reaches. In Dry Creek, redds were distributed throughout the reach; however densities were highest in the upper area. Redds throughout the study area were found almost exclusively at the end of a pool or at the start of a riffle with course gravel to small cobble sized substrate and water depths greater than 20 cm. These observed spawning habitat requirements are likely a

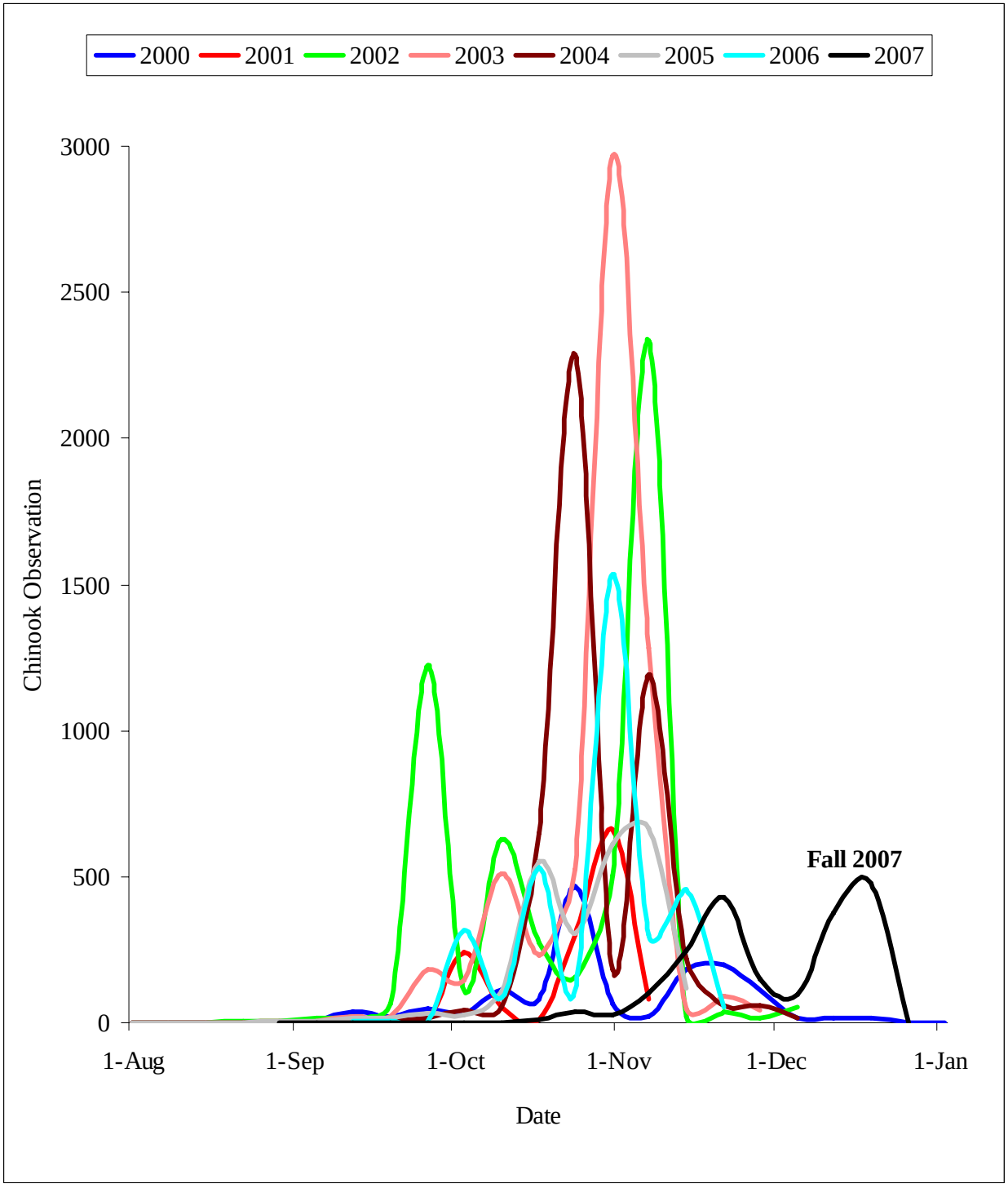

Figure 1: Weekly adult Chinook salmon migration counts. Observations are from an underwater camera station at the Agency's inflatable dam fish ladder on the Russian River near Wohler Road Bridge, fall 2000-2007.

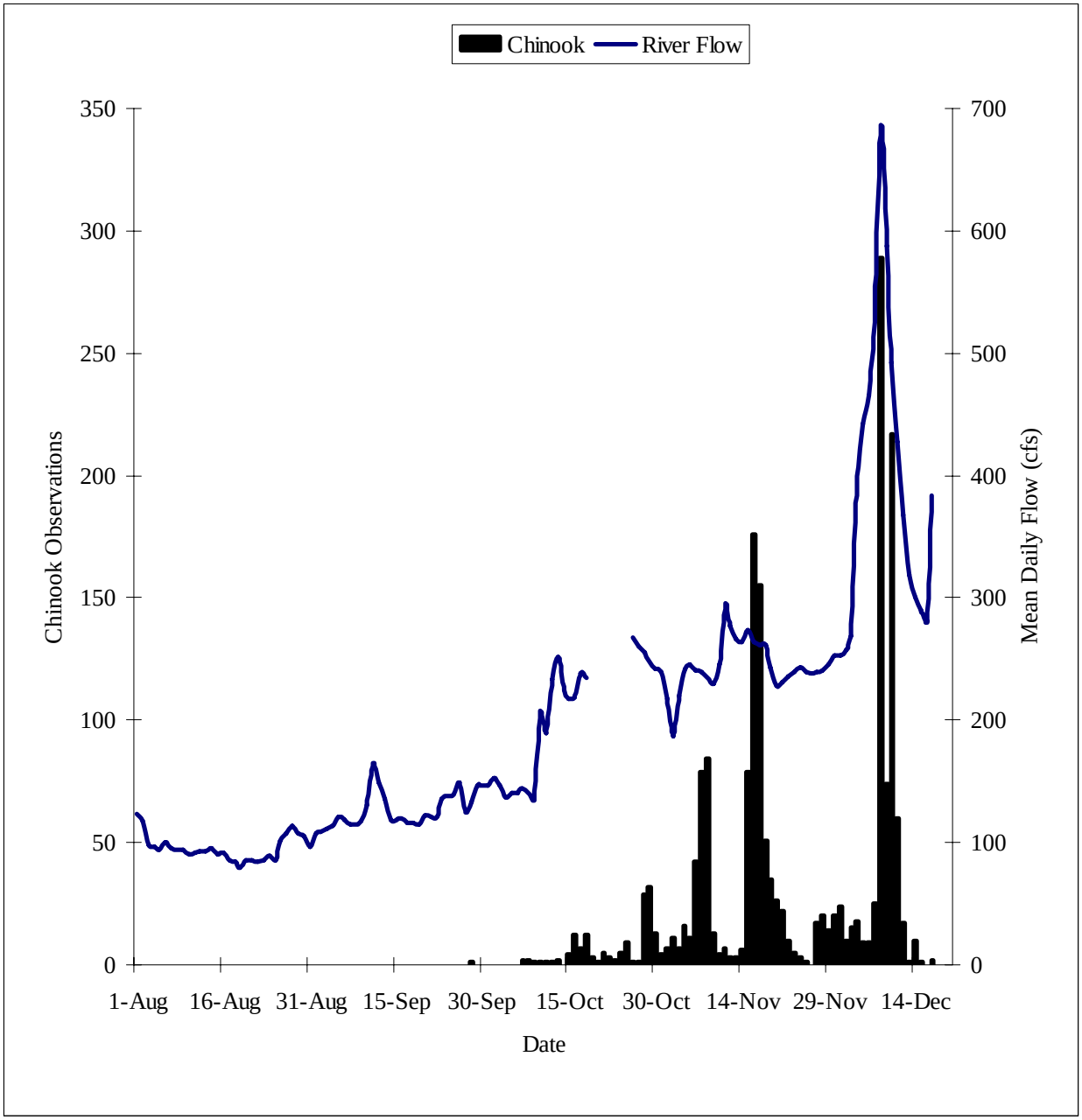

Figure 2: Daily Chinook salmon observations and Russian River flow, fall 2007. Observations are from an underwater camera station at the Agency's inflatable dam fish ladder near Wohler Road bridge.

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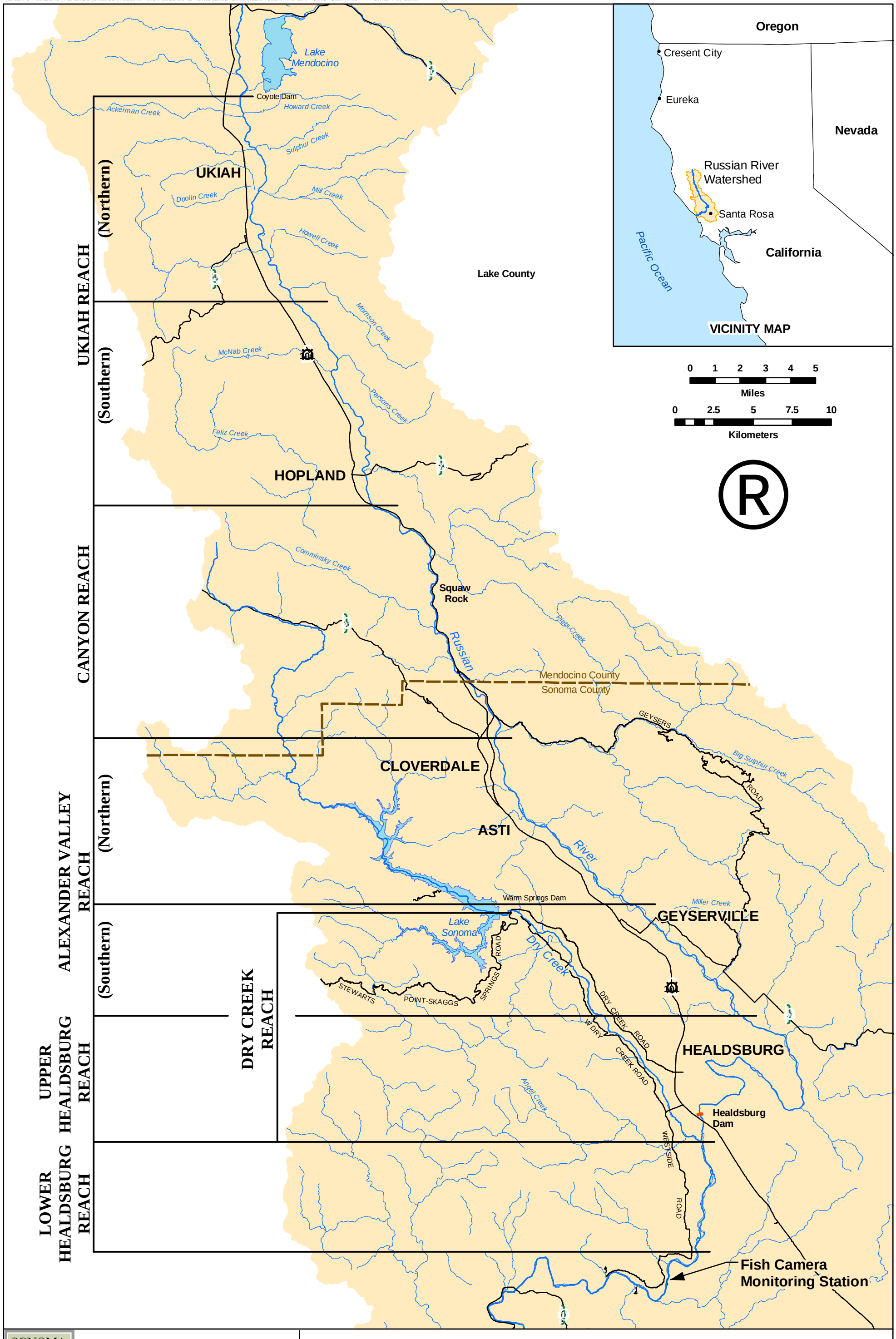

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Location Map

Chinook Salmon Spawning Study, Russian River

Figure 3

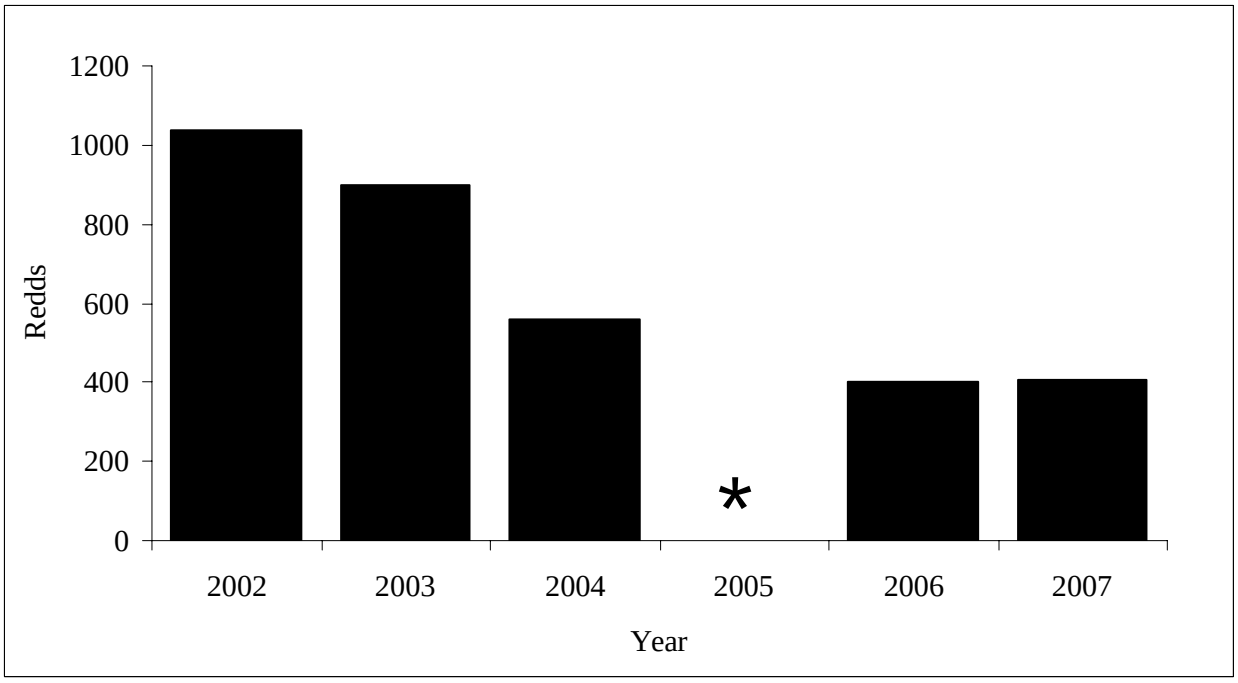

Figure 11: Chinook salmon redds from 2002 to 2007 in the upper Russian River mainstem. *Data not shown due to incomplete surveys.

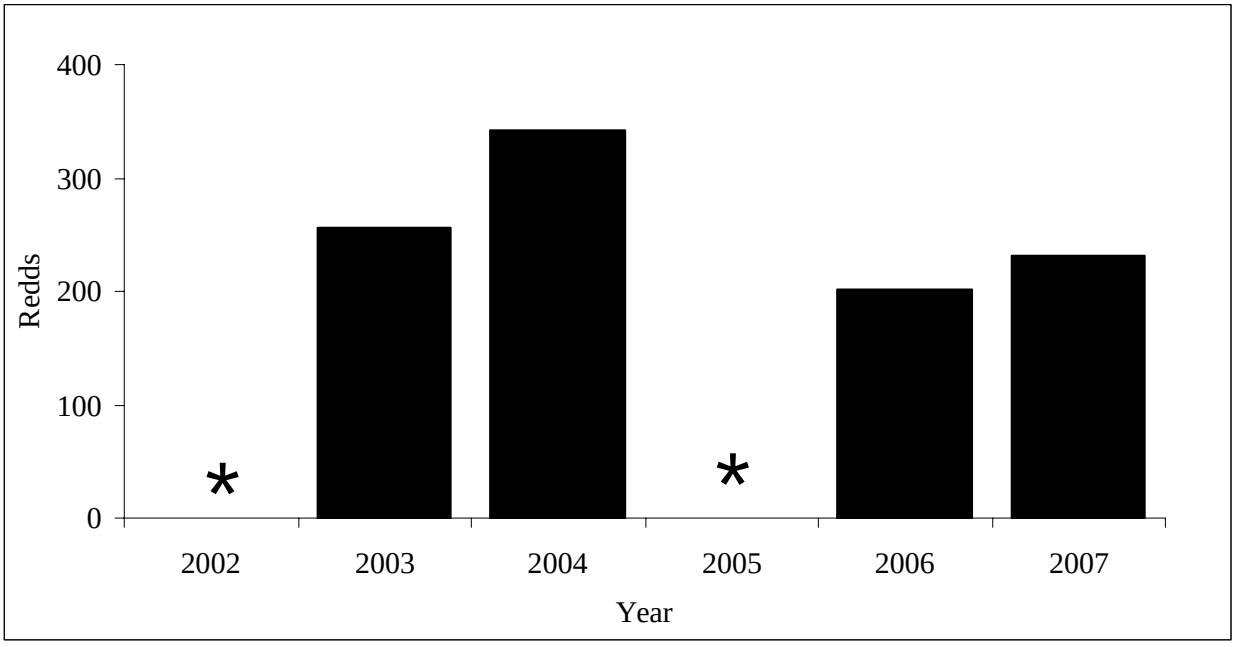

Figure 12: Chinook salmon redd observations in Dry Creek, 2002-2007. *Surveys not conducted in 2002 and incomplete in 2005.

Table 1. Chinook salmon redd abundances by reach, upper Russian River and Dry Creek, 2002-2007. *Survey either not conducted or incomplete.

Reach	Reach (rkm)	Redd Observations 2002	2003	2004	2005	2006	2007
Redd Count							
Lower Healdsburg (River Park- Dry Cr)	8.2	6	0	7	*	1	2
Upper Healdsburg (Dry Cr-AV Rd)	25.6	79	40	8	*	23	67
Alexander (AV Rd-Sulphur Cr)	26.2	163	213	90	*	62	131
Canyon (Sulphur Cr-Hwy 101)	20.8	277	190	169	*	68	88
Ukiah (Hwy 101-Forks)	33.1	511	458	284	*	248	118
Russian River Subtotal	**113.9**	**1036**	**901**	**558**		**402**	**406**
Dry Creek (Russian River- WS Dam)	21.7	*	256	342	*	201	231
Total	**135.6**		**1157**	**900**		**603**	**637**
Relative Contribution of Redds							
Russian River	84.0%		77.9%	62.0%		66.7%	63.7%
Dry Creek	16.0%		22.1%	38.0%		33.3%	36.3%
Total	100%		100%	100%		100%	100%

factor limiting the distribution of redds in the Lower and Upper Healdsburg reaches where the stream gradient is low resulting in few riffles.

The number of Chinook salmon redd observations declined during the study period from 2002 to 2006 (Figure 11; Table 1). Redd numbers in the Russian River mainstem were highest during 2002 at 1,036 redds and were as low as 402 redds in 2006. In 2007, there was a slight increase over the previous year with 406 redds recorded. Redd numbers in Dry Creek have ranged from 201 to 342 redds (Figure 12; Table 1) with no apparent pattern with mainstem annual redd abundances (see Figure 11). Redd counts in 2007 were 231 in Dry Creek. Based on reach length, the relative contribution of redds in Dry Creek was proportionately greater than in the Russian River mainstem (Table 2). The Dry Creek reach included 16.0% (21.7 rkm) of the study area compared to 84.0% (113.9 rkm) of the upper Russian River mainstem. However, Dry Creek contributed from 22.1% to 38.0% of the redds observed annually. During 2007, Dry Creek contributed 36.3% of the observed redds in the study area, which is the second highest contribution since 2003.

In general, the abundance of redds progressively increased upstream in the Russian River mainstem and this pattern occurred annually (Figure 13). Most of the Chinook salmon spawning occurred in the upper 3 reaches of the Russian River mainstem and in Dry Creek (Table 1). The Lower and Upper Healdsburg reaches had relatively low frequencies of redds compared to the Alexander Valley, Canyon, and Ukiah reaches located upstream (Table 2). Redds in the Lower and Upper Healdsburg reaches ranged from 0.0 to 3.1 redds/km. The Ukiah reach, located at the upstream end of the Russian River study area, typically had the highest frequency of redds annually in the mainstem, and has been as high as 15.5 redds/rkm in 2002. However, during 2007 redd frequencies in the Canyon and Alexander Valley reaches at 4.2 redd/rkm and 5.0 redd/rkm, respectively, were higher than in the Ukiah reach at 3.6 redd/rkm. Redd occurrences in Dry Creek had the highest redd frequency of all the study reaches at 15.8 redds/km during 2004 and the highest frequency during 2007 at 10.6 redds/rkm.

In the Dry Creek and Ukiah reaches the abundance of redds generally increased with proximity to the upstream terminal ends with dams (Figures 14 and 15). Dry Creek is accessible to Chinook salmon from the Russian River confluence to Warm Springs Dam at Lake Sonoma, and the Don Clausen Fish Hatchery (Figures 10 and 15). The pattern of abundance of redds in both these reaches was similar each year. The upper half of the Dry Creek reach contained greater than 80% of the redds annually. This trend was not as strong in the Ukiah reach where the upper half of the reach contained greater than 62% of the redds annually. The highest frequency of redds at Dry Creek was always at the upper terminal end, and during 2007 this creek section had a redd frequency of 50.0 redds/rkm (Figure 15). A similar spatial pattern was usually observed in the Ukiah reach with the highest frequency of redds near the terminus with Coyote Dam, Lake Mendocino. However, during 2007 the highest frequency of redds was at rkm 142 at 12.0 redd/rkm and the upstream end of this section at rkm 154 had a frequency of 8.0 redd/rkm.

DISCUSSION

The disproportionately high counts of adult Chinook salmon observed during video monitoring compared to redd counts suggests that many more redds could have been deposited than were observed annually. In 2007, Chinook salmon observations included 1959 adults at the

Table 2. Chinook salmon redd frequencies by reach, upper Russian River and Dry Creek, 2002-2007. *Survey either not conducted or incomplete.

Reach	Reach (rkm)	Frequency (redd/rkm) 2002	2003	2004	2005	2006	2007
Lower Healdsburg (River Park- Dry Cr)	8.2	0.7	0.0	0.9	*	0.1	0.2
Upper Healdsburg (Dry Cr-AV Rd)	25.6	3.1	1.6	0.3	*	0.9	2.6
Alexander (AV Rd-Sulphur Cr)	26.2	6.2	8.1	3.4	*	2.4	5.0
Canyon (Sulphur Cr-Hwy 101)	20.8	13.3	9.1	8.1	*	3.3	4.2
Ukiah (Hwy 101-Forks)	33.1	15.5	13.8	8.6	*	7.5	3.6
Russian River (all mainstem reaches)	113.9	9.1	7.9	4.9		3.5	3.6
Dry Creek (Dam-River)	21.7	*	11.8	15.8	*	9.3	10.6

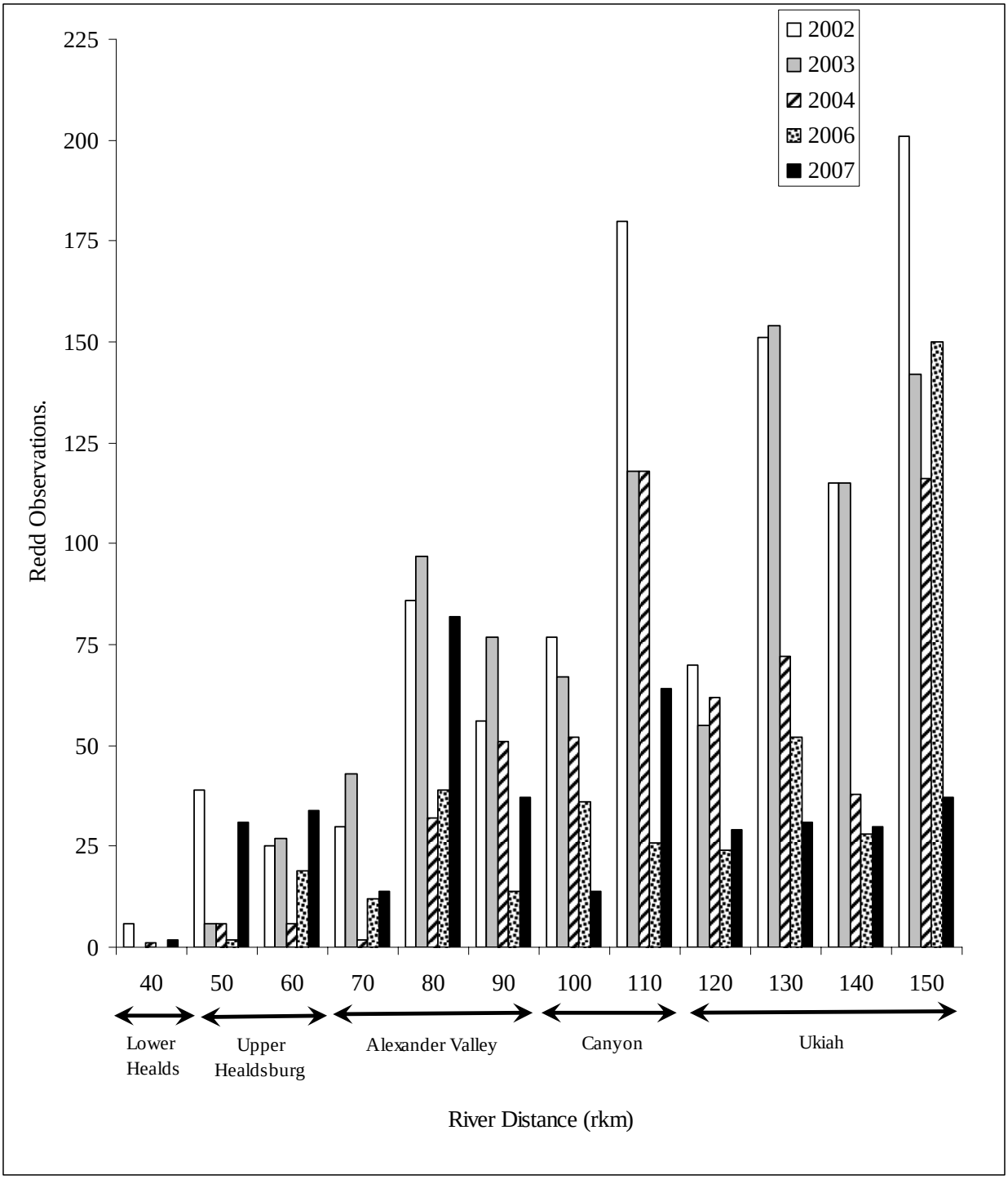

Figure 13: Chinook salmon redd observations in the upper Russian River from 2002 to 2007.

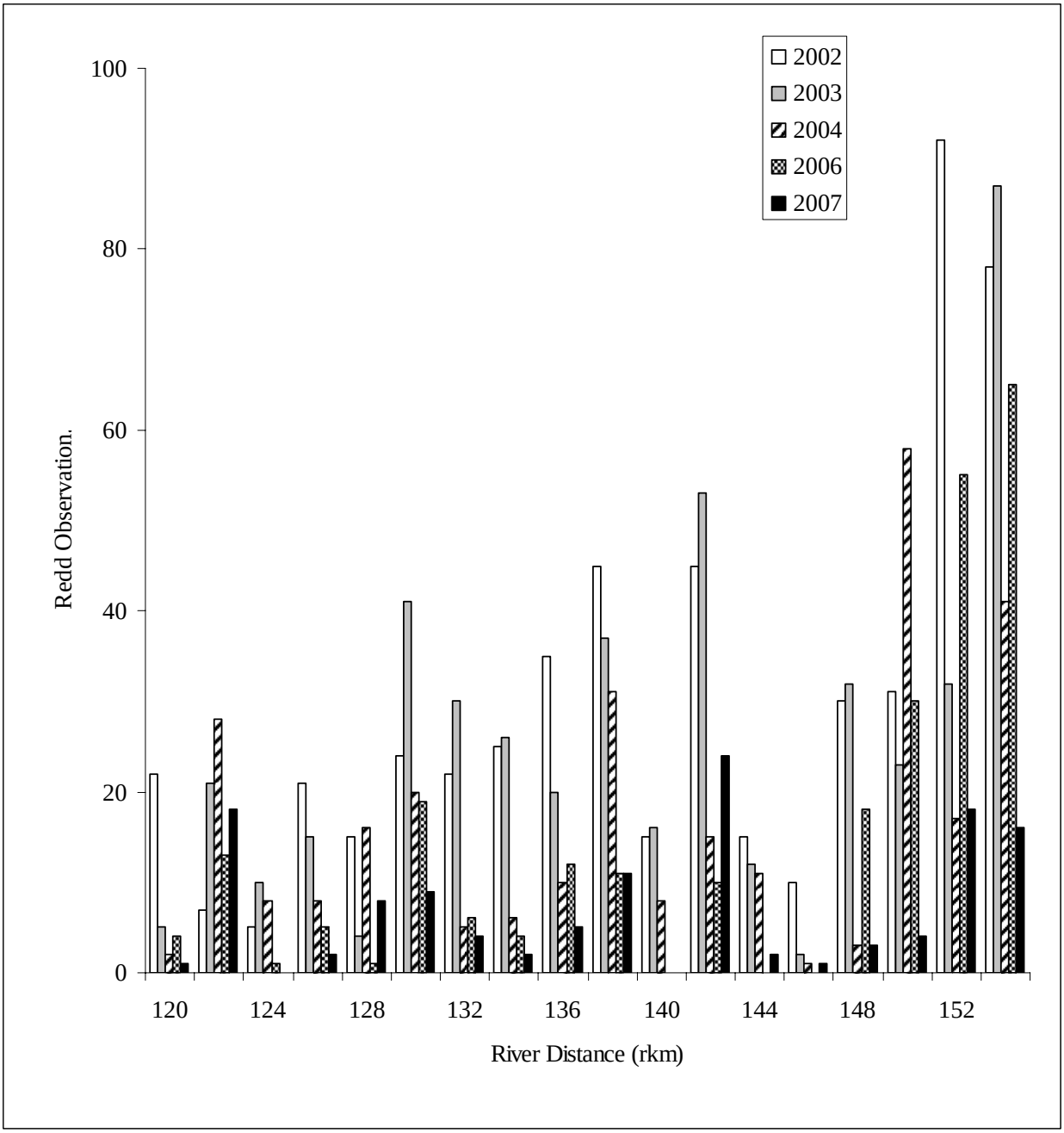

Figure 14: Frequency of Chinook salmon redds in the Ukiah reach, Russian River mainstem. Ukiah reach river distances are from 120 rkm located downstream of Highway 101 bridge (Hopland) to 154 rkm near the East and West Forks.

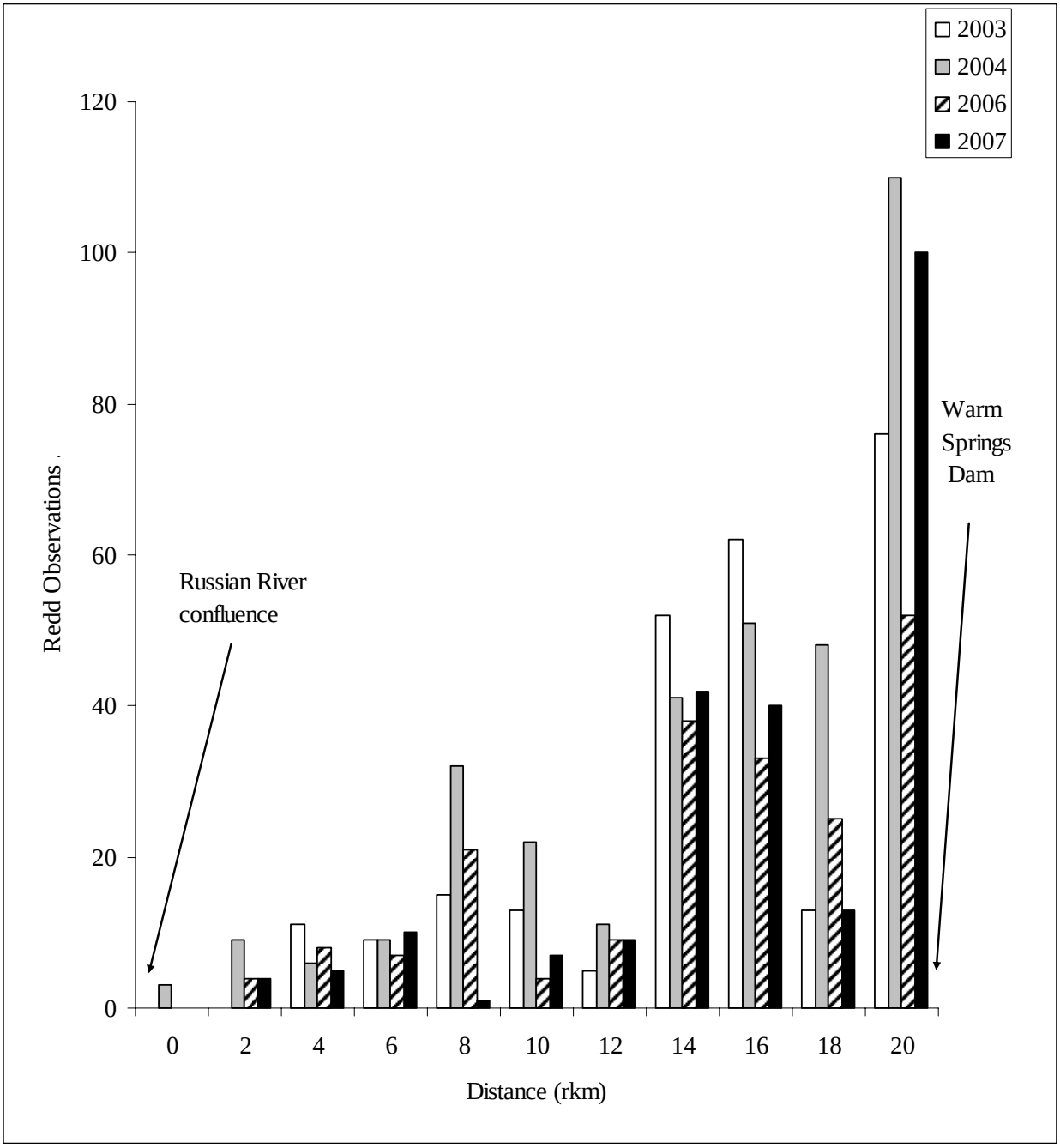

Figure 15: Frequency of Chinook salmon redds in Dry Creek. River distances extend from the Dry Creek confluence with the Russian River (0 rkm) to Warm Springs Dam at Lake Sonoma (22 rkm).

underwater camera station and 637 redds. This equates to approximately 3 times the number of migrating adults than observed redds. Based on an assumed 1 to 1 sex ratio, there could have been more than 340 additional redds deposited as observed. This discrepancy is probably due to spawning after our single-pass surveys were completed, superimposition (overlapping) of deposited redds, and spawning in tributaries that were outside of the study area.

The primary Chinook salmon spawning areas in the upper Russian River are located from Alexander Valley upstream to Ukiah Valley and in Dry Creek. The highest abundance of redds in 2007 were in the Alexander Valley and Canyon reaches along the Russian River mainstem and Dry Creek reach. During past survey years Ukiah reach has been the most productive for Chinook salmon along the mainstem. The below-normal rainfall in 2007 resulted in reduced water releases from Coyote Valley dam at Lake Mendocino that may have influenced the distribution of spawning in upper Ukiah reach. Also, the reduced storage of water in the lake appeared to have increased turbidity of released water from the dam that may have influenced spawning in the upper Ukiah reach, as well as reduced our detections of redds in the field. Redd abundance in the Lower Healdsburg and Upper Healdsburg reaches were very low. This is consistent with our observation of riffle habitat with substrate suitable for Chinook salmon spawning occurring primarily above Upper Healdsburg reach and in Dry Creek reach. Chinook salmon redds were typically concentrated in the Ukiah and Dry Creek reaches near the termini with dams. Releases of relatively cool, high flows of water from these dams are strong attractants for migrating Chinook salmon. Also, the gradient and relatively higher flows appear to provide good spawning substrate in these reaches, although substrate particle size and embeddedness in these reaches has not been quantified.

Overall there appears to be a marked increase in the number of spawning Chinook salmon since the 1980s when Chinook salmon were considered nearly extirpated from the Russian River watershed. This study documented 600 to over 1,000 redds annually from the upper Russian River basin. Although Chinook salmon numbers have increased over historic accounts, there was a decrease in the observed number of Chinook salmon redds from 2002 to 2006. However, it is probably not prudent to conclude that this represents a decline in Chinook salmon.

There are several factors that could explain the decrease in Chinook salmon redds during this study. First, this study provides the most quantitative analysis of Chinook salmon spawning conducted in the Russian River; however, 5 years of data is probably insufficient to fully assess population dynamics. Surveys conducted during several fish generations (10 to 20 years) would be needed to adequately assess population trends and patterns. Second, as discussed above, not all redds deposited were likely detected by this study so the results may not be an accurate assessment of the true redd production. Third, the pattern in the number of redds observed may be related to the natural cycle in fish populations. Fish species with a high fecundity and low survival rate, like Chinook salmon, naturally fluctuate over time. Reproduction in salmon can have “bust” and “boom” years due to a variety of environmental factors that influence the survival of offspring. In a species where females deposit 1,000s of eggs (Moyle 2002) and typically have a survival rate of <1% (Bradford 1995), an increase in survival of just 1% can result in a huge number of spawning salmon when these fish reach maturity.

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