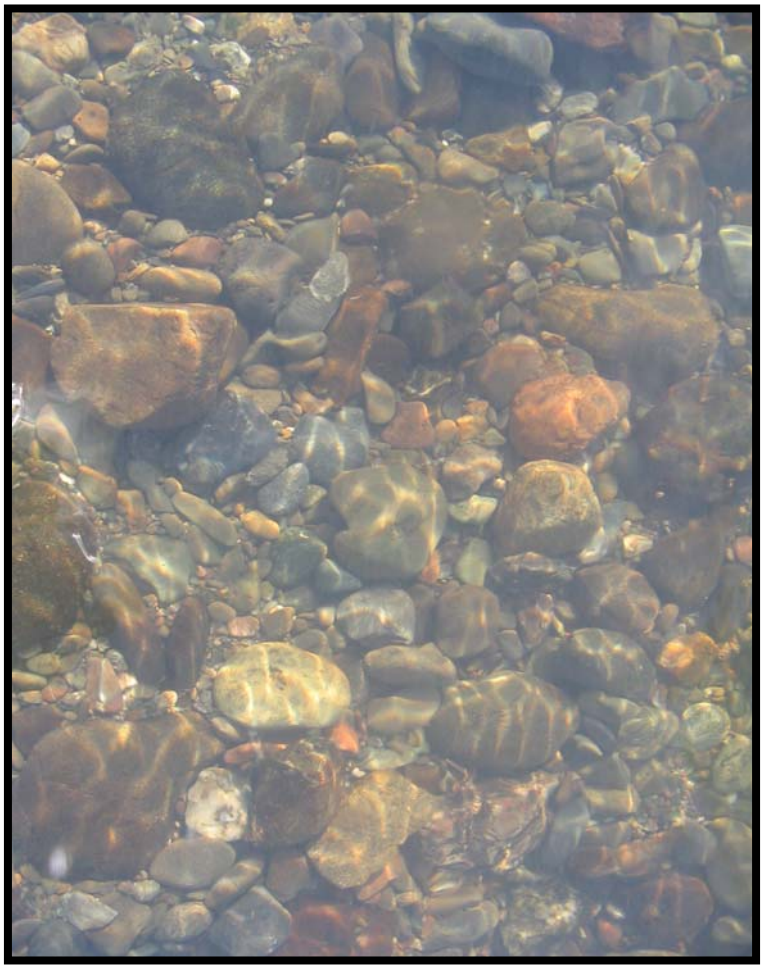
Chinook Salmon Spawning Study
Russian River Fall 2002-2004



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March 2005

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INTRODUCTION

Chinook salmon native to the Russian River basin were considered nearly extinct in the 1980's 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 Lake Mendocino may impact migrating and spawning Chinook salmon (Cook 2003). Releases were curtailed from the lake during fall 2002 and 2004 due to below normal rainfall and low levels in the lake. In 2003 water releases from Lake Mendocino were normal and were not expected to affect spawning salmon. Water releases from Lake Mendocino provide most of the flows in the upper Russian River during the fall season when adult Chinook salmon migrate upstream to spawn.

This study includes spawning surveys for Chinook salmon for three consecutive years from 2002 and 2004. The purpose of the study was to determine the distribution and abundance of Chinook salmon spawning sites and compare results among years. Background information on the natural history of Chinook salmon presented in Cook (2003 and 2004) has been incorporated into this report.

Life History

Russian River Chinook salmon follow the life history pattern of fall-run Chinook salmon, 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. Once accustomed to saltwater, smolts head out to sea 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, 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 study area in 2002 to 2004 included approximately 113 km of the upper Russian River from the East and West Forks of the Russian River near Ukiah to Riverfront Park south of Healdsburg. In 2003 and 2004, we added redd surveys in Dry Creek below Warm Springs Dam at Lake Sonoma. Dry Creek is the second largest tributary of the Russian River and the confluence is located downstream of Healdsburg approximately two km. Warm Spring Dam is the terminus for fish migration in Dry Creek and is located approximately 22 km upstream of the Russian River. As the name of this creek suggests, historically, Dry Creek was usually "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.

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). 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 12 August to 11 December 11 2002, 4 September to 2 December 2003, and 1 August to 7 December 2004. The video monitoring ended when heavy rainfall required the deflation of the dam. It is likely that Chinook salmon migration continued after the cameras were removed and would not have been documented. In addition, 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, unpubl. data).

Redd Surveys

The Russian River was sampled during fall 2002 to 2004, and Dry Creek was sampled in fall 2003 and 2004. The upstream migration of Chinook salmon recorded by video monitoring was used to coordinate the timing of redd surveys. The Russian River and Dry Creek study area was sectioned into 6 reaches based on gradient and surrounding topography, including:

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

Surveys were conducted to determine the distribution and abundance of Chinook salmon redds and spawning habitat used. Surveys were initiated after video monitoring indicted a peak in adult Chinook salmon migration. The study area was surveyed once in November during the three survey seasons. A crew of three 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.

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. In the Ukiah reach during 2002 the number of redds were visually estimated at several densely clustered sites. Also, Chinook salmon likely spawned in large tributaries outside of the study area.

RESULTS

Video Monitoring

A total of 5,465 adult Chinook salmon were observed at the video monitoring station during fall 2002, 6,081 during fall 2003, and 4,686 during fall 2004 (Figure 1, Chase et al. 2003 and 2004, Chase unpubl. data). A few Chinook salmon began migrating from 20 August to 29 September, but large numbers were not observed in 2002 and 2003 until 30 September and 16 October in 2004. During each year of study, fish movement peaked during three migration events. Migration peaks during 2002 and 2003 occurred from 30 September to 10 November. The major migration events during 2004 occurred later in the season from 16 October to 18 November. The 3 peaks during 2004 were on 19 and 26 October, and 11 November. Migration continued through the end of monitoring in early December of each year.

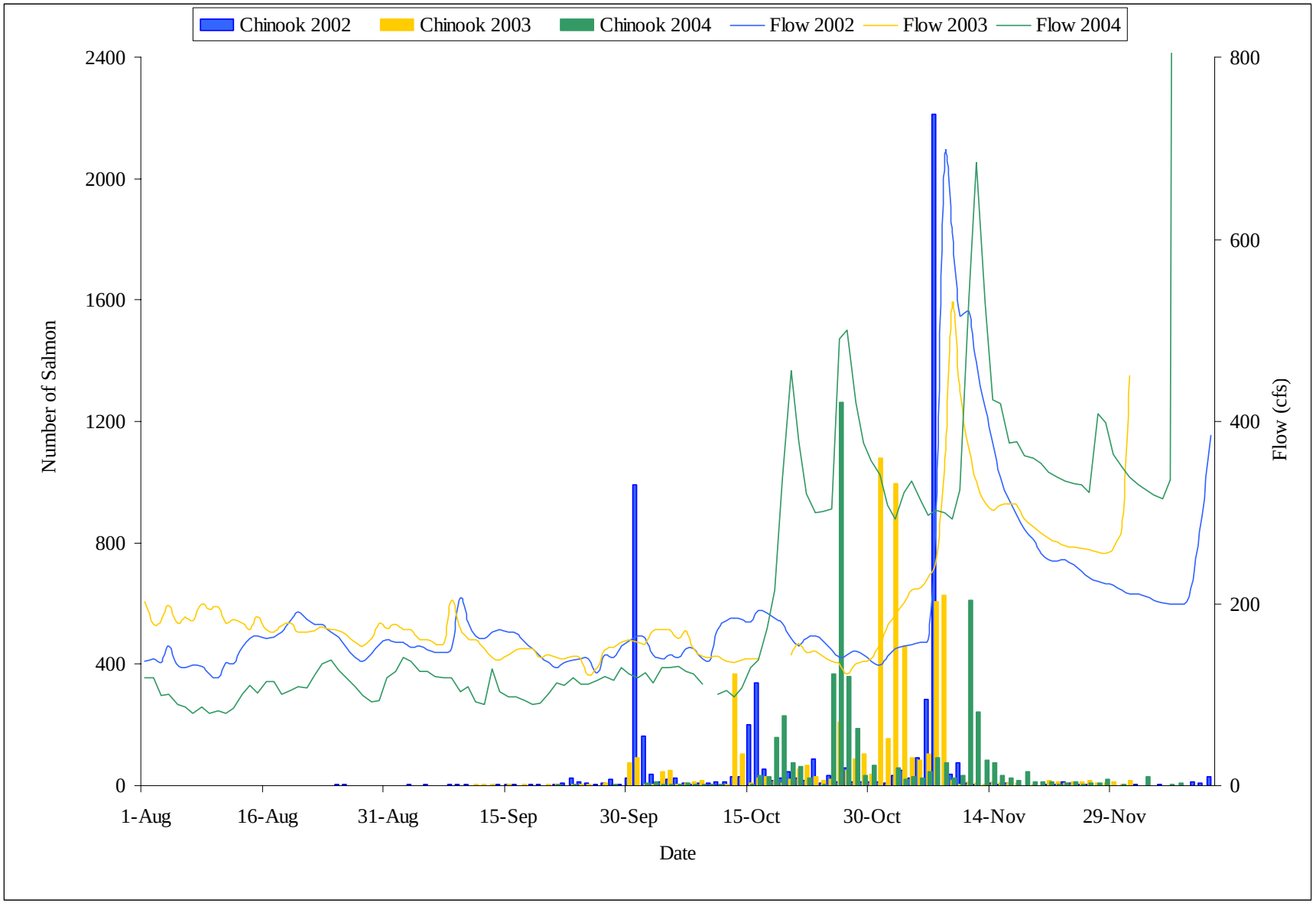

Figure 1: Chinook salmon observations at the Agency's inflatable dam fish ladder and river flow, fall 2002-2004.

Most peak migrations corresponded with increased flows from rainfall (Figure 1). However, the first relatively small pulse of migrating Chinook salmon during 2002 and 2003 occurred on 1 and 2 October, and the migration of fish corresponded with the removal of two summer dams in the Guerneville area, located downstream of Agency's video monitoring station. This pattern was not observed during 2004, possibly because of the later migration during 2004. 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 cubic feet per second (cfs) the day following the peak migration. During 2004 the largest one-day migration event was on 26 October with 1,262 salmon, which corresponded with a flow of 500 cfs the following day.

Redd Distribution and Abundance

The distribution of Chinook salmon redds in the Russian River and Dry Creek were similar during the years of study (Figures 2 through 9). The relatively few redds observed in the Lower Healdsburg reach were found near the upstream end of the reach near the confluence with Dry Creek. Redds in the Upper Healdsburg reach were clustered in the center and upstream end of the reach. In the 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 in riffle habitats with course gravel to small cobble sized substrate and water depths greater than 20 cm. These observed spawning habitat requirements are likely a 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 three year study period (Figure 9). Redd numbers in the Russian River mainstem were highest during 2002 at 1,044 redds and decreased to 907 redds and 558 redds in 2003 and 2004, respectively. Redd numbers in Dry Creek were 256 redds during 2003 and 342 redds during 2004. The increased Chinook salmon spawning in Dry Creek during 2004 may partially explain the lower redd number in the Russian River mainstem in 2004. Also, the lowest number of redds in 2004 corresponded to the lowest count of adult salmon during video monitoring.

The frequency of redds progressively increased upstream in the Russian River mainstem and this pattern occurred annually during the three years of study (Figure 10). Most of the Chinook salmon spawning occurred in the upper three reaches of the Russian River mainstem and in Dry Creek. The Lower and Upper Healdsburg reaches had relatively few redds compared to the Alexander Valley, Canyon, and Ukiah reaches located upstream. Redds in the Lower and Upper Healdsburg reaches ranged from 0.0 to 3.7 redds/km. The Ukiah reach, located at the upstream end of the Russian River study area, had the highest frequency of redds annually in the mainstem at 15.1 redds/km during 2002. Redd frequencies in Dry Creek were similar to the productive Ukiah reach and had the highest redd frequency of all the study reaches at 15.8 redds/km during 2004.

In the mainstem, redds decreased in each reach during 2004 compared to previous years, except Lower Healdsburg where spawning was limited (Figure 10). This pattern may be, in part, explained by fewer adult Chinook salmon in the river system (based on video monitoring) and

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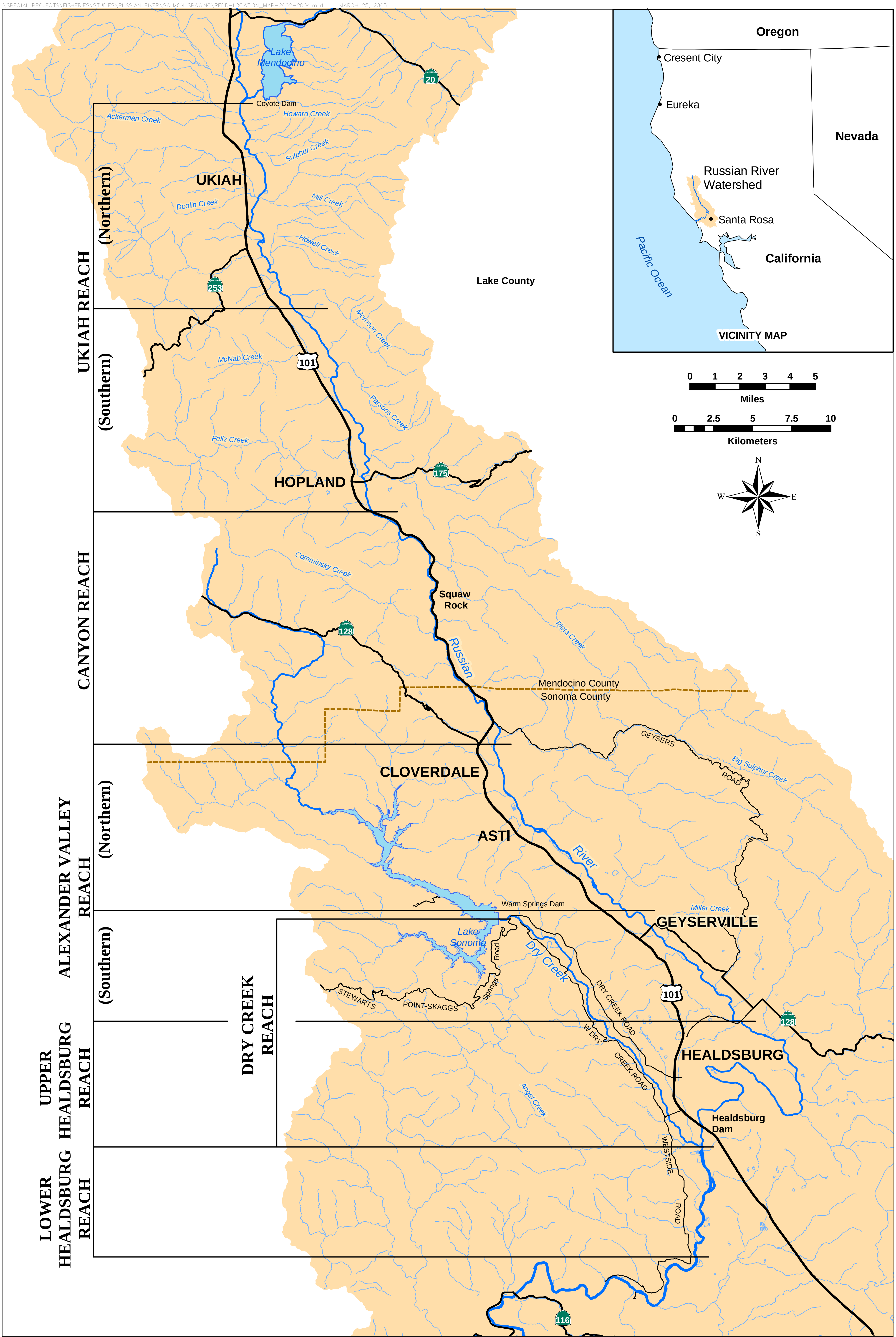

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Location Map

Chinook Salmon Spawning Study, Russian River

Figure 2

\SPECIAL PROJECTS\FISHERIES\STUDIES\RUSSIAN RIVER\SALMON SPAWNING\REDD-Ukiah-North-2002-2004.mxd MARCH 25, 2005

UKIAH REACH (Northern)

0 0.25 0.5 0.75 1
Miles
0 0.5 1 1.5 2
Kilometers

N
W E
S

Legend

- Redd Numbers, Fall 2002
- Redd Numbers, Fall 2003
- Redd Numbers, Fall 2004

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Chinook Salmon Redd Sites, Ukiah Reach (Northern)

Chinook Salmon Spawning Study, Russian River Fall 2002 - 2004

Figure 3

\SPECIAL PROJECTS\FISHERIES\STUDIES\RUSSIAN RIVER\SALMON SPAWNING\REDD-Ukiah-South-2002-2004.mxd MARCH 25, 2005

0 0.25 0.5 0.75 1
Miles
0 0.5 1 1.5 2
Kilometers

N
W E
S

Legend

- Redd Numbers, Fall 2002
- Redd Numbers, Fall 2003
- Redd Numbers, Fall 2004

UKIAH REACH (Southern)

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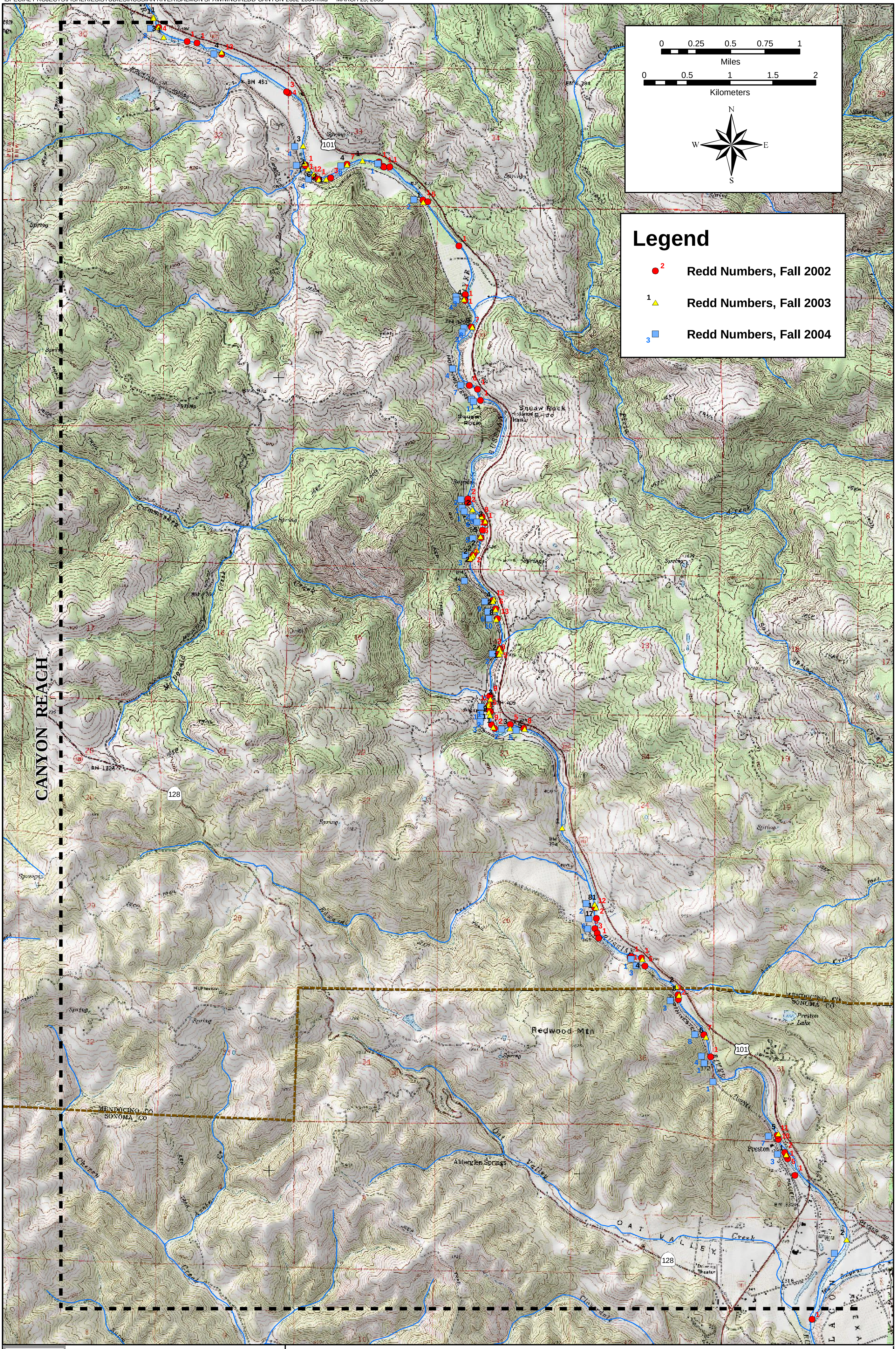
Chinook Salmon Redd Sites, Ukiah Reach (Southern)

Chinook Salmon Spawning Study, Russian River Fall 2002 - 2004

Figure 4

\SPECIAL PROJECTS\FISHERIES\STUDIES\RUSSIAN RIVER\SALMON SPAWNING\REDD-CANYON-2002-2004.mxd MARCH 25, 2005



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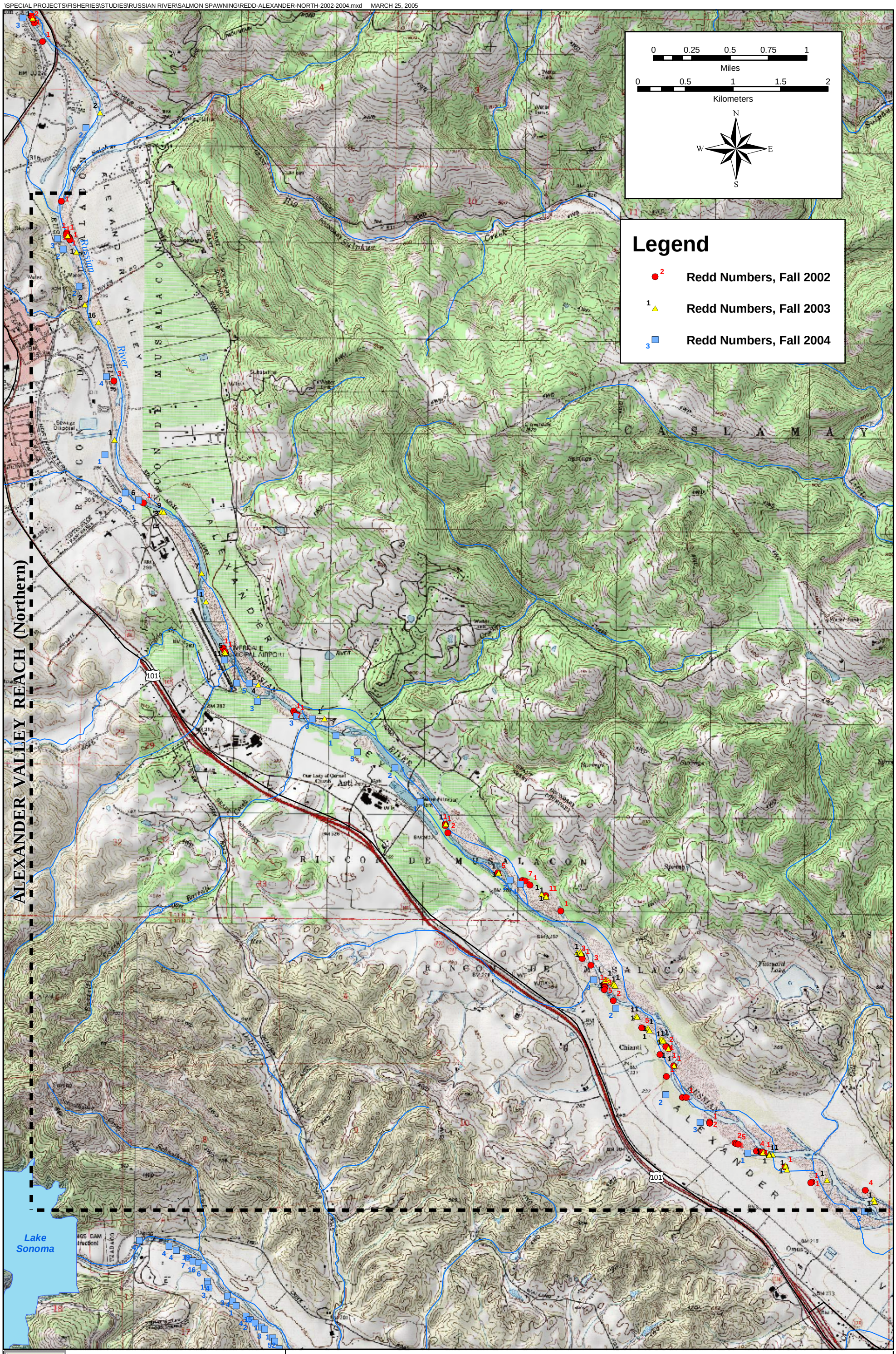
Chinook Salmon Redd Sites, Canyon Reach

Chinook Salmon Spawning Study, Russian River Fall 2002 - 2004

Figure 5

\SPECIAL PROJECTS\FISHERIES\STUDIES\RUSSIAN RIVER\SALMON SPAWNING\REDD-ALEXANDER-NORTH-2002-2004.mxd MARCH 25, 2005



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Chinook Salmon Redd Sites, Alexander Valley Reach (Northern)

Chinook Salmon Spawning Study, Russian River Fall 2002 - 2004

Figure 6

\SPECIAL PROJECTS\FISHERIES\STUDIES\RUSSIAN RIVER\SALMON SPAWNING\REDD-ALEXANDER-SOUTH-2002-2004.mxd MARCH 25, 2005

0 0.25 0.5 0.75 1
Miles

0 0.5 1 1.5 2
Kilometers

N
W E
S

Legend

- Redd Numbers, Fall 2002
- Redd Numbers, Fall 2003
- Redd Numbers, Fall 2004

ALEXANDER VALLEY REACH (Southern)

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Chinook Salmon Redd Sites, Alexander Valley Reach (Southern)

Chinook Salmon Spawning Study, Russian River Fall 2002 - 2004

Figure 7

\SPECIAL PROJECTS\FISHERIES\STUDIES\RUSSIAN RIVER\SALMON SPAWNING\REDD-HEALDSBURG-2002-2004.mxd MARCH 25, 2005

UPPER HEALDSBURG REACH

LOWER HEALDSBURG REACH

SONOMA

HEALDSBURG

RUSSIAN RIVER

Digger Bend

Healdsburg

Windsor

101

128

0 0.25 0.5 0.75 1
Miles

0 0.5 1 1.5 2
Kilometers

N
W E
S

Legend

- 2 — Redd Numbers, Fall 2002
- 1 — Redd Numbers, Fall 2003
- 3 — Redd Numbers, Fall 2004

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Chinook Salmon Redd Sites, Upper & Lower Healdsburg Reach

Chinook Salmon Spawning Study, Russian River Fall 2002 - 2004

Figure 8

\SPECIAL PROJECTS\FISHERIES\STUDIES\RUSSIAN RIVER\SALMON SPAWNING\REDD-DRYCREEK-2002-2004.mxd MARCH 28, 2005

0 0.25 0.5 0.75 1
Miles

0 0.5 1 1.5 2
Kilometers

N
W E
S

Legend

1 Redd Numbers, Fall 2003

3 Redd Numbers, Fall 2004

Lake Sonoma

DRY CREEK REACH

101

HEALDSBURG

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Chinook Salmon Redd Sites, Dry Creek Reach (Fall 2003 - 2004)

Chinook Salmon Spawning Study, Russian River Fall 2002 - 2004

Figure 9

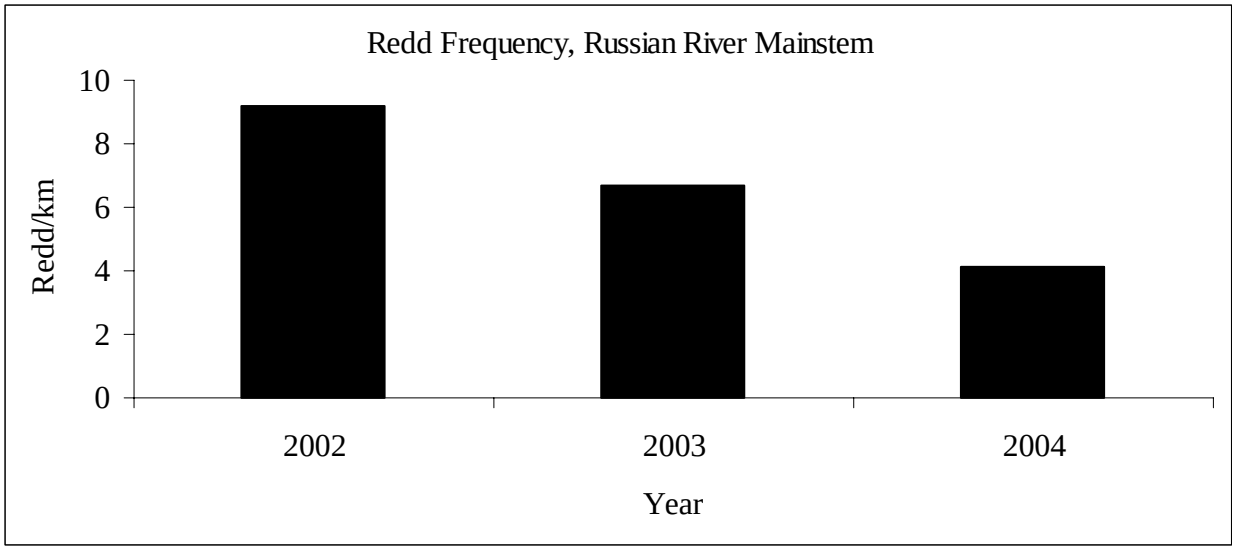

Figure 10: Frequency of Chinook salmon redds from 2002 to 2004 in the upper Russian River mainstem.

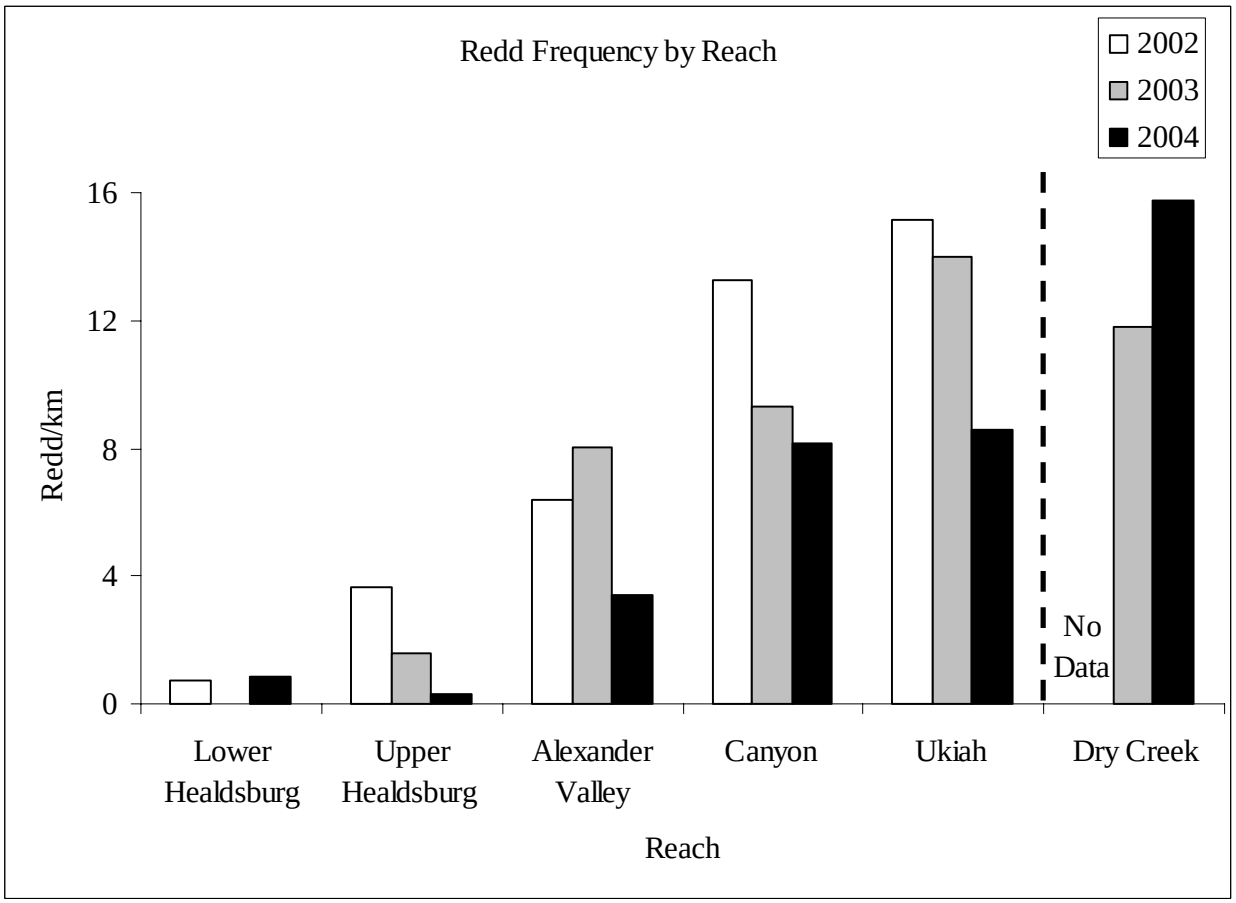

Figure 11: Chinook salmon redd frequencies along reaches of the upper Russian River from 2002 to 2004.

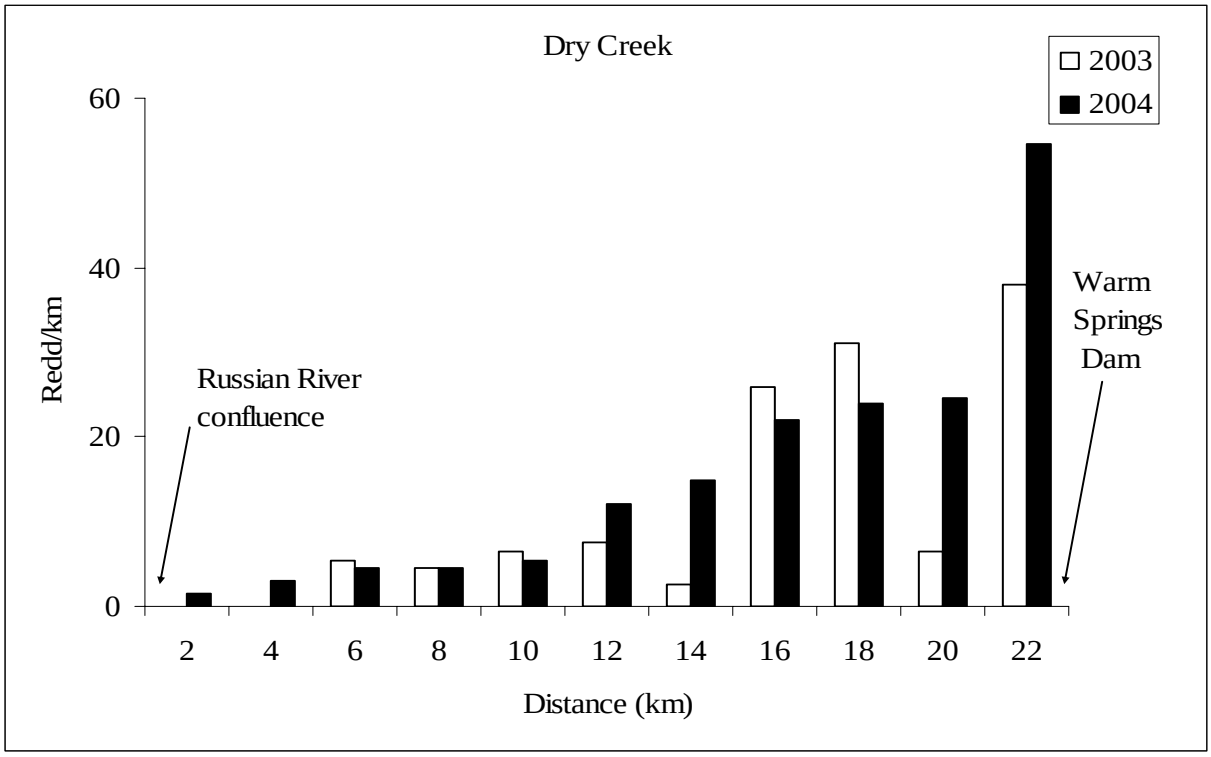

Figure 12: Distribution of Chinook salmon redds in the Dry Creek reach.

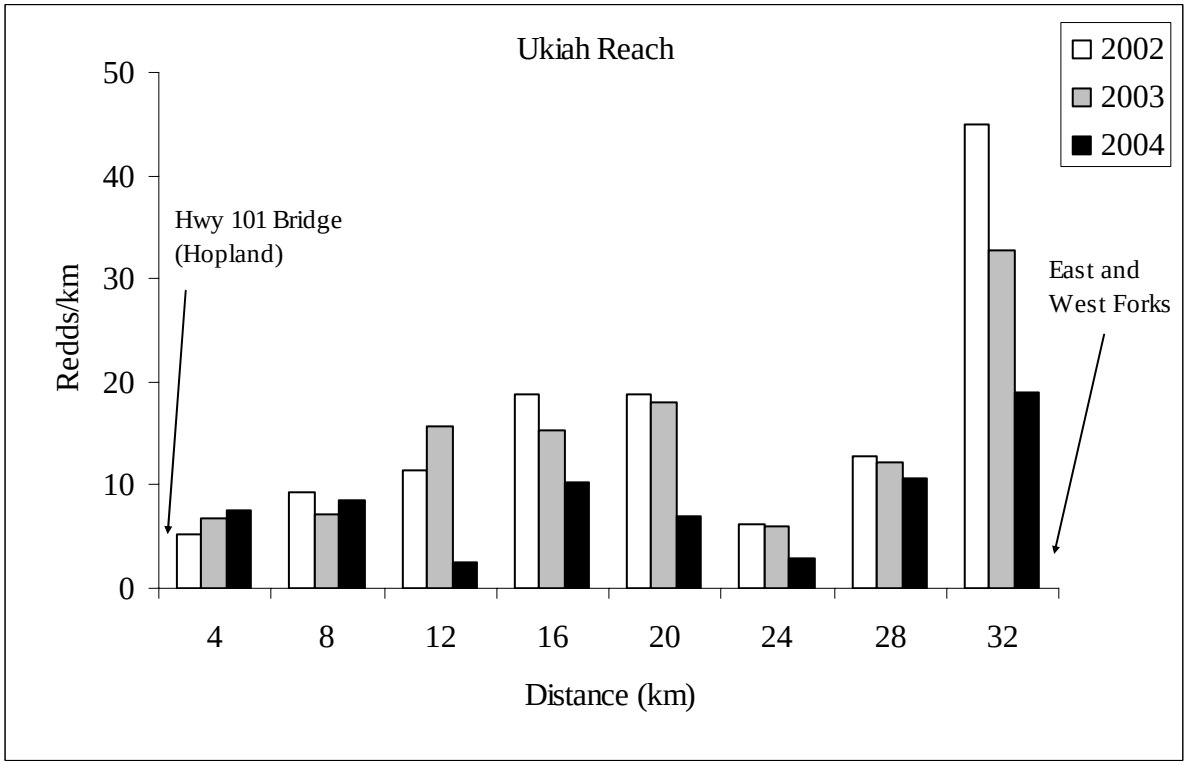

Figure 13: Distribution of Chinook salmon redds in the Ukiah reach.

the higher occurrence of spawning in Dry Creek. Dry Creek reach was the only reach where redds were higher in 2004 then in 2003, except Lower Healdsburg reach. Dry Creek reach contributed 38% of the redds found in the study area during 2004. A higher proportion of Chinook salmon spawning in Dry Creek would reduce the proportion of spawners in the mainstem.

The frequency of Chinook salmon redds was highest in the Dry Creek and Ukiah reaches. In general, the abundance of redds increased with proximity to the dams located near the upstream end the reaches (Figures 11 and 12). Dry Creek is accessible to Chinook salmon from the Russian River confluence for approximately 22 km before ending at the Warm Springs Dam, Lake Sonoma, and the Don Clausen Fish Hatchery (Figure 11). Dry Creek reach contributed 22% (256 redds) in 2003 of the observed redd production and nearly twice this proportion during 2004 at 38% (342 redds). The pattern of abundance of redds in both these reaches was similar each year. The upper segment of the Dry Creek reach contained greater than 80% of the redds during 2003 and 2004 with a high of 54.5 redds/km during 2004 at the upstream end of the reach. This trend was not as strong in the Ukiah reach where the upper half of the reach contained between 56% and 66% of the redds in the reach. However, the highest frequency of redds in the Ukiah reach was at the upstream end at the confluence of the East and West Forks of the Russian River and ranged from 19 to 45 redds/km from 2002 to 2004.

During the Chinook salmon peak migration periods of 2003 and 2004 Dry Creek contributed approximately one-third of the flow to the Russian River at the confluence and averaged 101 cubic-feet/second (cfs) in 2003 and 103 cfs in 2004 (Figure 13). Average flow in the Russian River at Healdsburg, located upstream of Dry Creek, was 176 cfs during fall 2003 and 262 cfs in 2004. Water releases in summer and fall 2004 from Coyote Dam were temporarily reduced due to low rainfall during the previous spring. This resulted in reduced releases during the fall migration period for Chinook salmon. However, three rain events during peak migration increased flows on average in 2004 to greater than average flows during 2003 that had normal water releases from Coyote Dam.

DISCUSSION

The disproportionately high counts of adult Chinook salmon observed during video monitoring compared to redd counts suggests that many more redds were deposited than were observed. There was approximately four to five times the number of migrating adults observed than redds. Based on an assumed 1- to -1 sex ratio, there could have been two to three times as many redds deposited annually. This discrepancy is probably due to the superimposition (overlapping) of deposited redds, spawning after surveys were completed, 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 and in Dry Creek. The highest densities were in the Ukiah and Dry Creek reaches. Redd abundance in the Lower Healdsburg and Upper Healdsburg reaches were very low. This is consistent with our observation of riffle habitat with substrate

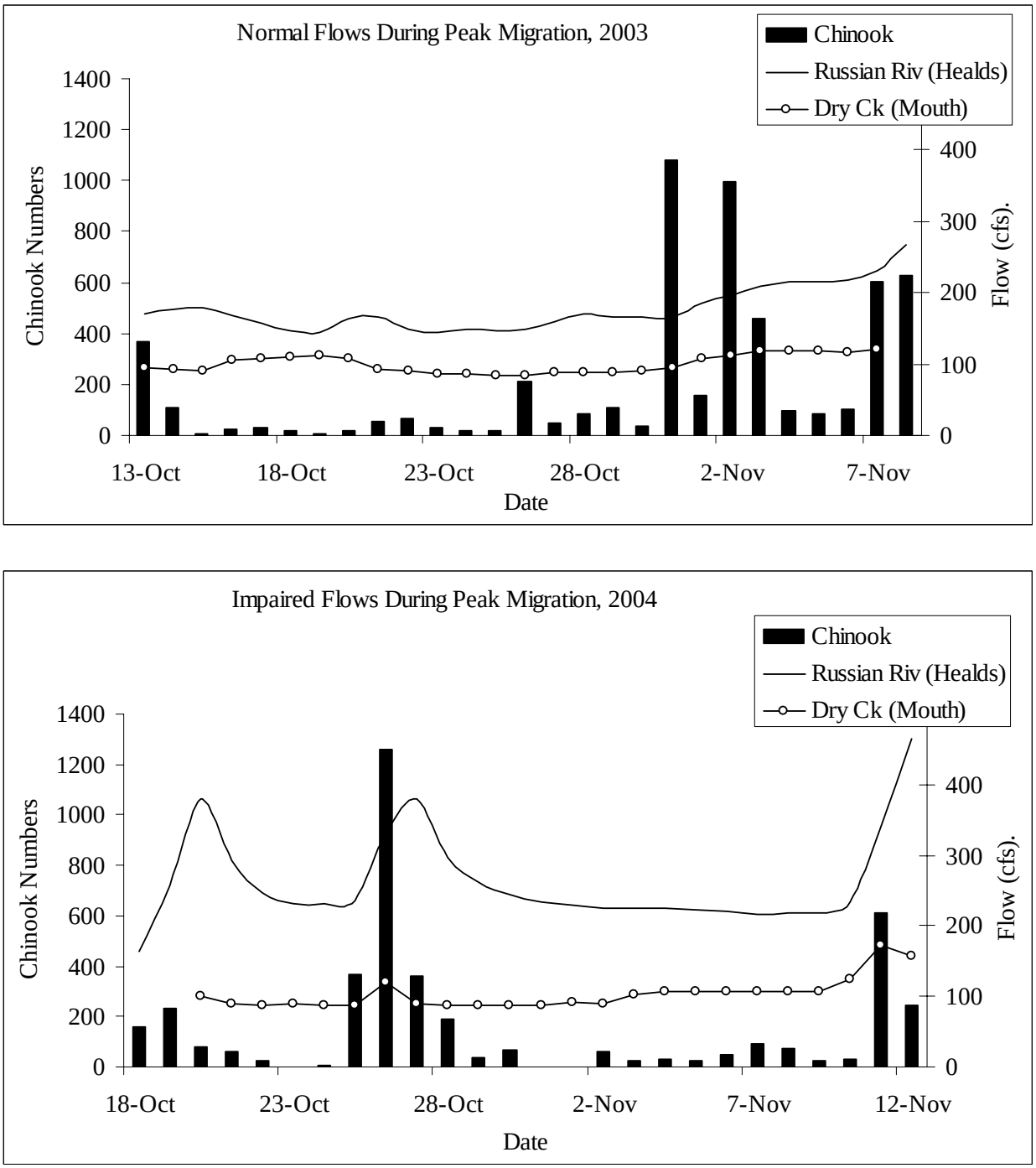

Figure 14: Flows during peak Chinook salmon migration period during normal water release year (2003) and temporarily reduced water release year (2004). Chinook salmon numbers are from video monitoring, and stream flows are from the mouth of Dry Creek and Russian River near Healdsburg. Peak migration is the period from the first day to the last day that a minimum of 100 fish pass the video monitoring station.

suitable for Chinook salmon spawning occurring primarily above Upper Healdsburg reach and in Dry Creek reach. Chinook salmon redds were 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. Relatively cool flows from Lake Sonoma (D. Cook pers. obs.) are probably the primary factor that attracted large numbers of spawning Chinook salmon to Dry Creek.

An expected outcome of temporarily reduced flows in the upper Russian River from reduced releases at Coyote Dam (Lake Mendocino) would be more fish spawning in Dry Creek. Reduced Coyote Dam releases would proportionally increase the contribution of flows from Dry Creek and attract more spawning Chinook salmon. Although more Chinook salmon spawned in Dry Creek during the temporarily reduced release year of 2004 than during the normal year of 2003, there was more flow in the Russian River during spawning in the temporarily reduced year than in the normal release year. This paradox can be explained by the three rainfall events in 2004 that occurred during peak Chinook salmon migration. Rainfall substantially increased flows in the upper Russian River when most Chinook salmon were migrating. This pattern of flows in 2004 during the migration period suggests that cool water released from Lake Sonoma may influence Chinook salmon spawning in Dry Creek more than simple flow.

Overall there has been a marked increase in the number of spawning Chinook salmon since the 1980s when Chinook salmon were considered nearly extirpated from the Russian River basin. This study documented 900 to over 1,000 redds annually from the upper Russian River. Although Chinook salmon numbers have increased over historic accounts, there was a decrease in the observed number of Chinook salmon redds during the three years of study. 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. First, this study provides the most quantitative analysis of Chinook salmon spawning conducted in the Russian River; however, three years of data is probably insufficient to fully assess population trends. Surveys conducted during several fish generations (10 to 20 years) would be needed to adequately assess trends. 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. For example, surveys in 2003 had the highest number of adult Chinook salmon counts but only the second highest number of redds suggesting that not all redds were detected. 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 adulthood in 2 to 4 years. Fourth, it is possible that the relatively large number of redds detected in the Russian River mainstem in 2002 was influenced by more salmon spawning in the mainstem than in Dry Creek, which was not surveyed in 2002. Chinook salmon may “stray” (Moyle 2002) between Dry Creek and the mainstem. Between 2003 and 2004 the proportion of redds doubled in Dry Creek, indicating that the annual utilization between Dry

Creek and the mainstem is considerable. Finally, it is likely that a combination of the above and possibly unidentified factors effect the annual abundance of redds.

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