COMPREHENSIVE ASSESSMENT AND MONITORING PROGRAM

A Compilation and Analysis
of Anadromous Fish Monitoring Data
From the Central Valley of California
1992-2006

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

October 2007

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TABLE OF CONTENTS

ACRONYMS AND ABBREVIATIONS

AFRP	Anadromous Fish Restoration Program
CAMP	Comprehensive Assessment and Monitoring Program
CDFG	California Department of Fish and Game
CNFH	Coleman National Fish Hatchery
CVPIA	Central Valley Project Improvement Act
MWT	midwater trawl
PFMC	Pacific Fishery Management Council
PSC	Pacific Salmon Commission
RBDD	Red Bluff Diversion Dam
USFWS	U.S. Fish and Wildlife Service
YOY	young-of-the-year

LIST OF TABLES

LIST OF FIGURES

EXECUTIVE SUMMARY

Section 3406(b)(16) of the Central Valley Project Improvement Act (CVPIA; Public Law 102-575) requires that a comprehensive assessment program be established to monitor fish and wildlife resources in the Central Valley of California and to assess the biological results and effectiveness of restoration activities pursuant to other CVPIA provisions. The Comprehensive Assessment and Monitoring Program (CAMP) was established to address this task.

CAMP has program 2 objectives: (1) assess overall (cumulative) effectiveness of habitat restoration actions implemented pursuant to CVPIA Section 3406(b) in meeting fish production targets quantified by the Anadromous Fish Restoration Program (AFRP) and (2) assess relative effectiveness of categories of Section 3406(b) actions (e.g., water management modifications, structural modifications, habitat restoration, and fish screens) toward meeting AFRP production targets. This report focuses specifically on program objective #1 and one broader area and 13 Central Valley watersheds of interest to the CAMP. The broader area includes San Pablo Bay/Suisun Bay/Sacramento-San Joaquin River Delta (Bay-Delta area), and the 13 watersheds are the American River, Battle Creek, Butte Creek, Clear Creek, Deer Creek, Feather River, Merced River, Mill Creek, Mokelumne River, Sacramento River mainstem, Stanislaus River, Tuolumne River, and Yuba River.

This report assesses progress toward AFRP production targets by synthesizing data collected between 1967 and 2006. These production targets quantify *natural* (as compared to hatchery) production of 9 anadromous fish taxa at the locations identified above. The 9 fish taxa include fall-, late fall-, winter-, and spring-run Chinook salmon; steelhead; striped bass; American shad; white sturgeon; and green sturgeon. The AFRP production targets for Chinook salmon include 3 tiers: (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, and (3) a Central Valley-wide production target for the combined total of all 4 runs of Chinook salmon. The production targets for the other 5 taxa do not possess tiers and instead refer to taxa-specific areas.

Progress toward AFRP production targets for the 9 taxa was assessed by quantifying the number of years AFRP production targets were met after 1991. This report also uses 3 additional tools to assess changes in abundance of Chinook salmon at the watershed level. These include: (1) for each of the 13 abovementioned watersheds, determining if average natural production of adult Chinook salmon during the 1967-1991 time period was greater or less than the production during the 1992-2006 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 2 time periods; and (3) utilizing rebuilding assessment methods developed by the Pacific Salmon Commission (PSC) to determine if incremental production targets between 1999 and 2004 were met. The PSC rebuilding assessment methods assign runs of salmon to 3 categories: (1) those at or above a series of annual production targets, (2) those that are rebuilding toward a series of annual production targets, and (3) those that are 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 that quantify natural production of adult Chinook salmon from the Central Valley during the 15-year period between 1992 and 2006 are summarized in Table 1. 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.

Table 1. Overall assessment of changes in natural production of Chinook salmon in the Central Valley of California, 1967-2006. SD = significantly different, NSD = not significantly different.

Watershed	Chinook salmon run	Metric to assess change in Chinook salmon production			
		Number of years the AFRP production target was exceeded / number of years monitoring occurred since 1992	Change in average production between the 1967-1991 and 1992-2006 time periods	statistical difference (α=0.05) in average production between the 1967-1991 and 1992-2006 time periods	Production status using the PSC's rebuilding assessment methods 1999-2004
American River*	fall-run	6/15	up	SD	above target
Battle Creek*	fall-run	13/15	up	SD	above target
Battle Creek*	late fall-run	7/15	up	SD	indeterminate
Butte Creek	fall-run	7/10	up	SD	above target
Butte Creek	spring-run	12/15	up	SD	above target
Clear Creek	fall-run	11/15	up	SD	above target
Deer Creek	fall-run	2/7	up	NSD	insufficient data
Deer Creek	spring-run	0/15	down	NSD	not rebuilding
Feather River*	fall-run	3/15	up	SD	not rebuilding
Merced River*	fall-run	1/15	down	NSD	not rebuilding
Mill Creek	fall-run	1/10	up	NSD	insufficient data
Mill Creek	spring-run	0/15	down	NSD	not rebuilding
Mokelumne River*	fall-run	8/15	up	SD	above target
Sacramento River	fall-run	0/15	down	NSD	not rebuilding
Sacramento River	late fall-run	1/14	down	NSD	not rebuilding
Sacramento River	winter-run	0/15	down	SD	not rebuilding
Sacramento River	spring-run	0/15	down	SD	not rebuilding
Stanislaus River	fall-run	0/15	down	NSD	not rebuilding
Tuolumne River	fall-run	0/15	down	SD	not rebuilding
Yuba River	fall-run	1/15	up	NSD	not rebuilding

* Indicates a fish hatchery is located in the watershed.

These data suggest that during the 15-year period between 1992 and 2006:

- Watershed-specific AFRP production targets for fall-run Chinook salmon were met 6 or more times in the following watersheds: American River, Battle Creek, Butte Creek, Clear Creek, and Mokelumne River. In contrast, production targets for fall-run Chinook salmon were met 3 or fewer times in the following watersheds: Deer Creek, Feather River, Merced River, Mill Creek, Sacramento River mainstem, Stanislaus River, Tuolumne River, and Yuba River.

- The watershed-specific AFRP production target for late fall-run Chinook salmon may have been met 7 times on Battle Creek. In contrast, the watershed-specific production target for late fall-run Chinook salmon on the Sacramento River mainstem was met once.

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

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

- The run-specific AFRP production target for fall-run Chinook salmon was probably never met, run-specific AFRP production targets for 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.

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

The statements above that the AFRP's fall-run and Central Valley-wide production targets were "probably never met" between 1992 and 2006 are made here because the CAMP does not monitor production of Chinook salmon in 8 watersheds that are considered by the AFRP. It is unlikely these two AFRP production targets would have been met, even if production from the 8 watersheds was considered.

In several watersheds, analyses that use Chinook salmon data from the 1967-1991 and 1992-2006 time periods and the PSC's rebuilding assessment methods complimented the analysis of the number of times the AFRP production targets were met; i.e., (1) production of Chinook salmon from the American River, Battle Creek, Butte Creek, Clear Creek, and Mokelumne River increased after 1991; and (2) production of Chinook salmon from the Merced River, Sacramento River mainstem, Stanislaus River, and Tuolumne River decreased after 1991. Some of these changes in Chinook salmon production were statistically significant, while others were not. Analyses using 1967-1991 and 1992-2006 data and the PSC's rebuilding assessment methods for Chinook salmon production on Deer Creek, Feather River, Mill Creek, and Yuba River did not yield results that complemented the analysis with the number of times the AFRP production targets were met. This discrepancy was due, in part, to inconsistent collection of monitoring data at some locations.

In watersheds where annual production estimates of Chinook salmon exceed the AFRP production targets, it is not appropriate to assume natural production of a specific taxa in a particular watershed is sustainable at the present time. In watersheds where AFRP production targets are rarely met, additional habitat improvement projects may be required to increase production of adult Chinook salmon.

It is not possible to assess progress toward the AFRP production target for adult steelhead. This condition primarily exists because operational changes at the Red Bluff Diversion Dam after 1994 preclude the ability to collect comparable data before and after 1994.

With respect to non-salmonid species:

- Monitoring of white sturgeon in San Pablo and Suisun Bays occurred in 7 years between 1992 and 2006. The AFRP production target for 15-year old white sturgeon was met once in those 7 years.

- Monitoring of green sturgeon in San Pablo and Suisun Bays occurred in 6 years between 1992 and 2006. The AFRP production target for green sturgeon ≥ 40 inches in length was met twice in those 6 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 3 of 15 years between 1992 and 2006.

- 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 9 years between 1992 and 2004. The AFRP production target for this species was never met during those 9 years.

In the future, staff from the CAMP will work with multiple partners in an effort to: (1) refine data collection techniques, and (2) collect fish production data each year. Each of these tasks must be completed to assess progress toward the AFRP production targets in a more statistically robust manner.

SECTION 1: INTRODUCTION

1.1 OVERVIEW OF THE CAMP AND AFRP

This is the fifth Comprehensive Assessment and Monitoring Program report prepared since 1992. This report provides estimates of natural production of 9 anadromous fish taxa between 1967 and 2006 from one broader area and 13 Central Valley watersheds of interest to the CAMP. The broader area includes the San Pablo Bay/Suisun Bay/Sacramento-San Joaquin River Delta, and the 13 watersheds are the American River, Battle Creek, Butte Creek, Clear Creek, Deer Creek, Feather River, Merced River, Mill Creek, Mokelumne River, Sacramento River mainstem, Stanislaus River, Tuolumne River, and Yuba River. The CVPIA defines natural production as "fish produced to adulthood without direct human intervention in the spawning, rearing, or migration processes." This report does not therefore 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 (*Oncorhynchus tshawytscha*).

The first 4 reports prepared by the CAMP provided monitoring data for the periods 1995-1997 (CH2M-Hill et al. 1998), 1995-1998 (CH2M-Hill 1999), 1995-1999 (CH2M-Hill 2001), and 1995-2000 (CH2M-Hill 2002). Production estimates for anadromous fish in a given year and location are sometimes presented as different values in different CAMP reports because data are occasionally re-analyzed using improved methods. This fifth report avoids this problem by presenting current estimates of natural production for each taxa, year, and location between 1967 and 2006.

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."

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). These fish taxa include fall-, late fall-, winter-, and spring-run Chinook salmon, steelhead trout (*Oncorhynchus mykiss*), striped bass (*Morone saxatilis*), American shad (*Alosa sapidissima*), white sturgeon (*Acipenser transmontanus*), and green sturgeon (*Acipenser medirostris*). The AFRP used the CDFG fish abundance estimates to develop production targets for the 9 fish taxa. These AFRP production targets are twice the average levels during the 1967-1991 baseline period and are quantified in the *Final Restoration Plan for the Anadromous Fish Restoration Program* (USFWS 2001).

The AFRP and several other entities implement a variety of habitat restoration activities in the Central Valley. These activities are intended to increase natural production of anadromous fish so fish production targets in particular watersheds can be achieved.

Pursuant to Section 3406(b)(16) of the CVPIA, the Secretary of the Interior is authorized and directed to "establish, in cooperation with independent entities and the State of California, a comprehensive assessment program 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)]". The CAMP was established to address this task. A CAMP Implementation Plan (Montgomery Watson et al. 1997) describes how the CAMP will monitor fish resources and assess the biological results and effectiveness of habitat restoration activities.

The CAMP Implementation Plan contains 2 program objectives that guide the program's monitoring and assessment activities:

1. assess overall (cumulative) effectiveness of habitat restoration actions implemented pursuant to CVPIA Section 3406(b) in meeting AFRP production targets, and

2. assess relative effectiveness of categories of Section 3406(b) actions (e.g., water management modifications, structural modifications, habitat restoration, and fish screens) toward meeting AFRP production targets.

Program Objective #1 generally focuses on monitoring natural production of adult anadromous fish, while Program Objective #2 focuses on monitoring the number of juvenile Chinook salmon. The CAMP evaluates and analyzes data at a system-wide level (e.g., entire watersheds or regions) and does not typically evaluate or analyze data pertaining to site-specific projects.

This report addresses CAMP program objective #1, and provides a compilation and analysis of natural production data for 9 anadromous fish taxa in the Central Valley between 1967 and 2006. The CAMP will address CAMP program objective #2 in one or more subsequent reports.

1.2 PRODUCTION TARGETS FOR ANADROMOUS FISH

The AFRP has developed fish production targets for the 9 abovementioned taxa. In regard to natural production of Chinook salmon, the AFRP has developed 3 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 4 runs of Chinook salmon.

The AFRP's Final Restoration Plan identifies Chinook salmon production targets in 22 watersheds. Of these 22 watersheds, the CAMP only attempts to monitor progress toward AFRP production targets in 13 of the watersheds. The 13 watersheds were selected by the CAMP because they: (1) account for most (97%) of the total average 1967-1991 Central Valley spawning escapement of fall-run Chinook salmon, (2) are the focus of more intense and comprehensive monitoring activities, (3) are considered representative of all of the major geographic areas that have AFRP production targets, and (4) have potential for increased salmon escapement resulting from implementation of AFRP restoration actions.

Because the CAMP monitors production of Chinook salmon in a subset of the watersheds that have an AFRP production target, it is necessary to develop "CAMP production targets" that pro-rate the AFRP's run-specific and Central Valley-wide production targets to account for watersheds that are not considered by the CAMP. The similarities and differences between the AFRP and CAMP production targets are depicted in Table 2, and are as follows:

The CAMP's watershed-specific production targets for different runs of Chinook salmon in the 13 "CAMP watersheds" are identical to AFRP watershed-specific production targets.

The AFRP's production targets for late fall-run, winter-run, and spring-run Chinook salmon are 68,000, 110,000, and 68,000 adult fish, respectively. The CAMP has adopted each of these production targets.

The AFRP's production target for fall-run Chinook salmon is 750,000 adult fish. This production target pertains to the 21 watersheds identified in Table 2. For CAMP assessment purposes, the fall-run Chinook salmon production target is pro-rated to 737,600 adult fish; this number reflects the 13 watersheds that are addressed by the CAMP and the AFRP watershed-specific production targets for fall-run Chinook salmon.

The AFRP's Central Valley-wide production target for the combined total of all 4 runs of Chinook salmon that are naturally produced in the Central Valley is 990,000 adult fish. The CAMP Central Valley-wide production target for the combined total of all 4 runs is 983,600 adult fish, i.e., it includes the CAMP fall-run production target plus the AFRP's late fall-, winter- and spring-run production targets (i.e., 737,600 + 68,000 + 110,000 + 68,000).

The CAMP has adopted the AFRP production targets pertaining to steelhead trout, striped bass, American shad, white sturgeon, and green sturgeon.

Table 2. Natural fish production targets for the Anadromous Fish Restoration Program and Comprehensive Assessment and Monitoring Program. With the exception of the American shad, all the production targets pertain to adult fish.

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

Table 2 (cont.). Natural fish production targets for the Anadromous Fish Restoration Program and Comprehensive Assessment and Monitoring Program. With the exception of the American shad, all the production targets pertain to adult fish.

Taxa	Watershed/area	1967-1991 baseline production estimate	AFRP production target	CAMP production target
CHINOOK SALMON				
Fall-run		370,000	750,000	737,600
Late fall-run		34,000	68,000	68,000
Winter-run		54,000	110,000	110,000
Spring-run run		34,000	68,000	68,000
Central Valley-wide, all 4 salmon runs combined		500,000	990,000	983,600
STEELHEAD	Sacramento River upstream of the Red Bluff Diversion Dam	6,546	13,000	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	2,500,000
AMERICAN SHAD[2]	Sacramento-San Joaquin River Delta, San Pablo Bay, and Suisun Bay	2,129	4,300	4,300
WHITE STURGEON[3]	San Pablo and Suisun Bays	5,571	11,000	11,000
GREEN STURGEON[3]	San Pablo and Suisun Bays	983	2,000	2,000

1 = Yoshiyama et al. (2001) suggest a real winter-run of 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 HoganDam

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.

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 populations includes elements of both production quantity and sustainability. To achieve this goal, it is necessary to both 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 same 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 targets reported by CAMP, herein, and in previous CAMP reports infer only progress toward numeric goals (also referred to as production targets) and do not infer 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. Future planned activities of the CAMP include addressing the sustainability element of the AFRP's goal to double natural production. 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.

1.4 DATA REPORTING CAVEATS

The fish production estimates presented in CAMP reports represent the best available information at the time of report production. It is important to recognize several factors that affect accuracy and/or precision of data and analyses provided in the reports. Some of these factors include, but are not limited to, the following elements:

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 4 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, formerly of the CDFG, developed and maintained the Grandtab spreadsheet that provides escapement estimates of Chinook salmon.

3. Marty Gingras and Mike Donnellan 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, and generously reviewed a variety of CAMP-generated spreadsheets that synthesize his data.

5. Nina Kogut of the CDFG provided abundance data for adult striped bass.

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SECTION 2: METHODS

2.1 OVERVIEW OF MONITORING LOCATIONS AND ACTIVITIES

The CAMP Implementation Plan identifies several monitoring techniques that should be used to quantify natural production of anadromous fish from the Bay-Delta area and the 13 CAMP watersheds (Figure 1). These monitoring techniques vary by taxa and include, but are not limited to, carcass surveys, mark-recapture surveys, and ocean harvest surveys. With the exception of the American shad, monitoring activities in the context of CAMP Program Objective #1 are focused on adult life stages of steelhead trout, striped bass, white sturgeon, green sturgeon, and the 4 runs of Chinook salmon. Monitoring of American shad focuses on the juvenile life stage. Specific techniques used to monitor the 9 anadromous fish taxa pursuant to CAMP Program Objective #1 are listed in Table 3.

Figure 1. Location of CAMP-recommended monitoring activities in the Central Valley. Big Chico Creek and San Joaquin River are not used to develop adult fish production estimates.

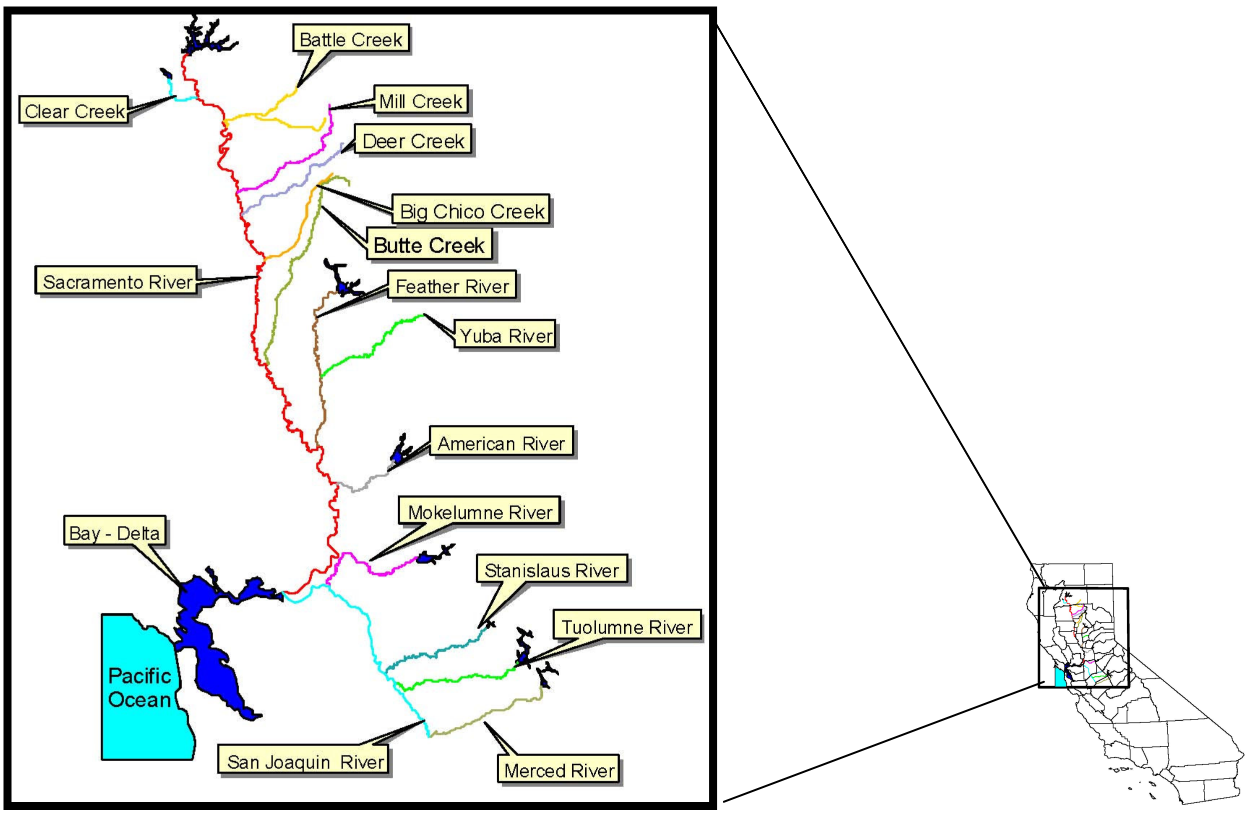


Table 3. CAMP-recommended monitoring activities for adult anadromous fish taxa.

Watershed	Taxa	Recommended techniques for monitoring fish abundance/production
American River	fall-run Chinook salmon	carcass survey, hatchery counts, hatchery marking, angler survey
Battle Creek	fall-run Chinook salmon	carcass survey, hatchery counts, hatchery marking
	late fall-run Chinook salmon	carcass survey, hatchery counts, hatchery marking
Butte Creek	fall-run Chinook salmon	carcass survey
	spring-run Chinook salmon	snorkel survey
Clear Creek	fall-run Chinook salmon	carcass survey
Deer Creek	fall-run Chinook salmon	carcass survey
	spring-run Chinook salmon	snorkel survey
Feather River	fall-run Chinook salmon	carcass survey, hatchery counts, hatchery marking, angler survey
Merced River	fall-run Chinook salmon	carcass survey, hatchery counts, hatchery marking
Mill Creek	fall-run Chinook salmon	carcass survey
	spring-run Chinook salmon	ladder counts
Mokelumne River	fall-run Chinook salmon	ladder counts, hatchery counts, hatchery marking, angler survey
Sacramento River	fall-run Chinook salmon	carcass survey, ladder counts, aerial redd counts, angler survey
	late fall-run Chinook salmon	aerial redd counts, angler survey
	winter-run Chinook salmon	carcass survey, ladder counts, aerial redd counts
	spring-run Chinook salmon	ladder counts, angler survey
San Joaquin River	fall-run Chinook salmon	angler survey
Stanislaus River	fall-run Chinook salmon	carcass survey, angler survey, Alaska weir*, Vaki camera system*
Tuolumne River	fall-run Chinook salmon	carcass survey
Yuba River	fall-run Chinook salmon	carcass survey, angler survey, Vaki camera system*
Pacific Ocean	fall-run Chinook salmon	ocean harvest sampling
	late fall-run Chinook salmon	ocean harvest sampling
	winter-run Chinook salmon	ocean harvest sampling
	spring-run Chinook salmon	ocean harvest sampling
Battle Creek	steelhead	hatchery counts, hatchery marking
Sacramento River	steelhead	in-river harvest
Sacramento-San Joaquin River Delta, and the lower portions of the Sacramento and San Joaquin Rivers	striped bass	mark-recapture program every other year
Sacramento-San Joaquin River Delta, San Pablo Bay, and Suisun Bay	American shad	midwater trawl survey: juvenile abundance index
San Pablo and Suisun Bays	white sturgeon	mark-recapture program for 2 years, followed by 2 non-estimate years
San Pablo and Suisun Bays	green sturgeon	estimate based on ratio of green to white sturgeon observed during tagging

* Alaska weirs and the Vaki camera systems are currently used to estimate fish production in some watersheds, but these tools are not described in the CAMP Implementation Plan.

Monitoring techniques in several watersheds were modified after the 1997 CAMP Implementation Plan was finalized. For example, on Battle Creek carcass surveys are no longer used to monitor adult escapement of fall-run Chinook salmon. Instead, video monitoring at a temporary weir is used to monitor fall-run escapement. Hatchery marking/hatchery returns of winter-run Chinook salmon are no longer monitored at Coleman National Fish Hatchery (CNFH). Instead, monitoring quantifies returns of adult winter-run Chinook salmon to Livingston Stone National Fish Hatchery on the Sacramento River mainstem. On Butte Creek, carcass counts are now used to monitor abundance of spring-run Chinook salmon in addition to traditional snorkel surveys.

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 MEASURE PRODUCTION OF SALMONID TAXA

2.2.1 METHODS FOR ADULT CHINOOK SALMON

For purposes of the CAMP, calculations to estimate natural production of Chinook salmon from each watershed include 3 components: (1) in-river run, (2) downstream angler harvest, and (3) ocean harvest. Figure 2 provides an illustration that demonstrates how the 3 components provide an estimate of the production of Chinook salmon from each watershed.

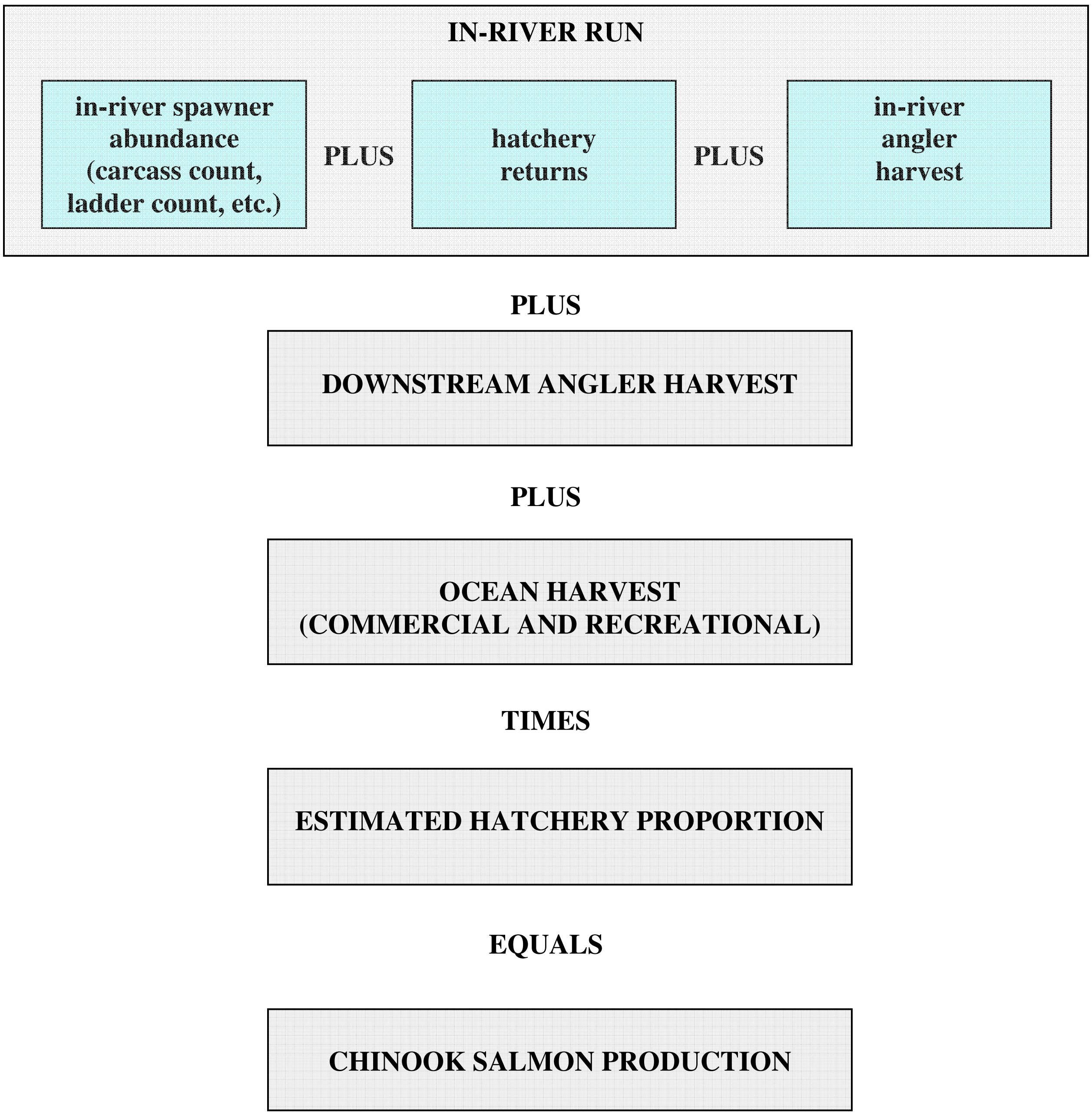
In-river run is estimated by summing in-river spawner abundance (estimated by carcass surveys, ladder counts, weir counts, snorkel surveys, and aerial redd counts) plus the number of salmon entering hatcheries (estimated by hatchery returns) plus in-river angler harvest. Monitoring of in-river angler harvest has not occurred on a consistent basis between 1992 and 2006. The amount of in-river angler harvest is therefore based on general estimates developed by fisheries biologists. These estimates are likely more accurate for winter- and spring-run Chinook salmon than fall-run Chinook salmon.

The magnitude of downstream angler harvest of Chinook salmon has not been monitored on a consistent basis between 1992 and 2006. Previous iterations of the CAMP reports reflect this data deficiency and this deficiency continues in this report. Chinook salmon production estimates in the CAMP reports may underestimate the total fish production from each watershed because downstream angler harvest levels have not been quantified on a regular basis.

Ocean harvest data that are used to develop fish production estimates in this report are based on values reported by the Pacific Fisheries Management Council (PFMC). This CAMP report uses PFMC ocean harvest data that reflect commercial and recreational catches from boats in the Monterey and San Francisco Bay areas because harvest data from these areas appear in the

Chinookprod spreadsheet. This report does not therefore reflect ocean harvest from boats based in Crescent City, Eureka, and Fort Bragg, as is recommended in the CAMP Implementation Plan.

Figure 2. Idealized components that should be used to calculate production of adult Chinook salmon. The CAMP uses these calculations to estimate production of each run of Chinook salmon in each watershed with an AFRP production target.



The final calculation used to estimate natural production for a particular run of salmon in each watershed consists of multiplying total production from a watershed by the estimated hatchery proportion; i.e., the estimated ratio of natural- vs. hatchery-origin fish in that watershed.

This report uses the following references to develop Chinook salmon production estimates: (1) the Grandtab020407.xls spreadsheet prepared by the CDFG; (2) the Chinookprod021307.xls spreadsheet prepared by the USFWS; and (3) commercial and recreational salmon harvest data summarized in the *Review of 2006 Ocean Salmon Fisheries* (PFMC 2007). The formulas that are used in the Chinookprod021307.xls spreadsheet to develop Chinook salmon production estimates are described in Appendix A.

2.2.2 CHINOOK SALMON POPULATION ASSESSMENTS

This report assesses the overall (cumulative) effectiveness of habitat restoration actions using 4 methods:

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

2. Determining if there is an upward or downward change in the average natural production of adult Chinook salmon from each of the 13 CAMP watersheds between the 1967-1991 and 1992-2006 time periods;

3. Using a Student's t-test to determine if there is a statistically significant ($\alpha = 0.05$) difference in the average production of adult Chinook salmon from each of the 13 CAMP watersheds between the 1967-1991 and 1992-2006 time periods; and

4. Using a modified version of the Pacific Salmon Commission's (PSC) rebuilding assessment methods to assess changes in production of Chinook salmon from each of the 13 CAMP watersheds. Use of the PSC's rebuilding assessment methods to assess changes in production of Chinook salmon is called for in the CAMP Implementation Plan (Montgomery Watson et al. 1997).

The PSC rebuilding assessment methods assign indicator runs of salmon to 3 categories: (1) those at or above a series of annual incremental production targets, (2) those rebuilding toward a series of annual incremental production targets, and (3) those not rebuilding toward a series of annual incremental production targets. The CAMP assigns individual runs in different watersheds in the Central Valley to these categories by comparing annual incremental production targets for runs in different watersheds with fish production estimates during a corresponding period. Because fish production estimates in 2005 and 2006 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 1999 and 2004. Appendix B describes the process for using the PSC's rebuilding assessment methods.

Analyses using the Student's t-test assume there were unequal variances in the average Chinook salmon production estimates between the 1967-1991 and 1992-2006 time periods.

2.2.3 METHODS FOR ADULT STEELHEAD

According to the CAMP Implementation Plan, production of steelhead on the upper Sacramento River should be monitored by quantifying the number of steelhead upstream of Red Bluff Diversion Dam (RBDD). Therefore: (1) adult steelhead should be counted as they return to Coleman national Fish Hatchery, (2) juvenile steelhead should be marked at CNFH before they are released to provide an ability to discriminate between natural- and hatchery-origin fish as adult steelhead return to the hatchery, and (3) surveys should be conducted to quantify the number of adult steelhead harvested by anglers above RBDD.

The AFRP's baseline production estimate for natural-origin steelhead during the 1967-1991 baseline period was developed by subtracting the number of steelhead that returned to CNFH (these fish were assumed to represent 100% hatchery-origin fish) from the number of steelhead counted at the fish ladder on RBDD. The resulting number was assumed to be a conservative estimate of the number of natural-origin steelhead returning to the upper Sacramento River above RBDD.

Prior to 1994, the gates on RBDD were closed on a year-round basis and the fish ladder on the dam could be used to count migrating salmonids on a daily basis. Since 1994, the gates on RBDD have remained open between September 15-May 15. When the gates are open, fish cannot be counted using the fish ladder (Jim Smith, USFWS, pers. comm.). Because the fish ladder is no longer useable when adult steelhead migrate between August and March, it is no longer possible to count steelhead in a manner comparable with the 1967-1991 baseline period.

Two additional factors make it difficult to measure temporal changes in natural production of steelhead numbers above RBDD. First, angler surveys that quantify harvest of steelhead from the Sacramento River have only occurred during 5 years (1998-2002) since the baseline period, making it difficult to assess temporal changes in harvest of steelhead. Second, steelhead raised at CNFH prior to the late 1990s were not marked or were marked on an inconsistent basis; it therefore is impossible to determine if the number of unmarked natural-origin adult steelhead that currently appear in Battle Creek has increased relative to the 1967-1991 baseline period.

Because the methods used to monitor abundance of steelhead during the 1967-1991 baseline period are no longer possible given the operational changes at the RBDD, this report will not provide an assessment of how natural production of steelhead has varied over time.

2.3 METHODS TO MEASURE 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 AFRP chose the 15-year old age class because, in the Sacramento-San Joaquin River area, Age 15 is the estimated mean age of recruitment of female white sturgeon into the spawning population (USFWS 1995, p. 3-Xh-1).

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 September and early November. The CDFG typically collects mark-recapture data in 2 consecutive years, followed by a 2-year period when mark-recapture data are not collected. Captured fish are marked with tags that have unique numbers, their length is measured, and they are then released. Subsequent trapping efforts collect marked fish and provide the data to develop population estimates. A Bailey's modified Peterson model is used to estimate production of white sturgeon ≥ 40 inches in total length, irrespective of age. A length-age regression line 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. 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) CUMPOP_MD2a.xls dated March 13, 2007; and (2) WSTALKEY.xls dated December 22, 2006. The CDFG spreadsheets that provided length-frequency information used to develop population estimates for green sturgeon include: (1) WST_length_1990-2006.xls dated June 6, 2007; and (2) qry_Length_GST_ALL.xls dated June 1, 2007.

2.3.2 METHODS FOR JUVENILE AMERICAN SHAD

Unlike the other 8 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. This choice was made because abundance of juvenile American shad was monitored in 23 of the 25 years between 1967 and 1991, and adult American shad were monitored in 2 of these years.

The AFRP production target for American shad uses data collected between 1964 and 1988 instead of the 1967 and 1991 baseline period that is applicable to the other 8 fish tax described in this report. The 1964-1988 baseline period for American shad was developed because there was a desire to develop a production target that included a 25-year time period, and YOY data for American shad between 1989 and 1991 were not available when the AFRP developed that species' production target (Rick Burmester, USFWS, pers. comm.).

A midwater trawl (MWT) survey provides data to estimate the juvenile abundance index for American shad. The CDFG conducts the MWT survey during 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 that are 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.

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., 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 include: (1) data summaries contained in an AMESHA FMWT indices 1967-1991.xls spreadsheet dated August 1, 2007; and (2) an AMS Length Frequency.xls spreadsheet dated January 22, 2007.

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 (Nina Kogut, CDFG, pers. comm.). Prior to 1982, legal-size fish were considered to be 16 or more inches in length. After 1982, legal-size fish were considered to be 18 or more inches in length.

A mark-recapture technique is used to monitor the 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 most commonly occur during 2 consecutive years, followed by a 2-year period when collection activities do not occur. 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 ASB_ABUNDANCEUPDATES_FOR_DOUG.xls. The date on this file is May 31, 2007.

SECTION 3: RESULTS

3.1   PRODUCTION OF ADULT CHINOOK SALMON

Because adult Chinook salmon data collected in 2005 and 2006 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 total Central Valley are tabulated in Appendix C.

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 2006 are presented in Table 4 and Figure 3. Natural production fluctuated between 25,113 and 255,422 fish between 1992 and 2006. Natural production experienced a general upward change from 25,113 fish in 1992 to 225,644 fish in 2004. Between 2004 and 2006, production declined from 225,644 to 33,467 fish.

The dashed line in Figures 3, 4, 5, and 6 constitutes a "rebuilding line" based on the PSC's rebuilding assessment methods. The rebuilding line provides a basis for developing incremental production targets that reflect annual increases in production of Chinook salmon from a production target in 1992 to the AFRP production target in 2002. For purposes of this report, the rebuilding line has been extended from 2002 through 2006 using the AFRP production target; i.e., in 2002, 2003, 2004, 2005, and 2006 annual incremental production targets and AFRP production targets are the same.

Estimated natural production of adult fall-run Chinook salmon between 1992 and 2006 exceeded the annual incremental production targets in 7 of 15 years. The AFRP production target is 160,000 fish. Estimated natural production of exceeded the AFRP production target 6 times between 1992 and 2006.

3.1.1.2   BATTLE CREEK

Estimates of natural production of adult fall-run Chinook salmon from Battle Creek between 1992 and 2006 are presented in Table 4 and Figure 3. With the exception of 2002 when natural production was estimated to be 71,842 fish, numbers fluctuated between 3,582 and 30,945 during the 1992-2006 time period.

Estimated natural production of adult fall-run Chinook salmon between 1992 and 2006 exceeded the annual incremental production targets in 13 of 15 years. The AFRP production target is 10,000 fish. Estimated natural production consistently remained above the AFRP production target each year since 1994.

Table 4. Estimated natural production of four runs of adult Chinook salmon in 13 Central Valley watersheds, 1992-2006. NE = no estimate.

			Year														
Taxa	**1967-1991 baseline**	**AFRP production target**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**
Fall-run Chinook salmon																	
American River	81,000	160,000	25,113	93,875	94,205	255,422	149,470	121,676	107,969	93,782	189,395	164,566	164,417	218,365	225,644	111,087	33,467
Battle Creek	5,000	10,000	3,582	5,608	12,856	30,945	16,879	26,973	20,155	21,839	16,320	17,774	71,842	23,656	20,914	30,805	11,033
Butte Creek	760	1,500	NE	NE	NE	1,347	930	1,682	823	NE	NE	5,014	5,647	4,100	4,570	6,345	2,184
Clear Creek	3,600	7,100	1,356	3,016	6,049	27,678	10,873	18,244	6,982	11,655	11,646	12,297	19,942	11,710	11,550	22,118	9,591
Deer Creek	760	1,500	NE	176	738	NE	NE	2,580	450	NE	NE	NE	NE	NE	543	1,398	2,171
Feather River	86,000	170,000	77,553	93,808	111,309	188,635	107,584	120,698	34,399	19,864	194,131	192,196	131,796	114,907	118,447	87,290	88,728
Merced River	9,000	18,000	2,393	4,348	9,171	9,296	8,731	8,349	7,218	7,469	24,392	13,168	14,266	4,085	8,439	4,668	2,634
Mill Creek	2,100	4,200	2,260	4,758	2,568	NE	NE	1,018	906	NE	NE	NE	3,236	2,990	2,166	3,605	1,599
Mokelumne River	4,700	9,300	2,779	5,703	5,641	12,295	10,889	16,251	8,878	5,820	9,665	6,819	10,014	9,500	16,267	20,893	4,984
Sacramento River	115,000	230,000	54,499	83,539	104,383	142,701	115,704	190,388	7,777	176,154	126,048	63,593	61,108	82,756	46,395	63,765	47,373
Stanislaus River	11,000	22,000	694	1,946	2,924	2,242	365	14,221	6,034	7,576	17,609	9,497	11,529	8,720	8,707	6,219	4,105
Tuolumne River	19,000	38,000	362	1,342	1,429	2,957	9,534	18,166	17,441	14,315	37,054	11,856	10,633	3,191	4,279	878	677
Yuba River	33,000	66,000	17,919	20,180	32,366	52,962	63,997	69,020	63,748	44,142	32,553	33,070	37,311	43,763	34,660	28,035	11,564
Total			188,510	318,299	383,639	726,480	494,956	609,266	282,780	402,616	658,813	529,850	541,741	527,743	502,581	387,106	220,110
Late-fall run Chinook salmon																	
Battle Creek	270	550	106	174	195	134	336	1,330	689	1,406	994	513	452	472	1,248	1,309	794
Sacramento River	34,000	68,000	27,612	2,236	868	630	111	NE	80,780	15,838	19,039	27,295	55,919	8,513	20,063	19,794	25,690
Total			27,718	2,410	1,063	764	447	1,330	81,469	17,244	20,033	27,808	56,371	8,985	21,311	21,103	26,484
Winter-run Chinook salmon																	
Sacramento River	54,000	110,000	3,800	1,244	588	4,937	2,553	2,453	6,727	6,533	3,226	12,682	12,627	13,844	19,503	32,199	26,860
Spring-run Chinook salmon																	
Butte Creek	1,000	2,000	2,061	1,951	1,411	27,905	3,234	1,700	41,538	6,707	8,966	13,584	13,638	6,797	16,765	19,809	6,516
Deer Creek	3,300	6,500	590	777	1,444	4,818	1,405	1,248	3,852	2,900	1,387	2,294	3,393	4,264	1,824	4,175	3,461
Mill Creek	2,200	4,400	669	183	2,153	1,190	579	541	870	1,021	1,184	1,556	2,474	2,204	2,264	2,145	1,426
Sacramento River	29,000	59,000	1,142	1,280	2,800	1,728	944	374	2,495	NE	168	1,135	463	0	975	61	0
Total			4,462	4,191	7,806	35,641	6,162	3,863	48,755	10,628	11,705	18,569	19,968	13,265	21,828	26,190	11,403
Total natural production of adult Chinook salmon			224,490	326,144	393,096	767,822	504,118	616,912	419,731	437,021	693,777	588,909	630,707	563,837	565,223	466,598	284,857

Estimates of natural production of adult late fall-run Chinook salmon from Battle Creek during the period 1992-2006 are presented Table 4 and Figure 3. Numbers were relatively low during the 1992-1996 time period when estimated production was between 106 and 336 fish. Between 1997 and 2006, estimated natural production fluctuated between 452 and 1,406 fish.

Estimated natural production of adult late fall-run Chinook salmon from Battle Creek between 1992 and 2006 may have exceeded the annual incremental production targets in 7 of 15 years. The AFRP production target for adult late fall-run Chinook salmon from Battle Creek is 550 fish. Estimated natural production also may have exceeded the AFRP production target 7 times between 1992 and 2006.

There is, however, a strong potential that production targets for late fall-run Chinook salmon from Battle Creek were not met in 7 of 15 years. This scenario arises because escapement surveys for late fall-run Chinook salmon in 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. 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's production estimates are based solely on counts of adult (and predominantly hatchery-origin) salmon that return 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.

3.1.1.3 BUTTE CREEK

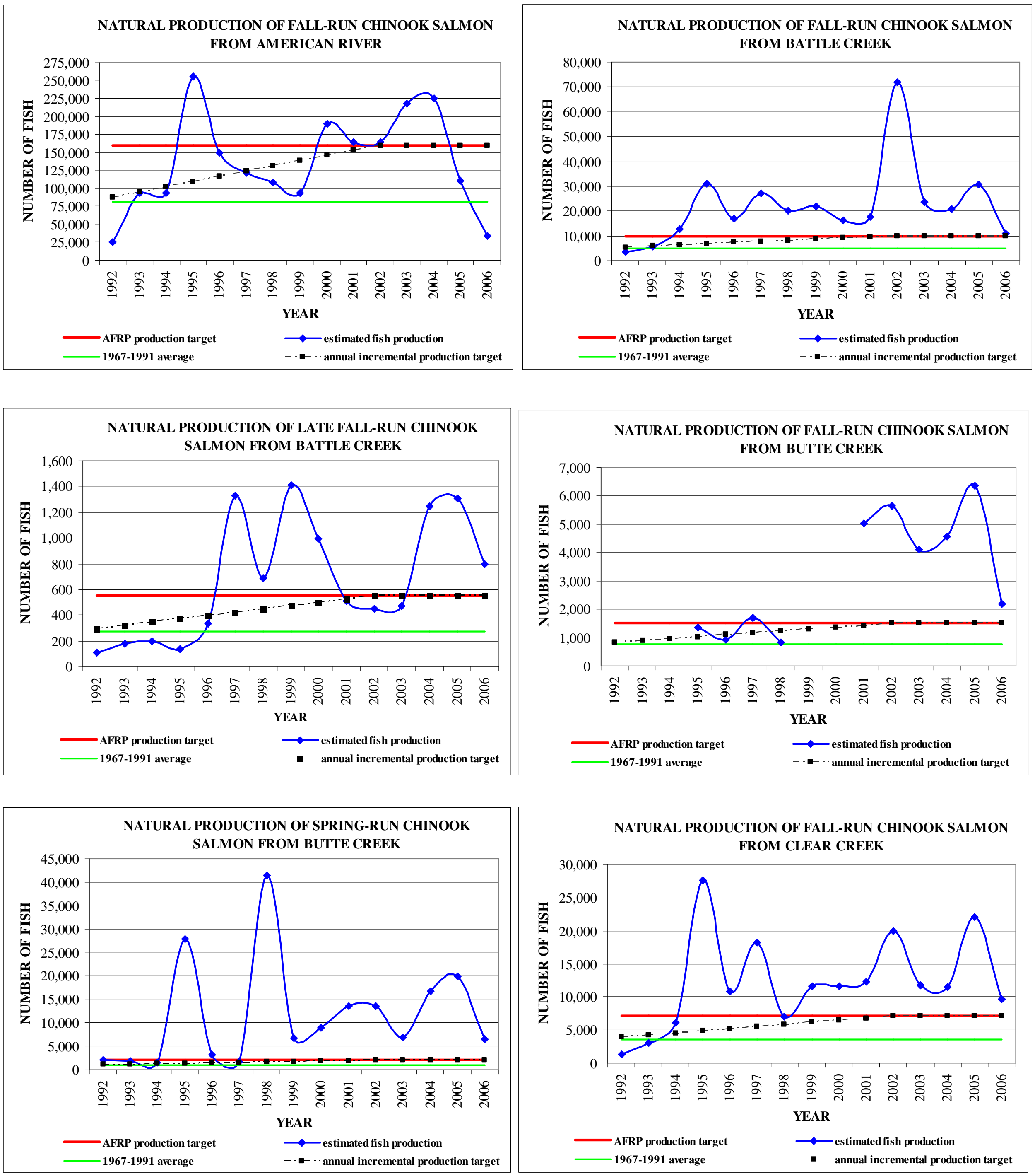
Estimates of natural production of adult fall-run Chinook salmon from Butte Creek between 1992 and 2006 is presented in Table 4 and Figure 3. Estimates of natural production are not available for 1992, 1993, 1994, 1999, and 2000. Numbers naturally produced between 1995 and 1998 fluctuated between 823 and 1,682 fish. During the 2001-2006 time period, natural production ranged between 2,184 and 6,345 fish.

Estimated natural production of adult fall-run Chinook salmon between 1992 and 2006 exceeded the annual incremental production targets in 8 of the 10 years when production was estimated. The AFRP production target is 1,500 fish. Estimated natural production has consistently remained above the AFRP production target each year since 2001.

Estimates of natural production of adult spring-run Chinook salmon between 1992 and 2006 are presented in Table 4 and Figure 3. Natural production experienced large fluctuations between 1992 and 1999; i.e., between 1,411 and 41,538 fish were produced. Between 2000 and 2006, Butte Creek produced between 6,516 and 19,809 adult spring-run Chinook salmon each year.

Estimated natural production of adult spring-run Chinook salmon between 1992 and 2006 exceeded the annual incremental production targets in all 15 years. The AFRP production target is 2,000 fish. Estimated natural production has consistently remained above the AFRP production target each year since 1998.

Figure 3. Estimated natural production of adult Chinook salmon from the American River, Battle Creek, Butte Creek, and Clear Creek, 1992-2006. Each graph provides the watershed's AFRP production target, annual incremental production targets based on the PSC's rebuilding assessment methods, estimated annual natural production of Chinook salmon between 1992 and 2006, and average natural production of Chinook salmon between 1967 and 1991. Annual incremental production targets after 2002 equal AFRP production targets.



3.1.1.4 CLEAR CREEK

Estimates of natural production of adult fall-run Chinook salmon from Clear Creek between 1992 and 2006 are presented in Table 4 and Figure 3. Estimates of production increased dramatically from 1,356 fish in 1992 to 27,678 fish in 1995. Between 1996 and 2006, estimated natural production fluctuated between 6,982 and 22,118 fish.

Estimated natural production of adult fall-run Chinook salmon between 1992 and 2006 exceeded the annual incremental production targets in 13 of the 15 years. The AFRP production target is 7,100 fish. Estimated natural production exceeded the AFRP production target eleven times between 1992 and 2006.

3.1.1.5 DEER CREEK

Estimates of natural production of adult fall-run Chinook salmon from Deer Creek between 1992 and 2006 are presented in Table 4 and Figure 4. Estimates are not available for 1992, 1995, 1996, 1999, 2000, 2001, 2002, and 2003. The number naturally produced in 1993, 1994, 1997, 1998, 2004, 2005, and 2006 fluctuated between 176 and 2,580 fish.

Estimated natural production of adult fall-run Chinook salmon between 1992 and 2006 exceeded the annual incremental production targets in 2 of the 7 years when production was estimated. The AFRP production target is 1,500 fish. Estimated natural production exceeded the AFRP production target twice in the 7 years when production was estimated between 1992 and 2006.

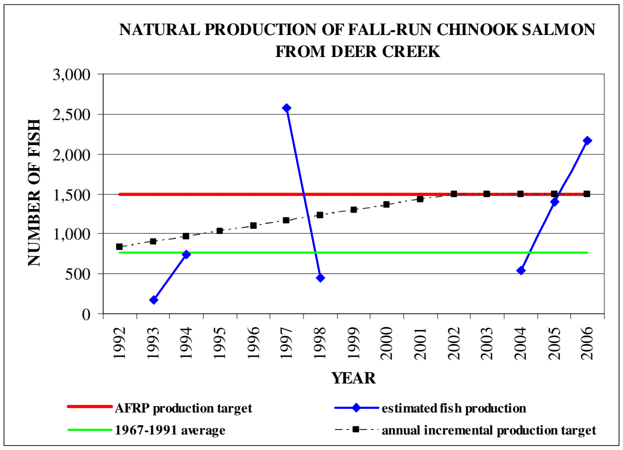
Estimates of natural production of adult spring-run Chinook salmon between 1992 and 2006 are presented in Table 4 and Figure 4. Estimates of the natural production of these fish have been cyclical between 590 and 4,818 fish during this period.

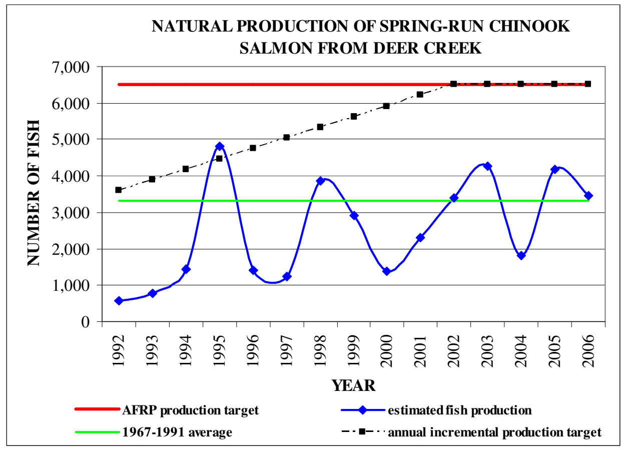
Estimated natural production of adult spring-run Chinook salmon between 1992 and 2006 exceeded the annual incremental production targets in 1 of 15 years. The AFRP production target for adult spring-run Chinook salmon is 6,500 fish. Estimated natural production of adult spring-run Chinook salmon never equaled or exceeded the AFRP production target between 1992 and 2006.

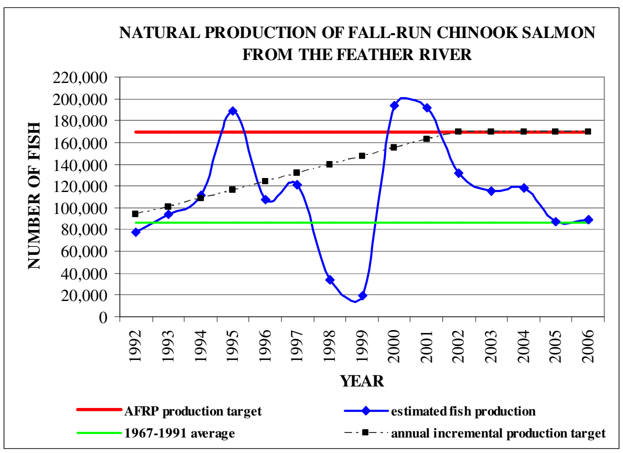
3.1.1.6 FEATHER RIVER

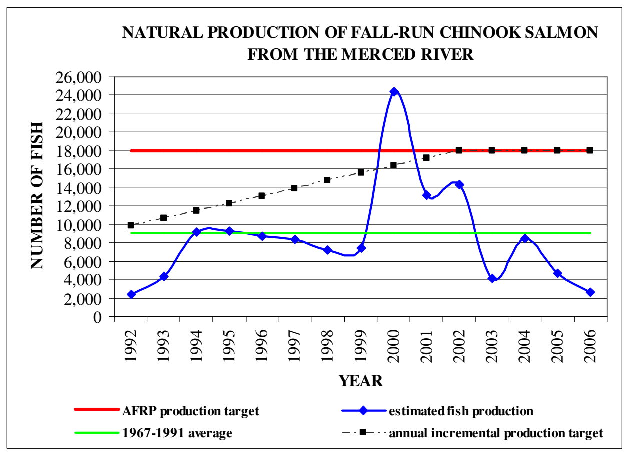
Estimates of natural production of adult fall-run Chinook salmon from the Feather River between 1992 and 2006 are presented in Table 4 and Figure 4. Estimated escapement to the Feather River Fish Hatchery includes fall- and spring-run Chinook salmon because no simple method for distinguishing between the 2 runs as they return to the hatchery. The fall-run Chinook salmon hatchery escapement estimate is therefore inflated due to presence of some spring-run Chinook salmon.

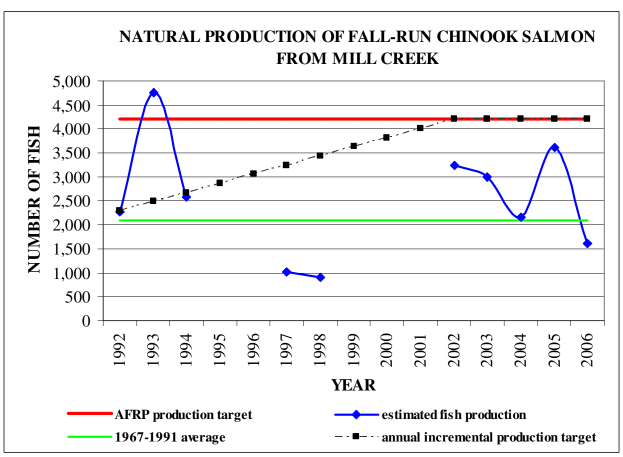
Figure 4. Estimated natural production of adult Chinook salmon from Deer Creek, Feather River, Merced River, and Mill Creek, 1992-2006. Each graph provides the watershed's AFRP production target, annual incremental production targets based on the PSC's rebuilding assessment methods, estimated annual natural production of Chinook salmon between 1992 and 2006, and average natural production of Chinook salmon between 1967 and 1991. Annual incremental production targets after 2002 equal AFRP production targets.

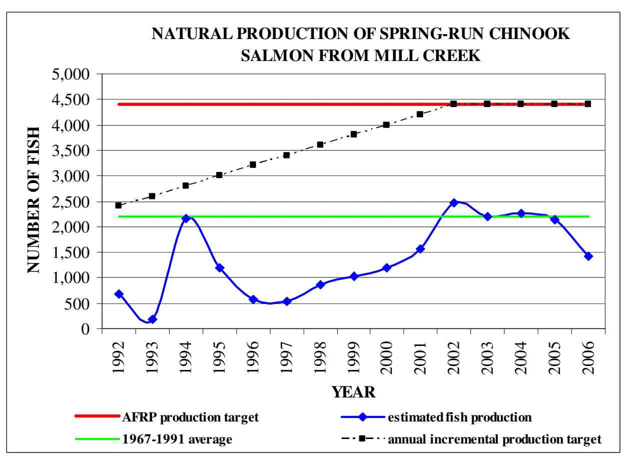












Estimates of fall-run natural production from the Feather River have fluctuated dramatically. Between 1992 and 1995, estimated natural production rose from 77,553 to 188,635 fish. Estimated natural production subsequently declined to 19,864 fish in 1999. Numbers then increased dramatically in 2000 and 2001 to 194,131 and 192,196 individuals, respectively. Estimated natural production then declined to 88,728 fish in 2006.

Natural production of adult fall-run Chinook salmon between 1992 and 2006 exceeded the annual incremental production targets in 4 of 15 years. The AFRP production target is 170,000 fish. Estimated natural production equaled or exceeded the AFRP production target 3 times between 1992 and 2006.

3.1.1.7 MERCED RIVER

Estimates of natural production of adult fall-run Chinook salmon from the Merced River between 1992 and 2006 are presented in Table 4 and Figure 4. With the exception of 2000 when natural production was estimated to be 24,392 fish, salmon production from this river fluctuated between 2,393 and 14,266 fish during the 1992-2006 time period.

Natural production between 1992 and 2006 exceeded annual incremental production targets in 1 of 15 years (2000). The AFRP production target for adult fall-run Chinook salmon is 18,000 fish. Estimated natural production equaled or exceeded the AFRP production target once between 1992 and 2006.

3.1.1.8 MILL CREEK

Estimates of natural production of adult fall-run Chinook salmon from Mill Creek between 1992 and 2006 are presented in Table 4 and Figure 4. Estimates are not available for 1995, 1996, 1999, 2000, and 2001. With the exception of 1993 when the natural production of adult fall-run Chinook salmon from this creek was estimated to be 4,758 fish, numbers fluctuated between 906 and 3,605 individuals during the 10 years that fish production was estimated between 1992 and 2006.

Estimated natural production of adult fall-run Chinook salmon produced during the years when production was estimated between 1992 and 2006 exceeded the annual incremental production targets in 1 of 10 years. The AFRP production target is 4,200 fish. Estimated natural production exceeded the AFRP production target once between 1992 and 2006.

Estimates of natural production of adult spring-run Chinook salmon between 1992 and 2006 are presented in Table 4 and Figure 4. Estimates during the 15-year time period have fluctuated between 183 and 2,474 fish. From 1997 to 2005, estimated natural production experienced a general upward change from 541 to 2,200 fish, then declined to 1,426 fish in 2006.

Estimated natural production of adult spring-run Chinook salmon between 1992 and 2006 never equaled or exceeded annual incremental production targets. The AFRP production target is 4,400 fish. Estimated natural production never equaled or exceeded the AFRP production target between 1992 and 2006.

3.1.1.9 MOKELUMNE RIVER

Estimates of natural production of adult fall-run Chinook salmon from the Mokelumne River between 1992 and 2006 are presented in Table 4 and Figure 5. Estimated natural production has fluctuated between 2,779 and 20,893 fish during the 1992-2006 time period.

Estimated natural production of adult fall-run Chinook salmon between 1992 and 2006 exceeded annual incremental production targets in 10 of 15 years. The AFRP production target is 9,300 fish. Estimated natural production equaled or exceeded the AFRP production target 8 times between 1992 and 2006.

3.1.1.10 SACRAMENTO RIVER MAINSTEM

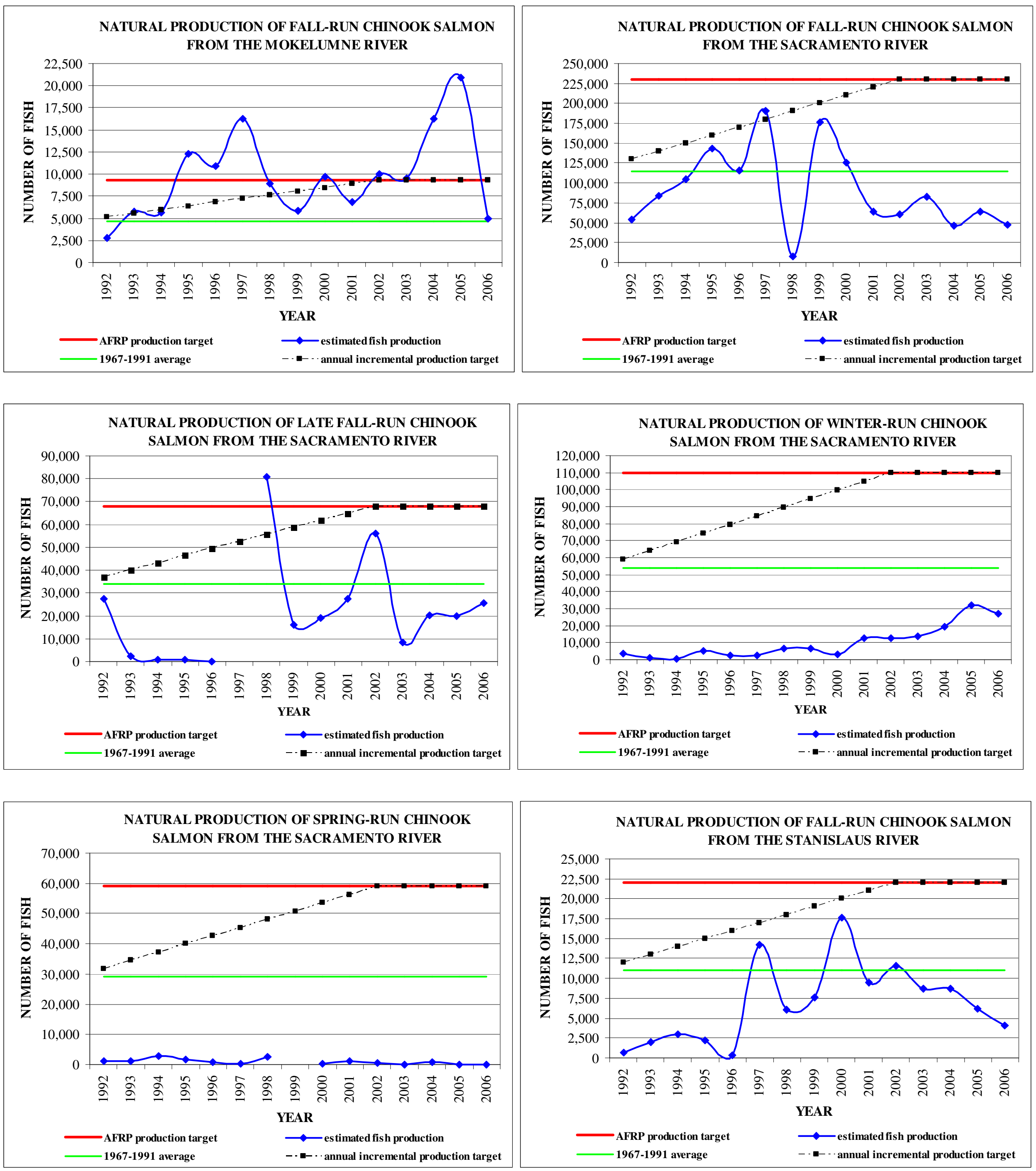
Estimates of natural production of adult fall-run Chinook salmon from the Sacramento River mainstem between 1992 and 2006 are presented in Table 4 and Figure 5. Estimated natural production, in general, increased from 54,499 fish in 1992 to 190,388 fish in 1997, then decreased dramatically to 7,777 fish in 1998. In 1999, estimated natural production recovered to 176,154 fish, then gradually declined to 47,373 fish in 2006.

Estimated natural production of adult fall-run Chinook salmon between 1992 and 2006 exceeded annual incremental production targets in only 1 of 15 years. The AFRP production target is 230,000 fish. Estimated natural production never equaled or exceeded the AFRP production target between 1992 and 2006.

Estimates of natural production of adult late fall-run Chinook salmon between 1992 and 2006 are presented in Table 4 and Figure 5. Estimates of natural production are not available for 1997. During the 14 years monitoring data were collected, estimated natural production fluctuated with no discernable pattern. Estimated production was particularly low between 1993 and 1996 when it ranged between 111 and 2,236 fish. In 1998, estimated natural production was 80,780 fish. With the exception of 2002 when estimated natural production was 55,919 individuals, estimated natural production between 1999 and 2006 ranged between 8,513 and 27,295 fish.

Estimated natural production of adult late fall-run Chinook salmon from the Sacramento River mainstem during the 14 years monitoring data were available between 1992 and 2006 equaled or exceeded annual incremental production targets only once. The AFRP production target is 68,000 fish. Estimated natural production exceeded the AFRP production target once between 1992 and 2006.

Figure 5. Estimated natural production of adult Chinook salmon from the Mokelumne River, Sacramento River mainstem, and Stanislaus River, 1992-2006. Each graph provides the watershed's AFRP production target, annual incremental production targets based on the PSC's rebuilding assessment methods, estimated annual natural production of Chinook salmon between 1992 and 2006, and average natural production of Chinook salmon between 1967 and 1991. Annual incremental production targets after 2002 equal AFRP production targets.



Estimates of natural production of adult winter-run Chinook salmon from the Sacramento River mainstem between 1992 and 2006 are presented in Table 4 and Figure 5. In general, natural production between 1992 and 2000 ranged between 588 and 6,727 fish. Estimated natural production between 2001 and 2006 was substantially greater than during the 1992 -2000 period, and steadily rose to 26,860 fish in 2006.

Estimated natural production of adult winter-run Chinook salmon between 1992 and 2006 never equaled or exceeded the annual incremental production targets. The AFRP production target is 110,000 fish. Estimated natural production never equaled or exceeded the AFRP production target between 1992 and 2006.

Estimates of natural production of adult spring-run Chinook salmon from the Sacramento River mainstem between 1992 and 2006 are presented in Table 4 and Figure 5. Estimates of natural production are not available for 1999. In general, natural production has remained at relatively low levels and has not exceeded 2,800 individuals during the 14 years when monitoring activities were conducted.

Estimated natural production of adult spring-run Chinook salmon between 1992 and 2006 never equaled or exceeded annual incremental production targets. The AFRP production target is 59,000 fish. Estimated natural production never equaled or exceeded the AFRP production target between 1992 and 2006.

3.1.1.11 STANISLAUS RIVER

Estimates of natural production of adult fall-run Chinook salmon from the Stanislaus River between 1992 and 2006 are presented in Table 4 and Figure 5. Estimated natural production fluctuated between 365 and 2,924 fish during the 1992-1996 time period. Between 1997 and 2001, estimated natural production increased relative to the 1992-1996 time period, and fluctuated between 6,034 and 17,609 fish. Between 2002 and 2006, production declined from 11,529 to 4,105 fish.

Estimated natural production of adult fall-run Chinook salmon between 1992 and 2006 never equaled or exceeded annual incremental production targets. The AFRP production target is 22,000 fish. Estimated natural production never equaled or exceeded the AFRP production target between 1992 and 2006.

3.1.1.12 TUOLUMNE RIVER

Estimates of natural production of adult fall-run Chinook salmon from the Tuolumne River between 1992 and 2006 are presented in Table 4 and Figure 6. Estimated natural production fluctuated between 362 and 2,957 fish between 1992 and 1995. Between 1996 and 2000, estimated natural production experienced a generally steady upward trend, and peaked at 37,054 fish in 2000. After 2000, natural production experienced a steady decline through 2006 when estimated production was 677 fish.

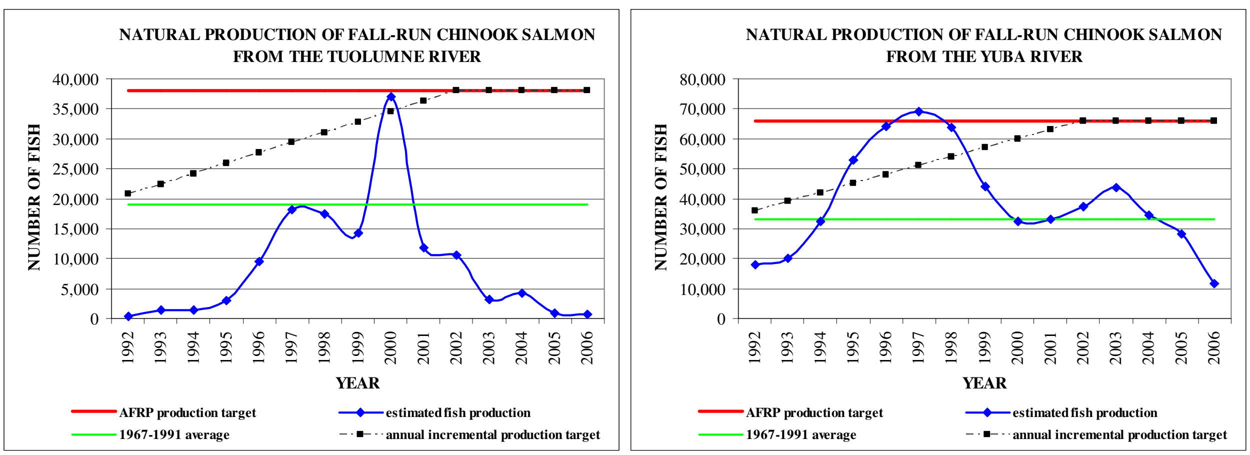
Estimated natural production of adult fall-run Chinook salmon from the Tuolumne River between 1992 and 2006 only equaled or exceeded the annual incremental production targets 1 year. The AFRP production target is 38,000 fish. Estimated production never equaled or exceeded the AFRP production target between 1992 and 2006.

3.1.1.13 YUBA RIVER

Estimates of natural production of adult fall-run Chinook salmon from the Yuba River between 1992 and 2006 are presented in Table 4 and Figure 6. Estimated natural production steadily rose from 17,919 fish in 1992 to 69,020 fish in 1997. After 1997, estimated natural production steadily declined to 32,553 fish in 2000, rose to 43,763 fish in 2003, and then steadily declined to 11,564 fish in 2006.

Estimated natural production of adult fall-run Chinook salmon between 1992 and 2006 equaled or exceeded the annual incremental production targets in 4 of 15 years. The AFRP production target is 66,000 fish. Estimated natural production equaled or exceeded the AFRP production target 1 year between 1992 and 2006.

Figure 6. Estimated natural production of adult Chinook salmon from the Tuolumne River and Yuba River, 1992-2006. Each graph provides the watersheds AFRP production target, annual incremental production targets based on the PSC's rebuilding assessment methods, estimated annual natural production of Chinook salmon between 1992 and 2006, and average natural production of Chinook salmon between 1967 and 1991. Annual incremental production targets after 2002 equal AFRP production targets.



3.1.2 TOTAL PRODUCTION FOR INDIVIDUAL RUNS

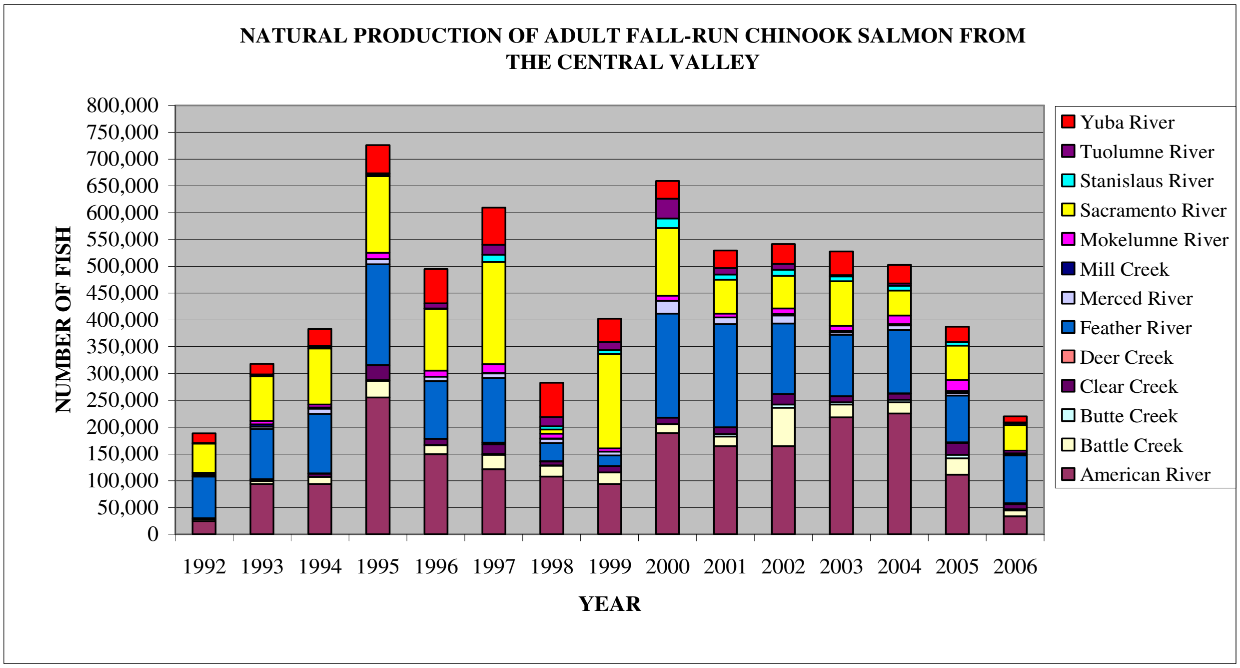
3.1.2.1 FALL-RUN CHINOOK SALMON

Estimates of total natural production of adult fall-run Chinook salmon in the Central Valley between 1992 and 2006 are presented in Table 4 and Figure 7. These production estimates include contributions from the 13 CAMP watersheds that are the American River, Battle Creek, Butte Creek, Clear Creek, Deer Creek, Feather River, Merced River, Mill Creek, Mokelumne River, Sacramento River mainstem, Stanislaus River, Tuolumne River, and Yuba River. In general, total natural production increased each year from 188,510 to 726,480 fish between 1992 and 1995, respectively; ranged between 282,780 and 658,813 fish between 1996 and 2001; and declined on a consistent basis from 541,741 fish in 2002 to 220,110 fish in 2006. Between 1992 and 2006, the following watersheds consistently produced the largest number of adult fall-run Chinook salmon in the Central Valley: American River, Battle Creek, Feather River, Sacramento River mainstem, and Yuba River.

The CAMP-specific portion of the AFRP production target for adult fall-run Chinook salmon from the 13 watersheds included in the CAMP program is 737,600 fish. Fish surveys in the Central Valley between 1992 and 2006 suggest the natural production of adult fall-run Chinook salmon never equaled or exceeded the CAMP production target during that 15-year period (Table 4, Figure 7).

The AFRP total production target for adult fall-run Chinook salmon is 750,000 fish. The AFRP has developed production targets for 8 tributaries that are not relevant to the CAMP: Antelope Creek, Bear River, Big Chico Creek, Cosumnes River, Cottonwood Creek, Cow Creek, some "miscellaneous creeks," and Paynes Creek. Combined annual natural production of Chinook salmon from these watersheds during the 1967-1991 baseline period averaged 17,200 fish. The CAMP assumes patterns in the production of Chinook salmon in the 8 tributaries is similar to the pattern in the production of Chinook salmon in the 13 tributaries assessed by the CAMP; i.e., they have likely declined since 1991. Because the annual production of fish from these watersheds is relatively small and has likely declined since 1992, there is a low probability the AFRP's total production target for adult fall-run Chinook salmon would have been met in the last 15 years, even if the salmon production from these 8 tributaries was added to production from the 13 CAMP watersheds.

Figure 7. Estimated total natural production of adult fall-run Chinook salmon from the Central Valley, 1992-2006. Annual estimates reflect contributions from 13 watersheds. The AFRP and CAMP fall-run production targets are 750,000 and 737,600 Chinook salmon, respectively.

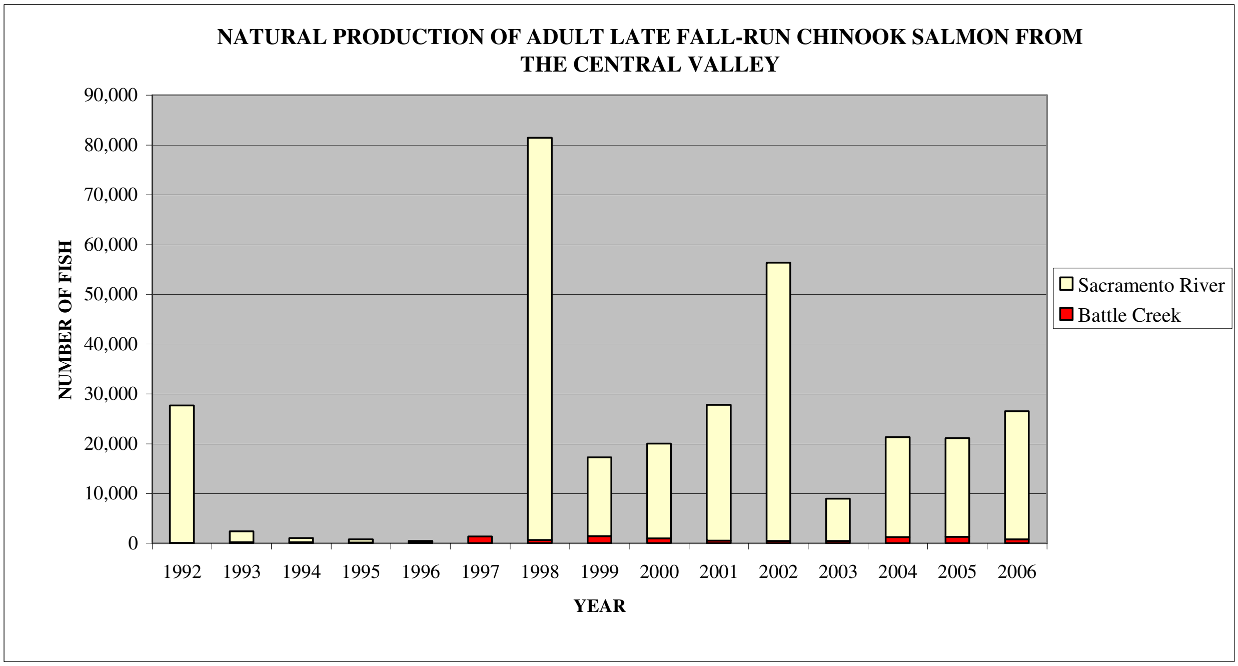


3.1.2.2 LATE FALL-RUN CHINOOK SALMON

Estimates of total natural production of adult late fall-run Chinook salmon in the Central Valley between 1992 and 2006 are presented in Table 4 and Figure 8. These production estimates include contributions from Battle Creek and the Sacramento River mainstem. In 1992, 27,718 adult late fall-run Chinook salmon were naturally produced from these 2 watersheds. Between 1993 and 1997, estimated total production never exceeded 2,410 fish. In 1998, total natural production from the 2 watersheds increased to 81,469 fish. During the period 1999-2006, natural production from Battle Creek and the Sacramento River mainstem fluctuated between 8,985 and 56,371 fish. Between 1992 and 2006, 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 equaled or exceeded this production target once during that 15-year period (1998).

Figure 8. Estimated total natural production of adult late fall-run Chinook salmon from the Central Valley, 1992-2006. Annual estimates reflect contributions from the Sacramento River mainstem and Battle Creek. AFRP and CAMP late fall-run production targets are 68,000 Chinook salmon.

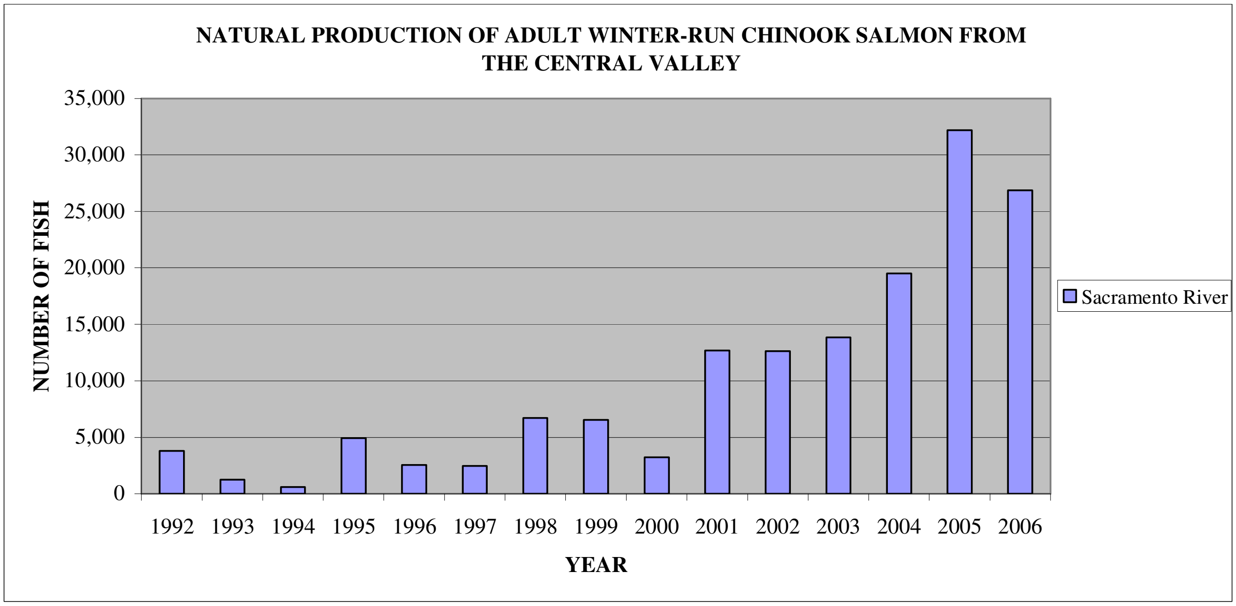


3.1.2.3 WINTER-RUN CHINOOK SALMON

Estimates of total natural production of adult winter-run Chinook salmon in the Central Valley between 1992 and 2006 are presented in Table 4 and Figure 9. These production estimates are limited to contributions from the Sacramento River mainstem. Natural production between 1992 and 2000 fluctuated between 588 and 6,727 fish. Between 2001 and 2005, the production of adult winter-run Chinook salmon increased from 12,682 to 32,199 fish. In 2006, the production of adult winter-run Chinook salmon from the Sacramento River mainstem declined from the previous year's level to 26,860 fish.

The AFRP total production target for adult winter-run Chinook salmon is 110,000 fish. Fish surveys indicate the natural production from the Sacramento River mainstem never equaled or exceeded this production target during that 15-year period.

Figure 9. Estimated total natural production of adult winter-run Chinook salmon from the Central Valley, 1992-2006. Annual estimates reflect contributions only from the Sacramento River mainstem. AFRP and CAMP winter-run production targets are 110,000 Chinook salmon.

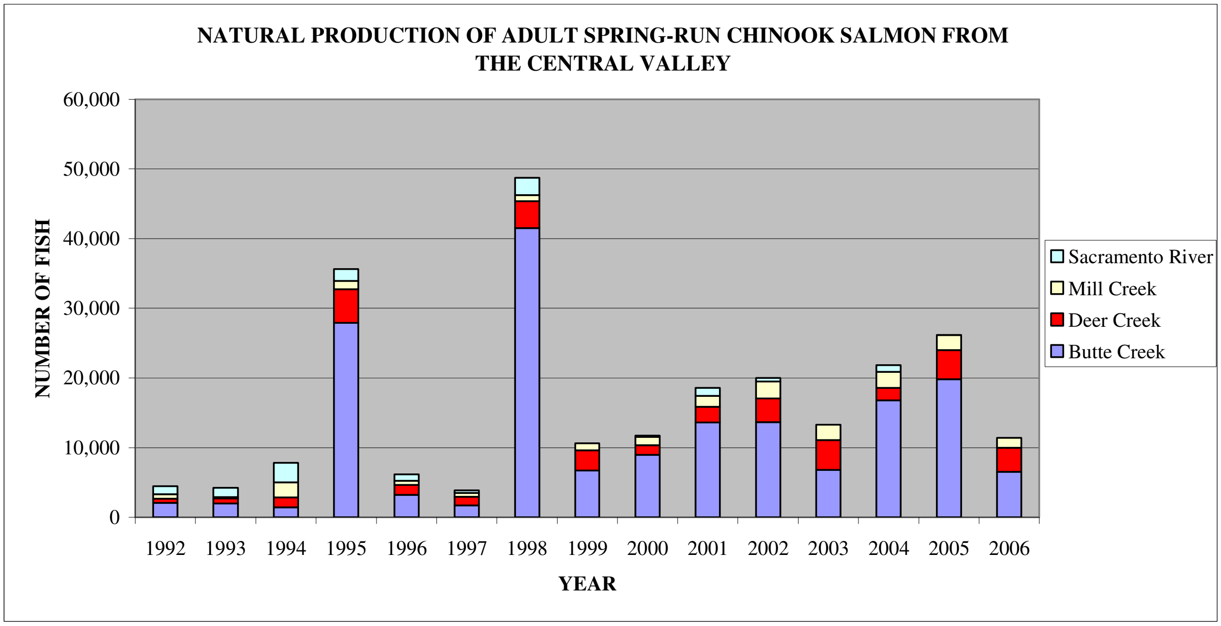


3.1.2.4 SPRING-RUN CHINOOK SALMON

Estimates of total natural production of adult spring-run Chinook salmon in the Central Valley between 1992 and 2006 are presented in Table 4 and Figure 10. 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 35,641 adult spring-run Chinook salmon were naturally produced from these 4 watersheds, combined natural production fluctuated between 3,863 and 7,806 fish between 1992 and 1997. In 1998, the total number produced was 48,755 fish. Between 1999 and 2006, total natural production was greater than between 1992 and 1997, and fluctuated between 10,628 and 26,190 fish. Butte Creek consistently produced as many or more adult spring-run Chinook salmon as the other 3 watersheds combined.

The AFRP total production target for adult spring-run Chinook salmon is 68,000 adult fish. Fish surveys in Butte Creek, Deer Creek, Mill Creek, and the mainstem of the Sacramento River mainstem between 1992 and 2006 suggest that natural production never equaled or exceeded this production target during that 15-year period (Table 4, Figure 10).

Figure 10. Estimated total natural production of adult spring-run Chinook salmon from the Central Valley, 1992-2006. Annual estimates reflect contributions from the Sacramento River mainstem, Mill Creek, Deer Creek, and Butte Creek. AFRP and CAMP spring-run production targets are 68,000 Chinook salmon.



3.1.3 TOTAL CENTRAL VALLEY PRODUCTION

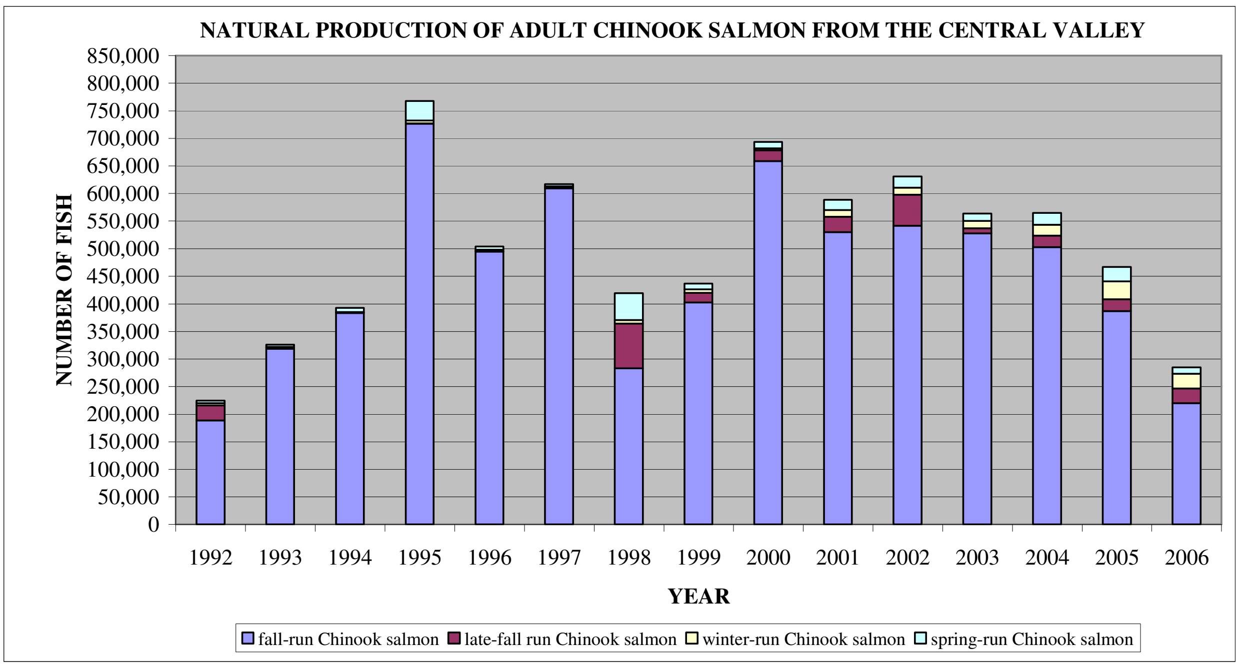
Estimates of the Central Valley-wide production for the combined total of all 4 runs of Chinook salmon from the American River, Battle Creek, Butte Creek, Clear Creek, Deer Creek, Feather River, Merced River, Mill Creek, Mokelumne River, Sacramento River mainstem, Stanislaus River, Tuolumne River, and Yuba River between 1992 and 2006 are presented in Table 4 and Figure 11. The combined production for all 4 runs from these 13 watersheds ranged between 224,490 and 767,822 fish during the 15-year period. In general, total natural production increased each year between 1992 and 1995 from 224,490 to 767,822 fish, fluctuated between 1996 and 2001 from 419,731 to 693,777 fish; and declined on a consistent basis from 630,707 to 284,857 fish from 2002 to 2006. During the 15-year period between 1992 and 2006, average contribution of fall-, late fall-, winter-, and spring-run Chinook salmon to total natural production of adult Chinook salmon from the 13 watersheds was 90%, 5%, 2%, and 3%, respectively.

The CAMP-specific portion of the AFRP Central Valley-wide production target for the combined total of all 4 runs of Chinook salmon is 983,600 fish. Surveys between 1992 and 2006 indicate that total Central Valley-wide production never equaled or exceeded the CAMP production target during that 15-year period.

The AFRP total Central Valley-wide production target for the combined total of all 4 runs of adult Chinook salmon is 990,000 fish. There is a low probability the AFRP's total Central Valley-wide production target for adult Chinook salmon could have been met between 1992 and

2006, even if salmon production from Antelope Creek, Bear River, Big Chico Creek, Cosumnes River, Cottonwood Creek, Cow Creek, some "miscellaneous creeks", and Paynes Creek were added to production estimates from the 13 CAMP watersheds. The rationale for this is described in section 3.1.2.1.

Figure 11. Estimated total natural production of adult fall-, late fall-, winter-, and spring-run Chinook salmon from the Central Valley, 1992-2006. Annual estimates reflect contributions from the American River, Battle Creek, Butte Creek, Clear Creek, Deer Creek, Feather River, Merced River, Mill Creek, Mokelumne River, Sacramento River mainstem, Stanislaus River, Tuolumne River, and Yuba River. The AFRP and CAMP total production targets are 990,000 and 983,600 Chinook salmon, respectively.



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 15-year period between 1992 and 2006 suggest:

- Watershed-specific AFRP production targets for fall-run Chinook salmon were met 6 or more times in the following watersheds: American River, Battle Creek, Butte Creek, Clear Creek, and Mokelumne River (Figure 12). In contrast, production targets for fall-run Chinook salmon were met 3 or fewer times in the following watersheds: Deer Creek, Feather River, Merced River, Mill Creek, Sacramento River mainstem, Stanislaus River, Tuolumne River, and Yuba River.

- Watershed-specific AFRP production target for late fall-run Chinook salmon may have been met 7 times on Battle Creek (Figure 13). 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 14).

- Watershed-specific AFRP production target for spring-run Chinook salmon was met twelve times on Butte Creek (Figure 15). In contrast, 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-run Chinook salmon was probably never met, run-specific AFRP production targets for 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 combined total of all 4 runs of Chinook salmon was probably never met.

There reason why the AFRP's fall-run and Central Valley-wide Chinook salmon production targets were "probably never met" is described in section 3.1.2.1. The reason the AFRP's late fall-run Chinook salmon for Battle Creek may or may not have been met is described in section 3.1.1.2.

Figure 12. Summary of the number of times natural production of adult fall-run Chinook salmon equaled or exceeded watershed-specific AFRP production targets for the 15-year period 1992-2006. Note: monitoring data for fall-run Chinook salmon from Butte Creek, Deer Creek, and Mill Creek are only available for 10, 7, and 10 of the 15 years since 1992, respectively.

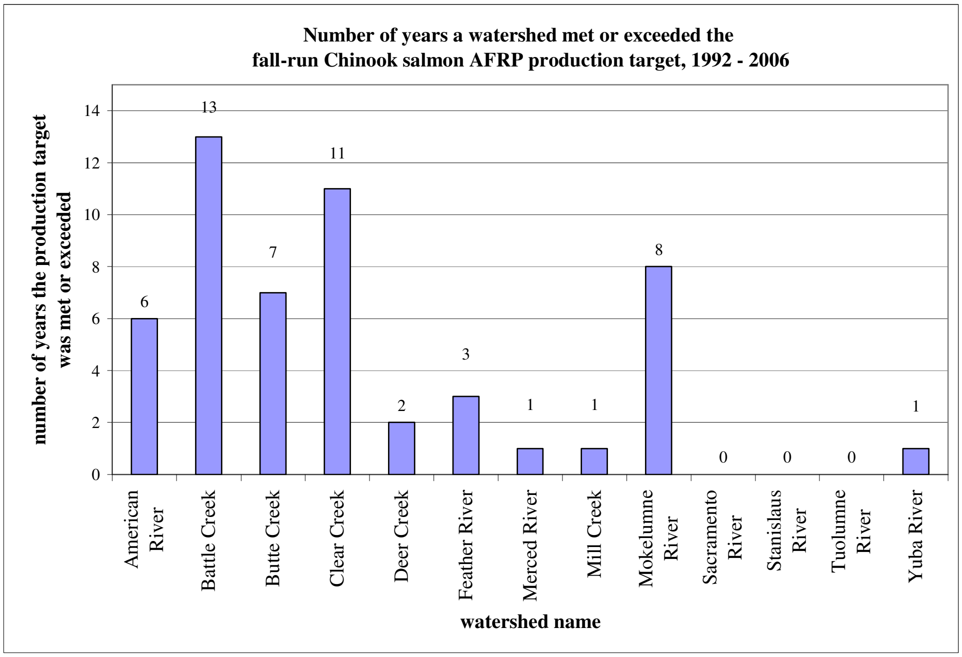


Figure 13. Summary of the number of times natural production of adult late fall-run Chinook salmon equaled or exceeded watershed-specific AFRP production targets for the 15-year period 1992-2006. Note: monitoring data for late fall-run Chinook salmon from the Sacramento River mainstem are only available for 14 of the 15 years since 1992.

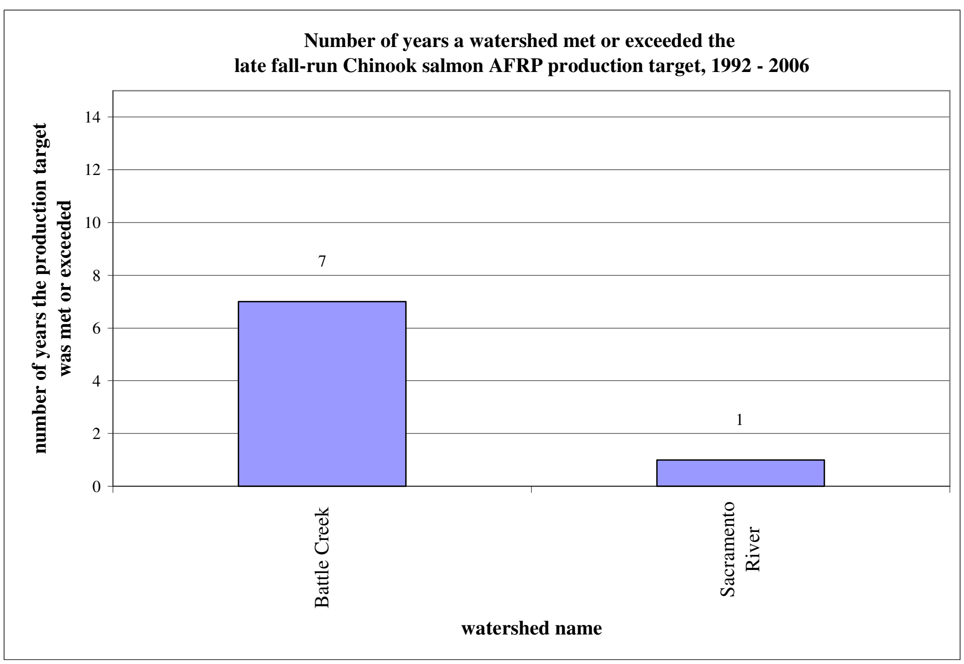


Figure 14. Summary of the number of times natural production of adult winter-run Chinook salmon equaled or exceeded the watershed-specific AFRP production target for the 15-year period 1992-2006.

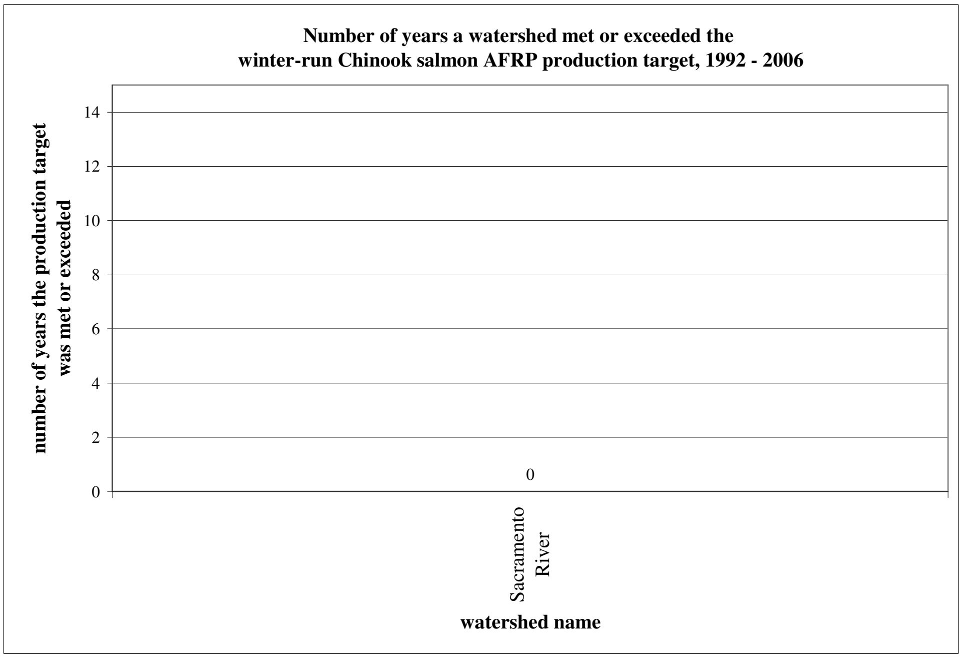
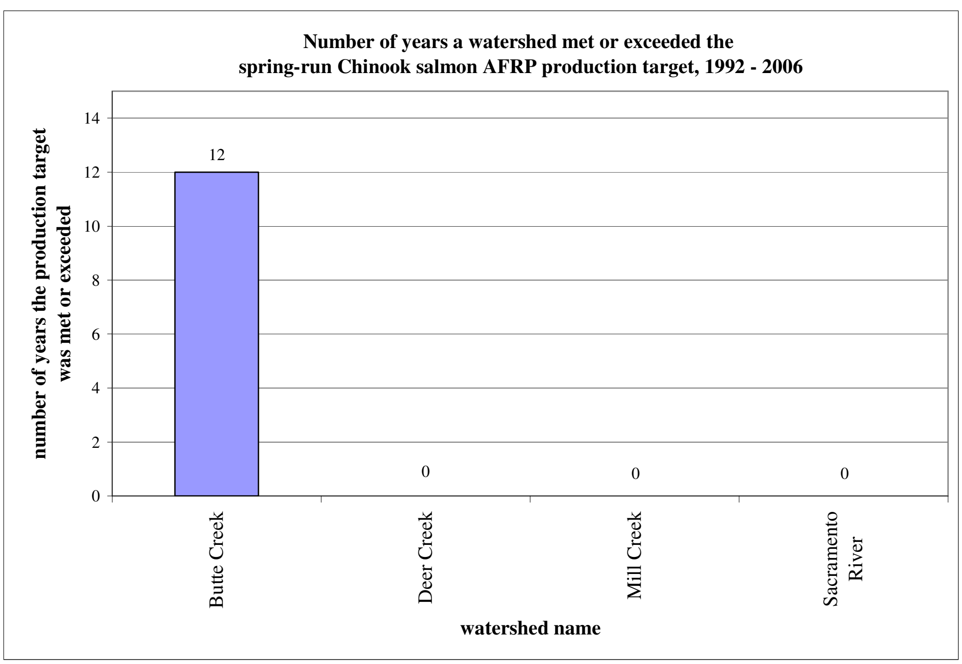


Figure 15. Summary of the number of times natural production of adult spring-run Chinook salmon equaled or exceeded watershed-specific AFRP production targets for the 15-year period 1992-2006.



3.2.2 CHANGES IN AVERAGE NATURAL PRODUCTION OF CHINOOK SALMON

A comparison of the average natural production of adult Chinook salmon in several watersheds in the Central Valley during the 1967-1991 and 1992-2006 time periods indicates there have been statistically significant changes in some watersheds (Table 5). In contrast, average natural production of adult Chinook salmon in other watersheds has not experienced a significant change over time.

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 1992-2006 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 1992-2006 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 over time.

For adult late fall-run Chinook salmon, average estimated natural production from Battle Creek may have been significantly greater during the 1992-2006 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 1992-2006 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 1992-2006 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 1992-2006 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.

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 1999-2004 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: (1) insufficient monitoring data were available to make an assessment, or (2) the PSC rebuilding assessment methods yielded mixed results and a run was therefore classified as "indeterminate" (Table 6).

Based on the PSC's rebuilding assessment methods, natural production of adult fall-run Chinook salmon met or exceeded the annual incremental production targets in the following locations: American River, Battle Creek, Butte Creek, Clear Creek, and the Mokelumne River. In contrast, production of adult fall-run Chinook salmon in the following watersheds did not rebuild toward the annual incremental production targets: Feather River, Merced River, Sacramento River mainstem, Stanislaus River, Tuolumne River, and Yuba River. On Mill and Deer Creeks, insufficient monitoring data were available to assess progress toward the annual incremental production targets.

For adult late fall-run Chinook salmon that originate in 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. On Battle Creek, variability in the annual production estimates of adult late fall-run Chinook salmon resulted in an indeterminate status determination that precluded an ability to determine if the salmon stock in that watershed was rebuilding.

For adult winter-run Chinook salmon that originate in the Sacramento River mainstem, the rebuilding assessment methods suggest natural production of these fish did not rebuild toward annual incremental production targets.

For adult spring-run Chinook salmon, the PSC rebuilding assessment methods suggest the natural production in Butte Creek met or exceeded the annual incremental production targets. In contrast, natural production of adult spring-run Chinook salmon in Deer Creek, Mill Creek, and the Sacramento River mainstem did not rebuild toward the annual incremental production targets.

Table 5. Summary statistics of average natural production of different runs of adult Chinook salmon in 13 Central Valley watersheds, 1967-2006. Summary statistics are derived from raw data in the February 13, 2007 version of the Chinookprod spreadsheet. N = number of years when monitoring data were available during the 1967-1991 or 1992-2006 time periods. SD = 1 standard deviation. S = significant at α = 0.05. NS = not significant at α = 0.05.

		1967-1991			1992-2006				
Watershed	Run	N	Average production	SD	N	Average production	SD	change in average production 1967-1991 vs. 1992-2006	Significance
American River	fall-run	25	80,846	36,580	15	136,564	67,325	up	S
Battle Creek	fall-run	25	5,012	5,484	15	22,079	15,951	up	S
Battle Creek	late fall-run	23	273	183	15	677	474	up	S
Butte Creek	fall-run	10	763	642	10	3,264	2,092	up	S
Butte Creek	spring-run	25	1,017	1,428	15	11,505	11,339	up	S
Clear Creek	fall-run	16	3,574	3,607	15	12,314	7,127	up	S
Deer Creek	fall-run	23	766	470	7	1,151	924	up	NS
Deer Creek	spring-run	18	3,273	4,416	15	2,522	1,395	down	NS
Feather River	fall-run	25	86,007	34,218	15	112,090	51,247	up	S
Merced River	fall-run	25	9,004	11,641	15	8,575	5,571	down	NS
Mill Creek	fall-run	24	2,118	2,236	10	2,511	1,194	up	NS
Mill Creek	spring-run	18	2,201	1,941	15	1,364	738	down	NS
Mokelumne River	fall-run	25	4,679	4,828	15	9,760	4,973	up	S
Sacramento River	fall-run	25	115,338	39,744	15	91,079	51,047	down	NS
Sacramento River	late fall-run	25	33,931	21,675	14	21,742	22,682	down	NS
Sacramento River	winter-run	25	54,294	63,118	15	9,985	9,661	down	S
Sacramento River	spring-run	25	29,402	18,823	14	969	893	down	S
Stanislaus River	fall-run	24	10,868	12,181	15	6,826	5,041	down	NS
Tuolumne River	fall-run	25	18,946	19,648	15	8,941	10,000	down	S
Yuba River	fall-run	25	33,253	23,109	15	39,019	17,313	up	NS

Table 6. Pacific Salmon Commission assessment scores and progress toward annual incremental production targets for four runs of adult Chinook salmon in the Central Valley, 1999-2004. Watersheds with salmon runs that are above the annual incremental production targets are not scored because the targets had been met.

		Pacific Salmon Commission metric				
Watershed	Run	Mean	Line	Short-term trend	Total score	Production status
American River	fall-run					above target
Battle Creek	fall-run					above target
Battle Creek	late fall-run	+1	-1	0	0	indeterminate
Butte Creek	fall-run					above target
Butte Creek	spring-run					above target
Clear Creek	fall-run					above target
Deer Creek	fall-run					insufficient data
Deer Creek	spring-run	-1	-1	0	-2	not rebuilding
Feather River	fall-run	-1	-1	0	-2	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
Mokelumne River	fall-run					above target
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	0	-2	not rebuilding
Sacramento River	spring-run	-1	-1	0	-2	not rebuilding
Stanislaus River	fall-run	-1	-1	0	-2	not rebuilding
Tuolumne River	fall-run	-1	-1	0	-2	not rebuilding
Yuba River	fall-run	-1	-1	0	-2	not rebuilding

3.3 PRODUCTION OF NON-SALMONID TAXA

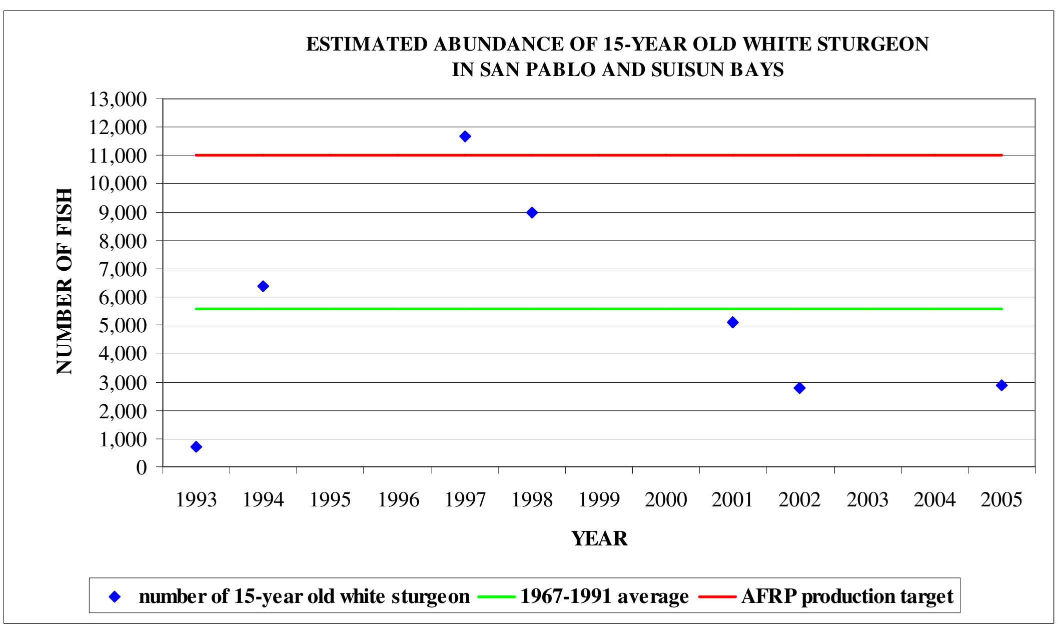
3.3.1 PRODUCTION OF ADULT WHITE AND GREEN STURGEON

Seven censuses were conducted for white sturgeon between 1992 and 2006 (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 7 years ranged between 692 and 11,689 fish (Table 7). The AFRP production target for white sturgeon is 11,000 fish. During the 1992-2006 timeframe, estimated number of 15-year old white sturgeon in San Pablo and Suisun Bays exceeded the AFRP production target in 1 of the 7 years when sampling was done (Figure 16).

Table 7. 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 16. Estimated abundance of 15-year old white sturgeon in San Pablo Bay and Suisun Bay, 1993-2005.

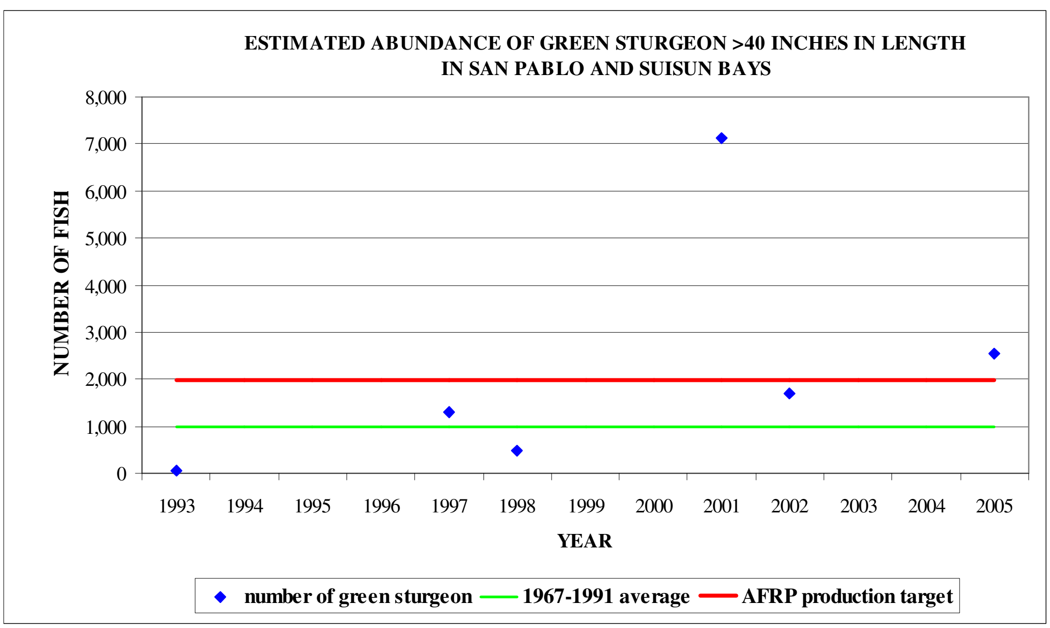


Six of the 7 sturgeon censuses can be used to develop abundance estimates for green sturgeon that were ≥ 40 inches in length in San Pablo and Suisun Bays. These were conducted in 1993, 1997, 1998, 2001, 2002, and 2005. Because the CDFG did not capture green sturgeon during the sturgeon census in 1994, it is not possible to develop an abundance estimate for green sturgeon in the 2 bays that year. The estimated abundance of green sturgeon ≥ 40 inches in length in the 2 bays between 1993 and 2005 ranged between 68 and 7,117 fish (Table 8). The AFRP production target for green sturgeon is 2,000 fish. During the 1992-2006 timeframe, the estimated abundance of green sturgeon ≥ 40 inches in length in San Pablo and Suisun Bays exceeded the AFRP production target in 2 of the 6 years when abundance estimates could be calculated (Figure 17).

Table 8. 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 17. Estimated abundance of adult green sturgeon in San Pablo Bay and Suisun Bay, 1993-2005.



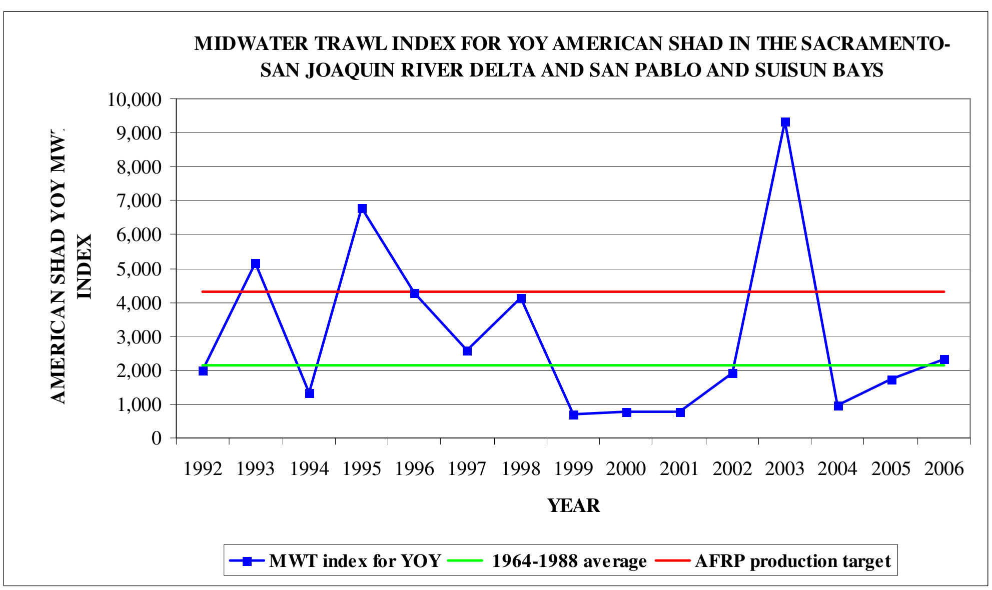
3.3.2 PRODUCTION OF JUVENILE AMERICAN SHAD

The midwater trawl index for YOY American shad in the Sacramento-San Joaquin River Delta and San Pablo and Suisun Bays during the 1992-2006 time period ranged between 715 and 9,350 (Table 9). The AFRP production target for American shad is 4,300 fish. Between 1992 and 2006, the MWT index exceeded the AFRP production target in 3 of 15 years (Figure 18).

Table 9: Midwater trawl index for young-of-the-year American shad in the Sacramento-San Joaquin River Delta and San Pablo and Suisun Bays, 1992-2006.

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

Figure 18. Midwater trawl index for young-of-the-year American shad in the Sacramento-San Joaquin River Delta and San Pablo and Suisun Bays, 1992-2006.



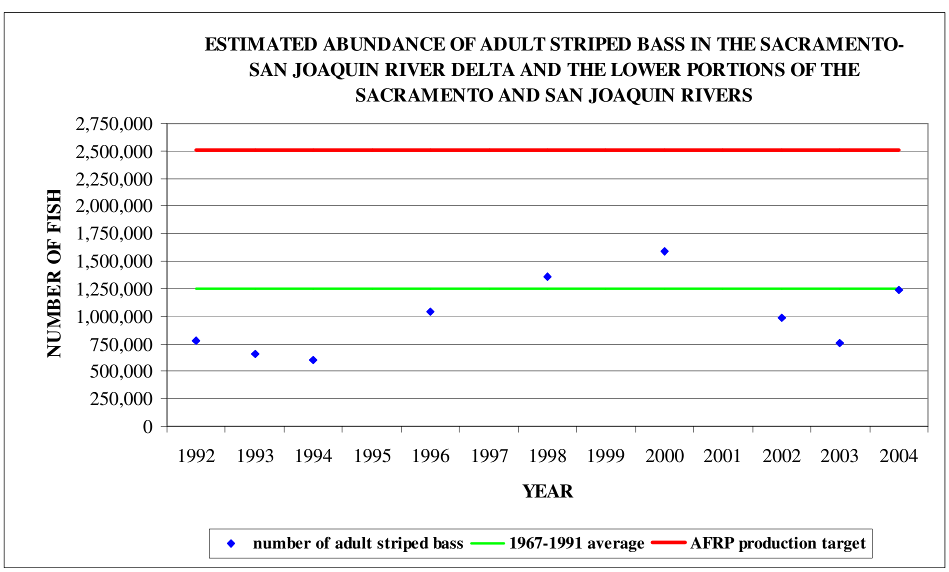
3.3.3 PRODUCTION OF ADULT STRIPED BASS

The CDFG did not conduct surveys for adult striped bass in 1995, 1997, 1999, and 2001. An estimate of the abundance of adult striped bass for 2005 has not yet been calculated, and an estimate for 2006 will not be developed because striped bass were not tagged that year. Between 1992 and 2004, 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 599,770 and 1,591,419 fish (Table 10). The AFRP production target for striped bass is 2,500,000 fish. Between 1992 and 2004, the estimated abundance of striped bass in the aforementioned area never exceeded the AFRP production target during the 9 years when population estimates were developed (Figure 19).

Table 10: Estimated abundance of 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, 1992-2004.

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	988,494
2003	756,767
2004	1,235,642

Figure 19. Estimated abundance of 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, 1992-2004.



SECTION 4: DISCUSSION

This section of the 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 9 anadromous fish taxa. This section also evaluates temporal changes in the average natural production of adult Chinook salmon and uses the PSC's rebuilding assessment methods to assess changes in the production of Chinook salmon.

As stated in the "Data Reporting Caveats" section on pages 10 and 11 above, several inherent challenges or assumptions are associated with the monitoring data presented in this report. These issues must be acknowledged as temporal changes in production of anadromous fish taxa in the Central Valley are assessed. For example, monitoring activities for a given 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.

The production of Chinook salmon at fish hatcheries also act as an additional confounding factor that makes it difficult to accurately monitor the natural production of these fish. These facilities are located on the American River, Battle Creek, Feather River, Merced River, and Mokelumne River. These fish hatcheries have produced fall-run Chinook salmon for many years or decades, and large numbers of Chinook salmon 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 contribution of natural- vs.-hatchery origin fish in a watershed.

The calculations in the Chinookprod spreadsheet currently rely on "best professional estimates" in regards to the amount of natural production in different watersheds. The accuracy of these estimates have not yet been established, and experts have disagreed on the relative contribution of natural- vs. hatchery-origin fish in a given watershed. Because the Chinookprod spreadsheet relies on estimates of the relative contribution of natural- vs. hatchery-origin fish, inaccuracies in these numbers could result in inflated natural production estimates that are skewed by many thousands of fish. This case is especially likely in watersheds where Chinookprod assumes hatchery-origin fish constitute 0% of the production; e.g., for fall-run Chinook salmon, the Stanislaus River, Tuolumne River, and Yuba River.

To the extent that is possible during the preparation of this report, there has been an effort to synthesize data for the 1969-1991 and 1992-2006 time periods using the same analytical techniques and approaches. This effort should increase comparability of data collected during the 2 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

As progress toward AFRP production targets are assessed, it is important to recognize CVPIA-related management activities to promote fish numbers did not begin until 1995, and relatively few of these activities were conducted prior to 1998. These management activities have therefore only occurred during a relatively short period; i.e., 10 years. In contrast, senior biologists with the AFRP assert that several decades will be required to restore watersheds inhabited by Chinook salmon (Jim Smith and John Icanberry, USFWS, pers. comm.).

An overall assessment of changes in natural production of different runs of Chinook salmon using the 3 tools described in this report generally yields similar results (Table 11). This overall comparison suggests individual watersheds can be separated into 3 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 6 or more times;
   b) average production of Chinook salmon between 1992 and 2006 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 3 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 the context of the PSC's rebuilding assessment methods.

2) Watersheds that possess adult Chinook salmon runs where:

   a) watershed-specific AFRP production targets were met or exceeded 2 or fewer times;
   b) average production of Chinook salmon between 1992 and 2006 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 3 tools do not provide a consistent assessment in changes in the abundance of fish.

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

In summary, increases in natural production of some runs of adult Chinook salmon in some watersheds in the Central Valley appear to have occurred in the past 10-15 years, sometimes meeting AFRP production targets. These increases suggest restoration activities may be producing benefits in these watersheds. In other watersheds, production of Chinook salmon has not increased or appears to have declined. In those watersheds, increased efforts to restore habitat will likely be required to promote measurable increases in Chinook salmon production.

There has been little progress within the past 15 years in meeting the AFRP's production targets that involve the run-specific or Central Valley-wide totals for all 4 runs of Chinook salmon. Future progress in meeting watershed-specific AFRP production targets, particularly in watersheds that have capacity to produce large numbers of Chinook salmon, will help meet the broader-scale AFRP production targets.

At the present time, it cannot be determined if the increased salmon production in some watersheds is sustainable. There are multiple reasons for this uncertainty. First, and most notably, there has not been a comprehensive effort to identify specific activities that may have led to increases in production of Chinook salmon in some watersheds. Such an analysis is relevant to CAMP Program Objective #2 to assess relative effectiveness of habitat restoration categories (e.g., water management modifications, structural modifications, habitat restoration, and fish screens) by monitoring juvenile salmon production. This analysis may be done in the future, and could provide a basis for identifying the specific activities that may have resulted in increases in natural production. Second, to demonstrate sustainability, it will be necessary to provide assurances those specific activities continue over the long-term to maintain the elevated salmon production levels. Third, natural production of Chinook salmon is intimately linked to uncontrollable factors (e.g., environmental factors in the ocean) that fluctuate greatly from year to year and are poorly understood. Monitoring and assessment activities will be required over a long period of time (several generations of Chinook salmon) to determine if increases in salmon numbers are due to improvements in freshwater habitats or changes in the ocean environment that are beyond human control and management.

Table 11. Overall assessment of changes in natural production of Chinook salmon in the Central Valley, 1967-2006. SD = significantly different, NSD = not significantly different.

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 1992	Change in average production between the 1967-1991 and 1992-2006 time periods	statistical difference (α=0.05) in average production between the 1967-1991 and 1992-2006 time periods	Production status using the PSC's rebuilding assessment methods 1999-2004
American River*	fall-run	6/15	up	SD	above target
Battle Creek*	fall-run	13/15	up	SD	above target
Battle Creek*	late fall-run	7/15	up	SD	indeterminate
Butte Creek	fall-run	7/10	up	SD	above target
Butte Creek	spring-run	12/15	up	SD	above target
Clear Creek	fall-run	11/15	up	SD	above target
Deer Creek	fall-run	2/7	up	NSD	insufficient data
Deer Creek	spring-run	0/15	down	NSD	not rebuilding
Feather River*	fall-run	3/15	up	SD	not rebuilding
Merced River*	fall-run	1/15	down	NSD	not rebuilding
Mill Creek	fall-run	1/10	up	NSD	insufficient data
Mill Creek	spring-run	0/15	down	NSD	not rebuilding
Mokelumne River*	fall-run	8/15	up	SD	above target
Sacramento River	fall-run	0/15	down	NSD	not rebuilding
Sacramento River	late fall-run	1/14	down	NSD	not rebuilding
Sacramento River	winter-run	0/15	down	SD	not rebuilding
Sacramento River	spring-run	0/15	down	SD	not rebuilding
Stanislaus River	fall-run	0/15	down	NSD	not rebuilding
Tuolumne River	fall-run	0/15	down	SD	not rebuilding
Yuba River	fall-run	1/15	up	NSD	not rebuilding
* Indicates a fish hatchery is located in the watershed; presence of hatchery fish can confound estimates of natural production.					

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 accurately quantify the ratio of natural- and hatchery-origin fish in different watersheds. In the absence of these 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). It is also likely several generations of fish must be studied on a consistent and long-term basis (25-50 years) to accurately assess production of adult Chinook salmon (Montgomery Watson et al. 1997).

4.2 PROGRESS TOWARD AFRP PRODUCTION TARGETS FOR NON-SALMONID SPECIES

Data that can be used to estimate the abundance of 15-year old white sturgeon in San Pablo and Suisun Bays have been collected in only 7 years since 1992. Estimates of the abundance of 15-year old white sturgeon during 6 of these years were below the AFRP production targets, and estimates for 4 of the 7 years were below the average level from the 1967-1991 baseline period. These figures do not suggest progress toward the white sturgeon AFRP production target is occurring. It is important to note the CDFG 2005 abundance estimate for the number of white sturgeon ≥ 40 inches in total length, and therefore the number of 15-year old sturgeon, will almost certainly be revised and increase to some degree as additional recapture data are collected. Overall, however, the number of white sturgeon ≥ 40 inches in total length, and therefore the number 15-year old white sturgeon, appears to have declined based on the number of sturgeon harvested by recreational anglers (Marty Gingras, CDFG, pers. comm.).

The techniques used to monitor white sturgeon and the methods used by the AFRP to develop the white sturgeon production target make it difficult to accurately assess changes in abundance of these fish. For example, the ability to accurately estimate abundance of white sturgeon depends upon the recapture of marked fish. Because relatively few white sturgeon are recaptured after they are tagged (e.g., 1 of the 384 white sturgeon that were marked in 1994 was subsequently recaptured), the confidence intervals associated with the white sturgeon abundance estimates are large. These large confidence intervals suggest the abundance estimates are not statistically robust, and it will be inherently difficult to use these data to accurately quantify: (1) number of white sturgeon ≥ 40 inches in total length, and (2) number of 15-year old white sturgeon in San Pablo and Suisun Bays. In addition to this problem, at least 1 major assumption in the Bailey's modified Peterson model that is used to develop the white sturgeon production target can not be fulfilled. This assumption assumes white sturgeon in San Pablo and Suisun Bays represent a closed population where individuals do not emigrate, immigrate, or die between mark-recapture efforts. Because white sturgeon in San Pablo and Suisun Bays are likely to emigrate, immigrate, and die between the sampling activities, abundance estimates developed with the Bailey's modified Peterson model should be viewed as being rough approximations as compared to being robust, definitive numbers.

The challenges associated with monitoring green sturgeon are also substantial because estimated abundance of this species is inherently linked to: (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 2 green sturgeon were incidentally caught during trapping activities for white sturgeon. If 3 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 AFRP production target for green sturgeon used methods that may not generate a robust abundance estimate, it may be necessary in the future to use a different method for assessing changes in the production of this species.

The CDFG is in the process of selecting a different model to estimate abundance of white sturgeon. The probability of violating the assumptions in the alternative model will be less than the Bailey's modified Peterson model. The fish abundance estimates generated by the alternative model should therefore provide a more definitive basis for assessing temporal changes in abundance of adult white sturgeon (Mike Donnellon, CDFG, pers. comm.). Correspondingly, the ability to more accurately determine if the number of green sturgeon is increasing or decreasing should also be improved. Accurately assessing changes in numbers of green sturgeon will continue to be a problem, however, as long as small numbers of this species are captured during sampling activities.

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 6 times in the past decade. 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 create conditions that favor increases in production of juvenile American shad.

Mark-recapture surveys for adult striped bass suggest the AFRP production target for this species was never met between 1992 and 2006, and abundance of these fish has been below the 1967-1991 average in 6 of the 9 years when abundance estimates were available after 1992. The methods during mark-recapture surveys for adult striped bass have been relatively consistent except that: (1) size of the fish that have been 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.). CAMP staff will attempt to work with CDFG staff in the future to assess how the tagging of different sizes of striped bass affect abundance estimates of this species.

SECTION 5: FUTURE WORK

As was stated in the "Introduction" section above, data presented in this report represent the best available information at the time of report production. In the future, the CAMP will collaborate with entities/partners that gather data to collect more precise and accurate information. These efforts will focus on:

1. Working with entities to develop standardized data collection protocols so there is an enhanced ability to assess temporal changes in fish abundance.
2. Developing documents that describe how sampling protocols have changed over time. These documents will provide a basis for understanding how these changes affect fish production or abundance estimates.
3. Developing confidence intervals that assess the precision of data that are collected.
4. Collecting empirical data that can be used in lieu of professional judgment to develop estimates of Chinook salmon production.
5. Archiving data in an easily retrievable manner.
6. Providing, on a limited basis, funding to ensure that CAMP-recommended monitoring activities occur, and that data from these activities are collected in a manner that meets the CAMP's needs.
7. Developing a methodology for determining when fish populations are at sustainable levels.

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APPENDIX A: METHODS FOR CALCULATING PRODUCTION OF ADULT CHINOOK SALMON IN THE CHINOOKPROD SPREADSHEET

The Chinookprod spreadsheet that was developed by AFRP staff in Stockton, California, provides watershed-specific production estimates of adult Chinook salmon in the Central Valley of California. This spreadsheet relies on a complex series of formulas to estimate the production of adult Chinook salmon. The text below is adapted from Appendix A of the *Final Restoration Plan for the Anadromous Fish Restoration Program* (USFWS 2001), and provides an updated description of those formulas.

In the following explanations and formulas, P is for production, E is for escapement, H is for harvest, and h is for the portion of total production not produced naturally. Subscripted letters following the normal letters and prior to the first comma represent different runs of Chinook salmon as follows: F for fall, L for late-fall, W for winter, S for spring, and C for all runs combined. Subscripted letters following the first comma represent the following: O for ocean, D for downstream, I for instream, N for natural, H for hatchery, and T for total. Subscripted letters following the second comma represent the following: CV for Central Valley, SF for San Francisco, M for Monterey, and other letter combinations correspond to specific streams (e.g., AM for American River). Subscripted letters following a third comma refer only to ocean harvest and are C for commercial and R for recreational. In all cases, a subscripted X acts as a "wildcard" place holder for an unspecified subscript.

1. A portion of production returns to spawn in each stream, both naturally and in the hatchery. Some of these fish are captured before spawning. These fish are counted toward production for the stream in which they spawned or were harvested according to the following:

    a. To determine the total spawning escapement ($E_{X,T,XX}$) for each run in each individual stream, sum the estimated number of each run of Chinook salmon returning to spawn naturally ($E_{X,N,XX}$) and in hatcheries ($E_{X,H,XX}$) for each individual stream.

$$E_{X,T,XX} = E_{X,N,XX} + E_{X,H,XX}$$

    Central Valley: column B, C, D
    fall-run, late fall-run, winter-run, spring-run: column B, C, D
    Sacramento River → Merced River: column B, C, D

b. To determine the portion of production for each run returning to each stream (inriver run-size, $P_{X,I,XX}$), add $E_{X,T,XX}$ to the estimated number of each run of Chinook salmon harvested in each stream ($H_{X,I,XX}$). $H_{X,I,XX}$ = Proportion harvested instream * $E_{X,T,XX}$. Estimates of $H_{X,I,XX}$ do not exist for all streams and all years. Where estimates are not available or are inadequate, best professional judgement must be used. Technical Teams should document options considered for estimation of $H_{X,I,XX}$ in the Program Plan or in issue papers that will be appended to the Program Plan.

$H_{X,I,XX}$ - Central Valley: column E
fall-run, late fall-run, winter-run, spring-run: column E
Sacramento River → Merced River: column F

$$P_{X,I,XX} = E_{X,T,XX} + H_{X,I,XX}$$

Central Valley: column F
fall-run, late fall-run, winter-run, spring-run: column F
Sacramento River → Merced River: column G

c. To determine the total number of each run of Chinook salmon returning to the Central Valley ($P_{X,I,CV}$), sum $P_{X,I,XX}$ for all streams in the Central Valley ($\sum P_{X,I,XX}$).

$$P_{X,I,CV} = \sum P_{X,I,XX}$$

Central Valley: column F

d. To determine the total number of Chinook salmon (all runs combined) returning to the Central Valley ($P_{C,I,CV}$), sum $P_{X,I,CV}$ for all runs of Chinook salmon ($P_{X,I,CV}$) .

$$P_{C,I,CV} = \sum P_{X,I,CV}$$

Central Valley: column F

2. A portion of production is harvested in the ocean and downstream of areas in rivers where the stream responsible for this production is not easily identified. To assign these harvested salmon to individual streams, the total number of salmon falling into this category is summed and subdivided to run and stream, proportional to the portion of production attributed to each run and returning to each stream, according to the following:

a. To determine the Central Valley component of ocean harvest ($H_{C,O,CV}$), sum commercial catch at San Francisco ($H_{C,O,SF,C}$) and Monterey ($H_{C,O,M,C}$), sum recreational catch at these same ports ($H_{C,O,SF,R} + H_{C,O,M,R}$), and add these together. This estimate of $H_{C,O,CV}$ is based on the Central Valley Index (CVI), where harvest of Central Valley stocks equals landings at major ports south of Point Arena (San Francisco and Monterey). Use of CVI to estimate the Central Valley component of ocean harvest assumes that the number of Central Valley Chinook salmon harvested from ports north of San Francisco is balanced by the number of Chinook salmon from drainages north of the Central Valley harvested from San Francisco and Monterey. To carry $H_{C,O,CV}$ forward in subsequent calculations, assume that each Chinook salmon harvested in the ocean fishery is equivalent to an adult salmon returning to spawn.

$$H_{C,O,CV} = H_{C,O,SF,C} + H_{C,O,M,C} + H_{C,O,SF,R} + H_{C,O,M,R}$$

$H_{C,O,CV}$ = Central Valley: column K = column G + column H + column I + column J

b. To account for that portion of inland harvest that occurs downstream of streams for which production is being estimated, estimate portion of inland recreational harvest captured downstream of spawning streams ($H_{C,D,CV}$). Information necessary to estimate $H_{C,D,CV}$ may not be available. If an estimate exists, use it. If an estimate of inland harvest for the entire Central Valley exists ($H_{X,I,CV}$), then sum all assignable inland harvest ($H_{X,I,XX}$) and subtract it from $H_{X,I,CV}$ to determine $H_{C,D,CV}$. If other options exist, these should be explored. $H_{C,D,CV}$ could be assumed to be small and therefore left out of the calculations or could be included in $H_{X,I,XX}$, in which case it would already be assigned to an individual stream.

c. To determine ocean and downstream inland harvest for the Central Valley ($H_{C,O+D,CV}$),sum $H_{C,O,CV}$ and $H_{C,D,CV}$.

$$H_{C,O+D,CV} = H_{C,O,CV} + H_{C,D,CV}$$

$H_{C,O+D,CV}$ = (Central Valley: column K) + (fall-run, late fall-run, winter-run, spring-run: column E)

d. To assign portions of $H_{C,O+D,CV}$ to specific runs, subdivide $H_{C,O+D,CV}$ to each run, proportional to the portion of production for each run returning to the entire Central Valley ($P_{X,I,CV}$) to the portion of production for all runs combined returning to the entire Central Valley ($P_{X,I,CV}$).

$P_{X,I,CV}/P_{C,I,CV}$ = fall-run, late fall-run, winter-run, spring-run: column G

$$H_{X,O+D,CV} = H_{C,O+D,CV} (P_{X,I,CV}/P_{C,I,CV})$$

$H_{X,O+D,CV}$ = (fall-run, late fall run, winter-run, spring-run: column G) * (fall-run, late fall-run, winter-run, spring-run: column H)

e. To assign portions of $H_{X,O+D,CV}$ to specific streams, subdivide $H_{X,O+D,CV}$ to each stream, proportional to the portion of production for that run returning to each stream ($P_{X,I,XX}$) to the portion of production for that run returning to the entire Central Valley ($P_{X,I,CV}$).

$$H_{X,O+D,XX} = H_{X,O+D,CV} (P_{X,I,XX}/P_{X,I,CV})$$

$H_{X,O+D,XX}$ = (Sacramento River → Merced River: column I) * (Sacramento River → Merced River: column H)

3. To determine total production for each run and stream ($P_{X,T,XX}$), sum $P_{X,I,XX}$ and $H_{X,O+D,XX}$.

$$P_{X,T,XX} = P_{X,I,XX} + H_{X,O+D,XX}$$

$P_{X,T,XX}$ = Central Valley: column L
$P_{X,T,XX}$ = fall-run, late fall-run, winter-run, spring-run: column I
$P_{X,T,XX}$ = Sacramento River → Merced River: column J

4. A portion of the total production was not produced naturally (h). For the baseline period, only hatchery-produced salmon will be considered to be produced by other than natural means. To determine the natural production for each individual stream ($P_{X,N,XX}$), multiply $P_{X,T,XX}$ by (1-h). Technical Teams should document options considered and chosen for estimation of h in issue papers that will be appended to the Program Plan or in the text for the Program Plan.

h = Sacramento River → Merced River: column K

$$P_{X,N,XX} = P_{X,T,XX} (1-h)$$

$P_{X,N,XX}$ = Central Valley: column M
$P_{X,N,XX}$ = fall-run, late fall-run, winter-run, spring-run: column J
$P_{X,N,XX}$ = Sacramento River → Merced River: column L

Numeric restoration goals for Chinook salmon in each stream will be calculated as at least double the average of $P_{X,N,XX}$ for each of the years during the baseline period.

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

The PSC rebuilding assessment methods assign indicator runs of salmon to 3 categories: (1) those that are at or above a series of annual incremental production targets, (2) those that 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 production data in 2005 and 2006 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 1999 and 2004.

Runs or species for which at least 4 of the last 5 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 3 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 and 2004. The mean of the annual production targets from the rebuilding line for each watershed between 2000 and 2004 is called the test value. The test value is compared to the mean estimated fish production that occurred between 2000 and 2004 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 3 or more of the previous 5 production estimates are on or above the rebuilding line during the period 2000-2004 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 5 most recent years of the rebuilding period.

3. *Short term trend criterion*. During the period 1999-2004, watersheds in which at least 4 of the 5 years possess an estimate of production exceeded by the previous year's estimate are assigned a trend score of +1. If 4 of the 5 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 3 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 2 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 2 of the 3 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 2 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 C: 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*	47,164	49,315	10,883	10,896	118,258

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 2006 Ocean Salmon Fisheries* (PFMC 2007); commercial harvest data is provided in Table A-3 and recreational harvest data is provided in Table A-5 of the *Review of 2006 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	25,517	41,854	60%	25,113
Battle Creek	5,433	7,275	1,271	21,843	35,822	10%	3,582
Butte Creek	NE	0	NE	NE	NE	80%	NE
Clear Creek	600	0	60	1,035	1,695	80%	1,356
Deer Creek	NE	0	NE	NE	NE	80%	NE
Feather River	24,105	17,937	8,408	78,805	129,255	60%	77,553
Merced River	618	368	49	1,624	2,659	90%	2,393
Mill Creek	999	0	100	1,726	2,825	80%	2,260
Mokelumne River	935	710	165	2,822	4,632	60%	2,779
Sacramento River	32,229	0	3,223	55,379	90,831	60%	54,499
Stanislaus River	255	0	13	426	694	100%	694
Tuolumne River	132	0	7	223	362	100%	362
Yuba River	6,362	0	636	10,921	17,919	100%	17,919
Total	76,479	32,746	19,002	200,321	328,548		188,510
Late-Fall Run Chinook Salmon							
Battle Creek	NE	344	69	645	1,058	10%	106
Sacramento River	9,389	398	1,957	18,334	30,078	0.918%	27,612
Total	9,389	742	2,026	18,979	31,136		27,718
Winter-Run Chinook Salmon							
Sacramento River	1,203	34	247	2,316	3,800	100%	3,800
Spring-Run Chinook Salmon							
Butte Creek	730	0	73	1,258	2,061	100%	2,061
Deer Creek	209	0	21	360	590	100%	590
Mill Creek	237	0	24	408	669	100%	669
Sacramento River	371	0	74	697	1143	100%	1,142
Total	1,547	0	192	2,723	4,462		4,462
Total Natural Production of Adult Chinook Salmon from the 13 CAMP watersheds							**224,490**

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	99,314	156,459	60%	93,875
Battle Creek	11,029	7,587	1,862	35,598	56,076	10%	5,608
Butte Creek	NE	0	NE	NE	NE	80%	NE
Clear Creek	1,246	0	125	2,399	3,770	80%	3,016
Deer Creek	72	0	7	141	220	80%	176
Feather River	30,923	16,663	9,517	99,244	156,347	60%	93,808
Merced River	1,269	409	84	3,069	4,831	90%	4,348
Mill Creek	1,975	0	198	3,775	5,948	80%	4,758
Mokelumne River	993	2,164	316	6,033	9,506	60%	5,703
Sacramento River	46,231	0	4,623	88,378	139,232	60%	83,539
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	12,807	20,180	100%	20,180
Total	130,343	37,479	35,195	352,840	555,857		318,299
Late-Fall Run Chinook Salmon							
Battle Creek	NE	528	106	1,107	1,741	10%	174
Sacramento River	339	400	148	1,550	2,436	0.918%	2,236
Total	339	928	254	2,657	4,178		2,410
Winter-Run Chinook Salmon							
Sacramento River	378	0	76	790	1,244	100%	1,244
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	391	0	78	811	1,280	100%	1,280
Total	1,361	0	175	2,655	4,191		4,191
Total Natural Production of Adult Chinook Salmon from all 4 runs of Chinook salmon in the 13 CAMP watersheds							**326,144**

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	98,883	157,009	60%	94,205
Battle Creek	24,274	18,991	4,327	80,965	128,557	10%	12,856
Butte Creek	NE	0	NE	NE	NE	80%	NE
Clear Creek	2,546	0	255	4,760	7,561	80%	6,049
Deer Creek	307	0	31	584	922	80%	738
Feather River	38,382	18,843	11,445	116,845	185,515	60%	111,309
Merced River	2,646	943	179	6,422	10,190	90%	9,171
Mill Creek	1,081	0	108	2,021	3,210	80%	2,568
Mokelumne River	1,238	1,919	316	5,928	9,401	60%	5,641
Sacramento River	58,546	0	5,855	109,571	173,972	60%	104,383
Stanislaus River	1,031	0	52	1,841	2,924	100%	2,924
Tuolumne River	506	0	25	898	1,429	100%	1,429
Yuba River	10,890	0	1,089	20,387	32,366	100%	32,366
Total	172,967	49,263	41,721	449,105	713,056		383,639
Late-Fall Run Chinook Salmon							
Battle Creek	NE	598	120	1,227	1,945	10%	195
Sacramento River	137	154	58	597	946	0.918%	868
Total	137	752	178	1,824	2,891		1,063
Winter-Run Chinook Salmon							
Sacramento River	144	42	37	365	588	100%	588
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	862	0	172	1,765	2,800	100%	2,800
Total	2,544	0	340	4,922	7,806		7,806
Total Natural Production of Adult Chinook Salmon from all 4 runs of Chinook salmon in the 13 CAMP watersheds							**393,096**

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	299,803	425,704	60%	255,422
Battle Creek	56,515	26,677	8,319	217,939	309,450	10%	30,945
Butte Creek	445	0	45	1,194	1,684	80%	1,347
Clear Creek	9,298	0	930	24,370	34,598	80%	27,678
Deer Creek	NE	0	NE	NE	NE	80%	NE
Feather River	59,912	17,563	15,495	221,421	314,391	60%	188,635
Merced River	2,320	602	146	7,261	10,329	90%	9,296
Mill Creek	NE	0	NE	NE	NE	80%	NE
Mokelumne River	2,194	3,323	552	14,423	20,492	60%	12,295
Sacramento River	63,934	0	6,393	167,508	237,835	60%	142,701
Stanislaus River	619	0	31	1,592	2,242	100%	2,242
Tuolumne River	827	0	41	2,089	2,957	100%	2,957
Yuba River	14,237	0	1,424	37,301	52,962	100%	52,962
Total	290,631	54,663	72,449	994,901	1,412,644		726,480
Late-Fall Run Chinook Salmon							
Battle Creek	NE	323	65	948	1,336	10%	134
Sacramento River	NE	166	33	487	686	0.918%	630
Total	NE	489	98	1,435	2,022		764
Winter-Run Chinook Salmon							
Sacramento River	1,166	43	242	3,486	4,937	100%	4,937
Spring-Run Chinook Salmon							
Butte Creek	7,500	0	750	19,655	27,905	100%	27,905
Deer Creek	1,295	0	130	3,393	4,818	100%	4,818
Mill Creek	320	0	32	838	1,190	100%	1,190
Sacramento River	349	77	85	1,217	1,728	100%	1,728
Total	9,464	77	997	25,103	35,641		35,641
Total Natural Production of Adult Chinook Salmon from all 4 runs of Chinook salmon in the 13 CAMP watersheds							**767,822**

NE No estimate

1996 Adult Chinook Salmon Production Estimates

Watershed	In-river spawner abundance	Fish entering a hatchery	Estimated in-river harvest	Estimated ocean harvest	Total production	Percent natural production	Natural production
Fall-Run Chinook Salmon							
American River	74,745	7,651	37,078	129,642	249,116	60%	149,470
Battle Creek	52,409	21,178	7,359	87,844	168,790	10%	16,879
Butte Creek	500	0	50	613	1,163	80%	930
Clear Creek	5,922	0	592	7,077	13,591	80%	10,873
Deer Creek	NE	0	NE	NE	NE	80%	NE
Feather River	57,170	14,488	14,332	93,316	179,306	60%	107,584
Merced River	3,291	1,141	222	5,048	9,702	90%	8,731
Mill Creek	NE	0	NE	NE	NE	80%	NE
Mokelumne River	4,038	3,883	792	9,435	18,148	60%	10,889
Sacramento River	84,086	0	8,409	100,345	192,840	60%	115,704
Stanislaus River	168	0	8	189	365	100%	365
Tuolumne River	4,362	0	218	4,954	9,534	100%	9,534
Yuba River	27,900	0	2,790	33,307	63,997	100%	63,997
Total	314,591	48,341	71,850	471,770	906,552		494,956
Late-Fall Run Chinook Salmon							
Battle Creek	NE	1,337	267	1,754	3,358	10%	336
Sacramento River	NE	48	10	63	121	0.918%	111
Total	NE	1,385	277	1,817	3,479		447
Winter-Run Chinook Salmon							
Sacramento River	1,012	NE	202	1,339	2,553	100%	2,553
Spring-Run Chinook Salmon							
Butte Creek	1,413	0	141	1,680	3,234	100%	3,234
Deer Creek	614	0	61	730	1,405	100%	1,405
Mill Creek	253	0	25	301	579	100%	579
Sacramento River	378	NE	76	490	944	100%	944
Total	2,658	0	303	3,201	6,162		6,162
Total Natural Production of Adult Chinook Salmon from all 4 runs of Chinook salmon in the 13 CAMP watersheds							**504,118**

NE No estimate

1997 Adult Chinook Salmon Production Estimates

Watershed	In-river spawner abundance	Fish entering a hatchery	In-river harvest	Estimated ocean harvest	Total production	Percent natural production	Natural production
Fall-Run Chinook Salmon							
American River	52,195	5,650	26,030	118,919	202,794	60%	121,676
Battle Creek	50,744	50,670	10,141	158,174	269,729	10%	26,973
Butte Creek	800	0	80	1,222	2,102	80%	1,682
Clear Creek	8,569	0	857	13,379	22,805	80%	18,244
Deer Creek	1,203	0	120	1,902	3,225	80%	2,580
Feather River	50,547	18,781	13,866	117,969	201,163	60%	120,698
Merced River	2,714	946	183	5,433	9,276	90%	8,349
Mill Creek	478	0	48	747	1,273	80%	1,018
Mokelumne River	3,681	6,494	1,018	15,892	27,085	60%	16,251
Sacramento River	119,296	0	11,930	186,088	317,314	60%	190,388
Stanislaus River	5,588	0	279	8,354	14,221	100%	14,221
Tuolumne River	7,146	0	357	10,663	18,166	100%	18,166
Yuba River	25,948	0	2,595	40,477	69,020	100%	69,020
Total	328,909	82,541	67,504	679,219	1,158,173		609,266
Late-Fall Run Chinook Salmon							
Battle Creek	NE	4,578	916	7,804	13,298	10%	1,330
Sacramento River	NE	NE	NE	NE	NE	0.918%	NE
Total	NE	4,578	916	7,804	13,298		1,330
Winter-Run Chinook Salmon							
Sacramento River	836	NE	167	1,450	2,453	100%	2,453
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	126	2	26	220	374	100%	374
Total	1,429	2	157	2,276	3,863		3,863
Total Natural Production of Adult Chinook Salmon from all 4 runs of Chinook salmon in the 13 CAMP watersheds							**616,912**

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	83,408	179,949	60%	107,969
Battle Creek	53,957	44,351	9,831	93,409	201,548	10%	20,155
Butte Creek	500	0	50	479	1,029	80%	823
Clear Creek	4,259	0	426	4,043	8,728	80%	6,982
Deer Creek	270	0	27	266	563	80%	450
Feather River	NE	25,635	5,127	26,570	57,332	60%	34,399
Merced River	3,292	799	205	3,724	8,020	90%	7,218
Mill Creek	546	0	55	532	1,133	80%	906
Mokelumne River	4,122	3,091	721	6,862	14,796	60%	8,878
Sacramento River	6,318	0	632	6,011	12,961	60%	7,777
Stanislaus River	3,087	0	154	2,793	6,034	100%	6,034
Tuolumne River	8,910	0	446	8,085	17,441	100%	17,441
Yuba River	31,090	0	3,109	29,549	63,748	100%	63,748
Total	171,143	85,664	50,744	265,731	573,282		282,780
Late-Fall Run Chinook Salmon							
Battle Creek	NE	3,079	616	3,193	6,888	10%	689
Sacramento River	39,340	NE	7,868	40,788	87,996	0.918%	80,780
Total	39,340	3,079	8,484	43,981	94,884		81,469
Winter-Run Chinook Salmon							
Sacramento River	2,903	99	600	3,125	6,727	100%	6,727
Spring-Run Chinook Salmon							
Butte Creek	20,259	0	2,026	19,253	41,538	100%	41,538
Deer Creek	1,879	0	188	1,785	3,852	100%	3,852
Mill Creek	424	0	42	404	870	100%	870
Sacramento River	1,115	0	223	1,157	2,495	100%	2,495
Total	23,677	0	2,479	22,599	48,755		48,755
Total Natural Production of Adult Chinook Salmon from all 4 runs of Chinook salmon in the 13 CAMP watersheds							**419,731**

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	61,910	156,304	60%	93,782
Battle Creek	92,929	26,970	11,990	86,497	218,386	10%	21,839
Butte Creek	NE	0	NE	NE	NE	80%	NE
Clear Creek	8,003	0	800	5,766	14,569	80%	11,655
Deer Creek	NE	0	NE	NE	NE	80%	NE
Feather River	NE	16,658	3,332	13,117	33,107	60%	19,864
Merced River	3,129	1,637	238	3,295	8,299	90%	7,469
Mill Creek	NE	0	NE	NE	NE	80%	NE
Mokelumne River	2,183	3,150	533	3,834	9,700	60%	5,820
Sacramento River	161,192	0	16,119	116,279	293,590	60%	176,154
Stanislaus River	4,349	0	217	3,010	7,576	100%	7,576
Tuolumne River	8,232	0	412	5,671	14,315	100%	14,315
Yuba River	24,230	0	2,423	17,489	44,142	100%	44,142
Total	359,586	58,175	65,359	316,868	799,988		402,616
Late-Fall Run Chinook Salmon							
Battle Creek	NE	7075	1,415	5,568	14,058	10%	1,406
Sacramento River	8,683	NE	1,737	6,833	17,253	0.918%	15,838
Total	8,683	7,075	3,152	12,401	31,311		17,244
Winter-Run Chinook Salmon							
Sacramento River	3,264	24	658	2,588	6,533	100%	6,533
Spring-Run Chinook Salmon							
Butte Creek	3,679	0	368	2,660	6,707	100%	6,707
Deer Creek	1,591	0	159	1,150	2,900	100%	2,900
Mill Creek	560	0	56	405	1,021	100%	1,021
Sacramento River	0	NE	0	0	0	100%	NE
Total	5,830	0	583	4,215	10,628		10,628
Total Natural Production of Adult Chinook Salmon from all 4 runs of Chinook salmon in the 13 CAMP watersheds							**437,021**

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	155,841	315,659	60%	189,395
Battle Creek	53,447	21,659	7,511	80,578	163,195	10%	16,320
Butte Creek	NE	0	NE	NE	NE	80%	NE
Clear Creek	6,687	0	669	7,201	14,557	80%	11,646
Deer Creek	NE	0	NE	NE	NE	80%	NE
Feather River	114,717	21,803	27,304	159,727	323,551	60%	194,131
Merced River	11,130	1,946	654	13,373	27,103	90%	24,392
Mill Creek	NE	0	NE	NE	NE	80%	NE
Mokelumne River	1,973	5,450	742	7,944	16,109	60%	9,665
Sacramento River	96,688	0	9,669	103,723	210,080	60%	126,048
Stanislaus River	8,498	0	425	8,686	17,609	100%	17,609
Tuolumne River	17,873	0	894	18,287	37,054	100%	37,054
Yuba River	14,995	0	1,500	16,058	32,553	100%	32,553
Total	425,067	62,018	98,967	571,418	1,157,469		658,813
Late-Fall Run Chinook Salmon							
Battle Creek	NE	4,194	839	4,908	9,941	10%	994
Sacramento River	8,751	NE	1,750	10,239	20,740	0.918%	19,039
Total	8,751	4,194	2,589	15,147	30,681		20,033
Winter-Run Chinook Salmon							
Sacramento River	1,263	89	270	1,604	3,226	100%	3,226
Spring-Run Chinook Salmon							
Butte Creek	4,118	0	412	4,436	8,966	100%	8,966
Deer Creek	637	0	64	686	1,387	100%	1,387
Mill Creek	544	0	54	586	1,184	100%	1,184
Sacramento River	71	0	14	83	168	100%	168
Total	5,370	0	544	5,791	11,705		11,705
Total Natural Production of Adult Chinook Salmon from all 4 runs of Chinook salmon in the 13 CAMP watersheds							**693,777**

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	11750	66,210	60,933	274,277	60%	164,566
Battle Creek	100,604	25082	12,569	39,482	177,737	10%	17,774
Butte Creek	4,430	0	443	1,394	6,267	80%	5,014
Clear Creek	10,865	0	1,087	3,419	15,371	80%	12,297
Deer Creek	NE	0	NE	NE	NE	80%	NE
Feather River	178,645	29005	41,530	71,147	320,327	60%	192,196
Merced River	9,181	1663	542	3,245	14,631	90%	13,168
Mill Creek	NE	0	NE	NE	NE	80%	NE
Mokelumne River	2,307	5728	804	2,526	11,365	60%	6,819
Sacramento River	74,952	0	7,495	23,541	105,988	60%	63,593
Stanislaus River	7,033	0	352	2,112	9,497	100%	9,497
Tuolumne River	8,782	0	439	2,635	11,856	100%	11,856
Yuba River	23,392	0	2,339	7,339	33,070	100%	33,070
Total	555,575	73,228	133,810	217,773	980,386		529,850
Late-Fall Run Chinook Salmon							
Battle Creek	NE	3,327	665	1,139	5,131	10%	513
Sacramento River	19,276	NE	3,855	6,602	29,733	0.918%	27,295
Total	19,276	3,327	4,520	7,741	34,864		27,808
Winter-Run Chinook Salmon							
Sacramento River	8,120	104	1,645	2,813	12,682	100%	12,682
Spring-Run Chinook Salmon							
Butte Creek	9,605	0	961	3,018	13,584	100%	13,584
Deer Creek	1,622	0	162	510	2,294	100%	2,294
Mill Creek	1,100	0	110	346	1,556	100%	1,556
Sacramento River	711	25	147	252	1,135	100%	1,135
Total	13,038	25	1,380	4,126	18,569		18,569
Total Natural Production of Adult Chinook Salmon from all 4 runs of Chinook salmon in the 13 CAMP watersheds							**588,909**

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	79,629	274,029	60%	164,417
Battle Creek	397,149	66,147	46,330	208,795	718,421	10%	71,842
Butte Creek	4,550	0	455	2,054	7,059	80%	5,647
Clear Creek	16,071	0	1,607	7,250	24,928	80%	19,942
Deer Creek	NE	0	NE	NE	NE	80%	NE
Feather River	105,163	24,696	25,972	63,829	219,660	60%	131,796
Merced River	8,866	1,840	535	4,610	15,851	90%	14,266
Mill Creek	2,611	0	261	1,173	4,045	80%	3,236
Mokelumne River	2,840	7,913	1,075	4,862	16,690	60%	10,014
Sacramento River	65,690	0	6,569	29,588	101,847	60%	61,108
Stanislaus River	7,787	0	389	3,353	11,529	100%	11,529
Tuolumne River	7,173	0	359	3,101	10,633	100%	10,633
Yuba River	24,051	0	2,405	10,855	37,311	100%	37,311
Total	766,203	110,413	146,288	419,099	1,442,003		541,741
Late-Fall Run Chinook Salmon							
Battle Creek	NE	2,669	534	1,312	4,515	10%	452
Sacramento River	36,004	NE	7,201	17,709	60,914	0.918%	55,919
Total	36,004	2,669	7,735	19,021	65,429		56,371
Winter-Run Chinook Salmon							
Sacramento River	7,360	104	1,493	3,670	12,627	100%	12,627
Spring-Run Chinook Salmon							
Butte Creek	8,785	0	879	3,974	13,638	100%	13,638
Deer Creek	2,185	0	219	989	3,393	100%	3,393
Mill Creek	1,594	0	159	721	2,474	100%	2,474
Sacramento River	273	0	55	135	463	100%	463
Total	12,837	0	1,312	5,819	19,968		19,968
Total Natural Production of Adult Chinook Salmon from all 4 runs of Chinook salmon in the 13 CAMP watersheds							**630,707**

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	104,930	363,942	60%	218,365
Battle Creek	64,764	88,281	15,305	68,212	236,562	10%	23,656
Butte Creek	3,310	0	331	1,484	5,125	80%	4,100
Clear Creek	9,475	0	948	4,215	14,638	80%	11,710
Deer Creek	NE	0	NE	NE	NE	80%	NE
Feather River	89,946	23,638	22,717	55,211	191,512	60%	114,907
Merced River	2,530	549	154	1,306	4,539	90%	4,085
Mill Creek	2,426	0	243	1,069	3,738	80%	2,990
Mokelumne River	2,122	8,117	1,024	4,571	15,834	60%	9,500
Sacramento River	89,229	0	8,923	39,775	137,927	60%	82,756
Stanislaus River	5,902	0	295	2,523	8,720	100%	8,720
Tuolumne River	2,163	0	108	920	3,191	100%	3,191
Yuba River	28,316	0	2,832	12,615	43,763	100%	43,763
Total	463,925	135,472	133,263	296,831	1,029,491		527,743
Late-Fall Run Chinook Salmon							
Battle Creek	NE	2,797	559	1,365	4,721	10%	472
Sacramento River	5,494	NE	1,099	2,680	9,273	0.918%	8,513
Total	5,494	2,797	1,658	4,045	13,994		8,985
Winter-Run Chinook Salmon							
Sacramento River	8,133	85	1,644	3,982	13,844	100%	13,844
Spring-Run Chinook Salmon							
Butte Creek	4,398	0	440	1,959	6,797	100%	6,797
Deer Creek	2,759	0	276	1,229	4,264	100%	4,264
Mill Creek	1,426	0	143	635	2,204	100%	2,204
Sacramento River	0	0	0	0	0	100%	0
Total	8,583	0	759	3,823	13,265		13,265
Total Natural Production of Adult Chinook Salmon from all 4 runs of Chinook salmon in the 13 CAMP watersheds							**563,837**

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	193,910	376,073	60%	225,644
Battle Creek	23,861	68,232	9,209	107,833	209,135	10%	20,914
Butte Creek	2,516	0	252	2,944	5,712	80%	4,570
Clear Creek	6,365	0	637	7,436	14,438	80%	11,550
Deer Creek	300	0	30	349	679	80%	543
Feather River	54,171	25,509	15,936	101,795	197,411	60%	118,447
Merced River	1,050	3,270	216	4,841	9,377	90%	8,439
Mill Creek	1,192	0	119	1,397	2,708	80%	2,166
Mokelumne River	1,588	10,356	1,194	13,973	27,111	60%	16,267
Sacramento River	34,050	0	3,405	39,870	77,325	60%	46,395
Stanislaus River	4,015	0	201	4,491	8,707	100%	8,707
Tuolumne River	1,984	0	99	2,196	4,279	100%	4,279
Yuba River	15,269	0	1,527	17,866	34,664	100%	34,660
Total	245,591	133,767	89,359	498,901	967,619		502,581
Late-Fall Run Chinook Salmon							
Battle Creek	NE	5,040	1,008	6,434	12,482	10%	1,248
Sacramento River	8,824	NE	1,765	11,266	21,855	0.918%	20,063
Total	8,824	5,040	2,773	17,700	34,337		21,311
Winter-Run Chinook Salmon							
Sacramento River	7,778	85	1,574	10,061	19,503	100%	19,503
Spring-Run Chinook Salmon							
Butte Creek	7,390	0	739	8,636	16,765	100%	16,765
Deer Creek	804	0	80	940	1,824	100%	1,824
Mill Creek	998	0	100	1,166	2,264	100%	2,264
Sacramento River	394	0	79	503	975	100%	975
Total	9,586	0	998	11,245	21,829		21,828
Total Natural Production of Adult Chinook Salmon from all 4 runs of Chinook salmon in the 13 CAMP watersheds							**565,223**

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	53,000	22,349	33,907	75,889	185,145	60%	111,087
Battle Creek	20,520	144,739	16,526	126,270	308,055	10%	30,805
Butte Creek	4,255	0	426	3,250	7,931	80%	6,345
Clear Creek	14,824	0	1,482	11,341	27,647	80%	22,118
Deer Creek	946	0	95	707	1,748	80%	1,398
Feather River	47,503	24,036	14,308	59,637	145,484	60%	87,290
Merced River	2,500	421	146	2,120	5,187	90%	4,668
Mill Creek	2,426	0	243	1,837	4,506	80%	3,605
Mokelumne River	10,535	8,145	1,868	14,273	34,821	60%	20,893
Sacramento River	57,012	NE	5,701	43,562	106,275	60%	63,765
Stanislaus River	3,500	0	175	2,544	6,219	100%	6,219
Tuolumne River	500	0	25	353	878	100%	878
Yuba River	15,048	0	1,505	11,482	28,035	100%	28,035
Total	232,569	199,690	76,407	353,265	861,931		387,106
Late-Fall Run Chinook Salmon							
Battle Creek	NE	6,435	1,287	5,369	13,091	10%	1,309
Sacramento River	10,600	NE	2,120	8,842	21,562	0.918%	19,794
Total	10,600	6,435	3,407	14,211	34,653		21,103
Winter-Run Chinook Salmon							
Sacramento River	15,730	109	3,168	13,193	32,199	100%	32,199
Spring-Run Chinook Salmon							
Butte Creek	10,625	0	1,063	8,121	19,809	100%	19,809
Deer Creek	2,239	0	224	1,712	4,175	100%	4,175
Mill Creek	1,150	0	115	880	2,145	100%	2,145
Sacramento River	30	0	6	25	61	100%	61
Total	14,044	0	1,408	10,738	26,190		26,190
Total Natural Production of Adult Chinook Salmon from all 4 runs of Chinook salmon in the 13 CAMP watersheds							**466,598**

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	12,673	55,779	60%	33,467
Battle Creek	19,493	58,017	7,751	25,072	110,333	10%	11,033
Butte Creek	1,920	0	192	618	2,730	80%	2,184
Clear Creek	8,422	0	842	2,725	11,989	80%	9,591
Deer Creek	1,905	0	191	618	2,714	80%	2,171
Feather River	81,700	13,533	19,047	33,601	147,881	60%	88,728
Merced River	2,000	150	108	669	2,927	90%	2,634
Mill Creek	1,403	0	140	456	1,999	80%	1,599
Mokelumne River	1,723	4,116	584	1,884	8,307	60%	4,984
Sacramento River	55,468	NE	5,547	17,940	78,955	60%	47,373
Stanislaus River	3,022	0	151	932	4,105	100%	4,105
Tuolumne River	500	0	25	152	677	100%	677
Yuba River	8,127	0	813	2,624	11,564	100%	11,564
Total	206,683	84,544	48,769	99,964	439,959		220,108
Late-Fall Run Chinook Salmon							
Battle Creek	NE	5,111	1,022	1,803	7,936	10%	794
Sacramento River	18,023	NE	3,605	6,357	27,985	0.918%	25,690
Total	18,023	5,111	4,627	8,160	35,921		26,484
Winter-Run Chinook Salmon							
Sacramento River	17,205	93	3,460	6,102	26,860	100%	26,860
Spring-Run Chinook Salmon							
Butte Creek	4,579	0	458	1,479	6,516	100%	6,516
Deer Creek	2,432	0	243	785	3,461	100%	3,461
Mill Creek	1,002	0	100	323	1,426	100%	1,426
Sacramento River	0	0	0	0	0	100%	0
Total	8,013	0	801	2,587	11,401		11,403
Total Natural Production of Adult Chinook Salmon from all 4 runs of Chinook salmon in the 13 CAMP watersheds							**284,857**

NE No estimate

APPENDIX D: 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 age abundance index is derived from CDFG's American Shad FMWT Abundance Summary.doc file dated 1/18/2007. Data on measured fish derived from CDFG's AMS Length Frequency.xls spreadsheet dated 1/22/2007. 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

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	
	YOY abundance index	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	
	YOY abundance index	1,117	142	644	405	2,307

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