Fall-run chinook salmon spawning survey, September 2005 through January 2006 Mokelumne River, California.

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Abstract: Weekly fall-run chinook salmon *Oncorhynchus tshawytscha* spawning surveys were conducted in the lower Mokelumne River from September 29, 2005 through December 29, 2005. The estimated escapement during this period was 18,709 chinook salmon. The estimated number of in-river chinook salmon spawners was 10,535 fish. During the survey period 2,170 chinook salmon redds were observed, of which 407 or 19% were superimposed. The reach from Camanche Dam to Mackville Road contained 1,953 salmon redds (90%) and the reach from Mackville Road to Elliott Road had 208 redds (9.6%). Nine additional redds (0.4%) were noted outside the typical survey reaches. Eleven hundred and eighty one redds (54.65%) were constructed in enhancement areas.

INTRODUCTION

The 627 sq. mile Mokelumne River watershed ranges from the Sierran Crest to the Sacramento - San Joaquin Delta. Pardee and Camanche reservoirs, located on the Mokelumne River (Figure 1), are owned and operated by East Bay Municipal Utility District (EBMUD), which provides water for 1.2 million customers in Alameda and Contra Costa Counties. Additionally, there are reservoirs and power generation facilities located upstream of Pardee Reservoir owned and operated by Pacific Gas & Electric Company (PG&E). Downstream of Camanche Dam, Woodbridge Irrigation District (WID) operates Woodbridge Dam (WD) and an associated system of irrigation canals near Lodi, CA.

The lower Mokelumne River (LMR) is used by fall-run chinook salmon *Oncorhynchus tshawytscha* and steelhead trout *O. mykiss* for spawning and rearing. Adult chinook salmon ascend the river as early as late August and may begin spawning in late September. The peak of the run usually occurs in November and tapers off through the month of December (Marine and Vogel 1994, Hartwell 1996, Setka 1997). The Mokelumne River Fish Hatchery (hatchery), constructed in 1964 to mitigate for spawning habitat lost with the construction of Camanche Dam, receives approximately 45.4% of the total run per year (1990-1998 average). EBMUD has conducted annual spawning surveys in the lower Mokelumne River (LMR) since 1990 (Hagar 1991, Hartwell 1996, Setka 1997). Concurrent with these surveys, EBMUD enumerates chinook salmon escapement at Woodbridge Dam (Biosystems 1992, Natural Resource Scientists Inc. 1996). Data generated from carcass surveys allow for an estimation of the number of chinook salmon within the LMR at any time during the spawning season.

OBJECTIVES

The primary objective of the 2005 spawning survey was to enumerate chinook salmon redds in the LMR. Total escapement to the river was estimated using carcass survey estimates. The escapement estimate was used to associate the number of redds and their characteristics with population structure or density. Additional objectives included:

- Map locations of individual redds
- Determine specific preferences of spawning chinook with cover (overhanging vegetation, canopy, undercut banks, water depth and turbulence, etc.), habitat type, and large organic debris (LOD)
- Enumerate redds impacted by superimposition
- Determine use of enhancement gravel areas

Environmental parameters and flow during the spawning period were summarized. An emergence timeline was constructed based on an egg model developed by Vogel (1993) from Piper et al. (1982).

METHODS

SURVEYS

The lower Mokelumne River is divided into 6 reaches between Camanche Dam and the confluence with the Sacramento-San Joaquin Delta. The reach designations are based on gradient, substrate and tidal influence. Reaches 5 and 6 cover a 15.8 km (9.8 mile) section of the river from Camanche Dam to Elliott Road. Beginning September 29, 2005, weekly redd surveys were conducted in the LMR from Camanche Dam to Elliott Road (Figure 1). The last survey was conducted December 29, 2005. A steelhead spawning survey was not conducted due to high flows in the river in January, February and March. The reaches were surveyed on 1, 2 or 3 days per week, depending on spawning activity. Surveys consisted of three individuals walking abreast down the river (water depths to 4 feet) and searching for signs of redd construction. This method has been used in past Mokelumne River spawning surveys and in other rivers and streams (Keefe et al. 1994, Fritsch 1995, Hartwell 1996, Setka 1997). A Canoe was used to transport surveyors between spawning areas. Redds were marked using 8 inch bolts with bright pink, numbered cattle tags attached to the head end. Locations were recorded using a hand-held Global Positioning System (GPS) unit (Trimble Pro XR) and a laser range finder (Laser Atlanta Advantage). Individuals positioned themselves directly behind redds (on the tailspill) to insert tags and have positions recorded with the laser range finder. Care was taken to avoid impacts to redds during the survey and with placement of tags.

DATA COLLECTION

Location data for each redd were stored in the GPS unit and later downloaded to an ArcMAP 9.3 (ESRI) data base. In addition to redd locations, notations were made regarding the characteristics and locations of redds. These measurements included cover type, number of fish associated with each redd, and redd depth. Water temperatures were measured using hand-held thermometers.

DATA ANALYSIS

Data analysis was performed using ArcMAP, Arc/Info (ESRI) systems and EBMUD LMR GIS. The lower river GIS is based on two data sets: regional USGS maps with a 1:24,000 scale and local maps based on orthorectified photos (taken February 28, 1994, at a release of 202cfs from Camanche Dam) with a 1:4,800 scale.

RESULTS

ESCAPEMENT AND REDD NUMBERS

The total estimated escapement to the Mokelumne River from September 2005 through January 2006 was estimated to be 18,709 chinook salmon (adults and grilse). The estimate was based on weekly carcass surveys performed in reaches 5 and 6, during the spawning season and hatchery returns. Video counts from Woodbridge Dam were not available for use due to technical difficulties.

Hatchery staff recorded 8,174 (43.6% of run) chinook salmon entering the hatchery during the 2005 spawning season. The sex and age composition of salmon returning to the hatchery was 4,770 adult females (58.3%), 2,473 adult males (30.3%), and 931 grilse (11.4%). The carcass counts gave an estimate of 10,535 in-river spawners during the 2005 season.

During the 2005 survey period, 2,170 redds were observed. The first redd was observed on September 29, 2005. Redd construction peaked during the first week of December and lasted through the end of the month (Figures 2 and 3). Reach 6 contained 1,953 (90%) redds, while Reach 5 contained 208 (9.6 %) redds. The season's redd count was almost 3 times the average red count in the previous 4 years (825 redds).

ENHANCEMENT GRAVEL USAGE

Since 1992 the District has conducted gravel enhancement projects in the lower Mokelumne River in cooperation with federal and state agencies. In 2005, 1,181 redds or 54.7% of the total number of redds were constructed in habitat enhancement areas (Figures 4 and 5). The overall percent use of enhancement areas increased in 2005 compared to 2004 (from 46.9% to 54.65%), as did the number of in-river spawners (Figure 6).

SUPERIMPOSITION

During the 2005 season 407 redds (18.8 %) were superimposed. Ninety-four percent of redd superimposition occurred in Reach 6, while the remaining 6% occurred in Reach 5. During the peak of the run, weekly SI levels were 12% to 19% (Figure 7). Site specific superimposition levels varied from 27% below the catwalk to 0% at Wykoff (Figure 8). The 2005 level of superimposition (18.8 %) is an increase from the 10.9% of 2004 (Figure 9).

ENVIRONMENTAL DATA

Water temperatures below Camanche Dam during the period of September 29, 2005 to December 31, 2005 ranged from 16.4°C to 13.4 °C (Figure 10). All redds were constructed in water temperatures under 16.4°C. Releases from Camanche Dam during the survey period ranged from 328cfs (December 12, 2005) to 651cfs (December 29, 2005 (Figure 10). Most redds during the season were constructed at flows of about 330cfs. Redds built in December were constructed at a variety of flows between 330cfs and 651cfs due to a significant number of flow changes throughout the month.

REDD PHYSICAL CHARACTERISTICS AND HABITAT PREFERENCES

There were 1,649 instances where cover was associated with individual redds. Many of these instances involved one redd associated with multiple cover types. The most common cover types used were turbulence (33.4%), canopy (28.5%), overhanging vegetation (25.3%) and LOD (8.8%).

BEHAVIOR

The number of salmon associated with a single redd ranged from 0 to 5. Of the 1,649 redds observed, 618 (28.5% of total redds) were active with at least one fish. There were 248 (11.4% of total redds) instances of at least 2 salmon on a single redd.

EMERGENCE TIMELINE

Using the egg model it was predicted that fry began emerging from redds the week of November 25, 2005 and continued through March 18, 2006 (Figure 11). The peak of fry emergence was estimated to be the week of February 22, 2006. The first fry captured in the rotary screwtraps at WD occurred on December 28, 2005 (traps installed December 19th).

DISCUSSION

The 2005-2006 escapement of 18,709 salmon was 230% of the historical 1940 through present average (4,318) and was the largest escapement recorded since monitoring began in the early 1990's (Figure 12). The hatchery took 8,174 of these fish, leaving approximately 10,535 in-river spawners during the 2005 season. This estimate of in-river spawners is more than two and a half times more than in the next largest on record (4,112) in 1998. The record number of spawning adults this year resulted in a record number of redds and had effects on the distribution of redds and superimposition levels.

There were 2,170 redds observed this season, 90% of which were observed in Reach 6 while approximately 10% of the total redds were observed in Reach 5. This is the highest percentage of redds recorded in the upper reach since surveys began in 1990. Twice during the peak of the run, we were forced to end our survey in the lower reach before surveying the entire spawning reach. The areas skipped were surveyed in subsequent weeks, however, so it is not likely that insufficient survey effort is responsible for the small percentage of redds recorded in the lower reach.

Despite the crowded conditions in Reach 6 (below Camanche Dam) fish did not appear to re-distribute themselves downstream. Instead, it appears that the fish spawned in areas between the most used habitats from previous years where spawning had not observed before. This is particularly true in the spawning areas from Alder Island up to the Catwalk, where the normally well-defined spawning areas often became connected by spawning between them. This trend may have been reinforced by the hatchery's new practice of returning un-spawned fish to the river. Much of this spawning activity occurred in areas that were deep, with low flow and sub-optimal gravel conditions.

Superimposition levels also increased as a result of the large number of in-river spawners. The superimposition rate for the 2005 season was 19%, with 94% of the superimposition in Reach 6. This is noticeably higher than the average superimposition from the last ten years (13%). It is not out of the range that would be expected given the crowded

conditions in the upper reach, however, and is consistent with the rates seen in the late 1990's when red numbers were high (approx.1,300 redds).

The overall percent use of enhancement areas increased in 2005 compared to 2004 (from 46.9% to 54.65%). This increase is expected due to an increase in quality habitat available and ongoing enhancements which are affecting a growing percentage of the prime spawning areas.

Hatchery effects

In 2005, the hatchery took about 43% of the run, a much lower percentage than in recent years. In addition, the hatchery began a new practice of releasing live fish that they did not spawn back into the river at the hatchery. In the past, these fish were sacrificed and the carcasses were returned to the river for nutrients. These two factors not only increased the number of in-river spawners and redds, but likely had an effect on the distribution of redds and superimposition level as discussed above. It is possible that the fish released from the hatchery are more likely to spawn at the top of the reach below the hatchery because of the delay they experience at the hatchery.

This year, the fish released from the hatchery were marked with disk tags so that they could be identified returning to the hatchery and on the river while spawning. Results indicate that the vast majority of these fish that spawn in the river do so in the upper reach, particularly in the day use area below the hatchery. The farthest downstream that a tagged fish was observed was the George Reed enhancement site. The majority of tagged fish that were observed, however, were found in the stretch of river above Highway 88. Superimposition rates in the day use area should be monitored to see if the practice of releasing these fish is likely to have significant impacts on redds in these areas. Concentrating enhancement efforts in the upper reach of the river in order to expand areas of quality spawning habitat should alleviate much of this problem if it occurs in the future.

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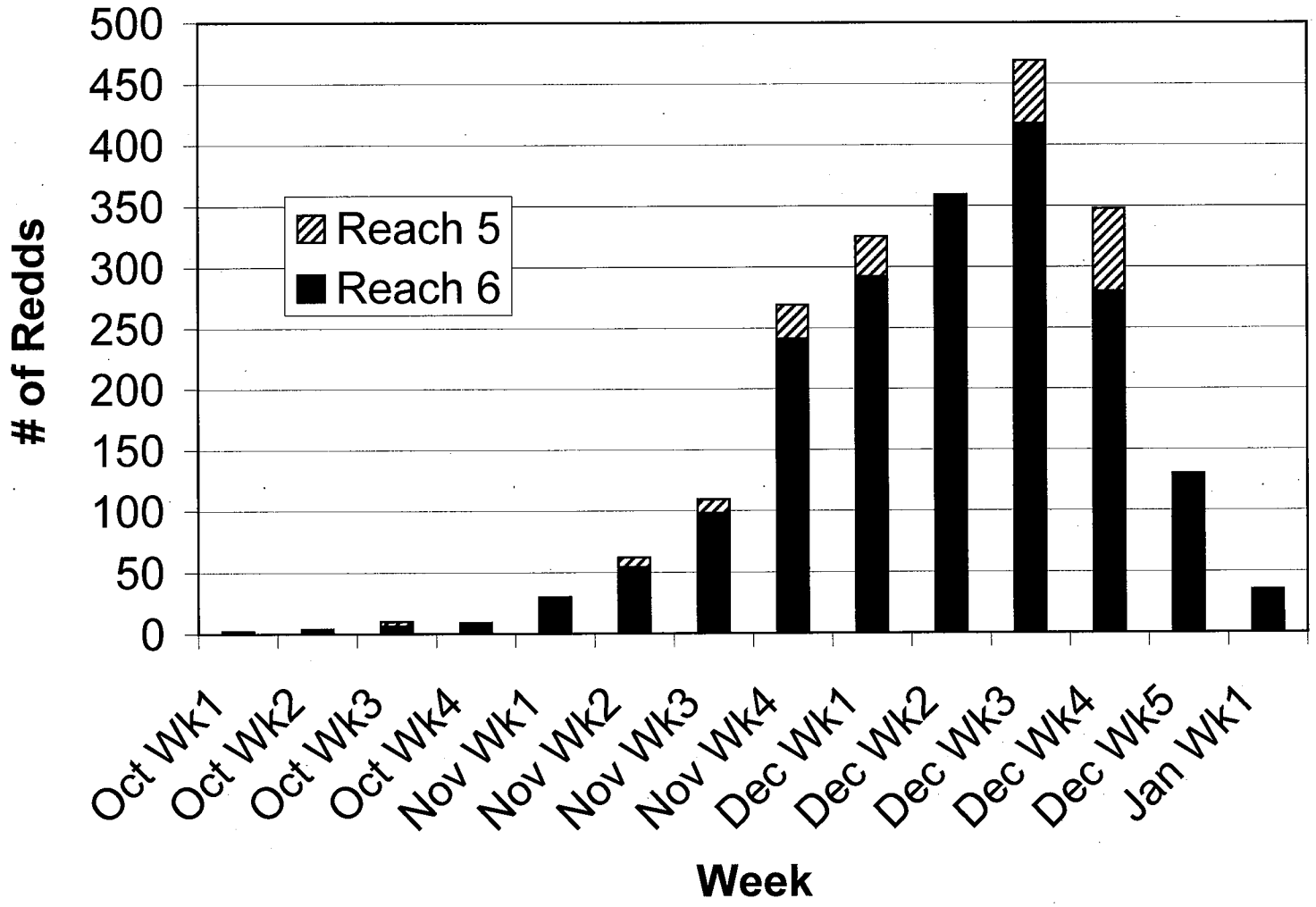

Figure 2: 2005 weekly redd counts by reach, lower Mokelumne River.

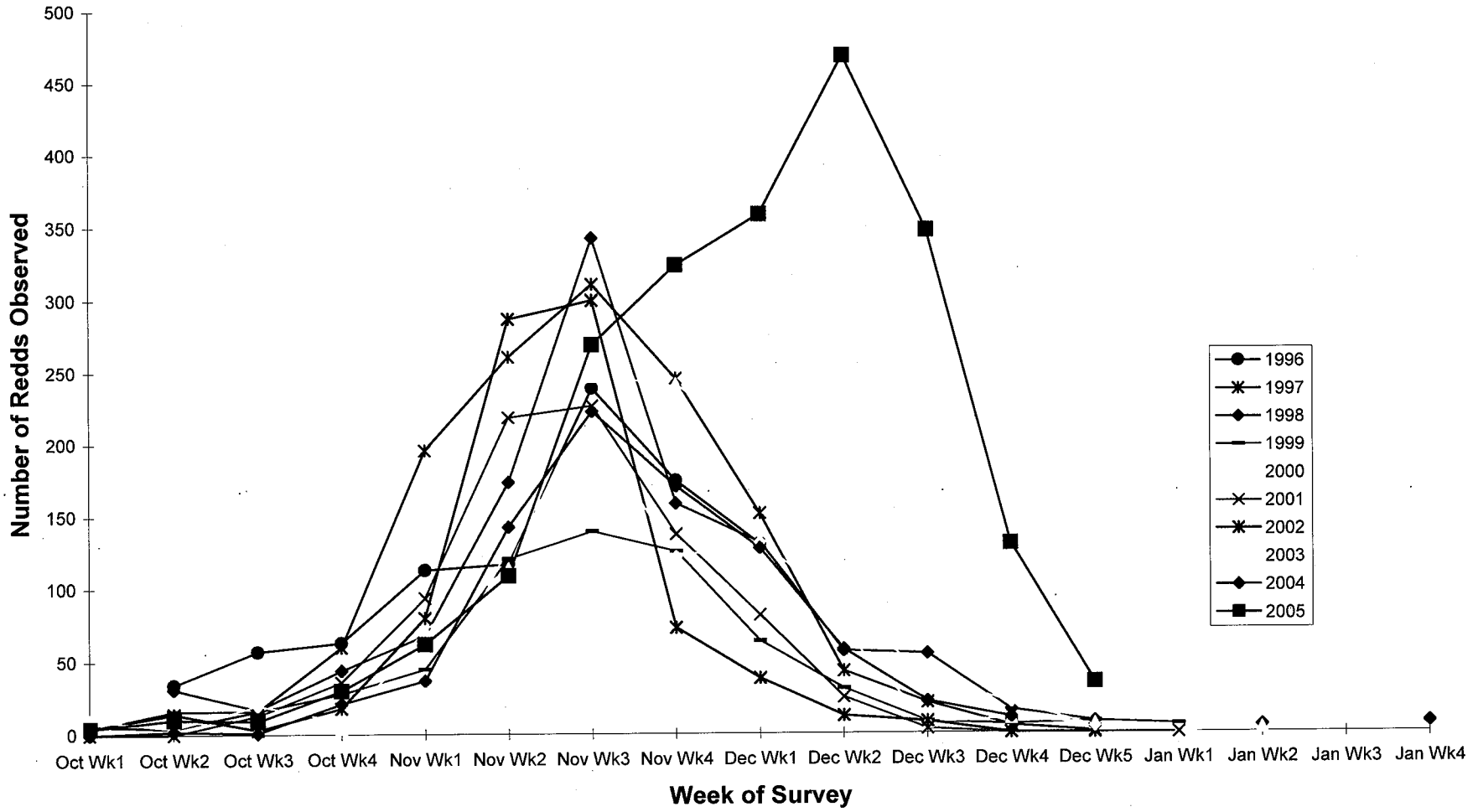

Figure 3: Chinook salmon redds built per week 1996-2005, lower Mokelumne River.

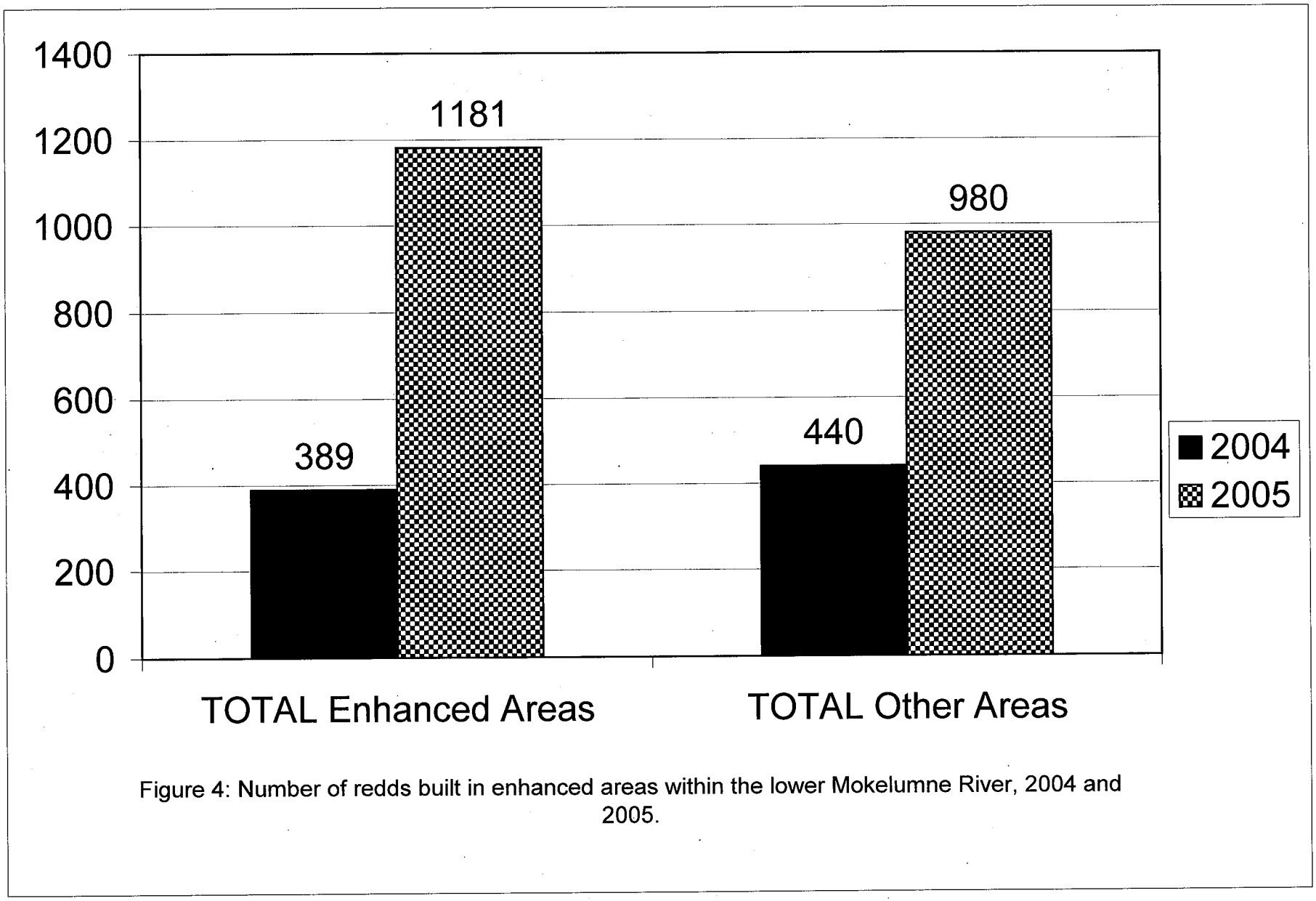

Figure 4: Number of redds built in enhanced areas within the lower Mokelumne River, 2004 and 2005.

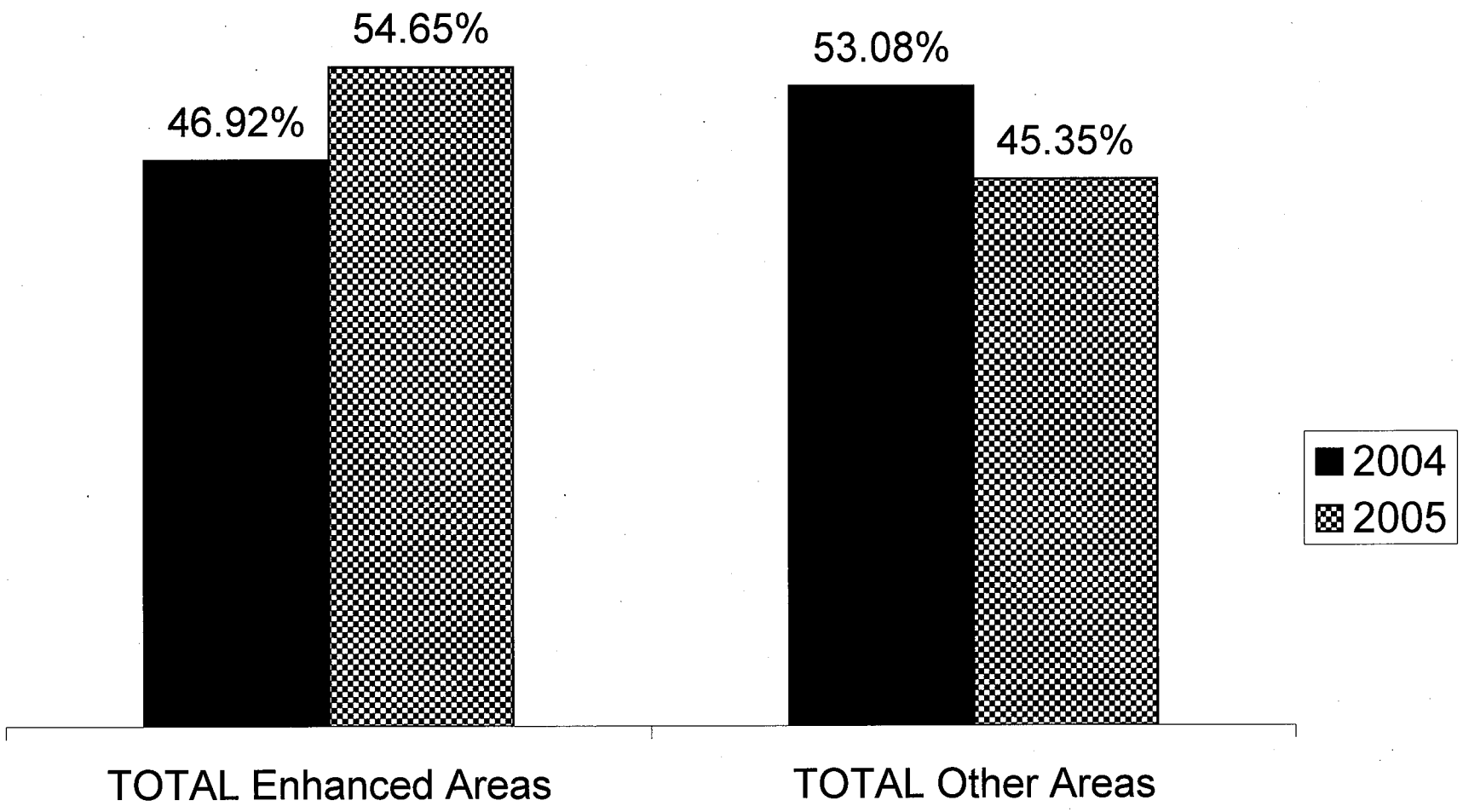

Figure 5: Percntage of redds built in enhanced areas within the lower Mokelumne River, 2004 and 2005.

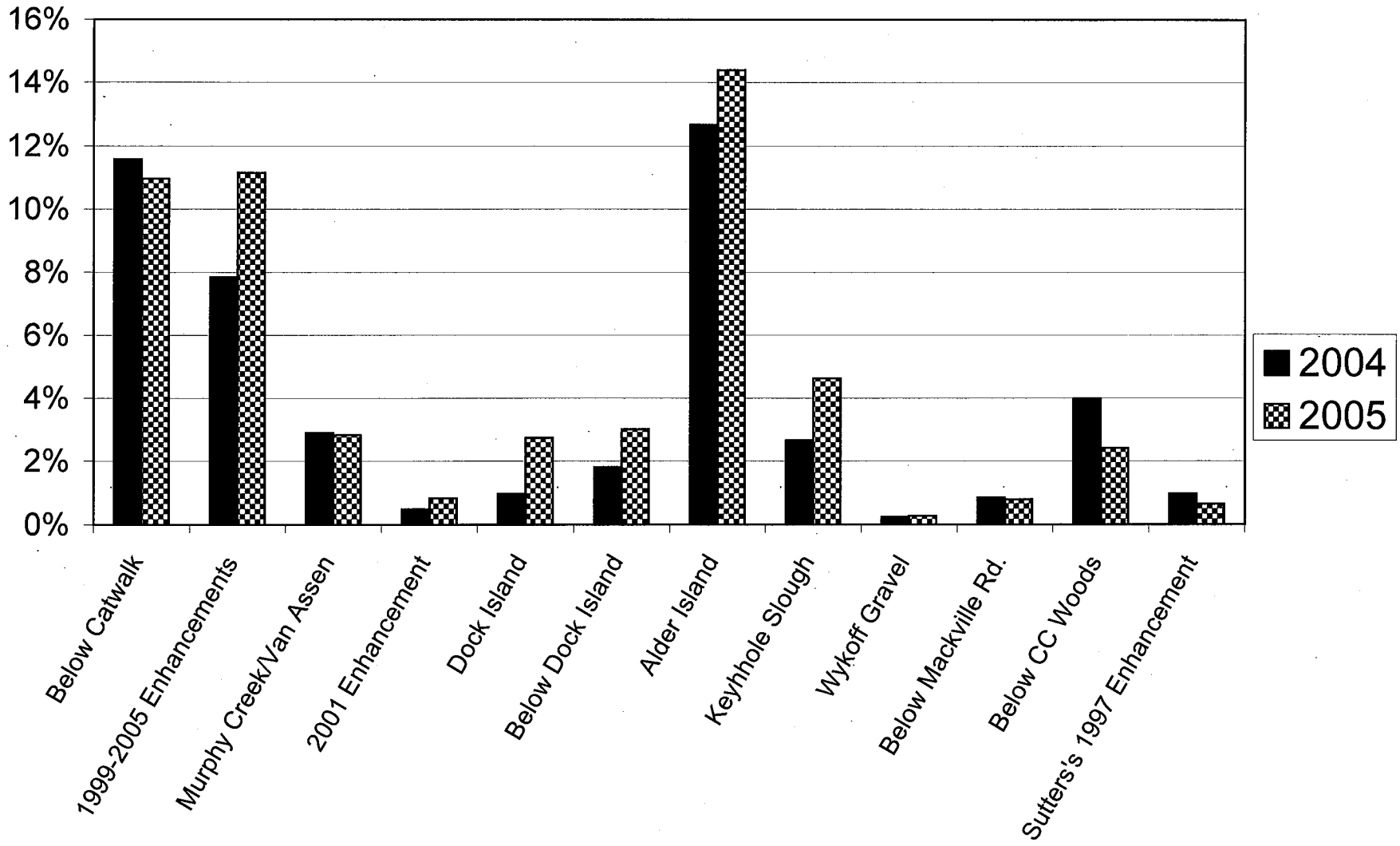

Figure 6: Percentage of redds built in specific enhancement areas within the lower Moklemne River, 2004 and 2005.

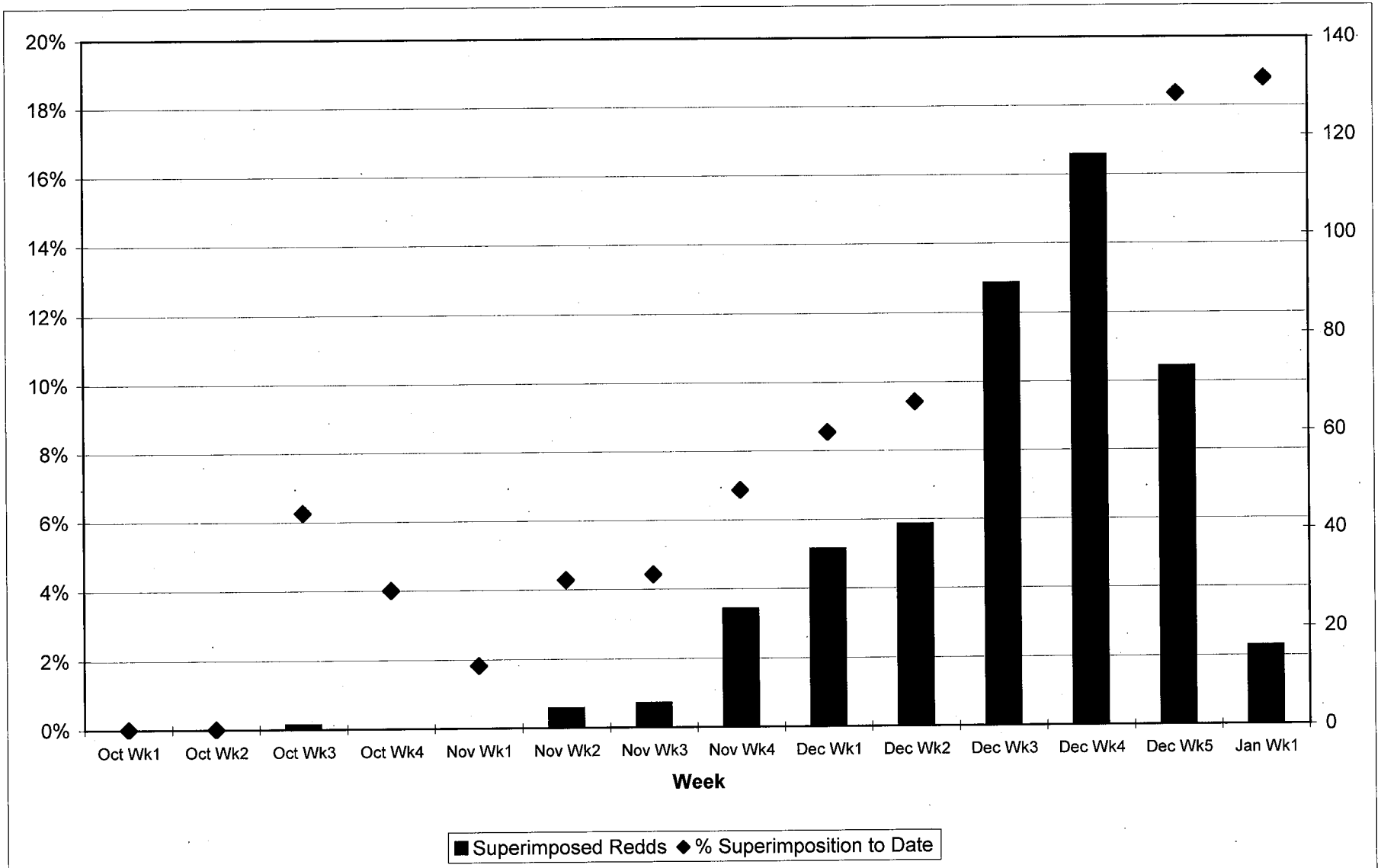

Figure 7: Number of superimposed redds and percent superimposed on the lower Mokelumne River, 2005.

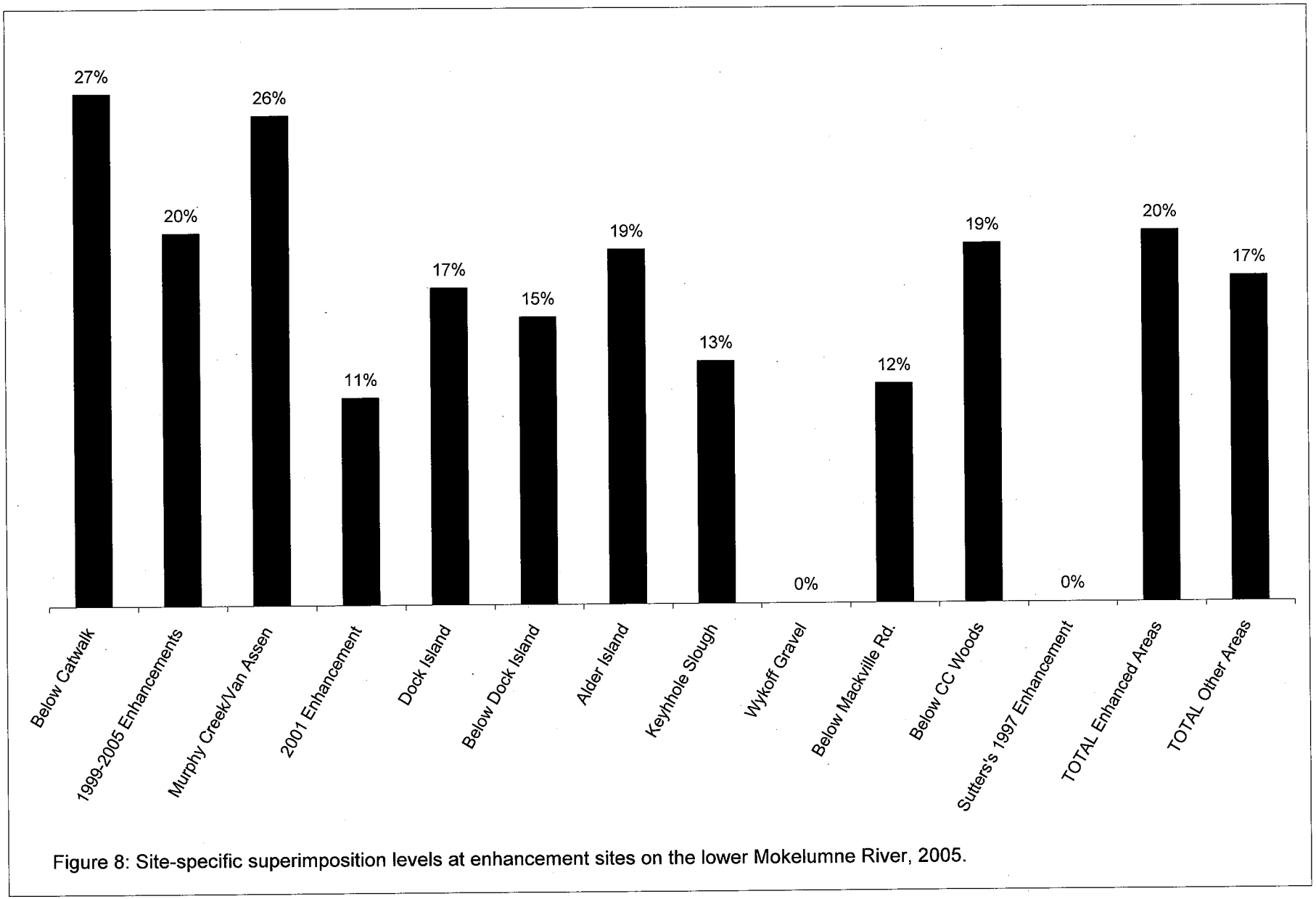

Figure 8: Site-specific superimposition levels at enhancement sites on the lower Mokelumne River, 2005.

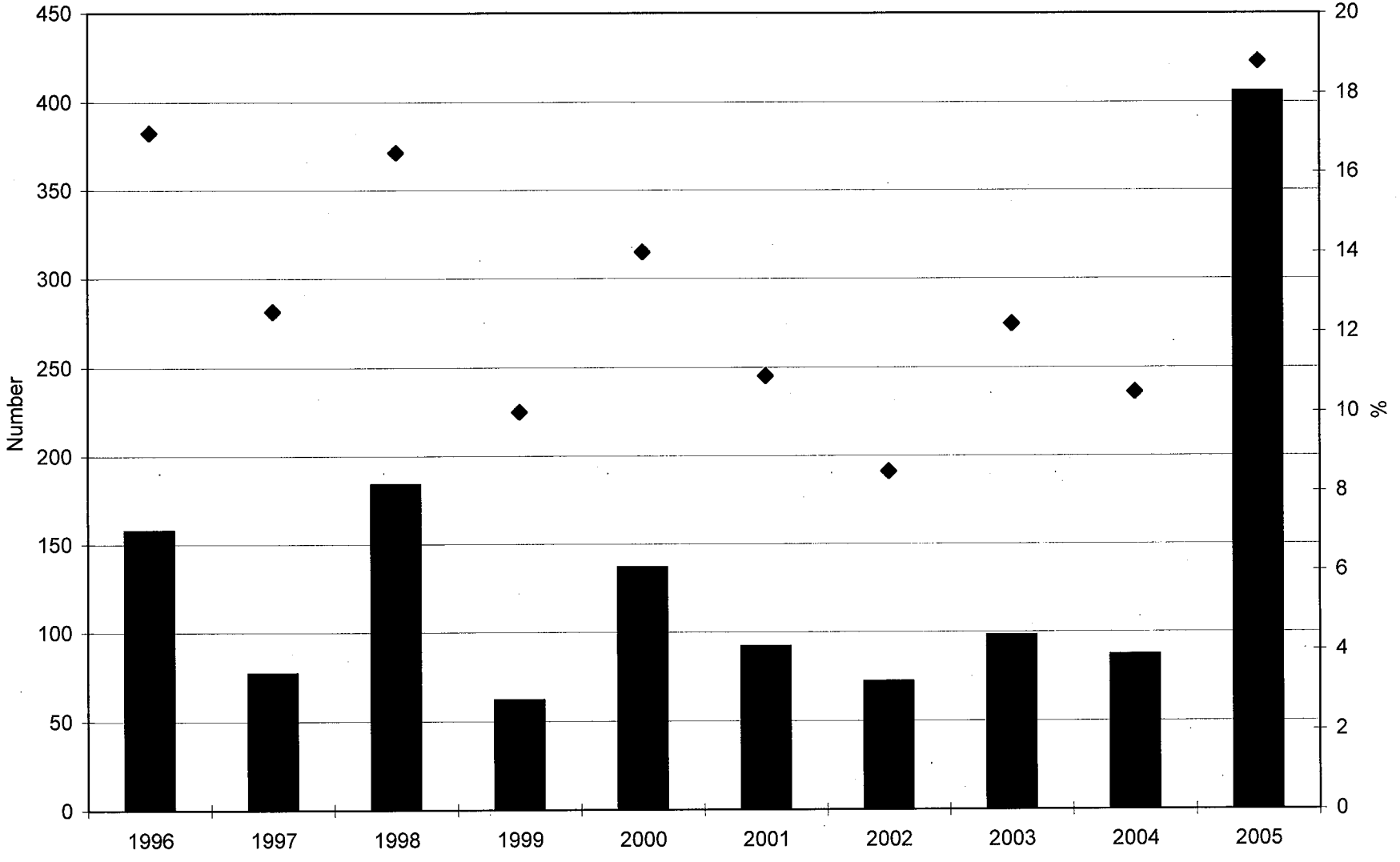

Figure 9: Number and percentage of redd superimposition on the lower Moklemne River, 1996-2005

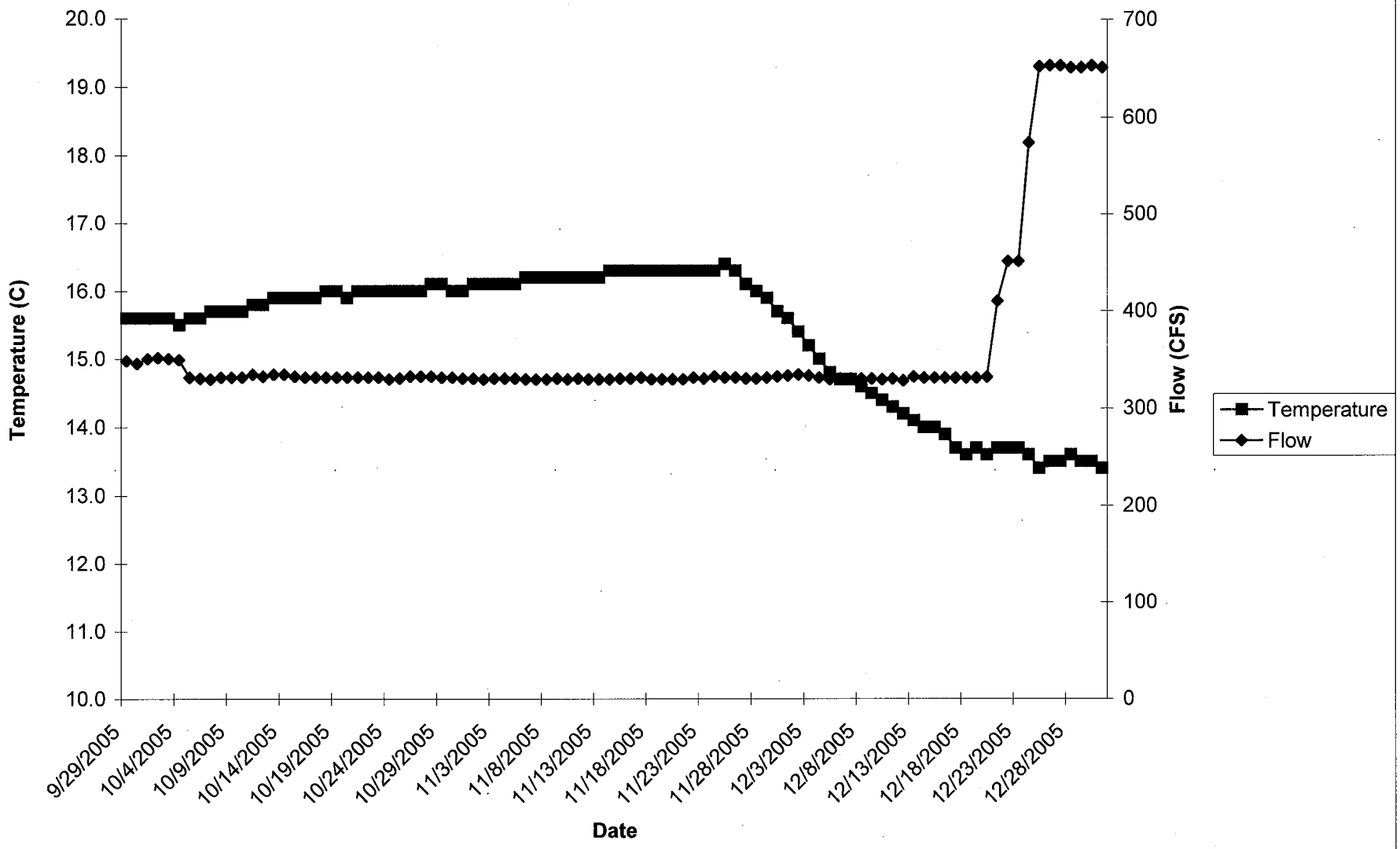

Figure 10: Temperature and Flow below Camanche Dam on the lower Mokelumne River for the 2005 spawning season.

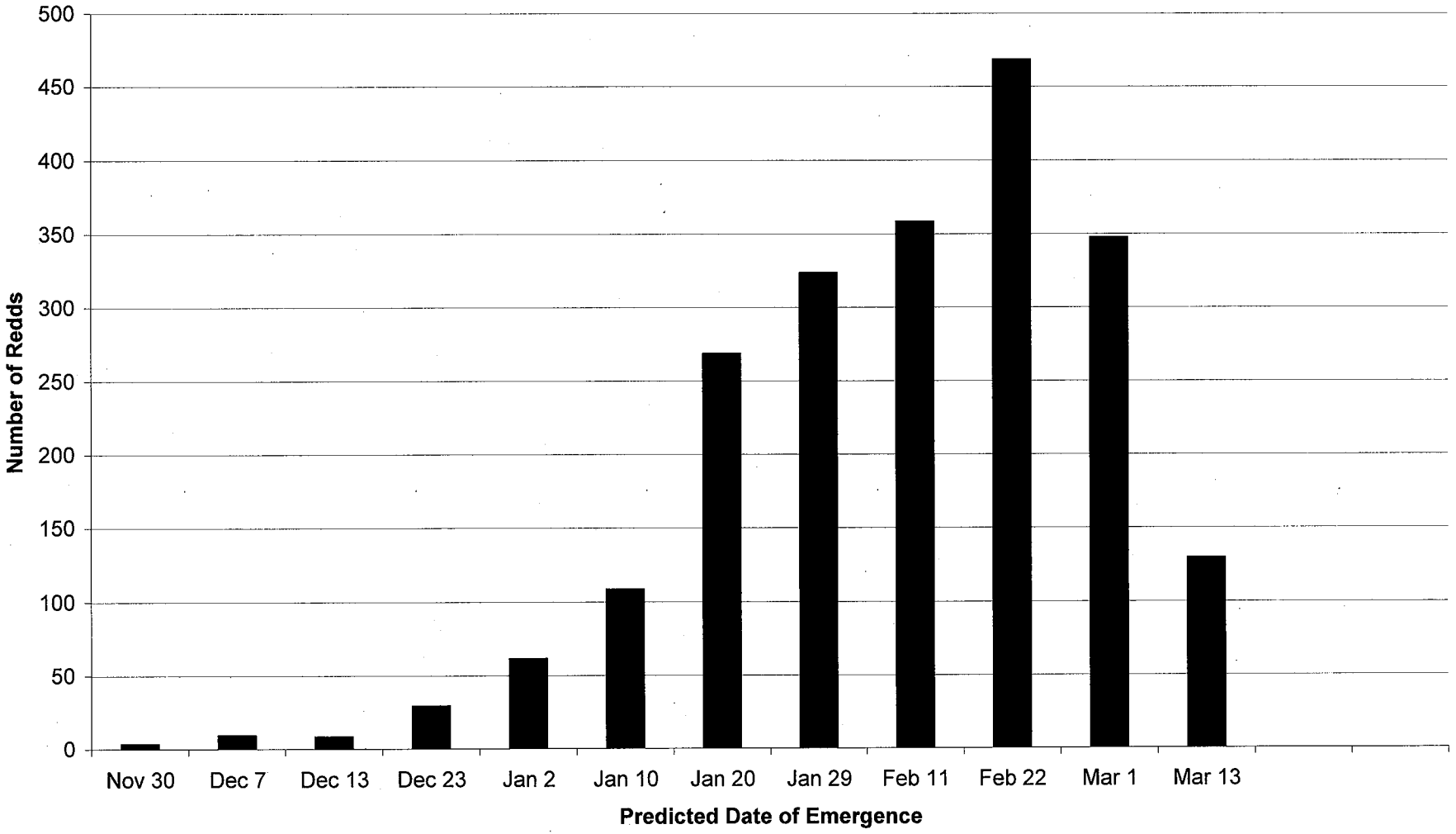

Figure 11: Predicted date of emergence for chinook salmon fry in the lower Mokelumne River, 2005-2006.

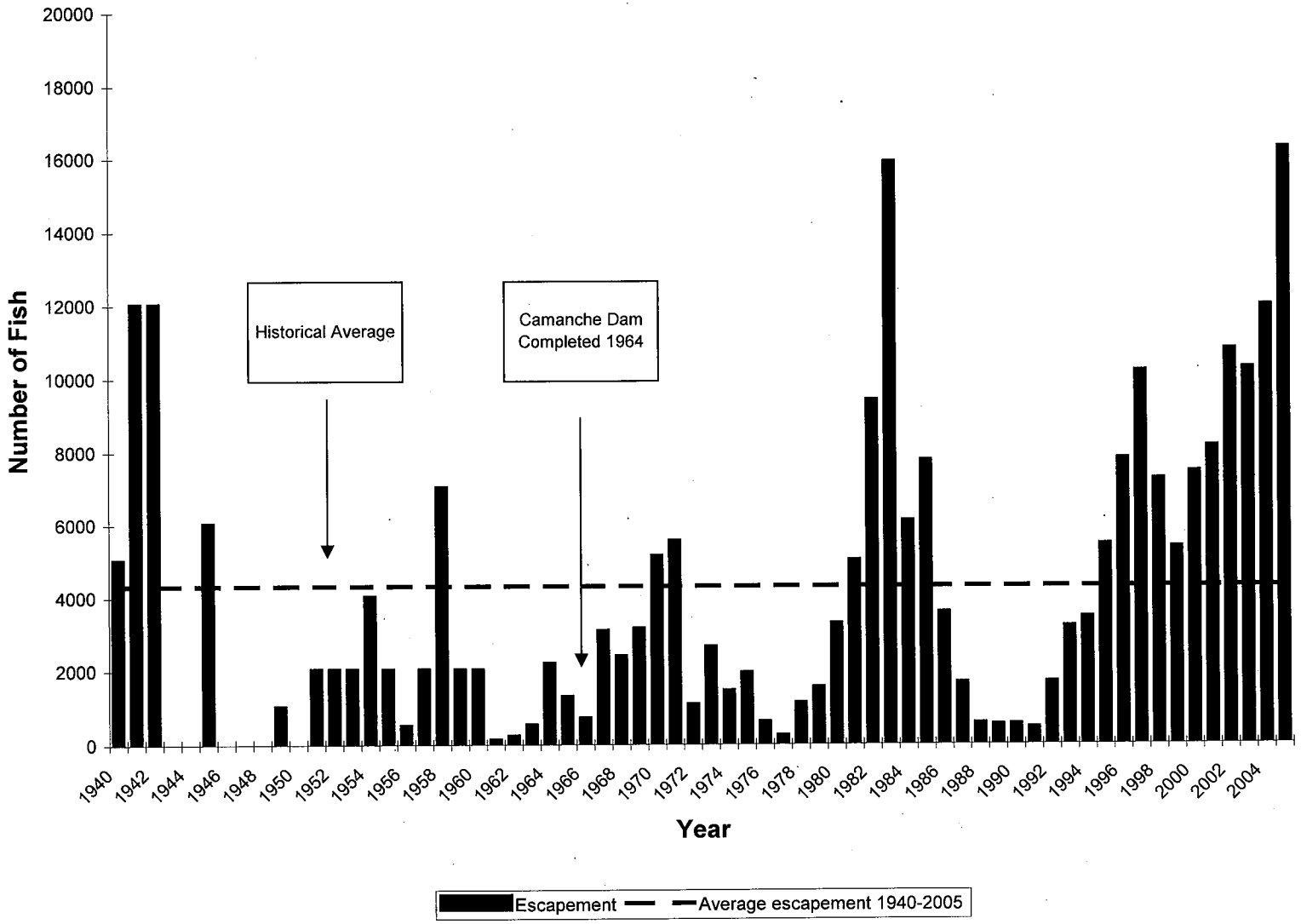

Figure 12. Estimated fall-run chinook salmon escapement to the lower Mokelumne River 1940 -2005.