LITERATURE SUMMARY

ESA/CESA-LISTED SALMONIDS DOWNSTREAM OF ENGLEBRIGHT DAM

DRAFT JUNE 2010

AVAILABLE FIELD STUDIES AND DATA COLLECTION REPORTS

CDFG. 1978. *Yuba River Steelhead, Yuba County.* Technical Memorandum, prepared by R. Rogers, CDFG Region 2, Rancho Cordova, California.

During the winter of 1975-76, records of steelhead caught, size, and angling effort in the lower Yuba River were acquired through angler survey questionnaires. All *O. mykiss* 14 in. total length (TL) or longer were considered steelhead, and *O. mykiss* less than 14 in. were considered resident rainbow trout. Monthly catch rates estimates were divided by various assumed harvest rates to devise population estimates. This technical memorandum suggested a reasonable population estimate of 2,000 steelhead, given the methods and assumptions utilized. This technical memorandum also suggested that a good fall-run and winter-run of steelhead occurred, indicating the stocking program of *O. mykiss* during the 1970s had been successful and Yuba River steelhead habitat had improved since completion of New Bullards Bar Dam.

CDFG. 1984. *Yuba River Steelhead Run During Winter of 1976-77.* Technical Memorandum, prepared by R. Rogers, CDFG Region 2, Rancho Cordova, California.

During the winter of 1976-77, CDFG and USFWS conducted trapping for marking and tagging and a creel survey to estimate size and timing of the steelhead spawning run, origin of spawners (wild vs. hatchery), harvest rate and catch rate by anglers. Upstream migrant steelhead were trapped at a weir located on the lower Yuba River 6 miles upstream from the confluence with the Feather River that was fished continuously from September 23, 1976 to March 6, 1977. Each morning and evening steelhead in the trap were marked or tagged, checked for sex, length, general condition, amount of dorsal fin wear, and scale samples were taken before being released upstream. All *O. mykiss* observed were equal to or greater than 16 in. fork length (FL), and were therefore considered to be steelhead rather than resident rainbow trout.

Population estimates based on the Peterson tag-recapture method resulted in an estimate of 494 steelhead in the annual run, although this technical memorandum acknowledged that much of the annual run was not sampled, that sampling was conducted during an extreme drought year, and that an estimate of the normal steelhead run as about 2,000 fish seems reasonable.

Two migration peaks of steelhead was observed, one in October and one in February. Average fork length of 69 males measured was 24.8 in. with a range of 16 to 33 in. Average fork length of 77 females measured was 23.6 in. with a range of 16 to 30 in. From dorsal fin wear, 49% of the steelhead observed were judged to be of hatchery origin, although this technical memorandum stated that designating origin of steelhead according to fin wear is not entirely reliable. From scale analysis, 50% of the fish were judged to be of wild origin, although this technical memorandum also acknowledged that information on the origin of fish (wild vs. hatchery) is inconclusive.

This technical memorandum stated that fishing for steelhead trout on the lower Yuba River has improved considerably since New Bullards Bar Reservoir filled in 1970.

CDFG. 1991. *The Lower Yuba River Fisheries Management Plan Final Report*. The Resources Agency, CDFG, Stream Evaluation Report No. 91-1. February 1991.

Between 1986 and 1988, the California Department of Fish and Game (CDFG) and its contractor (Beak Consultants Inc. 1989) conducted a comprehensive series of detailed studies addressing fish community structure, fish populations, fish passage, flow-habitat relationships, water temperature, water quality, riparian habitat, and diversion impacts. These studies were conducted in four reaches of the lower Yuba River: (1) Narrows Reach extending approximately 2.2 miles below Englebright Dam and downstream of the Narrows 1 and Narrows 2 powerhouses; (2) Garcia Gravel Pit Reach beginning downstream of the Narrows Reach and extending to the DPD located 12.5 miles downstream of Englebright Dam; the (3) DPD Reach extending 7.8 miles to the downstream terminus of the Yuba Goldfield; and (4) the remaining 3.5 miles below the Simpson bridge to the confluence with the Feather River in the town of Marysville. The results of these studies led to the development of CDFG's *The Lower Yuba River Fisheries Management Plan Final Report* in 1991.

Assessment of the fish community structure within the lower Yuba River included the estimation of fish species composition, relative abundance, and distribution parameters using electrofishing and snorkel survey techniques. Both methods were used because of their utility in addressing different informational needs of the study. Snorkeling surveys allowed for the characterization of juvenile salmonid habitat during spring months that were otherwise inaccessible to boat electrofishing, such as shallow near-shore and riffle areas. Electrofishing was conducted primarily to assess those species that were underrepresented in snorkel surveys.

Combined results from the electrofishing and snorkeling surveys resulted in the documentation of 15 fish species in the lower Yuba River. Chinook salmon and steelhead were observed in all river reaches downstream of the Englebright Dam, and were the only fish species observed in the Narrows Reach. Chinook salmon were the most abundant of all fish species in the lower Yuba River representing 49% of total number of fish observed, followed by steelhead/rainbow trout representing 22% of the total number of fish observed.

A total of 1,707 fish were collected by electrofishing with increasing species diversity in the downstream direction. Only Chinook salmon and two other fish species were captured in the Narrows Reach. Diversity was greater in the Garcia Gravel Pit Reach including Chinook salmon, steelhead/rainbow trout, and seven other species. Chinook salmon also were collected in the DPD Reach, although steelhead/rainbow trout were not. Relative abundance estimates from electrofishing indicated Chinook salmon and Sacramento sucker were the most abundant species, comprising 49% and 32% of total electrofishing efforts, respectively. Steelhead/rainbow trout represented less than 1% of lower Yuba River abundance.

A total of 8,815 fish were observed during snorkeling surveys. Chinook salmon and steelhead/rainbow trout were present in all four reaches and were the only fish observed just below Englebright Dam in the Narrows Reach. Snorkel survey abundance estimates suggested that Chinook salmon were the most abundant fish species in the lower Yuba River representing 49% of all fish observed, and steelhead/rainbow trout comprised 22% of total observations.

CDFG (1991) reported that a small spring-run Chinook salmon population historically occurred in the Yuba River but the run virtually disappeared by 1959. As of 1991, a remnant spring-run Chinook salmon population reportedly persisted in the lower Yuba River maintained by fish produced in the lower Yuba river, fish straying from the Feather River, or fish previously and infrequently stocked from the Feather River Hatchery. CDFG (1991) reported that adult spring-run Chinook salmon migrate into the lower Yuba River beginning in March extending into July, spend the summer in deep pools in the Narrows Reach, and spawn from early to mid-September into November. Spring-run Chinook salmon juvenile rearing reportedly occurred in off-channel areas, and emigration occurred as fry within a few weeks of emergence or as larger juveniles as late as June.

CDFG (1991) reported that approximately 200 steelhead/rainbow trout spawned in the lower Yuba River annually prior to 1970. During the 1970s, CDFG annually stocked hatchery steelhead from the Coleman National Fish Hatchery into the lower Yuba River, and by 1975 estimated a run size of about 2,000 fish (CDFG 1991). CDFG stopped stocking steelhead into the lower Yuba River in 1979. CDFG (1991) reported that steelhead enter the lower Yuba River as early as August, migration peaks in October through February, and may extend through March. A run of “half-pounder” steelhead reported occurred from late-June through the winter months. Spawning reportedly occurred from January through April with egg incubation occurring from January through May, with fry emerging between February and June. CDFG (1991) reported that juvenile steelhead reared throughout the year but, unlike Chinook salmon in the lower Yuba River, may spend from one to three years in freshwater before emigrating primarily from March to June. CDFG (1991) indicated that most juvenile steelhead rearing occurred above DPD in the Garcia Gravel Pit Reach.

CDFG (1991) reported that adult Chinook salmon densities were greatest in riffle and deep pool habitats, whereas juvenile Chinook salmon and steelhead/rainbow trout were highest in the fast flowing riffle and run/glide habitats.

Microhabitat use criteria were developed to address habitat-flow relationships in the lower Yuba River for the Chinook salmon spawning, fry, and juvenile rearing lifestages. Substrate criteria used frequency of observation of dominant substrate particle size, whereas water depth and velocity criteria were developed by applying the non-parametric tolerance limits method to the frequency-of-use distribution measurements taken on the lower Yuba River. CDFG (1991) considered spawning gravel resources in Garcia Gravel Pit and DPD reaches of the lower Yuba River to be excellent, and also recommended future habitat improvement including construction of shallow rearing areas and off-channel habitat to increase survival of fry and juveniles.

CDFG (1991) also conducted riparian vegetation mapping of lower Yuba River plant communities within the study area. Three plant communities (blue oak/digger pine woodland, riparian forest, and grassland/agriculture), one topographic feature (hydraulic mine tailings), and one urban region were mapped. Riparian vegetation accounted for 56% of the total lineal shoreline coverage downstream of Englebright Dam.

SWRI, JSA, and BE. 2000. *Hearing Exhibit S-YCWA-19. Expert Testimony on Yuba River Fisheries Issues.* Prepared for the California State Water Resources Control Board Water Rights Hearing on Lower Yuba River February 22-25 and March 6-9, 2000.

The SWRI et al. (2000) document summarized data collection in the lower Yuba River obtained from 1992 through 2000. Since 1992, Jones and Stokes Associates (JSA) biologists conducted fish population surveys in the lower Yuba River used snorkel surveys to determine annual and seasonal patterns of abundance and distribution of juvenile Chinook salmon and steelhead during the spring and summer rearing periods. The SWRI et al. (2000) report stated that in general, juvenile Chinook salmon were observed by snorkeling throughout the river but with higher abundances above DPD. This report suggested that higher abundances above DPD may have been due to larger numbers of spawners, greater amounts of more complex, high quality cover, and lower densities of predators such as striped bass and American shad, which reportedly were restricted to areas below the dam.

Chinook Salmon

The SWRI et al. (2000) report stated that in 1992, beach seining surveys were conducted to measure lengths and weights of juvenile Chinook salmon at several locations in the lower Yuba River upstream and downstream of DPD. Beach seining was conducted at four sites (two upstream and two downstream of DPD) at weekly intervals from April 30, 1992 to June 5, 1992. Weekly measurements of lengths and weights were also taken from emigrating juvenile Chinook salmon at the Hallwood-Cordua fish screen during this period. Major findings of the 1992 surveys were summarized in SWRI et al. (2000) as follows.

- Juvenile salmon in the lower Yuba River exhibited significant growth in 1992. The average fork length at the Parks Bar site increased from 51.0 mm on May 1 to 69.1 mm on May 29, for an average growth rate of approximately 0.65 mm per day. Although accurate estimates of growth were not possible at other sites because of small sample sizes, the average sizes of juvenile on specific sampling dates both upstream and downstream of DPD were consistent with relatively rapid growth based on generalized growth curves for Chinook salmon.

- The seining data indicated a general increase in the size of juvenile Chinook salmon with distance downstream on any given date, possibly reflecting downstream movement of larger fish.

- Emigrating Chinook salmon salvaged at the Hallwood-Cordua fish screen were larger on any given date and encompassed a narrower size range (64.6 mm on April 30 to 77.5 mm on June 4) than Chinook salmon sampled above DPD. Although differences in efficiency existed between beach seining and the fish screen, the larger, more consistent size of emigrating juveniles compared to juveniles sampled in the river is consistent with the general knowledge that smolt migrations begin after the fish reach a certain size.

The SWRI et al. (2000) report stated that in 1993, high flows precluded the use of beach seines, although direct observations of juvenile Chinook salmon during monthly snorkel surveys (March 2, 1993 through August 10, 1993) revealed increases in the average size of juvenile salmon from 30-40 mm in early March, to approximately 60-70 mm by mid-June. Significant numbers of juvenile Chinook salmon continued to rear in the lower Yuba River through August, attaining average sizes of 70-80 mm and maximum sizes up to 120 mm. The apparent slower growth rates, longer residence periods, and later emigration timing in 1993 compared to 1992 were consistent with the hypothesis that emigration readiness is determined, at least in part, by the effects of water temperature of growth and development of young Chinook salmon during the spring rearing period. SWRI et al. (2000) reported that beach seine surveys were again conducted in 1994 at several locations upstream and downstream of DPD. The growth rates and body sizes of juvenile Chinook salmon on specific dates appeared to be similar to those observed in 1992.

SWRI et al. (2000) reported that individual lengths and weights of juvenile Chinook salmon in 1992 and 1994 were used to calculate condition factors. During the 1992 and 1994 surveys, fish were also examined for the presence of outward signs of stress (i.e., physical abnormalities, lesions, parasites). In 1992, juvenile Chinook salmon exhibited good condition factors at all locations throughout the sampling period (average condition factor ranged from 1.01 to 1.21 among all sampling sites and dates). SWRI et al. (2000) suggested that growth conditions were better in 1992 than in 1994. In 1994, average condition factors among all sampling sites and dates ranged from 0.95 to 1.05. No outward signs of stress were observed either in 1992 and 1994.

The SWRI et al. (2000) report stated that based on daily records of the number of Chinook salmon salvaged at the Hallwood-Cordua canal fish screen, the spring emigration period of juvenile salmon can begin as early as mid-April and continue until mid-June. However, it was noted that CDFG had not initiated salvage operations early enough in the season to sufficiently address the overall outmigration period. For the sampling that had been conducted, SWRI et al. (2000) reported that most juvenile Chinook salmon emigrated past DPD in April and May with peak numbers in early to late May. However, of all fish sampled, the median date of emigration past the dam (date when 50% of the total number of fish were collected at the Hallwood-Cordua fish screen) varied from late April to early June and was positively related to average April-May flow measured at the Smartsville gage. The report also stated that, in general, the median date of outmigration was delayed approximately 7-8 days with each 1,000-cfs increase for flows ranging from 400 cfs to 4,000 cfs, and that emigration timing during 1992-1994 continued to follow that relationship.

SWRI et al. (2000) suggested that the relationship between flow and emigration timing may reflect the effect of spring water temperatures on salmon growth rates and readiness to migrate; low water temperatures associated with high flows during the spring rearing period result in slower growth rates and later emigration. Conversely, higher water temperatures associated with lower flows result in higher growth rates and earlier emigration. SWRI et al. (2000) also suggested that observations of extended rearing of juvenile Chinook salmon into the summer months in high-flow years and the consistent size of emigrating juvenile Chinook salmon at the Hallwood-Cordua fish screen also support that relationship.

Steelhead/Rainbow Trout

The SWRI et al. (2000) report stated that since 1992, snorkeling, electrofishing, and angling surveys revealed the presence of large numbers of juvenile steelhead/rainbow trout in the lower Yuba River. This report suggested that the presence of a highly-acclaimed sport fishery, the lack of direct hatchery influence, and the presence of juveniles represented by a number of age classes confirmed that significant natural spawning and rearing of steelhead/rainbow trout occurred in the lower Yuba River. The physical appearance of adults and the presence of seasonal runs and year-round residents suggested that both sea-run (steelhead) and resident rainbow trout existed in the lower Yuba River, although no definitive characteristics had been identified to distinguish young steelhead from resident trout. Therefore, observations presented in the SWRI et al. (2000) report may apply to juveniles of either or both steelhead and resident rainbow trout, as summarized below.

- The primary spawning and rearing habitat for juvenile steelhead/rainbow trout is upstream of DPD. In 1993 and 1994, snorkeling surveys indicated that the population densities and overall abundance of juvenile trout (age 0 and 1+) were substantially higher upstream of DPD, with decreasing abundance downstream of DPD. In 1992, a general increase in the average size of juvenile trout in seine catches from the uppermost to the lowermost monitoring sites suggested a similar distribution pattern.

- Since 1992, a broad range of trout size classes have been observed in the lower Yuba River during spring and summer snorkeling, electrofishing, and angling surveys. Juvenile trout ranging in size from 40-150 mm were commonly observed upstream of DPD. Numerous larger juveniles and resident trout up to 18 inches long were also commonly observed in the mainstem upstream and downstream of DPD.

- The 1999 results of the juvenile steelhead study suggested that the highest abundance of young-of-the-year steelhead occurred above DPD despite suitable flow and water temperatures below the dam. Age 0 (young-of-the-year) trout were clearly shown by the distinct mode in lengths of fish caught by electrofishing (40-100 mm fork length). A preliminary examination of scales indicated that most yearling (age 1+) and older trout were represented by fish greater than 110 mm long, including most if not all of the fish caught by hook and line. The sizes of age 0 and 1+ trout indicated substantial annual growth of steelhead/rainbow trout in the lower Yuba River. Seasonal growth of age 0 trout was evident from repeated sampling of trout in 1992 and 1999, but actual growth rates could not be estimated because of continued recruitment of fry (newly-emerged juveniles) or insufficient sample sizes.

- Approximately 200 juvenile trout in 1992 and 1,100 trout in 1999 were measured, weighed, and examined to determine their general health and condition. All trout appeared healthy and in good physical condition. Like salmon, condition factors for juvenile trout increased with increasing size. In spring 1992, average condition factors for age 0 trout (48-82 mm average fork length) ranged from 1.07 -1.34. In summer 1999, average condition factors for age 0 trout (43-60 mm average fork length) ranged from 0.89-1.03, while those of age 1+ and older trout (156-420 mm fork length) averaged 1.13.

The SWRI et al. (2000) document also developed proposed minimum instream flow requirements which built upon additional information developed since 1992, including fish habitat utilization and detailed analyses of fish habitat-flow relationships and water availability. Development of the proposed instream flow requirements was based primarily on: (1) updated information characterizing Yuba River Basin hydrology and water year type classification; (2) water availability assessments for lower Yuba River instream flows, based on five water year types; (3) updated and additional lower Yuba River fishery information; (4) improved flow-temperature relationships for the lower Yuba River; and (5) a definition of maintaining lower Yuba River fish resources in “good condition.”

CDFG. 2002. *Sacramento River Spring-run Chinook Salmon. 2001 Annual Report.* Prepared for the Fish and Game Commission. Habitat Conservation Division, Native Anadromous Fish and Watershed Branch. October 2002.

CDFG (2002) summarized information from limited upstream migration surveys conducted during 2001, reconnaissance-level redd surveys conducted during 2001 and 2002, and rotary screw trapping during 2001-2002. CDFG (2002) reported that despite limited information on the population size of spring-run Chinook salmon in the lower Yuba River, data at that time indicated that adult escapement of spring-run Chinook salmon was relatively low and had been greatly reduced from historical levels. Prior to 2001, when CDFG conducted a study to estimate the number of adult spring-run Chinook salmon immigrating into the Yuba River by trapping fish in the fish ladder at DPD, there was almost no specific information on the run timing and size of the population in the lower Yuba River (CDFG 2002). In the 2001 CDFG study, which involved limited sampling of fish ascending the north ladder at DPD, a total of 108 adult Chinook salmon were estimated to have passed the dam between March 1, 2001, and July 31, 2001 (CDFG 2002).

Based upon reconnaissance-level redd surveys conducted by CDFG on the lower Yuba River from the Narrows pool downstream to DPD from August 31 to September 28, 2001, CDFG (2002) reported that the first redd was observed on September 7, 2001, and a total of 288 redds were observed. They also reported that 205 redds were observed in the lower Yuba River during the same time period in 2000. CDFG (2002) suggested that spring- and fall-run Chinook salmon were restricted to spawning in the same reach of the lower Yuba River.

Rotary screw trap operations were conducted during the 2001-2002 season to document the outmigration patterns of juvenile salmonids in the lower Yuba River. Data collected included timing, duration, and size of all Chinook salmon at the time of emigration. Although spring- and fall-run spawning occurred in the same physical location, initial length-frequency data from juveniles captured in the rotary screw trap indicated the presence of both a dominant fall-run and a smaller population of spring-run Chinook salmon CDFG 2002). Spring-run Chinook salmon were determined by size-at-date differences through the operation of the rotary screw trap. A total of 6,719 juveniles classified as spring-run Chinook salmon were captured between November 10, 2001 and May 8, 2002. These juvenile Chinook salmon sized ranged from 26mm FL to 108mm FL.

Lower Yuba River Water Transfer Monitoring Reports 2001 – 2004

The summaries below regarding recent water transfer studies conducted on the lower Yuba River were derived from the following sources:

YCWA and SWRCB. 2001. *Environmental Assessment: Proposed Temporary Transfer of Water From Yuba County Water Agency to DWR, Year 2001*. Prepared for Yuba County Water Agency and the State Water Resources Control Board by EDAW.

YCWA. 2003. *Draft Evaluation of 2002 Yuba River Water Transfers.* Prepared for Yuba County Water Agency by Surface Water Resources, Inc. January 28, 2003.

YCWA. 2005. *Evaluation of the 2004 Yuba River Water Transfers, Draft.* Prepared for Yuba County Water Agency by Surface Water Resources, Inc.

Water transfers and related monitoring studies and evaluations were performed in the lower Yuba River during 2001, 2002, and 2004. The primary fisheries issues evaluated by these studies included: (1) juvenile steelhead downstream movement; (2) adult Chinook salmon immigration and the potential for increased straying of non-native fish into the lower Yuba River; and (3) water temperatures in the lower Yuba River and Feather River.

The 2001 water transfers (172,000 acre-feet) occurred between approximately July 1, 2001 and October 14, 2001. Over a few days, flows increased by about 1,200 cubic feet per second (cfs) and were generally sustained in the lower Yuba River through late August when ramp-down began.

The 2002 water transfers (157,050 acre-feet) occurred from mid-June through mid-September and did not have a definitive ramp-up period. Instead, the relatively high flows that occurred during spring were sustained until initiation of the water transfers. Relatively stable flows of approximately 1,200 to 1,400 cfs at the Marysville gage were maintained through August 16, 2002. The ramp-down period associated with the water transfers began on August 17, 2002 and ended on September 16, 2002.

The 2004 water transfers (100,487 acre-feet) lacked a definitive ramp-up period. The relatively stable high June flows averaged 946 cfs at Marysville and were sustained through the initiation of the transfers (July 1) to the cessation of transfers on August 28, when flows were approximately 970 cfs at Marysville. Although the water transfers continued through

September, a short ramp-down period occurred from August 28, 2004 through September 1, 2004, when flows at the Marysville gage were reduced to 531 cfs. Flows remained low and stable during the rest of September, averaging approximately 513 cfs.

Juvenile Steelhead/Rainbow Trout Non-Volitional Downstream Movement

Previous reporting of the water transfer studies used the term steelhead when referring to *O. mykiss* juveniles. However, it is recognized that both anadromous and resident lifehistory strategies of *O. mykiss* have been and continue to be present in the lower Yuba River, and that definitive distinction of juveniles between these lifehistory strategies were not previously conducted. Therefore, the following summaries use the term "steelhead/rainbow trout" when referring to *O. mykiss.*

The 2001 water transfer was characterized by a relatively large, rapid ramp-up period. A week subsequent to the start of the 2001 water transfers, the daily catch at the CDFG Hallwood Boulevard (RM 7) RST increased from less than 10 young-of-the-year (YOY) steelhead/rainbow trout juveniles per day, to more than 450 YOY per day (CDFG unpublished data). The next week, daily catches decreased to about 190 YOY per day and continued to further decrease during the following weeks while the transfers were continuing, but still surpassed catches prior to the water transfers, suggesting that juvenile steelhead/rainbow trout moved from the upstream reaches of the lower Yuba River to areas downstream of Hallwood Boulevard.

In response to these observations, an instream flow release schedule for the water transfers was created by YCWA, NMFS, USFWS, and CDFG to avoid a rapid increase in flow when the transfers begin, and to minimize or avoid potential impacts on anadromous fish in the lower Yuba River associated with non-volitional downstream movement. During the 2002 and 2004 water transfers, YCWA maintained instream flows in the lower Yuba River at a relatively stable rate in the late spring, with gradual changes in flow rates through initiation of the water transfer. Monitoring data (RST catch data) indicated that the large peak in downstream movement of juvenile steelhead/rainbow trout observed in 2001 did not occur in 2002 or 2004.

Water transfer monitoring in 2001, 2002, and 2004 indicated that the character of the initiation of the water transfers could potentially affect juvenile steelhead/rainbow trout downstream movement. Based upon the substantial differences in juvenile steelhead/rainbow trout downstream movements (RST catch data) noted between the 2001 study, and the 2002 and 2004 studies, it was apparent that the increases in juvenile steelhead/rainbow trout downstream movement associated with the initiation of the 2001 water transfers were avoided due to a more gradual ramping-up of flows that occurred in 2002 and 2004.

Attraction of Non-natal Adult Chinook Salmon in the Lower Yuba River

Water transfer monitoring efforts also studied the potential for the Yuba River water transfers to affect the straying of Feather River hatchery Chinook salmon into the lower Yuba River via decreased water temperatures and increased flow relative to the Feather River. YCWA and CDFG monitoring efforts in 2001, 2002, and 2004 water transfer years indicated that

Chinook salmon of hatchery origin ascended the fish ladders at DPD in the lower Yuba River during both the water transfer and non-transfer periods. Chinook salmon of hatchery origin also have been observed ascending the Yuba River in non-transfer years (CDFG unpublished data).

Sampling of adult Chinook salmon via ladder trapping at DPD during 2001 was not sufficient to provide a dataset that could be statistically analyzed, and although 2002 data were statistically analyzed, a number of unexpected procedural difficulties were encountered resulting in low reliability of 2001 and 2002 abundance estimates. However, observations made during these water transfer studies led to the June 2003 installation of a VAKIRiverwatcher system, an infrared detection device, as well as a photographic recorder at DPD.

The use of the VAKIRiverwatcher as a counting device enabled more efficient and reliable monitoring of adipose fin-clipped and non-adipose fin-clipped adult Chinook salmon that immigrated into the lower Yuba River before, during, and after the 2004 water transfer. Estimates were conducted of immigration rates (fish/day), abundance of adipose fin-clipped and non-adipose fin-clipped adult Chinook salmon, and proportions of adipose fin-clipped adult Chinook salmon. The findings of these analyses led to the following general conclusions:

- The temporal distributions of the daily counts of adipose fin-clipped and non-adipose fin-clipped adult Chinook salmon likely were reflections of Chinook salmon adult immigration life stage periodicity, with the relatively abundant fall-run Chinook salmon mostly migrating during the post-transfer period.

- The estimates of the proportions of clipped adult Chinook salmon to the total number of adult Chinook salmon immigrating into the lower Yuba River did not suggest the attraction of non-natal adult Chinook salmon during the 2004 transfer period, because the proportion calculated for the transfer period was not greater than the proportions for the pre-transfer and post-transfer periods.

- Multivariate time series analyses indicated that the immigration rates of non-adipose fin clipped and adipose-fin clipped Chinook salmon in 2004 were not significantly associated with: (1) attraction flows, defined as the difference between lower Yuba River and Feather River flows; or (2) attraction water temperatures, defined as the difference between lower Yuba River and Feather River water temperatures.

JSA. 2003, 2007, and 2008. *Lower Yuba River Redd Dewatering and Fry Stranding Monitoring and Evaluation Plan.* November 2003. *Lower Yuba River Redd Dewatering and Fry Stranding Study 2007 Annual Report* (JSA 2007) and *Lower Yuba River Redd Dewatering and Fry Stranding Study 2008 Annual Report* (JSA 2008).

In D-1644, the SWRCB in 2001 directed YCWA to submit a plan, in consultation with USFWS, NMFS, and CDFG that describes the scope and duration of future flow fluctuation studies to verify that Chinook salmon and steelhead redds are being adequately protected from dewatering with implementation of D-1644 criteria (JSA 1992). In RD-1644, the SWRCB in 2003 readopted this requirement. After various comments and revisions, the March 2002 Plan (Plan) was approved by the SWRCB on April 17, 2002. Phase I of the Plan was undertaken in 2002, and implementation of Phase II of the Plan continues.

These studies combine habitat mapping, field surveys, and information on the timing and distribution of fry rearing in the lower Yuba River to evaluate the effectiveness of D-1644 flow fluctuation and reduction criteria in protecting Chinook salmon and steelhead/rainbow trout fry. Two studies were conducted and summarized in the 2007 and 2008 *Lower Yuba River Redd Dewatering and Fry Stranding Annual Reports* (JSA 2007, 2008) to the SWRCB.

The first *Lower Yuba River Redd Dewatering and Fry Stranding Study* was conducted in April 2007 to evaluate bar and off-channel stranding of juvenile salmonids associated with a flow reduction of 1,300-900 cfs (at Smartsville) at a ramping rate of 100 cfs per hour. Bar stranding was again evaluated in June with a temporary flow reduction of 1,600-1,300 cfs at a rate of 100 cfs per hour. Snorkel surveys were conducted between Rose Bar and the Highway 20 Bridge in the lower Yuba River. During the April 5, 2007 drawdown, field crews observed 8 stranded salmon fry in the interstitial spaces of substrates on bar slopes (perpendicular to shoreline) ranging from 0.5 to 5.5%. No stranded fish were observed during surveys conducted on June 18, 2007. The presence of both juvenile Chinook salmon and steelhead/rainbow trout were confirmed in shallow, near-shore areas adjacent to the study sites, suggesting that the risk of bar stranding is greatly reduced by June. Following April 5, 2007 flow reductions, a total of 11,100 juvenile Chinook salmon were found in 20 isolated off-channel habitats. Most (93%) of the isolated juveniles were newly emerged and exhibited a length ranging from 30 to 50 mm.

An update *Lower Yuba River Redd Dewatering and Fry Stranding Study* was subsequently conducted from May 29, 2008 through June 4, 2008 with a scheduled flow reduction on June 1, 2008. Two of the three potential stranding locations had changed since the 2007 study. A total of 7 stranded trout fry (ranging between 30-35mm) were observed in the interstitial spaces of substrates on bar slopes (perpendicular to shoreline) ranging from 2.0 to 5.7%. Following the June 1, 2008 flow reductions, 266 juvenile salmonids were isolated in 6 off-channel sites. JSA (2008) suggested that the preliminary findings indicated that juvenile steelhead/rainbow trout fry may be less vulnerable to off-channel stranding than juvenile Chinook salmon because of their more restricted distribution and inability to access off-channel areas under late spring flow conditions. Long-term monitoring of several isolated off-channel sites confirmed that some sites can support juvenile salmonids for long periods and even produce favorable summer rearing conditions.

In accordance with the *Lower Yuba River Redd Dewatering and Fry Stranding Monitoring and Evaluation Plan* (2003), YCWA and JSA will continue to monitor and evaluate stranding risk and flow-habitat relationships for off-channel stranding. Future actions will include the following : (1) continued evaluation of the effects of time of day (night versus day) on stranding risk of juveniles; (2) inspection of interstitial habitats along the river margins to determine the presence of young fry before bar stranding evaluations; (3) evaluation of the effects of higher ramping rates (>100 cfs per hour) on stranding risk of larger fry and juveniles; (4) continued evaluation of the relationship between flow range and the number, area, and distribution of off-channel sites that become disconnected from the main river; (5) evaluation of the effect of peak winter and spring flows on the incidence of off-channel stranding; and (6) continued monitoring of habitat conditions and survival of Chinook salmon and steelhead/rainbow trout in selected off-channel monitoring sites where stranding is frequently observed.

Massa, D. 2004. *Yuba River Juvenile Chinook Salmon (Oncorhynchus tshawytscha), and Juvenile Central Valley Steelhead Trout (Oncorhynchus mykiss), Life History Survey: Annual Data Report 2003-2004.* California Department of Fish and Game Annual Report, Sacramento Valley & Central Sierra Region, Rancho Cordova, CA.

This study was conducted to continue development of baseline information for the Central Valley Project Improvements Act's (CVPIA), Anadromous Fish Restoration Program (AFRP) for juvenile Chinook salmon and steelhead/rainbow trout lifehistory strategies on the lower Yuba River. Data were collected to determine the timing and duration of downstream emigration, abundance and/or relative abundance, and to monitor the condition and size of outmigrating juvenile Chinook salmon and steelhead/rainbow trout. Emigrating juvenile Chinook salmon were coded-wire tagged (CWT) in an effort to enumerate and determine the relative contribution to adult escapement on the lower Yuba River.

Juvenile Chinook salmon and steelhead trout were captured using a rotary screw trap (RST) with an eight-foot diameter cone placed in the lower Yuba River located approximately 6 miles east of the city of Marysville, adjacent to the south end of Hallwood Boulevard. Except during extraordinarily high water flows or during periods of excessive debris, the trap was fished 24-hours-per-day, seven-days-a-week from October 15, 2003 through June 17, 2004 following its installation on October 1, 2003.

Twenty-one species of fish were captured in the RST including a total of 307,297 juvenile Chinook salmon. Steelhead/rainbow trout were captured less frequently and totaled 590 fish during the October – June trapping period. This study revealed that peak catches of juvenile Chinook salmon on the lower Yuba River occur between December and March, which is approximately one month earlier than observed during previous monitoring efforts. Over 67,000 juvenile Chinook salmon were captured during the first two weeks of December 2003, and captures remained high until mid-March 2004. A total of 21,396 captured fry for the month of March 2003 signified the conclusion of peak emigration for juvenile Chinook salmon. Massa (2004) suggested that three runs of Chinook salmon (spring-, fall-, and late-fall run) were identified by modal distributions of captures at the RST. Spring-run Chinook salmon were first observed on November 1, 2003, followed by fall-run observations in December 2003, and late-fall run during mid-April 2004. Fall-run Chinook represented the majority of juveniles captured in the lower Yuba River. Coded Wire Tagging (CWT) began November 26, 2003 and ended June 15, 2004 with the majority of tagging occurring during peak emigration between December 9, 2003 and March 18, 2004. Of the 307,397 total juvenile Chinook salmon captured in the RST, 185,305 juvenile Chinook salmon were successfully injected with a CWT and adipose-fin clipped prior to release.

Kozlowski, J.F. 2004. *Summer Distribution, Abundance, and Movements of Rainbow Trout (Oncorhynchus mykiss) and other Fishes in the Lower Yuba River, California*. UC Davis Thesis.

Kozlowski (2004) conducted electrofishing (early-July and late-August), two mid-channel snorkel surveys (late-July and early-September), and river margin surveys (mid-August) just prior to the second electrofishing period during 2000. In addition, he reviewed 1999-2000 salvage data for the Hallwood-Cordua canal, a diversion canal located at DPD, and 1999-2001 trapping data for the Hallwood rotary screw trap (RST) near Hallwood Boulevard. These surveys were conducted to assess the distribution, abundance, and movement of steelhead/rainbow trout and other species below Englebright Dam.

The study focused on the portion of the lower Yuba River between Marysville and the Narrows within the following four reaches: (1) the Simpson Lane Bridge (about RM 3.2) to the Yuba Goldfields (about RM 8.3); (2) the western boundary of the Yuba Goldfields (about RM 8.3) to DPD (about RM 11.5); (3) upstream from DPD (about RM 11.5) to the upstream side of Long Bar (about RM 16.2); and (4) Highway 20 (about RM 16.2) to the downstream side of the Narrows (about RM 22.2).

Backpack electrofishing and snorkel survey data collection methods were used to estimate distribution and abundance population parameters for various life stages of steelhead/rainbow trout, as well as assess the aquatic community composition in the lower Yuba River. Fish screen salvage at DPD and rotary screw trapping methods were used to assess fish movements within the lower Yuba River, including above and below DPD. Age-0, juvenile, and adult summer distribution, abundance and movements were investigated between 1999 and 2000.

During the study a total of at least 12 species were observed including Chinook salmon and steelhead/rainbow trout. Kozlowski (2004) found higher abundances of juvenile and adult steelhead/rainbow trout above DPD, relative to downstream of DPD. Chinook salmon occurrence and abundance increased throughout the summer.

Kozlowski (2004) observed age-0 and adult steelhead/rainbow trout throughout the entire study area, with highest densities in upstream habitats and declining densities with increasing distance from the Narrows. Total numbers of juvenile and adult steelhead/rainbow trout observed below DPD accounted for 18 to 26% of the total number of steelhead/rainbow trout observed in the study area. The distribution of age-0 steelhead/rainbow trout observed appeared to be related to the distribution of spawning adults. The majority of redds observed during snorkel surveying occurred in the upstream reach between Long Bar and the Narrows during winter and spring 2000.

Some age-0 steelhead/rainbow trout dispersed downstream soon after emerging, beginning in July and August, and continued throughout the year (Kozlowski 2004). Salvage data at the Hallwood-Cordua fish screen suggested that most juvenile fish initiated their downstream movements immediately preceding and following a new moon, indicating the presence of lunar periodicity in the timing or outmigration patterns in the lower Yuba River (Kozlowski 2004).

Kozlowski (2004) stated that flow and temperature did not appear to cause age-0 steelhead/rainbow trout to initiate these downstream movements since these factors varied little or not at all during the duration of the summer. Similarly, water temperatures remained within the range preferred by steelhead/rainbow trout throughout the study area and did not vary substantially among reaches. As a result, the distributional pattern of steelhead/rainbow trout in the study area could not be explained by differences in water temperatures in the lower Yuba River.

Kozlowski (2004) found that the density of age-0 steelhead/rainbow trout was positively correlated to median substrate size of the upstream reach suggesting suitable rearing habitat for this life stage in the lower Yuba River. Juvenile and adult steelhead/rainbow trout were observed in greater numbers in pool habitats, and identified more frequently downstream of the Narrows, than in run habitats. Kozlowski (2004) suggested that results of this study indicated a relatively higher degree of habitat complexity, suitable for various life stages, in the reaches just below the Narrows compared to farther downstream. This includes greater occurrence of pools-type microhabitat suitable for juvenile and adult steelhead/rainbow rearing and holding, as well as small boulders and cobbles preferred by the age-0 emerging life stage.

Growth of age-0 steelhead/rainbow trout in the lower Yuba River was relatively slow throughout the summer, averaging between 47.9 mm (July 3 2000 - July 14, 2000) and 56.5 mm (August 25, 2000 – September 11, 2000) during the summer (Kozlowski 2004). The mean size observed in the lower Yuba River during this study was reportedly smaller than the August mean fork length (70 mm) reported by Cavallo et al. (2003; as cited in Kozlowski 2004) for age-0 rainbow trout in the low flow channel of the lower Feather River, and the lower American River in July (82 mm) reported by Snider and Titus (1994) but may be due to the presence of sampling biases inherent to electrofishing and snorkeling or seining methods. In a comparison of sampling methodology for this study, Koslowski (2004) suggested that snorkeling methods underestimated age-0 steelhead/rainbow trout numbers at sites where electrofishing yielded relatively high catches, but appeared to be a better estimator of fish density at sites where electrofishing yielded low numbers and was attributed to steelhead/rainbow trout fleeing sampling sites rather than hiding in the substrate as the electrofishing crew sampled the river margin.

Massa, D. and C. McKibbin. 2005. *Yuba River Juvenile Chinook Salmon (Oncorhynchus tshawytscha), and Juvenile Central Valley Steelhead Trout (Oncorhynchus mykiss), Life History Survey: Annual Data Report 2004-2005.* California Department of Fish and Game Annual Report, Sacramento Valley & Central Sierra Region, Rancho Cordova, CA.

Massa and McKibbin (2005) is a continuation of the Life History Surveys for the annual period extending from 2004-2005. Juvenile Chinook salmon and steelhead/rainbow trout were captured using two rotary screw traps (RST) with an eight-foot diameter cone placed in the lower Yuba River approximately 6 miles east of the city of Marysville, adjacent to the south end of Hallwood Boulevard. Except during extraordinarily high water flows or during periods of excessive debris, the traps were fished 24 hours per day, 7 days a week from October 21, 2004 through June 27, 2005 (Trap 1) and from April 26, 2005 to June 20, 2005 (Trap 2).

Twenty-two species of fish were captured in the RST including a total of 285,034 juvenile Chinook salmon. Steelhead/rainbow trout were captured less frequently and totaled 614 fish during the trapping periods. Massa and McKibbin (2005) suggested that peak catches of juvenile Chinook salmon on the lower Yuba River were observed later in the calendar year than in the previous 2003-2004 season, but were consistent with observations from earlier monitoring efforts (1999-2002).

Massa and McKibbins (2005) suggested that three runs of juvenile Chinook salmon (spring-, fall-, and late-fall run) were identified by modal distributions of captures at the RST. Fall-run Chinook represented the majority of juveniles captured in the lower Yuba River. CWT began November 29, 2004 and ended June 7, 2005 with the majority of tagging occurring during peak emigration between early January 2005 and late February 2005. Of the 285,034 total juvenile Chinook salmon captured in the RST, 242,774 juvenile Chinook salmon were successfully injected with a CWT and adipose-fin clipped prior to release.

JSA. 2006. *2003 Fall-run Chinook salmon spawning escapement in the Yuba River*. Prepared for Yuba County Water Agency by Jones and Stokes Associates, Inc.

JSA (2006) reported that annual surveys of Chinook salmon carcasses have been conducted on the lower Yuba River since 1953 to estimate fall-run Chinook salmon (*Oncorhynchus tshawytscha*) spawning escapement (i.e., the number of salmon that return to spawn each year). They reported that CDFG has conducted annual surveys of Chinook salmon carcasses on the lower Yuba River from 1953 to 1989, but suspended its surveys because of budget cuts. In response, YCWA with the assistance of JSA in 1991, conducted subsequent escapement surveys through 2003. CDFG assisted JSA from 1992 through 1994. In 2002 and 2003, additional funding was provided by the California Department of Water Resources (CDWR) and the Pacific States Marine Fisheries Commission (PSMFC) to ensure a complete search for tagged hatchery strays. The main objective of the annual carcass surveys was to estimate annual spawning escapement of fall-run Chinook salmon in the lower Yuba River downstream of Englebright Dam.

JSA (2006) reported an estimate of 28,897 Chinook salmon spawned in the lower Yuba River based on surveys conducted during 2003. JSA (2006) reported that the average spawning escapement for 1996–2003 was estimated to be 24,563 fish, which was substantially higher than the average of 13,809 for the preceding period between 1972–1995 representing the post–New Bullards Bar Reservoir period. Overall, average spawning escapement for the pre- and post-reservoir periods (1953–1971 and 1972–2003) was 12,906 and 16,050 fish, respectively.

Grover, A. and B. Kormos. (undated). *The 2006 Central Valley Chinook Age Specific Run Size Estimates*. Scale Aging Program, California Department of Fish and Game 475 Aviation Blvd, Suite 130 Santa Rosa, CA 95403

Through scale aging, this study produced age-structured hatchery and natural escapement estimates for all principal reaches and runs of Chinook salmon (*Oncorhynchus tshawytscha*) in the Central Valley. Digital imaging and reading techniques were used, and a modified maximum likelihood estimator based on the work of Kimura and Chikuni (1987; as cited in Grover and Kormos undated) was utilized. This method uses known, aged CWT salmon scale samples in conjunction with those of unknown aged (non-CWT) fish to create biascorrected age proportions from which age-specific run size estimates were made. Grover and Kormos (undated) reported that preliminary results showed that there are differences between the age structure of hatchery and natural escapement. In addition, they indicated that there are age structure differences among the Chinook lifehistory types present in the Central Valley. Results from this study indicated that in the lower Yuba River about 4.5% of the 2006 total escapement was comprised of 2 year old Chinook salmon, 16% were age 3, and 79.5% were age 4.

Grover, A. and B. Kormos. (undated). *The 2007 Central Valley Chinook Age Specific Run Size Estimates.* Scale Aging Program, California Department of Fish and Game 475 Aviation Blvd, Suite 130 Santa Rosa, CA 95403

Results from the 2007 evaluation utilized the same methods and procedures described for the 2006 evaluation (presented above). Grover and Kormos (undated) stated that there are differences between the age structure of hatchery and natural escapement, and among the Chinook life history types present in the Central Valley. Results from this study indicated that in the lower Yuba River about 3% of the 2007 total escapement was comprised of 2 year old Chinook salmon, 36% were age 3, 59% were age 4, and 1.6% were age 5.

NMFS. 2007. *Biological Opinion on the Operation of Englebright and Daguerre Point Dam on the Yuba River, California.* File Number 151422-SWR-2006-SA00071:MET (PCTS # 2007/01232). November 21, 2007.

In November 2007, NMFS issued a BO on the operation of USACE's facilities on the Yuba River, including DPD and Englebright Dam. Central Valley spring-run Chinook salmon and Central Valley steelhead passage at DPD was addressed in the BO, although NMFS (2007) stated that a final preferred alternative was not identified to alleviate passage impediment issues at DPD. The BO did not address project effects on the threatened southern-DPS of North American green sturgeon.

According to NMFS (2007), infrared and videographic sampling at ladders located at DPD since 2003 has provided more robust estimates of spring-run Chinook salmon numbers migrating into the lower Yuba River. NMFS (2007) reported preliminary estimates of adult spring-run Chinook salmon ascending DPD as 1,250 in 2003, 431 in 2004, 1,019 in 2005, 217 in 2006, and 242 in 2007. However, NMFS (2007) considered these numbers to be preliminary, minimum estimates, because periodic problems with the sampling equipment resulted in periods when fish ascending the ladders were not counted, so it is likely that the actual numbers are higher than those reported. NMFS (2007) observed that the detection of adipose fin clips on some of these fish indicated that they were hatchery strays, most likely from the Feather River Hatchery, and that the short time period in which this sampling has been conducted, coupled with the salmon's three to four year life cycle made it difficult to determine decisive trends in the spring-run Chinook salmon population. While the data from 2006 and 2007 indicate a reduction in total abundance, passage in May (the primary spring-run migration month) of 2007 was the highest detected in that month since the sampling has been conducted (NMFS 2007).

Based on infrared and videographic sampling at both DPD fish ladders since 2003, NMFS (2007) reported that minimum, preliminary estimates of the number of steelhead ascending DPD were 170 in 2003, 762 in 2004, 356 in 2005, 150 in 2006, and 511 in 2007. Additionally, because steelhead can be similar in size to many other species of fish in the Yuba River, only those inferred images that were backed up by photographic images clearly showing that the fish was a steelhead were included in the counts (NMFS 2007). Therefore, NMFS (2007) stated that it is likely that the actual numbers of steelhead passing DPD were higher than those reported. The data indicated that through the first half of the month of July 2007, upstream adult steelhead passage at DPD was the highest since the device was installed in 2003, although determination of decisive trends in the Yuba River steelhead population was difficult at that time (NMFS 2007).

Massa, D. 2008. *Lower Yuba River Chinook Salmon Escapement Survey: October 2007 – January 2008.* California Department of Fish and Game Annual Report, North Central Region, Chico, CA.

This report presents results of Chinook salmon spawning escapement surveys during 2007 to 2008, as well as summary information from preceding years. Massa (2008) reported that although escapement surveys were conducted on the lower Yuba River to estimate the number of returning adult Chinook salmon since 1953, previous estimates were infrequent and unlike more recent surveys (1994, 1996-2006), because methods were not consistent from year to year. Survey duration and area of sampling varied, resulting in data that were statistically inappropriate for trend analysis.

Massa (2008) estimated 2,604 Chinook salmon (2,423 adult and 81 grilse) spawned in the lower Yuba River survey area during the period of October 2, 2007 to January 3, 2008. This estimate was the lowest observed in twelve consecutive years, and was less than a third of the escapement estimate reported for 2006 (8,231 fish).

Separate estimates could not be created for each of the six survey reaches due to low sample size, although previous surveys have suggested that the majority of spawning occurs above DPD (JSA 2006; Massa 2006; Massa 2007). Approximately 70% of the returning escapement in 2006 utilized the area between the Narrows pool and DPD (Massa 2007). Massa (2008) stated that although it is difficult to accurately determine time of spawning from carcass recovery dates, spring-run carcasses, as identified through CWT recovery, were recovered between October 3, 2007 and October 16, 2007. As observed in 2005, all spring-run Chinook salmon recoveries were from the Feather River Hatchery. A single fall-run recovery also originated from the Feather River Hatchery. No recoveries were observed from the CDFG's wild-tagging operation (*Lower Yuba River Life History Investigation*) during this survey. As observed in 2005 and 2006, the majority of Feather River Hatchery strays were from plants transported far from their natal hatchery, mostly to San Pablo Bay via the Wickland Oil net pens (Massa 2008).

Beginning in 2005, the Feather River Hatchery began tagging early arriving (May/June) spring-run Chinook salmon with floy tags and releasing these fish to the river. Incidentally, two of these floy-tagged Feather River spring-run Chinook salmon have been collected during escapement surveys on the lower Yuba River - one in 2006 and one in 2007 (Massa 2008).

Scale samples were collected at random from October 2, 2007 through January 3, 2008. As a result of low overall sample numbers, an attempt was made to collect scales from all fresh carcasses encountered. A total of 346 samples were collected.

Annual population abundance estimates of Chinook salmon for the Sacramento-San Joaquin River system, including the lower Yuba River, have been complied by the CDFG Fisheries Branch Anadromous Resource Assessment Unit and presented as an independent dataset in GrandTab. The GrandTab report is a compilation of sources estimating the late-fall, winter, spring, and fall-run Chinook salmon populations for all streams surveyed in the Central Valley and are based on counts of fish entering hatcheries, migrating past dams, annual carcass surveys, live fish counts, and ground and aerial redd surveys. Population estimate sources for GrandTab include: (1) CDFG; (2) USFWS; (3) CDWR; (4) the East Bay Municipal Utilities District; (5) PG&E; and (6) the Fisheries Foundation of California. Fall-run Chinook salmon have been monitored since 1952, spring-run Chinook salmon since 1960, and late-fall and winter Chinook salmon runs since 1970.

Zimmerman, C., G. Edwards, and K. Perry. 2009. *Maternal origin and Migratory History of Steelhead and Rainbow Trout Captured in Rivers of the Central Valley, California.* Trans. of the Amer. Fish. Soc. 138:280-291. February 23, 2009.

Zimmerman et al. (2009) stated that the treatment of sympatric life history forms as single populations exhibiting polyphenism or as reproductively isolated populations has profound implications in decisions related to protection and recovery of species (Zimmerman and Reeves 2000; McEwan 2001; as cited in Zimmerman et al. 2009). Zimmerman et al. (2009) analyzed otolith strontium:calcium (Sr:Ca) ratios to determine maternal origin (anadromous vs. non-anadromous) and migratory history (anadromous vs. non-anadromous) of *O. mykiss* collected in Central Valley rivers between 2001 and 2007, including the lower Yuba River.

Fish were captured by various sampling techniques including beach seining, rotary screw trapping, electrofishing, carcass surveying, and hook and line.

A total of 964 otoliths were examined to determine age, maternal origin, and migratory history. Age-0 fish were collected from only three sites: Deer Creek, lower Yuba River, and Calaveras River. Zimmerman et al. (2009) found that age and length composition of samples varied among locations, and that mean length-at-age varied among locations. They determined mean fork length of steelhead and rainbow trout collected from the lower Yuba River as age-0 (68mm ± 24mm), age-1 (228mm ± 2mm), age-2 (271mm ± 24mm), age-3 (348mm ± 25mm), and age-4 (424mm ± 29mm).

Of the 964 otoliths examined from Central Valley streams, 224 were classified as steelhead progeny and 740 were classified as progeny of rainbow trout females. The proportion of steelhead progeny ranged from 0.04 in the Merced River to 0.74 in Deer Creek (Zimmerman et al. 2009). Based on examination of Figure 5 in Zimmerman et al. (2009), for the lower

Yuba River it appeared that about 15% of age-0, 40% of age-1, 11% of age-2, 12% of age-3, and 9% of age-4 sampled *O. mykiss* were of anadromous maternal origin.

Mitchell, W.T. 2010. *Age, Growth, and Life History of Steelhead Rainbow Trout (Oncorhynchus mykiss) in the Lower Yuba River, California.* ICF International. March 2010.

Steelhead/rainbow trout age structure, lifehistory, stock composition, origin, and growth in the lower Yuba River were analyzed using scales, which is an effective method for determining these life history characteristics, as well as the relationships between growth, life history variation, and recruitment (Mitchell 2010). Scales from 787 juvenile and adult steelhead/rainbow trout were collected in the lower Yuba River from 1998 to 2007. Most fish were collected by trapping, angling, and electrofishing. Upstream migrants were captured at DPD between November 11, 2000 and March 12, 2001. The remainder of sampling was conducted opportunistically via hook-and-line angling from 2004 to 2007.

Scales were taken from 142 age 0+ and age 1+ steelhead/rainbow trout collected by electrofishing during July to September 1999 and July to August 2000. Sampled fish averaged 107 mm FL and ranged from 68 to 198 mm FL. Of 467 juvenile and adult steelhead rainbow trout collected by angling between September 1998 and June 2007, only four fish were identified as steelhead and ranged in length from 438 to 559 mm FL. Scales taken from 71 juvenile and adult steelhead/rainbow trout trapped in the fish ladder at DPD from November 1, 2000 through March 28, 2001averaged 401 mm FL and ranged from 220 to 720 mm FL, with ten fish identified as steelhead and ranging in length from 453 to 720 mm FL (Mitchell 2010).

Scale analysis indicates the presence of at least four age categories for steelhead/rainbow trout in the lower Yuba River that spent 1, 2, or 3 years in freshwater and 1 year at sea before spawning. Mitchell (2010) does not report any steelhead/rainbow trout spending more than 1 year at sea before returning to spawn. Two of the 14 steelhead sampled were returning to spawn for a second time. A relatively higher proportion of age-3/1 were reported.

Results from Mitchell (2010) indicate steelhead/rainbow trout in the lower Yuba River are exhibiting a predominately residential life history pattern. He found that only 14% of samples gathered from DPD, and 1% from angling were anadromous steelhead adults. Based on scale analysis, nearly all fish had spent 1 to 4 winters in freshwater with no evidence of ocean residence (Mitchell 2010).

Mitchell (2010) reported that back-calculation of fork length (FL) showed substantial variability in size and growth for steelhead/rainbow trout juvenile age classes (0+ and 1+ fry). Late summer emerging 0+fry were smaller (<70mm FL) than average (108mm FL) by the end of their first winter, while early spring emergers were generally larger than average by the end of winter. Age 1+ juveniles grew 146mm in length following their first winter, reaching an average FL of approximately 265mm by the end of their second winter. Analysis of scale growth patterns indicate a period of accelerated growth during the spring peaking in the summer months, and followed by decelerated growth in the fall and winter. Following the second winter, steelhead/rainbow trout in the lower Yuba River exhibit reduced annual growth in length with continued growth in mass until reaching reproductive age.

Additionally, more rapid juvenile and adult steelhead/rainbow trout growth occurred in the lower Yuba River compared to the lower Sacramento River and Klamath River steelhead/rainbow trout, with comparable growth rates to steelhead/rainbow trout in the upper Sacramento River (Mitchell 2010).

Garza, J.C., and D.E. Pearse. (undated). *Population Genetic Structure of Oncorhynchus mykiss in the California Central Valley*. Final report for California Department of Fish and Game Contract # PO485303. University of California, Santa Cruz and NOAA Southwest Fisheries Science Center.

Garza and Pearse (undated) reported that genotype data was collected from 18 highly variable microsatellite molecular markers in more than 1,600 fish from the Central Valley region sampled by CDFG biologists, as well as a sample of adult steelhead from Battle Creek sampled by the USFWS. Analyses of these data examined population structure within the region, relationships between populations above and below barriers to anadromy, relationships of Central Valley populations with coastal steelhead populations, and population genetic diversity.

The analysis in Garza and Pearse (undated) focused on 17 initial "population" samples, comprised of fish sampled from the Kings, Tuolumne, Stanislaus, Calaveras, American, Yuba, Feather, Butte, Deer, Battle, and McCloud river sub-basins. Additional analyses were conducted with data from the same microsatellite markers in rainbow trout hatchery stocks and steelhead from coastal and California Central Valley populations. These analyses examined whether specific fish are, or are descended, from hatchery strains used in local stocking efforts, as well as providing biogeographic context for the Central Valley regional results. Garza and Pearse (undated) reported that in general, all naturally-spawned populations within the Central Valley basin were closely related, regardless of whether they were sampled above or below a known barrier to anadromy. This is due to some combination of pre-impoundment historic shared ancestry, downstream migration and, possibly, limited, anthropogenic, upstream migration. However, lower genetic diversity in above-barrier populations indicates a lack of substantial genetic input upstream and highlights lower effective population sizes for above-barrier populations. In contrast to coastal steelhead, close relationships were not found between populations above and below barriers within the same sub-basin. Instead, above-barrier populations clustered with one another and below-barrier populations clustered with one another in all tree analyses. The consistent clustering of the above-barrier populations with one another, and their position in the California-wide trees, indicate that they are likely to most accurately represent the ancestral population genetic structure of steelhead in the Central Valley (Garza and Pearse undated).

Garza and Pearse (undated) also identified possible heterogeneity between samples from different tributaries of the upper Yuba and Feather rivers, although Linkage (gametic phase) Disequilibrium (LD) was lower in these populations. Other than in the Nimbus Hatchery sample, only one other fish, in the lower Yuba River population, was identified as a hatchery fish with high confidence. In fact, the salient characteristic of population structure for Central Valley *O. mykiss* inferred from this study is that the populations of naturally-spawning fish sampled here are all closely related, regardless of whether they are currently above or below barriers to anadromy. This indicates that hatchery rainbow trout planted above dams in the region have not replaced *O. mykiss* populations trapped upstream of dam construction, fish commonly referred to as residualized steelhead (Garza and Pearse undated).

Garza and Pearse (undated) stated that these results indicate smaller effective size in above-barrier populations, which is consistent with the expectation of decreased upstream migration and the lost influx of new genes through migration. This situation will lead to gradual genetic erosion, which can contribute to eventual population extirpation (Srikwan and Woodruff 2000 as cited in Garza and Pearse undated). Facilitating upstream migration might help to alleviate such eventual genetic effects, but may also counteract the potential adaptation of above-barrier populations that is expected because of the strong selection against downstream migration in such populations (Garza and Pearse undated).

Garza and Pearse (undated) stated that efforts to integrate above-barrier populations with those below dams to increase overall effective size of steelhead populations and reestablish historical connectivity should also proceed with great caution, as these fish have been under very strong selection against anadromy since dam construction. The consequences of such integration are not known, but could range from beneficial increases in genetic diversity and effective size, to decreased fitness of hybrids and various ecological interactions such as competition or direct predation (Garza and Pearse undated).

OTHER RELEVANT DOCUMENTS

CDFG. 1993. *Restoring Central Valley streams: A plan for action*. The Resources Agency, CDFG, Sacramento, California. November 1993.

The CDFG (1993) report assessed the condition of Central Valley anadromous fish habitat and associated riparian wetlands, and set priorities for taking actions to restore and protect aquatic ecosystems that support fish and wildlife and to protect threatened and endangered species. Priorities were identified to guide future efforts toward restoration. On the lower Yuba River, priority actions included installing fish screens on lower Yuba River diversions, improving spawning and rearing habitat, and protecting and managing riparian habitat. Recommendations for administrative actions to improve anadromous fish habitat in the lower Yuba River also included specific stream flow recommendations which were consistent with the CDFG (1991) report titled *The Lower Yuba River Fisheries Management Plan Final Report*. The recommendations also included target water temperatures, although no specific water temperature studies, flow-temperature relationships, or water temperature availability studies were presented.

Yoshiyama, R. M., E. R. Gerstung, F. W. Fisher, and P. B. Moyle. 1996. *Historical and present distribution of Chinook salmon in the Central Valley Drainage of California.* In: Sierra Nevada Ecosystem Project, Final Report to Congress, vol. 111, Assessments, Commissioned Reports, and Background Information (University of California, Davis, Centers for Water and Wildland Resources, 1996).

This report summarized historical accounts of spring-run Chinook salmon populations, including the Yuba River. Yoshiyama et al. (1996) reported that prior to the impacts associated with gold mining, dam construction, and water diversions, large numbers of spring-run Chinook salmon were taken by miners and Native Americans as far upstream as Downieville on the North Yuba River. During the construction of the original Bullards Bar Dam (1921 - 1924), numerous Chinook salmon congregated and died below the dam. Due to their presence high in the watershed, Yoshiyama et al. (1996) concluded that these fish were spring-run Chinook salmon. In addition, this report indicated that prior to the construction of Englebright Dam, CDFG fisheries biologists observed large numbers of steelhead spawning in the uppermost reaches of the Yuba River and its tributaries.

CDFG. 1996. *Steelhead Restoration and Management Plan for California.* Prepared by D. McEwan and T. Jackson. Inland Fisheries Division, Sacramento, CA.

CDFG developed the *Steelhead Restoration and Management Plan for California* (Steelhead Plan) in 1996 as a component of the SB 2261 program. As mandated by *The Salmon, Steelhead Trout, and Anadromous Fisheries Program Act of 1988 (SB 2261),* a policy of the State of California is to significantly increase the natural production of salmon and steelhead, and directed CDFG to develop a program that strives to double naturally spawning anadromous fish populations by the year 2000.

CDFG (1996) reported that the Yuba River historically supported the largest, naturally-reproducing, persistent population of steelhead in the Central Valley, and that wild stocks in the Sacramento River system are mostly confined to upper Sacramento River tributaries such as Antelope, Deer, and Mill creeks and the Yuba River. This report, referencing CDFG (1991), stated that the lower Yuba River maintained natural production, and was managed by CDFG as a naturally sustained population. CDFG (1996) reported that the run size for the Yuba River in 1984 was estimated to be about 2,000 steelhead (CDFG 1984 as cited in CDFG 1996).

This report stated that as of 1996, the status of the Yuba River steelhead population was unknown, although it appeared to be stable and continued to support a steelhead fishery, and that the Yuba River was essentially the only wild steelhead fishery remaining in the Central Valley. This report, referencing CDFG (1991), reported that the lower Yuba River was annually stocked with 27,270 to 217,378 yearling steelhead from the Coleman National Fish Hatchery between 1970 to 1979, and that as of 1996 it was unknown whether the steelhead stock was of native origin or was derived from the planting of Coleman National Fish Hatchery fish. Although no specific water temperature studies, flow-temperature relationship evaluations, or water temperature availability studies were presented, CDFG (1996) suggested that low flows and elevated water temperatures resulting from water diversions had affected the anadromous populations of the lower Yuba River.

The CDFG (1996) report recommended that efforts should continue to seek adequate flows and temperatures, and implement restoration actions for the lower Yuba River. This report also stated that CDFG should continue to manage the lower Yuba River as a wild steelhead fishery, and recommended that hatchery steelhead not be planted in the lower Yuba River.

CDFG. 1998. *A Status Review of the Spring-Run Chinook Salmon (Oncorhynchus tshawytscha) in the Sacramento River Drainage***.** Candidate Species Status Report 98-01. CDFG, Sacramento, CA.

This status report was prepared in response to a petition to list Sacramento River spring-run Chinook salmon as an endangered species pursuant to the California Endangered Species Act (Fish and Game Code Sections 2050 *et seq*.). Based on information available to CDFG at that time, and in consideration of existing and future proposed actions affecting spring-run Chinook salmon, CDFG (1998) concluded spring-run Chinook salmon to be threatened.

Regarding the lower Yuba River, this report suggested that spring-run Chinook salmon populations may be hybridized to some degree with fall-run Chinook salmon due to lack of spatial separation of spawning habitat. CDFG (1998) suggested measures to improve habitat and survival of spring-run Chinook salmon in the lower Yuba River, including: (1) supplement flows with water acquired from willing sellers; (2) reduce flow fluctuations; (3) maintain adequate instream flows for temperature control; (4) screen all diversions to meet CDFG and National Marine Fisheries Services (NMFS) criteria; (5) improve fish bypass at water diversions; (6) improve adult and juvenile passage at DPD; (7) maintain and improve riparian habitat; (8) operate reservoirs to provide adequate water temperatures; (9) evaluation of the feasibility of removal of Englebright Dam to re-introduce spring-run Chinook salmon to their historic range; and (10) changing CDFG fishing regulations to prevent take of adult spring-run Chinook salmon during upstream migration.

YCWA. 2000. *Draft Environmental Evaluation Report, Yuba County Water Agency, Yuba River Development Project* (FERC No. 2246). Prepared by Yuba County Water Agency, Surface Water Resources Inc., and Jones and Stokes Associates. December 2000.

An Environmental Evaluation Report was prepared to address potential effects of the operation of Yuba River Development Project (YRDP) on anadromous salmonids in the lower Yuba River below Englebright Dam. The report was prepared in response to the listing of steelhead as threatened in March 1998, the listing of spring-run Chinook salmon in September 1999, and designation of critical habitat in February 2000. The report evaluated potential flow and water temperature related effects, and compared instream conditions prior to the completion of New Bullards Bar Dam in 1970, and since that time. In addition, the report listed several conservation measures being undertaken as part of YRDP operations in the lower Yuba River.

Yoshiyama, R., E. Gerstung, F. Fisher, and P. Moyle. 2001. *Historical and Present Distribution of Chinook Salmon in the Central Valley Drainage of California*. In Contributions to the Biology of Central Valley Salmonids, California Fish and Game, Bulletin 179, Volume 1. Salmonid Symposium, Bodega Bay, California. October 22-24, 1997, Randall Brown, editor.

This report characterized historic distributions of Chinook salmon throughout the Central Valley of California and states that both spring- and fall-run Chinook salmon historically occurred in the Yuba River watershed.

Yoshiyama et al. (2001) reported that salmon were caught in the North Fork Yuba River by PG&E workers in the Bullards Bar area during the 1898–1911 period of operation of the Yuba Powerhouse Project, and that salmon ascended in “considerable numbers” up to Bullards Bar Dam during its period of construction (1921–1924). This report stated that there were no natural barriers above the Bullards Bar Dam site, so Chinook salmon and steelhead presumably had been able to ascend a considerable distance up the North Fork Yuba River, potentially as far as Downieville at the mouth of the Downie River (CDFG file records as cited in Yoshiyama et al. 2001). This report further suggested that: (1) there were no natural obstructions from Downieville upstream to Sierra City, where Salmon Creek enters, spring-run Chinook salmon and steelhead most likely were able to traverse that distance; (2) spring-run Chinook salmon and steelhead probably ascended the higher-gradient reaches up to about two miles above the juncture of Salmon Creek; and (3) the absolute upstream limit on the North Fork Yuba River would have been Loves Falls for spring-run Chinook salmon and steelhead.

This report stated that in the Middle Fork Yuba River, there were no significant natural obstructions except for a 10-foot falls in the lower reach, and Chinook salmon possibly had access to a considerable portion of the Middle Fork Yuba River. Both Chinook salmon and steelhead were observed in the lower part of the Middle Fork Yuba River, near where the North Fork Yuba River joins, during a CDFG survey in 1938 (CDFG unpublished data as cited in Yoshiyama et al. 2001). Steelhead were found as far upstream as the mouth of Bloody Run Creek (CDFG unpublished data as cited in Yoshiyama et al. 2001). Whether Chinook salmon also reached that far remains conjectural. Yoshiyama et al. (2001) concluded that direct information was lacking and it was uncertain if many salmon were able to surmount the 10-foot falls on the lower river, and they conservatively considered the falls located 1.5 mi. above the mouth as the effective upstream limit of salmon in the Middle Fork Yuba River.

Yoshiyama et al. (2001) reported that little is known of the original distribution of salmon in the South Fork Yuba River where the Chinook salmon population was severely depressed and upstream access was obstructed by dams when CDFG began surveys in the 1930s. There were records of salmon occurring within one to two miles upstream of the mouth of the South Fork Yuba River (DFG unpublished data as cited in Yoshiyama et al. 2001). A substantial cascade with at least a 12-foot drop, located one-half mile below the juncture of Humbug Creek (CRA 1972; Stanley and Holbek 1984; as cited in Yoshiyama et al. 2001), may have posed a significant obstruction to salmon migration, but it was not necessarily a complete barrier. However, Yoshiyama et al. (2001) categorized the cascade below Humbug Creek as essentially the historical upstream limit of salmon during most years of natural streamflows. They also stated that steelhead were known to have ascended the South Fork Yuba River as far as the juncture of Poorman Creek near the present town of Washington (CDFG unpublished data as cited in Yoshiyama et al. 2001), and perhaps some spring-run Chinook salmon historically also reached that point.

CDWR and USACE. 2003a. *Daguerre Point Dam Fish Passage Improvement Project 2002 Fisheries Studies – Analysis of Potential Benefits to Salmon and Steelhead from Improved Fish Passage at Daguerre Point Dam*. Prepared for CDWR and USACE by ENTRIX, Inc. and J. Monroe. March 2003.

The purpose of this report was to examine available data on habitat conditions, flow, passage, and spawning above and below DPD to assist in the analysis of potential benefits or impacts of improved passage at the dam prior to selection of an alternative concept(s) for consideration in the environmental review process. The report included a review of available data from CDFG, USFWS, JSA, and other sources. It also incorporated field observations of river habitat conditions made by ENTRIX, Inc. (ENTRIX) in September of 2002 (ENTRIX and J. Munroe 2003 as cited in CDWR and USACE 2003). The report described channel morphology, spawning habitat suitability, historical and potential habitat use by species, water temperature, hydrology, as well as discussions regarding conceptual benefits and impacts for different fish passage alternatives.

CDWR and USACE. 2003b. *Daguerre Point dam fish passage improvement project 2002 water resources studies.* Prepared for CDWR and USACE by ENTRIX, Inc. June 2003.

The purpose of this report was to summarize and analyze the available hydrologic (including groundwater and flooding), hydraulic, and sediment data for the lower Yuba River. This report characterized the conditions on the river, including hydrology (groundwater and surface water), flow hydraulics, sediment transport, and flooding as part of the DPD Fish Passage Improvement Project.

USACE. 2003. *Daguerre Point Dam Fish Passage Improvement Project – Alternative Concepts Evaluation.* Prepared for ENTRIX, Inc. by W. Rodgers, Inc. September 2003.

USACE (2003) focused conceptually on improving fish passage for native anadromous fish species at DPD while maintaining water interests and flood management. Project alternative feasibility was assessed with consideration given to fisheries benefits and limitations, environmental impacts, sediment/mercury containment, water supply impacts, operation and maintenance requirements, engineering and construction demands, and economics.

YCWA. 2003. *Initial Study/Proposed Mitigated Negative Declaration for the Narrows 2 Powerplant Flow Bypass System Project*. November 2003.

The Initial Study (YCWA 2003) addressed the environmental impacts of construction and operation of a synchronous full-flow bypass at YCWA's Narrows 2 Powerplant. Prior to implementation of the Narrows 2 Powerplant Full-flow Bypass System, the Narrows 2 Powerplant did not allow the full-flow capacity to be bypassed during non-operation. Even a brief loss of power resulted in a substantial loss of river flow. YCWA (2003) suggested that any facility shutdowns, particularly those occurring during the warm and dry summer months, could result in flow and temperature conditions in the lower Yuba River potentially detrimental to fish by increasing water temperatures in the river above physiologically suitable levels, or reducing flow magnitude to levels that could result in redd dewatering or juvenile stranding.

The primary objectives of the Narrows 2 Powerplant Full-flow Bypass System Project were to: (1) maintain more stable releases from the Narrows 2 Powerplant during emergency and maintenance shutdowns at the same flow rate as was being discharged before the shutdown occurred; and (2) make the flow fluctuation and reduction criteria stated in YCWA's FERC License No. 2246 more protective of downstream fish species than the criteria that were previously stated in that license. Detailed information on the population status, lifestages, general population trends, and critical habitat for Central Valley spring-run Chinook salmon and Central Valley steelhead in the lower Yuba was provided in Appendix B to the IS/MND.

Since the issuance of the SWRCB Yuba Accord Water Rights Decision (D-1644) in March 2008, a full-flow bypass structure has been installed on the Narrows 2 hydropower facility which will essentially eliminate the potential for detrimental flow and temperature fluctuations to occur in the lower Yuba River associated with maintenance and operation of the Narrows 2 Powerplant.

YCWA, FERC, and NMFS. 2003. *Biological Assessment, Yuba River Development Project* (FERC No. 2246) Proposed License Amendment. Prepared for Yuba County Water Agency, Federal Energy Regulatory Commission, and National Marine Fisheries Services by Surface Water Resources, Inc.

This Biological Assessment addressed a proposed amendment to the Federal Power Act (FPA) license for Project No. 2246 issued to the YCWA by the Federal Power Commission (FPC). Pursuant to 50 CFR 402.11, YCWA filed with the Federal Energy Regulatory Commission (FERC), a definitive proposal to amend the license to: (1) authorize YCWA to construct and operate a synchronous full-flow bypass (bypass) at YCWA's Narrows II Powerhouse; and (2) revise the license's flow reduction and fluctuation criteria.

This Biological Assessment concluded that the Proposed Action generally will improve conditions for Central Valley spring-run Chinook salmon and steelhead in the lower Yuba River by largely eliminating adverse effects on those species resulting from unplanned outages at the Narrows 2 Powerhouse; the primary element of the Proposed Action that will have this effect is the installation of a synchronous full-flow bypass at the Narrows II Powerhouse. Biological effects of short-term outages were expected to be eliminated by providing essentially simultaneous restoration of flows. Biological effects of long-term outages on spring-run Chinook salmon and steelhead were expected to be eliminated by allowing YCWA to bypass almost the entire river flow without generating electricity.

CALFED and YCWA. 2005. *Draft Implementation Plan for the Lower Yuba River Anadromous Fish Habitat Restoration: Multi-Agency Plan to Direct Near-Term Implementation of Prioritized Restoration and Enhancement Actions and Studies to Achieve Long-Term Ecosystem and Watershed Management Goals.* Prepared by Lower Yuba River Fisheries Technical Working Group. Funded by CALFED and Yuba County Water Agency. October 2005.

The purpose and goal of the CALFED and YCWA (2005) report was to facilitate the implementation of prioritized actions and studies that intended to protect, enhance, and restore: (1) the Yuba River aquatic and riparian habitats; (2) the key processes that create and maintain these habitats; and (3) the anadromous fish species that use such habitats.

The report described abiotic (geomorphology, water flow, and water temperature) and biotic (habitat, species-specific profile and population status) conditions in the lower Yuba River watershed to provide a technical basis for the development of species-specific conceptual models to assess how physical conditions may be affecting the anadromous fish species of primary management concern (i.e., spring- and fall-run Chinook salmon, steelhead, green sturgeon, American shad and striped bass). The conceptual models prioritized potential life-stage specific stressors that may negatively affect fish survival, growth or other critical lifecycle processes.

CALFED and YCWA (2005) identified major factors (directly flow-related) influencing the status of naturally-spawning spring-run Chinook salmon and steelhead in the lower Yuba River including: (1) restricted flow-dependent habitat availability; (2) limited habitat complexity and diversity; (3) elevated water temperatures; and (4) flow fluctuations. Major factors (not directly flow-related) influencing the status of naturally-spawning spring-run Chinook salmon and steelhead in the Yuba River were identified as: (1) blockage of historic spawning habitat resulting from the construction of the Englebright Dam in 1941, which has implications for the spatial structure of the populations; (2) impaired adult upstream passage at DPD; (3) unsuitable spawning substrate in the uppermost area (i.e., Englebright Dam to the Narrows) of the lower Yuba River; (4) limited riparian habitats, riverine aquatic habitats for salmonid rearing, and natural river function and morphology; and (5) impaired juvenile downstream passage at DPD.

NMFS. 2005. *Preliminary Biological Opinion Based on Review of the Proposed Yuba River Development Project License Amendment for Federal Energy Regulatory Commission License No. 2246, Located on the Yuba River in Yuba County, California, and Its Effects on Threatened Central Valley Spring-Run Chinook Salmon (Oncorhynchus Tshawytscha) and Central Valley*

Steelhead (O. Mykiss), in Accordance With Section 7 of the Endangered Species Act of 1973, As Amended. November 4, 2005.

NMFS issued a preliminary biological opinion (BO) to FERC which analyzed the potential effects of the proposed Yuba River Development Plan License Amendment (FERC License No. 2246) on threatened Central Valley spring-run Chinook salmon and Central Valley steelhead. Subsequent to the completion of this BO, the action area was proposed for designation as critical habitat for these two fish species, as well as for the southern-DPS of North America green sturgeon. A final rule designating critical habitat was published September 2, 2005 (70 FR 52488) and became effective January 2, 2006. Therefore the NMFS (2005) Preliminary BO as a final BO considering effects of the Yuba River Development Plan on Central Valley spring-run Chinook salmon and Central Valley steelhead, and as a conference opinion considering project effects on the Southern-DPS of North American green sturgeon.

NMFS (2005) provided a review of available information that generally described lifehistory characteristics for lower Yuba River threatened species. NMFS (2005) reported that a loss of habitat and altered instream flow conditions were the primary factors affecting the status of critical habitat for spring-run Chinook salmon. Additionally, NMFS (2005) reported that predation by striped bass and largemouth bass may be exacerbated by the alteration of natural flow regimes and structures.

Gard, M. 2007. *Flow-habitat relationships for spring and fall-run Chinook salmon and steelhead/rainbow trout spawning in the Yuba River.* Draft report prepared by the Energy Planning and Instream Flow Branch of the USFWS, Sacramento, CA. April 19, 2007.

The focus of the Gard (2007) report was to develop flow-habitat relationships for spring- and fall-run Chinook salmon and steelhead/rainbow trout spawning in the lower Yuba River. See the Licensee study plan titled *Instream Flow Study Below's Englebright Reservoir*.

Lindley, S., R. Schick, E. Mora, P. B. Adams, J. J. Anderson, S. Greene, C. Hanson, B. P. May, D. McEwan, R. B. MacFarlane, C. Swanson, and J. G. Williams. 2007. *Framework for Assessing Viability of Threatened and Endangered Chinook Salmon and Steelhead in the Sacramento-San Joaquin Basin.* San Francisco Estuary & Watershed Science Volume 5: California Bay-Delta Authority Science Program and the John Muir Institute of the Environment.

This report provided a framework to assess the viability of threatened and endangered Chinook salmon and steelhead in the Sacramento-San Joaquin basin, and included some information regarding the Yuba River. Lindley et al. (2007) reported that adult Chinook salmon expressing the phenotypic timing of adult immigration associated with spring-run Chinook salmon persisted and spawned in the lower Yuba River below the Englebright Dam, and that the lower Yuba River is among the last Central Valley floor tributaries supporting populations of naturally-spawning spring-run Chinook salmon and steelhead. They reported that in the long-term, the Yuba River has high potential for maintaining suitable anadromous salmonid habitat, despite the expected long-term climate warming, and that under the expected climate warming scenario of about 5°C by the year 2100, substantial salmonid habitat would be lost in the Central Valley, with the Yuba River being one of the only Central Valley tributaries with significant amounts of habitat remaining.

YCWA. 2007. *Draft Environmental Impact Report/Environmental Impact Statement for the Proposed Lower Yuba River Accord.* Prepared for the Department of Water Resources, Bureau of Reclamation and Yuba County Water Agency by HDR|SWRI. June 2007.

The Draft EIR/EIS for the Proposed Lower Yuba River Accord provided a comprehensive compilation of existing information regarding the aquatic resources of the lower Yuba River, as well as descriptions of the development of the Yuba Accord flow schedules and impact evaluation. The Fisheries Chapter of the Draft EIR/EIS consisted of 411 pages, with over 15,000 pages of related model output in the Appendices. Provided below is a brief summary of the most relevant information presented in YCWA (2007) regarding population characteristics of spring-run Chinook salmon and steelhead, and development of the Yuba Accord flow schedules.

Population Characteristics

The spring-run Chinook salmon spawning period extends from September through November, while the embryo incubation life stage generally extends from September to March. Limited redd surveys during late-August and September conducted by CDFG have detected spawning activities beginning during the first or second week of September. They have not detected a bimodal distribution of spawning activities (i.e., a distinct spring-run spawning period followed by a distinct fall-run Chinook salmon spawning period) but instead have detected a slow build-up of spawning activities starting in early September and transitioning into the main fall-run spawning period.

Spring-run Chinook salmon juveniles are believed to rear in the lower Yuba River year-round. In general, juvenile Chinook salmon have been observed throughout the lower Yuba River, but with higher abundances above DPD. This may be due to larger numbers of spawners, greater amounts of more complex, high-quality cover, and lower densities of predators such as striped bass and American shad, which reportedly are restricted to areas below DPD (YCWA 2007).

The spring-run Chinook salmon smolt emigration period is believed to extend from November through June, although based on CDFG's run-specific determinations, the vast majority (approximately 94 percent) of spring-run Chinook salmon were captured as post-emergent fry during November and December, with a relatively small percentage (nearly 6 percent) of individuals remaining in the lower Yuba River and captured as YOY from January through March. Only 0.6 percent of the juvenile Chinook salmon identified as spring-run were captured during April, 0.1 percent during May, and none were captured during June (YCWA 2007).

Steelhead adult immigration and holding in the lower Yuba River extends from August through March (YCWA 2007). Spawning generally extends from January through April, primarily occurring in reaches upstream of DPD. The embryo incubation life stage generally extends from January through May. Juvenile steelhead/rainbow trout are believed to rear in the lower Yuba River year-round.

Steelhead/rainbow trout juveniles have been observed moving downstream past the lower portion of the lower Yuba River during spring and summer months. However, at least some of this downstream movement may be associated with the pattern of flows in the river. Based upon the substantial differences in juvenile steelhead/rainbow trout downstream movements (RST catch data) noted between the 2001 study, and the 2002 and 2004 studies, it is apparent that the increases in juvenile steelhead downstream movement associated with the initiation of the 2001 water transfers were avoided due to a more gradual ramping-up of flows that occurred in 2002 and 2004. The steelhead smolt emigration period is believed to extend from October through May (YCWA 2007).

Yuba Accord Flow Schedules

Development of the flow schedules and the three agreements that comprise the Yuba Accord was a collaborative process that took place over a period of approximately two and a half years. The flow schedules were developed by a Technical Team of biologists representing YCWA, the NGOs, CDFG, NMFS, and USFWS with the express goal of optimizing fisheries conditions in the lower Yuba River. During development of the flow regime for the Yuba Accord, extensive stressor analyses were undertaken which principally considered steelhead, spring-run Chinook salmon, and fall-run Chinook salmon.

A suite of six flow schedules, plus Conference Year rules for 1-in-100 critically dry years, were developed and are based on water availability, including inflow into New Bullards Bar Reservoir and reservoir carry-over storage. In addition to the biological and other science-based considerations, one of the Technical Team's objectives was to maximize the probability of occurrence of the higher flow schedules (1 and 2) while minimizing the probability of occurrence of the very low flow schedules (6 and Conference Year). Based on computer simulation model results, the estimated predicted probabilities of occurrence over the 78-year period of hydrologic record indicate that the two most optimum flow schedules (1 and 2) would be achieved nearly 80 percent of the time.

To support the impact analyses conducted for the Yuba Accord EIR/EIS, hydrologic modeling was used to simulate potential changes in flows and water temperatures in the lower Yuba River that would be expected to occur as a result of implementing the Yuba Accord. The fisheries analyses utilized several methodologies to evaluate project-related impacts, including: (1) a flow-duration assessment; (2) evaluation of flow dependent spawning habitat availability expressed as weighted usable area; and (3) utilization of available data on flow and water temperature relationships to determine the cumulative probabilistic distribution of water temperatures for each month at a given river location.

A statistical water temperature model was developed to evaluate the potential impacts of the alternatives considered in the Yuba Accord EIR/EIS. The statistical model was used to estimate the effects of various New Bullards Bar Reservoir storage regimes, flow releases, and diversions at DPD on water temperatures in the lower Yuba River.

Water temperature evaluations conducted for the Yuba Accord EIR/EIS indicated that Yuba River water temperatures generally remain suitable for all life stages of spring-run Chinook salmon and steelhead with implementation of the Yuba Accord flow schedules. Water temperatures generally remained below 58°F year-round (including summer months) at Smartsville, and generally remain below 60°F year-round at DPD. At Marysville, water temperatures generally remain below 60°F from October through May, and generally remain below 65°F from June through September.

Gard, M. 2008a. *Flow-habitat relationships for juvenile spring/fall-run Chinook salmon and steelhead/rainbow trout rearing in the Yuba River.* Draft report prepared by the Energy Planning and Instream Flow Branch of the U.S. Fish and Wildlife Service, Sacramento, CA, dated August 12, 2008.

The focus of the Gard (2008a) report was to develop flow-habitat relationships for spring- and fall-run Chinook salmon and steelhead/rainbow trout juvenile rearing in the lower Yuba River (see the Licensee study plan titled *Instream Flow Study Below Englebright Reservoir*).

Gard, M. 2008b. *Sensitivity analysis for flow-habitat relationships for steelhead/rainbow trout spawning in the Yuba River. Draft report prepared by the Energy Planning and Instream Flow Branch of the U.S. Fish and Wildlife Service, Sacramento, CA, dated* October 17, 2008.

The focus of the Gard (2008b) report was to conduct a sensitivity analysis on flow-habitat relationships for spring- and fall-run Chinook salmon and steelhead/rainbow trout spawning in the lower Yuba River (see the Licensee study plan titled *Instream Flow Study Below Englebright Reservoir*).

NMFS. 2009. *Draft Recovery Plan for the Evolutionarily Significant Units of Sacramento River Winter-run Chinook Salmon and Central Valley Spring-run Chinook Salmon, and the Distinct Population Segment of Central Valley Steelhead.* National Marine Fisheries Service, Southwest Regional Office, Sacramento, California. October 2009.

The NMFS (2009) Public Draft Recovery Plan for the Evolutionarily Significant Units of Sacramento River Winter-run Chinook Salmon and Central Valley Spring-run Chinook Salmon, and the Distinct Population Segment of Central Valley Steelhead ("Draft Recovery Plan") recognizes the importance and potential to increase spring-run Chinook salmon and steelhead populations in the lower Yuba River. The Draft Recovery Plan (NMFS 2009) established three priority levels to help guide recovery efforts for watersheds that are currently occupied, and are referred to as Core 1, 2, and 3 populations. Core 1 Populations are highest priority, have a known ability or potential to support viable populations, and have the capacity to respond to recovery actions. Spring-run Chinook salmon and steelhead in the lower Yuba River are Core 1 populations. Core 1 populations form the foundation of the recovery strategy, and should be the first focus of an overall recovery effort (NMFS 2009).

The Draft Recovery Plan (NMFS 2009) states that *"…many of the processes and conditions that are necessary to support a viable independent population of spring-run Chinook salmon can be improved with provision of appropriate instream flow regimes, water temperatures, and habitat availability. Continued implementation of the Yuba Accord is expected to address these factors and considerably improve conditions in the lower Yuba River*".

The lower Yuba River, downstream of Englebright Dam, was characterized as having a high potential to support viable populations of spring-run Chinook salmon and steelhead, primarily because: (1) the river supports persistent populations of spring-run Chinook salmon and steelhead; (2) flow and water temperature conditions are generally suitable to support all life stage requirements; (3) the river does not have a hatchery on it; (4) spawning habitat availability does not appear to be limiting; and (5) there is high habitat restoration potential (NMFS 2009).

The Draft Plan (NMFS 2009) states, that in order to secure a viable independent population of spring-run Chinook salmon, and to secure the extant population and promote a viable population of steelhead in the lower Yuba River, several key near-term and long-term habitat restoration actions were identified, including the following:

- Continued implementation of the Yuba Accord flow schedules to provide suitable habitat (flow and water temperature) conditions for all life stages
- Improvements to adult salmonid upstream passage at DPD
- Improvements to juvenile salmonid downstream passage at DPD
- Implementation of a spawning gravel augmentation program in the uppermost reach (i.e., Englebright Dam to the Narrows) of the lower Yuba River
- Improvements to riparian habitats for juvenile salmonid rearing
- Creation and restoration of side-channel habitats to increase the quantity and quality of off-channel rearing (and spawning) areas
- Implementation of projects to increase floodplain habitat availability to improve habitat conditions for juvenile rearing

The Draft Plan (NMFS 2009) identified the following Priority 1 recovery actions for the Yuba River: (1) develop and implement a phased approach to salmon reintroduction planning to recolonize historic habitats above Englebright Dam; and (2) improve spawning habitat in the lower Yuba River by gravel restoration program below Englebright Dam and improve rearing habitat by increasing floodplain habitat availability.

Comments on the Draft Recovery Plan (NMFS 2009), including issues specific to the lower Yuba River and the Yuba River Watershed, have been provided to NMFS. FR (51553-51555) states that all comments received by the due date will be considered before NMFS' decision whether to adopt a final recovery plan. NMFS (74 FR 51553) specifically states that it will consider and address all substantive comments received during the comment period. A Final Recovery Plan has not yet been issued.

CDFG and PG&E. 2009. *Draft Habitat Expansion Agreement for Central Valley Spring-Run Chinook Salmon and California Central Valley Steelhead.* November 2009.

PG&E and CDWR entered into the *Habitat Expansion Agreement for Central Valley Spring-Run Chinook Salmon and California Central Valley Steelhead* (HEA) effective November 20, 2007, with multiple government and non-government entities including American Rivers, Arthur G. Baggett, Jr., CDFG, U.S. Department of Agriculture Forest Service, NMFS, USFWS, and the State Water Contractors. The overall goal of the HEA is to expand the amount of habitat with the physical characteristics necessary to support spawning, rearing and adult holding of spring-run Chinook salmon (and steelhead) in the Sacramento River Basin. Specifically, the Habitat Expansion Threshold (HET) is to expand spawning, rearing and adult habitat sufficiently to accommodate an annual estimated net increase of 2,000 to 3,000 spring-run Chinook salmon for spawning in the Sacramento River Basin. The HET is focused on spring-run Chinook salmon as the priority species, because expansion of habitat for spring-run Chinook salmon typically accommodates steelhead as well (CDFG and PG&E 2009). The intent of the HEA is to create "permanent" solutions to problems which provide benefits through the term duration of a typical FERC license (i.e., up to 50 years).

Substantial efforts have been undertaken to identify, develop and consider the relative merits of habitat restoration actions in the lower Yuba River. The need for, identification of, and relative merits of the actions to expand habitat and accomplish the goals of the Oroville FERC Relicensing HEA regarding biological, physical and operational considerations pertinent to the lower Yuba River were presented in a report as Appendix G to the Draft HEA during early November 2009. The lower Yuba River has been designated as having a high potential to meet the HEA goals and thresholds. A Final HEA has not yet been adopted.

ONGOING DATA COLLECTION, MONITORING AND EVALUATION ACTIVITIES

LOWER YUBA RIVER ACCORD MONITORING AND EVALUATION PROGRAM

The Yuba Accord River Management Team (RMT) is comprised of representatives of YCWA, NMFS, USFWS, CDFG, PG&E, CDWR, and the non-governmental organizations (NGOs) that are parties to the Fisheries Agreement of the Yuba Accord (South Yuba River Citizens League, Trout Unlimited, Friends of the River, The Bay Institute). The RMT, in collaboration with representatives from University of California at Davis and the Pacific States Marine Fisheries Commission, has developed a Monitoring and Evaluation Program (M&E Program) to guide the efficient expenditure of approximately $6 million to evaluate the effects of implementation of the Yuba Accord on the aquatic resources of the lower Yuba River over the period extending from 2008 to 2016. Monitoring and data from implementation of the M&E Program will be complied into annual reports and available at the RMT website www.yubaaccordrmt.com. The M&E Program embraces a monitoring-based adaptive management approach to increase the effectiveness of, and to address the scientific uncertainty associated with, specific monitoring and study activities, and restoration actions. Within the framework of this M&E Program, the RMT retains the flexibility to revise monitoring actions to address specific issues or obtain additional information. In addition, the parties to the Fisheries Agreement of the Yuba Accord intended that the monitoring and data collection activities implemented via the M&E Program will produce a useful database for the proceedings of the Federal Energy Regulatory Commission (FERC) regarding the relicensing of YCWA's Yuba River Development Project.

In addition to monitoring and evaluation of the fish community, the fisheries evaluations in this M&E Program focus on steelhead/rainbow trout and the two principal Chinook salmon runs that are known to use the lower Yuba River (i.e., fall-run and spring-run[1,2] Chinook salmon), although evaluations of Chinook salmon exhibiting the phenotypic characterization of lifestage periodicities associated with late fall-run Chinook salmon also are included[3]. Regarding steelhead/rainbow trout, the physical appearance of adults and the presence of seasonal runs and year-round residents indicate that both sea-run (steelhead[1]) and resident rainbow trout exist in the lower Yuba River. Thus, it is recognized that both anadromous and resident lifehistory strategies of *O. mykiss* have been and continue to be present in the lower Yuba River, resulting in the use of the term "steelhead/rainbow trout" when referring to *O. mykiss* in this document.

The primary purpose of the M&E Program is to provide the monitoring data necessary to evaluate whether implementation of the Yuba Accord will maintain fish resources (i.e., the fish community including native fish and non-native fish) of the lower Yuba River in good condition, and will maintain viable anadromous salmonid populations. The "Viable Salmonid Population" (VSP) concept was developed by McElhany et al. (2000; as cited in the M&E Program) in order to facilitate establishment of Evolutionarily Significant Unit (ESU)-level delisting goals and to assist in recovery planning by identifying key parameters related to population viability. Four key parameters were identified by McElhaney et al. (2000; as cited in the M&E Program) as the key to evaluating population viability status, including: (1) abundance; (2) productivity; (3) diversity; and (4) spatial structure. McElhaney et al. (2000; as cited in the M&E Program) interchangeably use the term population growth rate (i.e., productivity over the entire life cycle) and productivity. Good et al. (2007; as cited in the M&E Program) used the term productivity when describing this VSP parameter, which also is the term used for this parameter in the Yuba Accord M&E Program.

Abundance is an important determinant of risk, both by itself and in relationship to other factors (McElhaney et al. 2000 as cited in the M&E Program). Small populations are at a greater risk for extinction than larger populations because risks that affect the population dynamics operate differently on small populations than in large populations. A variety of risks are associated with the dynamics of small populations, including directional effects (i.e., density dependence - compensatory and depensatory), and random effects (i.e., demographic stochasticity, environmental stochasticity, and catastrophic events).

The parameter of productivity and factors that affect productivity provide information on how well a population is "performing" in the habitats it occupies during the life cycle (McElhaney et al. 2000 as cited in the M&E Program). Productivity and related attributes are indicators of a population's performance in response to its environment and environmental change and variability. Intrinsic productivity (the maximum production expected for a population sufficiently small relative to its resource supply not to experience density dependence), the

[1] Federally listed as threatened.
[2] State listed as threatened.
[3] Although late fall-run Chinook salmon populations occur primarily in the Sacramento River (CDFG Website 2007), use of the lower Yuba River by late fall-run Chinook salmon has been reported to occur (D. Massa, CDFG, pers. comm.; M. Tucker, NMFS, pers. comm.). When the various studies addressing steelhead and spring-run and fall-run Chinook salmon are conducted, the collected data will be analyzed to examine Chinook salmon exhibiting phenotypic characterizations of late fall-run Chinook salmon.

intensity of density dependence, and stage-specific productivity (productivity realized over a particular part of the life cycle) are useful in assessing productivity of a population.

Diversity refers to the distribution of traits within and among populations, and these traits range in scale from DNA sequence variation at single genes to complex life-history traits (McElhaney et al. 2000 as cited in the M&E Program). Traits can be completely genetic or vary do to a combination of genetics and environmental factors. Diversity in traits is an important parameter because: (1) diversity allows a species to use a wide array of environments; (2) diversity protects a species against short-term spatial and temporal changes in its environment; and (3) genetic diversity provides the raw material for surviving long-term environmental changes (McElhaney et al. 2000 as cited in the M&E Program). Some of the varying traits include run timing, spawning timing, age structure, outmigration timing, etc. Straying and gene flow strongly influence patterns of diversity within and among populations (McElhaney et al. 2000 as cited in the M&E Program).

Spatial structure reflects how abundance is distributed among available or potentially available habitats, and how it can affect overall extinction risk and evolutionary processes that may alter a population's ability to respond to environmental change. A population's spatial structure encompasses the geographic distribution of that population, as well as the processes that generate or affect that distribution (McElhaney et al. 2000 as cited in the M&E Program). A population's spatial structure depends fundamentally on habitat quality, spatial configuration, and dynamics as well as the dispersal characteristics of individuals in the population. Potentially suitable but unused habitat is an indication of the potential for population growth.

In the Yuba Accord M&E Program, performance indicators associated with each of the VSP parameters (Abundance, Productivity, Diversity and Spatial Structure) and analytical steps ("analytics") to address each of these performance indicators are provided separately for the adult and juvenile lifestages of the anadromous salmonids (including spring-run Chinook salmon and steelhead) in the lower Yuba River. In addition, each section includes examinations of potential relationships between measures of VSP parameters, and flows and water temperatures resulting from implementation of the Yuba Accord. Data for the analytics associated with the performance indicators for the VSP parameters, and for examination of potential relationships between measures of VSP parameters and flows and water temperatures are obtained from the specific sampling protocols and procedures. The RMT has developed the following Protocols and Procedures in accordance with the Yuba Accord M&E Program:

1) Flow and Water Temperature Monitoring
2) Topographic Mapping (Digital Elevation Model) – *physical habitat assessment*
3) Substrate and Cover Mapping – *spawning/juvenile rearing habitat characterization*
4) 2-D Hydrodynamic Modeling – *physical habitat dynamics and availability*
5) Mesohabitat Classification – *physical habitat characterization*
6) Riparian Vegetation Mapping – *juvenile rearing habitat characterization*
7) Acoustic Tagging and Tracking – *Chinook salmon immigration and holding*
8) VAKIRiverwatcher Monitoring – *adult immigration, temporal distribution*
9) Redd Surveys – *spawning spatial and temporal distribution, habitat utilization*

10) Carcass Surveys – *spawning stock escapement estimation*
11) Snorkel Surveys – *juvenile rearing, spatial/temporal distribution, habitat utilization*
12) Rotary Screw Trapping – *juvenile emigration, temporal distribution*
13) Genetic Sampling and Characterization – *Chinook salmon run differentiation*
14) Otolith Sampling and Characterization – *natal stream origin, growth, age, and size*

Each of the Yuba Accord M&E Program Protocols and Procedures prepared by the Yuba Accord RMT are summarized below. Detailed descriptions of each of the Protocols and Procedures may be referenced at www.yubaaccordrmt.com.

1) Flow and Water Temperature Monitoring

The lower Yuba River Accord consists of a Fisheries Agreement that requires YCWA to comply with the Yuba Accord flow schedules. In addition to simply documenting the flows and water temperatures in the lower Yuba River associated with implementation of the Yuba Accord, the overarching goal of the flow and water temperature monitoring is to provide the data to identify and evaluate potential relationships between flows and water temperatures with fish population/community responses, measures of Viable Salmonid Population parameters, and aquatic habitat attributes.

Flow and water temperature monitoring is considered to be a long-term effort to track in-river water temperature conditions over time with the implementation of the Yuba Accord. Water temperature monitoring is anticipated to be conducted annually for at least five years, from 2008/2009 through 2013/2014. The RMT will review the data and reports on an annual basis, and determine whether the overall duration of the water temperature monitoring study plan should be modified.

In the lower Yuba River, water temperature data loggers are deployed in the main channel at the following stations: (1) at Simpson Lane (RM 3); (2) at Marysville (RM 6); (3) at Walnut Avenue (RM 8.1); (4) at DPD (RM 11.4); (5) upstream of DPD (RM 13.2); (6) downstream of Dry Creek (RM 13.3); (7) at Long Bar (RM 16.0); (8) at Parks Bar (RM 17.4); (9) downstream of Deer Creek (RM 22.7); (10) downstream of Narrows 2 Powerhouse at Smartsville (RM 23.6); and (11)in Narrows 2 Powerhouse Penstock (RM 23.9)

In the Feather River, thermographs are deployed at the following stations: (1) one mile upstream of the Yuba River confluence (RM +1); (2) the left (east) bank at the Yuba River confluence (RM 0); and (3) the right (west) bank at the Yuba River confluence (RM 0).

Streamflow gages in the lower Yuba River are located at the following locations: (1) Smartsville downstream of Narrows 2 (USGS 11419000; PG&E NY28); and (2) Marysville (USGS 11421000).

Stream water temperatures in the Feather and lower Yuba rivers are monitored using StowAway Tidbits (Onset Computer Corporation) water temperature recorders that have 12-bit resolution with a minimum accuracy of +/- 0.2° C. All temperature data loggers are programmed to record water temperatures at 15 minute intervals. Redundant water temperature loggers are installed at each site as close as possible to the primary recorders.

Water temperature recorders are secured in the channel by a cable to a root mass, tree trunk, or man-made structure, or secured using embedded rebar where necessary. A GPS coordinate is taken and recorded at each installation point, along with other points that may be useful for retrieving the recorder (i.e., point lacks a distinct trail for access). Photographs are taken of each site, including recorder installation configuration.

The loggers are retrieved at approximately monthly intervals to check their status and download new data. During each visit, water temperature data are downloaded into an optic shuttle or directly to a personal computer. Prior to each download of the water temperature data, a National Institute of Standards and Technology (NIST) traceable digital thermometer is used to measure the water temperature at the recorder, and compared to the last logger reading to check for accuracy drift of the recorder. Only after the raw water temperature data is downloaded and safely backed-up is the optic shuttle cleared or data used. Data recorded for each site visit includes: (1) date; (2) time; (3) station ID; (4) field team; (5) air temperature; (6) water temperature (NIST); (7) current weather; (8) site notes (i.e., vandalism, logger replacement, etc); (9) download file name; (10) backup file name; (11) GPS coordinates (first visit); and (12) photo numbers (first visit or when appropriate).

Concurrent with in-river data retrieval activities each month, electronic records of flow data recorded at Smartsville and Marysville is obtained from the California Data Exchange (http://cdec.water.ca.gov/cgi-progs/staMeta?station_id=YRS) and/or from YCWA. These data are saved into the flow and water temperature monitoring database for use during preparation of the annual reports.

2) Topographic Mapping (Digital Elevation Model)

The overarching goal of the Topographic Mapping and Digital Elevation Model (DEM) Protocol and Procedure is to provide a highly detailed dataset to be used in the assessments of physical habitat, and in the identification and evaluation of potential relationships between flows and water temperatures with fish population/community responses and aquatic habitat attributes. Methods to obtain the data necessary to develop a detailed topographic map of the lower Yuba River include both airborne Light Detection And Ranging (LIDAR) mapping of the terrestrial river corridor and boat-based echo-sounding of the submerged river channel.

Lower Yuba River LIDAR data was acquired on September 21, 2008. On that day, the Yuba River discharge at Smartsville was constant at 860 cfs, Deer Creek was at 3 cfs, and Marysville was at 622 cfs. Bathymetric data was acquired on multiple dates: August 19, 20, 22, 25, and 26, 2008; September 16, 17, 18, and 19, 2008; March 4-6, 2009; May 6, 15, 20, 2009.

The topographic map of the lower Yuba River was completed during April 2010.

The study area for this protocol and procedure is the river corridor of the lower Yuba River extending from Englebright Dam to the confluence of the Yuba and Feather rivers (near Marysville, California).

After the flight, data was directly processed and reduced to obtain a detailed "bare earth" only dataset with a vertical accuracy of approximately 0.15-m, which is the level of resolution prescribed by the rigorous Class 1 standard. The spatial resolution for this protocol is 1 point every 0.738-m (1 pt per ~2 ft). The LIDAR survey also yielded the intensity of the LIDAR return signal at each point, rasterized to yield a black and white image of the river corridor, which serves as a base map for GIS and was used to construct a polygon shapefile of the water's edge. Data points from the LIDAR survey were imported into ArcGIS to create a DEM of the terrestrial land around the river using a standard TIN-based approach with breaklines and additional quality assurance measures.

The 2008-2009 mapping used multiple echo-sounders deployed simultaneously across the bow of the boat. A customized aluminum jet-boat was outfitted with up to five Odom Hydrotrack survey-grade fathometers (each with a 3,200-kHz transducer) and a TSS 335B motion sensor that adjusted for roll/pitch of the vessel. Position data for the fathometers was collected using real-time kinematic (RTK) GPS receiving corrections by radio from an on-site base station located on one of the pre-established benchmarks. These benchmarks were established by long-duration static surveys with an RTK GPS and then waiting to obtain "ultra precise" solutions through NOAA's Online Positioning User Service (OPUS).

Where depth permitted, the boat made cross sections on a approximate 3-m interval and performed six longitudinal transects approximately evenly spaced across the channel. To account for the water surface slope and its changes through time, Mini Troll 400 vented pressure transducers (In-situ, Inc., Fort Collins, CO) were placed in the river along the survey area and their elevations were surveyed using RTK GPS. An algorithm was used to interpolate water surface slopes based on the distance between the pressure transducers.

Position data was recorded every 1-s, and a radial filter was applied in post-processing to the boat-based data to obtain 0.6-m spacing between points, achieving the goal of obtaining bathymetric data at a resolution of 1 point per m^2 along the boat tracks.

To create the topographic map, the following items were obtained through data collection: LIDAR flight and data file tiling scheme polygon shapefile, LIDAR data coverage polygon shapefile, LIDAR intensity images (all returns), LIDAR ground-return point file (ASCII format), boat-based echo-sounder/RTKGPS point file filtered to 2-foot spacing, total station point data.

3) Substrate and Cover Mapping

Fluvial processes that are important for the lower Yuba River are influenced by a suite of hydrogeomorphic variables including channel topography, flows, substrate, and cover. A restricted amount of substrate and cover information exists for some sites on the lower Yuba River since the floods of 2006.

The objectives of the Substrate and Cover Mapping Protocol and Procedure are to: (1) produce a substrate map of the lower Yuba River; and (2) produce a cover map of the lower Yuba River. Each of these maps will then be used for a number of specific analytics in the M&E Program which includes activities such as characterization of microhabitat and mesohabitat conditions (including their spatial diversity) as well as assessment of dynamic fluvial processes and design of habitat rehabilitation projects.

Substrate and cover mapping is planned to occur during September 2010 because relatively low flows and high visibility conditions are expected to occur at that time.

The Substrate and Cover mapping Protocol and Procedure study area extends from Englebright Dam to the confluence with the lower Feather River. 2D hydrodynamic modeling of the lower Yuba River has yielded a wetted area boundary for a flow of 4,000 cfs at Smartsville, which will be converted to an ArcGIS polygon shapefile and uploaded into GPS units used by the mapping team. Substrate and cover will only be mapped in this domain. Because flow at the time of mapping will be <4,000 cfs, some of the mapping area will be on land and some underwater.

Regardless of whether the crew is on land or in water, the crew will start at Englebright Dam and work downstream one section at a time. In each section, the crew will map the substrate and cover by making three passes of the wetted channel and three passes of the terrestrial land. Each pass will consist of the following activities: (1) an initial pass to get an overview of the conditions in the section; (2) going back to the top and then mapping substrate polygons on the way down; and (3) going back to the top and then mapping all cover as points, lines, or polygons according to cover classification.

Crew members will create point, line, or polygon features of all substrates and cover features of interest using handheld differential GPS units (sub-meter accuracy) by plotting GPS coordinates while walking, driving, or boating around the perimeter of a feature. The procedure for mapping on land involves doing the three passes by walking or using an ATV, depending on accessibility for an ATV in each section and how rough the surface is for moving faster than walking speed on an ATV.

Substrate

A pre-established method for performing observational reconnaissance of the lower Yuba River substrate already exists for the salmonid redd surveys. Crew members have been trained to cover the whole submerged domain by scanning the river from the shore to the middle of the river, working downstream in a kayak. Side channels in the survey area are observed by walking. This method will be used for mapping substrate and cover. Surveyors will wear polarized sunglasses during walking or driving surveys, and use transparent bottom buckets while boating in shallow water areas. Deepwater surveys will be conducted via underwater video, snorkel, SCUBA, or other methods pending results of field-tested techniques during the spring through summer 2010.

Handheld GPS units require that each substrate polygon be larger than 5x5 m^2 to be accurately mapped, so that will be the minimum size of a substrate or cover patch recorded. However, if a substrate polygon has more than one substrate size class present in it with an area >10%, then the minimum polygon size will be 10x10 m^2. This constraint represents the consensus for balancing effort and cost relative to the needs of the dataset for analytic application.

Regardless of whether the crew is on land or in water, substrate classification categories will be used to make a "facies" map of the surficial pattern of substrate, with each area of a homogeneous substrate type mapped as a polygon. For each substrate polygon, the observer will estimate the percent of area composed of each substrate size class to the nearest 10% value, only recording those with >10% contribution. For a substrate polygon, a GPS data dictionary file accompanying the coordinates will identify the substrate classes present and the percent of each substrate class to the nearest 10%. Substrate classification categories include: (1) bedrock (no alluvium); (2) boulder field (D>256); (3) large cobble (128<D<256); (4) cobble (90<D< 128); (5) medium gravel/small cobble (32<D<90); (6) fine gravel (2<D<32); (7) sand (0.0625<D<2); and (8) silt/clay (D<0.0625).

Cover

For individual wood elements, length and mid-point diameter will be obtained using a tape measure and tree caliper, with recorded accuracies of ±5 cm and ±2 cm, respectively. Origins should be identified as bank erosion when roots are present, as cut or placed when evident by visual inspection, as limb breakage when the large wood piece could be matched up with a nearby scar on a riparian tree, and as unknown in all other cases.

For boulders, diameter should be measured with a tape measure and the angularity designated as angular (i.e., having sharp edges), well-rounded, or unknown. The following classification will be used to characterize cover on the lower Yuba River: (1) wood log (≥3 m long by ≥10 cm diameter); (2) wood jam (≥3 m); (3) boulder (>3 m); (4) boulder cluster (>3 m); (5) undercut bank (>3 m); (6) submerged aquatic (>3 m); (7) wetted channel woody vegetation (> 3 m long by >1 m above substrate); (8) overhanging riparian vegetation (> 3 m in longest dimension and >1 m above substrate); and (9) human detritus by name (car, cement block, refrigerator, and other items. ≥3-m long by ≥10-cm diameter).

4) 2-D Hydrodynamic Modeling

Two-dimensional (2D) numerical models solve vertically integrated conservation of momentum and mass equations using a finite element, finite difference, or finite volume computation method to acquire local water depth and depth-averaged 2D velocity vectors at each node in a computational mesh. These models further add the ability to consider full lateral and longitudinal variability down to the sub-meter scale, including effects of alternate bars, transverse bars, islands, and boulder complexes, but require highly detailed topographic maps of channels and floodplains. Four different 2D numerical models have been used on the lower Yuba River, including FLO-2D, RIVER2D, FESWMS, and SRH-2D. SRH-2D is a relatively new model that spans many of the capabilities of FLO-2D, RIVER2D and FESWMS, but it is more computationally efficient and numerically stable, so it can be used to simulate long river segments in very high resolution.

Presently, the Yuba Accord RMT is using SRH-2D to simulate hydraulics for the entire lower Yuba River downstream of the Highway 20 Bridge with 1-m intermodal spacing. To achieve this more efficiently, the lower Yuba River has been divided into three reaches: (1) Highway 20 Bridge to DPD; (2) DPD to the USGS Marysville gaging station; and (3) USGS Marysville gaging station to the confluence of the Yuba and Feather rivers. SRH-2D models of each reach are being run concurrently. Presently, the model is being run at variable discharges to test the model against available data. Subsequently, 4 flows between 700 and 4,500 cfs (at the Smartsville gage) will be simulated.

SRH-2D uses a flexible mesh that may contain arbitrarily shaped cells. A hybrid mesh may achieve the best compromise between solution accuracy and computing demand. SRH-2D adopts very robust and stable numerical schemes with a seamless wetting-drying algorithm. The resultant outcome is that few tuning parameters are needed to obtain the final solution. SRH-2D was evolved from SRH-W which had the additional capability of watershed runoff modeling. Many features are improved from SRH-W. As described by the USBR Technical Service Center, Sedimentation and River Hydraulics Group website (http://www.usbr.gov/pmts/sediment/model/srh2d/index.html), SRH-2D features include: (1) 2D depth-averaged dynamic wave equations (standard St. Venant equations) are solved with the finite-volume numerical method; (2) steady state (with constant discharge) or unsteady flows (with flow hydrograph) may be simulated; (3) an implicit scheme is used for time integration to achieve solution robustness and efficiency; (4) an unstructured, arbitrarily-shaped mesh is used which includes the structured quadrilateral mesh, the purely triangular mesh, a combination of the two, or a Cartesian or raster mesh; (5) all flow regimes (i.e., subcritical, transcritical, and supercritical flows) may be simulated simultaneously without the need for special treatments; (6) robust and seamless wetting-drying algorithm; and (7) solved variables include water surface elevation, water depth, and depth-averaged velocity.

5) Mesohabitat Classification

The M&E Program recognizes that the processes creating microhabitat are dynamic and spatially diverse, and management of a river that undergoes periodic planform changes requires more than a static depiction of microhabitat conditions. Consequently, "mesohabitat" is defined as the interdependent set of microhabitat variables (depth, velocity, substrate, cover, and hyporheic parameters) over a discernible landform known as a morphological unit (i.e., scour pool, riffle, and lateral bar) associated with a specific magnitude of flow. Mesohabitats typically occur at a spatial scale of approximately 0.5 to 10 times the length scale of channel width. This spatial scale directly ties to the fluvial processes responsible for channel dynamics and thus enables a mechanistic understanding of how fluvial dynamics drives spatial structure.

Morphological units evaluated at a meso-scale can be used to explain fluvial-ecological relations and may therefore be good indicators of fish utilization patterns. The goals of the Mesohabitat Classification Protocol and Procedure are to: (1) identify mesohabitat units throughout the lower Yuba River; (2) evaluate the quality, number, size and distribution of mesohabitats for various lifestages of adult and juvenile anadromous salmonids; and (3) evaluate the maintenance of watershed processes in the lower Yuba River.

Mesohabitat characterization is planned to begin during summer of 2010 and be completed the same year.

The proposed study area for this project is the lower Yuba River from Englebright Dam to the confluence of the Yuba and Feather rivers (near Marysville, California).

This Protocol and Procedure emphasizes a GIS-based analysis of existing data layers for developing the classification, and then uses field-based reconnaissance for QA/QC and ground truthing of the classification. The key data layers required to perform GIS-based characterization of morphological units are: (1) a DEM of the river corridor; (2) a water's edge shapefile and associated digital water surface elevation model for each discharge at which mesohabitats will be characterized (the model may be obtained by overlaying the edge shapefile onto the DEM and extracting the ground elevations along the water's edge); (3) a derived water depth map made by subtracting the DEM from the water surface elevation model; and (4) aerial photography of the river at each discharge of interest.

Descriptions of the objective and numeric criteria used to delineate morphologic units incorporate concepts provided by Montgomery and Buffington (1997) and Thomson et al. (2001) (see www.yubaaccordrmt.com. for additional descriptions). Morphological units to be identified in the lower Yuba River include the following: (1) forced pool; (2) pool; (3) chute; (4) run; (5) glide; (6) riffle entrance; (7) riffle; (8) recirculation; (9) backwater; and (10) medial bar.

Once the morphological unit classification and map is complete, a site reconnaissance will be performed by a team of two people to check the quality of the map in delineating the in-channel units. Upon arriving at a site by truck or boat, the crew will start at one end and systematically work along the river, wading or boating into each morphological unit and confirm that the depth and velocity criteria used to delineate the unit are met. Field-based delineation confirmation will consist of making 10 depth measurements using a graduated pole, and 10 water velocity measurements, using a velocity meter, at points randomly scattered around the unit. Resultant values will be compared to the criteria.

If field observations reveal a systematic error in the delineation of a specific unit, then the handheld GPS will be used to re-map the individual polygon by walking or boating around the perimeter and tracing the correct extent. Revised polygons will be imported into GIS to replace the faulty ones and boundaries of surrounding polygons will be amended to mesh with the revised boundary lines.

The definitions of the mesohabitats will be taken from the correspondingly named morphological units. Mesohabitat maps will be developed for forced pools, pools, secondary channels, backwaters, recirculations, chutes, riffles, riffle entrances, runs, and glides, using the appropriate shoreline shapefile and depth raster map.

6) Riparian Vegetation Mapping

The goal of this Riparian Vegetation Mapping Protocol and Procedure, under development by the RMT, is to obtain a map of riparian vegetation of the lower Yuba River. The riparian vegetation map will be used to evaluate performance measures for both juvenile and adult spatial structure.

Basic objectives for the Riparian Vegetation Mapping Protocol and Procedure include the following: (1) mapping locations by structural type (small/herbs, shrubs, trees) for completion of hydraulic model and cover type mapping (i.e., the corresponding protocol on Substrate and Cover Mapping); (2) developing a shared base map for analysis of riparian distribution with substrate, cover, topography and hydraulics; (3) classifying riparian vegetation types (i.e., stand types) according to a classification scheme suitable for testing spatial trends within the lower Yuba River and compared to other rivers of the Central Valley; (4) evaluating quality (diversity, structure, percent cover) of riparian relative to other comparable rivers in the region; and (5) determining if processes are maintaining or changing riparian vegetation, and how trends impact fish habitat.

Field surveys are coordinated with data collection for the Mesohabitat Classification and Substrate and Cover protocols and procedures, and are conducted most efficiently when flow is < 2,000 cfs to enable the best access and visibility for bank vegetation. It is anticipated that riparian vegetation mapping will be conducted during September to October 2010. Accurate classification of some vegetation may require field surveys during flowering in the spring during 2011. Work on desktop mapping can be initiated immediately.

The study area for the Riparian Vegetation Mapping Protocol and Procedure is the lower Yuba River from the bottom of the Narrows Canyon (2 miles downstream of Englebright Dam) to the confluence of the Yuba and Feather rivers (near Marysville, California). The study area encompasses all of the aquatic in the lower Yuba River, except for the short Narrows Canyon and the Englebright Dam Reach. These omitted areas are highly confined channels with very limited riparian vegetation. Moreover, imagery for these areas is problematic and not comparable for analysis due to topographic shading.

The lateral extent of the riparian mapping area would ideally include the entire 100-year floodplain, although the actual extent is likely to be a 10-20 year floodplain due to constraints of cost and area already covered by LIDAR. Inclusion of all functional floodplain surfaces would ensure an objective mapping area that does not arbitrarily omit vegetated areas with hydrologic connection to the river.

Vegetation is “all the plant species in a region, and the way they are arranged.” Vegetation appears as a mosaic of numerous, definable plant stand types (Saywer and Keeler-Wolf 1995 as cited in the M&E Program). The dominant canopy plant species defines the stand type, such that if there is a shift in species dominance, there is also a change in stand type. The classification of stand types will conform with the list used by the California Natural Diversity Database (CNDDB) and the California Native Plant Society (NPS), or a more sensitive and detailed list can be developed by a consulting riparian vegetation expert.

The first phase (Structural Mapping) of this Riparian Vegetation Mapping Protocol and Procedure involves delineating stands and classifying them according to the structural types in the table below. This effort will also delineate areas of open bar or no vegetation as the remainder of the default area.

Riparian Structure Type	Height Range	Application
Small/herbs	<1.5 m	Less than moderate roughness, minimal overhanging cover.
Shrubs	1.5 – 5 m	Moderate roughness; overhanging cover

Trees	>5 m	Source of large wood and understory habitats

This vegetation classification will use recently available LIDAR (2008) data collected for the lower Yuba River extending to the Highway 20 Bridge at Parks Bar, located four miles downstream from the Narrows Canyon. The initial result is a raster map with 1 m^2 pixels that has a value of average height, or 0 if no vegetation is present. Stands are delineated either by algorithm or semi-manual operation using the 3D analysis capabilities of ArcGIS.

Color NAIP imagery is used for the Timbuctoo Bend Reach (Narrows to Hwy 20 Bridge), and may also be used as an independent check of the vegetation presence/absence map. One problem to be addressed is that the 2009 NAIP imagery is georeferenced to within plus or minus 5 m of true position, whereas the LIDAR imagery is within approximately 10 centimeters of the correct horizontal position. Thus, either the NAIP imagery or any products derived form it will have to be "rubbersheeted" onto the LIDAR imagery as best as possible to obtain a more accurate positioning. This can be used as an independent check on the presence/absence map from the 2009 NAIP imagery or could be used to help classify the types and attributes of vegetation. The 2009 NAIP digital color imagery with 1 m ground sampling resolution is suitable for identifying presence/absence of vegetation. The approach for achieving this is to use image processing software, such as ENVI or IDRISI to identify the presence/absence of vegetation.

A second phase (Vegetation Type Mapping) of the Riparian Vegetation Protocol and Procedure will involve either field surveys or advanced use of the LIDAR data for classifying vegetation types. Because the first phase provides for the primary objectives of the study relating to cover and the location of riparian vegetation, the final procedures of the second phase can be developed subsequently. In fact, the use of LIDAR data for the structural mapping will reveal the information necessary to evaluate options for vegetation type mapping.

For the Narrows to Highway 20 Bridge Reach, field surveys will be used to classify stands according to alliances and associations recognized by the CNDDB and the NPS (Sawyer et al. 2009 as cited in the M&E Program). Field surveys may be used in conjunction with visual inspection of imagery and available helicopter video to classify stand types. The same type of field approach can be used for the other 18 miles of river, but LIDAR data provides an option that warrants further investigation. A map of the entire lower Yuba River has been compiled from topographic/bathymetric surveys conducted during 2008-2009, and LIDAR data that was acquired in September 2008. The 2009 imagery of the lower Yuba River was flown on July 2-3, and this may be utilized, if needed, for riparian mapping.

7) Acoustic Tagging and Tracking Surveys

The Acoustic Tagging and Tracking Protocol and Procedure consists of acoustic-tagging immigrating adult Chinook salmon and monitoring their distribution and movement in the lower Yuba River. Chinook salmon acoustic tagging will be conducted in conjunction with the Genetic Sampling and Characterization Protocol and Procedure.

Goals of the Acoustic Tagging and Tracking Protocol and Procedure include: (1) examination of habitat utilization of upstream migrating and spawning Chinook salmon exhibiting the run timing characteristics of spring-run Chinook salmon; (2) examination of the spatial and temporal distributions of holding spring-run Chinook salmon from spring through fall, and potential relationships with variable flow and water temperature regimes; (3) comparison of differential spatial and temporal distributions of immigrating and holding spring-run and fall-run Chinook salmon, and potential relationships with variable flow and water temperature regimes; and (4) examination of differential spatial and temporal distributions of spring- and fall-run Chinook salmon spawning (in conjunction with Chinook salmon redd surveys) and potential relationships with flow and water temperature regimes.

The adult spring-run Chinook salmon Acoustic Tagging and Tracking Survey is anticipated to be a multi-year effort. Acoustic tagging and tracking of 30 immigrating adult spring-run Chinook salmon occurred in the lower Yuba River from Englebright Dam downstream to the Yuba River and Feather River confluence from May to November 2009. During 2010, attempts will be made to tag 30 adult spring-run Chinook salmon during May and possibly into June, and for comparative purposes 30 adult fall-run Chinook salmon will be tagged during fall (October 2010). The RMT will review the data and reports annually, and will determine the overall duration of the acoustic tagging study.

Acoustic tagging of immigrating adult Chinook salmon will occur in the lower Yuba River downstream of DPD to the Yuba River and Feather River confluence. Adult Chinook salmon will be captured using hook-and-line sampling. Therefore, the exact location(s) for acoustic tagging will vary depending upon the specific locations of individual captures.

If an adult Chinook salmon is deemed to be sufficiently healthy for tagging, the fish will be placed in a CO_2 solution for anesthetization, and the following measurements and data will be recorded: (1) fork length (mm); (2) total length (mm); (3) body depth (mm); (4) sex (male or female); (5) adipose fin presence (Yes or No); (6) description and photograph of any visible parasites, fungi, lesions, or other signs of disease or injury, including potential hooking injuries; and (7) acoustic tag ID (serial) number of the tag that will be implanted into the fish.

After data collection, VEMCO V13-1L acoustic tags, programmed to have a "kill switch" and turn off after a pre-determined amount of time (i.e., 7 months) so that the tags do not interfere with other acoustic tagging studies after the tagged fishes have died, will be inserted into the fish. The esophageal insertion method will be used, where acoustic tags are inserted into the stomachs of spring-run Chinook salmon. Esophageal insertion will be used because surgery is not required, results in reduced tag loss and reduced changes in swimming behavior (due to the tag being placed near the center of the fish's gravity) compared to external tagging, and a relatively short recovery time is required prior to releasing the fish (Demco et al. 2003 as cited in the M&E Program).

After tagging, a caudal fin-clip will be taken for genetic sampling (refer to Genetic Sampling and Characterization Protocol and Procedure for more information). A floy tag will be implanted in the subdural region near the dorsal fin of the fish for identification during carcass surveys. After the fish is measured, acoustic-tagged, sampled for genetics, and floy-tagged, the fish will be immediately released back into the river where the water is relatively calm and the fish can be observed.

Monitoring for acoustic-tagged spring-run Chinook salmon will occur on the lower Yuba River from Englebright Dam to the Yuba River and Feather River confluence through the use of acoustic hydrophones currently in place (J. Nelson, CDFG, 2008, pers. comm.). As of February 2009, there are 16 hydrophones located throughout the lower Yuba River, with an additional hydrophone planned to be installed at the downstream end of the Narrows. Monitoring for tag pings may also occur outside the lower Yuba River if tagged Chinook salmon move into other rivers such as the lower Feather River. Static receiver hydrophones will operate continuously year-round and data will be obtained at least every other month by CDFG (The Heritage and Wild Trout and the Steelhead Management and Recovery Programs). Data will be sent to the RMT's lead biologist from the RMT acoustic-tagged spring-run Chinook salmon every other month.

In addition to fixed-station hydrophones (i.e., static receivers), mobile tracking surveys will be conducted to monitor acoustic-tagged spring-run Chinook from Englebright Dam to the Yuba River and Feather River confluence via jet boat or walking and use of a hydrophone. A jet boat will be used to survey from the Yuba River and Feather River confluence to the bottom of the Narrows. Surveyors will track acoustic tagged Chinook salmon from the Narrows Pool to Deer Creek and from Englebright Dam to Deer Creek by walking. Surveyors will only survey reaches that they deem safe between Englebright Dam and Narrows Pool. One omni-directional and one directional hydrophone will be used in conjunction with an acoustic receiver for the mobile tracking surveys. When an acoustically tagged fish is detected, the location will be recorded using a GPS unit.

Mobile tracking surveys will begin during mid-May, or soon after tagged fish are released. From below the Narrows to the Yuba River and Feather River confluence, mobile tracking surveys will be conducted every week. Mobile tracking surveys from below Englebright Dam to the bottom of the Narrows Reach also will be completed weekly if possible.

Prior to initiation of the acoustic tagging survey, acoustic tags will be placed in various habitat types in the lower Yuba River, and mobile tracking surveys will be conducted to test the ability of detecting tag pings in the various habitat types. Mobile tracking techniques will be refined as necessary to maximize the detection of acoustic tags in all habitat types in the lower Yuba River.

8) VAKIRiverwatcher Monitoring

Fish passage monitoring on the lower Yuba River is conducted using two VAKIRiverwatcher systems, in conjunction with digital photography located in the north and south fish ladders at DPD. The data collected by the VAKIRiverwatcher systems for Chinook salmon and steelhead will be used in conjunction with data from redd surveys, carcass surveys, and angler surveys. The combined datasets will be used to generate abundance estimates, help evaluate habitat use, and examine trends in fish passage.

Goals of the VAKIRiverwatcher monitoring include: (1) estimate the abundance of spring-run, fall-run, and late fall-run Chinook salmon and steelhead above DPD; (2) examine the temporal distribution of immigration of the total run, and natural origin spring-run, fall-run, and late fall-run Chinook salmon and steelhead immigrating past DPD; (3) examine the size structure of salmonids using length-frequency distributions; (4) examine the age structure of salmonids by examining the modalities of length-frequency distributions; (5) examine the annual and multi-year trends in timing of immigrating salmonids past DPD; (6) examine the annual and multi-year trends in timing of different sizes of immigrating salmonids past DPD; (7) use VAKIRiverwatcher data in conjunction with redd survey data to estimate the abundance of steelhead below DPD; and (8) use VAKIRiverwatcher data in conjunction with water temperature and flow data to evaluate potential relationships between water temperatures and flows, and the timing of adult salmonid immigration.

Both of the VAKIRiverwatcher systems are operated year-round for monitoring fish migration in the lower Yuba River. The VAKIRiverwatcher system began operation during 2003, and is anticipated to be operated continuously at least through 2014.

The VAKIRiverwatcher system records both silhouettes and electronic images of each fish passage event. By capturing silhouettes and images, fish passage can be accurately monitored even in under turbid conditions. Data for each fish passage event is downloaded directly to an on-site PC for further analysis.

Data collection for individual fish passage events are automatically recorded by the VAKIRiverwatcher systems. Each data record is reviewed by personnel to: (1) identify the fish species; (2) examine if Chinook salmon have an adipose fin, and (3) identify non-fish passage events (i.e., debris). The VAKIRiverwatcher systems record the time/date of each fish passage event, the upstream or downstream direction of passage, the speed of the fish moving through the system (m/sec), the fish's body depth (mm), and logs water temperature every hour. The body depth of a fish is converted to a length measurement (cm) by the program software (Winari v. 4.16) utilizing a body length-to-depth ratio. The morphometric body ratios were obtained by measuring 36 fall-run Chinook salmon in 2003 and 119 fall-run Chinook salmon in 2005 from the Feather River Hatchery and 168 steelhead from the lower Yuba River (D. Massa, CDFG, pers. comm. 2009). To maximize the accuracy of passage estimates generated by the VAKIRiverwatcher systems, a full-time technician will be employed to monitor the systems and minimize system off-line events.

9) Redd Surveys

Redd counts have been used widely to estimate or provide indices of adult salmonid escapement or abundance, and examine the spatial and temporal distribution of spawning adult salmonids. In addition, data pertaining to redd location and size will be obtained to develop indices of redd superimposition using GIS analyses for the Chinook salmon runs and steelhead/rainbow trout in the lower Yuba River.

Goals of the redd surveys conducted in the lower Yuba River include: (1) evaluate and compare the spatial and temporal distribution of redds and redd superimposition over the spawning seasons for the Chinook salmon runs and steelhead/rainbow trout spawning in the lower Yuba River; (2) compare the magnitude (and seasonal trends) of lower Yuba River flows and water temperatures with the spatial and temporal distribution of redds (and rates of redd superimposition) for the Chinook salmon runs and steelhead/rainbow trout; (3) estimate the total annual abundance of adult fall-run Chinook salmon and steelhead/rainbow trout in conjunction with angler surveys and VAKIRiverwatcher data; and (4) establish a long-term data set to be used to evaluate habitat utilization by the Chinook salmon runs and steelhead/rainbow trout in the lower Yuba River under variable biotic and abiotic conditions.

Reconnaissance-level redd surveys will be conducted during August to document the initiation of spawning activity in the lower Yuba River. The 2008-2009 and 2009-2010 redd surveys were conducted weekly beginning the week after a redd was first observed during the reconnaissance-level redd survey through the portion of the season encompassing the majority of Chinook salmon spawning activity. Prior redd and carcass surveys indicate that the majority of Chinook salmon spawning activity occurs through December, with reduced amounts of Chinook salmon spawning continuing through late-March, and steelhead/rainbow trout spawning extending through April. From the 2008-2009 pilot redd survey data and a simulation approach, a weekly sampling frequency was found to result in the most precise and accurate (least biased) estimates of spawning activity. Therefore, weekly redd surveys will be conducted from the initiation of spawning activity until May each year beginning during the 2010-2011 redd survey and subsequent surveys.

Approximately 20.9 mi. of the 24 mi. of total length of the lower Yuba River will be surveyed during the redd surveys. About 0.7 mi. of the lower Yuba River located immediately below the first set of riffles downstream of Deer Creek to the top of Narrows Pool will not be surveyed due to rugged and dangerous conditions in the steep canyon known as the Narrows. Additionally, an approximate 2 mi. section of the lower Yuba River from Simpson Lane Bridge to the confluence with the Feather River will not be regularly surveyed because redds have not been observed during past surveys. This section of the river will be surveyed once during peak Chinook salmon spawning to ascertain that this section is, in fact, not being utilized for spawning.

Several species of fish exist in the lower Yuba River known to construct redds including Chinook salmon, steelhead/rainbow trout, Sacramento sucker (*Catostomus occidentallis*), and Pacific lamprey (*Lampetra tridentata*). Visual differentiation between steelhead/rainbow trout redds and Sacramento sucker, and Pacific lamprey spawning nests is of concern because these three species clean the gravel during spawning. Sacramento suckers do not typically spawn until late-March and April, and are generally visible during their spawning season. Steelhead/rainbow trout redds are generally easy to distinguish, because they create a noticeable pit and tail spill in the gravel during redd construction. The Oregon Department of Fish and Wildlife (1999; as cited in the M&E Program) distinguish lamprey spawning nests and steelhead/rainbow trout redds using redd/nest dimension measurements. A steelhead/rainbow trout redd is distinguished by a longer length than width and the tailings are evenly distributed downstream by the current. Lamprey spawning nests generally have a neat and round appearance, with a conical bowl. The unique characteristic of a lamprey spawning nest is the placement of the tailings upstream from the nest. Lamprey excavate their spawning nests by sucking onto the gravel and then depositing it outside the nest.

Species-specific redd identification will be conducted by comparing the physical dimensions and locations for all known redds (i.e., redds which were positively identified with one species or another building or guarding them). During the redd surveys, each redd observed with an adult building or guarding them will be measured, and the species identified and recorded. Result from the 2008-2009 and 2009-2010 redd surveys in the lower Yuba River indicated that lamprey were observed spawning in late-March and early-April in the most downstream sampling reach of the lower Yuba River, where sand was the subdominant substrate.

The 2010-2011 redd surveys, and any subsequent surveys, will be conducted using two catarafts rather than the four kayaks used during the 2008-2009 and 2009-2010 redd surveys. Each surveyor, wearing polarized sunglasses, will scan the river from the shore to the middle of the river, working downstream. Side channels in the survey area may require walking. Visibility will be measured using a secchi disk at the top of the survey section.

Deep water surveys will be conducted during the 2010-2011 redd survey period in addition to the surveys conducted by cataraft. The specific methods employed for the deep-water surveys are being field tested during the winter and late-summer of 2010.

For each new redd observed throughout the sampling season, the following data will be recorded: (1) a GPS (Trimble GeoExplorer XT) location taken at the center of the redd's pit with a unique identifying number (i.e., Date + plus redd number; i.e. 082908-001); (2) total dimensional area (using a GPS) for areas appearing to contain multiple redds with no clear boundaries (i.e., mass aggregate spawning); (3) habitat type (i.e., pool, riffle, run, or glide); (4) substrate composition of ambient habitat based on substrate size immediately upstream of the pit; (5) redd species identification; (6) number of fish observed on the redd; (7) location information (i.e., side channel or main channel); (8) comments regarding observable redd superimposition (i.e., redd overlap); and (9) any additional comments.

The path undertaken by each surveyor down the river will be recorded using Garmin GPSMAP 60Cx GPS units to document specific locations of the river surveyed. The GPS (Trimble GeoExploerXT) and a data dictionary will be used to ensure redds counted during the previous survey weeks are not double-counted. In addition, surveyors will mark each redd at the pit with a painted rock. Redd area measurements will be conducted to examine redd superimposition throughout the lower Yuba River for the Chinook salmon runs and steelhead/rainbow trout.

At each fresh redd located, measurements of mean water column velocity, "nose velocity" (i.e., fish focal point water velocity, which is the water velocity at an observed fish's position or, when a fish is not observed actively preparing a redd, at the predetermined distance of 0.5 ft above the undisturbed streambed), total water depth and visual estimates of substrate composition will be made to approximate habitat conditions prior to gravel disturbance caused during redd construction. All measurements will be made 0.5 ft upstream of the leading edge of the pit along the mid-line of the redd, unless field personnel determine that measurements adjacent to the mid-point of the pit are more representative of undisturbed conditions for that specific location. The specific location of the measurements will be recorded on the data sheet.

Redd substrate composition will be visually estimated as percentage composition (to the nearest 10 percent) of each of eight size categories. Prior to conducting the steelhead/rainbow trout redd surveys, the field survey crews will become familiar with visual substrate size estimation by having undergone training by visually estimating substrate size, then comparing those estimates to results obtained by passing those substrate elements through a gravel template. Visual estimation of substrate sizes will be along the B axis of the substrate elements.

10) Carcass Surveys

The carcass surveys use a mark and recapture technique to estimate the abundance of spawning adult Chinook salmon. The annual abundance estimates are essential for monitoring trends in population size. In addition, biological data is collected from observed Chinook salmon carcasses (i.e., length, sex, spawning status, genetic tissue samples, scales, otoliths, and coded wire-tags) to monitor the populations.

Goals of the annual carcass surveys in conjunction with data collected from the VAKIRiverwatcher, and acoustic tagging survey include: (1) use the genetic tissue samples collected during the carcass survey and the acoustic tagging survey to differentiate spring-run and fall-run Chinook salmon; (2) use the coded-wire tags and otoliths collected to determine the origin of Chinook salmon (i.e., hatchery-origin, natural-origin and river of origin); (3) estimate the total, weekly, monthly and seasonal abundances of spring-run and fall-run Chinook salmon; (4) estimate the abundance of natural-origin and hatchery-origin spring-run and fall-run adult Chinook salmon; (5) use length data to examine the size structure of the spring-run and fall-run Chinook salmon populations; (6) use scale samples to examine the age structure of the spring-run and fall-run Chinook salmon populations; and (7) examine multi-year trends in the annual run sizes of spring-run and fall-run Chinook salmon (i.e., total population, hatchery-origin and natural-origin).

The annual Chinook salmon carcass surveys will be a long-term monitoring effort of the lower Yuba River spring-run and fall-run adult Chinook salmon populations. A consistent carcass survey methodology has been employed in the lower Yuba River since the mid-1990s (Massa 2008). Annual Chinook salmon carcass surveys will occur from the beginning of the spawning season (September) through the end of the spawning season (late-January). Begin and end dates of the annual carcass survey will vary depending on when Chinook salmon redds are observed and when the recapture rate of tagged carcasses in January approaches zero. Field reconnaissance teams begin to monitor Chinook salmon spawning during August. The first carcass survey will begin about 10 to 14 days after the first Chinook salmon redds are observed.

The study area for the carcass survey is the lower Yuba River extending from the Englebright Dam downstream to the Simpson Lane Bridge. The study area is divided into three survey reaches: (1) Narrows Pool to Highway 20 Bridge; (2) Highway 20 Bridge to DPD; and (3) DPD to Simpson Lane Bridge. All survey reaches will be surveyed once a week.

The weekly carcass survey will be conducted by a crew of 4-6 people and will be executed via jet boat and walking. Two crews will be utilized to collect scale samples, tissue samples, otoliths and heads for coded-wire tag recovery (i.e., 2008/2009 through 2013/2014).

During the weekly carcass survey, personnel will collect, count, and record data for: (1) fresh carcasses (carcass with red or pink gills, or at least one clear eye); (2) non-fresh carcasses (no clear eyes and gills are not red or pink); and (3) tagged carcasses. All observed non-fresh carcasses and adipose fin-clipped carcasses will be counted and chopped in half to prevent recounting during subsequent surveys. Tagged carcasses (recaptures from previous surveys) will be counted and chopped. Fresh carcasses that have an adipose fin will be counted and tagged. All carcasses will be released into the river. Fresh adult carcass data will be used in the Schaefer mark-recapture model (Schaefer 1951 as cited in the M&E Program) with modifications referenced to Taylor (1974; as cited in the M&E Program) to estimate abundance. Abundance will be estimated weekly throughout the annual spawning period, and annually.

11) Snorkel Surveys

The overall goal of the Snorkel Surveys Protocol and Procedure is to study anadromous salmonid diversity and habitat occurrence, in addition to observing community composition in the lower Yuba River. This Protocol and Procedure evaluates abiotic variables affecting fish diversity and habitat occurrence including external forces (i.e., daily cycle, time of year, flow, and fluvial landform structure), and internal responses to specific combinations of the external forces (i.e., spatial pattern of water depth and mesohabitat pattern).

It is anticipated that 2 years of snorkel surveys will be conducted, beginning during winter of 2011. Snorkel surveys will be conducted four times per week in January, February, April, and June. Sampling months have been selected so that all juvenile salmonid life stages will be present in the river during the course of snorkeling activities, however, it may be prudent to continue sampling through the duration of summer. Two day surveys and two night surveys will be conducted per week, at four different channel units each week. This will result in sixteen, 500 m units being sampled each month which amounts to approximately 22% of the lower Yuba River.

The study area for the snorkel surveys is the lower Yuba River from Englebright Dam to the confluence of the Yuba and Feather rivers (near Marysville, California).

The lower Yuba River will be divided into 74 channel units (each approximately 500 m long) for sampling, with each unit assigned a sequential number starting from 1 at Englebright Dam and going downstream. This study length includes a diverse assemblage of mesohabitat types as indicated by observed riffle habitat spacing at approximately 4-7 bankful widths in most gravel-bed rivers. Each unit will span the width of the alluvial river corridor to include mesohabitats such as main channel, side channels, floodplain ponds, etc. The Snorkel Survey Protocol and Procedure will represent mesohabitats on an equal effort basis. The channel units that include DPD and the rapids in the Narrows will not be sampled due to potential safety issues.

Prior to sampling each month, the channel units for the month should be selected using a random number generator (resulting in a spatially balanced sampling design). Unit selections will be made without replacement on a monthly basis (i.e., a unit can only be selected once during any month but is available for selection again in future months). Snorkel survey channel unit delineation of the lower Yuba River, and assignment of a corresponding number, will be completed using a GIS prior to being uploaded to Trimble GPS units for easy field location.

Divers will evaluate visibility in the lower Yuba River by taking NTU measurements before sampling each day to determine if surveying is warranted. For each day of sampling, "effective visibility' will be measured using a standard "4" lure and measured maximum distance for underwater identification of parr marks.

Surveys will be conducted with three people in the river and a fourth on the river bank. A second bank recorder may be necessary for units with high densities of fish. Channel units will be surveyed by divers daily beginning at the downstream end of the channel unit working towards the upstream end of the channel unit whenever possible. This includes working in an upstream direction along channel margins in swift areas. In deep, high velocity areas of the river where snorkelers are physically unable to snorkel upstream, they will survey the area by drifting downstream 3 abreast. In some areas of the river, it may be impossible to conduct snorkel surveys in either direction due to water velocity and in river hazards (i.e., rapids, rocks). In these non-sampled areas, probability statistics may need to be applied. Fish that are disturbed during the survey (i.e., swimming away and/or seeking refuge) will not be considered to be exhibiting normal behavior. Such fish will be enumerated but not sampled for Habitat Suitability Criteria (HSC). When undisturbed fish are located, snorkelers will first take a still image using their mask-integrated digital camera.

Snorkeling effort will not be uniform in all channel units because the lower Yuba River ranges in width from 10-100 m. Snorkelers will maintain "lanes" during surveys, spaced so that they are 3 m apart. Snorkelers are responsible for surveying the area 1.5 m on either side of their path through the river. The snorkeler closest to the bank should maintain a distance 1.5 m from the bank and is responsible for surveying the area from the bank to an imaginary line 3 m from the bank. The second snorkeler will be spaced 4.5 m from the bank and is responsible for surveying the area 4-6 m from the bank. The third snorkeler is spaced 7.5 m from the bank and is responsible for surveying the area 7-9 m from the bank. The river will be sampled along each bank and through the center of the river (where the river is wider than 18 m) for a total survey width of 18-27 m. Backwater habitats and off-channel pools will be visually sampled by the nearest surveyor.

Snorkelers will identify species and life stage, estimate fish length, and measure water depth that the fish is observed in. Fish length will be estimated in 20-mm size increments (i.e., 30-50 mm, 50-70 mm, etc.), which is believed to be the smallest interval that trained divers can distinguish. When a group of fish is observed, and it is not possible to characterize them all individually, then counts of the number of fish in habitat "patches" (defined by the area of riverbed that can be effectively observed by a single diver) will be made. A colored weight (large washers, fishing leads) with attached numbered tag and luminescent marker (to be used during night surveying only) will be placed on the bed to mark the location of either a single fish being observed or the central location of a group of fish too numerous to identify each one.

Once the entire channel unit has been surveyed, two divers will walk or drift back downstream with a Trimble GPS to relocate and record the following information for all bed tags identified during the snorkel survey: (1) GPS location; (2) bed tag number; (3) cover type (i.e., boulder, irregular bank, large wood, shaded, submerged vegetation, or open); (4) substrate type (i.e., bedrock, cobble, cobble/gravel, gravel, gravel/sand, sand, sand/mud, mud, heterogeneous mix of all sizes); (5) percent substrate covered by plants or detritus; and (6) visibility (NTU's). Bed tags should be retrieved before continuing the survey.

After completing each upstream line, the data recorder and one of the snorkelers will visit a subset of 10 individual-fish or fish-group locations to obtain more data during bed tag revisits (outlined above). The subsampled locations should be evenly spaced (i.e., if 40 fish locations are tagged on a line, every 4th bed tag should be selected). The following measurements should be made at this subset of locations: (1) water temperature; (2) water depth; (3) mean water-column velocity; (4) visibility; (5) ambient light levels/moon phase; and (6) substrate size distribution by a pebble count of 25 particles in a 1x1 m^2 area around the tag.

The area of non-sampled channel resulting from excessive water velocity will be quantified at a representative snorkeling discharge, or range of discharges, and subsequently classified as "swimmable" and "unswimmable" areas, as part of the M&E Program 2D Hydrodynamic Model of the lower Yuba River. The resulting two multi-feature GIS vector polygons will be intersected with the M&E Program Mesohabitat Map, as appropriate for that discharge, and used to determine the relative abundances of non-sampled mesohabitat at the lower Yuba River and study-site-only spatial scales.

12) Rotary Screw Trapping

Rotary Screw Traps (RSTs) are anchored at a fixed point in the stream channel and intercept a portion of the juveniles, smolts, or fry of juvenile salmonids migrating downstream, as well as other fishes, utilizing the force of moving water over baffles inside the cone to rotate. RSTs provide valuable information such as the presence/absence of migrating life-stages, determination of age and size at migration, condition, timing, species, and genetic characteristics (Volkhardt et al. 2007 as cited in the M&E Program).

Goals of the rotary screw trapping include: (1) document the (juvenile) fish community composition in the lower Yuba River; (2) estimate and examine trends in the weekly, monthly, seasonal and annual abundances of emigrating juvenile Chinook salmon and steelhead/rainbow trout from above DPD and the lower Yuba River; (3) estimate the number of juvenile spring-run Chinook salmon and steelhead/rainbow trout that rear during the summer and emigrate in the fall from DPD and the lower Yuba River; (4) examine the influence of lower Yuba River flows and water temperature on the timing of juvenile Chinook salmon and steelhead/rainbow trout emigration; (5) evaluate time-period specific size structure during juvenile Chinook salmon and steelhead/rainbow trout emigration; and (6) document the seasonal presence of developmental phases (i.e., yolk-sac fry, fry, parr, silvery parr, and smolt) of juvenile Chinook salmon and steelhead/rainbow trout.

RST sampling has been conducted seasonally on the lower Yuba River from 1999 to 2005 and year-round from 2006 to 2009. RST sampling has been temporarily suspended until the logistics associated with implementing a trapping device at or upstream of DPD have been resolved, in order to obtain comparable data between upstream and downstream locations for focused evaluations. It is anticipated that additional sampling will be conducted commencing in 2011, and may be conducted in subsequent years pending results, as evaluated by the RMT.

The RSTs are fished year-round, with the survey period defined as October 1 through September 31. Interruptions of sampling effort within a particular survey period due to, for example, excessive debris or high streamflow, is recorded and justified.

The M&E Program Rotary Screw Trapping activities have utilized a set of three RSTs near Hallwood Boulevard (approximately 0.5 mi. upstream of Hallwood Boulevard at RM 7.5). A fourth trap is intended for use upstream of DPD, although, the exact location has not been chosen. Two of the RSTs at the Hallwood Boulevard location are conically shaped with a cone diameter of 8 feet. The two 8-ft RSTs (RST 1 and RST 2) are fished in tandem and tethered to a rock anchor and set approximately 100 feet downstream of the 5-ft RST. The third RST at the Hallwood Boulevard location has a cone diameter of 5 feet, tethered by an earth anchor situated toward the downstream end of a large gravel bar.

A field crew of two to three technicians service the RSTs at least once per day to document their operational status, remove trapped fish from the live box, estimate rotation speed, remove debris, and record water temperature (°C), velocity (feet per second), and turbidity (NTUs). During periods of excessive algae growth (June-October), high debris loads, or high river flow events the RSTs will be serviced at least twice per day to keep them rotating continuously and reduce fish mortality.

Captured fish are processed on the bank of the river. Juvenile steelhead/rainbow trout and Chinook salmon are processed before other fish species and are kept in separate buckets for mark-recapture tests. Estimates of species abundance, weight (0.1 g), and fork length (mm) are made. Captured steelhead/rainbow trout and Chinook salmon are additionally assigned life-stage index values and run designation. Mark-recapture tests are performed approximately weekly for juvenile steelhead/rainbow trout and juvenile Chinook salmon once captured numbers equal or exceed the pre-specified target number (1000), or 5 days have elapsed, whichever comes first. A minimum of 300 juvenile Chinook salmon or steelhead/rainbow trout are needed for the efficiency tests. Fish are marked with Bismarck Brown powder on the day prior to release, held overnight, and released the next day. All recaptured fish in each of the RSTs are measured for fork length (mm), weighed (0.1 g), and assigned a life-stage index value. Trap efficiency is estimated using data collected during the seven days after a group of efficiency test fish is released. Marked fish are released 625 meters upstream from the trapping location and uniformly across the river for random dispersal. Capture efficiency tests will be performed throughout the year whenever catch of juvenile Chinook salmon or steelhead/rainbow trout in the RST is sufficient.

13) Genetic Sampling and Characterization

A genetic analysis of phenotypic spring-run Chinook salmon collected in the lower Yuba River will help identify the amount of introgression among spring-run and fall-run Chinook salmon, and source populations for phenotypic spring-run Chinook salmon that currently exist in the lower Yuba River. Additional monitoring such as Acoustic Tagging and Tracking and Carcass Surveying is ongoing, and will provide additional information regarding the current extent of reproductive isolation between spring-run and fall-run Chinook salmon in the lower Yuba River.

Goals of the Genetic Sampling and Characterization Protocol and Procedure are to use tissue samples to: (1) identify the genetic composition of lower Yuba River phenotypic fall-run and spring-run Chinook salmon; and (2) examine genetic differentiation between fall-run and spring-run Chinook salmon in the lower Yuba River.

Adult Chinook salmon genetic sampling began during May 2009, when 43 adult phenotypic spring-run Chinook salmon were sampled. Sampling also is being conducted during the May/June 2010 Acoustic Tagging and Tracking surveys, and during the 2010 fall Carcass Surveys (September through December). Additional sampling may be conducted during subsequent years, pending the RMT's review of the results from previous and planned sampling.

Genetic sampling will occur during the acoustic tagging and tracking survey of immigrating adult spring-run Chinook salmon (May/June) and during Chinook salmon carcass surveys (September through December). Genetic sampling of Chinook salmon carcasses will occur throughout the carcass surveys, beginning in September (targeting spring-run Chinook salmon) and continuing through late December (targeting fall-run Chinook salmon).

For the purpose of genetic sampling of adult Chinook salmon, the study area extends from the downstream terminus of the Narrows to the confluence of the lower Yuba River and the Feather River near Marysville, California.

Genetic sampling of live adult phenotypic spring-run Chinook salmon will occur on the lower Yuba River downstream of DPD. Tissue samples will be obtained from adult phenotypic spring-run Chinook salmon during acoustic tagging and tracking surveys. Therefore, the exact location(s) for genetic sampling will vary depending upon the specific locations of individual captures. Genetic sampling also will be conducted during the Chinook salmon carcass surveys, in survey reaches including: (1) Narrows pool to Highway 20 Bridge; (2) Highway 20 Bridge to DPD; and (3) DPD to Simpson Lane Bridge.

Guidelines for genetic sample collection provided by the NOAA Southwest Fisheries Science Center's Santa Cruz laboratory (refer to Attachment 2 of the M&E Program Genetic Sampling and Characterization Protocol and Procedure), as well as additional guidelines provided by the CDFG (refer to Attachment 3 of the M&E Program Genetic Sampling Protocol and Procedure), will be used to collect data and genetic samples from all live adult Chinook salmon and Fresh (i.e., pink or red gills or at least one clean eye) Chinook salmon carcasses. Genetic analyses are conducted by the NOAA Southwest Fisheries Science Center's Santa Cruz laboratory.

Scales are additionally collected as part of the M&E Programs Genetic Sampling and Characterization Protocol and Procedure for age assessment. If possible, all observed fresh Chinook salmon carcasses will have scale samples and associated data collected. For the CDFG Age Scale Program, a minimum goal of 550 scale samples is needed for each run of Chinook salmon being sampled (Kormos 2007 as cited in the M&E Program). In addition, scale samples are needed for all coded-wire tagged fish and all grilse. Scale samples are collected from a preferred scale area located on the left side of the fish. A diagonal section of 20-30 scales are taken from the posterior insertion of the dorsal fin and just slightly above the lateral line.

14) Otolith Sampling and Characterization

The Otolith Sampling and Characterization Protocol and Procedure will identify whether adults spawning on the Yuba River were originally born and reared in the lower Yuba River or whether they are strays to the lower Yuba River. The use of $^{87}Sr/^{86}Sr$ isotopic data permits the identification of whether individuals are of natural or hatchery origin, as well as their specific source of origin (e.g., Feather River Hatchery vs. Coleman National Fish Hatchery).

The Yuba River has an $^{87}Sr/^{86}Sr$ value of 0.7082 (Barnett-Johnson et al. 2008 as cited in the M&E Program). This relatively high ratio is distinct among other tributaries to the Sacramento River. Wild and hatchery-origin fish from the Feather River are likely sources of strays due to proximity to the lower Yuba River and are isotopically distinguishable from the lowerYuba River and each other, as are other potential sources of strays.

Goals of the Otolith Survey include: (1) determining the origin of Chinook salmon in the lower Yuba River (i.e., hatchery-origin, natural-origin and river of origin); and (2) evaluating the contribution of Chinook salmon naturally produced in the Yuba River to the returning spawning population.

Otolith sampling was conducted during 2009-2010 and will again be conducted during 2010-2011. The need for additional years of sampling will be determined pending the RMT's review of the results from previous and planned sampling. Otoliths are collected during the annual Chinook salmon carcass surveys as part of the long-term monitoring effort of the lower Yuba River spring-run and fall-run adult Chinook salmon populations. Annual Chinook salmon carcass surveys and otolith sampling occur from the beginning of the spawning season (September) through the end of the spawning season (late-January). Begin and end dates of the annual carcass survey will vary depending on when Chinook salmon redds are observed and when the recapture rate of tagged carcasses in January approaches zero.

In the field, otoliths are removed from all fresh non-adipose fin-clipped Chinook salmon carcasses. In addition, otoliths are removed from all of the heads collected from adipose fin-clipped carcasses in the laboratory unless a sub-sampling procedure (as described below) is required due to high carcass numbers. A "flip top" approach for removing otoliths is used so the fresh non-adipose fin-clipped fresh carcasses can be tagged for the mark-recapture study. A detailed description of this procedure is provided in the M&E Program Carcass Survey Protocol and Procedure.

The Otolith Sampling and Characterization Protocol and Procedure analyzes a minimum of 100 temporally stratified otoliths to reflect the distribution of spawners to the lower Yuba River and acquire a reasonable estimate of straying. Sample numbers may be increased to better constrain estimates as demonstrated during the 2009 Otolith Survey. Otolith survey results will be linked to the M&E Program Genetic Sampling analysis (spring- vs. fall-run Chinook salmon determination).

All fresh Chinook salmon carcasses were sampled during the 2009 carcass survey, with the exception of October 21, 2009 when sub-sampling methods were used because of a large sample size. Watershed-level composition estimate was attained by creating a 'Rand' variable in excel to assign a random number to each otolith sample. Samples were subsequently sorted in ascending order, and the first 120 samples used in analysis. The additional 20 samples were saved in case any of the initial 120 samples were compromised during the preparation process, or were required for later analysis.

Samples collected on October 21, 2009 were sub-sampled at a ratio 1:5 in the field. To ensure than these sub-samples were not underestimated in the watershed-level composition estimate, and to account for a greater representation of carcasses on that day that were not sampled, 4 “dummy” variables was created for each of samples collected, which represented the fish not sampled. The “dummy” variable was included in the original 'Rand' subsample. In the instance where a “dummy” variable was selected as part of the subsample, a collected otolith sampled from a carcass that day was substituted.

Otolith microchemistry analysis is performed via a contract with the Barnett-Johnson Fisheries and Otolith Laboratory at the University of California, Santa Cruz. Otolith microchemistry analyses conducted are expected to be similar to those used by Barnett-Johnson et al. (2007 and 2008; as cited in the M&E Program). The microchemistry analysis assessed the concentration of heavy and light Strontium isotopes, ^{87}Sr and ^{86}Sr respectively, because Sr substitutes for Ca in the otoliths carbonate matrix and can be extracted at daily growth increments. The technique analyses the ^{87}S /^{86}Sr isotopic ratios that identify natal freshwater habitat, small-scale movement patterns and timing of migration into freshwater from the ocean based on water chemistry or foodwebs disparities among habitats. In addition to otolith microchemistry analyses, efforts are underway to plan activities associated with otolith microstructure analyses to examine discrete daily growth increments deposited throughout the life of the fish.

OTHER DATA COLLECTION AND MONITORING PROGRAMS

CDFG Scale Aging Program

CDFG uses scales to estimate salmonid size at age, and obtain information on the age structure of the annual Chinook salmon runs in the Central Valley, including the lower Yuba River. Scale sampling occurs at hatcheries and on CDFG escapement surveys to reflect spatial and temporal differences in age structure among fish.

Goals of CDFG's Scale-Age Program include: (1) examining age structure and the variation in the age structure of the total (hatchery and natural origin) and of natural origin spring-run and fall-run Chinook salmon; and (2) estimating sex composition by age for the total (hatchery and natural origin) population and of natural origin adults, and determine the variability in sex composition of the adult population (by age) for spring-run and fall-run Chinook salmon.

Lower Yuba River Chinook salmon escapement surveys are conducted each year (see above). Scale samples are collected annually from October through January in the lower Yuba River. Results from the 2006-2007 and 2007-2008 are reported above (see Grover and Kormos undated).

Scale samples are collected from fresh Chinook salmon carcasses for age determination and cohort reconstruction through cooperation with the Ocean Salmon Project. The sample design was selected to achieve a non-biased estimate of age structure for the specific portion of the population where escapement estimates are made without respect to known or unknown age fish. Almost all of the adipose fin clipped fish from hatcheries are scale sampled to provide a reference collection of as many known age scales as possible. In hatcheries, samples are collected at a constant rate throughout the entire spawning period keeping track of the "random" age sample and the additional "non-random" known age samples. During carcass surveys, samples are collected at a constant rate as fish suitable for sampling are encountered. Because of the high sample rate for known age scales at hatcheries and the difficulty of sampling on spawning grounds, non-random samples are generally not taken from adipose fin clipped carcasses.

A skin patch containing between 20-30 scales is removed from the scale pocket located posterior of the last dorsal fin ray, and above the lateral line. Each skin patch is placed in an individual envelope containing: (1) unique sample code; (2) date; (3) location; (4) fork length; (5) sex; (6) ad-clip status; and (7) head tag number if available. Scale envelopes are placed in a dry storage area for later processing by the Ocean Salmon Project's scale aging team. State of the art mounting, digital imaging and digital reading techniques are currently used to examine age structures or patterns. Individual ages are determined from scales by counting winter annuli. Annuli can be identified as bands of closely spaced or broken circuli. Scale samples are read by an individual experienced reader and field biological data (sex and length) are taken into consideration only after the initial evaluation of age by the reader.

CDFG Angler Surveys

In 1998, the CDFG created the Central Valley Salmon and Steelhead Harvest Monitoring Project. The goal of this program is to estimate the number of adult Chinook salmon and steelhead resulting from natural production in Central Valley rivers and streams including: (1) determining annual estimates of the total in-river harvest of salmon and steelhead; and (2) provide limited harvest data on other anadromous and resident sport fish species.

River sections for the lower Yuba River are surveyed year round (D. Massa, CDFG, pers. comm., 2009) and are part of a long-term monitoring effort of the lower Yuba River spring-run and fall-run adult Chinook salmon populations. Chinook salmon can only be "legally" harvested from the lower Yuba River, downstream of DPD, between January 1 and February 28, and from August 1 to October 31 (CDFG 2007). No salmon can be legally harvested upstream of DPD. Because the CDFG Angler Survey covers multiple species, the survey period and location on the lower Yuba River extends beyond the legal period and area established for Chinook salmon angling. All sample sections were surveyed eight randomly-selected days per month; four weekdays and four weekend days. Weekdays and weekend days were placed in separate strata due to the increase in angling effort commonly associated with weekend days.

Two river sections have been previously surveyed by the Central Valley Angler Survey on the Yuba River including: (1) Marysville to DPD; and (2) DPD to 1 mile upstream of the Highway 20 Bridge.

The Yuba River is surveyed via kayak, so the angler count and interview data are collected in tandem as the surveyor travels downstream with the current. Start time and launch location are randomized using a random number generator. All data collected is linked to a unique number series assigned to the Central Valley tributaries of the Sacramento River that represent river miles.

Field data required to calculate angler use and catch estimates include hourly counts, angler counts, and angler interviews. During the angler count, time and location of anglers is collected, as well as parameters for angler effort such as the number of boats, the number of boat or shore anglers, and the start and finish times. An interview of all anglers observed during the angler count is preferable. However, if not feasible than every n^{th} angler is interviewed. Data collected during each interview includes: (1) angler location by river mile; (2) fishing method (boat or shore); (3) number of hours fished to the nearest quarter-hour; (4) number of anglers in group; (5) target species; (6) zip code; (7) whether the trip was completed; and (8) the number of fish kept and/or released by species.

Length is used to differentiate between steelhead and rainbow trout. All rainbow trout 16" or greater are considered to be steelhead. Rainbow trout less than 16" are recorded as rainbow trout. For Chinook salmon, steelhead/rainbow trout, striped bass, and sturgeon, fish are measured to the nearest ½ centimeter and inspected for any marks or tags. All Chinook salmon and steelhead caught are inspected for the presence of an adipose fin. A salmon or steelhead missing an adipose fin indicated the fish was of possible hatchery origin and likely contained a CWT in its snout. All heads are removed from adipose-clipped fish and sent to the CDFG Ocean Salmon Project Laboratory in Healdsburg, California for later extraction and analysis.

YCWA Lower Yuba River Redd Dewatering and Fry Stranding Monitoring and Evaluation

In D-1644, the SWRCB in 2001 directed YCWA to submit a plan, in consultation with USFWS, NMFS, and CDFG that describes the scope and duration of future flow fluctuation studies to verify that Chinook salmon and steelhead redds are being adequately protected from dewatering with implementation of D-1644 criteria (JSA 1992). In RD-1644, the SWRCB in 2003 readopted this requirement. After various comments and revisions, the March 2002 Plan (Plan) was approved by the SWRCB on April 17, 2002. Phase I of the Plan was undertaken in 2002, and implementation of Phase II of the Plan continues.

Studies associated with the Plan combine habitat mapping, field surveys, and information on the timing and distribution of fry rearing in the lower Yuba River to evaluate the effectiveness of D-1644 flow fluctuation and reduction criteria in protecting Chinook salmon and steelhead/rainbow trout fry. Goals of YCWA Lower Yuba River Redd Dewatering and Fry Stranding Monitoring and Evaluation include: (1) determine the potential magnitude of redd dewatering in relation to the timing and magnitude of flow fluctuations and reductions; (2) determine the potential magnitude of fry stranding in relation to the timing, magnitude, and rate of flow fluctuations and reductions; (3) evaluate the effectiveness of flow fluctuation and reduction criteria in protecting redds and fry; and (4) recommend additional measures to protect redds and fry from flow fluctuations and reductions, if warranted.

Two studies were conducted and summarized in the 2007 and 2008 *Lower Yuba River Redd Dewatering and Fry Stranding Annual Reports* (JSA 2007, 2008) to the SWRCB (see the Available Field Studies and Data Collection Reports section of this document).

In accordance with the *Lower Yuba River Redd Dewatering and Fry Stranding Monitoring and Evaluation Plan* (2003), YCWA and JSA will continue to monitor and evaluate stranding risk and flow-habitat relationships for off-channel stranding. Future actions will include the following: (1) continued evaluation of the effects of time of day (night versus day) on stranding risk of juveniles; (2) inspection of interstitial habitats along the river margins to determine the presence of young fry before bar stranding evaluations; (3) evaluation of the effects of higher ramping rates (>100 cfs per hour) on stranding risk of larger fry and juveniles; (4) continued evaluation of the relationship between flow range and the number, area, and distribution of off-channel sites that become disconnected from the main river; (5) evaluation of the effect of peak winter and spring flows on the incidence of off-channel stranding; and (6) continued monitoring of habitat conditions and survival of Chinook salmon and steelhead/rainbow trout in selected off-channel monitoring sites where stranding is frequently observed.

CDFG Steelhead/Rainbow Trout Acoustic Tagging and Tracking Survey

This is a multi-year study to monitor the movement patterns of wild juvenile and adult steelhead/rainbow trout in the lower Yuba River by CDFG (The Heritage and Wild Trout and the Steelhead Management and Recovery Programs). Utilizing acoustical tags and instream hydrophones, this project will track tagged trout movements, habitat selection, and evaluate tracking techniques over multiple seasons and flow conditions. The goal of this program is to develop understanding regarding the movement of steelhead/rainbow trout to help agencies better manage the trout populations on the lower Yuba River, thus providing anglers with a continued sport fishing opportunity for wild resident/anadromous trout in the Central Valley.

Monitoring for acoustic-tagged spring-run Chinook salmon occurs on the lower Yuba River from Englebright Dam to the Yuba River and Feather River confluence through the use of acoustic hydrophones currently in place (J. Nelson, CDFG, 2008, pers. comm.). As of February 2009, there are 16 hydrophones located throughout the lower Yuba River. Static receiver hydrophones will operate continuously year-round and data will be obtained at least every other month by CDFG.

Wild juvenile and adult steelhead/rainbow trout are captured using hook-and-line sampling, and acoustic tags are inserted into the fish. The exact location(s) for acoustic tagging will vary depending upon the specific locations of individual captures.

In addition to fixed-station hydrophones (i.e., static receivers), mobile tracking surveys are conducted. When an acoustically tagged fish is detected, the location is recorded using a GPS unit.