ABUNDANCE AND SURVIVAL

OF

JUVENILE CHINOOK SALMON

IN THE

SACRAMENTO-SAN JOAQUIN ESTUARY

2000 ANNUAL PROGRESS REPORT
STOCKTON FISH AND WILDLIFE OFFICE
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We extend particular gratitude to the many biological science field technicians that spent countless hours under all environmental conditions to collect data.

Introduction

The Delta Juvenile Fish Monitoring Program (DJFMP) at the Stockton Fish and Wildlife Office (STFWO) has been monitoring populations of juvenile Chinook salmon *(Oncorhynchus tshawytscha)* in the lower Sacramento River and Delta since the late 1970s. The program and its goals have evolved since then based on water management actions and endangered species listings. Prior to 1982, the program focused on monitoring juvenile salmon abundance and determining how reduced river flows would affect the survival of young salmon. After 1982 (the defeat of the Peripheral Canal proposal), part of the focus was changed to evaluate the impact of through-Delta water conveyance on juvenile salmon survival. The greatest change in the program occurred in 1992-1993 in response to the Federal Endangered Species listing of winter-run salmon. The Sacramento River winter-run race was listed by the state as "endangered" in May 1989 (California Code of Regulations, Title XIV, section 670.5, Filed 22 September 1989), and federally listed as "endangered" by the National Marine Fisheries Service (NMFS) in February 1994 (59 FR 440). The listing encouraged the Bureau of Reclamation to fund salmon monitoring in the lower Sacramento River and Delta between September 1 and May 31 of each year. Other listings of salmonids in the Central Valley followed. In 1998, the Central Valley steelhead was federally listed as threatened. Spring-run Chinook salmon was listed as threatened by the State of California in February 1999 and federally listed in November 1999. The DJFMP program responded by creating a sampling program that operates throughout the year at the entry (Sacramento and Mossdale) and exit (Chipps Island) points of the Delta and in areas where the fish reside (lower Sacramento and San Joaquin Rivers, Delta, and Bay). Annual reports have been written for each year to document sampling effort and summarize findings and are available from the STFWO.

Although the DJFMP monitors populations of juveniles from all fish species, this report will focus on Chinook salmon, the program's primary target species. Future reports will include long-term trends for all species.

Work in 2000 was conducted to update and refine our knowledge of the factors influencing the abundance, distribution, and survival of juvenile Chinook salmon in the Sacramento-San Joaquin Estuary. Field sampling and special studies were conducted with various sampling gears between August 1, 1999, and July 31, 2000 (referred to as the 2000 field season) as juveniles reared and migrated through the lower Sacramento and San Joaquin Rivers, Delta, and Bay.

Objectives in the 2000 field season were to:

1. Monitor relative abundance, distribution, and timing of juvenile Chinook salmon rearing and migrating through the lower Sacramento and San Joaquin Rivers, the Delta, and portions of San Francisco Bay.

2. Determine relative survival (using fall and late-fall hatchery smolts) of juvenile salmon released in the upper river and Delta, and identify potential factors influencing survival.

Midwater trawling, Kodiak trawling, and beach seining were employed at varying times and locations in the Delta, lower Sacramento and San Joaquin Rivers, and parts of the San Francisco Bay. Different sized juveniles of Chinook salmon presumably have distinct spatial and temporal distributions making them vulnerable to different gear types.

Race Delineation

The STFWO conducts one of several salmon monitoring programs within the Central Valley that use size and date of capture to determine juvenile Chinook salmon race in the lower Sacramento River and Delta. The size criterion was developed by Frank Fisher, of CDFG in 1992 and later modified to a daily criterion by Sheila Greene of California Department of Water Resources. At this time, it is the main tool used to determine race of juvenile salmon in the field. However, several problems exist regarding its validity that have been discussed in past reports (United States Fish and Wildlife Service 1995). For these reasons, the race designations used in this report should be used as only a rough approximation and not interpreted as definitive. Research on various markers for genetic differentiation of races is ongoing and may help determine true race of Central Valley salmon juveniles sampled in the future (e.g., Hedgecock et al. 2001, Greig et al. 2003).

In this report, fish identified as spring- and fall-run races according to the size criteria were combined into a "spring-/fall-run" group due to potential hybridization of these two races in the mainstem Sacramento River and at the hatcheries. Spring-run yearlings originating from Deer or Mill Creeks are likely categorized as late fall- or winter-run based on size criteria.

Late fall-run salmon enter the Delta on their way to the Pacific Ocean either as fry in spring and summer or as smolts/yearlings in fall and winter. These different life history characteristics within a brood year cause catches from multiple brood years to occur in one field year (August-July). As a result, in addition to total late fall-run catch, we report individuals from each brood year class for late fall-run fish.

Life Stage Delineation

Fish are classified as sac fry, fry, parr, silvery parr, smolt, and adult life stages in the field based on external characteristics including the presence or absence of an external yolk sac, visible parr marks, or deciduous scales. However, for this report, we used a fork length as a rough estimate of life stage as a simplified classification scheme. We defined fry as ≤70 mm fork length (FL). Juveniles that were >70 mm (FL) were defined as smolts because this is the approximate size at which they begin undergoing behavioral and physiological changes in preparation for transition to salt water. Because designation of life stages of juvenile Chinook depends primarily on the physiological state of a fish, fork length does not clearly define stages.

Escapement

To help understand patterns in abundance of juvenile salmon populations in the Delta, it is useful to view patterns in adults returning upstream to spawn for each race. These data were obtained by referencing Grand Tab, a Microsoft Excel spreadsheet that contains estimates of all races of Chinook salmon returning to a variety of locations within the Delta, commonly referred to as “escapement.” Grand Tab is regularly maintained and updated by CDFG, Inland Fisheries Division, Red Bluff. In particular, we focused on fish passing the Red Bluff Diversion Dam (RBDD) in the upper Sacramento River, returning to the Coleman National Fish Hatchery (CNFH), and other notable locations (Feather River, American River, and the combination of Stanislaus, Tuolumne, and Merced Rivers). The Feather and American Rivers were chosen because they empty into the Sacramento River downstream of the RBDD and generally support large spawning populations of fall-run Chinook salmon. The Stanislaus, Tuolumne, and Merced Rivers were chosen because, when combined, they represent the major tributaries of the San Joaquin River.

In order to obtain accurate escapement estimates at the RBDD, the gates must be in the closed position. Since 1993, this has not occurred during the late fall upstream migration. Gates are used to maximize RBDD diversion capabilities. The only time the gates can be closed, because of new regulations by NMFS in 1993, is May 15 through September 15. To account for this, returns to CNFH were used as late fall escapement estimates between 1993 and 1998. Since 1998, carcass surveys have been used.

Estimates of winter-run returns in 2000 were less than half of those from the previous two years (n = 1350 fish, Fig. 1). Spring-/fall-run returns were the fifth highest since 1978 (n = 87,793 fish). Late fall-run escapement in 2000 was 8632 fish, slightly lower than the previous year, but still much greater than 1993-96 estimates.

Fall-run escapements in the Feather and American Rivers were the highest on record (Fig. 2). Both escapement estimates exceeded 110,000 fish. Combined spawner population estimates from the Stanislaus, Tuolumne and Merced Rivers have been increasing since the early 1990's and estimates in 2000 were the highest since 1985.

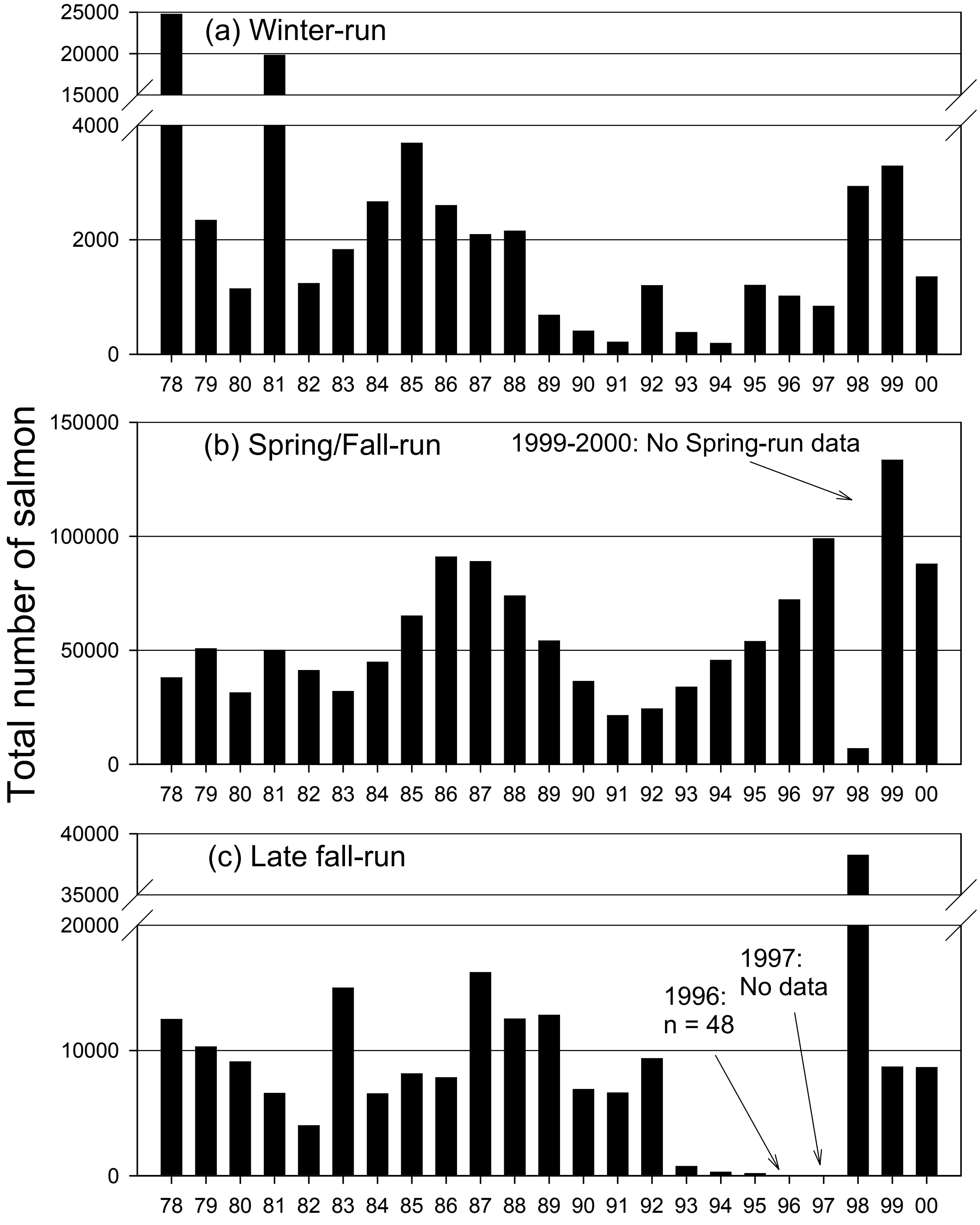

Figure 1. Yearly escapement estimates of adult (a) winter-, (b) spring-/fall-, and (c) late fall-run Chinook salmon at the RBDD. Values are the sum of both in-river and hatchery totals. Note change in scale among panels. Source: Grand Tab, CDFG, Inland Fisheries Division, Red Bluff.

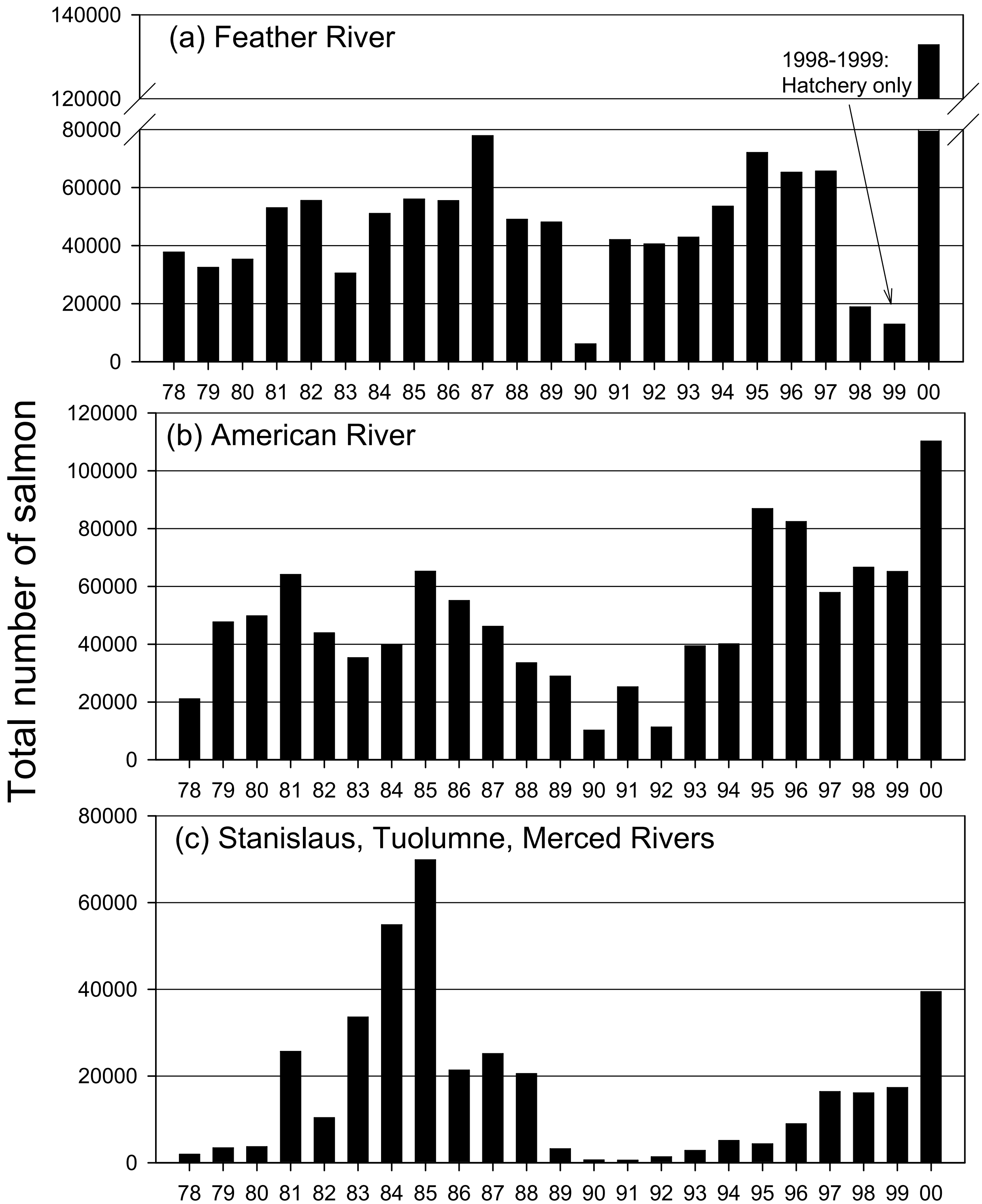

Figure 2. Population estimates of fall-run Chinook salmon spawners between 1978 and 2000 on the (a) Feather and (b) American Rivers, and (c) the combination of the Stanislaus, Tuolumne, and Merced Rivers. Values are the sum of both in-river and hatchery totals. Note change in scale among panels. Source: Grand Tab, CDFG, Inland Fisheries Division, Red Bluff.

Water Conditions
Data for water flow rates were obtained from CDEC (California Department of Water Resources, 2005) and Dayflow (Interagency Ecological Program, 2005) websites. We calculated mean daily flow rates by month at Colusa (rm 144) and Freeport (rm 48) for the lower Sacramento River and at Vernalis (rm 114) for the San Joaquin River. Further, we obtained net Delta outflow estimates as calculated by Dayflow to estimate flow past Chipps Island towards San Francisco Bay.

The 2000 water year (October 1999 through September 2000) was classified as an above normal precipitation year in both the Sacramento and San Joaquin Valleys (CDEC, 2005). Intra-annual variation in flow rates during 2000 was much higher than historical intra-annual variation (Fig. 3). Flow rates before January were at or below normal (Fig. 3). However, heavy precipitation during January-February resulted in higher than normal flow rates during February-March in the lower Sacramento River and in March in the San Joaquin River. Little precipitation occurred after April, resulting in average or below average flow for most of the water year (Le, 2001). State and federal water project staff adjusted water exports in Fall 2000 in an attempt to curtail water quality problems resulting from dry conditions.

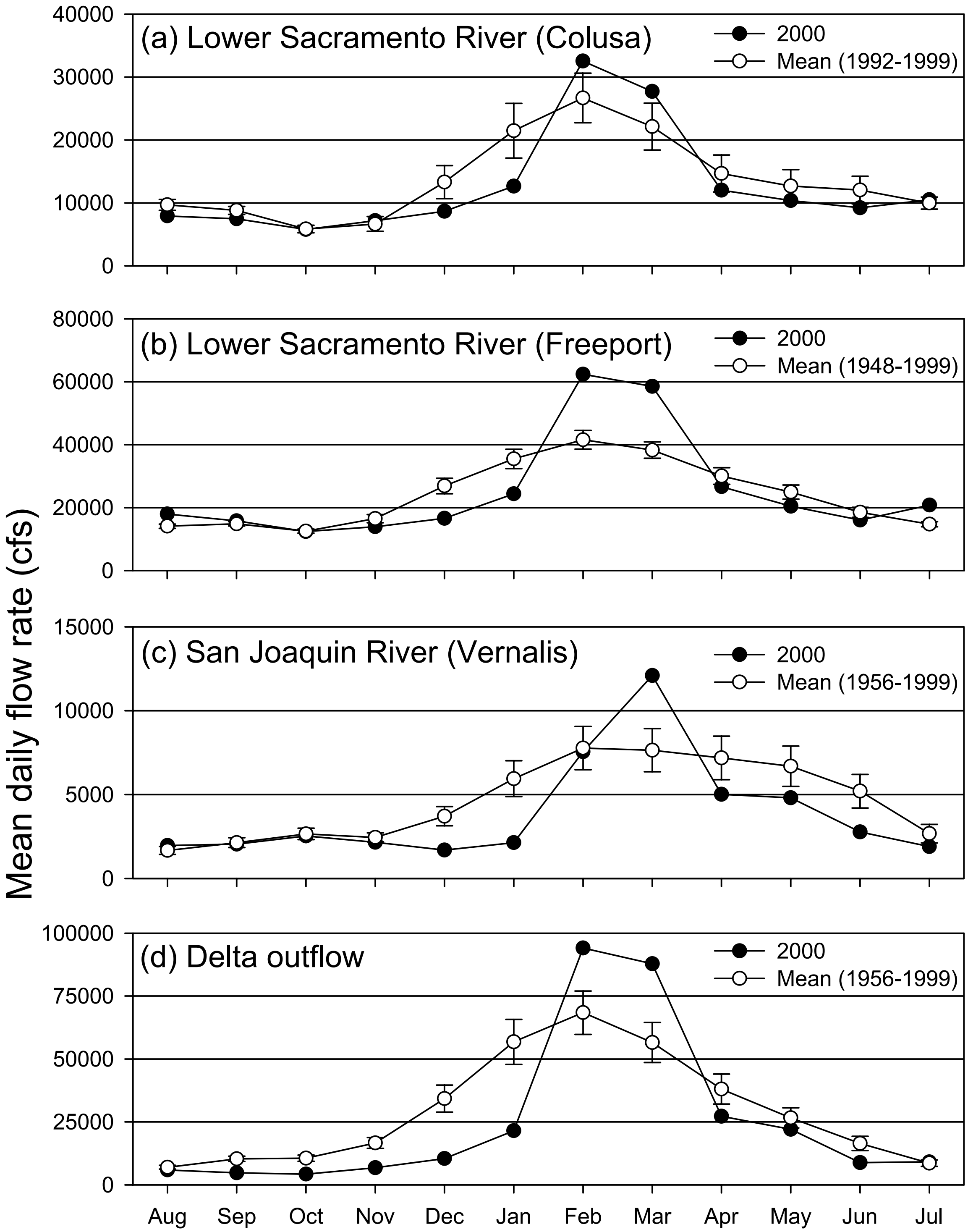

Figure 3. Mean daily flow rate (in cubic feet per second [cfs]) by month for the 2000 field season on the lower Sacramento River at (a) Colusa and (b) Freeport, (c) on the San Joaquin River at Vernalis, and (d) total calculated Delta outflow near Chipps Island. Historical means for each site are included for comparative purposes. Error bars are ±1 SE.

General Methods

Monitoring Locations

The majority of sites on the Sacramento River and Delta have been sampled since the mid-1970s by the DJFMP to document the relative abundance of juvenile Chinook salmon among and within years (Table 1; Figs. 4, 5). Sites have been added through time as more information has been needed. The sampling area is divided into six regions to facilitate data analysis and our understanding of fish abundance and movement throughout the system: (1) Lower Sacramento River (between Colusa and Elkhorn), (2) North Delta (Discovery Park to Antioch on the Sacramento River), (3) Central Delta (between the San Joaquin River and Sacramento River), (4) South Delta (adjacent to and south of the San Joaquin River), (5) San Joaquin River (between Mossdale and the Tuolumne River) and (6) San Francisco/San Pablo Bays (downstream of Pittsburg to Tiburon in San Francisco Bay). Regions were originally established in 1976 as areas where fish movement patterns should be similar and are delineated by locations of canals or water by-passes, where fish may be diverted from historical migration routes.

Additional beach seining is conducted on the Sacramento River in the Sacramento region between October and February to increase our sampling effort for less abundant races of salmon. This region includes sites from Regions 1 and 2 plus three additional sites (Miller Park, Sand Cove, and Sherwood Harbor) and is sampled three times per week. During the remainder of the year, sites at Verona and Elkhorn are grouped with Region 1 and Discovery Park, American River, and Garcia Bend are grouped with Region 2 sampling.

STFWO monitors sites that are influenced by water exiting from either the Sacramento or San Joaquin Valleys via the Sacramento and San Joaquin Rivers, respectively. The influence of these two watersheds may cause entirely different water conditions for different sites. Therefore, it is necessary to define the appropriate water year conditions. For ease of interpretation, we consider all sites in the San Joaquin River region to experience San Joaquin Valley water year conditions and all other sites to experience Sacramento Valley water year conditions. In addition, we attempt to relate each region to the closest water flow monitoring site available on CDEC and Dayflow web sites.

Table 1. Sites used by STFWO during 2000 field season organized by region. Station codes refer to body of water (first 2 letters; AR = American River, DS = Disappointment Slough, GS = Georgiana Slough, LP = Little Potato Slough, MK = Mokelumne River, MR = Middle River, MS = Mayberry Slough, OR = Old River, SA = San Francisco Bay, SB = Suisun Bay, SF = South Fork of Mokelumne River, SJ = San Joaquin River, SP=San Pablo Bay, SR = Sacramento River, SS = Steamboat Slough, TM = Three Mile Slough, WD = Werner Dredger Cut, or XC = Delta Cross Channel), river mile (3 digits), and location within site (last letter; N = north, S = south, W = west, E = east, or M = middle). For example, our Colusa State Park site is on the Sacramento River (SR) at river mile 144 on the west bank (W).

Site	Station Code
Region 1. Lower Sacramento River	
Colusa State Park	SR144W
Elkhorn*	SR071E
Knight's Landing	SR090W
Reels Beach	SR094E
South Meridian	SR130E
Verona*	SR080E
Ward's Landing	SR138E
Region 2. North Delta	
American River*	AM001S
Clarksburg	SR043W
Discovery Park*	SR060E
Garcia Bend*	SR049E
Isleton	SR017E
Koket	SR024E
Rio Vista	SR014W
Sherman Island	MS001N
Steamboat Slough (mouth)	SS011N
Stump Beach	SR012E
Region 3. Central Delta	
Antioch Dunes	SJ001S
B&W Marina	MK004W
Brannan Island	TM001N
Delta Cross Channel	XC001N
Eddo's	SJ005N
Georgiana Slough	GS010E
King's Island	DS002S
Terminous	LP003E
Wimpy's	SF014E
Sacramento Seine (additional sites)	
Sherwood Harbor	SR055E
Sand Cove	SR062E
Miller Park	SR057E
Region 4. South Delta	
Cruiser Haven	OR014W
Dad's Point	SJ041N
Dos Reis	SJ051E
Frank's Tract	OR003W
Lost Isle	SJ032S
Old River	OR019E
Union Island	OR023E
Veale Tract	WD002W
Venice Island	SJ026N
Woodward Island	MR010W
Region 5. San Joaquin River	
Big Beach	SJ063W
Durham Site	SJ068W
Mossdale	SJ056E
N. of Tuolumne River	SJ083W
Route 132	SJ077E
Sturgeon Bend	SJ074W
Wetherbee	SJ058W
Region 6. San Pablo and San Francisco Bays	
Berkeley Frontage Rd	SA007E
China Camp	SP001W
Keller Beach	SA009E
McNear's Beach	SP000W
Paradise Beach	SA008W
Point Molate	SP000E
Point Pinole East	SP003E
San Quentin Beach	SA010W
Tiburon Beach	SA004W
Treasure Island	SA001M
Trawls	
Chipps Island	SB018M,N,& S
Mossdale	SJ054M
Sacramento	SR055M

*Indicates site switched to Sacramento Seine region during 10/18/99-02/21/00 with more intense sampling (3 days per week)

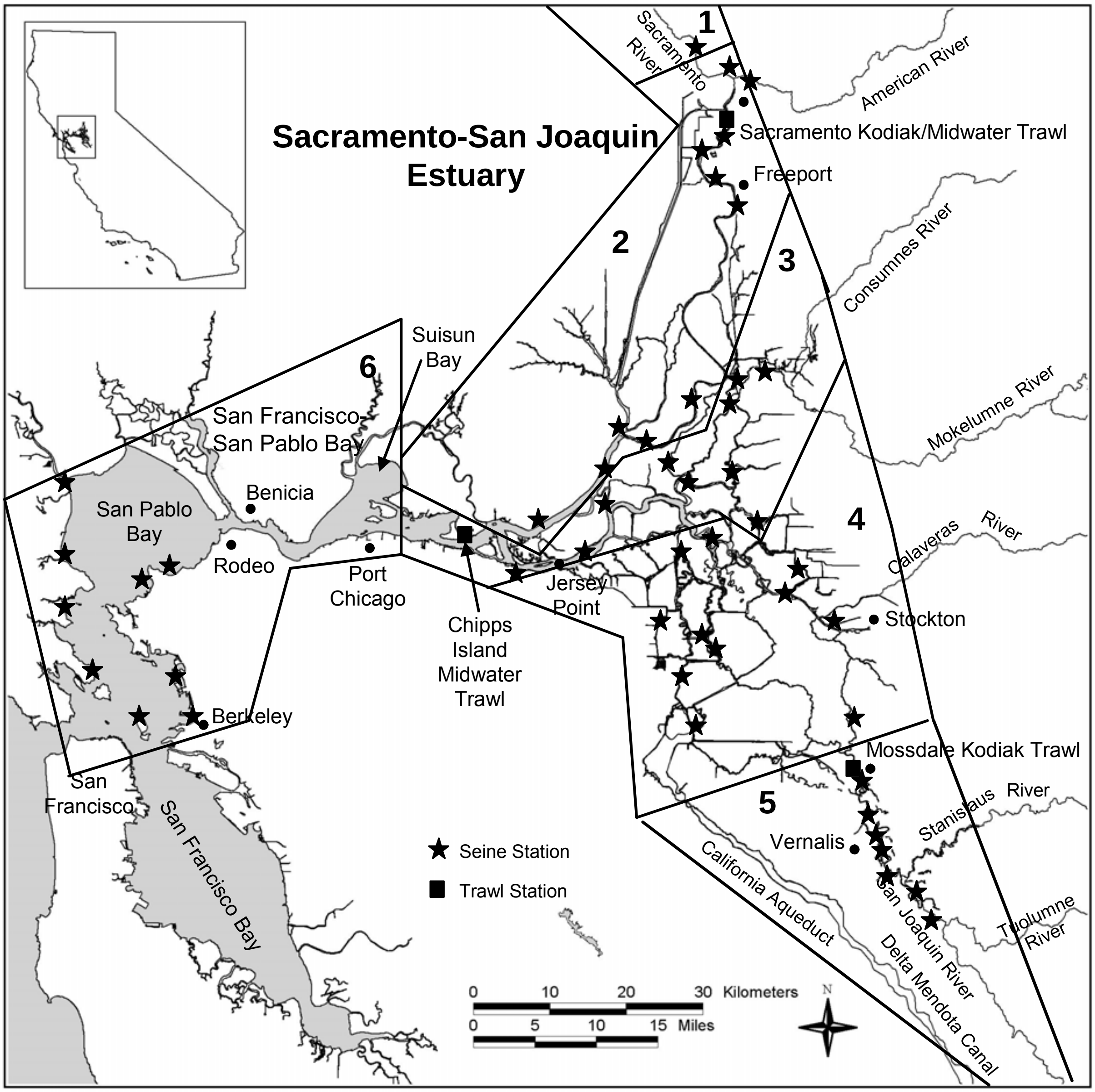

Figure 4. Trawl and beach seine sites for the 2000 field season. Regions are designated as: (1) lower Sacramento River (Knights Landing, Reels Beach, South Meridian, Wards Landing, and Colusa St. Park not shown), (2) North Delta, (3) Central Delta, (4) South Delta, (5) lower San Joaquin River, and (6) San Francisco/San Pablo Bay.

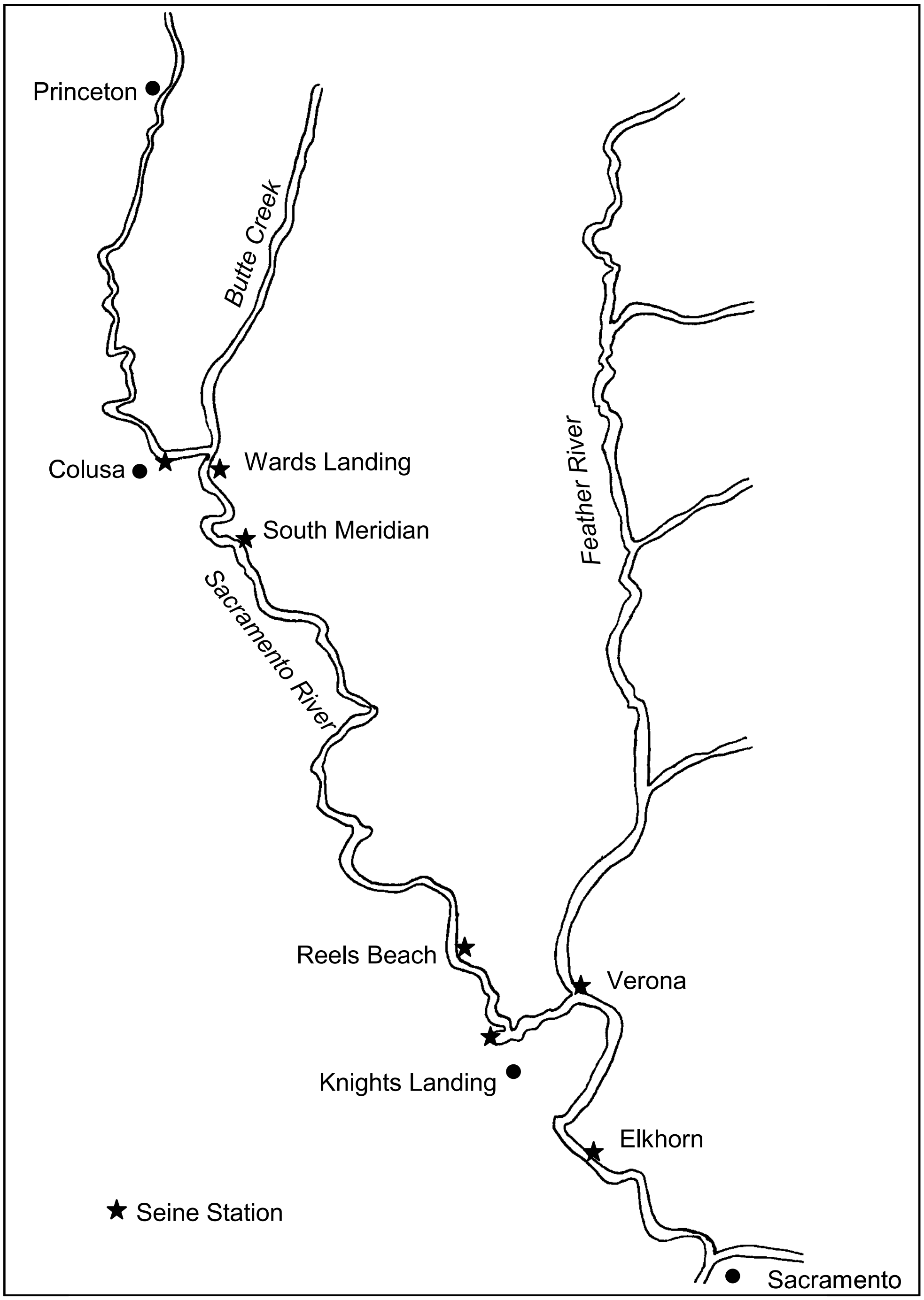

Figure 5. Lower Sacramento River beach seine sites for the 2000 field season that are not shown in Fig. 4. Between 10/18/99-02/21/00, Verona and Elkhorn were combined with other Sacramento area sites as part of the Sacramento area beach seine.

Monitoring Methods
We employed three field sampling methodologies for fish collection depending on site, purpose, and time of year: beach seine, midwater trawl, and Kodiak trawl.

<u>Beach Seine</u>
The purpose of conducting beach seining is to estimate the relative abundance of shallow, near shore benthic and pelagic juvenile fish populations. All seining is conducted using a 15 m x 1.2 m (50' x 4') beach seine with 3 mm (1/8") delta square mesh and a 1.2 m (4') bag. One seine haul is conducted at each site. Seine site substrata include pavement, sand, mud, or vegetation. Substrate at a given site may change throughout the year depending on river flow, river stage, and tide. Sites are accessed by either vehicle or small vessel.

To retain validity of year to year comparisons, our goal is to seine established historical sites. In this dynamic system, occasional changes in flow, habitat, or environmental conditions prevent sampling or make it necessary to temporarily relocate sites. If new sites are needed, we attempt to relocate to an area within 100 yards of the original location containing similar habitat characteristics (i.e., substrate, vegetation). In rare cases, sites have been relocated or removed completely because of more permanent issues (i.e., thick vegetation has grown in).

Before comparisons in abundance and timing within and among years can be made, catches are corrected for effort by standardizing to catch per unit effort (CPUE; in m^3) using the following equation:

$$Seine\ \ CPUE = \frac{Catch}{\tfrac{1}{2} Depth \times Width \times Length} \tag{1}$$

Effort is measured by volume of water sampled. Our measure of depth is the mean value of depth measured at the two deep corners (Fig. 6). By assuming a constant slope from shore to the corners where depth measurements were taken, we use ½ x depth in our CPUE calculations.

Mean CPUE calculations for beach seines
In all calculations, races of salmon (Winter, Late fall, and Fall/Spring) and regions were treated separately. All data from Regions 2-4 (North, Central, and South Delta) were combined into one “Delta” region.

Because the number and locations of sites sampled within a region varied within and among years, it is difficult to compare CPUE of a region through time. However, we attempted to ameliorate this issue through a variety of methods.

First because sampling at each site was attempted once per week (defined here as Sunday-Saturday), we used weekly means as replicates. We first calculated mean weekly CPUE for each site within a region. If a site was sampled only once in a given week, mean CPUE is identical to actual CPUE for that week. Therefore, this technique eliminates overweighting sites that were sampled more than once a week.

Next, we calculated the mean of mean CPUE of all sites within a region for each week. This value represents mean CPUE for all sites combined within each region in weekly intervals. In this calculation, weekly mean CPUE for each site is treated as a sub-sample and regional weekly mean CPUE is treated as the replicate. We plotted these values through time and compared them to previous years.

We also calculated mean CPUE by month for table presentation. In this case, we first calculated mean CPUE by month of each site separately, as we did for mean daily CPUE by week above. Next, we calculated mean of mean monthly CPUE of all sites within a region for each month separately. These monthly mean CPUE values were then compared to historical monthly mean CPUE for each region separately.

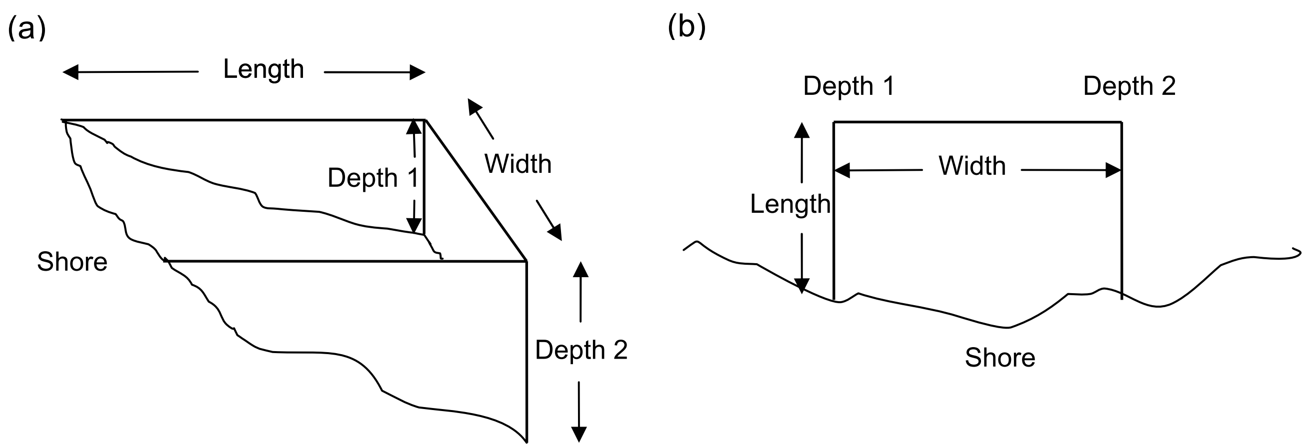

Figure 6. Schematic diagram of beach seine measurements: (a) three-dimensional view, (b) top view.

<u>Midwater trawl</u>

The purpose of conducting a midwater trawl (MWTR) is to estimate the relative abundance of fish in the top of the water column. Different sized MWTR nets are used depending on the site. Although called a “midwater trawl,” the net is actually towed at the top few meters of the water column.

The midwater trawl net used in the Sacramento River at Sacramento is composed of six panels, each decreasing in mesh size towards the cod end (Fig. 7). Mesh size ranges from 20.3 cm (8”) stretch at the mouth to 1.3 cm (½”) stretch just before the cod end. The cod end is composed of 0.7 cm (¼”) weave mesh. Fully extended mouth size is 1.8 x 4.6 m (6' x 15'). Depressors are made of 0.7 cm (¼”) stainless steel (one on each side of the net lead line) and are attached to the net with shackles to spread the bottom line of the mouth of the net. Hydrofoils are made of 0.7 cm (¼”) aluminum plate with split seine floats and spread the top of the net at the surface and are attached to the float line of the net with shackles. On each side, the depressor and hydrofoil are connected to the boat using two 30.5 m (100’) Amsteel rope bridles (0.6 cm diameter). Bridles are attached to 61 m (200’) Amsteel rope backing (1 cm diameter) using 0.8 cm (5/16”) stainless steel quick links. The net is fished 33 m (100’) behind the boat. Actual fishing dimensions of the net vary with currents and weather conditions, as described previously (USFWS 1993).

A larger MWTR net is used at Chipps Island (Fig. 8). It is similar in construction to the MWTR net used at Sacramento and has a mouth dimension of 3 x 9 m (10 x 30'). There are six panels, each with decreasing mesh size towards the cod end. Mesh size ranges from 10.2 cm (4”) stretch at the mouth to 1.3 cm (½”) stretch just before the cod end. The cod end is composed of 0.8 cm (5/16“) knotless material. Depressors and hydrofoils are appropriately larger and were connected identically to those on the Sacramento MWTR. The net is fished 46 m (150’) behind the boat (100’ bridle and 50’ backing).

Catch per unit effort (CPUE; in m^3) of the MWTR was calculated as:

$$CPUE = \frac{catch\ per\ tow}{net\ mouth\ area\ x\ distance\ traveled} \qquad (2)$$

Because MWTR nets do not open completely while under tow and net mouth dimensions vary within and among tows, we used previously quantified estimates of average net mouth area (Sacramento: 5.08 m^2, Chipps Island: 18.58 m^2; USFWS 1993). Distance traveled in the water was recorded with a General Oceanics mechanical flow meter (Model #2030). This measure of distance is not related to distance traveled relative to land, which can be affected by river flow rate and direction.

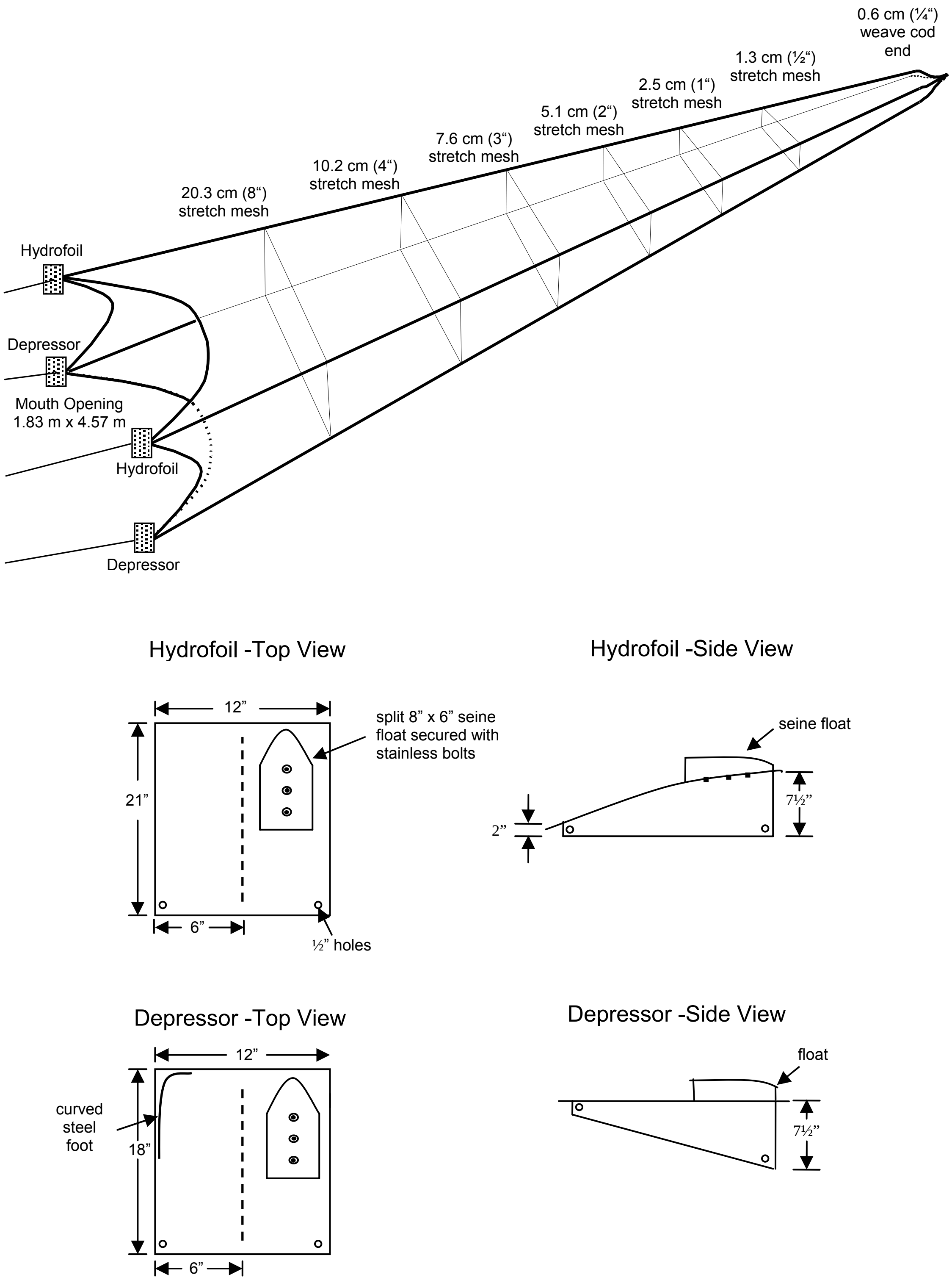

Figure 7. Schematic drawing of midwater trawl net (top), and hydrofoils and depressors (bottom) used at Sacramento during 2000 field season.

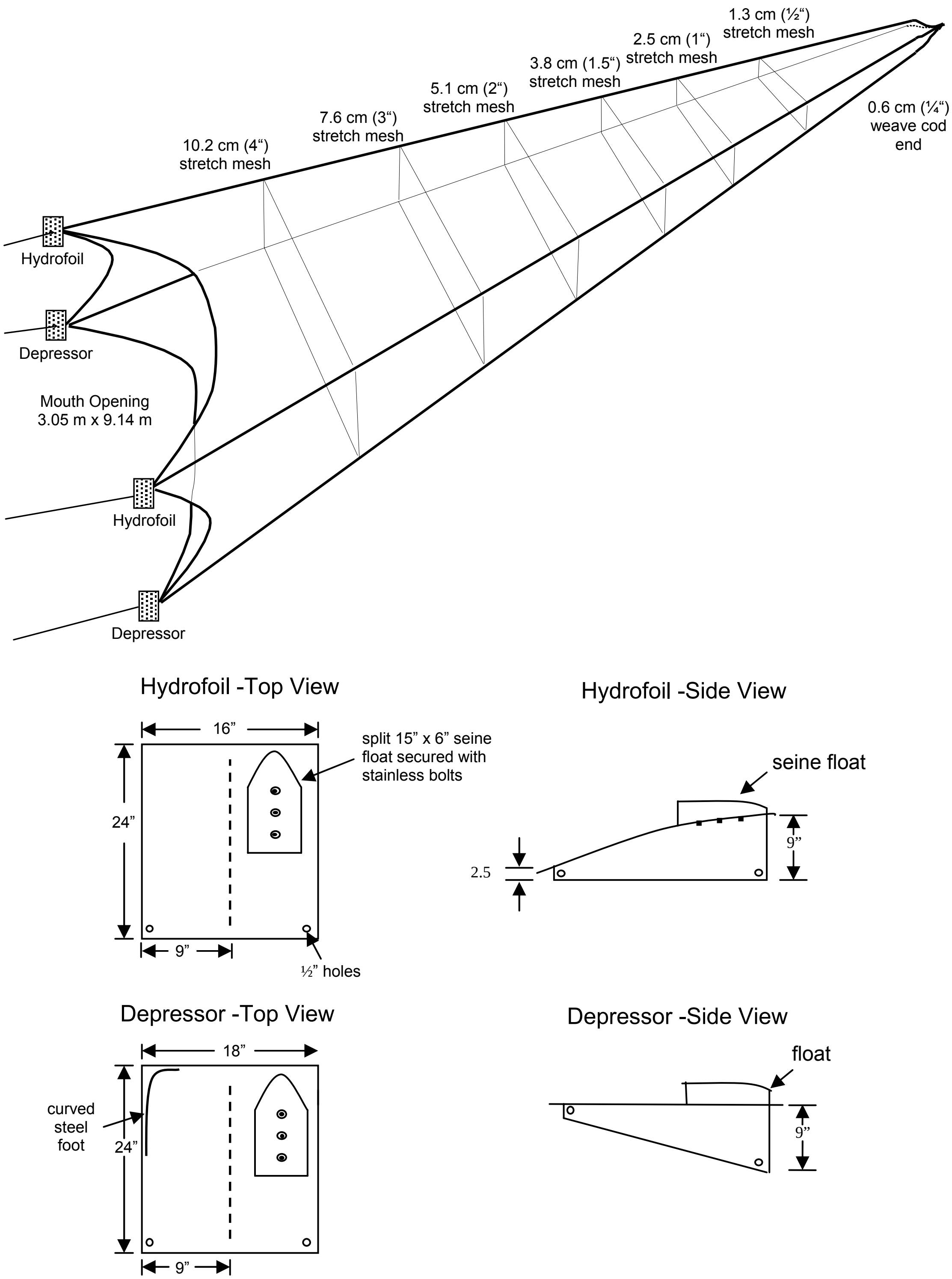

Figure 8. Schematic drawing of midwater trawl net (top) and hydrofoils and depressors (bottom) used at Chipps Island during 2000 field season.

Kodiak trawl

A Kodiak trawl (KDTR) net was used at Mossdale and Sacramento to collect pelagic fish in the top 1.83 m of the water column. The KDTR net is larger than the midwater trawl net used in the rivers, allowing for larger volumes of water to be sampled. However, because two boats are needed to pull the net, use of the KDTR net requires additional staff and vessels to operate. Nets were made of variable mesh with a fully expanded mouth opening of 1.83 x 7.62 m (6 x 25'; Fig. 9). A float line and lead line enable the net to fish the top 1.83 m of the water column. The net is fished 33 m (100') from the boat. At the front of each wing is a 1.83 m bar with floats at the top and weights at the bottom to keep depth constant. An aluminum live box at the cod end minimizes fish mortality. Two boats tow the net through the water, one pulling each wing. At the end of each tow, the boats come together and the trawl line is transferred to one of the boats. Field crew on the other boat retrieve the live box from the cod end of the net and remove fish for processing. Calculations of CPUE for the KDTR employ the same equation as the MWTR (Equation 2), where an average net mouth area of 12.54 m^2 (USFWS, 1993).

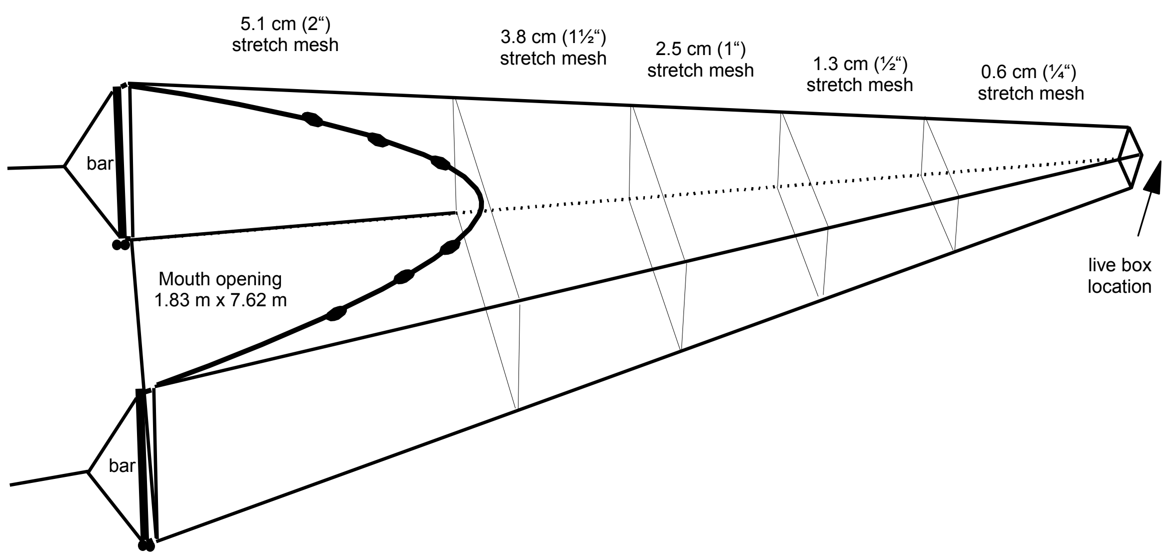

Figure 9. Schematic drawing of Kodiak trawl net used at Mossdale and Sacramento during 2000 field season.

Mean CPUE calculations for Kodiak and midwater trawls
In all calculations, races of salmon (Winter, Late Fall, and Spring/Fall) and trawl locations were treated separately. At Sacramento, where we use either a midwater or Kodiak trawl depending on time of year, each gear type is treated separately, although discussed together.

First, we calculated mean daily CPUE for all trawls in a given day (usually 10 trawls). This technique eliminates unequal weighting of sites that were not sampled 10 times per day. Next, we calculated the mean of daily mean CPUE for each week. In this calculation, daily mean CPUE is treated as a sub-sample and regional weekly mean CPUE is treated as the replicate. These values were plotted against historical values by week.

We also calculated mean CPUE by month for table presentation. In this case, we first calculated mean daily CPUE. Then, we calculated mean of mean daily CPUE by month of each site separately, as we did for mean daily CPUE by week above. These monthly mean CPUE values were then compared to historical monthly mean CPUE.

Juvenile Fish Monitoring by Gear Type and Region

Region 1. Lower Sacramento River Beach Seine

Methods
Beach seining was conducted at five to eight sites per week from 8/1/1999-7/31/2000 to estimate densities of juvenile Chinook salmon in lower Sacramento River (Fig. 4-5; Table 1-2). Sites were sampled one to three times per week, with more extensive sampling occurring between 10/31-1/31, when winter-run Chinook were likely present in the system. The sampling area extended from Colusa (rm 144) downstream to Elkhorn (rm 71). Sampling substrata included sandy and muddy beaches and paved boat ramps.

Table 2. Weekly sampling schedule for the 2000 field season. Shaded cells indicate that sampling was conducted during that week.

		Aug					Sep				Oct				Nov				Dec					Jan					Feb				Mar				Apr				May					Jun				Jul			
Seine	Region 1	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
	Region 2	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
	Region 3		■		■		■		■		■		■		■		■		■		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■		■		■
	Region 4	■		■		■		■		■		■		■		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■		■	
	Region 5#			■		■		■		■		■		■		■	■	■		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■				
	Region 6†	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Sacramento	Midwater	■	■	■	■	■	■	■	■	■	■																							■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Trawl	Kodiak										■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■																			
Mossdale	Kodiak												■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■						
Chipps Island	Midwater			■		■	■		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■

#Samples from Aug-Nov were conducted at Mossdale (SJ056E) only

†Half of the sites were sampled each week, such that all sites were visited every two weeks

Results

A total of 61 winter-run sized juvenile salmon were captured in lower Sacramento River beach seines during the 2000 field season (Figure 10a). Nearly all winter-run salmon were captured between December-March during periods that began with increasing flows. Peak weekly CPUE was observed in January. Relative to the previous seven field seasons, CPUE during 2000 was very low during November and December, but closer to mean CPUE values in January and February (Table 3a). Overall, annual CPUE of winter-run salmon was the lowest of the past eight field seasons.

Spring-/fall-run sized salmon were the most abundant races captured in the lower Sacramento River region (n = 5273, Figure 10b). Individuals were caught between December and June. Peak CPUE occurred in late February, coinciding with a period of high water flow in the lower Sacramento River. Monthly mean CPUE was generally above average during 2000, particularly in February (Table 3b) and annual CPUE was higher than average.

Only two late fall-run sized salmon were caught during all of the 2000 field season (Figure 10c). Both were caught during mid-January 2000 and were smolts/yearlings from the 1999 brood year (124 and 127 mm). This is the lowest CPUE of both yearlings and fry caught since year round sampling began in the lower Sacramento River region in 1993 (Table 3c).

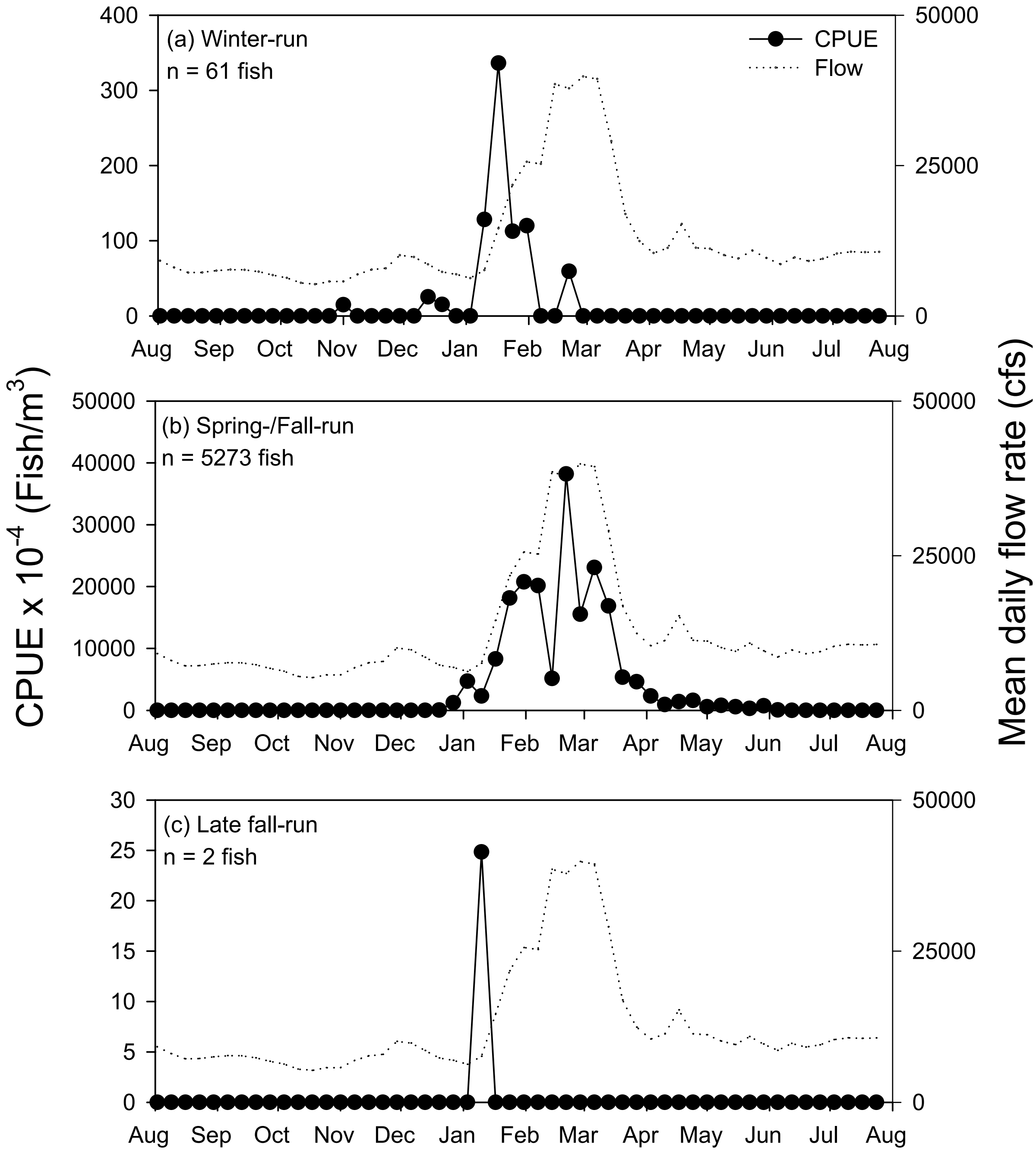

Figure 10. Catch per unit effort (x 10^{-4}) of (a) winter-, (b) spring-/fall-, and (c) late fall-run Chinook salmon in beach seines and concurrent mean daily flow rate in the lower Sacramento River region (Region 1) during the 2000 field season. All data were averaged by week, our standard unit of replication for seines. Flow rate was estimated at Colusa in lower Sacramento River by CDEC. Sample size (n) corresponds to total number of fish caught. Fall- and Spring-run salmon were combined because of difficulties in distinguishing between them at this size. Note change in scale among panels.

Table 3. Summary table of CPUE x 10^{-4} (fish/m^3) of (a) winter-, (b) spring -/fall-run, and (c) late fall-run Chinook salmon in the lower Sacramento River region (Region 1) by month and year. Yearly average and standard error (SE) values were calculated using years as replicates (n = 7). Weekly average and SE values were calculated using weeks as replicates (n = 44-52). Shaded boxes indicate peak monthly CPUE. Water year (CDEC, 2005): AN = above normal; C = critical; W = wet

(a) Winter-run

Field season	Water year	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Weekly avg (SE)
1992-1993	AN	--	34.0	0	137	112	227	224	0	0	0	0	0	73.9 (18.9)
1993-1994	C	0	0	1.05	0	4.00	51.2	56.5	0	0	0	0	0	11.2 (6.65)
1994-1995	W	0	0	0	18.5	8.56	156	37.6	49.6	0	0	0	0	17.9 (8.61)
1995-1996	W	0	0	0	0	238	197	45.1	11.6	2.47	0	0	0	42.0 (16.1)
1996-1997	W	0	0	0	0	148	0	38.6	27.0	0	0	0	0	27.6 (12.1)
1997-1998	W	0	0	6.35	352	336	316	0	0	0	0	0	0	76.3 (32.2)
1998-1999	W	0	35.3	0	890	415	294	153	4.96	0	0	0	0	158 (59.3)
Yearly avg 1993-1999 (SE)		0 (0)	9.90 (6.39)	1.06 (0.894)	200 (125)	180 (59.6)	177 (44.5)	79.2 (30.0)	13.3 (7.09)	0.353 (0.353)	0 (0)	0 (0)	0 (0)	58.1 (19.2)
1999-2000	AN	0	0	0	3.31	7.26	160	42.8	0	0	0	0	0	15.6 (7.48)

(b) Fall-/Spring-run

Field season	Water year	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Weekly avg (SE)
1992-1993	AN	--	0	0	0	244	2890	2740	3570	3690	429	62.6	0	1500 (327)
1993-1994	C	5.67	0	0.702	0	1030	1360	7420	4820	830	142	0	0	1430 (401)
1994-1995	W	0	0	0	0	48.7	7270	7710	8530	2960	1760	207	5.43	3080 (774)
1995-1996	W	6.58	0	0	0	1880	5940	15000	7900	2230	318	0	2.48	2790 (716)
1996-1997	W	0	0	0	0	640	5140	3010	2950	737	58.7	4.70	0	1410 (409)
1997-1998	W	0	0	0	0	623	6770	1500	4470	2950	2770	183	5.91	1900 (477)
1998-1999	W	4.51	0	0	12.9	1300	8140	20900	29400	6930	627	33.9	23.5	7240 (2180)
Yearly avg 1993-1999 (SE)		2.79 (1.28)	0 (0)	0.100 (0.100)	1.84 (1.84)	794 (218)	5270 (918)	8160 (2660)	8680 (3530)	2900 (791)	871 (382)	70.1 (33.4)	12.0 (7.52)	2760 (788)
1999-2000	AN	0	0	0	0	183	6960	16830	11500	1820	559	13.0	0	3730 (1090)

Table 3. (cont.)

(c) Late fall-run

		Previous field season's brood year								Current field season's brood year				
Field season	Water year	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Weekly avg (SE)
1992-1993	AN	--	0	2.19	6.54	26.5	4.45	2.24	0	40.2	22.6	0	0	8.75 (3.29)
1993-1994	C	2.84	1.72	35.3	6.72	18.4	0.857	11.9	0	0	0	0	0	6.81 (3.02)
1994-1995	W	0	0	0	9.45	21.1	22.4	0	0	0	13.6	0	0	5.27 (1.82)
1995-1996	W	14.1	0	0	0	25.1	8.56	0	0	0	0	4.99	0	4.50 (1.90)
1996-1997	W	0	0	0	5.79	26.3	0	0	0	0	0	0	0	4.09 (2.58)
1997-1998	W	0	0	0	45.6	78.7	3.38	0	0	0	40.3	88.1	0	21.0 (6.58)
1998-1999	W	11.1	0	0	308	77.4	0	0	0	49.6	24.1	0	0	39.9 (17.9)
Yearly avg 1993-1999 (SE)		4.68 (2.58)	0.246 (0.246)	5.368 (5.00)	54.5 (42.6)	38.9 (10.2)	5.69 (3.03)	2.02 (1.67)	0 (0)	12.8 (8.34)	14.4 (5.88)	13.3 (12.5)	0 (0)	12.9 (5.01)
1999-2000	AN	0	0	0	0	0	8.280	0	0	0	0	0	0	0.478 (0.478)

Regions 2-4. Delta Beach Seine (North, Central, and South Delta)

Methods

Beach seining was conducted weekly at 12 sites in Region 2 (North Delta) between 8/1/1999-7/31/2000 (Table 1-2). Sampling was conducted at 10 sites in Regions 3 (Central Delta) and 10 sites in Region 4 (South Delta) once every two weeks from 8/1/99 to 12/31/99 and 7/1/00 to 7/31/00, and once per week from 1/1/00 to 6/30/00. Three sites from Region 2 (Garcia Bend, American River, and Discovery Park) and two sites from the Region 1 (Elkhorn and Verona), were sampled up to three times per week during October-February as part of our Sacramento seine sampling (see below for information on Sacramento River region).

Results

Peak CPUE of winter-run sized salmon occurred during late January and early February after the onset of increased flows (Fig. 11a). Only 41 fish were caught in this region during the 2000 field season. This is much lower than in the previous year due to very low catches between November and January (Table 4a).

Spring-/fall-run fry were first captured regularly in January (Figure 11b). Weekly CPUE peaked in early February. The last individuals were seen in mid-May. The CPUE during December 2000 (4.42×10^{-4} fish/m^3) was much lower than mean December CPUE (883.0×10^{-4} fish/m^3), although CPUE during February 2000 was over two times greater than mean February CPUE (Table 4b). Overall, annual CPUE of spring-/fall-run salmon in the 2000 field season was higher than average.

A total of seven late fall-run salmon were caught in the 2000 field season in the Delta (Fig 11c). Six were smolts from the 1999 brood year and were caught between December and February. The one remaining fish was a 2000 brood year fry that was caught at Discovery Park in May. Peak CPUE occurred in early December. Mean CPUE of late-fall juveniles during the 2000 field season was nearly an order of magnitude lower than average annual CPUE (Table 4c).

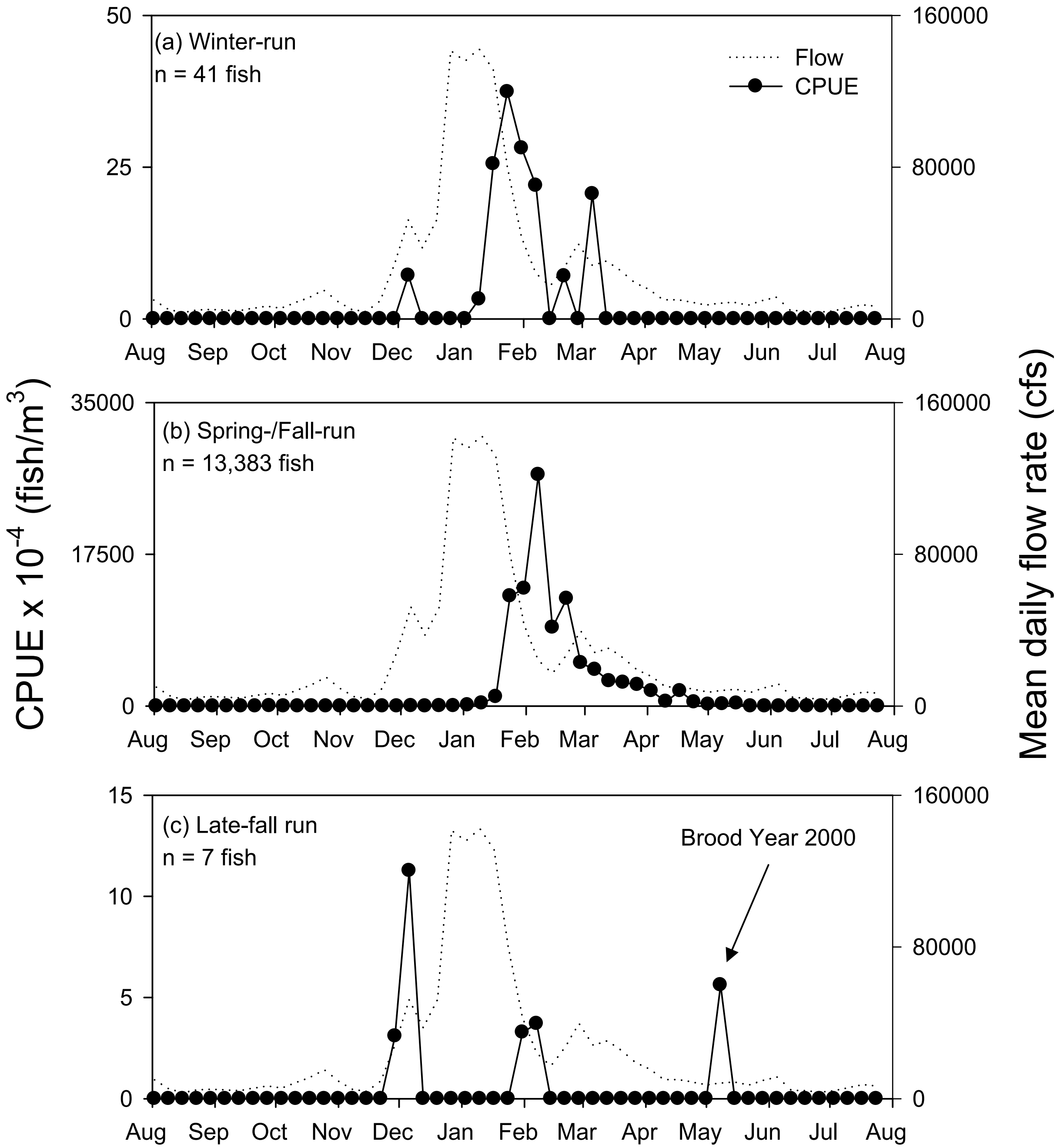

Figure 11. Catch per unit effort (x 10^{-4}) of (a) winter-, (b) spring-/fall-, and (c) late fall-run Chinook salmon in beach seines and concurrent mean daily flow rate in the interior Delta (North, Central, and South; Regions 2-4) during the 2000 field season. All data were averaged by week, our standard unit of replication for seines. Mean daily flow rate was Delta Outflow calculated by CDEC. Sample size (n) corresponds to total number of fish caught. Fall- and Spring-run salmon were combined because of difficulties in distinguishing between them at this size. Note change in scale among panels.

Table 4. Summary table of CPUE x 10^{-4} (fish/m^3) of (a) winter-, (b) spring-/fall-run, and (c) late fall-run Chinook salmon in the interior Delta (Regions 2-4) combined by month and year. Yearly average and standard error (SE) values were calculated using years as replicates (n = 7). Weekly average and SE values were calculated using weeks as replicates (n = 39-52). Shaded boxes indicate peak monthly CPUE. Water year (CDEC, 2005): AN = above normal; C = critical; W = wet

(a) Winter-run

Field season	Water year	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Weekly avg (SE)
1992-1993	AN	--	0	0	37.7	8.78	58.0	35.1	6.61	0	0	0	--	19.6 (7.76)
1993-1994	C	--	0	0	0	0	0	4.67	0	0	0	0	0	0.552 (0.552)
1994-1995	W	0	0	0	0	0	9.76	4.16	0.427	0	0	0	0	1.38 (0.559)
1995-1996	W	0	0	0	0	33.0	27.5	17.2	1.99	3.22	0	0	0	7.85 (2.63)
1996-1997	W	0	0	0	0.253	7.91	7.59	2.82	13.4	0	0	0	0	3.94 (1.63)
1997-1998	W	0	0	0	2.07	44.7	48.4	5.84	3.96	0	0	0	0	9.49 (4.04)
1998-1999	W	0	3.94	1.85	41.7	66.9	17.1	12.2	12.7	0	0	0	0	20.2 (7.96)
Yearly avg 1993-1999 (SE)		0	0.564 (0.564)	0.265 (0.265)	11.7 (7.26)	23.0 (9.74)	24.1 (8.26)	11.7 (4.36)	5.57 (2.10)	0.459 (0.459)	0	0	0	9.01 (3.07)
1999-2000	AN	0	0	0	0	2.98	36.78	29.87	19.00	0	0	0	0	7.15 (2.87)

(b) Spring-/Fall-run

Field season	Water year	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Weekly avg (SE)
1992-1993	AN	--	0	0	0	41.6	1320	1630	4960	2670	405	124	--	1240 (346)
1993-1994	C	--	0	0	6.64	36.3	325	4000	1430	496	53.0	2.58	0	723 (150)
1994-1995	W	0	1.93	0	0	31.1	8760	5260	6350	2640	499	65.9	2.81	2560 (876)
1995-1996	W	0	0	0	0	894	3300	9260	5360	1780	327	16.0	8.23	1960 (511)
1996-1997	W	0	0	0	0	1000	2490	2640	2170	886	83.5	5.54	0	961 (206)
1997-1998	W	1.56	0	0	0	60.4	4620	7690	4990	2710	754	121	0	1820 (425)
1998-1999	W	0	0	0	13.6	429	3100	6870	7980	2770	572	51.3	0.855	2080 (495)
Yearly avg 1993-1999 (SE)		0.312 (0.312)	0.276 (0.276)	0	2.90 (2.02)	357 (163)	3420 (1030)	5340 (1050)	4750 (861)	1990 (362)	385 (96.2)	55.3 (19.5)	1.98 (1.33)	1620 (251)
1999-2000	AN	0	5.79	0	0	4.42	7335.0	34422	8971.2	3844.6	444.6	2.24	0	4863.4 (1644.1)

Table 4. (cont.)

(c) Late fall-run

		Previous field season's brood year								Current field season's brood year				
Field season	Water year	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Weekly avg (SE)
1992-1993	AN	--	0	0	4.82	3.83	5.14	0	0	9.51	1.44	5.61	--	3.92 (1.47)
1993-1994	C	--	0	0	0	6.12	6.65	0	0	0	0	0	0	1.39 (0.805)
1994-1995	W	0	0	0	0.233	8.63	11.4	2.41	0	3.99	10.3	0	0	2.77 (1.14)
1995-1996	W	0	0	0	0	1.79	0.612	0.882	0	2.31	17.1	0	1.39	1.77 (0.830)
1996-1997	W	0	0	0	3.47	3.01	9.08	0	0	0	2.39	0	0	3.32 (2.40)
1997-1998	W	0	0	0	1.50	7.79	0	0	0	73.1	13.3	7.81	0	9.38 (4.99)
1998-1999	W	0	0	0.992	10.5	13.5	1.39	0	0	44.7	4.79	0	0	8.80 (3.82)
Yearly avg 1993-1999 (SE)		0	0	0.142 (0.142)	2.93 (1.44)	6.38 (1.52)	4.90 (1.67)	0.470 (1.67)	0	19.1 (10.8)	7.04 (2.48)	1.92 (1.26)	0.231 (0.231)	4.48 (1.24)
1999-2000	AN	0	0	0	0	6.09	0	3.90	0	0	2.47	0	0	1.19 (0.55)

Region 5. Lower San Joaquin River

Methods

Lower San Joaquin River beach seine sampling started in 1994 to document the distribution and abundance of Chinook salmon in the San Joaquin River. Before the 2000 field season, seining was conducted once per week between January and June each year. In 2000, sampling at the majority of sites was conducted once per week between January and June. Sampling was conducted year round at Mossdale; once per week between January and June and once every two weeks during August through December. Sampling rates increased in January-June to augment sampling when less abundant races of salmon are present. No sampling was conducted during July.

In the 2000 field season, we sampled 7 sites from Mossdale (rm 56) to North of the Tuolumne River (rm 83; Table 1-2, Fig. 4).

Results

All Chinook salmon in the San Joaquin River are classified as fall-run salmon even though some would be classified as spring run using “length at date” criterion. Spring-run salmon were extirpated from the three San Joaquin River tributaries (Stanislaus, Tuolumne, and Merced) by 1930 and from the mainstem by 1947 as a result of dam construction (USFWS, 1995).

We captured 170 fall-run salmon in Region 5 in the 2000 field season. Fish ranged in size from 31-95 mm (FL). Fish were caught between early February and late May (Fig. 12). As with other regions, the period of highest CPUE in Region 5 occurred during the period of highest flow rate (February-March). CPUE during January and February in 2000 was lower than mean CPUE over the past six years, but was near average values during March-May (Table 5).

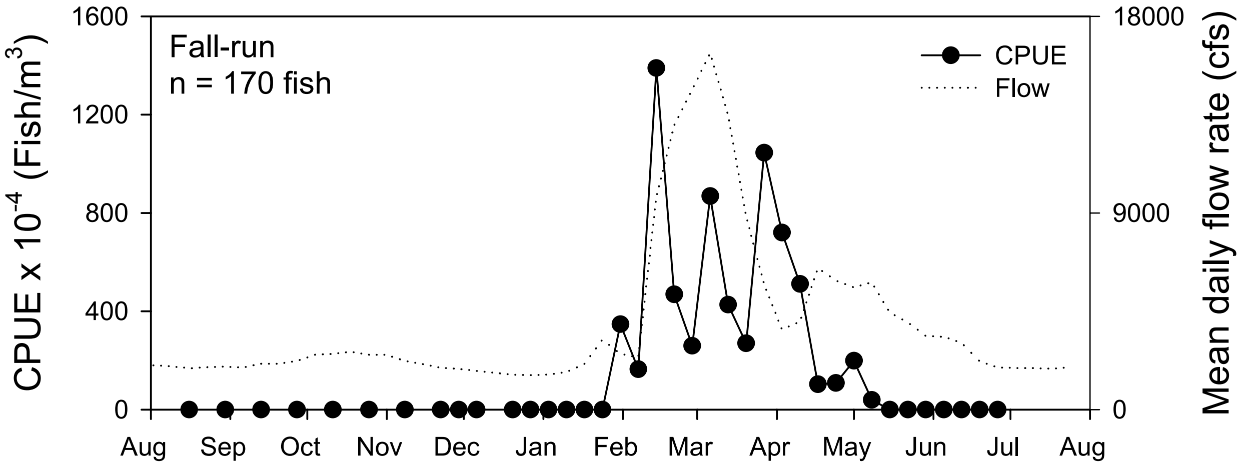

Figure 12. Catch per unit effort (x 10^{-4}) of fall-run Chinook salmon in beach seines and mean daily flow rate in the San Joaquin River region (Region 5) between August 1, 1999 and July 31, 2000 (the 2000 field season). All data were averaged by week, our standard unit of replication for seines. Flow rate was estimated at Vernalis in the San Joaquin River by CDEC. Sample size (n) corresponds to total number of fish caught. Weeks during which we did not sample have no points on the graph.

Table 5. Summary table of CPUE x 10^{-4} (fish/m^3) of fall-run Chinook salmon in the San Joaquin River region (Region 5) by month and year. Yearly average and standard error (SE) values were calculated using years as replicates (n = 6). Weekly average and SE values were calculated using weeks as replicates (n = 10-26). Shaded boxes indicate peak monthly CPUE. Water year (CDEC, 2005): AN = above normal; C = critical; W = wet

Field season	Water year	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Weekly avg (SE)
1993-1994	C	--	--	--	--	--	--	--	0	453	0	0	--	189 (150)
1994-1995	W	--	--	--	--	--	--	190	332	0	32.6	154	--	131 (44.0)
1995-1996	W	--	--	--	--	--	0	42.1	9.08	99.8	0	0	--	287 (12.9)
1996-1997	W	--	--	--	--	--	0	0	415.6	161.0	0	0	--	244 (182)
1997-1998	W	--	--	--	--	--	899	4100	167	448	22.3	0	--	707 (210)
1998-1999	AN	--	--	--	--	--	1650	6330	2420	753	110	19.8	--	1700 (480)
Yearly avg 1993-1999 (SE)		--	--	--	--	--	636 (398)	2130 (1310)	808 (409)	319 (115)	27.5 (17.4)	29.0 (25.3)	--	499 (258)
1999-2000	AN	0	0	0	0	0	0	641	734	247	59.5	0	--	182 (53.7)

Region 6. San Francisco/San Pablo Bays

Methods

Beach seining in San Francisco and San Pablo Bays was originally conducted by USFWS between December and May during 1980-1982. CDFG also sampled monthly year-round in the Bays during 1980-1986, but no sampling was conducted during 1987-1996. Beach seining was restarted by the DJFMP in 1997 to document the presence of Chinook salmon fry in downstream bays.

Seining was conducted year-round for the first time by USFWS in the 2000 field season (Table 2). Ten seine sites were separated into two seine routes of five sites sampled per week. As a result, each site was sampled once every two weeks. Data from 2000 are presented in biweekly increments in an attempt to include all sites in calculations. For each site, we calculated an average CPUE of multiple sampling dates, when necessary, during each two-week period. Next, means from each site were averaged to provide an estimate of mean of CPUE over all sites during each sampling period. Sites sampled during 2000 were a subset of those sampled by CDFG in the 1980s (Orsi, 1999).

Results

A total of 10 juvenile salmon were caught during 2000 in Region 6, all of which were spring/fall-run within the fry size range of 30-66 mm FL (Fig. 13). CPUE peaked during February and March, coinciding with increased Delta outflow (Table 6). All but two of these individuals were caught at McNear's Beach and Point Molate. A comparison of spring/fall-run salmon annual CPUE during the 2000 field season to among-year mean CPUE reveals that 2000 CPUE values were extremely low (15% of 1980-1986 mean CPUE and 4.3% of 1997-1999 mean CPUE). The 2000 field season had the third lowest catch on record for bay seines.

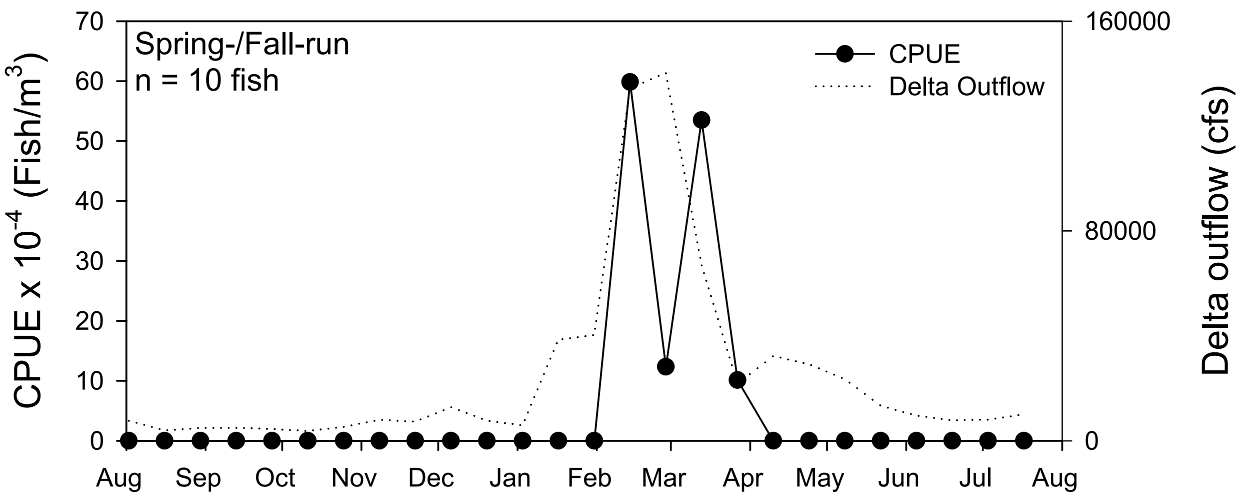

Figure 13. Catch per unit effort (x 10^{-4}) of spring-/fall-run Chinook salmon in beach seines in Region 6 (San Francisco/San Pablo Bays) and Delta outflow during the 2000 field season. All data were averaged biweekly because each site was sampled every other week. Delta outflow was calculated by CDEC. Fall- and Spring-run salmon were combined because of difficulties in distinguishing between them at this size. No other races of salmon were collected in bay seines. Sample size (n) corresponds to total number of fish caught during 2000 field season.

Table 6. Summary table of CPUE x 10^{-4} (fish/m^3) of spring-/fall-run Chinook salmon in bay seines (Region 6) by month and year. Yearly average and standard error (SE) values were calculated using years as replicates (n = 1-3 for USFWS, 1980-1982; n = 6-7 for CDFG, 1981-1987; n = 1-3 for USFWS, 1997-1999). Weekly average and SE values were calculated using one week periods as replicates (n = 5-18) for 1981-1987 data and two week periods as replicates for 1997-1999 data (n = 4-19). SE calculations were not possible when n = 1. Shaded boxes indicate peak monthly CPUE. Water year (CDEC, 2005): D = dry; W = wet; AN = above normal

Field season	Agency	Water year	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Weekly avg (SE)
1979-1980	USFWS	AN	--	--	--	--	--	2680	473	501	40.6	0	0	--	438 (209)
1980-1981	USFWS	D	--	--	--	--	--	--	67.6	0	213	40.6	--	--	83.7 (43.1)
1981-1982	USFWS	W	--	--	--	--	13.5	590	54.1	464	60.9	--	--	--	275 (142)
Yearly avg 1980-1982 (SE)	USFWS		--	--	--	--	13.5	1630 (1040)	198 (138)	322 (161)	105 (54.4)	20.3 (20.3)	0	--	266 (102)
1980-1981	CDFG	D	0	0	0	0	0	0	260	28.4	520	77.7	0	0	74.4 (41.6)
1981-1982	CDFG	W	0	0	0	0	0	24.4	206	28.6	47.4	6.31	2.72	0	27.2 (15.0)
1982-1983	CDFG	W	0	0	0	0	0	0	302	477	215	63.3	55.8	61.3	74.5 (34.7)
1983-1984	CDFG	W	0	0	0	0	0	15.3	0	0	0	0	1.86	55.8	8.71 (5.66)
1984-1985	CDFG	D	0	0	0	0	0	0	0	0	0	0	0	0	0 (0)
1985-1986	CDFG	W	0	55.6	0	0	0	43.3	768	52.4	22.9	8.65	7.44	0	57.7 (44.7)
1986-1987	CDFG	D	0	0	0	0	0	--	--	--	--	--	--	--	0 (0)
Yearly avg 1981-1987 (SE)	CDFG		0 (0)	7.94 (7.94)	0 (0)	0 (0)	0 (0)	13.8 (7.20)	256 (115)	97.7 (76.2)	134 (83.8)	26.0 (14.3)	11.3 (8.96)	19.5 (12.4)	34.6 (12.7)
1996-1997	USFWS	W	--	--	--	--	--	88.9	93.0	13.0	--	--	--	--	64.3 (37.0)
1997-1998	USFWS	W	--	--	--	--	--	239	385	240	--	--	--	--	280 (97.7)
1998-1999	USFWS	W	--	--	--	0	0	0	21.8	37.9	15.2	5.56	0	0	9.88 (4.95)
Yearly avg 1997-1999 (SE)			--	--	--	0	0	109 (69.8)	167 (111)	94.5 (69.4)	202 (187)	5.56	0	0	124 (85.1)
1999-2000	USFWS	AN	0	0	0	0	0	0	29.9	22.2	6.31	0	0	0	5.31 (3.19)

Sacramento Area Beach Seine

Methods

Starting in the 1994 field season, sampling intensity was increased during October-February at eight sites near the city of Sacramento. The goal was to increase detection of entry into the Delta by less common races and life stages of Chinook salmon, particularly winter-run fry and winter-, spring-, and late fall-run yearlings. This effort was developed to provide additional information to managers of water project operations (i.e., Delta Cross Channel gate closures). Two sites were chosen from the lower Sacramento region (Elkhorn and Verona), three from the North Delta region (American River, Discovery Park, and Garcia Bend) and three additional sites (Sherwood Harbor, Miller Park, and Sand Cove), all of which were on the Sacramento River upstream of the Delta (Table 1). During the 2000 field season, sampling was conducted up to three times per week from October through February. Because the goal of seining in the Sacramento area is to target less common races, we have separated spring-run sized from fall-run sized fish and only report spring-run sized, despite the potential for hybridization described above.

Results

There were four winter-run fry caught in the Sacramento Area beach seine: two in November, one in December, and one in January (Fig. 14a). In addition, 58 yearling-sized winter-run were captured, nearly all from mid-January to early February (Fig. 14b). Peak CPUE coincided with increased flow rates in the Sacramento River at Freeport. Mean CPUE of both fry and yearling winter-run classes was the third lowest on record and well below mean annual CPUE (Table 7a,b).

Spring-run fry were much more abundant than winter-run fry in the Sacramento area; 208 individuals were caught from late December until sampling ended (Fig. 14c). Peak CPUE occurred during January (Table 7c). There were no spring-run yearlings caught, which, with the exception of February, is consistent with previous years (Fig. 14d, Table 7d). This lack of yearling catch is most likely because spring-run individuals are too young to obtain yearling size during this time of year and are classified as fry (Fig. 14d).

Consistent with all other years sampled at Sacramento, there were no late fall-run sized fry captured between November and February (Fig. 14e, Table 7e). The most likely reason is that late fall-run individuals emigrate downstream primarily between May and November, which is outside of our sampling period for this group of sites. Those late-fall individuals that were caught were larger, and, therefore, categorized as yearlings (Fig 14f, Table 7f). We captured four late fall-run yearlings, all during early December. Mean CPUE of late fall-run yearlings for the 2000 field season was an order of magnitude lower than mean annual CPUE.

Overall, CPUE of all less common races and age classes during October-February 2000 at the Sacramento seine sites was lower than mean CPUE across the previous six years of sampling (Table 7). Winter-run fry abundances were extremely low in November and December compared to mean values, although January CPUE was near average. The CPUE of winter-run yearlings were extremely low during December and

February, but near normal during January. Spring-run fry CPUE was low in December and just below normal mean values during January and February. Late-fall yearling CPUE was very low relative to other years during all months sampled.

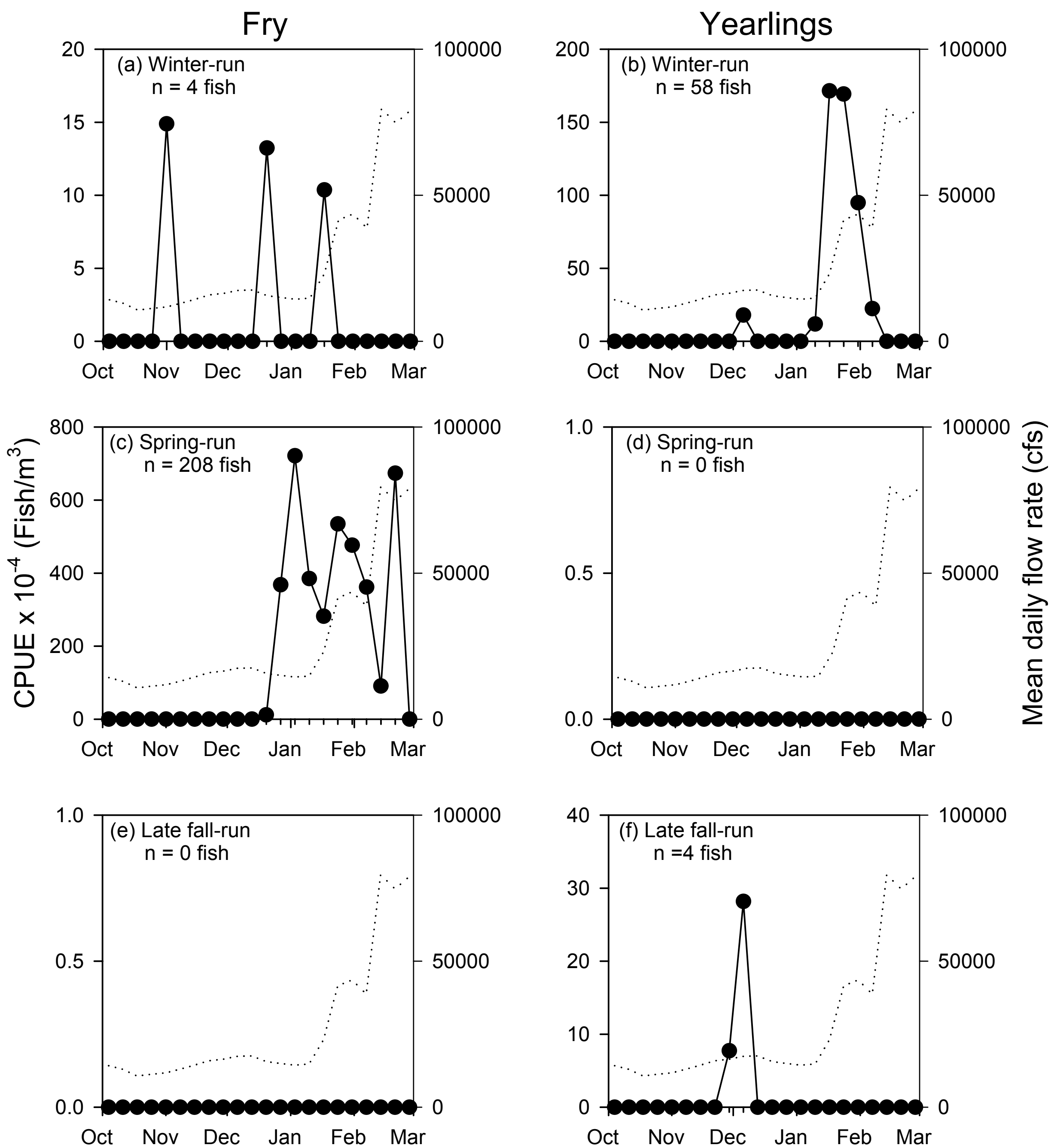

Figure 14. Catch per unit effort (x 10^{-4}) of fry and yearlings from winter- (a,b), spring- (c,d), and late fall-run (e,f) raced salmon in Sacramento area beach seines and concurrent mean daily flow rates at Freeport during the 2000 field season. All data were averaged by week, our standard unit of replication for seines. Sample size (n) corresponds to total number of fish caught during the 2000 field season. Note change in scale among panels.

Table 7. Summary table of CPUE x 10^{-4} (fish/m^3) of less common Chinook salmon races by age class during 1994-2000 field seasons in Sacramento area beach seines by month and year. Among-year average and standard error (SE) values were calculated using years as replicates (n = 6). Within-year average and SE values were calculated using weeks as replicates (n = 22-24). Shaded boxes indicate peak monthly CPUE. Water year (CDEC, 2005): AN = above normal; C = critical; W = wet

(a) Winter-run fry

Field season	Water year	Oct	Nov	Dec	Jan	Feb	Weekly avg (SE)
1994-1995	W	0	0	0	2.63	0	0.752 (0.752)
1995-1996	W	0	0	49.7	2.48	0	11.0 (8.68)
1996-1997	W	0	0	16.5	0	0	4.19 (2.91)
1997-1998	W	0	34.8	56.2	6.39	0	17.2 (9.75)
1998-1999	W	6.94	223	137	9.77	0	86.0 (51.7)
Yearly Avg 1994-1999 (SE)		1.39 (1.39)	51.6 (43.4)	51.9 (23.6)	4.25 (1.71)	0 (0)	23.8 (9.39)
1999-2000	AN	0	3.31	2.21	3.34	0	1.75 (0.972)

(b) Winter-run yearlings

Field season	Water year	Oct	Nov	Dec	Jan	Feb	Weekly avg (SE)
1994-1995	W	0	0	2.58	57.7	12.6	19.0 (7.78)
1995-1996	W	0	0	157	74.3	90.5	65.7 (22.3)
1996-1997	W	0	0.886	128	8.13	17.8	44.8 (18.8)
1997-1998	W	0	57.1	153	189	0	79.2 (28.2)
1998-1999	W	0	169	239	96.0	177	148 (44.1)
Yearly avg 1994-1999 (SE)		0 (0)	45.5 (32.9)	136 (38.2)	85.1 (29.8)	59.5 (33.3)	71.3 (5.98)
1999-2000	AN	0	0	4.47	92.7	28.2	22.2 (11.1)

(c) Spring-run fry

Field season	Water year	Oct	Nov	Dec	Jan	Feb	Weekly avg (SE)
1994-1995	W	0	0	50.7	332	756	234 (79.5)
1995-1996	W	0	0	415	568	224	276 (77.9)
1996-1997	W	0	0	593	1010	451	488 (130)
1997-1998	W	0	0	335	208	0	116 (38.0)
1998-1999	W	0	39.2	435	149	137	163 (44.4)
Yearly avg 1994-1999 (SE)		0 (0)	7.84 (7.84)	366 (89.1)	454 (157)	314 (133)	255 (16.3)
1999-2000	AN	0	0	63.4	450	336	177 (53.0)

Table 7 (cont.)

(d) Spring-run yearlings

Field season	Water year	Oct	Nov	Dec	Jan	Feb	Weekly avg (SE)
1994-1995	W	0	0	0	0	14.7	2.84 (2.00)
1995-1996	W	0	0	0	0	8.24	2.02 (1.34)
1996-1997	W	0	0	0	0	27.5	3.95 (3.37)
1997-1998	W	0	0	0	0	0	0 (0)
1998-1999	W	0	0	0	0	0	0 (0)
Yearly avg 1994-1999 (SE)		0 (0)	0 (0)	0 (0)	0 (0)	10.1 (5.1)	1.76 (0.64)
1999-2000	AN	0	0	0	0	0	0 (0)

(e) Late fall-run fry

Field season	Water year	Oct	Nov	Dec	Jan	Feb	Weekly avg (SE)
1994-1995	W	0	0	0	0	0	0 (0)
1995-1996	W	0	0	0	0	0	0 (0)
1996-1997	W	0	0	0	0	0	0 (0)
1997-1998	W	0	0	0	0	0	0 (0)
1998-1999	W	0	0	0	0	0	0 (0)
Yearly avg 1994-1999 (SE)		0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
1999-2000	AN	0	0	0	0	0	0 (0)

(f) Late fall-run yearlings

Field season	Water year	Oct	Nov	Dec	Jan	Feb	Weekly avg (SE)
1994-1995	W	0	0.611	33.4	35.0	0	13.2 (5.20)
1995-1996	W	0	0	22.5	4.02	3.53	6.07 (3.82)
1996-1997	W	0	5.82	29.0	0	0	9.37 (4.83)
1997-1998	W	0	5.24	43.2	3.38	0	9.40 (5.77)
1998-1999	W	3.72	78.6	73.6	2.63	0	35.9 (19.3)
Yearly avg 1994-1999 (SE)		0.744 (0.744)	18.1 (15.2)	40.3 (8.97)	9.01 (6.54)	0.706 (0.706)	14.8 (2.9)
1999-2000	AN	0	0	9.14	0	0	1.63 (1.31)

Sacramento Trawls

Methods

Data from midwater and Kodiak trawls have been used to estimate the abundance and timing of juvenile Chinook salmon entering the Delta from the Sacramento River. Trawling has been conducted at Sherwood Harbor, approximately 5 km downstream of Sacramento (rm 55), since 1988, except during 1990, when sampling was conducted approximately 34 km downstream near Courtland, CA (~rm 27). Sampling was conducted only during spring from 1988-1993, but has been conducted year-round since 1994. Ten 20-minute tows are conducted between three and seven days/week depending on the need to index the relative abundance of juvenile salmon entering the Delta.

Since December of 1994, Kodiak trawls have generally been conducted from mid-October through March and midwater trawls have been conducted the remainder of the year. During periods of high flow when large debris moves downstream, midwater trawls are used in place of Kodiak trawls due to their smaller size and better maneuverability for safety reasons.

During the 2000 field season, midwater trawls were conducted at Sacramento during August-September and April-July. Kodiak trawls were conducted during October-March.

All trawling was conducted in the middle of the channel facing upstream against the current within 1.5 km of Sherwood Harbor. Occasionally, inclement weather, mechanical problems, excessive fish catch, or some other uncontrollable event reduced tow times or number of tows on a given sampling day.

Results

A total of 53 winter-run sized salmon were caught in Sacramento trawls between late January and late March (Fig. 15a). The highest daily catch of winter-run (12 fish) occurred on 3/22/00, although this was unusually high for this time of year. Peak monthly CPUE of winter-run salmon occurred in February (Table 8a), coinciding with increased flows in the Sacramento River as measured at Freeport by CDEC. Historically, peak CPUE has occurred during February-March. The last winter-run sized salmon was captured in late March after midwater trawling began. Average weekly CPUE in 2000 of winter-run sized salmon was lower than mean CPUE from previous years for both sampling gears.

We caught 6142 spring-/fall-run salmon in Sacramento trawls during the 2000 field season (Fig. 15b). Most were caught between late January and late June. There were two peaks in daily CPUE: late January/early February and late April/early June. The highest daily CPUE (4/19/00) was nearly an order of magnitude greater than the next highest CPUE. Average monthly CPUE was highest during April, coinciding with higher flows at Freeport (Table 8b). As with winter-run, CPUE of spring/fall-run salmon during the 2000 field season was below mean weekly CPUE values from the previous 7 years. Capture of high numbers of spring-/fall-run salmon in April are likely an artifact of hatchery fish releases from Coleman National Fish Hatchery, where approximately 12 million smolts are released in mid-April.

Six late-fall Chinook juveniles were caught in Sacramento trawls during the 2000 field season. All were caught between August and January (Fig. 15c). Average yearly CPUE in both Kodiak and midwater trawls was an order of magnitude lower than average (Table 8c). Peak monthly CPUE occurred during August and was not associated with a change in flow rates in the river. However, these calculations were based on only six fish for the entire field season and, thus, conclusions should be applied cautiously.

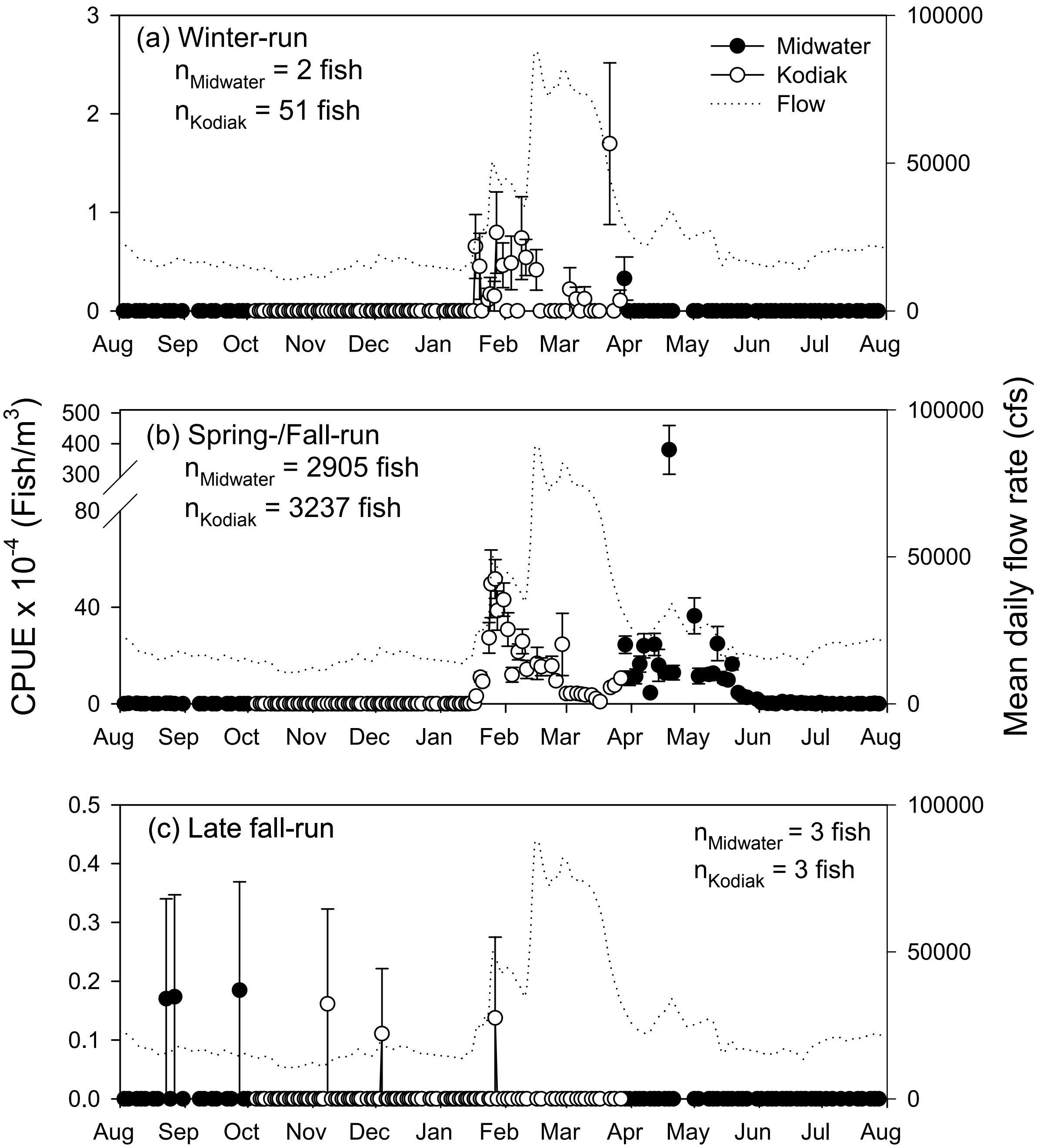

Figure 15. Mean daily catch per unit effort (x 10^{-4}) of (a) winter-, (b) spring-/fall-, and (c) late fall-run Chinook salmon in midwater and Kodiak trawls at Sherwood Harbor (Sacramento trawls) and concurrent mean daily flow rates at Freeport, Sacramento River during the 2000 field season. Sample size (n) corresponds to total number of fish caught in each gear type during the 2000 field season. Note change in scale among panels. Error bars are ± 1 SE.

Table 8. Summary table of CPUE x 10^{-4} (fish/m^3) of (a) Winter-, (b) Fall-/Spring-run, and (c) Late fall-run Chinook salmon in midwater and kodiak trawls at Sherwood Harbor (Sacramento trawls) by month and year. Among-year average and standard error (SE) values were calculated using years as replicates (n = 3-7 for MWTR, n = 5 for KDTR). Within-year average and SE values were calculated using weeks as replicates (n = 16-42). Shaded boxes indicate peak monthly CPUE. Water year (CDEC, 2005): AN = above normal; C = critical; W = wet

(a) Winter-run

Field season	Water year	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Weekly avg (SE)
1992-1993 MWTR	AN	--	0	0	0	0.0462	0.112	0.178	0.650	0.366	0	0	--	0.1434 (0.0447)
1993-1994 MWTR	C	--	0	0	0	0	0	0.107	0.0238	0.0536	0	0	--	0.0193 (0.00714)
1994-1995 MWTR	W	--	0	0	0	0	--	--	0.274	0.281	0	0	0	0.0543 (0.0311)
1994-1995 KDTR	W	--	--	0	0	0.0259	0.0328	0.268	0.892	0.344	--	--	--	0.269 (0.0367)
1995-1996 MWTR	W	0	0	0	--	--	--	--	--	0.0132	0	0	0	0.00182) 0.00182)
1995-1996 KDTR	W	--	--	0	0	0.239	0.137	0.201	0.769	0.0604	--	--	--	0.253 (0.0107)
1996-1997 MWTR	W	0	0	0	--	--	0	0.0407	0	0.0181	0	0	0	0.00472 (0.00294)
1996-1997 KDTR	W	--	--	0	0.0105	0.0456	0	0.200	0.144	--	--	--	--	0.0545 (0.0130)
1997-1998 MWTR	W	0	0	0	--	--	--	--	0	0.0743	0	0	--	0.0130 (0.00829)
1997-1998 KDTR	W	--	0	0.0678	0.0807	0.0189	0.125	0.290	0	--	--	--	--	0.0831 (0.0204)
1998-1999 MWTR	W	--	--	--	--	0.532	--	--	0.109	0.00843	0	0	0	0.0317 (0.0266)
1998-1999 KDTR	W	--	0	0.0157	0.475	0.146	0.0463	0.0313	0.106	--	--	--	--	0.124 (0.0142)
Yearly avg 1993-1999 MWTR (SE)		0 (0)	0 (0)	0 (0)	0 (0)	0.145 (0.130)	0.0373 (0.0373)	0.108 (0.0396)	0.176 (0.104)	0.116 (0.0550)	0 (0)	0 (0)	0 (0)	0.0383 (0.0188)
Yearly avg 1995-1999 KDTR (SE)		--	0	0.00393 (0.00393)	0.138 (0.113)	0.107 (0.0388)	0.0471 (0.0239)	0.165 (0.0404)	0.440 (0.163)	0.202 (0.142)	--	--	--	0.157 (0.0441)
1999-2000 MWTR	AN	0	0	0	--	--	--	--	0.164	0	0	0	0	0.00630 (0.00603)
1999-2000 KDTR	AN	--	--	0	0	0	0.147	0.218	0.206	--	--	--	--	0.102 (0.0386)

Table 8 (cont.)

(b) Spring-/Fall-run

Field season	Water year	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Weekly avg (SE)
1992-1993 MWTR	AN	--	0.0182	0	0.0416	0.263	1.80	2.47	2.38	50.9	58.3	8.37	--	12.0 (4.87)
1993-1994 MWTR	C	--	0.0416	0	0.00738	0.0865	2.61	14.1	0.781	93.7	30.8	1.53	--	15.9 (7.75)
1994-1995 MWTR	W	--	0	0	0	0.0861	--	--	18.0	18.1	13.6	4.06	0.293	5.86 (1.74)
1994-1995 KDTR	W	--	--	--	--	0	12.4	8.17	58.80	9.43	--	--	--	14.5 (4.33)
1995-1996 MWTR	W	0.0834	0	0	--	--	--	--	--	31.4	30.8	1.47	0.204	8.85 (3.17)
1995-1996 KDTR	W	--	--	0	0	2.52	32.5	172	18.2	51.2	--	--	--	36.7 (17.2)
1996-1997 MWTR	W	0	0	0	--	--	2.48	0.913	1.67	56.6	13.2	0.881	0.598	9.35 (4.12)
1996-1997 KDTR	W	--	--	0	0.00964	1.22	20.4	4.23	3.33	--	--	--	--	2.27 (0.982)
1997-1998 MWTR	W	0.167	0	0	--	--	--	--	7.35	25.9	19.3	8.77	--	10.0 (3.06)
1997-1998 KDTR	W	--	--	0	0.0129	0.309	72.6	53.0	12.2	--	--	--	--	28.87 (13.1)
1998-1999 MWTR	W	--	--	--	--	0	--	--	5.46	32.8	52.6	2.07	0.140	17.9 (6.88)
1998-1999 KDTR	W	--	0	0	0.0167	0.145	14.5	35.4	4.57	--	--	--	--	8.02 (3.02)
Yearly avg 1993-1999 MWTR (SE)		0.0835 (0.0482)	0.00996 (0.00699)	0 (0)	0.0163 (0.0128)	0.109 (0.0553)	2.30 (0.253)	5.84 (4.17)	5.94 (4.17)	44.2 (9.70)	31.2 (6.85)	3.88 (1.27)	0.309 (0.101)	11.4 (1.59)
Yearly avg 1995-1999 KDTR (SE)		--	0 (0)	0 (0)	0.00980 (0.00357)	0.839 (0.471)	30.5 (11.1)	54.5 (30.7)	19.4 (10.2)	30.3 (20.9)	--	--	--	18.1 (6.43)
1999-2000 MWTR	AN	0.0643	0	0	--	--	--	--	17.5	55.8	12.2	0.321	0.0212	9.38 (5.23)
1999-2000 KDTR	AN	--	--	0	0	0	12.3	18.6	4.72	--	--	--	--	6.18 (2.06)

Table 8 (cont.)

(c) Late fall-run

Field season	Water year	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Weekly avg (SE)
1992-1993 MWTR	AN	--	0	0	0.591	0.101	0.00721	0.00749	0	0.0200	0	0	--	0.0706 (0.0520)
1993-1994 MWTR	C	--	0.173	0.183	0.00654	0.0550	0.0138	0.0281	0	0	0	0	--	0.0399 (0.0189)
1994-1995 MWTR	W	--	0	0	0.0121	0.446	--	--	0	0	0	0	0.0134	0.0528 (0.0394)
1994-1995 KDTR	W	--	--	--	--	0.0484	0.0897	0	0	0	--	--	--	0.0539 (0.0889)
1995-1996 MWTR	W	0.0132	0.0157	0	--	--	--	--	--	0.00660	0	0	0	0.00549 (0.00329)
1995-1996 KDTR	W	--	--	0	0	0.0697	0.0423	0	0	0	--	--	--	0.0226 (0.0767)
1996-1997 MWTR	W	0	0	0	--	--	0.0958	0	0	0	0	0	0	0.00412 (0.00412)
1996-1997 KDTR	W	--	--	0	0.0374	0.0526	0.150	0.0139	0	--	--	--	--	0.0283 (0.0190)
1997-1998 MWTR	W	0.0823	0.0578	0.0560	--	--	--	--	0	0.0161	0	0.0140	--	0.0368 (0.0101)
1997-1998 KDTR	W	--	--	0	0.108	0.0431	0	0	0	0	--	--	--	0.0283 (0.0281)
1998-1999 MWTR	W	--	--	--	--	0.107	--	--	0	0.0150	0	0	0	0.00866 (0.00566)
1998-1999 KDTR	W	--	0	0.00737	0.134	0.0640	0	0	0	--	--	--	--	0.0309 (0.0668)
Yearly avg 1993-1999 MWTR (SE)		0.0318 (0.0255)	0.0410 (0.0279)	0.0398 (0.0300)	0.203 (0.194)	0.177 (0.0903)	0.0390 (0.0285)	0.0119 (0.00842)	0 (0)	0.00823 (0.00328)	0 (0)	0.00200 (0.00200)	0.00335 (0.00335)	0.0312 (0.00979)
Yearly avg 1995-1999 KDTR (SE)		--	0	0.00184 (0.00184)	0.0698 (0.0309)	0.0556 (0.00493)	0.0564 (0.0286)	0.00277 (0.00277)	0 (0)	0 (0)	--	--	--	0.0329 (0.00544)
1999-2000 MWTR	AN	0.0312	0.0231	0	--	--	--	--	0	0	0	0	0	0.00677 (0.00492)
1999-2000 KDTR	AN	--	--	0	0.00807	0.00583	0.00724	0	0	--	--	--	--	0.00373 (0.00213)

Kodiak Trawl at Mossdale

Methods

Kodiak trawling at Mossdale has been conducted since the 1997 field season to index juvenile salmon moving into the Delta from the San Joaquin River basin. As is done for beach seines along the San Joaquin River, all San Joaquin River Chinook salmon are classified as fall-run. The sampling schedule has changed every year, largely because boating and, therefore, sampling is not possible when flows on the San Joaquin River are too low. This is usually an issue during late summer and fall months before significant rainfall has occurred. Region 4 of CDFG has been sampling at Mossdale during the spring period since 1989 (San Joaquin River Group Authority, 2000 Annual Technical Report) and, in field season 2000, sampled from April 3-June 30. In the 2000 field season, sampling was conducted from mid-October until late June.

Results

A total of 1407 juvenile salmon were caught at Mossdale in the 2000 field season. Fish were first detected entering the Delta in January and continued until the middle of June (Fig. 16). The two highest average daily CPUE values occurred on consecutive sampling days (2/14/00 and 2/16/00) at the beginning of a spike in flows. Peak average monthly CPUE occurred in February (Table 9). This peak coincided with that of the 1999 field season but occurred earlier than peaks in 1997 and 1998 field seasons. However, sampling did not occur in January and February during 1997-1998 owing to low water flows in the San Joaquin River. It is unknown whether salmon abundance was high during these months, although it is unlikely because of flow levels. More sampling in the future will allow us to more confidently define temporal patterns in abundance of salmon at Mossdale.

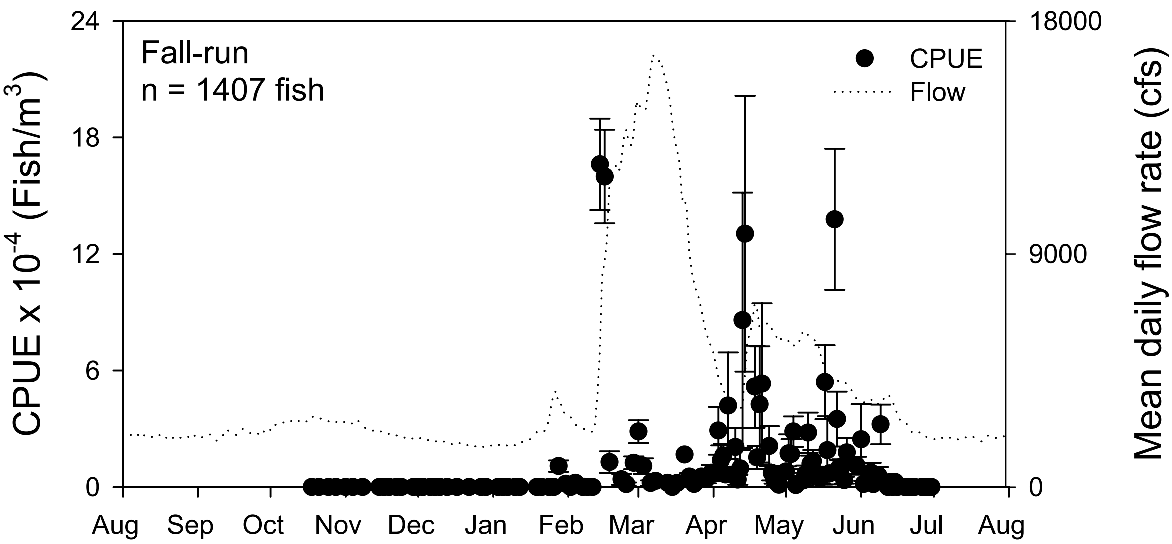

Figure 16. Mean daily catch per unit effort (x 10^{-4}) of fall-run Chinook salmon in Kodiak trawls at Mossdale, San Joaquin River and concurrent mean daily flow rate at Vernalis, San Joaquin River during the 2000 field season. Sample size (n) corresponds to total number of fish caught during the 2000 field season. Error bars are ± 1 SE.

Table 9. Summary table of CPUE x 10^{-4} (fish/m^3) of fall-run Chinook salmon in Mossdale Kodiak trawls by month and year. Among-year average and standard error (SE) values were calculated using years as replicates (n = 1-3). Within-year average and SE values were calculated using weeks as replicates (n = 14-35). Standard error calculations were not possible when n = 1. Shaded boxes indicate peak monthly CPUE for each year. Shaded boxes indicate peak monthly CPUE. Water year (CDEC, 2005): AN = above normal; W = wet.

Field season	Water year	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Weekly avg (SE)
1996-1997	W	--	0	0	0	0	--	--	0.325	2.14	1.06	0.393	--	0.493 (0.154)
1997-1998	W	--	--	--	--	--	--	--	--	2.58	6.09	2.50	--	3.47 (0.802)
1998-1999	AN	--	--	--	0	0	0.810	3.09	0.630	1.32	1.94	0.962	--	1.04 (0.231)
Yearly avg 1993-1999 (SE)		--	0	0	0 (0)	0 (0)	0.810	3.09	0.478 (0.153)	2.01 (0.367)	3.03 (1.55)	1.29 (0.629)	--	1.67 (0.204)
1999-2000	AN	--	--	0	0	0	0.113	3.26	0.681	2.92	2.05	0.372	--	4.17 (1.30)

Midwater Trawl at Chipps Island

Methods

The DJFMP has conducted midwater trawling at Chipps Island since May, 1976. This sampling was initiated as a way to gain information about fall-run juvenile salmon emigrating from the Delta towards the Pacific Ocean. We originally conducted ten 20-minute tows three to seven days each week from April to July. Sampling was conducted seven days/week only during experimental releases of hatchery salmon (usually December-January and April-May) to better recover coded wire tagged (CWT) fish released upstream and in the Delta. CWT information is used to estimate survival of salmon emigrating through the Delta (see sections below). Sampling effort has increased since 1976. In 1996, we began sampling year round to understand better the temporal patterns in salmon emigration downstream. In 1998, we began conducting 20 tows/day in split shifts to coincide with Vernalis Adaptive Management Plan (VAMP) salmon releases (April-May). This doubling of effort was implemented to increase the number of CWT salmon recovered from VAMP releases.

Trawls were conducted within a 3 km section of river upstream of the western tip of Chipps Island. Trawls were conducted in both directions (upstream and downstream) regardless of tide in three channel locations: north, south, and middle. Occasionally, inclement weather, mechanical problems, or excessive catch reduced tow times or number of tows per day.

During the 2000 field season, ten 20-minute tows were conducted between three and seven days/week depending on the need to recover CWT salmon for survival studies. Sampling generally was conducted three days/week, except for two release periods (12/1/00-1/21/00 and 3/28/00-6/9/00). Effort doubled for VAMP releases from 4/17/00-5/20/00. During this period, twenty 20-minute tows were conducted seven days/week.

Results

A total of 177 winter-run salmon were captured from 1/24/00-5/20/00 (Fig. 17a). Peak average daily CPUE occurred on April 2 and peak average monthly CPUE occurred during March (Table 10a). Annual CPUE was 31% lower than average annual CPUE.

A total of 18,264 spring-/fall-run Chinook salmon were caught throughout the 2000 field season (Fig. 17b). Most of these fish were captured well after peak water flows and coincide better with hatchery releases in April and May. Yearling size smolts were captured between September 2 and October 14, with fork lengths ranging from 93 to 265 mm. Peak daily CPUE occurred on 4/22/00 and peak mean monthly CPUE occurred during April (Table 10b). Yearly CPUE was below average and was the second lowest of the last eight years of sampling at Chipps Island.

We caught 36 late fall-run salmon between 9/28/00-2/22/00. Peak daily CPUE occurred on 11/8 when seven late fall-run salmon were caught. Peak mean monthly CPUE occurred during November. December CPUE was marginally lower. Consistent with previous years, most salmon migrated through the Delta during April-May, reflecting the influence of hatchery releases of fall-run salmon from CNFH.

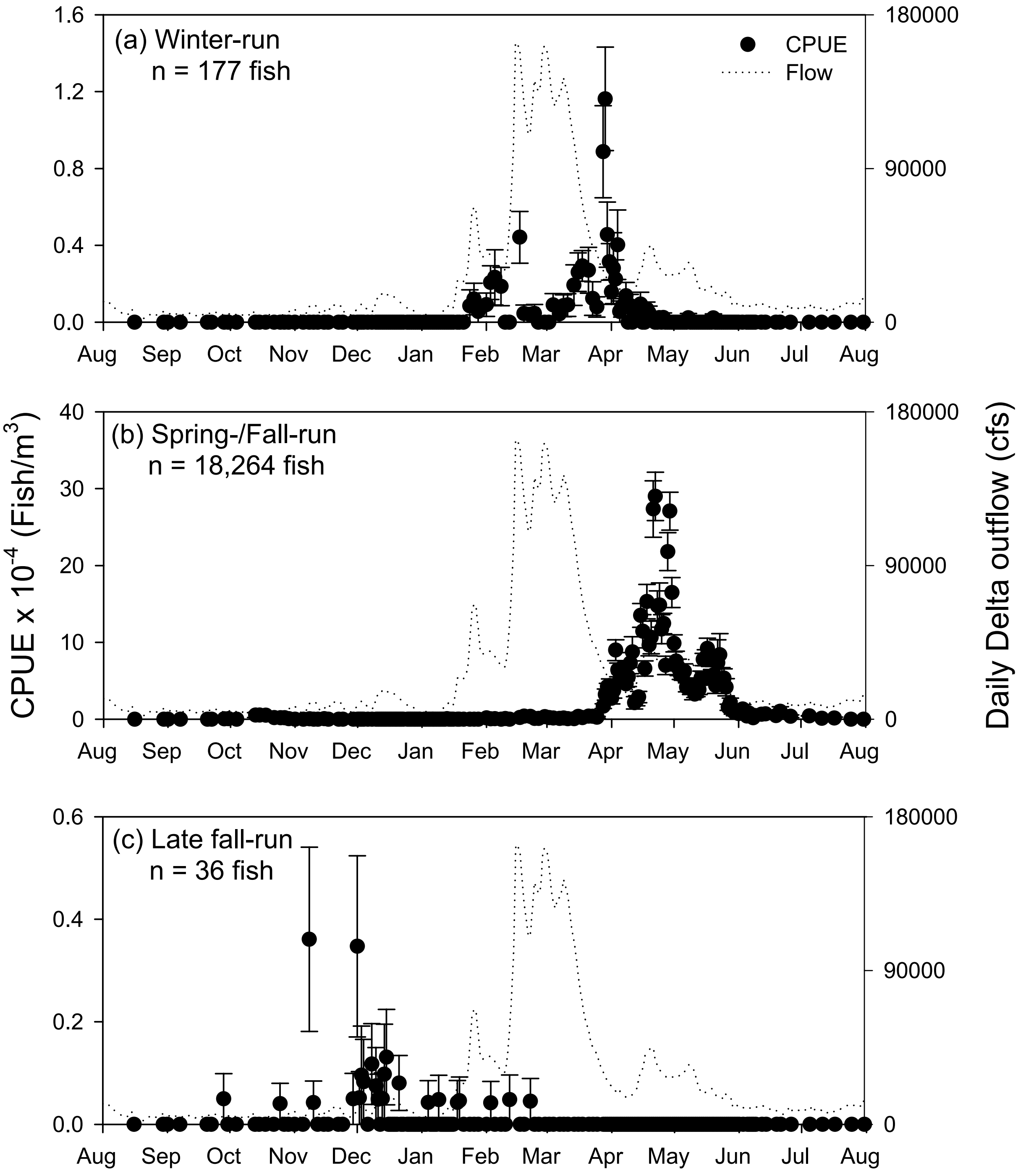

Figure 17. Mean daily catch per unit effort (x 10^{-4}) of (a) winter-, (b) spring-/fall-, and (c) late fall-run Chinook salmon in midwater trawls at Chipps Island and concurrent daily Delta outflow during the 2000 field season. Sample size (n) corresponds to total number of fish caught during the 2000 field season. Note change in scale among panels. Error bars are ± 1 SE.

Table 10. Summary table of CPUE x 10^{-4} (fish/m^3) of (a) winter-, (b) spring-/fall-, and (c) late fall-run Chinook salmon in midwater trawls at Chipps Island by month and year. Among-year average and standard error (SE) values were calculated using years as replicates (n = 7). Within-year average and SE values were calculated using weeks as replicates (n = 14-52). Shaded boxes indicate peak monthly CPUE for each year. Water year (CDEC, 2005): AN = above normal; C = critical; W = wet

(a) Winter-run

Field season	Water year	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Weekly avg (SE)
1992-1993	AN	--	--	--	--	--	--	--	--	0.328	0.00347	0	0	0.0881 (0.0519)
1993-1994	C	--	--	--	0	0	0.00313	0.00708	0.0834	0.0225	0.00136	0	--	0.0150 (0.00545)
1994-1995	W	--	--	0	0	0	0.0141	0.136	0.392	0.2906	0.00473	0	0	0.0830 (0.0276)
1995-1996	W	0	0	0	0	0.0639	0.0745	0.112	0.650	0.0760	0.00407	0	0	0.0836 (0.0320)
1996-1997	W	0	--	0	0	0.00203	0.02370	0.0852	0.239	0.0676	0.00289	0	0	0.0415 (0.0121)
1997-1998	W	0	0	0	0	0.0108	0.0289	0.0161	0.214	0.0444	0.00140	0	--	0.0315 (0.0124)
1998-1999	W	--	0	0	0	0.0207	0.0110	0.0835	0.258	0.0865	0	0	0	0.0425 (0.0143)
Yearly avg 1993-1999 (SE)		0 (0)	0 (0)	0 (0)	0 (0)	0.0162 (0.0101)	0.0259 (0.0104)	0.0733 (0.0211)	0.306 (0.797)	0.131 (0.0470)	0.00256 (0.000641)	0 (0)	0 (0)	0.0551 (0.0111)
1999-2000	AN	0	0	0	0	0	0.0124	0.107	0.290	0.0655	0.00143	0	0	0.0382 (0.0137)

(b) Spring-/Fall-run

Field season	Water year	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Weekly avg (SE)
1992-1993	AN	--	--	--	--	--	--	--	--	7.07	12.9	4.83	0.487	4.44 (1.36)
1993-1994	C	--	--	--	0.0433	0	0	0.00309	0.0164	6.01	2.54	0.200	--	0.876 (0.455)
1994-1995	W	--	--	0.0513	0.0338	0	0.623	0.416	0.934	8.48	15.1	4.52	0.330	2.48 (0.687)
1995-1996	W	0.0406	0.0639	0.167	0.0131	0.0308	0.126	4.42	1.83	8.77	13.3	2.15	0	2.86 (0.712)
1996-1997	W	0.141	--	0	0.00908	0.0143	0.235	0.00547	0.0896	3.92	2.15	0.360	0.0978	0.570 (0.200)
1997-1998	W	0.0388	0.0214	0.00265	0	0.00198	0.466	0.645	2.22	12.4	14.8	4.60	--	3.26 (0.829)
1998-1999	W	--	0.0596	0.0377	0	0	0.0372	0.935	0.516	4.55	9.97	2.60	0.0763	2.56 (0.666)
Yearly avg 1993-1999 (SE)		0.0735 (0.0339)	0.0483 (0.0135)	0.0518 (0.0305)	0.0166 (0.00737)	0.00785 (0.00512)	0.248 (0.101)	1.07 (0.686)	0.935 (0.374)	7.31 (1.09)	10.1 (2.10)	2.75 (0.747)	0.198 (0.0908)	2.44 (0.507)
1999-2000	AN	0	0.0150	0.275	0.0103	0	0.00229	0.148	1.04	10.8	5.16	0.633	0.140	1.58 (0.515)

Table 10. (cont.)

(c) Late fall-run

Field season	Water year	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Weekly avg (SE)
1992-1993	AN	--	--	--	--	--	--	--	--	0	0	0	0	0.0220 (0.00809)
1993-1994	C	--	--	--	0.0280	0.0815	0.00579	0.0168	0	0	0	0.00198	--	0.0136 (0.00489)
1994-1995	W	--	--	0	0.0207	0.0768	0.0444	0	0	0	0.00127	0	0	0.0198 (0.00957)
1995-1996	W	0	0.00562	0.0123	0	0.184	0.0606	0.00256	0	0	0.00133	0	0	0.0169 (0.00740)
1996-1997	W	0	--	0	0	0.151	0.0295	0	0	0	0	0	0	0.0197 (0.00532)
1997-1998	W	0.0188	0.0367	0.0197	0.0291	0.100	0.0280	0	0	0	0	0	--	0.0402 (0.0140)
1998-1999	W	--	0.0657	0	0.233	0.0939	0.00647	0.00306	0	0	0	0	0.0191	0.00320 (0.00166)
Yearly avg 1993-1999 (SE)		0.00627 (0.00627)	0.0360 (0.0173)	0.0064 (0.00409)	0.0518 (0.0366)	0.115 (0.0176)	0.0291 (0.00873)	0.00374 (0.00267)	0 (0)	0 (0)	0.000372 (0.000240)	0.000283 (0.000283)	0.00383 (0.00383)	0.0193 (0.00420)
1999-2000	AN	0	0.00825	0.00500	0.0453	0.0436	0.00854	0.0112	0	0	0	0	0	0.00993 (0.00389)

Absolute Abundance Estimates

Methods

Absolute abundance estimates of juvenile salmon migrating downstream past Chipps Island have been calculated each year from 1980 to 2000, excluding 1987, using methods set forth in USFWS (1987). No control (downstream) releases were conducted in 1987, prohibiting the calculation of absolute abundance estimates. Abundance estimates are based on recovery rates calculated from Chipps Island midwater trawls and ocean recovery estimates obtained from the Regional Mark Processing Center (RMPC) web site, <www.rmpc.org>, operated by the Pacific States Marine Fisheries Commission (PSMFC, 2005).

Chipps Island has been chosen for recovery of CWT juveniles because all emigrating juveniles originating in both the Sacramento and San Joaquin rivers must pass through this relatively narrow constriction of the confluence on their way towards the ocean. Prior to release, all CWT juvenile Chinook salmon are marked externally by clipping and removing the adipose fin. If a fin clip is observed by field technicians upon recovery, the fish is returned to the laboratory for processing. The CWT is dissected from the fish and read under a microscope. Tags are read independently by two different readers with any discrepancies resolved by a third reader. Each release group of fish has a unique coded wire tag code such that recovered fish can be traced back to their original hatchery and related release information.

Information on methods for adult ocean recovery estimates can be found on the RMPC web site.

Trawl recovery rate at Chipps Island was calculated for each release group in each field season as follows:

First, ocean recovery rates of the downstream control group (Benicia, Port Chicago, or Ryde), $R_{control}$ were calculated as:

$$R_{control} = \frac{N_{control,\,recovered}}{N_{control,\,released}} \tag{3}$$

where $N_{control,\,recovered}$ is the estimated number of fish from the control release recovered in the ocean and $N_{control,\,released}$ is the number of fish released in the control release.

Similarly, ocean recovery of each upstream release group, $R_{release}$, was calculated as:

$$R_{release} = \frac{N_{release,\,recovered}}{N_{release,\,released}} \tag{4}$$

where $N_{release,\,recovered}$ is the estimated number of fish from the upstream release group recovered in the ocean and $N_{release,\,released}$ is the number of fish released in the upstream release group.

From these two ocean recovery rates, a survival rate of each upstream release group to Chipps Island relative to the control group, $\hat{s}_{release}$, was calculated as:

$$\hat{s}_{release} = \frac{R_{release}}{R_{control}} \tag{5}$$

This calculation assumes that the difference in ocean recovery rates between the two groups is due to mortality between the upstream and downstream location. The downstream location is assumed to approximate the ocean recovery rate of fish had they been released at Chipps Island.

Next, an estimate of the number of fish surviving to Chipps from the upstream release site, $N_{Chipps,survived}$, was calculated as:

$$N_{Chipps,\,survived} = \hat{s}_{release} \times N_{release,\,released} \tag{6}$$

We then calculated the number of fish available for capture at Chipps, $N_{Chipps,\,available}$, as:

$$N_{Chipps,\,available} = N_{Chipps,\,survived} \times p_{time} \tag{7}$$

where ρ_{time} is the proportion of time from the first recovery to the last recovery at Chipps that sampling was conducted, or:

$$p_{time} = \frac{t_{sampled}}{t_{total}} \tag{8}$$

where $t_{sampled}$ is the amount of time trawled (in minutes) and t_{total} is the amount of time (in minutes) encompassing the entire sampling period.

Finally, trawl recovery rate for each release group, $TRR_{release}$, was determined as the proportion of fish available at Chipps that were recovered at Chipps, or:

$$TRR_{release} = \frac{N_{Chipps,\,recovered}}{N_{Chipps,\,available}} \tag{9}$$

Annual mean trawl recovery rate, $\overline{TRR}$, was then calculated by averaging all $TRR_{release}$ values within a year, or:

$$\overline{TRR} = \sum_{i=1}^{n} TRR_{release} \tag{10}$$

Releases where $\hat{s}_{release} > 1.0$ were not included in $\overline{TRR}$ calculations because they were outside the boundaries of reasonable estimates. Further, releases where $\hat{s}_{release} = 0$ were not used because recovery rates could not be estimated from null values. No fry releases were included in these calculations because they experience greater mortality and are recovered in lower numbers as they become of smolt size and migrate past Chipps Island. Also, only fall-run releases were included in calculations of $\overline{TRR}$. These criteria have changed from previous annual reports to improve our estimates, and, therefore, values of $\overline{TRR}$ and absolute abundance have also changed.

If $\hat{s}_{control}$ is unusually low in a year, $\hat{s}_{release}$ from many other releases would be >1. When this occurs, Ryde, which is approximately 25 miles upstream, is used as the control group. This has only occurred in two years: 1998, 1993. In addition, in 1995, Rodeo, which is just downstream of Carquinez Strait in San Pablo Bay, was used as the control site owing to unusually low ocean survival rates from Ryde.

In our estimates of trawl recovery rates at Chipps Island, we must assume that salmon are equally distributed in time and space and that our net is 100% efficient in catching fish located in the water that is sampled. Although these assumptions may be violated, they provide the best estimate currently available and are, therefore, used to estimate abundance.

Absolute abundance, N_i, was calculated for each month within a year by expanding fish catches at Chipps Island, n_i, using $\overline{TRR}$ for each year as:

$$N_i = \frac{n_i}{P_{time} \times \overline{\overline{TRR}}} \tag{11}$$

Results

Mean trawl recovery rate for the 2000 field season was 0.0066 ± 0.0022 (Fig. 18, Appendix 1,2). This value is below the average of the past 20 years (0.0100 ± 0.0017) although 50% higher than the 1999 recovery rate.

We estimate that 337,055 winter-run, 14,969,020 spring-/fall-run, and 101,592 late fall-run juvenile salmon passed Chipps Island during the 2000 field season (Table 11). Our estimate of winter-run salmon was the fourth highest over the past seven years. Abundance estimates of spring-/fall-run salmon in 2000 were the fifth highest in the past seven years. Our estimate of late fall-run juvenile abundance was the second lowest in the past seven years. Our winter-run salmon abundance estimate was highest in March, which is consistent with previous years, the spring-/fall-run abundance estimate was highest in April and May, and the late fall abundance estimate was highest in November and December, all fairly consistent with estimates from previous years.

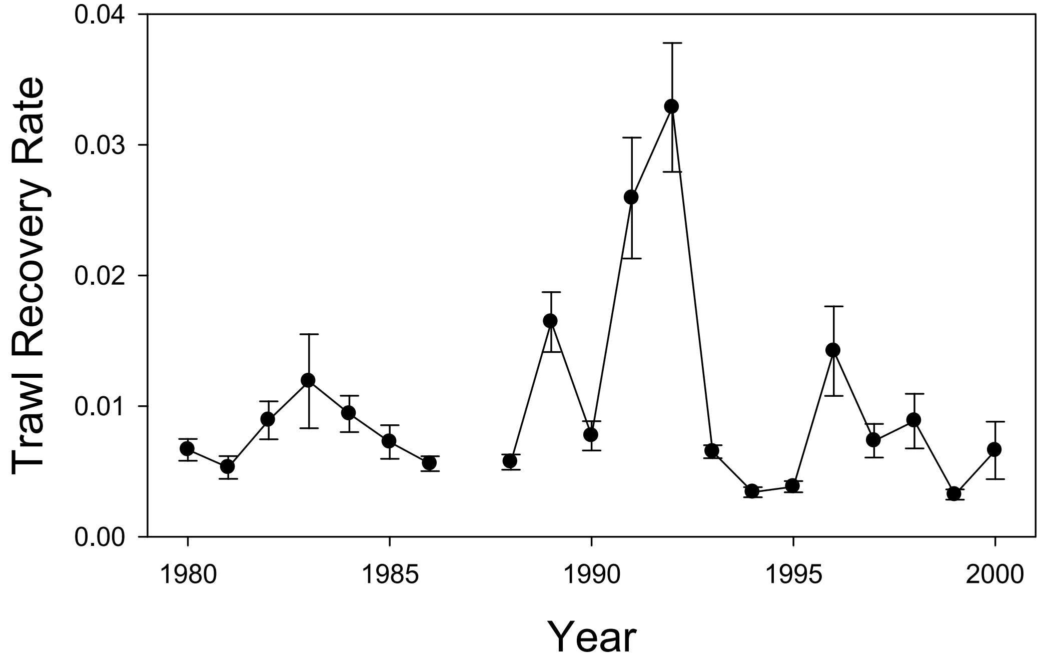

Figure 18. Trawl recovery rates of midwater trawls at Chipps Island between 1980 and 2000. No recovery rate was calculated for 1987 because no control release was conducted. Error bars are ± 1 SE.

Table 11. Abundance estimates of (a) winter-, (b) spring-/fall-, and (c) late fall-run Chinook salmon passing Chipps Island by month and field season.

(a) Winter

	1994	1995	1996	1997	1998	1999	2000
Aug	--	--	0	0	0	--	0
Sep	--	--	0	--	0	0	0
Oct	--	0	0	0	0	0	0
Nov	0	0	0	0	0	0	0
Dec	0	0	26,460	1,420	5,941	30,176	0
Jan	5,085	21,043	27,130	19,821	16,344	17,568	8,110
Feb	10,014	166,934	30,638	63,769	8,757	105,203	69,992
Mar	146,263	571,011	234,678	186,718	126,668	426,876	220,529
Apr	37,630	456,771	27,838	52,312	20,513	110,378	37,006
May	2,064	7,771	1,535	2,038	862	0	1,419
Jun	0	0	0	0	0	0	0
Jul	--	0	0	0	--	0	0
Total	201,613	1,223,530	348,280	326,078	179,085	690,201	337,055

(b) Spring/fall

	1994	1995	1996	1997	1998	1999	2000
Aug	--	--	15,711	101,355	24,016	--	0
Sep	--	--	17,022	--	13,557	94,853	18,007
Oct	--	67,427	62,016	0	2,009	158,554	186,583
Nov	58,735	46,270	7,602	7,006	0	0	10,227
Dec	2,620	0	13,230	9,939	990	0	0
Jan	0	961,674	42,124	55,858	242,824	55,213	1,622
Feb	5,007	549,124	1,465,067	3,865	304,309	1,087,101	100,788
Mar	25,218	1,372,522	675,559	70,019	1,348,779	827,073	813,910
Apr	10,523,059	12,641,369	3,021,505	2,906,894	7,742,431	7,668,242	9,133,569
May	4,321,237	22,453,937	5,223,930	1,348,341	8,801,787	14,304,817	4,144,722
Jun	395,959	6,418,641	1,051,861	281,462	2,516,730	4,571,215	458,857
Jul	--	486,975	0	75,292	--	95,679	100,735
Total	15,374,434	44,997,938	11,595,625	4,860,032	20,997,433	28,862,746	14,969,020

(c) Late fall

	1994	1995	1996	1997	1998	1999	2000
Aug	--	--	0	0	12,008	--	0
Sep	--	--	1,547	--	20,336	103,475	9,003
Oct	--	0	4,134	0	12,056	0	5,831
Nov	42,716	25,705	0	0	12,057	196,760	46,023
Dec	136,249	112,755	66,150	105,070	48,521	133,278	25,848
Jan	10,169	71,547	14,279	21,622	14,009	10,039	6,488
Feb	25,034	0	928	0	0	5,845	8,399
Mar	0	0	0	0	0	0	0
Apr	0	0	0	0	0	0	0
May	0	1,943	512	0	0	0	0
Jun	7,919	0	0	0	0	0	0
Jul	--	0	0	0	--	47,840	0
Total	222,705	211,950	87,551	126,693	118,986	497,236	101,592

Although numerous sources of error exist in our abundance estimates, two sources are worth particular mention. First, some fish releases yielded $\hat{s}_{release}$ >1.0 (Appendix 1), which, as indicated above, is not realistic (i.e., abundance of fish with a specific coded wire tag cannot increase through the Delta). One explanation for this is that the same group of fish were sampled repeatedly (fish moved past Chipps Island more than once due to a shift in tide direction). Alternatively, $\hat{s}_{release}$ values are based on a single control release that is likely not representative of each fish from each hatchery released at each site during the entire field season. This suggests that we need to increase replication of control releases in the future to account better for differences among hatcheries, rivers, and time of year.

Second, we conduct trawls just after sunrise and, during the VAMP period, just before sunset to maximize CPUE (Brandes & McLain 2001). While this may allow higher recovery rates, it may also inflate mean CPUE. Of greater importance, there is currently no consensus on temporal patterns of juvenile salmon catch and the mechanisms that may drive these patterns. Patterns in catch may be higher during the day than at night (Wickwire and Stevens 1966, Schaffter 1980, Brandes & McLain 2001), lower during the day than at night (Hansen 2004), or vary seasonally (Wilder & Ingram *in press*). Recent spring sampling protocols were developed based on 24 hour sampling at Jersey Point conducted in April and May of 1997 (Hanson Environmental, unpublished data, 1997). Further evaluation is needed to better understand patterns in juvenile salmon abundance in our catches to provide the best estimates available of true salmon abundance.

Figure 19 illustrates yearly abundance estimates at Chipps Island between April 1 and June 30 from 1978 to 2000 using the trawl recovery rate for each year or, if not available, mean trawl recovery rate during 1980-2000 (excluding 1987). Only April-June estimates were included because they are the only months in which we have sampled consistently since 1978. This graph provides a general index of the absolute production of Chinook salmon passing Chipps Island through time.

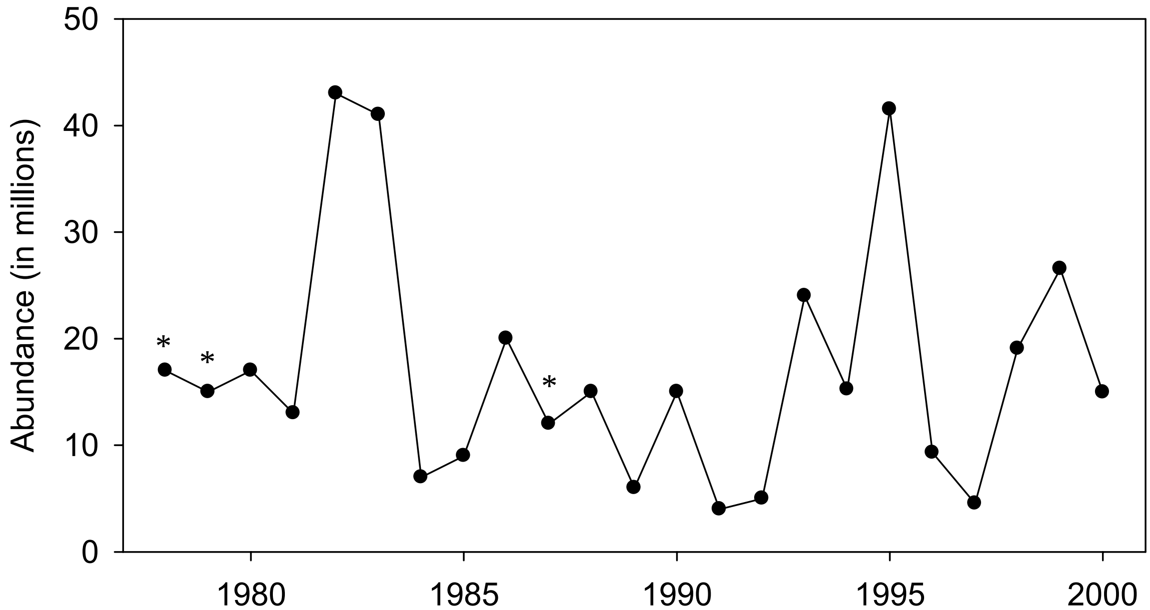

Figure 19. Absolute abundance estimates of all races of juvenile Chinook salmon combined between April 1 and June 30 from 1978-2000 using mean annual trawl recovery rates from ocean recoveries. *Indicates that trawl recovery rate was estimated by using average mean annual trawl recovery rate from 1980-2000.

2000 Mark and Recapture Experiments

Three separate mark and recapture experiments were conducted in 2000 to better understand juvenile Chinook salmon survival through the Sacramento/San Joaquin Delta: (1) Delta Action 8 experiment, (2) Sacramento River fall-run survival indexing experiment, and (3) Vernalis Adaptive Management Plan (VAMP) experiment.

<u>Delta Action 8 Experiment</u>

Background

In October 1996, the Anadromous Fish Restoration Program (AFRP), part of the Central Valley Project Improvement Act, proposed nine actions in the Delta that resulted in extending the time period for protective measure contained within the Delta Accord (1994), which later became the 1995 Water Quality Control Plan (WQCP, P. Brandes, *pers. comm.*). Much of the rationale behind these nine Delta Actions was based on the desire to protect both early and late outmigrants of the various salmon races to ensure greater life history diversity relative to outmigration timing. Proposed actions in the Delta were selected for the ability to contribute to increasing natural production of anadromous fish, but it was assumed that other species would also benefit from the proposed actions.

Delta Action 8 was originally implemented to establish conditions for a CWT winter -run juvenile survival experiment in December and January at exports of 65% and 35% of Delta inflow, respectively. The action was designed to relate the value of the lower export/inflow ratio to survival of juvenile salmon migrating through the Delta between November and January. Delta Action 8 was intended to provide data needed to assess the benefits of implementing Delta Action 9. Delta Action 9 was designed to limit the average combined exports of the CVP and SWP to no greater than 35% of Delta inflow during November through January, similar to the level prescribed in the 1995 WQCP between February and June.

Because of the low numbers and endangered status of winter-run Chinook salmon, late fall-run yearlings from CNFH were used as surrogates for winter-run owing to their larger size and earlier timing of outmigration relative to fall run. Fish are coded wire tagged, trucked, and released in Georgiana Slough and at Ryde (or Isleton). The experiment compares relative survival of the two release groups to Chipps Island (and as indexed in the ocean fishery) between two different export/inflow ratios. The experiment has been conducted previously in 12/93, 12/94, 1/95, and 1/96.

The experiment has been conducted in earlier years with fall-run juveniles (Wullschleger 1994). The late fall-run experiments conducted in 1993 and 1994, prior to the Delta Action 8 experiments, occurred when the Delta Cross Channel gates were open. In all other late-fall Delta Action 8 releases the gates were closed except during 1999. In 1999, water quality in the Delta was a problem and the gates were opened during the experiments. Over the course of the experiment, it has been requested that the gates be closed to minimize the variation in survival from a change in the gate operation. In 12/94, 1/95, and for both releases in 1999, the Ryde group was actually released at Isleton, about 3 miles further downstream on the Sacramento River than Ryde. The release groups were moved to Isleton to assure that none of the tagged fish would move upstream on the tides, at the lower flows, to be entrained into the open Delta Cross Channel (12/94) or Georgiana Slough.

In the early years of implementation of the experiment, it became apparent that Sacramento River flows were unpredictable, making it difficult to plan export levels. As a result, the experimental variable tested has changed from export/inflow ratios to just export levels.

Methods

There are two specific goals of the Delta Action 8 experiment: (1) to compare survival of winter-run juvenile salmon in the interior Delta (areas physically in between the Sacramento and San Joaquin Rivers) relative to the mainstem Sacramento River, and (2) to determine the relationship between relative survival of juvenile winter-run salmon in the interior Delta and the State Water Project (SWP) and the Central Valley Project (CVP) water exports out of the Delta. Two hypotheses were assessed in the 2000 Field Season: (1) survival of winter-run juvenile salmon is greater in the mainstem Sacramento River than in the interior Delta, and (2) relative survival of winter-run juvenile salmon in the interior Delta increases with decreased water exports by the SWP and CVP.

In the 2000 field season, four groups of CNFH late fall-run Chinook salmon were released in the Delta at Isleton (mainstem Sacramento River) and Georgiana Slough (interior Delta). There were two paired releases: (1) 12/10/99 at Georgiana Slough and 12/11/99 at Isleton; and (2) 12/20/99 at Georgiana Slough and 12/21/99 at Isleton. Approximately 130,000 and 102,000 fish were released at Georgiana Slough and Isleton, respectively. An additional release of 49,208 fish on 12/29/99 at Port Chicago served as a control group to factor out survival downstream of the Delta. Fish recoveries at Chipps Island were used to calculate survival indices. We sampled seven days per week at Chipps Island from 12/10/99 through 01/16/00 to increase recovery of these fish. We also recorded recoveries from the SWP and CVP salvage facilities of fish that came from these releases.

A survival index to Chipps Island for each release, $\hat{s}_{Chipps,\, release}$, was calculated as:

$$\hat{s}_{Chipps,\, release} = \frac{N_{release,\, recovered}}{N_{release,\, released} \times p_{time} \times p_{length}} \tag{11}$$

where p_{length} is the proportion of the distance across the river at Chipps Island that is sampled. A paired t-test was used to determine whether there was a statistical difference in survival index between Georgiana Slough and Isleton releases for all years combined (1993-2000, n = 10). We also calculated the ratio of survival index for Georgiana Slough to survival index for Isleton.

Results

The Delta Cross Channel gate was closed for the first pair of releases on 12/10-12/11/99. The gates were then opened and closed on 12/14, opened on 12/15 and closed again on 1/16. Thus, they were open for most of the recovery period for the first and the entire recovery period for the second set of releases.

Flow rates were relatively constant during the experimental period. For the two week period after the first pair of releases (12/10-12/24/00), daily flow rates in the lower Sacramento River at Freeport ranged from 15,100-17,800 cfs. Mean daily flow rates were 16,680 (±282) cfs (Table 12). For the two week period after the second pair of releases (12/20/99-1/3/00), daily flow rates in the lower Sacramento River at Freeport ranged from 14,400-15,800 cfs. Mean daily flow rates were 15,047 (±101) cfs.

Exports fluctuated substantially during the two periods. Exports started at 5000 cfs on the first day of the first release and were 1500 cfs from about day 4 until day 11 and increased back to 5000 cfs by day 14. Daily export rates during the two week period after the first pair of releases (12/10-12/24/00) ranged from 1469-6273 cfs and mean daily export rates were 2939 (±431) cfs. The second release had exports starting at 2000 cfs on day 1 and increased steadily to about 10729 on day 14. Daily export rates during the two week period after the second pair of releases (12/20-1/3/00) ranged from 2006-10,915 cfs and mean daily export rates were 7545 (±757) cfs.

Survival indices from the current field season were pooled with those of previous years. When pooled, mean survival indices to Chipps Island of late fall-run salmon released at Ryde or Isleton (mean $\hat{s}$ = 0.715) were significantly higher than those released into Georgiana Slough (mean $\hat{s}$ = 0.181; t_9 = 3.87, P = 0.004).

This indicates that higher 14 day average export rates in the second pair of releases corresponded to a lower ratio of survival for fish released at Georgiana Slough relative to those released at Isleton. Thus, the hypothesis that survival of winter-run Chinook salmon increases with decreased export rates is not supported by these data.

Table 12. Survival index and expanded CVP salvage, SWP salvage, and ocean recovery numbers for late fall-run releases made in the Delta during the 2000 field season. Mean daily flow rate was calculated for days from the first release to 14 days after the last release for each pair (n = 15 days total). Standard errors are reported in parentheses.

Release							Mean daily flow rate (cfs)	Mean daily export rate (cfs)	Expanded salvage		Expanded ocean recovery numbers
Date	Site	# Fish released	Truck temp (C)	River temp (C)	Survival index	Survival ratio			CVP	SWP	
12/10	Georgiana Slough	65517	12.2	11.1	0.054	0.161	16680 (282)	2939 (431)	24	0	43
12/11	Isleton	53426	12.2	10.0	0.338	**	**	**	0	0	128
12/20	Georgiana Slough	64515	22.2	17.2	0.350	0.668	15047 (101)	7545 (757)	60	22	151
12/21	Isleton	49341	15.0	10.0	0.525	**	**	**	0	4	160
12/29	Port Chicago (Control)	49208	12.2	11.1	**	**	**	**	0	0	274

Sacramento River Fall-run Survival Index

The Sacramento River fall-run survival indexing experiment estimates the survival of juvenile Chinook salmon in the Delta. In 2000, both fry and smolts were released. Coded wire tagged fry were released on the mainstem Sacramento River at Ryde and in the lower Mokelumne River to index relative fry survival of fish released on the mainstem Sacramento River versus interior Delta. Survival is also indexed for fall-run smolts as they migrate through the Delta from Sacramento to Chipps Island. Indices from the current year can be compared to similar indices generated from previous years. Indices also provide estimates of baseline survival to help evaluate Delta restoration and operational changes that may occur in the future. Data can also be used to improve Chinook smolt survival models for the Delta.

Methods

Fry

To estimate relative survival of juvenile salmon fry upstream and at differing locations in the Delta (north Delta versus central Delta), pairs of marked fall run hatchery fry (<60 mm FL) were released and later recovered in the ocean fishery. An index of survival was obtained for each release group by dividing the number of expanded ocean recoveries by the number released.

To compare upper Sacramento River fry survival to that observed in the Delta, a group was released on the Sacramento River just downstream of RBDD and paired with a group in the Delta released at Clarksburg. This pair was also replicated twice. To compare survival in the north Delta to survival in the central Delta, a group was released at Isleton and paired with a group released on the Lower Mokelumne River at Lighthouse Marina. This pair was also replicated twice.

Although some fry were recovered at Chipps Island, recoveries were too low to compare survival rates accurately. Therefore, we used ocean recovery rates to compare survival among sites.

Smolts

In the 2000 field season, three groups of hatchery smolts from the Feather River Fish Hatchery were released at the Broderick boat ramp in West Sacramento between 4/10-5/15. These releases overlapped the peak period of outmigration of wild fall-run Chinook salmon. Additional releases were conducted at Port Chicago (Concord Naval Weapons Station) on 4/12 and 5/3 to estimate survival from Sacramento to Port Chicago using ocean recoveries. The DCC gates were closed for the entire period of the study. Fish were recovered at Chipps Island and survival indices were calculated as for the Delta Action 8 experiment.

Results

Fry

In the first paired release comparing survival in the north Delta to the central Delta, the survival index of fall-run fry at Isleton, our site in the north Delta, was marginally higher than that at Lighthouse Marina, our site in the central Delta (Table 13). In the second paired release, the survival index of fall-run fry at Lighthouse Marina was twice that of Isleton. This suggests that there may not be a clear difference between the north and central Delta in survival of fall-run fry.

In the upper Sacramento River to Delta comparison, the survival index of fall-run fry released at RBDD was multiple times greater than that of fish released at Clarksburg for both pairs of releases. This suggests that survival of fry released in the upper Sacramento River was much higher than fish released in the Delta.

As more paired fry releases are conducted in future years, we will gain additional statistical power to make stronger inference about these results.

Table 13. Survival index of fall-run fry releases made for the 2000 Sacramento River fall-run fry survival index study. N/P = Not provided.

Release								
Date	Site	Region	# Fish released	Mean fork length (mm)	Truck temp (C)	River temp (C)	Expanded ocean recovery numbers	Survival index
2/14/00	Lighthouse Marina	Central Delta	50,361	52	12.2	12.2	3	0.00060
2/15/00	Isleton	North Delta	51,293	49	11.1	12.8	4	0.00078
2/28/00	Lighthouse Marina	Central Delta	52,973	63	8.9	12.8	19	0.00359
2/29/00	Isleton	North Delta	52,870	59	10.0	12.8	7	0.00132
3/6/00	RBDD	Upper Sac. River	47,341	57	N/P	N/P	245	0.00517
3/7/00	Clarksburg	Delta	47,168	57	10.0	12.2	41	0.00087
3/13/00	RBDD	Upper Sac. River	48,798	56	N/P	N/P	291	0.00596
3/14/00	Clarksburg	Delta	46,461	57	13.9	12.8	73	0.00157

<u>Smolts</u>

Survival indices during the study ranged from 0.344 to 0.680 (Table 14). Indices increased through time, corresponding with increasing fish lengths and decreasing mean daily flow rates. Unlike other years, despite the large variation in survival indices, the temperature differential between truck and river temperatures did not vary largely among releases. Combined with previous years, there is strong negative effect of temperature differential between the release truck and river on survival index ($R^2 = 0.32$, $p < 0.002$, Fig. 20a). If data from the two releases with survival indices >1.0 are removed, the strength of the relationship increases ($R^2 = 0.54$, $p < 0.0001$). It is thought that the cause of this relationship may be the physiological shock of such a dramatic change in temperature. There is no influence of truck temperature on survival (Fig 20b), but a strong negative effect of river temperature on survival ($R^2 = 0.66$; $p < 0.0001$; Fig.

20c). This indicates that survival rate may be due to either temperature differential or river temperature. Further research on the physiological effects of temperature on Chinook salmon is needed to determine the factors contributing to variation in survival rates.

Table 14. Survival index and expanded CVP salvage, SWP salvage, and ocean recovery numbers for fall-run releases made for the 2000 Sacramento River fall-run smolt survival index study. Mean daily flow rate was calculated for the 14 days following each release. Standard error of mean daily flow rate is reported in parentheses.

Release			Mean fork length (mm)	Truck temp (C)	River temp (C)		Mean daily flow rate (cfs)	Expanded salvage		Expanded ocean recovery numbers
Date	Site	# Fish released				Survival index		CVP	SWP	
04/10	West Sacramento	50,016	77	12.8	17.2	0.344	29,043 (885)	0	0	443
05/01	West Sacramento	41,539	83	13.9	17.8	0.591	24,464 (927)	0	0	434
05/15	West Sacramento	34,480	93	12.2	17.2	0.680	17,379 (329)	0	0	577
04/12	Port Chicago (Control)	46,934	79	12.8	17.2	**	**	0	0	260
05/03	Port Chicago (Control)	31,311	82	16.1	18.9	**	**	0	0	260

In recent VAMP studies, there has been an effort to determine the effect of temperature differential between truck and river on short term mortality. Mortality after 48 h is measured in a subset of fish from VAMP releases held in net pens. These studies indicate that very little mortality occurs in the first 48 h after release (San Joaquin River Agreement, 2000). This suggests that this instant change in temperature does not cause immediate mortality. Instead, the physiological shock associated with the instantaneous change in temperature may reduce the health of the fish over a longer term. An additional explanation is that prolonged exposure to higher river temperature decreases the health of the fish. Potential mechanisms for this include, but are not limited to, stress, higher susceptibility to predation and disease, lower dissolved oxygen concentration, and greater energy demands resulting from higher metabolism.

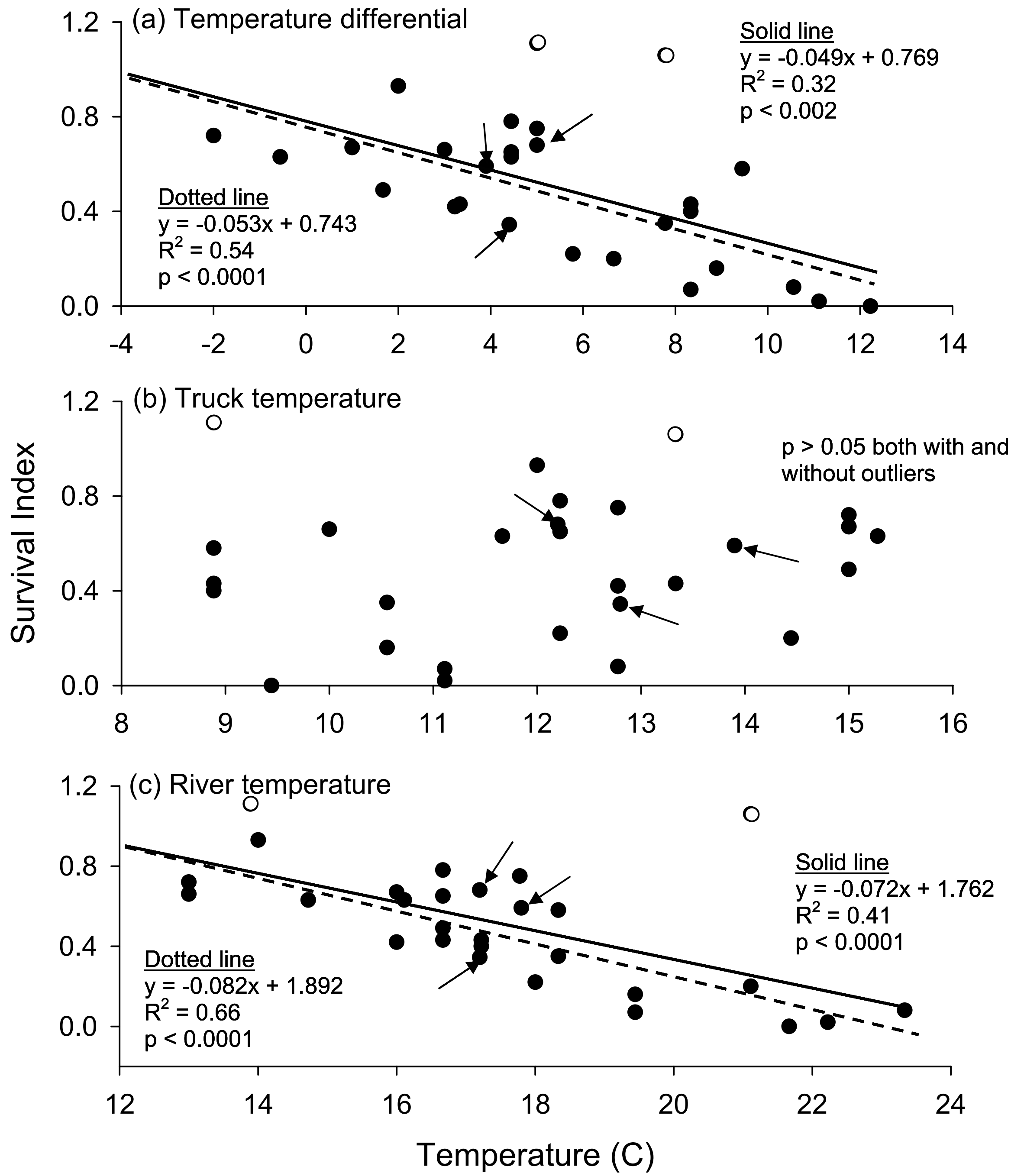

Figure 20. Relationship between survival index and (a) temperature differential between truck and river; (b) truck temperature; and (c) river temperature. Solid regression lines include the two open circles, which are releases where survival index >1.0. Dotted lines do not include these two points. Lines are drawn only where significant relationships were found. Arrows indicate releases from the 2000 field season.

VAMP

Escapement of Chinook salmon in the San Joaquin River and tributaries has fluctuated dramatically for many years, with peak escapement values near 70,000 fish (all races combined). Brandes (2000) reported that escapement is related to flows between April-June from 2.5 years prior, which is when juveniles migrate towards the ocean. Results from past smolt survival studies conducted in the South Delta indicate that survival to Chipps Island is very low in some years. Also, survival of salmon smolts in the mainstem San Joaquin River is generally greater than those in upper Old River (Brandes and McLain, 2001). A temporary barrier at the head of Old River was installed in 2000 as a way to increase smolt survival by preventing their migration into upper Old River.

The goal of the VAMP study is to evaluate the role of river flows and exports by the State Water Project (SWP) and the Central Valley Project (CVP) pumping facilities on juvenile Chinook salmon survival through the San Joaquin Delta. VAMP measures survival under specific flow and export targets with a barrier at the head of Old River.

Methods

The 2000 VAMP study involved releases of CWT Chinook salmon at three locations along the San Joaquin River: Durham Ferry on 4/17 and 4/28, Mossdale on 4/18 and 4/19-5/3, and Jersey Point on 4/20 and 5/1. There were two groups of fish released at Jersey Point on 5/1, one group from the Merced River hatchery and one from the Mokelumne River. The 2000 VAMP study was the first time Durham Ferry, which is approximately 10 rm upstream of Mossdale, was used as a release site (Table 15). This was done to address the concern that salmon released at Mossdale could disperse into upper Old River at a higher rate than those originating from the San Joaquin River tributaries during years when the Old River Barrier could not be installed. Fish were recovered at Chipps Island and survival indices were calculated as for the Delta Action 8 experiment.

Targeted flows of 5700 cfs and export rates of 2250 cfs were achieved during the 2000 VAMP experiment. The two sets of releases made at Durham Ferry, Mossdale, and Jersey Point were considered replicates measuring survival at similar flow and export rates.

Results

The first set of releases (4/17-4/20) had survival indices of 0.193, 0.195, and 0.623 for releases at Durham Ferry, Mossdale, and Jersey Point, respectively (Table 15). Survival was much higher at Jersey Point because of its proximity to Chipps Island. Survival indices for the second set of releases (4/28-5/1) were 0.147, 0.782, and 0.851 at Durham Ferry, Jersey Point (from Merced River hatchery), and Jersey Point (Mokelumne River hatchery), respectively. Again, survival at Jersey Point was high relative to Durham Ferry. Survival through the South Delta was generally high in 2000 compared to previous years. For further information about VAMP results see San Joaquin River Agreement (2000).

Table 15. Survival index and expanded CVP salvage, SWP salvage, and ocean recovery numbers for fall-run releases made for the VAMP study during the 2000 field season. Mean daily flow rate was calculated for the 14 days following each release at Vernalis. Standard error of mean daily flow is reported in parentheses. N/P = Not provided.

Release		# Fish Released	Mean fork length (mm)	Truck Temp (C)	River Temp (C)	Survival index	Mean daily flow rate (cfs)	Expanded salvage		Expanded Ocean Recovery Numbers
Date	Site							CVP	SWP	
4/17	Durham Ferry	72,163	80	13	14	0.193	6187 (113)	60	461	694
4/18	Mossdale	46,249	79	11	13	0.195	6146 (117)	24	433	380
4/20	Jersey Point	51,351	82	12	18	0.623	5941 (79)	0	0	0
4/28	Durham Ferry	74,392	77	11	17	0.147	5717 (49)	48	231	162
5/1	Jersey Point	50,233	77	12	17	0.782	5709 (50)	0	6	588
5/1	Jersey Point	101,612	86	N/P	N/P	0.851	5709 (50)	0	5	1358

<u>Georgiana Slough versus Ryde</u>

Beginning in 1999, additional groups of fall-run smolts were released to compare the relative survival of fish released in the main stem Sacramento River and the Delta both before and during VAMP export curtailment. Two sets of fall run smolts were released at Georgiana Slough and Ryde prior to and during VAMP.

In 1999, we found that the ratio of salmon survival rates from Georgiana Slough and Ryde releases was greater before the VAMP period (= 0.83) than during the VAMP period (= 0.51; Table 16). Survival rates of both release groups were greater during VAMP than before VAMP, but survival rate on the main stem Sacramento River was disproportionately higher during VAMP.

In 2000, ratios of salmon survival were identical both before and after the VAMP period (= 0.48 for both). Survival rates of both releases were nearly twice as high during VAMP exports.

As more paired releases are conducted in future years, we will gain additional statistical power to make stronger inference about these results.

Table 16. Georgiana Slough versus Ryde survival index comparison before and during VAMP. Flow and export rates are reported for the day of the release only.

Timing of release	Release Date	Release Site	# Fish Released	Mean fork length (mm)	Truck Temp (C)	River Temp (C)	Survival index	Survival Ratio (GS:Ryde)
Pre-VAMP	3/30/99	Georgiana Slough	52,578	75	13	8	0.261	0.83
	3/31/99	Ryde	51,006	75	12	12	0.316	
During VAMP	4/27/99	Georgiana Slough	49,970	86	12	17	0.355	0.51
	4/28/99	Ryde	52,303	86	13	16	0.698	
Pre-VAMP	3/28/00	Georgiana Slough	49,824	71	11	14	0.071	0.48
	3/29/00	Ryde	46,510	71	10	15	0.149	
During VAMP	4/27/00	Georgiana Slough	39,136	79	14	18	0.116	0.48
	4/28/00	Ryde	42,814	79	13	18	0.244	

Other CWT Recoveries in Sampling Gears During the 2000 Field Season
Coded wire tagged Chinook salmon of all races are recovered in all sampling gears throughout the field season. They are summarized here, but specific information on any individual fish is available at <http://baydelta.ca.gov>. Maps showing recovery numbers and locations of the various coded wire tag groups released in 2000 are available at <http://www.delta.dfg.ca.gov/jfmp/cwt.asp>.

Fall-run

Numerous CWT fall-run salmon are released throughout the year in the Central Valley. Many are recovered in trawling efforts at Sacramento (Sherwood Harbor) and Chipps Island and in beach seines in the lower Sacramento and San Joaquin Rivers and the Delta. Others were recovered in Jersey Point sampling as part of the VAMP experiment.

In the 2000 field season, we recovered 4062 CWT fall-run salmon (Table 17a). The majority were caught at Chipps Island (1504 fish), Jersey Point (1158 fish), and the State Fish Facility (936 fish). A map of these sites is available at <http://www.delta.dfg.ca.gov/data/rtm2000/sample-sites.asp>.

Many fall-run fish released on the Sacramento River (i.e., Battle Creek, Verona, and Ryde) were recovered at Jersey Point on the San Joaquin River. This may indicate that these fish moved into the central Delta via Georgiana Slough or Three Mile Slough. Alternatively, it may indicate that these fish moved upstream in the San Joaquin River to Jersey Point after migrating downstream past the confluence of the two rivers. Five fish that were recovered at Jersey Point and 10 that were recovered at Chipps Island had been released at Port Chicago, which is downstream of both Jersey Point and Chipps Island. This provides further support that fish can move upstream either from migration or tidal action.

Late fall-run

As mentioned in the Delta Action 8 Experiment section above, between 12/10/99 and 12/21/99, approximately 130,000 and 102,000 late fall-run salmon from CNFH were released at Georgiana Slough and Isleton, respectively. As expected, the majority of fish were recovered at Chipps Island (Georgiana Slough - 24; Isleton - 35) and the federal (Georgiana Slough - 7; Isleton - 0) and state (Georgiana Slough - 6; Isleton - 1) fish salvage facilities (Table 17b).

No late fall-run fish released at Isleton were recovered in the interior Delta. One Isleton fish was captured at Brannan Island, which is one river mile upstream from the Sacramento River in Three Mile Slough. Also, one fish that was released at Georgiana Slough was caught at Brannan Island and another caught at King's Island, which is in the interior Delta. These data support the Delta Action 8 assumption that fish released on the Sacramento River are not likely to stray into the interior Delta.

All late-fall recoveries of fish that were released at Port Chicago were at Chipps Island, which, as found with fall-run fish in the previous section, provides further evidence that fish can move upstream from Port Chicago either from migration or tidal action.

Approximately 813,000 late fall-run salmon were released from CNFH at Battle Creek between 11/99 and 1/00. Of 893 fish recovered, 686 were found on the Sacramento River or downstream of the confluence. Three individuals were salvaged at the State fish salvage facility in the interior Delta; 204 fish were recovered at Jersey Point.

Winter-run

Approximately 30,000 winter-run salmon from Livingston Stone National Fish Hatchery were released in the upper Sacramento River at Caldwell Park on 1/27/00. Only four fish were recovered in our sampling (Table 17c).

Spring-run

Approximately 59,000 wild spring-run salmon were released at Butte Creek and 189,500 were released from the Feather River hatchery at San Pablo Bay. We recovered a total of eight of these fish (Table 17d). Six were recovered at Chipps Island, one at Jersey Point, and one at the State fish salvage facility. Those released downstream of Chipps Island (San Pablo Bay) moved upstream to be caught at Chipps.

Table 17. Recoveries of coded wire tagged juvenile Chinook salmon released at hatcheries during the 2000 field season. Blank cells indicate that no fish were recovered.

Release Location	Recovery Location																																		Total
	Antioch Dunes	B&W Marina	Big Beach	Brannan Island	Chipps Island	Clarksburg	Colusa St. Park	Discovery Park	Dos Reis	Durham Site	Eddo's	Elkhorn	Federal Fish Facility	Garcia Bend	Georgiana Slough	Isleton	Jersey Point	King's Island	Koket	Lost Isle	Miller Park	Mossdale	Rio Vista	Sherman Island	Sherwood Harbor Trawl	South Meridian	State Fish Facility	Steamboat Sl. (mouth)	Stump Beach	Sturgeon Bend	Terminous	Verona	Wetherbee	Wimpy's	
(a) Fall																																			
Battle Creek					564	1	1										204								120		3								893
Clarksburg					24	2						1				3	3						1	2			5		4		1				46
Downstream Thermolito Bypass					6			1									2																		9
Durham Ferry			2		50				1	1			9				58			2		1					208						7		339
Elkhorn					3	2		1				10		2							1				3		1		1						24
Georgiana Slough		3			14												19										3				2				41
Grayson					4					1							1										3								9
Hatfield State Park					28								5				53										168								254
Isleton					5											7								2											14
Jersey Point	1			1	312						1						465										6								786
Knight's Ferry					4								43														75								122
La Grange					12				1				3				10										42								68
Lighthouse Marina					4																			1			3								8
Mossdale					25				1				3				39			2		17					142								229
Mouth of Mokelumne River					66												60										1								127
New Hope Landing					86								2				80										4							7	179

Table 17 (cont.)

	Recovery Location																																	
Release Location	Antioch Dunes	B&W Marina	Big Beach	Brannan Island	Chipps Island	Clarksburg	Colusa St. Park	Discovery Park	Dos Reis	Durham Site	Eddo's	Elkhorn	Federal Fish Facility	Garcia Bend	Georgiana Slough	Isleton	Jersey Point	King's Island	Koket	Lost Isle	Miller Park	Mossdale	Rio Vista	Sherman Island	Sherwood Harbor Trawl	South Meridian	State Fish Facility	Steamboat Sl. (mouth)	Stump Beach	Sturgeon Bend	Terminous	Verona	Wetherbee	Wimpy's	Total
Old Fisherman's Club					9								2				22			2							58			2			2		97
Port Chicago					10												5																		15
Red Bluff Diversion Dam					34								1				3								6	1	2								47
Roberts Ferry - Hughson					5								2				10										19								36
Ryde				1	32											1	20		1				2	1					1						59
Sac (rm 242.5)					1												1																		2
Thermolito Bypass					2																														2
Two Rivers					4								35														127								166
Upper Merced @ MRFF					33								6				35										64								138
Verona					52	1								1	1		24				1				18		1					9			108
West Sacramento					109	2								6			42				7				38		1	1							206
Woodbridge Dam					3												2																		5
Yolo Bypass					2																														2
Yolo Bypass Elkhorn/Toe drain					1							25		1									1		3										31
Fall Total	1	3	2	2	1504	8	1	2	3	2	1	36	111	10	1	11	1158	0	1	6	9	18	4	6	188	1	936	1	6	2	3	9	9	7	4062

Table 17 (cont.)

	Recovery Location																																		
Release Location	Antioch Dunes	B&W Marina	Big Beach	Brannan Island	Chipps Island	Clarksburg	Colusa St. Park	Discovery Park	Dos Reis	Durham Site	Eddo's	Elkhorn	Federal Fish Facility	Garcia Bend	Georgiana Slough	Isleton	Jersey Point	King's Island	Koket	Lost Isle	Miller Park	Mossdale	Rio Vista	Sherman Island	Sherwood Harbor Trawl	South Meridian	State Fish Facility	Steamboat Sl. (mouth)	Stump Beach	Sturgeon Bend	Terminous	Verona	Wetherbee	Wimpy's	Total
(b) Late fall																																			
Battle Creek					98		1					6	38	3	1				1		1				26	2	87								264
Georgiana Slough				1	24								7					1									6								39
Isleton				1	35																						1								37
Port Chicago					26																														26
Late fall Total	0	0	0	2	183	0	1	0	0	0	0	6	45	3	1	0	0	1	1	0	1	0	0	0	26	2	94	0	0	0	0	0	0	0	366
(c) Winter																																			
Caldwell Park					4																				2		1								7
Winter Total	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	1	0	0	0	0	0	0	0	7
(d) Spring																																			
Butte Creek					3												1										1								5
San Pablo Bay					3																														3
Spring Total	0	0	0	0	6	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	8
Grand Total	1	3	2	4	1697	8	2	2	3	2	1	42	156	13	2	11	1159	1	2	6	10	18	4	6	216	3	1032	1	6	2	3	9	9	7	4443

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Table of Acronyms

The following acronyms have been used in the preceding text:

AFRP – Anadromous Fish Restoration Program
CDEC – California Data Exchange
CDFG – California Department of Fish & Game
cfs – Cubic feet per second
CNFH – Coleman National Fish Hatchery
CPUE – Catch per unit effort
CVP – Central Valley Project
CVPIA – Central Valley Project Improvement Act
CWT – Coded wire tag
DJFMP – Delta Juvenile Fish Monitoring Program
FL – Fork length
IEP – Interagency Ecological Program
KDTR – Kodiak trawl
MWTR – Midwater trawl
NMFS – National Marine Fisheries Service
PSMFC – Pacific States Marine Fisheries Commission
RBDD – Red Bluff Diversion Dam
rm – River mile
RMPC – Regional Mark Processing Center
SE – Standard error
STFWO – Stockton Fish & Wildlife Office
SWP – State Water Project
USFWS – United States Fish & Wildlife Office
VAMP – Vernalis Adaptive Management Program
WQCP – Water Quality Control Plan

Appendix 1. Calculated recovery rates for CWT chinook salmon smolts released throughout the Central Valley and recovered by trawl at Chipps Island for the 2000 field season. Trawl recovery rate for a given tag code is calculated by estimating the number of fish surviving to Chipps (using the ocean recovery rate) corrected by the time sampled. FRH = Feather River Hatchery; MOK = Mokelumne River Hatchery; MRFF = Merced River Fish Facility

Tag code	Release site (Hatchery)	Release date	Number released	Size at release (FL)	Estimated ocean recov. (#)	Ocean recov. rate	Survival rate to Chipps	Number surviving to Chipps	Proportion of time sampled at Chipps	Number available for capture at Chipps	Number recovered at Chipps	Trawl recovery rate at Chipps (by release)	Mean (SE) annual trawl recovery rate at Chipps
5-38-29 & 30	Port Chicago (FRH)	04/12/00	46,934	79	260	0.0055							
6-26-51 & 52	Port Chicago (FRH)	05/03/00	31,311	82	260	0.0083							
	*Calculations of survival rate to Chipps for releases on or before 4/21/00 used the 4/12/00 Port Chicago control; Calculations of survival rate to Chipps for releases after 4/22/00 use the 5/3/00 Port Chicago control												
6-26-60	Live Oak (FRH)	06/07/00	42,275	109	179	0.0042	0.5099	21556		0	0		
6-2-44	Woodbridge Dam (Wild)	03/13/00	6,067	82	7	0.0012	0.2083	1264	0.227	287	3	0.0105	
5-1-2-8-3 & 4	Georgiana Slough (FRH)	03/28/00	49,824	71	75	0.0015	0.2717	13539	0.258	3493	7	0.0020	
5-1-2-8-5 & 6	Ryde (FRH)	03/25/00	46,510	71	85	0.0018	0.3299	15344	0.206	3161	11	0.0035	
6-2-49 & 52	New Hope Landing (MOK)	04/24/00	101,737	70	281	0.0028	0.3326	33840	0.261	8832	32	0.0036	
6-1-6-11-9 & 10	Georgiana Slough (FRH)	04/27/00	39,136	79	57	0.0015	0.1754	6864	0.2	1373	7	0.0051	
5-1-2-8-7 & 8	Ryde (FRH)	04/28/00	42,814	79	130	0.0030	0.3657	15656	0.261	4086	21	0.0051	
6-1-6-9-14 & 15, 6-1-11-8-14	Durham Ferry (MRFF)	04/28/00	74,392	77	162	0.0022	0.2622	19509	0.254	4955	22	0.0044	

Appendix 1 (cont.)

Tag code	Release site (Hatchery)	Release date	Number released	Size at release (FL)	Estimated ocean recov. (#)	Ocean recov. rate	Survival rate to Chipps	Number surviving to Chipps	Proportion of time sampled at Chipps	Number available for capture at Chipps	Number recovered at Chipps	Trawl recovery rate at Chipps (by release)	Mean (SE) annual trawl recovery rate at Chipps
6-2-55 & 56	New Hope Landing (MOK)	05/03/00	97,404	78	392	0.0040	0.4847	47207	0.26	12274	54	0.0044	
6-45-39 to 42	Merced River Fish Facility	04/12/00	101,533	78	114	0.0011	0.2027	20579	0.262	5392	17	0.0032	
6-45-43 to 45	Hatfield State Park (MRFF)	04/13/00	73,447	76	334	0.0045	0.8209	60292	0.262	15797	13	0.0008	
6-45-56	La Grange (MRFF)	04/13/00	23,603	74	73	0.0031	0.5583	13178	0.261	3439	6	0.0017	
6-45-61 & 62	Roberts Ferry - Hughson (MRFF)	04/13/00	19,198	82	76	0.0040	0.7146	13719	0.255	3498	5	0.0014	
6-45-60	Old Fisherman's Club - SJ River (MRFF)	04/14/00	21,698	75	107	0.0049	0.8902	19315	0.25	4829	5	0.0010	
6-45-57 & 58	La Grange (MRFF)	04/15/00	44,048	77	13	0.0003	0.0533	2347	0.256	601	4	0.0067	
6-45-59	Old Fisherman's Club - SJ River (MRFF)	04/16/00	23,071	73	141	0.0061	1.1032	Unusually high recovery rate-not used in calculation					
6-45-49 to 52	Merced River Fish Facility	04/24/00	102,146	76	125	0.0012	0.1474	15053	0.264	3974	16	0.0040	
6-45-53 to 55	Hatfield State Park (MRFF)	04/27/00	77,427	81	202	0.0026	0.3142	24326	0.256	6228	15	0.0024	
6-44-8 & 9	Knights Ferry (MRFF)	05/18/00	51,926	84	7	0.0001	0.0162	843	0.139	117	1	0.0085	

Appendix 1 (cont.)

Tag code	Release site (Hatchery)	Release date	Number released	Size at release (FL)	Estimated ocean recov. (#)	Ocean recov. rate	Survival rate to Chipps	Number surviving to Chipps	Proportion of time sampled at Chipps	Number available for capture at Chipps	Number recovered at Chipps	Trawl recovery rate at Chipps (by release)	Mean (SE) annual trawl recovery rate at Chipps
6-44-7	Knights Ferry (MRFF)	05/19/00	25,511	83	7	0.0003	0.0330	843	0.0820	69	3	0.0434	
6-44-10 & 11	Two Rivers (MRFF)	05/20/00	50,547	85	18	0.0004	0.0429	2168	0.1360	295	4	0.0136	0.0066 (0.0022)

Appendix 2. Chipps Island tag summary, survival calculations, expanded fish facility recoveries for coded wire tagged fish recovered during the 2000 field season (Sampling period: 8/16/99-7/31/00). The expanded ocean recovery numbers in this table are updated only once per year. For updated information, refer to the website: <www.rmpc.org>. CNFH = Coleman National Fish Hatchery; LSNFH = Livingston Stone National Fish Hatchery; FRH = Feather River Hatchery; MRFF = Merced River Fish Facility; MOK = Mokelumne River Hatchery

Tag code	Release site (Hatchery)	Date	Truck temp (F)	Release temp (F)	Number released	Avg FL (mm)	First day recov.	Last day recov.	Number recov.	Minutes fished	Percent sampled	Survival index	Group index	Expanded Salvage Numbers		Expanded Ocean Recovery Numbers
														CVP	SWP	
Late-fall run releases																
Upper Sacramento River and Tributaries																
05-01-02-04-12	Sacramento River RM 246 (CNFH)	10/18/99	N/P	N/P	4,769	100	-	-	0	-	-	-		0	0	15
05-51-40	Battle Creek (CNFH)	11/12/99	N/P	N/P	70,500	110	12/01/99	01/28/00	6	8880	0.105	0.106		12	10	155
05-51-41	Battle Creek (CNFH)	12/09/99	N/P	N/P	75,948	110	12/20/99	02/19/00	16	7590	0.085	0.322		36	32	297
05-52-14	Battle Creek (CNFH)	12/21/99	N/P	N/P	83,383	110	01/03/00	01/26/00	9	3770	0.109	0.129		0	33	81
05-52-07	Battle Creek (CNFH)		N/P	N/P	79,868	120	01/19/00	03/04/00	11	3640	0.055	0.326		84	69	574
05-52-08	Battle Creek (CNFH)		N/P	N/P	84,451	120	01/21/00	02/26/00	10	2840	0.053	0.289		84	87	650
05-52-09	Battle Creek (CNFH)		N/P	N/P	76,398	120	01/21/00	03/29/00	11	5615	0.057	0.331		36	43	478
05-52-10	Battle Creek (CNFH)		N/P	N/P	93,556	120	01/21/00	04/20/00	8	10,705	0.082	0.136		12	57	466
05-52-11	Battle Creek (CNFH)		N/P	N/P	81,228	120	01/21/00	03/21/00	8	4815	0.055	0.234		60	42	518
05-52-12	Battle Creek (CNFH)		N/P	N/P	81,352	120	01/21/00	02/05/00	5	1380	0.060	0.133		48	27	355
	Total	01/04/00			496,853		01/19/00	04/20/00	53	10,905	0.081		0.171			
05-52-13	Battle Creek (CNFH)	01/12/00	N/P	N/P	81,680	120	01/21/00	03/21/00	14	4815	0.055	0.407		84	28	497
Sacramento-San Joaquin Estuary																
05-51-30	Georgiana Slough (CNFH)	12/10/99	54	52	65,517	152	12/20/99	01/03/00	3	2360	0.109	0.054		24	0	43

Appendix 2 (cont.)

Tag code	Release site (Hatchery)	Date	Truck temp (F)	Release temp (F)	Number released	Avg FL (mm)	First day recov.	Last day recov.	Number recov.	Minutes fished	Percent sampled	Survival index	Group index	Expanded Salvage Numbers CVP	Expanded Salvage Numbers SWP	Expanded Ocean Recovery Numbers
05-51-32	Isleton (CNFH)	12/11/99	54	50	53,426	140	12/14/99	01/04/00	16	3650	0.115	0.338		0	0	128
05-51-31	Georgiana Slough (CNFH)	12/20/99	72	63	64,515	132	12/27/99	01/18/00	21	4000	0.121	0.350		60	22	151
05-51-33	Isleton (CNFH)	12/21/99	59	50	49,341	144	12/23/99	02/05/00	19	6180	0.095	0.525		0	4	160
05-51-34	Port Chicago (CNFH)	12/29/99	54	52	49,208	138	12/30/99	01/13/00	26	-	-	**		0	0	274

** Survival not calculated for releases downstream of Chipps Island

Winter run releases

Upper Sacramento River and Tributaries

Tag code	Release site (Hatchery)	Date	Truck temp (F)	Release temp (F)	Number released	Avg FL (mm)	First day recov.	Last day recov.	Number recov.	Minutes fished	Percent sampled	Survival index	Group index	Expanded Salvage Numbers CVP	Expanded Salvage Numbers SWP	Expanded Ocean Recovery Numbers
05-01-02-12-05	Caldwell Park (LSNFH)		N/P	N/P	860	80	03/29/00	03/29/00	1	200	0.139	1.088		0	0	0
05-01-02-12-06	Caldwell Park (LSNFH)		N/P	N/P	1,180	80	-	-	0	-	-	-		0	0	0
05-01-02-12-07	Caldwell Park (LSNFH)		N/P	N/P	1,283	80	-	-	0	-	-	-		0	0	0
05-01-02-12-08	Caldwell Park (LSNFH)		N/P	N/P	816	80	-	-	0	-	-	-		0	0	8
05-01-02-12-09	Caldwell Park (LSNFH)		N/P	N/P	1,000	80	-	-	0	-	-	-		0	0	0
05-01-02-12-10	Caldwell Park (LSNFH)		N/P	N/P	1,265	80	-	-	0	-	-	-		0	0	0
05-01-02-12-11	Caldwell Park (LSNFH)		N/P	N/P	1,557	80	-	-	0	-	-	-		0	0	0
05-01-02-12-12	Caldwell Park (LSNFH)		N/P	N/P	1,145	80	-	-	0	-	-	-		0	6	0
05-01-02-12-13	Caldwell Park (LSNFH)		N/P	N/P	1,738	80	03/18/00	03/18/00	1	200	0.139	0.539		0	0	8
05-01-02-12-14	Caldwell Park (LSNFH)		N/P	N/P	1,545	80	-	-	0	-	-	-		0	0	9
05-01-02-12-15	Caldwell Park (LSNFH)		N/P	N/P	1,205	80	-	-	0	-	-	-		0	0	0
05-01-02-13-01	Caldwell Park (LSNFH)		N/P	N/P	1,582	80	-	-	0	-	-	-		0	0	4
05-01-02-13-02	Caldwell Park (LSNFH)		N/P	N/P	2,115	80	-	-	0	-	-	-		0	0	12
05-01-02-13-03	Caldwell Park (LSNFH)		N/P	N/P	2,003	80	-	-	0	-	-	-		0	0	12
05-01-02-13-04	Caldwell Park (LSNFH)		N/P	N/P	1,716	80	03/21/00	03/21/00	1	180	0.125	0.606		0	0	5

Appendix 2 (cont.)

Tag code	Release site (Hatchery)	Date	Truck temp (F)	Release temp (F)	Number released	Avg FL (mm)	First day recov.	Last day recov.	Number recov.	Minutes fished	Percent sampled	Survival index	Group index	Expanded Salvage Numbers		Expanded Ocean Recovery Numbers
														CVP	SWP	
05-01-02-13-05	Caldwell Park (LSNFH)		N/P	N/P	2,125	80	-	-	0	-	-	-		0	0	4
05-01-02-13-06	Caldwell Park (LSNFH)		N/P	N/P	3,069	80	05/01/00	05/01/00	1	380	0.264	0.161		0	0	12
05-01-02-13-07	Caldwell Park (LSNFH)		N/P	N/P	4,232	80	-	-	0	-	-	-		0	0	4
	Total	01/27/00			30,436		03/18/00	05/01/00	4	10,450	0.161		0.106			

Spring run releases

Upper Sacramento River and Tributaries

Tag code	Release site (Hatchery)	Date	Truck temp (F)	Release temp (F)	Number released	Avg FL (mm)	First day recov.	Last day recov.	Number recov.	Minutes fished	Percent sampled	Survival index	Group index	CVP	SWP	Expanded Ocean Recovery Numbers
06-01-12-03-08	Butte Creek (Wild)	12/06/99	N/P	N/P	4,962	37	-	-	0	-	-	-		0	0	2
06-01-12-03-09	Butte Creek (Wild)	12/29/99	N/P	N/P	9,675	37	04/05/00	04/05/00	1	160	0.111	0.121		0	6	4
06-01-12-03-10	Butte Creek (Wild)	01/10/00	N/P	N/P	11,508	38	-	-	0	-	-	-		0	0	23
06-01-12-03-11	Butte Creek (Wild)	01/19/00	N/P	N/P	10,081	37	-	-	0	-	-	-		0	0	19
06-01-12-03-12	Butte Creek (Wild)	01/27/00	N/P	N/P	10,050	37	-	-	0	-	-	-		0	0	2
06-01-12-03-13	Butte Creek (Wild)	02/07/00	N/P	N/P	9,237	37	04/04/00	04/29/00	2	7490	0.200	0.141		0	0	7
06-01-12-03-14	Butte Creek (Wild)	02/22/00	N/P	N/P	3,341	38	-	-	0	-	-	-		0	0	0

Fall run releases

Upper Sacramento River and Tributaries

Tag code	Release site (Hatchery)	Date	Truck temp (F)	Release temp (F)	Number released	Avg FL (mm)	First day recov.	Last day recov.	Number recov.	Minutes fished	Percent sampled	Survival index	Group index	CVP	SWP	Expanded Ocean Recovery Numbers
06-01-06-10-09	Thermolito Bypass (FRH)	01/04/00	N/P	N/P	12,609	35	04/15/00	04/18/00	2	1180	0.205	0.101		0	0	9
06-01-06-10-10	Downstream Thermolito Bypass (FRH)	01/09/00	N/P	N/P	12,744	35	-	-	0	-	-	-		0	0	0

Appendix 2 (cont.)

Tag code	Release site (Hatchery)	Date	Truck temp (F)	Release temp (F)	Number released	Avg FL (mm)	First day recov.	Last day recov.	Number recov.	Minutes fished	Percent sampled	Survival index	Group index	Expanded Salvage Numbers CVP	Expanded Salvage Numbers SWP	Expanded Ocean Recovery Numbers
06-01-06-10-11	Downstream Thermolito Bypass (FRH)	01/15/00	N/P	N/P	12,165	35	04/20/00	04/20/00	1	400	0.278	0.038		0	0	0
06-01-06-10-12	Downstream Thermolito Bypass (FRH)	01/20/00	N/P	N/P	12,338	35	-	-	0	-	-	-		0	0	0
05-01-02-13-08	Sacramento River RM 242.5 (Wild)	01/21/00	N/P	N/P	10,365	39	-	-	0	-	-	-		0	0	2
06-01-06-10-13	Downstream Thermolito Bypass (FRH)	01/23/00	N/P	N/P	12,489	35	04/28/00	04/28/00	1	400	0.278	0.037		0	0	3
06-01-06-10-14	Downstream Thermolito Bypass (FRH)	01/28/00	N/P	N/P	12,503	35	-	-	0	-	-	-		0	0	3
06-01-06-10-15	Downstream Thermolito Bypass (FRH)	01/30/00	N/P	N/P	12,241	35	03/18/00	03/18/00	1	200	0.139	0.076		0	0	0
05-01-02-13-09	Sacramento River RM 242.5 (Wild)	01/31/00	N/P	N/P	10,154	42	05/01/00	05/01/00	1	380	0.264	0.049		0	0	3
06-01-06-11-01	Downstream Thermolito Bypass (FRH)	02/02/00	N/P	N/P	12,246	35	-	-	0	-	-	-		0	0	5
05-01-02-13-10	Sacramento River RM 242.5 (Wild)	02/07/00	N/P	N/P	11,072	40	-	-	0	-	-	-		0	0	3
06-01-06-11-02	Downstream Thermolito Bypass (FRH)	02/09/00	N/P	N/P	12,625	35	05/02/00	05/02/00	1	400	0.278	0.037		0	0	6
05-01-02-13-11	Sacramento River RM 242.5 (Wild)	02/11/00	N/P	N/P	6,383	42	-	-	0	-	-	-		0	0	0

Appendix 2 (cont.)

Tag code	Release site (Hatchery)	Date	Truck temp (F)	Release temp (F)	Number released	Avg FL (mm)	First day recov.	Last day recov.	Number recov.	Minutes fished	Percent sampled	Survival index	Group index	Expanded Salvage Numbers		Expanded Ocean Recovery Numbers
														CVP	SWP	
06-01-06-11-03	Downstream Thermolito Bypass (FRH)	02/14/00	N/P	N/P	14,494	35	05/02/00	05/02/00	1	400	0.278	0.032		0	0	0
06-01-06-11-12	Downstream Thermolito Bypass (FRH)	02/19/00	N/P	N/P	10,681	35	06/12/00	06/12/00	1	200	0.139	0.088		0	0	1
05-01-02-01-01	Red Bluff Diversion Dam (CNFH)	03/06/00	N/P	N/P	47,341	57	04/06/00	04/23/00	16	4930	0.190	0.231		12	0	245
06-01-06-11-11	Downstream Thermolito Bypass (FRH)	03/08/00	N/P	N/P	7,082	35	-	-	0	-	-	-		0	0	18
05-01-01-15-14	Red Bluff Diversion Dam (CNFH)	03/13/00	N/P	N/P	48,798	56	04/09/00	04/22/00	18	3940	0.195	0.245		0	6	329
05-01-02-13-13	Battle Creek (CNFH)		N/P	N/P	33,820	75	04/15/00	04/26/00	28	4380	0.253	0.425		0	3	353
05-01-02-13-14	Battle Creek (CNFH)		N/P	N/P	34,092	74	04/15/00	04/28/00	22	4980	0.247	0.340		0	0	306
	Total	04/07/00			67,912		04/15/00	04/28/00	50	4980	0.247		0.388			
05-01-02-13-15	Battle Creek (CNFH)		N/P	N/P	32,998	77	04/21/00	05/07/00	21	6435	0.263	0.315		0	0	468
05-01-02-14-01	Battle Creek (CNFH)		N/P	N/P	32,504	77	04/20/00	04/30/00	22	4200	0.265	0.332		0	0	481
05-01-02-14-02	Battle Creek (CNFH)		N/P	N/P	34,357	76	04/20/00	05/04/00	21	5680	0.263	0.302		0	0	469
05-01-02-14-03	Battle Creek (CNFH)		N/P	N/P	34,445	77	04/20/00	05/09/00	27	7635	0.265	0.384		0	0	512
05-01-02-14-04	Battle Creek (CNFH)		N/P	N/P	34,628	77	04/21/00	04/29/00	23	3400	0.262	0.329		0	0	549
05-01-02-14-05	Battle Creek (CNFH)		N/P	N/P	33,380	77	04/21/00	05/01/00	24	4180	0.264	0.354		0	0	529
05-01-02-14-06	Battle Creek (CNFH)		N/P	N/P	33,546	76	04/20/00	05/04/00	19	5680	0.263	0.280		0	0	474
05-01-02-14-07	Battle Creek (CNFH)		N/P	N/P	34,969	77	04/21/00	04/30/00	19	3800	0.264	0.268		0	0	552

Appendix 2 (cont.)

Tag code	Release site (Hatchery)	Date	Truck temp (F)	Release temp (F)	Number released	Avg FL (mm)	First day recov.	Last day recov.	Number recov.	Minutes fished	Percent sampled	Survival index	Group index	Expanded Salvage Numbers CVP	SWP	Expanded Ocean Recovery Numbers
05-01-02-14-08	Battle Creek (CNFH)		N/P	N/P	33,500	76	04/21/00	05/18/00	26	10,535	0.261	0.386		0	3	575
05-01-02-14-09	Battle Creek (CNFH)		N/P	N/P	34,381	75	04/21/00	05/21/00	26	11,535	0.258	0.380		0	0	555
05-01-02-14-10	Battle Creek (CNFH)		N/P	N/P	32,996	77	04/21/00	04/28/00	11	3000	0.260	0.166		0	0	582
05-01-02-14-11	Battle Creek (CNFH)		N/P	N/P	34,485	77	04/21/00	05/13/00	19	8535	0.258	0.278		0	3	548
	Total	04/14/00			406,189		04/20/00	05/21/00	258	11,935	0.259		0.319			
05-01-02-14-12	Battle Creek (CNFH)		N/P	N/P	35,099	78	04/28/00	05/29/00	15	10,455	0.227	0.245		0	0	503
05-01-02-14-13	Battle Creek (CNFH)		N/P	N/P	34,002	77	04/27/00	05/20/00	17	8935	0.259	0.251		0	0	496
05-01-02-14-14	Battle Creek (CNFH)		N/P	N/P	35,228	78	04/26/00	05/20/00	23	9335	0.259	0.327		0	0	588
05-01-02-14-15	Battle Creek (CNFH)		N/P	N/P	32,609	76	04/28/00	05/20/00	14	8735	0.264	0.212		0	0	542
05-01-02-15-01	Battle Creek (CNFH)		N/P	N/P	34,041	77	04/28/00	05/09/00	26	4635	0.268	0.370		0	0	435
05-01-02-15-02	Battle Creek (CNFH)		N/P	N/P	34,076	76	04/28/00	05/19/00	18	8335	0.263	0.261		0	0	372
05-01-02-15-03	Battle Creek (CNFH)		N/P	N/P	34,797	74	04/28/00	05/18/00	22	7935	0.262	0.313		0	0	429
05-01-02-15-04	Battle Creek (CNFH)		N/P	N/P	34,355	76	04/28/00	05/21/00	20	8935	0.259	0.293		0	0	329
05-01-02-15-05	Battle Creek (CNFH)		N/P	N/P	34,378	75	04/28/00	05/20/00	19	8735	0.264	0.272		0	0	410
05-01-02-15-06	Battle Creek (CNFH)		N/P	N/P	34,703	75	04/28/00	05/23/00	22	9275	0.248	0.333		0	0	279
05-01-02-15-07	Battle Creek (CNFH)		N/P	N/P	34,712	76	04/28/00	05/23/00	21	9275	0.248	0.317		0	0	309
05-01-02-15-08	Battle Creek (CNFH)		N/P	N/P	36,075	76	04/28/00	05/19/00	23	8335	0.263	0.315		0	0	337
05-01-02-15-09	Battle Creek (CNFH)		N/P	N/P	35,945	74	04/29/00	05/23/00	16	8875	0.247	0.235		0	0	256
	Total	04/21/00			450,020		04/26/00	05/29/00	256	11,055	0.233		0.317			
06-26-60	Live Oak (FRH)	06/07/00	N/P	N/P	42,275	109	-	-	0	-	-	-		0	0	179
Sacramento-San Joaquin Estuary																
06-01-13-02-07	Woodbridge Dam (Wild)	01/25/00	N/P	N/P	5,464	37	-	-	0	-	-	-		0	0	0

Appendix 2 (cont.)

Tag code	Release site (Hatchery)	Date	Truck temp (F)	Release temp (F)	Number released	Avg FL (mm)	First day recov.	Last day recov.	Number recov.	Minutes fished	Percent sampled	Survival index	Group index	Expanded Salvage Numbers CVP	SWP	Expanded Ocean Recovery Numbers
06-01-06-11-04	Yolo Bypass Elkhorn/Toedrain (FRH)	02/04/00	N/P	N/P	100,901	56	03/30/00	03/30/00	1	200	0.139	0.009		0	0	47
06-01-06-10-03	Lighthouse Marina (FRH)		54	54	26,302	52	03/07/00	03/07/00	1	200	0.139	0.036		0	6	0
06-01-06-10-04	Lighthouse Marina (FRH)		54	54	24,059	52	-	-	0	-	-	-		0	0	3
	Total	02/14/00			50,361		03/07/00	03/07/00	1	200	0.139		0.019			
06-01-06-10-05	Isleton (FRH)		52	55	24,857	49	-	-	0	-	-	-		0	0	0
06-01-06-10-06	Isleton (FRH)		52	55	26,436	49	03/29/00	03/29/00	1	200	0.139	0.035		0	0	4
	Total	02/15/00			51,293		03/29/00	03/29/00	1	200	0.139		0.018			
06-01-06-11-07	Elkhorn (FRH)	02/22/00	N/P	N/P	52,886	56	03/30/00	04/19/00	3	4690	0.155	0.048		0	0	46
06-01-06-10-07	Yolo Bypass (FRH)		N/P	N/P	27,250	57	04/15/00	04/19/00	2	1580	0.219	0.043		0	0	17
06-01-06-10-08	Yolo Bypass (FRH)		N/P	N/P	27,302	57	-	-	0	-	-	-		0	0	10
	Total	02/22/00			54,552		04/15/00	04/19/00	2	1580	0.219		0.022			
06-01-06-09-12	Lighthouse Marina (FRH)		48	55	27,514	63	03/30/00	03/30/00	1	200	0.139	0.034		0	6	13
06-01-06-09-13	Lighthouse Marina (FRH)		48	55	25,459	63	04/18/00	05/11/00	2	9015	0.261	0.039		0	0	6
	Total	02/28/00			52,973		03/30/00	05/11/00	3	12,925	0.209		0.035			
05-01-02-08-09	Isleton (FRH)		50	55	26,837	59	03/11/00	03/28/00	3	1575	0.061	0.239		0	0	7
05-01-02-08-10	Isleton (FRH)		50	55	26,033	59	04/04/00	04/04/00	1	200	0.139	0.036		0	0	0
	Total	02/29/00			52,870		03/11/00	04/04/00	4	2975	0.083		0.119			
05-01-02-01-02	Clarksburg (CNFH)	03/07/00	50	52	47,168	57	03/09/00	04/19/00	13	6665	0.110	0.325		0	6	41
06-02-44	Woodbridge Dam (Wild)	03/13/00	N/P	N/P	6,067	82	05/15/00	05/23/00	3	2940	0.227	0.283		0	0	7

Appendix 2 (cont.)

Tag code	Release site (Hatchery)	Date	Truck temp (F)	Release temp (F)	Number released	Avg FL (mm)	First day recov.	Last day recov.	Number recov.	Minutes fished	Percent sampled	Survival index	Group index	Expanded Salvage Numbers CVP	Expanded Salvage Numbers SWP	Expanded Ocean Recovery Numbers
05-01-01-15-15	Clarksburg (CNFH)	03/14/00	57	55	46,461	57	03/16/00	04/18/00	11	5670	0.116	0.266		0	18	73
06-26-57	Verona (FRH)		N/P	N/P	103,165	64	04/15/00	05/15/00	16	11,315	0.253	0.080		0	0	473
06-01-06-11-05	Verona (FRH)		N/P	N/P	101,115	64	04/06/00	05/14/00	36	12,665	0.226	0.205		0	3	336
	Total	03/22/00			204,280		04/06/00	05/15/00	52	13,065	0.227		0.146			
05-01-02-08-03	Georgiana Slough (FRH)		52	57	24,571	71	04/22/00	04/28/00	3	2600	0.258	0.062		0	9	35
05-01-02-08-04	Georgiana Slough (FRH)		52	57	25,253	71	04/21/00	05/21/00	4	11,535	0.258	0.080		0	6	40
	Total	03/28/00			49,824		04/21/00	05/21/00	7	11,535	0.258		0.071			
05-01-02-08-05	Ryde (FRH)		50	59	23,042	71	04/10/00	04/20/00	5	2940	0.186	0.152		0	0	56
05-01-02-08-06	Ryde (FRH)		50	59	23,468	71	04/06/00	04/29/00	6	7130	0.206	0.161		0	0	29
	Total	03/29/00			46,510		04/06/00	04/29/00	11	7130	0.206		0.149			
06-26-55	West Sacramento (FRH)		55	63	25,005	77	04/17/00	05/20/00	15	12,915	0.264	0.296		0	0	253
06-26-56	West Sacramento (FRH)		55	63	25,011	77	04/15/00	05/15/00	19	11,315	0.253	0.390		0	0	190
	Total	04/10/00			50,016		04/15/00	05/20/00	34	13,315	0.257		0.344			
05-38-29	Port Chicago (FRH)		55	63	23,582	79	04/14/00	04/14/00	1	-	-	**		0	0	84
05-38-30	Port Chicago (FRH)		55	63	23,352	79	04/18/00	04/21/00	2	-	-	**		0	0	176
	Total	04/12/00			46,934		04/14/00	04/21/00	3	-	-		**			

** Survival not calculated for releases downstream of Chipps Island

Tag code	Release site (Hatchery)	Date	Truck temp (F)	Release temp (F)	Number released	Avg FL (mm)	First day recov.	Last day recov.	Number recov.	Minutes fished	Percent sampled	Survival index	Group index	Expanded Salvage Numbers CVP	Expanded Salvage Numbers SWP	Expanded Ocean Recovery Numbers
06-04-01	Durham Ferry (MRFF)		55	57	23,529	80	04/22/00	04/29/00	7	3000	0.260	0.149		24	144	215
06-04-02	Durham Ferry (MRFF)		55	57	24,177	80	04/23/00	05/19/00	10	10,135	0.261	0.206		24	132	232

Appendix 2 (cont.)

Tag code	Release site (Hatchery)	Date	Truck temp (F)	Release temp (F)	Number released	Avg FL (mm)	First day recov.	Last day recov.	Number recov.	Minutes fished	Percent sampled	Survival index	Group index	Expanded Salvage Numbers CVP	Expanded Salvage Numbers SWP	Expanded Ocean Recovery Numbers
06-45-63	Durham Ferry (MRFF)		54	57	24,457	80	04/24/00	05/05/00	11	4480	0.259	0.226		12	185	247
	Total	04/17/00			72,163		04/22/00	05/19/00	28	10,535	0.261		0.193			
06-44-01	Mossdale (MRFF)		52	55	23,465	79	04/23/00	05/04/00	9	4480	0.259	0.192		12	213	0
06-44-02	Mossdale (MRFF)		52	55	22,784	79	04/23/00	04/29/00	9	2600	0.258	0.199		12	220	0
	Total	04/18/00			46,249		04/23/00	05/04/00	18	4480	0.259		0.195			
06-44-05	Mossdale (MRFF)	04/19/00	55	61	23,288	86	04/29/00	05/11/00	7	4835	0.258	0.151		12	144	0
06-44-03	Jersey Point (MRFF)		54	64	25,527	82	04/22/00	05/02/00	24	4180	0.264	0.463		0	0	0
06-44-04	Jersey Point (MRFF)		54	64	25,824	82	04/22/00	05/02/00	41	4180	0.264	0.782		0	0	0
	Total	04/20/00			51,351		04/22/00	05/02/00	65	4180	0.264		0.623			
06-26-62	Mouth of Mokelumne River (MOK)		N/P	N/P	24,353	94	04/23/00	05/04/00	32	4480	0.259	0.659		0	6	0
06-26-63	Mouth of Mokelumne River (MOK)		N/P	N/P	24,250	94	04/23/00	04/26/00	34	1600	0.278	0.656		0	0	0
	Total	04/21/00			48,603		04/23/00	05/04/00	66	4480	0.259		0.682			
06-02-49	New Hope Landing (MOK)		N/P	N/P	50,603	66	04/29/00	05/16/00	20	6735	0.260	0.198		0	0	144
06-02-52	New Hope Landing (MOK)		N/P	N/P	51,134	73	04/30/00	05/17/00	12	6735	0.260	0.117		0	0	137
	Total	04/24/00			101,737		04/29/00	05/17/00	32	7135	0.261		0.157			
06-01-06-11-09	Georgiana Slough (FRH)		57	64	19,471	79	05/15/00	05/28/00	2	3920	0.194	0.069		0	0	20
06-01-06-11-10	Georgiana Slough (FRH)		57	64	19,665	79	05/14/00	05/20/00	5	2800	0.278	0.119		0	0	37
	Total	04/27/00			39,136		05/14/00	05/28/00	7	4320	0.200		0.116			
05-01-02-08-07	Ryde (FRH)		55	64	21,419	79	04/30/00	05/17/00	9	6735	0.260	0.210		0	0	68
05-01-02-08-08	Ryde (FRH)		55	64	21,395	79	04/30/00	05/18/00	12	7135	0.261	0.280		0	0	62
	Total	04/28/00			42,814		04/30/00	05/18/00	21	7135	0.261		0.244			

Appendix 2 (cont.)

Tag code	Release site (Hatchery)	Date	Truck temp (F)	Release temp (F)	Number released	Avg FL (mm)	First day recov.	Last day recov.	Number recov.	Minutes fished	Percent sampled	Survival index	Group index	Expanded Salvage Numbers CVP	SWP	Expanded Ocean Recovery Numbers
06-01-06-09-14	Durham Ferry (MRFF)		52	63	23,698	77	05/04/00	05/14/00	7	4055	0.256	0.150		12	75	46
06-01-06-09-15	Durham Ferry (MRFF)		52	63	26,805	77	05/03/00	05/12/00	5	3655	0.254	0.096		24	96	45
06-01-11-08-14	Durham Ferry (MRFF)		52	63	23,889	77	05/04/00	05/21/00	10	6655	0.257	0.212		12	60	71
	Total	04/28/00			74,392		05/03/00	05/21/00	22	6955	0.254		0.151			
06-26-53	West Sacramento (FRH)		57	64	20,926	83	05/04/00	05/25/00	21	7385	0.233	0.560		0	0	213
06-26-54	West Sacramento (FRH)		57	64	20,613	83	05/05/00	05/18/00	23	5255	0.261	0.556		0	0	221
	Total	05/01/00			41,539		05/04/00	05/25/00	44	7385	0.233		0.591			
06-01-06-10-01	Jersey Point (MRFF)		54	63	25,572	78	05/03/00	05/17/00	48	5555	0.257	0.949		0	3	358
06-01-06-10-02	Jersey Point (MRFF)		54	63	24,661	76	05/02/00	05/14/00	30	4755	0.254	0.623		0	3	230
	Total	05/01/00			50,233		05/02/00	05/17/00	78	5955	0.258		0.782			
06-02-53	Jersey Point (MOK)		N/P	N/P	50,445	87	05/03/00	05/14/00	95	4355	0.252	0.971		0	5	732
06-02-54	Jersey Point (MOK)		N/P	N/P	51,167	85	05/02/00	05/12/00	74	4055	0.256	0.734		0	0	626
	Total	05/01/00			101,612		05/02/00	05/14/00	169	4755	0.254		0.851			
06-02-55	New Hope Landing (MOK)		N/P	N/P	46,721	80	05/09/00	05/20/00	22	4500	0.260	0.235		0	12	167
06-02-56	New Hope Landing (MOK)		N/P	N/P	50,683	77	05/09/00	05/20/00	32	4500	0.260	0.315		24	3	225
	Total	05/03/00			97,404		05/09/00	05/20/00	54	4500	0.260		0.277			
06-26-52	Port Chicago (FRH)		61	66	15,541	82	05/04/00	05/16/00	4	-	-	**		0	0	146
06-26-51	Port Chicago (FRH)		61	66	15,770	82	05/07/00	05/10/00	3	-	-	**		0	0	114
	Total	05/03/00			31,311		05/04/00	05/16/00	7	-	-		**			

** Survival not calculated for releases downstream of Chipps Island

Appendix 2 (cont.)

Tag code	Release site (Hatchery)	Date	Truck temp (F)	Release temp (F)	Number released	Avg FL (mm)	First day recov.	Last day recov.	Number recov.	Minutes fished	Percent sampled	Survival index	Group index	Expanded Salvage Numbers CVP	Expanded Salvage Numbers SWP	Expanded Ocean Recovery Numbers
06-26-49	West Sacramento (FRH)		54	63	17,416	93	05/19/00	05/25/00	19	1730	0.172	0.826		0	0	309
06-26-50	West Sacramento (FRH)		54	63	17,064	93	05/19/00	05/24/00	12	1530	0.177	0.516		0	0	268
	Total	05/15/00			34,480		05/19/00	05/25/00	31	1730	0.172		0.680			
Upper San Joaquin River and Tributaries																
06-45-39	Merced River Fish Facility		N/P	N/P	25,313	78	04/25/00	05/09/00	5	5635	0.261	0.098		0	20	23
06-45-40	Merced River Fish Facility		N/P	N/P	25,507	78	04/25/00	04/28/00	3	1400	0.243	0.063		0	51	22
06-45-41	Merced River Fish Facility		N/P	N/P	25,318	78	04/24/00	04/26/00	4	1200	0.278	0.074		12	41	10
06-45-42	Merced River Fish Facility		N/P	N/P	25,395	78	04/25/00	05/07/00	5	4835	0.258	0.099		12	47	59
	Total	04/12/00			101,533		04/24/00	05/09/00	17	6035	0.262		0.083			
06-45-43	Hatfield State Park (MRFF)		54	68	24,525	76	04/22/00	04/28/00	5	2600	0.258	0.103		12	146	116
06-45-44	Hatfield State Park (MRFF)		54	68	24,490	76	04/21/00	04/26/00	6	2400	0.278	0.115		0	128	80
06-45-45	Hatfield State Park (MRFF)		54	68	24,432	76	04/23/00	04/24/00	2	800	0.278	0.038		12	127	138
	Total	04/13/00			73,447		04/21/00	04/28/00	13	3000	0.262		0.088			
06-45-56	La Grange (MRFF)	04/13/00	55	52	23,603	74	04/29/00	05/17/00	6	7135	0.261	0.127		12	59	71
06-45-61	Roberts Ferry - Hughson (MRFF)		55	57	17,936	82	05/05/00	05/21/00	3	6255	0.256	0.085		24	44	49
06-45-62	Roberts Ferry - Hughson (MRFF)		55	57	19,198	82	05/02/00	05/21/00	2	7355	0.255	0.053		0	24	27
	Total	04/13/00			19,198		05/02/00	05/21/00	5	7355	0.255		0.133			
06-45-60	Old Fisherman's Club - SJ River (MRFF)	04/14/00	54	61	21,698	75	04/26/00	04/30/00	5	1800	0.250	0.120		12	95	106
06-45-57	La Grange (MRFF)		55	52	22,096	74	04/28/00	04/28/00	1	400	0.278	0.021		24	22	82

Appendix 2 (cont.)

Tag code	Release site (Hatchery)	Date	Truck temp (F)	Release temp (F)	Number released	Avg FL (mm)	First day recov.	Last day recov.	Number recov.	Minutes fished	Percent sampled	Survival index	Group index	Expanded Salvage Numbers CVP	Expanded Salvage Numbers SWP	Expanded Ocean Recovery Numbers
06-45-58	La Grange (MRFF)		54	52	21,952	80	04/24/00	05/23/00	5	10,675	0.247	0.120		0	59	68
	Total	04/15/00			44,048		04/24/00	05/23/00	6	10,675	0.247		0.072			
06-45-59	Old Fisherman's Club - SJ River (MRFF)	04/16/00	54	55	23,071	73	04/23/00	05/01/00	4	3380	0.261	0.086		12	116	141
06-46-08	Grayson (MRFF)	04/16/00	57	59	11,803	82	05/01/00	05/21/00	4	7735	0.256	0.172		0	3	13
06-45-49	Merced River Fish Facility		N/P	N/P	25,433	76	05/06/00	05/19/00	5	5255	0.261	0.098		0	9	40
06-45-50	Merced River Fish Facility		N/P	N/P	27,042	76	05/04/00	05/19/00	6	6055	0.263	0.110		36	12	37
06-45-51	Merced River Fish Facility		N/P	N/P	24,378	76	05/05/00	05/05/00	1	400	0.278	0.019		0	24	20
06-45-52	Merced River Fish Facility		N/P	N/P	25,293	76	05/04/00	05/20/00	4	6455	0.264	0.078		12	0	26
	Total	04/24/00			102,146		05/04/00	05/20/00	16	6455	0.264		0.077			
06-45-53	Hatfield State Park (MRFF)		54	57	25,794	81	05/06/00	05/12/00	5	2555	0.253	0.099		0	57	63
06-45-54	Hatfield State Park (MRFF)		54	57	26,189	81	05/08/00	05/11/00	4	1400	0.243	0.082		12	93	97
06-45-55	Hatfield State Park (MRFF)		54	57	25,444	81	05/05/00	05/15/00	6	4055	0.256	0.120		24	81	40
	Total	04/27/00			77,427		05/05/00	05/15/00	15	4055	0.256		0.098			
06-44-08	Knights Ferry (MRFF)		55	54	25,786	84	05/31/00	05/31/00	1	200	0.139	0.036		144	144	4
06-44-09	Knights Ferry (MRFF)		55	52	26,140	84	-	-	0	-	-	-		156	117	3
	Total	05/18/00			51,926		05/31/00	05/31/00	1	200	0.139		0.018			
06-44-07	Knights Ferry (MRFF)	05/19/00	55	54	25,511	83	05/29/00	06/06/00	3	1060	0.082	0.187		204	99	7
06-44-10	Two Rivers (MRFF)		57	70	25,712	85	05/24/00	05/28/00	4	980	0.136	0.149		276	471	12
06-44-11	Two Rivers (MRFF)		57	70	24,835	84	-	-	0	-	-	-		144	219	6
	Total	05/20/00			50,547		05/24/00	05/28/00	4	980	0.136		0.076			