COMPREHENSIVE ASSESSMENT AND MONITORING PROGRAM

Assessment of Anadromous Fish Production in the Central Valley of California between 1992 and 2011

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

2012

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ACRONYMS AND ABBREVIATIONS

AFRP	Anadromous Fish Restoration Program
CAMP	Comprehensive Assessment and Monitoring Program
CDFG	California Department of Fish and Game
CVPIA	Central Valley Project Improvement Act
MWT	midwater trawl
PFMC	Pacific Fishery Management Council
USFWS	U.S. Fish and Wildlife Service
YOY	young-of-the-year

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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 2011. 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 can not 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.

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 1992-2011 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 20-year period between 1992 and 2011 are summarized in Table 1.

Table 1. Overall assessment of changes in natural production of adult Chinook salmon from the Central Valley, 1967-2011. * 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 1992-2011 time periods**	**P values associated with changes in the average production between the 1967-1991 and 1992-2011 time periods**
American River*	fall-run	6/20	+ 32%	0.326
Antelope Creek	fall-run	0/1	???	???
Battle Creek*	fall-run	13/20	+ 249%	0.001**
Battle Creek*	late-fall-run	13/20	+ 150%	0.000**
Bear River	fall-run	0/0	???	???
Big Chico Creek	fall-run	0/0	???	???
Butte Creek	fall-run	8/15	+ 205%	0.052
Butte Creek	spring-run	16/20	+ 855%	0.000**
Calaveras River	winter-run	0/5	- 100%	???
Clear Creek	fall-run	12/20	+ 199%	0.000**
Cosumnes River	fall-run	0/13	- 55%	0.149
Cottonwood Creek	fall-run	0/6	- 43%	???
Cow Creek	fall-run	1/6	-21%	???
Deer Creek	fall-run	2/12	+ 9%	0.781
Deer Creek	spring-run	0/20	- 38%	0.599
Feather River*	fall-run	3/20	+ 3%	0.927
Merced River*	fall-run	1/20	- 26%	0.964
Mill Creek	fall-run	1/15	- 11%	0.795
Mill Creek	spring-run	0/20	- 46%	0.128
Miscellaneous Creeks	fall-run	0/3	- 86%	???
Mokelumne River*	fall-run	9/20	+ 79%	0.014**
Paynes Creek	fall-run	0/0	????	???
Sacramento River	fall-run	0/20	- 37%	0.004**
Sacramento River	late-fall-run	1/19	- 47%	0.004**
Sacramento River*	winter-run	0/20	- 88%	0.002**
Sacramento River	spring-run	0/20	- 98%	0.000**
Stanislaus River	fall-run	0/20	- 52%	0.311
Tuolumne River	fall-run	0/20	- 64%	0.011**
Yuba River	fall-run	1/20	- 4%	1.000

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 2011 are not currently available.

During the 20-year period between 1992 and 2011:

- Monitoring data that can be used to estimate salmon production have not been collected during the 1992-2011 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 remaining 16 watersheds with a fall-run Chinook salmon production target have: (a) met their production targets less than three times during the 20-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 13 times in the post-baseline period, and the Sacramento River mainstem only met its AFRP late-fall-run Chinook salmon target once in the 19 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 16 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.

Other Chinook salmon data presented in this report demonstrate that:

- In 2011 relative to 2010 and for the watersheds where monitoring data were available, production of different runs of Chinook salmon from the aforementioned 22 watersheds increased in 14 of the 24 combinations of watersheds and runs. A combination is considered to be a unique grouping of a salmon run and watershed where monitoring took place in 2010 and 2011, e.g., fall-run Chinook salmon from the American River, spring-run Chinook salmon from Deer Creek, or fall-run Chinook salmon from Deer Creek.

- The natural production of 180,537 Chinook salmon from the Central Valley in 2011 continued to be markedly less than what occurred prior to a decline in adult salmon production that began in or around 2005. To put the 2011 production estimate in context, 466,203 adult Chinook salmon were produced by the Central Valley in 2005.

- During the past 10 years, the production of adult Chinook salmon in the Central Valley reached its lowest level in 2008 and 2009, with estimates of 51,628 and 41,516 individuals, respectively. Those numbers were substantially influenced by a ban on the ocean harvest of adult salmon off the California coastline as the California Department of Fish and Game and Pacific Fishery Management Council curtailed salmon harvest to protect the dwindling fall-run Chinook salmon stock. Production in 2010 and 2011 was modestly greater with 130,546 and 180,537 individuals, respectively. Those increases relative to 2008 and 2009 reflect the easing of ocean and in-river harvest restrictions, and larger numbers of salmon in the ocean and in-river locations in the Central Valley.

- Achieving the Chinook salmon production targets called for in the CVPIA has become increasingly difficult since 2000. In that year, 44% (i.e., eight) of the combinations of runs and watersheds that were monitored exceeded their AFRP production target. In 2011, only 13% (i.e., three) of the combinations of runs and monitored watersheds exceeded their AFRP target.

- The persistently low production of adult salmon in recent years is reflected in the fact that only five combinations of the watersheds and runs monitored in 2011 (Battle Creek fall-run, Clear Creek fall-run, Mokelumne River fall-run, Battle Creek late-fall-run, Butte Creek spring-run) exceeded their respective production levels during the 1967-1991 baseline period.

- Five 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 11 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.

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 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 20 years between 1992 and 2011. The 2011 midwater trawl index for this species (892) increased from 2010 (683), but the 2011 index was markedly below the 1967-1991 baseline average of 2,129 shad and the AFRP production target of 4,300 shad.

- Monitoring of legal-size striped bass in the Central Valley's anadromous waters occurred in 15 years between 1992 and 2011. 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 five years when legal-size striped bass abundance estimates are considered to be provisional (2007, 2008, 2009, 2010, and 2011), the AFRP production target for this species was not met. It is unlikely that future revisions will result in the attainment of the target because the provisional abundance 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 Game (CDFG) 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 CDFG 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 tenth 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 2011.

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

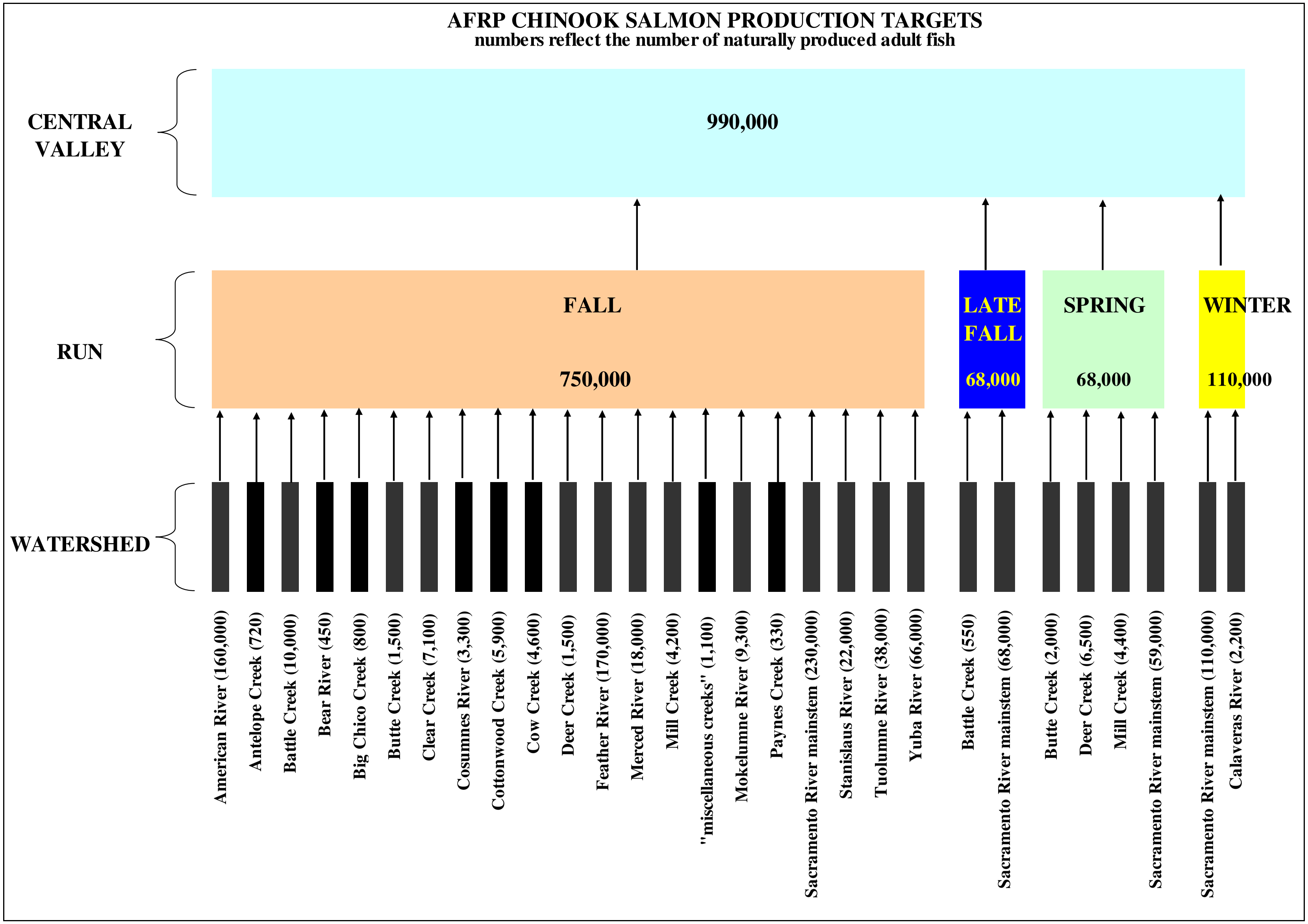
* = Hatchery in the tributary.

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 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 $\geq$ 40 inches in total length, respectively.

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



1.3 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 CDFG. 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 CDFG 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 2011 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 because large numbers of salmon pertaining to this run were produced 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 large numbers 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. In general, fishery biologists believe 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 comparing the assignment of individual salmon to a particular salmon run based on the use of genetic markers vs. phenotypic traits suggests 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 Game has collected angler harvest data in the Central Valley in 13 of the 20 years between 1992 and 2011. The angler harvest data is not classified according to salmon run, however, thereby making it difficult to directly incorporate CDFG'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.

1.4 ACKNOWLEDGEMENTS

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

1. Jason Azat (CDFG) provided the GrandTab spreadsheet that provides escapement estimates of Chinook salmon.

2. Dave Contreras (CDFG) provided spreadsheets that contain abundance data for juvenile American shad.

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

4. Kes Benn and Ramon Martin (USFWS), and Bob Evans (U.S. Bureau of Reclamation) provided useful comments as they reviewed portions of this report or provided technical advice.

SECTION 2: METHODS

2.1 OVERVIEW OF MONITORING LOCATIONS AND ACTIVITIES

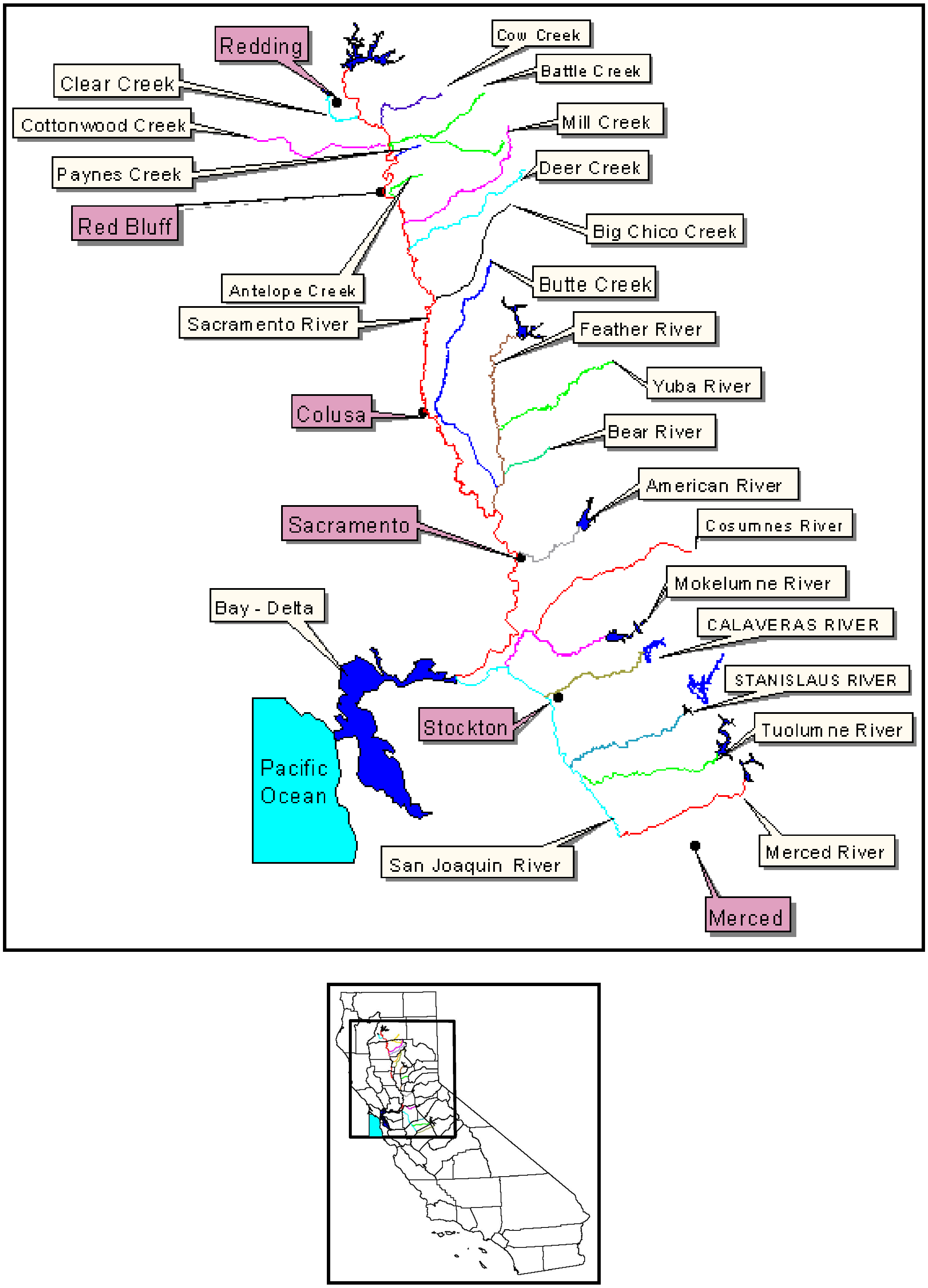
The watersheds and areas with an AFRP fish production target are depicted in Figure 2. Monitoring techniques used to assess the abundance of anadromous fish vary by taxa and are described in the 1997 CAMP Implementation Plan (Montgomery Watson et al. 1997). The techniques include, but are not limited 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). CAMP annual reports use PFMC ocean harvest data that reflect commercial and recreational catches from boats in the Monterey and San Francisco Bay areas. 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 are 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 A. 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.2012.04.24.xls" file prepared by CDFG staff; (2) commercial and recreational salmon harvest data summarized in the *Review of 2011 Ocean Salmon Fisheries* (PFMC 2012), and (3) a "Chinookprod" database that is used by USFWS staff to calculate natural salmon production estimates.

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.2012.04.24.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 2011 Ocean Salmon Fisheries* report (PFMC 2012).

3. For 2008 and 2009, the following in-river angler harvest proportions (AHPs) were adopted because the CDFG 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, i.e., the default value that existed in 2007. 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 1992-2011 time periods; and

3. Using a Mann Whitney U test to determine if there was a statistically significant ($\alpha = 0.05$) difference in the average natural production of adult Chinook salmon for each run and watershed between the 1967-1991 and 1992-2011 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 1992-2011 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.

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 ESTIMATING PRODUCTION OF NON-SALMONID TAXA

2.4.1 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.

Production of white sturgeon ≥ 40 inches in total length in San Pablo and Suisun bays is estimated using mark-recapture data collected by the CDFG. Prior to 2005, the CDFG 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 CDFG has conducted white sturgeon surveys every year to develop more robust population estimates for the post-2005 period. Trammel nets are used to collect the mark-recapture data between August and early 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 the 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 CDFG 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 CDFG 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.

2.4.2 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. A midwater trawl (MWT) survey provides data to estimate the juvenile abundance index for American shad.

The CDFG conducts the MWT survey four months each year, i.e., in September, October, November, and December. The CDFG did not conduct MWT surveys in 1974, September and December of 1976, and 1979.

The MWT survey is conducted in a region encompassing the Sacramento-San Joaquin River Delta, San Pablo Bay, and Suisun Bay. Within this region, the MWT surveys are conducted in 17 different areas. Within these 17 areas, a series of "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 MWT 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 survey index and it includes American shad of all ages (YOY, 1-, 2-, and 3-year old fish).

As American shad are collected during the MWT survey, the length of the majority of the captured shad are measured; these data can be 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 CDFG's all-ages abundance index by the proportion of fish in the YOY age class. Text in Appendix B 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 CDFG's all-ages abundance index to the number of juvenile shad in the YOY age class. In the 2009, 2010, and 2011 CAMP annual reports, a length frequency correction factor was used 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, CDFG, pers. comm., 11/3/2009).

The raw data used to develop American shad production estimates in this report are contained in two references that were provided by Dave Contreras of the CDFG on October 29, 2012: (1) a "FMWT AMS Indices 1967-2011.xls" spreadsheet dated October 29, 2012; and (2) an "AMS Length Frequency 1971-2011.xls" spreadsheet dated October 29, 2012.

2.4.3 METHODS FOR ADULT STRIPED BASS

The CDFG 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 CDFG. 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 CDFG 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 CDFG 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 was used to estimate production of adult striped bass using 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 and 2011 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.

A “SBAbundance 111512.xls” spreadsheet provides the striped bass production estimates summarized in this report. That spreadsheet was sent to the CAMP by Jason DuBois of the CDFG on November 15, 2012.

SECTION 3: RESULTS

3.1 PRODUCTION ESTIMATES FOR ADULT CHINOOK SALMON

Because adult Chinook salmon data collected in 2010 and 2011 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 A. 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 2011 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 2011.

3.1.1.2 ANTELOPE CREEK

Estimates of natural production of adult fall-run Chinook salmon from Antelope Creek between 1992 and 2011 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 2011. 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 2011 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 13 times between 1992 and 2011.

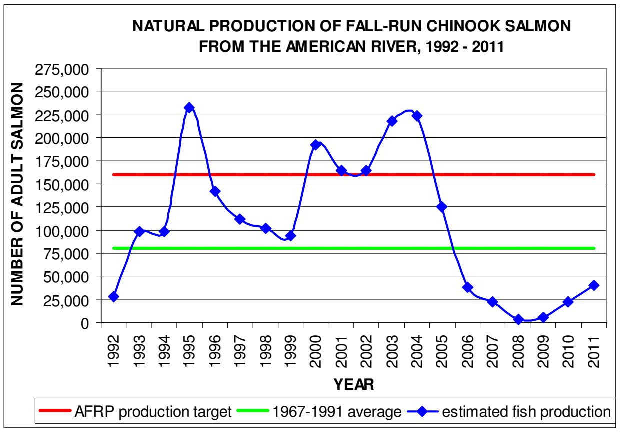
Table 3. Estimated natural production of adult fall-, late-fall-, winter-, and spring-run Chinook salmon from 22 watersheds in the Central Valley, 1992-2011. Blank cells represent years when data were not collected for a particular run and location.

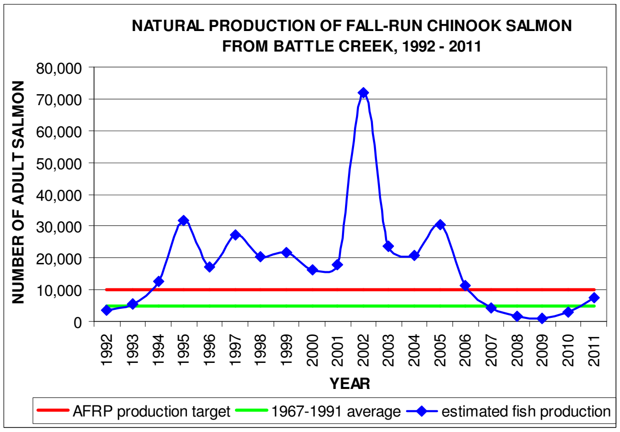
Taxa	**1967-1991 baseline**	**AFRP production target**	**YEAR**																			
			1992	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**
Fall-run Chinook salmon																						
American River	80,876	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	3,419	6,052	22,167	40,341
Antelope Creek	361	720	0																			
Battle Creek	5,013	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	7,310
Bear River	639	450																				
Big Chico Creek	402	800																				
Butte Creek	765	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	444
Clear Creek	3,576	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	6,780	5,157
Cosumnes River	1,660	3,300							620	410	1,021		2,113	194	2,731	692	771	146	15	0	872	70
Cottonwood Creek	2,964	5,900	3,574															1,940	408	844	1,071	2,285
Cow Creek	2,330	4,600															4,898	3,171	382	209	505	1,927
Deer Creek	766	1,500		176	737			2,580	449						544	1,418	2,216	874	155	46	156	706
Feather River	86,031	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	6,613	8,886	50,051	69,641
Merced River	9,005	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	2,221
Mill Creek	2,118	4,200	2,262	4,787	2,568			1,018	903				3,236	3,014	2,171	3,618	1,633	1,323	133	82	136	1,312
Miscellaneous Creeks	549	1,100																214	15	5		
Mokelumne River	4,680	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	5,088	14,855
Paynes Creek	170	330																				
Sacramento River	115,371	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	11,576	9,553
Stanislaus River	10,868	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	1,392	595	1,222	1,666
Tuolumne River	18,949	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	372	124	607	1,132
Yuba River	33,245	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	16,940	11,887
Total	374,049	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	39,778	30,604	121,140	170,508

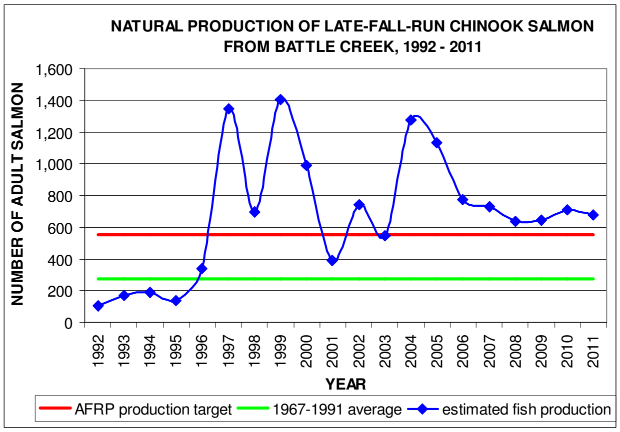
Table 3 (cont.). Estimated natural production of adult fall-, late-fall-, winter-, and spring-run Chinook salmon from 22 watersheds in the Central Valley, 1992-2011. Blank cells represent years when data were not collected for a particular run and location.

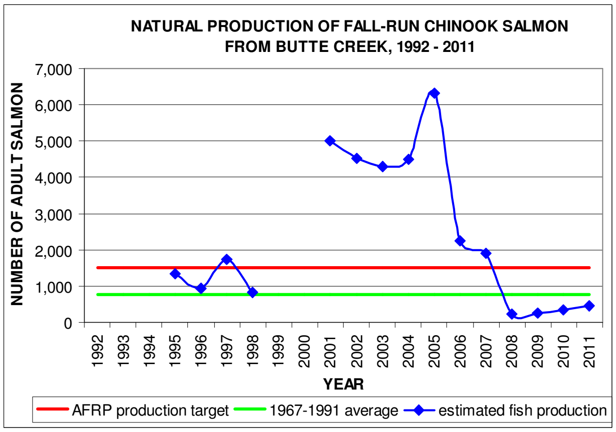
Taxa	1967-1991 baseline	AFRP production target	YEAR																			
			1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Late-fall run Chinook salmon																						
Battle Creek	273	550	106	174	195	134	340	1,350	702	1,410	991	392	746	548	1,281	1,131	773	726	635	646	711	680
Sacramento River	33,941	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	29,783	4,170	3,704	4,917	4,765
Total	34,192	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	30,509	4,806	4,350	5,628	5,445
Winter-run Chinook salmon																						
Calaveras River	770	2,200																0	0	0	0	0
Sacramento River	54,316	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	897
Total	54,439	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	897
Spring-run Chinook salmon																						
Butte Creek	1,018	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	2,838
Deer Creek	3,276	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
Mill Creek	2,202	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	362	220	568	488
Sacramento River	29,412	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
Total	34,374	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	4,489	2,492	2,244	3,687
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	155,042	51,628	41,516	130,546	180,537

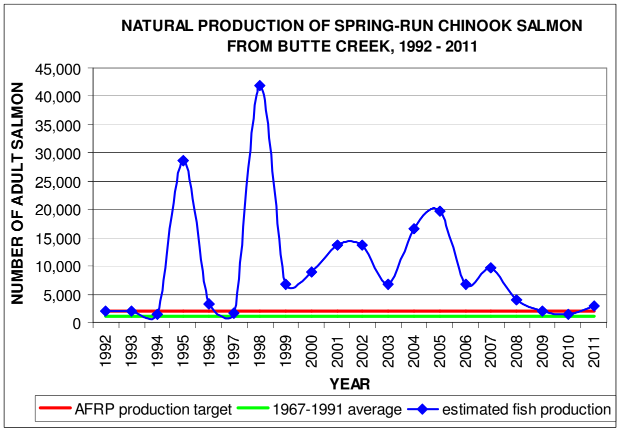
Figure 4. Estimated natural production of adult Chinook salmon from the American River, Battle Creek, Butte Creek, and Calaveras River, 1992-2011. Each graph provides the watershed's AFRP production target, estimated annual natural production of Chinook salmon between 1992 and 2011, and average natural production of Chinook salmon between 1967 and 1991.

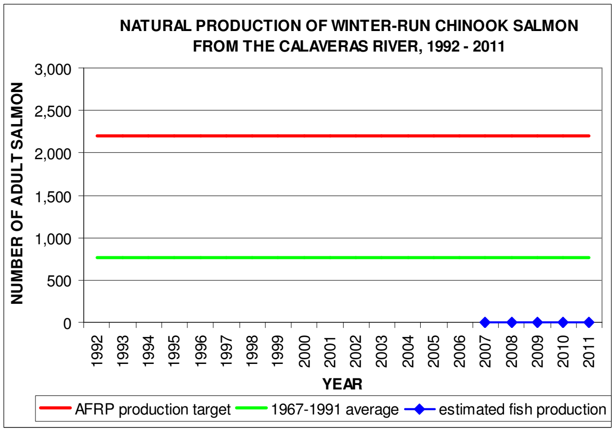












Estimates of natural production of adult late-fall-run Chinook salmon from Battle Creek during the period 1992-2011 are presented in Table 3 and Figure 4. The AFRP production target for adult late-fall-run Chinook salmon from Battle Creek is 550 salmon. Estimated natural production of this run of Chinook salmon from this watershed may have exceeded the AFRP production target 13 times between 1992 and 2011.

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 2011 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 2011. 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 2011. 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 2011 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 eight times in the 15 years when monitoring data were collected between 1992 and 2011.

Estimates of natural production of adult spring-run Chinook salmon from Butte Creek between 1992 and 2011 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 16 times between 1992 and 2011.

3.1.1.7 CALAVERAS RIVER

Estimates of natural production of adult winter-run Chinook salmon from Calaveras River between 1992 and 2011 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.

3.1.1.8 CLEAR CREEK

Estimates of natural production of adult fall-run Chinook salmon from Clear Creek between 1992 and 2011 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 12 times between 1992 and 2011.

3.1.1.9 COSUMNES RIVER

Estimates of natural production of adult fall-run Chinook salmon from Cosumnes River between 1992 and 2011 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 13 years of the 20 years since 1991. The production target was not met in any of those 13 years when Chinook salmon surveys were conducted on the Cosumnes River since 1991.

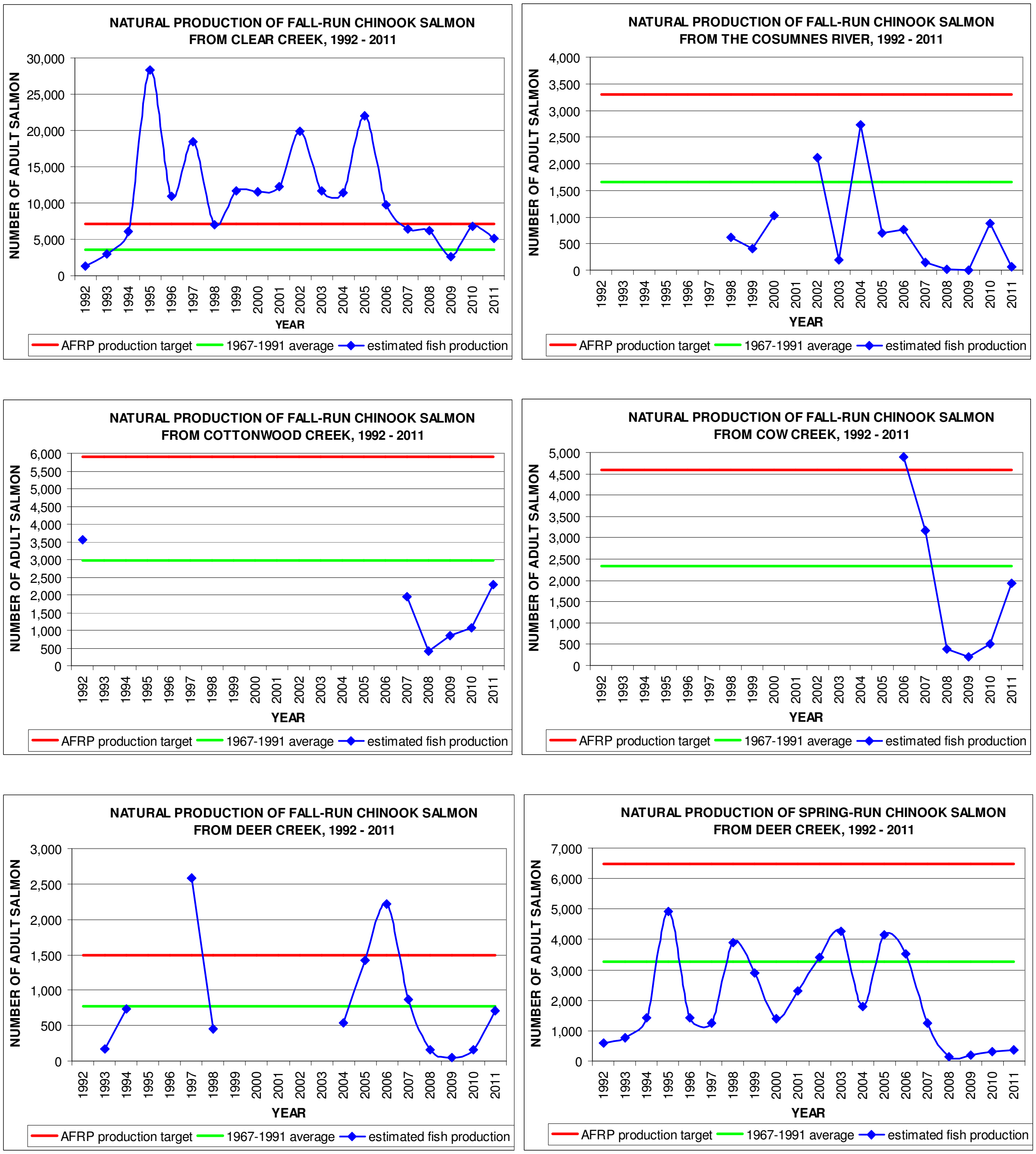
3.1.1.10 COTTONWOOD CREEK

Estimates of natural production of adult fall-run Chinook salmon from Cottonwood Creek between 1992 and 2011 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 six times since 1991. The production target was not met in any of the six years when monitoring data were collected since 1991.

3.1.1.11 COW CREEK

Estimates of natural production of adult fall-run Chinook salmon from Cow Creek between 1992 and 2011 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 six times since 1991. The AFRP production target was met in one of the six 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, 1992-2011. Each graph provides the watershed's AFRP production target, estimated annual natural production of Chinook salmon between 1992 and 2011, and average natural production of Chinook salmon between 1967 and 1991.



3.1.1.12 DEER CREEK

Estimates of natural production of adult fall-run Chinook salmon from Deer Creek between 1992 and 2011 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 12 years when monitoring data were collected between 1992 and 2011.

Estimates of natural production of adult spring-run Chinook salmon from Deer Creek between 1992 and 2011 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 2011.

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 2011 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 three times between 1992 and 2011, i.e., in 1995, 2000, and 2001.

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 2011 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 2011.

3.1.1.15 MILL CREEK

Estimates of natural production of adult fall-run Chinook salmon from Mill Creek between 1992 and 2011 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 15 years when monitoring data were collected since 1991.

Estimates of natural production of adult spring-run Chinook salmon from Mill Creek between 1992 and 2011 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 2011.

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.

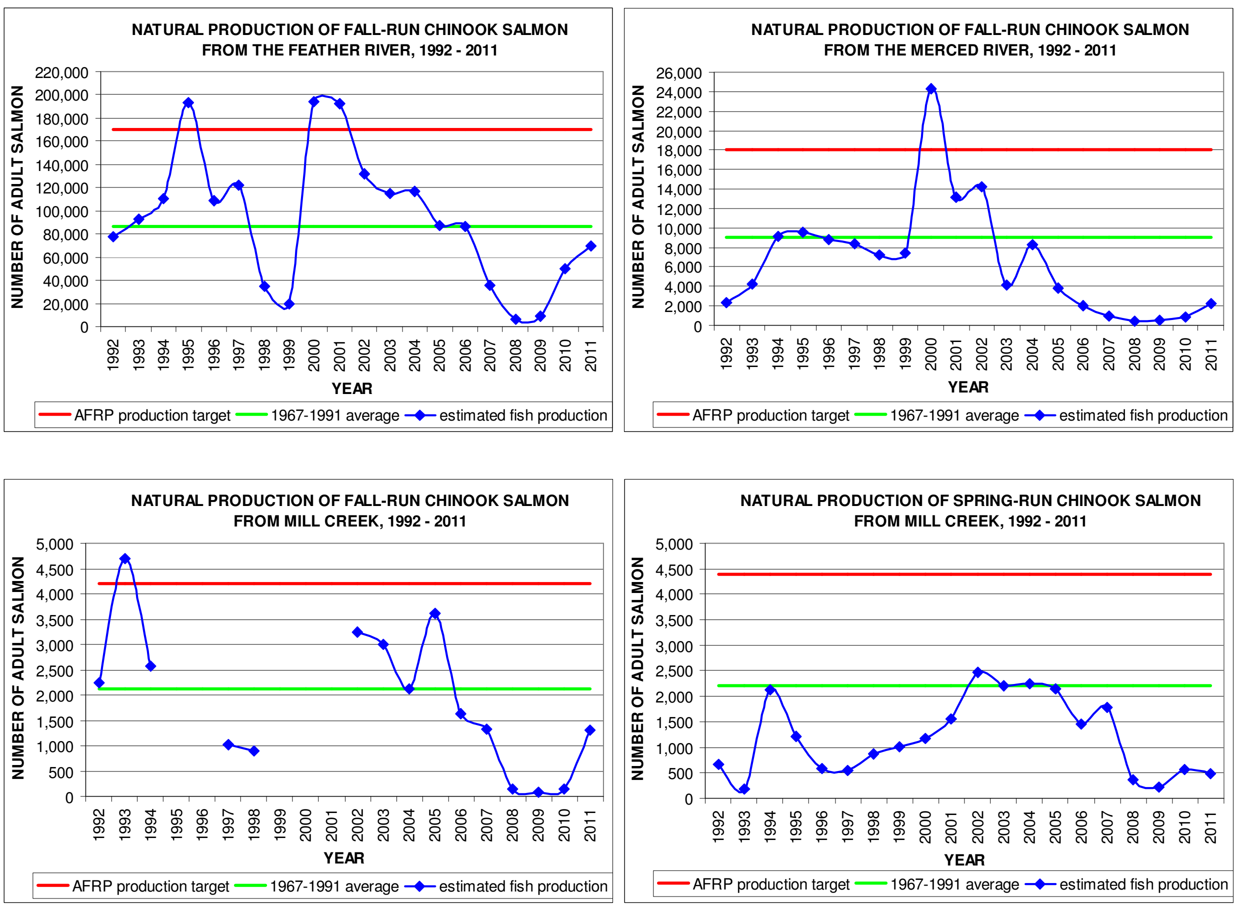
Estimates of the natural production of adult fall-run Chinook salmon from the one Miscellaneous Creek where monitoring took place between 1992 and 2011, i.e., Bear Creek, are presented in Table 3. A figure depicting the estimated production for the Miscellaneous Creeks is not presented in this report because six of the seven creeks were not monitored between 1992 and 2011. 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 2011 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 2011 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 nine times between 1992 and 2011.

Figure 6. Estimated natural production of adult Chinook salmon from the Feather River, Merced River, and Mill Creek, 1992-2011. Each graph provides the watershed's AFRP production target, estimated annual natural production of Chinook salmon between 1992 and 2011, 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 2011. 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 2011 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 2011.

Estimates of natural production of adult late-fall-run Chinook salmon between 1992 and 2011 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 19 years when monitoring data were collected between 1992 and 2011.

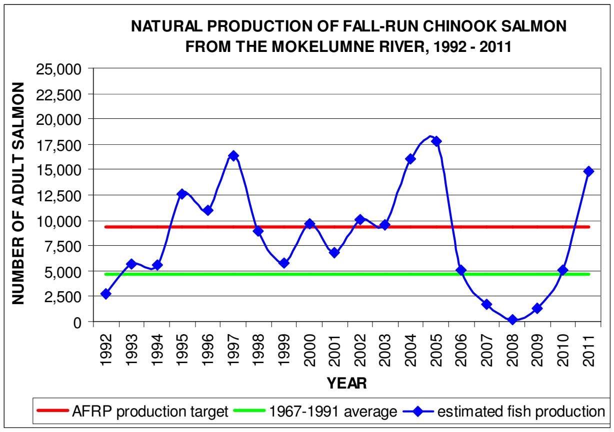
Estimates of natural production of adult winter-run Chinook salmon from the Sacramento River mainstem between 1992 and 2011 are presented in Table 3 and Figure 7. The AFRP production target for winter-run Chinook salmon from the Sacramento River is 110,000 salmon. Estimated natural production of this run of Chinook salmon from that watershed never equaled or exceeded the AFRP production target between 1992 and 2011.

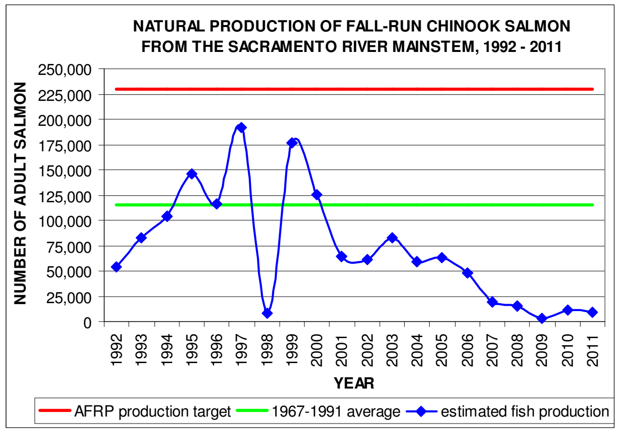
Estimates of natural production of adult spring-run Chinook salmon from the Sacramento River mainstem between 1992 and 2011 are presented in Table 3 and Figure 7. The AFRP production target for spring-run Chinook salmon from the Sacramento River is 59,000 salmon. Escapement estimates for this run in 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 2011.

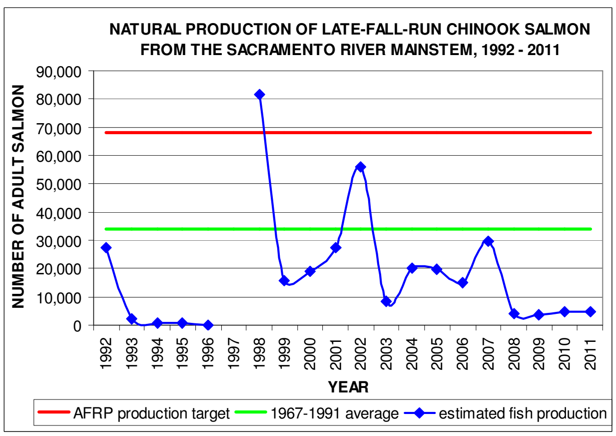
3.1.1.20 STANISLAUS RIVER

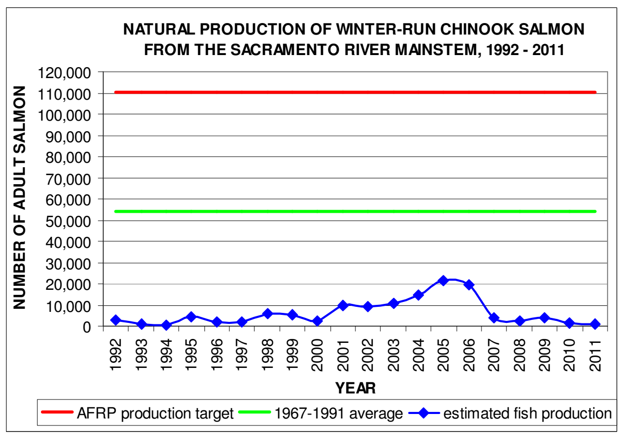
Estimates of natural production of adult fall-run Chinook salmon from the Stanislaus River between 1992 and 2011 are presented in Table 3 and Figure 7. The AFRP production target for fall-run Chinook salmon from the Stanislaus River is 22,000 salmon. The estimated natural production of adult fall-run Chinook salmon from this watershed never equaled or exceeded the AFRP production target between 1992 and 2011.

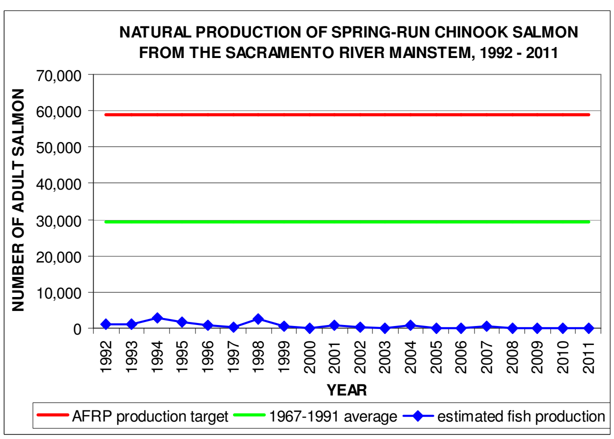
Figure 7. Estimated natural production of adult Chinook salmon from the Mokelumne River, Sacramento River, and Stanislaus River, 1992-2011. Each graph provides the watershed's AFRP production target, estimated annual natural production of Chinook salmon between 1992 and 2011, and average natural production of Chinook salmon between 1967 and 1991.

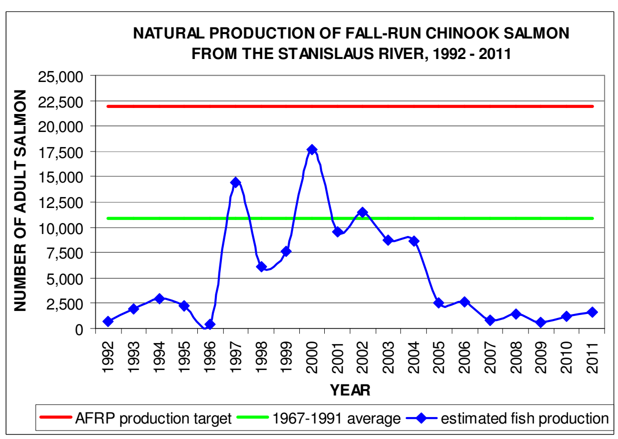












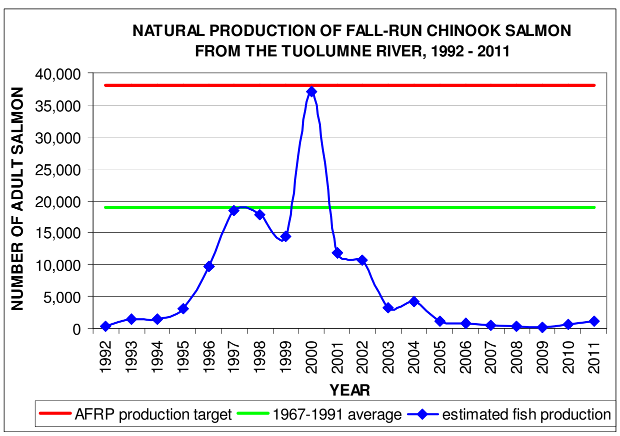
3.1.1.21 TUOLUMNE RIVER

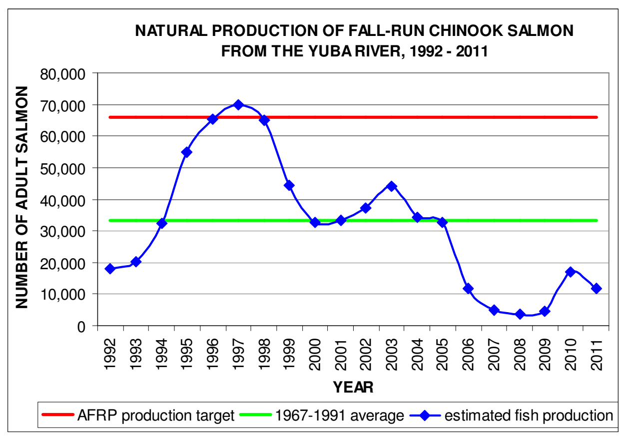
Estimates of natural production of adult fall-run Chinook salmon from the Tuolumne River between 1992 and 2011 are presented in Table 3 and Figure 8. The AFRP production target of fall-run Chinook salmon from the Tuolumne River is 38,000 salmon. Estimated natural production of adult fall-run Chinook salmon from this watershed never equaled or exceeded the AFRP production target between 1992 and 2011.

3.1.1.22 YUBA RIVER

Estimates of natural production of adult fall-run Chinook salmon from the Yuba River between 1992 and 2011 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 2011, i.e., in 1997.

Figure 8. Estimated natural production of adult Chinook salmon from the Tuolumne River and Yuba River, 1992-2011. Each graph provides the watershed's AFRP production target, estimated annual natural production of Chinook salmon between 1992 and 2011, and average natural production of Chinook salmon between 1967 and 1991.





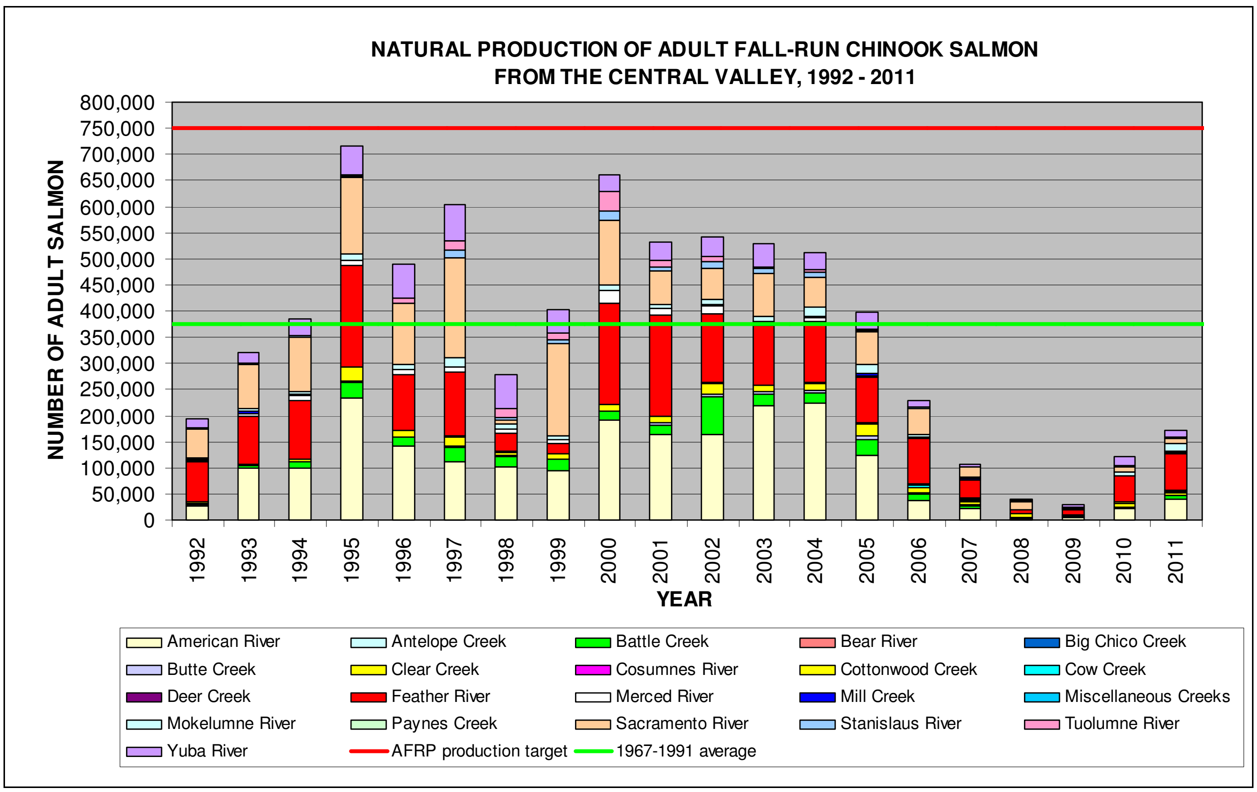
3.1.2 PRODUCTION ESTIMATES FOR INDIVIDUAL RUNS

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 2011 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 2011 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, 1992-2011. 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.

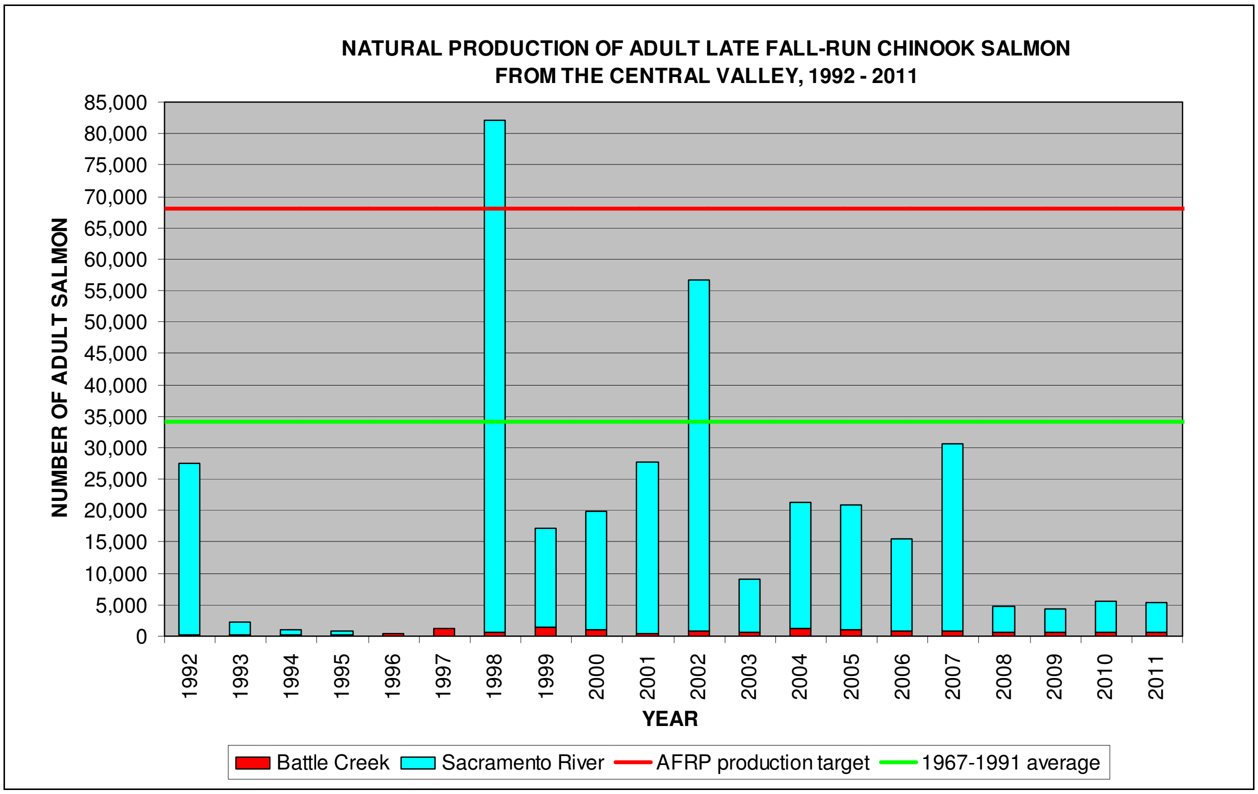


Between 1992 and 2011 and in descending order based on their average annual natural production during this period, the following watersheds consistently contributed the greatest number of fish to the AFRP fall-run Chinook salmon production target: American River, Feather River, Sacramento River mainstem, 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 2011 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 20-year period (i.e., in 1998).

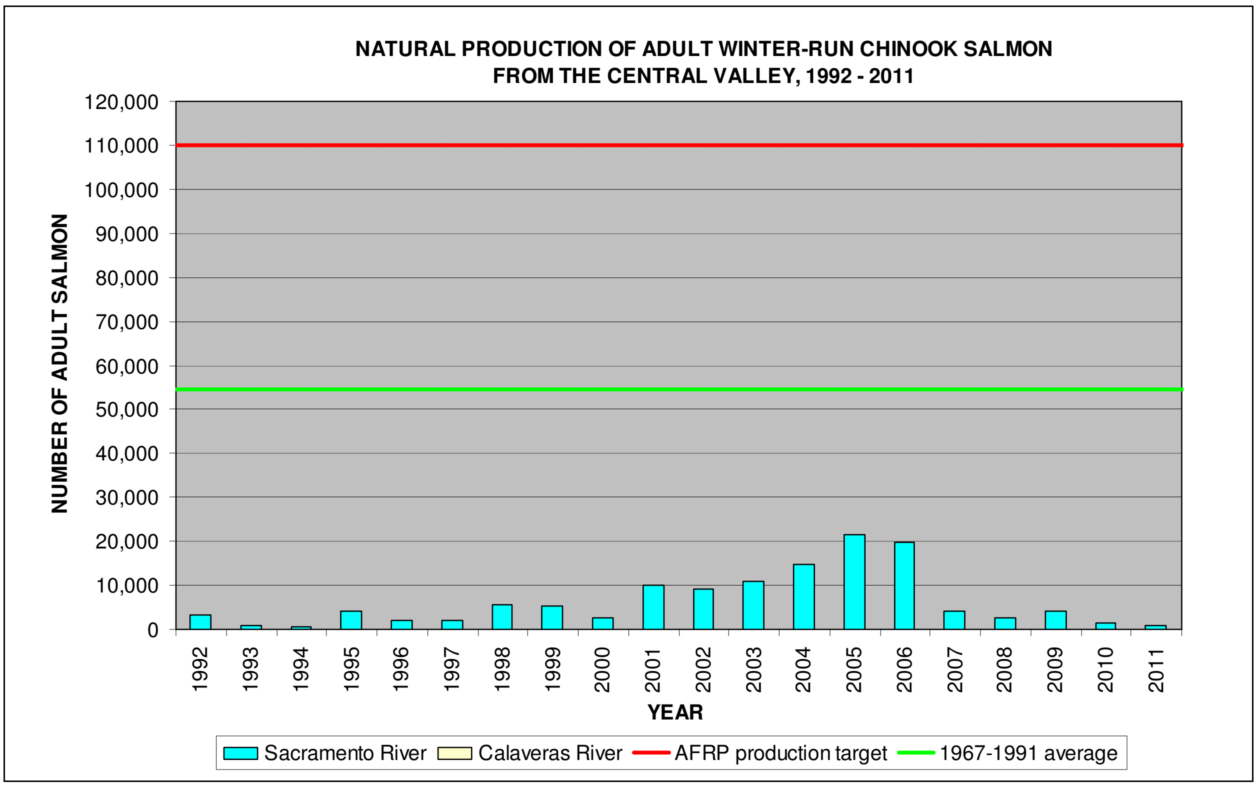
Figure 10. Estimated natural production of adult late-fall-run Chinook salmon from the Central Valley, 1992-2011. Annual estimates reflect the combined contributions from Battle Creek and the Sacramento River mainstem. The AFRP late-fall-run Chinook salmon production target is 68,000 Chinook salmon, 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 2011 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 latter river have only been done in five years since 1991, 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 2011 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 winter-run Chinook salmon production from the Calaveras River historically 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, 1992-2011. 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.

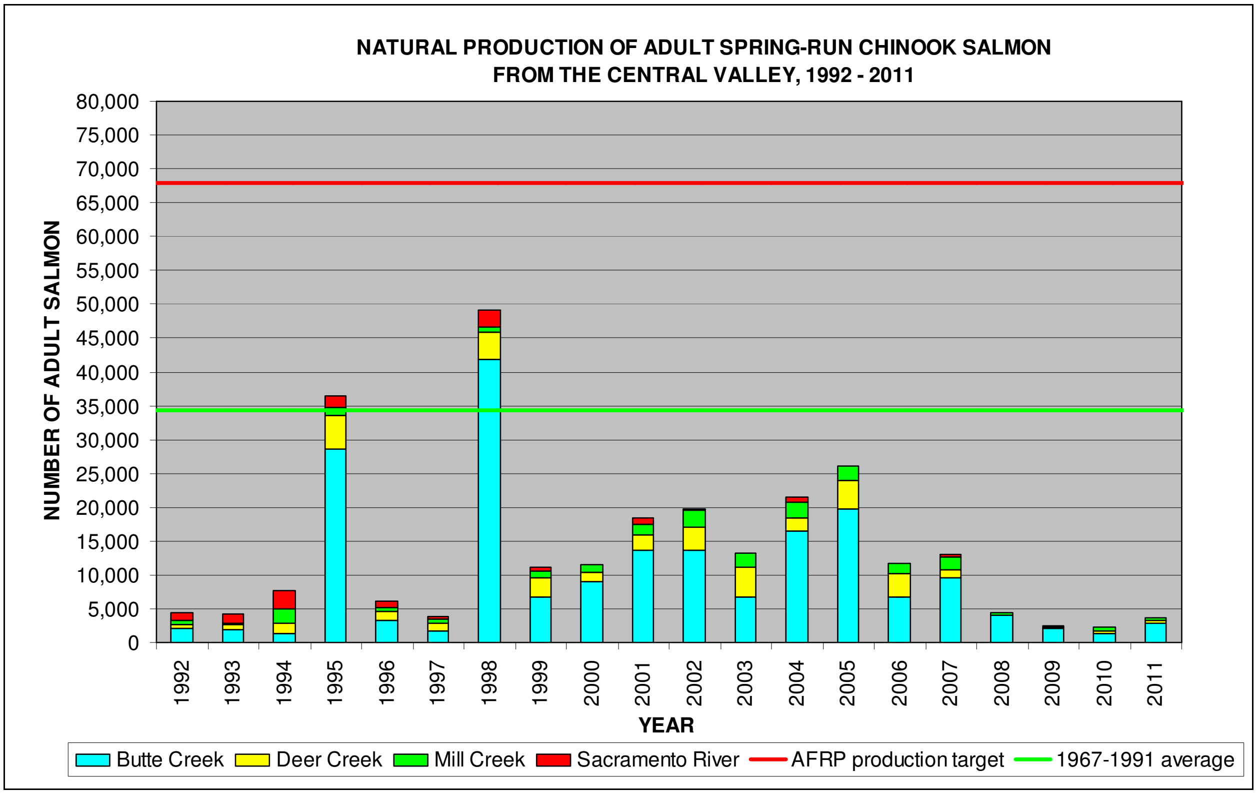


3.1.2.4 SPRING-RUN CHINOOK SALMON

Estimates of the natural production of adult spring-run Chinook salmon in the Central Valley between 1992 and 2011 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 2011 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, 1992-2011. 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.

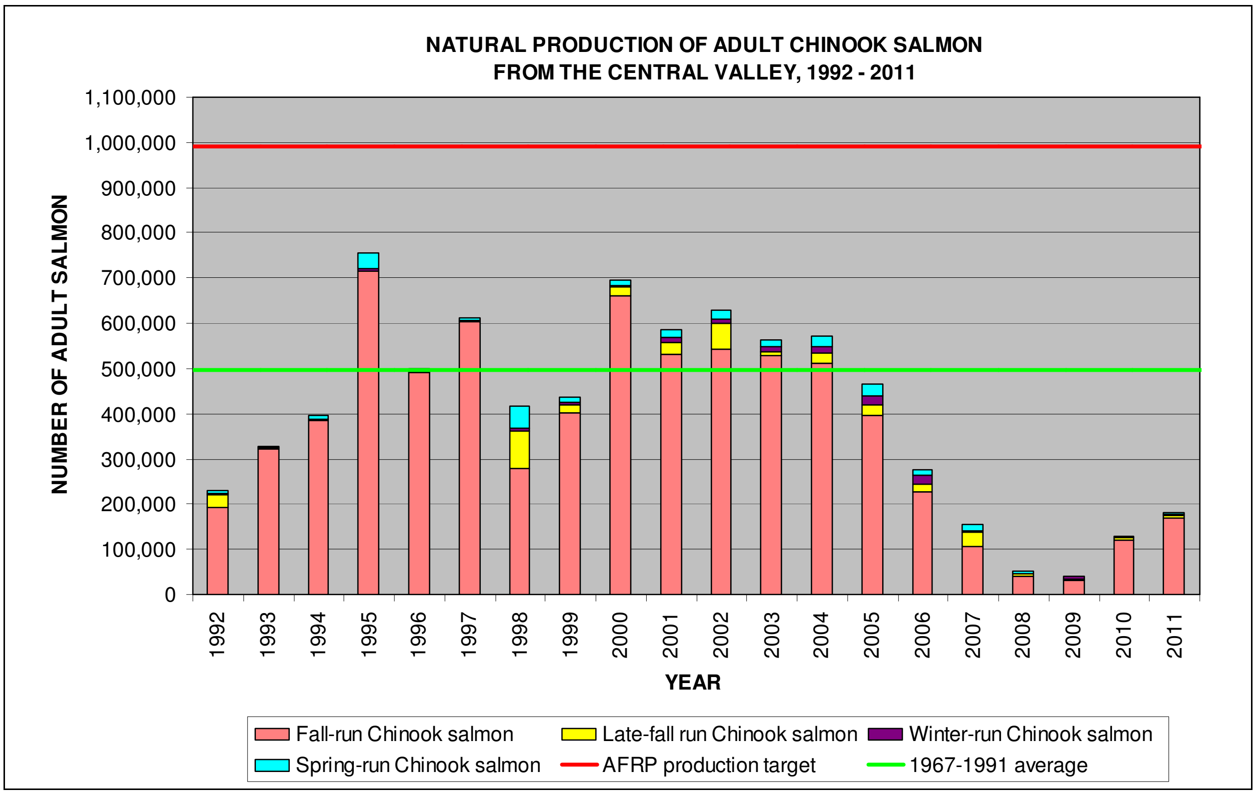


3.1.3 PRODUCTION ESTIMATES FOR THE CENTRAL VALLEY

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 2011 are presented in Table 4 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 2011 suggest this production target was never met during that 20-year period.

During the 20-year period between 1992 and 2011, 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, 1992-2011. 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 20-year period between 1992 and 2011 suggest:

- No data collection efforts occurred during the 1992-2011 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 remaining 16 watersheds with a fall-run Chinook salmon target: (a) met their production targets less than three times during the 20-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 12 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 18 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, 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 four years when surveys were done in the post-baseline period.

- The watershed-specific AFRP production target for spring-run Chinook salmon was met 15 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 20-year period 1992-2011. 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 2011.

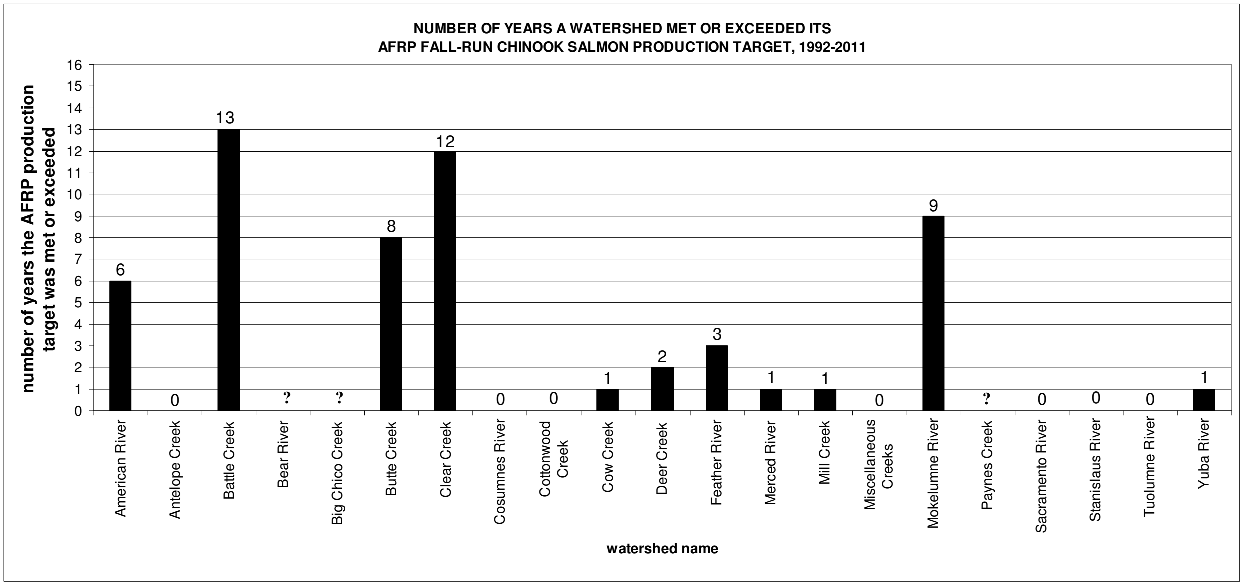


Figure 15. Number of times watershed-specific AFRP late-fall-run Chinook salmon production targets were met or exceeded during the 20-year period 1992-2011. Monitoring data for late-fall-run Chinook salmon from the Sacramento River mainstem were only collected in 19 of the 20 years since 1991.

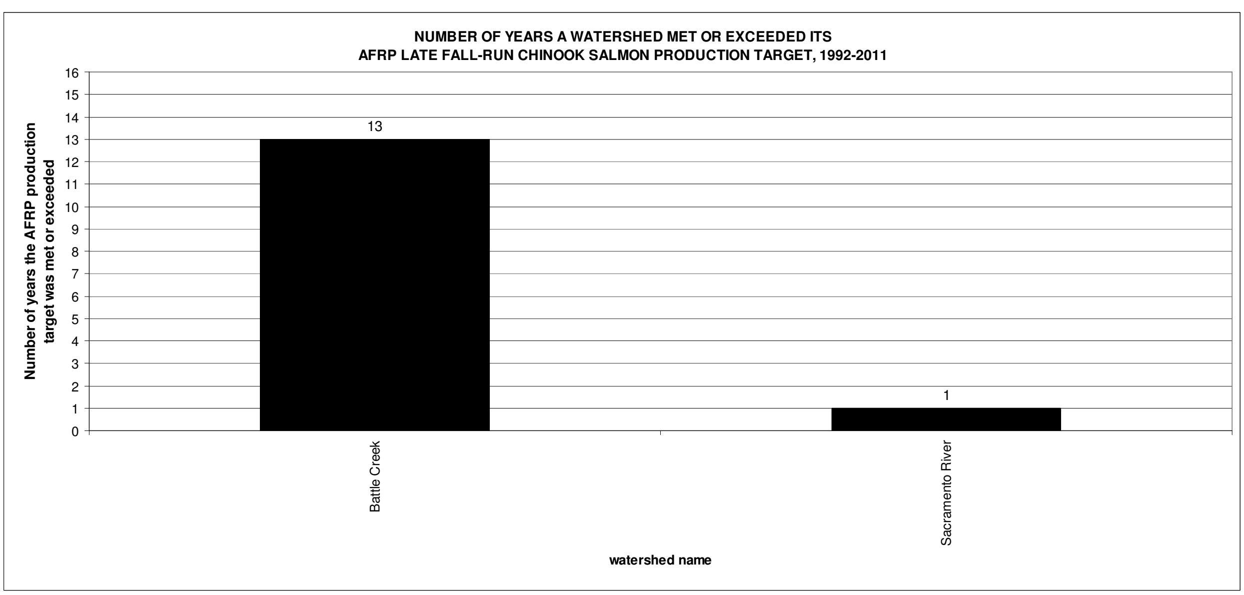


Figure 16. Number of times watershed-specific AFRP winter-run Chinook salmon production targets were met or exceeded during the 20-year period 1992-2011. Monitoring data from the Calaveras River were only collected during five years between 1992 and 2011.

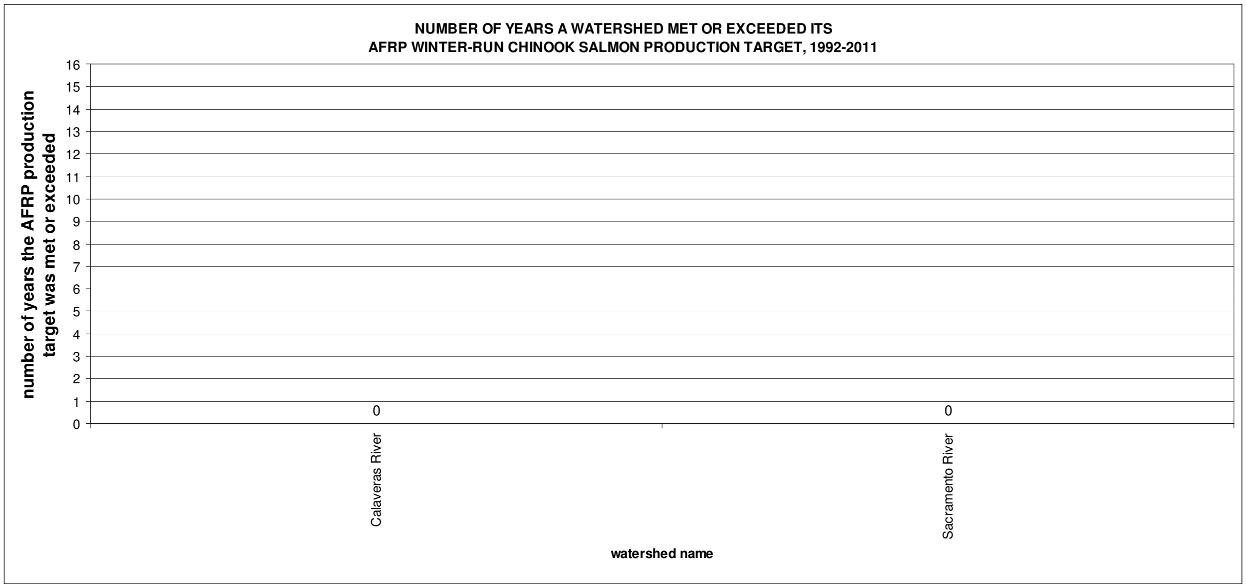
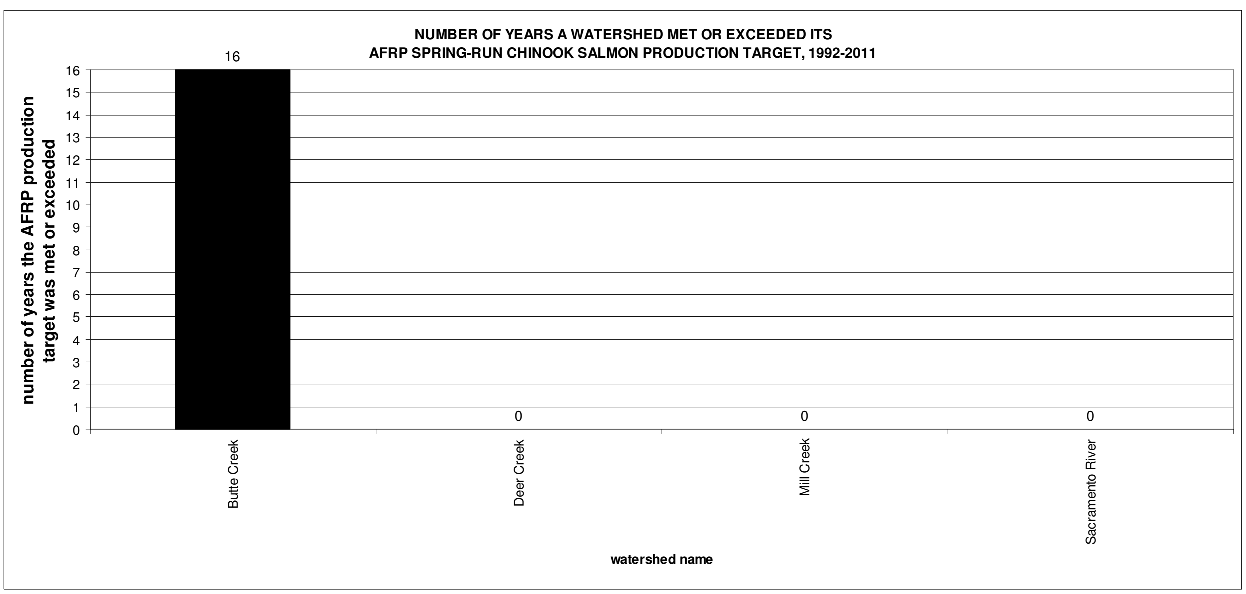


Figure 17. Number of times watershed-specific AFRP spring-run Chinook salmon production targets were met or exceeded during the 20-year period 1992-2011.



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 1992-2011 time periods is presented in Table 4, and suggests that watersheds can be grouped in one of three categories. These include:

Category #1: Watersheds experiencing an increase in the average natural production over time. Runs and watersheds applicable to 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 experiencing a decrease in the average natural production over time. 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 applicable to 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, 1967-2011. * 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		1992-2011		AFRP fish production target	Percent change in average production 1967-1991 vs. 1992-2011	P-value
		N	Average production	N	Average production			
American River*	Fall-run	25	80,876	20	106,915	160,000	+ 32%	0.326
Antelope Creek	Fall-run	19	361	1	0	720	???	???
Battle Creek*	Fall-run	25	5,013	20	17,511	10,000	+ 249%	0.001**
Battle Creek*	Late-fall-run	23	273	20	684	550	+ 150%	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	15	2,334	1,500	+ 205%	0.052
Butte Creek	Spring-run	25	1,018	20	9,713	2,000	+ 855%	0.000**
Calaveras River	Winter-run	4	770	5	0	2,200	- 100%	???
Clear Creek	Fall-run	16	3,576	20	10,685	7,100	+ 199%	0.000**
Cosumnes River	Fall-run	17	1,660	13	743	3,300	- 55%	0.149
Cottonwood Creek	Fall-run	17	2,964	6	1,687	5,900	- 43%	???
Cow Creek	Fall-run	12	2,330	6	1,849	4,600	- 21%	???
Deer Creek	Fall-run	23	766	12	838	1,500	+ 9%	0.781

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, 1967-2011. * 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		1992-2011		AFRP fish production target	Percent change in average production 1967-1991 vs. 1992-2011	P-value
		N	Average production	N	Average production			
Deer Creek	Spring-run	18	3,276	20	2,024	6,500	- 38%	0.599
Feather River*	Fall-run	25	86,031	20	88,562	170,000	+ 3%	0.927
Merced River*	Fall-run	25	9,005	20	6,644	18,000	- 26%	0.964
Mill Creek	Fall-run	24	2,118	15	1,880	4,200	- 11%	0.795
Mill Creek	Spring-run	18	2,202	20	1,199	4,400	- 46%	0.128
Miscellaneous Creeks	Fall-run	20	549	3	78	1,100	- 86%	???
Mokelumne River*	Fall-run	25	4,680	20	8,395	9,300	+ 79%	0.014**
Paynes Creek	Fall-run	9	170	0	???	330	????	???
Sacramento River	Fall-run	25	115,371	20	72,594	230,000	- 37%	0.004**
Sacramento River	Late-fall-run	25	33,941	19	18,030	68,000	- 47%	0.004**
Sacramento River*	Winter-run	25	54,316	20	6,320	110,000	- 88%	0.002**
Sacramento River	Spring-run	25	29,412	20	718	59,000	- 98%	0.000**
Stanislaus River	Fall-run	24	10,868	20	5,165	22,000	- 52%	0.311
Tuolumne River	Fall-run	25	18,949	20	6,912	38,000	- 64%	0.011**
Yuba River	Fall-run	25	33,245	20	31,906	66,000	- 4%	1.000

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 1992-2011 time periods is presented in Table 5. The average fall-run Chinook salmon production in the baseline and post-baseline periods has declined by 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 48, 88, and 60%, respectively, and each of these declines were statistically significant. The natural production of Chinook salmon across the Central Valley during the 1992-2011 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, 1967-2011. ** Indicates a statistically significant P value ($p<0.05$).

Chinook salmon group	**1967-1991 average production**	**1992-2011 average production**	**AFRP fish production target**	**Percent change in average production 1967-1991 vs. 1992-2011**	**P-value**
Fall-run	374,049	360,509	750,000	- 4%	0.927
Late-fall-run	34,192	17,812	68,000	- 48%	0.003**
Winter-run	54,439	6,320	110,000	- 88%	0.002**
Spring-run	34,374	13,654	68,000	- 60%	0.000**
All runs combined, Central Valley-wide	497,054	398,294	990,000	- 20%	0.193

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 1992-2011 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 appears to be significantly greater from Battle Creek, Clear Creek, and the Mokelumne River during the 1992-2011 time period than during the 1967-1991 baseline period. In contrast, significantly fewer adult fall-run Chinook salmon were likely 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 appear to have been produced on average from Battle Creek in the post-baseline period, and significantly smaller numbers of adult salmon appear to have been produced from the Sacramento River mainstem. During the post-baseline period, significantly fewer adult winter-run Chinook salmon appear to have been 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 appears to have been significantly greater in Butte Creek during the post-baseline period, but appears to have been significantly less in the Sacramento River mainstem.

3.3 PRODUCTION OF NON-SALMONID TAXA

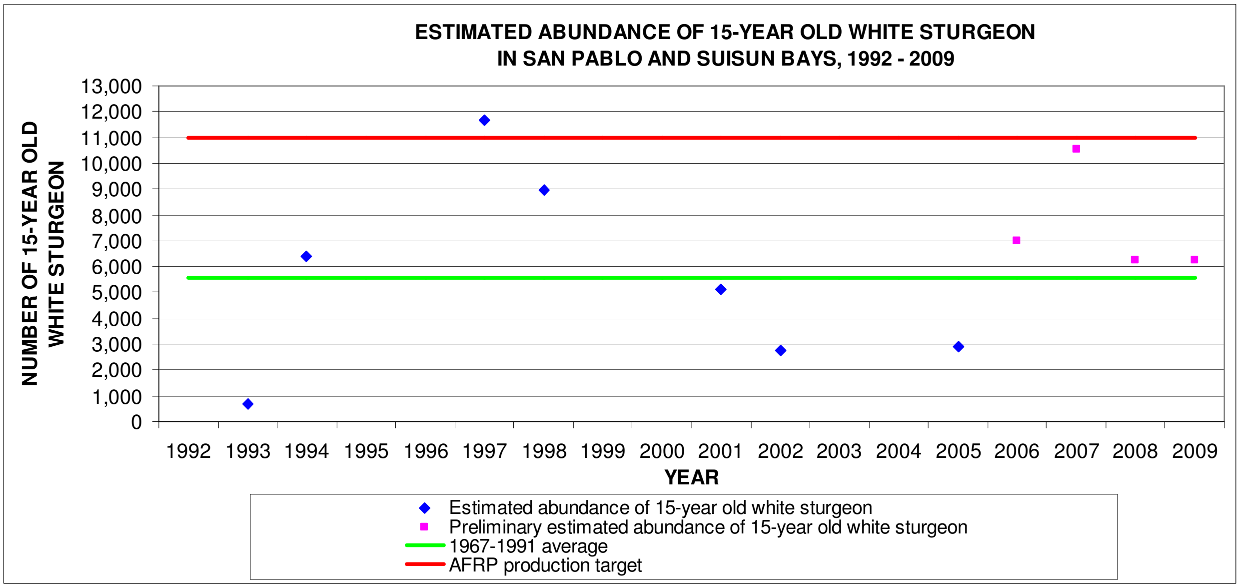
3.3.1 PRODUCTION OF ADULT WHITE AND GREEN STURGEON

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 6). 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 18).

Table 6. 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 18. 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.

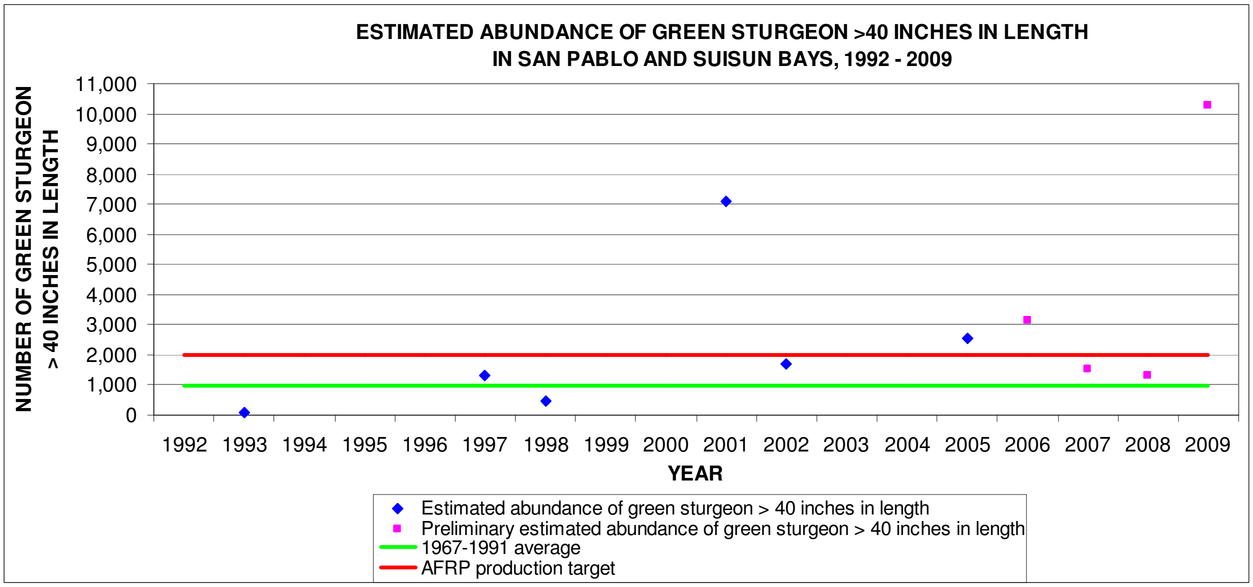


Ten of the eleven white sturgeon surveys conducted between 1992 and 2009 can be used to develop abundance estimates for green sturgeon that were ≥ 40 inches in length in San Pablo and Suisun bays. Because the CDFG did not capture green sturgeon during the sturgeon survey in 1994, it is not possible to 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 7). 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 19).

Table 7. 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 19. 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.



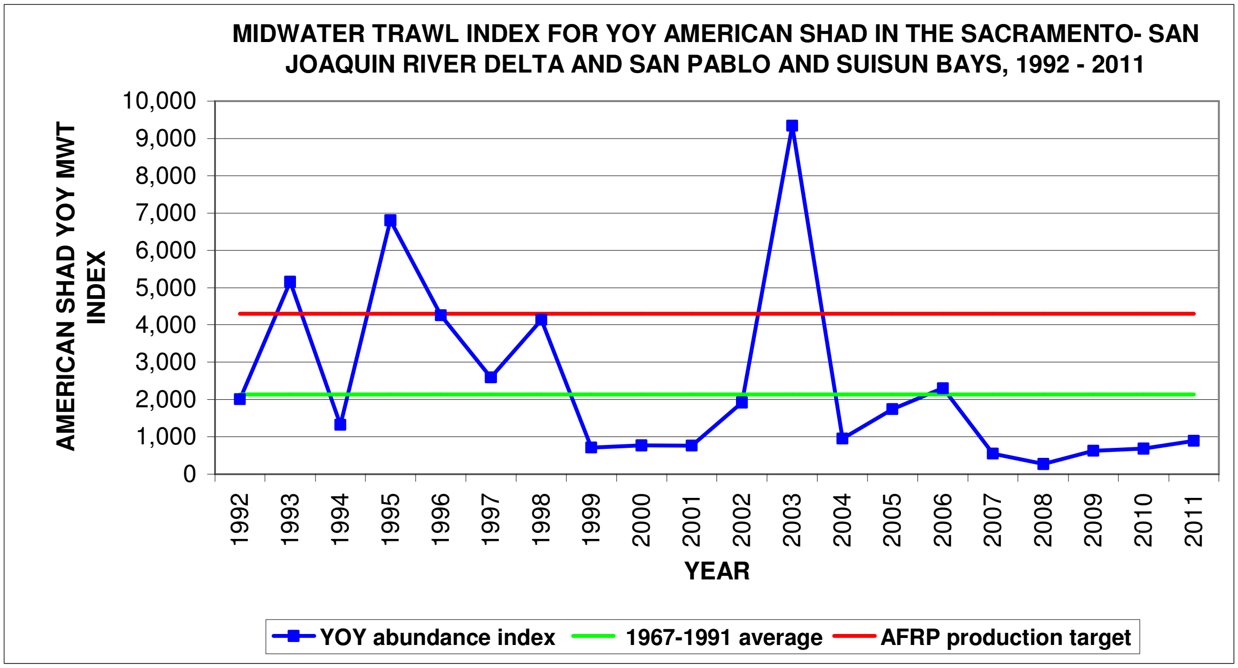
3.3.2 PRODUCTION OF JUVENILE AMERICAN SHAD

The midwater trawl index for YOY American shad in the Sacramento-San Joaquin River Delta and San Pablo and Suisun bays during the 1992-2011 time period ranged between 271 and 9,342 (Table 8). The AFRP production target for American shad is 4,300 fish. Between 1992 and 2011, the MWT YOY index exceeded the AFRP production target in 3 of 20 years (Figure 20).

Table 8: Midwater trawl index for young-of-the-year American shad in the Sacramento-San Joaquin River Delta and San Pablo and Suisun bays, 1992-2011.

Year	MWT index for young-of-the-year American shad
1992	2,010
1993	5,153
1994	1,318
1995	6,803
1996	4,260
1997	2,591
1998	4,134
1999	715
2000	764
2001	761
2002	1,914
2003	9,342
2004	947
2005	1,741
2006	2,303
2007	551
2008	271
2009	624
2010	683
2011	892

Figure 20. Midwater trawl index for young-of-the-year American shad in the Sacramento-San Joaquin River Delta and San Pablo and Suisun bays, 1992-2011.



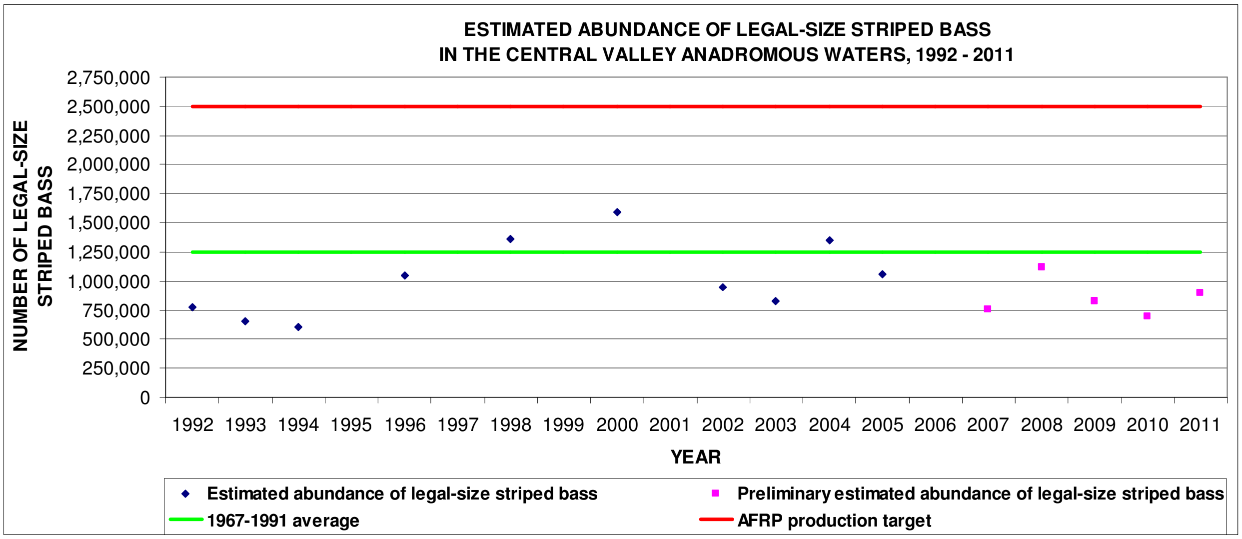
3.3.3 PRODUCTION OF ADULT STRIPED BASS

Fifteen surveys were intermittently conducted for striped bass between 1992 and 2011. Between 1992 and 2011, the abundance of adult striped bass in the anadromous waters of the Central Valley ranged between 599,770 and 1,591,419 fish (Table 9). Abundance estimates for 2007, 2008, 2009, 2010, and 2011 are provisional and subject to change. The AFRP production target for striped bass is 2,500,000 fish. Between 1992 and 2011, the AFRP striped bass production target was not met during the 15 years when population estimates were developed (Figure 21).

Table 9. Estimated abundance of legal-size striped bass in the Central Valley's anadromous waters, 1992-2011. 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	1,312,452
2005	1,058,679
2006	
2007*	752,275
2008*	1,116,062
2009*	830,641
2010* µ	696,159
2011* µ	894,606

Figure 21. Estimated abundance of legal-size striped bass in the Central Valley's anadromous waters, 1992-2011. Estimates in 2007, 2008, 2009, 2010, and 2011 are preliminary and subject to change.



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 1992-2011 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 2011, many of the brood year 2008 and 2009 juvenile fall-run Chinook salmon that were marked in 2009 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.

A review of information in the introduction section of this document is as follows:

- The CVPIA baseline period encompasses a 25-year period between 1967 and 1991, and a 20-year post-baseline period between 1992 and 2011.

- There are 29 combinations (i.e., permutations) of watersheds and runs of Chinook salmon with an AFRP production target.

- Twenty-two watersheds have one or more AFRP Chinook salmon fish production targets.

- Twenty-one watersheds have a fall-run Chinook salmon production target, two watersheds have a late-fall-run Chinook salmon production target, two watersheds have a winter-run Chinook salmon production target, and four watersheds have a spring-run Chinook salmon production target.

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 1992-2011 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 remaining 16 watersheds have: (a) met their productions targets less than three times over the 20-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 13 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 19 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 16 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.

Other data presented in this report demonstrate:

- 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.

- Five 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 11 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.

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

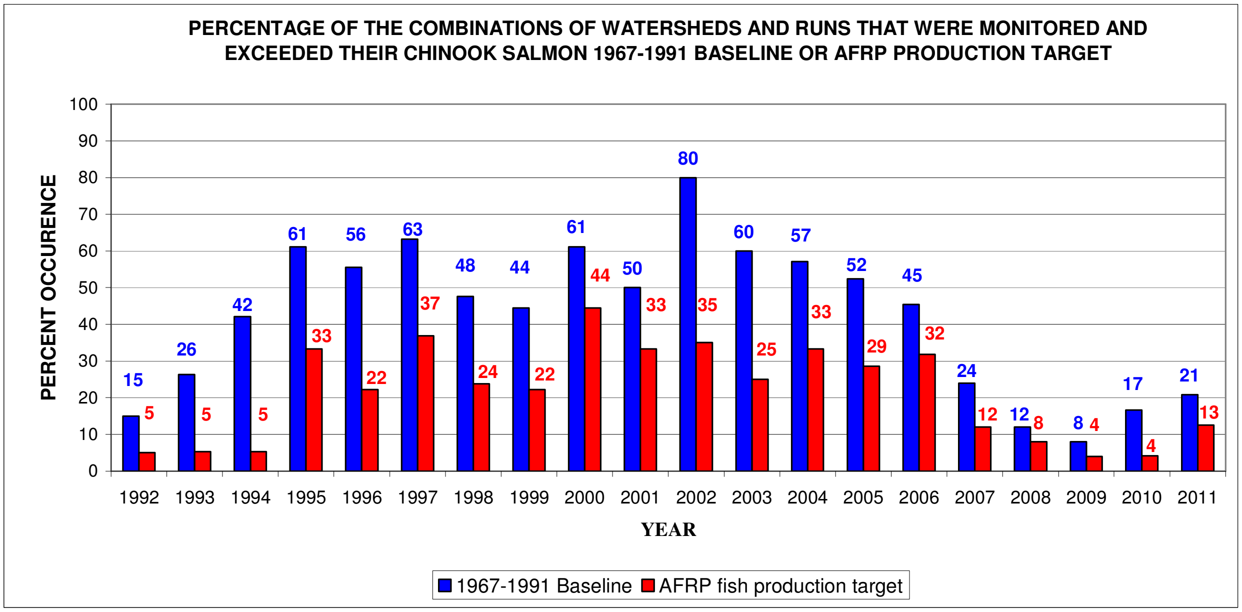
- Assumption #1, there are two independent samples that are randomly selected;
- Assumption #2, each of the two samples has more than 10 values; and
- Assumption #3, there is no requirement that the two populations have a normal distribution or any other particular distribution.

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, at least 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 CDFG's Ocean Salmon Project which collects commercial and recreational harvest data pertaining to Chinook salmon in the Pacific Ocean does collect recreational salmon harvest data in a randomized manner.

For the watersheds where monitoring data were available, production of different runs of Chinook salmon from the aforementioned 22 watersheds increased in 14 of the 24 combinations of watersheds and runs in 2011 relative to 2010. These increases in production resulted in a doubling of natural production in 2011 relative to 2008 and 2009, but were still substantially less than what occurred prior to 2007.

Progress in achieving the Chinook salmon production targets called for in the CVPIA has been less successful since 2000. In that year, 44% (i.e., eight) of the combinations of watersheds and runs that were monitored in the Central Valley exceeded their AFRP production target (Figure 22). By 2011, only 13% (i.e., three) of the monitored watersheds exceeded their AFRP target. The persistently low production of adult salmon in recent years is reflected in the fact that only five combinations of the watersheds and runs monitored in 2011 (Battle Creek fall-run, Clear Creek fall-run, Mokelumne River fall-run, Battle Creek late-fall-run, Butte Creek spring-run) exceeded their respective production levels during the 1967-1991 baseline period.

Figure 22. 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 2011.



YEAR	1967-1991 Baseline	AFRP fish production target
1992	15	5
1993	26	5
1994	42	5
1995	61	33
1996	56	22
1997	63	37
1998	48	24
1999	44	22
2000	61	44
2001	50	33
2002	80	35
2003	60	25
2004	57	33
2005	52	29
2006	45	32
2007	24	12
2008	12	8
2009	8	4
2010	17	4
2011	21	13

On a more positive note, substantial gains in salmon production have occurred in watersheds where CVPIA programs have had adequate resources to improve habitat conditions. For example, salmon production has increased on Butte, Battle, and Clear Creeks and those gains are likely correlated with efforts to resolve issues involving flow and fish passage. And increases in the number of salmon produced on Clear Creek and the Mokelumne River are likely correlated with substantial investments in habitat restoration activities.

In relation to specific salmon runs, the natural production of winter-run Chinook salmon continued to trend upward after 1994 until the poor returns in the last five years (2007-2011). Spring-run salmon numbers also trended upwards after 1991, but production was reduced between 2008 and 2011. Natural fall-run Chinook salmon production decreased to the 1967-1991 baseline levels due to the stock collapse observed in 2007-2010, but these numbers have increased in some watersheds in 2011. Late fall-run Chinook salmon production increased substantially since a low period between 1993 and 1997, but then declined to low levels between 2008 and 2011.

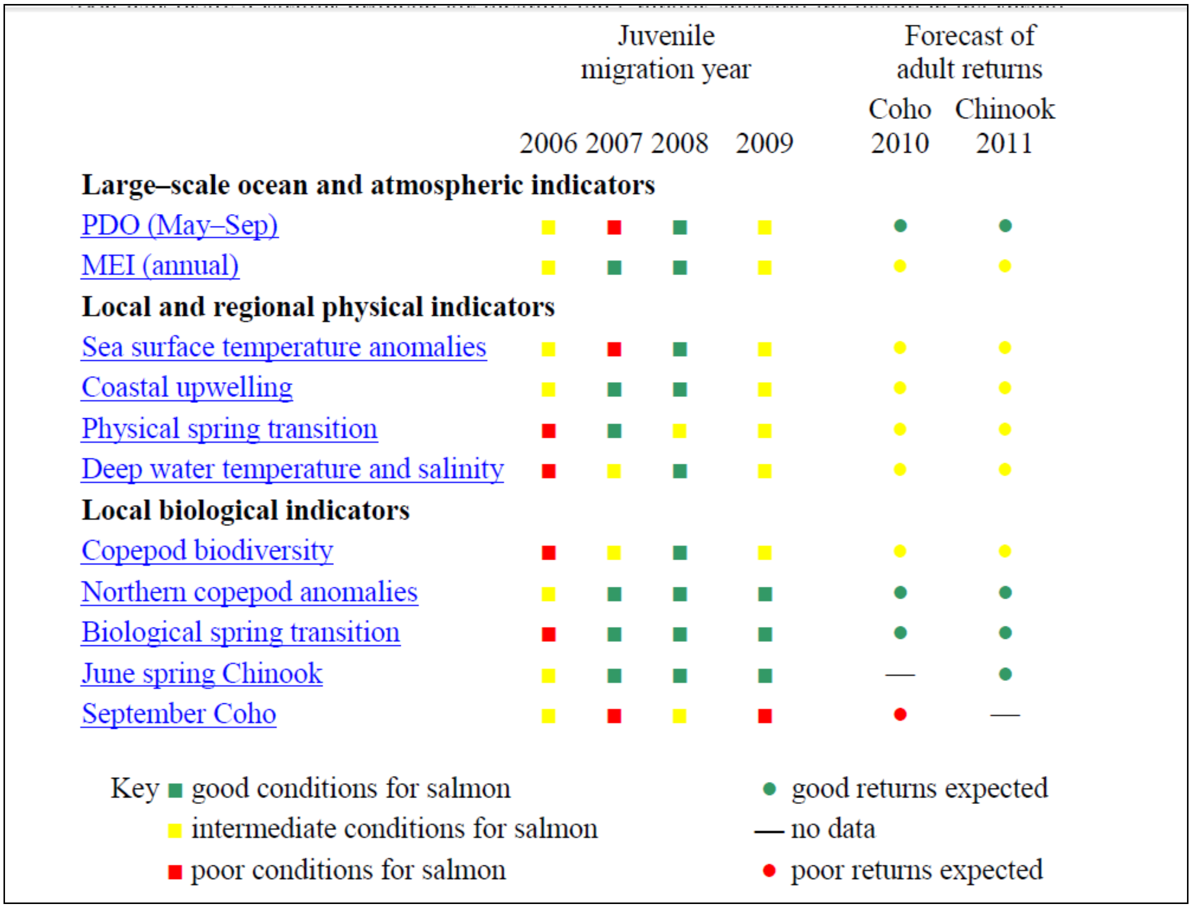
The production of Chinook salmon reported each year represents individuals that hatched from redds 2-4 years previously, and that successfully exited their rearing areas, emigrated down their natal streams, passed through the Delta and the San Francisco Bay estuaries, and survived predation, disease, and environmental conditions during the 2-4 year period they spent in the open ocean. Chinook salmon spend 66-75% of their life in the ocean. If there are adverse conditions in the ocean, this could cause a decrease in populations.

Cyclic phenomena such as the El Niño-Southern Oscillation (ENSO) and the Pacific Decadal Oscillation (PDO) can cause disruptions in the California Current which, in turn, can cause a decrease in coastal upwelling of nutrients (Schwing et al. 2005). The PDO is a climate index based upon patterns of variation in sea surface temperature of the North Pacific from 1900 to the present. The California Current flows south along the west coast of North America bringing colder water from the north. Northeasterly winds push the surface waters westward which enhances upwelling of nutrient-rich water. When this current is disrupted, the upwelling can weaken in areas critical to the migration and survival of several species, including Chinook salmon.

The decrease in upwelling of cold, nutrient-rich water can affect the entire food chain and, depending on the strength and timing of the event, could cause a collapse in the fish populations present in the ocean. A collapse in the ocean population will result in fewer returning adult salmon spawners and decrease adult Chinook salmon production. By removing a significant number of potential spawners from the population, a fishery collapse can have a ripple effect for the affected population for a number of years. The degree to which these phenomena affect fish populations is only now being investigated by many scientists and resource managers including those within the CVPIA Program.

The number of adult Chinook salmon spawners that return in a specific year is a reflection of the success and survival of a brood cohort that hatched two to three years before. A study by Lindley et al. (2009) examined the stock collapse of the Sacramento River fall-run Chinook and concludes that for "*the 2005 brood, the evidence suggests again that ocean conditions were the proximate cause of the poor performance of that brood. In particular, the cessation of coastal upwelling in May of 2006 was likely a serious problem for juvenile fall Chinook entering the ocean in the spring*." Juvenile fall-run Chinook salmon enter the ocean during the May-June time period. If there is insufficient food available to juvenile salmon during the portion of their life cycle when they are present in the ocean, the potential for their survival is significantly reduced. Peterson et al. (2010) suggested that good ocean conditions for juvenile Chinook salmon when they entered the ocean in 2008, and intermediate conditions were present for juvenile salmon entering the ocean in 2009 (Figure 23). The PDO changed to a "cool" phase that lasted from September 2007 through July 2009 while ENSO conditions remained favorable until May 2009 signaling a return to warm ocean conditions. These conditions were also reflected in local and regional physical parameters (i.e., sea surface temperatures and coastal upwelling) where warm water temperatures and "down welling" events were observed in 2009. Additionally, the local biodiversity indicators also indicated favorable food conditions for salmon in 2008, but copepod biodiversity declining in 2009. Therefore, Chinook salmon production in 2011 should not have been negatively affected by the ocean conditions in 2008 although juvenile fish entering the ocean in 2009 may have experienced less favorable ocean conditions.

Figure 23. Relationship between ocean ecosystem indicators of the Northern California Current, periods when different brood years of juvenile salmon were present in the Pacific Ocean, and forecasts of adult salmon returns. From Table 1, Peterson et al. 2010.



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 2011 midwater trawl index for juvenile American shad (892) increased slightly from the 2010 index (683), but the 2011 index was markedly below the 1967-1991 baseline average of 2,129 shad and the AFRP production target of 4,300 shad. The process of collecting data to calculate the MWT index did vary prior to 1980; i.e., during a portion of the period of record that was used to develop the AFRP production. Overall, however, the vast majority of the core sampling stations used to calculate the MWT index have been monitored on a consistent basis since 1980 (Dave Contreras, CDFG, pers. comm.). The depressed MWT 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. The conclusion is further substantiated because the geographic distribution of the area sampled during the MWT index has remained essentially unchanged since 1980.

Data used to estimate the abundance of legal-size striped bass also suggest that species' abundance levels is at relatively low levels, e.g., population estimates for twelve of the fifteen years when monitoring data were collected between 1992 and 2011 were less than what was observed during the 1967-1991 baseline period. The 2007-2011 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.

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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	21,790	19,565	6,361	12,406	60,122

Total Ocean Harvest Values include the number of fish that were captured for commercial and recreation purposes from San Francisco and Monterey. The fish that are caught from boats that originate in the ports are thought to originate in the Central Valley. The source of the data is the *Review of 2011 Ocean Salmon Fisheries* (PFMC 2012); commercial harvest data is provided in Table A-3 and recreational harvest data is provided in Table A-5.

ANGLER HARVEST AND 2008 - 2011 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 Game'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.

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	3,184	0	0	5,698	60	3,419
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	5,082	0	0	11,021	60	6,613
Merced River	389	76	0	0	465	90	419
Mill Creek	166	0	0	0	166	80	133
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	1,392	0	0	0	1,392	100	1,392
Tuolumne River	372	0	0	0	372	100	372
Yuba River	3,508	0	0	0	3,508	100	3,508
Total	52,650	19,220	0	0	71,870		39,778
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	362	0	0	0	362	100	362
Sacramento River	52	0	0	0	52	100	52
Total	4,489	0	0	0	4,489		4,489
Total 2008 Natural Production of Adult Chinook Salmon							**51,628**

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	2,460	36,945	60	22,167
Antelope Creek							0
Battle Creek	6,631	17,238	2,387	1,873	28,129	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	564	8,475	80	6,780
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	5,555	83,419	60	50,051
Merced River	651	146	40	60	896	90	807
Mill Creek	144	0	14	11	169	80	136
Miscellaneous Creeks						80	0
Mokelumne River	1,920	5,275	720	565	8,480	60	5,088
Paynes Creek							0
Sacramento River	16,372	0	1,637	1,284	19,293	60	11,576
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	1,128	16,940	100	16,940
Total	111,462	51,727	31,011	13,851	208,050		121,140
Late-Fall Run Chinook Salmon							
Battle Creek	27	5,505	1,106	473	7,112	10	711
Sacramento River	4,282	81	637	356	5,356	91.8	4,917
Total	4,309	5,586	1,743	830	12,468		5,628
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							**130,546**

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	11,691	67,235	60	40,341
Antelope Creek							0
Battle Creek	12,513	42,383	5,490	12,709	73,095	10	7,310
Bear River							0
Big Chico Creek							0
Butte Creek	416	0	42	97	555	80	444
Clear Creek	4,841	0	484	1,122	6,447	80	5,157
Cosumnes River	53	0	5	11	70	100	70
Cottonwood Creek	2,144	0	214	498	2,856	80	2,285
Cow Creek	1,810	0	181	418	2,409	80	1,927
Deer Creek	662	0	66	155	883	80	706
Feather River	47,289	32,616	15,981	20,183	116,069	60	69,641
Merced River	1,571	371	97	429	2,468	90	2,221
Mill Creek	1,231	0	123	286	1,640	80	1,312
Miscellaneous Creeks						80	0
Mokelumne River	2,674	15,922	1,860	4,303	24,759	60	14,855
Paynes Creek							0
Sacramento River	11,957	0	1,196	2,770	15,922	60	9,553
Stanislaus River	1,309	0	65	292	1,666	100	1,666
Tuolumne River	893	0	45	195	1,132	100	1,132
Yuba River	8,928	0	893	2,066	11,887	100	11,887
Total	123,917	103,972	43,979	57,224	329,092		170,508
Late-Fall Run Chinook Salmon							
Battle Creek	42	4,635	935	1,183	6,795	10	680
Sacramento River	3,686	55	546	904	5,191	91.8	4,765
Total	3,728	4,690	1,482	2,086	11,986		5,445
Winter-Run Chinook Salmon							
Calaveras River	0	0	0	0	0	100	0
Sacramento River	738	88	0	174	1,000	89.7	897
Total	738	88	0	174	1,000		897
Spring-Run Chinook Salmon							
Butte Creek	2,130	0	213	495	2,838	100	2,838
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	643	3,687		3,687
Total 2011 Natural Production of Adult Chinook Salmon							**180,537**

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

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 Game (CDFG).

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 adult 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 CDFG "FMWT AMS Indices 1967-2010 v2.xls" spreadsheet dated November 30, 2011 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 CDFG "AMS Length Frequency 1971-2010.xls" spreadsheet dated November 22, 2011 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
	number of fish older than age 0 measured	0	0	1	1	
	number of YOY measured	404	319	293	121	
	total number of fish measured	404	319	294	122	
	percent YOY	100.0	100.0	99.7	99.2	
	YOY abundance index	755	530	461	264	2,010
1993	all age abundance index	1,972	1,567	908	710	5,157
	number of fish older than age 0 measured	0	0	1	1	
	number of YOY measured	557	432	382	362	
	total number of fish measured	557	432	383	363	
	percent YOY	100.0	100.0	99.7	99.7	
	YOY abundance index	1,972	1,567	906	708	5,153
1994	all age abundance index	439	387	391	117	1,334
	number of fish older than age 0 measured	5	4	2	1	
	number of YOY measured	421	270	237	71	
	total number of fish measured	426	274	239	72	
	percent YOY	98.8	98.5	99.2	98.6	
	YOY abundance index	434	381	388	115	1,318
1995	all age abundance index	3,246	2,220	791	555	6,812
	number of fish older than age 0 measured	2	1	0	0	
	number of YOY measured	979	774	484	345	
	total number of fish measured	981	775	484	345	
	percent YOY	99.8	99.9	100.0	100.0	
	YOY abundance index	3,239	2,217	791	555	6,803
1996	all age abundance index	1,756	1,072	935	523	4,286
	number of fish older than age 0 measured	2	5	3	2	
	number of YOY measured	632	509	507	245	
	total number of fish measured	634	514	510	247	
	percent YOY	99.7	99.0	99.4	99.2	
	YOY abundance index	1,750	1,062	930	519	4,260
1997	all age abundance index	265	565	639	1,125	2,594
	number of fish older than age 0 measured	2	1	0	0	
	number of YOY measured	325	338	347	611	
	total number of fish measured	327	339	347	611	
	percent YOY	99.4	99.7	100.0	100.0	
	YOY abundance index	263	563	639	1,125	2,591
1998	all age abundance index	1,318	2,093	515	214	4,140
	number of fish older than age 0 measured	1	0	2	0	
	number of YOY measured	622	638	275	99	
	total number of fish measured	623	638	277	99	
	percent YOY	99.8	100.0	99.3	100.0	
	YOY abundance index	1,316	2,093	511	214	4,134
1999	all age abundance index	346	155	145	69	715
	number of fish older than age 0 measured	0	0	0	0	
	number of YOY measured	228	184	149	86	
	total number of fish measured	228	184	149	86	
	percent YOY	100.0	100.0	100.0	100.0	
	YOY abundance index	346	155	145	69	715

	field containing raw data					
	field with a calculated value					
2000	all age abundance index	253	326	126	59	764
	number of fish older than age 0 measured	0	0	0	0	
	number of YOY measured	132	278	107	41	
	total number of fish measured	132	278	107	41	
	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
	number of fish older than age 0 measured	0	0	0	2	
	number of YOY measured	311	230	114	40	
	total number of fish measured	311	230	114	42	
	percent YOY	100.0	100.0	100.0	95.2	
	YOY abundance index	338	239	110	74	761
2002	all age abundance index	372	832	334	382	1,920
	number of fish older than age 0 measured	1	2	0	1	
	number of YOY measured	286	478	242	236	
	total number of fish measured	287	480	242	237	
	percent YOY	99.7	99.6	100.0	99.6	
	YOY abundance index	371	829	334	380	1,914
2003	all age abundance index	3,345	2,947	1,279	1,789	9,360
	number of fish older than age 0 measured	4	1	0	0	
	number of YOY measured	911	760	656	760	
	total number of fish measured	915	761	656	760	
	percent YOY	99.6	99.9	100.0	100.0	
	YOY abundance index	3,330	2,943	1,279	1,789	9,342
2004	all age abundance index	680	83	78	106	947
	number of fish older than age 0 measured	0	0	0	0	
	number of YOY measured	391	122	91	67	
	total number of fish measured	391	122	91	67	
	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
	number of fish older than age 0 measured	1	0	0	0	
	number of YOY measured	288	253	129	114	
	total number of fish measured	289	253	129	114	
	percent YOY	99.7	100.0	100.0	100.0	
	YOY abundance index	823	552	177	189	1,741
2006	all age abundance index	1,119	142	646	406	2,313
	number of fish older than age 0 measured	1	0	2	1	
	number of YOY measured	321	118	280	223	
	total number of fish measured	322	118	282	224	
	percent YOY	99.7	100.0	99.3	99.6	
	YOY abundance index	1,116	142	641	404	2,303
2007	all age abundance index	123	257	116	57	553
	number of fish older than age 0 measured	0	1	0	0	
	number of YOY measured	140	155	89	55	
	total number of fish measured	140	156	89	55	
	percent YOY	100.0	99.4	100.0	100.0	
	YOY abundance index	123	255	116	57	551

field containing raw data
field with a calculated value

2008	all age abundance index	14	25	19	213	271
	number of fish older than age 0 measured	0	0	0	0	
	number of YOY measured	55	31	25	151	
	total number of fish measured	55	31	25	151	
	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
	number of fish older than age 0 measured	0	0	0	0	
	number of YOY measured	196	164	208	164	
	total number of fish measured	196	164	208	164	
	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
	number of fish older than age 0 measured	0	0	0	0	
	number of YOY measured	158	60	107	176	
	total number of fish measured	158	60	107	176	
	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
	number of fish older than age 0 measured	0	0	2	0	
	number of YOY measured	311	254	122	81	
	total number of fish measured	311	254	124	81	
	percent YOY	100.0	100.0	98.4	100.0	
	YOY abundance index	413	204	140	135	892