**State of California**
**The Resources Agency**
**Department of Water Resources**

# ADULT CHINOOK SALMON MIGRATION AND HOLDING PATTERNS SP-F10 TASK 1E

## Oroville Facilities Relicensing FERC Project No. 2100

AUGUST 2005


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## REPORT SUMMARY

Task 1E evaluates water temperatures and migration patterns of pre-spawning adult Chinook salmon in the Feather River below the Fish Barrier Dam. Adult Chinook salmon were captured and tagged with a radio tag or a combination radio/archive tag. Of the 51 fish tagged during the 2003 and 2004 spawning seasons, 48 were subsequently relocated. Of these 48 fish, eight were harvested by anglers, four entered the hatchery, and three were recovered during the escapement survey. While the fate of the remaining 33 fish is uncertain, 21 were last detected on acknowledged spawning grounds that range from the uppermost portions of the low flow channel to as far downstream as Honcut Creek. The fate of the remaining 12 is uncertain but they may have been harvested or left the Feather.

Water temperatures used by pre-spawning adult Chinook salmon in the Feather River were compared to a recommended migration temperature (16°C) and an estimated maximum thermal limit (20°C) to determine the frequency in which they were exceeded. Archival tag data from 2003 indicated water temperatures used by individual fish (N = 6) ranged from 12.8-20.8°C but most observations occurred between 16 and 20°C. Although archival data for 2004 was unavailable, gauging station data for the 2003 and 2004 telemetry season illustrated that the Robinson Riffle compliance point fell within recommended water temperatures. However, the Thermalito Outlet exceeded them approximately 3-5% of the time and Gridley about 10-16% of the time. Water temperatures in the high flow channel at Gridley exceeded the suggested maximum thermal limit in June of both years until flows were above 5500 cfs. While downstream water temperatures were warmer in 2004, more Chinook salmon were last detected below Gridley than in 2003.

Radiotelemetry data were used to determine what sections of the river were used for holding and the effect of artificial structures, such as the Thermalito Afterbay Outlet, on migration. In 2003, over 90% of the final fish locations and assumed areas of spawning occurred upstream of Gridley compared to the 72% for the 2004 fish. The Thermalito Afterbay Outlet appears to be both a positive and a negative factor regarding the migration of Chinook salmon. While the Outlet provides a deep spot in which the fish seemingly prefer to hold, concentrated fishing pressure occurs at the Outlet. Overall, ten radio tagged Chinook salmon held in this location for more than a week. During 2003, more than 17% of the tagged fish were harvested there. However, 3% of the 2004 fish were harvested at the Outlet even though a higher percentage held in this location.

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# 1.0 INTRODUCTION

Adult migrating Feather River Chinook salmon were captured and tagged to assess migration patterns and preferences regarding holding habitat and spawning locations.

## 1.1 BACKGROUND INFORMATION

Adult Chinook salmon exhibiting spring-run life history migrate upstream beginning in March and continue through July (NMFS 2001). When these adult Chinook salmon enter freshwater, they are sexually immature and their gonads mature during the summer holding period (DWR and USBR 2000). Chinook salmon exhibiting spring-run life-history hold in their natal tributaries for up to several months in deep coldwater pools, usually greater than two meters, before spawning occurs (NMFS 2001; Moyle 2002). These salmon usually do not hold in the same pool all summer but rather exhibit upstream movement between pools (Moyle 2002). In the Feather River, most pre-spawning adult Chinook salmon typically hold in the upper three miles of the Feather River below the Fish Barrier Dam (D. Painter, pers. com. as cited in DWR and USBR 2000), where water temperatures are cooler than downstream (DWR and USBR 2000). Torgersen et al. (1999) cited 16°C as the thermal optima for migrating spring-run Chinook in the John Day River, Oregon. The estimated maximum thermal limit for pre-spawning adults falls around 20°C (Marine 1992; NOAA Fisheries 1997).

Because Thermalito Afterbay releases generally cause warmer water temperatures downstream, the most suitable holding habitats are likely upstream of the Thermalito Afterbay Outlet (DWR and USBR 2000). A water temperature modeling effort was conducted on the Feather River for DWR and USBR's Biological Assessment of the effects of the Central Valley Project and State Water Project on Chinook salmon exhibiting spring-run life-history. It concluded that for 2000 and 2001, it was unlikely that adult Chinook would use the portion of the Feather River below the Thermalito Afterbay outlet except as a migration corridor to the upper reaches of the river (DWR and USBR 2000). However, fieldwork is necessary to determine whether water temperatures downstream of the Thermalito Afterbay Outlet are suitable for holding adult Chinook salmon.

### 1.1.1 Statutory/Regulatory Requirements

Section 4.51(f)(3) of 18 CFR requires reporting of certain types of information in the Federal Energy Regulatory Commission (FERC) application for license of major hydropower projects, including a discussion of the fish, wildlife and botanical resources in the vicinity of the project. The discussion needs to identify the potential impacts of the project on these resources, including a description of any anticipated continuing impact for on-going and future operations. This report fulfills these requirements, by evaluating potential project effects on migrating Chinook salmon and their habitat in the Feather River below the Fish Barrier Dam.

### 1.1.2 Study Area

The upstream extent of the telemetry study was the Fish Barrier Dam and the downstream extent was the confluence of the Feather and Sacramento Rivers.

## 1.2 DESCRIPTION OF FACILITIES

The Oroville Facilities were developed as part of the State Water Project (SWP), a water storage and delivery system of reservoirs, aqueducts, power plants, and pumping plants. The main purpose of the SWP is to store and distribute water to supplement the needs of urban and agricultural water users in northern California, the San Francisco Bay area, the San Joaquin Valley, and southern California. The Oroville Facilities are also operated for flood management, power generation, to improve water quality in the Delta, provide recreation, and enhance fish and wildlife.

FERC Project No. 2100 encompasses 41,100 acres and includes Oroville Dam and Reservoir, three power plants (Hyatt Pumping-Generating Plant, Thermalito Diversion Dam Power Plant, and Thermalito Pumping-Generating Plant), Thermalito Diversion Dam, the Feather River Fish Hatchery and Fish Barrier Dam, Thermalito Power Canal, Oroville Wildlife Area (OWA), Thermalito Forebay and Forebay Dam, Thermalito Afterbay and Afterbay Dam, and transmission lines, as well as a number of recreational facilities. An overview of these facilities is provided on Figure 1.2-1. The Oroville Dam, along with two small saddle dams, impounds Lake Oroville, a 3.5-million-acre-feet (maf) capacity storage reservoir with a surface area of 15,810 acres at its normal maximum operating level.

The hydroelectric facilities have a combined licensed generating capacity of approximately 762 megawatts (MW). The Hyatt Pumping-Generating Plant is the largest of the three power plants with a capacity of 645 MW. Water from the six-unit underground power plant (three conventional generating and three pumping-generating units) is discharged through two tunnels into the Feather River just downstream of Oroville Dam. The plant has a generating and pumping flow capacity of 16,950 cfs and 5,610 cfs, respectively. Other generation facilities include the 3-MW Thermalito Diversion Dam Power Plant and the 114-MW Thermalito Pumping-Generating Plant.

Thermalito Diversion Dam, four miles downstream of the Oroville Dam creates a tail water pool for the Hyatt Pumping-Generating Plant and is used to divert water to the Thermalito Power Canal. The Thermalito Diversion Dam Power Plant is a 3-MW power plant located on the left abutment of the Diversion Dam. The power plant releases a maximum of 615 cubic feet per second (cfs) of water into the river.

The Power Canal is a 10,000-foot-long channel designed to convey generating flows of 16,900 cfs to the Thermalito Forebay and pump-back flows to the Hyatt Pumping-Generating Plant. The Thermalito Forebay is an off-stream regulating reservoir for the

114-MW Thermalito Pumping-Generating Plant. The Thermalito Pumping-Generating Plant is designed to operate in tandem with the Hyatt Pumping-Generating Plant and has generating and pump-back flow capacities of 17,400 cfs and 9,120 cfs, respectively. When in generating mode, the Thermalito Pumping-Generating Plant discharges into the Thermalito Afterbay, which is contained by a 42,000-foot-long earth-fill dam. The Afterbay is used to release water into the Feather River downstream of the Oroville Facilities, helps regulate the power system, provides storage for pump-back operations, and provides recreational opportunities. Several local irrigation districts receive water from the Afterbay.

The Feather River Fish Barrier Dam is downstream of the Thermalito Diversion Dam and immediately upstream of the Feather River Fish Hatchery. The flow over the dam maintains fish habitat in the low-flow channel of the Feather River between the dam and the Afterbay outlet, and provides attraction flow for the hatchery. The hatchery was intended to compensate for spawning grounds lost to returning salmon and steelhead trout from the construction of Oroville Dam. The hatchery can accommodate 15,000 to 20,000 adult fish annually.

The Oroville Facilities support a wide variety of recreational opportunities. They include: boating (several types), fishing (several types), fully developed and primitive camping (including boat-in and floating sites), picnicking, swimming, horseback riding, hiking, off-road bicycle riding, wildlife watching, hunting, and visitor information sites with cultural and informational displays about the developed facilities and the natural environment. There are major recreation facilities at Loafer Creek, Bidwell Canyon, the Spillway, North and South Thermalito Forebay, and Lime Saddle. Lake Oroville has two full-service marinas, five car-top boat launch ramps, ten floating campsites, and seven dispersed floating toilets. There are also recreation facilities at the Visitor Center and the OWA.

The OWA comprises approximately 11,000-acres west of Oroville that is managed for wildlife habitat and recreational activities. It includes the Thermalito Afterbay and surrounding lands (approximately 6,000 acres) along with 5,000 acres adjoining the Feather River. The 5,000 acre area straddles 12 miles of the Feather River, which includes willow and cottonwood lined ponds, islands, and channels. Recreation areas include dispersed recreation (hunting, fishing, and bird watching), plus recreation at developed sites, including Monument Hill day use area, model airplane grounds, three boat launches on the Afterbay and two on the river, and two primitive camping areas. California Department of Fish and Game's (DFG) habitat enhancement program includes a wood duck nest-box program and dry land farming for nesting cover and improved wildlife forage. Limited gravel extraction also occurs in a number of locations.

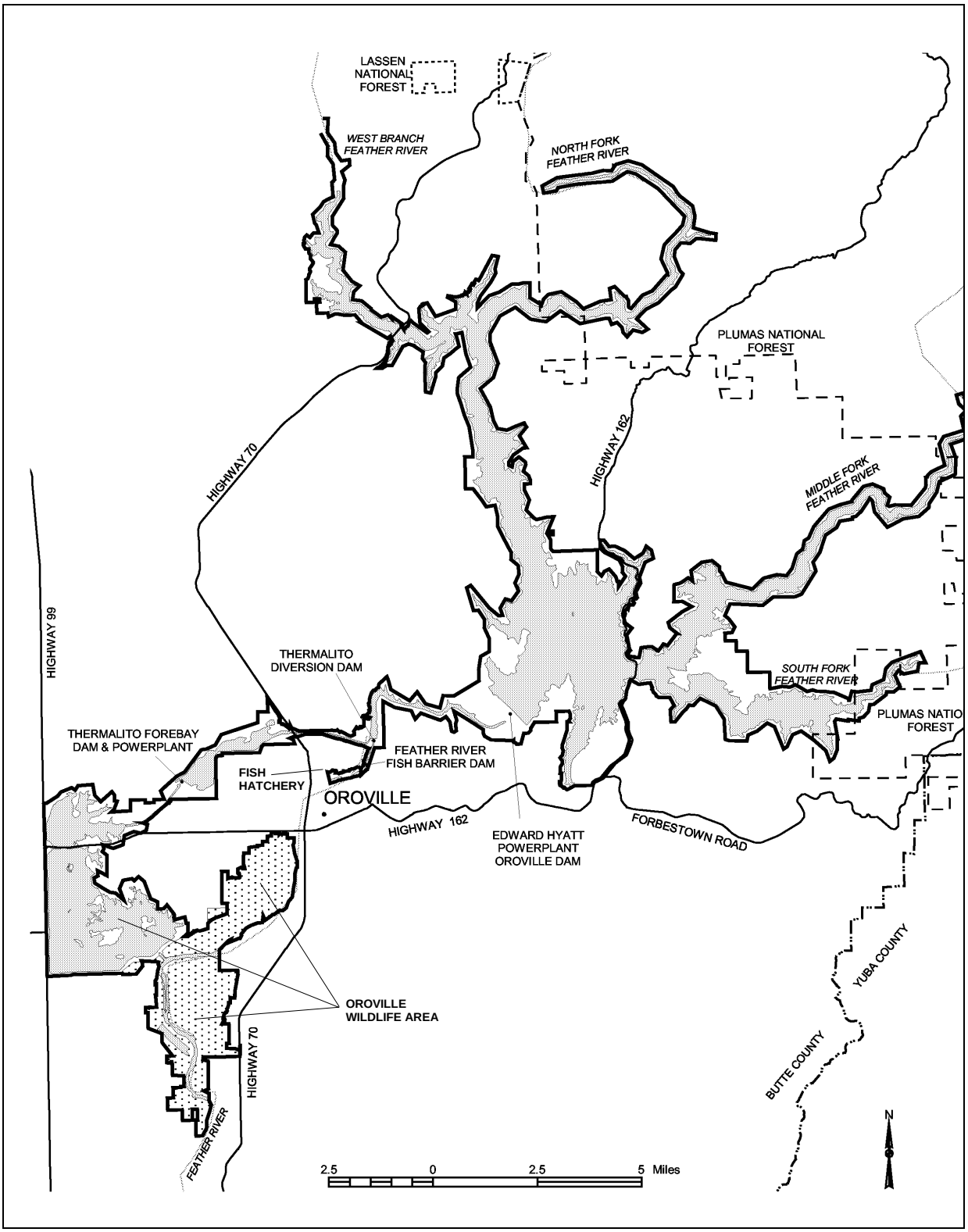



**Figure 1.2-1. Oroville Facilities FERC Project Boundary**

## 1.3 CURRENT OPERATIONAL CONSTRAINTS

Operation of the Oroville Facilities varies seasonally, weekly and hourly, depending on hydrology and the objectives DWR is trying to meet. Typically, releases to the Feather River are managed to conserve water while meeting a variety of water delivery requirements, including flow, temperature, fisheries, recreation, diversion and water quality. Lake Oroville stores winter and spring runoff for release to the Feather River as necessary for project purposes. Meeting the water supply objectives of the SWP has always been the primary consideration for determining Oroville Facilities operation (within the regulatory constraints specified for flood control, in-stream fisheries, and downstream uses). Power production is scheduled within the boundaries specified by the water operations criteria noted above. Annual operations planning is conducted for multi-year carry over. The current methodology is to retain half of the Lake Oroville storage above a specific level for subsequent years. Currently, that level has been established at 1,000,000 acre-feet (af); however, this does not limit draw down of the reservoir below that level. Additional water would be released from Lake Oroville if hydrology is drier than expected or requirements greater than expected. The operations plan is updated regularly to reflect changes in hydrology and downstream operations. Typically, Lake Oroville is filled to its maximum annual level of up to 900 feet above mean sea level (msl) in June and then can be lowered as necessary to meet downstream requirements, to its minimum level in December or January. During drier years, the lake may be drawn down more and may not fill to the desired levels the following spring. Project operations are directly constrained by downstream operational constraints and flood management criteria as described below.

### 1.3.1 Downstream Operation

An August 1983 agreement between DWR and DFG entitled, “Agreement Concerning the Operation of the Oroville Division of the State Water Project for Management of Fish & Wildlife,” sets criteria and objectives for flow and temperatures in the low flow channel and the reach of the Feather River between Thermalito Afterbay and Verona. This agreement: (1) establishes minimum flows between Thermalito Afterbay Outlet and Verona which vary by water year type; (2) requires flow changes under 2,500 cfs to be reduced by no more than 200 cfs during any 24-hour period, except for flood management, failures, etc.; (3) requires flow stability during the peak of the fall-run Chinook spawning season; and (4) sets an objective of suitable temperature conditions during the fall months for salmon and during the later spring/summer for shad and striped bass.

#### *1.3.1.1 Instream Flow Requirements*

The Oroville Facilities are operated to meet minimum flows in the Lower Feather River as established by the 1983 agreement (see above). The agreement specifies that Oroville Facilities release a minimum of 600 cfs into the Feather River from the

Thermalito Diversion Dam for fisheries purposes. This is the total volume of flows from the diversion dam outlet, diversion dam power plant, and the Feather River Fish Hatchery pipeline.

Generally, the instream flow requirements below Thermalito Afterbay are 1,700 cfs from October through March, and 1,000 cfs from April through September. However, if runoff for the previous April through July period is less than 1,942,000 af (i.e., the 1911-1960 mean unimpaired runoff near Oroville), the minimum flow can be reduced to 1,200 cfs from October to February, and 1,000 cfs for March. A maximum flow of 2,500 cfs is maintained from October 15 through November 30 to prevent spawning in overbank areas that might become de-watered.

#### *1.3.1.2 Temperature Requirements*

The Diversion Pool provides the water supply for the Feather River Fish Hatchery. The hatchery objectives are 52°F for September, 51°F for October and November, 55°F for December through March, 51°F for April through May 15, 55°F for last half of May, 56°F for June 1-15, 60°F for June 16 through August 15, and 58°F for August 16-31. A temperature range of plus or minus 4°F is allowed for objectives, April through November.

There are several temperature objectives for the Feather River downstream of the Afterbay Outlet. During the fall months, after September 15, the temperatures must be suitable for fall-run Chinook. From May through August, they must be suitable for shad, striped bass, and other warmwater fish.

The National Marine Fisheries Service has also established an explicit criterion for steelhead trout and spring-run Chinook salmon. Memorialized in a biological opinion on the effects of the Central Valley Project and SWP on Central Valley spring-run Chinook and steelhead as a reasonable and prudent measure; DWR is required to control water temperature at Feather River mile 61.6 (Robinson's Riffle in the low-flow channel) from June 1 through September 30. This measure requires water temperatures less than or equal to 65°F on a daily average. The requirement is not intended to preclude pump-back operations at the Oroville Facilities needed to assist the State of California with supplying energy during periods when the California ISO anticipates a Stage 2 or higher alert.

The hatchery and river water temperature objectives sometimes conflict with temperatures desired by agricultural diverters. Under existing agreements, DWR provides water for the Feather River Service Area (FRSA) contractors. The contractors claim a need for warmer water during spring and summer for rice germination and growth (i.e., 65°F from approximately April through mid May, and 59°F during the remainder of the growing season). There is no obligation for DWR to meet the rice

water temperature goals. However, to the extent practical, DWR does use its operational flexibility to accommodate the FRSA contractor's temperature goals.

#### *1.3.1.3 Water Diversions*

Monthly irrigation diversions of up to 190,000 (July 2002) af are made from the Thermalito Complex during the May through August irrigation season. Total annual entitlement of the Butte and Sutter County agricultural users is approximately 1 maf. After meeting these local demands, flows into the lower Feather River continue into the Sacramento River and into the Sacramento-San Joaquin Delta. In the northwestern portion of the Delta, water is pumped into the North Bay Aqueduct. In the south Delta, water is diverted into Clifton Court Forebay where the water is stored until it is pumped into the California Aqueduct.

#### *1.3.1.4 Water Quality*

Flows through the Delta are maintained to meet Bay-Delta water quality standards arising from DWR's water rights permits. These standards are designed to meet several water quality objectives such as salinity, Delta outflow, river flows, and export limits. The purpose of these objectives is to attain the highest water quality, which is reasonable, considering all demands being made on the Bay-Delta waters. In particular, they protect a wide range of fish and wildlife including Chinook salmon, Delta smelt, striped bass, and the habitat of estuarine-dependent species.

### 1.3.2 Flood Management

The Oroville Facilities are an integral component of the flood management system for the Sacramento Valley. During the wintertime, the Oroville Facilities are operated under flood control requirements specified by the U.S. Army Corps of Engineers (USACE). Under these requirements, Lake Oroville is operated to maintain up to 750,000 af of storage space to allow for the capture of significant inflows. Flood control releases are based on the release schedule in the flood control diagram or the emergency spillway release diagram prepared by the USACE, whichever requires the greater release. Decisions regarding such releases are made in consultation with the USACE.

The flood control requirements are designed for multiple use of reservoir space. During times when flood management space is not required to accomplish flood management objectives, the reservoir space can be used for storing water. From October through March, the maximum allowable storage limit (point at which specific flood release would have to be made) varies from about 2.8 to 3.2 maf to ensure adequate space in Lake Oroville to handle flood flows. The actual encroachment demarcation is based on a wetness index, computed from accumulated basin precipitation. This allows higher levels in the reservoir when the prevailing hydrology is dry while maintaining adequate flood protection. When the wetness index is high in the basin (i.e., wetness in the

watershed above Lake Oroville), the flood management space required is at its greatest amount to provide the necessary flood protection. From April through June, the maximum allowable storage limit is increased as the flooding potential decreases, which allows capture of the higher spring flows for use later in the year. During September, the maximum allowable storage decreases again to prepare for the next flood season. During flood events, actual storage may encroach into the flood reservation zone to prevent or minimize downstream flooding along the Feather River.

## 2.0 NEED FOR STUDY

Insufficient field data exists to corroborate assumptions regarding Chinook salmon migration timing and holding habitat in the Feather River. Reasons for this include a lack of a permanently established migration monitoring program, such as annual operation of a counting weir. In addition, there is no geographic segregation of early arriving and later arriving adult Chinook. Therefore, arrival time cannot be clearly distinguished in the field by observation because it is not possible to tell whether an adult has been holding for days (fall-run life-history) or months (spring-run life-history) prior to spawning. Little is known about where pre-spawning Chinook salmon adults hold in the Feather River. The water temperature regime associated with the ongoing operation of the Oroville facilities may expose pre-spawning adult Chinook salmon to elevated water temperatures during the migration and holding period, which may adversely impact reproductive success. This study was conducted to collect data to evaluate water temperature and migration patterns of pre-spawning adult Chinook salmon in the Feather River below the Fish Barrier Dam.

## 3.0 STUDY OBJECTIVE(S)

Task 1E evaluates Feather River water temperatures and migration patterns of pre-spawning adult Chinook salmon. Operation of the Oroville Facilities affects the water temperature regime in the lower Feather River. Water temperature is an important factor influencing adult Chinook salmon upstream migration and spawning success. In addition, water temperature may provide an attraction cue and influence pre-spawning adult survival and egg viability. Task 1E is broken into three objectives.

Objective 1: Evaluate archival tag and gauging station water temperature data with recommended pre-spawning temperatures.

Objective 2: Analyze tracking data to determine adult Chinook salmon migration patterns.

Objective 3: Compare/contrast data from 2003 telemetry season with 2004 telemetry season.

# 4.0 METHODOLOGY

## 4.1 STUDY DESIGN

In order to assess migration patterns and holding habitat, 51 adult Chinook salmon (18 in 2003 and 33 in 2004) were captured and tagged with a radio tag or a combination radio/archival tag. Fish movements were monitored using a combination of manual tracking and fixed data logging stations. Water temperature was logged using archival tags. Unlike radiotelemetry tags, information from archival tags cannot be retrieved remotely so tags must be retrieved from anglers, the hatchery, or from carcasses encountered during the adult escapement survey.

## 4.2 HOW AND WHERE THE STUDIES WERE CONDUCTED

### 4.2.1 Angling

Angling began July 9 and continued every week until August 8, 2003 (Table 4.2.1-1). The majority of adult Chinook salmon was captured at River Mile (RM) 53.6 in the lower Feather River. A total of 421 angler hours were accumulated in this effort.

**Table 4.2.1-1. Dates, locations, and angling effort for the 2003 Chinook salmon telemetry study.**

| Angling dates | Location | Angler hours |
|---|---|---|
| July 9 | RM 53.6 | 49 |
| July 15 & 17 | RM 53.6 | 42 |
| July 22 & 24 | RM 53.6 | 42 |
| July 28 - August 1 | RM 53.6 | 144 |
| August 4 - 8 | RM 53.6 | 144 |
| | Total hours: | 421 |

Beginning June 1, 2004, adult Chinook salmon were captured by angling downstream of the following locations: Shanghai Bend, the confluence with the Yuba River, Sunset Pumps, and Thermalito Afterbay Outlet. Angling continued weekly until July 14th, 2004 (Table 4.2.2-1). This effort accounted for a total of 213.5 angler hours. Angling efforts for both years were guided by Craig Smith of Craig Smith Fishing Guide Service.

**Table 4.2.2-1. Dates, locations, and angling effort for the 2004 Chinook salmon telemetry study.**

| Angling dates | Location (downstream of) | Angler hours |
|---|---|---|
| June 1-4 & 7-11 | Shanghai Bend | 220.5 |
| June 14-18 | Confluence of Yuba River | 122.5 |
| June 21-25 & 28-30 | Sunset Pumps | 196 |
| July 1-2, 5-9 & 12-14 | Thermalito Outlet | 297.5 |
| | Total hours: | 836.5 |

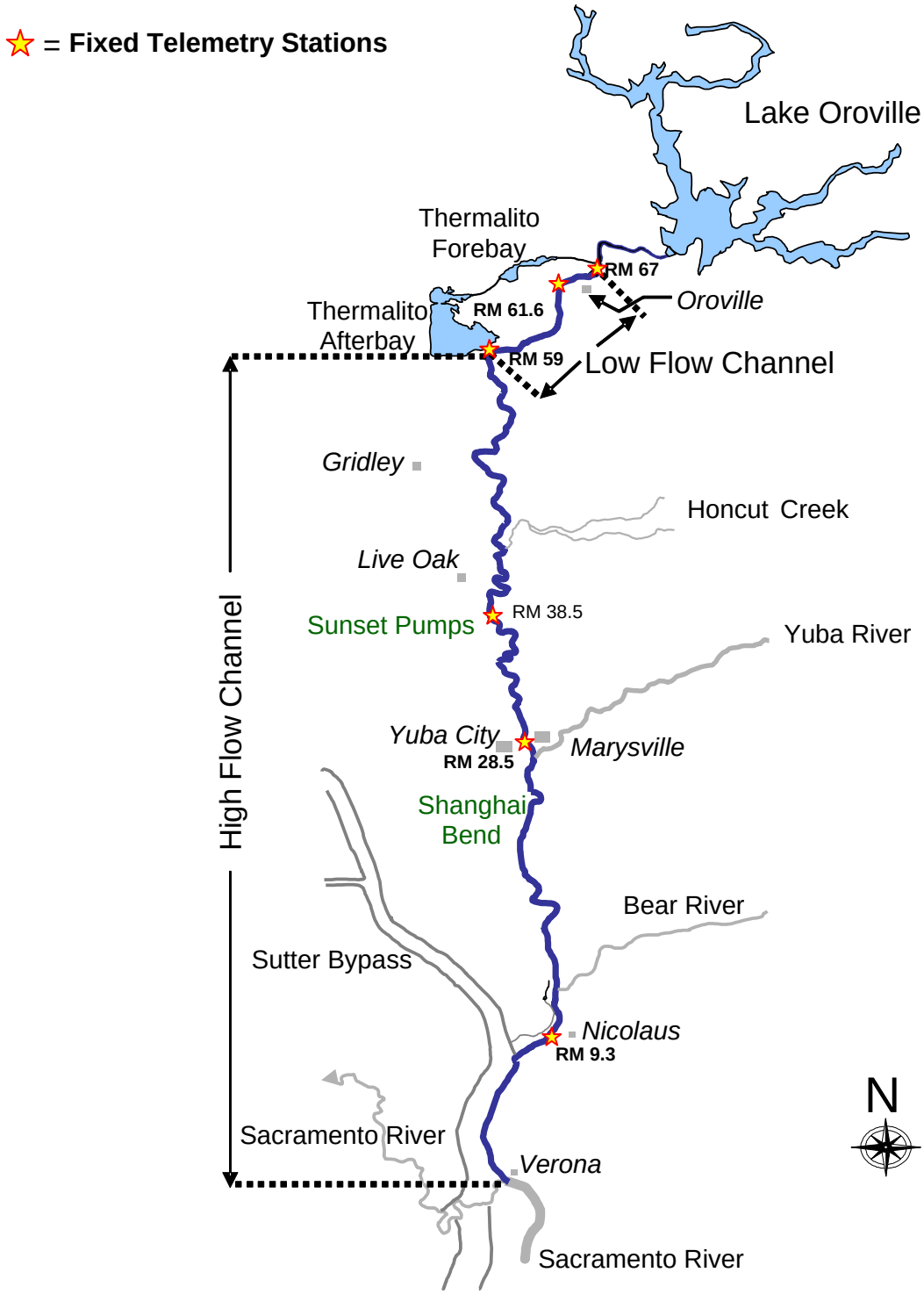
### 4.2.2 Fyke Trap (2004 season only)

In conjunction with SP-F3.2 Task 3A, a 3-m diameter fyke trap was deployed approximately four miles downstream of Star Bend Boat Ramp (13.8) from January 6 - June 9 and approximately two miles downstream of Sunset Pumps (RM 36.7) from June 12 - August 9. The fyke was checked every one to three days depending on the amount of fish captured. All fish species were identified and measured to the nearest centimeter. All Chinook salmon captured were radio-tagged.

### 4.2.3 Telemetry

Figure 4.2.3-1 shows the fixed receiving stations located at the Feather River Hatchery (RM 67) and those within gauging stations located at Robinson (RM 61.6), the Thermalito Afterbay Outlet (RM 59), the Yuba City/Marysville Bridge (RM 28.5) and Nicolaus (RM 9.3). Sunset Pumps (RM 38.5) was added in 2004. Fixed station receivers were located in areas that exhibited potential holding habitat and/or limited access to protect against equipment vandalism.

**Figure 4.2.3-1. Adult Chinook salmon telemetry study site showing fixed station locations and corresponding river mile (RM).**



### *4.2.3.1 2003 Telemetry Season*

Eighteen adult Chinook salmon received an esophageal implant of a shrink-wrapped combination radio tag and water temperature archival tag (Table 4.2.3.1-1). Tagged fish were immediately released in the vicinity of their capture. The gender of the fish tagged in 2003 was distinguishable since they were caught later in the summer. Approximately 65% of the fish tagged were females.

**Table 4.2.3.1-1. Individual information on all Chinook salmon captured for the 2003 telemetry study. Grey rows indicate tagged fish that were never relocated after release. Note: N/a = unknown. Recapture information is only included for fish recovered during the 2003 study.**

| Radio Tag # | Date | Fork (cm) | Sex | Capture/Release Location (RM) | Recapture Date | Recapture Location | Tag Returned | Spawned |
|---|---|---|---|---|---|---|---|---|
| 50 | 8/4/03 | 880 | F | Big Riffle (53.6) | | | | |
| 52 | 8/4/03 | 870 | M | Big Riffle (53.6) | 8/9/03 | RM 59 | No | N/a |
| 54 | 8/1/03 | 860 | F | Big Riffle (53.6) | 8/17/03 | RM 59 | Yes | N/a |
| 56 | 8/6/03 | 860 | M | Big Riffle (53.6) | | | | |
| 62 | 8/6/03 | 790 | F | Big Riffle (53.6) | | | | |
| 68 | 8/1/03 | 760 | F | Big Riffle (53.6) | | | | |
| 69 | 8/7/03 | 860 | F | Big Riffle (53.6) | | | | |
| 72 | 8/4/03 | 810 | M | Big Riffle (53.6) | 10/1/03 | Hatchery | Yes | Yes |
| 76 | 7/9/03 | 710 | N/A | Yuba City (28.5) | | | | |
| 78 | 7/30/03 | 940 | M | Big Riffle (53.6) | 9/8/2003 † | RM 59 | No | N/a |
| 79 | 7/30/03 | 900 | F | Big Riffle (53.6) | 8/18/03 | RM 59 | Yes | N/a |
| 81 | 7/30/03 | 940 | F | Big Riffle (53.6) | 10/2/03 | Hatchery | Yes | Yes |
| 82 | 8/7/03 | 780 | F | Big Riffle (53.6) | 8/24/03 | unknown | Yes | N/a |
| 83 | 8/4/03 | 840 | M | Big Riffle (53.6) | | | | |
| 84 | 7/30/03 | 820 | F | Big Riffle (53.6) | | | | |
| 86 | 8/4/03 | 920 | F | Big Riffle (53.6) | | | | |
| 87 | 8/1/03 | 880 | M | Big Riffle (53.6) | 8/14/03 | 61.6 | Yes | N/a |
| 88 | 8/1/03 | 720 | F | Big Riffle (53.6) | 9/8/03 | Hatchery | Yes | No |

† Fixed station data indicates this fish was in the system after the recapture date. Tag number may have been misidentified by angler- unable to verify.

Manual tracking by boat occurred at one to two week intervals from July 18, 2003 until January 8, 2004 except during October when all personnel were required for the adult escapement survey and tracking was not conducted. Manual tracking by plane occurred weekly from July 18 through August 26, 2003 (there was no August 19 flight). Flights were used to cover a larger search area to determine if some of the tagged fish that could not be located had moved into the Yuba River or the Sacramento River below the confluence with the Feather River.

### *4.2.3.2 2004 Telemetry Season*

Thirty-three adult Chinook salmon received an esophageal implant of a radio tag or a combination radio/temperature archive tag and immediately released in the vicinity of their capture (Table 4.2.3.2-1). Earlier catch dates made distinguishing gender more difficult at time of tagging. Consequently, we know at least 42% of the fish were female.

**Table 4.2.3.2-1. Individual information on Chinook salmon captured for the 2004 telemetry study. The grey row specifies tagged fish that was never relocated after release. Note: N/a = unknown. Recapture information is only included for fish recovered during the 2003 study.**

| Radio Tag # | Date | Fork (cm) | Sex | Capture/Release Location (RM) | Recapture Date | Recapture Location | Tag Returned | Spawned |
|---|---|---|---|---|---|---|---|---|
| 1 | 6/17/04 | 72 | N/a | Hatchery (67) | | | | |
| 15 | 6/17/04 | 67 | N/a | Hatchery (67) | | | | |
| 18 | 7/13/04 | 87 | F | Outlet (58.9) | 10/12/04 | RM 66.1 | Escapement | Yes |
| 29 | 7/12/04 | 94 | F | Fyke (38) | | | | |
| 34 | 6/17/04 | 72 | N/a | Hatchery (67) | | | | |
| 51 | 7/14/04 | 96 | M | Outlet (58.9) | 10/7/04 | Hatchery | Yes | Yes |
| 53 | 7/2/04 | 81 | F | Fyke (38) | | | | |
| 54 | 7/12/04 | 82.5 | N/a | Hour Riffle (56) | | | | |
| 55 | 7/9/04 | 78 | F | Hour Riffle (56) | | | | |
| 57 | 7/6/04 | 98 | F | Fyke (38) | | | | |
| 58 | 7/12/04 | 77.5 | F | Outlet (58.9) | | | | |
| 59 | 7/6/04 | 75 | F | Fyke (38) | | | | |
| 60 | 7/1/04 | 71 | F | Hour Riffle (56) | | | | |
| 61 | 7/13/04 | 58 | N/a | Outlet (58.9) | | | | |
| 63 | 7/9/04 | 85 | M | Outlet (58.9) | | | | |
| 64 | 6/18/04 | 91.5 | F | Sunset Pumps (38.5) | | | | |
| 66 | 7/8/04 | 81 | F | Outlet (58.9) | 10/11/04 | RM 66.5 | Escapement | Yes |
| 72 | 7/12/04 | 72 | F | Outlet (58.9) | | | | |
| 79 | 7/13/04 | 77 | N/a | Big Hole WC (57.9) | | | | |
| 81 | 7/12/04 | 87 | F | Outlet (58.9) | | | | |
| 82 | 7/9/04 | 95 | M | Hour Riffle (56) | | | | |
| 87 | 7/14/04 | 89 | M | East Channel (58.7) | | | | |
| 100 | 7/14/04 | 54 | N/a | Outlet (58.9) | | | | |
| 109 | 6/17/04 | 73 | N/a | Hatchery (67) | | | | |
| 114 | 6/17/04 | 78 | N/a | Hatchery (67) | | | | |
| 129 | 6/17/04 | 82 | N/a | Hatchery (67) | | | | |
| 138 | 7/30/04 | 104 | M | Fyke (38) | | | | |
| 152 | 6/17/04 | 80 | N/a | Hatchery (67) | | | | |
| 169 | 7/13/04 | 88 | M | Outlet (58.9) | | | | |
| 178 | 6/17/04 | 85 | N/a | Hatchery (67) | 6/29/04 | RM 61.1 | Yes | N/a |
| 179 | 7/13/04 | 78 | F | Outlet (58.9) | | | | |
| 183 | 6/17/04 | 77 | N/a | Hatchery (67) | 6/24/04 | RM 59 | Yes | N/a |
| 203 | 6/17/04 | 84 | F | Hatchery (67) | 9/21/04 | RM 60.5 | Escapement | Yes |

Manual tracking by boat occurred weekly from June 21 through October 27, 2004 from the Fish Barrier Dam downstream to Verona. Manual tracking was ended in October after all signals were repeatedly detected in the same general area for approximately a month (i.e., not showing any movement). No flights were taken during the 2004 telemetry season.

# 5.0 STUDY RESULTS

## 5.0.1 2003 Telemetry Season

Sixteen out of the 18 combo-tags deployed in 2003 were subsequently relocated. Of these 16, anglers harvested six and three fish entered the Feather River Fish Hatchery where two were spawned (Tag 72 and 81) and one died beforehand (Tag 88). The fate of the remaining seven fish is uncertain. Five non-moving signals were detected in acknowledged spawning areas which are located from Honcut Creek (RM 44) upstream to the Fish Barrier Dam, but the tags were not found in any reachable salmon carcasses. Two tags traced to a pool at Upper Robinson and another tag at the Thermalito Outlet was too deep for carcass retrieval. Two additional signals were traced to searchable areas but carcasses retrieved did not contain any of the tags. These tags may have been regurgitated or fell out of decomposed fish and therefore may have been buried in the substrate. Tag 57 was last detected at RM 57 on August 18 and may have been harvested (Table 5.0.1-1). Tag 84 was last detected at RM 9.3 on September 13 and may have left the system (Table 5.0.1-1).

**Table 5.0.1-1. Individual migration patterns for Chinook salmon during the 2003 telemetry study. Status indicates the probable fate of each fish based on last detection. Note: FRH = returned to hatchery, H = harvested, LH = likely harvested, LS = left the system, N/A = information not available since fish was not relocated after tagging, SG = on spawning grounds.**

| Tag # | At Large† | Total (RM) | Net (RM)†† | Days at 59§ | Last Location (RM), Date | Status |
|---|---|---|---|---|---|---|
| 50 | 136 | 21.6 | 12 | 2 | 60, Dec. 18 | SG |
| 52 | 5 | 5.4 | 5.4 | 4 | 59, Aug. 9 | H |
| 54 | 16 | 10.6 | 8 | 1 | 59, Aug. 17 | H |
| 56 | 146 | 11.6 | 8.8 | 2 | 61.6, Dec. 30 | SG |
| 62 | 139 | 21.2 | 13.5 | 42 | 61.6, Dec. 30 | SG |
| 68 | N/A | N/A | N/A | N/A | N/A | N/A |
| 69 | 103 | 26.6 | 14.8 | 2 | 63, Nov. 18 | SG |
| 72 | 55 | 11 | 9.6 | 1 | FRH, Oct. 1 | FRH |
| 76 | N/A | N/A | N/A | N/A | N/A | N/A |
| 78 | 59 | 38.2 | 22.5 | 4 | 59, Sept. 8 | H |
| 79 | 19 | 13.2 | 8.2 | 4 | 59, Aug. 18 | H |
| 81 | 52 | 13.4 | 13.4 | 19 | FRH, Oct. 2 | FRH |
| 82 | 11 | 1.4 | -1.4 | 0 | 52.2, Aug. 24 | H |
| 83 | 141 | 38.2 | 15.5 | 33 | 59, Dec. 23 | SG |
| 84 | 45 | 82.7 | -44.3 | 0 | 9.3, Sept. 13 | LS |
| 86 | 14 | 7.4 | 5.4 | 1 | 57, Aug. 18 | LH |
| 87 | 12 | 8.2 | 8.2 | 4 | 61.6, Aug. 14 | H |
| 88 | 24 | 13.4 | 13.4 | 2 | FRH, Sept.8 | FRH |

† Equals the amount of days between date of being tagged and date of recapture/last detection
†† A negative sign indicates fish were last detected downstream of initial tagging/release site
§ Equals the total number of nonconsecutive days the fish was detected at the Thermalito Afterbay Outlet while at liberty

### 5.0.2 2004 Telemetry Season

Of the 33 tags deployed in 2004, 32 were relocated. Of these 32, two were harvested by fishermen, three spent females were recovered in the carcass survey, and one male fish recovered at the Feather River Fish Hatchery was spawned (Table 4.2.3.2-1). The fate of the remaining 26 fish is ambiguous. Sixteen of 26 non-moving signals were detected in acknowledged spawning areas, but these tags were not found among any of the reachable salmon carcasses surveyed. Three of these fish (Tags 29, 53, and 82) were last detected in early to mid-September and may have been harvested before spawning activity commenced. The fate of the ten remaining fish is vague. Due to the fact that Tags 58 and 72 were last detected in July and Tag 15 in mid-August, it is likely they were harvested (Table 5.0.2-1). Tag 179 was likely harvested since it was last detected downstream of Star Bend which is a common fishing area. Although Tag 109 was last detected early in July, it should not have been harvested. This fish was located downstream of the Yuba River mouth which, according to CDFG fishing regulations (CFGC 2005), was closed to fishing until July 15 in order to preserve spring-run entering the Yuba River. Since Tag 109 was one of the more mobile individuals, it may have left the system to enter the Yuba River. Tag 59 was last detected lower in the system near Nicolaus and showed the highest total movement of all fish in the study (Table 5.0.2-1), so it is feasible it left the system and entered the Sacramento River. If Tag 57 was not harvested, this highly mobile fish may have left the Feather River to enter the Yuba River. It was last detected near the Yuba confluence at the beginning of September. The status of Tag 138 and 152 is uncertain since both of these fish were located far downstream of the known spawning grounds in early October. Tag 34 was last detected two miles downstream of acknowledged spawning grounds late in October. While the outcome for these fish was unclear, signal tracking indicated movement which suggested these individuals may have found a pocket of suitable spawning habitat.

**Table 5.1-1. Individual migration patterns for Chinook salmon during the 2004 telemetry study. Status indicates the probable fate of each fish based on last detection. Note: FRH = returned to hatchery, H = harvested, LH = likely harvested, LS = left the system, N/A = information not available since fish was not relocated after tagging, SG = on spawning grounds, ? = located outside of known spawning grounds.**

| Tag # | At Large† | Total (RM) | Net (RM)†† | Days at 59§ | Last Detected (RM), Date | Status |
|---|---|---|---|---|---|---|
| 1 | 127 | 18.9 | -16.3 | 1 | 50.7, Oct 22 | SG |
| 15 | 54 | 3.6 | -3 | 0 | 64, Aug 10 | LH |
| 18 | 91 | 9.3 | 6.9 | 71 | 65.8, Oct 12 | SG |
| 29 | 64 | 26.1 | 26.1 | 51 | 64.1, Sept 7 | SG |
| 34 | 127 | 38.2 | -25 | 1 | 42, Oct 22 | ? |
| 51 | 85 | 9.7 | 8.1 | 28 | FRH, Oct 7 | FRH |
| 53 | 74 | 29 | 29 | 11 | 67, Sept 14 | SG |
| 54 | N/A | N/A | N/A | N/A | N/A | N/A |
| 55 | 105 | 5.5 | 1.9 | 13 | 57.9, Oct 22 | SG |
| 57 | 58 | 77.1 | -9.5 | 11 | 28.5, Sept 2 | LH or LS |
| 58 | 6 | 0.1 | 0.1 | 6 | 59, Jul 18 | LH |
| 59 | 14 | 97.3 | -28.7 | 2 | 9.3, Jul 20 | LS |
| 60 | 113 | 7.3 | -0.1 | 0 | 55.7, Oct 22 | SG |
| 61 | 101 | 33.4 | -12.5 | 2 | 46.4, Oct 22 | SG |
| 63 | 75 | 8.6 | 8.6 | 3 | 67, Sept 22 | SG |
| 64 | 93 | 29 | 29 | 1 | 67, Sept 19 | SG |
| 66 | 95 | 22.2 | 7.6 | 1 | 66.5, Oct 11 | SG |
| 72 | 3 | 0.1 | 0.1 | 3 | 59, Jul 15 | LH |
| 79 | 101 | 28.2 | 5.6 | 1 | 63.5, Oct 22 | SG |
| 81 | 107 | 8.7 | 0.1 | 10 | 59, Oct 27 | SG |
| 82 | 66 | 21.5 | 11.5 | 5 | 67.5, Sept 13 | SG |
| 87 | 100 | 9.9 | -9.9 | 0 | 48.8, Oct 22 | SG |
| 100 | 100 | 2.1 | 2.1 | 6 | 61, Oct 22 | SG |
| 109 | 20 | 68.1 | -48.3 | 1 | 18.7, Jul 7 | LS |
| 114 | 127 | 10.4 | -6.8 | 0 | 60.2, Oct 22 | SG |
| 129 | 113 | 10.5 | -0.3 | 0 | 66.5, Oct 8 | SG |
| 138 | 64 | 45.9 | -9.5 | 0 | 28.5, Oct 2 | ? |
| 152 | 108 | 28.6 | -28.5 | 1 | 38.5, Oct 3 | ? |
| 169 | 77 | 11 | 7.6 | 3 | 66.5, Sept 28 | SG |
| 178 | 12 | 6 | -6 | 1 | 61, Jun 29 | H |
| 179 | 65 | 48.3 | -42.1 | 1 | 16.8, Sept 16 | LH |
| 183 | 7 | 8 | -8 | 5 | 59, Jun 24 | H |
| 203 | 96 | 21 | -6.5 | 0 | 60.5, Sept 21 | SG |

† Equals the amount of days between date of being tagged and date of recapture/last detection
†† A negative sign indicates fish were last detected downstream of initial tagging/release site
§ Equals the total number of nonconsecutive days the fish was detected at the Thermalito Afterbay Outlet while at liberty

## 5.1 WATER TEMPERATURE

Archival tags containing in situ water temperature data on individual fish were only recovered during the 2003 telemetry season. Therefore, to compare 2003 and 2004 data for the frequency in which water temperatures exceeded recommended migration temperatures, hourly water temperatures were analyzed for three sites in the lower Feather River. Water temperatures from June 1 through October 1 of each year were downloaded from the California Data Exchange Center for the Robinson Riffle compliance point (Station ID FRA; RM 61.6) and Gridley stations (Station ID GRL; RM 50.75) and from the Bay Delta and Tributaries Project for the Thermalito Outlet (Station ID 15858; RM 59). This type of comparison does not account for thermal complexity but previous studies found little evidence for cold water thermal refugia in the Feather River (DWR 2004).

### 5.1.1 2003 Telemetry Season

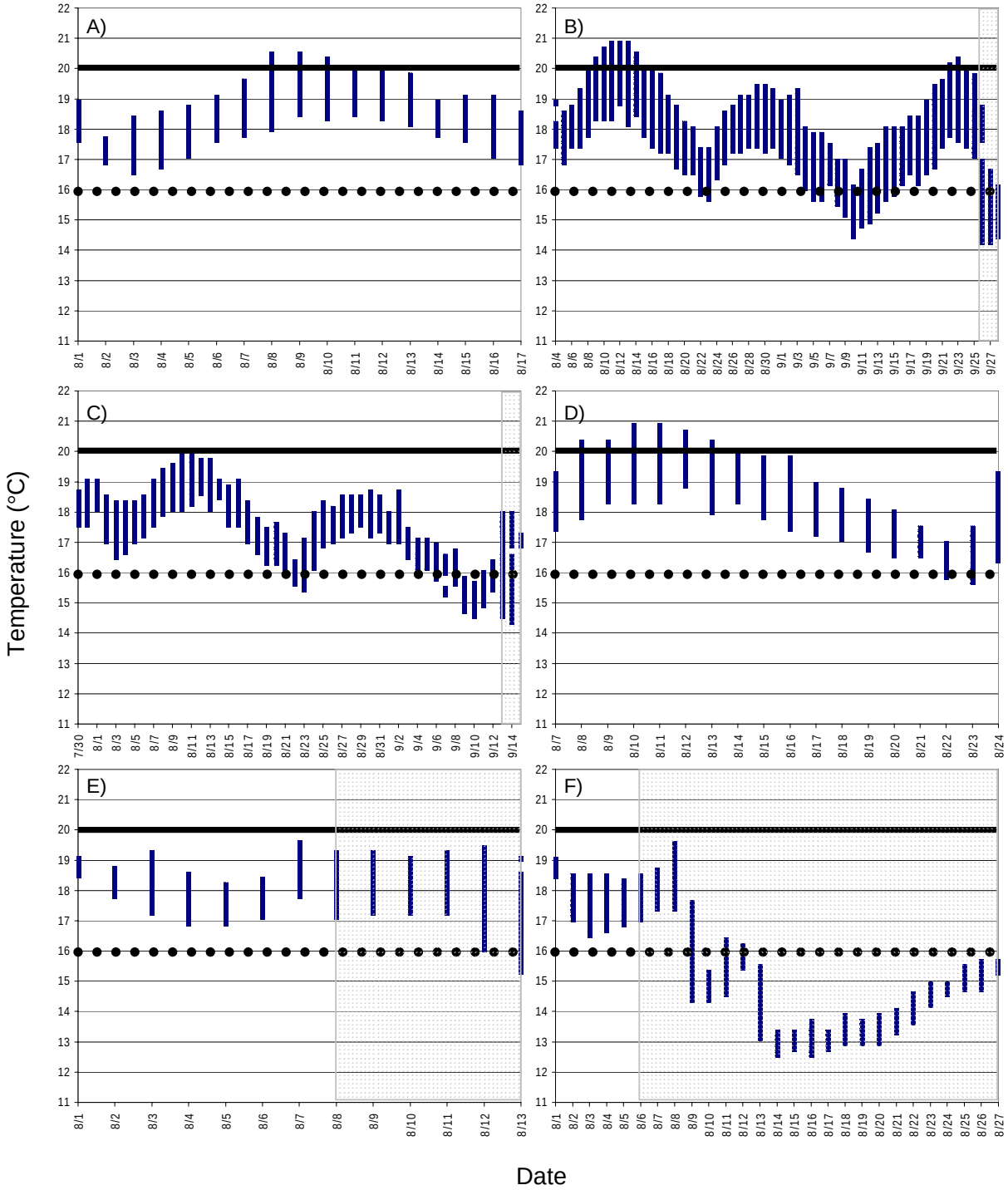
#### *5.1.1.1 Archival Data*

As part of the first objective, archived water temperatures used by pre-spawning adult Chinook salmon in the lower Feather River were compared to a recommended migration temperature (16°C) and an estimated maximum thermal limit (20°C) to determine the frequency with which temperature recommendations were exceeded. Temperature data were downloaded upon retrieval of the seven tags recovered from anglers and the Feather River Hatchery. While seven archival tags were recovered, the data from Tag 79 were deemed unreliable (e.g., temperatures below 9°C were recorded on August 14) and was excluded from analysis. Five of the six fish were typically found in waters between the recommended migration temperature and a suggested upper water temperature limit while fish Tag 88 regularly frequented waters that were cooler than the recommended migration temperature (Table 5.1.1.1-1). Three of the fish were recorded from 3-8% of the time above the estimated maximum thermal limit (Table 5.1.1.1-1). Overall, tagged Chinook salmon traveled in waters between the temperatures of 12.8-20.8°C (Figure 5.1.1.1-1).

**Table 5.1.1.1-1. Frequency of water temperature use of individual Chinook salmon in the lower Feather River during the 2003 telemetry study where 16°C equals a recommended migration temperature and 20°C equals an estimated maximum thermal limit.**

| Temperature °C | Tag 54 | Tag 72 | Tag 81 | Tag 82 | Tag 87 | Tag 88 |
|---|---|---|---|---|---|---|
| **< 16** | 0.0% | 12.2% | 10.6% | 2.4% | 1.2% | 67.2% |
| **≥16 and < 20** | 95.0% | 84.9% | 89.4% | 89.5% | 98.8% | 32.8% |
| **≥ 20** | 5.0% | 2.9% | 0.0% | 8.1% | 0.0% | 0.0% |

**Figure 5.1.1.1-1. Temperature profiles of individual Chinook salmon: A) Tag 54; B) Tag 72; C) Tag 81; D) Tag 82; E) Tag 87; and F) Tag 88 in the lower Feather River during the 2003 telemetry study. The upper solid line represents an estimated maximum thermal limit and the lower dotted line represents the suggested migration temperature. The shaded area indicates the fish was located in the low flow channel while the unshaded area indicates the high flow channel.**



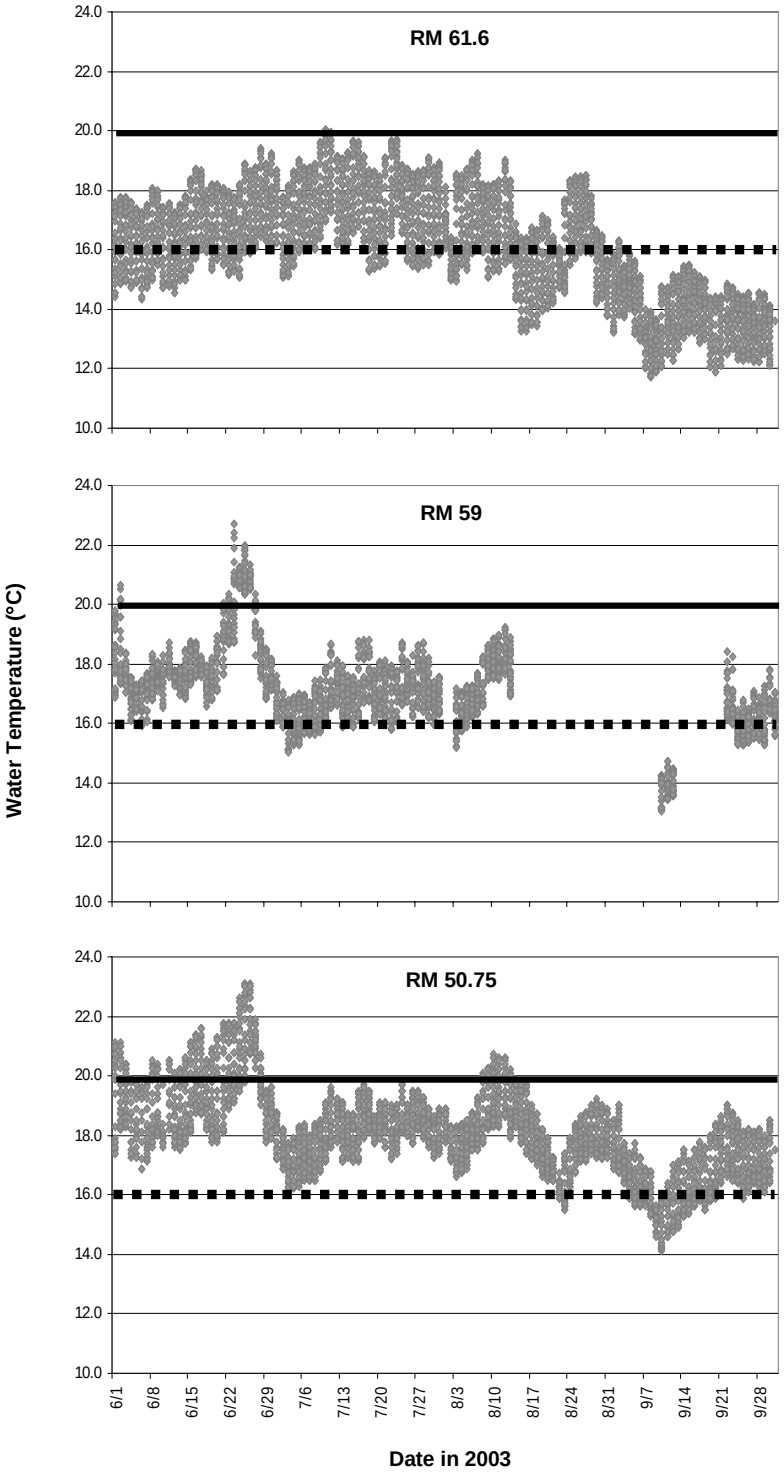
### *5.1.1.2 Gauging Station Data*

For 2003, hourly water temperatures at RM 61.6 very rarely exceeded 20°C (Table 5.1.1.2-1). If no thermal refuges existed, the estimated maximum thermal limit was exceeded almost five percent of the time at RM 59 and approximately ten percent of the time at RM 50.75 (Table 5.1.1.2-1). Higher hourly water temperatures were more common in June (Figure 5.1.1.2-1) when mean river discharge at Gridley decreased from about 4000 to approximately 2000 cfs. Hourly water temperatures decreased when flows were over 8000 cfs at the end of June (Figure 5.1.1.2-1).

**Table 5.1.1.2-1. Frequency of hourly water temperatures recorded from June 1 through October 1, 2003 at three locations in the lower Feather River.**

| Water Temperature °C | RM 61.6 | RM 59 | RM 50.75 |
|---|---|---|---|
| **< 16** | 42.9% | 12.9% | 7.0% |
| **≥ 16 and < 20** | 57.0% | 82.3% | 83.1% |
| **≥ 20** | 0.1% | 4.8% | 9.9% |

**Figure 5.1.1.2-1. Hourly temperature profiles from June 1 through October 1, 2003 for RM 61.6 in the low flow channel and in the high flow channel at RM 59 and RM 50.75 of the lower Feather River. The upper solid line represents the estimated maximum thermal limit while the lower dotted line represents the suggested migration temperature.**



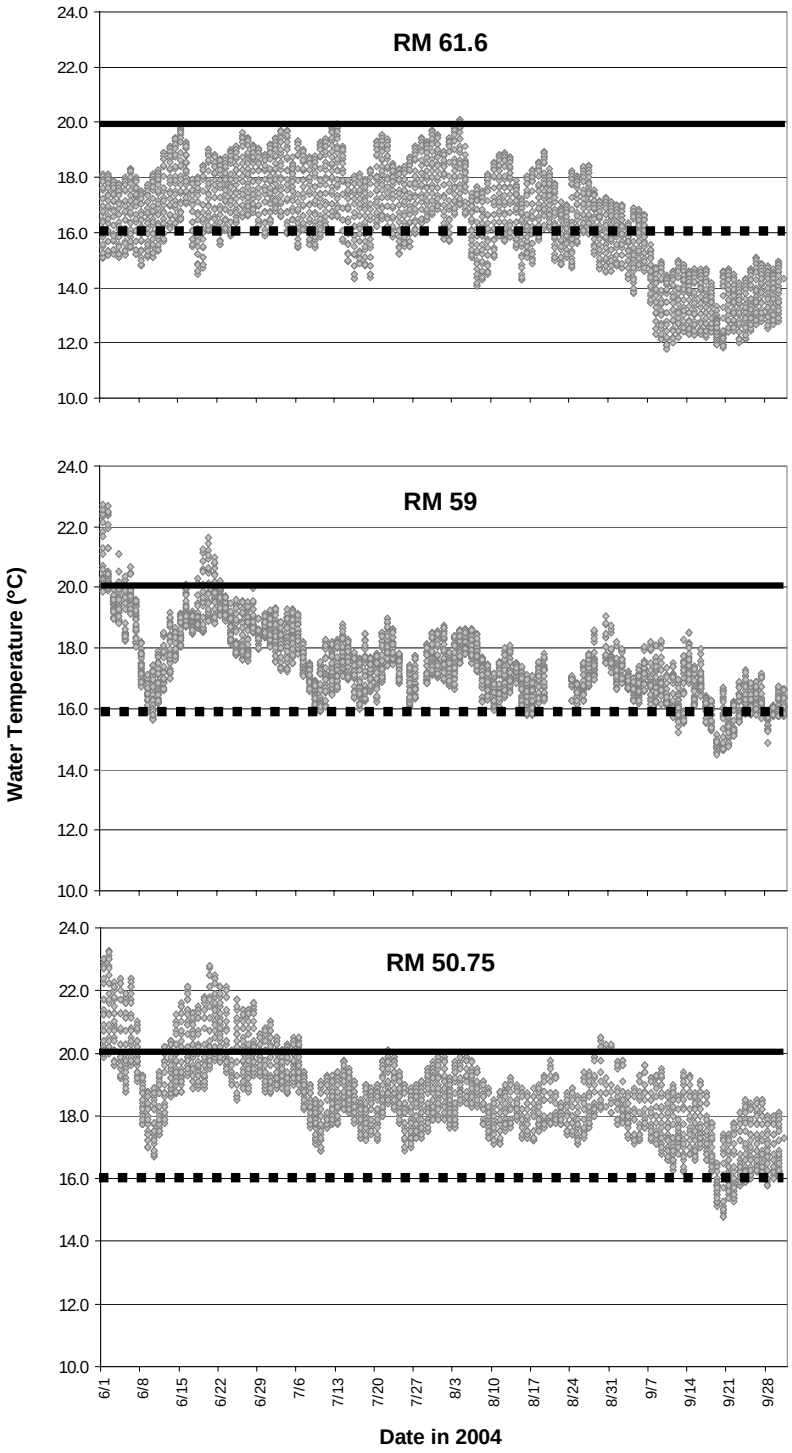
### 5.1.2 2004 Telemetry Season

Two of the recovered tags were the combination radio/archive tags. However, one tag was missing the archive portion and the second tag's archived data was deemed unreliable (e.g., archive tag temperatures averaged 1°C higher than air temperatures and almost 7°C higher than water temperatures recorded at a downstream gauging station). Because of the lack of archive data during the 2004 telemetry season, water temperatures were downloaded from RM 61.6, RM 59 and RM 50.75 in order to compare and determine the frequency in which a recommended migration temperature (16°C) and an estimated maximum thermal limit (20°C) were exceeded. Hourly water temperatures at RM 61.6 very rarely exceeded 20°C (Table 5.1.2-1). If no thermal refuges existed, the estimated maximum thermal limit was exceeded three percent of the time at RM 59 and sixteen percent of the time at RM 50.75 (Table 5.1.2-1). Higher hourly water temperatures were more common in June (Figure 5.1.2-1) when mean river discharge at Gridley oscillated between 2000 and 4500 cfs. In early July, hourly water temperatures dropped when flows were increased to over 5500 cfs (Figure 5.1.2-1).

**Table 5.1.2-1. Frequency of hourly water temperatures recorded from June 1 through October 1, 2004 at three locations in the lower Feather River.**

| Water Temperature °C | RM 61.6 | RM 59 | RM 50.75 |
|---|---|---|---|
| **< 16** | 35.8% | 8.3% | 2.4% |
| **≥ 16 and < 20** | 64.1% | 88.5% | 81.7% |
| **≥ 20** | 0.1% | 3.1% | 16.0% |

**Figure 5.1.2-1. Hourly temperature profiles from June 1 through October 1, 2004 for RM 61.6 in the low flow channel and in the high flow channel at RM 59 and RM 50.75 in the lower Feather River. The upper solid line represents the estimated maximum thermal limit while the lower dotted line represents the suggested migration temperature.**



## 5.2 MIGRATION PATTERNS

To fulfill the second objective, movement of adult Chinook migrants was analyzed for holding habitat use patterns. Radiotelemetry data were used to determine what sections of the river were used for holding and the effect of artificial structures (e.g., Thermalito Afterbay Outlet) on migration behavior.

### 5.2.1 2003 Telemetry Season

Of the 18 fish tagged, 16 were relocated at least once. Fish were at liberty or detected anywhere from 5-146 days after being tagged (Table 5.0.1-1). Fourteen fish exhibited variable upstream movements (i.e., the last place the fish was detected was upstream of its initial tagging/release location) and two fish moved downstream (Table 5.0.1-1 and Figure 5.2.1-1). The total distance moved by tagged Chinook salmon ranged from 5.4 to 82.7 RM. The largest observed net movement of 44.3 RM was migrated downstream by fish Tag 84 (Table 5.0.1-1). The Thermalito Outlet appeared to influence the migration behavior and fate of tagged salmon. Depending on the individual, fish were detected in this area from zero to 42 days. Of the sixteen fish successfully tracked, three fish spent at least seven days at the Thermalito Outlet and four other fish were harvested at it (Table 5.0.1-1 and Figure 5.2.1-1). In comparison, four fish spent over a week near the Robinson Riffle compliance point.

### 5.2.2 2004 Telemetry Season

Of the 33 Chinook salmon tagged, 32 were relocated. Fish were at liberty or detected anywhere from 3-127 days after being tagged (Table 5.0.2-1). Seventeen fish exhibited variable upstream movement and 16 fish demonstrated variable downstream movement (Table 5.0.2-1and Figure 5.2.2-1). The total observed distance traveled by tagged Chinook salmon ranged from 0.1 to 97.3 river miles. The largest surveyed net movement was 48.3 RM, which was navigated downstream by fish Tag 109 (Table 5.0.2-1). Chinook salmon had movement ratios ranging from 1.0 to a high value of 87.0 (Table 5.0.1-1). The amount of time individual fish spent around the Thermalito Outlet ranged from zero to 71 days. Of the 32 fish successfully tracked, seven fish spent at least seven days at the Thermalito Outlet (Table 5.0.2-1 and Figure 5.2.2-1) suggesting it may have an influence on the migration behavior of tagged salmon. Only one fish was confirmed to have been harvested there (Table 5.0.2-1). Several areas that fish remained at least seven days included Sunset Pumps ($n$ = 2), Junkyard Riffle (RM 48.8, $n$ = 1), downstream of the Gridley Bridge (RM .50.7, $n$ = 1), Big Hole (RM 57.9, $n$ = 2), Eye (RM 60.2, $n$ = 1), Steep (RM 61, $n$ = 1), Bedrock Park (RM 65.8; $n$ = 1), and below the Fish Barrier Dam ($n$ = 5).

**Figure 5.2.1-1. Locations of individual adult Chinook salmon by tag number in the lower Feather River during the 2003 telemetry study. Two graphs are used to help separate fish for easier viewing. RM 67.5 = Fish Barrier Dam (FBD), RM 59 = Thermalito Afterbay Outlet (TOA), and RM 50.75 = Gridley (GRL). Fixed receiving stations were located at RM 9.3, 28.5, 59, 61.6, and 67.**

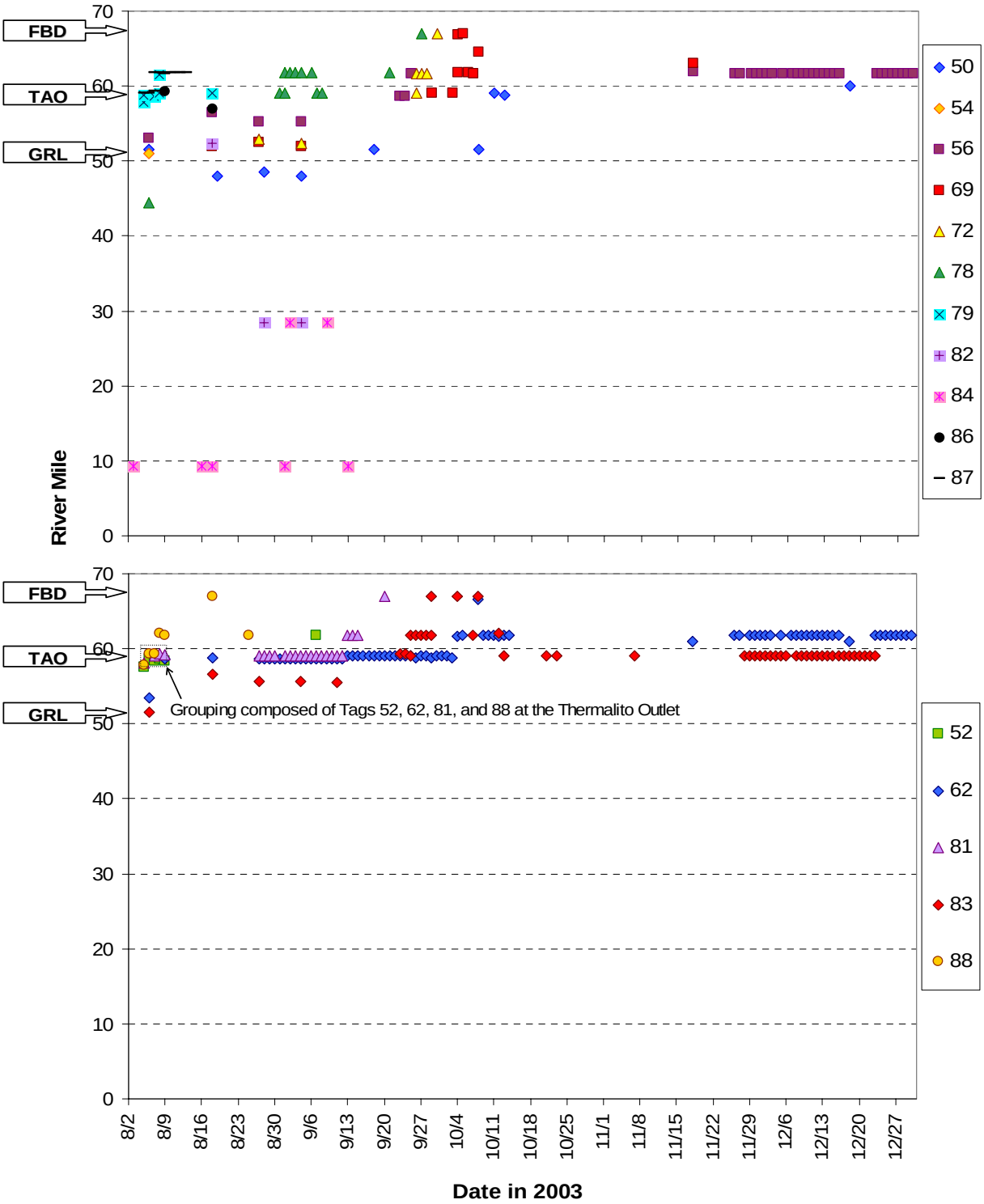
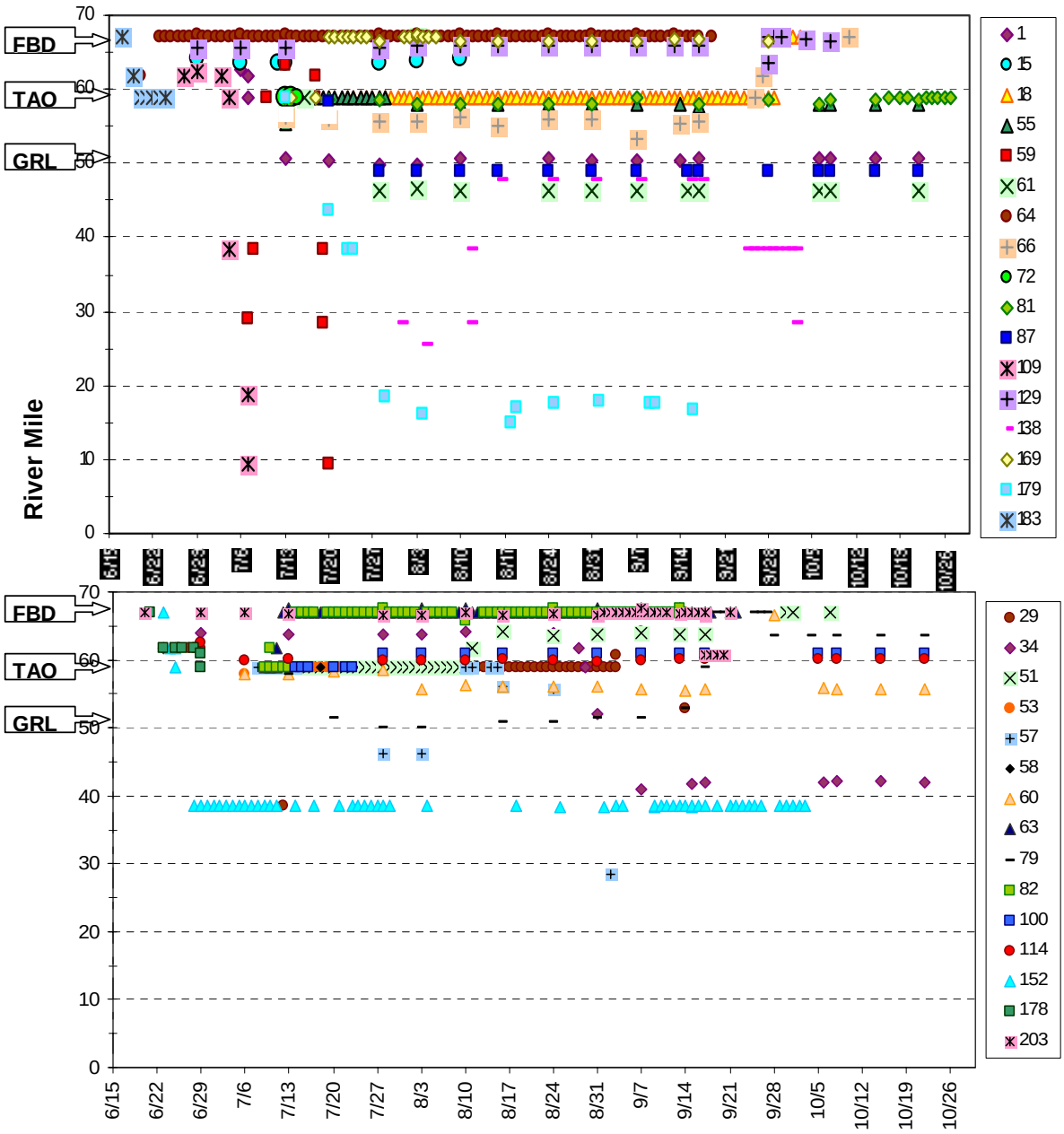


**Figure 5.2.2-1. Locations of individual adult Chinook salmon by tag number in the lower Feather River during the 2004 telemetry study. Two graphs are used to help separate fish for easier viewing. RM 67.5 = Fish Barrier Dam (FBD), RM 59 = Thermalito Afterbay Outlet (TOA), and RM 50.75 = Gridley (GRL). Fixed receiving stations were located at RM 9.3, 28.5, 38.5, 59, 61.6, and 67.**



# 6.0 ANALYSES

## 6.1 EXISTING CONDITIONS/ENVIRONMENTAL SETTING

### 6.1.1 Holding/Migration Characteristics

#### *6.1.1.1 Archive Temperature Data*

In general, most of the archive temperature data from tagged adult Chinook salmon fell between the recommended migration temperature and the estimated maximum water temperature. Analysis of individual archive water temperatures from Tag 54 and 82, which were both located near Gridley, were very similar to temperatures recorded at the Gridley gauging station (Figure 5.1.1.1-1 A & D; Figure 5.1.1.2-1). In addition, Tag 88 archival data corroborated with temperature loggers near the Fish Barrier Dam that water temperatures, as low as approximately 12.5°C, were available in mid-August (Figure 5.1.1.1-1 F) during the 2003 telemetry season. Fish Tag 88 spent the most amount of the time in water below the recommended migration temperature prior to entering the hatchery but died before being spawned.

In addition to determining which water temperatures were utilized by adult Chinook salmon, archive temperatures were also compared to gauging station data to establish if thermal refugia existed within the lower Feather River. However, the lack of thermal complexity reported in “SP-W6: Project Effects on Temperature Regime” (DWR 2004) is corroborated by the archive data.

#### *6.1.1.2 Water Temperature Gauging Station Data*

Gauging station data for both years indicated that water temperatures at the Robinson Compliance Point rarely exceeded the maximum thermal limit of 20°C. Furthermore, temperatures at Robinson were cooler than the suggested migration temperature of 16°C more than 35% of the time. Temperatures were above the recommended maximum thermal limit 3-5% of the time at the Thermalito Afterbay Outlet and 10-16% of the time at Gridley. Water temperatures did not seem to affect spawning ability since the three females recovered in the 2004 adult escapement survey were spent. However, these three fish were always detected upstream of Gridley throughout the study period (Figure 5.2.2-1).

### 6.1.2 Migration Patterns

Burger et al. (1985) and Bernard et al. (1999) have shown that tagged adult Chinook salmon have a tendency to head downstream after release and later may resume upstream migration. Approximately 50% of the relocated Chinook salmon tagged in this study moved and/or remained downstream for a period ranging from a few days to over

four months. Telemetry indicates that while the majority of these fish exhibited holding behaviors, others were highly mobile. Overall, the majority (>90%) of 2003's final fish detection locations and assumed spawning occurred above RM 50 (Gridley). However in 2004, more fish were last detected further downstream. Only 72% were located above RM 50. These may be inter-annual differences but it is also possible that the fish captured between the two study years are displaying different life history strategies. Fish from 2003 were captured, tagged and released one month later than fish from 2004. Whatever these cause, this study showed that the majority of tagged Chinook salmon did not hold within three miles downstream of the Fish Barrier Dam as cited in DWR and USBR (2000).

Between the two study seasons, at least five fish were confirmed to have been harvested at Thermalito Outlet. If these fish were not harvested, they may have resided at Thermalito Outlet for an extended period of time. Overall, ten Chinook salmon held for more than a week at the Thermalito Outlet. Fish during the 2003 study also had a tendency to hold around RM 61.6 (Robinson) for longer periods of time while fish during the 2004 season were often located near the Fish Barrier Dam. Yet, more 2003 fish were recovered from the Feather River Hatchery than in 2004.

## 6.2 PROJECT RELATED EFFECTS

Pre-spawning Chinook salmon commonly utilized water temperatures between 16-20°C during the lower Feather River telemetry studies. The recommended temperatures were available in the low flow channel under the current flow and temperature regimes. However, water temperatures in the high flow channel at Gridley were above the suggested maximum thermal limit in June of both years until flows were increased to 5,500 cfs. While water temperature profiles indicated that downstream water temperatures were warmer in 2004, more Chinook salmon were detected below Gridley than in the previous year. Out of the three fish from the escapement survey whose spawning status is known, all were spent which suggests there were minimal temperature impacts on spawning ability if the fish held above Gridley.

There is no clear trend regarding the effects that the Thermalito Afterbay Outlet has on the migration of Chinook salmon since it appears to be both a positive and a negative factor. While the Outlet provides a deep spot in which the fish seemingly prefer to hold, concentrated fishing pressure occurs at the Outlet. Angling intensity was apparent during 2003 when more than 20% of the tagged fish were harvested there. However, less than 5% of the 2004 fish were harvested there even though a higher percentage held in this location. Consequently, it is unclear if the inter-annual dissimilarities were the result of fishing effort or possible behavioral variations among life history strategies. No creel data is available to further investigate these observations.

## 7.0 REFERENCES


BDAT (Bay Delta and Tributaries Project). 2004. BDAT home page. http://www.bdat.ca.gov/index.html. Accessed April 4, 2005.

Bernard, D. R., J. J. Hasbrouck, and S. J. Fleischman. 1999. Handling-induced delay and downstream movement of adult Chinook salmon in rivers. Fisheries Research 44:37-46.

Burger, C. V., R. L. Wilmot, and D. B. Wangaard. 1985. Comparison of spawning areas and times for two runs of Chinook salmon (*Oncorhynchus tshawytscha*) in the Kenai River, Alaska. Canadian Journal of Fisheries and Aquatic Sciences 42:693-700.

CDEC (California Data Exchange Center). October 7, 2004. CDEC home page. http://cdec4gov.water.ca.gov/. Accessed April 4, 2005.

CFGC (California Fish and Game Commission). May 24, 2005. CFGC regulations page. http://www.fgc.ca.gov/html/regs.html. Accessed May 24, 2005.

DWR (California Department of Water Resources). 2004. SP-W6: Project effects on temperature regime. Draft final report for the Oroville Facilities Relicensing, FERC Project No. 2100. CDWR, Northern District, Red Bluff, California. July 2004.

DWR and USBR (United States Bureau of Reclamation). 2000. Biological Assessment. Effects of the Central Valley Project and State Water Project on steelhead and spring-run Chinook salmon. November 2000.

Marine, K. R. 1992. A background investigation and review of the effects of elevated water temperature on reproductive performance of adult Chinook salmon (*Oncorhynchus tshawytscha*) with suggestions for approaches to the assessment of temperature induced reproductive impairment of Chinook salmon stocks in the American River, California. Department of Wildlife and Fisheries Biology, University of California Davis.

Moyle, P. B. 2002. Inland Fishes of California, 2nd Edition. University of California Press, Berkeley, California.

NMFS (National Marine Fisheries Service). 2001. Biological Opinion on interim operations of the Central Valley Project and State Water Project.

NOAA (National Oceanic & Atmospheric Administration) Fisheries. 1997. NMFS Proposed Recovery Plan for the Sacramento River Winter-Run Chinook Salmon. Long Beach, CA: National Marine Fisheries Service, Southwest Region.

Torgersen C. E., D. M. Price, H. W. Li, and B. A. McIntosh. 1999. Multiscale thermal refugia and stream habitat associations of Chinook salmon in northeastern Oregon. Ecological Applications 9:301-319.