NOAA Technical Memorandum NMFS

MARCH 2005

SUMMARY OF MONITORING ACTIVITIES FOR ESA-LISTED SALMONIDS IN CALIFORNIA'S CENTRAL VALLEY

Kerrie A. Pipal

NOAA-TM-NMFS-SWFSC-373

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Southwest Fisheries Science Center

NOAA Technical Memorandum NMFS

The National Oceanic and Atmospheric Administration (NOAA), organized in 1970, has evolved into an agency which establishes national policies and manages and conserves our oceanic, coastal, and atmospheric resources. An organizational element within NOAA, the Office of Fisheries is responsible for fisheries policy and the direction of the National Marine Fisheries Service (NMFS).

In addition to its formal publications, the NMFS uses the NOAA Technical Memorandum series to issue informal scientific and technical publications when complete formal review and editorial processing are not appropriate or feasible. Documents within this series, however, reflect sound professional work and may be referenced in the formal scientific and technical literature.

NOAA Technical Memorandum NMFS
This TM series is used for documentation and timely communication of preliminary results, interim reports, or special purpose information. The TMs have not received complete formal review, editorial control, or detailed editing.

MARCH 2005

SUMMARY OF MONITORING ACTIVITIES FOR ESA-LISTED SALMONIDS IN CALIFORNIA'S CENTRAL VALLEY

Kerrie A. Pipal

Santa Cruz Laboratory
Southwest Fisheries Science Center
NOAA National Marine Fisheries Service
110 Shaffer Road
Santa Cruz, CA 95060

NOAA-TM-NMFS-SWFSC-373

U.S. DEPARTMENT OF COMMERCE
Carlos M. Gutierrez, Secretary
National Oceanic and Atmospheric Administration
Vice Admiral Conrad C. Lautenbacher, Jr., Under Secretary for Oceans and Atmosphere
National Marine Fisheries Service
William T. Hogarth, Assistant Administrator for Fisheries

TABLE OF CONTENTS

LIST OF ABBREVIATIONS AND ACRONYMS

ACID	Anderson-Cottonwood Irrigation District
BY	Brood year
CDFG	California Department of Fish and Game
CDWR	California Department of Water Resources
CESA	California Endangered Species Act
CMC	Carl Mesick Consultants
CNFH	Coleman National Fish Hatchery
CVP	Central Valley Project
CVPIA	Central Valley Project Improvement Act
CWT	Coded wire tag
DNA	Deoxyribonucleic acid
EBMUD	East Bay Municipal Utility District
ESA	Endangered Species Act
ESU	Evolutionary Significant Unit
FL	Forklength
FRH	Feather River Hatchery
GCID	Glenn-Colusa Irrigation District
GPS	Global Positioning System
IEP	Interagency Ecological Program
JPE	Juvenile production estimate
JPI	Juvenile production index
LSNFH	Livingston Stone National Fish Hatchery
MRFH	Mokelumne River Fish Hatchery
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
PG&E	Pacific Gas & Electric Company
PPDD	Parrott-Phelan Diversion Dam
RBDD	Red Bluff Diversion Dam
RK	River kilometer
RST	Rotary screw trap
SEWD	Stockton East Water District
SPCA	S. P. Cramer & Associates
SPI	Sierra Pacific Industries
SRFG	Stanislaus River Fish Group
TE	Trap efficiency
USBR	U. S. Bureau of Reclamation
USFS	U. S. Forest Service
USFWS	U. S. Fish and Wildlife Service
VES	Vogel Environmental Sciences
WIDD	Woodbridge Irrigation District Dam
YCWA	Yuba County Water Agency
YOY	Young-of-year

LIST OF TABLES

LIST OF TABLES (cont.)

LIST OF APPENDICES

LIST OF APPENDICES (cont.)

LIST OF APPENDICES (cont.)

LIST OF APPENDICES (cont.)

LIST OF APPENDICES (cont.)

LIST OF APPENDICES (cont.)

LIST OF APPENDICES (cont.)

LIST OF APPENDICES (cont.)

LIST OF APPENDICES (cont.)

LIST OF APPENDICES (cont.)

LIST OF APPENDICES (cont.)

EXECUTIVE SUMMARY

This report presents summaries of past and current adult and juvenile freshwater monitoring activities for winter- and spring-run chinook salmon (*Oncorhynchus tshawytscha*) and steelhead (*O. mykiss*) in California's Central Valley. This information was compiled for use in technical recovery planning to aid resource scientists and managers in better understanding existing data sets and study methods. Relevant data and study method descriptions focus mainly on types of information that best benefit recovery planning, which include abundance, distribution, life history, and productivity studies. Textual descriptions of survey techniques are given in the main body of this report, followed by referenced appendices, which include data tables.

Survey methods and relevant data were compiled mainly from agency reports and personal communications with study personnel and regional biologists. The report contains three main sections, including winter-run chinook, spring-run chinook, and steelhead. Each section is further divided into adult and juvenile monitoring activities, with these sections organized by watershed location, starting at the furthest upstream in each system. Smaller data tables are included in the main body of text, while larger data sets are located in the appendices and are referenced in the corresponding textual descriptions.

All existing adult winter-run chinook data were collected from the Sacramento River mainstem, mainly at or upstream from the Red Bluff Diversion Dam (RK 391). Ladder counts of upstream migrating adult winter-run chinook at the dam started in 1967 and are ongoing. These data are used to determine adult escapement to the upper Sacramento River system. The federal (1994) and state (1989) listings of winter-run chinook to an Endangered Species Act status of 'Endangered' created a need for changes in the way the diversion dam operated. During periods when adult winter-run chinook were expected to be migrating upstream past this point, dam gates were raised to facilitate passage. This made counting impossible, as migrating fish were not forced to utilize the fish ladders as they were when dam gates were in the closed position. To enable diversion dam counts to continue for winter-run chinook, the average historical migration timing at the dam from 1982-1986 was used to determine counts. Resulting winter-run chinook escapement estimates have ranged from 117,808 in 1969 to only 186 in 1994. Based on these dam counts, the average number of chinook returning to the upper Sacramento since their 1994 ESA listing of 'Endangered' was 3,956 fish, including grilse and adults.

In 1996, the California Department of Fish and Game and U. S. Fish and Wildlife Service started conducting carcass surveys to aid in estimating winter-run chinook instream spawner escapement in the Sacramento River. Estimates were made using mark-recapture methods and application of the Jolly-Seber method of population estimation, although other estimators (Petersen and Schaefer methods) were also used initially. Average winter-run chinook escapement based on carcass survey data from 2001-2003

was 7871 fish, which included naturally spawning, wild and hatchery-origin grilse and adults.

Starting in 1981, the California Department of Fish and Game conducted aerial redd surveys of the Sacramento River mainstem to document temporal and spatial distribution of spawners. River sections from Keswick Dam (RK 486) to Princeton Ferry (RK 264) were surveyed. The accuracy and reliability of these surveys varied with observer experience, visibility, and redd superimposition. The number of surveys conducted per year was initially low in the early to mid-1980's, however, since 1992, at least 10 surveys were completed each spawning season. According to the aerial redd survey data from 1981 to 2004, most winter-run chinook redds were located between the Anderson-Cottonwood Irrigation District Dam (RK 480) and the Highway 44 Bridge crossing.

Most information on winter-run chinook juveniles in the Sacramento-San Joaquin River system was collected using rotary screw traps to trap downstream migrating fish. Rotary screw traps were utilized on the Sacramento River at Balls Ferry/Deschutes Road, the Red Bluff Diversion Dam, the Glenn-Colusa Irrigation District oxbow, and Knights Landing and on Battle Creek. Most trapping operations started in the mid to late 1990's, except for the Glenn-Colusa Irrigation District oxbow which started in 1988. Data from rotary screw traps were used to estimate juvenile abundance and outmigrant timing.

Other techniques to study juvenile winter-run chinook were also used in the lower Sacramento River and in the Sacramento-San Joaquin Delta, including use of fyke nets, beach seines, and midwater and Kodiak trawls. All of these survey types were used to determine distribution trends and relative abundance. Beach seining efforts were started in 1976 by the U. S. Fish and Wildlife Service, surveying river sections in the Sacramento River, San Joaquin River, and the Delta. Another long-running study on juvenile winter-run chinook by the U. S. Fish and Wildlife Service includes the trawling efforts conducted at Chipps Island in the Delta, which have been ongoing since 1976. Trawling was also conducted near the city of Sacramento (midwater and Kodiak trawls) and on the San Joaquin River near Mossdale. Studies at Knights Landing (starting in 1995) have employed the use of rotary screw traps, fyke nets, and Kodiak trawls. Data from these surveys is used together to document winter-run chinook juvenile outmigration timing, size, and changes in relative abundance over time.

Spring-run chinook salmon escapement estimates have been made since 1940 and include a collection of dam counts, carcass surveys, and redd counts from the Sacramento River and various tributaries. Escapement to the upper Sacramento River was estimated using fish counts from the Red Bluff Diversion Dam since 1972. As with winter-run chinook, operation of the gates at the diversion dam affect the ability of spring-run chinook to be enumerated as they pass upstream beyond this point. To account for this, average historical migration timing based on 1970-1988 passage data for spring-run chinook has been used to aid in escapement estimates since the change in the operation of the diversion dam gates (1986-87). Counts of adult spring-run chinook passage at the Red Bluff Diversion Dam ranged from a high of 25,983 in 1976 to a low of 189 in 1997. Spring-run chinook escapement estimate average over ten years from 1989 until it was

deemed worthy of a 'Threatened' status listing (1999) under state and federal Endangered Species Act regulations was 1390 fish.[1] As with winter-run chinook, aerial redd surveys were also used in the mainstem Sacramento River from Keswick Dam to Princeton Ferry to document spring-run chinook spawning distribution. Aerial redd surveys were conducted much less frequently for spring-run chinook, with an average of 2.2 surveys conducted each year, as opposed to an average of 10.8 conducted annually for winter-run chinook.[2]

Spring-run chinook spawning migrations continue beyond the upper Sacramento River mainstem into smaller tributaries such as Clear, Beegum, and Battle Creeks. While only periodic annual snorkel surveys have been conducted in Beegum Creek since 1973, more comprehensive life history surveys have been conducted in Clear and Battle Creeks, especially since 1996 (Battle Creek) and 1999 (Clear Creek). Adult spring-run chinook populations were monitored in Clear Creek using a combination of snorkel and redd surveys to determine an annual population index and provide information on spawning location and substrate quality. Since 1999, adult spring-run chinook counts in Clear Creek have ranged from zero fish in 2001 to 98 fish in 2004. In Battle Creek, adult spring-run chinook populations were monitored using snorkeling and walking surveys, trapping at the Coleman National Fish Hatchery barrier weir, and video monitoring at the weir. Analyses of tissues collected during adult chinook surveys on Battle Creek were useful in determining run of origin. Coded wire tag recovery and resultant analyses were also used to differentiate between chinook races.

Antelope, Deer, and Mill Creek also maintain small populations of spring-run chinook. In Antelope Creek, known spring-run chinook holding habitat was snorkeled annually during the spawning season from 1995 until 2004. An average of 31 fish were counted each year over the past 10 years, ranging from zero fish in 1997 to 154 fish in 1998. A dam counting station (at either Clough or Ward Dams) was used on Mill Creek to estimate adult spring-run chinook populations from 1954-1964 and from 1986-1996. Since 1970, carcass surveys have also been used to estimate spring-run chinook escapement. Early spring-run chinook escapement on Deer Creek was estimated using a weir and counting station from 1941-1948. Use of carcass surveys started in 1970, however access and terrain difficulties limit survey frequency and feasibility, as is also the case with Mill Creek.

Intermittent adult spring-run chinook surveys were conducted on Butte and Big Chico Creeks, until the California Department of Fish and Game started more comprehensive studies on these systems in 1995. The complete life history of spring-run chinook in Butte Creek, which supports one of the remaining independent, extant spring-run chinook populations, has been studied intensively since 1995. Snorkel surveys were mainly used

[1] This ten-year average escapement estimate takes into account the sport fishery catch above the Red Bluff Diversion Dam (Appendix 2-C).

[2] For spring-run chinook the average number for aerial surveys conducted per annual spawning period was based on the years surveyed between 1983 and 2004, totaling 21. For winter-run chinook aerial redd surveys, the average number conducted per spawning season was based on the years surveyed between 1981 and 2004, also equaling 21.

to estimate adult escapement. However, starting in 2001, carcass surveys were also conducted. Initially, these surveys were started to generate greater recovery of coded wire tags from chinook straying from the Feather River Hatchery and from Butte Creek produced juveniles tagged as part of the life history studies. However, estimates from carcass surveys were also used to compare to results from snorkel surveys, providing an alternate method of estimating escapement. Researchers utilized coded-wire tags on out-migrating juveniles to complement adult spawner surveys.

Spring-run chinook populations in the Feather River were drastically changed as the result of hydroelectric dam construction, the addition of numerous water diversions, and the resultant negative impacts from upstream hydraulic mining operations, including siltation of spawning gravels and decreased water quality. The Feather River Hatchery was built to mitigate for the loss of spawning habitat due to Oroville Dam construction in the late 1960's. Information on naturally-spawning spring-run chinook is mainly learned through fall-run chinook carcass mark-recapture studies on the Feather River. However, most of the information collected was from hatchery-produced fish spawning in the river. Due to the overlap of run-timing and the timing of the carcass surveys between fall- and spring-run chinook in this system, coded wire tag recoveries are one of the only methods used to provide more information about spring-run chinook in this system. Feather River Hatchery counts of spring-run chinook adults are used to estimate escapement.

Due to mining activities and water diversions, the Yuba River has also experienced a significant loss of spring-run chinook spawning habitat, decreased existing habitat quality, and increased water temperatures. Recent attempts to enumerate adult spring-run chinook populations in the Yuba River include fish passage monitoring at Daguerre Point Dam using video monitoring at fish ladders. A trapping program was utilized in 2001, but not in 2002 or 2003. Current project goals using a VAKI Riverwatcher Fish Monitoring System at Daguerre Point Dam hope to be able to utilize a combination of phenotypic characteristics and run timing to distinguish between and spring- and fall-run chinook.

Juvenile spring-run chinook data yielding relative abundance, distribution, and migration timing estimates were collected using rotary screw traps at the mouths of tributaries and in some of the larger systems such as the upper Sacramento River. Rotary screw traps were used on the mainstem Sacramento River at Balls Ferry/Deschutes Road Bridge, the Red Bluff Diversion Dam, and Knights Landing and on Clear, Battle, Deer, Mill, Big Chico, and Butte Creeks, and the Yuba River.

Most adult and juvenile steelhead data collected in the Central Valley were collected as ancillary information as part of chinook salmon studies. Variations in steelhead life history and difficulties in distinguishing between resident and anadromous *O. mykiss* during visual surveys make this species difficult to study and quantify. Surveys occurred throughout the Central Valley, from the upper Sacramento River and its tributaries to the San Joaquin River system and Delta. As with winter- and spring-run chinook salmon, steelhead historical spawning and rearing habitat has been severely limited in the Central Valley, mainly due to dam construction and water diversions to support agriculture

activities and increasing water needs due to urbanization. Access to historical spawning grounds has been blocked or severely limited, therefore restricting access to the lower watersheds in many larger systems like the Feather and American Rivers. State and federal hatcheries were built on some of these systems to mitigate for this loss of habitat. In the Central Valley, steelhead propagation occurs at the Coleman National Fish Hatchery (Battle Creek), Feather River Hatchery, Nimbus Hatchery (American River), and Mokelumne River Fish Hatchery. Hatchery returns comprise the longest running dataset for adult steelhead, starting in 1966-67 and continuing to be consistently reported each year.

Due to its popularity and importance as a recreational fishery, steelhead harvest monitoring has periodically been conducted throughout the Central Valley to obtain in-river harvest estimates. From 1953 through 1959, steelhead sport catch in the Sacramento River was determined using a mark-recapture technique where a known number of tagged fish were added to the system and then later recaptured by anglers. From 1998-2001, the Central Valley Salmon and Steelhead Harvest Monitoring Project monitored recreational catch from the Sacramento, Feather, Yuba, American, San Joaquin, Mokelumne, and Stanislaus Rivers.

In 2001, steelhead redd surveys were conducted in Clear, Beegum, Battle, and Antelope Creeks, using snorkeling, walking, and kayaking techniques to identify, count, and measure steelhead redds. In Battle Creek, upstream passage monitoring for steelhead was also recorded above the Coleman National Fish Hatchery. During these visual surveys, it was sometimes difficult or impossible to determine if fish were the anadromous or resident form. Physical characteristics such as adipose fin condition (clipped or unclipped) were recorded whenever possible.

Adult steelhead in Mill Creek were initially monitored using counts at Clough Dam from 1953-1963. In 1993, a fish counter was installed at the Dam to record fish passage. Live adult steelhead and redd counts were conducted in 2001, yielding one live adult female and 17 redds. Besides one adult steelhead count of 1006 fish in Deer Creek from 1967, no or few attempts were made to enumerate steelhead in this system before the early 1990's. In 1993, a fish counter was installed at Stanford-Vina Dam. Redd counts using snorkel and foot surveys were conducted in 2001, as previously described for other systems. Weekly counts from April 10 to May 17 yielded a total of 37 adult steelhead and 35 redd observations.

Early adult steelhead data from the Feather River is primarily made up of hatchery returns from the Feather River Hatchery and recreational catch from the Central Valley Salmon and Steelhead Harvest Monitoring Project. Little information was available on spawning adults or natural escapement estimates for this system. Due to the Oroville Dam Federal Energy Regulating Commission relicensing process, additional funding was available and the level of interest increased regarding the need for improved knowledge of steelhead life history information on this system. In 2003, the California Department of Water Resources conducted redd surveys from January to April using wading techniques and drift boats. Microhabitat data for each observed redd were also collected.

A total of 108 steelhead and 75 redds were observed. Over 50% of the redds were located in the 1.6 km section below the Feather River Hatchery Fish Barrier Dam.

In 1955, construction of Folsom and Nimbus Dams on the American River limited steelhead spawning habitat to the lower 37 km of river. Nimbus Hatchery was built to mitigate for this loss of spawning habitat for anadromous salmonid species. Hatchery returns are the longest running dataset for adult steelhead on this system. Starting in 2001 and continuing each year through 2004, steelhead redd surveys were conducted to estimate abundance of in-river spawning populations. A combination of boat, canoe, and snorkeling surveys were used to conduct the redd surveys. Researchers also attempted to determine adipose fin condition (clipped or unclipped) to distinguish between wild and hatchery-produced spawners.

Adult steelhead in the Mokelumne River were monitored as part of fall-run chinook studies. Data from the late 1990's were based on results from chinook spawner surveys, which also counted live adult steelhead and redds and documented timing of observations. Angler surveys were also used on the Mokelumne River in the mid to late 1990's, mainly to better understand the steelhead/rainbow trout fishery and the existing fishing pressure. Adult steelhead passage was monitored at Woodbridge Irrigation District's diversion dam (RK 63) using an upstream migrant fish trap and a video monitoring system. This study was also focused on fall-run chinook, but included observations of steelhead. Steelhead observations were based on length criteria, considering any *O. mykiss* over 380 mm FL as an adult steelhead.

Starting in 2003, adult steelhead passage on the Stanislaus River was monitored using a portable resistance board weir. The first adult steelhead was captured at the weir on December 27, 2003. Continued weir operations will enable the steelhead population on this system to be better understood in population size, fish characteristics, and run timing.

Juvenile steelhead in the Sacramento-San Joaquin River system and Delta are found emigrating throughout the year. Efforts to monitor emigration include use of rotary screw traps, beach seines, Kodiak and midwater trawls, and, in some cases, snorkel surveys. As with adult studies, most juvenile steelhead monitoring data are collected as ancillary information to chinook studies. If traps are not operated throughout the year, projects may not capture steelhead emigrating from the system at different times than the targeted juvenile chinook populations. Also, if traps are being operated primarily to capture juvenile chinook, trapping efficiency is not usually calculated for *O. mykiss*. When trapping efficiency is calculated for chinook and the resulting value is low, researchers assume capture rate for *O. mykiss* is even lower.

In the upper Sacramento River, rotary screw traps were operated at Balls Ferry/Deschutes Road Bridge starting in 1996. Clear Creek and Battle Creek were also monitored for juvenile steelhead emigration using rotary screw traps. To complement their adult steelhead surveys, the U. S. Fish and Wildlife Service have operated traps in Clear Creek since 1998. The number of captured emigrating steelhead in this system has increased annually from 3706 fish in 1999 to 30,725 fish in 2004. The increase was partially

attributed to the removal of the McCormick-Seltzer Dam in 2000, which increased access and habitat availability for steelhead. The number of emigrating juvenile steelhead captured in the Battle Creek rotary screw traps has fluctuated during 1999 to 2004 sampling. In 2000, 42,151 steelhead were captured, but in 2003 only 9398 fish were captured. In 2001, the traps were only in operation for six months, capturing only 536 fish (January and August through December).

In 1996, the California Department of Water Resources started a juvenile salmonid emigration study on the Feather River. The study focused on chinook salmon, but also included the collection of steelhead data when possible. Rotary screw traps were operated at the Thermalito Afterbay Outlet (RK 96.6) and downstream from the Honcut Creek inlet (RK 67.6). Trapping operations were periodically suspended during periods of high flows and no steelhead were captured during 1997 operations due to a large flood event that flushed juveniles out of the system when traps were not in place. From 1998-2001, a total of 1551 juvenile steelhead were captured, mostly (90%) from the Thermalito Afterbay Outlet site. From 1999 to 2003, snorkel and seining surveys were also used to document seasonal distribution, relative abundance, and habitat use by juvenile steelhead. Observed fish were categorized by size. Results from these surveys in the Feather River indicate juvenile steelhead emigration occurs from February through September, peaking in March through mid-April.

Beach seines and rotary screw traps were used on the American River to document juvenile steelhead distribution and relative abundance from 1992 through 1998. Rotary screw traps were also used on the Mokelumne (1993-2004), Calaveras (2002-2004), and Stanislaus (1993-2004) Rivers and at Knights Landing on the lower Sacramento River (1995-2004) to monitor juvenile salmonid passage. Most of these trapping operations are ongoing. Beach seining surveys have been conducted since 1976 by the U. S. Fish and Wildlife Service at many different locations within three major areas of the Central Valley, the Sacramento River, San Joaquin River, and the Delta. Juvenile steelhead data were also collected during trawling efforts from Chipps Island in the Delta (1976-2004) and from midwater and Kodiak trawls operated in the Sacramento River near Sacramento.

1 INTRODUCTION

Tremendous amounts of time, effort, and money have been dedicated to monitoring chinook salmon (*Oncorhynchus tshawytscha*) and steelhead (*O. mykiss*) populations in California's Central Valley. This energy is spent by state and federal agencies, private industry, landowners, non-profit groups, and resource managers attempting to better understand salmonid populations within their jurisdiction. Reasons for collecting data on these populations are as diverse as the organizations conducting studies, ranging from economic benefits of a well-managed commercial and recreational resource to government mandate when small or dwindling population sizes dictate the need for more information to personal interest in conservation or watershed management.

Decades of research have yielded datasets of varying quality, longevity, and usefulness, as researchers have often had to balance monitoring needs with realities of available funding, fluctuating resource interest levels, difficult survey conditions, and in some cases lack of suitable resources to adequately sample salmonid populations. Changes over time in environmental features, funding sources, political climate, and resource importance have impacted data quality. Advancements made in fisheries science and practices have also led to evolving survey techniques. Locating and analyzing resulting datasets can prove challenging to resource managers as they strive to develop and implement management strategies to effectively monitor population trends. Yet, however imperfect these data collections may be, they play a critical role in helping to effectively manage Central Valley salmonid populations.

Past and present salmonid monitoring efforts have become vitally important as population sizes have changed (drastically in some cases) and must now be managed accordingly. Trends showing increases in population size may mean more fish can be taken in commercial or recreational fisheries or that habitat restoration efforts are working to help population sizes grow. Decreases in abundance can mean that species are at risk of extinction or that environmental threats are causing permanent or temporary changes to population size or an alteration of life history characteristics. Monitoring factors (e.g. abundance, distribution, life history characteristics, and productivity) that affect these trends in population size become critical for species management and survival.

Resource managers and scientists tasked with developing recovery plans for winter- and spring-run chinook and steelhead in the Central Valley face a problem in that a centralized location of existing datasets and accompanying descriptions of methodologies focusing on the three target species does not exist. Locating complete and accurate datasets and determining the statistical validity of available data is an important part of the process of developing species recovery plans.

This report summarizes past and current freshwater monitoring activities for winter- and spring-run chinook salmon (*Oncorhynchus tshawytscha*) and steelhead trout (*O. mykiss*)

throughout California's Central Valley. Adult and juvenile data are included when available. Every attempt was made to include the most data for each study, however, sometimes this was not possible. If available, contact information is provided on how to obtain additional information. Data sources include: agency documents, discussions with regional biologists, internet/website searches, and hatchery reports. The relevance and importance of monitoring activities and data collection to current recovery efforts is also discussed. Preceding each species' section of data summaries is a table listing past and present monitoring activities, study location, survey methods, dates, and other relevant information.

2 WINTER-RUN CHINOOK SALMON

Winter-run chinook salmon are genetically distinct from the other three recognized chinook salmon runs (fall, late-fall, and spring) in California's Central Valley (Banks et al. 2000). Differences from other chinook salmon runs in the Central Valley include spatial and temporal life history variations (Fisher 1994) and genetic divergence. The National Marine Fisheries Service (NMFS) designated winter-run chinook as a separate Evolutionary Significant Unit (ESU), referred to as the 'Sacramento River Winter-Run ESU' (Myers et al. 1998). In 1989, winter-run chinook were listed as endangered under the California Endangered Species Act (CESA) and as threatened under the United States Endangered Species Act of 1973 (ESA). The ESA listing was reclassified to endangered in 1994 (NMFS 1994). Critical habitat for winter-run chinook has been designated from the Golden Gate Bridge, San Francisco to Keswick Dam, Shasta County (Sacramento River Kilometer [RK] 486) in 1993 (NMFS 1993).

Winter-run chinook adults enter the Sacramento-San Joaquin Delta from November through May (CDFG 1993) and migrate to the upper Sacramento River to spawn. The first migrating adults usually reach Red Bluff Diversion Dam (RBDD) in December, with peak migration rates typically occurring in March, depending on flows and run timing. The later part of the run can pass RBDD as late as mid-July. Since no fish ladder is available at Keswick Dam, fish are stopped at this point along their migration route. Fish hold-over in deeper pools for up to several months before spawning activity occurs from April through August, with peak spawning in early June. Historically, winter-run chinook tended to spawn in spring-fed streams as cool water was required for holding over in pools during the summer. Although actual percentages vary from year-to-year, most returning spawners are age-3 fish. Winter-run chinook females have the lowest fecundity of the four Central Valley chinook salmon runs, averaging 3700 eggs per spawning female (Fisher 1994). Egg incubation and hatching takes place from April through early October, with rearing and migration periods spanning July through March.

The construction of Shasta Dam (1945), Keswick Dam (1950), and Red Bluff Diversion Dam (1966) severely limited the amount of available spawning habitat for winter-run chinook. Before these migration barriers were built, winter-run chinook utilized spawning and rearing habitat in the upper tributaries to the Sacramento River, including Little Sacramento, Pit, Fall, and McCloud Rivers (Yoshiyama et al. 1996; Myers et al.

1998; CDWR 2003a; Schick et al. 2004). Presence of winter-run chinook in the Calaveras River is mentioned in several reports (Hoopaugh 1977, 1978; Knutson 1980; Kano et al. 1996). Hoopaugh (1978) reports that an unplanned spillage from an irrigation dam into the Old Calaveras River channel caused a surge of approximately 500 winter-run chinook to enter the river in late April, 1976. Also, in 1984 irrigation district personnel and a California Department of Fish and Game (CDFG) warden reported observing around 100 winter-run chinook downstream from Hogan Dam (Kano et al. 1996). However, these accounts are primarily anecdotal in nature and are not a verifiable indication the mentioned fish were truly winter-run chinook in origin.

The earliest attempts to enumerate chinook salmon in the Central Valley occurred in 1937, in response to the proposed construction of Shasta Dam. Counts were conducted by CDFG, U. S. Fish and Wildlife Service (USFWS), and U. S. Bureau of Reclamation (USBR). In these early accounts, no attempt was made to differentiate winter-run chinook from fall- or late fall-run chinook, although the difference in runs was noted by Fry (1961). Table 1 summarizes winter-run chinook monitoring projects presented in this report.

Table 1. Summary of winter-run chinook salmon (*Oncorhynchus tshawytscha*) adult and juvenile monitoring activities in California's Central Valley.

Tributary	Life Stage	Monitoring method	Variable measured	Date(s)	Agency	Project Leader(s)	Data location in this report[a]
Upper Sacramento River (RBDD)	Adult	RBDD Ladder counts	Escapement	1967-2003*	USFWS, CDFG	Kurt Brown, USFWS	Appendices 1-A and 1-B
Upper Sacramento River	Adult	Sport fishery catch and angler surveys	Recreational harvest and catch rates	1967-1991	CDFG	Kyle Murphy, CDFG	Appendices 1-C and 1-D
Upper Sacramento River	Adult	Carcass surveys	Escapement	1996-2003*	CDFG, USFWS	Doug Killam, CDFG	Section 2.1.2 and Table 2
Upper Sacramento River	Adult	Aerial redd surveys	Temporal and spatial spawning distribution	1981-2004*	CDFG	Doug Killam, CDFG	Appendices 1-E and 1-F
Upper Sacramento River	Adult	Keswick Dam, RBDD, and Coleman barrier weir fish traps	Adult returns and broodstock collection	1989-2001*	USFWS, CDFG, USBR	Kevin Niemela, USFWS	Appendix 1-G[b]
Upper Sacramento River	Juvenile	Habitat surveys (snorkel/seine)	Spatial and temporal distribution	1996-2001	CDFG, USFWS	-	n/a[c]
Upper Sacramento River (Balls Ferry/Deschutes Road)	Juvenile	Rotary screw traps	Emigration timing and relative abundance	1996-1999	CDFG, USFWS	Rob Titus, CDFG	Table 3

Table 1 (cont.). Summary of winter-run chinook salmon (*Oncorhynchus tshawytscha*) adult and juvenile monitoring activities in California's Central Valley.

Tributary	Life Stage	Monitoring method	Variable measured	Date(s)	Agency	Project leader(s)	Data location in this report[a]
Upper Sacramento River (RBDD)	Juvenile	Rotary screw traps	Abundance and outmigrant timing	1994-1999, 2002-2004*	USFWS, CDFG	Bill Poytress, USFWS	Appendices 1-H, 1-I, and 1-J
Battle Creek	Juvenile	Rotary screw traps	Abundance and outmigrant timing	1999-2004*	USFWS	Matt Brown, USFWS	Section 2.2.4
Sacramento River mainstem (GCID oxbow)	Juvenile	Rotary screw trap	Emigration timing and efficacy of fish screens	1988-2004*	GCID, CDFG	Diane Coulon, CDFG	Appendix 1-K (1988-1990 only)
Lower Sacramento River (Knights Landing)	Juvenile	Rotary screw traps, fyke nets, and Kodiak trawls	Emigration timing and relative abundance	1995-2004*	CDFG	Rob Titus, CDFG	Appendices 1-L through 1-Z
Sacramento River (Sacramento)	Juvenile	Midwater and Kodiak trawls	Emigration timing and relative abundance	1988-2004*	USFWS	Paul Cadrett, USFWS	Appendix 1-AA
Sacramento-San Joaquin Delta	Juvenile	Beach seines	Emigration timing and relative abundance	1977-2004*	USFWS	Paul Cadrett, UFWS	Appendix 1-BB (1977-89 only)
Sacramento-San Joaquin Delta (Chipps Island)	Juvenile	Trawls	Emigration timing and relative abundance	1976-2004*	USFWS	Paul Cadrett, UFWS	Appendices 1-CC and 1-DD
Sacramento-San Joaquin Delta (Golden Gate)	Juvenile	Trawls	Emigration timing and abundance	1983-1986	USFWS	Paul Cadrett, UFWS	Appendix 1-EE

* Indicates project is ongoing beyond end year provided.

[a] Data not available or present in this report is listed as 'n/a.'

[b] Trapping started in the 1950's, but data quality is poor and inconsistent until 1989.

[c] Chinook run origin not differentiated in reports (CDFG 1997, 1998a, 1999, and 2000).

2.1 Adult winter-run chinook data summaries

Existing data for adult winter-run chinook salmon are mainly comprised of annual run counts from RBDD, trapping data from Keswick Dam, angler surveys from the Sacramento River, aerial redd surveys, coded-wire tag (CWT) recoveries, some hatchery return totals, and spawning surveys on the mainstem Sacramento River. Methodologies vary from year to year and between agencies. Quantitative escapement estimates were not made for winter-run chinook before 1967 and the implementation of RBDD.

2.1.1 Red Bluff Diversion Dam counts

RBDD is located on the Sacramento River south of Red Bluff at RK 391 approximately 96.6 km downstream from Shasta and Keswick Dams. Construction of this facility was completed in 1966, with fish counts starting in August of 1966 (Fry and Petrovich 1970). This diversion dam provides water to Tehama-Colusa and Corning canals for use in irrigation. Dam gates are used to control water flow between the river and canals. Under normal flow conditions when dam gates are in the closed position, fish navigate through one of three fishways, one on each side of the dam and one in the center, and are then counted as they pass closed-circuit television monitoring systems. Late summer and fall counts are made when water levels and turbidity are relatively low, making counts more reliable. However, winter-run chinook counts can prove more challenging, as fish begin reaching RBDD in December and January when winter storms can drastically increase flows and turbidity levels and decrease visibility for counters. Flooding is also possible, causing the need for the gates to be raised and enabling fish to pass through the dam instead of the fishways. From 1967-1986, gates were closed during winter-run chinook upstream migration, allowing counts to be conducted. From November 1969 through mid-July 1971, television monitors were operated 16 hours per day (Taylor 1972). Adjustments were made to account for night migrations when fish could not be counted. Winter-run chinook were distinguished from other runs by the timing of passage and external fish characteristics. Beginning in mid-July, 1971, counts were made continuously on a 24-hour basis by recording nighttime passage on videotape for later review and enumeration.

Although salmon counts from RBDD were considered fairly reliable from 1967-1986, there were problems with achieving precise run enumeration and classification. When flows were low to moderate and water was relatively clear (mainly in late summer or early fall), counts were made continuously and were assumed to be fairly accurate. In winter, however, or during heavy storms, water turbidity increased which did not allow counts to be made. Also, to prevent flooding, dam gates were sometimes raised which made counts impossible as fish could migrate upstream without utilizing fish ladders.

Starting in late 1986, RBDD gates were raised for increasingly longer periods during the winter-run chinook upstream migration period to facilitate their passage beyond RBDD. Since 1994, dam gates have remained open from approximately September 15 through

May 15 each year to allow unimpeded upstream migration of adult winter-run chinook. The estimated average proportion of winter-run chinook passage during this period is 15%, based on the historical average proportional run distribution from 1968-1985 (Kano 1998b). However, the proportion of adults passing through the ladders from 1969 through 1985 fluctuated from as much as 3-48% (Gaines and Poytress 2004). Since this proportion can vary significantly from year to year, winter-run chinook escapement estimates based on counts at RBDD from 1987 through 2004 are therefore imprecise. The average historical migration timing for winter-run chinook at RBDD is presented in Appendix 1-A, based on data from 1982-1986. Values presented in Appendix 1-A are based on years when RBDD gates were in the closed position year-round and the fish trap and ladders were operated on a continuous basis. These data were used to estimate numbers of winter-run passing RBDD when direct counts could not be made.

Winter-run chinook estimates from 1967 through 2003 shown in Appendix 1-B are based on fish counts at RBDD. Each year reported represents the year spawning occurred. For example, if passage occurred during December of 1970, the fish would be included in the 1971 run total. It is assumed that most winter-run chinook spawn above RBDD, although small numbers of fish spawn below this point as well. Escapement estimates from 1967-1971 based on RBDD counts assume that all fish passing this location contribute to the spawning population. Fishing pressure can be heavy above RBDD (Taylor 1972). Since 1972, sport fishery catch of winter-run chinook above RBDD has been accounted for and was subtracted from the dam counts to yield an instream spawner escapement estimate (Appendix 1-C).

2.1.2 Sacramento River carcass surveys

Winter-run chinook carcass surveys were initiated by CDFG and USFWS in 1996 to estimate instream spawner escapement in the Sacramento River using mark-recapture techniques. From April 29 through September 5, 1996, CDFG and USFWS conducted carcass surveys on the upper Sacramento River from the mouth of Battle Creek to Keswick Dam to determine escapement. The section of river was divided into four reaches, with each surveyed once per week. Most of the survey was conducted by boat along the shoreline, however several sections required surveying on foot due to limited boat access. Based on low tag recovery rate (15%) and the majority of spawners (90%) only utilizing spawning habitat in the upper 22.5 km of the original survey reach in 1996, subsequent surveys in the years following were divided into two, 11.3 km sections directly downstream from Keswick Dam (CDFG 1999). Keswick Dam (RK 486) to Cypress Street Bridge (RK 475) constituted one section, and Cypress Street Bridge to Redding Water Treatment Plant (RK 463) made up the other. These sections were surveyed approximately 2.5 times per week. Decreasing the survey reach length allowed researchers to increase survey frequency and, therefore, tag recovery, in hopes of improving accuracy of escapement estimators.

Each year, size and age distribution were determined by measuring forklength (FL) and developing a length frequency distribution. Male and female adults and grilse were

determined using these distributions. For example, in 1996 male adult salmon were determined as fish ≥ 65 cm FL, while male salmon under that size were classified as grilse. No size separation was found for females in that same year, suggesting all female carcasses encountered were adults (CDFG 1997). Temporal and spatial distribution of redds were based on redd construction timing and location. Escapement estimates were made using mark-recapture techniques and the Petersen method of estimation (Ricker 1975) in 1996. However, when compared to estimates for winter-run chinook passing RBDD and redd counts, Petersen estimators tended to over-estimate escapement (CDFG 1997). Comparisons between methodologies suggest 1996 escapement was probably closer to 650 fish. Depending on which model assumptions were met from year-to-year, CDFG was able to use multiple estimation methods to obtain escapement (Snider et al. 2001), including a modified Petersen estimator, Schaefer estimator (Schaefer 1951), and/or Jolly-Seber estimator (Seber 1982). Each estimator differs slightly in its assumptions and the way in which the data are used.

Continuous improvements have been made to carcass survey field and estimation methods since 1996. Estimates are currently based on application of the Jolly-Seber model (Seber 1982). In 2001, CDFG's Winter-run Chinook Salmon Technical Recovery Team has recommended use of winter-run chinook carcass survey data to generate escapement estimates rather than data from the RBDD counts (CDFG 2004a). Starting in 2003, methods to calculate the estimate were further improved. Prior to 2003, the carcass survey data were used to estimate adult numbers without separating the sexes. Beginning in 2003, the number of adult females was estimated using only the adult female data from the carcass survey and applying the Jolly-Seber model. The number of adult males was then derived from the adult female estimate, using the male-to-female sex ratio for the winter-run chinook population observed by the USFWS at the Keswick Dam trapping station. The number of grilse was estimated based on the ratio of adults to grilse found in fresh fish sampled in the carcass survey. These changes were made because of the recognized sex bias in the carcass survey data (CDFG 2004a). Escapement estimates shown in Table 2 for 2001-2003 include naturally spawning, wild and hatchery-origin winter-run chinook in the upper Sacramento River, but not those fish trapped at Keswick Dam and retained for broodstock use.

Table 2. Winter-run chinook salmon in-river escapement estimates for the upper Sacramento River, based on application of the Jolly-Seber population estimation model (CDFG 2004a).

Year	Grilse	Adults	Total
2001	787	7333	8120
2002	412	6948	7360
2003	535	7598	8133

2.1.3 Sacramento River aerial redd surveys

Aerial redd surveys for winter-run chinook have been conducted on the mainstem Sacramento River since 1981 to determine the temporal and spatial distribution of spawners (Appendices 1-D and 1-E). Planes or helicopters were used to survey the study reaches, which extend from Keswick Dam (RK 486) to Princeton Ferry (RK 264). CDFG assumes April 21 as the start of the winter-run chinook spawning period, however this overlaps with in-river trout spawning, potentially causing some redds to be misidentified as winter-run chinook.[3] Aerial redd survey results have been used to expand carcass survey estimates to include fish spawning downstream of the carcass survey area, but results are used primarily to determine distribution, not spawner abundance. The accuracy and reliability of these surveys are affected by a variety of factors, mainly visibility and redd superimposition. Observer experience can also make a difference in count reliability and consistency. Surveys conducted in 2003 indicate an upstream shift in the distribution of winter-run chinook redds, probably due to fish passage improvements made at the Anderson-Cottonwood Irrigation District (ACID) Dam (CDFG 2004a).

2.1.4 Keswick Dam fish trap

Keswick Dam was built as part of the Central Valley Project (CVP) and is located 14.5 km downstream from Shasta Dam on the Sacramento River. Winter-run chinook are trapped here and taken for use in artificial propagation (Livingston Stone National Fish Hatchery [LSNFH]) and captive broodstock programs (LSNFH and Bodega Marine Laboratory). Coleman National Fish Hatchery (CNFH) on Battle Creek was originally used to attempt propagation of winter-run chinook (1958-1967 and 1978-1985), however most efforts during this time were unsuccessful. Consistently successful efforts to raise winter-run chinook at CNFH were not made until 1989, and continued through 1995. During 1996-1997, no winter-run chinook were collected at Keswick Dam or CNFH, as a moratorium on collection was imposed due to concerns that hatchery-reared adult winter-run chinook would return to CNFH (Battle Creek) instead of the upper Sacramento River. With completion of LSNFH facilities in 1998, the artificial propagation program was re-initiated at that location.

The Keswick Fish Trap is located between the dam powerhouse and spillway, near the center of the dam. Fish are attracted to the fish ladder by a jet pump that flushes water through the trap and ladder. After reaching the top of the ladder, fish pass through a fyke weir and into a fiberglass enclosure. When the enclosure is lifted (referred to as a 'brail-lift'), fish are transferred to an elevator and then released to a transport vehicle (USFWS 2001). The trap is operated by USFWS and maintained by USBR. Appendix 1-F summarizes trapping data from Keswick Dam, RBDD, and Coleman barrier weir from 1989-2001. Winter-run chinook were occasionally trapped at the barrier weir on Battle Creek from 1998-2000 to supplement captive broodstock and artificial propagation programs when trapping at the Keswick Fish Trap did not meet annual program goals.

[3] D. Killam, CDFG, 2440 Main Street, Red Bluff, CA 96080, 02 March 2005, personal communication.

2.1.5 Sacramento River angler surveys

Creel census has been used in the Central Valley to monitor and develop estimates of anadromous fish harvest by anglers. To conduct surveys, a stratified-random sampling design was used to systematically survey anglers at specified locations and times, usually during the fishing season. Creel surveys in the Central Valley have been vulnerable to budgetary cuts and a limited number of available resources, thus creating sometimes fragmented or incomplete surveys. Many surveys only cover a limited number of streams or river sections over a relatively small number of sampling days. Data collected on catch and effort requires expansion to account for missed days due to infrequent sampling. Appendix 1-G lists winter-run chinook harvest estimates in the Sacramento River (exclusive of tributaries) from 1967 through 1991.

Current angling regulations for the mainstem Sacramento River, which have been in effect since 1990, were designed to prevent instream harvest of winter- and spring-run chinook. Regulations consist of time and area closures, gear restrictions, and zero bag limits. The regulations were modified in October of 2002 (took effect January 1, 2003) to further preclude winter-run chinook harvest. Based on the best available data, the current no-retention periods cover the entire period when adult winter-run chinook occur in the Sacramento River (CDFG 2004a). This assumption is based on no additional coded wire tags being recovered during the inland sport harvest.

2.2 Juvenile winter-run chinook data summaries

Winter-run chinook fry typically emerge from the substrate from July through October, with downstream migration starting in August and continuing until February or March, depending on flow. Freshwater residence time for juveniles ranges from 5 to 10 months. Most enter the ocean as smolts from November through May, with an average FL of 120 mm as they pass through the Delta sampling stations. More growth could occur as fish pass from the Delta to the ocean environment. Most available juvenile winter-run chinook data is derived from rotary screw traps placed downstream from major spawning or outmigration locations. These data are useful for estimating juvenile abundance and outmigrant timing, as well as size-at-migration. Rearing habitat assessments are also available, indicating habitat usage by juvenile winter-run chinook and spatial distribution. These surveys were most often conducted using snorkeling and seining techniques.

2.2.1 Upper Sacramento River habitat surveys

CDFG and USFWS initiated a 5-year study investigating rearing habitat conditions in the upper Sacramento River in August 1996. These surveys were used to detect spatial and temporal distributions of juvenile salmonids, including winter-run chinook salmon. Results aided in developing flow recommendations to satisfy Central Valley Project Improvement Act (CVPIA) requirements. Survey reaches in the Sacramento River from Keswick Dam (RK 486) to Battle Creek (RK 436) were surveyed using habitat mapping,

snorkel surveys, and beach seining. Each habitat unit was classified as bar complex, flatwater, side channel, or off channel; units were further delineated as pool, riffle, run, or glide. Each unit was mapped using a combination of aerial photographs and ground surveys. Snorkelers surveyed 45-meter sections along the bank of each habitat unit, collecting information on species observed, approximate size, and other habitat characteristics such as depth and cover. Approximately half of the units snorkeled were surveyed using a beach seine to sample part of the unit, recording number, size, and weight of salmonids captured. Salmonid data reported by CDFG (1997, 1998a, 1999, and 2000) were divided between chinook salmon and rainbow trout, however, no effort was made to distinguish run of origin for chinook.

2.2.2 Upper Sacramento River rotary screw trapping

To complement the upper Sacramento River habitat rearing study, RSTs were used to trap emigrating juvenile salmonids at Balls Ferry and the Deschutes Road Bridge. Data were used to determine emigration timing and relative abundance. In 1996, two RSTs were operated near Balls Ferry (RK 444), with placement aimed at avoiding direct hatchery influence from CNFH on Battle Creek (RK 436). In 1997 and 1998, two RSTs were operated near Balls Ferry and another was located at Deschutes Road Bridge (RK 452). Captured salmon were enumerated, measured, and classified by race according to length-at-date criteria developed by Fisher (1992). A brief summary of winter-run-chinook-sized juveniles captured during RST operations is presented in Table 3.

Table 3. Summary of juvenile winter-run-chinook-sized salmon captured during rotary screw trap sampling at Balls Ferry (RK 444) and Deschutes Road Bridge (RK 452), Sacramento River from 1996 through 1999 (CDFG 1997, 1998a, 1999, and 2000).

Weeks	Corresponding dates	Brood year	Average FL (mm)	Total
12-18	Mar 17-Apr 28, 1996	1995 +	22-160	1730
27-40	Jun 30-Sep 29, 1996	1996		
40-52	Oct 1-Dec 22, 1996	not reported		
6-19	Feb 2-May 4, 1997	not reported	22-169	11,367
27-38	Jun 29-Sep 14, 1997	not reported		
28-40	Jul 5-Sep 27, 1998	not reported	28-205	8774
40-6	Oct 1, 1998-Jan 31, 1999	1998	27-165	2201
27-39	Jun 27-Sep 19, 1999	1999		5179

2.2.3 Red Bluff Diversion Dam rotary screw trapping

From June 1994 through June 2000 and 2002 to the present, USFWS used four rotary screw traps (RST) directly downstream from RBDD to capture downstream migrating juvenile winter-run chinook salmon. Captured salmonids were enumerated, measured

(FL), and released downstream from the traps. Chinook salmon race was determined using length-at-date criteria developed by Fisher (1992) and further modified by Greene in 1992.[4] These surveys enabled development of a juvenile production index (JPI) for juvenile winter-run chinook in the upper Sacramento River (Appendix 1-H). Indices were representative of nine complete brood years (BY) of winter-run chinook juvenile production (1995-1999 and 2002-2004). USFWS also used this data in conjunction with winter-run chinook escapement estimates based on RBDD ladder counts and carcass surveys, and to aid in estimation of egg-to-fry survival rates. Gaines and Poytress (2003 and 2004) produced a table of results, comparing juvenile production estimates (JPE) and rotary screw trapping juvenile production indices (Appendix 1-I). Historically, RBDD fish counts were used as the adult escapement portion of the juvenile production model, until recently when winter-run chinook carcass survey escapement estimates were used (Gaines and Poytress 2004).

Vogel and Marine (1991) developed estimates of cumulative percentages of winter-run chinook brood year's monthly passage at RBDD (Appendix 1-J). These estimates were made using data from CDFGs downstream migrant trap at RBDD.

2.2.4 Battle Creek rotary screw trapping

USFWS operates two RSTs in Battle Creek, on at RK 4.6 and the other about the CNFH barrier weir at RK 9.5. Trapping results indicate that Battle Creek does not appear to have a self-sustaining run of winter-run chinook. Although winter-run sized chinook do appear in the traps, there is no detectable production of fry from July through October, when they would be expected to occur in the system. During the winter months, winter-run sized chinook are captured in the lower trap. These fish range in size from 45-120mm FL, which is similar to non-natal rearing of fry spawning the mainstem Sacramento River. It is likely that the few winter-run sized chinook (90-110 mm FL) captured in the upper trap are late spawned late-fall-run chinook (USFWS 2005a). From 1999-2003, only 1-2 winter-run sized chinook were captured each year in the upper trap.

2.2.5 Glenn-Colusa Irrigation District oxbow catch totals

The Glenn-Colusa Irrigation District's (GCID) Hamilton City pumping station is located about 161 km north of Sacramento. This station is situated at an oxbow and pumps water from the mainstem Sacramento River and delivers it to various water projects through canals, primarily to support agricultural activities. Rotary screw trapping has been used to monitor juvenile emigration through the oxbow beginning in 1988, but on a more consistent basis since 1991. Data are used to monitor the timing of winter-run emigration from the upper Sacramento River, for use in Delta water project operations. Improved fish screens were added in 2000 by USBR to improve survival of juvenile salmonids

[4] Sheila Greene, California Department of Water Resources, Environmental Services Office, Sacramento, CA, (916)227-7538.

emigrating past this location. Appendix 1-K shows winter-run chinook juvenile catch data at GCID for 1988-1990.[5]

2.2.6 Sacramento-San Joaquin Delta rotary screw trapping

CDFG initiated a pilot study in November 1995 to monitor juvenile salmonid emigration at Knights Landing (RK 144), enabling collection of data from fish leaving the Sacramento River system and entering the Sacramento-San Joaquin Delta. These surveys utilized two RSTs to capture emigrating fish, as well as fyke nets and a Kodiak trawl to determine trap and gear efficiency. Wild and hatchery fish were captured during trapping periods, as presented in Appendices 1-L through 1-X. Fish which were not adipose fin-clipped were assumed to be produced 'in-river' (Snider and Titus 1998). In addition to direct counts of fish caught in the traps, CDFG also produced relative abundance estimates of the total number of salmon (by run) and *O. mykiss* passing the Knights Landing monitoring site during trapping periods. Average trap efficiency is reported separately for each year. Appendices 1-Y and 1-Z provide summaries of hatchery and in-river produced chinook salmon and *O. mykiss* abundance indices captured during these surveys.

2.2.7 Sacramento-San Joaquin Delta seining and trawling

The Interagency Ecological Program (IEP) for the Central Valley funds monitoring programs to study distribution and abundance of juvenile salmon in the lower Sacramento and San Joaquin Rivers, the Delta, and San Francisco Bay. Monitoring activities include beach seining and midwater and Kodiak trawls. Timing of these efforts tends to mainly detect trends in juvenile fall-run chinook abundance and distribution (Brandes et al. 2000). Beach seining is used to document trends in distribution and long-term abundance for nearshore areas. Sampling occurs at 45 sites between the lower Sacramento River (downstream from Colusa) to Treasure Island in the San Francisco Bay. From 1981 to 1986 (and then starting again in 1997), sampling occurred either once per week or once every two weeks depending on location and time of year. Sampling using midwater and Kodiak trawls has been conducted on the Sacramento River near Sacramento from April through June since 1988 (Appendix 1-AA) and at Chipps Island from April through June since 1976. From 1976 through 1992, Chipps Island trawls were initially mainly focused on detection of fall-run chinook as they emigrated toward the Delta. However, since 1991 additional trawl sites were added and sampling times were adjusted to take place year-round, enabling more effective monitoring of all Central Valley juvenile chinook races.

Winter-run chinook juvenile outmigration size and timing through the Delta are summarized using various agency and project data, including data from catches at water diversion fish screens, USFWS beach seining (Appendix 1-BB), Chipps Island

[5] GCID rotary screw trapping data from 1991-2005 is available from Diane Coulon, CDFG, P.O. Box 117, Hamilton City, CA 95951, phone number (530) 865-9331 or from the IEP website (http://baydelta.ca.gov).

(Appendices 1-CC and 1-DD) and Golden Gate trawls (Appendix 1-EE), Central Valley and State Water Project salvage information, and other reports (Brown and Green 1992). Hedgecock (2002) used a log-likelihood ratio test to determine individual run assignment in Delta pumping operations. This test can be used to determine if a fish can be classified as a winter-run or non-winter-run chinook salmon, thus enabling a better understanding of timing and growth rates as juvenile salmonids migrate through the Delta.

3 SPRING-RUN CHINOOK SALMON

Under the United States Endangered Species Act of 1973 and the California Endangered Species Act, spring-run chinook salmon in California's Central Valley were listed as a threatened species in 1999 (NMFS 1999). They belong to the 'Central Valley Spring-run Chinook Salmon' ESU (Myers et al. 1998; Lindley et al. 2004). Spring-run chinook were historically present throughout the entire Sacramento-San Joaquin River systems (Yoshiyama et al. 1996; Schick et al. 2004) and were thought to be the predominant run of the four major chinook salmon runs in the Central Valley (winter, spring, fall, and late-fall). Historically, spring-run chinook adults migrated into the upper watersheds during high spring flows. This is one life history trait that distinguishes them from the Central Valley's fall- and late-fall-run chinook, which are limited in their upstream spawning migrations by generally lower fall flows. Their propensity for traveling the furthest upstream to complete spawning migrations has adversely affected spring-run chinook population size, as significant amounts of upstream habitat were lost in the 1950s and 1960s due to dam construction and other water diversion projects. Dams and other water diversions have also dramatically reduced stream flows, leading to increased water temperatures during the summer adult holding period. The remaining extant Central Valley spring-run chinook populations include those in Mill, Deer, and Butte Creeks, and the Feather River. However, based on findings by Hedgecock (2002), Feather River spring-run chinook are more genetically similar to fall-run than other spring-run chinook populations (Lindley et al. 2004).

Adult spring-run chinook salmon leave the ocean and begin entering the Sacramento River system in late January to early February (Ward and McReynolds 2001). As fish reach their native spawning streams in March through June, they hold-over in deep pools to take advantage of cooler water and begin spawning in the late summer, from the end of August through the end of October. Spring-run chinook are sexually immature when they leave the ocean and are able to utilize this hold-over time to reach maturation before spawning. They require relatively low water temperatures during summer hold-over in these pools, and are thus limited to streams where cooler temperatures prevail during the hottest times of the year. In locations such as the Stanislaus River, where spring- and fall-run chinook spawning habitat overlap, it is likely that spring-run chinook redds are vulnerable to destruction by fall-run chinook (CMC and SPCA 2002), as fall-run chinook spawn later (late-October through December).

Spring-run chinook females are of average fecundity when compared to other chinook runs in the Central Valley, on the order of 4900 eggs per spawning female. Age of returning adults was also estimated from 1985 through 1991 by trapping and examining spring-run chinook at RBDD. These values were used to estimate cohort replacement rates. Most returning fish were determined to be three-year-olds (CDFG 2001), however, age-at-return is variable, depending on the year. Table 4 summarizes spring-run chinook monitoring projects presented in this report.

Table 4. Summary of spring-run chinook salmon (*Oncorhynchus tshawytscha*) adult and juvenile monitoring activities in California's Central Valley.

Tributary	Life Stage	Monitoring method	Variable measured	Date(s)	Agency	Project Leader(s)	Data location in this report[a]
Sacramento-San Joaquin River systems (including tribs)	Adult	Miscellaneous (Dam counts, carcass and redd surveys)	Escapement	1940-2004*	Multiple	Jim Smith, USFWS / Doug Killam, CDFG	Appendices 2-A and 2-B
Upper Sacramento River (RBDD)	Adult	RBDD counts	Escapement	1972-2002*	USFWS, CDFG	-	Appendix 2-C
Upper Sacramento River	Adult	Sport fishery catch	Recreational catch rates	1972-1996	CDFG	-	Appendix 2-C
Mainstem Sacramento River only	Adult	Sport fishery catch	Recreational catch rates	1967-1991	CDFG	-	Appendix 2-D
Mainstem Sacramento River	Adult	Aerial redd surveys	Spawning distribution	1983-2004*	CDFG	Doug Killam, CDFG	Appendices 2-G and 2-H (tributaries)
Clear Creek	Adult	Snorkel surveys	Population indices	1999-2004*	USFWS	Matt Brown, USFWS	Table 5
Clear Creek	Adult	Redd surveys	Spawning distribution	1999-2004*	USFWS	Matt Brown, USFWS	Section 3.1.5
Clear Creek	Adult	Carcass surveys	Age/sex composition of spawners	1999-2004*	USFWS	Matt Brown, USFWS	Section 3.1.5

Table 4 (cont.). Summary of spring-run chinook salmon (*Oncorhynchus tshawytscha*) adult and juvenile monitoring activities in California's Central Valley.

Tributary	Life Stage	Monitoring method	Variable measured	Date(s)	Agency	Project Leader(s)	Data location in this report[a]
Beegum Creek	Adult	Snorkel (infrequent carcass and aerial redd surveys)	Population indices, spawning distribution	1973-2003*	CDFG	Doug Killam, CDFG	Appendices 2-E and 2-H
Battle Creek	Adult	Coleman barrier weir and video monitoring	Fish passage beyond barrier	2001	USFWS	Matt Brown, USFWS	Appendix 2-A and Table 6
Battle Creek	Adult	Snorkel and redd surveys	Spring-run chinook presence and spawning distribution	1996-2004*	USFWS	Matt Brown, USFWS	Section 3.1.8
Antelope Creek	Adult	Snorkel surveys	Spring-run chinook presence and spawning distribution	1989-2004*	CDFG, USFS, SPI	Colleen Harvey-Arrison, CDFG	Section 3.1.9 and Table 7
Mill Creek	Adult	Estimates only	Escapement	1947-1953	USFWS	-	Appendix 2-A
Mill Creek	Adult	Clough Dam counts	Escapement	1953-1964, 1986-1996	CDFG	-	Appendix 2-A
Mill Creek	Adult	Carcass and snorkel surveys	Escapement and age/sex composition of spawners	1970-1976	CDFG	-	Appendix 2-A
Mill Creek	Adult	Aerial and ground surveys of spawning area	Escapement and spawning distribution	1997-2004*	CDFG	Colleen Harvey-Arrison, CDFG	Appendices 2-A and 2-H

Table 4 (cont.). Summary of spring-run chinook salmon (*Oncorhynchus tshawytscha*) adult and juvenile monitoring activities in California's Central Valley.

Tributary	Life Stage	Monitoring method	Variable measured	Date(s)	Agency	Project Leader(s)	Data location in this report[a]
Deer Creek	Adult	Miscellaneous - counting stations, carcass and snorkel surveys	Escapement	1941-2004*	USFWS, CDFG, USFS	Colleen Harvey-Arrison, CDFG	Appendices 2-A and 2-H
Big Chico Creek	Adult	Snorkel, carcass, and redd surveys	Escapement	1957-2004*	CDFG	Paul Ward, CDFG	Appendix 2-A
Butte Creek	Adult	Snorkel, carcass, and redd surveys	Escapement	1953-2004*	CDFG	Paul Ward, CDFG	Appendix 2-A
Feather River	Adult	Feather River Hatchery (FRH) counts	Adult returns	1967-2004*	CDFG	Anna Kastner, FRH	Appendix 2-F
Feather River	Adult	Carcass surveys	Escapement	1995-2004*	CDWR	Brad Cavallo, CDWR	Appendix 2-A
Yuba River	Adult	Redd counts	Spawning distribution	1995-2004*	CDFG	John Nelson, CDFG	Section 3.1.15 and Appendix 2-H
Yuba River	Adult	Daguerre Point Dam fish passage monitoring	Escapement	2001-2004*	CDFG, USFWS, YCWA	Duane Massa, CDFG	Section 3.1.15
Upper Sacramento River (Balls Ferry/Deschutes Road Bridge)	Juvenile	Rotary screw traps	Abundance and outmigrant timing	1996-1999	USFWS	Rob Titus, CDFG	Appendix 2-I

Table 4 (cont.). Summary of spring-run chinook salmon (*Oncorhynchus tshawytscha*) adult and juvenile monitoring activities in California's Central Valley.

Tributary	Life Stage	Monitoring method	Variable measured	Date(s)	Agency	Project Leader(s)	Data location in this report[a]
Upper Sacramento River (RBDD)	Juvenile	Rotary screw traps	Abundance and outmigrant timing	1994-1999*	USFWS, CDFG	Bill Poytress, USFWS	Appendix 2-J
Upper Sacramento River	Juvenile	Habitat surveys (snorkel/seine)	Spatial and temporal distribution	1996-2001	CDFG, USFWS	-	n/a[b]
Clear Creek	Juvenile	Rotary screw traps	Relative abundance and population trends	1999-2004*	USFWS	Matt Brown, USFWS	Section 3.2.1
Battle Creek	Juvenile	Rotary screw traps	Abundance and outmigrant timing	1998-2004*	USFWS	Matt Brown, USFWS	Section 3.2.2
Mill Creek	Juvenile	Rotary screw traps	Abundance and outmigrant timing	2000-2003*	CDFG	Colleen Harvey-Arrison, CDFG	Appendix 2-K
Deer Creek	Juvenile	Rotary screw traps	Abundance and outmigrant timing	2000-2003*	CDFG	Colleen Harvey-Arrison, CDFG	Appendix 2-L
Big Chico Creek	Juvenile	Rotary screw traps	Abundance and outmigrant timing	1999-2004*	CDFG	Paul Ward, CDFG	Table 9
Butte Creek	Juvenile	Rotary screw traps and CWT	Abundance and outmigrant timing	1995-2002*	CDFG	Paul Ward, CDFG	Appendix 2-M

Table 4 (cont.). Summary of spring-run chinook salmon (*Oncorhynchus tshawytscha*) adult and juvenile monitoring activities in California's Central Valley.

Tributary	Life Stage	Monitoring method	Variable measured	Date(s)	Agency	Project Leader(s)	Data location in this report[a]
Yuba River	Juvenile	Rotary screw traps	Run timing and differentiation from fall-run chinook	1999-2004*	CDFG	John Nelson, CDFG	Section 3.2.8
Lower Sacramento River (Knights Landing)	Juvenile	Rotary screw traps, fyke nets, and Kodiak trawls	Emigration timing and relative abundance	1995-2004*	CDFG	Rob Titus, CDFG	Appendices 1-L through 1-T and 1-Z
Sacramento River (Sacramento)	Juvenile	Midwater and Kodiak trawls	Emigration timing and relative abundance	1988-2004*	USFWS	Paul Cadrett, USFWS	Appendix 2-N
Sacramento-San Joaquin Delta (Chipps Island)	Juvenile	Trawls	Emigration timing and relative abundance	1976-2004*	USFWS	Paul Cadrett, UFWS	Appendix 2-O

* Indicates project is ongoing beyond end year provided.
[a] Data not available or present in this report is listed as 'n/a.'
[b] Chinook run origin not differentiated in reports.

3.1 Adult spring-run chinook data summaries

CDFG started monitoring spring-run chinook in the Central Valley in the early 1940s, however, more comprehensive studies of distribution, life history and run enumeration did not begin until the 1990s. Spring-run chinook spawning escapement estimates from 1940-1952 are spotty and only include counts on scattered streams, without relating escapement numbers to larger river systems within the Central Valley. Detailed historical accounts of spring-run chinook population estimation methodologies are listed in CDFG (1998b). Starting in 1953, escapement numbers from different streams and rivers were combined to yield an overall escapement estimate for the entire Central Valley, although these counts are far from being considered complete. Stream survey methods tended to be inconsistent from year-to-year. Also, in some systems like the Feather River where spring- and fall-run chinook overlap in time and space, little or no effort is made to separate the counts of these two chinook runs. Spring-run chinook are included in fall-run chinook counts, making it impossible to extract and report numbers of spring-run chinook for these systems during certain time periods.

Spring-run chinook escapements listed in Appendices 2-A and 2-B are not considered complete, especially those before the early 1990's. Early fisheries biologists in the Central Valley had not yet developed consistent and accurate methods for counting salmon runs. Counting weirs, fish ladders, tag and recovery methods, and spawning area/redd counts were used in developing population estimates. However, these methods were plagued with problems such as inexperienced crews, difficult survey conditions, inefficient equipment, lack of reliable estimators for uncounted fish, and inability to distinguish between runs when using certain methods. For example, counting weirs were used in some locations, but were passable under certain flows. Fish were able to get through or around some weirs, and an appropriate method for estimating these fish was not developed in the early years. Generally, the larger the system the more chance that escapement estimates were understated due to problems with undetected passage at weirs or counting stations (Fry 1961). Also, counts do not include spawning fish below counting stations. It is probable that in some years, estimates given were too high and in others too low, depending on crew adequacy and environmental conditions.

Limited resources at monitoring agencies like CDFG and USFWS have been a factor in the inability to obtain complete spawner counts for spring-run chinook from streams where spring-run chinook once existed or currently exist in small numbers. Surveys generally focused on locations where the largest numbers of spring-run chinook were known to exist in each system. Only limited surveys were conducted on systems with small numbers of spring-run chinook present, and no surveys were attempted where spring-run chinook were not known to exist.

3.1.1 Early escapement estimate attempts

Estimates from 1953 represent a peak in spring-run chinook escapement (Fry and Petrovich 1970). From 1940-1969, attempts were made to estimate escapement using

carcass surveys for Chico Creek, Butte Creek, and the Feather River. Field crews walked or floated spawning streams and counted the number of carcasses present in the section surveyed. Carcasses observed were cut in half to prevent double counting. Surveys were conducted from one to ten times per system, depending on system productivity (i.e. streams with more spawning fish were sampled more frequently). From the surveys, the number of probable spawners was calculated as an estimate and referred to as the 'escapement estimate,' or total number of spawners for a particular run in a certain area.

3.1.2 Sacramento River escapement estimates

Spring-run chinook escapement in the Sacramento River above RBDD was estimated using methods similar to those described in Section 2.1.1. Upstream passage at RBDD was monitored using a closed circuit video camera to record salmon passing through the ladders, and daily counts were conducted by USFWS. Weekly counts were adjusted for periods when counts could not be made due to increased river turbidity levels, flood conditions causing dam gates to be opened, or night hours when counts were not made. Interpolation was used to adjust for counting lapses during the daytime, and a factor of 1.042 was multiplied by daytime counts for night-counting adjustments (Taylor 1974). Appendix 1-A shows the average historical migration timing for spring-run chinook passing RBDD from 1970-1988. These data were used when estimating the number of spring-run chinook passing RBDD during times when exact counts were not possible. The spring-run chinook estimate for the Sacramento River in 1969 (20,000 fish) was based on periodic sampling at the RBDD fish trap by USFWS (Menchen 1970), not on carcass survey counts as no effort was made to separate fall- and spring-run chinook carcasses. This number served as an estimate of natural spawners occurring upstream from the diversion dam. As shown in Appendix 2-C, spring-run chinook escapement above RBDD was adjusted by subtracting the sport fishery catch (see Section 3.1.3). Spring-run chinook estimates in smaller tributaries to the Sacramento River (mainly Antelope Creek, Clear Creek, Cottonwood Creek, Cow Creek, and Paynes Creek) were between 500 and 1,000 in the three years surveyed between 1950 and 1960. Periodic carcass surveys were generally used to obtain these estimates. Spawning escapement estimates in the Sacramento River system south of RBDD were based primarily on spawning bed surveys and carcass counts (Taylor 1973).

3.1.3 Sacramento River angler harvest

Spring-run chinook sport fishery catch (Appendix 2-C) was estimated using bi-weekly surveys of fishing resorts and public boat launches. Catch was estimated by multiplying the number reported caught for an entire season by a factor of 1.5944. This factor is reported in Reavis (1983) without much explanation on how it was derived.

Estimates for spring-run chinook angler harvest above RBDD were determined using the same methods as winter run (see Section 2.1.5). Mills and Fisher (1994) summarized

harvest of all chinook salmon races in the Sacramento River from 1967 through 1991. Appendix 2-D lists spring-run chinook harvest estimates, not including tributaries.

3.1.4 Sacramento River aerial redd surveys

Redd distribution has been assessed using aerial surveys for spring-run chinook in the mainstem Sacramento River from Keswick Dam to Princeton Ferry (Appendix 2-G) and in selected tributaries (Appendix 2-H). Methods are the same as those described for winter-run chinook in Section 2.1.3. Spring-run chinook redd determination can be difficult as spawn timing overlaps with fall-run chinook. CDFG assumes August 20 as the approximate start date for spring-run chinook spawning.[6] CDFG considers chinook salmon spawning in the mainstem Sacramento River in September to be spring-run chinook, however, no evidence exists to prove this assumption. Genetic analysis is currently underway that should yield more information about differentiating between spring- and fall-run chinook spawners. Run timing estimates could be changed or fine-tuned based on the results of this analysis.

3.1.5 Clear Creek life history studies

Clear Creek, located in Shasta County, is a tributary to the upper Sacramento River, entering the river at RK 465. Clear Creek supports spawning populations of spring- and fall-run chinook and steelhead. However, habitat degradation occurring in the 1960's through the 1980's caused significant declines in salmonid production in this system. Loss of quality spawning gravels due to extensive gravel mining, impaired flows due to construction of Whiskeytown Dam and other smaller water diversions, and blockage of upstream anadromous fish migration at Saeltzer Dam (Clear Creek RK 9.7) have contributed to the decline in salmonid populations (CDWR 1986). However, various habitat restoration programs, including increased instream flows, Saeltzer Dam removal (2000), and gravel replenishment, have aided in attempting to improve spawning and rearing conditions for salmonids at different life history stages.

Currently, all anadromous salmonid restoration and monitoring activities occur in the portion of Clear Creek below Whiskeytown Dam, which is a barrier to upstream migration. Restoration actions target, in part, re-establishing a population of spring-run chinook in Clear Creek. Adult spring-run chinook studies conducted by USFWS include snorkel surveys, redd measurements, environmental variable monitoring, natural barrier analysis, and the operation of a temporary weir (beginning in 2003) to separate spawning spring- and fall-run chinook. Counts of live fish from snorkel surveys provide an annual population index from this small population of spring-run chinook. Life history characteristics such as run timing and spatial distribution can also be documented. Carcass counts provide information on carcass distribution, genetic and age analysis (when tissue or scale samples are taken), and information on physical characteristics of returning adult salmon. Redd surveys show spawning distribution and can provide

[6] D. Killam, CDFG, 2440 Main Street, Red Bluff, CA 96080, 02 March 2005, personal communication.

estimates of the spawner population size. Additional gravel analysis allows for monitoring of restoration efforts as related to artificial gravel being added to the system to enhance spawning grounds. Natural barriers were also documented and classified as to upstream passage by chinook.

USFWS started surveys for spring-run chinook in Clear Creek in 1999, with monthly surveys of a 26.4 km section below Whiskeytown Dam beginning in 2000. Survey frequency increased to every two weeks during the spawning season (September through October) in 2002 to more accurately determine spawn timing. Snorkel surveys focus on counting spring-run from April through November with the August count being the annual population index (Table 5). The most consistent survey conditions existed in August with excellent visibility and low flows (Newton and Brown 2004). Snorkel surveys focus on counting spring-run chinook from April through November. The most consistent survey conditions existed in August, with excellent visibility and low flows (Newton and Brown 2004). Divers counted live fish, carcasses, and redds. Some live fish counts, especially those in late-fall are considered *potential* spring-run chinook due to the possibility that fish might be fall-run in origin and it can be impossible to positively distinguish between the two runs based solely on visual observation. Counts from Clear Creek mainly utilize run timing as the determining factor when classifying fish as spring- or fall-run chinook. The spatial separation of spring- and fall-run chinook was achieved in 2003 and 2004 by the operation of a temporary picket weir during September and October (CDFG 2004b). The weir prevented hybridization and served to increase the accuracy of run designation of live chinook, carcasses, and redds.

Coded-wire tags are recovered during spawner surveys, revealing presence of both spring- and fall-run chinook which originated from the Feather River Hatchery in Oroville, California (Newton and Brown 2004). One Butte Creek spring-run chinook (BY 2000) was discovered in Clear Creek based on October 1, 2003 CWT collection (CDFG 2004b). USFWS also counts and measures redds, takes substrate samples, and records other environmental variables during spawner surveys. As with fish identification when spring- and fall-run chinook overlap temporally and spatially, redds could not be differentiated as to run. Surveys were conducted infrequently during winter months. Conducting surveys in January and February can be difficult due to increased turbidity, resulting in decreased visibility for divers.

Table 5. Spring-run chinook salmon annual population indices resulting from snorkel surveys in Clear Creek from 1999-2004 (CDFG 2004b; Newton and Brown 2004).

	1999	2000	2001	2002	2003	2004
Population index	35	9	0	66	25	98[7]

[7] J. Newton, USFWS, 10950 Tyler Road, Red Bluff, CA 96080, 11 January 2005, personal communication.

3.1.6 Cow and Cottonwood Creek spawner surveys

Cow Creek and Cottonwood Creek were thought to historically support small runs of spring-run chinook, although Cow Creek was less likely to have a consistent run due to natural barriers blocking access to spawning grounds and a lack of over-summering habitat (Yoshiyama et al. 1996). In 1989 and 1991, Cow Creek was surveyed for presence of spawning spring-run chinook. Cottonwood Creek was surveyed in 1989 and 1993, as well. Few or no salmon were observed during snorkel surveys of both creeks.

3.1.7 Beegum Creek spawner surveys

Beegum Creek, a tributary to Cottonwood Creek, currently hosts a small, but growing population of spring-run chinook. This population travels the furthest upstream of any Central Valley spring-run chinook population and encounters some of the highest temperatures as they enter Cottonwood Creek from the Sacramento River (CDFG 2004b). Spring-run chinook arrive as early as late March in this system, with spawning starting in late September. Eleven kilometers of spring-run chinook holding pools of Beegum Creek were snorkeled each year from 2000 through 2003. Only three carcasses were found during the 2000 survey, but aerial redd surveys were also completed and confirmed spring-run chinook spawning presence and spatial isolation from spawning fall-run chinook (CDFG 2001). Tissue samples were collected from these carcasses. Spawner surveys confirmed the continued separation of Beegum Creek spring-run chinook and Cottonwood Creek fall-run chinook salmon (CDFG 2004b). Appendix 2-E lists spring-run chinook snorkel counts in Beegum Creek from 1973 through 2003. Killam and Moore (2001) note that of the 340 salmon counted during monthly 2001 snorkel surveys, probably only 50 survived to participate in spawning activities due to high water temperatures during the summer holding period.

3.1.8 Battle Creek monitoring surveys

A spring-run chinook population exists in Battle Creek (USFWS 2001). USFWS monitors fish passage beyond the Coleman National Fish Hatchery on Battle Creek using the upstream ladder of the hatchery's barrier weir. This is accomplished by live trapping at the weir for part of the season and using a video camera later in the season. Marked versus unmarked fish are noted. Hatchery fish are 'marked' by clipping their adipose fin. Some unmarked fish (assumed to not be of hatchery-origin) pass in late spring and early summer and could potentially be considered spring- ,winter-, fall-, or even late-fall-run chinook. Passage decreases to zero during the mid to late summer, perhaps due to lower flows and increased water temperatures (assumed too high for chinook to tolerate) or possibly due to temporal separation of spring- and fall-run chinook populations in Battle Creek. It is possible that small numbers of spring-run chinook can enter Battle Creek as late as November, when large numbers of fall-run chinook also begin entering the system. Without taking samples for genetic analysis from each fish at this point, it is impossible to determine if chinook salmon passing the video monitor are of spring- or

fall-run origin. Most are considered early-arriving fall-run chinook. In 2004, the barrier weir ladder was closed to prevent upstream passage of early-arriving fall-run chinook.

Monitoring passage using the live trap at the weir can allow for tissue collection to determine run origin. Phenotypic characteristics and run timing are also important factors used when establishing run origin. Based on the absence of certainty for determining if fish are spring-run chinook in Battle Creek, several reports (CDFG 2001 and 2002a) list resultant escapement estimates as 'potentially' spring-run chinook. For example, USFWS reports 144 'potential' spring-run chinook migrated beyond the Coleman barrier weir in 2002 based on a combination of results from live trapping and weir passage video monitoring data.

Battle Creek enters the Sacramento River at RK 438. Its importance to spring- and winter-run chinook salmon lies in its ability to naturally sustain a remnant population of spring-run chinook and to provide another spawning and rearing location for winter-run chinook. In 1996, USFWS started snorkel and redd count surveys for spring-run chinook salmon in Battle Creek. Snorkel surveys were conducted daily (Monday through Friday) from September 1 through October 11, 1996 to locate spring-run chinook spawning areas and to determine spawn timing (Croci and Hamelberg 1998). The study section was divided into 8 reaches, with generally two reaches being surveyed each day so that the entire study area was snorkeled once per week. During the survey period in 1996, 15 redds were counted above the CNFH barrier weir, with the first redd observed on 17 September 1996.

From March through October 2001, USFWS conducted comprehensive surveys on Battle Creek to assess information about spring-run chinook salmon life history. Surveys included trapping fish at the CNFH barrier weir, video monitoring to count upstream migrants, and stream surveys to monitor adult salmonids. The CNFH barrier weir operated from September 1, 2000 through March 3, 2001, completely blocking upstream passage and sometimes diverting fish into the hatchery for propagation (fall- and late-fall-run chinook and steelhead only). Live trapping occurred from March 3 through May 8, 2001, with video monitoring starting May 9 and ending August 31, 2001. Fish were identified as 'clipped' or 'unclipped,' referring to their adipose fin condition. Due to the overlap of all four runs of Central Valley chinook in the system, unclipped chinook were not initially assigned to run, although most would likely be considered spring-run chinook due to survey timing. Later genetic analysis suggested that most of the unclipped fish in 2001 were spring-run chinook, however, in subsequent years the proportion of spring-run chinook decreased. Peak passage for unclipped chinook occurred from May 13-19. Passage estimates (Table 6) were calculated using unknown clip status fish apportioned to unclipped or clipped status and adjusting for number of hours when video taping did not occur (Brown and Newton 2002). Tissue samples were collected from unclipped chinook captured during trapping operations. Of the unclipped chinook listed in Table 6, USFWS estimates approximately 100 of these could be classified as spring-run, based on run timing, CWT recoveries, and genetic analyses.

Table 6. Passage estimates for *Oncorhynchus tshawytscha* beyond the CNFH barrier weir on Battle Creek, California in 2001 (Brown and Newton 2002).

Passage location / timing peak	*O. tshawytscha* (clipped)	*O. tshawytscha* (unclipped)
Timing peak	March 11-17	May 13-19
CNFH	0	94
Trap	0	29
Video	5	82
Totals	5	205

During barrier weir trapping at CNFH in 2002 and 2003, tissue samples were collected from unclipped chinook during live trapping operations. From March 1 through May 27, 2002 a total of 129 unclipped chinook passed above the weir, and from March 3 through May 30, 2003, a total of 67 unclipped chinook passed this location. Following genetic tissue analyses, the 2002 samples yielded 73.7% spring-run chinook and the 2003 samples yielded 68% spring-run chinook (CDFG 2004b).

Starting in 2001, USFWS conducted snorkeling and walking surveys of Battle Creek spawning habitat above and below the barrier weir. Crews completed downstream snorkel surveys once per month from July through October 2001, dividing 34.8 km of stream into 7 reaches. Snorkelers counted live salmonids, redds, and carcasses. Genetic samples were collected from all carcasses encountered and heads were taken from adipose fin-clipped fish for later CWT extraction and analysis. Tissue samples were sent to the UC Davis Bodega Marine Laboratory for genetic analysis. The Lab tested 35 fish from the 2001 surveys, confirming 92% as spring-run chinook salmon (Brown and Newton 2002). Of those identified as spring-run chinook, 51% were most similar to fish of Butte Creek origin and 41% were similar to Mill/Deer Creek spring-run chinook. However, due to the relatively small sample size and type of test used (microsatellite DNA analysis), these determinations should not be used to assign samples to a certain population (M. Brown[8]). The samples could be reanalyzed in the future, using a higher power test to determine population origin.

Of the 15 CWTs recovered and examined during USFWS surveys, 14 identified as CNFH late-fall-run chinook and one was identified as a spring-run chinook from Feather River Hatchery (FRH). Redd location was recorded using a Global Positioning System (GPS) receiver and spawn time was estimated based on redd condition when encountered. Since 2002, USFWS has attempted to complete snorkel surveys once to twice per month from May through November.

[8] M. Brown, USFWS, 10950 Tyler Road, Red Bluff, CA 96080, 13 December 2004, personal communication.

3.1.9 Antelope Creek snorkel surveys

Holding habitat in Antelope Creek was snorkeled annually from 1989 through 1997, however, only seven live salmon or fewer were observed each year. No population estimates were made for these years. The survey in 1998 yielded a high count of 154 spring-run chinook. Snorkel surveys continue on Antelope Creek once per year in July. Most of the spawning habitat is snorkeled, covering approximately 24 km of spring-run chinook holding habitat, including the north fork, south fork and mainstem. These surveys are completed cooperatively between three agencies, CDFG, U. S. Forest Service (USFS), and Sierra Pacific Industries (SPI). Table 7 provides snorkel counts for Antelope Creek spring-run chinook from 1995 through 2004.

Table 7. Adult spring-run chinook salmon population counts based on annual snorkel surveys of holding and spawning habitat in Antelope Creek, 1995 to 2004 (CDFG 2004b).

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Count	7	1	0	154	40	9	8	46	46	3[9]

3.1.10 Mill Creek surveys

USFWS estimated spring-run chinook escapement in Mill Creek from 1947 through 1953. From 1953-1964, CDFG used a counting station at Clough dam to determine spring-run chinook escapement. This dam is a concrete diversion dam located 6.6 km upstream from the creek mouth. It is assumed that most spring-run chinook spawn above the dam. Escapement was not determined from 1965-1969. In 1970, CDFG began utilizing carcass surveys to estimate spring-run chinook escapement in Mill Creek. Snorkel surveys were also occasionally implemented when complete carcass surveys were not possible. Very few carcass survey trips were made each fall, and low carcass recovery rates were experienced due to difficulties in sampling deep pools and spawning reach inaccessibility (Menchen 1971). Terrain and access can be challenging in upper Mill Creek, making surveys difficult and infrequent. In some years, over ten days were required to complete a single survey. In 1976, a lack of resources led to an incomplete, one-day survey resulting in the observation of 87 live fish (Hoopaugh 1978), thus no escapement estimate was made for that year.

CDFG began using Clough Dam counts on Mill Creek again in 1986 and continued this practice through 1996. Fish were counted as they passed through a fish ladder and subsequent tunnel, which led them past an attached electronic fish counter. Counter accuracy was validated by visual observation twice each week (Kano 1997). In years where the counting station did not monitor the entire spring-run chinook migration period, an expansion of historical data (1954-1963) was used to determine a more

[9] C. Harvey-Arrison, CDFG, P.O. Box 578, Red Bluff, CA 96080, 11 January 2005, personal communication.

complete escapement estimate. Due to high spring flows in 1993, the counter was not installed at Clough Dam and was used at Ward Dam instead. Severe flooding in 1997 caused significant damage to Clough Dam, which is currently scheduled for removal. Starting in 1997, spring-run chinook spawning population estimates were made using a combination of aerial and ground surveys from the Highway 36 Bridge to the transmission lines spanning the creek just below the Little Mill Creek confluence, covering approximately 40 km. Surveys are conducted each year during the first two weeks of October. From these surveys, redd counts were expanded to determine the spawning escapement estimate. Separate fall-run chinook surveys verify spatial and temporal differences between spring- and fall-run chinook spawning patterns.

3.1.11 Deer Creek surveys

Deer Creek spring-run chinook escapement estimates were made by USFWS using a weir and counting station from 1941-1948. Estimates were made to determine existing natural run size, as a plan existed to transfer spring-run chinook taken at Keswick Dam to Deer Creek to supplement natural spawning. However, after 1948 the counting station was not used and from 1949-1956 spring-run chinook escapement was only determined using a 'best-guess' estimate. Specific estimation methods are not given in the literature for this time period. Planting fish taken from Keswick Dam into Deer Creek did not seem to change the population size in this system, as escapement estimates remained relatively unchanged.

Carcass surveys were used in Deer Creek starting in 1970. The first survey yielded an estimate of 2,000 fish and was based on counts of 200 live fish and 30 carcasses observed on two survey trips. Deer Creek exhibits terrain difficulties similar to those of Mill Creek, making access challenging and multiple survey trips rarely feasible. An informal snorkel survey was used to estimate escapement in 1985 by USFS. Kano and Reavis (1996) suggest USFS used 'professional judgment' to develop a spawning population estimate based on that particular survey. A USFWS fish ladder count of 543 fish at Stanford-Vina Dam was used as the 1986 escapement estimate, although CDFG also conducted a survey of live fish in selected spawning reaches. In 1987, U.C. Davis personnel snorkeled an index reach of Deer Creek (from Highway 32 to the A-Line Road crossing). Based on a ratio developed between the 1986 spawner surveys and Stanford-Vina Dam counts, a 1987 population estimate of 200 spring-run chinook salmon was determined (Kano and Reavis 1997b). In 1988, the same index reach was snorkeled again, and the ratio used between spawner survey and dam counts in 1986 (31%) was used to determine spring-run chinook escapement of 371 fish (Kano 1997). Similar methods were used to estimate escapement for 1989 through 1991. Based on comparisons between spring- and fall-run chinook spawner surveys in Deer Creek, it is presumed that these two runs remain temporally and spatially isolated from one another (CDFG 2002a). Since 1992, CDFG has snorkeled the entire spawning habitat of Deer Creek once during the first or second week of August. This is a cooperative effort between CDFG, USFS, SPI, NOAA Fisheries Service, and USFWS. During 2002 and

2003 surveys, spatial and temporal isolation between spring- and fall-run chinook was confirmed (CDFG 2004b).

3.1.12 Big Chico Creek life history studies

Big Chico Creek was not surveyed for spring-run chinook consistently until the late 1990's. However, periodic surveys were conducted in years prior to 1998. The estimate of 200 fish for Big Chico Creek in 1969 was based on a one-day carcass survey, where thirteen carcasses were recovered with six redds and thirteen live fish observed (Menchen 1970). Surveys in years after 1969 were conducted over a period of several days during the spawning period. Carcasses, redds, and live fish were counted to estimate escapement. CDFG started using snorkel surveys in Big Chico Creek in 1989, surveying sections of upper and lower Bidwell Park and a pool ("Higgins Hole") at the known upstream limit for spring-run chinook (Higgins Hole, 0.8 km upstream from Ponderosa Way crossing). Too few fish were observed to estimate escapement. Similar results were obtained in 1990, when a brief snorkel survey yielded no observations of adult salmon. One aerial survey was made in 1992, but no live fish or redds were observed, and no escapement estimate was made. A snorkel survey in 1993 yielded a spawning population estimate of 38 fish, with similar surveys in 1994-1996 only detecting several adult salmon. Big Chico Creek was added to the Butte Creek spring-run chinook life history studies in 1998, when snorkel surveys were initiated to estimate adult escapement.

3.1.13 Butte Creek life history studies

Butte Creek enters the Sacramento River at the Butte Slough outfall gates and at the downstream end of the Sutter Bypass, near the confluence between the Feather and Sacramento Rivers. As one of the major tributaries to the middle Sacramento River, Butte Creek is an unusual system in that it generally maintains a larger spring-run chinook population than fall-run chinook population. The relatively large number of spring-run chinook present in the system from February through April in the mid-1980's was even enough to enable development of a short-term sport fishery (Kano and Reavis 1997a). Early spring-run chinook estimates were based on carcass surveys, usually taking place on only a few days over an entire spawning period. Many surveys involved counting carcasses, redds, and live fish on redds and producing a population estimate based on these variables. In the mid-1980's, helicopter and canoe surveys were used to estimate spawning population size. Redd counts were the basis of spawner population estimates during years when helicopter surveys were conducted. CDFG conducted a snorkel survey in 1989 to count adult spring-run chinook present in the system from Centerville Head Dam to Helltown Bridge (Kano 1998a). The count was combined with results from carcass surveys of other sections of Butte Creek to derive an escapement estimate of approximately 1300 fish. This method was also used in 1990. No survey was attempted the following year. The 1992 spawning population estimate of 730 salmon was based on one aerial survey by CDFG and several snorkel surveys by Pacific Gas and

Electric Company (PG&E). Snorkel surveys continued to be used for Butte Creek from 1993 until the present.

CDFG started extensive Butte Creek spring-run chinook salmon life history studies in 1995, which included snorkel surveys to determine escapement estimates, juvenile outmigrant trapping, juvenile CWT tagging, tissue collection, and adult CWT recovery. Starting in 1995, the entire spring-run chinook holding habitat in Butte Creek was snorkeled to develop an escapement estimate. This section covers approximately 16.9 km from Centerville Head Dam to Parrott-Phelan Diversion Dam (Hill and Webber 1999). Observers snorkeled downstream through holding pools and counted the number of salmon present in each pool. From 1995 to 2000, where exact counts were not possible due to high numbers of salmon present, divers made estimates. The resulting annual escapement estimates were based on the sum of the maximum count or estimate for all pools snorkeled. Since 2001, the total population estimate was derived by the summation of the average number of salmon per pool, as determined by individual diver counts. Outliers were removed from the average calculation.

Intensive carcass surveys were added to CDFG's spring-run chinook life history studies on Butte Creek in 2001. These surveys were originally intended to generate recovery of CWTs from returning adult salmon, both from juveniles tagged within the system and from possible strays from nearby hatcheries, mainly Feather River Hatchery (Ward et al. 2002). However, the surveys also provided an alternate method of estimating escapement that could be used as a comparison with the snorkel survey escapement estimates. In 2001, the Butte Creek spring-run chinook carcass survey was conducted from September 11 through October 25 on a stretch of creek from Quartz Bowl Pool to the Covered Bridge (about 17.7 km). Standard carcass survey mark-recapture techniques were used, with surveys occurring once per week. CDFG used the Schaefer method (Schaefer 1951) to estimate escapement. Due to the observation of pre-spawn mortality during the 2001 snorkel survey, a separate Schaefer mark-recapture survey was conducted beginning in 2002.

3.1.14 Feather River monitoring surveys

Historically, spring-run chinook were able to ascend the Feather River as far as Big Meadow (now Lake Almanor) and its tributaries on the North Fork, Stirling City on the West Branch, Bald Rock Falls on the Middle Fork, and the upper limit of Lake Oroville on the South Fork (Yoshiyama et al. 1996). However, increased construction of hydroelectric dams and water diversions and resultant effects from hydraulic mining related to gold mining drastically reduced access and quality of available spawning habitat. In the late 1950's through early 1960's, the Feather River still supported a fair-sized spring-run chinook population, averaging almost 2000 fish per year. However, as with other systems in the Central Valley, the effects from water diversions, dams, and especially mining activities on this system continued to severely limit natural spawning opportunities and caused increased water temperatures each summer during spring-run chinook hold-over periods.

Prior to the construction of Oroville Dam in 1968, spring-run chinook spawned predominately in the Middle Fork of the Feather River. Smaller numbers of fish were also able to utilize the West Branch, North Fork, and South Fork. However, the dam completely eliminated all natural spawning in parts of the mainstem, Middle Fork, West Branch, North Fork, and South Fork. Feather River Hatchery was built to mitigate for spawning habitat lost due to Oroville Dam construction. From 1963 through 1967, fish were trapped below the dam and transported about 10.5 km above the dam construction site (Table 8). Early counts of spring-run chinook in the Feather River are rather arbitrary as a specific date was set at the hatchery each year to designate fish entering as spring- or fall-run chinook. For example, in 1981 and 1982 salmon entering the hatchery between September 1 and October 1 were designated as spring-run chinook (Reavis 1983), when it is possible some were actually early-arriving fall-run chinook. All chinook entering after October 1 were assumed to be fall-run chinook. Subsequent CWT analysis from a sample of these fish indicated that some fish deemed 'spring-run' chinook had fall-run chinook parents, indicating the likelihood of run misidentification when based solely on hatchery entry timing.

Table 8. Spring-run chinook salmon trapped and transported above Feather River Hatchery Interim Facility during construction of Oroville Dam from 1963-1967 (Rice 1964, 1967, and 1968; Rice and Pollitt 1965).

Trapping Period	Number of Spring-run Chinook
Sep 30, 1963 – Mar 15, 1964	0 [a]
Mar 16 – Jun 30, 1964	2908
Jul 1, 1964 – Jun 30, 1965	1185
Jul 1, 1965 – Jun 30, 1966	744
Jul 1, 1966 – Nov 22, 1966	0 [b]

[a] Trapping facility was not completed in time to capture any spring-run chinook; only fall-run chinook and steelhead were trapped and transported.
[b] Report specifies chinook as fall-run and does not provide an explanation of why fall- and spring-run chinook counts were not separated.

California Department of Water Resources (CDWR) conducts carcass mark-recapture surveys to estimate fall-run chinook salmon escapement in the Feather River. Surveys generally last from September through December. Naturally-spawning spring-run chinook are not differentiated in these spawner surveys, as overlap occurs in run timing and spatial distribution of spring- and fall-run chinook in this system (Cavallo et al. 2003), as previously discussed in this report. CWT recoveries are made during these surveys which provide information about the number of hatchery-produced spring-run chinook present during fall-run chinook spawner surveys.

3.1.15 Yuba River spawner surveys and upstream passage monitoring

The Yuba River experienced many of the same problems related to hydraulic mining and water diversions as did the Feather River in the mid-1800's, including a dramatic increase in sedimentation and limited fish access to spawning habitat. Before construction of Daguerre Point Dam in 1910, the North Fork Yuba River supported large sized chinook salmon runs (Yoshiyama et al. 1996). Some fish passage was possible beyond this dam, but later construction of Englebright Dam (20.1 km upstream) in the late 1930's served as a complete migration barrier to spring-run chinook. Small numbers of spring-run chinook were still known to exist on the Yuba River in the early 1940's, but no run-size estimate was made. As water diversions and temperatures increased, most of the spring-run chinook formerly present here have disappeared. In some years, spawner population estimates for the Yuba River were based on the number of coded-wire tagged fish from the Feather River Hatchery found during fall-run chinook carcass surveys. The estimate of 200 fish in 1981 was based solely on the assumption of CDFG personnel, not on an actual survey (Reavis 1983). CDFG conducted a one-day survey using bank observations in October 1989, however no population estimate was made from an observation of 150 live fish and about 150 redds. Since spring- and fall-run chinook are not spatially isolated on the Yuba River, run differentiation during spawning surveys can be difficult. In general, CDFG considers spawning occurring in September to be composed of spring-run chinook based on historical run timing accounts.

CDFG initiated Yuba River spawner surveys in 2000, covering approximately 16 km of spawning habitat upstream from Daguerre Point Dam. From 2000 through 2003, 205, 288, 239, and 212 redds were counted, respectively. Generally, the first spawning activity was noted in early September each year. These redds were assumed to be from spring-run chinook based on historical run timing information, however, some could also be from fall-run chinook.

Fish passage monitoring at Daguerre Point Dam on the Yuba River was conducted in 2001, as CDFG and CDWR initiated a trapping program at the dam's fish ladders. Approximately 19 km of spawning habitat exist between Daguerre Point Dam and Englebright Dam (a complete barrier to anadromy). The traps were operated from March 1 through July 31, 2001, with 108 adult chinook salmon captured during this time. Trapping did not occur in 2002 or 2003. In July 2003, CDFG, with the help of Yuba County Water Agency (YCWA) and funding from USFWS, installed a VAKI Riverwatcher Fish Monitoring System on fish ladders at Daguerre Point Dam to monitor fish passage. This system electronically monitors fish as they pass upstream or downstream through the fish ladders. The project hopes to eventually utilize phenotypic characteristics and run timing to differentiate between spring- and fall-run chinook.

3.1.16 Other Central Valley systems

The lower American River supported a small spring-run chinook population until at least 1951. However, mixing with the more numerous fall-run chinook eventually prevented

CDFG from distinguishing between the two runs. Taylor (1973) noted presence of an estimated 500 spring-run chinook in the lower Calaveras River in 1972. However, this finding was not documented on an annual basis and the Calaveras River was not considered a significant location for spring-run chinook to spawn. Since the construction of the major dams and the start of water diversions, no sizeable spring-run chinook spawning population has occurred in the Cosumnes, Mokelumne, Stanislaus, Tuolumne, or Merced Rivers (CDFG 2003). Dam construction and water diversions create high water temperatures in the summer and dramatic flow fluctuations, inhibiting consistent spring-run chinook occurrence. The significance of a large spring-run chinook population in the San Joaquin River system in the early 1940's was noted in Fry (1961). However, this run was completely eliminated by the construction of Friant Dam (32 km northeast of Fresno, California) on the San Joaquin River in 1942.

3.1.17 Central Valley hatchery returns

Summaries are also available for spring-run chinook salmon returning to the Feather River Hatchery (FRH). Appendix 2-F provides summaries of spring-run chinook returns to the FRH from 1967 through 2004.

3.2 Juvenile spring-run chinook data summaries

Spring-run chinook salmon fry emerge from the gravel November through March and can reside in freshwater from 3 to 15 months following emergence, although most emigrate from natal streams as fry or fingerlings (Ward et al. 2002). Downstream migrants tend to enter the ocean environment in the largest numbers in March through June and November through March at an average size of 80 mm FL. These findings are based primarily on the CDFG life history studies in Butte Creek (Ward and McReynolds 2001; Ward et al. 2002 and 2003). Spring-run chinook are found migrating through the Sacramento-San Joaquin Delta primarily as yearlings (70 to 150 mm FL) from October 1 though December 31 (Brandes et al. 2000).

3.2.1 Clear Creek rotary screw trapping

USFWS monitors juvenile spring-run chinook salmon outmigration and annual production in Clear Creek. The goals of this project are to better understand life history patterns of spring-run chinook in the system, to assess effectiveness of restoration programs, and to monitor population trends and relative abundance of juveniles as they relate to goals of the CVPIA. Spring-run chinook juveniles are monitored using RSTs at two locations on Clear Creek, RK 2.7 and 13.4. Following capture, fish are enumerated, measured, and released downstream of the trapping site. Environmental variables such as flow, temperature, and weather conditions are also recorded.

Juveniles have previously been classified to run based on length-at-date criteria based on tables developed by Fisher (1992). In 2003 and 2004, a temporary barrier weir was installed to prevent fall-run chinook from accessing spring-run chinook spawning areas. A rotary screw trap was installed just upstream of the weir, allowing production estimates of the upstream spring-run population without the confounding presence of fall-run chinook. The upper Clear Creek RST production for BY 2003 was approximately 65,000 (USFWS 2005b). All chinook trapped above the weir were considered spring-run chinook regardless of length-at date criteria (CDFG 2004b). Approximately 95% of this spring-run chinook production would have been mis-categorized as fall-run chinook based on length-at-date criteria. Therefore, production estimates base on length-at-date are highly inaccurate for this system. USFWS are revising estimates produced prior to 2003, based on genetic analysis of a subsample of chinook salmon collected in the lower trap.

3.2.2 Battle Creek rotary screw trapping

Since 1998, USFWS has monitored juvenile spring-run chinook outmigration and annual production in Battle Creek using rotary screw traps located at RK 4.5 and 9.5. Following capture, fish are enumerated, measured, and released downstream of the trapping site. Juveniles are classified to run based on length-at-date criteria. Numbers reflect a component of fall-run chinook in early spawning years and may exclude some spring-run chinook production in years where delayed spawning occurs due to high water temperatures (USFWS 2005b). Preliminary juvenile spring-run chinook passage indices for the trap operating at RK 9.5 were 15,589 in 2002 and 121,260 in 2003, based on data collected through March 7, 2004 (CDFG 2004a). Spatial and temporal overlap between spring- and fall-run chinook in Battle Creek make fry differentiation difficult, if not impossible. However, water level and flow during barrier weir operation helps USFWS make assumptions about passage of adult spring- and fall-run chinook above this point, thus yielding information about early captures in rotary screw traps.

3.2.3 Upper Sacramento River rotary screw trapping

Spring-run chinook juveniles were captured during USFWS and CDFG surveys of the upper Sacramento River (Balls Ferry/Deschutes Road Bridge) in the late 1990's. Methods used were the same as those described in winter-run chinook Section 2.2.3 "Upper Sacramento River rotary screw trapping." Appendix 2-I summarizes spring-run chinook capture data for these surveys.

3.2.4 Red Bluff Diversion Dam rotary screw trapping

Rotary screw trapping data at RBDD was conducted to provide abundance estimates and to yield more information about the emigration timing of juvenile salmonids. Four RSTs were fished year round to enable sampling of all four runs of Central Valley chinook

salmon. Sampling started in June 1994 and continued through June 2000 (Appendix 2-J). After a delay as the result of project funding issues, sampling resumed in 2002. Captured salmonids are identified to race, enumerated, and measured (FL). Race identification is made using the length-at-date criteria developed by CDFG.

3.2.5 Deer and Mill Creeks rotary screw trapping

RSTs were used on Mill and Deer Creeks from 1994 through 2003 to enumerate juveniles emigrating from these systems (Appendices 2-K and 2-L). RSTs are located below Upper Diversion Dam on Deer Creek and above Clough Dam on Mill Creek. Numbers represent total number caught in traps, not total stream production (CDFG 2004b). Emigrating juveniles are not coded-wire-tagged, due to low fish numbers. As noted in the relevant appendices, spring- and fall-run chinook fry were not differentiated during trapping periods.

3.2.6 Big Chico Creek rotary screw trapping

Similar efforts to capture, measure, and enumerate juvenile spring-run chinook in Big Chico Creek were started in February 1999, except that fish were not coded-wire tagged, as they were in the Butte Creek studies (Ward and McReynolds 2001). A rotary screw trap was used near Chico at the Bidwell Park Municipal Golf Course (Table 9).

Table 9. Numbers of juvenile spring-run chinook salmon captured in a rotary screw trap on Big Chico Creek from 1999-2002 (Ward and McReynolds 2001, Ward et al. 2002 and 2003).

Trapping period	Total no. captured	Total no. of trapping days
2/16/99-5/31/99	404	91
11/16/99-5/31/00	110	155
12/1/00-5/31/01	1057	163
11/14/01-5/31/02	1752	181

3.2.7 Butte Creek rotary screw trapping and coded wire tagging

Juvenile life history patterns in Butte Creek have been studied by CDFG since 1995. Monitoring efforts include use of rotary screw traps based at two locations near Chico and one location at Sutter Bypass, southwest of Yuba City. Juvenile salmon are tagged using coded-wire tags at one of the trap locations near Chico (Parrott-Phelan Diversion Dam). A percentage of the tagged fish are recovered at the Sutter Bypass trapping site and further analyzed for length of time spent in the system between trapping locations and growth estimates. This percentage varies from year to year. Most spring-run chinook emigrate from Butte Creek as fry, but some remain in the creek through summer

and emigrate in the fall (Hill and Webber 1999). These fish are considered yearlings. Age for yearlings is determined using length-frequency distributions of fish trapped at the two traps near Chico. Fish over 80 mm FL captured at Parrott-Phelan Diversion Dam (PPDD) are considered yearlings based on the distributions. The Sutter Bypass is considered a rearing area for juvenile spring-run chinook based on CDFG juvenile life history studies, as significant growth rates are found for fish residing in this area during winter and spring before subsequent emigration. Juvenile relative abundance was measured using catch comparisons between brood years at PPDD. Estimates are considered highly accurate relative abundance estimates, however due to erratic flow conditions during the trapping season, estimates are not expanded for total abundance. Trap efficiency trials are not feasible due to trap removal during periods of unusually high flows and resultant debris build-up. Appendix 2-M provides summarized results of CDFG trapping efforts on Butte Creek. Ward et al. (2003) note that the relative contribution rate to the ocean fishery of yearlings rearing above PPDD is higher than that for fry rearing below the diversion dam.

3.2.8 Yuba River rotary screw trapping

Since spring- and fall-run chinook are not spatially isolated in the Yuba River, problems exist with differentiating between runs during outmigrant trapping. However, since CDFG initiated a juvenile outmigrant trapping program using RSTs in 1999, length-frequency data have been used to help differentiate between runs. This method of run determination is not without problems and would benefit with the addition of genetic analysis to confirm run identification. Length-frequency rotary screw trap data have yielded presence of a larger fall-run chinook population and a smaller, sub-dominant spring-run chinook population. In 2001, 6719 juvenile spring-run chinook were captured from November 10, 2001 through May 8, 2002, with forklengths ranging from 26 to 108 mm. The next juvenile trapping period (October 15, 2003 to December 31, 2003) yielded a total of 46,629 spring-run chinook.

3.2.9 Sacramento-San Joaquin Delta rotary screw trapping

CDFG has monitored juvenile salmonid emigration at Knights Landing (RK 144) since November 1995. CDFG collected information on relative abundance and emigration timing from spring-run chinook exiting the Sacramento River system and entering the Sacramento-San Joaquin Delta. The surveys utilized two RSTs to capture emigrating fish, as well as fyke nets and a Kodiak trawl to determine trap and gear efficiency. Appendices 1-L through 1-T and 1-Z summarize results from the trapping.

3.2.10 Sacramento-San Joaquin Delta seining and trawling

Spring-run chinook were captured during the U. S. Fish and Wildlife seining and trawling efforts in the Sacramento-San Joaquin Rivers systems and Delta, as described in Section

2.2.7 of this report. Appendix 2-N provides a summary of juvenile spring-run chinook captured during midwater and Kodiak trawls used in the Sacramento River near the city of Sacramento from 1988-2004. Chipps Island trawling results for spring-run chinook from 1976-2004 are provided in Appendix 2-O.

4 STEELHEAD

The 'Central Valley Steelhead' ESU (Busby et al. 1996) includes the Sacramento and San Joaquin River systems. Steelhead trout, the anadromous form of *Oncorhynchus mykiss*, were listed as Threatened under the United States Endangered Species Act on March 19, 1998 (NMFS 1998). This was further defined as only applying to naturally reproducing portions of the population below natural and man-made barriers. Steelhead exhibit diverse life history patterns with varying freshwater residence time, run timing and seasonal variation, and the ability to return to freshwater multiple times for spawning activities. As with winter- and spring-run chinook salmon, steelhead have lost much of their historic spawning habitat due to the construction of dams and water diversions in the Central Valley (Yoshiyama et al. 1996; Schick et al. 2004). However, steelhead have probably lost more habitat due to their ability to travel further upstream than chinook. Especially in the San Joaquin River system, currently available spawning and rearing habitat have been severely degraded by loss of spawning gravels, increased water temperatures, run-off from agricultural projects, poorly screened water diversions, and inadequate riparian zones to maintain cooler water temperatures (SRFG 2004).

Much of the available steelhead data in the Central Valley were collected incidentally as part of studies geared toward more intensive surveys of chinook salmon life histories and habitat usage. Although the two species exhibit similar life history patterns and have similar habitat characteristics, many steelhead datasets are considered incomplete or not robust enough to allow any meaningful statistical analyses since studies were not directly focused on the species. As a result, fishery managers have had to piece together steelhead distribution and life history patterns in many Central Valley watersheds. This can make monitoring programs, collection of statistically valid data, and resulting management decisions difficult. Some studies started as early as 1950, but many researchers and funding sources are only now beginning to realize the importance of steelhead surveys which are independent of chinook studies. Table 10 summarizes steelhead monitoring projects presented in this report.

Table 10. Summary of steelhead trout (*Oncorhynchus mykiss*) adult and juvenile monitoring activities in California's Central Valley.

Tributary	Life Stage	Monitoring method	Variable measured	Date(s)	Agency	Project Leader(s)	Data location in this report[a]
Upper Sacramento River	Adult	Fyke net	Abundance and distribution	1953-1957	CDFG	-	Appendices 3-A, 3-E, and 3-F
Upper Sacramento River	Adult	RBDD Counts	Population size	1966-2004*	CDFG	-	Appendices 3-B and 3-D
Upper Sacramento River	Adult	CNFH Trap counts	Population size	1953-1988	CDFG	-	Appendix 3-B
Upper Sacramento River	Adult	Sport fishery catch	Recreational catch rates	1953-1959 1983-1991	CDFG, USFWS	-	Appendices 3-C, 3-D, and 3-G
Sacramento and San Joaquin River systems	Adult	Angler surveys	Recreational catch rates	1998-2001	CDFG	Kyle Murphy, CDFG	Section 4.1.2, Table 11, and Appendix 3-H
Sacramento and San Joaquin River systems	Adult	Hatchery counts	Adult returns	1956-2004*	CDFG, USFWS	-	Table 12 and Appendix 3-I
Clear Creek	Adult	Snorkel and kayak surveys and redd counts	Spawning abundance and distribution	1999-2004*	USFWS	Matt Brown, USFWS	n/a
Beegum Creek	Adult	Snorkel surveys and redd counts	Presence and spawner distribution	2001	CDFG	-	Section 4.1.5, Table 13

Table 10 (cont.). Summary of steelhead trout (*Oncorhynchus mykiss*) adult and juvenile monitoring activities in California's Central Valley.

Tributary	Life Stage	Monitoring method	Variable measured	Date(s)	Agency	Project Leader(s)	Data location in this report[a]
Battle Creek	Adult	Snorkel and kayak surveys and redd counts	Spawning abundance and distribution	2001	USFWS	Matt Brown, USFWS	Appendix 3-J
Battle Creek	Adult	Barrier weir passage	Abundance and migration timing	1996-2004*	USFWS	Matt Brown, USFWS	Section 4.1.6, Table 14
Antelope Creek	Adult	Beach seines	Presence	1988, 1990	CDFG	-	Section 4.1.7
Antelope Creek	Adult	Snorkel surveys and redd counts	Spawning abundance and distribution	2001	CDFG	-	Appendix 3-K
Mill Creek	Adult	Clough Dam fish passage	Abundance and migration timing	1953-1963, 1993-1994	CDFG	-	Appendices 3-L and 3-M
Mill Creek	Adult	Live fish and redd counts	Presence and spawning distribution	2001	CDFG	-	Section 4.1.8
Deer Creek	Adult	Fish counts (Stanford-Vina Dam)	Abundance and migration timing	1993-1994	CDFG	-	Appendix 3-N
Deer Creek	Adult	Live fish and redd counts	Presence and spawning distribution	2001	CDFG	-	Appendix 3-O
Feather River	Adult	Feather River Hatchery (FRH) returns	Adult returns	1967-2003*	CDFG	Anna Kastner, CDFG	Appendix 3-I

Table 10 (cont.). Summary of steelhead trout (*Oncorhynchus mykiss*) adult and juvenile monitoring activities in California's Central Valley.

Tributary	Life Stage	Monitoring method	Variable measured	Date(s)	Agency	Project Leader(s)	Data location in this report[a]
Feather River	Adult	Redd surveys	Spawning distribution, timing, and magnitude	2002-2003*	CDWR	Brad Cavallo, CDWR	Section 4.1.10
American River	Adult	Redd counts	Spawning distribution	2001-2004*	USBR, CDFG	John Hannon, USBR	Appendices 3-P and 3-Q, Section 4.1.11
Mokelumne River	Adult	Redd counts	Spawning distribution	1998-1999	EBMUD	Michelle Workman and Joe Merz, EBMUD	Section 4.1.12
Mokelumne River	Adult	Angler surveys	Presence and recreational catch rates	1995-1998	EBMUD	Michelle Workman and Joe Merz, EBMUD	Appendices 3-R and 3-S, Section 4.1.12
Mokelumne River	Adult	Fish passage at Woodbridge Irrigation District Dam	Migration timing and run size	1990-2001	VES, EBMUD	Michelle Workman and Joe Merz, EBMUD	Appendix 3-T
Stanislaus River	Adult	Weir trapping	Migration timing and run size	2003-2004*	SPCA	Doug Demko and Andrea Fuller, SPCA	Section 4.1.13

Table 10 (cont.). Summary of steelhead trout (*Oncorhynchus mykiss*) adult and juvenile monitoring activities in California's Central Valley.

Tributary	Life Stage	Monitoring method	Variable measured	Date(s)	Agency	Project Leader(s)	Data location in this report[a]
Upper Sacramento River (Balls Ferry/Deschutes Road Bridge)	Juvenile	Rotary screw traps	Abundance and outmigrant timing	1996-1999	USFWS, CDFG	Rob Snider, CDFG	Appendix 3-U
Upper Sacramento River (RBDD)	Juvenile	Rotary screw traps	Abundance and outmigrant timing	1994-1999*	USFWS, CDFG	Bill Poytress, USFWS	Appendix 3-V
Upper Sacramento River	Juvenile	Habitat surveys (snorkel/seine)	Spatial and temporal distribution	1996-2001	CDFG, USFWS	-	n/a
Clear Creek	Juvenile	Rotary screw traps	Abundance and outmigrant timing	1998-2004*	USFWS	Matt Brown, USFWS	Section 4.2.1 and Table 15
Battle Creek	Juvenile	Rotary screw traps	Abundance and outmigrant timing	1998-2004*	USFWS	Matt Brown, USFWS	Section 4.2.4 and Table 16
Feather River	Juvenile	Rotary screw traps	Abundance and outmigrant timing	1996-2003	CDWR	Brad Cavallo, CDWR	Section 4.2.5 and Appendices 3-W and 3-X
Feather River	Juvenile	Seining	Distribution and abundance	1997-2001	CDWR	Brad Cavallo, CDWR	Table 17

Table 10 (cont.). Summary of steelhead trout (*Oncorhynchus mykiss*) adult and juvenile monitoring activities in California's Central Valley.

Tributary	Life Stage	Monitoring method	Variable measured	Date(s)	Agency	Project Leader(s)	Data location in this report[a]
Feather River	Juvenile	Snorkeling	Seasonal distribution, relative abundance, and habitat use	1999-2001	CDWR	Brad Cavallo, CDWR	Section 4.2.5
American River	Juvenile	Beach seines	Distribution	1992-1995	CDFG, Sacramento County, EBMUD	-	Appendices 3-Y and 3-DD
American River	Juvenile	Rotary screw traps	Outmigrant timing	1995-1998	CDFG	Rob Titus, CDFG	Appendices 3-Z, 3-AA, 3-BB, and 3-CC
Mokelumne River	Juvenile	Rotary screw traps	Outmigrant timing	1993-2001	VES, EBMUD	Michelle Workman, EBMUD	Appendices 3-EE and 3-FF
Calaveras River	Juvenile	Rotary screw traps	Outmigrant timing	2002-2004*	SPCA	Doug Demko and Andrea Fuller, SPCA	Appendix 3-GG
Stanislaus River	Juvenile	Rotary screw traps	Abundance and distribution; size and smolting characteristics	1993-2004*	SPCA	Doug Demko and Andrea Fuller, SPCA	Appendices 3-II to 3-LL
San Joaquin River (Mossdale)	Juvenile	Trawls	Presence and size	1988-2004*	CDFG	Paul Cadrett, USFWS	Appendix 3-HH

Table 10 (cont.). Summary of steelhead trout (*Oncorhynchus mykiss*) adult and juvenile monitoring activities in California's Central Valley.

Tributary	Life Stage	Monitoring method	Variable measured	Date(s)	Agency	Project Leader(s)	Data location in this report[a]
Sacramento-San Joaquin Delta (Knights Landing)	Juvenile	Rotary screw traps	Emigration timing and relative abundance	1995-2004*	CDFG	Rob Titus, CDFG	Appendices 3-MM through 3-UU
Sacramento River (Sacramento)	Juvenile	Midwater and Kodiak trawls	Emigration timing and relative abundance	1988-2004*	USFWS	Paul Cadrett, USFWS	Appendices 3-VV and 3-WW
Sacramento-San Joaquin Delta (Chipps Island)	Juvenile	Trawls	Emigration timing and relative abundance	1976-2004*	USFWS	Paul Cadrett, UFWS	Appendices 3-XX and 3-YY
Sacramento-San Joaquin Delta	Juvenile	Beach seines	Emigration timing and relative abundance	1977-2004*	USFWS	Paul Cadrett, UFWS	n/a

* Indicates project is ongoing beyond end year provided.
[a] Data not available or present in this report is listed as 'n/a.'

4.1 Adult steelhead data summaries

Steelhead occur in most major tributaries of the Central Valley, with numbers of fish generally coinciding with the amount of run-off the stream experiences; more run-off leads to more fish utilizing the stream for spawning and rearing (Hallock et al. 1961). Run timing varies for steelhead depending on the system. In the upper Sacramento River, an early run of steelhead migrates upstream from late July through February, with most spawning occurring from December through February. A later run migrates from December through April, spawning from January through March with spawning peaks in February and March.

4.1.1 Sacramento River surveys

Early attempts to enumerate adult steelhead population sizes and document life history characteristics in the Sacramento River include the use of fyke nets (Appendix 3-A), RBDD and CNFH trap counts (Appendix 3-B), and estimates of annual sport fishery catch and harvest (Appendices 3-C and 3-D). Most early motivation for studying steelhead was derived from the high value of the species in the river sport fishery.

One of the most comprehensive early steelhead assessments was undertaken as a six-year study by CDFG, involving the evaluation of hatchery steelhead in the Sacramento River system (Hallock et al. 1961). USFWS, CNFH, California Kamloops, Inc., and Steelhead Unlimited were also responsible for portions of the study. The purpose of their efforts was to determine if stocking migrant-sized steelhead would ultimately result in more fish returning to spawn to create a large, sustainable population to support increasing pressure from river recreational fisheries. In addition, researchers were hoping to learn more about life history, abundance, and any noticeable population trends of steelhead in the Sacramento River. Collection and analysis of scales from naturally-produced steelhead allowed length-frequency and age comparisons. Population estimates were derived using mark-recapture techniques by capturing fish with fyke nets placed in the Sacramento River near the mouth of the Feather River. A modified Petersen model was developed and utilized to estimate steelhead population size from 1953-1959 (Appendix 3-E). Total run estimates were further separated between hatchery and wild fish in Appendix 3-F.

Steelhead sport catch was also analyzed by Hallock et al. (1961) from 1953 through 1959. CDFG determined catch by dividing the number of tags recovered and sent in by anglers by the fraction of the total run known to have been tagged. This method is assumed to produce a minimum estimate, as some portion of tags recovered by anglers was not sent in to CDFG and the catch estimate equation used does not account for this factor. Appendix 3-G provides a summary of steelhead sport catch estimates in the Sacramento River in the 1950's.

4.1.2 Central Valley angler surveys

Due primarily to budgetary constraints, CDFG has not maintained consistent angler surveys in the Central Valley. Most efforts to obtain river harvest estimates occur in a limited area in a small time frame. A more recent effort to improve harvest monitoring was made by starting the Central Valley Salmon and Steelhead Harvest Monitoring Project in 1998. This angler survey mainly focused its efforts on river and stream sections with the most significant fishing effort for salmon and steelhead, based on data from past survey efforts. The study area was divided into 20 survey sections (Table 11), and each section was sampled eight times per month. A stratified random sampling design was used to estimate freshwater angler harvest.

In years when budgetary cuts occurred to the program, certain sections were not surveyed or were surveyed less frequently. Due to budget cuts in 2001, the entire San Joaquin River system was only surveyed in January. Changes in sampling frequency affects data usefulness in that inconsistencies occur when compared with years when all sections were surveyed completely. Appendix 3-H summarizes estimated angler hours, number of steelhead harvested, and number of steelhead released from 1998-2001.

Table 11. Sampling locations for the Central Valley Salmon and Steelhead Harvest Monitoring Project, 1998-2001 (Schroyer et al. 2002).

System sampled	Location (from)	Location (to)	Section number(s)
Sacramento River	Carquinez Bridge	ACID Dam (Redding)	1, 2, 3, 4, 5, 6, 7, 8
Feather River	Confluence with Sacramento River (Verona)	Oroville Project Fish Barrier Dam / Thermalito River outlet	11, 12.0, 12.1
Yuba River	Confluence with Feather River (Marysville)	1.6 km upstream from Highway 20 Bridge	13, 14
American River	Discovery Park (Sacramento)	Nimbus Dam (Rancho Cordova)	9, 10.0, 10.1
San Joaquin River/Delta	Confluence with Sacramento River	Mossdale crossing (Tracy)	15
Mokelumne River, South Fork and North Fork	Confluence with San Joaquin River	Interstate 5 Bridge (including North Fork)	16, 17
Stanislaus River	McHenry Avenue bridge (Myers)	Goodwin Dam	18

4.1.3 Central Valley hatchery returns

Adult steelhead information is also available from Central Valley hatcheries, which have been raising and releasing steelhead in the Central Valley since the mid-1950's (Nimbus Hatchery on the American River). Hatchery-produced steelhead are not included in the Central Valley Steelhead ESU. Hatchery data mainly exist in the form of estimated numbers of adult steelhead returns. Appendix 3-I lists steelhead hatchery returns for all Central Valley hatcheries from 1967 through 1991. The number of naturally spawning steelhead in the upper Sacramento River (listed in Appendix 3-I) is derived from subtracting the number of steelhead returning to CNFH from RBDD counts. This number is thought to be a conservative estimate of natural spawning escapement in this section of the Sacramento River (Mills and Fisher 1994). Earlier hatchery return totals (1956-1966) for Nimbus Hatchery on the American River are provided in Table 12.

Table 12. Adult steelhead counts at Nimbus Hatchery, 1956 – 1966 (Staley 1976).

Year	Total
1956	110
1957	115
1958	51
1959	102
1960	778
1961	316
1962	137
1963	2141
1964	1216
1965	778
1966	874

4.1.4 Clear Creek snorkel surveys and redd counts

USFWS started winter steelhead and rainbow trout redd surveys on Clear Creek in 2001. In 2003, USFWS transitioned from snorkel to kayak surveys to increase survey frequency and length. Kayak surveys were conducted once or twice per month between December and April and cover a 26.4 km section below Whiskeytown Dam. In addition to steelhead redd surveys, USFWS has been counting live steelhead/rainbow trout and redds during spring-run chinook snorkel surveys (April to November) since 1999. Since accurate underwater visual identification between steelhead and rainbow trout can prove difficult, counts are divided into size classes: small (parr marks visible, but not considered a YOY), medium (<56 cm without visible parr marks), and large (>56 cm).

4.1.5 Beegum Creek snorkel surveys and redd counts

Beegum Creek was surveyed for live adult steelhead and redds from March 27 to May 31, 2001 by CDFG. Three snorkel surveys were completed, covering 10.5 km of the mainstem (Table 13). Steelhead presence in Beegum Creek was also noted during CDFG spring-run chinook surveys in 2001 (Killam and Moore 2001).

Table 13. Summary of adult steelhead and steelhead redd counts encountered during snorkel surveys of Beegum Creek from March 27 to May 31, 2001 (Moore 2001).

Date	Section	No. of adult steelhead	No. of steelhead redds
Mar 27	North Fork trailhead to Diversion Dam trailhead	7	2
Apr 24	North Fork trailhead to Diversion Dam trailhead	4	0
May 31	North Fork trailhead to Diversion Dam trailhead	0	0

4.1.6 Battle Creek upstream passage monitoring and snorkel surveys

Steelhead passage above CNFH was monitored during USFWS surveys of Battle Creek in mid-2001. However, no attempt was made to distinguish between anadromous and non-anadromous forms; all were referred to as rainbow trout. During trapping and video monitoring operations, adipose fin condition (clipped or unclipped), timing, and number of fish passing were noted. Table 14 shows the estimated number of *O. mykiss* passing the barrier weir during the March through October 2001 trapping period. Migration timing peaked for clipped and unclipped *O. mykiss* during two weeks over the trapping period, March 3-10 and May 13-19. USFWS also conducted snorkel surveys from March through October to count live *O. mykiss* and carcasses and to attempt to identify redds. *O. mykiss* were classified as small, medium, or large, using the same size classifications as mentioned in Clear Creek surveys (Appendix 3-J).

Table 14. Passage estimates for *Oncorhynchus mykiss* beyond the CNFH barrier weir on Battle Creek, California in 2001 (Brown and Newton 2002).

Passage location	*O. mykiss* (clipped)	*O. mykiss* (unclipped)
CNFH	1352[a]	131
Trap	25	61
Video	5	33
Totals	1382	225

[a] These fish entered CNFH, but were not used for the steelhead propagation program. They were released above the barrier weir prior to March 3, 2001.

4.1.7 Antelope Creek redd counts

CDFG conducted steelhead redd counts in Antelope Creek in 2001 to try and increase knowledge about life history and population size of adult steelhead utilizing the system for spawning. Eight snorkel surveys were conducted between March 13 and May 3, counting adult steelhead and redds (Appendix 3-K). Twenty-six kilometers of stream were surveyed, 16 km of the mainstem, 6.4 km of the North Fork and 3.2 km of the South Fork. This distance represents about 53% of the total habitat area accessible by anadromous fish. According to Moore (2001), the only other assessment of steelhead in Antelope Creek was a count of 22 live adult steelhead (plus two carcasses) captured during beach seining in 1988 and 1990 at the canyon mouth of mainstem Antelope Creek.

4.1.8 Mill Creek surveys

Adult steelhead were monitored in Mill Creek as they passed Clough Dam from 1953 through 1963 (Appendix 3-L). According to Hallock (1989), about 60% of the run in this system pass the dam from October through December and 30% pass in January and February. In 1993, a fish counter was installed at the Clough Dam fish ladder on Mill Creek. The counter was operated from mid-October through mid-January, but was dependent on favorable flow conditions for optimum counting accuracy. Appendix 3-M shows estimated adult steelhead passage on Mill Creek past Clough Dam from October 1993 through June 1994. Ratios of observed chinook to steelhead were used in steelhead passage estimations. The observed chinook salmon-to-steelhead ratio was multiplied by the total weekly counter counts to yield estimated steelhead passage.

CDFG conducted live adult steelhead and redd counts using foot surveys on April 13, 2001. The survey covered 2.6 km, representing about 3% of the total habitat available to anadromous fish. One live adult female and 17 redds were counted. Poor visibility and survey conditions limited the number of surveys conducted on this system in 2001.

4.1.9 Deer Creek surveys

Before 1993, the only adult steelhead count for Deer Creek was 1006 fish counted in 1967 (Harvey 1995). The next attempt to quantify steelhead passage occurred when CDFG installed a fish counter at Stanford-Vina Dam on Deer Creek. This dam is located 6.4 km upstream from the confluence with the Sacramento River, and represents the first of three diversion dams on Deer Creek (Harvey 1995). Counts started on October 12, 1993, however, the counting instrument was removed from December 9, 1993 through March 9, 1994 due to high flows. Appendix 3-N provides estimated numbers of adult steelhead migrating past this dam from October 1993 through June 1994. Adjustments were made to counts due to high flows when the counter was not in use. Estimates were derived the same as in Mill Creek (Section 4.1.8).

CDFG initiated live adult steelhead and redd counts on Deer Creek in 2001. Three snorkel surveys and two foot surveys were conducted from April 10 and May 17, 2001 (Appendix 3-O). Eight kilometers of mainstem Deer Creek were surveyed, encompassing approximately 12% of the available anadromous fish habitat (Moore 2001).

4.1.10 Feather River surveys

Oroville Dam construction was completed in 1967, completely blocking upstream passage to steelhead in the Feather River above the town of Oroville. Yoshiyama et al. (2001) and Schick et al. (2004) suggest that historically steelhead were able to ascend much higher into the West Branch and North, Middle, and South Forks of the Feather River to spawn. However, spawning habitat is currently limited to the lower 35.31 km of the mainstem Feather River (Schick et al. 2004). To mitigate for the loss of spawning habitat, CDWR and CDFG have operated the Feather River Hatchery since 1967 (CDWR 2003b). FRH adult steelhead returns from 1967 to 2003 are provided in Appendix 3-I. Angler creel survey data and hatchery returns account for most of the existing adult steelhead data from the Feather River in the first decade after Oroville Dam was constructed. However, little information was available on wild or hatchery spawning adults in the river below the dam.

As part of the Oroville Dam Federal Energy Regulating Commission relicensing process, CDWR conducted redd surveys to collect more information on steelhead spawning in the Feather River. Surveys were conducted between the Fish Barrier Dam (RK 108) and Honcut Creek (RK 70.8). In general, Feather River steelhead begin upstream migrations in late August and continue through June, with spawning occurring November through June, peaking in January and February. Redd surveys were conducted using wading techniques through specified river transects in areas where the highest redd concentration was expected based on previous snorkel surveys (related to juvenile steelhead). Some sections were also sampled using a drift boat. Adipose fin condition (clipped versus unclipped) was not recorded, as this was probably not possible to determine during these surveys. Therefore, no distinction between wild and hatchery-origin spawners could be

determined. Microhabitat data such as water depth, water velocity, redd length, and redd width were also collected from each redd site. From January 6 and April 3, 2003, thirteen weekly redd surveys were conducted. A total of 108 steelhead and 75 redds were observed (CDWF 2003b). The number of redds is considered a minimum estimate due to poor visibility in certain sections and restrictive redd identification protocols. Almost 50% of the redds were constructed in the 1.6 km section below the Fish Barrier Dam at the hatchery.

4.1.11 American River surveys

Construction of Folsom and Nimbus Dams on the American River was completed in 1955, limiting available spawning habitat for steelhead to the lower 37 km of river. Nimbus Hatchery was built by USBR to mitigate for the loss of anadromous fish spawning and rearing habitat. Adult American River steelhead begin migrating into the system in late September. Migration continues through May (Hannon et al. 2003), with spawning occurring December through May with peak spawning periods in January and February. Natural production is limited by lack of suitable spawning habitat. Currently, CDFG and USBR are conducting studies to determine the percentage of in-river spawning that is occurring due to wild steelhead as opposed to hatchery-produced fish.

USBR and CDFG conducted steelhead redd counts in the American River from 2001 through 2004, hoping to develop a method to estimate abundance of in-river spawning populations of steelhead from year to year. Two surveys were conducted in 2001 to assess the effects of lowered flows (less than 1500 cfs) on steelhead redds. However, flows were never less than 1500 cfs during the study period, and thus the effects on redds could not be measured. Effort increased to 10 surveys in 2002 to enable more complete estimates of spawning escapement and total redd counts for steelhead (Appendix 3-P). Redd surveys were conducted using a combination of boat or canoe and snorkel survey methods. Redd locations were marked using the GPS, and each redd was measured to determine area and water depth. Spawning activity peaked in early March, with most spawning activity occurring from Sailor Bar downstream to Paradise Beach, a distance of 29 km. During the 2001-2002 run, 1253 adult steelhead returned to Nimbus Hatchery, including 498 females and 755 males. Using redd counts (total = 159) and a female to male ratio of 1.00:1.52, an in-river spawning population index of 400 fish was calculated (using one redd per female). No confidence intervals were provided since sampling efficiency was unknown (Hannon and Healey 2002).

Redd surveys continued in 2003, yielding an estimated 243 to 486 in-river spawners based on redd counts (Hannon et al. 2003). Using an area-under-the-curve (English et al. 1992; Hilborn et al. 1999) population estimate based on fish observations, 343 spawning steelhead and 967 in-river, but not spawning steelhead were present during the surveys. During 2003 surveys, adipose fin condition (clipped or unclipped) was determined for 21 fish. Of these, only two were unclipped (9.5%); five of the 21 fish were observed on redds, but all of these had a clipped adipose fin. 2004 surveys were conducted using methods similar to those of 2003. Observer efficiency was estimated for fish on redds

and fish not on redds, approximating 90% and 10% respectively for 2004 surveys (Hannon and Deason 2004). Residence time was estimated using repeated observations of individual redds with fish on them. During 2004 surveys, 197 redds were counted from December 17 through June 17, with 68 steelhead observed on redds. USBR also experimented in using an underwater video camera in 2004 to determine adipose fin status. Adipose fin clip status was determined for 32 fish during 2004 surveys, with only 2 fish observed with adipose fin clip status as 'unclipped.' One of these unclipped fish was observed on a redd, out of 5 fish observed on redds when adipose fin clip status could be determined through visual observation. A summary of results for the American River redd surveys from 2002-2004 is provided in Appendix 3-Q.

4.1.12 Mokelumne River surveys

Pardee and Camanche Dams were built on the Mokelumne River in 1929 and 1963, respectively. Both reservoirs associated with the dams are owned and operated by East Bay Municipal Utility District (EBMUD). Pardee Dam is further upstream and poses a complete barrier to migrating salmon and steelhead. Although fall-run chinook probably did not spawn above this location, it is highly probable that steelhead and spring-run chinook spawned in areas as far as 30.6 km upstream from the dam site (Yoshiyama et al. 1996). With the placement of Camanche Dam 19.3 km downstream from Pardee Dam, considerable spawning habitat was lost in the river section between the two barriers. As mitigation for this loss of spawning habitat, a small hatchery and spawning channel were built by EBMUD in 1964. Steelhead migration in the Mokelumne River generally occurs from late September through April, with spawning occurring from December through April.

As part of their fall-run chinook spawner surveys in the lower Mokelumne River, EBMUD also documented incidental steelhead spawning. Criteria for identifying steelhead versus resident rainbow trout for these surveys were mainly based on size classification, including any *O. mykiss* over 40 cm FL as the anadromous form. In surveys extending from August 19, 1998 through January 31, 1999, 11 adult steelhead were observed and 9 redds were counted (Setka 1999). The first steelhead redd was observed on December 16, 1998, and all steelhead redds were constructed in the Mokelumne River Day Use Area. The next year's survey yielded 56 adult steelhead and 20 redds, with the first steelhead redd observed on December 22, 1999 (Setka 2000).

EBMUD conducted angler surveys of the Mokelumne River Day-Use Area to better understand the *O. mykiss* fishery and existing fishing pressure. The 1996 survey was conducted on 15 randomly selected days between September 1 through October 15, and the 1997 survey occurred on 21 days between January 1 and April 16 (Appendix 3-R). In 1998, the survey dates were extended from January 1 through October 15, surveying on 85 days chosen randomly (Appendix 3-S). The survey area extended from Camanche Dam to 1.6 km downstream. Anglers were asked a series of questions and scale samples were collected when possible. Photographs were also taken from all fish observed in order to aid in determining life history and any notable morphological characteristics.

According to Choi and Merz (1997), three different morphological types of *O. mykiss* were noted during angler surveys of the Mokelumne River. The three types included: 1) hatchery reared (determined by presence of silvery color and worn caudal fins, plus yearling steelhead from the Mokelumne River Fish Hatchery (MRFH) were identified from pelvic fin clips), 2) second year fish confirmed using scale analysis that appeared to be part of a run of half-pounders, and 3) large, adult wild steelhead confirmed as three year old fish, exhibiting spawning coloration and secondary sexual characteristics and a robust body type. Detection of these different groups of fish suggests both hatchery and wild populations are present in this system (Choi and Merz 1997).

Vogel Environmental Sciences (VES) monitored fish passage at Woodbridge Irrigation District's diversion dam (RK 63) below Lake Lodi on the Mokelumne River. Their study was primarily focused on fall-run chinook salmon, but also included collection of steelhead data. VES used an upstream migrant fish trap and a closed-circuit video monitoring system to determine daily counts of fish migrating upstream. Adult steelhead were determined using a size criterion developed by Hallock et al. (1961) where fish 380 mm FL and greater were considered adult (Appendix 3-T). This was based on length frequency data from three-year-old steelhead from the Sacramento River.

4.1.13 Stanislaus River upstream passage monitoring

A portable resistance board weir ('Alaskan Weir') was placed in the Stanislaus River in early 2003 to monitor chinook and steelhead passage. No steelhead were captured between an initial trapping period from January 27 through March 7, 2003 (SRFG 2004). However, it was later determined in the fall of 2003 that the weir was improperly configured to retain fish and would need to be modified and re-installed in the river. The first live, adult steelhead was captured at the weir on December 27, 2003, a 380 mm FL male. Researchers hope to learn more about steelhead populations in the Stanislaus River as weir operation progresses.

4.2 Juvenile steelhead data summaries

Juvenile steelhead are found migrating downstream in the Sacramento-San Joaquin River systems during most months of the year, with a peak emigration period occurring in the spring (McEwan 2001). Most juvenile steelhead data are collected using rotary screw traps to collect information on emigration timing and relative abundance. Some studies (e.g. Feather River) also combine snorkel and seining surveys to complement rotary screw trapping data. These additional methods can yield information regarding habitat usage and seasonal distribution.

4.2.1 Clear Creek outmigration monitoring

As part of their comprehensive adult steelhead surveys in Clear Creek, USFWS also conducts sampling for juvenile outmigrants, using RSTs. These traps have been operated continuously since 1998. In 2000, the removal of McCormick-Seltzer Dam allowed for increased upstream passage for adult steelhead. Juvenile populations have been stable or increasing since then (USFWS 2005c). The increased instream flow since 1999 from June through October may also be responsible for more adequate rearing conditions for juvenile steelhead in Clear Creek (USFWS 2005c). Table 15 shows outmigrant production from 1999 through 2004, based on calendar year trapping results.

Table 15. Juvenile steelhead (*Oncorhynchus mykiss*) production from Clear Creek based on rotary screw trap results from 1999 through 2004 (USFWS 2005c).

Year	1999	2000	2001	2002	2003	2004[a]
No. of fish	3706	8848	12,988	14,131	11,995	30,725

[a] Preliminary data, as November and December trapping results are not included.

4.2.2 Upper Sacramento River rotary screw trapping

In the upper Sacramento River juvenile rainbow trout (potentially steelhead) were captured during RST sampling conducted by USFWS and CDFG, starting in 1996 (Appendix 3-U). Sampling locations include traps placed at Balls Ferry (RK 444) and Deschutes Road Bridge (RK 452). Methods used were the same as those described in Section 2.2.2 of this document.

4.2.3 Red Bluff Diversion Dam rotary screw trapping

Juvenile *O. mykiss* are captured during rotary screw trapping operations below RBDD (see winter- and spring-run chinook Sections 2.2.3 and 3.2.4). Summaries of monthly juvenile passage estimates for brood years 1995 through 1999 are provided in Appendix 3-V.

4.2.4 Battle Creek rotary screw trapping

USFWS utilizes RSTs on Battle Creek to monitor outmigrating juvenile steelhead. This effort started in 1998 and has operated continuously, except for a 6-month period from February through July 2001 when traps were not operated due to funding issues (M. Brown[10]). CNFH pass most unmarked steelhead and several marked fish upstream

[10] M. Brown, USFWS, 10950 Tyler Road, Red Bluff, CA 96080, 13 December 2004, personal communication.

during the spawning season, although the number of adults passed upstream varies from year to year depending on adult return numbers and hatchery production goals. Table 16 presents outmigrant production from 1999 through 2004 in Battle Creek, based on calendar year trapping results.

Table 16. Juvenile steelhead (*Oncorhynchus mykiss*) production from Battle Creek based on rotary screw trap results from 1999 through 2004 (USFWS 2005d).

Year	1999	2000	2001[a]	2002	2003	2004[b]
No. of fish	15,508	42,151	536	23,586	9398	3069

[a] Traps were not in operation from February through July 2001.
[b] Preliminary data, as August through December trapping results are not included.

4.2.5 Feather River rotary screw trapping, snorkeling, and seining

CDWR started a pilot study in March 1996 to document juvenile salmonid emigration on the Feather River, mainly focusing on fall-run chinook. However, ancillary information was also collected for steelhead, including data on emigration timing and abundance, as well as environmental variables such as flow, water temperature, and turbidity. The potential effects of river flow on juvenile salmonid emigration was also important in sampling efforts (CDWR 2003c). Study site selection was based on available salmon spawning habitat in the lower Feather River (RK 0 to 108). From RK 0 to 71, the lower river is primarily slower-moving water with fines representing the majority of substrate (CDWR 1999a), creating limited spawning opportunities for salmonids. The two selected study reaches occur in the mainstem Feather River from RK 71 to 108, where spawning habitat quality is higher. RSTs were used to trap downstream-migrating fish from mid-December through June. CDWR operated two RSTs downstream from their study reaches, one placed upstream from the Thermalito Afterbay Outlet (RK 96.6) and the other downstream from the Honcut Creek inlet (RK 67.6, referred to as 'Live Oak' in agency reports). RST efficiency was tested using mark-recapture of juvenile chinook only. In 1996, trap operation started in March instead of December due to manufacturing and installation delays. No steelhead were encountered during 1997 surveys, mainly due to a January flood event that damaged traps and scoured much of the spawning habitat and created sustained, high flows which flushed out juveniles from the system prematurely (CDWR 1999b). Summaries of steelhead captured during these surveys are listed in Appendices 3-W and 3-X. CDWR continued use of rotary screw traps in the Feather River from December 1998 through June 2001. A total of 1551 juvenile steelhead were captured over the 3 years, mainly February through June (CDWR 2003d). Over 90% of steelhead captured from 1998-2001 were from the Thermalito RST. A total of 1524 YOY steelhead were captured at the Thermalito RST from 1998-2001, but no yearlings (> 150 mm FL) were trapped during this time (CDWR 2002). At the Live Oak RST, only 36 YOY and 4 yearlings were captured from 1998-2001.

From 1999 to 2003, CDWR conducted snorkel surveys on the Feather River to document seasonal distribution, relative abundance, and habitat use and information primarily for *O. mykiss* and other salmonids. The two study areas included the low flow channel (Fish Barrier Dam to Thermalito Afterbay, RK 108 to 94.9) and the high flow channel (Thermalito Afterbay to the Gridley Bridge, RK 94.9 to 81.7). *O. mykiss* observations were categorized as age-0 (< 100mm FL) or age-1 (> 100mm FL), as data were not collected to enable age determination. Combining all years of snorkel data, 99% of age-0 and 97% of age-1 steelhead were observed in the low flow channel study reach (CDWR 2003d).

To determine fish distribution and abundance, CDWR conducted seining surveys in the lower Feather River from January 1997 through August 2003. Sampling locations were between RK 37 to the Fish Barrier Dam (RK 108). Between January 1997 and August 2001, seining effort intensity and distribution were modified, including the addition of more sample sites in 1997 and again in 1998 which resulted in a final total of 16 permanent stations plus occasionally sampled alternate sites (Seesholtz et al. 2004). Total catch was reported for each sample site and overall length frequency data were provided for the entire study area. Table 17 provides mean steelhead catch per seine haul in the low and high flow channels of the Feather River from 1997-2001.

Table 17. Mean catch per seine haul of *Oncorhynchus mykiss* in the low flow channel (LFC) and high flow channel (HFC) of the lower Feather River from 1997-2001 (Seesholtz et al. 2004).

	1997-98		1998-99		1999-2000		2000-01	
Channel	HFC	LFC	HFC	LFC	HFC	LFC	HFC	LFC
No. of hauls per year	61	27	132	61	112	57	96	53
Mean catch per seine haul	<0.1	0.1	<0.1	2.5	<0.1	3.3	0.3	0.6

Results from rotary screw trap, snorkel, and seining data suggest steelhead emigration in the Feather River occurs from February through September, peaking in March through mid-April for most study years (CDWR 2003d). During the summer of 2003, CDWR also conducted a mark-recapture growth study of juvenile steelhead rearing in the Feather River low flow channel[11] to assess growth, survival, and movement (CDWR 2004a). In conjunction with this study, intensive seining and electrofishing surveys were conducted in the low flow channel in June and August of 2002 and 2003 (CDWR 2004b).

[11] The 'low flow channel' of the Feather River is located downstream from Oroville Dam. The majority of water releases from the dam at Lake Oroville are directed through the Thermalito Complex. The remainder is returned to the mainstem Feather River via the Thermalito Afterbay Outlet. Any remaining releases are directed through the 'low flow channel,' considered the historic river channel. This channel typically maintains around 600 cfs (CDWR 2004b).

4.2.6 American River surveys

A cooperative study effort between CDFG, County of Sacramento, and EBMUD was initiated on the American River to survey fish populations in the lower American River, from Nimbus Dam to the river's confluence with the Sacramento River. Beach seining was used to determine species composition and distribution, covering RK 0 to 36.2 in 4 reaches (Appendix 3-Y). Steelhead and rainbow trout were not differentiated during these surveys, only size differences were recorded. The cooperative effort for this study ended in 1994, with the study now being funded by USBR.

CDFG also utilized RSTs to collect information on emigrating salmonids from the American River. One RST was operated downstream from the Watt Avenue Bridge on the lower American River. This study focused on fall-run chinook salmon emigration, but also included trapping data for juvenile steelhead (Appendices 3-Z, 3-AA, and 3-BB). Snider and Titus (2000a and 2001) report capturing a small number of spring- and winter-run-sized-chinook during these surveys, as well. A summary of *O. mykiss* life history stage composition and seining collection summaries for steelhead are given in Appendices 3-CC and 3-DD.

4.2.7 Mokelumne River rotary screw trapping

As part of their Mokelumne River Fishery Monitoring Program, EBMUD monitored downstream steelhead passage using two RSTs at Woodbridge Dam. As with most Central Valley salmonid studies geared towards chinook salmon data collection, this study did not include measuring trap efficiency for steelhead, only fall-run chinook. Juvenile steelhead abundance estimates were reported, but were based on fall-run chinook salmon rotary screw trap calibrations. During trapping from January through July 1993, one trap was operated at Woodbridge Dam and another at Elliot Road (near Elliot Road bridge at RK 85.3) due to higher than normal precipitation and resulting flows (Vogel and Marine 1994). Appendices 3-EE and 3-FF provide summaries of *O. mykiss* trapping data from October 1993 through July 2004.

4.2.8 Calaveras River rotary screw trapping

Built in 1964, New Hogan Dam limits upstream steelhead access and controls water releases into the Calaveras River. However, small numbers of steelhead (and fall-run chinook salmon) still occur in the lower river. Since 2002, S. P. Cramer & Associates, Inc. (SPCA) and Stockton East Water District (SEWD) have used a rotary screw trap on the Calaveras River to monitor outmigrating juvenile *O. mykiss*. The trap is placed at Shelton Road Bridge (RK 45) from winter through late spring/early summer. *O. mykiss* captured in the trap were divided into two size classes, young-of-year (≤100mm FL) and age 1+ (>100 mm FL). Fin clip status (clipped or unclipped) was checked for each *O. mykiss* and a smoltification rating was assigned (1 = yolk-sac fry, 2 = fry, 3 = parr, 4 =

silvery parr, and 5 = smolt). Appendix 3-GG summarizes Calaveras River rotary screw trapping data from 2002-2004.

4.2.9 San Joaquin River, Mossdale trawls

On the lower San Joaquin River (Mossdale trawl site), CDFG monitored *O. mykiss* downstream migration as part of another survey targeting chinook salmon smolts. Fish captured at this site represent fish that could have originated in the Merced, Tuolumne or Stanislaus Rivers. Appendix 3-HH provides a summary of these data. Smolt condition was not reported in Marston (2003), however he noted that conditions were not favorable to support resident rainbow trout in this section of the river. Also, trapping efficiency rates were as low as 1 to 2 percent for chinook smolts, indicating that only a small fraction of the actual number of *O. mykiss* migrating were captured.

4.2.10 Stanislaus River rotary screw trapping

SPCA was contracted to operate rotary screw traps on the Stanislaus River to monitor emigrating juvenile salmonids starting in 1996, however, trapping has occurred in this system since 1993 by either CDFG, USFWS, or SPCA. Their primary goal was to estimate number, size, and emigration timing of juvenile fall-run chinook salmon, as they migrated past two trapping locations, Oakdale (RK 66.3) and Caswell (RK 64.5). However, an ancillary objective to their project also included collecting information on the size and smolting characteristics of emigrating juvenile steelhead/rainbow trout, as well as environmental factors (turbidity, flow, and water temperature) that may influence run timing or other migration attributes. In most years, two RSTs were operated side-by-side near Caswell State Park and one near Oakdale (Appendix 3-II).

Traps were tested for efficiency by releasing marked fish upstream at the Oakdale trapping site and determining a mark-recapture ratio when marked fish were captured at the Caswell location. However, only fall-run chinook were used for these tests, rather than steelhead due to their threatened status. Only 4 steelhead were captured at the Caswell site and 13 at the Oakdale location during the 1996 survey (Appendix 3-JJ). SPCA used a smolt index to rank the degree of smoltification of captured fish, with 1 representing an obvious parr and 3 an obvious smolt (Demko and Cramer 1997). The smolt index ranking was changed in 1999 to a scale of 1 to 5 (1 = yolk-sac fry, 2 = fry, 3 = parr, 4 = silvery parr, and 5 = smolt). Appendices 3-KK and 3-LL summarize *O. mykiss* rotary screw trapping data from operations at Caswell and Oakdale locations from December 2000 through May 2004.

4.2.11 Sacramento-San Joaquin Delta rotary screw trapping

As part of the 1995-1998 CDFG pilot program to monitor juvenile salmonid migration from the Sacramento River into the Sacramento-San Joaquin Delta, steelhead were also

captured and included in RST data (Appendices 3-MM through 3-UU). Methods are the same as those described in Section 2.2.6 of this report. Counts were divided into three age groups: young-of-the-year (<100 mm FL), yearling (100-300 mm FL), and adult (>300 mm FL). Adipose fin status (clipped or unclipped) was also noted, affirming hatchery origin if clipped and suggesting naturally-produced if unclipped (although recorded as 'unknown' origin). Scales were collected from fish >100 mm FL to determine age class.

4.2.12 Sacramento-San Joaquin Delta seining and trawling

Juvenile *O. mykiss* were captured during USFWS seining and trawling activities in the Sacramento-San Joaquin River systems and the Delta from 1988-2004. Methods are the same as those described in Section 2.2.7 of this report. Appendix 3-VV and 3-WW summarize *O. mykiss* catch data resulting from midwater and Kodiak trawls in the Sacramento River near the city of Sacramento from 1988-2004. Juvenile *O. mykiss* were also captured during 1976-2004 USFWS midwater trawling operations at Chipps Island in the Sacramento-San Joaquin Delta, as summarized in Appendices 3-XX and 3-YY.

ACKNOWLEDGEMENTS

Many thanks to Steve Lindley (NOAA Fisheries Service) for his help in the creation and completion of this document. I am grateful to those who submitted reports and data and answered all my questions via email or phone conversations. I also extend my appreciation to the many reviewers that provided valuable feedback and suggestions. Thank you to John Williams (private consultant), Alice Low (CDFG), Tracy McReynolds (CDFG), Duane Massa (CDFG), J. D. Wikert (USFWS), Matt Brown (USFWS), Doug Killam (CDFG), Colleen Harvey-Arrison (CDFG), Jess Newton (USFWS), and Michael Mohr (NOAA Fisheries Service) for their thorough and thoughtful reviews.

REFERENCES

Banks, M. A., V. K. Rashbrook, M. J. Calavetta, C. A. Dean, and D. Hedgecock. 2000. Analysis of microsatellite DNA resolves genetic structure and diversity of chinook salmon (*Oncorhynchus tshawytscha*) in California's Central Valley. Canadian Journal of Fisheries and Aquatic Sciences 57:915-927.

Brandes, P., K. Perry, E. Chappell, J. McLain, S. Greene, R. Sitts, D. McEwan, and M. Chotkowski (Delta Project Work Team). 2000. Delta juvenile salmon monitoring program review. 144 p.

Brown, R. L. and S. Greene. 1992. Biological Assessment: effects of Central Valley Project and State Water Project Delta Operations on winter-run chinook salmon. California Department of Water Resources. Sacramento, California. 137 p.

Brown, M. R. and J. M. Newton. 2002. Monitoring adult chinook salmon, rainbow trout, and steelhead in Battle Creek, California, from March through October 2001. USFWS Report. Red Bluff Fish and Wildlife Office, Red Bluff, California. 47 p.

Busby, P. J., T. C. Wainwright, G. J. Bryant, L. Lierheimer, R. S. Waples, F. W. Waknitz, and I. V. Lagomarsino. 1996. Status review of west coast steelhead from Washington, Idaho, Oregon, and California. U. S. Dep. Commer., NOAA Tech. Memo. NMFS-NWFSC-27. 261 p.

California Department of Fish and Game (CDFG). 1993. Restoring Central Valley streams: a plan for action. California Department of Fish and Game, Sacramento, California. 129 p.

California Department of Fish and Game (CDFG). 1997. Central Valley anadromous fish-habitat evaluations: Sacramento and American River investigations, October 1995 through September 1996. Annual Progress Report. California Department of Fish and Game, Environmental Services Division, Stream Flow and Habitat Evaluation Program. 27 p.

California Department of Fish and Game (CDFG). 1998a. Central Valley anadromous fish-habitat evaluations: October 1996 through September 1997. Annual Progress Report. California Department of Fish and Game, Environmental Services Division, Stream Evaluation Program. 26 p.

California Department of Fish and Game (CDFG). 1998b. Report to the Fish and Game Commission: a status review of the spring-run chinook salmon (*Oncorhynchus tshawytscha*) in the Sacramento River drainage. Candidate Species status report 98-01. CDFG. Sacramento, California. 239 p.

California Department of Fish and Game (CDFG). 1999. Central Valley anadromous

fish-habitat evaluations: October 1997 through September 1998. Annual Progress Report. California Department of Fish and Game, Water and Aquatic Habitat Conservation Branch, Stream Evaluation Program, Technical Report No. 99-4. 21 p.

California Department of Fish and Game (CDFG). 2000. Central Valley anadromous fish-habitat evaluations: October 1998 through September 1999. Annual Progress Report. California Department of Fish and Game, Native Habitat Conservation Division, Native Anadromous Fish and Watershed Branch, Stream Evaluation Program, Technical Report No. 00-08. 25 p.

California Department of Fish and Game (CDFG). 2001. Spring-run chinook salmon. California Department of Fish and Game, Habitat Conservation Division, Native Anadromous Fish and Watershed Branch Annual Report. March 2001. 23 p.

California Department of Fish and Game (CDFG). 2002a. Sacramento River spring-run chinook salmon. California Department of Fish and Game, Habitat Conservation Division, Native Anadromous Fish and Watershed Branch, Annual Report, October 2002. 28 p.

California Department of Fish and Game (CDFG). 2002b. Sacramento River winter-run chinook salmon. Biennial Report, 2000-2001. California Department of Fish and Game, Habitat Conservation Division, Native Anadromous Fish and Watershed Branch, March 2002. 25 p.

California Department of Fish and Game (CDFG). 2004a. Sacramento River winter-run chinook salmon. Biennial Report, 2002-2003. California Department of Fish and Game, Habitat Conservation Division, Native Anadromous Fish and Watershed Branch, June 2004. 23 p.

California Department of Fish and Game (CDFG). 2004b. Sacramento River spring-run chinook salmon. Biennial Report, 2002-2003. California Department of Fish and Game, Habitat Conservation Division, Native Anadromous Fish and Watershed Branch, June 2004. 35 p.

California Department of Fish and Game (CDFG). 2005. Winter- and spring-run chinook and steelhead rotary screw trapping data from Knights Landing (Sacramento River) from 2000-2004. California Department of Fish and Game. Sacramento, California. Unpublished data.

California Department of Water Resources (CDWR). 1986. Clear Creek fishery study. California Department of Water Resources, Northern District Report. 70 p.

California Department of Water Resources (CDWR). 1999a. Feather River study:

chinook salmon emigration survey, March through June 1996. California Department of Water Resources, Environmental Services Office. Sacramento, California. November 1999. 24 p.

California Department of Water Resources (CDWR). 1999b. Feather River study: chinook salmon emigration survey, October through December 1996. California Department of Water Resources, Environmental Services Office. Sacramento, California. November 1999. 17 p.

California Department of Water Resources (CDWR). 1999c. Feather River study: chinook salmon emigration survey, December 1997 through June 1998. California Department of Water Resources, Environmental Services Office. Sacramento, California. November 1999. 31 p.

California Department of Water Resources (CDWR). 2002. Emigration of juvenile chinook salmon in the Feather River, 1998-2001. California Department of Water Resources, Sacramento, California. 26 p. (plus appendices)

California Department of Water Resources (CDWR). 2003a. Fish passage improvement: Bulletin 250-2002, Public Review Draft, v. 2. California Department of Water Resources, Sacramento, California.

California Department of Water Resources (CDWR). 2003b. Lower Feather River steelhead (*Oncorhynchus mykiss*) redd survey. Oroville Facilities Relicensing, FERC Project No. 2100, SP-F10 Task 2B. California Department of Water Resources. Sacramento, California.

California Department of Water Resources (CDWR). 2003c. River flow effects on emigration juvenile salmonids in the lower Feather River. Oroville Facilities Relicensing, FERC Project No. 2100, SP-F10 Task 4A. California Department of Water Resources. Sacramento, California.

California Department of Water Resources (CDWR). 2003d. Timing, thermal tolerance ranges, and potential water temperature effects on emigrating juvenile salmonids in the lower Feather River. Oroville Facilities Relicensing, FERC Project No. 2100, SP-F10 Task 4B. California Department of Water Resources. Sacramento, California.

California Department of Water Resources (CDWR). 2004a. Distribution and habitat use of juvenile steelhead and other fishes of the lower Feather River. Oroville Facilities Relicensing, FERC Project No. 2100, SP-F10 Task 3A. California Department of Water Resources. Sacramento, California.

California Department of Water Resources (CDWR). 2004b. Growth investigations of

wild and hatchery steelhead in the lower Feather River. Oroville Facilities Relicensing, FERC Project No. 2100, SP-F10 Task 3B. California Department of Water Resources. Sacramento, California.

Carl Mesick Consultants (CMC) and S. P. Cramer & Associates, Inc. (SPCA). 2002. Initial working document: a plan to restore anadromous fish habitat in the lower Stanislaus River. Stanislaus River Fish Group, Stockton, California. December 2002. 62 p.

Cavallo, B., A. Thompson, J. Kindopp, R. Kurth, and A. Seesholtz. 2003. Summary of 2002 Feather River salmon spawning escapement surveys. California Department of Water Resources, Division of Environmental Services, Sacramento, California. 8 p.

Choi, A. S. and J. E. Merz. 1997. Angler survey of the Mokelumne River Day-Use Area, San Joaquin County, California, January 1 through April 16, 1997. East Bay Municipal Utility District, Lodi, California. 10 p.

Croci, S. J. and S. Hamelberg. 1998. Escapement of unclipped (spring) chinook salmon (*Oncorhynchus tshawytscha*) to Battle Creek, California from March through October 1996. U. S. Fish and Wildlife Service. Red Bluff, California. 16 p.

Demko, D. B. and S. P. Cramer. 1997. Outmigrant trapping of juvenile salmonids in the lower Stanislaus River, Caswell State Park site, 1996. Final Report. S. P. Cramer & Associates, Inc., Gresham, Oregon. 154 p.

Demko, D. B. and S. P. Cramer. 1998. Outmigrant trapping of juvenile salmonids in the lower Stanislaus River, Caswell State Park site, 1997. Final Report. S. P. Cramer & Associates, Inc., Gresham, Oregon. 109 p.

Demko, D. B., C. Gemperle, S. P. Cramer and A. Phillips. 1999. Outmigrant trapping of juvenile salmonids in the lower Stanislaus River, Caswell State Park site, 1998. S. P. Cramer & Associates, Inc., Gresham, Oregon. 134 p.

Demko, D. B., C. Gemperle, A. Phillips and S. P. Cramer. 2000. Outmigrant trapping of juvenile salmonids in the lower Stanislaus River, Caswell State Park site, 1999. S. P. Cramer & Associates, Inc., Gresham, Oregon. 145 p.

English, K. K., R. C. Bocking, and J. R. Irvine. 1992. A robust procedure for estimating salmon escapement based on the area-under-the-curve method. Canadian Journal of Fisheries and Aquatic Sciences 49(10):1982-1989.

Fisher, F. W. 1992. Chinook salmon, *Oncorhynchus tshawytscha*, growth and occurrence in the Sacramento-San Joaquin river system. California Department of Fish and Game, Inland Fisheries Division, Red Bluff, California.

Fisher, F. W. 1994. Past and present status of Central Valley chinook salmon. Conservation Biology 8(3):870-873.

Fry, D. H., Jr. 1961. King salmon spawning stocks of the California Central Valley, 1940-1959. California Department of Fish and Game. 47(1):55-71.

Fry, D. H., Jr. and A., Jr. Petrovich. 1970. King salmon (*Oncorhynchus tshawytscha*) spawning stocks of the California Central Valley, 1953-1969. California Department of Fish and Game, Anadromous Fisheries Administrative Report No. 70-11. 21 p.

Fuller, A. 2005. Calaveras River rotary screw trapping, 2002-2004. S. P. Cramer & Associates, Inc. Oakdale, California. Unpublished data. 2 p.

Gaines, P. D. and C. D. Martin. 2002. Abundance and seasonal, spatial and diel distribution patterns of juvenile salmonids passing the Red Bluff Diversion Dam, Sacramento River. Red Bluff Research Pumping Plant Report Series, Volume 14. U. S. Fish and Wildlife Service, Red Bluff, California. 178 p.

Gaines, P. D. and W. R. Poytress. 2003. Brood-year 2002 winter chinook juvenile production indices with comparisons to adult escapement. U. S. Fish and Wildlife Service, Red Bluff, California. 31 p.

Groh, F. 1970. Annual report, Feather River salmon and steelhead hatchery, first year of operation, 1967-68. California Department of Fish and Game, Anadromous Fisheries Administrative Report No. 70-9. 18 p.

Groh, F. 1971. Annual report, Feather River salmon and steelhead hatchery, second year of operation, 1968-69. California Department of Fish and Game, Anadromous Fisheries Branch Administrative Report No. 72-5. 23 p.

Hallock, R. J., D. H. Fry, Jr., and D. A. LaFaunce. 1957. The use of wire fyke traps to estimate the runs of adult salmon and steelhead in the Sacramento River. California Fish and Game 43(4):271-298.

Hallock, R. J., W. F. Van Woert, and L. Shapovalov. 1961. An evaluation of stocking hatchery-reared steelhead rainbow trout (*Salmo gairdnerii gairdnerii*) in the Sacramento River system. California Department of Fish and Game Bulletin No. 114.

Hallock, R. J. 1989. Upper Sacramento River steelhead (*Oncorhynchus mykiss*), 1952-1988. Report prepared for the U. S. Fish and Wildlife Service, Red Bluff, California. 86 p.

Hannon, J. and M. Healey. 2002. American River steelhead redd surveys, 2001-2002. U. S. Bureau of Reclamation and California Department of Fish and Game, Sacramento, California. 19 p.

Hannon, J., M. Healey, and B. Deason. 2003. American River steelhead (*Oncorhynchus mykiss*) spawning, 2001-2003. U. S. Bureau of Reclamation and California Department of Fish and Game, Sacramento, California. 36 p.

Hannon, J. and B. Deason. 2004. American River steelhead (*Oncorhynchus mykiss*) spawning, 2001-2004. U. S. Bureau of Reclamation, Sacramento, California. 43 p.

Harvey, C. D. 1995. Adult steelhead counts in Mill and Deer Creeks, Tehama County, October 1993 through June 1994. California Department of Fish and Game, Inland Fisheries, Administrative Report No. 95-3. 9 p.

Hedgecock, D. 2002. Microsatellite DNA for the management and protection of California's Central Valley chinook salmon (*Oncorhynchus tshawytscha*). Final report for the amendment to agreement No. B-59638. University of California, Davis, Bodega Bay, California.

Hilborn, R., B. G. Bue, and S. Sharr. 1999. Estimating spawning escapements from periodic counts: a comparison of methods. Canadian Journal of Fisheries and Aquatic Sciences. 56:888-896.

Hill, K. A. and J. D. Webber. 1999. Butte Creek spring-run chinook salmon, *Oncorhynchus tshawytscha*, juvenile outmigration and life history, 1995-1998. California Department of Fish and Game, Inland Fisheries Administrative Report No. 99-5. 46 p.

Hoopaugh, D. A. (ed.) 1977. King (chinook) salmon spawning stocks in California's Central Valley, 1975. California Department of Fish and Game, Anadromous Fisheries Branch, Administrative Report No. 77-12. 29 p.

Hoopaugh, D. A. (ed.) 1978. King (chinook) salmon spawning stocks in California's Central Valley, 1976. California Department of Fish and Game, Anadromous Fisheries Branch, Administrative Report No. 78-19. 33 p.

Hoopaugh, D. A. and A. C. Knutson, Jr. (eds.) 1979. Chinook (King) salmon spawning stocks in California's Central Valley, 1977. California Department of Fish and Game, Anadromous Fisheries Branch Report No. 79-11. 36 p.

Kano, R. M. (ed.) 1997. Annual report, chinook salmon spawner stocks in California's Central Valley, 1988. California Department of Fish and Game, Inland Fisheries Division, Administrative Report No. 97-10. 41 p.

Kano, R. M. (ed.) 1998a. Annual report, chinook salmon spawner stocks in California's Central Valley, 1989. California Department of Fish and Game, Inland Fisheries Division, Administrative Report No. 98-2. 42 p.

Kano, R. M. (ed.) 1998b. Annual report, chinook salmon spawner stocks in California's Central Valley, 1990. California Department of Fish and Game, Inland Fisheries Division, Administrative Report No. 98-6. 34 p.

Kano, R. M. (ed.) 1999a. Chinook salmon spawner stocks in California's Central Valley, 1993. California Department of Fish and Game, Inland Fisheries Division, Administrative Report No. 99-1. 43 p.

Kano, R. M. (ed.) 1999b. Chinook salmon spawner stocks in California's Central Valley, 1994. California Department of Fish and Game, Inland Fisheries Division, Administrative Report No. 99-2. 41 p.

Kano, R. M. (ed.) 1999c. Chinook salmon spawner stocks in California's Central Valley, 1995. California Department of Fish and Game, Inland Fisheries Division, Administrative Report No. 99-7. 42 p.

Kano, R. M., and R. Reavis (eds.) 1996. Annual report, chinook salmon spawning stocks in California's Central Valley, 1985. California Department of Fish and Game, Inland Fisheries Division, Administrative Report No. 96-4. 39 p.

Kano, R. M., and R. Reavis (eds.) 1997a. Annual report, chinook salmon spawner stocks in California's Central Valley, 1986. California Department of Fish and Game, Inland Fisheries Division, Administrative Report No. 97-2. 40 p.

Kano, R. M., and R. Reavis (eds.) 1997b. Annual report, chinook salmon spawner stocks in California's Central Valley, 1987. California Department of Fish and Game, Inland Fisheries Division, Administrative Report No. 97-4. 37 p.

Kano, R. M., R. Reavis, and F. Fisher (eds.) 1996. Annual report, chinook salmon spawning stocks in California's Central Valley, 1984. California Department of Fish and Game, Inland Fisheries Division, Administrative Report No. 96-3. 40 p.

Killam, D. and C. Harvey-Arrison. 2001. Chinook salmon spawner populations for the upper Sacramento River system, 2001. California Department of Fish and Game, Red Bluff, California. Unpublished report.

Killam, D. and C. Harvey-Arrison. 2002. Chinook salmon spawner populations for the upper Sacramento River system, 2002. California Department of Fish and Game, Red Bluff, California. Unpublished report.

Killam, D. and T. Moore. 2001. 2001 Beegum Creek results. California Department of Fish and Game. 8 p.

Killam, D. 2005. Sacramento River chinook salmon aerial redd survey data, 1969-2004. California Department of Fish and Game, Sacramento, California. Unpublished data.

Knutson, A. C., Jr. 1980. Chinook (King) salmon spawning stocks in California's Central Valley, 1978. California Department of Fish and Game, Anadromous Fisheries Branch, Administrative Report No. 80-6. 32 p.

Lindley, S. T., R. Schick, B. P. May, J. J. Anderson, S. Green, C. Hanson, A. Low, D. McEwan, R. B. MacFarlane, C. Swanson, and J. G. Williams. 2004. Population structure of threatened and endangered chinook salmon ESUs in California's Central Valley Basin. U. S. Dept. Commer., NOAA Tech. Memo. NOAA-TM-NMFS-SWFSC-360. 56 p.

Marine, K. and D. A. Vogel. 1993. A report on monitoring of the upstream spawning migration of chinook salmon and steelhead during October through December 1992. The Mokelumne River chinook salmon and steelhead monitoring program, 1992-1993. Report to EBMUD, Watershed and Recreation Division, Orinda, California. Vogel Environmental Sciences, Red Bluff, California. 48 p.

Marine, K. and D. A. Vogel. 1994. A report on monitoring of the upstream spawning migration of chinook salmon and steelhead during October through December 1993 and monitoring of emigration of the 1993 fall release of yearling chinook salmon from Mokelumne Fish Installation during October 1993 through February 1994. The Mokelumne River chinook salmon and steelhead monitoring program, 1993-1994. Report to EBMUD, Watershed and Recreation Division, Orinda, California. Vogel Environmental Sciences, Red Bluff, California. 49 p.

Marine, K. R. and D. A. Vogel. 1996. Monitoring of the upstream spawning migration of chinook salmon and steelhead during October through December 1994. Mokelumne River chinook salmon and steelhead monitoring program, 1994-1995. Report to EBMUD, Watershed and Recreation Division, Orinda, California. Vogel Environmental Sciences, Red Bluff, California. 58 p.

Marine, K. R. and D. A. Vogel. 1998. A technical report on the monitoring of the upstream spawning migration of chinook salmon and steelhead during September through December 1995. Mokelumne River chinook salmon and steelhead monitoring program, 1995-1996. Report to EBMUD, Watershed and Recreation Division, Orinda, California. Natural Resource Scientists, Inc., Red Bluff, California. 46 p.

Marine, K. R. and D. A. Vogel. 1999a. A technical report on the monitoring of the upstream spawning migration of chinook salmon and steelhead during September 1997 through February 1998. Mokelumne River chinook salmon and steelhead monitoring program, 1997-1998. Report to EBMUD, Fisheries and Wildlife

Division, Orinda, California. Natural Resource Scientists, Inc., Red Bluff, California. 44 p.

Marine, K. R. and D. A. Vogel. 1999b. A technical report on the upstream migration monitoring at Woodbridge Dam during August 1998 through March 1999. Lower Mokelumne River fisheries monitoring program, 1998-1999. Report to EBMUD, Fisheries and Wildlife Division, Lodi, California. Natural Resource Scientists, Inc., Red Bluff, California. 48 p.

Marine, K. R. and D. A. Vogel. 2000. A technical report on the upstream migration monitoring at Woodbridge Dam during August 1999 through March 2000. Lower Mokelumne River fisheries monitoring program, 1999-2000. Report to EBMUD, Fisheries and Wildlife Division, Lodi, California. Natural Resource Scientists, Inc., Red Bluff, California. 48 p.

Marston, D., California Department of Fish and Game. [Letter to M. Martinez, National Marine Fisheries Service]. 2003 January 9.

Martin, C. D., P. D. Gaines and R. R. Johnson. 2001. Estimating the abundance of Sacramento River juvenile winter chinook salmon with comparisons to adult escapement. Red Bluff Research Pumping Plant Report Series, Volume 5. U. S. Fish and Wildlife Service, Red Bluff, California. 46 p.

Massa, D. 2004. Central Valley Harvest Monitoring Project: angler survey estimate summaries, steelhead trout 1998-2000. California Department of Fish and Game, unpublished data.

McEwan, D. R. 2001. Central Valley steelhead. In: R. L. Brown, editor, *Fish Bulletin 179: Contributions to the biology of Central Valley salmonids*, volume 1, pages 1-44. California Department of Fish and Game, Sacramento, California.

Menchen, R. S. (ed.) 1970. King (chinook) salmon spawning stocks in California's Central Valley, 1969. California Department of Fish and Game, Anadromous Fisheries Branch, Administrative Report No. 70-14. 26 p.

Menchen, R. S. (ed.) 1971. King (chinook) salmon spawning stocks in California's Central Valley, 1970. California Department of Fish and Game, Anadromous Fisheries Branch, Administrative Report No. 72-2. 27 p.

Merz, J. 1997. Creel and angler survey for the Mokelumne River Day Use Area, San Joaquin County, California, September 1 through October 15, 1996. East Bay Municipal Utility District, Oakland, California. 7 p.

Merz, J. 1998. An angler survey of the Lower Mokelumne River, San Joaquin County, California, January 1 through October 15, 1998. East Bay Municipal Utility District, Lodi, California. 15 p.

Mills, T. J. and F. Fisher. 1994. Central Valley anadromous sport fish annual run-size, harvest, and population estimates, 1967 through 1991. California Department of Fish and Game, Inland Fisheries Technical Report. 70 p.

Moore, T. 2001. Steelhead survey report for Antelope, Deer, Beegum and Mill Creeks, 2001. California Department of Fish and Game, Sacramento River Salmon and Steelhead Assessment Program. 8 p.

Myers, J. M., R. G. Kope, G. J. Bryant, D. Teel, L. J. Lierheimer, T. C. Wainwright, W. S. Grant, F. W. Waknitz, K. Neely, S. T. Lindley, and R. S. Waples. 1998. Status review of chinook salmon from Washington, Idaho, Oregon, and California. U. S. Dept. Commer., NOAA Tech. Memo. NMFS-NWFSC-35. 443 p.

National Marine Fisheries Service (NMFS). 1993. Designated Critical Habitat; Sacramento River winter-run chinook salmon. Federal Register [Docket No. 920783-3085; June 16, 1993] 58(114):33212-33219.

National Marine Fisheries Service (NMFS). 1994. Endangered and threatened species; Status of Sacramento River winter-run chinook salmon. Federal Register [Docket No. 930779-3330; I.D. 051192B; January 4, 1994] 59(2):440-450.

National Marine Fisheries Service (NMFS). 1998. Endangered and threatened species: Threatened status for two Evolutionary Significant Units (ESUs) of steelhead in Washington, Oregon, and California. Federal Register [Docket No. 980225046-8060-02; I.D. 073097E; March 19, 1998] 63(53):13347-13371.

National Marine Fisheries Service (NMFS). 1999. Endangered and threatened species; Threatened status for two chinook salmon Evolutionary Significant Units (ESUs) in California. Federal Register [Docket No. 990303060-9231-03; I.D. 022398C; September 16, 1999] 64(179):50394-50415.

Newton, J. M. and M. R. Brown. 2004. Adult spring chinook salmon monitoring in Clear Creek, California, 1999-2002. U. S. Fish and Wildlife Service, Red Bluff Fish and Wildlife Office, Red Bluff, California. 63 p.

Overton, P. H. 1995. Annual report, Feather River hatchery, 1994-95. California Department of Fish and Game, Inland Fisheries Administrative Report (Draft).

Overton, P. H. 1996. Annual report, Feather River hatchery, 1995-96. California Department of Fish and Game, Inland Fisheries Administrative Report (Draft).

Overton, P. H. 1997. Annual report, Feather River hatchery, 1996-97. California Department of Fish and Game, Inland Fisheries Administrative Report (Draft).

Reavis, R. L., Jr. 1981. Chinook (King) salmon spawning stocks in California's Central

Valley, 1980. California Department of Fish and Game, Anadromous Fisheries Branch, Administrative Report No. 81-7. 36 p.

Reavis, R. L., Jr. 1983. Chinook salmon spawning stocks in California's Central Valley, 1981. California Department of Fish and Game, Anadromous Fisheries Branch, Administrative Report No. 83-2. 41 p.

Reavis, R. 1985. Chinook salmon spawning stocks in California's Central Valley, 1983. California Department of Fish and Game, Anadromous Fisheries Branch, Administrative Report No. 86-01. 39 p.

Rice, G. V. 1964. Annual report, Feather River Hatchery Interim Facility, 1963-64. California Department of Fish and Game, Inland Fisheries Administrative Report No. 64-17. 15 p.

Rice, G. V. 1967. Annual report, Feather River Hatchery Interim Facility, 1965-66. California Department of Fish and Game, Inland Fisheries Administrative Report No. 67-5. 21 p.

Rice, G. V. 1968. Annual report, Feather River Hatchery Interim Facility, 1966-67. California Department of Fish and Game, Inland Fisheries Administrative Report No. 68-4. 19 p.

Rice, G. V. and A. F. Pollitt. 1965. Annual report, Feather River Hatchery Interim Facility, 1964-65. California Department of Fish and Game, Inland Fisheries Administrative Report No. 65-19. 20 p.

Ricker, W. E. 1975. Computation and interpretation of biological statistics of fish populations. Canada Dept. of Environ., Fish. and Mar. Serv. Bull. 191. 382 p.

Schaefer, M. B. 1951. Estimation of the size of animal populations by marking experiments. U.S. Fish and Wildlife Service Bulletin 52:189-203.

Schick, R. S., A. L. Edsall, and S. T. Lindley. 2004. Historical and current distribution of Pacific salmonids in the Central Valley, CA. U. S. Dept. Commer., NOAA Tech. Memo. NOAA-NMFS-SWFSC-SC-2004-01. 25 p.

Schlichting, D. 1973a. Annual report, Feather River salmon and steelhead hatchery fifth year of operation, 1971-72. California Department of Fish and Game, Anadromous Fisheries Branch Administrative Report No. 73-11. 24 p.

Schlichting, D. L. 1973b. Feather River salmon and steelhead hatchery annual report, 1969-70. California Department of Fish and Game, Anadromous Fisheries Branch Administrative Report No. 74-5. 20 p.

Schlichting, D. 1974. Annual report, Feather River salmon and steelhead hatchery,

1970-71. California Department of Fish and Game, Anadromous Fisheries Branch Administrative Report No. 74-11. 23 p.

Schlichting, D. 1976. Annual report, Feather River salmon and steelhead hatchery, 1972-73. California Department of Fish and Game, Anadromous Fisheries Branch Administrative Report No. 76-5. 25 p.

Schlichting, D. L. 1978a. Annual report, Feather River salmon and steelhead hatchery, 1973-74. California Department of Fish and Game, Anadromous Fisheries Branch Administrative Report No. 78-12. 22 p.

Schlichting, D. L. 1978b. Annual report, Feather River salmon and steelhead hatchery, 1974-75. California Department of Fish and Game, Anadromous Fisheries Branch Administrative Report No. 78-13. 21 p.

Schlichting, D. L. 1978c. Annual report, Feather River salmon and steelhead hatchery, 1975-76. California Department of Fish and Game, Anadromous Fisheries Branch Administrative Report No. 78-14. 21 p.

Schlichting, D. L. 1982a. Annual report, Feather River hatchery, 1976-77. California Department of Fish and Game, Anadromous Fisheries Branch Administrative Report No. 82-10. 20 p.

Schlichting, D. L. 1982b. Annual report, Feather River hatchery, 1977-78. California Department of Fish and Game, Anadromous Fisheries Branch Administrative Report No. 82-35. 20 p.

Schlichting, D. L. 1982c. Annual report, Feather River hatchery, 1978-79. California Department of Fish and Game, Anadromous Fisheries Branch Administrative Report No. 82-36. 19 p.

Schlichting, D. L. 1982d. Annual report, Feather River hatchery, 1979-80. California Department of Fish and Game, Anadromous Fisheries Branch Administrative Report No. 82-33. 21 p.

Schlichting, D. L. 1983a. Annual report, Feather River hatchery, 1980-81. California Department of Fish and Game, Anadromous Fisheries Branch Administrative Report No. 83-4. 22 p.

Schlichting, D. L. 1983b. Annual report, Feather River hatchery, 1981-82. California Department of Fish and Game, Anadromous Fisheries Branch Administrative Report No. 83-5. 21 p.

Schlichting, D. L. 1983c. Annual report, Feather River hatchery, 1982-83. California Department of Fish and Game, Anadromous Fisheries Branch Administrative Report No. 83-14. 21 p.

Schlichting, D. L. 1984. Annual report, Feather River hatchery, 1983-84. California Department of Fish and Game, Inland Fisheries Administrative Report No. 87-2. 21 p.

Schlichting, D. L. 1986. Annual report, Feather River hatchery, 1984-85. California Department of Fish and Game, Inland Fisheries Administrative Report No. 87-3. 13 p.

Schlichting, D. L. 1987. Annual report, Feather River hatchery, 1985-86. California Department of Fish and Game, Inland Fisheries Administrative Report No. 87-19. 13 p.

Schlichting, D. L. 1988. Annual report, Feather River hatchery, 1986-87. California Department of Fish and Game, Inland Fisheries Administrative Report No. 88-10. 12 p.

Schlichting, D. L. 1990. Annual report, Feather River hatchery, 1987-88. California Department of Fish and Game, Inland Fisheries Administrative Report No. 90-13. 11 p.

Schlichting, D. L. 1991. Annual report, Feather River hatchery, 1988-89. California Department of Fish and Game, Inland Fisheries Administrative Report No. 91-12. 11 p.

Schlichting, D. L. 1993a. Annual report, Feather River hatchery, 1989-90. California Department of Fish and Game, Inland Fisheries Administrative Report No. 93-4. 10 p.

Schlichting, D. L. 1993b. Annual report, Feather River hatchery, 1990-91. California Department of Fish and Game, Inland Fisheries Administrative Report No. 93-5. 10 p.

Schlichting, D. L. 1993c. Annual report, Feather River hatchery, 1991-92. California Department of Fish and Game, Inland Fisheries Administrative Report No. 93-7. 11 p.

Schlichting, D. L. 1994a. Annual report, Feather River hatchery, 1992-93. California Department of Fish and Game, Inland Fisheries Administrative Report (Draft).

Schlichting, D. L. 1994b. Annual report, Feather River hatchery, 1993-94. California Department of Fish and Game, Inland Fisheries Administrative Report (Draft).

Schroyer, T., D. Massa, and K. Murphy. 2002. Central Valley salmon and steelhead harvest monitoring project: 2001 Angler survey. California Department of Fish and Game. Rancho Cordova, California. 25 p.

Seber, G. A. 1982. The estimation of animal abundance and related parameters. 2nd. MacMillan, New York, N. Y. 654 p.

Seesholtz, A., B. J. Cavallo, J. Kindopp, and R. Kurth. 2004. Juvenile fishes of the lower Feather River: distribution, emigration patterns, and associations with environmental variables. American Fisheries Society Symposium 39:141-166.

Setka, J. D. 1999. Fall-run chinook salmon and steelhead trout spawning survey, September 1998 through January 1999, Mokelumne River, California. East Bay Municipal Utility District, Orinda, California. 11 p.

Setka, J. D. 2000. Fall-run chinook salmon and steelhead trout spawning survey, September 1999 through January 2000, Mokelumne River, California. East Bay Municipal Utility District, Orinda, California. 10 p.

Smith, J. G. 2002. Release report for brood year 2001 winter chinook salmon juveniles propagated at the U. S. Fish and Wildlife Service's Livingston Stone National Fish Hatchery. U. S. Fish and Wildlife Service, Red Bluff Fish and Wildlife Office, Red Bluff, California. 20 p.

Snider, B. and D. McEwan. 1993. Fish community survey, lower American River, February through July 1992. California Department of Fish and Game, Environmental Services Division, Stream Evaluation Program, Technical Report No. 93-3. 94 p.

Snider, B. and N. Keenan. 1994. Fish community survey, lower American River, January through August 1993. California Department of Fish and Game, Environmental Services Division, Stream Evaluation Program, Technical Report No. 94-1. 37 p. (plus appendices)

Snider, B. and R. Titus. 1996. Fish community survey, lower American River, January through June 1995. California Department of Fish and Game, Environmental Services Division, Stream Evaluation Program, Technical Report No. 96-3. 21 p. (plus appendices)

Snider, B. and R. Titus. 1998. Evaluation of juvenile anadromous salmonid emigration in the Sacramento River near Knights Landing, November 1995 through July 1996. California Department of Fish and Game, Environmental Services Division, Stream Evaluation Program. 26 p. (plus appendices)

Snider, B., R. G. Titus, and B. A. Payne. 1998. Lower American River emigration survey, October 1995-September 1996. California Department of Fish and Game, Environmental Services Division, Stream Evaluation Program, Technical Report No. 98-6. 19 p. (plus appendices)

Snider, B. and R. G. Titus. 2000a. Lower American River emigration survey, October 1996-September 1997. California Department of Fish and Game, Native Anadromous Fish and Watershed Branch, Stream Evaluation Program, Technical Report No. 00-2. 25 p. (plus appendices)

Snider, B. and R. G. Titus. 2000b. Timing, composition and abundance of juvenile anadromous salmonid emigration in the Sacramento River near Knights Landing, October 1996-September 1997. California Department of Fish and Game, Native Anadromous Fish and Watershed Branch, Stream Evaluation Project, Technical Report No. 00-04. 30 p. (plus appendices)

Snider, B. and R. G. Titus. 2000c. Timing, composition and abundance of juvenile anadromous salmonid emigration in the Sacramento River near Knights Landing, October 1997-September 1998. California Department of Fish and Game, Native Anadromous Fish and Watershed Branch, Stream Evaluation Project, Technical Report No. 00-15. 27 p. (plus appendices)

Snider, B. and R. G. Titus. 2000d. Timing, composition and abundance of juvenile anadromous salmonid emigration in the Sacramento River near Knights Landing, October 1998-September 1999. California Department of Fish and Game, Native Anadromous Fish and Watershed Branch, Stream Evaluation Project, Technical Report No. 00-6. 28 p. (plus appendices)

Snider, B. and R. G. Titus. 2001. Lower American River emigration survey, October 1997-September 1998. California Department of Fish and Game, Native Anadromous Fish and Watershed Branch, Stream Evaluation Program, Technical Report No. 01-6. 21 p. (plus appendices)

Snider, B., B. Reavis, R. G. Titus, and S. Hill. 2002. Upper Sacramento River winter-run chinook salmon escapement survey, May through August 2001. California Department of Fish and Game, Native Anadromous Fish and Watershed Branch, Stream Evaluation Program, Technical Report No. 02-1. 30 p.

S. P. Cramer & Associates. 2001. Stanislaus River data report, final data. S. P. Cramer & Associates. Oakdale, California. Unpublished report.

S. P. Cramer & Associates. 2002. Stanislaus River data report supplement, final data. S. P. Cramer & Associates. Oakdale, California. Unpublished report.

S. P. Cramer & Associates. 2003. Stanislaus River data report supplement, final data. S. P. Cramer & Associates. Oakdale, California. Unpublished report.

S. P. Cramer & Associates. 2004. Stanislaus River data report supplement, final data. S. P. Cramer & Associates. Oakdale, California. Unpublished report. July 2004.

Staley, J. R. 1976. American River steelhead (*Salmo gairdnerii gairdnerii*)

management, 1956-1974. California Department of Fish and Game, Anadromous Fisheries Branch, Administrative Report No. 76-2. 41 p.

Stanislaus River Fish Group (SRFG). 2004. A summary of fisheries research in the lower Stanislaus River. Initial working draft produced by SRFG, March 10, 2004. Stockton, California. 98 p.

Taylor, S. N. (ed). 1972. King (chinook) salmon spawning stocks in California's Central Valley, 1971. California Department of Fish and Game, Anadromous Fisheries Branch, Administrative Report No. 73-2. 36 p.

Taylor, S. N. (ed). 1973. King (chinook) salmon spawning stocks in California's Central Valley, 1972. California Department of Fish and Game, Anadromous Fisheries Branch, Administrative Report No. 74-6. 32 p.

U.S. Fish and Wildlife Service (USFWS). 2001. Biological assessment of artificial propagation at Coleman National Fish Hatchery and Livingston Stone National Fish Hatchery: program description and incidental take of chinook salmon and steelhead trout. Red Bluff, California: U.S. Fish and Wildlife Service. 231 p, plus appendices.

U. S. Fish and Wildlife Service (USFWS). 2005a. Winter- and spring-run chinook salmon, Battle Creek rotary screw trapping from 1999-2004. U. S. Fish and Wildlife Service. Red Bluff, California. Unpublished data.

U. S. Fish and Wildlife Service (USFWS). 2005b. Winter- and spring-run chinook salmon, Clear Creek rotary screw trapping from 1999-2004. U. S. Fish and Wildlife Service. Red Bluff, California. Unpublished data.

U. S. Fish and Wildlife Service (USFWS). 2005c. Steelhead (*Oncorhynchus mykiss*), Clear Creek rotary screw trapping from 1999-2004. U. S. Fish and Wildlife Service. Red Bluff, California. Unpublished data.

U. S. Fish and Wildlife Service (USFWS). 2005d. Steelhead (*Oncorhynchus mykiss*), Battle Creek rotary screw trapping from 1999-2004. U. S. Fish and Wildlife Service. Red Bluff, California. Unpublished data.

U. S. Fish and Wildlife Service (USFWS). 2005e. Winter- and spring-run chinook salmon and steelhead, Kodiak and midwater trawl data from sampling locations within the Sacramento-San Joaquin River system and Delta. U. S. Fish and Wildlife Service. Stockton, California. Unpublished data.

U. S. Fish and Wildlife Service (USFWS). 2005f. Winter- and spring-run chinook salmon and steelhead, midwater trawl data from Chipps Island in the Sacramento-San Joaquin Delta. U. S. Fish and Wildlife Service. Stockton, California. Unpublished data.

U. S. Fish and Wildlife Service (USFWS). 2005g. Steelhead (*Oncorhynchus mykiss*), Mossdale trawling results from 1996-2004. U. S. Fish and Wildlife Service. Stockton, California. Unpublished data.

Vogel, D. A. and K. R. Marine. 1991. Guide to upper Sacramento River chinook salmon life history. Prepared for U.S. Bureau of Reclamation, Central Valley Project. CH2M Hill, Redding, California. 55 p.

Vogel, D. A. and K. R. Marine. 1994. Evaluation of the downstream migration of juvenile chinook salmon and steelhead in the lower Mokelumne River and the Sacramento-San Joaquin Delta (January through July 1993). The Mokelumne River chinook salmon and steelhead monitoring program, 1992-1993. East Bay Municipal Utility District, Watershed and Recreation Division, Orinda, California. 59 p.

Vogel, D. A. and K. R. Marine. 1996. Evaluation of the downstream migration of juvenile chinook salmon and steelhead in the lower Mokelumne River and the Sacramento-San Joaquin Delta (January through July 1994). The Mokelumne River chinook salmon and steelhead monitoring program, 1993-1994. East Bay Municipal Utility District, Watershed and Recreation Division, Orinda, California. 66 p.

Vogel, D. A. and K. R. Marine. 1998. Evaluation of the downstream migration of juvenile chinook salmon and steelhead in the lower Mokelumne River and the Sacramento-San Joaquin Delta (January through July 1995). Mokelumne River chinook salmon and steelhead monitoring program, 1994-1995. East Bay Municipal Utility District, Watershed and Recreation Division, Orinda, California. 55 p.

Vogel, D. A. and K. R. Marine. 1999a. Evaluation of the downstream migration of juvenile chinook salmon and steelhead in the lower Mokelumne River and the Sacramento-San Joaquin Delta (January through July 1997). Mokelumne River chinook salmon and steelhead monitoring program, 1996-1997. East Bay Municipal Utility District, Fisheries and Wildlife Division, Orinda, California.

Vogel, D. A. and K. R. Marine. 1999b. Evaluation of the downstream migration of juvenile chinook salmon and steelhead in the lower Mokelumne River and the Sacramento-San Joaquin Delta (December 1997 through July 1998). Mokelumne River chinook salmon and steelhead monitoring program, 1997-1998. East Bay Municipal Utility District, Fisheries and Wildlife Division, Orinda, California.

Vogel, D. A. and K. R. Marine. 2000. A technical report on downstream migration monitoring at Woodbridge Dam during December 1998 through July 1999. Lower Mokelumne River fisheries monitoring program, 1998-1999. East Bay Municipal Utility District, Fisheries and Wildlife Division, Lodi, California. 38 p.

Ward, P. D. and T. R. McReynolds. 2001. Butte and Big Chico Creeks spring-run chinook salmon, *Oncorhynchus tshawytscha*, life history investigation, 1998-2000. California Department of Fish and Game, Inland Fisheries Branch, Administrative Report No. 2001-2. 61 p.

Ward, P. D., T. R. McReynolds, and C. E. Garman. 2002. Butte and Big Chico Creeks spring-run chinook salmon, *Oncorhynchus tshawytscha*, life history investigation, 2000-2001. California Department of Fish and Game, Inland Fisheries Branch, Administrative Report No. 2004-3. 40 p.

Ward, P. D., T. R. McReynolds, and C. E. Garman. 2003. Butte and Big Chico Creeks spring-run chinook salmon, *Oncorhynchus tshawytscha*, life history investigation, 2001-2002. California Department of Fish and Game, Inland Fisheries Branch, Administrative Report No. 2004-4. 53 p.

Workman, M. L. 2001. Lower Mokelumne River upstream fish migration monitoring conducted at Woodbridge Irrigation District Dam, August 2000 through April 2001. East Bay Municipal Utility District, Lodi, California. 21 p.

Workman, M. L. 2002. Downstream migration monitoring at Woodbridge Dam on the lower Mokelumne River, California, December 2000 through July 2001. East Bay Municipal Utility District, Lodi, California. 39 p.

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. Sierra Nevada Ecosystem Project: final report to US Congress. Volume III, assessments, commissioned reports and background information. p 309-361.

Yoshiyama, R. M., E. R. Gerstung, F. W. Fisher and P. B. Moyle. 2001. Historical and present distribution of chinook salmon in the Central Valley drainage of California. In R. L. Brown, editor, *Fish Bulletin 179: Contributions to the biology of Central Valley salmonids*., volume 1, pages 71-176. California Department of Fish and Game, Sacramento, California.

APPENDICES

Appendix 1-A. Average historical migration timing for winter- and spring-run chinook salmon and steelhead passing the Red Bluff Diversion Dam from 1970-1988 (Killam and Harvey-Arrison 2002).

		Based on years 1982-86		Based on years 1970-88		Based on years 1970-88	
		Winter-run chinook		Spring-run chinook		Steelhead	
Month	Week	%	Cum. %	%	Cum. %	%	Cum. %
JAN	1	1.70	3.45			0.97	91.84
	2	1.78	5.23			0.80	92.64
	3	0.35	5.57			0.61	93.25
	4	1.28	6.85			0.50	93.75
FEB	5	2.38	9.23			0.29	94.05
	6	3.12	12.35			0.45	94.50
	7	3.08	15.44			0.56	95.06
	8	0.97	16.41			0.53	95.59
MAR	9	6.35	22.76			0.49	96.09
	10	7.72	30.48			0.46	96.54
	11	9.23	39.70	**START**		0.38	96.92
	12	7.79	47.49	0.10	0.10	0.30	97.22
	13	4.91	52.40	0.25	.035	0.28	97.50
APR	14	7.64	60.04	0.58	0.93	0.35	97.85
	15	8.26	68.29	0.96	1.89	0.28	98.12
	16	9.19	77.48	1.38	3.27	0.19	98.31
	17	3.47	80.95	1.63	4.90	0.17	98.48
MAY	18	2.02	82.98	1.60	6.50	0.16	98.63
	19	1.60	84.58	1.71	8.21	0.17	98.80
	20	2.17	86.75	2.16	10.37	0.23	99.03
	21	3.09	89.84	2.63	13.00	0.18	99.20
JUN	22	2.03	91.87	2.86	15.86	0.20	99.40
	23	1.63	93.50	2.61	18.47	0.13	99.54
	24	1.84	95.34	2.93	21.40	0.14	99.68
	25	0.51	95.85	3.50	24.89	0.15	99.82
	26	0.76	96.61	3.10	27.99	0.18	100.00
JUL	27	1.60	98.20	3.67	31.66	0.13	0.13
	28	0.31	98.52	6.02	37.68	0.18	0.31
	29	1.04	99.55	4.75	42.44	0.18	0.49
	30	0.44	99.99	3.21	45.65	0.22	0.72
AUG	31	0.01	100.00	4.12	49.77	0.26	0.98
	32	**END**		6.97	56.74	0.39	1.36
	33			6.07	62.81	0.68	2.04
	34			6.75	69.55	1.12	3.16
	35			5.74	75.29	2.36	5.52
SEP	36			7.22	82.51	3.82	9.34
	37			6.68	89.19	5.80	15.14
	38			5.23	94.42	7.54	22.67
	39			3.70	98.12	8.95	31.63
OCT	40			1.19	99.31	11.75	13.37
	41			0.69	100.00	11.27	54.65
	42			**END**		9.79	64.44
	43					6.51	70.95
NOV	44					5.17	76.12
	45					4.04	80.17
	46					2.44	82.61
	47					2.21	84.82
DEC	48	**START**				2.05	86.87
	49	0.17	0.17			1.44	88.31
	50	0.38	0.55			1.04	89.35
	51	0.49	1.04			0.69	90.04
	52	0.71	1.75			0.83	90.87

Appendix 1-B. Estimated numbers of winter-run chinook salmon passing Red Bluff Diversion Dam from 1967 through 2003 (CDFG 2002b and 2004a).

Year	Grilse	Adults	Total
1967	24,985	32,321	57,306
1968	10,299	74,115	84,414
1969	8,953	108,855	117,808
1970	8,324	32,085	40,409
1971	20,864	32,225	53,089
1972	8,541	28,592	37,133
1973	4,623	19,456	24,079
1974	3,788	18,109	21,897
1975	7,498	15,932	23,430
1976	8,634	26,462	35,096
1977	2,186	15,028	17,214
1978	1,193	23,669	24,862
1979	113	2,251	2,364
1980	1,072	84	1,156
1981	1,744	18,297	20,041
1982	270	972	1,242
1983	392	1,439	1,831
1984	1,869	794	2,663
1985	329	3,633	3,962
1986	496	2,101	2,597
1987	277	1,909	2,186
1988	1,008	1,878	2,886
1989	125	571	696
1990	43	387	430
1991	19	192	211
1992	80	1,160	1,240
1993	137	250	387
1994	124	62	186
1995	29	1,268	1,297
1996	629	708	1,337
1997	352	528	880
1998	924	2,079	3,003
1999	2,466	822	3,288
2000	789	563	1,352
2001	3,827	1,696	5,523
2002	1,555	7,614	9,169
2003	3,585	6,172	9,757

Appendix 1-C. Adjusted winter-run chinook escapement estimates based on RBDD counts, accounting for sport fishery catch above RBDD from 1972 to 1993 (Taylor 1972, 1973, and 1974; Hoopaugh 1976 and 1978; Hoopaugh and Knutson 1979; Knutson 1980; Reavis 1981a, 1981b, 1983a, 1983b, and 1985; Kano and Reavis 1996, 1997a, and 1997b; Kano 1997, 1998a, 1998b, 1998c, 1998d, and 1999a; CDFG 2004a).

Year	RBDD Count	Sport fishery catch	Escapement estimate
1972	37,133	1204	35,929
1973	24,079	1428	22,651
1974	19,116	580	18,536
1975	23,430	851	22,579
1976	35,096	2067	33,029
1977	17,214	744	16,470
1978	24,862	127	24,735
1979	2364	25	2339
1980	1156	14	1142
1981	20,041	246	19,795
1982	1242	9	1233
1983	1831	4	1827
1984	2663	1	2662
1985	3960	276	3684
1986	2424	30	2394
1987	1998	20	1978
1988	2096	21	2075
1989	532	5	527
1990	441	4	437
1991	191	1	190
1992	1180	3	1177
1993	342	9	333

-Counts beyond 1993 are not included, as 'RBDD Counts' are provided in Appendix 1-B and 'Sport Fishery Catch' is assumed to be zero due to recreational fishing regulations.

Appendix 1-D. Estimated harvest of winter-run chinook salmon in the Sacramento River from 1967 through 1991 (Mills and Fisher 1994).

Year	Spawner estimate above RBDD	Estimated catch above RBDD[a]	Harvest rate above RBDD[b] (%)	Total river harvest rate[c] (%)	Harvest estimate[d]
1967	57,306	No est.	No est.	6.3	3602
1968	84,414	5631	6.7	13.4	11,308
1969	117,808	3628	3.1	7.7	9095
1970	40,409	2080	5.1	11.0	4440
1971	43,089	3484	8.1	15.6	6735
1972	37,133	1204	3.2	8.0	2944
1973	24,079	1428	5.9	12.2	2944
1974	21,897	580	2.6	7.0	2014
1975	23,430	851	3.6	8.6	2014
1976	35,096	2067	5.9	12.2	4268
1977	17,214	744	4.3	9.7	1667
1978	24,862	127	0.5	3.7	910
1979	2364	25	1.1	4.5	107
1980	1156	14	1.2	4.8	55
1981	20,041	246	1.2	4.8	961
1982	1242	9	0.7	4.0	50
1983	1831	4	0.2	3.2	59
1984	2663	1	0.0	2.9	78
1985	3962	275	6.9	13.8	548
1986	2464	43	1.7	5.6	138
1987	1997	20	1.0	4.4	89
1988	2094	21	1.0	0.0	0
1989	533	5	0.9	4.4	0
1990	441	4	0.9	0.0	0
1991	191	0	0.0	0.0	0
Annual average	22,709	937	2.8	6.5	2143

[a] Based on RBDD ladder counts combined with estimated catches from numbers reported at boat ramps and resorts, yielding rough estimates of annual harvest above RBDD.
[b] This column represents the proportion of the estimated catch above RBDD by the total spawning escapement estimate above RBDD.
[c] 'Total river harvest rate' is based on regression analysis (Mills and Fisher 1994).
[d] 'Harvest estimate' is based on application of the estimated annual harvest rate for the total river to the spawning escapement estimate for each year. This estimate is considered a harvest index.

Appendix 1-E. Winter-run chinook salmon redd distribution in the mainstem Sacramento River from 1981 to 2004, as enumerated during aerial surveys from Keswick Dam to Princeton Ferry (CDFG 2002b and 2004a; Killam 2005).

Year	No. of surveys conducted	Total no. of redds counted	Location on Sacramento River with highest density	Percent distribution at highest density location (%)
1981[a]	1	90	Hwy 44 Bridge to Airport Rd Bridge	86
1982[b]	1	33	ACID Dam to Highway 44 Bridge	56
1983	0	n/a	n/a	n/a
1984	0	n/a	n/a	n/a
1985[c]	1	103	Hwy 44 Bridge to Airport Rd Bridge / RBDD to Tehama Bridge	29 / 28
1986	0	n/a	n/a	n/a
1987[d]	10	313	Battle Creek to Jellys Ferry Road	20
1988[e]	11	1295	Hwy 44 Bridge to Airport Rd Bridge	30
1989[f]	11	47	Hwy 44 Bridge to Airport Rd Bridge	47
1990[g]	10	104	Hwy 44 Bridge to Airport Rd Bridge	51
1991[h]	9	10	ACID Dam to Highway 44 Bridge	70
1992[i]	12	55	Hwy 44 Bridge to Airport Rd Bridge	49
1993[j]	13	44	ACID Dam to Highway 44 Bridge	61
1994[k]	14	17	Airport Rd Bridge to Balls Ferry Bridge	41
1995[l]	11	175	ACID Dam to Highway 44 Bridge	83
1996[m]	15	70	ACID Dam to Highway 44 Bridge	71
1997[n]	13	30	ACID Dam to Highway 44 Bridge	83
1998[o]	13	121	ACID Dam to Highway 44 Bridge	77
1999	14	1144	Hwy 44 Bridge to Airport Rd Bridge	65
2000	16	588	Hwy 44 Bridge to Airport Rd Bridge	47
2001[p]	15	1396	Hwy 44 Bridge to Airport Rd Bridge	45
2002[q]	13	610	Keswick Dam to ACID Dam	49
2003[r]	12	878	Keswick Dam to ACID Dam	66
2004	12	621	Hwy 44 Bridge to Airport Rd Bridge	49

[a,d,g, h, i, j, k, l, q, r] River section from Woodson Bridge to Princeton Ferry was not surveyed.

[b, m, n] River section from Tehama Bridge to Princeton Ferry was not surveyed.

[c,e, p] River section from Hamilton City Bridge to Princeton Ferry was not surveyed.

[f, o] River section from Ord Ferry Bridge to Princeton Ferry was not surveyed.

Appendix 1-F. Winter-run chinook salmon instream escapement estimates for the entire Sacramento River Winter-run Chinook Salmon ESU, including RBDD counts adjusted to account for angler harvest and spawning population estimates based on aerial redd surveys below RBDD on the mainstem Sacramento River from 1975 to 1996 (Hoopaugh 1976 and 1978; Hoopaugh and Knutson 1979; Knutson 1980; Reavis 1981a, 1981b, 1983a, 1983b, and 1985; Kano and Reavis 1996, 1997a, and 1997b; Kano et al. 1996; Kano 1997, 1998a, 1998b, 1998c, 1998d, 1999a, 1999b, 1999c, and 2000).

Year	RBDD counts – Angler harvest	Estimated number of spawners in the Sacramento River mainstem[a]	Instream spawning escapement
1975	22,579	--	23,079
1976	33,029	--	33,529
1977	16,470	--	16,470
1978	24,735	--	24,985
1979	2339	--	2339
1980	1142	--	1142
1981	19,795	--	19,795
1982	1233	--	1233
1983	1827	--	1827
1984	2662	--	2762
1985	3684	1364	5048
1986	2394	--	2394
1987	1978	67	2045
1988	2075	728	2803
1989	527	12	539
1990	437	35	472
1991	190	0	190
1992	1177	69	1246
1993	333	7	340
1994	147[b]	0	189
1995	1230[b] + 88[c]	0	1318
1996	1349	0	1349

-- Indicates no estimate was attempted.

[a] Based on the total estimated number of winter-run chinook in the Sacramento River mainstem counted during weekly aerial surveys during spawning season.

[b] Does not include fish trapped at the Keswick Fish Trap or RBDD, which were later transferred to CNFH for artificial spawning (Kano 1999b and 1999c).

[c] These fish migrated beyond the CNFH fish ladder/barrier dam and were enumerated using video monitoring (Kano 1999c).

Appendix 1-G. Keswick Dam, RBDD, and Coleman barrier weir trapping data for winter-run chinook salmon (1989-2002). Fish were used as broodstock for Coleman National Fish Hatchery (1989-1995) and Livingston Stone National Fish Hatchery (1998-2002) propagation programs (USFWS 2001; Killam and Harvey-Arrison 2002; Smith 2002).

Year	Collection location	Number of fish collected at each location
1989	Keswick Dam	18
	RBDD	24
1990	Keswick Dam	12
	RBDD	2
1991	Keswick Dam	18
	RBDD	5
1992	Keswick Dam	29
	RBDD	5
1993	Keswick Dam	20
	RBDD	0
1994	Keswick Dam	30
	RBDD	12
1995	Keswick Dam	43
	RBDD	0
1996	Keswick Dam	0
	RBDD	0
1997	Keswick Dam	0
	RBDD	0
1998	Keswick Dam, RBDD, Coleman barrier weir[a]	121
1999	Keswick Dam, RBDD, Coleman barrier weir[a]	25
2000	Keswick Dam, RBDD, Coleman barrier weir[a]	113
2001[b]	Keswick Dam	0
	RBDD	0
2002[b]	Keswick Dam	100
	RBDD	4

[a] Number of fish collected at each location not differentiated.
[b] Killam and Harvey-Arrison (2002).

Appendix 1-H. Monthly juvenile production indices (JPI) for winter-run chinook salmon captured using rotary screw traps below the Red Bluff Diversion Dam, Sacramento River for brood years 1995 through 1999 (Martin et al. 2001; Gaines and Martin 2002).

Month	N[a]	Median Forklength (mm)	Monthly juvenile production indices			
			Total JPI[b]	Fry JPI	Pre-smolt/ smolt JPI	Fry equivalent JPI
Brood year 1995						
Jul	21	36	751	751	0	751
Aug	23	34	81,804	81,688	105	81,877
Sep	8	35	1,147,684	1,139,431	8253	1,153,419
Oct	5	36	299,047	207,033	92,014	362,989
Nov	6	62	66,197	2663	63,534	110,348
Dec	9	70	13,998	0	13,998	23,725
Jan	11	97	6523	0	6523	11,056
Feb	2	102	35,712	0	35,712	60,529
Mar	17	124	7015	0	7015	11,890
Apr	30	137	236	0	236	400
May	13	-	0	0	0	0
Jun	13	-	0	0	0	0
Total	158		1,658,968	1,431,577	227,390	1,816,984
Brood year 1996						
Jul	14	34	903	903	0	903
Aug	19	34	18,836	18,836	0	18,836
Sep	12	34	228,197	225,698	2499	229,943
Oct	17	35	24,226	16,285	7941	29,744
Nov	22	70	66,167	0	66,167	112,147
Dec	8	82	8801	0	8801	14,917
Jan	0	-	12,124	0	12,124	20,549
Feb	15	114	15,429	0	15,429	26,151
Mar	16	120	7791	0	7791	13,205
Apr	24	126	1378	0	1378	2336
May	19	137	272	0	272	461
Jun	16	-	0	0	0	0
Total	182		384,124	261,722	122,402	469,183
Brood year 1997						
Jul	19	35	18,584	18,584	0	18,584
Aug	16	35	134,165	133,633	532	134,535
Sep	13	35	925,284	912,652	12,632	934,062
Oct	10	36	410,781	333,955	76,826	464,169
Nov	11	63	295,668	3546	292,121	498,667
Dec	11	69	30,139	0	30,139	51,083

Appendix 1-H (cont.). Monthly juvenile production indices (JPI) for winter-run chinook salmon captured using rotary screw traps below the Red Bluff Diversion Dam, Sacramento River for brood years 1995 through 1999 (Martin et al. 2001; Gaines and Martin 2002).

Month	N[a]	Median Forklength (mm)	Monthly juvenile production indices			
			Total JPI[b]	Fry JPI	Pre-smolt/ smolt JPI	Fry equivalent JPI
Jan	5	82	7826	0	7826	13,264
Feb	0	-	20,220	0	20,220	34,271
Mar	11	108	32,619	0	32,619	55,286
Apr	11	138	732	0	732	1241
May	8	-	-	-	-	-
Jun	11	-	-	-	-	-
Total	126		1,876,018	1,402,370	473,647	2,205,162
			Brood year 1998			
Jul	17	34	184,896	184,896	0	184,896
Aug	13	34	1,540,408	1,538,369	2039	1,541,825
Sep	18	34	2,128,386	2,081,786	46,600	2,160,769
Oct	24	37	404,275	250,098	154,177	511,415
Nov	19	57	245,739	11,263	234,476	408,680
Dec	26	69	49,018	0	49,018	83,081
Jan	24	103	49,753	0	49,753	84,327
Feb	16	97	8833	0	8833	14,971
Mar	28	114	4150	0	4150	7034
Apr	23	138	1754	0	1754	2973
May	26	150	262	0	262	445
Jun	30	-	-	-	-	-
Total	264		4,617,474	4,066,412	551,062	5,000,416
			Brood year 1999			
Jul	31	36	8186	8186	0	8186
Aug	28	35	91,836	91,836	0	91,836
Sep	23	35	404,378	398,421	5957	408,517
Oct	21	38	163,482	95,859	67,623	210,475
Nov	24	60	155,239	7124	148,115	258,166
Dec	29	74	60,397	0	60,397	102,368
Jan	20	91	94,675	0	94,675	160,466
Feb	16	101	44,918	0	44,918	76,132
Mar	25	117	28,042	0	28,042	47,529
Apr	25	121	1092	0	1092	1851
May	27	152	375	0	375	636
Jun	24	-	0	0	0	0
Total	293		1,052,620	601,426	451,194	1,366,162

[a] N represents the number of completed 4-trap 24-hour samples within each month.
[b] Total JPI equals the summation of fry production and pre-smolt/smolt production.

Appendix 1-I. Comparisons between juvenile production estimates (JPE) and rotary screw trapping juvenile production indices (JPI) for winter-run chinook salmon, Sacramento River, California (Gaines and Poytress 2003).

Brood-year	Rotary screw trapping			Carcass survey		Fish ladder at RBDD	
		90% Confidence interval					
	Fry equivalent JPI	Lower	Upper	Fry equivalent JPE	No. of female spawners	Fry equivalent JPE	No. of female spawners
1995	1,816,984	1,658,967	2,465,169	-	-	764,082	792
1996	469,183	384,124	818,096	550,872	571	406,160	421
1997	2,205,163	1,876,018	3,555,314	1,386,346	1437	297,143	308
1998	5,000,416	4,617,475	6,571,241	4,676,143	4847	1,141,299	1183
1999	1,366,161	1,052,620	2,652,305	1,568,684	1626	411,948	427
2000	-	-	-	4,126,949	3530	1,284,742	1099
2001	-	-	-	5,386,672	4607	1,451,158	1241
2002	8,114,841	4,798,472	11,431,210	6,978,583	5670	5,270,598	4673

Appendix 1-J. Estimated cumulative percentage of winter-run chinook year's brood emigrating from the upper Sacramento River past Red Bluff Diversion Dam by mid-month (Vogel and Marine 1991).

Month	Wet Year (1983)	Dry Year (1985)
August	5-10	<5
September	10-50	5-10
October	20-75	10-20
November	50-75	30-40
December	60-90	50-75
January	75-95	60-90
February	80-100	75-95
March	100	100

Appendix 1-K. Weekly total catches of juvenile winter-run chinook salmon in the GCID oxbow, 1988-1990 (from Brown and Greene 1992).

	DFG Trap			GCID Trap	Pump Q
End of week	1988	1989	1990	1990	1990
8-Jul	0	0	0	0	2312
15-Jul	0	0	0	0	2358
22-Jul	4	0	0	0	2360
29-Jul	9	0	0	0	2367
5-Aug	10	2	0	0	2313
12-Aug	37	3	0	1	2352
19-Aug	97	2	5	2	2274
26-Aug	66	2	47	15	2106
2-Sep	12	6	34	24	1783
9-Sep	16	22	13	24	1414
16-Sep	15	13	37	84	973
23-Sep	3	137	24	120	782
30-Sep	1	13	9	87	742
7-Oct	2	19	0	17	700
14-Oct	2	1	2	9	643
21-Oct	1	2	2	11	675
28-Oct	0	105	0	13	800
4-Nov	0	21	1	7	778
11-Nov	0	4	0	27	750
18-Nov	0	0	0	5	350
25-Nov	0	2	0	7	0
2-Dec		0	0	2	0
9-Dec			0	0	0
16-Dec			0	1	0
23-Dec			5	4	0
31-Dec			14	58	0
Totals	275	354	193	518	28,832

Appendix 1-L. Summary of catch and size range data for in-river produced juvenile winter- and spring-run chinook salmon captured during rotary screw trapping at Knights Landing (Sacramento River) from November 1995 through July 1996 (Snider and Titus 1998).

	Spring-run chinook		Winter-run chinook	
Week	Number	FL range (mm)	Number	FL range (mm)
48	0		0	
49	0		0	
50	0		0	
51	240	37-47	99	52-104
52	34	39-43	4	56-88
1	73	40-51	24	56-113
2	0		1	62
3	8	45-51	9	64-108
4	30	46-56	18	78-126
5	46	49-66	27	78-128
6	26	51-61	40	71-126
7	14	53-68	38	73-130
8	2	60-62	11	85-115
9	7	60-73	10	88-123
10	7	65-79	4	91-102
11	19	64-87	21	93-143
12	[a]		7	91-124
13	[a]		11	96-152
14	[a]		0	
15	[a]		0	
16	[a]		0	
17	[a]		0	
18	[a]		0	
19	[a]		0	
20	[a]		0	
21	0		0	
22	0		0	
23	0		0	
24	0		0	
25	0		0	
26	0		0	
27	0		0	
28	0		0	
Total	506	37-103	324	52-152

[a] From weeks 12-20, over 4900 chinook were captured and initially deemed 'spring-run' chinook. However, after review of CWT data and examination of fall-run chinook size distribution, these fish were later classified as fall-run chinook (Snider and Titus 1998).

Appendix 1-M. Summary of catch and size range data for in-river produced juvenile winter- and spring-run chinook salmon captured during rotary screw trapping at Knights Landing (Sacramento River) from September 29, 1996 – October 4, 1997 (Snider and Titus 2000b).

	Spring-run chinook		Winter-run chinook	
Week	Number	FL range (mm)	Number	FL range (mm)
40	0		0	
41	0		0	
42	0		0	
43	0		0	
44	0		0	
45	0		0	
46	0		0	
47	0		0	
48	8	30-38	27	61-87
49	0		0	
50	1101	35-40	79	61-98
51	541	34-44	20	63-98
52	18	38-41	2	68-89
1	67	40-52	1	102
2	26	42-52	7	87-110
3	38	44-56	15	60-121
4	7	46-50	11	77-124
5	12	49-59	10	82-126
6	6	51-64	7	93-118
7	4	55-62	8	93-135
8	31	55-73	8	83-141
9	110	58-78	15	78-120
10	139	61-84	13	85-110
11	143	63-86	12	85-130
12	32	68-90	3	92-119
13	7	72-87	2	105
14	15	72-94	0	
15	1619	76-90	1	131
16	717	61-91	2	115-127
17	625	83-99	3	125-138
18	366	87-103	2	128-144
19	44	91-99	2	131-141
20	9	95-104	0	
21	1	104	0	
22	0		0	
23	0		0	
24	0		0	
25	0		0	
26	0		0	

Appendix 1-M (cont.). Summary of catch and size range data for in-river produced juvenile winter- and spring-run chinook salmon captured during rotary screw trapping at Knights Landing (Sacramento River) from September 29, 1996 – October 4, 1997 (Snider and Titus 2000b).

	Spring-run chinook		Winter-run chinook	
Week	Number	FL range (mm)	Number	FL range (mm)
27	0		0	
28	0		0	
29	0		0	
30	0		0	
31	0		0	
32	0		0	
33	0		0	
34	0		1	37
35	0		0	
36	0		0	
37	0		1	39
38	0		2	34-38
39	0		0	
40	0		1	38
Total	2305[a]	30-94	250[c]	61-144
	3381[b]	61-104	5[d]	34-38

[a] All spring-run-sized chinook collected after week 14 were considered fall-run chinook based upon CWT data and size distributions of fall-run chinook released from CNFH.
[b] Total captured after week 14, considered CNFH-produced, fall-run chinook.
[c] BY 1996.
[d] BY 1997.

Appendix 1-N. Summary of catch and size range data for in-river produced juvenile winter- and spring-run chinook salmon captured during rotary screw trapping at Knights Landing (Sacramento River) from September 28, 1997 - October 3, 1998 (Snider and Titus 2000c).

	Spring-run chinook		Winter-run chinook	
Week	Number	FL range (mm)	Number	FL range (mm)
40	0		1	38
41	0		1	38
42	0		0	
43	0		0	
44	0		0	
45	0		0	
46	0		0	
47	0		3	74-78
48	8	30-39	163	48-88
49	148	28-39	342	45-92
50	9	36-39	7	65-90
51	77	36-42	17	60-99
52	19	38-40	5	65-87
1	1	40	0	
2	48	42-53	37	61-109
3	20	43-48	19	71-100
4	11	46-58	15	74-100
5	4	48-57	6	81-111
6	4	50-53	3	80-117
7	7	52-54	4	72-97
8	4	57-62	4	88-113
9	8	58-65	10	94-107
10	12	60-78	9	99-122
11	178	63-77	13	88-149
12	272	66-89	26	92-120
13	152	69-90	3	94-106
14	68	72-96	0	
15	81	75-100	0	
16	28	79-99	0	
17	12	83-90	0	
18	7	89-95	0	
19	0		0	
20	2	95-96	0	
21	0		0	
22	0		0	
23	2	110-117	0	
24	0		0	
25	0		0	
26	0		0	

Appendix 1-N (cont.). Summary of catch and size range data for in-river produced juvenile winter- and spring-run chinook salmon captured during rotary screw trapping at Knights Landing (Sacramento River) from September 28, 1997 - October 3, 1998 (Snider and Titus 2000c).

	Spring-run chinook		Winter-run chinook	
Week	Number	FL range (mm)	Number	FL range (mm)
27	0		0	
28	0		0	
29	0		0	
30	0		0	
31	0		0	
32	0		0	
33	0		0	
34	0		3	35-36
35	0		3	36-38
36	0		5	34-39
37	0		1	48
38	0		5	37-39
39	0		3	34-38
40	0		8	31-39
Total	380[a]	28-78	688[c]	38-149
	802[b]	63-117	28[d]	31-48

[a] Total captured before week 11, considered in-river produced spring-run chinook.
[b] Total captured after week 10, considered CNFH-produced, fall-run chinook.
[c] BY 1997.
[d] BY 1998.

Appendix 1-O. Summary of catch and size range data for in-river produced juvenile winter- and spring-run chinook salmon captured during rotary screw trapping at Knights Landing (Sacramento River) from September 27, 1998 - October 2, 1999 (Snider and Titus 2000d).

	Spring-run chinook		Winter-run chinook	
Week	Number	FL range (mm)	Number	FL range (mm)
40	0		8	31-39
41	0		1	37
42	0		0	
43	0		0	
44	0		0	
45	0		1	38
46	0		34	52-79
47	0		52	53-83
48	2	33-41	220	49-86
49	78	33-38	109	51-89
50	77	34-39	65	51-93
51	87	36-41	29	53-98
52	43	38-42	24	51-95
1	5	39-52	2	63-69
2	1	-	0	
3	1	51	0	
4	36	46-60	23	65-115
5	38	47-62	45	66-129
6	7	50-60	10	70-101
7	14	53-69	26	72-117
8	4	57-65	6	75-125
9	3	59-68	6	94-131
10	0		6	92-118
11	0		2	115-123
12	0		6	94-116
13	8	71-88	4	95-114
14	27	72-96	11	98-139
15	77	75-90	0	
16	30	79-99	0	
17	10	85-90	0	
18	6	87-92	0	
19	0		0	
20	2	96-115	0	
21	1	102	0	
22	1	105	0	
23	0		0	
24	0		0	
25	0		0	
26	0		0	

Appendix 1-O (cont.). Summary of catch and size range data for in-river produced juvenile winter- and spring-run chinook salmon captured during rotary screw trapping at Knights Landing (Sacramento River) from September 27, 1998 - October 2, 1999 (Snider and Titus 2000d).

	Spring-run chinook		Winter-run chinook	
Week	Number	FL range (mm)	Number	FL range (mm)
27	0		0	
28	0		0	
29	0		0	
30	0		0	
31	0		0	
32	0		0	
33	0		0	
34	0		0	
35	0		0	
36	0		0	
37	0		0	
38	0		1	41
39	0		0	
40	0		0	
Total	396[a]	33-69	690[c]	31-139
	162[b]	46-115	1[d]	41

[a] All spring-run sized chinook collected after Week 12 were considered fall-run chinook based upon CWT data and size distribution of fall-run chinook released from CNFH.
[b] Total captured after Week 12, considered CNFH-produced fall-run chinook.
[c] BY 1998.
[d] BY 1999.

Appendix 1-P. Summary of catch and size range data for juvenile winter- and spring-run chinook salmon captured during rotary screw trapping at Knights Landing (Sacramento River), 2000 (CDFG 2005).

	Spring-run chinook		Winter-run chinook	
Week	Number	FL range (mm)	Number	FL range (mm)
40-47	0		0	
48	0		1	66
49	0		3	65-78
50	0		5	68-85
51	0		0	
52	0		0	
1	0		1	96
2	0		0	
3	0		1	109
4	1	47	0	
5	5	47-58	3	80-120
6	8	50-62	7	70-119
7	5	53-60	5	106-116
8	8	55-63	16	75-129
9	4	56-69	2	120-122
10	3	60-73	5	83-129
11	2	63, 66	3	112-115
12	2	66, 70	5	90-127
13	11	68-86	0	
14	40	72-96	0	
15	6	75-84	0	
16	13	80-90	0	
17	24	83-98	0	
18	4	85-93	0	
19	1	93	0	
20-39	0		0	

Appendix 1-Q. Summary of catch and size range data for juvenile winter- and spring-run chinook salmon captured during rotary screw trapping at Knights Landing (Sacramento River), 2001 (CDFG 2005).

	Spring-run chinook		Winter-run chinook	
Week	Number	FL range (mm)	Number	FL range (mm)
40-45	0		0	
46	0		2	71-76
47-50	0		0	
51	0		1	68
52	2	38, 39	16	67-101
1	0		0	
2	1	46	13	72-111
3	4	46-48	57	66-119
4	0		12	82-104
5	19	46-66	141	71-131
6	2	55, 62	4	93-107
7	19	58-62	14	75-123
8	0		5	83-111
9	17	60-75	66	81-137
10	0		6	92-106
11	6	65-75	7	88-113
12	11	71-92	0	
13	34	71-93	0	
14	7	74-93	0	
15	18	78-91	0	
16	28	82-88	2	-
17	15	86-95	1	-
18	6	90-109	0	
19	6	93-112	0	
20	1	114	0	
21-39	0		0	

Appendix 1-R. Summary of catch and size range data for juvenile winter- and spring-run chinook salmon captured during rotary screw trapping at Knights Landing (Sacramento River), 2002 (CDFG 2005).

	Spring-run chinook		Winter-run chinook	
Week	Number	FL range (mm)	Number	FL range (mm)
40-45	0		0	
46	0		2	71-73
47	0		15	44-75
48	53	31-39	184	45-88
49	15	34-44	11	47-71
50	9	35-40	17	54-89
51	24	37-41	29	50-98
52	57	39-52	31	53-102
1	20	40-49	36	55-108
2	11	43-58	44	61-118
3	12	44-53	31	61-122
4	3	52-56	1	73
5	3	57-65	2	70-131
6	3	53-68	1	124
7	13	53-71	4	80-127
8	20	55-75	7	78-127
9	20	59-77	7	80-131
10	2	62-82	4	86-108
11	12	66-85	2	87-104
12	3	69-91	0	
13	23	75-92	0	
14	25	74-97	0	
15	8	79-87	2	114-136
16	25	81-94	0	
17	486	84-97	3	116-120
18	34	88-95	0	
19	10	92-100	0	
20	1	97	0	
21-39	0		0	

Appendix 1-S. Summary of catch and size range data for juvenile winter- and spring-run chinook salmon captured during rotary screw trapping at Knights Landing (Sacramento River), 2003 (CDFG 2005).

	Spring-run chinook		Winter-run chinook	
Week	Number	FL range (mm)	Number	FL range (mm)
40-44	0		0	
45	0		3	62-68
46	0		4	63-78
47	0		0	
48	0		0	
49	0		0	
50	0		1	63
51	854	36-48	380	50-102
52	156	36-51	99	52-98
1	178	40-55	135	56-109
2	112	42-54	101	60-113
3	26	44-55	32	66-107
4	40	46-58	24	67-120
5	8	49-58	14	69-110
6	11	51-57	4	79-114
7	8	57-68	2	76-83
8	41	55-73	11	80-110
9	7	58-72	6	90-102
10	25	63-82	5	92-112
11	79	65-88	5	86-106
12	29	67-91	3	101-108
13	50	71-92	0	
14	96	73-98	3	99-110
15	458	77-102	0	
16	85	80-90	2	129-137
17	143	84-94	1	157
18	7	89-91	0	
19	4	92-96	0	
20-39	0		0	

Appendix 1-T. Summary of catch and size range data for juvenile winter- and spring-run chinook salmon captured during rotary screw trapping at Knights Landing (Sacramento River), 2004 (CDFG 2005).

	Spring-run chinook		Winter-run chinook	
Week	Number	FL range (mm)	Number	FL range (mm)
40	0		0	
41	0		4	38-42
42	0		1	57
43	0		0	
44	0		1	36
45	0		0	
46	0		0	
47	0		5	63-78
48	0		0	
49	0		0	
50	976	35-47	1289	48-95
51	235	37-48	262	50-92
52	144	38-42	117	53-102
1	92	40-51	74	57-104
2	77	42-55	69	57-107
3	111	44-58	67	61-108
4	10	46-62	12	67-110
5	8	48-53	3	70-81
6	26	50-69	29	69-131
7	27	52-70	17	77-115
8	27	55-75	31	78-116
9	6	58-67	9	82-99
10	10	59-72	10	91-142
11	20	62-81	23	92-111
12	99	65-91	24	89-124
13	104	68-92	2	96-97
14	41	72-93	0	
15	15	75-95	1	125
16	5	80-100	0	
17	403	77-92	0	
18	55	86-95	0	
19	6	91-110	0	
20	1	95	0	
21-39	0		0	

Appendix 1-U. Summary of catch and size range data for adipose fin-clipped, hatchery produced juvenile winter-run chinook salmon captured during rotary screw trapping at Knights Landing (Sacramento River) from November 1995 through July 1996 (Snider and Titus 1998).

Week	Number	FL range (mm)
48-52	0	
1-4	0	
5	1	70
6	1	71
7	5	69-79
8	1	86
9	0	
10	0	
11	0	
12	1	95
13	1	107
14-21	0	
Total	10	69-107

Appendix 1-V. Summary of catch and size range data for adipose fin-clipped, hatchery produced juvenile winter-run chinook salmon captured during rotary screw trapping at Knights Landing (Sacramento River) from September 29, 1996 - October 4, 1997 (Snider and Titus 2000b).

Week	Number	FL range (mm)
40-52	0	
1-14	0	
15	1	69
16	0	
17	0	
18	1	81
19	0	
20-23	0	
Total	2	69-81

Appendix 1-W. Summary of catch and size range data for adipose fin-clipped, hatchery produced juvenile winter-run chinook salmon captured during rotary screw trapping at Knights Landing (Sacramento River) from September 28, 1997 - October 3, 1998 (Snider and Titus 2000c).

Week	Number	FL range (mm)
40-52	0	
1-15	0	
16	1	77
17	4	76-87
18	3	76-92
19	1	95
20-23	0	
Total	9	76-95

Appendix 1-X. Summary of catch and size range data for adipose fin-clipped, hatchery produced juvenile winter-run chinook salmon captured during rotary screw trapping at Knights Landing (Sacramento River) from September 27, 1998 - October 2, 1999 (Snider and Titus 2000d).

Week	Number	FL range (mm)
40-5	0	
6	35	56-100
7	84	67-98
8	2	82-81-95
9	2	
10	0	
11	0	
12	0	
13	3	96-105
14	3	89-95
15	1	112
16-21	0	
Total	130	56-112

Appendix 1-Y. Estimates of the number of hatchery-produced chinook salmon and yearling *Oncorhynchus mykiss* that passed the Sacramento River-Knights Landing monitoring site (Snider and Titus 1998; Snider and Titus 2000b, 2000c, and 2000d).

		A	B	C	D	E	F	G
Year	Type	Marked (caught)	Marked estimate (A/TE[a])	No. of planted marked	Survival (B/C)	No. of planted unmarked	No. of estimated unmarked (D*E)	Estimated total (B+F)
1995-96	Winter-run chinook	10	962	51,267	0.019	0	0	962
	O. mykiss	14	1346	125,764	0.011	401,220	4413	5759
1996-97	Winter-run chinook	2	138	4718	0.029	0	0	138
	O. mykiss	0	0	0	-	540,287	-	-
1997-98	Winter-run chinook	9	1125	21,271	0.053	0	0	1125
	O. mykiss	131	16,375	401,062	0.041	143,517	5884	22,259
1998-99	Winter-run chinook	141	22,742	153,908	0.148	0	0	22,742
	O. mykiss	85	13,710	496,525	0.028	0	0	13,710

[a] Mean weekly trap efficiency (TE) was 0.0104 for 1995-96, 0.0145 for 1996-97, 0.0008 for 1997-98, and 0.0062 for 1998-99.

Appendix 1-Z. Estimates of the number of in-river-produced chinook salmon and yearling *Oncorhynchus mykiss* that passed the Sacramento River-Knights Landing monitoring site (Snider and Titus 1998; Snider and Titus 2000b, 2000c, and 2000d).

		A	B	C	D
Year	Type	Total caught	Estimated total (A/TE[a])	Hatchery total (from Appendix 1-R)	In-river total (B-C)
1995-96	Winter-run chinook	334	32,115	962	31,153
	Spring-run chinook	506	48,654	0	48,654
	O. mykiss	182	17,500	5759	11,741
1996-97	Winter-run chinook	273	18,828	138	18,690
	Spring-run chinook	2324	160,276	0	160,276
	O. mykiss	168	11,586	0	11,586
1997-98	Winter-run chinook (BY 1997)	873	109,125	1125	108,000
	Winter-run chinook (BY 1998)	28	3500	0	3500
	Spring-run chinook	434	54,250	0	54,250
	O. mykiss	244	30,500	21,866	8634
1998-99	Winter-run chinook (BY 1998)	987	159,194	22,742	136,452
	Winter-run chinook (BY 1999)	1	161	0	161
	Spring-run chinook	461	74,355	0	74,335
	O. mykiss	130	20,968	13,710	7258

[a] Mean weekly trap efficiency (TE) was 0.0104 for 1995-96, 0.0145 for 1996-97, 0.0008 for 1997-98, and 0.0062 for 1998-99.

Appendix 1-AA. Summary of non-adipose fin-clipped juvenile winter-run chinook salmon catch during Kodiak and midwater trawls in the Sacramento River near the city of Sacramento from 1988-2004 (U. S. Fish and Wildlife Service 2005e).

Year	Month	Total catch
1988	Apr	36
	May	3
1992	Feb	125
	Mar	28
	May	2
	Dec	1
1993	Jan	15
	Feb	26
	Mar	152
	Apr	67
1994	Feb	8
	Mar	2
	Apr	5
	Dec	1
1995	Jan	3
	Feb	41
	Mar	50
	Apr	56
	Dec	61
1996	Jan	31
	Feb	31
	Mar	120
	Apr	5
	Nov	2
	Dec	8
1997	Feb	15
	Mar	23
	Apr	2
	Nov	10
	Dec	9
1998	Jan	2
	Feb	3
	Mar	62
	Apr	5
	Oct	2
	Dec	22
1999	Jan	6
	Feb	3
	Mar	13
	Apr	1
2000	Jan	16
	Feb	18
	Mar	19
2001	Jan	8
	Feb	49
	Mar	10
	Apr	1
	Sep	1
	Nov	44
	Dec	24
2002	Jan	2
	Feb	17
	Apr	1
	Nov	1
	Dec	36
2003	Jan	11
	Feb	15
	Mar	19
	Apr	4
	Dec	81
2004	Jan	16
	Feb	9
	Mar	7

Appendix 1-BB. Summary of estimated winter-run chinook salmon catch by major area[12], USFWS beach seine data, 1977-1989 (Brown and Greene 1992).

Area	Month	Total Catch	No. of winter-run chinook	Area	Month	Total Catch	No. of winter-run chinook
1	Jan	3039	119	3	Jan	77	0
	Feb	4474	111		Feb	60	0
	Mar	6325	56		Mar	114	0
	Apr	2318	7		Apr	34	0
	May	645	0		May	2	0
	Jun	113	0		Jun	-	-
	Jul	-	-		Jul	-	-
	Aug	-	-		Aug	-	-
	Sept	-	-		Sept	-	-
	Oct	5	4		Oct	-	-
	Nov	25	20		Nov	-	-
	Dec	128	36		Dec	1	0
2	Jan	1819	49	4	Jan	1421	39
	Feb	2956	29		Feb	3510	31
	Mar	3332	19		Mar	3595	26
	Apr	1471	4		Apr	1317	5
	May	667	0		May	271	1
	Jun	166	0		Jun	133	0
	Jul	2	0		Jul	4	0
	Aug	-	-		Aug	-	-
	Sept	-	-		Sept	-	-
	Oct	1	0		Oct	1	0
	Nov	3	2		Nov	2	1
	Dec	26	2		Dec	27	0

'-' Indicates no sampling.
Note: Classification as 'winter-run' was designated using length-at-date criteria developed by CDFG

[12] 'Major Area' was designated in Brown and Greene (1992) as a way to geographically group over 40 USFWS beach seining sites in the Sacramento-San Joaquin River system. Area 1 is comprised of all sites upstream from the city of Sacramento; Area 2 consists of 6 sites downstream from Sacramento; Area 3 is made up of sites in the northern reach of San Francisco Bay; and Area 4 is located in the San Joaquin River system.

Appendix 1-CC. Summary of Chipps Island chinook salmon trawl data, 1976-1990 (Brown and Greene 1992).

Year	Month	No. of trawls	Total catch	No. of winter-run chinook	Winter-run chinook catch/tow	% Winter-run chinook
1976	May	76	509	2	0.03	0.4
	June	188	1101	1	0.005	0.1
1977	May	174	834	2	0.01	0.2
1978	April	101	625	140	1.14	22.4
	June	90	612	5	0.06	0.8
1979	April	77	490	77	1	15.7
	May	78	419	2	0.3	0.5
	June	190	1080	1	0.005	0.1
1980	January	15	22	1	0.07	4.5
	February	26	36	18	0.69	5
	March	24	41	31	1.3	76
	April	65	364	203	3.1	76
	May	81	609	38	0.5	6.2
	June	252	2699	1	0.004	0.04
1981	April	52	300	56	1.07	19
	May	61	341	1	0.02	0.3
1982	April	43	337	130	3.02	39
	May	120	1267	23	0.19	1.8
1983	April	66	370	140	2.12	38
	May	128	913	19	0.15	2.1
	June	146	932	1	0.007	0.01
1984	April	73	238	92	1.26	39
	May	99	1760	6	6.01	0.3
1985	April	72	866	137	1.9	16
	May	294	7030	12	0.04	0.02
1986	April	95	2142	270	2.8	13
	May	284	7972	46	0.16	0.6
1987	-	-	-	-	-	-
1988	April	122	1199	200	1.63	17
	May	490	9091	8	0.02	0.09
1989	April	187	3764	154	0.82	4.1
	May	292	7410	10	0.03	0.1
1990	April	175	2772	191	1.09	6.9
	May	266	4828	4	0.02	0.08

Appendix 1-DD. Summary of juvenile winter-run chinook salmon captured during midwater trawling operations at Chipps Island from 1991-2004 (U. S. Fish and Wildlife Service 2005f).

Year	Month	Total catch
1991	Apr	15
	May	2
1992	Apr	555
	May	1
1993	Apr	221
	May	2
1994	Jan	1
	Feb	2
	Mar	29
	Apr	14
	May	1
1995	Jan	10
	Feb	38
	Mar	109
	Apr	151
	May	4
	Dec	4
1996	Jan	38
	Feb	33
	Mar	239
	Apr	39
	May	3
	Dec	1
1997	Jan	11
	Feb	33
	Mar	72
	Apr	44
	May	2
	Dec	6
1998	Jan	14
	Feb	4
	Mar	54
	Apr	29
	May	2
1999	Jan	7
	Feb	18
	Mar	64
	Apr	55
2000	Jan	5
	Feb	25
	Mar	97
	Apr	48
	May	2
2001	Jan	5
	Feb	21
	Mar	69
	Apr	14
	May	1
	Dec	5
2002	Jan	10
	Feb	6
	Mar	38
	Apr	56
	May	1
	Dec	25
2003	Jan	41
	Feb	33
	Mar	106
	Apr	35
	May	4
	Dec	6
2004	Jan	6
	Feb	8
	Mar	90
	Apr	5

Note: Winter-run chinook included in this table were non-adipose fin-clipped fish; chinook race designation determined by length-at-date criteria.

Appendix 1-EE. Summary of Golden Gate winter-run chinook salmon trawl data, 1983-1986 (Brown and Greene 1992).

Year	Month	No. of trawls	Total catch	No. of winter-run chinook	Winter-run chinook catch/tow	% Winter-run chinook
1983	April	68	267	117	1.7	44
	May	181	3191	222	1.2	7.0
	June	140	2999	12	0.09	0.4
	July	29	193	0	0	0
	August	39	150	0	0	0
	September	29	108	0	0	0
1984	April	50	118	48	0.96	41
	May	109	669	4	0.04	0.6
	June	114	575	0	0	0
	July	150	598	0	0	0
	August	30	110	0	0	0
1985	April	90	382	135	1.50	35
	May	228	6698	187	0.82	2.8
	June	74	952	5	0.07	0.5
	July	29	28	0	0	0
1986	April	89	676	89	1.0	13
	May	88	3316	14	0.16	0.4
	June	153	2391	4	0.03	0.2

Appendix 2-A. Spring-run chinook salmon counts in the Sacramento-San Joaquin River system from 1940 to 2003 (Fry 1961; Fry and Petrovich 1970; CDFG Annual reports; CDFG 2004b).

Year	Sac. River	Battle Creek	Mill Creek	Deer Creek	Big Chico Creek	Butte Creek	Feather River	Other tribs	San Joaquin River
1940	11,000	--	--	< 500					
1941	15,000	--	--	1000					
1942	3000	--	--	1000					
1943	6000	--	--	1000	--	--	--	--	35,000
1944	12,000	--	--	3000	--	--	--	--	5000
1945	4000	--	--	3000	--	--	--	--	56,000
1946	27,000	2000	--	4000	--	--	2000	--	30,000
1947	25,000	1000	3000	3000	--	--	--	--	6000
1948	9000	--	2000	2000	--	--	--	--	2000
1949	7000	--	1000	1000	--				
1950	18,000	1000	2000	2000	--	--	--	--	< 500
1951	5000	2000	< 500	2000	--				
1952	7000	2000	2000	2000	--				
1953	8000	2000	3000	2000	--	< 500			
1954	9000	2000	2000	2000	--	--	3000	< 500	
1955	17,000	2000	3000	3000	--	400	1000	< 500	
1956	7000	2000	2000	3000	--	3000	2000	1,000	
1957	--	--	1000	--	100	2000	1000	--	
1958	--	--	2000	--	1000	1000	3000[a]	--	
1959	--	--	2000	--	200	< 500	4000[a]	--	
1960	--	--	2000	--	--	7000	4000[a]		
1961	--	--	1000	--	--	3000	--		
1962	--	--	1692	--	200	1750	--		
1963	--	--	1300	1700	500	5000	600[a]		
1964	--	--	1500	3000	100	600	3000		
1965	--	--	--	--	100	1000	700		
1966	--	--	--	--	100	100	300		
1967	--	--	--	--	200	200	100[b]		
1968	--	--	--	--	200	300	200[b]		
1969	20,000	--	--	--	200	800	300[b]		
1970	3652	--	1500	2000	0	285	235[b]	--	--
1971	5830[c]	--	1000	1500	--	470	481[b]	--	--
1972	7038	--	500	400	--	150	256[b]	--	500
1973	7175	--	1700	2000	50	300	205[b]	--	--
1974	3800	--	1500	3500	100	150	198[b]	--	--
1975	10,234	--	3500	8500	--	650	691[b]	--	--
1976	25,095	--	--	--	--	46	699[b]	--	
1977	11,703	--	460[d]	340[d]	100	100	185[b]	--	--

Appendix 2-A (cont.). Spring-run chinook salmon counts in the Sacramento-San Joaquin River system from 1940 to 2004 (Fry 1961; Fry and Petrovich 1970; CDFG Annual reports; CDFG 2004b).

Year	Sac. River	Battle Creek	Mill Creek	Deer Creek	Big Chico Creek	Butte Creek	Feather River	Other tribs	San Joaquin River
1978	5669	--	925	1200	--	128	204[b]	--	--
1979	2856	--	--	--	--	10	250[b]	--	--
1980	9636	--	500	1500	--	226	269[b]/400[e]	200[f]	--
1981	20,655	--	--	--	--	250	469[b]/531[g]	200	--
1982	23,156	--	700	1500	--	534	1910[b]/90[g]	--	--
1983	5647	--	--	500	--	50	1702[b]	59[h]	--
1984	7823	--	--	--	--	23	1562[b]	--	--
1985	10,200	--	121[i]	301[i]	--	254	1632[b]	--	--
1986	15,824	--	291	543	--	1371	1433[b]	--	--
1987	12,611	--	90	200	--	14	1213[b]	--	--
1988	9829	--	572	371	--	1290	6833[b]	--	--
1989	5139	7[j]	563	84	--	1300	5078[b]	--	--
1990	4072	2[j]	844	496	--	250	1893[b]	--	--
1991	820	--	319	479	--	--	4303[b]	--	--
1992	372	--	237	209	--	730	1497[b]	--	--
1993	386	--	61	259	38	650	4672[b]	4[k]	--
1994	740	--	723	485	2	474	3641[b]	--	--
1995	318	66	320	1295	200	7480	5414[b]	17	--
1996	378	34	252	614	2	1400	6381[b]	7	--
1997	126	--	200	466	2	635	7017[b]	2	--
1998	1115	--	424	1879	369	20,259	6746[b]	679	--
1999	469	70	560	1591	27	3679	3731[b]	141	--
2000	252	40[m]	544	637	27	4118	3657[b]	129	--
2001	956	100[m]	1104	1622	39	9605	2468[b]	361	--
2002	483	144[m]	1594	2185	0[l]	8785	4189[b]	171	--
2003	0	94[m]	1426	2759	81	4398	8662[b]	144	--
2004	n/a	n/a	998	804	n/a	n/a	n/a	n/a	--

-- Indicates estimate not made.

'n/a' Indicates data not available.

1997-2002 data extracted from CDFG's GrandTab (2004).

[a] Could include fall-run chinook.

[b] Fish taken into the hatchery or spawning channel; not based on natural spawning estimates.

[c] Taylor (1972).

[d] Due to drought conditions in 1977, fish were trapped at RBDD and the Keswick Fish Trap and taken to spawning reaches in other tributaries. The population estimate is based on a carcass survey and all fish encountered are assumed to be those transported from the fish traps.

Appendix 2-A, notes (cont.):

[e] An escapement estimate of an additional 400 chinook was made based on 26 spring-run chinook carcasses found during fall-run chinook spawner surveys in the Feather River. These fish were coded-wire tagged from the Feather River Hatchery as spring-run chinook (Reavis 1981).
[f] Estimated number of Feather River Hatchery fish spawning in the Yuba River. This estimate is based on an observation of 14 coded-wire tagged fish (Reavis 1981).
[g] Estimated number of fish that spawn naturally in the Feather River; some are still of hatchery origin as identified by recovered coded-wire tags. For the 1981 estimate, Reavis (1983) reports 469 chinook entered the Feather River Hatchery and "…it is assumed a similar number spawned in the river, resulting in an estimated total of about 1,000 spring-run salmon in the Feather River."
[h] Based on an observation of 20 live fish by U. S. Forest Service (USFS) on Antelope Creek (Reavis 1985).
[i] Based on a snorkel survey by USFS (Kano and Reavis 1996).
[j] Fish were taken into CNFH and released upstream. No actual spring-run chinook spawner surveys were conducted.
[k] Reported in Kano (1999a) and based on adult salmon observed during multiple snorkel surveys of Clear Creek (1 fish) and Antelope Creek (3 fish).
[l] CDFG reported observation of approximately 40 adult spring-run chinook salmon prior to their snorkel survey on August 8, 2002. However, no salmon were observed during the survey and those fish previously observed were assumed to have perished during the summer (Ward et al. 2003).
[m] Based on upstream weir passage at CNFH (CDFG 2004b).

Appendix 2-B. Total escapement estimates of naturally spawning spring-run chinook salmon in California's Central Valley, grouped by location of tributaries from 1969 to 2003. (Note: Numbers of spring-run chinook taken into Feather River Hatchery for artificial spawning are not included in this table, but are reported in Appendix 2-A).

Year	Location	Estimation Method	Number of Fish
1969	Sacramento R., mainstem	RBDD counts	20,000
	Sac R tribs North of Big Chico Creek	-	No estimate
	Sac R tribs, Big Chico Creek + South	Carcass survey	1378
	San Joaquin R and tribs	-	0
		Annual System Total = 21,378	
1970	Sacramento R., mainstem	RBDD counts	3652
	Sac R tribs North of Big Chico Creek	Spawner/carcass survey	3500
	Sac R tribs, Big Chico Creek + South	Carcass survey	520
	San Joaquin R and tribs	-	0
		Annual System Total = 7672	
1971	Sacramento R., mainstem	RBDD counts	5830
	Sac R tribs North of Big Chico Creek	Spawner/carcass survey	3451
	Sac R tribs, Big Chico Creek + South	Carcass survey	951
	San Joaquin R and tribs	-	0
		Annual System Total = 9281	
1972	Sacramento R., mainstem	RBDD counts	7038
	Sac R tribs North of Big Chico Creek	Carcass survey	900
	Sac R tribs, Big Chico Creek + South	Carcass survey	150
	San Joaquin R and tribs	Fish 'rescue' [a]	500
		Annual System Total = 8588	
1973	Sacramento R., mainstem	RBDD counts	7175
	Sac R tribs North of Big Chico Creek	Carcass survey	3700
	Sac R tribs, Big Chico Creek + South	Carcass survey	350
	San Joaquin R and tribs	-	0
		Annual System Total = 11,225	
1974	Sacramento R., mainstem	RBDD counts	3800
	Sac R tribs North of Big Chico Creek	Carcass survey	5000
	Sac R tribs, Big Chico Creek + South	Carcass survey	250
	San Joaquin R and tribs	-	0
		Annual System Total = 9050	
1975	Sacramento R., mainstem	RBDD counts	10,234
	Sac R tribs North of Big Chico Creek	Carcass survey	12,000
	Sac R tribs, Big Chico Creek + South	Carcass survey	650
	San Joaquin R and tribs	-	0
		Annual System Total = 22,884	

Appendix 2-B (cont.). Total escapement estimates of naturally spawning spring-run chinook salmon in California's Central Valley, grouped by location of tributaries from 1969 to 2003. (Note: Numbers of spring-run chinook taken into Feather River Hatchery for artificial spawning are not included in this table, but are reported in Appendix 2-A.)

Year	Location	Estimation Method	Number of Fish
1976	Sacramento R., mainstem	RBDD counts	25,095
	Sac R tribs North of Big Chico Creek	-	No estimate
	Sac R tribs, Big Chico Creek + South	Carcass survey	46
	San Joaquin R and tribs	-	0
		Annual System Total = 25,141	
1977	Sacramento R., mainstem	RBDD counts	11,703
	Sac R tribs North of Big Chico Creek	Carcass survey	800
	Sac R tribs, Big Chico Creek + South	Carcass survey	200
	San Joaquin R and tribs	-	0
		Annual System Total = 12,703	
1978	Sacramento R., mainstem	RBDD counts	5669
	Sac R tribs North of Big Chico Creek	Carcass survey	2125
	Sac R tribs, Big Chico Creek + South	Carcass survey	128
	San Joaquin R and tribs	-	0
		Annual System Total = 7922	
1979	Sacramento R., mainstem	RBDD counts	2856
	Sac R tribs North of Big Chico Creek	-	No estimate
	Sac R tribs, Big Chico Creek + South	Carcass survey	10
	San Joaquin R and tribs	-	0
		Annual System Total = 2866	
1980	Sacramento R., mainstem	RBDD counts	9636
	Sac R tribs North of Big Chico Creek	Spawner survey	2000
	Sac R tribs, Big Chico Creek + South	Carcass survey	826
	San Joaquin R and tribs	-	0
		Annual System Total = 12,462	
1981	Sacramento R., mainstem	RBDD counts	20,655
	Sac R tribs North of Big Chico Creek	-	No estimate
	Sac R tribs, Big Chico Creek + South	Carcass survey/estimate	981
	San Joaquin R and tribs	-	0
		Annual System Total = 21,636	
1982	Sacramento R., mainstem	RBDD counts	23,156
	Sac R tribs North of Big Chico Creek	Carcass survey	2200
	Sac R tribs, Big Chico Creek + South	Carcass survey	624
	San Joaquin R and tribs	-	0
		Annual System Total = 25,980	

Appendix 2-B (cont.). Total escapement estimates of naturally spawning spring-run chinook salmon in California's Central Valley, grouped by location of tributaries from 1969 to 2003. (Note: Numbers of spring-run chinook taken into Feather River Hatchery for artificial spawning are not included in this table, but are reported in Appendix 2-A.)

Year	Location	Estimation Method	Number of Fish
1983	Sacramento R., mainstem	RBDD + Aerial survey	5647
	Sac R tribs North of Big Chico Creek	Carcass + live fish count	559
	Sac R tribs, Big Chico Creek + South	Carcass survey	50
	San Joaquin R and tribs	-	0
		Annual System Total = 6256	
1984	Sacramento R., mainstem	RBDD counts	7823
	Sac R tribs North of Big Chico Creek	-	-
	Sac R tribs, Big Chico Creek + South	Carcass survey	23
	San Joaquin R and tribs	-	0
		Annual System Total = 7846	
1985	Sacramento R., mainstem	RBDD + Aerial survey	12,913
	Sac R tribs North of Big Chico Creek	Carcass survey	422
	Sac R tribs, Big Chico Creek + South	Carcass survey	254
	San Joaquin R and tribs	-	0
		Annual System Total = 13,589	
1986	Sacramento R., mainstem	RBDD + Aerial survey	21,886
	Sac R tribs North of Big Chico Creek	Dam + snorkel survey	834
	Sac R tribs, Big Chico Creek + South	Carcass + redd survey	1371
	San Joaquin R and tribs	-	0
		Annual System Total = 24,091	
1987	Sacramento R., mainstem	RBDD + Aerial survey	12,611
	Sac R tribs North of Big Chico Creek	Dam + snorkel survey	290
	Sac R tribs, Big Chico Creek + South	Carcass survey	14
	San Joaquin R and tribs	-	0
		Annual System Total = 12,915	
1988	Sacramento R., mainstem	RBDD + Aerial survey	9829
	Sac R tribs North of Big Chico Creek	Dam + snorkel survey	943
	Sac R tribs, Big Chico Creek + South	Carcass survey	1290
	San Joaquin R and tribs	-	0
		Annual System Total = 12,062	
1989	Sacramento R., mainstem	RBDD counts	5139
	Sac R tribs North of Big Chico Creek	Dam + snorkel survey	654
	Sac R tribs, Big Chico Creek + South	Carcass + snorkel survey	1300
	San Joaquin R and tribs	-	0
		Annual System Total = 7093	

Appendix 2-B (cont.). Total escapement estimates of naturally spawning spring-run chinook salmon in California's Central Valley, grouped by location of tributaries from 1969 to 2003. (Note: Numbers of spring-run chinook taken into Feather River Hatchery for artificial spawning are not included in this table, but are reported in Appendix 2-A.)

Year	Location	Estimation Method	Number of Fish
1990	Sacramento R., mainstem	RBDD + Aerial survey	4072
	Sac R tribs North of Big Chico Creek	Dam + snorkel survey	1342
	Sac R tribs, Big Chico Creek + South	Carcass + snorkel survey	250
	San Joaquin R and tribs	-	0
		Annual System Total = 5664	
1991	Sacramento R., mainstem	RBDD + Aerial survey	820
	Sac R tribs North of Big Chico Creek	Dam + snorkel survey	798
	Sac R tribs, Big Chico Creek + South	No estimate	0
	San Joaquin R and tribs	-	0
		Annual System Total = 1618	
1992	Sacramento R., mainstem	RBDD counts	372
	Sac R tribs North of Big Chico Creek	Dam + snorkel survey	446
	Sac R tribs, Big Chico Creek + South	Carcass + snorkel survey	730
	San Joaquin R and tribs	-	0
		Annual System Total = 1548	
1993	Sacramento R., mainstem	RBDD counts	386
	Sac R tribs North of Big Chico Creek	Dam + snorkel survey	324
	Sac R tribs, Big Chico Creek + South	Carcass + snorkel survey	688
	San Joaquin R and tribs	-	0
		Annual System Total = 1398	
1994	Sacramento R., mainstem	RBDD counts	740
	Sac R tribs North of Big Chico Creek	Dam + snorkel survey	1208
	Sac R tribs, Big Chico Creek + South	Carcass + snorkel survey	476
	San Joaquin R and tribs	-	0
		Annual System Total = 2424	
1995	Sacramento R., mainstem	RBDD counts	318
	Sac R tribs North of Big Chico Creek	Dam + snorkel survey	1698
	Sac R tribs, Big Chico Creek + South	Snorkel survey	7700
	San Joaquin R and tribs	-	0
		Annual System Total = 9716	
1996	Sacramento R., mainstem	RBDD counts	378
	Sac R tribs North of Big Chico Creek	Dam + snorkel survey	908
	Sac R tribs, Big Chico Creek + South	Snorkel survey	1415
	San Joaquin R and tribs	-	0
		Annual System Total = 2701	

Appendix 2-B (cont.). Total escapement estimates of naturally spawning spring-run chinook salmon in California's Central Valley, grouped by location of tributaries from 1969 to 2003. (Note: Numbers of spring-run chinook taken into Feather River Hatchery for artificial spawning are not included in this table, but are reported in Appendix 2-A.)

Year	Location	Estimation Method	Number of Fish
1997	Sacramento R., mainstem	RBDD counts	126
	Sac R tribs North of Big Chico Creek	Dam + snorkel survey	666
	Sac R tribs, Big Chico Creek + South	Snorkel survey	637
	San Joaquin R and tribs	-	-
		Annual System Total = 1429	
1998	Sacramento R., mainstem	RBDD counts	1115
	Sac R tribs North of Big Chico Creek	Dam + snorkel survey	2982
	Sac R tribs, Big Chico Creek + South	Snorkel survey	20,628
	San Joaquin R and tribs	-	-
		Annual System Total = 24,725	
1999	Sacramento R., mainstem	RBDD counts	469
	Sac R tribs North of Big Chico Creek	Dam + snorkel survey	2362
	Sac R tribs, Big Chico Creek + South	Snorkel survey	3706
	San Joaquin R and tribs	-	-
		Annual System Total = 6537	
2000	Sacramento R., mainstem	RBDD counts	252
	Sac R tribs North of Big Chico Creek	Dam + snorkel survey	1350
	Sac R tribs, Big Chico Creek + South	Snorkel survey	4145
	San Joaquin R and tribs	-	-
		Annual System Total = 5745	
2001	Sacramento R., mainstem	RBDD counts	956
	Sac R tribs North of Big Chico Creek	Dam + snorkel survey	2826
	Sac R tribs, Big Chico Creek + South	Snorkel survey	9644
	San Joaquin R and tribs	-	-
		Annual System Total = 13,426	
2002	Sacramento R., mainstem	RBDD counts	483
	Sac R tribs North of Big Chico Creek	Dam + snorkel survey	4094
	Sac R tribs, Big Chico Creek + South	Snorkel survey	8785
	San Joaquin R and tribs	-	-
		Annual System Total = 13,362	
2003	Sacramento R., mainstem	RBDD counts	0
	Sac R tribs North of Big Chico Creek	Dam + snorkel survey	4423
	Sac R tribs, Big Chico Creek + South	Snorkel survey	4479
	San Joaquin R and tribs	-	-
		Annual System Total = 8902	

Appendix 2-B, notes:

1969-1996 data extracted from CDFG annual reports, and 1997-2003 data extracted from CDFGs GrandTab (2004) spreadsheet.

[a] Estimate based on 236 fish trapped below irrigation dam. Fish were trapped and moved above a series of irrigation dams to a suitable spawning reach. Hoopaugh (1973) estimated run-size at 500 fish.

Appendix 2-C. Spring-run chinook escapement estimates for the Sacramento River above RBDD from 1972-2002, adjusted for sport fishery catch above the dam only (Taylor 1972, 1973, and 1974; Hoopaugh 1976 and 1978; Hoopaugh and Knutson 1979; Knutson 1980; Reavis 1981a, 1981b, 1983a, 1983b, and 1985; Kano and Reavis 1996, 1997a, and 1997b; Kano 1997, 1998a, 1998b, 1998c, 1998d, 1999a, 1999b, 1999c, and 2000; Killam and Harvey-Arrison 2001 and 2002; CDFG 2004a).

Year	RBDD Count	Sport fishery catch	Escapement estimate
1972	7346	308	7038
1973	7762	587	7175
1974	3932	132	3800
1975	10,703	469	10,234
1976	25,983	888	25,095
1977[a]	13,730	277	11,703
1978	5903	234	5669
1979	2900	44	2856
1980	9969	333	9636
1981	21,025	370	20,655
1982	23,438	282	23,156
1983	3931	77	3854
1984	8147	324	7823
1985	10,747	547	10,200
1986	16,691	867	15,824
1987	11,205	233	10,972
1988	9771	203	9568
1989	5255	109	5146
1990	3923	65	3858
1991	805	43	762
1992	431	59	372
1993	388	1	387
1994	740	0	740
1995	394	0	394
1996	418	0[b]	418
1997	189	0	189
1998	1639	0	1639
1999[c]	-	0	-
2000[c]	-	0	-
2001	956	0	956
2002	608	0	608

[a] Escapement estimate does not account for 1750 fish that were trapped and relocated to other spawning areas in the Sacramento River system in tributaries from Clear Creek to Butte Creek (Hoopaugh and Knutson 1979).
[b] Sport-fishing closed during spring-run chinook migration/spawning; catch assumed to be zero fish.
[c] Contact CDFG (Red Bluff, CA) office for available data (530-527-8892).

Appendix 2-D. Estimated harvest of spring-run chinook salmon in the mainstem Sacramento River from 1967 through 1991 (Mills and Fisher 1994).

Year	Spawner estimate above RBDD	Estimated catch above RBDD[a]	Harvest rate above RBDD[b] (%)	Total river harvest rate[c] (%)	Harvest estimate[d]
1967	23,514	No est.	No est.	8.0	1885
1968	14,864	239	1.6	5.4	802
1969	26,505	571	2.2	6.3	1659
1970	3652	416	11.4	20.9	762
1971	5830	148	2.5	6.9	400
1972	7346	308	4.2	9.5	1149
1973	7762	587	7.6	14.8	1149
1974	3933	133	3.4	8.2	1047
1975	10,703	469	4.4	9.8	1047
1976	25,983	888	3.4	8.3	2145
1977	13,730	277	2.0	6.0	830
1978	5903	234	4.0	9.1	538
1979	2900	43	1.5	5.2	151
1980	9696	333	3.4	8.3	803
1981	21,025	370	1.8	5.6	1185
1982	23,438	282	1.2	4.8	1115
1983	3931	77	2.0	5.9	234
1984	8147	324	4.0	9.1	745
1985	10,747	547	5.1	10.9	1171
1986	16,691	867	5.2	11.1	1846
1987	11,204	233	2.1	6.1	688
1988	9781	203	2.1	6.1	600
1989	5255	109	2.1	6.1	322
1990	3922	65	1.7	5.5	215
1991	773	22	2.8	7.4	57
Average	11,089	323	3.4	8.2	855

[a] Based on RBDD ladder counts combined with estimated catches from numbers reported at boat ramps and resorts, yielding rough estimates of annual harvest above RBDD.
[b] This column represents the proportion of the estimated catch above RBDD by the total spawning escapement estimate above RBDD.
[c] 'Total river harvest rate' is based on regression analysis (Mills and Fisher 1994).
[d] 'Harvest estimate' is based on application of the estimated annual harvest rate for the total river to the spawning escapement estimate for each year. This estimate is considered a harvest index.

Appendix 2-E. Adult spring-run chinook salmon counted during snorkel surveys of Beegum Creek from 1973 through 2003 (Killam and Moore 2001; CDFG 2004b).

Year	Count
1973	0
1974	3
1975	3
1976-1981	Not surveyed
1982	0
1983-1988	Not surveyed
1989	0
1990-1992	Not surveyed
1993	1
1994	Not surveyed
1995	8
1996	6
1997	0
1998	477
1999	102
2000	120
2001	340
2002	125
2003	73

Appendix 2-F. Returns of spring-run chinook salmon to the Feather River Hatchery from 1967 through 2004 (Feather River Hatchery annual reports).

Year	No. of grilse	Total no. of adults	No. of males vs. females[a]	Total
1967	3	143	55 / 88	146
1968	0	216	-	216
1969	-	229	-	229[b]
1970	0	235	82 / 153	235
1971	0	484	272 / 212	484
1972	0	256	128 / 116	256
1973	0	205	104 / 105	205
1974	0	198	83 / 69	198
1975	0	691	283 / 330	691
1976	14	699	281 / 432	713
1977	0	194	78 / 116	194
1978	0	202	90 / 112	202
1979	0	250	83 / 167	50
1980	0	122	64 / 58	122
1981	113	356	211 / 145	469
1982	210	1700	770 / 930	1910
1983	72	1640	724 / 916	1712
1984	251	1311	831 / 480	1562
1985	39	1593	801 / 792	1632
1986	191	1242	546 / 696	1433
1987	287	926	489 / 437	1213
1988	283	6550	3780 / 2770	6833
1989	69	4385	2207 / 2178	5078
1990	587	1306	715 / 591	1893
1991	155	3293	1802 / 1491	3448
1992	173	1324	680 / 644	1670
1993	729	3943	1996 / 1947	4672
1994	856	2785	1416 / 1369	3641
1995	412	5002	2484 / 2518	5414
1996	812	5569	2784 / 2785	6381
1997	-	-	-	3653
1998	-	-	-	6746
1999	-	-	-	3731
2000	-	-	-	3657
2001	-	-	-	4135
2002	207	3982	2220 / 1762	4189
2003	389	8273	4556 / 3717	8662
2004	572	3630	2100 / 1530	4202

- Indicates data not provided in report.

[a] Number of males and females sexed by hatchery personnel after fish were allowed to enter the hatchery. Numbers may not always equal adult totals, as some fish may have died before they were sexed.

[b] Although 345 fish entered the hatchery between April 1 and August 25, 1969, 116 died due to a fungus infection and were not included in the totals (Schlicting 1973).

Appendix 2-G. Spring-run chinook salmon redd distribution in the mainstem Sacramento River from 1983 to 2004, as enumerated during aerial surveys from Keswick Dam to Princeton Ferry (CDFG 2001 and 2004b; Killam 2005).

Year	No. of surveys conducted	Total No. of redds counted	Location on Sacramento River with highest density	Percent distribution at highest density location (%)
1983	2	37	ACID Dam to Highway 44 Bridge	62
1984	1	15	ACID Dam to Highway 44 Bridge	40
1985	1	14	Hwy 44 Bridge to Airport Rd Bridge	29
1986[a]	1	2	Hwy 44 Bridge to Balls Ferry Bridge	100
1987	0	n/a	n/a	n/a
1988[b]	2	156	Hwy 44 Bridge to Airport Rd Bridge	58
1989[c]	1	4	ACID Dam to Airport Rd Bridge	100
1990[d]	2	11	Hwy 44 Bridge to Airport Rd Bridge	64
1991[e]	1	3	Hwy 44 Bridge to Airport Rd Bridge	100
1992[f]	1	4	Hwy 44 Bridge to Airport Rd Bridge	50
1993[g]	1	1	ACID Dam to Highway 44 Bridge	100
1994[h]	3	67	Hwy 44 Bridge to Airport Rd Bridge	27
1995[i]	6	11	ACID Dam to Highway 44 Bridge	55
1996[j]	2	39	ACID Dam to Highway 44 Bridge	80
1997[k]	5	103	ACID Dam to Highway 44 Bridge	50
1998[l]	4	30	Hwy 44 Bridge to Airport Rd Bridge	47
1999[m]	1	1	Hwy 44 Bridge to Airport Rd Bridge	100
2000	2	14	ACID Dam to Highway 44 Bridge	86
2001[n]	1	29	Battle Creek to Jellys Ferry Bridge	28
2002[o]	2	105	Hwy 44 Bridge to Airport Rd Bridge	24
2003[p]	3	22	ACID Dam to Highway 44 Bridge	32
2004[q]	4	44	Hwy 44 Bridge to Airport Rd Bridge	68

[a, c] River section Hamilton City Bridge to Princeton Ferry was not surveyed.
[b, e, f, g, j, n, o] River section from Woodson Bridge to Princeton Ferry was not surveyed.
[d, h, i, l] River section from Ord Ferry Bridge to Princeton Ferry was not surveyed.
[k, p, q] River section from Tehama Bridge to Princeton Ferry was not surveyed.
[m] River section from Airport Road Bridge to Princeton Ferry was not surveyed.

Appendix 2-H. Numbers of redds and carcasses counted during spring-run chinook salmon spawning surveys in specified tributaries to the Sacramento River from 1997 to 2003, with 2004 counts listed for certain systems (CDFG 2002a; CDFG 2004b).[a]

Tributary	Year	No. of redds	No. of carcasses	Additional surveys
Sacramento River mainstem	2001	29	n/a	n/a
	2002	105		
	2003	22		
	2004	44		
Clear Creek	2001	-	-	Tissues collected
	2002	-	-	
	2003[b]	53	25	
	2004[c]	35	57	
Beegum/ Cottonwood Creek	2000	-	3	Tissues collected
	2001	6	6	
	2002	39	3	
	2003	n/a	n/a	
Battle Creek	2001	-	-	Genetic study
	2002	78	-	
	2003	176	-	
Mill Creek	1997	100	13	Tissues collected
	1998	212	26	
	1999	280	14	
	2000	272	21	
	2001	552	54	
	2002	797	60	
	2003	713	70	
Deer Creek	1997	275	43	n/a
	1998	793	137	
	1999	1495	220	
	2000	256	25	
	2001	715	239	
	2002	1022	290	
	2003	1087	125	
Butte Creek	2001	n/a	-	Tissues collected
	2002	-	-	
	2003	-	-	
Yuba River	2000	205	-	n/a
	2001	288	-	
	2002	239	-	
	2003	212	-	

[a] Snorkeling or walking surveys were conducted for most systems, except the Sacramento River mainstem which was surveyed using aerial surveys.
[b] Of the 25 carcasses recovered, 8 (32%) were found on the temporary picket weir used to separate spring- and fall-run spawning habitat.[13]
[c] Of the 57 carcasses recovered, 43 (75%) were found on the temporary picket weir used to separate spring- and fall-run spawning habitat.[14]

[13] J. Newton, USFWS 10950 Tyler Road, Red Bluff, CA 96080, 11 January 2005, personal communication.

Appendix 2-I. Summary of juvenile spring-run chinook sized-salmon captured during rotary screw trap sampling at Balls Ferry (RK 444) and Deschutes Road Bridge (RK 452), Sacramento River from 1996 through 1999 (CDFG 1997, 1998a, 1999, and 2000).

Weeks	Corresponding dates	Brood year	Average FL (mm)	Total
12-22 (not 21)	17 Mar-26 May 1996	1995	69-115[a]	471
42-1 6-23	13 Oct-29 Dec 1996 02 Feb-01 Jun 1997	not reported	25-137	1441
11-25	08 Mar-14 Jun 1998	not reported	65-119[a]	571
43-7 11-22	18 Oct 1998-07 Feb 1999 07 Mar-23 May 1999	not reported	30-125	1100

[a] Spring-run chinook emergents not captured due to late start timing of sampling.

[14] J. Newton, USFWS 10950 Tyler Road, Red Bluff, CA 96080, 11 January 2005, personal communication.

Appendix 2-J. Monthly juvenile passage estimates (JPE) for spring-run chinook salmon captured using rotary screw traps below the Red Bluff Diversion Dam, Sacramento River for brood years 1995 through 1999 (Gaines and Martin 2002).

Month	N[a]	Median FL (mm)	JPE	75% C. I.		90% C. I.	
				Lower	Upper	Lower	Upper
Brood year 1995							
Oct	11	34	9056	7495	10,616	825	17,286
Nov	6	33	22,062	19,414	24,709	8090	36,033
Dec	9	36	3152	2874	3430	1687	4617
Jan	11	51	3237	8679	3794	296	6178
Feb	2	58	4294	2950	5638	0	11,398
Mar	17	72	753,635	663,718	843,552	279,412	1,227,859
Apr	30	87	49,304	48,414	50,194	44,608	54,000
May	13	96	6105	5755	6454	4262	7947
Jun	13	-	0	0	0	0	0
Jul	14	-	0	0	0	0	0
Aug	19	-	0	0	0	0	0
Sep	12	-	0	0	0	0	0
Total	157		850,844	753,301	948,387	339,180	1,365,318
Brood year 1996							
Oct	13	32	491	427	555	155	827
Nov	22	33.5	6505	5790	7220	2732	10,279
Dec	8	38	68,052	60,235	75,868	26,828	109,275
Jan	-	-	34,913	0	100,562	0	381,148
Feb	15	59.5	1775	1534	2016	501	3048
Mar	16	77	1091	991	1191	564	1618
Apr	24	79	136,766	127,086	146,446	85,676	187,856
May	19	98	3889	3521	4258	1946	5833
Jun	16	114	404	326	482	0	816
Jul	19	117	99	67	130	0	265
Aug	16	-	0	0	0	0	0
Sep	13	-	0	0	0	0	0
Total	181		253,985	199,977	338,728	118,401	700,966
Brood year 1997							
Oct	15	34.5	1207	1045	1370	352	2063
Nov	11	33	9419	7759	11,079	657	18,181
Dec	11	37	307,340	268,467	346,213	102,322	512,358
Jan	5	45	7379	6288	8469	1627	13,131
Feb	-	-	35,727	1219	70,235	0	218,153
Mar	11	66	64,076	54,521	73,631	13,683	114,468
Apr	11	76	70,874	56,460	85,288	0	146,948
May	8	98	10,762	9596	11,927	4616	16,907

Appendix 2-J (cont.). Monthly juvenile passage estimates (JPE) for spring-run chinook salmon captured using rotary screw traps below the Red Bluff Diversion Dam, Sacramento River for brood years 1995 through 1999 (Gaines and Martin 2002).

Month	N[a]	Median FL (mm)	JPE	75% C. I.		90% C. I.	
				Lower	Upper	Lower	Upper
Jun	11	118	482	327	637	0	1300
Jul	17	-	0	0	0	0	0
Aug	13	-	0	0	0	0	0
Sep	18	-	0	0	0	0	0
Total	131		507,265	405,682	608,849	123,257	1,043,509
			Brood year 1998				
Oct	26	34	26,394	23,916	28,871	13,330	39,457
Nov	19	33	18,057	17,011	19,103	12,535	23,579
Dec	26	38	296,856	225,529	368,184	0	673,037
Jan	24	49	20,974	17,058	24,890	323	41,625
Feb	16	59	4199	3514	4884	577	7821
Mar	28	80	5847	5475	6218	3887	7807
Apr	23	84	20,608	19,942	21,275	17,091	24,126
May	26	99	3004	2806	3203	1959	4050
Jun	30	124.5	110	85	134	0	240
Jul	31	169.5	129	100	158	0	283
Aug	28	-	0	0	0	0	0
Sep	23	-	0	0	0	0	0
Total	300		396,178	315,437	476,920	49,701	822,026
			Brood year 1999				
Oct	21	34	20,414	18,943	21,885	12,655	28,173
Nov	24	34	6815	6547	7083	5400	8231
Dec	29	38	30,621	29,877	31,364	26,701	34,541
Jan	20	51	113,874	103,765	123,982	60,563	167,184
Feb	16	57	37,712	34,278	41,145	19,562	55,862
Mar	25	80	58,898	53,987	63,810	32,996	84,801
Apr	25	85	281,808	248,047	315,570	103,619	459,997
May	27	104	19,374	18,686	20,062	15,743	23,005
Jun	24	116	466	409	522	169	762
Jul	0	-	0	0	0	0	0
Aug	0	-	0	0	0	0	0
Sep	0	-	0	0	0	0	0
Total	211		569,981	514,540	625,423	277,408	862,555

[a] N represents the number of days sampled each month.

Appendix 2-K. Numbers of juvenile spring- and fall-run chinook salmon captured in a rotary screw trap on Mill Creek from 2000-2003 (CDFG Annual reports; CDFG 2004b).

Trapping period	No. of spring-run chinook captured (yearlings)	No. of spring- and fall-run chinook captured (fry)	Date of first fry captured	Date of first yearling captured
Oct 00 – Jan 01	292 (BY[a] 1999)	181 (BY 2000)	18 Dec 00	11 Oct 00
Oct 01 – Mar 02	795 (BY 2000)	1493 (BY 2001)	07 Dec 01	10 Oct 01
Oct 02 – May 03	127 (BY 2001)	681 (BY 2002)	05 Feb 03	08 Nov 02
Oct 03 - current[b]	148 (BY 2002)	-	09 Dec 03	29 Oct 03

[a] BY = Brood Year.

[b] Incomplete, as trapping continues through completion of this report.

Appendix 2-L. Numbers of juvenile spring- and fall-run chinook salmon captured in a rotary screw trap on Deer Creek from 2000-2003 (CDFG Annual reports; CDFG 2004b).

Trapping period	No. of spring-run chinook captured (yearlings)	No. of spring- and fall-run chinook captured (fry)	Date of first fry captured	Date of first yearling captured
Oct 00 – Jan 01	606 (BY[a] 1999)	57,200 (BY 2000)	12 Jan 01	11 Oct 00
Oct 01 – Mar 02	575 (BY 2000)	1385 (BY 2001)	06 Dec 01	31 Oct 01
Oct 02 – Mar 03	193 (BY 2001)	1640 (BY 2002)	10 Jan 03	08 Nov 02
Oct 03 – current[b]	114 (BY 2002)	-	08 Nov 03	13 Nov 03

[a] BY = Brood Year.

[b] Incomplete, as trapping continues through completion of this report.

Appendix 2-M. Juvenile spring-run chinook salmon trapping results on Butte Creek for 1995 to 2001 brood years (Hill and Webber 1999; Ward and McReynolds 2001; Ward et al. 2002 and 2003). Note: "Total no. captured" for 1995 through 1998 does not include yearling captures.

Trap location	Trapping period	Total no. captured[c]	Combined no. of trapping days[b]	No. of fish tagged + released	No. of tagged fish recaptured
PPDD[a]	11/28/95-7/8/96	119,514	183	14,452	-
Sutter Bypass	1/16/96-7/8/96	52,285	151	-	59
PPDD + Adams Dam	9/17/96-6/26/97	1892	239	429	-
Sutter Bypass	3/21/97-3/24/97	111	4	-	0
PPDD + Adams Dam	10/6/97-7/23/98	9550	270	3408	-
Sutter Bypass	4/16/98-7/17/98	15480	92	-	5
PPDD	10/1/98-7/15/99	410,115	265	111,352	-
Sutter Bypass	1/1/99-6/30/99	128,386	153	-	421
PPDD	10/1/99-6/30/99	255,104	257	58,854	-
Sutter Bypass	11/1/99-6/15/00	94,058	164	-	172
PPDD	9/1/00-6/30/01	697,317	282	166,570	-
Sutter Bypass[d]	1/9/01-6/22/01	13,241	147	-	110
PPDD	9/15/01-6/28/02	375,274	271	155,413	-
Sutter Bypass	11/20/01-6/28/02	14,732	193	-	37

[a] Parrott-Phelan Diversion Dam.
[b] Includes diversion dam screen trap and rotary screw trap operating at PPDD.
[c] Includes all runs of chinook salmon in the Sacramento River system, not just spring-run chinook.
[d] Traps were moved upstream twice, once on April 4, 2001 and again on May 17, 2001 due to excessive debris build-up.

Appendix 2-N. Summary of non-adipose fin-clipped juvenile spring-run chinook salmon captured during Kodiak and midwater trawls in the Sacramento River near the city of Sacramento from 1988-2004 (U. S. Fish and Wildlife Service 2005e).

Year	Month	Total catch
1988	Apr	2080
	May	13,535
1992	Feb	20
	Mar	79
	May	41
	Dec	4
1993	Mar	76
	Apr	1391
	May	56
	Jun	1
	Dec	1
1994	Feb	15
	Mar	44
	Apr	2283
	May	36
	Dec	2
1995	Jan	2
	Feb	118
	Mar	260
	Apr	637
	May	34
	Dec	63
1996	Jan	43
	Feb	30
	Mar	990
	Apr	1823
	May	78
	Jun	1
	Nov	1
	Dec	90
1997	Feb	18
	Mar	103
	Apr	1589
	May	40
	Jun	1
	Nov	2
	Dec	24
1998	Jan	4
	Feb	1
	Mar	310
	Apr	346
	May	16
	Jun	6
	Nov	1
	Dec	10
1999	Jan	12
	Feb	10
	Mar	23
	Apr	316
	May	7
2000	Jan	19
	Feb	12
	Mar	201
	Apr	225
	May	13
2001	Feb	31
	Mar	5
	Apr	67
	May	2
	Nov	2
	Dec	12
2002	Jan	7
	Feb	20
	Mar	28
	Apr	98
	May	1
	Dec	43
2003	Jan	30
	Feb	69
	Mar	170
	Apr	674
	May	10
	Dec	55
2004	Jan	6
	Feb	27
	Mar	45
	Apr	185
	May	13

Appendix 2-O. Summary of juvenile spring-run chinook salmon captured during midwater trawling operations at Chipps Island from 1976-2004 (U. S. Fish and Wildlife Service 2005f).

Year	Month	Total catch
1976	May	60
	Jun	13
1977	May	451
	Jun	8
1978	Apr	896
	May	139
	Jun	1
1979	Apr	543
	May	100
	Jun	5
1980	Mar	4
	Apr	283
	May	294
	Jun	38
1981	Apr	290
	May	22
1982	Apr	236
	May	550
	Jun	12
1983	Apr	1207
	May	1395
	Jun	718
1984	Apr	165
	May	166
1985	Apr	571
	May	697
1986	Apr	1442
	May	1075
	Jun	3
1987	Apr	695
	May	574
	Jun	3
1988	Apr	898
	May	3088
1989	Apr	1155
	May	282
	Jun	1
1990	Apr	1297
	May	1243
	Jun	2
1991	Apr	271
	May	671
	Jun	4
1992	Apr	6740
	May	661
	Jun	2
1993	Apr	1818
	May	455
	Jun	5
1994	Mar	3
	Apr	1102
	May	81
1995	Jan	2
	Feb	4
	Mar	113
	Apr	2433
	May	1188
	Sep	1
	Dec	1
1996	Feb	4
	Mar	546
	Apr	2031
	May	641
	Jun	10
	Dec	2
1997	Jan	1
	Feb	1
	Mar	26
	Apr	1240
	May	146
	Jun	1
1998	Mar	283
	Apr	4491
	May	1793
	Jun	18
1999	Jan	1
	Mar	43
	Apr	1332
	May	279
	Jun	2

Appendix 2-O (cont.). Summary of juvenile spring-run chinook salmon captured during midwater trawling operations at Chipps Island from 1976-2004 (U. S. Fish and Wildlife Service 2005f).

Year	Month	Total catch
2000	Feb	1
	Mar	337
	Apr	3191
	May	361
	Jun	1
2001	Mar	2
	Apr	447
	May	78
2002	Mar	9
	Apr	1093
	May	125
	Jun	1
	Sep	1
2003	Mar	178
	Apr	3428
	May	339
	Jun	2
	Sep	1
2004	Feb	1
	Mar	151
	Apr	620
	May	115
	Jun	2

Note: Spring-run chinook included in this table were non-adipose fin-clipped fish; chinook race designation determined by length-at-date criteria.

Appendix 3-A. Adult steelhead fyke net trapping results from the Sacramento River from 1953-1957 (Hallock 1957).

	1953-54			1954-55			1955-56			1956-57		
Month	No. of trap hours	No. of steelhead trapped	Catch per 100 trap hours	No. of trap hours	No. of steelhead trapped	Catch per 100 trap hours	No. of trap hours	No. of steelhead trapped	Catch per 100 trap hours	No. of trap hours	No. of steelhead trapped	Catch per 100 trap hours
July	1687	23	1.36	1581	78	4.93	2488	51	2.05	1550	3	0.19
August	3923	523	13.33	3606	591	16.39	3529	667	18.9	3799	371	9.76
September	3410	861	25.25	3636	3545	97.5	3548	1300	36.64	3296	1829	55.49
October	3480	471	13.53	3441	1521	44.2	3168	709	22.38	3736	1443	38.62
November	2760	104	3.77	2075	284	13.69	2066	142	6.87	2198	189	8.6
December	2840	82	2.89	860	67	7.79	716	24	3.35	1454	40	2.75
January	2304	57	2.47									
February	812	8	0.99	189	17	8.99						
March	1416	4	0.28									
April	648	0	0.00									
May	672	0	0.00									
June	1008	3	0.30									
Totals	24,960	2136	-	15,388	6103	-	15,515	2893	-	16,033	3875	-

Appendix 3-B. Red Bluff Diversion Dam (RBDD) counts and Coleman National Fish Hatchery (CNFH) trapping results for Sacramento River steelhead from 1953 through 1988 (Hallock 1989).

Year	RBDD Counts	CNFH Trapping
1953	-	424
1954	-	960
1955	-	1063
1956	-	889
1957	-	962
1958	-	816
1959	-	992
1960	-	1653
1961	-	1739
1962	-	1486
1963	-	1737
1964	-	2965
1965	-	1643
1966	13,011	1532
1967	17,416	3229
1968	13,648	4939
1969	11,590	4046
1970	10,876	3742
1971	5641	1486
1972	7978	2645
1973	3101	1834
1974	5205	1099
1975	8196	2162
1976	5928	2069
1977	2467	697
1978	3487	865
1979	10,994	4264
1980	2898	1118
1981	2394	945
1982	3150	938
1983	1969	529
1984	4404	2565
1985	3358	2604
1986	2809	850
1987	1796	915
1988	432	286

Appendix 3-C. Estimated number and percentage of adult steelhead population caught in the upper Sacramento River from 1953 through 1988 (Hallock 1989).

Year	Number of fish	Percent of population
1953-58	7600	37
1962-65	11,850	42
1967-69	19,000	47
1971-74	7800	36
1975-79	8200	32
1980-84	4100	29
1985-88	2980	25

Appendix 3-D. Estimated harvest of adult steelhead above RBDD from 1967 through 1991 (Mills and Fisher 1994).

Year	Upper Sacramento population estimate	Estimated angler harvest above RBDD
1967	15,312	5795
1968	19,615	5761
1969	15,222	5761
1970	13,240	5011
1971	11,887	4499
1972	6041	2286
1973	8921	3376
1974	7150	2706
1975	5579	2111
1976	8902	3369
1977	6099	2308
1978	2527	956
1979	3499	1324
1980	11,887	4499
1981	3363	1273
1982	2757	1043
1983	3486	1319
1984	2036	771
1985	4489	1699
1986	3769	1426
1987	2963	860
1988	1872	708
1989	470	178
1990	2272	860
1991	991	375
Average	6574	2488

Appendix 3-E. Steelhead population estimates in the upper Sacramento River from 1953 through 1959, based on fish migrating upstream at fyke nets placed at the mouth of the Feather River (Hallock et al. 1961).[a]

					95 % confidence intervals	
Season	No. of fish tagged	No. of fish sampled above tagging site	No. of tagged fish in sample	No. of fish in the population	Lower limit	Upper limit
1953-54	1451	882	88	14,400	11,960	17,760
1954-55	4473	2901	456	28,400	26,170	30,980
1955-56	2270	3081	246	28,320	25,240	32,070
1956-57	2982	3069	497	18,380	17,000	19,970
1957-58	1824	2978	279	19,410	17,420	21,780
1958-59	1735	2688	322	14,340	12,980	15,940

[a] Estimates based on fish over 355 mm FL.

Appendix 3-F. Estimates of steelhead populations in the upper Sacramento River from 1953 through 1959, divided by hatchery and wild fish (Hallock et al. 1961).

Season	Hatchery fish	Wild fish	Total run
1953-54	404	13,996	14,400
1954-55	2315	26,085	28,400
1955-56	5223	23,097	28,320
1956-57	3205	15,175	18,380
1957-58	2876	16,534	19,410
1958-59	942	13,398	14,340
Averages	2494	18,048	20,542

Appendix 3-G. Estimated upper Sacramento River steelhead sport catch landings from 1953 through 1959, based on tag returns to CDFG (Hallock et al. 1961).[a]

	1953-54		1954-55		1955-56		1956-57		1957-58		1958-59	
Month	No. of fish caught	Percentage of catch	No. of fish caught	Percentage of catch	No. of fish caught	Percentage of catch	No. of fish caught	Percentage of catch	No. of fish caught	Percentage of catch	No. of fish caught	Percentage of catch
Jul	-	-	-	-	-	-	-	-	-	-	-	-
Aug	-	-	9	0.1	86	1.1	-	-	10	0.2	-	-
Sep	168	5.8	485	5.3	727	9.3	301	4.7	75	1.5	262	5.0
Oct	1002	44.6	4078	44.6	3032	38.8	2520	39.4	1468	29.3	2429	46.4
Nov	1010	34.9	2460	26.9	2298	29.4	2040	31.9	2084	41.6	1466	28.0
Dec	318	11.0	604	6.6	774	9.9	499	7.8	722	14.4	497	9.5
Jan	119	4.1	604	6.6	297	3.8	435	6.8	386	7.7	230	4.4
Feb	229	7.9	622	6.8	273	3.5	358	5.6	130	2.6	157	3.0
Mar	9	0.3	18	0.2	148	1.9	32	0.5	20	0.4	42	0.8
Apr	-	-	137	1.5	86	1.1	70	1.1	20	0.4	26	0.5
May	40	1.4	101	1.1	39	0.5	70	1.1	75	1.5	47	0.9
Jun	-	-	27	0.3	16	0.2	6	0.1	-	-	11	0.2
Month unknown	-	-	-	-	39	0.5	64	1.0	20	0.4	68	1.3
Totals	2895	100.0	9145	100.0	7815	100.0	6395	100.0	5010	100.0	5235	100.0
% of run caught	20.1		32.2		27.6		34.8		25.8		36.5	

[a] Estimates based on fish over 355 mm FL.

Appendix 3-H. Summary of steelhead sport fishery harvest estimates from the Central Valley Harvest Monitoring Project, 1998-2001 (Massa 2004; Schroyer et al. 2002).

Variable	1998	1999	2000	2001[a]
Angler hours	38,694	108,932	108,672	53,951
Total number released	2651	10,567	11,090	6163
Total number harvested	210	886	1014	639

[a] San Joaquin River system only sampled during January 2001.

Appendix 3-I. Estimated number of steelhead returning to Central Valley hatcheries from 1967 through 2004 (Mills and Fisher 1994; USFWS 2001; Annual hatchery reports; CDWR 2003b).

	Natural spawning	Steelhead returns to hatcheries					
Year	Upper Sacramento River	Coleman National Fish Hatchery	Feather River Hatchery	Nimbus Hatchery	Mokelumne River Fish Hatchery	Subtotal	Grand Total
1966-1967	15,312	1532	n/a	642	17	2754	18,066
1967-1968	19,615	3229	n/a	1183	103	5520	25,135
1968-1969	15,222	4939	1005	2449	24	8380	23,602
1969-1970	13,240	4046	361	1734	134	7859	21,099
1970-1971	11,887	3742	n/a	3033	215	6968	18,855
1971-1972	6041	1486	78	2256	14	4044	10,085
1972-1973	8921	2645	288	2506	11	6162	15,083
1973-1974	7150	1834	1000	3157	18	5724	12,874
1974-1975	5579	1099	715	2164	2	3723	9302
1975-1976	8902	2162	485	3181	0	5916	14,818
1976-1977	6099	2069	573	1307	0	3539	9638
1977-1978	2527	697	163	619	0	1447	3974
1978-1979	3499	865	131	680	0	1734	5233
1979-1980	11,887	4264	189	1310	0	5888	17,775
1980-1981	3363	1118	314	821	0	2486	5849
1981-1982	2757	1275	547	3190	0	5356	8113
1982-1983	3486	938	891	1003	0	3179	6665
1983-1984	2036	529	1239	5155	0	6467	8503
1984-1985	4489	2084	783	910	0	4715	9204
1985-1986	3769	2299	1721	1193	0	5046	8815
1986-1987	2963	1176	1554	1431	48	3673	6636
1987-1988	1872	915	1018	705	0	4207	6079
1988-1989	470	492	2587	289	7	1894	2364
1989-1990	2272	1319	1106	594	11	3117	5389
1990-1991	991	991	1193	223	20	2258	3249
1991-1992	-	4429	1025	1359	29	-	-
1992-1993	-	2862	1028	241	108	-	-
1993-1994	-	3387	297	504	83	-	-
1994-1995	-	2185	1594	3803	25	-	-

Appendix 3-I. (cont.) Estimated number of steelhead returning to Central Valley hatcheries from 1967 through 2004 (Mills and Fisher 1994; USFWS 2001; Annual hatchery reports; CDWR 2003b).

	Natural spawning	Steelhead returns to hatcheries					
Year	Upper Sacramento River	Coleman National Fish Hatchery	Feather River Hatchery	Nimbus Hatchery	Mokelumne River Fish Hatchery	Subtotal	Grand Total
1995-1996	-	3106	877	2257	39	-	-
1996-1997	-	2529	1058	1309	46	-	-
1997-1998	-	1409	2113	509	5	-	-
1998-1999	-	1755	1023	1056	0	-	-
1999-2000	-	-	633	1506	32	-	-
2000-2001	-	-	1742	2877	32	-	-
2001-2002	-	-	2161	2825	43	-	-
2002-2003	-	-	1431	852	52	-	-
2003-2004	-	-	2999	1734	57	-	-

- Indicates data not available or not calculated.

Appendix 3-J. *Oncorhynchus mykiss* counts resulting from USFWS snorkel surveys in Battle Creek, California from July 23 through August 29, 2001. Totals are listed by month and reach number; all size classes are included. Number of large trout (>56 cm) is presented in parentheses next to monthly totals (Brown and Newton 2002).[a]

Reach	July	August	September	October	Mean count
1	671 (0)	612 (0)	783 (0)	727 (0)	698
2	709 (2)	607 (0)	373 (0)	274 (0)	491
4	657 (6)	1381 (0)	690 (0)	855 (0)	896
5	554 (3)	554 (0)	643 (0)	485 (0)	559
6	238 (2)	146 (0)	209 (1)	174 (2)	192
7	-	57 (17)	44 (7)	-	51
Totals	2829 (13)	330 (17)	2698 (8)	2515 (2)	-

[a] Reach 3 was walked instead of snorkeled and is not included in this table. Reach 7 was not surveyed in July or October.

Appendix 3-K. Summary of adult steelhead and steelhead redd counts resulting from snorkel surveys of Antelope Creek from March 13 to May 3, 2001 (Moore 2001).

Date	Section	No. of adult steelhead	No. of steelhead redds
Mar 13	Facht Place crossing to Little Grapevine Creek	0	0
Mar 14	Confluence of North and South Forks to Paynes Place crossing	17	6
Mar 16	Paynes Place crossing to canyon mouth	7	3
Mar 20	South Fork Gun Club property line to confluence with North Fork	7	17
Mar 20	North Fork falls to confluence with North Fork	8	12
Mar 22	Forks confluence to Paynes Place crossing (USFS foot survey)	13	14
Mar 23	South Fork barrier falls below campground to 0.40 km downstream	0	4
Apr 12	Canyon mouth to Facht Place crossing	5	9
May 3	Forks confluence to Paynes Place crossing	3	1

Appendix 3-L. Summary of adult steelhead passage at Clough Dam, Mill Creek from 1953 through 1963 (Hallock 1989).

Season	No. of steelhead
1953-54	715
1954-55	1492
1955-56	1213
1956-57	1443
1957-58	1301
1958-59	790
1959-60	417
1960-61	742
1961-62	1222
1962-63	2269

Appendix 3-M. Estimated adult steelhead migration past Clough Dam, Mill Creek from October 1993 through June 1994 (Harvey 1995).

Month	Dates	Observed counts		Counter counts	Total counts	Ratio – chinook to steelhead	Estimated steelhead
		Chinook	STHD				
Oct	08-11	553	9	255	817	61:1	5
	12-17	56	1	128	185	56:1	13
	18-24	9	1	104[a]	114	9:1	3
	25-31	1	0	14[a]	15	1:0	13
Nov	01-07	1	0	5	6	1:0	0
	08-14	0	0	0	0	1:0	0
	15-21	0	0	1	1	0:0	0
	22-28	0	0	8	8	0:0	0
	29-05	0	0	0	0	0:0	0
Dec	06-12	0	0		0		
	13-19	0	0		0		
	20-26	0	0		0		
	27-02	0	0		0		
Jan	03-09	0	0		0		
	10-16	0	0		0		
	14-23	0	0		0		
	24-30	0	0		0		
	31-06	0	0		0		
Feb	07-13	0	0		0		
	14-20	0	0		0		
	21-27	0	0		0		
	28-06	0	0		0		
Mar	07-13	0	0	0	0	0:0	0
	14-20	0	0	3	3	0:0	0
	21-27	0	0	0	0	0:0	0
	28-03	0	0	17	17	0:0	0
Apr	04-10	1	0	23	24	1:0	0
	11-17	10	0	35	45	1:0	0
	18-24	9	0	100	109	1:0	0
	25-01	0	0	64	64	1:0	0
May	02-08	23	0	73	96	1:0	0
	09-15	2	0	75	77	1:0	0
	16-22	14	0	96	110	1:0	0
	23-29	14	0	99	113	1:0	0
	30-05	3	0	34	37	1:0	0
Jun	06-12	0	0	28	28	0:0	0
	13-19	0	0	0	0	0:0	0
Totals		696	11	1162	1169		34

[a] Estimate only.

Appendix 3-N. Estimated adult steelhead migration past Stanford-Vina Dam, Deer Creek from October 1993 through June 1994 (Harvey 1995).

Month	Dates	Observed counts		Counter counts	Total counts	Ratio – chinook to steelhead	Estimated steelhead
		Chinook	STHD				
Oct	12-17	5	0	8	13	1:0	0
	18-24	1	0	8	9	1:0	0
	25-31	0	0	41	41	0:0	0
Nov	01-07	0	0	1	1	0:0	0
	08-14	0	0	5	5	0:0	0
	15-21	0	0	1	1	0:0	0
	22-28	0	0	1	1	0:0	0
	29-05	0	0	0	0	0:0	0
Dec	06-12	0	0	1	1	0:0	0
	13-19	0	0	0	0	0:0	0
	20-26	0	0		0		
	27-02	0	0		0		
Jan	03-09	0	0		0		
	10-16	0	0		0		
	14-23	0	0		0		
	24-30	0	0		0		
	31-06	0	0		0		
Feb	07-13	0	0		0		
	14-20	0	0		0		
	21-27	0	0		0		
	28-06	0	0		0		
Mar	07-13	2	0	2	4	1:0	0
	14-20	0	0	13	13	0:0	0
	21-27	0	0	5	5	0:0	0
	28-03	2	0	5	7	1:0	0
Apr	04-10	3	0	14	17	1:0	0
	11-17	0	0	31	31	0:0	0
	18-24	0	0	36	36	0:0	0
	25-01	0	0	29	29	0:0	0
May	02-08	0	0	15	15	0:0	0
	09-15	0	0	65	65	0:0	0
	16-22	0	0	15	15	0:0	0
	23-29	0	0	14	14	0:0	0
	30-05	0	0	0	0	0:0	0
Jun	06-12	0	0	0	0	0:0	0
	13-19	0	0	0	0	0:0	0
Totals		13	0	310	323		0

Appendix 3-O. Summary of adult steelhead and steelhead redd counts conducting during snorkel and foot surveys of Deer Creek from April 10 to May 17, 2001 (Moore 2001).

Date	Section	No. of adult steelhead	No. of steelhead redds
Apr 10	Lower Deer Creek (snorkel)	10	1
May 1	Lower Deer Creek Falls to A-Line Bridge (foot)	5	21
May 9	Potato Patch Campground to Highway 36 Bridge (snorkel)	15	10
May 11	Lower Deer Creek (snorkel)	7	0
May 17	Lower Deer Creek Falls to A-Line Bridge (foot)	0	3

Appendix 3-P. Steelhead redd surveys conducted on the American River in 2001 through 2004 (Hannon and Healey 2002; Hannon et al. 2003; Hannon and Deason 2004).

Date	Reach	Flow (cfs)	Method	No. of new redds	No. of steelhead
02/20/01	Sailor Bar to Rossmoor	1500	Canoe and snorkel	10	29
03/09/01	Sailor Bar to Rossmoor	1500	Canoe and snorkel	20	27
02/07/02	Sailor Bar to Gristmill	1500	Canoe	16	3
02/25/02	Sailor Bar to Rossmoor	1500	Canoe	25	-
02/26/02	Goethe to Watt	1500	Canoe	12	-
03/07/02	Paradise Beach	2000	Snorkel	11	-
03/13/02	Upper Sunrise side channel	4000	Wading	18	22
03/14/02	Sailor Bar to Ancil Hoffman	3500	Canoe	25	9
03/15/02	Goethe to Watt and Paradise Beach	3500	Drift boat, wading	11	-
04/02/02	Sailor Bar to mouth	3000	Drift boat	41	6
01/07/03-01/09/03	Nimbus Dam to Paradise Beach	1500	-	10	20
01/22/03-01/23/03	Nimbus Dam to Paradise Beach	2800	-	20	28
02/05/03-02/07/03	Nimbus Dam to Paradise Beach	4000	-	36	42
02/18/03-02/21/03	Nimbus Dam to Paradise Beach	4000-5500	-	81	53
03/03/03-03/05/03	Nimbus Dam to Paradise Beach	2000-2500	-	32	29
03/17/03-03/19/03	Nimbus Dam to Paradise Beach	2000	-	32	30
04/03/03-04/04/03	Nimbus Dam to Paradise Beach	1800	-	4	6
12/31/03-01/05/04	Nimbus Dam to Paradise Beach	2000	-	3	113
01/13/04-01/14/04	Nimbus Dam to Paradise Beach	3000	-	9	54
01/27/04-01/28/04	Nimbus Dam to Paradise Beach	2200	-	28	48
02/09/04-02/10/04	Nimbus Dam to Paradise Beach	2200	-	45	85
02/24/04-02/25/04	Nimbus Dam to Paradise Beach	7000-6000	-	43	47
03/05/04-03/08/04	Nimbus Dam to Paradise Beach	3000	-	34	33
03/16/04-03/17/04	Nimbus Dam to Paradise Beach	3500	-	22	21
03/30/04-03/31/04	Nimbus Dam to Paradise Beach	4000-3500	-	10	4
04/14/04-04/16/04	Nimbus Dam to Paradise Beach	5000-5500	-	2	0
04/28/04-04/30/04	Nimbus Dam to Paradise Beach	2400	-	-	0

- Indicates no data provided. Two steelhead observed on December 17, 2003. One new redd observed May 26, 2004.

Appendix 3-Q. Summary of results from *Oncorhynchus mykiss* redd surveys, American River, 2002-2004 (Hannon and Deason 2004).

Year	No. of redds counted	Survey date range	Spawning peak	Redd density per mile	Redd-based population estimate (2 and 1 redds/female) [a]	Area-under-the-curve population estimate [b]
2002	159	Feb 7-April 2	Early March	8.8	200 to 401	n/a
2003	215	Jan 7-April 4	Mid-February	11.9	240 to 479	343
2004	197	Dec 17-Jun 17	Mid-February	9.9	221 to 441	330

[a] Based on male to female steelhead ratio from steelhead entering Nimbus Hatchery.
[b] Based on number of fish and represents the estimated number of in-river spawning adult steelhead.

Appendix 3-R. Summary of *Oncorhynchus mykiss* captures reported during angler surveys of the lower Mokelumne River during 1996 and 1997 (Merz 1997; Choi and Merz 1997).

Survey date	Forklength (mm)	Age class
10/09/96	640	No scales collected
10/09/96	300	No scales collected
10/09/96	300	No scales collected
10/13/96	270	No scales collected
2/15/97	250	No scales collected
2/15/97	410	No scales collected
3/9/97	315	1^{+}
3/9/97	335	1^{+}
3/9/97	280	1^{+}
3/9/97	305	1^{+}
3/9/97	575	2^{+}
3/23/97	280	1^{+}

Appendix 3-S. Summary of results from lower Mokelumne River *Oncorhynchus mykiss* angler surveys from 1996-1998 (Merz 1997; Choi and Merz 1997; Merz 1998).

Survey period	No. of *O. mykiss* captured	No. of anglers interviewed	Estimated no. of *O. mykiss* captured	Estimated number of anglers	CPUE (catch per unit effort)	No. of successful anglers
9/1/95 – 10/15/95	6	-	8	-	0.0268	-
9/1/96 – 10/15/96	4	74	17	220	-	-
1/1/97 – 4/16/97	8	35	262	1149	0.123 fish/angler-hour	7 (20%)
1/1/98 – 10/15/98	213	441	775	26,746	0.062	-

- Indicates data not available.

Appendix 3-T. Count summaries from upstream passage of steelhead at Woodbridge Irrigation District Dam (WIDD), Mokelumne River from October 1992 through March 2000 (Marine and Vogel 1993, 1994, 1996, 1998, 1999a, 1999b, and 2000; Workman 2001).

Time period	Males	Females	Unknown sex	Total
Oct - Dec 1990	-	-	4	4
Oct – Dec 1991	-	-	-	n/a
Oct – Dec 1992	2	5	0	7
Oct – Dec 1993	3	4	1	8
Oct – Dec 1994	11	7	1	19
Sep – Dec 1995	10	2	64	76
Sep 1997 – Feb 1998[a]	0	5	0	5
Aug 1998 – Mar 1999[b]	0	3	4	7
Aug 1999 – Mar 2000[c]	15	7	54	76
Aug 2000 – Mar 2001[d]	9	30	9	48

[a] Not included in total counts were 19 juvenile/half-pounder and 12 hatchery released steelhead.

[b] Not included in total counts were 74 juvenile/half-pounder and 423 hatchery released steelhead.

[c] Not included in total counts were 20 juvenile/half-pounder and 660 hatchery released steelhead.

[d] Of the total 48 steelhead, 45 were adipose fin-clipped. Not included in the total count were 2596 subadult steelhead which passed through WIDD during this trapping period and were assumed to be part of a 112,373 fish release from the Mokelumne River Fish Hatchery between December 27, 2000 and January 3, 2001.

Appendix 3-U. Summary of results for juvenile *Oncorhynchus mykiss* captured during rotary screw trap sampling at Balls Ferry (RK 444) and Deschutes Road Bridge (RK 452), Sacramento River from 1996 through 1999 (CDFG 1997, 1998a, 1999, 2000).

Weeks	Corresponding dates	Total catch range	FL Range (mm)	Total
12-40 (not 20)	Mar17 - Sep 29, 1996	2-109 fish/wk	19-263[a]	953
40-52 and 6-38	Oct 1, 1997- Sep 14, 1998	0-118 fish/wk	32-135	1072
11-40 (not 13)	Mar 8 - Sep 27, 1998	1-202 fish/wk	21-200	1565
40-52 and 1-40[b]	Oct 1, 1998 – Sep 26, 1999	0-74 fish/wk	15-750	674

[a] Emergent-sized trout were captured during 26 of 29 weeks sampled (CDFG 1997).
[b] No trout were captured during weeks 45, 47, 48, 49, 51 (1998) and 6, 8, 11, 16 (1999).

Appendix 3-V. Monthly juvenile passage estimates (JPE) for rainbow trout (*Oncorhynchus mykiss*) captured using rotary screw traps below the Red Bluff Diversion Dam, Sacramento River for brood years 1995 through 1999, including year 2000 results through June (Gaines and Martin 2002).

Month	N[a]	Median FL (mm)	JPE	75% C. I.		90% C. I.	
				Lower	Upper	Lower	Upper
Brood year 1995							
Jan	3	200	0	0	0	0	0
Feb	20	187	10,592	0	37,187	0	49,104
Mar	8	200	26,280	2641	49,918	0	60,468
Apr	20	198	5626	3258	7724	2590	8662
May	15	72	39,102	0	107,177	0	137,558
Jun	29	90	2541	1782	3299	1443	3638
Jul	21	29	2230	1311	3148	901	3558
Aug	23	53	22,418	18,543	26,293	16,813	28,023
Sep	8	62	34,485	21,832	47,138	16,178	52,793
Oct	5	96	1400	381	2419	0	2874
Nov	6	95.5	788	238	1337	0	1582
Dec	9	120	287	0	590	0	725
Total	167		145,749	50,256	286,231	37,925	348,986
Brood year 1996							
Jan	11	189	12,259	8655	15,864	7046	17,472
Feb	2	227	10,730	0	48,431	0	65,325
Mar	17	212	9201	4974	13,429	3087	15,316
Apr	30	72.5	2524	1990	3058	1751	3297
May	13	64.5	4412	1908	6917	790	8035
Jun	13	76.5	3098	1355	4842	575	5621
Jul	14	71	1342	495	2189	117	2566
Aug	19	60	8012	6194	9829	5383	10,640
Sep	12	62	34,164	24,737	43,591	20,524	47,804
Oct	17	76	3109	2439	3779	2140	4078
Nov	22	89	1186	844	1529	691	1682
Dec	8	260	205	0	444	0	551
Total	178		90,243	53,590	153,903	42,105	182,389
Brood year 1997							
Jan	-	-	16,733	0	75,349	0	101,509
Feb	15	220	33,261	25,177	41,344	21,555	44,967
Mar	16	230	6496	4935	8058	4238	8755
Apr	24	205	8183	5368	10,998	4111	12,255
May	19	173.5	9796	5387	8204	4758	8833
Jun	16	214	4951	3384	6519	2684	7219
Jul	19	63	3686	2730	4642	2304	5068

Appendix 3-V (cont.). Monthly juvenile passage estimates (JPE) for rainbow trout (*Oncorhynchus mykiss*) captured using rotary screw traps below the Red Bluff Diversion Dam, Sacramento River for brood years 1995 through 1999, including year 2000 results through June (Gaines and Martin 2002).

				75% C. I.		90% C. I.	
Month	N[a]	Median FL (mm)	JPE	Lower	Upper	Lower	Upper
Aug	16	52	5282	4467	6097	4104	6461
Sep	13	61	1758	1141	2374	866	2650
Oct	10	78	632	350	913	225	1038
Nov	11	218	839	468	1210	303	1376
Dec	11	226	1552	701	2404	320	2784
Total	170		90,170	54,110	168,112	45,467	202,916
			Brood year 1998				
Jan	5	215	44,914	4493	85,336	0	103,375
Feb	-	-	25,606	0	115,070	0	155,160
Mar	11	207	6299	2312	10,285	533	12,064
Apr	11	61	5083	2937	7228	1979	8187
May	8	64	11,632	4453	18,811	1249	22,014
Jun	11	88	4777	3167	6387	2448	7107
Jul	17	46.5	3647	2724	4569	2312	4981
Aug	13	55.5	12,889	10,048	15,730	8780	16,998
Sep	18	60.5	10,432	6790	14,074	5163	15,702
Oct	24	72	1156	362	1951	7	2305
Nov	19	83	1456	922	1990	683	2228
Dec	26	392.5	1482	468	2496	15	2949
Total	163		129,372	38,676	283,926	23,169	353,070
			Brood year 1999				
Jan	24	176	1472	279	2665	0	3197
Feb	16	261	2097	329	3865	0	4657
Mar	28	225	9308	2216	16,400	0	19,565
Apr	23	198	1571	1133	2008	937	2204
May	26	62	8040	5746	10,334	4723	11,358
Jun	30	73	4465	3167	5762	2588	6341
Jul	31	54	5092	4305	5879	3954	6230
Aug	28	54	12,810	11,395	14,225	10,763	14,857
Sep	23	60	11,605	8869	14,342	7646	15,565
Oct	21	79	1146	814	1479	665	1627
Nov	24	85	598	352	845	242	955
Dec	29	110	670	448	892	349	991
Total	303		58,874	39,053	78,695	31,867	87,547

Appendix 3-V (cont.). Monthly juvenile passage estimates (JPE) for rainbow trout (*Oncorhynchus mykiss*) captured using rotary screw traps below the Red Bluff Diversion Dam, Sacramento River for brood years 1995 through 1999, including year 2000 results through June (Gaines and Martin 2002).

Month	N[a]	Median FL (mm)	JPE	75% C. I.		90% C. I.	
				Lower	Upper	Lower	Upper
Brood year 2000							
Jan	20	198	3097	1539	4655	844	5350
Feb	16	177	2515	501	4528	0	5431
Mar	25	111	8300	181	16,418	0	20,041
Apr	25	68	4881	3050	6711	2232	7529
May	27	74	10,131	8805	11,458	8213	12,050
Jun	24	66	3815	3141	4490	2839	4792
Total	137		32,739	17,217	48,260	14,128	55,193

[a] N represents the number of days sampled each month.

Appendix 3-W. *Oncorhynchus mykiss* catch summaries from RST sampling on the Feather River from March 3 through June 30, 1996 (CDWR 1999a).

	Thermalito RST				Live Oak RST			
	YOY		Juveniles of other age classes		YOY		Juveniles of other age classes	
Dates	Count	Mean FL (mm)	Count	Mean FL (mm)	Count	Mean FL (mm)	Count	Mean FL (mm)
Mar 03-09	0		0		0		2	246
Mar 10-16	22	26.7	0		1	37	2	191
Mar 17-23	34	27.3	0		1	38	1	185
Mar 24-30	2	27.5	2	202	0			
Mar 31-Apr 6	2	36.3	0		1	35	1	200
Apr 07-13	1	24	2	228	1	35		
Apr 14-20	0		0		0			
Apr 21-27	4	35.3	0		0			
Apr 28-May 4	1	61	0		0		1	240
May 05-11	4	55	1	311	0			
May 12-18	1	73	0		0			
May 19-25	Trap not operated this week				1	37		
May 26-Jun 1	3	52.3	0		0			
Jun 02-08	1	78	0		0			
Jun 09-15	0		1	267	0			
Jun 16-22	0		1	285	0			
Jun 23-30	3	83	0		0		1	282
Totals	78	34.4	7	246.1	5	36.4	8	222.6

Appendix 3-X. *Oncorhynchus mykiss* catch summaries from RST sampling on the Feather River from December 23, 1997 through July 1, 1998 (CDWR 1999c).

	Thermalito RST				Live Oak RST			
	YOY		Juveniles of other age classes		YOY		Juveniles of other age classes	
Dates	Count	Mean FL (mm)	Count	Mean FL (mm)	Count	Mean FL (mm)	Count	Mean FL (mm)
Dec 23-27								
Jan 28-03							2	210
Jan 04-10							1	204
Jan 11-17			2	219				
Jan 18-24								
Jan 25-31			1	243				
Feb 01-07								
Feb 08-14								
Feb 15-21			1	183				
Feb 22-28								
Mar 01-07							1	243
Mar 08-14	13	26						
Mar 15-21	12	26						
Mar 22-28	4	27						
Mar 29-Apr 4	1	26						
Apr 05-11	6	27	1	187			1	238
Apr 12-18	64	26						
Apr 19-25	28	28			1	26		
Apr 26-May 2	10	30						
May 03-09	12	27						
May 10-16	1	26						
May 17-23	2	38						
May 24-30								
May 31-Jun 6								
Jun 07-13					1	47		
Jun 14-20								
Jun 21-Jul 1								
Total	153		5	208	2	26, 47	5	224

Appendix 3-Y. Total catch and size data for *Oncorhynchus mykiss* collected using beach seining techniques from the lower American River from February through July 1992 (Snider and McEwan 1993), January through August 1993 (Snider and Keenan 1994), and January through June 1995 (Snider and Titus 1996).

	1992 Cohort			Yearling and older		
		Forklength (mm)			Forklength (mm)	
Month	Number	Average	Range	Number	Average	Range
February	1	44		8	220	152-265
March	16	30	27-35	43	245	179-300
April	441	37	22-63	3	234	215-765
May	312	51	25-97	1		
June	155	78	35-126	0		
July	57	107	68-176	0		
Total	982		27-176	55		152-765
	1993 Cohort			Yearling and older		
		Forklength (mm)			Forklength (mm)	
Month	Number	Average	Range	Number	Average	Range
January	0			7	338	194-671
February	0			2	234	182-285
March	20	28	25-34	0		
April	452	34	23-56	0		
May	617	42	24-100	0		
June	418	57	26-105	0		
July	80	61	33-110	0		
August	33	87	48-126	0		
Total	1620		23-126	9		182-671
	1995 Cohort			Yearling and older		
		Forklength (mm)			Forklength (mm)	
Month	Number	Average	Range	Number	Average	Range
January	0			3	238	228-256
February	0			0		
March	15	29	23-33	0		
April	204	30	24-39	0		
May	397	46	23-73	0		
June	615	56	24-96	0		
Total	1231		23-96	3		228-256

Appendix 3-Z. *Oncorhynchus mykiss* rotary screw trap catch summaries from the lower American River emigration survey, October 1995 through September 1996 (CDFG 1997 and Snider et al. 1998).

	Young-of-the-year		Yearling		Adult	
Week	Count	Mean FL (mm) and range[a]	Count	Mean FL (mm) and range[a]	Count	Mean FL (mm) and range
51	0		0		1	366
52	0		0		0	
1	0		0		0	
2	0		0		0	
3	0		2		2	457, 497
4	0		3		1	384
5	0		0		0	
6	0		0		0	
7	0		0		0	
8	0		0		0	
9	0		0		0	
10	0		0		0	
11	4	28 (26-33)	1		0	
12	8	30 (26-34)	1		0	
13	3	29 (26-35)	0		0	
14	9	31 (25-42)	0		0	
15	0		0		0	
16	12	39 (26-52)	0		0	
17	13	36 (26-49)	0		0	
18	5	35 (28-46)	0		0	
19	5	57 (49-67)	0		0	
20	15	54 (41-69)	0		0	
21	10	46 (22-61)	0		0	
22	19	51 (32-76)	0		0	
23	7	61 (56-74)	0		0	
24	1	63	0		0	
25	1	78	0		0	
26	0		0		0	
27	0		0		0	
28	4	81 (68-106)	0		1	341
29	8	89 (69-115)	0		0	
30	8	105 (85-128)	0		0	
31	3	94 (90-101)	0		0	
32	1	106	0		1	322
33	0		0		1	342
34	1	123	0		0	

Appendix 3-Z (cont.). *Oncorhynchus mykiss* rotary screw trap catch summaries from the lower American River emigration survey, October 1995 through September 1996 (CDFG 1997 and Snider et al. 1998).

	Young-of-the-year		Yearling		Adult	
Week	Count	Mean FL (mm) and range[a]	Count	Mean FL (mm) and range[a]	Count	Mean FL (mm) and range
35	0		0		0	
36	0		0		0	
37	1	162	0		0	
Total	137	54 (22-162)	7	233 (131-296)	7	387 (322-497)

[a] Original data rounded off to nearest whole number.

Appendix 3-AA. *Oncorhynchus mykiss* rotary screw trap catch summaries from the lower American River emigration survey, October 1996 through September 1997 (Snider and Titus 2000a).

	Young-of-the-year		Yearling		Adult	
Week	Count	Mean FL (mm) and range[a]	Count	Mean FL (mm) and range[a]	Count	Mean FL (mm) and range[a]
51	0		0		0	
52	0		1	137	0	
1	0		20	228 (220-250)	0	
2	0		14	204 (140-255)	0	
3	1	31	0		10	216 (172-262)
4	0		2	173, 267	4	237 (216-251)
5	0		0		0	
6	0		0		1	201
7	0		0		5	236 (212-258)
8	0		0		0	
9	0		3	227 (189-248)	0	
10	0		0		0	
11	0		0		0	
12	0		0		0	
13	3	33 (28-33)	1	160	0	
14	0		0		0	
15	0		0		0	
16	0		0		0	
17	1	36	0		0	
18	3	42 (39-45)	1	195	1	237
19	2	51, 56	0		0	
20	6	46 (39-45)	0		0	
21	20	55 (44-64)	0		0	
22	6	59 (48-72)	0		0	
23	0		0		0	
24	1	84	0		0	
25	3	78 (51-96)	0		0	
26	0		0		0	
Total	49	52 (28-96)	42	215 (137-267)	21	225 (172-262)

[a] Original data rounded off to nearest whole number.

Appendix 3-BB. *Oncorhynchus mykiss* rotary screw trap catch summaries from the lower American River emigration survey, October 1997 through September 1998 (Snider and Titus 2001).

	Young of the year		Yearling	
Week	Count	Mean FL (mm) and range[a]	Count	Mean FL (mm) and range[a]
1-12	0		0	
13	2	27 (25-28)	0	
14	5	25 (22-28)	0	
15	7	26 (23-29)	0	
16	9	27 (24-32)	1	271
17	4	31 (27-33)	0	
18	3	30 (25-34)	0	
19	1	25	0	
20	11	43 (36-51)	0	
21	17	50 (36-58)	1	290
22	43	49 (30-65)	0	
23	8	47 (35-66)	0	
24	1	53	0	
25	0		0	
26	0		0	
27	0		0	
28	1	92	0	
29	0		0	
30	0		0	
31	1	97	0	
32	0		0	
33	2	89 (86-91)	0	
Total	115	47 (22-97)	2	281 (271-290)

[a] Original data rounded off to nearest whole number.

Appendix 3-CC. Life stage composition by age and origin for *Oncorhynchus mykiss* caught during the lower American River emigration survey from October 1996 through September 1998 (Snider and Titus 2000a and 2001).

	Young-of-the-year		Yearling		Adult	
Life stage	Count	Mean FL (mm) and range[a]	Count	Mean FL (mm) and range[a]	Count	Mean FL (mm) and range[a]
Oct 1996 – Sep 1997						
Fry	5	34 (28-39)	0		0	
Parr	36	53 (33-84)	2	187 (185-188)	0	
Silvery Parr	4	73 (51-96)	4	164 (137-207)	0	
Smolts	0		8	213 (160-267)	20	225 (172-262)
Oct 1997 – Sep 1998						
Yolk-sac fry	1	25	0			
Fry	60	38 (22-66)	0			
Parr	38	49 (30-65)	0			
Silvery Parr	3	90 (86-92)	0			
Smolts	0		2	281 (270-290)		

[a] Original data rounded off to nearest whole number.

Appendix 3-DD. Catch summary for *Oncorhynchus mykiss* collected using beach seines during the lower American River emigration survey from October 1996 through September 1997 (Snider and Titus 2000a).

Week	No. of hauls	Count	Fish/haul	Mean FL (mm)	FL range (mm)
3	13	114	8.8	228.6	115-390
4	23	636	27.7	225.8	138-339
5	26	2	0.08	182.0	166-198
6	31	3	0.01	175.0	122-212
7	27	4	0.15	190.0	190
8	28	321	11.5	222.8	118-294
9	26	140	5.4	226.7	25-288
10	26	4	0.15	163.5	29-225
13	46	2	0.04	121.5	23-220
15	54	9	0.17	111.8	22-230
18	40	241	6.0	30.5	21-45
19	11	36	3.3	33.9	21-42
21	49	626	12.8	39.1	21-69
26	48	149	3.1	69.2	38-103
Totals	448	2287	5.0		

Appendix 3-EE. Number of *Oncorhynchus mykiss* captured during downstream migrant rotary screw trapping at Woodbridge Dam, Mokelumne River, from October 1993 through July 2001 (Vogel and Marine 1996, 1998, 1999a, 1999b, and 2000; Workman 2002).

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Total
1993-94	5	13	2	5	35	4	5	12	24	33	138
1995	-	-	-	1	10	28	13	22	10	62	146
1997	-	-	-	0	8	12	24	131	30	24	229
1997-98	-	-	170	229	3	14	20	11	20	29[a]	496
1998-99	-	-	545	72	15	6	23	16	100	59	836
2000-2001	-	-	0	10	16	44	30	89	139	120	448

[a] Includes trapping through August 2, 1998.

Appendix 3-FF. Total numbers of *Oncorhynchus mykiss* captured during downstream migrant trapping at Woodbridge Dam, Mokelumne River, from January 1993 through July 2001 (Vogel and Marine 1994, 1996, 1998, 1999a, 1999b, and 2000; Workman 2002).

Trapping period	YOY	1+
Jan - Jul 1993	20	47
Oct 1993 - Jul 1994	34	104
Jan – Jul 1995	100	46
Jan – Jul 1997	37	192
Dec 1997 – Aug 1998	50	446
Dec 1998 – Jul 1999[a]	162	674
Dec 2000 – Jul 2001[b]	343	105

[a] Does not include 436 adipose-fin clipped, hatchery origin steelhead captured during each month of the trapping period. These fish make up over 65% of all yearling steelhead captured.

[b] Does not include 473 adipose-fin clipped, hatchery origin and one adult steelhead captured during the trapping period (June).

Appendix 3-GG. Summary of *Oncorhynchus mykiss* captured during rotary screw trapping operations in the lower Calaveras River, 2002-2004 (Fuller 2005).

Year	Dates sampled	Number and percent days sampled	Number of O. mykiss captured	Number of smolts (Smolt index = 5)	Number of silvery parr (Smolt index =4)
2002	Jan 17-Feb 14 Apr 6-May 10	15 (52) 29 (83)	1131	159	137
2003	Jan 4-Mar 24 Apr 9-Jul 17	36 (45) 50 (50)	1539	103	216
2004	Dec 2-Mar 17 Apr 3-May 13	69 (64) 24 (59)	1411	204	669

Appendix 3-HH. Summary of downstream migrating *Oncorhynchus mykiss* captured during trawls at Mossdale (lower San Joaquin River) from 1988-2004 (Marston 2003; USFWS 2005g).

Year	Count	Average forklength (mm)
1988	30	226
1989	23	230
1990	14	235
1991	1	215
1992	3	220
1993	5	235
1994	2	175
1995	5	283
1996	2	228
1997	2	261
1998	5	235
1999	6	251
2000	4	257
2001	8	238
2002	7	243
2003	17	n/a
2004	12	n/a

Appendix 3-II. Date, location and number of rotary screw traps operated in the Stanislaus River from 1993 through 2004 (Demko et al. 2000; SPCA 2001; Fuller 2005).

Year	Trap location	No. of traps	Start date	End date	No. of days sampled
1993	Oakdale	1	Apr 21	Jun 29	54
1994			- No sampling -		
1995	Oakdale	1	Mar 18	Jul 1	106
1995	Caswell	2	Mar 28	May 26	59
1996	Oakdale	1	Feb 1	Jun 8	115
1996	Caswell	2	Feb 5	Jul 2	142
1997	Caswell	2	Mar 19	Jun 27	98
1998	Oakdale	1	Jan 26	Jul 15	145
1998	Caswell	2	Jan 8	Jul 16	154
1999	Oakdale	1	Jan 18	Jun 30	145
1999	Caswell	2	Jan 18	Jun 30	152
2000	Oakdale	1	Dec 16	Jun 30	182
2000	Caswell	2	Dec 16	Jun 30	178
2001	Oakdale	1	Dec 12	Jun 29	186
2001	Caswell	2	Dec 22	Jun 28	179
2002	Oakdale	1	Dec 12	Jun 7	131
2002	Caswell	2	Jan 16	Jun 7	82
2003	Oakdale	1	Dec 19	Jun 5	137
2003	Caswell	2	Jan 17	Jun 5	101
2004	Oakdale	1	Jan 3	Jun 4	132
2004	Caswell	2	Jan 10	Jun 4	102

Appendix 3-JJ. Summary of *Oncorhynchus mykiss* captured during rotary screw trap sampling of the Stanislaus River, California from April 1993 through July 1998 (Demko and Cramer 1997, 1998; Demko et al. 1999).

Date	Trapping location	Forklength (mm)	Smolt appearance rating[a]
04/22/93	Oakdale	-	-
04/26/93	Oakdale	-	-
04/27/93	Oakdale	-	-
05/02/93	Oakdale	-	-
05/02/93	Oakdale	-	-
05/02/93	Oakdale	-	-
05/12/93	Oakdale	-	-
05/18/93	Oakdale	-	-
05/29/93	Oakdale	-	-
06/08/93	Oakdale	-	-
03/22/95	Oakdale	200	3
03/22/95	Oakdale	150	3
03/22/95	Oakdale	200	1
03/22/95	Oakdale	255	1
03/24/95	Oakdale	242	1
03/26/95	Oakdale	240	1
03/27/95	Oakdale	217	3
03/27/95	Oakdale	321	3
03/28/95	Oakdale	245	3
03/31/95	Oakdale	248	3
04/01/95	Oakdale	230	3
04/02/95	Oakdale	258	3
04/03/95	Oakdale	256	3
04/04/95	Oakdale	227	1
04/05/95	Oakdale	233	3
04/06/95	Oakdale	219	3
04/06/95	Caswell	231	-
04/07/95	Oakdale	203	3
04/09/95	Oakdale	224	3
04/10/95	Oakdale	193	3
04/11/95	Oakdale	252	3
04/13/95	Oakdale	227	3
04/14/95	Oakdale	213	3
04/17/95	Caswell	304	-
05/11/95	Oakdale	288	3
05/18/95	Caswell	273	-
02/04/96	Oakdale	34	1
02/06/96	Oakdale	356	3
02/06/96	Caswell	260	3
02/06/96	Caswell	275	3
02/12/96	Oakdale	49	1

Appendix 3-JJ (cont.). Summary of *Oncorhynchus mykiss* captured during rotary screw trap sampling of the Stanislaus River, California from April 1993 through July 1998 (Demko and Cramer 1997, 1998; Demko et al. 1999).

Date	Trapping location	Forklength (mm)	Smolt appearance rating[a]
02/12/96	Oakdale	270	3
02/12/96	Oakdale	58	1
02/19/96	Caswell	34	1
02/26/96	Oakdale	320	1
03/06/96	Oakdale	45	1
03/06/96	Oakdale	55	1
03/09/96	Oakdale	35	1
04/05/96	Oakdale	218	3
04/07/96	Oakdale	230	3
04/07/96	Oakdale	292	3
05/18/96	Oakdale	238	3
06/06/96	Caswell	94	2
03/29/97	Caswell	225	3
04/01/97	Caswell	204	3
04/18/97	Caswell	205	3
04/22/97	Caswell	238	3
04/28/97	Caswell	223	3
05/01/97	Caswell	226	3
05/02/97	Caswell	275	3
05/16/97	Caswell	224	3
05/26/97	Caswell	210	3
05/28/97	Caswell	221	3
05/30/97	Caswell	197	3
01/27/98	Oakdale	283	3
03/08/98	Oakdale	270	3
03/08/98	Oakdale	225	3
03/09/98	Oakdale	220	3
03/26/98	Oakdale	250	3
03/26/98	Oakdale	218	3
03/31/98	Caswell	299	3
04/03/98	Caswell	228	3
04/04/98	Caswell	265	3
04/04/98	Oakdale	243	3
04/04/98	Oakdale	247	3
04/09/98	Oakdale	215	3
04/11/98	Caswell	257	3
04/20/98	Oakdale	215	3
04/25/98	Oakdale	250	3
04/25/98	Oakdale	250	3
05/11/98	Oakdale	227	3
05/12/98	Oakdale	230	3

Appendix 3-JJ (cont.). Summary of *Oncorhynchus mykiss* captured during rotary screw trap sampling of the Stanislaus River, California from April 1993 through July 1998 (Demko and Cramer 1997, 1998; Demko et al. 1999).

Date	Trapping location	Forklength (mm)	Smolt appearance rating[a]
05/13/98	Oakdale	243	3
05/27/98	Oakdale	256	3
06/16/98	Oakdale	76	2
06/18/98	Oakdale	66	2
07/08/98	Oakdale	106	3
07/08/98	Oakdale	95	2

[a] Rating from 1 to 3, with 1 an obvious parr and 3 an obvious smolt.
- Indicates data not available in report.

Appendix 3-KK. Summary of *Oncorhynchus mykiss* captured during rotary screw trap sampling at Caswell State Park (RK 64.5), Stanislaus River, California from February 1999 through May 2004 (SPCA 2001, 2002, 2003, and 2004; Fuller 2005).

Date	FL (mm)	Smolt index [a]	Date	FL (mm)	Smolt index [a]
02/15/99	204	5	03/07/01	240	5
02/27/99	236	5	03/07/01	240	5
03/05/99	194	5	03/07/01	231	5
03/28/99	192	5	03/07/01	210	5
04/02/99	205	5	03/07/01	235	5
04/15/99	255	5	03/08/01	255	5
04/15/99	220	5	03/09/01	253	5
04/18/99	198	3	03/10/01	225	5
05/06/99	250	5	03/13/01	220	5
05/18/99	251	5	03/13/01	210	5
06/08/99	197	5	03/14/01	240	5
06/30/99	83	3	03/17/01	243	5
01/26/00	223	5	03/29/01	300	5
01/28/00	245	5	03/31/01	290	5
02/05/00	252	5	03/31/01	240	5
02/13/00	236	5	04/02/01	290	5
02/16/00	209	4	04/14/01	216	5
02/19/00	285	5	04/16/01	260	5
03/30/00	180	5	04/25/01	58	3
04/21/00	215	5	05/05/01	212	5
04/23/00	259	5	05/31/01	234	5
04/23/00	51	3	05/31/01	225	5
04/23/00	51	3	02/28/02	229	5
04/25/00	220	5	03/14/02	245	5
05/10/00	200	5	04/15/02	240	5
05/19/00	235	5	04/25/02	175	5
06/18/00	67	3	04/26/02	210	5
01/10/01	236	4	04/30/02	208	5
02/14/01	265	5	05/02/02	221	5
02/26/01	238	5	05/04/02	405	5
02/26/01	215	5	05/12/02	129	5
02/27/01	210	5	05/13/02	205	5
02/27/01	201	5	02/14/03	285	5
03/05/01	222	5	02/25/03	285	5
03/06/01	195	5	03/12/03	265	5
03/06/01	176	5	03/14/03	280	5
03/06/01	228	5	03/16/03	198	4
03/06/01	285	5	03/18/03	260	5
03/07/01	236	5	04/18/03	170	4

Appendix 3-KK (cont.). Summary of *Oncorhynchus mykiss* captured during rotary screw trap sampling at Caswell State Park (RK 64.5), Stanislaus River, California from February 1999 through May 2004 (SPCA 2001, 2002, 2003, and 2004; Fuller 2005).

Date	FL (mm)	Smolt index [a]	Date	FL (mm)	Smolt index [a]
04/22/03	233	5	02/27/04	245	5
04/23/03	238	5	02/29/04	262	5
04/25/03	212	5	02/29/04	276	5
04/26/03	188	5	03/01/04	242	5
04/28/03	62	3	03/02/04	220	5
05/14/03	192	5	03/07/04	229	5
02/07/04	228	5	03/15/04	212	4
02/19/04	245	5	03/18/04	245	5
02/20/04	232	5	03/19/04	291	5
02/20/04	246	5	03/25/04	239	5
02/20/04	220	5	05/02/04	201	5
02/22/04	252	5	05/16/04	229	5
02/26/04	268	5			

[a] Smolt index based on a scale of 1 to 5 (1 = yolk-sac fry, 2 = fry, 3 = parr, 4 = silvery parr, and 5 = smolt).

Appendix 3-LL. Summary of *Oncorhynchus mykiss* captured during rotary screw trap sampling at Oakdale trapping site (RK 66.3), Stanislaus River, California from January 1999 through May 2004 (SPCA 2001, 2002, 2003, and 2004; Fuller 2005).

Date	FL (mm)	Smolt index [a]	Date	FL (mm)	Smolt index [a]
01/18/99	203	5	06/14/99	83	3
02/05/99	250	5	06/24/99	80	3
03/13/99	212	5	06/25/99	68	3
03/15/99	262	5	06/25/99	74	3
03/18/99	245	5	01/06/00	240	4
03/21/99	245	5	01/08/00	268	5
03/29/99	365	5	01/09/00	56	3
03/30/99	218	5	01/13/00	232	5
03/30/99	260	5	01/25/00	235	5
04/01/99	255	5	01/25/00	275	5
04/02/99	248	5	01/25/00	222	5
04/05/99	228	5	01/26/00	249	5
04/17/99	39	2	01/26/00	282	5
04/17/99	31	2	01/27/00	232	5
04/19/99	41	3	01/31/00	149	4
04/22/99	320	5	02/02/00	300	5
04/24/99	330	5	02/02/00	220	5
04/28/99	54	3	02/05/00	356	5
04/28/99	54	3	02/05/00	164	4
04/28/99	44	3	02/08/00	280	5
04/29/99	36	3	02/12/00	300+	5
04/29/99	45	2	02/13/00	280	5
04/30/99	41	3	02/14/00	245	5
04/30/99	41	3	02/15/00	356	5
05/01/99	45	3	02/20/00	230	5
05/02/99	44	3	03/10/00	30	1
05/04/99	45	3	03/24/00	280	5
05/19/99	240	5	03/26/00	220	5
05/21/99	54	3	04/05/00	30	2
05/26/99	51	3	04/13/00	31	2
05/26/99	68	3	04/19/00	220	5
05/27/99	280	5	04/19/00	37	2
06/01/99	59	3	05/01/00	34	2
06/03/99	53	3	05/12/00	71	3
06/04/99	55	3	06/01/00	66	3
06/05/99	83	3	06/12/00	64	3
06/05/99	71	3	06/13/00	60	3
06/05/99	56	3	06/14/00	64	3
06/06/99	64	3	06/14/00	98	3
06/07/99	58	3	06/15/00	68	3

Appendix 3-LL (cont.). Summary of *Oncorhynchus mykiss* captured during rotary screw trap sampling at Oakdale trapping site (RK 66.3), Stanislaus River, California from January 1999 through May 2004 (SPCA 2001, 2002, 2003, and 2004; Fuller 2005).

Date	FL (mm)	Smolt index [a]	Date	FL (mm)	Smolt index [a]
06/15/00	56	3	01/25/01	210	5
06/15/00	299	5	01/28/01	242	5
06/15/00	63	3	01/29/01	214	5
06/15/00	70	3	01/31/01	215	4
06/16/00	67	3	02/10/01	195	5
06/17/00	74	3	02/11/01	370	5
06/20/00	106	3	02/13/01	176	5
06/29/00	282	5	02/13/01	296	5
06/30/00	340	5	02/13/01	224	5
12/12/00	160	4	02/14/01	263	5
12/13/00	223	4	03/01/01	244	5
12/13/00	212	5	03/01/01	240	5
12/13/00	222	5	03/05/01	285	5
12/14/00	184	4	03/06/01	232	5
12/14/00	182	4	03/06/01	237	5
12/15/00	210	4	03/06/01	296	5
12/19/00	222	4	03/06/01	240	5
12/21/00	180	4	03/07/01	223	5
12/22/00	155	5	03/07/01	223	5
12/28/00	230	4	03/07/01	270	5
01/02/01	220	4	03/08/01	320	5
01/06/01	215	5	03/12/01	230	5
01/16/01	198	5	03/27/01	260	5
01/16/01	231	5	03/27/01	159	5
01/17/01	270	5	04/23/01	43	3
01/18/01	125	5	04/25/01	39	3
01/18/01	218	5	04/29/01	47	2
01/18/01	185	5	05/06/01	56	3
01/18/01	225	5	05/06/01	52	3
01/18/01	195	5	05/06/01	58	3
01/18/01	204	5	05/06/01	55	3
01/18/01	243	5	05/06/01	60	3
01/18/01	220	5	05/21/01	54	3
01/18/01	278	5	05/21/01	55	3
01/18/01	223	5	05/22/01	54	3
01/18/01	229	5	05/22/01	49	3
01/19/01	215	5	05/23/01	62	3
01/20/01	231	5	05/23/01	61	3
01/21/01	240	5	05/23/01	30	2
01/22/01	255	5	05/23/01	85	3

Appendix 3-LL (cont.). Summary of *Oncorhynchus mykiss* captured during rotary screw trap sampling at Oakdale trapping site (RK 66.3), Stanislaus River, California from January 1999 through May 2004 (SPCA 2001, 2002, 2003, and 2004; Fuller 2005).

Date	FL (mm)	Smolt index [a]	Date	FL (mm)	Smolt index [a]
05/23/01	46	3	01/12/03	203	5
05/25/01	65	3	01/15/03	153	4
05/25/01	73	3	01/18/03	110	3
05/29/01	54	3	01/29/03	226	5
06/05/01	81	3	01/31/03	240	5
01/11/02	196	5	02/04/03	216	5
01/18/02	225	5	02/08/03	291	5
01/18/02	210	5	02/26/03	270	5
01/18/02	260	5	02/26/03	275	5
01/20/02	235	5	02/27/03	345	5
01/21/02	215	5	03/04/03	28	2
01/21/02	217	5	03/06/03	249	5
01/22/02	230	5	03/13/03	255	5
01/24/02	240	5	03/14/03	425	5
01/24/02	200	5	03/16/03	33	2
01/25/02	284	5	03/18/03	126	4
01/25/02	224	5	04/02/03	37	2
01/31/02	255	5	04/03/03	41	2
02/04/02	233	5	04/09/03	49	3
02/04/02	278	5	04/10/03	238	5
02/18/02	192	5	04/26/03	61	3
03/01/02	298	5	04/26/03	46	3
03/04/02	280	5	04/29/03	57	3
03/07/02	32	2	04/29/03	37	3
03/08/02	245	5	05/05/03	42	3
03/09/02	245	5	05/06/03	57	3
03/15/02	212	5	05/06/03	65	3
03/18/02	226	5	05/06/03	64	3
04/02/02	34	2	05/08/03	44	3
04/11/02	42	2	05/13/03	64	3
04/13/02	55	3	05/23/03	248	5
04/16/02	204	5	05/30/03	78	4
04/23/02	189	5	06/03/03	69	3
04/24/02	195	5	01/03/04	210	4
05/11/02	42	3	01/03/04	238	5
05/29/02	47	3	01/04/04	236	5
12/20/02	222	5	01/04/04	188	4
01/05/03	226	5	01/04/04	203	4
01/05/03	232	5	01/04/04	254	5
01/12/03	158	3	01/06/04	214	5

Appendix 3-LL (cont.). Summary of *Oncorhynchus mykiss* captured during rotary screw trap sampling at Oakdale trapping site (RK 66.3), Stanislaus River, California from January 1999 through May 2004 (SPCA 2001, 2002, 2003, and 2004; Fuller 2005).

Date	FL (mm)	Smolt index [a]	Date	FL (mm)	Smolt index [a]
01/06/04	214	5	02/28/04	255	5
01/06/04	199	4	03/04/04	212	5
01/06/04	182	4	03/05/04	245	5
01/06/04	202	4	03/07/04	220	5
01/08/04	138	3	03/13/04	262	5
01/08/04	225	4	03/14/04	240	5
01/08/04	225	5	03/22/04	196	4
01/08/04	208	5	04/18/04	45	3
01/11/04	244	4	04/21/04	no data [b]	no data [b]
01/21/04	201	5	04/24/04	37	2
01/24/04	44	2	04/24/04	54	2
01/24/04	245	5	04/24/04	45	2
01/24/04	233	4	04/27/04	51	3
01/29/04	235	5	04/30/04	66	3
01/29/04	225	5	04/30/04	31	2
01/30/04	234	5	05/01/04	59	3
01/31/04	238	5	05/06/04	52	3
02/05/04	229	5	05/12/04	53	3
02/18/04	239	5	05/16/04	54	3
02/18/04	254	5	05/19/04	60	3
02/19/04	257	5	05/22/04	60	3
02/22/04	260	5	05/22/04	58	3
02/26/04	258	5	05/24/04	42	2
02/27/04	240	4	05/25/04	55	3
02/27/04	244	5	05/25/04	50	3
02/27/04	247	5			

[a] Smolt index based on a scale of 1 to 5 (1 = yolk-sac fry, 2 = fry, 3 = parr, 4 = silvery parr, and 5 = smolt).

[b] Trout jumped from bucket before FL and smolt index could be recorded.

Appendix 3-MM. Catch summaries for *Oncorhynchus mykiss* caught by rotary screw trap at Knights Landing (Sacramento River) from November 1995 through July 1996 (Snider and Titus 1998).

		Young-of-year		Yearling (no clip)		Yearling (adipose clip)	
Week	Start date	Count	Mean FL and range (mm)	Count	Mean FL and range (mm)	Count	Mean FL and range (mm)
47-50	21 Nov 1995	0		0		0	
51	16 Dec 1995	0		1	290	0	
52	23 Dec 1995	0		0		1	385
1	30 Dec 1995	0		1	182	0	
2	06 Jan 1996	0		1	203	3	197 (164-217)
3	13 Jan 1996	0		36	218 (82-255)	5	200 (166-240)
4	20 Jan 1996	0		60	221 (132-279)	1	207
5	27 Jan 1996	0		6	239 (211-273)	0	
6	03 Feb 1996	0		9	233 (201-290)	2	203 (195, 210)
7	10 Feb 1996	0		8	235 (210-255)	1	194
8	17 Feb 1996	0		6	207 (194-238)	0	
9	24 Feb 1996	0		0		0	
10	03 Mar 1996	0		1	199	1	190
11	10 Mar 1996	0		8	204 (181-259)	1	190
12	17 Mar 1996	0		10	233 (196-280)	0	
13	24 Mar 1996	0		8	235 (193-345)	0	
14	31 Mar 1996	1	47	5	204 (181-224)	0	
15	07 Apr 1996	0		0		0	
16	14 Apr 1996	0		0		0	
17	21 Apr 1996	0		1	187	0	
18	28 Apr 1996	0		2	204 (19, 217)	0	
19	05 May 1996	0		3	213 (205-226)	0	
20	12 May 1996	0		0		1	205
21	19 May 1996	9	37 (36-38)	0		1	258
22-25	26 May 1996	0		0		0	
Total		10	39 (36-47)	165	221 (82-345)	17	218 (164-385)

Appendix 3-NN. Catch summaries for *Oncorhynchus mykiss* caught by rotary screw trap at Knights Landing (Sacramento River) from September 29, 1996 - October 4, 1997 (Snider and Titus 2000b).

	YOY	Yearling (no clip)		Adult	
Week	Count	Count	Mean FL (mm) range	Count	Mean FL (mm) range
40-2	No *O. mykiss* were captured				
3	0	3	170 (155-190)	0	
4	0	8	215 (181-240)	1	306
5	0	4	246 (214-295)	1	310
6	0	9	222 (206-248)	0	
7	0	17	216 (188-268)	0	
8	0	18	225 (195-275)	0	
9	0	23	220 (117-287)	2	500 (452-549)
10	0	5	225 (202-246)	0	
11	0	4	222 (205-250)	0	
12	0	8	233 (200-260)	0	
13	0	5	238 (196-270)	1	357
14	0	3	232 (220-238)	0	
15	0	1	285	0	
16	0	1	224	0	
17	0	16	230 (182-265)	2	390 (345-434)
18	0	18	223 (193-262)	0	
19	0	5	219 (195-255)	1	410
20	0	7	208 (189-224)	1	395
21	0	1	229	0	
22-25	No *O. mykiss* were captured				
26	0	0		1	340
27	0	0		0	
28	1 (97 mm)	0		0	
29-40	No *O. mykiss* were captured				
Total	1	156	224 (117-295)	10	390 (306-549)

Appendix 3-OO. Catch summaries for *Oncorhynchus mykiss* caught by rotary screw trap at Knights Landing (Sacramento River) from September 28, 1997 - October 3, 1998 (Snider and Titus 2000c).

	YOY	Yearling (no clip)		Yearling (adipose clip)		Adult	
Week	Count	Count	Mean FL (mm) range	Count	Mean FL (mm) range	Count	Mean FL (mm) range
40-50	No *O. mykiss* caught						
51	0	1	245	0		0	
52-1	No *O. mykiss* caught						
2	0	0		1	180	1	339
3	0	1	250	5	182 (130-210)	1	310
4	0	7	207 (165-255)	6	235 (214-260)		
5	0	3	228 (220-244)	3	221 (215-229)		
6	0	3	232 (210-246)	1	240		
7	0	1	190	3	230 (219-237)		
8	0	1	245	3	227 (210-245)		
9	0	1	209	4	229 (218-245)		
10	0	11	216 (178-250)	11	213 (185-255)		
11	0	22	223 (134-270)	22	216 (113-290)		
12	0	30	223 (153-275)	54	217 (111-283)		
13	0	13	231 (156-300)	10	215 (184-230)		
14	0	2	175 (175-176)	1	184		
15	0	0		0			
16	0	1	239	0			
17	0	2	191 (173-210)	0		1	445
18	0	8	207 (180-240)	5	199 (125-240)		
19	0	1	188	0			
20	0	2	212 (205-220)	0		1	309
21-40	No *O. mykiss* caught						
Total	0	110	220 (134-300)	129	216 (111-290)	4	351 (309-445)

Appendix 3-PP. Catch summaries for *Oncorhynchus mykiss* caught by rotary screw trap at Knights Landing (Sacramento River) from September 27, 1998 - October 2, 1999 (Snider and Titus 2000d).

	YOY	Yearling (no clip)		Yearling (adipose clip)		Adult	
Week	Count	Count	Mean FL (mm) range	Count	Mean FL (mm) range	Count	Mean FL (mm) range
40-48	No *O. mykiss* caught						
49	2	2	176 (113-238)	0		0	
50		0		0		0	
51		0		0		0	
52		0		0		0	
1		0		0		0	
2		0		0		1	348
3		0		0		0	
4		1	195	14	212 (179-270)	0	
5		0		16	220 (190-263)	0	
6		0		5	214 (203-235)	0	
7		1	253	11	220 (193-232)	0	
8		0		1	192	0	
9		2	212 (201-222)	1	235	0	
10		1	215	3	216 (202-226)	0	
11		1	194	1	209	0	
12		1	201	1	201	0	
13		1	196	2	217 (203-230)	0	
14		5	230 (161-260)	13	220 (115-280)	0	
15		8	219 (175-266)	4	215 (208-234)	0	
16		3	220 (197-240)	3	211 (206-218)	1	326
17		2	181 (157-204)	4	196 (145-237)	0	
18		5	221 (196-276)	1	215	1	475
19		1	206	0		1	403
20		1	202	2	227 (225-228)	0	
21		0		0		0	
22		4	215 (179-278)	0		1	310
23		4	216 (196-246)	0		0	
24-40	No *O. mykiss* caught						
Total	2	43	214 (113-278)	82	216 (115-280)	5	372 (310-475)

Appendix 3-QQ. Summary of catch and size range data for non-adipose fin-clipped and adipose fin-clipped juvenile *Oncorhynchus mykiss* captured during rotary screw trapping at Knights Landing (Sacramento River), 2000 (CDFG 2005).

	Non-adipose fin-clipped *O. mykiss*		Adipose fin-clipped *O. mykiss*	
Week	Number	FL range (mm)	Number	FL range (mm)
40-52	0		0	
1	0		0	
2	0		0	
3	0		2	215-228
4	0		4	194-225
5	0		10	169-241
6	0		4	210-240
7	1	335	2	200-230
8	1	175	0	
9	1	372	0	
10	0		2	169-254
11	0		1	236
12	0		1	247
13	0		0	
14	0		0	
15	0		0	
16	0		0	
17	5	191-241	2	231-234
18	0	228	0	
19	1		0	
20-39	0		0	

Appendix 3-RR. Summary of catch and size range data for non-adipose fin-clipped and adipose fin-clipped juvenile *Oncorhynchus mykiss* captured during rotary screw trapping at Knights Landing (Sacramento River), 2001 (CDFG 2005).

	Non-adipose fin-clipped *O. mykiss*		Adipose fin-clipped *O. mykiss*	
Week	Number	FL range (mm)	Number	FL range (mm)
40-52	0		0	
1	0		0	
2	0		1	308
3	0		53	118-226
4	1	233	9	117-200
5	1	220	123	98-223
6	0		19	164-220
7	0		32	116-250
8	0		1	223
9	2	213-260	4	195-247
10	0		2	164-197
11	1	199	3	179-501
12	0		0	
13	1	233	0	
14	0		1	169
15	0		0	
16	0		0	
17	0	211-238	0	
18	4	234-238	0	
19	2	237-208	1	241
20	2		0	
21-39	0		0	

Appendix 3-SS. Summary of catch and size range data for non-adipose fin-clipped and adipose fin-clipped juvenile *Oncorhynchus mykiss* captured during rotary screw trapping at Knights Landing (Sacramento River), 2002 (CDFG 2005).

	Non-adipose fin-clipped *O. mykiss*		Adipose fin-clipped *O. mykiss*	
Week	Number	FL range (mm)	Number	FL range (mm)
40-52	0		0	
1	0		0	
2	0		1	370
3	1	267	1	200
4	2	210-385	24	93-354
5	2	196-298	28	170-267
6	0		23	193-241
7	0		5	170-267
8	1	-	11	172-245
9	2	164-315	11	179-227
10	0		1	184
11	0		0	
12	0		0	
13	1	201	1	221
14	2	169-375	2	210, 210
15	1	211	0	
16	2	238-248	1	236
17	5	49-230	3	221-269
18	5	193-287	2	257, 257
19	6	188-435	0	
20	2	204-211	1	235
21	0		0	
22	1	198	0	
23	1	247	0	
24-39	0		0	

Appendix 3-TT. Summary of catch and size range data for non-adipose fin-clipped and adipose fin-clipped juvenile *Oncorhynchus mykiss* captured during rotary screw trapping at Knights Landing (Sacramento River), 2003 (CDFG 2005).

	Non-adipose fin-clipped *O. mykiss*		Adipose fin-clipped *O. mykiss*	
Week	Number	FL range (mm)	Number	FL range (mm)
40-52	0		0	
1	0		1	175
2	0		1	167
3	0		1	138
4	1	208	4	150-222
5	0		3	159-208
6	1	280	2	189-191
7	0		1	208
8	0		1	195
9	0		1	197
10	0		0	
11	0		0	
12	1	216	3	195-395
13	0		4	193-245
14	2	200-209	1	274
15	0		0	
16	1	216	0	
17	2	205-352	0	
18	0		0	
19	0		0	
20	0		2	215-228
21-39	0		0	

Appendix 3-UU. Summary of catch and size range data for non-adipose fin-clipped and adipose fin-clipped juvenile *Oncorhynchus mykiss* captured during rotary screw trapping at Knights Landing (Sacramento River), 2004 (CDFG 2005).

	Non-adipose fin-clipped *O. mykiss*		Adipose fin-clipped *O. mykiss*	
Week	Number	FL range (mm)	Number	FL range (mm)
40-50	0		0	
51	1	240	0	
52	0		0	
1	0		0	
2	0		0	
3	1	251	3	190-225
4	0		6	190-216
5	1	233	7	183-227
6	0		5	198-228
7	0		3	202-211
8	2	245, 245	5	117-220
9	0		1	195
10	0		1	228
11	4	216-253	4	201-272
12	4	206-278	9	179-228
13	2	234-318	3	171-217
14	2	205-213	1	250
15	0		0	
16	0		0	
17	2	197-242	0	
18	5	220-240	1	223
19	3	191-237	1	207
20-39	0		0	

Appendix 3-VV. Summary of non-adipose fin-clipped juvenile *Oncorhynchus mykiss* captured during Kodiak and midwater trawls in the Sacramento River near the city of Sacramento from 1988-2004 (U. S. Fish and Wildlife Service 2005e).

Year	Month	Total catch
1988	Apr	21
	May	18
1992	Jan	36
	Feb	254
	Mar	16
	May	5
	Dec	3
1993	Jan	34
	Feb	118
	Mar	428
	Apr	46
	May	3
1994	Jan	34
	Feb	40
	Mar	34
	Apr	3
	May	3
1995	Jan	4
	Feb	50
	Mar	20
	Apr	311
	May	5
	Jul	1
1996	Jan	60
	Feb	109
	Mar	48
	Apr	74
	May	2
	Nov	1
1997	Feb	145
	Mar	159
	Apr	3
	May	1
	Dec	1
1998	Jan	3
	Mar	25
	May	3
	Jun	1
1999	Jan	1
	Feb	1
	Mar	2
	Apr	2
	May	1
	Dec	1
2000	Jan	2
	Mar	3
	Apr	1
2001	Jan	2
	Feb	1
	Mar	1
	Apr	1
	May	2
	Sep	1
2002	Jan	2
2003	Mar	1
	Apr	2
2004	Feb	1
	Mar	1

Appendix 3-WW. Summary of adipose fin-clipped juvenile *Oncorhynchus mykiss* captured during Kodiak and midwater trawls in the Sacramento River near the city of Sacramento from 1992-2004 (U. S. Fish and Wildlife Service 2005e).

Year	Month	Total catch
1992	Jan	2
	Feb	25
1993	Jan	4
	Feb	38
	Apr	1
	Mar	14
1994	Jan	13
	Feb	7
1995	Feb	24
	Mar	3
	Apr	11
1996	Jan	17
	Feb	5
	Mar	9
	Apr	1
1997	n/a	n/a
1998	Jan	8
	Feb	1
	Mar	55
	Apr	5
1999	Jan	37
	Feb	41
	Mar	25
	Apr	4
	Nov	1
2000	Jan	48
	Feb	20
	Mar	10
2001	Jan	74
	Feb	73
	Mar	4
	May	1
2002	Jan	10
	Feb	14
	Mar	4
	Apr	1
	Nov	1
	Dec	5
2003	Jan	15
	Feb	13
	Mar	3
	Apr	2
2004	Jan	6
	Feb	9
	Mar	2

Appendix 3-XX. Summary of non-adipose fin-clipped juvenile *Oncorhynchus mykiss* captured during midwater trawls at Chipps Island in the Sacramento-San Joaquin Delta from 1976-2004 (U. S. Fish and Wildlife Service 2005f).

Year	Month	Total catch
1976	May	4
	Jun	5
1977	May	21
	Jun	3
1978	Apr	156
	May	22
1979	Apr	56
	May	8
	Jun	4
1980	Jan	5
	Feb	10
	Mar	7
	Apr	72
	May	4
	Jun	4
	Oct	1
1981	Apr	80
	May	2
	Jun	1
1982	Apr	16
	May	7
1983	Apr	31
	May	14
	Jun	3
1984	Apr	40
	May	13
	Jun	1
1985	Apr	28
	May	19
1986	Apr	28
	May	15
1987	Apr	10
	May	2
1988	Apr	15
	May	23
1989	Apr	41
	May	18
1990	Apr	19
	May	9
	Jun	7
1991	Apr	27
	May	9
	Jun	1
1992	Apr	38
	May	16
1993	Apr	88
	May	16
	Jun	4
	Dec	1
1994	Jan	26
	Feb	69
	Mar	34
	Apr	35
	May	12
	Jun	3
	Oct	2
1995	Jan	7
	Feb	100
	Mar	61
	Apr	214
	May	72
	Jun	3
1996	Jan	85
	Feb	74
	Mar	58
	Apr	34
	May	20
	Oct	1
	Nov	1
	Dec	4
1997	Jan	16
	Feb	44
	Mar	65
	Apr	37
	May	8
	Jun	1
	Oct	12
	Nov	2
1998	Jan	5
	Feb	3

Appendix 3-XX (cont.). Summary of non-adipose fin-clipped juvenile *Oncorhynchus mykiss* captured during midwater trawls at Chipps Island in the Sacramento-San Joaquin Delta from 1976-2004 (U. S. Fish and Wildlife Service 2005f).

Year	Month	Total catch
1998 (cont)	Mar	13
	Apr	20
	May	22
	Jun	3
	Sep	1
	Nov	1
	Dec	2
1999	Jan	5
	Feb	2
	Mar	6
	Apr	13
	May	19
	Jun	5
	Jul	3
2000	Feb	8
	Mar	7
	Apr	27
	May	14
	Jun	1
2001	Jan	6
	Feb	4
	Mar	7
	Apr	10
	May	13
	Jun	2
	Jul	1
	Aug	1
2002	Mar	1
	Apr	25
	May	12
	Sep	1
	Oct	1
2003	Jan	2
	Mar	2
	Apr	10
	May	13
	Jun	2
2004	Jan	3
	Feb	5
	Mar	6
	Apr	5
	May	18
	Jun	4

Appendix 3-YY. Summary of adipose fin-clipped juvenile *Oncorhynchus mykiss* captured during midwater trawls at Chipps Island in the Sacramento-San Joaquin Delta from 1993-2004 (U. S. Fish and Wildlife Service 2005f).

Year	Month	Total catch
1993	Apr	2
1994	Jan	3
	Feb	14
	Mar	4
	Apr	4
1995	Jan	1
	Feb	25
	Mar	10
	Apr	5
	May	1
1996	Jan	13
	Feb	7
	Mar	2
	Apr	2
1997	Oct	1
	Dec	1
1998	Jan	53
	Feb	11
	Mar	24
	Apr	12
	May	10
1999	Jan	79
	Feb	33
	Mar	22
	Apr	33
	May	3
	Jun	1
	Dec	1

Year	Month	Total catch
2000	Jan	37
	Feb	48
	Mar	12
	Apr	37
	May	7
2001	Jan	26
	Feb	62
	Mar	31
	Apr	7
	May	4
	Jun	1
2002	Jan	18
	Feb	41
	Mar	28
	Apr	28
	May	10
	Dec	13
2003	Jan	37
	Feb	19
	Mar	13
	Apr	15
	May	20
2004	Jan	6
	Feb	58
	Mar	14
	Apr	3
	May	6