COMPREHENSIVE ASSESSMENT AND MONITORING PROGRAM

Assessment of Anadromous Fish Production in the Central Valley of California between 1992 and 2013

Report prepared by the
United States Department of the Interior
U.S. Fish and Wildlife Service
and
U.S. Bureau of Reclamation

2014

COMPREHENSIVE ASSESSMENT AND MONITORING PROGRAM

Assessment of Anadromous Fish Production in the Central Valley of California between 1992 and 2013

Report prepared by the
United States Department of the Interior

U.S. Fish and Wildlife Service
2800 Cottage Way, Room W-2605
Sacramento, California 95825

and

U.S. Bureau of Reclamation
2800 Cottage Way, MP-400A
Sacramento, California 95825

2014

The suggested citation for this report is:

U.S. Department of the Interior. 2014. Assessment of anadromous fish production in the Central Valley of California between 1992 and 2013. Report prepared by the U.S. Fish and Wildlife Service and Bureau of Reclamation, Comprehensive Assessment and Monitoring Program. Sacramento, California. 121 pp.

TABLE OF CONTENTS

ACRONYMS AND ABBREVIATIONS

AFRP	Anadromous Fish Restoration Program
CAMP	Comprehensive Assessment and Monitoring Program
CDFW	California Department of Fish and Wildlife
CVPIA	Central Valley Project Improvement Act
FMWT	Fall Midwater Trawl
PFMC	Pacific Fishery Management Council
PSMFC	Pacific States Marine Fisheries Commission
USFWS	U.S. Fish and Wildlife Service
YOY	young-of-the-year

LIST OF TABLES

LIST OF FIGURES

EXECUTIVE SUMMARY

This Comprehensive Assessment and Monitoring Program (CAMP) annual report compiles and synthesizes anadromous fish production data from the Central Valley of California between 1992 and 2013. These data are then used to assess overall (cumulative) effectiveness of habitat restoration actions implemented pursuant to Section 3406(b) of the Central Valley Project Improvement Act (CVPIA) in meeting fish production targets developed by the Anadromous Fish Restoration Program (AFRP). To accomplish these tasks, this report quantifies the *natural* (as compared to hatchery) production of eight anadromous fish taxa in one broader area and 22 Central Valley watersheds where AFRP fish production targets exist. The eight fish taxa include fall-, late-fall-, winter-, and spring-run Chinook salmon; striped bass; American shad; white sturgeon; and green sturgeon. The broader area includes San Pablo Bay, Suisun Bay, and the Sacramento-San Joaquin River Delta. The 22 watersheds are the American River, Antelope Creek, Battle Creek, Bear River, Big Chico Creek, Butte Creek, Calaveras River, Clear Creek, Cosumnes River, Cottonwood Creek, Cow Creek, Deer Creek, Feather River, Merced River, Mill Creek, seven "Miscellaneous Creeks" upstream of the Red Bluff Diversion Dam on the Sacramento River mainstem, Mokelumne River, Paynes Creek, Sacramento River mainstem, Stanislaus River, Tuolumne River, and Yuba River. The CAMP cannot assess progress toward the AFRP's steelhead production target because comparable monitoring data for this taxon before and after 1994 have not been collected due to operational changes at the Red Bluff Diversion Dam on the Sacramento River.

The AFRP production targets for Chinook salmon consist of three tiers that include: (1) watershed-specific production targets for different locations and runs of Chinook salmon, (2) a run-specific production target for each of the four runs of Chinook salmon in the Central Valley, and (3) a Central Valley-wide production target for the combined total of all four runs of Chinook salmon. The production targets for white and green sturgeon, American shad, and striped bass only consist of one tier in the Central Valley.

Progress toward the AFRP production targets for the eight taxa was assessed by: (1) quantifying the number of years each AFRP production target was met after 1991, (2) determining if the average natural production of adult Chinook salmon from each watershed during the 1992-2013 post-baseline period was greater or less than production during the 1967-1991 baseline period, and (3) determining if there is a statistically significant ($\alpha = 0.05$) difference in the average natural production of adult Chinook salmon from each watershed between these two time periods. Monitoring data quantifying the natural production of adult Chinook salmon from the Central Valley during the 22-year period between 1992 and 2013 are summarized in Table 1.

Table 1. Overall assessment of changes in natural production of adult Chinook salmon from the Central Valley, 1967-2013. * Indicates a fish hatchery is present in the watershed. ** Indicates a statistically significant P value (p<0.05). ??? = insufficient data to assess change in average production or a P value.

Watershed	Chinook salmon run	Number of years the AFRP production target was exceeded / number of years monitoring occurred since 1991	Change in average production between the 1967-1991 and 1992-2013 time periods	P values associated with changes in the average production between the 1967-1991 and 1992-2013 time periods
American River*	fall-run	6/22	+ 29%	0.348
Antelope Creek	fall-run	0/1	???	???
Battle Creek*	fall-run	15/22	+ 250%	0.000**
Battle Creek*	late-fall-run	15/22	+ 147%	0.000**
Bear River	fall-run	0/0	???	???
Big Chico Creek	fall-run	0/0	???	???
Butte Creek	fall-run	9/17	+ 199%	0.015**
Butte Creek	spring-run	18/22	+ 915%	0.000**
Calaveras River	winter-run	0/5	- 100%	???
Clear Creek	fall-run	14/22	+ 206%	0.000**
Cosumnes River	fall-run	0/15	- 54%	0.068
Cottonwood Creek	fall-run	0/8	- 28%	???
Cow Creek	fall-run	1/8	-9%	???
Deer Creek	fall-run	2/14	+ 17%	0.438
Deer Creek	spring-run	0/22	- 41%	0.266
Feather River*	fall-run	4/22	+ 10%	0.297
Merced River*	fall-run	1/22	- 28%	0.500
Mill Creek	fall-run	1/17	- 10%	0.351
Mill Creek	spring-run	0/22	- 46%	0.054
Miscellaneous Creeks	fall-run	0/3	- 86%	???
Mokelumne River*	fall-run	11/22	+ 87%	0.003**
Paynes Creek	fall-run	0/0	????	???
Sacramento River	fall-run	0/22	- 40%	0.001**
Sacramento River	late-fall-run	1/21	- 50%	0.001**
Sacramento River*	winter-run	0/22	- 88%	0.001**
Sacramento River	spring-run	0/22	- 98%	0.000**
Stanislaus River	fall-run	0/22	- 52%	0.167
Tuolumne River	fall-run	0/22	- 66%	0.003**
Yuba River	fall-run	1/22	- 8%	0.399

The presence of fish hatcheries in several watersheds confounds the ability to accurately assess natural salmon production because the proportions of natural- vs. hatchery-origin salmon needed to calculate natural production for different salmon runs and watersheds in 2013 are not currently available.

Chinook salmon data presented in this report demonstrate that:

- The production of adult fall-run Chinook salmon has steadily risen each year during the past four years, and was 404,269 individuals in 2013. This suggests a steady rebuilding of that salmon stock following the marked decline that occurred between 2004 and 2009, with a nadir in the production of 30,604 adult fall-run Chinook salmon in 2009.

- As the production of adult fall-run Chinook salmon increased during the past four years, the combined production of all four runs of adult Chinook salmon in Central Valley-wide also increased because fall-run Chinook salmon predominate in their contribution to the Central Valley total. The combined Central Valley-wide adult production of all four salmon runs in 2013 was 440,920 salmon, vs. the 41,516 salmon in 2009.

- Six combinations of watersheds and runs had significantly greater numbers of adult Chinook salmon in the post-baseline period than during the 1967-1991 baseline period, and five had significantly fewer numbers of Chinook salmon. In 10 combinations of watersheds and runs, there were no significant changes in adult salmon production over time, and there were eight combinations where insufficient monitoring data were collected to determine if there was a significant change.

- The use of a Cormack-Jolly-Seber mark recapture model during adult Chinook salmon escapement surveys in the past three years in some watersheds is beginning to produce data that will provide a more statistically robust approach to assessing long-term trends in the production of adult salmon.

During the 22-year period between 1992 and 2013:

- Monitoring data that can be used to estimate salmon production have not been collected during the 1992-2013 post-baseline period in three of the 22 watersheds that have an AFRP fish production target. These watersheds are relatively small and consist of Bear River, Big Chico Creek, and Paynes Creek. Six of the seven "Miscellaneous Creeks" also have not been surveyed during the post-baseline period.

- The watershed-specific AFRP fall-run Chinook salmon production targets were met six or more times in five of the 21 watersheds with a fall-run target. These watersheds are: American River, Battle Creek, Butte Creek, Clear Creek, and the Mokelumne River. The watershed-specific AFRP fall-run Chinook salmon production target for the Feather River was met four times. The remaining 15 watersheds with a fall-run Chinook salmon production target have: (a) met their production targets less than three times during the 22-year post-baseline period, or (b) were not surveyed each year since 1991.

- The watershed-specific AFRP late-fall-run Chinook salmon production target for Battle Creek was met 15 times in the post-baseline period, and the Sacramento River mainstem only met its AFRP late-fall-run Chinook salmon target once in the 21 years when monitoring data were collected for this run and watershed.

- The watershed-specific AFRP winter-run Chinook salmon production target for the Sacramento River mainstem was never met during the post-baseline period, and the Calaveras River did not meet its AFRP winter-run Chinook salmon target in the five years surveys were conducted.

- The watershed-specific AFRP spring-run Chinook salmon production target was met 18 times on Butte Creek in the post-baseline period. The other three watersheds with a spring-run Chinook salmon target (Deer Creek, Mill Creek, and the Sacramento River mainstem) have never met their AFRP targets in the post-baseline period.

- Run-specific AFRP production targets for fall-, winter-, and spring-run Chinook salmon were never met in the post-baseline period, and the run-specific AFRP production target for late-fall-run Chinook salmon was met once in 1998.

- The Central Valley-wide AFRP production target for the combined total of all four runs of Chinook salmon from 22 watersheds was never met in the post-baseline period.

Data results for non-salmonid species were as follows:

- Monitoring data for white sturgeon in San Pablo and Suisun bays are available for eleven years between 1992 and 2009. In the seven years when 15-year-old white sturgeon abundance estimates are considered to be final and not subject to revision (i.e., between 1993 and 2005), the AFRP production target for this species was met once. In the four years when white sturgeon estimates are considered to be provisional (i.e., 2006, 2007, 2008, and 2009), the AFRP production target for 15-year-old white sturgeon was not met.

- Monitoring data for green sturgeon in San Pablo and Suisun bays are available for ten years between 1992 and 2009. In the six years when green sturgeon abundance estimates are considered to be final and not subject to revision (i.e., between 1993 and 2005), the AFRP production target for this species was met twice. In the four years when green sturgeon estimates are considered to be provisional (i.e., 2006, 2007, 2008, and 2009), the AFRP production target for this species was also met twice.

- The Fall Midwater Trawl index for juvenile American shad in the Sacramento-San Joaquin River Delta and San Pablo and Suisun bays suggests the AFRP production target for this species was met in three of 22 years between 1992 and 2013. The 2013 index for this species (309) was the second on record since 1992.

- Monitoring of legal-size striped bass in the Central Valley's anadromous waters occurred in 16 years between 1992 and 2012. In the 10 years when legal-size striped bass abundance estimates are considered to be final and not subject to revision (i.e., between

1992 and 2005), the AFRP production target for this species was never met. In six years between 2007 and 2012 when legal-size striped bass abundance estimates are considered to be provisional, the AFRP production target for this species was not met. It is unlikely that future revisions in the provisional numbers will result in the attainment of the production target because the provisional estimates are markedly below the production target.

SECTION 1: INTRODUCTION

1.1 OVERVIEW OF THE CVPIA, AFRP, AND CAMP

The CVPIA was authorized in October 1992 (Public Law 102-575, Title 34), and amends the authority of the Central Valley Project to include fish and wildlife protection, restoration, and mitigation activities as having equal priority with other Central Valley Project functions. Section 3406(b)(1) of the CVPIA directs the Secretary of the Interior to "…implement a program which makes all reasonable efforts to ensure that, by the year 2002, natural production of anadromous fish in Central Valley rivers and streams will be sustainable, on a long-term basis, at levels not less than twice the average levels attained during the period of 1967-1991." The CVPIA defines natural production as "fish produced to adulthood without direct human intervention in the spawning, rearing, or migration processes." The CAMP annual reports adopt that emphasis, and therefore quantify the *natural* (as compared to hatchery) production of anadromous fish taxa.

Pursuant to Section 3406(b)(1) of the CVPIA, the AFRP was established to restore anadromous fish populations through a variety of management strategies. The CAMP was established pursuant to CVPIA section 3406(b)(16) to "…monitor fish and wildlife resources in the Central Valley to assess the biological results and effectiveness of actions implemented pursuant to subsection [3406(b)]".

In 1994, the California Department of Fish and Wildlife (CDFW) issued a report that quantified abundance of fish taxa in the Central Valley between 1967 and 1991 (Mills and Fisher 1994). The AFRP used the CDFW fish abundance estimates to develop production targets for nine anadromous fish taxa in one broader area and 22 watersheds in the Central Valley. The AFRP production targets are twice the average levels during the 1967-1991 baseline period and are quantified in the *Final Restoration Plan for the Anadromous Fish Restoration Program* (USFWS 2001). The nine fish taxa include fall-, late-fall-, winter-, and spring-run Chinook salmon (*Oncorhynchus tshawytscha*), steelhead (*Oncorhynchus mykiss*), striped bass (*Morone saxatilis*), American shad (*Alosa sapidissima*), white sturgeon (*Acipenser transmontanus*), and green sturgeon (*Acipenser medirostris*). The broader area includes San Pablo Bay, Suisun Bay, and the Sacramento-San Joaquin River Delta (Bay-Delta), and the 22 watersheds are the American River, Antelope Creek, Battle Creek, Bear River, Big Chico Creek, Butte Creek, Calaveras River, Clear Creek, Cosumnes River, Cottonwood Creek, Cow Creek, Deer Creek, Feather River, Merced River, Mill Creek, seven "Miscellaneous Creeks" upstream of the Red Bluff Diversion Dam on the Sacramento River mainstem, Mokelumne River, Paynes Creek, Sacramento River mainstem, Stanislaus River, Tuolumne River, and Yuba River.

To address its mandate, the CAMP produces annual reports that compile and synthesize anadromous fish production data from the Central Valley. These data are used to assess overall (cumulative) effectiveness of habitat restoration actions implemented pursuant to CVPIA Section 3406(b) in meeting the AFRP fish production targets; the habitat restoration actions include water management modifications, structural modifications, habitat restoration, and fish screens. This is the eleventh CAMP annual report prepared since 1992. Each of the CAMP annual

reports is available on the CAMP website at: http://www.fws.gov/sacramento/Fisheries/CAMP-Program/Documents-Reports/fisheries_camp-program_documents-reports.htm.
CAMP annual reports do not estimate production of fish that originate at fish hatcheries. For purposes of this report: (1) the word "taxa" refers to different species of anadromous fish or different runs of Chinook salmon, (2) references to the "baseline period" reflect the years between 1967 and 1991, and (3) references to the "post-baseline period" reflect the years between 1992 and 2013.

1.2 PRODUCTION TARGETS FOR ANADROMOUS FISH TAXA

The AFRP has developed baseline production estimates and fish production targets for each of the nine aforementioned taxa (Table 2). With regard to natural production of Chinook salmon, the AFRP developed three tiers of production targets. These include: (1) watershed-specific production targets for different runs of Chinook salmon, (2) run-specific production targets for each run of Chinook salmon, and (3) a Central Valley-wide production target for the combined total of all four runs of Chinook salmon from 22 watersheds. Figure 1 provides an illustration that demonstrates how the three tiers of production targets are interrelated. In contrast to the Chinook salmon production targets, the targets for striped bass, American shad, white sturgeon, and green sturgeon are not tiered and there is only one production target for each of these species.

CAMP annual reports can not address progress toward the AFRP's steelhead production target for reasons explained in the 2007 CAMP annual report (USFWS 2007). In short, it is not possible to assess progress toward the AFRP production target for adult steelhead because operational changes at the Red Bluff Diversion Dam after 1994 preclude the ability to collect comparable post-baseline data for this taxon.

Table 2. Anadromous Fish Restoration Program adult fish production targets. American shad production targets pertain to juvenile fish.

Taxa	Watershed/area	1967-1991 baseline production estimate	AFRP production target
CHINOOK SALMON			
Fall-run	American River*	80,876	160,000
	Antelope Creek	361	720
	Battle Creek*	5,013	10,000
	Bear River	639	450
	Big Chico Creek	402	800
	Butte Creek	765	1,500
	Clear Creek	3,576	7,100
	Cosumnes River	1,660	3,300
	Cottonwood Creek	2,964	5,900
	Cow Creek	2,330	4,600
	Deer Creek	766	1,500
	Feather River*	86,031	170,000
	Merced River*	9,005	18,000
	Mill Creek	2,118	4,200
	Miscellaneous Creeks	549	1,100
	Mokelumne River*	4,680	9,300
	Paynes Creek	170	330
	Sacramento River mainstem	115,371	230,000
	Stanislaus River	10,868	22,000
	Tuolumne River	18,949	38,000
	Yuba River	33,245	66,000
Late-fall-run	Battle Creek*	273	550
	Sacramento River mainstem	33,941	68,000
Winter-run	Calaveras River[1]	770	2,200
	Sacramento River mainstem*	54,316	110,000
Spring-run	Butte Creek	1,018	2,000
	Deer Creek	3,276	6,500
	Mill Creek	2,202	4,400
	Sacramento River mainstem	29,412	59,000

Table 2 (cont.). Anadromous Fish Restoration Program fish production targets.

Taxa	Watershed/area	1967-1991 baseline production estimate	AFRP production target
CHINOOK SALMON			
Fall-run	Central Valley	374,049	750,000
Late-fall-run	Central Valley	34,192	68,000
Winter-run	Central Valley	54,439	110,000
Spring-run	Central Valley	34,374	68,000
Central Valley-wide (all 4 salmon runs combined)	Central Valley	497,054	990,000
STEELHEAD	Sacramento River upstream of Red Bluff Diversion Dam	6,546	13,000
STRIPED BASS	Sacramento-San Joaquin River Delta, and the lower portions of the Sacramento and San Joaquin rivers	1,252,259	2,500,00
AMERICAN SHAD[2]	Sacramento-San Joaquin River Delta, San Pablo Bay, and Suisun Bay	2,129	4,300
WHITE STURGEON[3]	San Pablo and Suisun bays	5,571	11,000
GREEN STURGEON[3]	San Pablo and Suisun bays	983	2,000

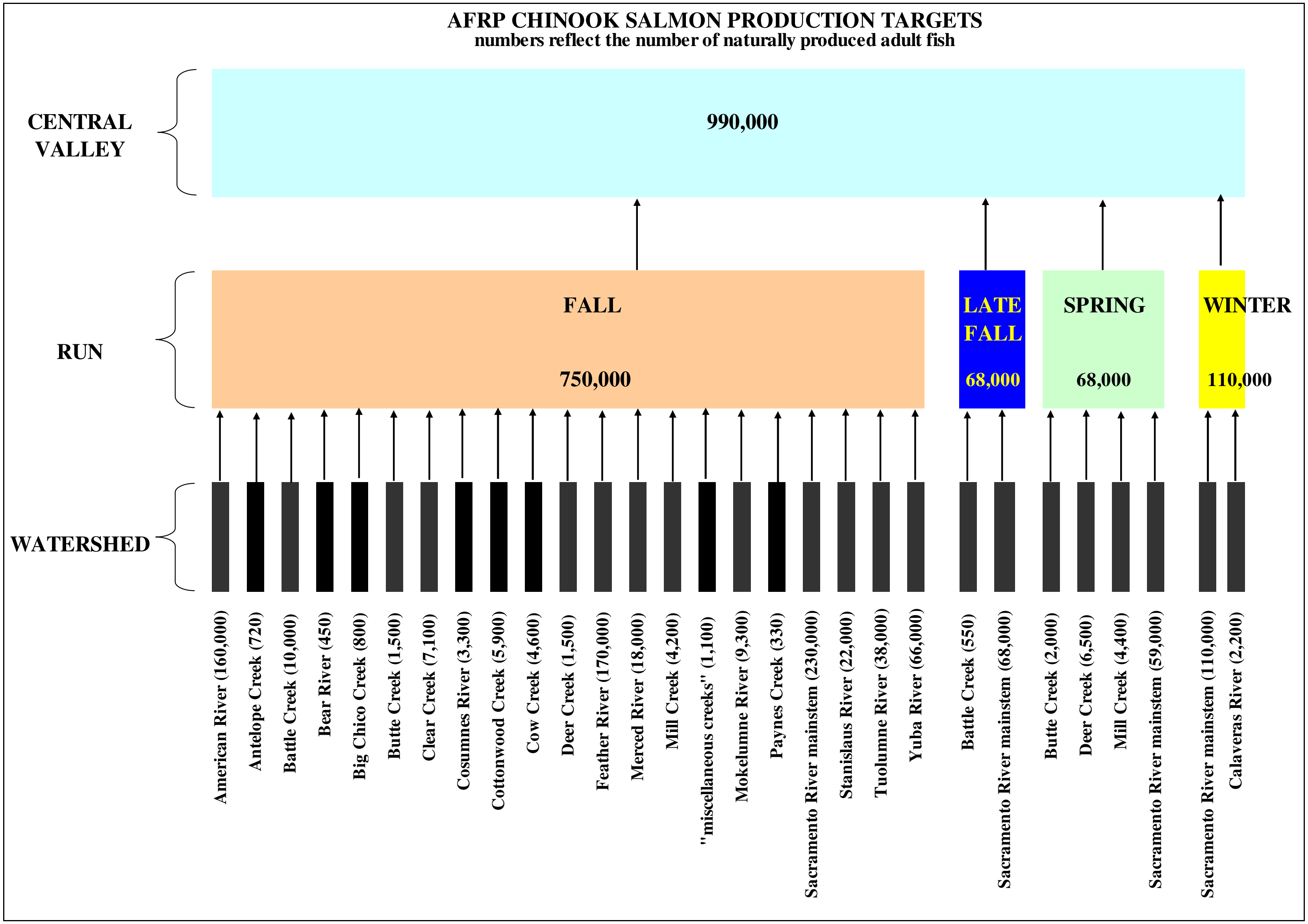
* = Hatchery in the tributary.

1 = Yoshiyama et al. (2001) suggest winter-run Chinook salmon may not have existed in the Calaveras River. The putative winter-run fish may actually have been a late-fall-run attracted to the river when flows were released in late winter and spring by New Hogan Dam.

2 = The baseline production estimate and production target for American shad is based on the Fall Midwater Trawl index for young-of-the-year fish.

3 = The baseline production estimates and production targets for white and green sturgeon refer to 15-year old adult fish and fish ≥ 40 inches in total length, respectively.

Figure 1. Relationship between the three tiers of AFRP Chinook salmon production targets.



1.3 JUVENILE SALMON, ADULT SALMON, AND THEIR RELATIONSHIP WITH PACIFIC OCEAN CONDITIONS

Recent literature has suggested there is a relationship between the survival of juvenile Chinook salmon that emigrate to the Pacific Ocean and the number of adult salmon that return to the Central Valley to spawn a few years after emigration occurs (Lindley et al. 2009). That relationship is posited to exist because the survival of juvenile salmon is thought to be most at risk in the first few months after juvenile salmon enter the ocean (Pearcy 1992), and adult returns are a function of the survival of individuals that migrated to the ocean as juveniles. The survival of those juveniles is likely a function of several variables that include, but are not limited to, food availability, predation, and environmental conditions. In regard to environmental conditions, the factors that are thought to be of particular importance are:

1. Sea surface temperatures (SSTs),

2. Ocean upwelling indices and anomalies,

3. The "Pacific Decadal Oscillation" (PDO), which is a long-lived El Niño-like pattern of Pacific Ocean climate variability, and

4. The Oceanic Niño Index (ONI), which is a running 3-month mean SST anomaly for the Niño 3.4 region in the Pacific Ocean. That region is located in a polygon bounded between the 5° North and -5° South latitudes and the 120° and 170° West longitudes.

In general, higher juvenile Chinook salmon survival rates in the Pacific Ocean are associated with cooler SSTs, greater upwelling and larger upwelling anomalies, and lower PDO and ONI values.

Fall-run Chinook salmon in California's Central Valley are the predominate salmon run in terms of the number of adult salmon counted during escapement surveys. Most of the Central Valley fall-run Chinook salmon escapement occurs in the Sacramento River and its associated tributaries, i.e., the Sacramento Basin, as compared to the San Joaquin River Basin (DOI 2012a). In 2011, for example, the total fall-run Chinook salmon escapement for the Sacramento Basin represented 92.7% of the total Central Valley Chinook salmon escapement for all watersheds and salmon runs combined.

The life cycle of fall-run Chinook salmon originating in California's Central Valley can be partitioned into a series of phases. In Phase I, adult salmon return to the Central Valley to spawn and lay their eggs in year *t*. Phase II in year *t +1* reflects the year when the vast majority of the fall-run Chinook salmon fry, parr, and smolts emigrate to the Pacific Ocean. In year *t +2*, two-year old jack and jill salmon return to their natal watersheds, and in year *t +3*, three-year old adult salmon return to their natal watershed. Within the Central Valley, there is variability in the predominate age class that returns to spawn in a given year. In general, however, at least 81% of the salmon that returned to the Sacramento River between 2000 and 2012 returned as adult salmon, e.g., three-year old salmon in year *t +3* (e.g., Killam and Johnson 2013).

Trawl data that can be used to assess the geographic distribution of juvenile Central Valley Chinook salmon in the Pacific Ocean suggest younger juveniles are most commonly caught on the shallow continental shelf between San Francisco and Point Arena (Fisher et al. 2007). Most of the juvenile salmon referenced in Fisher et al. (2007) were sub yearlings (they were recent emigrants to the ocean), and a small number of older yearlings were also captured.

To assess how the escapement of adult 3-year old fall-run Chinook salmon from the Central Valley is influenced by conditions in the Pacific Ocean, a series of analyses were performed in this CAMP annual report. Such analyses have been performed for many years in the Pacific Northwest by staff affiliated with the National Marine Fisheries Service (NMFS) (Peterson et al. 2013). As such, the work done by the NMFS provides a framework and analytical process for clarifying the relationship that exists between Central Valley Chinook salmon escapement levels and ocean conditions. This relationship was documented in 2009 when the NMFS produced a report evaluating the factors that caused the collapse of the Sacramento Basin fall-run Chinook salmon stock in 2008 (Lindley et al. 2009). This CAMP report builds on the Lindley et al. (2009) effort by using the Peterson et al. (2013) methods, and evaluates the effect ocean conditions have had on Sacramento Basin fall-run Chinook salmon escapement levels in the period after the CVPIA was authorized in 1992.

NMFS staff from the Pacific Northwest use three broad classes of data as they evaluate the relationship between salmon numbers and ocean conditions. These classes include: (1) large–scale ocean and atmospheric indicators, (2) local and regional physical indicators, and (3) local biological indicators. The large–scale ocean and atmospheric indicators consist of the Pacific Decadal Oscillation and Oceanic Niño Index. The local and regional physical indicators include: (1) sea surface temperatures, (2) coastal upwelling indices, and (3) deep–water temperature and salinity. The biological indicators consist of several parameters collected during research vessel cruises in the Pacific Ocean. During those cruises, a variety of data are collected. These include, but are not limited to, copepod diversity and the abundance of icthyoplankton during the winter months. A complete description of the biotic and abiotic factors used by the NMFS can be found in Peterson et al. (2013).

This CAMP annual report replicates the techniques and analyses performed by the NMFS staff, and focuses on those datasets that are long-term in nature and are available in the context of the Central Valley, i.e., the PDO, ONI, sea surface temperatures, and coastal upwelling indices. As such, the data for the other parameters used by the NMFS staff (e.g., copepod diversity) are not used in the CAMP's analyses because those data had not been collected or were unavailable for Central Valley on a long-term basis.

1.4 DATA CAVEATS

The fish production estimates presented in CAMP annual reports represent the best available information at the time of report production. These estimates are based on digital files maintained by the AFRP and the CDFW. It is important to note that fish production estimates for a given year, location, and taxon frequently differ in different iterations of the CAMP annual reports. These differences arise as the CDFW and AFRP staffs update the digital files used to track fish abundance/production.

Several factors affect the accuracy and/or precision of data and analyses provided in the CAMP annual reports. Some of these factors include, but are not limited to:

1. The CAMP-recommended process for calculating Chinook salmon production requires an accurate understanding of the relative abundance of natural- vs. hatchery-origin salmon in each watershed. Because the amount of data pertaining to this ratio prior to 2013 is limited, the process of calculating natural production has thus far relied upon best professional judgments of the ratio of natural- vs. hatchery-origin fish in each watershed (USFWS 1995). Potential problems associated with not having definitive data on the ratio are more pronounced for fall-run Chinook salmon than other salmon runs because large numbers of fall-run salmon were produced in Central Valley hatcheries prior to 2007 and those salmon were not marked. In contrast, the problem is minimal for spring-, late-fall-, and winter-run Chinook salmon because most or all the hatchery-produced fish for these runs have been marked for many years and they are recognizable in the field. The uncertainty pertaining to the hatchery proportion of fall-run Chinook salmon should become less pronounced in future years because approximately 25% of these salmon have been marked at Central Valley fish hatcheries since the spring of 2007, and it will gradually become possible to replace the best professional judgments with empirically-based hatchery proportions based on the recovery of marked salmon.

2. The CAMP has not attempted to determine how changes in sampling methods, frequency, or intensity at a given location have changed over time. These changes have the potential to affect fish abundance estimates.

3. The ability of field biologists to assign each salmon to the correct salmon run may introduce a bias that affects salmon production estimates. Agency staff use different criteria, e.g., run timing, to assign Chinook salmon to particular runs. Some fishery biologists believe the problems with using run timing to identify different runs of Chinook salmon are relatively small, because other features (e.g., phenotypic differences or spawning condition) also provide clues as to the taxonomic identity of a particular salmon. Similarly, the ability to accurately identify spring-run Chinook salmon is enhanced because they tend to migrate farther up-stream than fall-run Chinook salmon, and hold over in deep pools during summer when the adult life phase of other salmon runs tend to be absent. One research study, however, compared the assignment of individual salmon to a particular salmon run based on the use of genetic markers vs. phenotypic traits and noted there may be large discrepancies between the run assignments using these two techniques (Smith et al. 2009). At larger scales, these incorrect run assignments may affect the accuracy of the salmon production estimates presented in this report.

4. The CAMP-recommended process for calculating Chinook salmon production in each watershed should include an estimate of the number of fish *harvested downstream of the watershed*; i.e., downstream angler harvest. Because harvest of Chinook salmon between

the Pacific Ocean and the Central Valley watersheds has not been consistently monitored (i.e., harvest is frequently not monitored in the Sacramento-San Joaquin River Delta or San Francisco Bay), this harvest may not be accurately accounted for in production estimates for individual watersheds, runs, or the Central Valley as a whole.

5. The CAMP-recommended process for calculating the production of each run of Chinook salmon in each watershed should include an estimate of the number of salmon *harvested in each watershed*, i.e., in-river angler harvest. The California Department of Fish and Wildlife has collected angler harvest data in the Central Valley in 16 of the 22 years between 1992 and 2013. The angler harvest data is not classified according to salmon run, however, thereby making it difficult to directly incorporate CDFW's angler harvest into the database which is used to calculate the salmon production estimates provided in this report. The in-river angler harvest estimates which are reflected in the natural production estimates in this report are therefore based on the best professional judgment of field biologists, and therefore may deviate from actual conditions in the watersheds.

6. The production estimates presented in this report may be subject to future revision as agency staff refine and analyze raw data.

1.5 ACKNOWLEDGEMENTS

This report would not have been possible without the substantial support of several individuals:

1. Jason Azat (CDFW) provided a GrandTab spreadsheet with escapement estimates of adult Chinook salmon.

2. Steven Slater (CDFW) provided spreadsheets containing abundance data for juvenile American shad.

3. Jason DuBois (CDFW) provided abundance data for legal-size striped bass, and green and white sturgeon.

4. Dan Welsh (USFWS) provided useful comments as he reviewed portions of this report.

5. The following individuals graciously provided access to population estimates that were developed in different watersheds with a Cormack-Jolly-Seber mark recapture model: Clint Garmin (CDFW), Doug Killam (CDFW), Matt Johnson (CDFW), Jeanine Phillips (CDFW), Steve Tsao (CDFW), Duane Massa (Pacific States Marine Fisheries Commission), and Kyle Hartwigsen (California Department of Water Resources).

6. Jay O. Peterson with the National Marine Fisheries Service's Hatfield Marine Science Center provided indispensable advice and data that was instrumental in understanding the relationship between ocean conditions off the Oregon coast and in-river adult salmon escapement numbers.

SECTION 2: METHODS

2.1 OVERVIEW OF MONITORING LOCATIONS AND ACTIVITIES

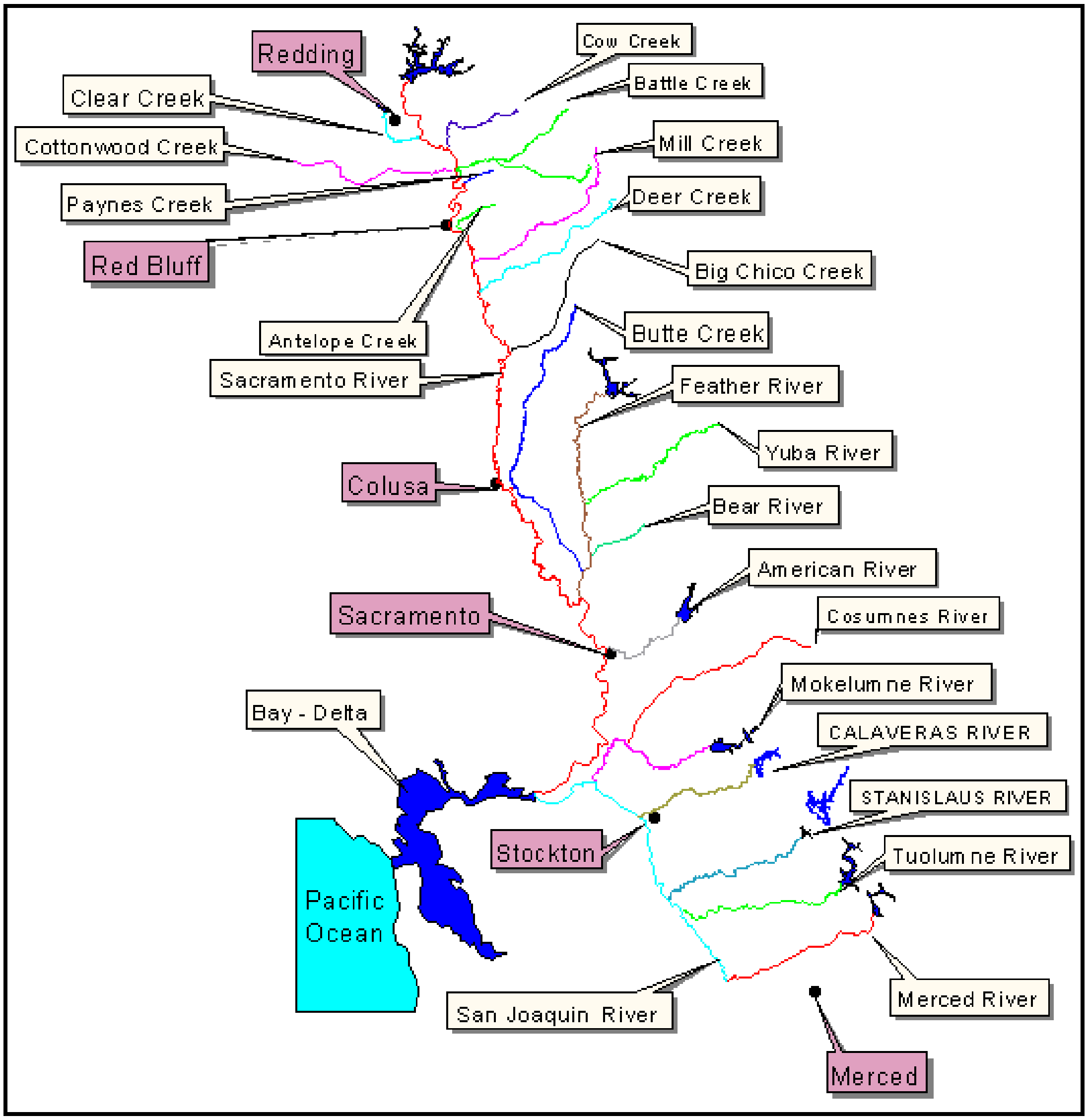
The watersheds and areas with an AFRP fish production target are depicted in Figure 2. Monitoring techniques used to assess the abundance of anadromous fish vary by taxa and are described in the 1997 CAMP Implementation Plan (Montgomery Watson et al. 1997). The techniques include, but are not limited to, carcass surveys, mark-recapture surveys, and ocean harvest surveys. Monitoring activities relating to AFRP fish production targets are focused on adult life stages of striped bass, white sturgeon, green sturgeon, and the four runs of Chinook salmon. Monitoring of American shad focuses on the juvenile life stage.

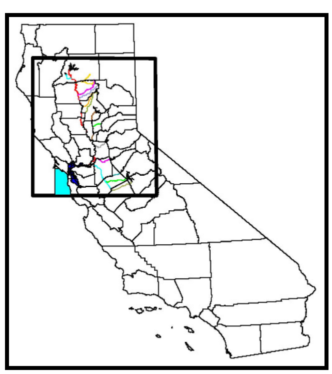
Every CAMP-recommended monitoring activity in a given watershed may not occur each year. For example, an estimate of the production of adult fall-run Chinook salmon from the American River should be quantified using: (1) carcass counts, (2) marking of hatchery-produced salmon to develop a ratio of natural- vs. hatchery-origin fish, (3) counts of salmon returning to the Nimbus Salmon and Steelhead Hatchery, (4) surveys to quantify in-river angler harvest, and (5) assessments of the harvest of Chinook salmon in the Pacific Ocean. In reality, estimates of production of salmon from this watershed include census-derived data (e.g., carcass counts, counts of salmon returning to the hatchery, and estimates of ocean harvest) and approximations that reflect best professional judgments (e.g., an estimate of the ratio of natural- vs. hatchery-origin salmon and the amount of in-river angler harvest).

2.2 METHODS FOR ESTIMATING PRODUCTION OF ADULT CHINOOK SALMON

Calculations to estimate natural production of each run of Chinook salmon from each watershed include up to four components: (1) in-river spawner abundance (i.e., escapement), (2) hatchery returns, (3) in-river harvest by anglers, and (4) ocean harvest. In-river spawner abundance is quantified using carcass surveys, ladder counts, weir counts, snorkel surveys, and aerial redd counts. Hatchery returns are quantified by counting the number of salmon that enter fish hatcheries; production estimates for watersheds that do not have a fish hatchery will not include this component. Surveys to measure in-river harvest by anglers have not occurred every year since 1992. The amount of in-river harvest used to calculate Chinook salmon production is therefore based on best professional judgments of angler harvest developed by fishery biologists. Ocean harvest is quantified by monitoring the number of Chinook salmon captured by commercial and recreational boats; the values are reported by the Pacific Fishery Management Council (PFMC). Because the CAMP has adopted the methods the AFRP used to develop the salmon production targets, the CAMP annual reports use PFMC ocean harvest data that reflect commercial and recreational catches from boats in the Monterey and San Francisco Bay areas (Appendix A). This report does not therefore reflect ocean harvest of Central Valley Chinook salmon from boats based in Crescent City, Eureka, and Fort Bragg.

Figure 2. Watersheds and areas in the Central Valley that possess AFRP fish production targets. Figure does not include the 7 Miscellaneous Creeks described in section 3.1.1.16 of this report. The San Joaquin River does not have a fish production target and is only presented for illustrative purposes. Red labels pertain to cities and yellow labels pertain to watershed names.





Collectively, the sum of the four components is used to estimate the total Chinook salmon production for a particular salmon run and watershed. To calculate the natural production for a particular salmon run and watershed, the watershed-specific total production estimate for a given run is then multiplied by an estimated hatchery proportion, i.e., the estimated ratio of natural- vs. hatchery-origin salmon of a given run in that watershed. This estimate reflects best professional judgments by fisheries biologists because empirical data for each watershed's hatchery proportion over a series of many years are not currently available. The specific hatchery proportions pertaining to each watershed, run, and year are presented in Appendix B. Figure 3 illustrates how natural production estimates of Chinook salmon for different runs in each watershed are calculated.

This report uses the following references to develop Chinook salmon production estimates: (1) a "GrandTab.2014.04.22.xls" file prepared by CDFW staff; (2) commercial and recreational salmon harvest data summarized in the *Review of 2013 Ocean Salmon Fisheries* (PFMC 2014), and (3) a "Chinookprod" database that is used by USFWS staff to calculate natural salmon production estimates (USFWS 2012).

The data that were entered into the Chinookprod database for use in this report assume that:

1. The in-river spawner and hatchery return data from the GrandTab.2014.04.22.xls file were imported verbatim into the Chinookprod database.

2. There was no ocean harvest of salmon in 2008 or 2009. For other years, the ocean harvest values reflect the values in the *Review of 2013 Ocean Salmon Fisheries* report (PFMC 2014).

3. For 2008 and 2009, the following in-river angler harvest proportions (AHPs) were adopted because the CDFW fishing regulations only permitted the capture and possession of late-fall-run Chinook salmon on the Sacramento River mainstem in those two years: (a) the fall-, spring-, and winter-run Chinook salmon AHPs were set to a 0 value; (b) the AHP for late-fall-run Chinook salmon on Battle Creek was set to a 0 value; and (c) the AHP for late-fall-run Chinook salmon on the Sacramento River mainstem was set to a 0.146 value. The AHPs for all four salmon runs and watersheds in years other than 2008 and 2009 were set to their normal default values, i.e., the values that existed in 2007.

2.3 METHODS FOR ASSESSING CHANGE IN ADULT CHINOOK SALMON POPULATIONS

This report uses three tools to assess the overall (cumulative) effectiveness of habitat restoration actions implemented pursuant to CVPIA Section 3406(b) in meeting the AFRP fish production targets:

1. Enumerating the number of years the estimated annual production of Chinook salmon met or exceeded the AFRP's watershed-specific, run-specific, and Central Valley-wide production targets since 1991.

2. Determining the percent change in the average natural production of adult Chinook salmon in the 22 aforementioned watersheds between the 1967-1991 and 1992-2013 time periods.

3. Using a Mann Whitney U test to determine if there was a statistically significant (α = 0.05) difference in the average natural production of adult Chinook salmon for each run and watershed between the 1967-1991 and 1992-2013 time periods. As such, this test was used to evaluate the following null hypothesis:

   > H_0: the average natural production of specific Chinook salmon runs in specific watersheds are the same in the 1967-1991 and 1992-2013 time periods.

   A nonparametric Mann Whitney U test was used to identify statistically significant changes in salmon production between the two time periods because it does not require normally distributed data. As such, this test is more flexible than other tests (e.g., a Student's t test) but it is also less powerful and therefore requires a greater change in fish abundance before a statistically significant change is detected. In this report, a normal approximation z statistic is used to assess differences when at least 10 production estimates are available in each of the baseline and post-baseline years. And,

4. Using a Cormack-Jolly-Seber mark recapture model in some watersheds and for some salmon runs to determine if changes in adult salmon escapement occurred in 2011, 2012, and 2013. The mark recapture model results were also used to calculate coefficients of variation, and confidence intervals using a percentile method.

Figure 3. Components used to calculate natural production of each run of adult Chinook salmon in 22 Central Valley watersheds.

IN-RIVER SPAWNER ABUNDANCE
(from carcass counts, ladder counts, etc.)

PLUS

HATCHERY RETURNS

PLUS

IN-RIVER HARVEST BY ANGLERS

PLUS

OCEAN HARVEST
(commercial and recreational)

TIMES

ESTIMATED HATCHERY PROPORTION

EQUALS

CHINOOK SALMON
NATURAL PRODUCTION ESTIMATE

2.4 METHODS FOR COMPARING OCEAN CONDITIONS WITH ADULT SALMON ESCAPEMENT

The methods used to evaluate the relationship between ocean conditions and Sacramento Basin fall-run Chinook salmon escapement levels mirrors the analytical framework and processes used in the Pacific Northwest by the NMFS (Peterson et al. 2013). Because the CVPIA was authorized in 1992, data analyses were focused on the year 1992 to the last year when a complete record of environmental conditions in the Pacific Ocean was available, i.e., 2013. Because many of the data sets the NMFS uses are not available for the Central Valley, the CAMP analyses focused on the following four data sets to characterize ocean conditions:

1. Sea surface temperatures,
2. Coastal upwelling anomalies,
3. Pacific Decadal Oscillation, and
4. Oceanic Niño Index.

The data compilation procedures for each of these environmental parameters are described below.

Sea surface temperatures: to model the effect of sea surface temperature (SST) on the survival of juvenile Central Valley Chinook salmon, NMFS buoy data were used. The NMFS's Bodega Bay buoy (Station 46013) 77 nautical kilometers North Northwest of San Francisco was chosen to characterize the SST for Central Valley juvenile salmon because that buoy's location most closely approximates the geographic distribution of Central Valley juvenile salmon in the ocean. Annual data files for the Bodega Bay buoy were downloaded from http://www.ndbc.noaa.gov/station_history.php?station=46013, and those files were then combined in an Access database. Anomalous SST values with a value of "99" or "999" and duplicate SST values with the same date/time value were deleted from the SST data set prior to data summarization.

Peterson et al. (2013) use an Excel spreadsheet pivot table to develop annual mean SSTs using the months of May, June, July, and September each year. As that data synthesis occurs, the pivot table calculates the daily average SSTs for each day, then calculates the monthly averages based on the daily averages, then uses the May, June, July, and September averages to calculate the May-September SST average. The CAMP did not adopt this approach because the process of using daily averages to calculate the monthly averages can create rounding errors in the compiled data and it distorts the SST data when data are not collected in each hour of each month. Therefore, the CAMP did not calculate mean daily SSTs, and instead used an Access database query to calculate meanly monthly SSTs using all the data that were recorded by the buoy in a given month. The CAMP then used the year-specific May, June, July, and September averages to calculate the May-September SST average for each year between 1992 and 2013.

Coastal upwelling anomalies: data for the coastal upwelling anomalies were obtained from http://upwell.pfeg.noaa.gov/products/PFELData/upwell/monthly/upindex.mon. For each year between 1992 and 2013, the sum of the coastal upwelling anomalies for the months of April and May were calculated using data from a position at 39° North, 125° West. That position is located approximately 110 kilometers west of Point Arena. The data currently available on the Internet are posted in 3 x 3 degree cells, and coastal upwelling anomaly data for a location that is more centrally located between Point Arena and the Golden Gate Bridge where juvenile salmon must pass as they emigrate to the ocean are not available.

Pacific Decadal Oscillation: data for the PDO were obtained from http://jisao.washington.edu/pdo/. For each of the years between 1992 and 2013, the sum of the PDO values for the months May – September were calculated.

Oceanic Niño Index: data for the ONI were obtained from http://www.cpc.noaa.gov/products/analysis_monitoring/ensostuff/ensoyears.shtml. For each of the years between 1992 and 2013, the average ONI for the months January - June was calculated.

After each of the four parameters were calculated for each year between 1992 and 2013, they were assigned a rank value. The highest ranks for the PDO and ONI were assigned to the most negative values and the lowest ranks were assigned to the largest positive numbers. The highest ranks for the SSTs were assigned to the smallest positive values and the lowest ranks were assigned to the largest positive numbers. The highest ranks for the coastal upwelling anomalies were assigned to the largest positive values and the lowest ranks were assigned to the most negative values. An annual rank for each parameter was then assigned to a tertile with a "good", "intermediate", or "poor" category such that good categories were assigned a green color, intermediate categories were assigned a yellow color, and poor categories were assigned a red color. The Mean of Ranks for the four parameters was then calculated and used to calculate and color code a Rank of the Mean Rank that represented a composite of the environmental conditions in the Pacific Ocean in the year that juvenile Chinook salmon emigrated from the Central Valley.

The relationship between environmental conditions when emigrating juvenile salmon reach the ocean, i.e., the Rank of the Mean Rank in year $t+1$, and escapement levels of adult fall-run Chinook salmon to the Sacramento Basin in year $t+3$ was assessed by plotting a linear regression in graph form and evaluating the slope and R Square value of the linear regression.

2.5 METHODS FOR ESTIMATING PRODUCTION OF NON-SALMONID TAXA

2.5.1 METHODS FOR ADULT WHITE AND GREEN STURGEON

The AFRP production target for white sturgeon pertains to the number of 15-year-old white sturgeon in San Pablo and Suisun bays. The process that was used to develop the AFRP's white and green sturgeon production targets is as follows.

Production of white sturgeon in San Pablo and Suisun bays is estimated using mark-recapture data collected by the CDFW. Prior to 2005, the CDFW normally collected mark-recapture data for white sturgeon in two consecutive years, followed by a two year period when mark-recapture data were not collected. Since 2005, the CDFW has conducted white sturgeon surveys every year to develop more robust population estimates during the post-2005 period.

Trammel nets are used to collect the mark-recapture data between August and November. Captured sturgeon are marked with tags that have unique numbers, their length is measured, and they are then released. Subsequent efforts collect marked and unmarked sturgeon and provide data to develop population estimates. A Bailey's modified Peterson model is used to estimate abundance of white sturgeon ≥ 40 inches in total length, irrespective of age. A length-age key provides an estimate of the proportion of the population that is 15-years-old. The estimate of the number of 15-year-old white sturgeon in San Pablo and Suisun bays in a given year is calculated by multiplying annual production estimates of white sturgeon ≥ 40 inches in total length by the corresponding estimated fraction of the population that is 15-years-old.

Trammel net surveys in San Pablo and Suisun bays can also be used to monitor the abundance of green sturgeon. As surveys for white sturgeon are conducted, the numbers of green sturgeon that are incidentally caught is also tabulated. Production of green sturgeon in a given year is calculated by dividing the annual production estimate of white sturgeon ≥ 40 inches in total length by the ratio of white sturgeon to green sturgeon caught that year, i.e., abundance of green sturgeon ≥ 40 inches in length = abundance of white sturgeon ≥ 40 inches in length * (number of captured green sturgeon ≥ 40 inches in length / number of captured white sturgeon ≥ 40 inches in length). The estimate of green sturgeon production is therefore indexed to the total production of white sturgeon ≥ 40 inches in total length, and is not related to the estimated number of 15-year-old white sturgeon.

This report uses the following CDFW spreadsheets to develop white sturgeon production estimates: (1) a "CUMPOP_MD2a.xls" file dated March 13, 2007; (2) a "WSTALKEY.xls" file dated December 22, 2006; and (3) a "Stu Data for Doug Threloff 121611.xls" file dated December 16, 2011. The CDFW spreadsheets that provided length-frequency information used to develop population estimates for green sturgeon include: (1) a "WST_length_1990-2006.xls" file dated June 6, 2007; (2) a "Qry_Length_GST_ALL.xls" file dated June 1, 2007; and (3) a "Stu Data for Doug Threloff 121611.xls" file dated December 16, 2011.

Sturgeon abundance estimates between 2006 and 2009 are preliminary and subject to change as new monitoring data become available to update the preliminary estimates.

2.5.2 METHODS FOR JUVENILE AMERICAN SHAD

Unlike the other seven fish taxa described in this report, changes in the abundance of American shad are indexed to a juvenile, i.e., young-of-the-year (YOY), age class instead of an adult age class. The Fall Midwater Trawl (FMWT) survey provides data to estimate the juvenile abundance index for American shad.

The CDFW conducts the FMWT survey four months each year, i.e., in September, October, November, and December. The CDFW did not conduct FMWT surveys in 1974, September and December of 1976, and 1979. CDFW has extrapolated an index for each month in 1976 based on the months that were actually sampled in that year.

The FMWT survey is conducted in a region encompassing the Sacramento-San Joaquin River Delta, San Pablo Bay, and Suisun Bay. Within this region, the FMWT surveys are conducted in 17 different areas. Within these 17 areas, a series of 100 "core index stations" exist. The core index stations used to estimate the juvenile American shad abundance index in this report are 303, 305-316, 321-340, 401-418, 501-519, 601-608, 701-711, 802, 804, 806-815, and 901-915.

For each month when the FMWT survey is conducted, catches of American shad within each area are summed and an average catch per tow is calculated. The average catch per tow for each area is then weighted by the water volume (thousands of acre feet) in that area. The weighted catches are summed over all areas. This sum is the monthly survey index and it includes American shad of all ages (YOY, 1-, 2-, and 3-year old fish), although the vast majority of the captured shad are in the YOY age class. The indices from the four monthly surveys are summed to develop an annual index.

As American shad are collected during the FMWT survey, the lengths of the first 50 shad caught at each index station are measured. The length frequency of the measured shad is then expanded to the total catch to develop adjusted length frequencies. These data are then used to determine the proportion of shad less than 1-year old, i.e., fish that are in the YOY age class.

Because the AFRP production target for American shad is limited to the YOY abundance index, the CAMP has prorated the CDFW's all-ages abundance index by the proportion of fish in the YOY age class. Text in Appendix C provides additional information on the procedure to transform the annual all-ages abundance index to an index limited to the YOY age class. The 2007 and 2008 CAMP annual reports did not rely on a length frequency correction factor to transform CDFW's all-ages abundance index to the number of juvenile shad in the YOY age class. Since the 2009 CAMP annual report was produced, the CAMP has used a length frequency correction factor to calculate the number of shad in the YOY age class after 1992 because this factor adjusts for instances when every shad in a trawl was not measured for length; this length frequency correction factor is likely to lead to more accurate estimations of the number of YOY American shad caught each year (D. Contreras, CDFW, pers. comm.).
The raw data used to develop American shad production estimates in this report are contained in two references that were provided by Steven Slater of the CDFW on May 23, 2014:
(1) a "FMWT AMS Indices 1967-2013.xls" spreadsheet; and (2) an "AMS Length Frequency 1971-2013.xls" spreadsheet.

2.5.3 METHODS FOR ADULT STRIPED BASS

The CDFW monitors abundance of "legal-size" striped bass in anadromous waters in the Central Valley. "Legal-size" refers to the minimum length of striped bass that anglers can legally harvest, per the fishing regulations determined by the CDFW. The length of legal-size fish has changed over time. Prior to 1982, legal-size striped bass were considered to be 16 or more inches in length. From 1982 to the present time, legal-size striped bass have been considered to be 18 or more inches in length.

A mark-recapture technique is used to monitor abundance of legal-size striped bass. The CDFW uses gill nets and/or fyke traps to collect striped bass from early April to as late as mid-June. These collections usually occur each year. Nets and traps collect striped bass between Broad Slough and Colusa on the Sacramento River and between Broad Slough and Venice Island on the San Joaquin River. As striped bass are collected they were measured, tagged with individually numbered disc-dangler tags, and released. The CDFW conducts creel surveys on a year-round basis each year to monitor the number and proportion of marked and unmarked striped bass. These creel censuses occur between the Pacific Ocean and Colusa on the Sacramento River, and between the Pacific Ocean and Mossdale on the San Joaquin River. A Bailey's modified Peterson model is used to estimate production of adult striped bass based on the mark-recapture data.

The pre-2010 striped bass abundance estimates provided in this report are based on the above-mentioned mark-recapture data and the Bailey's modified Peterson model. The 2010, 2011, and 2012 striped bass abundance estimates in this report are predicted values based on a linear regression equation that reflects catch per unit effort (CPUE) and striped bass abundance estimates developed with the mark-recapture data. The CPUE data has been collected from commercial passenger fishing vessels (i.e., "party boats") since 1980 and through the present day. Striped bass abundance estimates between 2007 and 2011 are preliminary and subject to change as new monitoring data become available to update the preliminary estimates, and previous estimates based on the linear regression equation are replaced with estimates using the mark-recapture model.

A "SBAbundance 100313.xls" spreadsheet provides the striped bass production estimates summarized in this report. That spreadsheet was sent to the CAMP by Jason DuBois of the CDFW on October 3, 2013.

SECTION 3: RESULTS

3.1 PRODUCTION ESTIMATES FOR ADULT CHINOOK SALMON

Because adult Chinook salmon data collected in 2012 and 2013 are subject to revision and refinement, salmon production estimates and any analyses for these years should be considered provisional. Annual production estimates for individual watersheds, runs, and the Central Valley are tabulated in Appendix B. The presence of a fish hatchery in a watershed confounds the ability to monitor natural production of Chinook salmon because it is not always possible to accurately discriminate between, and therefore count, wild salmon and unmarked hatchery salmon.

3.1.1 PRODUCTION ESTIMATES FOR INDIVIDUAL WATERSHEDS

3.1.1.1 AMERICAN RIVER

The Nimbus Fish Hatchery is located on the American River. It produces fall-run Chinook salmon.

Estimates of natural production of adult fall-run Chinook salmon from the American River between 1992 and 2013 are presented in Table 3 and Figure 4. The AFRP production target for fall-run Chinook salmon from the American River is 160,000 salmon. Estimated natural production of this run of Chinook salmon from this watershed exceeded the AFRP production target six times between 1992 and 2013.

3.1.1.2 ANTELOPE CREEK

Estimates of natural production of adult fall-run Chinook salmon from Antelope Creek between 1992 and 2013 are presented in Table 3. The AFRP production target for fall-run Chinook salmon from Antelope Creek is 720 salmon. Monitoring data that can be used to estimate the production of fall-run Chinook salmon from Antelope Creek have only been collected in one year between 1992 and 2013. In 1992, 0 adult fall-run Chinook salmon were observed in Antelope Creek, and the AFRP production target of 720 salmon therefore was not met.

3.1.1.3 BATTLE CREEK

The Coleman National Fish Hatchery is located on Battle Creek. It produces fall- and late-fall-run Chinook salmon.

Estimates of natural production of adult fall-run Chinook salmon from Battle Creek between 1992 and 2013 are presented in Table 3 and Figure 4. The AFRP production target for fall-run Chinook salmon from Battle Creek is 10,000 salmon. Estimated natural production of this run of Chinook salmon from this watershed exceeded the AFRP production target 14 times between 1992 and 2013.

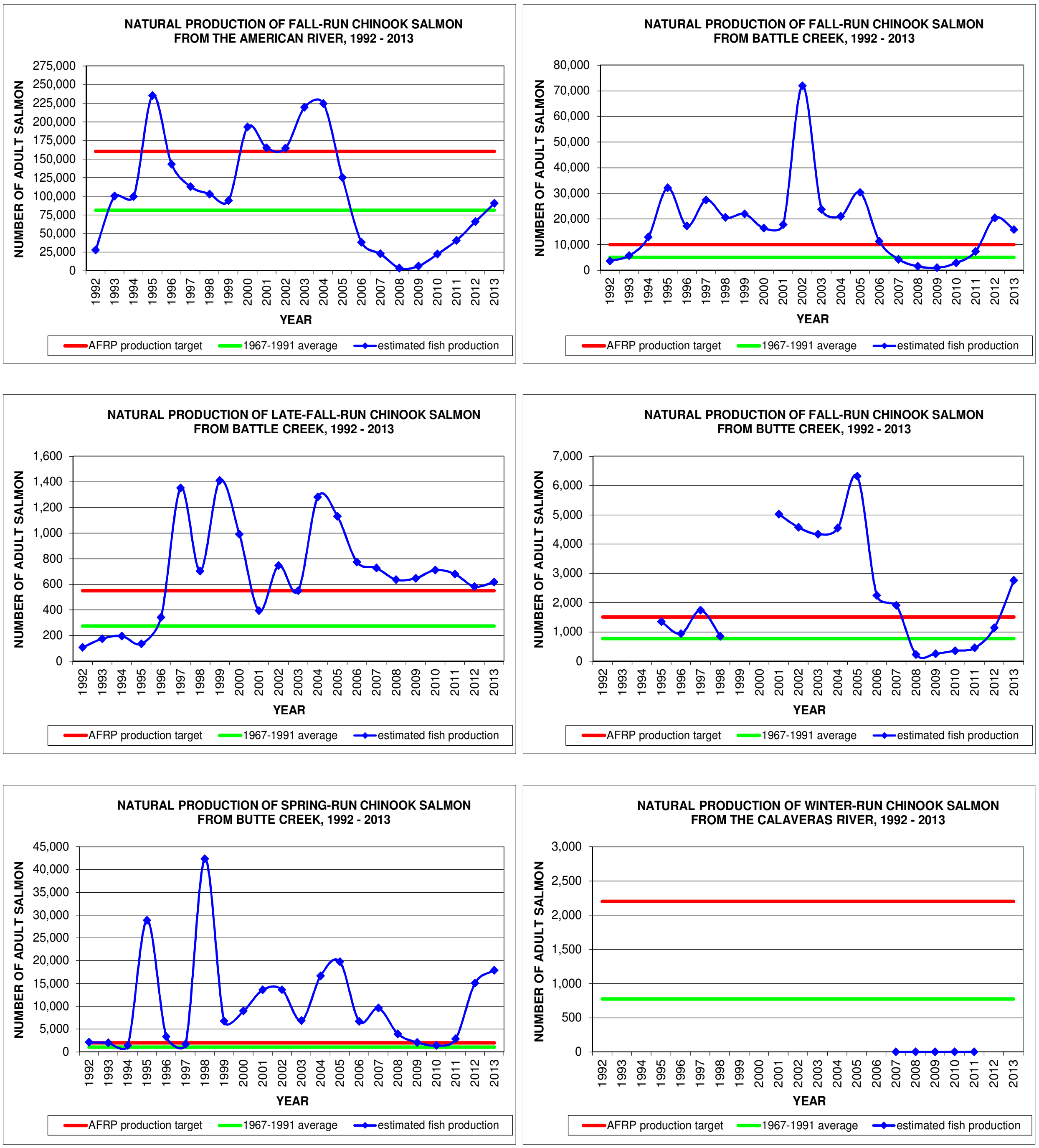
Table 3. Estimated natural production of adult fall-, late-fall-, winter-, and spring-run Chinook salmon from 22 watersheds in the Central Valley, 1992-2013. Blank cells represent years when data were not collected for a particular run and location.

Taxa	**AFRP production target**	**YEAR**																					
		1992	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**
Fall-run Chinook salmon																							
American River	160,000	27,618	100,028	99,415	235,027	143,005	112,797	102,859	94,113	192,719	164,912	164,608	219,322	224,190	124,868	38,276	22,566	3,448	6,052	22,166	40,411	65,693	90,426
Antelope Creek	720	0																					
Battle Creek	10,000	3,588	5,648	12,897	32,060	17,191	27,365	20,539	21,916	16,341	17,756	71,890	23,750	20,993	30,302	11,250	4,197	1,493	920	2,813	7,322	20,396	15,790
Bear River	450																						
Big Chico Creek	800																						
Butte Creek	1,500				1,346	931	1,736	841			5,019	4,565	4,333	4,538	6,312	2,238	1,897	220	245	349	445	1,131	2,754
Clear Creek	7,100	1,358	3,017	6,085	28,704	11,062	18,515	7,127	11,707	11,648	12,322	19,972	11,761	11,492	22,030	9,799	6,445	6,142	2,582	6,779	5,166	10,648	16,665
Cosumnes River	3,300							620	410	1,021		2,113	194	2,731	692	771	146	15	0	872	70	1,864	0
Cottonwood Creek	5,900	3,574															1,940	408	844	1,071	2,289	3,573	3,460
Cow Creek	4,600															4,898	3,171	382	209	505	1,930	2,085	3,759
Deer Creek	1,500		176	737			2,580	449						544	1,418	2,216	874	155	46	156	707	1,222	1,285
Feather River	170,000	74,927	85,238	104,572	181,758	99,824	115,982	25,828	15,468	189,180	188,783	127,696	106,619	111,437	86,975	86,129	35,634	6,512	8,886	50,048	69,763	120,884	182,756
Merced River	18,000	2,396	4,381	9,212	9,652	8,902	8,470	7,335	7,470	24,450	13,196	14,263	4,113	8,365	3,773	1,970	943	419	544	807	2,225	4,505	5,263
Mill Creek	4,200	2,262	4,787	2,568			1,018	903				3,236	3,014	2,171	3,618	1,633	1,323	174	82	136	1,314	1,237	2,752
Miscellaneous Creeks	1,100																214	15	5				
Mokelumne River	9,300	2,781	5,747	5,641	12,769	11,116	16,494	9,037	5,840	9,702	6,836	10,012	9,539	16,178	17,792	5,122	1,771	247	1,340	5,087	14,881	12,660	11,482
Paynes Creek	330																						
Sacramento River	230,000	54,599	84,175	104,713	147,850	117,862	193,147	7,924	176,797	126,217	64,020	61,196	83,102	59,042	63,513	48,416	19,846	14,846	3,496	11,575	9,570	30,061	37,544
Stanislaus River	22,000	695	1,946	2,924	2,241	365	14,424	6,145	7,577	17,671	9,503	11,527	8,753	8,623	2,532	2,671	824	865	595	1,222	1,669	6,665	4,238
Tuolumne River	38,000	362	1,377	1,430	3,056	9,723	18,437	17,777	14,348	37,121	11,886	10,631	3,192	4,287	1,201	778	410	388	124	607	1,134	1,295	2,863
Yuba River	66,000	17,957	20,326	32,458	54,836	65,180	70,035	64,954	44,305	32,618	33,158	37,345	43,954	34,427	32,728	11,818	5,052	3,508	4,635	16,939	11,907	13,375	23,233
Total	750,000	192,117	316,846	382,650	709,299	485,160	601,000	272,337	399,951	658,688	527,391	539,052	521,646	509,017	397,755	227,985	107,253	39,236	30,604	121,132	170,805	297,294	404,269

Table 3 (cont.). Estimated natural production of adult fall-, late-fall-, winter-, and spring-run Chinook salmon from 22 watersheds in the Central Valley, 1992-2013. Blank cells represent years when data were not collected for a particular run and location.

Taxa	**AFRP production target**	**YEAR**																					
		1992	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**
Late-fall run Chinook salmon																							
Battle Creek	550	106	174	195	134	340	1,350	702	1,410	991	392	746	548	1,281	1,131	773	726	635	646	711	678	581	616
Sacramento River	68,000	27,672	2,237	869	630	112		82,325	15,889	18,942	27,363	55,991	8,596	20,063	19,707	14,826	29,782	4,170	3,704	5,149	4,975	5,019	8,221
Total	68,000	27,778	2,411	1,063	764	453	1,350	83,027	17,299	19,933	27,756	56,737	9,144	21,343	20,838	15,600	30,508	4,806	4,350	5,860	5,654	5,600	8,838
Winter-run Chinook salmon																							
Calaveras River	2,200																0	0	0	0	0		
Sacramento River	110,000	3,167	1,060	505	4,284	2,160	2,079	5,680	5,472	2,657	9,938	9,195	10,911	14,862	21,511	19,712	4,142	2,555	4,070	1,534	899	3,804	7,798
Total	110,000	3,167	1,060	505	4,284	2,160	2,079	5,680	5,472	2,657	9,938	9,195	10,911	14,862	21,511	19,712	4,142	2,555	4,070	1,534	899	3,804	7,798
Spring-run Chinook salmon																							
Butte Creek	2,000	2,061	1,968	1,412	28,877	3,311	1,702	42,323	6,716	8,968	13,604	13,630	6,831	16,664	19,742	6,663	9,582	3,935	2,059	1,367	2,839	15,044	17,905
Deer Creek	6,500	590	784	1,444	4,987	1,439	1,249	3,925	2,904	1,387	2,297	3,406	4,285	1,813	4,160	3,539	1,248	140	213	309	361	1,282	1,105
Mill Creek	4,400	669	185	2,154	1,232	593	541	885	1,022	1,185	1,564	2,473	2,215	2,250	2,137	1,458	1,783	381	220	568	488	1,341	1,005
Sacramento River	59,000	1,143	1,291	2,801	1,789	966	374	2,542	522	102	960	330	0	911	60	0	524	52	0	0	0	0	0
Total	68,000	4,463	4,229	7,811	36,884	6,309	3,866	49,676	11,163	11,643	18,424	19,839	13,331	21,638	26,099	11,659	13,138	4,508	2,492	2,244	3,688	17,668	20,015
Total Natural Production of Adult Chinook Salmon		227,524	324,546	392,030	751,231	494,081	608,296	410,720	433,886	692,921	583,510	624,822	555,033	566,861	466,203	274,956	155,041	51,105	41,516	130,769	181,046	324,365	440,920

Figure 4. Estimated natural production of adult Chinook salmon from the American River, Battle Creek, Butte Creek, and Calaveras River, 1992-2013. Each graph provides the watershed's AFRP production target, estimated annual natural production of Chinook salmon between 1992 and 2013, and average natural production of Chinook salmon between 1967 and 1991.



Estimates of natural production of adult late-fall-run Chinook salmon from Battle Creek during the period 1992-2013 are presented in Table 3 and Figure 4. The AFRP production target for adult late-fall-run Chinook salmon from Battle Creek is 550 salmon. Estimated natural production of this run of Chinook salmon from this watershed may have exceeded the AFRP production target 15 times between 1992 and 2013.

The inference of the number of times the AFRP production target for late-fall-run Chinook salmon from Battle Creek is confounded by multiple factors. First, the Chinookprod spreadsheet used to develop production estimates relies solely on counts of adult (and predominantly hatchery-origin) salmon returning to the hatchery and in-river escapement estimates of wild salmon are not available. There are, therefore, no definitive monitoring data to infer what the natural production of adult late-fall-run Chinook salmon from Battle Creek has been. Second, a relatively small number (i.e., 19-216) of wild late-fall-run salmon entered Coleman National Fish Hatchery between 2000 and 2013 and were released upstream of the hatchery, thereby contributing to natural in-river escapement. These fish have been accounted for in the Chinookprod and GrandTab spreadsheets and are used to calculate and track natural production. Third, because the management practices for hatchery-origin late-fall-run Chinook salmon have improved since 1996, the number of hatchery-produced late-fall-run Chinook salmon has increased since that time.

3.1.1.4 BEAR RIVER

Monitoring data that can be used to estimate the production of fall-run Chinook salmon from Bear River have not been collected in any year between 1992 and 2013. It is therefore not possible to determine if the AFRP production target of 450 salmon was met in this watershed during that period.

3.1.1.5 BIG CHICO CREEK

Monitoring data that can be used to estimate the production of fall-run Chinook salmon from Big Chico Creek have not been collected in any year between 1992 and 2013. It is therefore not possible to determine if the AFRP production target of 800 salmon was met in this watershed during that period.

3.1.1.6 BUTTE CREEK

Estimates of natural production of adult fall-run Chinook salmon from Butte Creek between 1992 and 2013 are presented in Table 3 and Figure 4. Estimates of natural production are not available for 1992, 1993, 1994, 1999, and 2000. The AFRP production target for fall-run Chinook salmon from Butte Creek is 1,500 salmon. Estimated natural production of this run of Chinook salmon from this watershed exceeded the AFRP production target nine times in the 17 years when monitoring data were collected between 1992 and 2013.

Estimates of natural production of adult spring-run Chinook salmon from Butte Creek between 1992 and 2013 are presented in Table 3 and Figure 4. The AFRP production target for spring-run Chinook salmon from Butte Creek is 2,000 salmon. Estimated natural production of this run of Chinook salmon from that watershed exceeded the AFRP production target 18 times between 1992 and 2013.

3.1.1.7 CALAVERAS RIVER

Estimates of natural production of adult winter-run Chinook salmon from Calaveras River between 1992 and 2013 are presented in Table 3 and Figure 4. The AFRP production target for winter-run Chinook salmon from the Calaveras River is 2,200 salmon. Since 1992, surveys for winter-run Chinook salmon from the Calaveras River were conducted in 2007, 2008, 2009, 2010, and 2011. In each of those years, no winter-run Chinook salmon were detected, i.e., the AFRP production target for winter-run Chinook salmon from the Calaveras River was not met in any of the five years when surveys were done since 1992. The absence of winter-run Chinook salmon in the Calaveras River during recent surveys may not be unusual, given that Yoshiyama et al. (2001) suggested winter-run Chinook salmon may not have existed in the Calaveras River. The putative winter-run fish observed from 1972-1984 may actually have been a late-fall-run attracted to the river when flows were released in late winter and spring by New Hogan Dam.

3.1.1.8 CLEAR CREEK

Estimates of natural production of adult fall-run Chinook salmon from Clear Creek between 1992 and 2013 are presented in Table 3 and Figure 5. The AFRP production target for fall-run Chinook salmon from Clear Creek is 7,100 salmon. Estimated natural production of this run of Chinook salmon from that watershed exceeded the AFRP production target 14 times between 1992 and 2013.

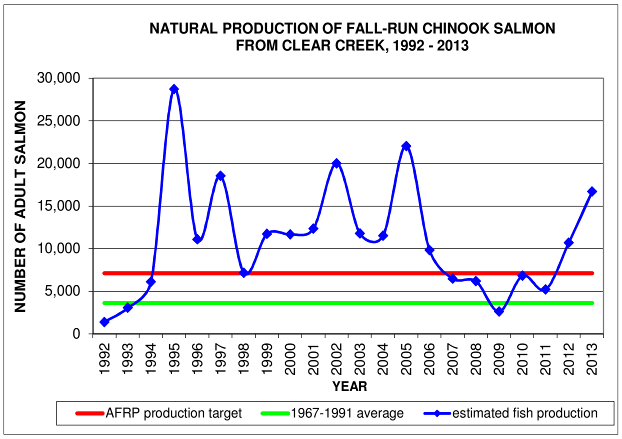
3.1.1.9 COSUMNES RIVER

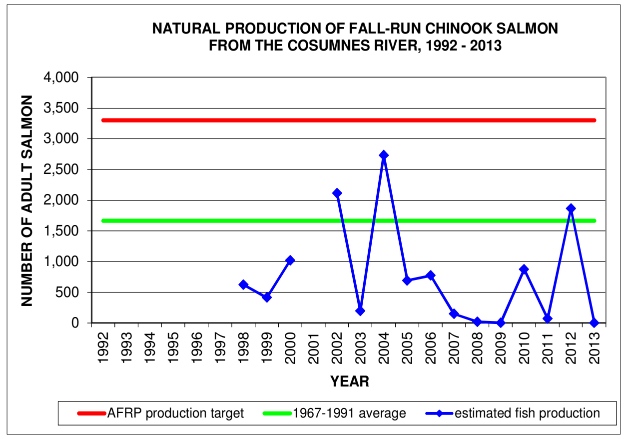
Estimates of natural production of adult fall-run Chinook salmon from Cosumnes River between 1992 and 2013 are presented in Table 3 and Figure 5. The AFRP production target for fall-run Chinook salmon from the Cosumnes River is 3,300 salmon. Monitoring data for Chinook salmon from the Cosumnes River were collected in 15 years of the 22 years since 1991. The production target was not met in any of those 15 years when Chinook salmon surveys were conducted on the Cosumnes River since 1991.

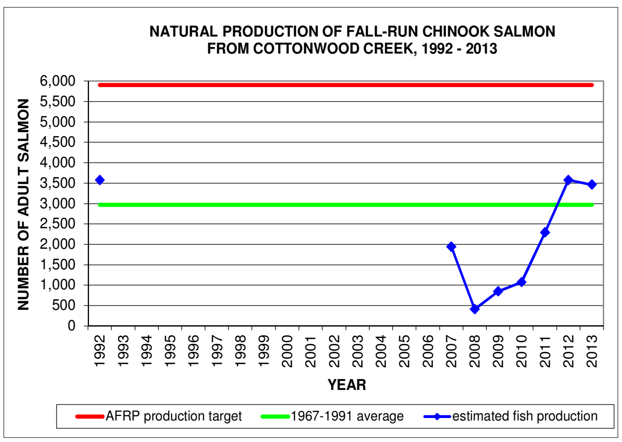
3.1.1.10 COTTONWOOD CREEK

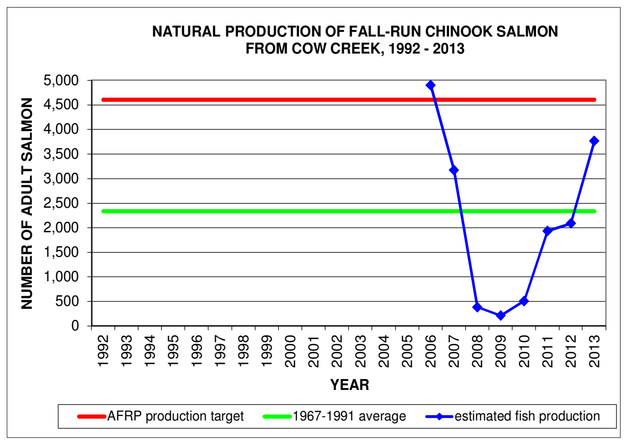
Estimates of natural production of adult fall-run Chinook salmon from Cottonwood Creek between 1992 and 2013 are presented in Table 3 and Figure 5. The AFRP production target for fall-run Chinook salmon from Cottonwood Creek is 5,900 salmon. Monitoring data for Chinook salmon from Cottonwood Creek have only been collected eight times since 1991. The production target was not met in any of the eight years when monitoring data were collected since 1991.

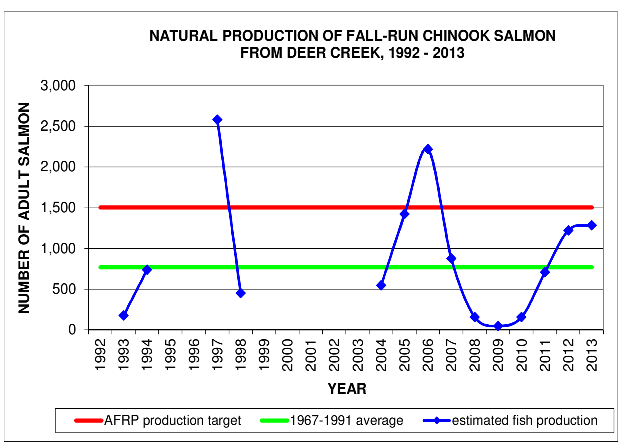
Figure 5. Estimated natural production of adult Chinook salmon from Clear Creek, Cosumnes River, Cottonwood Creek, Cow Creek, and Deer Creek, 1992-2013. Each graph provides the watershed's AFRP production target, estimated annual natural production of Chinook salmon between 1992 and 2013, and average natural production of Chinook salmon between 1967 and 1991.

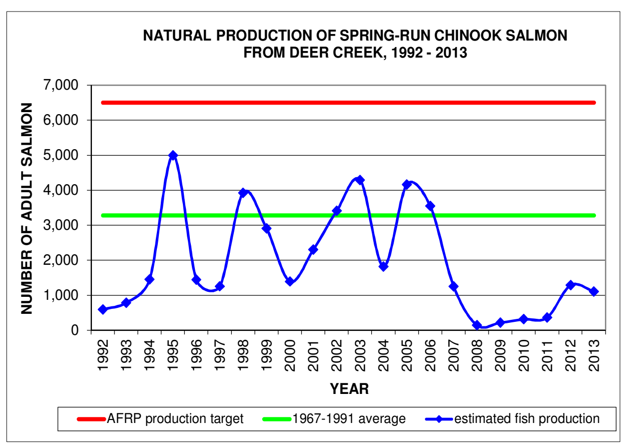












3.1.1.11 COW CREEK

Estimates of natural production of adult fall-run Chinook salmon from Cow Creek between 1992 and 2013 are presented in Table 3 and Figure 5. The AFRP production target for fall-run Chinook salmon from Cow Creek is 4,600 salmon. Monitoring data for Chinook salmon from Cow Creek have only been collected eight times since 1991. The AFRP production target was met in one of the eight years when monitoring data were collected since 1991.

3.1.1.12 DEER CREEK

Estimates of natural production of adult fall-run Chinook salmon from Deer Creek between 1992 and 2013 are presented in Table 3 and Figure 5. The AFRP production target for fall-run Chinook salmon from Deer Creek is 1,500 salmon. Production estimates are not available for 1992, 1995, 1996, 1999, 2000, 2001, 2002, and 2003. Estimated natural production exceeded the AFRP production target twice in the 14 years when monitoring data were collected between 1992 and 2013.

Estimates of natural production of adult spring-run Chinook salmon from Deer Creek between 1992 and 2013 are presented in Table 3 and Figure 5. The AFRP production target for adult spring-run Chinook salmon from Deer Creek is 6,500 salmon. Estimated natural production of adult spring-run Chinook salmon from this watershed never equaled or exceeded the AFRP production target between 1992 and 2013.

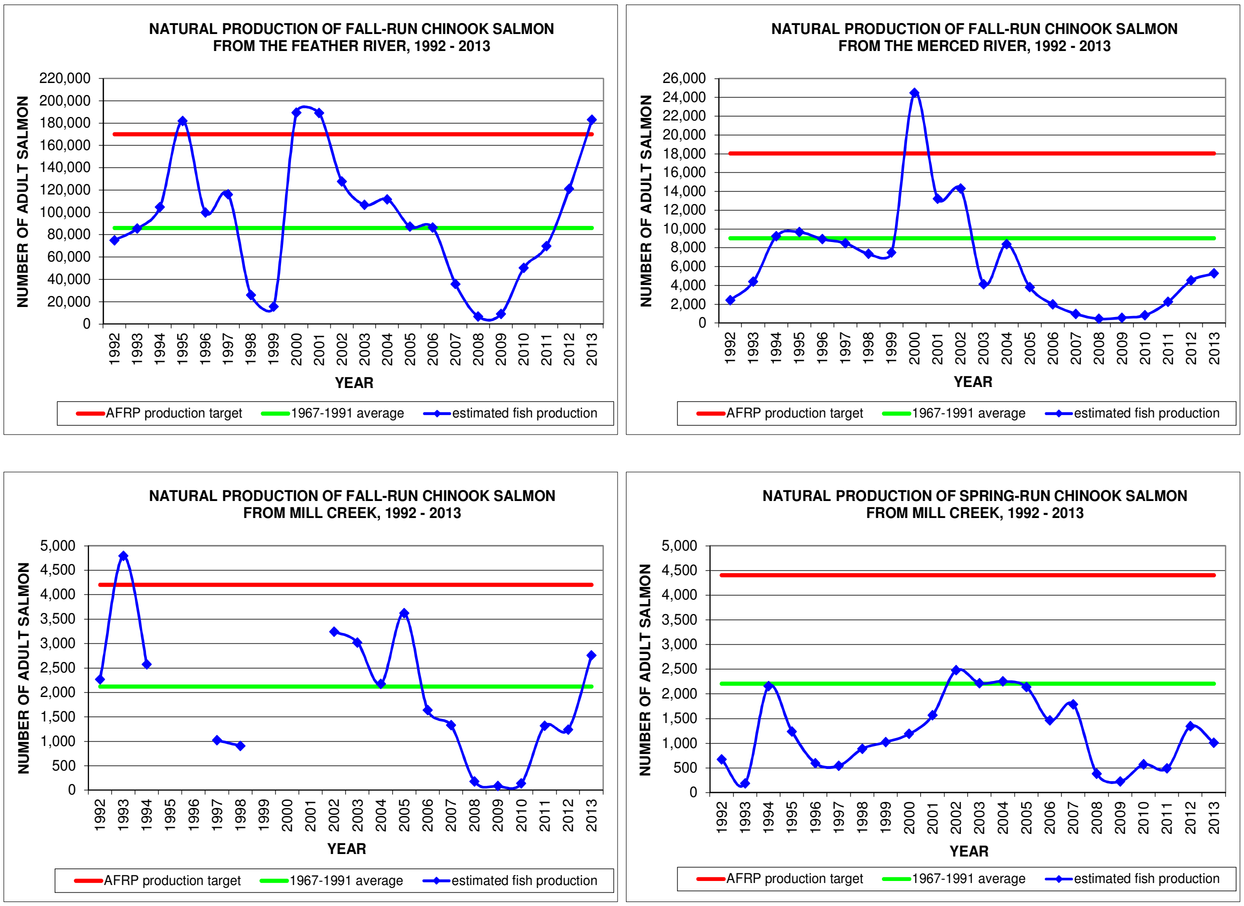
3.1.1.13 FEATHER RIVER

The Feather River Fish Hatchery is located on the Feather River. It produces fall- and spring-run Chinook salmon.

Estimates of natural production of adult fall-run Chinook salmon from the Feather River between 1992 and 2013 are presented in Table 3 and Figure 6. Prior to 2005, estimates of the number of fall-run Chinook salmon that returned to the hatchery included a combination of fall- and spring-run Chinook salmon because no simple method for distinguishing between the two runs existed. Beginning in 2005 and to the present time, spring-run Chinook salmon have been marked with floy tags and released back into the river so they can be distinguished from fall-run Chinook salmon as fall-run salmon return to the hatchery. However, hatchery return numbers used to estimate natural production of fall-run Chinook salmon continue to include some spring-run Chinook salmon; this tends to inflate the fall-run production estimates to some degree because they include some spring-run Chinook salmon. Natural production estimates for 1998 and 1999 are anomalously low because carcass surveys were not used to estimate in-river spawner abundance, and those fish could not therefore be included in natural production estimates.

The AFRP production target for fall-run Chinook salmon from the Feather River is 170,000 salmon. Estimated natural production of adult fall-run Chinook salmon from this watershed equaled or exceeded this AFRP production target four times between 1992 and 2013, i.e., in 1995, 2000, 2001, and 2013.

Figure 6. Estimated natural production of adult Chinook salmon from the Feather River, Merced River, and Mill Creek, 1992-2013. Each graph provides the watershed's AFRP production target, estimated annual natural production of Chinook salmon between 1992 and 2013, and average natural production of Chinook salmon between 1967 and 1991.



3.1.1.14 MERCED RIVER

The Merced River Fish Hatchery is located on the Merced River. It produces fall-run Chinook salmon.

Estimates of natural production of adult fall-run Chinook salmon from the Merced River between 1992 and 2013 are presented in Table 3 and Figure 6. The AFRP production target for adult fall-run Chinook salmon from the Merced River is 18,000 salmon. Estimated natural production equaled or exceeded the AFRP production target once between 1992 and 2013.

3.1.1.15 MILL CREEK

Estimates of natural production of adult fall-run Chinook salmon from Mill Creek between 1992 and 2013 are presented in Table 3 and Figure 6. The AFRP production target for fall-run Chinook salmon from Mill Creek is 4,200 salmon. Monitoring data for fall-run Chinook salmon from Mill Creek were not collected in 1995, 1996, 1999, 2000, and 2001. Estimated natural production exceeded the AFRP production target once in the 17 years when monitoring data were collected since 1991.

Estimates of natural production of adult spring-run Chinook salmon from Mill Creek between 1992 and 2013 are presented in Table 3 and Figure 6. The AFRP production target for spring-run Chinook salmon from Mill Creek is 4,400 salmon. The estimated natural production of these fish from that watershed never equaled or exceeded the AFRP production target between 1992 and 2013.

3.1.1.16 MISCELLANEOUS CREEKS

The AFRP fish production target for the Miscellaneous Creeks includes the combined production from seven watersheds above the Red Bluff Diversion Dam. These watersheds are Spring Gulch, China Gulch, Olney Creek, Ash Creek, Stillwater Creek, Inks Creek, and Bear Creek (Rick Burmester, AFRP, pers. comm.). The combined production target for these watersheds only pertains to fall-run Chinook salmon. Between 1992 and 2006, the abundance of Chinook salmon was not monitored in any of the seven Miscellaneous Creeks. In 2007, 2008, and 2009, the only Miscellaneous Creek above the Red Bluff Diversion Dam where monitoring for Chinook salmon took place was Bear Creek. Monitoring did not occur in any of the Miscellaneous Creeks in 2010 or 2011.

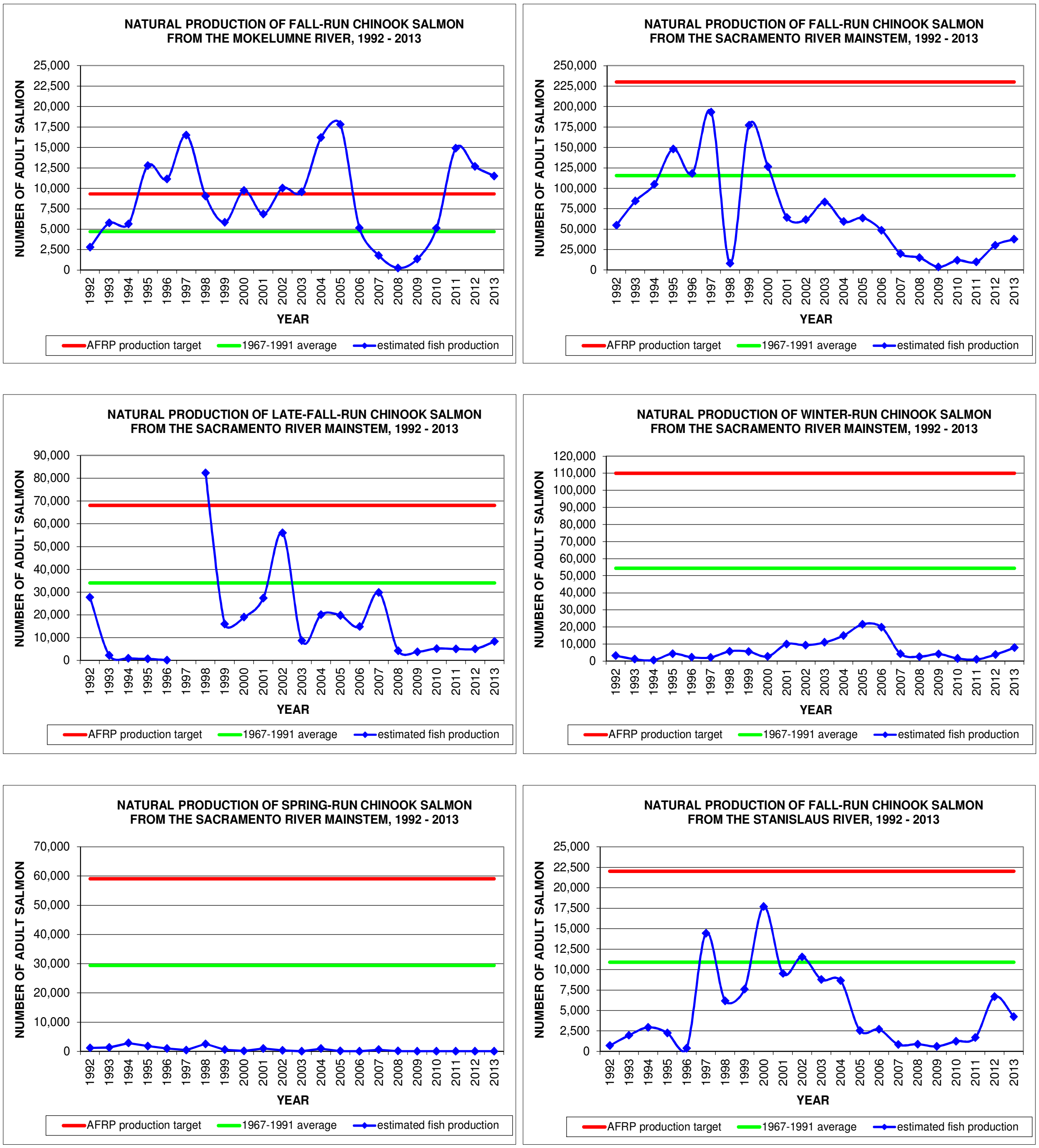
Estimates of the natural production of adult fall-run Chinook salmon from the one Miscellaneous Creek where monitoring took place between 1992 and 2011, i.e., Bear Creek, are presented in Table 3. A figure depicting the estimated production for the Miscellaneous Creeks is not presented in this report because six of the seven creeks were not monitored between 1992 and 2013. The AFRP production target for fall-run Chinook salmon from the seven Miscellaneous Creeks above the Red Bluff Diversion Dam is 1,100 salmon. The natural production of fall-run Chinook salmon from the only Miscellaneous Creek that was monitored between 1992 and 2013 did not exceed the AFRP Miscellaneous Creek production target in any of the three years when monitoring data were collected.

3.1.1.17 MOKELUMNE RIVER

The Mokelumne River Fish Hatchery is located on the Mokelumne River. It produces fall-run Chinook salmon.

Estimates of natural production of adult fall-run Chinook salmon from the Mokelumne River between 1992 and 2013 are presented in Table 3 and Figure 7. The AFRP production target for fall-run Chinook salmon on the Mokelumne River is 9,300 salmon. Estimated natural production equaled or exceeded this AFRP production target 11 times between 1992 and 2013.

Figure 7. Estimated natural production of adult Chinook salmon from the Mokelumne River, Sacramento River, and Stanislaus River, 1992-2013. Each graph provides the watershed's AFRP production target, estimated annual natural production of Chinook salmon between 1992 and 2013, and average natural production of Chinook salmon between 1967 and 1991.



3.1.1.18 PAYNES CREEK

Monitoring data that can be used to estimate the production of fall-run Chinook salmon from Paynes Creek were not collected in any of the years between 1992 and 2013. It is therefore not possible to determine if the AFRP production target of 330 salmon was met in this watershed during that period.

3.1.1.19 SACRAMENTO RIVER MAINSTEM

The Livingston Stone National Fish Hatchery is located on the Sacramento River mainstem just below Shasta Dam. It produces winter-run Chinook salmon.

Estimates of natural production of adult fall-run Chinook salmon from the Sacramento River mainstem between 1992 and 2013 are presented in Table 3 and Figure 7. The AFRP production target for fall-run Chinook salmon from the Sacramento River is 230,000 salmon. Estimated natural production of this run of Chinook salmon from that watershed never equaled or exceeded the AFRP production target between 1992 and 2013.

Estimates of natural production of adult late-fall-run Chinook salmon between 1992 and 2013 are presented in Table 3 and Figure 7. Monitoring data for this salmon run and watershed were not collected in 1997. The AFRP production target for late-fall-run Chinook salmon from the Sacramento River is 68,000 salmon. Estimated natural production of this run of Chinook salmon from that watershed exceeded the AFRP production target once in the 21 years when monitoring data were collected between 1992 and 2013.

Estimates of natural production of adult winter-run Chinook salmon from the Sacramento River mainstem between 1992 and 2013 are presented in Table 3 and Figure 7. The AFRP production target for winter-run Chinook salmon from the Sacramento River is 110,000 salmon. Estimated natural production of this run of Chinook salmon from that watershed never equaled or exceeded the AFRP production target between 1992 and 2013.

Estimates of natural production of adult spring-run Chinook salmon from the Sacramento River mainstem between 1992 and 2013 are presented in Table 3 and Figure 7. The AFRP production target for spring-run Chinook salmon from the Sacramento River is 59,000 salmon. Escapement estimates for this run in the watershed in 2003, 2006, 2009, 2010, and 2011 were zero because no spring-run Chinook salmon were known to spawn in the Sacramento River mainstem during those years. Since there is no hatchery for spring-run Chinook salmon in this watershed, the formulas in the Chinookprod spreadsheet used to estimate natural production generate a zero value for those years. The estimated natural production of adult spring-run Chinook salmon from the Sacramento River mainstem therefore never equaled or exceeded the AFRP production target between 1992 and 2013.

3.1.1.20 STANISLAUS RIVER

Estimates of natural production of adult fall-run Chinook salmon from the Stanislaus River between 1992 and 2013 are presented in Table 3 and Figure 7. The AFRP production target for fall-run Chinook salmon from the Stanislaus River is 22,000 salmon. The estimated natural production of adult fall-run Chinook salmon from this watershed never equaled or exceeded the AFRP production target between 1992 and 2013.

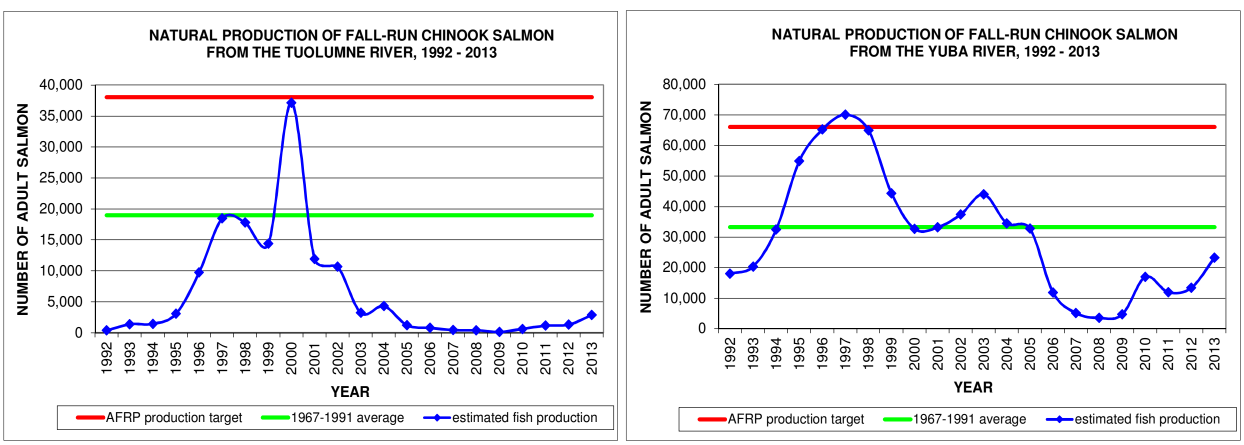
3.1.1.21 TUOLUMNE RIVER

Estimates of natural production of adult fall-run Chinook salmon from the Tuolumne River between 1992 and 2013 are presented in Table 3 and Figure 8. The AFRP production target of fall-run Chinook salmon from the Tuolumne River is 38,000 salmon. Estimated natural production of adult fall-run Chinook salmon from this watershed never equaled or exceeded the AFRP production target between 1992 and 2013.

3.1.1.22 YUBA RIVER

Estimates of natural production of adult fall-run Chinook salmon from the Yuba River between 1992 and 2013 are presented in Table 3 and Figure 8. The AFRP production target of fall-run Chinook salmon from the Yuba River is 66,000 salmon. Estimated natural production of adult fall-run Chinook salmon from this watershed equaled or exceeded the AFRP production target one year between 1992 and 2013, i.e., in 1997.

Figure 8. Estimated natural production of adult Chinook salmon from the Tuolumne River and Yuba River, 1992-2013. Each graph provides the watershed's AFRP production target, estimated annual natural production of Chinook salmon between 1992 and 2013, and average natural production of Chinook salmon between 1967 and 1991.



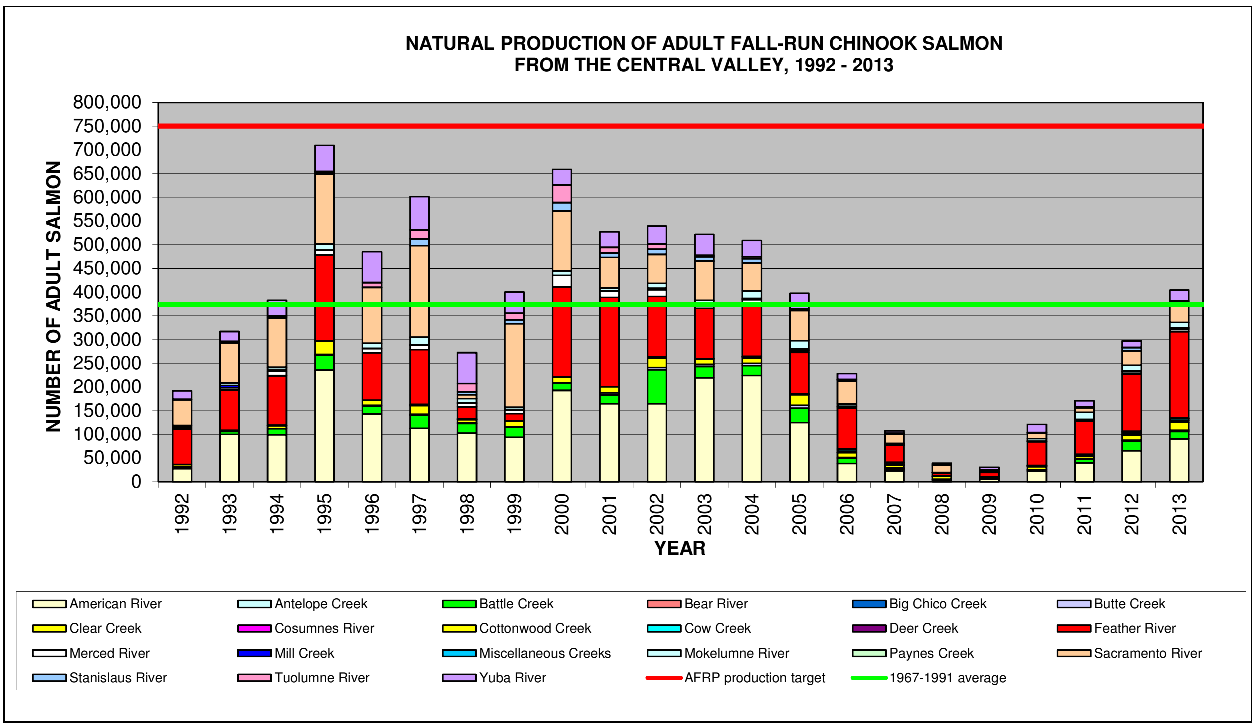
3.1.2 PRODUCTION ESTIMATES FOR INDIVIDUAL RUNS

The production estimates for each of the four Chinook salmon runs only include fish abundance estimates from watersheds and runs having an AFRP fish production target. Therefore, the spring-run production estimates only include fish from Butte Creek, Deer Creek, Mill Creek, and the Sacramento River mainstem, and do not include salmon from other watersheds where spring-run Chinook salmon occur, e.g., Antelope, Battle, Big Chico, Clear, Cottonwood, and Thomes creeks, or the Feather and Yuba rivers.

3.1.2.1 FALL-RUN CHINOOK SALMON

Estimates of the natural production of adult fall-run Chinook salmon from the Central Valley between 1992 and 2013 are presented in Table 3 and Figure 9. The estimates include the combined contributions from the aforementioned 21 watersheds with an AFRP fall-run Chinook salmon production target. The AFRP production target for adult fall-run Chinook salmon from the 21 watersheds in the Central Valley is 750,000 salmon. Salmon surveys in the Central Valley between 1992 and 2013 suggest the combined natural production of adult fall-run Chinook salmon from the 21 watersheds never equaled or exceeded this production target during that period.

Figure 9. Estimated natural production of adult fall-run Chinook salmon from the Central Valley, 1992-2013. Annual estimates of natural production reflect the combined contributions from 21 watersheds. The AFRP fall-run Chinook salmon production target is 750,000 Chinook salmon, and the 1967-1991 baseline average is 374,049 Chinook salmon.

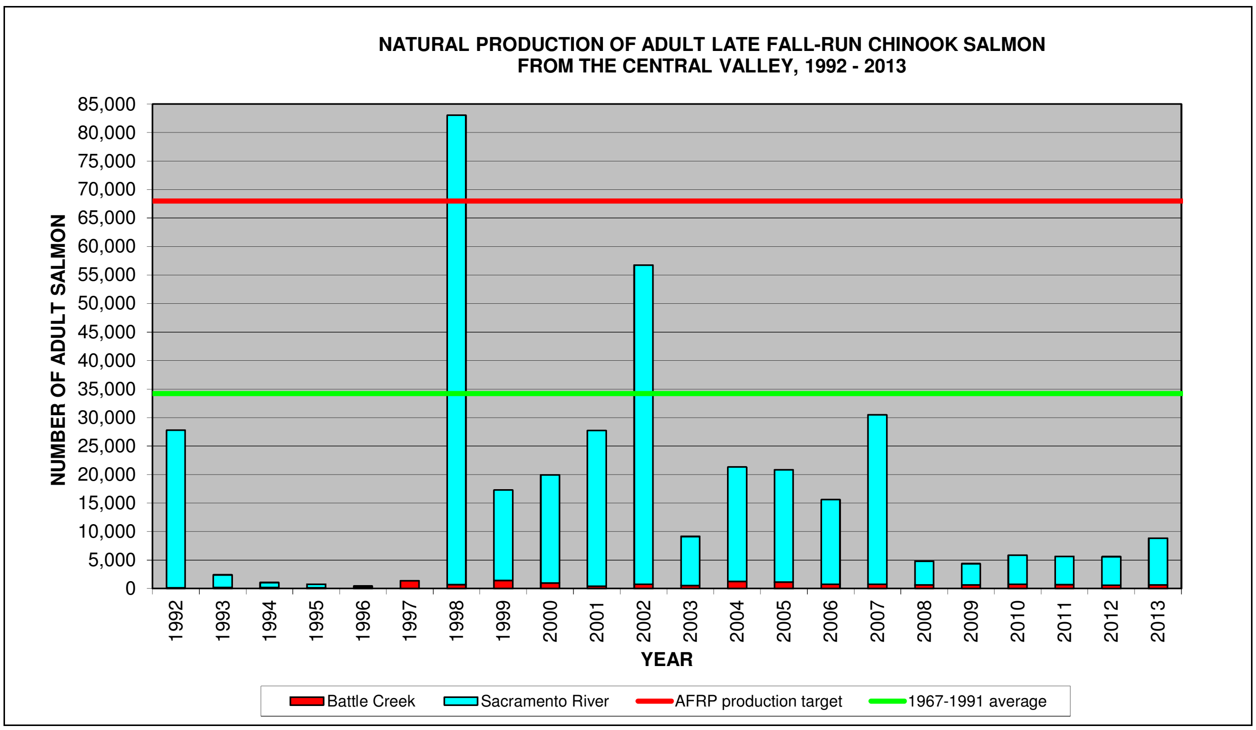


Between 1992 and 2013 and in descending order based on their average annual natural production during this period, the following watersheds consistently contributed the greatest number of fish to the AFRP fall-run Chinook salmon production target: American River, Feather River, Sacramento River mainstem, Yuba River, and Battle Creek.

3.1.2.2 LATE-FALL-RUN CHINOOK SALMON

Estimates of the natural production of adult late-fall-run Chinook salmon from the Central Valley between 1992 and 2013 are presented in Table 3 and Figure 10. These production estimates include the combined contributions from Battle Creek and the Sacramento River mainstem. The AFRP production target for adult late-fall-run Chinook salmon is 68,000 salmon. Fish surveys indicate the combined natural production of adult late-fall-run Chinook salmon from Battle Creek and the Sacramento River mainstem met this production target once during that 22-year period (i.e., in 1998).

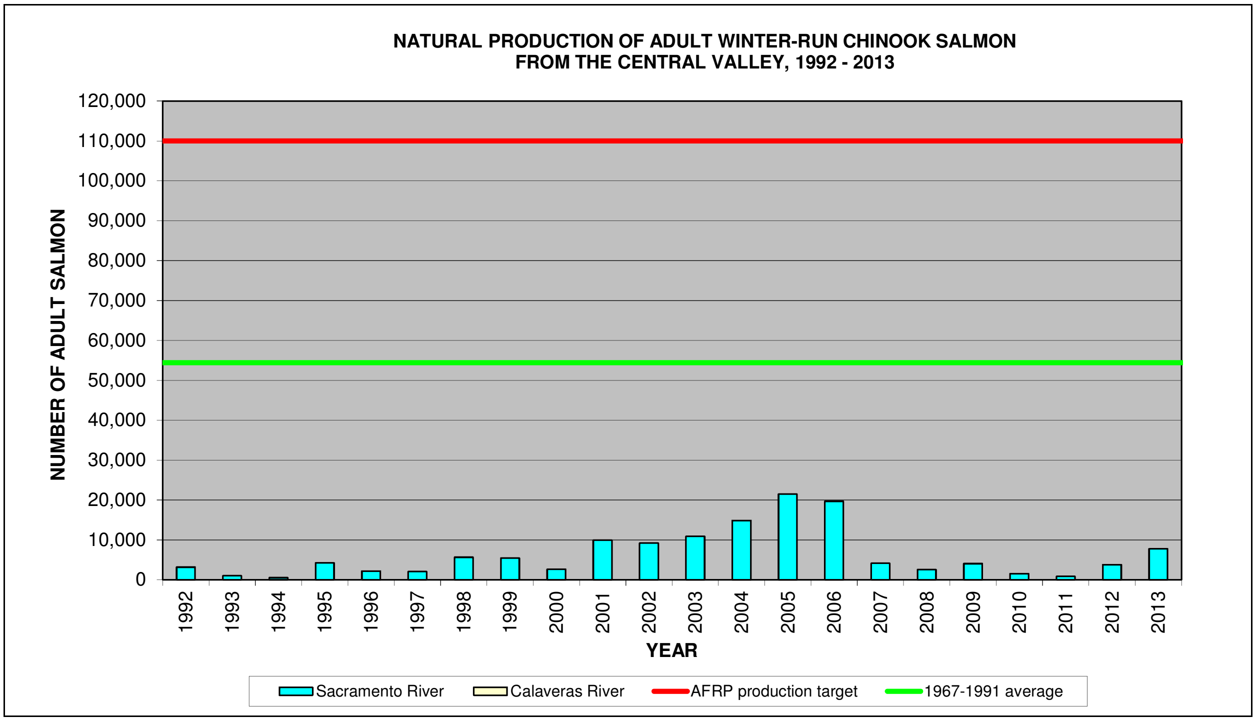
Figure 10. Estimated natural production of adult late-fall-run Chinook salmon from the Central Valley, 1992-2013. Annual estimates reflect the combined contributions from Battle Creek and the Sacramento River mainstem. The AFRP late-fall-run Chinook salmon production target is 68,000 Chinook salmon, and the 1967-1991 baseline average is 34,192 Chinook salmon.



3.1.2.3 WINTER-RUN CHINOOK SALMON

Estimates of the natural production of adult winter-run Chinook salmon from the Central Valley between 1992 and 2013 are presented in Table 3 and Figure 11. These production estimates consist of the combined contributions from the Calaveras River and Sacramento River mainstem. Surveys in the Calaveras River have only been done in five years since 1992, and no winter-run Chinook salmon were detected during those surveys. The AFRP production target for adult winter-run Chinook salmon is 110,000 salmon. Chinook salmon surveys indicate the winter-run Chinook salmon production target between 1992 and 2013 was never met because: (1) the winter-run Chinook salmon production from the Sacramento River mainstem since 1992 has been markedly below the AFRP's winter-run Chinook salmon production target, and (2) the historical winter-run Chinook salmon production from the Calaveras River, if any, was too small to contribute to the AFRP winter-run Chinook salmon production target in a substantial way.

Figure 11. Estimated natural production of adult winter-run Chinook salmon from the Central Valley, 1992-2013. Annual estimates reflect the combined contributions from the Calaveras River and Sacramento River mainstem. The AFRP winter-run Chinook salmon production target is 110,000 Chinook salmon, and the 1967-1991 baseline average is 54,439 Chinook salmon.

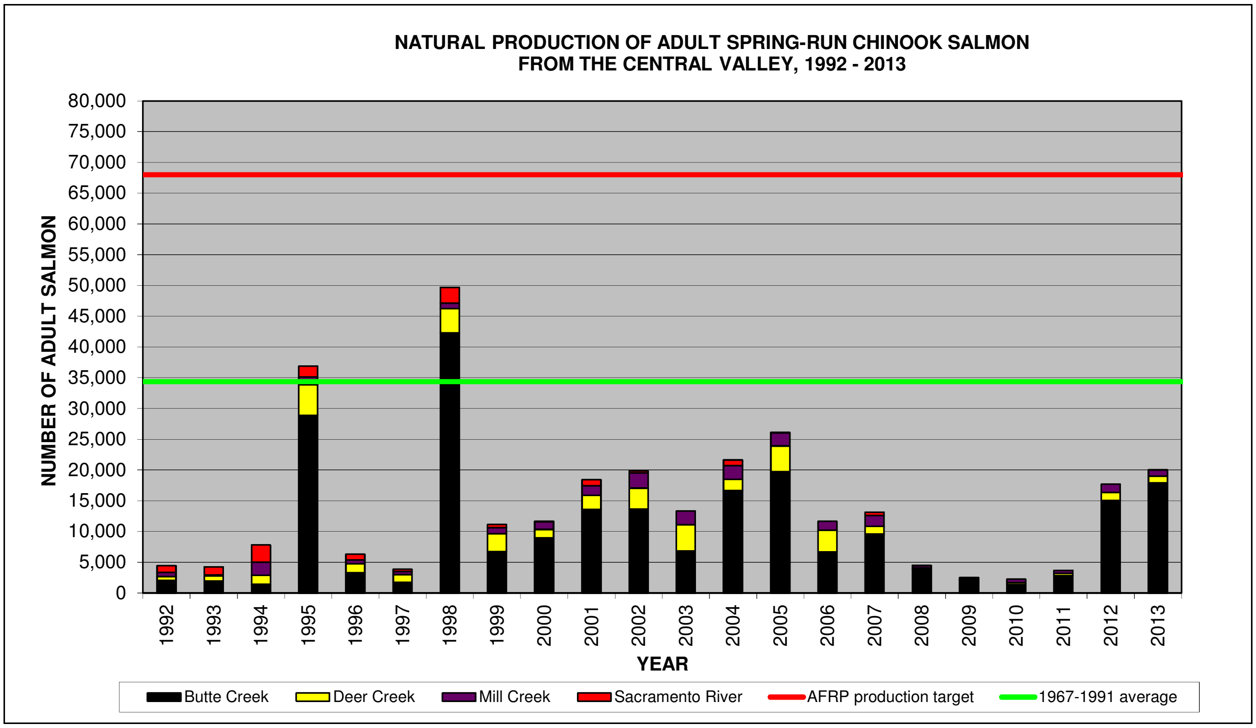


3.1.2.4 SPRING-RUN CHINOOK SALMON

Estimates of the natural production of adult spring-run Chinook salmon in the Central Valley between 1992 and 2013 are presented in Table 3 and Figure 12. The estimates include the combined contributions from Butte Creek, Deer Creek, Mill Creek, and the Sacramento River mainstem. The AFRP production target for adult spring-run Chinook salmon is 68,000 salmon. Surveys between 1992 and 2013 suggest the combined natural production of adult spring-run Chinook salmon from these four watersheds never equaled or exceeded this production target during that period.

Butte Creek has routinely produced as many or more adult spring-run Chinook salmon than the combined total from Deer Creek, Mill Creek, and the Sacramento River mainstem.

Figure 12. Estimated natural production of adult spring-run Chinook salmon from the Central Valley, 1992-2013. Annual estimates reflect the combined contributions from Butte Creek, Deer Creek, Mill Creek, and the Sacramento River mainstem. The AFRP spring-run Chinook salmon production target is 68,000 Chinook salmon, and the 1967-1991 baseline average is 34,374 Chinook salmon.

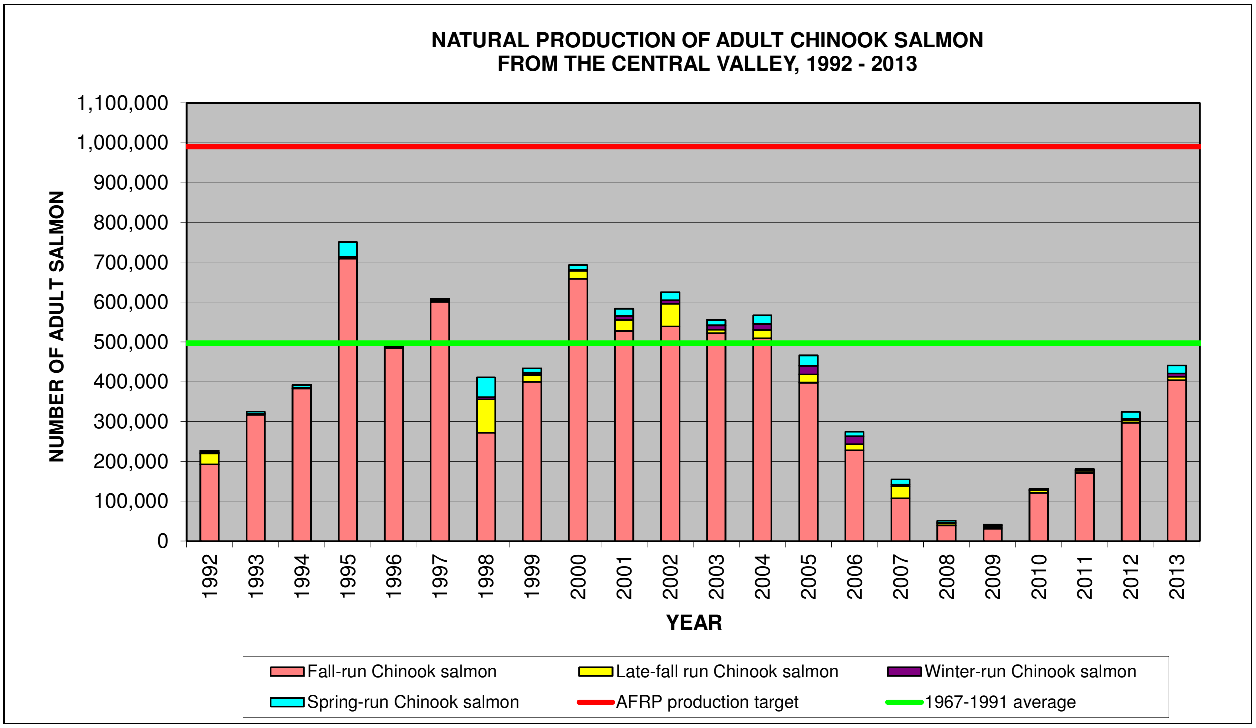


3.1.3 PRODUCTION ESTIMATES FOR THE CENTRAL VALLEY

Estimates of the combined natural production of all four runs of Chinook salmon from the aforementioned 22 watersheds in the Central Valley between 1992 and 2013 are presented in Table 3 and Figure 13. These production estimates only include salmon abundance estimates for watersheds and runs having an AFRP fish production target. For example, the Central Valley-wide production estimates include spring-run Chinook salmon from Butte Creek, Deer Creek, Mill Creek, and the Sacramento River mainstem, but do not include spring-run Chinook salmon from other watersheds where spring-run Chinook salmon escapement estimates are available, e.g., Battle Creek, Big Chico Creek, or the Yuba River. The AFRP Central Valley-wide adult Chinook salmon production target is 990,000 salmon. Chinook salmon surveys on the aforementioned 22 watersheds between 1992 and 2013 suggest this production target was never met during that 22-year period.

During the 22-year period between 1992 and 2013, the average contribution of the number of fall-, late-fall-, winter-, and spring-run Chinook salmon to the Central Valley-wide production target was 91%, 4%, 2%, and 3%, respectively.

Figure 13. Estimated total natural production of adult fall-, late-fall-, winter-, and spring-run Chinook salmon from the Central Valley, 1992-2013. Annual estimates reflect the combined total production of all four runs of Chinook salmon from 22 watersheds. The AFRP Central Valley-wide production target for adult Chinook salmon is 990,000 Chinook salmon, and the 1967-1991 baseline average is 497,054 Chinook salmon.



3.2 POPULATION ASSESSMENTS OF ADULT CHINOOK SALMON

3.2.1. NUMBER OF YEARS AFRP CHINOOK SALMON PRODUCTION TARGETS WERE MET

Annual monitoring data that quantify natural production of adult Chinook salmon in the Central Valley during the 22-year period between 1992 and 2013 suggest:

- No data collection efforts occurred during the 1992-2013 post-baseline period in three of the 22 watersheds having an AFRP fish production target. These watersheds are relatively small and consist of Bear River, Big Chico Creek, and Paynes Creek. Six of the seven Miscellaneous Creeks also have not been surveyed during the post-baseline period.

- Watershed-specific AFRP fall-run Chinook salmon production targets were met six or more times in five of the 21 watersheds with a fall-run Chinook salmon target (Figure 14). These watersheds are: American River, Battle Creek, Butte Creek, Clear Creek, and the Mokelumne River. The watershed-specific AFRP fall-run Chinook salmon production target for the Feather River was met four times. The remaining 15 watersheds with a fall-run Chinook salmon target: (a) met their production targets less than three times during the 22-year post-baseline period, or (b) were not surveyed each year since 1991.

- The watershed-specific AFRP production target for late-fall-run Chinook salmon may have been met 15 times on Battle Creek (Figure 15). The reason the AFRP's late-fall-run Chinook salmon production target for Battle Creek may (or may not) have been met is described in section 3.1.1.3 of this report. In contrast, the watershed-specific production target for late-fall-run Chinook salmon from the Sacramento River mainstem was met once in the 21 years when monitoring data were collected since 1991.

- The watershed-specific AFRP production target for winter-run Chinook salmon was never met on the Sacramento River mainstem (Figure 16). Surveys for winter-run Chinook salmon from the Calaveras River were only conducted in 2007, 2008, 2009, 2010, and 2011. In each of those years, no winter-run Chinook salmon were detected in the Calaveras River, i.e., the AFRP production target for winter-run Chinook salmon from the Calaveras River was not met in any of the five years when surveys were done in the post-baseline period. The absence of winter-run Chinook salmon in the Calaveras River since 1992 may be an artifact of the possible misidentification of salmon that were attributed to that run in 1970s or 1980s.

- The watershed-specific AFRP production target for spring-run Chinook salmon was met 18 times on Butte Creek (Figure 17). In contrast, data suggest the watershed-specific production targets for spring-run Chinook salmon were never met on Deer Creek, Mill Creek, and the Sacramento River mainstem since 1991.

- The run-specific AFRP production targets for fall, winter-, and spring-run Chinook salmon were never met since 1991, and the run-specific AFRP production target for late-fall-run Chinook salmon was met once.

- The Central Valley-wide AFRP production target for the combined total of all four runs of Chinook salmon in 22 watersheds was never met in the post-baseline period.

Figure 14. Number of times watershed-specific AFRP fall-run Chinook salmon production targets were met or exceeded during the 22-year period 1992-2013. Monitoring data are not available each year in the following watersheds and readers should review Table 1 to understand how frequently monitoring was done for Antelope Creek, Butte Creek, Cosumnes River, Cottonwood Creek, Cow Creek, Deer Creek, Mill Creek, and seven Miscellaneous Creeks. Monitoring data were not collected from Bear River, Big Chico Creek, or Paynes Creek between 1992 and 2013.

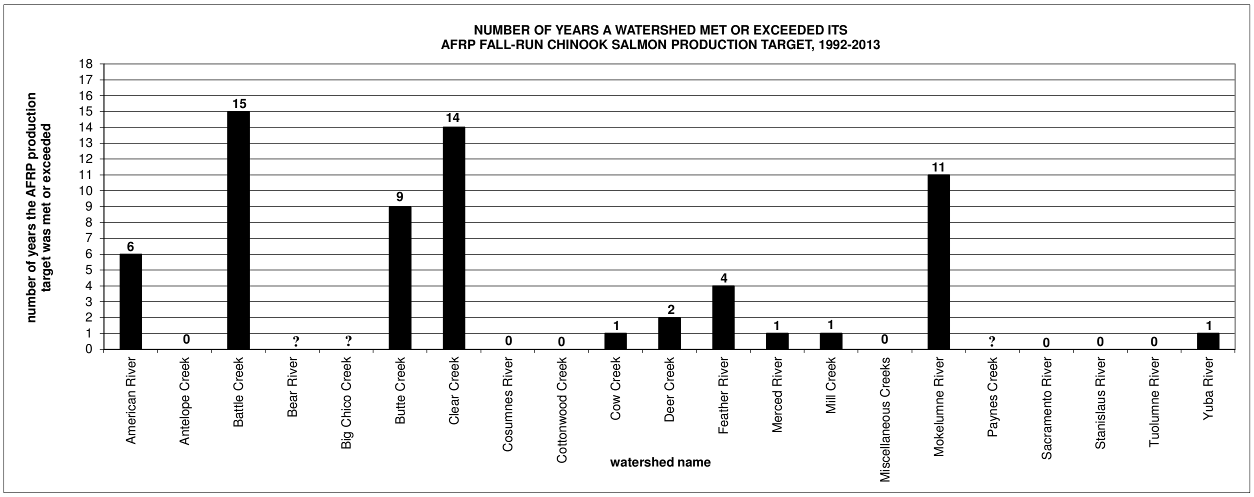


Figure 15. Number of times watershed-specific AFRP late-fall-run Chinook salmon production targets were met or exceeded during the 22-year period 1992-2013. Monitoring data for late-fall-run Chinook salmon from the Sacramento River mainstem were only collected in 21 of the 22 years since 1991.

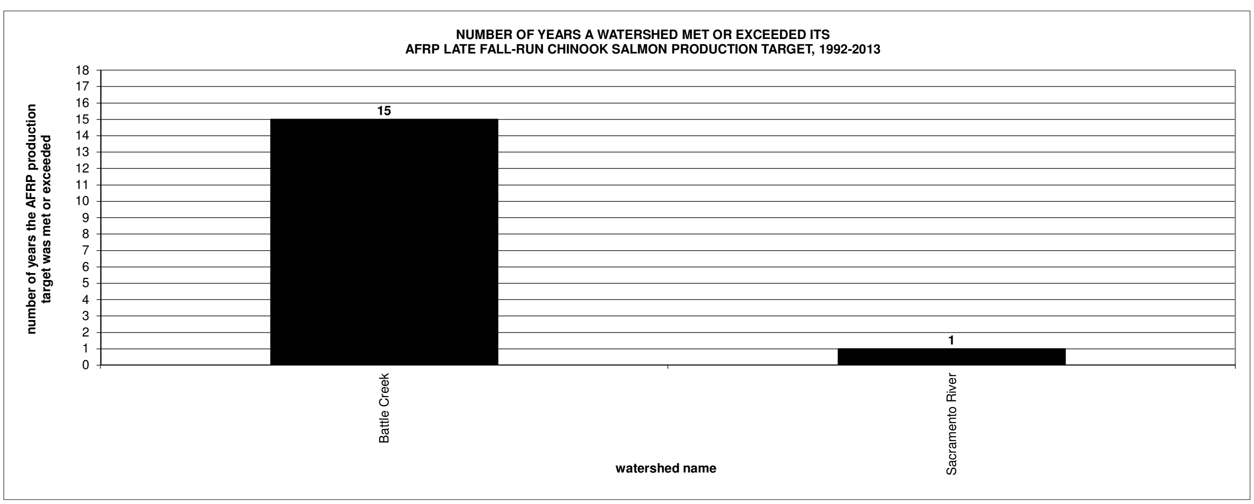


Figure 16. Number of times watershed-specific AFRP winter-run Chinook salmon production targets were met or exceeded during the 22-year period 1992-2013. Monitoring data from the Calaveras River were only collected during five years between 1992 and 2013.

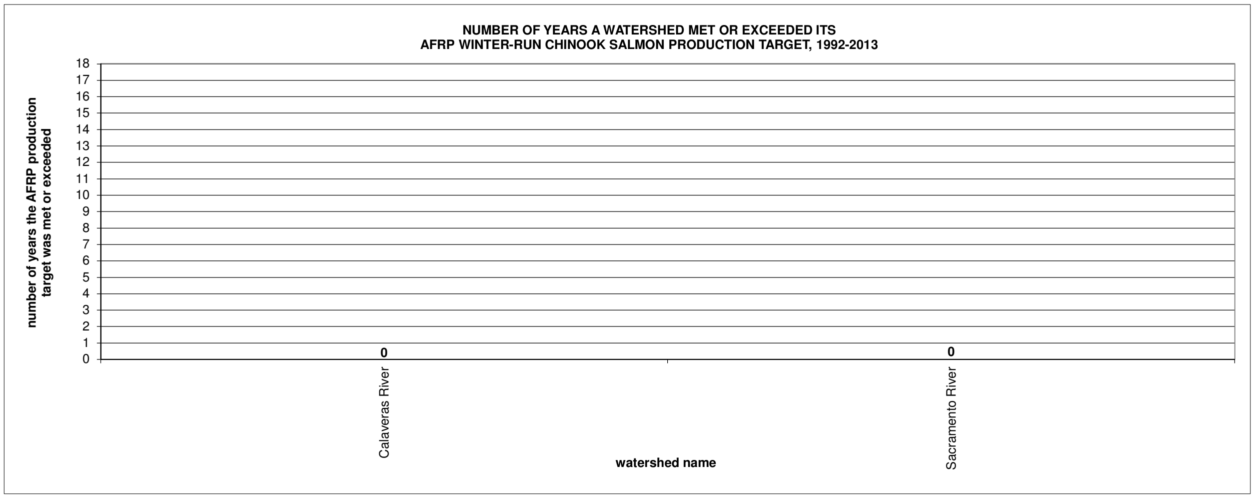
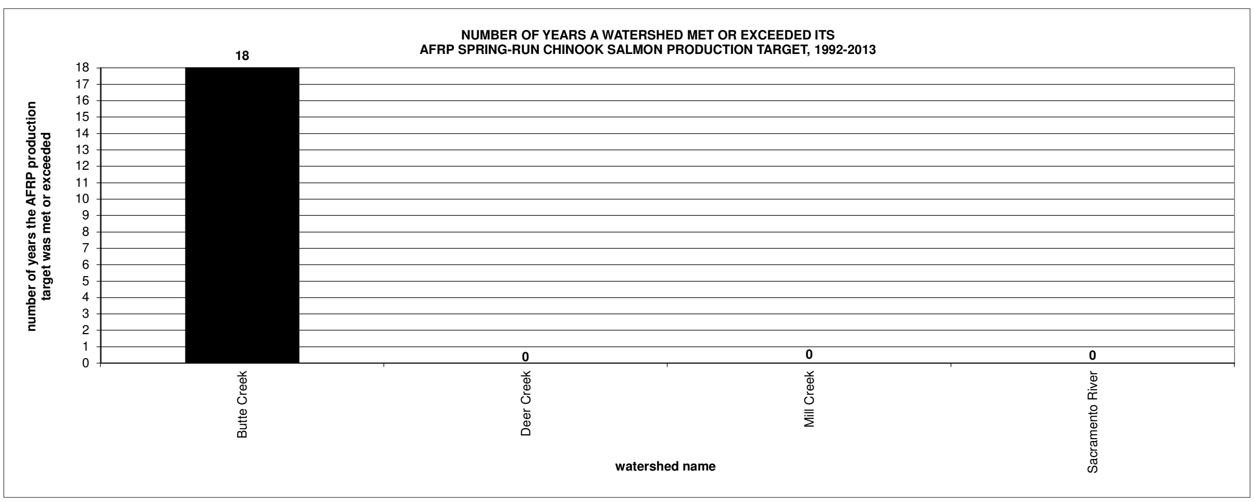


Figure 17. Number of times watershed-specific AFRP spring-run Chinook salmon production targets were met or exceeded during the 22-year period 1992-2013.



3.2.2 CHANGES IN THE AVERAGE NATURAL PRODUCTION OF CHINOOK SALMON

A comparison of the average natural production of different runs of adult Chinook salmon in 22 watersheds in the Central Valley during the 1967-1991 and 1992-2013 time periods is presented in Table 4, and suggests that watersheds can be grouped in one of three categories. These include:

Category #1: Watersheds that are producing larger numbers of adult salmon in the post-baseline period relative to the baseline period. Runs and watersheds in this category are:

Fall-run Chinook salmon: American River, Battle Creek, Butte Creek, Clear Creek, Deer Creek, Feather River, and Mokelumne River.

Late-fall-run Chinook salmon: Battle Creek.

Winter-run Chinook salmon: none.

Spring-run Chinook salmon: Butte Creek.

Category #2: Watersheds that are producing smaller numbers of adult salmon in the post-baseline period relative to the baseline period. Runs and watersheds applicable to this category are:

Fall-run Chinook salmon: Cosumnes River, Cottonwood Creek, Cow Creek, Merced River, Mill Creek, Miscellaneous Creeks, Sacramento River mainstem, Stanislaus River, Tuolumne River, and Yuba River.

Late-fall-run Chinook salmon: Sacramento River mainstem.

Winter-run Chinook salmon: Calaveras River, and Sacramento River mainstem.

Spring-run Chinook salmon: Deer Creek, Mill Creek, and Sacramento River mainstem.

Category #3: Watersheds where insufficient monitoring data were collected to assess a change in the average natural production of a particular run. Runs and watersheds in this category are:

Fall-run Chinook salmon: Antelope Creek, Bear River, Big Chico Creek, and Paynes Creek.

Late-fall-run Chinook salmon: none.

Winter-run Chinook salmon: none.

Spring-run Chinook salmon: none.

Table 4. Summary statistics of the average natural production of adult fall-, late-fall-, winter, and spring-run Chinook salmon from 22 Central Valley watersheds, 1967-2013. * Indicates a fish hatchery is present in the watershed. N = number of years monitoring data were collected during a time period. ** Indicates a statistically significant P value ($p<0.05$). ??? = insufficient data to assess change in average production or a P value.

Watershed	**Run**	**1967-1991**		**1992-2013**		**AFRP fish production target**	**Percent change in average production 1967-1991 vs. 1992-2013**	**P-value**
		N	**Average production**	**N**	**Average production**			
American River*	Fall-run	25	80,876	22	104,296	160,000	+ 29%	0.348
Antelope Creek	Fall-run	19	361	1	0	720	???	???
Battle Creek*	Fall-run	25	5,013	22	17,564	10,000	+ 250%	0.000**
Battle Creek*	Late-fall-run	23	273	22	676	550	+ 147%	0.000**
Bear River	Fall-run	1	639	0	???	450	???	???
Big Chico Creek	Fall-run	3	402	0	???	800	???	???
Butte Creek	Fall-run	10	765	17	2,288	1,500	+ 199%	0.015**
Butte Creek	Spring-run	25	1,018	22	10,327	2,000	+ 915%	0.000**
Calaveras River	Winter-run	4	770	5	0	2,200	- 100%	???
Clear Creek	Fall-run	16	3,576	22	10,956	7,100	+ 206%	0.000**
Cosumnes River	Fall-run	17	1,660	15	768	3,300	- 54%	0.068
Cottonwood Creek	Fall-run	17	2,964	8	2,145	5,900	- 28%	???
Cow Creek	Fall-run	12	2,330	8	2,117	4,600	- 9%	???
Deer Creek	Fall-run	23	766	14	898	1,500	+ 17%	0.438

Table 4 (cont.). Summary statistics of the average natural production of adult fall-, late-fall-, winter, and spring-run Chinook salmon from 22 Central Valley watersheds, 1967-2013. * Indicates a fish hatchery is present in the watershed. N = number of years monitoring data were collected during a time period. ** Indicates a statistically significant P value (p<0.05). ??? = insufficient data to assess change in average production or a P value.

Watershed	**Run**	**1967-1991**		**1992-2013**		**AFRP fish production target**	**Percent change in average production 1967-1991 vs. 1992-2013**	**P-value**
		N	**Average production**	**N**	**Average production**			
Deer Creek	Spring-run	18	3,276	22	1,949	6,500	- 41%	0.266
Feather River*	Fall-run	25	86,031	22	94,314	170,000	+ 10%	0.297
Merced River*	Fall-run	25	9,005	22	6,484	18,000	- 28%	0.500
Mill Creek	Fall-run	24	2,118	17	1,896	4,200	- 10%	0.351
Mill Creek	Spring-run	18	2,202	22	1,198	4,400	- 46%	0.054
Miscellaneous Creeks	Fall-run	20	549	3	78	1,100	- 86%	???
Mokelumne River*	Fall-run	25	4,680	22	8,731	9,300	+ 87%	0.003**
Paynes Creek	Fall-run	9	170	0	???	330	????	???
Sacramento River	Fall-run	25	115,371	22	69,069	230,000	- 40%	0.001**
Sacramento River	Late-fall-run	25	33,941	21	16,964	68,000	- 50%	0.001**
Sacramento River*	Winter-run	25	54,316	22	6,273	110,000	- 88%	0.001**
Sacramento River	Spring-run	25	29,412	22	653	59,000	- 98%	0.000**
Stanislaus River	Fall-run	24	10,868	22	5,167	22,000	- 52%	0.167
Tuolumne River	Fall-run	25	18,949	22	6,474	38,000	- 66%	0.003**
Yuba River	Fall-run	25	33,245	22	30,670	66,000	- 8%	0.399

A comparison of average natural production of the four runs of Chinook salmon from the Central Valley as a whole during the 1967-1991 and 1992-2013 time periods is presented in Table 5. The average fall-run Chinook salmon production in the baseline and post-baseline periods has declined 4% between the two periods; that change is not statistically significant. In contrast, the production of late-fall-, winter, and spring-run Chinook salmon declined by 51, 88, and 59%, respectively, and each of these declines were statistically significant. The natural production of Chinook salmon across the Central Valley during the 1992-2013 time period in the 22 aforementioned Central Valley watersheds was 20% less than during the 1967-1991 baseline period, but the decrease was not statistically significant.

Table 5. Summary statistics of the average natural production of four runs of adult Chinook salmon from the Central Valley, 1967-2013. ** Indicates a statistically significant P value (p<0.05).

Chinook salmon group	**1967-1991 average production**	**1992-2013 average production**	**AFRP fish production target**	**Percent change in average production 1967-1991 vs. 1992-2013**	**P-value**
Fall-run	374,049	359,613	750,000	- 4%	0.466
Late-fall-run	34,192	16,869	68,000	- 51%	0.001**
Winter-run	54,439	6,273	110,000	- 88%	0.001**
Spring-run	34,374	14,127	68,000	- 59%	0.000**
All runs combined, Central Valley-wide	497,054	396,881	990,000	- 20%	0.065

3.2.3 STATISTICALLY SIGNIFICANT CHANGES IN NATURAL PRODUCTION OF CHINOOK SALMON

An analysis using a nonparametric Mann Whitney U test suggests some watersheds and salmon runs experienced significant changes in average natural production when data from the 1967-1991 and 1992-2013 time periods are compared, i.e., it may be reasonable to reject the null hypothesis in some cases (Table 4). For watersheds containing adult fall-run Chinook salmon, average production was significantly greater from Battle Creek, Butte Creek, Clear Creek, and the Mokelumne River during the 1992-2013 time period than during the 1967-1991 baseline period. In contrast, significantly fewer adult fall-run Chinook salmon were produced on average by the Sacramento River mainstem and Tuolumne River during the post-baseline period. For late-fall-run Chinook salmon, significantly greater numbers of adult salmon were produced on average by Battle Creek in the post-baseline period, and significantly smaller numbers of adult salmon were produced by the Sacramento River mainstem. During the post-baseline period, significantly fewer adult winter-run Chinook salmon were produced on average by the Sacramento River mainstem than during the baseline period. In regard to average natural production of spring-run Chinook salmon, production was significantly greater in Butte Creek during the post-baseline period, but was significantly less in the Sacramento River mainstem.

3.2.4 CORMACK-JOLLY-SEBER MODEL ESCAPEMENT RESULTS

Adult Chinook salmon escapement estimates, confidence intervals, and coefficients of variation in 2011, 2012, and 2013 and that are based on a Cormack-Jolly-Seber (CJS) mark recapture model are provided in Table 6 below. Graphs illustrating the escapement estimates and confidence intervals based on that model are presented in Appendix D. The estimates for the Merced, Stanislaus, and Tuolumne rivers are provisional and subject to change.

The watersheds where the CJS mark recapture model is being used during carcass surveys include the American River, Butte Creek, Clear Creek, Feather River, Merced River, Sacramento River, Tuolumne River, and Yuba River. The watersheds where the CJS mark recapture model is being used during video camera surveys includes Battle Creek, Cow Creek, Mill Creek, and the Yuba River. Except for the Feather River where the CJS mark recapture model results include a combination of fall- and spring run Chinook salmon, the model results pertain to a single salmon run.

The CJS mark recapture model results suggest there has been a steady increase in the escapement of adult fall-run Chinook salmon in several of the Central Valley watersheds during the past three years. Increases in some of the watersheds that produce the largest numbers of adult salmon (e.g., the American River, Feather River, and the Sacramento River) have likely been statistically significant as evidenced by the lack of overlapping confidence intervals in adjoining years.

Unexpectedly, the coefficients of variation for escapement surveys in many of the watersheds where carcass surveys have been conducted in the Central Valley are unusually small, i.e., less than 0.050. Coefficients of variation during wildlife and fisheries population assessments are rarely this small, and their occurrence during the Central Valley Chinook salmon escapement surveys is largely explained by the fact Central Valley biologists are collecting and marking a large majority of the dead salmon carcasses present in their respective watersheds (Ryan Nielson, West Inc., pers. comm.). The occurrence of small coefficients of variation also holds true for some watersheds where escapement surveys were done with cameras. The epitome of this case occurs on the Yuba River where VAKI cameras were successfully operated each day during the past three years as the escapement of spring-run Chinook salmon was monitored (Duane Massa, PSMFC, pers. comm.), thereby producing a coefficient of variation of 0.000.

Table 6. Adult Chinook salmon escapement estimates and 90% confidence intervals from the Central Valley based on a Cormack-Jolly-Seber mark recapture model, 2011 – 2013. Blank cells represent periods when data are not available at the time of report production.

YEAR	SURVEY TYPE	WATERSHED	SALMON RUN	POINT ESTIMATE	LOWER 90% CONFIDENCE INTERVAL	UPPER 90% CONFIDENCE INTERVAL	COEFFICIENT OF VARIATION
2011	carcass survey	American River	fall-run Chinook salmon	21,320	20,312	22,109	0.026
2012	carcass survey	American River	fall-run Chinook salmon	34,900	31,933	37,513	0.049
2013	carcass survey	American River	fall-run Chinook salmon	54,259	52,221	56,083	0.022
2011	video camera	Battle Creek	fall-run Chinook salmon	54,895	52,109	57,858	0.032
2012	video camera	Battle Creek	fall-run Chinook salmon	116,847	108,848	125,907	0.044
2013	video camera	Battle Creek	fall-run Chinook salmon	101,548	94,524	108,413	0.042
2011	carcass survey	Butte Creek	fall-run Chinook salmon	416	284	607	0.236
2012	carcass survey	Butte Creek	fall-run Chinook salmon	813	423		
2013	carcass survey	Butte Creek	fall-run Chinook salmon	2,200	2,005	2,457	0.062
2011	carcass survey	Butte Creek	spring-run Chinook salmon	4,859	4,268		
2012	carcass survey	Butte Creek	spring-run Chinook salmon	16,140	15,806	16,885	0.020
2013	carcass survey	Butte Creek	spring-run Chinook salmon	15,887	15,400	16,477	0.021
2011	carcass survey	Clear Creek	fall-run Chinook salmon	4,841	4,596	5,106	0.032
2012	carcass survey	Clear Creek	fall-run Chinook salmon	7,631	7,047	8,215	0.047
2013	carcass survey	Clear Creek	fall-run Chinook salmon	13,337	12,429	14,246	0.041
2011	video camera	Cottonwood Creek	fall-run Chinook salmon	2,144	2,038	2,250	0.030
2012	video camera	Cottonwood Creek	fall-run Chinook salmon	2,556	2,333	2,812	0.057
2013	video camera	Cottonwood Creek	fall-run Chinook salmon	2,774	2,304	2,971	0.073
2011	video camera	Cow Creek	fall-run Chinook salmon	1,617	1,442	1,747	0.057
2012	video camera	Cow Creek	fall-run Chinook salmon	1,488	1,195	1,818	0.127
2013	video camera	Cow Creek	fall-run Chinook salmon	3,011	2,663	3,326	0.067
2011	carcass survey	Feather River	fall and spring-run Chinook salmon combined	47,289	46,337	48,342	0.013
2012	carcass survey	Feather River	fall and spring-run Chinook salmon combined	63,648	62,842	64,503	0.008
2013	carcass survey	Feather River	fall and spring-run Chinook salmon combined	151,209			

Table 6. Adult Chinook salmon escapement estimates and 90% confidence intervals from the Central Valley based on a Cormack-Jolly-Seber mark recapture model, 2011 – 2013. Blank cells represent periods when data are not available at the time of report production.
* Indicates the escapement is provisional and subject to change.

YEAR	SURVEY TYPE	WATERSHED	SALMON RUN	POINT ESTIMATE	LOWER 90% CONFIDENCE INTERVAL	UPPER 90% CONFIDENCE INTERVAL	COEFFICIENT OF VARIATION
2011*	carcass survey	Merced River	fall-run Chinook salmon	1,615	1,473	1,811	0.064
2012*	carcass survey	Merced River	fall-run Chinook salmon	2,257	2,119	3,436	0.177
2013*	carcass survey	Merced River	fall-run Chinook salmon	2,865	2,564	3,150	0.062
2011	video camera	Mill Creek	fall-run Chinook salmon	1,485	1,068	1,610	0.111
2012	video camera	Mill Creek	fall-run Chinook salmon	823	724	1,611	0.328
2013	video camera	Mill Creek	fall-run Chinook salmon	2,197	2,033	2,468	0.060
2011	carcass survey	Sacramento River	fall-run Chinook salmon	11,592	10,056	13,126	0.080
2012	carcass survey	Sacramento River	fall-run Chinook salmon	28,701	26,527	30,875	0.046
2013	carcass survey	Sacramento River	fall-run Chinook salmon	40,084	37,197	42,972	0.044
2011	carcass survey	Sacramento River	winter-run Chinook salmon	824			
2012	carcass survey	Sacramento River	winter-run Chinook salmon	2,674	2,451	2,896	0.051
2013	carcass survey	Sacramento River	winter-run Chinook salmon	6,075	5,275	6,677	0.070
2011	carcass survey	Sacramento River	late fall-run Chinook salmon	3,725			
2012	carcass survey	Sacramento River	late fall-run Chinook salmon	2,869	2,468	3,175	0.075
2013	carcass survey	Sacramento River	late fall-run Chinook salmon	5,267	0	13,545	0.782
2011*	carcass survey	Stanislaus River	fall-run Chinook salmon	1,063	1,010	1,120	0.031
2012*	carcass survey	Stanislaus River	fall-run Chinook salmon	4,006	3,746	4,322	0.044
2013*	carcass survey	Stanislaus River	fall-run Chinook salmon	2,858	2,729	2,999	0.029
2011*	carcass survey	Tuolumne River	fall-run Chinook salmon	878	856	900	0.015
2012*	carcass survey	Tuolumne River	fall-run Chinook salmon	789	740	804	0.025
2013*	carcass survey	Tuolumne River	fall-run Chinook salmon	1,958	1,934	1,988	0.008
2011	carcass survey	Yuba River	fall-run Chinook salmon	1,398	1,281	1,472	0.042
2012	carcass survey	Yuba River	fall-run Chinook salmon	1,082	999	1,173	0.049
2013	carcass survey	Yuba River	fall-run Chinook salmon	3,608	3,462	3,746	0.024
2011	VAKI camera	Yuba River	spring-run Chinook salmon	7,723	7,723	7,723	0.000
2012	VAKI camera	Yuba River	spring-run Chinook salmon	6,649	6,649	6,649	0.000
2013	VAKI camera	Yuba River	spring-run Chinook salmon				

3.3 RELATIONSHIP BETWEEN OCEAN CONDITIONS AND ADULT SALMON ESCAPEMENT

Table 7 and Figure 18 represent the relationship between a composite of environmental conditions in the Pacific Ocean when juvenile Chinook salmon emigrated to the ocean from the Central Valley between 1992 and 2011, and the corresponding escapement levels of three-year old adult fall-run Chinook salmon from the Sacramento Basin two years later. The smaller the Mean of Ranks on the X axis in Figure 18, the better the ocean conditions were for juvenile salmon entering the ocean. Conversely, the higher that number is, the worse the conditions were for juvenile salmon. The Y axis in Figure 18 provides the adult escapement levels of three-year old adult fall-run Chinook salmon from the Sacramento Basin. Because some of the Mean of Ranks for the ocean conditions composite had duplicate values in some years, the Rank of the Mean Rank in Table 7 only had 19 values between 1992 and 2011, despite the fact that period spanned a 21-year period.

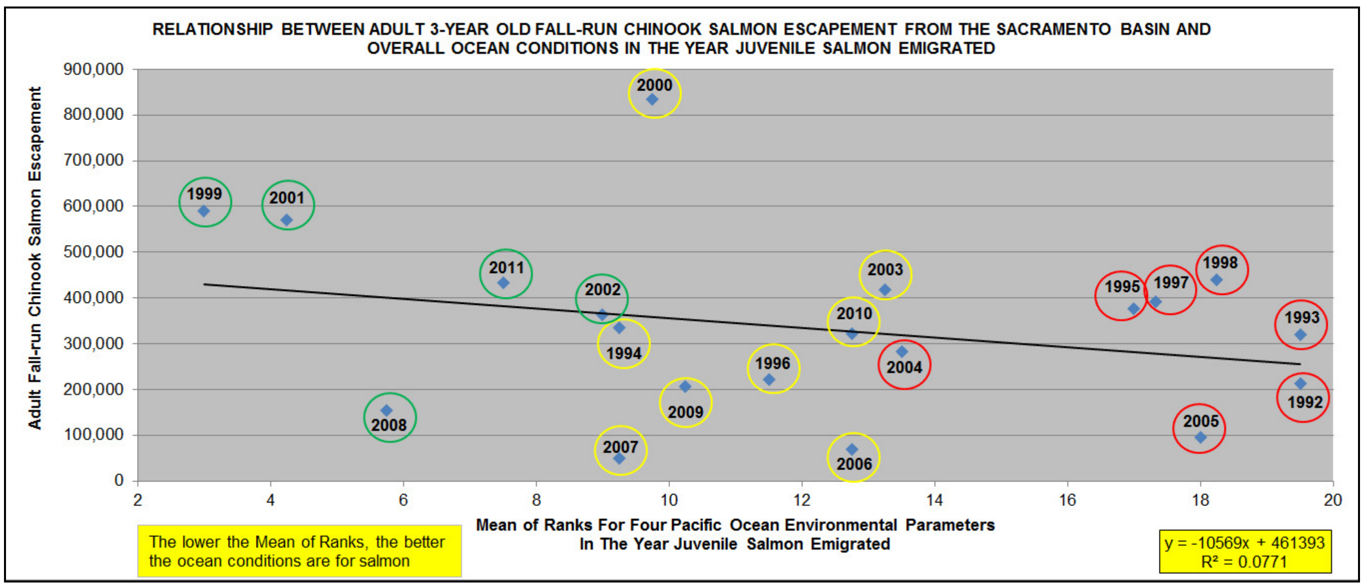
Because the regression line in Figure 18 has a negative slope, it indicates that in general, as ocean conditions in year $t+1$ become less favorable, adult salmon returns two years in year $t + 3$ decrease. The R squared value is relatively small (0.0771), indicating the data are relatively noisy, do not fit the regression line in a robust fashion, and may have limited predictive value. Of special note are the data points for ocean conditions in 2004 and 2005 in Figure 18; those data points are correlated with the collapse of the Sacramento Basin fall-run Chinook salmon stock in 2007 and 2008. The data point for ocean conditions in 2000 is also of interest because it represents an outlier where the Rank of the Mean Rank is classified as a "medium" category, but the escapement two years later is the highest on record since 1992.

Because there is a 2-year lag between the time juvenile salmon emigrate to the ocean and when adult three-year old salmon return to the Central Valley to spawn, Table 7 does not contain adult salmon escapement estimates for juvenile salmon that entered the ocean in 2012 or 2013. As adult 3-year old fall-run Chinook salmon return to spawn in the Sacramento River in 2014, it will be possible to add one more data point to the graph reflecting the relationship between ocean conditions in 2012 and the corresponding adult returns in 2014. The Rank of the Mean Rank parameter for ocean conditions in 2012 (i.e., 2) suggests the adult Chinook salmon returns to the Central Valley in 2014 should be relatively robust, and it indicates that for the 19 Rank of the Mean Rank values between 1992 and 2011, the ocean conditions in 2012 were the second best for juvenile salmon during that period. The Rank of the Mean Rank parameter for ocean conditions in 2013 (i.e., 5) suggests that adult returns two years later, i.e., in 2015, should also be relatively robust.

Table 7. Data quantifying the ocean conditions and escapement levels for 3-year old fall-run Chinook salmon from the Sacramento Basin, 1992-2013. Red, yellow, and green shading indicates years with ocean conditions that are poor, intermediate, or good for juvenile salmon. Black shading = no data.

	Ocean Condition Year (year t + 1)																					
ECOSYSTEM INDICATOR	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**
PDO (May - September Sum)	6.97	11.07	-0.4	5.81	4.15	11.92	-0.37	-5.13	-3.58	-4.22	-0.26	3.42	2.96	3.48	0.28	0.91	-7.63	-1.11	-3.53	-6.45	-7.79	-3.47
PDO (May - September Sum) Rank	20	21	10	19	18	22	11	4	6	5	12	16	15	17	13	14	2	9	7	3	1	8
ONI (January - June Average)	1.23	0.45	0.25	0.48	-0.53	0.18	1.08	-1.10	-1.13	-0.42	0.23	0.33	0.20	0.37	-0.38	0.02	-1.05	-0.27	0.70	-0.77	-0.42	-0.38
ONI (January - June Average) Rank	22	18	15	19	5	12	21	2	1	6	14	16	13	17	8	11	3	10	20	4	7	9
SST bouy 46013 (May - September average)	12.96	11.69	10.70	11.78	10.87		12.33	10.77	11.25	10.65	10.76	11.12	11.68	12.13	11.69	11.06	11.37	11.39	11.02	11.08	10.29	10.97
SST bouy 46013 (May - September average) Rank	21	17	3	18	6		20	5	12	2	4	11	15	19	16	9	13	14	8	10	1	7
39N 125W Upwelling anomoly (April - May sum)	5	-158	88	28	-14	-41	-72	455	-56	190	126	46	29	-49	8	192	188	113	0	19	124	219
39N 125W Upwelling anomoly (April - May sum) Rank	15	22	9	12	17	18	21	1	20	4	6	10	11	19	14	3	5	8	16	13	7	2
Mean of Ranks	19.50	19.50	9.25	17.00	11.50	17.33	18.25	3.00	9.75	4.25	9.00	13.25	13.50	18.00	12.75	9.25	5.75	10.25	12.75	7.50	4.00	6.50
RANK of the Mean Rank	19	19	8	15	11	16	18	1	9	3	7	13	14	17	12	8	4	10	12	6	2	5
Juvenile fall-run Chinook salmon brood year (year t)	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Juvenile fall-run Chinook salmon outmigration year (year t +1)	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Adult 3-year old fall-run Chinook salmon escapement year (year t + 3)	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Adult 3-year old fall-run Chinook salmon Sacramento Basin escapement amount (natural and hatchery salmon)	212,384	320,283	334,668	376,228	222,425	391,350	438,351	589,937	834,900	569,487	363,377	416,896	282,489	94,339	69,146	49,573	152,831	205,096	320,861	432,703	???	???

Figure 18. Relationship between adult 3-year old fall-run Chinook salmon escapement levels from the Sacramento Basin and ocean conditions when those salmon emigrated to the Pacific Ocean as juvenile fish. Red, yellow, and green circles indicate years with ocean conditions that are poor, intermediate, or good for juvenile salmon.



3.4 PRODUCTION OF NON-SALMONID TAXA

3.3.1 PRODUCTION OF ADULT WHITE AND GREEN STURGEON

Eleven surveys were intermittently conducted for white sturgeon between 1992 and 2009. The estimated abundance of 15-year-old white sturgeon in San Pablo and Suisun bays during those seven years ranged between 692 and 11,689 fish (Table 8). The AFRP production target for white sturgeon is 11,000 fish. During the 1992-2009 time period, the estimated number of 15-year-old white sturgeon in San Pablo and Suisun bays exceeded the AFRP production target in one of the eleven years when sampling was done (Figure 19).

The annual production estimates of 15-year-old white sturgeon between 2006 and 2009 using the Peterson model are preliminary and subject to change as new monitoring data become available to update the preliminary estimates.

Since 2009, the CDFW has not provided white sturgeon data that is comparable to the data used to develop the AFRP white sturgeon production target. Therefore, progress toward the AFRP white sturgeon production target after 2009 cannot be assessed at this time.

Ten of the eleven white sturgeon surveys conducted between 1992 and 2009 can be used to develop abundance estimates for green sturgeon that were ≥ 40 inches in length in San Pablo and Suisun bays. Because the CDFW did not capture green sturgeon during the sturgeon survey in 1994, it is not possible to develop an abundance estimate for green sturgeon in the two bays that year. The estimated abundance of green sturgeon ≥ 40 inches in length in the two bays between 1992 and 2009 ranged between 68 and 10,272 fish (Table 9). The AFRP production target for green sturgeon is 2,000 fish. During the 1992-2009 time period, the estimated abundance of green sturgeon ≥ 40 inches in length in San Pablo and Suisun bays exceeded the AFRP production target in four of the ten years when abundance estimates could be calculated (Figure 20).

The annual production estimates of green sturgeon between 2006 and 2009 are preliminary and subject to change as the new monitoring data for white sturgeon that are needed to update the green sturgeon estimates become available.

Since 2009, the CDFW has not provided green sturgeon data that is comparable to the data used to develop the AFRP green sturgeon production target. Therefore, progress toward the AFRP green sturgeon production target after 2009 cannot be assessed at this time.

Table 8. Estimated abundance of white sturgeon in San Pablo Bay and Suisun Bay, 1992-2009. Blank rows represent years when surveys for the species were not conducted. * = preliminary estimate subject to change.

Year	Estimated abundance of white sturgeon ≥ 40 inches in total length	Percentage of 15-year-old white sturgeon in the population ≥ 40 inches in total length	Estimated abundance of 15-year-old white sturgeon
1992			
1993	18,257	3.789	692
1994	144,672	4.418	6,392
1995			
1996			
1997	143,795	8.129	11,689
1998	98,717	9.088	8,971
1999			
2000			
2001	57,641	8.898	5,129
2002	32,283	8.595	2,775
2003			
2004			
2005	55,180	5.252	2,898
2006*	124,844	5.599	6,991
2007*	175,981	6.000	10,559
2008*	100,915	6.200	6,257
2009*	90,702	6.899	6,258

Figure 19. Estimated abundance of 15-year old white sturgeon in San Pablo Bay and Suisun Bay, 1992-2009. Estimates in 2006, 2007, 2008, and 2009 are preliminary and subject to change.

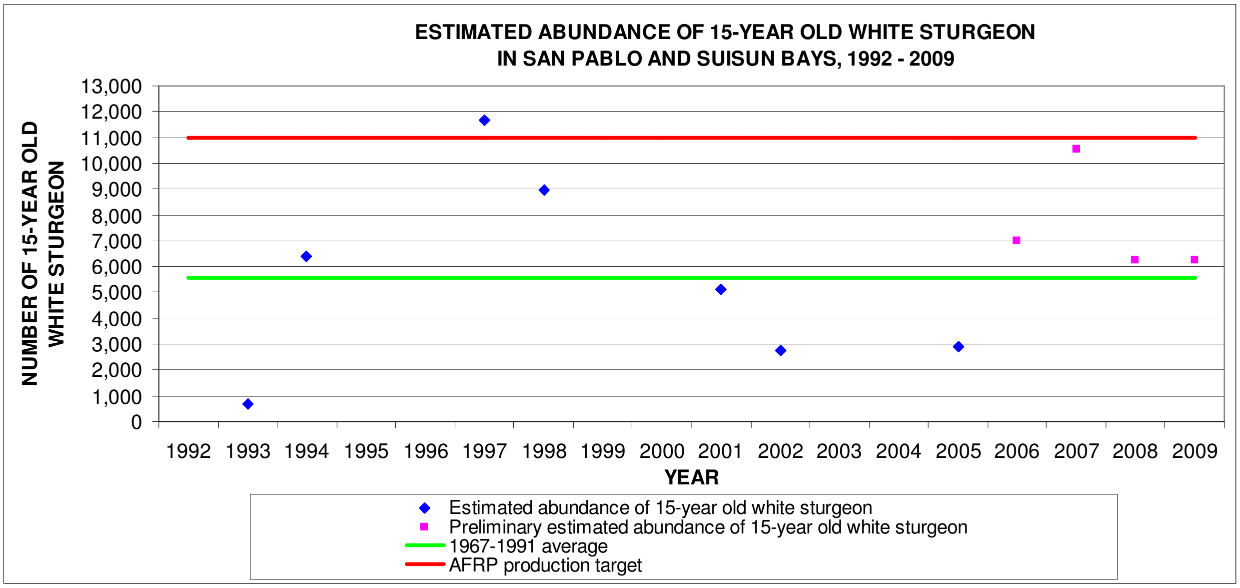
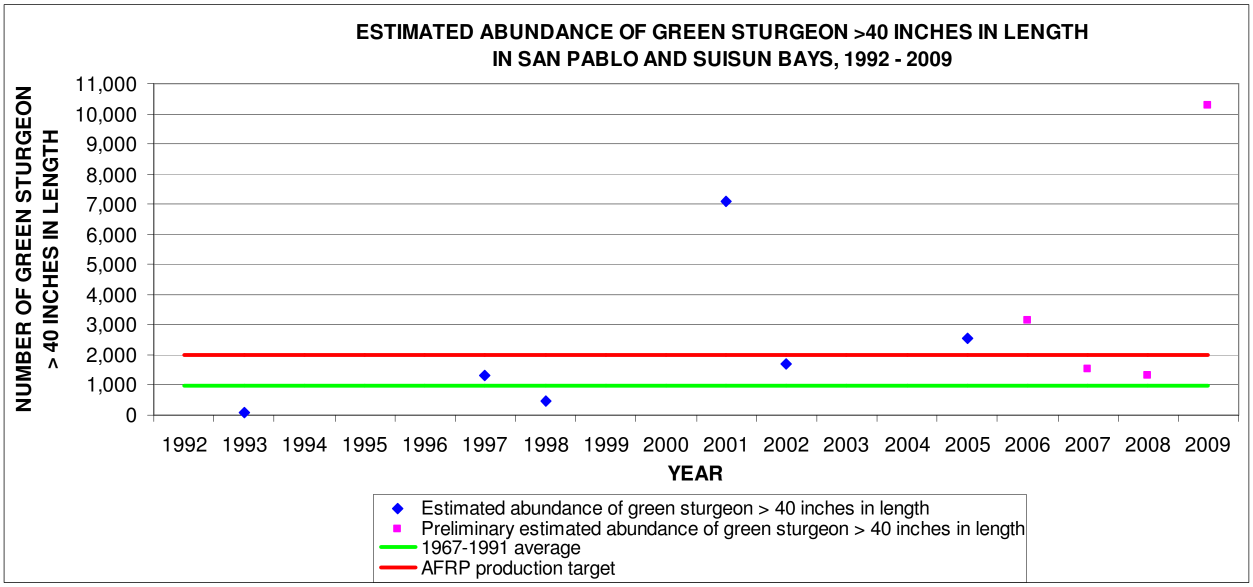


Table 9. Estimated abundance of green sturgeon in San Pablo Bay and Suisun Bay, 1992-2009. Blank rows represent years when surveys for the species were not conducted. * = preliminary estimate subject to change.

Year	**Estimated abundance of white sturgeon ≥ 40 inches in total length**	**Number of captured white sturgeon ≥ 40 inches in total length**	**Number of captured green sturgeon ≥ 40 inches in total length**	**Ratio of white to green sturgeon**	**Estimated abundance of green sturgeon ≥ 40 inches in total length**
1992					
1993	18,257	534	2	267.0:1	68
1994	144,672	593	0	---	---
1995					
1996					
1997	143,795	1,321	12	110.1:1	1,306
1998	98,717	1,469	7	209.9:1	470
1999					
2000					
2001	57,641	1,080	133	8.1:1	7,098
2002	32,283	478	25	19.1:1	1,688
2003					
2004					
2005	55,180	259	12	21.6:1	2,557
2006*	124,844	675	17	39.7:1	3,144
2007*	175,981	690	6	115.0:1	1,530
2008*	100,915	531	7	75.9:1	1,330
2009*	90,702	459	52	8.8:1	10,272

Figure 20. Estimated abundance of green sturgeon > 40 inches in length in San Pablo Bay and Suisun Bay, 1992-2009. Estimates in 2006, 2007, 2008, and 2009 are preliminary and subject to change.



3.3.2 PRODUCTION OF JUVENILE AMERICAN SHAD

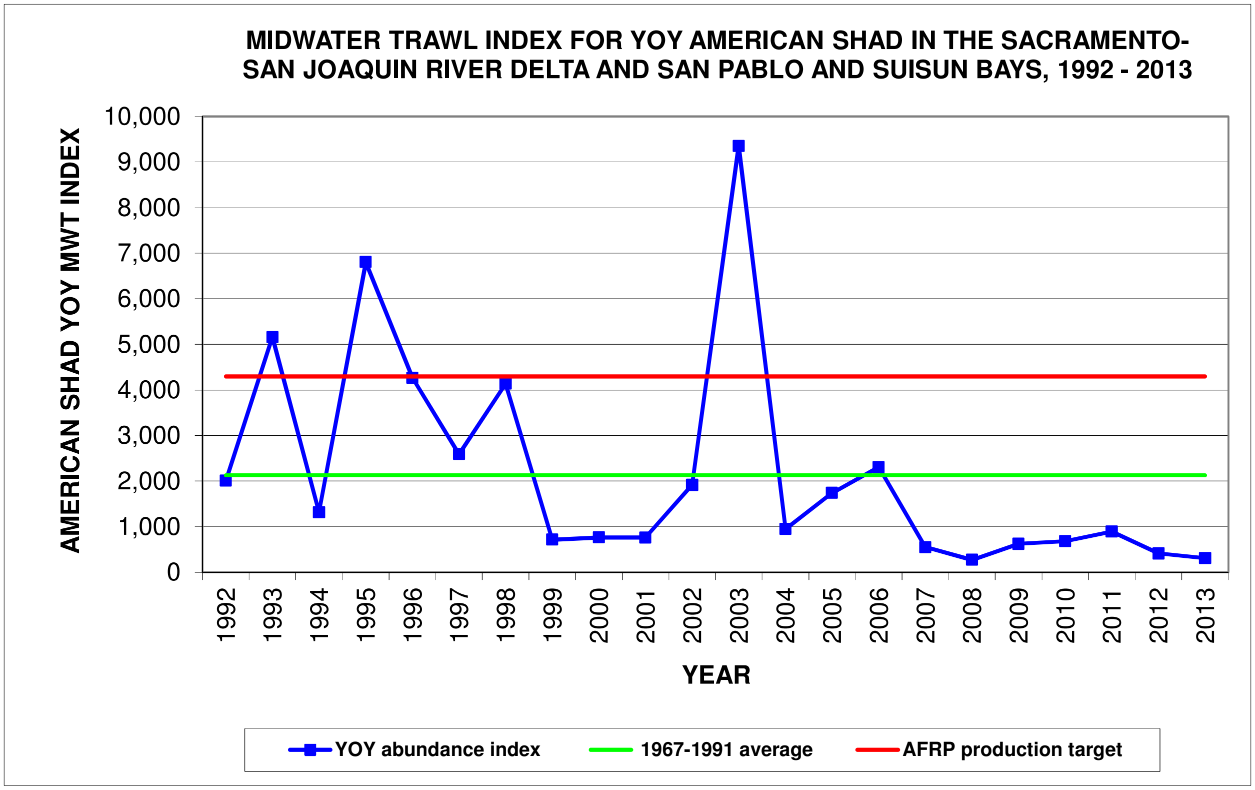
The annual Fall Midwater Trawl index for YOY American shad in the Sacramento-San Joaquin River Delta and San Pablo and Suisun bays during the 1992-2013 time period ranged between 271 and 9,355 (Table 10). The AFRP production target for American shad is 4,300 fish. Between 1992 and 2013, the FMWT YOY index exceeded the AFRP production target in 3 of 22 years (Figure 21).

The FMWT YOY indices reported in this CAMP annual report are slightly different than the values reported in previous editions of the CAMP annual report. These differences exist because the data in previous reports inadvertently did not include the *frequency* of the adjusted fork length correction factors, but instead provided the *count* of the adjusted fork length correction factors. This error resulted in discrepancies in previous FMWT YOY indices that were on the order of 2 -12 shad per year. These discrepancies were not large enough, however, to change the conclusion of how many years the AFRP production target was met.

Table 10. Fall Midwater Trawl index for young-of-the-year American shad in the Sacramento-San Joaquin River Delta and San Pablo and Suisun bays, 1992-2013.

Year	FMWT index for young-of-the-year American shad
1992	2,012
1993	5,155
1994	1,317
1995	6,808
1996	4,270
1997	2,590
1998	4,137
1999	715
2000	764
2001	763
2002	1,916
2003	9,355
2004	947
2005	1,742
2006	2,304
2007	552
2008	271
2009	624
2010	683
2011	894
2012	414
2013	309

Figure 21. Fall Midwater Trawl index for young-of-the-year American shad in the Sacramento-San Joaquin River Delta and San Pablo and Suisun bays, 1992-2013.



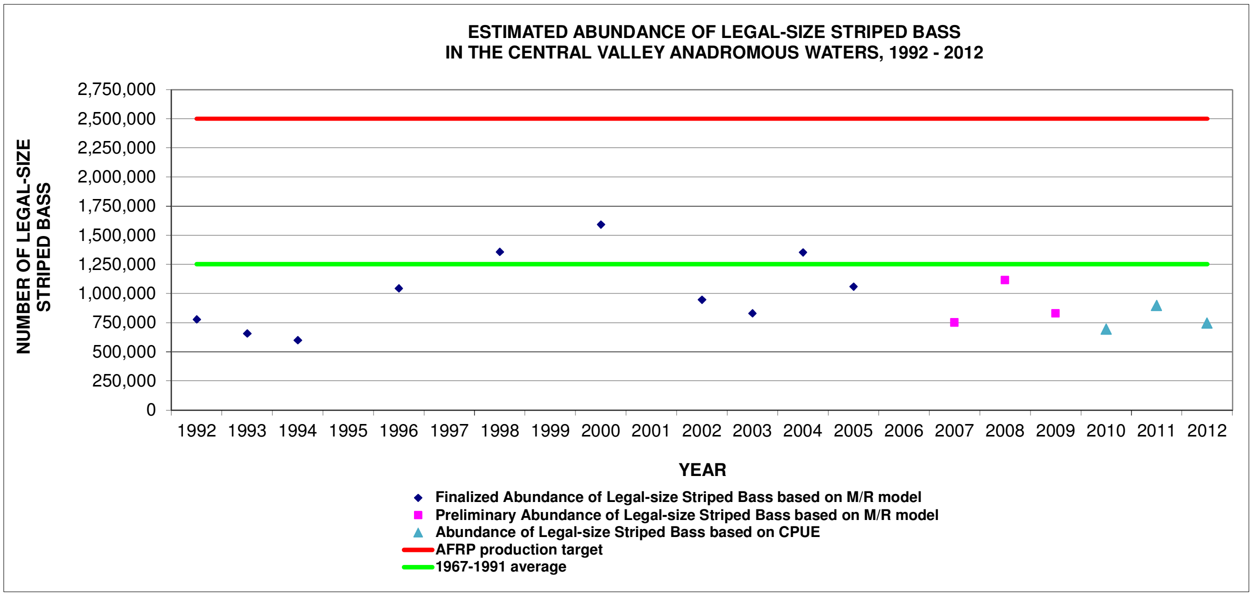
3.3.3 PRODUCTION OF ADULT STRIPED BASS

Sixteen surveys were intermittently conducted for striped bass between 1992 and 2012. Between 1992 and 2012, the abundance of adult striped bass in the anadromous waters of the Central Valley ranged between 599,770 and 1,591,419 fish (Table 11). Abundance estimates between 2007 and 2012 are provisional and subject to change. The AFRP production target for striped bass is 2,500,000 fish. Between 1992 and 2012, the AFRP striped bass production target was not met during the 16 years when population estimates were developed (Figure 22).

Table 11. Estimated abundance of legal-size striped bass in the Central Valley's anadromous waters, 1992-2012. Blank rows represent years when surveys for the species were not conducted. * = preliminary estimate subject to change. µ = estimate not based on mark/recapture data.

Year	Estimated number of legal-size striped bass
1992	777,293
1993	656,505
1994	599,770
1995	
1996	1,043,239
1997	
1998	1,356,412
1999	
2000	1,591,419
2001	
2002	945,878
2003	829,111
2004	1,352,335
2005	1,058,679
2006	
2007*	752,275
2008*	1,116,062
2009*	830,641
2010* µ	693,288
2011* µ	895,774
2012* µ	744,604

Figure 22. Estimated abundance of legal-size striped bass in the Central Valley's anadromous waters, 1992-2012. Estimates between and including 2007 - 2012 are preliminary and subject to change. "M/R" refers to estimates based on a Mark- Recapture model, and "CPUE" refers to estimates based on a Catch Per Unit Effort model.



SECTION 4: DISCUSSION

The “Discussion” section of this document provides an assessment of the overall (cumulative) effectiveness of habitat restoration actions implemented pursuant to Section 3406(b) of the CVPIA in meeting the AFRP production targets for eight anadromous fish taxa. These habitat restoration actions include water management modifications, structural modifications, habitat restoration, and fish screens.

As stated in the “Data Caveats” section of this report, several inherent challenges or assumptions are associated with monitoring anadromous fish species in the Central Valley. These issues must be acknowledged as temporal changes in the production of anadromous fish are assessed. For example, monitoring activities for the eight taxa in a given location may not have been conducted with a standardized protocol and with the same level of effort over time. Developing definitive conclusions as to how fish production or abundance has changed over time is therefore difficult.

To the extent possible, this report attempts to synthesize data for the 1967-1991 and 1992-2013 time periods using the same analytical techniques and approaches. This effort should increase comparability of data collected during the two time periods and thereby increase the probability of making accurate inferences about changes in fish numbers. This report also provides the most current data available at the time of report production, i.e., the individuals that were responsible for collecting different data sets (e.g., for green and white sturgeon, striped bass, and American shad) were contacted a few weeks prior to the development of this report to ensure that the most accurate, timely data were used to quantify fish abundance and population estimates.

4.1 PROGRESS TOWARD AFRP PRODUCTION TARGETS FOR CHINOOK SALMON

The production of Chinook salmon at fish hatcheries in the Central Valley makes it difficult to accurately monitor the natural production of Chinook salmon. These facilities are located on the American River, Battle Creek, Feather River, Merced River, Mokelumne River, and Sacramento River mainstem. These hatcheries, with the exception of the Livingston Stone National Fish Hatchery on the Sacramento River mainstem, produced large numbers of unmarked juvenile fall-run Chinook salmon for many years or decades prior to 2007. If hatchery-produced juvenile salmon are not marked prior to their release from a hatchery, it is difficult to identify these salmon when they return to a river to spawn as adults. This factor makes it difficult to accurately quantify the relative proportion of natural- vs. hatchery-origin Chinook salmon in a watershed.

The calculations in the Chinookprod spreadsheet currently rely on “best professional judgments” in regard to the amount of in-river angler harvest and the estimated hatchery proportion in each watershed (USFWS 1995). The accuracy of the natural production estimates has been the subject of some debate, particularly in regard to the estimated hatchery proportions. An effort to lay the groundwork to accurately quantify the relative proportion of natural- vs. hatchery-origin fall-run Chinook salmon has occurred since 2007; this effort involves the marking and coded wire tagging of at least 25% of the fall-run Chinook salmon produced at fish hatcheries in the Central Valley. In 2013, many of the brood year 2010 and 2011 juvenile fall-run Chinook salmon that were marked during the Constant Fractional Marking Program returned to the Central Valley to spawn as 2- or 3-year-old adult fish. The collection and analysis of these coded wire tagged salmon is expected to provide an enhanced ability to quantify the hatchery proportion in different Central Valley rivers and streams, and more accurate production estimates using these hatchery proportions will be provided by the CAMP as these hatchery proportions become available.

An overall assessment of changes in natural production of different runs of Chinook salmon in the 22 watersheds with an AFRP production target is summarized in Table 1 on page 2 of this report. The data in that table indicates that since 1991:

- Monitoring data have not been collected during the 1992-2013 post-baseline period in three of the 22 watersheds that have an AFRP fish production target. These watersheds are relatively small and consist of Bear River, Big Chico Creek, and Paynes Creek. Six of the seven "Miscellaneous Creeks" also have not been surveyed during the post-baseline period.

- The watershed-specific AFRP fall-run Chinook salmon production targets were met six or more times in five of the 21 watersheds with a fall-run Chinook salmon target. These watersheds are: American River, Battle Creek, Butte Creek, Clear Creek, and the Mokelumne River. The watershed-specific AFRP fall-run Chinook salmon production target for the Feather River was met four times. The remaining 15 watersheds have: (a) met their productions targets less than three times over the 22-year post-baseline period, or (b) were not surveyed each year since 1991.

- The watershed-specific AFRP late-fall-run Chinook salmon production target for Battle Creek was met 15 times in the post-baseline period, and the Sacramento River mainstem only met its AFRP late-fall-run Chinook salmon target one time in the 21 years when monitoring data were collected.

- The watershed-specific AFRP winter-run Chinook salmon production target for the Sacramento River mainstem was never met in the post-baseline period. Surveys for winter-run Chinook salmon from the Calaveras River were only conducted in 2007, 2008, 2009, 2010, and 2011. In each of those years, no winter-run Chinook salmon were detected, i.e., the AFRP production target for winter-run Chinook salmon from the Calaveras River was not met in any of the five years when surveys were done.

- The watershed-specific AFRP spring-run Chinook salmon production target was met 18 times on Butte Creek in the post-baseline period. The other three watersheds with a spring-run Chinook salmon target (Deer Creek, Mill Creek, and the Sacramento River mainstem) have never met their AFRP targets in the post-baseline period.

- Run-specific AFRP production targets for fall-, winter-, and spring-run Chinook salmon were never met in the post-baseline period, and the run-specific AFRP production target for late-fall-run Chinook salmon was met once.

- The Central Valley-wide AFRP production target for the combined total of all four runs of Chinook salmon from 22 watersheds was never met in the post-baseline period.

Differences in salmon production between the baseline and post-baseline periods were statistically compared using a nonparametric Mann Whitney U test. The assumptions associated with the Mann Whitney U test are as follows:

- Assumption #1, there are two independent samples that are randomly selected;
- Assumption #2, each of the two samples has more than 10 values; and
- Assumption #3, there is no requirement that the two populations have a normal distribution or any other particular distribution. As such, the Mann Whitney U test is more flexible than the parametric Student's t test, but it is also less powerful, i.e., a greater change is required before the nonparametric test is able to detect a significant change.

Assumptions #2 and #3 can readily be met in the context of testing whether there are significant differences in the average natural production of Chinook salmon for a particular salmon run and watershed between the baseline and post-baseline periods. Assumption #1 possesses two aspects: (a) there are two independent samples, and (b) the samples are randomly chosen. To varying degrees each year, the salmon that return to spawn in a particular watershed are not independent because the same brood cohort contributes to salmon production over a period of two to five years as adult fish return to spawn. That lack of independence may, however, be relatively weak compared to sampling noise. In regard to samples being randomly chosen, some of the data used to develop watershed-specific Chinook salmon production estimates are based on random samples, and some are not. For example, the CDFW's Ocean Salmon Project which collects commercial and recreational harvest data pertaining to Chinook salmon in the Pacific Ocean collects recreational salmon harvest data in a randomized manner.

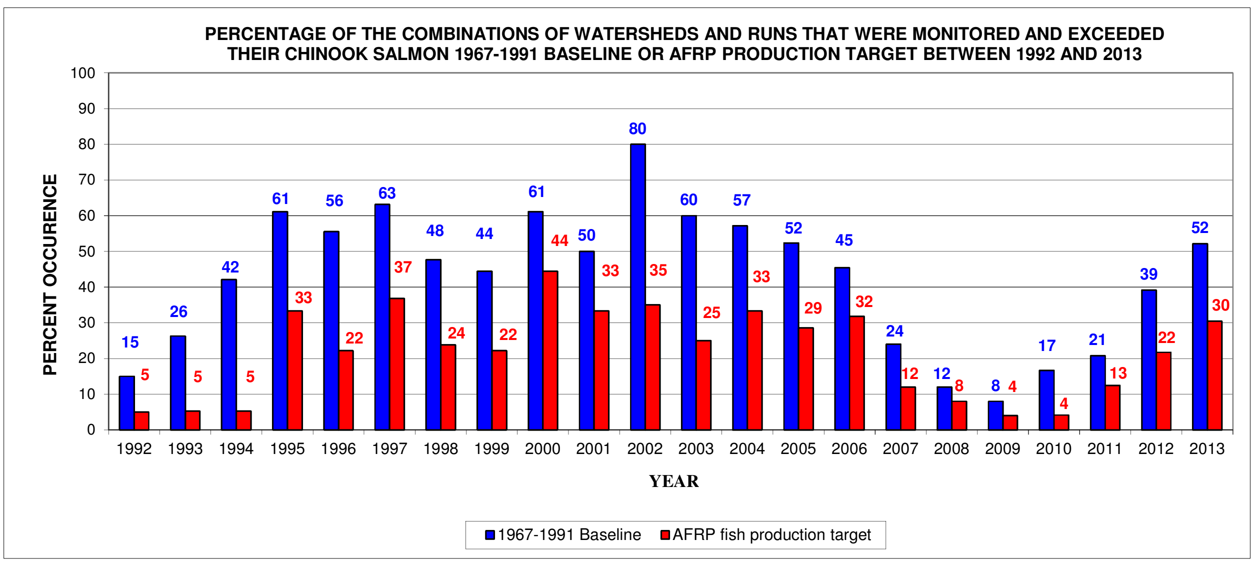
The analyses using the Mann Whitney U test indicate six combinations of watersheds and runs had significantly greater numbers of Chinook salmon in the post-baseline period than the 1967-1991 baseline period, and five had significantly fewer numbers of Chinook salmon. In 10 combinations of watersheds and runs, there were no significant changes in salmon production over time, and there were eight combinations where insufficient monitoring data were collected to determine if there was a significant change.

The production of adult fall-run Chinook salmon has steadily risen each year during the past four years, with the result the production of those fish was 404,269 individuals in 2013. This suggests a steady rebuilding of that salmon stock following the marked decline that occurred between 2004 and 2009, with a nadir in the production of 30,604 adult fall-run Chinook salmon in 2009. As the production of adult fall-run Chinook salmon has increased during the past four years, the combined production of all four runs of adult Chinook salmon in the Central Valley has also increased because fall-run Chinook salmon predominate in their contribution to the

Central Valley total. In 2013, the combined Central Valley-wide adult production of all four salmon runs was 440,920 salmon, vs. the 41,516 salmon that were produced in 2009.

There are 29 combinations (i.e., permutations) of watersheds and runs of Chinook salmon with an AFRP production target. Figure 23 illustrates the percentage of the combinations of watersheds and runs that were monitored and exceeded their Chinook salmon 1967-1991 baseline level or their AFRP fish production target between 1992 and 2013. Figure 23 also illustrates the rebuilding of the Central Valley salmon stocks following the 2004 – 2009 salmon decline. In 2009, only 4% (i.e., one) of the combinations of watersheds and runs that were monitored in the Central Valley exceeded their AFRP production target. By 2013, this number had steadily increased to 30%, (i.e., seven watersheds), and 52% of the combination of monitored watersheds and runs had recovered to the point their production again at least equaled the level during the 1967-1991 baseline period.

Figure 23. Percentage of watersheds and runs that were monitored and exceeded their Chinook salmon 1967-1991 baseline level or their AFRP fish production target between 1992 and 2013.



It is important to note that the post-2010 adoption of a Cormack-Jolly-Seber mark recapture model as adult Chinook salmon escapement surveys were done is beginning to produce data that will provide a more statistically robust approach to assessing trends in the production of adult salmon. As additional years of data from the Cormack-Jolly-Seber mark recapture model become available, the CAMP will use this data to assess the significance of short-term changes in escapement trends of adult Chinook salmon.

4.2 PROGRESS TOWARD AFRP PRODUCTION TARGETS FOR NON SALMONID SPECIES

Because green and white sturgeon are long-lived species, many years of monitoring data are required to develop final abundance estimates for these species in a given year. Monitoring data for white sturgeon in San Pablo and Suisun bays are available for eleven years between 1992 and 2009. In the seven years when 15-year-old white sturgeon abundance estimates are considered to be final and not subject to revision (i.e., between 1993 and 2005), the AFRP production target for this species was met once. In the four years when white sturgeon estimates are considered to be provisional (i.e., 2006, 2007, 2008, and 2009), the AFRP production target for 15-year-old white sturgeon was not met. Because the provisional white sturgeon abundance estimate in 2007 was relatively high, the final abundance estimate for that year may ultimately exceed the AFRP's white sturgeon production target.

Monitoring data for green sturgeon in San Pablo and Suisun bays are available for ten years between 1992 and 2009. In the six years when green sturgeon abundance estimates are considered to be final and not subject to revision (i.e., between 1993 and 2005), the AFRP production target for this species was met twice. In the four years when green sturgeon estimates are considered to be provisional (i.e., 2006, 2007, 2008, and 2009), the AFRP production target for this species was also met twice.

The 2013 Fall Midwater Trawl index for juvenile American shad (309) was the second lowest on record since 1992. Because the vast majority of the core sampling stations used to calculate the FMWT index have been monitored on a consistent basis since 1980 (Dave Contreras, CDFW, pers. comm.), the depressed FMWT index for juvenile American shad is therefore likely to reflect an actual decline in fish numbers and probably is not an artifact of reduced sampling effort. That conclusion is further substantiated because the geographic distribution of the area sampled during the FMWT index has remained essentially unchanged since 1980.

Data used to estimate the abundance of legal-size striped bass also suggest that species' abundance is at a relatively low level, e.g., population estimates for thirteen of the sixteen years when monitoring data were collected between 1992 and 2012 were less than what was observed during the 1967-1991 baseline period. The 2007-2012 striped bass abundance estimates are preliminary, however, and subject to revision as new data become available. Because the number of legal-size striped bass has been consistently below the AFRP production target for that species, it is unlikely that future revisions to the preliminary estimates will result in attainment of the striped bass AFRP production target. It is important to note that the 2010, 2011, and 2012 striped bass abundance estimates provided in this report are based on a Catch Per Unit Effort model that was not used as the AFRP striped bass production target was developed. Estimates for those years may or may not, therefore, produce results that are directly comparable to the prior estimates that were developed with a mark recapture model.

4.3 RELATIONSHIP BETWEEN OCEAN CONDITIONS AND ADULT SALMON ESCAPEMENT

Lindley et al. (2009) provided a foundation suggesting there is a relationship between the survival of juvenile Chinook salmon that emigrate to the Pacific Ocean and the number of adult fall-run Chinook salmon that return to spawn in the Sacramento Basin. This CAMP annual report extends the timeline used by Lindley et al. (2009) to the entire period since the CVPIA was authorized, adopts the framework and data analysis routines used by NMFS staff that conduct similar analyses in the Pacific Northwest, and customizes the analysis to include ocean environmental conditions most relevant to juvenile Chinook salmon from the Central Valley.

The results of the analysis provided in Section 3.3 of this CAMP annual report support the hypothesis that the number of adult salmon returning to the Sacramento Basin is influenced by the ocean conditions that existed when those salmon emigrated to the Pacific Ocean as juveniles. The strength of the relationship between these variables is highly variable among years, however, and is undoubtedly affected by numerous factors that have not been accounted for in the CAMP analysis. For example, one important factor that has not been accounted for in the CAMP analysis involves the amount of river discharge as juveniles emigrate from their natal stream. In the case of the Stanislaus River in southern portion of the Central Valley, for example, the survival rate of juvenile salmon moving through the river was found to be substantially greater when river discharges were relatively high (Merz et al. 2013). Presumably, the greater in-river survival in some years as juveniles emigrate from that river could lead to higher levels of adult escapement, i.e., higher adult returns would be a byproduct of better survival as juvenile salmon emigrated from their natal streams *and* better ocean conditions when they reached the ocean. This annual report does, however, provide a foundation that can be expanded upon in future reports as the relationship between ocean conditions when juveniles emigrated and the number of adult salmon that return to spawn is refined.

A more definitive understanding of the relationship between adult Chinook salmon escapement in the Sacramento Basin and ocean conditions would benefit from the collection of a series of new, long-term data sets. For example, the multi-year effort to correlate adult salmon escapement with ocean conditions off the coast of Oregon in the Pacific Northwest relies on several data sets that are not included in the CAMP analysis. Those data sets include a suite of local biological indictors that substantially affect juvenile salmon survival, and include but are not limited to copepod diversity and the abundance of icthyoplankton present in the ocean during the winter months. The significance of the winter icthyoplankton may be especially important because that parameter involves the prey items that act as the food base for juvenile salmon that have emigrated to the ocean.

From a management perspective, it should be expected that the number of adult salmon returning to the Central Valley will be subpar in some years. That subpar performance will be an artifact of the loss of large numbers of juvenile salmon that emigrated to the Pacific Ocean, but then perished because of unfavorable ocean conditions after they benefited from habitat restoration activities conducted by CVPIA staff and other entities. In the absence of those restoration activities, it is unlikely that large numbers of juvenile salmon would emigrate to the ocean, thereby leading to robust Chinook salmon escapement numbers in years that were preceded by favorable ocean conditions. In years when ocean conditions were favorable for emigrating juvenile salmon, the benefits of habitat restoration activities are likely to lead to progress in the doubling of the number of adult salmon as specified in section 3406(b) of the CVPIA.

REFERENCES

California Department of Fish and Wildlife (CDFW). 2006. WSTALKEY.xls spreadsheet. December 22, 2006. Prepared by Marty Gingras. Unpublished spreadsheet providing capture and population data for white sturgeon.

California Department of Fish and Wildlife (CDFW). 2007. CUMPOP_MD2a.xls spreadsheet. March 13, 2007. Prepared by Mike Donnellan. Unpublished spreadsheet providing capture and population data for white sturgeon.

California Department of Fish and Wildlife (CDFW). 2007. Qry_Length_GST_ALL.xls spreadsheet. June 1, 2007. Prepared by Mike Donnellan. Unpublished spreadsheet providing capture and population data for green sturgeon.

California Department of Fish and Wildlife (CDFW). 2007. WST_length_1990-2006.xls spreadsheet. June 6, 2007. Prepared by Mike Donnellan. Unpublished spreadsheet providing capture and population data for green sturgeon.

California Department of Fish and Wildlife (CDFW). 2011. Stu Data for Doug Threloff 121611.xls spreadsheet. December 16, 2011. Prepared by Jason DuBois. Unpublished spreadsheet providing green and white sturgeon abundance data.

California Department of Fish and Wildlife (CDFW). 2014. GrandTab.2014.04.22.xls spreadsheet. April 24, 2014. Prepared by Jason Azat. Unpublished spreadsheet providing in-river Chinook salmon spawner escapement and hatchery return data for adult Chinook salmon in California's Central Valley.

California Department of Fish and Wildlife (CDFW). 2014. FMWT AMS Length Frequency 1971-2013.xlsx spreadsheet. May 23, 2014. Prepared by Steven Slater. Unpublished spreadsheet providing American shad data in California's Central Valley.

California Department of Fish and Wildlife (CDFW). 2014. FMWT AMS Indices 1967-2013.xlsx spreadsheet. May 23, 2014. Prepared by Steven Slater. Unpublished spreadsheet providing American shad data in California's Central Valley.

California Department of Fish and Wildlife (CDFW). 2013. SBAbundance_100313.xls spreadsheet. October 3, 2013. Prepared by Jason DuBois. Unpublished spreadsheet providing striped bass abundance data in California's Central Valley.

Fisher, J.P., M. Trudel, A. Ammann, J. A. Orsi, J. Piccolo, C. Bucher, E. Casillas, J. A. Harding, R. B. MacFarlane, R. D. Brodeur, J. F. T. Morris, and D.W.Welch. 2007. Comparisons of the coastal distributions and abundances of juvenile Pacific salmon from central California to the northern Gulf of Alaska. *In* The ecology of juvenile salmon in the northeast Pacific Ocean: regional comparisons, C. B. Grimes, R. D. Brodeur, L. J. Haldorson, and S. M. McKinnell, editors, pages 31–80. American Fisheries Society, Bethesda, MD.

Killam, D., and M. Johnson. 2013. Chinook salmon populations of the Upper Sacramento River Basin in 2012. Report prepared by the California Department of Fish and Wildlife--Northern Region Red Bluff Fisheries Office. RBFO Technical Report No. 02-2013. 99 pp.

Lindley, S.T., C.B. Grimes, M.S. Mohr, W. Peterson, J. Stein, J.T. Anderson, L.W. Botsford, D.L. Bottom, C.A. Busack, T.K. Collier, J. Ferguson, J.C. Garza, A.M. Grover, D.G. Hankin, R.G. Kope P.W. Lawson, A. Low, R.B. MacFarlane, K. Moore, M. Palmer-Zwahlen, F.B. Schwing, J. Smith, C. Tracy, R. Webb, B.K. Wells, and T.H. Williams. 2009. What caused the Sacramento River fall Chinook stock collapse? NOAA Technical Memorandum NOAA-TM-NMFS-SWFSC-447. National Oceanic & Atmospheric Administration, National Marine Fisheries Service, Southwest Fisheries Science Center, Santa Cruz, California. 125 pp. http://swfsc.noaa.gov/publications/TM/SWFSC/NOAA-TM-NMFS-SWFSC-447.PDF.

Merz J.E., M.L. Workman, D. Threloff, and B. Cavallo. 2013. Salmon lifecycle considerations to guide stream management: examples from California's Central Valley. San Francisco Estuary and Watershed Science 11(2).

Mills, T.J., and R. Fisher. 1994. Central Valley Anadromous Sport Fish Annual Run-Size, Harvest, and Population Estimates, 1967 through 1991. Revised August 1994. Report prepared for the California Department of Fish and Game. Inland Fisheries Technical Report. Sacramento, California. http://www.fws.gov/stockton/afrp/documents/BookofNumbers.pdf

Montgomery Watson, Jones & Stokes Associates, Inc., and CH2M-HILL. 1997. Comprehensive Assessment and Monitoring Program (CAMP) Implementation Plan. Report prepared for the U.S. Fish and Wildlife Service, Central Valley Fish and Wildlife Restoration Program Office, Sacramento, California. http://www.fws.gov/sacramento/Fisheries/CAMP-Program/Documents-Reports/Documents/CAMP_Implementation_Plan_1997.pdf

Pacific Fishery Management Council (PFMC). 2014. Review of 2013 Ocean Salmon Fisheries: Stock Assessment and Fishery Evaluation Document for the Pacific Coast Salmon Fishery Management Plan. (Document prepared for the Council and its advisory entities.) Pacific Fishery Management Council, 7700 NE Ambassador Place, Suite 101, Portland, Oregon 97220-1384. http://www.pcouncil.org/wp-content/uploads/salsafe2013_appdxa.pdf

Pearcy, W.G. 1992. Ocean ecology of North Pacific salmonids. Washington Sea Grant Program, University of Washington Press, Seattle and London.

Peterson, W.T., C.A. Morgan, J.O. Peterson, J.L. Fisher, B.J. Burke, and K. Fresh. 2013. Ocean Ecosystem Indicators of Salmon Marine Survival in the Northern California Current. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Northwest Fisheries Science Center. Newport, Oregon.

Smith, C.T., A.R. LaGrange, and W.R. Arden. 2009. Run composition of Chinook salmon at Red Bluff Diversion Dam during gates-in operations: a comparison of phenotypic and genetic assignment to run type. Unpublished report prepared for the U.S. Bureau of Reclamation, Mid Pacific Region, Red Bluff, CA. CY2007 report. Technical Information Leaflet No. AB-08-01. 33 pp.

U.S. Fish and Wildlife Service (USFWS). 1995. Working Paper on restoration needs: habitat restoration actions to double natural production of anadromous fish in the Central Valley of California. Volume 3. May 9, 1995. Prepared for the U.S. Fish and Wildlife Service under the direction of the Anadromous Fish Restoration Program Core Group. Stockton, CA. http://www.fws.gov/stockton/afrp/documents/WorkingPaper_v3.pdf

U.S. Fish and Wildlife Service (USFWS). 2001. Final Restoration Plan for the Anadromous Fish Restoration Program. Prepared for the U.S. Fish and Wildlife Service under the direction of the Anadromous Fish Restoration Program Core Group. Stockton, CA. http://www.fws.gov/stockton/afrp/documents/finalrestplan.pdf

U.S. Fish and Wildlife Service (USFWS). 2007. A compilation and analysis of anadromous fish monitoring data from the Central Valley of California, 1992-2006. Report prepared by the U.S. Fish and Wildlife Service and Bureau of Reclamation, Comprehensive Assessment and Monitoring Program. Sacramento, California. 99 pp. http://www.fws.gov/sacramento/Fisheries/CAMP-Program/Documents-Reports/Documents/2007_CAMP_annual_report.pdf

U.S. Department of the Interior (DOI). 2012. Assessment of anadromous fish production in the Central Valley of California between 1992 and 2011. Report prepared by the U.S. Fish and Wildlife Service and Bureau of Reclamation, Comprehensive Assessment and Monitoring Program. Sacramento, California. 101 pp.

U.S. Fish and Wildlife Service (USFWS). 2012. "Chinookprod" database. December 2012. Unpublished database prepared for the U.S. Fish and Wildlife Service by Laura Ryley, Pacific States Marine Fisheries Commission.

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 of California. California Department of Fish and Game. Fish Bulletin 179(1): 71-176.

APPENDIX A: RAW DATA USED TO ESTIMATE PRODUCTION OF ADULT CHINOOK SALMON

OCEAN HARVEST ESTIMATES OF CHINOOK SALMON

Year	Commercial harvest for San Francisco	Recreational harvest for San Francisco	Commercial harvest for Monterey	Recreational harvest for Monterey	Total ocean harvest attributable to the Central Valley
1992	95,800	47,193	64,500	19,526	227,019
1993	154,999	78,733	104,663	20,584	358,979
1994	219,856	140,977	70,508	24,835	456,176
1995	357,486	155,677	313,112	198,875	1,025,150
1996	167,379	84,471	181,467	44,812	478,129
1997	253,484	123,974	228,731	84,427	690,616
1998	126,120	70,969	95,433	43,468	335,990
1999	180,960	69,251	78,709	7,140	336,060
2000	250,368	64,653	197,184	81,782	593,987
2001	136,630	39,856	35,940	20,039	232,465
2002	242,872	87,008	69,980	47,703	447,563
2003	202,876	56,616	36,099	13,126	308,717
2004	298,229	130,220	64,707	44,845	538,001
2005	170,531	72,824	117,408	30,706	391,469
2006	47,689	54,926	11,204	10,970	124,789
2007	75,254	16,796	14,009	6,261	112,320
2008	0	0	0	0	0
2009	0	0	0	0	0
2010	1,105	6,116	1,430	6,295	14,946
2011	21,912	19,734	6,414	12,703	60,763
2012	119,100	46,189	59,972	30,364	255,625
2013	143,358	58,719	27,588	10,606	240,271

Chinook salmon ocean harvest data reflect the number of salmon captured by commercial and recreation boats based in San Francisco and Monterey. The source of the data is the *Review of 2013 Ocean Salmon Fisheries* (PFMC 2014).

ANGLER HARVEST AND 2008 - 2013 RESTRICTIONS THAT LIMITED HARVEST OF ADULT CHINOOK SALMON

Because restrictions on ocean and in-river harvest of adult Chinook salmon affect the natural production estimates developed by the USFWS, a synopsis of angler harvest restrictions during the past four years is provided below.

The California Department of Fish and Wildlife's Central Valley Angler Survey Program does not assign salmon run to the adult salmon data it collects and reports.

In 2008 and 2009, the Chinook salmon ocean harvest season was closed because there was concern about abnormally low numbers of adult fall-run Chinook salmon that originated in California's Central Valley. Because California's Fish and Game Commission authorized limited in-river harvest seasons in 2008 and 2009, CAMP staff have assumed that the start dates for those seasons were selected to avoid a period when adult fall-run Chinook salmon were likely to be present, i.e., the harvest season start date can be used to infer when fall-run Chinook salmon and late-fall-run Chinook salmon were likely present. While such an inference oversimplifies the biological reality that there is a period when both runs could be present in a watershed due to overlapping periods in run timing, the approach makes it possible to infer which salmon runs were being harvested during different harvest periods. Because the 2008 start date for in-river angler harvest began on November 1, CAMP staff have attributed the tables below so salmon harvested on or before October 31 are fall-run Chinook salmon, and salmon harvested on or after November 1 are late-fall-run Chinook salmon.

2008 Angler Harvest Restrictions

Year	Targeted salmon run	Watershed	Dates open to salmon harvest
2008	fall-run	Closed everywhere.	none
	late-fall-run	Middle Sacramento River, Red Bluff Diversion Dam to Knights Landing.	Nov. 1 to Dec. 31

In 2008, the harvest of Chinook salmon in the Pacific Ocean along the California coastline by commercial and recreational anglers was prohibited, and inland river harvest was limited to a brief season for late-fall-run Chinook salmon in the Sacramento River.

2009 Angler Harvest Restrictions

Year	Targeted salmon run	Watershed	Dates open to salmon harvest
2009	fall-run	Closed everywhere.	none
	late-fall-run	Middle Sacramento River, Red Bluff Diversion Dam to Knights Landing.	Nov. 16 to Dec. 31

In 2009, the harvest of Chinook salmon in the Pacific Ocean along the California coastline by commercial and recreational anglers was prohibited, and inland river harvest was limited to a brief season for late-fall-run Chinook salmon in the Sacramento River.

2010 Angler Harvest Restrictions

Year	Targeted salmon run	Watershed	Dates open to salmon harvest
2010	fall- and/or late-fall-run	American River, Ancil Hoffman Park to American River mouth.	Oct. 30 to Nov. 28
	fall-run	Feather River, Thermiloto Afterbay Outlet to Feather River mouth.	July 31 to August 29
	fall-run	Upper Sacramento River, Deschutes Road Bridge (Anderson) to 500 feet upstream of Red Bluff Diversion Dam.	Oct. 9 to Oct. 31
	fall- and/or late-fall-run	Middle Sacramento River, Lower Red Bluff Boat Ramp to Hwy 133 Bridge (Knights Landing).	Oct. 9 to Dec. 12
	fall-run	Lower Sacramento River, Carquinez Straight to Hwy 133 Bridge (Knights Landing).	Sept. 4 to Oct. 3

In 2010, an abbreviated ocean harvest season for Chinook salmon along the California coastline by commercial and recreational anglers was authorized as follows:

(1) Two four-day periods were open to commercial anglers in July south of Point Arena, and an additional fishery was authorized in the Fort Bragg area during late July and August, and

(2) Recreational anglers were allowed to harvest Chinook salmon seven days per week between April 3 and 30, and Thursday through Monday between May 1 and September 6.

In 2010, an abbreviated inland river harvest of adult fall- and/or late-fall-run Chinook salmon was authorized on portions of the American River, Feather River, and Sacramento River.

2011 Angler Harvest Restrictions

Year	Targeted salmon run	Watershed	Dates open to salmon harvest
2011	fall- and/or late-fall-run	American River, from Nimbus Dam to the Hazel Avenue bridge piers.	July 16 to Dec. 31
	fall-run	American River, from Hazel Avenue bridge piers to the U.S. Geological Survey gauging station cable crossing about 300 yards downstream from the Nimbus Hatchery fish rack site.	July 16 to Sept. 14
	fall-run	American River, from the U.S. Geological Survey gauging station cable crossing about 300 yards downstream from the Nimbus Hatchery fish rack site to the SMUD power line crossing at the southwest boundary of Ancil Hoffman Park.	July 16 to Oct. 31.
	fall- and/or late-fall-run	American River, from the SMUD power line crossing at the southwest boundary of Ancil Hoffman Park downstream to the Jibboom Street bridge.	July 16 to Dec. 31
	fall- and/or late-fall-run	American River, from the Jibboom Street bridge to the mouth.	July 16 to Dec. 11.
	fall- and/or late-fall-run	Feather River, from 1,000 feet below the Thermalito Afterbay Outfall to the mouth.	July 16 to Dec 11.
	fall- and/or late-fall-run	Upper Sacramento River, Deschutes Road Bridge to 500 feet upstream from Red Bluff Diversion Dam.	Aug. 1 to Dec. 18.
	fall- and/or late-fall-run	Middle Sacramento River, 150 feet below the Lower Red Bluff Boat Ramp to Hwy 113 Bridge (Knights Landing).	July 16 to Dec. 18.
	fall- and/or late-fall-run	Lower Sacramento River, from the Hwy 113 bridge near Knights Landing to the Carquinez Bridge.	July 16 to Dec. 11.

In 2011, the ocean harvest of Chinook salmon off the California coastline was similar to years prior to 2008, and inland river harvest of adult fall- and/or late-fall-run Chinook salmon was authorized on portions of the American River, Feather River, and Sacramento River.

2012 Angler Harvest Restrictions

Year	Targeted salmon run	Watershed	Dates open to salmon harvest
2012	fall- and/or late-fall-run	American River, from Nimbus Dam to the Hazel Avenue bridge piers.	July 16 to Dec. 31.
	fall-run	American River, from Hazel Avenue bridge piers to the U.S. Geological Survey gauging station cable crossing about 300 yards downstream from the Nimbus Hatchery fish rack site.	July 16 to August 15
	fall-run	American River, from the U.S. Geological Survey gauging station cable crossing about 300 yards downstream from the Nimbus Hatchery fish rack site to the SMUD power line crossing at the southwest boundary of Ancil Hoffman Park.	July 16 to Oct. 31.
	fall- and/or late-fall-run	American River, from the SMUD power line crossing at the southwest boundary of Ancil Hoffman Park downstream to the Jibboom Street bridge.	July 16 to Dec. 31.
	fall- and/or late-fall-run	American River, from the Jibboom Street bridge to the mouth.	July 16 to Dec. 16.
	fall-run	Feather River, from the unimproved boat ramp above the Thermalito Afterbay Outfall to 200 yards above the Live Oak boat ramp.	July 16 to Oct. 15.
	fall- and/or late-fall-run	Feather River, from 200 yards above Live Oak boat ramp to the mouth.	July 16 to Dec. 16.
	fall-run	Mokelumne River, From Camanche Dam to Highway 99 bridge.	July 16 to Oct. 15.
	fall- and/or late-fall-run	Mokelumne River, From the Highway 99 bridge to the Woodbridge Irrigation District Dam including Lodi Lake.	July 16 through Dec. 31.
	fall- and/or late-fall-run	Mokelumne River, From the Lower Sacramento Road bridge to the mouth.	July 16 through Dec. 16.
	fall- and/or late-fall-run	Upper Sacramento River, Deschutes Road Bridge to 500 feet upstream from Red Bluff Diversion Dam.	Aug. 1 to Dec. 16.
	fall- and/or late-fall-run	Middle Sacramento River, 150 feet below the Lower Red Bluff Boat Ramp to Hwy 113 Bridge (Knights Landing).	July 16 to Dec. 16.
	fall- and/or late-fall-run	Lower Sacramento River, from the Hwy 113 bridge near Knights Landing to the Carquinez Bridge.	July 16 to Dec. 16.

In 2012, the ocean harvest of Chinook salmon off the California coastline was similar to years prior to 2008, and inland river harvest of adult fall- and/or late-fall-run Chinook salmon was authorized on portions of the American, Feather, Mokelumne, and Sacramento Rivers.

2013 Angler Harvest Restrictions

Year	Targeted salmon run	Watershed	Dates open to salmon harvest
2013	fall- and/or late-fall-run	American River, from Nimbus Dam to the Hazel Avenue bridge piers.	July 16 to Dec. 31.
	fall-run	American River, from Hazel Avenue bridge piers to the U.S. Geological Survey gauging station cable crossing about 300 yards downstream from the Nimbus Hatchery fish rack site.	July 16 to August 15
	fall-run	American River, from the U.S. Geological Survey gauging station cable crossing about 300 yards downstream from the Nimbus Hatchery fish rack site to the SMUD power line crossing at the southwest boundary of Ancil Hoffman Park.	July 16 to Oct. 31.
	fall- and/or late-fall-run	American River, from the SMUD power line crossing at the southwest boundary of Ancil Hoffman Park downstream to the Jibboom Street bridge.	July 16 to Dec. 31.
	fall- and/or late-fall-run	American River, from the Jibboom Street bridge to the mouth.	July 16 to Dec. 16.
	fall-run	Feather River, from the unimproved boat ramp above the Thermalito Afterbay Outfall to 200 yards above the Live Oak boat ramp.	July 16 to Oct. 15.
	fall- and/or late-fall-run	Feather River, from 200 yards above Live Oak boat ramp to the mouth.	July 16 to Dec. 16.
	fall-run	Mokelumne River, From Camanche Dam to Highway 99 bridge.	July 16 to Oct. 15.
	fall- and/or late-fall-run	Mokelumne River, From the Highway 99 bridge to the Woodbridge Irrigation District Dam including Lodi Lake.	July 16 through Dec. 31.
	fall- and/or late-fall-run	Mokelumne River, From the Lower Sacramento Road bridge to the mouth.	July 16 through Dec. 16.
	fall- and/or late-fall-run	Upper Sacramento River, Deschutes Road Bridge to 500 feet upstream from Red Bluff Diversion Dam.	Aug. 1 to Dec. 16.
	fall- and/or late-fall-run	Middle Sacramento River, 150 feet below the Lower Red Bluff Boat Ramp to Hwy 113 Bridge (Knights Landing).	July 16 to Dec. 16.
	fall- and/or late-fall-run	Lower Sacramento River, from the Hwy 113 bridge near Knights Landing to the Carquinez Bridge.	July 16 to Dec. 16.

In 2013, the ocean harvest of Chinook salmon off the California coastline was similar to years prior to 2008, and inland river harvest of adult fall- and/or late-fall-run Chinook salmon was authorized on portions of the American, Feather, Mokelumne, and Sacramento Rivers.

APPENDIX B: ANNUAL CHINOOK SALMON PRODUCTION TABLES

1992 Adult Chinook Salmon Production Estimates							
Watershed	**In-river spawner abundance**	**Fish entering a hatchery**	**Estimated in-river harvest**	**Ocean harvest**	**Total production**	**Percent natural production**	**Natural production**
Fall-Run Chinook Salmon							
American River	5,911	6,456	5,565	28,099	46,031	60	27,618
Antelope Creek	0	0	0	0	0	80	0
Battle Creek	5,433	7,275	1,271	21,897	35,876	10	3,588
Bear River						100	0
Big Chico Creek						100	0
Butte Creek						80	0
Clear Creek	600	0	60	1,037	1,697	80	1,358
Cosumnes River						100	0
Cottonwood Creek	1,585	0	159	2,724	4,468	80	3,574
Cow Creek						80	0
Deer Creek						80	0
Feather River	24,105	16,440	8,109	76,224	124,878	60	74,927
Merced River	618	368	49	1,627	2,662	90	2,396
Mill Creek	999	0	100	1,728	2,827	80	2,262
Miscellaneous Creeks						80	0
Mokelumne River	935	710	165	2,826	4,636	60	2,781
Paynes Creek						80	0
Sacramento River	32,229	0	3,223	55,547	90,998	60	54,599
Stanislaus River	255	0	13	427	695	100	695
Tuolumne River	132	0	7	224	362	100	362
Yuba River	6,362	0	636	10,959	17,957	100	17,957
Total	79,164	31,249	19,356	203,318	333,087		192,117
Late-Fall Run Chinook Salmon							
Battle Creek		344	69	648	1,060	10	106
Sacramento River	9,389	398	1,957	18,399	30,144	91.8	27,672
Total	9,389	742	2,026	19,047	31,204		27,778
Winter-Run Chinook Salmon							
Calaveras River						100	0
Sacramento River	1,203	34	0	1,930	3,167	100	3,167
Total	1,203	34	0	1,930	3,167	100	3,167
Spring-Run Chinook Salmon							
Butte Creek	730	0	73	1,258	2,061	100	2,061
Deer Creek	209	0	21	360	590	100	590
Mill Creek	237	0	24	408	669	100	669
Sacramento River	371	0	74	697	1,143	100	1,143
Total	1,547	0	192	2,724	4,463		4,463
Total 1992 Natural Production of Adult Chinook Salmon							**227,524**

1993 Adult Chinook Salmon Production Estimates							
Watershed	**In-river spawner abundance**	**Fish entering a hatchery**	**Estimated in-river harvest**	**Ocean harvest**	**Total production**	**Percent natural production**	**Natural production**
Fall-Run Chinook Salmon							
American River	31,027	10,656	18,757	106,273	166,713	60	100,028
Antelope Creek						80	0
Battle Creek	11,029	7,587	1,862	36,001	56,478	10	5,648
Bear River						100	0
Big Chico Creek						100	0
Butte Creek						80	0
Clear Creek	1,246	0	125	2,400	3,771	80	3,017
Cosumnes River						100	0
Cottonwood Creek						80	0
Cow Creek						80	0
Deer Creek	72	0	7	141	220	80	176
Feather River	30,923	11,991	8,583	90,566	142,063	60	85,238
Merced River	1,269	409	84	3,106	4,868	90	4,381
Mill Creek	1,975	0	198	3,812	5,984	80	4,787
Miscellaneous Creeks						80	0
Mokelumne River	993	2,164	316	6,106	9,579	60	5,747
Paynes Creek						80	0
Sacramento River	46,231	0	4,623	89,437	140,291	60	84,175
Stanislaus River	677	0	34	1,235	1,946	100	1,946
Tuolumne River	471	0	24	882	1,377	100	1,377
Yuba River	6,703	0	670	12,953	20,326	100	20,326
Total	132,616	32,807	35,281	352,913	553,617		316,846
Late-Fall Run Chinook Salmon							
Battle Creek		528	106	1,107	1,741	10	174
Sacramento River	339	400	148	1,550	2,436	91.8	2,237
Total	339	928	253	2,656	4,177		2,411
Winter-Run Chinook Salmon							
Calaveras River						100	0
Sacramento River	378	0	0	682	1,060	100	1,060
Total	378	0	0	682	1,060	100	1,060
Spring-Run Chinook Salmon							
Butte Creek	650	0	65	1,253	1,968	100	1,968
Deer Creek	259	0	26	499	784	100	784
Mill Creek	61	0	6	118	185	100	185
Sacramento River	391	0	78	822	1,291	100	1,291
Total	1,361	0	175	2,692	4,229		4,229
Total 1993 Natural Production of Adult Chinook Salmon							**324,546**

1994 Adult Chinook Salmon Production Estimates							
Watershed	**In-river spawner abundance**	**Fish entering a hatchery**	**Estimated in-river harvest**	**Ocean harvest**	**Total production**	**Percent natural production**	**Natural production**
Fall-Run Chinook Salmon							
American River	33,598	8,567	18,974	104,552	165,691	60	99,415
Antelope Creek						80	0
Battle Creek	24,274	18,991	4,327	81,378	128,969	10	12,897
Bear River						100	0
Big Chico Creek						100	0
Butte Creek						80	0
Clear Creek	2,546	0	255	4,805	7,606	80	6,085
Cosumnes River						100	0
Cottonwood Creek						80	0
Cow Creek						80	0
Deer Creek	307	0	31	584	922	80	737
Feather River	38,382	15,202	10,717	109,986	174,287	60	104,572
Merced River	2,646	943	179	6,467	10,236	90	9,212
Mill Creek	1,081	0	108	2,021	3,210	80	2,568
Miscellaneous Creeks						80	0
Mokelumne River	1,238	1,919	316	5,928	9,401	60	5,641
Paynes Creek						80	0
Sacramento River	58,546	0	5,855	110,121	174,521	60	104,713
Stanislaus River	1,031	0	52	1,841	2,924	100	2,924
Tuolumne River	506	0	25	898	1,430	100	1,430
Yuba River	10,890	0	1,089	20,479	32,458	100	32,458
Total	175,045	45,622	41,927	449,060	711,654		382,650
Late-Fall Run Chinook Salmon							
Battle Creek		598	120	1,227	1,945	10	195
Sacramento River	137	154	58	597	946	91.8	869
Total	137	752	178	1,825	2,892		1,063
Winter-Run Chinook Salmon							
Calaveras River						100	0
Sacramento River	144	42	0	319	505	100	505
Total	144	42	0	319	505	100	505
Spring-Run Chinook Salmon							
Butte Creek	474	0	47	891	1,412	100	1,412
Deer Creek	485	0	49	911	1,444	100	1,444
Mill Creek	723	0	72	1,358	2,154	100	2,154
Sacramento River	862	0	172	1,767	2,801	100	2,801
Total	2,544	0	341	4,927	7,811		7,811
Total 1994 Natural Production of Adult Chinook Salmon							**392,030**

1995 Adult Chinook Salmon Production Estimates							
Watershed	**In-river spawner abundance**	**Fish entering a hatchery**	**Estimated in-river harvest**	**Ocean harvest**	**Total production**	**Percent natural production**	**Natural production**
Fall-Run Chinook Salmon							
American River	70,618	6,498	34,702	279,893	391,712	60	235,027
Antelope Creek						80	0
Battle Creek	56,515	26,677	8,319	229,085	320,596	10	32,060
Bear River						100	0
Big Chico Creek						100	0
Butte Creek	445	0	45	1,193	1,683	80	1,346
Clear Creek	9,298	0	930	25,653	35,881	80	28,704
Cosumnes River						100	0
Cottonwood Creek						80	0
Cow Creek						80	0
Deer Creek						80	0
Feather River	59,912	12,149	14,412	216,458	302,931	60	181,758
Merced River	2,320	602	146	7,656	10,724	90	9,652
Mill Creek						80	0
Miscellaneous Creeks						80	0
Mokelumne River	2,194	3,323	552	15,213	21,281	60	12,769
Paynes Creek						80	0
Sacramento River	63,934	0	6,393	176,089	246,417	60	147,850
Stanislaus River	619	0	31	1,591	2,241	100	2,241
Tuolumne River	827	0	41	2,187	3,056	100	3,056
Yuba River	14,237	0	1,424	39,175	54,836	100	54,836
Total	280,919	49,249	66,995	994,194	1,391,357		709,299
Late-Fall Run Chinook Salmon							
Battle Creek		323	65	948	1,336	10	134
Sacramento River		166	33	487	686	91.8	630
Total	0	489	98	1,435	2,022		764
Winter-Run Chinook Salmon							
Calaveras River						100	0
Sacramento River	1,166	43	0	3,075	4,284	100	4,284
Total	1,166	43	0	3,075	4,284	100	4,284
Spring-Run Chinook Salmon							
Butte Creek	7,500	0	750	20,627	28,877	100	28,877
Deer Creek	1,295	0	130	3,562	4,987	100	4,987
Mill Creek	320	0	32	880	1,232	100	1,232
Sacramento River	426	0	85	1,278	1,789	100	1,789
Total	9,541	0	997	26,346	36,884		36,884
Total 1995 Natural Production of Adult Chinook Salmon							**751,231**

1996 Adult Chinook Salmon Production Estimates							
Watershed	**In-river spawner abundance**	**Fish entering a hatchery**	**Estimated in-river harvest**	**Ocean harvest**	**Total production**	**Percent natural production**	**Natural production**
Fall-Run Chinook Salmon							
American River	69,745	7,651	34,828	126,117	238,341	60	143,005
Antelope Creek						80	0
Battle Creek	52,409	21,178	7,359	90,966	171,912	10	17,191
Bear River						100	0
Big Chico Creek						100	0
Butte Creek	500	0	50	613	1,163	80	931
Clear Creek	5,922	0	592	7,313	13,827	80	11,062
Cosumnes River						100	0
Cottonwood Creek						80	0
Cow Creek						80	0
Deer Creek						80	0
Feather River	57,170	8,107	13,055	88,041	166,374	60	99,824
Merced River	3,291	1,141	222	5,237	9,891	90	8,902
Mill Creek						80	0
Miscellaneous Creeks						80	0
Mokelumne River	4,038	3,883	792	9,814	18,527	60	11,116
Paynes Creek						80	0
Sacramento River	84,086	0	8,409	103,941	196,436	60	117,862
Stanislaus River	168	0	8	189	365	100	365
Tuolumne River	4,362	0	218	5,143	9,723	100	9,723
Yuba River	27,900	0	2,790	34,490	65,180	100	65,180
Total	309,591	41,960	68,323	471,865	891,739		485,160
Late-Fall Run Chinook Salmon							
Battle Creek		1,337	267	1,800	3,404	10	340
Sacramento River		48	10	65	122	91.8	112
Total	0	1385	277	1,865	3,527		453
Winter-Run Chinook Salmon							
Calaveras River						100	0
Sacramento River	1,012	0	0	1,148	2,160	100	2,160
Total	1,012	0	0	1,148	2,160	100	2,160
Spring-Run Chinook Salmon							
Butte Creek	1,413	0	141	1,756	3,311	100	3,311
Deer Creek	614	0	61	763	1,439	100	1,439
Mill Creek	253	0	25	315	593	100	593
Sacramento River	378	0	76	513	966	100	966
Total	2,658	0	304	3,347	6,309		6,309
Total 1996 Natural Production of Adult Chinook Salmon							**494,081**

1997 Adult Chinook Salmon Production Estimates							
Watershed	**In-river spawner abundance**	**Fish entering a hatchery**	**Estimated in-river harvest**	**Ocean harvest**	**Total production**	**Percent natural production**	**Natural production**
Fall-Run Chinook Salmon							
American River	47,195	5,650	23,780	111,370	187,995	60	112,797
Antelope Creek						80	0
Battle Creek	50,744	50,670	10,141	162,097	273,652	10	27,365
Bear River						100	0
Big Chico Creek						100	0
Butte Creek	800	0	80	1,290	2,170	80	1,736
Clear Creek	8,569	0	857	13,717	23,143	80	18,515
Cosumnes River						100	0
Cottonwood Creek						80	0
Cow Creek						80	0
Deer Creek	1,203	0	120	1,901	3,225	80	2,580
Feather River	50,547	15,128	13,135	114,493	193,303	60	115,982
Merced River	2,714	946	183	5,568	9,411	90	8,470
Mill Creek	478	0	48	747	1,273	80	1,018
Miscellaneous Creeks						80	0
Mokelumne River	3,681	6,494	1,018	16,298	27,490	60	16,494
Paynes Creek						80	0
Sacramento River	119,296	0	11,930	190,686	321,912	60	193,147
Stanislaus River	5,588	0	279	8,556	14,424	100	14,424
Tuolumne River	7,146	0	357	10,933	18,437	100	18,437
Yuba River	25,948	0	2,595	41,492	70,035	100	70,035
Total	323,909	78,888	64,523	679,151	1,146,471		601,000
Late-Fall Run Chinook Salmon							
Battle Creek		4,578	916	8,011	13,505	10	1,350
Sacramento River							0
Total	0	4578	916	8,011	13,505		1,350
Winter-Run Chinook Salmon							
Calaveras River						100	0
Sacramento River	836	0	0	1,243	2,079	100	2,079
Total	836	0	0	1,243	2,079	100	2,079
Spring-Run Chinook Salmon							
Butte Creek	635	0	64	1,003	1,702	100	1,702
Deer Creek	466	0	47	736	1,249	100	1,249
Mill Creek	202	0	20	319	541	100	541
Sacramento River	128	0	26	221	374	100	374
Total	1,431	0	156	2,279	3,866		3,866
Total 1997 Natural Production of Adult Chinook Salmon							**608,296**

1998 Adult Chinook Salmon Production Estimates							
Watershed	**In-river spawner abundance**	**Fish entering a hatchery**	**Estimated in-river harvest**	**Ocean harvest**	**Total production**	**Percent natural production**	**Natural production**
Fall-Run Chinook Salmon							
American River	50,457	11,788	28,010	81,176	171,431	60	102,859
Antelope Creek						80	0
Battle Creek	53,957	44,351	9,831	97,253	205,392	10	20,539
Bear River						100	0
Big Chico Creek						100	0
Butte Creek	500	0	50	502	1,052	80	841
Clear Creek	4,259	0	426	4,224	8,909	80	7,127
Cosumnes River	300	0	30	290	620	100	620
Cottonwood Creek						80	0
Cow Creek						80	0
Deer Creek	270	0	27	264	561	80	449
Feather River		18,889	3,778	20,380	43,047	60	25,828
Merced River	3,292	799	205	3,854	8,150	90	7,335
Mill Creek	546	0	55	528	1,129	80	903
Miscellaneous Creeks						80	0
Mokelumne River	4,122	3,091	721	7,128	15,062	60	9,037
Paynes Creek						80	0
Sacramento River	6,318	0	632	6,257	13,206	60	7,924
Stanislaus River	3,087	0	154	2,904	6,145	100	6,145
Tuolumne River	8,910	0	446	8,421	17,777	100	17,777
Yuba River	31,090	0	3,109	30,755	64,954	100	64,954
Total	167,108	78,918	47,473	263,935	557,433		272,337
Late-Fall Run Chinook Salmon							
Battle Creek		3,079	616	3,325	7,020	10	702
Sacramento River	39,340	0	7,868	42,471	89,679	91.8	82,325
Total	39,340	3,079	8,484	45,795	96,698		83,027
Winter-Run Chinook Salmon							
Calaveras River						100	0
Sacramento River	2,893	99	0	2,688	5,680	100	5,680
Total	2,893	99	0	2,688	5,680	100	5,680
Spring-Run Chinook Salmon							
Butte Creek	20,259	0	2,026	20,038	42,323	100	42,323
Deer Creek	1,879	0	188	1,858	3,925	100	3,925
Mill Creek	424	0	42	419	885	100	885
Sacramento River	1,115	0	223	1,204	2,542	100	2,542
Total	23,677	0	2,479	23,519	49,676		49,676
Total 1998 Natural Production of Adult Chinook Salmon							**410,720**

1999 Adult Chinook Salmon Production Estimates							
Watershed	**In-river spawner abundance**	**Fish entering a hatchery**	**Estimated in-river harvest**	**Ocean harvest**	**Total production**	**Percent natural production**	**Natural production**
Fall-Run Chinook Salmon							
American River	55,339	9,760	29,295	62,462	156,855	60	94,113
Antelope Creek						80	0
Battle Creek	92,929	26,970	11,990	87,276	219,164	10	21,916
Bear River						100	0
Big Chico Creek						100	0
Butte Creek						80	0
Clear Creek	8,003	0	800	5,831	14,634	80	11,707
Cosumnes River	229	0	23	158	410	100	410
Cottonwood Creek						80	0
Cow Creek						80	0
Deer Creek						80	0
Feather River		12,927	2,585	10,268	25,780	60	15,468
Merced River	3,129	1,637	238	3,296	8,300	90	7,470
Mill Creek						80	0
Miscellaneous Creeks						80	0
Mokelumne River	2,183	3,150	533	3,866	9,733	60	5,840
Paynes Creek						80	0
Sacramento River	161,192	0	16,119	117,350	294,661	60	176,797
Stanislaus River	4,349	0	217	3,011	7,577	100	7,577
Tuolumne River	8,232	0	412	5,704	14,348	100	14,348
Yuba River	24,230	0	2,423	17,652	44,305	100	44,305
Total	359,815	54,444	64,636	316,873	795,768		399,951
Late-Fall Run Chinook Salmon							
Battle Creek		7,075	1,415	5,613	14,103	10	1,410
Sacramento River	8,683	0	1,737	6,888	17,308	91.8	15,889
Total	8,683	7,075	3,152	12,501	31,411		17,299
Winter-Run Chinook Salmon							
Calaveras River						100	0
Sacramento River	3,264	24	0	2,184	5,472	100	5,472
Total	3,264	24	0	2,184	5,472	100	5,472
Spring-Run Chinook Salmon							
Butte Creek	3,679	0	368	2,669	6,716	100	6,716
Deer Creek	1,591	0	159	1,154	2,904	100	2,904
Mill Creek	560	0	56	406	1,022	100	1,022
Sacramento River	262	0	52	207	522	100	522
Total	6,092	0	635	4,436	11,163		11,163
Total 1999 Natural Production of Adult Chinook Salmon							**433,886**

2000 Adult Chinook Salmon Production Estimates							
Watershed	**In-river spawner abundance**	**Fish entering a hatchery**	**Estimated in-river harvest**	**Ocean harvest**	**Total production**	**Percent natural production**	**Natural production**
Fall-Run Chinook Salmon							
American River	100,852	11,160	50,405	158,781	321,198	60	192,719
Antelope Creek						80	0
Battle Creek	53,447	21,659	7,511	80,791	163,408	10	16,341
Bear River						100	0
Big Chico Creek						100	0
Butte Creek						80	0
Clear Creek	6,687	0	669	7,204	14,560	80	11,648
Cosumnes River	460	0	46	515	1,021	100	1,021
Cottonwood Creek						80	0
Cow Creek						80	0
Deer Creek						80	0
Feather River	114,717	18,146	26,573	155,865	315,301	60	189,180
Merced River	11,130	1,946	654	13,437	27,166	90	24,450
Mill Creek						80	0
Miscellaneous Creeks						80	0
Mokelumne River	1,973	5,450	742	8,005	16,170	60	9,702
Paynes Creek						80	0
Sacramento River	96,688	0	9,669	104,005	210,362	60	126,217
Stanislaus River	8,498	0	425	8,748	17,671	100	17,671
Tuolumne River	17,873	0	894	18,354	37,121	100	37,121
Yuba River	14,995	0	1,500	16,124	32,618	100	32,618
Total	427,320	58,361	99,086	571,829	1,156,596		658,688
Late-Fall Run Chinook Salmon							
Battle Creek	0	4,181	836	4,896	9,913	10	991
Sacramento River	8,702	0	1,740	10,191	20,634	91.8	18,942
Total	8,702	4,181	2,577	15,087	30,547		19,933
Winter-Run Chinook Salmon							
Calaveras River						100	0
Sacramento River	1,261	89	0	1,307	2,657	100	2,657
Total	1,261	89	0	1,307	2,657	100	2,657
Spring-Run Chinook Salmon							
Butte Creek	4,118	0	412	4,438	8,968	100	8,968
Deer Creek	637	0	64	687	1,387	100	1,387
Mill Creek	544	0	54	587	1,185	100	1,185
Sacramento River	43	0	9	51	102	100	102
Total	5,342	0	539	5,762	11,643		11,643
Total 2000 Natural Production of Adult Chinook Salmon							**692,921**

2001 Adult Chinook Salmon Production Estimates							
Watershed	**In-river spawner abundance**	**Fish entering a hatchery**	**Estimated in-river harvest**	**Ocean harvest**	**Total production**	**Percent natural production**	**Natural production**
Fall-Run Chinook Salmon							
American River	135,384	11,750	66,210	61,508	274,853	60	164,912
Antelope Creek						80	0
Battle Creek	100,604	24,698	12,530	39,731	177,564	10	17,756
Bear River						100	0
Big Chico Creek						100	0
Butte Creek	4,433	0	443	1,398	6,274	80	5,019
Clear Creek	10,865	0	1,087	3,451	15,403	80	12,322
Cosumnes River						100	0
Cottonwood Creek						80	0
Cow Creek						80	0
Deer Creek						80	0
Feather River	178,645	24,870	40,703	70,420	314,638	60	188,783
Merced River	9,181	1,663	542	3,276	14,663	90	13,196
Mill Creek						80	0
Miscellaneous Creeks						80	0
Mokelumne River	2,307	5,728	804	2,556	11,394	60	6,836
Paynes Creek						80	0
Sacramento River	75,296	0	7,530	23,874	106,699	60	64,020
Stanislaus River	7,033	0	352	2,119	9,503	100	9,503
Tuolumne River	8,782	0	439	2,665	11,886	100	11,886
Yuba River	23,392	0	2,339	7,426	33,158	100	33,158
Total	555,922	68,709	132,979	218,424	976,034		527,391
Late-Fall Run Chinook Salmon							
Battle Creek	98	2,439	507	879	3,923	10	392
Sacramento River	19,276	0	3,855	6,676	29,808	91.8	27,363
Total	19,374	2,439	4,363	7,555	33,731		27,756
Winter-Run Chinook Salmon							
Calaveras River						100	0
Sacramento River	8,120	104	0	2,371	10,595	93.8	9,938
Total	8,120	104	0	2,371	10,595		9,938
Spring-Run Chinook Salmon							
Butte Creek	9,605	0	961	3,038	13,604	100	13,604
Deer Creek	1,622	0	162	513	2,297	100	2,297
Mill Creek	1,104	0	110	349	1,564	100	1,564
Sacramento River	621	0	124	214	960	100	960
Total	12,952	0	1,357	4,115	18,424		18,424
Total 2001 Natural Production of Adult Chinook Salmon							**583,510**

2002 Adult Chinook Salmon Production Estimates							
Watershed	**In-river spawner abundance**	**Fish entering a hatchery**	**Estimated in-river harvest**	**Ocean harvest**	**Total production**	**Percent natural production**	**Natural production**
Fall-Run Chinook Salmon							
American River	124,252	9,817	60,331	79,946	274,346	60	164,608
Antelope Creek						80	0
Battle Creek	397,149	65,924	46,307	209,518	718,898	10	71,890
Bear River						100	0
Big Chico Creek						100	0
Butte Creek	3,665	0	367	1,675	5,707	80	4,565
Clear Creek	16,071	0	1,607	7,287	24,965	80	19,972
Cosumnes River	1,350	0	135	628	2,113	100	2,113
Cottonwood Creek						80	0
Cow Creek						80	0
Deer Creek						80	0
Feather River	105,163	20,507	25,134	62,022	212,826	60	127,696
Merced River	8,866	1,840	535	4,607	15,848	90	14,263
Mill Creek	2,611	0	261	1,173	4,045	80	3,236
Miscellaneous Creeks						80	0
Mokelumne River	2,840	7,913	1,075	4,858	16,686	60	10,012
Paynes Creek						80	0
Sacramento River	65,690	0	6,569	29,734	101,993	60	61,196
Stanislaus River	7,787	0	389	3,350	11,527	100	11,527
Tuolumne River	7,173	0	359	3,099	10,631	100	10,631
Yuba River	24,051	0	2,405	10,888	37,345	100	37,345
Total	766,668	106,001	145,475	418,785	1,436,928		539,052
Late-Fall Run Chinook Salmon							
Battle Creek	216	4,186	880	2,174	7,456	10	746
Sacramento River	36,004	0	7,201	17,788	60,992	91.8	55,991
Total	36,220	4,186	8,081	19,961	68,449		56,737
Winter-Run Chinook Salmon							
Calaveras River						100	0
Sacramento River	7,337	104	0	3,043	10,484	87.7	9,195
Total	7,337	104	0	3,043	10,484		9,195
Spring-Run Chinook Salmon							
Butte Creek	8,785	0	879	3,966	13,630	100	13,630
Deer Creek	2,195	0	220	991	3,406	100	3,406
Mill Creek	1,594	0	159	720	2,473	100	2,473
Sacramento River	195	0	39	96	330	100	330
Total	12,769	0	1,296	5,774	19,839		19,839
Total 2002 Natural Production of Adult Chinook Salmon							**624,822**

2003 Adult Chinook Salmon Production Estimates							
Watershed	**In-river spawner abundance**	**Fish entering a hatchery**	**Estimated in-river harvest**	**Ocean harvest**	**Total production**	**Percent natural production**	**Natural production**
Fall-Run Chinook Salmon							
American River	163,742	14,887	80,383	106,525	365,537	60	219,322
Antelope Creek						80	0
Battle Creek	64,764	88,234	15,300	69,204	237,502	10	23,750
Bear River						100	0
Big Chico Creek						100	0
Butte Creek	3,492	0	349	1,575	5,416	80	4,333
Clear Creek	9,475	0	948	4,279	14,701	80	11,761
Cosumnes River	122	0	12	59	194	100	194
Cottonwood Creek						80	0
Cow Creek						80	0
Deer Creek						80	0
Feather River	89,946	14,976	20,984	51,792	177,698	60	106,619
Merced River	2,530	549	154	1,337	4,570	90	4,113
Mill Creek	2,426	0	243	1,099	3,768	80	3,014
Miscellaneous Creeks						80	0
Mokelumne River	2,122	8,117	1,024	4,635	15,898	60	9,539
Paynes Creek						80	0
Sacramento River	89,229	0	8,923	40,352	138,504	60	83,102
Stanislaus River	5,902	0	295	2,555	8,753	100	8,753
Tuolumne River	2,163	0	108	921	3,192	100	3,192
Yuba River	28,316	0	2,832	12,807	43,954	100	43,954
Total	464,229	126,763	131,554	297,140	1,019,686		521,646
Late-Fall Run Chinook Salmon							
Battle Creek	57	3,183	648	1,597	5,485	10	548
Sacramento River	5,494	38	1,106	2,725	9,364	91.8	8,596
Total	5,551	3,221	1,754	4,322	14,848		9,144
Winter-Run Chinook Salmon							
Calaveras River						100	0
Sacramento River	8,133	85	0	3,365	11,583	94.2	10,911
Total	8,133	85	0	3,365	11,583		10,911
Spring-Run Chinook Salmon							
Butte Creek	4,398	0	440	1,993	6,831	100	6,831
Deer Creek	2,759	0	276	1,250	4,285	100	4,285
Mill Creek	1,426	0	143	646	2,215	100	2,215
Sacramento River	0	0	0	0	0	0	0
Total	8,583	0	858	3,889	13,331		13,331
Total 2003 Natural Production of Adult Chinook Salmon							**555,033**

2004 Adult Chinook Salmon Production Estimates							
Watershed	**In-river spawner abundance**	**Fish entering a hatchery**	**Estimated in-river harvest**	**Ocean harvest**	**Total production**	**Percent natural production**	**Natural production**
Fall-Run Chinook Salmon							
American River	99,230	26,400	56,534	191,486	373,650	60	224,190
Antelope Creek						80	0
Battle Creek	23,861	69,172	9,303	107,589	209,925	10	20,993
Bear River						100	0
Big Chico Creek						100	0
Butte Creek	2,516	0	252	2,905	5,673	80	4,538
Clear Creek	6,365	0	637	7,363	14,364	80	11,492
Cosumnes River	1,208	0	121	1,402	2,731	100	2,731
Cottonwood Creek						80	0
Cow Creek						80	0
Deer Creek	300	0	30	351	681	80	544
Feather River	54,171	21,297	15,094	95,167	185,729	60	111,437
Merced River	3,270	1,050	216	4,758	9,294	90	8,365
Mill Creek	1,192	0	119	1,402	2,714	80	2,171
Miscellaneous Creeks						80	0
Mokelumne River	1,588	10,356	1,194	13,824	26,963	60	16,178
Paynes Creek						80	0
Sacramento River	43,604	0	4,360	50,439	98,403	60	59,042
Stanislaus River	4,015	0	201	4,408	8,623	100	8,623
Tuolumne River	1,984	0	99	2,204	4,287	100	4,287
Yuba River	15,269	0	1,527	17,631	34,427	100	34,427
Total	258,573	128,275	89,686	500,929	977,463		509,017
Late-Fall Run Chinook Salmon							
Battle Creek	40	5,166	1,041	6,560	12,807	10	1,281
Sacramento River	8,824	60	1,777	11,194	21,855	91.8	20,063
Total	8,864	5,226	2,818	17,754	34,662		21,343
Winter-Run Chinook Salmon							
Calaveras River						100	0
Sacramento River	7,784	85	0	8,285	16,154	92	14,862
Total	7,784	85	0	8,285	16,154	100	14,862
Spring-Run Chinook Salmon							
Butte Creek	7,390	0	739	8,535	16,664	100	16,664
Deer Creek	804	0	80	929	1,813	100	1,813
Mill Creek	998	0	100	1,153	2,250	100	2,250
Sacramento River	370	0	74	467	911	100	911
Total	9,562	0	993	11,083	21,638		21,638
Total 2004 Natural Production of Adult Chinook Salmon							**566,861**

2005 Adult Chinook Salmon Production Estimates							
Watershed	**In-river spawner abundance**	**Fish entering a hatchery**	**Estimated in-river harvest**	**Ocean harvest**	**Total production**	**Percent natural production**	**Natural production**
Fall-Run Chinook Salmon							
American River	62,679	22,349	38,263	84,823	208,114	60	124,868
Antelope Creek						80	0
Battle Creek	20,520	142,673	16,319	123,509	303,021	10	30,302
Bear River						100	0
Big Chico Creek						100	0
Butte Creek	4,255	0	426	3,209	7,889	80	6,312
Clear Creek	14,824	0	1,482	11,231	27,538	80	22,030
Cosumnes River	370	0	37	285	692	100	692
Cottonwood Creek						80	0
Cow Creek						80	0
Deer Creek	963	0	96	713	1,772	80	1,418
Feather River	49,160	22,405	14,313	59,080	144,958	60	86,975
Merced River	1,942	421	118	1,711	4,193	90	3,773
Mill Creek	2,426	0	243	1,854	4,523	80	3,618
Miscellaneous Creeks						80	0
Mokelumne River	10,406	5,563	1,597	12,087	29,653	60	17,792
Paynes Creek						80	0
Sacramento River	57,012	0	5,701	43,143	105,856	60	63,513
Stanislaus River	1,427	0	71	1,034	2,532	100	2,532
Tuolumne River	668	0	33	499	1,201	100	1,201
Yuba River	17,630	0	1,763	13,335	32,728	100	32,728
Total	244,282	193,411	80,463	356,514	874,670		397,755
Late-Fall Run Chinook Salmon							
Battle Creek	23	5,562	1,117	4,605	11,307	10	1,131
Sacramento River	10,524	79	2,121	8,744	21,467	91.8	19,707
Total	10,547	5,641	3,238	13,349	32,775		20,838
Winter-Run Chinook Salmon							
Calaveras River						100	0
Sacramento River	15,730	109	0	10,883	26,722	80.5	21,511
Total	15,730	109	0	10,883	26,722	100	21,511
Spring-Run Chinook Salmon							
Butte Creek	10,625	0	1,063	8,054	19,742	100	19,742
Deer Creek	2,239	0	224	1,697	4,160	100	4,160
Mill Creek	1,150	0	115	872	2,137	100	2,137
Sacramento River	30	0	6	24	60	100	60
Total	14,044	0	1,407	10,648	26,099		26,099
Total 2005 Natural Production of Adult Chinook Salmon							**466,203**

2006 Adult Chinook Salmon Production Estimates							
Watershed	**In-river spawner abundance**	**Fish entering a hatchery**	**Estimated in-river harvest**	**Ocean harvest**	**Total production**	**Percent natural production**	**Natural production**
Fall-Run Chinook Salmon							
American River	24,540	8,728	14,971	15,554	63,793	60	38,276
Antelope Creek						80	0
Battle Creek	19,493	57,832	7,733	27,439	112,496	10	11,250
Bear River						100	0
Big Chico Creek						100	0
Butte Creek	1,920	0	192	685	2,797	80	2,238
Clear Creek	8,422	0	842	2,985	12,249	80	9,799
Cosumnes River	530	0	53	188	771	100	771
Cottonwood Creek						80	0
Cow Creek	4,209	0	421	1,492	6,122	80	4,898
Deer Creek	1,905	0	191	674	2,770	80	2,216
Feather River	76,414	14,034	18,090	35,011	143,549	60	86,129
Merced River	1,429	150	79	531	2,189	90	1,970
Mill Creek	1,403	0	140	497	2,041	80	1,633
Miscellaneous Creeks						80	0
Mokelumne River	1,732	4,139	587	2,078	8,536	60	5,122
Paynes Creek						80	0
Sacramento River	55,468	0	5,547	19,678	80,693	60	48,416
Stanislaus River	1,923	0	96	652	2,671	100	2,671
Tuolumne River	562	0	28	188	778	100	778
Yuba River	8,121	0	812	2,885	11,818	100	11,818
Total	208,071	84,883	49,781	110,540	453,274		227,985
Late-Fall Run Chinook Salmon							
Battle Creek	50	4,822	974	1,887	7,733	10	773
Sacramento River	10,163	12	2,035	3,941	16,151	91.8	14,826
Total	10,213	4,834	3,009	5,828	23,884		15,600
Winter-Run Chinook Salmon							
Calaveras River						100	0
Sacramento River	17,197	93	0	5,578	22,868	86.2	19,712
Total	17,197	93	0	5,578	22,868		19,712
Spring-Run Chinook Salmon							
Butte Creek	4,579	0	458	1,626	6,663	100	6,663
Deer Creek	2,432	0	243	864	3,539	100	3,539
Mill Creek	1,002	0	100	356	1,458	100	1,458
Sacramento River	0	0	0	0	0	0	0
Total	8,013	0	801	2,845	11,659		11,659
Total 2006 Natural Production of Adult Chinook Salmon							**274,956**

2007 Adult Chinook Salmon Production Estimates							
Watershed	**In-river spawner abundance**	**Fish entering a hatchery**	**Estimated in-river harvest**	**Ocean harvest**	**Total production**	**Percent natural production**	**Natural production**
Fall-Run Chinook Salmon							
American River	10,120	4,597	6,623	16,270	37,610	60	22,566
Antelope Creek						80	0
Battle Creek	9,904	11,744	2,165	18,160	41,973	10	4,197
Bear River						100	0
Big Chico Creek						100	0
Butte Creek	1,225	0	123	1,024	2,371	80	1,897
Clear Creek	4,157	0	416	3,483	8,056	80	6,445
Cosumnes River	77	0	8	61	146	100	146
Cottonwood Creek	1,250	0	125	1,050	2,425	80	1,940
Cow Creek	2,044	0	204	1,715	3,964	80	3,171
Deer Creek	563	0	56	473	1,092	80	874
Feather River	21,909	6,170	5,616	25,696	59,391	60	35,634
Merced River	485	79	28	455	1,047	90	943
Mill Creek	851	0	85	718	1,654	80	1,323
Miscellaneous Creeks	140	0	14	114	268	80	214
Mokelumne River	470	1,051	152	1,278	2,951	60	1,771
Paynes Creek						80	0
Sacramento River	17,061	0	1,706	14,309	33,077	60	19,846
Stanislaus River	443	0	22	359	824	100	824
Tuolumne River	224	0	11	175	410	100	410
Yuba River	2,604	0	260	2,188	5,052	100	5,052
Total	73,527	23,641	17,614	87,528	202,311		107,253
Late-Fall Run Chinook Salmon							
Battle Creek	72	3,360	686	3,139	7,258	10	726
Sacramento River	15,275	66	3,068	14,034	32,444	91.8	29,783
Total	15,347	3,426	3,755	17,174	39,701		30,509
Winter-Run Chinook Salmon							
Calaveras River	0	0	0	0	0	100	0
Sacramento River	2,487	54	0	1,932	4,473	92.6	4,142
Total	2,487	54	0	1,932	4,473		4,142
Spring-Run Chinook Salmon							
Butte Creek	4,943	0	494	4,145	9,582	100	9,582
Deer Creek	644	0	64	540	1,248	100	1,248
Mill Creek	920	0	92	771	1,783	100	1,783
Sacramento River	248	0	50	227	524	100	524
Total	6,755	0	700	5,683	13,138		13,138
Total 2007 Natural Production of Adult Chinook Salmon							**155,042**

2008 Adult Chinook Salmon Production Estimates							
Watershed	**In-river spawner abundance**	**Fish entering a hatchery**	**Estimated in-river harvest**	**Ocean harvest**	**Total production**	**Percent natural production**	**Natural production**
Fall-Run Chinook Salmon							
American River	2,514	3,232	0	0	5,746	60	3,448
Antelope Creek							0
Battle Creek	4,286	10,639	0	0	14,925	10	1,493
Bear River							0
Big Chico Creek							0
Butte Creek	275	0	0	0	275	80	220
Clear Creek	7,677	0	0	0	7,677	80	6,142
Cosumnes River	15	0	0	0	15	100	15
Cottonwood Creek	510	0	0	0	510	80	408
Cow Creek	478	0	0	0	478	80	382
Deer Creek	194	0	0	0	194	80	155
Feather River	5,939	4,914	0	0	10,853	60	6,512
Merced River	389	76	0	0	465	90	419
Mill Creek	218	0	0	0	218	80	174
Miscellaneous Creeks	19	0	0	0	19	80	15
Mokelumne River	173	239	0	0	412	60	247
Paynes Creek							0
Sacramento River	24,743	0	0	0	24,743	60	14,846
Stanislaus River	865	0	0	0	865	100	865
Tuolumne River	388	0	0	0	388	100	388
Yuba River	3,508	0	0	0	3,508	100	3,508
Total	52,191	19,100	0	0	71,291		39,236
Late-Fall Run Chinook Salmon							
Battle Creek	19	6,334	0	0	6,353	10	635
Sacramento River	3,964	0	579	0	4,543	91.8	4,170
Total	3,983	6,334	579	0	10,896		4,806
Winter-Run Chinook Salmon							
Calaveras River	0	0	0	0	0	100	0
Sacramento River	2,725	105	0	0	2,830	90.3	2,555
Total	2,725	105	0	0	2,830		2,555
Spring-Run Chinook Salmon							
Butte Creek	3,935	0	0	0	3,935	100	3,935
Deer Creek	140	0	0	0	140	100	140
Mill Creek	381	0	0	0	381	100	381
Sacramento River	52	0	0	0	52	100	52
Total	4,508	0	0	0	4,508		4,508
Total 2008 Natural Production of Adult Chinook Salmon							**51,105**

2009 Adult Chinook Salmon Production Estimates							
Watershed	**In-river spawner abundance**	**Fish entering a hatchery**	**Estimated in-river harvest**	**Ocean harvest**	**Total production**	**Percent natural production**	**Natural production**
Fall-Run Chinook Salmon							
American River	5,297	4,789	0	0	10,086	60	6,052
Antelope Creek							0
Battle Creek	3,047	6,152	0	0	9,199	10	920
Bear River							0
Big Chico Creek							0
Butte Creek	306	0	0	0	306	80	245
Clear Creek	3,228	0	0	0	3,228	80	2,582
Cosumnes River	0	0	0	0	0	100	0
Cottonwood Creek	1,055	0	0	0	1,055	80	844
Cow Creek	261	0	0	0	261	80	209
Deer Creek	58	0	0	0	58	80	46
Feather River	4,847	9,963	0	0	14,810	60	8,886
Merced River	358	246	0	0	604	90	544
Mill Creek	102	0	0	0	102	80	82
Miscellaneous Creeks	6	0	0	0	6	80	5
Mokelumne River	680	1,553	0	0	2,233	60	1,340
Paynes Creek							0
Sacramento River	5,827	0	0	0	5,827	60	3,496
Stanislaus River	595	0	0	0	595	100	595
Tuolumne River	124	0	0	0	124	100	124
Yuba River	4,635	0	0	0	4,635	100	4,635
Total	30,426	22,703	0	0	53,129		30,604
Late-Fall Run Chinook Salmon							
Battle Creek	32	6,429	0	0	6,461	10	646
Sacramento River	3,489	32	514	0	4,035	91.8	3,704
Total	3,521	6,461	514	0	10,496		4,350
Winter-Run Chinook Salmon							
Calaveras River	0	0	0	0	0	100	0
Sacramento River	4,416	121	0	0	4,537	89.7	4,070
Total	4,416	121	0	0	4,537		4,070
Spring-Run Chinook Salmon							
Butte Creek	2,059	0	0	0	2,059	100	2,059
Deer Creek	213	0	0	0	213	100	213
Mill Creek	220	0	0	0	220	100	220
Sacramento River	0	0	0	0	0	100	0
Total	2,492	0	0	0	2,492		2,492
Total 2009 Natural Production of Adult Chinook Salmon							**41,516**

2010 Adult Chinook Salmon Production Estimates							
Watershed	**In-river spawner abundance**	**Fish entering a hatchery**	**Estimated in-river harvest**	**Ocean harvest**	**Total production**	**Percent natural production**	**Natural production**
Fall-Run Chinook Salmon							
American River	14,688	9,095	10,702	2,457	36,943	60	22,166
Antelope Creek							0
Battle Creek	6,631	17,238	2,387	1,871	28,127	10	2,813
Bear River							0
Big Chico Creek							0
Butte Creek	370	0	37	29	436	80	349
Clear Creek	7,192	0	719	563	8,474	80	6,779
Cosumnes River	740	0	74	58	872	100	872
Cottonwood Creek	1,137	0	114	89	1,339	80	1,071
Cow Creek	536	0	54	42	631	80	505
Deer Creek	166	0	17	12	195	80	156
Feather River	44,914	19,973	12,977	5,549	83,413	60	50,048
Merced River	651	146	40	59	896	90	807
Mill Creek	144	0	14	11	169	80	136
Miscellaneous Creeks						80	0
Mokelumne River	1,920	5,275	720	565	8,479	60	5,087
Paynes Creek							0
Sacramento River	16,372	0	1,637	1,283	19,292	60	11,575
Stanislaus River	1,086	0	54	82	1,222	100	1,222
Tuolumne River	540	0	27	40	607	100	607
Yuba River	14,375	0	1,438	1,126	16,939	100	16,939
Total	111,462	51,727	31,011	13,836	208,035		121,132
Late-Fall Run Chinook Salmon							
Battle Creek	27	5,505	1,106	473	7,111	10	711
Sacramento River	4,282	81	873	373	5,609	91.8	5,149
Total	4,309	5,586	1,979	846	12,720		5,860
Winter-Run Chinook Salmon							
Calaveras River	0	0	0	0	0	100	0
Sacramento River	1,533	63	0	114	1,710	89.7	1,534
Total	1,533	63	0	114	1,710		1,534
Spring-Run Chinook Salmon							
Butte Creek	1,160	0	116	91	1,367	100	1,367
Deer Creek	262	0	26	21	309	100	309
Mill Creek	482	0	48	38	568	100	568
Sacramento River	0	0	0	0	0	100	0
Total	1,904	0	190	149	2,244		2,244
Total 2010 Natural Production of Adult Chinook Salmon							**130,769**

2011 Adult Chinook Salmon Production Estimates							
Watershed	**In-river spawner abundance**	**Fish entering a hatchery**	**Estimated in-river harvest**	**Ocean harvest**	**Total production**	**Percent natural production**	**Natural production**
Fall-Run Chinook Salmon							
American River	25,626	12,680	17,238	11,808	67,352	60	40,411
Antelope Creek							0
Battle Creek	12,513	42,383	5,490	12,837	73,222	10	7,322
Bear River							0
Big Chico Creek							0
Butte Creek	416	0	42	98	556	80	445
Clear Creek	4,841	0	484	1,133	6,458	80	5,166
Cosumnes River	53	0	5	12	70	100	70
Cottonwood Creek	2,144	0	214	503	2,861	80	2,289
Cow Creek	1,810	0	181	422	2,413	80	1,930
Deer Creek	662	0	66	156	884	80	707
Feather River	47,289	32,616	15,981	20,385	116,271	60	69,763
Merced River	1,571	371	97	433	2,473	90	2,225
Mill Creek	1,231	0	123	289	1,643	80	1,314
Miscellaneous Creeks						80	0
Mokelumne River	2,674	15,922	1,860	4,346	24,802	60	14,881
Paynes Creek							0
Sacramento River	11,957	0	1,196	2,797	15,950	60	9,570
Stanislaus River	1,309	0	65	295	1,669	100	1,669
Tuolumne River	893	0	45	197	1,134	100	1,134
Yuba River	8,928	0	893	2,086	11,907	100	11,907
Total	123,917	103,972	43,979	57,798	329,666		170,805
Late-Fall Run Chinook Salmon							
Battle Creek	28	4,635	933	1,189	6,785	10	678
Sacramento River	3,686	39	745	950	5,420	91.8	4,975
Total	3,714	4,674	1,678	2,139	12,204		5,654
Winter-Run Chinook Salmon							
Calaveras River	0	0	0	0	0	100	0
Sacramento River	738	88	0	176	1,002	89.7	899
Total	738	88	0	176	1,002		899
Spring-Run Chinook Salmon							
Butte Creek	2,130	0	213	496	2,839	100	2,839
Deer Creek	271	0	27	63	361	100	361
Mill Creek	366	0	37	85	488	100	488
Sacramento River	0	0	0	0	0	100	0
Total	2,767	0	277	644	3,688		3,688
Total 2011 Natural Production of Adult Chinook Salmon							**181,046**

2012 Adult Chinook Salmon Production Estimates							
Watershed	**In-river spawner abundance**	**Fish entering a hatchery**	**Estimated in-river harvest**	**Ocean harvest**	**Total production**	**Percent natural production**	**Natural production**
Fall-Run Chinook Salmon							
American River	38,328	9,257	21,413	40,490	109,488	60	65,693
Antelope Creek							0
Battle Creek	31,554	85,293	11,685	75,425	203,957	10	20,396
Bear River							0
Big Chico Creek							0
Butte Creek	813	0	81	520	1,414	80	1,131
Clear Creek	7,631	0	763	4,916	13,311	80	10,648
Cosumnes River	1,071	0	107	685	1,864	100	1,864
Cottonwood Creek	2,556	0	256	1,655	4,466	80	3,573
Cow Creek	1,488	0	149	969	2,606	80	2,085
Deer Creek	873	0	87	567	1,528	80	1,222
Feather River	63,649	42,160	21,162	74,503	201,474	60	120,884
Merced River	2,011	1,000	151	1,844	5,005	90	4,505
Mill Creek	890	0	89	567	1,546	80	1,237
Miscellaneous Creeks						80	0
Mokelumne River	5,471	6,620	1,209	7,800	21,100	60	12,660
Paynes Creek							0
Sacramento River	28,701	0	2,870	18,531	50,102	60	30,061
Stanislaus River	4,006	0	200	2,458	6,665	100	6,665
Tuolumne River	783	0	39	473	1,295	100	1,295
Yuba River	7,668	0	767	4,940	13,375	100	13,375
Total	197,493	144,330	61,028	236,344	639,195		297,294
Late-Fall Run Chinook Salmon							
Battle Creek	19	3,031	610	2,152	5,812	10	581
Sacramento River	2,822	47	574	2,025	5,467	91.8	5,019
Total	2,841	3,078	1,184	4,177	11,280		5,600
Winter-Run Chinook Salmon							
Calaveras River						100	0
Sacramento River	2,581	93	0	1,566	4,240	89.7	3,804
Total	2,581	93	0	1,566	4,240		3,804
Spring-Run Chinook Salmon							
Butte Creek	8,615	0	862	5,568	15,044	100	15,044
Deer Creek	734	0	73	475	1,282	100	1,282
Mill Creek	768	0	77	496	1,341	100	1,341
Sacramento River	0	0	0	0	0	100	0
Total	10,117	0	1,012	6,539	17,668		17,668
Total 2012 Natural Production of Adult Chinook Salmon							**324,365**

2013 Adult Chinook Salmon Production Estimates							
Watershed	**In-river spawner abundance**	**Fish entering a hatchery**	**Estimated in-river harvest**	**Ocean harvest**	**Total production**	**Percent natural production**	**Natural production**
Fall-Run Chinook Salmon							
American River	64,150	9,076	32,952	44,532	150,710	60	90,426
Antelope Creek							0
Battle Creek	30,834	70,303	10,114	46,646	157,897	10	15,790
Bear River							0
Big Chico Creek							0
Butte Creek	2,200	0	220	1,023	3,443	80	2,754
Clear Creek	13,337	0	1,334	6,160	20,831	80	16,665
Cosumnes River	0	0	0	0	0	100	0
Cottonwood Creek	2,774	0	277	1,273	4,324	80	3,460
Cow Creek	3,011	0	301	1,387	4,699	80	3,759
Deer Creek	1,026	0	103	477	1,606	80	1,285
Feather River	151,209	27,622	35,766	89,996	304,593	60	182,756
Merced River	2,826	1,098	196	1,728	5,848	90	5,263
Mill Creek	2,197	0	220	1,023	3,440	80	2,752
Miscellaneous Creeks						80	0
Mokelumne River	7,071	5,181	1,225	5,660	19,137	60	11,482
Paynes Creek							0
Sacramento River	40,084	0	4,008	18,481	62,574	60	37,544
Stanislaus River	2,845	0	142	1,250	4,238	100	4,238
Tuolumne River	1,926	0	96	841	2,863	100	2,863
Yuba River	14,880	0	1,488	6,865	23,233	100	23,233
Total	340,370	113,280	88,442	227,343	769,436		404,269
Late-Fall Run Chinook Salmon							
Battle Creek	42	3,577	724	1,822	6,165	10	616
Sacramento River	5,227	30	1,051	2,647	8,955	91.8	8,221
Total	5,269	3,607	1,775	4,469	15,120		8,838
Winter-Run Chinook Salmon							
Calaveras River						100	0
Sacramento River	5,959	164	0	2,571	8,694	89.7	7,798
Total	5,959	164	0	2,571	8,694		7,798
Spring-Run Chinook Salmon							
Butte Creek	11,470	0	1,147	5,288	17,905	100	17,905
Deer Creek	708	0	71	326	1,105	100	1,105
Mill Creek	644	0	64	297	1,005	100	1,005
Sacramento River	0	0	0	0	0	100	0
Total	12,822	0	1,282	5,911	20,015		20,015
Total 2013 Natural Production of Adult Chinook Salmon							**440,920**

APPENDIX C: RAW DATA USED TO CALCULATE THE YOUNG-OF-THE-YEAR INDEX FOR JUVENILE AMERICAN SHAD

Fall Midwater Trawl surveys are conducted during the fall months of September, October, November, and December each year to monitor the abundance of American shad. These surveys are conducted by the California Department of Fish and Wildlife (CDFW).

Unlike the eight other anadromous fish species that have an AFRP fish production target pertaining to adult fish, the AFRP target for American shad involves a young-of-the-year (YOY) age class. Because the survey data used to estimate annual shad abundance span a four month period when young shad are actively growing, month-specific fork length size thresholds are used to distinguish between YOY and older shad. The size thresholds used to identify YOY shad are as follows:

Month	Fork Length
Sept.	< 150.9 mm
Oct.	< 156.9 mm
Nov.	< 161.9 mm
Dec.	< 164.9 mm

The data used to calculate annual production estimates for YOY American shad are derived from two files: (1) a CDFW “FMWT AMS Indices 1967-2013.xls” spreadsheet dated May 23, 2014 provides total (YOY plus adult) shad abundance indices for the months of September, October, November, and December each year between 1992 and 2010; and (2) a CDFW “AMS Length Frequency 1971-2013.xls” spreadsheet dated May 23, 2014 provides length frequency data that can be used to determine the percentage of the total catch of American shad that belong to the YOY age class each month.

field containing raw data
field with a calculated value

1992	all age abundance index	755	530	463	266	2,014
	adjusted number of fish older than age 0 measured	0.0	0.0	0.0	1.0	
	adjusted total number of fish measured	565.0	434.0	338.0	136.0	
	percent YOY	100.0%	100.0%	100.0%	99.3%	
	YOY abundance index	755	530	463	264	2,012
1993	all age abundance index	1,972	1,567	908	710	5,157
	adjusted number of fish older than age 0 measured	0.0	0.0	0.0	1.4	
	adjusted total number of fish measured	1515.0	1228.0	663.0	503.0	
	percent YOY	100.0%	100.0%	100.0%	99.7%	
	YOY abundance index	1,972	1,567	908	708	5,155
1994	all age abundance index	439	387	391	117	1,334
	adjusted number of fish older than age 0 measured	5.0	4.0	2.2	1.0	
	adjusted total number of fish measured	345.0	265.0	237.0	72.0	
	percent YOY	98.6%	98.5%	99.1%	98.6%	
	YOY abundance index	433	381	387	115	1,317
1995	all age abundance index	3,246	2,220	791	555	6,812
	adjusted number of fish older than age 0 measured	2.2	1.0	0.0	0.0	
	adjusted total number of fish measured	2584.0	1760.0	541.0	346.0	
	percent YOY	99.9%	99.9%	100.0%	100.0%	
	YOY abundance index	3,243	2,219	791	555	6,808
1996	all age abundance index	1,756	1,072	935	523	4,286
	adjusted number of fish older than age 0 measured	1.0	5.0	3.0	2.0	
	adjusted total number of fish measured	1231.0	815.0	604.0	324.0	
	percent YOY	99.9%	99.4%	99.5%	99.4%	
	YOY abundance index	1,755	1,065	930	520	4,270
1997	all age abundance index	265	565	639	1,125	2,594
	adjusted number of fish older than age 0 measured	2.0	1.0	0.0	0.0	
	adjusted total number of fish measured	198.0	458.0	503.0	774.0	
	percent YOY	99.0%	99.8%	100.0%	100.0%	
	YOY abundance index	262	564	639	1,125	2,590
1998	all age abundance index	1,318	2,093	515	214	4,140
	adjusted number of fish older than age 0 measured	0.0	0.0	2.0	0.0	
	adjusted total number of fish measured	989.0	1554.0	347.0	111.0	
	percent YOY	100.0%	100.0%	99.4%	100.0%	
	YOY abundance index	1,318	2,093	512	214	4,137
1999	all age abundance index	346	155	145	69	715
	adjusted number of fish older than age 0 measured	0.0	0.0	0.0	0.0	
	adjusted total number of fish measured	273.0	133.0	118.0	41.0	
	percent YOY	100.0%	100.0%	100.0%	100.0%	
	YOY abundance index	346	155	145	69	715

(yellow)	field containing raw data
(cyan)	field with a calculated value

2000	all age abundance index	253	326	126	59	764
	adjusted number of fish older than age 0 measured	0.0	0.0	0.0	0.0	
	adjusted total number of fish measured	166.0	255.0	79.0	41.0	
	percent YOY	100.0%	100.0%	100.0%	100.0%	
	YOY abundance index	253	326	126	59	764
2001	all age abundance index	338	239	110	78	765
	adjusted number of fish older than age 0 measured	0.0	0.0	0.0	1.0	
	adjusted total number of fish measured	259.0	188.0	96.0	42.0	
	percent YOY	100.0%	100.0%	100.0%	97.6%	
	YOY abundance index	338	239	110	76	763
2002	all age abundance index	372	832	334	382	1,920
	adjusted number of fish older than age 0 measured	1.0	1.0	0.0	1.0	
	adjusted total number of fish measured	293.0	648.0	206.0	237.0	
	percent YOY	99.7%	99.8%	100.0%	99.6%	
	YOY abundance index	371	831	334	380	1,916
2003	all age abundance index	3,345	2,947	1,279	1,789	9,360
	adjusted number of fish older than age 0 measured	2.7	1.0	0.0	0.0	
	adjusted total number of fish measured	2391.0	2224.0	996.0	1098.0	
	percent YOY	99.9%	100.0%	100.0%	100.0%	
	YOY abundance index	3,341	2,946	1,279	1,789	9,355
2004	all age abundance index	680	83	78	106	947
	adjusted number of fish older than age 0 measured	0.0	0.0	0.0	0.0	
	adjusted total number of fish measured	577.0	68.0	65.0	66.0	
	percent YOY	100.0%	100.0%	100.0%	100.0%	
	YOY abundance index	680	83	78	106	947
2005	all age abundance index	826	552	177	189	1,744
	adjusted number of fish older than age 0 measured	1.0	0.0	0.0	0.0	
	adjusted total number of fish measured	344.0	398.0	141.0	123.0	
	percent YOY	99.7%	100.0%	100.0%	100.0%	
	YOY abundance index	824	552	177	189	1,742
2006	all age abundance index	1,119	142	646	406	2,313
	adjusted number of fish older than age 0 measured	3.8	0.0	2.0	1.0	
	adjusted total number of fish measured	881.0	87.0	522.0	235.0	
	percent YOY	99.6%	100.0%	99.6%	99.6%	
	YOY abundance index	1,114	142	644	404	2,304
2007	all age abundance index	123	257	116	57	553
	adjusted number of fish older than age 0 measured	0.0	1.0	0.0	0.0	
	adjusted total number of fish measured	112.0	216.0	90.0	48.0	
	percent YOY	100.0%	99.5%	100.0%	100.0%	
	YOY abundance index	123	256	116	57	552

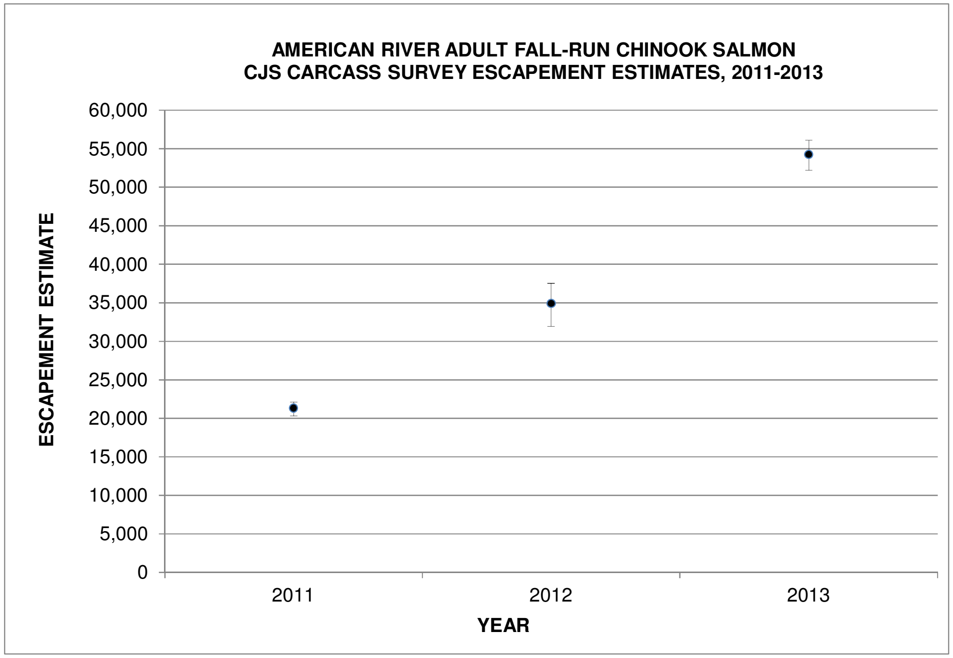
	field containing raw data
	field with a calculated value

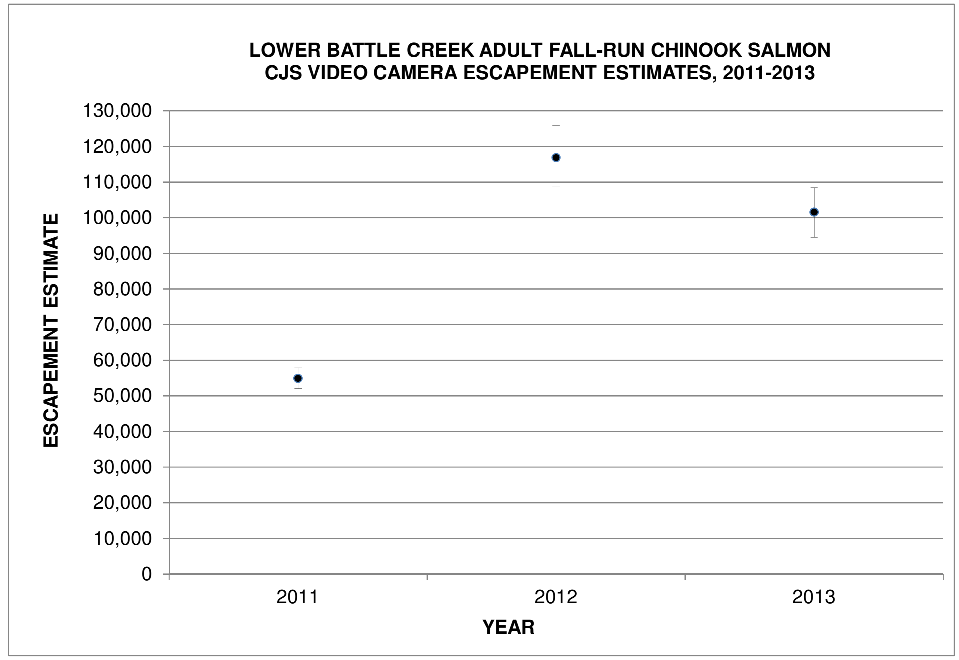
2008	all age abundance index	14	25	19	213	271
	adjusted number of fish older than age 0 measured	0.0	0.0	0.0	0.0	
	adjusted total number of fish measured	12.0	20.0	13.0	153.0	
	percent YOY	100.0%	100.0%	100.0%	100.0%	
	YOY abundance index	14	25	19	213	271
2009	all age abundance index	81	75	252	216	624
	adjusted number of fish older than age 0 measured	0.0	0.0	0.0	0.0	
	adjusted total number of fish measured	59.0	35.0	192.0	153.0	
	percent YOY	100.0%	100.0%	100.0%	100.0%	
	YOY abundance index	81	75	252	216	624
2010	all age abundance index	130	54	114	385	683
	adjusted number of fish older than age 0 measured	0.0	0.0	0.0	0.0	
	adjusted total number of fish measured	109.0	31.0	80.0	189.0	
	percent YOY	100.0%	100.0%	100.0%	100.0%	
	YOY abundance index	130	54	114	385	683
2011	all age abundance index	413	204	142	135	894
	adjusted number of fish older than age 0 measured	0.0	0.0	0.0	0.0	
	adjusted total number of fish measured	306.0	175.0	82.0	74.0	
	percent YOY	100.0%	100.0%	100.0%	100.0%	
	YOY abundance index	413	204	142	135	894
2012	all age abundance index	135	141	34	105	415
	adjusted number of fish older than age 0 measured	0.0	1.0	0.0	0.0	
	adjusted total number of fish measured	110.0	95.0	33.0	63.0	
	percent YOY	100.0%	98.9%	100.0%	100.0%	
	YOY abundance index	135	140	34	105	414
2013	all age abundance index	74	61	86	88	309
	adjusted number of fish older than age 0 measured	0.0	0.0	0.0	0.0	
	adjusted total number of fish measured	63.0	48.0	63.0	57.0	
	percent YOY	100.0%	100.0%	100.0%	100.0%	
	YOY abundance index	74	61	86	88	309

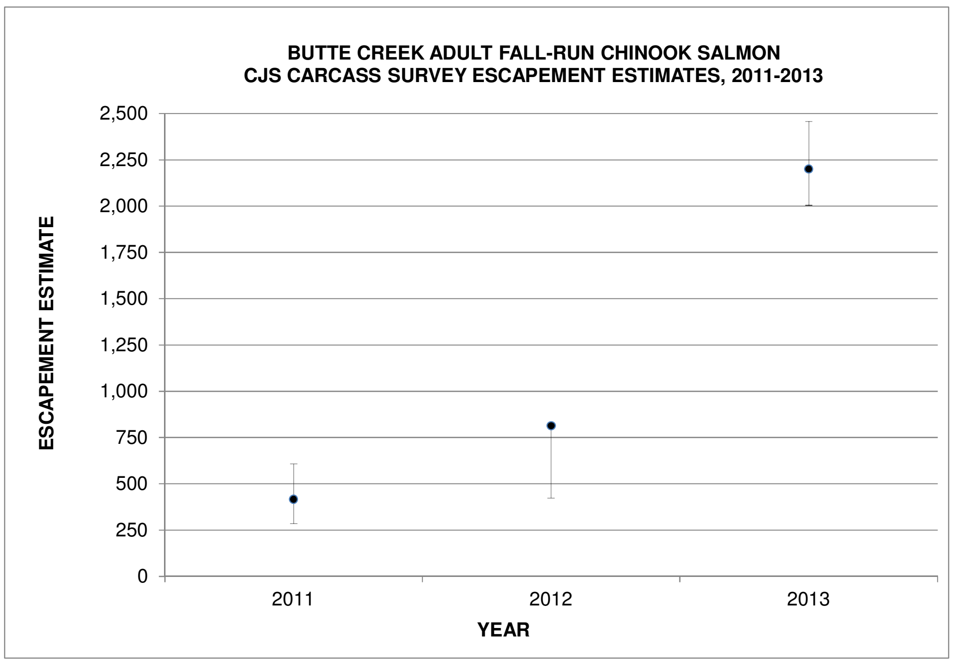
APPENDIX D: ADULT CHINOOK SALMON ESCAPEMENT ESTIMATE GRAPHS BASED ON A CORMACK-JOLLY-SEBER MARK RECAPTURE MODEL

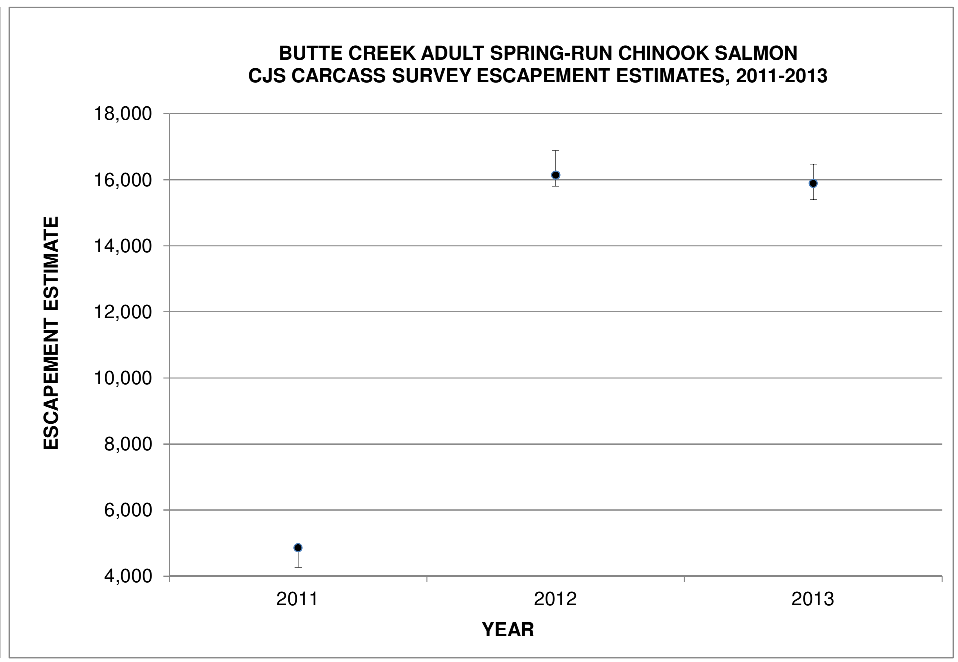
The data in the graphs below are based on analyses that utilize a superpopulation modification of a Cormack-Jolly-Seber mark recapture model. The error bars represent the upper and lower bounds of 90% confidence intervals.

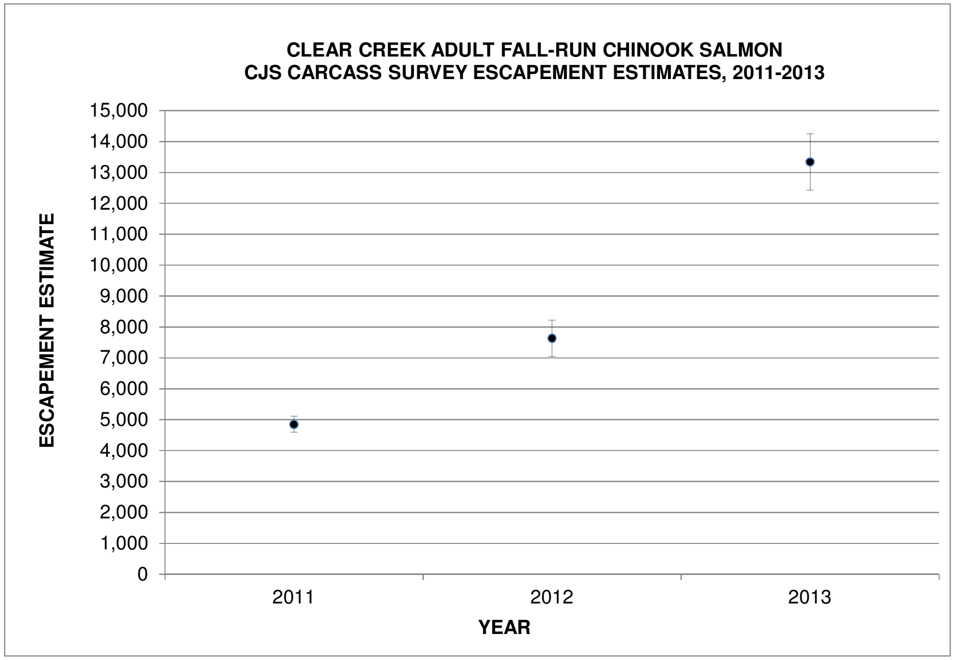
In a few cases, data are omitted from the graphs where data were not available at that the time this report was produced. The data for the Merced, Stanislaus, and Tuolumne Rivers should be considered to be provisional and subject to possible revision. For the graph displaying spring-run Chinook salmon video camera data from the Yuba River, there are no error bars because the video cameras at that site have worked successfully on a continuous basis since the beginning of 2011, i.e., the point estimates reflect complete, accurate counts of the salmon passing by the camera and no error bars are necessary.

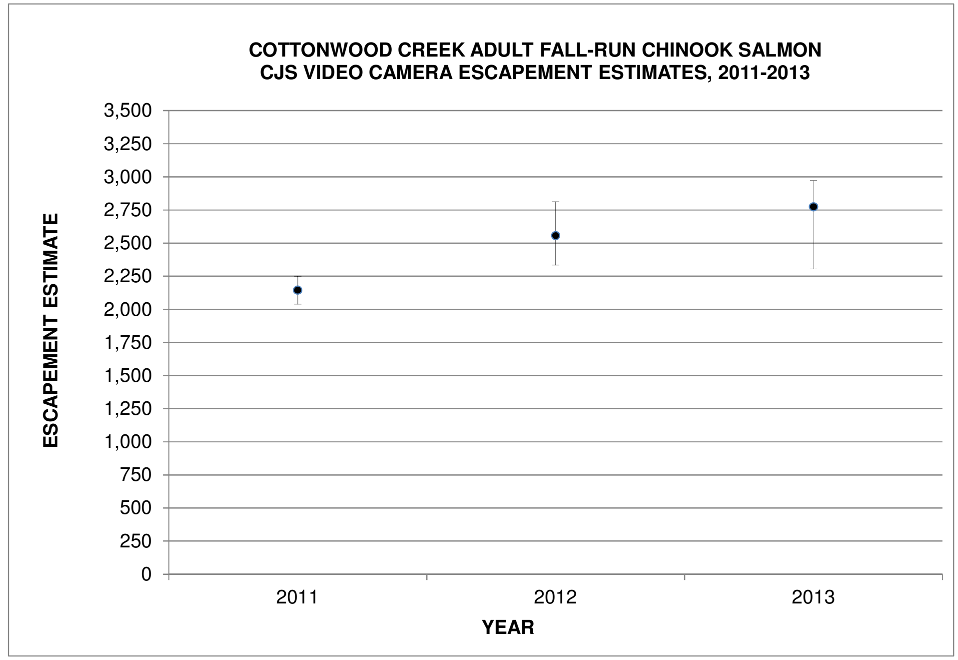

AMERICAN RIVER ADULT FALL-RUN CHINOOK SALMON
CJS CARCASS SURVEY ESCAPEMENT ESTIMATES, 2011-2013
ESCAPEMENT ESTIMATE
60,000
55,000
50,000
45,000
40,000
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
2011
2012
2013
YEAR

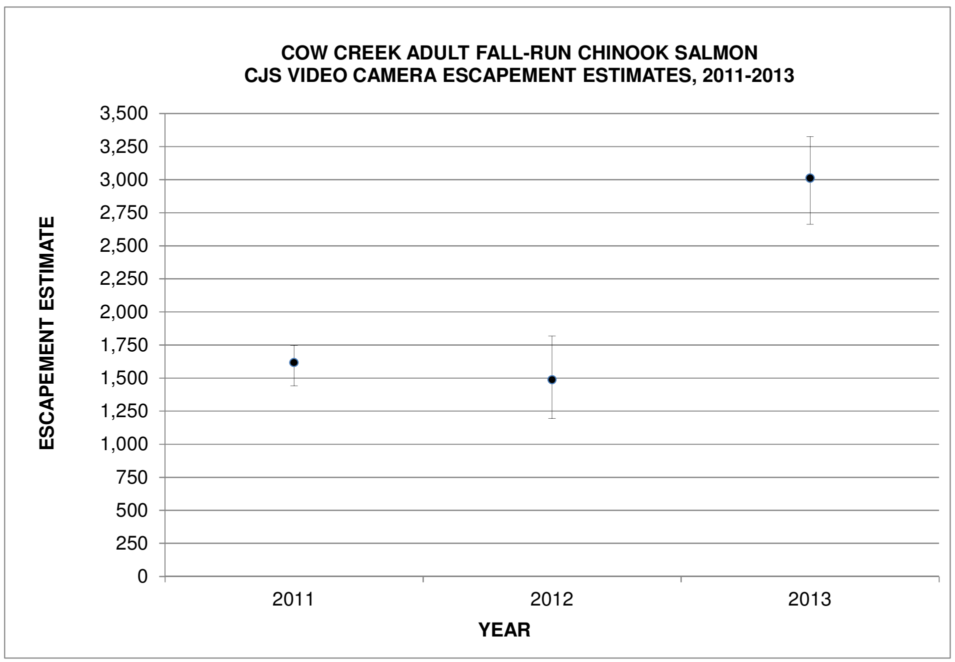

LOWER BATTLE CREEK ADULT FALL-RUN CHINOOK SALMON
CJS VIDEO CAMERA ESCAPEMENT ESTIMATES, 2011-2013
ESCAPEMENT ESTIMATE
130,000
120,000
110,000
100,000
90,000
80,000
70,000
60,000
50,000
40,000
30,000
20,000
10,000
0
2011
2012
2013
YEAR

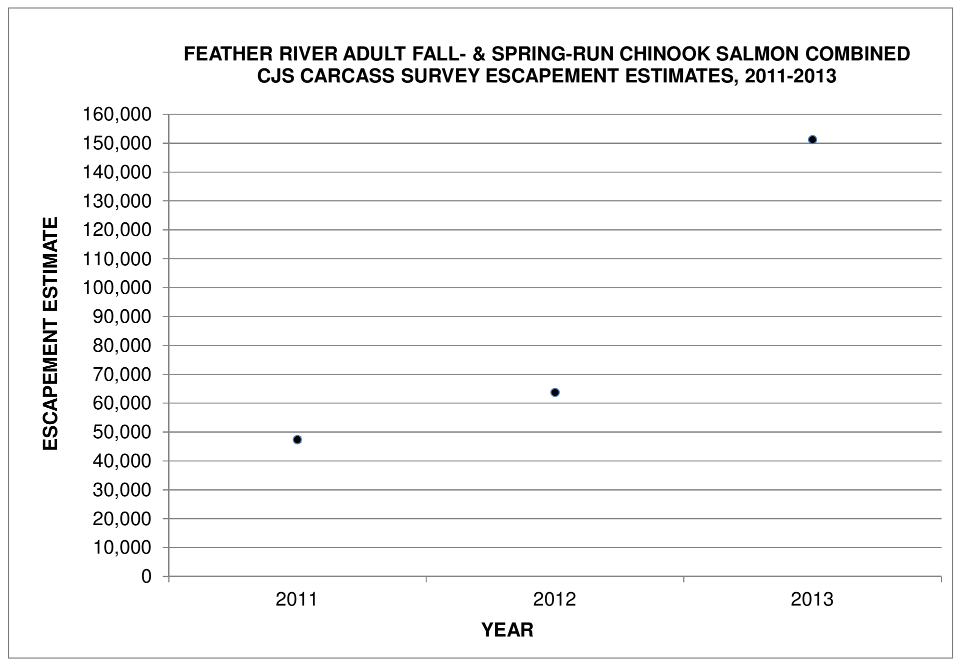

BUTTE CREEK ADULT FALL-RUN CHINOOK SALMON
CJS CARCASS SURVEY ESCAPEMENT ESTIMATES, 2011-2013
ESCAPEMENT ESTIMATE
2,500
2,250
2,000
1,750
1,500
1,250
1,000
750
500
250
0
2011
2012
2013
YEAR

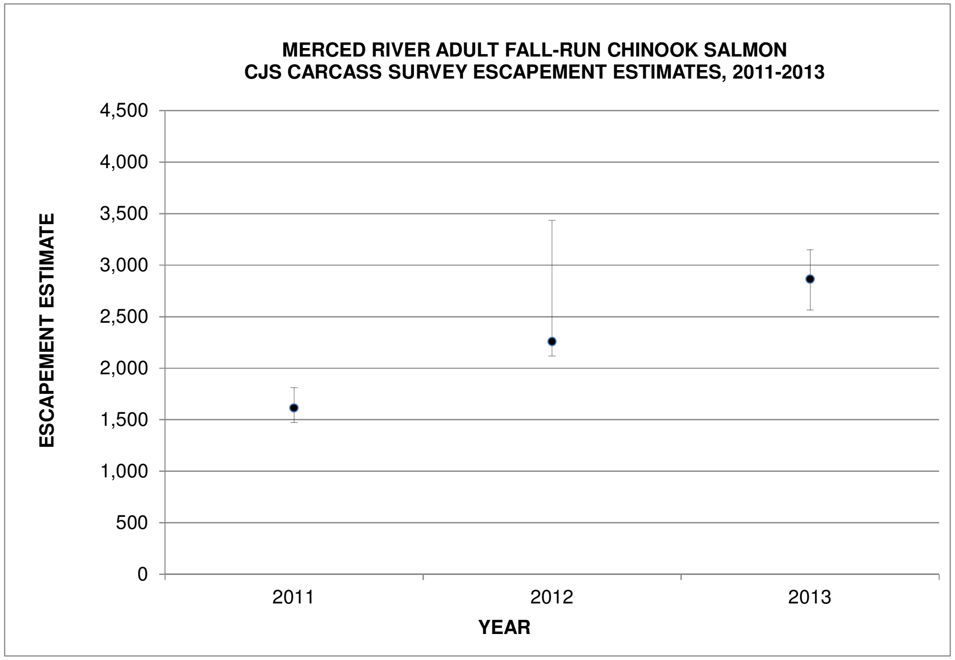

BUTTE CREEK ADULT SPRING-RUN CHINOOK SALMON
CJS CARCASS SURVEY ESCAPEMENT ESTIMATES, 2011-2013
ESCAPEMENT ESTIMATE
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2011
2012
2013
YEAR

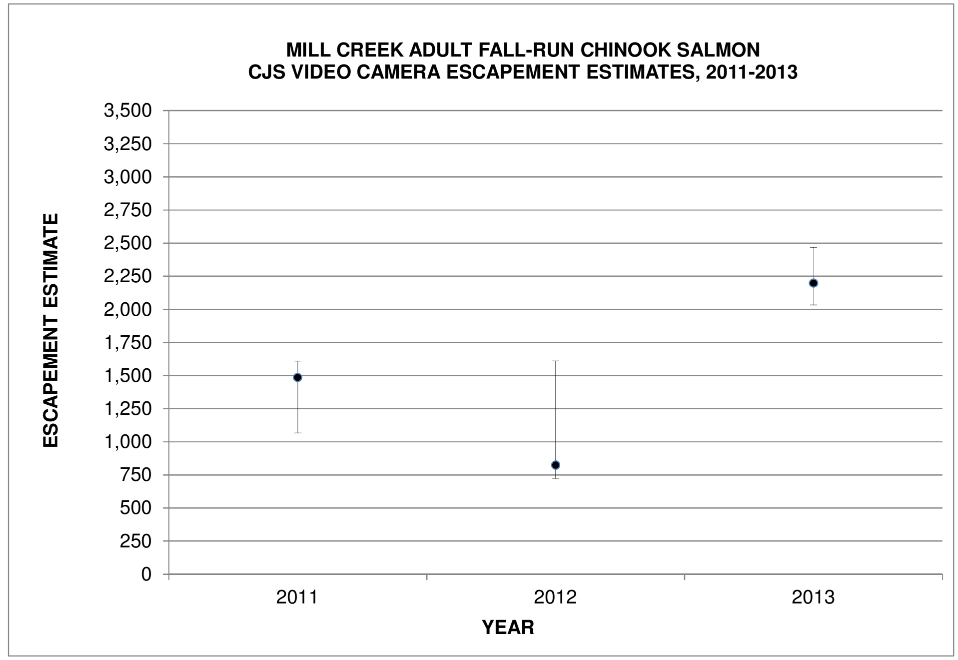

CLEAR CREEK ADULT FALL-RUN CHINOOK SALMON
CJS CARCASS SURVEY ESCAPEMENT ESTIMATES, 2011-2013
ESCAPEMENT ESTIMATE
15,000
14,000
13,000
12,000
11,000
10,000
9,000
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
2011
2012
2013
YEAR

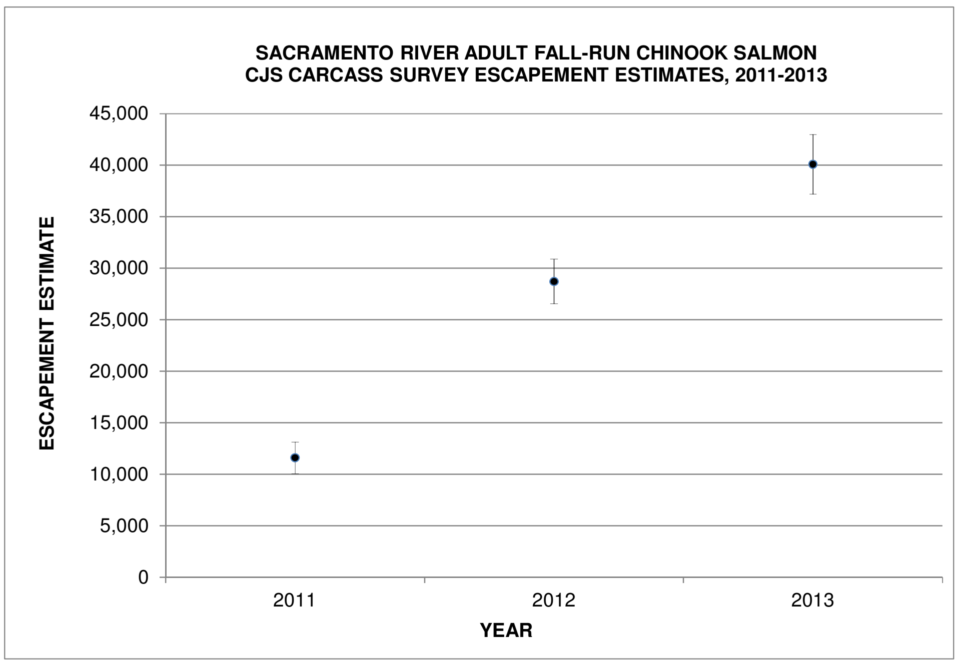

COTTONWOOD CREEK ADULT FALL-RUN CHINOOK SALMON
CJS VIDEO CAMERA ESCAPEMENT ESTIMATES, 2011-2013
ESCAPEMENT ESTIMATE
3,500
3,250
3,000
2,750
2,500
2,250
2,000
1,750
1,500
1,250
1,000
750
500
250
0
2011
2012
2013
YEAR

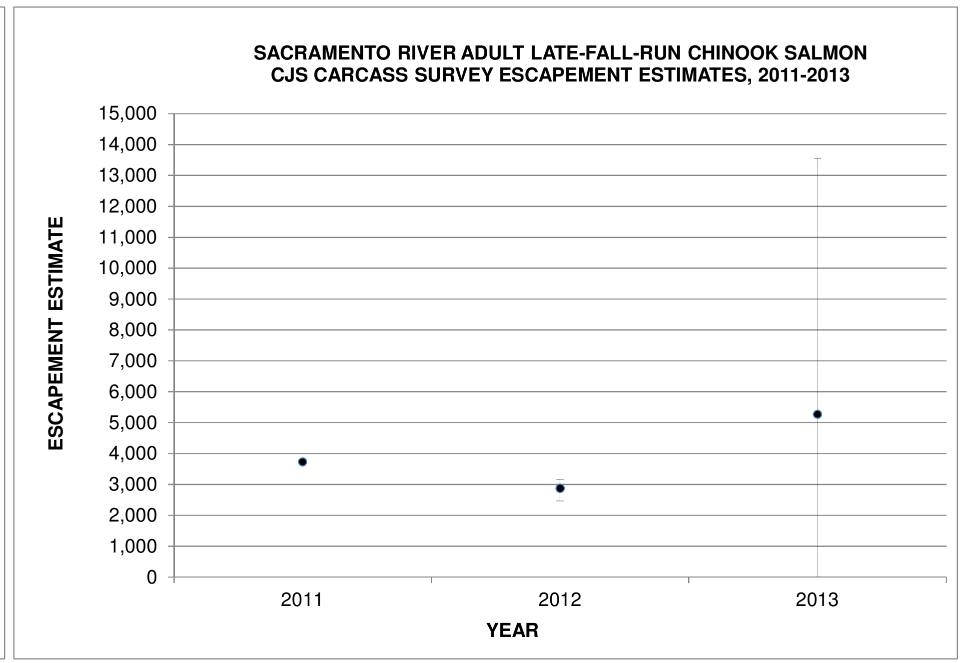

COW CREEK ADULT FALL-RUN CHINOOK SALMON
CJS VIDEO CAMERA ESCAPEMENT ESTIMATES, 2011-2013
ESCAPEMENT ESTIMATE
3,500
3,250
3,000
2,750
2,500
2,250
2,000
1,750
1,500
1,250
1,000
750
500
250
0
2011
2012
2013
YEAR

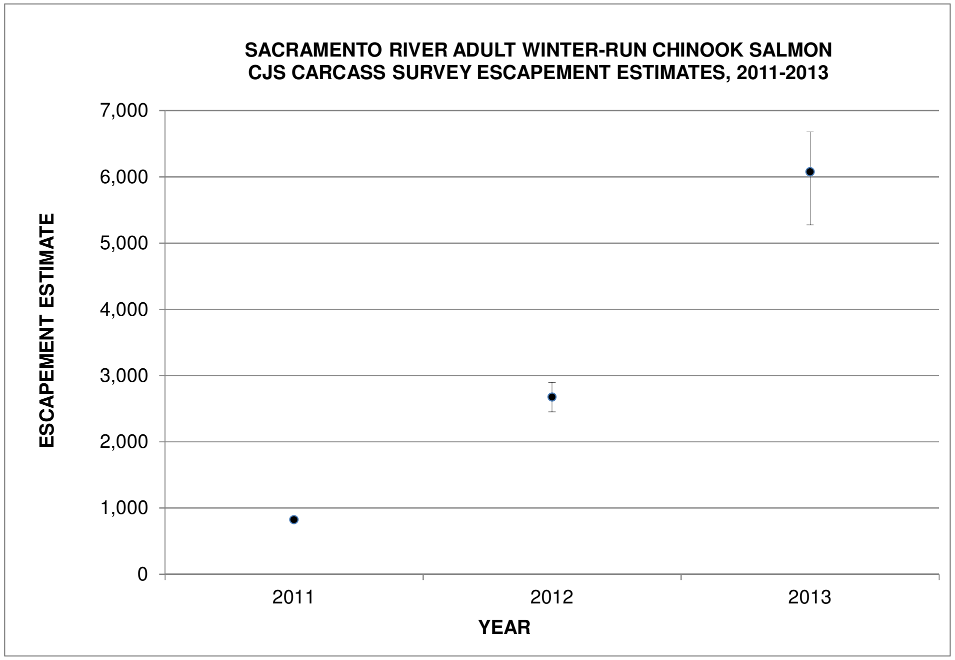

FEATHER RIVER ADULT FALL- & SPRING-RUN CHINOOK SALMON COMBINED
CJS CARCASS SURVEY ESCAPEMENT ESTIMATES, 2011-2013
ESCAPEMENT ESTIMATE
160,000
150,000
140,000
130,000
120,000
110,000
100,000
90,000
80,000
70,000
60,000
50,000
40,000
30,000
20,000
10,000
0
2011
2012
2013
YEAR

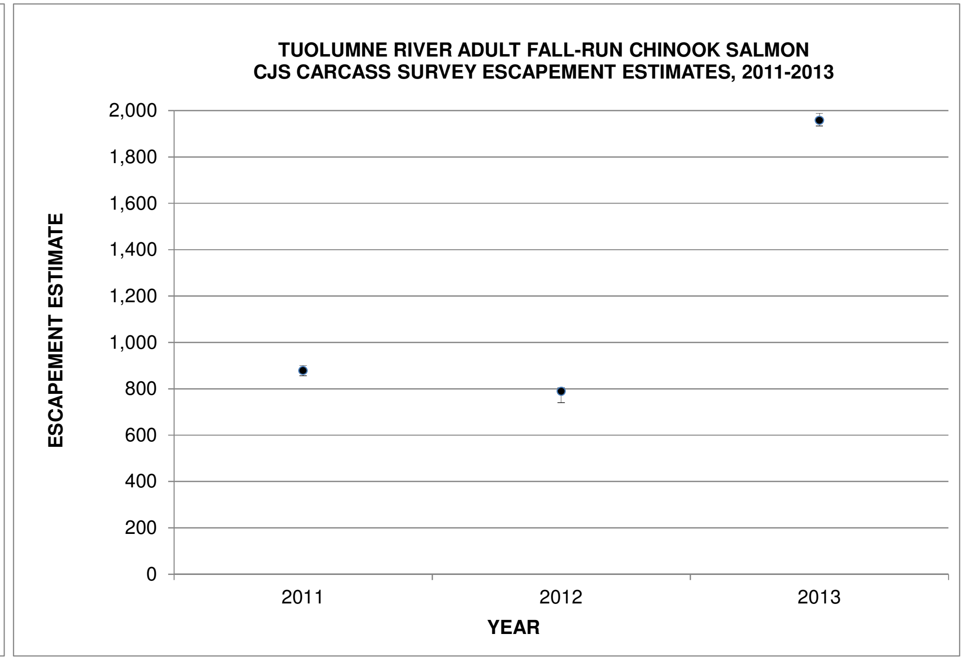

MERCED RIVER ADULT FALL-RUN CHINOOK SALMON
CJS CARCASS SURVEY ESCAPEMENT ESTIMATES, 2011-2013
ESCAPEMENT ESTIMATE
4,500
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
2011
2012
2013
YEAR

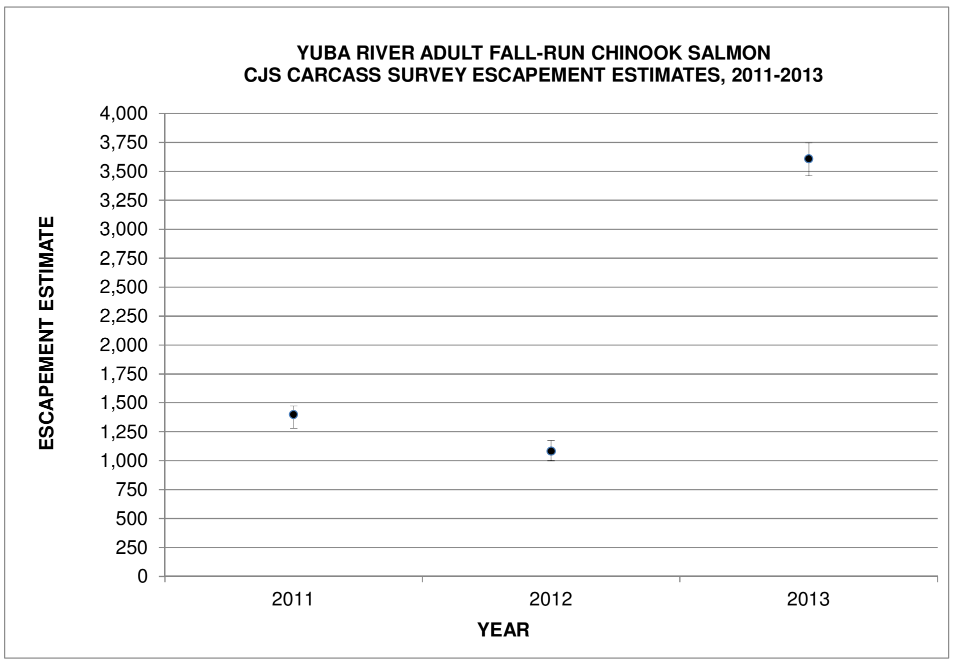

MILL CREEK ADULT FALL-RUN CHINOOK SALMON
CJS VIDEO CAMERA ESCAPEMENT ESTIMATES, 2011-2013
ESCAPEMENT ESTIMATE
3,500
3,250
3,000
2,750
2,500
2,250
2,000
1,750
1,500
1,250
1,000
750
500
250
0
2011
2012
2013
YEAR

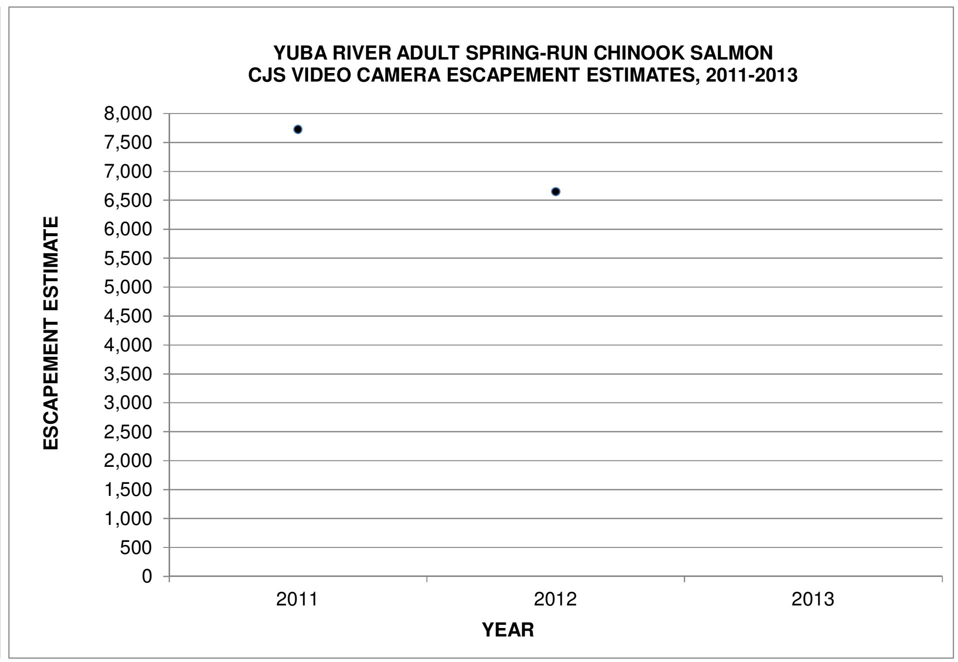

SACRAMENTO RIVER ADULT FALL-RUN CHINOOK SALMON
CJS CARCASS SURVEY ESCAPEMENT ESTIMATES, 2011-2013
ESCAPEMENT ESTIMATE
45,000
40,000
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
2011
2012
2013
YEAR


SACRAMENTO RIVER ADULT LATE-FALL-RUN CHINOOK SALMON
CJS CARCASS SURVEY ESCAPEMENT ESTIMATES, 2011-2013
ESCAPEMENT ESTIMATE
15,000
14,000
13,000
12,000
11,000
10,000
9,000
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
2011
2012
2013
YEAR


SACRAMENTO RIVER ADULT WINTER-RUN CHINOOK SALMON
CJS CARCASS SURVEY ESCAPEMENT ESTIMATES, 2011-2013
ESCAPEMENT ESTIMATE
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
2011
2012
2013
YEAR


TUOLUMNE RIVER ADULT FALL-RUN CHINOOK SALMON
CJS CARCASS SURVEY ESCAPEMENT ESTIMATES, 2011-2013
ESCAPEMENT ESTIMATE
2,000
1,800
1,600
1,400
1,200
1,000
800
600
400
200
0
2011
2012
2013
YEAR


YUBA RIVER ADULT FALL-RUN CHINOOK SALMON
CJS CARCASS SURVEY ESCAPEMENT ESTIMATES, 2011-2013
ESCAPEMENT ESTIMATE
4,000
3,750
3,500
3,250
3,000
2,750
2,500
2,250
2,000
1,750
1,500
1,250
1,000
750
500
250
0
2011
2012
2013
YEAR


YUBA RIVER ADULT SPRING-RUN CHINOOK SALMON
CJS VIDEO CAMERA ESCAPEMENT ESTIMATES, 2011-2013
ESCAPEMENT ESTIMATE
8,000
7,500
7,000
6,500
6,000
5,500
5,000
4,500
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
2011
2012
2013
YEAR