U.S. Fish and Wildlife Service

Annual Report:
Juvenile fish monitoring during the 2010 and 2011 field seasons within the San Francisco Estuary, California

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EXECUTIVE SUMMARY

The Delta Juvenile Fish Monitoring Program (DJFMP) has monitored juvenile Chinook salmon (*Oncorhynchus tshawytscha*) within the San Francisco Estuary since 1976 using a combination of surface trawls and beach seines. Since 2000, 58 beach seine sites and 3 trawl sites have been sampled weekly or biweekly within the Estuary and lower Sacramento and San Joaquin rivers. Currently, the objectives of the DJFMP are to determine the abundance and distribution trends of unmarked juvenile winter-, fall-, spring-, and late fall-run Chinook salmon migrating through the Estuary and report the catch of other fishes of management concern including four native species (Central Valley steelhead *Oncorhynchus mykiss irideus*, delta smelt *Hypomesus transpacificus*, longfin smelt *Spirinchus thaleichthys*, Sacramento splittail *Pogonichthys macrolepidotus*) and two nonnative species (striped bass *Morone saxatilis*, and threadfin shad *Dorosoma petenense*). This report describes the monitoring and data collected during the 2010 and 2011 field seasons. While sampling efforts were roughly equal, in-river flows were markedly higher in the 2011 field season compared to that of the 2010 field season and provided for an interesting contrast in the relative abundance and/or distribution of the species collected.

We completed 9,112 surface trawl and 3,790 beach seine samples during the 2010 and 2011 field seasons. Trawl samples were distributed relatively evenly among sites and seasons. Conversely, considerable spatial and temporal variability existed in the number of samples collected at sites within nearly all seine regions during the 2010 and 2011 field seasons.

A total of 441,889 fishes, representing 77 different species, were captured during the 2010 and 2011 field seasons. During the 2010 and 2011 field seasons, approximately 71% (n=109,279) and 41% (n=116,649) of the fishes captured during the 2010 and 2011 field seasons were identified as species not native to the San Francisco Estuary, respectively. The higher proportion of native fishes observed during the 2011 field season relative to the 2010 field season may have resulted, in part, from higher recruitment of two native fish species (i.e., Sacramento splittail and Chinook salmon) in response to higher in-river flows and cooler water temperatures within the San Francisco Estuary and its watershed.

The spatial distribution and abundances of unmarked juvenile Chinook varied temporally and among races. In general, unmarked juvenile winter-run Chinook salmon were detected by the DJFMP from October through April. Unmarked juvenile spring-run Chinook salmon were detected from October through May. However, unmarked juvenile fall- and late fall-run Chinook salmon were generally detected throughout the year. The abundance of unmarked winter- and late fall-run smolt sized juvenile Chinook salmon (fork length $\geq$ 70 mm) reached record lows during the 2010 and 2011 field seasons. Whereas the abundance of unmarked fall- and spring-run smolt sized juvenile Chinook salmon increased during the 2010 and 2011 field seasons from near record lows observed in 2008. Similarly, the relative abundance of fry sized juvenile Chinook salmon (fork length < 70 mm) for all races increased during the 2010 and the 2011 field seasons from near record lows observed in 2008 and 2009. The higher abundance of most unmarked juvenile Chinook salmon during the 2011 field season was likely in response to higher adult escapement combined with a higher river discharge.

The DJFMP observed the majority of steelhead from January to May during the 2010 and 2011 field seasons. Because of consistently low captures, few inter-annual trends could be discerned. However, there is evidence that the number of wild steelhead within the Estuary appears to have steadily declined since the 1998 field season.

Due to consistently low and/or isolated catches, few inferences could be made regarding the relative abundance or distribution of delta smelt or longfin smelt within the Estuary. However, we detected some adult delta smelt and longfin smelt in beach seine and trawl samples during their upstream migration from the low salinity zone (1-6 ppt) during the winter and spring or when the low salinity zone was in proximity to a sample location (i.e., Chipps Island). Overall, the DJFMP should be viewed only as a source of anecdotal information regarding these species, since neither delta smelt nor longfin smelt were targeted species and in some cases (i.e., Chipps Island) sampling efforts were curtailed when delta smelt were present in the sampling area to minimize incidental take.

Juvenile Sacramento splittail were generally detected from May through July during the 2010 and 2011 field seasons. The relative abundance of juvenile Sacramento splittail reached a record high during the 2011 field season in all seine regions. The increase in relative abundance during the 2011 field season was likely in response to higher river discharges and seasonal floodplain inundation, particularly within the San Joaquin River basin.

In general, the relative abundances of threadfin shad responded negatively to higher river discharges and cooler water temperatures within and among field seasons. Most threadfin shad were observed during the summer and fall months during the 2010 and 2011 field seasons. Low densities of threadfin shad were observed from February to June; likely in response to poor survival caused by cool water temperatures during the month of January. The relative abundance of threadfin shad in most sampling locations reached near record lows during the 2011 field season.

The DJFMP captured juvenile or sub-adult striped bass primarily from July to October during the 2010 and 2011 field seasons. The relative abundance of striped bass reached near record lows during the 2011 field season at all trawl sites. However, no discernible inter-annual trend in striped bass relative abundance could be detected within and among seine regions since the 2000 field season.

The correct citation for this report is:

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We also acknowledge and extend gratitude to the many biological science field technicians and boat operators who spent countless hours under all environmental conditions to collect these data. We would like to especially thank Amber Aguilera, Denise Barnard, Ken Behen, Crystal Castle, Amy Combs, Dustin Dinh, David Dominguez, Kate Erly, Kyle Fronte, Carlie Jackson, David LaPlante, Jerrica Lewis, Mike Marshall, Paul Miklos, Greg Nelson, Scott Porter, Pam Tarelli, Phil Voong, Jolene Willis, and Julie Wolford for assistance with sampling, Jackie Hagen, Ron Hagins, Patrick Hapgood, and Bill Powell for boating assistance, John Pedretti for his help with fish identification, and Angie Bourandas for helping oversee data entry and quality control during the 2010 and 2011 field seasons.

TABLE OF ACRONYMS

The following acronyms have been used in this report:

CESA – California Endangered Species Act
CDFW – California Department of Fish & Wildlife
CDWR – California Department of Water Resources
CNFH – Coleman National Fish Hatchery
CPUE – Catch Per Unit Effort
CVP – Central Valley Project
CWT – Coded Wire Tag
DJFMP – Delta Juvenile Fish Monitoring Program
ESA – Federal Endangered Species Act
FL – Fork Length
FRFH – Feather River Fish Hatchery
KDTR – Kodiak Trawl
MWTR – Mid-water Trawl
NMFS – National Marine Fisheries Service
RM – River Mile
RMIS – Regional Mark Information System
SD – Standard Deviation
SE – Standard Error
SJRGA – San Joaquin River Group Authority
STFWO – Stockton Fish & Wildlife Office
SWP – State Water Project
USFWS – United States Fish & Wildlife Service
USGS – United States Geological Survey

INTRODUCTION

The San Francisco Estuary is notably the largest estuary in California and provides spawning habitat, nursery habitat, and migratory pathways for over 40 freshwater, estuarine, euryhaline marine, and anadromous fish species (Moyle 2002). Historically, the Estuary was maintained by natural runoff from an estimated 40% of California's surface area (Nichols et al. 1986). However, perpetual increases in agriculture and urbanization throughout California over the last century, coupled with California's Mediterranean climate (i.e., wet winters and dry summers), have necessitated intense water management within the Sacramento – San Joaquin River Basin, resulting in the damming of most rivers, confinement of channels, and water diversions and exports (Nichols et al. 1986). Anthropogenic activities have subjected the San Francisco Estuary to artificial flow regimes that can have profound impacts on aquatic habitats and organisms (Stevens and Miller 1983; Brandes and McLain 2001; Bunn and Arthington 2002; Kimmerer 2002; Feyrer and Healey 2003). As a result, fish species of management concern within the Estuary have been studied and monitored by the Delta Juvenile Fish Monitoring Program (DJFMP) of the Stockton Fish and Wildlife Office to assess and minimize the effects of water operations on fish populations.

Background

The DJFMP, working in conjunction with IEP members, has monitored the relative abundance and distribution of juvenile fishes annually within the San Francisco Estuary since 1976 (Brandes et al. 2000). The specific goals of the DJFMP have evolved since inception based on both water management actions and listings under the Endangered Species acts. Prior to 1982, goals of the DJFMP were to (1) monitor the relative abundance of juvenile Chinook salmon to determine the importance of the San Francisco Estuary as a nursery habitat and (2) determine how reduced river flows below the proposed Peripheral Canal intake would affect the survival of juvenile Chinook salmon in the San Francisco Estuary (Brandes et al. 2000). After the defeat of the Peripheral Canal proposal in 1982, the goals of the DJFMP were changed to evaluating the impact of through-Delta water conveyance on juvenile Chinook salmon distribution and survival (Brandes et al. 2000).

Prior to 1992, the majority of the annual juvenile Chinook salmon monitoring was conducted between April and June during peak Chinook salmon emigration within the San Francisco Estuary. However, after the Sacramento River winter-run Chinook salmon was listed as “Endangered” under the California Endangered Species Act (CESA) in 1989 (CDFG 2005) and under the Endangered Species Act of 1973 (ESA) in 1994 (NMFS 2009), goals expanded to include monitoring the abundance, distribution, and survival of juvenile Chinook salmon in the Estuary annually from September to June (Brandes et al. 2000). Other listings of fishes occurring in the San Francisco Estuary followed (USFWS 1995; CDFG 2005; NMFS 2009). For example, the delta smelt was listed as “Threatened” under the CESA and ESA in 1993, the Central Valley steelhead and spring-run Chinook salmon were listed as “Threatened” under both the CESA and ESA in 1999, and the longfin smelt was listed as “Threatened” under the CESA in 2009 (USFWS 1995; CDFG 2005; CDFG 2009; NMFS 2009).

In response to the additional fish listings and a program review in 2000, the DJFMP expanded its goals further to include monitoring all juvenile fishes throughout the year to detect trends in the relative abundance and distribution of fish species of management concern in the San Francisco Estuary. Although the DJFMP had historically recorded data on non-salmonid fishes, it was not until 2001 that program objectives were broadened to reflect the value of gathering information on non-salmonid species. In recognition of the value of understanding assemblage-level responses and biotic interactions in the Delta, data from all species captured have been reported in the DJFMP annual reports since 2006.

Current Objectives

The fish data collected by the DJFMP are intended to provide basic biological and demographic information that can be used by natural resource managers to evaluate the effectiveness of water operations and fish management practices within the San Francisco Estuary and its watershed. This report will primarily focus on non-benthic fishes of management concern based on the limitations of the sampling methodologies and locations used by the DJFMP. Fishes of management concern include juvenile fall-, late fall-, winter-, and spring-run Chinook salmon, steelhead, delta smelt, longfin smelt, Sacramento splittail, striped bass, and threadfin shad; USFWS 1995; CDFG 2009; NMFS 2009; MacNally et al. 2010; USFWS 2011). The objectives of the annual report for the 2010 (August 1, 2009 to July 31, 2010) and 2011 (August 1, 2010 to July 31, 2011) field seasons were to:

1. Determine the relative abundance, and spatial and temporal distributions of unmarked juvenile fall-, late fall-, winter-, and spring-run Chinook salmon migrating through the San Francisco Estuary.

2. Report the recovery of marked juvenile fall-, late-fall, winter-, and spring-run Chinook salmon migrating through the San Francisco Estuary.

3. Estimate the annual absolute abundance of unmarked juvenile fall-, late fall-, winter-, and spring-run Chinook salmon emigrating out of the Delta.

4. Report the relative abundance of unmarked juvenile Chinook salmon near Sacramento to inform future water operations during periods of possible water diversion.

5. Report the relative abundance, and spatial and temporal distributions of other fishes of management concern observed within the San Francisco Estuary.

6. Relate the relative abundance of fish species of management concern to river discharge.

7. Determine the length frequency distributions of fish species of management concern captured during the 2010 and 2011 field seasons.

METHODS

Monitoring Locations

The San Francisco Estuary consists of three distinct segments: the Sacramento – San Joaquin Delta, Suisun Bay, and San Francisco Bay (Moyle 2002). During the 2010 and 2011 field seasons, the DJFMP sampled at 58 beach seine sites and 3 trawl sites located within the lower Sacramento and San Joaquin rivers, at and between the entry and exit points of the Delta, and within the San Francisco Bay (Figure 1; Table A1). The DJFMP has sampled the majority of these sites annually since the mid-1990s (Table A1).

We used surface trawls to facilitate our understanding of the relative abundance of fishes migrating through the San Francisco Estuary. Trawl sites were located at the entry (Sacramento and Mossdale Trawl sites) and exit (Chipps Island Trawl Site) points of the Sacramento – San Joaquin Delta (Figure 1; Table A1). The DJFMP attempted to sample each trawl site three days per week, ten times per day throughout the 2010 and 2011 field seasons. Trawl sites were generally sampled Monday, Wednesday, and Friday each week throughout the field season to maximize temporal coverage. The CDFG has traditionally sampled the Mossdale Trawl Site, following similar methodologies, in place of the DJFMP between April and June (SJRGA 2005). Data collected from both the DJFMP and CDFG at the Mossdale Trawl Site are included in this report.

We used beach seines to quantify the spatial distribution of fishes occurring in shallow habitats (e.g., beaches and boat ramps <1.2 m in depth) throughout the lower Sacramento and San Joaquin rivers and the San Francisco Estuary. Beach seine sites were stratified into seven geographic regions: (1) Lower Sacramento River Seine, (2) North Delta Seine, (3) Central Delta Seine, (4) South Delta Seine, (5) Lower San Joaquin River Seine (6) San Francisco and San Pablo Bay Seine and (7) Sacramento Area Seine (Figure 1; Table A1). Seine regions were delineated by proximity to canals or water bypasses where fish may be diverted from historical migration routes. Fish movement patterns within regions were assumed to be similar.

In this dynamic system, occasional changes in river flow or environmental conditions prevent sampling or make it necessary to temporarily relocate seine sites. If new seine sites were needed, we attempted to relocate the site to another suitable location with similar habitat (e.g., hydrogeomorphic characteristics) that was less than 100m from the original site. Different combinations of beach seine sites were sampled within the Lower San Joaquin River Region during the 2010 and 2011 field seasons based on fluctuations in site accessibility as a result of river flow conditions (Table A1). When the discharge of the lower San Joaquin River was greater than 51 m^3/s, the historic beach seine sites were accessible by boat and sampled. Conversely, when the discharge of the lower San Joaquin River was below 51m^3/s, the river was no longer navigable by boat and only the beach seine sites that were accessible by land were sampled (Table A1). More information on seine site relocations or other seine monitoring site modifications can be found in the STFWO Metadata file at http://www.fws.gov/stockton/jfmp/datamanagement.asp.

We attempted to sample fishes at the beach seine sites one day per week, one time per day throughout the 2010 and 2011 field seasons within all seine regions except the Sacramento Area Seine Region, the Lower San Joaquin River Region, and the San Francisco and San Pablo Bay Seine Region. The beach seine sites that were located within the Sacramento Area Seine Region were generally sampled three days per week, one time per day from October 1st to January 31 st to better detect ESA listed winter- and spring-run Chinook salmon migrating near the Delta Cross Channel during periods of potential water diversion (Brandes et al. 2000). The beach seine sites that were located within the Lower San Joaquin River Region were generally sampled one day per week, one time per day from January 1st to July 31st and one day every two weeks from August 1st to December 31st based on minimal occurrence of fishes of management concern coupled with poor accessibility to seine sites. The beach seine sites that were located within the San Francisco and San Pablo Bay Seine Region were generally sampled one day per two weeks, one time per day throughout the 2010 and 2011 field seasons based on logistical limitations and the low occurrence of fish species of management concern.

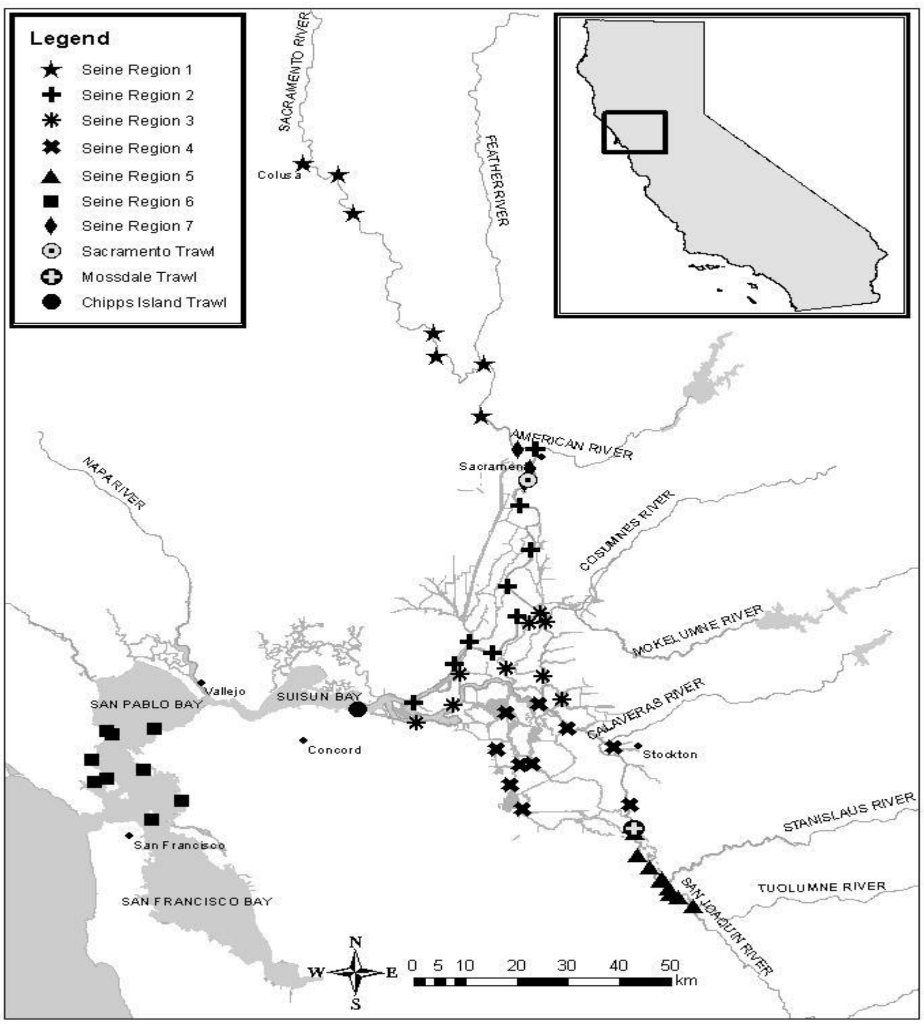

Figure 1. Sites sampled during the 2010 and 2011 field seasons within the lower Sacramento and San Joaquin rivers and San Francisco Estuary.

Beach Seine Methodology

Sampling at beach seine sites was conducted between sunrise and sunset. We sampled using a 15.2 x 1.3 m beach seine net with 3 mm delta square mesh, a 1.2 m bag in the center of the net, and a float line and lead line attached to 1.8 m tall wooden poles on each side. In general, beach seines were deployed along the shoreline by two crew members within unobstructed habitats including boat ramps, mud banks, and sandy beaches. When sampling mud dominated habitats (i.e., dominated by substrata with particles < 62.5 µm in diameter), we applied rollers to the lead line of the beach seine to limit the net from sinking into the substrate and impeding the completion of the seine.

The beach seines were generally deployed starting from the downstream portion of each site to limit disturbance (e.g., displacement of sediment into the site). Crew member 1 distributed the seine into the water, perpendicular from the shoreline, as crew member 2 secured the opposite end of the seine to the shoreline (Figure 2a). After reaching a depth of up to 1.2 m, a distance (i.e., length) of up to15 m, or an obstacle, crew member 1 measured and recorded the distance to the shoreline and depth to the nearest 1 m and 0.1 m, respectively (Figure 3). Obstacles were defined as structure that could compromise safety or gear efficiency including steep banks or holes, fast water current, submerged aquatic vegetation, or large woody debris. Next, crew member 2 carried their end of the seine to crew member 1 and placed their end of the seine in the same location as crew member 1. The seine was then distributed from that point upstream and as parallel to the shoreline as possible by crew member 1 (Figure 2b). When crew member 1 reached a depth of up to 1.2 m, a distance (i.e., width) of up to15 m, or an obstacle that could compromise safety or gear efficiency, crew member 1 would stop and the width and depth of the seine was measured to the nearest 1 m and 0.1 m, respectively (Figure 3). If the depths of the seine varied between measurements, the maximum seine depth was obtained by averaging the two depth measurements. Lastly, crew members 1 and 2 pulled the ends of the seine simultaneously toward (i.e., perpendicular) the shoreline while attempting to maintain the starting distance (i.e., seine width) apart (Figure 2c). The net was continuously pulled towards the shoreline until the lead line of the seine's bag was on shore (Figure 2d). After the seine haul was completed, all fish were collected from the bag and other parts of the seine and placed in a holding container filled with river water for processing.

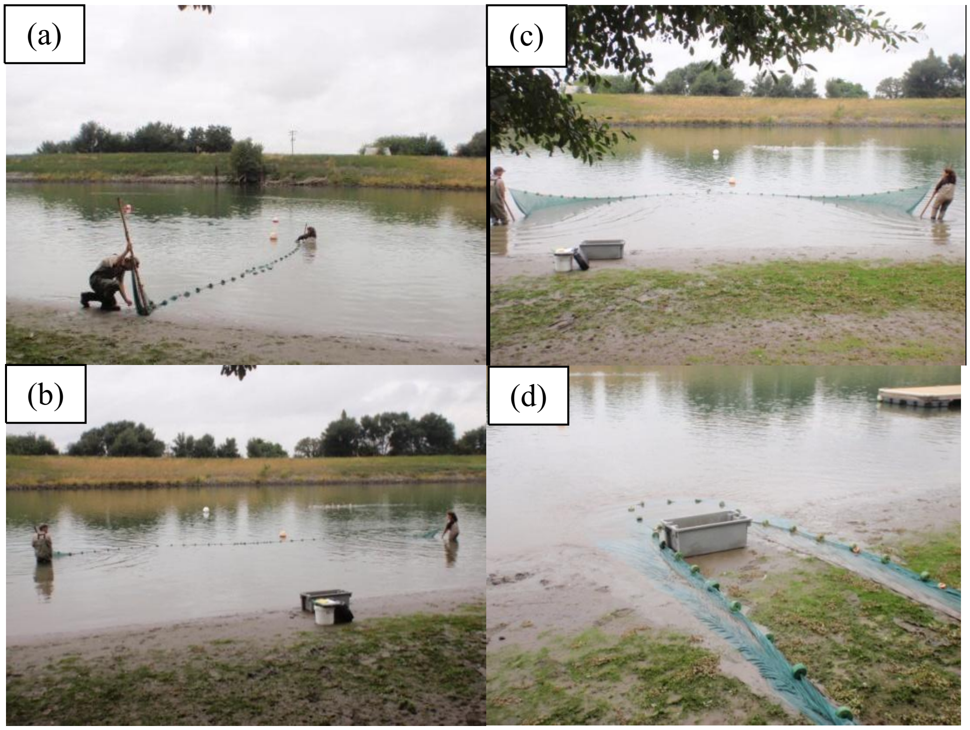

Figure 2. Photographs of the DJFMP conducting a beach seine at station SR024E on the bank of the Sacramento River: seine (a) deployed downstream of site, (b) distributed upstream parallel to the shoreline, (c) pulled in toward the shoreline, and (d) position at the end of a haul.

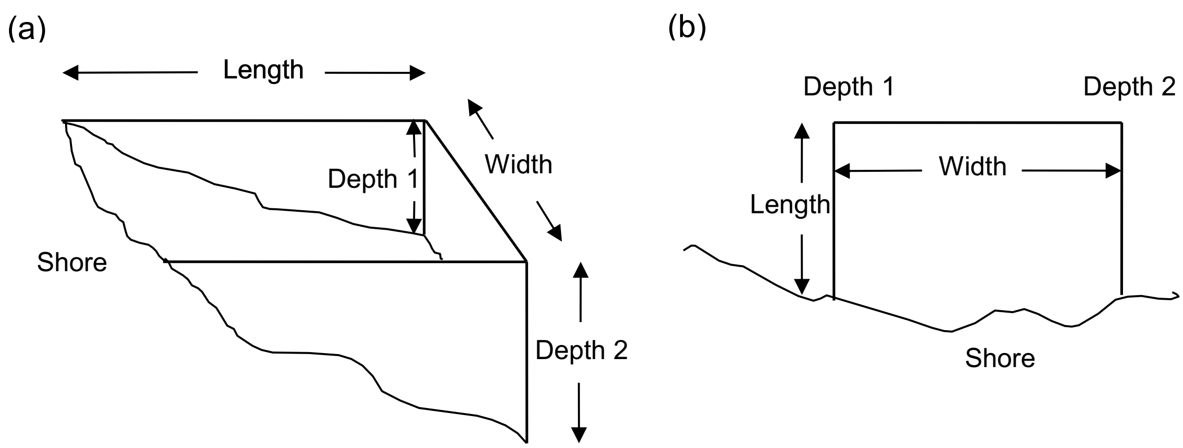

Figure 3. Schematic diagram of beach seine measurements: (a) three-dimensional view and (b) overhead view.

Trawl Methodology

We sampled at trawl sites with Kodiak (KDTR) and mid-water (MWTR) trawls. The DJFMP exclusively uses a MWTR at the Chipps Island Trawl Site and a KDTR at the Mossdale Trawl Site. The Sacramento Trawl Site has exclusively used a MWTR prior to 1994, and has used a KDTR from October to March and a MWTR for the remainder of each field season thereafter (Brandes et al. 2000). The KDTR has been used in place of the MWTR at the Sacramento Trawl Site to maximize the capture of larger Chinook salmon (Brandes et al. 2000).

During each sampling day, we attempted a maximum of ten 20-minute tows between sunrise and sunset, at all trawl sites. All tows were conducted facing upstream in the middle of the channel at the Sacramento and Mossdale Trawl sites, which constitute a reach length approximately 6.5 km and 3 km, respectively. In contrast, tows were generally conducted facing both upstream and downstream, regardless of tidal stage, in the north, south, and middle portions of the channel at the Chipps Island Trawl Site, which constitutes a reach length of approximately 4 km. The MWTR and KDTR nets were towed by one and two boats, respectively, in the top few meters of the water column at a speed necessary and distance apart (for KDTR) to ensure the net mouth remained fully extended and submerged. The measure of the distance traveled during each tow was recorded using a mechanical flow meter (General Oceanics, Model #2030). In general, the Sacramento MWTR net was towed at speeds between 0.7-1.0 meters per second (m/s), the Chipps Island MWTR net was towed at speeds between 0.9-1.12 m/s, and the KDTR nets were towed at speeds between 0.45-0.67 m/s at both the Mossdale and Sacramento Trawl sites.

The Sacramento MWTR net was composed of six panels, each decreasing in mesh size towards the cod end (Figure 4). The mesh size for each panel ranged from 20.3 cm stretch at the mouth to 0.6 cm stretch just before the cod end. The cod end was composed of 0.3 cm weave mesh. The fully extended mouth size was 4.15 x 5 m. Two depressors and hydrofoils enabled the net to remain at the top few meters of the water column while sampling. Depressors were made of 0.7 cm thick stainless steel (one on each side of the net lead line) and were attached to the net with shackles to extend the bottom line of the mouth. Hydrofoils were made of 0.7 cm thick aluminum plates with split floats (one on each side of the net float line) and were attached to the net with shackles to extend the top of the net at the water's surface. On each side of the net, the depressor and hydrofoil were connected to the boat using a 30.5 m Amsteel rope bridle (0.64 cm diameter). The net was fished approximately 30 m behind the boat.

The MWTR net used at the Chipps Island Trawl Site was similar in construction to the MWTR net used at the Sacramento Trawl Site (Figure 5). There were five panels, each with decreasing mesh size towards the cod end. The mesh size for each panel ranged from 10.2 cm stretch at the mouth to 2.5 cm stretch just before the cod end. The cod end was composed of 0.8 cm knotless material. The fully extended mouth size of the Chipps Island MWTR net was 7.64 x 9.65 m. The depressors and hydrofoils of the Chipps Island MWTR were larger and were connected to the boat identically to those on the Sacramento MWTR. On each side of the net, the depressor and hydrofoil were connected to the boat using a 30.5 m Amsteel rope bridle (0.6 cm diameter) attached to a 15.2 m tow rope (0.95 cm diameter). As a result, the Chipps Island MWTR net was fished approximately 45 m behind the boat.

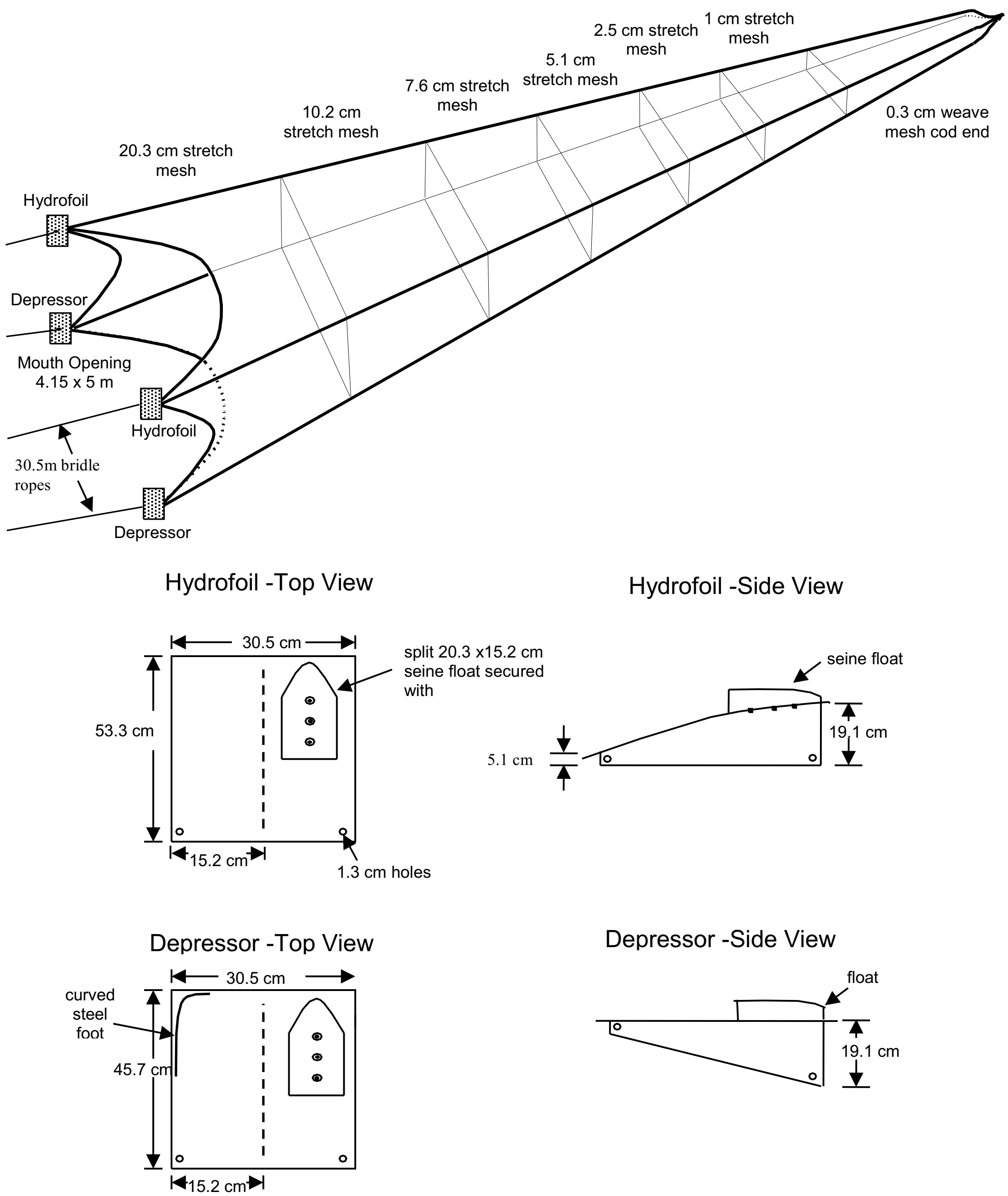

Figure 4. Schematic drawing of mid-water trawl net (top), and hydrofoils and depressors (bottom) used at the Sacramento Trawl Site during the 2010 and 2011 field seasons.

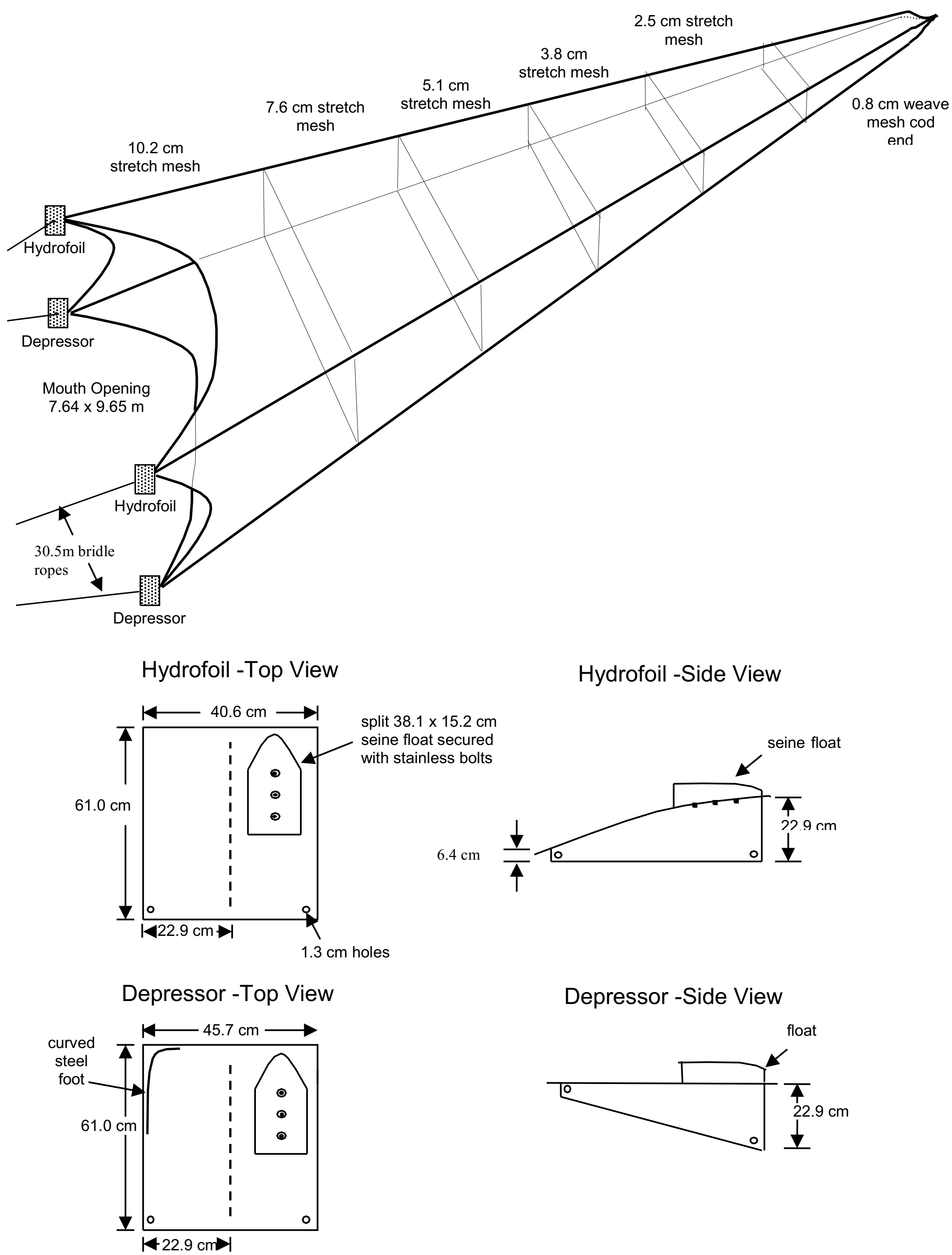

Figure 5. Schematic drawing of mid-water trawl net (top) and hydrofoils and depressors (bottom) used at the Chipps Island Trawl Site during the 2010 and 2011 field seasons.

The KDTR nets used at the Mossdale and Sacramento Trawl sites were composed of five panels, each decreasing in mesh size towards a live box at the cod end (Figure 6). The mesh size for each panel ranged from 5.1 cm stretch at the mouth to 0.6 cm stretch just before the live box. The live box (36 cm wide x 36 cm tall x 49 cm long) was composed of 0.18 cm think aluminum that was perforated with numerous 0.46 cm diameter holes. The live box contained several internal baffles to minimize fish mortality and stress due to flow pressure. The fully extended mouth size of the KDTR nets were 1.96 x 7.62 m. A float line and lead line enabled the nets to remain at the top few meters of the water column while sampling. In addition, at the front of each wing of the net was a 1.83 m bar with floats at the top and weights at the bottom to keep depth constant while sampling. The KDTR nets were connected to the boats using a 2.3 m rope bridle (2.4 cm diameter) attached to a 30.5 m tow rope (0.95 cm diameter) on each side of the net. The net was fished approximately 31 m from the boats.

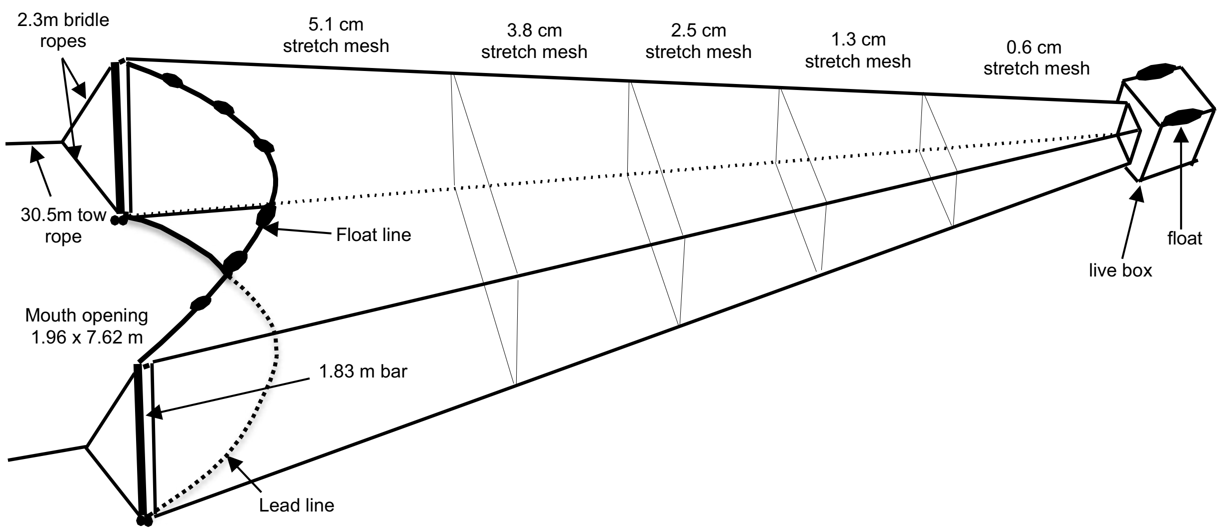

Figure 6. Schematic drawing of Kodiak trawl net used at Sacramento and Mossdale Trawl sites during the 2010 and 2011 field seasons.

At the end of each tow, the MWTR nets were retrieved by the towing vessel using winches to collect all the fishes observed in the cod ends. Whereas at the end of each tow using the KDTR nets, the two towing vessels (i.e., net and chase boats) would come together and the chase boat would transfer its tow rope to the net boat. The crew on the chase boat would then retrieve the live box from the KDTR net and collect all the fishes observed. All fishes collected from the cod ends or live boxes were placed in a holding container filled with river water for processing.

Fish Processing

We identified all fish in each sample to species or race that were ≥25 mm fork length (FL) , with the exception of five species that were readily identified at ≥ 20 mm FL (e.g. Sacramento splittail). Prior to release at the site of capture, we measured fish to the nearest 1 mm FL. If greater than 50 individuals of a Chinook salmon race or other species of management concern were collected, a sub sample of at least 50 individuals were randomly measured for FL. Fish that could not be accurately identified in the field were initially preserved in the field and brought back to the laboratory. Preserved fishes were later identified to species or race and measured for FL.

Only juvenile Chinook salmon and steelhead with missing (i.e., clipped) adipose fins were considered marked fish. Fish possessing other forms of marks (e.g., stain dye, disc tags, hydro-acoustic tags, etc.) were not included within this report to further minimize the influence of recaptures and/or unnatural occupancy induced by other fishery investigations. All marked juvenile steelhead were considered to be reared in a hatchery and all unmarked juvenile steelhead were considered wild (i.e., spawned outside of a hatchery). Hatcheries within the Central Valley have marked nearly all hatchery reared steelhead for management purposes since 1997 (Kevin Niemela, USFWS, personal communication). All marked juvenile Chinook salmon during the 2010 and 2011 field seasons were considered hatchery reared and assumed to contain a coded wire tag (CWT). In general, hatcheries have attempted to mark and tag most winter-, spring- and late fall-run juvenile Chinook salmon within the Central Valley. Conversely, hatchery marking ad tagging rates of juvenile fall-run Chinook salmon have varied considerably (5-95%; Johnson 2004). Starting in 2007, Central Valley hatcheries began implementing the constant fractional marking of produced juvenile fall-run Chinook salmon where at least 25% of individuals are marked and tagged (Kevin Niemela, USFWS, personal communication). Therefore, we considered all unmarked juvenile Chinook salmon either wild (i.e., spawned outside of a hatchery) or unmarked hatchery reared individuals.

Because recovered CWTs can provide a variety of important biological information (e.g., an individual's race, hatchery of origin, date and location released in the Sacramento-San Joaquin River basin, etc.) to natural resource managers, all marked Chinook salmon were preserved in the field and brought back to the laboratory. In the laboratory, marked fish were checked for a CWT, and, if present, had their CWT removed, read, and recorded. The DJFMP also processed the marked Chinook salmon recovered at the State Water Project (SWP) and the Central Valley Water Project (CVP) pumping facilities for CWTs during the 2010 field season. CWT data collected from the DJFMP, SWP, and CVP were included in this report. We obtained all CWT information (e.g., race and release location) from the Regional Mark Information System maintained by the Pacific States Marine Fisheries Commission (PSMFC 2012).

The race of all unmarked juvenile Chinook salmon was determined using the size at date of capture river criteria developed by Fisher (1992) and modified by Greene (1992). The assumptions associated with the size at date of capture river criteria for the Sacramento-San Joaquin River basin include that the (1) spawning of fall-run Chinook salmon occurs between 1Oct – 31Dec, (2) spawning of late fall-run Chinook salmon occurs between 1Jan – 15Apr, (3) spawning of winter-run Chinook salmon occurs between 16Apr – 15Aug, (4) spawning of spring-run Chinook salmon occurs between 16Aug – 30Sep, and (5) growth rate of juveniles is identical among all races of Chinook salmon (Fisher 1992). Although one or more of these assumptions are likely violated (Fisher 1994; Yoshiyama et al. 1998), the river criteria is currently widely used by managers, and is the only cost effective and logistically feasible way to differentiate between the different races of juvenile Chinook salmon in the field. Fisher (1994) noted that Chinook salmon races within the Central Valley do appear to spawn at distinctly separate time periods except for fall- and spring-run due to the loss of headwater habitats (e.g., dams), forced coexistence, and subsequent hybridization within the Sacramento River Basin (Cope and Slater 1957; Slater 1963). As a result, many of the Chinook salmon characterized as spring-run by the size at date of capture river criteria may be fall-run within the Estuary. Therefore, the race designations used in this report should be considered a rough approximation and not interpreted as definitive, particularly differentiating between fall- and spring-run. Ongoing genetic analyses of DNA genotypes are underway to help elucidate the accuracy of the size at date of capture river criteria to determine all Chinook salmon races within the San Francisco Estuary (e.g., Banks et al. 2000; Greig et al. 2003).

Because fall-run Chinook salmon are reportedly the only race to still occur within the San Joaquin River and its main tributaries (Yoshiyama et al. 1998), all juvenile Chinook salmon collected at the Mossdale Trawl Site and within the Lower San Joaquin River Seine Region (Region 5) were classified as fall-run regardless of their size at the date of capture. Although the South and Central Delta Seine regions are located within the San Joaquin River basin, there is potential for spring-, winter-, and late fall-run juveniles of Sacramento River origin to migrate into the interior delta through the Georgiana Slough, the Delta Cross Channel, and the San Joaquin River during water diversions or transfers. Therefore the size at date of capture river criteria was still used to determine the race of juvenile Chinook salmon within the South and Central Delta Seine regions.

Relative Abundance Calculations

For each species or race, samples from each gear type were standardized to catch-per-unit effort (CPUE) as fish per unit volume (fish / 10,000 m^3) using the following equations:

$$\text{Seine CPUE} = \frac{\text{Catch}}{\frac{1}{2}\text{Depth} \times \text{Width} \times \text{Length}} \times 10{,}000 \qquad (1)$$

$$\text{Trawl CPUE} = \frac{\text{Catch}}{\text{Distance Traveled} \times \text{Net Mouth Area}} \times 10{,}000 \qquad (2)$$

Effort was measured by the volume of water sampled by a beach seine, KDTR, or MWTR. By assuming a constant slope from the shore to the maximum seine depth, the volume of the water sampled using beach seines was calculated by using ½ x depth in calculations. Because the MWTR and KDTR nets do not open completely while under tow and net mouth dimensions vary within and among tows (USFWS 1993), we used previously quantified estimates of mean net mouth area for this report. The mean net mouth area for MWTR nets used for the Chipps Island and Sacramento Trawl sites were obtained from 3-4 physical measurements taken while sampling and were reported as 18.58 m^2 and 5.08 m^2, respectively (USFWS 1993). The mean net mouth area for KDTR nets used for the Mossdale and Sacramento Trawl sites were obtained by extrapolating from the mean net mouth area of the MWTRs and were reported as 12.54 m^2 (USFWS 1998).

The relative abundance of fishes of management concern is presented as mean monthly and yearly CPUE values. We treated species, seine regions, trawl sites, and gear types separately for all mean CPUE calculations. Because the number of samples collected varied within and among weeks for sites within seine regions and trawl sites, data were summarized using daily, weekly, monthly, and yearly CPUE averages to minimize the overweighting of sample days and/or locations.

The mean daily CPUE was calculated as the sum of the trawl or seine CPUE for a trawl or seine site during each sample day divided by the number of samples taken each day. The mean weekly CPUE was calculated for trawl sites and seine regions as the sum of the mean daily CPUE for a trawl or seine site during each sample week divided by the number of days sampled each sample week. Subsequently, the mean weekly CPUE values were averaged among seine sites within regions. A sample week was defined as Sunday to Saturday. The mean monthly CPUE was calculated as the sum of the mean weekly CPUE for a trawl site or seine region during each calendar month divided by the number of sample weeks sampled each calendar month. If a sample week occurred in more than one calendar month, the sample week was assigned to the calendar month that contained the start of the sample week. The mean yearly CPUE was calculated as the sum of the mean monthly CPUE for a trawl site or seine region during each field season divided by the number of months sampled each field season.

For inter-annual comparisons of CPUE for all fishes of management concern, we generally calculated mean yearly CPUE values starting in the 2000 field season. Sampling methods have generally remained consistent from 2000 to the present, including year round sampling and standardized gears and mesh sizes. However, we calculated mean yearly CPUE values for the Mossdale Trawl Site only during the 2004 through 2011 field seasons for fishes of management concern because the start of year round collaborative sampling with the CDFG did not occur until January 2003. Prior to the 2004 field season, the only months consistently sampled at the Mossdale Trawl Site were April through June by the CDFG. As a result, we did not report only April through June data because the DJFMP was not involved in the sampling and these data have been already reported annually by the CDFG. In addition, we calculated mean yearly CPUE values from April to June during the 1978 through 2011 field seasons for fall-run Chinook salmon at Chipps Island. We also calculated mean yearly CPUE values during the 1995 through 2011 field seasons for all races of juvenile Chinook salmon and steelhead at the Chipps Island Trawl Site given the site's historical context for monitoring juvenile salmonids. Prior to the 1995 field season, the Chipps Island Trawl Site was only consistently sampled by the DJFMP from April through June to target juvenile fall-run Chinook salmon, and was sampled in all months thereafter to monitor all Chinook salmon races.

We also calculated and graphed the mean monthly CPUE of all fishes of management concern to make intra-annual comparisons during the 2010 and 2011 field seasons. We only calculated the CPUE of unmarked juvenile winter- and spring-run Chinook salmon for the Sacramento Area Seine Region to reflect the objective of monitoring the presence of ESA listed Chinook salmon races near the Delta Cross Channel during periods of potential water diversion. The Sacramento Area Seine Region was presented separate from all other seine regions based on seasonal sampling and the inclusion of data collected at seine sites from other seine regions in the CPUE calculations.

Length Frequency

We calculated length frequency distributions for all species of management concern during the 2010 and 2011 field seasons for each seine region and trawl site. In cases where fish of management concern were "plus counted" or not measured within a sample, the FLs of the unmeasured fish were obtained by extrapolating from the fish that were measured within the sample. For example, if 100 individuals were plus counted within a sample and 20% of the measured individuals had a FL of 45 mm, we assumed that 20 of the 100 plus counted individuals also possessed a FL of 45 mm. Because we identified the race of unmarked juvenile Chinook salmon using the size at date of capture river criteria, we reported the length frequency distribution of all unmarked juvenile Chinook salmon together for each seine region and trawl site without any race distinction to avoid bias.

Absolute Abundance Calculation

The absolute abundance of unmarked juvenile fall-, late fall-, winter-, and spring-run Chinook salmon emigrating out of the San Francisco Estuary were estimated monthly from the 1978 to 2011 field seasons using the data collected at the Chipps Island Trawl Site. Annual comparisons of the absolute abundance of unmarked juvenile Chinook salmon were limited to years and months when sampling was relatively consistent. The monthly absolute abundance of unmarked juvenile fall-, late fall-, winter-, or spring-run Chinook salmon (N) was estimated using the methods modified from Kjelson (1987) as:

$$N_i = \frac{n_i}{t_i \text{ x } \overline{TRR}} \qquad (3)$$

where *i* indexes months, n_i represents the total number of unmarked juveniles collected at the Chipps Island Trawl Site during a month, t_i represents the fraction of time the Chipps Island Trawl Site was sampled during a month, and $\overline{TRR}$ represents the mean trawl recovery rate at the Chipps Island Trawl Site. The assumption of this approach is that juvenile salmon are equally distributed in time as they migrate past Chipps Island and are never recaptured.

The trawl recovery rate (TRR) at the Chipps Island Trawl Site was estimated using the capture of CWT juvenile Chinook salmon released approximately10 and 12 km upstream of the Chipps Island Trawl Site at Sherman Island or Jersey Point, respectively, as:

$$TRR_k = \frac{n_{recovered}}{n_{available}} \qquad (4)$$

where *k* indexes release groups at Sherman Island or Jersey Point, $n_{recovered}$ represents the total number of juvenile CWT Chinook salmon within a release group collected at the Chipps Island Trawl Site, and $n_{available}$ represents the number of juvenile CWT Chinook salmon within a release group available for collection at the Chipps Island Trawl Site. Recognizing that the TRR can vary among release groups based on differences in sampling effort, $n_{available}$ was estimated for each release group as:

$$n_{available} = n_{released} \times t \quad (5)$$

where $n_{released}$ represents the total number of CWT juvenile Chinook salmon within a release group and t represents the fraction of time the Chipps Island Trawl Site was sampled from the first recovery to the last recovery of CWT juvenile Chinook salmon in the release group. The assumption of this approach is that juvenile Chinook salmon within a release group are equally distributed in time and have 100% survival.

A release group was defined as a group of CWT juvenile Chinook salmon that had the same hatchery origin and were released at the same location and time. A total of 74 releases have occurred at Sherman Island or Jersey Point from field seasons 1989 to 2011. All release groups at Sherman Island and Jersey Point were included in the calculation of $\overline{TRR}$ to maximize sample size and obtain a more robust estimate. Fork lengths from the release groups ranged from 76 mm to 183 mm (mean = 93 mm), which covers the size range of the majority of unmarked juvenile Chinook salmon historically collected at Chipps Island. All release group data were obtained through the Regional Mark Information System (PSMFC 2012).

The $\overline{TRR}$ was calculated as an average of TRRs weighted by the number of individuals within each release group. To incorporate uncertainty in the estimated $\overline{TRR}$, the monthly absolute abundance estimates were calculated using the $\overline{TRR}$ and its 95% confidence limits. We calculated absolute abundance estimates from April to June during the 1978 through 2011 field seasons for fall-run Chinook salmon and calculated annual absolute abundance estimates during the 1995 through 2011 field seasons for all races of Chinook salmon to reflect increases in sampling frequency throughout the field season at Chipps Island during the 1990s.

River Flow Conditions

River flow data were obtained from the USGS and CDWR (USGS 2012; CDWR 2012a). We obtained mean daily discharge data at the Colusa (River Mile, RM 144) and Freeport (RM 48) gauging stations on the lower Sacramento River, and at the Vernalis (RM 114) gauging station on the lower San Joaquin River to represent the primary flow inputs into the Estuary. Further, daily Delta outflow estimates were obtained from Dayflow (CDWR 2012a) to estimate discharge past Chipps Island towards the San Francisco Bay, which takes into account water exports. We also obtained water year type classifications for the Sacramento and San Joaquin River basins from the California Data Exchange Center (CDWR 2012b).

We presented the mean monthly CPUE of fishes of management concern along with mean monthly discharge during the 2010 and 2011 field seasons to examine species relationships with flow. Similarly, we compared the yearly CPUE of fishes of management concern along with mean yearly discharge at each trawl site and seine region. In addition, we related the mean weekly CPUE with mean weekly discharge for the 2010 and 2011 field seasons for fish species that appeared to have a distinct relationship to river discharge. The mean CPUE estimates of fishes of management concern within a seine region or trawl site were related to mean discharge estimates thought to represent discharge within the trawl site and seine regions. Generally, the CPUE of fishes within the Lower Sacramento River Seine Region were related to discharge data measured at Colusa. The CPUE of fishes within the North Delta Seine Region and the Sacramento Trawl Site were related to discharge data measured at Freeport. The CPUE data from the Lower San Joaquin River Seine Region, South Delta Seine Region, Central Delta Seine Region, and the Mossdale Trawl Site were related to discharge data measured at Vernalis. Finally, the CPUE of fishes within the Chipps Island Trawl Site and San Francisco and San Pablo Bay Seine Region were related to estimated delta outflow (henceforth referred to as delta discharge) data. The mean weekly CPUE of each species of management concern were related to flow conditions only during months of occurrence within each seine region or trawl site to account for possible seasonal migration patterns.

Water temperature data were also obtained from the USGS and CDWR to compliment available discharge data (USGS 2012; CDWR 2012b). We obtained daily maximum water temperature data from the Mallard Island gauging station during the 1989 to 2011 field seasons to represent the temperature of water exiting the Delta (CDWR 2012b). The Mallard Island gauging station is the only water station near the Chipps Island Trawl Site that provided continuous water temperature data prior to the 2000 field season. We also obtained daily maximum water temperature data from the Freeport and Vernalis gauging stations to represent the temperature of water entering the Delta from the Sacramento and San Joaquin rivers, respectively during the 2000 to 2011 field seasons. Within this report, we calculated the mean maximum water temperature by month and field season.

RESULTS AND DISCUSSION

During the 2010 and 2011 field seasons, a total of 12,902 fish samples (e.g., seine hauls or trawl tows) were collected without any severe gear malfunctions and were included in our analysis. We completed 2,954 trawl tows at the Chipps Island Trawl Site, 3,441 trawls at the Mossdale Trawl Site, and 2,717 trawl tows at the Sacramento Trawl Site. The trawl tows were evenly distributed throughout the 2010 and 2011 field seasons (Tables A2 and A3). As a result, inter- and intra-annual trawl catch comparisons were considered robust due to minimal spatial and temporal bias.

Conversely, there was considerable spatial and temporal variability in the number of samples collected at sites within nearly all seine regions during the 2010 and 2011 field seasons (Tables A4 - A17). For example, on average only approximately 50% and 53% of the historically sampled sites within the South Delta Seine Region were effectively sampled during sample weeks within the 2010 and 2011 field seasons, respectively (Tables A12 and A13). The number of samples collected within the South Delta Seine Region during the 2010 (n=256) and 2011 (n=275) field season were considerably lower than the previous decade's annual average ($\bar{x}$=329, SE=15.7). In addition, on average only approximately 31% and 26% of the historically sampled sites within the Lower San Joaquin Seine Region were effectively sampled during sample weeks within the 2010 and 2011 field seasons, respectively (Tables A14 and A15). The number of samples collected within the Lower San Joaquin River Seine Region during the 2010 (n=120) and 2011 (n=99) field season were considerably lower than the previous decade's annual average ($\bar{x}$=160, SE=4.88). As a result, catch data associated with these seine regions may contain both inter- and intra-annual bias.

Throughout the 2010 and 2011 field seasons, the inability to effectively sample sites resulted from high tides, the expansion of submerged, emergent, and floating aquatic vegetation, and extreme river discharge (e.g., high and low). However, the Sacramento Area Seine Region appeared to be only sampled one day per week versus the traditional three days per week throughout the month of January during both the 2010 and 2011 field seasons (Tables A8 and A9) likely due to scheduling errors. The DJFMP is currently investigating the feasibility of implementing a stratified random sampling design for beach seining within the San Francisco Estuary or replacing problematic seine sites with suitable and adaptable replicates to reduce the impact of recent and growing inaccessibility to fixed sites within seine regions. New sampling methods or sites are needed to re-establish and ensure future continuity of non-biased representative catch data.

Within this report, seine catch data were primarily used to evaluate the general temporal and spatial distribution patterns (i.e., occupancy) of fish within the San Francisco Estuary. Although the spatial and temporal variability of the samples collected within seine regions can affect occupancy patterns (e.g., discerning between false absences within regions; decreasing detection probability with fewer samples), the DJFMP seine catch data does successfully document the presence of fishes at a given time and location. However, detection probability and the probability of reporting false absences (present but not captured) remain unknown.

A total of 441,889 fishes, representing 77 different species, were captured during the 2010 and 2011 field seasons (Table A18 and A19). Sixty-five percent (n=288,825) of the fishes were observed during the 2011 field season. Approximately 71% (n=109,279) and 41% (n=116,649) of the fishes captured during the 2010 and 2011 field seasons were identified as species not native to the San Francisco Estuary, respectively. A total of 5,428 fishes were unable to be accurately identified during the 2010 and 2011 field seasons. All unidentified fish were observed at the Mossdale Trawl Site during the period when the CDFG conducted sampling. Of the 77 species observed, the inland silverside (*Menidia beryllina*), Sacramento splittail, juvenile Chinook salmon, red shiner (*Cyprinella lutrensis*), Sacramento sucker (*Catostomus occidentalis*), American shad (*Alosa sapidissima*), and threadfin shad comprised 84% and 87% of the total catch during the 2010 and 2011 field seasons, respectively. The Sacramento sucker was the most common species observed and comprised 25% (n=14,174) of all fishes captured in the Lower Sacramento River Seine Region (Region 1) during the 2010 and 2011 field seasons (Table A18 and A19). Within the Lower San Joaquin River Seine Region (Region 5), the red shiner was the most common species observed and comprised 50% (n=24,616) of all fishes captured. The inland silverside was the most common species observed and comprised 58% (n=106,072) of all fishes captured in the North Delta (Region 2), Central Delta (Region 3), and South Delta (Region 4) Seine regions. Within the San Francisco/San Pablo Bay Seine Region (Region 6), the top smelt (*Atherinops affinis*) was the most common fish species observed and comprised 60% (n=9,620) of all fishes captured. At the Chipps Island Trawl Site, the American shad was the most common species observed and comprised 52% (n=18,137) of the fishes captured during the 2010 and 2011 field seasons. Conversely, the juvenile Chinook salmon and Sacramento splittail were the most common species captured at the Sacramento and Mossdale Trawl sites, respectively.

The higher proportion of native fishes observed during the 2011 field season relative to the 2010 field season may have resulted, in part, from higher recruitment of a few native fishes (i.e., Sacramento splittail and Chinook salmon) in response to higher in-river flows and cooler water temperatures within the San Francisco Estuary and its watershed. The water year classification index for 2011 was identified as "wet" within both the Sacramento and San Joaquin River basins. Conversely, the index for 2010 was identified as below normal and above normal within the Sacramento and San Joaquin River basins, respectively. Indices from 2007 to 2009 were also generally identified as "dry" or "critically dry" (Table A20; CDWR 2012b). In addition, the mean maximum water temperatures were, on average, lower during the months of February through June within the entry and exit points of the Delta during the 2011 field season relative to the 2010 field season (Tables A21-A23). Because the majority of the non-native fishes observed by the DJFMP are considered warm water species originating from the Mississippi River Basin (Tables A18 and A19; Moyle 2002), the aquatic habitats occurring within the San Francisco Estuary and the lower Sacramento and San Joaquin rivers were likely less optimal for non-native species in terms of spawning or rearing during the 2011 field season relative to native species.

Chinook salmon

We captured 11,389 and 20,556 juvenile Chinook salmon during the 2010 and 2011 field seasons, respectively (Tables A18 and A19). During the 2010 field season, 8,514 individuals were unmarked and 1.7% (n=145) were identified as winter-run, 83.6% (n=7,119) were identified as fall-run, 14% (n=1,194) were identified as spring-run, and less than 1% (n=56) were identified as late fall-run (Table A18). Of the 2,875 marked juvenile Chinook salmon recovered during 2010, 97% (n=2,791) contained a CWT (Table A24). During the 2011 field season, 18,451 individuals were unmarked and 1.5% (n=280) were identified as winter-run, 87.4% (n=16,117) were identified as fall-run, 10.9% (n=2,002) were identified as spring-run, and less than 1% (n=52) were identified as late fall-run Chinook salmon (Table A19). Of the 2,105 marked juvenile Chinook salmon recovered during 2011, 94% (n=1,984) contained a CWT (Table A25).

During the 2010 and 2011 field seasons, marked juvenile winter-run Chinook salmon containing a CWT were recovered by the DJFMP within the Lower Sacramento River Seine Region, the Sacramento Trawl Site, and the Chipps Island Trawl Site (Tables A24 and A25). All recovered CWT winter-run Chinook salmon were released by the Livingston Stone National Fish Hatchery which tagged and released 792,962 and 123,870 CWT juveniles during the 2010 and 2011 field seasons, respectively (PSMFC 2012). Marked juvenile spring-run Chinook salmon were recovered within the Lower Sacramento River and North Delta Seine regions, the Sacramento Trawl Site, and the Chipps Island Trawl Site during the 2010 and 2011 field seasons (Tables A24 and A25). All recovered CWT spring-run Chinook salmon were released by the Feather River Fish Hatchery which tagged and released 2,126,054 and 2,312,010 CWT juveniles during the 2010 and 2011 field seasons, respectively (PSMFC 2012). Marked juvenile fall-run Chinook salmon containing a CWT were recovered within the Lower Sacramento River, North Delta, Central Delta, Lower San Joaquin River, and Sacramento Area Seine regions, the Sacramento Trawl Site, the Mossdale Trawl Site, and the Chipps Island Trawl Site (Tables A24 and A25). In the 2010 field season, 17,828,674 CWT juvenile fall-run Chinook salmon were released in the combined release efforts of the Coleman National Fish Hatchery (16%), Feather River Fish

Hatchery (46%), Mokelumne River Fish Hatchery (11%), Nimbus Fish Hatchery (26%), and Merced River Fish Facility (1%; PSMFC 2012). In the 2011 field season, 9,244,498 CWT juvenile fall-run Chinook salmon were released in the combined release efforts of the Coleman National Fish Hatchery (35%), Feather River Fish Hatchery (31%), Nimbus Fish Hatchery (15%), and Merced River Fish Facility (1%; PSMFC 2012). During the 2010 and 2011 field seasons, marked juvenile late fall-run Chinook salmon containing a CWT were recovered within the Lower Sacramento River, North Delta, Central Delta, and Sacramento Area Seine regions, the Sacramento Trawl Site, and the Chipps Island Trawl Site (Tables A24 and A25). All recovered CWT late fall-run Chinook salmon were found to be released by the Coleman National Fish Hatchery which tagged and released a total of 1,154,761 and 1,011,972 CWT juveniles during the 2010 and 2011 field seasons, respectively (PSMFC 2012). During the 2010 field season, the Federal and State Fish facilities recovered 29 winter-run, eight fall-run, and 313 late fall-run CWT juvenile Chinook salmon (Table A24). Therefore, based on CWT recoveries by the DJFMP and fish facilities during the 2010 and 2011 field seasons, there is evidence that races specific to the Sacramento River Basin (e.g., winter-, spring-, and late fall-run) can occur within the Central and South Delta likely based on water diversions, exports, and tides. As a result, CWT recovery data further validates our application of the size at date of capture river criteria to identify the race of unmarked juvenile Chinook salmon captured in all seine regions with the exception of the Lower San Joaquin River Seine Region.

Unmarked Winter-Run Distribution and Relative Abundance

Unmarked juvenile winter-run Chinook salmon were captured in relatively low numbers within in the Lower Sacramento River, North Delta, Central Delta, and Sacramento Area Seine regions, the Sacramento Trawl Site, and the Chipps Island Trawl Site during the 2010 and 2011 field seasons (Tables A18 and A19). Individuals were generally captured from January through April at the Chipps Island Trawl Site and October through April at the Sacramento Trawl Site (Figures 7 and 8). The CPUE at the Sacramento Trawl Site peaked in February and December during the 2010 and 2011 field seasons, respectively. Conversely, the CPUE at the Chipps Island Trawl Site peaked in March and April during the 2010 and 2011 field seasons, respectively. Because there was generally a one to three month time lag in the first detection or peak CPUE of winter-run at the Sacramento and Chipps Island Trawl sites during both field seasons, there is evidence that unmarked juvenile winter-run may rear within the Sacramento and San Joaquin Delta for several weeks, which is similar to other runs within the Estuary (Kjelson et al. 1982). The mean yearly CPUE at the Sacramento and Chipps Island Trawl sites were near record lows during both the 2010 and 2011 field seasons (Figures 7 and 8).

In beach seines, unmarked juvenile winter-run Chinook salmon were detected in most months from October through April during the 2010 and 2011 field seasons (Figure 9). Mean monthly CPUE peaked in the Lower Sacramento River, North Delta, and Central Delta Seine regions during the month of January and December during the 2010 and 2011 field seasons, respectively. However, only two and one fish were captured within the Central Delta Seine Region during the 2010 and 2011 field seasons, respectively. The mean yearly CPUE estimates suggest that unmarked juvenile winter-run Chinook salmon were consistently observed in higher densities within the Lower Sacramento River Seine Region relative to other seine regions since the 2000 field season (Figure 9). Similar to the Sacramento Trawl Site, unmarked winter-run Chinook salmon were first detected within the Sacramento Area Seine Region near the Delta Cross Channel water diversion gates during the month of October for both the 2010 and 2011 field seasons (Figure 10).

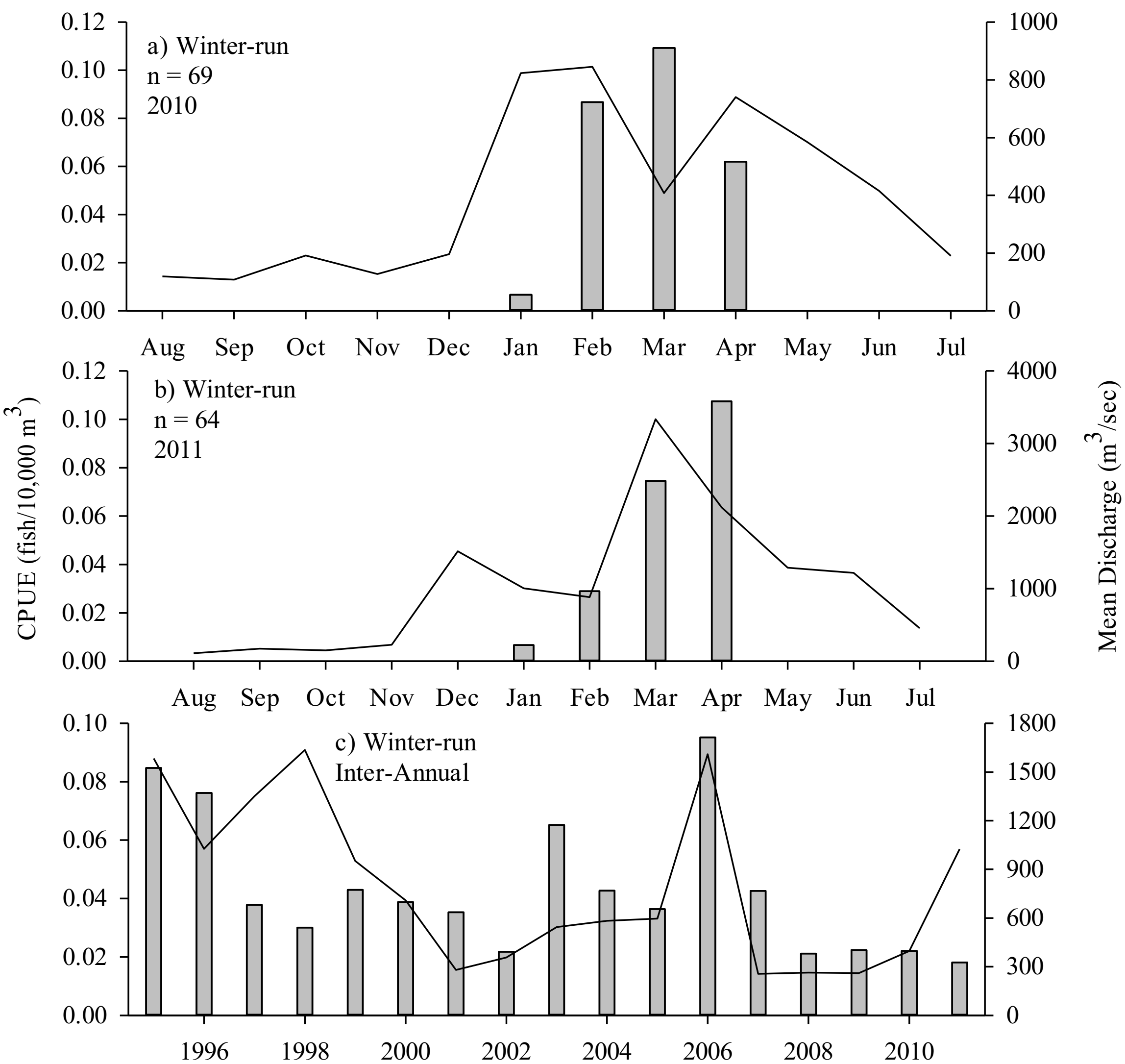

Figure 7. Mean monthly and yearly CPUE (bars) of unmarked juvenile winter-run Chinook salmon captured in mid-water trawls (MWTRs) at the Chipps Island Trawl Site and mean monthly and yearly Delta discharges (lines) during the a) 2010, b) 2011, and c) 1995 through 2011 field seasons. Sample size (n) corresponds to total number of fish caught.

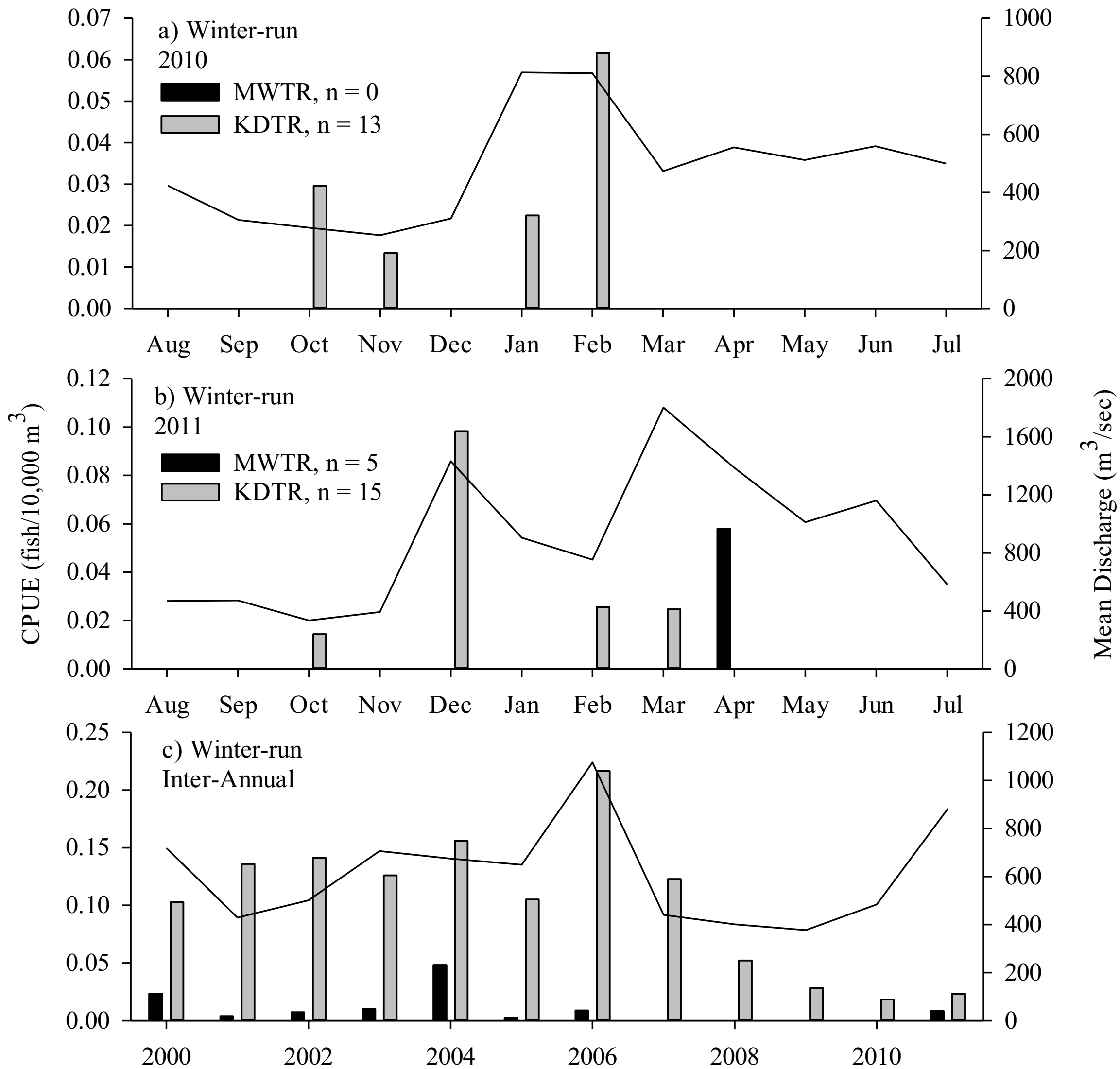

Figure 8. Mean monthly and yearly CPUE (bars) of unmarked juvenile winter-run Chinook salmon captured in mid-water (MWTRs) and Kodiak trawls (KDTRs) at the Sacramento Trawl Site and mean monthly Sacramento River discharge at Freeport (lines) during the a) 2010, b) 2011, and c) 2000 through 2011 field seasons. Sample size (n) corresponds to total number of fish caught.

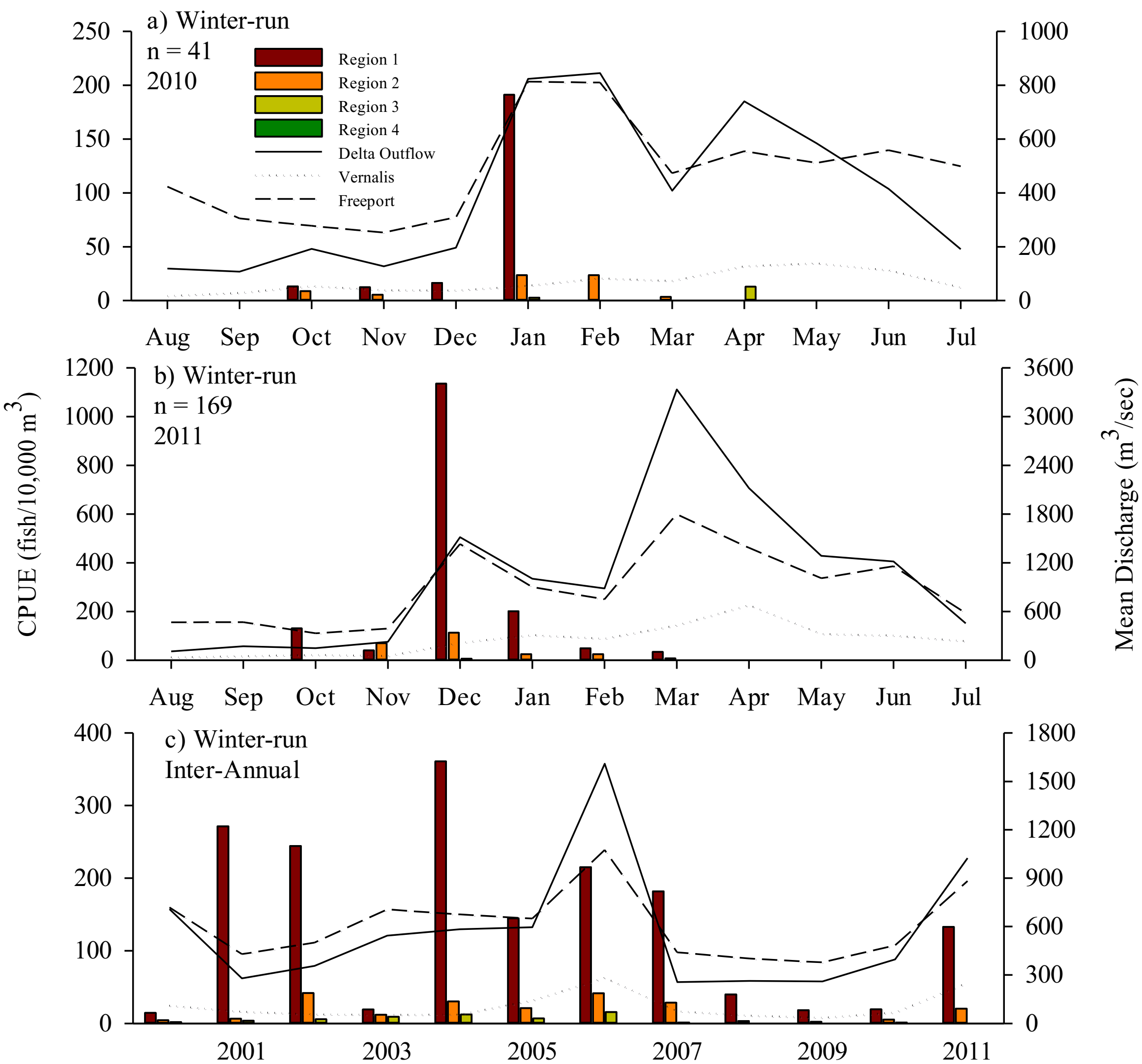

Figure 9. Mean monthly and yearly CPUE of unmarked juvenile winter-run Chinook salmon captured in beach seines at regions one through six, and mean monthly and yearly Sacramento River discharge at Freeport, San Joaquin River discharge at Vernalis, and Delta discharge during the a) 2010, b) 2011, and c) 2000 through 2011 field seasons. Sample size (n) corresponds to total number of fish caught.

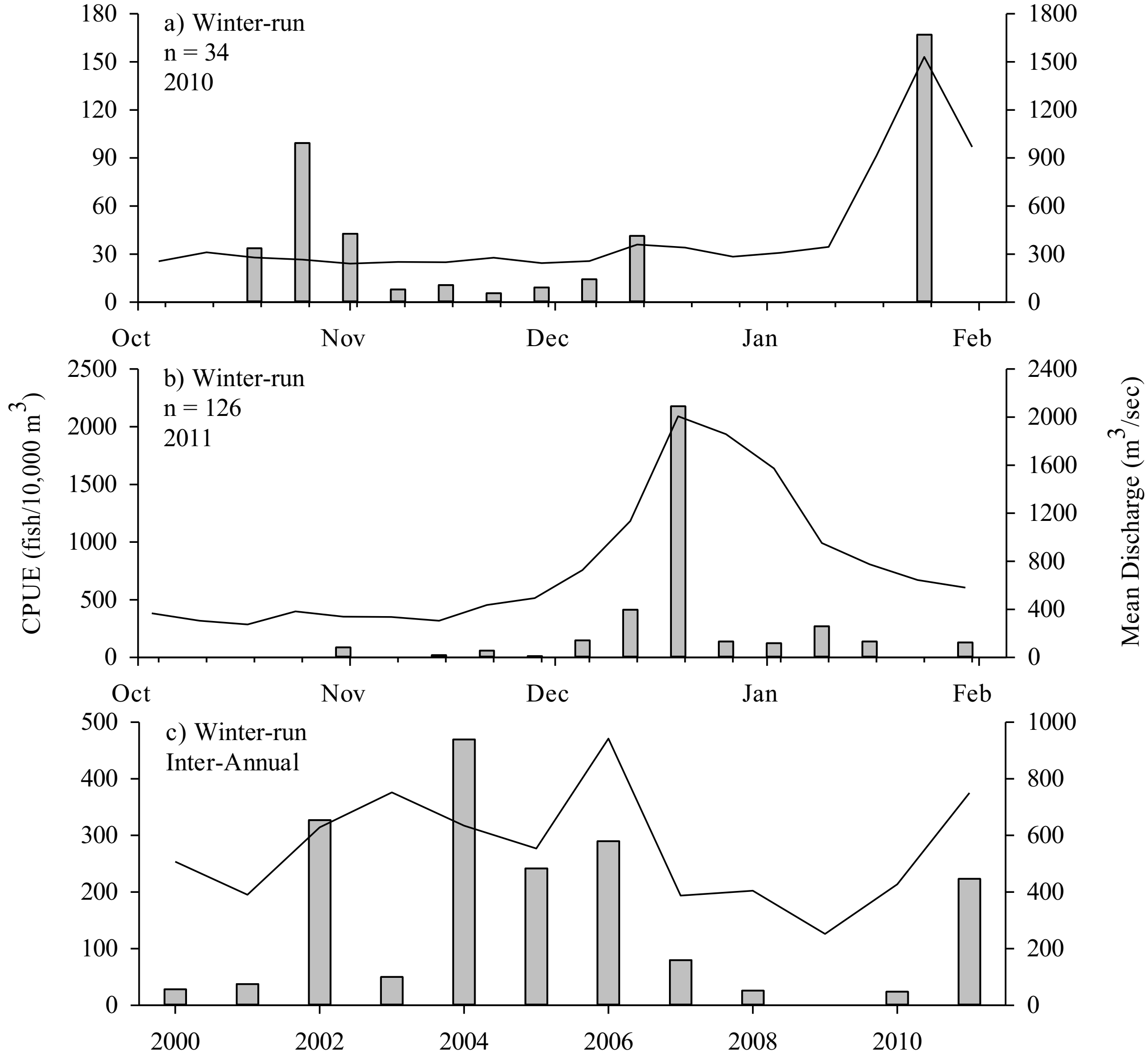

Figure 10. Mean weekly and yearly CPUE (bars) of unmarked juvenile winter-run Chinook salmon captured in beach seines at the Sacramento Area Seine (Region 7), and mean weekly and yearly Sacramento River discharge at Freeport (lines) from October to January during the a) 2010, b) 2011, and c) 2000 through 2011 field seasons. Sample size (n) corresponds to total number of fish caught.

Unmarked Fall-Run Distribution and Relative Abundance

Unmarked juvenile fall-run Chinook salmon were captured in nearly all seine regions and trawl sites during the 2010 and 2011 field seasons (Tables A18 and A19). However, no individuals were captured within the Lower San Joaquin Seine Region during the 2011 field season. At the Chipps Island Trawl Site, individuals were captured from March through October and the largest mean monthly CPUE estimates were observed from April through June (Figure 11). Individuals were generally captured from January through July at the Sacramento Trawl Site during both field seasons, but individuals also were observed in relatively high densities in the month of December during the 2011 field season (Figure 12). At the Mossdale Trawl Site, unmarked juvenile fall-run Chinook salmon were primarily captured from February through July during both field seasons, but individuals also were observed in relatively low densities from November through January during the 2011 field season (Figure 13). Therefore, it appears that the period of immigration of unmarked juvenile fall-run Chinook salmon into the San Francisco Estuary from both the San Joaquin and Sacramento River basins was earlier and longer in 2011 than 2010. The mean monthly CPUE at all three trawl sites peaked either in April or May during both field seasons.

The mean yearly CPUE at the Chipps Island Trawl Site has increased annually since the record low observed during the 2008 field season (Figure 11). In addition, the 2011 mean yearly April through June CPUE estimate (4.75 fish/10,000m^3) did exceed the 1978 to 2009 average (4.62 fish/10,000m^3; Figure 14). The mean yearly CPUE at the Mossdale Trawl Site was the lowest during 2010 and was a record high during 2011 since the 2004 field season (Figure 13). Similarly, the mean yearly CPUE at the Sacramento Trawl Site was the lowest in 2010 since the 2000 field season and increased slightly during the 2011 field season (Figure 12).

In terms of beach seine monitoring, unmarked juvenile fall-run Chinook salmon were detected in months from December to June during the 2010 and 2011 field seasons (Figure 15). The mean monthly CPUE peaked in the Lower Sacramento River, North Delta, and Central Delta Seine regions during the months of January and February, whereas the mean monthly CPUE generally peaked in the Lower San Joaquin River and South Delta Seine regions during the months of February and March (Figure 15). Within the San Francisco/San Pablo Bay Seine Region, mean monthly CPUE peaked during the month of May during both field seasons, however only a total of one and four individuals were captured during the 2010 and 2011 field seasons, respectively. The mean yearly CPUE estimates suggest that unmarked juvenile fall-run Chinook salmon were observed in higher densities particularly within the Lower Sacramento River, North Delta, and Central Delta Seine regions relative to other seine regions since the 2000 field season. Densities within these regions have increased annually since the record low was observed in 2009 (Figure 15).

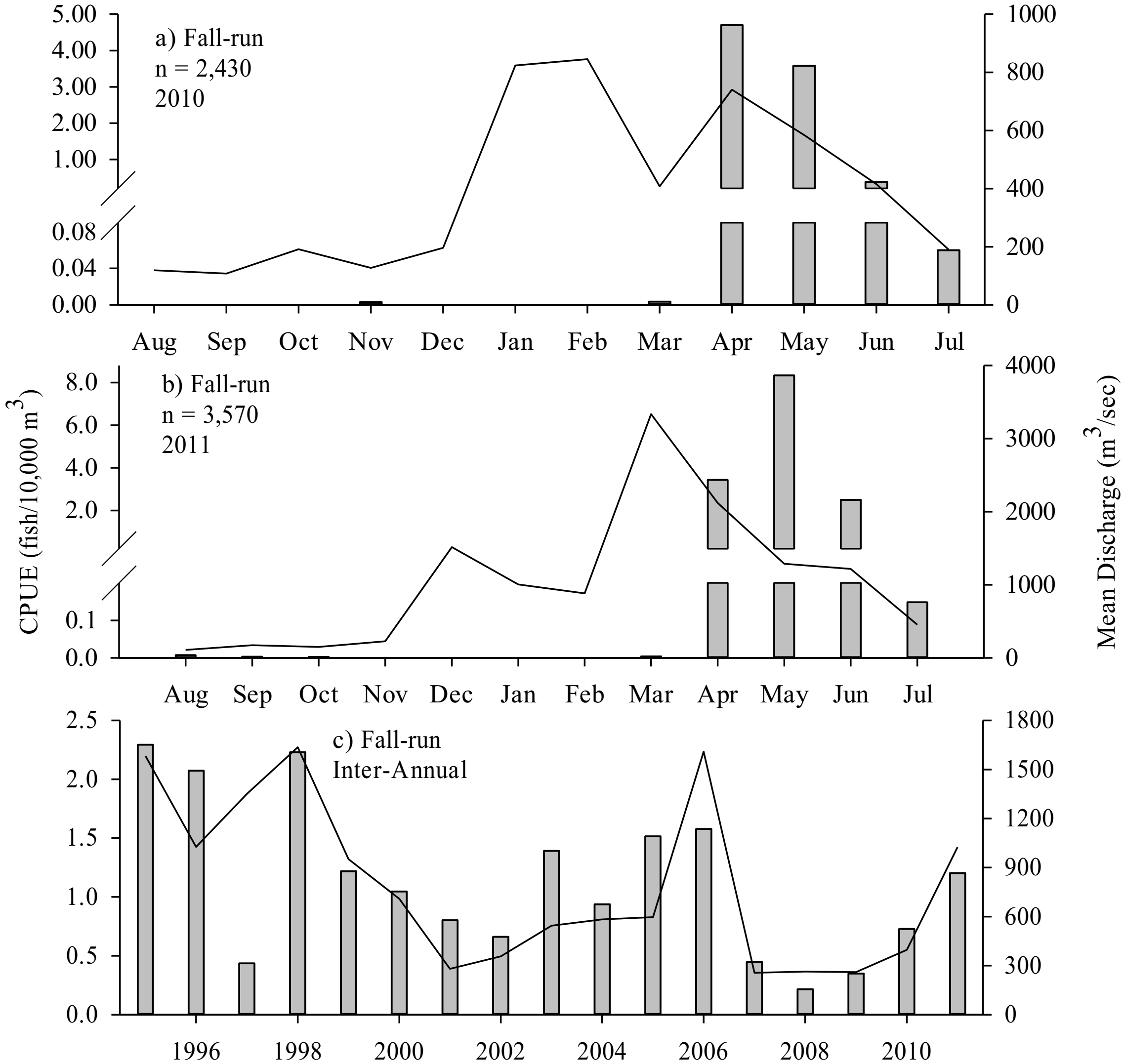

Figure 11. Mean monthly and yearly CPUE (bars) of unmarked juvenile fall-run Chinook salmon captured in mid-water trawls (MWTRs) at the Chipps Island Trawl Site and mean monthly and yearly Delta discharges (lines) during the a) 2010, b) 2011, and c) 1995 through 2011 field seasons. Sample size (n) corresponds to total number of fish caught.

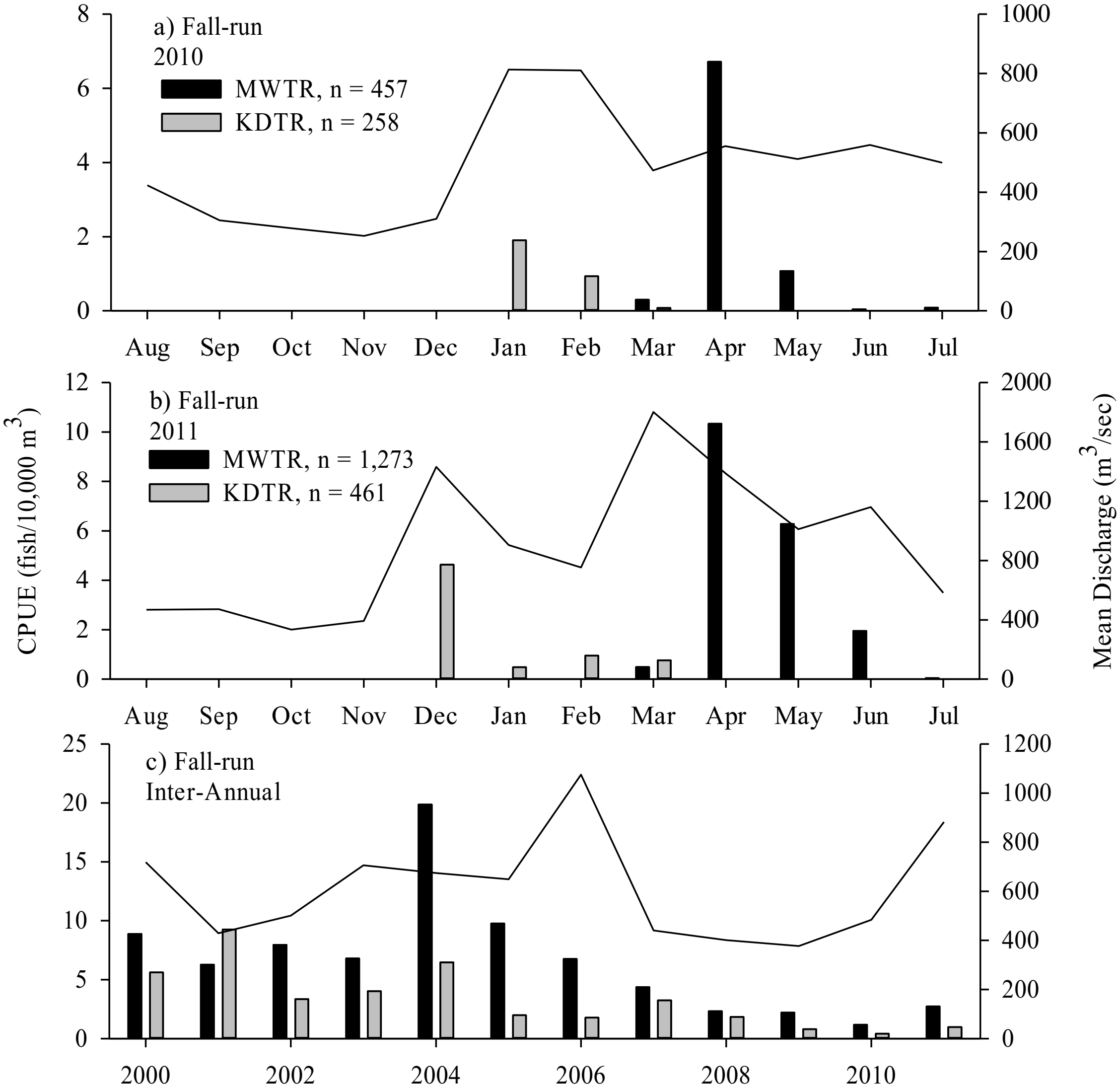

Figure 12. Mean monthly and yearly CPUE (bars) of unmarked juvenile fall-run Chinook salmon captured in mid-water (MWTRs) and Kodiak trawls (KDTRs) at the Sacramento Trawl Site and mean monthly Sacramento River discharge at Freeport (lines) during the a) 2010, b) 2011, and c) 2000 through 2011 field seasons. Sample size (n) corresponds to total number of fish caught.

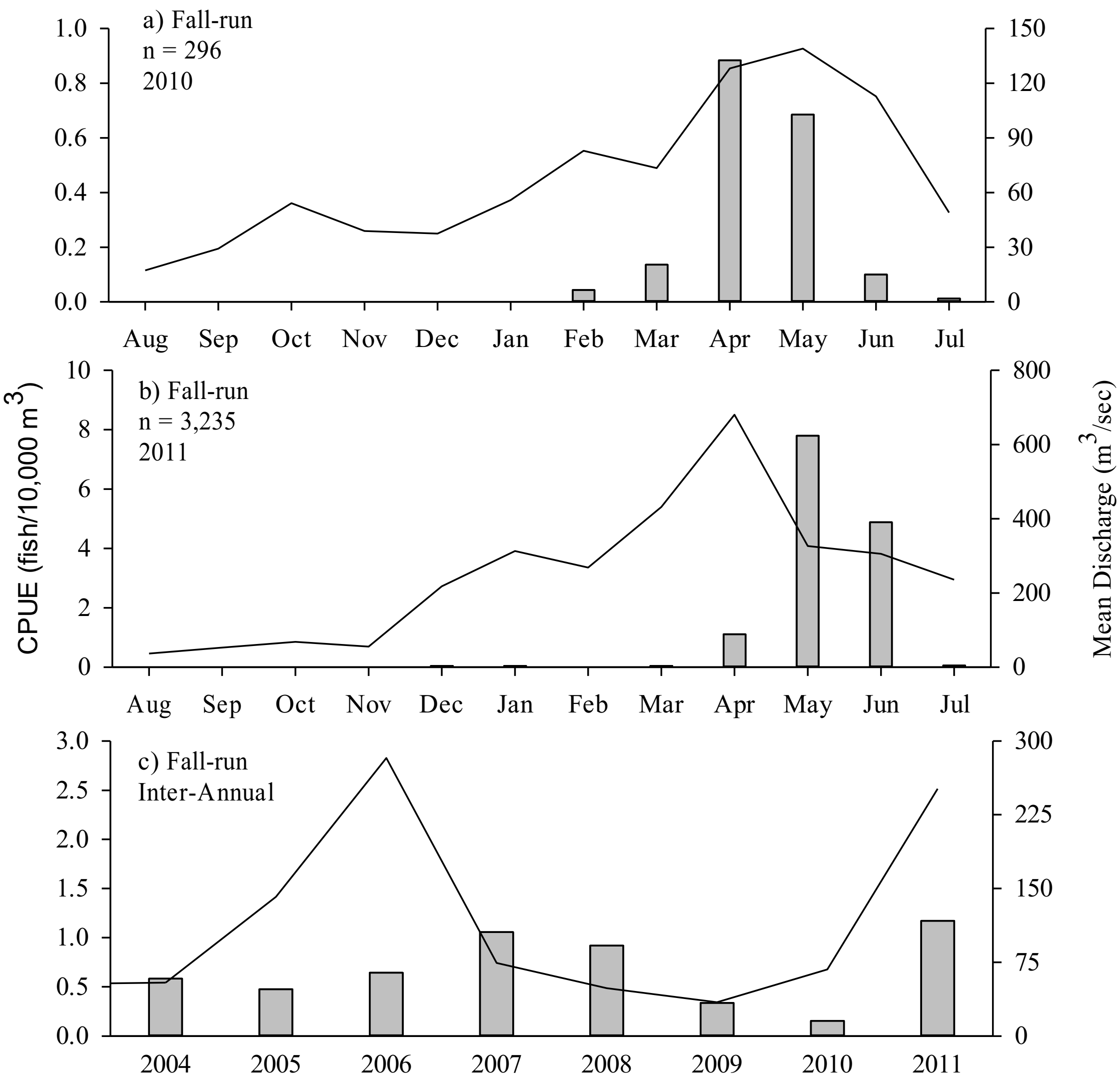

Figure 13. Mean monthly and yearly CPUE (bars) of unmarked juvenile fall-run Chinook salmon captured in Kodiak trawls (KDTRs) at the Mossdale Trawl Site and mean monthly and yearly San Joaquin River discharge at Vernalis (lines) during the a) 2010, b) 2011, and c) 2004 through 2011 field seasons. Sample size (n) corresponds to total number of fish caught.

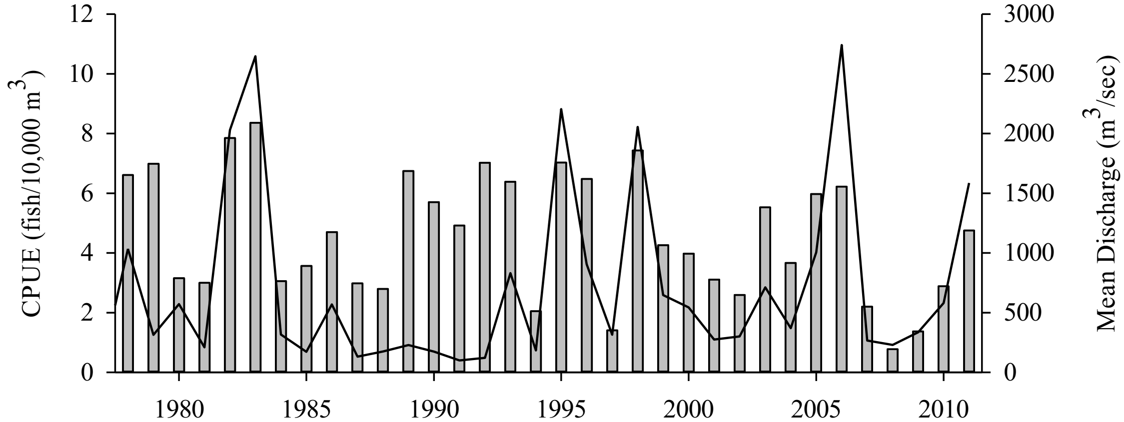

Figure 14. Mean CPUE (bars) of unmarked juvenile fall-run Chinook salmon captured in mid-water trawls (MWTRs) at the Chipps Island Trawl Site and mean Delta discharges (line) during April through June from the 1978 to 2011 field seasons.

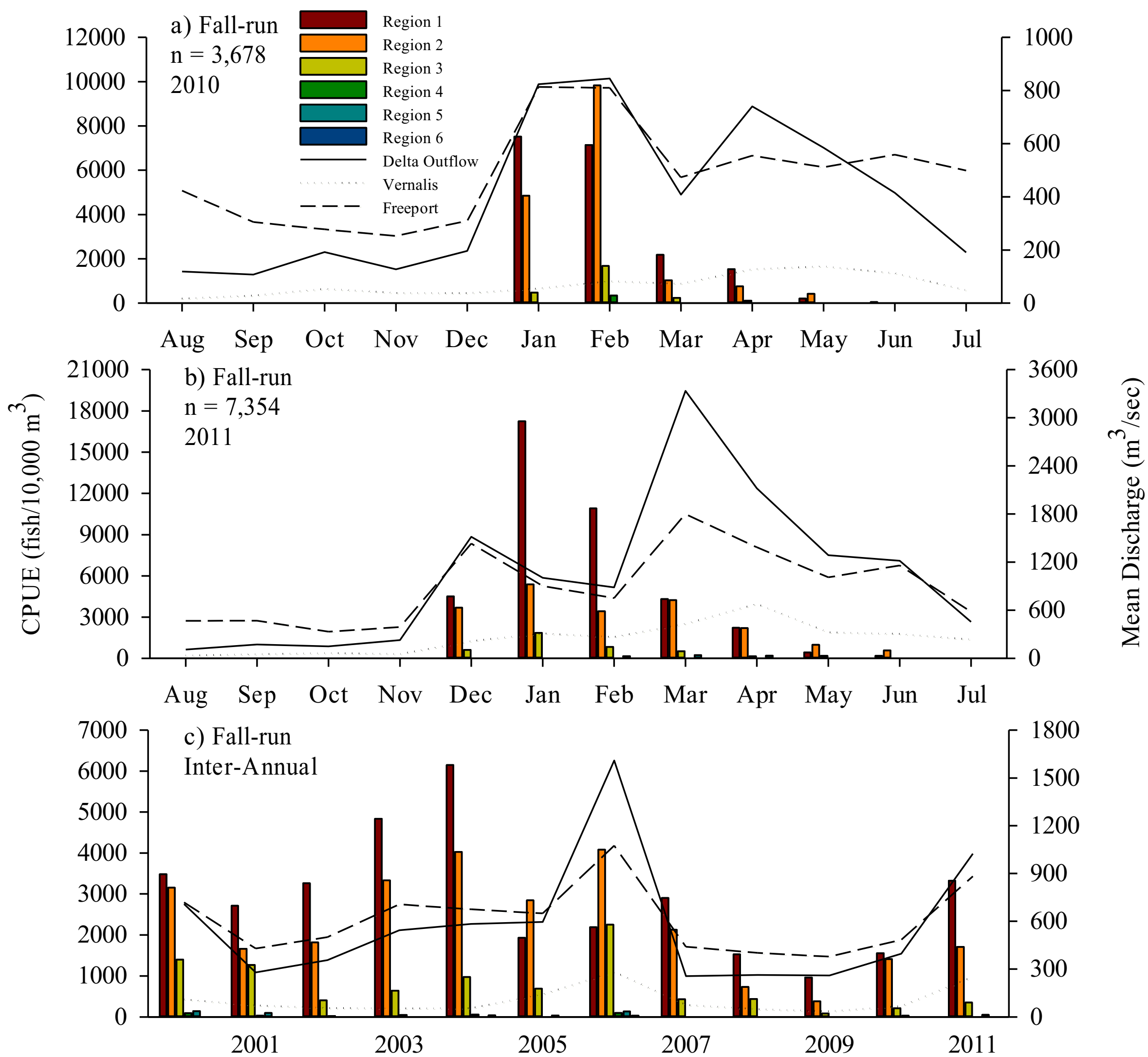

Figure 15. Mean monthly and yearly CPUE of unmarked juvenile fall-run Chinook salmon captured in beach seines at regions one through six, and mean monthly and yearly Sacramento River discharge at Freeport, San Joaquin River discharge at Vernalis, and Delta discharge during the a) 2010, b) 2011, and c) 2000 through 2011 field seasons. Sample size (n) corresponds to total number of fish caught.

Unmarked Spring-Run Distribution and Relative Abundance

Unmarked juvenile spring-run Chinook salmon were captured in the Lower Sacramento River, North Delta, Central Delta, and South Delta Seine regions, the Sacramento Trawl Site, and the Chipps Island Trawl Site during the 2010 and 2011 field seasons (Tables A18 and A19). Additionally, one individual was captured in the San Francisco/San Pablo Bay Seine Region during the 2011 field season. At the Chipps Island Trawl Site, individuals were primarily captured from March through May during both field seasons, and during the month of June during the 2011 field season (Figure 16). Individuals were generally captured from January through May at the Sacramento Trawl Site (Figure 17). The mean monthly CPUE at the Sacramento and Chipps Island Trawl sites peaked strongly in April during the 2010 and 2011 field seasons, suggesting a short residence time within the Delta. The mean yearly CPUE at the Chipps Island and Sacramento Trawl sites increased during the 2010 and 2011 field seasons from near record lows observed in 2008 (Figures 16 and 17).

In beach seines, unmarked juvenile spring-run Chinook salmon were detected during the months of December through April and October through May during the 2010 and 2011 field seasons, respectively (Figure 18). The mean monthly CPUE peaked in the Lower Sacramento River, North Delta, and Central Delta Seine regions within the 2010 field season during February through April. In contrast, the mean monthly CPUE generally peaked in the same regions during the 2011 field season in January and February (Figure 18). Within the South Delta Seine Region, unmarked juvenile spring-run Chinook salmon were detected in very low numbers in March (n=1) during the 2010 field season, and April and May (n=4) during the 2011 field season. The mean yearly CPUE estimates suggest that unmarked juvenile spring-run Chinook salmon were consistently observed in higher densities within the Lower Sacramento River and North Delta Seine regions relative to other seine regions since the 2000 field season. Densities within these regions have increased annually since a near record low was observed in 2008 and 2009 (Figure 18). Unmarked spring-run Chinook salmon were first detected within the Sacramento Area Seine Region near the Delta Cross Channel water diversion gates during late December and early November for the 2010 and 2011 field seasons, respectively (Figure 19).

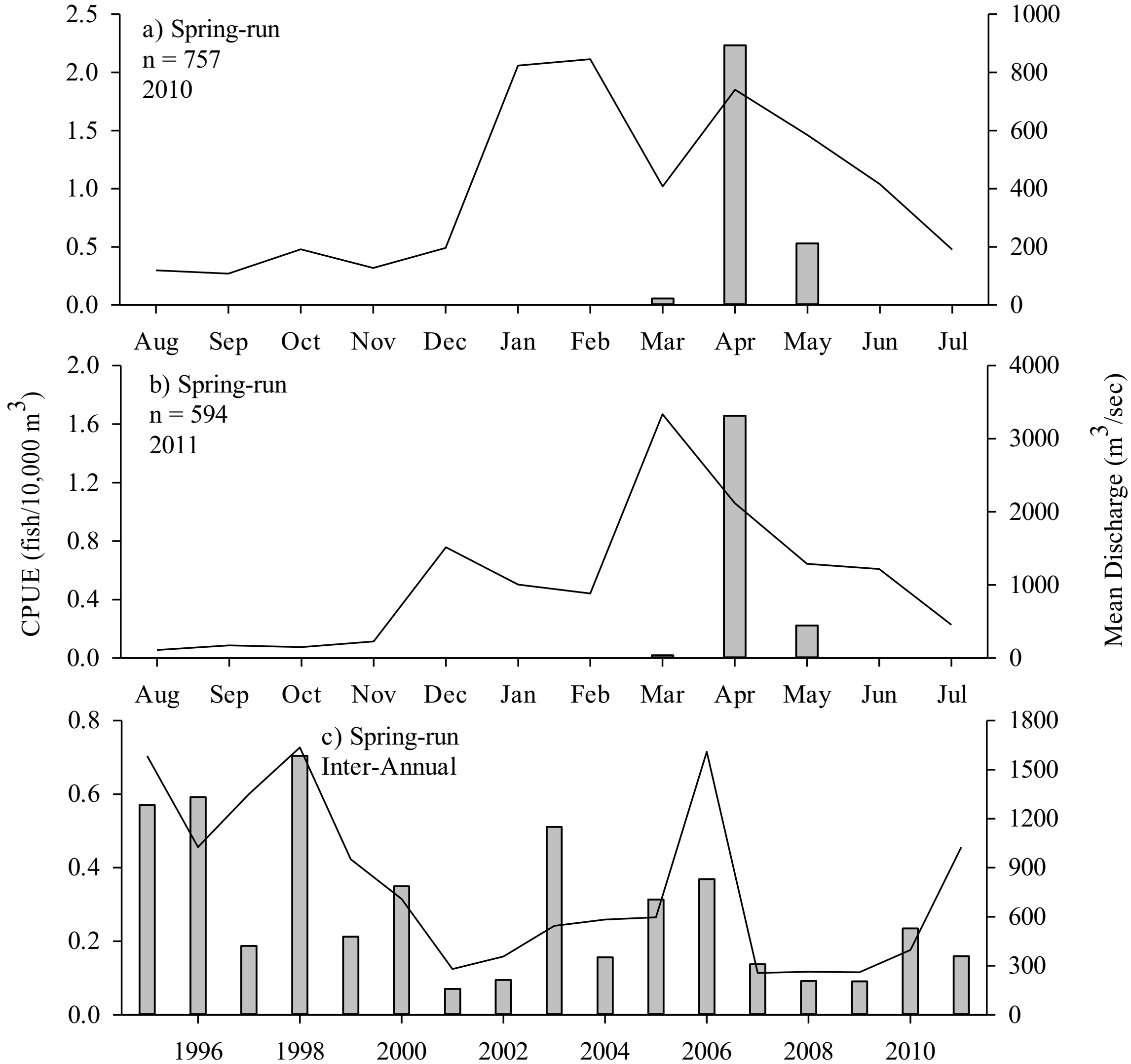

Figure 16. Mean monthly and yearly CPUE (bars) of unmarked juvenile spring-run Chinook salmon captured in mid-water trawls (MWTRs) at the Chipps Island Trawl Site and mean monthly and yearly Delta discharges (lines) during the a) 2010, b) 2011, and c) 1995 through 2011 field seasons. Sample size (n) corresponds to total number of fish caught.

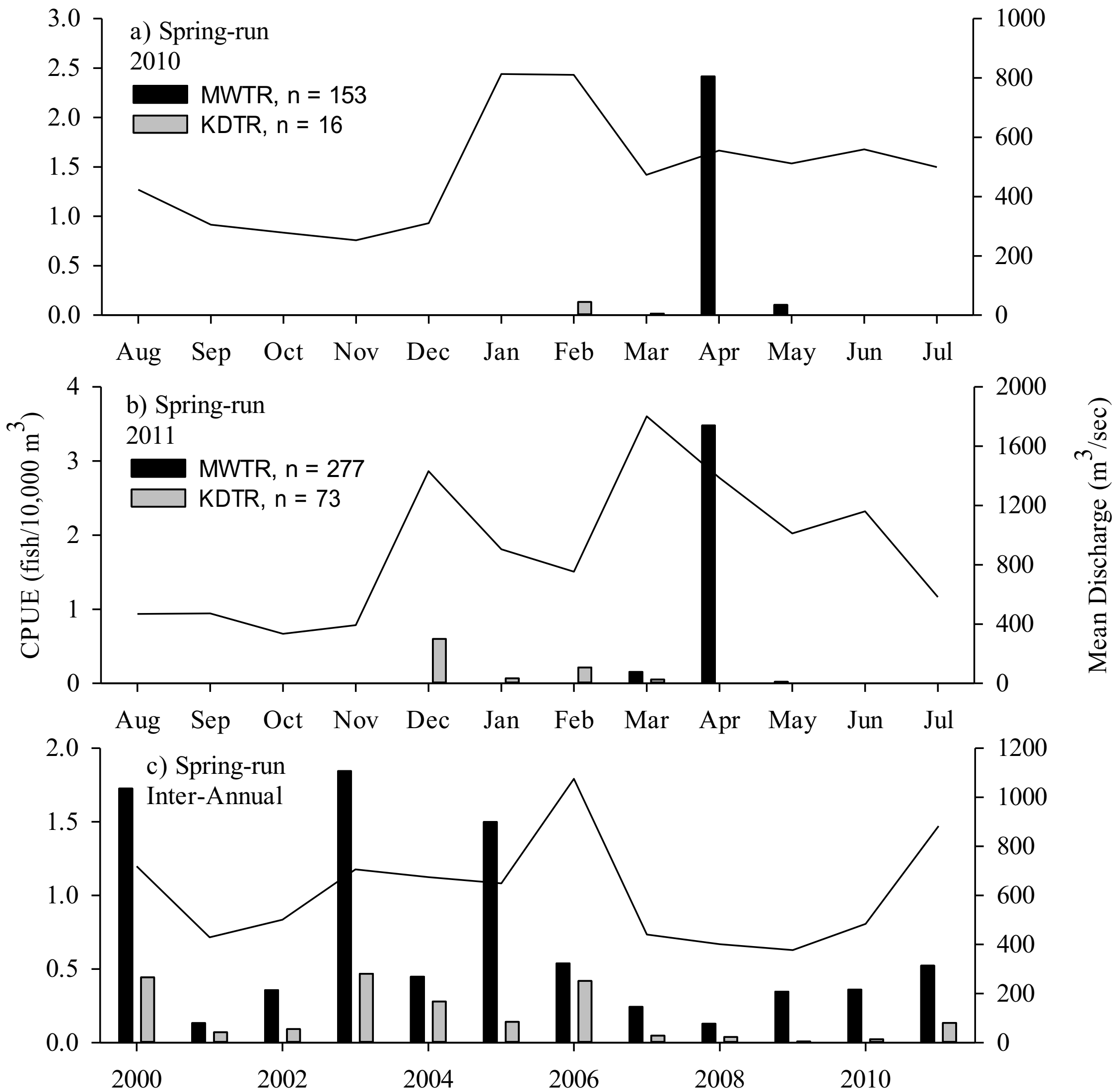

Figure 17. Mean monthly and yearly CPUE (bars) of unmarked juvenile spring-run Chinook salmon captured in mid-water (MWTRs) and Kodiak trawls (KDTRs) at the Sacramento Trawl Site and mean monthly Sacramento River discharge at Freeport (lines) during the a) 2010, b) 2011, and c) 2000 through 2011 field seasons. Sample size (n) corresponds to total number of fish caught.

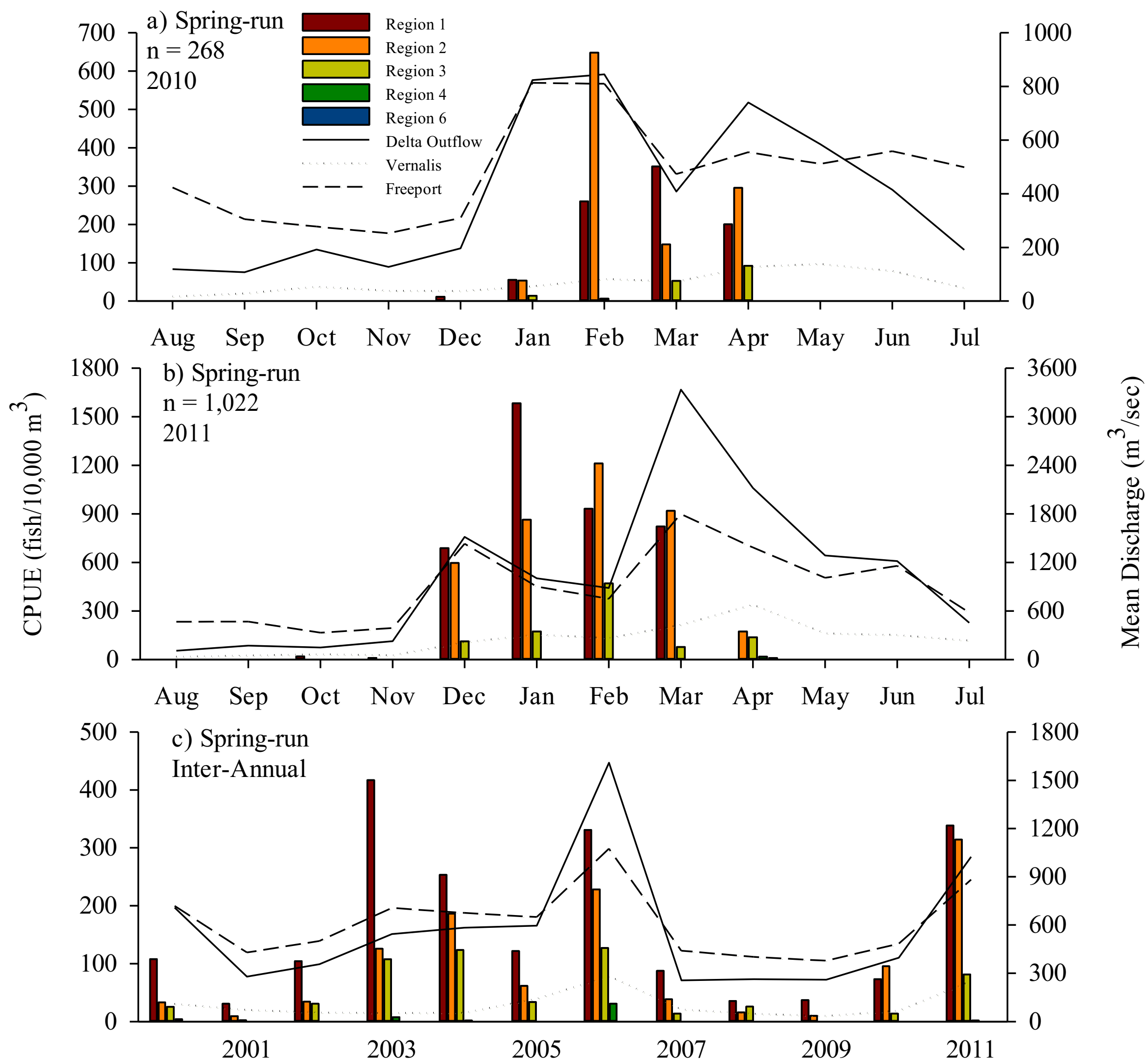

Figure 18. Mean monthly and yearly CPUE of unmarked juvenile spring-run Chinook salmon captured in beach seines at regions one through six, and mean monthly and yearly Sacramento River discharge at Freeport, San Joaquin River discharge at Vernalis, and Delta discharge during the a) 2010, b) 2011, and c) 2000 through 2011 field seasons. Sample size (n) corresponds to total number of fish caught.

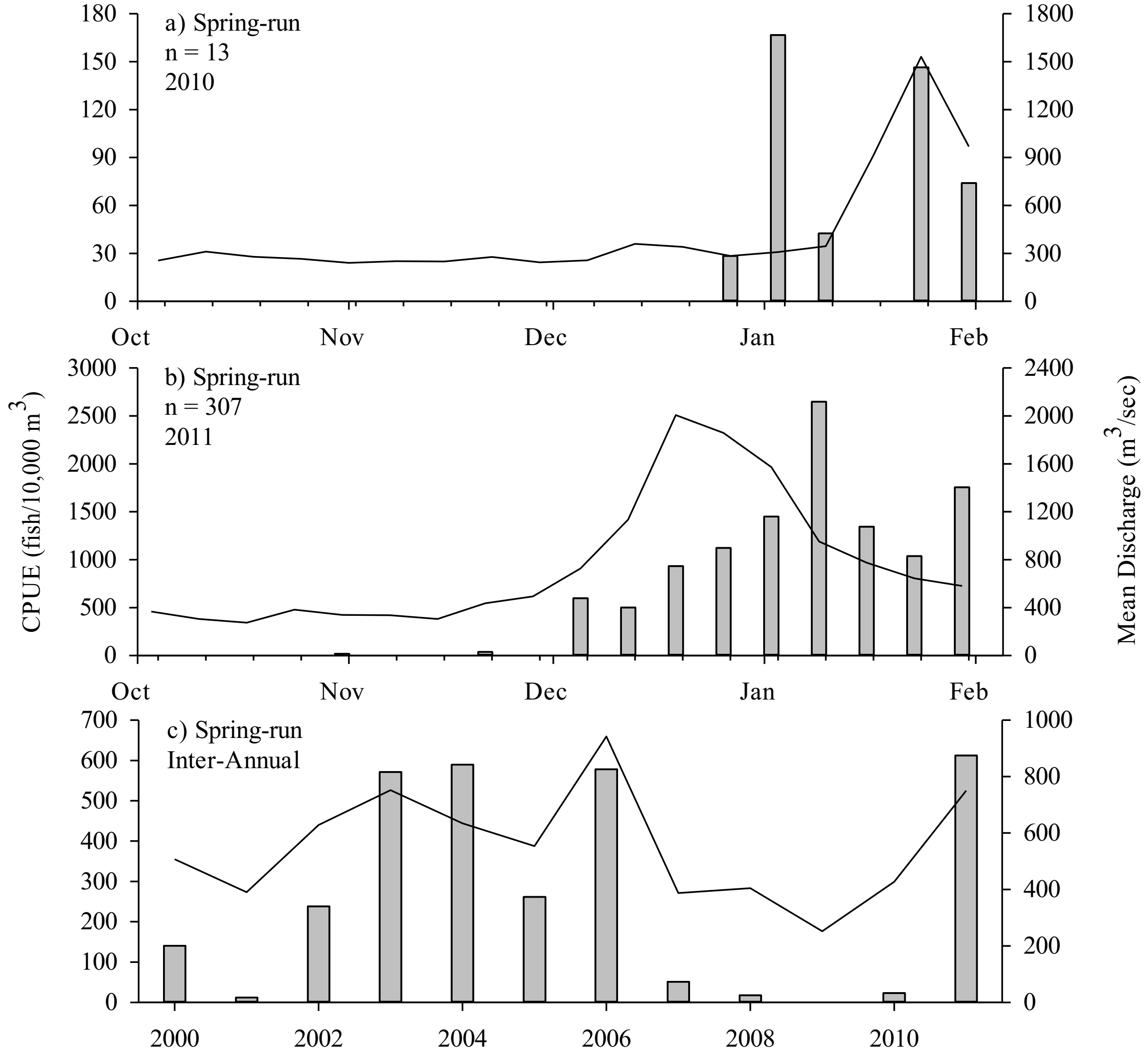

Figure 19. Mean weekly and yearly CPUE (bars) of unmarked juvenile spring-run Chinook salmon captured in beach seines at the Sacramento Area Seine (Region 7), and mean weekly and yearly Sacramento River discharge at Freeport (lines) from October to January during the a) 2010, b) 2011, and c) 2000 through 2011 field seasons. Sample size (n) corresponds to total number of fish caught.

Unmarked Late Fall-Run Distribution and Relative Abundance

We captured low numbers of unmarked juvenile late fall-run Chinook salmon in the Lower Sacramento River and North Delta Seine regions, the Sacramento Trawl Site, and the Chipps Island Trawl Site during the 2010 and 2011 field seasons (Tables A18 and A19). Four individuals also were detected in the Central Delta Seine Region during the 2010 field season. Individuals were generally detected in months from September through January at the Chipps Island Trawl Site and August through December at the Sacramento Trawl Site (Figures 20 and

21). The mean monthly CPUE at the Chipps Island Trawl Site peaked in January and December during the 2010 and 2011 field seasons, respectively. Because of the relatively few detections combined with low catches per month (n=1), no discernible peaks in mean monthly CPUE can be identified at the Sacramento Trawl Site during either field season. The mean yearly CPUE at the Chipps Island and Sacramento Trawl sites were near record lows during both the 2010 and 2011 field seasons (Figures 20 and 21).

Unmarked juvenile late fall-run Chinook salmon were generally detected in low numbers in beach seines from October through January and April through May during both the 2010 and 2011 field seasons (Figure 22), suggesting a bimodal distribution as a result of two distinct age classes. However, no individuals were detected in the Lower Sacramento River Seine Region in the spring during the 2011 field season. The mean yearly CPUE estimates also suggest that unmarked juvenile late fall-run Chinook salmon were consistently observed in higher densities within the Lower Sacramento River and North Delta Seine regions relative to other seine regions since the 2000 field season. Densities within these regions have increased annually since a near record low was observed in 2008 and 2009 (Figure 22).

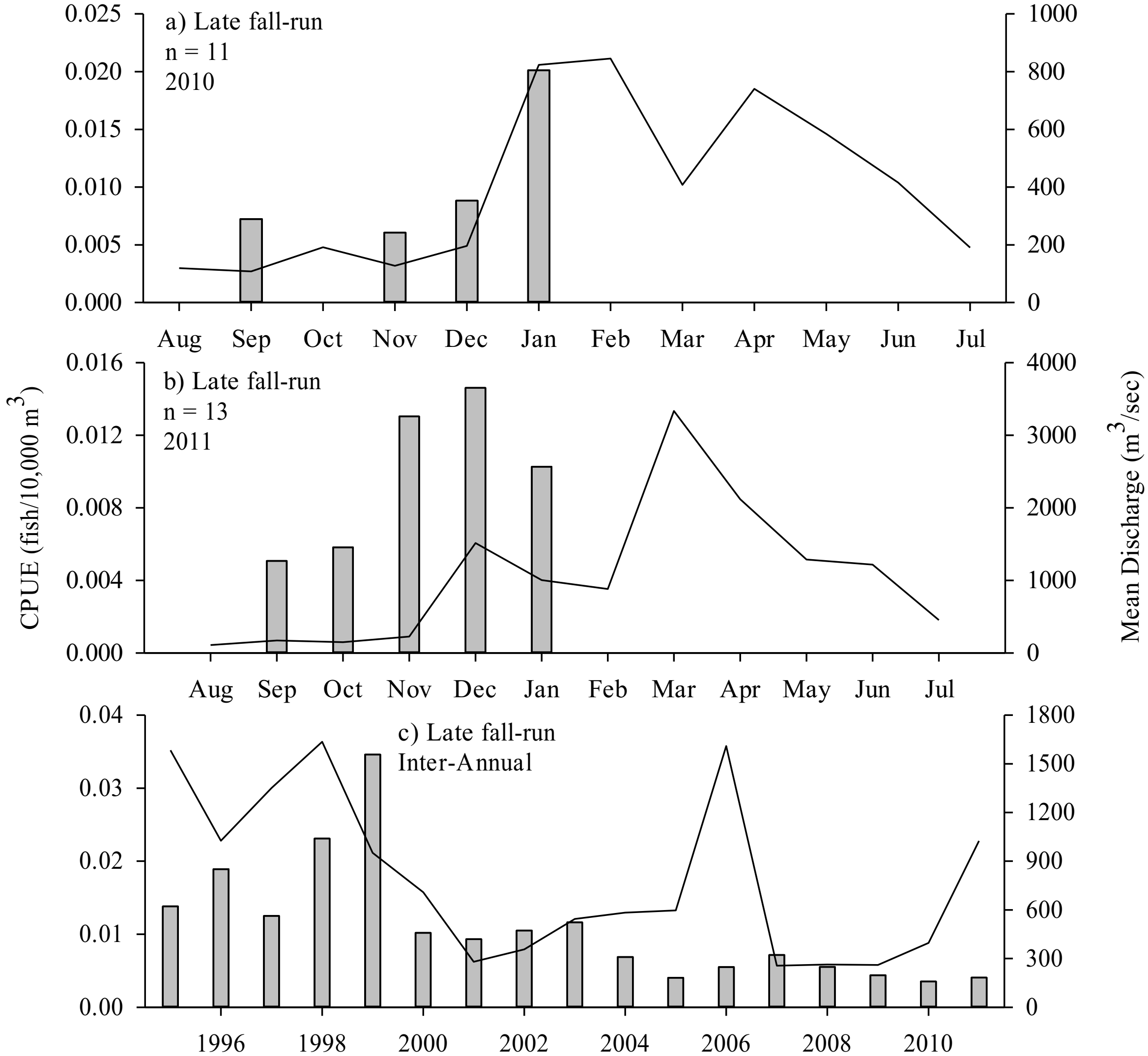

Figure 20. Mean monthly and yearly CPUE (bars) of unmarked juvenile late fall-run Chinook salmon captured in mid-water trawls (MWTRs) at the Chipps Island Trawl Site and mean monthly and yearly Delta discharges (lines) during the a) 2010, b) 2011, and c) 1995 through 2011 field seasons. Sample size (n) corresponds to total number of fish caught.

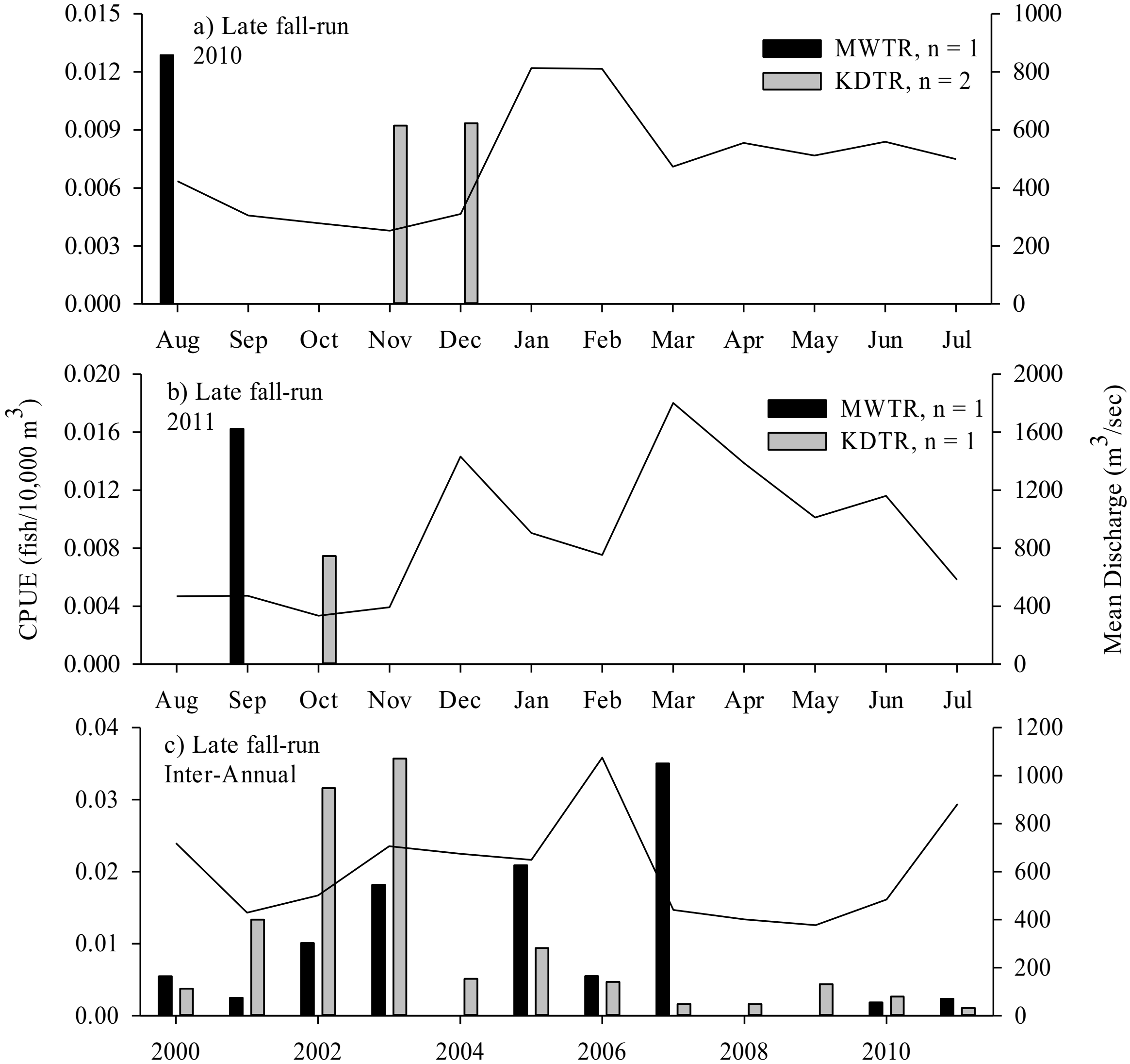

Figure 21. Mean monthly and yearly CPUE (bars) of unmarked juvenile late fall-run Chinook salmon captured in mid-water (MWTRs) and Kodiak trawls (KDTRs) at the Sacramento Trawl Site and mean monthly Sacramento River discharge at Freeport (lines) during the a) 2010, b) 2011, and c) 2000 through 2011 field seasons. Sample size (n) corresponds to total number of fish caught.

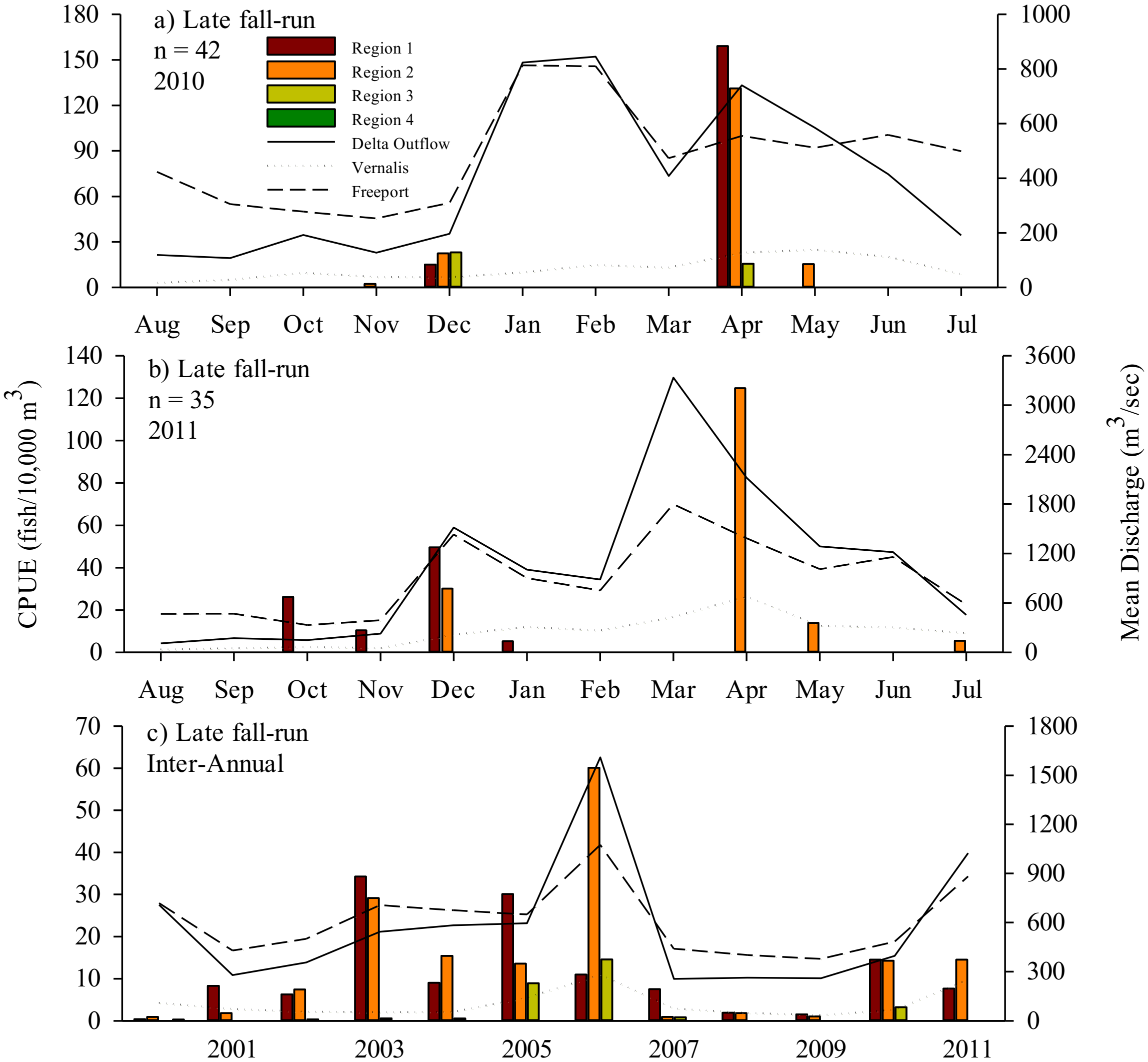

Figure 22. Mean monthly and yearly CPUE of unmarked juvenile late fall-run Chinook salmon captured in beach seines at regions one through six, and mean monthly and yearly Sacramento River discharge at Freeport, San Joaquin River discharge at Vernalis, and Delta discharge during the a) 2010, b) 2011, and c) 2000 through 2011 field seasons. Sample size (n) corresponds to total number of fish caught.

Influence of River Discharge

During the 2010 and 2011 field seasons, the mean CPUE of all unmarked juvenile Chinook salmon races generally peaked, particularly at the trawl sites and the Lower Sacramento River and North Delta Seine regions, during an increase in mean river discharge at nearly all temporal scales (i.e., weeks, months, and years; Figures 11 - 22). To examine these correlations, we developed simple linear regression models of mean weekly CPUE against $\log_{10}$ of the weekly mean river discharge data for each Chinook salmon race at the Chipps Island Trawl Site (Figure 23), Sacramento Trawl Site (Figure 24), Mossdale Trawl Site (Figure 25), the Lower Sacramento

Seine Region (Figure 26), and the North Delta Seine Region (Figure 27) during periods of occurrence in the 2010 and 2011 field seasons. Models were only developed during periods when Chinook salmon were captured in the 2010 and 2011 field seasons. Data for the 2010 and 2011 seasons were grouped to examine a broad range of discharge values with 2011 demonstrating greater discharge relative to the 2010 field season (Table A20; CDWR 2012b).

The mean weekly CPUE of unmarked juvenile winter-, fall-, spring-, and late fall-run Chinook salmon during the 2010 and 2011 field seasons was consistently positively correlated with transformed ($\log_{10}$) mean weekly river discharge. However, model results were generally weak and inconclusive (p-value > 0.05). For unmarked juvenile winter-run Chinook salmon, the proportion of mean weekly CPUE variability explained by river discharge ranged from 12% to 23% among trawl sites and seine regions. The strongest correlation was observed at the Sacramento Trawl Site with approximately 23% (n = 60, p-value = 0.05) of the variability in the mean weekly CPUE from October to April explained by the mean Sacramento River discharge at Freeport (Figure 24a). For unmarked juvenile fall-run Chinook salmon, the proportion of mean weekly CPUE variability explained by river discharge ranged from 11% to 36%. The strongest correlation was observed within the North Delta Seine Region with 36% (n = 60, p-value < 0.01) of the variability in catch from December to June explained by the Sacramento River discharge at Freeport (Figure 27b). For unmarked juvenile spring-run Chinook salmon, the proportion of mean weekly CPUE variability explained by river discharge ranged from 15% to 41%. The strongest correlation also was observed within the North Delta Seine Region ($r^2 = 0.41$, n = 42, p-value < 0.01; Figure 27c). For unmarked juvenile late fall-run Chinook salmon, the proportion of mean weekly CPUE variability explained by river discharge ranged from 11% to 19% among the Chipps Island Trawl Site and Lower Sacramento River and North Delta Seine regions. The strongest correlation was observed at the Chipps Island Trawl Site with approximately 19% (n = 44, p-value = 0.04) of the variability in catch explained by the mean weekly Delta discharge (Figure 23d). A negative correlation was observed between the mean weekly CPUE at the Sacramento Trawl Site and the mean Sacramento River discharge at Freeport from August through December (Figure 24d). However, the regression was based on the capture of only five individuals and was therefore not considered robust.

Although the models were largely inconclusive for 2010 and 2011, the results consistently demonstrated a positive correlation between catch rates and discharge during periods of juvenile Chinook salmon occurrence within the San Francisco Estuary. Consequently, peaks in river discharge likely contributed to the earlier months of occupancy and higher relative abundances observed at most trawl sites and within seine regions during the 2011 field season compared to the 2010 field season. Our results are consistent with other investigations that have demonstrated that river discharge and/or water temperature (often correlated) are factors influencing the movement and abundance of juvenile Chinook salmon within the San Francisco Estuary (Kjelson et al. 1982; Stevens and Miller 1983; Kjelson and Brandes 1989; Kope and Botsford 1990; Brandes and McLain 2001; Jager and Rose 2003). Brandes and McLain (2001) analyzed historical DJFMP data and found that high Sacramento River discharges likely increased both the movement and survival of fry sized (<70 mm in FL) juvenile Chinook salmon through the Estuary. In addition, Newman (2003) utilized a variety of modeling approaches in combination with DJFMP data and confirmed that river discharge and temperature were among the most influential predictors of hatchery reared juvenile Chinook salmon survival (i.e., catch) through the San Francisco Estuary.

Despite the results from the present study, there is considerable uncertainty regarding if the increase in the relative abundance of unmarked juvenile Chinook salmon during periods of high river discharge reflects active or passive dispersal (Williams 2006). For example, fry may simply be involuntarily swept downstream into and through portions of the Estuary during periods of high discharge. Alternatively, higher river discharge may directly or indirectly improve aquatic habitats that are utilized by individuals to fulfill one or more of their life cycle requirements. Despite the evidence that river discharge does influence the relative abundance and distribution of unmarked juvenile Chinook salmon within the San Francisco Estuary, the importance of river discharge relative to water quality (e.g., contaminants, temperature, turbidity, salinity, etc.), other physical habitat characteristics (e.g., water current, floodplain availability, etc.), predation rates, innate cues (e.g., endogenous rhythms, celestial, etc.), and their interactions is still debated among researchers (e.g., Williams 2006; Zeug and Cavallo 2012). As a result, during the 2012 field season the DJFMP initiated consistent data collection of several environmental variables hypothesized to influence the movement or survival of juvenile Chinook salmon to more properly assess the influence of water operations within the San Francisco Estuary.

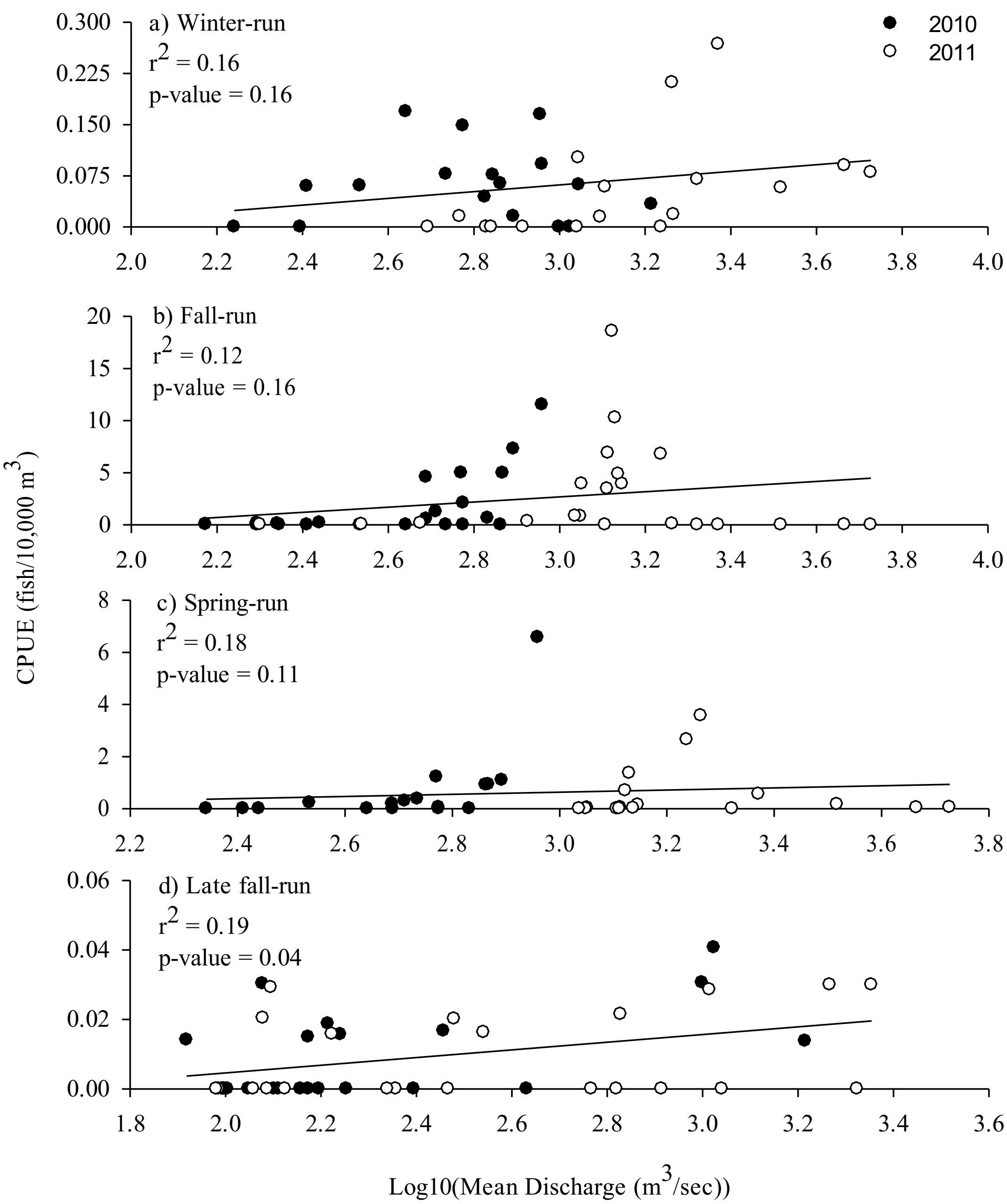

Figure 23. Linear regressions of mean weekly CPUE of unmarked juvenile a) winter-, b) fall-, c) spring-, and d) late fall-run juvenile Chinook salmon captured in mid-water trawls (MWTRs) at the Chipps Island Trawl Site and concurrent mean weekly Delta discharges from a) January-April, b) March-July, c) March-June, and d) September-January during the 2010 and 2011 field seasons.

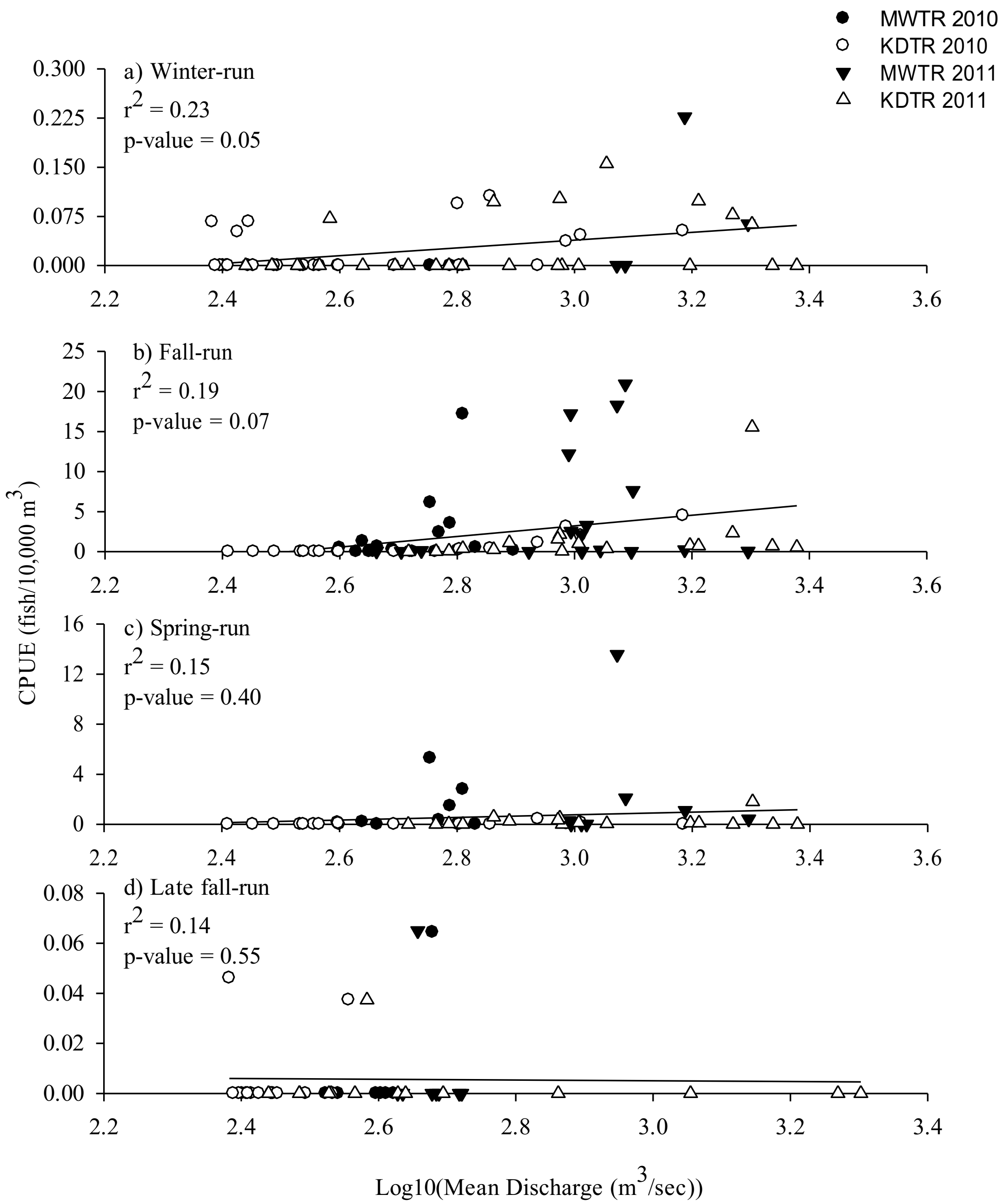

Figure 24. Linear regressions of mean weekly CPUE of unmarked juvenile a) winter-, b) fall-, c) spring-, and d) late fall-run juvenile Chinook salmon captured in mid-water (MWTRs) and Kodiak trawls (KDTRs) at the Sacramento Trawl Site and mean weekly Sacramento River discharge at Freeport from a) October-April, b) December-July, c) December-May, and d) August-December during the 2010 and 2011 field seasons.

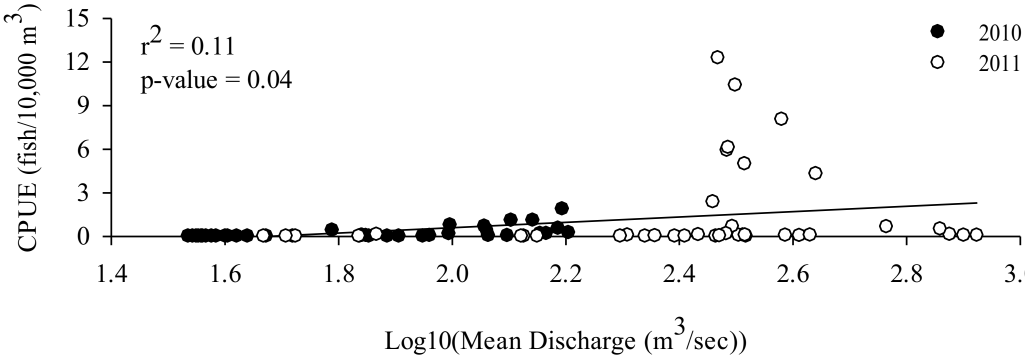

Figure 25. Linear regressions of mean weekly CPUE of unmarked juvenile Fall-run Chinook salmon captured in Kodiak trawls (KDTRs) at the Mossdale Trawl Site and mean weekly San Joaquin discharge at Vernalis from November-July during the 2010 and 2011 field seasons.

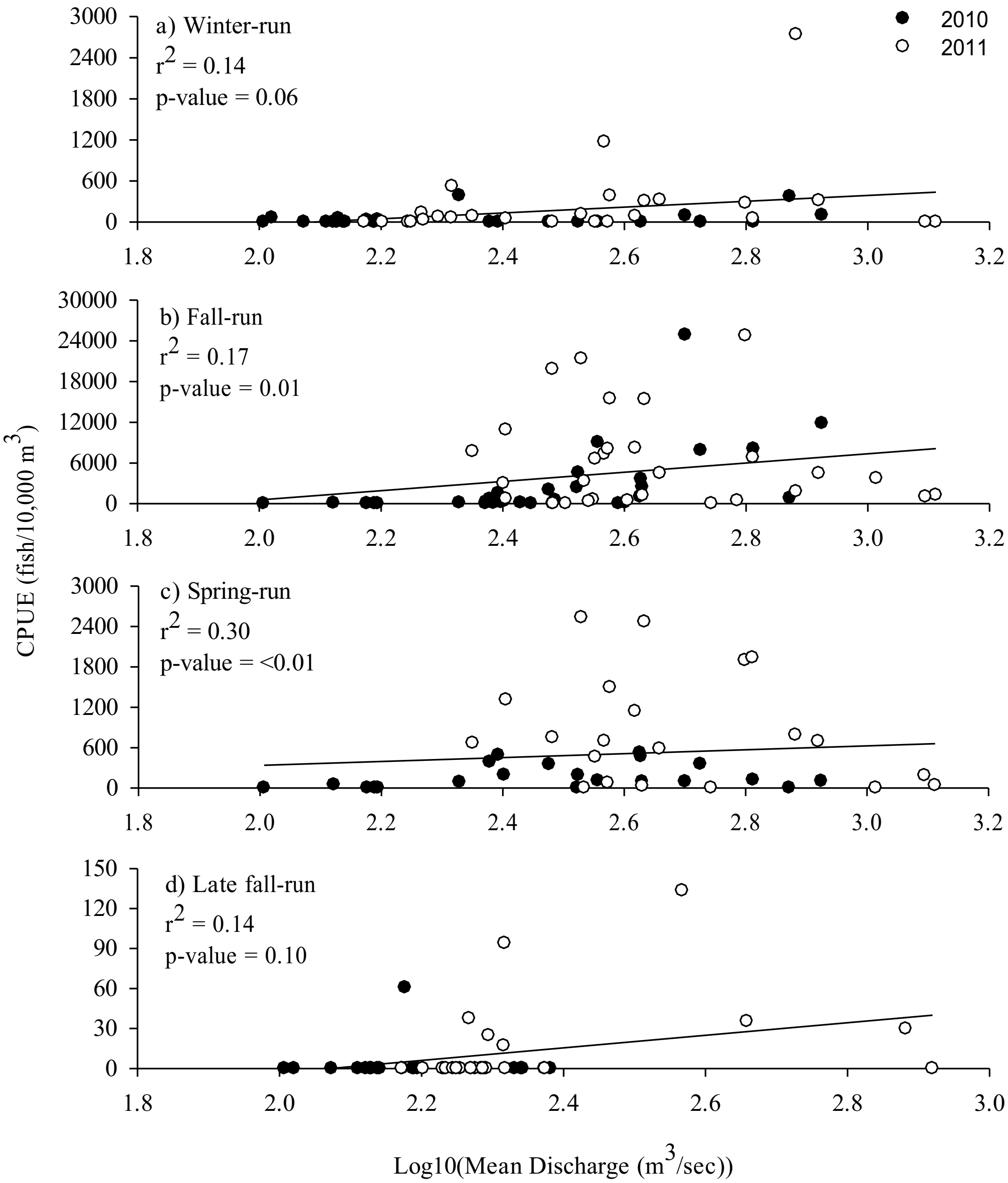

Figure 26. Linear regressions of mean weekly CPUE of unmarked juvenile a) winter-, b) fall-, c) spring-, and d) late fall-run Chinook salmon captured in beach seines in the Lower Sacramento Seine Region (Region 1) and mean weekly Sacramento River discharge at Colusa from a) October-March, b) December-June, c) December-April, and d) August-December during the 2010 and 2011 field seasons.

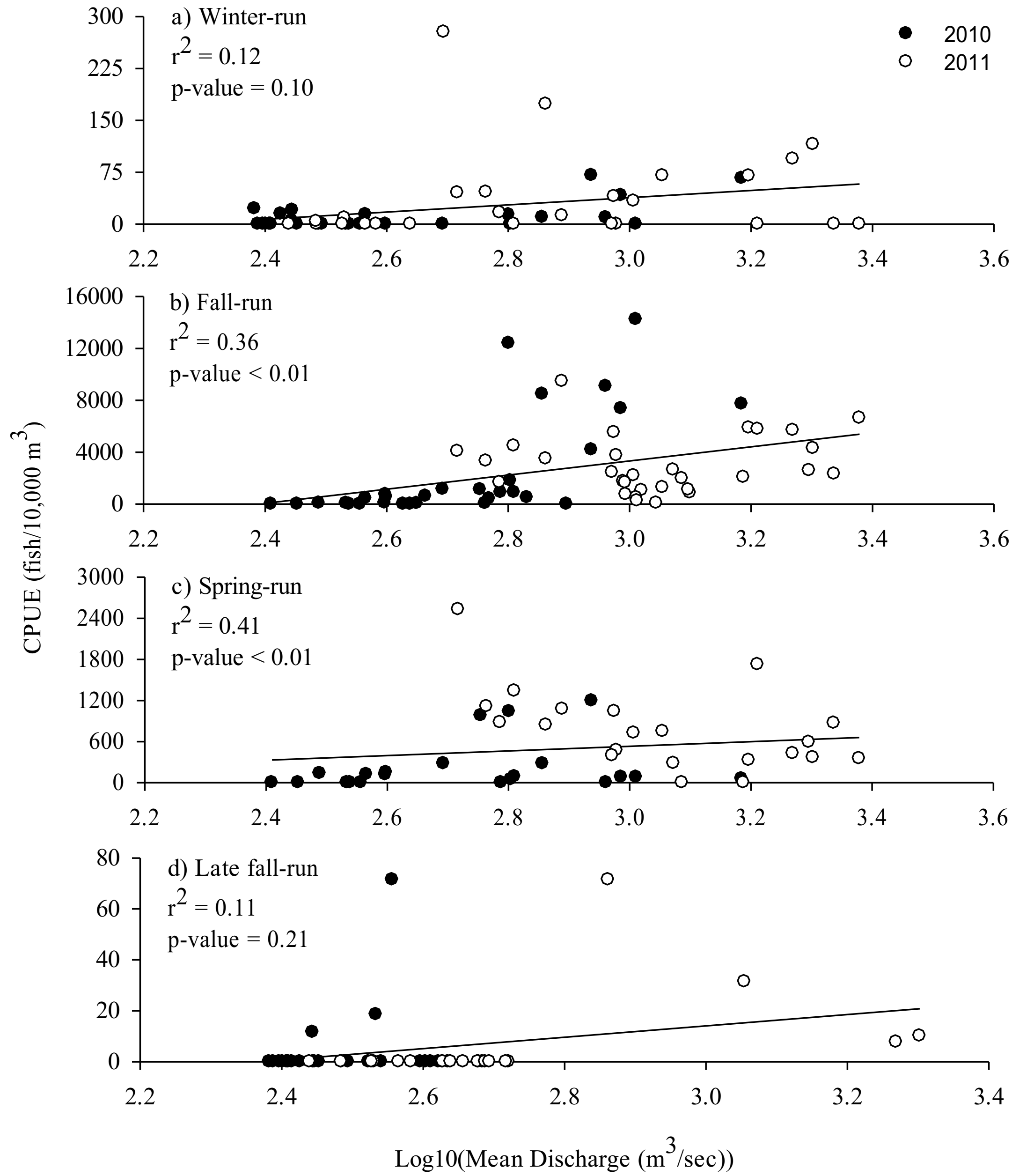

Figure 27. Linear regressions of mean weekly CPUE of unmarked juvenile a) winter-, b) fall-, c) spring-, and d) late fall-run Chinook salmon captured in beach seines in the North Delta Seine Region (Region 2) and concurrent mean weekly Sacramento River discharge at Freeport from a) October-March, b) December-June, c) December-April, and d) August-December during the 2010 and 2011 field seasons.

Fork Length Distributions

Unmarked juvenile Chinook salmon varied considerably in size between seine regions and trawl sites during the 2010 and 2011 field seasons (Figures 28-32). However, there were only weak inter-annual differences in FLs within beach seine regions and trawl sites between the 2010 and 2011 field seasons. In general, the FLs of unmarked juvenile Chinook salmon captured by beach seines during both the 2010 and 2011 field seasons displayed bimodal distributions ranging from 30-65 mm and 65-100 mm (Figures 30-32). The majority of fishes were identified as fry (FL<70 mm; Kjelson et al. 1982) and individuals were slightly (1-6 mm) smaller during the 2011 field season particularly within the Lower Sacramento, North Delta, and Central Delta Seine regions. These results are consistent with previous DJFMP findings that noted higher proportions of smaller individuals (i.e., fry) are observed in wet water years relative to normal or dry water years (Kjelson et al. 1982; Brandes and McLain 2001). In trawls, the FL distribution of unmarked juvenile Chinook salmon captured during both the 2010 and 2011 field seasons ranged from 70-110 mm using the MWTR at the Chipps Island Trawl Site (Figure 28). At the Mossdale Trawl Site, the FL of fish captured by the KDTR ranged from 70-120 mm (Figure 28). Fish captured by the KDTR and MWTR at the Sacramento Trawl Site ranged from 30-65 mm and 60-100 mm (FL), respectively (Figure 29). In contrast to beach seine catches, the majority of fishes captured by trawls were identified as smolts (FL≥70 mm; Kjelson et al. 1982). However, fishes captured within the KDTR at the Sacramento Trawl Site were generally identified as fry. Our results indicate that fry and smolt sized individuals occupy both open water mid-channel and near shore littoral habitats.

Although our data and other investigations (e.g., Kjelson et al. 1982) imply that fry may prefer near-shore littoral habitat and that smolts may prefer to occupy open water mid-channel habitat during the day, these patterns could be confounded by the influence of sample bias from variable gear efficiencies (Bayley and Peterson 2001). For example, each trawl site was sampled using varying trawl methods (i.e., Chipps Island = MWTR, Mossdale = KDTR, and Sacramento = KDTR & MWTR), cod-end designs (i.e., Mossdale = live box, Chipps Island = mesh, and Sacramento = mesh and live box), and cod-end "mesh" sizes (i.e., Chipps Island MWTR = 0.8 mm, Mossdale and Sacramento KDTR = 0.46 mm, and Sacramento MWTR = 0.3 mm), which can greatly affect the gear efficiency for different size classes of fish. Furthermore, the beach seine methods used by the DJFMP are thought to select for smaller individuals based on the fact that larger individuals are more likely able to avoid the gear during sampling. Thus the DJFMP is strongly considering the following changes to its standard operating procedures: (1) standardize trawl equipment and methods among all trawl sites, (2) determine if and how gear efficiency varies among gear types, methods, and locations, and (3) possibly adjust catch data to better elucidate size and growth patterns within and among field seasons.

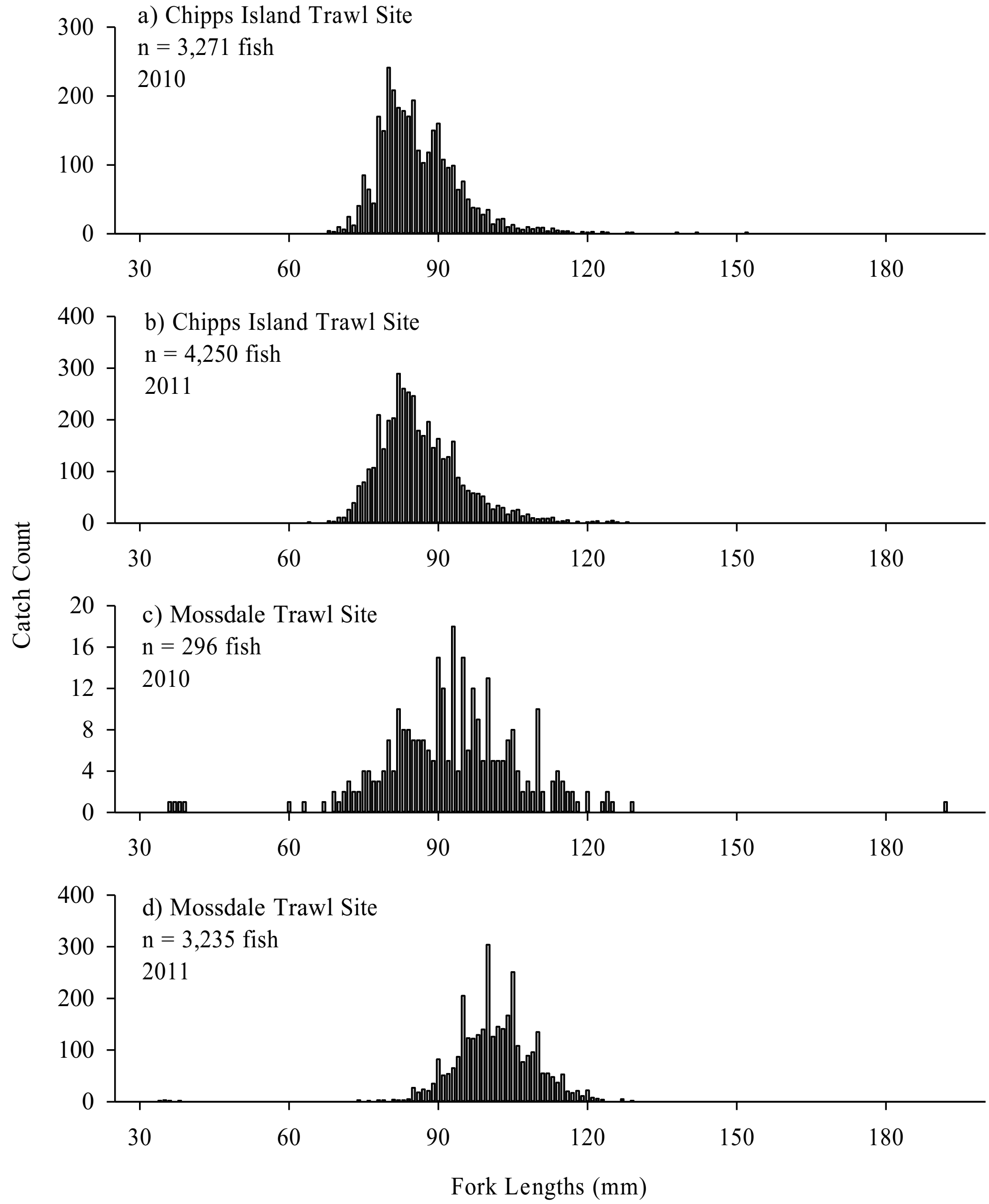

Figure 28. Fork length distributions of all unmarked juvenile Chinook salmon captured in mid-water (MWTRs) and Kodiak trawls (KDTRs) at the Chipps Island and Mossdale Trawl sites, respectively during the 2010 and 2011 field seasons.

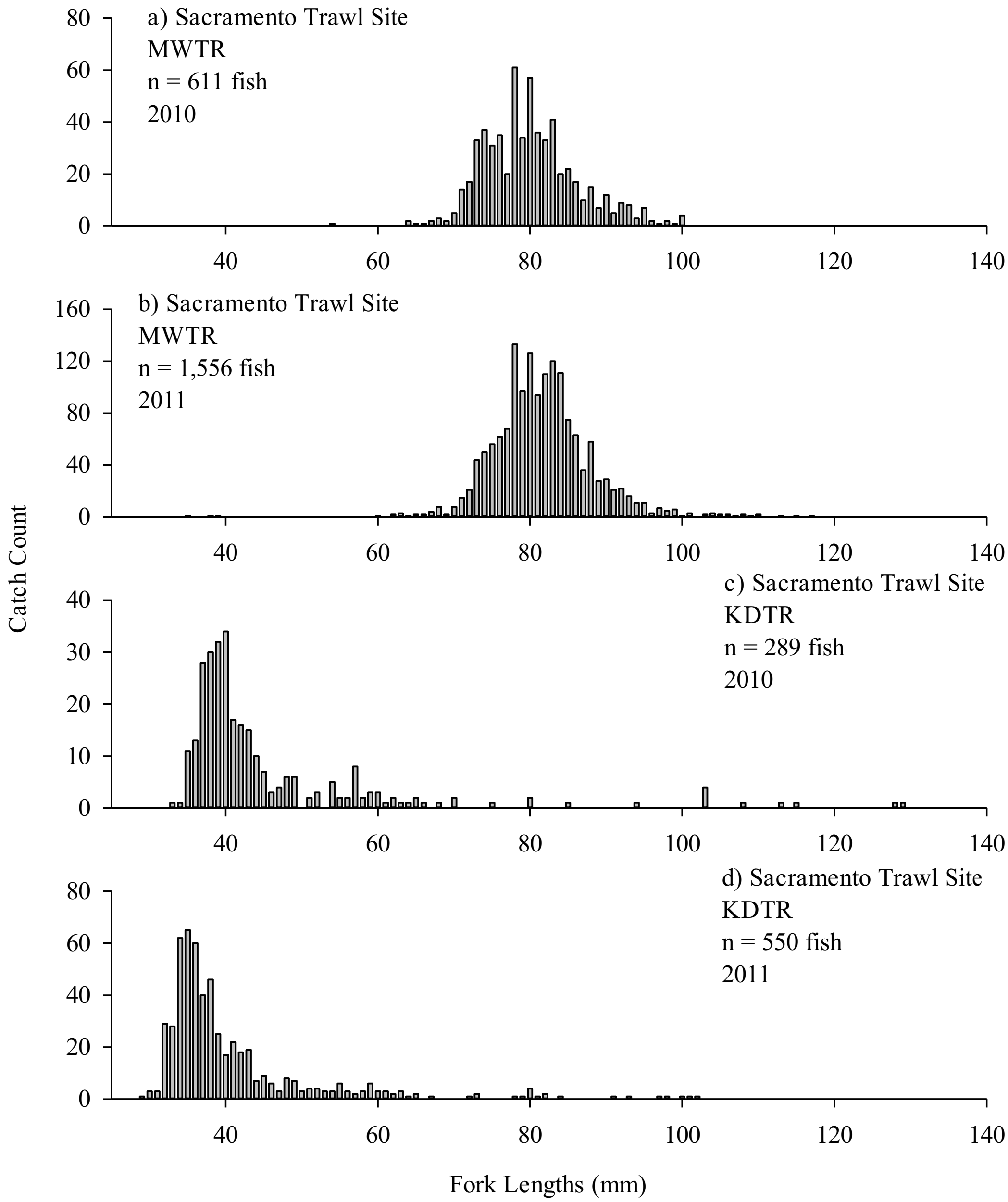

Figure 29. Fork length distributions of unmarked juvenile Chinook salmon captured in mid-water (MWTRs) and Kodiak trawls (KDTRs) at the Sacramento Trawl Site by gear during the 2010 and 2011 field seasons.

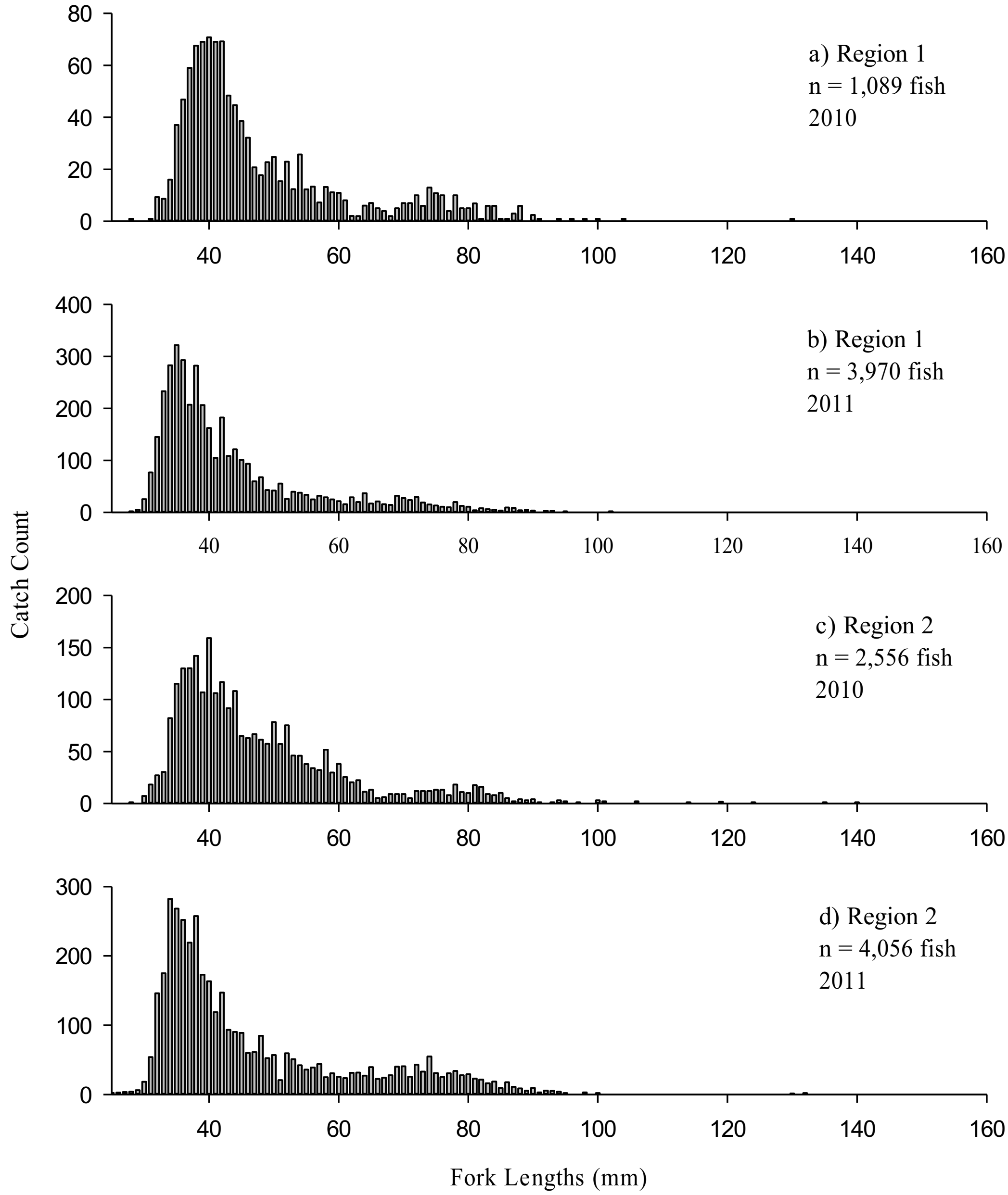

Figure 30. Fork length distributions of all unmarked juvenile Chinook salmon captured in beach seines at the Lower Sacramento River Seine (Region 1) and North Delta Seine regions (Region 2) during the 2010 and 2011 field seasons.

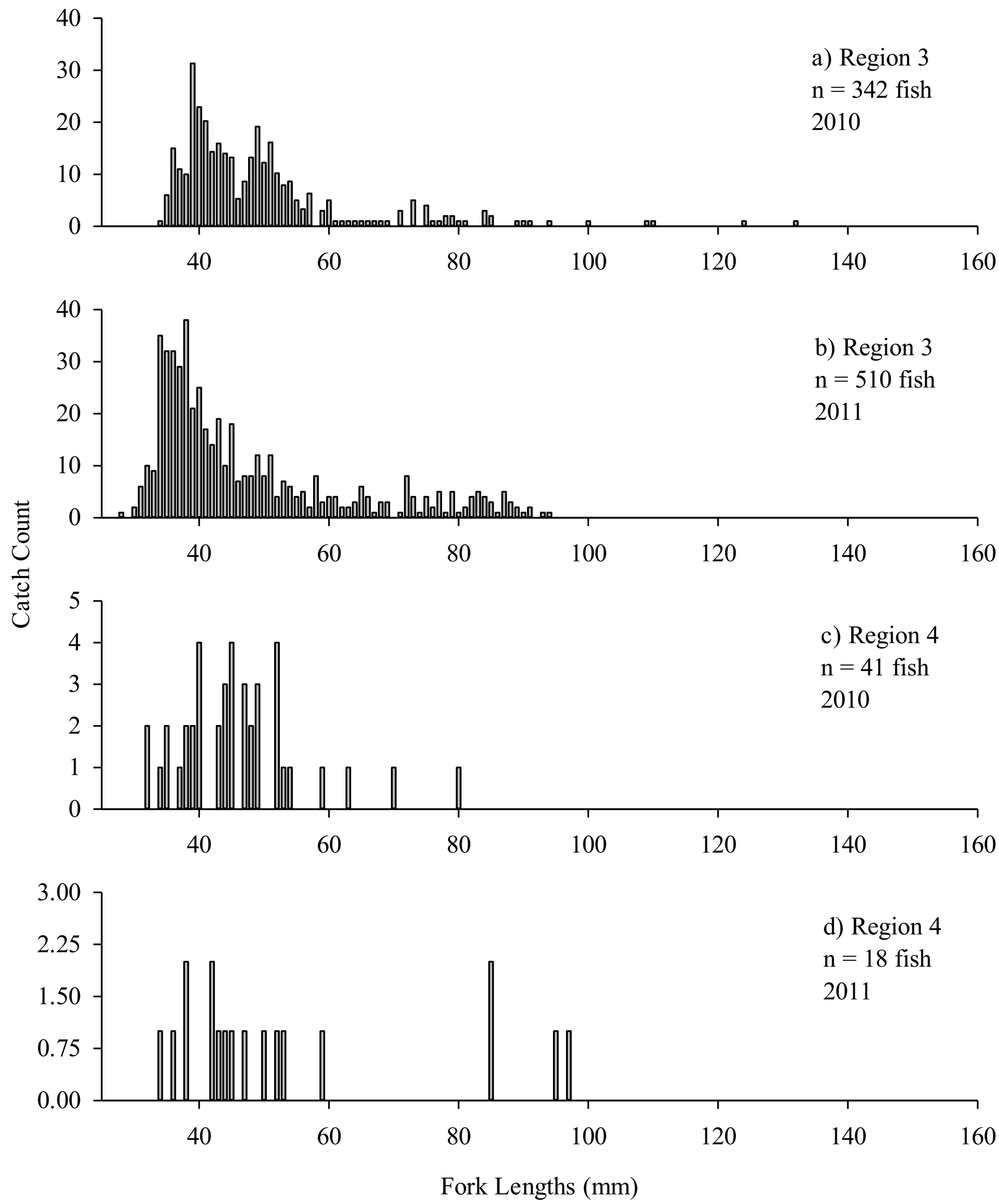

Figure 31. Fork length distributions of all unmarked juvenile Chinook salmon captured in beach seines at the Central Delta Seine (Region 3) and South Delta Seine regions (Region 4) during the 2010 and 2011 field seasons.

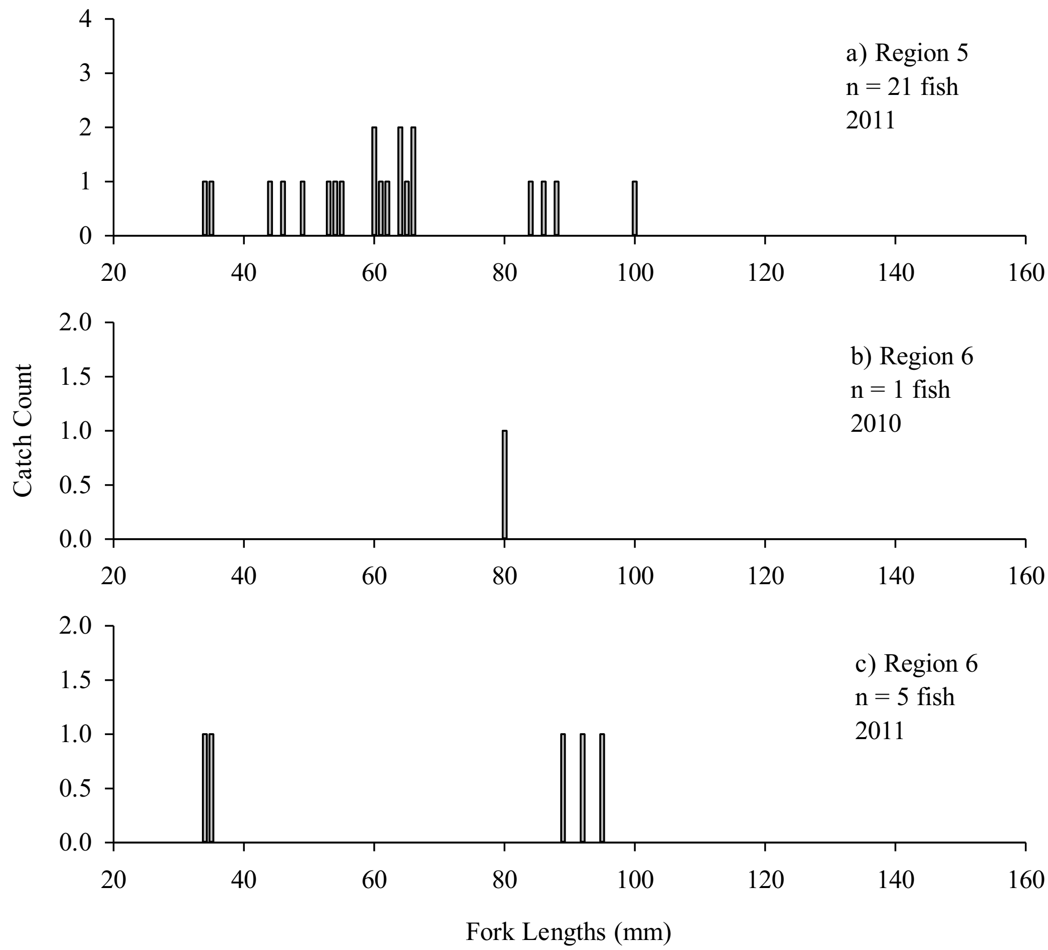

Figure 32. Fork length distributions of all unmarked juvenile Chinook salmon captured in beach seines at the Lower San Joaquin River Seine (Region 5) and San Francisco/San Pablo Bay Seine regions (Region 6) during the 2010 and 2011 field seasons. No juvenile Chinook salmon were captured in Region 5 during the 2010 field season.

Absolute Abundance

Among the 74 release groups used to estimate the $\overline{TRR}$ at the Chipps Island Trawl Site, a total of 6,464,717 fish were marked with a CWT (PSMFC 2012). Release groups ranged in size from 22,911 to 717,966 individuals. The $\overline{TRR}$ was estimated at 0.6% (±0.1%) after CWT releases from 1989 to 2011. The duration of recoveries of CWT fish within a release group spanned, on average, 14 days. Only one release group had no recoveries.

The mean absolute abundance of unmarked juvenile Chinook salmon emigrating out of the Sacramento-San Joaquin Delta was estimated at 8,995,853 and 11,562,683 individuals during the 2010 and 2011 field seasons, respectively (Figure 33). During the 2010 field season, approximately 2% (n = 177,078) of the Chinook salmon were winter-run, 75% (n = 6,740,952) were fall-run, 23% (n = 2,046,131) were spring-run, and <1% (n = 31,691) were late fall-run individuals. During the 2011 field season, approximately 1% (n = 166,451) of the Chinook salmon were winter-run, 85% (n = 9,792,957) were fall-run, 14% (n = 1,565,705) were spring-run, and <1% (n = 37,569) were late fall-run individuals. In general, the absolute abundance of unmarked juvenile Chinook salmon at the Chipps Island Trawl Site appears to have declined since at least the 1990s, reaching record lows for all races during either the 2008 or 2009 field season (Figures 33 and 34). The abundance of unmarked juvenile winter- and late fall-run Chinook salmon have remained at historically low levels since the 2008 field season (Figure 33). The abundance of both unmarked juvenile fall- and spring-run Chinook salmon at the Chipps Island Trawl Site have generally increased since their record low in 2008, but remain less than their historical averages (i.e., 1995-2009; fall = 11,236,411 and spring = 2,768,873). As reported by Azat (2012), the adult Chinook salmon escapement estimate for 2011 was the highest since 2006 within the Central Valley and the fall- and spring-run portion of adult escapement comprised 96% of the total estimate. As a result, the increase in relative and absolute abundances of fall- and spring-run Chinook salmon observed during the 2010 and 2011 field seasons is likely attributed, in part, to a strong escapement of fall- and spring-run adults.

Contrary to previous DJFMP annual reports, we demonstrated weak linear correlation between the historical annual absolute abundance estimates for unmarked juvenile Chinook salmon migrating past the Chipps Island Trawl Site and the annual adult escapement estimates for the Sacramento-San Joaquin River Basin ($r^2 = 0.02$; Table A26). Conversely, we found relatively good fit between the annual abundance estimates of juveniles at Chipps Island and adult escapement assuming a quadratic relationship ($r^2 = 0.43$; Figure 35). Because nearly all individuals captured at the Chipps Island Trawl Site are smolt sized individuals (FL≥70 mm; Figure 28), there is evidence that higher proportions of juvenile Chinook salmon emigrating out of the Delta are likely fry during years when total adult escapement exceeds 500,000, suggesting a possible density-dependent growth relationship within the Estuary and its watershed (Grant and Imre 2005). Although Brandes and McLain (2001) determined that a larger proportion of individuals entering and migrating through the Delta were fry during periods of high river discharge, there was no assessment of the influence of spawning stock or how it may interact with river discharge on the proportion of smolts or fry emigrating from the Delta. Further investigations are needed to substantiate these hypotheses.

The absolute abundance estimates for unmarked juvenile Chinook salmon migrating past Chipps Island presented in this report likely contains bias from several sources. Firstly, we assumed that unmarked individuals were never recaptured. This assumption was evidently violated based on the capture of CWT individuals that were released downstream of Chipps Island (e.g., San Pablo Bay) by the Chipps Island MWTR (Tables A24 and A25). Therefore our abundance estimates are overestimated to an unknown degree. Secondly, we assumed that juvenile Chinook salmon were equally distributed in time, which is likely violated based on diel migratory patterns. Several studies have demonstrated that more juvenile Chinook salmon migrate during the night relative to the day (Williams 2006 and references therein). As a result, given that the DJFMP samples during the day, the absolute abundance of unmarked juvenile Chinook salmon could be underestimated at Chipps Island. Thirdly, we may have underestimated the absolute abundance of juvenile Chinook salmon at the Chipps Island Trawl Site due to the MWTR's possible selectivity of smolt sized individuals, as discussed above, which could greatly bias estimates during wet water years (Brandes and McLain 2001). Lastly, the misidentification of race using the size at date of capture river criteria could greatly bias high and low race specific estimates, particularly for fall- and spring-run Chinook salmon (Williams 2006).

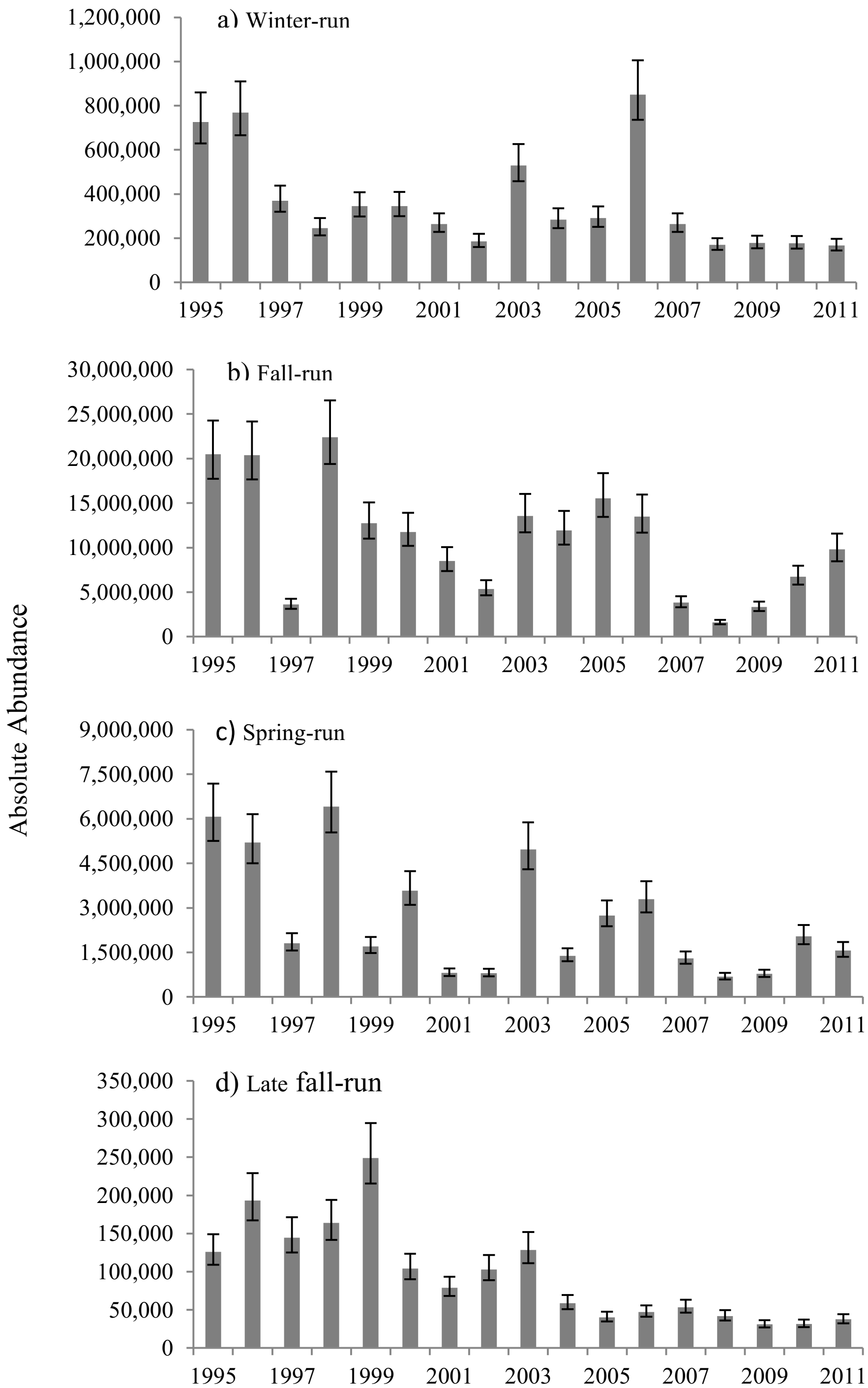

Figure 33. Mean annual absolute abundance estimates and their 95% confidence intervals for a) winter-, b) fall-, c) spring-, and d) late fall-run juvenile Chinook salmon at the Chipps Island Trawl Site from the 1995 to 2011 field seasons. Constant fractional marking (25%) of fall-run Chinook salmon was implemented by hatcheries in 2007 (tagging rates varied prior to 2007).

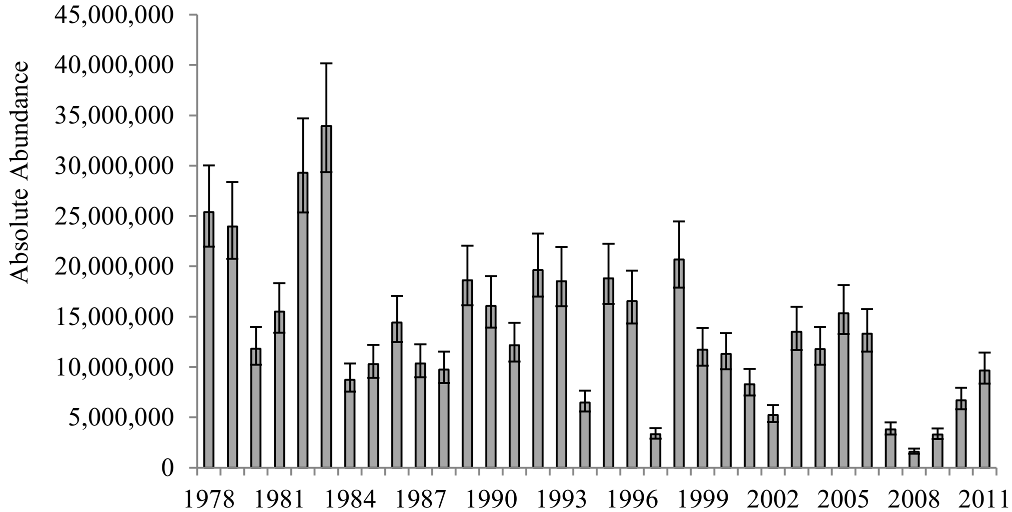

Figure 34. Mean absolute abundance estimates and their 95% confidence intervals for fall-run juvenile Chinook salmon at the Chipps Island Trawl Site during April through June from the 1978 to 2011 field seasons. Constant fractional marking (25%) of fall-run Chinook was implemented by hatcheries in 2007 (tagging rates varied prior to 2007).

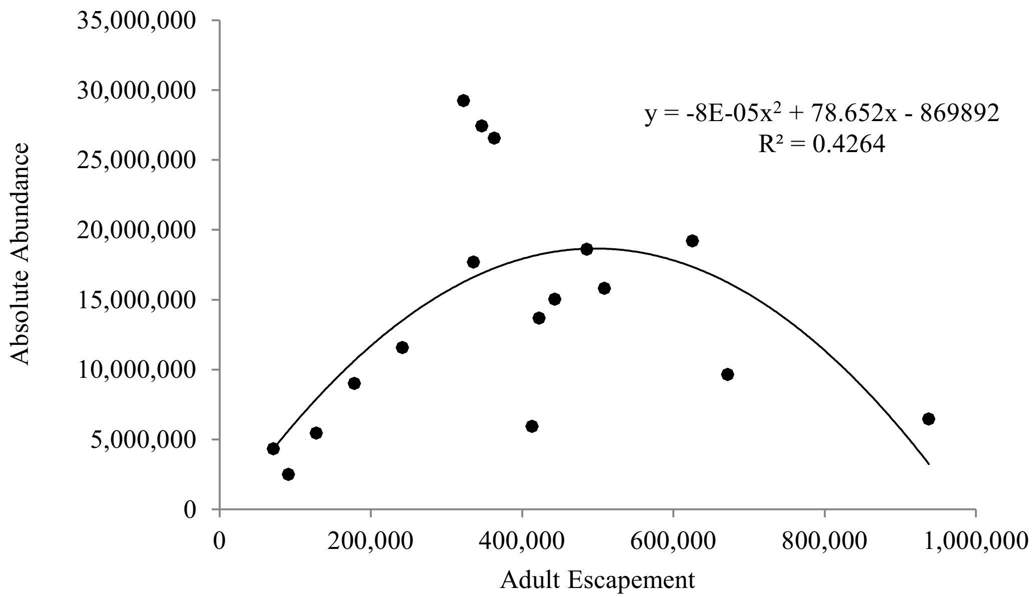

Figure 35. Mean annual absolute abundance estimates for all unmarked juvenile Chinook salmon at the Chipps Island Trawl Site related to total adult Chinook salmon escapement for the Sacramento-San Joaquin River Basin from 1995 to 2011.

Steelhead

We captured 188 and 154 steelhead during the 2010 and 2011 field seasons, respectively (Tables A18 and A19). Approximately 90% of all steelhead captured in 2010 (n = 171) and 2011 (n = 140) were marked and considered to be hatchery reared.

Distribution and Relative Abundance

The DJFMP captured steelhead in low numbers at all trawl sites during the 2010 and 2011 field seasons with the majority of observations at Chipps Island (Tables A18 and A19). Both hatchery-reared and wild steelhead were generally detected from January through May at the Chipps Island Trawl Site and January through June at the Sacramento Trawl Site (Figures 36 and 37). The mean monthly CPUE at the Chipps Island and Sacramento Trawl sites peaked in February. Relatively few individuals (total<5 per field season) were detected at the Mossdale Trawl Site primarily during April and May (Figure 38). Although the 2010 and 2011 mean yearly CPUE estimates at the Chipps Island Trawl Site were similar to those observed over the last decade, the total number of wild individuals have steadily declined since 1995 and were near record lows during the 2010 and 2011 field seasons (Figure 36). Because all hatchery reared steelhead within the Central Valley have been marked for management purposes since 1998 (Kevin Niemela, USFWS, personal communication), the decline in wild steelhead CPUE from 1998 through 2011 can be a result of declining wild stock(s). Lower CPUE estimates for wild fish are consistent with natural escapement estimates (McEwan 2001). No trends of mean yearly CPUE estimates at the Sacramento and Mossdale Trawl sites were apparent (Figures 37 and 38).

In beach seines, steelhead were generally detected in very low numbers and only within the Lower Sacramento River, North Delta, and Central Delta Seine regions (Figures 39 and 40). Steelhead were observed from January through February and January through March during the 2010 and 2011 field seasons, respectively. Only one wild steelhead was detected in 2010 and this individual was observed in the Lower Sacramento River Seine Region. All wild steelhead observed in 2011 (n=3) were detected in the North Delta Seine Region. The trends of mean yearly CPUE estimates for wild and hatchery reared steelhead within seine regions were inconclusive based on consistently low catch numbers (Figures 39 and 40).

Influence of River Discharge

During the 2010 and 2011 field seasons, the mean monthly CPUE of all steelhead generally peaked during the same months at each trawl site or seine region regardless of mean monthly river discharge (e.g., during February at Chipps Island; Figure 36). In addition, there was generally no discernible difference between the mean monthly CPUE estimates at any given location between years, suggesting there was little influence of water year type on the relative abundance of steelhead. Previous investigations have indicated that wild and hatchery reared juvenile steelhead migrate at higher rates during periods of higher river discharges (Giorgi et al. 1997). However, because the majority of individuals that the DJFMP captured were hatchery reared, steelhead catches were likely highly influenced by the timing and location of hatchery releases and less likely influenced by river discharge. Many of the hatchery reared steelhead were captured in beach seines that are at or near known hatchery release sites. Therefore, the capture of primarily hatchery-reared steelhead combined with relatively low catches of wild steelhead likely created relatively poor relationships between river discharge and steelhead densities.

Fork Length Distributions

Due to low captures of steelhead, trends were weak or not apparent for the 2010 and 2011 length-frequency distributions (Figures 41-46). The FL of steelhead captured by the DJFMP generally ranged from 200 to 300 mm among the trawl sites and 160 to 300 mm among seine regions. Steelhead captured by the DJFMP did not appear to vary in size among gear types, seine regions, or trawl sites. However, the FL of wild steelhead was slightly smaller (more individuals with FL<120 mm) relative to hatchery reared steelhead at the Sacramento and Mossdale Trawl sites and North Delta Seine Region (Figures 42-46). Again, this trend is likely a result of the small sample size.

If we assume that size-specific sampling efficiency is similar for steelhead and Chinook salmon and seines and KDTR gears are effective at sampling small fish (FL<70 mm), our results indicate that juvenile steelhead entering and migrating through the Sacramento-San Joaquin Delta are mostly large individuals from multiple age classes. Lindley et al. (2006) showed that the lower San Joaquin River and the Sacramento-San Joaquin Delta were mostly unsuitable for rearing based on relatively high water temperatures, making the Delta function primarily as a migratory corridor. Furthermore, it was determined that wild juvenile steelhead from the Sacramento River Basin spend one to three years (average = two) rearing in fresh water before emigrating (Williams 2006 and references therein), suggesting that smaller juvenile steelhead from the Sacramento River are not using the Delta for rearing habitat. Lastly, in an attempt to maximize survival, fish hatcheries often rear steelhead to larger sizes before releasing them within or just upstream of the Estuary. Although the DJFMP is able to detect small numbers of larger juvenile steelhead during each field season, we presume that DJFMP methods are not very efficient in catching these large and highly mobile individuals. Therefore, the DJFMP may not be adequately monitoring juvenile steelhead within the San Francisco Estuary and sampling efficiency needs to be determined. An investigation of sampling efficiency would help elucidate this uncertainty.

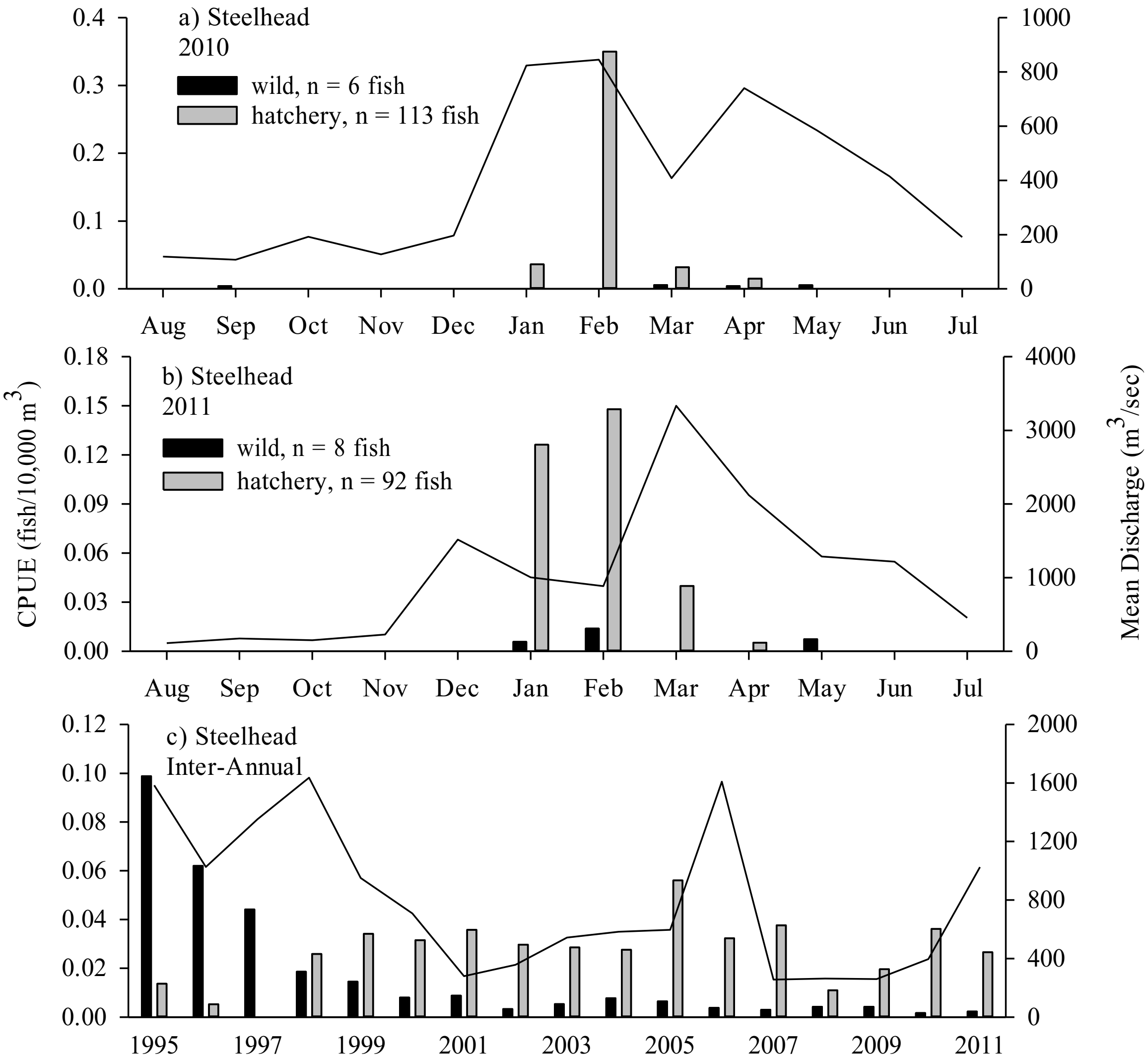

Figure 36. Mean monthly and yearly CPUE (bars) of hatchery and wild steelhead captured in mid-water trawls (MWTRs) at the Chipps Island Trawl Site, and mean monthly and yearly Delta discharge (lines) during the a) 2010, b) 2011, and c) 1995 through 2011 field seasons. Sample size (n) corresponds to total number of fish caught.

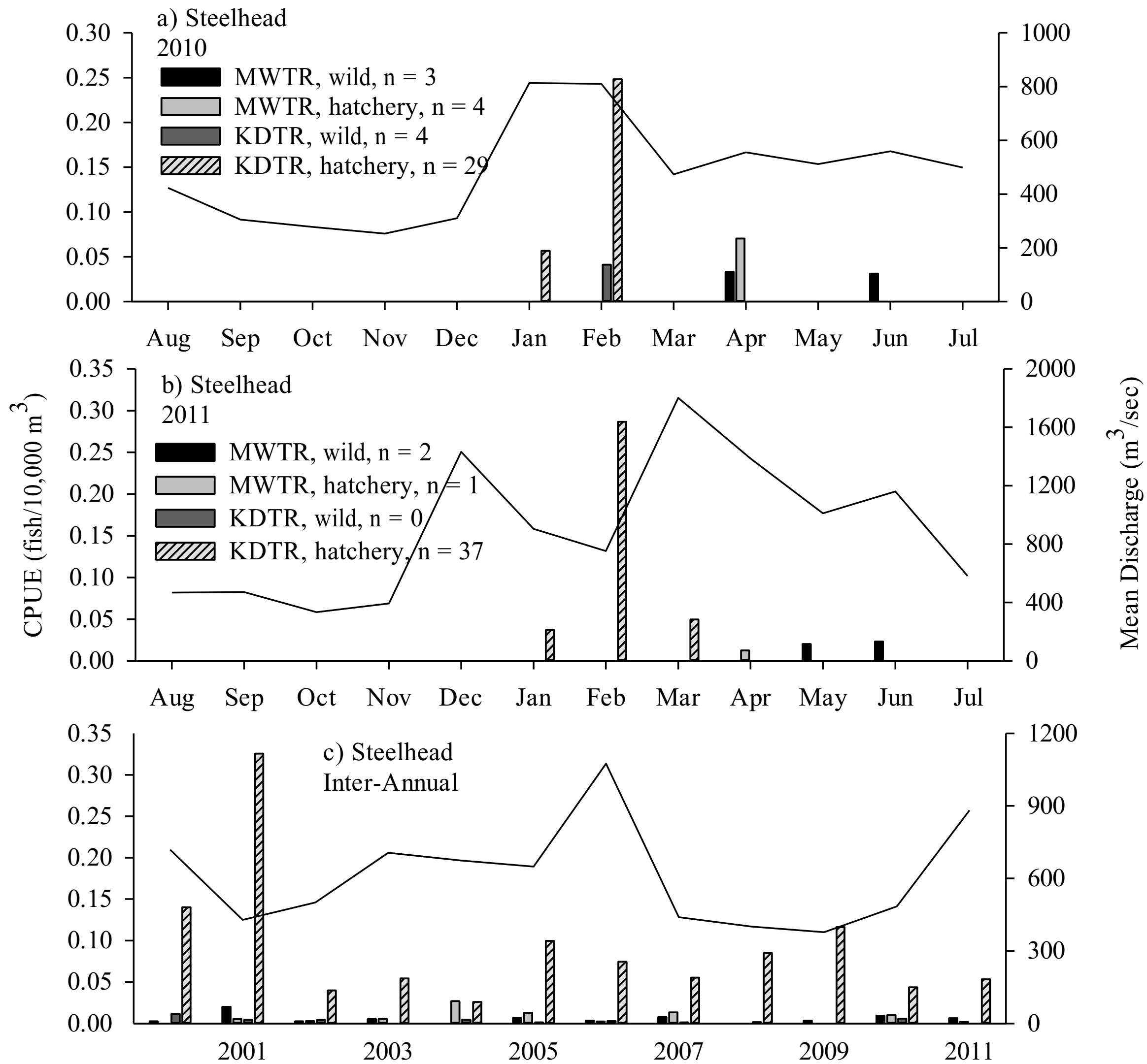

Figure 37. Mean monthly and yearly CPUE (bars) of hatchery and wild steelhead captured in mid-water (MWTRs) and Kodiak trawls (KDTRs) at the Sacramento Trawl Site, and mean monthly and yearly Sacramento River discharge at Freeport (lines) during the a) 2010, b) 2011, and c) 2000 through 2011 field seasons. Sample size (n) corresponds to total number of fish caught.

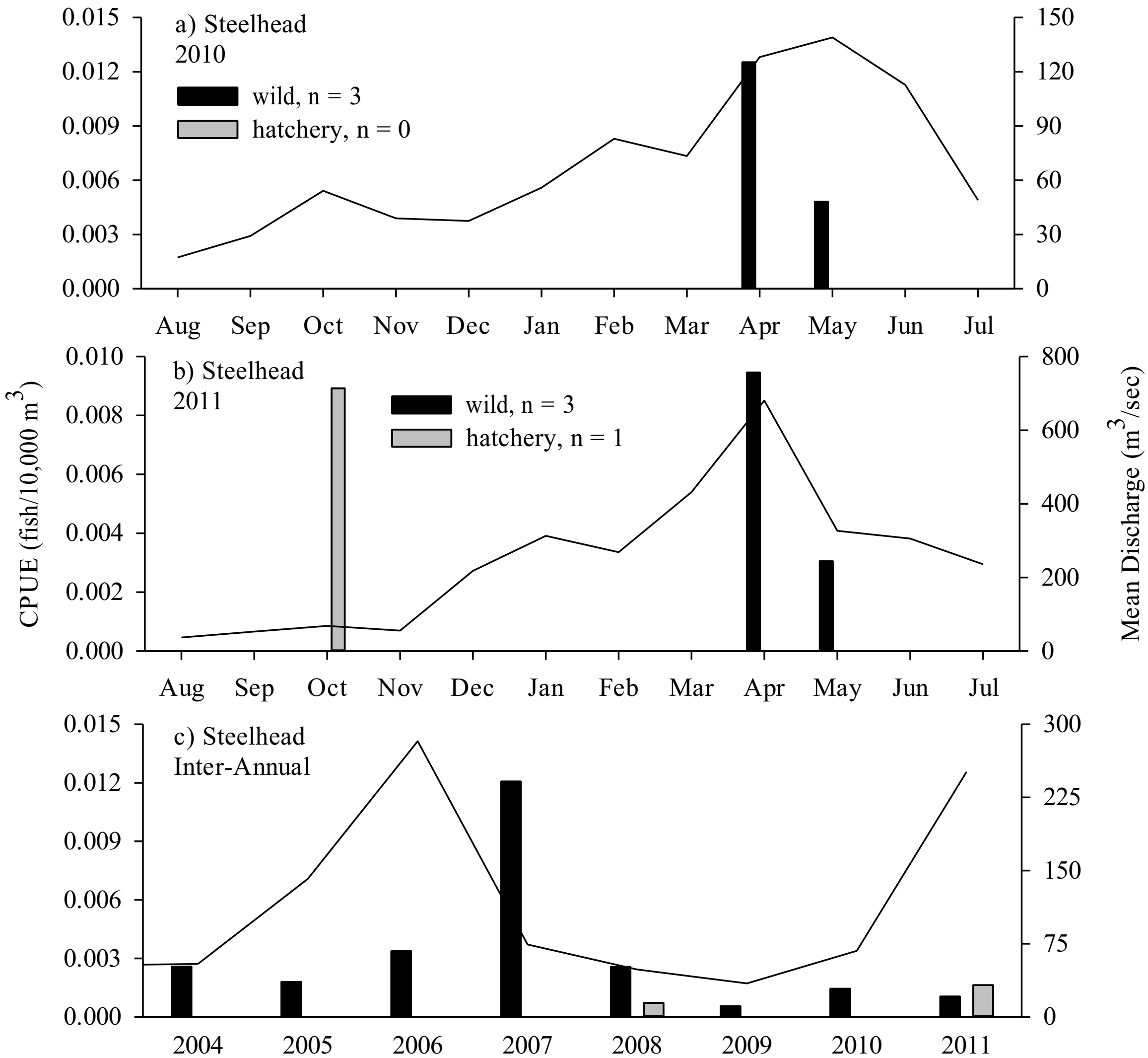

Figure 38. Mean monthly and yearly CPUE (bars) of hatchery and wild steelhead captured in Kodiak trawls (KDTRs) at the Mossdale Trawl Site, and mean monthly and yearly San Joaquin River discharge at Vernalis (lines) during the a) 2010, b) 2011, and c) 2004 through 2011 field seasons. Sample size (n) corresponds to total number of fish caught.

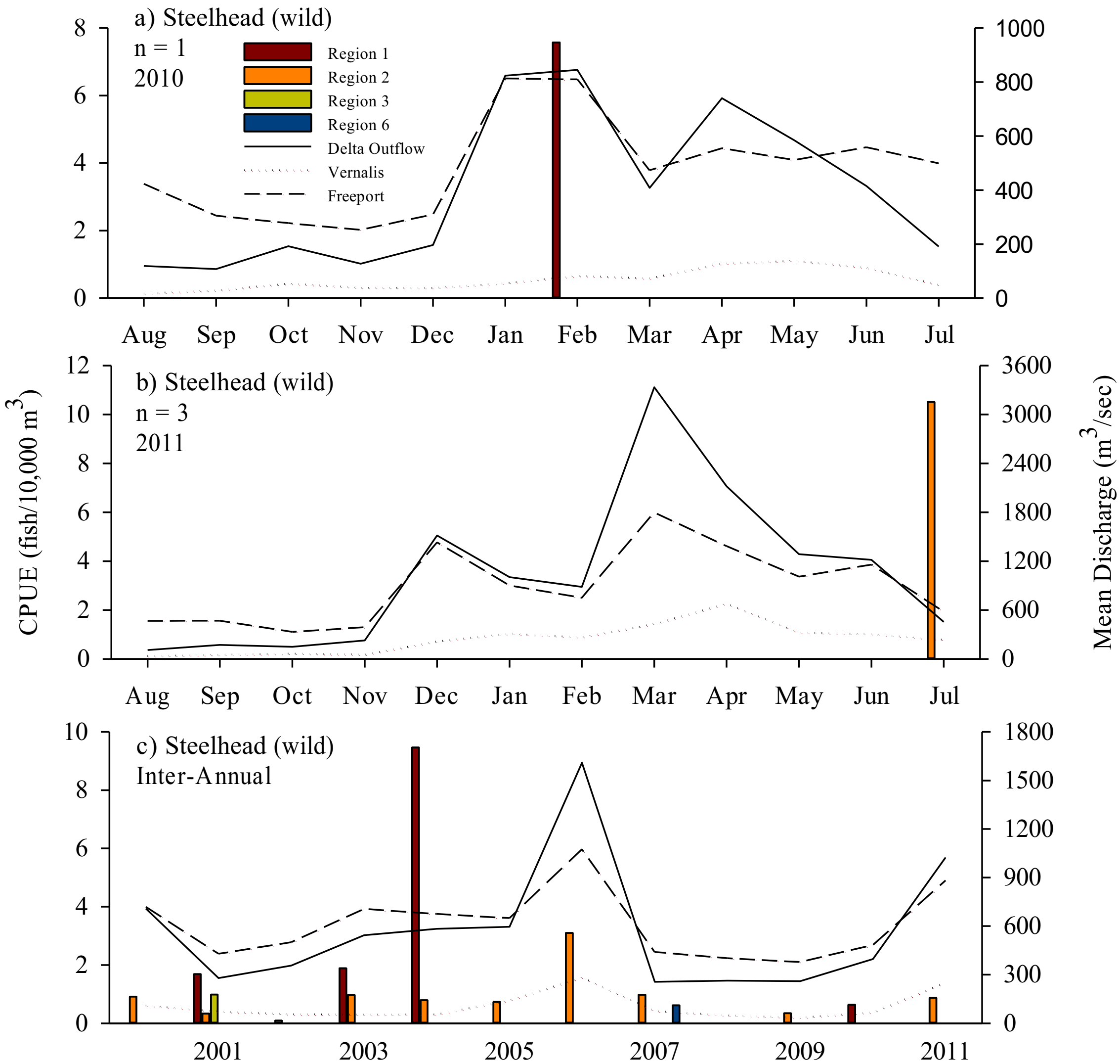

Figure 39. Mean monthly and yearly CPUE of wild steelhead captured in beach seines at Regions 1-6, and mean monthly and yearly Sacramento River discharge at Freeport, San Joaquin River discharge at Vernalis, and Delta discharge during the a) 2010, b) 2011, and c) 2000 through 2011 field seasons. Sample size (n) corresponds to total number of fish caught.

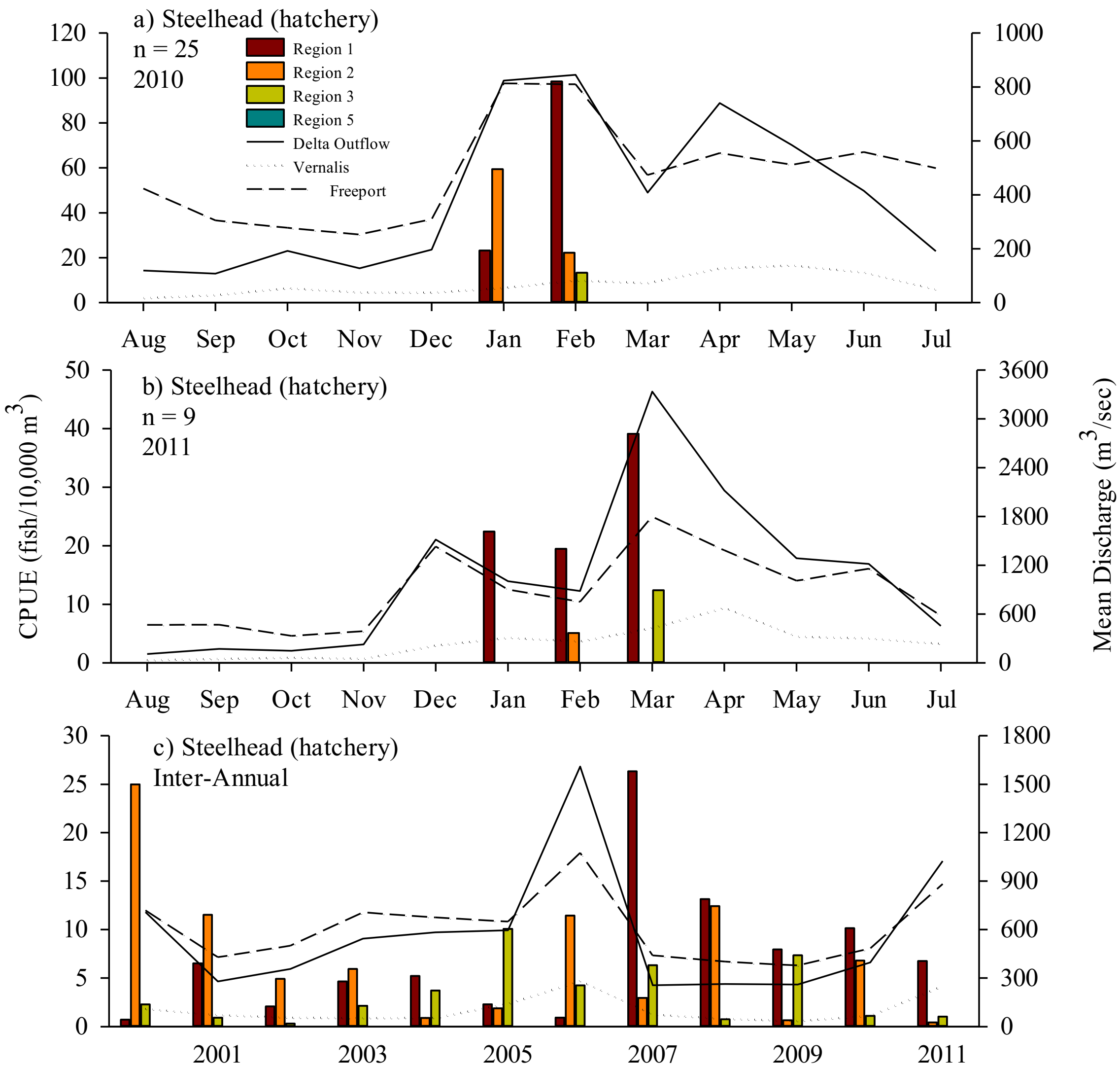

Figure 40. Mean monthly and yearly CPUE of hatchery steelhead captured in beach seines at Regions 1-6, and mean monthly and yearly Sacramento River discharge at Freeport, San Joaquin River discharge at Vernalis, and Delta discharge during the a) 2010, b) 2011, and c) 2000 through 2011 field seasons. Sample size (n) corresponds to total number of fish caught.

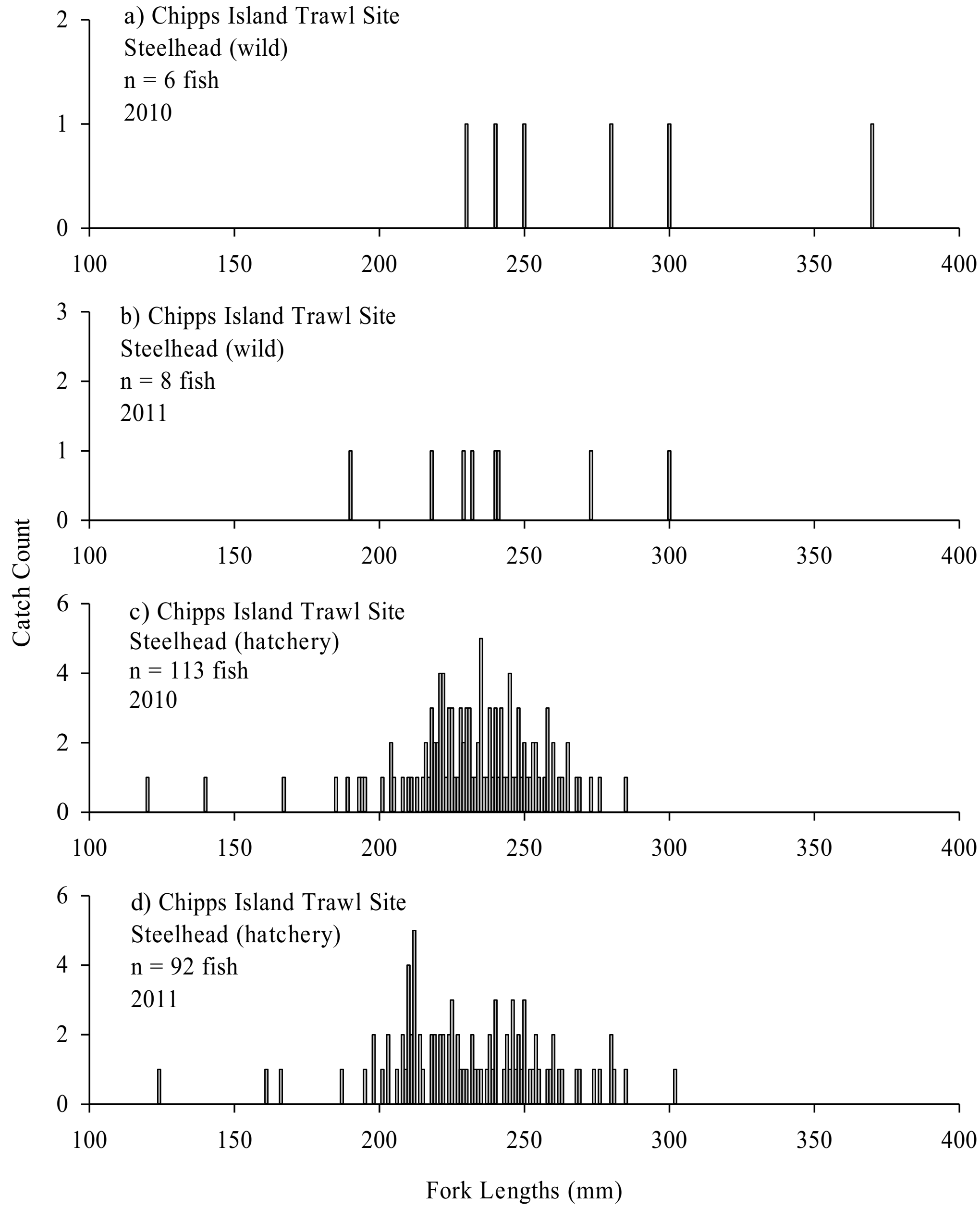

Figure 41. Fork length distributions for all hatchery and wild steelhead captured in mid-water trawls (MWTRs) at the Chipps Island Trawl Site during the 2010 and 2011 field seasons.

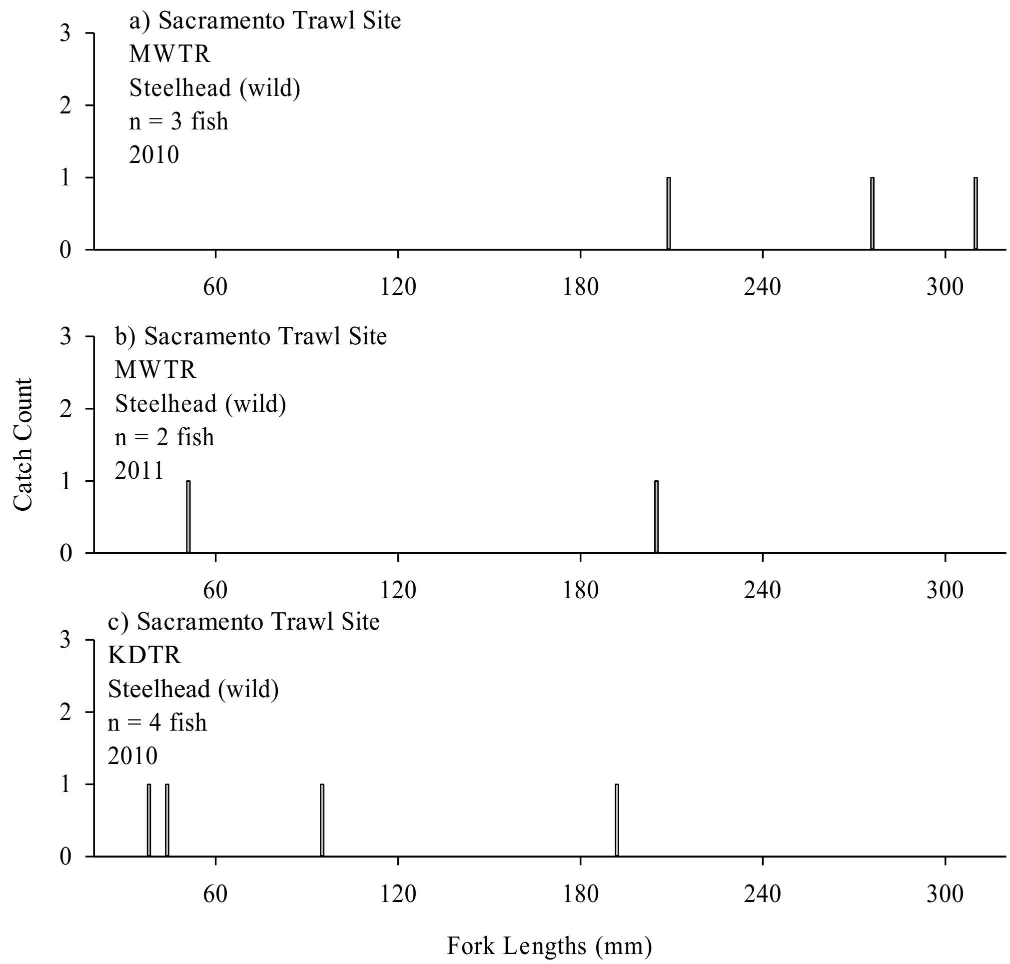

Figure 42. Fork length distributions for wild steelhead captured in mid-water (MWTRs) and Kodiak trawls (KDTRs) at the Sacramento Trawl Site during the 2010 and 2011 field seasons. No wild steelhead were captured at the Sacramento Trawl Site during the 2011 field season using KDTRs.

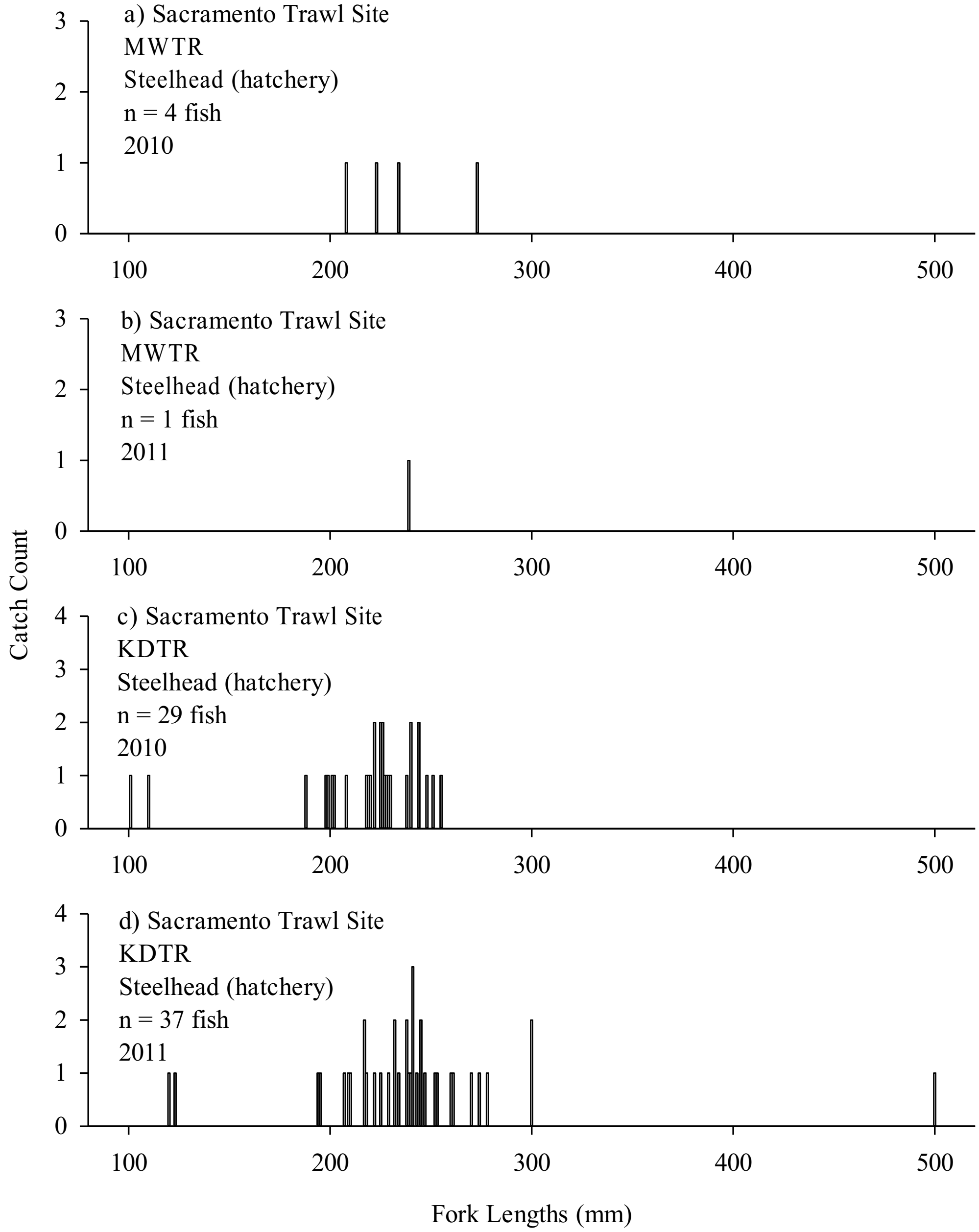

Figure 43. Fork length distributions for hatchery steelhead captured in mid-water (MWTRs) and Kodiak trawls (KDTRs) at the Sacramento Trawl Site during the 2010 and 2011 field seasons.

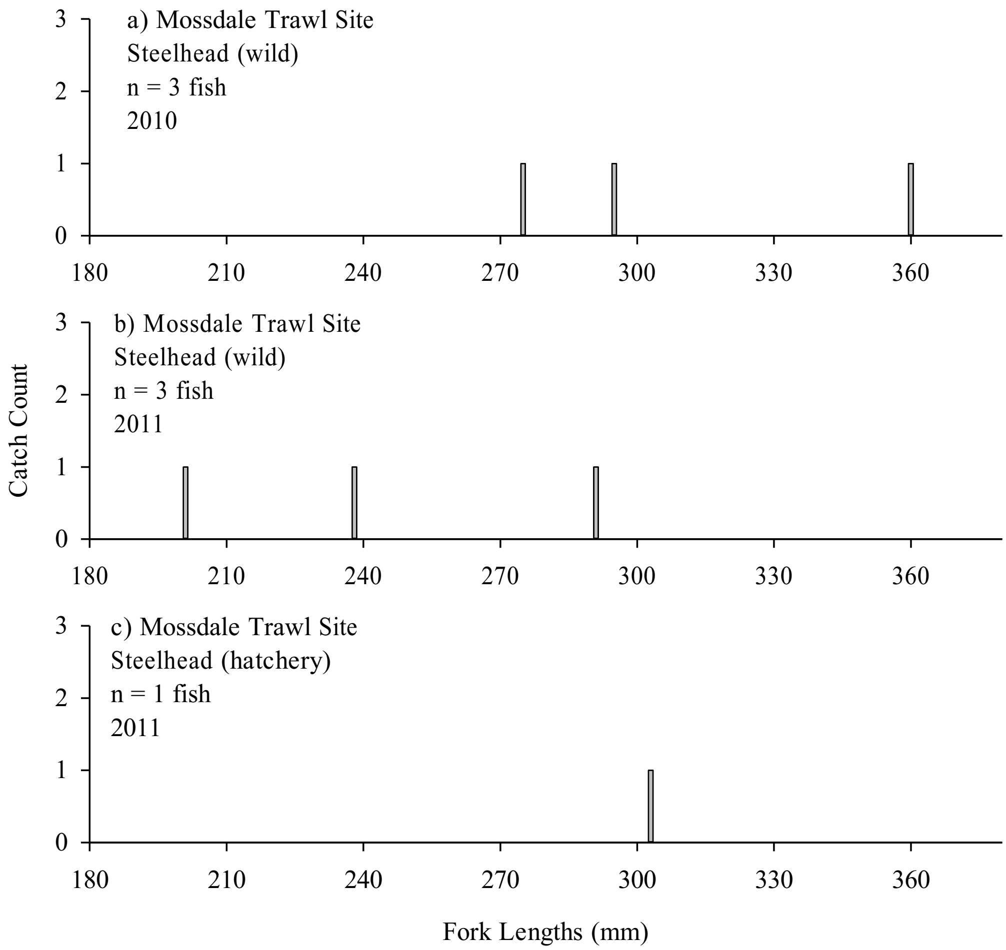

Figure 44. Fork length distributions for hatchery and wild steelhead captured in Kodiak trawls (KDTRs) at the Mossdale Trawl Site during the 2010 and 2011 field seasons. No hatchery steelhead were captured at the Mossdale Trawl Site during the 2010 field season.

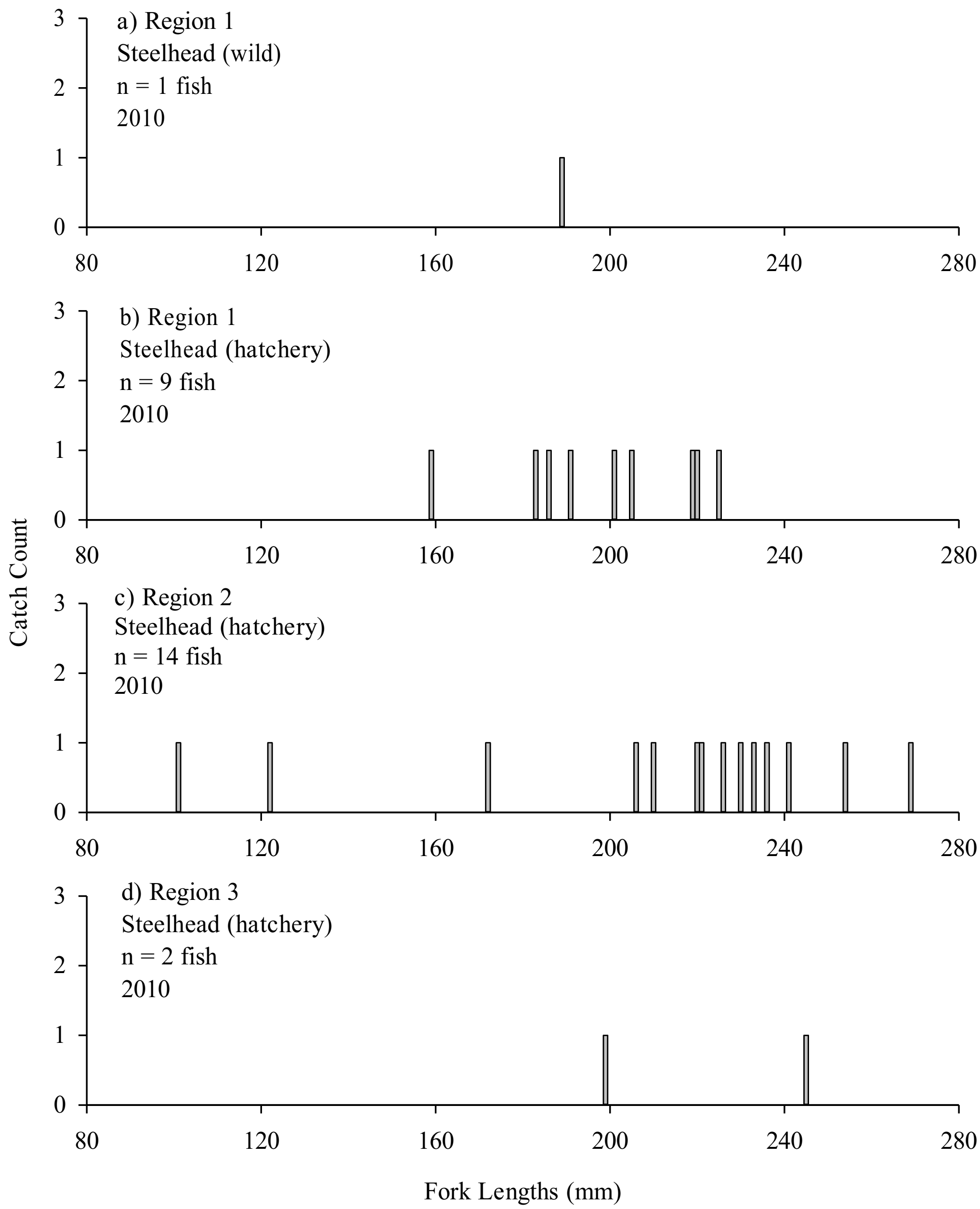

Figure 45. Fork length distributions for hatchery and wild steelhead captured in beach seines within the Lower Sacramento River (Region 1), North Delta (Region 2), and Central Delta (Region 3) Seine regions during the 2010 field season.

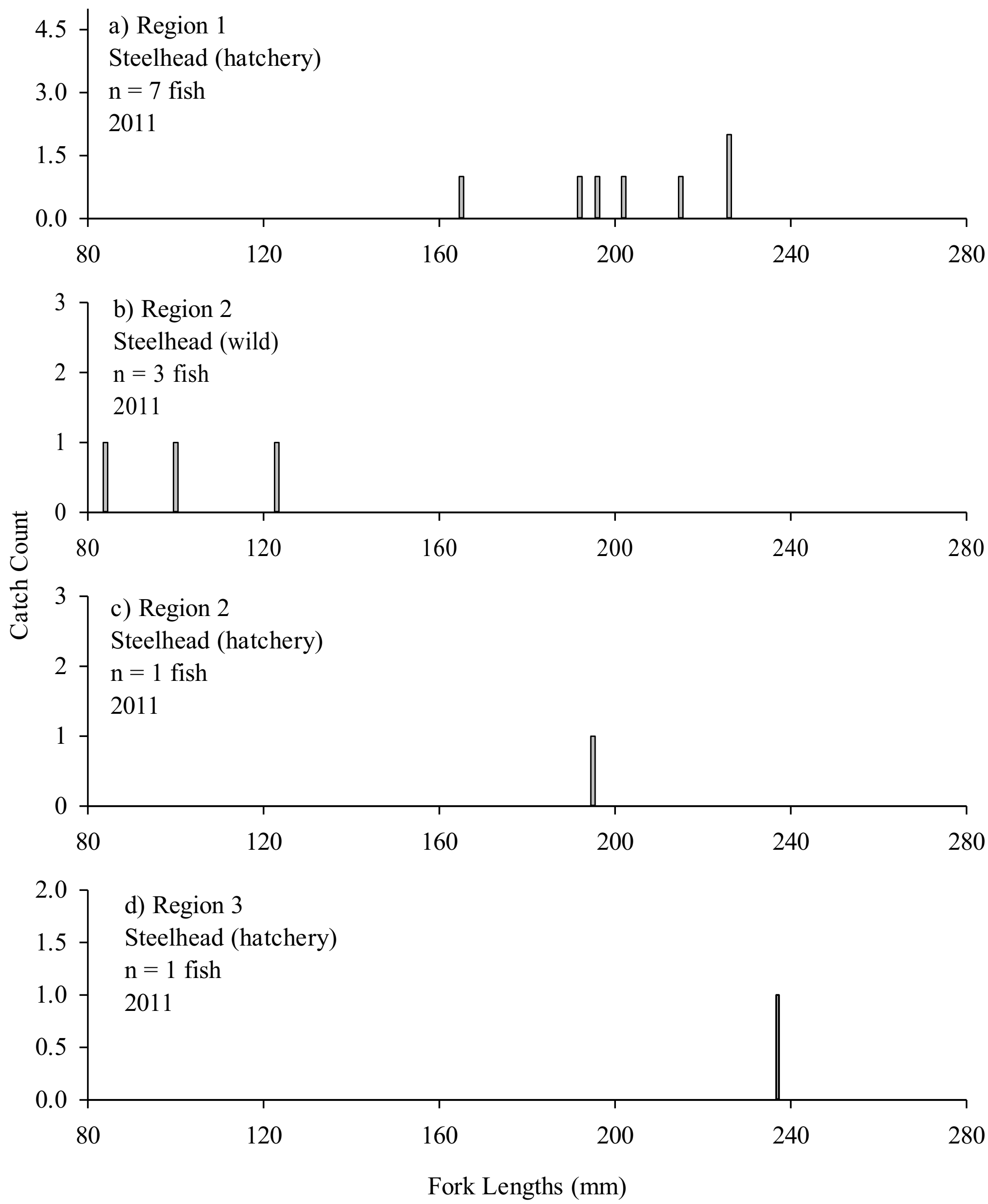

Figure 46. Fork length distributions for hatchery and wild steelhead captured in beach seines within the Lower Sacramento River (Region 1), North Delta (Region 2), and Central Delta (Region 3) Seine regions during the 2011 field season.

Delta Smelt

A total of 390 and 373 delta smelt were captured by the DJFMP during the 2010 and 2011 field seasons, respectively (Tables A18 and A19).

<u>Distribution and Relative Abundance</u>

The majority (>75%) of delta smelt were captured at the Chipps Island Trawl Site during the 2010 and 2011 field seasons (Tables A18 and A19). Although delta smelt were captured in most months, the mean monthly CPUE at Chipps Island peaked in summer (July and August) and autumn (November) and was lowest in spring (April and May) in 2010. Similarly, CPUE peaked in August and December and was lowest in spring (April and May) in 2011 (Figure 47). In 2010, we captured one delta smelt at the Sacramento and Mossdale Trawl sites during March and June, respectively (Figures 48 and 49). No delta smelt were captured at the Sacramento and Mossdale Trawl sites during the 2011 field season. The mean yearly CPUE estimates suggest that delta smelt at the Chipps Island and Sacramento Trawl sites were near record lows during both years. The mean yearly CPUE estimates at the Mossdale Trawl Site were also low and similar to those observed since 2004. The declines of mean yearly CPUE at all trawl sites is likely a result of a precipitous drop in population size starting in the early 2000s (Sommer et al. 2007; Contreras et al. 2012).

Delta smelt were primarily captured using beach seines within the North Delta Seine Region from December to April during the 2010 field season (Figure 50). We captured one and two individuals within the South Delta and Central Delta Seine regions, respectively. During the 2011 field season, delta smelt were detected only within the North Delta Seine Region generally from February to August. Peak monthly CPUE occurred in February and March during the 2010 and 2011 field seasons, respectively. The mean yearly CPUE estimates suggest that delta smelt were observed in higher densities consistently within the North Delta Seine Region relative to other seine regions since the 2000 field season, and that the densities within the North Delta have increased annually since the record low was observed in 2008 (Figure 50).

Delta smelt are generally confined to the upper portions of the San Francisco Estuary (i.e., Suisun Bay and Delta) based on their life history strategy (Moyle et al. 1992). Delta smelt typically have a one year life cycle and reside primarily in and near the low salinity zone (1-6 ppt) except when they migrate into freshwater and spawn during the spring (Stevens et al. 1990, Moyle et al. 1992; Jassby et al. 1995; Dege and Brown 2004). The relatively high monthly CPUEs observed during the winter and summer at the Chipps Island Trawl Site throughout the 2010 and 2011 field seasons is likely a result of juveniles and sub-adults residing within or migrating through Suisun Bay (near the low salinity zone) during the summer and adults later migrating upstream into the Delta during the spring to reproduce. The occurrence of delta smelt in the Mossdale and Sacramento Trawl sites and within the interior Delta seine regions during the spring is likely an indication of immigration, spawning, rearing, and/or emigration within the freshwater Delta. Although our catch data appears to broadly illustrate shifts in distribution and changes in population size during particular life stages, more robust IEP surveys are conducted to monitor the distribution and relative abundance of delta smelt within the Estuary.

Influence of River Discharge

Mean monthly and yearly CPUE of delta smelt at the Chipps Island Trawl Site showed little to no relationship to river discharge during the 2010 and 2011 field seasons (Figure 47). This may be due to the Chipps Island MWTR primarily capturing delta smelt as they migrate to and from the low salinity zone further downstream. Although the mean monthly CPUE of delta smelt appeared correlated with mean monthly river discharge within the North Delta Seine Region, we failed to detect a relationship between mean weekly CPUE and mean weekly river discharges during December through April in 2010 and from February through July in 2011 ($n = 46$, $r^2 = 0.028$, p-value = 0.75). Overall, our results suggest that river discharge does not appear to directly influence DJFMP catch densities. This finding is supported by the conclusions of more thorough investigations (e.g., Stevens and Miller 1983; Dege and Brown 2004; Miller et al. 2012). Stevens and Miller (1983) found no significant correlation between delta smelt abundance indices during the fall and Delta inflow during the spring and summer. Similarly, Dege and Brown (2004) demonstrated that there was no significant relationship between the abundance indices of larval or juvenile delta smelt and Delta outflow. Therefore the effect of river discharge on DJFMP delta smelt catch densities appears to be indirect through influencing the position of the low salinity zone which affects the distribution of delta smelt (Dege and Brown 2004).

Fork Length Distributions

The length-frequency distribution of delta smelt captured at the Chipps Island Trawl Site during the 2010 and 2011 field seasons generally ranged from 45 to 95 mm (FL), with most individuals measuring between 60 and 70 mm (Figure 51). The FLs observed at the Mossdale and Sacramento Trawl sites during the 2010 field season were 25 mm and 70 mm, respectively. The FLs within beach seine regions generally ranged from 59 to 77 mm in 2010 and from 26 to 87 mm in 2011 (Figures 52 and 53). Although the 25mm (FL) delta smelt captured at the Mossdale Trawl Site during June 2010 seems unlikely, this fish was identified by the DFG within their Region 4 laboratory. These data suggest that the DJFMP captured either sub-adults or adults migrating into and from Suisun Bay and either juveniles or adults migrating to and from the Delta pre and post spawn during the 2010 and 2011 field seasons.

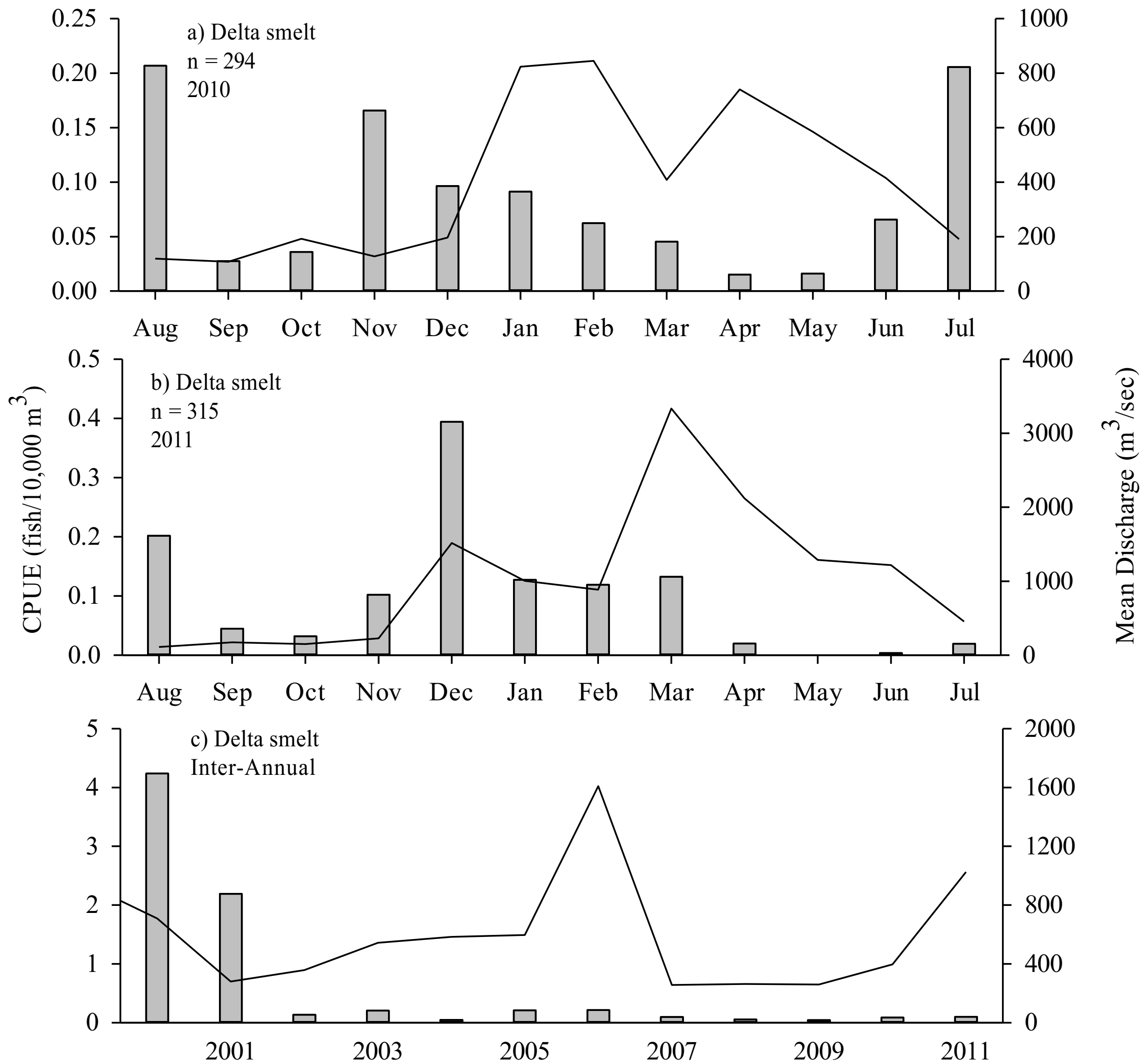

Figure 47. Mean monthly and yearly CPUE of delta smelt captured in mid-water trawls (MWTRs) at the Chipps Island Trawl Site, and mean monthly and yearly Delta discharge during the a) 2010, b) 2011, and c) 2000 through 2011 field seasons. Sample size (n) corresponds to total number of fish caught.

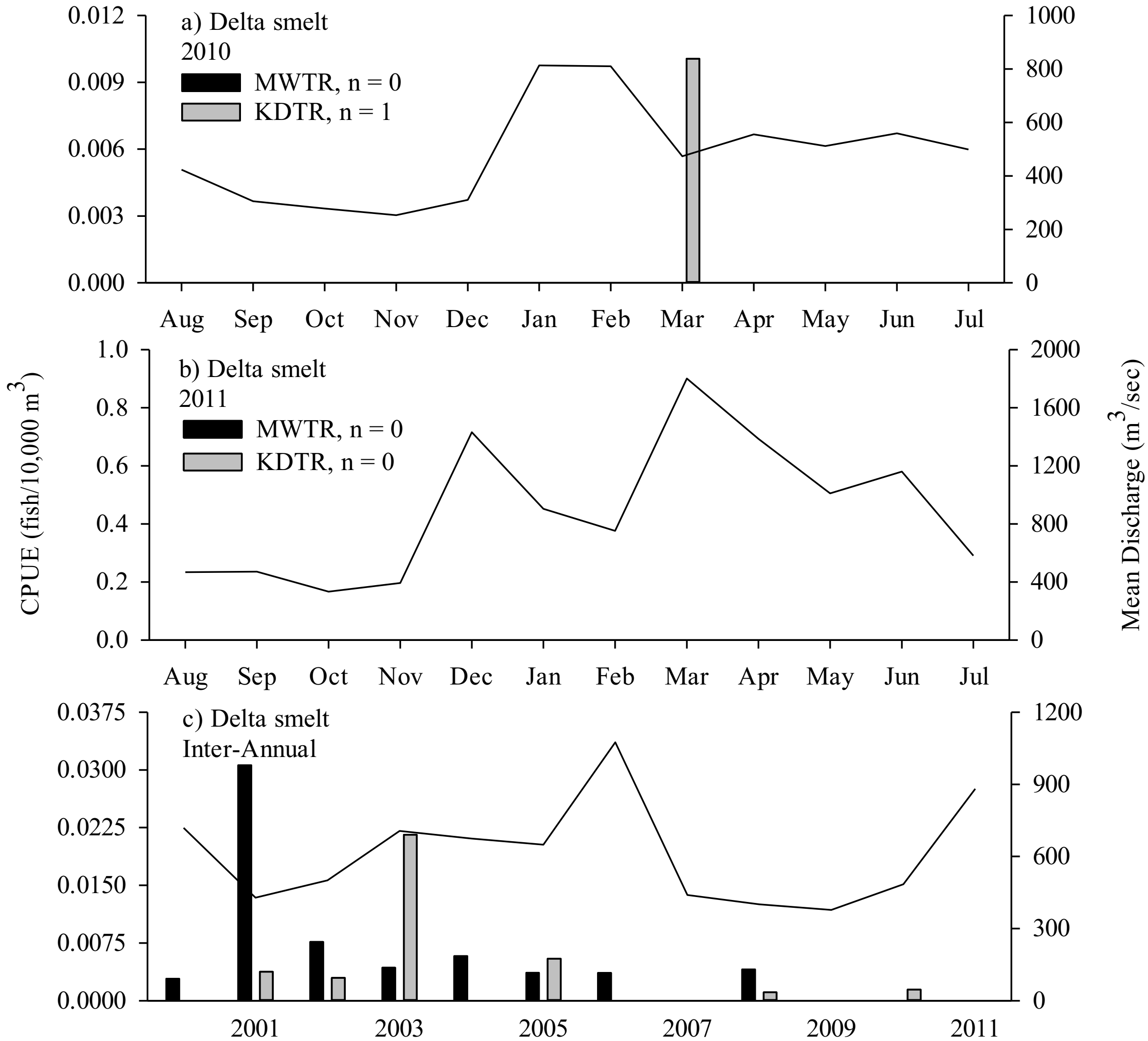

Figure 48. Mean monthly and yearly CPUE of delta smelt captured in mid-water (MWTRs) and Kodiak trawls (KDTRs) at the Sacramento Trawl Site, and mean monthly and yearly Sacramento River discharge at Freeport during the a) 2010, b) 2011, and c) 2000 through 2011 field seasons. Sample size (n) corresponds to total number of fish caught.

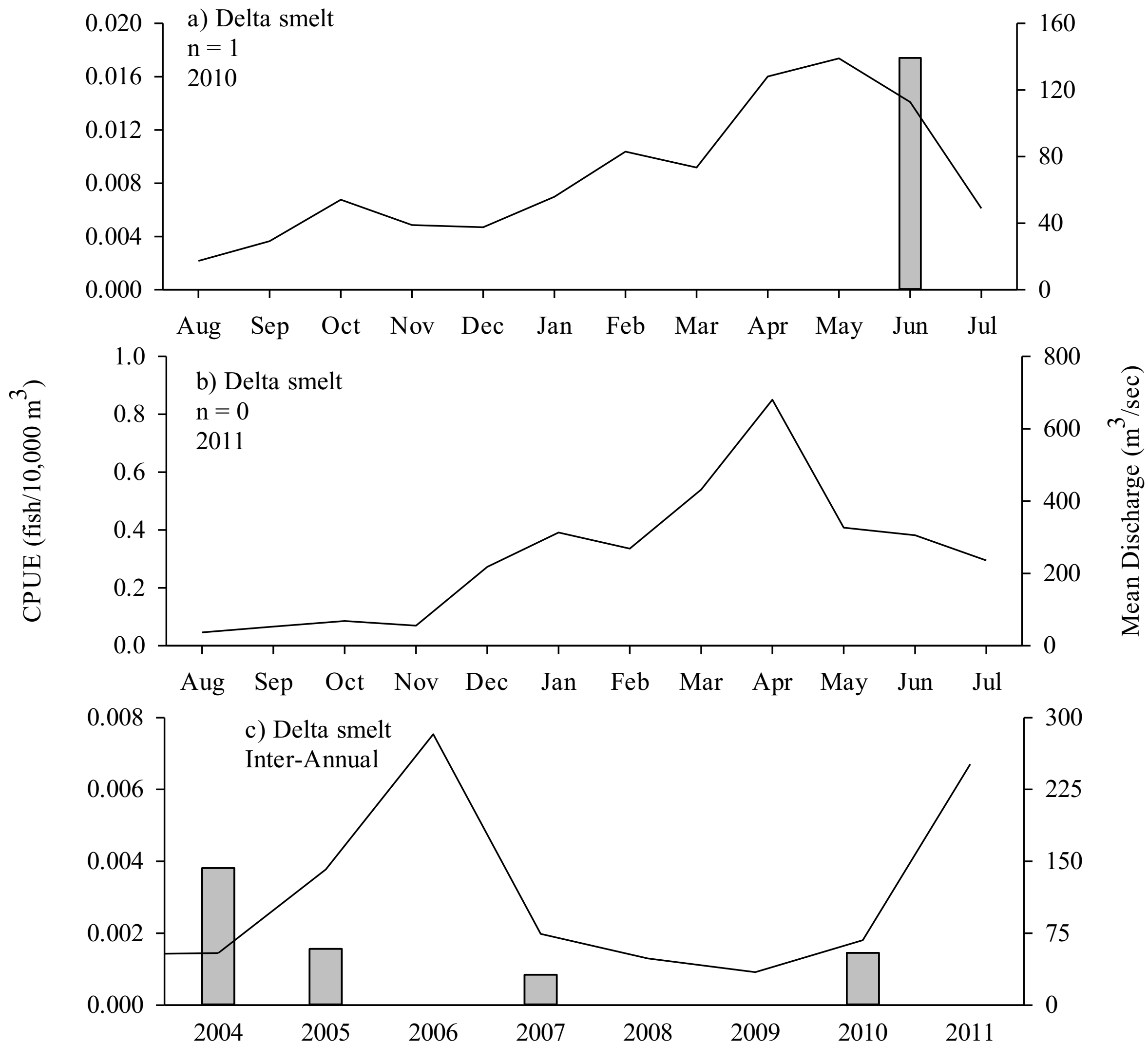

Figure 49. Mean monthly and yearly CPUE of delta smelt captured in Kodiak trawls (KDTRs) at the Mossdale Trawl Site, and mean monthly and yearly San Joaquin River discharge at Vernalis during the a) 2010, b) 2011, and c) 2004 through 2011 field seasons. Sample size (n) corresponds to total number of fish caught.

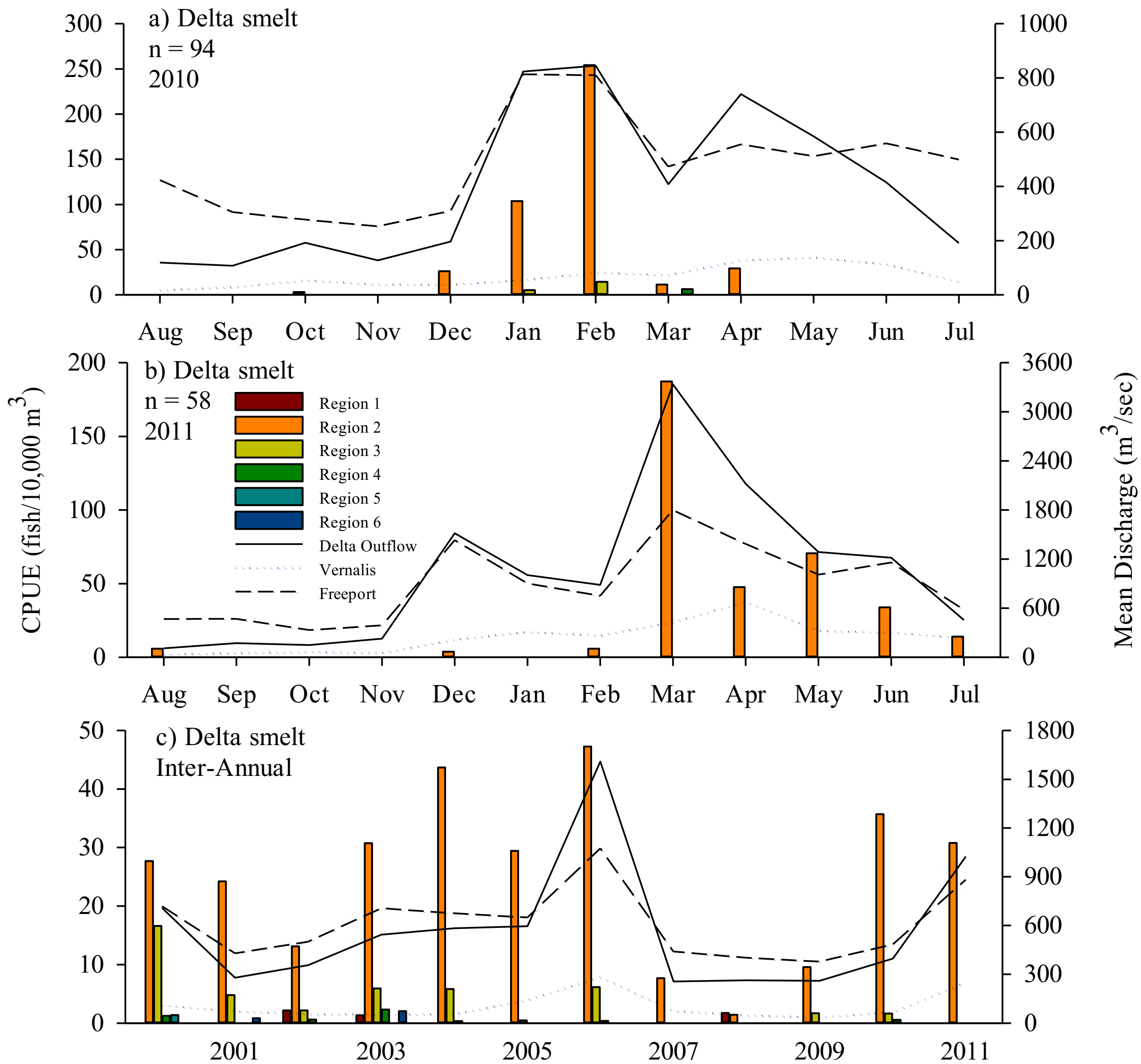

Figure 50. Mean monthly and yearly CPUE of delta smelt captured in beach seines at Regions 1-6, and mean monthly and yearly Sacramento River discharge at Freeport, San Joaquin River discharge at Vernalis, and Delta discharge during the a) 2010, b) 2011, and c) 2000 through 2011 field seasons. Sample size (n) corresponds to total number of fish caught.

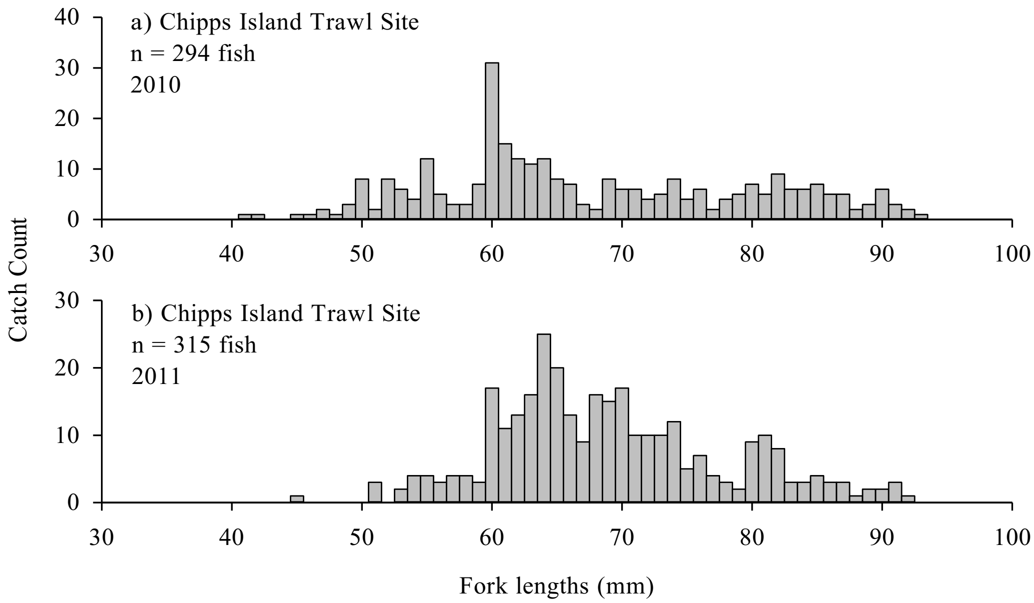

Figure 51. Fork length distributions for all delta smelt captured in mid-water trawls (MWTRs) at the Chipps Island Trawl Site during the 2010 and 2011 field seasons.

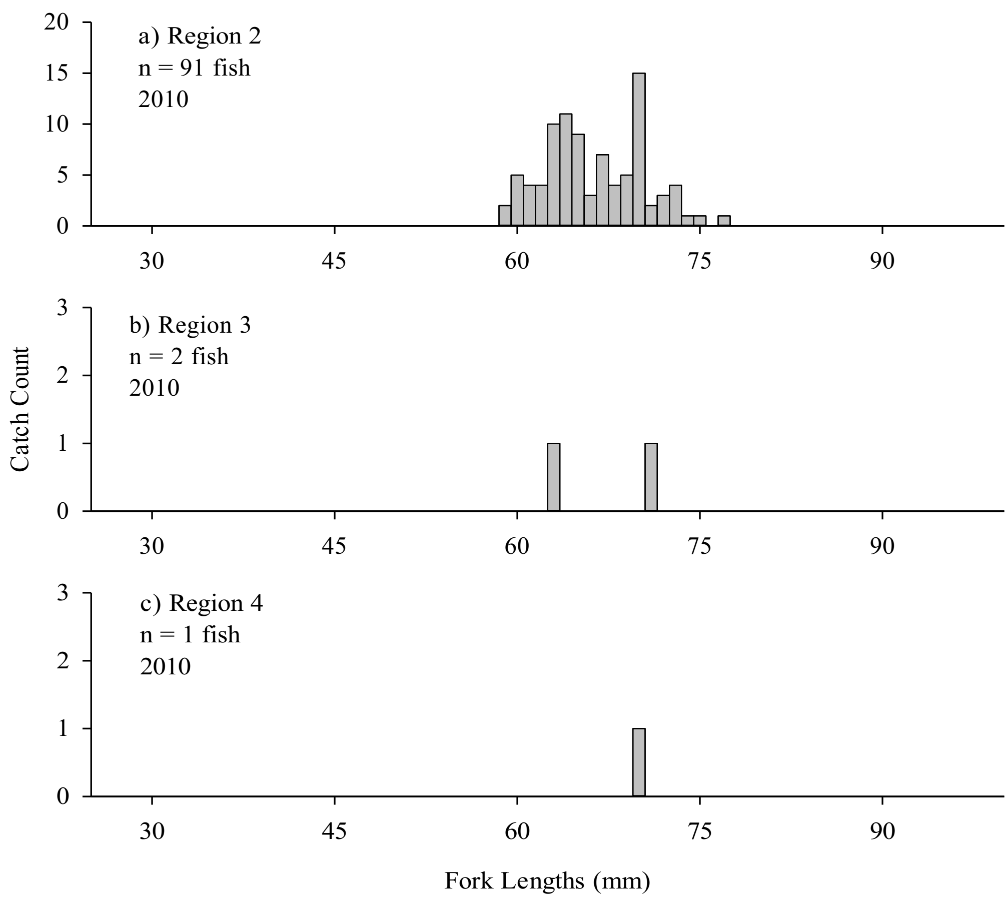

Figure 52. Fork length distributions for delta smelt captured in beach seines within the North Delta (Region 2), Central Delta (Region 3), and South Delta (Region 4) Seine regions during the 2010 field season.

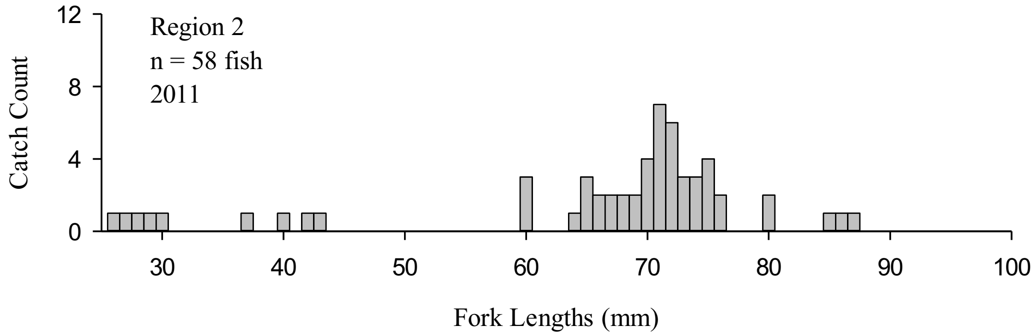

Figure 53. Fork length distributions for delta smelt captured in beach seines within the North Delta Seine Region (Region 2) during the 2011 field season.

Longfin Smelt

We captured 584 and 219 longfin smelt during the 2010 and 2011 field seasons, respectively (Tables A18 and A19).

<u>Distribution and Relative Abundance</u>

All longfin smelt observed during the 2010 field season and nearly all longfin smelt (~98%) observed during the 2011 field season were detected at the Chipps Island Trawl Site (Tables A18 and A19). No longfin smelt were captured at the Mossdale or Sacramento Trawl sites. The majority of longfin smelt were caught at the Chipps Island Trawl Site from December to March during the 2010 field season and from December to January in 2011 (Figure 54). The mean yearly CPUE for longfin smelt at Chipps Island declined in 2003 and has remained relatively low through 2011 (Figure 54). As with delta smelt, the declines of longfin smelt mean yearly CPUE at the Chipps Island Trawl Site is likely a result of a precipitous drop in population size starting in the early 2000s (Sommer et al. 2007; Contreras et al. 2012).

We did not collect longfin smelt in beach seines in 2010 and only four individuals were caught during the 2011 field season (Tables A18 and A19). Three of the four longfin smelt observed in 2011 were captured within the San Francisco/San Pablo Bay Seine Region during August and one individual was captured within the North Delta Seine Region in December (Figure 55). Mean yearly CPUE estimates indicate that longfin smelt have only been captured within these seine regions at relatively low densities (Figure 55).

Longfin smelt are short lived and adults primarily reside in and near the San Francisco and San Pablo bays where the salinity ranges from 15-30ppt (Moyle 2002). Starting as early as November through June, adults migrate and spawn further upstream within the Estuary in the lower portions of the Delta and Upper Suisun Bay (Moyle 2002). Because the occurrence and relatively high monthly CPUEs observed by the DJFMP were typically isolated from December to March upstream of San Pablo Bay, individuals observed were likely adults migrating pre or post spawn. However, our longfin smelt catch data reported here should be used only as anecdotal information for migration timing based on the limited catch data. More robust IEP surveys are conducted to monitor the distribution and relative abundance of longfin smelt within the Estuary.

Influence of River Discharge

Although previous studies have reported a positive correlation between longfin smelt abundance and Delta discharge (Stevens and Miller 1983; Rosenfield and Baxter 2007), mean yearly CPUE at the Chipps Island Trawl Site has shown a consistent decline regardless of flow since the 2003 field season (Figure 54). However, our results suggest that the peak mean monthly CPUE of longfin smelt at the Chipps Island Trawl Site may be positively related to the first large increase in river discharge prior to or during their spawning period (i.e., November to June). In 2010, the mean daily Delta discharge increased from 158 to 1,897m^3/sec over 11 consecutive days during late January and mean monthly CPUE peaked soon after in February. In 2011, the mean daily Delta discharge increased from 239 to 2,478 m^3/sec over 20 consecutive days during the middle of December and mean monthly CPUE peaked during the same month. Further investigation is needed to substantiate this hypothesis understanding that the migration of longfin smelt is likely influenced by a multitude of physical variables, biological factors, and their interactions.

Fork Length Distributions

The length-frequency distributions of longfin smelt captured at the Chipps Island Trawl Site generally ranged from 70 to 140 mm and from 90 to 140 mm (FL) during the 2010 and 2011 field seasons, respectively (Figure 56). During the 2011 field season, individuals captured within the San Francisco/San Pablo Bay Seine Region were <44 mm (FL) and the individual captured within the North Delta Seine Region had a 103 mm FL (Figure 57). These data suggest that the majority of the longfin smelt were adults either migrating into the Delta from Suisun Bay to spawn or migrating into Suisun Bay from the Delta post spawn.

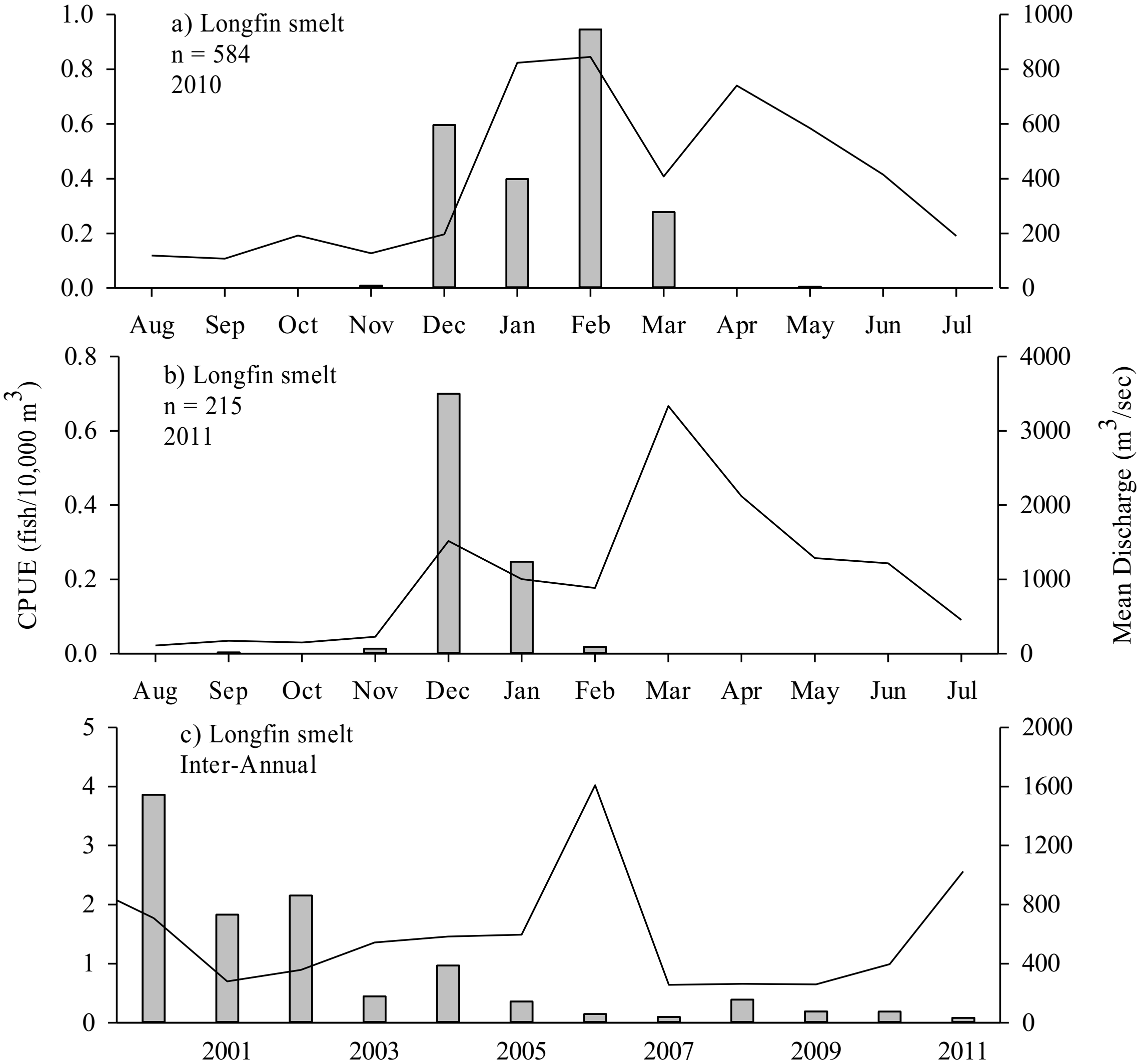

Figure 54. Mean monthly and yearly CPUE of longfin smelt captured in mid-water trawls (MWTRs) at the Chipps Island Trawl Site, and mean monthly and yearly Delta discharge during the a) 2010, b) 2011, and c) 2000 through 2011 field seasons. Sample size (n) corresponds to total number of fish caught.

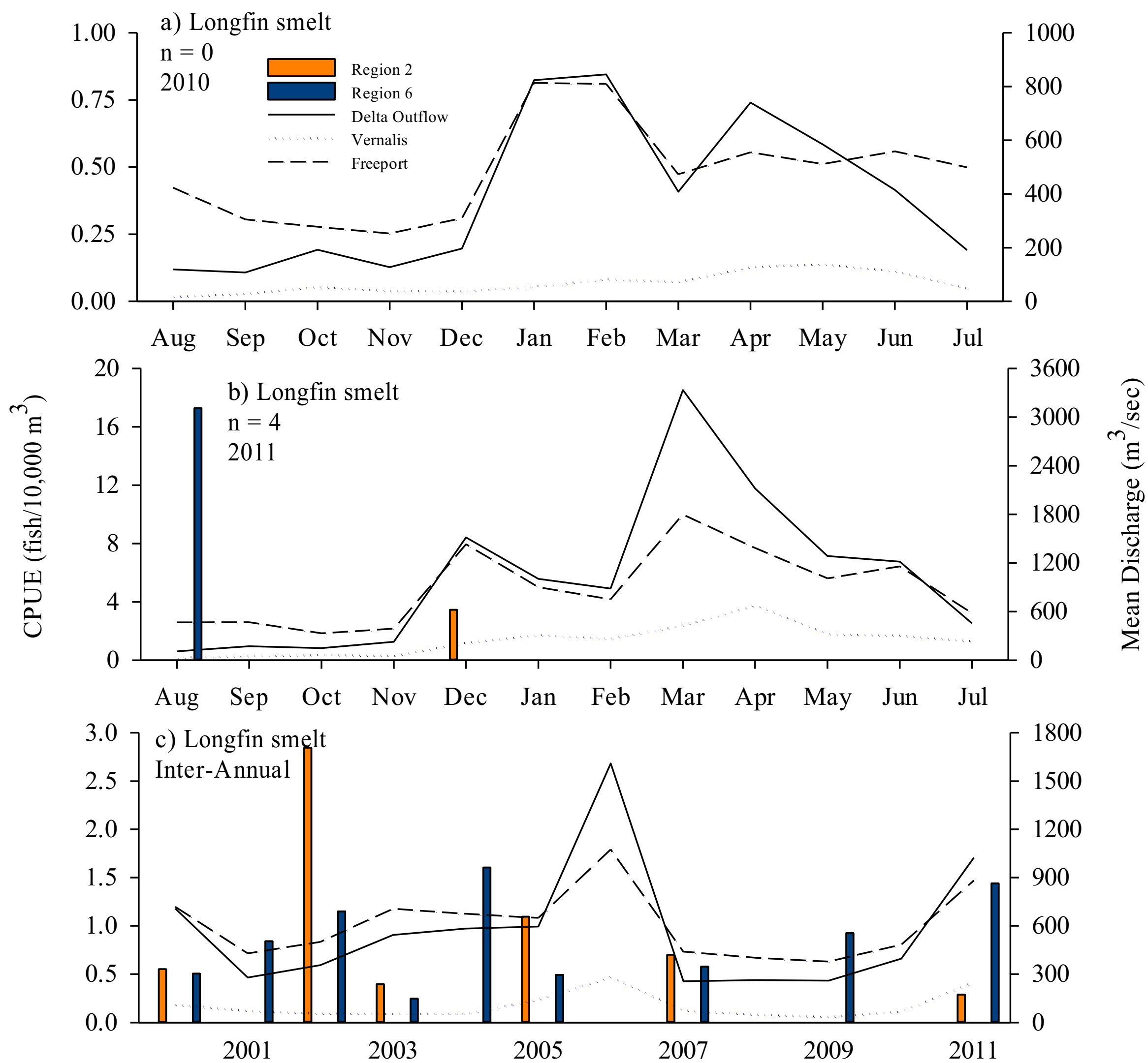

Figure 55. Mean monthly and yearly CPUE of longfin smelt captured in beach seines at Regions 1-6, and mean monthly and yearly Sacramento River discharge at Freeport, San Joaquin River discharge at Vernalis, and Delta discharge during the a) 2010, b) 2011, and c) 2000 through 2011 field seasons. Sample size (n) corresponds to total number of fish caught.

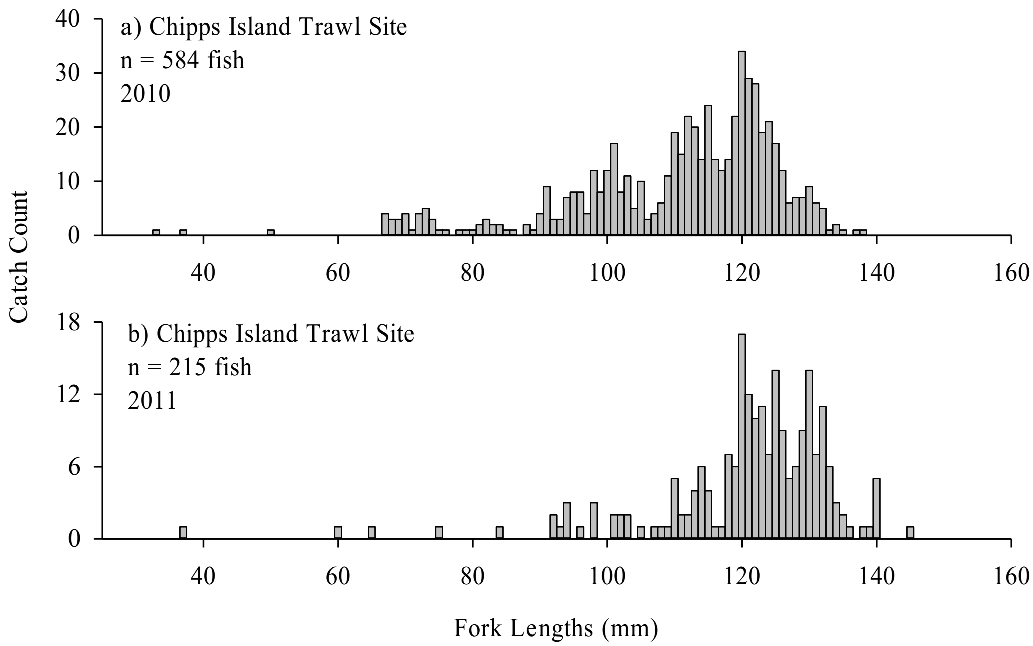

Figure 56. Fork length distributions for all longfin smelt captured in mid-water trawls (MWTRs) at the Chipps Island Trawl Site during the 2010 and 2011 field seasons.

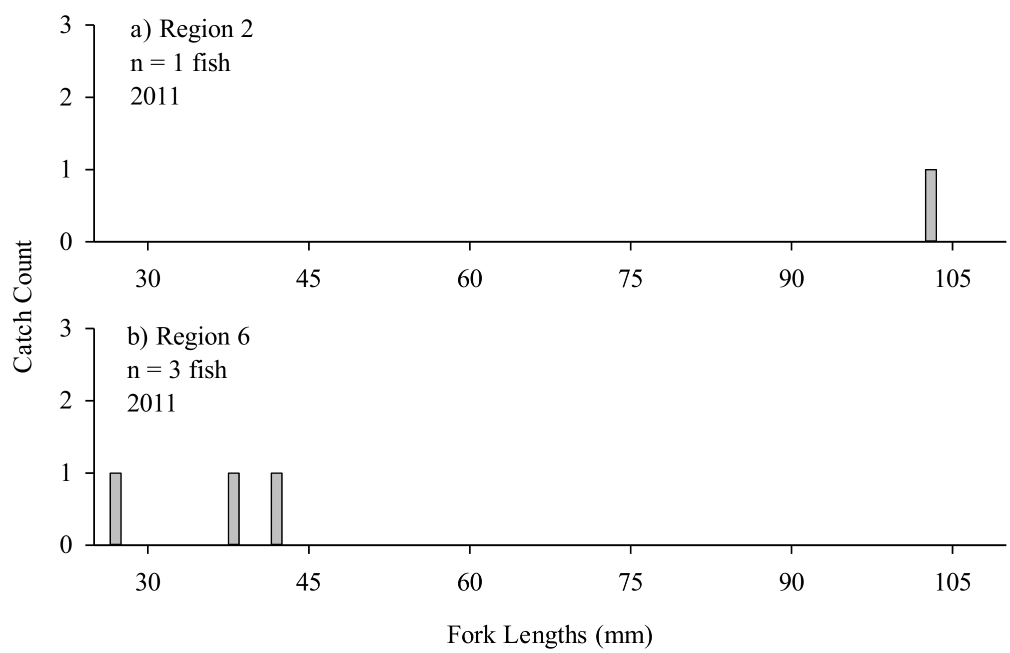

Figure 57. Fork length distributions for longfin smelt captured in beach seines within the North Delta (Region 2) and San Francisco/San Pablo Bay (Region 6) Seine regions during the 2011 field season.

Sacramento Splittail

A total of 10,023 and 115,117 Sacramento splittail were captured by the DJFMP during the 2010 and 2011 field seasons, respectively (Tables A18 and A19).

Distribution and Relative Abundance

Sacramento splittail were captured in nearly all seine regions and trawl sites during the 2010 and 2011 field season (Tables A18 and A19). At the Chipps Island Trawl Site, individuals were generally captured throughout the 2010 field season, and during December through April and July in the 2011 field season (Figure 58). The mean monthly CPUE estimates peaked during January and July in 2010 and during December and July in 2011 (Figure 58). In contrast, we only captured one individual in 2010 and four individuals in 2011 at the Sacramento Trawl Site (Figure 59). The mean yearly CPUE at the Chipps Island and Sacramento Trawl sites were near record lows during the 2010 and 2011 field season. The majority of all individuals captured by DJFMP trawls were caught at the Mossdale Trawl Site from May to July during both field years with peak catches in May (Figure 60). The mean yearly CPUE at the Mossdale Trawl Site was relatively low in 2010, but increased considerably in 2011 to become the second highest yearly CPUE observed since 2004 (Figure 60).

In beach seines, Sacramento splittail were captured from April through July and May through July during the 2010 and 2011 field seasons, respectively (Figure 61). However, no captures were reported at the San Francisco/San Pablo Seine Region during the 2010 field season. The mean monthly CPUE peaked in nearly all seine regions during May. The mean yearly CPUE estimates suggest that Sacramento splittail were generally observed in higher densities within the Lower San Joaquin River and Central Delta Seine regions relative to other seine regions since the 2000 field season. Densities within all seine regions increased to record highs during the 2011 field season compared to catches from 2000 through 2010 (Figure 61).

Sacramento splittail are a relatively long lived (7-9 years), endemic to the Central Valley, and primarily reside within the lower portions of the San Francisco Estuary (Young and Cech 1996; Moyle et al. 2004). In general, adults migrate upstream from as early as November to February and can spawn from January to April within low gradient portions of the Sacramento River, San Joaquin River, and tributaries (Sommer et al. 1997; Moyle et al. 2004). In addition, studies have demonstrated that offspring subsequently migrate downstream within the Estuary from April through June to rear in shallow brackish habitats (Feyrer et al. 2005). Therefore, the increase in the mean monthly CPUE of Sacramento splittail at the Chipps Island Trawl Site during the winter of both field seasons likely reflected adult spawning migrations. Whereas the increase in the mean monthly CPUE from May to July at most trawl sites and within all beach seine regions was likely a result of juveniles migrating downstream to the lower portions of the Estuary.

Influence of River Discharge

The relatively high mean yearly CPUE observed during the 2011 field season at the Mossdale Trawl Site and within all seine regions was likely a result of higher river discharges, extended floodplain inundation, and lower water temperatures, particularly within the San Joaquin River

Basin (Tables A20 and A23; Figures 60 and 61). Sacramento splittail are obligate floodplain spawners and numerous investigations have demonstrated that year class strength is positively associated with wet water years and high river discharges (Sommer et al. 1997; Sommer et al. 2001; Moyle et al. 2004). While splittail can spawn without floodplain access, they do require fairly continuous floodplain inundation at least one month in duration to produce strong year classes (Sommer et al. 1997; Sommer et al. 2001; Moyle et al. 2004). Because the San Joaquin River is less channelized than the Sacramento River, the San Joaquin River and its tributaries presumably have more floodplain spawning habitat during wet water years, which likely contributed to the higher mean CPUEs observed near and within the Lower San Joaquin River from May through July.

During the 2010 and 2011 field seasons, the mean monthly CPUE of Sacramento splittail generally peaked at the Chipps Island Trawl Site during increased mean Delta discharge (Figure 58) from November to January, suggesting a positive correlation during the adult upstream migration period (Moyle et al. 2004). To better understand the influence of Delta discharge on adult migration near and within Suisun Bay, we developed a simple linear regression model of mean weekly CPUE and $\log_{10}$ of the weekly mean Delta discharge data at the Chipps Island Trawl Site. Assuming a linear relationship, we showed a significant positive correlation (p-value = 0.04) where 31% of the variability in the mean weekly CPUE from November to January could be explained by Delta discharge (Figure 62). Our results support the hypothesis of Moyle et al. (2004) that intra-annual river discharge likely influences the timing and magnitude of adults migrating upstream prior to spawning.

In addition, the mean monthly CPUE generally declined during decreasing mean river discharge within the Lower San Joaquin River, South Delta, and Central Delta Seine regions from May to July, suggesting a positive correlation during the juvenile migration period (Moyle et al. 2004). We further examined the relationship between mean weekly CPUE and transformed discharge with simple linear regression models. Although the results were largely inconclusive, the mean weekly CPUE of Sacramento splittail during the 2010 and 2011 field seasons was positively correlated with mean weekly river discharge (Figure 63). The proportion of mean weekly CPUE variability explained by river discharge ranged from 18% to 44% among each seine region. The strongest correlation was observed at the Lower San Joaquin River Seine Region with approximately 44% (n = 60, p-value = 0.01) of the variability in the mean weekly CPUE from May to July being explained by Delta discharge (Figure 63). Therefore there is evidence that the timing and magnitude of juveniles migrating downstream also is positively influenced by higher river discharge or other correlated environmental variables (e.g., lower temperatures).

Fork Length Distributions

The FLs of Sacramento splittail captured at the Chipps Island Trawl Site generally ranged from 45 to 325 mm during the 2010 and 2011 field seasons (Figure 64). However, all individuals captured at Chipps Island from October to May were > 90 mm (FL) and all individuals captured from June through August were < 90 mm (FL). Furthermore, nearly all individuals captured at the Sacramento and Mossdale Trawl sites and within all seine regions were < 60 mm (FL), particularly from April to July (Figures 65-70). These data suggest that the DJFMP captured primarily adults migrating upstream to spawn from November to January and juveniles were captured while migrating downstream into and through the Estuary from May to June post spawn.

The DJFMP appears to be effectively sampling juvenile Sacramento splittail in all gear types, but adults were primarily captured by the Chipps Island MWTR. For beach seines, adult splittail may not readily occupy shallow (depth < 2 m) littoral habitat. In addition, adults may be able to avoid beach seines during sampling. Further investigation of seine efficiency is recommended to determine the effectiveness of sampling adult Sacramento splittail in littoral habitats. The Sacramento and Mossdale trawls are ineffective in sampling adult splittail during their upstream migration based on the fact that these trawls are towed upstream and not downstream. During the downstream migration of adults, individuals are likely able to avoid the trawls. Overall, the DJFMP appears to provide adequate information on the recruitment and migration of juvenile Sacramento splittail within the San Francisco Estuary and lower Sacramento and San Joaquin rivers.

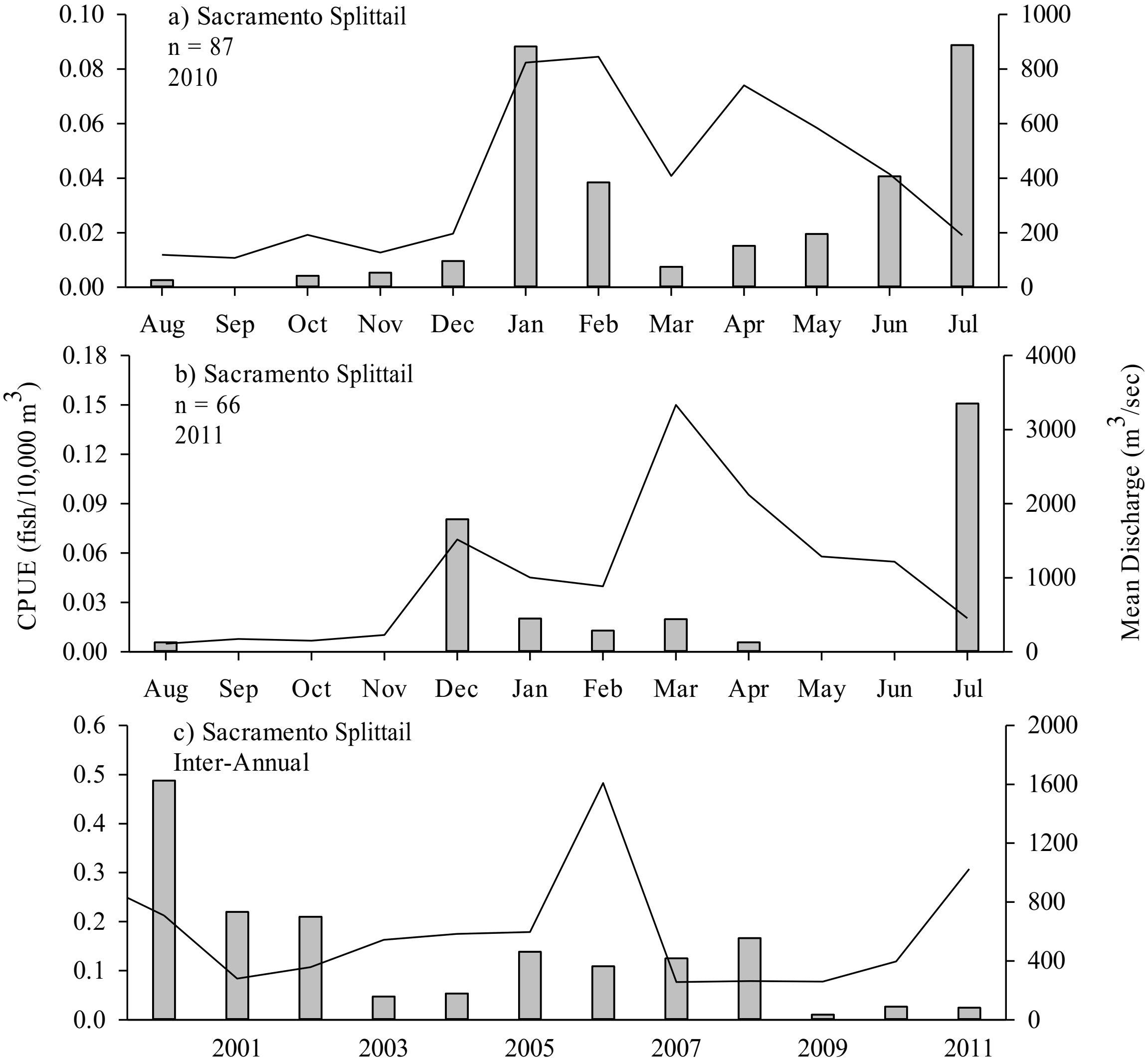

Figure 58. Mean monthly and yearly CPUE of Sacramento splittail captured in mid-water trawls (MWTRs) at the Chipps Island Trawl Site, and mean monthly and yearly Delta discharge during the a) 2010, b) 2011, and c) 2000 through 2011 field seasons. Sample size (n) corresponds to total number of fish caught.

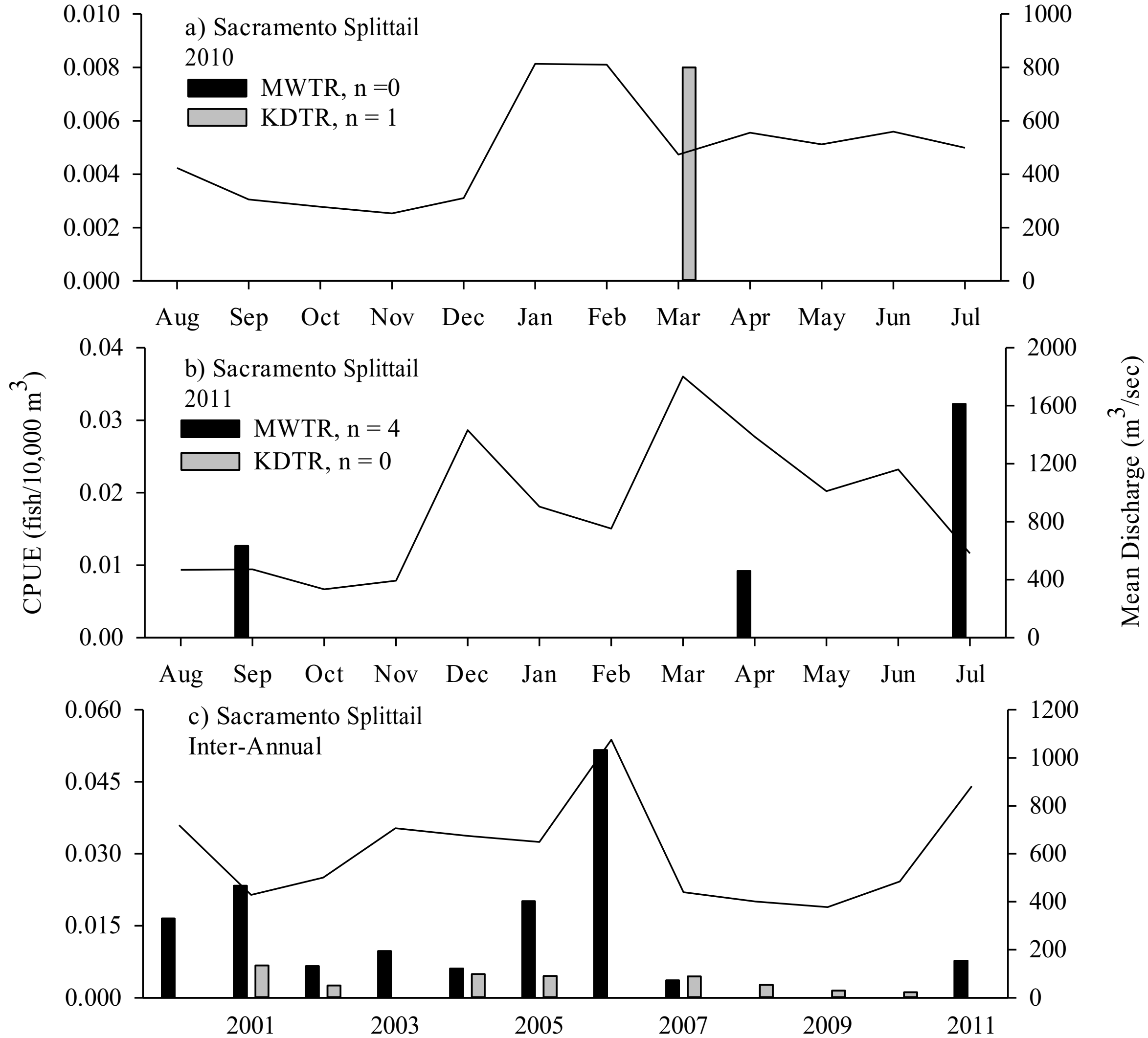

Figure 59. Mean monthly and yearly CPUE of Sacramento splittail captured in mid-water (MWTRs) and Kodiak trawls (KDTRs) at the Sacramento Trawl Site, and mean monthly and yearly Sacramento River discharge at Freeport during the a) 2010, b) 2011, and c) 2000 through 2011 field seasons. Sample size (n) corresponds to total number of fish caught.

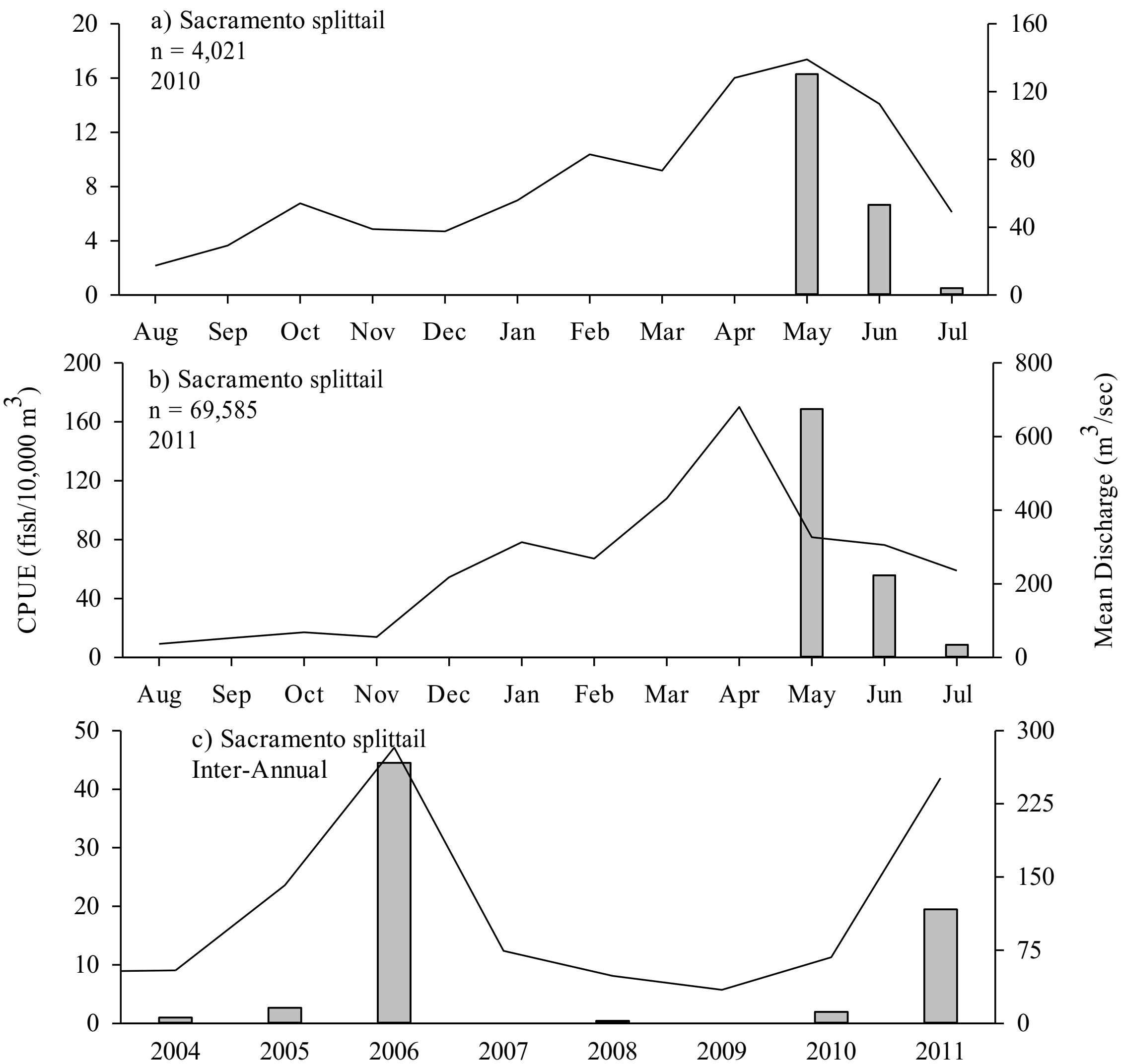

Figure 60. Mean monthly and yearly CPUE of Sacramento splittail captured in Kodiak trawls (KDTRs) at the Mossdale Trawl Site, and mean monthly and yearly San Joaquin River discharge at Vernalis during the a) 2010, b) 2011, and c) 2004 through 2011 field seasons. Sample size (n) corresponds to total number of fish caught.

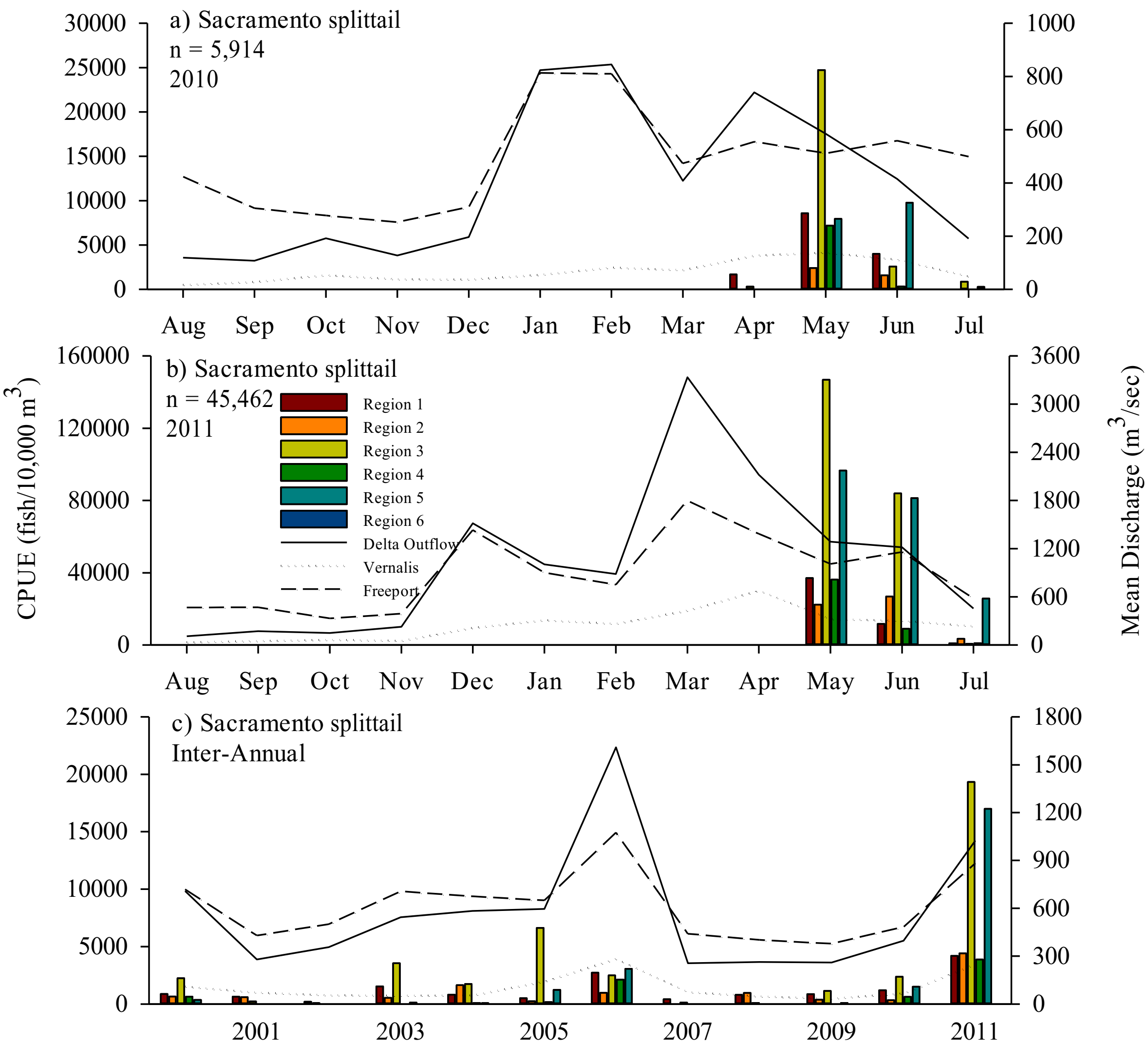

Figure 61. Mean monthly and yearly CPUE of Sacramento splittail captured in beach seines at Regions 1-6, and mean monthly and yearly Sacramento River discharge at Freeport, San Joaquin River discharge at Vernalis, and Delta discharge during the a) 2010, b) 2011, and c) 2000 through 2011 field seasons. Sample size (n) corresponds to total number of fish caught.

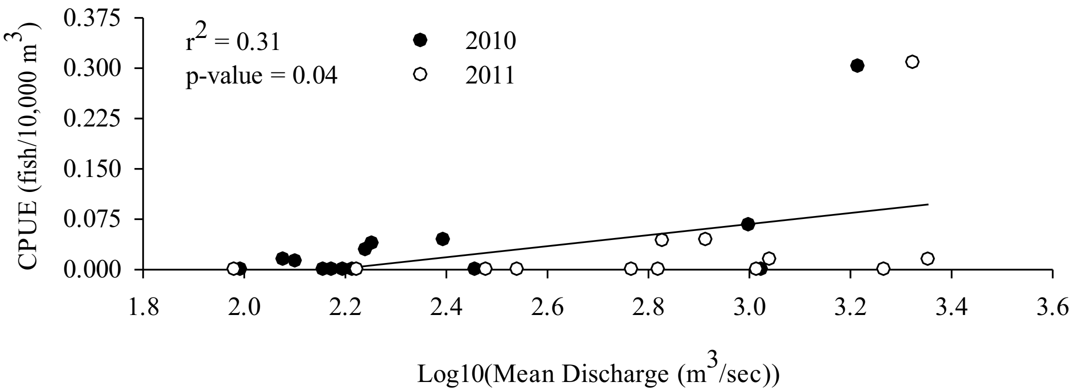

Figure 62. Linear regressions of mean weekly CPUE of Sacramento splittail captured at the Chipps Island Trawl Site and mean weekly Delta discharge from November to January during the 2010 and 2011 field seasons.

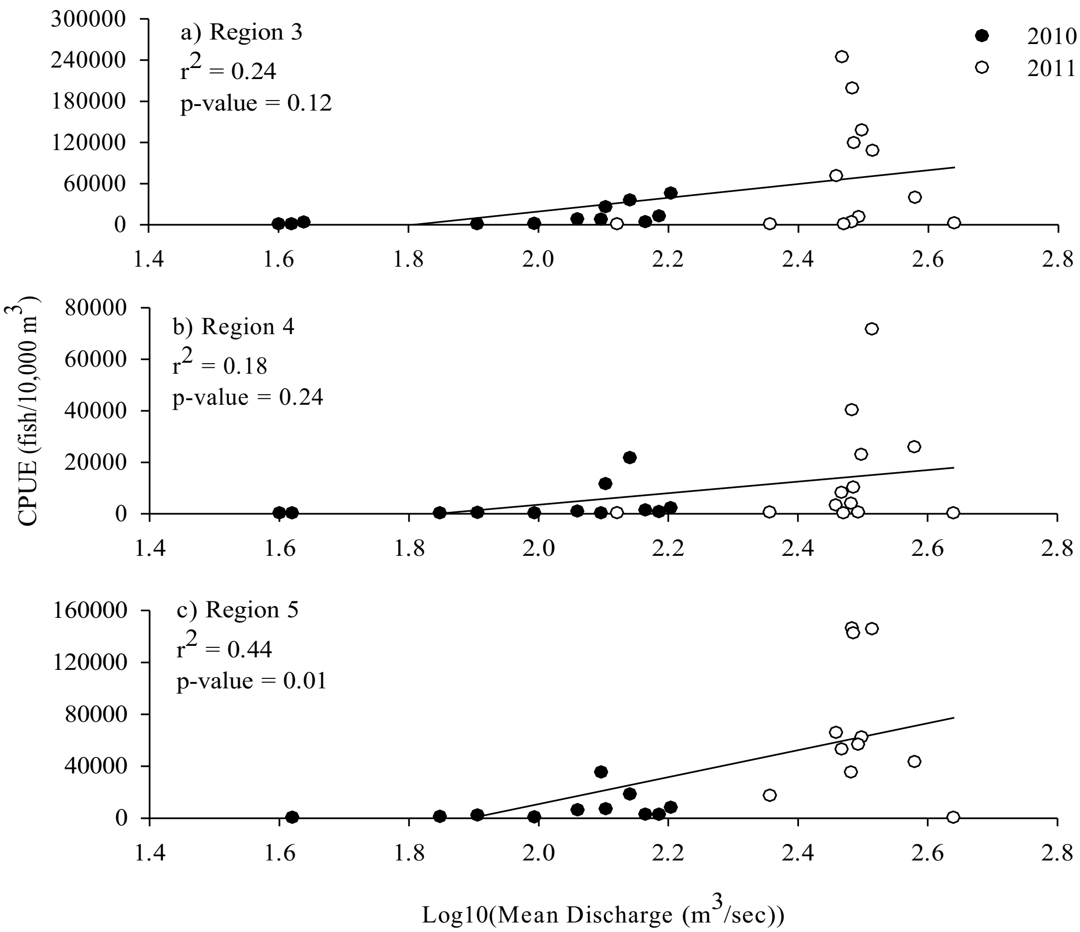

Figure 63. Linear regressions of mean weekly CPUE of Sacramento splittail captured in beach seines in the a) Central Delta Seine Region (Region 3), b) South Delta Seine Region (Region 4) and c) Lower San Joaquin Seine Region (Region 5) and mean weekly San Joaquin River discharge at Vernalis from May to July during the during the 2010 and 2011 field seasons.

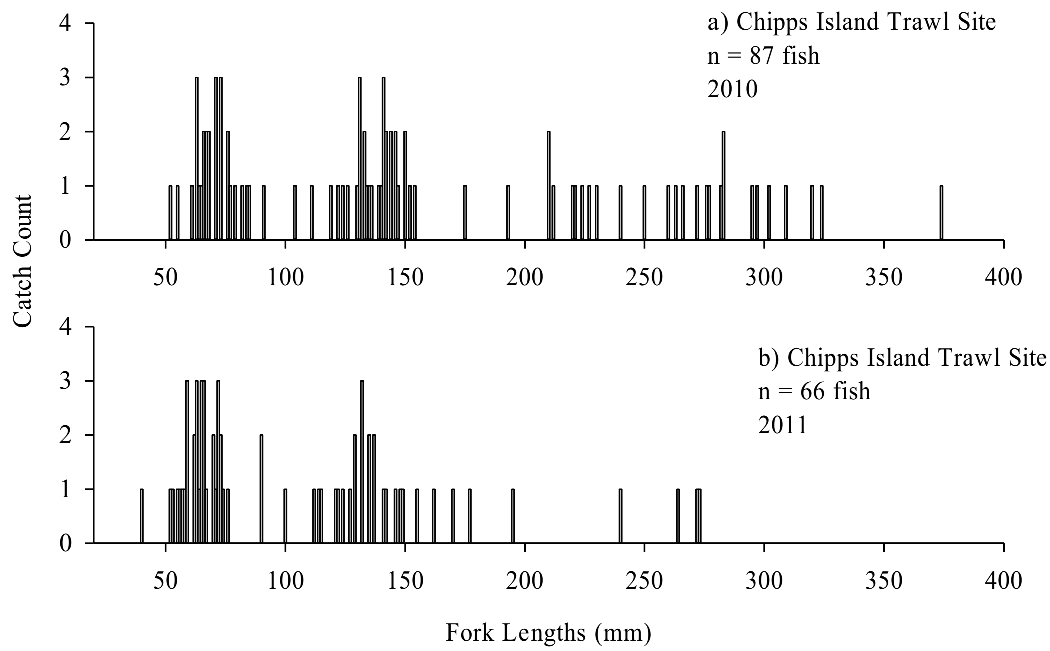

Figure 64. Fork length distributions for Sacramento splittail captured in mid-water trawls (MWTRs) at the Chipps Island Trawl Site during the 2010 and 2011 field seasons.

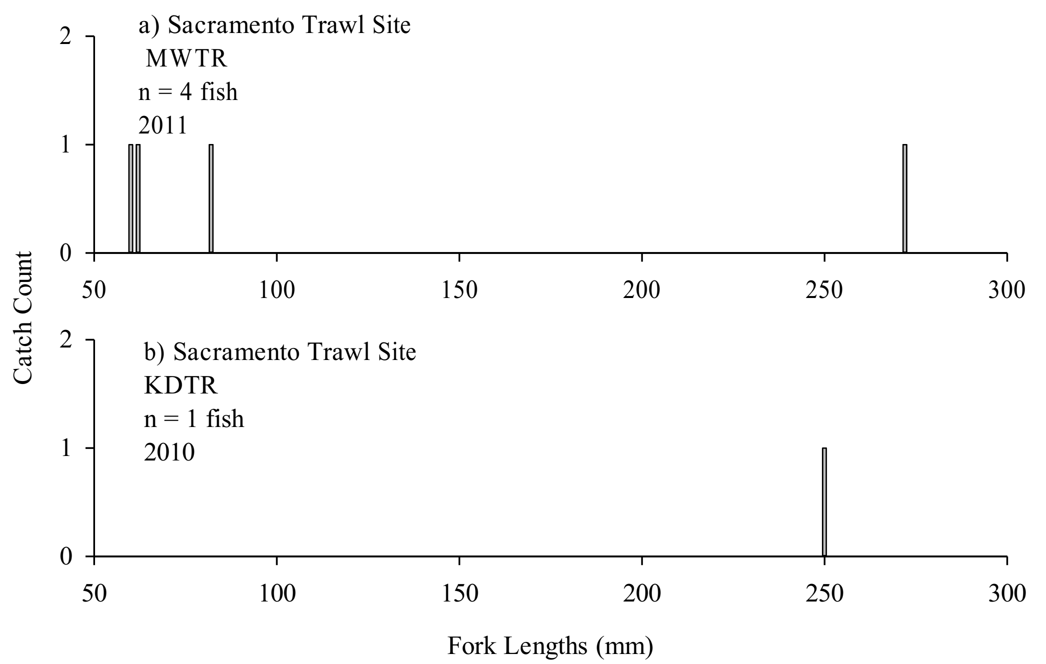

Figure 65. Fork length distributions for Sacramento splittail captured in mid-water (MWTRs) and Kodiak trawls (KDTRs) at the Sacramento Trawls Site during the 2010 and 2011 field seasons. No splittail were captured in MWTR and KDTR at the Sacramento Trawl Site during the 2010 and 2011 field seasons, respectively.

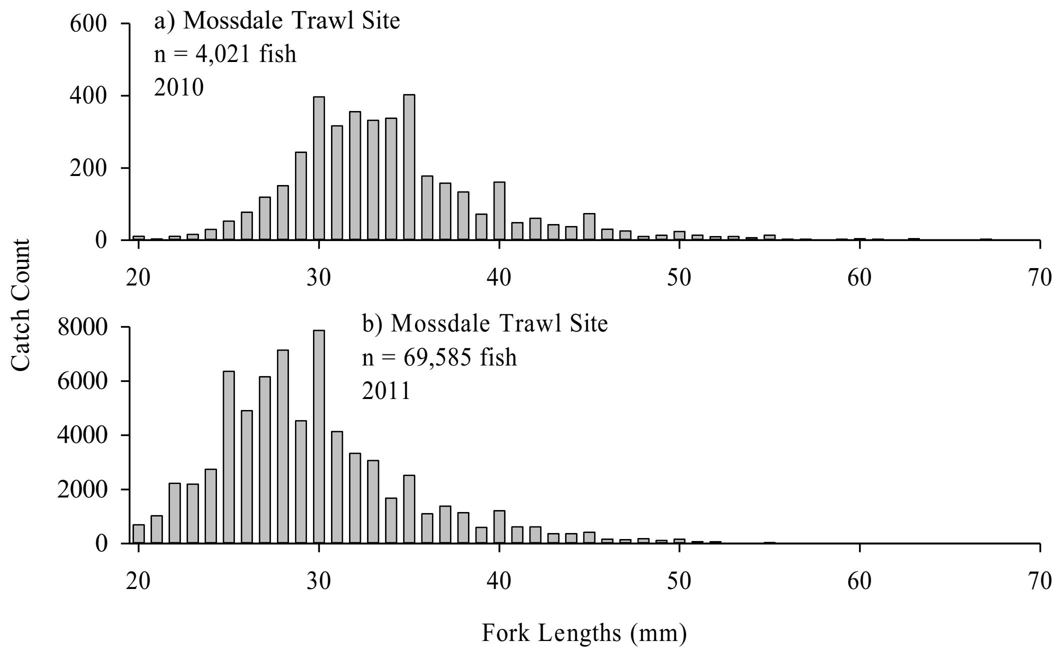

Figure 66. Fork length distributions for Sacramento splittail captured in Kodiak trawls (KDTRs) at the Mossdale Trawl Site during the 2010 and 2011 field seasons.

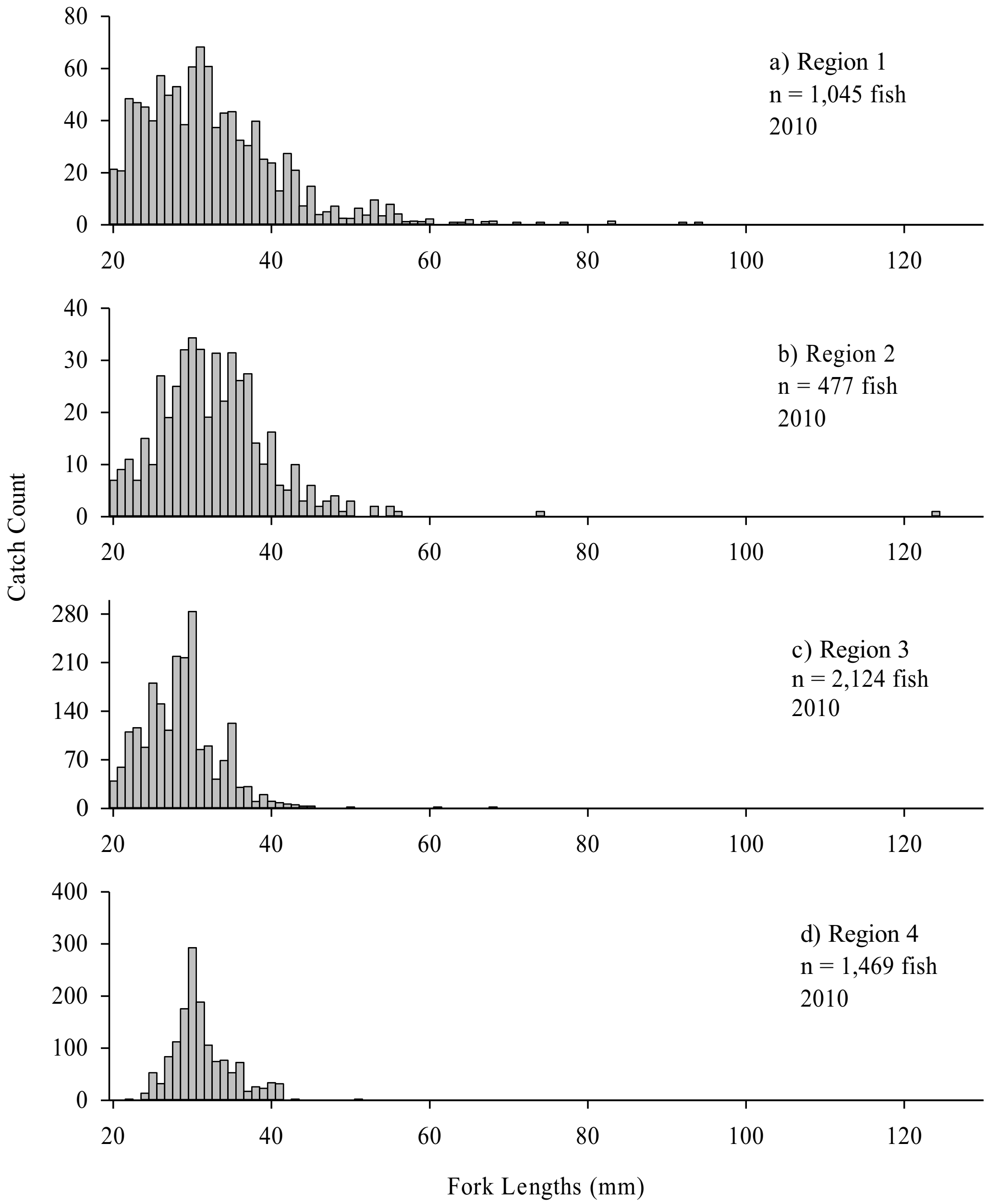

Figure 67. Fork length distributions for Sacramento splittail captured in beach seines within the Lower Sacramento River (Region 1), North Delta (Region 2), Central Delta (Region 3), and South Delta (Region 4) Seine regions during the 2010 field season.

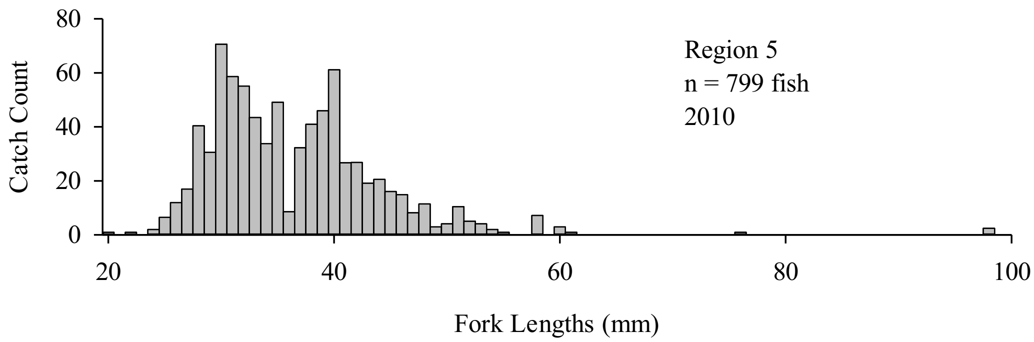

Figure 68. Fork length distributions for Sacramento splittail captured in beach seines within the Lower San Joaquin River Seine Region (Region 5) during the 2010 field season.

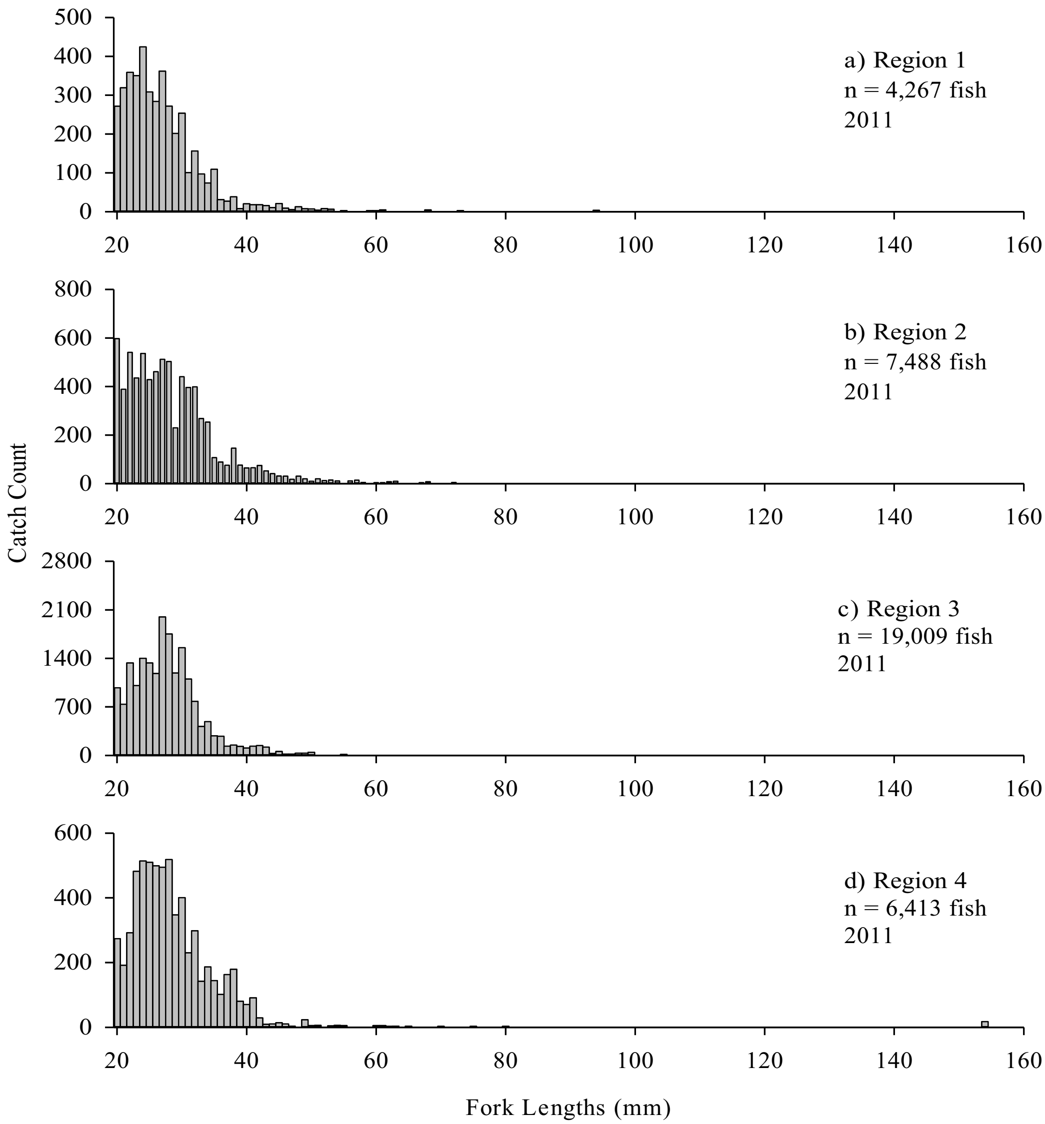

Figure 69. Fork length distributions for Sacramento splittail captured in beach seines within the Lower Sacramento River (Region 1), North Delta (Region 2), Central Delta (Region 3), and South Delta (Region 4) Seine regions during the 2011 field season.

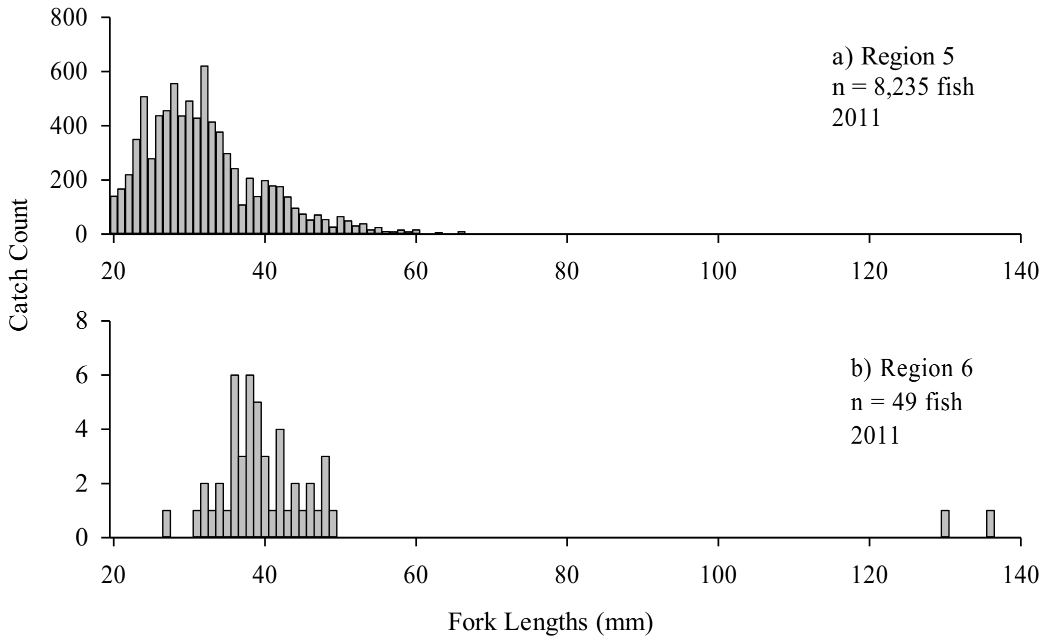

Figure 70. Fork length distributions for Sacramento splittail captured in beach seines within the Lower San Joaquin River (Region 5) and San Francisco/San Pablo Bay (Region 6) Seine regions during the 2011 field season.

Threadfin Shad

We captured 6,155 and 8,004 threadfin shad during the 2010 and 2011 field seasons, respectively (Tables A18 and A19).

<u>Distribution and Relative Abundance</u>

Threadfin shad were captured in nearly all seine regions and trawl sites during the 2010 and 2011 field seasons (Tables A18 and A19). At the Chipps Island Trawl Site, individuals were generally captured from June to February with higher densities observed from October through December in 2010 and from November through December in 2011 (Figure 71). Threadfin shad were observed in most months at the Sacramento Trawl Site during both field seasons and the mean monthly CPUE peaked during November in 2010 and December in 2011 (Figure 72). The majority of all threadfin shad captured by DJFMP trawls in 2010 and 2011 were caught by the Mossdale KDTR. Although individuals were detected during all months of the field season, very low mean monthly CPUEs were observed in February through May (Figure 73). The mean monthly CPUE at the Mossdale Trawl Site peaked in August and December during the 2010 and 2011 field season, respectively. The mean yearly CPUE at the Chipps Island and Sacramento Trawl sites reached the lowest levels since 2000 during the 2010 and 2011 field seasons (Figures 71 and 72). Similarly, the mean yearly CPUE at the Mossdale Trawl Site was relatively low in 2010 and 2011, and were comparable to the low catches observed in 2006 and 2007 (Figure 73).

Threadfin shad were captured in beach seines primarily from July through December during the 2010 and 2011 field seasons (Figure 74). However, we did not capture threadfin shad at the San Francisco/San Pablo Seine Region in 2010. The mean monthly CPUE peaked within most seine regions from October through November during the 2010 field season and from September through October during the 2011 field season. The mean yearly CPUE estimates suggest that threadfin shad have generally been observed in higher densities within the Lower Sacramento River, Lower San Joaquin River and South Delta Seine regions relative to other seine regions since the 2000 field season. In general, the densities within most seine regions have declined considerably over the last decade (Figure 74). The relatively low densities and declines of threadfin shad observed by the DJFMP in most trawl sites and seine regions is consistent with the findings from other fish surveys and investigations within the San Francisco Estuary (e.g., Sommer et al. 2007; Contreras et al. 2012).

The threadfin shad is an introduced and short lived (~2 years) warmwater species that is dependent on fresh water. Threadfin shad are distributed throughout the Central Valley within reservoirs, the Sacramento-San Joaquin River system, and the upper portions of San Francisco Estuary and adults spawn from April through June when water temperatures exceed 20°C (Moyle 2002). Previous studies demonstrated that threadfin shad experience low survival within the Sacramento-San Joaquin Delta during the winter when water temperatures approach 8°C (Turner 1966). Therefore the low densities of threadfin shad observed during 2010 and 2011 from February to June at all trawl sites and seine regions may be, in part, the result of cool water temperatures, particularly during the month of January (Tables A21-A23). Based on the assumption that the survival of overwintering threadfin shad was likely poor within the Estuary during the 2010 and 2011 field seasons, we believe that most individuals captured by the DJFMP from July through January may have been individuals immigrating into the DJFMP sampling area from further upstream, particularly from the warmer San Joaquin River drainage.

<u>Influence of River Discharge</u>

During the 2010 and 2011 field seasons, threadfin shad were typically not captured by the DJFMP from February to June during periods of relatively high river discharges, suggesting a very distinct negative flow relationship (Figures 71-74). However this relationship may have been in response to high mortality resulting from low water temperature. Therefore, we attempted to isolate the impact of discharge on threadfin shad CPUE by evaluating catch data from July to December when water temperatures were suitable and there was occupancy throughout most of the Estuary. The mean monthly CPUEs of threadfin shad at most trawl sites and within all seine regions showed little to no relationship to river discharge during the 2010 and 2011 field seasons from July to January (Figures 71, 72, and 74). However, we did observe that the mean monthly CPUE of threadfin shad at the Mossdale Trawl Site declined during periods of lower mean river discharge in months following the spawning period (i.e., August-October; Figure 73). Therefore, we developed a simple linear regression model to examine the influence of discharge at Vernalis ($\log_{10}$ transformed) on the mean weekly CPUE of threadfin shad at the Mossdale Trawl Site. Assuming a linear relationship, we demonstrated a significant negative correlation (p-value = 0.01) where 40% of the variability in the mean weekly CPUE from August to October was explained by river discharge (Figure 75). Therefore, there is some evidence that river discharge may have influenced the number of threadfin shad entering the

Delta from the San Joaquin River during 2010 and 2011. Overall, our observations suggest that threadfin shad densities within the Estuary were likely mediated by a combination of limiting conditions (e.g., high river discharge, low temperatures, high salinity, and low turbidity; Moyle 2002; Feyrer et al. 2007; MacNally et al. 2010) rather than solely river discharge (Dege and Brown 2004) during the 2010 and 2011 field seasons.

Fork Length Distributions

The FLs of threadfin shad captured during the 2010 and 2011 field seasons generally ranged from 45 to 140 mm at the Chipps Island and Sacramento Trawl sites and from 25 to 160 mm at the Mossdale Trawl Site (Figures 76-78). The length-frequency distributions likely represented three separate age classes (Moyle 2002). The FLs of threadfin shad within most seine regions ranged from 25 to 120 mm (Figures 79-82). The majority of threadfin shad < 50 mm (FL) were captured at the Mossdale Trawl Site and Lower San Joaquin River, Lower Sacramento River, North Delta, and South Delta Seine regions suggesting that only a small portion of the Estuary was used as rearing habitat. However, these results can be confounded by variable gear efficiencies and sample bias (Van Den Avyle et al. 1995).

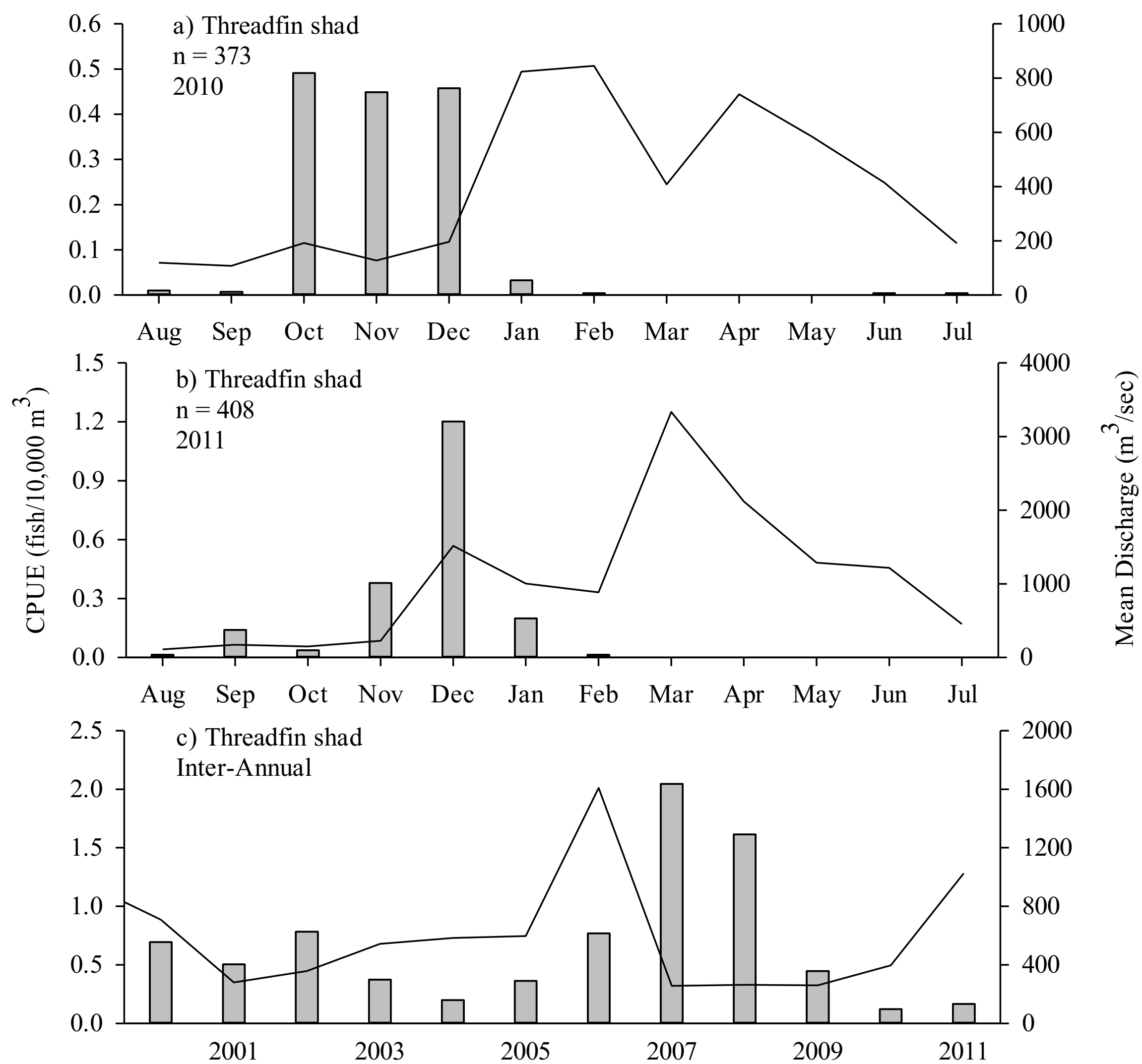

Figure 71. Mean monthly and yearly CPUE of threadfin shad captured in mid-water trawls (MWTRs) at the Chipps Island Trawl Site, and mean monthly and yearly Delta discharge during the a) 2010, b) 2011, and c) 2000 through 2011 field seasons. Sample size (n) corresponds to total number of fish caught.

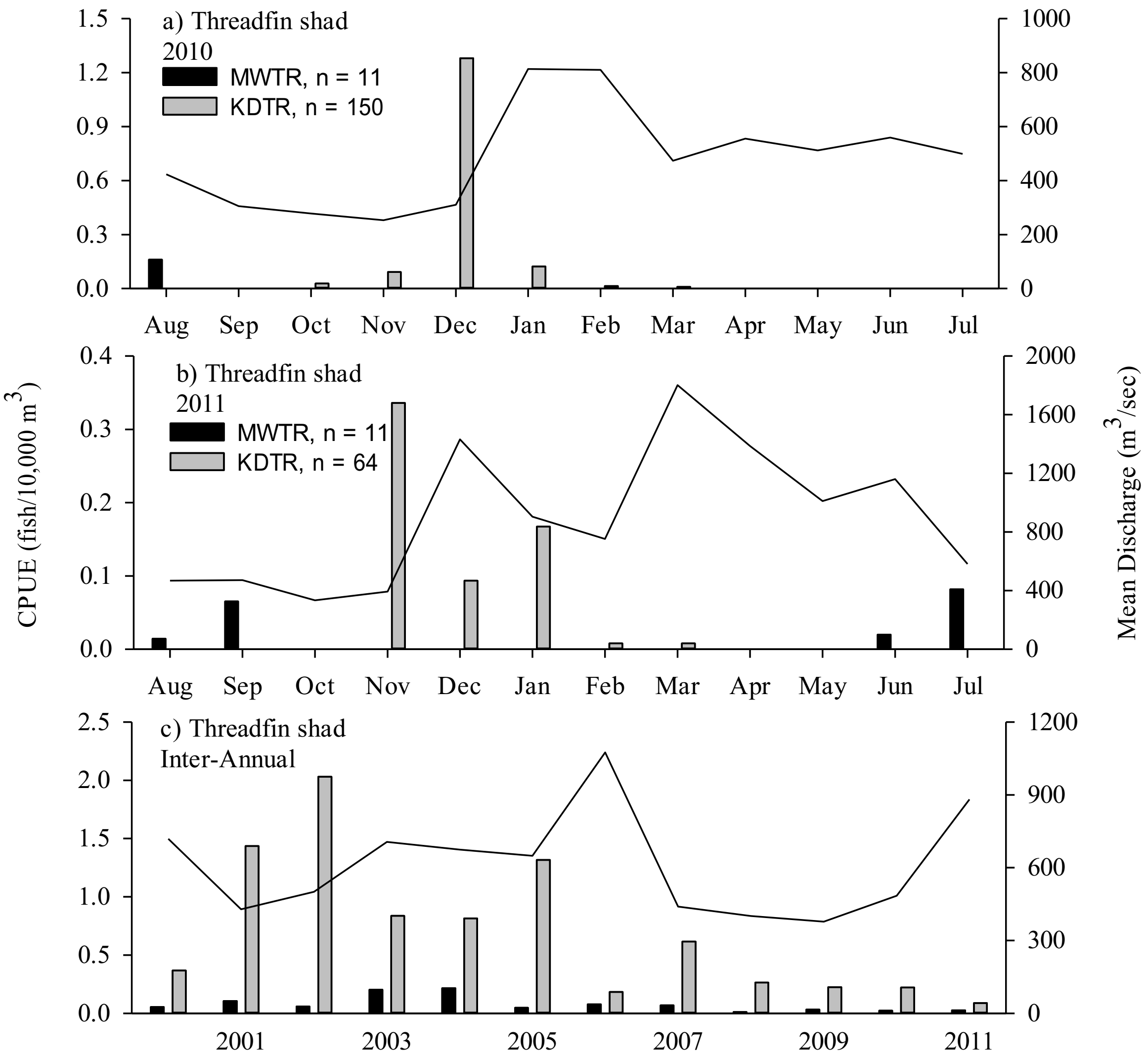

Figure 72. Mean monthly and yearly CPUE of threadfin shad captured in mid-water (MWTRs) and Kodiak trawls (KDTRs) at the Sacramento Trawl Site, and mean monthly and yearly Sacramento River discharge at Freeport during the a) 2010, b) 2011, and c) 2000 through 2011 field seasons. Sample size (n) corresponds to total number of fish caught.

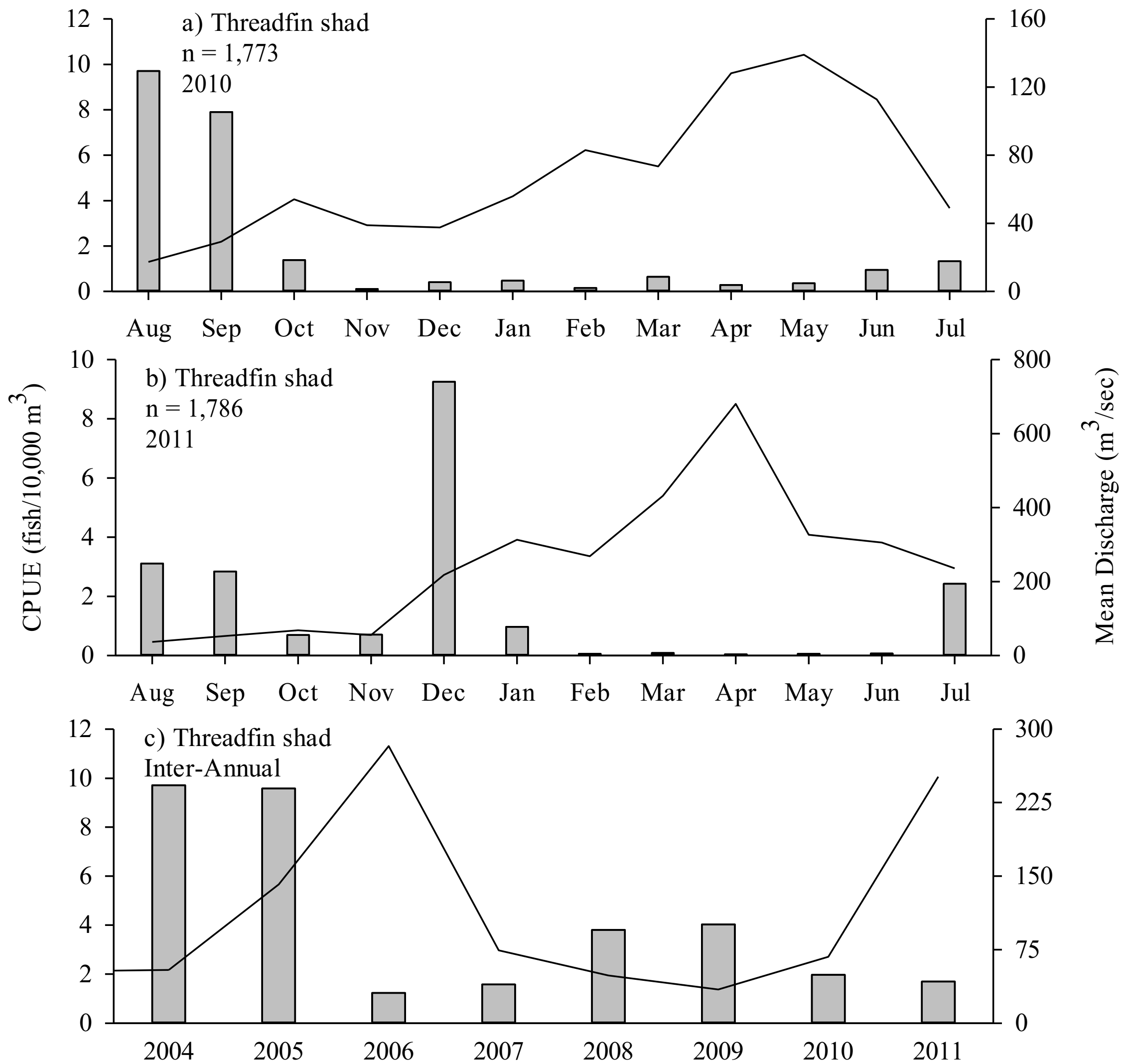

Figure 73. Mean monthly and yearly CPUE of threadfin shad captured in Kodiak trawls (KDTRs) at the Mossdale Trawl Site, and mean monthly and yearly San Joaquin River discharge at Vernalis during the a) 2010, b) 2011, and c) 2004 through 2011 field seasons. Sample size (n) corresponds to total number of fish caught.

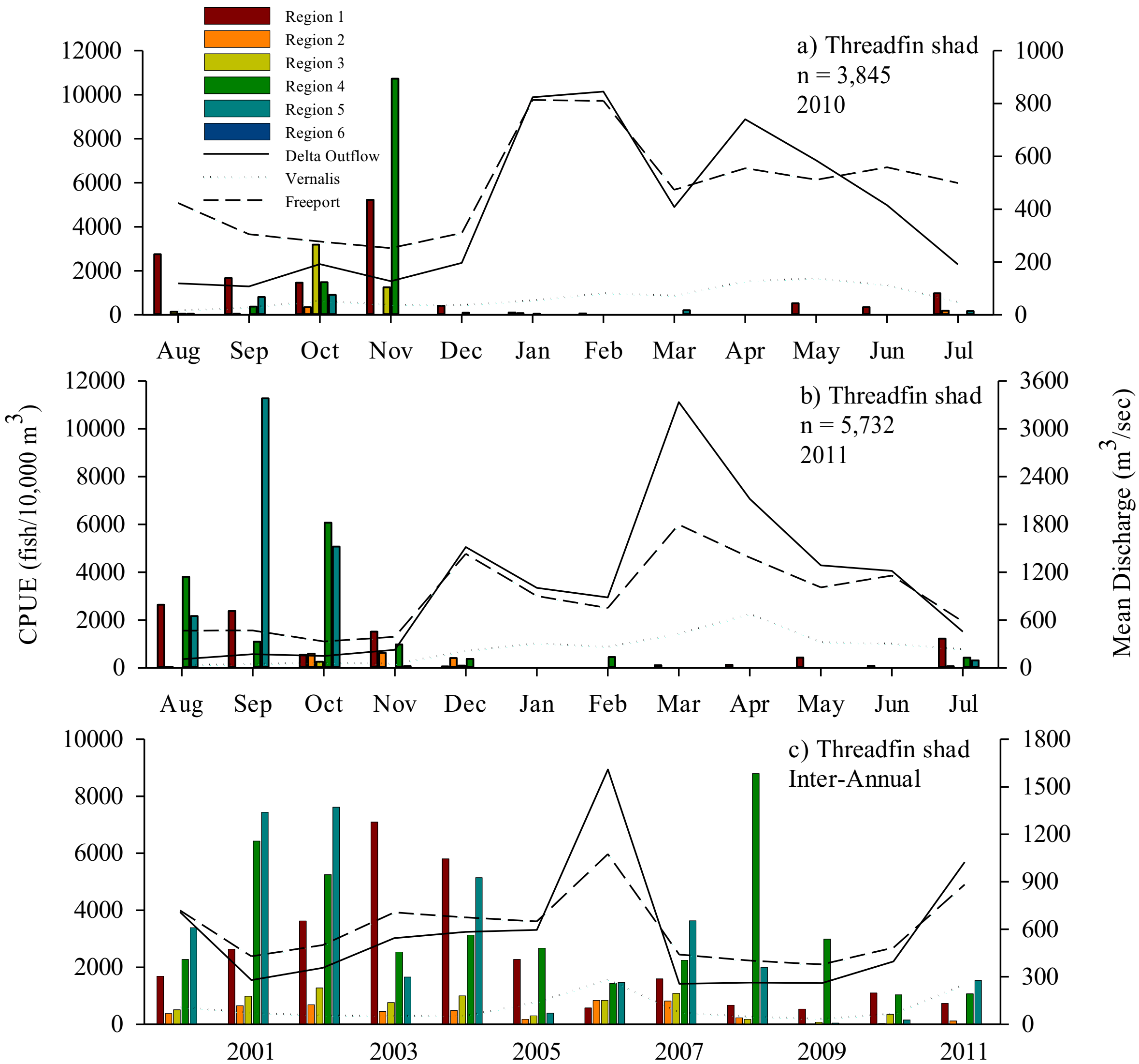

Figure 74. Mean monthly and yearly CPUE of threadfin shad captured in beach seines at Regions 1-6, and mean monthly and yearly Sacramento River discharge at Freeport, San Joaquin River discharge at Vernalis, and Delta discharge during the a) 2010, b) 2011, and c) 2000 through 2011 field seasons. Sample size (n) corresponds to total number of fish caught.

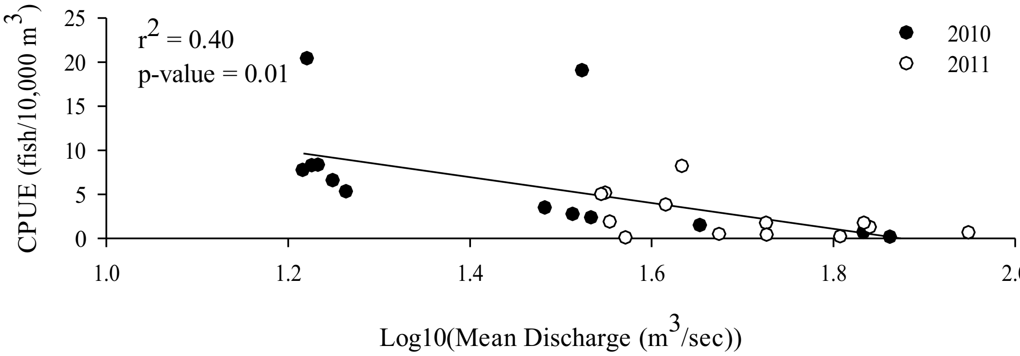

Figure 75. Linear regressions of mean weekly CPUE of threadfin shad captured in Kodiak trawls (KDTRs) at the Mossdale Trawl Site and mean weekly San Joaquin River discharge at Vernalis from August through October during the 2010 and 2011 field seasons.

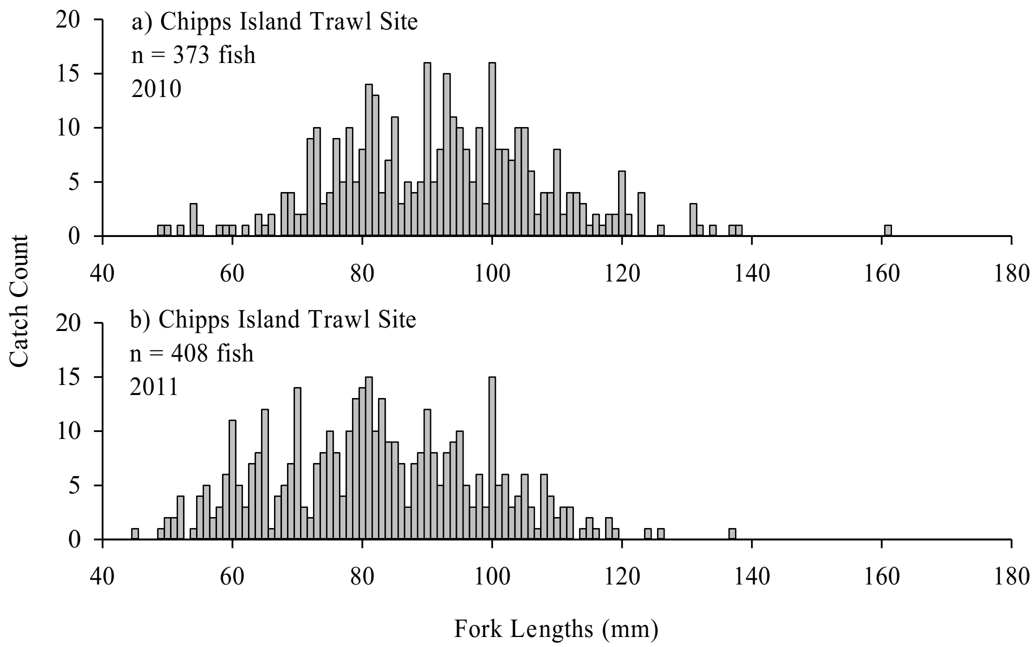

Figure 76. Fork length distributions for threadfin shad captured in mid-water trawls (MWTRs) at the Chipps Island Trawl Site during the 2010 and 2011 field seasons.

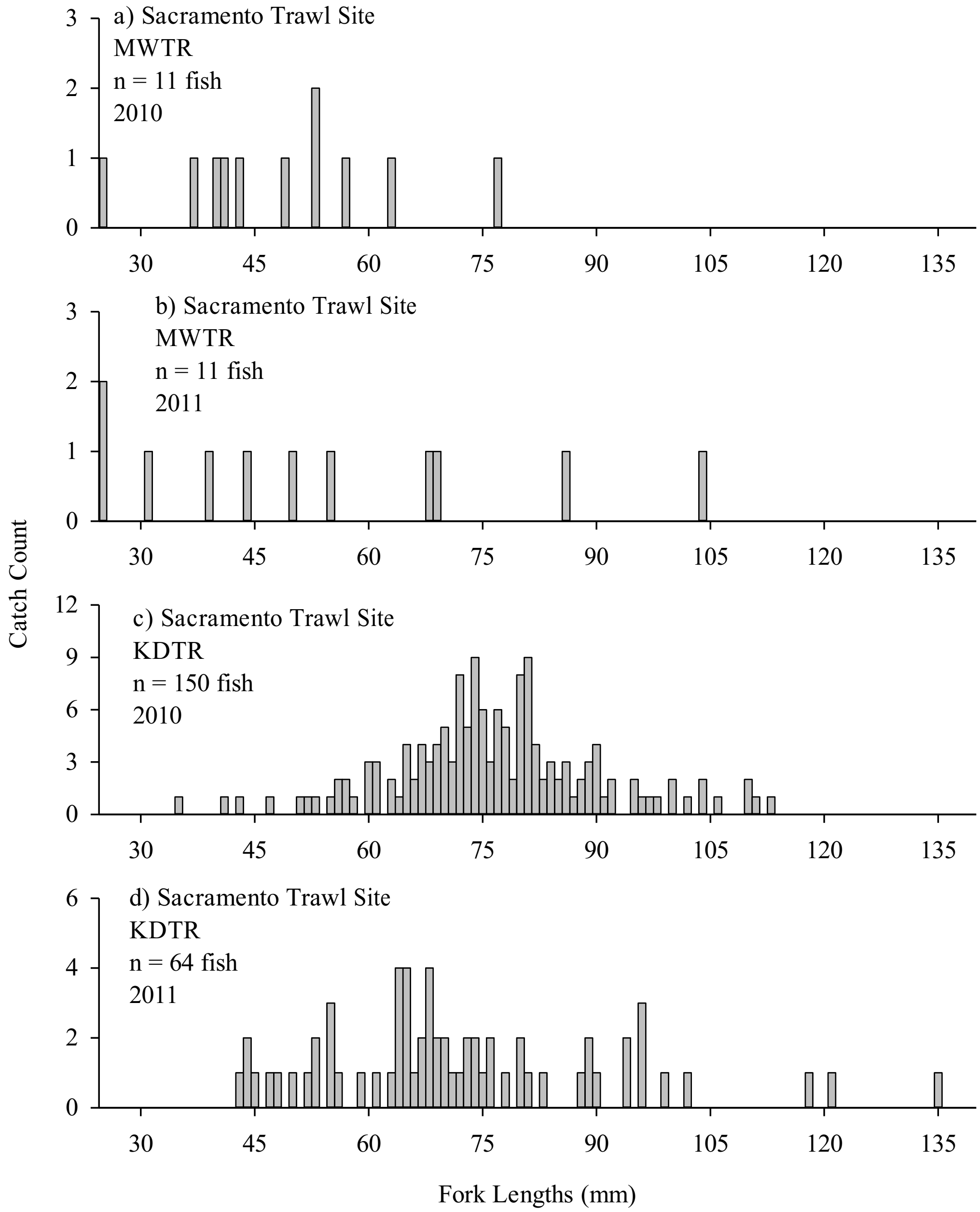

Figure 77. Fork length distributions for threadfin shad captured in mid-water (MWTRs) and Kodiak trawls (KDTRs) at the Sacramento Trawl Site during the 2010 and 2011 field seasons.

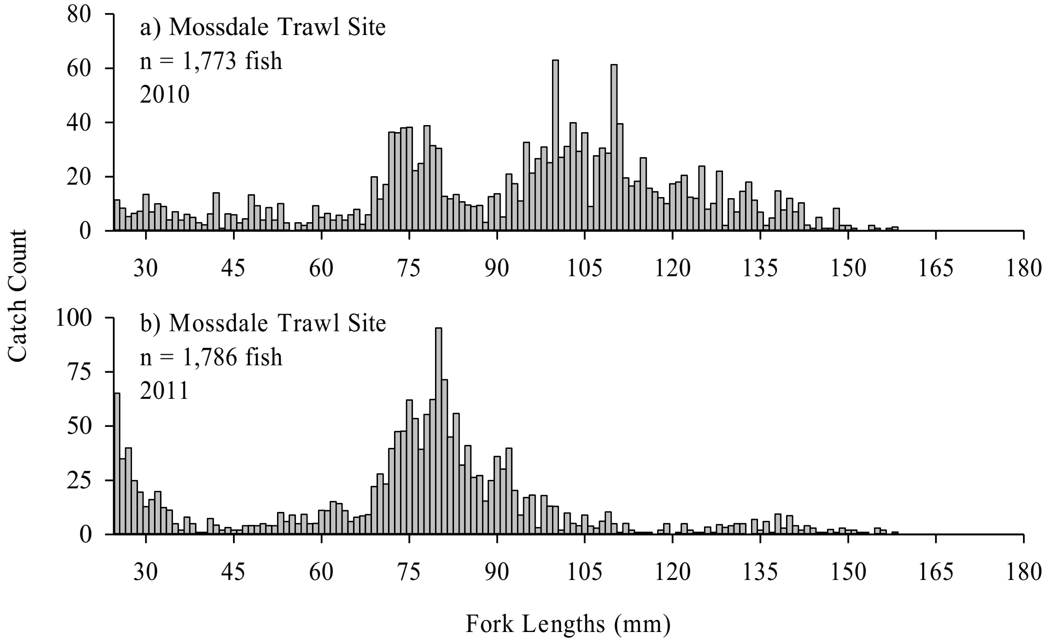

Figure 78. Fork length distributions for threadfin shad captured in Kodiak trawls (KDTRs) at the Mossdale Trawl Site during the 2010 and 2011 field seasons.

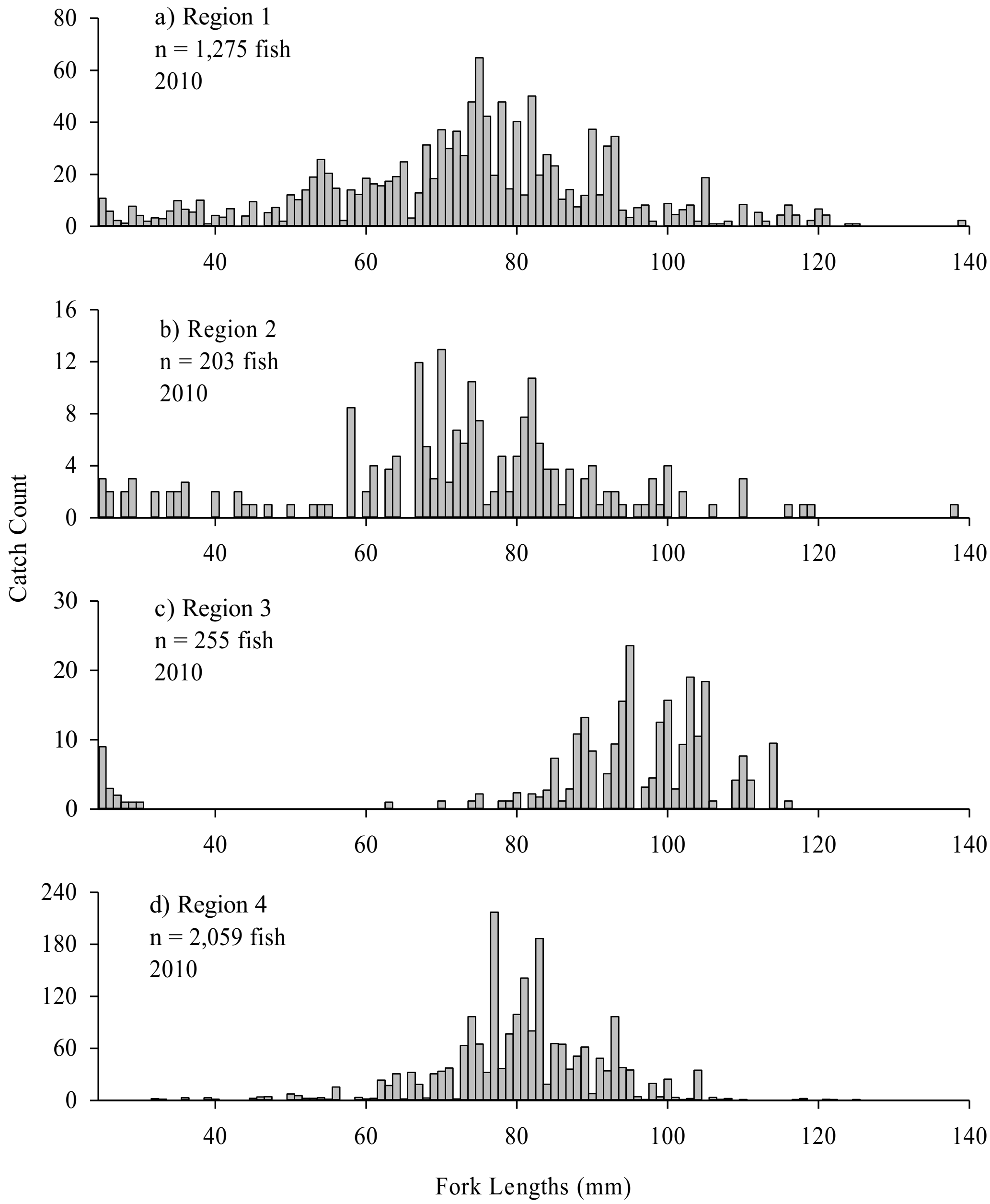

Figure 79. Fork length distributions for threadfin shad captured in beach seines within the Lower Sacramento River (Region 1), North Delta (Region 2), Central Delta (Region 3), and South Delta (Region 4) Seine regions during the 2010 field season.

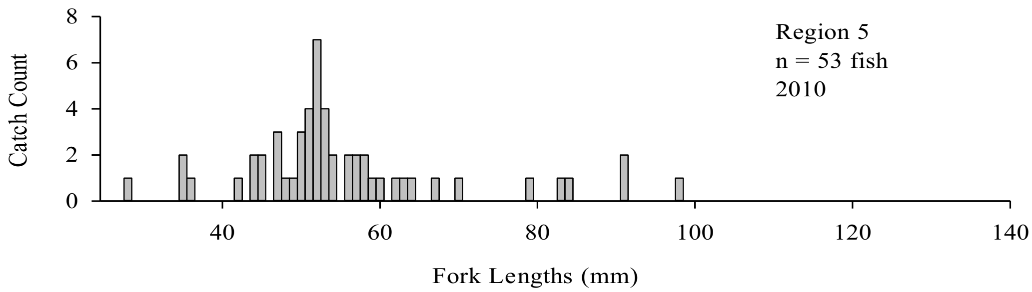

Figure 80. Fork length distributions for threadfin shad captured in beach seines within the Lower San Joaquin River Seine Region (Region 5) during the 2010 field season.

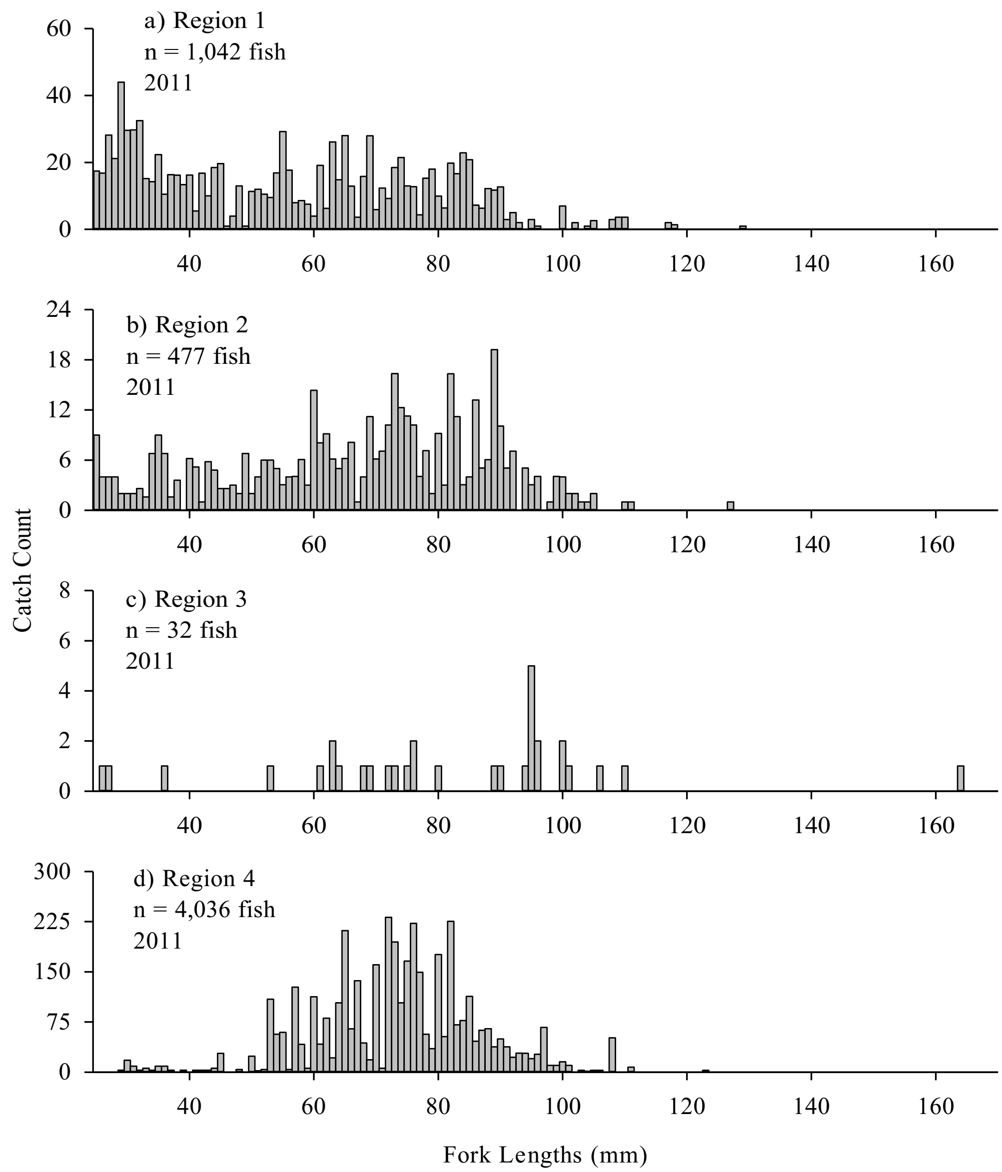

Figure 81. Fork length distributions for threadfin shad captured in beach seines within the Lower Sacramento River (Region 1), North Delta (Region 2), Central Delta (Region 3), and South Delta (Region 4) Seine regions during the 2011 field season.

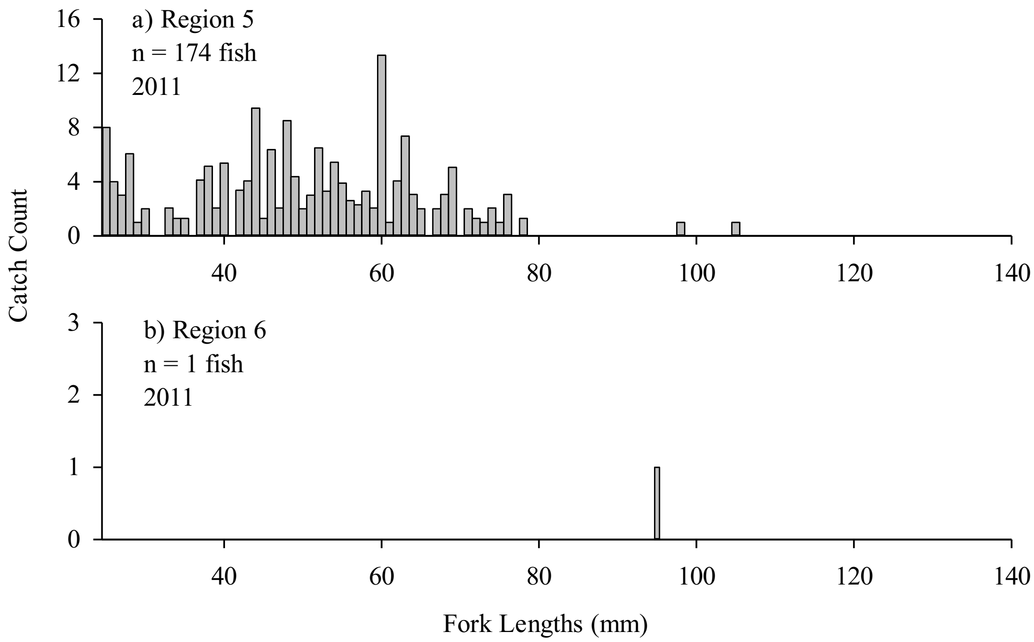

Figure 82. Fork length distributions for threadfin shad captured in beach seines within the Lower San Joaquin River (Region 5) and San Francisco/San Pablo Bay (Region 6) Seine regions during the 2011 field season.

Striped Bass

A total of 1,085 and 591 striped bass were captured by the DJFMP during the 2010 and 2011 field seasons, respectively (Tables A18 and A19).

<u>Distribution and Relative Abundance</u>

We captured striped bass at all trawl sites and within all seine regions during the 2010 and 2011 field seasons (Tables A18 and A19). The majority of all striped bass captured by the DJFMP in 2010 and 2011 were caught at the Chipps Island Trawl Site. Individuals were captured at Chipps Island during all months, but relatively low densities were observed from March through June (Figure 83). The mean monthly CPUE peaked at Chipps Island in October and August during the 2010 and 2011 field seasons, respectively (Figure 83). The mean yearly CPUE at the Chipps Island Trawl Site reached the lowest levels since 2000 during the 2010 and 2011 field seasons (Figure 83). Very few striped bass (total < 6) were observed at the Sacramento Trawl Site during the 2010 and 2011 field seasons (Figure 84). Individuals were captured by the Sacramento MWTR during the spring and summer. The mean yearly CPUE estimates suggest that striped bass captures at the Sacramento Trawl Site have been consistently low since the 2000 field season (Figure 84). At the Mossdale Trawl Site, striped bass monthly CPUE peaked in either July or August and few or no individuals were captured from February to July (Figure 85). The mean yearly CPUEs were relatively low at the Mossdale Trawl Site for the 2010 and 2011 field seasons and were less than a quarter of those observed during the 2008 and 2009 field seasons (Figure 85).

Striped bass were primarily captured in beach seines from July through September during the 2010 and 2011 field seasons (Figure 86). However, no individuals were observed within the Central Delta Seine Region in 2011. The mean monthly CPUE peaked within most seine regions in August or September. The North Delta, Lower San Joaquin River, and South Delta Seine regions showed the highest striped bass densities relative to other seine regions throughout much of the last decade. No discernible inter-annual trend in striped bass CPUE could be detected within and among seine regions since the 2000 field season (Figure 86).

The striped bass is a long-lived, introduced, anadromous, and iteroparous species (Moyle 2002). Adults generally occur within the lower portions of the San Francisco Estuary (e.g., San Francisco and San Pablo bays) and/or the Pacific Ocean throughout much of the year and migrate upstream to spawn within or upstream of the lower Sacramento and San Joaquin rivers from April to June (Turner and Chadwick 1972; Moyle 2002). After spawning, embryos and larval striped bass are often translocated by rivers to the Estuary where juveniles normally rear in and near the low salinity zone (Turner and Chadwick 1972; Moyle 2002; Sommer et al. 2011). The relative higher densities of striped bass at the Mossdale Trawl Site and within the North Delta and Lower San Joaquin River Seine regions from July to September during the 2010 and 2011 field seasons was likely a result of juveniles migrating to the low salinity zone post spawn. Furthermore, the low densities or absence of striped bass from January to June at nearly all seine regions and trawl sites was likely due to most juveniles and sub-adults (i.e., individuals most susceptible to DJFMP sampling methods) occupying the low salinity zone which was located downstream of the Chipps Island Trawl Site (i.e., the majority of all DJFMP sampling locations) during the spring of both field seasons. Because the DJFMP does not sample the entire Estuary, the inter-annual abundance trends do not account for distribution shifts and the resulting bias is unknown (Kimmerer et al. 2001; Sommer et al. 2011).

Influence of River Discharge

During the 2010 and 2011 field seasons, striped bass were typically captured by the DJFMP from July to January during periods of relatively low river discharge, suggesting a distinct negative flow relationship (Figures 83-86). However this relationship was likely in response to high river discharges shifting the low salinity zone and hence the distribution of striped bass downstream of the DJFMP sampling locations (Turner and Chadwick 1972; Kimmerer et al. 2001; Sommer et al. 2011). Therefore, we attempted to isolate the effect of discharge on striped bass densities by evaluating catch data from June to September when the position of the low salinity zone was at or upstream of the Chipps Island Trawl Site and there were likely juveniles occurring within the Delta. The mean monthly CPUEs of striped bass at all trawl sites and within all seine regions showed no discernible relationship to river discharge during the 2010 and 2011 field seasons. As a result, these data suggest that the relative abundance of striped bass at DJFMP sampling locations within or upstream of the Delta was likely mediated by the timing and success of spawning adults and the location of the low salinity zone rather than river discharge (Stevens et al. 1985; Dege and Brown 2004). Previous investigations have suggested that river discharge positively influences the abundance of juvenile striped bass (e.g., Turner and Chadwick 1972; Stevens 1977), however this relationship has greatly weakened since the 1970s (Kimmerer et al. 2001).

Fork Length Distributions

The majority of striped bass captured during the 2010 and 2011 field seasons ranged from 50 to 150 mm (FL) at the Chipps Island Trawl Site (Figure 87) and from 25 to 125 mm (FL) at the Mossdale Trawl Site (Figure 88). At the Sacramento Trawl Site, the few individuals observed ranged from 100 to 500 mm in FL (Figure 89). In beach seines, the FLs of striped bass were typically less than 150 mm except within the San Francisco/San Pablo Bay Seine Region where individuals captured had FLs up to 300 mm (Figures 90-93). These data further support that the DJFMP captured primarily juveniles or sub-adults (age-0 or age-1; Moyle 2002) migrating into and rearing within the upper portions of the San Francisco Estuary from primarily July to October prior to the low salinity habitat shifting downstream into Suisun and/or San Pablo bays by increased river discharges.

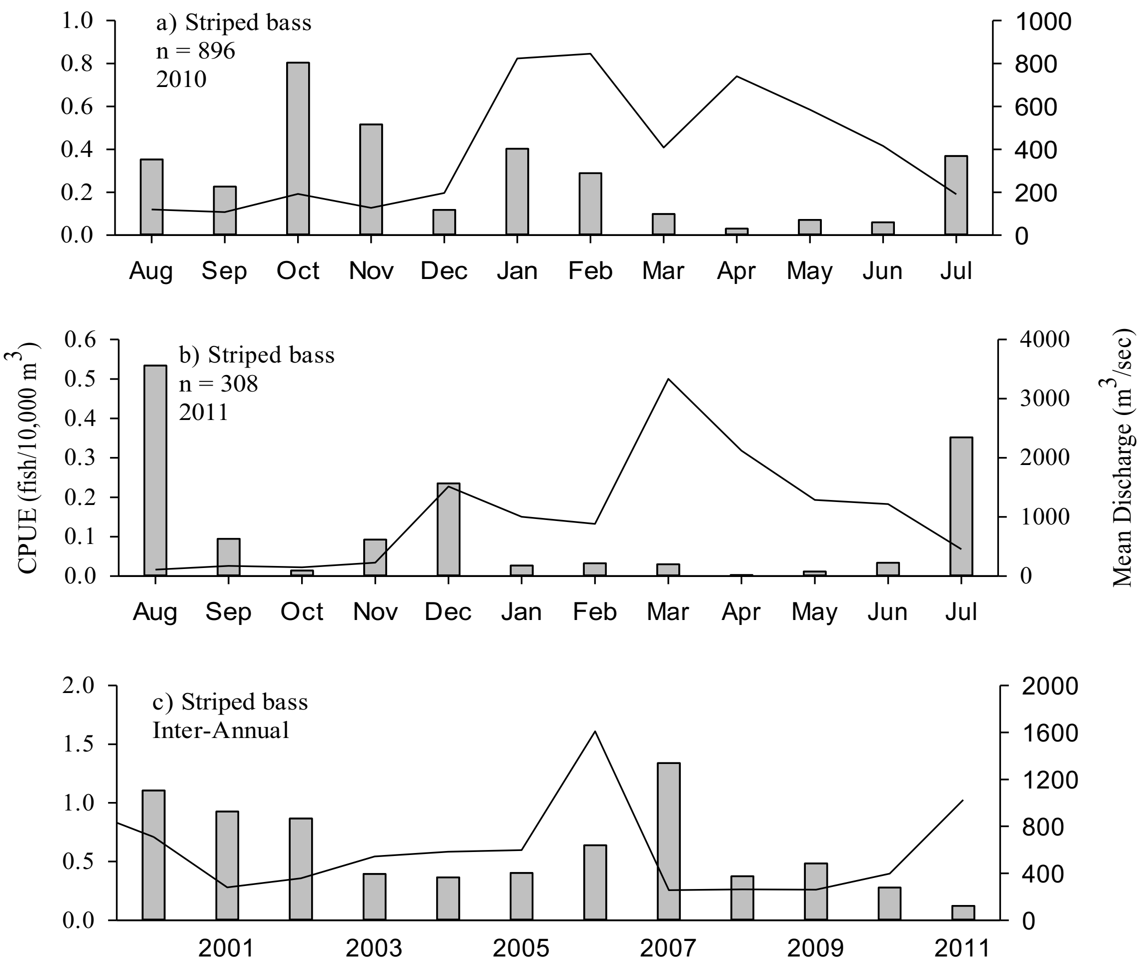

Figure 83. Mean monthly and yearly CPUE of striped bass captured in mid-water trawls (MWTRs) at the Chipps Island Trawl Site, and mean monthly and yearly Delta discharge during the a) 2010, b) 2011, and c) 2000 through 2011 field seasons. Sample size (n) corresponds to total number of fish caught.

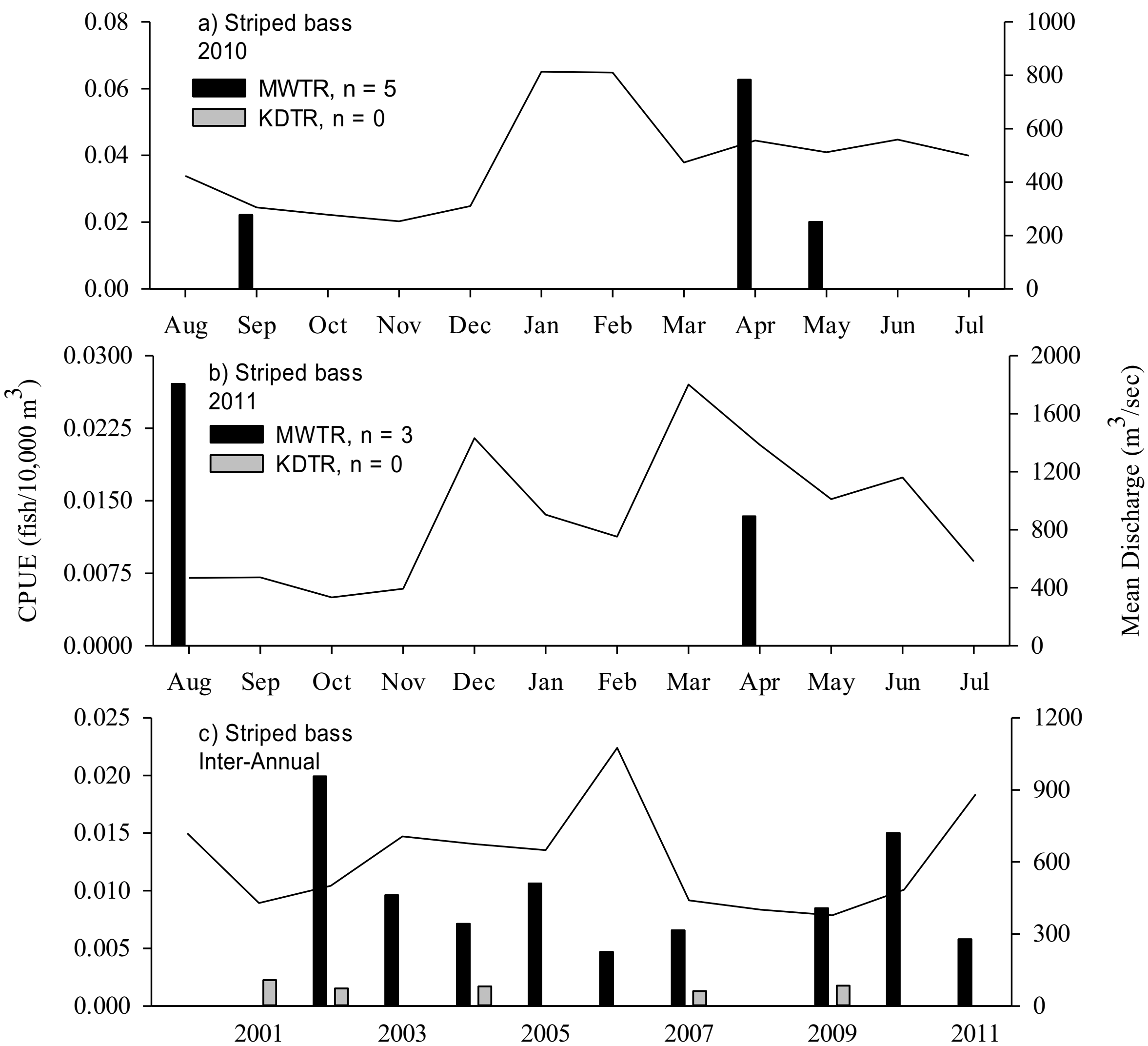

Figure 84. Mean monthly and yearly CPUE of striped bass captured in mid-water (MWTRs) and Kodiak trawls (KDTRs) at the Sacramento Trawl Site, and mean monthly and yearly Sacramento River discharge at Freeport during the a) 2010, b) 2011, and c) 2000 through 2011 field seasons. Sample size (n) corresponds to total number of fish caught.

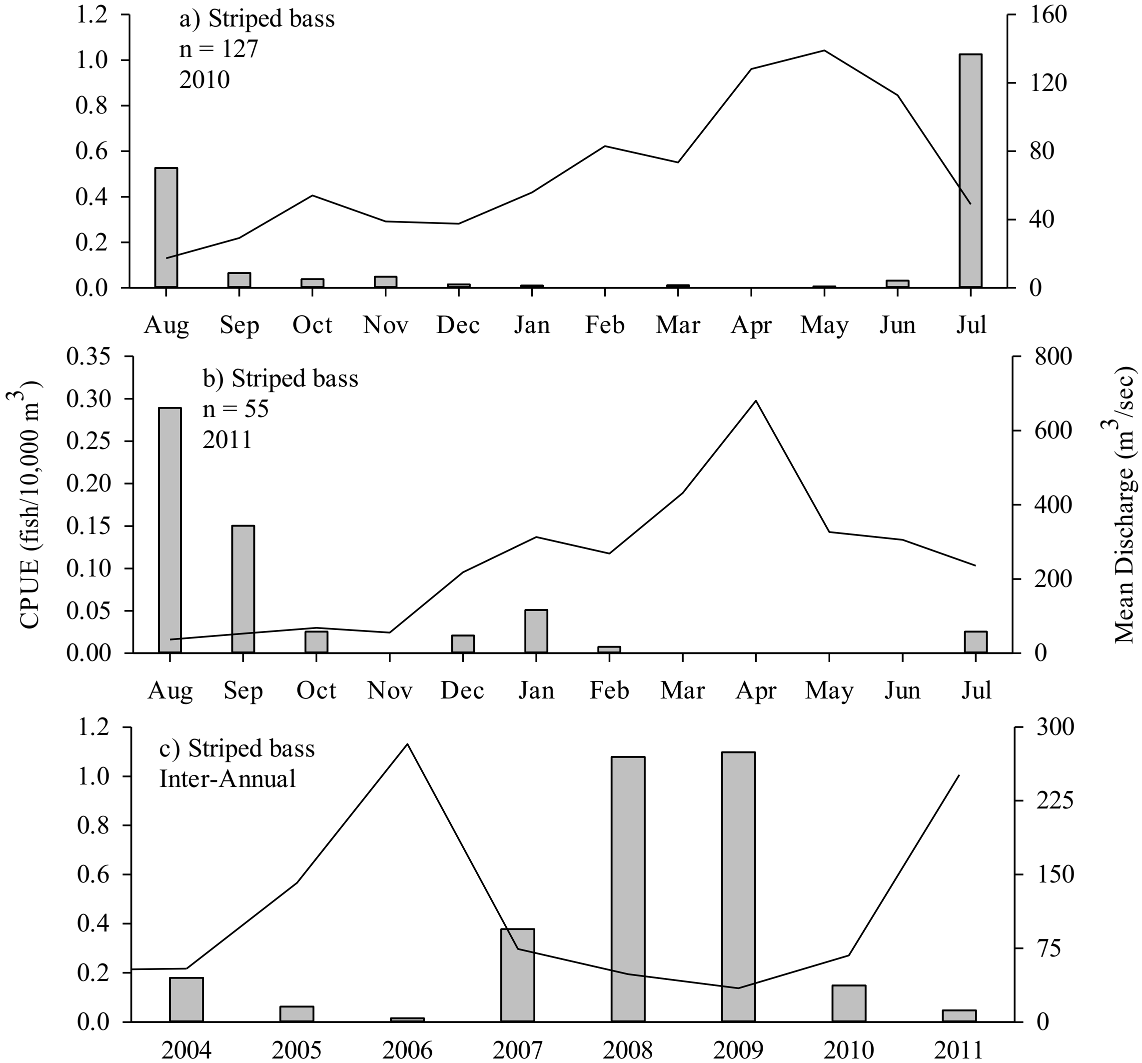

Figure 85. Mean monthly and yearly CPUE of striped bass captured in Kodiak trawls (KDTRs) at the Mossdale Trawl Site, and mean monthly and yearly San Joaquin River discharge at Vernalis during the a) 2010, b) 2011, and c) 2004 through 2011 field seasons. Sample size (n) corresponds to total number of fish caught.

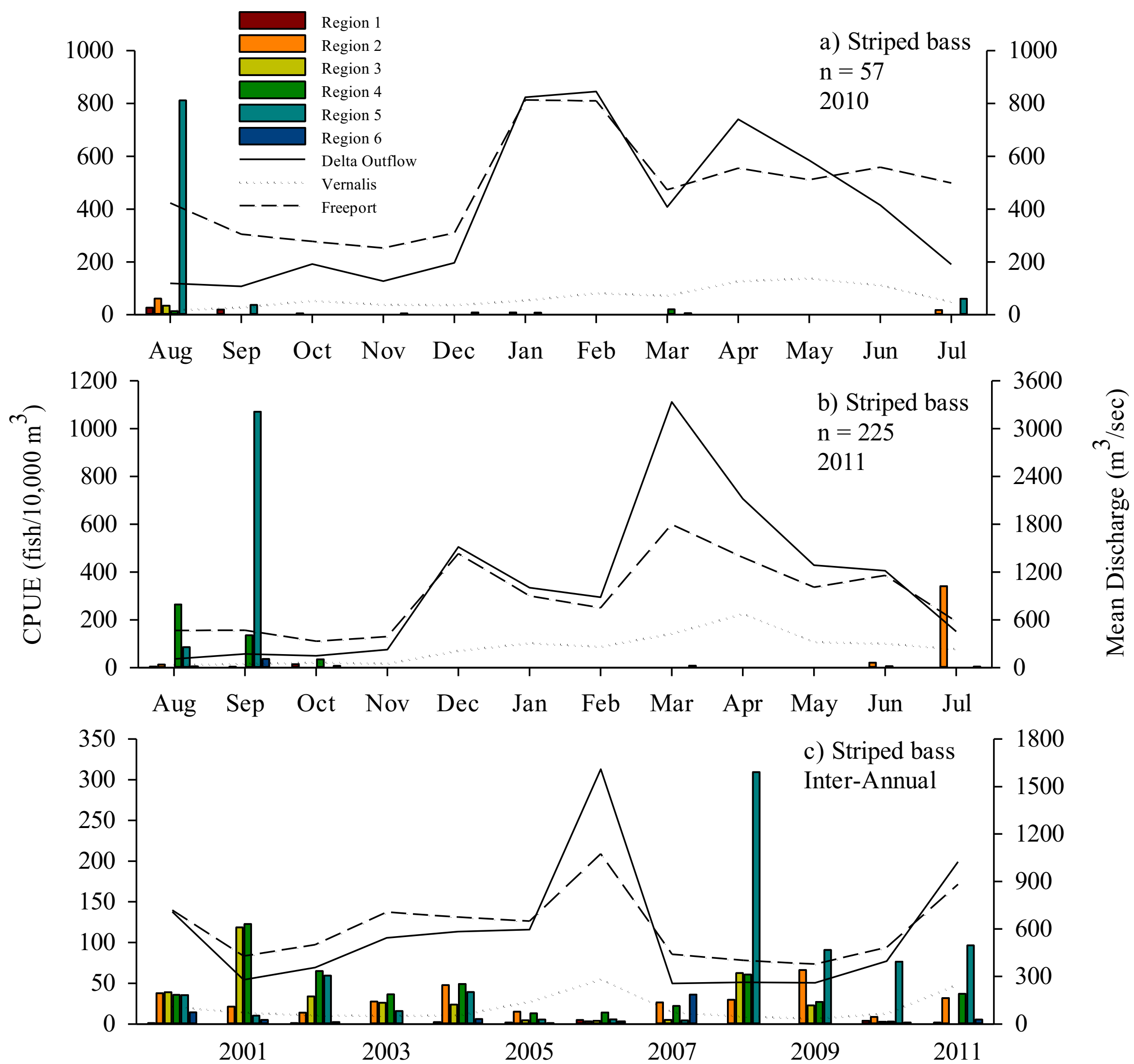

Figure 86. Mean monthly and yearly CPUE of striped bass captured in beach seines at Regions 1-6, and mean monthly and yearly Sacramento River discharge at Freeport, San Joaquin River discharge at Vernalis, and Delta discharge during the a) 2010, b) 2011, and c) 2000 through 2011 field seasons. Sample size (n) corresponds to total number of fish caught.

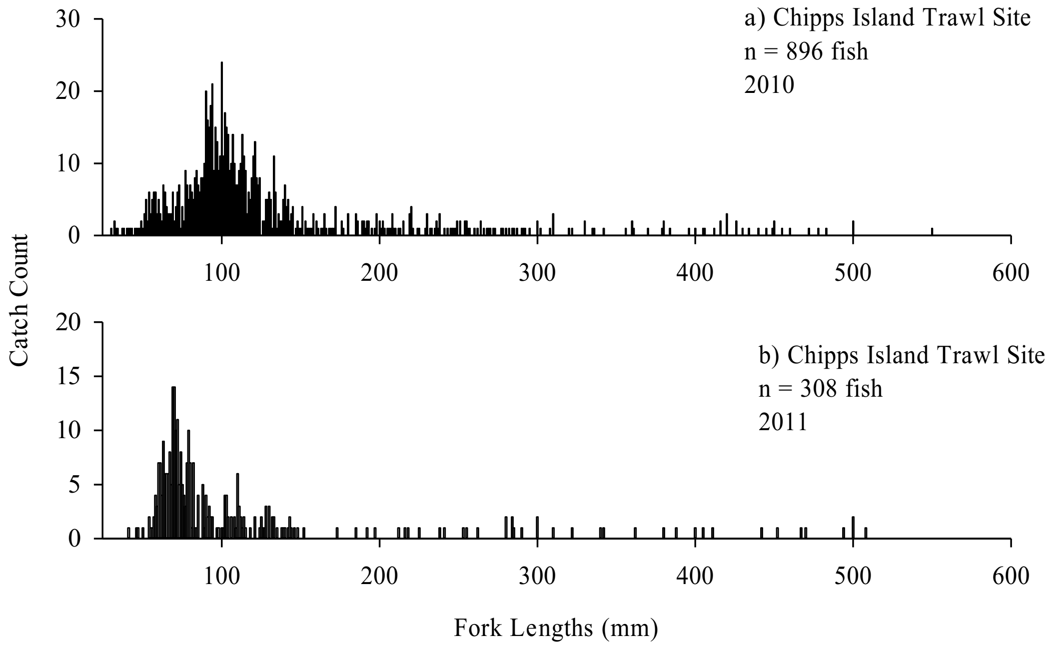

Figure 87. Fork length distributions for striped bass captured in mid-water trawls (MWTRs) at the Chipps Island Trawl Site during the 2010 and 2011 field seasons.

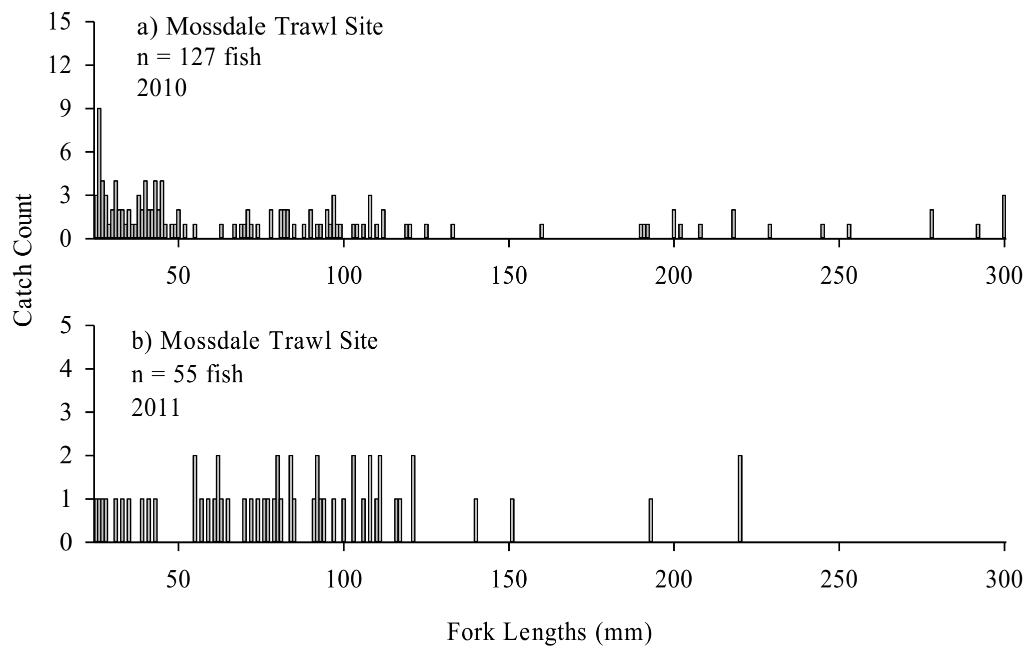

Figure 88. Fork length distributions for striped bass captured in Kodiak trawls (KDTRs) at the Mossdale Trawl Site during the 2010 and 2011 field seasons.

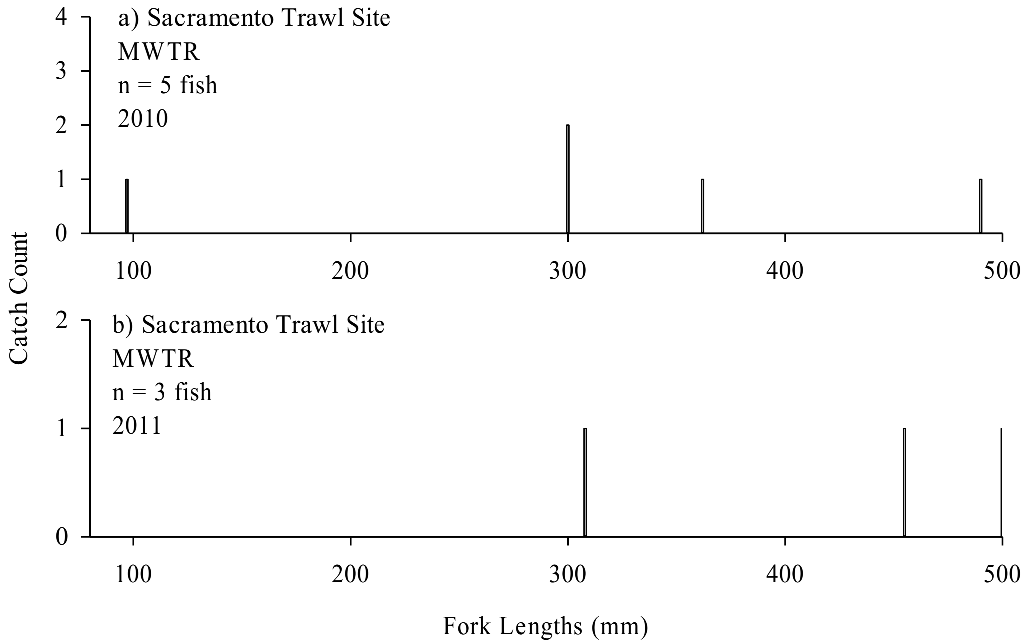

Figure 89. Fork length distributions for striped bass captured in mid-water (MWTRs) and Kodiak trawls (KDTRs) at the Sacramento Trawl Site during the 2010 and 2011 field seasons.

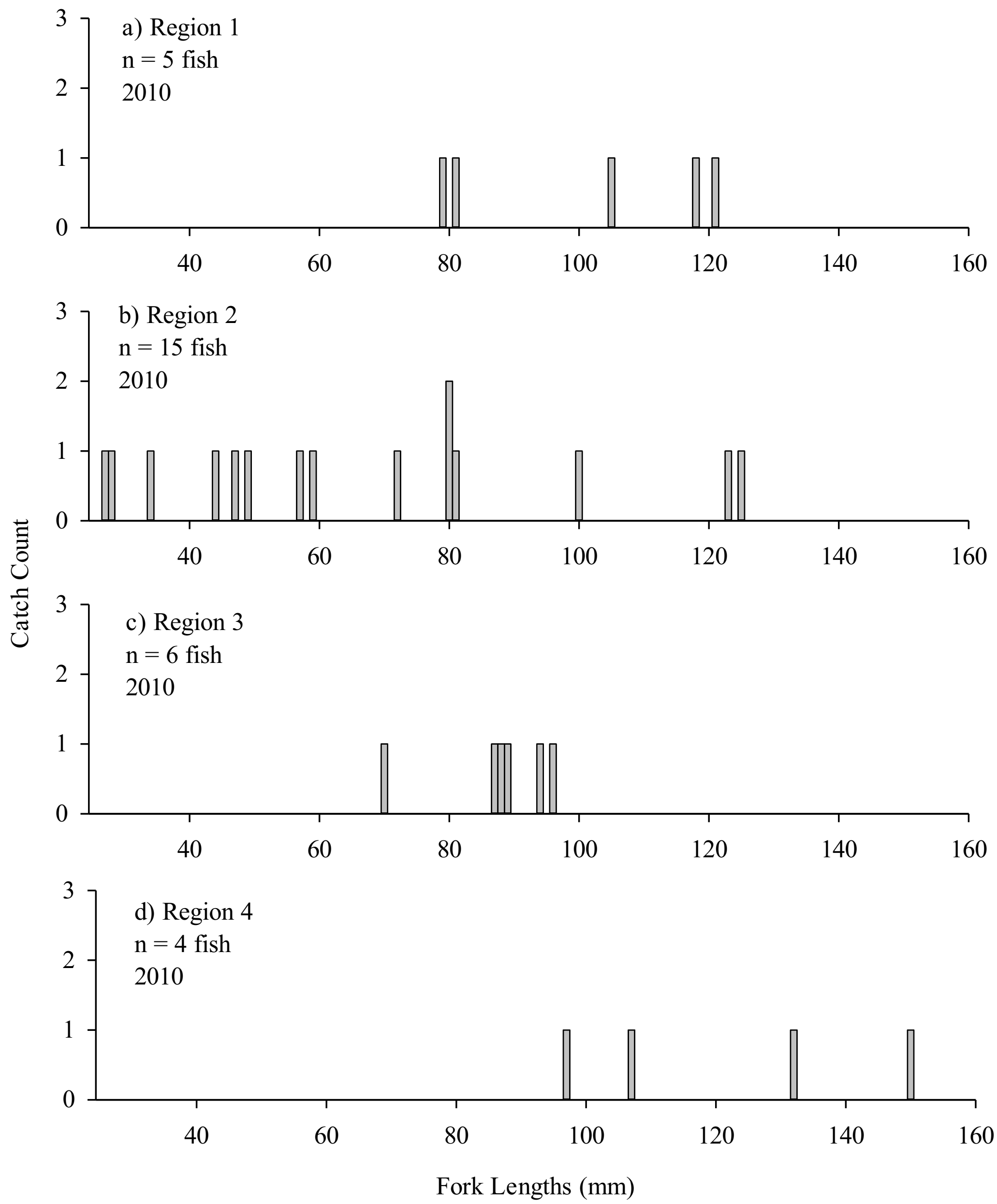

Figure 90. Fork length distributions for striped bass captured in beach seines within the Lower Sacramento River (Region 1), North Delta (Region 2), Central Delta (Region 3), and South Delta (Region 4) Seine regions during the 2010 field season.

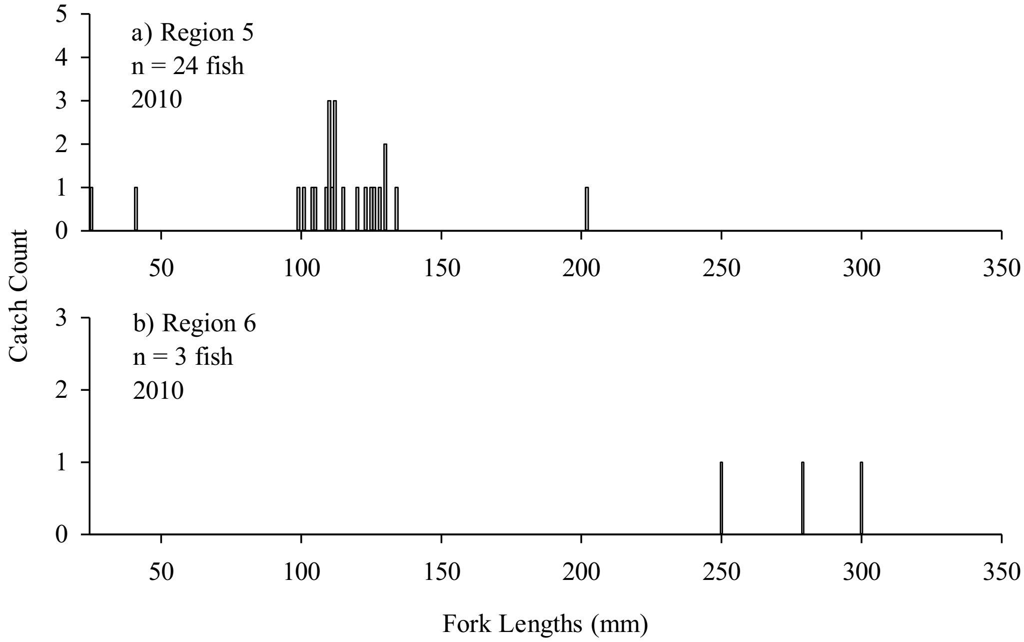

Figure 91. Fork length distributions for striped bass captured in beach seines within the Lower San Joaquin River (Region 5) and San Francisco/San Pablo Bay (Region 6) Seine regions during the 2010 field season.

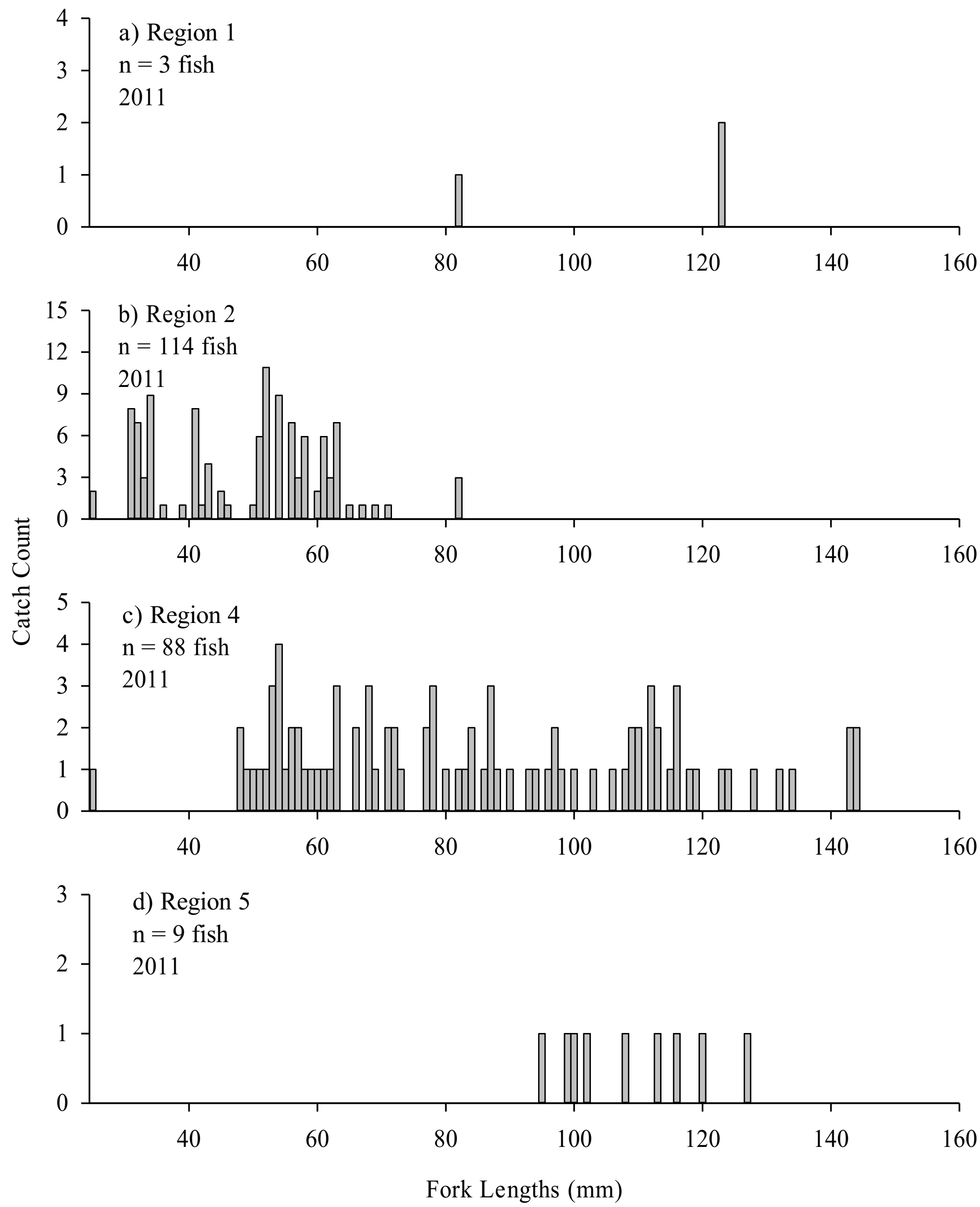

Figure 92. Fork length distributions for striped bass captured in beach seines within the Lower Sacramento River (Region 1), North Delta (Region 2), South Delta (Region 4), and Lower San Joaquin River (Region 5) Seine regions during the 2011 field season.

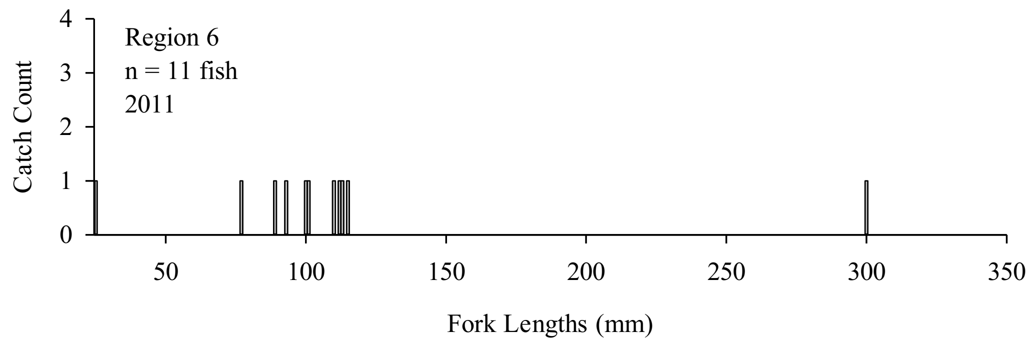

Figure 93. Fork length distributions for striped bass in beach seines within the San Francisco/San Pablo Bay Seine Region (Region 6) during the 2011 field season.

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APPENDIX

Table A1. Sites sampled during the 2010 field season categorized by gear or 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 = mid channel). For example, Colusa State Park is on the Sacramento River (SR) at river mile 144 on the west bank (W).

Site Code	Site Name	County	UTM Coordinates			First Year Sampled Annually
			Zone	Northing	Easting	
Region 1: Lower Sacramento River Seine						
SR144W	Colusa State Park	Colusa	10 S	4341652	585032	1981
SR138E	Ward's Landing	Colusa	10 S	4338873	591787	1981
SR130E	South Meridian	Sutter	10 S	4329625	594819	1981
SR094E	Reels Beach	Sutter	10 S	4301235	610500	1981
SR090W	Knight's Landing	Yolo	10 S	4295506	610842	1981
SR080E*	Verona	Sutter	10 S	4293731	620049	1981
SR071E*	Elkhorn	Sacramento	10 S	4281359	619626	1981
Region 2: North Delta Seine						
SR060E*	Discovery Park	Sacramento	10 S	4273503	629820	1976
AM001S*	American River	Sacramento	10 S	4273377	630121	1976
SR049E*	Garcia Bend	Sacramento	10 S	4259863	627056	1976
SR043W	Clarksburg	Yolo	10 S	4249352	629186	1976
SS011N	Steamboat Slough	Sacramento	10 S	4240586	624600	1992
SR024E	Koket	Sacramento	10 S	4233475	626473	1976
SR017E	Isleton	Sacramento	10 S	4224781	621633	1976
SR014W	Rio Vista	Solano	10 S	4227355	617119	1976
SR012W	Sandy Beach	Solano	10 S	4222029	614333	2007
MS001N	Sherman Island	Sacramento	10 S	4212733	606513	1976
Region 3: Central Delta Seine						
SJ005N	Eddo's	Sacramento	10 S	4212249	614110	1976
SJ001S	Antioch Dunes	Contra Costa	10 S	4208157	606855	1979
XC001N	Delta Cross Channel	Sacramento	10 S	4234115	630930	1976
GS010E	Georgiana Slough	Sacramento	10 S	4231900	628914	1976
MK004W	B&W Marina	Sacramento	10 S	4220909	624418	1979
SF014E	Wimpy's	San Joaquin	10 S	4232068	632064	1976
TM001N	Brannan Island	Sacramento	10 S	4219577	615378	1976
DS002S	King's Island	San Joaquin	10 S	4213457	635248	1979
LP003E	Terminous	San Joaquin	10 S	4219075	631488	1979

Table A1. Continued.

Site Code	Site Name	County	UTM Coordinates Zone	Northing	Easting	First Year Sampled Annually
Region 4: South Delta Seine						
SJ051E	Dos Reis	San Joaquin	10 S	4188374	648601	1994
SJ041N	Dad's Point	San Joaquin	10 S	4202181	645287	1979
SJ032S	Lost Isle	San Joaquin	10 S	4206624	636393	1993
SJ026S	Medford Island	San Joaquin	10 S	4212589	630739	2002
OR023E	Union Island	San Joaquin	10 S	4187462	627498	1997
OR019E	Old River	San Joaquin	10 S	4193094	625167	1993
OR014W	Cruiser Haven	Contra Costa	10 S	4198087	626927	1993
OR003W	Frank's Tract	Contra Costa	10 S	4210312	624458	1993
MR010W	Woodward Island	San Joaquin	10 S	4198130	629336	1979
WD002W	Veale Tract	Contra Costa	10 S	4201793	622619	1993
Region 5: Lower San Joaquin River Seine						
SJ083W[a]	N. of Tuolumne River	Stanislaus	10 S	4164462	660960	1994
SJ077E[a]	Route 132	Stanislaus	10 S	4167222	656395	1994
SJ074W[a]	Sturgeon Bend	San Joaquin	10 S	4170903	654784	1994
SJ068W[a]	Durham Site	San Joaquin	10 S	4173594	652327	1994
SJ063W[a]	Big Beach	San Joaquin	10 S	4176666	650093	1994
SJ058W[ab]	Wetherbee[ab]	San Joaquin	10 S	4181923	649451	1994
SJ056E[ab]	Mossdale[ab]	San Joaquin	10 S	4183536	649043	1994
SJ079E[b]	San Luis Refuge	Stanislaus	10 S	4166449	657914	2008
SJ076W[b]	N. of Route 132	Stanislaus	10 S	4168198	656679	2008
SJ074A[b]	Sturgeon Bend Alternate	San Joaquin	10 S	4170228	654634	2008
Region 6: San Francisco and San Pablo Bay Seine						
SA007E	Berkeley Frontage Rd	Alameda	10 S	4189562	561459	1997
SP001W	China Camp	Marin	10 S	4206179	546771	1997
SA009E	Keller Beach	Contra Costa	10 S	4196872	553964	1998
SP000W	McNear's Beach	Marin	10 S	4205405	547852	1997
SA008W	Paradise Beach	Marin	10 S	4194678	546872	1997
SP003E	Point Pinole East	Contra Costa	10 S	4206789	556219	1998
SA010W	San Quentin Beach	Marin	10 S	4199230	544068	1997
SA004W	Tiburon Beach	Marin	10 S	4193885	544413	1997
SA001M	Treasure Island	San Francisco	10 S	4185026	555671	1997

Table A1. Continued.

Site Code	Site Name	County	UTM Coordinates			First Year Sampled Annually
			Zone	Northing	Easting	
Region 7: Sacramento Area Seine						
SR062E	Sand Cove	Sacramento	10 S	4273283	626860	1994
SR057E	Miller Park	Sacramento	10 S	4269001	629279	1994
SR055E	Sherwood Harbor	Sacramento	10 S	4265358	628190	1994
Trawls						
SR055M	Sacramento	Sacramento	10 S	4265084	628299	1988
SJ054M	Mossdale	San Joaquin	10 S	4182898	649315	1996
SB055M,N,S	Chipps Island	Contra Costa	10 S	4211218	595531	1976

* Indicates site was also included within Region 7 from Oct 1st to Jan 31st for data analysis

[a] Indicates site was sampled when San Joaquin River discharge was > $51 m^3/s$

[ab] Indicates site was sampled throughout the year

[b] Indicates site was sampled when San Joaquin River discharge was ≤ $51 m^3/s$

Table A2. Number of sample days and average number, standard deviation, and range of trawls per sample day for trawl sites within sample weeks during the 2010 field season.

Sample Week	Chipps Island (SB018M,N,S) Sample Days	Average Trawls per Sample Day (SD)	Range	Mossdale (SJ054M) Sample Days	Average Trawls per Sample Day (SD)	Range	Sacramento (SR055M) Sample Days	Average Trawls per Sample Day (SD)	Range
8/2/2009	3	10 (0)	10	3	10 (0)	10	3	10 (0)	10
8/9/2009	3	10 (0)	10	3	10 (0)	10	3	10 (0)	10
8/16/2009	3	10 (0)	10	3	10 (0)	10	3	10 (0)	10
8/23/2009	3	10 (0)	10	3	8 (3.46)	4 - 10	3	10 (0)	10
8/30/2009	3	8.3 (1.53)	7 - 10	3	9.3 (1.15)	8 - 10	3	9 (1.73)	7 - 10
9/6/2009	3	10 (0)	10	3	10 (0)	10	3	10 (0)	10
9/13/2009	3	10 (0)	10	3	10 (0)	10	3	10 (0)	10
9/20/2009	3	10 (0)	10	3	10 (0)	10	3	10 (0)	10
9/27/2009	3	10 (0)	10	3	10 (0)	10	3	10 (0)	10
10/4/2009	3	8.3 (1.53)	7 - 10	3	9 (1.73)	7 - 10	3	9 (1.73)	7 - 10
10/11/2009	3	10 (0)	10	2	10 (0)	10	2	10 (0)	10
10/18/2009	3	10 (0)	10	3	10 (0)	10	3	10 (0)	10
10/25/2009	3	9.3 (0.58)	9 - 10	3	10 (0)	10	3	10 (0)	10
11/1/2009	3	10 (0)	10	3	10 (0)	10	3	10 (0)	10
11/8/2009	3	10 (0)	10	3	10 (0)	10	3	9.3 (1.15)	8 - 10
11/15/2009	3	10 (0)	10	3	8.7 (2.31)	6 - 10	3	10 (0)	10
11/22/2009	3	8.3 (2.89)	5 - 10	3	8.3 (2.89)	5 - 10	3	9 (1.73)	7 - 10
11/29/2009	3	9.7 (0.58)	9 - 10	3	9.3 (1.15)	8 - 10	3	10 (0)	10
12/6/2009	3	9.3 (1.15)	8 - 10	3	10 (0)	10	3	10 (0)	10
12/13/2009	3	11 (3.61)	8 - 15	3	10 (0)	10	3	10 (0)	10
12/20/2009	3	10 (0)	10	2	9.5 (0.71)	9 - 10	2	10 (0)	10
12/27/2009	3	9.7 (0.58)	9 - 10	3	8.7 (2.31)	6 - 10	3	8.3 (2.89)	5 - 10
1/3/2010	3	10 (0)	10	3	10 (0)	10	3	10 (0)	10
1/10/2010	3	10 (0)	10	3	10 (0)	10	3	10 (0)	10
1/17/2010	1	10 (0)	10	2	6.5 (4.95)	3 - 10	0	-	-
1/24/2010	3	10 (0)	10	3	9.3 (1.15)	8 - 10	2	9.5 (0.71)	9 - 10
1/31/2010	3	10 (0)	10	3	10 (0)	10	3	10 (0)	10
2/7/2010	3	10 (0)	10	3	10 (0)	10	3	9.7 (0.58)	9 - 10
2/14/2010	3	10 (0)	10	3	10 (0)	10	3	8 (1.73)	7 - 10
2/21/2010	3	10 (0)	10	3	10 (0)	10	3	10 (0)	10
2/28/2010	3	10 (0)	10	3	10 (0)	10	3	10 (0)	10
3/7/2010	3	10 (0)	10	3	10 (0)	10	3	10 (0)	10
3/14/2010	3	10 (0)	10	3	8.7 (2.31)	6 - 10	3	10 (0)	10
3/21/2010	3	10 (0)	10	3	9 (1.73)	7 - 10	3	10 (0)	10
3/28/2010	3	10 (0)	10	4	10.3 (0.50)	10 - 11	3	10 (0)	10
4/4/2010	3	10 (0)	10	5	10.4 (0.89)	10 - 12	3	9.3 (1.15)	8 - 10
4/11/2010	3	9.3 (0.58)	9 - 10	5	9.6 (0.89)	8 - 10	3	10 (0)	10
4/18/2010	3	10 (0)	10	5	10 (0)	10	3	8.7 (2.31)	6 - 10
4/25/2010	3	10 (0)	10	4	10.25 (0.5)	10 - 11	3	10 (0)	10
5/2/2010	3	10 (0)	10	5	10 (0)	10	2	10 (0)	10
5/9/2010	3	9.7 (0.58)	9 - 10	5	10 (0)	10	2	10 (0)	10
5/16/2010	3	10 (0)	10	5	10.2 (0.45)	10 - 11	2	10 (0)	10
5/23/2010	3	8.7 (2.31)	6 - 10	5	10 (0)	10	2	10 (0)	10
5/30/2010	3	10 (0)	10	4	11.25 (2.50)	10 - 15	2	10 (0)	10
6/6/2010	3	10 (0)	10	3	10 (0)	10	2	8.5 (2.12)	7 - 10
6/13/2010	3	8.3 (2.89)	5 - 10	3	10.7 (0.58)	10 - 11	2	10 (0)	10
6/20/2010	3	10 (0)	10	2	10 (0)	10	2	10 (0)	10
6/27/2010	3	8.7 (2.31)	6 - 10	3	9.3 (1.15)	8 - 10	2	10 (0)	10
7/4/2010	3	10 (0)	10	3	10 (0)	10	3	10 (0)	10
7/11/2010	2	10 (0)	10	2	10 (0)	10	2	10 (0)	10
7/18/2010	3	9.3 (1.15)	8 - 10	3	10 (0)	10	3	10 (0)	10

Table A3. Number of sample days and average number, standard deviation, and range of trawls per sample day for trawl sites within sample weeks during the 2011 field season.

Sample Week	Chipps Island (SB018M,N,S) Sample Days	Chipps Island Average Trawl per Sample Day (SD)	Chipps Island Range	Mossdale (SJ054M) Sample Days	Mossdale Average Trawl per Sample Day (SD)	Mossdale Range	Sacramento (SR055M) Sample Days	Sacramento Average Trawl per Sample Day (SD)	Sacramento Range
8/1/2010	3	10 (0)	10	3	10 (0)	10	3	10 (0)	10
8/8/2010	3	8.7 (2.3)	6-10	3	10 (0)	10	3	9.7 (0.6)	9-10
8/15/2010	3	8.3 (2.9)	5-10	3	10 (0)	10	3	10 (0)	10
8/22/2010	3	9.7 (0.6)	9-10	3	10 (0)	10	3	10 (0)	10
8/29/2010	3	8.7 (2.3)	6-10	3	9.3 (1.2)	8-10	3	8.7 (2.3)	6-10
9/5/2010	3	10 (0)	10	3	10 (0)	10	3	10 (0)	10
9/12/2010	3	10 (0)	10	3	10 (0)	10	3	10 (0)	10
9/19/2010	3	9 (1.7)	7-10	3	10 (0)	10	3	10 (0)	10
9/26/2010	3	10 (0)	10	3	10 (0)	10	3	9 (1)	8-10
10/3/2010	3	8.3 (2.9)	5-10	3	8.7 (1.5)	7-10	3	9 (1.7)	7-10
10/10/2010	3	10 (0)	10	3	10 (0)	10	3	8 (3.5)	4-10
10/17/2010	3	10 (0)	10	3	10 (0)	10	3	10 (0)	10
10/24/2010	3	10 (0)	10	3	10 (0)	10	3	10 (0)	10
10/31/2010	3	9.3 (1.2)	8-10	3	10 (0)	10	3	10 (0)	10
11/7/2010	3	10 (0)	10	3	10 (0)	10	3	10 (0)	10
11/14/2010	3	10 (0)	10	3	10 (0)	10	3	10 (0)	10
11/21/2010	3	8.3 (2.9)	5-10	3	8.3 (2.9)	5-10	3	8 (3.5)	4-10
11/28/2010	3	9 (1)	8-10	3	9.3 (1.2)	8-10	3	10 (0)	10
12/5/2010	3	9 (1.7)	7-10	3	10 (0)	10	3	8.3 (2.9)	5-10
12/12/2010	3	10 (0)	10	3	10 (0)	10	3	9.7 (0.6)	9-10
12/19/2010	3	8.3 (2.9)	5-10	2	9 (1.4)	8-10	2	5.5 (3.5)	3-8
12/26/2010	2	10 (0)	10	2	10 (0)	10	2	6 (1.4)	5-7
1/2/2011	3	9.3 (1.2)	8-10	3	9.3 (1.2)	8-10	3	10 (0)	10
1/9/2011	3	10 (0)	10	3	10 (0)	10	3	10 (0)	10
1/16/2011	3	10 (0)	10	3	9.3 (1.2)	8-10	3	10 (0)	10
1/23/2011	3	8 (1.7)	7-10	2	8 (2.8)	6-10	2	7.5 (3.5)	5-10
1/30/2011	3	10 (0)	10	3	9.7 (0.6)	9-10	3	8.7 (1.5)	7-10
2/6/2011	3	10 (0)	10	3	10 (0)	10	3	10 (0)	10
2/13/2011	3	10 (0)	10	3	10 (0)	10	3	10 (0)	10
2/20/2011	3	10 (0)	10	3	10 (0)	10	3	9 (1.7)	7-10
2/27/2011	3	10 (0)	10	3	10 (0)	10	3	10 (0)	10
3/6/2011	3	10 (0)	10	3	10 (0)	10	3	9.3 (1.2)	8-10
3/13/2011	3	10 (0)	10	3	9.7 (0.6)	9-10	3	9 (1.7)	7-10
3/20/2011	3	10 (0)	10	2	10 (0)	10	2	9.5 (0.7)	9-10
3/27/2011	3	10 (0)	10	3	10 (0)	10	3	10 (0)	10
4/3/2011	3	10 (0)	10	5	10 (0)	10	3	7.7 (4.0)	3-10
4/10/2011	3	10 (0)	10	5	10 (0)	10	3	10 (0)	10
4/17/2011	3	10 (0)	10	5	10 (0)	10	3	8.7 (2.3)	6-10
4/24/2011	3	10 (0)	10	5	10 (0)	10	3	10 (0)	10
5/1/2011	3	10 (0)	10	5	9.2 (1.8)	6-10	2	10 (0)	10
5/8/2011	3	10 (0)	10	6	13.3 (2.6)	10-15	2	10 (0)	10
5/15/2011	3	10 (0)	10	7	13.9 (3)	7-15	2	9.5 (0.7)	9-10
5/22/2011	3	7.7 (2.1)	6-10	6	13.3 (2.6)	10-15	2	10 (0)	10
5/29/2011	3	10 (0)	10	5	10.2 (0.4)	10-11	2	10 (0)	10
6/5/2011	3	10 (0)	10	5	9.8 (1.8)	7-12	2	10 (0)	10
6/12/2011	3	10 (0)	10	5	10 (0)	10	2	10 (0)	10
6/19/2011	3	10 (0)	10	3	10 (0)	10	2	10 (0)	10
6/26/2011	3	8.7 (2.3)	6-10	2	10 (0)	10	2	10 (0)	10
7/3/2011	3	10 (0)	10	3	10 (0)	10	3	10 (0)	10
7/10/2011	3	10 (0)	10	3	10 (0)	10	3	10 (0)	10
7/17/2011	3	10 (0)	10	3	10 (0)	10	3	10 (0)	10
7/24/2011	3	7 (5.2)	1-10	3	10 (0)	10	3	10 (0)	10

Table A4. Sample weeks that fish samples were collected at least once at seine sites in the Lower Sacramento River Region during the 2010 field season.

Sample	Station Code						
Week	SR144W	SR138E	SR130E	SR094E	SR090W	SR080E	SR071E
8/2/2009	X	X			X	X	X
8/9/2009	X	X		X	X	X	X
8/16/2009	X	X			X	X	X
8/23/2009		X		X	X	X	X
8/30/2009	X	X			X	X	X
9/6/2009	X	X			X	X	X
9/13/2009	X	X		X	X	X	
9/20/2009	X	X			X	X	X
9/27/2009	X	X		X	X	X	X
10/4/2009		X			X	X	X
10/11/2009	X	X	X		X	X	X
10/18/2009	X	X	X	X	X	X	X
10/25/2009	X	X			X	X	X
11/1/2009	X	X	X		X	X	X
11/8/2009	X	X			X	X	X
11/15/2009	X				X	X	X
11/22/2009	X				X	X	X
11/29/2009	X				X	X	X
12/6/2009					X	X	X
12/13/2009	X			X	X	X	X
12/20/2009	X			X	X	X	X
12/27/2009	X		X		X	X	X
1/3/2010	X		X		X	X	X
1/10/2010	X	X		X	X	X	X
1/17/2010	X				X	X	
1/24/2010	X	X			X	X	X
1/31/2010		X			X	X	X
2/7/2010	X	X			X	X	X
2/14/2010	X	X		X	X	X	X
2/21/2010	X	X		X	X	X	X
2/28/2010	X	X			X	X	X
3/7/2010	X	X			X	X	X
3/14/2010	X	X			X	X	X
3/21/2010	X	X		X	X	X	X
3/28/2010	X	X			X	X	X
4/4/2010	X	X	X	X	X	X	X
4/11/2010	X	X			X	X	X
4/18/2010	X	X			X	X	X
4/25/2010	X	X			X	X	X
5/2/2010	X	X			X		X
5/9/2010	X	X			X		X
5/16/2010	X				X		X
5/23/2010	X	X			X	X	
5/30/2010	X	X			X	X	X
6/6/2010	X	X			X	X	X
6/13/2010	X	X			X	X	X
6/20/2010	X	X			X		X
6/27/2010	X	X			X		X
7/4/2010							
7/11/2010							
7/18/2010	X	X	X		X	X	X
7/25/2010	X	X	X	X	X	X	X

Table A5. Sample weeks that fish samples were collected at least once at seine sites in the Lower Sacramento River Region during the 2011 field season.

Sample Week	Station Code SR144W	SR138E	SR130E	SR094E	SR090W	SR080E	SR071E
8/1/2010	X	X	X	X	X	X	X
8/8/2010	X	X			X	X	X
8/15/2010	X	X	X	X	X	X	X
8/22/2010		X		X	X	X	X
8/29/2010	X	X	X	X	X	X	X
9/5/2010		X	X		X	X	X
9/12/2010	X	X	X	X	X	X	X
9/19/2010	X	X	X		X	X	X
9/26/2010	X	X	X		X	X	X
10/3/2010		X	X		X	X	X
10/10/2010	X	X	X		X	X	X
10/17/2010			X		X	X	X
10/24/2010	X	X	X		X	X	X
10/31/2010	X	X	X		X	X	X
11/7/2010	X	X	X	X	X	X	X
11/14/2010	X	X	X	X	X	X	X
11/21/2010	X	X	X	X	X	X	X
11/28/2010	X		X	X	X	X	X
12/5/2010	X	X			X	X	X
12/12/2010	X	X			X	X	X
12/19/2010	X	X			X	X	X
12/26/2010	X	X			X	X	X
1/2/2011	X	X			X	X	X
1/9/2011	X	X		X	X	X	X
1/16/2011	X	X			X	X	X
1/23/2011	X	X		X	X	X	X
1/30/2011	X	X			X	X	X
2/6/2011	X	X			X	X	X
2/13/2011	X	X			X	X	X
2/20/2011	X	X	X	X	X	X	X
2/27/2011	X	X	X	X	X	X	X
3/6/2011	X	X		X	X	X	X
3/13/2011	X	X	X		X	X	X
3/20/2011	X			X	X	X	X
3/27/2011	X	X			X	X	X
4/3/2011	X	X			X	X	
4/10/2011	X	X			X		
4/17/2011	X	X		X	X	X	
4/24/2011	X	X	X		X	X	X
5/1/2011	X	X	X	X	X	X	X
5/8/2011	X	X	X	X	X	X	X
5/15/2011	X	X			X		X
5/22/2011	X	X	X		X	X	X
5/29/2011	X	X	X		X	X	X
6/5/2011	X	X			X	X	X
6/12/2011	X	X	X	X	X	X	X
6/19/2011	X	X	X		X	X	X
6/26/2011	X	X			X		
7/3/2011	X	X	X	X	X	X	X
7/10/2011	X	X			X	X	X
7/17/2011	X	X		X	X	X	X
7/24/2011	X	X		X	X	X	X

Table A6. Sample weeks that fish samples were collected at least once at seine sites in the North Delta Region during the 2010 field season.

Sample Week	Station Code									
	SR060E	AM001S	SR049E	SR043W	SS011N	SR024E	SR017E	SR014W	SR012W	MS001N
8/2/2009	X	X	X	X		X	X	X		X
8/9/2009	X	X	X	X	X	X	X	X	X	
8/16/2009	X	X	X	X	X	X	X	X	X	X
8/23/2009	X	X	X	X	X	X	X	X	X	X
8/30/2009	X	X	X	X			X	X	X	
9/6/2009	X	X	X	X	X	X	X	X	X	X
9/13/2009	X	X	X	X			X	X	X	
9/20/2009	X	X	X		X	X	X	X	X	X
9/27/2009	X	X	X	X	X	X	X	X	X	X
10/4/2009	X	X	X	X	X	X	X	X	X	X
10/11/2009	X	X	X	X	X	X	X	X	X	X
10/18/2009	X	X	X	X	X	X	X	X	X	X
10/25/2009	X	X	X	X	X	X	X	X	X	
11/1/2009	X	X	X	X	X	X	X	X	X	
11/8/2009	X	X	X	X		X	X	X	X	X
11/15/2009	X	X	X	X	X	X	X	X	X	
11/22/2009	X	X	X	X	X	X	X	X	X	
11/29/2009	X	X	X	X	X	X	X	X	X	
12/6/2009	X	X	X	X	X	X	X	X	X	X
12/13/2009	X	X	X	X	X	X	X	X	X	X
12/20/2009	X	X	X	X	X	X	X	X	X	X
12/27/2009	X	X	X	X	X	X	X	X	X	X
1/3/2010	X	X	X	X	X	X	X	X	X	X
1/10/2010	X	X	X	X	X	X	X	X	X	X
1/17/2010	X	X	X	X	X	X	X		X	X
1/24/2010	X	X	X	X	X	X	X	X	X	X
1/31/2010	X	X	X	X	X	X	X	X	X	X
2/7/2010	X	X	X	X	X	X	X	X	X	
2/14/2010	X	X	X	X	X	X	X	X	X	X
2/21/2010	X	X	X	X	X	X	X	X	X	
2/28/2010	X	X	X	X	X	X	X	X	X	X
3/7/2010	X	X	X	X	X	X	X			X
3/14/2010	X	X	X	X	X			X	X	
3/21/2010	X	X	X	X	X	X	X	X	X	X
3/28/2010	X	X	X	X	X	X	X	X	X	X
4/4/2010	X	X	X	X	X	X	X	X	X	X
4/11/2010	X	X	X	X	X	X	X	X	X	X
4/18/2010	X	X	X	X		X	X	X		X
4/25/2010	X	X	X	X		X	X	X	X	X
5/2/2010	X	X	X	X		X	X	X	X	X
5/9/2010	X			X	X	X	X		X	X
5/16/2010	X	X	X	X	X	X	X	X	X	X
5/23/2010	X	X	X	X	X		X		X	X
5/30/2010	X		X	X	X			X	X	X
6/6/2010	X	X	X	X		X	X	X	X	X
6/13/2010	X	X	X	X	X	X	X		X	
6/20/2010	X	X	X	X	X	X	X	X		X
6/27/2010	X	X	X	X		X	X		X	
7/4/2010										
7/11/2010								X	X	X
7/18/2010	X		X		X	X	X	X	X	X
7/25/2010	X	X	X	X	X	X	X	X		X

Table A7. Sample weeks that fish samples were collected at least once at seine sites in the North Delta Region during the 2011 field season.

Sample Week	Station Code SR060E	AM001S	SR049E	SR043W	SS011N	SR024E	SR017E	SR014W	SR012W	MS001N
8/1/2010	X	X	X	X	X	X	X	X	X	X
8/8/2010	X	X	X	X	X	X	X	X	X	X
8/15/2010	X	X	X	X	X	X	X	X	X	X
8/22/2010	X	X	X	X	X	X	X	X	X	X
8/29/2010	X	X	X	X	X	X	X	X	X	X
9/5/2010	X	X	X	X	X	X	X	X	X	
9/12/2010	X	X	X	X	X	X	X	X	X	X
9/19/2010	X	X	X	X	X	X	X	X	X	X
9/26/2010	X	X	X	X	X	X	X	X	X	X
10/3/2010	X	X	X	X	X	X	X	X	X	X
10/10/2010	X	X	X					X	X	X
10/17/2010	X	X	X	X	X	X	X	X	X	X
10/24/2010	X	X	X					X	X	X
10/31/2010	X	X	X	X	X	X	X	X	X	X
11/7/2010	X	X	X	X	X	X	X	X	X	X
11/14/2010	X	X	X	X	X	X	X	X	X	X
11/21/2010	X	X	X	X	X	X	X	X	X	X
11/28/2010	X	X	X	X	X	X	X	X	X	X
12/5/2010	X	X	X	X	X	X	X	X	X	X
12/12/2010	X	X	X	X	X	X	X	X	X	X
12/19/2010	X	X	X		X	X	X		X	X
12/26/2010			X	X	X	X	X	X	X	X
1/2/2011	X	X	X	X	X	X	X	X	X	X
1/9/2011	X		X	X	X	X	X		X	X
1/16/2011	X	X	X	X	X	X	X	X	X	X
1/23/2011	X	X	X	X	X	X	X		X	X
1/30/2011	X	X	X	X		X	X	X	X	X
2/6/2011	X	X	X					X	X	X
2/13/2011	X	X	X		X	X	X	X	X	X
2/20/2011	X	X	X	X		X	X		X	X
2/27/2011	X	X	X	X	X	X	X	X	X	X
3/6/2011	X	X	X	X	X	X	X	X	X	X
3/13/2011		X	X	X	X	X	X	X	X	X
3/20/2011	X	X	X	X	X	X	X		X	X
3/27/2011	X	X	X	X			X	X	X	X
4/3/2011	X	X	X	X		X	X	X	X	X
4/10/2011		X	X			X	X	X	X	X
4/17/2011	X	X	X	X		X	X		X	X
4/24/2011	X	X	X	X	X	X	X	X		X
5/1/2011	X		X		X	X	X	X	X	X
5/8/2011	X	X	X	X		X	X	X	X	X
5/15/2011	X	X	X	X		X	X	X		X
5/22/2011	X	X	X			X	X	X	X	X
5/29/2011	X	X	X	X	X	X	X	X	X	
6/5/2011	X	X	X	X	X	X	X	X	X	X
6/12/2011	X	X	X	X		X	X	X	X	X
6/19/2011	X	X	X	X	X	X	X	X		X
6/26/2011	X	X	X	X	X	X	X	X	X	
7/3/2011	X	X	X	X		X	X	X		X
7/10/2011	X	X	X	X		X		X	X	
7/17/2011	X	X		X			X	X	X	X
7/24/2011	X	X	X	X	X	X	X	X	X	X

Table A8. The number of juvenile fish samples collected (i.e., number of days samples were collected) at seine sites by sample week in the Sacramento Area Beach Seine Region during the 2010 field season.

Sample Week	Station Code							
	SR080E	SR071E	SR062E	SR060E	AM001S	SR057E	SR055E	SR049E
9/27/2009	1	1		2	2	1		2
10/4/2009	3	3	3	3	1	3	3	3
10/11/2009	2	2	2	1	1	1	1	1
10/18/2009	3	3	3	3	1	3	3	3
10/25/2009	3	3	3	3	1	3	3	3
11/1/2009	3	3	2	3	1	3	2	3
11/8/2009	3	3	3	3	1	3	2	3
11/15/2009	3	3	3	3	1	3	3	3
11/22/2009	3	3	3	3	1	3	3	3
11/29/2009	3	3	3	3	1	3	3	2
12/6/2009	3	3	3	3	1	3	3	3
12/13/2009	3	3	3	3	1	3	3	3
12/20/2009	2	2	2	2	1	2	2	2
12/27/2009	2	2	2	2	1	2	2	2
1/3/2010	3	3	3	3	1	3	3	3
1/10/2010	1	1	1	1	1	1	1	1
1/17/2010	1		1	1	1			1
1/24/2010	1	1	1	1	1			1

Table A9. The number of juvenile fish samples collected (i.e., number of days samples were collected) at seine sites by sample week in the Sacramento Area Beach Seine Region during the 2011 field season.

Sample Week	Station Code							
	SR080E	SR071E	SR062E	SR060E	AM001S	SR057E	SR055E	SR049E
9/26/2010	1	2	1	2	2	1	1	1
10/3/2010	3	3	2	3	1	3	3	3
10/10/2010	3	3	3	3	1	3	3	2
10/17/2010	3	3	2	3	1	3	3	3
10/24/2010	3	3	3	3	1	3	3	3
10/31/2010	3	3	2	3	1	3	3	2
11/7/2010	3	3	2	2	1	3	3	3
11/14/2010	3	3	3	3	1	3	3	3
11/21/2010	3	3	2	3	1	3	3	3
11/28/2010	3	3	3	3	1	3	3	3
12/5/2010	3	3	3	3	1	3	3	3
12/12/2010	3	3	2	3	1	3	2	3
12/19/2010	1	1		1	1	1		1
12/26/2010	3	2				1		3
1/2/2011	3	2	1	2	1	2		3
1/9/2011	1	1	1	1		1		1
1/16/2011	1	1	1	1	1	1	1	1
1/23/2011	1	1	1	1	1	1	1	1

Table A10. Sample weeks that fish samples were collected at least once at seine sites in the Central Delta Region during the 2010 field season.

Sample Week	Station Code								
	SJ005N	SJ001S	XC001N	GS010E	MK004W	SF014E	TM001N	DS002S	LP003E
8/2/2009	X	X		X	X	X		X	X
8/9/2009	X	X	X	X	X	X	X	X	X
8/16/2009	X	X		X	X	X		X	X
8/23/2009	X	X		X	X	X		X	X
8/30/2009	X	X			X	X	X	X	X
9/6/2009	X	X		X	X	X			X
9/13/2009	X	X		X	X	X			X
9/20/2009	X	X		X	X	X	X	X	X
9/27/2009	X	X		X	X	X	X	X	X
10/4/2009	X	X		X	X	X	X	X	X
10/11/2009	X		X	X	X	X		X	X
10/18/2009	X			X	X	X	X	X	
10/25/2009	X			X		X	X	X	X
11/1/2009	X			X	X	X	X	X	X
11/8/2009	X	X		X	X	X	X		X
11/15/2009	X		X	X	X	X	X	X	X
11/22/2009	X	X	X	X	X	X	X	X	X
11/29/2009	X			X	X	X		X	X
12/6/2009	X	X	X	X	X	X	X	X	X
12/13/2009	X			X	X	X	X	X	X
12/20/2009	X			X	X	X		X	X
12/27/2009				X	X	X	X	X	X
1/3/2010	X	X	X	X	X	X	X	X	X
1/10/2010	X			X	X	X		X	X
1/17/2010	X	X		X	X	X	X	X	X
1/24/2010	X			X	X	X		X	X
1/31/2010	X	X		X	X	X		X	X
2/7/2010	X		X	X	X	X		X	X
2/14/2010	X	X	X	X	X	X	X	X	X
2/21/2010	X	X		X	X	X		X	X
2/28/2010	X	X		X		X		X	X
3/7/2010	X			X	X	X	X	X	X
3/14/2010		X	X		X	X		X	X
3/21/2010	X			X	X	X		X	X
3/28/2010	X	X		X	X	X	X	X	X
4/4/2010	X	X		X	X	X		X	X
4/11/2010	X	X		X	X	X	X	X	X
4/18/2010	X	X		X	X	X		X	X
4/25/2010	X	X		X	X	X	X	X	X
5/2/2010	X			X	X	X		X	X
5/9/2010	X	X			X	X	X	X	X
5/16/2010		X		X	X	X		X	
5/23/2010	X	X		X	X	X		X	X
5/30/2010	X	X		X	X	X	X	X	X
6/6/2010	X	X		X	X	X	X	X	X
6/13/2010	X	X		X	X	X		X	X
6/20/2010	X	X		X	X	X	X	X	X
6/27/2010	X	X		X	X	X	X	X	X
7/4/2010									
7/11/2010	X	X			X		X	X	X
7/18/2010	X	X	X	X	X	X	X	X	X
7/25/2010	X	X		X	X	X	X	X	

Table A11. Sample weeks that fish samples were collected at least once at seine sites in the Central Delta Region during the 2011 field season.

Sample Week	Station Code								
	SJ005N	SJ001S	XC001N	GS010E	MK004W	SF014E	TM001N	DS002S	LP003E
8/1/2010	X	X	X	X	X	X		X	X
8/8/2010	X	X		X	X	X	X	X	X
8/15/2010	X	X	X	X	X	X		X	X
8/22/2010	X	X	X	X		X		X	
8/29/2010	X	X	X	X	X	X		X	X
9/5/2010	X	X		X	X	X		X	X
9/12/2010	X	X	X	X	X	X	X	X	X
9/19/2010	X	X	X	X	X	X		X	X
9/26/2010	X	X		X	X	X		X	X
10/3/2010	X	X	X	X	X	X	X	X	X
10/10/2010	X	X			X		X	X	X
10/17/2010	X	X	X	X	X	X	X	X	X
10/24/2010	X	X			X			X	X
10/31/2010	X	X	X	X	X	X	X	X	X
11/7/2010	X	X		X	X	X	X	X	X
11/14/2010	X	X	X	X	X	X	X	X	X
11/21/2010	X			X	X	X		X	X
11/28/2010	X	X	X	X	X	X		X	X
12/5/2010	X	X			X	X		X	X
12/12/2010	X	X		X	X	X		X	X
12/19/2010	X			X	X	X		X	X
12/26/2010	X	X			X	X	X	X	X
1/2/2011	X	X			X	X		X	X
1/9/2011	X	X		X	X	X		X	X
1/16/2011	X	X		X	X	X	X	X	X
1/23/2011	X	X		X	X	X		X	X
1/30/2011	X			X	X	X	X	X	X
2/6/2011	X				X	X		X	X
2/13/2011	X			X	X	X		X	X
2/20/2011	X	X		X	X	X		X	X
2/27/2011	X	X	X	X	X	X	X	X	X
3/6/2011	X	X		X	X	X	X	X	X
3/13/2011	X	X			X	X	X	X	X
3/20/2011	X	X		X	X	X		X	X
3/27/2011	X	X			X	X	X	X	X
4/3/2011	X			X	X	X		X	
4/10/2011	X	X		X	X	X	X	X	X
4/17/2011	X	X		X	X	X		X	X
4/24/2011	X			X	X	X	X	X	X
5/1/2011	X	X		X	X	X	X	X	X
5/8/2011	X			X	X	X	X	X	X
5/15/2011	X	X		X		X	X	X	X
5/22/2011	X	X		X	X	X		X	X
5/29/2011	X	X		X	X	X		X	X
6/5/2011	X	X		X	X	X		X	X
6/12/2011	X	X		X	X	X	X	X	X
6/19/2011	X	X		X		X		X	X
6/26/2011	X	X		X	X	X	X	X	X
7/3/2011		X		X	X		X	X	
7/10/2011	X	X			X	X	X	X	X
7/17/2011	X	X			X	X	X	X	X
7/24/2011	X	X			X	X	X	X	X

Table A12. Sample weeks that fish samples were collected at least once at seine sites in the South Delta Region during the 2010 field season.

Sample	Station Code									
Week	SJ051E	SJ041N	SJ032S	SJ026S	OR023E	OR019E	OR014W	OR003W	WD002W	MR010W
8/2/2009		X	X	X	X	X		X	X	X
8/9/2009		X	X	X			X	X		X
8/16/2009			X				X			X
8/23/2009	X	X	X	X			X	X	X	X
8/30/2009			X	X				X	X	X
9/6/2009		X	X	X						X
9/13/2009		X		X			X	X	X	
9/20/2009		X	X	X			X	X	X	X
9/27/2009		X	X	X		X	X	X		X
10/4/2009	X	X	X	X						X
10/11/2009										
10/18/2009	X		X				X			X
10/25/2009										
11/1/2009	X	X	X	X			X	X		X
11/8/2009		X	X	X						X
11/15/2009	X	X	X	X		X	X	X	X	X
11/22/2009		X	X	X			X			X
11/29/2009	X	X	X	X			X	X		X
12/6/2009		X	X				X			
12/13/2009	X	X	X				X			X
12/20/2009		X	X							
12/27/2009	X	X	X							X
1/3/2010	X	X	X							X
1/10/2010	X	X	X	X			X	X		X
1/17/2010	X									
1/24/2010	X	X	X	X						
1/31/2010	X	X	X				X	X		X
2/7/2010	X	X	X	X			X	X		X
2/14/2010	X	X	X	X						
2/21/2010	X	X	X	X			X	X	X	X
2/28/2010	X									X
3/7/2010	X	X	X	X			X	X		X
3/14/2010	X	X	X	X	X	X	X	X	X	X
3/21/2010	X	X	X				X			
3/28/2010	X	X	X							X
4/4/2010	X	X	X							
4/11/2010	X	X	X	X			X	X		X
4/18/2010	X	X	X	X			X			
4/25/2010	X						X			
5/2/2010	X	X	X				X			X
5/9/2010	X	X	X					X		X
5/16/2010	X	X	X							X
5/23/2010	X	X	X				X	X		X
5/30/2010	X	X	X					X		X
6/6/2010	X	X	X	X			X	X		X
6/13/2010	X		X							X
6/20/2010	X	X	X	X			X	X	X	X
6/27/2010	X		X					X		X
7/4/2010	X	X	X	X			X	X		X
7/11/2010										
7/18/2010	X	X	X	X			X	X	X	X
7/25/2010			X				X			X

Table A13. Sample weeks that fish samples were collected at least once at seine sites in the South Delta Region during the 2011 field season.

Sample Week	Station Code SJ051E	SJ041N	SJ032S	SJ026S	OR023E	OR019E	OR014W	OR003W	WD002W	MR010W
8/1/2010	X	X	X	X		X	X	X	X	X
8/8/2010							X			X
8/15/2010	X	X	X	X	X	X	X	X	X	
8/22/2010		X	X	X		X	X	X	X	X
8/29/2010		X	X	X			X	X		X
9/5/2010							X			X
9/12/2010	X	X	X	X			X	X	X	X
9/19/2010		X		X			X	X		X
9/26/2010	X	X	X	X			X	X		X
10/3/2010		X	X	X		X	X	X	X	X
10/10/2010	X	X	X	X		X	X	X	X	
10/17/2010		X	X	X		X	X	X		X
10/24/2010		X	X	X			X	X		X
10/31/2010		X	X	X		X	X	X	X	
11/7/2010	X		X				X			X
11/14/2010		X	X	X				X		X
11/21/2010	X	X	X							
11/28/2010		X	X	X			X	X		X
12/5/2010	X	X		X			X	X		X
12/12/2010		X	X	X						
12/19/2010		X	X	X			X	X		
12/26/2010		X								
1/2/2011	X	X	X	X			X			X
1/9/2011	X	X	X				X			
1/16/2011	X	X	X	X			X	X	X	X
1/23/2011	X		X							
1/30/2011	X	X								
2/6/2011	X	X	X							
2/13/2011	X	X	X	X						
2/20/2011	X									
2/27/2011	X	X	X	X	X	X	X	X	X	X
3/6/2011	X						X			X
3/13/2011	X	X	X	X			X	X		X
3/20/2011										
3/27/2011			X	X			X	X	X	X
4/3/2011	X									
4/10/2011	X	X	X	X		X	X	X		X
4/17/2011	X		X	X			X	X		X
4/24/2011	X	X								
5/1/2011	X	X	X	X			X	X		X
5/8/2011	X	X	X	X		X	X	X		X
5/15/2011	X		X	X			X	X		X
5/22/2011	X	X	X	X						
5/29/2011	X		X	X			X	X		X
6/5/2011	X	X	X	X			X	X		X
6/12/2011	X									X
6/19/2011		X	X	X			X	X		
6/26/2011			X				X	X	X	X
7/3/2011	X	X	X	X			X	X		X
7/10/2011		X	X	X			X	X	X	X
7/17/2011	X	X	X	X			X	X		X
7/24/2011		X	X	X		X		X	X	

Table A14. Sample weeks that fish samples were collected at least once at seine sites in the Lower San Joaquin River Region during the 2010 field season.

Sample	Station Code									
Week	SJ083W	SJ079E	SJ077E	SJ076W	SJ074W	SJ074A	SJ068W	SJ063W	SJ058W	SJ056E
8/2/2009										
8/9/2009		X								
8/16/2009										
8/23/2009				X		X			X	X
8/30/2009										
9/6/2009		X		X		X			X	X
9/13/2009										
9/20/2009		X							X	X
9/27/2009										
10/4/2009				X		X			X	X
10/11/2009										
10/18/2009										X
10/25/2009										
11/1/2009									X	X
11/8/2009										
11/15/2009		X							X	X
11/22/2009										
11/29/2009		X		X		X				X
12/6/2009										
12/13/2009				X		X			X	X
12/20/2009										
12/27/2009		X								X
1/3/2010		X				X				X
1/10/2010		X				X			X	X
1/17/2010									X	X
1/24/2010									X	X
1/31/2010						X			X	X
2/7/2010							X		X	X
2/14/2010									X	X
2/21/2010									X	X
2/28/2010									X	X
3/7/2010							X	X	X	X
3/14/2010			X		X		X	X	X	X
3/21/2010									X	X
3/28/2010									X	X
4/4/2010									X	X
4/11/2010									X	X
4/18/2010					X		X		X	X
4/25/2010									X	X
5/2/2010					X			X	X	X
5/9/2010									X	X
5/16/2010									X	X
5/23/2010	X				X			X	X	X
5/30/2010					X			X	X	X
6/6/2010					X				X	X
6/13/2010					X				X	X
6/20/2010					X				X	X
6/27/2010	X				X				X	X
7/4/2010	X		X		X		X	X	X	X
7/11/2010										
7/18/2010		X		X					X	X
7/25/2010										

Table A15. Sample weeks that fish samples were collected at least once at seine sites in the Lower San Joaquin River Region during the 2011 field season.

Sample	Station Code									
Week	SJ083W	SJ079E	SJ077E	SJ076W	SJ074W	SJ074A	SJ068W	SJ063W	SJ058W	SJ056E
8/1/2010				X					X	X
8/8/2010										
8/15/2010		X				X			X	X
8/22/2010										
8/29/2010										
9/5/2010										
9/12/2010										X
9/19/2010										
9/26/2010		X		X		X				X
10/3/2010										
10/10/2010										X
10/17/2010										
10/24/2010					X			X	X	X
10/31/2010										
11/7/2010	X						X			X
11/14/2010										
11/21/2010		X		X		X			X	X
11/28/2010										
12/5/2010	X				X			X	X	X
12/12/2010										
12/19/2010										
12/26/2010										
1/2/2011					X				X	X
1/9/2011					X					X
1/16/2011									X	X
1/23/2011									X	X
1/30/2011	X				X				X	X
2/6/2011					X			X	X	X
2/13/2011										X
2/20/2011										X
2/27/2011					X			X	X	X
3/6/2011									X	X
3/13/2011					X			X	X	X
3/20/2011										
3/27/2011										
4/3/2011										X
4/10/2011										X
4/17/2011										X
4/24/2011										X
5/1/2011										X
5/8/2011										X
5/15/2011										X
5/22/2011										X
5/29/2011					X			X	X	X
6/5/2011	X		X		X		X	X	X	X
6/12/2011	X				X			X	X	
6/19/2011	X				X			X	X	
6/26/2011		X			X			X		
7/3/2011	X				X		X	X	X	X
7/10/2011										
7/17/2011	X				X		X	X	X	
7/24/2011										

Table A16. Sample weeks that fish samples were collected at least once at seine sites in the San Francisco/San Pablo Bays Region during the 2010 field season.

Sample	Station Code								
Week	SA009E	SA007E	SA001M	SP003E	SA010W	SA008W	SA004W	SP001W	SP000W
8/2/2009	X	X	X						
8/9/2009					X	X		X	X
8/16/2009	X		X	X					
8/23/2009					X	X		X	X
8/30/2009	X	X							
9/6/2009					X	X		X	X
9/13/2009	X	X	X	X					
9/20/2009					X		X	X	X
9/27/2009					X	X	X	X	X
10/4/2009	X		X	X					
10/11/2009					X	X	X	X	X
10/18/2009	X	X	X	X					
10/25/2009					X	X	X	X	X
11/1/2009	X	X	X	X					
11/8/2009					X	X	X	X	X
11/15/2009	X	X	X	X					
11/22/2009					X	X		X	X
11/29/2009	X	X	X	X					
12/6/2009					X	X		X	X
12/13/2009	X	X	X	X					
12/20/2009					X	X	X	X	X
12/27/2009	X	X		X					
1/3/2010					X	X		X	X
1/10/2010	X	X		X					
1/17/2010					X	X	X	X	X
1/24/2010	X	X	X	X					
1/31/2010					X	X	X	X	X
2/7/2010	X	X	X	X					
2/14/2010					X	X		X	X
2/21/2010	X	X	X	X					
2/28/2010					X	X	X	X	X
3/7/2010	X	X	X	X					
3/14/2010					X		X	X	X
3/21/2010	X	X	X	X					
3/28/2010					X	X	X	X	X
4/4/2010	X	X		X					
4/11/2010					X	X	X	X	X
4/18/2010	X	X		X					
4/25/2010					X	X			
5/2/2010	X	X	X						
5/9/2010					X	X			
5/16/2010	X	X	X	X					
5/23/2010					X	X	X	X	X
5/30/2010	X	X	X	X					
6/6/2010					X	X	X	X	X
6/13/2010	X		X						
6/20/2010					X	X	X	X	X
6/27/2010	X	X	X	X					
7/4/2010					X	X	X	X	X
7/11/2010									
7/18/2010					X	X	X	X	X
7/25/2010	X	X	X						

Table A17. Sample weeks that fish samples were collected at least once at seine sites in the San Francisco/San Pablo Bays Region during the 2011 field season.

Sample Week	Station Code								
	SA009E	SA007E	SA001M	SP003E	SA010W	SA008W	SA004W	SP001W	SP000W
8/1/2010					X	X		X	X
8/8/2010	X	X	X						
8/15/2010					X	X	X	X	X
8/22/2010	X	X	X						
8/29/2010					X	X	X	X	X
9/5/2010	X	X	X	X					
9/12/2010					X	X	X	X	X
9/19/2010	X	X	X	X					
9/26/2010					X	X	X	X	X
10/3/2010	X	X	X	X					
10/10/2010						X	X	X	X
10/17/2010	X	X	X	X					
10/24/2010					X	X	X	X	X
10/31/2010	X	X	X	X					
11/7/2010					X	X	X	X	X
11/14/2010	X	X	X	X					
11/21/2010					X	X	X	X	X
11/28/2010		X	X	X					
12/5/2010					X	X	X	X	X
12/12/2010	X	X	X	X					
12/19/2010							X	X	X
12/26/2010		X	X	X					
1/2/2011	X	X	X	X	X	X	X	X	X
1/9/2011	X	X	X	X	X	X		X	X
1/16/2011	X	X	X	X	X		X	X	X
1/23/2011	X	X	X	X	X	X			
1/30/2011	X	X		X	X	X	X	X	X
2/6/2011	X	X	X	X	X	X		X	X
2/13/2011					X	X	X	X	X
2/20/2011	X	X	X	X					
2/27/2011					X	X	X	X	X
3/6/2011	X	X	X						
3/13/2011					X	X	X	X	X
3/20/2011	X	X	X						
3/27/2011					X	X	X	X	X
4/3/2011	X	X	X						
4/10/2011					X	X	X	X	X
4/17/2011	X	X	X						
4/24/2011					X	X			X
5/1/2011	X	X							
5/8/2011					X	X	X	X	X
5/15/2011	X	X	X						
5/22/2011					X		X		
5/29/2011	X	X	X						
6/5/2011					X	X		X	
6/12/2011	X	X	X						
6/19/2011					X	X		X	X
6/26/2011	X	X	X	X					
7/3/2011					X	X		X	X
7/10/2011	X	X	X	X					
7/17/2011					X	X		X	
7/24/2011	X	X	X						

Table A18. Total of individuals captured grouped by species, trawl site, and seine region during the 2010 field season. Fish species are listed in phylogenetic order. Seine regions represent sites as assigned in Table A1.

Organism	Trawl Sites			Beach Seine Regions						
	Sherwood Hbr.	Chipps Is.	Mossdale	1	2	3	4	5	6	7
river lamprey, *Lampetra ayresii*	1	0	5	0	0	0	0	0	0	0
Pacific lamprey, *Lampetra tridentata*	3	0	361	0	0	0	0	0	0	0
lamprey unknown, *Lampetra* spp.	11	0	0	0	4	0	0	0	0	0
white sturgeon, *Acipenser transmontanus*	0	2	0	0	0	0	0	0	0	0
northern anchovy, *Engraulis mordax*	0	364	0	0	0	0	0	0	113	0
American shad, *Alosa sapidissima*	27	12618	12	0	63	16	19	1	2	1
Pacific herring, *Clupea pallasii*	0	132	0	0	0	0	0	0	1133	0
threadfin shad, *Dorosoma petenense*	161	373	1773	1275	203	255	2059	53	0	3
goldfish, *Carassius auratus*	3	0	30	1	1	0	0	1	0	0
red shiner, *Cyprinella lutrensis*	1	0	7	2121	33	0	544	16017	0	32
common carp, *Cyprinus carpio*	2	0	6	56	0	0	2	2	0	0
hitch, *Lavinia exilicauda*	0	0	0	33	4	12	7	1	0	0
hardhead, *Mylopharodon conocephalus*	0	0	0	64	9	1	0	0	0	0
golden shiner, *Notemigonus crysoleucas*	2	4	10	327	76	90	28	55	0	2
fathead minnow, *Pimephales promelas*	1	0	0	878	37	1	1	22	0	3
Sacramento splittail, *Pogonichthys macrolepidotus*	1	87	4021	1045	477	2124	1469	799	0	0
Sacramento pikeminnow, *Ptychocheilus grandis*	15	1	1	828	378	107	85	9	0	21
Sacramento sucker, *Catostomus occidentalis*	0	0	6	6137	2141	1559	253	142	0	65
white catfish, *Ameiurus catus*	0	3	178	0	2	0	0	1	0	0
black bullhead, *Ameiurus melus*	0	0	1	0	0	0	0	0	0	0
brown bullhead, *Ameiurus nebulosus*	0	0	1	0	0	0	0	0	0	0
channel catfish, *Ictalurus punctatus*	1	0	122	10	0	0	0	0	0	0
wakasagi, *Hypomesus nipponensis*	18	0	0	7	19	1	0	0	0	10
surf smelt, *Hypomesus pretiosus*	0	0	0	0	0	0	0	0	26	0
delta smelt, *Hypomesus transpacificus*	1	294	1	0	91	2	1	0	0	0
longfin smelt, *Spirinchus thaleichthys*	0	584	0	0	0	0	0	0	0	0

Table A18. Continued.

Organism	Trawl Sites: Sherwood Hbr.	Trawl Sites: Chipps Is.	Trawl Sites: Mossdale	Beach Seine Regions: 1	2	3	4	5	6	7
steelhead, *Oncorhynchus mykiss*	40	119	3	10	14	2	0	0	0	0
Unmarked steelhead	7	6	3	1	0	0	0	0	0	0
Marked steelhead	33	113	0	9	14	2	0	0	0	0
Chinook salmon, *Oncorhynchus tshawytscha*	1224	5714	296	1127	2593	369	41	0	1	24
Unmarked winter-run	13	69	0	20	19	2	0	0	0	22
Unmarked fall-run	715	2430	296	997	2320	320	40	0	1	0
Unmarked spring-run	169	757	0	63	188	16	1	0	0	0
Unmarked late fall-run	3	11	0	9	29	4	0	0	0	0
Marked/CWT	324	2447	0	38	37	27	0	0	0	2
plainfin midshipman, *Porichthys notatus*	0	0	0	0	0	0	0	0	1	0
topsmelt, *Atherinops affinis*	0	50	0	0	0	0	0	0	4653	0
jacksmelt, *Atherinopsis californiensis*	0	64	0	0	0	0	0	0	2	0
inland silverside, *Menidia beryllina*	121	4	813	5269	15136	13623	15409	7107	97	1857
rainwater killifish, *Lucania parva*	0	0	0	0	17	39	72	1	29	0
western mosquitofish, *Gambusia affinis*	0	0	4	2127	247	173	148	1690	0	7
threespine stickleback, *Gasterosteus aculeatus*	3	12	0	0	138	32	0	0	48	0
bay pipefish, *Syngathus leptorhynchus*	0	0	0	0	0	0	0	0	233	0
brown rockfish, *Sebastes auriculatus*	0	0	0	0	0	0	0	0	8	0
prickly sculpin, *Cottus asper*	0	0	3	5	28	7	15	0	0	1
Pacific staghorn sculpin, *Leptocottus armatus*	0	1	0	0	21	31	1	0	519	0
tidepool sculpin, *Oligocottus maculosus*	0	0	0	0	0	0	0	0	2	0
cabezon, *Scorpaenichthys marmortatus*	0	0	0	0	0	0	0	0	2	0
striped bass, *Morone saxatilis*	5	896	127	5	15	6	4	24	3	0
green sunfish, *Lepomis cyanellus*	0	0	0	2	1	1	0	0	0	0
warmouth, *Lepomis gulosus*	5	0	0	0	0	1	0	0	0	0
bluegill, *Lepomis macrochirus*	14	3	534	98	58	71	99	290	0	2
redear sunfish, *Lepomis microlophus*	2	0	64	40	24	258	269	17	0	0

Table A18. Continued.

Organism	Trawl Sites: Sherwood Hbr.	Chipps Is.	Mossdale	Beach Seine Regions: 1	2	3	4	5	6	7
smallmouth bass, *Micropterus dolomieu*	0	0	1	5	11	3	0	1	0	0
spotted bass, *Micropterus punctulatus*	0	1	1	13	41	22	2	3	0	1
largemouth bass, *Micropterus salmoides*	2	3	52	144	96	267	387	49	0	1
white crappie, *Pomoxis annularis*	0	1	15	41	4	0	0	0	0	0
black crappie, *Pomoxis nigromaculatus*	2	1	11	139	1	1	2	4	0	0
bigscale logperch, *Percina macrolepida*	0	0	5	722	28	14	12	5	0	1
barred surfperch, *Amphistichus argenteus*	0	0	0	0	0	0	0	0	8	0
shiner perch, *Cymatogaster aggregata*	0	0	0	0	0	0	0	0	64	0
black perch, *Embiotoca jacksoni*	0	0	0	0	0	0	0	0	2	0
walleye surfperch, *Hyperprosopon argenteum*	0	0	0	0	0	0	0	0	57	0
tule perch, *Hysterocarpus traskii*	1	15	1	90	202	197	3	0	0	0
dwarf surfperch, *Micrometrus minimus*	0	0	0	0	0	0	0	0	232	0
pile perch, *Rhacochilus vacca*	0	0	0	0	0	0	0	0	1	0
penpoint gunnel, *Apodichthys flavidus*	0	0	0	0	0	0	0	0	3	0
saddleback gunnel, *Pholis ornata*	0	0	0	0	0	0	0	0	10	0
crevice kelpfish, *Gibbonsia montereyensis*	0	0	0	0	0	0	0	0	27	0
yellowfin goby, *Acanthogobius flavimanus*	0	9	3	1	161	221	23	2	0	0
arrow goby, *Clevelandia ios*	0	0	0	0	0	0	0	0	321	0
longjaw mudsucker, *Gillichthys mirabilis*	0	0	0	0	0	0	0	0	1	0
cheekspot goby, *Hypnus gilberti*	0	0	0	0	0	0	0	0	4	0
bay goby, *Lepidogobius lepidus*	0	0	0	0	0	0	0	0	5	0
Shokihaze goby, *Tridentiger barbatus*	0	5	0	0	0	0	0	0	0	0
Shimofuri goby, *Tridentiger bifasciatus*	0	17	3	0	71	27	7	0	2	0
English sole, *Parophrys vetulus*	0	0	0	0	0	0	0	0	12	0
starry flounder, *Platichthys stellatus*	0	6	0	0	1	0	0	0	11	0
diamond turbot, *Pleuronichthys guttulatus*	0	0	0	0	0	0	0	0	17	0
sand sole, *Psettichthys melanostictus*	0	0	0	0	0	0	0	0	5	0
unidentified fish	0	0	1	0	0	0	0	0	0	0

Table A19. Total of individuals captured grouped by species, trawl site, and seine region during the 2011 field season. Fish species are listed in phylogenetic order. Seine regions represent sites as assigned in Table A1.

Organism	Trawl Sites			Beach Seine Regions						
	Sherwood Hbr.	Chipps Is.	Mossdale	1	2	3	4	5	6	7
river lamprey, *Lampetra ayresii*	1	0	0	0	0	0	0	0	0	0
Pacific lamprey, *Lampetra tridentata*	1	0	5	0	0	0	0	0	0	0
lamprey unknown, *Lampetra* spp.	0	0	0	1	1	0	0	0	0	0
leopard shark, *Triakis semifasciata*	0	0	0	0	0	0	0	0	1	0
thornback, *Platyrhinoidis triseriata*	0	0	0	0	0	0	0	0	1	0
white sturgeon, *Acipenser transmontanus*	0	0	0	0	0	0	0	0	0	0
northern anchovy, *Engraulis mordax*	0	425	0	0	0	0	0	0	21	0
American shad, *Alosa sapidissima*	36	5519	6	1	60	21	0	0	2	0
Pacific herring, *Clupea pallasii*	0	149	0	0	0	0	0	0	727	0
threadfin shad, *Dorosoma petenense*	75	408	1786	1042	447	32	4036	174	1	3
goldfish, *Carassius auratus*	3	0	159	8	0	1	0	21	0	0
red shiner, *Cyprinella lutrensis*	0	0	20	1367	40	6	1075	8599	0	16
common carp, *Cyprinus carpio*	20	0	356	113	146	61	31	441	0	0
hitch, *Lavinia exilicauda*	0	0	6	76	38	232	1	0	0	0
hardhead, *Mylopharodon conocephalus*	0	0	0	203	41	0	0	1	0	0
golden shiner, *Notemigonus crysoleucas*	4	5	20	2606	102	70	63	7	0	8
fathead minnow, *Pimephales promelas*	0	0	2	457	55	0	6	20	0	9
Sacramento blackfish, *Orthodon microlepidotus*	0	0	3	0	0	0	0	1	0	0
Sacramento splittail, *Pogonichthys macrolepidotus*	4	66	69585	4267	7488	19009	6413	8235	49	1
Sacramento pikeminnow, *Ptychocheilus grandis*	52	6	2	2122	2095	131	74	31	0	9
Sacramento sucker, *Catostomus occidentalis*	0	0	55	8037	4953	562	87	947	0	422
white catfish, *Ameiurus catus*	3	1	98	0	2	1	2	2	0	0
black bullhead, *Ameiurus melus*	0	0	2	1	4	0	1	0	0	0
brown bullhead, *Ameiurus nebulosus*	0	0	0	0	3	1	0	0	0	0
channel catfish, *Ictalurus punctatus*	1	0	97	3	0	0	0	0	0	0
wakasagi, *Hypomesus nipponensis*	4	3	0	1	29	0	0	0	0	0

Table A19. Continued.

Organism	Trawl Sites			Beach Seine Regions						
	Sherwood Hbr.	Chipps Is.	Mossdale	1	2	3	4	5	6	7
surf smelt, *Hypomesus pretiosus*	0	0	0	0	0	0	0	0	4	0
delta smelt, *Hypomesus transpacificus*	0	315	0	0	58	0	0	0	0	0
longfin smelt, *Spirinchus thaleichthys*	0	215	0	0	1	0	0	0	3	0
steelhead, *Oncorhynchus mykiss*	40	100	4	7	4	1	0	0	0	0
Unmarked steelhead	2	8	3	0	3	0	0	0	0	0
Marked steelhead	38	92	1	7	1	1	0	0	0	0
Chinook salmon, *Oncorhynchus tshawytscha*	2378	5542	3662	4006	4123	514	18	23	5	285
Unmarked winter-run	20	64	0	108	60	1	0	0	0	27
Unmarked fall-run	1734	3574	3235	3487	3414	412	16	21	4	220
Unmarked spring-run	350	594	0	365	557	97	2	0	1	36
Unmarked late fall-run	2	13	0	10	25	0	0	0	0	2
Marked/CWT	272	1297	427	36	67	4	0	2	0	0
plainfin midshipman, *Porichthys notatus*	0	0	0	0	0	0	0	0	0	0
topsmelt, *Atherinops affinis*	0	137	0	0	0	0	0	0	4967	0
jacksmelt, *Atherinopsis californiensis*	0	0	0	0	0	0	0	0	3	0
inland silverside, *Menidia beryllina*	25	0	1178	6526	33168	16052	12684	3546	30	3874
rainwater killifish, *Lucania parva*	0	0	0	0	26	94	203	0	2	0
western mosquitofish, *Gambusia affinis*	0	0	2	1051	242	270	134	654	1	4
threespine stickleback, *Gasterosteus aculeatus*	0	3	0	0	17	4	0	0	185	2
bay pipefish, *Syngathus leptorhynchus*	0	0	0	0	0	0	0	0	316	0
prickly sculpin, *Cottus asper*	0	0	0	12	83	27	22	22	0	0
Pacific staghorn sculpin, *Leptocottus armatus*	0	0	0	0	21	10	0	0	623	0
tidepool sculpin, *Oligocottus maculosus*	0	0	0	0	0	0	0	0	2	0
cabezon, *Scorpaenichthys marmortatus*	0	0	0	0	0	0	0	0	1	0
striped bass, *Morone saxatilis*	3	308	55	3	114	0	88	9	11	0
green sunfish, *Lepomis cyanellus*	0	0	0	2	4	0	2	0	0	0
warmouth, *Lepomis gulosus*	0	0	0	1	0	1	1	0	0	0

Table A19. Continued.

Organism	Trawl Sites			Beach Seine Regions						
	Sherwood Hbr.	Chipps Is.	Mossdale	1	2	3	4	5	6	7
bluegill, *Lepomis macrochirus*	6	2	269	78	42	110	266	128	0	0
redear sunfish, *Lepomis microlophus*	4	0	69	42	62	422	767	19	0	0
redeye bass, *Micropterus coosae*	0	0	0	0	2	0	0	0	0	0
smallmouth bass, *Micropterus dolomieu*	0	0	2	2	16	1	2	1	0	0
spotted bass, *Micropterus punctulatus*	1	0	14	10	124	1248	9	6	0	0
largemouth bass, *Micropterus salmoides*	5	0	35	228	218	400	458	44	0	0
white crappie, *Pomoxis annularis*	0	0	19	28	3	0	0	1	0	0
black crappie, *Pomoxis nigromaculatus*	7	0	74	77	5	4	2	1	0	0
bass unknown, *Micropterus* spp.	0	0	1	0	0	0	0	0	0	0
bigscale logperch, *Percina macrolepida*	0	0	5	576	44	6	17	126	0	0
barred surfperch, *Amphistichus argenteus*	0	0	0	0	0	0	0	0	14	0
shiner perch, *Cymatogaster aggregata*	0	0	0	0	0	0	0	0	42	0
black perch, *Embiotoca jacksoni*	0	0	0	0	0	0	0	0	2	0
walleye surfperch, *Hyperprosopon argenteum*	0	0	0	0	0	0	0	0	105	0
tule perch, *Hysterocarpus traskii*	2	5	1	26	600	334	13	0	0	0
dwarf surfperch, *Micrometrus minimus*	0	0	0	0	0	0	0	0	260	0
white seaperch, *Phanerodonfurcatus*	0	0	0	0	0	0	0	0	1	0
pile perch, *Rhacochilus vacca*	0	0	0	0	0	0	0	0	1	0
penpoint gunnel, *Apodichthys flavidus*	0	0	0	0	0	0	0	0	2	0
saddleback gunnel, *Pholis ornata*	0	0	0	0	0	0	0	0	0	0
crevice kelpfish, *Gibbonsia montereyensis*	0	0	0	0	0	0	0	0	2	0
yellowfin goby, *Acanthogobius flavimanus*	0	1	3	2	97	24	11	1	54	0
arrow goby, *Clevelandia ios*	0	0	0	0	0	0	0	0	734	0
longjaw mudsucker, *Gillichthys mirabilis*	0	0	0	0	0	0	0	0	3	0
cheekspot goby, *Hypnus gilberti*	0	0	0	0	0	0	0	0	1	0
bay goby, *Lepidogobius lepidus*	0	0	0	0	0	0	0	0	3	0
Shokihaze goby, *Tridentiger barbatus*	0	0	0	0	0	0	1	0	0	0

Table A19. Continued.

Organism	Trawl Sites			Beach Seine Regions						
	Sherwood Hbr.	Chipps Is.	Mossdale	1	2	3	4	5	6	7
Shimofuri goby, *Tridentiger bifasciatus*	3	0	1	0	136	10	4	0	0	0
chameleon goby, *Tridentiger trigonocephalus*	0	0	0	0	0	0	0	0	1	0
English sole, *Parophrys vetulus*	0	0	0	0	0	0	0	0	110	0
starry flounder, *Platichthys stellatus*	0	3	0	0	1	0	0	0	53	0
diamond turbot, *Pleuronichthys guttulatus*	0	0	0	0	0	0	0	0	28	0
sand sole, *Psettichthys melanostictus*	0	0	0	0	0	0	0	0	0	0
unidentified fish	0	0	5427	0	0	0	0	0	0	0

Table A20. Water year types for the Sacramento and San Joaquin River basins from 1978 to 2011 (CDWR 2012b). Water year types were classified as wet (W), above normal (AN), below normal (BN), dry (D), and critically dry (C).

Water Year	Water Year Type	
	Sacramento River	San Joaquin River
1978	AN	W
1979	BN	AN
1980	AN	W
1981	D	D
1982	W	W
1983	W	W
1984	W	AN
1985	D	D
1986	W	W
1987	D	C
1988	C	C
1989	D	C
1990	C	C
1991	C	C
1992	C	C
1993	AN	W
1994	C	C
1995	W	W
1996	W	W
1997	W	W
1998	W	W
1999	W	AN
2000	AN	AN
2001	D	D
2002	D	D
2003	AN	BN
2004	BN	D
2005	AN	W
2006	W	W
2007	D	C
2008	C	C
2009	D	BN
2010	BN	AN
2011	W	W

Table A21. Mean maximum water temperatures (°C) by month and field season measured at Mallard Island (near the Chipps Island Trawl Site) from 1989 to 2011.

Field Season	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Average
1989	21.60	20.34	18.98	15.79	11.63	9.06	9.98	13.93	17.91	19.23	20.58	22.28	16.775
1990	21.68	20.38	19.57	16.13	11.58	9.66	10.37	13.96	17.75	19.61	20.95	22.28	16.993
1991	22.00	21.58	19.79	14.76	9.81	7.91	12.40	---	15.15	16.79	19.41	---	15.962
1992	21.03	20.70	19.56	15.12	10.11	8.98	11.43	15.54	17.78	20.23	20.59	22.26	16.944
1993	21.87	20.61	20.94	16.59	10.83	8.82	10.92	14.98	15.68	19.04	20.69	21.90	16.906
1994	22.00	20.69	18.52	14.73	10.39	9.66	11.14	14.84	17.32	18.63	20.78	20.99	16.641
1995	22.33	20.92	18.46	13.69	10.22	10.67	11.75	12.74	15.07	16.24	19.27	21.31	16.057
1996	22.40	20.45	19.10	---	10.88	10.91	12.17	13.25	16.06	18.56	21.13	22.27	17.016
1997	22.43	20.52	18.07	14.47	11.47	10.10	11.73	12.50	---	20.73	21.62	22.27	16.902
1998	22.35	22.32	18.10	16.48	10.35	9.78	10.53	13.50	15.09	17.12	18.93	22.53	16.422
1999	23.36	21.97	18.14	14.81	9.87	8.71	10.11	12.24	15.01	17.39	20.11	21.90	16.133
2000	21.40	20.14	19.33	15.95	11.27	10.51	12.02	13.47	16.62	18.97	21.55	21.72	16.912
2001	22.60	21.81	18.55	13.77	11.59	9.69	10.35	14.80	16.83	21.02	22.40	22.17	17.131
2002	21.89	20.59	19.23	16.43	10.67	10.43	11.13	13.39	16.72	18.29	20.98	22.11	16.821
2003	21.06	20.84	18.21	14.87	11.41	10.58	11.52	14.25	15.56	18.06	20.88	22.62	16.655
2004	21.90	21.20	18.96	14.61	10.93	9.41	10.93	15.09	16.62	19.64	20.94	21.86	16.841
2005	21.93	21.80	18.09	14.20	10.65	9.88	11.75	14.96	15.89	18.56	20.18	22.65	16.711
2006	21.55	19.91	18.28	15.19	11.26	10.76	11.27	11.39	14.08	19.40	21.65	23.52	16.522
2007	21.29	19.87	17.32	15.02	10.75	8.24	10.68	13.97	16.29	18.61	20.47	21.74	16.187
2008	21.49	20.83	17.59	15.57	10.66	8.40	9.65	13.67	15.64	18.58	20.40	21.44	16.160
2009	21.70	20.82	18.11	15.39	10.68	9.20	10.68	13.39	16.21	18.97	20.28	21.41	16.403
2010	21.22	21.56	17.73	14.59	9.97	9.39	11.55	13.45	15.35	17.17	20.44	20.71	16.095
2011	20.07	20.71	18.82	14.81	11.03	9.06	10.25	11.58	15.32	16.78	19.04	21.67	15.762

Table A22. Mean maximum water temperatures (°C) by month and field season measured at Freeport on the Sacramento River from the 2000 to 2011.

Field Season	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Average
2000	21.41	20.23	17.13	12.83	9.89	9.84	10.59	12.16	16.48	18.81	21.87	21.35	16.049
2001	---	---	---	---	---	8.45	9.36	14.45	16.97	22.39	22.27	22.68	16.651
2002	22.69	21.52	18.95	14.60	9.60	9.52	10.18	12.34	16.39	18.72	21.68	22.03	16.519
2003	21.90	20.83	17.25	13.54	10.57	10.75	10.66	13.82	14.93	16.97	20.90	21.90	16.169
2004	21.45	21.10	20.08	12.00	11.23	9.94	10.93	14.47	16.70	21.11	22.68	22.82	17.042
2005	22.48	21.13	17.74	13.50	10.13	9.13	11.70	14.11	15.85	17.34	19.12	23.10	16.278
2006	22.87	19.85	17.00	13.88	10.74	10.32	10.64	10.82	12.97	17.11	20.60	23.03	15.821
2007	21.90	19.75	17.12	14.05	9.88	8.05	11.20	---	20.93	21.68	22.89	22.48	17.266
2008	22.89	20.57	16.89	14.39	9.65	8.44	9.94	14.13	16.92	21.05	22.14	23.39	16.700
2009	24.20	22.29	18.62	15.15	9.91	9.84	10.88	13.82	16.50	18.96	21.72	22.10	16.999
2010	22.41	22.35	17.45	13.42	9.32	9.82	11.84	13.54	14.98	16.85	19.74	22.24	16.164
2011	21.92	20.29	17.78	13.65	11.68	10.19	10.24	10.98	13.83	15.27	18.11	20.64	15.383

Table A23. Mean maximum water temperatures (°C) by month and field season measured at Vernalis on the San Joaquin River from the 2000 to 2011.

Field Season	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Average
2000	24.34	22.59	18.52	13.48	10.57	11.31	12.83	14.08	17.72	19.40	25.73	25.31	17.989
2001	---	---	---	---	---	9.84	11.76	17.24	17.90	21.89	24.96	26.77	18.623
2002	26.37	23.85	19.69	15.07	10.85	10.74	13.14	15.65	18.45	20.27	25.36	27.16	18.884
2003	26.32	24.10	18.56	14.22	11.21	12.05	13.05	14.67	16.93	20.56	22.92	27.29	18.490
2004	26.02	24.30	19.44	13.12	11.23	10.50	12.47	16.87	18.84	21.39	24.42	26.76	18.778
2005	26.47	23.50	18.56	13.23	10.42	9.82	12.82	14.32	14.50	16.73	19.32	23.45	16.928
2006	24.39	22.20	18.48	14.08	11.34	10.90	11.57	11.76	14.88	18.48	20.92	23.94	16.912
2007	22.60	20.35	16.14	14.07	10.41	---	12.51	16.53	18.23	19.20	23.20	24.78	18.001
2008	26.15	23.04	17.90	14.23	9.65	8.81	12.91	15.46	16.87	19.34	24.95	26.46	17.981
2009	26.58	24.02	18.49	14.58	9.83	10.38	12.88	16.33	18.03	20.67	23.50	26.74	18.503
2010	26.07	23.09	17.25	13.35	10.17	10.88	13.36	15.26	16.32	16.59	20.51	24.53	17.282
2011	25.51	---	---	---	---	10.48	10.80	12.76	16.08	16.77	18.34	20.85	16.450

Table A24. Recoveries of all coded wire tagged juvenile a) winter-, b) fall-, c) spring-, and d) late fall-run Chinook salmon by the DJFMP and fish facilities during the 2010 field season by release location and hatchery of origin. The hatcheries of origin included the Coleman National Fish Hatchery (ColemNFH), Livingston Stone National Fish Hatchery (LivinNFH), Feather River Fish Hatchery (FeathFH), Mokelumne River Fish Hatchery (MokFH), Nimbus Fish Hatchery (NimbFH), and Merced River Fish Facility (MercFF; PSMFC 2012).

Release Location (Hatchery of Origin)	Recovery Location												
	Region 1	Region 2	Region 3	Region 4	Region 5	Region 6	Region 7	Chipps Island Trawl Site	Sacramento Trawl Site	Mossdale Trawl Site	DJFMP Total	Federal Fish Facility	State Fish Facility
a) Winter-run													
Caldwell Park (LivinNFH)	5	0	0	0	0	0	0	54	22	0	81	23	6
b) Fall-run													
American River (NimbFH)	0	7	2	0	0	0	0	245	4	0	258	4	0
Battle Creek (ColemNFH)	19	11	1	0	0	0	1	516	101	0	649	2	1
Jersey Point (MercFF)	0	0	0	0	0	0	0	19	0	0	19	0	0
San Pablo Bay (FeathFH)	0	0	0	0	0	0	0	6	0	0	6	0	0
Sherman Island (MokFH)	0	5	19	0	0	0	0	1285	0	0	1309	1	1
Wickland Oil (FeathFH)	0	0	0	0	0	0	0	3	0	0	3	0	0
c) Spring-run													
Boyd's Ramp (FeathFH)	2	4	0	0	0	0	0	188	180	0	374	0	0
San Pablo Bay (FeathFH)	0	0	0	0	0	0	0	3	0	0	3	0	0
d) Late fall-run													
Battle Creek (ColemNFH)	11	6	2	0	0	0	1	66	4	0	90	185	128

Table A25. Recoveries of all coded wire tagged juvenile a) winter-, b) fall-, c) spring-, and d) late fall-run Chinook salmon by the DJFMP during the 2011 field season by release location and hatchery of origin. The hatcheries of origin included the Coleman National Fish Hatchery (ColemNFH), Livingston Stone National Fish Hatchery (LivinNFH), Feather River Fish Hatchery (FeathFH), Mokelumne River Fish Hatchery (MokFH), Nimbus Fish Hatchery (NimbFH), and Merced River Fish Facility (MercFF; PSMFC 2012).

Release Location (Hatchery of Origin)	Recovery Location										
	Region 1	Region 2	Region 3	Region 4	Region 5	Region 6	Region 7	Chipps Island Trawl Site	Sacramento Trawl Site	Mossdale Trawl Site	DJFMP Total
a) Winter-run											
Caldwell Park (LivinNFH)	0	0	0	0	0	0	0	3	0	0	3
b) Fall-run											
American River (NimbuFH)	0	37	0	0	0	0	0	82	1	0	120
Battle Creek (ColemNFH)	12	9	0	0	0	0	0	355	172	0	548
Discovery Park (NimbuFH)	0	5	0	0	0	0	0	229	47	0	281
Thermalito Bypass (Wild)	0	0	0	0	0	0	0	1	1	0	2
Wickland Oil (FeathFH)	0	0	0	0	0	0	0	2	0	0	2
Wickland Oil (NimbuFF)	0	0	0	0	0	0	0	3	0	0	3
Merced River (MercFF)	0	0	0	0	0	0	0	1	0	151	152
San Joaquin River (MercFF)	0	0	0	0	0	0	0	0	0	1	1
Mokelumne River (MokFH)	0	0	0	0	0	0	0	5	0	0	5
Mossdale (MercFF)	0	0	0	0	2	0	0	1	0	0	3
Hatfield State Park (MercFF)	0	0	0	0	0	0	0	0	0	192	192
San Pablo Bay (FeathFH)	0	0	0	0	0	0	0	4	0	0	4
Sherman Island (MokFH)	0	1	4	0	0	0	0	199	0	0	204
c) Spring-run											
Boyds Pump (FeathFH)	22	7	0	0	0	0	0	278	34	0	341
d) Late fall-run											
Battle Creek (ColemNFH)	1	8	0	0	0	0	0	106	8	0	123

Table A26. Total adult Chinook salmon escapement estimates by race for the Sacramento and San Joaquin River basins from 1978 to 2011 (CDFG 2012).

Year	Winter-run	Fall-run	Spring-run	Late fall-run
1978	25,012	156,962	8,126	12,479
1979	2,364	227,646	3,116	10,284
1980	1,156	172,137	12,464	9,093
1981	22,797	260,259	22,105	6,718
1982	1,281	230,706	27,890	6,899
1983	1,831	205,290	7,958	15,089
1984	2,763	262,907	9,599	10,388
1985	5,407	356,304	15,221	10,180
1986	2,596	297,820	25,696	8,301
1987	2,185	301,583	13,888	16,571
1988	2,878	268,436	18,933	13,218
1989	696	182,350	12,163	12,872
1990	430	87,853	7,683	8,078
1991	211	132,455	5,926	8,263
1992	1,240	110,413	3,044	10,131
1993	387	165,423	6,076	1,267
1994	186	220,667	6,187	889
1995	1,297	330,168	15,238	489
1996	1,337	351,551	9,083	1,385
1997	880	402,797	5,193	4,578
1998	2,992	246,026	31,649	42,419
1999	3,288	414,259	10,100	15,758
2000	1,352	485,681	9,244	12,883
2001	8,224	624,631	17,598	21,813
2002	7,441	872,669	17,419	40,406
2003	8,218	590,992	17,691	8,772
2004	7,869	386,848	13,982	14,090
2005	15,839	437,693	16,126	16,188
2006	17,296	292,954	10,948	15,047
2007	2,542	97,168	9,935	18,773
2008*	2,830	71,870	6,420	10,317
2009*	4,537	53,129	3,801	9,982
2010*	1,596	163,190	3,792	9,895
2011*	827	227,889	5,033	8,418

* indicates years containing preliminary data