Juvenile Fish Monitoring and Abundance and distribution of Chinook Salmon in the Sacramento-San Joaquin Estuary

2007- 2008 ANNUAL REPORT
STOCKTON FISH AND WILDLIFE OFFICE
U.S. FISH AND WILDLIFE SERVICE
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Interagency Ecological Program
Cooperative Ecological Investigations Since 1970

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Cover photo: DJFMP field staff conduct a mid-water trawl at Chipps Island in Suisun Bay (Credit: Jackie Hagen)

Acknowledgments

Much of this sampling was conducted for and funded by the Interagency Ecological Program (IEP) for the Sacramento-San Joaquin Estuary. Members of the IEP are: three state (California Department of Water Resources, California Department of Fish and Game, and State Water Resources Control Board), and six federal agencies (U.S. Bureau of Reclamation, U.S. Geological Survey, U.S. Fish and Wildlife Service, National Marine Fisheries Service, U.S. Army Corps of Engineers, and the U.S. Environmental Protection Agency).

We extend particular gratitude to the many biological science field technicians and boat operators who spent countless hours under all environmental conditions to collect data.

Table of Acronyms
The following acronyms have been used in the following report:

CDEC – California Data Exchange Center
CDFG – California Department of Fish & Game
CNFH – Coleman National Fish Hatchery
CPUE – Catch Per Unit Effort
CVP – Central Valley Project
CWT – Coded Wire Tag
DJFMP – Delta Juvenile Fish Monitoring Program
DWR – California Department of Water Resources
FL – Fork Length
IEP – Interagency Ecological Program
KDTR – Kodiak Trawl
LSNFH – Livingston Stone National Fish Hatchery
MWTR – Midwater Trawl
NMFS – National Marine Fisheries Service
NRSI – Natural Resource Scientists, Inc.
PSMFC – Pacific States Marine Fisheries Commission
RBDD – Red Bluff Diversion Dam
rm – river mile
RMPC – Regional Mark Processing Center
SE – Standard Error
SLNWR - Stone Lakes National Wildlife Refuge
STFWO – Stockton Fish & Wildlife Office
SWP – State Water Project
USFWS – United States Fish & Wildlife Service
USGS – United States Geological Survey
VAMP – Vernalis Adaptive Management Program
WQCP – Water Quality Control Plan

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 1970s. The program goals have evolved since its inception based on water management actions and endangered species listings. Prior to 1982, the program focused on monitoring juvenile salmon relative 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 of California 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 other areas where fish may reside (lower Sacramento and San Joaquin Rivers, Delta, and Bay). Although DJFMP has historically identified and measured all juvenile fishes, it was in 2001 that the programs name changed from Juvenile Salmon Monitoring Program to its current name to reflect the broadened focus of the program. Annual reports have been written each year to document sampling effort and summarize findings and are available from the STFWO.

The DJFMP historically monitors populations of juveniles from all fish species. This report will focus on unmarked Chinook salmon and five other juvenile fish species of concern: delta smelt *Hypomesus transpacificus*, longfin smelt *Spirinchus thaleichthys*, rainbow trout *Oncorhynchus mykiss*, striped bass *Morone saxatilis*, and threadfin shad *Dorosoma petenense*.

Work in 2007 - 2008 was conducted to update and refine our knowledge of the factors influencing juvenile salmon relative abundance, distribution, and survival in the Sacramento-San Joaquin Estuary. Field sampling and special studies for each field season were conducted between August 1 of the previous year and July 31 of the following year, as juveniles reared and migrated through the lower Sacramento and San Joaquin Rivers, Delta, and Bay.

Two objectives of the 2007 - 2008 field seasons were:

1. Determine the relative abundance, distribution, and timing of juvenile Chinook salmon migrating through the lower Sacramento and San Joaquin Rivers, the Delta, and portions of San Pablo and San Francisco Bays.

2. Determine catch-per-unit effort and distribution of all juvenile fishes in the Sacramento and San Joaquin Rivers, the Delta, and portions of San Pablo and San Francisco Bays.

General Methods

Marked and Unmarked Fish

For this report fish with a clipped adipose fin are considered marked fish. Marked fish are hatchery reared and may be coded wire tagged (CWT). Unmarked fish have an adipose fin and are considered naturally spawned or their origin is unknown. Marked and unmarked classification of fish in this report applies to Chinook salmon and rainbow trout.

Race Delineation

The STFWO conducts one of several salmon monitoring programs within the central valley that uses size and date of capture to estimate race of juvenile Chinook salmon in the lower Sacramento River and Delta. Size criterion was developed by Frank Fisher of California Department of Fish and Game (CDFG) in 1992 as a weekly model of Chinook salmon growth (Fisher 1992) and was later modified to a daily criterion by California Department of Water Resources (DWR; Green 1992). At this time, it is the only tool used by DJFMP to determine race of juvenile salmon in the field. However, several problems exist regarding the validity of the size at date criterion (United States Fish and Wildlife Service, (USFWS 1995). For these reasons, the race designations used in this report should be used only as 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, spring- and fall-run races were combined into a “spring-/fall-run” group due to the close overlap in size and emigration timing of the two races. However, 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

In the field, salmon are classified as sac fry, fry, parr, silvery parr, smolt, and adult life stages based on external characteristics: the presence or absence of an external yolk sac, visible parr marks, or deciduous scales. However, for this report, fork length (FL) was used as a simplified classification scheme to provide a rough estimate of life stage.

We defined fry as ≤70 mm fork length FL. Juveniles >70 mm FL were defined as smolts because this is the approximate length at which they begin undergoing behavioral and physiological changes in preparation for transition to salt water. However, because designation of life stages of juvenile Chinook depends primarily on the physiological state of a fish, FL does not always define life stage. Therefore, life-stage designation in this report should be interpreted only as a rough approximation.

Escapement

Methods

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 annually by CDFG, Fisheries Branch Anadromous Resource Assessment Unit (http://www.calfish.org/IndependentDatasets/CDFGFisheriesBranch/tabid/157/Default.aspx, accessed on April 29, 2009). In particular, we focused on fish passing the Red Bluff Diversion Dam (RBDD) in the upper Sacramento River, returning to Coleman National Fish Hatchery (CNFH), 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. Stanislaus, Tuolumne, and Merced Rivers were chosen because, when combined, they represent the major tributaries of the lower San Joaquin River.

Gates used to maximize RBDD diversion capabilities must be in the closed position to obtain accurate escapement estimates. Since 1993, this has not occurred during late-fall upstream migration (October-April). Regulations established by NMFS in 1993 order that gates can be closed only between May 15 and September 15. Returns to CNFH were used as late fall escapement estimates between 1993 and 1998 to account for the lack of closure during upstream migration. Since 1998, carcass surveys have been used to estimate late-fall escapement.

Results

Estimates of winter-run salmon returns in 2007 and 2008 were the lowest since 2000 (Figure 1a). Estimates of spring/fall-run salmon returns in 2007 were the second lowest since 1978 (n = 14,345 fish, Figure 1b). In 2008, there were no estimates of returns for spring-run salmon however, fall-run estimates in 2008 (n = 23,559 fish) were greater than the combined spring/fall-run return estimates for 2007 (Figure 1b). Late fall-run return estimates in 2007 nearly doubled from 2006 and then decreased in 2008 to the fifth lowest on record (n = 3,783 fish, Figure 1c).

Fall-run escapements on the Feather River in 2007 (n = 27,203 fish) and 2008 (n = 13,210 fish) were the fourth and third lowest on record (Figure 2a). The fall-run escapements in the American River have been declining for the last five years and in 2008 had the lowest estimates of return on record (n = 5,926 fish, Figure 2b). Combined spawner population estimates from the Stanislaus, Tuolumne and Merced

Rivers have been decreasing for the past eight years (Figure 2c). Combined spawner population estimates in 2007 were the third lowest since 1978 (n = 1,472 fish). Combined spawner population estimates in 2008 were the fourth lowest since 1978 (n = 2,388 fish).

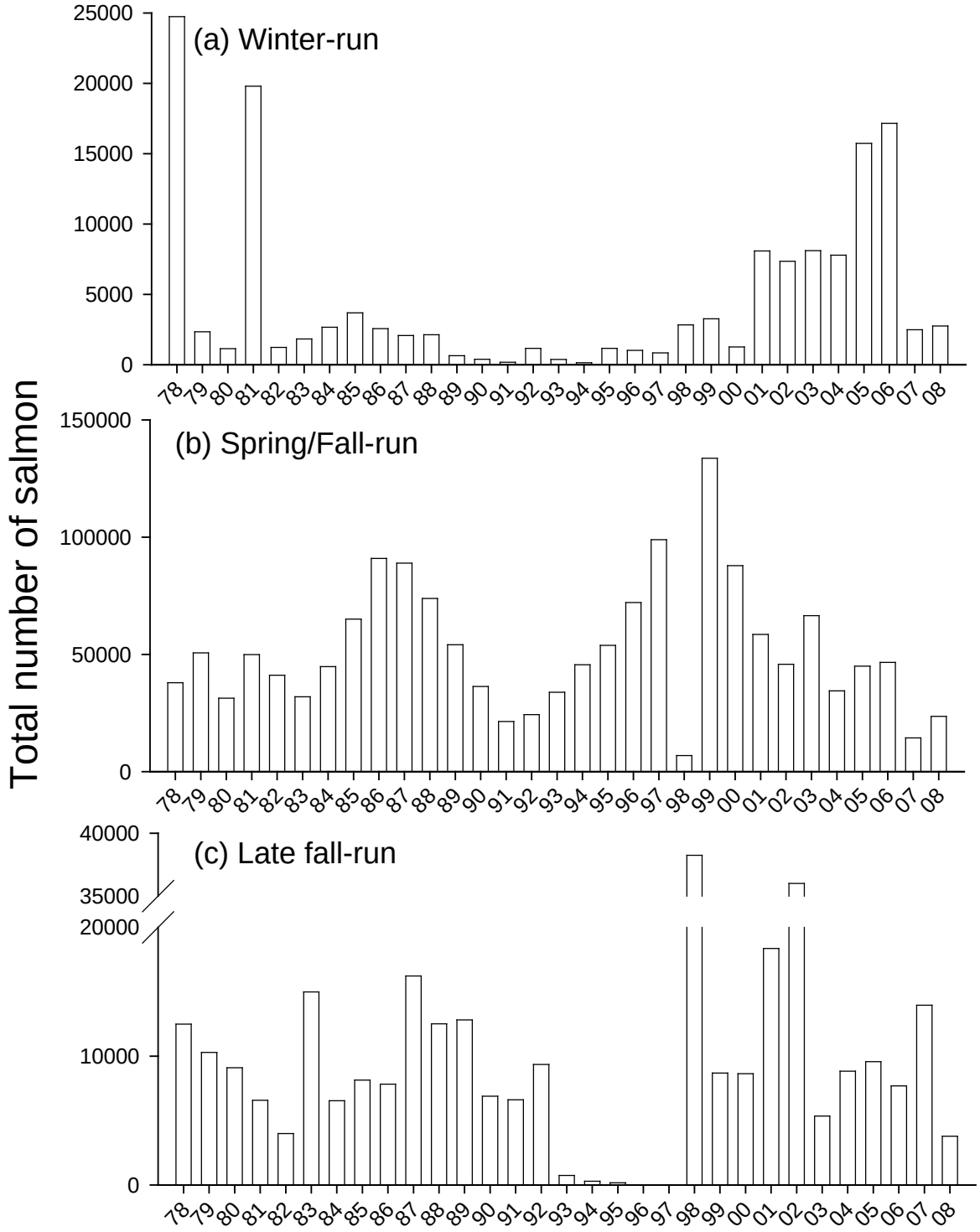


Figure 1. Yearly escapement estimates of adult (a) winter, (b) fall-/spring-, and (c) late fall-run Chinook salmon at the RBDD. Values are the sum of both in-river and hatchery totals. There was no spring-run data for 1999-2000, 2006, and 2008. Late-fall 1996 n = 48. There was no late fall-run data for 1997. Source: Grand Tab, CDFG, Fisheries Branch Anadromous Resource Assessment Unit.

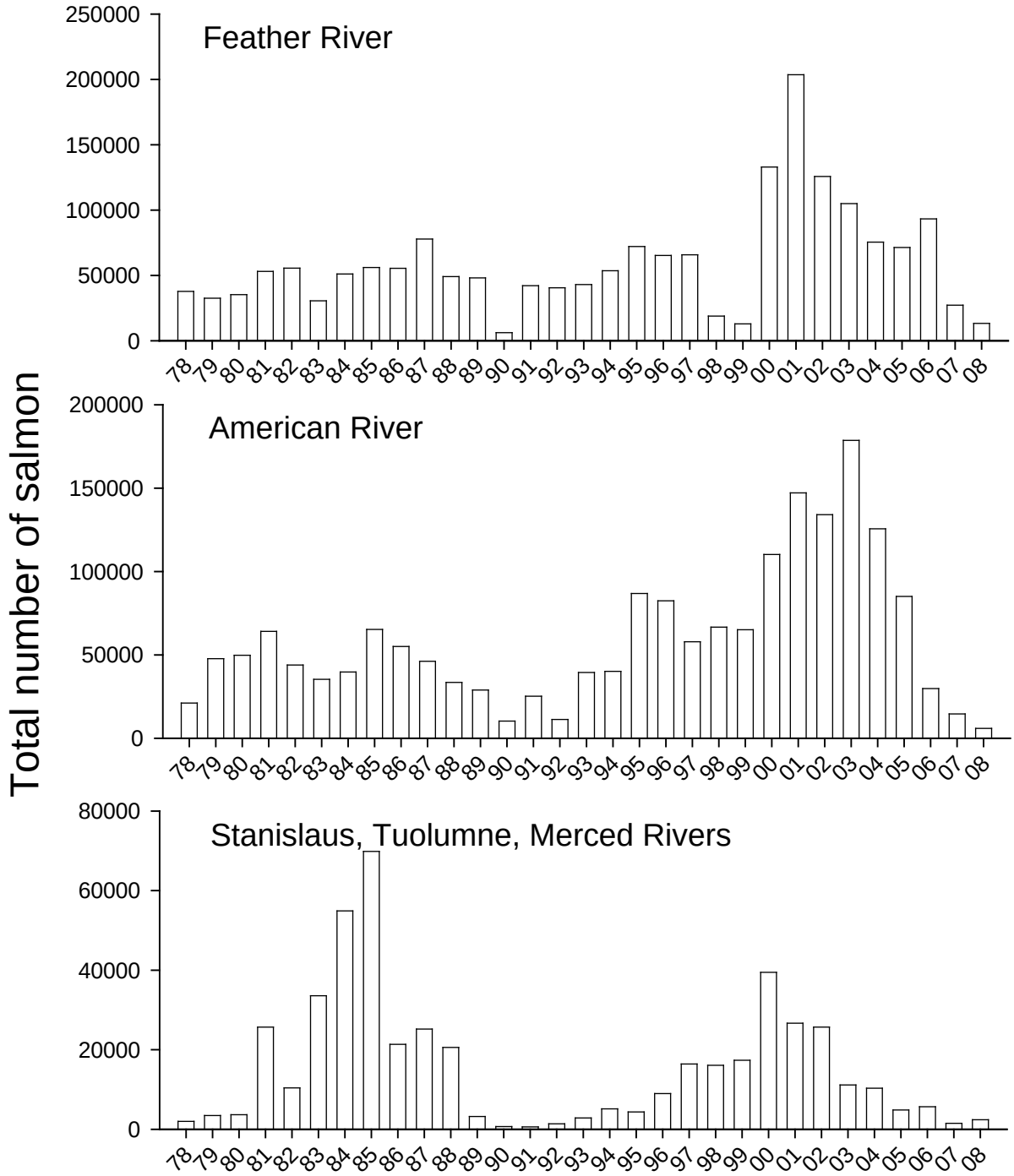


Figure 2. Population estimates of fall-run Chinook salmon spawners between 1978 and 2008 on the (a) Feather and (b) American Rivers, and (c) a combination of the Stanislaus, Tuolumne, and Merced Rivers. Values are the sum of both in-river and hatchery totals. Only hatchery data was available for 1998-1999. Source: Grand Tab, CDFG, Fisheries Branch Anadromous Resource Assessment Unit.

Water Conditions

Methods

Discharge data were obtained from United States Geological Survey (USGS; http://ca.water.usgs.gov/, accessed on 1/26/09) and Dayflow (Interagency Ecological Program (IEP), http://www.iep.ca.gov/dayflow/index.html accessed on 1/26/09) websites. We calculated mean daily discharge by month at Colusa, river mile (rm) 144 and Freeport (rm 48) on the lower Sacramento River and at Vernalis (rm 114) on the San Joaquin River (Figures 3a, b, and c). Further, we obtained net Delta discharge estimates as calculated by Dayflow to estimate discharge past Chipps Island towards San Francisco Bay (Figure 3d). Water year classifications were obtained from the California Data Exchange Center (CDEC; http://cdec.water.ca.gov, accessed on 2/9/2008). The 2007 water year (October 2006 through September 2007) was classified as a dry year in the Sacramento Valley and critical in the San Joaquin Valley. The 2008 water year (October 2007 through September 2008) was classified as critical in both the Sacramento and San Joaquin Valleys.

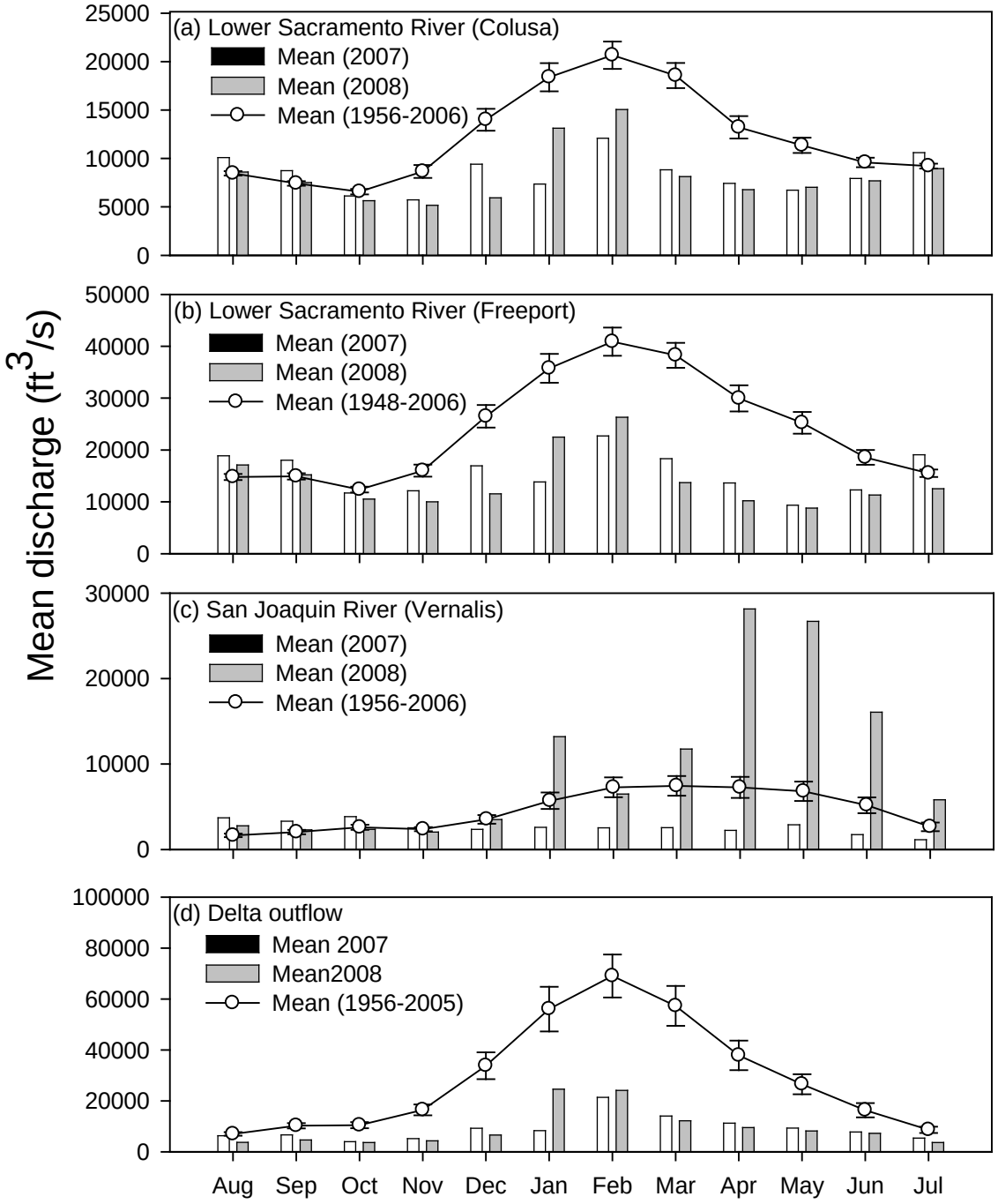


Figure 3. Mean daily discharge (ft^3/s) by month for the 2007-2008 field seasons on the lower Sacramento River at (a) Colusa and (b) Freeport, (c) on the San Joaquin River at Vernalis, and (d) total calculated Delta discharge near Chipps Island. Historical means for each site are included for comparative purposes. Error bars are ±1 SE. Sources: USGS; http://ca.water.usgs.gov/ and IEP; http://www.iep.ca.gov/dayflow/index.html.

Fish Sampling

Different sized juvenile fish have distinct spatial and temporal distributions making them vulnerable to capture by different gear types. Beach seining, midwater trawling, and Kodiak trawling were used at varying times and locations in the Delta, lower Sacramento and San Joaquin Rivers, and parts of San Pablo and San Francisco Bays for fish collection.

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 and other juvenile fishes among and within years (Table 1; Figure 4). Sites have been added through time as more information has been needed. The sampling area is currently divided into six regions to facilitate data analyses 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 bypasses 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 January 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 (Table 1).

New sites that can be accessed by land were added on the San Joaquin River in June 2008 between Mossdale and Tuolumne River to facilitate sampling within this region when discharge in the San Joaquin River is less than 1800 ft^3/s and beach seine sites are no longer accessible by boat. These sites included Critchett Road, Durham Bridge, Sturgeon Bend Alternate, and Stanislaus RV Park. Durham Bridge and Stanislaus RV Park were only sampled a few times in July 2008 then eliminated because the sites were not conducive to effective sampling.

All of our sample sites are influenced by either the Sacramento or San Joaquin Rivers. Different watersheds have different drainage patterns resulting in discharge conditions specific to locality. Therefore, it was necessary to define site-specific discharge conditions. For ease of interpretation, we considered 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 attempted to relate each region to the closest water discharge measurement station available on

USGS and Dayflow web sites.

Table 1. Sites sampled by DJFMP during the 2007 and 2008 field seasons 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, Colusa State Park is on the Sacramento River (SR) at river mile 144 on the west bank (W).

Site	Station Code	Site	Station Code
Region 1. Lower Sacramento River		**Region 4. South Delta**	
Colusa State Park	SR144W	Dos Reis	SJ051E
Ward's Landing	SR138E	Dad's Point	SJ041N
South Meridian	SR130E	Lost Isle	SJ032S
Knight's Landing	SR090W	Medford Island	SJ026S
Reels Beach	SR094E	Frank's Tract	OR003W
Verona*	SR080E	Veale Tract	WD002W
Elkhorn*	SR071E	Cruiser Haven	OR019E
		Old River	OR019E
Region 2. North Delta		Union Island	OR023E
Discovery Park*	SR060E	Woodward Island	MR010W
American River*	AM001S		
Garcia Bend*	SR049E	**Region 5. San Joaquin River**	
Clarksburg	SR043W	N. of Tuolumne River	SJ083W
Steamboat Slough (mouth)	SS011N	Route 132	SJ077E
Koket	SR024E	Sturgeon Bend	SJ074W
Isleton	SR017E	Durham Site	SJ068W
Rio Vista	SR014W	Big Beach	SJ063W
Stump Beach	SR012E	Wetherbee	SJ058W
Sandy Beach	SR012W	Mossdale	SJ056E
		Sturgeon Bend Aternate[c]	SJ074A
Region 3. Central Delta		Critchett Road[c]	SJ065W
Antioch Dunes	SJ001S	Stanislaus RV Park[c]	SJ075E
B&W Marina	MK004W	Durham Bridge[c]	SJ072E
Brannan Island	TM001N		
Delta Cross Channel	XC001N	**Region 6. Bay**	
Eddo's	SJ005N	Berkeley Frontage Rd	SA007E
Georgiana Slough	GS010E	China Camp	SP001W
King's Island	DS002S	Keller Beach	SA009E
Terminous	LP003E	McNear's Beach	SP000W
Wimpy's	SF014E	Paradise Beach	SA008W
		Point Pinole East	SP003E
Sacramento Seine (additional sites)		San Quentin Beach	SA010W
Sand Cove	SR062E	Tiburon Beach	SA004W
Sherwood Harbor	SR055E	Treasure Island	SA001M
Miller Park	SR057E		
		Trawls	
		Chipps Island	SB01BM,N,&S
		Mossdale	SJ055M
		Sacramento	SR055M

* Indicates site switched to Sacramento Seine region during periods with more intense sampling (3 days per week, Oct. – Jan.).

[c] Indicates site done by car when San Joaquin River discharge is below 1800 ft^3/s.

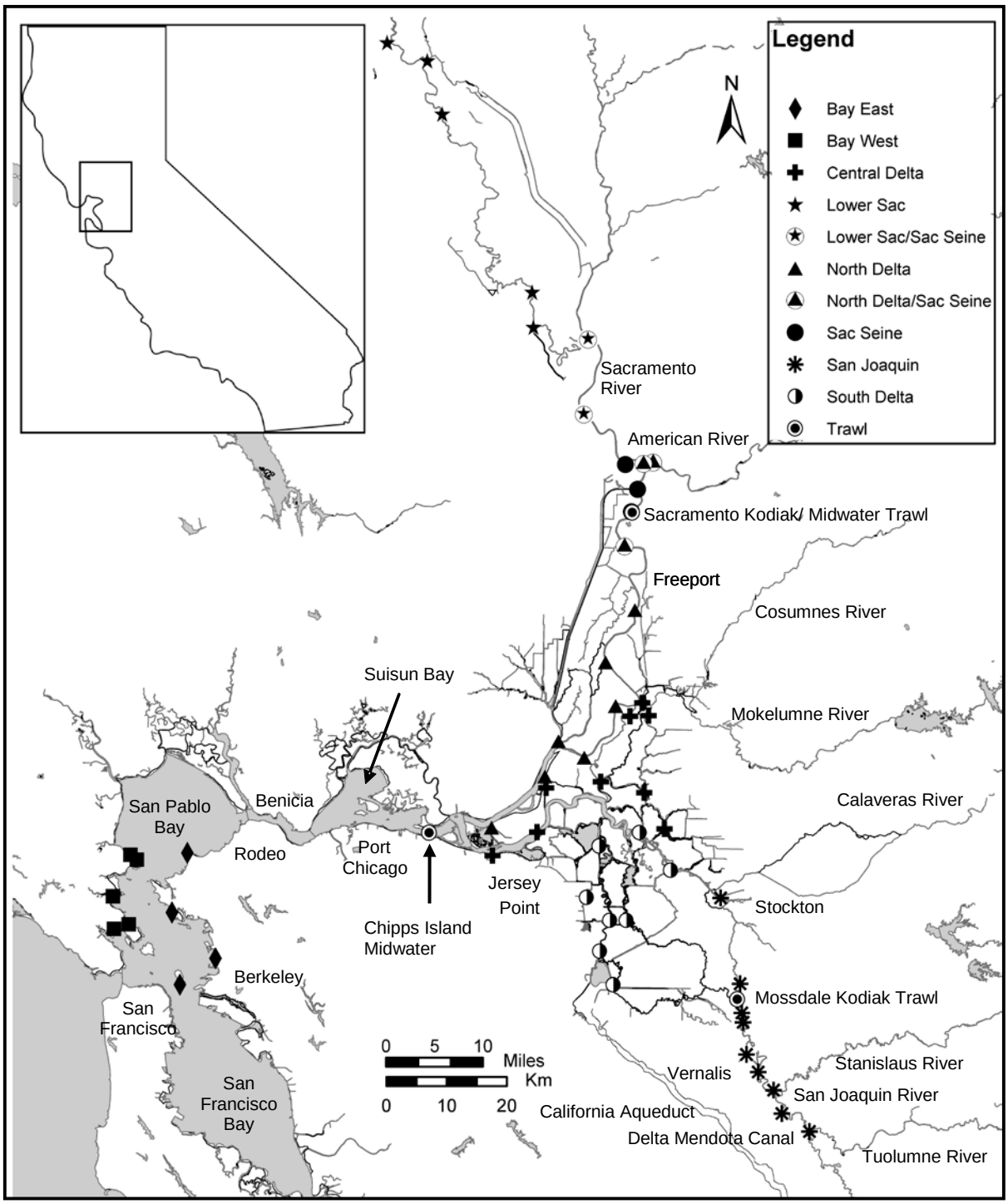


Figure 4. Trawl and beach seine sites for the 2007 - 2008 field seasons. Regions are designated as: (1) lower Sacramento, (2) North Delta, (3) Central Delta, (4) South Delta, (5) lower San Joaquin River, and (6) San Francisco/San Pablo Bay.

Beach Seine

Methods

Beach seining is conducted to estimate the relative abundance of near-shore benthic and pelagic juvenile fish populations. 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 is used for all beach seining. One seine haul is conducted at each site. Sites are accessed by vehicle or small vessel.

To allow for annual site-specific 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 meters of the original location containing similar habitat characteristics (i.e., substrate, vegetation). In rare cases, sites have been permanently relocated or removed because of more permanent issues (i.e., thick vegetation inundated the site). More information on sample site relocations or other sampling modifications can be found at http://www.fws.gov/stockton/jfmp/Docs/Data%20Management/STFWO%20Metadata%20(Updated%20December%2018,%202008).pdf.

Catches are corrected for effort by standardizing to catch-per-unit effort (CPUE; fish/m^3) using the following equation:

$$Seine\ CPUE = \frac{Catch}{\frac{1}{2} Depth \times Width \times Length} \qquad (1)$$

Effort is measured by volume of water sampled. Our measure of depth is the mean value of depth measured at the two deepest corners (Figure 5). By assuming a constant slope from shore to the corners where depth measurements were taken, we calculate the volume of the wedge of water sampled by taking ½ x depth in calculations.

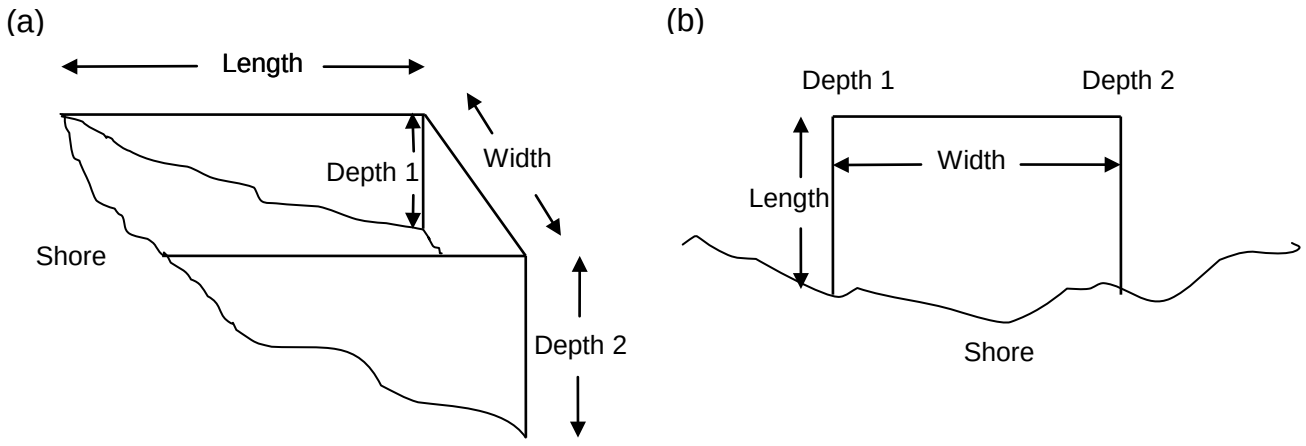


Figure 5. Schematic diagram of beach seine measurements: (a) three-dimensional view, (b) overhead view.

Mean CPUE calculations for beach seines

In all calculations, races of salmon (Winter, Late Fall, and Fall/Spring) and regions were treated separately. Data from north, central, and south Delta regions were combined into a single "Delta" region.

Because the number and location 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 sub-samples. 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. This technique diminishes temporal pseudo replication caused by taking multiple samples during a short period of time.

Next, we calculated the mean of mean weekly CPUE of all sites within a region for each week. This value was multiplied by 10^4 for ease of viewing and 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 against discharge data of the same time period.

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 the mean of mean monthly CPUE of all sites within a region for each month separately.

Region 1. Lower Sacramento River

Methods

Beach seining was conducted at five to eight sites per week from August 1 through July 31 for each field season in 2007 and 2008 to estimate densities of juvenile Chinook salmon and other juvenile fish in the lower Sacramento River. Sites were sampled one to two times per week, with more extensive sampling occurring between October 1 and January 31 of each field season, when winter-run Chinook were likely present in the system.

Results

There were 209 winter-run salmon captured in region 1 beach seines during the 2007 field season (Figure 6a). Peak weekly CPUE in 2007 was observed the week of December 31. Monthly CPUE peaked in December of the 2007 field season and was the fifth highest since 1993 (Table 2a). There were 43 winter-run salmon captured in region 1 beach seines during the 2008 field season (Figure7a). Peak weakly CPUE in

2008 was observed the week of February 10, when 16 winter-run salmon were captured at Knights Landing (rm 90). Monthly CPUE peaked in February 2008 (Table 2b). In both field seasons, most winter-run salmon were captured between December and February.

During the 2007 field season, 2,177 spring/fall-run salmon were captured in region 1 beach seines (Figure 6b). Peak weekly CPUE occurred the week of February 25, when 569 spring/fall-run salmon were captured. Spring/fall-run salmon were captured between December and May in both field seasons. During the 2008 field season, 983 spring/fall-run salmon were captured in region 1 beach seines (Figure 7b). Peak weekly CPUE occurred the week of February 3 when 137 spring/fall-run salmon were captured. Peaked monthly CPUE was observed in February of both field seasons (Table 2b).

There were nine late fall-run salmon captured in region 1 beach seines during the 2007 field season (Figure 6c). All nine were yearlings from the 2006 brood year. Peak weekly CPUE was observed the week of November 19, 2006. There were two late fall-run salmon captured in the 2008 field season, both were yearlings from the 2007 brood year (Figure 7c). The first late-fall salmon was captured on December 18, 2007 at Knights Landing (rm 90) and the second late fall-run salmon was captured on January 8, 2008 at Elkhorn (rm71). Peak weekly CPUE was observed the week of January 6, 2008. Peak monthly CPUE for both field seasons occurred in December (Table 2c).

We captured 16 hatchery-reared rainbow trout in region 1 beach seines during the 2007 field season (Figure 8a) and seven hatchery-reared rainbow trout in during the 2008 field season (Figure 9a). Peak weekly CPUE for both field seasons occurred the third week of February, one to two weeks after peak discharge for the season. Most of the hatchery trout were captured at Verona (rm 80).

There were no delta smelt captured in region 1 beach seines during the 2007 field season (Figure 9b) and only one delta smelt captured in the 2008 field season. The delta smelt was captured at Verona (rm 80) on January 18, 2008.

In 2007, we captured 392 splittail in region 1 beach seines (Figure 8b). Peak weekly CPUE occurred the week of May 20 when 107 splittail were captured. In 2008, we captured 512 splittail in region 1 beach seines (Figure 9c). Peak weekly CPUE occurred the week of June 15 when 163 splittail were captured. In both field seasons peak weekly CPUE occurred well after peak discharge in the Sacramento River.

Only one striped bass was captured in the region 1 beach seines during the 2007 field season (Figure 8c) and none were captured in 2008. The striped bass was captured at Knight's Landing (rm 90) on August 27, 2006 during a period of decreasing discharge in the Sacramento River.

Threadfin shad were captured throughout the 2007 and 2008 field seasons, increasing in numbers during the months of August, November, and July. There were 2,299 shad captured (Figure 8d) in 2007. Peak weekly CPUE was observed the week of November 29, when 480 threadfin shad were captured. There were 783 shad captured in 2008 (Figure 9d). Peak weekly CPUE in 2008 occurred the week of August 12 when 180

threadfin shad were captured.

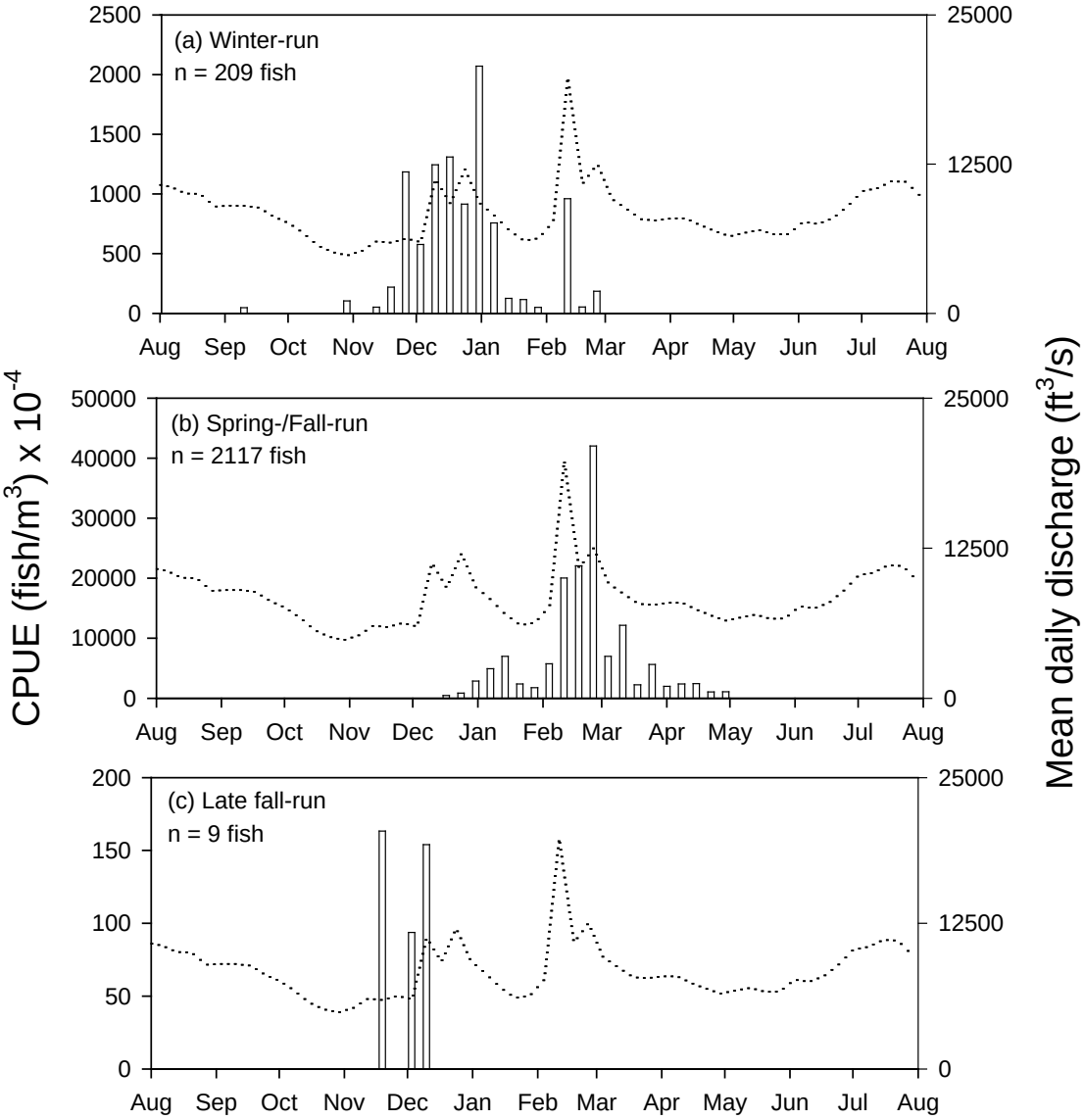


Figure 6. Catch-per-unit effort (x 10^{-4}) of (a) winter-, (b) spring-/fall-, and (c) late fall-run Chinook salmon in beach seines and mean daily discharge in lower Sacramento River region (Region 1) during the 2007 field season. All data were averaged by week. Sample size (n) corresponds to total number of fish caught. Fall- and spring-run salmon were combined because of difficulties in distinguishing between them at this size.

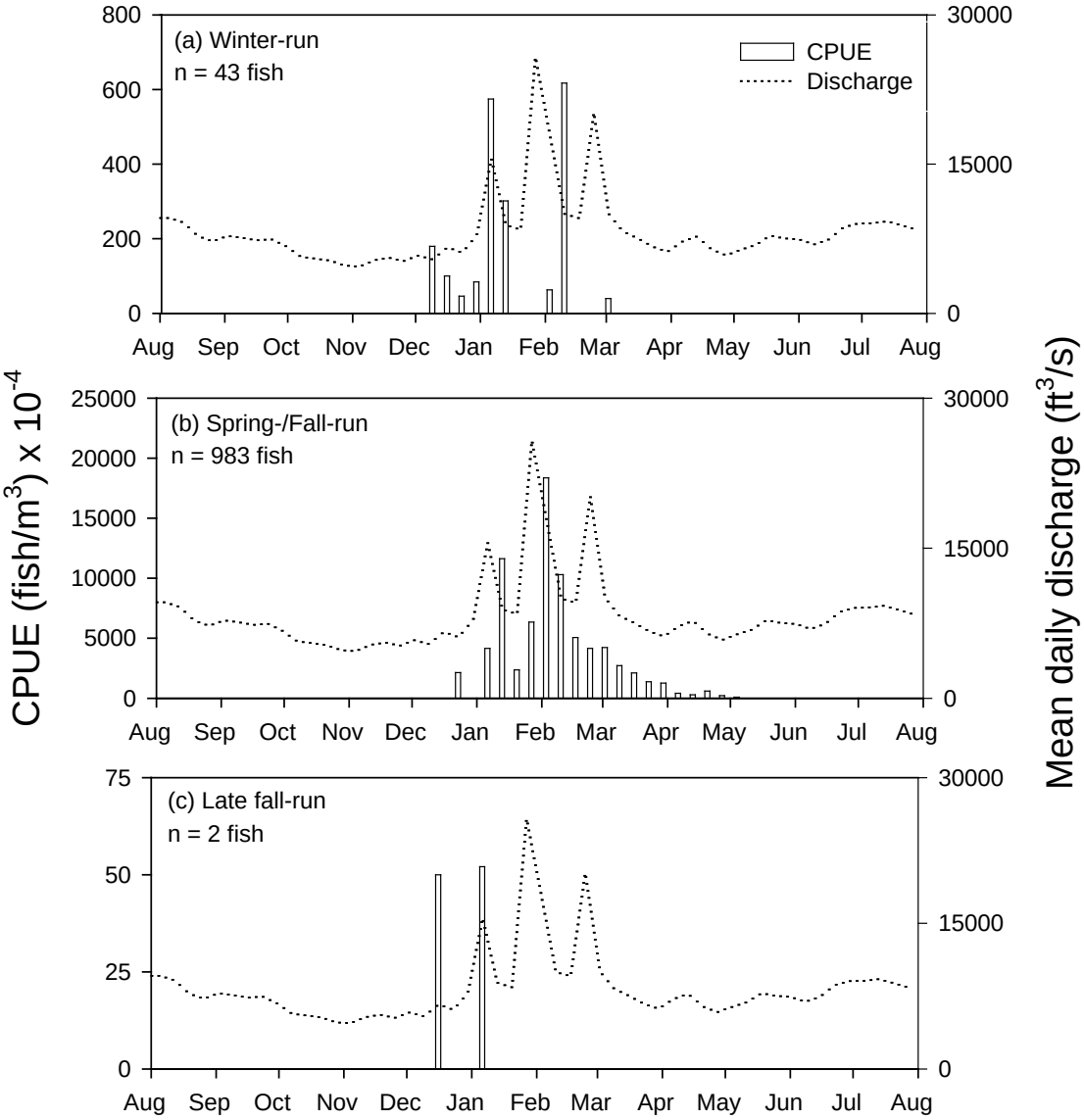


Figure 7. Catch-per-unit effort (x 10^{-4}) of (a) winter-, (b) spring-/fall-, and (c) late fall-run Chinook salmon in beach seines and mean daily discharge in lower Sacramento River region (Region 1) during the 2008 field season. All data were averaged by week. Sample size (n) corresponds to total number of fish caught. Fall- and spring-run salmon were combined because of difficulties in distinguishing between them at this size.

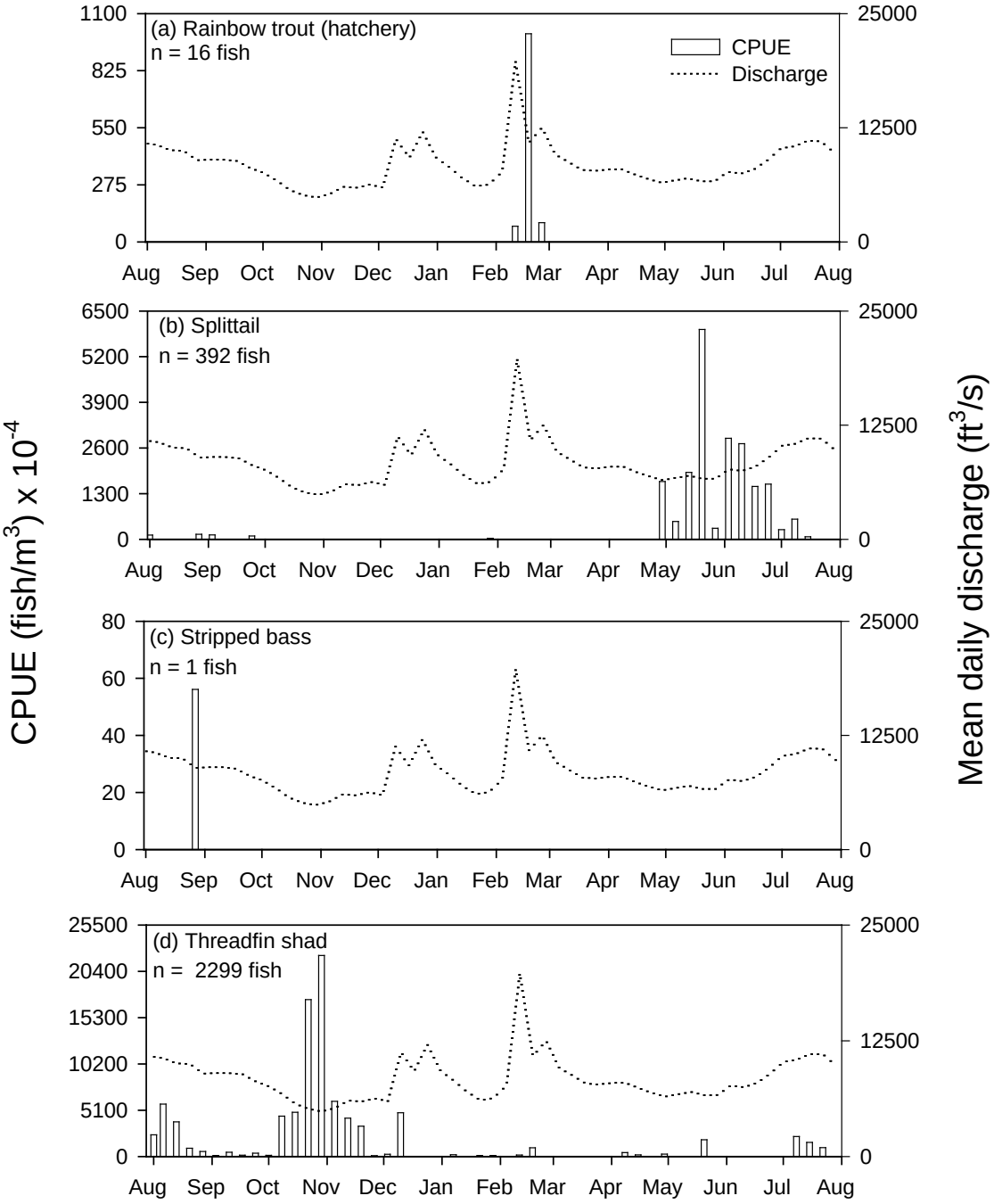


Figure 8. Catch-per-unit effort (x 10^{-4}) of (a) rainbow trout (hatchery), (b) spilttail, (c) striped bass, and (d) threadfin shad in beach seines and mean daily discharge in lower Sacramento River region (Region 1) during the 2007 field season. All data were averaged by week. Sample size (n) corresponds to total number of fish caught.

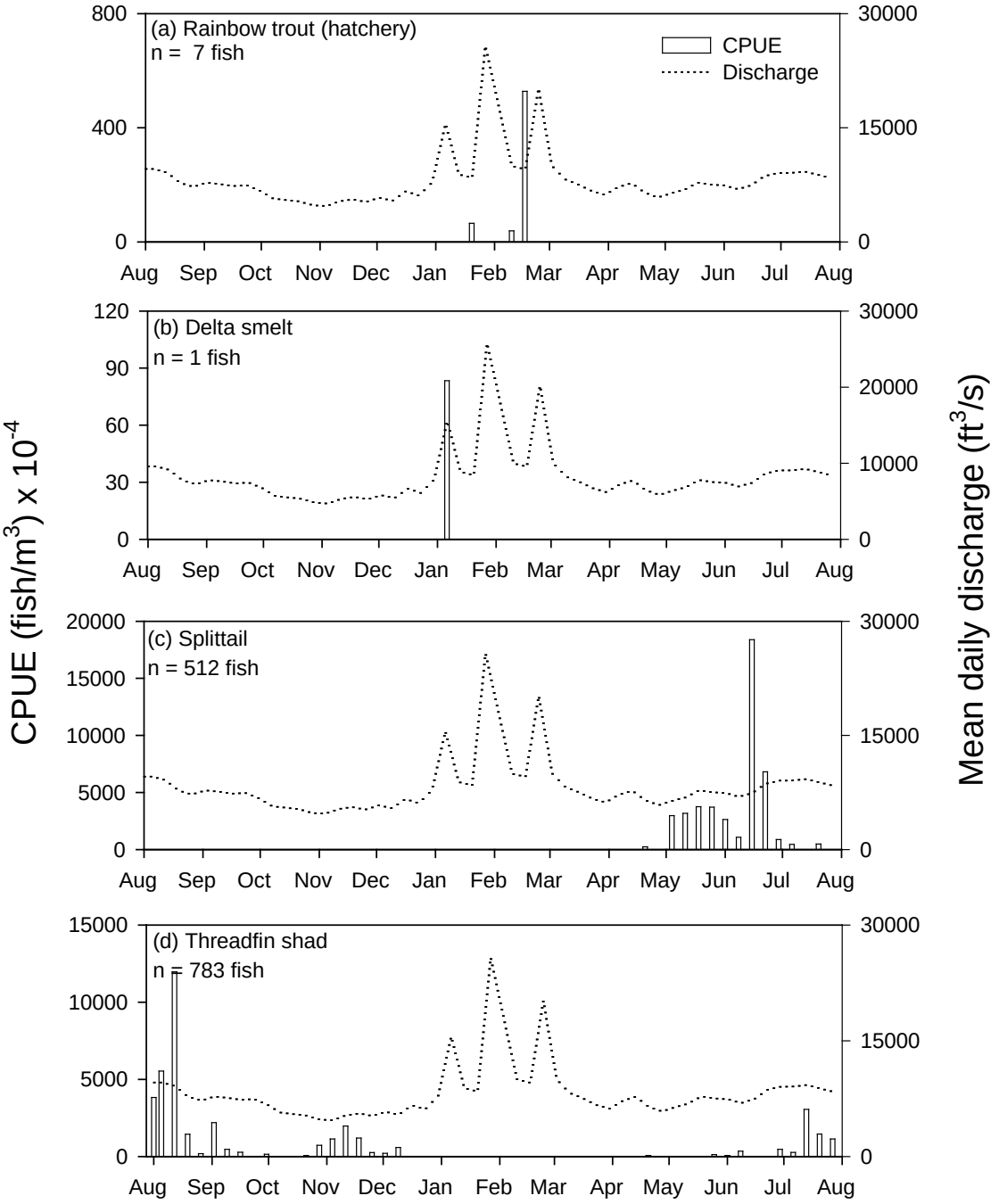


Figure 9. Catch-per-unit effort (x 10^{-4}) of (a) rainbow trout (hatchery), (b) delta smelt, (c) splittail, and (d) threadfin shad in beach seines and mean daily discharge in lower Sacramento River region (Region 1) during the 2008 field season. All data were averaged by week. Sample size (n) corresponds to total number of fish caught.

Table 2. Summary table of CPUE (fish/m^3) x 10^{-4} of (a) winter-, (b) fall-/spring-run, and (c) late fall-run Chinook salmon in lower Sacramento River region (Region 1) by month and year. Yearly mean and standard error (SE) values were calculated using years as replicates (n = 13-14). Weekly mean and SE values were calculated using weeks as replicates (n = 44-53). Shaded boxes indicate peak monthly CPUE. Water year (CDEC, 2008): AN = above normal; BN = below normal; C = critical; D = dry; W = wet

(a) Winter-run

Field Season	Water year	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Weekly mean (SE)
1993	AN	--	34.0	0	137	112	227	224	0	0	0	0	0	73.9 (18.9)
1994	C	0	0	1.05	0	4.00	51.2	56.5	0	0	0	0	0	11.2 (6.65)
1995	W	0	0	0	18.5	8.56	156	37.6	49.6	0	0	0	0	17.9 (8.61)
1996	W	0	0	0	0	238	197	45.1	11.6	2.47	0	0	0	42.0 (16.1)
1997	W	0	0	0	0	148	0	38.6	27.0	0	0	0	0	27.6 (12.1)
1998	W	0	0	6.35	352	336	316	0	0	0	0	0	0	76.3 (32.2)
1999	W	0	35.3	0	890	415	294	153	4.96	0	0	0	0	158 (59.3)
2000	AN	0	0	0	3.31	7.26	160	42.8	0	0	0	0	0	15.6 (7.48)
2001	D	0	0	5.25	238	33.1	1780	267	0	0	0	0	0	167(90.6)
2002	D	0	0	0	1580	1230	190	70.0	0	0	0	0	0	262 (119)
2003	AN	0	0	0	0	64.4	42.0	18.0	9.92	0	0	0	0	21.8 (9.89)
2004	BN	0	0	0	92.2	3050	80.7	75.0	0	0	0	0	0	310 (165)
2005	BN	0	0	0	344	781	338	32.1	13.3	0	0	0	0	184 (83.5)
2006	W	0	0	23.3	279	1467	163	66.8	4.45	0	0	0	0	182 (59.6)
Yearly mean 1993-2006 (SE)		0 0	4.95 (3.36)	2.57 (1.69)	281 (119)	564 (229)	285 (118)	80.5 (21.0)	8.63 (3.78)	0.176 (0.176)	0 0	0 0	0 0	111 (26.5)
2007	D	0	23.8	0	477	1071	658	332	0	0	0	0	0	192 (60.9)
2008	C	0	0	0	0	81.5	140	165	39.7	0	0	0	0	37.8 (16.9)

Table 2. (cont.)

(b) Fall-/Spring-run

Field Season	Water year	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Weekly mean (SE)
1993	AN	--	0	0	0	244	2890	2740	3570	3690	429	62.6	0	1500 (327)
1994	C	5.67	0	0.702	0	1030	1360	7420	4820	830	142	0	0	1430 (401)
1995	W	0	0	0	0	48.7	7270	7710	8530	2960	1760	207	5.43	3080 (774)
1996	W	6.58	0	0	0	1880	5940	15000	7900	2230	318	0	2.48	2790 (716)
1997	W	0	0	0	0	640	5140	3010	2950	737	58.7	4.70	0	1410 (409)
1998	W	0	0	0	0	623	6770	1500	4470	2950	2770	183	5.91	1900 (477)
1999	W	4.51	0	0	12.9	1300	8140	20900	29400	6930	627	33.9	23.5	7240 (2180)
2000	AN	0	0	0	0	183	6960	16800	11500	1820	559	13.0	0	3730 (1090)
2001	D	0	0	0	0	8.68	4420	18700	5320	292	35.3	22.3	0	27600 (11600)
2002	D	0	0	0	57.5	3170	16400	8730	8240	1590	90.9	0	0	40500 (1630)
2003	AN	0	0	0	0	4170	13200	14100	10800	2530	1090	0	18.1	44200 (10800)
2004	BN	0	0	0	0	5240	26600	14900	12500	2760	127	0	0	53400 (17000)
2005	AN	0	0	0	0	1020	5750	5180	5690	1900	883	107	0	23800 (5670)
2006	W	0	0	0	15.2	3611	7582	4055	3595	2183	1905	95.3	0	2726 (681)
Yearly mean 1993-2006 (SE)		1.29 (0.690)	0 (0)	0.050 (0.052)	6.11 (4.34)	1654 (473)	8458 (1795)	10053 (1808)	8820 (1876)	2385 (448)	771 (232)	48.7 (19.6)	3.96 (2.08)	15380 (5007)
2007	D	0	0	0	0	277	3584	20737	6126	1749	235	0	30.7	2812 (994)
2008	C	0	0	0	0	220	3760	8260	3019	623	46	0	0	1470 (470)

Table 2. (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 mean (SE)
1993	AN	--	0	2.19	6.54	26.5	4.45	2.24	0	40.2	22.6	0	0	8.75 (3.29)
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)
1995	W	0	0	0	9.45	21.1	22.4	0	0	0	13.6	0	0	5.27 (1.82)
1996	W	14.1	0	0	0	25.1	8.56	0	0	0	0	4.99	0	4.50 (1.90)
1997	W	0	0	0	5.79	26.3	0	0	0	0	0	0	0	4.09 (2.58)
1998	W	0	0	0	45.6	78.7	3.38	0	0	0	40.3	88.1	0	21.0 (6.58)
1999	W	11.1	0	0	308	77.4	0	0	0	49.6	24.1	0	0	39.9 (17.9)
2000	AN	0	0	0	0	0	8.280	0	0	0	0	0	0	0.478 (0.478)
2001	D	0	0	0	68.0	0	3.05	0	0	0	0	0	0	50.2 (45.1)
2002	D	0	0	0	32.7	40.2	0	0	0	0	0	0	0	69.8 (36.5)
2003	AN	0	0	0	35.3	10.1	0	0	0	0	296	0	0	140 (68.8)
2004	BN	0	0	0	0	40.7	14.7	0	0	31.4	0	0	0	77.5 (35.8)
2005	BN	0	0	10.3	9.02	29.8	0	0	0	0	419	0	0	193 (81.0)
2006	W	0	0	0	17.4	23.7	0	0	0	43.5	13.0	0	0	11.1(5.00)
Yearly mean 1993-2006 (SE)		2.16 (1.31)	0.123 (0.127)	3.41 (2.66)	38.9 (22.2)	29.9 (6.59)	4.69 (1.87)	1.01 (0.885)	0 (0)	11.8 (5.45)	59.2 (35.9)	6.65 (6.51)	0 (0)	45.2 (15.6)
2007	D	0	0	0	54.4	71.2	0	0	0	0	0	0	0	7.90 (4.59)
2008	C	0	0	0	0	81.5	7.44	0	0	0	0	0	0	1.93 (1.35)

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

Methods

Beach seining was conducted weekly at 12 sites in region 2 (North Delta), ten sites in Region 3 (Central Delta), and 10 sites in Region 4 (South Delta) between August 1 through July 31 during the 2007 and 2008 field seasons. Three sites from region 2 (Garcia Bend, American River, and Discovery Park) were sampled up to three times per week during October-January as part of our Sacramento seine sampling (see below for Sacramento area beach seine).

Results

In 2007, 103 winter-run salmon were captured in regions 2-4 beach seines (Figure 10a). Peak weekly CPUE of winter-run salmon occurred the week of February 11 coinciding with peak discharge. Peak monthly CPUE for 2007 also occurred in February (Table 3a). In 2008, seven winter-run salmon were captured in regions 2-4 beach seines (Figure 11a). Peak weekly CPUE in 2008 occurred the week of January 20 coinciding with increasing discharge. Peak monthly CPUE was observed in January 2008 and was the second lowest since 1993 (Table 3a). The mean of the mean weekly CPUE for winter-run salmon in 2008 was an order of magnitude less than 2007 and was the lowest since 1993 (Table 3a).

There were 3,701 spring/fall-run salmon captured in regions 2-4 in 2007 (Figure 10b). Peak weekly CPUE occurred the week of February 18, a week after peak discharge. Peak monthly CPUE was observed in February 2007. The mean of the weekly mean CPUE for 2007 was the third lowest since 1993 (Table 3b). There were 1,806 spring/fall-run salmon captured in regions 2-4 in 2008 (Figure 11b). Peak weekly CPUE occurred the week of February 17, two weeks after peak discharge. Peak monthly CPUE occurred in February 2008 and was the lowest since 1993 (Table 3b).

Only three late fall-run sized salmon were captured in regions 2-4 beach seines in 2007(Figure 10c), two yearlings from the 2006 brood year and one fry from the 2007 brood year. Peak weekly CPUE occurred the week of April 22, 2007. Peak monthly CPUE occurred in April and was the second lowest since 1993 (Table 3c). There were five late-fall run sized salmon captured in 2008 (Figure 11c), all five were late-fall yearlings from the 2007 brood year. Peak weekly CPUE for 2008 occurred the week of August 1. Peak monthly CPUE in 2008 occurred in August and was the first time since 1995 we captured late-fun run salmon in August (Table 3c). We more commonly see peak monthly CPUE for late-fun run salmon in April.

There were three wild rainbow trout and eleven hatchery rainbow trout captured in regions 2-4 beach seines in 2007 (Figures 12a and 12b). Peak weekly CPUE for wild rainbow trout occurred the week of April 4, 2007 when two wild trout were captured at Discovery Park (rm 60). Peak weekly CPUE for hatchery reared rainbow trout occurred the week of February 18, 2008 when four hatchery trout were captured, one at Garcia Bend (rm 49) and three at Wimpy's (rm14). In 2008, only hatchery reared rainbow trout (n = 18 fish) were captured in regions 2-4 beach seines (Figure 13a). Peak weekly

CPUE for hatchery trout occurred the week of July 6, 2008 when ten trout were captured, one at Clarksburg (rm 43), and nine at Garcia Bend.

In 2007, 17 delta smelt were captured in regions 2-4 beach seines (Figure 12c). Weekly CPUE peaked the week of February 18, 2007 when four delta smelt were captured at Rio Vista, a week after peak total delta discharge (rm14). There were three delta smelt captured in regions 2-4 beach seines in 2008. Peak weekly CPUE was observed the week of April 27, 2008 when one delta smelt was captured at Garcia Bend, three months after peak total delta discharge (Figure 13b).

There was one longfin smelt captured in 2007 regions 2-4 beach seines and no longfin smelt captured in 2008. The longfin smelt in 2007 was captured on May 25 at Sherman Island (rm 1) during a period of decreasing total delta discharge (Figure 12d).

In the 2007 field season, 209 splittail were captured in regions 2-4 beach seines (Figure 12e). Peak weekly CPUE occurred the week of May 6, 2007 when 65 splittail were captured, one at Isleton (rm17) and 64 at Wimpy's. In 2008, 645 splittail were captured in regions 2-4 beach seines (Figure 13c). Peak weekly CPUE occurred the week of May 25, 2008 when 107 splittail were captured during decreasing delta discharge.

We captured 109 striped bass in regions 2-4 beach seines in 2007 (Figure 12f). Weekly CPUE peaked the week June 17 when 10 striped bass were captured during a period of decreasing total delta discharge. There were 291 striped bass captured in 2008 (Figure 13d). Weekly CPUE occurred the week of June 29 when 54 striped bass were captured during a period of decreasing total delta discharge.

Threadfin shad were the most abundant non-salmonid species captured in both 2007 and 2008 field seasons (n = 12,568 fish and n = 24,507 fish, respectively; Figures 12g and 13e). Although they were not captured in large numbers in every month, they were regularly captured throughout both field seasons. Peak weekly CPUE in 2007 occurred the week of August 13 when 1,362 threadfin were captured. In 2008, weekly CPUE peaked the week of December 2 when 9,727 threadfin shad were captured.

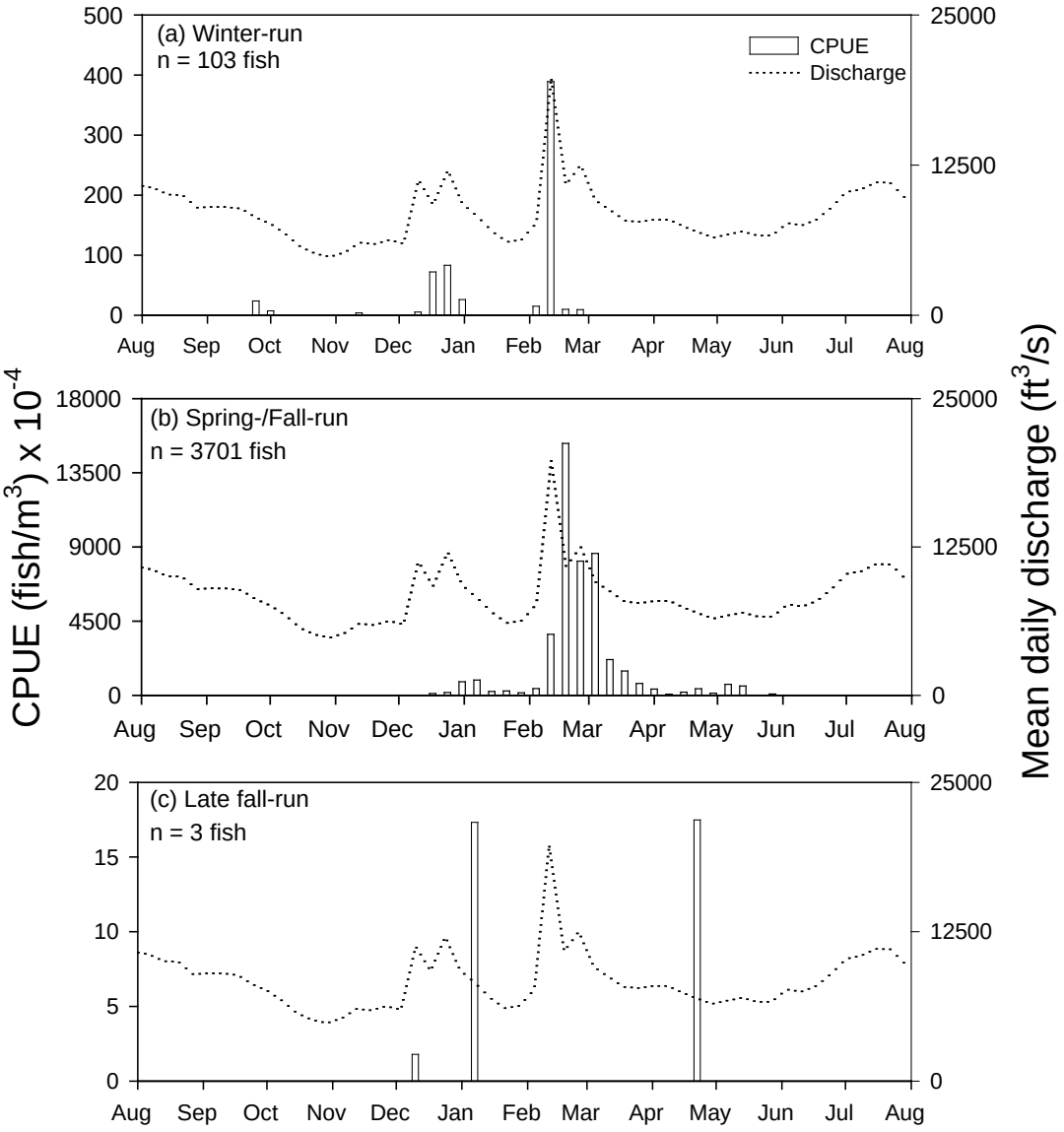


Figure 10. Catch-per-unit effort (x 10^{-4}) of (a) winter-, (b) spring-/fall-, and (c) late fall-run Chinook salmon in beach seines and concurrent mean daily discharge in interior Delta (North, Central, and South; Regions 2-4) during the 2007 field season. All data were averaged by week. Sample size (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.

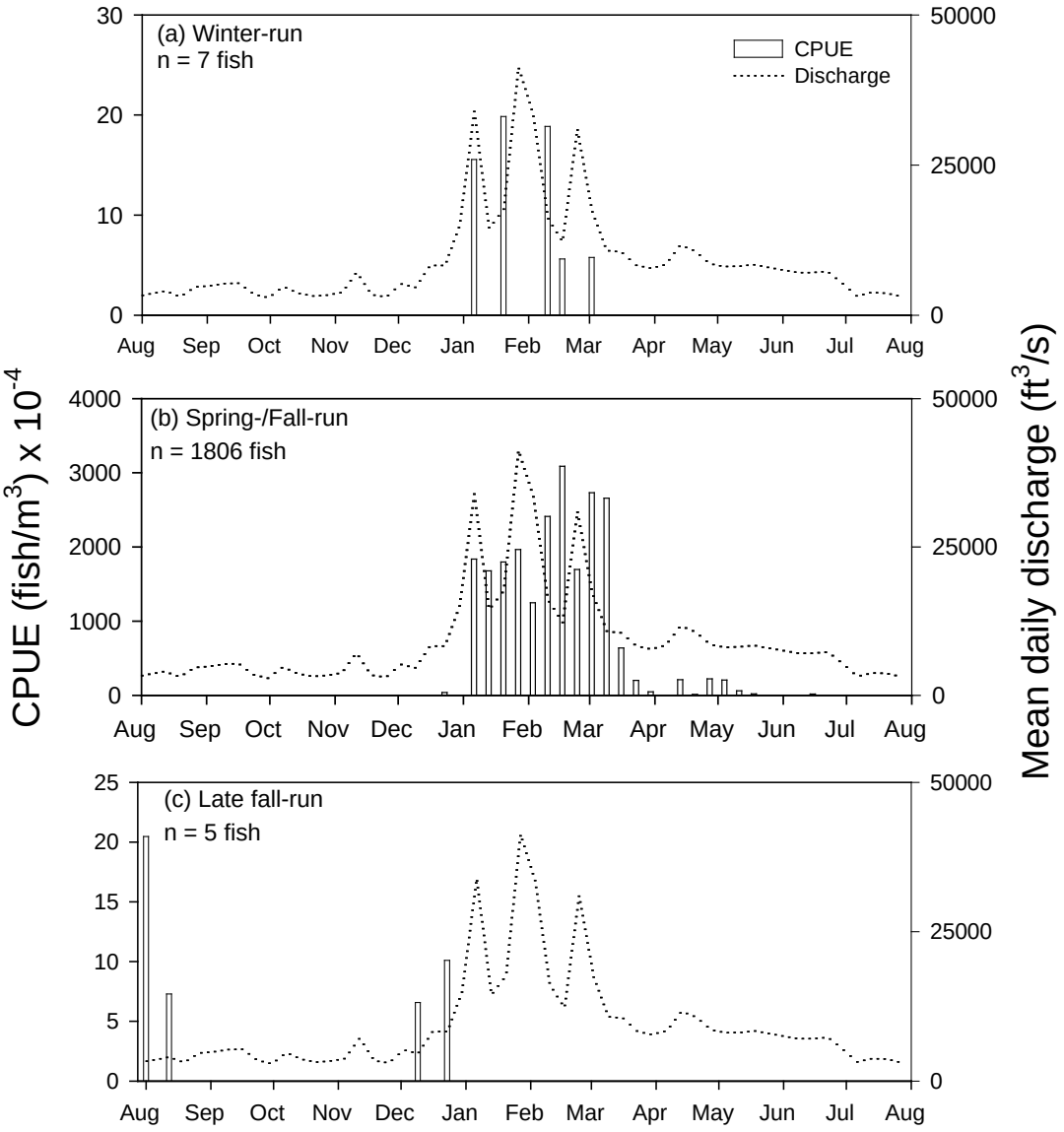


Figure 11. Catch-per-unit effort (x 10^{-4}) of (a) winter-, (b) spring-/fall-, and (c) late fall-run Chinook salmon in beach seines and concurrent mean daily discharge in interior Delta (North, Central, and South; Regions 2-4) during the 2008 field season. All data were averaged by week. Sample size (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.

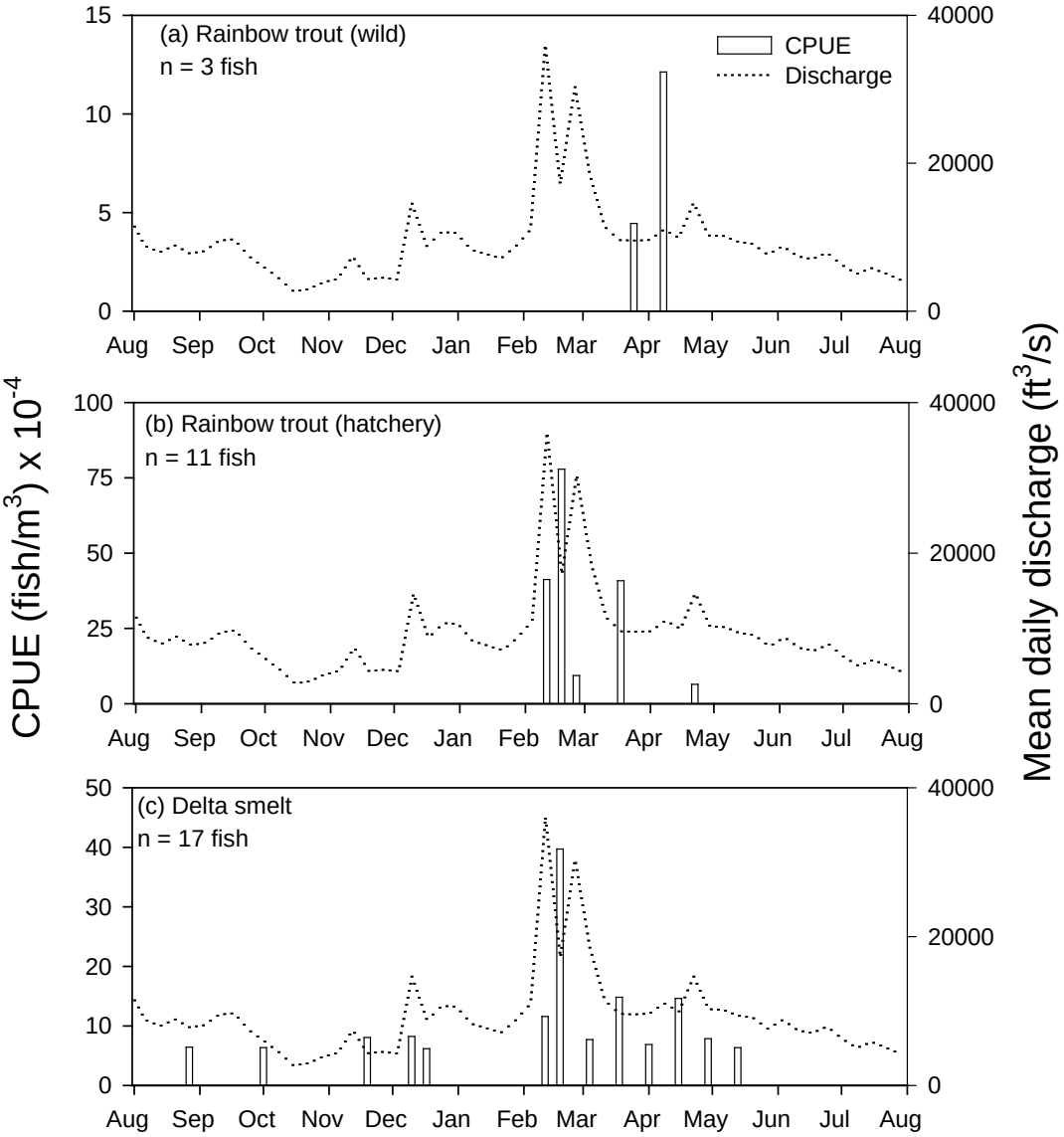
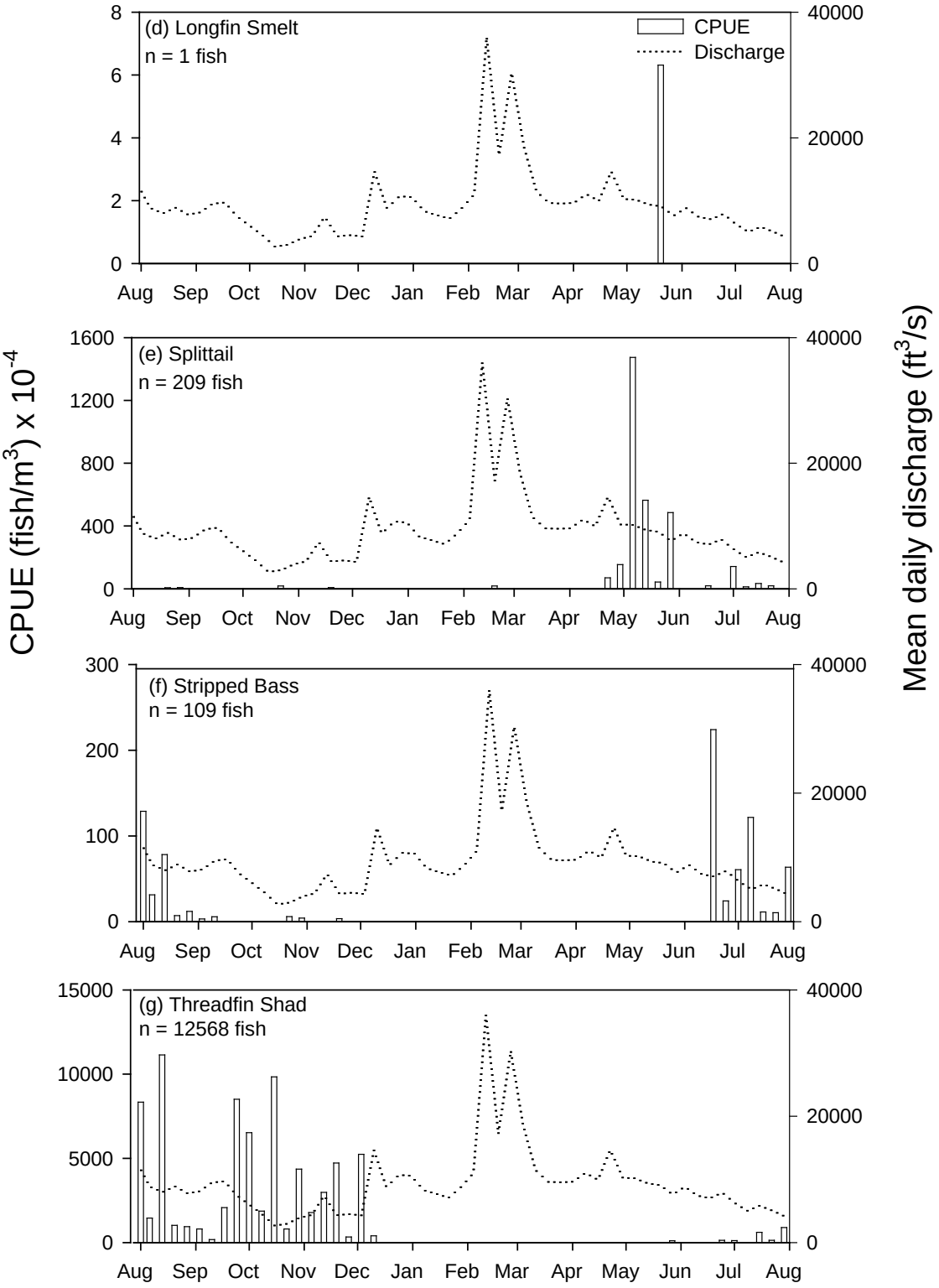


Figure 12. Catch-per-unit effort (x 10^{-4}) of (a) rainbow trout (wild), (b) rainbow trout (hatchery), (c) delta smelt, (d) longfin smelt, (e) spilttail, and (f) striped bass, and (g) threadfin shad in beach seines and mean daily discharge in interior Delta (North, Central, and South; Regions 2-4) during the 2007 field season. All data were averaged by week. Sample size (n) corresponds to total number of fish caught.

Figure 12 cont.



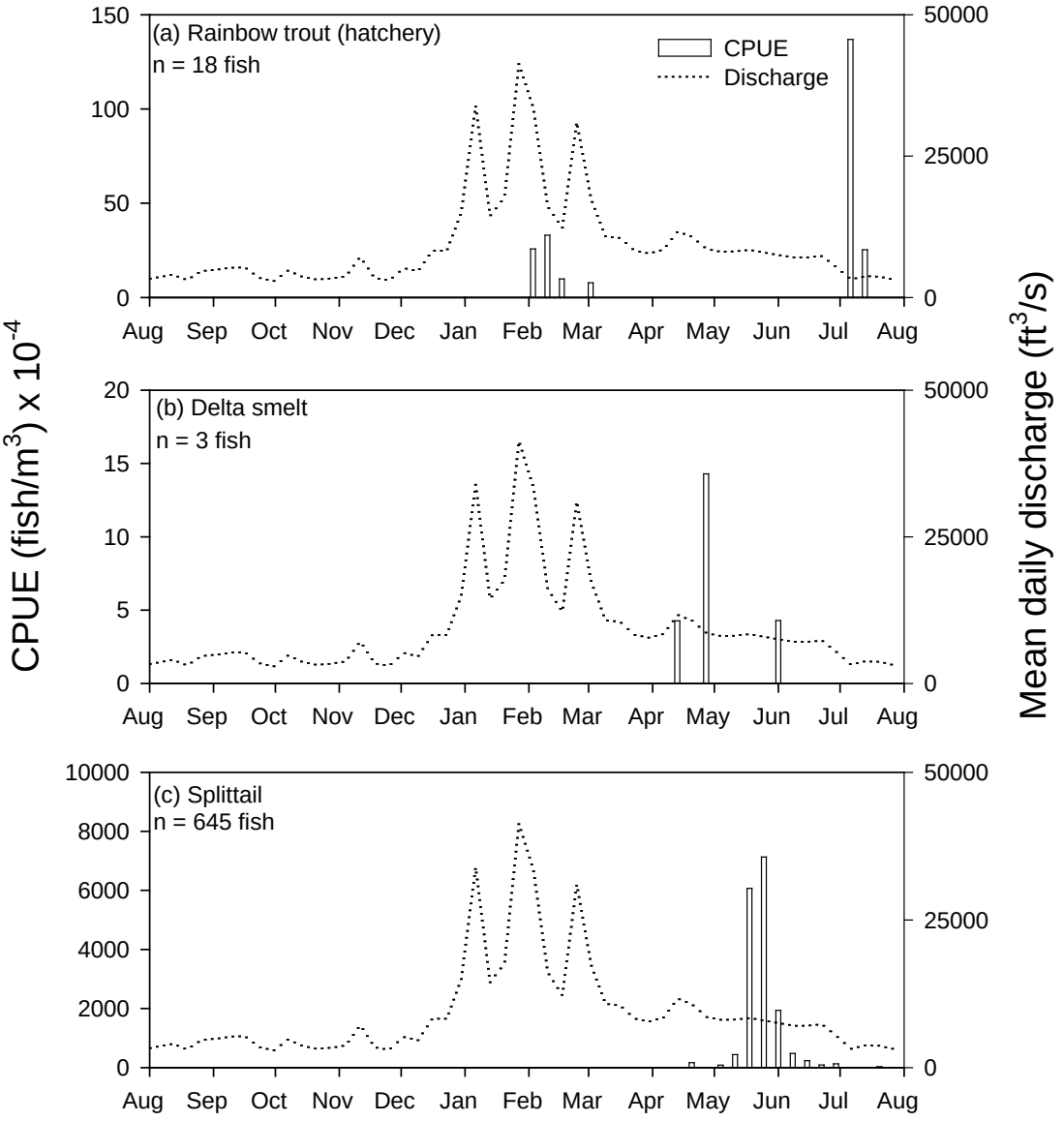


Figure 13. Catch-per-unit effort (x 10^{-4}) of (a) rainbow trout (hatchery), (b) delta smelt, (c) spilttail, and (d) striped bass in beach seines and mean daily discharge in the interior Delta (North, Central, and South; Regions 2-4) during the 2008 field season. All data were averaged by week. Sample size (n) corresponds to total number of fish caught.

Figure 13 cont.

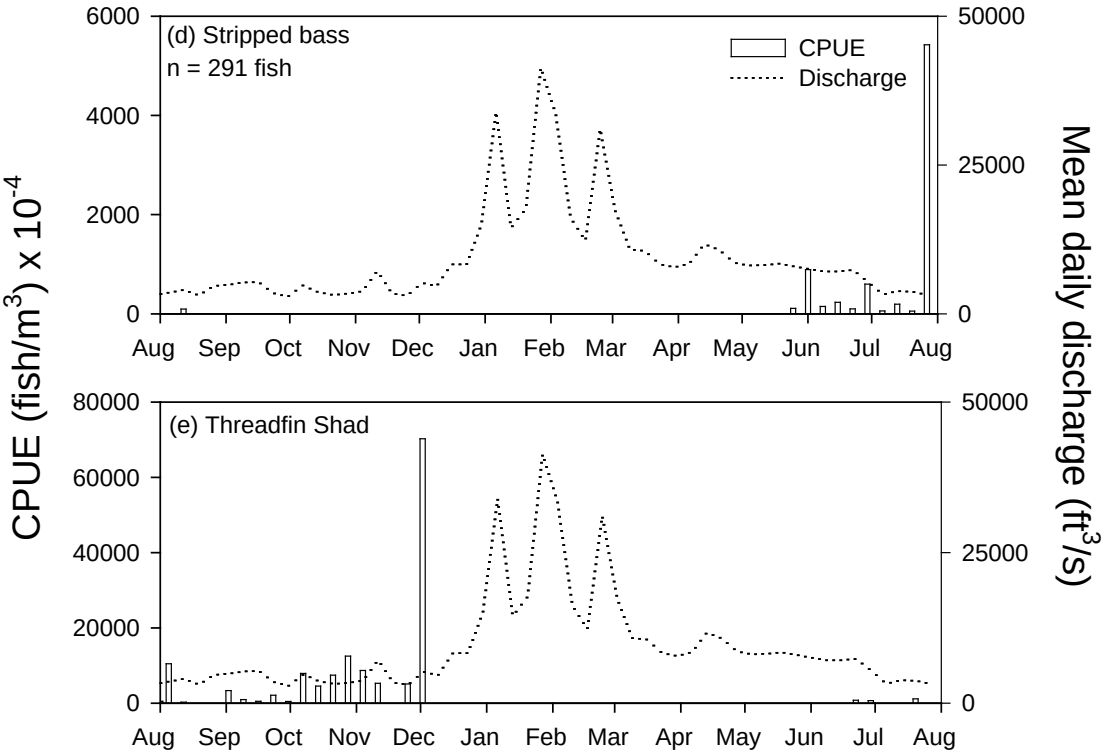


Table 3. Summary table of CPUE (fish/m^3 x 10^{-4}) of (a) winter-, (b) fall-/spring-run, and (c) late fall-run Chinook salmon in interior Delta (North, Central, and South; Regions 2-4) combined by month and year. Yearly mean and standard error (SE) values were calculated using years as replicates (n = 12-14). Weekly mean and SE values were calculated using weeks as replicates (n = 39-53). Shaded boxes indicate peak monthly CPUE. Water year (CDEC, 2006): AN = above normal; BN = below normal; C = critical; D = dry; W = wet.

(a) Winter-run

Field Season	Water year	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Weekly mean (SE)
1993	AN	--	0	0	37.7	8.78	58.0	35.1	6.61	0	0	0	--	19.6 (7.76)
1994	C	--	0	0	0	0	0	4.67	0	0	0	0	0	0.552 (0.552)
1995	W	0	0	0	0	0	9.76	4.16	0.427	0	0	0	0	1.38 (0.559)
1996	W	0	0	0	0	33.0	27.5	17.2	1.99	3.22	0	0	0	7.85 (2.63)
1997	W	0	0	0	0.253	7.91	7.59	2.82	13.4	0	0	0	0	3.94 (1.63)
1998	W	0	0	0	2.07	44.7	48.4	5.84	3.96	0	0	0	0	9.49 (4.04)
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)
2000	AN	0	0	0	0	2.98	36.8	29.87	19.0	0	0	0	0	7.15 (2.87)
2001	D	1.16	0	0	0.48	0	5.67	14.7	8.56	0	0	0	0	3.56 (1.08)
2002	D	0	0	0	51.8	125	44.1	6.44	0	0	0	0	0	32.1(13.6)
2003	AN	0	0	0	0	31.0	36.1	12.1	0	0	0	0	0	10.2 (4.05)
2004	BN	0	0	0	0	80.0	29.3	44.6	1.60	0	0	0	0	18.9 (6.63)
2005	BN	0	0	0	0.893	33.8	49.1	24.3	4.34	0	0	0	0	18.6 (7.80)
2006	W	0	0	2.97	45.2	151	31.2	5.42	6.41	1.53	0	0	0	25.8 (8.9)
Yearly mean 1993-2006 (SE)		0.097 (0.097)	0.281 (0.281)	0.344 (0.241)	12.9 (5.53)	41.8 (12.9)	28.6 (4.81)	15.7 (3.50)	5.64 (1.58)	0.339 (0.247)	0 (0)	0 (0)	0 (0)	12.8 (2.60)
2007	D	0	4.10	1.47	0.786	35.4	4.45	73.4	0	0	0	0	0	12.2 (7.58)
2008	C	0	0	0	0	0	5.64	4.89	1.51	0	0	0	0	1.24(0.59)

Table 3. cont.

(b) Spring-/fall-run

Field Season	Water year	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Weekly mean (SE)
1993	AN	--	0	0	0	41.6	1320	1630	4960	2670	405	124	--	1240 (346)
1994	C	--	0	0	6.64	36.3	325	4000	1430	496	53.0	2.58	0	723 (150)
1995	W	0	1.93	0	0	31.1	8760	5260	6350	2640	499	65.9	2.81	2560 (876)
1996	W	0	0	0	0	894	3300	9260	5360	1780	327	16.0	8.23	1960 (511)
1997	W	0	0	0	0	1000	2490	2640	2170	886	83.5	5.54	0	961 (206)
1998	W	1.56	0	0	0	60.4	4620	7690	4990	2710	754	121	0	1820 (425)
1999	W	0	0	0	13.6	429	3100	6870	7980	2770	572	51.3	0.855	2080 (495)
2000	AN	0	5.79	0	0	4.42	7340	34400	8970	3840	445	2.24	0	4860 (1640)
2001	D	0	14.9	12.4	0	1.19	1610	3820	40900	398	64.2	4.93	1.37	21000 (6170)
2002	D	0	0	0	11.2	519	2190	2470	4180	460	212	19	1.67	19600 (5130)
2003	AN	0	0	0	0	420	5150	8430	2240	603	394	33.7	1.02	35700 (11900)
2004	BN	0	0	0	0	1078	4980	6880	6880	1670	389	13.8	0	49200 (10600)
2005	BN	0	0	0	0	181	2060	3840	3810	2530	661	114	3.19	30100 (6230)
2006	W	0	0	0	0.51	1080	2710	3860	6640	6930	585	92.3	0	2724 (640)
Yearly mean 1993-2006 (SE)		0.13 (0.13)	1.62 (1.11)	0.886 (0.886)	2.28 (1.24)	412 (115)	3570 (631)	7220 (2180)	7630 (2630)	2170 (469)	389 (59.4)	47.6 (12.6)	1.47 (0.641)	12470 (4260)
2007	D	0	0	0	0	64.8	401	5420	2860	249	275	0	0	862 (361)
2008	C	0	0	0	0	3.29	1160	1930	1390	93.5	67.2	3.31	0	430 (118)

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 mean (SE)
1993	AN	--	0	0	4.82	3.83	5.14	0	0	9.51	1.44	5.61	--	3.92 (1.47)
1994	C	--	0	0	0	6.12	6.65	0	0	0	0	0	0	1.39 (0.805)
1995	W	0	0	0	0.233	8.63	11.4	2.41	0	3.99	10.3	0	0	2.77 (1.14)
1996	W	0	0	0	0	1.79	0.612	0.882	0	2.31	17.1	0	1.39	1.77 (0.830)
1997	W	0	0	0	3.47	3.01	9.08	0	0	0	2.39	0	0	3.32 (2.40)
1998	W	0	0	0	1.50	7.79	0	0	0	73.1	13.3	7.81	0	9.38 (4.99)
1999	W	0	0	0.992	10.5	13.5	1.39	0	0	44.7	4.79	0	0	8.80 (3.82)
2000	AN	0	0	0	0	6.09	0	3.90	0	0	2.47	0	0	1.19 (0.55)
2001	D	0	0	0	0	1.39	0	0	0	3.80	0	0	0	17.5 (8.88)
2002	D	0	0	0	4.71	19.0	0	0	0	0	0	13.9	1.82	102 (36.8)
2003	AN	0	0	0	0	0	0	0	0	10.8	118	0	0	240 (146)
2004	BN	0	0	0	0	3.03	0	0	0	50.1	8.47	0	0	122 (50.6)
2005	BN	0	0	0	0	1.76	0	0	0	48.8	15.2	12.8	0	187 (62.7)
2006	W	0	0	0	1.49	4.22	0	0	0	226	25.9	1.54	1.09	37.1 (16.2)
Yearly mean 1993-2006(SE)		0 (0)	0 (0)	0.071 (0.071)	1.91 (0.816)	5.73 (1.39)	2.45 (1.05)	0.514 (0.315)	0 (0)	33.8 (16.2)	15.7 (8.14)	2.98 (1.34)	0.331 (0.179)	52.7 (21.1)
2007	D	0	0	0	0	0.339	2.60	0	0	3.92	0	0	0	0.690 (0.460)
2008	C	4.13	0	0	0	3.92	0	0	0	0	0	0	0	0.838 (0.459)

Region 5. San Joaquin River Beach Seine

Methods

San Joaquin River beach seine sampling began in 1994 to document the distribution and abundance of Chinook salmon in the San Joaquin River. Prior to 2000, sampling on the San Joaquin River was typically conducted from January to June of each year. Starting in 2000, sampling was conducted year-round. In 2007 and 2008, sampling at most of the sites was conducted once every other week from July through December and once a week from December through June of each field season.

From Mossdale (rm 56) to north of the Tuolumne River (rm 83, Figure. 4), we sampled 2-7 sites during the 2007 field season and 1-7 sites during the 2008 field season.

Spring-run salmon were extirpated from three San Joaquin River tributaries (Stanislaus, Tuolumne, and Merced Rivers) by 1930 and from the mainstem by 1947 because of dam construction (Fry 1961; Yoshivana et al. 1998). As a result, all Chinook salmon in the San Joaquin River are classified as fall-run salmon regardless of their size at a given date.

Results

We captured two fall-run salmon in region 5 during the 2007 field season, one the week of February 25 at Sturgeon Bend (rm 74) and one the week of April 25 at Big Beach (rm 63; Figure 14). Peak monthly CPUE occurred in March and was the lowest since 1994 (Table 4). In 2008, we captured two fall-run salmon in region 5, one the week of January 6 at Route 132 (rm 77) and one the week of April 4 at Mossdale (rm 56; Figure 15). Peak monthly CPUE occurred in January and was the second lowest since 1994 (Table 4).

There were no delta smelt, longfin smelt, hatchery rainbow trout or wild rainbow trout captured in region 5 beach seines in the 2007 and 2008 field seasons. There was only one splittail captured in region 5 beach seines during the 2007 field season (Figure 16a). The splittail was captured on May 31 at Route 132 during decreasing discharge in the San Joaquin River. In 2008, there were 4 splittail captured in region 5 beach seines, two at Durham Bridge (rm 72) and two at Route 132 (rm 77).

Only one striped bass was caught in 2007 region 5 beach seines (Figure 16b). The striped bass was captured at Mossdale (rm 56) on July 17. There were 73 striped bass captured in region 5 beach seines in 2008 (Figure 17b). Peak weekly CPUE occurred the week of July 13 when 29 striped bass were captured, 26 at Mossdale (rm 56) and 3 at Weatherbee (rm 58).

There were 2,427 threadfin shad captured in region 5 during the 2007 field season (Figure 17c). Peak weekly CPUE occurred the week of September 10 when 566 threadfin were captured. There were 785 threadfin shad captured in region 5 during the 2008 field season (Figure18c). Peak weekly CPUE occurred the week of October 7 when 103 threadfin shad were captured, one at Weatherbee (rm 58) and 102 at

Mossdale (rm 56).

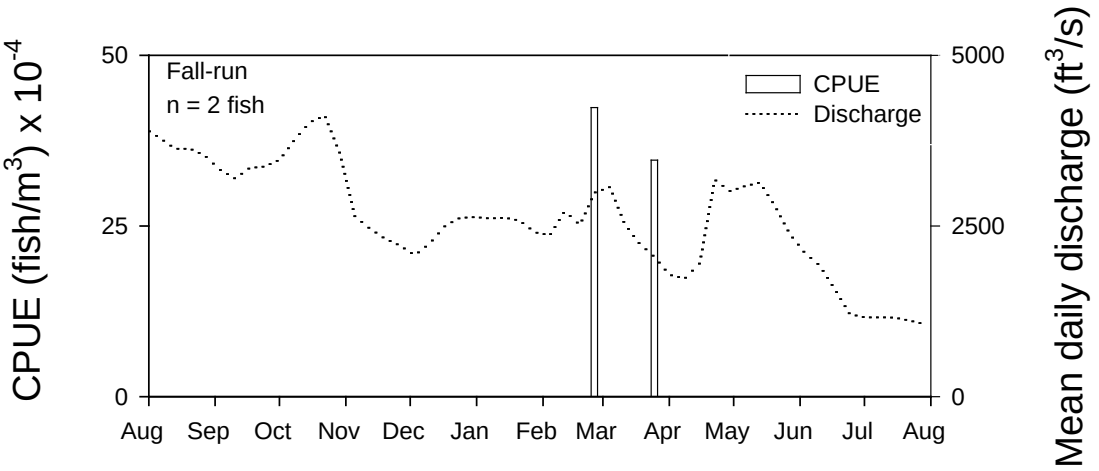


Figure 14. Catch-per-unit effort (x 10^{-4}) of fall-run Chinook salmon in beach seines and mean daily discharge in the San Joaquin River region (Region 5) during the 2007 field season. All data were averaged by week. Sample size (n) corresponds to total number of fish caught.

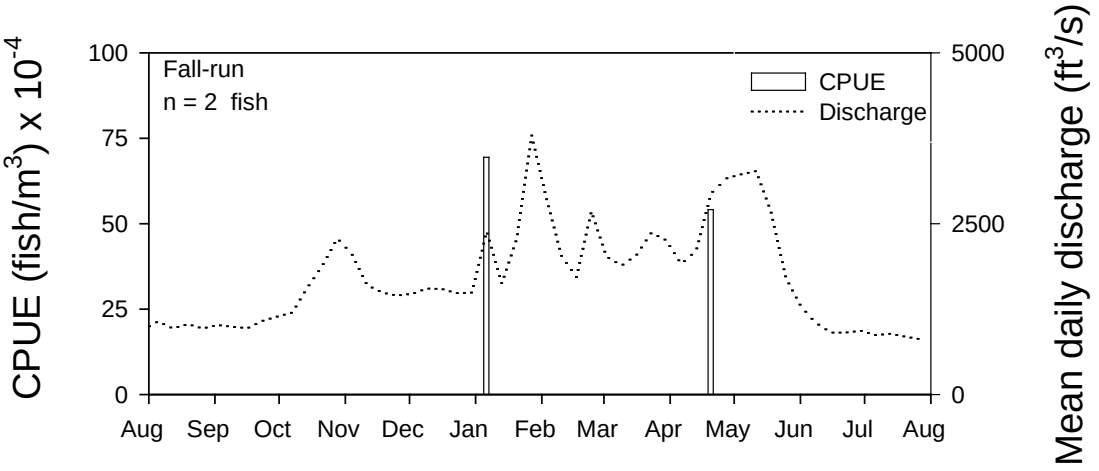


Figure 15. Catch-per-unit effort (x 10^{-4}) of fall-run Chinook salmon in beach seines and mean daily discharge in the San Joaquin River region (Region 5) during the 2008 field season. All data were averaged by week. Sample size (n) corresponds to total number of fish caught.

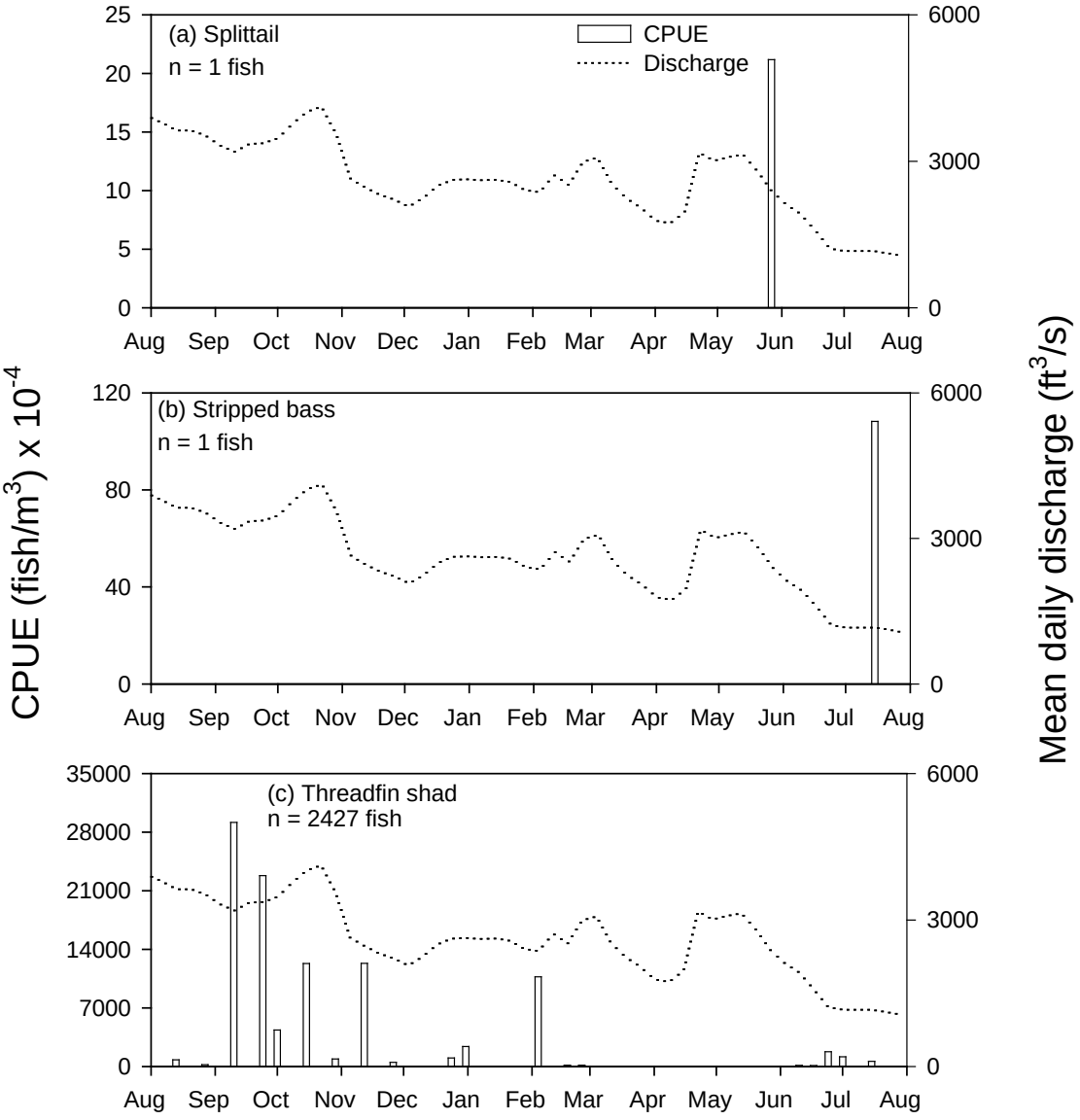


Figure 16. Catch-per-unit effort (x 10^{-4}) of (a) spilttail, (b) striped bass, and (c) threadfin shad, in beach seines and mean daily discharge in the San Joaquin River region (Region 5) during the 2007 field season. All data were averaged by week. Sample size (n) corresponds to total number of fish caught.

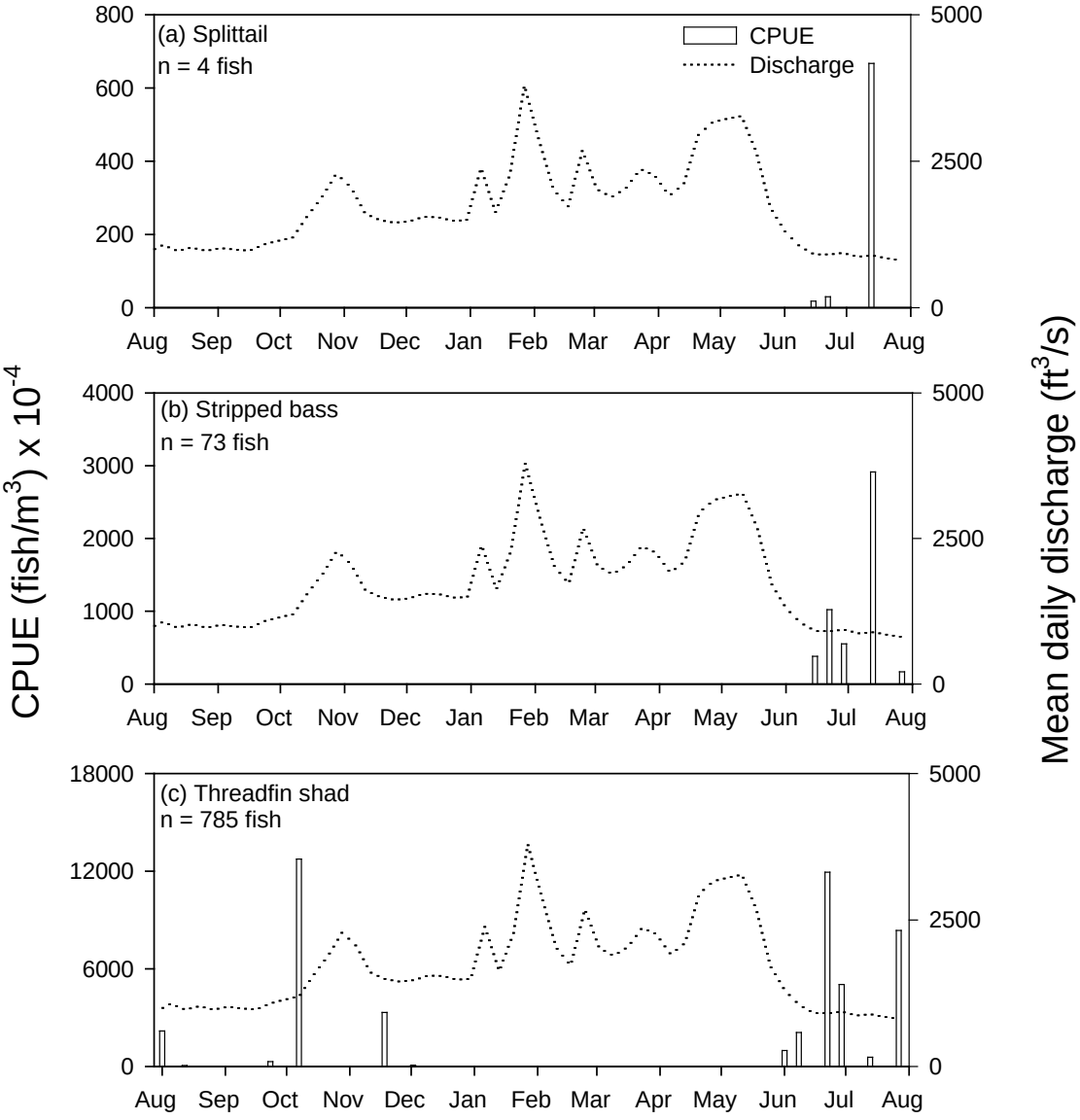


Figure 17. Catch-per-unit effort (x 10^{-4}) of (a) spilttail, (b) striped bass, and (c) threadfin shad, in beach seines and mean daily discharge in the San Joaquin River region (Region 5) during the 2008 field season. All data were averaged by week. Sample size (n) corresponds to total number of fish caught.

Table 4. Summary table of CPUE (fish/m^3 x 10^{-4}) of fall-run Chinook salmon in the San Joaquin River region (Region 5) by month and year. Yearly mean and standard error (SE) values were calculated using years as replicates (n = 7-13). Weekly mean and SE values were calculated using weeks as replicates (n = 10 - 40). Shaded boxes indicate peak monthly CPUE. Water year (CDEC, 2008): AN = above normal; BN = below normal; C = critical; D = dry; W = wet

Field Season	Water year	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Weekly mean (SE)
1994	C	--	--	--	--	--	--	--	0	453	0	0	--	189 (150)
1995	W	--	--	--	--	--	--	190	332	0	32.6	154	--	131 (44.0)
1996	W	--	--	--	--	--	0	42.1	9.08	99.8	0	0	--	287 (12.9)
1997	W	--	--	--	--	--	0	0	416	161.0	0	0	--	244 (182)
1998	W	--	--	--	--	--	899	4100	167	448	22.3	0	--	707 (210)
1999	AN	--	--	--	--	--	1650	6330	2420	753	110	19.8	--	1700 (480)
2000	AN	0	0	0	0	0	0	641	734	247	59.5	0	0	182 (53.7)
2001	D	0	0	0	0	0	0	12.1	998	39.5	24.3	0	0	647 (445)
2002	D	0	0	0	0	0	43.4	0	8.5	0	8.50	0	0	18.9 (10.8)
2003	BN	0	0	0	0	0	0	45.5	14.9	6.61	0	0	0	34.8 (18.8)
2004	D	0	0	0	0	0	0	19.8	127	8.88	0	0	0	89.5 (49.5)
2005	W	0	0	0	0	0	10.6	309	71.8	47.9	0	0	0	179 (84.3)
2006	W	0	0	0	0	50.1	101	314	859	65.7	0	0	0	202 (60.2)
Yearly mean 1994-2006 (SE)		0 (0)	0 (0)	0 (0)	0 (0)	7.16 (7.16)	246 (162)	1000 (587)	474 (189)	179 (65.1)	19.8 (9.05)	13.4 (11.8)	0 (0)	354(126)
2007	C	0	0	0	0	0	0	0	15.40	0	0	0	0	1.92 (1.35)
2008	C	0	0	0	0	0	19.8	0	0	10.8	0	0	0	3.09 (2.17)

Region 6. San Francisco/San Pablo Bays Beach Seines

Methods

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

Seining was conducted year-round for the first time by USFWS in the 2000 field season. Ten seine sites were separated into two seine routes of five sites sampled per week (Figure 4). As a result, each individual site was sampled once every two weeks. In the 2003 field season, one site was eliminated (Pt. Molate, SP000E) due to inaccessibility. Data from 2007 and 2008 are presented in biweekly increments in an attempt to include all sites in calculations. For each site, we calculated mean CPUE for multiple sampling dates, when necessary, during each two-week period. Means from each site were averaged to provide an estimate of mean CPUE of all sites during each sampling period. Sites sampled during 2007 and 2008 were a subset of those sampled by CDFG in the 1980s (Orsi 1999).

Results

We did not capture any salmon, hatchery reared rainbow trout, delta smelt, longfin smelt, or splittail in region 6 beach seines in 2007 and 2008 field seasons. In 2007, we captured one wild rainbow trout on March 28 at Berkley Frontage Road (rm 07; Figure 18a). There were no wild rainbow trout captured in region 6 beach seines in 2008.

In 2007, we captured 36 striped bass in region 6 beach seines (Figure 18b). Peak weekly CPUE occurred the week of February 25 when 12 striped bass were captured, one at McNear's Beach (rm 08) and 11 at China Camp (rm 01). There were no striped bass captured in region 6 beach seines in 2008.

We captured three threadfin shad in region 6 beach seines in 2007 (Figure 18c). Of the three threadfin shad captured, two were captured at China Camp and one at Pointe Pinole East (rm 03). We did not capture any threadfin shad in region 6 beach seines during the 2008 field season.

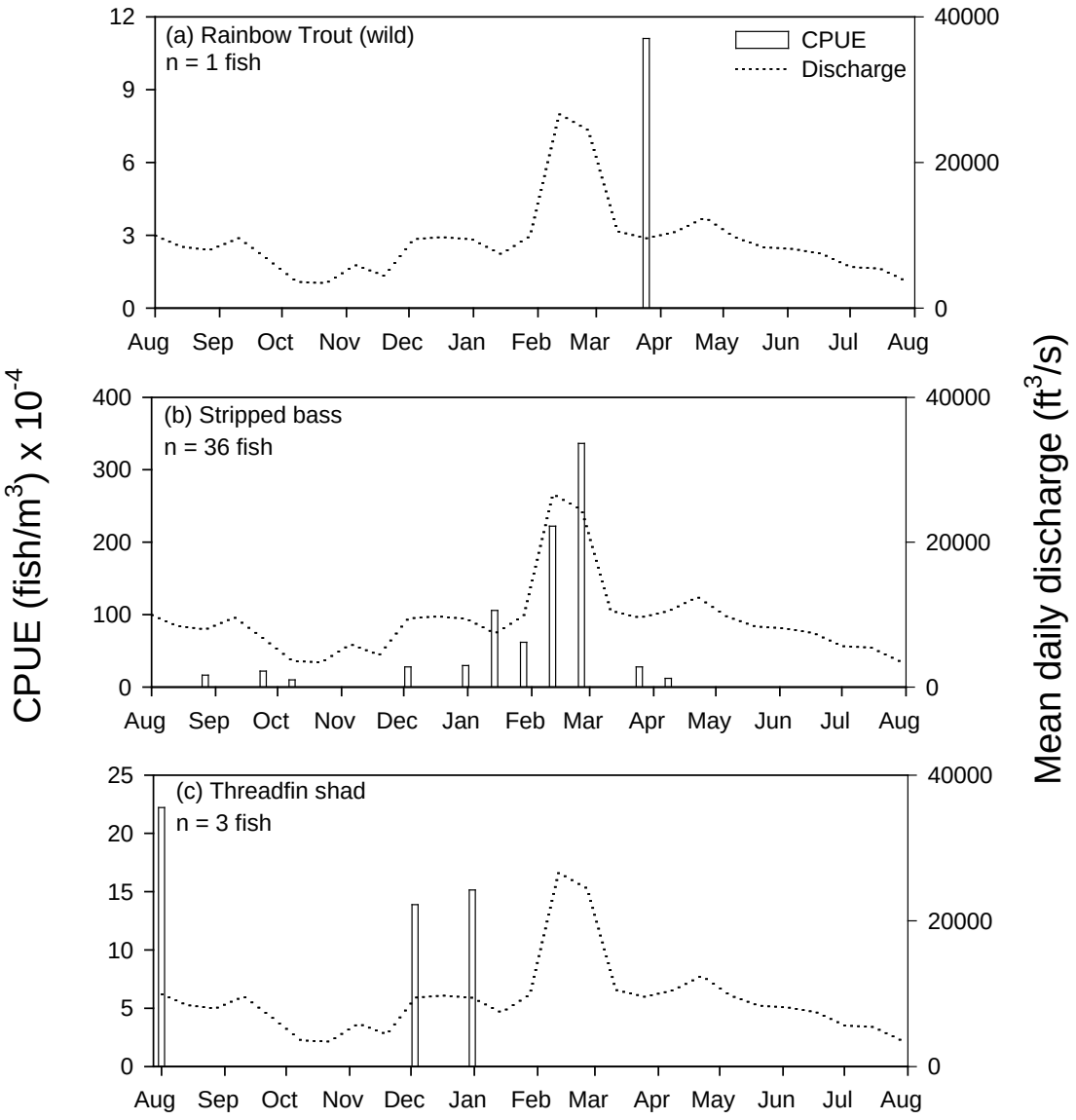


Figure 18. Catch-per-unit effort (x 10^{-4}) of (a) rainbow trout (wild), (b) striped bass, and (c) threadfin shad in beach seines in San Francisco/San Pablo Bays (Region 6) and delta discharge during the 2007 field season. All data were averaged biweekly because each site was sampled every other week. Sample size (n) corresponds to total number of fish caught.

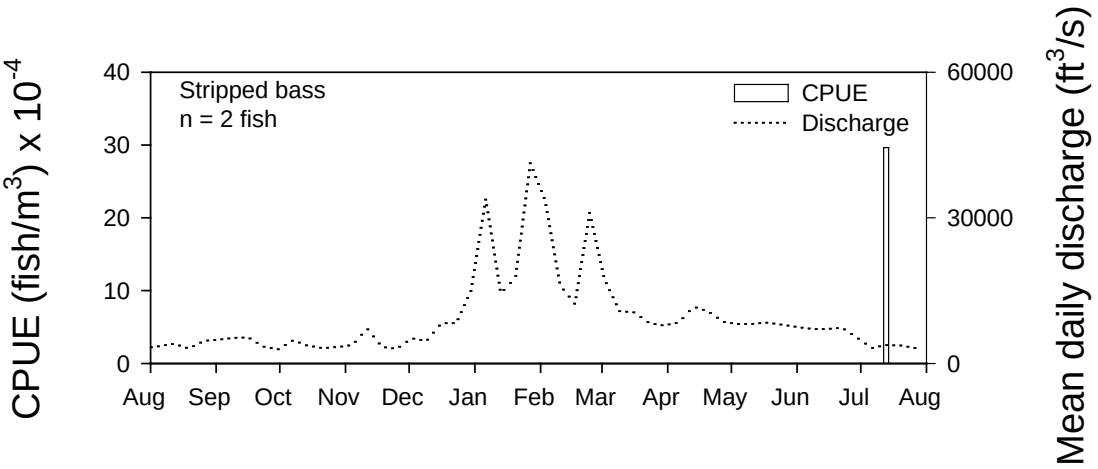


Figure 19. Catch-per-unit effort (x 10^{-4}) of striped bass in beach seines in San Francisco/San Pablo Bays (Region 6) and delta discharge during the 2008 field season. All data were averaged biweekly because each site was sampled every other week. Sample size (n) corresponds to total number of fish caught.

Table 5. Summary table of CPUE (fish/m^3) x 10^{-4} of spring-/fall-run Chinook salmon in San Francisco/San Pablo Bays (Region 6) by month and year. Yearly mean and standard error (SE) values were calculated using years as replicates (n = 6-7 for 1981-1987; n = 7-10 for 1997-2006). Weekly mean 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 1997-2006 data (n = 4-52). Calculations of SE were not possible when n = 1. Data from 1980-1986 were collected by CDF&G; data from 1997-2008 were collected by STWFO. No race other than spring-/fall-run has ever been collected in bay seines in this sampling. Shaded boxes indicate peak monthly CPUE. Water year (CDEC, 2008): AN = above normal; BN = below normal; D = dry; W = wet.

Field Season	Water year	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Weekly mean (SE)
1981	D	0	0	0	0	0	0	260	28.4	520	77.7	0	0	74.4 (41.6)
1982	W	0	0	0	0	0	24.4	206	28.6	47.4	6.31	2.72	0	27.2 (15.0)
1983	W	0	0	0	0	0	0	302	477	215	63.3	55.8	61.3	74.5 (34.7)
1984	W	0	0	0	0	0	15.3	0	0	0	0	1.86	55.8	8.71 (5.66)
1985	D	0	0	0	0	0	0	0	0	0	0	0	0	0 (0)
1986	W	0	55.6	0	0	0	43.3	768	52.4	22.9	8.65	7.44	0	57.7 (44.7)
1987	D	0	0	0	0	0	--	--	--	--	--	--	--	0 (0)
Yearly mean 1981-1987 (SE)		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)
1997	W	--	--	--	--	--	88.9	93.0	13.0	--	--	--	--	64.3 (37.0)
1998	W	--	--	--	--	--	239	385	240	--	--	--	--	280 (97.7)
1999	W	--	--	--	0	0	0	21.8	37.9	15.2	5.56	0	0	9.88 (4.95)
2000	AN	0	0	0	0	0	0	29.9	22.2	6.31	0	0	0	5.31 (3.19)
2001	D	0	0	0	0	0	0	0	0	0	40.2	0	0	33.0 (19.4)
2002	D	0	0	0	0	0	4.88	0	0	0	0	0	0	5.43 (5.43)
2003	AN	0	0	0	0	0	0	0	0	0	0	4.12	0	2.74 (2.74)
2004	BN	0	0	0	0	0	5.41	0	380	56.1	12.2	0	0	332 (188)
2005	BN	0	0	0	0	0	0	0	0	0	7.72	0	0	4.75 (4.75)
2006	W	0	0	0	0	0	279	19.1	20.6	24.5	34.2	41.2	0	34.6 (17.3)
Yearly avg 1997-2006 (SE)		0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	61.7 (34.1)	54.9 (37.8)	71.4 (41.3)	12.7 (6.96)	12.5 (5.63)	5.67 (5.10)	0 (0)	77.2 (38.8)
2007	D	0	0	0	0	0	0	0	0	0	0	0	0	0 (0)
2008	C	0	0	0	0	0	0	0	0	0	0	0	0	0 (0)

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 put forth in order to provide additional information to managers of water-project operations (i.e., Delta Cross Channel). 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 (Table 1: Figure 4). Sampling was conducted up to three times per week during October-January during the 2007 and 2008 field seasons. 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.

Results

There were 128 winter-run fry captured in the Sacramento area beach seines in the 2007 field season (Figure 20a). Peak weekly CPUE occurred the week of December 24, 2006 when 73 winter-run fry were captured. Peak monthly CPUE also occurred in December and was the fourth highest since 1995 (Table 6a). In the 2008 field season, one winter-run fry was captured at Sherwood Harbor (rm 55) on October 15 (Figure 21a). Peak monthly CPUE occurred in October and was the lowest monthly CPUE since 1995 (Table 6a).

We captured 86 winter-run yearlings in the Sacramento area beach seines in the 2007 field season (Figure 20b). Peak weekly CPUE was observed the week of December 24, 2006 when 49 winter-run yearlings were captured. Peak monthly CPUE was observed in December (Table 6b). We captured 13 winter-run yearlings in the Sacramento area beach seines in the 2008 field season (Figure 21b). Peak weekly CPUE occurred the week of January 6 when nine winter-run yearlings were captured. Peak monthly CPUE occurred in January (Table 6b). Peak weekly CPUE of winter-run yearlings coincided with peak discharge in the Sacramento River during both field seasons.

In 2007, we captured 60 spring-run fry salmon in Sacramento area beach seines (Figure20c). Peak weekly CPUE was observed the week of December 24, 2006 when 31 spring-run fry were captured. Peak monthly CPUE was observed in January (Table 6c). In 2008, we captured nine spring-run fry in Sacramento area beach seines (Figure 21c). Peak weekly CPUE was observed the week of December 23, 2007 when three spring-run fry were captured. Peak monthly CPUE peaked in January and was the second lowest since 1995. There were no spring-run yearlings captured during the 2007 and 2008 field seasons.

Consistent with previous years of Sacramento area beach seines, there were no late fall-run salmon fry captured between October and January of field seasons 2007 and 2008. There were nine late fall-run salmon yearlings captured from mid December through early January during the 2007 field season (Figure 20d). Peak weekly CPUE occurred the week of January 7, 2007. Peak monthly CPUE occurred in December (Table 6f). There were eight late fall-run salmon captured during the 2008 field season (Figure 21d). Peak weekly CPUE occurred the week of January 9 when six late fall-run salmon were captured. Peak monthly CPUE occurred in January (Table 6f).

We did not capture any rainbow trout (hatchery or wild), delta smelt, or longfin smelt, in Sacramento area beach seines in field seasons 2007 and 2008. We did not capture any splittail or striped bass in the 2007 field season. However, we did capture 2,224 threadfin shad from early October through early January of the 2007 field season (Figure 22). Peak weekly CPUE of threadfin shad occurred the week of October 22, 2006 when 274 threadfin shad were captured.

There were six splittail captured in the Sacramento area beach seines in 2008 (Figure 23a). Weekly CPUE peaked the week of January 6, coinciding with an increase in discharge in the Sacramento River. In addition, we captured one striped bass and 67 threadfin shad during the 2008 field season (Figure 23b and c). The striped bass was captured at Garcia Bend on October 19, 2007. Peak weekly CPUE of threadfin shad occurred the week of October 28, 2007 when 43 threadfin shad were captured.

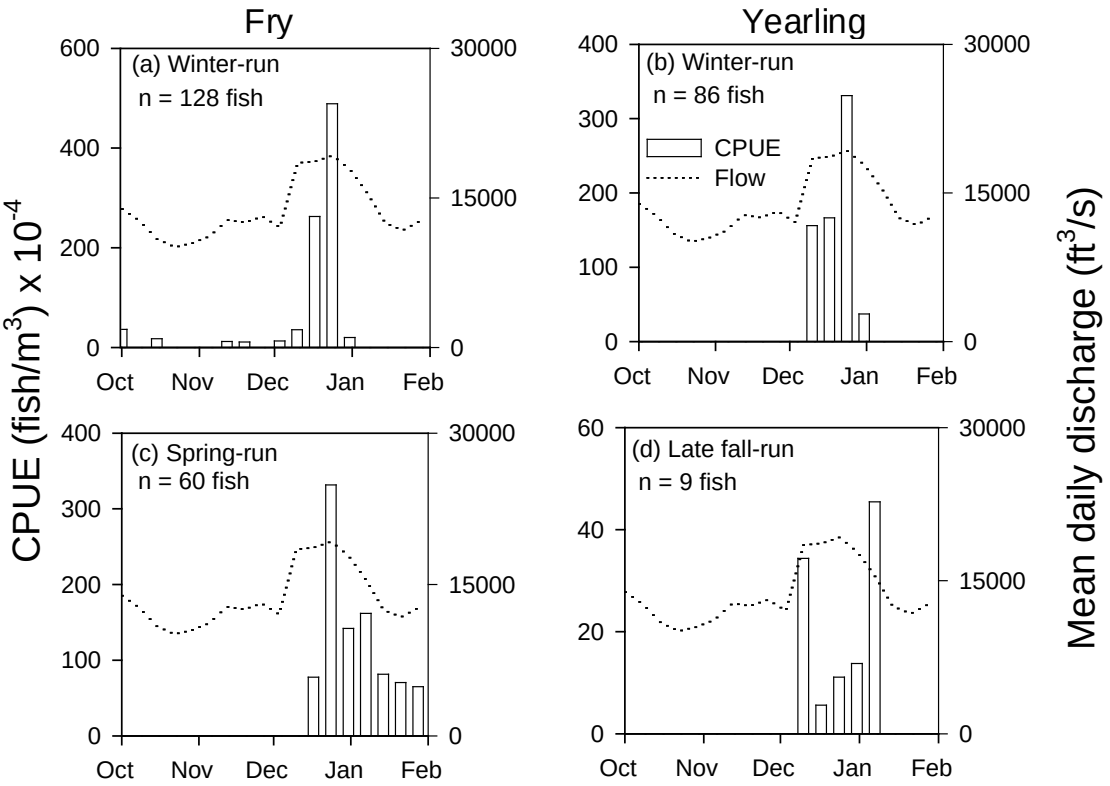


Figure 20. Catch-per-unit effort (x 10^{-4}) of fry and yearlings from winter-, spring-, and late fall-run raced salmon in Sacramento area beach seines and concurrent mean daily discharge at Freeport during the 2007 field season. All data were averaged by week. Sample size (n) corresponds to total number of fish caught.

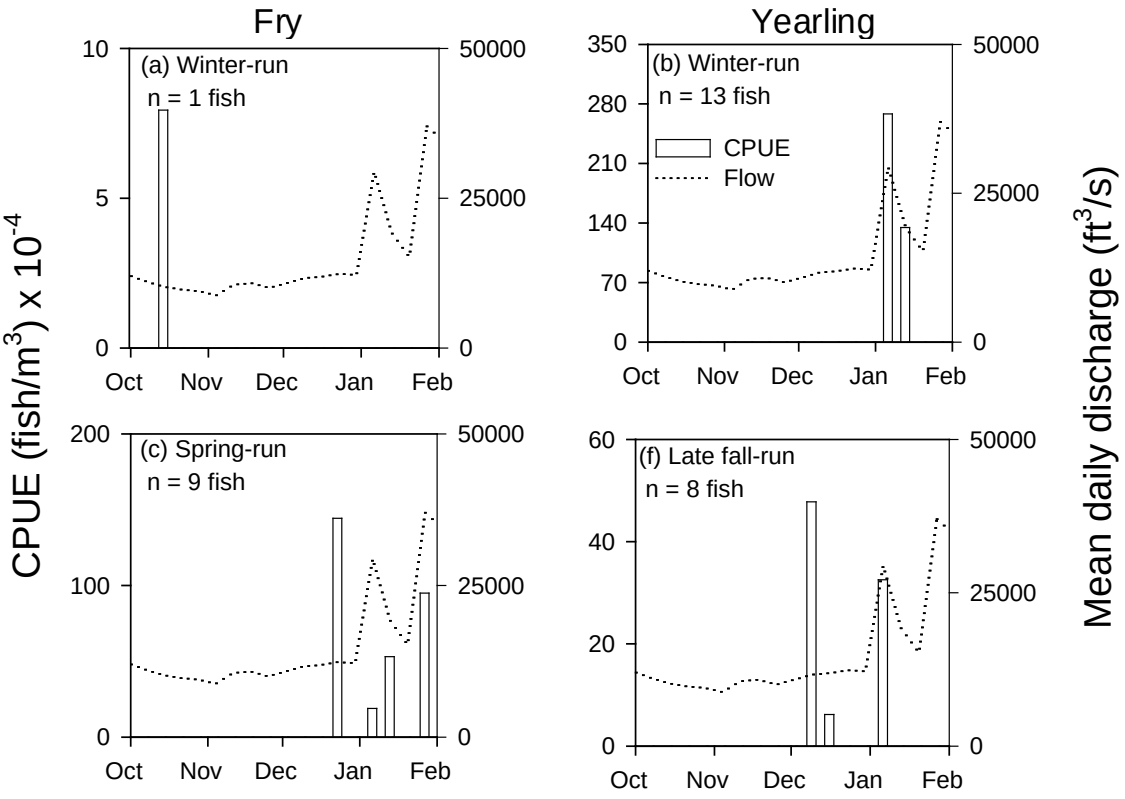


Figure 21. Catch-per-unit effort (x 10^{-4}) of fry and yearlings from winter-, spring-, and late fall-run raced salmon in Sacramento area beach seines and concurrent mean daily discharge at Freeport during the 2008 field season. All data were averaged by week. Sample size (n) corresponds to total number of fish caught.

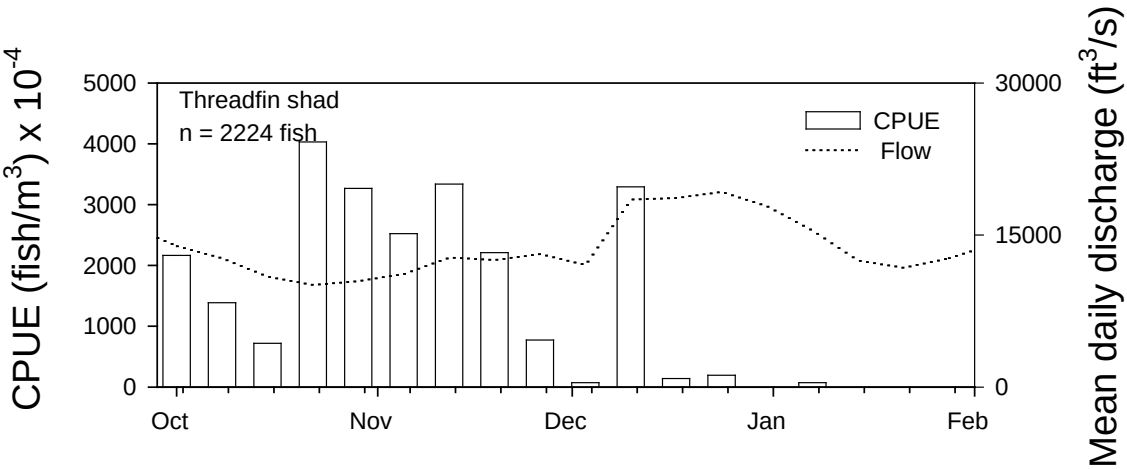


Figure 22. Catch-per-unit effort (x 10^{-4}) of threadfin shad in Sacramento area beach seines and concurrent mean daily discharge at Freeport during the 2007 field season. All data were averaged by week. Sample size (n) corresponds to total number of fish caught.

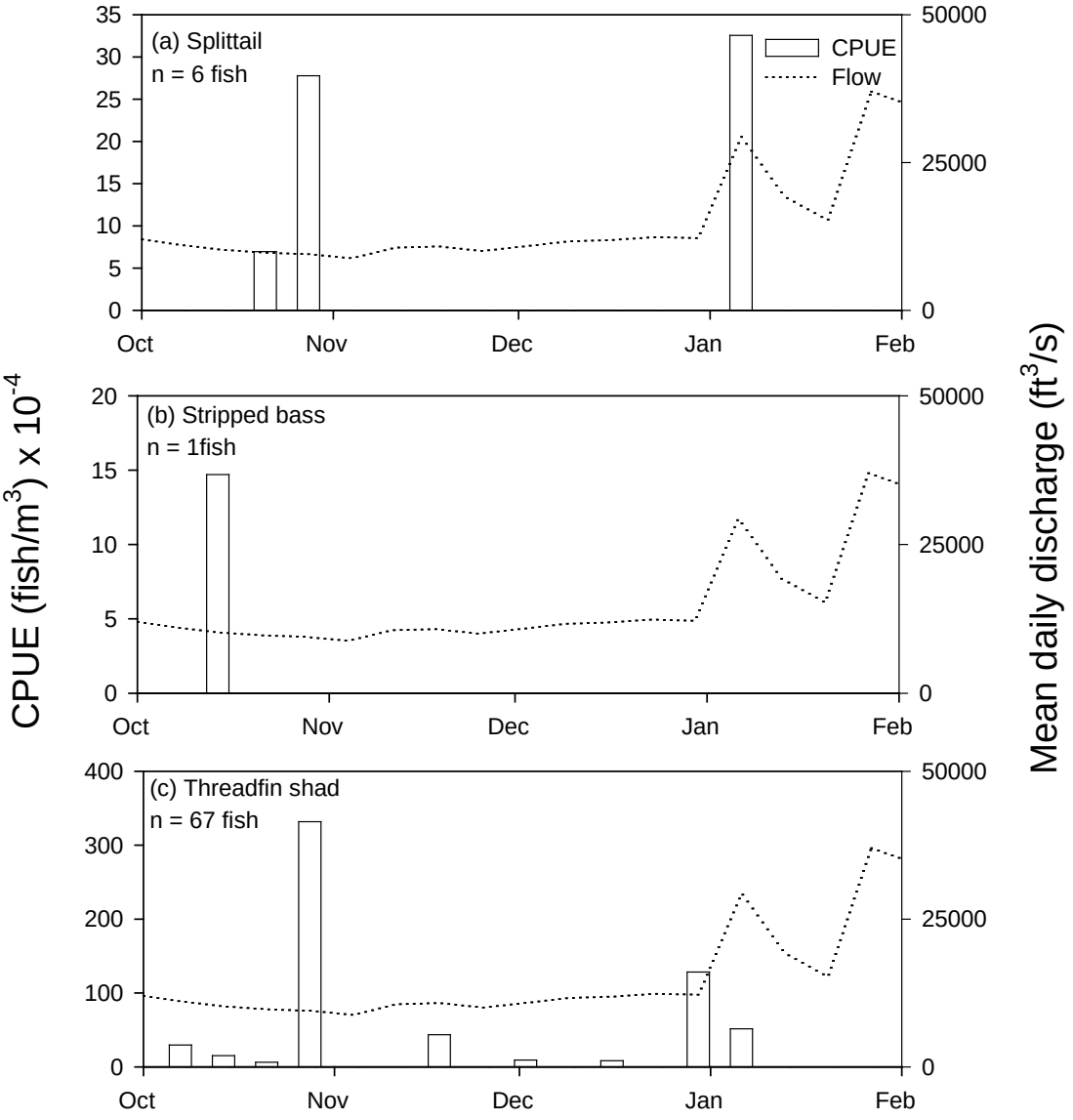


Figure 23. Catch-per-unit effort (x 10^{-4}) of (a) spilttail, and (b) striped bass, and (c) threadfin shad in Sacramento area beach seines and concurrent mean daily discharge at Freeport during the 2008 field season. All data were averaged by week. Sample size (n) corresponds to total number of fish caught.

Table 6. Summary table of CPUE (fish/m^3) x 10^{-4} of less common Chinook salmon races by age class during 1994-2006 field seasons in Sacramento area beach seines by month and year. Yearly mean and standard error (SE) values were calculated using years as replicates (n = 5-12). Weekly mean and SE values were calculated using weeks as replicates (n = 12-24). Shaded boxes indicate peak monthly CPUE. Water year (CDEC, 2006): AN = above normal; BN = below normal; D = dry; W = wet

(a) Winter-run fry

Field Season	Water year	Oct	Nov	Dec	Jan	Feb	Weekly mean (SE)
1995	W	0	0	0	2.63	0	0.752(0.752)
1996	W	0	0	49.7	2.48	0	10.9 (8.69)
1997	W	0	0	16.5	0	0	4.19 (2.91)
1998	W	0	34.8	56.2	6.39	0	17.2 (9.75)
1999	W	6.94	223	137	9.77	0	86.0 (51.7)
2000	AN	0	3.31	2.21	3.34	0	1.75 (0.972)
2001	D	4.59	7.19	0	0	0	6.36 (5.05)
2002	D	3.09	365	689	112	--	376 (176)
2003	AN	0	0	34.4	18.8	--	22.0 (9.88)
2004	BN	0	7.49	693	3.23	--	283 (192)
2005	BN	2.00	58.1	72.5	12.6	--	43.9 (15.9)
2006	W	11.1	145	423	13.7	--	121 (47.2)
Yearly mean 1995-2006 (SE)		1.51 (0.724)	63.5 (36.1)	159 (80.2)	15.6 (9.80)	0 (0)	77.5 (38.8)
2007	D	14.2	6.05	222	4.54	--	49.8 (29.5)
2008	C	1.83	0	0	0	--	0.441 (0.441)

(b) Winter-run yearlings

Field Season	Water year	Oct	Nov	Dec	Jan	Feb	Weekly mean (SE)
1995	W	0	0	2.58	57.7	12.6	19.0 (7.78)
1996	W	0	0	157	74.3	90.5	65.7 (22.3)
1997	W	0	0.886	128	8.13	17.8	44.8 (18.7)
1998	W	0	57.1	153	189	0	79.2 (28.2)
1999	W	0	169	239	96.0	177	148 (44.1)
2000	AN	0	0	4.47	92.7	28.2	22.2 (11.1)
2001	D	0	0	0	103	205	122 (64.6)
2002	D	0	59.6	174	126	--	104 (32.0)
2003	AN	0	0	90.0	89.2	--	51.9 (20.1)
2004	BN	0	3.97	519	43.7	--	207 (116)
2005	BN	0	12.1	259	264	--	175 (66.1)
2006	W	0	24.4	200	122	--	146 (55.7)
Yearly mean 1995-2006 (SE)		0 (0)	27.5 (15.7)	156 (45.3)	104 (21.2)	75.8 (31.8)	94.4 (18.9)
2007	D	0	0	195	9.92	--	38.4 (21.1)
2008	C	0	0	0	88.2	--	22.4 (16.3)

Table 6 cont.

(c) Spring-run fry

Field Season	Water year	Oct	Nov	Dec	Jan	Feb	Weekly mean (SE)
1995	W	0	0	50.7	332	756	234 (79.5)
1996	W	0	0	415	568	224	276 (77.9)
1997	W	0	0	593	1010	451	488 (130)
1998	W	0	0	335	208	0	116 (38.0)
1999	W	0	39.2	435	149	137	163 (44.4)
2000	AN	0	0	63.4	450	336	177 (52.9)
2001	D	0	0	1.58	29.4	29.8	28.1 (11.1)
2002	D	0	74.2	587	261	--	278 (74.6)
2003	AN	0	0	529	737	--	460 (148)
2004	BN	0	0	1340	293	--	622 (277)
2005	BN	0	0	716	224	--	288 (119)
2006	W	0	18.5	415	700	--	261 (87.8)
Yearly mean 1995-2006 (SE)		0 (0)	11.0 (6.71)	457 (104)	413 (82.9)	276 (100)	283 (58.4)
2007	D	0	0	98.6	100	--	51.7 (20.6)
2008	C	0	0	11.9	38.6	--	17.3 (9.51)

(d) Spring-run yearlings

Field Season	Water year	Oct	Nov	Dec	Jan	Feb	Weekly mean (SE)
1995	W	0	0	0	0	14.7	2.84 (2.00)
1996	W	0	0	0	0	8.24	2.02 (1.34)
1997	W	0	0	0	0	27.5	3.95 (3.37)
1998	W	0	0	0	0	0	0 (0)
1999	W	0	0	0	0	0	0 (0)
2000	AN	0	0	0	0	0	0 (0)
2001	D	0	0	0	0	0	0 (0)
2002	D	0	0	0	0	--	0 (0)
2003	AN	0	0	0	0	--	0 (0)
2004	BN	0	0	0	0	--	0 (0)
2005	BN	0	0	0	0	--	0 (0)
2006	W	0	0	0	0	--	0 (0)
Yearly mean 1995-2006 (SE)		0 (0)	0 (0)	0 (0)	0 (0)	7.21 (4.01)	0.734 (0.402)
2007	D	0	0	0	0	--	0
2008	C	0	0	0	0	--	0

Table 6 cont.

(e) Late fall-run fry

Field Season	Water year	Oct	Nov	Dec	Jan	Feb	Weekly mean (SE)
1995	W	0	0	0	0	0	0 (0)
1996	W	0	0	0	0	0	0 (0)
1997	W	0	0	0	0	0	0 (0)
1998	W	0	0	0	0	0	0 (0)
1999	W	0	0	0	0	0	0 (0)
2000	AN	0	0	0	0	0	0 (0)
2001	D	0	0	0	0	0	0 (0)
2002	D	0	0	0	0	--	0 (0)
2003	AN	0	0	0	0	--	0 (0)
2004	BN	0	0	0	0	--	0 (0)
2005	BN	0	0	0	0	--	0 (0)
2006	W	0	0	0	0	--	0 (0)
Yearly mean 1995-2006 (SE)		0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
2007	D	0	0	0	0	--	0 (0)
2008	C	0	0	0	0	--	0 (0)

(f) Late fall-run yearlings

Field Season	Water year	Oct	Nov	Dec	Jan	Feb	Weekly mean (SE)
1995	W	0	0.611	33.4	35.0	0	13.2 (5.20)
1996	W	0	0	22.5	4.02	3.53	6.07 (3.82)
1997	W	0	5.82	29.0	0	0	9.37 (4.83)
1998	W	0	5.24	43.2	3.38	0	9.40 (5.77)
1999	W	3.72	78.6	73.6	2.63	0	35.9 (19.3)
2000	AN	0	0	9.14	0	0	1.63 (1.31)
2001	D	0	0	8.07	6.19	0	3.19 (1.52)
2002	D	0	22.17	34.6	6.80	--	17.6 (7.06)
2003	AN	0	0	1.16	0	--	0.309 (0.309)
2004	BN	0	0	35.7	3.28	--	14.5 (7.79)
2005	BN	2.53	2.98	23.5	0	--	8.38 (4.64)
2006	W	0	7.67	9.49	0	--	3.20 (1.90)
Yearly mean 1995-2006 (SE)		0.568 (0.390)	10.5 (7.09)	28.3 (6.0)	5.57 (3.03)	0.504 (0.504)	10.9 (2.59)
2007	D	0	0	12.8	11.4	--	6.13 (3.09)
2008	C	0	0	19.6	6.8	--	4.8 (3.11)

Trawls

Methods

Midwater Trawls

Midwater trawls (MWTR) are conducted to estimate relative abundance of fishes using 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 in the top few meters of the water column.

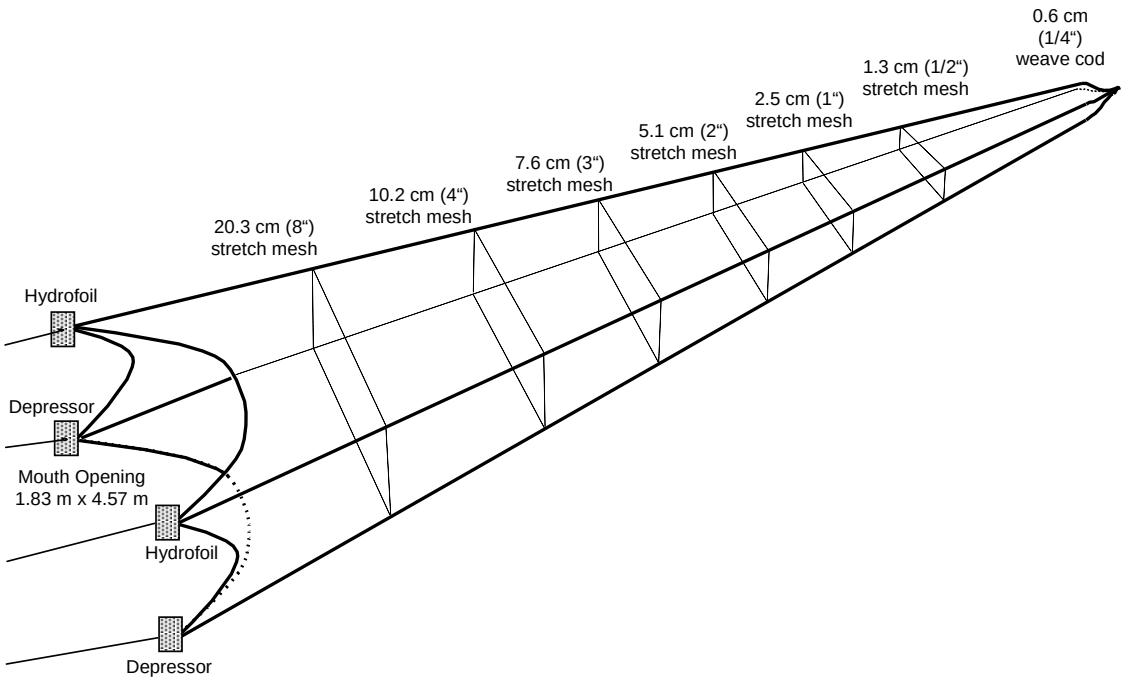
The MWTR net used at Sacramento is composed of six panels, each decreasing in mesh size towards the cod end (Figure 24). Mesh size ranges from 20.3 cm (8") stretch at the mouth to 1.3 cm (½") stretch just before the cod end. The cod end is composed of 0.7 cm (1/8") weave mesh. Fully extended mouth size is 1.83 x 4.57 m (6' x 15'). Depressors are made of 0.7 cm (¼") stainless steel (one on each side of the net lead line) and attach to the net with shackles to spread the bottom line of the mouth. Hydrofoils are made of 0.7 cm (¼") aluminum plates with split floats (one on each side of the net float line) and attach to the net with shackles to spread the top of the net at the surface. 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 31 m (100') behind the boat. Actual fishing dimensions of the net vary with environmental conditions (USFWS 1993).

A larger MWTR net is used at Chipps Island (Figure 25). 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 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 mean 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 mechanical flow meter (General Oceanics, Model #2030, Miami, Florida). This measure of distance is not related to distance traveled relative to land, since boat distance traveled can be affected by river discharge rate and direction.



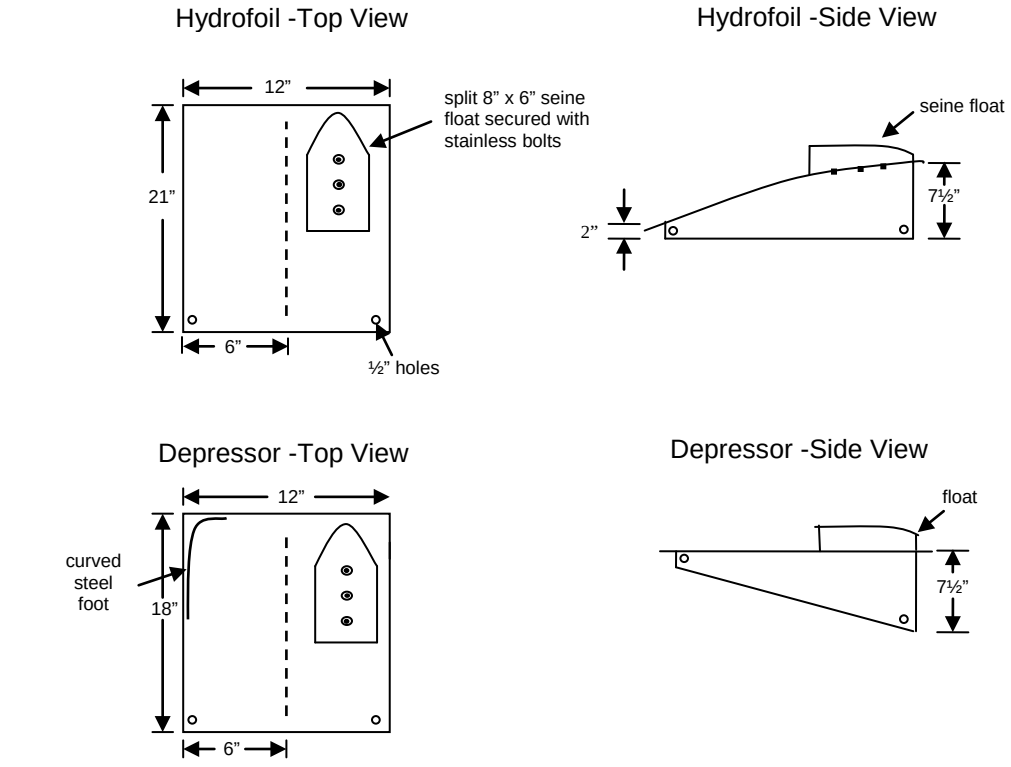


Figure 24. Schematic drawing of midwater trawl net (top), and hydrofoils and depressors (bottom) used at Sacramento during 2007 and 2008 field seasons.

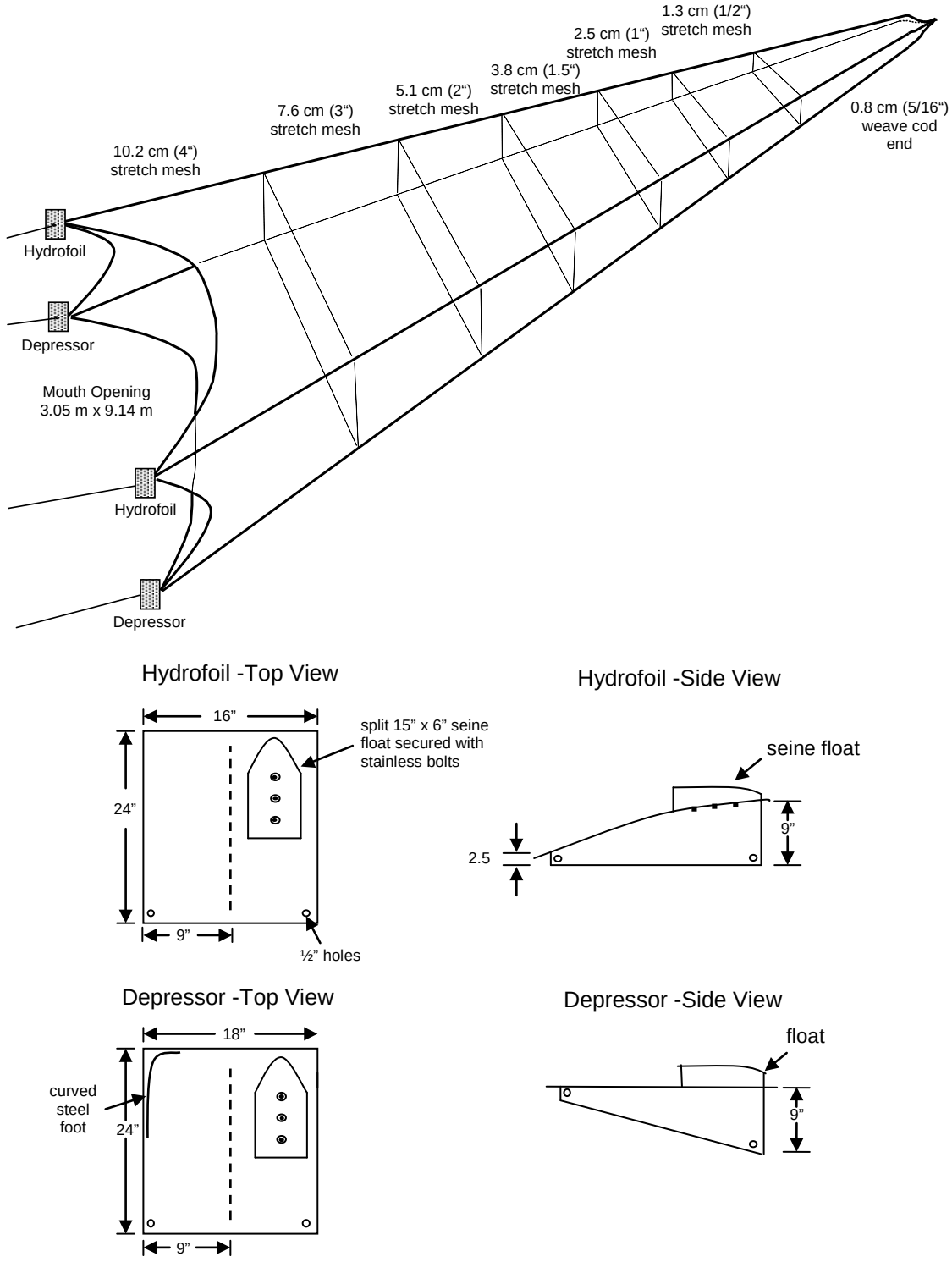


Figure 25. Schematic drawing of midwater trawl net (top) and hydrofoils and depressors (bottom) used at Chipps Island during 2007 and 2008 field seasons.

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, allowing for larger volumes of water to be sampled. Nets were made of variable mesh with a fully expanded mouth opening of 1.83 x 7.62 m (6 x 25'; Figure 26). 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 (108') 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. The field crew on the other boat retrieves the live box from the cod end of the net and removes fish for processing. Calculations of CPUE for the KDTR employ the same equation as the MWTR (Equation 2), with a mean net mouth area of 12.54 m^2 (USFWS 1993).

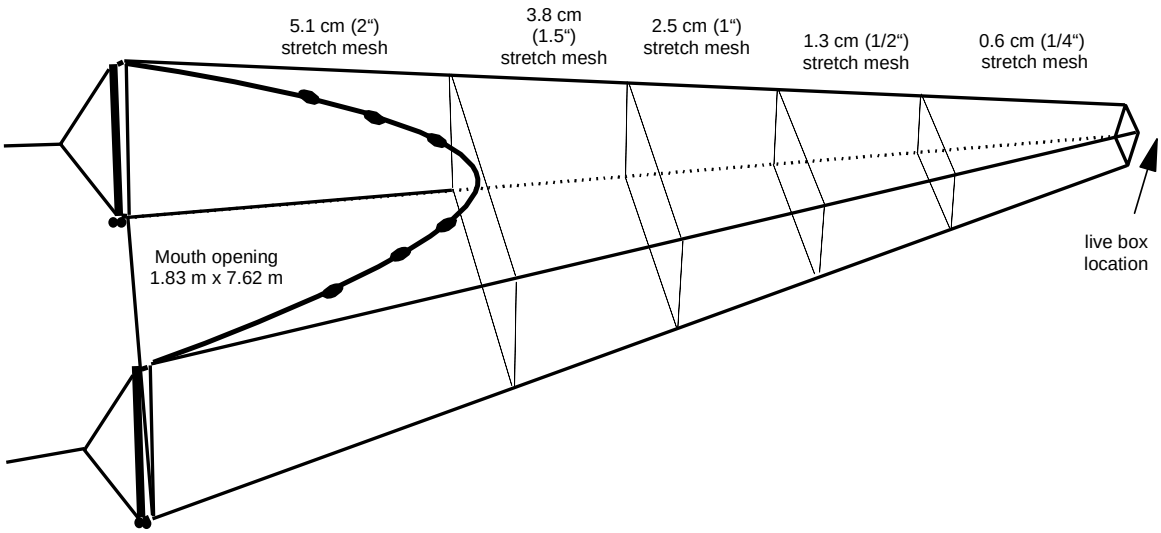


Figure 26. Schematic drawing of Kodiak trawl net used at Sacramento during 2007 and 2008 field seasons.

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, 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 multiplied by 10^{-4} for ease of viewing and plotted against discharge data 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 (not statistically) to historical monthly mean CPUE.

Sacramento Trawls

Methods

Data from midwater and Kodiak trawls have been used to estimate the relative 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 were usually conducted from October through March and midwater trawls were conducted the remainder of the year. During periods of high flow when large debris moves downstream, midwater trawls were used in place of Kodiak trawls for safety reasons due to their smaller size and better maneuverability.

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

We captured 95 winter-run salmon in Sacramento trawls between November and March of the 2007 field season (Figure 27a). Peak daily CPUE occurred on February 12, 2007, coinciding with peak discharge in the Sacramento River. Consistent with the past four years, peak monthly CPUE was observed in December (Table 7a). We captured 32 winter-run salmon in Sacramento trawls between January and March of the 2008 field season (Figure 28a). Peak daily CPUE occurred on January 9, 2008 during a period of increasing discharge in the Sacramento River. Peak monthly CPUE occurred in January for the first time since 1995 (Table 7a). All winter-run salmon captured in 2007 and 2008 field seasons were captured while Kodiak trawling.

During the 2007 field season, 4,932 spring/fall-run salmon were captured in Sacramento trawls, 2,733 in MWTR and 2,199 in KDTR (Figure 27b). Peak daily CPUE occurred on May 1, 2007 during a period of decreasing discharge in the Sacramento River. Peak monthly CPUE was observed in May and was the second lowest peak monthly average since 1993 (Table 7b). During the 2008 field season in Sacramento trawls, 1,740 spring/fall-run salmon were captured, 532 in MWTR and 1,208 in KDTR (Figure 28b). Peak daily CPUE occurred on May 8, 2008 during a period of decreasing discharge in the Sacramento River. Peak monthly CPUE was observed in May and was the lowest peak monthly average since 1993 (Table 7b).

In field season 2007, 17 late fall-run salmon were captured in Sacramento trawls, 15 in MWTR and 2 in KDTR (Figure 27c). There were five late fall yearlings from the 2007 brood year and 12 late fall fry from 2008 brood year. Peak daily CPUE occurred on July 23, 2007, during a period of increasing discharge. Peak monthly CPUE was observed in July for the first time since 1993 (Table 7c). In field season 2008, one late fall-run salmon was captured in Sacramento trawls. (Figure 28c). The late-fall run salmon was captured on January 12, 2008 during a KDTR and was a yearling from the 2007 brood year.

There were three wild rainbow trout caught in Sacramento trawls during the 2007 field season, two in MWTR and one KDTR (Figure 29a). Peak daily CPUE occurred on June 12, 2007 during a period of increasing discharge. Only one wild rainbow trout was captured in the 2008 field season (Figure 30a). The wild trout was captured on January 11, 2008 during a KDTR.

We captured 39 hatchery rainbow trout in Sacramento trawls during the 2007 field season, 34 in KDTR and 5 in MWTR (Figure 29b). Peak daily CPUE occurred on February 16, 2007, three days after peak discharge in the Sacramento River. We captured 55 hatchery rainbow trout in Sacramento trawls during the 2008 field season, 55 in KDTR and none in the MWTR (Figure 30b). Peak daily CPUE occurred on February 15, 2008, two weeks after peak discharge on the Sacramento River.

There were no delta smelt captured in Sacramento trawls during the 2007 field season. We captured two delta smelt during the 2008 field season, one in a MWTR and one in

KDTR (Figure 30c). Both smelt were captured after peak discharge in the Sacramento River.

We captured five splittail in Sacramento trawls during the 2007 field season, two in MWTR and three in KDTR (Figure 29c). Peak daily CPUE occurred on August 14. We captured two splittail in the Sacramento trawls in the 2008 field season both were captured in KDTR. (Figure 30d)

Only five striped bass were captured in Sacramento trawls in the 2007 field season, four in MWTR and one KDTR (Figure 29d). All five striped bass were captured during decreasing discharge in the Sacramento River. We did not capture striped bass in the Sacramento trawls during the 2008 field season.

There were 563 threadfin shad captured in Sacramento trawls during the 2007 field season, 30 in MWTR and 533 in KDTR (Figure 29e). Peak daily CPUE occurred on December 29, 2006 during a period of increasing discharge in the Sacramento River. There were 183 threadfin shad captured in Sacramento trawls during the 2008 field season, five in MWTR and 178 in KDTR (Figure 30e). Peak daily CPUE occurred on January 9, 2008 during a period of increasing discharge in the Sacramento River.

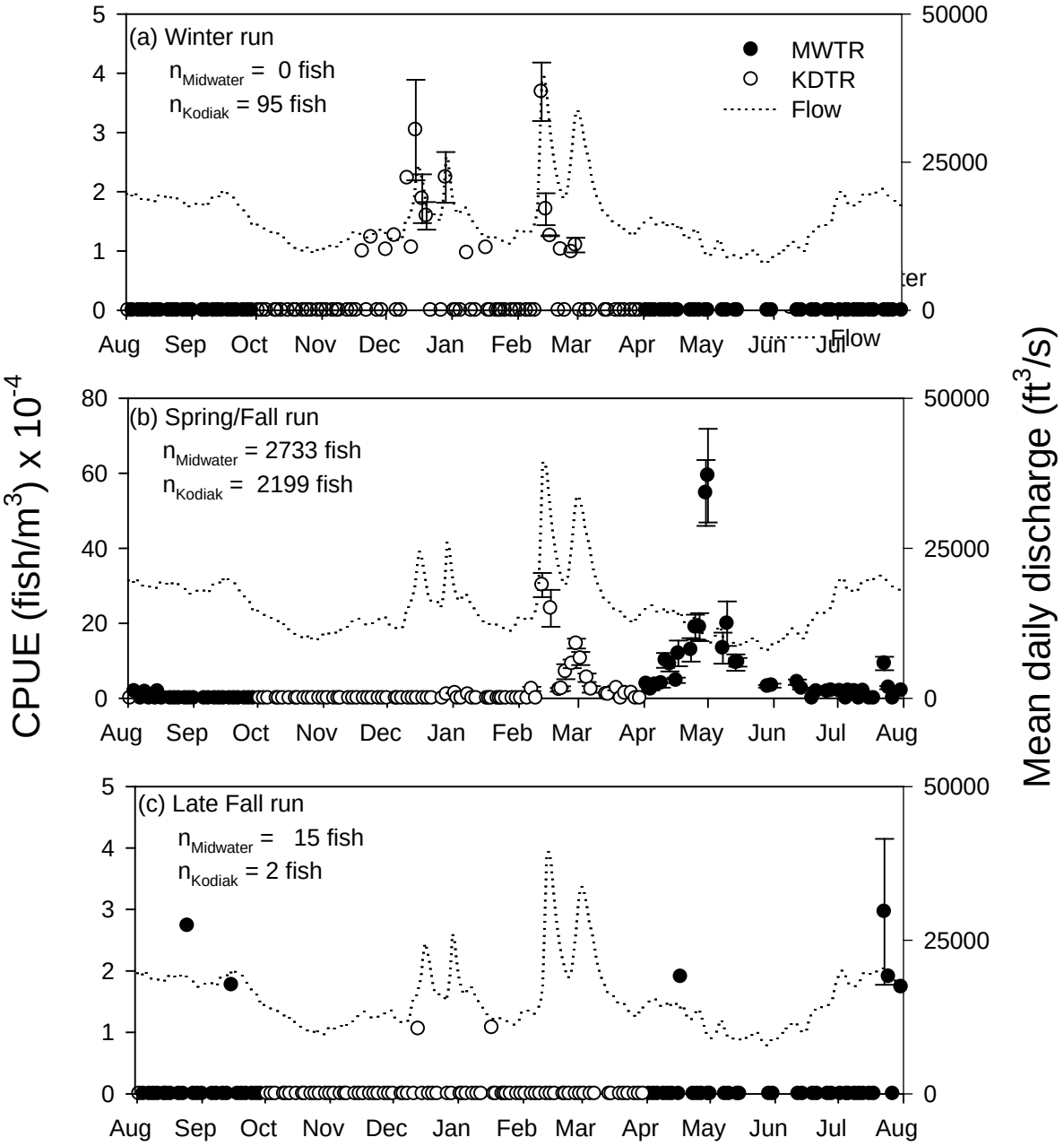


Figure 27. Mean-daily-catch per unit effort (x 10^{-4}) of (a) winter-, (b) spring/fall-, and (c) late fall-run Chinook salmon in trawls at Sherwood Harbor (Sacramento trawls) and concurrent mean daily discharge at Freeport, Sacramento River during the 2007 field season. Sample size (n) corresponds to total number of fish caught. Error bars are ± 1 SE.

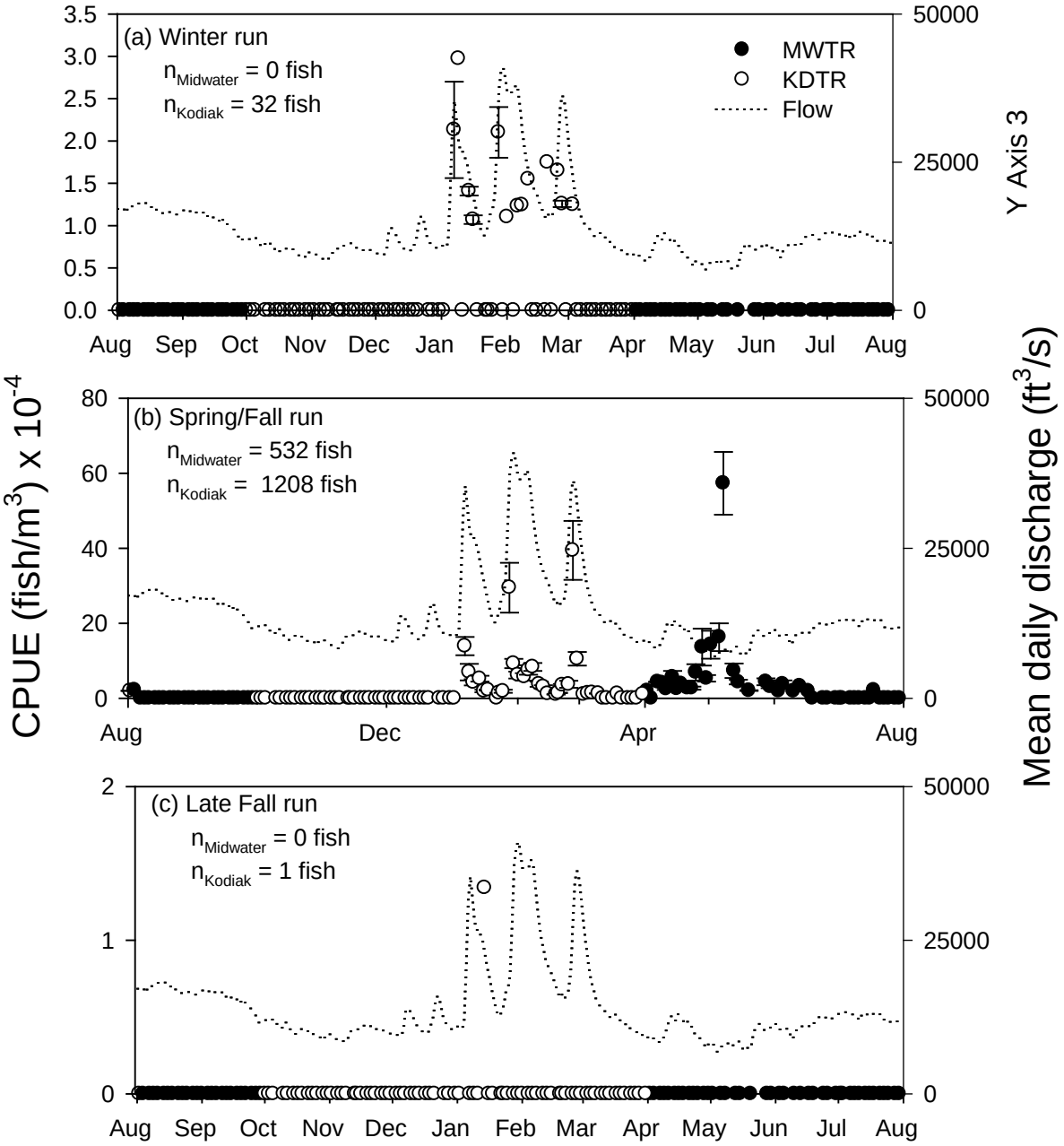


Figure 28. Mean-daily-catch per unit effort (x 10^{-4}) of (a) winter-, (b) spring/fall-, and (c) late fall-run Chinook salmon in trawls at Sherwood Harbor (Sacramento trawls) and concurrent mean daily discharge at Freeport, Sacramento River during the 2008 field season. Sample size (n) corresponds to total number of fish caught. Error bars are ± 1 SE.

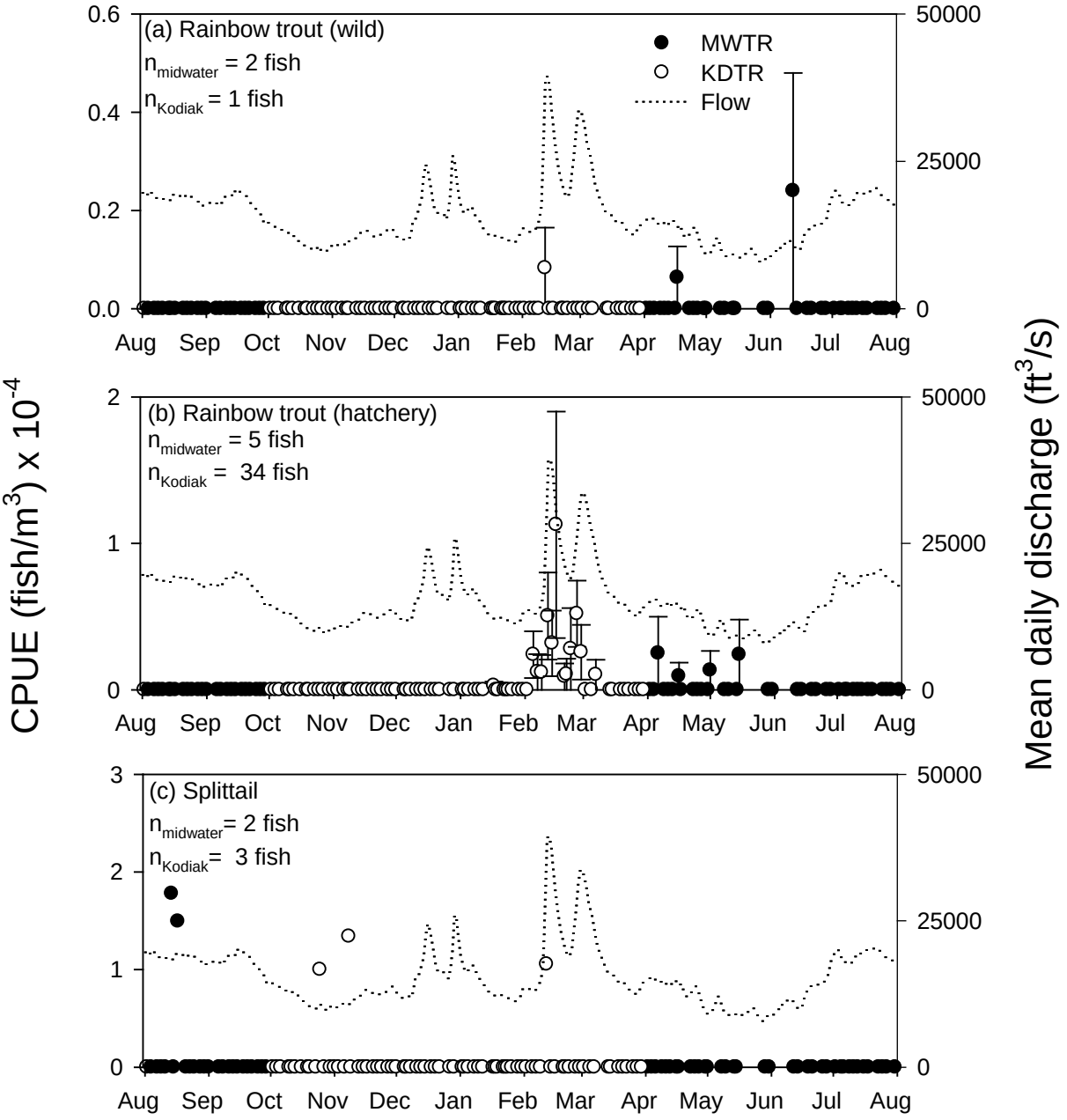
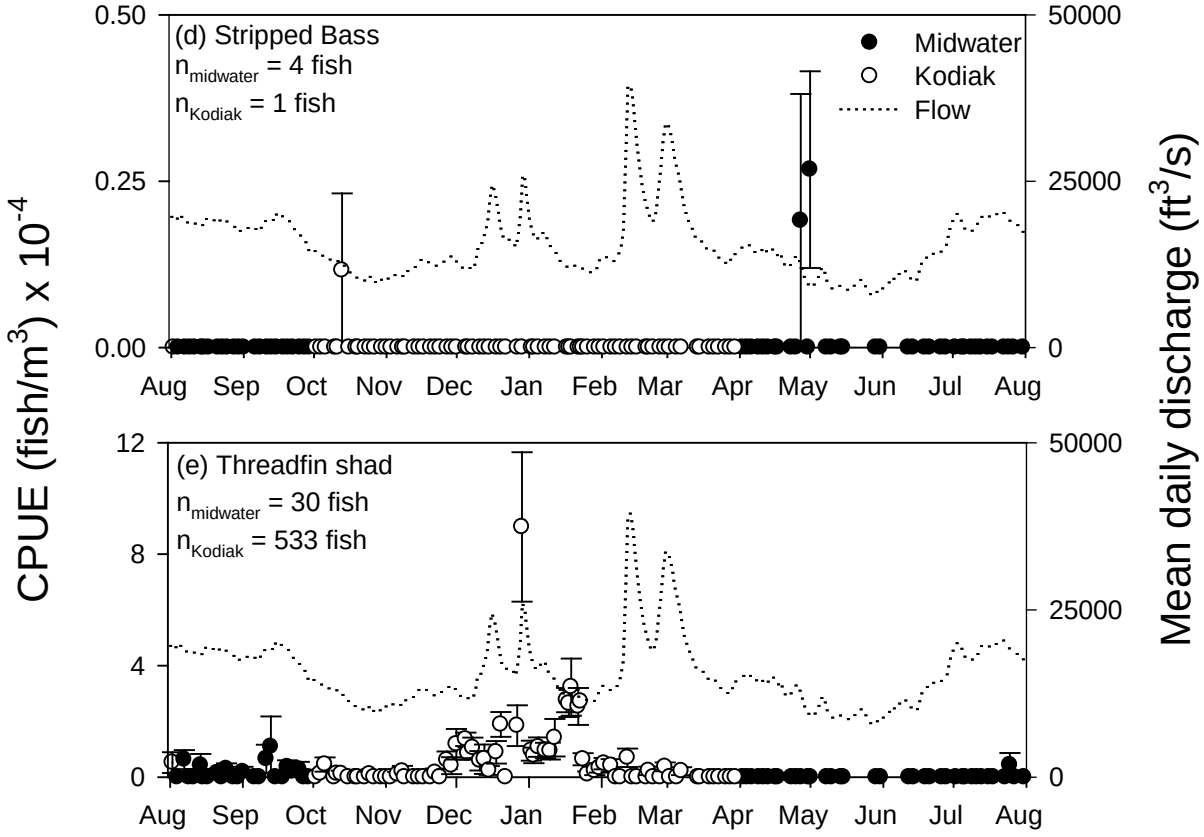


Figure 29. Mean daily catch per unit effort (x 10^{-4}) of (a) rainbow trout (wild), (b) rainbow trout (hatchery), (c) splittail, (d) striped bass and (e) threadfin shad in trawls at Sherwood Harbor (Sacramento trawls) and concurrent mean daily discharge at Freeport, Sacramento River during the 2007 field season. Sample size (n) corresponds to total number of fish caught. Error bars are ± 1 SE.

Figure 29 cont.



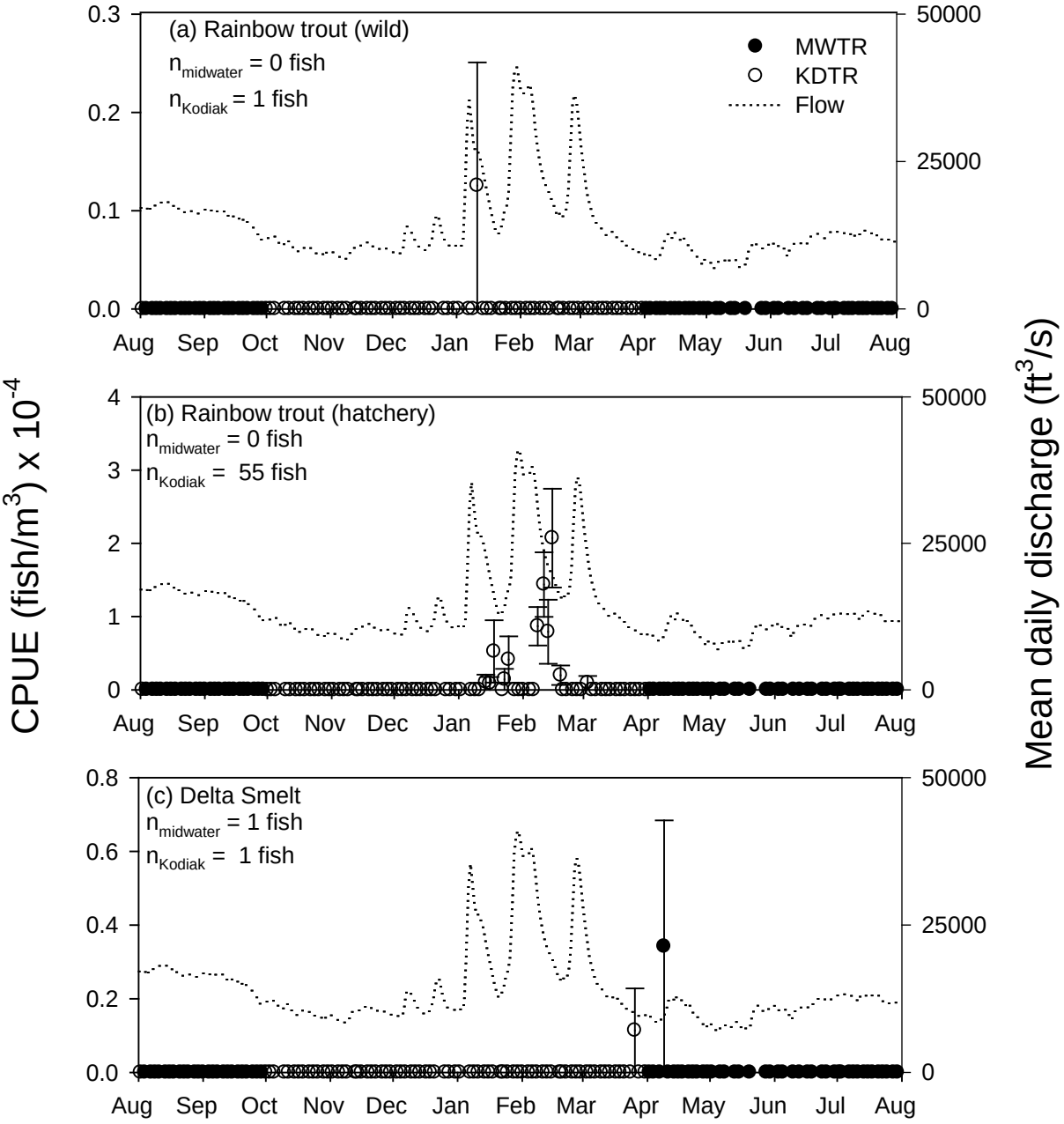


Figure 30. Mean daily catch per unit effort (x 10^{-4}) of (a) rainbow trout (wild), (b) rainbow trout (hatchery), (c) delta smelt, (d) splittail and (e) threadfin shad in trawls at Sherwood Harbor (Sacramento trawls) and concurrent mean daily discharge at Freeport, Sacramento River during the 2008 field season. Sample size (n) corresponds to total number of fish caught. Error bars are ± 1 SE.

Figure 30 cont.

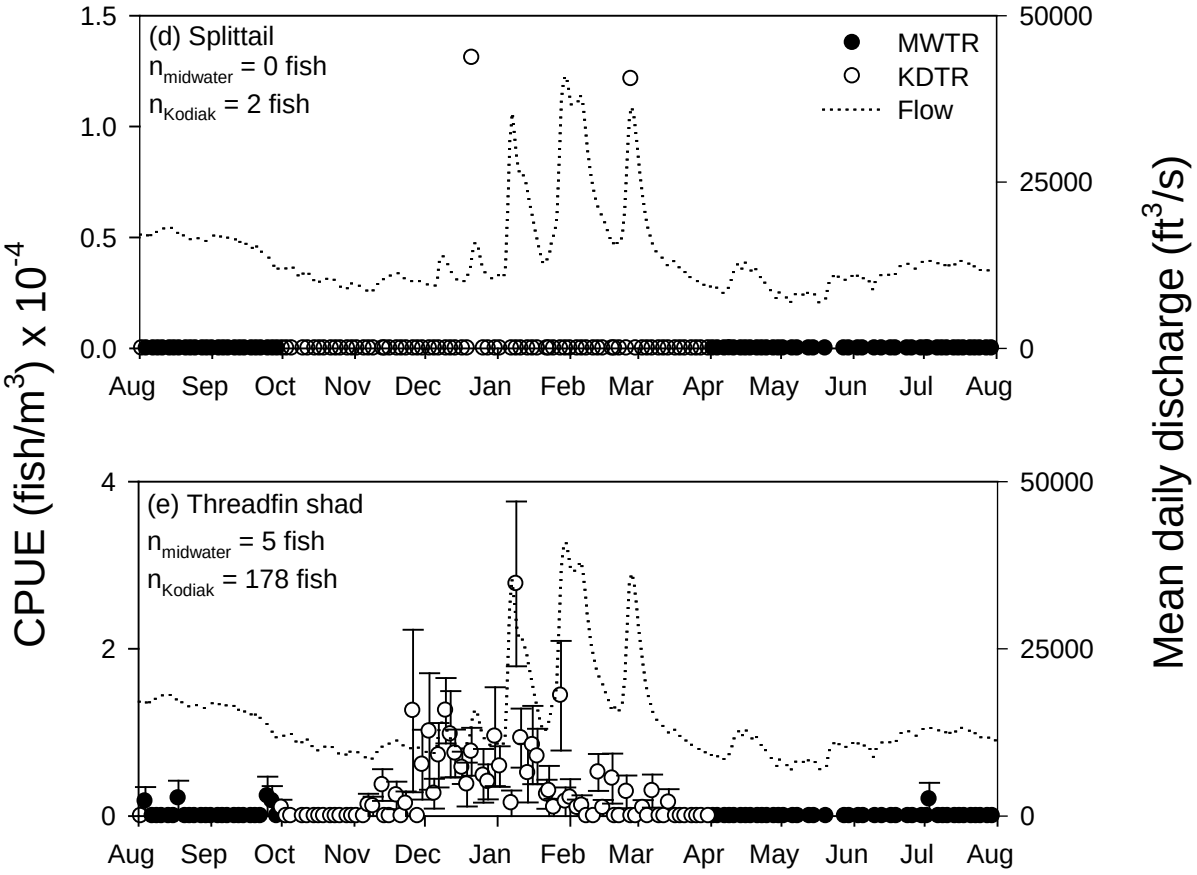


Table 7. Summary table of CPUE (fish/m^3) x 10^{-4} of (a) winter-, (b) fall/spring-run, and (c) late fall-run Chinook salmon in midwater and Kodiak trawls at Sherwood Harbor (Sacramento trawls) by month and year. Yearly mean and standard error (SE) values were calculated using years as replicates (n = 3-14 for MWTR, n = 10-12 for KDTR). Weekly mean and SE values were calculated using weeks as replicates (n = 20-42 for MWTR, n = 16-29 for KDTR). Shaded boxes indicate peak monthly CPUE. Water year (CDEC, 2006): AN = above normal; BN = below normal; C = critical; D = dry; W = wet

(a) Winter-run

Field Season	Water year	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Weekly mean (SE)
1993 MWTR	AN	--	0	0	0	0.0462	0.112	0.178	0.650	0.366	0	0	--	0.1435 (0.0519)
1994 MWTR	C	--	0	0	0	0	0	0.107	0.0238	0.0536	0	0	--	0.0193 (0.0189)
1995 MWTR	W	--	0	0	0	0	--	--	0.274	0.281	0	0	0	0.0543 (0.0394)
1995 KDTR	W	--	--	0	0	0.0259	0.0328	0.268	0.892	0.344	--	--	--	0.269 (0.0367)
1996 MWTR	W	0	0	0	--	--	--	--	--	0.0132	0	0	0	0.00212 (0.00333)
1996 KDTR	W	--	--	0	0	0.239	0.137	0.201	0.769	0.0604	--	--	--	0.249 (0.0107)
1997 MWTR	W	0	0	0	--	--	0	0.0407	0	0.0181	0	0	0	0.00472 (0.00412)
1997 KDTR	W	--	--	0	0.0105	0.0456	0	0.200	0.144	--	--	--	--	0.0536 (0.0130)
1998 MWTR	W	0	0	0	--	--	--	--	0	0.0743	0	0	--	0.0130 (0.0101)
1998 KDTR	W	--	0	0	0.0678	0.0807	0.0189	0.125	0	--	--	--	--	0.0831 (0.0204)
1999 MWTR	W	--	--	--	--	0.532	--	--	0.109	0.00843	0	0	0	0.0317 (0.00567)
1999 KDTR	W	--	0	0.0157	0.475	0.145	0.0463	0.0313	0.106	--	--	--	--	0.124 (0.0142)
2000 MWTR	AN	0	0	0	--	--	--	--	0.164	0	0	0	0	0.00630 (0.00630)
2000 KDTR	AN	--	--	0	0	0	0.147	0.218	0.206	--	--	--	--	0.102 (0.0386)
2001 MWTR	D	0	0	--	--	--	--	--	0	0.0228	0	0	0	0.0105 (0.0105)
2001 KDTR	D	--	--	0	0	0	0.069	0.519	0.133	--	--	--	--	0.136 (0.0674)
2002 MWTR	D	0	0.0222	--	--	--	--	--	0	0.0138	0	0	0	0.0541 (0.0313)
2002 KDTR	D	--	--	0	0.587	0.314	0.0194	0.187	0	--	--	--	--	0.167 (0.0719)
2003 MWTR	AN	0	0	--	--	--	--	--	--	0.0658	0	0	0	0.0317 (0.0187)
2003 KDTR	AN	--	0	0	0.0107	0.341	0.104	0.183	0.186	--	--	--	--	0.154 (0.0669)
2004 MWTR	BN	0	0	--	--	--	--	0.419	0.0769	0	0	0	0	0.0689 (0.0545)
2004 KDTR	BN	--	--	0	0	0.701	0.142	0.0491	0.0804	--	--	--	--	0.177 (0.110)
2005 MWTR	AN	0	0	--	--	--	--	--	--	0.0124	0	0	0	0.00689 (0.00689)
2005 KDTR	AN	--	--	0	0.0515	0.291	0.192	0.136	0.0602	--	--	--	--	0.116 (0.0453)
2006 MWTR	W	0	0	--	--	--	--	--	--	0.0641	0	0	0	0.00974 (0.00573)
2006 KDTR	W	--	--	0	0.247	0.455	0.0302	0.169	0.271	--	--	--	--	0.1889 (0.108)
Yearly mean 1993-2006 MWTR (SE)		0 (0)	0.00171 (0.00171)	0 (0)	0 (0)	0.145 (0.130)	0.0373 (0.0373)	0.186 (0.0825)	0.130 (0.0645)	0.0710 (0.0297)	0 (0)	0 (0)	0 (0)	0.0344 (0.0109)
Yearly mean 1995-2006 KDTR (SE)		--	0 (0)	0.00131 (0.00131)	0.121 (0.0592)	0.220 (0.0619)	0.0782 (0.0183)	0.191 (0.0357)	0.237 (0.0836)	0.202 (0.142)	--	--	--	0.148 (0.0198)
2007 MWTR	D	0	0	--	--	--	--	--	--	0	0	0	0	0 (0)
2007 KDTR	D	--	--	0	0.171	1.19	0.135	0.813	0	--	--	--	--	0.378 (0.124)
2008 MWTR	C	0	0	--	--	--	--	--	--	0	0	0	0	0 (0)
2008 KDTR	C	--	--	0	0	0	0.807	0.752	0.096	--	--	--	--	0.256 (0.0873)

Table 7 cont.

(b) Spring-/Fall-run

Field Season	Water year	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Weekly mean (SE)
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)
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)
1995 MWTR	W	--	0	0	0	0.0861	--	--	18.0	18.1	13.6	4.06	0.293	5.87 (1.74)
1995 KDTR	W	--	--	--	--	0	12.4	8.17	58.80	9.43	--	--	--	14.5 (4.33)
1996 MWTR	W	0.0834	0	0	--	--	--	--	--	31.4	30.8	1.47	0.204	8.96 (3.47)
1996 KDTR	W	--	--	0	0	2.52	32.5	172	18.2	51.2	--	--	--	36.7 (17.2)
1997 MWTR	W	0	0	0	--	--	2.48	0.913	1.67	56.6	13.2	0.881	0.598	9.35 (4.12)
1997 KDTR	W	--	--	0	0.00964	1.22	20.4	4.23	3.33	--	--	--	--	2.27 (0.982)
1998 MWTR	W	0.167	0	0	--	--	--	--	7.35	25.9	19.3	8.77	--	10.0 (3.06)
1998 KDTR	W	--	--	0	0.0129	0.309	72.6	53.0	12.2	--	--	--	--	28.8 (13.1)
1999 MWTR	W	--	--	--	--	0	--	--	5.46	32.8	52.6	2.07	0.140	17.9 (6.88)
1999 KDTR	W	--	0	0	0.0167	0.145	14.5	35.4	4.57	--	--	--	--	8.02 (3.02)
2000 MWTR	AN	0.0643	0	0	--	--	--	--	17.5	55.8	12.2	0.321	0.0212	9.38 (5.23)
2000 KDTR	AN	--	--	0	0	0	12.3	18.6	4.72	--	--	--	--	6.18 (2.06)
2001 MWTR	D	0	0	--	--	--	--	--	0.251	23.5	29.9	0.803	0.930	22.8 (11.8)
2001 KDTR	D	--	--	0	0	0	3.28	40.8	7.01	--	--	--	--	9.34 (4.58)
2002 MWTR	D	0.0605	0.0469	--	--	--	--	--	1.35	33.2	17.0	0.957	0.203	22.1 (14.3)
2002KDTR	D	--	--	0	0.0256	0.857	4.43	14.4	3.66	--	--	--	--	4.02 (1.90)
2003 MWTR	AN	0	0	--	--	--	--	--	--	48.2	6.25	0.573	0.0455	25.7 (15.1)
2003 KDTR	AN	--	0	0	0	2.90	10.1	10.1	6.15	--	--	--	--	5.06 (1.59)
2004 MWTR	BN	0.0302	0	--	--	--	--	57.8	25.5	83.3	21.0	0.601	0.0508	50.2 (27.3)
2004 KDTR	BN	--	--	0	0	9.50	7.83	22.1	11.8	--	--	--	--	6.80 (2.23)
2005 MWTR	AN	0.0358	0.032	--	--	--	--	--	--	21	49.1	0.939	0.129	28.4 (12.8)
2005 KDTR	AN	--	--	0	0	0.572	1.96	4.44	6.94	--	--	--	--	2.29 (0.762)
2006 MWTR	W	0.0113	0	--	--	--	--	--	--	6.59	35.0	2.09	0.459	6.99 (1.82)
2006 KDTR	W	--	--	0	0	1.52	2.88	3.59	4.34	--	--	--	--	2.19 (0.548)
Yearly mean 1993-2006 MWTR (SE)		0.0503 (0.0176)	0.0116 (0.00528)	0 (0)	0.0163 (0.0128)	0.109 (0.0553)	2.30 (0.253)	18.8 (13.3)	8.02 (2.85)	41.5 (6.65)	27.8 (4.34)	2.39 (0.744)	0.279 (0.0844)	18.4 (3.33)
Yearly mean 1995-2006 KDTR (SE)		--	0 (0)	0 (0)	0.00540 (0.00272)	1.63 (0.769)	16.3 (5.70)	32.2 (13.5)	11.8 (4.50)	30.3 (20.9)	--	--	--	11.3 (3.40)
2007 MWTR	D	0.414	0	--	--	--	--	--	--	12.9	16.9	2.08	1.82	5.59 (2.35)
2007 KDTR	D	--	--	0	0	0.081	0.158	18.3	2.36	--	--	--	--	3.26 (2.33)
2008 MWTR	C	0.320	0	--	--	--	--	--	--	4.32	13.6	1.42	0.165	3.02 (2.35)
2008 KDTR	C	--	--	0	0	0	1.26	1.26	0.0002	--	--	--	--	2.24 (0.890)

Table 7 cont.

(c) Late fall-run

		Previous season brood year								Current season brood year				
Field Season	Water year	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Weekly mean (SE)
1993 MWTR	AN	--	0	0	0.591	0.101	0.00721	0.00749	0	0.0200	0	0	--	0.0706 (0.0520)
1994 MWTR	C	--	0.173	0.183	0.00654	0.0550	0.0138	0.0281	0	0	0	0	--	0.0399 (0.0189)
1995 MWTR	W	--	0	0	0.0121	0.446	--	--	0	0	0	0	0.0134	0.0528 (0.0394)
1995 KDTR	W	--	--	--	--	0.0484	0.0897	0	0	0	--	--	--	0.0539 (0.0889)
1996 MWTR	W	0.0132	0.0157	0	--	--	--	--	--	0.00660	0	0	0	0.00564 (0.00329)
1996 KDTR	W	--	--	0	0	0.0697	0.0423	0	0	0	--	--	--	0.0206 (0.0742)
1997 MWTR	W	0	0	0	--	--	0.0958	0	0	0	0	0	0	0.00412 (0.00412)
1997 KDTR	W	--	--	0	0.0374	0.0526	0.150	0.0139	0	--	--	--	--	0.0272 (0.0190)
1998 MWTR	W	0.0823	0.0578	0.0560	--	--	--	--	0	0.0161	0	0.0140	--	0.0368 (0.0101)
1998 KDTR	W	--	--	0	0.108	0.0431	0	0	0	0	--	--	--	0.0283 (0.0281)
1999 MWTR	W	--	--	--	--	0.107	--	--	0	0.0150	0	0	0	0.00866 (0.00566)
1999 KDTR	W	--	0	0.00737	0.134	0.0640	0	0	0	--	--	--	--	0.0309 (0.0668)
2000 MWTR	AN	0.0312	0.0231	0	--	--	--	--	0	0	0	0	0	0.00677 (0.00492)
2000 KDTR	AN	--	--	0	0.00807	0.00583	0.00724	0	0	--	--	--	--	0.00373 (0.00213)
2001 MWTR	D	0	0.0231	--	--	--	--	--	0	0	0	0	0	0.00801 (0.00801)
2001 KDTR	D	--	--	0	0	0.0539	0.0351	0	0	--	--	--	--	0.0153 (0.00771)
2002 MWTR	D	0.0231	0.0449	--	--	--	--	--	0	0	0	0	0	0.0277 (0.0156)
2002 KDTR	D	--	--	0	0.197	0.0569	0.0101	0	0	--	--	--	--	0.0362 (0.0265)
2003 MWTR	AN	0.0163	0.043	--	--	--	--	--	--	0.0323	0.0475	0	0	0.0541(0.0313)
2003 KDTR	AN	--	0	0	0	0.206	0	0	0	--	--	--	--	0.0458 (0.0401)
2004 MWTR	BN	0	0	--	--	--	--	0	0	0	0	0	0	0(0)
2004 KDTR	BN	--	--	0	0	0.0353	0	0	0	--	--	--	--	0.00631 (0.00486)
2005 MWTR	AN	0	0	--	--	--	--	--	--	0	0.162	0	0	0.0541 (0.0455)
2005 KDTR	AN	--	--	0.00931	0	0.0500	0.00816	0	0	--	--	--	--	0.0102 (0.00560)
2006 MWTR	W	0.0117	0	--	--	--	--	--	--	0.0153	0	0	0.0124	0.00609 (0.00609)
2006 KDTR	W	--	--	0	0	0.0253	0	0	0	--	--	--	--	0.00337 (0.00337)
Yearly mean 1993-2006 MWTR (SE)		0.0178 (0.00886)	0.0293 (0.0132)	0.0341 (0.0260)	0.203 (0.194)	0.177 (0.0903)	0.0390 (0.0285)	0.00890 (0.00664)	0 (0)	0.00752 (0.00279)	0.0150 (0.0118)	0.001 (0.001)	0.00235 (0.00158)	0.0331 (0.00711)
Yearly mean 1995-2006 KDTR (SE)		--	0 (0)	0.00152 (0.00103)	0.0440 (0.0210)	0.0593 (0.0142)	0.0286 (0.0135)	0.00116 (0.00116)	0 (0)	0 (0)	--	--	--	0.0253 (0.00484)
2007 MWTR	D	0.21	0.147	--	--	--	--	--	--	0.159	0	0	0.551	0.233 (0.103)
2007 KDTR	D	--	--	0	0	0.0881	0.0718	0	0	--	--	--	--	0.0274 (0.0190)
2008 MWTR	C	0	0	--	--	--	--	--	--	0	0	0	0	0 (0)
2008 KDTR	C	--	--	0	0	0	0.112	0	0	--	--	--	--	0.0165 (0.0165)

Kodiak Trawl at Mossdale

Methods

Kodiak trawling at Mossdale has been conducted since the 1997 field season to document juvenile salmon moving into the Delta from the San Joaquin River and tributaries. All San Joaquin River Chinook salmon captured in the Kodiak trawl are classified as fall-run. Although we attempt to sample year-round, this is rarely possible because of low flows on the San Joaquin River. This is usually an issue during late summer and fall months before significant rainfall has occurred. Region 4 of CDFG has sampled at Mossdale in place of the DJFMP during spring months (April, May and June) since 1989 (San Joaquin River Group Authority, 2005).

Results

We captured 3,797 fall run-salmon in Mossdale trawls in the 2007 field season (Figure 31). Peak daily CPUE occurred on April 23, 2007, during a period of increasing discharge in the San Joaquin River. Peak monthly CPUE occurred in April and was the second highest monthly peak since 1997 (Table 8). We capture 1,696 fall run-salmon in Mossdale trawls in the 2008 field season (Figure 32). Peak daily CPUE occurred on May 16, 2007, during a period of increasing discharge in the San Joaquin River. Peak monthly CPUE occurred in May and was the third highest monthly peak since 1997 (Table 8).

There were 41 wild rainbow trout captured in Mossdale trawls during the 2007 field season (Figure 33a). Daily CPUE peaked on April 16 when three wild rainbow trout were captured. There were not any hatchery-reared rainbow trout captured in Mossdale trawls during the 2007 field season. There were four wild rainbow trout captured in Mossdale trawls during the 2008 field season (Figure 34a). Peak daily CPUE occurred on May 29, 2008. There was one hatchery-reared rainbow trout captured in Mossdale trawls during the 2008 field season (Figure 35b). The hatchery-reared rainbow trout was captured on March 5, 2008.

On July 3, 2007, we captured one delta smelt while trawling in the San Joaquin River at Mossdale (Figure 33b). There were no other delta smelt captured while trawling at Mossdale during the 2007 or 2008 field season.

In the 2007 field season, we captured 83 splittail in trawls at Mossdale (Figure 33c). Daily CPUE peaked on Juuly13, 2007 during a period of decreasing discharge in the San Joaquin River. No splittail were captured while trawling at Mossdale during the 2008 field season.

We captured 373 striped bass in KDTR at Mossdale during the 2007 field season (Figure 33d). Peaked daily CPUE occurred on July 2, 2008, when 76 striped bass were captured. We captured 872 striped bass in KDTR at Mossdale during the 2008 field season (Figure 34d). Peaked daily CPUE occurred on July 2, 2008, when 456 striped

bass were captured. Most striped bass captured in 2007 and 2008 field seasons occurred during periods of decreasing discharge in the San Joaquin River.

There were 1,575 threadfin shad captured in Mossdale trawls during the 2007 field season (Figure 33e). Peak daily CPUE occurred on November 29, 2006 when 245 threadfin shad were captured. There were 4,180 threadfin shad captured in Mossdale trawls during the 2008 field season (Figure 34d). Peak daily CPUE occurred on June 23, 2008 when 636 threadfin shad were captured.

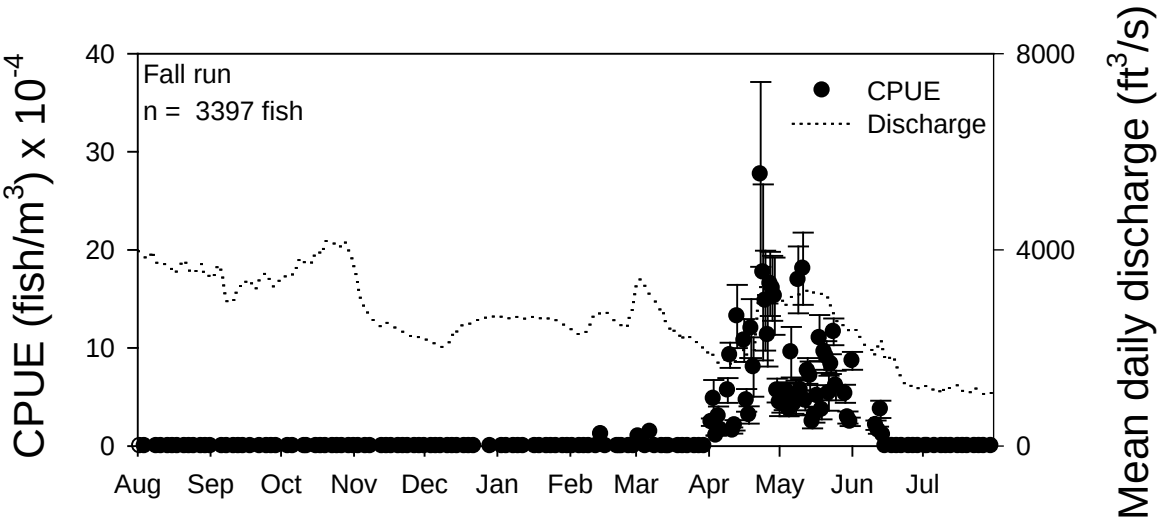


Figure 31. Mean daily catch-per-unit effort (x 10^{-4}) of fall-run Chinook salmon juveniles in Kodiak trawls at Mossdale, San Joaquin River and concurrent mean daily discharge at Vernalis during the 2007 field season. Sample size (n) corresponds to total number of fish caught. Error bars are ± 1 SE.

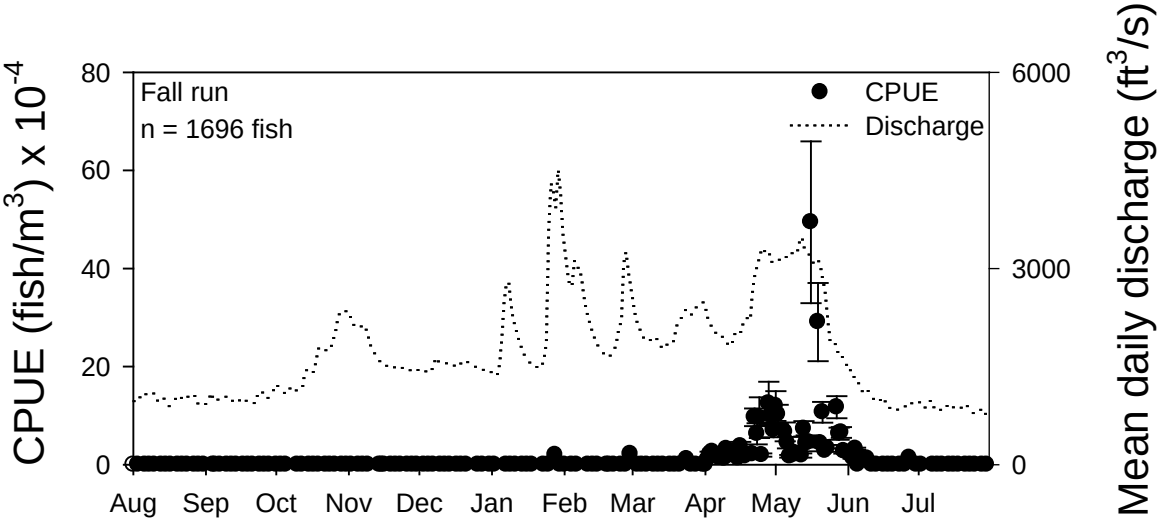


Figure 32. Mean daily catch-per-unit effort (x 10^{-4}) of fall-run Chinook salmon juveniles in Kodiak trawls at Mossdale, San Joaquin River and concurrent mean daily discharge at Vernalis during the 2008 field season. Sample size (n) corresponds to total number of fish caught. Error bars are ± 1 SE.

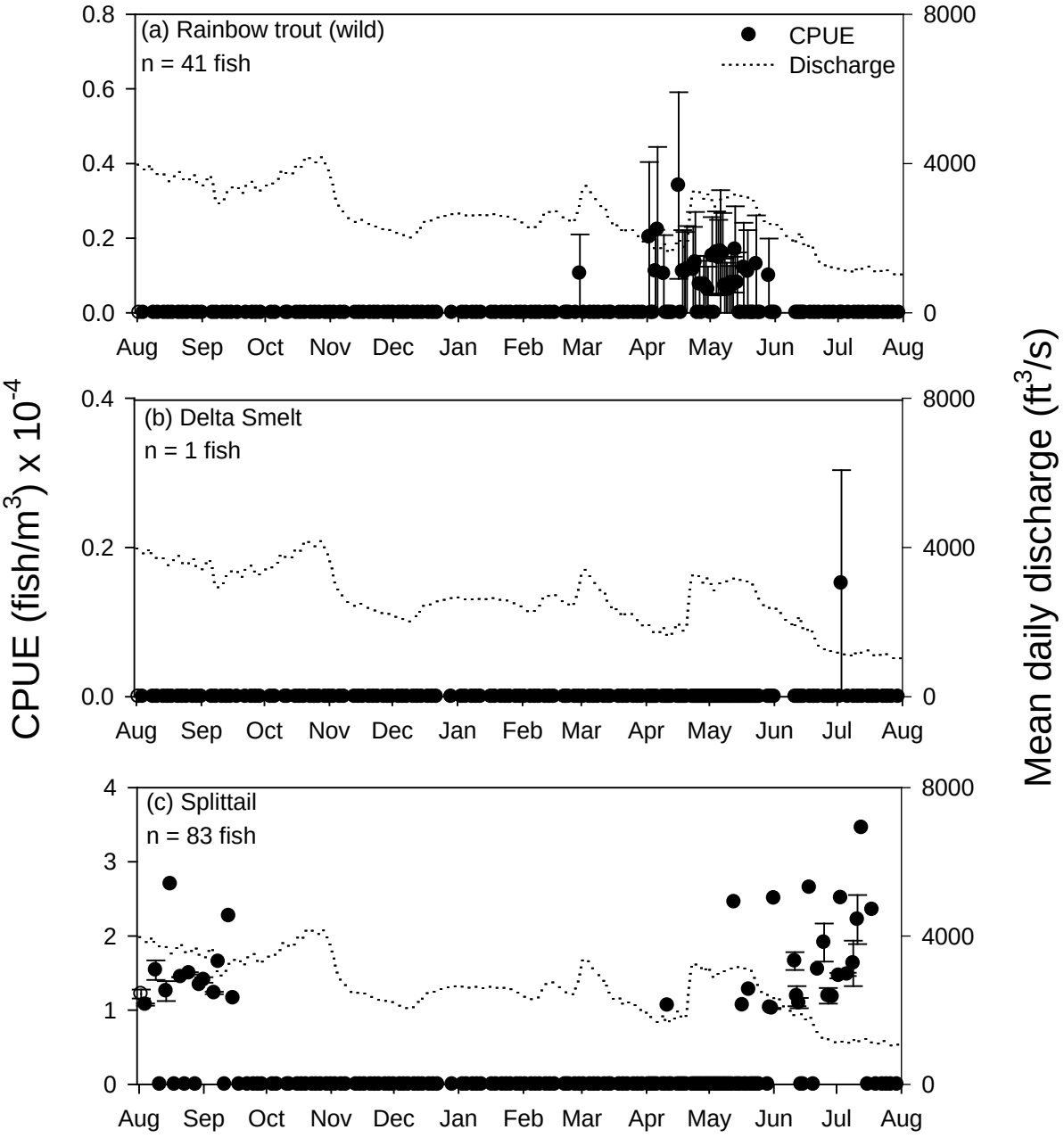
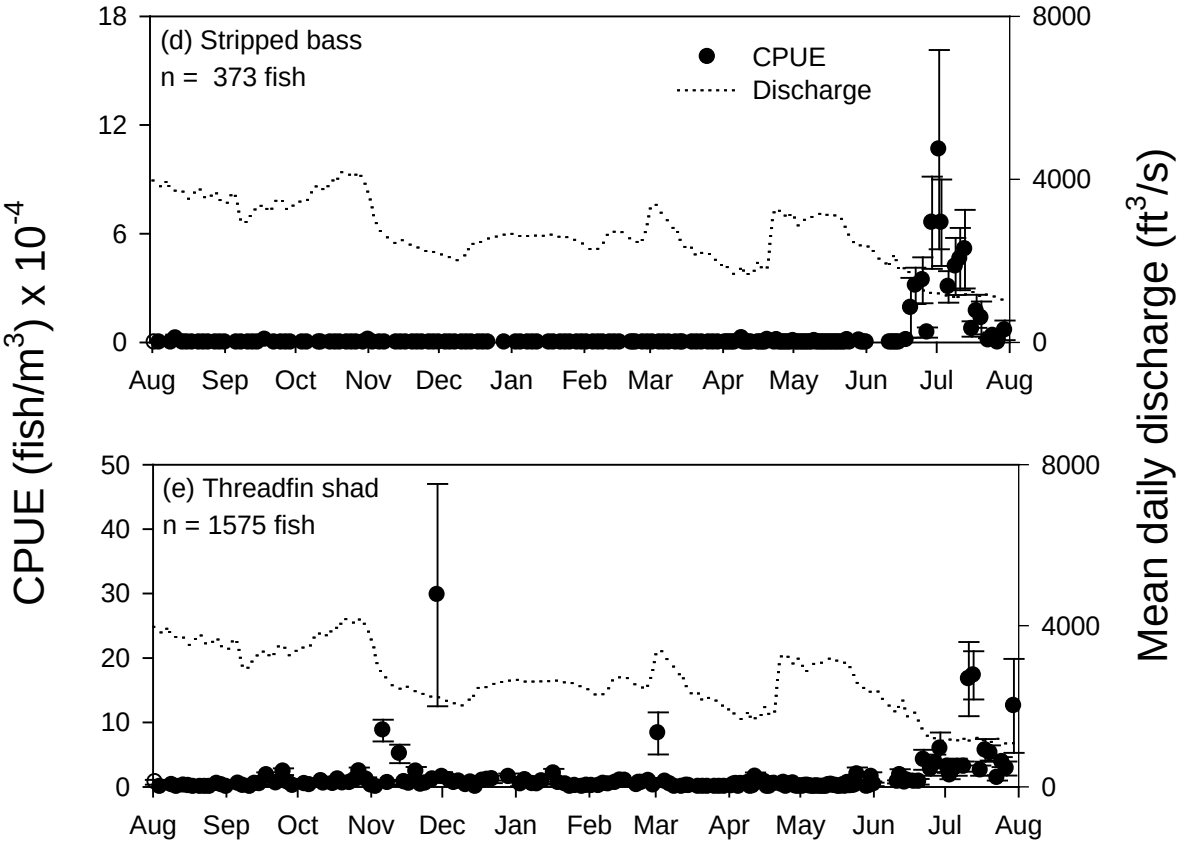


Figure 33. Mean daily catch-per-unit effort (x 10^{-4}) of (a) rainbow trout (wild), (b) spilttail, (c) striped bass, (d) threadfin shad in Kodiak trawls at Mossdale, San Joaquin River and concurrent mean daily discharge at Vernalis during the 2007 field season. Sample size (n) corresponds to total number of fish caught. Error bars are ± 1 SE.

Figure 33 cont.



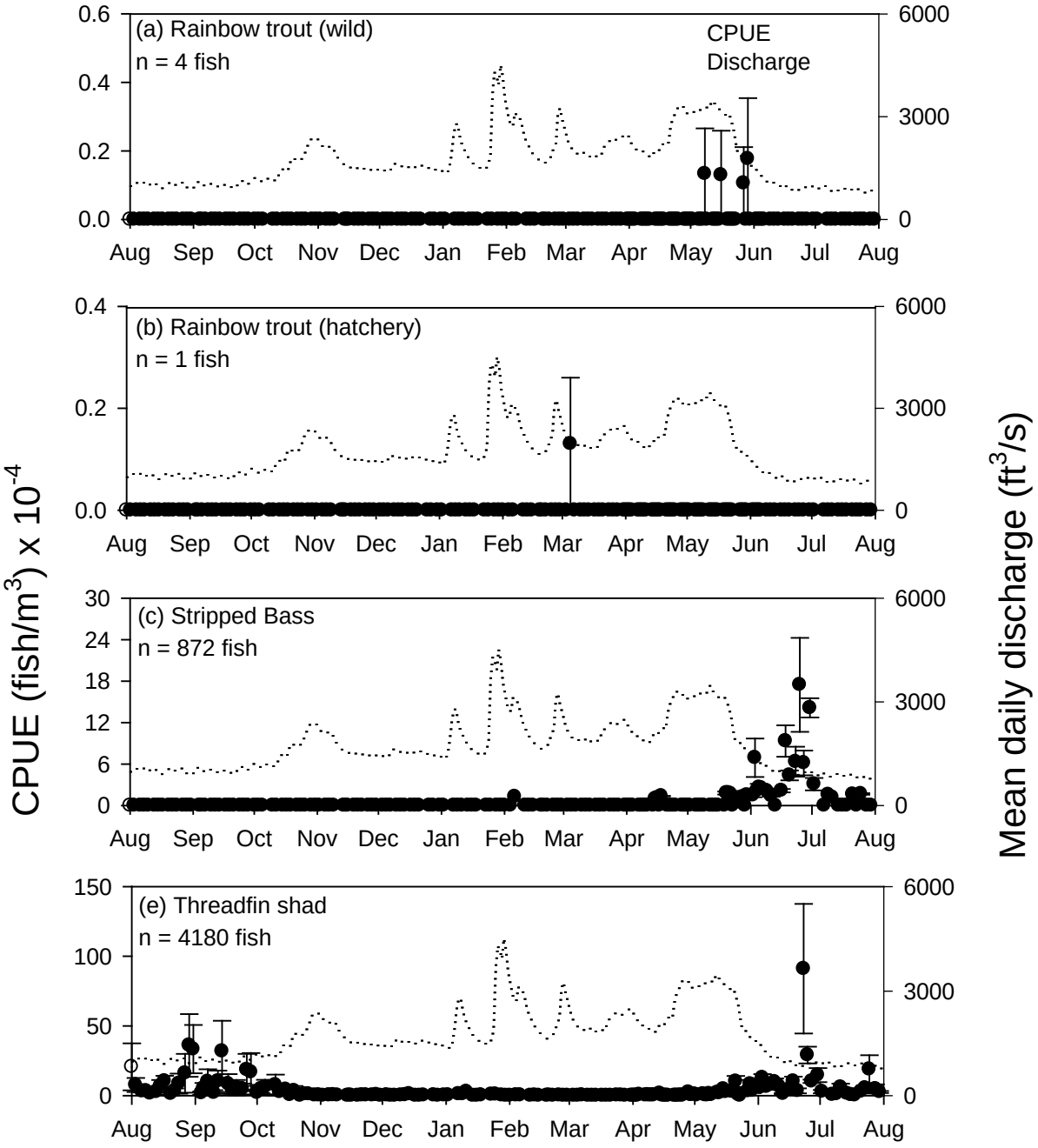


Figure 34. Mean daily catch-per-unit effort (x 10^{-4}) of (a) rainbow trout (wild), (b) rainbow trout (hatchery), (c) striped bass, (d) threadfin shad in Kodiak trawls at Mossdale, San Joaquin River and concurrent mean daily discharge at Vernalis during the 2008 field season. Sample size (n) corresponds to total number of fish caught. Error bars are ± 1 SE.

Table 8. Summary table of CPUE (fish/m^3) x 10^{-4} of fall-run Chinook salmon in Mossdale Kodiak trawls by month and year. Yearly mean and standard error (SE) values were calculated using years as replicates (n = 3-9). Weekly mean and SE values were calculated using weeks as replicates (n = 14-37). 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, 2006): AN = above normal; BN = below normal; D = dry; W = wet

Field Season	Water year	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Weekly mean (SE)
1997	W	--	0	0	0	0	--	--	0.325	2.14	1.06	0.393	--	0.493 (0.154)
1998	W	--	--	--	--	--	--	--	--	2.58	6.09	2.50	--	3.47 (0.802)
1999	AN	--	--	--	0	0	0.810	3.09	0.630	1.32	1.94	0.962	--	1.04 (0.231)
2000	AN	--	--	0	0	0	0.113	3.26	0.681	2.92	2.05	0.372	--	1.03 (0.349)
2001	D	--	--	--	--	--	--	0.125	0.455	8.62	7.071	0.409	0.016	2.82 (0.940)
2002	D	0	0	--	--	--	0.0144	0	0	1.97	9.61	0.207	0	1.62 (0.815)
2003	BN	--	--	--	--	0	1.23	0	0.332	4.15	3.52	0.0435	0	1.12 (0.359)
2004	D	0	0	0	0	0	0.01	0.115	2.22	2.65	2.72	0	0	0.591 (0.200)
2005	W	0	0	0	0	0	0.264	0.218	0.37	0.929	4.17	0.539	0.0196	0.514 (0.175)
2006	W	0	0	0	0	0.0102	0.0160	0.0223	0.150	0.591	3.34	4.30	0.109	1.12 (0.187)
Yearly mean 1997-2006 (SE)		0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0.351 (0.182)	0.854 (0.507)	0.574 (0.218)	2.79 (0.726)	4.16 (0.844)	0.973 (0.435)	0.0241 (0.0174)	1.38 (0.317)
2007	C	0	0	0	0	0	0	0.100	0.186	9.06	6.72	1.44	0	1.37 (0.461)
2008	C	0	0	0	0	0	0.180	0.180	0.0860	3.90	8.78	0.717	0	1.13 (0.395)

Chipps Island Trawl

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. Originally, ten 20-minute tows were conducted three to seven days each week from April to July. Sampling was conducted seven days/week only during experimental releases of coded wire tagged (CWT) salmon, usually December-January for the Delta Action 8 experiment and April-May for the Vernalis Adaptive Management Plan (VAMP). Coded wire tag information is used to estimate survival of salmon emigrating through the Delta (USFWS, 2001-2005). Sampling effort has increased since 1976. In 1996, we began sampling year round to better understand the temporal patterns of salmon emigration downstream. In 1998, we began conducting 20 tows per day in split shifts to coincide with CWT salmon releases from VAMP. This doubling of effort was implemented to increase the number of CWT salmon recovered from VAMP releases. In 2007, we transitioned from CWT salmon to acoustically tagged salmon for the VAMP study, therefore the increased effort from April to May at Chipps Island was not conducted during the 2007 and 2008 field seasons. We used CWT salmon and acoustic tagged salmon for Delta Action 8 study and increased effort at Chipps Island to seven days a week from December –January during the 2007 and 2008 field seasons.

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 duration or number of tows per day. We also encountered delta smelt take restrictions on May 25 during the 2007 field season that required us to discontinue trawling at Chipps Island for the remainder of the field season. We resumed trawling at Chipps Island on October 2, 2008 and continued trawling until February 4, 2008 when we reached our delta smelt take limit. Trawling operations were moved to Benicia (Carquinez Strait rm08) following the same protocols used at Chipps Island. We continued trawling at Benicia until March 8, 2008 when we moved trawling operations back to Chipps Island.

During the 2007 and 2008 field seasons, ten 20-minute tows were conducted between three and seven days per week depending on the need to recover CWT salmon for survival studies. Sampling generally was conducted three days/week, except during CWT recapture periods. The recapture period during the 2007 field season was December 4 through February 17. The recapture period for the 2008 field season was December 6 through February 4 at Chipps Island and February 8 through February 15 at Benicia. During these recapture periods, sampling increased to seven days/week.

Results

We captured 115 winter-run salmon from January through April in the 2007 field season (Figure 35a). Daily CPUE peaked on March 15 at the onset of decreasing total delta discharge. Peak monthly CPUE occurred in March at the third highest since 1993 (Table 9a). We captured 46 winter-run salmon in the 2008 field season, 42 in the Chipps Island trawls (Figure 36a), and four in trawls at Benicia (Figure 37). Daily CPUE peaked on January 30 during a period of increasing total delta discharge. Peak monthly CPUE occurred in March at the second highest peak monthly CPUE since 1993 (Table 9a).

There were 3,255 spring/fall-run salmon captured in Chipps Island trawls during the 2007 field season (Figure 35b). Peak daily CPUE occurred on April 24, two months after peak delta discharge. Peak monthly CPUE of spring/fall-run salmon occurred in April of the 2007 field season at the third lowest peak monthly CPUE since 1993 (Table 9b). There were 586 spring/fall-run salmon captured in Chipps Island trawl during the 2008 field season (Figure 36b). Peak daily CPUE occurred on June 2, during a period of decreasing total delta discharge. Peak monthly CPUE occurred in May and was the lowest peak monthly CPUE since 1993 (Table 9b). There were no spring/fall-run salmon captured in trawls at Benicia during the 2008 field season.

During the 2007 field season, we captured 35 late fall-run salmon in trawls at Chipps Island (Figure 35c). All late fall-run salmon were captured were yearlings from the 2006 Brood Year. Peak daily CPUE occurred on December 22 when three salmon were captured. Peak monthly CPUE occurred in December and was the second highest peak monthly CPUE since 1993 (Table 9c). During the 2008 field season, we captured 27 late fall-run salmon in trawls at Chipps Island (Figure 36c). All late fall-run salmon captured were yearlings from the 2007 brood year. Peak daily CPUE occurred on December 16 when two late fall-run salmon were captured. Peak monthly CPUE occurred in December and was the highest peak monthly CPUE since 1993 (Table 9c). There were no late fall-run salmon captured in trawls at Benicia during the 2008 field season.

During the 2007 field season the DJFMP captured ten wild rainbow trout in trawls at Chipps Island (Figure 38a). Peak daily CPUE occurred during a period of decreasing total delta discharge. During the 2008 field season the DJFMP captured seven wild rainbow trout in trawls at Chipps Island (Figure 39b). Peak daily CPUE occurred on March 17 when during a period of decreasing total delta discharge. During the 2008 field season the DJFMP captured two wild rainbow trout in trawls at Benicia, one on February 15 during a period of decreasing total delta discharge and on February 26 during a period of increasing total delta discharge (Figure 40a).

There were 132 hatchery-reared rainbow trout captured in trawls at Chipps Island during the 2007 field season (Figure 38b). Peak daily CPUE occurred on March 6 when 15 hatchery-reared rainbow trout were captured during a period of decreasing total delta discharge. There were 27 hatchery-reared rainbow trout captured in trawls at Chipps

Island during the 2008 field season (Figure 39b). Peak daily CPUE occurred when seven hatchery-reared rainbow trout were captured during increasing total delta discharge. There were 55 hatchery-reared rainbow trout captured in trawls at Benicia during the 2008 field season (Figure 40b). Peak daily CPUE occurred on February 20 when 13 hatchery-reared rainbow trout were captured during a period of decreasing total delta discharge.

We captured 339 delta smelt during the 2007 field season in Chipps Island trawls (Figure 38c). Peak daily CPUE occurred on October 2 when 10 delta smelt were captured during a period of decreasing total delta discharge. We captured 93 delta smelt during the 2008 field season in Chipps Island trawls (Figure 39c). Peak daily CPUE occurred on January 9 when nine delta smelt were captured during a period of decreasing total delta discharge. There were no delta smelt captured in trawls at Benicia during the 2008 field season.

In the 2007 field season, 368 longfin smelt were captured at Chipps Island (Figure 38d). Peaked daily CPUE occurred on December 29 when 19 longfin smelt were captured during a period of decreasing total delta discharge. In the 2008 field season, 593 longfin smelt were captured at Chipps Island (Figure 39d). Peak daily CPUE occurred on February 4 when 54 longfin smelt were captured during a period of decreasing total delta discharge. In the 2008 field season, 151 longfin smelt were captured in trawls at Benicia (Figure 40c). Peak daily CPUE occurred on February 8 when 11 longfin smelt were captured during a period of decreasing total delta discharge.

There were 559 splittail captured in Chipps Island trawls during the 2007 field season (Figure 38e). Peak daily CPUE was observed on August 21 when one splittail was captured during a period of increasing total delta discharge. There were 209 splittail captured in Chipps Island trawls during the 2008 field season (Figure 39e). Peak daily CPUE occurred on February 3 when 24 splittail were captured during a period of increasing total delta discharge. There were 24 splittail captured in Benicia trawls during the 2008 field season (Figure 40d). Peak daily CPUE occurred on February 26 when 13 splittail were captured during a period of increasing total delta discharge.

We captured 2,727 striped bass in trawls at Chipps Island during the 2007 field season (Figure 38f). Peak daily CPUE occurred on August 28 when 111 striped bass were captured during a period of decreasing total delta discharge. We captured 697 striped bass in Chipps Island trawls during the 2008 field season (Figure 39f). Peak daily CPUE occurred on October 30 when 91 striped bass were captured during a period of increasing total delta discharge. We captured 173 striped bass in trawls at Benicia during the 2008 field season (Figure 40e). Peak daily CPUE occurred on February 9 when 41 striped bass were captured during a period of decreasing total delta discharge.

There were 6,287 threadfin shad captured in MWTR at Chipps Island during the 2007 field season (Figure 38g). Daily CPUE peaked on October 11 when 393 threadfin shad were captured during a period of decreasing total delta discharge. There were 4,562 threadfin shad captured in MWTR at Chipps Island during the 2008 field season (Figure

39g). Daily CPUE peaked on October 30 when 155 threadfin shad were captured during a period of increasing total delta discharge. There were 10 threadfin shad captured in MWTR at Benicia during the 2008 field season (Figure 40f). Daily CPUE peaked on February 8 when 1 threadfin shad was captured during a period of decreasing total delta discharge.

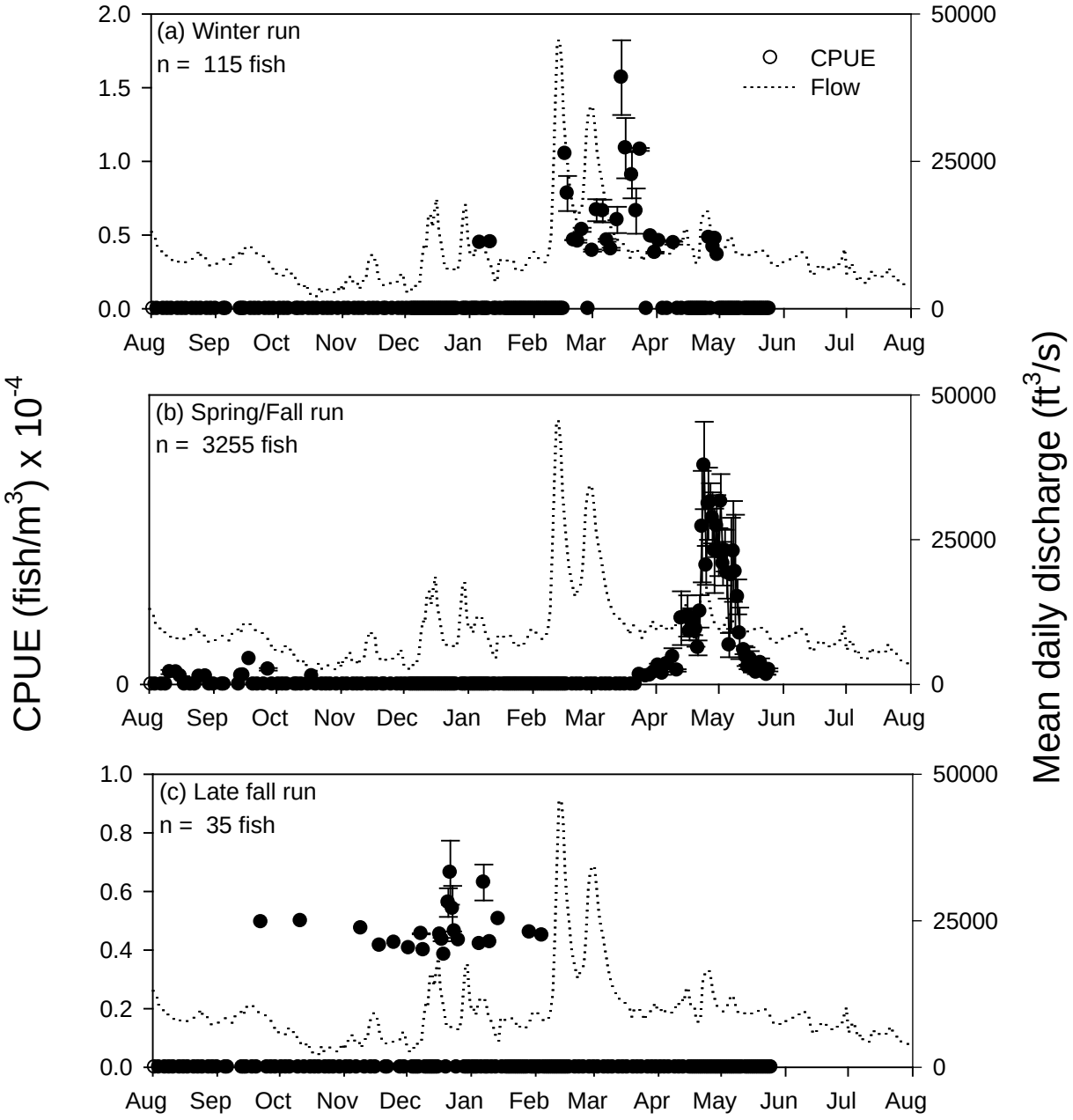


Figure 35. Mean daily catch-per-unit effort (x 10^{-4}) of (a) winter-, (b) spring-/fall-, and (c) late fall-run Chinook salmon in midwater trawls at Chipps Island and concurrent daily Delta discharge during the 2007 field season. Sample size (n) corresponds to total number of fish caught. Error bars are ± 1 SE.

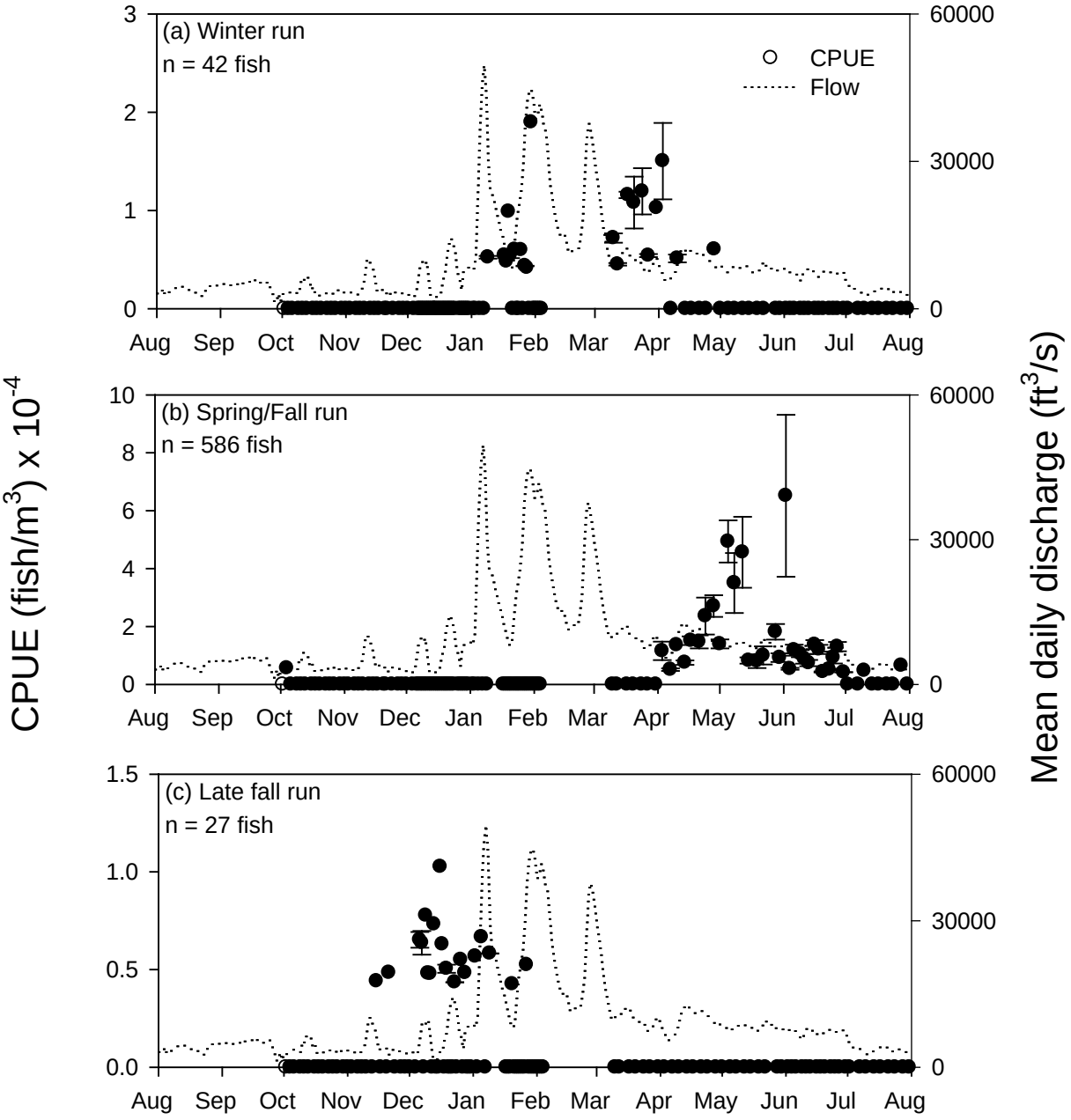


Figure 36. Mean daily catch-per-unit effort (x 10^{-4}) of (a) winter-, (b) spring-/fall-, and (c) late fall-run Chinook salmon in midwater trawls at Chipps Island and concurrent daily Delta discharge during the 2008 field season. Sample size (n) corresponds to total number of fish caught. Error bars are ± 1 SE.

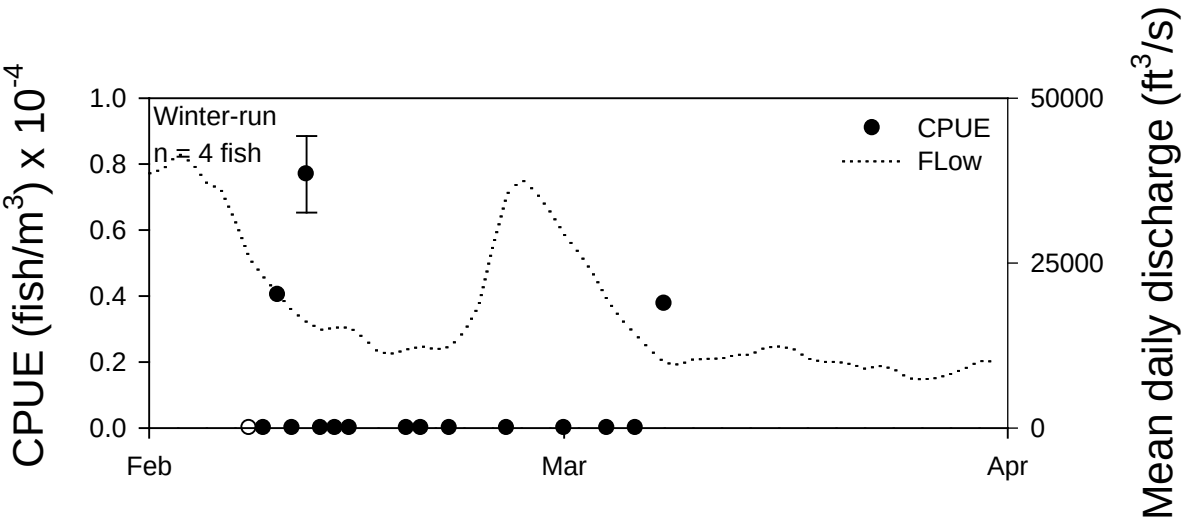


Figure 37. Mean daily catch-per-unit effort (x 10^{-4}) of winter-run Chinook salmon in midwater trawls at Benicia and concurrent daily Delta discharge during the 2008 field season. Sample size (n) corresponds to total number of fish caught. Error bars are ± 1 SE.

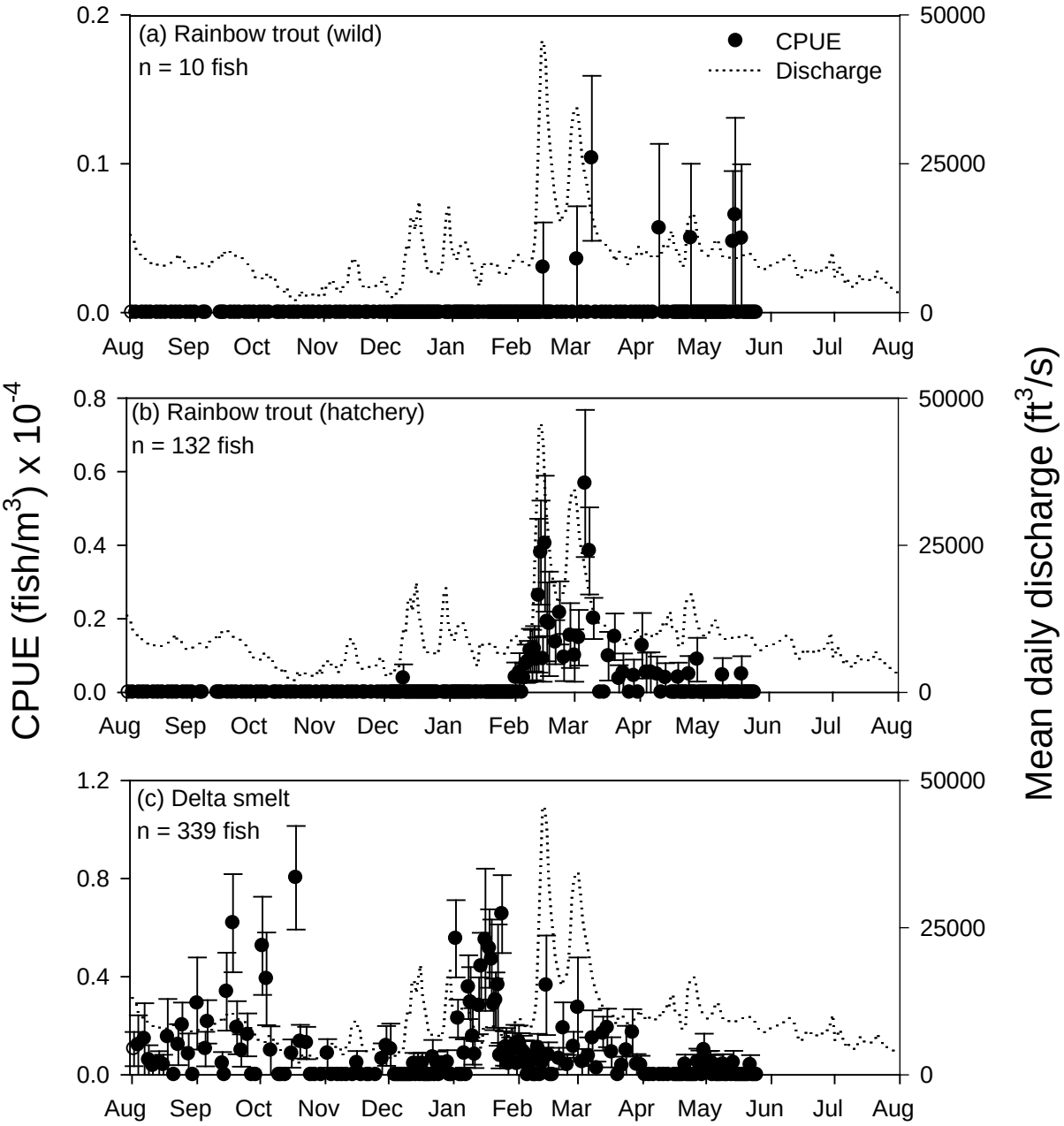
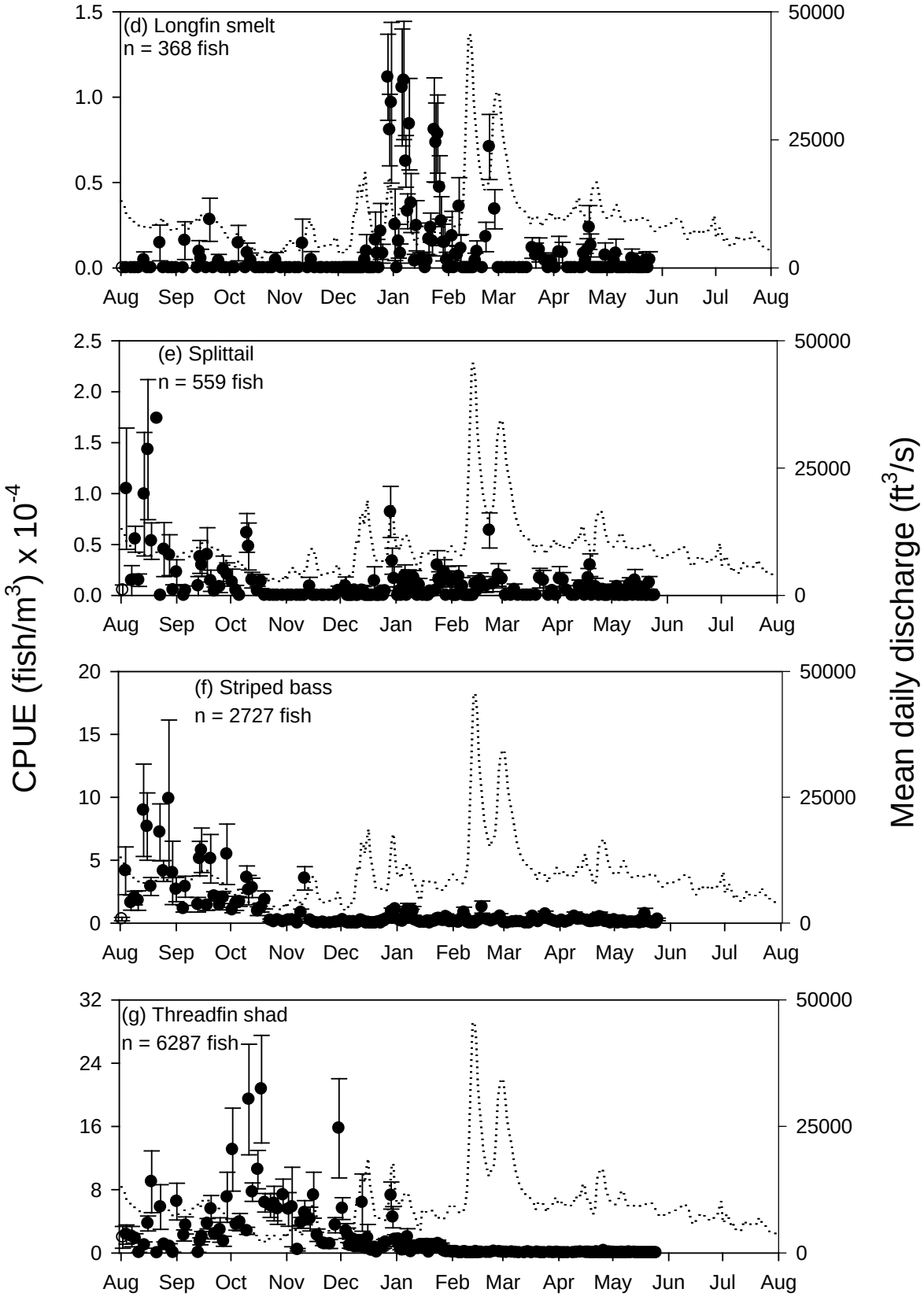


Figure 38. Mean daily catch-per-unit effort (x 10^{-4}) of (a) rainbow trout (wild), (b) rainbow trout (hatchery), (c) delta smelt, (d) longfin smelt, (e) spilttail, (f) striped bass, and (g) threadfin shad in midwater trawls at Chipps Island and concurrent daily Delta discharge during the 2007 field season. Sample size (n) corresponds to total number of fish caught. Error bars are ± 1 SE.

Figure 38 cont.



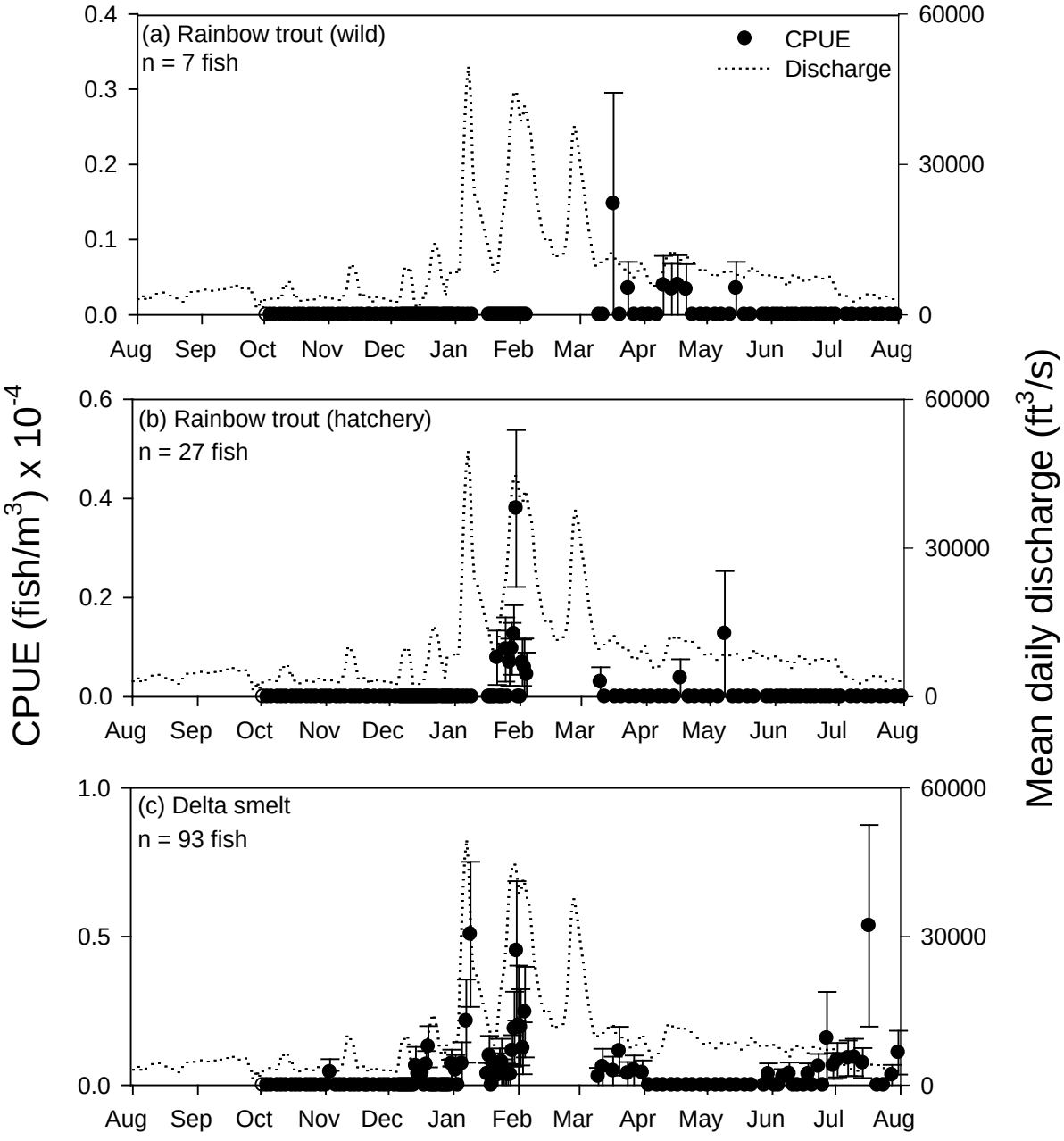
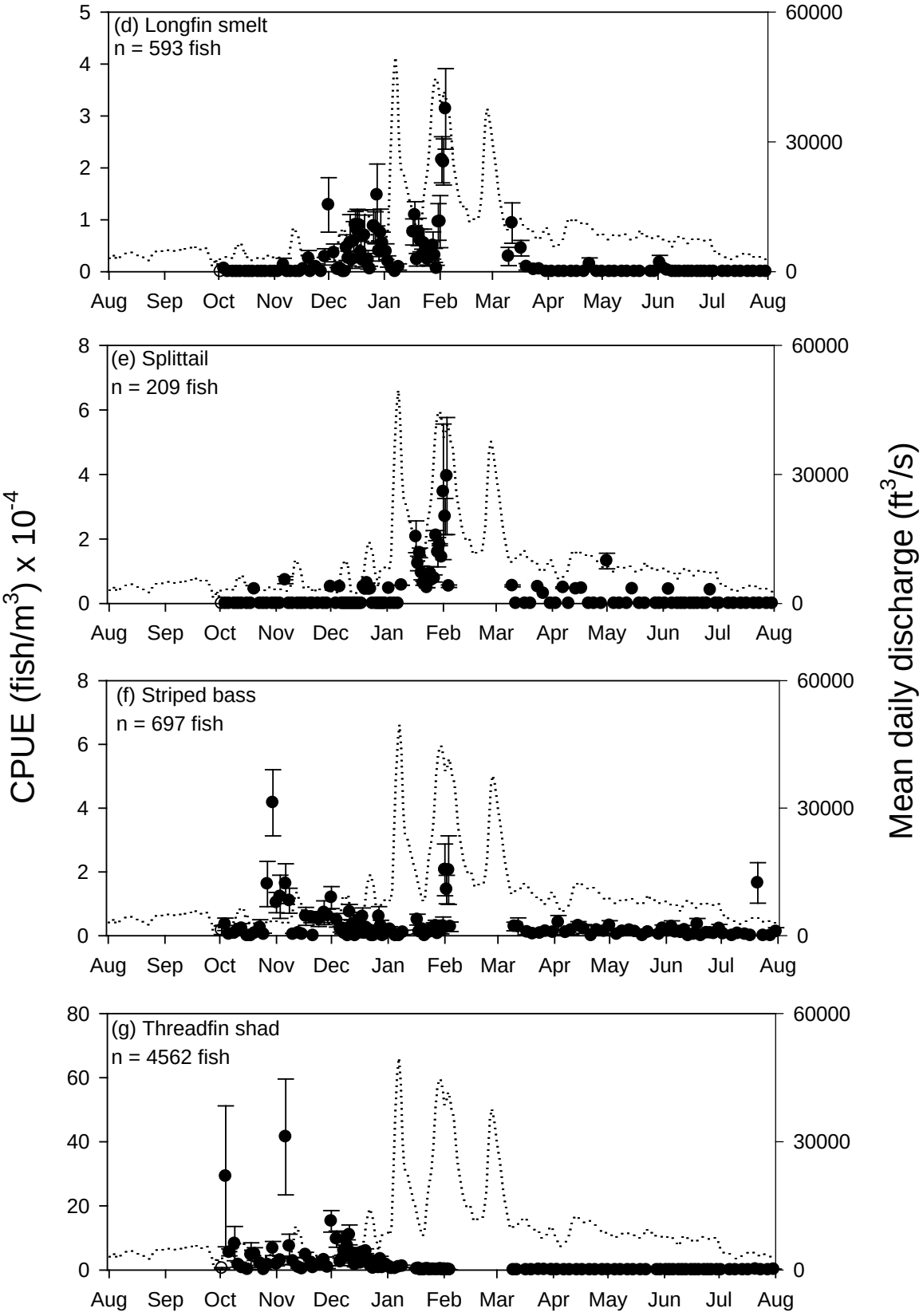


Figure 39. Mean daily catch-per-unit effort (x 10^{-4}) of (a) rainbow trout (wild), (b) rainbow trout (hatchery), (c) delta smelt, (d) longfin smelt, (e) spilttail, (f) striped bass, and (g) threadfin shad in midwater trawls at Chipps Island and concurrent daily Delta discharge during the 2008 field season. Sample size (n) corresponds to total number of fish caught. Error bars are ± 1 SE.

Figure 39 cont.



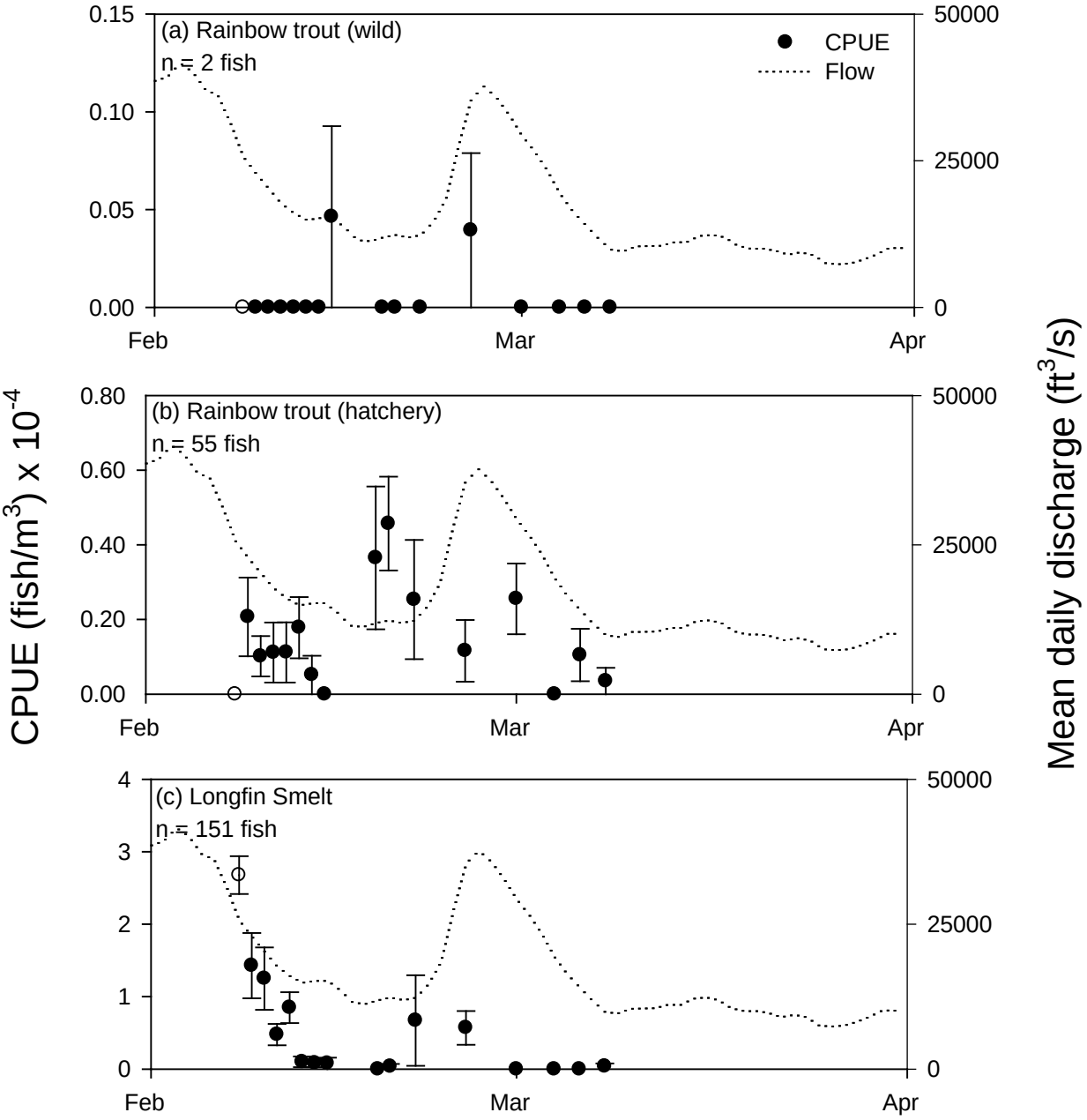


Figure 40. Mean daily catch-per-unit effort (x 10^{-4}) of (a) rainbow trout (wild), (b) rainbow trout (hatchery), (c) longfin smelt, (d) spilttail, (e) striped bass, and (f) threadfin shad in midwater trawls at Benicia and concurrent daily Delta discharge during the 2008 field season. Sample size (n) corresponds to total number of fish caught. Error bars are ± 1 SE.

Figure. 40 cont.

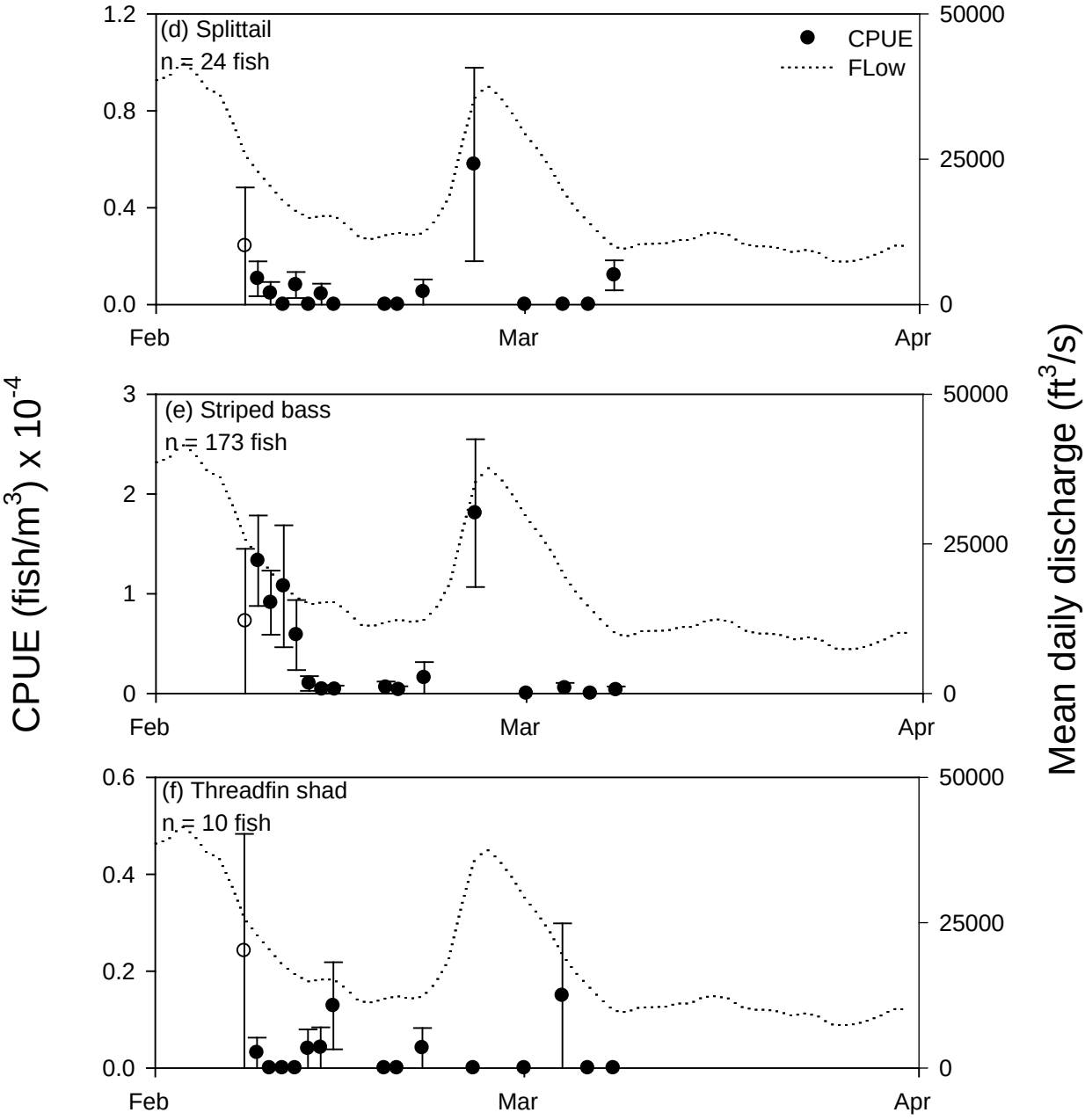


Table 9. Summary table of CPUE (fish/m^3) x 10^{-4} of (a) winter-, (b) spring-/fall-, and (c) late fall-run Chinook salmon in midwater trawls at Chipps Island by month and year. Among-year mean and standard error (SE) values were calculated using years as replicates (n = 10-14). Within-year mean and SE values were calculated using weeks as replicates (n = 14-49). Shaded boxes indicate peak monthly CPUE for each year. Water year (CDEC, 2008): AN = above normal; BN = below normal; C = critical; D = dry; W = wet

(a) Winter-run

Field Season	Water year	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Weekly mean (SE)
1993	AN	--	--	--	--	--	--	--	--	0.328	0.00347	0	0	0.0919 (0.0506)
1994	C	--	--	--	0	0	0.00313	0.00708	0.0834	0.0225	0.00136	0	--	0.0151 (0.00544)
1995	W	--	--	0	0	0	0.0141	0.136	0.392	0.2906	0.00473	0	0	0.0836 (0.0275)
1996	W	0	0	0	0	0.0639	0.0745	0.112	0.650	0.0760	0.00407	0	0	0.0853 (0.0323)
1997	W	0	--	0	0	0.00203	0.02370	0.0852	0.239	0.0676	0.00289	0	0	0.0417 (0.0121)
1998	W	0	0	0	0	0.0108	0.0289	0.0161	0.214	0.0444	0.00140	0	--	0.0316 (0.0124)
1999	W	--	0	0	0	0.0207	0.0110	0.0835	0.258	0.0865	0	0	0	0.0437 (0.0194)
2000	AN	0	0	0	0	0	0.0124	0.107	0.290	0.0655	0.00143	0	0	0.0401 (0.0147)
2001	D	0	0	0	0	0	0.0147	0.0647	0.254	0.0294	0.000701	0	0	0.0330 (0.0120)
2002	D	0	0	0	0	0.0205	0.0187	0.0238	0.153	0.0565	0.000900	0	0	0.0228 (0.00781)
2003	AN	0	0	0	0	0.0493	0.0989	0.1500	0.434	0.0912	0.00334	0	0	0.0682 (0.0188)
2004	BN	0	0	0	0	0.0112	0.0144	0.0471	0.343	0.0150	0	0	0	0.097 (0.0170)
2005	BN	0	0	0	0	0.00613	0.0302	0.101	0.210	0.0584	0.000613	0	0	0.0341 (0.0116)
2006	W	0	0	0	0	0.0339	0.0529	0.439	1.57	1.93	0.00274	0	0	0.354 (0.117)
Yearly mean 1993-2006(SE)		0 (0)	0 (0)	0 (0)	0 (0)	0.0168 (0.00573)	0.0306 (0.00782)	0.105 (0.0304)	0.392 (0.106)	0.226 (0.133)	0.00198 (0.000412)	0 (0)	0 (0)	0.0745 (0.0227)
2007	D	0	0	0	0	0	0.0333	0.157	0.669	0.126	0	--	--	0.106 (0.0360)
2008	C	--	--	0	0	0	0.351	0	0.881	0.327	0	0	0	0.149 (0.0503)

Table 9 cont.

(b) Spring/fall-run

Field Season	Water year	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Weekly mean (SE)
1993	AN	--	--	--	--	--	--	--	--	7.07	12.9	4.83	0.487	7.25 (1.83)
1994	C	--	--	--	0.0433	0	0	0.00309	0.0164	6.01	2.54	0.200	--	0.977 (0.497)
1995	W	--	--	0.0513	0.0338	0	0.623	0.416	0.934	8.48	15.1	4.52	0.330	2.87 (0.789)
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	2.63 (0.648)
1997	W	0.141	--	0	0.00908	0.0143	0.235	0.00547	0.0896	3.92	2.15	0.360	0.0978	0.634 (0.223)
1998	W	0.0388	0.0214	0.00265	0	0.00198	0.466	0.645	2.22	12.4	14.8	4.60	--	3.00 (0.770)
1999	W	--	0.0596	0.0377	0	0	0.0372	0.935	0.516	4.55	9.97	2.60	0.0763	1.65 (0.458)
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)
2001	D	0.0271	0.0572	0.0563	0.0162	0	0	0.00426	0.0543	5.38	5.88	0.438	0.0885	0.888 (0.390)
2002	D	0.0211	0.00716	0.00460	0	0	0	0	0.0317	2.64	5.11	0.576	0.145	0.694 (0.260)
2003	AN	0	0.0103	0	0.00211	0	0	0	0.718	13.7	9.30	1.06	0.0462	1.75 (0.641)
2004	BN	0.0204	0.00768	0	0	0	0	0.00460	0.572	7.80	6.59	0.785	0.0790	1.09 (0.453)
2005	BN	0.0202	0.00880	0.00619	0	0	0	0	0.391	11.0	9.83	3.20	0.201	1.87 (0.637)
2006	W	0.0678	0.0656	0	0	0	0	0.0147	0.906	33.59	43.7	11.1	0.790	7.01 (2.52)
Yearly mean 1993-2006 (SE)		0.0377 (0.0131)	0.0317 (0.00827)	0.0501 (0.0247)	0.00984 (0.00391)	0.00362 (0.00251)	0.115 (0.0570)	0.507 (0.337)	0.717 (0.190)	9.72 (2.03)	11.2 (2.75)	2.65 (0.793)	0.207 (0.066)	2.42 (0.571)
2007	D	0.193	0.251	0.033	0	0	0	0	0.144	4.65	3.15	--	--	0.701 (0.272)
2008	C	--	--	0.0430	0	0	0	0	0	1.48	2.20	1.32	0.126	0.558 (0.152)

Table 9 cont.

(c) Late fall-run

		Previous field season brood year								Current field season				
Field Season	Water year	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Weekly mean (SE)
1993	AN	--	--	--	--	--	--	--	--	0	0	0	0	0 (0)
1994	C	--	--	--	0.0280	0.0815	0.00579	0.0168	0	0	0	0.00198	--	0.0177 (0.00571)
1995	W	--	--	0	0.0207	0.0768	0.0444	0	0	0	0.00127	0	0	0.0134 (0.00521)
1996	W	0	0.00562	0.0123	0	0.184	0.0606	0.00256	0	0	0.00133	0	0	0.0209 (0.00948)
1997	W	0	--	0	0	0.151	0.0295	0	0	0	0	0	0	0.0139 (0.00675)
1998	W	0.0188	0.0367	0.0197	0.0291	0.100	0.0280	0	0	0	0	0	--	0.0232 (0.0629)
1999	W	--	0.0657	0	0.233	0.0939	0.00647	0.00306	0	0	0	0	0.0191	0.0371 (0.0132)
2000	AN	0	0.00825	0.00500	0.0453	0.0436	0.00854	0.0112	0	0	0	0	0	0.0100 (0.00393)
2001	D	0	0	0.00460	0.0331	0.0469	0.0140	0.00323	0	0	0	0	0.00430	0.00985 (0.00389)
2002	D	0	0.0247	0	0.0368	0.0680	0.00601	0	0.00369	0	0	0	0.00442	0.0111 (0.00371)
2003	AN	0	0.00915	0.00876	0.00398	0.121	0.0351	0	0	0	0	0	0	0.0128 (0.00619)
2004	BN	0	0.01300	0	0.00777	0.0483	0.0136	0	0	0	0	0	0	0.00649 (0.00236)
2005	BN	0.00318	0.00319	0	0.00816	0.0224	0.0163	0	0	0	0	0	0	0.00408 (0.00159)
2006	W	0	0	0.0224	0.0492	0.137	0.0129	0.0109	0	0	0	0	0	0.0187 (0.00573)
Yearly mean 1993-2006 (SE)		0.00220 (0.00187)	0.0166 (0.00656)	0.00606 (0.00234)	0.0381 (0.0169)	0.0903 (0.0131)	0.0216 (0.00470)	0.00367 (0.00156)	0.00028 (0.00028)	0 (0)	0.000186 (0.000126)	0.000141 (0.000141)	0.00232 (0.00160)	0.0381 (0.0257)
2007	D	0	0.0413	0.0384	0.101	0.193	0.0905	0.0214	0	0	0	--	--	0.0497 (0.0135)
2008	C	--	--	0	0.0712	0.274	0.138	0	0	0	0	0	0	0.0553 (0.0172)

All Fish Species Captured in all Sampling Gears

In the 2007 field season, 277,019 organisms from 70 different species were captured in the combined efforts of the DJFMP trawls and beach seines (Table 10). Of the 70 different species captured, five species comprised 85% of the total catch. Those five species were: American Shad (n = 78,296 fish), Inland silverside (n = 74,606 fish), Black Sea Jellyfish (n = 36,095 jellyfish), Threadfin shad (n = 23,366 fish) and Chinook salmon (n = 17,925 fish). Catch from Chipps Island trawls totaled 127,971 organisms from 33 different species. American shad was the most abundant species captured (n = 77,753 fish) in Chipps Island trawls. Mossdale catch totaled 11,676 organisms from 31 different species. Inland silversides (n = 4,863 fish) were the most abundant species captured in trawls at Mossdale. Catch from Sacramento trawls (Sherwood Harbor) totaled 5,632 organisms from 28 different species. Chinook salmon (n = 4,512 fish) was the most abundant species captured in Sacramento trawls. Total catch from region 1 beach seines was 22,323 organisms from 32 different species. Sacramento sucker (n = 7,452 fish) was the most abundant species captured in region 1 beach seines. Total catch from region 2-4 beach seines was 89,856 organisms from 43 different species. Inland silverside (n = 58,472 fish) was the most abundant species captured in region 2-4 beach seines. Total catch from region 5 beach seines totaled 12,812 organisms from 26 different species. Inland silverside (n = 7,010 fish) was the most abundant species captured in region 5 beach seines. Total catch from region 6 beach seines was 6749 organisms from 36 different species. Topsmelt (n = 5,472 fish) was the most abundant species captured in region 6 beach seines.

In the 2008 field season, 205,203 organisms from 81 different species were captured in the combined efforts of the DJFMP trawls and beach seines (Table 11). Of the 81 different species captured, seven species comprised 85% of the total catch. Those seven species were: Inland silverside (n = 88,090 fish), Threadfin shad (n = 35,011 fish), Redshiner (n = 17,067 fish), Sacramento sucker (n = 11,461 fish), Black sea jellyfish (n = 7,903 jellyfish), American shad (n = 7,382 fish) and Chinook salmon (n = 6,339 fish). Total catch from Benicia was 912 organisms from 20 different species. American shad (n = 348 fish) was the most abundant species captured in trawls at Benicia. Catch from Chipps Island trawls totaled 22,201 organisms from 32 different species. Although the black sea jellyfish was the most abundant species captured (n = 7,903 jellyfish) in Chipps Island trawls, the American shad was the most abundant fish species captured (n = 7,219 fish). Mossdale catch totaled 22,645 organisms from 38 different species. Inland silversides (n = 6,947 fish) were the most abundant species captured in trawls at Mossdale. Catch from Sacramento trawls (Sherwood Harbor) totaled 2,753 organisms from 29 different species. Chinook salmon (n = 1,481 fish) was the most abundant species captured in Sacramento trawls. Total catch from region 1 beach seines was 20,585 organisms from 30 different species. Sacramento sucker (n = 9,084 fish) was the most abundant species captured in region 1 beach seines. Total catch from region 2-4 beach seines was 104,726 organisms from 43 different species. Inland silverside (n = 66,315 fish) was the most abundant species captured in region 2-4 beach seines. Total catch from region 5 beach seines totaled 26,715 organisms from 26 different species. Inland silverside (n = 10,356 fish) was the most abundant species

captured in region 5 beach seines. Total catch from region 6 beach seines was 5,418 organisms from 36 different species. Topsmelt (n = 3,758 fish) was the most abundant species captured in region 6 beach seines.

Table 10. Total of all species captured from all trawl sites and seine regions during the 2007 field season.

	Trawl sites			Seine regions			
Organism	**Chipps Island**	**Mossdale**	**Sherwood Harbor**	**1**	**2-4**	**5**	**6**
American Shad	77753	55	346	31	102		9
Arrow Goby							25
Bluegill	7	47	4	139	548	20	
Black Bullhead					10		
Black Crappie	2	67	2	61	19	17	
Bay Pipefish							78
Brown Bullhead					1		
Black Surfperch							1
Barred Surfperch							8
Blackfordia virginica							1
Common Carp	1	27	3	64	38	222	
California Halibut							2
Chrysaora fuscescens							7
Channel Catfish	3	398	9	7			
Chameleon Goby							3
Chinook Salmon	3414	3397	4512	2349	4251	2	
Cheekspot Goby							1
Diamond Turbot							12
Delta Smelt	339	1			17		
Dwarf Surfperch							130
Fathead Minnow		1	1	613	182	3	
Goldfish		1	1	1	7	2	

Table 10 cont.

	Trawl sites			Seine regions			
Organism	**Chipps Island**	**Mossdale**	**Sherwood Harbor**	**1**	**2-4**	**5**	**6**
Giant Kelpfish							2
Green Sunfish				2			
Golden Shiner	13	76	12	637	899	82	
Hitch			1	89	37	1	
Hardhead			1	16	6	1	
Jacksmelt							2
Lamprey Unidentified		1	3	1	2		
Logperch		1		197	157	142	
Maeotias Marginata	36094				1		
Western Mosquitofish			2	971	605	21	1
Inland Silverside	5	4863	100	4104	58472	7010	52
Northern Anchovy	16						88
Pacific Herring	436						4
Pleurobrachia Bachei	1						89
Pacific Lamprey			11				
Polorchis Penicillatus							3
Prickly Sculpin	2	6		3	54	9	
Pacific Staghorn Sculpin	2				7		160
Rainbow Trout	10	41	3		3		1
Redear Sunfish	6	60		25	747	15	
Rainwater Killifish					58		12
River Lamprey		1	3				

Table 10 cont.

	Trawl sites			Seine regions			
Organism	**Chipps Island**	**Mossdale**	**Sherwood Harbor**	**1**	**2-4**	**5**	**6**
Red Shiner		229	1	1050	6100	1797	
Redtail Surfperch							2
Sacramento Pikeminnow		4	28	900	567	7	
Sacramento Sucker		98	1	7452	2731	843	
Sacramento Blackfish	4	1	8	47	45	4	
Shimofuri Gogy	40				130		4
Smallmouthe Bass		7		16	19	2	
Spotted Bass		2		10	23	2	
Spilttail	350	83	5	392	209	1	
Shiner Perch	1						165
Striped Bass	2727	373	5	1	109	1	36
Starry Flounder	46				3		43
Threadfin Shad	6287	1575	563	2903	12608	2427	3
Tule Perch	5	39		22	205	5	
Topsmelt	2						5472
Threespine Stickleback	13				5		11
Warmouth	1		1	1	1		
Wakasagi	5	3	3	15	1		
White Catfish	2	198	2		1		
White Crappie		2	1	32	3	3	
Walleye Surfperch							3
Yellowfin Goby	14				375		280

Table 11. Total of all species captured from all trawl sites and seine regions during the 2008 field season.

	Trawl sites				Seine regions			
Organism	Benicia	Chipps Island	Mossdale	Sherwood Harbor	1	2-4	5	6
American Shad	348	7219	25	33	1	101		3
Arrow Goby								31
Barred Surfperch								3
Bass (unknown species)			6196			12		
Bay Goby								11
Bay Pipefish								66
Black Bullhead			1	1		2		
Black Crappie			62	2	21	11	10	
Black Sea Jellyfish		7903						
Black Surfperch								1
Blackfordia virginica	25							
Bluegill		6	599	31	33	1104	96	
Brown Bullhead						1		
Calico Surfperch								2
California Halibut								1
Chameleon Goby						3		1
Channel Catfish		1	481	2				
Chinook Salmon	2	189	1697	1481	1043	1927	2	
Common Carp			13	4	75	1	2	
Crevice Kelpfish								3
Delta Smelt		93		2	1	3		

Table 11 cont.

	Trawl sites				Seine regions			
Organism	Benicia	Chipps Island	Mossdale	Sherwood Harbor	1	2-4	5	6
Diamond Turbot	1							5
Dwarf Surfperch								55
Egg Yolk Jelly								1
English Sole								1
Fathead Minnow				6	799	70	15	
Golden Shiner		3	157	5	616	647	7	
Goldfish			4	2	2	2	3	
Green Sunfish				2	2	2		
Harhead					64			
Hitch			1	2	129	20		
Inland Silverside		3	6947	128	4323	66315	10356	18
Jacksmelt		3						
Kelp Perch								1
Lamprey Unidentified			5	423	1	8		
Largemouth Bass		1	20	2	170	498	38	
Logperch			7		176	73	18	
Longfin Smelt	151	593						
Longjaw Mudsucker								41
Moon Jelly								46
Northern Anchovy		131						6
Pacific Herring	56	556						101
Pacific Lamprey		3	214	102				

Table 11 cont.

	Trawl sites				Seine regions			
Organism	Benicia	Chipps Island	Mossdale	Sherwood Harbor	1	2-4	5	6
Pacific Staghorn Sculpin	1	8				259		184
Penicillate Jellyfish	11							17
Penpoint Gunnel								1
Pleurobrachia Bachei	84							851
Prickly Sculpin			3		15	45	9	
Rainbow Trout	2	7	4	1				
Rainwater Killifish						135		5
Redear Sunfish		1	101	5	17	870	15	
Redeye bass						8		
Redshiner			109		628	2257	14073	
River Lamprey	1	2	16	222				
Sacramento Blackfish			3	3	4	8		
Sacramento Pikeminnow		1	1	83	1366	379	34	
Sacramento Sucker			19	4	9084	1838	516	
Saddleback Gunnel								2
Shimofuri Goby	4	6	6			93		1
Shiner Perch								43
Shokihaze Goby	1	2						
Smallmouth Bass			1		27	59	4	
Spilttail	24	209	524	2	517	645	4	
Spotted Bass			6	1	25	53	9	
Starry Flounder	4	9	3			2		14

Table 11 cont.

	Trawl sites				Seine regions			
Organism	Benicia	Chipps Island	Mossdale	Sherwood Harbor	1	2-4	5	6
Striped Bass	173	697	872			291	73	2
Surf Smelt								79
Threadfin Shad	10	4561	4180	183	791	24511	785	
Threespine Stickleback		6				39		43
Tidepool Sculpin								2
Topsmelt	1	667						3758
Tule Perch		11	8	6	98	372	6	
Wakasagi		1	1	12	56	74		
Walleye Surfperch								2
Warmouth			1	3		1		
Western Mosquitofish					474	760	95	
White Catfish		1	323			3		
White Crappie			33		27	1	3	
White Croaker	1							
White Seaperch								3
White Sturgeon		3						
Yellow Bullhead			1					
Yellowfin Goby	12	5	1			1223	2	14

Other Coded wire tag recoveries in sampling gears during the 2007 and 2008 field seasons

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. In addition, the State Water Project (SWP) and the Central Valley Water Project (CVP) facilities recover CWT's. Coded wire tagged Chinook salmon of all races were recovered in all sampling gears throughout the 2007 and 2008 field seasons.

Results

Fall-run

In the 2007 field season, 9,003,775 CWT fall-run salmon were released in the combined release efforts of Coleman National Fish Hatchery (CNFH; 3,241,782 fish), Feather River Fish Hatchery (2,741,445 fish), Merced Fish Facility (MFF; 77,589 fish), Mokelumne River Fish Hatchery (MRFH, 1,489,155 fish), and Nimbus Fish Hatchery (1,248,450 fish). There were 205,354 wild-tagged fall-run salmon released in the Stanislaus River and Sacramento Tributaries. The DJFMP recovered 1,456 CWT fall-run salmon (Table 12a), 461 in Chipps Island trawls, 897 in trawls at Sherwood Harbor, and 98 in beach seines. Half of the fish recovered by beach seines were at two locations, B&W Marina (26 fish) on the Mokelumne River and Eddo's (28 fish) on the San Joaquin River. The SWP and CVP facilities recovered five CWT's each. A map of these sites is available at (http://www.delta.dfg.ca.gov/data/ rtm2000/sample-sites.asp).

In the 2008 field season, 8,550,218 CWT fall-run salmon were released in the combined release efforts of Coleman National Fish Hatchery (CNFH; 3,317,265 fish), Feather River Fish Hatchery (2,865,969 fish), Mokelumne River Fish Hatchery (MRFH, 1,148,229 fish), and Nimbus Fish Hatchery (1,218,755 fish). The DJFMP recovered 270 CWT fall-run salmon (Table 13a), 87 in Chipps Island trawls, 123 in trawls at Sherwood Harbor, and 60 in beach seines. The SWP recovered 10 CWT fall-run salmon and the CVP recovered 12 CWT fall-run salmon.

Late fall-run

Coleman National Fish Hatchery released 1,105,411 CWT late-fall salmon during the 2007 field season, 1,080,541 at various locations in the Sacramento River and 24,870 at Benicia (Carquinez Strait rm08). There were 628 CWT late-fall salmon recovered during the 2007 field season (Table 12b). Trawls at Chipps Island (254 fish) and Sherwood Harbor (190 fish) recovered 71%, the SWP (95 fish) and CVP (82 fish) recovered 28%, and beach seines (9 fish) recovered 1%.

Coleman National Fish Hatchery released 9,82,916 CWT late-fall salmon during the 2007 field season, 957,897 at various locations in the Sacramento River and 25,019

at Port Chicago in Suisun Bay. There were 1,077 CWT late-fall salmon recovered during the 2008 field season (Table 13b). The SWP (336 fish) and CVP (493 fish) recovered 77%, trawls at Chipps Island (182 fish) and Sherwood Harbor (41 fish) recovered 21%, and beach seines (25 fish) recovered 2%.

Spring-run

Feather River Fish Hatchery released 1,931,161 CWT spring-run salmon during the 2007 field season, 1,004,600 were released at the hatchery, and 926,561 were released in Carquinez Strait. There were 198 CWT spring-run salmon recovered during the 2007 field season (Table 12c). Trawling efforts by the DJFMP recovered 193 CWT spring-run salmon and the DJFMP beach seines recovered five CWT spring-run salmon. Releases made at the Feather River Fish Hatchery contributed to 95% of the CWT spring-run recovered.

Feather River Fish Hatchery released 2,842,385 CWT spring-run salmon during the 2008 field season, 1,714,388 at various locations in the Sacramento River, and 1,127,997 were released in San Pablo Bay. There were 21,238 wild-tagged spring-run salmon released into the Sacramento River tributaries during the 2008 field season. There were 200 CWT spring-run salmon recovered during the 2007 field season (Table 13c). Trawling efforts by the DJFMP recovered 183 CWT spring-run salmon and the DJFMP beach seines recovered ten CWT spring-run salmon. Most of the CWT spring-run recovered were from releases made at Boyd's Pump Ramp. The CVP recovered three CWT spring-run salmon and the SWP recovered four CWT spring-run salmon. None of the wild-tagged CWT spring-run salmon were recovered during the 2008 field season by the DJFMP, SWP, or CVP sampling efforts.

Winter-run

Livingston Stone National Fish Hatchery (LSNFH) released 1,96,268 winter-run salmon in the Sacramento River at Caldwell Park during the 2007 field season. Only 31 of these fish were recovered, 25 in Chipps Island trawls, one in trawls at Sherwood harbor, one in DJFMP beach seines, two at the SWP and two at the CVP (Table 12d).

Livingston Stone National Fish Hatchery (LSNFH) released 71,883 winter-run salmon in the Sacramento River at Caldwell Park during the 2008 field season. Only 18 of these fish were recovered, two in Chipps Island trawls, one in trawls at Sherwood harbor, five in DJFMP beach seines, three at the SWP, and seven at the CVP (Table 13d).

Table 12. Recoveries of coded wire tagged juvenile Chinook salmon during the 2007 field season. Blank cells indicate no fish were recovered.

	Recovery Location																			
ReleaseLocation	B&W Marina	Brannan Island	Chipps Island	Colusa St. Park	Discovery Park	Eddo's	Elkhorn	Federal Fish Facility	Garcia Bend	Isleton	Knights Landing	Medford Island	Miller Park	Reels Beach	Rio Vista	Sherman Island	Sherwood Harbor	State Fish Facility	Wimpy's	Total
(a) Fall																				
Battle Creek	2		311	1			2	1									331	1		649
Benicia			4														60			64
Caswell								2												2
Clarksburg			11														1			12
Hatfield State Park			2																	2
Isleton		10	3												7	5		1		26
Lighthouse Marina	24					1		2				2						2	2	33
Merced River			1																	1
New Hope Landing			3																11	14
Red Bluff Diversion Dam			11														5			16
San Pablo Bay			10						1											11
Thermalito Bypass			3		1															4
West Sacramento			21														482			503
Wickland Oil Terminal			68																	68
YoloByPass			10				26		1							1	16	1		56
Yuba River			3														2			5
Fall Total	26	10	461	1	1	1	28	5	2	0	0	2	0	0	7	6	897	5	13	1466

Table 12 cont.

	Recovery Location																			
ReleaseLocation	B&W Marina	Brannan Island	Chipps Island	Colusa St. Park	Discovery Park	Eddo's	Elkhorn	Federal Fish Facility	Garcia Bend	Isleton	Knights Landing	Medford Island	Miller Park	Reels Beach	Rio Vista	Sherman Island	Sherwood Harbor	State Fish Facility	Wimpy's	Total
(b) Late fall																				
Battle Creek			207					63	2				2	1			25	63		363
Benicia			1																	1
Discovery Park			17					10									129	16		172
Isleton			20					6								1		14		41
West Sacramento			9					3	1								36	2		51
Late fall Total	0	0	254	0	0	0	0	82	3	0	0	0	2	1	0	1	190	95	0	628
(c) Spring																				
Butte Creek			1								1									2
Feather River			111				1			1							76			189
Wickland Oil Terminal			2																	2
Yuba River			2				1		1								1			5
Spring Total	0	0	116	0	0	0	2	0	1	1	1	0	0	0	0	0	77	0	0	198
(d) Winter																				
Caldwell Park			25					2						1			1	2		31
Winter Total	0	0	25	0	0	0	0	2	0	0	0	0	0	1	0	0	1	2	0	31
Grand Total	26	10	856	1	1	1	30	89	6	1	1	2	2	2	7	7	1165	102	13	2323

Table 13. Recoveries of coded wire tagged juvenile Chinook salmon during the 2008 field season. Blank cells indicate no fish were recovered.

	Recovery Location																							
Release Location	American River	B&W Marina	Benicia	Chipps Island	Clarksburg	Discovery Park	Eddo's	Elkhorn	Federal Fish Facility	Garcia Bend	Georgiana Slough	Isleton	King's Island	Knights Landing	Koket	Medford Island	Reels Beach	Rio Vista	Sandy Beach	Sherwood Harbor	State Fish Facility	Steamboat Sl. (mouth)	Woodward Island	Total
(a) Fall																								
Benicia				5																				5
Clarksburg		1		1	4				2	1		1										2		12
Coleman NFH	3	1		49		1			1			1			1					114				171
Isleton		1					1		5			7						6			3		1	24
Lighthouse Marina		4							3				2			2					7			18
New Hope Landing				1																				1
Red Bluff Diversion Dam									1											1				2
Rodeo Minor Port				1																				1
San Pablo Bay				24																				24
Thermalito Bypass				1																				1
West Sacramento				5						20										8				33
Fall Total	3	7	0	87	4	1	1	0	12	21	0	9	2	0	1	2	0	6	0	123	10	2	1	292
(b) Late fall																								
Battle Creek			5	138	3			2	310	2	1			1	1	1	1			40	207	2		714
Georgiana Slough		2	1	16					174												125			318
Port Chicago				2																				2
Ryde			1	26					9						2					1	4			43
Late fall Total	0	2	7	182	3	0	0	2	493	2	1	0	0	1	3	1	1	0	0	41	336	2	0	1077

Table 13 cont.

	Recovery Location																							
Release Location	American River	B&W Marina	Benicia	Chipps Island	Clarksburg	Discovery Park	Eddo's	Elkhorn	Federal Fish Facility	Garcia Bend	Georgiana Slough	Isleton	King's Island	Knights Landing	Koket	Medford Island	Reels Beach	Rio Vista	Sandy Beach	Sherwood Harbor	State Fish Facility	Steamboat Sl. (mouth)	Woodward Island	Total
(c) Spring																								
Boyds Pump Ramp				92					1											53	3			149
Butte Creek				2																				2
San Pablo Bay				8																				8
Selby				8																				8
YoloByPass				5	2	4		2	2	1									1	15	1			33
Spring Total	0	0	0	115	2	4	0	2	3	1	0	0	0	0	0	0	0	0	1	68	4	0	0	200
(d) Winter																								
Caldwell Park				2	1			1	7					3						1	3			18
Winter Total	0	0	0	2	1	0	0	1	7	0	0	0	0	3	0	0	0	0	0	1	3	0	0	18
Grand Total	3	9	7	386	10	5	1	5	515	24	1	9	2	4	4	3	1	6	1	233	353	4	1	1587

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