COMPREHENSIVE ASSESSMENT AND MONITORING PROGRAM

Assessment of Anadromous Fish Production in the Central Valley of California between 1992 and 2009

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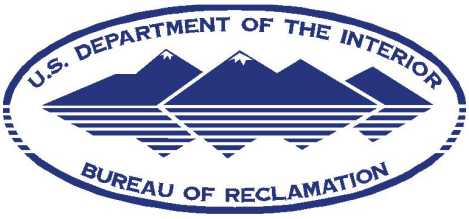

2010

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2800 Cottage Way, Room W-2605
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2010

The suggested citation for this report is:

U.S. Department of the Interior. 2010. Assessment of anadromous fish production in the Central Valley of California between 1992 and 2009. Report prepared by the U.S. Fish and Wildlife Service and Bureau of Reclamation, Comprehensive Assessment and Monitoring Program. Sacramento, California. 94 pp.

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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 2009. 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" above the Red Bluff Diversion Dam, 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 1967 - 1991 baseline period was greater or less than production during the 1992-2009 post-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 18-year period between 1992 and 2009 are summarized in Table 1.

Table 1. Overall assessment of changes in natural production of adult Chinook salmon from the Central Valley, 1967-2009. * Indicates a fish hatchery is present in the watershed. ** In this report, P values <0.05 are interpreted as being statistically significant. ??? = 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 1992-2009 time periods	P values associated with changes in the average production between the 1967-1991 and 1992-2009 time periods
American River*	fall-run	6/18	+ 42%	0.115
Antelope Creek	fall-run	0/1	???	???
Battle Creek*	fall-run	13/18	+ 275%	0.000**
Battle Creek*	late-fall-run	11/18	+ 149%	0.001**
Bear River	fall-run	0/0	???	???
Big Chico Creek	fall-run	0/0	???	???
Butte Creek	fall-run	8/13	+ 243%	0.018**
Butte Creek	spring-run	15/18	+ 932%	0.000**
Calaveras River	winter-run	0/3	- 100%	???
Clear Creek	fall-run	11/18	+ 212%	0.000**
Cosumnes River	fall-run	0/11	- 52%	0.196
Cottonwood Creek	fall-run	0/4	- 43%	???
Cow Creek	fall-run	1/4	- 8%	???
Deer Creek	fall-run	2/10	+ 15%	0.969
Deer Creek	spring-run	0/18	- 33%	0.800
Feather River*	fall-run	3/18	+ 12%	0.431
Merced River*	fall-run	1/18	- 20%	0.844
Mill Creek	fall-run	1/13	- 4%	0.525
Mill Creek	spring-run	0/18	- 42%	0.184
Miscellaneous Creeks	fall-run	0/3	- 85%	???
Mokelumne River*	fall-run	8/18	+ 75%	0.021**
Paynes Creek	fall-run	0/0	????	???
Sacramento River	fall-run	0/18	- 32%	0.010**
Sacramento River	late-fall-run	1/17	- 42%	0.011**
Sacramento River*	winter-run	0/18	- 87%	0.007**
Sacramento River	spring-run	0/18	- 97%	0.000**
Stanislaus River	fall-run	0/18	- 49%	0.402
Tuolumne River	fall-run	0/18	- 60%	0.024**
Yuba River	fall-run	1/18	+ 1%	0.730

The presence of fish hatcheries in several watersheds may confound the ability to accurately assess salmon production because the proportion of natural- vs. hatchery-origin salmon that is needed to calculate natural production is not currently known.

During the 18-year period between 1992 and 2009, the available Chinook salmon monitoring data in Table 1 indicate:

- Monitoring data that can be used to estimate salmon production have not been collected during the 1992-2009 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 18-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 11 times in the post-baseline period, and the Sacramento River mainstem only met its AFRP late-fall-run Chinook salmon target once in the 17 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 three years surveys were conducted.

- The watershed-specific AFRP spring-run Chinook salmon production target was met 15 times on Butte Creek in the post-baseline period. The other three watersheds with a spring-run Chinook salmon target (Deer Creek, Mill Creek, and the Sacramento River mainstem) have never met their AFRP targets in the post-baseline period.

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

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

Other Chinook salmon data presented in this report demonstrate that:

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

- Chinook salmon production estimates in 2008 and 2009 are unusual in comparison to past years because they do not include an ocean harvest component. The absence of that component in those years was caused by regulations that limited salmon harvests in response to concerns about unusually low numbers of fall-run Chinook salmon from the Sacramento River and it tributaries. The ocean harvest component normally accounts for a substantial fraction (~50%) of the Central Valley Chinook salmon production. The regulations prompting restrictions on the ocean harvest of Central Valley Chinook salmon do not appear to have led to substantially larger numbers of adult salmon returning to the Central Valley to spawn.

- For the watersheds where monitoring data were available, production of different runs of Chinook salmon from the aforementioned 22 watersheds declined in 14 of the 25 combinations of watersheds and runs in 2009 relative to 2008.

- Progress in achieving the Chinook salmon production targets called for in the CVPIA has become increasing difficult since 2000. In that year, 44% of the watersheds that were monitored exceeded their AFRP production target. By 2009, only 8% of the monitored watersheds exceeded their AFRP target. The recent decline in Chinook salmon production has become so substantial that only two combinations of the watersheds and runs monitored in 2009 (Battle Creek late-fall-run and Butte Creek spring-run), i.e, 8% of the watersheds, exceeded the production levels observed during the 1967-1991 baseline period.

With respect to non-salmonid species:

- Monitoring data for white sturgeon in San Pablo and Suisun bays are available for seven years between 1992 and 2005. The AFRP production target for 15-year-old white sturgeon was met once in those seven years. White sturgeon data for the post-2005 period are not currently available.

- Monitoring data for green sturgeon in San Pablo and Suisun bays are available for six years between 1992 and 2005. The AFRP production target for green sturgeon $\geq$ 40 inches in length was met twice in those six years. Green sturgeon data for the post-2005 period are not currently available.

- 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 18 years between 1992 and 2009. The 2009 midwater trawl index for this species is the third lowest value recorded during the 1992-2009 post-baseline period.

- Monitoring of adult striped bass in the Sacramento-San Joaquin River Delta and the lower portions of the Sacramento and San Joaquin rivers occurred in 11 of the years between 1992 and 2007. In the eight years during this period when bass abundance estimates are considered to be final and not subject to revision, the AFRP production target for this species was never met. In the three years (2004, 2005, and 2007) when the abundance estimates are considered to be provisional, it is unlikely that future revisions will result in the attainment of the AFRP production target because any revisions are likely to be minor and the provisional estimates are markedly below the AFRP 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."

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. These 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" above the Red Bluff Diversion Dam, Mokelumne River, Paynes Creek, Sacramento River mainstem, Stanislaus River, Tuolumne River, and Yuba River.

To address its mandate, the CAMP attempts to produce 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 eighth CAMP annual report prepared since 1992. Each of the CAMP annual reports is available on the CAMP website at:
http://www.fws.gov/sacramento/CAMP/camp_documents_and_projects.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 2009.

1.2 PRODUCTION TARGETS FOR ANADROMOUS FISH

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.

The Chinook salmon baseline production estimates provided in the 2007 and 2008 CAMP annual reports (USFWS 2007, 2008) reported rounded values provided on page 3-Xa-2 of Volume 3 of the AFRP's *Working Paper on Restoration Needs* (USFWS 1995). In 2009, the CAMP (1) adopted Chinook salmon baseline production estimates that are unrounded (e.g., 80,874 vs. 81,000), and (2) limited its data syntheses to only reflect watersheds and runs where an AFRP production target was developed for the Final Restoration Plan (USFWS 2001). This change was made to ensure that the AFRP and CAMP can consistently track progress towards achieving the CVPIA anadromous fish doubling goals.

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*	80,874	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*	86,028	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	115,369	230,000
	Stanislaus River	10,868	22,000
	Tuolumne River	18,949	38,000
	Yuba River	33,267	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	374,064	750,000
Late-fall-run	Central Valley	34,192	68,000
Winter-run	Central Valley	54,439	110,000
Spring-run run	Central Valley	34,374	68,000
Central Valley-wide (all 4 salmon runs combined)	Central Valley	497,069	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

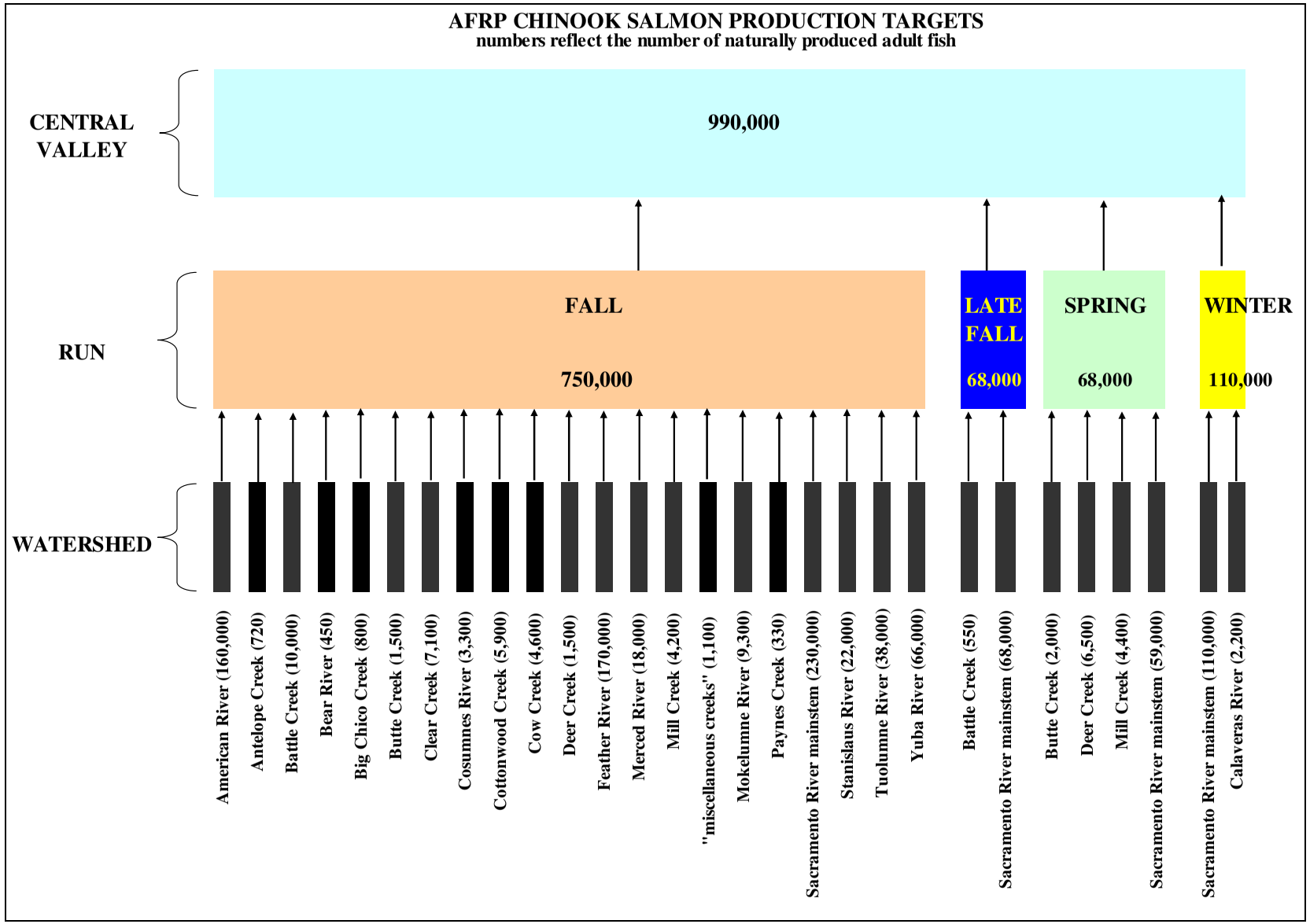
* = Hatchery in the tributary.

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 ≥ 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 taxa frequently differ in different iterations of the CAMP annual reports. These differences arise as the CDFG and AFRP staff 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 2009 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. Potential problems associated with not having definitive data on the ratio are more pronounced for fall-run Chinook salmon because large numbers of this run are produced and 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 of these runs are marked and recognizable in the field. The hatchery proportion issue for 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 Chinook salmon production in each watershed should include an estimate of the number of fish *harvested in each watershed*; i.e., in-river angler harvest. Because the amount of in-river angler harvest has not been monitored on a consistent basis, the production estimate for a watershed only includes a best professional judgment of the amount of in-river angler harvest and does not include an actual count of the number of angler-harvested salmon.

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. Rick Burmester (USFWS) provided the Chinookprod spreadsheet that tabulates values related to the production of Chinook salmon.

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

3. Marty Gingras (CDFG) provided spreadsheets that summarize data relative to the abundance of adult green and white sturgeon.

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

5. Marty Gingras (CDFG) provided abundance data for adult striped bass.

6. Cesar Blanco (USFWS), Dan Welsh (USFWS), Rick Burmester (USFWS), 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

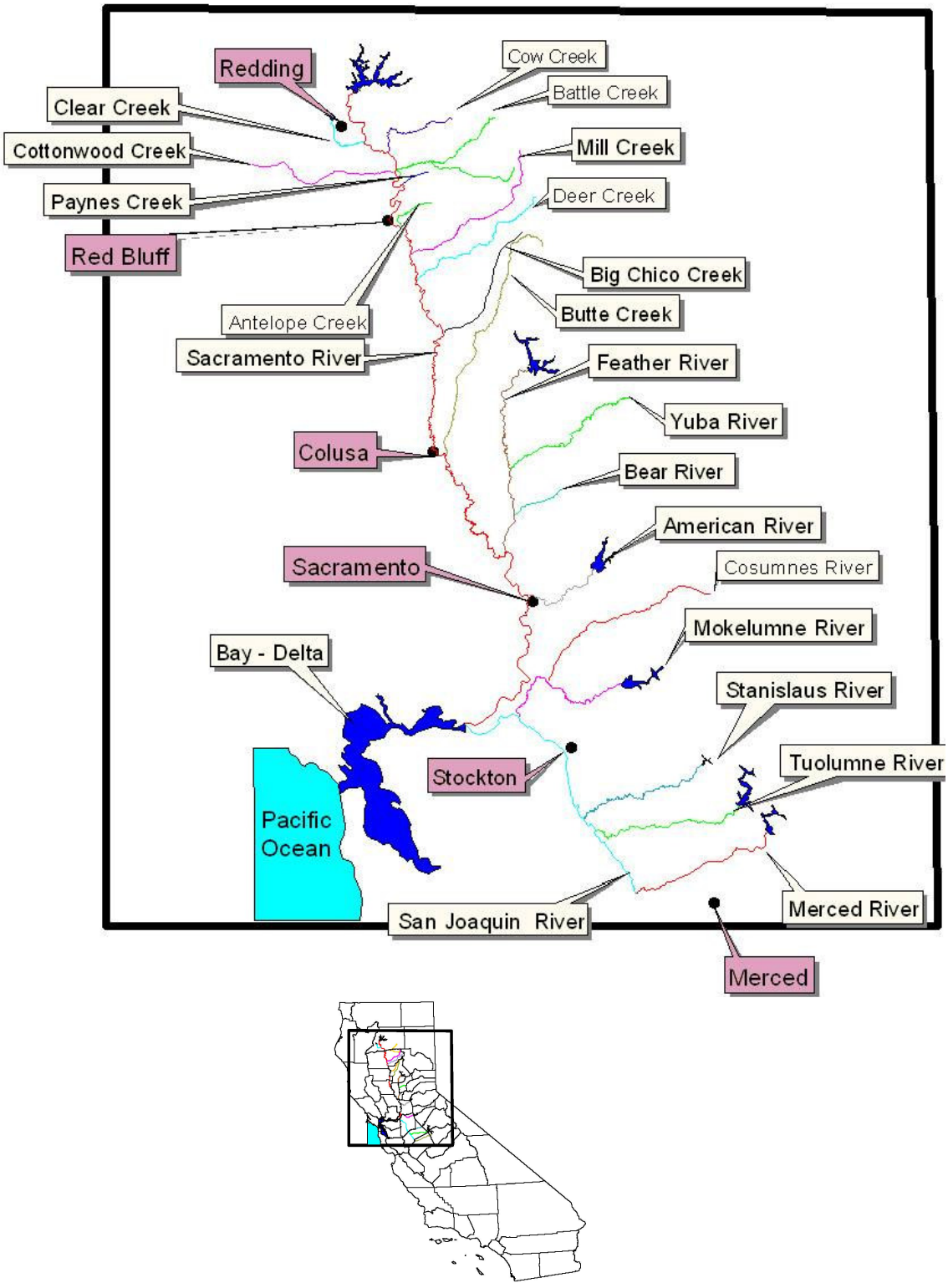
The watersheds and areas with an AFRP fish production target are depicted in Figure 2. Monitoring techniques used to assess the abundance of anadromous fish vary by taxa and are described in the 1997 CAMP Implementation Plan (Montgomery Watson et al. 1997). The techniques include, but are not limited 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 on a consistent basis. 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 Fisheries 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 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 "GrandTab030910.pdf" file prepared by CDFG staff; (2) a "Chinookprod_042210.xls" spreadsheet prepared by AFRP staff; the version of that spreadsheet used in this CAMP annual report included minor revisions that were incorporated into the Chinookprod spreadsheet as of November 4, 2010; and (3) commercial and recreational salmon harvest data summarized in the *Review of 2009 Ocean Salmon Fisheries* (PFMC 2010).

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;

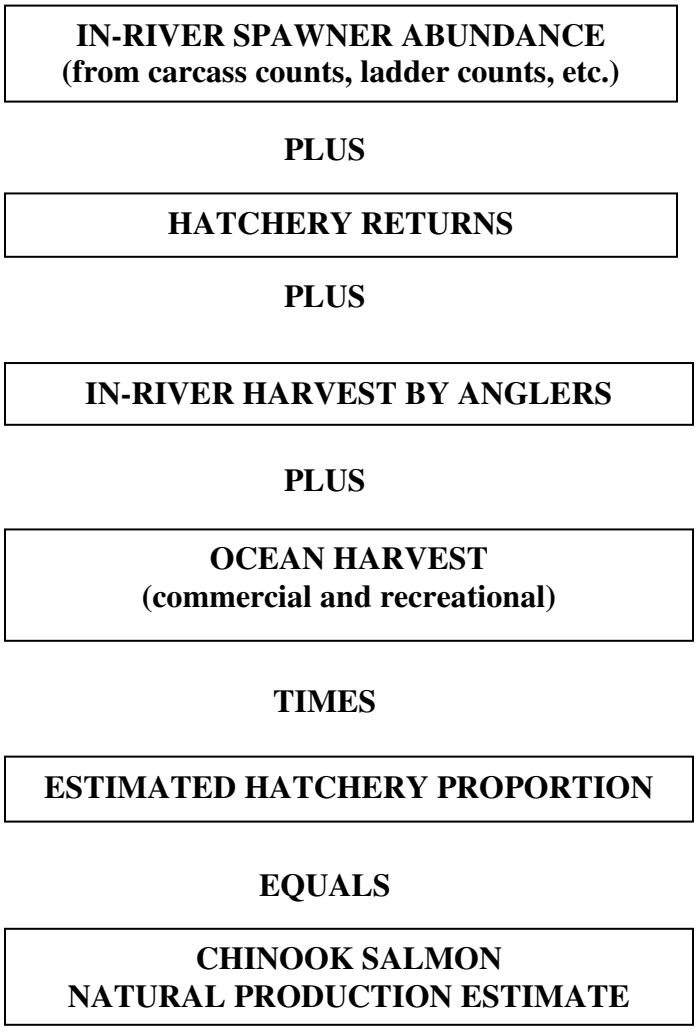
2. Determining the percent change in the average natural production of adult Chinook salmon in the 22 aforementioned watersheds between the 1967-1991 and 1992-2009 time periods; and

3. Using a Mann Whitney U test to determine if there was a statistically significant (α = 0.05) difference in the average natural production of adult Chinook salmon for each run and watershed between the 1967-1991 and 1992-2009 time periods. As such, this test was used to evaluate the following null hypothesis:

   H_0: the average natural production of different Chinook salmon runs in different watersheds are the same in the 1967-1991 and 1992-2009 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.

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



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.

The 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 the annual production estimates of white sturgeon ≥ 40 inches in total length by the corresponding estimated fraction of the population believed to be 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; and (2) a "WSTALKEY.xls" file dated December 22, 2006. 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; and (2) a "qry_Length_GST_ALL.xls" file dated June 1, 2007. At the time this report was prepared, the CDFG had not released sturgeon data that were collected after 2005.

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 and 2010 CAMP annual reports, a length frequency correction factor was used to calculate the number of fish in the YOY age class 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: (1) a "FMWT AMS Indices 1967-2009.xls" spreadsheet dated October 1, 2010; and (2) an "AMS Length Frequency 1971-2009.xls" spreadsheet dated October 1, 2010.

2.4.3 METHODS FOR ADULT STRIPED BASS

The CDFG monitors abundance of "legal-size" adult striped bass in the Sacramento-San Joaquin River Delta, the portion of the Sacramento River downstream from the town of Colusa, and the portion of the San Joaquin River downstream from the town of Mossdale. 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 fyke traps to collect striped bass from early April to 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 fish are collected they are 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 is used to estimate production of adult striped bass using the mark-recapture data.

A "DRAFT_ASB_ABUNDACEUPDATES.xls" spreadsheet provides the production estimates for striped bass in this report. This spreadsheet was provided to the CAMP by Jason DuBois of the CDFG on September 21, 2009.

SECTION 3: RESULTS

3.1 PRODUCTION ESTIMATES FOR ADULT CHINOOK SALMON

Because adult Chinook salmon data collected in 2008 and 2009 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 occurs in the American River watershed. It produces fall-run Chinook salmon.

Estimates of natural production of adult fall-run Chinook salmon from the American River between 1992 and 2009 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 2009.

3.1.1.2 ANTELOPE CREEK

Estimates of natural production of adult fall-run Chinook salmon from Antelope Creek between 1992 and 2009 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 2009. 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 occurs within the Battle Creek watershed. 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 2009 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 2009.

Table 3. Estimated natural production of adult fall-, late-fall-, winter-, and spring-run Chinook salmon from 22 watersheds in the Central Valley, 1992-2009. Blank cells represent years when data were not collected for a particular run and location. * indicates a fish hatchery is present in the watershed.

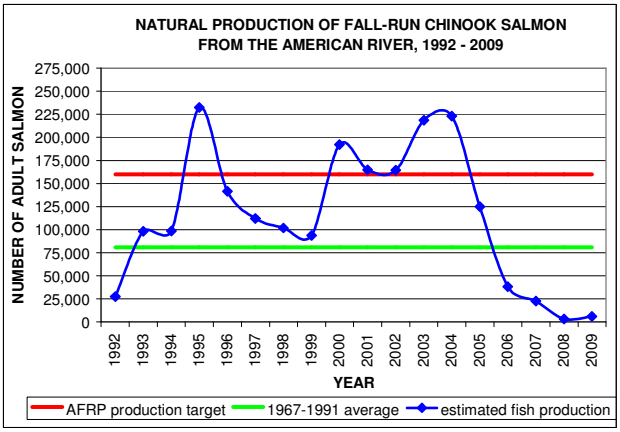
	YEAR																	
Taxa	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Fall-run Chinook salmon																		
American River*	27,409	98,338	98,403	232,428	141,661	112,158	101,832	93,791	192,033	164,683	164,381	218,446	223,073	124,868	38,305	22,572	3,419	6,052
Antelope Creek	0																	
Battle Creek*	3,562	5,554	12,768	31,703	17,028	27,219	20,335	21,842	16,278	17,733	71,785	23,656	20,885	30,302	11,256	4,212	1,494	920
Bear River																		
Big Chico Creek																		
Butte Creek				1,347	931	1,736	822			5,020	4,532	4,310	4,500	6,312	2,238	1,909	220	245
Clear Creek	1,342	2,961	6,014	28,317	10,950	18,408	7,040	11,659	11,602	12,305	19,938	11,715	11,416	22,030	9,807	6,425	6,142	2,582
Cosumnes River							622	410	1,021		2,113	194	2,732	692	771	146	15	0
Cottonwood Creek	3,561															1,944	408	844
Cow Creek															4,810	3,181	382	209
Deer Creek		161	722			2,229	564						545	1,418	2,216	789	155	46
Feather River*	77,116	92,903	110,522	193,244	108,535	121,805	34,706	19,870	193,700	192,346	131,767	114,959	117,069	86,975	85,246	34,640	6,613	8,876
Merced River*	2,379	4,287	9,092	9,566	8,818	8,410	7,259	7,472	24,347	13,177	14,263	4,087	8,323	3,721	2,029	959	419	544
Mill Creek	2,247	4,704	2,568			1,018	905				3,236	2,991	2,132	3,590	1,632	1,238	133	82
"miscellaneous creeks"																221	15	5
Mokelumne River*	2,771	5,643	5,587	12,594	11,004	16,374	8,950	5,822	9,668	6,824	10,012	9,505	16,094	17,792	5,128	1,773	247	1,337
Paynes Creek																		
Sacramento River mainstem	54,192	82,735	103,648	146,174	116,742	192,111	7,834	176,168	125,737	63,810	61,095	82,776	58,734	63,513	48,450	19,913	14,855	3,806
Stanislaus River	675	1,911	2,924	2,242	365	14,290	6,082	7,547	17,557	9,504	11,527	8,724	8,627	2,532	2,671	823	1,392	595
Tuolumne River	363	1,342	1,430	3,057	9,630	18,303	17,586	14,319	37,006	11,865	10,631	3,193	4,239	1,290	866	418	372	124
Yuba River	17,829	19,979	32,148	54,259	64,573	69,636	64,307	44,124	32,504	33,094	37,303	43,783	34,290	32,728	11,982	5,063	3,508	4,635
Total	193,447	320,517	385,827	714,930	490,236	603,698	278,843	403,023	661,453	530,360	542,583	528,336	512,657	397,764	227,407	106,225	39,789	30,901

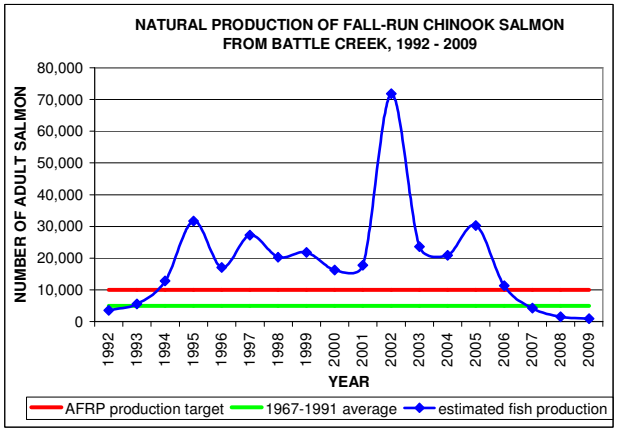
Table 3 (cont.). Estimated natural production of adult fall-, late-fall-, winter-, and spring-run Chinook salmon from 22 watersheds in the Central Valley, 1992-2009. Blank cells represent years when data were not collected for a particular run and location. * indicates a fish hatchery is present in the watershed.

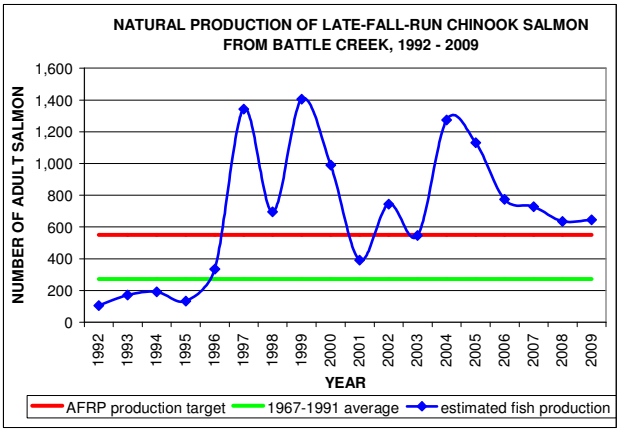
	YEAR																	
Taxa	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Late-fall run Chinook salmon																		
Battle Creek*	105	171	191	134	336	1,344	695	1,406	990	392	744	547	1,275	1,131	774	729	635	646
Sacramento River mainstem	27,471	2,198	855	630	111		81,496	15,838	19,231	27,326	56,157	8,514	19,850	19,707	14,843	30,060	4,181	3,704
Total	27,576	2,369	1,047	764	447	1,344	82,190	17,243	20,221	27,717	56,901	9,060	21,125	20,838	15,617	30,789	4,816	4,350
Winter-run Chinook salmon																		
Calaveras River																0	0	0
Sacramento River mainstem*	3,144	1,024	505	4,182	2,112	2,010	5,613	5,439	2,659	9,791	9,215	10,882	14,763	21,572	19,734	4,164	2,555	4,178
Total	3,144	1,024	505	4,182	2,112	2,010	5,613	5,439	2,659	9,791	9,215	10,882	14,763	21,572	19,734	4,164	2,555	4,178
Spring-run Chinook salmon																		
Butte Creek	2,051	1,935	1,396	28,556	3,261	1,702	41,894	6,695	8,943	13,592	13,607	6,799	16,599	19,742	6,663	9,615	3,935	2,059
Deer Creek	587	771	1,428	4,931	1,417	1,249	3,885	2,895	1,383	2,295	3,384	4,265	1,806	4,160	3,539	1,253	140	213
Mill Creek	666	182	2,128	1,218	584	541	876	1,019	1,181	1,557	2,469	2,204	2,242	2,137	1,458	1,789	362	220
Sacramento River mainstem	1,137	1,270	2,768	1,769	952	374	2,516	520	168	1,136	462	0	966	60	0	526	52	0
Total	4,440	4,157	7,720	36,474	6,213	3,866	49,172	11,130	11,676	18,581	19,922	13,269	21,613	26,099	11,659	13,183	4,489	2,492
Total Natural Production of Adult Chinook Salmon	228,607	328,067	395,099	756,350	499,007	610,917	415,818	436,835	696,008	586,449	628,620	561,548	570,159	466,272	274,418	154,360	51,649	41,921

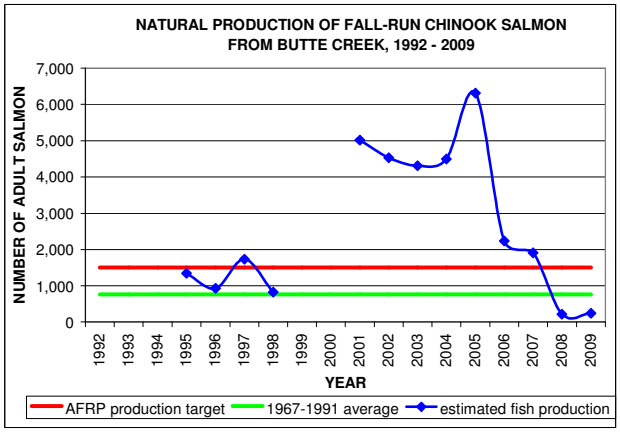
blank cells represent periods when data were not collected for a particular run and location

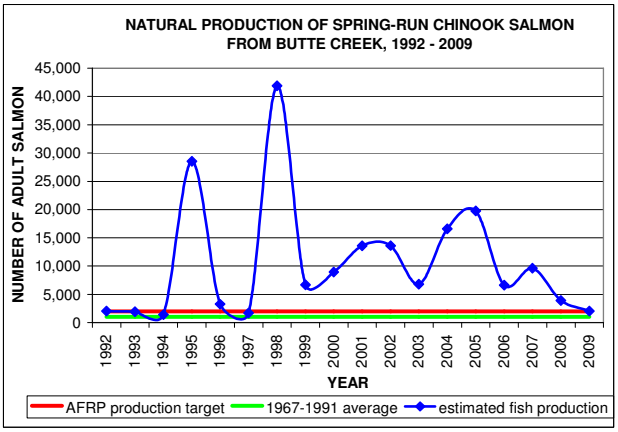
Figure 4. Estimated natural production of adult Chinook salmon from the American River, Battle Creek, Butte Creek, and Calaveras River, 1992-2009. Each graph provides the watershed's AFRP production target, estimated annual natural production of Chinook salmon between 1992 and 2009, and average natural production of Chinook salmon between 1967 and 1991.

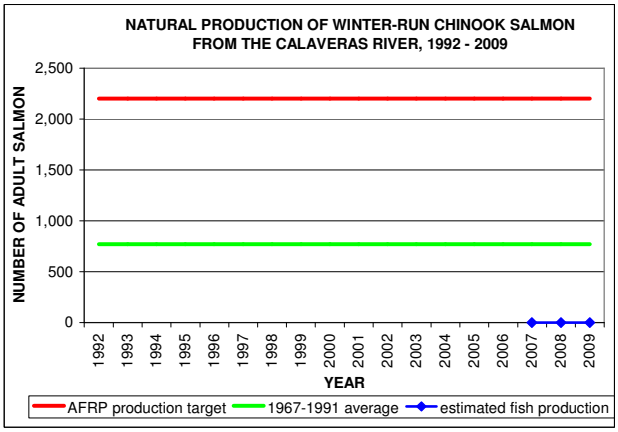












Estimates of natural production of adult late-fall-run Chinook salmon from Battle Creek during the period 1992-2009 are presented in Table 3 and Figure 4. The AFRP production target for adult late-fall-run Chinook salmon from Battle Creek is 550 salmon. Estimated natural production of this run of Chinook salmon from this watershed may have exceeded the AFRP production target 11 times between 1992 and 2009.

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 1998 and 2009 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 2009. 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 2009. 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 2009 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 13 years when monitoring data were collected between 1992 and 2009.

Estimates of natural production of adult spring-run Chinook salmon from Butte Creek between 1992 and 2009 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 15 times between 1992 and 2009.

3.1.1.7 CALAVERAS RIVER

Estimates of natural production of adult winter-run Chinook salmon from Calaveras River between 1992 and 2009 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, and 2009. 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 three 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 2009 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 11 times between 1992 and 2009.

3.1.1.9 COSUMNES RIVER

Estimates of natural production of adult fall-run Chinook salmon from Cosumnes River between 1992 and 2009 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 11 years of the 18 years since 1991. The production target was not met in any of those 11 years when Chinook salmon surveys were conducted on the Cosumnes River since 1991.

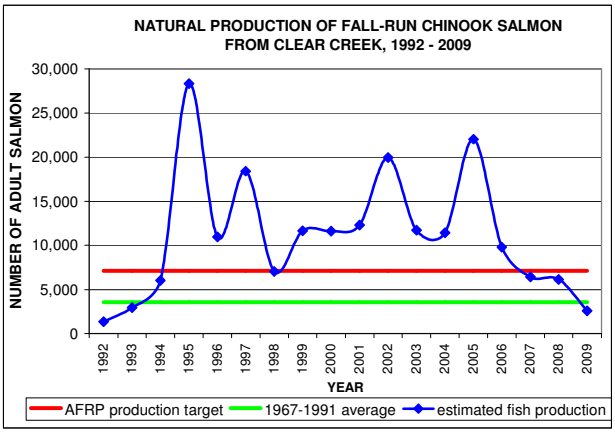
3.1.1.10 COTTONWOOD CREEK

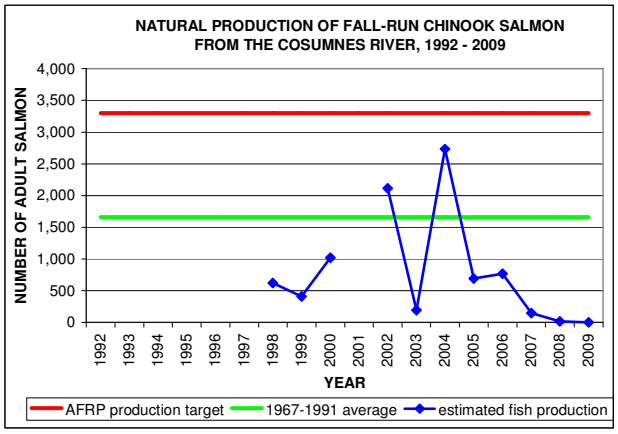
Estimates of natural production of adult fall-run Chinook salmon from Cottonwood Creek between 1992 and 2009 are presented in Table 3 and Figure 5. The AFRP production target for fall-run Chinook salmon from Cottonwood Creek is 5,900 salmon. Monitoring data for Chinook salmon from Cottonwood Creek have only been collected four times since 1991. The production target was not met in any of the four years when monitoring data were collected since 1991.

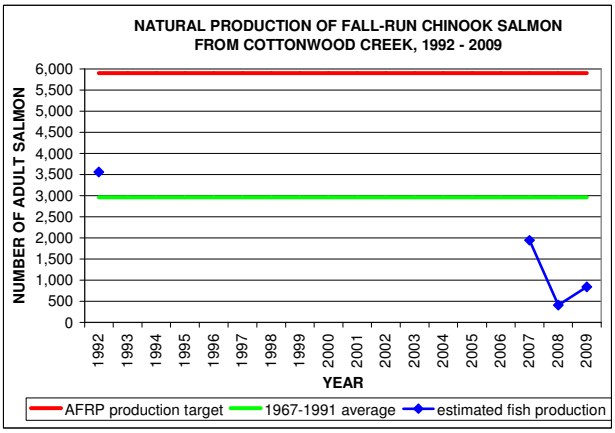
3.1.1.11 COW CREEK

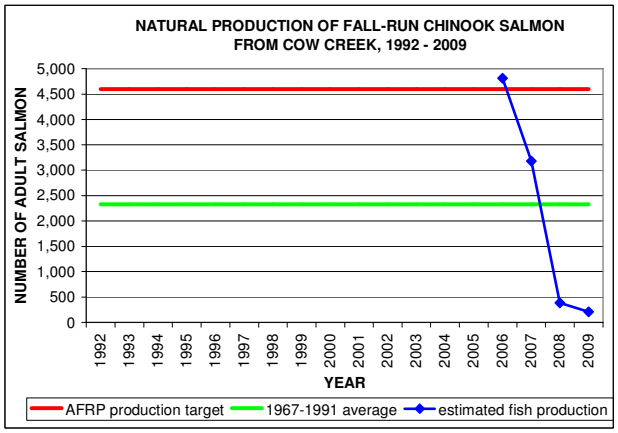
Estimates of natural production of adult fall-run Chinook salmon from Cow Creek between 1992 and 2009 are presented in Table 3 and Figure 5. The AFRP production target for fall-run Chinook salmon from Cow Creek is 4,600 salmon. Monitoring data for Chinook salmon from Cow Creek have only been collected four times since 1991. The AFRP production target was met in one of the four years when monitoring data were collected since 1991.

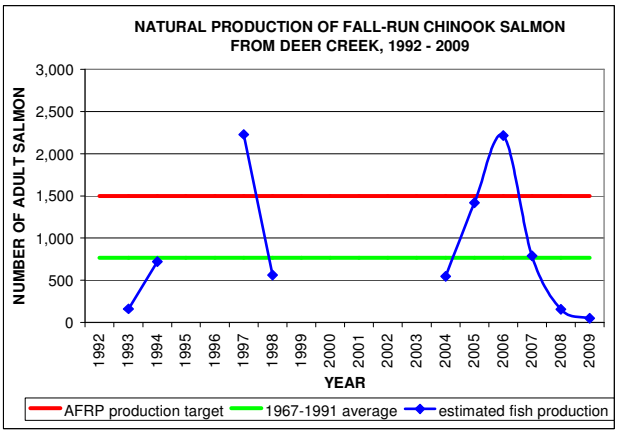
Figure 5. Estimated natural production of adult Chinook salmon from Clear Creek, Cosumnes River, Cottonwood Creek, Cow Creek, and Deer Creek, 1992-2009. Each graph provides the watershed's AFRP production target, estimated annual natural production of Chinook salmon between 1992 and 2009, and average natural production of Chinook salmon between 1967 and 1991.

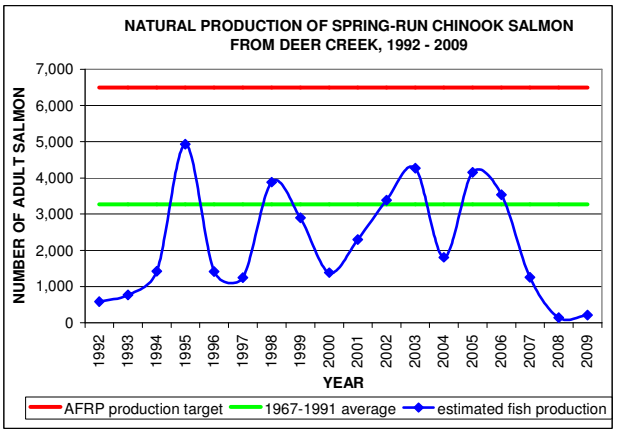












3.1.1.12 DEER CREEK

Estimates of natural production of adult fall-run Chinook salmon from Deer Creek between 1992 and 2009 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 10 years when monitoring data were collected between 1992 and 2009.

Estimates of natural production of adult spring-run Chinook salmon from Deer Creek between 1992 and 2009 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 2009.

3.1.1.13 FEATHER RIVER

The Feather River Fish Hatchery is located in the Feather River watershed. 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 2009 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 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 2009, i.e., in 1995, 2000, and 2001.

3.1.1.14 MERCED RIVER

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

Estimates of natural production of adult fall-run Chinook salmon from the Merced River between 1992 and 2009 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 2009.

3.1.1.15 MILL CREEK

Estimates of natural production of adult fall-run Chinook salmon from Mill Creek between 1992 and 2009 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 13 years when monitoring data were collected since 1991.

Estimates of natural production of adult spring-run Chinook salmon from Mill Creek between 1992 and 2009 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 2009.

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.

Estimates of the natural production of adult fall-run Chinook salmon from the one Miscellaneous Creek where monitoring took place between 1992 and 2009, 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 2009. 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 2009 did not exceed the AFRP Miscellaneous Creek production target in any of the three years when monitoring data were collected.

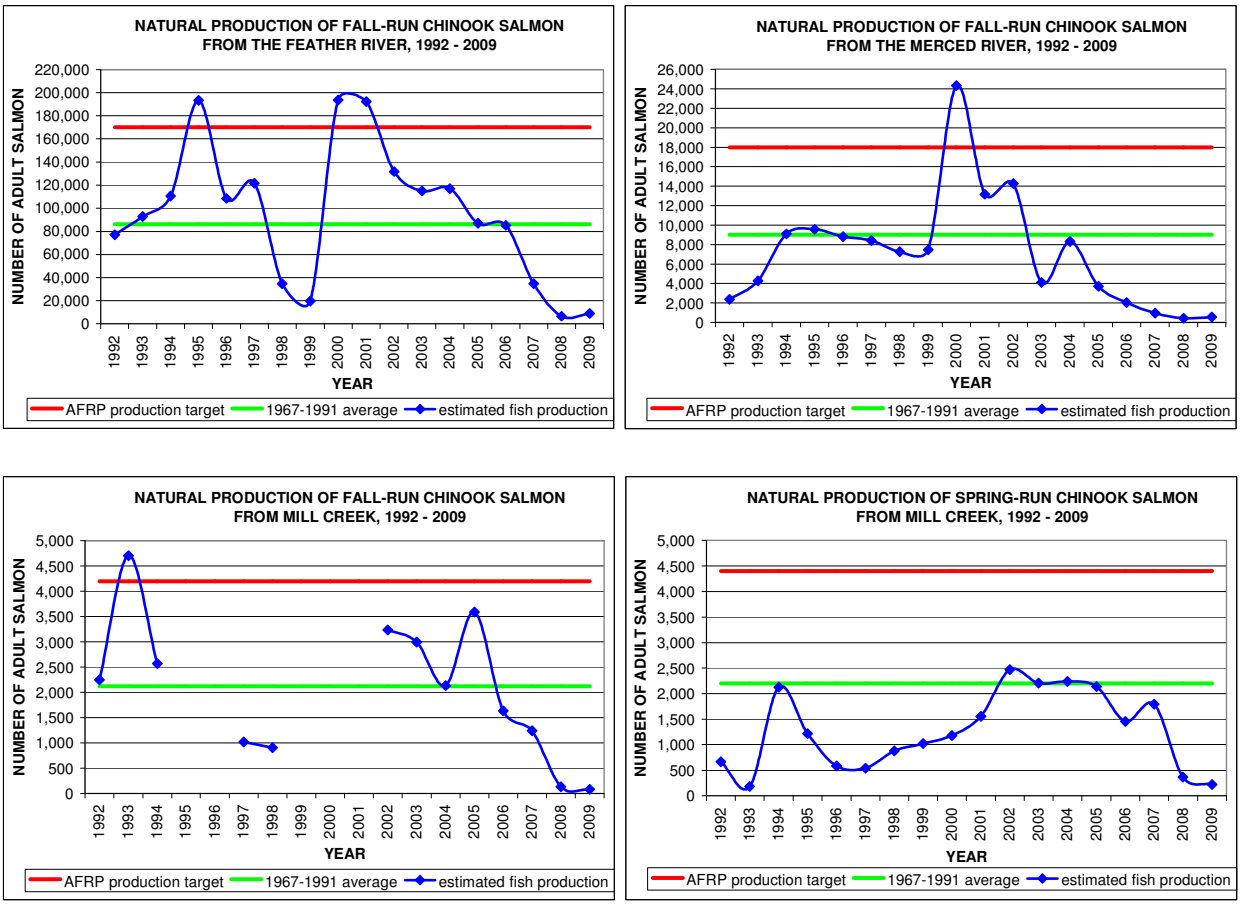
3.1.1.17 MOKELUMNE RIVER

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

Estimates of natural production of adult fall-run Chinook salmon from the Mokelumne River between 1992 and 2009 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 eight times between 1992 and 2009.

Figure 6. Estimated natural production of adult Chinook salmon from the Feather River, Merced River, and Mill Creek, 1992-2009. Each graph provides the watershed's AFRP production target, estimated annual natural production of Chinook salmon between 1992 and 2009, 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 2009. 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 2009 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 2009.

Estimates of natural production of adult late-fall-run Chinook salmon between 1992 and 2009 are presented in Table 3 and Figure 7. 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 between 1992 and 2009.

Estimates of natural production of adult winter-run Chinook salmon from the Sacramento River mainstem between 1992 and 2009 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 2009.

Estimates of natural production of adult spring-run Chinook salmon from the Sacramento River mainstem between 1992 and 2009 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, and 2009 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 2009.

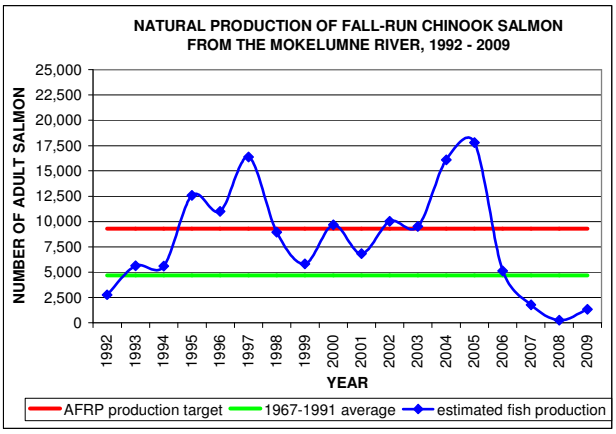
3.1.1.20 STANISLAUS RIVER

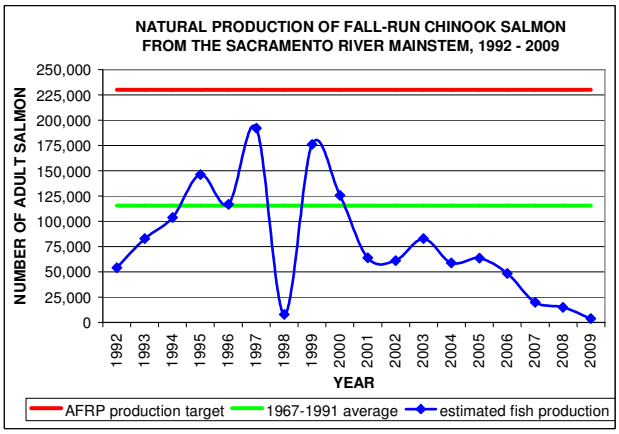
Estimates of natural production of adult fall-run Chinook salmon from the Stanislaus River between 1992 and 2009 are presented in Table 3 and Figure 7. The AFRP production target for fall-run Chinook salmon from the Stanislaus River is 22,000 salmon. The estimated natural production of adult fall-run Chinook salmon from this watershed never equaled or exceeded the AFRP production target between 1992 and 2009.

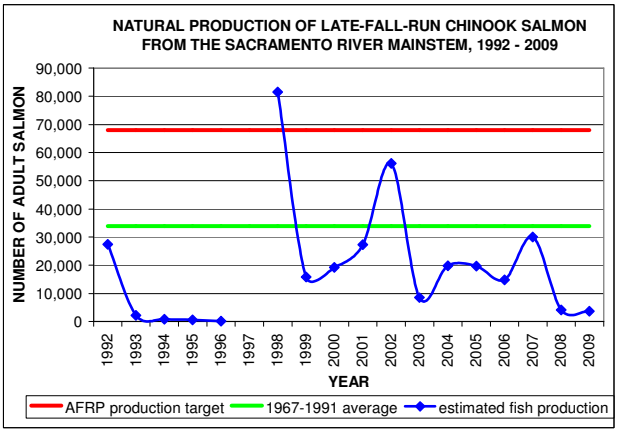
3.1.1.21 TUOLUMNE RIVER

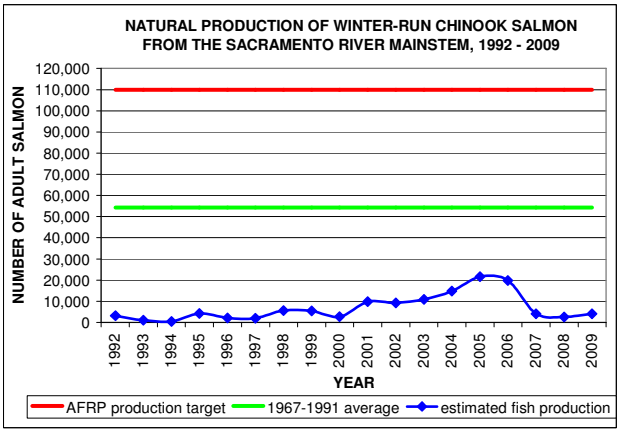
Estimates of natural production of adult fall-run Chinook salmon from the Tuolumne River between 1992 and 2009 are presented in Table 3 and Figure 8. The AFRP production target of fall-run Chinook salmon from the Tuolumne River is 38,000 salmon. Estimated natural production of adult fall-run Chinook salmon from this watershed never equaled or exceeded the AFRP production target between 1992 and 2009.

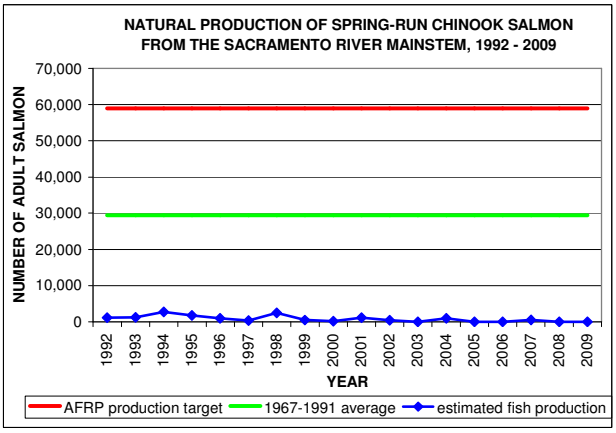
Figure 7. Estimated natural production of adult Chinook salmon from the Mokelumne River, Sacramento River, and Stanislaus River, 1992-2009. Each graph provides the watershed's AFRP production target, estimated annual natural production of Chinook salmon between 1992 and 2009, and average natural production of Chinook salmon between 1967 and 1991.

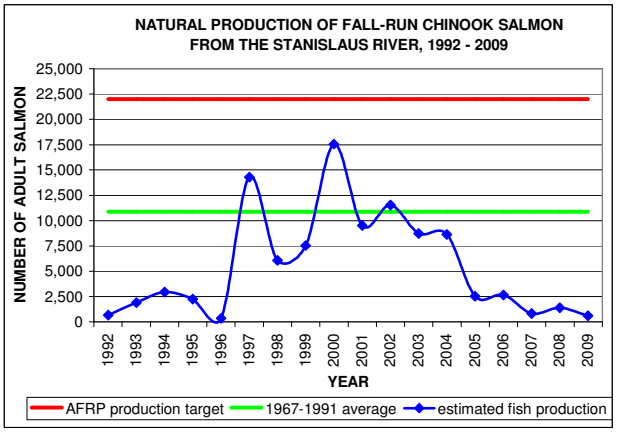








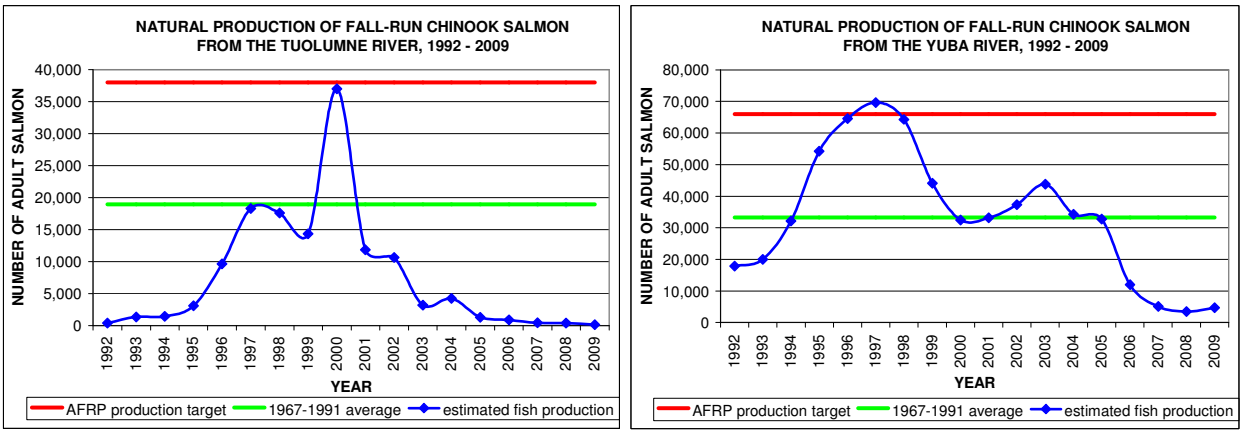




3.1.1.22 YUBA RIVER

Estimates of natural production of adult fall-run Chinook salmon from the Yuba River between 1992 and 2009 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 2009, i.e., in 1997.

Figure 8. Estimated natural production of adult Chinook salmon from the Tuolumne River and Yuba River, 1992-2009. Each graph provides the watershed's AFRP production target, estimated annual natural production of Chinook salmon between 1992 and 2009, 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.

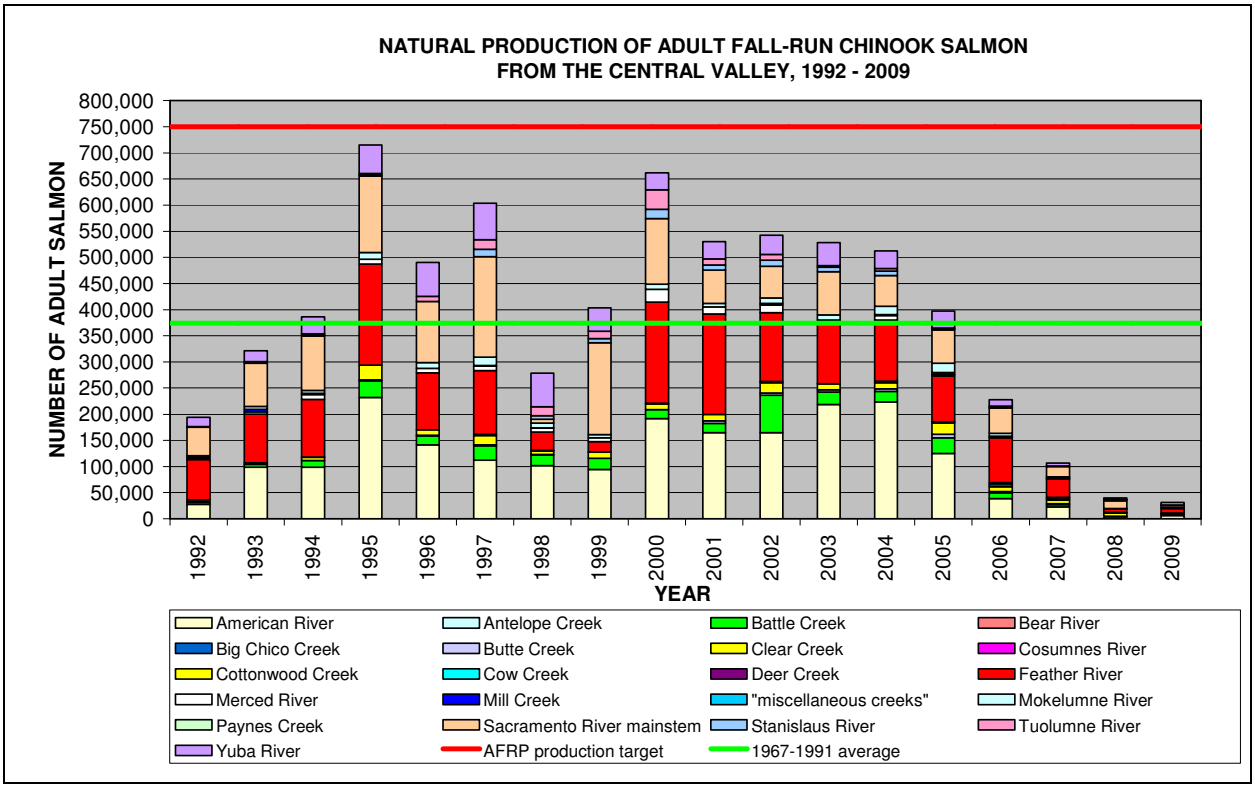
3.1.2.1 FALL-RUN CHINOOK SALMON

Estimates of the natural production of adult fall-run Chinook salmon from the Central Valley between 1992 and 2009 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 2009 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.

Between 1992 and 2009 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.

Figure 9. Estimated natural production of adult fall-run Chinook salmon from the Central Valley, 1992-2009. 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 374,064 Chinook salmon.

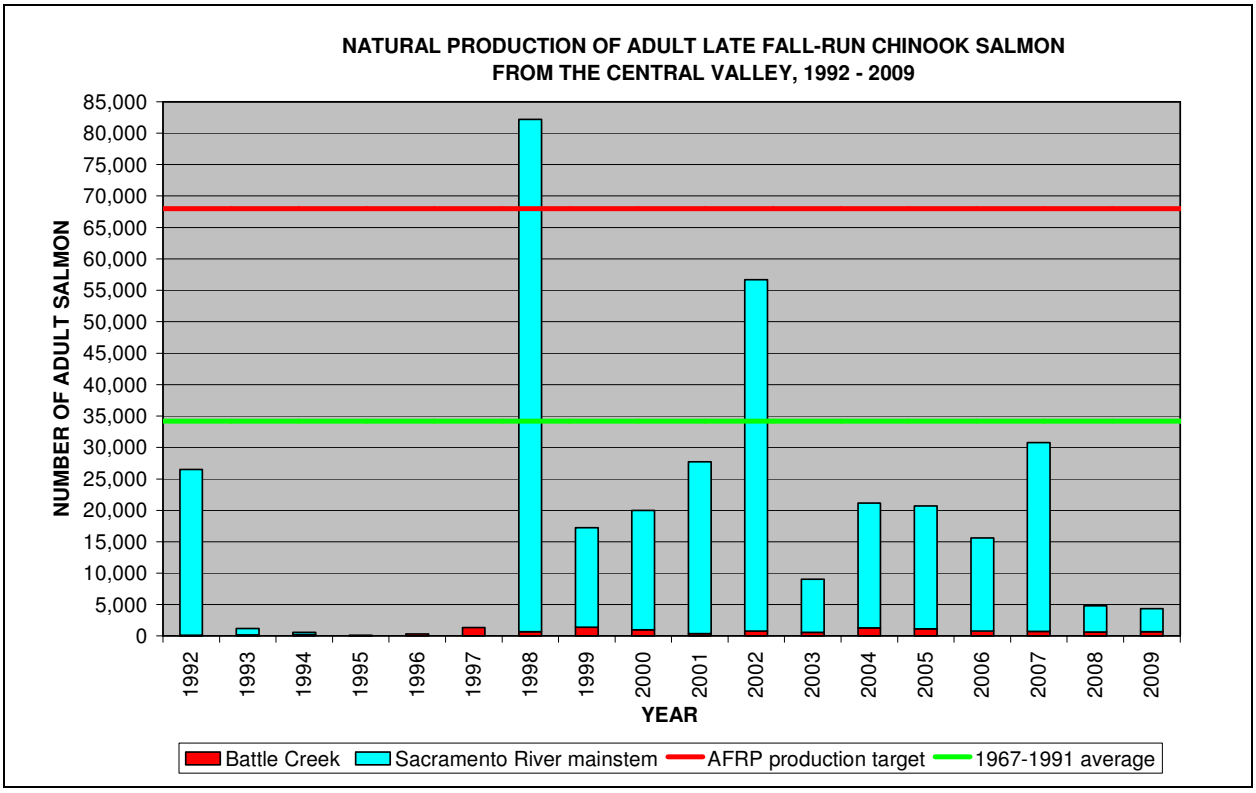


3.1.2.2 LATE-FALL-RUN CHINOOK SALMON

Estimates of the natural production of adult late-fall-run Chinook salmon from the Central Valley between 1992 and 2009 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 18-year period (i.e., in 1998).

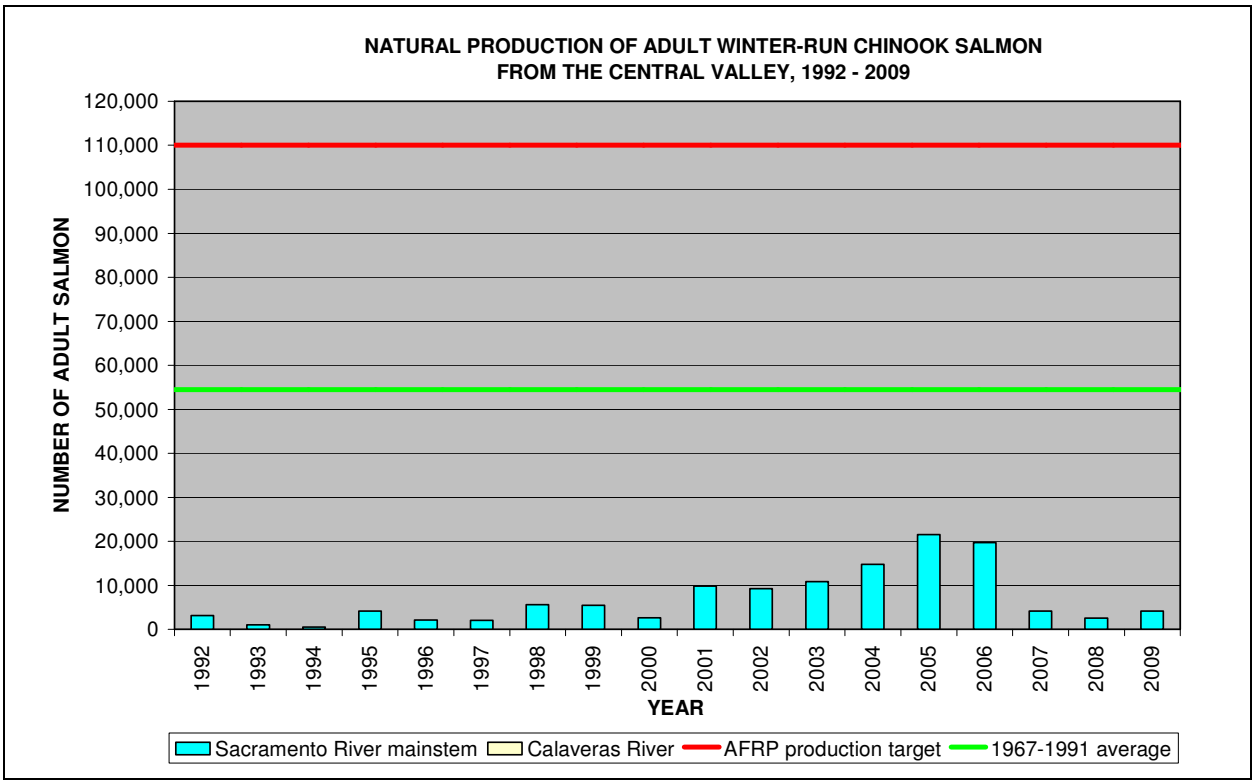
Figure 10. Estimated natural production of adult late-fall-run Chinook salmon from the Central Valley, 1992-2009. Annual estimates reflect the combined contributions from Battle Creek and the Sacramento River mainstem. The AFRP late-fall-run Chinook salmon production target is 68,000 Chinook salmon, 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 2009 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 three 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 2009 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, 1992-2009. 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.

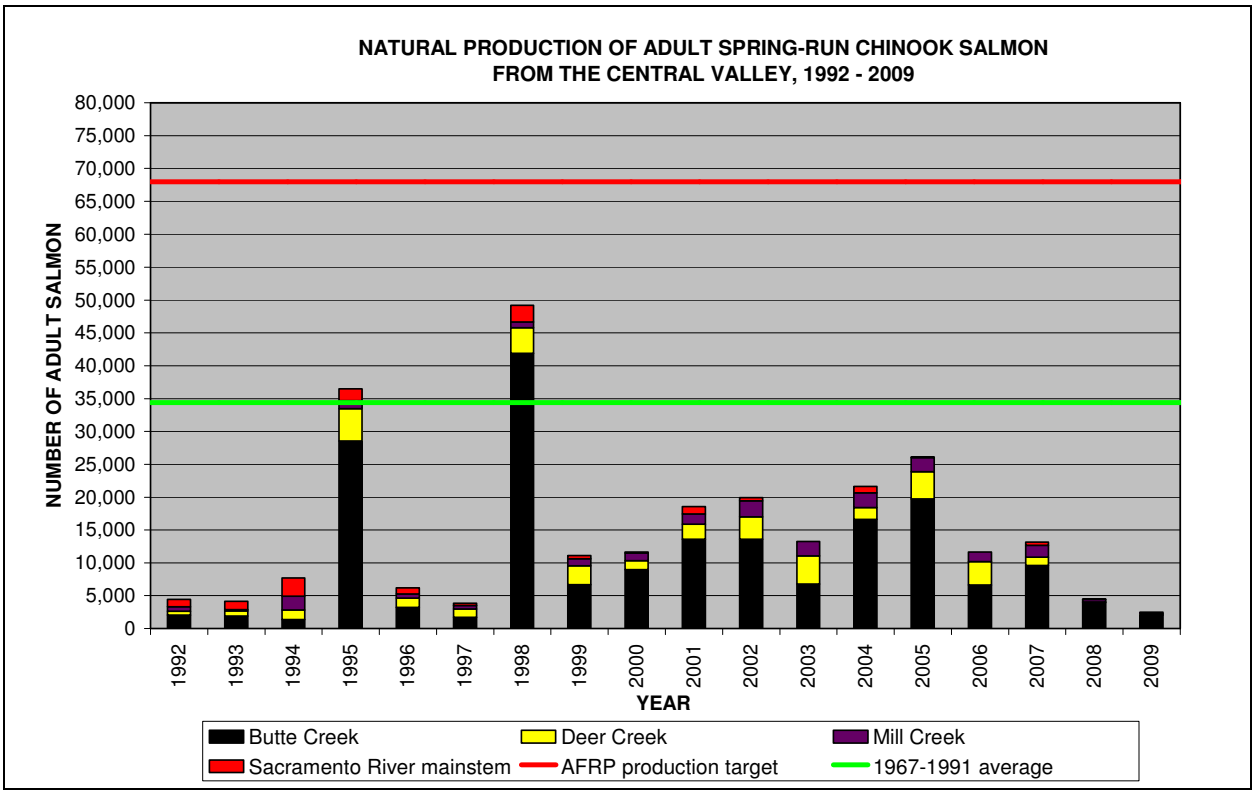


3.1.2.4 SPRING-RUN CHINOOK SALMON

Estimates of the natural production of adult spring-run Chinook salmon in the Central Valley between 1992 and 2009 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 2009 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 as the other three watersheds combined.

Figure 12. Estimated natural production of adult spring-run Chinook salmon from the Central Valley, 1992-2009. 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.

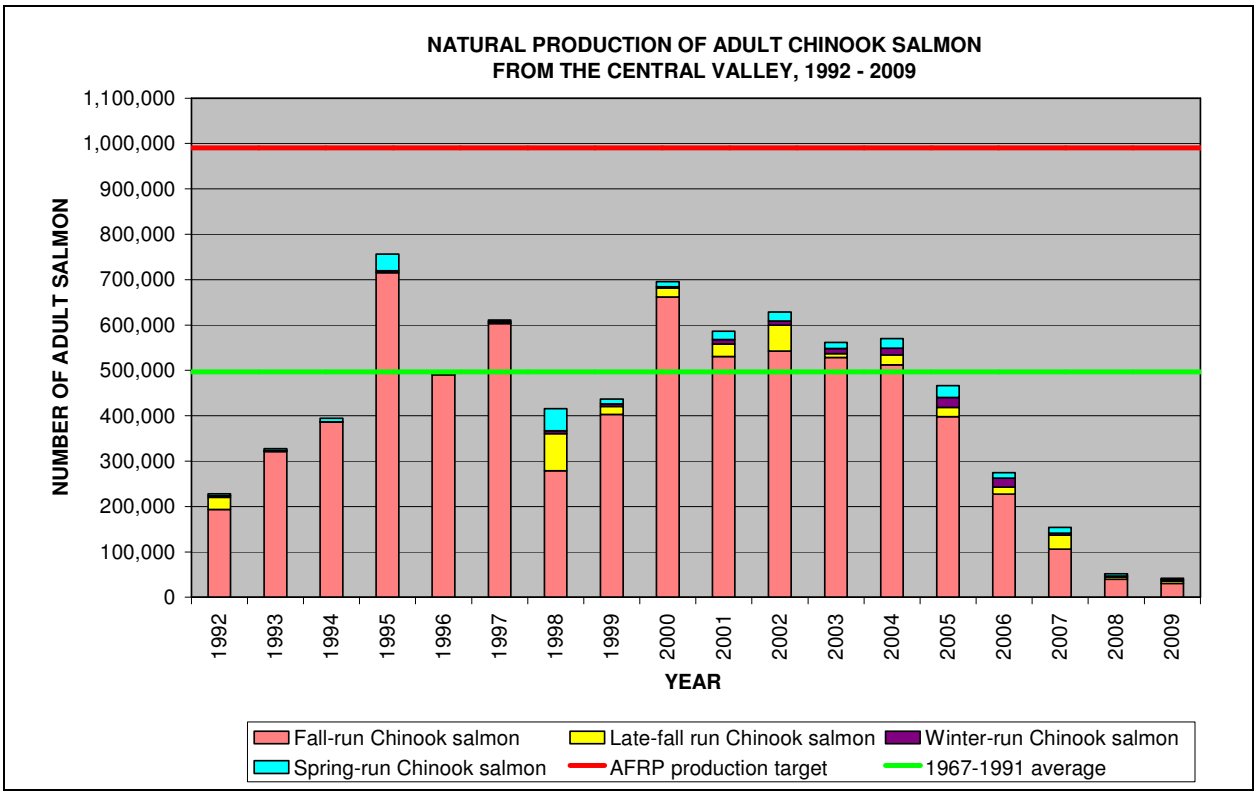


3.1.3 PRODUCTION ESTIMATES FOR THE CENTRAL VALLEY

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 2009 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 2009 suggest this production target was never met during that 18-year period.

During the 18-year period between 1992 and 2009, 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, 1992-2009. 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 497,069 Chinook salmon.



3.2 ADULT SALMON POPULATION ASSESSMENTS

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 18-year period between 1992 and 2009 suggest:

- No data collection efforts occurred during the 1992-2009 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 18-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 11 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 17 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, and 2009. 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 three 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 18-year period 1992-2009. 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 2009. * indicates a fish hatchery is present in the watershed.

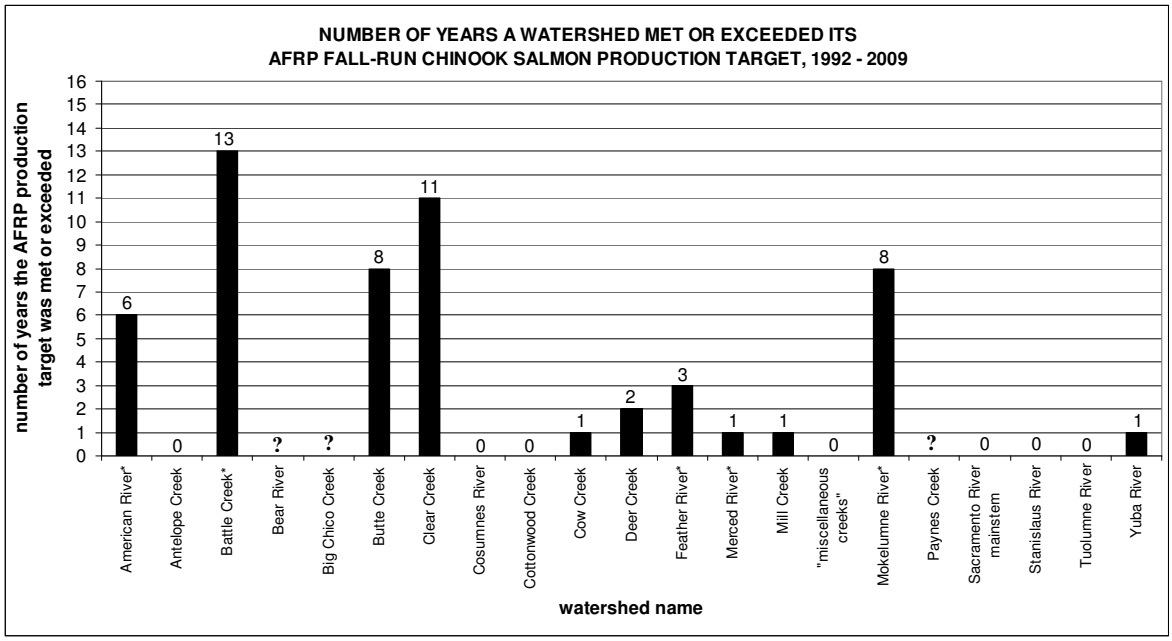


Figure 15. Number of times watershed-specific AFRP late-fall-run Chinook salmon production targets were met or exceeded during the 18-year period 1992-2009. Monitoring data for late-fall-run Chinook salmon from the Sacramento River mainstem were only collected in 17 of the 18 years since 1991. * indicates a fish hatchery is present in the watershed.

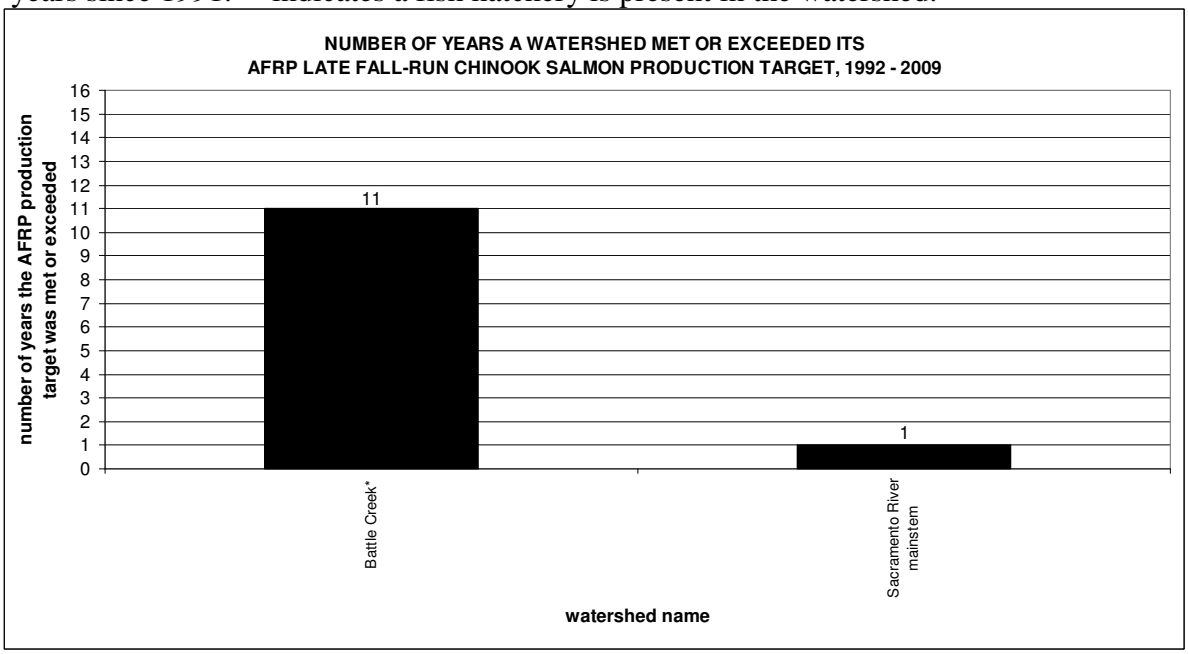


Figure 16. Number of times watershed-specific AFRP winter-run Chinook salmon production targets were met or exceeded during the 18-year period 1992-2009. Monitoring data from the Calaveras River were only collected during three years between 1992 and 2009. * indicates a fish hatchery is present in the watershed.

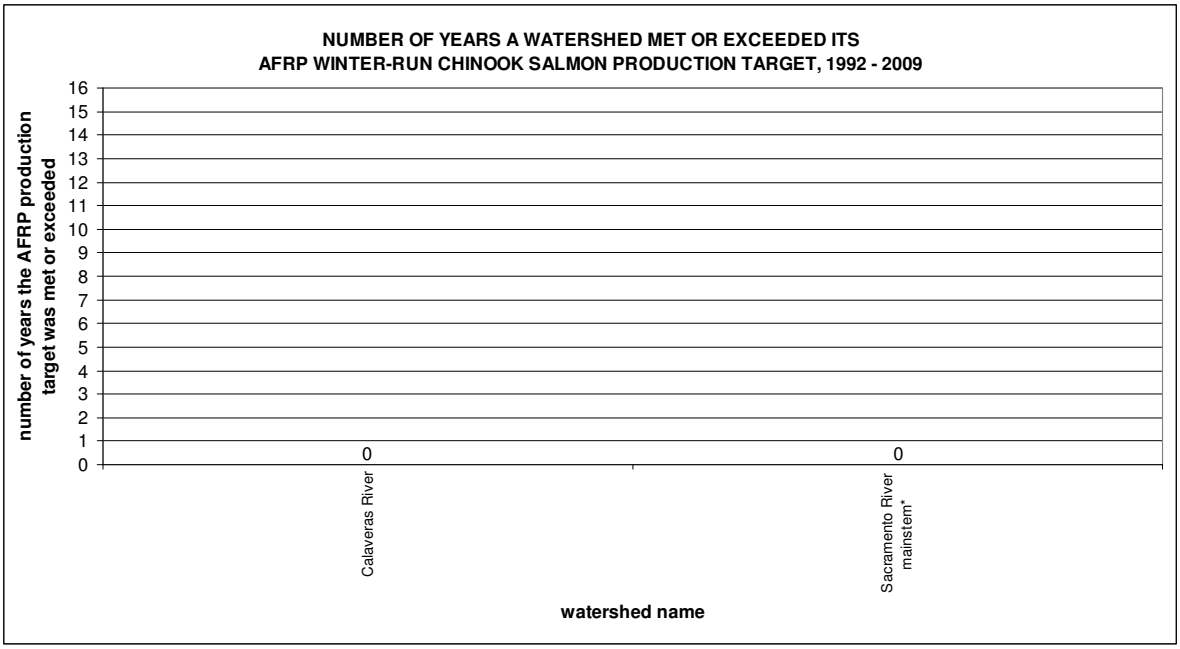
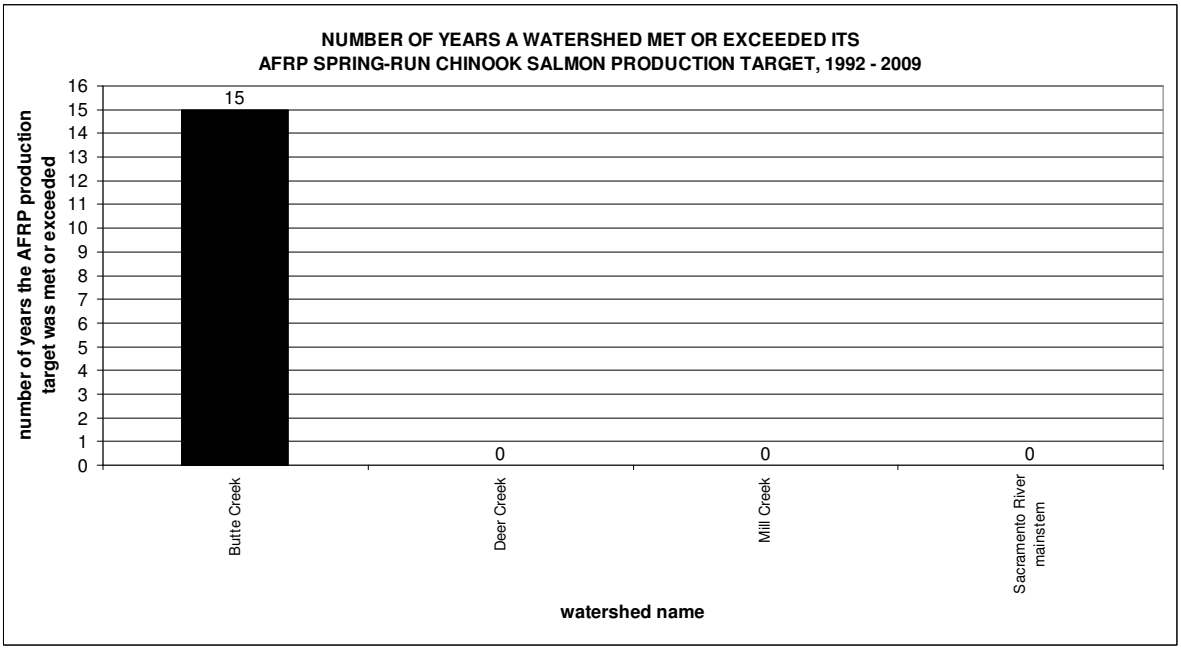


Figure 17. Number of times watershed-specific AFRP spring-run Chinook salmon production targets were met or exceeded during the 18-year period 1992-2009.



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 1992-2009 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, Mokelumne River, and Yuba 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, and Tuolumne River.

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

Winter-run Chinook salmon: Calaveras River, 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, 1967-2009. * Indicates a fish hatchery is present in the watershed. N = number of years monitoring data were collected during a time period. ** In this report, P values <0.05 are interpreted as being statistically significant.
??? = insufficient data to assess change in average production or a P value.

Watershed	Run	1967-1991		1992-2009		AFRP fish production target	Percent change in average production 1967-1991 vs. 1992-2009	P-value
		N	Average production	N	Average production			
American River*	Fall-run	25	80,874	18	114,658	160,000	+ 42%	0.115
Antelope Creek	Fall-run	19	361	1	0	720	???	???
Battle Creek*	Fall-run	25	5,013	18	18,807	10,000	+ 275%	0.000**
Battle Creek*	Late-fall-run	23	273	18	680	550	+ 149%	0.001**
Bear River	Fall-run	1	639	0	???	450	???	???
Big Chico Creek	Fall-run	3	402	0	???	800	???	???
Butte Creek	Fall-run	10	765	13	2,625	1,500	+ 243%	0.018**
Butte Creek	Spring-run	25	1,018	18	10,502	2,000	+ 932%	0.000**
Calaveras River	Winter-run	4	770	3	0	2,200	- 100%	???
Clear Creek	Fall-run	16	3,576	18	11,147	7,100	+ 212%	0.000**
Cosumnes River	Fall-run	17	1,660	11	792	3,300	- 52%	0.196
Cottonwood Creek	Fall-run	17	2,964	4	1,689	5,900	- 43%	???
Cow Creek	Fall-run	12	2,330	4	2,145	4,600	- 8%	???
Deer Creek	Fall-run	23	766	10	884	1,500	+ 15%	0.969

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, 1967-2009. * Indicates a fish hatchery is present in the watershed. N = number of years monitoring data were collected during a time period. ** In this report, P values <0.05 are interpreted as being statistically significant. ??? = insufficient data to assess change in average production or a P value.

Watershed	Run	1967-1991		1992-2009		AFRP fish production target	Percent change in average production 1967-1991 vs. 1992-2009	P-value
		N	Average production	N	Average production			
Deer Creek	Spring-run	18	3,276	18	2,200	6,500	- 33%	0.800
Feather River*	Fall-run	25	86,028	18	96,161	170,000	+ 12%	0.431
Merced River*	Fall-run	25	9,005	18	7,175	18,000	- 20%	0.844
Mill Creek	Fall-run	24	2,118	13	2,037	4,200	- 4%	0.525
Mill Creek	Spring-run	18	2,202	18	1,269	4,400	- 42%	0.184
Miscellaneous Creeks	Fall-run	20	549	3	80	1,100	- 85%	???
Mokelumne River*	Fall-run	25	4,680	18	8,174	9,300	+ 75%	0.021**
Paynes Creek	Fall-run	9	170	0	???	330	????	???
Sacramento River	Fall-run	25	115,369	18	79,016	230,000	- 32%	0.010**
Sacramento River	Late-fall-run	25	33,941	17	19,539	68,000	- 42%	0.011**
Sacramento River*	Winter-run	25	54,316	18	6863	110,000	- 87%	0.007**
Sacramento River	Spring-run	25	29,412	18	815	59,000	- 97%	0.000**
Stanislaus River	Fall-run	24	10,868	18	5,555	22,000	- 49%	0.402
Tuolumne River	Fall-run	25	18,949	18	7,557	38,000	- 60%	0.024**
Yuba River	Fall-run	25	33,267	18	33,652	66,000	+ 1%	0.730

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 1992-2009 time periods is presented in Table 5. During the latter period, fall-run Chinook salmon production increased by 3% but the increase was not statistically significant. In contrast, the production of late-fall-, winter, and spring-run Chinook salmon declined by 44, 87, and 57%, respectively, and each of these declines were statistically significant. The natural production of Chinook salmon across the Central Valley during the 1992-2009 time period in the 22 aforementioned Central Valley watersheds was 14% 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, 1967-2009. ** In this report, P values <0.05 are interpreted as being statistically significant.

Chinook salmon group	1967-1991 average production	1992-2009 average production	AFRP fish production target	Percent change in average production 1967-1991 vs. 1992-2009	P-value
Fall-run	374,064	387,111	750,000	+ 3%	0.588
Late-fall-run	34,192	19,134	68,000	- 44%	0.008**
Winter-run	54,439	6,863	110,000	- 87%	0.007**
Spring-run	34,374	14,786	68,000	- 57%	0.000**
Central Valley-wide	497,069	427,895	990,000	- 14%	0.431

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 1992-2009 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, Butte Creek, Clear Creek, and the Mokelumne River during the 1992-2009 time period than during the 1967-1991 time 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

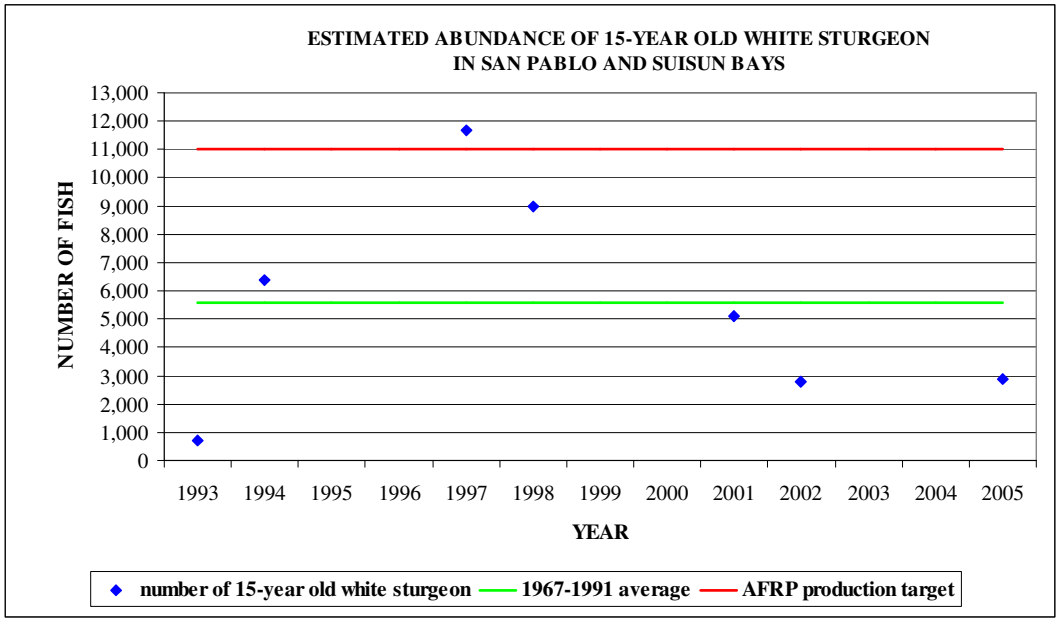
3.3.1 PRODUCTION OF ADULT WHITE AND GREEN STURGEON

Seven surveys were conducted for white sturgeon between 1992 and 2005 (i.e., 1993, 1994, 1997, 1998, 2001, 2002, and 2005). 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 1992-2005 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 seven years when sampling was done (Figure 18).

Table 6. Estimated abundance of white sturgeon in San Pablo Bay and Suisun Bay, 1993-2005.

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
1993	18,257	3.789	692
1994	144,672	4.418	6,392
1997	143,795	8.129	11,689
1998	98,717	9.088	8,971
2001	57,641	8.898	5,129
2002	32,283	8.595	2,775
2005	55,180	5.252	2,898

Figure 18. Estimated abundance of 15-year old white sturgeon in San Pablo Bay and Suisun Bay, 1993-2005.

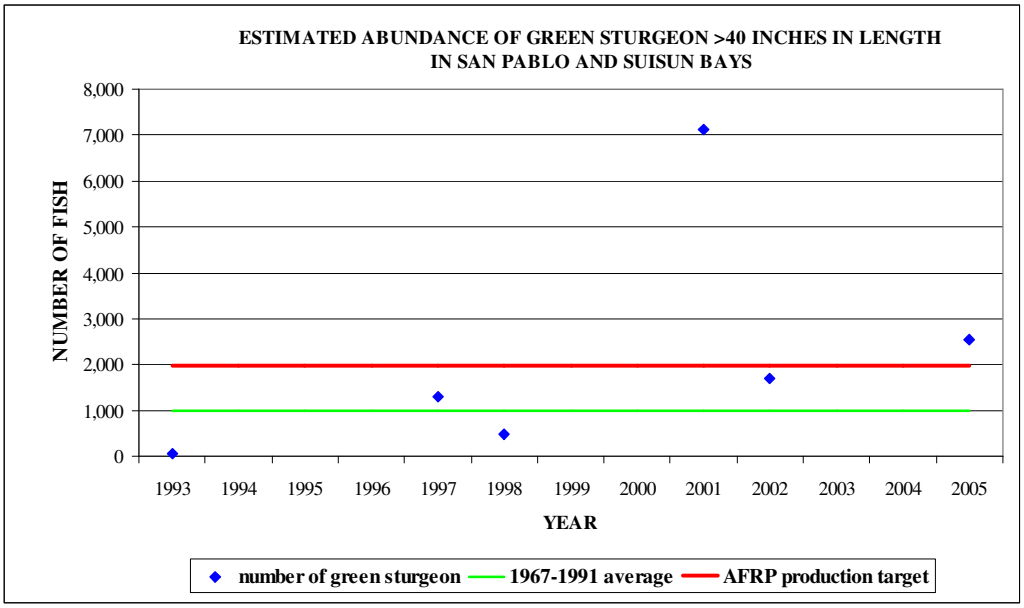


Six of the seven white sturgeon surveys can be used to develop abundance estimates for green sturgeon that were ≥ 40 inches in length in San Pablo and Suisun bays. These were conducted in 1993, 1997, 1998, 2001, 2002, and 2005. Because the CDFG did not capture green sturgeon during the sturgeon survey 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 1993 and 2005 ranged between 68 and 7,117 fish (Table 7). The AFRP production target for green sturgeon is 2,000 fish. During the 1992-2005 time period, the estimated abundance of green sturgeon ≥ 40 inches in length in San Pablo and Suisun bays exceeded the AFRP production target in two of the six years when abundance estimates could be calculated (Figure 19).

Table 7. Estimated abundance of green sturgeon in San Pablo Bay and Suisun Bay, 1993-2005.

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
1993	18,257	534	2	267.0:1	68
1994	144,672	593	0	---	---
1997	143,795	1,321	12	110.1:1	1,306
1998	98,717	1,469	7	209.9:1	470
2001	57,641	1,080	133	8.1:1	7,117
2002	32,283	478	25	19.1:1	1,690
2005	55,180	259	12	21.6:1	2,555

Figure 19. Estimated abundance of adult green sturgeon in San Pablo Bay and Suisun Bay, 1993-2005.



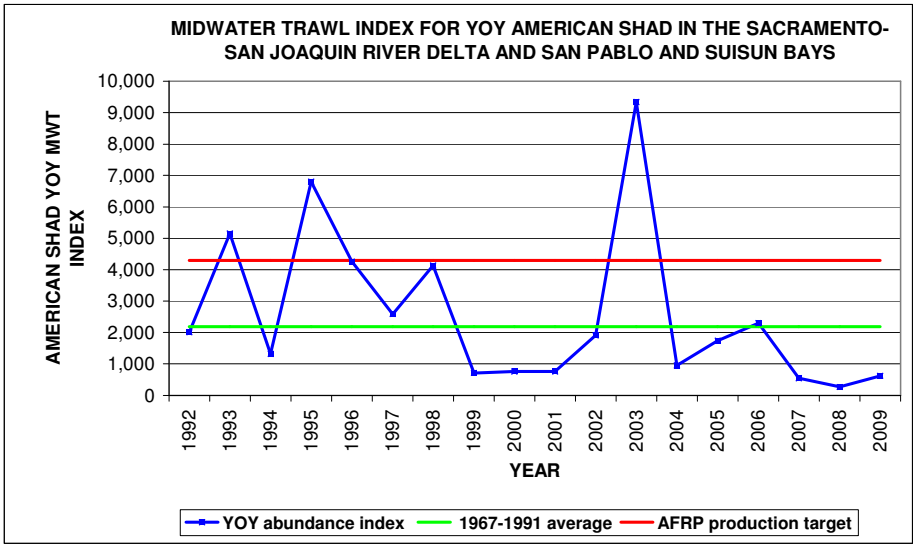
3.3.2 PRODUCTION OF JUVENILE AMERICAN SHAD

The midwater trawl index for YOY American shad in the Sacramento-San Joaquin River Delta and San Pablo and Suisun bays during the 1992-2009 time period ranged between 271 and 9,342 (Table 8). The AFRP production target for American shad is 4,300 fish. Between 1992 and 2009, the MWT YOY index exceeded the AFRP production target in 3 of 18 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, 1992-2009.

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	951
2005	1,741
2006	2,303
2007	551
2008	271
2009	624

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, 1992-2009.



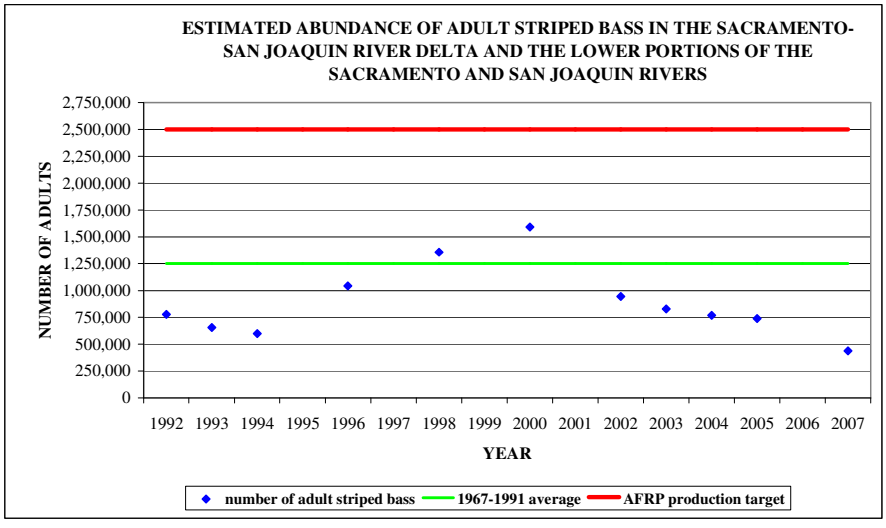
3.3.3 PRODUCTION OF ADULT STRIPED BASS

CDFG did not conduct surveys for adult striped bass in 1995, 1997, 1999, and 2001. The abundance of adult striped bass in 2006 was not determined because striped bass were not tagged that year. The 2004, 2005, and 2007 abundance estimates only include male fish because very few females were tagged those years. Between 1992 and 2007, abundance of adult striped bass in the Sacramento-San Joaquin River Delta, the portion of the Sacramento River downstream of Colusa, and the portion of the San Joaquin River downstream from Mossdale ranged between 436,688 and 1,591,419 fish (Table 9). Abundance estimates for 2004, 2005, and 2007 are provisional. The AFRP production target for striped bass is 2,500,000 fish. Between 1992 and 2007, the AFRP striped bass production target was not met during the 11 years when population estimates were developed (Figure 21).

Table 9. Estimated abundance of adult striped bass in the Sacramento-San Joaquin River Delta, Sacramento River downstream from the town of Colusa, and San Joaquin River downstream from the town of Mossdale, 1992-2007. * = estimate only includes male fish.

Year	Estimated number of adult striped bass
1992	777,293
1993	656,506
1994	599,770
1996	1,043,239
1998	1,356,412
2000	1,591,419
2002	945,878
2003	829,111
2004*	767,312
2005*	738,740
2007*	436,688

Figure 21. Estimated abundance of adult striped bass in the Sacramento-San Joaquin River Delta, Sacramento River downstream from the town of Colusa, and San Joaquin River downstream from the town of Mossdale, 1992-2007. * = estimate only includes male fish.



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 1969-1991 and 1992-2009 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. 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 2009, many of the brood year 2006 juvenile fall-run Chinook salmon that were marked in 2007 returned to the Central Valley to spawn as 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 18-year post-baseline period between 1992 and 2009;

- 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; and

- 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. The data in that table indicates that since 1991:

- Monitoring data have not been collected during the 1992-2009 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 18-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 11 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 17 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, and 2009. 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 three years when surveys were done.

- The watershed-specific AFRP spring-run Chinook salmon production target was met 15 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.

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

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.

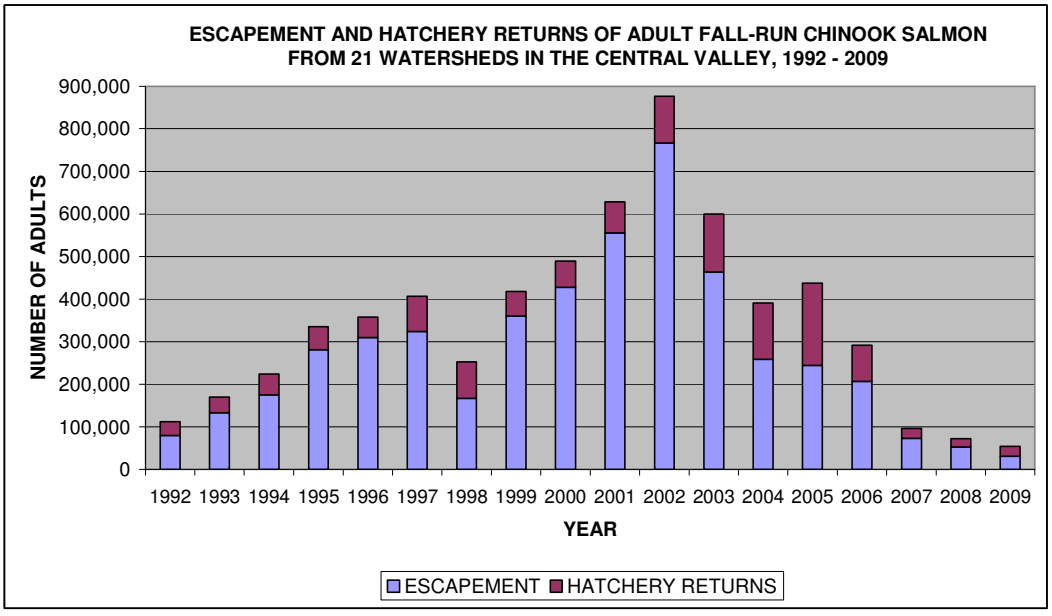
Assumptions #2 and #3 can readily be met in the context of testing whether there are significant differences in the average natural production of Chinook salmon from different watersheds between the baseline and post-baseline periods. Assumption #1 possesses two aspects: (a) there are two independent 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 is based on

random samples, and some is 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.

In 2009 relative to 2008, the production of Chinook salmon declined in 14 of the 25 permutations of runs and watersheds where Chinook salmon were monitored. The only watersheds where fall-run Chinook salmon production was greater in 2009 than 2008 were the American River, Butte Creek, Cottonwood Creek, Feather River, Merced River, Mokelumne River, and Yuba River. The decline in salmon production in 2009 affected Chinook salmon from watersheds that historically have been viewed as success stories in the context of CVPIA and CALFED restoration activities. For example, the production of fall-run Chinook salmon from Clear Creek in 2007, 2008, and 2009 was less than the watershed's AFRP fish production target, despite the fact that the watershed exceeded its production target for eight consecutive years prior to 2007.

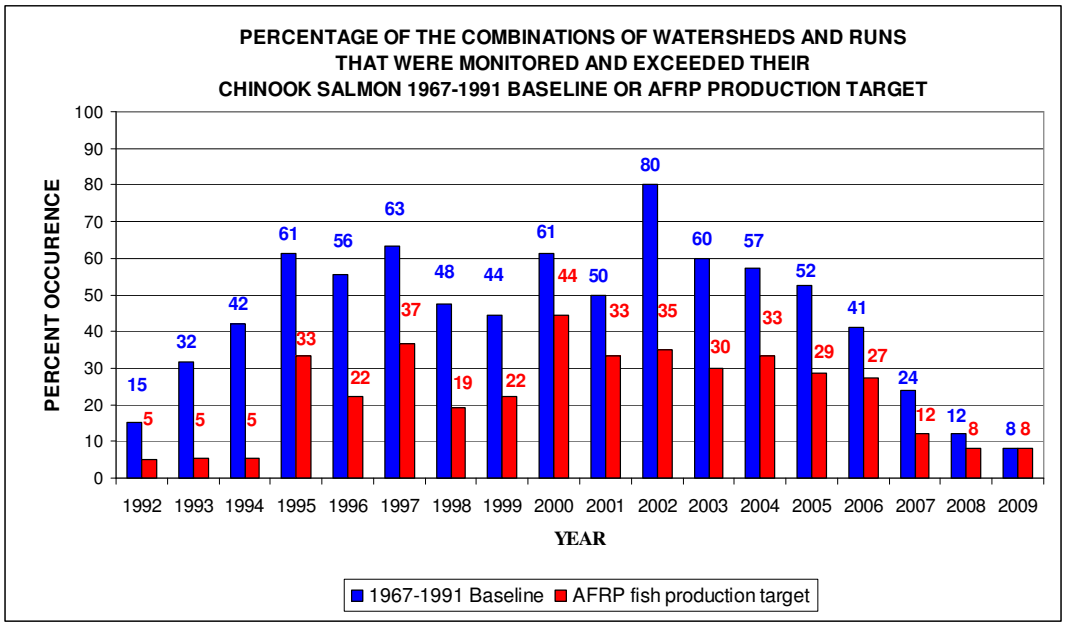
Part of the decline in Chinook salmon production in 2009 can be attributed to the fact that approximately one half of a watershed's annual production in the Chinookprod spreadsheet is normally attributed to salmon that are harvested in the Pacific Ocean and restrictions prohibiting the ocean harvest of Chinook salmon were in effect in 2008 and 2009. However, when in-river escapement and hatchery returns are compared across years with and without ocean harvest restrictions, it becomes obvious the 2008 and 2009 in-river returns were substantially lower than levels during the 1992-2007 time period. For example, the 2009 combined annual in-river escapement and hatchery returns for the 21 watersheds possessing a fall-run Chinook salmon production target was less than in any other year since 1991 (Figure 22). This decline occurred despite the total ban on ocean harvest and a substantial ban on in-river angler harvest which should have resulted in substantial numbers of the unharvested salmon returning to Central Valley rivers and streams to spawn in 2009.

Figure 22. Combined annual in-river escapement and hatchery returns for the 21 watersheds possessing an AFRP fall-run Chinook salmon production target, 1992-2009.



Progress in achieving the Chinook salmon production targets called for in the CVPIA has been less successful since 2000. In that year, 44% of the watersheds and runs that were monitored in the Central Valley exceeded their AFRP production target (Figure 23). By 2009, only 8% of the monitored watersheds exceeded their AFRP target. The recent decline in Chinook salmon production has become so substantial that only 8% of the watersheds monitored in 2009 exceeded the production levels observed during the 1967-1991 baseline period.

Figure 23. Percentage of watersheds and runs that were monitored and exceeded their Chinook salmon 1967-1991 baseline level or their AFRP fish production target between 1992 and 2009.



4.2 PROGRESS TOWARD AFRP PRODUCTION TARGETS FOR NON-SALMONID SPECIES

A discussion describing changes in the production of white sturgeon and green sturgeon during the 1992-2005 time period is provided in the 2008 CAMP annual report (USFWS 2008). Because new data from 2006 and beyond are not currently available for these species, this 2009 CAMP annual report will not re-assess progress toward those species' AFRP production targets.

The 2009 midwater trawl index for juvenile American shad was the third lowest on record during the 1992-2009 post-baseline period and is far below that species' AFRP production target. 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.

Surveys used to estimate the abundance of striped bass also suggest this species' abundance is at unusually low levels. The 2007 striped bass abundance estimate, for example, is the smallest estimate during the 1992-2009 time period; this number is likely to be revised, however, as additional bass surveys are conducted and female adult bass are incorporated into the revised 2007 estimate. There is little reason to believe, however, that revised 2004, 2005, and 2007 striped bass abundance estimates that include female fish will make it more likely this species' AFRP production target was met because the female contribution is likely to be relatively small compared to male fish.

4.3 RESTRICTIONS THAT LIMIT THE HARVEST OF CHINOOK SALMON IN 2010

In 2008 and 2009, concerns about unusually low numbers of fall-run Chinook salmon from the Central Valley of California prompted a total ban on the recreational and commercial harvest of Chinook salmon in areas where fall-run Chinook salmon were likely to occur in the Pacific Ocean. These concerns also prompted regulations that dramatically reduced the inland harvest of Chinook salmon in Central Valley rivers and streams. In 2010, the projected Sacramento Index for fall-run Chinook salmon was estimated to be 245,500 adult salmon, thereby suggesting that sufficient numbers of adult salmon were likely to be present to support a limited fishery of Chinook salmon. The Sacramento Index is an estimate of the combined natural and hatchery escapement and estimated ocean harvest from September 1 – August 31 south of Cape Falcon of fall-run Chinook salmon from the Sacramento River and its tributaries. As a result of the projected Sacramento Index, a limited commercial and recreational ocean harvest season was reinstated in 2010, and the number of Chinook salmon that could be harvested in Central Valley rivers and streams was also increased. The process that allowed for the limited harvest of Chinook salmon in 2010 is as follows:

1. On April 15, 2010, the PFMC adopted recommendations to allow limited recreational and commercial ocean harvest of Chinook salmon between Cape Falcon, Oregon and the United States-Mexico border. On May 5, 2010, the National Marine Fishery Service published a regulation in the Federal Register (75 FR 24482) adopting the PFMC recommendations to allow a limited recreational and commercial ocean harvest of Chinook salmon in federal waters (3 to 200 nautical miles offshore) south of Cape Falcon. Between Point Arena and the United States/Mexico border (i.e., the portion of the California coastline used to estimate the ocean production of Chinook salmon in this CAMP annual report), two four-day commercial salmon seasons were authorized with a minimum Chinook salmon size limit of 27 inches in total length. For this same area, a recreational ocean harvest season of two salmon per day was authorized seven days per week between April 3 and April 30, and Thursday through Monday between May 1 and September 6. To retain captured salmon for those two periods, the minimum size limits was 20 and 24 inches in total length, respectively.

2. The California Fish and Game Commission (Commission) determines the amount of ocean harvest of fisheries that occur in California state waters (0 to 3 nautical miles offshore from the California coastline). In May of 2010, the Commission adopted the abovementioned PFMC recommendations, and voted to reinstate a limited amount of recreational and commercial ocean harvest of Chinook salmon in California state waters.

3. On May 20, 2010, the Commission voted to allow a limited in-river and downstream angler harvest of Chinook salmon in the Central Valley. A maximum of two salmon per day were allowed as follows: fall-run Chinook salmon, lower Sacramento River (Carquinez Bridge, north to Knights Landing) from September 4 to October 3, 2010; fall-run Chinook salmon, upper Sacramento River (Red Bluff Diversion Dam to Deschutes bridge) from October 9 to October 31, 2010; and late-fall-run Chinook salmon, Sacramento River (Knights Landing to Red Bluff Diversion Dam) from October 9 - December 12, 2010. All other Central Valley rivers and streams where Chinook salmon were historically harvested (e.g., the American and Feather Rivers) were closed to angler harvest in 2010.

4.4 POSSIBLE REASONS FOR THE RECENT DECLINES IN PRODUCTION OF FALL-RUN CHINOOK SALMON

The causal factors for the recent decline in the abundance of fall-run Chinook salmon from the Central Valley have been the subject of substantial debate and analysis. To some degree, it is reasonable to assume the recent decline is an extension and exacerbation of anthropogenic factors adversely affecting all four runs of Chinook salmon from the Central Valley since the late 1800s. The historical and current factors affecting the runs have been described by several authors (e.g., Yoshiyama et al. 1998; Moyle 2002; NMFS 2009). These factors (in no particular order) include, but are not limited to:

1. The construction of dams and water diversion infrastructure which have eliminated historical salmon spawning areas or altered hydrologic conditions;
2. Harvest of adult salmon in the ocean and natal watersheds;
3. Entrainment of juvenile salmon by water diversion infrastructure;
4. Loss of juvenile salmon floodplain and estuarine rearing habitat through diking and draining of habitat;
5. Enhanced predation of juvenile salmon, particularly by non-native fish species;
6. A variety of effects relating to the hatchery production of juvenile salmon (e.g., changes in the genetic diversity of a native salmon stock due to introgression with hatchery-produced salmon);
7. Elevated incidents of diseases that may affect adult and juvenile salmon;
8. Pollution;
9. Losses of riparian cover that lead to elevated temperature regimes in the areas where adult and juvenile salmon could occur;
10. Siltation of spawning areas where juvenile salmon hatch or rear;
11. Introduced species that change the processes and function in the ecosystem where salmon occur; and

12. Factors that include long periods of drought, extreme flood events, and periods of low ocean productivity.

In a comprehensive review, Lindley et al. (2009) identified specific factors that were probably responsible for the large decline in the number of adult fall-run Chinook salmon that returned to the Central Valley in 2007 and 2008. The proximate cause for the decline probably consisted of anomalous conditions in the coastal portion of the Pacific Ocean in 2005 and 2006 which then resulted in unusually poor survival of the 2004 and 2005 broods of juvenile fall-run Chinook salmon that had migrated to the ocean. Some of the anomalous conditions in the ocean that may have caused the poor survival of juvenile Chinook salmon entering the Pacific Ocean include weak upwelling of ocean water which resulted in low primary productivity, warm sea surface temperatures that may have led to a general reduction in fish health, and low densities of the prey items that juvenile salmon consume. Lindley et al. (2009) also suggest other factors likely compounded the problems created by unusual ocean conditions. These include, in descending order of importance:

1. The ongoing degradation of freshwater and estuarine habitats that juvenile salmon depend upon for rearing and growth;

2. The production of juvenile fall-run Chinook salmon at five fish hatcheries in the Central Valley which have contributed to the loss of genetic diversity in, and therefore the fitness of, native salmon populations; and

3. Inaccurate forecasts of the number of adult salmon that were projected to return to the Central Valley to spawn, and the subsequent establishment of harvest levels that over-estimated the number of adult salmon that could be harvested on a sustainable basis.

Some of the factors responsible for reductions in Chinook salmon populations can be minimized through restoration actions pursuant to the CVPIA. For example, adverse effects related to changes in the quality of gravel substrates where salmon eggs are laid, hydrologic conditions, entrainment of juvenile salmon, and the loss of juvenile salmon rearing habitat can be minimized by management actions conducted by the Spawning Gravel Program, Dedicated Project Yield Program, Anadromous Fish Screen Program, and Anadromous Fish Restoration Program, respectively. It is not clear, however, if the cumulative benefits created by these restoration programs and other programs administered by entities such as the CDFG or National Marine Fisheries Service can successfully offset conditions in the ocean where salmon spend approximately two-thirds of their lives.

REFERENCES

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

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

California Department of Fish and Game. 2007. qry_Length_GST_ALL.xls file dated June 1, 2007. Prepared by Mike Donnellan. Unpublished spreadsheet providing capture and population data for green sturgeon.

California Department of Fish and Game. 2007. WST_length_1990-2006.xls file dated June 6, 2007. Prepared by Mike Donnellan. Unpublished spreadsheet providing capture and population data for green sturgeon.

California Department of Fish and Game. 2010. FMWT AMS Indices 1967-2009.xls spreadsheet dated October 1, 2010. Prepared by Dave Contreras. Unpublished spreadsheet providing American shad data.

California Department of Fish and Game. 2010. AMS Length Frequency 1971-2009.xls spreadsheet dated October 1, 2010. Prepared by Dave Contreras. Unpublished spreadsheet providing American shad data.

California Department of Fish and Game. 2010. GrandTab030910.pdf. Unpublished spreadsheet providing in-river escapement and hatchery return data for Chinook salmon. http://www.calfish.org/LinkClick.aspx?fileticket=F6dez%2bhfAYo%3d&tabid=104&mid=524.

California Department of Fish and Game. 2009. DRAFT_ASB_ABUDANCEUPDATES.xls spreadsheet dated September 21, 2009. Prepared by Jason DuBois. Unpublished spreadsheet providing striped bass abundance data.

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

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

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

Moyle, P. B. 2002. Inland Fishes of California. Berkeley, CA: University of California Press.

National Marine Fisheries Service (NMFS). 2009. Public Draft Recovery Plan for the Evolutionarily Significant Units of Sacramento River Winter-run Chinook Salmon and Central Valley Spring-run Chinook Salmon and the Distinct Population Segment of Central Valley Steelhead. Sacramento Protected Resources Division. October 2009. http://swr.nmfs.noaa.gov/recovery/centralvalleyplan.htm

Pacific Fishery Management Council (PFMC). 2010. Review of 2009 Ocean Salmon Fisheries. (Document prepared for the Council and its advisory entities.) Pacific Fishery Management Council, 7700 NE Ambassador Place, Suite 200, Portland, Oregon 97220-1384. http://www.pcouncil.org/wp-content/uploads/Salmon_Review_2009_Final.pdf.

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

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

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

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

U.S. Fish and Wildlife Service (USFWS). 2008. A compilation and analysis of anadromous fish monitoring data from the Central Valley of California, 1992-2007. Report prepared by the U.S. Fish and Wildlife Service and Bureau of Reclamation, Comprehensive Assessment and Monitoring Program. Sacramento, California. 106 pp. http://www.fws.gov/sacramento/CAMP/CAMP_documents/2008_CAMP_annual_report.pdf

U.S. Fish and Wildlife Service (USFWS). 2010. "Chinookprod_042210.xls" spreadsheet prepared by Rick Burmester on April 22, 2010, and subsequently modified in November 2010. Unpublished spreadsheet providing Chinook salmon data. http://www.fws.gov/stockton/afrp/Documents/Chinookprod_042210.xls.

Yoshiyama, R. M., F. W. Fisher, and P. B. Moyle. 1998. Historical abundance and decline of chinook salmon in the Central Valley region of California. North American Journal of Fisheries Management 18:487–521.

Yoshiyama, R.M., E.R. Gertstung, F.W. Fisher and P.B. Moyle. 2001. Historical and present distribution of Chinook salmon in the Central Valley of California. California Department of Fish and Game. Fish Bulletin 179(1): 71-176.

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

Ocean harvest estimates of Chinook salmon

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

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 2009 Ocean Salmon Fisheries* (PFMC 2010); commercial harvest data is provided in Table A-3 and recreational harvest data is provided in Table A-5.

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	27,749	45,682	60	27,409
Antelope Creek	0					80	
Battle Creek	5,433	7,275	1,271	21,642	35,620	10	3,562
Bear River						100	
Big Chico Creek						100	
Butte Creek						80	
Clear Creek	600	0	60	1,018	1,678	80	1,342
Cosumnes River						100	
Cottonwood Creek	1,585	0	159	2,708	4,451	80	3,561
Cow Creek						80	
Deer Creek						80	
Feather River	24,105	17,937	8,408	78,077	128,527	60	77,116
Merced River	618	368	49	1,608	2,644	90	2,379
Mill Creek	999	0	100	1,710	2,809	80	2,247
"miscellaneous creeks"						80	
Mokelumne River	935	710	165	2,810	4,619	60	2,771
Paynes Creek						80	
Sacramento River mainstem	32,229	0	3,223	54,868	90,320	60	54,192
Stanislaus River	255	0	13	407	675	100	675
Tuolumne River	132	0	7	224	363	100	363
Yuba River	6,362	0	636	10,831	17,829	100	17,829
Total	79,164	32,746	19,655	203,652	335,217		193,447
Late-Fall Run Chinook Salmon							
Battle Creek	0	344	69	640	1,053	10	105
Sacramento River mainstem	9,389	398	1,957	18,180	29,924	91.8	27,471
Total	9,389	742	2,026	18,820	30,977		27,576
Winter-Run Chinook Salmon							
Sacramento River mainstem	1,203	34	0	1,907	3,144	100	3,144
Calaveras River						100	
Total	1,203	34	0	1,907	3,144	100	3,144
Spring-Run Chinook Salmon							
Butte Creek	730	0	73	1,248	2,051	100	2,051
Deer Creek	209	0	21	357	587	100	587
Mill Creek	237	0	24	405	666	100	666
Sacramento River mainstem	371	0	74	692	1,137	100	1,137
Total	1,547	0	192	2,701	4,440		4,440
Total 1992 Natural Production of Adult Chinook Salmon							**228,607**

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	103,456	163,896	60	98,338
Antelope Creek						80	
Battle Creek	11,029	7,587	1,862	35,062	55,540	10	5,554
Bear River						100	
Big Chico Creek						100	
Butte Creek						80	
Clear Creek	1,246	0	125	2,330	3,701	80	2,961
Cosumnes River						100	
Cottonwood Creek						80	
Cow Creek						80	
Deer Creek	72	0	7	122	201	80	161
Feather River	30,923	16,663	9,517	97,736	154,839	60	92,903
Merced River	1,269	409	84	3,001	4,763	90	4,287
Mill Creek	1,975	0	198	3,707	5,880	80	4,704
"miscellaneous creeks"						80	
Mokelumne River	993	2,164	316	5,932	9,405	60	5,643
Paynes Creek						80	
Sacramento River mainstem	46,231	0	4,623	87,037	137,891	60	82,735
Stanislaus River	677	0	34	1,201	1,911	100	1,911
Tuolumne River	471	0	24	847	1,342	100	1,342
Yuba River	6,703	0	670	12,605	19,979	100	19,979
Total	132,616	37,479	36,216	353,037	559,348		320,517
Late-Fall Run Chinook Salmon							
Battle Creek	0	528	106	1,077	1,711	10	171
Sacramento River mainstem	339	400	148	1,508	2,394	91.8	2,198
Total	339	928	253	2,585	4,105		2,369
Winter-Run Chinook Salmon							
Sacramento River mainstem	378	0	0	646	1,024	100	1,024
Calaveras River						100	
Total	378	0	0	646	1,024	100	1,024
Spring-Run Chinook Salmon							
Butte Creek	650	0	65	1,220	1,935	100	1,935
Deer Creek	259	0	26	486	771	100	771
Mill Creek	61	0	6	115	182	100	182
Sacramento River mainstem	391	0	78	800	1,270	100	1,270
Total	1,361	0	175	2,621	4,157		4,157
Total 1993 Natural Production of Adult Chinook Salmon							**328,067**

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	102,866	164,005	60	98,403
Antelope Creek						80	
Battle Creek	24,274	18,991	4,327	80,092	127,683	10	12,768
Bear River						100	
Big Chico Creek						100	
Butte Creek						80	
Clear Creek	2,546	0	255	4,717	7,517	80	6,014
Cosumnes River						100	
Cottonwood Creek						80	
Cow Creek						80	
Deer Creek	307	0	31	565	903	80	722
Feather River	38,382	18,843	11,445	115,533	184,203	60	110,522
Merced River	2,646	943	179	6,334	10,102	90	9,092
Mill Creek	1,081	0	108	2,021	3,210	80	2,568
"miscellaneous creeks"						80	
Mokelumne River	1,238	1,919	316	5,840	9,312	60	5,587
Paynes Creek						80	
Sacramento River mainstem	58,546	0	5,855	108,346	172,747	60	103,648
Stanislaus River	1,031	0	52	1,842	2,924	100	2,924
Tuolumne River	506	50	25	898	1,430	100	1,430
Yuba River	10,890	0	1,089	20,169	32,148	100	32,148
Total	175,045	49,313	42,655	449,222	716,185		385,827
Late-Fall Run Chinook Salmon							
Battle Creek	0	598	120	1,197	1,914	10	191
Sacramento River mainstem	137	154	58	582	931	91.8	855
Total	137	752	178	1,779	2,846		1,047
Winter-Run Chinook Salmon							
Sacramento River mainstem	144	42	0	319	505	100	505
Calaveras River						100	
Total	144	42	0	319	505	100	505
Spring-Run Chinook Salmon							
Butte Creek	474	0	47	874	1,396	100	1,396
Deer Creek	485	0	49	894	1,428	100	1,428
Mill Creek	723	0	72	1,333	2,128	100	2,128
Sacramento River mainstem	862	0	172	1,734	2,768	100	2,768
Total	2,544	0	341	4,835	7,720		7,720
Total 1994 Natural Production of Adult Chinook Salmon							**395,099**

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	275,561	387,379	60	232,428
Antelope Creek						80	
Battle Creek	56,515	26,677	8,319	225,522	317,034	10	31,703
Bear River						100	
Big Chico Creek						100	
Butte Creek	445	0	45	1,194	1,683	80	1,347
Clear Creek	9,298	0	930	25,169	35,396	80	28,317
Cosumnes River						100	
Cottonwood Creek						80	
Cow Creek						80	
Deer Creek						80	
Feather River	59,912	17,563	15,495	229,104	322,074	60	193,244
Merced River	2,320	602	146	7,561	10,629	90	9,566
Mill Creek						80	
"miscellaneous creeks"						80	
Mokelumne River	2,194	3,323	552	14,922	20,991	60	12,594
Paynes Creek						80	
Sacramento River mainstem	63,934	0	6,393	173,295	243,623	60	146,174
Stanislaus River	619	0	31	1,592	2,242	100	2,242
Tuolumne River	827	0	41	2,189	3,057	100	3,057
Yuba River	14,237	0	1,424	38,598	54,259	100	54,259
Total	280,919	54,663	68,078	994,706	1,398,366		714,930
Late-Fall Run Chinook Salmon							
Battle Creek	0	323	65	948	1,336	10	134
Sacramento River mainstem	0	166	33	487	686	91.8	630
Total	0	489	98	1,435	2,022		764
Winter-Run Chinook Salmon							
Sacramento River mainstem	1,166	43	0	2,973	4,182	100	4,182
Calaveras River						100	
Total	1,166	43	0	2,973	4,182	100	4,182
Spring-Run Chinook Salmon							
Butte Creek	7,500	0	750	20,306	28,556	100	28,556
Deer Creek	1,295	0	130	3,507	4,931	100	4,931
Mill Creek	320	0	32	866	1,218	100	1,218
Sacramento River mainstem	426	0	85	1,258	1,769	100	1,769
Total	9,541	0	997	25,936	36,474		36,474
Total 1995 Natural Production of Adult Chinook Salmon							**756,350**

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	123,877	236,101	60	141,661
Antelope Creek						80	
Battle Creek	52,409	21,178	7,359	89,333	170,279	10	17,028
Bear River						100	
Big Chico Creek						100	
Butte Creek	500	0	50	613	1,163	80	931
Clear Creek	5,922	0	592	7,173	13,687	80	10,950
Cosumnes River						100	
Cottonwood Creek						80	
Cow Creek						80	
Deer Creek						80	
Feather River	57,170	14,488	14,332	94,902	180,891	60	108,535
Merced River	3,291	1,141	222	5,144	9,797	90	8,818
Mill Creek						80	
"miscellaneous creeks"						80	
Mokelumne River	4,038	3,883	792	9,627	18,340	60	11,004
Paynes Creek						80	
Sacramento River mainstem	84,086	0	8,409	102,075	194,569	60	116,742
Stanislaus River	168	0	8	189	365	100	365
Tuolumne River	4,362	0	218	5,049	9,630	100	9,630
Yuba River	27,900	0	2,790	33,883	64,573	100	64,573
Total	309,591	48,341	69,600	471,866	899,398		490,236
Late-Fall Run Chinook Salmon							
Battle Creek	0	1,337	267	1,754	3,358	10	336
Sacramento River mainstem	0	48	10	63	121	91.8	111
Total	0	1385	277	1,817	3,479		447
Winter-Run Chinook Salmon							
Sacramento River mainstem	1,012	0	0	1,100	2,112	100	2,112
Calaveras River						100	
Total	1,012	0	0	1,100	2,112	100	2,112
Spring-Run Chinook Salmon							
Butte Creek	1,413	0	141	1,706	3,261	100	3,261
Deer Creek	614	0	61	742	1,417	100	1,417
Mill Creek	253	0	25	306	584	100	584
Sacramento River mainstem	378	0	76	498	952	100	952
Total	2,658	0	304	3,252	6,213		6,213
Total 1996 Natural Production of Adult Chinook Salmon							**499,007**

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	110,305	186,931	60	112,158
Antelope Creek						80	
Battle Creek	50,744	50,670	10,141	160,636	272,191	10	27,219
Bear River						100	
Big Chico Creek						100	
Butte Creek	800	0	80	1,291	2,171	80	1,736
Clear Creek	8,569	0	857	13,584	23,010	80	18,408
Cosumnes River						100	
Cottonwood Creek						80	
Cow Creek						80	
Deer Creek	1,203	0	120	1,463	2,786	80	2,229
Feather River	50,547	18,781	13,866	119,815	203,008	60	121,805
Merced River	2,714	946	183	5,502	9,345	90	8,410
Mill Creek	478	0	48	747	1,273	80	1,018
"miscellaneous creeks"						80	
Mokelumne River	3,681	6,494	1,018	16,098	27,290	60	16,374
Paynes Creek						80	
Sacramento River mainstem	119,296	0	11,930	188,959	320,185	60	192,111
Stanislaus River	5,588	0	279	8,422	14,290	100	14,290
Tuolumne River	7,146	0	357	10,800	18,303	100	18,303
Yuba River	25,948	0	2,595	41,093	69,636	100	69,636
Total	323,909	82,541	65,254	678,714	1,150,418		603,698
Late-Fall Run Chinook Salmon							
Battle Creek	0	4,578	916	7,942	13,436	10	1,344
Sacramento River mainstem						91.8	
Total	0	4578	916	7,942	13,436		1,344
Winter-Run Chinook Salmon							
Sacramento River mainstem	836	0	0	1,174	2,010	100	2,010
Calaveras River						100	
Total	836	0	0	1,174	2,010	100	2,010
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 mainstem	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							**610,917**

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	79,464	169,719	60	101,832
Antelope Creek						80	
Battle Creek	53,957	44,351	9,831	95,208	203,347	10	20,335
Bear River						100	
Big Chico Creek						100	
Butte Creek	500	0	50	478	1,028	80	822
Clear Creek	4,259	0	426	4,115	8,800	80	7,040
Cosumnes River	300	0	30	292	622	100	622
Cottonwood Creek						80	
Cow Creek						80	
Deer Creek	270	0	27	408	705	80	564
Feather River	0	25,635	5,127	27,081	57,843	60	34,706
Merced River	3,292	799	205	3,770	8,066	90	7,259
Mill Creek	546	0	55	531	1,132	80	905
"miscellaneous creeks"						80	
Mokelumne River	4,122	3,091	721	6,983	14,917	60	8,950
Paynes Creek						80	
Sacramento River mainstem	6,318	0	632	6,106	13,056	60	7,834
Stanislaus River	3,087	0	154	2,841	6,082	100	6,082
Tuolumne River	8,910	0	446	8,230	17,586	100	17,586
Yuba River	31,090	0	3,109	30,108	64,307	100	64,307
Total	167,108	85,664	48,822	265,615	567,209		278,843
Late-Fall Run Chinook Salmon							
Battle Creek	0	3,079	616	3,254	6,949	10	695
Sacramento River mainstem	39,340	0	7,868	41,567	88,775	91.8	81,496
Total	39,340	3,079	8,484	44,821	95,724		82,190
Winter-Run Chinook Salmon							
Sacramento River mainstem	2,893	99	0	2,621	5,613	100	5,613
Calaveras River						100	
Total	2,893	99	0	2,621	5,613	100	5,613
Spring-Run Chinook Salmon							
Butte Creek	20,259	0	2,026	19,609	41,894	100	41,894
Deer Creek	1,879	0	188	1,818	3,885	100	3,885
Mill Creek	424	0	42	410	876	100	876
Sacramento River mainstem	1,115	0	223	1,178	2,516	100	2,516
Total	23,677	0	2,479	23,015	49,172		49,172
Total 1998 Natural Production of Adult Chinook Salmon							**415,818**

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	61,924	156,318	60	93,791
Antelope Creek						80	
Battle Creek	92,929	26,970	11,990	86,529	218,418	10	21,842
Bear River						100	
Big Chico Creek						100	
Butte Creek						80	
Clear Creek	8,003	0	800	5,771	14,574	80	11,659
Cosumnes River	229	0	23	159	410	100	410
Cottonwood Creek						80	
Cow Creek						80	
Deer Creek						80	
Feather River	0	16,658	3,332	13,127	33,116	60	19,870
Merced River	3,129	1,637	238	3,298	8,302	90	7,472
Mill Creek						80	
"miscellaneous creeks"						80	
Mokelumne River	2,183	3,150	533	3,837	9,703	60	5,822
Paynes Creek						80	
Sacramento River mainstem	161,192	0	16,119	116,302	293,613	60	176,168
Stanislaus River	4,349	0	217	2,980	7,547	100	7,547
Tuolumne River	8,232	0	412	5,676	14,319	100	14,319
Yuba River	24,230	0	2,423	17,471	44,124	100	44,124
Total	359,815	58,175	65,382	317,073	800,445		403,023
Late-Fall Run Chinook Salmon							
Battle Creek	0	7,075	1,415	5,568	14,058	10	1,406
Sacramento River mainstem	8,683	0	1,737	6,833	17,252	91.8	15,838
Total	8,683	7,075	3,152	12,401	31,310		17,243
Winter-Run Chinook Salmon							
Sacramento River mainstem	3,264	24	0	2,151	5,439	100	5,439
Calaveras River						100	
Total	3,264	24	0	2,151	5,439	100	5,439
Spring-Run Chinook Salmon							
Butte Creek	3,679	0	368	2,648	6,695	100	6,695
Deer Creek	1,591	0	159	1,145	2,895	100	2,895
Mill Creek	560	0	56	403	1,019	100	1,019
Sacramento River mainstem	262	0	52	206	520	100	520
Total	6,092	0	635	4,402	11,130		11,130
Total 1999 Natural Production of Adult Chinook Salmon							**436,835**

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	157,638	320,055	60	192,033
Antelope Creek						80	
Battle Creek	53,447	21,659	7,511	80,162	162,779	10	16,278
Bear River						100	
Big Chico Creek						100	
Butte Creek						80	
Clear Creek	6,687	0	669	7,147	14,503	80	11,602
Cosumnes River	460	0	46	515	1,021	100	1,021
Cottonwood Creek						80	
Cow Creek						80	
Deer Creek						80	
Feather River	114,717	21,803	27,304	159,010	322,834	60	193,700
Merced River	11,130	1,946	654	13,322	27,052	90	24,347
Mill Creek						80	
"miscellaneous creeks"						80	
Mokelumne River	1,973	5,450	742	7,948	16,113	60	9,668
Paynes Creek						80	
Sacramento River mainstem	96,688	0	9,669	103,205	209,562	60	125,737
Stanislaus River	8,498	0	425	8,634	17,557	100	17,557
Tuolumne River	17,873	0	894	18,240	37,006	100	37,006
Yuba River	14,995	0	1,500	16,010	32,504	100	32,504
Total	427,320	62,018	99,818	571,829	1,160,985		661,453
Late-Fall Run Chinook Salmon							
Battle Creek	0	4,181	836	4,878	9,895	10	990
Sacramento River mainstem	8,751	100	1,770	10,328	20,949	91.8	19,231
Total	8,751	4,281	2,606	15,206	30,844		20,221
Winter-Run Chinook Salmon							
Sacramento River mainstem	1,263	89	0	1,307	2,659	100	2,659
Calaveras River						100	
Total	1,263	89	0	1,307	2,659	100	2,659
Spring-Run Chinook Salmon							
Butte Creek	4,118	0	412	4,413	8,943	100	8,943
Deer Creek	637	0	64	683	1,383	100	1,383
Mill Creek	544	0	54	583	1,181	100	1,181
Sacramento River mainstem	71	0	14	83	168	100	168
Total	5,370	0	544	5,762	11,676		11,676
Total 2000 Natural Production of Adult Chinook Salmon							**696,008**

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	61,128	274,472	60	164,683
Antelope Creek						80	
Battle Creek	100,604	24,698	12,530	39,499	177,332	10	17,733
Bear River						100	
Big Chico Creek						100	
Butte Creek	4,433	0	443	1,398	6,275	80	5,020
Clear Creek	10,865	0	1,087	3,430	15,381	80	12,305
Cosumnes River						100	
Cottonwood Creek						80	
Cow Creek						80	
Deer Creek						80	
Feather River	178,645	29,005	41,530	71,396	320,576	60	192,346
Merced River	9,181	1,663	542	3,255	14,641	90	13,177
Mill Creek						80	
"miscellaneous creeks"						80	
Mokelumne River	2,307	5,728	804	2,534	11,373	60	6,824
Paynes Creek						80	
Sacramento River mainstem	75,152	0	7,515	23,682	106,349	60	63,810
Stanislaus River	7,033	0	352	2,119	9,504	100	9,504
Tuolumne River	8,782	0	439	2,643	11,865	100	11,865
Yuba River	23,392	0	2,339	7,362	33,094	100	33,094
Total	555,778	72,844	133,791	218,449	980,862		530,360
Late-Fall Run Chinook Salmon							
Battle Creek	98	2,439	507	873	3,918	10	392
Sacramento River mainstem	19,276	0	3,855	6,635	29,767	91.8	27,326
Total	19,374	2,439	4,363	7,509	33,684		27,717
Winter-Run Chinook Salmon							
Sacramento River mainstem	8,120	104	0	2,318	10,438	93.8	9,791
Calaveras River						100	
Total	8,120	104	0	2,318	10,438	100	9,791
Spring-Run Chinook Salmon							
Butte Creek	9,605	0	961	3,027	13,592	100	13,592
Deer Creek	1,622	0	162	511	2,295	100	2,295
Mill Creek	1,100	0	110	347	1,557	100	1,557
Sacramento River mainstem	736	0	147	253	1,136	100	1,136
Total	13,063	0	1,380	4,138	18,581		18,581
Total 2001 Natural Production of Adult Chinook Salmon							**586,449**

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	79,569	273,969	60	164,381
Antelope Creek						80	
Battle Creek	397,149	65,924	46,307	208,471	717,851	10	71,785
Bear River						100	
Big Chico Creek						100	
Butte Creek	3,665	0	367	1,633	5,665	80	4,532
Clear Creek	16,071	0	1,607	7,245	24,923	80	19,938
Cosumnes River	1,350	0	135	628	2,113	100	2,113
Cottonwood Creek						80	
Cow Creek						80	
Deer Creek						80	
Feather River	105,163	24,696	25,972	63,781	219,612	60	131,767
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	
Mokelumne River	2,840	7,913	1,075	4,858	16,686	60	10,012
Paynes Creek						80	
Sacramento River mainstem	65,690	0	6,569	29,566	101,825	60	61,095
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	10,847	37,303	100	37,303
Total	766,668	110,190	146,313	418,827	1,441,997		542,583
Late-Fall Run Chinook Salmon							
Battle Creek	216	4,186	880	2,161	7,443	10	744
Sacramento River mainstem	36,004	177	7,236	17,756	61,173	91.8	56,157
Total	36,220	4,363	8,117	19,917	68,616		56,901
Winter-Run Chinook Salmon							
Sacramento River mainstem	7,360	104	0	3,043	10,507	87.7	9,215
Calaveras River						100	
Total	7,360	104	0	3,043	10,507	100	9,215
Spring-Run Chinook Salmon							
Butte Creek	8,785	0	879	3,943	13,607	100	13,607
Deer Creek	2,185	0	219	981	3,384	100	3,384
Mill Creek	1,594	0	159	715	2,469	100	2,469
Sacramento River mainstem	273	0	55	134	462	100	462
Total	12,837	0	1,311	5,774	19,922		19,922
Total 2002 Natural Production of Adult Chinook Salmon							**628,620**

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	105,064	364,076	60	218,446
Antelope Creek						80	
Battle Creek	64,764	88,234	15,300	68,259	236,557	10	23,656
Bear River						100	
Big Chico Creek						100	
Butte Creek	3,492	0	349	1,546	5,387	80	4,310
Clear Creek	9,475	0	948	4,222	14,644	80	11,715
Cosumnes River	122	0	12	59	194	100	194
Cottonwood Creek						80	
Cow Creek						80	
Deer Creek						80	
Feather River	89,946	23,638	22,717	55,297	191,598	60	114,959
Merced River	2,530	549	154	1,308	4,541	90	4,087
Mill Creek	2,426	0	243	1,070	3,739	80	2,991
"miscellaneous creeks"						80	
Mokelumne River	2,122	8,117	1,024	4,578	15,841	60	9,505
Paynes Creek						80	
Sacramento River mainstem	89,229	0	8,923	39,808	137,960	60	82,776
Stanislaus River	5,902	0	295	2,527	8,724	100	8,724
Tuolumne River	2,163	0	108	922	3,193	100	3,193
Yuba River	28,316	0	2,832	12,635	43,783	100	43,783
Total	464,229	135,425	133,287	297,294	1,030,235		528,336
Late-Fall Run Chinook Salmon							
Battle Creek	57	3,183	648	1,580	5,468	10	547
Sacramento River mainstem	5,494	1	1,099	2,680	9,274	91.8	8,514
Total	5,551	3,184	1,747	4,260	14,742		9,060
Winter-Run Chinook Salmon							
Sacramento River mainstem	8,133	85	0	3,334	11,552	94.2	10,882
Calaveras River						100	
Total	8,133	85	0	3,334	11,552	100	10,882
Spring-Run Chinook Salmon							
Butte Creek	4,398	0	440	1,962	6,799	100	6,799
Deer Creek	2,759	0	276	1,230	4,265	100	4,265
Mill Creek	1,426	0	143	636	2,204	100	2,204
Sacramento River mainstem	0	0	0	0	0	0	0
Total	8,583	0	858	3,828	13,269		13,269
Total 2003 Natural Production of Adult Chinook Salmon							**561,548**

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	189,625	371,788	60	223,073
Antelope Creek						80	
Battle Creek	23,861	69,172	9,303	106,517	208,853	10	20,885
Bear River						100	
Big Chico Creek						100	
Butte Creek	2,516	0	252	2,857	5,625	80	4,500
Clear Creek	6,365	0	637	7,268	14,270	80	11,416
Cosumnes River	1,208	0	121	1,404	2,732	100	2,732
Cottonwood Creek						80	
Cow Creek						80	
Deer Creek	300	0	30	351	681	80	545
Feather River	54,171	25,509	15,936	99,499	195,115	60	117,069
Merced River	3,270	1,050	216	4,712	9,248	90	8,323
Mill Creek	1,192	0	119	1,353	2,665	80	2,132
"miscellaneous creeks"						80	
Mokelumne River	1,588	10,356	1,194	13,684	26,823	60	16,094
Paynes Creek						80	
Sacramento River mainstem	43,604	0	4,360	49,925	97,889	60	58,734
Stanislaus River	4,015	0	201	4,411	8,627	100	8,627
Tuolumne River	1,984	0	99	2,155	4,239	100	4,239
Yuba River	15,269	0	1,527	17,494	34,290	100	34,290
Total	258,573	132,487	90,529	501,256	982,844		512,657
Late-Fall Run Chinook Salmon							
Battle Creek	40	5,166	1,041	6,507	12,754	10	1,275
Sacramento River mainstem	8,824	2	1,765	11,032	21,623	91.8	19,850
Total	8,864	5,168	2,806	17,539	34,377		21,125
Winter-Run Chinook Salmon							
Sacramento River mainstem	7,784	85	0	8,178	16,047	92	14,763
Calaveras River						100	
Total	7,784	85	0	8,178	16,047	100	14,763
Spring-Run Chinook Salmon							
Butte Creek	7,390	0	739	8,470	16,599	100	16,599
Deer Creek	804	0	80	922	1,806	100	1,806
Mill Creek	998	0	100	1,144	2,242	100	2,242
Sacramento River mainstem	394	0	79	493	966	100	966
Total	9,586	0	998	11,029	21,613		21,613
Total 2004 Natural Production of Adult Chinook Salmon							**570,159**

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	
Battle Creek	20,520	142,673	16,319	123,509	303,021	10	30,302
Bear River						100	
Big Chico Creek						100	
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	
Cow Creek						80	
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	1,921	421	117	1,676	4,135	90	3,721
Mill Creek	2,426	0	243	1,818	4,487	80	3,590
"miscellaneous creeks"						80	
Mokelumne River	10,406	5,563	1,597	12,087	29,653	60	17,792
Paynes Creek						80	
Sacramento River mainstem	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	719	0	36	535	1,290	100	1,290
Yuba River	17,630	0	1,763	13,335	32,728	100	32,728
Total	244,312	193,411	80,464	356,479	874,666		397,764
Late-Fall Run Chinook Salmon							
Battle Creek	23	5,562	1,117	4,605	11,307	10	1,131
Sacramento River mainstem	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							
Sacramento River mainstem	15,730	145	0	10,922	26,797	80.5	21,572
Calaveras River						100	
Total	15,730	145	0	10,922	26,797	100	21,572
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 mainstem	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							**466,272**

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	15,603	63,841	60	38,305
Antelope Creek						80	
Battle Creek	19,493	57,832	7,733	27,504	112,561	10	11,256
Bear River						100	
Big Chico Creek						100	
Butte Creek	1,920	0	192	685	2,797	80	2,238
Clear Creek	8,422	0	842	2,995	12,259	80	9,807
Cosumnes River	530	0	53	188	771	100	771
Cottonwood Creek						80	
Cow Creek	4,130	0	413	1,470	6,013	80	4,810
Deer Creek	1,905	0	191	674	2,770	80	2,216
Feather River	75,430	14,034	17,893	34,719	142,076	60	85,246
Merced River	1,470	151	81	553	2,255	90	2,029
Mill Creek	1,403	0	140	497	2,041	80	1,632
"miscellaneous creeks"						80	
Mokelumne River	1,732	4,139	587	2,088	8,547	60	5,128
Paynes Creek						80	
Sacramento River mainstem	55,468	0	5,547	19,735	80,750	60	48,450
Stanislaus River	1,923	0	96	652	2,671	100	2,671
Tuolumne River	625	0	31	210	866	100	866
Yuba River	8,231	0	823	2,928	11,982	100	11,982
Total	207,222	84,884	49,592	110,501	452,199		227,407
Late-Fall Run Chinook Salmon							
Battle Creek	50	4,827	975	1,891	7,743	10	774
Sacramento River mainstem	10,171	12	2,037	3,949	16,169	91.8	14,843
Total	10,221	4,839	3,012	5,840	23,912		15,617
Winter-Run Chinook Salmon							
Sacramento River mainstem	17,205	98	0	5,591	22,894	86.2	19,734
Calaveras River						100	
Total	17,205	98	0	5,591	22,894	100	19,734
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 mainstem	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							**274,418**

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	10,073	4,597	6,602	16,349	37,620	60	22,572
Antelope Creek						80	
Battle Creek	9,904	11,744	2,165	18,303	42,116	10	4,212
Bear River						100	
Big Chico Creek						100	
Butte Creek	1,225	0	123	1,038	2,386	80	1,909
Clear Creek	4,129	0	413	3,490	8,031	80	6,425
Cosumnes River	77	0	8	61	146	100	146
Cottonwood Creek	1,250	0	125	1,056	2,431	80	1,944
Cow Creek	2,044	0	204	1,727	3,976	80	3,181
Deer Creek	508	0	51	427	986	80	789
Feather River	21,862	5,341	5,441	25,090	57,734	60	34,640
Merced River	495	79	29	462	1,065	90	959
Mill Creek	796	0	80	672	1,547	80	1,238
"miscellaneous creeks"	140	0	14	122	276	80	221
Mokelumne River	470	1,051	152	1,282	2,956	60	1,773
Paynes Creek						80	
Sacramento River mainstem	17,061	0	1,706	14,421	33,188	60	19,913
Stanislaus River	443	0	22	358	823	100	823
Tuolumne River	224	0	11	183	418	100	418
Yuba River	2,604	0	260	2,198	5,063	100	5,063
Total	73,305	22,812	17,404	87,239	200,760		106,225
Late-Fall Run Chinook Salmon							
Battle Creek	72	3,361	687	3,167	7,286	10	729
Sacramento River mainstem	15,341	87	3,086	14,232	32,745	91.8	30,060
Total	15,413	3,448	3,772	17,398	40,032		30,789
Winter-Run Chinook Salmon							
Sacramento River mainstem	2,487	55	0	1,954	4,496	92.6	4,164
Calaveras River	0	0	0	0	0	100	0
Total	2,487	55	0	1,954	4,496	100	4,164
Spring-Run Chinook Salmon							
Butte Creek	4,943	0	494	4,178	9,615	100	9,615
Deer Creek	644	0	64	544	1,253	100	1,253
Mill Creek	920	0	92	777	1,789	100	1,789
Sacramento River mainstem	248	0	50	229	526	100	526
Total	6,755	0	700	5,728	13,183		13,183
Total 2007 Natural Production of Adult Chinook Salmon							**154,360**

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						80	
Battle Creek	4,290	10,648	0	0	14,938	10	1,494
Bear River						100	
Big Chico Creek						100	
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						80	
Sacramento River mainstem	24,759	0	0	0	24,759	60	14,855
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	52,670	19,229	0	0	71,899		39,789
Late-Fall Run Chinook Salmon							
Battle Creek	19	6,334	0	0	6,353	10	635
Sacramento River mainstem	3,964	10	580	0	4,554	91.8	4,181
Total	3,983	6,344	580	0	10,907		4,816
Winter-Run Chinook Salmon							
Sacramento River mainstem	2,725	105	0	0	2,830	90.3	2,555
Calaveras River	0	0	0	0	0	100	0
Total	2,725	105	0	0	2,830	100	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 mainstem	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							**51,649**

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						80	
Battle Creek	3,047	6,152	0	0	9,199	10	920
Bear River						100	
Big Chico Creek						100	
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	9,946	0	0	14,793	60	8,876
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	1,549	0	0	2,229	60	1,337
Paynes Creek						80	
Sacramento River mainstem	6,343	0	0	0	6,343	60	3,806
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	30,942	22,682	0	0	53,624		30,901
Late-Fall Run Chinook Salmon							
Battle Creek	32	6,429	0	0	6,461	10	646
Sacramento River mainstem	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							
Sacramento River mainstem	4,537	121	0	0	4,658	89.7	4,178
Calaveras River	0	0	0	0	0	100	0
Total	4,537	121	0	0	4,658	100	4,178
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 mainstem	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							**41,921**

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

The indices below are based on the fall midwater trawl surveys conducted by the California Department of Fish and Game (CDFG). Data on the all ages abundance index is derived from CDFG's "FMWT Indices 1967-2009.xls" spreadsheet dated October 1, 2010. Data used to determine the proportion of American shad belonging to the young-of-the-year age class are derived from CDFG's "AMS Length Frequency 1971-2009.xls" spreadsheet dated October 1, 2010. NS = no sampling.

Grey-shaded cells denote periods when length frequency data were not collected. To develop YOY abundance indices for such months (i.e., all months in 1967, 1968, 1969, 1970, and 1984; September of 1971 and 1973; and September and December of 1976), the 10-year average abundance for YOY fish in a particular month in 1972, 1975, 1977, 1978, 1980-1983, 1985, and 1986 was multiplied by the all age abundance index in a month when length frequency data were not available. For example, the YOY abundance index in September 1967 was calculated by multiplying the all age abundance index for September 1967 by the average percent YOY value for the month of September during the 10-year period of 1972, 1975, 1977, 1978, 1980-1983, 1985, and 1986; i.e., 1519 * 0.9868 = 1499.

YOY length criteria

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

Unlike previous CAMP annual reports the MWT index for 1976 is not reported in this report because sampling did not occur in September and December.

year		monthly index				annual index
		September	October	November	December	
1967	all age abundance index	1,519	1,091	607	205	3,422
	number of fish older than age 0 measured					
	number of YOY measured					
	total number of fish measured					
	estimated percent YOY	98.7	99.0	99.4	99.1	
	YOY abundance index	1,499	1,081	603	203	3,386
1968	all age abundance index	274	277	137	70	758
	number of fish older than age 0 measured					
	number of YOY measured					
	total number of fish measured					
	estimated percent YOY	98.7	99.0	99.4	99.1	
	YOY abundance index	270	274	136	69	750
1969	all age abundance index	1,320	1,177	789	402	3,688
	number of fish older than age 0 measured					
	number of YOY measured					
	total number of fish measured					
	estimated percent YOY	98.7	99.0	99.4	99.1	
	YOY abundance index	1,303	1,166	784	398	3,651
1970	all age abundance index	366	254	170	66	856
	number of fish older than age 0 measured					
	number of YOY measured					
	total number of fish measured					
	estimated percent YOY	98.7	99.0	99.4	99.1	
	YOY abundance index	361	252	169	65	847
1971	all age abundance index	351	473	380	255	1,459
	number of fish older than age 0 measured		3	1	0	
	number of YOY measured		136	89	45	
	total number of fish measured		139	90	45	
	percent YOY (estimated in Sept.)	98.7	97.8	98.9	100.0	
	YOY abundance index	346	463	376	255	1,440
1972	all age abundance index	140	56	109	30	335
	number of fish older than age 0 measured	0	0	0	0	
	number of YOY measured	7	24	27	13	
	total number of fish measured	7	24	27	13	
	percent YOY	100.0	100.0	100.0	100.0	
	YOY abundance index	140	56	109	30	335
1973	all age abundance index	599	193	211	82	1,085
	number of fish older than age 0 measured		1	0	0	
	number of YOY measured		77	84	28	
	total number of fish measured		78	84	28	
	percent YOY (estimated in Sept.)	98.7	98.7	100.0	100.0	
	YOY abundance index	591	191	211	82	1,075
1974	all age abundance index	NS	NS	NS	NS	NS
	number of fish older than age 0 measured					
	number of YOY measured					
	total number of fish measured					
	percent YOY					
	YOY abundance index	NS	NS	NS	NS	NS
1975	all age abundance index	1,240	587	486	178	2,491
	number of fish older than age 0 measured	5	0	1	0	
	number of YOY measured	423	251	243	106	
	total number of fish measured	428	251	244	106	
	percent YOY	98.8	100.0	99.6	100.0	
	YOY abundance index	1,226	587	484	178	2,475

year		monthly index				annual index
		September	October	November	December	
1976	all age abundance index	NS	69	102	NS	
	number of fish older than age 0 measured		0	0		
	number of YOY measured		40	64		
	total number of fish measured		40	64		
	percent YOY (estimated in Sept. and Decem.)		100.0	100.0		
	YOY abundance index	NS	69	102	NS	
1977	all age abundance index	126	147	233	130	636
	number of fish older than age 0 measured	2	1	1	0	
	number of YOY measured	84	97	127	74	
	total number of fish measured	86	98	128	74	
	percent YOY	97.7	99.0	99.2	100.0	
	YOY abundance index	123	146	231	130	630
1978	all age abundance index	762	1,060	321	221	2,364
	number of fish older than age 0 measured	1	1	2	1	
	number of YOY measured	304	247	181	124	
	total number of fish measured	305	248	183	125	
	percent YOY	99.7	99.6	98.9	99.2	
	YOY abundance index	760	1,056	317	219	2,352
1979	all age abundance index	NS	NS	NS	NS	NS
	number of fish older than age 0 measured					
	number of YOY measured					
	total number of fish measured					
	percent YOY					
	YOY abundance index	NS	NS	NS	NS	NS
1980	all age abundance index	1,295	1,697	523	401	3,916
	number of fish older than age 0 measured	13	13	2	5	
	number of YOY measured	213	218	196	134	
	total number of fish measured	226	231	198	139	
	percent YOY	94.2	94.4	99.0	96.4	
	YOY abundance index	1,221	1,601	518	387	3,726
1981	all age abundance index	286	522	349	277	1,434
	number of fish older than age 0 measured	2	4	4	1	
	number of YOY measured	183	265	192	62	
	total number of fish measured	185	269	196	63	
	percent YOY	98.9	98.5	98.0	98.4	
	YOY abundance index	283	514	342	273	1,412
1982	all age abundance index	2,245	1,609	1,325	210	5,389
	number of fish older than age 0 measured	3	2	0	1	
	number of YOY measured	583	587	502	113	
	total number of fish measured	586	589	502	114	
	percent YOY	99.5	99.7	100.0	99.1	
	YOY abundance index	2,234	1,604	1,325	208	5,370
1983	all age abundance index	962	852	958	159	2,931
	number of fish older than age 0 measured	0	1	2	1	
	number of YOY measured	433	316	366	73	
	total number of fish measured	433	317	368	74	
	percent YOY	100.0	99.7	99.5	98.6	
	YOY abundance index	962	849	953	157	2,921
1984	all age abundance index	292	172	267	86	817
	number of fish older than age 0 measured					
	number of YOY measured					
	total number of fish measured					
	estimated percent YOY	98.7	99.0	99.4	99.1	
	YOY abundance index	288	170	265	85	809

year		monthly index				annual index
		September	October	November	December	
1985	all age abundance index	316	332	564	386	1,598
	number of fish older than age 0 measured	0	1	2	1	
	number of YOY measured	204	236	350	197	
	total number of fish measured	204	237	352	198	
	percent YOY	100.0	99.6	99.4	99.5	
	YOY abundance index	316	331	561	384	1,591
1986	all age abundance index	694	567	313	286	1,860
	number of fish older than age 0 measured	3	0	0	0	
	number of YOY measured	146	206	148	131	
	total number of fish measured	149	206	148	131	
	percent YOY	98.0	100.0	100.0	100.0	
	YOY abundance index	680	567	313	286	1,846
1987	all age abundance index	261	292	222	124	899
	number of fish older than age 0 measured	19	10	0	0	
	number of YOY measured	160	157	100	66	
	total number of fish measured	179	167	100	66	
	percent YOY	89.4	94.0	100.0	100.0	
	YOY abundance index	233	275	222	124	854
1988	all age abundance index	805	310	300	135	1,550
	number of fish older than age 0 measured	1	1	4	0	
	number of YOY measured	302	204	150	69	
	total number of fish measured	303	205	154	69	
	percent YOY	99.7	99.5	97.4	100.0	
	YOY abundance index	802	308	292	135	1,538
1989	all age abundance index	569	339	592	378	1,878
	number of fish older than age 0 measured	1	0	0	1	
	number of YOY measured	263	223	299	192	
	total number of fish measured	264	223	299	193	
	percent YOY	99.6	100.0	100.0	99.5	
	YOY abundance index	567	339	592	376	1,874
1990	all age abundance index	1,493	947	1,369	507	4,316
	number of fish older than age 0 measured	0	2	5	4	
	number of YOY measured	435	355	540	232	
	total number of fish measured	435	357	545	236	
	percent YOY	100.0	99.4	99.1	98.3	
	YOY abundance index	1,493	942	1,356	498	4,290
1991	all age abundance index	1,076	779	872	260	2,987
	number of fish older than age 0 measured	2	0	2	0	
	number of YOY measured	461	435	409	153	
	total number of fish measured	463	435	411	153	
	percent YOY	99.6	100.0	99.5	100.0	
	YOY abundance index	1,071	779	868	260	2,978
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

year		monthly index				annual index
		September	October	November	December	
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
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

year		monthly index				annual index
		September	October	November	December	
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	87	78	106	951
	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	87	78	106	951
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
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	100	100	100	
	YOY abundance index	81	75	252	216	624

average percent YOY value for the 10-year period of 1972, 1975, 1977, 1978, 1980-1983, 1985, and 1986	98.68	99.04	99.36	99.13