COMPREHENSIVE ASSESSMENT AND MONITORING PROGRAM

Assessment of Anadromous Fish Production in the Central Valley of California between 1992 and 2007

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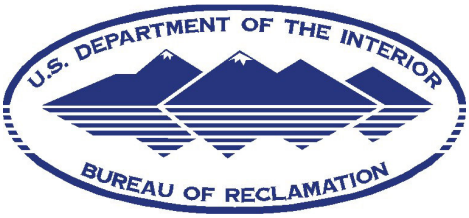

2008

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U.S. Fish and Wildlife Service
2800 Cottage Way, Room W-2605
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2008

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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
PSC	Pacific Salmon Commission
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 2007. These data are 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 quantified by the Anadromous Fish Restoration Program (AFRP). To address these topics, this report quantifies the *natural* (as compared to hatchery) production of eight anadromous fish taxa in one broader area and 21 Central Valley watersheds where the AFRP has established fish production targets. 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/Sacramento-San Joaquin River Delta (Bay-Delta area), and the 21 watersheds are the American River, Antelope Creek, Battle Creek, Bear River, Big Chico Creek, Butte Creek, Clear Creek, Cosumnes River, Cottonwood Creek, Cow Creek, Deer Creek, Feather River, Merced River, Mill Creek, some "miscellaneous creeks", Mokelumne River, Paynes Creek, Sacramento River mainstem, Stanislaus River, Tuolumne River, and Yuba River. This report does not assess progress toward the AFRP steelhead production target because comparable monitoring data before and after 1994 can not be collected for this taxon.

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 run 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 the other four taxa only consist of one tier.

Progress toward AFRP production targets for the eight taxa was assessed by quantifying the number of years AFRP production targets were met after 1991. This report also uses three additional tools to assess changes in abundance of Chinook salmon. These include: (1) for each watershed, determining if average natural production of adult Chinook salmon during the 1967-1991 time period was greater or less than production during the 1992-2007 time period; (2) 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; and (3) utilizing rebuilding assessment methods developed by the Pacific Salmon Commission (PSC) to determine if incremental production targets between 2000 and 2005 were met. The PSC rebuilding assessment methods assign runs of salmon to one of three categories: (1) those at or above a series of annual production targets, (2) those rebuilding toward a series of annual production targets, and (3) those not rebuilding toward a series of annual production targets. The assignment of these categories is made by comparing annual incremental production targets for runs in different watersheds with fish production estimates during a corresponding period. A particular run's progress toward an annual production targets can not be assessed if: (1) insufficient monitoring data were available to make an assessment, or (2) the PSC rebuilding assessment methods yielded mixed results and a run is therefore classified as "indeterminate".

Monitoring data quantifying natural production of adult Chinook salmon from the Central Valley during the 16-year period between 1992 and 2007 are summarized in Table 1.

Table 1. Overall assessment of changes in natural production of Chinook salmon in the Central Valley, 1967-2007. ???? = insufficient data to assess change in average production. * Indicates a fish hatchery is present in the watershed; presence of hatchery fish can confound estimates of natural production. ** indicates a statistically significant change with $\alpha = 0.05$.

Watershed	Chinook salmon run	Metric to assess changes in Chinook salmon abundance			
		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 1992-2007 time periods	P values associated with changes in the average production between the 1967-1991 and 1992-2007 time periods	Production status using the PSC's rebuilding assessment methods 2000-2005
American River*	fall-run	6/16	up	0.0034**	above target
Antelope Creek	fall-run	0/0	????	????	insufficient data
Battle Creek*	fall-run	13/16	up	0.0003**	above target
Battle Creek*	late fall-run	8/16	up	0.0007**	indeterminate
Bear River	fall	0/0	????	????	insufficient data
Big Chico Creek	fall	0/0	????	????	insufficient data
Butte Creek	fall-run	8/11	up	0.0009**	above target
Butte Creek	spring-run	13/16	up	0.0004**	above target
Clear Creek	fall-run	11/16	up	0.00009**	above target
Cosumnes River	fall	0/2	down	????	insufficient data
Cottonwood Creek	fall	0/2	down	????	insufficient data
Cow Creek	fall	1/2	up	????	insufficient data
Deer Creek	fall-run	2/8	up	0.1257	insufficient data
Deer Creek	spring-run	0/16	down	0.2125	indeterminate
Feather River*	fall-run	3/16	up	0.0421**	not rebuilding
Merced River*	fall-run	1/16	down	0.3619	not rebuilding
Mill Creek	fall-run	1/11	up	0.2972	insufficient data
Mill Creek	spring-run	0/16	down	0.0421**	not rebuilding
“miscellaneous creeks”	fall-run	0/1	down	????	insufficient data
Mokelumne River*	fall-run	8/16	up	0.0023**	above target
Paynes Creek	fall-run	0/0	????	????	insufficient data
Sacramento River	fall-run	0/16	down	0.0178**	not rebuilding
Sacramento River	late fall-run	1/15	down	0.0332**	not rebuilding
Sacramento River	winter-run	0/16	down	0.0007**	indeterminate
Sacramento River	spring-run	0/15	down	0.00001**	not rebuilding
Stanislaus River	fall-run	0/16	down	0.0452**	not rebuilding
Tuolumne River	fall-run	0/16	down	0.0130**	not rebuilding
Yuba River	fall-run	1/16	up	0.2628	not rebuilding

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

During the 16-year period between 1992 and 2007, the available monitoring data indicate the:

- Watershed-specific AFRP production targets for fall-run Chinook salmon were met six or more times in the following watersheds: American River, Battle Creek, Butte Creek, Clear Creek, and Mokelumne River. In contrast, the available data suggest production targets for fall-run Chinook salmon were met three or fewer times in the following watersheds when monitoring was conducted: Cosumnes River, Cottonwood Creek, Cow Creek, Deer Creek, Feather River, Merced River, Mill Creek, seven "miscellaneous creeks", Sacramento River mainstem, Stanislaus River, Tuolumne River, and Yuba River. Some of these watersheds did not meet their AFRP production targets on a frequent basis in spite of frequent monitoring, while others may not have met their targets because monitoring data were not collected frequently enough to demonstrate they met their targets. Monitoring data for fall-run Chinook salmon have not been collected on Antelope Creek, Bear River, Big Chico Creek, and Paynes Creek since 1991, and it is therefore not possible to quantify how often the watershed-specific AFRP production targets for fall-run Chinook salmon were met in these locations.

- Watershed-specific AFRP production target for late fall-run Chinook salmon may have been met eight times on Battle Creek based on the number of salmon returning to a fish hatchery. In contrast, the watershed-specific AFRP production target for late fall-run Chinook from the Sacramento River mainstem was met once.

- Watershed-specific AFRP production target for winter-run Chinook salmon was never met on the Sacramento River mainstem.

- Watershed-specific AFRP production target for spring-run Chinook salmon was met thirteen times on Butte Creek. In contrast, the available data suggest the watershed-specific AFRP production targets for spring-run Chinook were never met on Deer Creek, Mill Creek, and the Sacramento River mainstem.

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

- Central Valley-wide AFRP production target for the combined total of all four runs of Chinook salmon was never met.

Analyses comparing average Chinook salmon production during the 1967-1991 and 1992-2007 time periods and the PSC's rebuilding assessment methods generally yield inferences that are consistent with the assessment of the number of times the AFRP production targets were met. Data in Table 1 also suggest some watersheds have significantly more Chinook salmon in the 1992-2007 period compared to the 1967-1991 period (e.g., spring-run Chinook salmon in Butte

Creek), while the salmon production in other watersheds has experienced significant declines over time (e.g., spring-run Chinook salmon in the Sacramento River).

With respect to non-salmonid species:

- Monitoring of white sturgeon in San Pablo and Suisun Bays occurred in seven years between 1992 and 2005. The AFRP production target for 15-year old white sturgeon was met once in those seven years.

- Monitoring of green sturgeon in San Pablo and Suisun Bays occurred in six years between 1992 and 2005. The AFRP production target for green sturgeon ≥ 40 inches in length was met twice in those six years.

- 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 16 years between 1992 and 2007.

- 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 10 of the years between 1992 and 2005. The AFRP production target for this species was never met during those 10 years.

In the short-term, production of different runs of Chinook salmon from the aforementioned 21 watersheds declined in 17 of the 20 combinations of watersheds and runs in 2007 relative to 2006. Further evidence that the Central Valley anadromous fish taxa are experiencing substantial declines in abundance is demonstrated by the fact that the 2007 midwater trawl index pertaining to the production of juvenile American shad was the lowest on record since 1992, and the second lowest on record since that survey began in 1967.

Concerns about the low number of adult fall-run Chinook salmon from the Central Valley prompted regulations that eliminated or dramatically reduced the ocean harvest and in-river angler harvest of these fish in 2008.

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 21 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). These 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/Sacramento-San Joaquin River Delta (Bay-Delta area), and the 21 watersheds are the American River, Antelope Creek, Battle Creek, Bear River, Big Chico Creek, Butte Creek, Clear Creek, Cosumnes River, Cottonwood Creek, Cow Creek, Deer Creek, Feather River, Merced River, Mill Creek, some "miscellaneous creeks", 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. This is the sixth CAMP annual report prepared since 1992. All the CAMP annual reports are available on the CAMP website at: http://www.fws.gov/sacramento/CAMP/camp_documents_and_projects.htm
The reports do not estimate production of fish that originate at fish hatcheries. For purposes of this report, the word "taxa" refers to different species of anadromous fish or different runs of Chinook salmon.

1.2 PRODUCTION TARGETS FOR ANADROMOUS FISH

The AFRP has developed fish production targets for each of the abovementioned taxa (Table 2). In 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. 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.

This CAMP annual report will not address progress toward the steelhead AFRP 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 data for this taxon before and after 1994.

The AFRP's *Final Restoration Plan for the Anadromous Fish Restoration Program* (USFWS 2001) identifies Chinook salmon production targets in 22 watersheds. The CAMP monitors progress toward the AFRP production targets in 21 of these watersheds but does not monitor production in the Calaveras River because there is conflicting evidence that winter-run Chinook salmon historically occurred in this watershed.

1.3 SUSTAINABILITY AND THE AFRP PRODUCTION TARGETS

Pursuant to CVPIA section 3406(b)(1), the AFRP's goal to double natural production of fish includes elements of both production quantity and long-term sustainability. To achieve this goal, it is necessary to reach the numeric goals *and* demonstrate that the numeric goal is sustainable on a long-term basis. The AFRP Position Paper in the *Final Restoration Plan for the Anadromous Fish Restoration Program* (USFWS 2001) defines "sustainable" conditions: "Production levels specified by numeric goals will be considered sustainable when they are maintained under the entire range of conditions resulting from legal human activities, as superimposed on natural variability inherent in the system." In this document, "long-term" is described as encompassing "…at least several generations of fish (not less than 5) over a variety of hydrologic conditions (to allow for natural variation in production) and will continue indefinitely."

Production estimates can only be used to infer progress toward numeric goals, i.e., production targets, and can not be used to infer the sustainability of these numbers. Two reasons for this are: (1) there has not been an effort to identify and characterize the anthropogenic and environmental factors that may have caused changes in fish numbers; and (2) at present, there is no ability to demonstrate a long-term commitment to continue the management actions that may have caused increases in salmon numbers in some watersheds. At present, it cannot be assumed that reaching a production target (i.e., numeric goal) for a fish taxon indicates that the AFRP's goal to double natural production of the taxon has been achieved.

Table 2. Anadromous Fish Restoration Program production targets. With the exception of the American shad, all production targets pertain to adult fish.

Taxa	Watershed/area	1967-1991 baseline production estimate	AFRP production target
CHINOOK SALMON			
Fall-run	American River*	81,000	160,000
	Antelope Creek	360	720
	Battle Creek*	5,000	10,000
	Bear River	220	450
	Big Chico Creek	400	800
	Butte Creek	760	1,500
	Clear Creek	3,600	7,100
	Cosumnes River	1,600	3,300
	Cottonwood Creek	3,000	5,900
	Cow Creek	2,300	4,600
	Deer Creek	760	1,500
	Feather River*	86,000	170,000
	Merced River*	9,000	18,000
	Mill Creek	2,100	4,200
	"miscellaneous creeks"	550	1,100
	Mokelumne River*	4,700	9,300
	Paynes Creek	160	330
	Sacramento River mainstem	115,000	230,000
	Stanislaus River	11,000	22,000
	Tuolumne River	19,000	38,000
	Yuba River	33,000	66,000
Late fall-run	Battle Creek*	270	550
	Sacramento River mainstem	34,000	68,000
Winter-run	Calaveras River[1]	1,100	2,200
	Sacramento River mainstem	54,000	110,000
Spring-run	Butte Creek	1,000	2,000
	Deer Creek	3,300	6,500
	Mill Creek	2,200	4,400
	Sacramento River mainstem	29,000	59,000

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

Taxa	Watershed/area	1967-1991 baseline production estimate	AFRP production target
CHINOOK SALMON			
Fall-run		370,000	750,000
Late fall-run		34,000	68,000
Winter-run		54,000	110,000
Spring-run run		34,000	68,000
Central Valley-wide, all four salmon runs combined		500,000	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

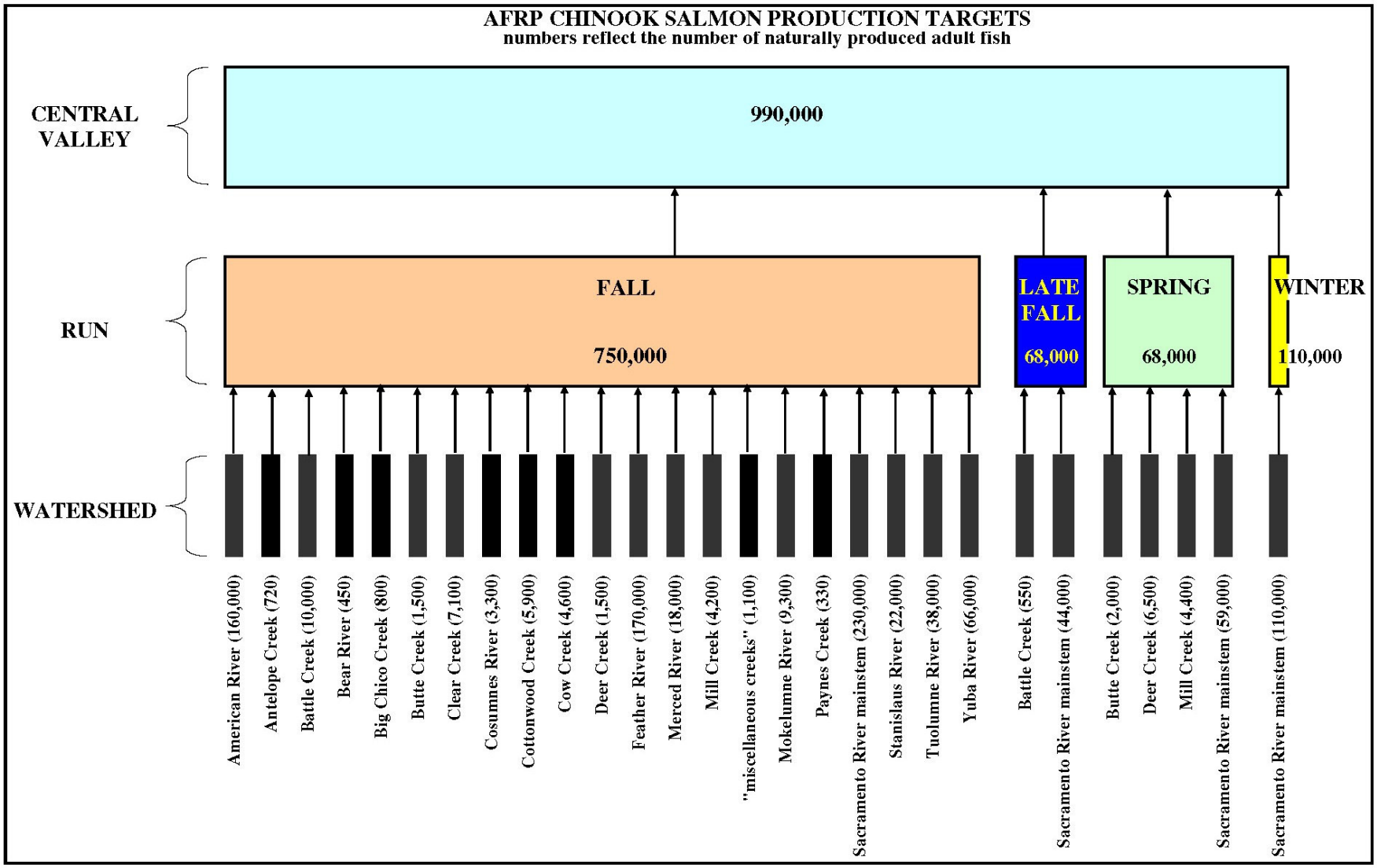
* = Hatchery in the tributary

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. Illustration demonstrating the relationship between the three tiers of AFRP Chinook salmon production targets.



1.4 DATA CAVEATS

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

2. Agency staff use different criteria, e.g. run timing, to assign Chinook salmon to particular runs. The dates when the four runs of Chinook salmon return to a natal stream may overlap and there are not distinct and non-overlapping periods when each run of salmon return to spawn. In general, fisheries 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 Chinook salmon. Similarly, the ability to accurately identify spring-run Chinook salmon may be 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. However, there is the potential that fisheries biologists could mistakenly assign individual fish to the wrong run of Chinook salmon, and thereby bias the number of salmon that are attributable to a particular run.

3. The CDFG has revised many fish abundance estimates in the Central Valley. Some of these estimates pertain to the 1967-1991 baseline period. The CAMP has made no attempt to account for these changes as it assesses progress toward the AFRP production targets.

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 13 watersheds that are of interest to the CAMP 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 monitoring of the amount of in-river angler harvest does not occur on a consistent basis, the production estimate for a watershed only includes an estimate of the amount of in-river angler harvest and does not include an actual count of the number of angler-harvested salmon.

6. 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 definitive data on this ratio are not available, the process of calculating natural production relies on estimates of the ratio of natural- vs. hatchery-origin fish in each watershed. The accuracy of these estimates has been the subject of some concern (Newman and Hankin 2004), and the few reports that have been written on this subject (e.g., Dettman and Kelley 1987, Cramer 1991) have not resulted in a consensus on what the actual ratios are. 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-run Chinook salmon because all hatchery-produced fish of this run are marked and recognizable in the field.

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

8. The statistical analyses in this report that evaluate changes in the average production of Chinook salmon from the 13 watersheds between the 1967-1991 and 1992-2006 time periods assume there are similar degrees of bias, variance, and sampling error during the two time periods. These assumptions can not be validated until all the data pertaining to escapement estimates, hatchery returns, and ocean harvest are consolidated into a single matrix and the appropriate analyses have been done.

1.5 ACKNOWLEDGEMENTS

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

1. Rick Burmester in the U.S. Fish and Wildlife Service (USFWS) Stockton Fish and Wildlife Office devoted a substantial effort to developing and maintaining the Chinookprod spreadsheet that tabulates values related to the production of Chinook salmon.

2. Bob Kano and other CDFG staff developed and maintained the Grandtab spreadsheet that provides escapement estimates of Chinook salmon.

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

4. Dave Contreras of the CDFG provided spreadsheets that contain abundance data for juvenile American shad.

5. Jason DuBois and Marty Gingras of the CDFG provided abundance data for adult striped bass.

6. Rick Burmester (USFWS), Dan Welsh (USFWS), Ken Newman (USFWS), Dan Cox (USFWS), Brenda Olson (USFWS), Kellie Whitton (USFWS), Jess Newton (USFWS), Marty Gingras (CDFG), Jason DuBois (CDFG), Scott Barrow (CDFG), Melodie Palmer-Zwahlen (CDFG), John Hannon (Bureau of Reclamation), Chuck Tracy (Pacific Fishery Management Council), and Neil Schwertman, Nancy Carter, and Katherine Gray (Chico State University) 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 locations where natural production of the aforementioned anadromous fish taxa are monitored in the Central Valley are depicted in Figure 2. Monitoring techniques used to assess the abundance of these 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.

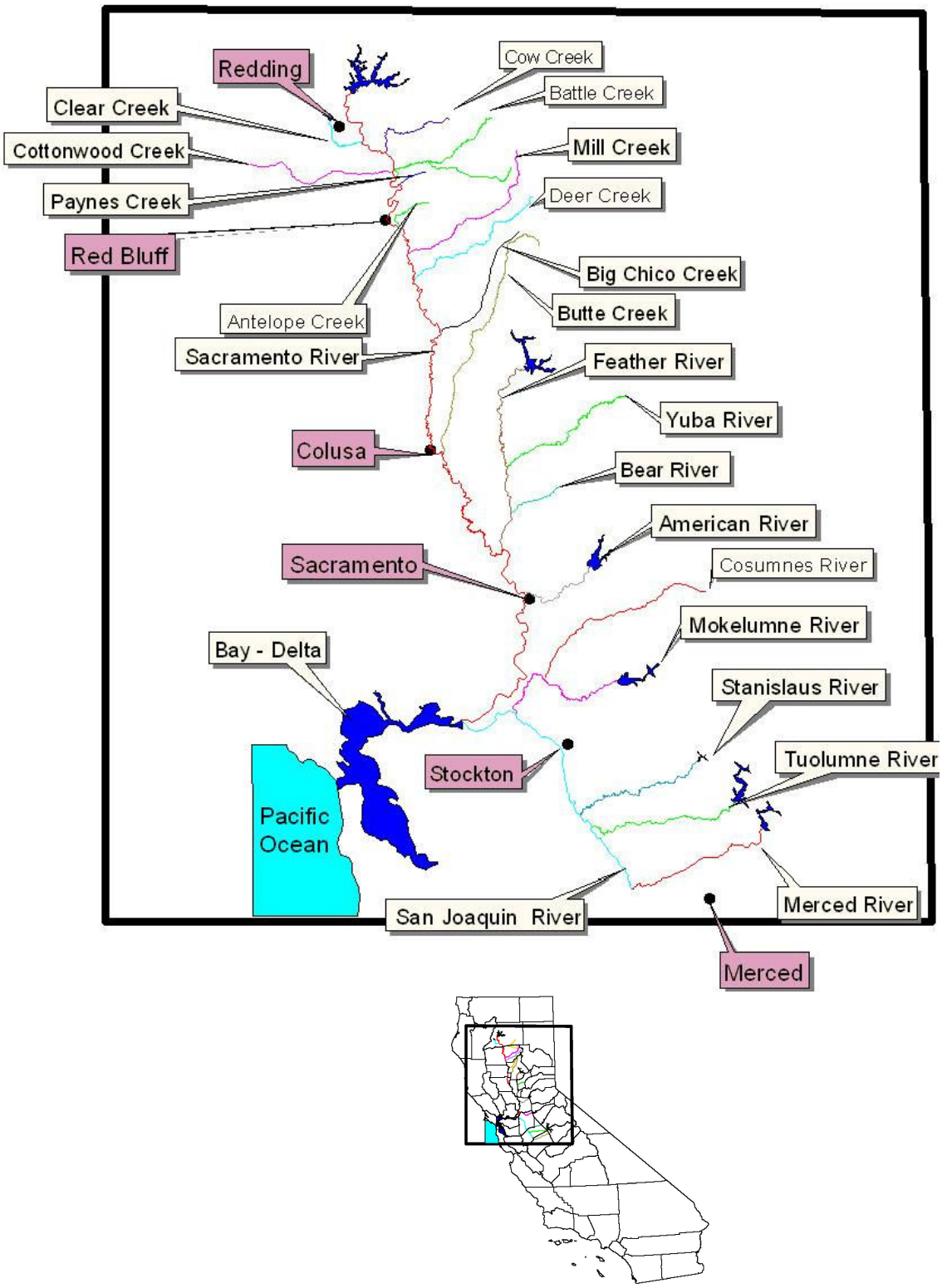
Every CAMP-recommended monitoring activity in a given watershed may not occur each year. For example, an estimate of production of adult fall-run Chinook salmon on the American River should be quantified using: (1) carcass counts, (2) marking of hatchery-produced fish to develop a ratio of natural- vs.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

2.2 METHODS TO ESTIMATE PRODUCTION OF SALMONID TAXA

2.2.1 METHODS FOR ADULT CHINOOK SALMON

Calculations to estimate natural production of each run of Chinook salmon from each watershed includes 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 general estimates 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. Map depicting the locations where the abundance of anadromous fish are monitored in the Central Valley. Map does not include the 7 "miscellaneous creeks" described below.



Collectively, the sum of the 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. Figure 3 provides an illustration demonstrating how the natural production of Chinook salmon for different runs in each watershed is calculated. The formulas used to develop the production estimates are contained in a "Chinookprod" spreadsheet maintained by the U.S. Fish and Wildlife Service.

This report uses the following references to develop Chinook salmon production estimates: (1) a "2008 DRAFT-3-1-08 Grandtab.xls" spreadsheet prepared by the CDFG on March 1, 2008; (2) a "Chinookprod 031308.xls" spreadsheet prepared by the AFRP on March 13, 2008; and (3) commercial and recreational salmon harvest data summarized in the *Review of 2007 Ocean Salmon Fisheries* (PFMC 2008a). The formulas used by the Chinookprod spreadsheet to develop Chinook salmon production estimates are described in Appendix A of the 2007 CAMP annual report (USFWS 2007).

2.2.2 CHINOOK SALMON POPULATION ASSESSMENTS

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

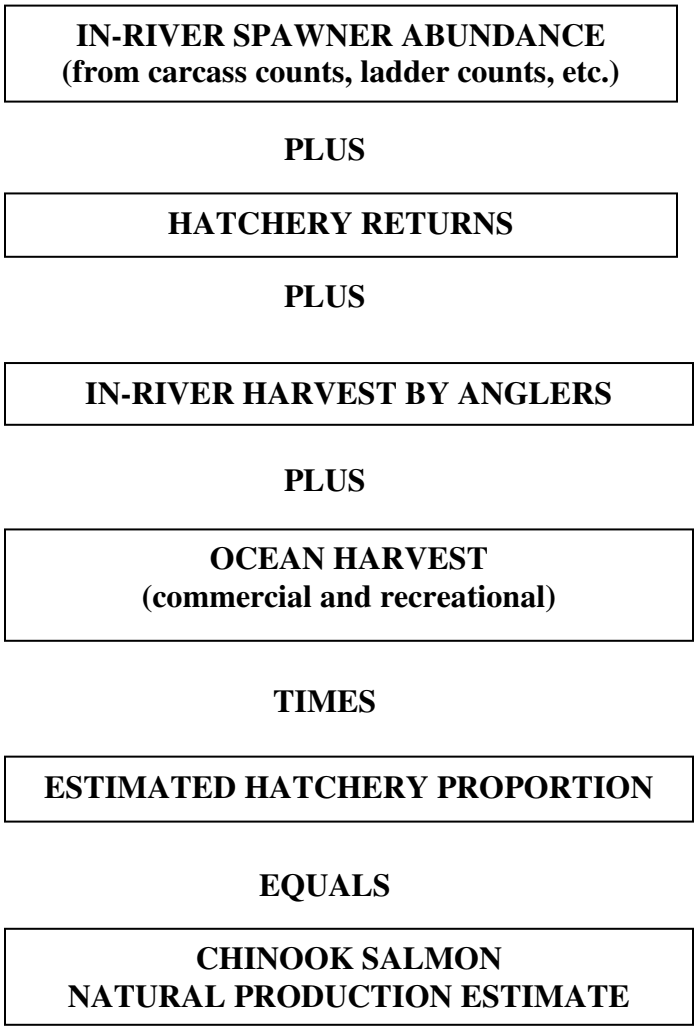
1. Counting the number of years the estimated annual production of Chinook salmon met or exceeded the AFRP's watershed, run-specific, and Central Valley-wide production targets since 1991;

2. Determining if there is an upward or downward change in the average natural production of adult Chinook salmon in the 21 aforementioned watersheds between the 1967-1991 and 1992-2007 time periods;

3. Using a Student's t-test to determine if there is a statistically significant ($\alpha = 0.05$) difference in the means of the estimated natural production of adult Chinook salmon from each of the watersheds between the 1967-1991 and 1992-2007 time periods; and

4. Using a modified version of the PSC's rebuilding assessment methods to assess changes in production of Chinook salmon. Use of the PSC's rebuilding assessment methods to assess changes in production of Chinook salmon is called for in the 1997 CAMP Implementation Plan (Montgomery Watson et al. 1997).

Figure 3. Components used to calculate natural production of each run of adult Chinook salmon in 21 Central Valley watersheds.



The PSC rebuilding assessment methods assign runs of salmon to one of three categories: (1) those at or above a series of annual production targets, (2) those rebuilding toward a series of annual production targets, and (3) those not rebuilding toward a series of annual production targets. The assignment of these categories is made by comparing annual incremental production targets for runs in different watersheds with fish production estimates during a corresponding period. A particular run's progress toward an annual production targets can not be assessed if: (1) insufficient monitoring data were available to make an assessment, or (2) the PSC rebuilding assessment methods yielded mixed results and a run is therefore classified as "indeterminate". Because fish production estimates in 2006 and 2007 are provisional and will probably be revised, the CAMP will use the PSC's rebuilding assessment methods using data that are not expected to change; i.e., data that were collected between 2000 and 2005. Appendix A describes the process for using the PSC's rebuilding assessment methods.

The following assumptions were used during the Student's t-test to determine if there was a statistically significant difference in the means of the estimated natural production of adult Chinook salmon from each of the watersheds between the 1967-1991 and 1992-2007 time periods:

1. the natural production from each watershed is not known, and production figures therefore represent production estimates;

2. the observation error during the surveys to estimate fish production is not routinely quantified, but can reasonably be assumed to be different during each year when sampling is done;

3. a difference in the mean production of adult Chinook salmon between the two time periods was not estimated unless data were collected in three or more years in each watershed during each time period;

4. because current data collection activities in the majority of the Central Valley watersheds do not report a coefficient of variation (CV), the calculations used during the t-test assumed a constant CV of 0.25 each year;

5. a one-tailed t-test was used to evaluate differences in the means;

6. the degrees of freedom (df) during the t-test reflected the smaller (more conservative) number of times production estimates were available during the two sampling periods. For example, if production estimates were available in a watershed 25 times between 1967-1991, and 16 times between 1992-2007, the smaller number was used to estimate the df, e.g., 16-1 = 15;

7. the test for significance assumes an $\alpha = 0.05$; and

8. if the $p < 0.05$, then the differences in the mean production between the two time periods were deemed to be significant.

The following parameters were calculated using Microsoft Excel software: (1) the mean production from each Chinook salmon run and watershed during each time period, and (2) the population variance of the production estimates from each Chinook salmon run and watershed during each time period.

The estimated variance of the production estimates, i.e., $\hat{V}_{Nt}(N_t)$, during a time period *t* was calculated with the following formula:

$$\frac{\hat{V}(\hat{N}_t) - \overline{CV_t}^2 \overline{\hat{N}_t}^2}{1 + \overline{CV_t}^2} \qquad \text{equation 1}$$

where

$\overline{CV_t}^2$ is the square of the mean coefficient of variation during a time period,

$\overline{\hat{N}_t}^2$ is the square of the mean production estimate during a time period, and

$\hat{V}(\hat{N}_t)$ is the population variance of the production estimates during each time period.

The estimated standard deviation (SD) of the production estimates was calculated with the following formula:

$$\hat{SD}_{N_t}(N_t) = \sqrt{\hat{V}_{N_t}(N_t)} \qquad \text{equation 2}$$

The estimation of the t statistic was calculated using the following formula, and where n = the number of production estimates during a time period:

$$t = \frac{\overline{\hat{N}}_{1967-1991} - \overline{\hat{N}}_{1992-2007}}{\sqrt{\frac{SD^2_{1967-1991}}{n_{1967-1991}} + \frac{SD^2_{1992-2007}}{n_{1992-2007}}}} \qquad \text{equation 3}$$

2.3 METHODS TO ESTIMATE PRODUCTION OF NON-SALMONID TAXA

2.3.1 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. Trammel nets are used to collect these data between August and early November. Prior to 2005, the CDFG normally collected mark-recapture data for white sturgeon in two consecutive years, followed by a 2-year period when mark-recapture data are not collected. Since 2005, the CDFG has conducted white sturgeon surveys every year to develop more robust population estimates for the post 2005 period. Captured sturgeon are marked with tags that have unique numbers, their length is measured, and they are then released. Subsequent efforts collect marked fish 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 production of white sturgeon ≥ 40 inches in total length by the corresponding estimated fraction of the population believed to be 15 years of age.

Trammel net surveys in San Pablo and Suisun Bays are also used to monitor the abundance of green sturgeon. As surveys for white sturgeon are conducted, the number of green sturgeon incidentally caught is tabulated. Production of green sturgeon in a given year is calculated by dividing the annual production estimate of white sturgeon ≥ 40 inches in 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 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.

2.3.2 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 index is based on sampling 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 303-316, 321-340, 401-418, 501-519, 601-608, 701-711, 802, 804, 806-815, and 901-915.

The location and number of index stations where the CDFG conducted the MWT survey within each of the 17 areas varied somewhat before 1980, but since that time most index stations have been consistently sampled; e.g., the percentage of core index stations sampled in September, October, November, and December since 1980 has been 97%, 97%, 96%, and 93%, respectively. The number of tows conducted during MWT surveys has increased on an annual basis from an average of 329 tows between 1967 and 1991 (excluding 1974 and 1979 when sampling was not done) to an average of 400 tows between 1992 and 2006. The number of stations that were sampled during the MWT survey in 2007 was the same time as during the past five years (Dave Contreras, CDFG, pers. comm.)

For each of the four months when sampling occurs, catches of juvenile American shad within each area are summed and a mean catch per tow is calculated. The mean catch per tow for each area is then weighted by the water volume (thousands of acre feet) in that area. These weighted catches are then summed for all areas to develop a monthly index, and the four monthly indices are summed to develop an annual MWT index. This index 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 captured fish are measured; these data can be used to determine the proportion of fish 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 D provides additional information on the procedure to transform the annual all-ages abundance index to an index limited to the YOY age class.

The raw data used to develop American shad production estimates in this report are contained in two references dated July 24, 2008: (1) an "AMESHA FMWT Indices 1967-2007.xls" spreadsheet; and (2) an "AMS Length Frequency 1971-2007.xls" spreadsheet.

2.3.3 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.

The Excel spreadsheet that provides production estimates for striped bass in this report is named "DRAFT --- ASB_Abundnace.xls". The date on this file is August 4, 2008.

SECTION 3: RESULTS

3.1 PRODUCTION OF ADULT CHINOOK SALMON

Because adult Chinook salmon data collected in 2006 and 2007 are subject to revision and refinement, salmon production estimates and any analyses for these years should be considered provisional. Production estimates for Chinook salmon that pertain to individual watersheds, runs, and the Central Valley are tabulated in Appendix B. The presence of a fish hatchery in a watershed confounds the ability to monitor natural production of Chinook salmon because it is not possible to accurately discriminate between, and therefore count, wild fish and unmarked hatchery fish.

3.1.1 PRODUCTION FOR INDIVIDUAL WATERSHEDS AND RUNS

3.1.1.1 AMERICAN RIVER

Estimates of natural production of adult fall-run Chinook salmon from the American River between 1992 and 2007 are presented in Table 3 and Figure 4. Natural production fluctuated between 20,810 and 255,478 fish between 1992 and 2007. Natural production experienced a general upward change from 25,193 fish in 1992 to 255,478 fish in 1995. Between 1996 and 2004, natural production fluctuated between 93,825 and 218,509 fish. Natural production then declined from 223,602 fish in 2004 to 20,810 fish in 2007.

The AFRP production target for fall-run Chinook salmon from the American River is 160,000 fish. Estimated natural production of this run of Chinook salmon in this watershed exceeded the AFRP production target six times between 1992 and 2007.

3.1.1.2 ANTELOPE CREEK

Data that monitor the abundance of fall-run Chinook salmon from Antelope Creek have not been collected in any year between 1992 and 2007. It is therefore not possible to determine if the AFRP production target of 720 fish has been met in this watershed during this period.

3.1.1.3 BATTLE CREEK

Estimates of natural production of adult fall-run Chinook salmon from Battle Creek between 1992 and 2007 are presented in Table 3 and Figure 4. With the exception of 2002 when natural production was estimated to be 71,867 fish, production fluctuated between 3,594 and 30,952 fish during the 1992-2007 time period.

The AFRP production target for fall-run Chinook salmon from Battle Creek is 10,000 fish. Estimated natural production of this run of Chinook salmon in this watershed consistently remained above the AFRP production target from 1994 to 2006, then dropped below the AFRP production target in 2007.

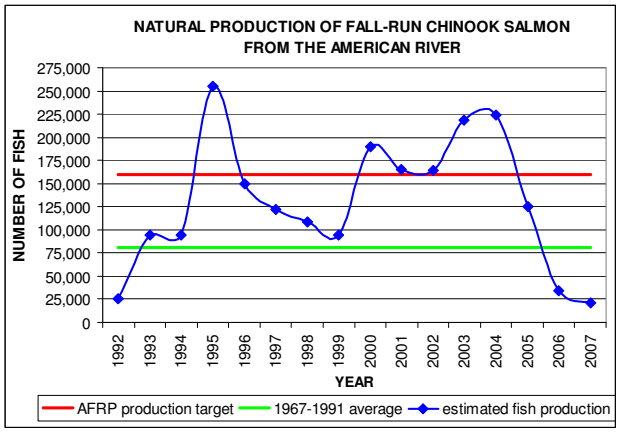
Table 3. Estimated natural production of adult fall-run Chinook salmon from 21 Central Valley watersheds, 1992-2007. Blank cells represent years when data were not collected for a particular run and location. * indicates a fish hatchery is present in the watershed.

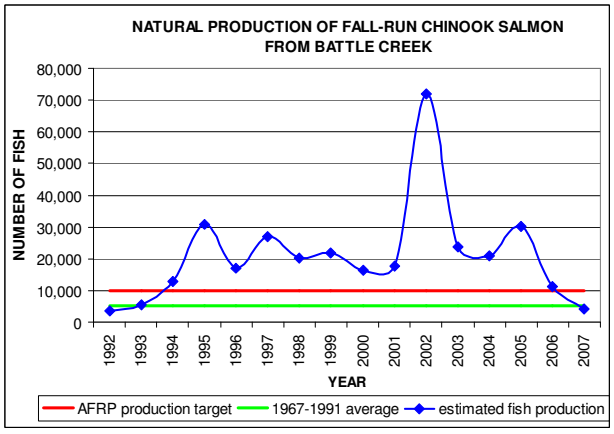
	YEAR															
Taxa	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**
Fall-run Chinook salmon																
American River*	25,193	93,900	94,218	255,478	149,501	121,699	108,216	93,825	189,454	164,670	164,473	218,509	223,602	125,002	34,047	20,810
Antelope Creek																
Battle Creek*	3,594	5,609	12,857	30,952	16,882	26,978	20,201	21,849	16,324	17,784	71,867	23,672	20,726	30,261	11,225	4,190
Bear River																
Big Chico Creek																
Butte Creek				1,347	931	1,682	825			5,017	5,649	4,103	4,540	6,340	2,222	1,892
Clear Creek	1,361	3,017	6,049	27,684	10,875	18,247	6,998	11,661	11,649	12,305	19,950	11,718	11,455	22,031	9,758	6,382
Cosumnes River							624									102
Cottonwood Creek	3,582															1,935
Cow Creek															4,786	3,162
Deer Creek		176	737			2,580	451						545	1,403	2,208	788
Feather River*	77,802	93,833	111,323	188,676	107,606	120,719	34,478	19,873	194,191	192,333	131,841	114,983	117,363	88,984	90,267	37,791
Merced River*	2,401	4,349	9,172	9,299	8,733	8,350	7,234	7,473	24,400	13,177	14,271	4,088	8,368	4,654	2,679	959
Mill Creek	2,267	4,759	2,568			1,018	908				3,238	2,992	2,132	3,618	1,627	1,229
"miscellaneous creeks"																123
Mokelumne River*	2,788	5,705	5,641	12,298	10,891	16,254	8,898	5,823	9,668	6,824	10,017	9,507	16,123	17,992	5,070	1,759
Paynes Creek																
Sacramento River mainstem	54,673	83,561	104,396	142,732	115,728	190,422	7,794	176,236	126,087	63,810	61,129	82,811	58,881	63,581	48,194	19,779
Stanislaus River	696	1,946	2,924	2,242	365	14,224	6,048	7,580	17,615	9,504	11,533	8,726	8,626	2,535	4,176	583
Tuolumne River	363	1,342	1,430	2,958	9,536	18,169	17,481	14,322	37,065	11,865	10,637	3,193	4,238	882	689	216
Yuba River	17,977	20,185	32,370	52,974	64,010	69,033	63,894	44,163	32,563	33,094	37,323	43,792	34,338	27,964	11,764	4,946
Total	192,696	318,381	383,686	726,639	495,060	609,375	284,050	402,804	659,014	530,382	541,927	528,093	510,936	395,247	228,711	106,647

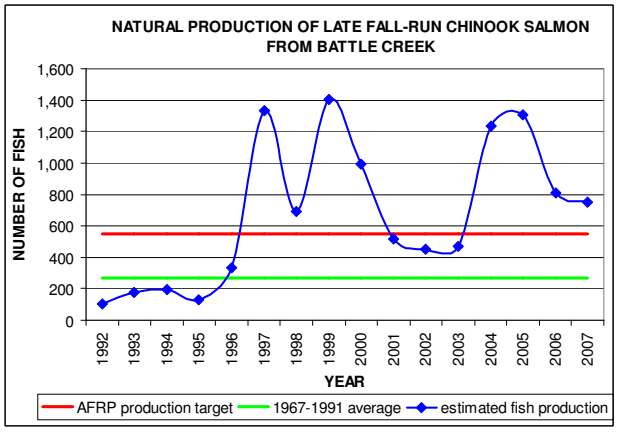
Table 4. Estimated natural production of adult late fall-, winter-, and spring-run Chinook salmon from Central Valley watersheds, 1992-2007. Blank cells represent years when data were not collected for a particular run and location. * indicates a fish hatchery is present in the watershed.

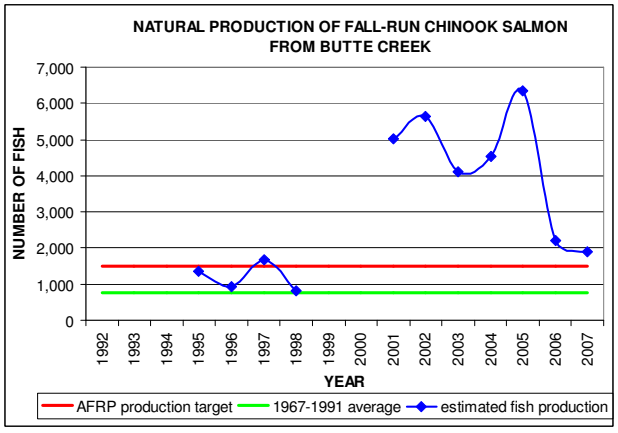
	YEAR															
Taxa	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**
Late-fall run Chinook salmon																
Battle Creek*	106	174	195	134	336	1,330	690	1,406	995	513	452	472	1,236	1,305	808	749
Sacramento River	26,487	2,237	869	630	111		78,692	15,838	18,793	25,996	55,919	8,289	19,874	17,675	20,549	29,487
Total	26,594	2,411	1,063	764	447	1,330	79,382	17,243	19,788	26,510	56,370	8,762	21,111	18,981	21,357	30,236
Winter-run Chinook salmon																
Sacramento River	3,190	1,024	506	4,079	2,112	2,010	5,623	5,439	2,659	10,572	10,508	11,552	16,101	26,761	22,782	4,461
Spring-run Chinook salmon																
Butte Creek	2,061	1,951	1,411	27,917	3,236	1,700	41,623	6,714	8,931	13,590	13,620	6,805	16,618	19,759	6,629	9,555
Deer Creek	590	777	1,444	4,819	1,406	1,248	3,860	2,903	1,381	2,295	3,387	4,269	1,808	4,164	3,521	1,245
Mill Creek	669	183	2,153	1,192	579	541	872	1,022	1,180	1,556	2,471	2,206	2,245	2,139	1,451	1,778
Sacramento River	1,143	1,280	2,800	1,731	945	374	2,500		168	1,136	462	0	966	61	0	523
Total	4,463	4,192	7,807	35,658	6,166	3,863	48,855	10,640	11,659	18,578	19,940	13,280	21,637	26,123	11,601	13,101
Total Natural Production of Adult Chinook Salmon	226,942	326,008	393,062	767,140	503,785	616,578	417,909	436,126	693,121	586,042	628,746	561,687	569,785	467,112	284,450	154,446

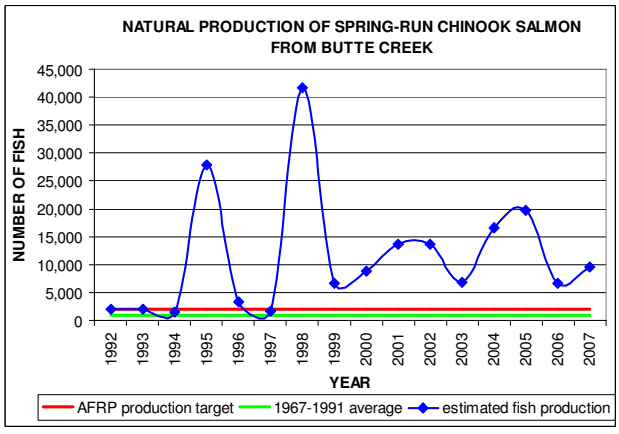
Figure 4. Estimated natural production of adult Chinook salmon from the American River, Battle Creek, Butte Creek, and Clear Creek, 1992-2007. Each graph provides the watershed's AFRP production target, estimated annual natural production of Chinook salmon between 1992 and 2007, and average natural production of Chinook salmon between 1967 and 1991.

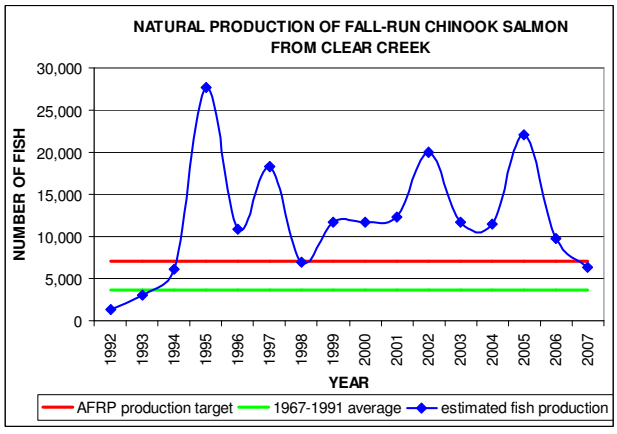












Estimates of natural production of adult late fall-run Chinook salmon from Battle Creek during the period 1992-2007 are presented Table 4 and Figure 4. Natural production was relatively low during the 1992-1996 period when estimated production was between 106 and 336 fish. Between 1997 and 2006, estimated natural production fluctuated between 452 and 1,406 fish.

The AFRP production target for adult late fall-run Chinook salmon from Battle Creek is 550 fish. Estimated natural production of this run of Chinook salmon in this watershed may have exceeded the AFRP production target eight times between 1992 and 2007.

There is, however, a strong potential that production targets for late fall-run Chinook salmon from Battle Creek were not met in eight years between 1992 and 2007. This scenario arises because escapement surveys for late fall-run Chinook salmon below the Coleman National Fish Hatchery on Battle Creek are not done, and estimates of natural production of these fish at that location in the Chinookprod spreadsheet are based solely on counts of adult salmon returning to Coleman National Fish Hatchery. Most, if not all, the salmon that return to the hatchery are hatchery-origin fish.

A relatively small number (i.e., 6-213) of wild late fall-run salmon entered the hatchery between 1998 and 2008 and were released upstream of the hatchery, thereby contributing to natural in-river escapement. These fish have not, however, been accounted for in the Chinookprod spreadsheet prior to 2006 and therefore are not used to calculate or track natural production. Because (1) management practices for hatchery-origin late fall-run Chinook salmon have improved since 1996, (2) the number of these fish has increased since that time, and (3) the Chinookprod spreadsheet production estimates prior to 2006 are based solely on counts of adult (and predominantly hatchery-origin) salmon returning to the hatchery, there is no definitive monitoring data that can be used to infer what the natural production of adult late fall-run Chinook salmon from Battle Creek is or has been.

3.1.1.4 BEAR RIVER

Data that monitor the abundance of fall-run Chinook salmon from Bear River have not been collected in any year between 1992 and 2007. It is therefore not possible to determine if the AFRP production target of 450 fish has been met in this watershed during this period.

3.1.1.5 BIG CHICO CREEK

Data that monitor the abundance of fall-run Chinook salmon from Big Chico Creek have not been collected in any year between 1992 and 2007. It is therefore not possible to determine if the AFRP production target of 800 fish has been met in this watershed during this period.

3.1.1.6 BUTTE CREEK

Estimates of natural production of adult fall-run Chinook salmon from Butte Creek between 1992 and 2007 is presented in Table 3 and Figure 4. Estimates of natural production are not available for 1992, 1993, 1994, 1999, and 2000. Numbers naturally produced between 1995 and 1998 fluctuated between 825 and 1,682 fish. During the 2001-2005 time period, natural

production ranged between 4,103 and 6,340 fish. Natural production of adult fall-run Chinook salmon from Butte Creek in 2006 and 2007 was markedly less than during the 2001-2005 period, with 2,222 and 1,892 fish, respectively.

The AFRP production target for fall-run Chinook salmon in Butte Creek is 1,500 fish. Estimated natural production consistently remained above the AFRP production target each year since 2001.

Estimates of natural production of adult spring-run Chinook salmon between 1992 and 2007 are presented in Table 4 and Figure 4. Natural production experienced large fluctuations between 1992 and 1999; i.e., between 1,411 and 41,623 fish were produced. Between 2000 and 2006, Butte Creek produced between 6,629 and 19,759 adult spring-run Chinook salmon each year.

The AFRP production target for spring-run Chinook salmon from Butte Creek is 2,000 fish. Estimated natural production has consistently remained above the AFRP production target each year since 1998.

3.1.1.7 CLEAR CREEK

Estimates of natural production of adult fall-run Chinook salmon from Clear Creek between 1992 and 2007 are presented in Table 3 and Figure 4. Estimates of production increased dramatically from 1,361 fish in 1992 to 27,684 fish in 1995. Between 1996 and 2006, estimated natural production fluctuated between 6,998 and 22,031 fish. In 2007, natural production of fall-run Chinook salmon from Clear Creek decreased to 6,382.

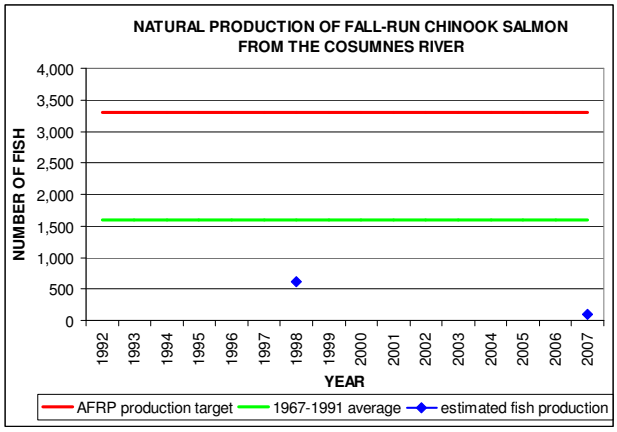
The AFRP production target for fall-run Chinook salmon from Clear Creek is 7,100 fish. Estimated natural production exceeded the AFRP production target eleven times between 1992 and 2007. The decline in the natural production of adult fall-run Chinook salmon from Clear Creek in 2007 marked the first time the AFRP production target in this watershed was not met since 1998.

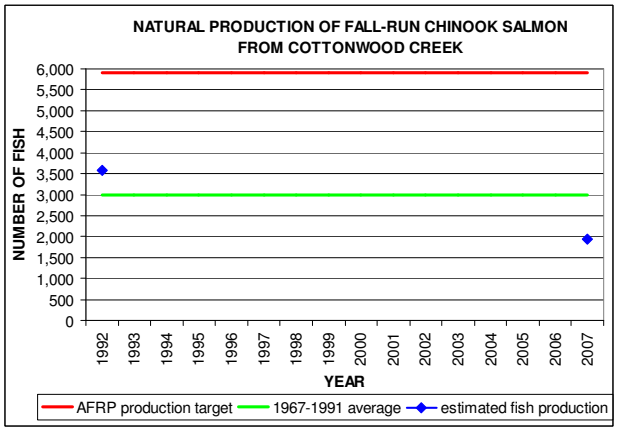
3.1.1.8 COSUMNES RIVER

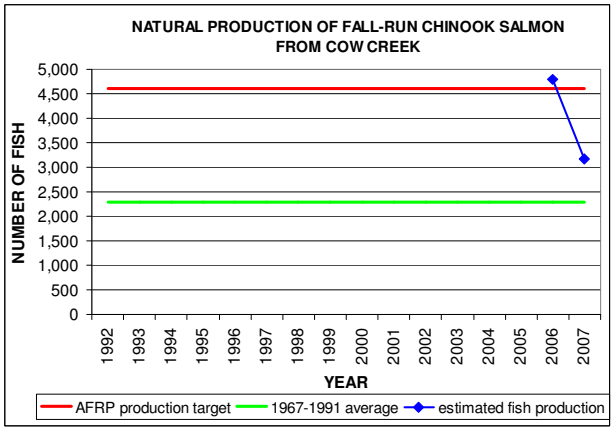
Estimates of natural production of adult fall-run Chinook salmon from Cosumnes River between 1992 and 2007 are presented in Table 3 and Figure 5. The natural production of fall-run Chinook salmon from Cosumnes River has only been quantified two times since 1992. Natural production of these fish from this watershed was estimated to be 624 fish in 1998, and 102 fish in 2007.

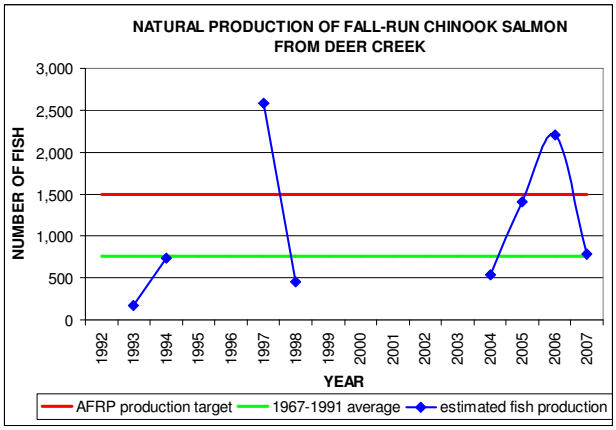
The AFRP production target for fall-run Chinook salmon from the Cosumnes River is 3,300 fish. The production target was not therefore met in either of the two years when monitoring was done since 1992.

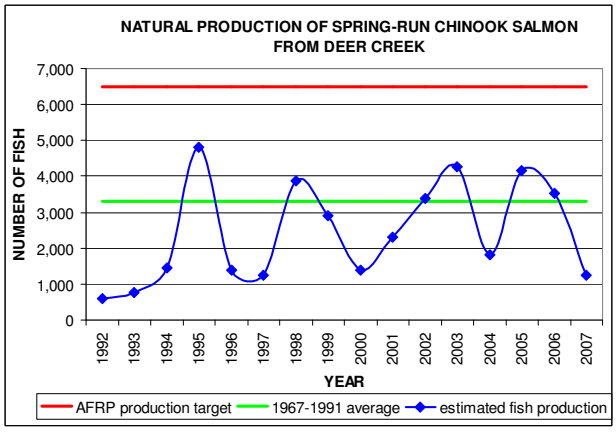
Figure 5. Estimated natural production of adult Chinook salmon from the Cosumnes River, Cottonwood Creek, Cow Creek, Deer Creek, and the Feather River, 1992-2007. Each graph provides the watershed's AFRP production target, estimated annual natural production of Chinook salmon between 1992 and 2007, and average natural production of Chinook salmon between 1967 and 1991.

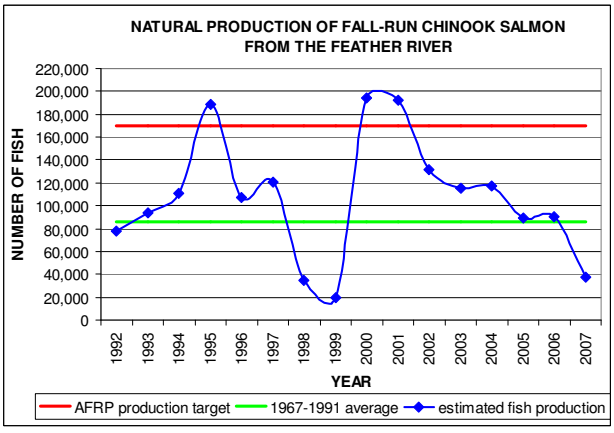












3.1.1.9 COTTONWOOD CREEK

Estimates of natural production of adult fall-run Chinook salmon from Cottonwood Creek between 1992 and 2007 are presented in Table 3 and Figure 5. Natural production of fall-run Chinook salmon from Cottonwood Creek has only been quantified two times since 1992. Natural production of these fish from this watershed was estimated to be 3,582 fish in 1992, and 1,935 fish in 2007.

The AFRP production target for fall-run Chinook salmon from Cottonwood Creek is 5,900 fish. The production target was not therefore met in either of the two years when monitoring was done since 1992.

3.1.1.10 COW CREEK

Estimates of natural production of adult fall-run Chinook salmon from Cow Creek between 1992 and 2007 are presented in Table 3 and Figure 5. Natural production of fall-run Chinook salmon from Cow Creek has only been quantified two times since 1992. The natural production of these fish from this watershed was estimated to be 4,786 fish in 2006, and 3,162 fish in 2007.

The AFRP production target for fall-run Chinook salmon from Cow Creek is 4,600 fish. The AFRP production target was therefore met in 2006, but was not met in 2007.

3.1.1.11 DEER CREEK

Estimates of natural production of adult fall-run Chinook salmon from Deer Creek between 1992 and 2007 are presented in Table 3 and Figure 5. Production estimates are not available for 1992, 1995, 1996, 1999, 2000, 2001, 2002, and 2003. The natural production of adult fall-run Chinook salmon from Deer Creek during the eight years monitoring was done between 1992 and 2007 fluctuated between 176 and 2,580 fish.

The AFRP production target for fall-run Chinook salmon from Deer Creek is 1,500 fish. Estimated natural production exceeded the AFRP production target twice in the eight years when production was estimated between 1992 and 2007.

Estimates of natural production of adult spring-run Chinook salmon from Deer Creek between 1992 and 2007 are presented in Table 4 and Figure 5. Estimates of the natural production of these fish in this watershed have ranged between 590 and 4,819 fish during this period.

The AFRP production target for adult spring-run Chinook salmon from Deer Creek is 6,500 fish. Estimated natural production of adult spring-run Chinook salmon in this watershed never equaled or exceeded the AFRP production target between 1992 and 2007.

3.1.1.12 FEATHER RIVER

Estimates of natural production of adult fall-run Chinook salmon from the Feather River between 1992 and 2007 are presented in Table 3 and Figure 5. Prior to 2003, estimates of the number of

fall-run Chinook salmon that returned to the Feather River Fish Hatchery included a combination of fall- and spring-run Chinook salmon because no simple method for distinguishing between the two runs existed. Beginning in 2003 and to the present time, spring-run Chinook salmon are 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. The hatchery return numbers used to estimate natural production of fall-run Chinook salmon prior to 2003 therefore tend to inflate the production estimates because they include some spring-run Chinook salmon.

Estimates of the natural production of adult fall-run Chinook salmon from the Feather River have fluctuated over time. Between 1992 and 1995, estimated natural production rose from 77,802 to 188,676 fish. In 1996 and 1997 production was somewhat lower, with 107,606 and 120,719 fish, respectively. The 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 the natural production estimate. In 2000 and 2001, natural production was 194,191 and 192,333 individuals, respectively. Estimated natural production then declined to 37,791 fish in 2007.

The AFRP production target for fall-run Chinook salmon from the Feather River is 170,000 fish. Estimated natural production equaled or exceeded this AFRP production target three times between 1992 and 2006, i.e., in 1995, 2000, and 2001.

3.1.1.13 MERCED RIVER

Estimates of natural production of adult fall-run Chinook salmon from the Merced River between 1992 and 2007 are presented in Table 3 and Figure 6. Natural production of fall-run Chinook salmon in this watershed ranged between 2,401 and 9,299 fish between 1992 and 1999, then rose to an exceptionally high level in 2000 when natural production was estimated to be 24,400 fish. Since 2000, salmon production from this river steadily declined from 13,177 fish in 2001 to 959 fish in 2007.

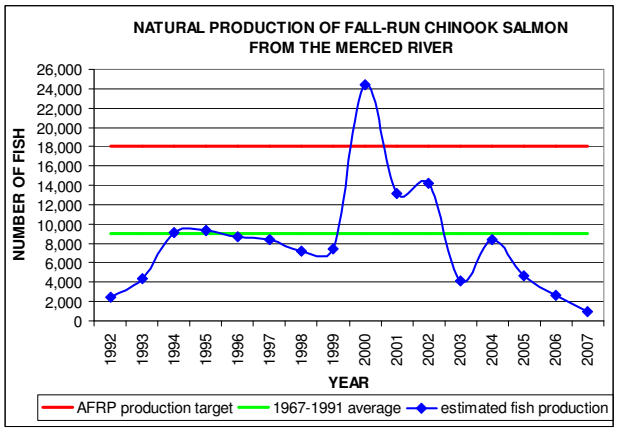
The AFRP production target for adult fall-run Chinook salmon from the Merced River is 18,000 fish. Estimated natural production equaled or exceeded the AFRP production target once between 1992 and 2007.

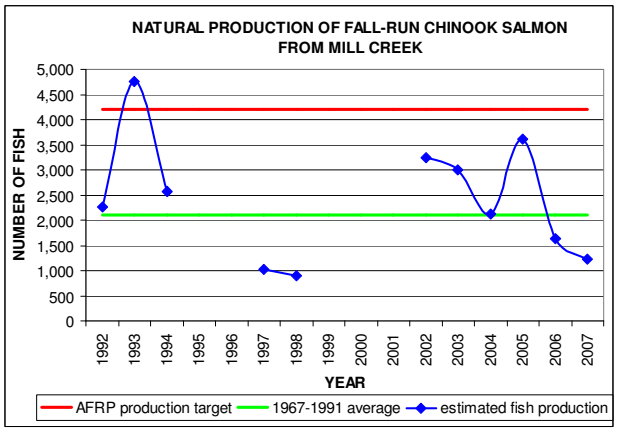
3.1.1.14 MILL CREEK

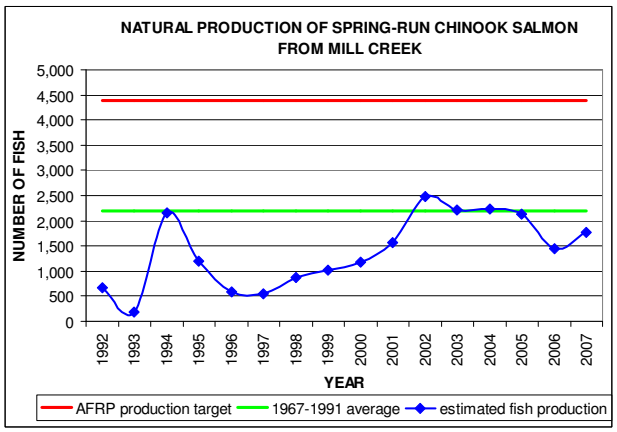
Estimates of natural production of adult fall-run Chinook salmon from Mill Creek between 1992 and 2007 are presented in Table 3 and Figure 6. Estimates are not available for 1995, 1996, 1999, 2000, and 2001. With the exception of 1993 when natural production of adult fall-run Chinook salmon from this creek was estimated to be 4,759 fish, numbers fluctuated between 908 and 3,618 individuals during the 11 years when fish production was estimated between 1992 and 2007.

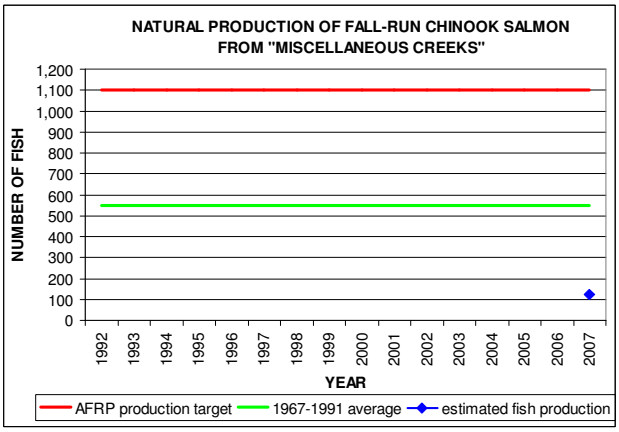
The AFRP production target for fall-run Chinook salmon from Mill Creek is 4,200 fish. Estimated natural production exceeded the AFRP production target once between 1992 and 2007, i.e., in 1993.

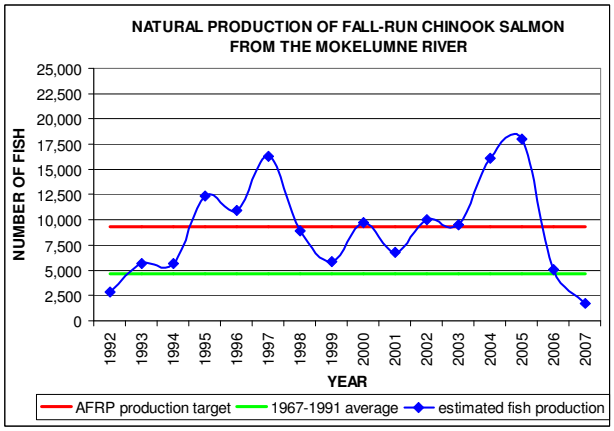
Figure 6. Estimated natural production of adult Chinook salmon from the Merced River, Mill Creek, seven "miscellaneous creeks", and the Mokelumne River, 1992-2007. Each graph provides the watershed's AFRP production target, estimated annual natural production of Chinook salmon between 1992 and 2007, and average natural production of Chinook salmon between 1967 and 1991.











Estimates of natural production of adult spring-run Chinook salmon from Mill Creek between 1992 and 2007 are presented in Table 4 and Figure 6. Estimates during this 16-year period have fluctuated between 183 and 2,471 fish. Most notably, between 1997 and 2002, estimated natural production experienced a general upward change from 541 to 2,471 fish. Between 2003 and 2007, natural production of spring-run Chinook salmon from Mill Creek fluctuated between 1,451 and 2,206 fish.

The AFRP production target for spring-run Chinook salmon from Mill Creek is 4,400 fish. The estimated natural production of these fish in this watershed never equaled or exceeded the AFRP production target between 1992 and 2007.

3.1.1.15 MISCELLANEOUS CREEKS

The AFRP fish production target that relates to the "miscellaneous creeks" includes the following seven watersheds above the Red Bluff Diversion Dam: 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, the only "miscellaneous creek" above the Red Bluff Diversion Dam where monitoring for Chinook salmon took place was Bear Creek.

Estimates of the combined natural production of adult fall-run Chinook salmon from the "miscellaneous creeks" between 1992 and 2007 are presented in Table 3 and Figure 6. The only production estimate that is available for the seven aforementioned watersheds during this 16-year period relates to the natural production of 123 fall-run Chinook salmon from Bear Creek in 2007.

The AFRP production target for fall-run Chinook salmon from the seven "miscellaneous creeks" above the Red Bluff Diversion Dam is 1,100 fish. The estimated natural production of fall-run Chinook salmon from these watersheds between 1992 and 2007 did not exceed the AFRP production target in the one year when monitoring data was done in one of the seven "miscellaneous creeks".

3.1.1.16 MOKELUMNE RIVER

Estimates of natural production of adult fall-run Chinook salmon from the Mokelumne River between 1992 and 2007 are presented in Table 3 and Figure 6. Estimated natural production rose from 2,788 fish in 1992 to 16,254 fish in 1997. Between 1998 and 2003, natural production fluctuated between 5,823 and 10,017 fish, then rose to 17,992 fish in 2005. Natural production of adult Chinook salmon from the Mokelumne River in 2006 and 2007 was markedly less, with 5,070 and 1,759 fish, respectively.

The AFRP production target for fall-run Chinook salmon on the Mokelumne River is 9,300 fish. Estimated natural production equaled or exceeded the AFRP production target eight times between 1992 and 2007.

3.1.1.17 PAYNES CREEK

The abundance of fall-run Chinook salmon from Paynes Creek was not monitored between 1992 and 2007. It is therefore not possible to determine if the AFRP production target of 330 fish was met in this watershed during this period.

3.1.1.18 SACRAMENTO RIVER MAINSTEM

Estimates of natural production of adult fall-run Chinook salmon from the Sacramento River mainstem between 1992 and 2007 are presented in Table 3 and Figure 7. Estimated natural production, in general, increased from 54,673 fish in 1992 to 190,422 fish in 1997. In 1998, the estimated natural production was 7,794 fish; this number is anomalously low due to a one-year change in the way the CDFG estimated in-river spawner abundance that year. In 1999, estimated natural production was 176,236 fish, then gradually declined to 19,779 fish in 2007.

The AFRP production target for fall-run Chinook salmon from the Sacramento River is 230,000 fish. Estimated natural production of this run of Chinook salmon in this watershed never equaled or exceeded the AFRP production target between 1992 and 2007.

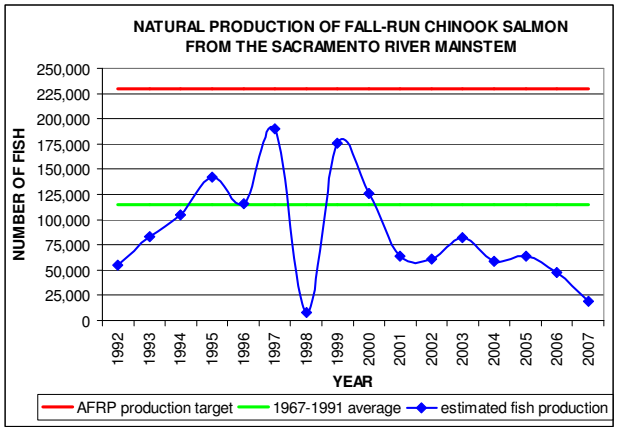
Estimates of natural production of adult late fall-run Chinook salmon between 1992 and 2007 are presented in Table 4 and Figure 7. Estimates of natural production are not available for 1997. During the 15 years monitoring data were collected between 1992 and 2007, estimated natural production has fluctuated in a marked way. Estimated production was particularly low between 1993 and 1996 when it ranged between 111 and 2,237 fish. In 1998, the estimated natural production was exceptionally high with 78,692 fish. With the exception of 2002 when estimated natural production was 55,919 individuals, estimated natural production between 1999 and 2007 ranged between 8,289 and 29,487 fish.

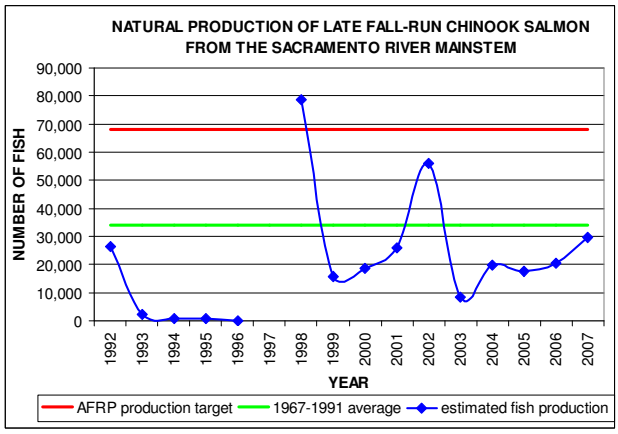
The AFRP production target for late fall-run Chinook salmon from the Sacramento River is 68,000 fish. Estimated natural production exceeded the AFRP production target once between 1992 and 2007.

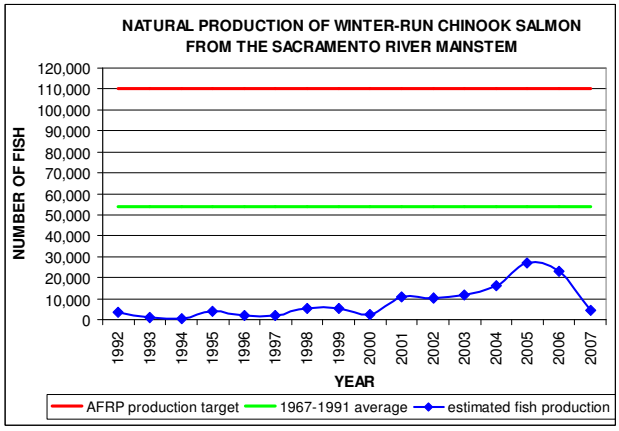
Estimates of natural production of adult winter-run Chinook salmon from the Sacramento River mainstem between 1992 and 2007 are presented in Table 4 and Figure 7. In general, natural production between 1992 and 2000 ranged between 506 and 5,623 fish. Estimated natural production between 2001 and 2006 was substantially greater than during the 1992-2000 period, and ranged between 10,508 and 26,761 fish. In 2007, natural production of adult winter-run Chinook salmon from the Sacramento River mainstem was 4,461 fish.

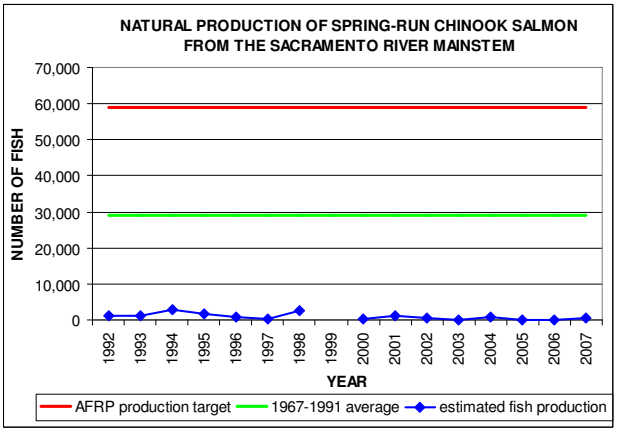
The AFRP production target for winter-run Chinook salmon from the Sacramento River is 110,000 fish. Estimated natural production never equaled or exceeded the AFRP production target between 1992 and 2007.

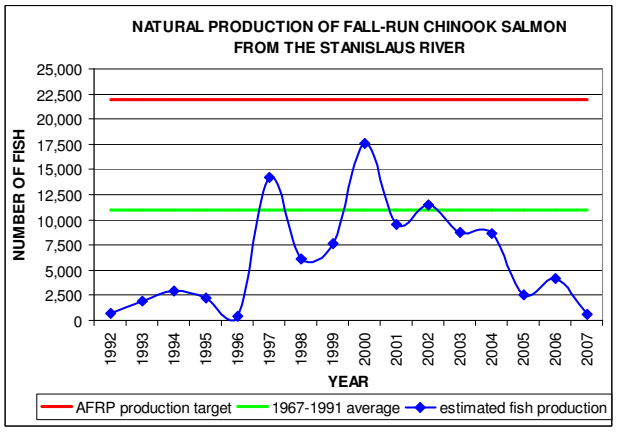
Figure 7. Estimated natural production of adult Chinook salmon from the Sacramento River, Stanislaus River, and Tuolumne River, 1992-2007. Each graph provides the watersheds AFRP production target, estimated annual natural production of Chinook salmon between 1992 and 2007, and average natural production of Chinook salmon between 1967 and 1991.

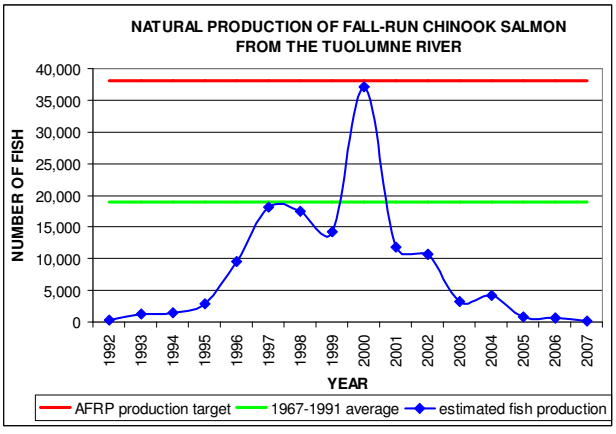












Estimates of natural production of adult spring-run Chinook salmon from the Sacramento River mainstem between 1992 and 2007 are presented in Table 4 and Figure 7. Escapement estimates for this run in this watershed in 2003 and 2006 were zero because no spring-run Chinook salmon were known to spawn in the river those years. Because there are no hatchery returns in this watershed with this run, the formulas in the Chinookprod spreadsheet used to estimate natural production generate a zero value for those years. At the time this report was produced, the Chinookprod 031808.xls spreadsheet inadvertently omitted a production estimate for this run in this watershed in 1999. In general, natural production has remained at relatively low levels since 1992, and has not exceeded 2,800 individuals during the 15 years when production estimates were calculated by the Chinookprod spreadsheet.

The AFRP production target for spring-run Chinook salmon from the Sacramento River is 59,000 fish. Estimated natural production never equaled or exceeded the AFRP production target between 1992 and 2007.

3.1.1.19 STANISLAUS RIVER

Estimates of natural production of adult fall-run Chinook salmon from the Stanislaus River between 1992 and 2007 are presented in Table 3 and Figure 7. Estimated natural production fluctuated between 365 and 2,924 fish during the 1992-1996 period. Between 1997 and 2004, estimated natural production increased relative to the 1992-1996 time period, and fluctuated between 6,048 and 17,615 fish. Between 2005 and 2007, production was less than during the 1997-2004 period, and ranged between 4,176 and 583 fish.

The AFRP production target for fall-run Chinook salmon from the Stanislaus River is 22,000 fish. Estimated natural production never equaled or exceeded the AFRP production target between 1992 and 2007.

3.1.1.20 TUOLUMNE RIVER

Estimates of natural production of adult fall-run Chinook salmon from the Tuolumne River between 1992 and 2007 are presented in Table 3 and Figure 7. Estimated natural production fluctuated between 363 and 2,958 fish between 1992 and 1995. Between 1996 and 1999, estimated natural production was greater than during the 1992-1995 period with 9,536-18,169 fish, and in 2000 natural production was estimated to be 37,065 fish. After 2000, natural production experienced a steady decline through 2007 when estimated natural production was 216 fish.

The AFRP production target of fall-run Chinook salmon from the Tuolumne River is 38,000 fish. Estimated production never equaled or exceeded the AFRP production target between 1992 and 2007.

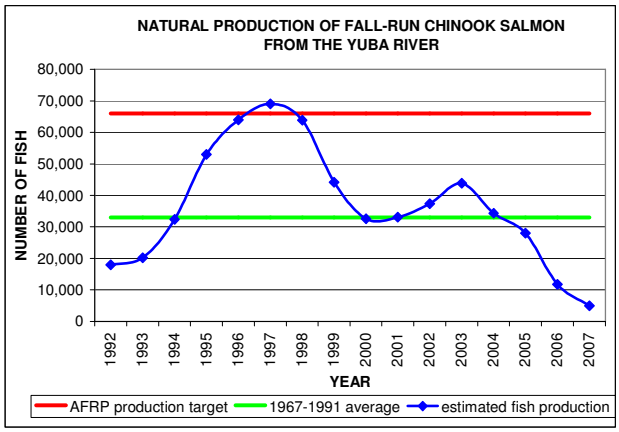
3.1.1.21 YUBA RIVER

Estimates of natural production of adult fall-run Chinook salmon from the Yuba River between 1992 and 2007 are presented in Table 3 and Figure 8. Estimated natural production steadily rose

from 17,977 fish in 1992 to 69,033 fish in 1997. After 1997, estimated natural production steadily declined to 32,563 fish in 2000, rose to 43,792 fish in 2003, and then steadily declined to 4,946 fish in 2007.

The AFRP production target of fall-run Chinook salmon from the Yuba River is 66,000 fish. Estimated natural production equaled or exceeded the AFRP production target one year between 1992 and 2007.

Figure 8. Estimated natural production of adult Chinook salmon from the Yuba River, 1992-2007. The graph provides the watershed's AFRP production target, estimated annual natural production of Chinook salmon between 1992 and 2007, and average natural production of Chinook salmon between 1967 and 1991.



3.1.2 TOTAL PRODUCTION FOR INDIVIDUAL RUNS

The production estimates for each of the four runs below only include fish abundance estimates for watersheds and runs having an AFRP fish production target. For example, the spring-run production estimates only includes fish from Butte Creek, Deer Creek, Mill Creek, and the Sacramento River, and would not account for fish in other watersheds where spring-run Chinook salmon occur, e.g., Battle Creek, Clear Creek, or Cottonwood Creek. This same concept applies to the other three runs and the total Central Valley production estimates.

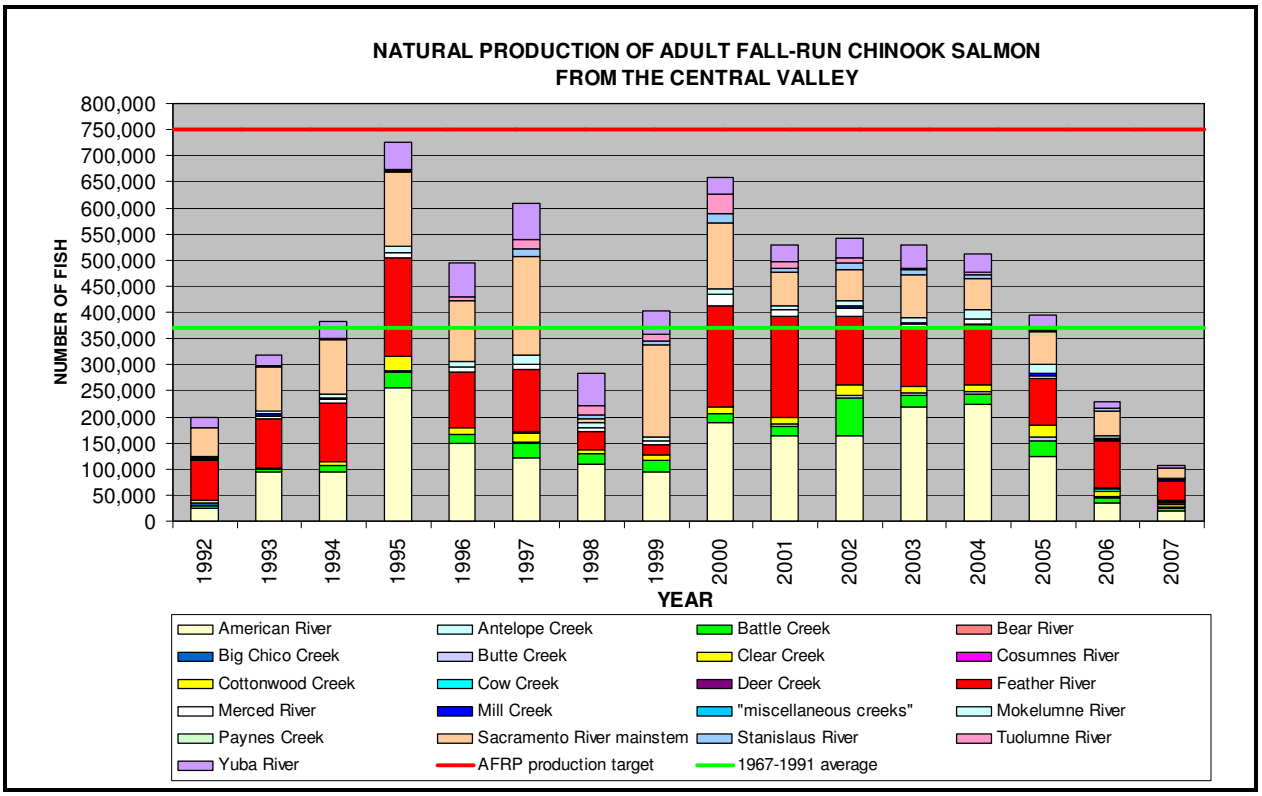
3.1.2.1 FALL-RUN CHINOOK SALMON

Estimates of total natural production of adult fall-run Chinook salmon in the Central Valley between 1992 and 2007 are presented in Table 3 and Figure 9. The fall-run production estimates include the combined contributions from the aforementioned 21 watersheds. In general, total natural production increased each year from 192,696 in 1992 to 726,639 fish in 1995; ranged between 284,050 and 659,014 fish between 1996 and 2001; and declined on a consistent basis from 541,927 fish in 2002 to 106,647 fish in 2007. Between 1992 and 2007 and in descending order based on their average annual production during this period, the following watersheds

consistently contributed the greatest number of salmon to the fall-run Chinook salmon production estimate: American River, Feather River, Sacramento River mainstem, Yuba River, and Battle Creek.

The AFRP production target for adult fall-run Chinook salmon from the aforementioned 21 watersheds in the Central Valley is 750,600 fish. Fish surveys in the Central Valley between 1992 and 2007 suggest the total natural production of adult fall-run Chinook salmon from these watersheds never equaled or exceeded this production target during that period.

Figure 9. Estimated total natural production of adult fall-run Chinook salmon from the Central Valley, 1992-2007. Annual estimates of natural production reflect contributions from 21 watersheds. The AFRP fall-run Chinook salmon production target is 750,000 fish, and the 1967-1991 baseline average is 370,000 Chinook salmon.



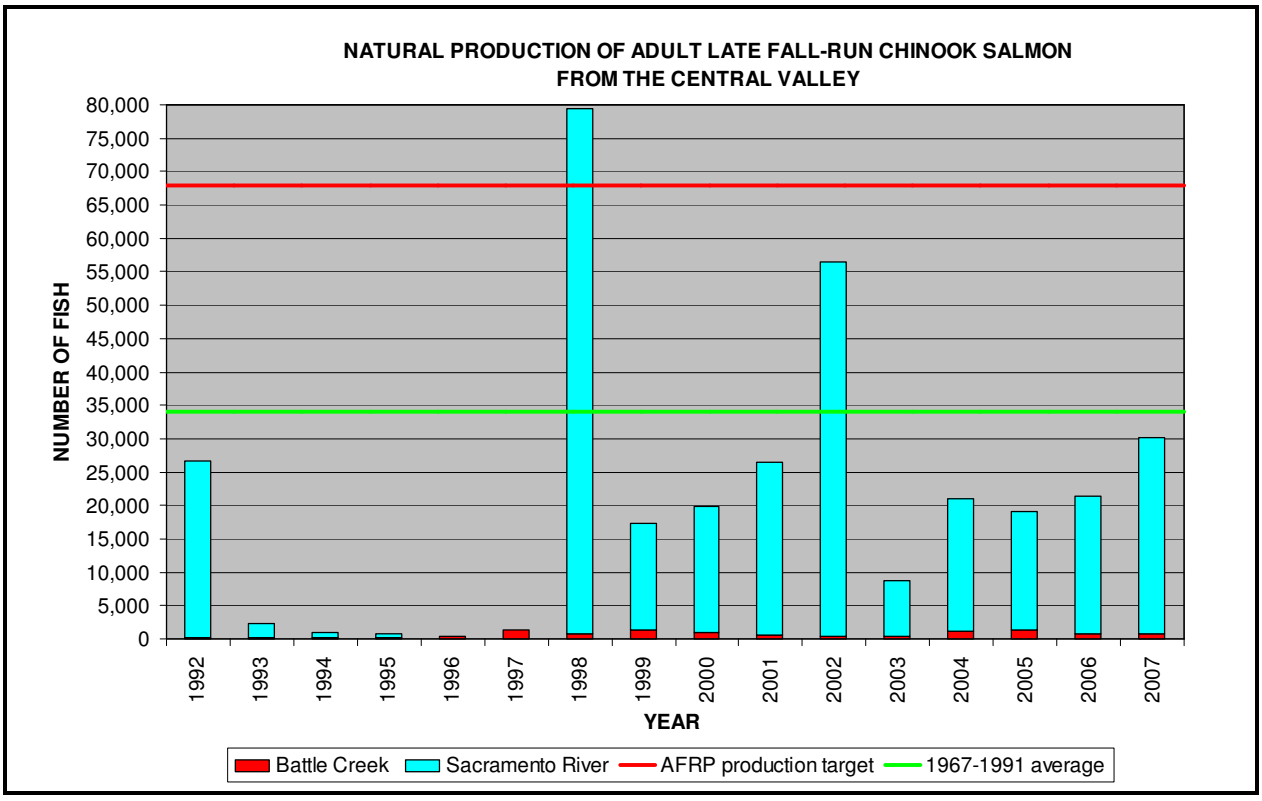
3.1.2.2 LATE FALL-RUN CHINOOK SALMON

Estimates of total natural production of adult late fall-run Chinook salmon in the Central Valley between 1992 and 2007 are presented in Table 4 and Figure 10. These production estimates include contributions from Battle Creek and the Sacramento River mainstem. In 1992, 26,594 adult late fall-run Chinook salmon were naturally produced from these two watersheds. Between 1993 and 1997, estimated total production never exceeded 2,411 fish. In 1998, total natural production from the two watersheds increased to 79,382 fish. During the period 1999-2007, the

total natural production from Battle Creek and the Sacramento River mainstem fluctuated between 8,762 and 56,370 fish. Between 1992 and 2007, the Sacramento River mainstem consistently produced far more adult late fall-run Chinook salmon than Battle Creek.

The AFRP total production target for adult late fall-run Chinook salmon is 68,000 fish. Fish surveys indicate total natural production of adult late fall-run Chinook salmon from Battle Creek and the Sacramento River mainstem met this production target once during that 16-year period (i.e., in 1998).

Figure 10. Estimated total natural production of adult late fall-run Chinook salmon from the Central Valley, 1992-2007. Annual estimates reflect contributions from the Sacramento River mainstem and Battle Creek. The AFRP late fall-run Chinook salmon production target is 68,000 fish, and the 1967-1991 baseline average is 34,000 Chinook salmon.

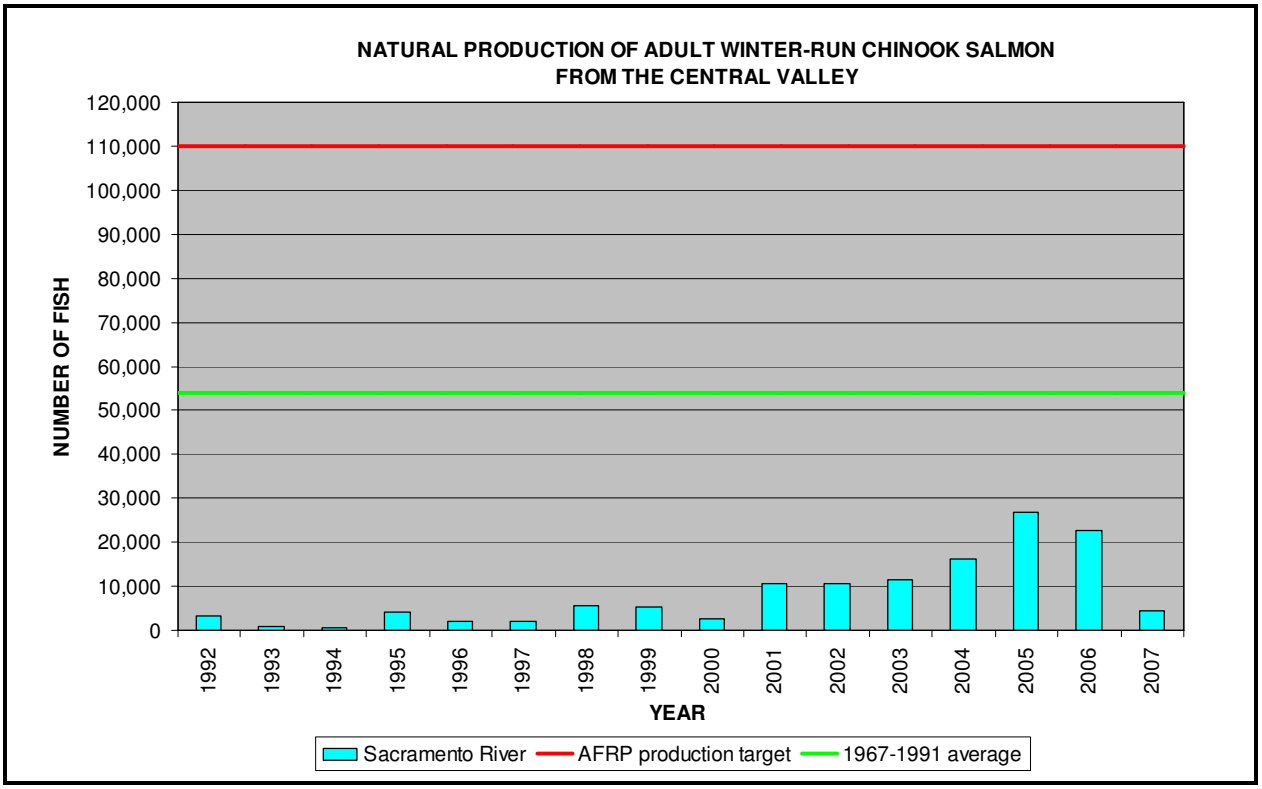


3.1.2.3 WINTER-RUN CHINOOK SALMON

Estimates of total natural production of adult winter-run Chinook salmon from the Central Valley between 1992 and 2007 are presented in Table 4 and Figure 11. These production estimates are limited to contributions from the Sacramento River mainstem. Natural production between 1992 and 2000 fluctuated between 506 and 5,623 fish. Between 2001 and 2005, the production of adult winter-run Chinook salmon steadily increased from 10,572 to 26,761 fish, then declined to 4,461 fish in 2007.

The AFRP total production target for adult winter-run Chinook salmon is 110,000 fish. Chinook salmon surveys indicate natural production from the Sacramento River mainstem between 1992 and 2007 never met that production target during that 16-year period.

Figure 11. Estimated total natural production of adult winter-run Chinook salmon from the Central Valley, 1992-2007. Annual estimates reflect contributions only from the Sacramento River mainstem. The AFRP winter-run Chinook salmon production target is 110,000 fish, and the 1967-1991 baseline average is 54,000 Chinook salmon.

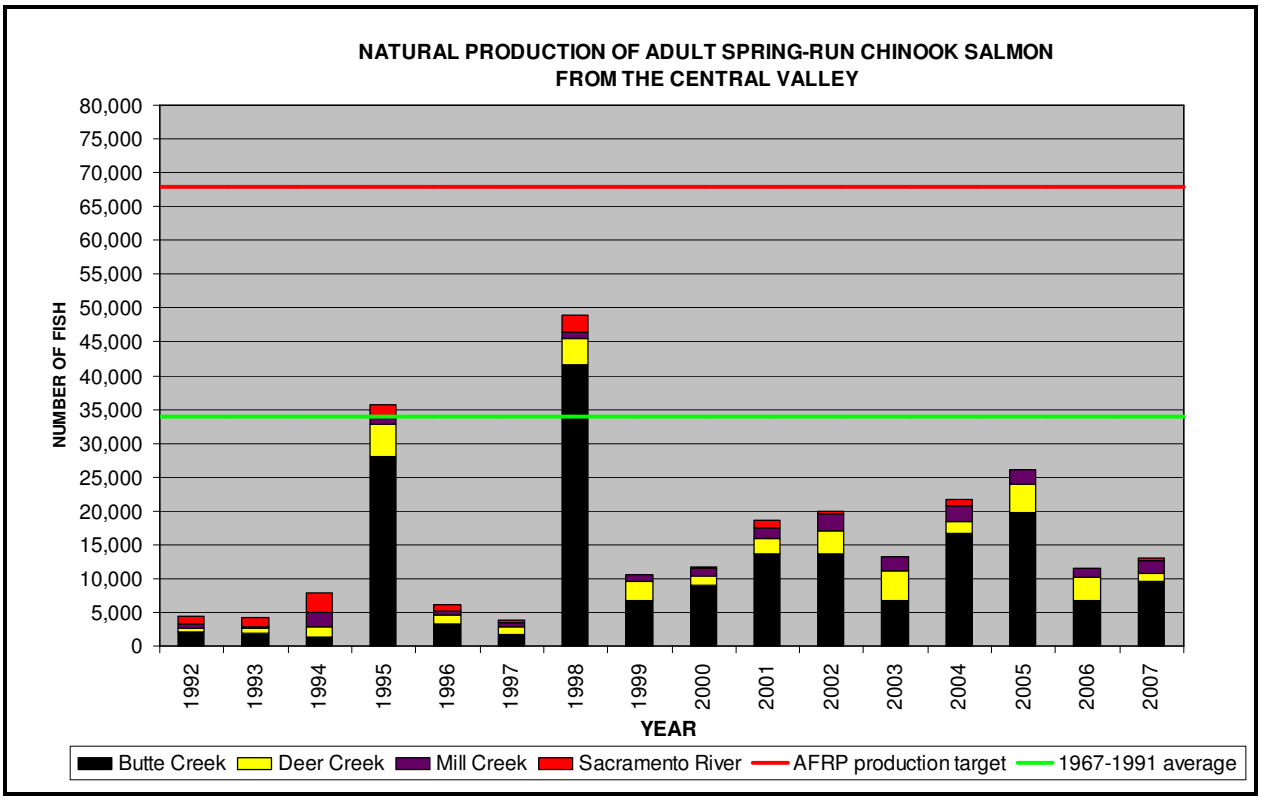


3.1.2.4 SPRING-RUN CHINOOK SALMON

Estimates of total natural production of adult spring-run Chinook salmon in the Central Valley between 1992 and 2007 are presented in Table 4 and Figure 12. Production estimates include contributions from Butte Creek, Deer Creek, Mill Creek, and the Sacramento River mainstem. With the exception of 1995 when a total of 35,658 adult spring-run Chinook salmon were naturally produced from these four watersheds, combined natural production fluctuated between 3,863 and 7,807 fish between 1992 and 1997. In 1998, the total number produced was 48,855 fish. Between 1999 and 2007, total natural production fluctuated between 10,640 and 26,123 fish. Butte Creek consistently produced as many or more adult spring-run Chinook salmon as the other three watersheds combined.

The AFRP total production target for adult spring-run Chinook salmon is 68,000 adult fish. Chinook salmon surveys in Butte Creek, Deer Creek, Mill Creek, and the Sacramento River mainstem between 1992 and 2007 suggest this production target was never met during that 16-year period.

Figure 12. Estimated total natural production of adult spring-run Chinook salmon from the Central Valley, 1992-2007. Annual estimates reflect 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 34,000 Chinook salmon.



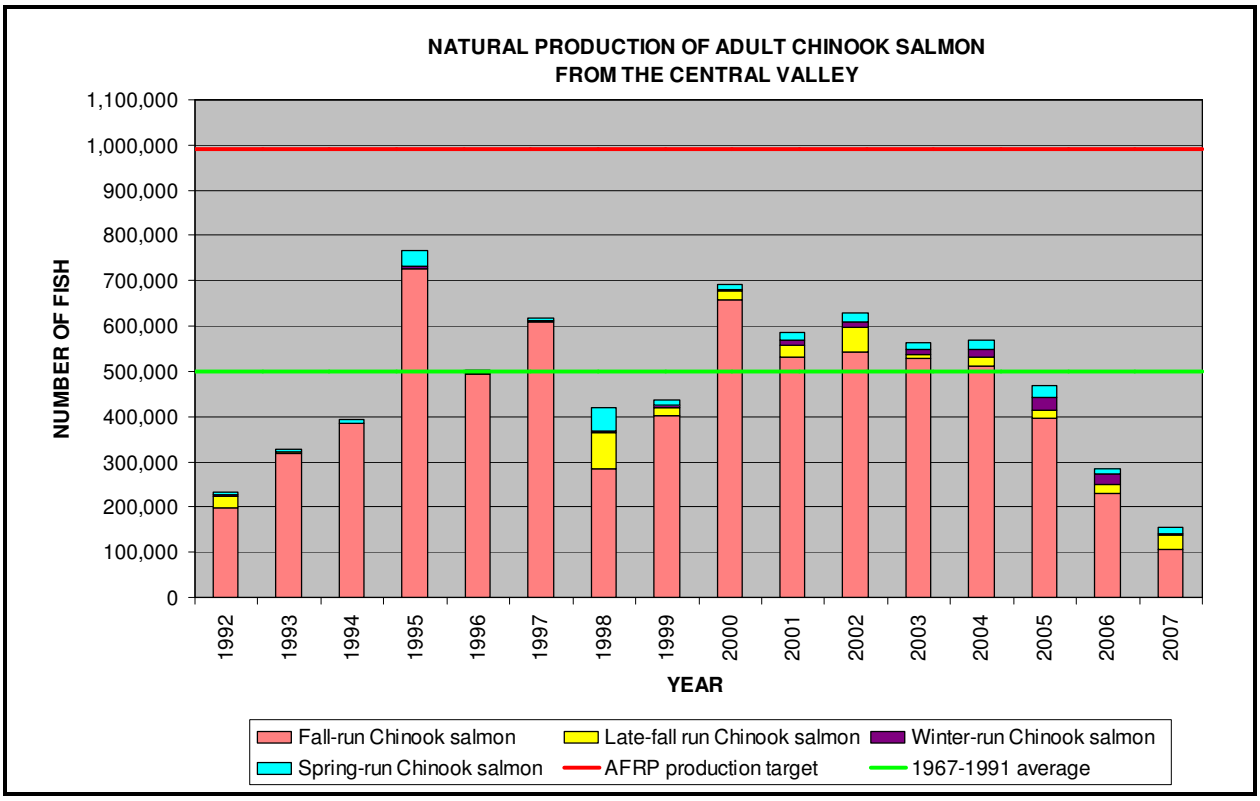
3.1.3 TOTAL CENTRAL VALLEY PRODUCTION

Estimates of the Central Valley-wide production for the combined total of all four runs of Chinook salmon from the aforementioned 21 watersheds between 1992 and 2007 are presented in Table 4 and Figure 13. The combined production for all 4 runs from these 21 watersheds ranged between 154,446 and 767,140 fish during the 16-year period. In general, total natural production increased each year between 1992 and 1995 from 226,942 to 767,140 fish, fluctuated between 417,909 and 693,121 salmon from 1996 and 2001; and declined on a consistent basis from 628,746 Chinook salmon in 2002 to 154,446 Chinook salmon in 2007. During the 16-year period between 1992 and 2007, the average contribution of fall-, late fall-, winter-, and spring-

run Chinook salmon to the total Central Valley natural production was 91%, 4%, 2%, and 3%, respectively.

The AFRP total Central Valley production target for adult Chinook salmon is 990,000 fish. Chinook salmon surveys on the aforementioned 21 watersheds between 1992 and 2007 suggest this production target was never met during that 16-year period.

Figure 13. Estimated total natural production of adult fall-, late fall-, winter-, and spring-run Chinook salmon from the Central Valley, 1992-2007. Annual estimates reflect the combined total production of all four runs of Chinook salmon from 21 watersheds. The AFRP total Central Valley production target for adult Chinook salmon is 990,000 fish, and the 1967-1991 baseline average is 500,000 Chinook salmon.



3.2 ADULT SALMON POPULATION ASSESSMENTS

3.2.1. NUMBER OF YEARS AFRP PRODUCTION TARGETS WERE MET

Annual monitoring data that quantify natural production of adult Chinook salmon in the Central Valley during the 16-year period between 1992 and 2007 suggest the:

- Watershed-specific AFRP production targets for fall-run Chinook salmon were met six or more times in the following watersheds: American River, Battle Creek, Butte Creek,

Clear Creek, and Mokelumne River (Figure 14). In contrast, the available data suggest production targets for fall-run Chinook salmon were met three or fewer times in the following watersheds when monitoring was conducted: Cosumnes River, Cottonwood Creek, Cow Creek, Deer Creek, Feather River, Merced River, Mill Creek, seven "miscellaneous creeks", Sacramento River mainstem, Stanislaus River, Tuolumne River, and Yuba River. In some of these watersheds, sufficient data are available on an annual basis to determine they did not meet their AFRP production target. In others, there was insufficient monitoring on a regular basis to determine whether or not they met their targets. Monitoring data for fall-run Chinook salmon have not been collected on Antelope Creek, Bear River, Big Chico Creek, and Paynes Creek since 1991, and it is therefore not possible to quantify how often the watershed-specific AFRP production targets for fall-run Chinook salmon were met in these locations.

- Watershed-specific AFRP production target for late fall-run Chinook salmon may have been met eight times on Battle Creek (Figure 15). The reason the AFRP's late fall-run Chinook salmon 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 on the Sacramento River mainstem was met once.

- Watershed-specific AFRP production target for winter-run Chinook salmon was never met on the Sacramento River mainstem (Figure 16).

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

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

- Central Valley-wide AFRP production target for the combined total of all 4 runs of Chinook salmon was never met.

Figure 14. Number of times watershed-specific AFRP fall-run Chinook salmon production targets were met or exceeded during the 16-year period 1992-2007. Monitoring data are not available each year in the following watersheds and readers should review Table 5 to understand how frequently monitoring was done: Butte Creek, Cosumnes River, Cottonwood Creek, Cow Creek, Deer Creek, Mill Creek, and seven "miscellaneous creeks". Monitoring data were not collected in Antelope Creek, Bear River, Big Chico Creek, or Paynes Creek between 1992 and 2007.

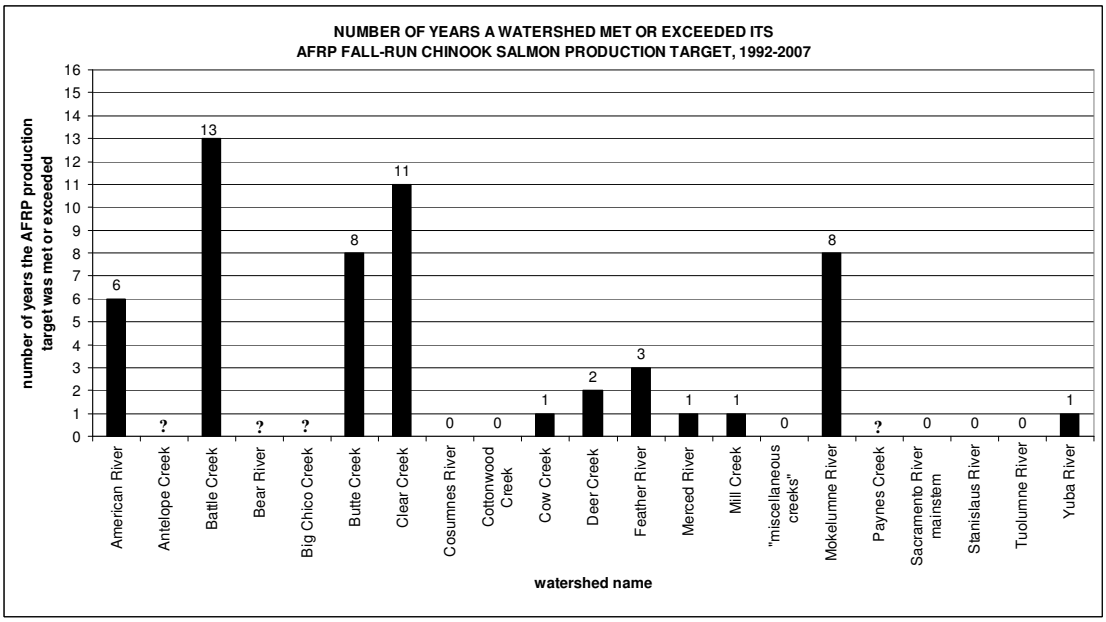


Figure 15. Number of times the watershed-specific AFRP late fall-run Chinook salmon production targets were met or exceeded during the 16-year period 1992-2007. Monitoring data for late fall-run Chinook salmon from the Sacramento River mainstem are available for 15 of the 16 years since 1992.

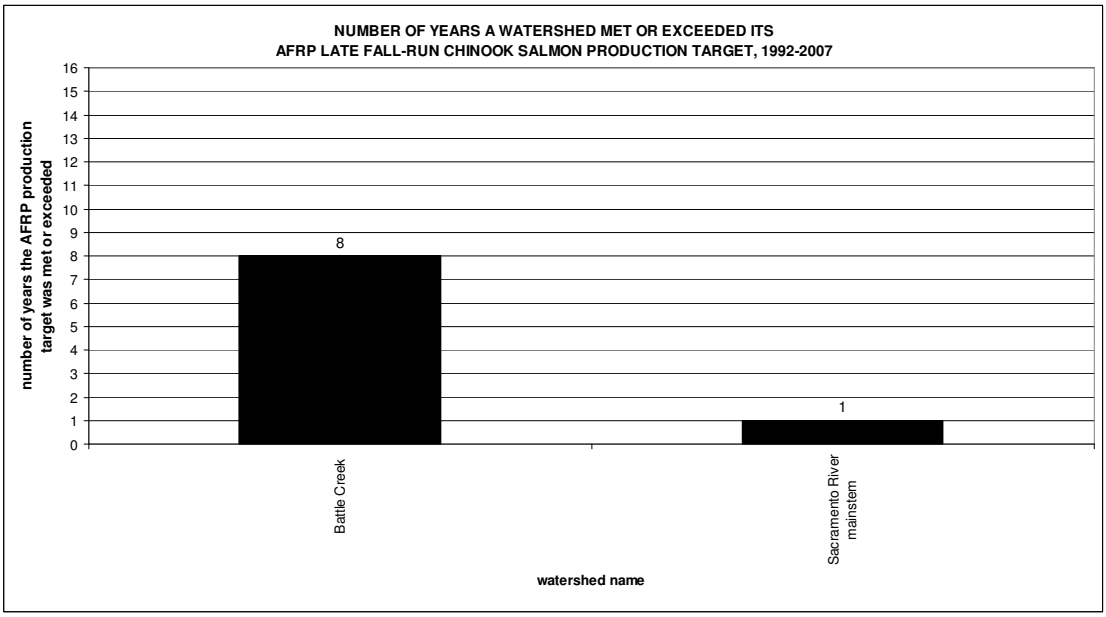


Figure 16. Number of times the watershed-specific AFRP winter-run Chinook salmon production target was met or exceeded during the 16-year period 1992-2007.

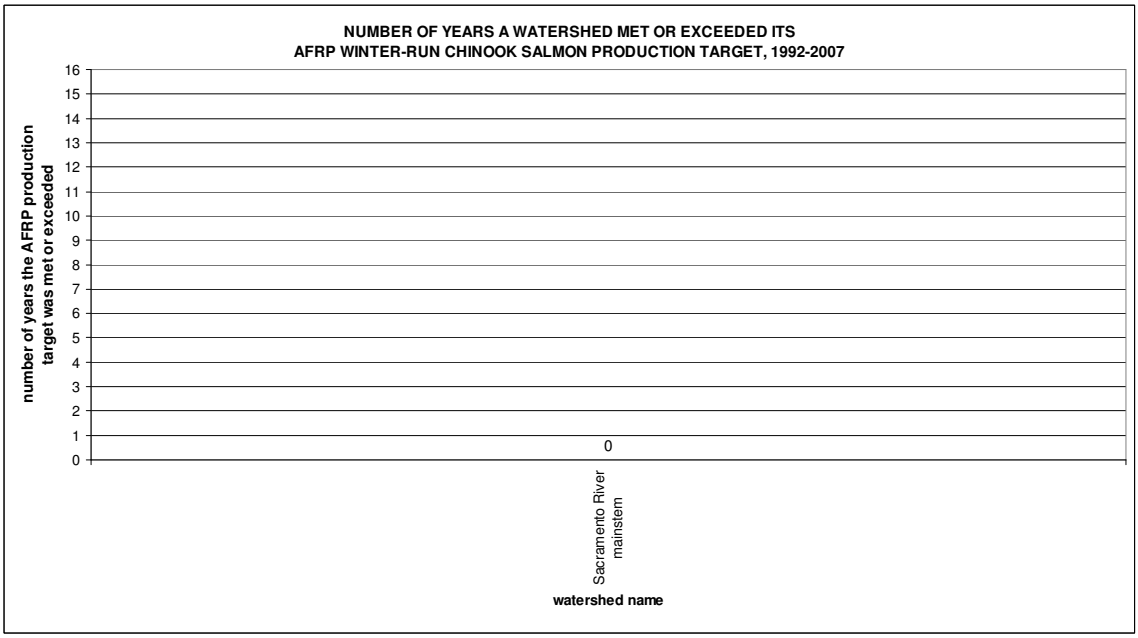
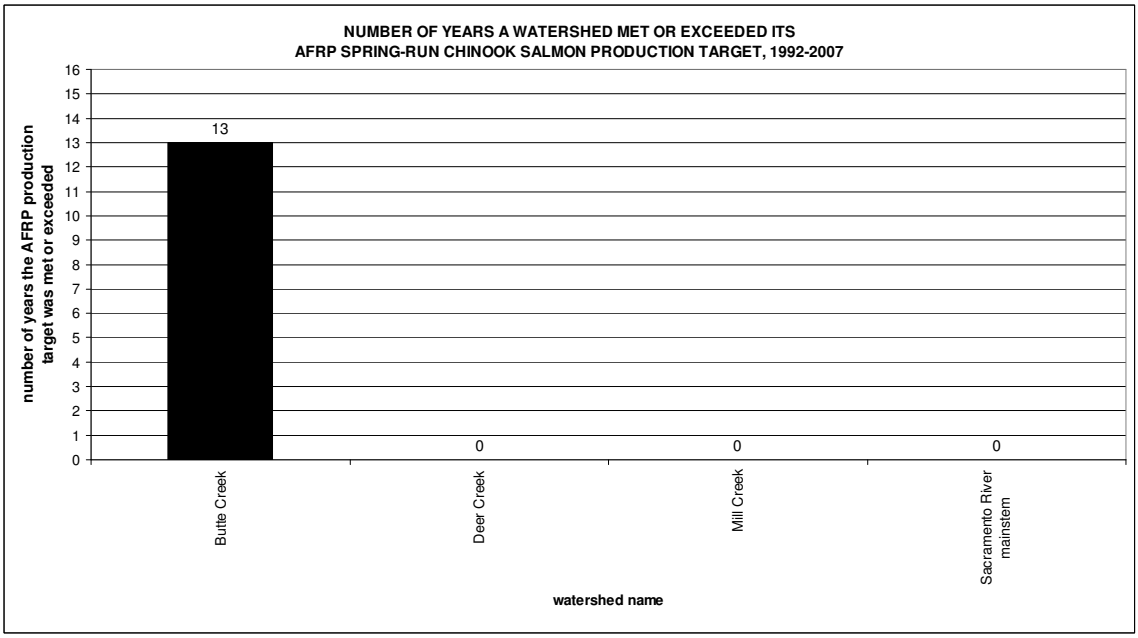


Figure 17. Number of times the watershed-specific AFRP spring-run Chinook salmon production targets were met or exceeded during the 16-year period 1992-2007. Monitoring data for spring-run Chinook salmon from the Sacramento River mainstem are currently available for 15 of the 16 years since 1992.



3.2.2 CHANGES IN THE AVERAGE NATURAL PRODUCTION OF CHINOOK SALMON FROM DIFFERENT WATERSHEDS

A comparison of the average natural production of adult Chinook salmon in several watersheds in the Central Valley during the 1967-1991 and 1992-2007 time periods indicates there have been statistically significant changes in some watersheds (Tables 5 and 6). In contrast, average natural production of adult Chinook salmon in other watersheds has not experienced a significant change over time. Changes in the average natural production of adult Chinook salmon from Antelope Creek, Bear River, Big Chico Creek, Cosumnes River, Cottonwood Creek, Cow Creek, the seven "miscellaneous creeks ", and Paynes Creek could not be assessed due to the low number of years monitoring was done in the 1967-1991 or 1992-2007 time periods.

For adult fall-run Chinook salmon, average estimated natural production was significantly greater from the American River, Battle Creek, Butte Creek, Clear Creek, Feather River, and Mokelumne River during the 1992-2007 time period than during the 1967-1991 time period. Significantly fewer adult fall-run Chinook salmon were produced on average in the Tuolumne River during the latter period. Average estimated natural production of adult fall-run Chinook salmon from Deer Creek, Mill Creek, and the Yuba River was greater during the 1992-2007 time period than during the 1967-1991 time period, but these increases were not statistically significant. While not statistically significant, average estimated natural production of adult fall-run Chinook salmon from the Merced, Sacramento, and Stanislaus Rivers declined during the latter period relative to the baseline period.

For adult late fall-run Chinook salmon, average estimated natural production from Battle Creek may have been significantly greater during the 1992-2007 time period than during the 1967-1991 time period. Average estimated natural production of these fish from the Sacramento River mainstem was less in the later period, but not significantly so.

For adult winter-run Chinook salmon, average estimated natural production from the Sacramento River mainstem was significantly less during the 1992-2007 time period than during the 1967-1991 time frame.

For adult spring-run Chinook salmon, average estimated natural production from Butte Creek was significantly greater during the 1992-2007 time period than during the 1967-1991 time frame. In contrast, average estimated natural production of adult spring-run Chinook salmon from the Sacramento River mainstem was significantly less during the 1992-2007 time period. In Deer and Mill Creeks, average estimated natural production of adult spring-run Chinook salmon declined over time, although these decreases were not statistically significant.

Table 5. Summary statistics of average natural production of adult fall-run Chinook salmon from 21 Central Valley watersheds, 1967-2007. n = number of years monitoring data were available during a time period. SD = 1 standard deviation. * = significant at α = 0.05. ???? = insufficient data.

	1967-1991			1992-2007				
Watershed	n	Average production	SD	n	Average production	SD	change in average production 1967-1991 vs. 1992-2007	P-value
American River	25	80,846	28,715	16	130,162	58,550	up	0.0034*
Antelope Creek	19	361	312	0	???	???	???	???
Battle Creek	25	5,012	5,069	16	20,936	14,166	up	0.0003*
Bear River	1	639	???	0	???	???	???	???
Big Chico Creek	3	402	297	0	???	???	???	???
Butte Creek	10	763	561	11	3,141	1,709	up	0.0009*
Clear Creek	16	3,574	3,275	16	11,946	5,936	up	0.00009*
Cosumnes River	17	1,659	1,897	2	363	238	down	???
Cottonwood Creek	17	2,962	3,250	2	2,759	437	down	???
Cow Creek	12	2,330	3,631	2	3,974	???	up	???
Deer Creek	23	766	406	8	1,111	744	up	0.1257
Feather River	25	86,007	24,956	16	107,629	42,170	up	0.0421*
Merced River	25	9,004	10,848	16	8,100	4,989	down	0.3619
Mill Creek	24	2,118	2,061	11	2,396	942	up	0.2972
miscellaneous creeks	20	550	492	1	123	???	down	???
Mokelumne River	25	4,679	4,447	16	9,079	3,921	up	0.0023*
Paynes Creek	9	170	123	0	???	???	???	???
Sacramento River	25	115,338	25,391	16	87,488	43,846	down	0.0178*
Stanislaus River	24	10,868	11,264	16	6,208	4,650	down	0.0452*
Tuolumne River	25	18,946	18,102	16	8,399	9,083	down	0.013*
Yuba River	25	33,253	20,432	16	36,899	15,193	up	0.2628

Table 6. Summary statistics of average natural production of adult late fall-, winter-, and spring-run Chinook salmon from Central Valley watersheds, 1967-2007. N = number of years monitoring data were available during a time period. SD = 1 standard deviation. * = significant at $\alpha = 0.05$.

		1967-1991			1992-2007				
Watershed	Run	n	Average production	SD	n	Average production	SD	change in average production 1967-1991 vs. 1992-2007	P-value
Battle Creek	late fall-run	23	273	160	16	681	396	up	0.0007*
Butte Creek	spring-run	25	1,017	1,335	16	11,383	9,929	up	0.0004*
Deer Creek	spring-run	18	3,273	4,087	16	2,445	1,161	down	0.2125
Mill Creek	spring-run	18	2,201	1,751	16	1,390	584	down	0.0421*
Sacramento River	late fall-run	25	33,931	18,888	15	21,430	19,493	down	0.0332*
Sacramento River	winter-run	25	54,294	58,534	16	8,086	7,126	down	0.0007*
Sacramento River	spring-run	25	29,402	16,409	15	939	782	down	0.00001*

3.2.3 CHANGES IN NATURAL PRODUCTION OF CHINOOK SALMON BASED ON THE PSC'S REBUILDING ASSESSMENT METHODS

An assessment of changes in estimated natural production of adult Chinook salmon using the PSC's rebuilding assessment methods during the period 2000-2005 are presented in Table 7. The assessment suggests: (1) annual incremental production targets were met in some watersheds; (2) production of adult Chinook salmon in some watersheds did not rebuild toward the annual incremental production targets, or (3) it is not possible to use the PSC's rebuilding assessment methods to assess changes in anadromous fish numbers because: (a) insufficient monitoring data were available to make an assessment, or (b) the PSC rebuilding assessment methods yielded mixed results and a run was therefore classified as "indeterminate".

Application of the PSC's rebuilding assessment methods to data collected during the 2000-2005 time frame suggests natural production of adult fall-run Chinook salmon was above the incremental targets in the following watersheds: American River, Battle Creek, Butte Creek, Clear Creek, and the Mokelumne River. In contrast, fall-run Chinook salmon production in the following watersheds was not rebuilding toward the annual incremental production targets: Feather River, Merced River, Sacramento River mainstem, Stanislaus River, Tuolumne River, and Yuba River. On Antelope Creek, Bear River, Big Chico Creek, Cosumnes River, Cottonwood Creek, Cow Creek, Deer Creek, Mill Creek, the seven "miscellaneous creeks", and Paynes Creek, insufficient monitoring data were available to assess progress toward the fall-run Chinook salmon annual incremental production targets. The total scores using the PSC's

rebuilding assessment methods for fall-run Chinook salmon during the 2000-2005 period were less than the 1999-2004 period for the Feather River, Stanislaus River, and Tuolumne River.

On Battle Creek, variability in the annual production estimates of adult late fall-run Chinook salmon during the 2000-2005 time frame resulted in an indeterminate status determination that precluded an ability to determine if the salmon stock in that watershed was rebuilding. For adult late fall-run Chinook salmon that originated from the Sacramento River mainstem, the PSC's rebuilding assessment methods suggest natural production of these fish did not rebuild toward the annual incremental production targets.

For adult winter-run Chinook salmon that originated in the Sacramento River mainstem during the 2000-2005 time period, variability in the annual production estimates of this run of Chinook salmon resulted in an indeterminate status determination that precluded an ability to determine if the salmon stock in that watershed was rebuilding. The total score for winter-run Chinook salmon in this watershed during the 2000-2005 period were greater than the 1999-2004 period; this change caused the production status of "not rebuilding" in the earlier period to change to an "indeterminate" status in the latter period.

For adult spring-run Chinook salmon during the 2000-2005 time frame, the PSC rebuilding assessment methods suggest the natural production from Butte Creek was above the annual incremental production targets. In contrast, natural production of adult spring-run Chinook salmon from Mill Creek and the Sacramento River mainstem did not rebuild toward the annual incremental production targets. Variability in the annual production estimates of adult spring-run from Deer Creek during the 2000-2005 time frame resulted in an indeterminate status determination that precluded an ability to determine if this salmon stock in that watershed was rebuilding. The total score for spring-run Chinook salmon on Deer Creek using the PSC's rebuilding assessment methods during the 2000-2005 period were greater than the 1999-2004 period; this change was reflect in a production status of "not rebuilding" in the earlier period, and an "indeterminate" status in the latter period.

Table 7. Assessment scores and progress toward annual incremental production targets for four runs of adult Chinook salmon from the Central Valley, based on a modified version of the Pacific Salmon Commission's rebuilding assessment methods, 2000-2005. Watersheds with salmon runs that are above the annual incremental production targets are not scored because the targets had been met. * represents a change from the 2007 CAMP annual report.

		Pacific Salmon Commission metric				
Watershed	Run	Mean	Line	Short-term trend	Total score	Production status
American River	fall-run					above target
Antelope Creek	fall-run					insufficient data
Battle Creek	fall-run					above target
Battle Creek	late fall-run	+1	-1	0	0	indeterminate
Bear River	fall-run					insufficient data
Big Chico Creek	fall-run					insufficient data
Butte Creek	fall-run					above target
Butte Creek	spring-run					above target
Clear Creek	fall-run					above target
Cosumnes River	fall-run					insufficient data
Cottonwood Creek	fall-run					insufficient data
Cow Creek	fall-run					insufficient data
Deer Creek	fall-run					insufficient data
Deer Creek	spring-run	-1	-1	+1	-1*	indeterminate*
Feather River	fall-run	-1	-1	-1	-3*	not rebuilding
Merced River	fall-run	-1	-1	0	-2	not rebuilding
Mill Creek	fall-run					insufficient data
Mill Creek	spring-run	-1	-1	0	-2	not rebuilding
"miscellaneous creeks"	fall-run					insufficient data
Mokelumne River	fall-run					above target
Paynes Creek	fall-run					insufficient data
Sacramento River	fall-run	-1	-1	0	-2	not rebuilding
Sacramento River	late fall-run	-1	-1	0	-2	not rebuilding
Sacramento River	winter-run	-1	-1	+1	-1*	indeterminate*
Sacramento River	spring-run	-1	-1	0	-2	not rebuilding
Stanislaus River	fall-run	-1	-1	-1	-3*	not rebuilding
Tuolumne River	fall-run	-1	-1	-1	-3*	not rebuilding
Yuba River	fall-run	-1	-1	0	-2	not rebuilding

3.2.4 CHANGES IN THE NATURAL PRODUCTION OF CHINOOK SALMON BASED ON INDIVIDUAL RUNS OR THE ENTIRE CENTRAL VALLEY

Box and whisker graphs comparing the natural production of different runs of Chinook salmon in the Central Valley during the 1967-1991 and 1992-2007 time periods are depicted in Figure 18. For fall-run Chinook salmon, the median natural production based on the combined production from 21 watersheds was greater in the 1992-2007 time period than the 1967-1991 time period. For late fall-run Chinook salmon, the median natural production based on combined production from Battle Creek and the Sacramento River mainstem was less in the latter period. Late fall-run Chinook salmon natural production estimates in 1972 (i.e., 87,763 fish) and 1998 (i.e., 79,382 fish) can be considered to be unusually high because they represent outlier values that were 1.5-3.0 times the 75th quartile. For winter-run Chinook salmon from the Sacramento River, the median natural production was markedly less in the 1992-2007 time period than the 1967-1991 time period. Production estimates for this run in 1969 (i.e., 238,743 fish) and 2005 (i.e., 26,761 fish) can be considered to be unusually high and represent outlier values. For spring-run Chinook salmon, the median natural production based on the combined production from Butte Creek, Deer Creek, Mill Creek, and the Sacramento River Valley was also less in the latter time period, and production in 1998 was notably high (i.e., 48,855 fish) during the 1992-2007 time period. The data for the four runs collectively suggest the median natural production of Chinook salmon increased over time for fall-run Chinook salmon, but decreased for the other three runs.

A box and whisker graph comparing the natural production for the combined total of all four runs of Chinook salmon in the Central Valley during the 1967-1991 and 1992-2007 time periods is depicted in Figure 19. The median natural production estimates of Chinook salmon in the Central Valley during the 1967-1991 and 1992-2007 time periods was 830,039 and 767,140 fish, respectively. This fact, in combination with the information from the preceding paragraph above suggests that while environmental or management actions have likely led to an increase in the production of fall-run Chinook salmon during the latter period, this increase has been offset by the combined declines in the production of the other three salmon runs.

Figure 18. Box and whisker graphs comparing the median, 25th quartile, 75th quartile, and largest and smallest non-outlier natural production values for fall-, late fall-, winter-, and spring-run Chinook salmon from the Central Valley during the periods 1967-1991 and 1992-2007. Plots also depict outlier production values 1.5-3.0 times the 75th quartile.

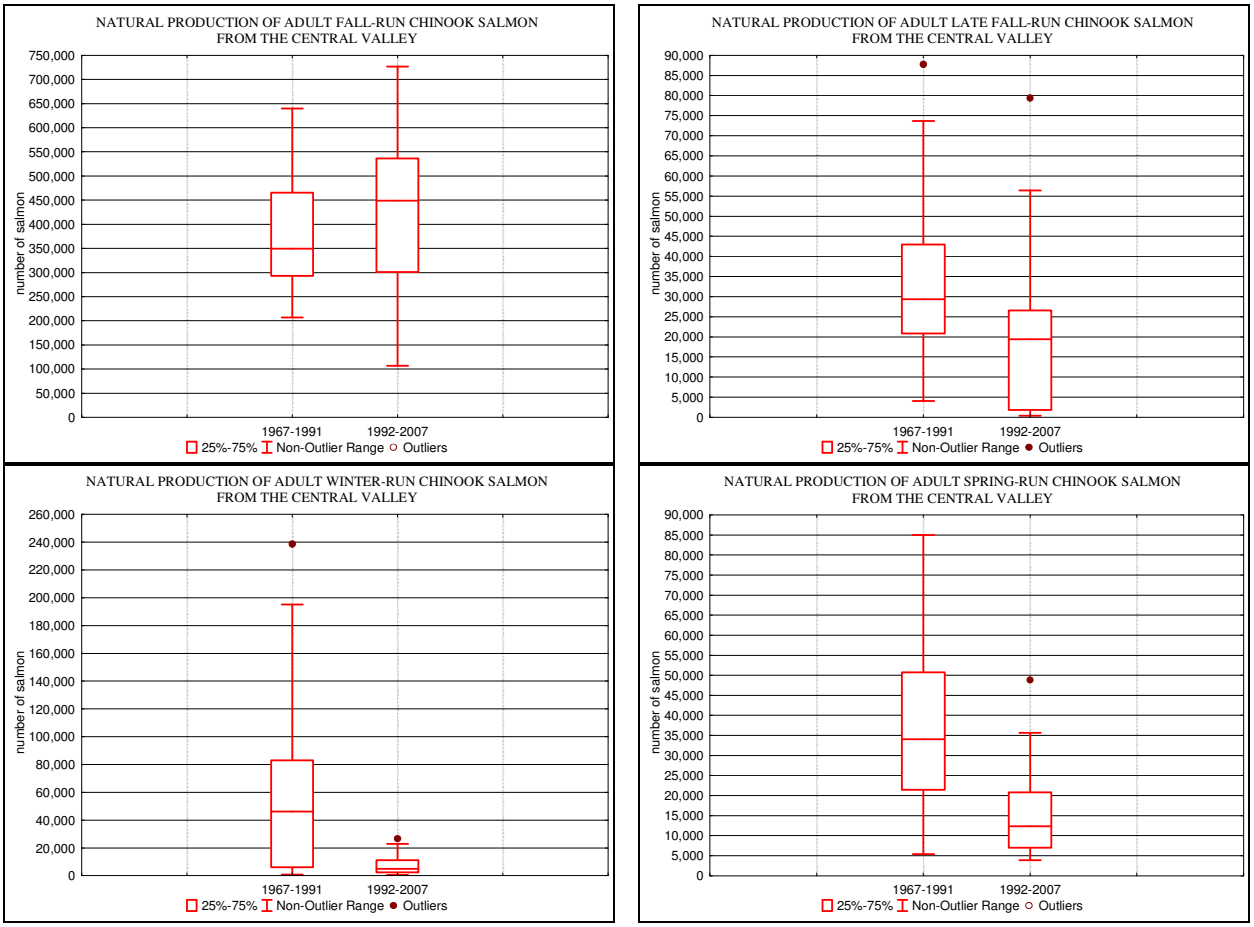
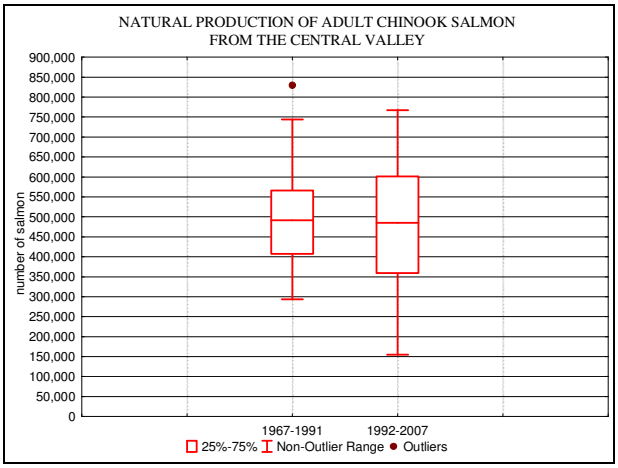


Figure 19. Box and whisker graph comparing the median, 25th quartile, 75th quartile, and largest and smallest non-outlier natural production values for Chinook salmon from the Central Valley during the periods 1967-1991 and 1992-2007. The plot also depict one outlier value.



3.3 PRODUCTION OF NON-SALMONID TAXA

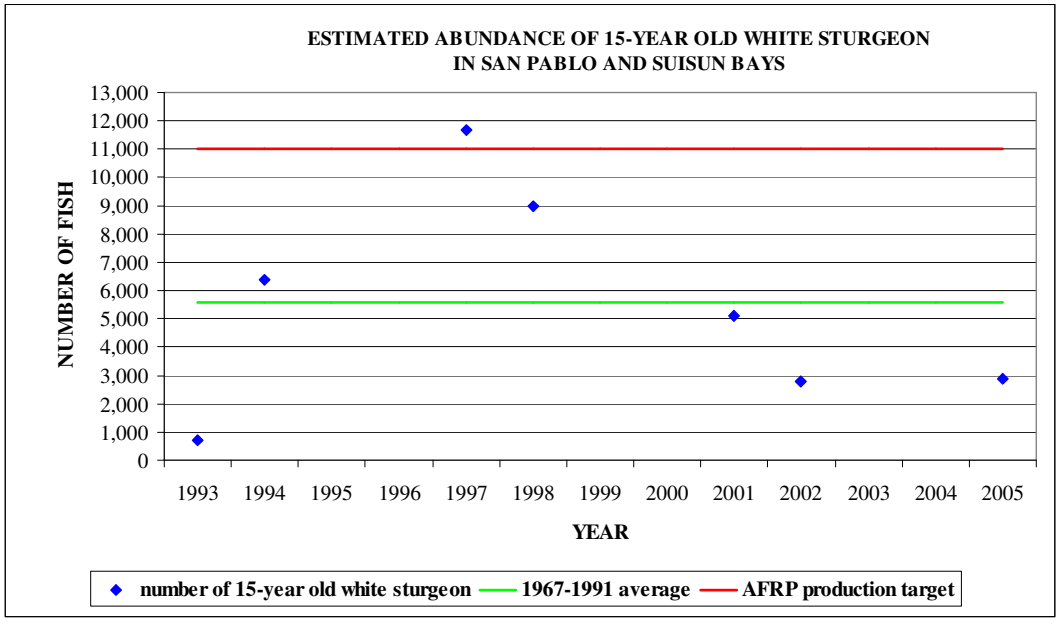
3.3.1 PRODUCTION OF ADULT WHITE AND GREEN STURGEON

Seven censuses 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 8). The AFRP production target for white sturgeon is 11,000 fish. During the 1992-2005 timeframe, the estimated number of 15-year old white sturgeon in San Pablo and Suisun Bays exceeded the AFRP production target in one of seven years when sampling was done (Figure 20).

Table 8. Estimated abundance of white sturgeon in San Pablo Bay and Suisun Bay, 1993-2005.

Year	Estimated abundance of white sturgeon ≥ 40 inches in length	Percentage of 15-year old fish in the population ≥ 40 inches in 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 20. Estimated abundance of 15-year old white sturgeon in San Pablo Bay and Suisun Bay, 1993-2005.

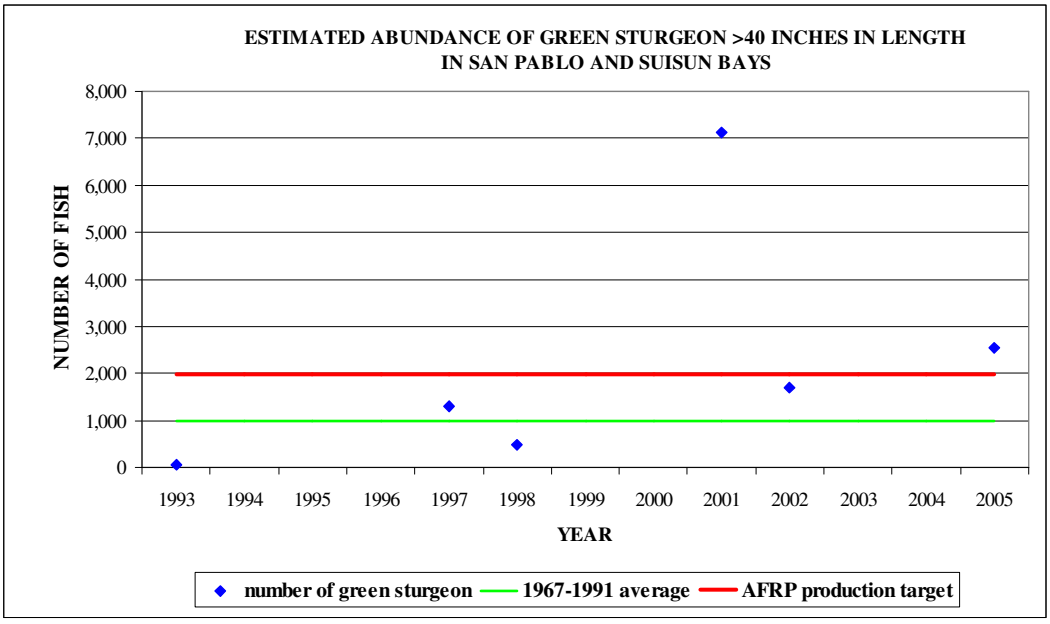


Six of the seven white sturgeon censuses can be used to develop abundance estimates for green sturgeon that were ≥ 40 inches in length in San Pablo and Suisun Bays. These were conducted in 1993, 1997, 1998, 2001, 2002, and 2005. Because the CDFG did not capture green sturgeon during the sturgeon census 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 9). The AFRP production target for green sturgeon is 2,000 fish. During the 1992-2005 timeframe, 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 21).

Table 9. Estimated abundance of green sturgeon in San Pablo Bay and Suisun Bay, 1993-2005.

Year	Estimated abundance of white sturgeon ≥ 40 inches in length	Number of captured white sturgeon ≥ 40 inches in length	Number of captured green sturgeon ≥ 40 inches in length	Ratio of white to green sturgeon	Estimated abundance of green sturgeon ≥ 40 inches in 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 21. Estimated abundance of adult green sturgeon in San Pablo Bay and Suisun Bay, 1993-2005.



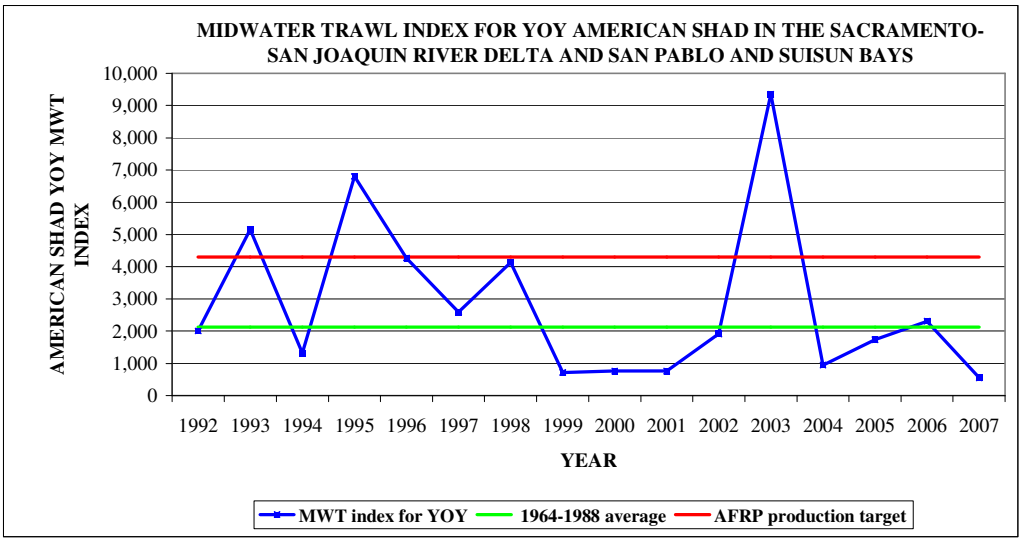
3.3.2 PRODUCTION OF JUVENILE AMERICAN SHAD

The midwater trawl index for YOY American shad in the Sacramento-San Joaquin River Delta and San Pablo and Suisun Bays during the 1992-2007 time period ranged between 552 and 9,350 (Table 10). The AFRP production target for American shad is 4,300 fish. Between 1992 and 2007, the MWT index exceeded the AFRP production target in three of 16 years (Figure 22).

Table 10: Midwater trawl index for young-of-the-year American shad in the Sacramento-San Joaquin River Delta and San Pablo and Suisun Bays, 1992-2007.

Year	MWT index for young-of-the-year American Shad
1992	2,007
1993	5,153
1994	1,320
1995	6,806
1996	4,270
1997	2,592
1998	4,136
1999	715
2000	764
2001	765
2002	1,914
2003	9,350
2004	947
2005	1,736
2006	2,307
2007	552

Figure 22. Midwater trawl index for young-of-the-year American shad in the Sacramento-San Joaquin River Delta and San Pablo and Suisun Bays, 1992-2007.



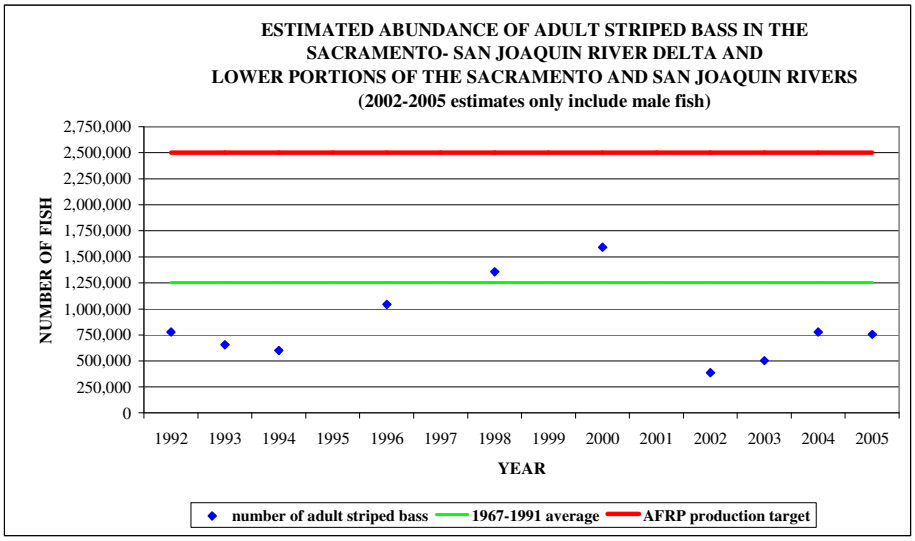
3.3.3 PRODUCTION OF ADULT STRIPED BASS

CDFG did not conduct surveys for adult striped bass in 1995, 1997, 1999, and 2001 between 1992 and 2005. The abundance of adult striped bass in 2006 was not determined because striped bass were not tagged that year. The 2002-2005 abundance estimates provided below only include male fish because very few females were tagged that year. Between 1992 and 2005, 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 387,435 and 1,591,419 fish (Table 11). Abundance estimates for 2003, 2004, and 2005 are provisional. The AFRP production target for striped bass is 2,500,000 fish. Between 1992 and 2005, the AFRP striped bass production target was not met during the 10 years when population estimates were developed (Figure 23).

Table 11: Estimated abundance of adult striped bass in the Sacramento-San Joaquin River Delta, Sacramento River downstream from the town of Colusa, and portion of the San Joaquin River downstream from the town of Mossdale, 1992-2005. * = 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*	387,435
2003*	502,937
2004*	776,419
2005*	755,592

Figure 23. Estimated abundance of adult striped bass in the Sacramento-San Joaquin River Delta, Sacramento River downstream from the town of Colusa, and portion of the San Joaquin River downstream from the town of Mossdale, 1992-2005. * = 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. This section also evaluates temporal changes in the average natural production of adult Chinook salmon using three additional methods.

As stated in the "Data Caveats" section of this report, several inherent challenges or assumptions are associated with the monitoring anadromous fish in the Central Valley . These issues must be acknowledged as temporal changes in the production of anadromous fish taxa in the Central Valley 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 1992-2007 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.

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, mainstem Sacramento River (i.e., the Livingstone Stone National Fish Hatchery), Merced River, and Mokelumne River. Except for the Livingstone Stone National Fish Hatchery, the hatcheries produced fall-run Chinook salmon for many years or decades, and large numbers of these fish were not consistently marked until 2007. If hatchery-produced fish are not marked prior to their release from a hatchery, it is not possible to identify these fish 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 estimates" in regards to the amount of in-river angler harvest and the estimated hatchery proportion in each watershed. The accuracy of the natural production estimates has therefore been the subject of ongoing studies to better refine these estimates. An effort to quantify the relative proportion of natural- vs.-hatchery origin Chinook salmon was recently initiated by the CALFED Ecosystem Restoration Program. This program provided funding to purchase equipment and mark approximately eight million fall-run Chinook salmon that were reared at fish hatcheries in the Central Valley in 2007 and 2008. The juvenile Chinook salmon were marked with coded wire tags, and the recovery of tagged fish in the Pacific Ocean and the Central Valley watersheds will

provide a basis for estimating the relative proportion of natural- vs.-hatchery origin Chinook salmon in various locations. In 2008, the return of two-year old grilse to the Central Valley watersheds will provide an initial indication of the hatchery proportion, while the return of three-year old fish to Central Valley rivers and streams in the fall of 2009 will provide a more substantial data set to infer the hatchery proportion. The marking and subsequent recovery of several cohorts of hatchery-reared juvenile salmon will be required before the inter-annual variability in the hatchery proportion can be understood. To ensure that the variability in the hatchery proportion can be accurately understood, several years of secure funding will be required to mark fish for a sustained period of time.

An overall assessment of changes in natural production of different runs of Chinook salmon using the tools described in this report generally yields similar results (Table 12). This overall comparison suggests individual watersheds can be separated into four distinct categories:

1) Watersheds that possess adult fall- or spring-run Chinook salmon, and where:

   a) watershed-specific AFRP production targets were met or exceeded six or more times;
   b) average production of Chinook salmon between 1992 and 2007 was significantly greater than the average production between 1967 and 1991; and
   c) PSC's rebuilding assessment methods suggest fish production met or exceeded annual incremental production targets.

   Watersheds with fall-run Chinook salmon that possess these characteristics are the American River, Battle Creek, Butte Creek, Clear Creek, and Mokelumne River. The only watershed with spring-run Chinook salmon that possesses these characteristics is Butte Creek. Late fall-run Chinook salmon from Battle Creek would also meet these characteristics except for three relatively low production estimates in 2001, 2002, and 2003. The late fall-run Chinook salmon from Battle Creek therefore had an indeterminate production status in 2007 in the context of the PSC's rebuilding assessment methods.

2) Watersheds that possess any run with adult Chinook salmon and where:

   a) watershed-specific AFRP production targets were met or exceeded three or fewer times;
   b) average production of Chinook salmon between 1992 and 2007 was less than the average production between 1967 and 1991; and
   c) PSC's rebuilding assessment methods suggest fish production is not rebuilding toward annual incremental production targets.

   Watersheds and salmon runs that possess these characteristics are as follows: for fall-run Chinook salmon, the watersheds are the Merced River, Sacramento River mainstem, Stanislaus River, and Tuolumne River; for late fall-run Chinook salmon, the sole watershed is the Sacramento River mainstem; for winter-run Chinook salmon, the sole watershed is the Sacramento River mainstem; for spring-run Chinook salmon, the watersheds are Deer Creek, Mill Creek, and the Sacramento River mainstem.

3) Watersheds where the three tools do not provide a consistent assessment in changes in the abundance of Chinook salmon.

   For fall-run Chinook salmon, these watersheds are Deer Creek, Feather River, Mill Creek, and Yuba River.

4) Watersheds where insufficient data have been collected to assess changes in the abundance of Chinook salmon. For fall-run Chinook salmon, these watersheds are Antelope Creek, Bear River, Big Chico Creek, Cosumnes River, Cottonwood Creek, Cow Creek, the seven "miscellaneous creeks", and Paynes Creek.

The various tools used to monitor production of Chinook salmon provide different temporal time frames for assessing changes in the production of fish. The number of years the AFRP production target was exceeded since 1991 and a change in average production between the 1967-1991 and 1992-2007 time periods provide a long-term temporal assessment of production status. Application of the PSC's rebuilding assessment methods provides a mid-term temporal assessment of production status. And finally, year to year changes, e.g., from 2006 to 2007, provide a short-term temporal assessment of how production is changing.

Using the PSC's rebuilding assessment methods, the total scores for winter-run Chinook salmon from the Sacramento River mainstem and spring-run Chinook salmon from Deer Creek during the 2000-2005 period were greater than during the 1999-2004 period. The change in scores resulted in their production status changing from "not rebuilding" in the earlier period to an "indeterminate" status in the latter period, thereby suggesting environmental and/or management conditions in these watersheds may have become more conducive to the fish during the latter period. Conversely, the PSC total scores for fall-run Chinook salmon from the Feather River, Stanislaus River, and Tuolumne River were less during the 2000-2005 period than for the 1999-2004 period. These changes suggest that in the mid-term, environmental and/or management conditions in these five watersheds became less conducive to the production of fall-run Chinook salmon.

In the short-term, the production of different runs of Chinook salmon from the aforementioned 21 watersheds declined in 17 of the 20 combinations of watersheds and runs in 2007 relative to 2006. The only runs and watersheds where production was greater in 2007 than 2006 were spring-run Chinook salmon from Butte and Mill Creeks and late fall-run Chinook salmon from the Sacramento River mainstem. The 2007 decline in production affected Chinook salmon from watersheds that historically have been viewed as success stories in the context of CVPIA and CALFED restoration activities, e.g. the production of fall-run Chinook salmon from Clear Creek in 2007 declined below the watershed's AFRP fish production target for the first time since 1999. Such examples raise questions about the sustainability of past increases and the reason why past increases in salmon production occurred.

Table 12. Overall assessment of changes in natural production of Chinook salmon in the Central Valley, 1967-2007. ???? = insufficient data to assess change in average production. * Indicates a fish hatchery is present in the watershed; presence of hatchery fish can confound estimates of natural production. ** indicates a statistically significant change with $\alpha = 0.05$.

Watershed	Chinook salmon run	Metric to assess changes in Chinook salmon abundance			
		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 1992-2007 time periods	P values associated with changes in the average production between the 1967-1991 and 1992-2007 time periods	Production status using the PSC's rebuilding assessment methods 2000-2005
American River*	fall-run	6/16	up	0.0034**	above target
Antelope Creek	fall-run	0/0	????	????	insufficient data
Battle Creek*	fall-run	13/16	up	0.0003**	above target
Battle Creek*	late fall-run	8/16	up	0.0007**	indeterminate
Bear River	fall	0/0	????	????	insufficient data
Big Chico Creek	fall	0/0	????	????	insufficient data
Butte Creek	fall-run	8/11	up	0.0009**	above target
Butte Creek	spring-run	13/16	up	0.0004**	above target
Clear Creek	fall-run	11/16	up	0.00009**	above target
Cosumnes River	fall	0/2	down	????	insufficient data
Cottonwood Creek	fall	0/2	down	????	insufficient data
Cow Creek	fall	1/2	up	????	insufficient data
Deer Creek	fall-run	2/8	up	0.1257	insufficient data
Deer Creek	spring-run	0/16	down	0.2125	indeterminate
Feather River*	fall-run	3/16	up	0.0421**	not rebuilding
Merced River*	fall-run	1/16	down	0.3619	not rebuilding
Mill Creek	fall-run	1/11	up	0.2972	insufficient data
Mill Creek	spring-run	0/16	down	0.0421**	not rebuilding
"miscellaneous creeks"	fall-run	0/1	down	????	insufficient data
Mokelumne River*	fall-run	8/16	up	0.0023**	above target
Paynes Creek	fall-run	0/0	????	????	insufficient data
Sacramento River	fall-run	0/16	down	0.0178**	not rebuilding
Sacramento River	late fall-run	1/15	down	0.0332**	not rebuilding
Sacramento River	winter-run	0/16	down	0.0007**	indeterminate
Sacramento River	spring-run	0/15	down	0.00001**	not rebuilding
Stanislaus River	fall-run	0/16	down	0.0452**	not rebuilding
Tuolumne River	fall-run	0/16	down	0.0130**	not rebuilding
Yuba River	fall-run	1/16	up	0.2628	not rebuilding

The efficacy of the Student's t-test used to evaluate differences in the means of the estimated natural production of adult Chinook salmon from different watersheds during the 1967-1991 and 1992-2007 time periods is subject to interpretation. This condition exists because the precision of the components used to calculate production are rarely known. For example, the precision of ocean harvest estimates, in-river angler surveys, hatchery returns, and escapement estimates for the Central Valley is rarely calculated; the calculation of confidence intervals for the escapement estimates on the Mokelumne River may be the notable exception to this trend.

Because the precision of the Chinook salmon production estimates are not known, the t-test used in this report assumed the CV for all years and watersheds equaled 0.25. Modeling efforts that apply a CV of 0.10 and 0.33 in the Student's t-test generally do not affect the determination of whether or not there were significant differences between the means of the estimated natural production of adult Chinook salmon from different watersheds during the 1967-1991 and 1992-2007 time periods. This effect occurs because the amount of reduction in the observed standard deviation of the production estimates increases as the coefficient of variation increases. The inferences in this report that suggest significant changes in Chinook salmon production in some watersheds has or has not occurred therefore appear to be valid despite the fact that the precision of various data are not known.

The ability to accurately identify changes in production of adult Chinook salmon will rely on improvements in the methods used to count adult salmon numbers. These improvements are essential to determining if AFRP production targets are in fact being met. For example, there is a critical need to continue the effort to mark hatchery-reared fish that was initiated in 2007 so the hatchery proportion can be quantified under a variety of environmental and management conditions. In the absence of such improvements, there will not be a statistically rigorous method for producing data that are needed to assess overall (cumulative) effectiveness of habitat restoration actions implemented pursuant to CVPIA Section 3406(b).

4.2 PROGRESS TOWARD AFRP PRODUCTION TARGETS FOR NON-SALMONID SPECIES

Mark-recapture data to estimate abundance of 15-year old white sturgeon in San Pablo and Suisun Bays have been collected in seven of the years since 1992. Estimates of the abundance of 15-year old white sturgeon during six of these years were below the AFRP production target, and estimates for four of the seven years were below the average level from the 1967-1991 baseline period. These figures do not suggest progress toward the AFRP white sturgeon production target is occurring, and population abundance has generally declined since 1997. The decline in the number of white sturgeon harvested by recreational anglers (Marty Gingras, CDFG, pers. comm.) also suggests this species' abundance has declined over time. It is important to note the CDFG 2005 abundance estimate for the number of white sturgeon $\geq$ 40 inches in total length and the number of 15-year old sturgeon will, however, almost certainly be revised and increase to some degree as additional recapture data are collected.

The techniques currently used to monitor the abundance of white sturgeon make it difficult to accurately assess changes their abundance. Because relatively few white sturgeon are recaptured after they are tagged (e.g., 1 of the 384 white sturgeon marked in 1994 was subsequently

recaptured), the confidence intervals associated with the white sturgeon abundance estimates are large. These large confidence intervals suggest the white sturgeon abundance estimates are relatively imprecise as compared to being robust numbers that can be used to infer trends. In an effort to develop more robust abundance estimates, the CDFG, since 2005, has conducted sturgeon surveys on an annual basis to increase the probability that a greater number of white sturgeon are marked and subsequently recaptured. It is expected these additional data will result in more precise abundance estimates with smaller confidence intervals, and a more robust ability to gage trends in fish abundance.

The challenges associated with monitoring green sturgeon are also substantial because the estimated abundance of this species is inherently linked to the: (1) challenges associated with estimating the abundance of white sturgeon, and (2) ratio of white to green sturgeon caught during sampling activities. Formulas that use the ratio of white to green sturgeon to calculate the abundance of green sturgeon are especially problematic in years when few green sturgeon are caught. For example, in 1993, only two green sturgeon were incidentally caught during trapping activities for white sturgeon. If three green sturgeon had instead been caught that year, estimated abundance of green sturgeon in San Pablo and Suisun Bays would have been 102 instead of 68 fish. Because the green sturgeon production estimates are relatively weak, it may be necessary in the future to use a different method for assessing changes in the production of this species.

The midwater trawl index associated with juvenile American shad suggests the AFRP production target for this species has only been equaled or exceeded one time in the last decade, and the index has been below the 1967-1991 average seven times in the past decade. It is notable the MWT index in 2007 is the lowest on record since 1992, and the second lowest record since the survey began in 1967. 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, most sampling stations have been monitored on a consistent basis since 1980 (Dave Contreras, CDFG, pers. comm.). It therefore appears progress toward the AFRP production target for American shad has not been substantial, and additional management will be necessary to promote increases in the production of this species.

The AFRP production target for adult striped bass was not met during the ten years when mark-recapture surveys were conducted between 1992 and 2005, and abundance of these fish has been below the 1967-1991 average in eight of the 10 years when abundance estimates were available after 1992. It is important to note very few female striped bass were captured during the surveys in 2002, 2003, 2004, and 2005, and abundance estimates provided in this report therefore only account for the abundance of male fish. The paucity of females contributing to the striped bass abundance estimates between 2002 and 2005 further compromises the ability to meet the AFRP striped bass production target.

The methods during mark-recapture surveys for adult striped bass have been relatively consistent except that: (1) size of the fish tagged has changed since sampling for striped bass began, and (2) location of the fyke traps that are used to collect striped bass moved from a location downstream from Sacramento to upstream of Knights Landing in the early 1990s. Overall, however, the process of collecting striped bass data has remained extremely consistent (Marty Gingras, CDFG, pers. comm.). The increase in minimum size of marked striped bass from 16 to

18 inches could result in smaller striped bass abundance estimates because smaller fish that would have been included in the abundance estimate between 1967 and 1988 are no longer included in the post-1982 abundance estimates. At the present time, it is not possible to quantitatively assess how the change in the minimum size of marked fish affects adult striped bass population estimates (Nina Kogut, CDFG, pers. comm.).

Assessing progress toward the AFRP striped bass production target is difficult because artificially propagated striped bass were planted in San Pablo Bay and the Sacramento and San Joaquin Rivers between 1980 and 1990. During this period, the CDFG released 11,153,613 hatchery-reared striped bass into the Bay-Delta area (Harris and Kohlhorst 2002). Many of these fish were marked prior to release. Mark-recapture studies of striped bass in the Bay-Delta area indicate the estimated percentage of hatchery-reared striped bass in this area increased from about 1% for the 1981 year class to almost 35% for the 1990 year class (Kohlhorst 1999), and up to 26% of the legal size striped bass in this area between 1981 and 1990 were of hatchery origin (Harris and Kohlhorst 2002). Beginning in 1992, juvenile striped bass were salvaged from fish screens in the southern Delta and reared in floating pens to facilitate their growth. These fish were subsequently released in the Bay-Delta area. Based on data in a "Draft Extraction of Striped Bass Stocking Data.xls" file developed by CDFG staff, the number of pen-reared striped bass released into the Bay-Delta area between 1993 and 2000 totaled 2,045,044 fish. Since 2000, no artificially propagated striped bass have been released into the Bay-Delta area by the CDFG.

By definition, the AFRP's baseline fish production estimates and fish production targets should only include naturally-produced fish. The release of millions of hatchery-reared striped bass in the Bay-Delta area during the CVPIA 1967-1991 baseline period and artificially pen-reared striped bass during a portion of the post-baseline period creates two problems. First, the AFRP striped bass production target of 2,500,000 may be artificially inflated because annual fish abundance estimates used to develop the baseline striped bass production estimate likely include large numbers of hatchery-reared (not naturally-produced) fish. Second, because the artificial augmentation of striped bass numbers in the Bay-Delta area no longer occurs, ongoing monitoring activities are likely to generate lower striped bass estimates because they will no longer include artificially-produced fish. In either case, it will be more difficult to determine if the natural production of striped bass during the CVPIA post-baseline period is twice as great as during the baseline period.

4.3 RESTRICTIONS THAT LIMIT THE HARVEST OF CHINOOK SALMON IN 2008

For the purposes of this section of the CAMP annual report, any references to Sacramento River fall-run Chinook salmon (SRFCS) refer to fall-run Chinook salmon that originate in the Sacramento River mainstem and all the watersheds that are tributary to the mainstem. The figures presented in this section of the report rely on values presented in other agency documents, and may differ slightly from values reported by the CAMP.

Concerns about the low number of adult (age 3 and older) and grilse (primarily age 2) SRFCS that returned to the Central Valley in 2007 and the extremely low forecast of SRFCS ocean

abundance prompted a series of severe harvest restrictions in 2008. These restrictions are historic, given that large-scale restrictions on the harvest of SRFCS have never been enacted.

In 2007, it is estimated 87,966 adult SRFCS returned to spawn in the Central Valley (PFMC 2008a). This number reflects: (1) in-river spawner abundance (estimated by carcass surveys, ladder counts, weir counts, snorkel surveys, and aerial redd counts) plus the number of salmon entering hatcheries (i.e., hatchery returns); and (2) a combination of wild- and hatchery-origin fish. The term "escapement" refers to the combination of in-river spawner abundance and hatchery returns. The 87,966 figure is the lowest escapement estimate of adult SRFCS since 1991 and the second lowest return on record since comprehensive monitoring of Chinook salmon from the Central Valley began in 1970.

In 2007, 1,897 SRFCS grilse are estimated to have returned to the Central Valley. This figure is the lowest recorded value of SRFCS grilse escapement, following the second lowest return (8,048) of SRFCS grilse in 2006.

The Salmon Fishery Plan of the Pacific Fisheries Management Council (PFMC) has established a conservation objective stating that 122,000-180,000 adult SRFCS should return to Central Valley rivers or hatcheries to spawn each year. The 87,966 figure was substantially below this objective.

The number of grilse Chinook salmon that return to the Central Valley in year *t* is used by the PFMC to roughly estimate the abundance of adult SRFCS remaining in the ocean. This abundance is then used by the PFMC to determine the adult SRFCS available for ocean harvest and the number expected to return to spawn in year *t +1*.

Given the low return of SRFCS adults and two successive record-low returns of grilse, the Salmon Technical Team of the PFMC developed a new model that specifically addressed the coastwide ocean harvest and spawner escapement of SRFCS. Using the "Sacramento Index," an ocean abundance of approximately 54,570 SRFCS adults was predicted for the 2008 season (PFMC 2008b). Even without any additional ocean or in-river harvest, the SRFCS was not expected to meet its conservation objective in 2008. In addition, there was serious concern that Central Valley hatcheries would not be able to meet their egg-take goals in 2008 if any additional SRFCS were harvested.

Because the forecasted ocean abundance of adult SRFCS was significantly below the PFMC's conservation objective, the following actions were taken in 2008 to reduce the probability that the SRFCS adult escapement would be less than predicted:

1. The National Marine Fishery Service (NMFS) regulates fisheries that occur in federal waters (3-200 nautical miles) off the west coast. The PFMC's Pacific Coast Salmon Plan requires that PFMC area salmon fisheries impacting a stock that is projected to be less than it's conservation objective be closed. Therefore, on April 10, 2008, the PFMC developed a recommendation to eliminate recreational and commercial ocean harvest of Chinook salmon between Cape Falcon, Oregon and the United States-Mexico border. The recommendation pertained to the period between April 1, 2008, and May 1, 2009.

On May 1, 2008, the NMFS published a regulation that adopted the PFMC recommendation to eliminate the recreational and commercial ocean harvest of Chinook salmon in federal waters (3 to 200 nautical miles offshore) south of Cape Falcon, Oregon in 2008.

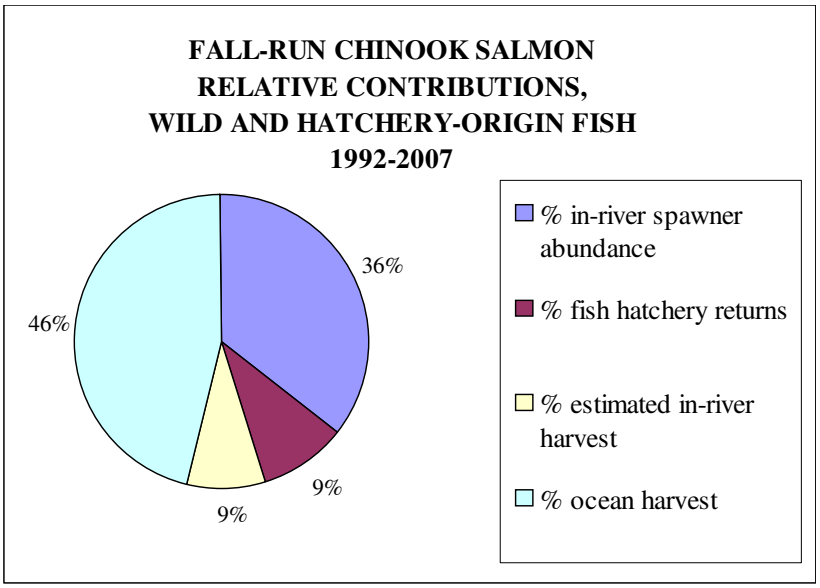
2. The California Fish and Game Commission (Commission) determines the amount of ocean harvest of fisheries that occur in California state waters (0 to 3 nautical miles offshore from the California coastline). On April 15, 2008, the Commission adopted the PFMC recommendation, and voted unanimously to prohibit recreational and commercial ocean harvest of Chinook salmon from 0 to 3 nautical miles offshore from the California coastline in 2008.

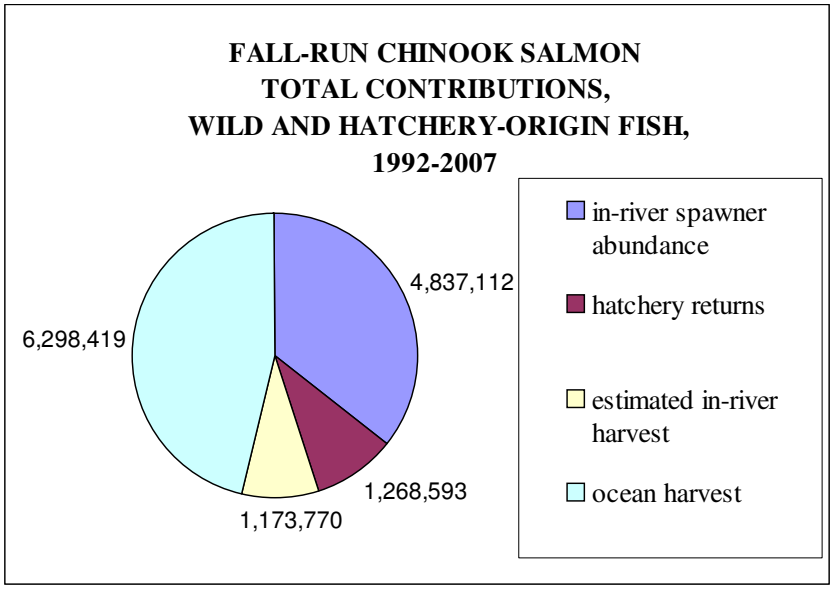
3. On May 9, 2008, the Commission voted to eliminate the in-river and downstream angler harvest of fall-run Chinook salmon in inland waters of the Central Valley with one exception. The Sacramento River mainstem between the Red Bluff Diversion Dam and Knights Landing was open to salmon fishing from November 1 to December 31 with a one salmon bag limit. All the other Central Valley rivers and streams where SRFCS salmon have historically been harvested (e.g., the American and Feather Rivers), were closed to angler harvest in 2008 after July 3rd when the Commission action became effective.

Escapement, and to a lesser degree, natural production estimates of Chinook salmon are heavily influenced by the recreational and commercial ocean harvest of fish. Between 1992 and 2007, approximately 46% of the combined total production of adult wild- and hatchery-origin fall-run Chinook salmon from the Central Valley was attributable to ocean harvest (Figure 24). The total production of adult wild- and hatchery-origin fall-run Chinook salmon from the Central Valley during this same period was estimated to be 13,577,894 fish; of this amount, 6,298,419 fish were harvested in the Pacific Ocean. Given these facts, the closure of the Chinook salmon season off the California coastline in 2008 will eliminate harvest of the category of fish that historically has contributed to the greatest fraction of the Central Valley production. It is expected that at least some of the fish that would have contributed to ocean harvest will instead return to the Central Valley and alternatively contribute to escapement, angler harvest, or hatchery returns.

The closure will also be significant because it will affect the ability to collect a variety of data related to the marking of hatchery-origin juvenile Chinook salmon in 2007. For example, the closure of ocean harvest in 2008 will eliminate the ability to gather new data to learn about the distribution of Central Valley-origin Chinook salmon along the California coastline and the relative abundance of wild- vs. hatchery-origin Central Valley Chinook salmon in the ocean.

Figure 24. Relative and total contributions of in-river spawner abundance, hatchery returns, estimated in-river harvest, and ocean harvest to the total production of adult fall-run Chinook salmon from the Central Valley. Values reflect contributions from 21 watersheds, and contributions from wild- and hatchery-origin fish.





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APPENDIX A: CATEGORIZING SALMON RUNS USING THE PACIFIC SALMON COMMISSION'S REBUILDING ASSESSMENT METHODS

The PSC rebuilding assessment methods assign indicator runs of salmon to three categories: (1) those that are at or above a series of annual incremental production targets, (2) those that are rebuilding toward a series of annual incremental production targets, and (3) those that are not rebuilding toward a series of annual incremental production targets. The assignment of these categories is made by comparing each run's annual incremental production targets with the estimated fish production data during a corresponding period. Because fish abundance data in the CDFG's Grandtab spreadsheet in 2006 and 2007 are provisional and therefore likely to be revised, this CAMP annual report will use the PSC's methods to evaluate changes in fish abundance using data that are unlikely to change; i.e., data collected between 2000 and 2005.

Runs or species for which at least four of the last five annual incremental production estimates are at or above the production target and for which the most recent 5-year average production estimate is equal to or greater than the production target are classified as "above target", and were not further analyzed. The remaining watersheds where the number of Chinook salmon was "below target" were subject to three tests:

1. *Mean criterion*. The "rebuilding line" represents the linear trend from the 1992 production target to the 2002 production target and has been extended to include 2003, 2004, and 2005. The mean of the annual production targets from the rebuilding line for each watershed between 2001 and 2005 is called the test value. The test value is compared to the mean estimated fish production that occurred between 2001 and 2005 for each watershed. Watersheds in which the mean estimated fish production is greater than or equal to the test value are assigned a mean criterion score of +1. Otherwise, a mean criterion score of –1 is assigned. The mean criterion score evaluates whether the average fish production over the 5-year test period is above or below the average production target expected during the corresponding rebuilding period.

2. *Line criterion*. The observed trend in the estimated fish production of naturally spawning adults is compared to the rebuilding line for each watershed. Watersheds in which three or more of the previous five production estimates are on or above the rebuilding line during the period 2001-2005 are assigned a line criterion score of +1. Otherwise a line score of –1 is assigned. The line criterion score evaluates whether the yearly production estimates are generally above or below the expected production targets during the five most recent years of the rebuilding period.

3. *Short term trend criterion*. During the period 2000-2005, watersheds in which at least four of the five years possess an estimate of production exceeded by the previous year's estimate are assigned a trend score of +1. If four of the five years showed a decline from the previous year, a trend score of –1 is assigned. Others are given a trend score of 0.

The short term trend criterion score evaluates whether the trend in production has been positive, neutral, or negative.

The scores from all three tests (i.e., mean, line, and short term trend) are added together to determine the status of each run of Chinook salmon in the 13 aforementioned watersheds. If two or more of the tests are positive and the total score is +2 or +3, the status of the population is considered to be "rebuilding." If two of the three tests are negative and the total score is –2 or –3, the status of the population is considered to be "not rebuilding." Intermediate scores on some of the tests or contradictory results on two tests (i.e., 1 positive, 1 negative) that result in a total score of -1, 0, or +1 result in a population status that is considered to be "indeterminate."

APPENDIX B: 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	705,508	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*	74,703	16,728	13,896	6,267	111,594

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 2007 Ocean Salmon Fisheries* (PFMC 2008a); commercial harvest data is provided in Table A-3 and recreational harvest data is provided in Table A-5 of the *Review of 2007 Ocean Salmon Fisheries*.

* data considered to be preliminary.

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	4,811	6,456	5,070	25,651	41,988	60	25,193
Antelope Creek							
Battle Creek	5,433	7,275	1,271	21,958	35,936	10	3,594
Bear River							
Big Chico Creek							
Butte Creek							
Clear Creek	600	0	60	1,041	1,701	80	1,361
Cosumnes River							
Cottonwood Creek	1,585	0	159	2,735	4,478	80	3,582
Cow Creek							
Deer Creek							
Feather River	24,105	17,937	8,408	79,219	129,669	60	77,802
Merced River	618	368	49	1,633	2,668	90	2,401
Mill Creek	999	0	100	1,735	2,833	80	2,267
"miscellaneous creeks"							
Mokelumne River	935	710	165	2,837	4,646	60	2,788
Paynes Creek							
Sacramento River mainstem	32,229	0	3,223	55,670	91,121	60	54,673
Stanislaus River	255	0	13	429	696	100	696
Tuolumne River	132	0	7	224	363	100	363
Yuba River	6,362	0	636	10,979	17,977	100	17,977
Total	78,064	32,746	19,160	204,108	334,078		192,696
Late-Fall Run Chinook Salmon							
Battle Creek	NE	344	69	649	1,062	10	106
Sacramento River mainstem	8,958	398	1,871	17,626	28,853	91.8	26,487
Total	8,958	742	1,940	18,275	29,915		26,594
Winter-Run Chinook Salmon							
Sacramento River mainstem	1,203	34	0	1,952	3,190	100	3,190
Spring-Run Chinook Salmon							
Butte Creek	730	0	73	1,258	2,061	100	2,061
Deer Creek	209	0	21	360	590	100	590
Mill Creek	237	0	24	408	669	100	669
Sacramento River mainstem	371	0	74	697	1,143	100	1,143
Total	1,547	0	192	2,724	4,463		4,463
Total 1992 Natural Production of Adult Chinook Salmon							**226,942**

NE = No Estimate

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	28,754	10,656	17,735	99,355	156,499	60	93,900
Antelope Creek							
Battle Creek	11,029	7,587	1,862	35,612	56,090	10	5,609
Bear River							
Big Chico Creek							
Butte Creek							
Clear Creek	1,246	0	125	2,400	3,771	80	3,017
Cosumnes River							
Cottonwood Creek							
Cow Creek							
Deer Creek	72	0	7	141	220	80	176
Feather River	30,923	16,663	9,517	99,284	156,388	60	93,833
Merced River	1,269	409	84	3,071	4,833	90	4,349
Mill Creek	1,975	0	198	3,777	5,949	80	4,759
"miscellaneous creeks"							
Mokelumne River	993	2,164	316	6,035	9,508	60	5,705
Paynes Creek							
Sacramento River mainstem	46,231	0	4,623	88,414	139,268	60	83,561
Stanislaus River	677	0	34	1,235	1,946	100	1,946
Tuolumne River	471	0	24	847	1,342	100	1,342
Yuba River	6,703	0	670	12,812	20,185	100	20,185
Total	130,343	37,479	35,193	352,983	555,998		318,381
Late-Fall Run Chinook Salmon							
Battle Creek	NE	528	106	1,107	1,741	10	174
Sacramento River mainstem	339	400	148	1,550	2,436	91.8	2,237
Total	339	928	253	2,656	4,177		2,411
Winter-Run Chinook Salmon							
Sacramento River mainstem	378	NE	0	646	1,024	100	1,024
Spring-Run Chinook Salmon							
Butte Creek	650	0	65	1,236	1,951	100	1,951
Deer Creek	259	0	26	492	777	100	777
Mill Creek	61	0	6	116	183	100	183
Sacramento River mainstem	391	0	78	811	1,280	100	1,280
Total	1,361	0	175	2,656	4,192		4,192
Total 1993 Natural Production of Adult Chinook Salmon							**326,008**

NE = No Estimate

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	31,520	8,567	18,039	98,903	157,029	60	94,218
Antelope Creek							
Battle Creek	24,274	18,991	4,327	80,982	128,573	10	12,857
Bear River							
Big Chico Creek							
Butte Creek							
Clear Creek	2,546	0	255	4,761	7,562	80	6,049
Cosumnes River							
Cottonwood Creek							
Cow Creek							
Deer Creek	307	0	31	584	922	80	737
Feather River	38,382	18,843	11,445	116,869	185,539	60	111,323
Merced River	2,646	943	179	6,423	10,191	90	9,172
Mill Creek	1,081	0	108	2,021	3,210	80	2,568
"miscellaneous creeks"							
Mokelumne River	1,238	1,919	316	5,929	9,401	60	5,641
Paynes Creek							
Sacramento River mainstem	58,546	0	5,855	109,593	173,993	60	104,396
Stanislaus River	1,031	0	52	1,842	2,924	100	2,924
Tuolumne River	506	0	25	898	1,430	100	1,430
Yuba River	10,890	0	1,089	20,391	32,370	100	32,370
Total	172,967	49,263	41,720	449,196	713,145		383,686
Late-Fall Run Chinook Salmon							
Battle Creek	NE	598	120	1,227	1,945	10	195
Sacramento River mainstem	137	154	58	597	946	91.8	869
Total	137	752	178	1,825	2,892		1,063
Winter-Run Chinook Salmon							
Sacramento River mainstem	144	42	0	319	506	100	506
Spring-Run Chinook Salmon							
Butte Creek	474	0	47	890	1,411	100	1,411
Deer Creek	485	0	49	910	1,444	100	1,444
Mill Creek	723	0	72	1,357	2,153	100	2,153
Sacramento River mainstem	862	0	172	1,765	2,800	100	2,800
Total	2,544	0	341	4,923	7,807		7,807
Total 1994 Natural Production of Adult Chinook Salmon							**393,062**

NE = No Estimate

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	80,330	6,498	39,073	299,896	425,797	60	255,478
Antelope Creek							
Battle Creek	56,515	26,677	8,319	218,007	309,518	10	30,952
Bear River							
Big Chico Creek							
Butte Creek	445	0	45	1,194	1,684	80	1,347
Clear Creek	9,298	0	930	24,378	34,606	80	27,684
Cosumnes River							
Cottonwood Creek							
Cow Creek							
Deer Creek							
Feather River	59,912	17,563	15,495	221,489	314,459	60	188,676
Merced River	2,320	602	146	7,264	10,332	90	9,299
Mill Creek							
"miscellaneous creeks"							
Mokelumne River	2,194	3,323	552	14,428	20,496	60	12,298
Paynes Creek							
Sacramento River mainstem	63,934	0	6,393	167,560	237,887	60	142,732
Stanislaus River	619	0	31	1,592	2,242	100	2,242
Tuolumne River	827	0	41	2,090	2,958	100	2,958
Yuba River	14,237	0	1,424	37,313	52,974	100	52,974
Total	290,631	54,663	72,448	995,210	1,412,952		726,639
Late-Fall Run Chinook Salmon							
Battle Creek	NE	323	65	948	1,336	10	134
Sacramento River mainstem	NE	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	2,870	4,079	100	4,079
Spring-Run Chinook Salmon							
Butte Creek	7,500	0	750	19,667	27,917	100	27,917
Deer Creek	1,295	0	130	3,395	4,819	100	4,819
Mill Creek	320	0	32	840	1,192	100	1,192
Sacramento River mainstem	426	0	85	1,219	1,731	100	1,731
Total	9,541	0	997	25,121	35,658		35,658
Total 1995 Natural Production of Adult Chinook Salmon							**767,140**

NE = No Estimate

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	74,745	7,651	37,078	129,695	249,169	60	149,501
Antelope Creek							
Battle Creek	52,409	21,178	7,359	87,879	168,825	10	16,882
Bear River							
Big Chico Creek							
Butte Creek	500	0	50	614	1,164	80	931
Clear Creek	5,922	0	592	7,079	13,594	80	10,875
Cosumnes River							
Cottonwood Creek							
Cow Creek							
Deer Creek							
Feather River	57,170	14,488	14,332	93,354	179,344	60	107,606
Merced River	3,291	1,141	222	5,050	9,704	90	8,733
Mill Creek							
"miscellaneous creeks"							
Mokelumne River	4,038	3,883	792	9,439	18,152	60	10,891
Paynes Creek							
Sacramento River mainstem	84,086	0	8,409	100,386	192,881	60	115,728
Stanislaus River	168	0	8	189	365	100	365
Tuolumne River	4,362	0	218	4,956	9,536	100	9,536
Yuba River	27,900	0	2,790	33,320	64,010	100	64,010
Total	314,591	48,341	71,850	471,961	906,743		495,060
Late-Fall Run Chinook Salmon							
Battle Creek	NE	1,337	267	1,754	3,358	10	336
Sacramento River mainstem	NE	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	NE	0	1,100	2,112	100	2,112
Spring-Run Chinook Salmon							
Butte Creek	1,413	0	141	1,682	3,236	100	3,236
Deer Creek	614	0	61	731	1,406	100	1,406
Mill Creek	253	0	25	301	579	100	579
Sacramento River mainstem	378	0	76	491	945	100	945
Total	2,658	0	304	3,205	6,166		6,166
Total 1996 Natural Production of Adult Chinook Salmon							**503,785**

NE = No Estimate

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	52,195	5,650	26,030	118,956	202,831	60	121,699
Antelope Creek							
Battle Creek	50,744	50,670	10,141	158,223	269,778	10	26,978
Bear River							
Big Chico Creek							
Butte Creek	800	0	80	1,223	2,103	80	1,682
Clear Creek	8,569	0	857	13,383	22,809	80	18,247
Cosumnes River							
Cottonwood Creek							
Cow Creek							
Deer Creek	1,203	0	120	1,902	3,226	80	2,580
Feather River	50,547	18,781	13,866	118,005	201,198	60	120,719
Merced River	2,714	946	183	5,435	9,278	90	8,350
Mill Creek	478	0	48	747	1,273	80	1,018
"miscellaneous creeks"							
Mokelumne River	3,681	6,494	1,018	15,897	27,089	60	16,254
Paynes Creek							
Sacramento River mainstem	119,296	0	11,930	186,144	317,370	60	190,422
Stanislaus River	5,588	0	279	8,356	14,224	100	14,224
Tuolumne River	7,146	0	357	10,666	18,169	100	18,169
Yuba River	25,948	0	2,595	40,490	69,033	100	69,033
Total	328,909	82,541	67,504	679,427	1,158,381		609,375
Late-Fall Run Chinook Salmon							
Battle Creek	NE	4,578	916	7,804	13,298	10	1,330
Sacramento River mainstem	NE	NE	NE	NE	NE		NE
Total	0	4578	916	7,804	13,298		1,330
Winter-Run Chinook Salmon							
Sacramento River mainstem	836		0	1,174	2,010	100	2,010
Spring-Run Chinook Salmon							
Butte Creek	635	0	64	1,002	1,700	100	1,700
Deer Creek	466	0	47	735	1,248	100	1,248
Mill Creek	202	0	20	319	541	100	541
Sacramento River mainstem	128	0	26	220	374	100	374
Total	1,431	0	156	2,276	3,863		3,863
Total 1997 Natural Production of Adult Chinook Salmon							**616,578**

NE = No Estimate

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	54,792	11,788	29,961	83,819	180,360	60	108,216
Antelope Creek							
Battle Creek	53,957	44,351	9,831	93,869	202,008	10	20,201
Bear River							
Big Chico Creek							
Butte Creek	500	0	50	481	1,031	80	825
Clear Creek	4,259	0	426	4,063	8,748	80	6,998
Cosumnes River	300	0	30	294	624	100	624
Cottonwood Creek							
Cow Creek							
Deer Creek	270	0	27	267	564	80	451
Feather River	NE	25,635	5,127	26,701	57,463	60	34,478
Merced River	3,292	799	205	3,742	8,037	90	7,234
Mill Creek	546	0	55	535	1,135	80	908
"miscellaneous creeks"							
Mokelumne River	4,122	3,091	721	6,896	14,830	60	8,898
Paynes Creek							
Sacramento River mainstem	6,318	0	632	6,041	12,990	60	7,794
Stanislaus River	3,087	0	154	2,806	6,048	100	6,048
Tuolumne River	8,910	0	446	8,125	17,481	100	17,481
Yuba River	31,090	0	3,109	29,695	63,894	100	63,894
Total	171,443	85,664	50,773	267,334	575,213		284,050
Late-Fall Run Chinook Salmon							
Battle Creek	NE	3,079	616	3,207	6,901	10	690
Sacramento River mainstem	38,239		7,648	39,834	85,721	91.8	78,692
Total	38,239	3,079	8,264	43,040	92,622		79,382
Winter-Run Chinook Salmon							
Sacramento River mainstem	2,903	99	0	2,621	5,623	100	5,623
Spring-Run Chinook Salmon							
Butte Creek	20,259	0	2,026	19,338	41,623	100	41,623
Deer Creek	1,879	0	188	1,793	3,860	100	3,860
Mill Creek	424	0	42	406	872	100	872
Sacramento River mainstem	1,115	0	223	1,162	2,500	100	2,500
Total	23,677	0	2,479	22,699	48,855		48,855
Total 1998 Natural Production of Adult Chinook Salmon							**417,909**

NE = No Estimate

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	61,982	156,376	60	93,825
Antelope Creek							
Battle Creek	92,929	26,970	11,990	86,598	218,486	10	21,849
Bear River							
Big Chico Creek							
Butte Creek							
Clear Creek	8,003	0	800	5,773	14,576	80	11,661
Cosumnes River							
Cottonwood Creek							
Cow Creek							
Deer Creek							
Feather River	NE	16,658	3,332	13,132	33,122	60	19,873
Merced River	3,129	1,637	238	3,299	8,303	90	7,473
Mill Creek							
"miscellaneous creeks"							
Mokelumne River	2,183	3,150	533	3,838	9,705	60	5,823
Paynes Creek							
Sacramento River mainstem	161,192	0	16,119	116,415	293,726	60	176,236
Stanislaus River	4,349	0	217	3,013	7,580	100	7,580
Tuolumne River	8,232	0	412	5,678	14,322	100	14,322
Yuba River	24,230	0	2,423	17,510	44,163	100	44,163
Total	359,586	58,175	65,359	317,239	800,359		402,804
Late-Fall Run Chinook Salmon							
Battle Creek	NE	7,075	1,415	5,568	14,058	10	1,406
Sacramento River mainstem	8,683		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
Spring-Run Chinook Salmon							
Butte Creek	3,679	0	368	2,667	6,714	100	6,714
Deer Creek	1,591	0	159	1,153	2,903	100	2,903
Mill Creek	560	0	56	406	1,022	100	1,022
Sacramento River mainstem	NE	NE	NE	NE	NE		NE
Total	5,830	0	583	4,227	10,640		10,640
Total 1999 Natural Production of Adult Chinook Salmon							**436,126**

NE = No Estimate

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	99,059	11,160	49,599	155,938	315,756	60	189,454
Antelope Creek							
Battle Creek	53,447	21,659	7,511	80,628	163,245	10	16,324
Bear River							
Big Chico Creek							
Butte Creek							
Clear Creek	6,687	0	669	7,205	14,561	80	11,649
Cosumnes River							
Cottonwood Creek							
Cow Creek							
Deer Creek							
Feather River	114,717	21,803	27,304	159,827	323,651	60	194,191
Merced River	11,130	1,946	654	13,381	27,111	90	24,400
Mill Creek							
"miscellaneous creeks"							
Mokelumne River	1,973	5,450	742	7,948	16,114	60	9,668
Paynes Creek							
Sacramento River mainstem	96,688	0	9,669	103,787	210,144	60	126,087
Stanislaus River	8,498	0	425	8,692	17,615	100	17,615
Tuolumne River	17,873	0	894	18,299	37,065	100	37,065
Yuba River	14,995	0	1,500	16,068	32,563	100	32,563
Total	425,067	62,018	98,965	571,774	1,157,824		659,014
Late-Fall Run Chinook Salmon							
Battle Creek	NE	4,194	839	4,914	9,947	10	995
Sacramento River mainstem	8,632		1,726	10,114	20,472	91.8	18,793
Total	8,632	4,194	2,565	15,028	30,419		19,788
Winter-Run Chinook Salmon							
Sacramento River mainstem	1,263	89	0	1,307	2,659	100	2,659
Spring-Run Chinook Salmon							
Butte Creek	4,118	0	412	4,401	8,931	100	8,931
Deer Creek	637	0	64	680	1,381	100	1,381
Mill Creek	544	0	54	582	1,180	100	1,180
Sacramento River mainstem	71	0	14	83	168	100	168
Total	5,370	0	544	5,745	11,659		11,659
Total 2000 Natural Production of Adult Chinook Salmon							**693,121**

NE = No Estimate

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	61,106	274,451	60	164,670
Antelope Creek							
Battle Creek	100,604	25,082	12,569	39,587	177,841	10	17,784
Bear River							
Big Chico Creek							
Butte Creek	4,430	0	443	1,398	6,271	80	5,017
Clear Creek	10,865	0	1,087	3,430	15,381	80	12,305
Cosumnes River							
Cottonwood Creek							
Cow Creek							
Deer Creek							
Feather River	178,645	29,005	41,530	71,374	320,554	60	192,333
Merced River	9,181	1,663	542	3,255	14,641	90	13,177
Mill Creek							
"miscellaneous creeks"							
Mokelumne River	2,307	5,728	804	2,534	11,373	60	6,824
Paynes Creek							
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	555,775	73,228	133,829	218,492	981,325		530,382
Late-Fall Run Chinook Salmon							
Battle Creek	NE	3,327	665	1,142	5,134	10	513
Sacramento River mainstem	18,351		3,670	6,297	28,318	91.8	25,996
Total	18,351	3,327	4,336	7,439	33,452		26,510
Winter-Run Chinook Salmon							
Sacramento River mainstem	8,120	104	0	2,348	10,572	100	10,572
Spring-Run Chinook Salmon							
Butte Creek	9,605	0	961	3,025	13,590	100	13,590
Deer Creek	1,622	0	162	511	2,295	100	2,295
Mill Creek	1,100	0	110	346	1,556	100	1,556
Sacramento River mainstem	736	0	147	253	1,136	100	1,136
Total	13,063	0	1,380	4,135	18,578		18,578
Total 2001 Natural Production of Adult Chinook Salmon							**586,042**

NE = No Estimate

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	79,722	274,122	60	164,473
Antelope Creek							
Battle Creek	397,149	66,147	46,330	209,040	718,665	10	71,867
Bear River							
Big Chico Creek							
Butte Creek	4,550	0	455	2,056	7,061	80	5,649
Clear Creek	16,071	0	1,607	7,259	24,937	80	19,950
Cosumnes River							
Cottonwood Creek							
Cow Creek							
Deer Creek							
Feather River	105,163	24,696	25,972	63,904	219,734	60	131,841
Merced River	8,866	1,840	535	4,615	15,857	90	14,271
Mill Creek	2,611	0	261	1,175	4,047	80	3,238
"miscellaneous creeks"							
Mokelumne River	2,840	7,913	1,075	4,867	16,696	60	10,017
Paynes Creek							
Sacramento River mainstem	65,690	0	6,569	29,623	101,882	60	61,129
Stanislaus River	7,787	0	389	3,357	11,533	100	11,533
Tuolumne River	7,173	0	359	3,105	10,637	100	10,637
Yuba River	24,051	0	2,405	10,867	37,323	100	37,323
Total	766,203	110,413	146,288	419,590	1,442,495		541,927
Late-Fall Run Chinook Salmon							
Battle Creek	NE	2,669	534	1,312	4,515	10	452
Sacramento River mainstem	36,004		7,201	17,709	60,914	91.8	55,919
Total	36,004	2,669	7,735	19,021	65,429		56,370
Winter-Run Chinook Salmon							
Sacramento River mainstem	7,360	104	0	3,043	10,508	100	10,508
Spring-Run Chinook Salmon							
Butte Creek	8,785	0	879	3,956	13,620	100	13,620
Deer Creek	2,185	0	219	984	3,387	100	3,387
Mill Creek	1,594	0	159	718	2,471	100	2,471
Sacramento River mainstem	273	0	55	134	462	100	462
Total	12,837	0	1,311	5,792	19,940		19,940
Total 2002 Natural Production of Adult Chinook Salmon							**628,746**

NE = No Estimate

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	105,170	364,182	60	218,509
Antelope Creek							
Battle Creek	64,764	88,281	15,305	68,368	236,717	10	23,672
Bear River							
Big Chico Creek							
Butte Creek	3,310	0	331	1,488	5,129	80	4,103
Clear Creek	9,475	0	948	4,225	14,647	80	11,718
Cosumnes River							
Cottonwood Creek							
Cow Creek							
Deer Creek							
Feather River	89,946	23,638	22,717	55,337	191,638	60	114,983
Merced River	2,530	549	154	1,309	4,542	90	4,088
Mill Creek	2,426	0	243	1,071	3,740	80	2,992
"miscellaneous creeks"							
Mokelumne River	2,122	8,117	1,024	4,582	15,845	60	9,507
Paynes Creek							
Sacramento River mainstem	89,229	0	8,923	39,866	138,018	60	82,811
Stanislaus River	5,902	0	295	2,529	8,726	100	8,726
Tuolumne River	2,163	0	108	922	3,193	100	3,193
Yuba River	28,316	0	2,832	12,644	43,792	100	43,792
Total	463,925	135,472	133,261	297,511	1,030,169		528,093
Late-Fall Run Chinook Salmon							
Battle Creek	NE	2,797	559	1,368	4,724	10	472
Sacramento River mainstem	5,346		1,069	2,614	9,030	91.8	8,289
Total	5,346	2,797	1,629	3,982	13,754		8,762
Winter-Run Chinook Salmon							
Sacramento River mainstem	8,133	85	0	3,334	11,552	100	11,552
Spring-Run Chinook Salmon							
Butte Creek	4,398	0	440	1,967	6,805	100	6,805
Deer Creek	2,759	0	276	1,234	4,269	100	4,269
Mill Creek	1,426	0	143	638	2,206	100	2,206
Sacramento River mainstem	0	0	0	0	0	0	0
Total	8,583	0	858	3,839	13,280		13,280
Total 2003 Natural Production of Adult Chinook Salmon							**561,687**

NE = No Estimate

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	190,507	372,670	60	223,602
Antelope Creek							
Battle Creek	23,861	68,232	9,209	105,954	207,256	10	20,726
Bear River							
Big Chico Creek							
Butte Creek	2,516	0	252	2,907	5,675	80	4,540
Clear Creek	6,365	0	637	7,318	14,319	80	11,455
Cosumnes River							
Cottonwood Creek							
Cow Creek							
Deer Creek	300	0	30	351	681	80	545
Feather River	54,171	25,509	15,936	99,990	195,606	60	117,363
Merced River	1,050	3,270	216	4,761	9,297	90	8,368
Mill Creek	1,192	0	119	1,353	2,664	80	2,132
"miscellaneous creeks"							
Mokelumne River	1,588	10,356	1,194	13,733	26,871	60	16,123
Paynes Creek							
Sacramento River mainstem	43,604	0	4,360	50,170	98,135	60	58,881
Stanislaus River	4,015	0	201	4,411	8,626	100	8,626
Tuolumne River	1,984	0	99	2,155	4,238	100	4,238
Yuba River	15,269	0	1,527	17,542	34,338	100	34,338
Total	255,145	133,767	90,314	501,152	980,377		510,936
Late-Fall Run Chinook Salmon							
Battle Creek	NE	5,040	1,008	6,317	12,365	10	1,236
Sacramento River mainstem	8,824		1,765	11,061	21,650	91.8	19,874
Total	8,824	5,040	2,773	17,377	34,014		21,111
Winter-Run Chinook Salmon							
Sacramento River mainstem	7,784	85	0	8,231	16,101	100	16,101
Spring-Run Chinook Salmon							
Butte Creek	7,390	0	739	8,489	16,618	100	16,618
Deer Creek	804	0	80	923	1,808	100	1,808
Mill Creek	998	0	100	1,147	2,245	100	2,245
Sacramento River mainstem	394	0	79	493	966	100	966
Total	9,586	0	998	11,053	21,637		21,637
Total 2004 Natural Production of Adult Chinook Salmon							**569,785**

NE = No Estimate

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	85,047	208,337	60	125,002
Antelope Creek							
Battle Creek	20,520	142,283	16,280	123,522	302,606	10	30,261
Bear River							
Big Chico Creek							
Butte Creek	4,255	0	426	3,245	7,925	80	6,340
Clear Creek	14,824	0	1,482	11,233	27,539	80	22,031
Cosumnes River							
Cottonwood Creek							
Cow Creek							
Deer Creek	946	0	95	713	1,754	80	1,403
Feather River	49,160	23,972	14,626	60,549	148,307	60	88,984
Merced River	2,500	421	146	2,104	5,171	90	4,654
Mill Creek	2,426	0	243	1,854	4,523	80	3,618
"miscellaneous creeks"							
Mokelumne River	10,406	5,736	1,614	12,231	29,987	60	17,992
Paynes Creek							
Sacramento River mainstem	57,013	0	5,701	43,254	105,969	60	63,581
Stanislaus River	1,429	0	71	1,034	2,535	100	2,535
Tuolumne River	500	0	25	357	882	100	882
Yuba River	15,048	0	1,505	11,411	27,964	100	27,964
Total	241,706	194,761	80,477	356,553	873,498		395,247
Late-Fall Run Chinook Salmon							
Battle Creek	NE	6,434	1,287	5,330	13,051	10	1,305
Sacramento River mainstem	9,493		1,899	7,863	19,254	91.8	17,675
Total	9,493	6,434	3,185	13,193	32,305		18,981
Winter-Run Chinook Salmon							
Sacramento River mainstem	15,730	109	0	10,922	26,761	100	26,761
Spring-Run Chinook Salmon							
Butte Creek	10,625	0	1,063	8,072	19,759	100	19,759
Deer Creek	2,239	0	224	1,701	4,164	100	4,164
Mill Creek	1,150	0	115	874	2,139	100	2,139
Sacramento River mainstem	30	0	6	25	61	100	61
Total	14,044	0	1,407	10,672	26,123		26,123
Total 2005 Natural Production of Adult Chinook Salmon							**467,112**

NE = No Estimate

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	21,000	8,728	13,378	13,639	56,745	60	34,047
Antelope Creek							
Battle Creek	19,493	58,017	7,751	26,984	112,245	10	11,225
Bear River							
Big Chico Creek							
Butte Creek	1,920	0	192	665	2,777	80	2,222
Clear Creek	8,422	0	842	2,933	12,197	80	9,758
Cosumnes River							
Cottonwood Creek							
Cow Creek	4,130	0	413	1,439	5,982	80	4,786
Deer Creek	1,905	0	191	665	2,761	80	2,208
Feather River	81,700	13,533	19,047	36,165	150,444	60	90,267
Merced River	2,000	150	108	720	2,977	90	2,679
Mill Creek	1,403	0	140	491	2,034	80	1,627
"miscellaneous creeks"							
Mokelumne River	1,723	4,116	584	2,028	8,451	60	5,070
Paynes Creek							
Sacramento River mainstem	55,468	0	5,547	19,309	80,324	60	48,194
Stanislaus River	3,022	0	151	1,003	4,176	100	4,176
Tuolumne River	500	0	25	164	689	100	689
Yuba River	8,127	0	813	2,824	11,764	100	11,764
Total	210,813	84,544	49,180	109,028	453,565		228,711
Late-Fall Run Chinook Salmon							
Battle Creek	NE	5,111	1,022	1,942	8,075	10	808
Sacramento River mainstem	14,168		2,834	5,383	22,385	91.8	20,549
Total	14,168	5,111	3,856	7,325	30,460		21,357
Winter-Run Chinook Salmon							
Sacramento River mainstem	17,205	98	0	5,478	22,782	100	22,782
Spring-Run Chinook Salmon							
Butte Creek	4,579	0	458	1,592	6,629	100	6,629
Deer Creek	2,432	0	243	846	3,521	100	3,521
Mill Creek	1,002	0	100	348	1,451	100	1,451
Sacramento River mainstem	0	0	0	0	0	0	0
Total	8,013	0	801	2,786	11,601		11,601
Total 2006 Natural Production of Adult Chinook Salmon							**284,450**

NE = No Estimate

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	9,019	4,597	6,127	14,941	34,684	60	20,810
Antelope Creek							
Battle Creek	9,904	11,778	2,168	18,054	41,904	10	4,190
Bear River							
Big Chico Creek							
Butte Creek	1,225	0	123	1,017	2,365	80	1,892
Clear Creek	4,129	0	413	3,435	7,977	80	6,382
Cosumnes River	53	0	5	43	102	100	102
Cottonwood Creek	1,250	0	125	1,044	2,419	80	1,935
Cow Creek	2,044	0	204	1,705	3,953	80	3,162
Deer Creek	508	0	51	426	985	80	788
Feather River	21,862	8,015	5,975	27,133	62,986	60	37,791
Merced River	497	79	29	461	1,066	90	959
Mill Creek	796	0	80	661	1,537	80	1,229
"miscellaneous creeks"	140	0	14	0	154	80	123
Mokelumne River	470	1,049	152	1,261	2,932	60	1,759
Paynes Creek							
Sacramento River mainstem	17,058	0	1,706	14,201	32,965	60	19,779
Stanislaus River	315	0	16	252	583	100	583
Tuolumne River	115	0	6	96	216	100	216
Yuba River	2,559	0	256	2,131	4,946	100	4,946
Total	71,944	25,518	17,449	86,861	201,772		106,647
Late-Fall Run Chinook Salmon							
Battle Creek	234	3,319	711	3,227	7,490	10	749
Sacramento River mainstem	15,237		3,047	13,836	32,121	91.8	29,487
Total	15,471	3,319	3,758	17,063	39,611		30,236
Winter-Run Chinook Salmon							
Sacramento River mainstem	2,488	54	0	1,919	4,461	100	4,461
Spring-Run Chinook Salmon							
Butte Creek	4,943	0	494	4,118	9,555	100	9,555
Deer Creek	644	0	64	536	1,245	100	1,245
Mill Creek	920	0	92	766	1,778	100	1,778
Sacramento River mainstem	248	0	50	225	523	100	523
Total	6,755	0	700	5,646	13,101		13,101
Total 2007 Natural Production of Adult Chinook Salmon							**154,446**

NE = No Estimate

APPENDIX C: RAW DATA USED TO CALCULATE THE MIDWATER TRAWL INDEX FOR JUVENILE AMERICAN SHAD

Indices 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 "AMESHA FMWT Indices 1967-2007.xls" spreadsheet dated July 24, 2008. 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 1971-2007.xls" spreadsheet dated July 24, 2008. 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., 1505 * 0.99 = 1490.

YOY length criteria

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

The MWT index for 1976 is unusually low 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	0	0	0	0	
	number of YOY measured	0	0	0	0	
	total number of fish measured	0	0	0		
	estimated percent YOY	99.0	99.1	99.4	99.2	
	YOY abundance index	1,504	1,081	603	203	3,392
1968	all age abundance index	274	277	137	70	758
	number of fish older than age 0 measured	0	0	0	0	
	number of YOY measured	0	0	0	0	
	total number of fish measured	0	0	0		
	estimated percent YOY	99.0	99.1	99.4	99.2	
	YOY abundance index	271	275	136	69	751
1969	all age abundance index	1,320	1,177	789	402	3,688
	number of fish older than age 0 measured	0	0	0	0	
	number of YOY measured	0	0	0	0	
	total number of fish measured	0	0	0		
	estimated percent YOY	99.0	99.1	99.4	99.2	
	YOY abundance index	1,307	1,166	784	399	3,656
1970	all age abundance index	366	254	170	66	856
	number of fish older than age 0 measured	0	0	0	0	
	number of YOY measured	0	0	0	0	
	total number of fish measured	0	0	0	0	
	estimated percent YOY	99.0	99.1	99.4	99.2	
	YOY abundance index	362	252	169	65	849
1971	all age abundance index	351	473	380	255	1,459
	number of fish older than age 0 measured	0	3	1	0	
	number of YOY measured	0	142	93	45	
	total number of fish measured	0	145	94	45	
	percent YOY (estimated in Sept.)	99.0	97.9	98.9	100.0	
	YOY abundance index	347	463	376	255	1,442
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

Year		Monthly index				Annual index
		September	October	November	December	
1973	all age abundance index	599	193	211	82	1,085
	number of fish older than age 0 measured	0	1	0	0	
	number of YOY measured	0	83	86	28	
	total number of fish measured	0	84	86	28	
	percent YOY (estimated in Sept.)	99.0	98.8	100.0	100.0	
	YOY abundance index	593	191	211	82	1,077
1974	all age abundance index	NS	NS	NS	NS	NS
	number of fish older than age 0 measured	0	0	0	0	
	number of YOY measured	0	0	0	0	
	total number of fish measured	0	0	0	0	
	percent YOY	0.0	0.0	0.0	0.0	
	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	560	332	273	110	
	total number of fish measured	565	332	274	110	
	percent YOY	99.1	100.0	99.6	100.0	
	YOY abundance index	1,229	587	484	178	2,478
1976	all age abundance index	NS	69	102	NS	171
	number of fish older than age 0 measured	0	0	0	0	
	number of YOY measured	0	42	65	0	
	total number of fish measured	0	42	65	0	
	percent YOY (estimated in Sept. and Dec.)	0.0	100.0	100.0	0.0	
	YOY abundance index	NS	69	102	NS	171
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	86	111	140	75	
	total number of fish measured	86	112	141	75	
	percent YOY	100.0	99.1	99.3	100.0	
	YOY abundance index	126	146	231	130	633
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	321	272	191	126	
	total number of fish measured	322	273	193	127	
	percent YOY	99.7	99.6	99.0	99.2	
	YOY abundance index	760	1,056	318	219	2,353

Year		Monthly index				Annual index
		September	October	November	December	
1979	all age abundance index	NS	NS	NS	NS	NS
	number of fish older than age 0 measured	0	0	0	0	
	number of YOY measured	0	0	0	0	
	total number of fish measured	0	0	0	0	
	percent YOY	0.0	0.0	0.0	0.0	
	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	216	229	198	135	
	total number of fish measured	229	242	200	140	
	percent YOY	94.3	94.6	99.0	96.4	
	YOY abundance index	1,221	1,606	518	387	3,732
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	192	289	203	118	
	total number of fish measured	194	293	207	119	
	percent YOY	99.0	98.6	98.1	99.2	
	YOY abundance index	283	515	342	275	1,415
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	752	734	637	118	
	total number of fish measured	755	736	637	119	
	percent YOY	99.6	99.7	100.0	99.2	
	YOY abundance index	2,236	1,605	1,325	208	5,374
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	532	374	407	74	
	total number of fish measured	532	375	409	75	
	percent YOY	100.0	99.7	99.5	98.7	
	YOY abundance index	962	850	953	157	2,922
1984	all age abundance index	292	172	267	86	817
	number of fish older than age 0 measured	0	0	0	0	
	number of YOY measured	0	0	0	0	
	total number of fish measured	0	0	0	0	
	estimated percent YOY	99.0	99.1	99.4	99.2	
	YOY abundance index	289	170	265	85	810

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	228	266	467	225	
	total number of fish measured	228	267	469	226	
	percent YOY	100.0	99.6	99.6	99.6	
	YOY abundance index	316	331	562	384	1,593
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	163	231	160	137	
	total number of fish measured	166	231	160	137	
	percent YOY	98.2	100.0	100.0	100.0	
	YOY abundance index	681	567	313	286	1,847
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	172	173	106	73	
	total number of fish measured	191	183	106	73	
	percent YOY	90.1	94.5	100.0	100.0	
	YOY abundance index	235	276	222	124	857
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	401	239	173	72	
	total number of fish measured	402	240	174	72	
	percent YOY	99.8	99.6	99.4	100.0	
	YOY abundance index	803	309	298	135	1,545
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	441	247	361	211	
	total number of fish measured	442	247	361	212	
	percent YOY	99.8	100.0	100.0	99.5	
	YOY abundance index	568	339	592	376	1,875
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	619	452	637	247	
	total number of fish measured	619	454	642	251	
	percent YOY	100.0	99.6	99.2	98.4	
	YOY abundance index	1,493	943	1,358	499	4,293

Year		Monthly index				Annual index
		September	October	November	December	
1991	all age abundance index	1,076	780	872	260	2,988
	number of fish older than age 0 measured	2	0	2	0	
	number of YOY measured	541	535	454	161	
	total number of fish measured	543	535	456	161	
	percent YOY	99.6	100.0	99.6	100.0	
	YOY abundance index	1,072	780	868	260	2,980
1992	all age abundance index	755	530	463	262	2,010
	number of fish older than age 0 measured	0	0	1	1	
	number of YOY measured	479	387	339	132	
	total number of fish measured	479	387	340	133	
	percent YOY	100.0	100.0	99.7	99.2	
	YOY abundance index	755	530	462	260	2,007
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	736	563	469	428	
	total number of fish measured	736	563	470	429	
	percent YOY	100.0	100.0	99.8	99.8	
	YOY abundance index	1,972	1,567	906	708	5,153
1994	all age abundance index	439	387	391	117	1,334
	number of fish older than age 0 measured	5	4	2	1	
	number of YOY measured	497	304	255	73	
	total number of fish measured	502	308	257	74	
	percent YOY	99.0	98.7	99.2	98.6	
	YOY abundance index	435	382	388	115	1,320
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	1699	1283	720	450	
	total number of fish measured	1701	1284	720	450	
	percent YOY	99.9	99.9	100.0	100.0	
	YOY abundance index	3,242	2,218	791	555	6,806
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	1139	900	754	336	
	total number of fish measured	1141	905	757	338	
	percent YOY	99.8	99.4	99.6	99.4	
	YOY abundance index	1,753	1,066	931	520	4,270

Year		Monthly index				Annual index
		September	October	November	December	
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	456	540	550	805	
	total number of fish measured	458	541	550	805	
	percent YOY	99.6	99.8	100.0	100.0	
	YOY abundance index	264	564	639	1,125	2,592
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	1149	1172	364	111	
	total number of fish measured	1150	1172	366	111	
	percent YOY	99.9	100.0	99.5	100.0	
	YOY abundance index	1,317	2,093	512	214	4,136
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	323	218	171	107	
	total number of fish measured	323	218	171	107	
	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	166	437	127	41	
	total number of fish measured	166	437	127	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	385	324	119	43	
	total number of fish measured	385	324	119	43	
	percent YOY	100.0	100.0	100.0	100.0	
	YOY abundance index	338	239	110	78	765
2002	all age abundance index	372	831	334	382	1,919
	number of fish older than age 0 measured	1	2	0	1	
	number of YOY measured	404	706	303	261	
	total number of fish measured	405	708	303	262	
	percent YOY	99.8	99.7	100.0	99.6	
	YOY abundance index	371	829	334	381	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	1676	1507	1080	1182	
	total number of fish measured	1680	1508	1080	1182	
	percent YOY	99.8	99.9	100.0	100.0	
	YOY abundance index	3,337	2,945	1,279	1,789	9,350
2004	all age abundance index	680	83	78	106	947
	number of fish older than age 0 measured	0	0	0	0	
	number of YOY measured	673	159	99	72	
	total number of fish measured	673	159	99	72	
	percent YOY	100.0	100.0	100.0	100.0	
	YOY abundance index	680	83	78	106	947
2005	all age abundance index	826	546	177	189	1,738
	number of fish older than age 0 measured	1	0	0	0	
	number of YOY measured	465	438	174	125	
	total number of fish measured	466	438	174	125	
	percent YOY	99.8	100.0	100.0	100.0	
	abundance index for YOY	824	546	177	189	1,736
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	507	175	525	290	
	total number of fish measured	508	175	527	291	
	percent YOY	99.8	100.0	99.6	99.7	
	abundance index for YOY	1,117	142	644	405	2,307
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	179	277	101	60	
	total number of fish measured	179	278	101	60	
	percent YOY	100.0	99.6	100.0	100.0	
	abundance index for YOY	123	256	116	57	552

average percent YOY value for the 10-year period of 1972, 1975, 1977, 1978, 1980-1983, 1985, and 1986	99.0	99.1	99.4	99.2