The Use of the Environmental Water Account for the Protection of Anadromous Salmonids in the Sacramento/San Joaquin Delta in 2002-2003

Prepared by

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October 2003

I. Introduction

This report describes the use of Environmental Water Account (EWA) to protect salmon and steelhead during the 2003 water year (WY, Oct.1 В Sept. 30). The report follows on from the two previous salmonid reports to the EWA Science Panel. (A separate report was written on EWA use for delta smelt.) EWA water was used in the Delta to reduce exports to protect salmon, steelhead, and delta smelt. EWA water upstream was managed to produce instream benefits incidental to conveying water to the Delta. EWA assets were used in an operation that made lower river outlet releases from Folsom Dam (bypassing power generation) to provide cooler water to the lower American River. The outcomes for each of these fish actions were benefits upstream and in the Delta and no exceedence of take limits for listed species at the export pumps. In regard to the 2002 recommendations, some were implemented but many were precluded from implementation this year by budget and staff constraints. The team looks forward to progress through continued interaction and guidance from the EWA Science Panel.

II. Actions taken this year

A. Fish Actions

Fish Action #2-03: October 25 through November 19, 2002

Background

The temperature shutters (power generation penstock inlet ports) at Folsom Dam under normal conditions are used to manage the reservoir's cold water pool to provide suitable water temperatures for over-summering juvenile steelhead and spawning salmon. Temperature compliance is required below Nimbus Dam to protect over summering juvenile steelhead (NMFS – OCAP biological opinion). The only way to access the cold water pool once all the shutter adjustments have been made is through release of water from Folsom Dam's lower river outlets. Even with a power bypass at Folsom in the fall 2001, water temperatures in the lower American River did not decline to less than 60^{o} F until November 13. Pre-spawning salmon mortality in 2001 was reduced by using the river level outlets, but it still exceeded 60 percent.

In the fall of 2002, concerns arose about the availability of cold water in Folsom Reservoir needed to provide suitable salmonid spawning habitat in the lower American River. Water temperatures in the lower American River were still high and were not expected to decrease to 60^{o} F or less (which is the temperature when Chinook salmon begin spawning in the lower American River) prior to mid- to late-November.

By early October, the cold water pool (i.e.: water $\leq 60^{o}$F) was below the shutters and very little remained at the level of the power penstocks. Releasing water through the lower river outlets bypasses the generation units; thereby reducing the amount of power that otherwise would have been generated from the reservoir.

The Bureau of Reclamation compensated Western Area Power Administration with EWA funds for the loss of generation resulting from implementation of the Folsom Dam lower river outlet release and bypass operation which reduced the water temperature in the river.

Description of Action

Between October 25 and November 19, 2002, the river level outlets at Folsom Dam were used to release colder water from the bottom of the lake and blend with water released through the powerhouse penstocks. The combination of powerhouse and lower river outlet releases in the lower American River ranged between 1,532 cfs and 1,600 cfs. Of that, releases from the lower river outlets, bypassing the powerhouse, ranged between 331 cfs and 528 cfs. These flows were maintained in order to provide some spawning habitat and sufficient flows over salmon redds during the egg incubation period. The temperature of the water released through the lower river outlets at Folsom Dam was approximately 49^{o}F. The temperature in the lower American River dropped by 3^{o}F on October 25, 2002, when the blended releases reached the river. By October 8, 2002, the water temperature at Nimbus Dam had decreased to 60^{o}F. By October 29, 2002, temperatures at Watt Avenue decreased to 60ºF and remained in the 57º F - 60º F range, until the bypass was discontinued on November 19, 2002.

The river level outlet release/power generation bypass helped improve salmon spawning conditions downstream of Nimbus Dam three weeks earlier than what would have happened without the bypass. The CDFG reported that spawning was initiated once the temperature dropped to about 60^{o}F. (Reference: Mike Healy, CDFG) Pre-spawning salmon mortality in 2002 was approximately 30 percent, much lower than in 2001.

Estimated Cost Of Action

The amount of CVP water bypassed was 13,359 acre-feet. The amount of power used for this action was 6.52 GWH. EWA funds were used to compensate WAPA for this lost generation. EWA water was not used in this action.

Fish Action #3-03: Release of SGA water on the Lower American River

Description of Action

The Project and Management Agencies contracted for up to 10,000 acre-feet (AF), and purchased 7,142.6 AF of EWA water from Sacramento Groundwater Authority (SGA). We received 4,645.8 AF from San Juan Water District which was stored in Folsom Reservoir between June and November, 2002; and 2,496.8 AF from the City of Sacramento which was released into the Sacramento River downstream of Folsom

Reservoir between July and November, 2002. Of that, 323 AF was released between September 1 – 2, and 8 – 9, 2002; and 621.25 AF was released on December 4, 2002. The remaining amount was scheduled for release during a time that would coincide with providing benefits to the fish in the lower American River.

The Management Agencies requested the release of the EWA water between December 20 and 29, 2002, to supplement base flow and (b)(2) fish releases to help maintain flows between 1,501 cfs and 1,562 cfs on the lower American River during December. The release of EWA water stabilized instream flows and provided suitable spawning conditions and egg incubation for both steelhead and Chinook salmon.

Estimated Cost Of Action

Carriage water losses are applicable to water transported from areas upstream of the Delta on the Sacramento River and its tributaries to the export facilities. Based upon modeling results, a carriage water loss of 20% was assessed to the EWA water that was exported by the CVP and the SWP. Therefore, the amount of this EWA water exported by the SWP and CVP was 258.4 AF and 497 AF, respectively, and was subsequently stored in San Luis Reservoir. The water purchased from the San Juan Water District could not be pumped at either facility due to the Delta being in excess conditions. The remaining water purchased from Sacramento Groundwater Authority also could not be pumped due to the unavailability of capacity at either facility.

Fish Action #4-03: December 27, 2002 through January 2, 2003

Description of Action

Concerns were expressed during a Data Assessment Team call on December 18, 2002, regarding the salvage of winter-run Chinook at the export facilities exceeding the criteria for an export reduction as established by the Juvenile Salmon Protection Plan. The Management Agencies recommended an export reduction for five days should the criteria be met or exceeded. Based upon daily loss densities of older juvenile salmon exceeding the Juvenile Salmon Protection Plan criteria of >15 salmon/thousand acre-feet, combined exports were reduced to 6,000 cfs (4,000 cfs at the SWP and 2,000 cfs at the CVP) beginning December 27, 2002, and continuing through December 31, 2002. Although aimed primarily at spring-run Chinook yearlings, the reduction was assumed to benefit delta smelt as well. After evaluating the fish salvage numbers on December 30, 2002, the DAT recommended modifying the action to a combined SWP/CVP export rate of 9,000 cfs. After review of current data, the export curtailment was discontinued on January 2, 2003.

Estimated Cost of Action

The Department of Water Resources has estimated that these actions reduced SWP exports by approximately 41 TAF. The estimate assumes SWP exports would have been between approximately 7,400 and 7,450 cfs in the base operation. The actual amount could be either more or less dependent upon the actual operations required in meeting the Delta Standards. The CVP export reductions are charged to the (b)(2).

Fish Action #5-03: January 15 through 20, 2003

Description of Action

The salvage of adult Delta smelt increased steadily at the CVP/SWP export facilities beginning mid-December such that by January 13, 2003, the 14-day average of daily combined delta smelt salvage exceeded 400. Approximately 75 - 80% of the delta smelt salvage was at the SWP. After consultation with the Delta Smelt Working Group, the Management Agencies recommended reducing exports at the SWP by 5,000 cfs beginning on January 15, 2003, based upon exceeding the warning level of delta smelt as well as a concern about high losses of spring-run Chinook salmon surrogates.

The export reduction began on January 15 and ended on January 21, 2003, after losses of both Delta smelt and Chinook salmon decreased below levels of immediate concern.

Estimated Cost of Action

The Department of Water Resources has estimated that these actions reduced SWP exports by approximately 60 TAF. The estimate assumes SWP exports would have been between approximately 7,250 and 7,350 cfs in the base operation. The actual amount could be either more or less dependent upon the actual operations required in meeting the Delta Standards.

Fish Action #6-03: January 25 through 28, 2003

Description of Action

The Management Agencies recommended an export reduction at the SWP by 2,500 cfs on January 25, 2003 due to the increasing and high loss of clipped late-fall Chinook (coded wire tagged hatchery salmon used as surrogates for spring-run Chinook yearlings) between January 20 and January 23, 2003, at the SWP. Because the coded wire tags from all of the tagged salmon recovered at the SWP/CVP had not yet been read (decoded), the specific release groups of each individual fish came from was unknown. However, a conservative interpretation would mean that these losses pushed the cumulative loss of spring-run surrogates to twice the incidental take limit (or re-consultation level). The surrogate concept relies on the assumption that the loss of surrogates is representative of the loss of wild fish. Although losses of unclipped Chinook remained relatively low, the Management Agencies concluded that the high losses of the surrogate Chinook released from Coleman Hatchery represented a moderately adverse impact to yearling spring-run sized and winter-run sized Chinook.

Declining losses of clipped fish prompted the resumption of baseline operations on January 29, 2003.

Estimated Cost of Action

The Department of Water Resources has estimated that these actions reduced SWP exports by approximately 20 TAF. The estimate assumes SWP exports would have been approximately 7,250 cfs in the base operation. The actual amount could be either more or less dependent upon the actual operations required in meeting the Delta Standards.

Fish Action #7-03: April 15 through May 15, 2003
(Vernalis Adaptive Management Plan)

Description of Action

The Management Agencies requested an export reduction at the State Water Project and Central Valley Project facilities consistent with the San Joaquin River Agreement and the Vernalis Adaptive Management Plan (VAMP). Pursuant to the VAMP study plan, and after an evaluation to determine the base flow, the target flow at Vernalis was set at 3,200 cfs with exports at the CVP and SWP established at a combined 1,500 cfs between April 15 and May 15, 2003. The purpose of the VAMP is to evaluate the relative effects of exports, inflow and the Head of Old River (HORB) on juvenile San Joaquin basin Chinook salmon survival and assist in providing protection for both anadromous and estuarine species. An increase in the survival of juvenile salmon and steelhead emigrating from the Sacramento River basin and East-side tributaries to the Delta may also occur due to improved Delta hydrodynamic conditions created by the VAMP.

Installation of the temporary barrier at the Head of Old River was completed on April 15, 2003 with three out of the six culverts open, allowing some San Joaquin River water to flow into upper Old River. Two of the three agricultural barriers (Old River near the Delta Mendota Canal and Middle River) were also completed on April 14 and 15, 2003, respectively, with the flap gates operating tidally. The agricultural barrier at Grant Line Canal was also completed on April 15, 2003, with the center weir section remaining open. The Delta Cross Channel gates were closed during this period due to high flows in the Sacramento River and would have been closed anyway as required by Decision 1641.

Estimated Cost of Action

The Department of Water Resources has estimated that this action reduced the State Water Project exports by approximately 32 TAF. The estimate assumes SWP exports would have continued at a level approximately between 943 and 1,380 cfs in the base operation. The actual amount could be either more or less dependent upon the actual operations allowed under D-1641.

Fish Action #8-03: May 16 through May 31, 2003 (VAMP Shoulder)

Description of Action

The U.S. Fish and Wildlife Service convened the Delta Smelt Workgroup on May 12, 2003 to discuss salvage levels of delta smelt at the SWP and CVP export facilities. (The re-consultation level for May in a below normal year is 55,277 fish).

The Delta Smelt Workgroup's recommendation was based upon the very low abundance of both adults and juveniles, as reflected by the 2002 Fall Midwater Trawl and 2003 Spring 20-mm surveys, respectively. The high level of concern was moderated somewhat by the geographical distribution found in the 4th 20-mm survey, which indicated that approximately 36% of the delta smelt sampled was north and west of the confluence of the Sacramento and San Joaquin Rivers and thus removed from the influence of the export facilities. Consequently, they recommended the following:

- Breach the barrier at the Head of Old River on May 16, 2003, immediately following the conclusion of the VAMP study, and tie open the flap gates on the agricultural barriers through the end of May such that higher flows through South Delta channels would potentially assist in the western movement of larvae out of the South Delta.
- Continue to limit combined SWP/CVP exports to 1,500 cfs through May 18, 2003.
- On May 19, 2003, begin ramping at a combined SWP/CVP pumping rate of 500 cfs per day until the current combined export levels matched the San Joaquin River flow at Vernalis. Once the combined exports match the Vernalis flow, which was approximately 2,200 cfs, continue to match the export level with Vernalis flow through the end of the month. This reduction in exports was expected to support South Delta habitat, promote westward migration, and improve the overall survival of young delta smelt.

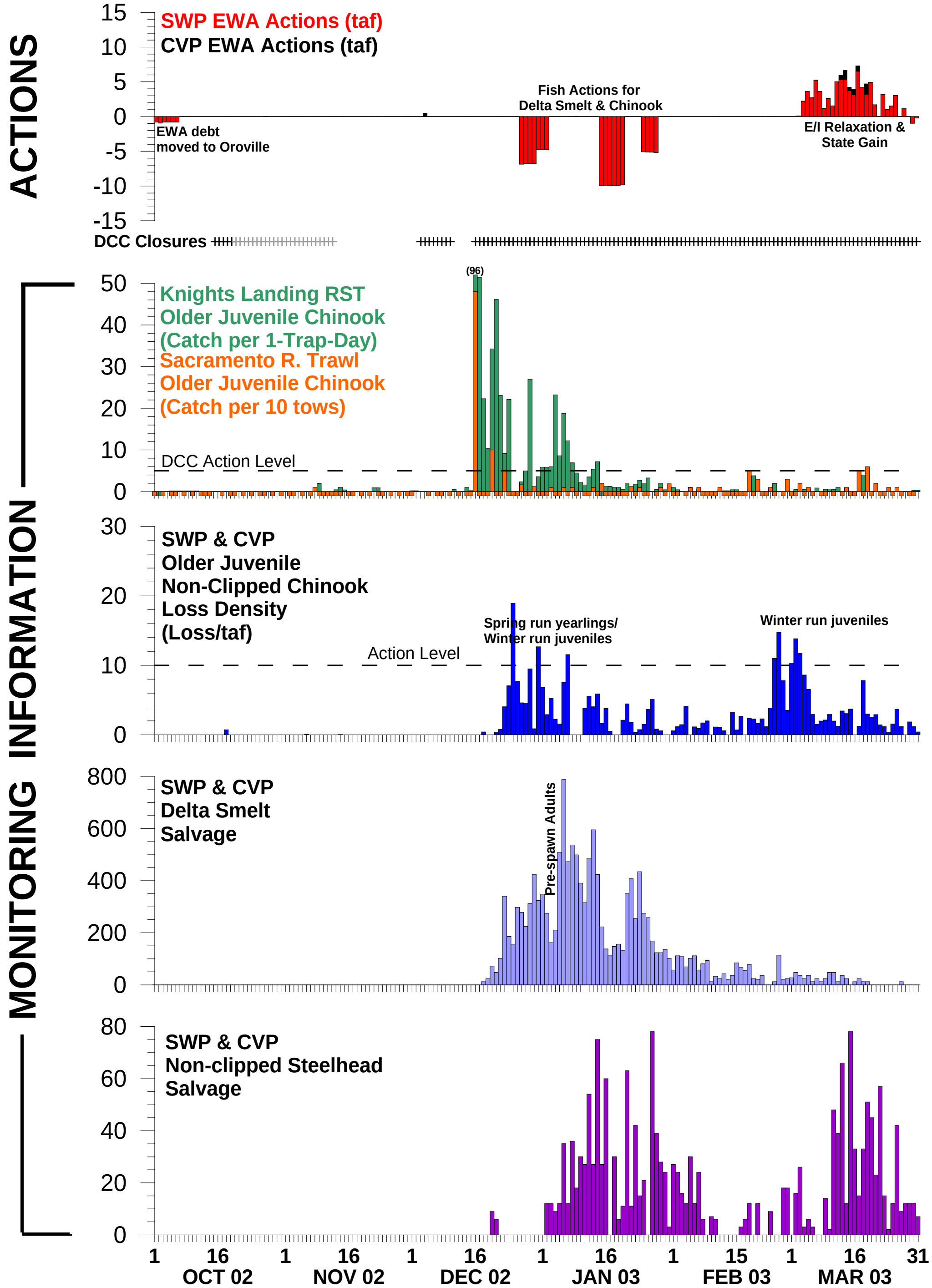
This recommendation was subsequently discussed and adopted by the Water Operations Management Team. The Head of Old River barrier was breached beginning on May 19, 2003. Concurrently, all flap gates on the South Delta agricultural barriers (at Old River near the Delta Mendota Canal, at Middle River and Grant Line Canal (with its center portion remaining open)) were tied open. With the exception of the barrier at Grant Line Canal, these flap gates resumed normal tidal operations on June 2, 2003.

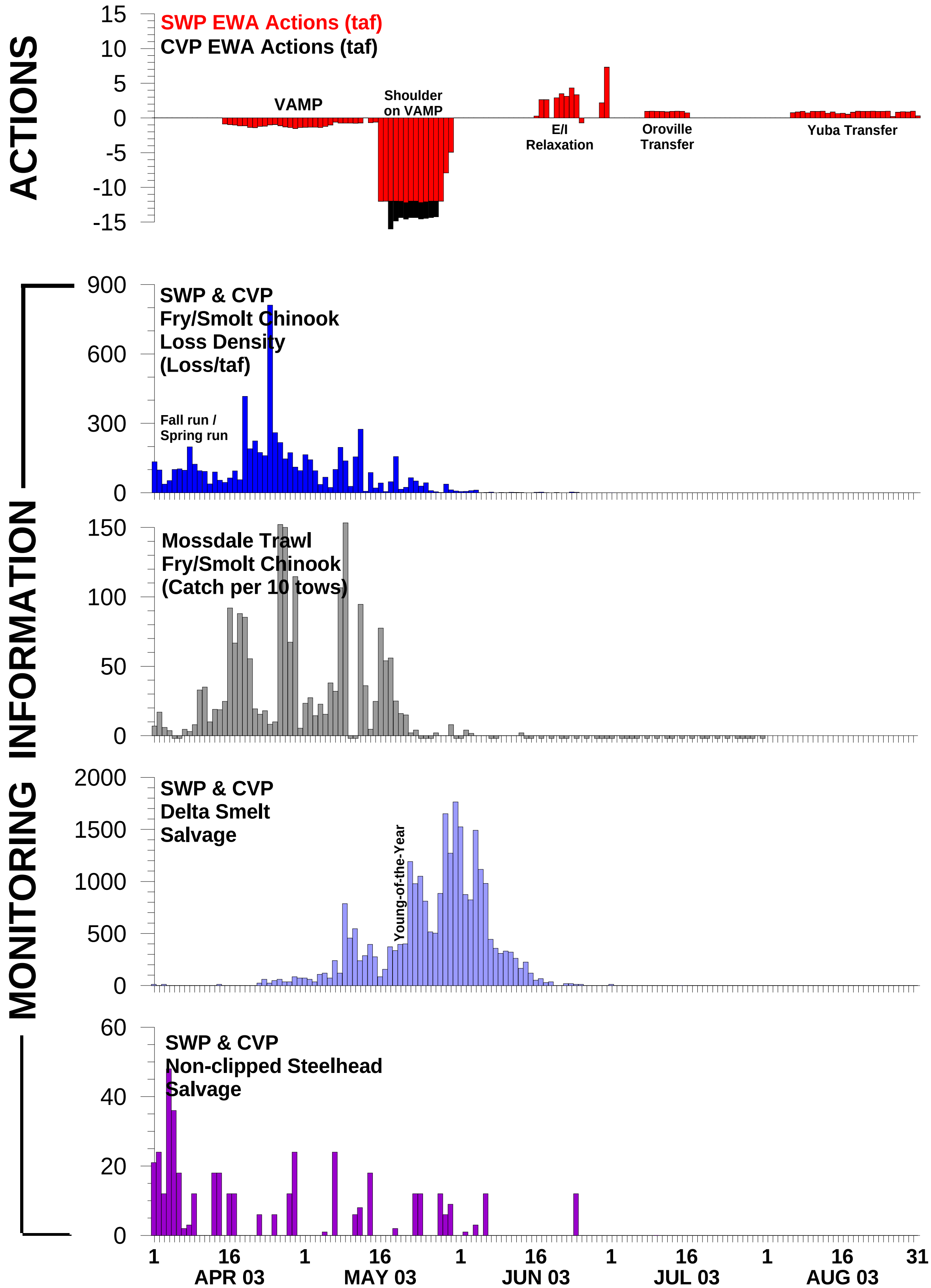
The Delta Cross Channel gates remained closed due to high flows in the Sacramento River.

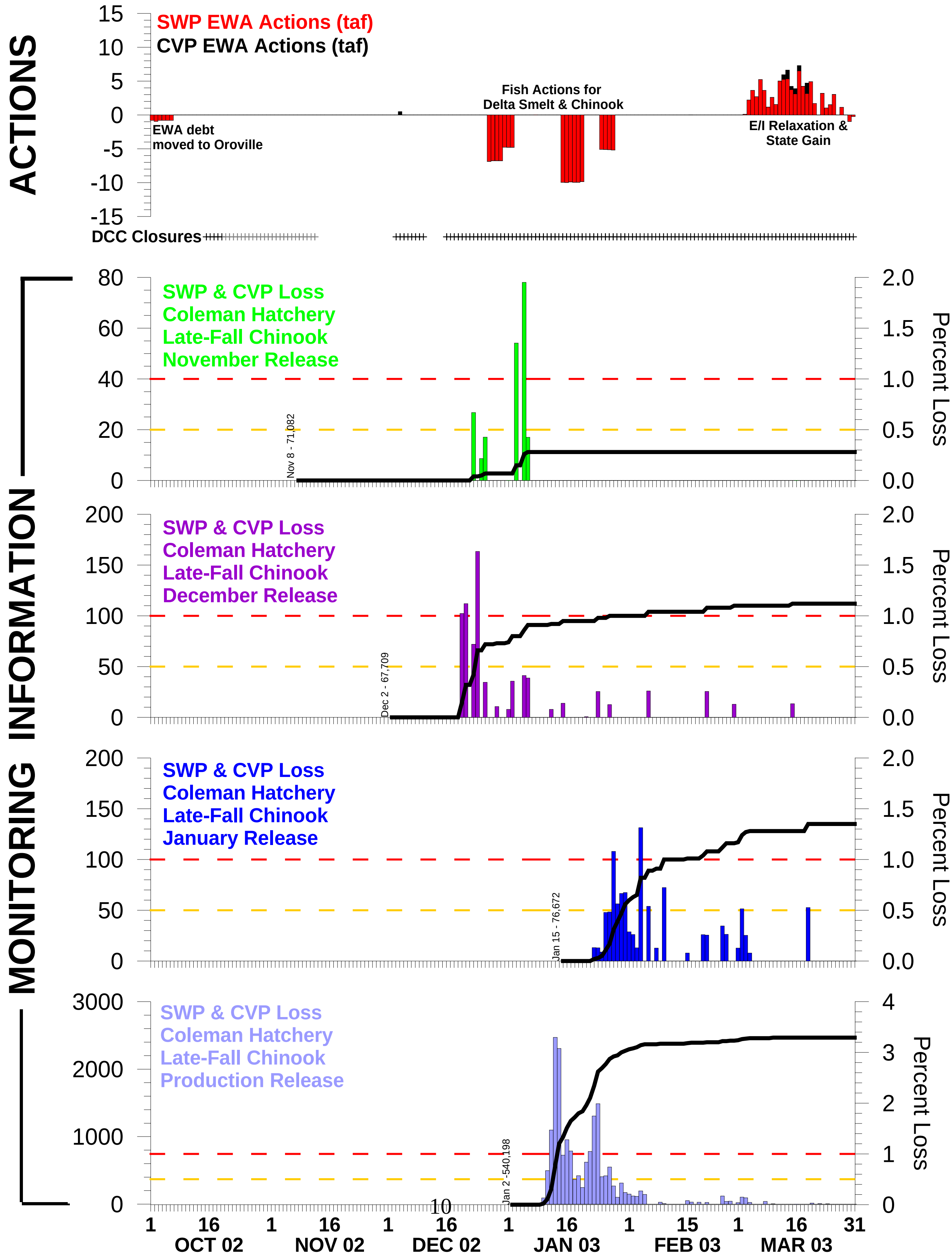
Estimated Cost Of Action

The Project Agencies estimated that these actions reduced the State Water Project and the Central Valley Project exports by 169 TAF and 26 TAF, respectively. These estimates assume SWP and CVP exports would continue at a level approximately 6,680 cfs, and 1,700 cfs to 2,889 cfs, respectively, in the base operation. The actual amount could be either more or less dependent upon the actual operations required in meeting the Delta standards.

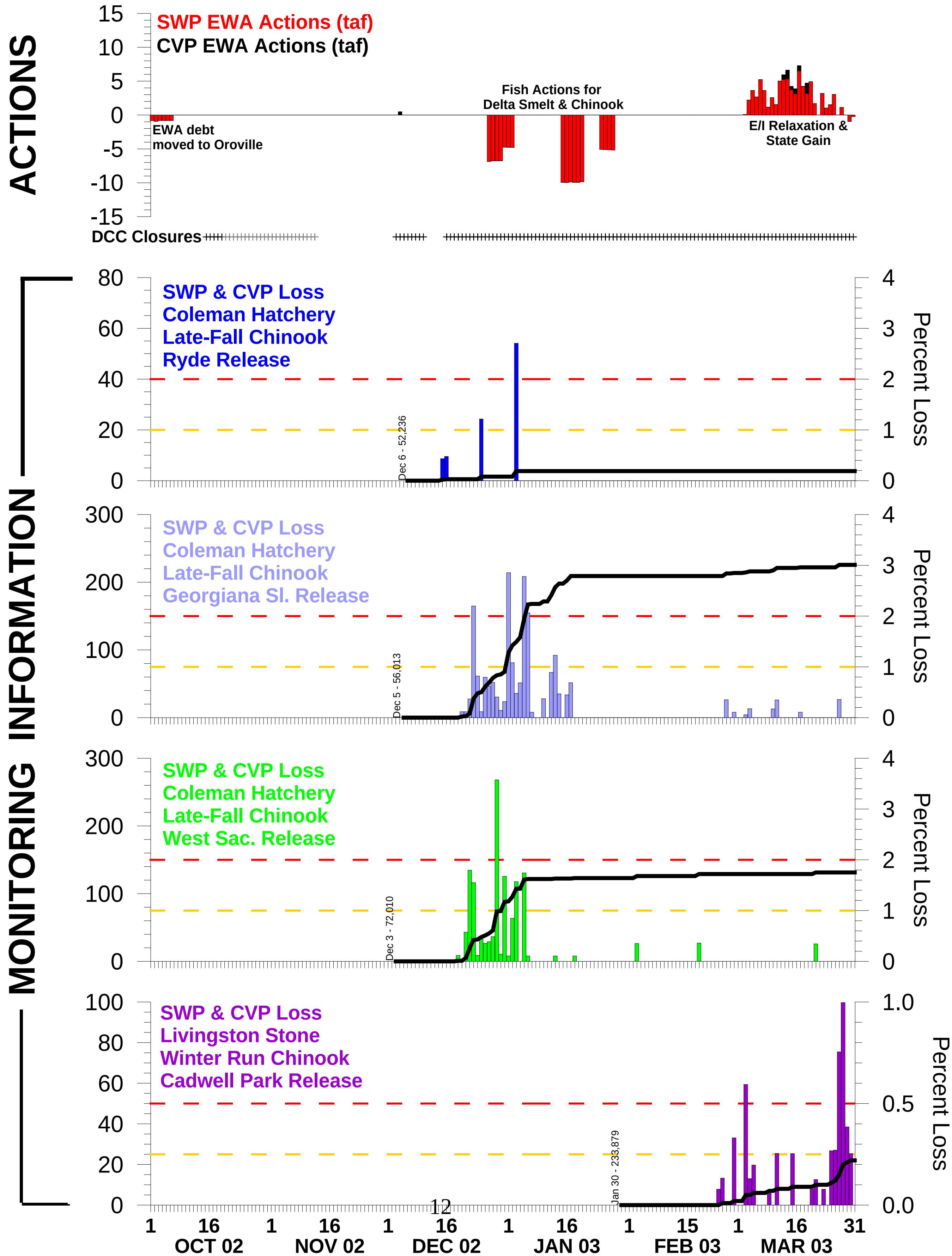
B. Chronology Graphics




ACTIONS
SWP EWA Actions (taf)
CVP EWA Actions (taf)
VAMP
Shoulder on VAMP
E/I Relaxation
Oroville Transfer
Yuba Transfer
MONITORING INFORMATION
SWP & CVP Fry/Smolt Chinook Loss Density (Loss/taf)
Fall run / Spring run
Mossdale Trawl Fry/Smolt Chinook (Catch per 10 tows)
SWP & CVP Delta Smelt Salvage
Young-of-the-Year
SWP & CVP Non-clipped Steelhead Salvage
APR 03
MAY 03
JUN 03
JUL 03
AUG 03



ACTIONS
SWP EWA Actions (taf)
CVP EWA Actions (taf)
15
10
5
0
-5
-10
-15
EWA debt moved to Oroville
Fish Actions for Delta Smelt & Chinook
E/I Relaxation & State Gain
DCC Closures
MONITORING INFORMATION
SWP & CVP Loss
Coleman Hatchery
Late-Fall Chinook
November Release
Nov 8 - 71,082
80
60
40
20
0
2.0
1.5
1.0
0.5
0.0
Percent Loss
SWP & CVP Loss
Coleman Hatchery
Late-Fall Chinook
December Release
Dec 2 - 67,709
200
150
100
50
0
Percent Loss
SWP & CVP Loss
Coleman Hatchery
Late-Fall Chinook
January Release
Jan 15 - 76,672
Percent Loss
SWP & CVP Loss
Coleman Hatchery
Late-Fall Chinook
Production Release
Jan 2 -540,198
3000
2000
1000
0
4
3
2
1
0
Percent Loss
1
16
OCT 02
1
16
NOV 02
1
16
DEC 02
1
16
JAN 03
1
15
FEB 03
1
16
MAR 03
31


ACTIONS
SWP EWA Actions (taf)
CVP EWA Actions (taf)
Fish Actions for Delta Smelt & Chinook
EWA debt moved to Oroville
E/I Relaxation & State Gain
DCC Closures
MONITORING INFORMATION
SWP & CVP Loss
Coleman Hatchery
Late-Fall Chinook
Ryde Release
Dec 6 - 52,236
Percent Loss
SWP & CVP Loss
Coleman Hatchery
Late-Fall Chinook
Georgiana Sl. Release
Dec 5 - 56,013
SWP & CVP Loss
Coleman Hatchery
Late-Fall Chinook
West Sac. Release
Dec 3 - 72,010
SWP & CVP Loss
Livingston Stone
Winter Run Chinook
Cadwell Park Release
Jan 30 - 233,879
OCT 02
NOV 02
DEC 02
JAN 03
FEB 03
MAR 03

III. Accomplishments this year

A. Develop Analysis Plan

The Agency EWA Salmon Biologists convened in late April to determine how best to use our time and resources to further the goals of using EWA for salmon   A plan was developed that identified 1) the goals of EWA for salmon 2) the objectives of the program 3) the need for conceptual models for each goal 4) performance measure criteria that were tied to each goal and objective and 5) analyses that needed to be done to further understand using EWA for salmon (Attachment A (The plan)) .

The analyses plan attempts to break down the various goals of the program starting with the immediate and focused needs to long term and broader needs. The goals of the EWA program for salmon were identified as: 1) Determining effective and efficient methods to implement existing regulatory requirements, 2) Determining if minimizing take and maximizing survival through the Delta provides the greatest population benefits relative to other uses of EWA water and 3) Relate population benefits of EWA actions to other potential actions.

The objectives of the program are how the agencies are trying to meet the goal. The objectives of the program were identified as: 1) Avoid exceeding regulatory take levels and minimize take, 2) Maximize survival of emigration in context of exports and DCC gate closures, 3) Use EWA water to maximize its salmon population benefits and 4) Take most effective actions to protect the salmon population.

Conceptual models need to be developed to better understand and justify why a particular goal is important to the EWA process.   They can also be used to document present understanding and uncertainties. For example, it is assumed that by minimizing take, survival for salmon through the Delta is increased either through direct or indirect means. Further exploration of this assumption through articulation of the conceptual model may benefit the process.

The performance measures are listed to determine if the objective was achieved. The performance measures are 1) Did we avoid yellow or red light? 2) Did we take actions at appropriate times, 3) Did the Decision Process lead to appropriate actions? 4) Did we improve survival for salmon in the Delta 5) Did we get the greatest relative salmon population benefits from EWA water and 6) How did benefits from EWA compare to other potential actions and what were the combined benefits with and without EWA?

The list of potential analyses is lengthy and specific. It is assumed that if the suggested analyses were completed that we would have a stronger base on which to assess the performance measures and to ultimately take the most effective actions to protect the salmon population. We acknowledge that there are some suggested analyses that are not possible with present data. This is the first step to the development of methods to address these very complex issues. However, by going through the process of identifying where and why gaps occur we will be able to prioritize additional needed monitoring efforts.

The analyses that have been started or completed are discussed in sections B – R below by topic and loosely follows the order of the analyses plan. Additional analyses and activities were conducted in 2002-2003 and follow in sections S – U.

B. Limitation of SWP/CVP Delta Export Loss Estimation

1. Limitation of SWP/CVP Export Fish Salvage Estimation

In the mid-1970's, DFG contracted with a statistician from University of the Pacific to determine the level of effort necessary to estimate the total number of fish salvaged at the Delta Fish Salvage Facilities within certain limits (plus or minus 100% for samples less than 10,000, and plus or minus 50% for samples greater than 10,000) at the 80% confidence level. We attached the report for your reference.

2. Pre-screening mortality estimates in Clifton Court Forebay

From October 1976 through November 1993, SDF conducted mark/recapture experiments at Clifton Court Forebay to estimate pre-screen loss (mortality) to entrained juvenile fishes. They conducted 8 studies on hatchery reared juvenile Chinook. Pre-screen loss estimates were 63-99%. A multiple regression analysis showed 91% of the variance in pre-screen loss was explained by export rate, fish size and water temperature. We attached the IEP Technical Report 55, AMark/Recapture Experiments at Clifton Court Forebay to Estimate Pre-Screening Loss to Juvenile Fishes: 1977-1993", for your reference.

C. Incorporating genetic characterization into endangered Chinook run identification

Molecular biologists at University of California at Davis (Dr. Hedgecock), and Oregon State University (Dr. Banks) completed methodology to identify individual winter run Chinook in a mixed population with a high degree of accuracy. The population structure was published in Canadian Journal Fisheries Aquatic Science in 2000, and individual identification in Journal of Heredity in 2000. We attached the reports for your reference. The results were 99% accuracy at identifying individual winter run using 7 loci.

So far we haven=t sampled consistently at the SWP/CVP export facilities or in the monitoring programs due to lack of funding during the research phase of genetic characterization. We used the samples that we have collected to date at the SWP/CVP exports to illustrate how genetic characterization can be used to estimate loss of winter run, or other endangered Chinook runs. The following table (C.1) contains the results of calculating loss based on genetic characterization and loss based on length/date criteria. We could improve the genetic based loss estimate by improving the sampling protocol and sampling more fish, but both would require significant additional funding.

Table C.1

WINTER RUN CHINOOK LOSS CALCULATED BASED ON LENGTH CRITERION AND GENETIC CHARACTERIZATION IDENTIFICATION						
DRAFT	1999/2000		2000/2001		2001/2002	
	SWP	CVP	SWP	CVP	SWP	CVP
Length Criterion Identification Loss	5,324	506	18,840	1,219	2,750	545
Genetic Characterization Identification Loss	1,391	349	14,120	807	607	183
Fraction Genetic Characterization Loss of Length Criterion Loss	0.26	0.69	0.75	0.66	0.22	0.34

D. Relationships between the number of winter-run spawners and the number of winter-run juveniles emigrating to several points downstream

- There is a strong quantitative relationship between the estimated number of spawners and the number of fry equivalents estimated passing Red Bluff Diversion Dam on the upper Sacramento River each year (Figure D.1).
- A significant relationship has been found between the estimated number of winter-run fry equivalents at RBDD on the upper Sacramento River and catch/cubic meter in the beach seine study in the lower Sacramento River (Figure D.2).
- Also, there is significant relationship between the mean catch/per cubic meter in the trawl surveys at Sacramento and Chipps Island in the Delta (Figure D.3).

Figure D.1

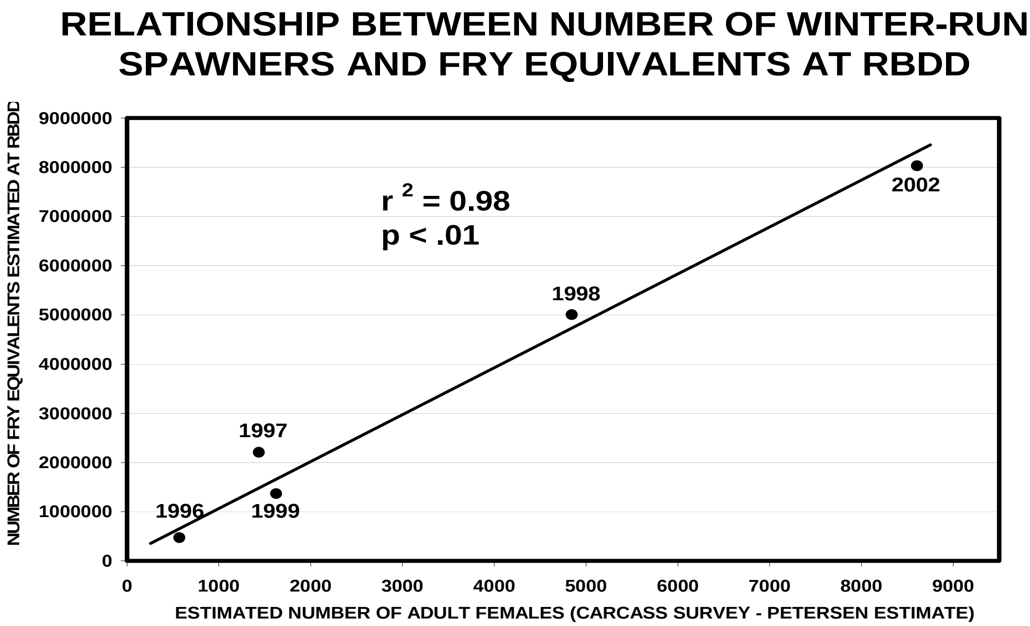

RELATIONSHIP BETWEEN NUMBER OF WINTER-RUN SPAWNERS AND FRY EQUIVALENTS AT RBDD
NUMBER OF FRY EQUIVALENTS ESTIMATED AT RBDD
ESTIMATED NUMBER OF ADULT FEMALES (CARCASS SURVEY - PETERSEN ESTIMATE)
r 2 = 0.98
p < .01
1996
1997
1998
1999
2002
0
1000000
2000000
3000000
4000000
5000000
6000000
7000000
8000000
9000000
0
1000
2000
3000
4000
5000
6000
7000
8000
9000

Figure D.2

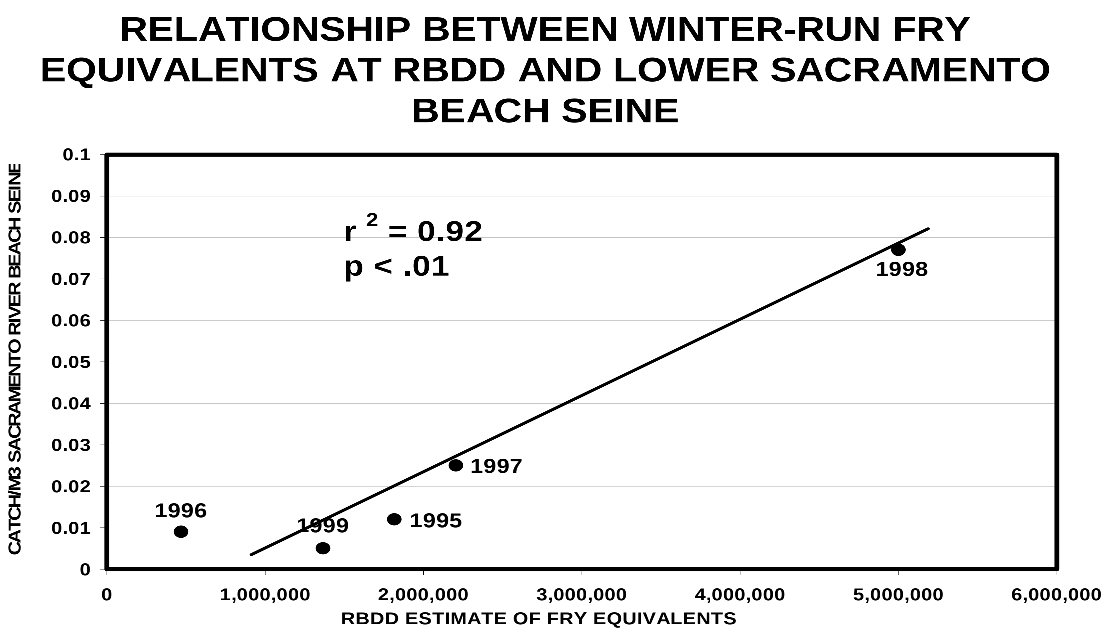

RELATIONSHIP BETWEEN WINTER-RUN FRY EQUIVALENTS AT RBDD AND LOWER SACRAMENTO BEACH SEINE
CATCH/M3 SACRAMENTO RIVER BEACH SEINE
RBDD ESTIMATE OF FRY EQUIVALENTS
r 2 = 0.92
p < .01
1995
1996
1997
1998
1999
0
0.01
0.02
0.03
0.04
0.05
0.06
0.07
0.08
0.09
0.1
0
1,000,000
2,000,000
3,000,000
4,000,000
5,000,000
6,000,000

Figure D.3

RELATIONSHIP BETWEEN WINTER-RUN MEAN DEC-APRIL CPM AT SACRAMENTO TRAWL AND CHIPPS ISLAND

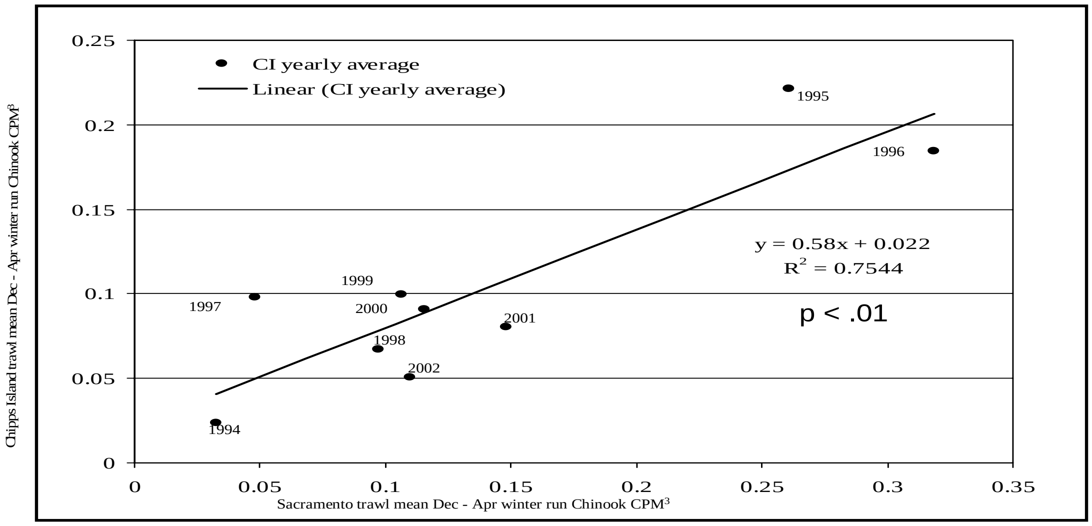


Figure ___. Winter run Chinook from Sacramento trawl regressed on Chipps Island trawl, December through April, 1993-1994 through 2001-2002

E. Compile Central Valley Salmon Monitoring Programs

We have compiled the following summaries, Tables E.1 and E.2, of existing salmonid monitoring programs in the Central Valley.

Table E.1. Existing Central Valley Adult Salmon and Steelhead Monitoring Programs

Stream	Species/run	Monitoring Method	Variable Measured	Agency
UPPER SACRAMENTO RIVER BASIN				
Upper Sacramento River	Chinook	Carcass counts	Annual escapement (fall, late-fall, and winter-run)	CDFG/USFWS
		RBDD ladder counts	Annual escapement (fall, winter-run)	USFWS
		Trapping (Keswick Dam)	Adult returns (winter-run)	USFWS
		Aerial redd surveys	Spawning distributions (all runs)	CDFG (NMFS funding for winter-run)
		Angler survey (Sacramento River)	In-river harvest	CDFG
Clear Creek	Chinook (Fall-run)	Carcass survey	Annual escapement	CDFG/USFWS
	Chinook (Late fall-run)	Carcass survey	Annual escapement	USFWS
	Chinook (Spring-run), Steelhead	Snorkel survey	Annual escapement	USFWS
	Chinook (Fall, late-fall, spring-run), Steelhead	Redd counts	Annual escapement	USFWS
Battle Creek	Chinook (fall-run)	Carcass survey	Annual escapement	CDFG
		Hatchery counts	Annual returns	USFWS
	Chinook (Late-fall, spring, winter-run), Steelhead	Barrier weir trap	Annual escapement	USFWS
	Chinook (Spring, winter-run), Steelhead	Snorkel survey	Annual escapement	USFWS
		Redd survey	Annual escapement	USFWS
Antelope Creek	Chinook (spring-run)	Snorkel survey	Annual escapement	CDFG

Butte Creek	Chinook (Fall and spring-run)	Carcass survey	Annual escapement	CDFG
	Chinook (Spring-run)	Snorkel survey	Annual escapement	CDFG
Stream	Species/run	Monitoring Method	Variable Measured	Agency
Big Chico Creek	Chinook (Spring-run)	Snorkel survey	Annual escapement	CDFG
Beegum Creek	Chinook (Spring-run)	Snorkel survey	Annual escapement	CDFG
Deer Creek	Chinook (Spring-run)	Snorkel survey	Annual escapement	CDFG
Mill Creek	Chinook (Spring-run)	Redd counts	Annual escapement	CDFG
LOWER SACRAMENTO R BASIN				
Yuba River	Chinook (fall-run)	Carcass counts	Annual escapement	YCWA funds/ JSA conducts
	Chinook (spring-run)	Redd counts	Spawning distribution	CDFG
Feather River	Chinook	Carcass counts	Annual escapement (fall-run)	DWR/DFG
		Aerial photo survey with ground truthing	Spawning distribution vs flow & escapement	
		Hatchery counts	(Fall and spring-run)	CDFG
	Steelhead	Hatchery counts		CDFG
		Coded Wire Tagging		
American River	Chinook	Carcass counts	Annual escapement (fall-run)	CDFG
		Aerial redd surveys	Spawning habitat use relative to flow conditions	CDFG
		Hatchery counts	Annual returns	CDFG
	Steelhead	Hatchery Counts	Annual returns	CDFG
		Coded Wire Tagging		
	Steelhead	Redd surveys	Annual escapement/spawning distribution	DFG/USBR
DELTA TRIBUTARIES				
Cosumnes River	Chinook	Aerial redd survey		CDFG

		Carcass and redd surveys		TNC
Mokelumne River	Chinook	Ladder counts / video monitoring	Annual escapement (fall-run)	EBMUD
Stream	Species/run	Monitoring Method	Variable Measured	Agency
Mokelumne River (cont'd)		Redd counts	Spawning distribution	EBMUD
		Hatchery count	Adult returns (fall and late fall-run)	CDFG
	Steelhead	Ladder counts / video monitoring	Annual escapement	EBMUD
		Redd counts	Spawning distribution	EBMUD
		Hatchery count	Monitor adult returns	CDFG
SAN JOAQUIN RIVER BASIN				
Stanislaus River	Chinook (fall-run)	Carcass counts	Annual escapement	CDFG
		Redd surveys	Spawning distribution	CDFG
		Weir counts	Annual escapement	S.P. Cramer and Associates
	Steelhead	Weir counts	Annual escapement	S.P. Cramer and Associates
Tuolumne River	Chinook (fall-run)	Carcass counts	Annual escapement	CDFG
		Redd surveys	Spawning distributions	CDFG
Merced River	Chinook (fall-run)	Carcass counts	Annual escapement	CDFG
		Redd surveys	Spawning distributions	CDFG
		Hatchery counts		CDFG

Table E.2. Existing Central Valley juvenile salmon and steelhead monitoring programs.

Stream	Target Species	Monitoring Method	Variable Measured	Agency
UPPER SACRAMENTO RIVER BASIN				
Upper Sacramento River	All Chinook races, steelhead	Rotary Screw Trap @ Red Bluff Diversion Dam	Abundance/Outmigrant Timing	USFWS
	All Chinook races, steelhead	Rotary Screw Trap @ GCID	Abundance/Outmigrant Timing	CDFG
	All Chinook runs, Steelhead	Beach Seining (Redding to Princeton)	Spatial/temporal Distribution, Outmigration Timing	USFWS (proposed)
Clear Creek	Chinook, Steelhead	Rotary Screw Trap	Abundance/Outmigrant Timing	USFWS
	Chinook	Snorkel survey	Habitat Use	USFWS
	Chinook, Steelhead	Visual, nets	Stranding, isolation	USFWS
Battle Creek	Chinook, Steelhead	Rotary Screw Trap	Abundance/Outmigrant Timing	USFWS
Big Chico Creek	Spring-run Chinook	Rotary Screw Trap	Abundance/Outmigrant Timing	CDFG
Butte Creek/Sutter Bypass	Spring-run Chinook	Rotary Screw Trap	Abundance/Outmigrant Timing	CDFG
Deer Creek	Spring-run Chinook	Rotary Screw Trap	Relative Abundance/Outmigrant Timing	CDFG
Mill Creek	Spring-run Chinook	Rotary Screw Trap	Relative Abundance/Outmigrant Timing	CDFG
LOWER SACRAMENTO RIVER BASIN				
Lower Sacramento River	All Chinook races, steelhead	Rotary Screw Trap @ Knights Landing	Abundance/Outmigrant Timing	CDFG
	All Chinook runs, Steelhead	Beach Seining	Spatial/temporal Distribution, Outmigration Timing	USFWS
	All Chinook runs, Steelhead	Kodiak trawling @ Sacramento	Spatial/temporal Distribution, Outmigration Timing	USFWS
	Fall-run Chinook, less abundant races	Midwater trawling @ Sacramento	Spatial/temporal Distribution, Outmigration Timing	USFWS
Feather River	Fall-run Chinook, Steelhead	Rotary Screw Trap	Abundance/Outmigrant Timing	DWR
	Chinook	Stranding survey (visual)	Numbers of fish stranded	DWR

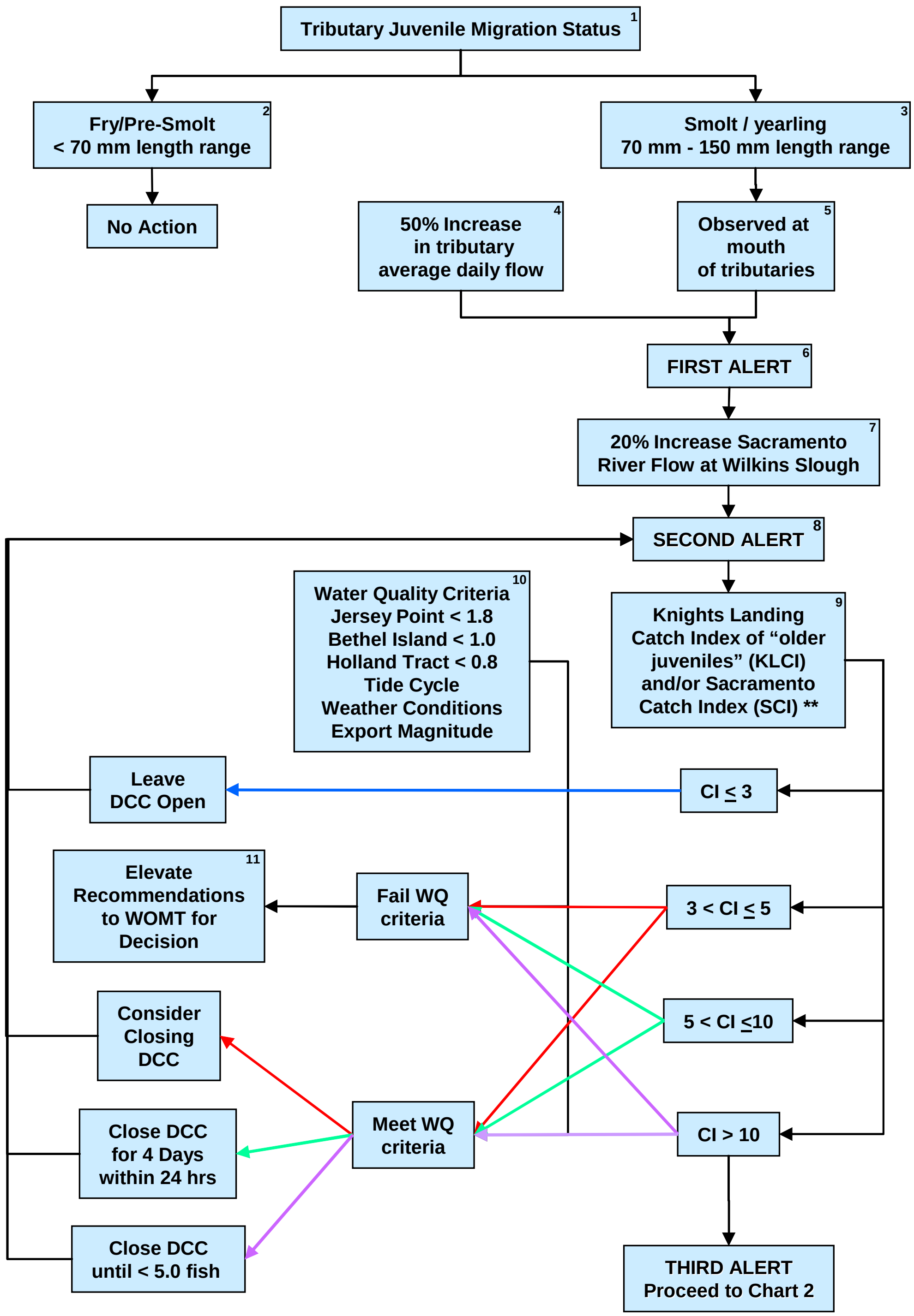
	Steelhead	Snorkel survey	Survival rates until Fall	DWR
Yuba River	Fall-run, spring-run Chinook,Steelhead	Rotary Screw Trap	Abundance/Outmigrant Timing	CDFG
	Fall-run, spring-run Chinook,Steelhead	Rotary Screw Trap	Abundance/Outmigrant Timing	YCWA (proposed)
	Fall-run Chinook, Steelhead	Snorkel survey	Juvenile rearing	YCWA
American River	Fall-run Chinook, Steelhead	Rotary Screw Trap	Abundance/Outmigrant Timing	CDFG
	Steelhead	PIT tagging	Individual growth rates	CDFG
DELTA TRIBUTARIES				
Cosumnes River	Fall-run Chinook	Seining surveys	Distribution and Abundance	TNC
	Fall-run Chinook, Steelhead	Rotary Screw Trap	Abundance/Outmigrant Timing	Fishery Foundation/CDFG/USFWS
Mokelumne River	Fall-run Chinook, Steelhead	Rotary screw traps / incline plane trap	Abundance/Outmigrant Timing	EBMUD
	Chinook	Coded Wire Tagging	Smolt survival rates, assess effects of size and release location on juvenile survival	EBMUD
	Fall-run Chinook, Steelhead	Seine and electrofishing surveys	Distribution and Abundance	EBMUD
Calaveras River	Fall-run Chinook, Steelhead	Snorkel survey	Abundance/Distribution	USFWS/Fishery Foundation
	Fall-run Chinook, Steelhead	Rotary Screw Trap	Abundance/Outmigrant Timing	SEWD/S.P. Cramer and Associates
SAN JOAQUIN RIVER BASIN				
San Joaquin River	Fall-run Chinook, Steelhead	Kodiak trawl at Mossdale	Abundance/Outmigration Timing	CDFG
	Fall-run Chinook, Steelhead	Beach Seine	Year Round Abundance	USFWS
Stanislaus River	Fall-run Chinook, Steelhead	Rotary Screw Traps	Abundance/Outmigrant Timing	S.P. Cramer and Assoc. under contract with USFWS

	Fall-run Chinook	Snorkel survey	Presence of juveniles at end of outmigration period	USBR/Fishery Foundation
	Fall-run Chinook	Smolt Survival Studies	Effects of flow and other factors on survival of coded-wire tagged smolts	CDFG
	Fall-run Chinook	Radio tagging	Smolt movement	S.P. Cramer and Assoc.
Tuolumne River	Fall-run Chinook, Steelhead	Rotary Screw Trap	Abundance/Outmigrant Timing, Recovery of marked smolts	CDFG, TID, AFRP
	Fall-run Chinook	Smolt Survival Studies	Effects of flow and other factors on survival of coded-wire tagged smolts	CDFG
	Fall-run Chinook	Beach Seining	Distribution relative to water temperatures and flow fluctuations	TID
Merced River	Fall-run Chinook, Steelhead	Rotary Screw Trap	Abundance/Outmigrant Timing	CDFG
	Fall-run Chinook, Steelhead	Fyke nets	Evaluation of entrainment of juvenile salmonids in water diversions	CDFG
	Fall-run Chinook	Smolt Survival Studies	Effects of flow and other factors on survival of coded-wire tagged smolts	CDFG
Sacramento-San Joaquin Bay-Delta Estuary				
North Delta (throughout)	All Chinook Runs	Beach Seining	Abundance/Outmigrant Timing, Recovery of marked smolts	USFWS
Central Delta (throughout)	All Chinook Runs	Beach Seining	Abundance/Outmigrant Timing, Recovery of marked smolts	USFWS
South Delta (throughout)	All Chinook Runs	Beach Seining	Abundance/Outmigrant Timing, Recovery of marked smolts	USFWS
Suisun Bay	All Chinook runs	Mid Water Trawl at Chipps Island	Abundance/Outmigrant Timing, Recovery of marked smolts	USFWS
SF/San Pablo Bays	All Chinook Runs	Beach Seining	Abundance/Outmigrant Timing	USFWS

F. Annotating the Salmon Decision Process

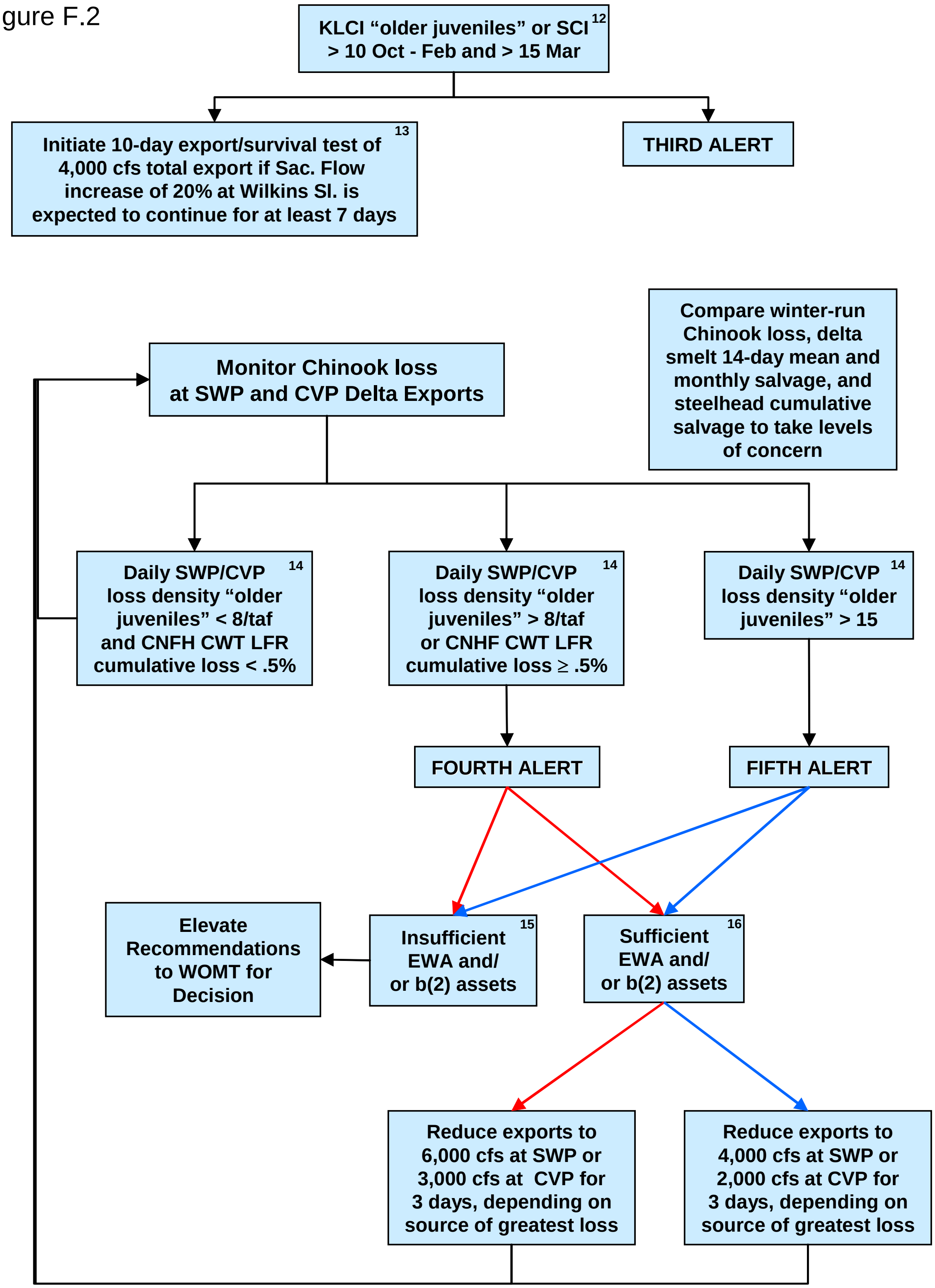
We annotated the Salmon Decision Process with text and the data used to develop the decisions (Figures F.1 - F.12).

Figure F.1



2001/2002 Chinook decision process October through March (Chart 1 of 2).

Figure F.2



2001/2002 Chinook decision process October through March (Chart 2 of 2).

Figure F.3

Annotation - 2003 Salmon Decision Process

1 - Mill, Deer and Butte creeks are the most important populations of spring Chinook today (DFG. June 1998. Report to the Fish and Game Commission: A Status Review of the Spring-run Chinook Salmon in the Sacramento River Drainage. Candidate Species Status Report 98-01). DFG operates rotary screw traps near the mouths of these three tributaries to monitor the emigration of spring run yearlings, and later, spring run and fall run fry.

2 - Juvenile Chinook in the spring Chinook tributaries less than 70 mm between October and April are fall run or spring run fry or pre-smolts (Figure 1) and not the focus of the Salmon Decision Process actions.

3 - Juvenile Chinook in the spring run tributaries greater than 70 mm between October and April are spring run yearlings (Figure 1) and the focus of the Salmon Decision Process actions.

4 - Yearling spring run are difficult to trap, due to their low numbers and strong swimming ability, therefore a significant increase in flow is a surrogate for trapping yearling spring run. The first significant flow in October is associated with the beginning of emigration (Figures 2 - 4).

5 - Yearling spring run at the mouths of the spring run tributaries are in the Sacramento River and are susceptible to Delta mortality factors associated with the Delta Cross Channel (DCC) and SWP/CVP export operations.

6 - The "First Alert" is the early warning criteria for closing the DCC..

7 - Wilkins Slough is the flow gage near Knights Landing, and about 35 miles upstream of the Delta. A significant flow increase at Wilkins Slough is associated with juvenile emigration past Knights Landing (Figure 5).

8 - The "Second Alert" is the warning criteria for closing the DCC. The First and Second alerts alerts are important warning criteria because information and data dissemination, and agency coordination for an action can take several days.

9 - Catches Indexes at Knights Landing and/or Sacramento are the criteria upon which the first action is based; closing the Delta Cross Channel Gates (DCC) (Figures 6 and 7). The raw catches are standardized to one day of effort, but do not include catch efficiency. Depending on the catch magnitude, there are several options for closing the DCC, ranging from not closing them, and continuing to monitor catch at KL and/or Sac, to closing them until the catch index decreases to 5 fish per day.

Figure F.4

10 - Closing the DCC for fish protection can adversely impact Delta salinity from November through January. Without Sacramento River freshwater flowing through the DCC and into the central Delta to the bay, saline ocean water can intrude into the central and southern Delta. Water project operators developed an objective set of water salinity criteria that indicate when the Delta becomes susceptible to salinity intrusion if the DCC is closed and exports are maintained.

11 - Fish and water salinity needs are frequently mutually exclusive, with respect to the DCC position, from November through January. Under the situation, if the Data Assessment Team (DAT) and Operations and Fish Forum (OFF) can't resolve the contradiction, they elevate it to the Water Operations Management Team (WOMT).

12 - The KL and/or Sac catch index of > 10 from November through February, and > 15 from March through April indicates the "Third Alert". A significant number of juvenile Chinook are in the Delta and potentially exposed to the south Delta exports in the following weeks.

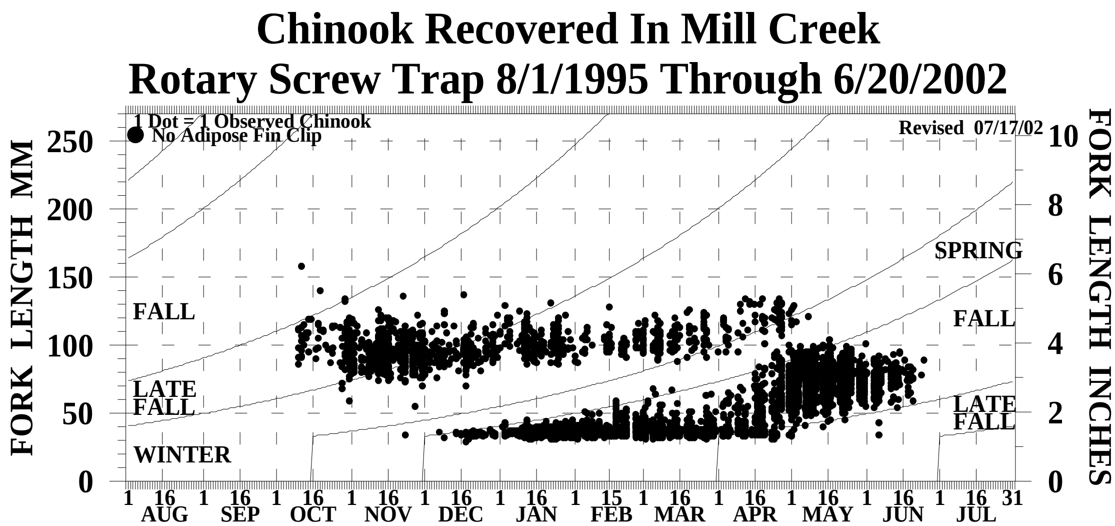
13 - FWS conducts a juvenile Chinook Delta survival experiment each year in December and January. The goal is to try to determine the relationship between survival, exports and flow. The objective is 10 consecutive days of consistent environmental parameters, exports and inflow. The criteria to achieve the objective is a KL and/or Sac catch index > 10, and projected Sacramento River flow increased by 20%.

14 - Juvenile Chinook loss at the exports is the only export reduction criteria. The two loss criteria are based on non-clipped Chinook loss density (Figure 8), and Coleman late fall hatchery Chinook cumulative loss. Non-clipped Chinook loss density and hatchery Chinook cumulative loss are the "Fourth and Fifth alerts".

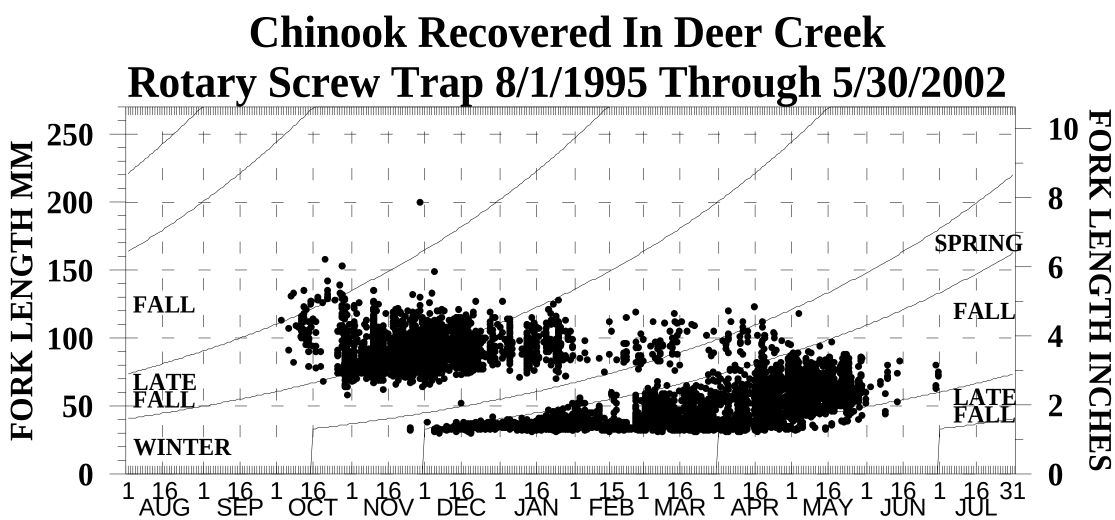
15 - Fish Management Agencies (MA) determine whether there is sufficient EWA assets to reduce exports. If there are insufficient EWA assets, the MAs elevate the issue to WOMT for resolution.

16 - If EWA assets are sufficient, the MAs reduce exports for a number of days and resume monitoring loss.

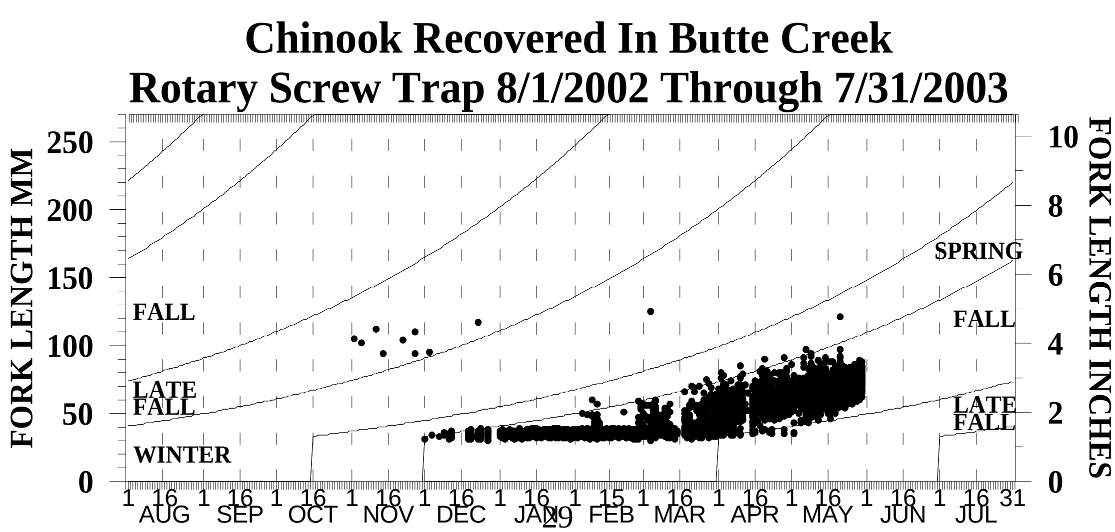
Figure F.5



Chinook Recovered In Mill Creek
Rotary Screw Trap 8/1/1995 Through 6/20/2002
1 Dot = 1 Observed Chinook
No Adipose Fin Clip
Revised 07/17/02
FORK LENGTH MM
FORK LENGTH INCHES
FALL
LATE FALL
WINTER
SPRING



Chinook Recovered In Deer Creek
Rotary Screw Trap 8/1/1995 Through 5/30/2002
FORK LENGTH MM
FORK LENGTH INCHES
FALL
LATE FALL
WINTER
SPRING



Chinook Recovered In Butte Creek
Rotary Screw Trap 8/1/2002 Through 7/31/2003
FORK LENGTH MM
FORK LENGTH INCHES
FALL
LATE FALL
WINTER
SPRING

Figure F.6

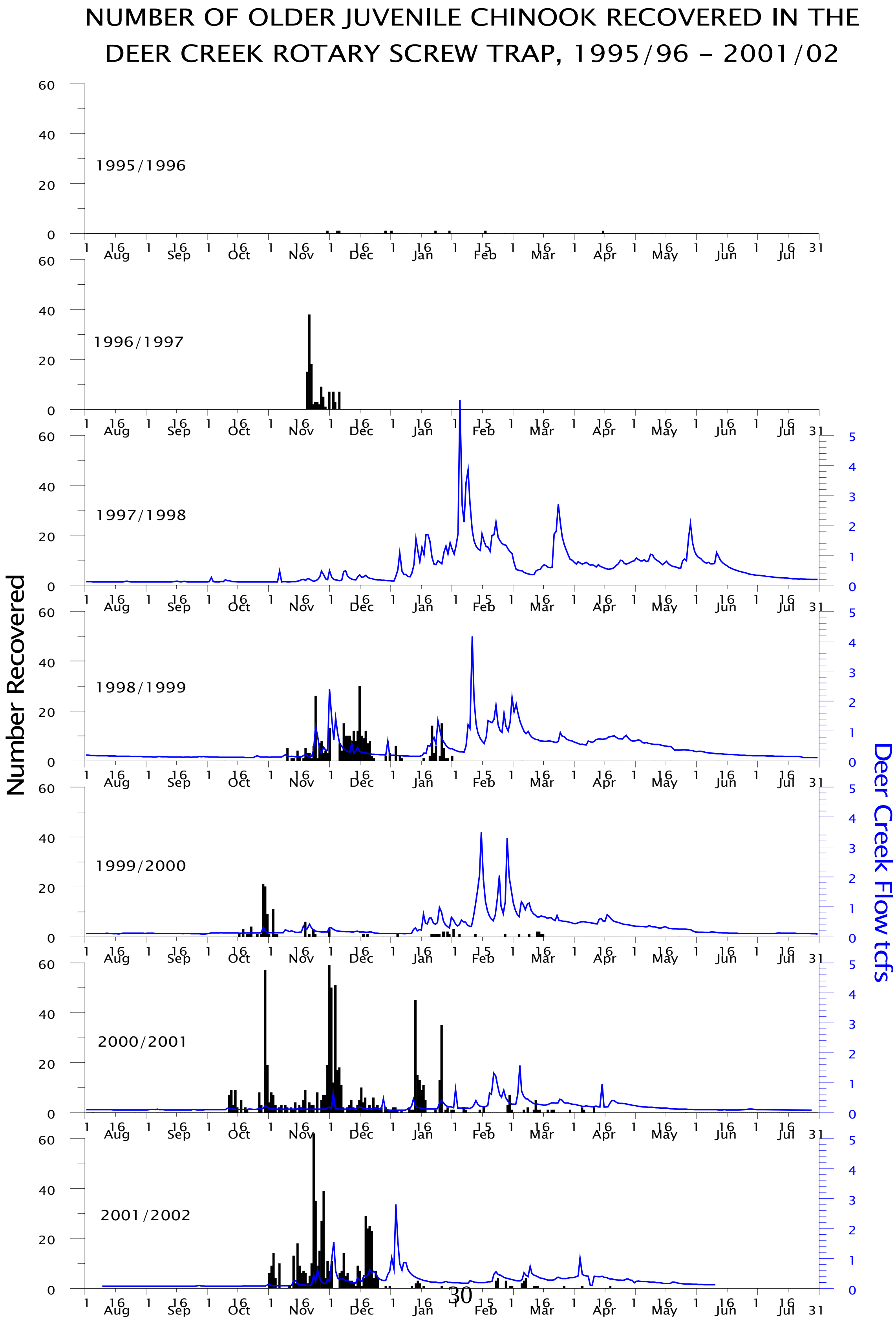

NUMBER OF OLDER JUVENILE CHINOOK RECOVERED IN THE
DEER CREEK ROTARY SCREW TRAP, 1995/96 - 2001/02
1995/1996
1996/1997
1997/1998
1998/1999
1999/2000
2000/2001
2001/2002
Number Recovered
Deer Creek Flow tcfs
0
20
40
60
0
1
2
3
4
5
1
16
Aug
Sep
Oct
Nov
Dec
Jan
15
Feb
Mar
Apr
May
Jun
Jul
31

Figure F.7

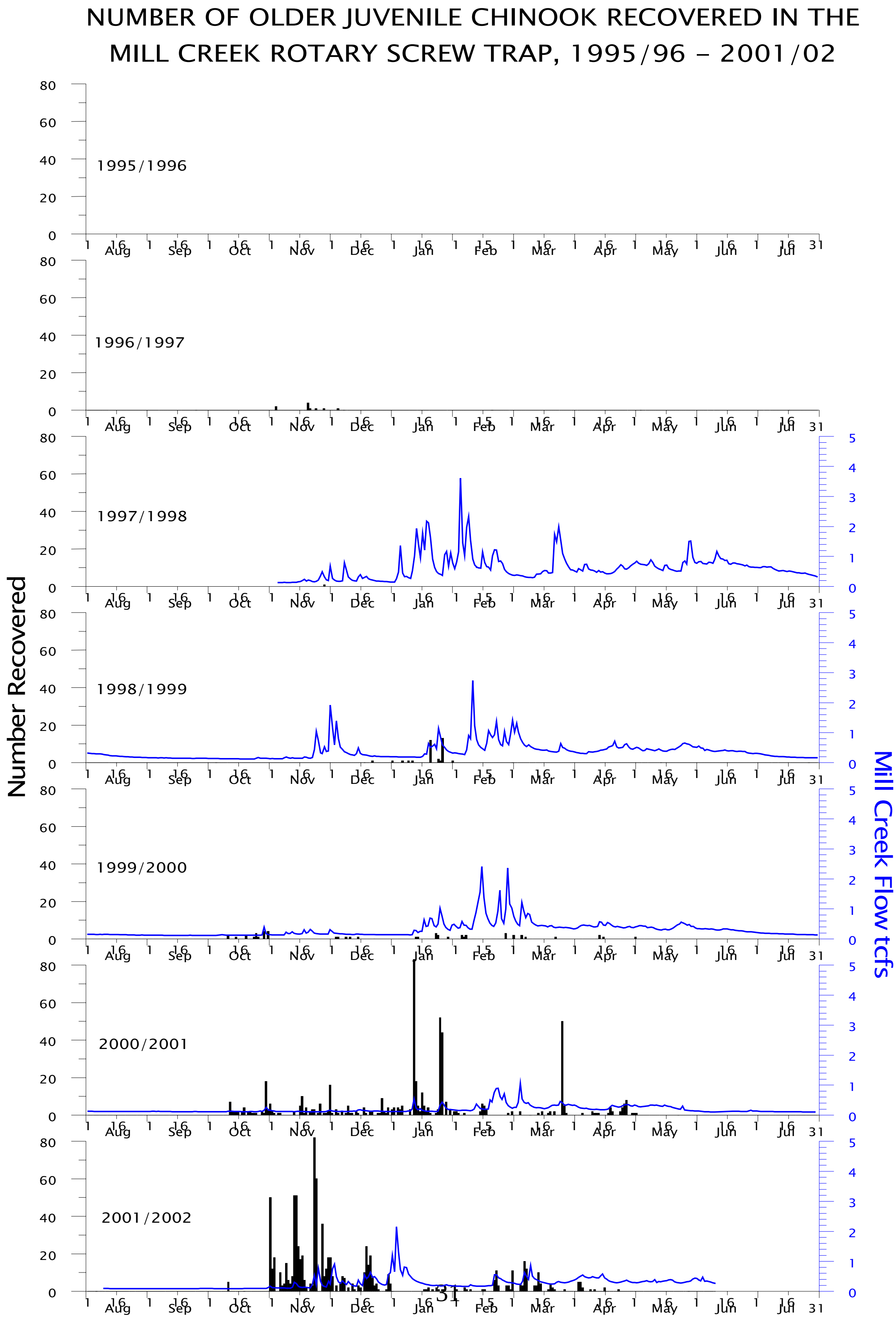

NUMBER OF OLDER JUVENILE CHINOOK RECOVERED IN THE
MILL CREEK ROTARY SCREW TRAP, 1995/96 – 2001/02
Number Recovered
Mill Creek Flow tcfs
1995/1996
1996/1997
1997/1998
1998/1999
1999/2000
2000/2001
2001/2002
0
20
40
60
80
0
1
2
3
4
5
Aug
Sep
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
1
16
15
31

Figure F.8

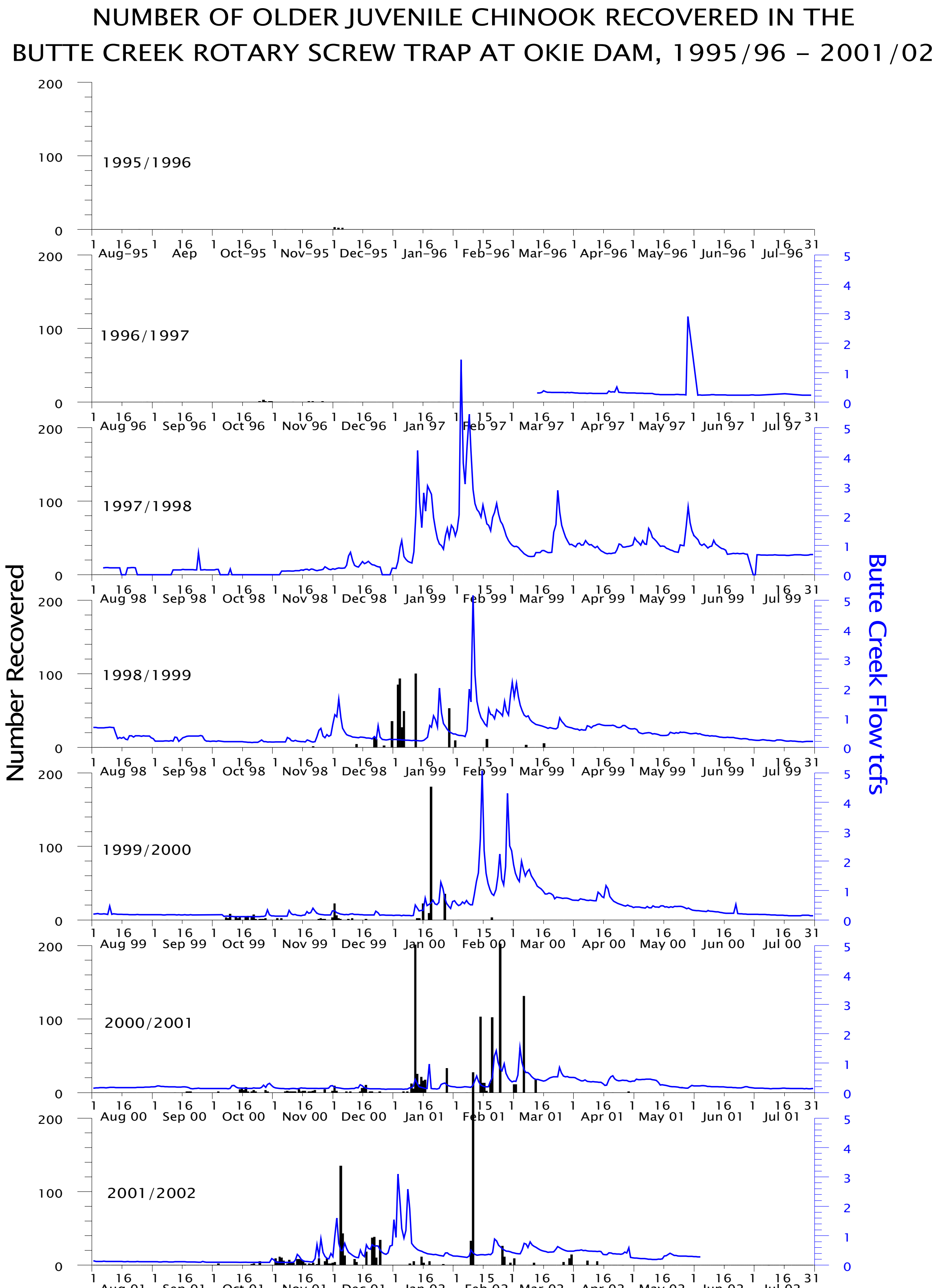

NUMBER OF OLDER JUVENILE CHINOOK RECOVERED IN THE
BUTTE CREEK ROTARY SCREW TRAP AT OKIE DAM, 1995/96 - 2001/02
Number Recovered
Butte Creek Flow tcfs
1995/1996
1996/1997
1997/1998
1998/1999
1999/2000
2000/2001
2001/2002
Aug-95 Aep Oct-95 Nov-95 Dec-95 Jan-96 Feb-96 Mar-96 Apr-96 May-96 Jun-96 Jul-96
Aug 96 Sep 96 Oct 96 Nov 96 Dec 96 Jan 97 Feb 97 Mar 97 Apr 97 May 97 Jun 97 Jul 97
Aug 98 Sep 98 Oct 98 Nov 98 Dec 98 Jan 99 Feb 99 Mar 99 Apr 99 May 99 Jun 99 Jul 99
Aug 99 Sep 99 Oct 99 Nov 99 Dec 99 Jan 00 Feb 00 Mar 00 Apr 00 May 00 Jun 00 Jul 00
Aug 00 Sep 00 Oct 00 Nov 00 Dec 00 Jan 01 Feb 01 Mar 01 Apr 01 May 01 Jun 01 Jul 01
Aug 01 Sep 01 Oct 01 Nov 01 Dec 01 Jan 02 Feb 02 Mar 02 Apr 02 May 02 Jun 02 Jul 02

Figure F.9

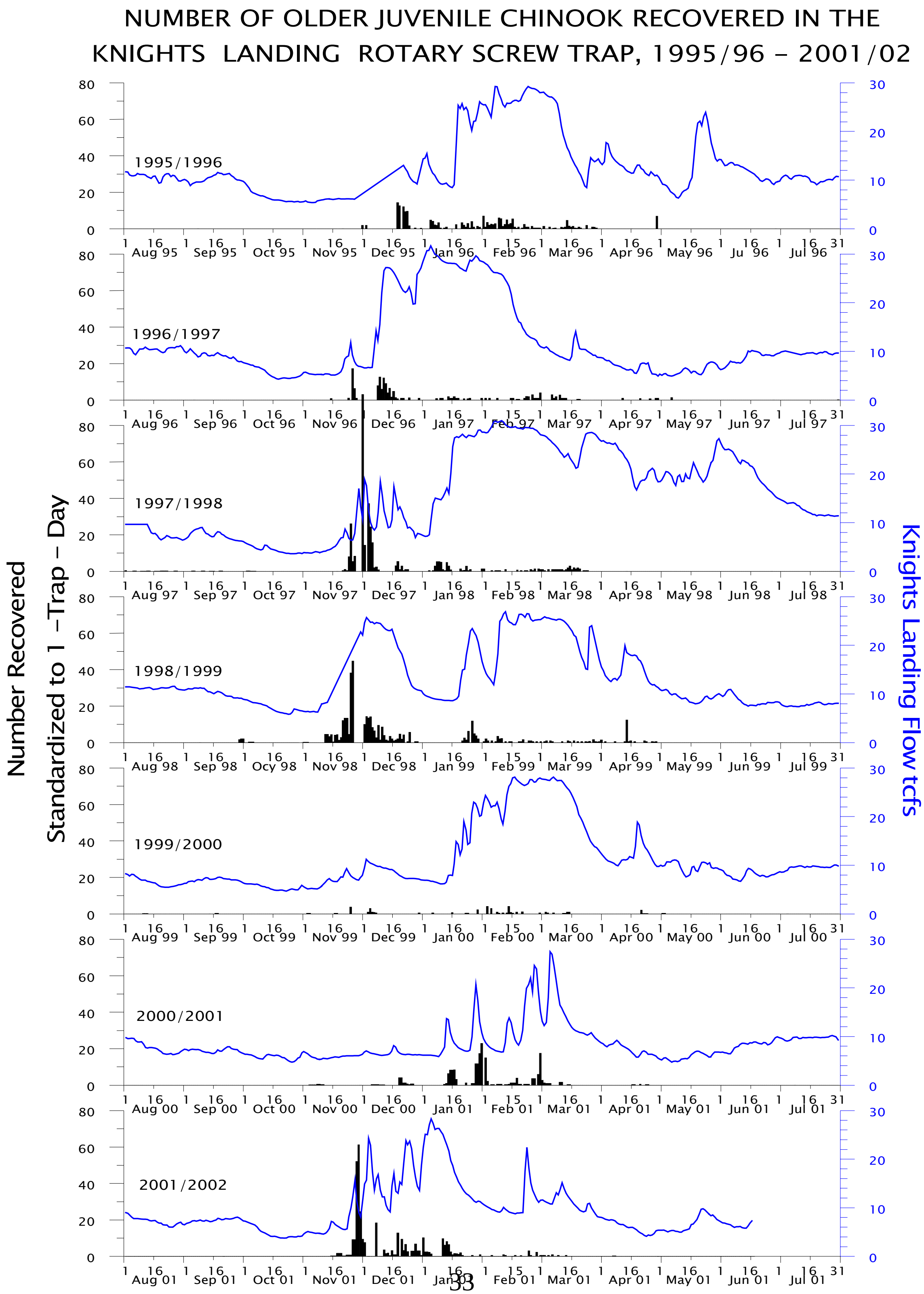

NUMBER OF OLDER JUVENILE CHINOOK RECOVERED IN THE
KNIGHTS LANDING ROTARY SCREW TRAP, 1995/96 – 2001/02
Number Recovered
Standardized to 1 –Trap – Day
Knights Landing Flow tcfs
1995/1996
1996/1997
1997/1998
1998/1999
1999/2000
2000/2001
2001/2002

Figure F.10

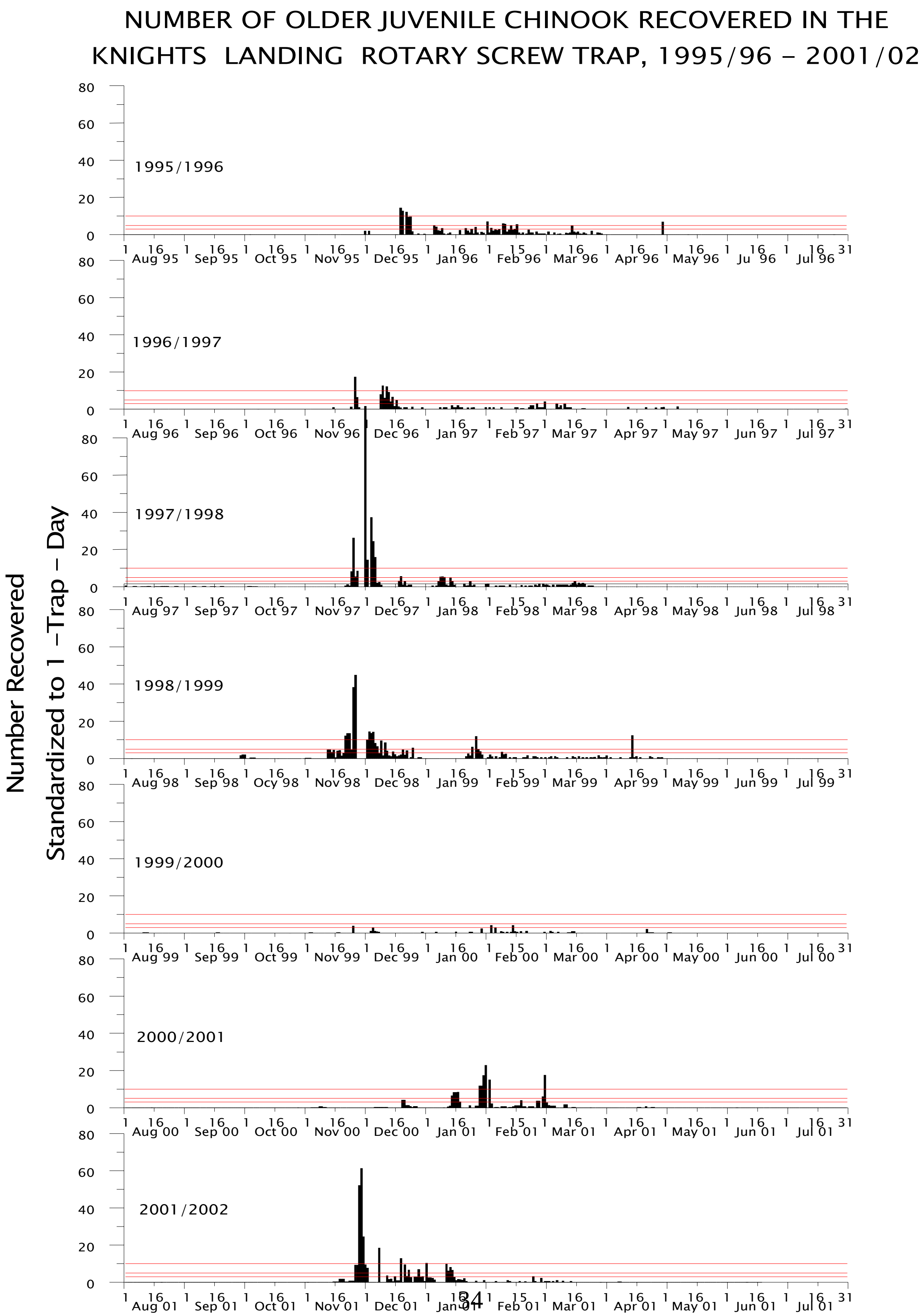

NUMBER OF OLDER JUVENILE CHINOOK RECOVERED IN THE KNIGHTS LANDING ROTARY SCREW TRAP, 1995/96 - 2001/02
Number Recovered
Standardized to 1 -Trap - Day
1995/1996
1996/1997
1997/1998
1998/1999
1999/2000
2000/2001
2001/2002
0
20
40
60
80
Aug 95
Sep 95
Oct 95
Nov 95
Dec 95
Jan 96
Feb 96
Mar 96
Apr 96
May 96
Ju 96
Jul 96
Aug 01
Sep 01
Oct 01
Nov 01
Dec 01
Jan 01
Feb 01
Mar 01
Apr 01
May 01
Jun 01
Jul 01

Figure F.11

NUMBER OF OLDER JUVENILE CHINOOK RECOVERED
IN THE SACRAMENTO TRAWL, 1995/96 - 2001/02

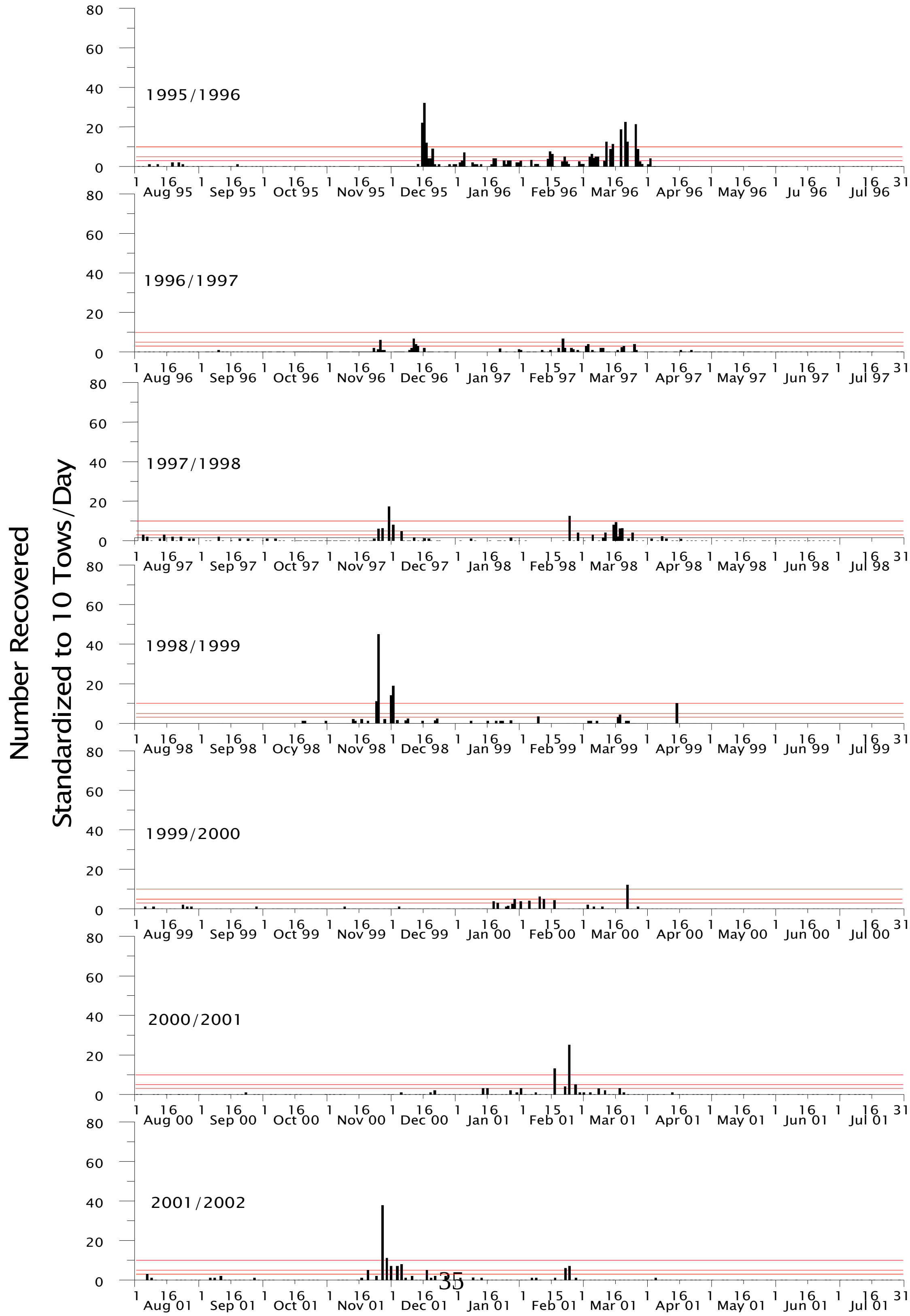
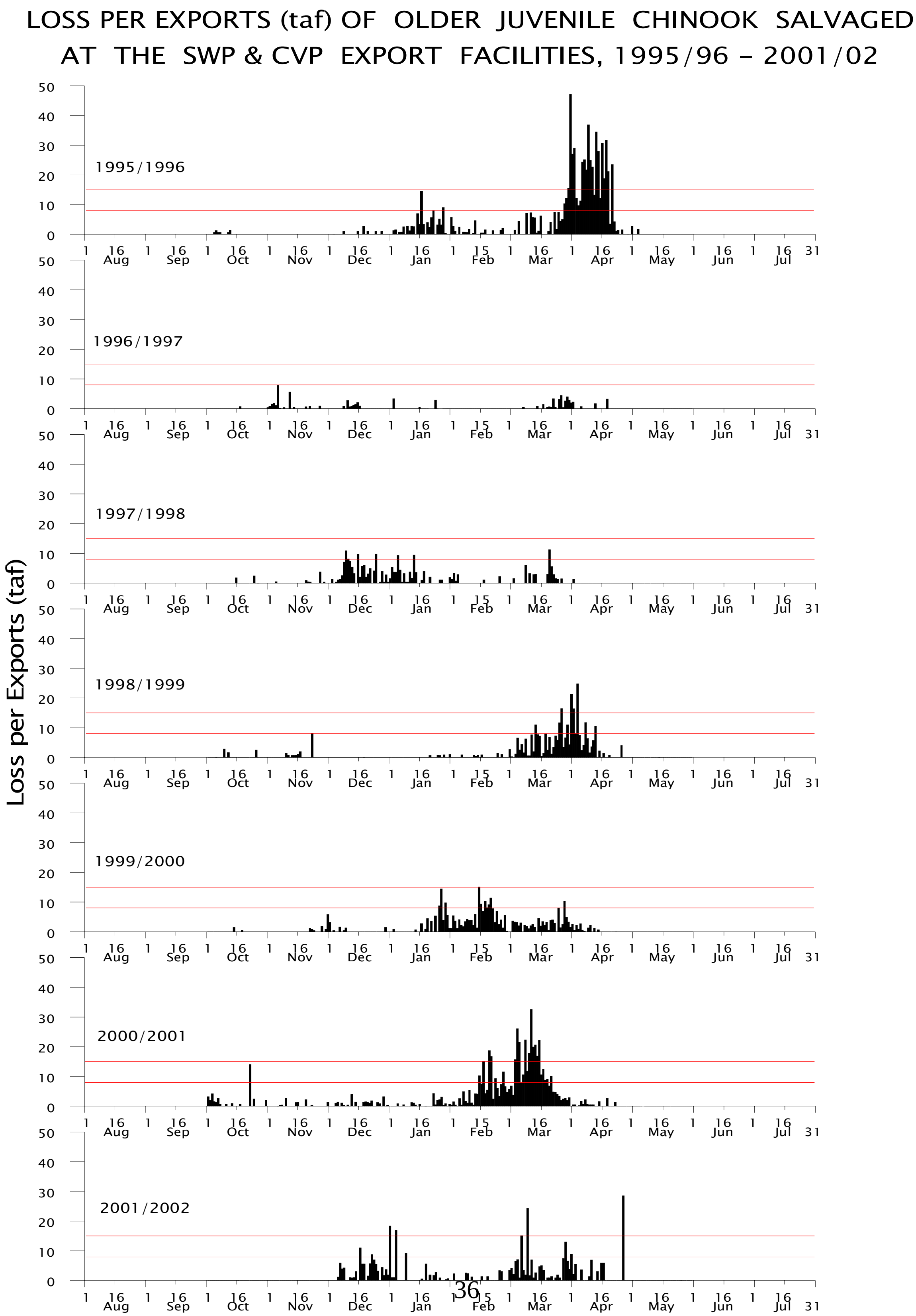


Figure F.12


LOSS PER EXPORTS (taf) OF OLDER JUVENILE CHINOOK SALVAGED AT THE SWP & CVP EXPORT FACILITIES, 1995/96 - 2001/02
Loss per Exports (taf)
1995/1996
1996/1997
1997/1998
1998/1999
1999/2000
2000/2001
2001/2002
0
10
20
30
40
50
Aug
Sep
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
1
16
15
31

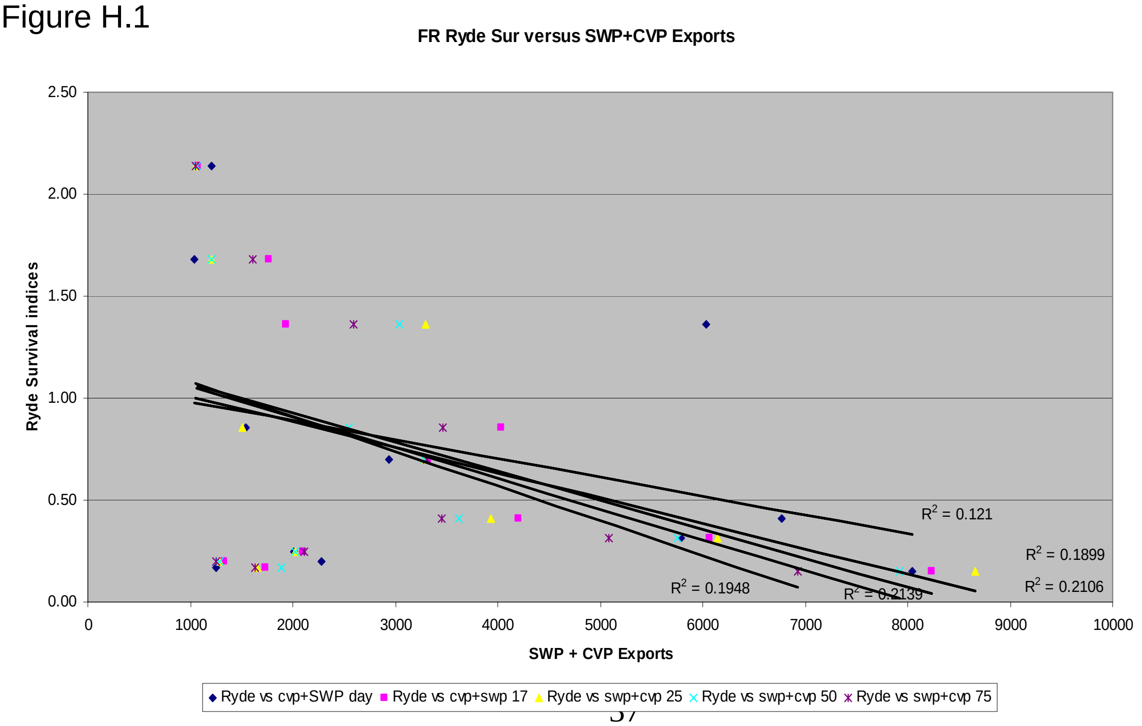
G. Past Analyses on Predicting Episodes of Take

Two past efforts have tried to correlate episodes of high take at the fish facilities to environmental variables or monitoring catches. Jones and Stokes did an analysis that tied QWEST values to episodic take at the fish facilities. We are in the process of tracking this analysis down to determine if episodes of salmon take can be predicted based on QWEST values. The 1995 Real Time Monitoring Program (IEP Tech Report 47) attempted to determine if salmon, splittail and delta smelt catches in real time monitoring could predict high take at the fish facilities. With the exception of splittail at Mossdale they could not. The best correlations with splittail were for the SWP versus Mossdale 1 day after sampling (r2 = .956) and for the CVP 4 days after sampling (r2 = .943). Further exploration is needed on this topic.

H. Incorporate several different averaging ranges for environmental parameters for the Delta Action 8 relationship.

A series of regressions were run using the survival ratios of fall and late fall releases into Georgiana Slough and Ryde. Two estimates of survival were generated for the late-fall releases at Ryde and Georgiana Slough and for the ratios. The best relationship was between the GS/Ryde ratio and average combined exports for the 3 days following release. The best fitting relationship using the fall run survival indices was between the Ryde survival indices and CVP+SWP exports (Figure H.1). We are still evaluating this relationship and have engaged Ken Newman to explore it further (see AInvestigate the assumption of Ryde survival as a adequate control group for the GS/Ryde ratio, above).

Figure H.1



I. Calculate confidence limits around the Sacramento trawl and beach seines.

As an example, FWS calculated the confidence limit around each trawl and seine in 1995 (Figures I.1 and I.2).

Figure F.1

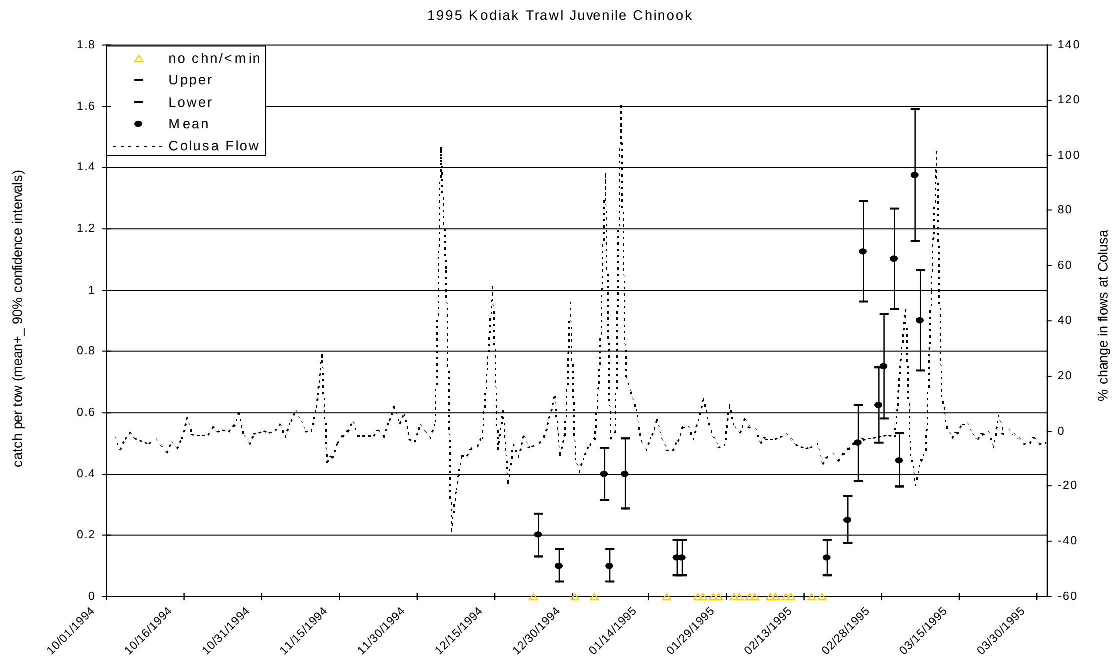
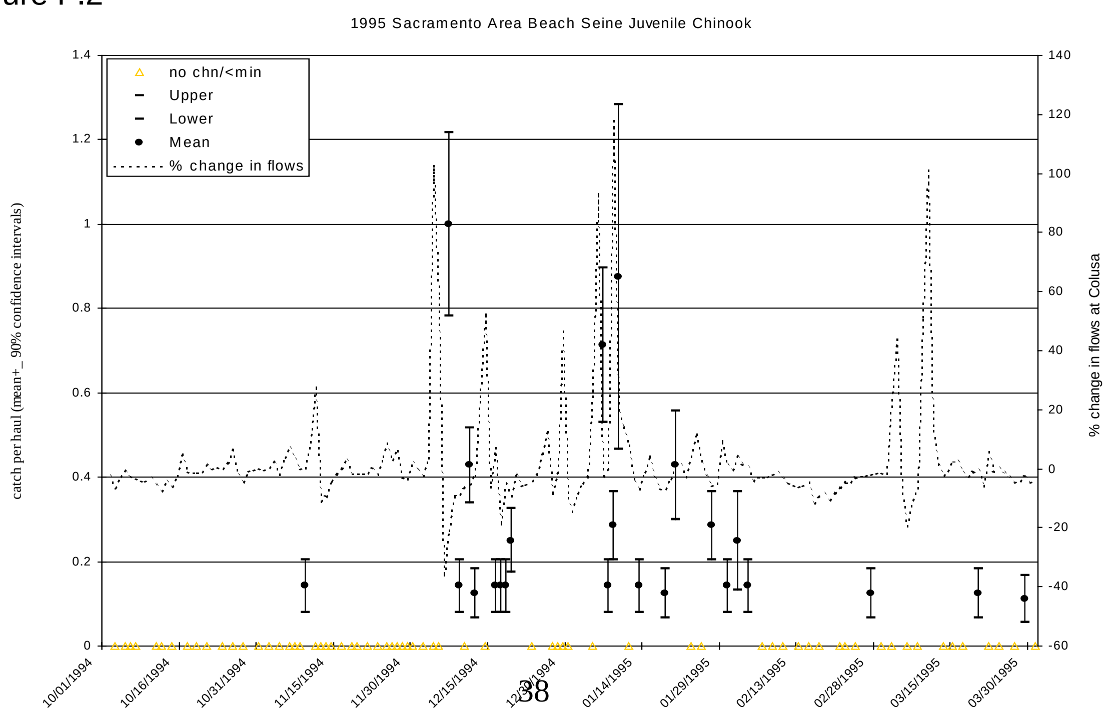


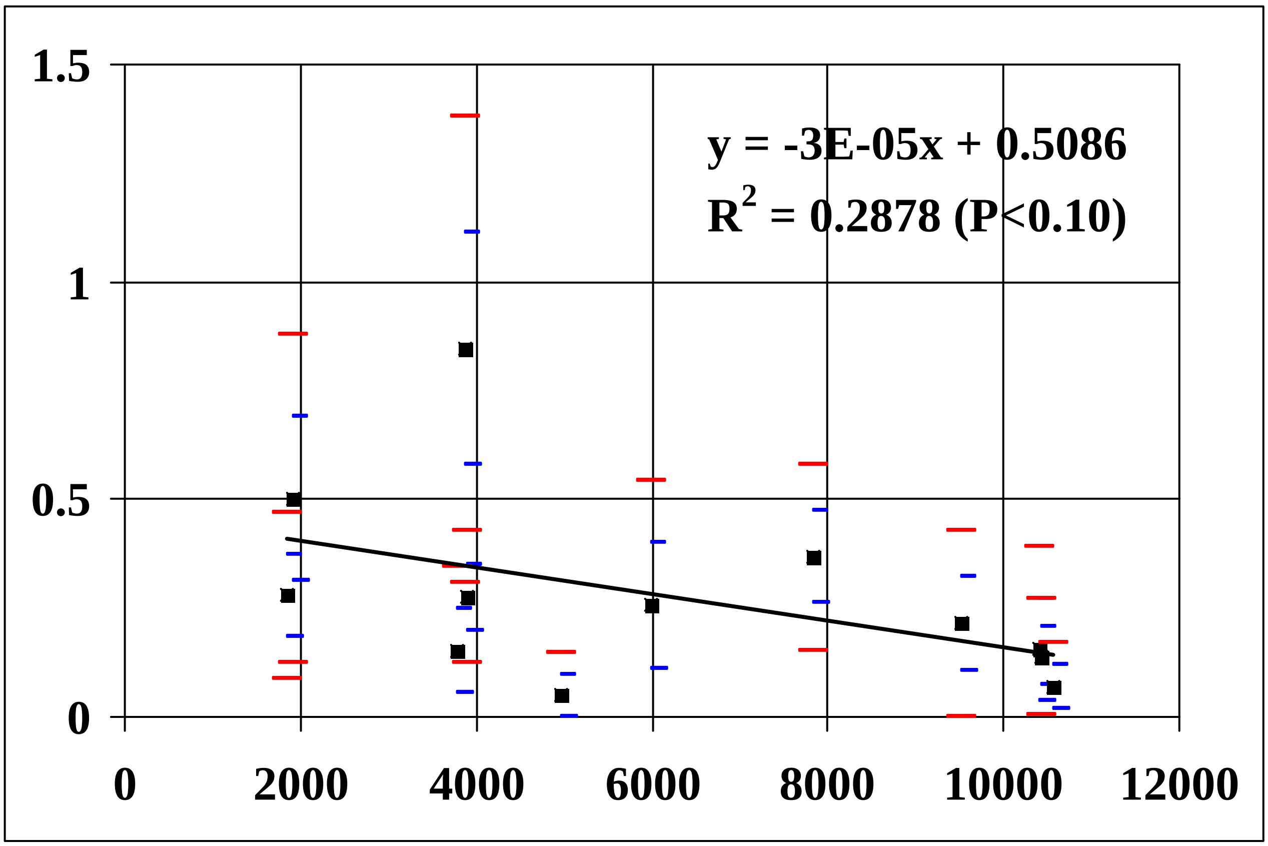
Figure F.2



J. Incorporating confidence limits around the individual Georgiana Slough/Ryde survival ratios in the relationship with exports was done in 2003.

Ken Newman recommended that the Delta method be used to calculate standard errors of the differential recovery rates of two CWT groups recovered at Chipps Island. I used this method and calculated differential recovery rates of the Georgiana Slough groups relative to the Ryde groups (includes 2003 data) plus and minus 1 and 2 standard error(s) and graphed them (Figure J.1). Since recovery numbers were relatively small standard error estimates were relatively large and most individual data points were not significantly different from one another.

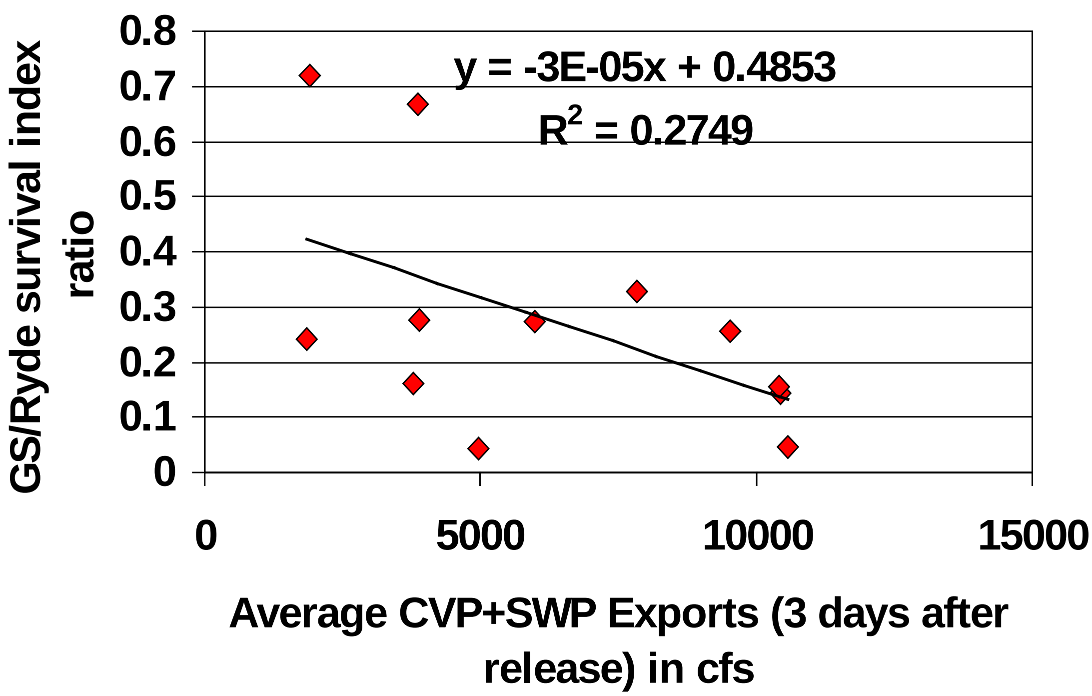
Figure J.1



K. Resolve Uncertainty in Relationship between Exports and Total Delta Mortality

In 2003, the Delta Action 8 experiments were continued using late-fall hatchery fish from Coleman National Fish Hatchery. Groups of CWT fish were released in December of 2002, with groups being released at Ryde and into Georgiana Slough as in past years. In 2002, releases were also made at Sacramento and Port Chicago to estimate survival through the Delta both using Chipps Island and ocean recoveries to compliment information obtained on the differential survival in the interior Delta relative to being released in the mainstem Sacramento River. The results of the ratio between Georgiana Slough survival index and the Ryde index is shown in Figure K.1. It is similar to the differential recovery rate that Ken Newman recommended but is calculated slightly different and incorporates different sampling effort between groups into the estimates.

Figure K.1



L. Apply Newman Models

The various Delta salmon survival models developed by Newman and Rice and Newman are complicated and difficult to use. The first Newman and Rice model (the unpaired model) was put into a spreadsheet for quick comparisons between alternative strategies. We want to update this spreadsheet model to incorporate the latest revisions to the coefficients within the model. In addition, we would like Newman=s paired hierarchical model to be put into a similar interface to predict survival under various management scenarios. We have a scope of work and a cost estimate, but no funds have been allocated to this task at this time.

On a separate note, the USFWS has funded Ken to validate his models based on additional data generated since 1995. He is waiting on additional data to start.

M. Investigate the assumption of Ryde survival as anadequate control group for the GS/Ryde ratio.

To validate the concern that the Ryde groups are not affected by exports, Ken Newman is rerunning his models to test this assumption. The contract has been let and we expect Ken=s results soon.

N. Evaluate prescriptive DCC closures in December

Requirements for DCC gate closures are specified in the 1995 Water Quality Control Plan. From November through January, the gates may be closed for a total of 45 days for fishery protection. There is a strong positive relationship between the proportion of flow entering the Interior Delta through the DCC and Georgiana Slough in December and the estimated proportion of the winter-run juvenile population that is subsequently lost at the Delta export facilities each year. Although we have not evaluated DCC gate closures in December as a prescriptive measure to protect winter-run juveniles from entering the Interior Delta, this relationship is now considered when making real-time decisions on gate closures in December.

O. Investigate passage estimate in the Delta.

1. Coded Wire Tag Recoveries

EWA salmon biologists are working on determining the optimal time to close the Delta Cross Channel gates (DCC) to maximize the protection for juvenile Chinook salmon as they emigrate down the Sacramento River from October through January. There are limited assets available to biologists during those months for DCC gate closures. Monitoring at Knights Landing and the Sacramento River trawl give biologists an indication when yearling Chinook are moving towards the DCC gates. However there is little available data on the timing between Knights Landing and/or Sacramento River trawl and the DCC gates. In order to determine the average migration rate past the DCC gates I compared the recoveries of Coleman Hatchery late-fall Chinook upstream (Knights Landing or Sacramento River trawl) and downstream (Chipps Island or the Delta Fish Facilities) between water years 1999/2000 and 2002/2003. The Coleman Hatchery late-fall Chinook were released at the hatchery in three surrogate releases, one in November, one in December, and one in January. A production release was also made in early January each year.

In the November surrogate releases the detection in the upstream monitoring was limited and often occurred after downstream recoveries in years with drier falls. In the wetter years recoveries were made at both Knights Landing and the Sacramento River trawl and the Chinook were recovered in the downstream monitoring within one week. For the December surrogate releases recoveries were also made downstream prior to recoveries upstream in the drier years. However in the wetter years downstream recoveries were made within one to four days following detection in the upstream monitoring. In the January surrogate releases upstream recoveries occurred first in all years. However in drier years downstream recoveries occurred 5 to 19 days after detection in upstream monitoring while in wetter years it only took one to four days. The January production release was similar to the January surrogate release. In drier years downstream recoveries occurred two to eight days after detection upstream and in wetter year it took two to five days.

Therefore, Chinook moving past Knights Landing and the Sacramento trawl in November and December usually pass the DCC gates within one week in wetter years, and 3 weeks in drier years. Due to detection problems in the upstream monitoring the passage of Chinook in drier years is still unknown. Chinook detected at Knights Landing and the Sacramento trawl in January take up to several weeks to pass the DCC gates in drier years but pass within one to five days in wetter years.

2. Environmental Variables

The current Chinook salmon decision tree uses the catch of Aolder juvenile@ Chinook at Knights Landing and the Sacramento River trawl to trigger Delta Cross Channel gates (DCC) closures between October and January. We now have seven consecutive years of monitoring data at both stations so the EWA salmon biologists are continuing to work on better ways to predict passage. We re-analyzed changes in environmental parameters such as flow, water temperature, precipitation, and turbidity prior to the peak juvenile Chinook salmon migration past each monitoring station. Our focus was on changes that occurred between two to five days prior to the migration to allow fish resource MAs enough time to make a decision to close the DCC gates and the water Project Agencies to implement the recommendation.

At Knights Landing, a combination of flow, temperature, and catch criteria best predicted the start of the peak migration. The temperature and flow criteria work in series. When the water temperature decreases below 13.5 degrees C the next flow increase to 7,500 cfs indicated that the start of peak migration would occur within the next four to six days (Figure O.2.1). For the Sacramento trawl and the Sacramento Area beach seine a criteria that incorporated the change in flow, turbidity, and catch predicted the start of the peak migration. A three-day change in flow between 600cfs and 3,000cfs for four consecutive days followed by a secchi reading less than 0.75 meters and a catch index criterion of three Aolder juvenile@ Chinook indicated the start of the peak migration within two to seven days (Figure O.2.2). The catch index is the daily catch standardized to ten tows per day for the trawl and standardized to eight hauls per day for the beach seine.

Even though the criteria are specific for both Knights Landing and the Sacramento trawl/beach seine, both sets of criteria were met within a week of each other in all years (Figure O.2.3). This indicates that these criteria will help us improve our decision process and increase the protection of juvenile Chinook salmon migrating past the DCC.

Figure O.2.1

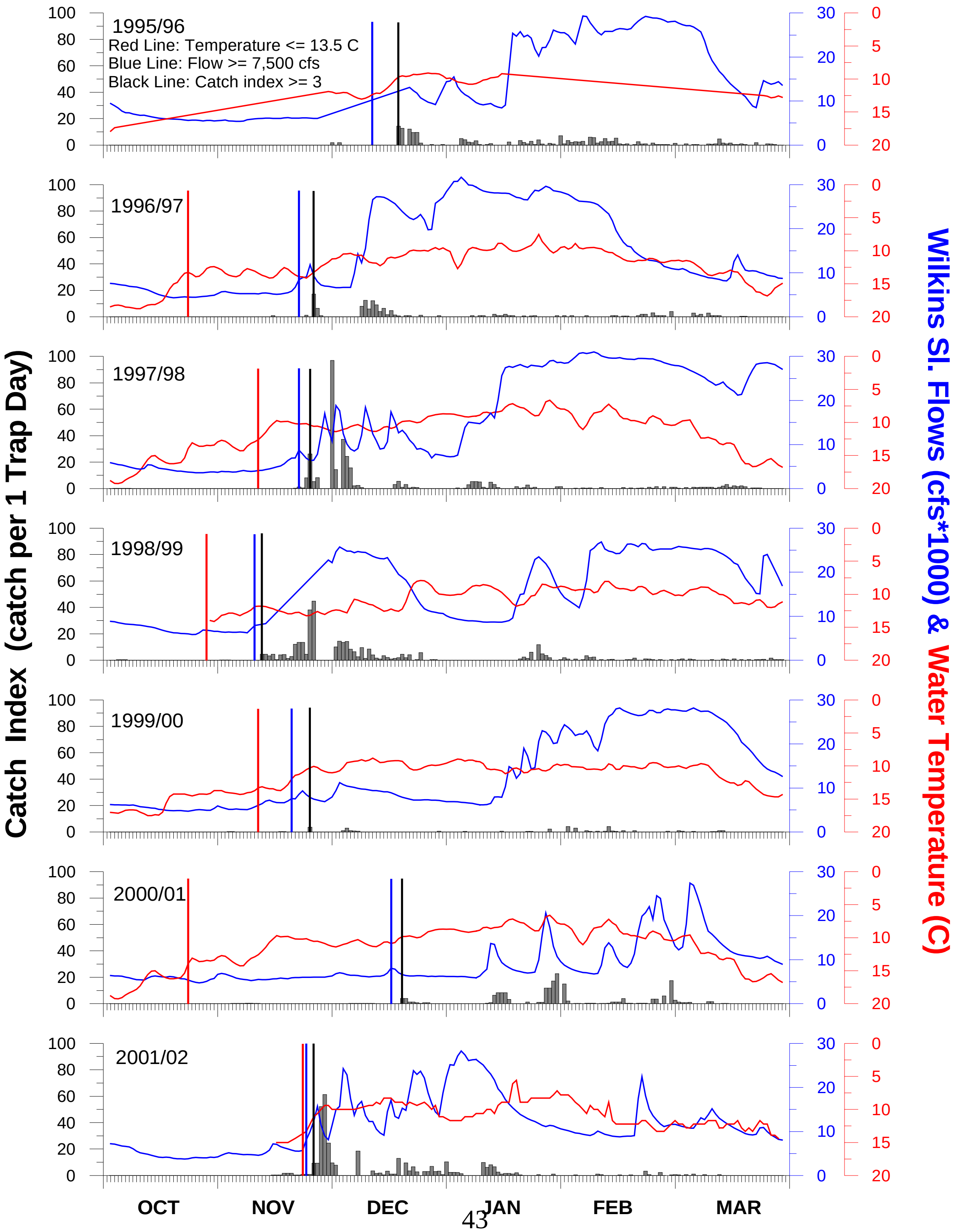
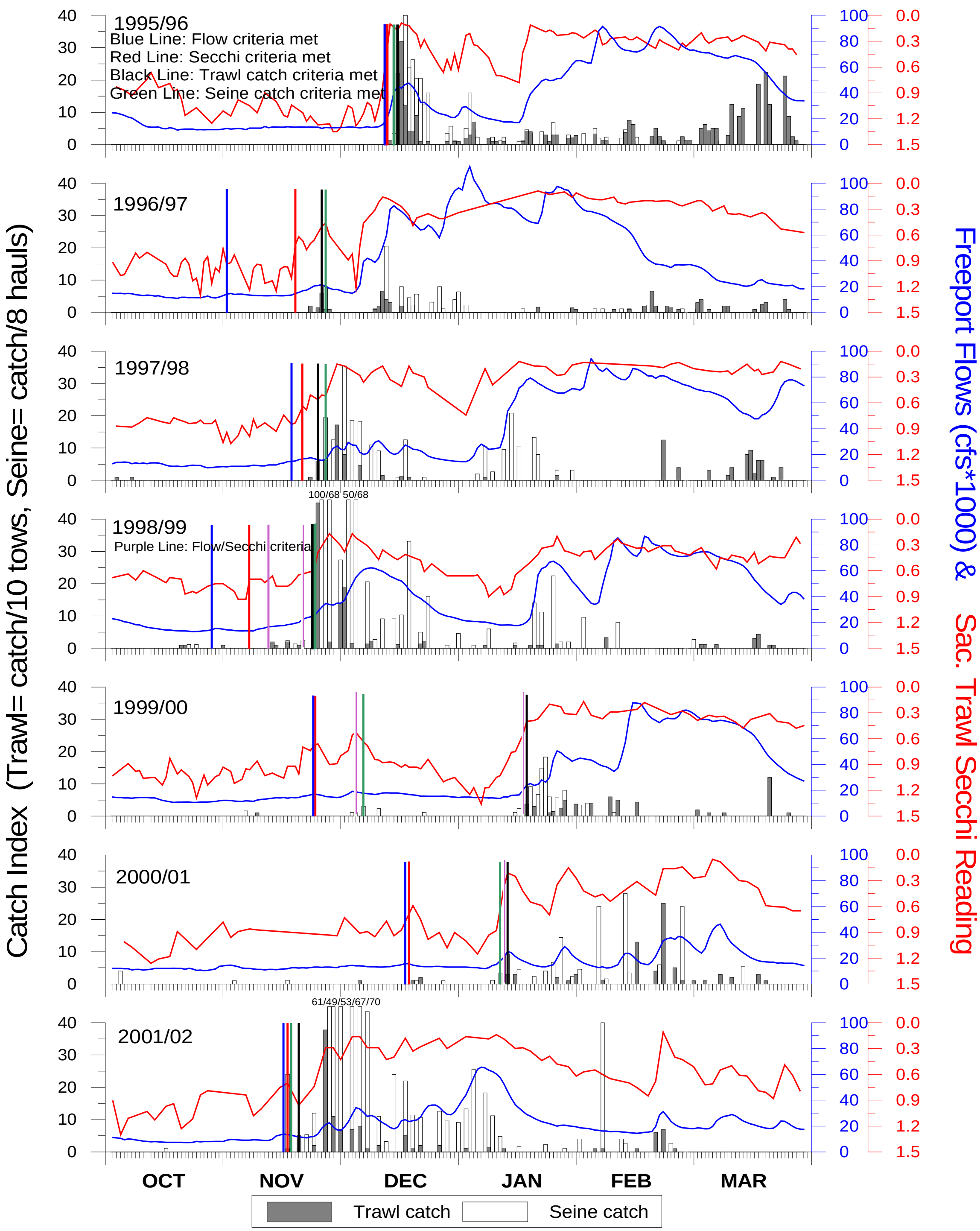
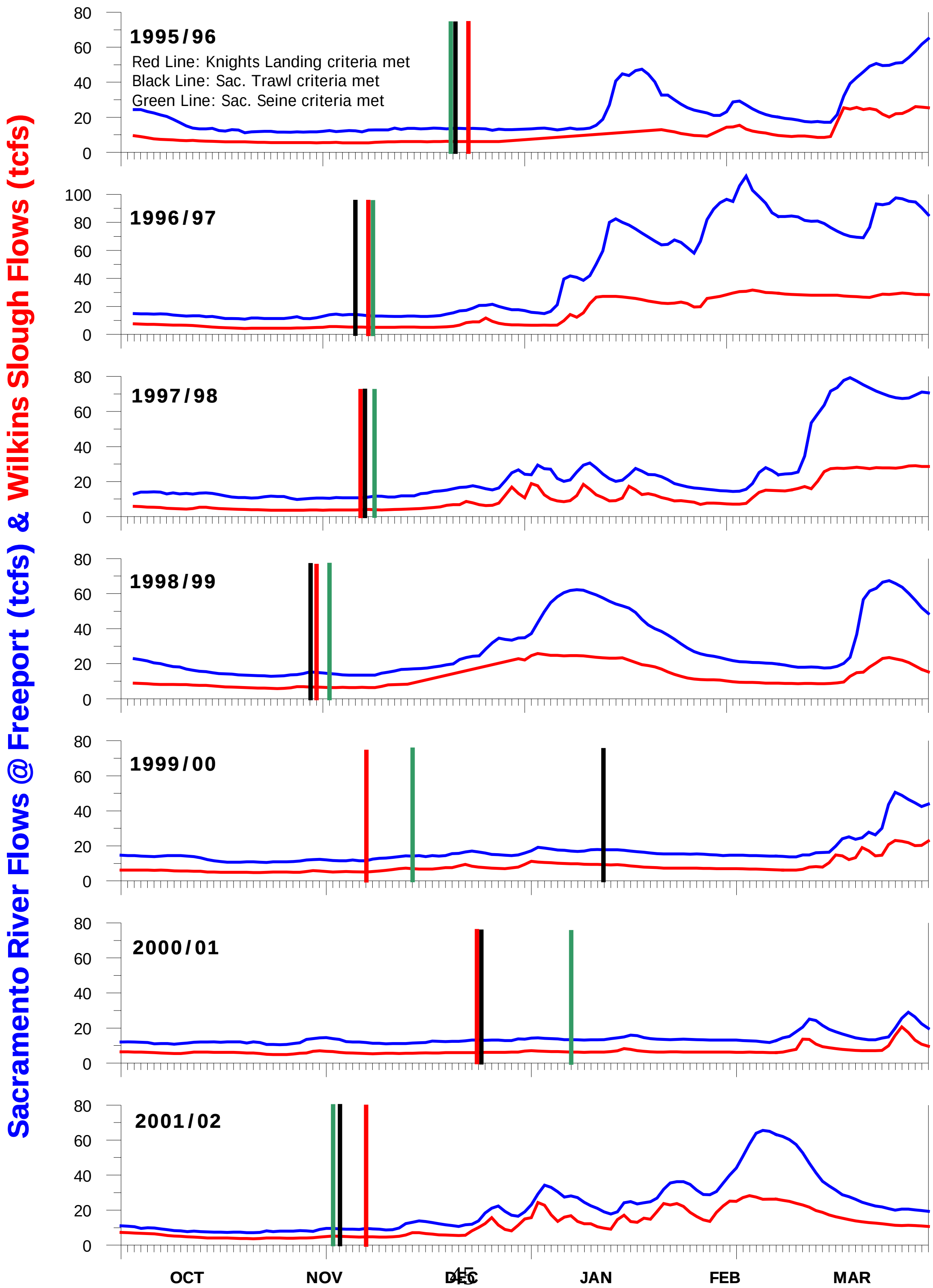


Figure O.2.2



1995/96
Blue Line: Flow criteria met
Red Line: Secchi criteria met
Black Line: Trawl catch criteria met
Green Line: Seine catch criteria met
1996/97
1997/98
100/68 50/68
1998/99
Purple Line: Flow/Secchi criteria
1999/00
2000/01
61/49/53/67/70
2001/02
Catch Index (Trawl= catch/10 tows, Seine= catch/8 hauls)
Freeport Flows (cfs*1000) &
Sac. Trawl Secchi Reading
OCT
NOV
DEC
JAN
FEB
MAR
Trawl catch
Seine catch

Figure O.2.3


Sacramento River Flows @ Freeport (tcfs) & Wilkins Slough Flows (tcfs)
1995/96
Red Line: Knights Landing criteria met
Black Line: Sac. Trawl criteria met
Green Line: Sac. Seine criteria met
1996/97
1997/98
1998/99
1999/00
2000/01
2001/02
OCT
NOV
DEC
JAN
FEB
MAR

P. Quantifying benefits of EWA actions

1. SWP/CVP Export Facilities

There are several levels to quantifying the benefits of EWA export reduction actions. One level is direct loss at the SWP/CVP Delta export facilities. In the last two years, we have calculated the number of juvenile Chinook saved by subtracting the loss based on the EWA case operation from the loss based on the theoretical base case. We assumed the density of Chinook adjacent to the SWP/CVP Delta export facilities was the same under the EWA and base case operation.

This year we attempted to relate the direct loss to the population emigrating through the Delta grouped by older juveniles, fry/smolts and hatchery origin surrogates. Tables P.1.1 - P.1.3 contain the number of Chinook saved with each EWA export reduction, the estimated number of winter run Chinook entering the Delta, and the number of older juveniles and fry/smolts exiting the Delta over the last three years. The winter run entering the Delta is the winter run Juvenile Production Estimate. The older juveniles and fry/smolts exiting the Delta is the abundance estimate at Chipps Island.

While it is apparent the number of juvenile Chinook saved from direct loss at the export facilities is proportionately low compared to the Delta population estimates, it doesn=t include the number saved from mortality in the Delta due to indirect mortality associated with the exports.

Table P.1.1

2000/2001 EWA CHINOOK ACTIONS									
			NON-CLIPPED CHINOOK						
			OLDER JUVENILE		WINTER RUN			FRY/SMOLT	
ACTIONS	DATE(S)	EWA WATER USED (-1) ACQUIRED (+) TAF	SAVED AT SWP/CVP SOUTH DELTA EXPORTS	SAVED AS FRACTION CHIPPS ISLAND ABUNDANCE INDEX (358,578)	SAVED AT SWP/CVP SOUTH DELTA EXPORTS	SAVED AS FRACTION OF JUVENILE PRODUCTION ESTIMATE (370,200 RBDD) (2,613,700 CARCASS)	SAVED AS FRACTION CHIPPS ISLAND ABUNDANCE INDEX (212,372)	SAVED AT SWP/CVP SOUTH DELTA EXPORTS	SAVED AS FRACTION CHIPPS ISLAND ABUNDANCE INDEX (7,352,423)
Delta Action 8	1/17/01 1/21/01	-24	0	0.00000	0	0.00000	0.00000	0	0
Fish Action	1/27/01 1/31/01	-45	61	0.00017	61	0.00002	0.00029	0	0
Fish Action	2/01/01 2/05/01	-17	35	0.00010	35	0.00001	0.00016	0	0
Fish Action	2/16/01 2/23/01	-38	1,253	0.00349	1,253	0.00048	0.00590	17.8	0.00000
Pre-VAMP	2/27/01 3/11/01	-82	4,635	0.01293	4,619	0.00177	0.02175	204.5	0.00003
VAMP	4/22/01 6/4/01	-56	0	0.00000	0	0.00000	0.00000	37084.1	0.00504
SEASON TOTAL		-206	5,984	0.01669	5,968	0.00228	0.02810	37306.4	0.00507

Table P.1.2

2001/2002 EWA CHINOOK ACTIONS									
			NON-CLIPPED CHINOOK						
			OLDER JUVENILE		WINTER RUN			FRY/SMOLT	
ACTIONS	DATE(S)	EWA WATER USED (-1) ACQUIRED (+) TAF	SAVED AT SWP/CVP SOUTH DELTA EXPORTS	SAVED AS FRACTION CHIPPS ISLAND ABUNDANCE INDEX (257,806)	SAVED AT SWP/CVP SOUTH DELTA EXPORTS	SAVED AS FRACTION OF JUVENILE PRODUCTION ESTIMATE (1,991,150)	SAVED AS FRACTION CHIPPS ISLAND ABUNDANCE INDEX (148,691)	SAVED AT SWP/CVP SOUTH DELTA EXPORTS	SAVED AS FRACTION CHIPPS ISLAND ABUNDANCE INDEX (4,911,278)
Merced & Placer County Water Transfers	10/20/01 11/16/01	22.8	0	0.00000	0	0.00000	0.00000	0	0.00000
E/I Relaxation	11/18/01 11/20/01	24.6	0	0.00000	0	0.00000	0.00000	0	0.00000
Fish Action for Delta Smelt and Chinook	1/05/02 1/09/02	-66.4	119	0.00046	119	0.00006	0.00080	0	0.00000
E/I Relaxation	2/01/02 2/26/02	76.0	-60	-0.00023	-60	-0.00003	-0.00040	0	0.00000
EWA Assets Converted to SWP	3/23/02 3/29/02	-38.1	65	0.00025	65	0.00003	0.00044	227	0.00005
VAMP (including shoulders)	4/15/02 6/02/02	-107.3	59	0.00023	59	0.00003	0.00040	14,999	0.00305
SEASON TOTAL		-88.4	183	0.00071	183	0.00009	0.00123	15,226	0.00310

Table P.1.3

2002/2003 EWA CHINOOK ACTIONS									
			NON-CLIPPED CHINOOK						
			OLDER JUVENILE		WINTER RUN			FRY/SMOLT	
ACTIONS	DATE(S)	EWA WATER USED (-1) ACQUIRED (+) TAF	SAVED AT SWP/CVP SOUTH DELTA EXPORTS	SAVED AS FRACTION CHIPPS ISLAND ABUNDANCE INDEX	SAVED AT SWP/CVP SOUTH DELTA EXPORTS	SAVED AS FRACTION OF JUVENILE PRODUCTION ESTIMATE (2,136,750)	SAVED AS FRACTION CHIPPS ISLAND ABUNDANCE INDEX	SAVED AT SWP/CVP SOUTH DELTA EXPORTS	SAVED AS FRACTION CHIPPS ISLAND ABUNDANCE INDEX
EWA Assets to Oroville	10/1/2002 10/6/2003	-4.89	0		0	0.00000		0	
FISH ACTION (CVP)	12/04/02	0.50	0		0	0.00000		0	
FISH ACTION	12/27/2002 01/02/2003	-41.42	371		300	0.00014		0	
FISH ACTION	1/15/2003 1/20/2003	-59.50	195		113	0.00005		54	
FISH ACTION	1/25/2003 1/28/2003	-20.43	100		100	0.00005		0	
E/I RELAXATION & STATE GAIN	3/3/2003 3/31/2003	60.14	-230		-231	-0.00011		-639	
Flood Control Releases (no EWA Cost)	4/2/2003 4/12/2003	-5.03	9		9	0.00000		789	
VAMP	4/15/2003 5/12/2003	-31.77	0		0	0.00000		9256	
SHOULDERS ON VAMP	5/14/2003 5/30/2003	-194.77	0		0	0.00000		14610	
SEASON TOTAL		-297.17	445		291	0.00014		24070	

2. Delta

It was our attempt to model the benefits for salmon of the EWA actions taken in 2003 as well as in past years. A spreadsheet was developed to assess the benefits of 2001 and a similar approach was to be used for 2002 and 2003. However, very few actions were taken specifically for salmon, thus the benefits were likely small due to the small proportion of the population that experienced the benefit. Further work will be made on assessing these annual EWA benefits for salmon using a spreadsheet or other model in the future.

Q. Refine reservoir management to increase cold water and other upstream uses.

FOLSOM OUTLET RELEASE DURING FALL 2002 TO PROVIDE COLD WATER FOR SALMONID RESOURCES IN THE LOWER AMERICAN RIVER

Throughout the summer of 2002 the U.S. Bureau of Reclamation and the CALFED Management Agencies (U.S. Fish and Wildlife Service (FWS), California Department of Fish and Game (DFG), and National Marine Fisheries Service(NMFS)) met with the American River Operations Group (AROG) to discuss the management of water temperatures in the lower American River below Nimbus and Folsom Dams to maintain suitable rearing conditions for oversummering juvenile steelhead. The NMFS Biological Opinion requires water temperature compliance below Nimbus Dam to protect juvenile steelhead between June 1 and November 30. Reclamation attempted to maintain temperatures at or below 651 F (measured at the Watt Avenue Bridge) using temperature shutters installed over the power penstock inlet ports on Folsom Dam. As the summer progressed Reclamation used the temperature shutters to blend cold water from the lower portions of the reservoir with higher temperature water to try to meet the water temperature objective at the Watt Avenue Bridge. By October the cold-water pool available to the temperature shutters was almost exhausted and adult fall-run chinook salmon were returning to the lower river to spawn. River temperatures in mid-October ranged from 62 - 651 F. These elevated water temperatures may cause prespawning mortality and reduce embryo viability (U.S. Fish and Wildlife Service. 1995.). These temperatures also exceed the 601 F criteria that is generally accepted by Central Valley fishery biologists as the maximum temperature at which chinook salmon will initiate spawning in the lower American River. See Figures Q.1 and Q.2 from Snider et.al. 1995.

The thermal requirements for Chinook salmon in the Central Valley have been evaluated in a few thermal physiological studies. In 1997 A.A. Rich reported to the California State Water Resource Control Board that thermal stress for migrating adult salmon had been reported at temperatures beginning at 591 F, and that temperatures demonstrated to be lethal began at 62.61 F. Incubating eggs were even more sensitive, and temperatures demonstrated to be lethal to incubating eggs began at 551 F (Rich, A.A. 1997). Rich based her testimony on results of thermal studies both within the Sacramento-San Joaquin River system and elsewhere indicating that constant exposure of salmonid eggs to temperatures above 131 C (55-561 F) will result in some egg mortality. See Figure Q.3, cited in U.S. Fish and Wildlife Service. 1995.

On October 24, 2002 the AROG recommended that a river outlet release from Folsom Dam be initiated to improve temperature conditions needed to provide suitable spawning habitat for fall-run chinook salmon in the lower American River. As a result of Folsom Reservoir cold-water pool supplies being significantly diminished, the only available cold water (less than 50,000 acre-feet (AF) of water below 601F) existed below the temperature shutters. See Figure Q.4. Access to the cold-water pool once it is below the temperature shutters is through releases from Folsom Dam=s lower river outlets which bypasses power generation. Consequently, AROG requested that the CALFED Agencies use Environmental Water Account (EWA) assets to pay for the foregone generation resulting from a river outlet release. The CALFED agencies concurred, and on October 25 a Folsom Dam river outlet located below the temperature shutters was opened and approximately 500 cfs of the remaining cold-water pool (at approximately 491F) was released resulting in a bypass of power generation. An additional 1,000 cfs continued to be released through the temperature shutters and penstocks. See Figure Q.5.

It took about three days for the cooler water released at Folsom on October 25 to circulate through Lake Natoma and decrease river temperatures at Nimbus Dam and the Watt Avenue Bridge. On October 25, the daily mean temperature below Nimbus Dam was 621F and by October 28 had decreased to 591F. The daily mean temperature at Watt Avenue Bridge on October 25 was 631 F and by October 29 had decreased to 601 F. Temperatures at Watt Avenue Bridge remained in the 57-591 range until the river outlet release was discontinued on November 19, 2002. See Figures Q.6 and Q.7. These water temperatures and flows were maintained in order to improve fall-run chinook salmon spawning habitat and provide sufficient flows over salmon redds during the egg incubation period.

The water released through the Folsom Dam lower river outlets did not generate hydroelectric power and represented a lost amount of energy to the Central Valley Project (CVP). The total amount of CVP water bypassed was 26,500 acre-feet. The amount of power foregone during this action was 6.52 GWH. EWA funds were used to compensate the Western Area Power Administration for lost power generation. EWA water was not used in this action.

Discussion - It is estimated that the 2002 river outlet release at Folsom Dam decreased temperatures in the lower American River and improved spawning conditions for fall-run Chinook salmon about 12 days earlier than what would have occurred without the bypass. See Figure Q.8. Prior to the river outlet release, temperatures in the river were approximately 631 F, which is above the 601 F spawning criteria and may have contributed to pre-spawning mortality. Within three days, temperatures in the lower American River had dropped to 601 F and remained in the 57-591 F range for the duration of the bypass.

In the fall of 2001 a similar situation took place, in which conventional temperature shutter operations were unable to maintain suitable temperatures in the lower American River during the salmon spawning season. Temperatures in the lower river in early November averaged 651 F and a significant pre-spawning mortality was reported by DFG. A lower river outlet release took place between November 10-26, which resulted in a decrease in lower river temperatures to 601 F by November 17. See Figure P.9.

It should be noted that conditions in 2001 were much worse than they were in 2002. Overall storage behind Folsom Dam was low (271 TAF), there was a very small cold-water pool (21 TAF) and releases to the lower American River were only 1,000 cfs.

	2001	2002
Date river outlet release started:	November 10	October 25
Folsom storage prior to outlet release:	270 TAF	464 TAF
Est. cold-water pool (<601F)	21 TAF	50 TAF
Avg. water temp at Watt Br. prior to outlet release:	63.71F	62.71F
Average daily air temperature:	611F	611F
Total release to River:	1,000 cfs	1,500 cfs
Fall-run escapement (preliminary):	130,785	118,114
Pre-spawn mortality (preliminary):	67%	30%

In hindsight, it could be argued that the river outlet release in 2001 should have been initiated sooner. The AROG knew that pre-spawning mortality was taking place, but did not know the severity of the problem. They were also keenly aware that the cold-water pool was limited and were concerned that the cold water would be exhausted before the spawning season was over and/or natural fall cooling would start to drop river temperatures. Given the circumstances the AROG made their request based on what the group thought was the best use of the remaining cold water.

In 2002 more cold-water assets were available and the group used what they had learned from their experience in 2001 to initiate the river outlet release earlier in the season. Even with more cold water and a relatively early bypass, pre-spawning mortality was still approximately 30%.

In both years DFG biologists reported that spawning initiated when river temperatures approached 601F. The river outlet release operations in 2001 and 2002 were successful in decreasing water temperatures in the lower American River and improved spawning conditions for fall run chinook salmon.

References:

Rich, A.A. 1997. Appendix A. Water Temperature Requirements for Chinook Salmon and Steelhead Trout. Testimony of Alice A. Rich, PH.D., Submitted to State Water Resources Control Board. July 1997. 14 pp.

Snider, B. and K. Vyverberg. 1995. Chinook salmon redd survey: lower American River, fall 1993. California Department of Fish and Game, Environmental Sciences Division, Stream Flow and Habitat Evaluation Program. Sacramento, CA.

U.S. Bureau of Reclamation. 1992a. Long-term Central Valley project operations criteria and plan CVP-OCAP. October 1992. Sacramento, CA.

U.S. Fish and Wildlife Service. 1995. Working paper: habitat restoration actions to double natural production of anadromous fish in the Central Valley of California. Volume 2. May 9, 1995.

Yaworsky, Russ. Hydrologist. U.S. Bureau of Reclamation, Sacramento, CA. Temperature summaries for Folsom Lake and lower American River, and graphs of estimated temperature effects of river outlet blending in 1991 and 1992. Information provided to the American River Operations Group in 2001 and 2002.

Figure Q.1

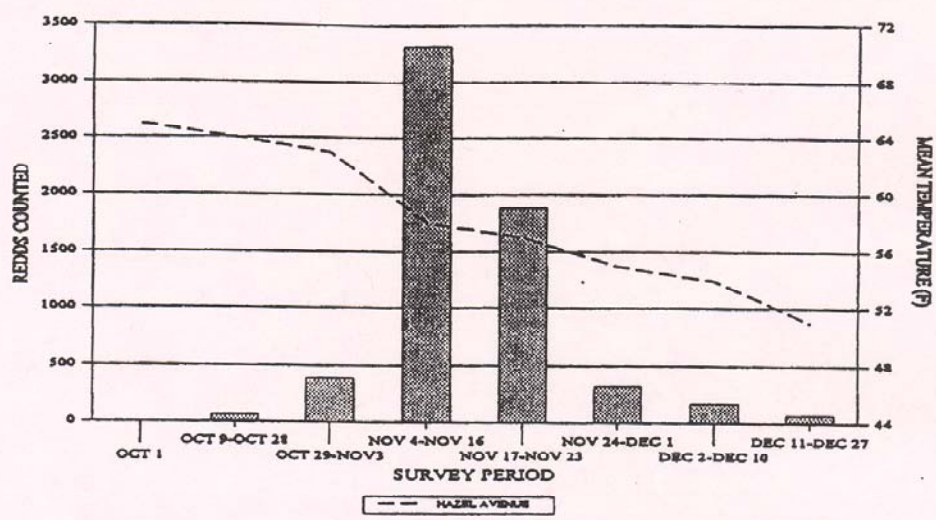


Figure '.1. Number of fall-run chinook salmon redds versus mean temperature during each survey period, lower American River, fall 1993.

Figure Q.2

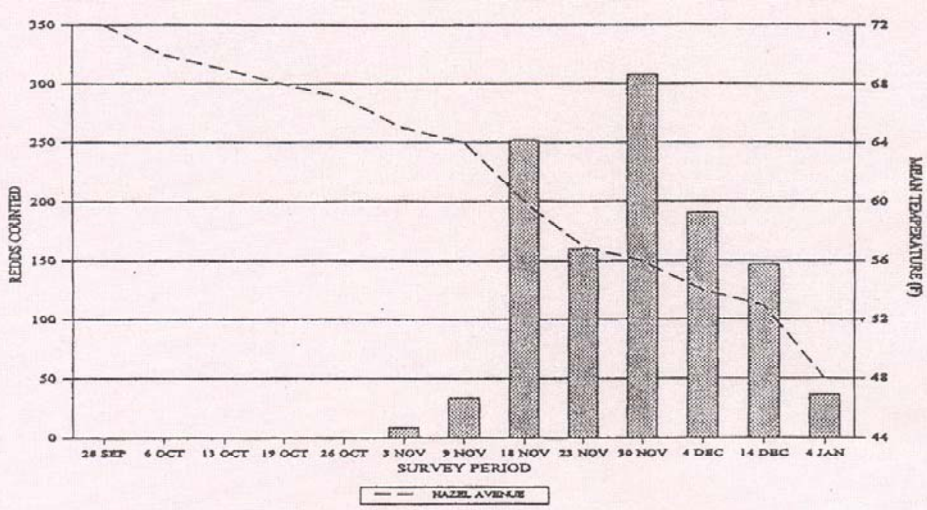
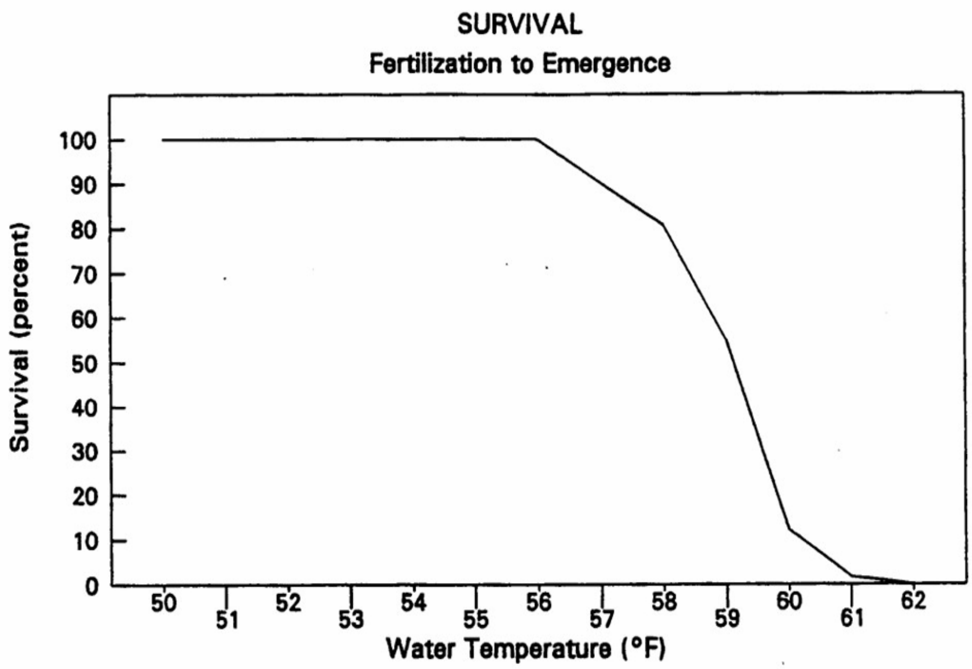


Figure 2. Number of fall-run chinook salmon redds versus mean temperature during each survey period, lower American River, fall 1992.

FIGURE 3 CHINOOK SALMON EGG AND LARVAL DEVELOPMENT TIME AND SURVIVAL VERSUS WATER TEMPERATURE



SOURCE: U. S. Bureau of Reclamation 1992a.

Figure Q.4

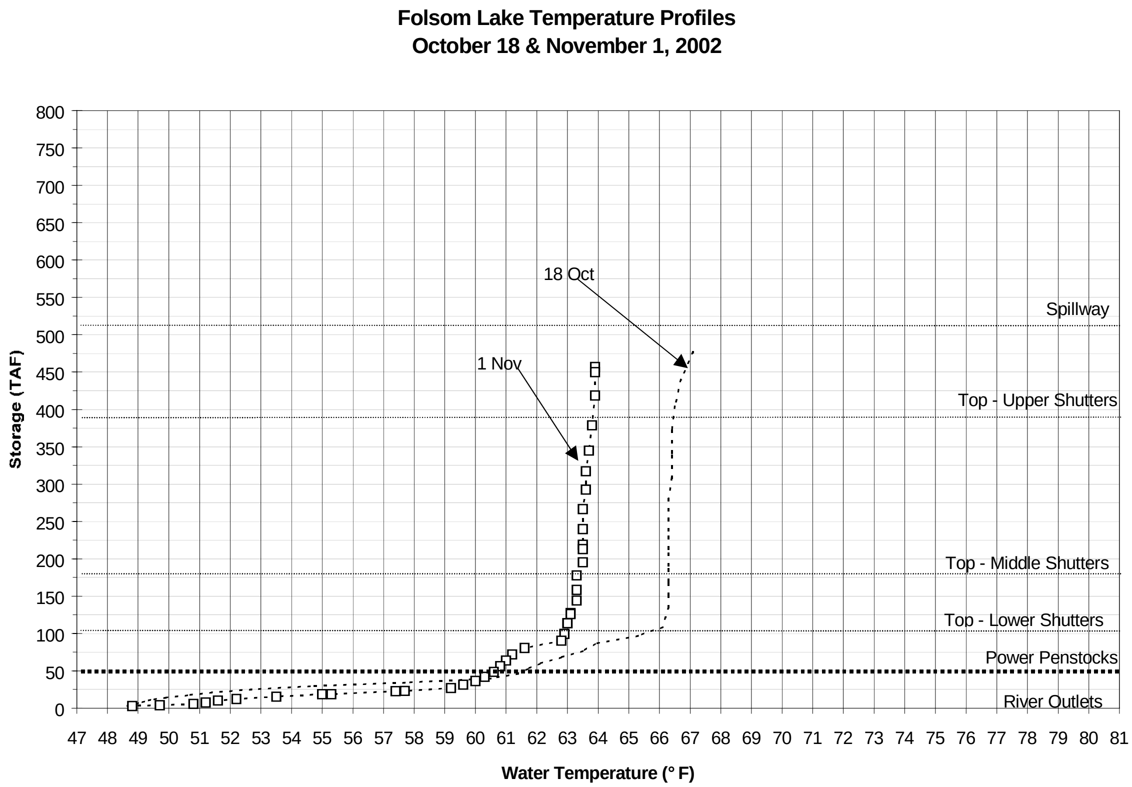


Figure Q.5

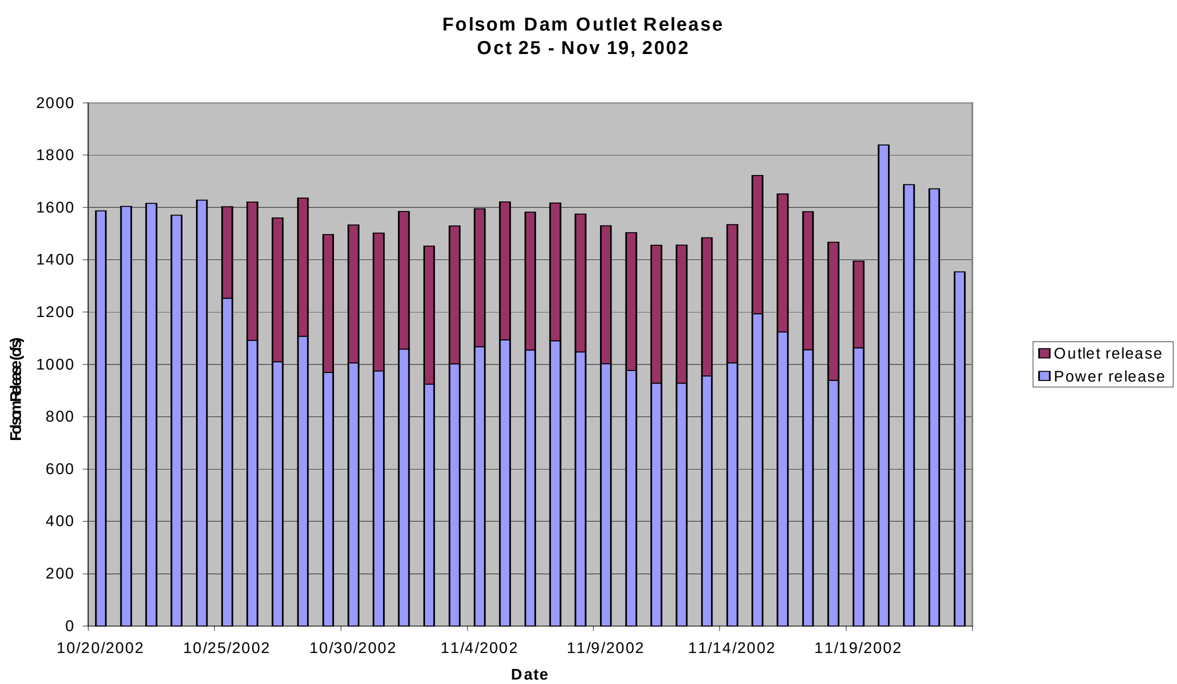


Figure Q.6

Summary for Folsom Lake and Lower American River - October 2002

Day	Mean Daily Water Temperature (?F) NFA	ARP	AFD	Penstock Units 1-3	AHZ	AWP	AWB	EOP Stor (TAF) Folsom	Release (cfs) Nimbus	Sacramento Mean Daily Air Temperature (?F)
1	64.3	#	64.6	O M(65) L(35)	63.8	64.2	64.8	507.3	1,508	66
2	62.4	#	64.4	O M(65) L(35)	63.0	63.4	63.4	505.0	1,506	68
3	61.6	#	63.1	O M(65) L(35)	62.2	63.3	63.7	502.6	1,507	69
4	62.6	#	62.5	O M(65) L(35)	63.2	64.2	64.9	500.6	1,505	73
5	63.7	#	64.7	O M(65) L(35)	63.8	65.0	65.8	498.6	1,505	75
6	64.5	#	63.0	O M(65) L(35)	63.8	65.4	66.5	496.9	1,508	76
7	64.9	#	61.7	O M(65) L(35)	64.5	65.6	66.7	494.9	1,512	79
8	65.2	#	64.3	O M(65) L(35)	64.5	66.0	67.1	494.0	1,508	79
9	65.1	#	64.2	O M(65) L(35)	64.1	65.6	66.7	493.5	1,506	77
10	64.5	#	64.1	O M(65) L(35)	64.0	64.5	65.2	492.3	1,504	65
11	63.4	#	62.7	O M(65) L(35)	63.9	64.3	64.3	490.5	1,506	66
12	62.4	#	62.8	O M(65) L(35)	63.8	64.5	64.9	488.4	1,507	69
13	62.2	#	63.7	O M(65) L(35)	63.6	64.6	65.1	486.0	1,504	72
14	62.1	#	63.8	O M(65) L(35)	63.7	64.6	65.2	483.5	1,508	75
15	61.6	#	62.8	O M(65) L(35)	63.7	64.3	64.8	482.4	1,511	65
16	61.4	#	63.4	O M(65) L(35)	63.5	64.0	64.3	480.6	1,507	64
17	60.8	#	62.6	O M(65) L(35)	63.2	63.8	63.9	479.0	1,504	63
18	60.4	#	62.9	O M(65) L(35)	62.8	63.5	63.7	477.1	1,511	62
19	60.4	#	63.1	O M(65) L(35)	62.9	63.6	63.8	474.3	1,507	67
20	60.3	#	63.2	O M(65) L(35)	63.0	63.7	64.1	471.1	1,503	67
21	60.2	#	62.8	O M(65) L(35)	63.0	63.7	64.2	468.7	1,507	69
22	59.8	#	62.6	O M(65) L(35)	63.2	63.6	63.9	467.1	1,501	61
23	59.5	#	62.6	O M(65) L(35)	63.0	63.3	63.3	464.8	1,505	57
24	57.1	#	62.9	O M(65) L(35)	62.5	62.5	62.3	463.7	1,502	56
25	54.2	#	* 59.9	O M(0) L(100)	62.0	62.6	62.7	463.6	1,503	63
26	53.8	#	* 57.9	O M(0) L(100)	61.9	62.3	62.4	462.4	1,507	62
27	54.1	#	* 57.7	O M(0) L(100)	60.2	61.7	62.2	460.5	1,564	63
28	53.3	#	* 57.6	O M(0) L(100)	59.1	60.4	61.1	459.4	1,503	65
29	52.6	#	* 57.5	O L(0) L(100)	58.4	59.5	60.0	458.4	1,503	63
30	51.9	#	* 57.4	O L(0) L(100)	58.2	58.9	59.0	457.4	1,502	60
31	51.2	#	* 57.3	O L(0) L(100)	57.7	58.3	58.2	456.8	1,511	55
Average	60.0		62.1		62.6	63.4	63.8		1,508	67
Total af									92,717	

! Includes incomplete or estimated data
N Data not recorded or collected
Station out of service
Shutter Position (U-Upper raised; M-Middle raised; L-Lower raised; A-All lowered; O-Unit Offline)
* See notes on next page
Penstock Unit Blending (a value in parentheses represents approximate % total daily load)

Figure Q.7

Summary for Folsom Lake and Lower American River - November 2002

Day	Mean Daily Water Temperature (?F) NFA	ARP	AFD	Penstock Units 1-3	AHZ	AWP	AWB	EOP Stor (TAF) Folsom	Release (cfs) Nimbus	Sacramento Mean Daily Air Temperature (?F)
1	50.5	50.5	* 57.2	O L(50) L(50)	57.7	57.7	57.5	456.6	1,502	55
2	49.9	49.6	* 57.0	O L(50) L(50)	57.2	57.4	57.2	455.7	1,502	54
3	49.7	50.0	* 57.2	O L(50) L(50)	57.0	57.4	57.2	454.1	1,509	59
4	49.6	49.9	* 57.1	O L(50) L(50)	56.8	57.2	57.1	453.7	1,500	58
5	49.7	49.4	* 56.8	O L(0) L(100)	56.8	57.2	57.1	452.5	1,504	59
6	50.0	49.6	* 57.1	O L(50) L(50)	56.8	57.1	57.0	451.0	1,504	57
7	51.2	51.2	* 57.6	O L(50) L(50)	56.7	57.3	57.4	450.8	1,506	60
8	53.9	53.0	* 57.9	O L(50) L(50)	56.5	57.9	58.3	451.3	1,509	63
9	55.1	52.1	* 58.3	O L(50) L(50)	56.9	57.5	57.6	455.4	1,511	59
10	54.2	51.7	* 58.4	O L(50) L(50)	57.4	57.6	57.4	456.0	1,504	57
11	53.1	51.8	* 58.0	O L(50) L(50)	57.3	58.0	58.0	458.4	1,504	58
12	52.6	51.2	* 57.6	O L(50) L(50)	57.6	58.3	58.2	460.2	1,503	61
13	53.4	51.7	* 57.4	O L(50) L(50)	57.6	58.4	58.7	460.8	1,504	60
14	52.7	50.7	* 57.6	O L(50) L(50)	57.7	58.2	58.1	461.4	1,506	60
15	51.8	49.7	* 57.8	O L(50) L(50)	57.5	58.0	57.9	461.8	1,505	57
16	51.8	49.6	* 57.8	O L(50) L(50)	57.4	58.0	58.0	461.8	1,504	56
17	51.4	49.9	* 57.4	O L(50) L(50)	57.4	57.7	57.6	460.5	1,507	55
18	50.6	49.3	* 57.4	O L(50) L(50)	57.3	57.6	57.2	459.8	1,502	56
19	50.4	48.8	* 57.5	O L(50) L(50)	57.0	57.4	57.0	459.8	1,510	53
20	50.9	49.3	57.9	O L(50) L(50)	57.0	57.5	57.4	458.2	1,509	58
21	51.4	49.3	57.8	O L(50) L(50)	57.2	57.6	57.4	457.4	1,504	! 59
22	52.1	49.8	57.5	O L(50) L(50)	57.4	57.8	57.6	456.3	1,508	! 56
23	52.5	50.8	57.7	O L(0) L(100)	57.5	57.6	57.5	455.9	1,738	52
24	52.2	50.9	57.5	O L(0) L(100)	57.3	57.5	57.3	453.4	1,758	55
25	51.6	50.9	57.5	O L(50) L(50)	56.9	57.4	57.2	452.2	1,756	59
26	49.7	48.6	57.3	O L(50) L(50)	56.7	56.8	56.3	452.0	1,755	55
27	49.2	48.0	57.2	O L(50) L(50)	56.5	56.6	56.2	451.1	1,753	52
28	49.1	47.8	57.0	O L(50) L(50)	56.6	56.6	56.2	449.7	1,752	53
29	48.1	46.7	56.8	O L(50) L(50)	56.5	56.5	56.0	447.8	1,759	53
30	47.5	46.5	56.6	O L(50) L(50)	56.3	56.1	55.5	446.5	1,753	49
Average	51.2	49.9	57.5		57.1	57.5	57.3		1,571	57
Total af									93,502	

! Includes incomplete or estimated data

N Data not recorded or collected

\# Station out of service

Shutter Position (U-Upper raised; M-Middle raised; L-Lower raised; A-All lowered; O-Unit Offline)

* See notes on next page

Penstock Unit Blending (a value in parentheses represents approximate % total daily load)

Figure Q.8

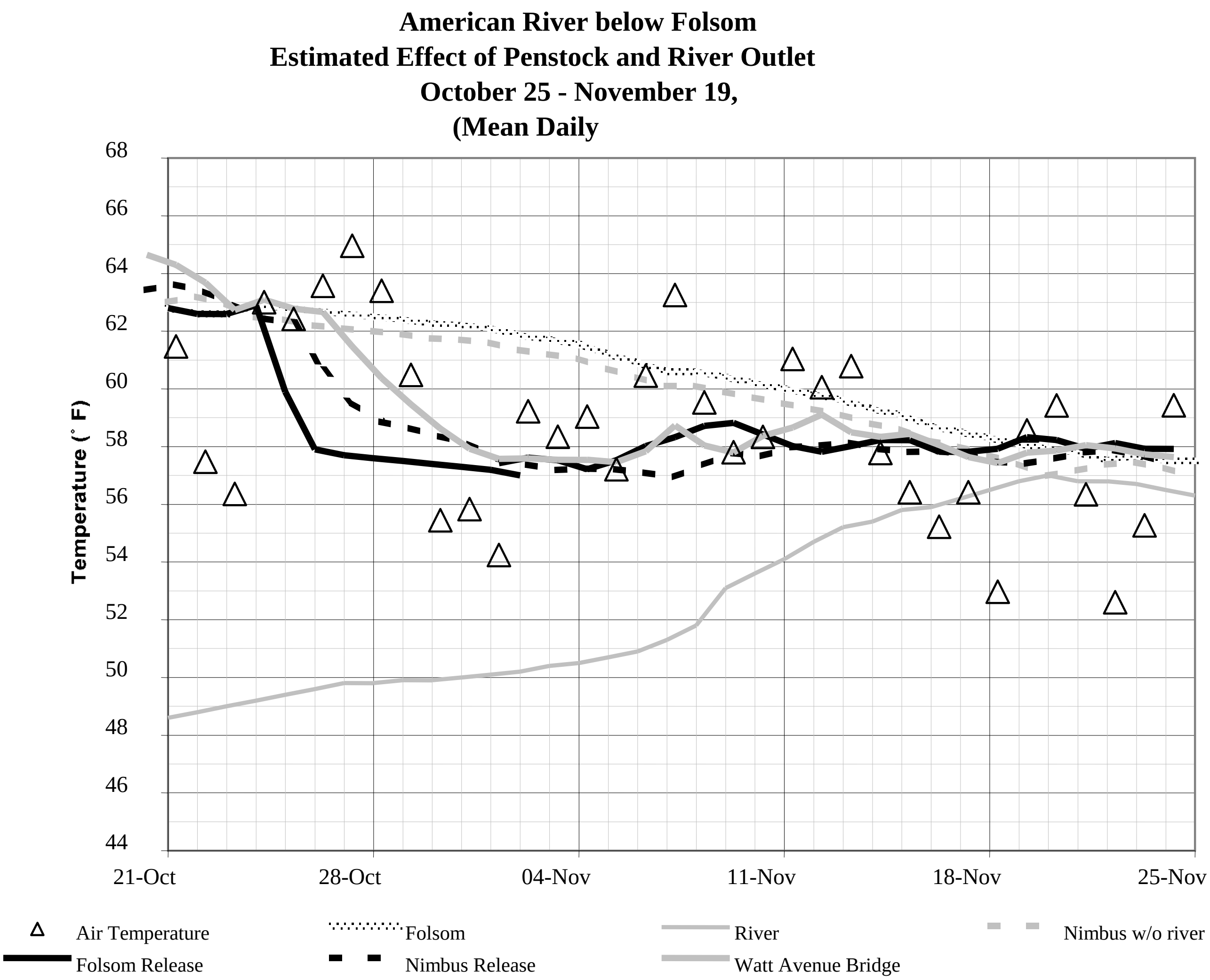
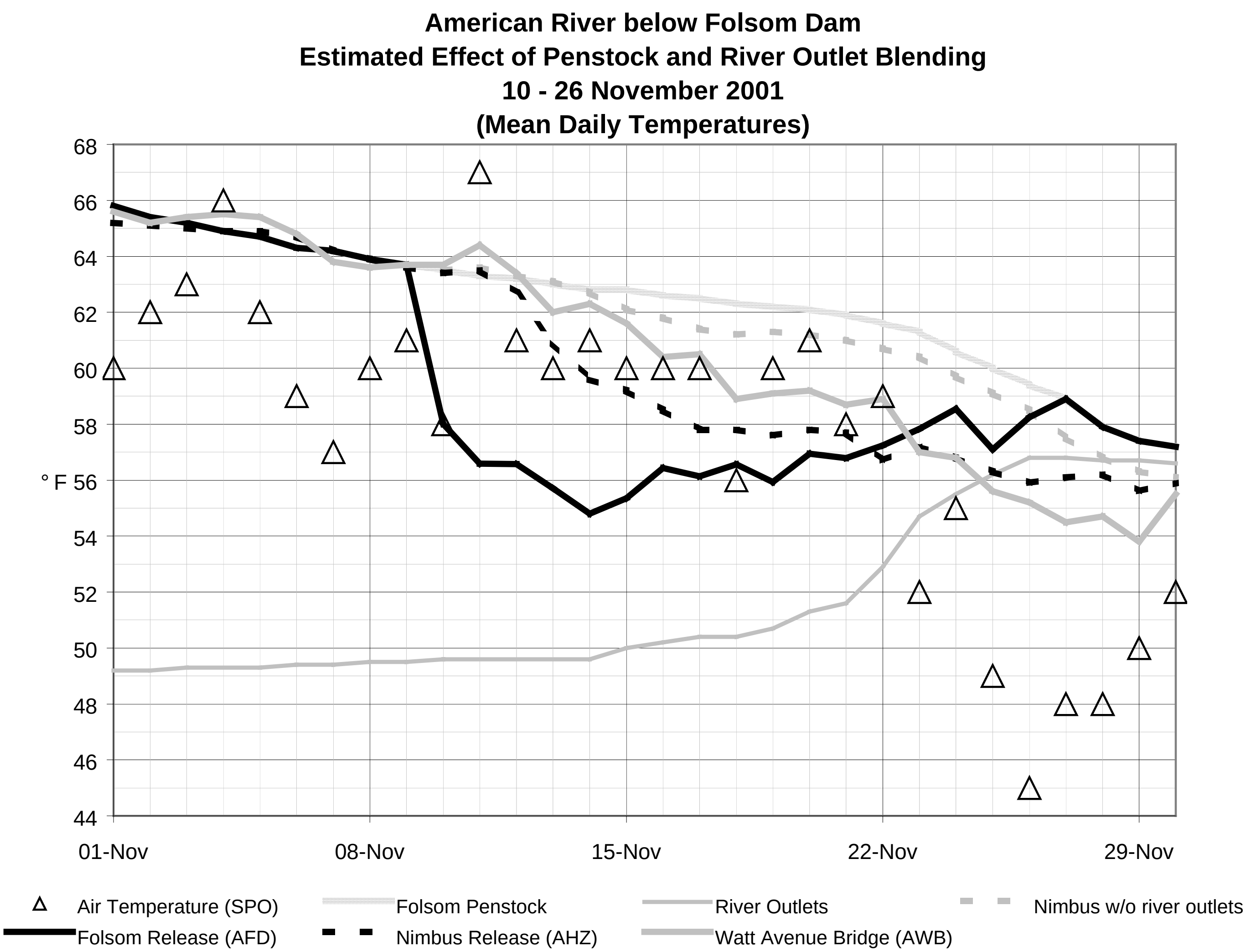

American River below Folsom
Estimated Effect of Penstock and River Outlet
October 25 - November 19,
(Mean Daily
68
66
64
62
60
58
56
54
52
50
48
46
44
Temperature (˚ F)
21-Oct
28-Oct
04-Nov
11-Nov
18-Nov
25-Nov
Air Temperature
Folsom
River
Nimbus w/o river
Folsom Release
Nimbus Release
Watt Avenue Bridge

Figure Q.9


American River below Folsom Dam
Estimated Effect of Penstock and River Outlet Blending
10 - 26 November 2001
(Mean Daily Temperatures)
68
66
64
62
60
58
° F 56
54
52
50
48
46
44
01-Nov
08-Nov
15-Nov
22-Nov
29-Nov
Air Temperature (SPO)
Folsom Penstock
River Outlets
Nimbus w/o river outlets
Folsom Release (AFD)
Nimbus Release (AHZ)
Watt Avenue Bridge (AWB)

R. Review existing salmon life cycle models

Although we have not yet developed a complete life cycle model for any of the Central Valley Chinook salmon races, we have made considerable progress toward defining the components needed to assemble a quantitative life cycle synthesis for the endangered Sacramento River winter-run Chinook salmon. We have looked at quantitative relationships in the freshwater life phase, between the number of spawners, and the timing and number of juveniles migrating to the ocean. NMFS staff has also developed a complete cohort reconstruction for winter-run Chinook throughout their ocean life phase, based on recent coded-wire tagging studies.

The California Urban Water Agency (CUWA) has initiated development of an integrated life cycle model for winter-run Chinook. The purpose of the model is to assist resource managers and water users in understanding biological responses resulting from ecosystem restoration and water management actions. As part of the first step in model development, several existing salmon models were reviewed, and a conceptual modeling framework and prototype quantitative model have been developed. The final model will be founded on the winter-run life cycle, and will incorporate both science and policy in a common framework to inform decision-makers.

Reference: Cramer, S.P., M. Daigneault, M. Teply, and R2 Resource Consultants. 2003. Step 1 Report, Review Draft, Conceptual Framework for an Integrated Life Cycle Model of Winter-run Chinook Salmon in the Sacramento River. August 2003.

S. Evaluate CVP/SWP affects using GS/Ryde survival versus export equation to help resolve uncertainty pertaining to total and direct export mortality

Additional analyses have been done using the change in Gs/Ryde survival ratios relative to exports to mathematically estimate the relative effects of exports on juvenile salmon survival. The number of smolts affected by the change in survival due to exports is estimated using the percent of water diverted into the interior Delta through the DCC and Georgiana Slough. Estimates have been made comparing the relative effects of total export mortality and direct mortality of winter run migrating through the Delta between 1993 and 2003 (Brandes, Salmon Workshop 7/2003). The percent of winter run each year diverted into the interior Delta was estimated using the percent of water diverted into the interior Delta in December. This analysis showed that total export related mortality ranged between 4 and 18% each year and averaged 9%. Direct mortality (based on loss) averaged 0.5% for the same years (Figure S.1).

Further field research by the DCC team is planned for the fall of 2003 on the question of what percent of salmon are diverted into Georgiana slough when the DCC gates are closed.

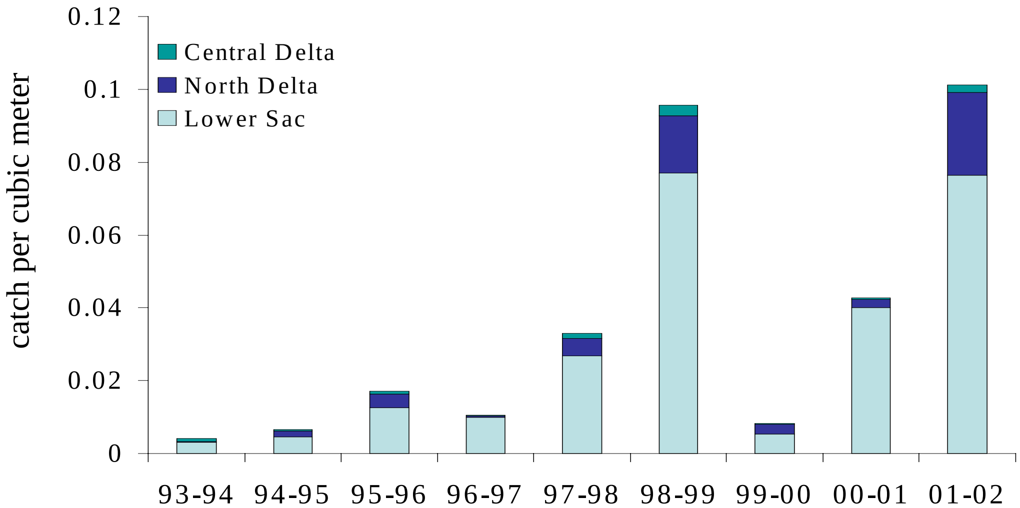
Figure S.1

Year	X D-A 15 Exports	GS/Ryde ratio	Ryde survival	% in mainstem	Interior Delta survival	% in interior Delta	Combined Delta survival	change (%) in survival	
1995-1996	5143	0.30	0.80	74	0.24	26	0.65		
1995-1996	0	0.50	0.80	74	0.40	26	0.70	0.07	
1996-1997	5418	0.29	0.80	85	0.23	15	0.71		
1996-1997	0	0.50	0.80	85	0.40	15	0.74	0.04	
1997-1998	4858	0.31	0.80	83	0.25	17	0.71		
1997-1998	0	0.50	0.80	83	0.40	17	0.73	0.04	
1998-1999	9000	0.14	0.80	85	0.12	15	0.70		
1998-1999	0	0.50	0.80	85	0.40	15	0.74	0.06	
1999-2000	7550	0.20	0.80	69	0.16	31	0.60		
1999-2000	0	0.50	0.80	69	0.40	31	0.68	0.12	
2000-2001	7687	0.20	0.80	60	0.16	40	0.54		
2000-2001	0	0.50	0.80	60	0.40	40	0.64	0.18	
2001-2002	9234	0.13	0.80	81	0.11	19	0.67		
2001-2002	0	0.50	0.80	81	0.40	19	0.72	0.08	
2002-2003	9516	0.12	0.80	75	0.10	25	0.62		
2002-2003	0	0.50	0.80	75	0.40	25	0.70	0.12	
							mean	0.09	

T. Determine Extent of Delta Rearing

A cursory analyses was done evaluating winter and fall run fry catch by area (lower Sacramento River, North, Central and South Delta). We found that most salmon in the winter run size criteria between November and February were caught in the lower Sacramento River as compared to the North Delta or central Delta beach seining sites. In contrast fall run between January and March were caught more equally between the lower Sacramento River and North Delta. Relatively more fall run were caught in the central Delta than winter run. (Figures T.1 and T.2).

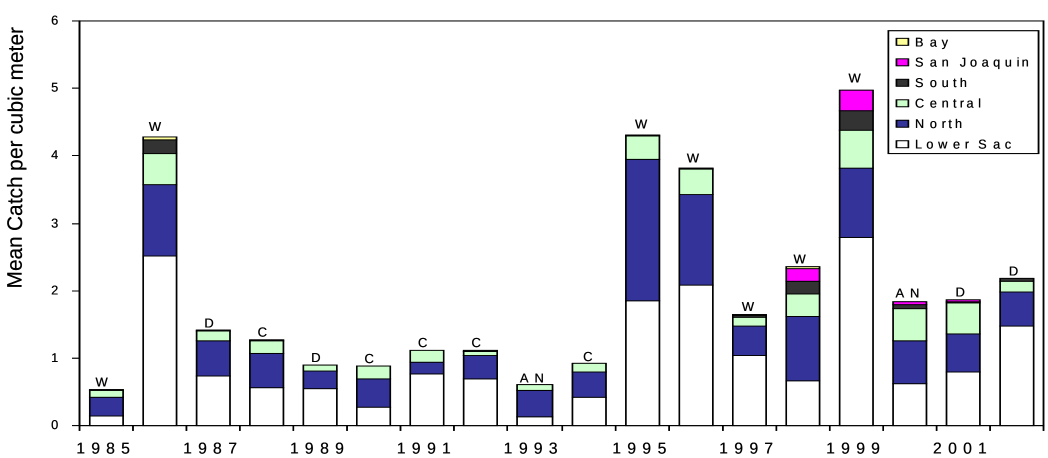
Figure T.1



Mean catch per cubic meter of winter run sized salmon (November – February).

Where do most of the winter run rear?

Figure T.2



Mean catch per cubic meter (Jan- Mar)

Where are fall/spring run fry in the Delta ?
Where are they rearing?

Bay sampling (1985,1986, 1997-2002)
SJ sampling (1998-2002)

U. Discrepancies between river and Delta mortalities

We were unclear what discrepancies were being referred to in your recommendations. We need further understanding on this issue to address it.

During discussions with the panel in October of 2002, Jim Cowen questioned the results at Chipps Island of the differential recovery of the Ryde group relative to the Georgiana Slough group. He thought a possible explanation was that those released in the interior Delta were growing at a faster rate, making them less vulnerable to being caught in the trawl at Chipps Island. To follow up on this question, I looked at differences between the mean recovery size at Chipps Island relative to the mean recovery size at the State Water Project or Central Valley Project. I assumed that the CWT fish salvaged at the fish facilities would not be biased for size. In 6 of the 11 Georgiana Slough, late-fall releases, released between 1993 and 2002, mean size of recovery was greater at Chipps Island than at the SWP and/or CVP indicating no size difference in the recovery of these CWT yearlings at Chipps Island or at the fish salvage facilities.

V. Better Communication About Growth and Mortality in the Delta

The panel recommended that growth and mortality be measured in the Delta. Some data on growth and survival has been measured in the Delta and we are unsure how to use the data to assess the benefits of EWA for salmon. More specifics on how it could be used for this purpose would be welcomed. A general summary of what has been done relative to measuring growth and mortality is provided below.

Juvenile salmon have been sampled routinely at various locations in the Delta since the 1970's. All salmon caught are enumerated and most are measured. The data is housed on the IEP data server and is update frequently. One problem of estimating growth in different areas of the Delta is the uncertainty of how long that individual has been at that location, since it could immigrate or emigrate from one area to another at any time.

To address this issue average length at recovery has been compared to average length at release for individuals within a coded wire tagged group. This apparent growth has been reported for fry in Kjelson 1982 and was used to determine if it could explain why fry survival upstream was greater than in the Delta in wet years in Brandes and McLain, 2001. Growth for shorter periods of time would also be available using the average release and recovery lengths of smolts and yearlings for fall, late-fall and winter run that are released and/or recovered in sampling in the Delta.

In addition, researchers are using otoliths to measure juvenile chinook salmon growth in the Central Valley (Titus et.al. 2003 and McFarlane, 2001). Titus specifically has been systematically collecting specimens through-out the Central Valley for several years, but as of yet has not analyzed all of the data (Titus, personal communication).

Survival has been measured for marked fish released through-out the Delta since 1978. Comparative evaluations of survival between release locations have been made for fry released in the interior Delta versus mainstem Sacramento River and upstream versus Delta releases. The results of these studies are available in Brandes and McLain, 2001. The results of survival indices and estimates for smolts and yearlings are also discussed in Brandes and McLain, 2001. Ken Newman's models use the wealth of the survival information to determine how certain factors influence fall run hatchery smolt survival through the Delta.

W. Statistical Help

The IEP and Salmon EWA biologists need additional statistical expertise. We have been using Ken Newman on a contract basis for specific questions, but a full time permanent statistician/modeler is needed to help design studies, test data, and interpret results. The VAMP studies, Delta Action 8 studies and general monitoring projects are a few that could be helped with additional statistical expertise. The determination of sample sizes, sensitivity analyses and modeling could all be done in house on a variety of projects instead of on an ad hoc basis when Ken is available. We will continue to formalize our statistical and modeling needs and convey them to management and CALFED to meet this unfunded need.

X. Long term monitoring needs

To determine if EWA and any others actions have increased the production of salmon a large and comprehensive monitoring program needs to be in place. Assessing actions on the number of returning adults does not consider the annual variation in the fishery, ocean conditions or age structure of the population. Juvenile assessments of actions taken inland for salmon are more direct, but also would not translate directly to adult numbers unless there are no density dependent affects in the ocean. Large scale and long term monitoring, both inland and in the ocean, are needed to determine if actions have been successful. While research may be able to answer the why questions, if we do not index the population sizes at different life stages, we cannot hope to link the two. The largest impediment to determining whether actions during the juvenile life-stage are impacting adult numbers is aging the ocean catch and escapement and marking a representative sample of all hatchery releases. Estimating and aging the inland catch would complete population assessments of the adult life-stage for each year class. Indexing the juvenile production leaving each stream each year in conjunction with estimating the adult contribution rates (ocean and inland fishery and in the escapement) would provide a means to measure survival in each stream to assess the benefits of any local actions.

Each monitoring method has limitations and biases. A successful and robust monitoring effort measures the parameter of interest in multiple ways. Thus a complete and comprehensive monitoring program will be an expensive investment and a long-term commitment. But without one there is no hope of measuring whether the population is increasing, decreasing or staying the same because of any action or even suite of actions occurring inland. Monitoring also provides the means to develop relationships to use in modeling and predicting outcomes of present and future actions.

Y. Developing conceptual models

Conceptual models are needed to document how factors affect the survival and behavior of salmon at different lifestages. It is also important to compare differing conceptual models so that key uncertainties can be addressed with future monitoring or research. For example in one forum, several biologists provided their conceptual models of how juvenile salmon migrate through the north Delta. It was useful to identify the various models and their differences and recommend future studies based on the comparisons. In this process the conceptual models helped organize and document the differing hypothesis to assess changes due to a proposed “Through Delta Facility”, transferring water through the interior Delta, and to guide future research.

Z. Participate in developing performance measures

We have developed performance measures for the specific goals of the EWA for salmon. Broader performance measures are being considered by others in this and other CALFED forums. We support those processes in developing realistic, comprehensive and meaningful measures of performance to determine the benefits of EWA actions, as well as collaborative CALFED programs and restoration and other actions to improve the health and sustainability of the ecosystem, which include setting a trajectory to restoring endangered species.