U.S. Fish and Wildlife Service

Annual Report: Juvenile fish monitoring during the 2012 and 2013 field seasons within the San Francisco Estuary, California

Denise Barnard, Jonathan Speegle, and Joseph Kirsch*

U.S. Fish and Wildlife Service
Lodi Fish and Wildlife Office
Delta Juvenile Fish Monitoring Program
850 South Guild Ave, Suite 105
Lodi, CA 95240
(209) 334-2968
August 2015
*Corresponding author: joseph_kirsch@fws.gov

EXECUTIVE SUMMARY

The Delta Juvenile Fish Monitoring Program (DJFMP) has monitored juvenile Chinook Salmon *Oncorhynchus tshawytscha* within the San Francisco Estuary (Estuary) since 1976 using a combination of surface trawls and beach seines. Since 2000, 3 trawl sites and 58 beach seine sites have been sampled weekly or biweekly within the Estuary and lower Sacramento and San Joaquin rivers. The objectives of the DJFMP Annual Report for the 2012 (August 1, 2011 to July 31, 2012) and 2013 (August 1, 2012 to July 31, 2013) field seasons were to (1) report water quality information collected concurrently while monitoring fish during the 2012 and 2013 field seasons, (2) document the fish assemblage structure at monitoring sites, (3) determine the abundance and distribution of naturally and hatchery produced juvenile Chinook Salmon migrating into and out of the Delta, (4) document the length frequency distributions of unmarked juvenile Chinook Salmon captured, and (5) discuss how the relative abundance indices of unmarked winter-run sized or older juvenile Chinook Salmon occurring near Sacramento informed real-time Delta Cross Channel (DCC) water operation decisions.

We generally observed highly variable water quality parameters across all trawl sites and seine regions. We observed overall higher water temperatures in 2013 than in 2012, frequently exceeding 25°C in the summer months. We also observed highly variable dissolved oxygen values in the lower San Joaquin River during the 2013 field season, which increased to above 12 mg/L in May and decreased to less than 3 mg/L during June and July. In general, the turbidity was lower within the Central Delta and South Delta seine regions relative to other regions throughout most of the field seasons. Little distinct inter-annual patterns were observed in water conductivity in trawl sites or seine regions.

The fish assemblage was dominated by nonnative resident fish, and there was an overall increase of nonnative fish captured during the 2013 field season compared to 2012. In general, anadromous-pelagic-nonnative species dominated at Chipps Island and resident pelagic-nonnative fish dominated at the Mossdale Trawl Site. In contrast, anadromous-pelagic-native fish were relatively more abundant at the Sacramento Trawl Site. The mean yearly catch-per-unit effort estimates among beach seine regions demonstrated that fish densities for most assemblage groups were relatively low during the 2012 field season and increased slightly in 2013.

We developed a technique to estimate the origin of unmarked juvenile Chinook Salmon using the known ratio of unmarked to marked individuals in hatchery release groups, and estimated that nearly all juvenile salmon captured using beach seines since the 2000 field season were of natural origin. Conversely, most of the hatchery origin fish were captured using trawls. This suggested that hatchery juvenile Chinook Salmon may be less likely to occur in unobstructed near shore habitats within the San Francisco Estuary than natural origin juvenile Chinook Salmon.

We also estimated that the number of juvenile Chinook Salmon migrating into the Delta increased in the 2013 field season relative to 2012. However, the overall number of juvenile Chinook Salmon migrating out of the Delta decreased in the 2013 field season relative to 2012. We also observed that the overall abundance of winter-run and fall-, late fall-, and spring-run

sized juvenile Chinook Salmon migrating out of the Delta in the 2012 and 2013 field seasons has decreased relative to historic densities.

The DJFMP calculated a Sacramento Catch Index (SCI) using the relative abundance indices of unmarked winter-run or older juvenile Chinook Salmon near Sacramento. The SCI did not trigger any DCC operations in the 2012 field season. However, the SCI exceeded the threshold of the salmon decision process on 13 sampling dates during the 2013 field season. This, in conjunction with other criteria, either triggered or maintained the closure of the DCC gates on 12 occasions.

The suggested citation for this report is:

Barnard, D., J. Speegle, and J. Kirsch. 2015. Annual report: juvenile fish monitoring during the 2012 and 2013 field seasons within the San Francisco Estuary, California. Lodi Fish and Wildlife Office, United States Fish and Wildlife Service, Lodi, California.

TABLE OF CONTENTS

ACKNOWLEDGMENTS

All fish sampling presented in this report was conducted for the Interagency Ecological Program (IEP) for the San Francisco Estuary and funded by the California Department of Water Resources and the U.S. Bureau of Reclamation. Members of the IEP include three state agencies (the California Department of Water Resources, California Department of Fish and Wildlife, and State Water Resources Control Board) and six federal agencies (the U.S. Bureau of Reclamation, U.S. Geological Survey, U.S. Fish and Wildlife Service, National Marine Fisheries Service, U.S. Army Corps of Engineers, and the U.S. Environmental Protection Agency).

We also acknowledge and extend gratitude to the many biological science field technicians and boat operators who spent countless hours under all weather conditions to collect these data. We would like to especially thank Amber Aguilera, Crystal Castle, Laura Chumney, Jeffrey Cullen, Lauren Damon, Dustin Dinh, David Dominguez, Kate Erly, Kyle Fronte, Garrett Giannetta, Christopher Hart, Jack Ingram, Carlie Jackson, David LaPlante, Jerrica Lewis, Mike Marshall, Tim Matt, Paul Miklos, Greg Nelson, Jacob Osborne, John Pedretti, Scott Porter, Pam Tarelli, Phil Voong, and Jolene Willis for biological sampling; Jackie Hagen, Curtis Hagen, Ron Hagins, Patrick Hapgood, and Bill Powell for boat operation; and Angie Bourandas for helping oversee data entry and quality control during the 2012 and 2013 field seasons. We would also like to thank Patricia Brandes, Matthew Dekar, Lori Smith, and Kim Webb for improvements to earlier drafts of this report.

ACRONYMS

The following acronyms have been used in this report:

CI—Confidence interval
CDFW—California Department of Fish and Wildlife
CDWR—California Department of Water Resources
CPUE—Catch-per-unit effort
CVP—Central Valley Project
CWT—Coded wire tag
DAT—Data Assessment Team
DCC—Delta Cross Channel
DJFMP—Delta Juvenile Fish Monitoring Program
DOSS—Delta Operations for Salmon and Sturgeon working group
ESA—Endangered Species Act
FL—Fork length
IEP—Interagency Ecological Program
KDTR—Kodiak trawl
KLCI—Knights Landing Catch Index
LDC—Length-at-capture-date criteria
LFWO—Lodi Fish and Wildlife Office
MWTR—Mid-water trawl
NMFS—National Marine Fisheries Service
PSMFC—Pacific States Marine Fisheries Commission
RM—River mile
RMIS—Regional Mark Information System
SCI—Sacramento Catch Index
SD—Standard deviation
SE—Standard error
SJRGA—San Joaquin River Group Authority
SWP—State Water Project
SWRCB—State Water Resources Control Board
USBR—United States Bureau of Reclamation
USFWS—United States Fish and Wildlife Service
USGS—United States Geological Survey
WOMT—Water Operations Management Team

LONG-TERM MONITORING

Introduction

The San Francisco Estuary (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, 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 Estuary and its watershed. The damming of most rivers, confinement of channels, and water diversions and exports has subjected the Estuary to artificial flow regimes that can have profound impacts on aquatic habitats and organisms (Stevens and Miller 1983; Nichols et al. 1986; 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 monitored and studied, in part, by the Delta Juvenile Fish Monitoring Program (DJFMP) of the Lodi Fish and Wildlife Office (LFWO, formerly Stockton Fish and Wildlife Office) to assess and minimize the effects of water operations on fish populations.

The DJFMP, as part of the Interagency Ecological Program, has been monitoring populations of juvenile Chinook Salmon *Oncorhynchus tshawytscha* within the Sacramento-San Joaquin Delta (Delta) and its watershed since 1976 (Dekar et al. 2013). The DJFMP and its goals have evolved based on water management needs and endangered species listings. Prior to 1992, the DJFMP conducted annual monitoring between April and June to assess the effects of water operations on the inter- and intra-annual abundance and distribution of primarily juvenile fall-run Chinook Salmon within the Delta and lower Sacramento River. Following the listing of Sacramento River winter-run Chinook Salmon as endangered by the State of California in 1989 (CDFW 2005) and by the National Marine Fisheries Service in 1994 (59 FR 440), the DJFMP expanded the long-term sampling program to one that operated between October and June to collect more information on all races of juvenile Chinook Salmon in the Estuary. The DJFMP was further expanded in 1995 to sample year-round, in part, to expand the temporal and geographic monitoring of resident fish and Central Valley Steelhead *Oncorhynchus mykiss* (Dekar et al. 2013). Today, year-round monitoring continues with an emphasis on populations of all races of Chinook Salmon in the Delta per the monitoring and reporting terms of the Biological Opinion and Conference Opinion on the Long-Term Operations of the Central Valley Project (CVP) and State Water Project (SWP, NMFS 2009a).

In general, the fish data collected by the DJFMP are intended to provide basic biological and demographic information that can be used to assess trends over time. The first section of this report will focus on the DJFMP's long-term observations of juvenile Chinook Salmon and fish assemblage structure. The objectives of the annual report for the 2012 (August 1, 2011 to July 31, 2012) and 2013 (August 1, 2012 to July 31, 2013) field seasons were to (1) report water quality information collected concurrently while monitoring fish during the 2012 and 2013 field seasons, (2) document the fish assemblage structure at monitoring sites, (3) determine the abundance and distribution of naturally and hatchery produced juvenile Chinook Salmon migrating into and out of the Delta, and (4) document the length frequency distributions of unmarked juvenile Chinook Salmon. Although the water quality data are intended to document the spatial and temporal variation of potential fish habitat characteristics within the Estuary and lower rivers, rigorous fish-habitat analyses are beyond the scope of this report.

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 2012 and 2013 field seasons, the DJFMP sampled fishes at 3 trawl sites and 58 beach seine 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 A.1).

We used surface trawls to examine the relative abundance of fishes migrating into and out of the Delta. Trawl sites were located at the entry (Sacramento and Mossdale trawl sites) and exit (Chipps Island Trawl Site) points of the Delta (Figure 1; Table A.1). In general, the DJFMP sampled each trawl site three days per week, with ten tows per day throughout the 2012 and 2013 field seasons. Trawl sites were generally sampled Monday, Wednesday, and Friday each week throughout the field season to maximize temporal coverage. The California Department of Fish and Wildlife (CDFW) has traditionally sampled the Mossdale Trawl Site, following similar methodologies, in place of the DJFMP between April and June (SJRGA 2009). Data collected from both the DJFMP and CDFW at the Mossdale Trawl Site are included in this report.

We used beach seines to quantify the spatial distribution of fishes occurring in unobstructed shallow near-shore habitats (e.g., beaches and boat ramps $\leq$ 1.2 m in depth) throughout the lower Sacramento and San Joaquin rivers and the Estuary. Beach seine sites were stratified into six geographic seine regions: (1) Lower Sacramento River, (2) North Delta, (3) Central Delta, (4) South Delta, (5) Lower San Joaquin River, and (6) San Francisco and San Pablo Bay (Figure 1; Table A.1). Seine regions were delineated by proximity to canals or water bypasses where fish may be diverted from historical migration routes.

In this dynamic system, occasional changes in river flow or environmental conditions prevent sampling or make it necessary to temporarily relocate seine sites (e.g., tidal conditions, or submerged or floating aquatic vegetation blocking access to sites). If new seine sites were needed, we attempted to relocate the site to another location with similar habitat (e.g., hydrogeomorphic characteristics) that was less than 100 m from the original site. Accessibility of beach seine sites in the San Joaquin River Seine Region varied in difficulty between flow conditions. During the 2000–2012 field seasons, when the discharge of the lower San Joaquin River dropped below 51 m^3/s boat access to specific beach seine locations became difficult, so only sites that were accessible from land were sampled (Table A.1). To accommodate for the inaccessible sites we sampled alternative sites, some of which were over 100 m from the original sampling locations. However, we discontinued the use of alternative sites in the San Joaquin River Seine Region in the 2013 field season in order to decrease biases in fish abundance and distribution patterns caused by changing sites during variable flow conditions; and only the sites that were sampled when the river was above 51 m^3/s during the 2000–2012 field seasons were sampled throughout the entire 2013 field season. More information on monitoring site modifications can be found in the LFWO Metadata file at http://www.fws.gov/lodi/jfmp/.

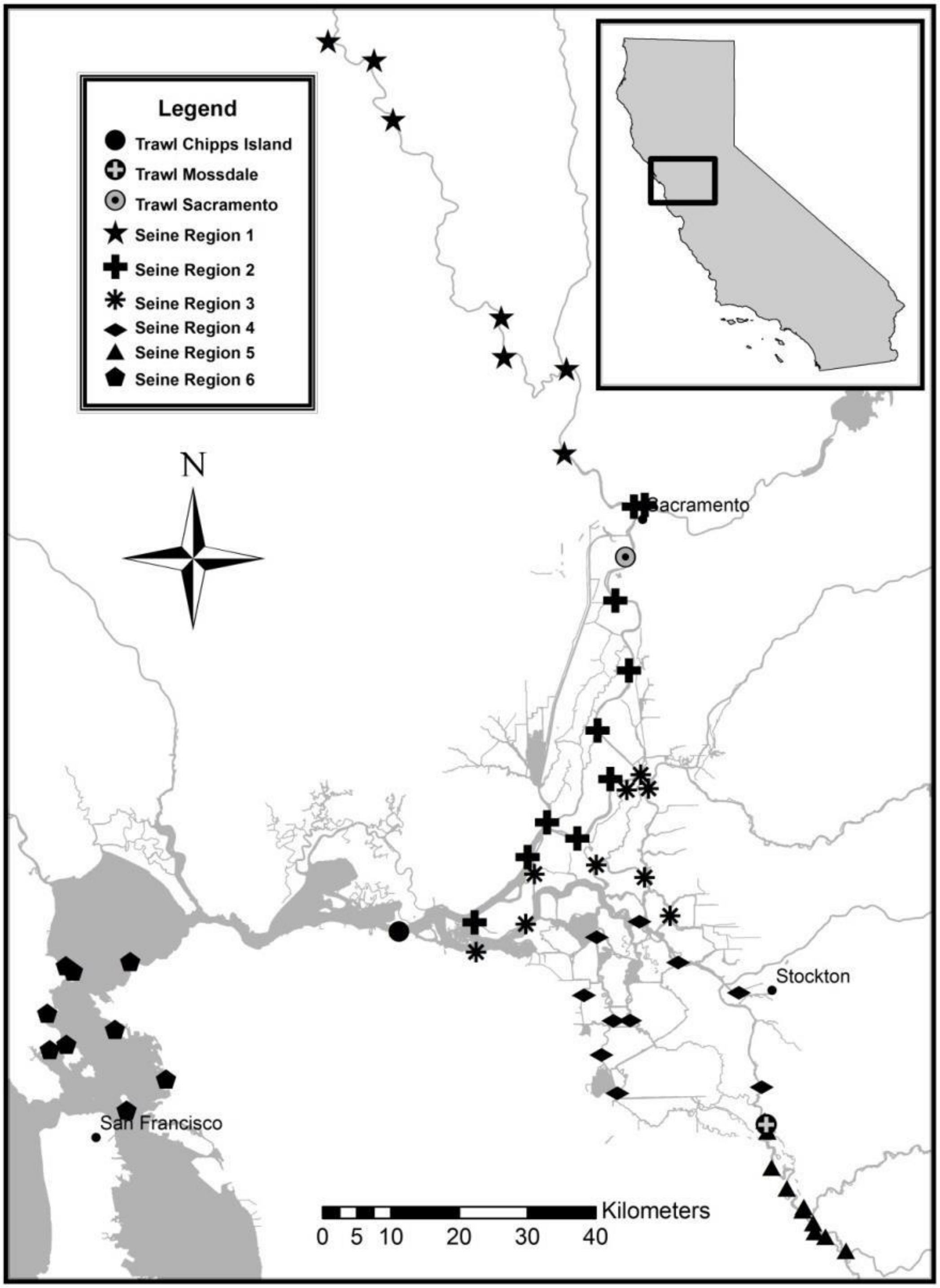

Figure 1. Sites sampled during the 2012 and 2013 field season within the lower Sacramento and San Joaquin rivers and San Francisco Estuary.

In general, we sampled fishes at the beach seine sites one day per week, one time per day throughout the 2012 and 2013 field seasons within all seine regions except the Lower San Joaquin River and the San Francisco and San Pablo Bay seine regions. The beach seine sites that were located within the Lower San Joaquin River Seine Region were generally sampled one day per week, one time per day from January 1 to July 31 and one day every two weeks from August 1 to December 31. The beach seine sites that were located within the San Francisco and San Pablo Bay Seine Region were generally sampled one day per every two weeks, one time per day throughout the 2012 and 2013 field seasons based on logistical limitations and the low occurrence of fish species of management concern.

Trawl Methodology

We sampled at trawl sites using 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 DJFMP exclusively used a MWTR at the Sacramento Trawl Site prior to 1994, and has used a KDTR from October to March and a MWTR for the remainder of each field season thereafter (Dekar et al. 2013). The KDTR has been used in place of the MWTR at the Sacramento Trawl Site from October to March to maximize the capture of larger Chinook Salmon and to provide more robust juvenile winter-run Chinook Salmon catch indices (Dekar et al. 2013).

During each sampling day, we attempted ten 20-minute tows between sunrise and sunset at all trawl sites. All tows were conducted mid-channel and facing upstream at the Sacramento and Mossdale trawl sites, which constitute a reach length of approximately 6.5 km and 3 km, respectively. In contrast, tows were generally conducted facing both upstream and downstream in the north, south, and middle portions of the channel at the Chipps Island Trawl Site based on tidal influence on net water velocities. The Chipps Island Trawl Site 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 that the net mouth remained fully extended and submerged. The measure of the distance traveled during each tow was recorded using a calibrated mechanical flow meter (General Oceanics, Model #2030) deployed alongside the boat. 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 2). 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 by 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 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 larger and similar in construction to the MWTR net used at the Sacramento Trawl Site (Figure 3). 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 by 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.

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 4A). 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 by 36 cm tall by 49 cm long) was composed of 0.18 cm thick aluminum that was perforated with 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 by 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. Additionally, at the front of each wing of the net was a 1.83 m metal bar with floats at the top and weights at the bottom to keep depth constant while sampling. The KDTR nets were towed behind two boats sitting approximately 4.5 m apart (Figure 4B). 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), which was attached to the metal bar on each side of the net. The net was fished approximately 31 m behind the boats.

At the end of each MWTR tow, the net was retrieved by the towing vessel using winches to collect all the fishes observed in the cod ends. At the end of each KDTR tow, the two towing vessels (i.e., net and chase boats) would maneuver alongside each other, and the chase boat would transfer its tow rope to the net boat. Subsequently, the crew on the chase boat would travel downstream to the live box connected to the KDTR, retrieve, secure, and pull the live box from the water into the boat (Figure 5). All fishes collected from the cod end or live box were placed in a holding container filled with river water for processing. Lastly, the crew would determine the condition of each tow as either "normal" (defined as no twists, snags, or tears in the net, little to no [<5%] debris in/on the net, and no [<5%] blockage between the mouth of the net to the live box), "fair" (defined as partial twists, snags, or small tears in the net, some [5–25% coverage] debris in/on the net, or partial [5–25%] blockage between the mouth of the net to the live box), or "poor" (defined as complete twists, snags, or large tears in the net, heavy [>25% coverage] debris in/on the net, or near complete [>25%] blockage between the mouth of the net to the live box).

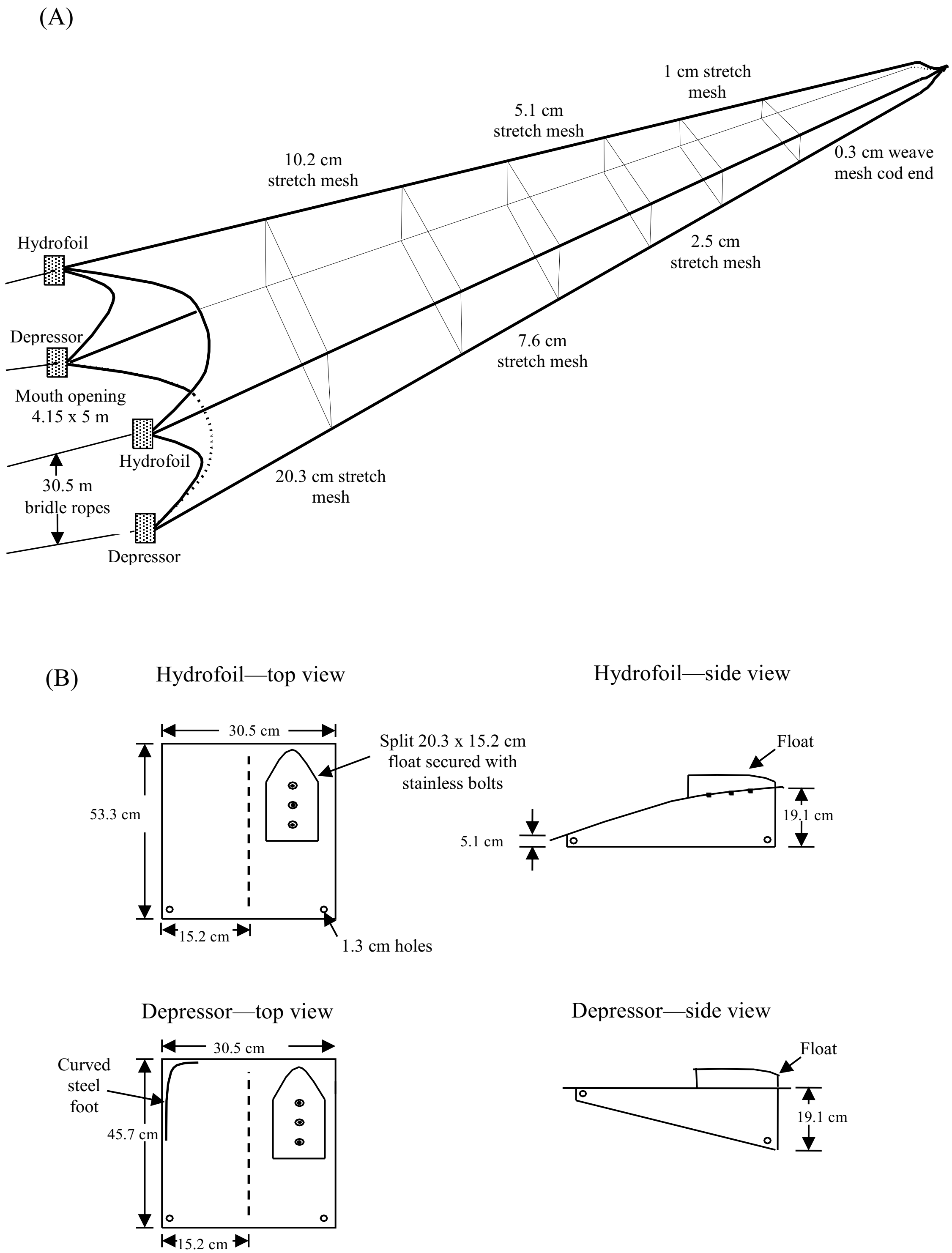

Figure 2. Schematic drawing of the (A) mid-water trawl net and (B) hydrofoils and depressors used at the Sacramento Trawl Site during the 2012 and 2013 field seasons.

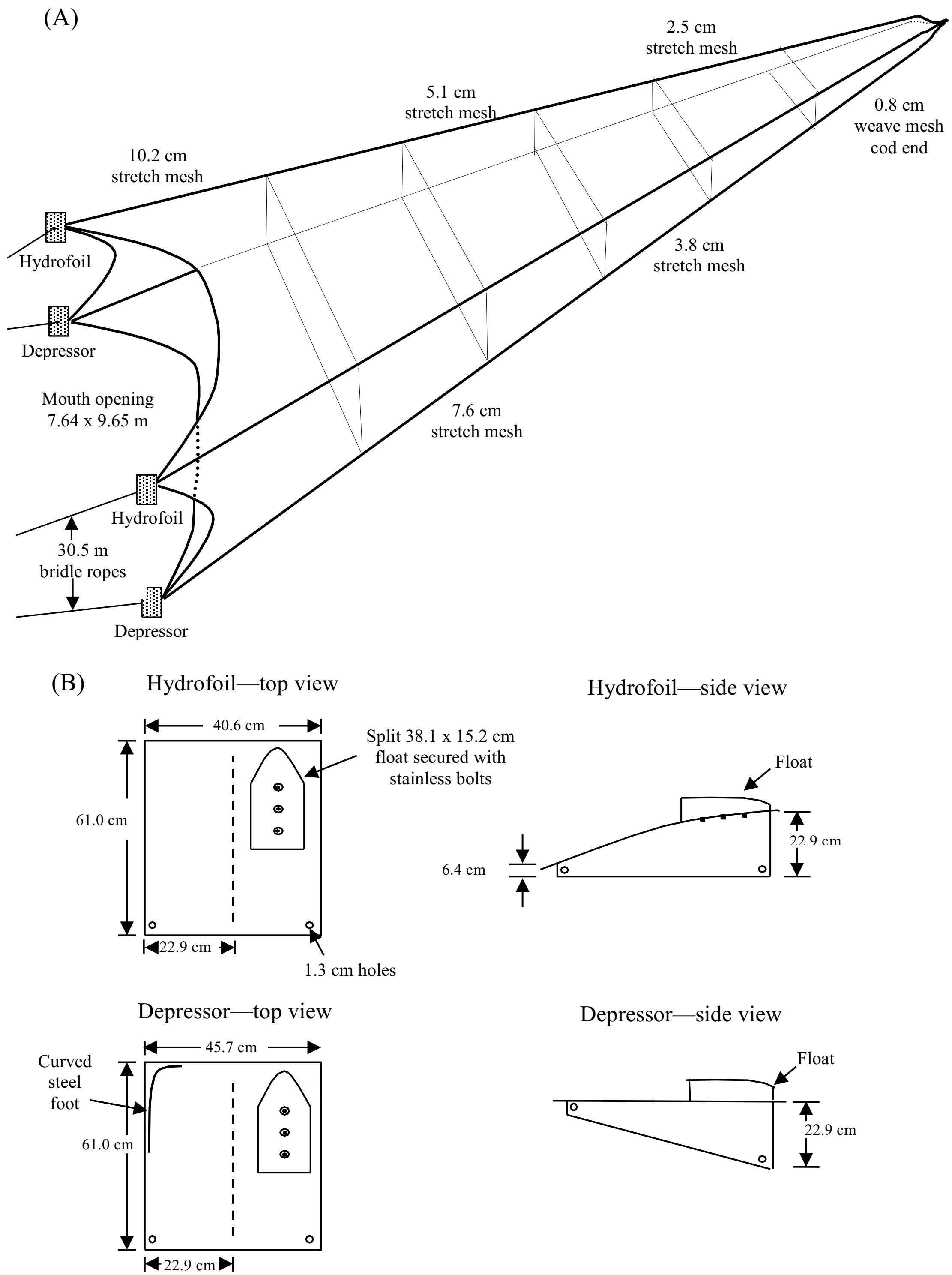

Figure 3. Schematic drawing of the (A) mid-water trawl net and (B) hydrofoils and depressors used at the Chipps Island Trawl Site during the 2012 and 2013 field seasons.

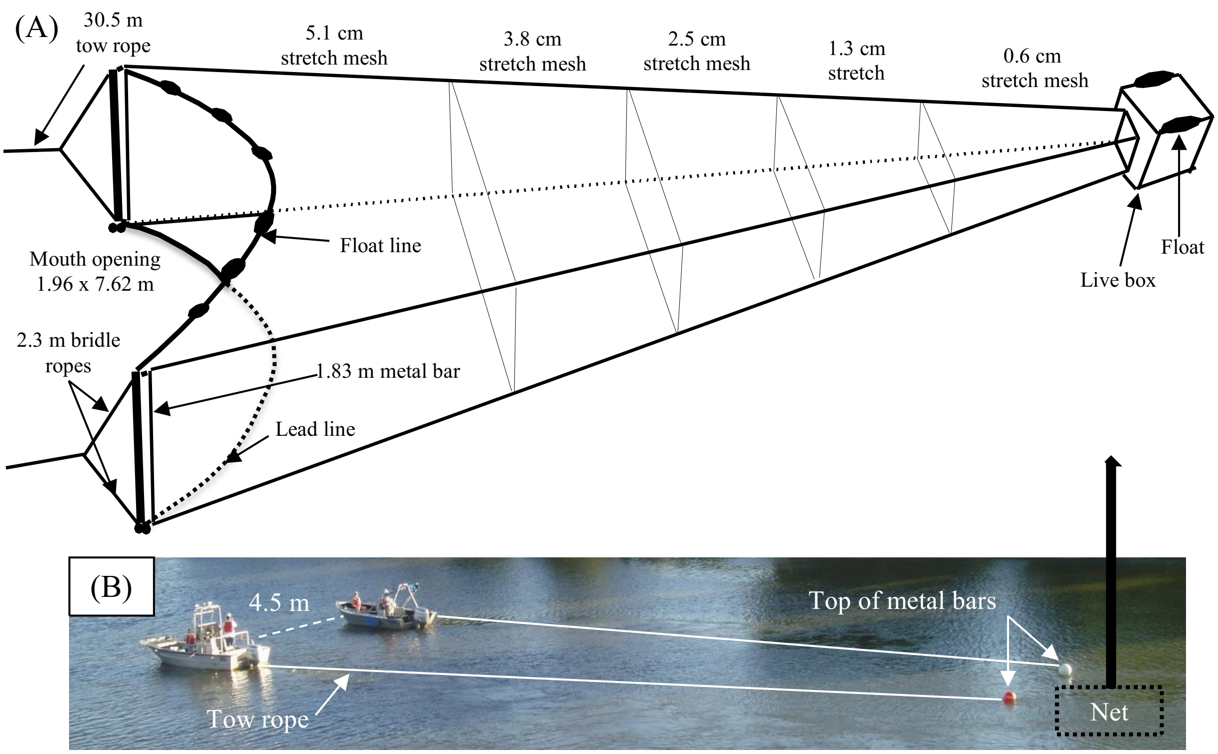

Figure 4. Schematic drawing of the (A) Kodiak trawl net used and (B) position of the boats during Kodiak trawling at the Sacramento and Mossdale trawl sites during the 2012 and 2013 field seasons.

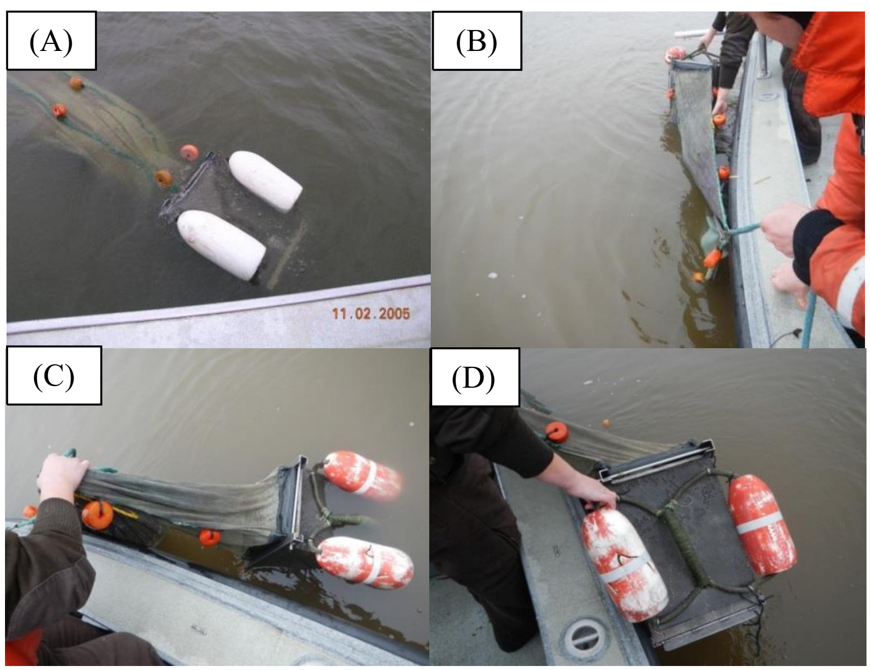

Figure 5. The Kodiak trawl (A) live box (B) being retrieved, (C) secured, and (D) pulled into the vessel.

Beach Seine Methodology

Sampling at beach seine sites was conducted between sunrise and sunset. We sampled using a 15.2 by 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. Occasionally rollers were added to the lead line of the beach seine to prevent the net from sinking into fine substrates (i.e., substrata with particles <62.5 µm in diameter), which would otherwise impede the completion of the seine haul.

The beach seines were generally deployed by two crewmembers starting from the downstream portion of each site to limit disturbance (e.g., displacement of sediment into the site). Crew member 1 pulled the seine into the water, perpendicular from the shoreline, as crew member 2 secured the opposite end of the seine to the shoreline (Figure 6A). After reaching a depth of up to 1.2 m, a distance of up to 15 m, or an obstacle; crew member 1 stopped and measured the distance (i.e., length) to the shoreline and depth to the nearest 1 m and 0.1 m, respectively (Figure 7). Obstacles were defined as any structure that could compromise safety or gear efficiency; e.g., steep banks or holes, fast water current, submerged aquatic vegetation, or large woody debris. If the depths of the seine varied between measurements, the maximum seine depth was obtained by averaging the two depth measurements. Next, crew member 2 carried their end of the seine to crew member 1 and placed it 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 6B). Lastly, crew members 1 and 2 pulled the ends of the seine simultaneously toward and perpendicular to the shoreline while attempting to maintain the starting width (Figure 6C). The net was continuously pulled towards the shoreline until the lead line of the seine bag was on shore (Figure 6D). 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. The crew would then determine the condition of the sample as either “normal” (defined as no twists, snags, or tears in the net, and the seine was pulled steadily while keeping the lead line in contact with the substrate and float line at or above the water’s surface), “fair” (defined as partial twists, snags, or small tears in the net, but the seine was pulled steadily while keeping the lead line in contact with the substrate and float line at or above the water surface), or “poor” (defined as complete twists, snags, or large tears in the net, or the seine was not pulled steadily, or the lead line was not in contact with the substrate, or float line was below the water surface).

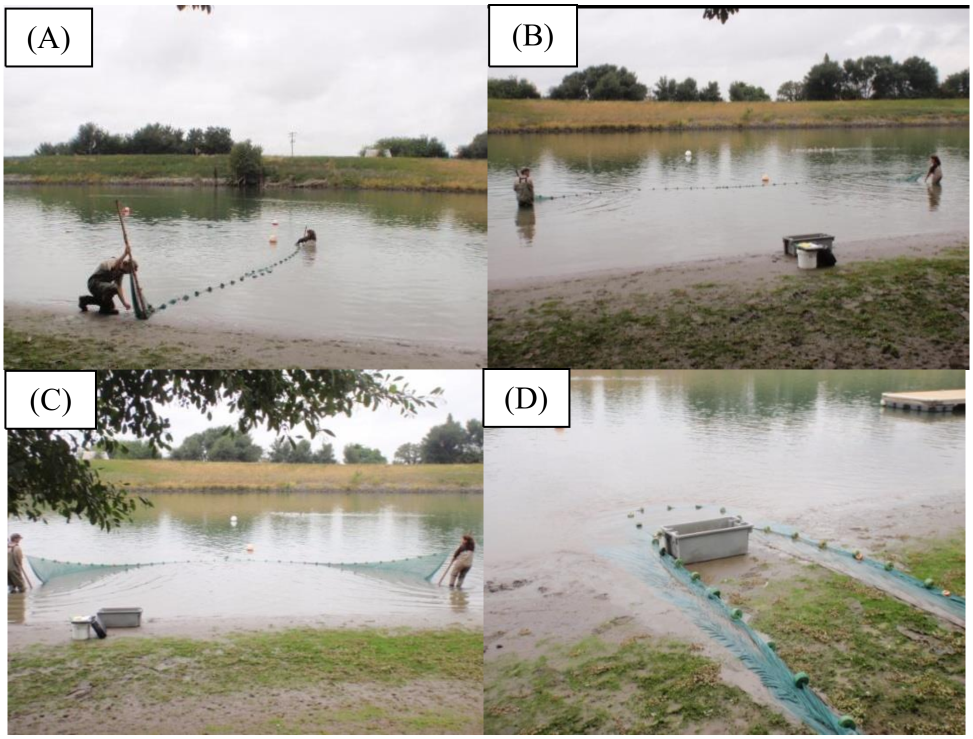

Figure 6. Photographs of the DJFMP conducting a beach seine at station SR024E on the bank of the Sacramento River: seine (A) deployed downstream of site, (B) distributed upstream parallel to the shoreline (C) pulled in toward the shoreline, and (D) position at the end of a haul.

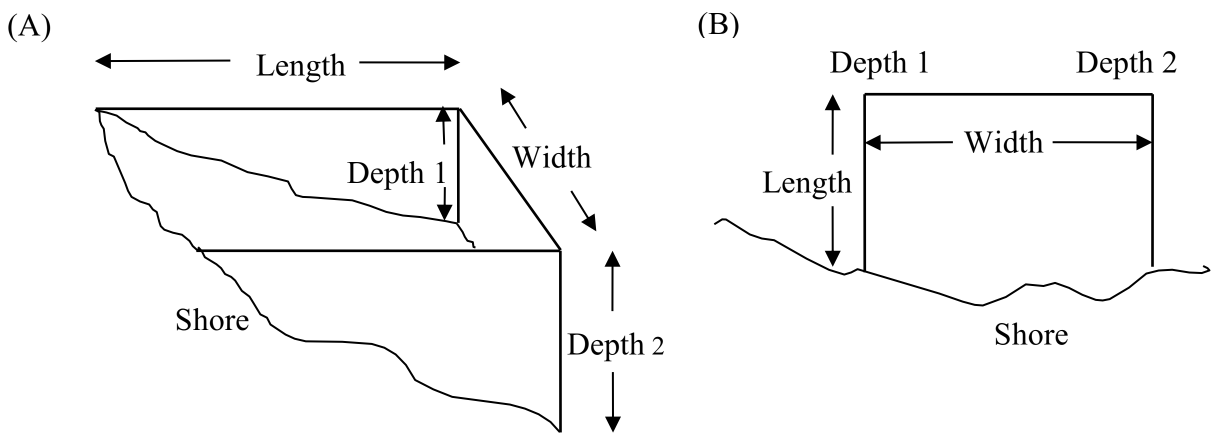

Figure 7. Schematic diagram of beach seine measurements: (A) three-dimensional view and (B) overhead view.

Fish Processing

We identified all fish in each sample that were ≥ 25 mm fork length (FL) to species or race, with the exception of five species that were readily identified at ≥ 20 mm FL: Sacramento Splittail *Pogonichthys macrolepidotus*, Three-spine Stickleback *Gasterosteus aculeatus*, Western Mosquito Fish *Gambusia affinis*, Rainwater Killifish *Lucania parva*, and Sacramento Sucker *Catostomus occidentalis*. 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, as designated by the river length-at-capture-date criteria (LDC, see paragraph below), or other species listed under the Endangered Species Act (ESA) were captured, a subsample of 50 individuals was randomly measured for FL and the rest were counted and not measured. If greater than 30 individuals of a non-listed species were captured, a subsample of 30 individuals was randomly measured for FL and the rest were counted and not measured. Fish that could not be accurately identified in the field were preserved and brought back to the laboratory. The identification of preserved fishes was then confirmed with the use of dichotomous keys or with the aid of a microscope.

Only juvenile Chinook Salmon with missing (clipped) adipose fins were considered marked fish. In general, fish possessing other forms of marks (e.g., stain dye, disc tags, acoustic tags) were not included within this report to further minimize the influence of recaptures and/or unnatural occupancy induced by other fishery investigations. Stain dye marked juvenile Chinook Salmon released near the Mossdale Trawl Site were only used to estimate trawl efficiency (see "Absolute Abundance Calculation" section). All clipped juvenile Chinook Salmon observed during the 2012 and 2013 field seasons were considered hatchery-reared and were brought back to the lab to process the coded wire tag (CWT).

Recovered CWTs can provide important biological information to natural resource managers (e.g., an individual's race, hatchery of origin, and the date and location released). Therefore, all clipped Chinook Salmon were euthanized in the field and brought back to the laboratory. We then removed, read, and recorded the tag code of all CWTs recovered. We obtained corresponding tag information (e.g., race and release location) from the Regional Mark Information System (RMIS) maintained by the Pacific States Marine Fisheries Commission (PSMFC 2014). Details regarding CWT recoveries during the 2012 and 2013 field seasons can be found in the "Appendix" section.

The race of all unmarked juvenile Chinook Salmon was determined using the river LDC developed by Fisher (1992) and modified by Greene (1992). The assumptions associated with the river LDC for the Sacramento-San Joaquin River basin include that (1) spawning of fall-run Chinook Salmon occurs between October 1–December 31, (2) spawning of late fall-run Chinook Salmon occurs between January 1–April 15, (3) spawning of winter-run Chinook Salmon occurs between April 16–August 15, (4) spawning of spring-run Chinook Salmon occurs between August 16–September 30, 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 LDC 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., resulting from 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 river LDC may actually be fall-run. Additionally, some genetic analyses of DNA genotypes have demonstrated the inaccuracy of the river LDC that has been used to determine Chinook Salmon races within the San Francisco Estuary, especially between fall- and spring-run salmon (e.g., Banks et al. 2000; Greig et al. 2003; Banks 2014). Therefore, we used the river LDC to differentiate only between winter-run and a combined group of fall-, late fall-, and spring-run juvenile Chinook Salmon. The race designations used in this report should be considered a rough approximation and not interpreted as definitive.

All juvenile Chinook Salmon collected at the Mossdale Trawl Site and within the Lower San Joaquin River Seine Region were classified as fall-run regardless of their length at the date of capture, and thus included in the fall-, late fall-, and spring-run group, 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). Although the South and Central Delta seine regions are located within the San Joaquin River basin, there is potential for late fall-, winter-, and spring-run juveniles of Sacramento River origin to migrate into the interior delta through the Georgiana Slough, the Delta Cross Channel (DCC), and the San Joaquin River during water diversions or transfers. Therefore, the river LDC was still used to determine the race of juvenile Chinook Salmon within the South and Central Delta seine regions.

<u>Water Quality</u>

We measured temperature, dissolved oxygen, turbidity, and conductivity immediately before each trawl and during or after each seine haul during the 2012 and 2013 field seasons. We have consistently measured water temperature at all monitoring sites during or immediately before each sampling occasion since the late 1970s. Additionally, we have consistently measured dissolved oxygen, turbidity, and conductivity at all monitoring locations since January of 2012. However, CDFW only measured water temperature at the Mossdale Trawl Site during April, May, and June of 2012 due to lack of the appropriate equipment.

We used a YSI 85 or YSI PRO 2030 meter to measure water temperature to the nearest 0.1˚C, dissolved oxygen to the nearest 0.01 mg/L, and conductivity to the nearest 0.01 microsiemen/centimeter (µS/cm) for freshwater or millisiemen/centimeter (mS/cm) for salt water. Turbidity was measured using a HACH 2100Q turbidity meter to the nearest 0.01 nephelometric turbidity unit (NTU). All measurements or samples were collected 20–30 cm below the surface of the water

We presented the raw temperature, dissolved oxygen, turbidity, and conductivity estimates by month for each trawl site and beach seine region during the 2012 and 2013 field seasons as box plots (median and percentiles) to demonstrate the spatial and temporal variability of the habitat conditions representative of our monitoring sites during sampling.

Fish Assemblage

We classified fish species into seven distinct assemblage groups based on shared origin, habitat requirements, and life history strategies (Moyle 2002): (1) anadromous-benthic-native, (2) anadromous-pelagic-native, (3) anadromous-pelagic-nonnative, (4) benthic-native, (5) benthic-nonnative, (6) pelagic-native, and (7) pelagic-nonnative (Table A.2). All juvenile unmarked Chinook Salmon captured were considered members of the anadromous-pelagic-native group. No marked Chinook Salmon or steelhead were included in any of the assemblage groups, though unmarked hatchery Chinook Salmon were included.

Estimate of Hatchery and Natural Origin Juvenile Chinook Salmon

In general, hatcheries have used CWTs, indicated by clipped adipose fins, to mark all hatchery produced late fall-, winter-, and spring-run juvenile Chinook Salmon in the Central Valley (Kevin Niemela, USFWS, personal communication; Williams 2006). However, a small proportion of late fall-, winter-, and spring-run Chinook Salmon fin clips are missed during tagging at the hatchery, and recorded in RMIS as unmarked (Kevin Niemela, USFWS, personal communication; PSMFC 2014). Conversely, the marking and CWT tagging rates of hatchery reared 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 hatchery produced juvenile fall-run Chinook Salmon, where at least 25% of individuals within each hatchery release group are marked and have a CWT inserted (Nandor et al. 2010). Because unmarked hatchery reared juvenile Chinook Salmon are still being released into the Central Valley, there is considerable uncertainty concerning the origin (i.e., naturally or hatchery produced) of unmarked juvenile Chinook Salmon observed during DJFMP monitoring. This uncertainty impacts the program’s ability to inform research or management decisions concerning naturally-produced juvenile Chinook Salmon (Williams 2006; Dekar et al. 2013).

Therefore, we developed an equation to estimate the origin of juvenile Chinook Salmon observed during the 2000 to 2013 field seasons. We applied the equation to all races of juvenile Chinook Salmon to account for any possible unmarked proportion of a hatchery release group, either caused by intentional unmarking (fall-run), or clip failure during tagging (late fall-, winter-, and spring-run).We estimated the number of unmarked hatchery origin juvenile Chinook Salmon (H_s) for each sample (e.g., trawl tow or seine haul) and race group as:

$$H_s \;\; = \sum (C_g \; x \; P_g) \qquad (1)$$

where s indexes an individual sample (i.e., a beach seine haul or trawl tow), g indexes a CWT release groups, C_g represents the total number of marked individuals collected from the CWT release group, and P_g represents the proportion of unmarked to marked individuals within the CWT release group. P_g was obtained from state and federal hatchery records (PSMFC 2014). The primary assumption of this approach was that marked and unmarked individuals within a CWT release group have identical capture probabilities and availability during sampling.
We included juvenile Chinook Salmon that were reported as fall- and spring-run hybrids in hatchery records in the combined fall-, late fall-, and spring-run group. We also included all

other hybrid-run juvenile Chinook Salmon without race descriptions in this group based on unlikely hybridization between winter-run Chinook Salmon and other races (Slater 1963). Additionally, we omitted any CWT release groups that were associated with "wild type" origin juvenile Chinook Salmon based on these groups being experimental and rare.

We then summed the total number of unmarked hatchery origin juvenile Chinook Salmon observed within a sample day for each race group and monitoring site (H_d). Subsequently, we estimated the number of natural juvenile Chinook Salmon for each race group and monitoring site within a sample day (W_d) as:

$$W_d = O_d - H_d \tag{2}$$

where O_d denotes the total number of unmarked juvenile salmon observed during a sample day for a race group and monitoring site. If the estimated number of unmarked hatchery origin individuals exceeded the total number of unmarked juvenile Chinook Salmon observed for a race group during a sample day at a monitoring location (occurred in < 1% of samples), we designated all unmarked individuals observed as unmarked hatchery individuals. All clipped juvenile Chinook Salmon included in the analysis were considered to be of hatchery origin.

Prior to 2000, large groups of unmarked fall-run juvenile Chinook Salmon were regularly released by the state and federal hatcheries throughout the Delta that were not associated with any marked group (Kevin Niemela, USFWS, personal communication; PSMFC 2014). Consequently, our approach to estimate the number of natural and hatchery juvenile Chinook Salmon at our monitoring locations could not be applied to our catch data for the fall-, late fall-, and spring-run group during this time. As a result, all unmarked fall-, late fall-, and spring-run fish observed prior to the 2000 field season were considered to have an unknown origin. After 2000, groups containing only unmarked individuals were released at Battle Creek, Sacramento River, Feather River, and downstream of Chipps Island. We assumed that unmarked releases downstream of Chipps Island would not bias our estimation of fish origin because most juvenile Chinook Salmon were likely actively migrating downstream and observations of CWT individuals released at these locations are minimal.

To minimize the impact of unmarked hatchery releases at other locations, we estimated periods of time when individuals from these unmarked hatchery release groups likely occurred within the Delta. We considered all unmarked individuals observed while monitoring during these periods of time to have unknown origin. We estimated periods of occupancy within the Delta using the observed travel times of individual CWT fish released from each of the locations where groups containing only unmarked hatchery fish have been released (i.e., Battle Creek, Feather River, Sacramento River at Verona, and Sacramento River at Red Bluff Diversion Dam) to the entry (Sacramento Trawl Site) and exit (Chipps Island Trawl Site) locations of the Delta (Table 1). To incorporate uncertainty, we defined the periods of occupancy using the time (i.e., days) between when the first and last 2.5% of marked fish were detected at either Sacramento or Chipps Island relative to the release date of unmarked hatchery groups (Table 1). CWT fish released in the Sacramento River at Verona and the Red Bluff Diversion Dam took longer to reach the Chipps Island and Sacramento trawl sites than CWT fish released at Battle Creek or Feather River. The longer travel times may have been the result of fewer observations of CWT fish originating from the Sacramento River at Verona and the Red Bluff Diversion Dam release sites, resulting in higher uncertainty in the estimated days of occupancy within the Delta. Alternatively, the releases at Verona and the Red Bluff Diversion Dam may have contained higher proportions of fry (Pat Brandes, USFWS, personal communication), which move less quickly through the Delta than smolts (Kjelson et al. 1982) and may have caused the longer travel times.

Table 1. The estimated period (days) of occupancy of CWT fish between when CWT fish were released at locations where unmarked releases occurred and captured at the Chipps Island and Sacramento trawl sites during the 2000–2013 field seasons.

Release location	Capture location (trawl site)	N (# of CWT fish observed)	Days between capture of first 2.5% of fish and release date	Days between capture of last 2.5% of fish and release date	Estimated days of occupancy within Delta
Battle Creek	Chipps Island	3613	7	30	25
	Sacramento	2223	5	21	
Feather River	Chipps Island	1292	4	33	33
	Sacramento	190	2	35	
Sacramento River at Verona	Chipps Island	67	24	76	74
	Sacramento	107	2	28	
Sacramento River at Red Bluff Diversion Dam	Chipps Island	121	28	75	71
	Sacramento	30	4	66	

Relative Abundance Calculations

We standardized the samples collected within a day for each assemblage and for the origin groups of winter-run and the fall-, late fall-, and spring-run group of juvenile Chinook Salmon to catch-per-unit effort (CPUE) as fish per unit volume sampled (fish/10,000 m^3) using the following equations:

$$Seine\ CPUE_d = \frac{\sum(Catch_s)}{\sum(0.5 \cdot Depth_s \cdot Width_s \cdot Length_s)} \cdot 10{,}000 \tag{3}$$

$$Trawl\ CPUE_d = \frac{\sum(Catch_s)}{\sum(Distance\ traveled_s \cdot Net\ mouth\ area)} \cdot 10{,}000 \quad (4)$$

where s indexes individual samples (i.e., a beach seine haul or trawl tow), and d indexes sample days. 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 0.5 multiplied by the depth. 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).

We examined the spatial and temporal trends of the relative abundance by averaging and comparing CPUE estimates at monthly and yearly scales. The primary assumption associated with these CPUE comparisons is that gear efficiency (i.e., detection probabilities) is constant over time at each trawl or seine site, and comparable among trawl sites and seine regions. We treated Chinook Salmon races and origin groups or assemblage groups, 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 weekly, monthly, and yearly CPUE averages to minimize the overweighting of sample days and/or locations. To limit the bias of diel effects or variable gear efficiency on CPUE value comparisons, we only averaged samples collected between 07:00 am and 04:00 pm, and excluded those of poor condition (i.e., compromised gear deployment) within our calculations.

The mean weekly CPUE was calculated for each trawl site and seine region as the sum of the 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. However, sample weeks including the first or last day of the field season only included days falling within the field season. 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 last sample week of September and March of the 2013 field season included September 1 or March 1, respectively, which is when we switched between gear types (MWTR and KDTR) at the Sacramento Trawl Site. Therefore, we presented the monthly CPUE averages for both KDTR and MWTR samples during September and March of the 2013 field season. This also resulted in the KDTR CPUE for September and the MWTR CPUE for March of the 2013 field season at the Sacramento Trawl Site being each generated from only 3 sample days, occurring in 1 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.

We calculated and graphed the mean monthly CPUE of Chinook Salmon and assemblage groups to make intra-annual comparisons during the 2012 and 2013 field seasons. For inter-annual comparisons of CPUE for juvenile Chinook Salmon and assemblage groups, we calculated and graphed mean yearly CPUE values starting in the 2000 field season for most trawl sites and seine regions. Confidence limits were omitted from the CPUE figures since uncertainty could not be accurately quantified after the computational series of averages. Thus, values presented are estimates and may incorporate a high degree of uncertainty.

In general, sampling methods have remained consistent from the 2000 field season to the present, including year-round sampling and standardized methods and gears. However, we calculated mean yearly CPUE values for the Mossdale Trawl Site only during the 2004 through 2013 field seasons for juvenile Chinook Salmon and assemblage groups because the start of year-round collaborative sampling with the CDFW 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. We did not report April through June data prior to 2004 because the DJFMP was not involved in the sampling, and these data have been already reported annually by the CDFW. We also calculated mean yearly CPUE values during the 1995 through 2013 field seasons year-round for both race groups of juvenile Chinook Salmon at the Chipps Island Trawl Site, based on 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. We calculated mean yearly CPUE values using April through June at the Chipps Island Trawl Site during the 1978 through 2013 field seasons for juvenile fall-, late fall-, and spring-run Chinook Salmon to extend our historical coverage. Though the relative abundances for the fall-, late fall-, and spring-run race groups are not presented individually, the total catch of each race of juvenile Chinook Salmon caught in the 2012 and 2013 field seasons can be found in Tables A.3 and A.4.

Absolute Abundance Calculation

The absolute abundances of juvenile Chinook Salmon of each origin group of winter-run and the combined fall-, late fall-, and spring-run group immigrating into and emigrating out of the Delta were estimated on a monthly scale from the 1978 to 2013 field seasons using the data collected at the Sacramento, Mossdale, and Chipps Island trawl sites. Annual comparisons of the absolute abundance of juvenile Chinook Salmon were limited to years and months when sampling was relatively consistent. The monthly absolute abundance (*N*) of (1) marked, (2) natural origin, (3) hatchery origin, and (4) unknown origin juvenile Chinook Salmon for both the juvenile winter-run, and fall-, late fall-, and spring-run groups were estimated using the methods modified from USFWS (1987) as:

$$N_i = \frac{n_i}{t_i \cdot \overline{\overline{TRR}}} \tag{5}$$

where i indexes months, n_i represents the total number of juveniles collected at the trawl site during a month, t_i represents the fraction of time the trawl site was sampled during a month, and $\overline{TRR}$ represents the mean trawl recovery rate at the trawl site. The assumption of this approach is that juvenile salmon are equally distributed in time as they migrate past the trawl sites and are never recaptured. It also assumes that the efficiency of the trawls is constant in space (i.e., throughout all sampling conditions) and time (i.e., within and among months).

The trawl recovery rate (*TRR*) for the Chipps Island trawl was estimated using the capture of CWT juvenile Chinook Salmon released approximately 10 and 12 km upstream of the Chipps Island Trawl Site at Sherman Island or Jersey Point. We estimated the *TRR* for the Sacramento trawl using the capture of CWT juvenile Chinook Salmon released approximately 4 and 8 km upstream of the Sacramento Trawl Site at Miller Park and the Broderick Boat Ramp, respectively. The *TRR* was calculated separately for the MWTR and KDTR nets used at the Sacramento Trawl Site to reflect possible differences in net efficiency. Lastly, we estimated the *TRR* for the Mossdale trawl using the capture of CWT and dye marked juvenile Chinook Salmon released approximately 3 km upstream of the Mossdale Trawl Site at Mossdale Crossing. The *TRR* for each trawl site was calculated as:

$$TRR_k = \frac{n_{recovered}}{n_{available}} \qquad (6)$$

where k indexes release groups at a release site, $n_{recovered}$ represents the total number of CWT juvenile Chinook Salmon within a release group collected at the trawl site, and $n_{available}$ represents the number of CWT juvenile Chinook Salmon within a release group available for collection at the 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:

$$n_{available} = n_{released} \cdot t \qquad (7)$$

where $n_{released}$ represents the total number of CWT juvenile Chinook Salmon within a release group and t represents the fraction of time the 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 similarly tagged or marked (CWT or spray dyed) juvenile Chinook Salmon that had the same hatchery origin and were released at the same location and time. A total of 102 CWT releases have occurred at Sherman Island or Jersey Point between the 1989 to 2013 field seasons. Forty-seven CWT releases have occurred at Miller Park and Broderick Boat Ramp between the 1988 and 2009 field seasons. We calculated the $\overline{TRR}$ for the Chipps Island Trawl Site and the Sacramento Trawl Site using the recoveries from all the groups released at Sherman Island and Jersey Point, and at Miller Park and Broderick Boat Ramp, respectively, to maximize sample size and obtain a more robust estimate. The average fork lengths for the release groups near Chipps Island and Sacramento trawl sites ranged from 70–179 mm and 56–138 mm, respectively, which corresponds to the majority of unmarked juvenile Chinook Salmon historically collected at these locations. All CWT release group data were obtained through the Regional Mark Information System (PSMFC 2014).

A total of five CWT releases have occurred at Mossdale Crossing since the 2003 field season. There were two releases that were listed as Jersey Point, however RMIS notes that a proportion of the fish were released at Mossdale due to truck malfunction (PSMFC 2014). These fish were not included in the efficiency estimate because of the uncertainty associated with their release information. In addition, the CDFW has released 48 stain dye marked groups of hatchery reared juvenile Chinook Salmon at Mossdale Crossing to estimate trawl efficiency at the Mossdale Trawl Site since the 1997 field season (SJRGA 2009; Steve Tsao, CDFW, personal communication). To maximize sample size, we estimated the $\overline{TRR}$ for the Mossdale Trawl Site using the recoveries of all CWT and spray dye release groups. Although the stain dye releases often reused marks (i.e., dye colors) within seasons, these releases were spaced at least 7 days apart and we determined that approximately 98% of CWT individuals released at Mossdale Crossing were detected at the Mossdale Trawl Site within 7 days from being released.

The $\overline{TRR}$ was calculated for each trawl site 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 interval (CI). The intervals should be considered minimum confidence limits because they only incorporate the uncertainty associated with the $\overline{TRR}$ estimates. We calculated absolute abundance estimates at the Chipps Island Trawl Site from April through June during the 1978 through 2013 field seasons for fall-, late fall-, and spring-run juvenile Chinook Salmon. We also calculated annual absolute abundance estimates during the 1995–2013, 2000–2013, and 2004–2013 field seasons at the Chipps Island, Sacramento, and Mossdale trawl sites, respectively, for both winter-run and the fall-, late fall-, and spring-run group of Chinook Salmon.

Length Frequency

We plotted length frequency distributions for all unmarked juvenile Chinook Salmon during the 2012 and 2013 field seasons for each seine region and trawl site. In cases where Chinook Salmon were "plus counted" (i.e., only counted and 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 categorized the race of unmarked juvenile Chinook Salmon using the river LDC, 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.

River Flow Conditions

River flow data were obtained from the USGS and CDWR (USGS 2014; CDWR 2014a). 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, estimates of the daily Delta outflow past Chipps Island towards the San Francisco Bay, which takes into account water exports, were obtained from Dayflow (CDWR 2014a). We also obtained water year type classifications for the Sacramento and San Joaquin River basins from the California Data Exchange Center (CDWR 2014b).

We presented the mean monthly CPUE of Chinook Salmon races and fish assemblage groups along with mean monthly discharge during the 2012 and 2013 field seasons. Similarly, we compared the yearly CPUE of Chinook Salmon races and fish assemblage groups along with mean yearly discharge at each trawl site and seine region. The CPUE of fishes within the Lower Sacramento River Seine Region, 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. These comparisons were selected to broadly represent what fish experience, in terms of average daily flow, at the sampling locations.

Results and Discussion

During the 2012 and 2013 field seasons, 8,659 trawl samples were collected without any severe gear malfunctions. We completed 2,306 trawls at the Chipps Island Trawl Site, 3,496 trawls at the Mossdale Trawl Site, and 2,857 trawls at the Sacramento Trawl Site. The trawl tows were evenly distributed throughout the 2012 and 2013 field seasons (Tables A.5 and A.6). As a result, we considered the inter- and intra-annual trawl catch comparisons robust due to minimal spatial and temporal bias.

During the 2012 and 2013 field seasons, 4,005 seine samples were collected without any severe gear malfunctions. There was considerable spatial and temporal variability in the number of samples collected at sites within nearly all seine regions during the 2012 and 2013 field seasons (Tables A.7–A.18), similar to the 2010 and 2011 field seasons (Speegle et al. 2013). For example, on average approximately 46% and 49% of the historically sampled sites within the South Delta Seine Region were effectively sampled during sample weeks within the 2012 and 2013 field seasons, respectively (Tables A.13 and A.14). The number of samples collected within the South Delta Seine Region during the 2012 (n=246) and 2013 (n=261) field seasons were considerably lower than the previous decade's annual average ($\bar{x}$=329, SE=15.7). In addition, on average approximately 44% and 62% of the historically sampled sites within the Lower San Joaquin Seine Region were effectively sampled during sample weeks within the 2012 and 2013 field seasons, respectively (Tables A.15 and A.16). As a result, catch data associated with these seine regions may contain both inter- and intra-annual bias.

Throughout the 2012 and 2013 field seasons, the inability to effectively sample seine sites resulted from high tides, the expansion of submerged, emergent, and floating aquatic vegetation, and low river discharge (Table A.19). The DJFMP is currently investigating the feasibility of implementing a stratified random sampling design for boat electrofishing to supplement beach seining within the San Francisco Estuary. New sampling methods are needed to re-establish and ensure future continuity of non-biased representative catch data within near-shore littoral habitats within the lower rivers and Delta.

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 documents the presence of fishes at a given time and location (Tables A.5–A.18). However, detection probability and the probability of reporting false absences (present but not captured) remain unknown.

Water Quality

We collected 43,052 water quality samples during the 2012 and 2013 field seasons: 12,619 water temperature, 10,393 conductivity, 10,313 dissolved oxygen, and 9,727 turbidity samples. The intra-annual variability in water temperature was consistent among the beach seine regions and trawl sites during the 2012 and 2013 field seasons (Figures 8 and 9). Temperature ranged from 4.4 to 27.4°C among our seine regions and trawl sites during the 2012 field season and 4.7 to 30.2°C during the 2013 field season. Water temperatures, on average, were highest within the lower San Joaquin River and South Delta regions relative to other regions during the summer of both field seasons. Further, the summer temperatures were, on average, higher during the 2013 field season relative to the 2012 field season within the lower San Joaquin River and South Delta. Temperatures often exceeded 25°C during the summer (June through August) of the 2013 field season, a critically dry year within the San Joaquin River Basin (Table A.19).

We observed dissolved oxygen values ranging from 2.3 to 17.3 mg/L among our seine regions and trawl sites during the 2012 field season and 1.4 to 19.5 mg/L among our seine regions and trawl sites during the 2013 field season (Figures 10 and 11). In general, dissolved oxygen was highest during the winter season and lowest during the summer season for all seine regions and trawl sites during both field seasons. On average, dissolved oxygen varied more within the Lower San Joaquin River and South Delta seine regions, and at the Mossdale Trawl Site from May to August during both field seasons. During the 2013 field season, we observed the dissolved oxygen increase to above 12 mg/L at the Mossdale Trawl Site starting in May and decrease to less than 3 mg/L during June and July. This is likely due to agricultural nutrient inputs supporting increased primary production followed by increased bacterial respiration supported by excess nutrients or increased detritus from aquatic plants and algae (Dunne and Leopold 1978).

Turbidity samples ranged from 2 to 638 NTU and 1 to 384 NTU during the 2012 and 2013 field seasons, respectively (Figures 12 and 13). In general, the turbidity was lower within the Central Delta and South Delta seine regions relative to other regions throughout most of the year. In addition, the turbidity varied considerably within the San Pablo Bay Seine Region possibly due to wind and wave erosion during the spring and summer seasons. We also observed increased turbidity in December during the 2013 field season in all seine regions and trawl sites, possibly resulting from increased precipitation and discharge.

Conductivity varied considerably among trawls sites and seine regions during the 2012 and 2013 field seasons (Figures 14 and 15). We observed that conductivity was highest across all months within the San Francisco and San Pablo Bay Seine Region. This was expected because the San Francisco and San Pablo Bay Seine Region is the closest in proximity to the Pacific Ocean and is the seine region most similar to a marine environment. Conversely, the conductivity within the Lower Sacramento River and North Delta seine regions, and at the Sacramento and Mossdale trawl sites, were lower and more consistent relative to other monitoring locations, which may be due to these sites being less exposed to tidal exchange. The conductance within the South Delta and lower San Joaquin River seine regions, and at the Chipps Island Trawl Site, were the most variable within and among months, possibly due to agricultural inputs, water operations, and tidal exchange. Little distinct inter-annual patterns were observed.

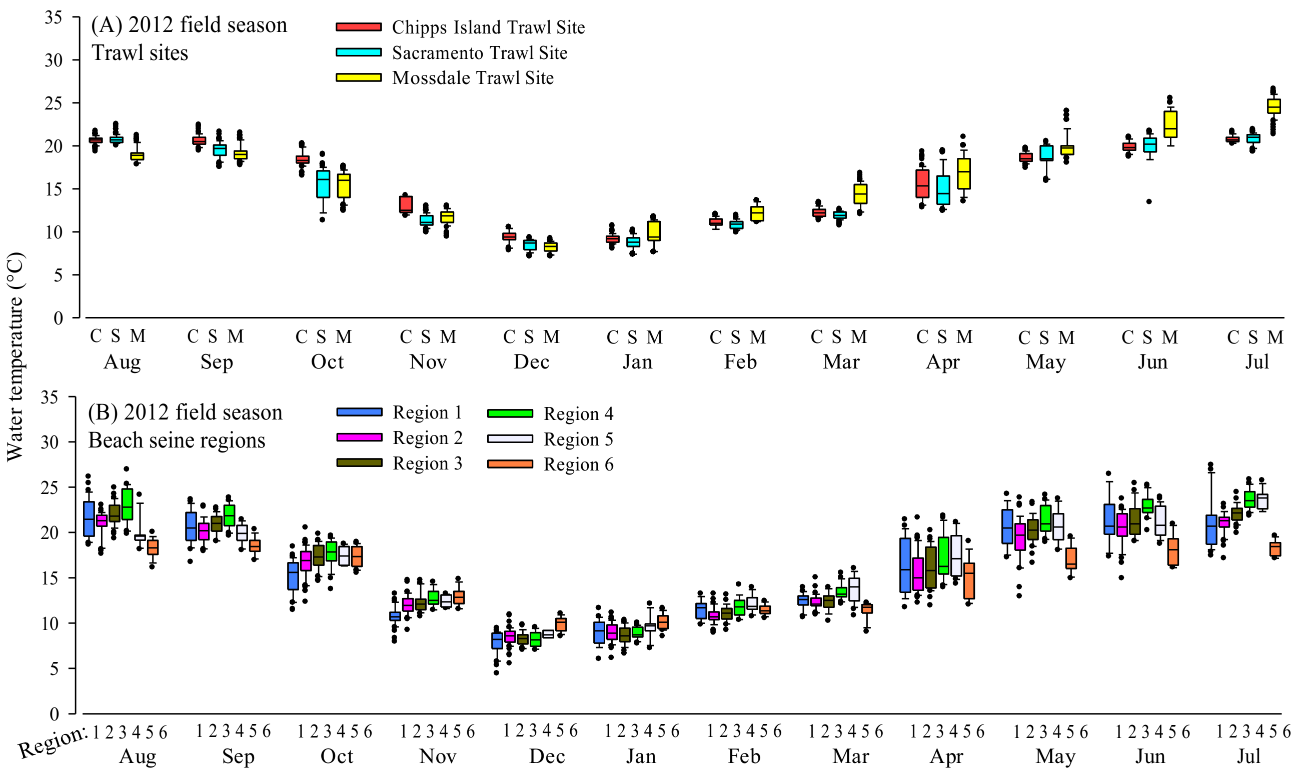

Figure 8. Water temperature data collected by month during sampling at the **(A)** Chipps Island (C), Sacramento (S), and Mossdale (M) trawl sites and within the **(B)** Lower Sacramento River (Region 1), North Delta (Region 2), Central Delta (Region 3), South Delta (Region 4), Lower San Joaquin River (Region 5), and San Francisco and San Pablo Bay (Region 6) seine regions during the 2012 field season. The boxes represent the 25th and 75th percentiles, the line within the box represents the median, the whiskers represent the 10th and 90th percentiles, and points represent outliers.

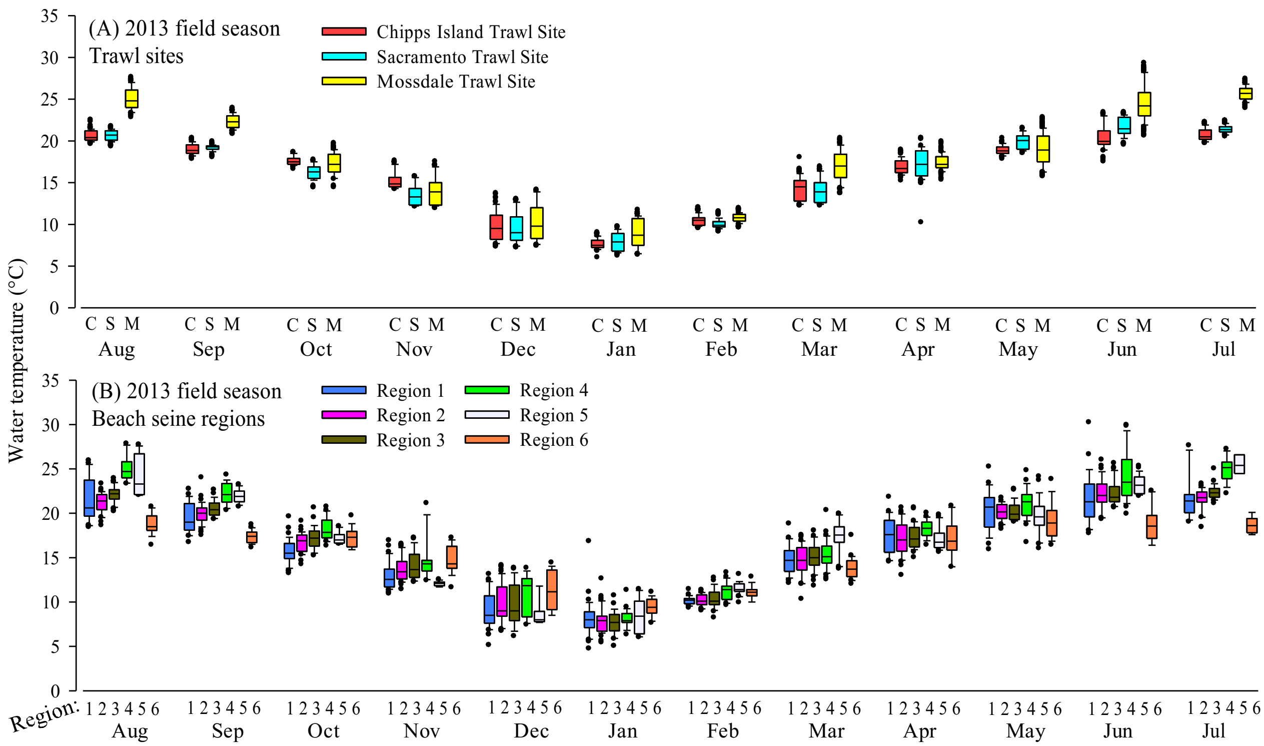

Figure 9. Water temperature data collected by month during sampling at the **(A)** Chipps Island (C), Sacramento (S), and Mossdale (M) trawl sites and within the **(B)** Lower Sacramento River (Region 1), North Delta (Region 2), Central Delta (Region 3), South Delta (Region 4), Lower San Joaquin River (Region 5), and San Francisco and San Pablo Bay (Region 6) seine regions during the 2013 field season. The boxes represent the 25th and 75th percentiles, the line within the box represents the median, the whiskers represent the 10th and 90th percentiles, and points represent outliers.

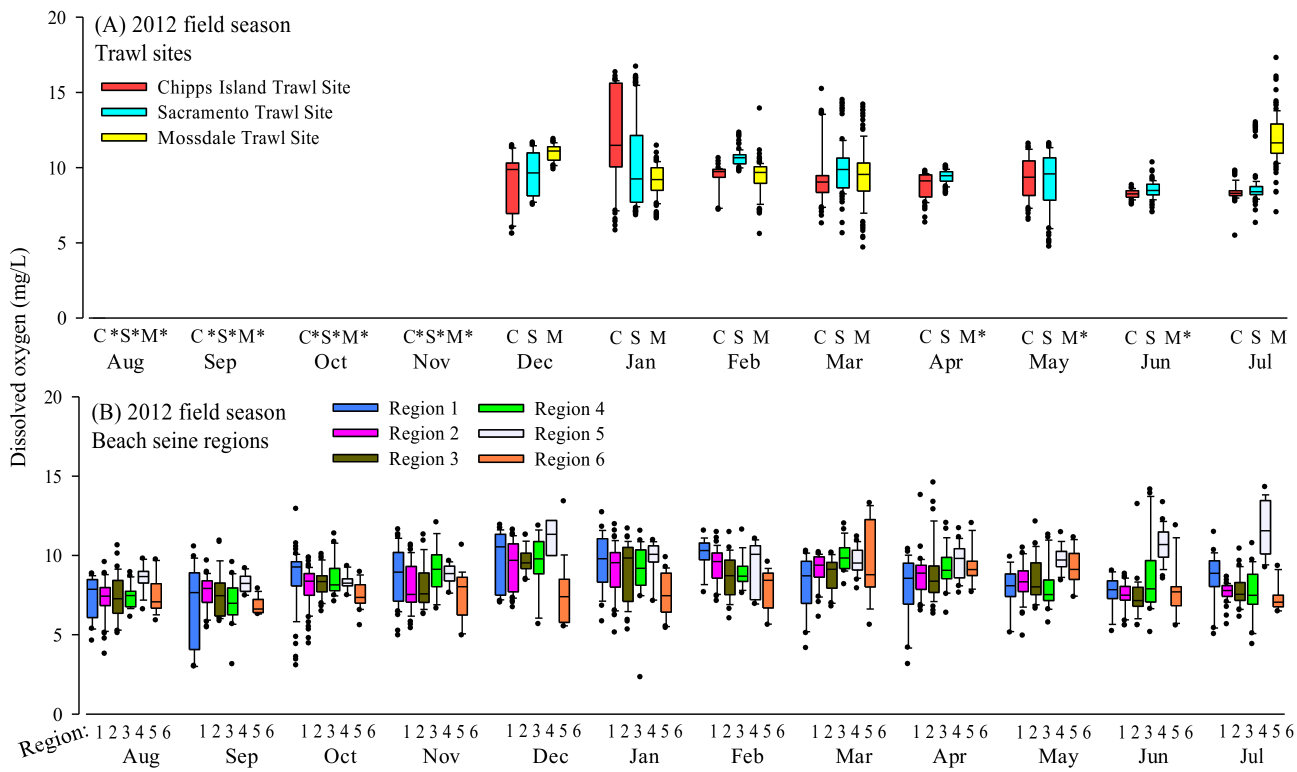

Figure 10. Dissolved oxygen data collected by month during sampling at the **(A)** Chipps Island (C), Sacramento (S), and Mossdale (M) trawl sites and within the **(B)** Lower Sacramento River (Region 1), North Delta (Region 2), Central Delta (Region 3), South Delta (Region 4), Lower San Joaquin River (Region 5), and San Francisco and San Pablo Bay (Region 6) seine regions during the 2012 field season. The boxes represent the 25th and 75th percentiles, the line within the box represents the median, the whiskers represent the 10th and 90th percentiles, and points represent outliers. *Dissolved oxygen not sampled.

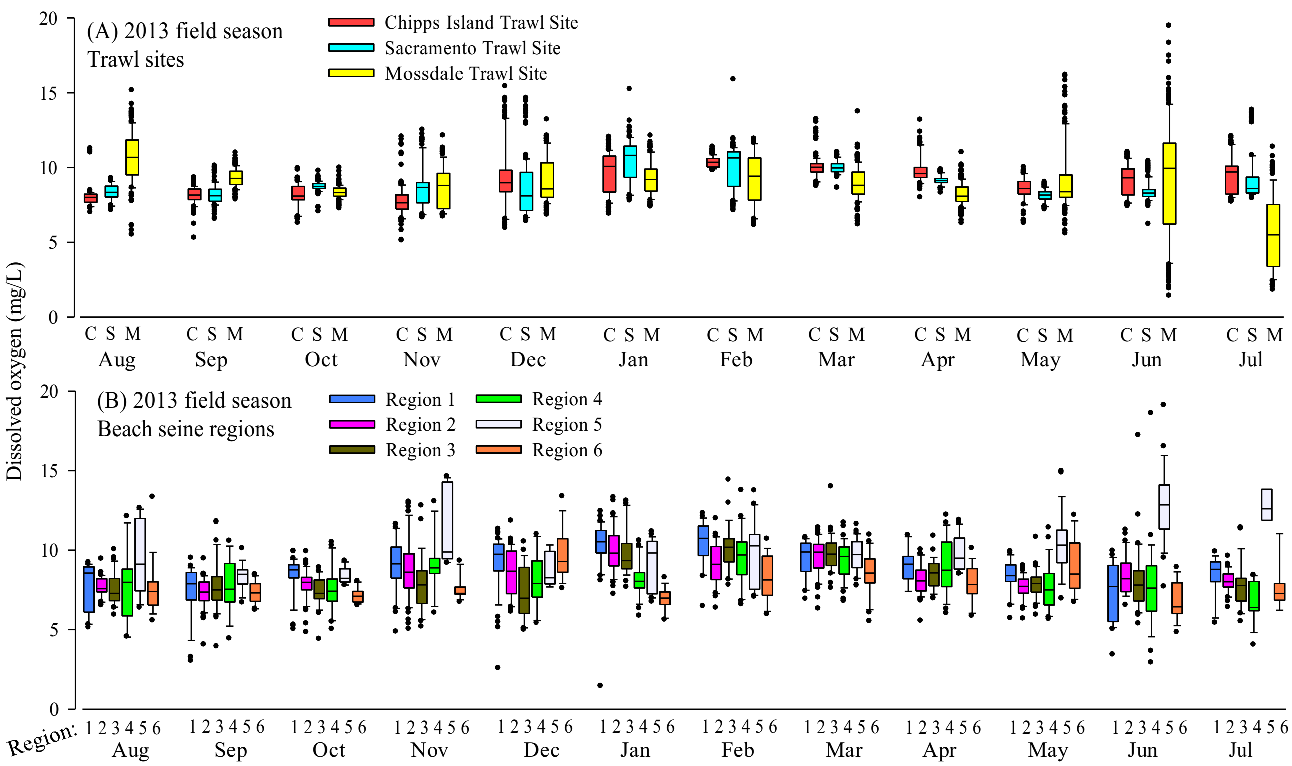

Figure 11. Dissolved oxygen data collected by month during sampling at the **(A)** Chipps Island (C), Sacramento (S), and Mossdale (M) trawl sites and within the **(B)** Lower Sacramento River (Region 1), North Delta (Region 2), Central Delta (Region 3), South Delta (Region 4), Lower San Joaquin River (Region 5), and San Francisco and San Pablo Bay (Region 6) seine regions during the 2013 field season. The boxes represent the 25^{th} and 75^{th} percentiles, the line within the box represents the median, the whiskers represent the 10^{th} and 90^{th} percentiles, and points represent outliers.

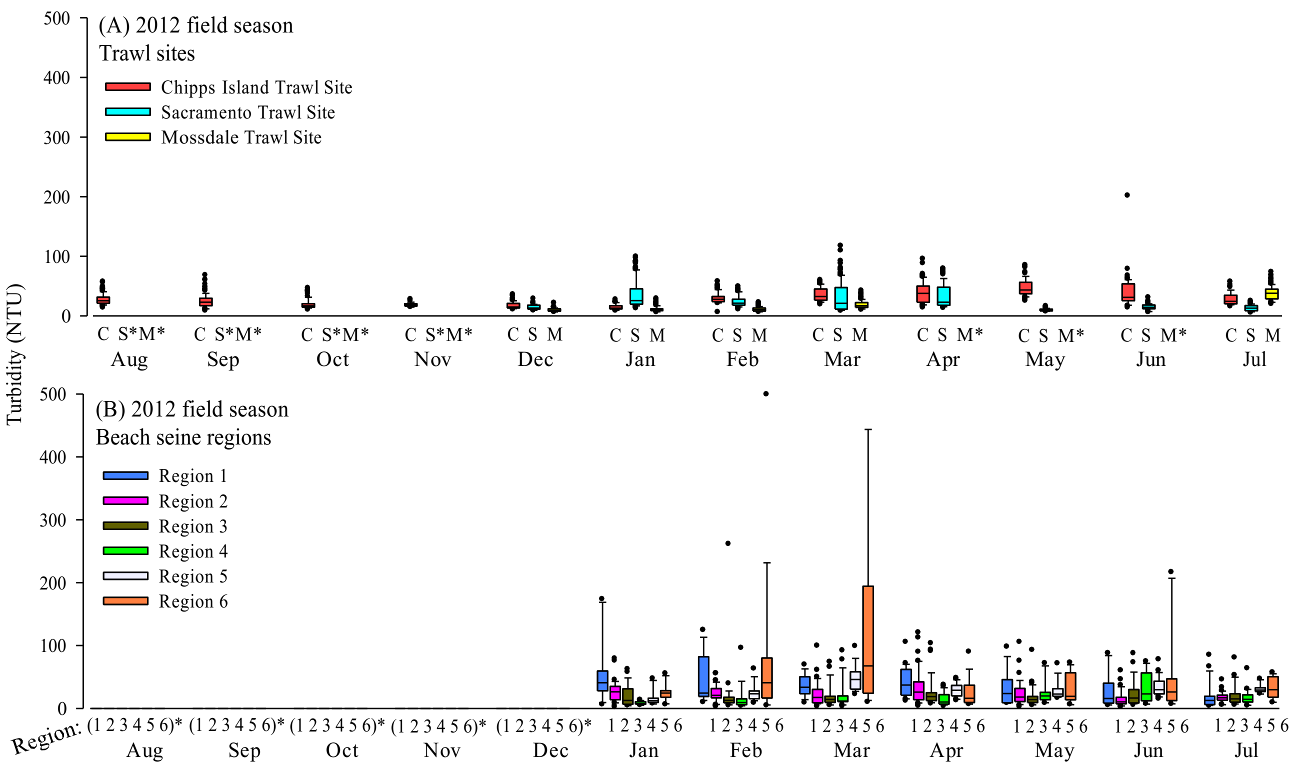

Figure 12. Turbidity data collected by month during sampling at the **(A)** Chipps Island (C), Sacramento (S), and Mossdale (M) trawl sites and within the **(B)** Lower Sacramento River (Region 1), North Delta (Region 2), Central Delta (Region 3), South Delta (Region 4), Lower San Joaquin River (Region 5), and San Francisco and San Pablo Bay (Region 6) seine regions during the 2012 field season. The boxes represent the 25th and 75th percentiles, the line within the box represents the median, the whiskers represent the 10th and 90th percentiles, and points represent outliers. *Turbidity not sampled.

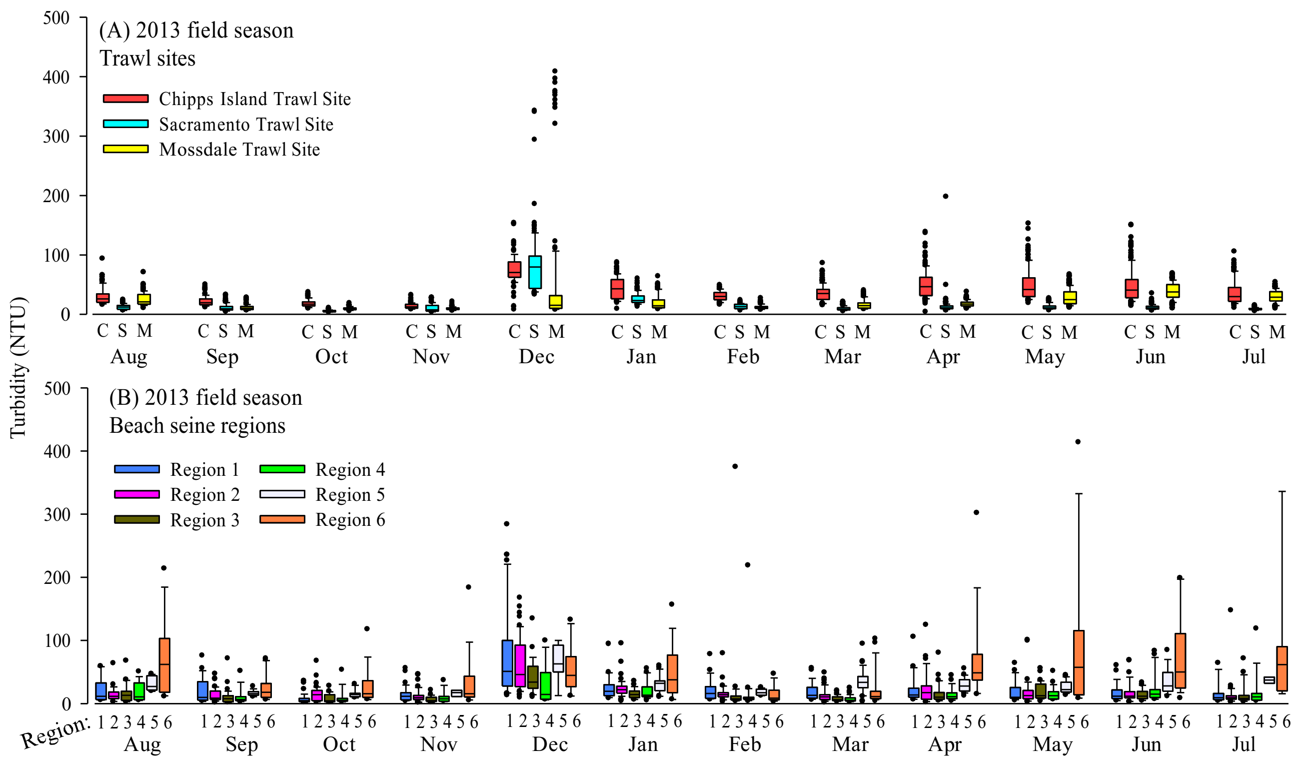

Figure 13. Turbidity data collected by month during sampling at the **(A)** Chipps Island (C), Sacramento (S), and Mossdale (M) trawl sites and within the **(B)** Lower Sacramento River (Region 1), North Delta (Region 2), Central Delta (Region 3), South Delta (Region 4), Lower San Joaquin River (Region 5), and San Francisco and San Pablo Bay (Region 6) seine regions during the 2013 field season. The boxes represent the 25th and 75th percentiles, the line within the box represents the median, the whiskers represent the 10th and 90th percentiles, and points represent outliers.

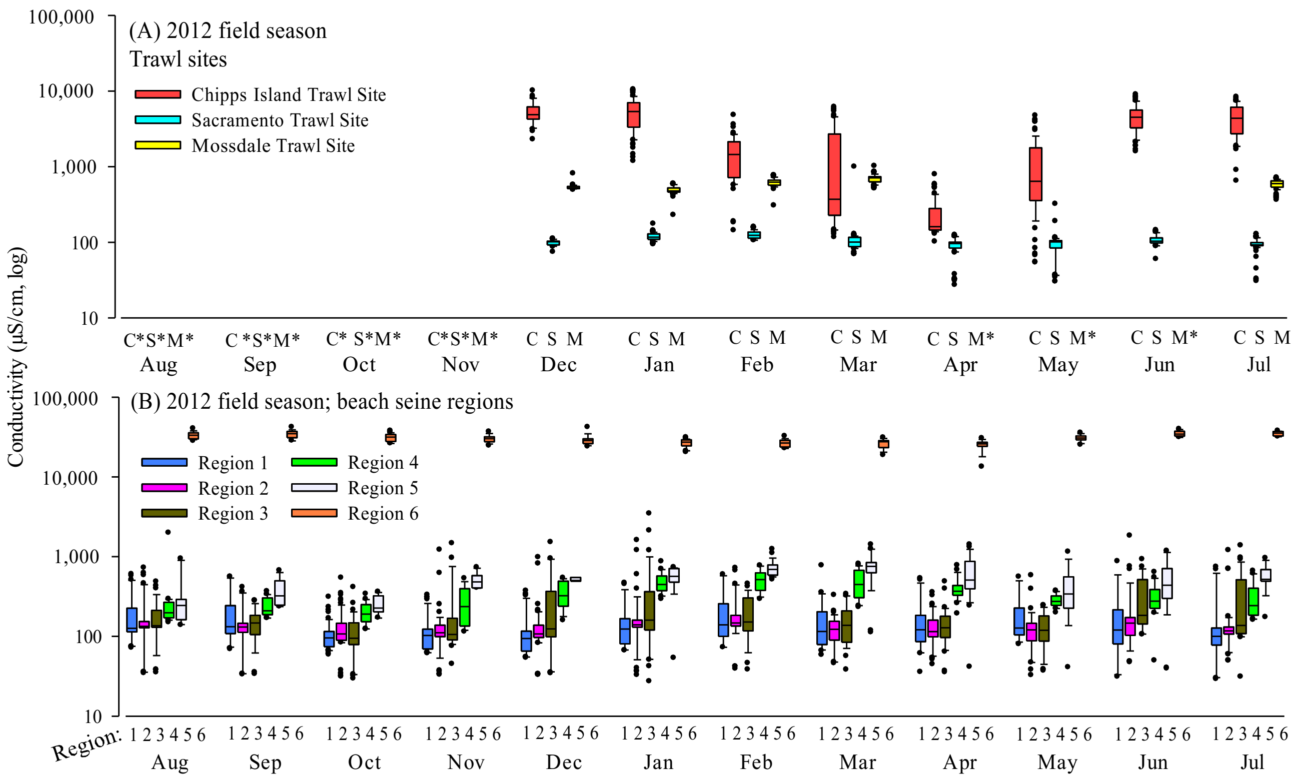

Figure 14. Conductivity data collected by month during sampling at the **(A)** Chipps Island (C), Sacramento (S), and Mossdale (M) trawl sites and within the **(B)** Lower Sacramento River (Region 1), North Delta (Region 2), Central Delta (Region 3), South Delta (Region 4), Lower San Joaquin River (Region 5), and San Francisco and San Pablo Bay (Region 6) seine regions during the 2012 field season. The boxes represent the 25th and 75th percentiles, the line within the box represents the median, the whiskers represent the 10th and 90th percentiles, and points represent outliers. The y-axis is presented on a common log scale. *Conductivity not sampled.

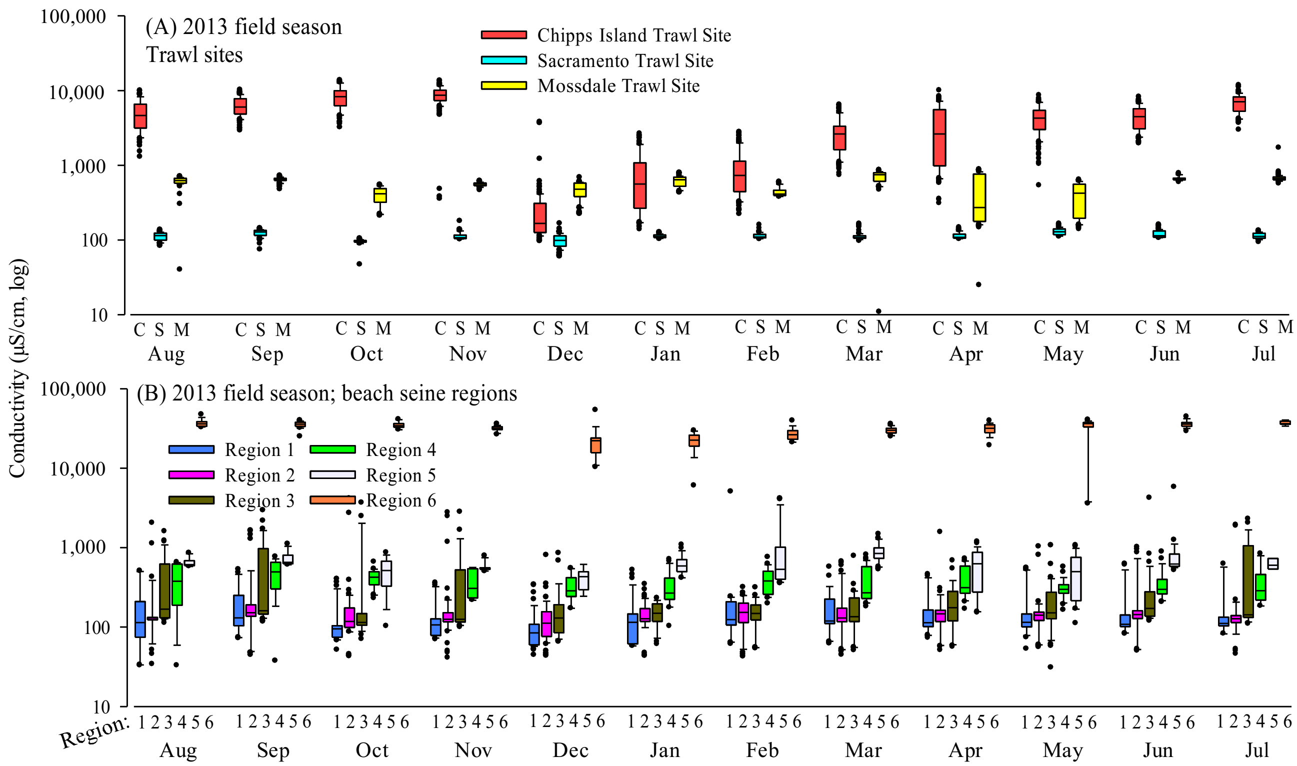

Figure 15. Conductivity data collected by month during sampling at the **(A)** Chipps Island (C), Sacramento (S), and Mossdale (M) trawl sites and within the **(B)** Lower Sacramento River (Region 1), North Delta (Region 2), Central Delta (Region 3), South Delta (Region 4), Lower San Joaquin River (Region 5), and San Francisco and San Pablo Bay (Region 6) seine regions during the 2013 field season. The boxes represent the 25th and 75th percentiles, the line within the box represents the median, the whiskers represent the 10th and 90th percentiles, and points represent outliers. The y-axis is presented on a common log scale.

Fish Assemblage

A total of 355,181 fishes, representing 83 species, was collected within samples (beach seines and trawls) used for assemblage analyses during the 2012 and 2013 field seasons (does not include marked or unidentified fish; Tables A.3 and A.4). Sixty-five percent (n=229,145) of the fishes were observed during the 2013 field season. Approximately 70% (n=88,373) and 81% (n=184,648) of the fishes captured during the 2012 and 2013 field seasons, respectively, were identified as species not native to the San Francisco Estuary. Of the 83 species observed, the most abundant species were the Inland Silverside *Menidia beryllina*, juvenile Chinook Salmon, Red Shiner *Cyprinella lutrensis*, Sacramento Sucker, American Shad *Alosa sapidissima*, and Threadfin Shad *Dorosoma petenense*, which together comprised 74% and 87% of the total catch during the 2012 and 2013 field seasons, respectively.

In general, anadromous-pelagic-nonnative fishes dominated the catch at the Chipps Island Trawl Site during the 2012 and 2013 field seasons (Figure 16). Within this group, the American Shad was the most common species observed at the Chipps Island Trawl Site, and comprised 79% (n=19,959) and 63% (n=9,866) of the fishes captured during the 2012 and 2013 field seasons, respectively (Tables A.3 and A.4). Anadromous-pelagic-nonnative fishes (e.g., American Shad) dominated the catch at the Chipps Island Trawl Site from July to December (Figure 16). However, we observed that anadromous-pelagic-native fishes (e.g., juvenile Chinook Salmon) dominated the catch during most of the months between December and May. The mean yearly CPUE estimates suggested that anadromous-pelagic-native fishes have declined steadily at the Chipps Island Trawl Site since the 1996 field season. Anadromous-pelagic-nonnative fishes have also declined during this period; however this group appears to respond positively to improved outflow conditions.

During the 2012 and 2013 field seasons, the most common species captured at the Sacramento Trawl Site was juvenile Chinook Salmon (82%, n=4,788; Tables A.3 and A.4). We observed that these anadromous-pelagic-native fishes were generally captured between November and June, and their CPUE peaked in April during both field seasons (Figure 17). However, some nonnative anadromous and resident pelagic fishes were observed in relatively low densities from August to February. The mean yearly CPUE of anadromous-pelagic-native fishes has increased annually at the Sacramento Trawl Site since the 2010 field season. However, the mean yearly CPUE estimate remains below the 2000 to 2011 average (MWTR=7.38, KDTR=3.54).

The Inland Silverside was overall the most common species observed and comprised 55% (n=162,542) of the fishes captured at the Mossdale Trawl Site and in the Lower Sacramento River, North Delta, Central Delta, South Delta, and Lower San Joaquin River seine regions during the 2012 and 2013 field seasons (Tables A.3 and A.4). As a result, the pelagic-nonnative fishes dominated the observed fish assemblage within the Mossdale Trawl Site and most seine regions throughout both field seasons (Figures 18–20). We observed the majority of fishes at the Mossdale Trawl Site in July during both field seasons (Figure 18). This may be due to increased primary productivity within the lower San Joaquin River as indicated by dissolved oxygen samples (Figures 12 and 13). In general, pelagic-nonnative fishes dominated the observed assemblage in nearly all months at the Mossdale Trawl Site except April and May when anadromous-pelagic-native fishes (e.g., juvenile Chinook Salmon) were present. In addition to pelagic-nonnative fishes, the mean monthly CPUE estimates suggest that the fish assemblage within the North Delta and Lower Sacramento River seine regions contained considerable densities of anadromous-pelagic-native fishes from January to March and benthic-native fishes (e.g., lamprey and Sacramento Sucker; Tables A.3 and A.4) from April to July (Figure 19). The mean yearly CPUE estimates among beach seine regions and the Mossdale Trawl demonstrated that fish densities for most assemblage groups were relatively low during the 2012 field season and increased slightly in the 2013 field season, excluding the pelagic-nonnative fishes group which sharply increased in 2013 compared to past years (Figures 18 and 20).

Within the San Francisco and San Pablo Bay Seine Region, the Topsmelt *Atherinops affinis* was the most common fish species observed and comprised 68% (n=9,260) of all fishes captured during both the 2012 and 2013 field seasons (Tables A.3 and A.4). The mean monthly CPUE estimates suggested that pelagic-nonnative fishes were observed in higher proportions within and among all field seasons relative to other assemblages groups (Figures 19 and 20). Nearly all fishes observed within this seine region, including Topsmelt, are considered marine fish presumably due to the higher conductivity within the region (Figures 14 and 15). In general, we cannot discern any temporal patterns from monthly or yearly CPUE estimates in this region for any fish assemblage group due to relatively low catch numbers.

There was an overall increase of nonnative fishes captured during the 2013 field season from the 2012 field season (n=184,648 and n=88,373, respectively; Tables A.3 and A.4). Many of the nonnative resident fishes that dominated our assemblage groups (e.g., Inland Silverside and Red Shiner) originate from unstable, stagnant, warm water environments (Moyle 2002). The 2013 field season was the second year of drought (Table A.19), which may have produced water quality conditions more favorable to these species. Likely for this reason, we observed that water temperatures generally increased in the 2013 field season relative to the 2012 field season, particularly within the South Delta and San Joaquin River seine regions (Figures 8 and 9). Further, we determined that the 2013 field season had the highest proportion of nonnative resident fishes, especially within the South Delta and Lower San Joaquin River seine regions (Figure 20).

The overall higher densities of fishes in the 2013 field season correspond to a higher peak flow occurring earlier in the year than in 2012 (around 1400 m^3/sec in December of the 2013 field season for Delta Outflow and the discharge at the Sacramento River at Freeport versus 800 m^3/sec in April of 2012; Figures 16–20). The increased discharge observed at the Sacramento Trawl Site in 2013 may also explain the earlier occurrence of anadromous-pelagic-native fishes. In contrast, the increased outflow in March through April may explain the overall increased fish densities captured at Chipps Island in 2012. The later flows in the 2012 field season may have also extended the occurrence of the anadromous-pelagic-native fishes in the beach seines (Figure 20).

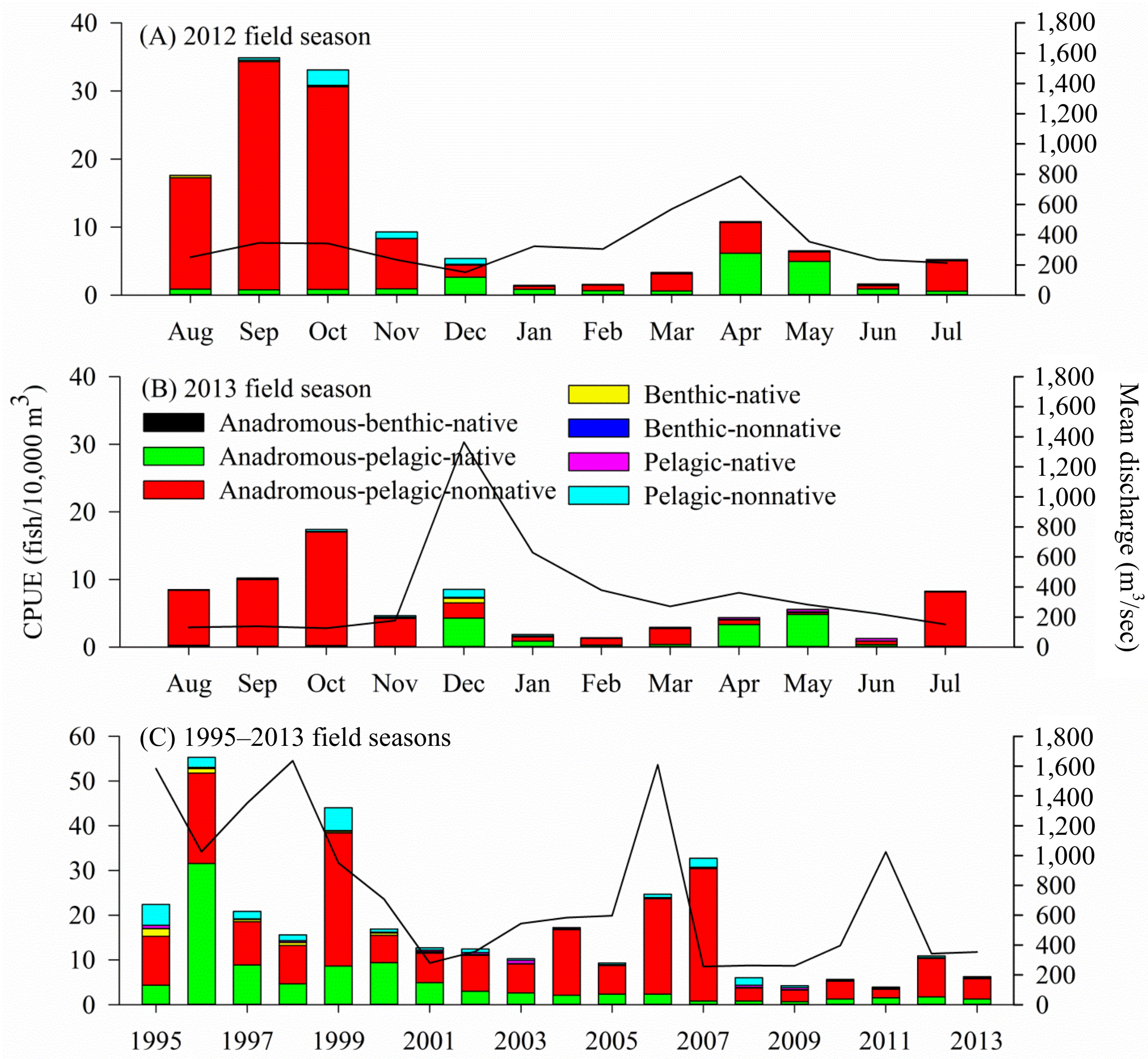

Figure 16. The mean monthly and yearly CPUE (bars) of juvenile fish assemblages captured in MWTRs at the Chipps Island Trawl Site, and the estimated mean monthly and yearly Delta outflow (solid line) during the **(A)** 2012, **(B)** 2013, and **(C)** 1995 through 2013 field seasons.

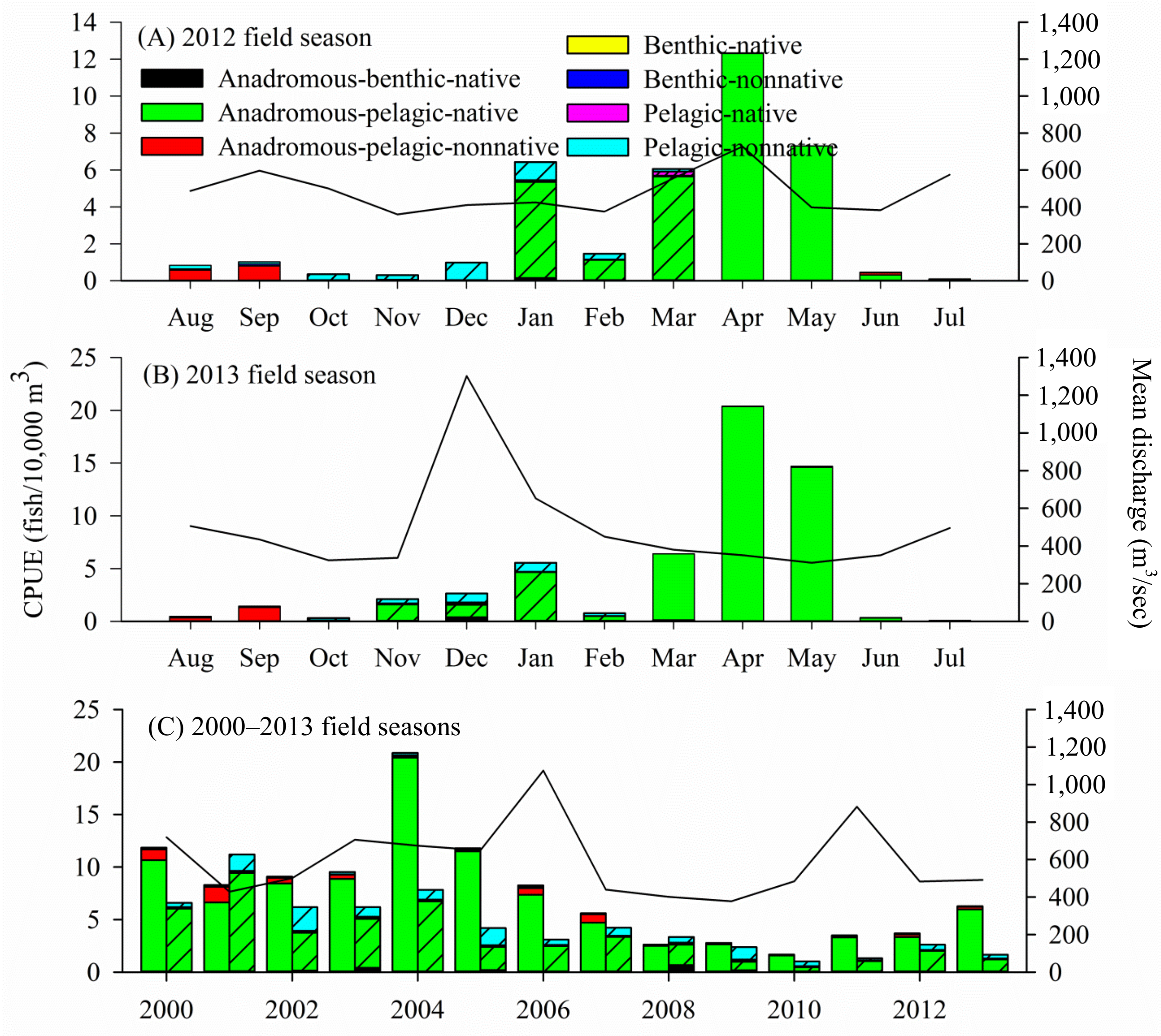

Figure 17. The mean monthly and yearly CPUE of juvenile fish assemblages captured in MWTRs (solid bars) and KDTRs (striped bars) at the Sacramento Trawl Site, and the mean monthly and yearly Sacramento River discharge at Freeport (solid line) during the **(A)** 2012, **(B)** 2013, and **(C)** 2000 through 2013 field seasons.

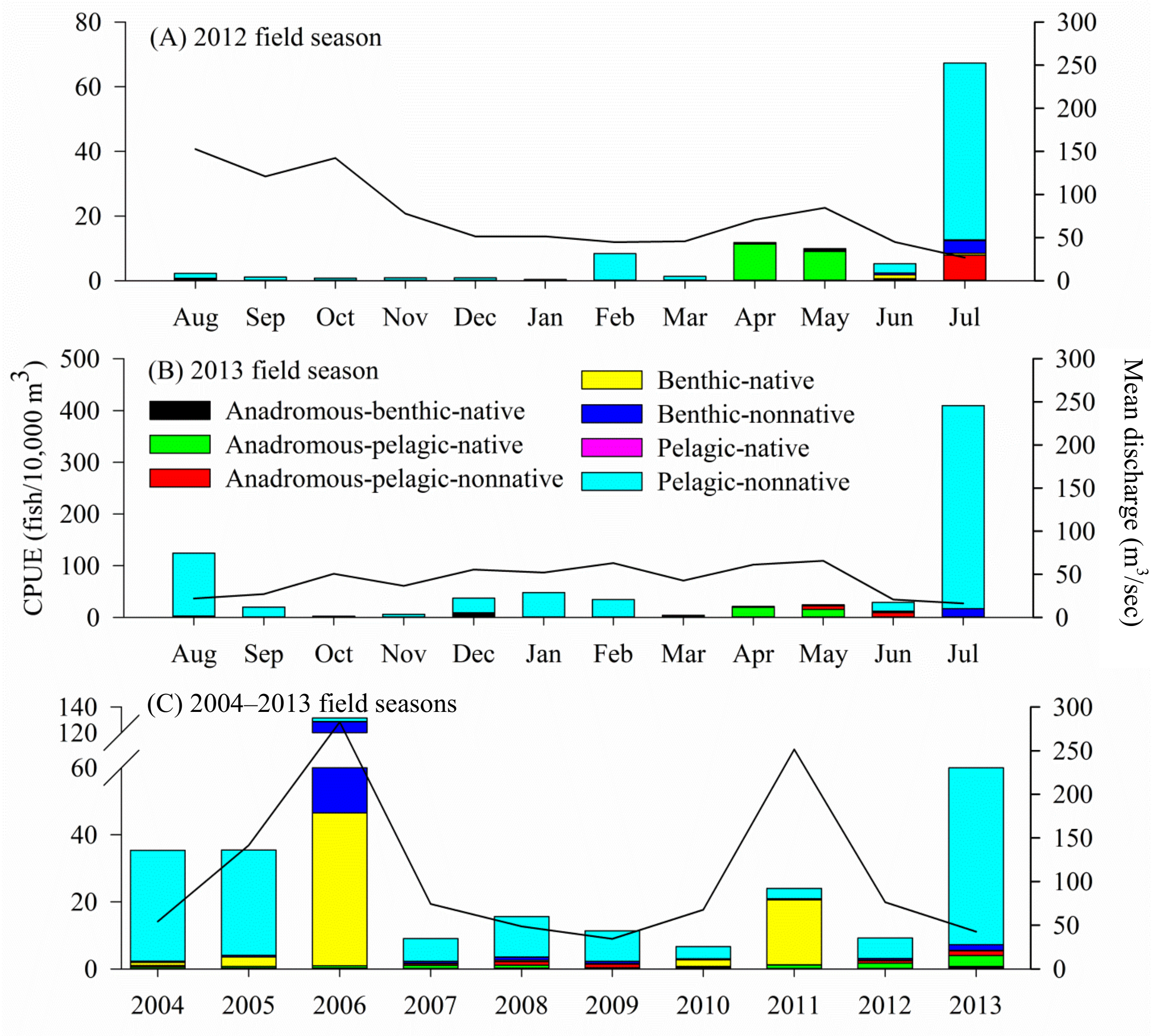

Figure 18. The mean monthly and yearly CPUE (bars) of juvenile fish assemblages captured in KDTRs at the Mossdale Trawl Site, and the mean monthly and yearly San Joaquin River discharge at Vernalis (solid line) during the **(A)** 2012, **(B)** 2013, and **(C)** 2004 through 2013 field seasons.

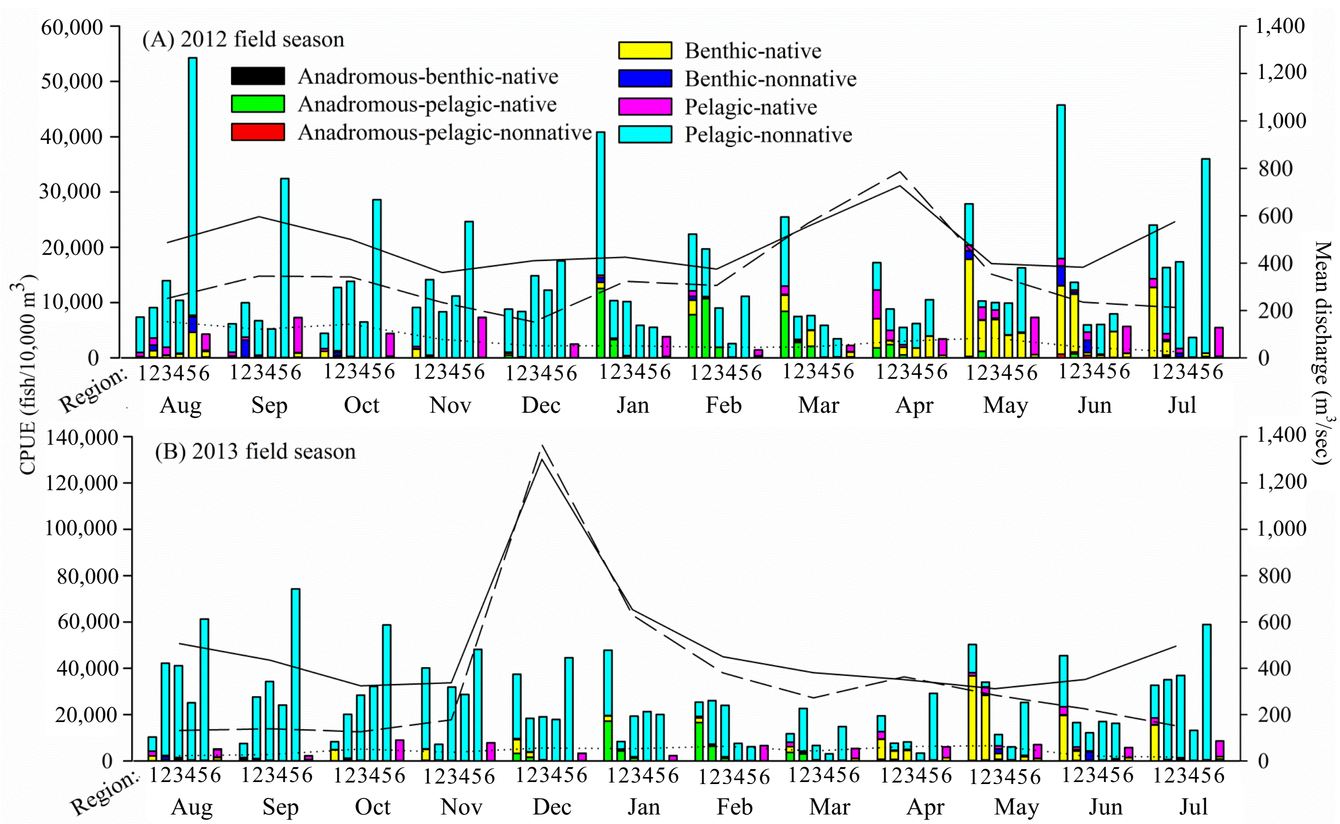

Figure 19. The mean monthly CPUE (bars) of juvenile fish assemblages captured within the Lower Sacramento River (1), North Delta (2), Central Delta (3), South Delta (4), Lower San Joaquin River (5), and San Francisco and San Pablo Bay (6) beach seine regions, and the estimated mean monthly and yearly Delta outflow (dashed line), Sacramento River discharge at Freeport (solid line), and San Joaquin River discharge at Vernalis (dotted line) during the **(A)** 2012 and **(B)** 2013 field seasons.

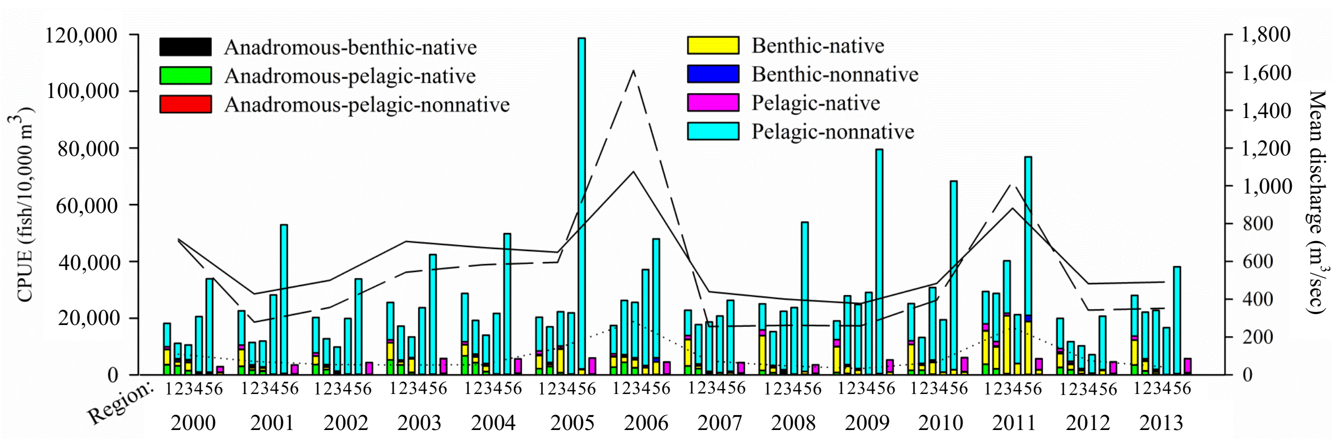

Figure 20. The mean yearly CPUE (bars) of juvenile fish assemblages captured within the Lower Sacramento River (1), North Delta (2), Central Delta (3), South Delta (4), Lower San Joaquin River (5), and San Francisco and San Pablo Bay (6) beach seine regions, and the estimated mean monthly and yearly Delta outflow (dashed line), Sacramento River discharge at Freeport (solid line), and San Joaquin River discharge at Vernalis (dotted line) during the 2000 through 2013 field seasons.

Juvenile Chinook Salmon

We captured 15,750 and 18,341 juvenile Chinook Salmon during the 2012 and 2013 field seasons, respectively (Tables A.3 and A.4). During the 2012 field season, 13,561 individuals were unmarked, of which 1% (n=167) were categorized as winter-run, 69% (n=10,944) as fall-run, 15% (n=2,407) as spring-run, and less than 1% (n=24) as late fall-run using the river LDC or were not raced (n=19, Tables A.3 and A.4). Of the 2,189 marked (i.e., clipped adipose fin) juvenile Chinook Salmon recovered during 2012, 97% (n=2,114) contained a readable CWT (Table A.20). During the 2013 field season, 16,968 individuals were unmarked, of which 2% (n=432) were categorized as winter-run, 78% (n=14,367) as fall-run, 12% (n=2,134) as spring-run, and less than 1% (n=35) as late fall-run Chinook Salmon (Tables A.3 and A.4). Of the 1,373 marked juvenile Chinook Salmon recovered during 2013, 97% (n=1,339) contained a readable CWT (Table A.21).

We recovered a total of 21 and 9 marked juvenile winter-run Chinook Salmon containing a CWT during the 2012 and 2013 field seasons, respectively, within the Lower Sacramento River Seine Region (2013 only), the Sacramento Trawl Site, and the Chipps Island Trawl Site (Tables A.20 and A.21). All recovered CWT winter-run Chinook Salmon were released by the Livingston Stone National Fish Hatchery, which released 194,264 (185,313 marked and with a CWT) and 181,857 (169,967 marked and with a CWT) juvenile winter-run Chinook Salmon in the Central Valley during the 2012 and 2013 field seasons (PSMFC 2014).

We recovered a total of 225 and 18 marked juvenile spring-run Chinook Salmon containing a CWT during the 2012 and 2013 field seasons, respectively, within the Lower Sacramento River, North Delta, and Central Delta seine regions, the Sacramento Trawl Site, and the Chipps Island Trawl Site (Tables A.20 and A.21). All recovered CWT spring-run Chinook Salmon were released by the Feather River Fish Hatchery, which released 2,244,989 (2,213,475 marked and with a CWT) and 2,159,071 (2,121,964 marked and with a CWT) juvenile spring-run Chinook Salmon in the Central Valley (49.5% and 52.1%) and the San Francisco area bays (50.5% and 47.9%) during the 2012 and 2013 field seasons (PSMFC 2014).

We recovered a total of 1,816 and 1,263 marked juvenile fall-run Chinook Salmon containing a CWT during the 2012 and 2013 field seasons, respectively, within the Lower Sacramento River, North Delta, Central Delta, South Delta, Lower San Joaquin River, and San Pablo Bay Area seine regions, the Sacramento Trawl Site, and the Chipps Island Trawl Site (Tables A.20 and A.21). In the 2012 field season, 33,877,856 (9,289,470 marked and with a CWT) hatchery reared juvenile fall-run Chinook Salmon were released into the Central Valley (67.6%) and the San Francisco area bays (32.4%) in the combined release efforts of the Coleman National Fish Hatchery (36.9%), Feather River Fish Hatchery (28.9%), Mokelumne River Fish Hatchery (19.3%), Nimbus Fish Hatchery (14.2%), and Merced River Fish Facility (0.8%; PSMFC 2014). In the 2013 field season, 28,057,046 (7,706,497 marked and with a CWT) hatchery reared juvenile fall-run Chinook Salmon were released into the Central Valley (75.8%) or the San Francisco area bays (24.2%) in the combined release efforts of the Coleman National Fish Hatchery (42.3%), Feather River Fish Hatchery (22.3%), Mokelumne River Fish Hatchery (18.7%), Nimbus Fish Hatchery (14.3%), and Merced River Fish Facility (2.4%; PSMFC 2014).

We recovered a total of 52 and 140 marked juvenile late fall-run Chinook Salmon containing a CWT during the 2012 and 2013 field seasons, respectively, within the Lower Sacramento River and North Delta seine regions, the Sacramento Trawl Site, and the Chipps Island Trawl Site (Tables A.20 and A.21). All recovered CWT late fall-run Chinook Salmon were released by the Coleman National Fish Hatchery, which released 1,053,282 (1,037,859 marked) and 1,094,288 (1,031,419 marked) juvenile late fall-run Chinook Salmon in the Central Valley during the 2012 and 2013 field seasons (PSMFC 2014).

Based on CWT recoveries during the 2012 and 2013 field seasons, there is evidence that races specific to the Sacramento River Basin (e.g., late fall-, winter-, and spring-run) occurred within the Central and South Delta likely based on water diversions, exports, and tidal exchange (Tables A.20 and A.21). As a result, CWT recovery data further justifies our application of the river LDC to identify the race of unmarked juvenile Chinook Salmon captured in all seine regions except the Lower San Joaquin River Seine Region.

Nearly all of the juvenile Chinook Salmon captured using beach seines since the 2000 field season were estimated to have natural origin (93.5% natural origin, 0.2% hatchery origin, 1.2% marked, 5.0% unknown origin). While hatcheries typically release smolt-sized fish and few fry (PSMFC 2014), both fry- and smolt-sized Chinook Salmon were observed in the beach seines (see "Fork Length Distributions" section). This suggested that hatchery juvenile Chinook Salmon may be less likely to occur in unobstructed near shore habitats within the San Francisco Estuary than natural origin juvenile Chinook Salmon.

Winter-Run Distribution and Relative Abundance

In general, nearly 100% of all juvenile winter-run Chinook Salmon produced by the Livingston Stone National Fish Hatchery have been released marked and containing a CWT since production began in 1995 (PSMFC 2014). We estimated that natural juvenile winter-run sized Chinook Salmon were captured in relatively low numbers at the Chipps Island Trawl Site, the Sacramento Trawl Site, and in the Lower Sacramento River, North Delta, Central Delta, and South Delta seine regions during the 2012 and 2013 field seasons (Figures 21–24). Although genetic analyses have determined that the river LDC is fairly accurate for winter-run Chinook Salmon designation, it should be noted that significant numbers of individuals from other races are included within the winter-run criteria (Pyper et al. 2013), thus the abundance is significantly over-estimated using the river LDC.

Consistent with the 2010 and 2011 field seasons (Speegle et al. 2013), winter-run sized juvenile Chinook Salmon were generally captured from December through April at the Chipps Island Trawl Site and November through April at the Sacramento Trawl Site (Figures 21 and 22). The CPUE at the Sacramento Trawl Site peaked in March and November during the 2012 and 2013 field seasons, respectively. Conversely, the CPUE at the Chipps Island Trawl Site peaked in April and March during the 2012 and 2013 field seasons. There was generally only a one month time lag between the peak CPUE at the Sacramento Trawl Site (March) and the Chipps Island Trawl Site (April) during the 2012 field season, which occurred during the time of peak Sacramento River discharge into the Delta. However, there was a four month time lag between the peak CPUE at the Sacramento Trawl Site (November) and the Chipps Island Trawl Site (March) during the 2013 field season. The Sacramento River discharge, on average, peaked in November during the 2013 field season. This may indicate that residency time within the Delta is likely influenced by the interaction between the size of fish entering the Delta and the timing of peak Sacramento River discharge into the Delta within the year. The mean yearly CPUE at the Sacramento Trawl Site has increased considerably since the record low observed during the 2011 field season (Figure 22), whereas the mean yearly CPUE at the Chipps Island Trawl Site was near the record low during both the 2012 and 2013 field seasons (Figure 21). The data in 2012 and 2013 suggested that increased residency time in the Delta may not correspond to higher numbers of Chinook Salmon emigrating out of the Delta. However, the relative abundance between years is likely masked by the variation in the large numbers of false positives contained within the winter-run LDC.

Estimated natural winter-run sized Chinook Salmon were captured using beach seines in most months from October through March during the 2012 and 2013 field seasons (Figure 23). We did not observe any marked fish in beach seines during the 2012 field season. We observed marked fish only during the month of February within the North Delta Seine Region during the 2013 field season, which corresponds with hatchery releases within the watershed. In 2013, the mean monthly CPUE of natural winter-run juveniles peaked in the Lower Sacramento River and North Delta seine regions in January compared to December during the 2012 field season (Figure 23). Conversely, the monthly CPUE in the Central Delta and South Delta seine regions peaked either in February (2013) or March (2012). The mean yearly CPUE estimates suggested that natural 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 24).

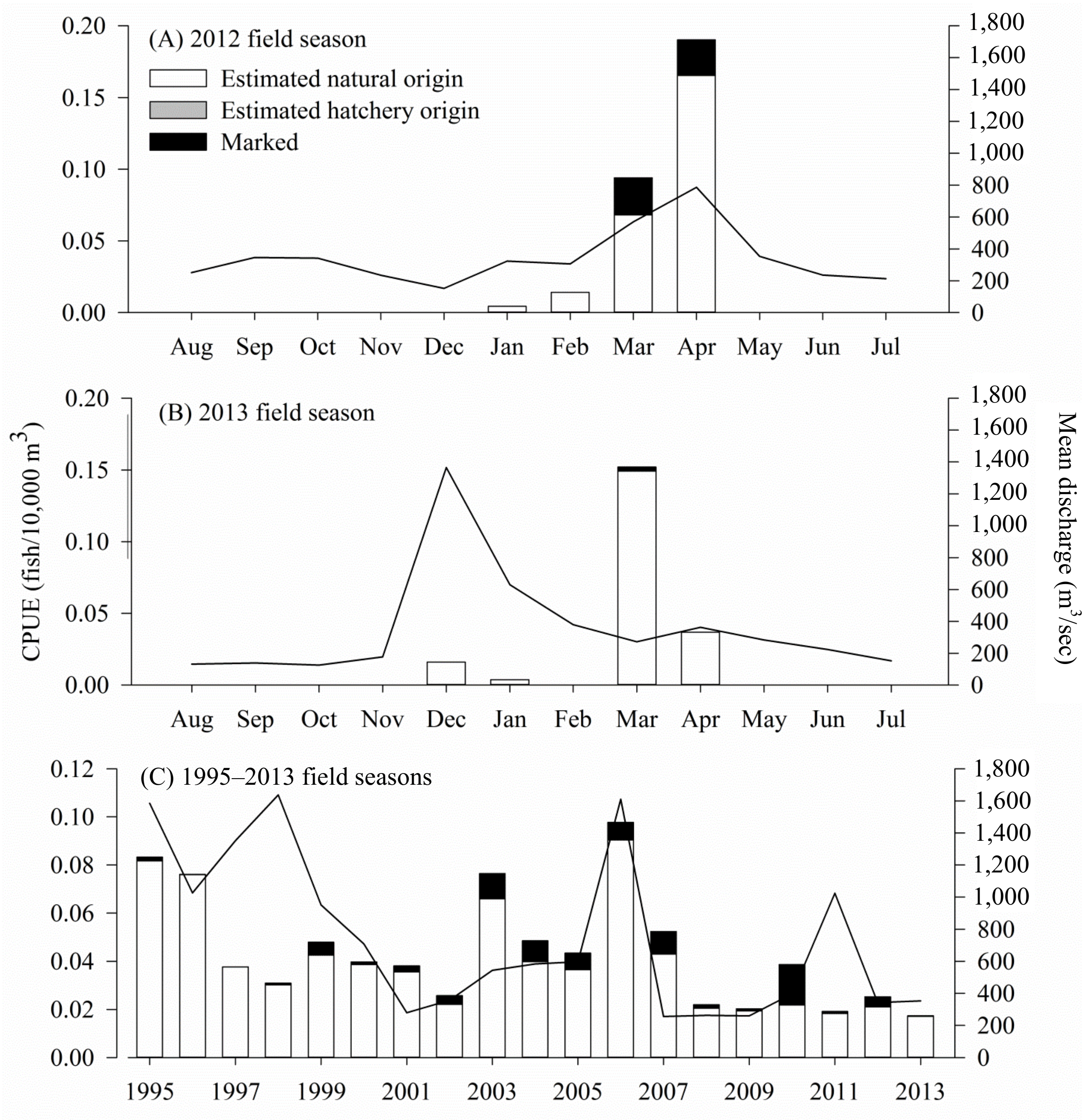

Figure 21. The mean monthly and yearly CPUE (bars) of juvenile winter-run Chinook Salmon captured in MWTRs at the Chipps Island Trawl Site, and the estimated mean monthly and yearly Delta outflow (solid line) during the **(A)** 2012, **(B)** 2013, and **(C)** 1995 through 2013 field seasons.

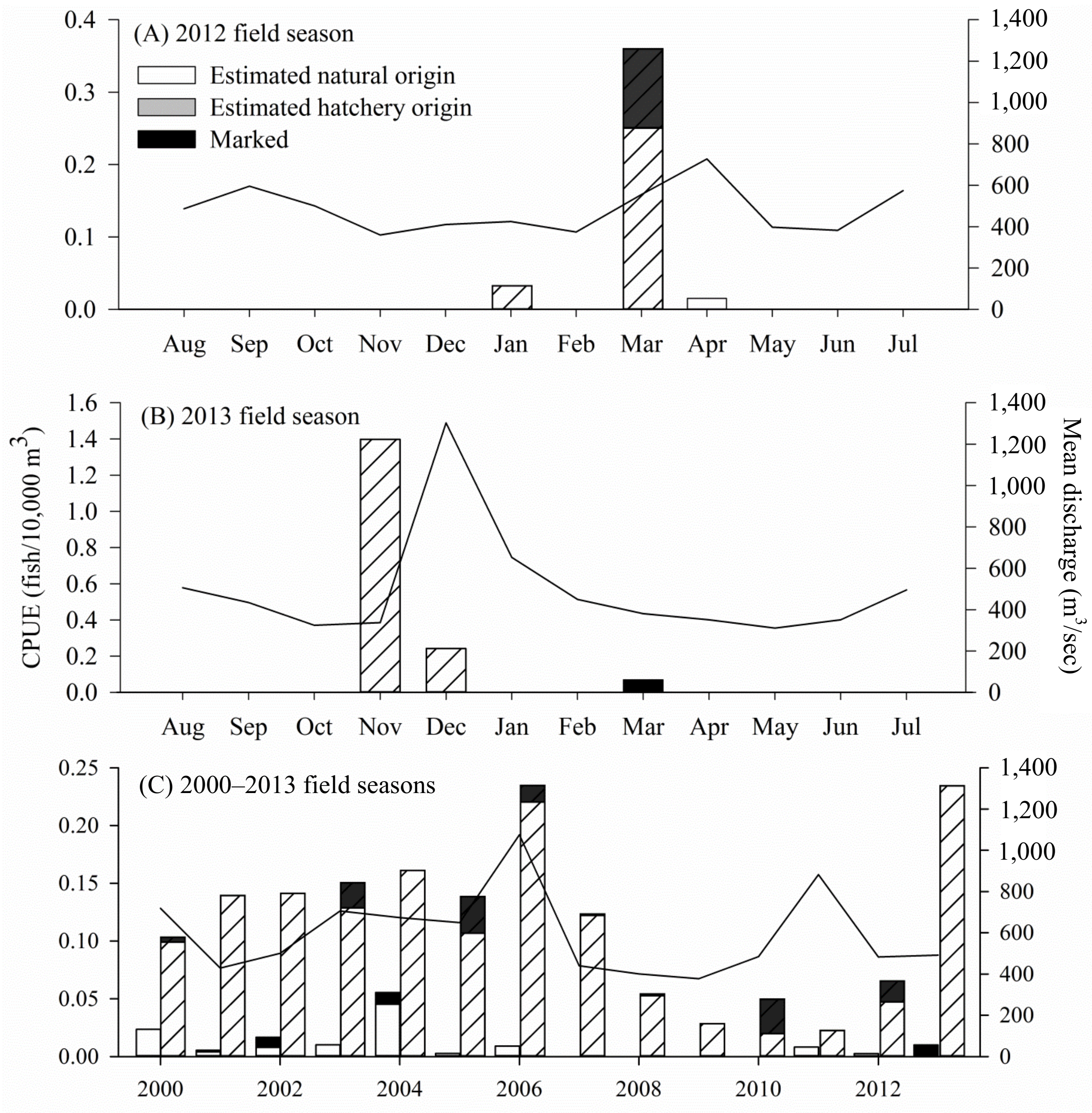

Figure 22. The mean monthly and yearly CPUE of juvenile winter-run Chinook Salmon captured in MWTRs (solid bars) and KDTRs (striped bars) at the Sacramento Trawl Site, and the mean monthly and yearly Sacramento River discharge at Freeport (solid line) during the **(A)** 2012, **(B)** 2013, and **(C)** 2000 through 2013 field seasons.

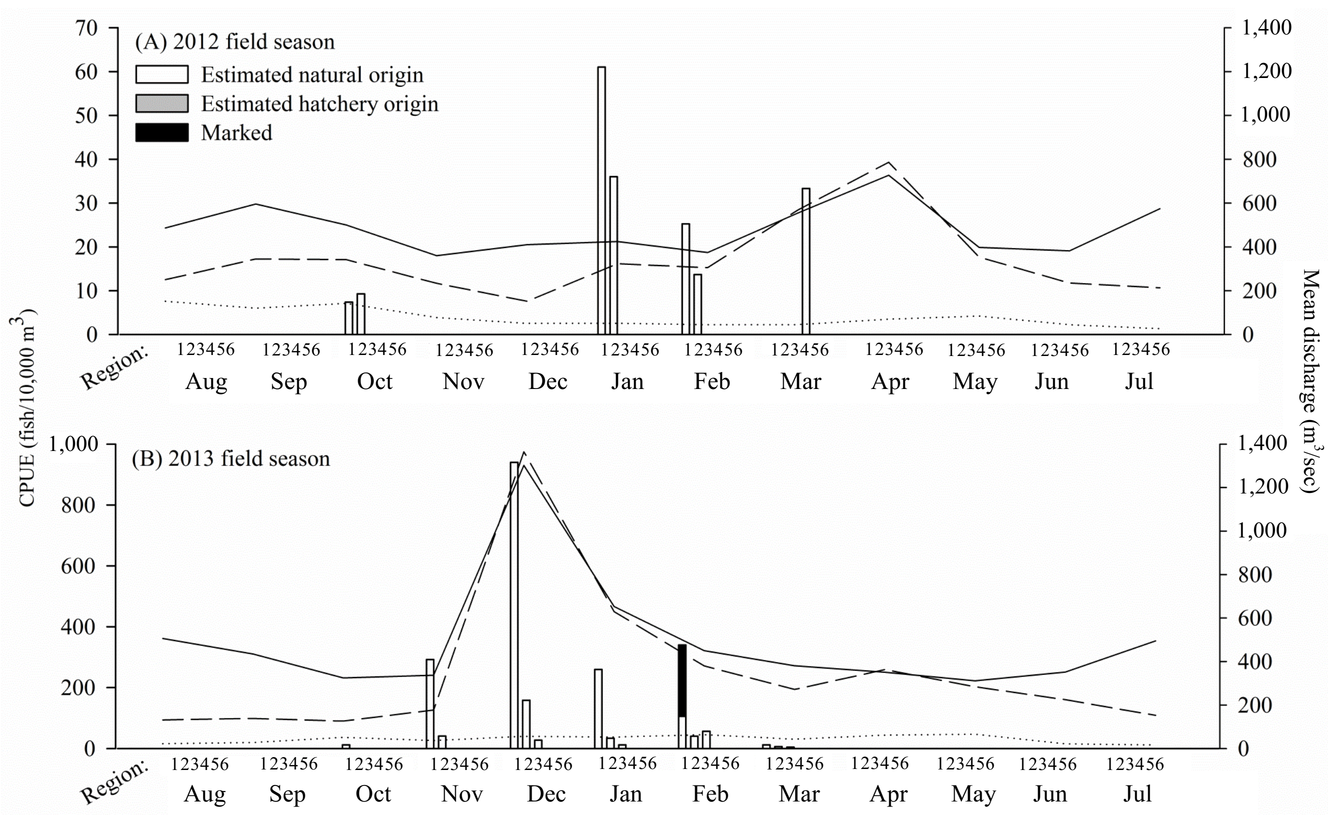

Figure 23. The mean monthly CPUE (bars) of juvenile winter-run Chinook Salmon captured within the Lower Sacramento River (1), North Delta (2), Central Delta (3), South Delta (4), Lower San Joaquin River (5), and San Francisco and San Pablo Bay (6) beach seine regions, and the estimated mean monthly and yearly Delta outflow (dashed line), Sacramento River discharge at Freeport (solid line), and San Joaquin River discharge at Vernalis (dotted line) during the **(A)** 2012 and **(B)** 2013 field seasons.

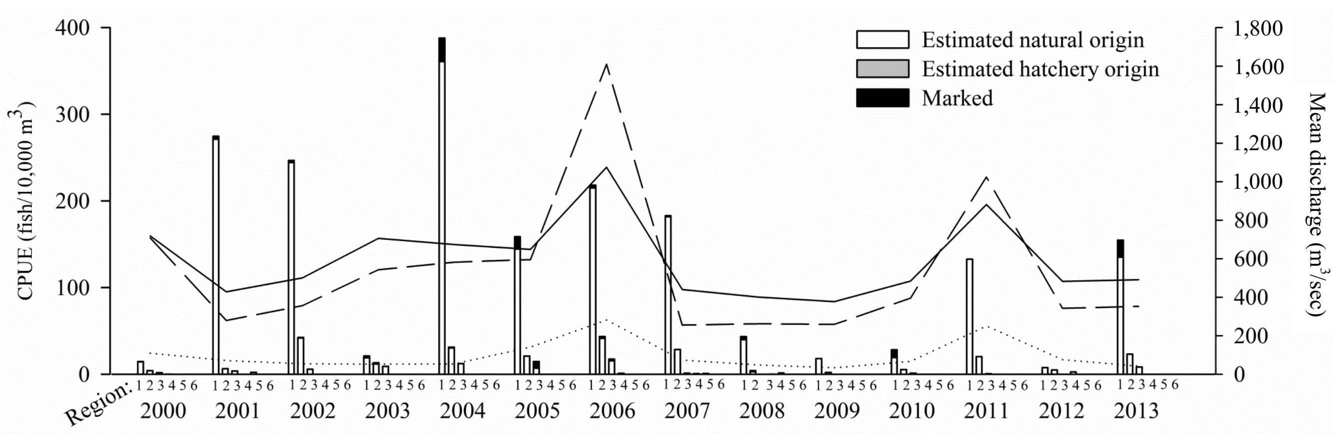

Figure 24. The mean yearly CPUE (bars) of juvenile winter-run Chinook Salmon captured within the Lower Sacramento River (1), North Delta (2), Central Delta (3), South Delta (4), Lower San Joaquin River (5), and San Francisco and San Pablo Bay (6) beach seine regions, and the estimated mean monthly and yearly Delta outflow (dashed line), Sacramento River discharge at Freeport (solid line), and San Joaquin River discharge at Vernalis (dotted line) during the 2000 through 2013 field seasons.

Fall-, Late Fall-, and Spring-Run Distribution and Relative Abundance

We captured juvenile fall-, late fall-, or spring-run Chinook Salmon in nearly all seine regions and trawl sites during the 2012 and 2013 field seasons (Tables A.3 and A.4). Until the 2000 field season, hatchery fish were often released in groups within the watershed that did not have any marked individuals containing a CWT (Kevin Niemela, USFWS, personal communication; PSMFC 2014). As a result, we were unable to determine the origin of large numbers of fish captured at the Chipps Island and Sacramento trawl sites prior to the 2000 field season.

At the Chipps Island Trawl Site, juvenile fall-, late fall-, or spring-run Chinook Salmon were generally captured during December through July during both field seasons (Figure 25). Individuals were generally captured from January through June at the Sacramento Trawl Site, but some individuals were observed as early as November during the 2013 field season corresponding to increased discharge (Figure 26). In general, we observed a greater proportion of hatchery fish (estimated and marked) relative to natural fish during this period at the Chipps Island and Sacramento trawl sites based on hatchery releases upstream of these locations. The majority of fish captured at the Mossdale Trawl Site that occurred between March and June were considered to be natural origin due to few hatchery releases occurring in the San Joaquin Basin (PSMFC 2014; Figure 27). At all the trawl sites, the peak-mean monthly CPUE representing natural individuals occurred in April and May during both field seasons. The mean yearly CPUE at the Chipps Island Trawl Site has declined annually since the 2011 field season, however the 2012 and 2013 CPUEs exceeded or were equal to their historical averages (Figures 25 and 28). This assumes that catch efficiency at Chipps Island did not vary between 2011 (a high flow year) and 2012 and 2013 (low flow years; Table A.19). Conversely, the mean yearly CPUE at the Sacramento and Mossdale trawl sites appear to be increasing since their record low CPUE was observed during the 2010 field season (Figures 26 and 27). During the 2013 field season, we observed the record high CPUE of natural juvenile fall-, late fall-, or spring-run Chinook Salmon at the Mossdale Trawl Site relative to the 2004 through 2011 field seasons (Figure 27). Although these races are grouped for consistency within this report, juvenile Chinook Salmon captured at Mossdale are assumed to be fall-run.

Estimated natural juvenile fall-, late fall-, or spring-run Chinook Salmon were generally captured using beach seines between December and May during the 2012 and 2013 field seasons (Figure 29). We observed few marked fish during both field seasons. The mean monthly CPUE of natural fall-, late fall-, or spring-run Chinook Salmon peaked in the Lower Sacramento River and North Delta seine regions during January and February. The mean yearly CPUE estimates suggested that natural juvenile fall-, late fall-, or spring-run Chinook Salmon were consistently observed in higher densities within the Lower Sacramento River and North Delta seine regions, and to a lesser extent the Central Delta seine regions, relative to other seine regions since the 2000 field season (Figure 30).

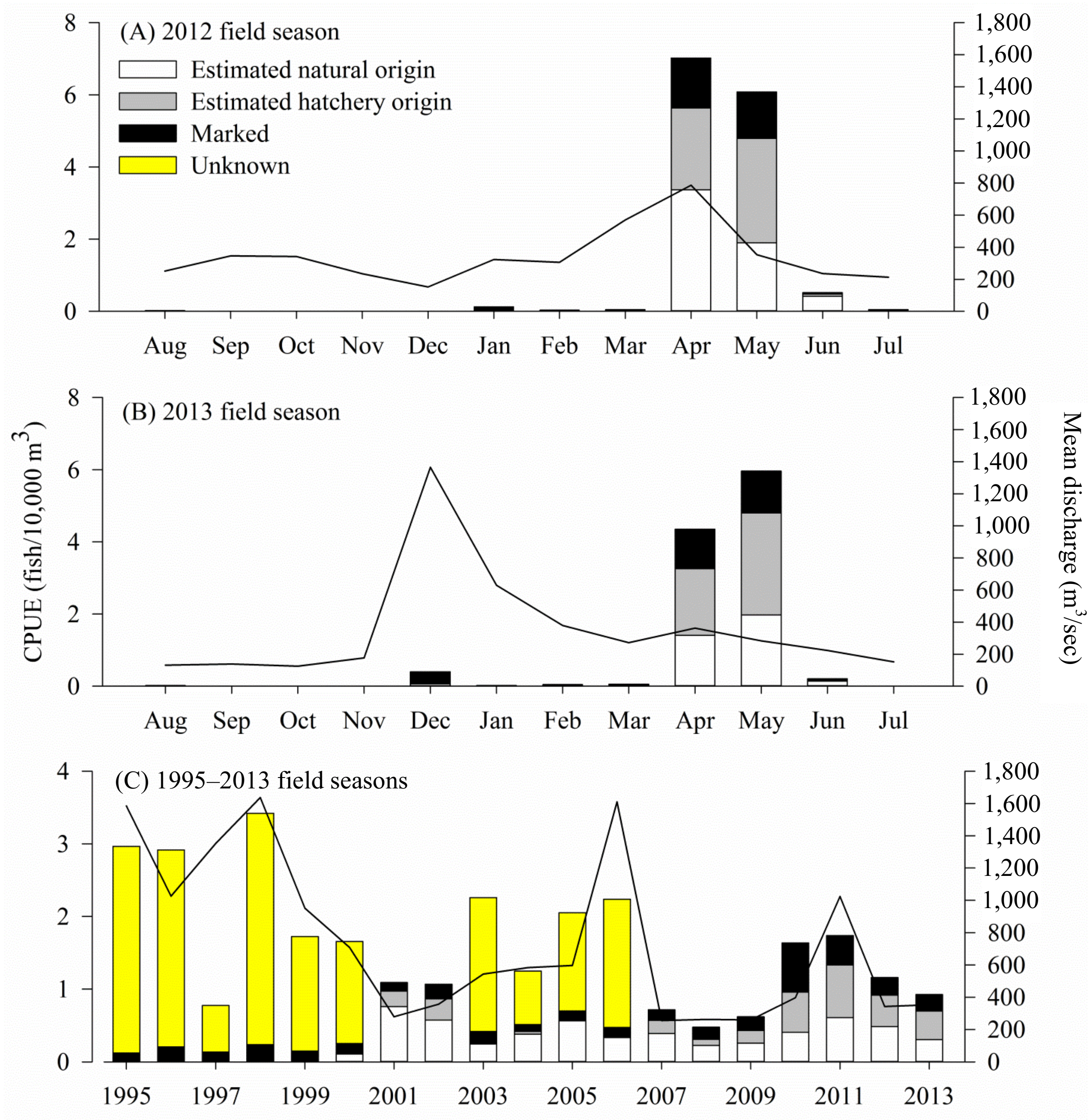

Figure 25. The mean monthly and yearly CPUE (bars) of juvenile fall-, late fall-, and spring-run Chinook Salmon captured in MWTRs at the Chipps Island Trawl Site, and the estimated mean monthly and yearly Delta outflow (solid line) during the **(A)** 2012, **(B)** 2013, and **(C)** 1995 through 2013 field seasons.

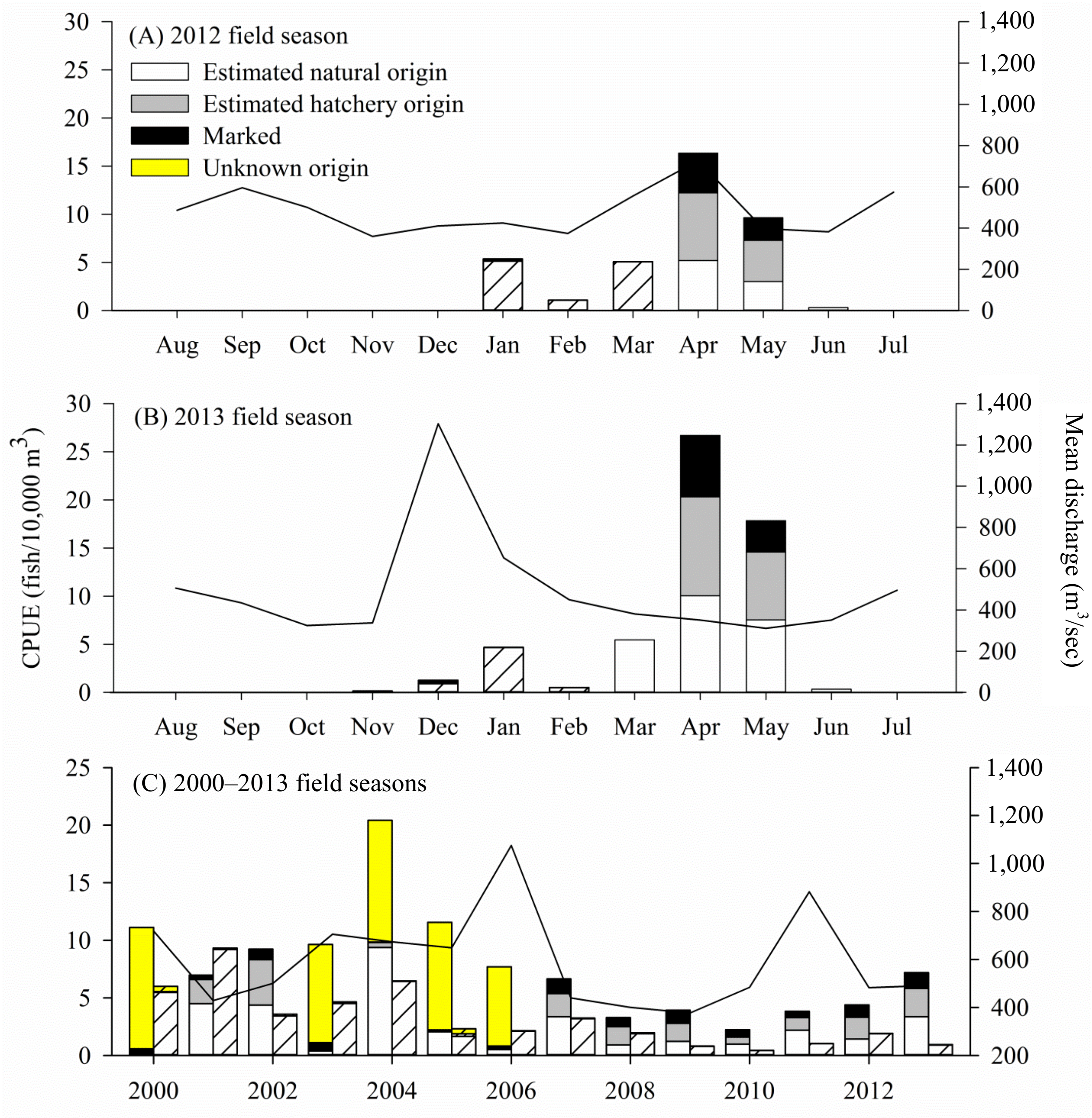

Figure 26.The mean monthly and yearly CPUE (bars) of juvenile fall-, late fall-, and spring-run Chinook Salmon captured in MWTRs (solid bars) and KDTRs (striped bars) at the Sacramento Trawl Site, and the mean monthly and yearly Sacramento River discharge at Freeport (solid line) during the **(A)** 2012, **(B)** 2013, and **(C)** 2000 through 2013 field seasons.

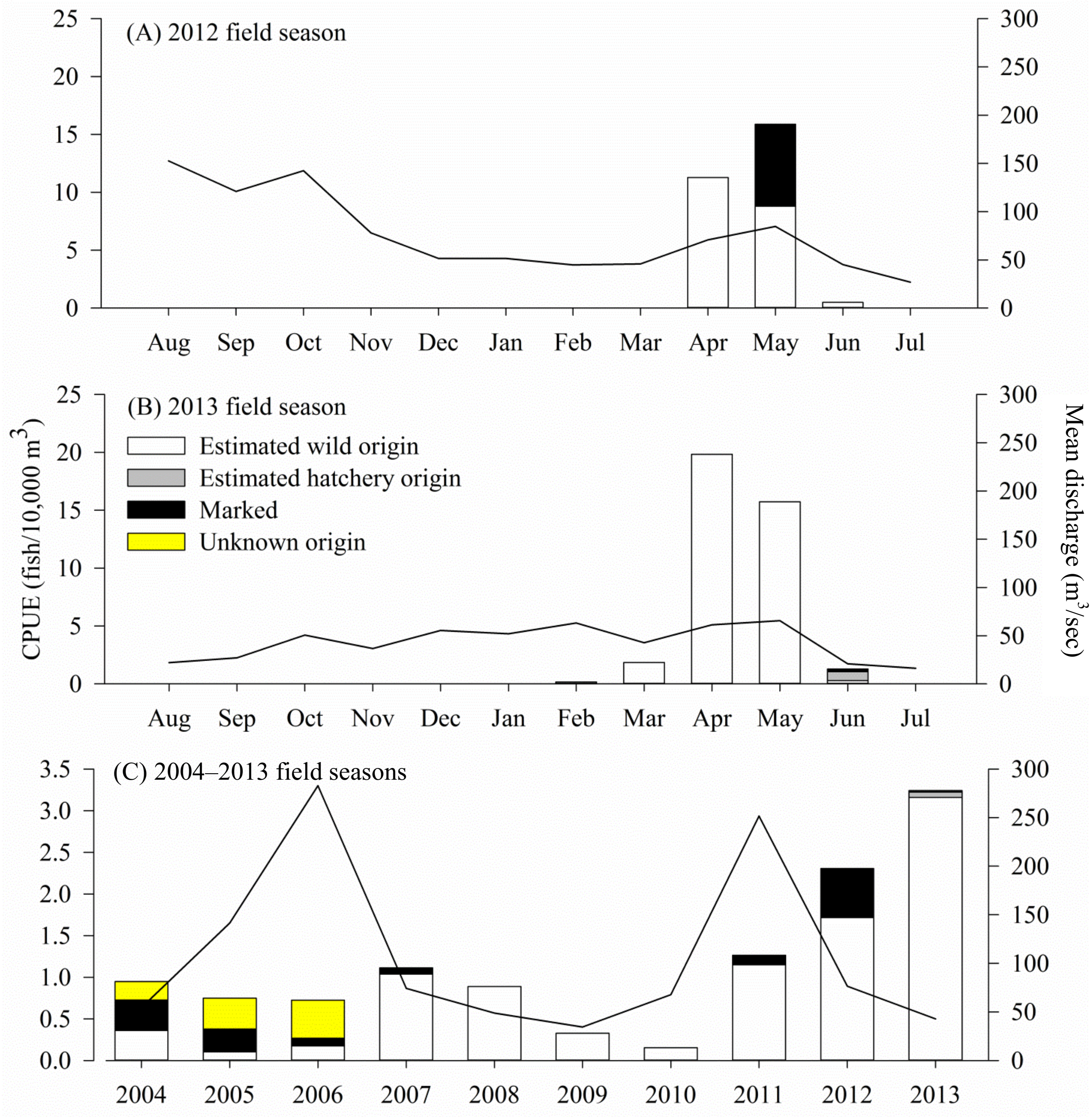

Figure 27. The mean monthly and yearly CPUE (bars) of juvenile fall-, late fall-, and spring-run Chinook Salmon captured in KDTRs at the Mossdale Trawl Site, and the mean monthly and yearly San Joaquin River discharge at Vernalis (solid line) during the **(A)** 2012, **(B)** 2013, and **(C)** 2004 through 2013 field seasons. Juvenile Chinook Salmon captured at Mossdale are assumed to be fall-run only.

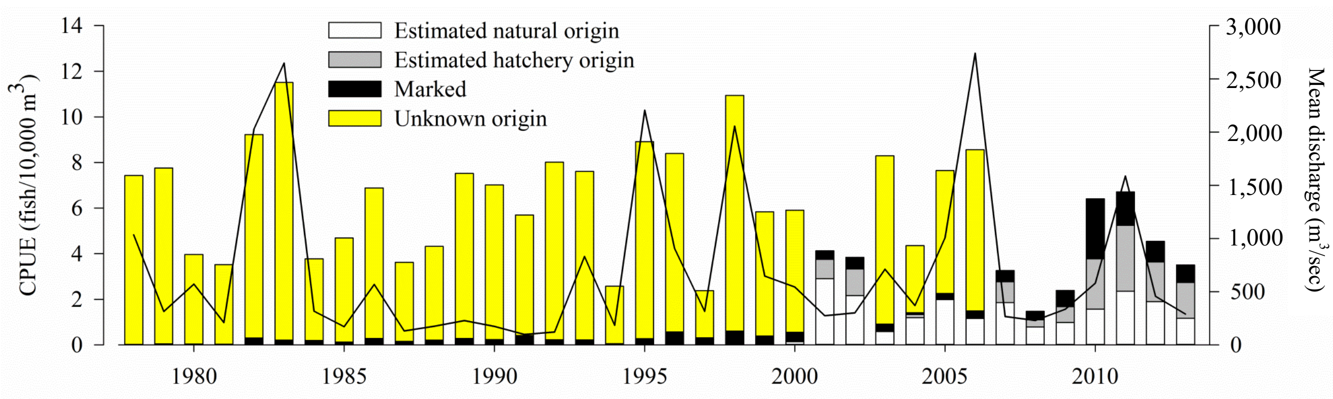

Figure 28. The mean monthly and yearly CPUE (bars) of juvenile fall-, late fall-, and spring-run Chinook Salmon captured in MWTRs at the Chipps Island Trawl Site, and the estimated mean monthly and yearly Delta outflow (solid line) during April–June of the 1978–2013 field seasons.

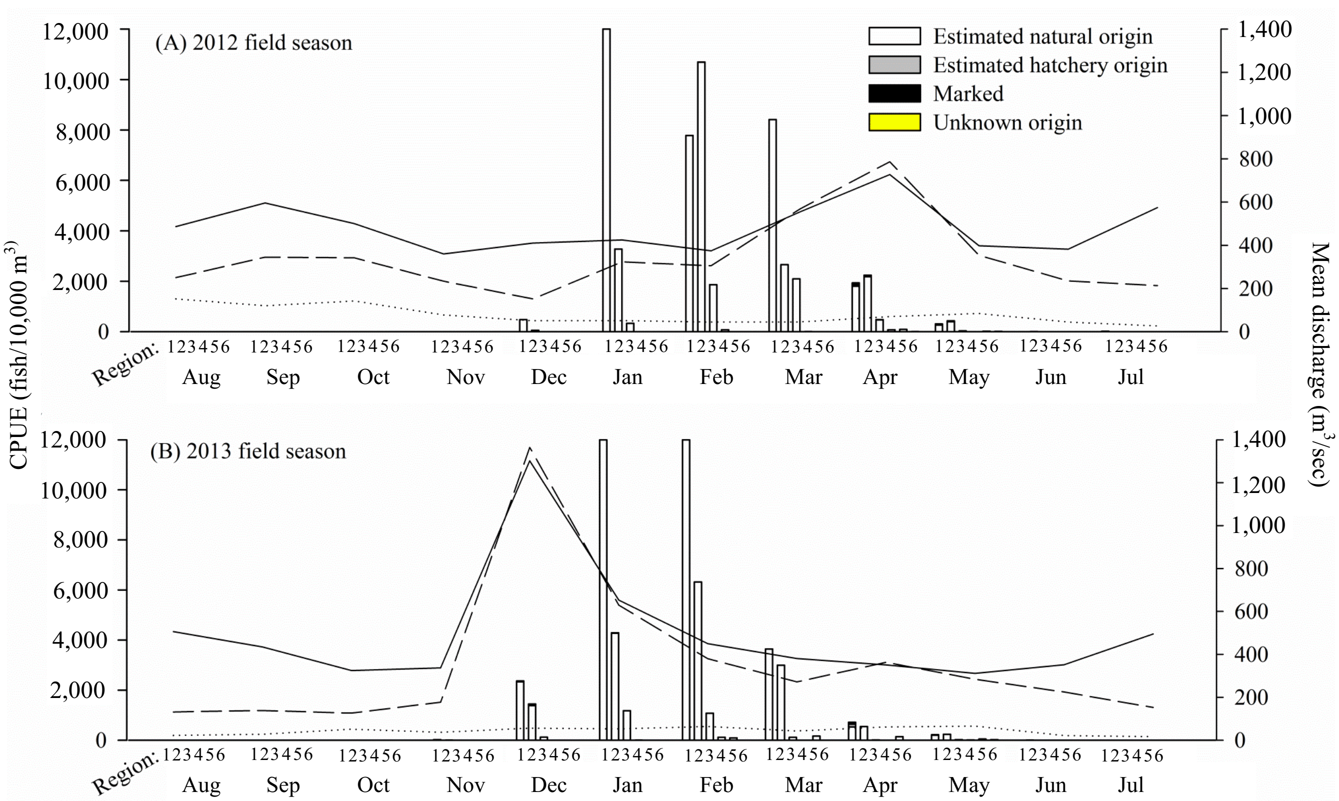

Figure 29. The mean monthly CPUE (bars) of juvenile fall-, late fall-, and spring-run Chinook Salmon captured within the Lower Sacramento River (1), North Delta (2), Central Delta (3), South Delta (4), Lower San Joaquin River (5), and San Francisco and San Pablo Bay (6) beach seine regions, and the estimated mean monthly and yearly Delta outflow (dashed line), Sacramento River discharge at Freeport (solid line), and San Joaquin River discharge at Vernalis (dotted line) during the **(A)** 2012 and **(B)** 2013 field seasons.

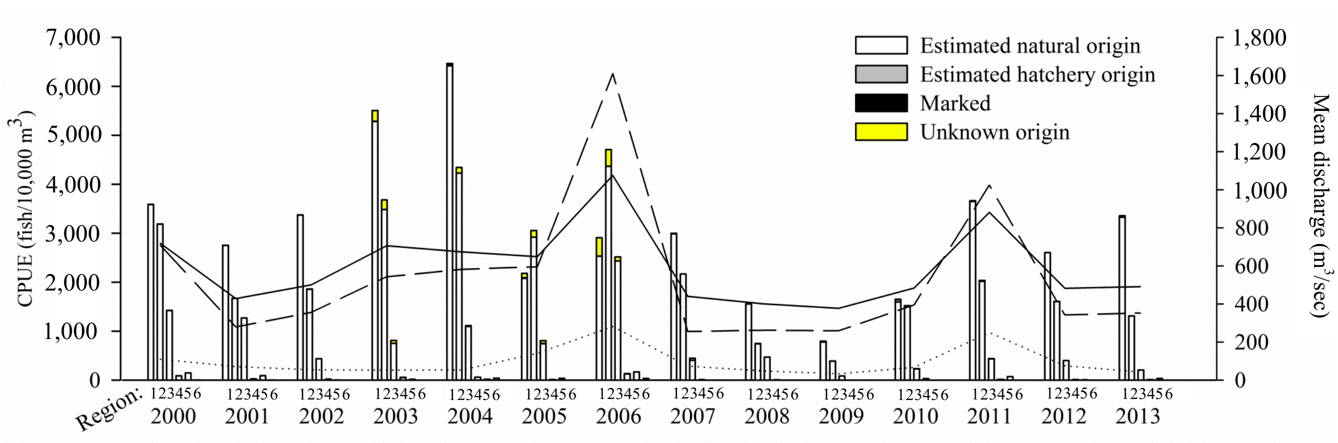

Figure 30. The mean yearly CPUE (bars) of juvenile fall-, late fall-, and spring-run Chinook Salmon captured within the Lower Sacramento River (1), North Delta (2), Central Delta (3), South Delta (4), Lower San Joaquin River (5), and San Francisco and San Pablo Bay (6) beach seine regions, and the estimated mean monthly and yearly Delta outflow (dashed line), Sacramento River discharge at Freeport (solid line), and San Joaquin River discharge at Vernalis (dotted line) during the 2000 through 2013 field seasons.

Absolute Abundance

Among the 102 release groups used to estimate the $\overline{TRR}$ at the Chipps Island Trawl Site, 9,670,244 fish were marked with a CWT (PSMFC 2014). Release groups ranged in size from 22,911 to 717,966 individuals. The $\overline{TRR}$ at the Chipps Island Trawl Site was estimated to be 0.48% ± 0.08% (mean ± 95% CI), using CWT recoveries from 1989 to 2013. The duration of recoveries of CWT fish within a release group spanned, on average, 11.5 days.

We used 42 release groups to estimate the $\overline{TRR}$ of the MWTR at the Sacramento Trawl Site. Within these release groups, 2,398,810 fish were marked with a CWT. Release groups ranged in size from 34,480 to 104,516 individuals. The duration of recoveries of CWT fish within a release group spanned, on average, 10.8 days. Two of the release groups did not have any individuals captured at the site. The $\overline{TRR}$ of the MWTR was estimated to be 0.82% ± 0.35%, using CWT releases from 1988 to 2009. We used 5 release groups to estimate the $\overline{TRR}$ of the KDTR at the Sacramento Trawl Site, where a total of 300,960 fish were marked with a CWT (PSMFC 2014). Release groups ranged in size from 48,987 to 69,490 individuals. The duration of recoveries of CWT fish within a release group spanned, on average, 4.9 days. The $\overline{TRR}$ of the KDTR was estimated to be 0.74% ± 0.87% between 1996 and 2006.

There were 53 release groups used to estimate the $\overline{TRR}$ at the Mossdale Trawl Site. Among these release groups, 438,529 individuals were marked either with stain dye (Steve Tsao, CDFW, personal communication) or an adipose fin clip and contained a CWT (PSMFC 2014). Release groups ranged in size from 1,195 to 74,411 individuals. The $\overline{TRR}$ was estimated to be 2.88% ± 3.00%, using CWT and stain dye releases from 1997 to 2013. The duration of recoveries of marked fish within a release group spanned, on average, 1 day. Six of the release groups did not have any recoveries. While the $\overline{TRR}$ rate for the CWT groups (0.64% ± 0.83%) was comparable with the estimate for the Chipps Island and Sacramento trawl sites (0.48% ± 0.08% and 0.82% ± 0.35%, respectively; see above), the $\overline{TRR}$ of the stain dye groups were considerably higher (6.52% ± 4.93%). The increased recoveries may be due to unintentional targeting of marked fish or a time effect. In general, CWT releases occurred at random relative to sampling at the Mossdale Trawl Site, whereas spray dye fish were released at the beginning of a sample day (SJRGA 2009).

The $\overline{TRR}$ had a negative lower 95% confidence limit for both the Sacramento Trawl Site (KDTR) and the Mossdale Trawl Site, which is due to relatively small sample sizes coupled with considerable variation among samples. Because a negative or zero value of $\overline{TRR}$ results in an absolute abundance of infinity, and the lower $\overline{TRR}$ confidence limit was used to estimate the upper absolute abundance confidence limit, we assigned the lower $\overline{TRR}$ confidence limit as 0.10% in order to provide absolute abundance confidence limits. This value was chosen based on a conservative comparison to the lower $\overline{TRR}$ confidence limits at the Chipps Island and Sacramento (MWTR) trawl sites (0.40% and 0.47%, respectively; see above). We highly recommend further investigation of the efficiency of each of the trawls to obtain more precise and accurate absolute abundance estimates that can be used to inform future management decisions within the San Francisco Estuary and its watershed.

We estimated, on average, a total of 107,224 (68% natural origin, 32% marked) and 208,658 (99% natural origin, 1% marked) juvenile winter-run sized Chinook Salmon immigrating into the Delta at the Sacramento Trawl Site during the 2012 and 2013 field seasons, respectively (Figure 31). However, a total of 292,903 (84% natural origin, 16% marked) and 217,001 (99% natural, origin, 1% marked) juvenile winter-run sized Chinook Salmon were estimated to emigrate from the Delta at Chipps Island during the 2012 and 2013 field seasons, respectively (Figure 32). Since we estimated that more winter-run sized Chinook Salmon exited the Delta than entered the Delta in 2012, no reproduction of winter-run Chinook Salmon can occur in the Delta, and no hatchery releases of winter-run Chinook Salmon were made downstream of the Sacramento Trawl Site; we believe that either the absolute abundance of winter-run Chinook Salmon at Chipps Island is over-estimated or the absolute abundance at the Sacramento Trawl Site is under-estimated. It might be more likely that the absolute abundance at Chipps Island is over-estimated, since the river LDC has been shown to over-estimate a higher number of genetic winter-run at Chipps Island than at the Sacramento Trawl Site (Dekar et al. 2013). Genetic tissue sampling could help us distinguish between true winter-run and winter-run sized fish in the catch and allow more precise and accurate estimates of winter-run abundance at the Sacramento and Chipps Island trawl sites. Regardless, it is apparent that the abundance of winter-run Chinook Salmon at Chipps Island is highly variable and has declined considerably since the 1990s (Figure 32).

The mean yearly absolute abundance of all juvenile fall-, late fall-, and spring-run Chinook Salmon immigrating into the Delta was estimated to be 7,736,290 and 9,688,494 individuals during the 2012 and 2013 field seasons, respectively (Figures 33 and 34). We estimated, on average, a total of 6,254,907 (62% natural origin, 24% hatchery origin, 14% marked) and 7,626,927 (52% natural origin, 28% hatchery origin, 19% marked) juveniles at the Sacramento Trawl Site during the 2012 and 2013 field seasons (Figure 33). Additionally, 1,481,383 (72% natural origin, 28% marked) and 2,061,567 (97% natural origin, 2% hatchery origin, 1% marked) juveniles were estimated at the Mossdale Trawl Site during the 2012 and 2013 field seasons (Figure 34). At the Chipps Island Trawl Site, we estimated a total of 13,404,233 (43% natural origin, 37% hatchery origin, 21% marked) and 11,095,289 (33% natural origin, 43% hatchery origin, 23% marked) juveniles emigrating from the Delta during the 2012 and 2013 field seasons (Figure 35).

Although inter-annual trends in abundance at the Sacramento and Mossdale trawl sites are difficult to discern due to the high uncertainty, it is apparent that the abundance of juvenile fall-, late fall-, and spring-run Chinook Salmon has declined considerably at the Chipps Island Trawl Site relative to the 1990s (Figure 35). The absolute abundance of juvenile fall-, late fall-, or spring-run Chinook Salmon at Chipps Island increased in 2012 relative to the 2010 and 2011 field seasons, and in 2013 remained similar to the 2010 and 2011 field seasons (Speegle et al. 2013). While there was increased adult escapement in both 2012 and 2013 (Table A.22), the decrease in absolute abundance at Chipps Island during the 2013 field season may be partly due to the worsening drought conditions in 2013 (Swain et al. 2014; Table A.19).

The absolute abundance estimates for juvenile Chinook Salmon presented in this report likely contain bias from several sources, in addition to potentially inaccurate race designations caused by the application of the LDC. Firstly, we assumed that unmarked individuals were never recaptured. This assumption was violated based on the capture of five CWT individuals in 2012 and four CWT individuals in 2013 that were released downstream of Chipps Island (San Pablo Bay) by the Chipps Island MWTR (Tables A.20 and A.21). Therefore, our abundance estimates may be over-estimated to an unknown degree. Secondly, we may have under-estimated the absolute abundance of juvenile Chinook Salmon at each of the trawl sites due to the possible size selectivity of the MWTR's and KDTR's cod end design and mesh. Thirdly, we assumed that juvenile Chinook Salmon were equally distributed in time, which is unlikely due to diel migratory patterns. Several studies have shown primarily nocturnal migratory behavior in juvenile Chinook Salmon (Gaines and Martin 2002; Williams 2006 and references therein), while some studies in the Delta have provided evidence for diurnal migration of juvenile Chinook Salmon during the spring (Buchanan 2014; Wilder and Ingram 2006). While Bradford and Higgins (2001) mostly observed nocturnal activity, additional observations of a variety of diel activity patterns in the Bridge River of British Columbia led them to conclude that diel activity is caused by individual fish responding to fine-scale habitat attributes and is difficult to generalize. Given that the DJFMP only samples during the day, any diel activity patterns of juvenile Chinook Salmon could produce an unknown effect on the estimate of absolute abundance at all sampling locations. More investigation is needed to understand the effect of diel migratory patterns of juvenile Chinook Salmon on catch efficiency.

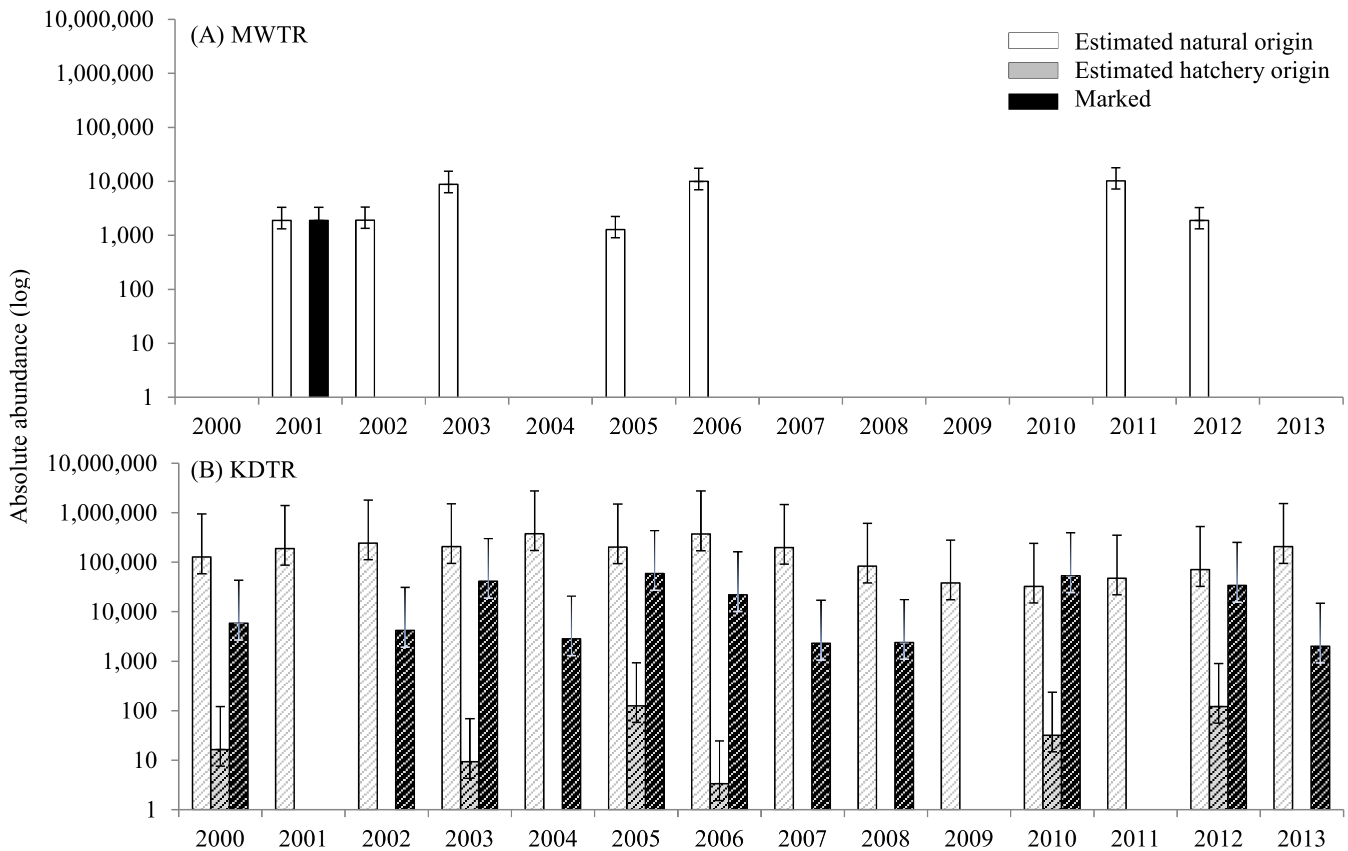

Figure 31. Mean absolute abundance estimates and their 95% confidence intervals for juvenile winter-run Chinook Salmon at the Sacramento Trawl Site when **(A)** MWTRs (solid bars) and **(B)** KDTRs (striped bars) were used during the 2000–2013 field seasons. The y-axis is presented on a common log scale.

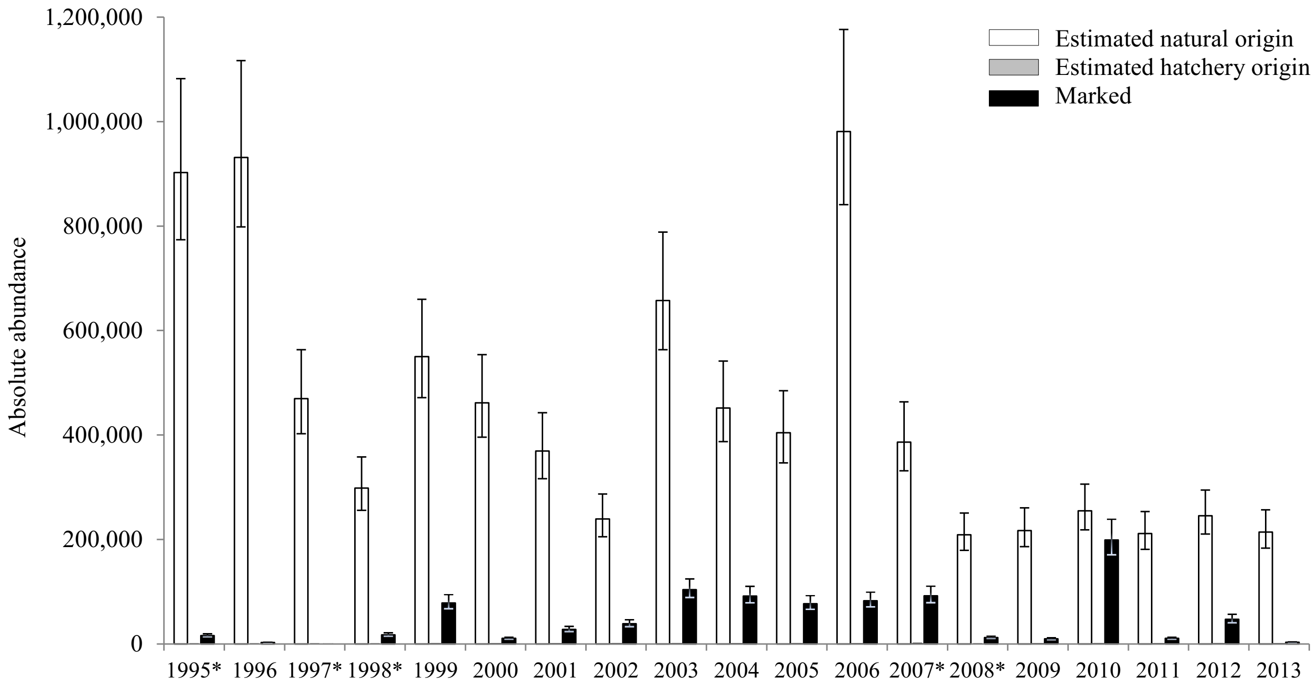

Figure 32. Mean absolute abundance estimates and their 95% confidence intervals for juvenile winter-run Chinook Salmon at the Chipps Island Trawl Site during the 1995–2013 field seasons. Years with asterisks indicate that 1 or 2 months of that field season were not sampled, which may bias low the annual estimate.

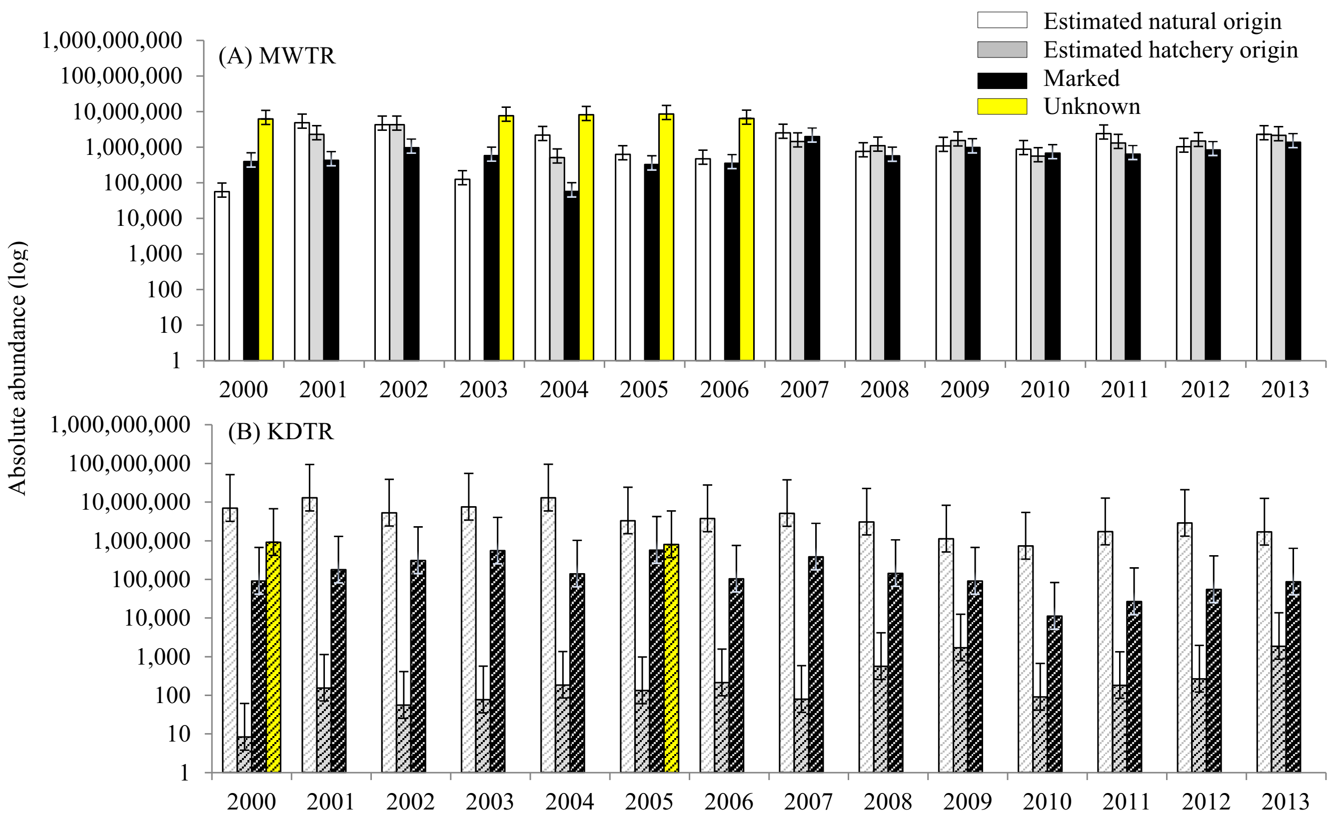

Figure 33. Mean absolute abundance estimates and their 95% confidence intervals for juvenile fall-, late fall-, and spring-run Chinook Salmon at the Sacramento Trawl Site when **(A)** MWTRs (solid bars) and **(B)** KDTRs (striped bars) were used during the 2000–2013 field seasons. The y-axis is presented on a common log scale.

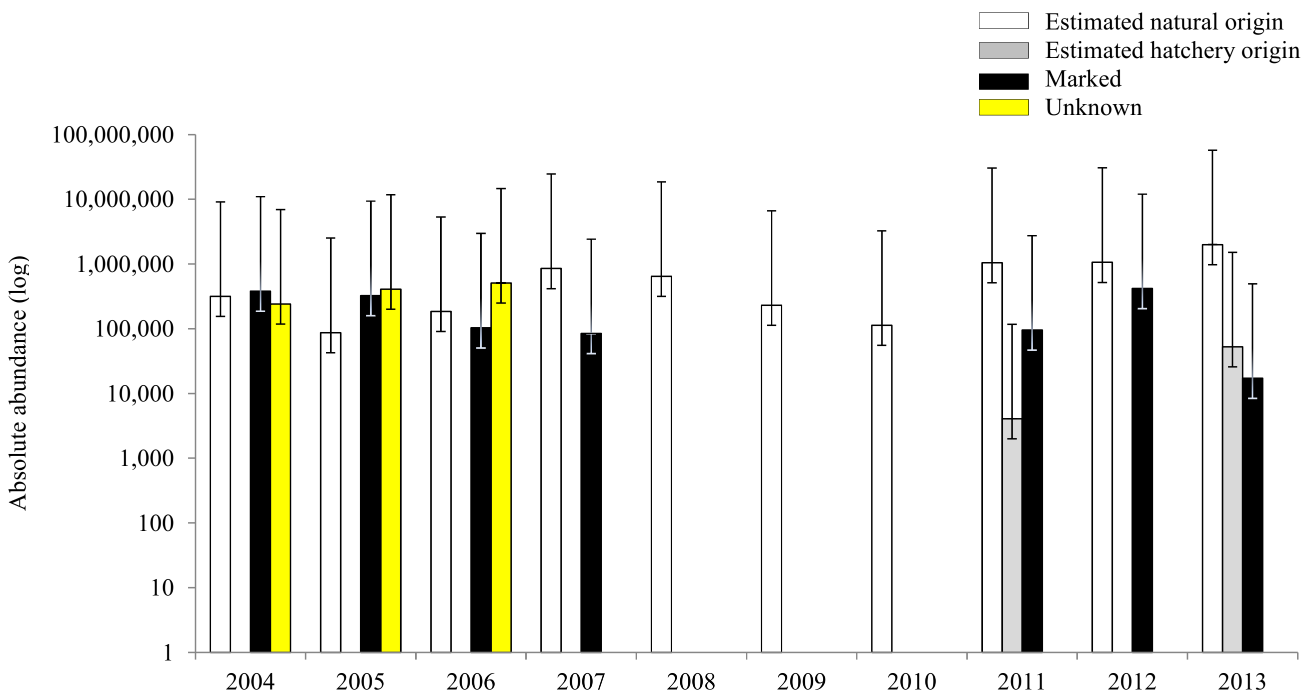

Figure 34. Mean absolute abundance estimates and their 95% confidence intervals for juvenile fall-, late fall-, and spring-run Chinook Salmon at the Mossdale Trawl Site during the 2004–2013 field seasons. The y-axis is presented on a common log scale. Juvenile Chinook Salmon captured at Mossdale are assumed to be fall-run only.

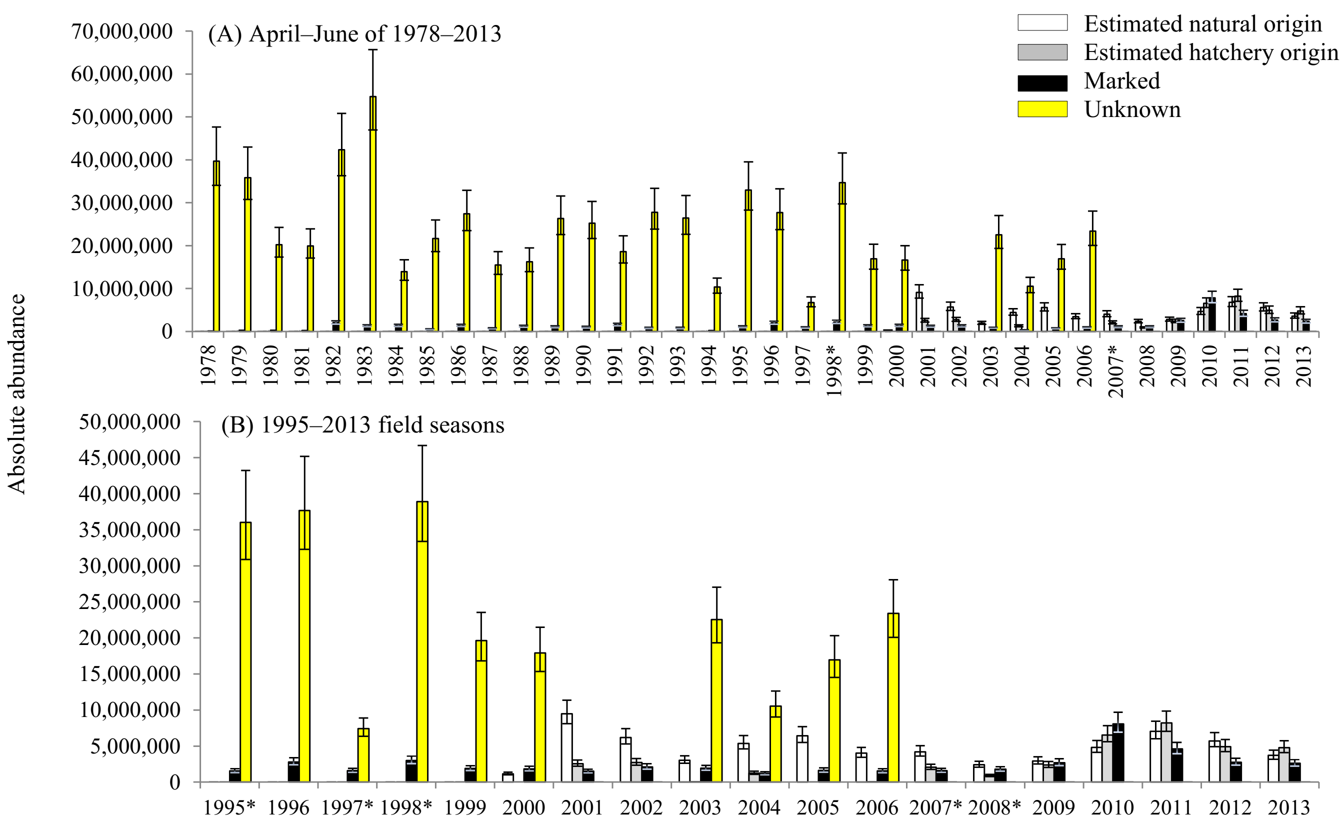

Figure 35. Mean absolute abundance estimates and their 95% confidence intervals for juvenile fall-, late fall-, and spring-run Chinook Salmon at the Chipps Island Trawl Site **(A)** during April–June during the 1978–2013 field seasons and **(B)** year-round during the 1995–2013 field seasons. Years with asterisks indicate that 1 or 2 months of that field season were not sampled, which may bias low the annual estimate.

Fork Length Distributions

Unmarked juvenile Chinook Salmon varied considerably in size between seine regions and trawl sites during the 2012 and 2013 field seasons (Figures 36–40). However, there were only weak inter-annual differences in FLs within beach seine regions and trawl sites between the 2012 and 2013 field seasons. The majority of fishes were identified as fry (FL<70 mm; Kjelson et al. 1982) and individuals were slightly larger (1–6 mm FL) within most seine regions and trawl sites during the 2012 field season. The 2012 field season was wetter compared to the 2013 field season, but both field seasons occurred during below normal, dry, and critically dry water years (Table A.19). The FL distribution of unmarked juvenile Chinook Salmon captured during both the 2012 and 2013 field seasons ranged from 60–140 mm using the MWTR at the Chipps Island Trawl Site (Figure 36). At the Mossdale Trawl Site, the FL of fish captured by the KDTR ranged from 60–110 mm (Figure 36). Fish captured by the KDTR and MWTR at the Sacramento Trawl Site ranged from 30–65 mm and 60–100 mm (FL), respectively (Figure 37). For beach seines, the range was 26–111 mm in 2012 and 26–199 mm during the 2013 field season (Figures 38–40). In contrast to beach seine catches, the majority of fishes captured by MWTR 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 are largely consistent with the observations made during the 2010 and 2011 field seasons (Speegle et al. 2013) and 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 nets (i.e., Chipps Island=MWTR, Mossdale=KDTR, and Sacramento=KDTR and 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 considering determining if and how gear efficiency varies among gear types, methods, and locations.

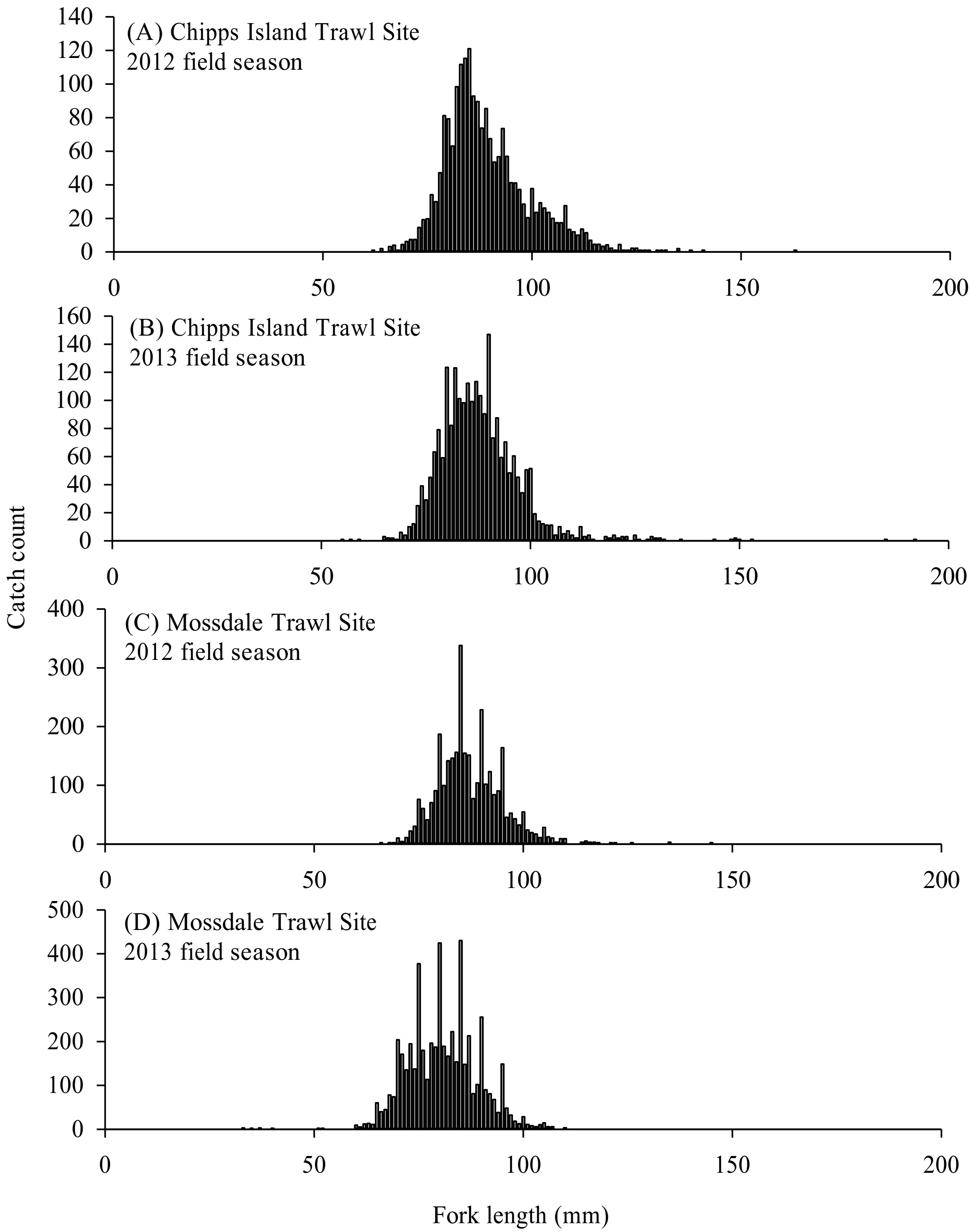

Figure 36. Fork length distributions for juvenile Chinook Salmon captured in MWTRs at the Chipps Island Trawl Site and KDTRs at the Mossdale Trawl Site during the 2012 and 2013 field seasons.

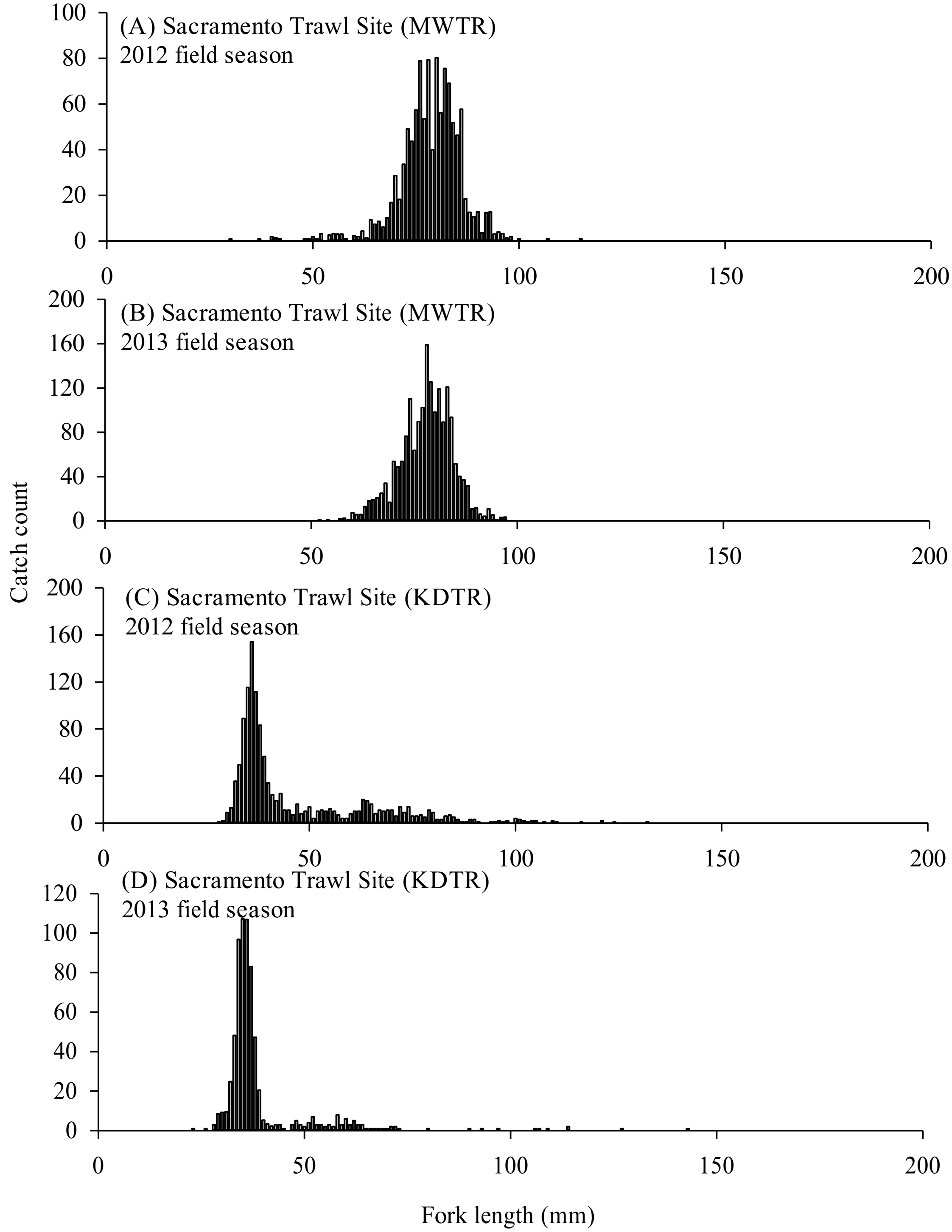

Figure 37. Fork length distributions for unmarked juvenile Chinook Salmon captured in MWTRs and KDTRs at the Sacramento Trawl Site during the 2012 and 2013 field seasons.

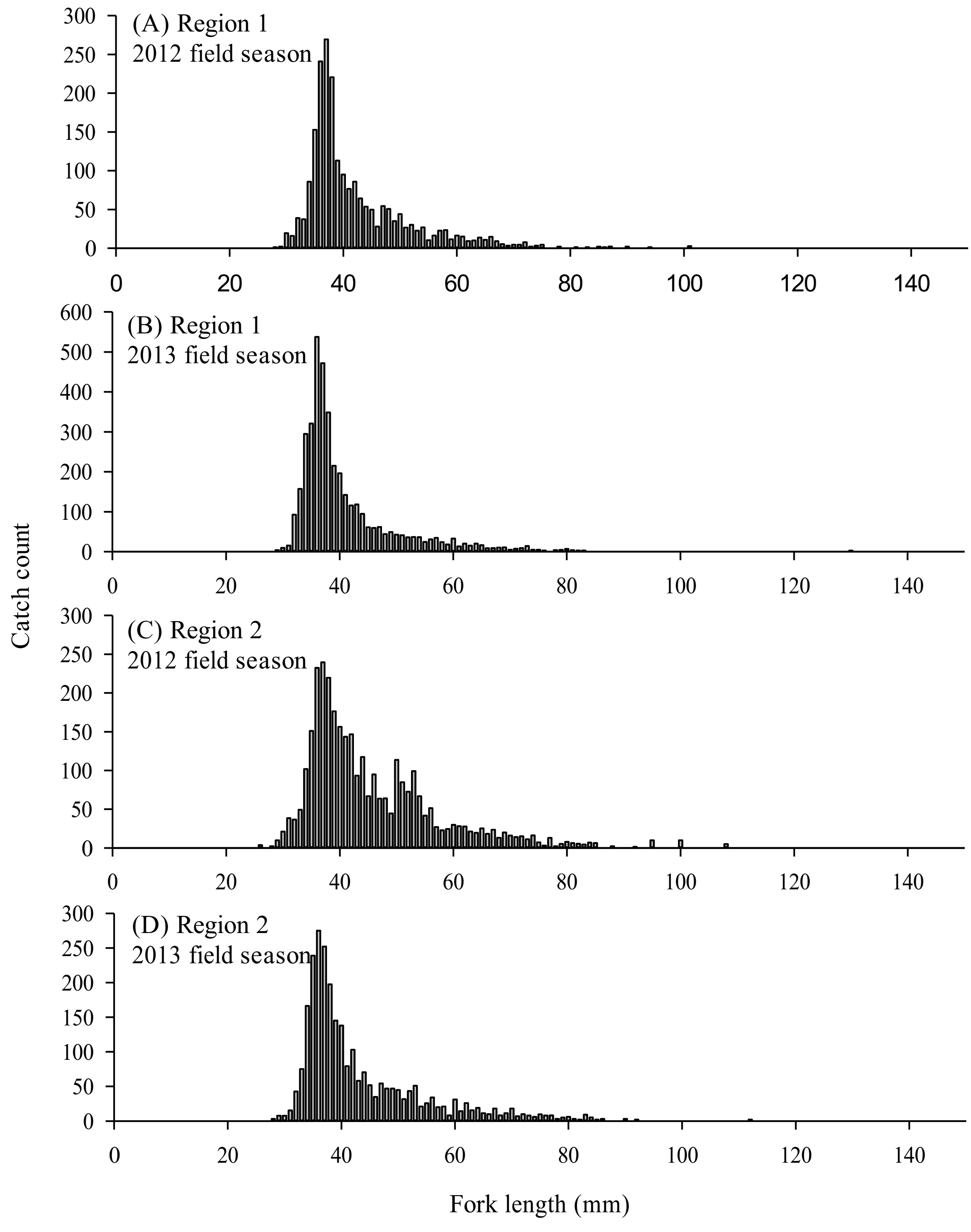

Figure 38. Fork length distributions for unmarked juvenile Chinook Salmon captured in beach seines within the Lower Sacramento River (Region 1) and North Delta (Region 2) beach seine regions during the 2012 and 2013 field seasons.

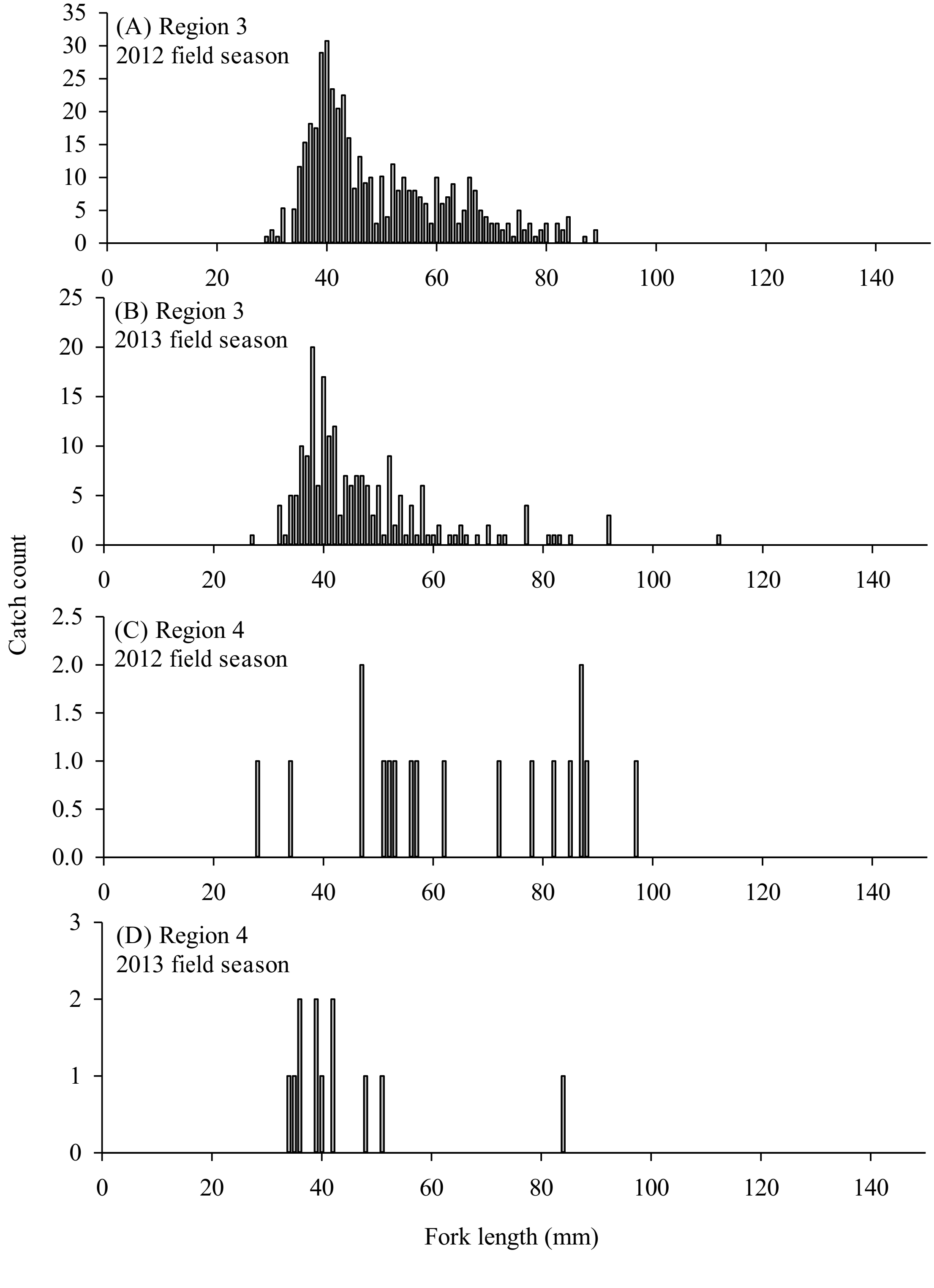

Figure 39. Fork length distributions for unmarked juvenile Chinook Salmon captured in beach seines within the Central Delta (Region 3) and South Delta (Region 4) beach seine regions during the 2012 and 2013 field seasons.

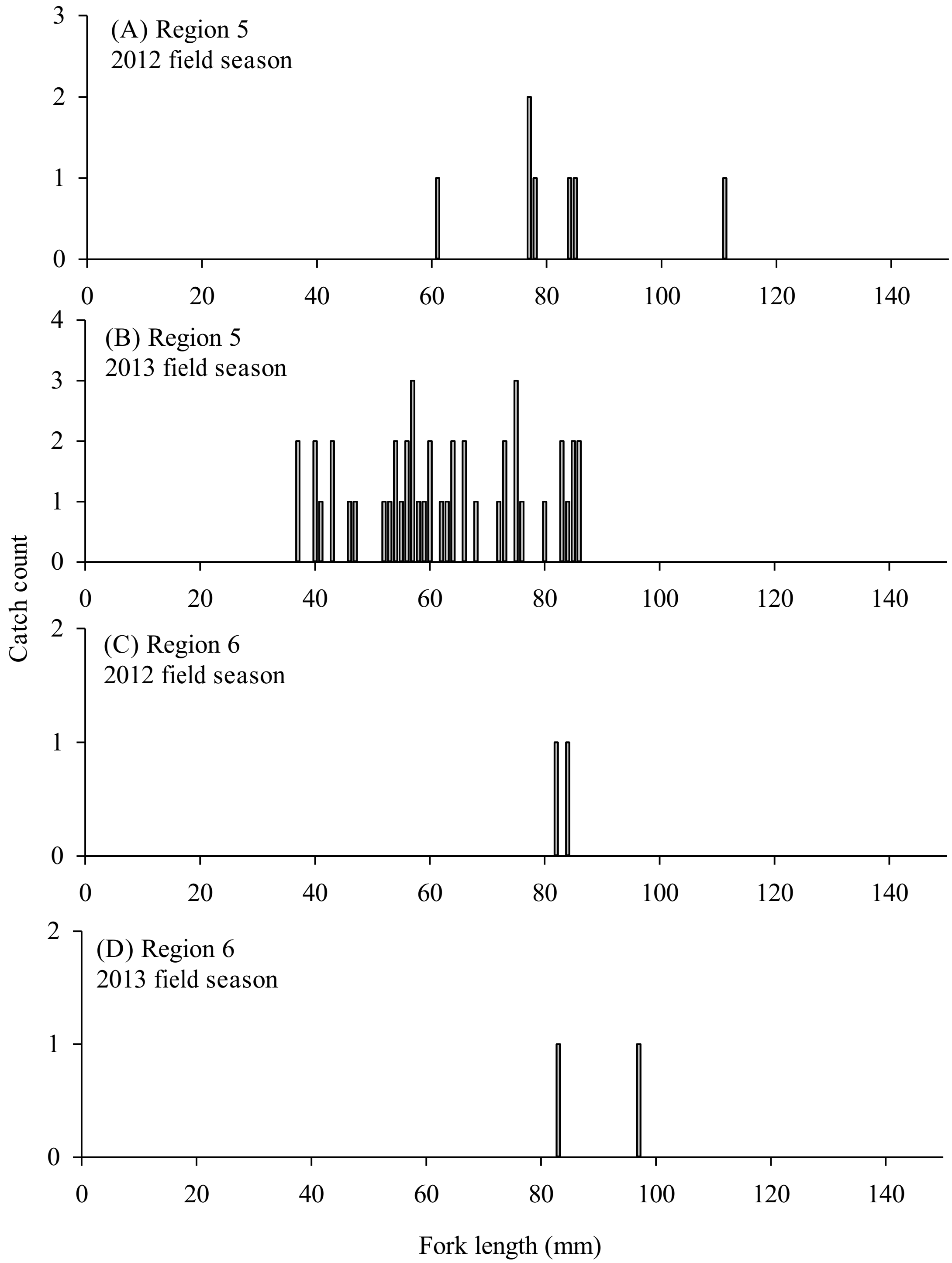

Figure 40. Fork length distributions for unmarked juvenile Chinook Salmon captured in beach seines within the Lower San Joaquin River (Region 5) and San Francisco and San Pablo Bay (Region 6) beach seine regions during the 2012 and 2013 field seasons.

MONITORING FOR DELTA CROSS CHANNEL OPERATIONS

Introduction

The DCC was constructed by the U.S. Bureau of Reclamation (USBR) in 1951 at Walnut Grove, California. The DCC was designed to facilitate the transfer of fresh water from the Sacramento River southwards through the channels of the Mokelumne River system towards the south Delta. Ultimately, water is diverted to the CVP and SWP pumps at Tracy which provide water for agricultural, municipal, and industrial uses within the Central Valley and southern California. The DCC gates enable USBR operators to prevent mixing of Sacramento River water with the more saline water in the western Delta prior to export. Before 1978, the DCC gates remained open, except during periods of high Sacramento River flow (20,000 to 25,000 cfs) when risks of channel scouring or downstream flooding warranted their closure. The USBR currently operates the DCC gates in the open position to (1) improve the transfer of water from the Sacramento River to the CVP and SWP pumping facilities, (2) improve water quality in the southern Delta, and (3) reduce saltwater intrusion rates in the western Delta.

The operation of the DCC gates alters tidal and river flows throughout the Estuary and thereby influences the migration pathways and survival of emigrating juvenile Chinook Salmon (Kjelson and Brandes 1989; Kimmerer 2008; Newman and Brandes 2010; Perry et al. 2010). Both the Federal ESA-listed spring-run and winter-run juvenile Chinook Salmon can be diverted into the central Delta when the DCC gates are open. In the central Delta, juvenile Chinook Salmon may experience lower survival rates due to water export, high temperatures, predation, and pollution (Moyle 1994; Brandes and McLain 2001; Kimmerer 2008; Newman and Brandes 2010). Because ESA-listed species, including spring-run and winter-run Chinook Salmon, are affected by DCC operations, attempts have been made by state and federal agencies to reduce their entry into the central Delta.

In 1978, the State Water Resources Control Board (SWRCB) instituted a decision (D-1485) to amend the water right permits of the CDWR and USBR for the SWP and the CVP facilities, respectively (SWRCB 1978). This decision mandated that in addition to reducing direct water diversion at the project pumps and releasing stored or natural water flows, DCC gate operations could be used to ensure adequate river flow for salinity control and to improve water quality for fish and wildlife in the estuarine ecosystem. The 1995 Water Quality Control Plan (WQCP) for the San Francisco Estuary (95-1) included specific guidelines for the operation of the DCC gates for the protection of threatened or endangered fish (SWRCB 1995), which were reaffirmed by the SWRCB in 1999 (D-1641) and the 2006 WQCP for the San Francisco Estuary (SWRCB 2006). Recovery and protection plans for juvenile winter-run and spring-run Chinook Salmon were the basis for the salmon decision processes in controlling DCC gate operations for the protection of ESA-listed species (NMFS 1997, 2009b).

Further modifications of DCC gate operations were instituted through the 2009 NMFS RPA, with 2011 amendments (NMFS 2011) that resulted from 2010 independent review panel report (Anderson et al. 2010). The current DCC operation plan (NMFS 2011, Action IV.1.2) mandates that the DCC gates be closed from October through November if fish are present. Contingent upon water quality conditions, the DCC gates remain closed from December through January except during experiments approved by NMFS investigating fish migration patterns occurring from December 1 through December 14 (Table 2). The NMFS RPA mandates DCC closures from February 1 to May 20 and from May 21 to June 15 if needed (NMFS 2011).

To facilitate coordination among the fishery resource agencies and project operators, a salmon decision process (refer to NMFS 2011 for the current process, Action IV.1.2) was drafted to minimize the impact of the DCC on emigrating salmonids and Green Sturgeon *Acipenser medirostris*. Once the salmon decision process is triggered, depending on the magnitude of the catch and the water quality, recommendations are made to USBR through the Delta Operations for Salmonids and Sturgeon group (DOSS) to close the DCC gates (Table 2). The DOSS group is a technical advisory group made up of NMFS, USFWS, CDWR, CDFW and USBR (NMFS 2011, Action IV.5). The Knights Landing Catch Index (KLCI) and the Sacramento Catch Index (SCI) are the criteria upon which the first action is based for closing the DCC gates. The KLCI is calculated using catch data from the CDFW rotary screw trap located at Knights Landing. The SCI is generated from beach seine and trawl catch data collected by the DJFMP on the Sacramento River.

The catch data are provided to the DOSS group through the Data Assessment Team (DAT) report. The SCI, used alone or in conjunction with the KLCI or increases in the average daily flow rates, may trigger various actions of the modified Chinook Salmon decision process (Table 2). In this section of the report, we will discuss how the relative abundance indices of unmarked winter-run sized or older juvenile Chinook Salmon occurring near Sacramento informed real-time DCC water operation decisions.

Methods

The SCI was calculated using unmarked juvenile Chinook Salmon catch data collected either at the Sacramento Trawl Site or within the Sacramento Area Seine Region (Table 1; Figure 41). In general, the Sacramento Trawl Site was sampled three days per week from October through January during the 2012 and 2013 field seasons. In addition, eight beach seine sites located within the Sacramento Area Seine Region were sampled three days per week from October through December and one day per week in January (Tables A.23 and A.24). The increased sampling frequency using beach seines during October through December was intended to better detect winter-run sized or older juvenile Chinook Salmon migrating near the DCC and inform real-time water diversion decisions (NMFS 2011). Although the frequency of sampling at the Sacramento Trawl Site was not increased during this period, the Sacramento trawl did use a larger KDTR in place of the MWTR to sample larger juvenile Chinook Salmon. The sampling methodologies and fish processing methods were the same as described earlier within the "Long-Term Monitoring" section. The race of all unmarked juvenile Chinook Salmon was categorized using the river LDC developed by Fisher (1992) and modified by Greene (1992).

Table 2. The Salmon Decision Process (NMFS 2011, RPA Action IV.1).

Time	Trigger	Action
Oct 1–Nov 30	Water quality criteria met, Knights Landing Catch Index (KLCI) and/or Sacramento Catch Index (SCI) > 3 and ≤ 5	Close Delta Cross Channel (DCC) gates for 3 days within 24 hours
	Water quality criteria met, KLCI and/or SCI > 5	Close DCC gates until index < 3
	Water quality criteria not met, KLCI and/or SCI > 3	DOSS elevates decision to NMFS & Water Operations Management Team (WOMT)
Dec 1–Dec 14	Water quality criteria are met	DCC gates closed, may be opened for Delta Action 8
	Water quality criteria not met, and KLCI and/or SCI < 3	Open DCC gates until water quality criteria met
	Water quality criteria not met, and KLCI and/or SCI > 3	DOSS elevates decision to NMFS & WOMT
Dec 15–Jan 31	No triggers needed	DCC gates closed
	NMFS-approved experiments conducted	DCC gates may be opened for 5 days
Feb 1–May 20	D-1641 mandatory gate closure	DCC gates closed per water quality criteria
May 21–Jun 15	D-1641 gate operations criteria	DCC gates closed for 14 days, if NMFS warrants

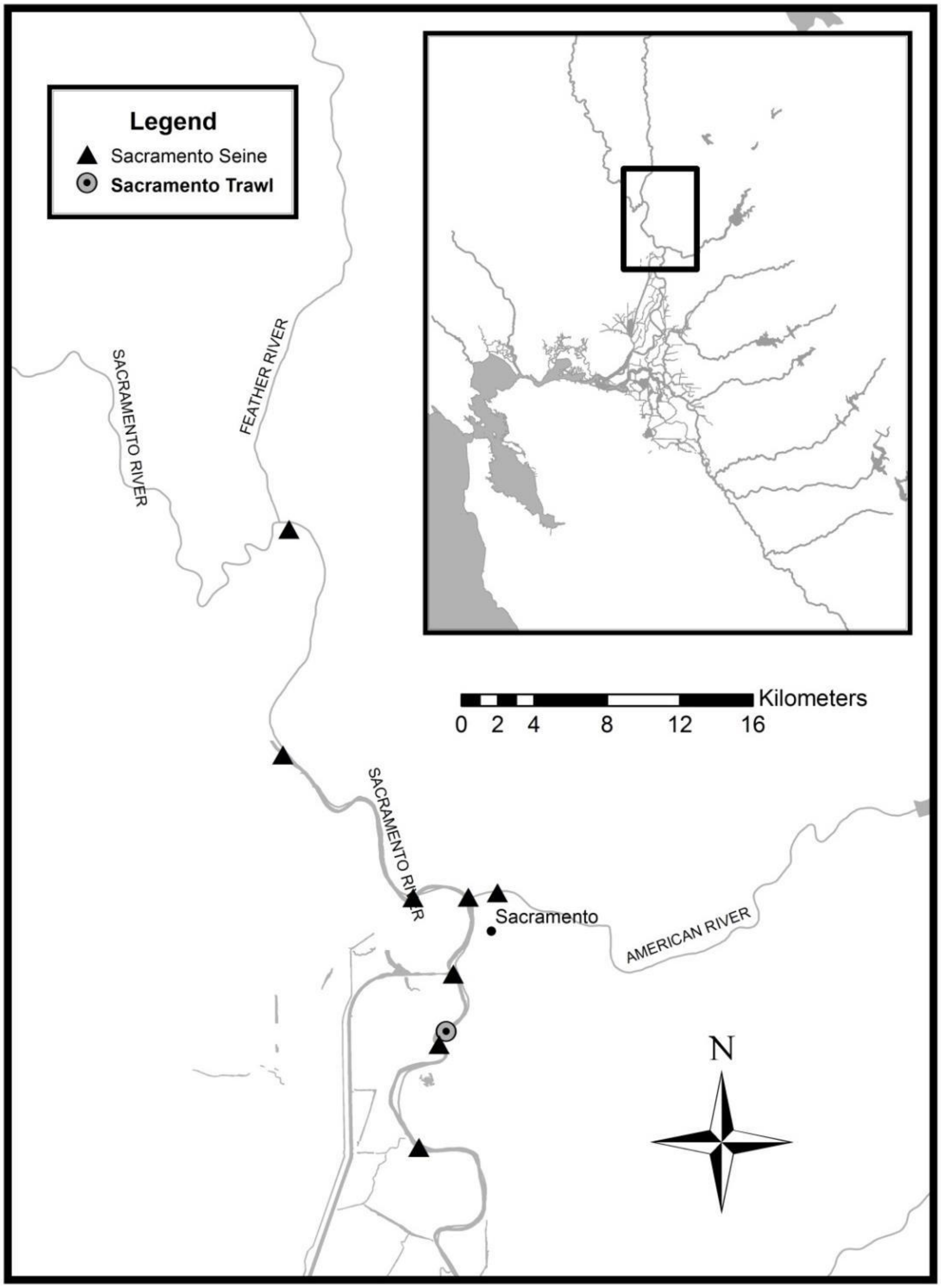

Figure 41. Delta Cross Channel sites sampled during the 2012 and 2013 field season within the lower Sacramento and San Joaquin rivers and San Francisco Estuary.

The SCI represents the number of winter-run size or larger juvenile Chinook Salmon captured within a day at the Sacramento Trawl Site or within the Sacramento Area Seine Region standardized to one day of effort and is calculated as:

$$SCI_{dG} = \frac{\sum Catch_{dG}}{Samples_{dG}} \cdot SE_G \tag{8}$$

Where d indexes a sample day, G indexes gear type (i.e., seine or trawl), $Catch_{dG}$ represents the number of winter-run sized or larger juvenile Chinook Sample captured using gear type G during sample day d, $Samples_{dG}$ represents the number of seine hauls or trawl tows completed during sample day d using gear type G, and SE_G represents the standard number of samples completed using gear type G during a typical sample day (SE_{seine}=8 and SE_{trawl}=10). All samples regardless of their condition (e.g., good, poor, etc.) were used for SCI estimates for each sample day.

Results and Discussion

Unmarked winter-run sized or larger juvenile Chinook Salmon were first detected within the Sacramento Area Beach Seine Region near the DCC water diversion gates during the months of October and November for the 2012 and 2013 field seasons respectively (Figure 42). The DJFMP Sacramento Catch Index did not trigger any DCC operations in the 2012 field season. However, the Sacramento Trawl SCI or the Sacramento Beach Seine SCI exceeded the threshold of the salmon decision process on 13 sampling dates during the 2013 field season (Table 3; Figure 42). This either triggered or maintained the closure of the DCC gates in conjunction with the KLCI and water quality indices on 12 occasions (DCC operational logs and final DOSS notes; Edmund Yu, CDWR, personal communication).

In general, the 2012 and 2013 monitoring conducted at the Sacramento Trawl Site and within the Sacramento Area Beach Seine Region was used to inform real-time water operations at the DCC water diversion gates. The monitoring likely prevented ESA-listed juvenile Chinook Salmon diversions into the Central Delta and maximized flexibility in water operations. To improve the monitoring and our understanding regarding the true occupancy of winter-run sized or larger juvenile Chinook Salmon near the DCC, we recommend a thorough investigation of the gear efficiency. Knowing the gear efficiency will assist to inform real-time water operation decisions more effectively and efficiently.

Table 3. Salmon Decision Process trigger events (Sacramento Catch Index=SCI, Knights Landing Catch Index=KLCI) by sample day and gear type (beach seine or trawl) during the 2012 and 2013 field seasons.

Sample date	SCI (beach seine)	SCI (trawl)	Action
11/21/2012	3.43		SCI would have triggered closure had index been calculated
11/23/2012	6.86	9.00	All three indices triggered (KLCI, SCIs), gates closed on 11/27
11/24/2012			
11/25/2012			
11/26/2012	16.00	44.00	All three indices triggered (KLCI, SCIs), gates closed on 11/27
11/27/2012			
11/28/2012	17.14		KLCI triggered on 11/27, SCI kept gates closed until 11/30
12/01/2012	17.60		SCI maintained closure until 12/14
12/02/2012			
12/03/2012	40.00	25.00	SCI maintained closure until 12/14
12/04/2012	48.00		SCI maintained closure until 12/14
12/05/2012			
12/06/2012	14.40		SCI maintained closure until 12/14
12/07/2012	24.00	9.23	SCI maintained closure until 12/14
12/08/2012			
12/09/2012			
12/10/2012	42.67		SCI maintained closure until 12/14
12/11/2012			
12/12/2012	20.57		SCI maintained closure until 12/14
12/13/2012	8.00		SCI maintained closure until 12/14
12/14/2012	4.57		SCI maintained closure until 12/14

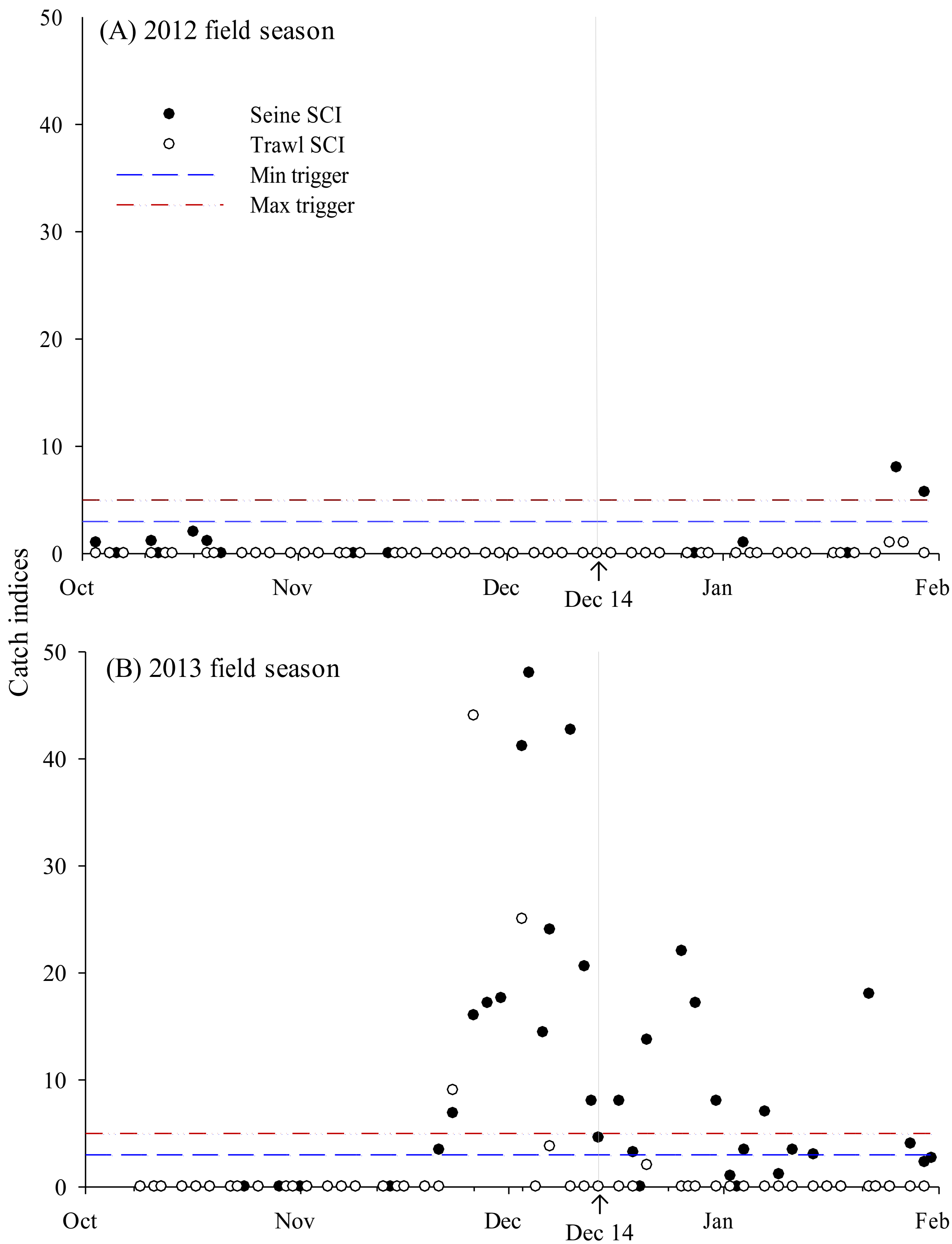

Figure 42. Sacramento Catch Index (SCI) estimates generated by the catch of winter-run size or larger juvenile Chinook Salmon in the Sacramento Trawl Site and within the Sacramento Area Beach Seine Region during the **(A)** 2012 and **(B)** 2013 field seasons and the minimum (blue dashed line) and maximum (red dashed line) SCI values required to trigger recommendations to close the Delta Cross Channel gates.

REFERENCES

Anderson, J. J., R. T. Kneib, S. A. Luthy, and P. E. Smith. 2010. Report of the 2010 Independent Review Panel (IRP) on the Reasonable and Prudent Alternative (RPA) actions affecting the Operations Criteria and Plan (OCAP) for state/federal water operations. Prepared for: Delta Stewardship Council, Delta Science Program. December 9. Available: http://deltacouncil.ca.gov/science-program-event-products. (January 2014).

Banks, M. A., V. K. Rashbrook , M. J. Calavetta, C. A. Dean, and D. Hedgecock. 2000. Analysis of microsatellite DNA resolves genetic structure and diversity of Chinook Salmon (*Oncorhynchus tshawytscha*) in California's Central Valley. Canadian Journal of Fisheries and Aquatic Sciences 57:915–927.

Banks, M. A., D. P. Jacobson, I. Meusnier, C. A. Greig, V. K. Rashbrook, W. R. Ardren, C. T. Smith, J. Bernier-Latmani, J. Van Sickle, and K. G. O'Malley. 2014. Testing advances in molecular discrimination among Chinook Salmon life histories: evidence from a blind test. Animal Genetics. 45(3):412–420.

Bayley, P. B., and J. T. Peterson. 2001. An approach to estimate probability of presence and richness of fish species. Transactions of the American Fisheries Society 130:620–633.

Bradford, J. J., and P. S. Higgins. 2001. Habitat-, season-, and size specific variation in diel activity patterns of juvenile Chinook Salmon (*Oncorhynchus tshawystcha*) and steelhead trout (*Oncorhynchus mykiss*). Canadian Journal of Fisheries and Aquatic Sciences 58:365–374.

Brandes, P. L., and J. S. McClain. 2001. Juvenile Chinook Salmon abundance, distribution, and survival in the Sacramento-San Joaquin Estuary. Pages 39–138 i*n* R. L. Brown, editor. Contributions to the biology of Central Valley salmonids. Fish Bulletin 179:(2), California Department of Fish and Game, Sacramento, California.

Buchanan, R. A. 2015. Chinook Salmon 2012 acoustic-tagging study: statistical methods and results. Report prepared for P. Brandes. Stockton Fish and Wildlife Office, United States Fish and Wildlife Service, Lodi, California.

Bunn, S. E., and A. H. Arthington. 2002. Basic principles and ecological consequences of altered flow regimes for aquatic biodiversity. Environmental Management 30(4):492–507.

California Department of Fish and Wildlife (CDFW). 2005. The status of rare, threatened, and endangered plants and animals of California 2000–2004. Available: https://www.wildlife.ca.gov/Conservation/CESA. (January 2014).

California Department of Fish and Wildlife (CDFW). 2014. California Central Valley Sacramento and San Joaquin River systems Chinook Salmon escapement. Available: http://www.calfish.org/ProgramsData/Species/CDFWAnadromousResourceAssessment.aspx. (January 2014).

California Department of Water Resources (CDWR). 2014a. Dayflow database. Available: http://www.water.ca.gov/dayflow. (January 2014).

California Department of Water Resources (CDWR). 2014b. California Data Exchange Center. Available: http://cdec.water.ca.gov. (January 2014).

Cope, O. B., and D. W. Slater. 1957. Role of Coleman Hatchery in maintaining a King Salmon run. Fish and Wildlife Service Research Report 47.

Dekar, M., P. Brandes, J. Kirsch, L. Smith, J. Speegle, P. Cadrett, and M. Marshall. 2013. USFWS Delta Juvenile Fish Monitoring Program review background report. Stockton Fish and Wildlife Office, United States Fish and Wildlife Service, Lodi, California. Available: http://www.water.ca.gov/iep/activities/reviews.cfm. (January 2015).

Dunne, T., and L. B. Leopold. 1978. Water in Environmental Planning. W. H. Freeman and Co, New York.

Feyrer, F., and M. P. Healey. 2003. Fish community structure and environmental correlates in the highly altered southern Sacramento-San Joaquin Delta. Environmental Biology of Fishes 66:123–132.

Fisher, F. W. 1992. Chinook Salmon, *Oncorhynchus tshawytscha*, growth and occurrence in the Sacramento-San Joaquin River system. Draft Inland Fisheries Division Office Report. California Department of Fish and Game. Sacramento, California.

Fisher, F. W. 1994. Past and present status of Central Valley Chinook Salmon. Conservation Biology 8(3):870–873.

Gaines, P. D., and C. D. Martin. 2002. Abundance and seasonal, spatial, and diel distribution patterns of juvenile salmonids passing the Red Bluff Diversion Dam, Sacramento River. United States Fish and Wildlife Service, Red Bluff, California.

Greene, S. 1992. Memorandum: Daily length tables. California Department of Water Resources. Environmental Services Office Sacramento, California. May 1992.

Greig, C., D. P. Jacobson, and M. A. Banks. 2003. New tetranucleotide microsatellites for fine-scale discrimination among endangered Chinook Salmon (*Oncorhynchus tshawytscha*). Molecular Ecology Notes 3:376–379.

Johnson, J. K. 2004. Regional overview of coded wire tagging of anadromous salmon and steelhead in Northwest America. Regional Mark Processing Center, Pacific States Marine Fisheries Commission, Portland, Oregon.

Kimmerer, W. J. 2002. Physical, biological, and management responses to variable freshwater flow into the San Francisco Estuary. Estuaries 25(6):1275–1290.

Kimmerer, W. J. 2008. Losses of Sacramento River Chinook Salmon and Delta Smelt (*Hypomesus transpacificus*) to entrainment in water diversions in the Sacramento-San Joaquin Delta. San Francisco Estuary and Watershed Science [online serial] 6(2): article 2. Available: http://escholarship.org/uc/item/7v92h6fs. (January 2015).

Kjelson, M. A., P. F. Raquel, and F. W. Fisher. 1982. Life history of fall-run juvenile Chinook Salmon, *Oncorhynchus tshawytscha*, in the Sacramento-San Joaquin Estuary, California. Pages 393–411 *in* V.S. Kennedy, editor. Estuarine Comparisons. Academic Press, New York, New York, USA.

Kjelson, M. A., and P. L. Brandes. 1989. The use of smolt survival estimates to quantify the effects of habitat changes on salmonid stocks in the Sacramento-San Joaquin Rivers, California. Canadian Special Publication of Fisheries and Aquatic Sciences 105:100–115.

Moyle, P. B. 1994. The decline of anadromous fishes in California. Conservation Biology, 8:869–870.

Moyle, P. B. 2002. Inland fishes of California, revised and expanded. University of California Press, Berkeley.

Nandor, G. F., J. R. Longwill, and D. L. Webb. 2010. Overview of coded wire tag program in the greater Pacific region of North America. Pages 5–46 *in* K.S. Wolf and J.S. O'Neal, editors. Tagging, telemetry, and marking measures for monitoring fish populations. Pacific Northwest Aquatic Monitoring Partnership, Special Publication 2010-002. Available: www.pnamp.org/document/2888. (January 2014).

Newman, K. B., and P. L. Brandes. 2010. Hierarchical modeling of juvenile Chinook Salmon survival as a function of Sacramento–San Joaquin Delta water exports. North American Journal of Fisheries Management. 30:157–169.

Nichols, F. H., J. E. Cloern, S. N. Luoma, and D. H. Peterson. 1986. The modification of an estuary. Science 23:567–573.

National Marine Fisheries Service (NMFS). 2009a. Biological opinion and conference opinion on the long-term operations of the central valley project and state water project. NMFS Southwest Region. Long Beach, California.

National Marine Fisheries Service (NMFS). 2009b. Public draft recovery plan for the evolutionarily significant units of Sacramento River winter-run Chinook Salmon and Central Valley spring-run Chinook Salmon and the distinct population segment of Central Valley steelhead. Sacramento Protected Resources Division. Sacramento, California.

National Marine Fisheries Service (NMFS). 2011. 2009 RPA with 2011 amendments. National Marine Fisheries Service. Southwest Region. Long Beach, California.

Pacific States Marine Fisheries Commission (PSMFC). 2014. Regional Mark Information System (RMIS) website. Available: http://www.rmpc.org. (January 2014).

Perry, R. W., P. L. Brandes, P. T. Sandstrom, A. Ammann, B. MacFarlane, A. P. Klimley, and J. R. Skalski. 2010. Estimating survival and migration route probabilities of juvenile Chinook Salmon in the Sacramento–San Joaquin River Delta. North American Journal of Fisheries Management. 30:142–156.

Pyper, B., T. Garrison, S. Cramer, P. Brandes, D. Jacobson, and M. Banks. 2013. Absolute abundance estimates of juvenile spring-run and winter-run Chinook Salmon at Chipps Island. Cramer Fish Sciences Technical Report for U.S. Fish and Wildlife Service, Lodi, CA.

San Joaquin River Group Authority (SJRGA). 2009. 2008 Annual technical report on the implementation and monitoring of the San Joaquin River Agreement and the Vernalis Adaptive Management Plan. Stockton, California.

Slater, D. W. 1963. Winter-run Chinook Salmon in the Sacramento River, California, with notes on water temperature requirements at spawning. US Fish and Wildlife Special Science Report 461:9.

Speegle, J., J. Kirsch, and J. Ingram. 2013. Annual report: juvenile fish monitoring during the 2010 and 2011 field seasons within the San Francisco Estuary, California. Stockton Fish and Wildlife Office, United States Fish and Wildlife Service, Lodi, California.

Stevens, D. E., and L. W. Miller. 1983. Effects of river flow on abundance of young Chinook Salmon, American Shad, Longfin Smelt, and Delta Smelt in the Sacramento-San Joaquin River System. North American Journal of Fisheries Management 3(4):425–437.

State Water Resources Control Board (SWRCB, CalEPA). 1978. Water Right Decision 1485. Available: www.swrcb.ca.gov. (January 2014).

State Water Resources Control Board (SWRCB, CalEPA). 1995. Water Quality Control Plan for the San Francisco Bay-San Joaquin Delta Estuary. 95-1 WR. May 1995.

State Water Resources Control Board (SWRCB, CalEPA). 1999. Water Right Decision 1641.

State Water Resources Control Board (SWRCB, CalEPA). 2006. Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary. December 2006.

Swain, D. L., M. Tsiang, M. Haugen, D. Singh, A. Charland, B. Rajaratnam, and N. Diffenbaugh. 2014. The extraordinary California drought of 2013/2014: character, context, and the role of climate change, Bulletin of the American Meteorological Society (September 2014).

United States Fish and Wildlife Service (USFWS). 1987. Exhibit 31: The needs of Chinook Salmon, *Oncorhynchus tshawystcha* in the Sacramento-San Joaquin Estuary. Presented to the State Water Resources Control Board for the 1987 Water Quality/Water Rights Proceedings on the San Francisco Bay/Sacramento-San Joaquin Delta.

United States Fish and Wildlife Service (USFWS). 1993. 1992 Annual progress report: abundance and survival of juvenile Chinook Salmon in the Sacramento-San Joaquin Estuary. Stockton Fish and Wildlife Office, United States Fish and Wildlife Service, Stockton, California.

United States Fish and Wildlife Service (USFWS). 1998. 1995 Annual progress report: abundance and survival of juvenile Chinook Salmon in the Sacramento-San Joaquin Estuary. Stockton Fish and Wildlife Office, United States Fish and Wildlife Service, Stockton, California.

United States Geological Survey (USGS). 2014. California Water Science Center website. http://ca.water.usgs.gov. (January 2014).

Wilder, R. M., and J. F. Ingram. 2006. Temporal patterns in catch rates of juvenile Chinook Salmon and trawl net efficiencies in the lower Sacramento River. Interagency Ecological Program Newsletter 19:18–28.

Williams, J. G. 2006. Central Valley salmon: a perspective on Chinook and steelhead in the Central Valley of California. San Francisco Estuary and Watershed Science [online serial] 4(3): article 2. Available: http://escholarship.org/uc/item/21v9x1t7. (January 2015).

Yoshiyama, R. M., F. W. Fisher, and P. B. Moyle. 1998. Historical abundance and decline of Chinook Salmon in the Central Valley Region of California. North American Journal of Fisheries Management 18:487–521.

APPENDIX

Table A.1. Sites sampled during the 2012 and 2013 field seasons 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	Coordinates (UTM)			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	Knights Landing	Yolo	10 S	4295506	610842	1981
SR080E[a]	Verona[a]	Sutter	10 S	4293731	620049	1981
SR071E[a]	Elkhorn[a]	Sacramento	10 S	4281359	619626	1981
Region 2: North Delta Seine						
SR060E[b]	Discovery Park[b]	Sacramento	10 S	4273503	629820	1976
AM001S[b]	American River[b]	Sacramento	10 S	4273377	630121	1976
SR049E[b]	Garcia Bend[b]	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 A.1. Continued.

Site code	Site name	County	Coordinates (UTM) 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[c]	N. of Tuolumne River[c]	Stanislaus	10 S	4164462	660960	1994
SJ077E[c]	Route 132[c]	Stanislaus	10 S	4167222	656395	1994
SJ074W[c]	Sturgeon Bend[c]	San Joaquin	10 S	4170903	654784	1994
SJ068W[c]	Durham Site[c]	San Joaquin	10 S	4173594	652327	1994
SJ063W[c]	Big Beach[c]	San Joaquin	10 S	4176666	650093	1994
SJ058W[d]	Weatherbee[d]	San Joaquin	10 S	4181923	649451	1994
SJ056E[d]	Mossdale[d]	San Joaquin	10 S	4183536	649043	1994
SJ079E[e]	San Luis Refuge[e]	Stanislaus	10 S	4166449	657914	2008
SJ076W[e]	N. of Route 132[e]	Stanislaus	10 S	4168198	656679	2008
SJ074A[e]	Sturgeon Bend Alternate[e]	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 A.1. Continued.

Site code	Site name	County	Coordinates (UTM)			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

[a] Site was included within both Region 1 and Region 7 from Oct 1 to Jan 31.

[b] Site was included within both Region 2 and Region 7 from Oct 1 to Jan 31.

[c] Site was sampled when San Joaquin River discharge was > $51 m^3/s$ during the 2000–2012 field seasons, and year-round during the 2013 field season.

[d] Site was sampled throughout the field season during 2000–2013.

[e] Site was sampled when San Joaquin River discharge was ≤ $51 m^3/s$ during the 2000–2012 field seasons.

Table A.2. Fish species, common names, and assemblage groups. Fish species are listed in phylogenetic order.

Common name	Genus	Species	Assemblage group
River Lamprey	*Lampetra*	*ayresii*	Anadromous-benthic-native
Western Brook Lamprey	*Lampetra*	*richardsoni*	Benthic-native
Pacific Lamprey	*Lampetra*	*tridentatus*	Anadromous-benthic-native
Spiny Dogfish	*Squalus*	*acanthias*	Benthic-native
Gray Smoothhound	*Mustelus*	*californicus*	Benthic-native
Brown Smoothhound	*Mustelus*	*henlei*	Benthic-native
Leopard Shark	*Triakis*	*semifasciata*	Benthic-native
Pacific Electric Ray	*Torpedo*	*californica*	Benthic-native
Thornback Ray	*Platyrhinoidis*	*triseriata*	Benthic-native
Big Skate	*Raja*	*binoculata*	Benthic-native
Bat Ray	*Myliobatis*	*californica*	Benthic-native
Green Sturgeon	*Acipenser*	*medirostris*	Anadromous-benthic-native
White Sturgeon	*Acipenser*	*transmontanus*	Anadromous-benthic-native
American Eel	*Anguilla*	*rostrata*	Benthic-nonnative
Northern Anchovy	*Engraulis*	*mordax*	Pelagic-native
American Shad	*Alosa*	*sapidissima*	Anadromous-pelagic-nonnative
Pacific Herring	*Clupea*	*pallasii*	Pelagic-native
Threadfin Shad	*Dorosoma*	*petenense*	Pelagic-nonnative
Pacific Sardine	*Sardinops*	*sagax*	Pelagic-native
Goldfish	*Carassius*	*auratus*	Pelagic-nonnative
Red Shiner	*Cyprinella*	*lutrensis*	Pelagic-nonnative
Common Carp	*Cyprinus*	*carpio*	Benthic-nonnative
Tui Chub	*Gila*	*bicolor*	Pelagic-native
California Roach	*Hesperoleucus*	*symmetricus*	Pelagic-native
Hitch	*Lavinia*	*exilicauda*	Pelagic-native
Hardhead	*Mylopharodon*	*conocephalus*	Pelagic-native
Golden Shiner	*Notemigonus*	*crysoleucas*	Pelagic-nonnative
Sacramento Blackfish	*Orthodon*	*microlepidotus*	Pelagic-native
Rosyface Shiner	*Notropis*	*rubellus*	Pelagic-nonnative
Fathead Minnow	*Pimephales*	*promelas*	Pelagic-nonnative
Sacramento Splittail	*Pogonichthys*	*macrolepidotus*	Benthic-native
Sacramento Pikeminnow	*Ptychocheilus*	*grandis*	Pelagic-native
Speckled Dace	*Rhinichthys*	*osculus*	Pelagic-native
Sacramento Sucker	*Catostomus*	*occidentalis*	Benthic-native
White Catfish	*Ameiurus*	*catus*	Benthic-nonnative
Black Bullhead	*Ameiurus*	*melas*	Benthic-nonnative
Yellow Bullhead	*Ameiurus*	*natalis*	Benthic-nonnative
Brown Bullhead	*Ameiurus*	*nebulosus*	Benthic-nonnative
Blue Catfish	*Ictalurus*	*furcatus*	Benthic-nonnative

Table A.2. Continued.

Common name	Genus	Species	Assemblage group
Channel Catfish	*Ictalurus*	*punctatus*	Benthic-nonnative
Northern Pike	*Esox*	*lucius*	Pelagic-nonnative
Whitebait Smelt	*Allosmerus*	*elongatus*	Pelagic-native
Wakasagi	*Hypomesus*	*nipponensis*	Pelagic-nonnative
Surf Smelt	*Hypomesus*	*pretiosus*	Pelagic-native
Delta Smelt	*Hypomesus*	*transpacificus*	Anadromous-pelagic-native
Night Smelt	*Spirinchus*	*starksi*	Pelagic-native
Longfin Smelt	*Spirinchus*	*thaleichthys*	Anadromous-pelagic-native
Pink Salmon	*Oncorhynchus*	*gorbuscha*	Anadromous-pelagic-nonnative
Coho Salmon	*Oncorhynchus*	*kisutch*	Anadromous-pelagic-native
Kokanee (lacustrine Sockeye Salmon)	*Oncorhynchus*	*nerka*	Pelagic-nonnative
Steelhead	*Oncorhynchus*	*mykiss*	Anadromous-pelagic-native
Chinook Salmon	*Oncorhynchus*	*tshawytscha*	Anadromous-pelagic-native
Brown Trout	*Salmo*	*trutta*	Anadromous-pelagic-nonnative
Plainfin Midshipman	*Porichthys*	*notatus*	Benthic-native
Pacific Tomcod	*Microgadus*	*proximus*	Pelagic-native
Striped Mullet	*Mugil*	*cephalus*	Pelagic-native
Topsmelt	*Atherinops*	*affinis*	Pelagic-native
Jacksmelt	*Atherinopsis*	*californiensis*	Pelagic-native
Inland Silverside	*Menidia*	*beryllina*	Pelagic-nonnative
Rainwater Killifish	*Lucania*	*parva*	Pelagic-nonnative
Western Mosquitofish	*Gambusia*	*affinis*	Pelagic-nonnative
Threespine Stickleback	*Gasterosteus*	*aculeatus*	Anadromous-pelagic-native
Bay Pipefish	*Syngnathus*	*leptorhynchus*	Pelagic-native
Brown Rockfish	*Sebastes*	*auriculatus*	Benthic-native
Lingcod	*Ophiodon*	*elongatus*	Benthic-native
Prickly Sculpin	*Cottus*	*asper*	Benthic-native
Riffle Sculpin	*Cottus*	*gulosus*	Benthic-native
Pacific Staghorn Sculpin	*Leptocottus*	*armatus*	Benthic-native
Tidepool Sculpin	*Oligocottus*	*maculosus*	Benthic-native
Saddleback Sculpin	*Oligocottus*	*rimensis*	Benthic-native
Cabezon	*Scorpaenichthys*	*marmoratus*	Benthic-native
White Bass	*Morone*	*chrysops*	Pelagic-nonnative
Striped Bass	*Morone*	*saxatilis*	Anadromous-pelagic-nonnative
Sacramento Perch	*Archoplites*	*interruptus*	Pelagic-native
Green Sunfish	*Lepomis*	*cyanellus*	Pelagic-nonnative
Pumpkinseed	*Lepomis*	*gibbosus*	Pelagic-nonnative

Table A.2. Continued.

Common name	Genus	Species	Assemblage group
Warmouth	*Lepomis*	*gulosus*	Pelagic-nonnative
Bluegill	*Lepomis*	*macrochirus*	Pelagic-nonnative
Redear Sunfish	*Lepomis*	*microlophus*	Pelagic-nonnative
Smallmouth Bass	*Micropterus*	*dolomieu*	Pelagic-nonnative
Spotted Bass	*Micropterus*	*punctulatus*	Pelagic-nonnative
Redeye Bass	*Micropterus*	*coosae*	Pelagic-nonnative
Largemouth Bass	*Micropterus*	*salmoides*	Pelagic-nonnative
White Crappie	*Pomoxis*	*annularis*	Pelagic-nonnative
Black Crappie	*Pomoxis*	*nigromaculatus*	Pelagic-nonnative
Yellow Perch	*Perca*	*flavescens*	Pelagic-nonnative
Bigscale Logperch	*Percina*	*macrolepida*	Pelagic-nonnative
Pacific Pompano	*Peprilus*	*simillimus*	Pelagic-native
White Croaker	*Genyonemus*	*lineatus*	Pelagic-native
Barred Surfperch	*Amphistichus*	*argenteus*	Pelagic-native
Calico Surfperch	*Amphistichus*	*koelzi*	Pelagic-native
Redtail Surfperch	*Amphistichus*	*rhodoterus*	Pelagic-native
Kelp Perch	*Brachyistius*	*frenatus*	Pelagic-native
Shiner Perch	*Cymatogaster*	*aggregata*	Pelagic-native
Black Perch	*Embiotoca*	*jacksoni*	Pelagic-native
Striped Seaperch	*Embiotoca*	*lateralis*	Pelagic-native
Spotfin Surfperch	*Hyperprosopon*	*anale*	Pelagic-native
Walleye Surfperch	*Hyperprosopon*	*argenteum*	Pelagic-native
Silver Surfperch	*Hyperprosopon*	*ellipticum*	Pelagic-native
Tule Perch	*Hysterocarpus*	*traskii*	Pelagic-native
Dwarf Surfperch	*Micrometrus*	*minimus*	Pelagic-native
White Seaperch	*Phanerodon*	*furcatus*	Pelagic-native
Rubberlip Seaperch	*Rhacochilus*	*toxotes*	Pelagic-native
Pile Perch	*Rhacochilus*	*vacca*	Pelagic-native
Penpoint Gunnel	*Apodichthys*	*flavidus*	Benthic-native
Saddleback Gunnel	*Pholis*	*ornata*	Benthic-native
Red Gunnel	*Pholis*	*schultzi*	Benthic-native
Wolf-Eel	*Anarrhichthys*	*ocellatus*	Benthic-native
Striped Kelpfish	*Gibbonsia*	*metzi*	Pelagic-native
Crevice Kelpfish	*Gibbonsia*	*montereyensis*	Pelagic-native
Giant Kelpfish	*Heterostichus*	*rostratus*	Pelagic-native
Yellowfin Goby	*Acanthogobius*	*flavimanus*	Benthic-nonnative
Arrow Goby	*Clevelandia*	*ios*	Benthic-native
Tidewater Goby	*Eucyclogobius*	*newberryi*	Benthic-native
Longjaw Mudsucker	*Gillichthys*	*mirabilis*	Benthic-native
Cheekspot Goby	*Ilypnus*	*gilberti*	Benthic-native
Bay Goby	*Lepidogobius*	*lepidus*	Benthic-native

Table A.2. Continued.

Common name	Genus	Species	Assemblage group
Shokihaze Goby	*Tridentiger*	*barbatus*	Benthic-nonnative
Shimofuri Goby	*Tridentiger*	*bifasciatus*	Benthic-nonnative
Chameleon Goby	*Tridentiger*	*trigonocephalus*	Benthic-nonnative
Pacific Sanddab	*Citharichthys*	*sordidus*	Benthic-native
Speckled Sanddab	*Citharichthys*	*stigmaeus*	Benthic-native
Bigmouth Sole	*Hippoglossina*	*stomata*	Benthic-nonnative
California Halibut	*Paralichthys*	*californicus*	Benthic-native
Pacific Halibut	*Hippoglossus*	*stenolepis*	Benthic-native
Butter Sole	*Isopsetta*	*isolepis*	Benthic-native
Rock Sole	*Lepidopsetta*	*bilineata*	Benthic-native
English Sole	*Parophrys*	*vetulus*	Benthic-native
Starry Flounder	*Platichthys*	*stellatus*	Benthic-native
Diamond Turbot	*Pleuronichthys*	*guttulatus*	Benthic-native
Sand Sole	*Psettichthys*	*melanostictus*	Benthic-native

Table A.3. Total of individuals observed in samples used to assess the fish assemblage structure during the 2012 field season. Counts are grouped by species and trawl site or seine region. Fish species are listed in phylogenetic order. Beach seine regions represent sites as assigned in Table A.1.

Fish species	Trawl site			Beach seine region					
	Sacramento	Mossdale	Chipps Island	1	2	3	4	5	6
River Lamprey *Lampetra ayresii*	18	0	0	0	0	0	0	0	0
Pacific Lamprey *Lampetra tridentatus*	2	3	2	0	0	0	0	0	0
Lamprey unknown *Lampetra* spp.	4	0	0	1	1	1	0	0	0
Leopard Shark *Triakis semifasciata*	0	0	0	0	0	0	0	0	1
Bat Ray *Myliobatis californica*	0	0	0	0	0	0	0	0	1
White Sturgeon *Acipenser transmontanus*	0	0	2	0	0	0	0	0	0
Northern Anchovy *Engraulis mordax*	0	0	27	0	0	0	0	0	171
American Shad *Alosa sapidissima*	103	82	19,959	74	124	8	10	4	19
Pacific Herring *Clupea pallasii*	0	0	56	0	0	0	0	0	50
Threadfin Shad *Dorosoma petenense*	99	894	481	1,026	562	86	443	235	0
Goldfish *Carassius auratus*	3	4	0	11	1	0	0	20	0
Red Shiner *Cyprinella lutrensis*	0	286	0	716	110	1	364	5,896	0
Common Carp *Cyprinus carpio*	9	10	1	395	11	0	2	198	0
Hitch *Lavinia exilicauda*	1	1	1	101	9	4	0	4	0
Hardhead *Mylopharodon conocephalus*	1	33	0	36	38	0	0	0	0
Golden Shiner *Notemigonus crysoleucas*	24	43	2	1,292	124	62	114	58	0
Sacramento Blackfish *Orthodon microlepidotus*	1	2	0	63	1	0	0	9	0
Fathead Minnow *Pimephales promelas*	5	0	0	1,841	100	0	1	7	0
Sacramento Splittail *Pogonichthys macrolepidotus*	3	215	216	1,030	1,101	599	13	214	0
Sacramento Pikeminnow *Ptychocheilus grandis*	35	2	2	1,014	955	102	27	20	0
Sacramento Sucker *Catostomus occidentalis*	1	57	0	3,713	3,072	356	184	1,131	0
White Catfish *Ameiurus catus*	0	221	2	1	6	1	1	0	0
Black Bullhead *Ameiurus melas*	0	0	0	0	3	0	0	1	0

Table A.3. Continued.

Fish species	Trawl site			Beach seine region					
	Sacramento	Mossdale	Chipps Island	1	2	3	4	5	6
Brown Bullhead *Ameiurus nebulosus*	0	1	0	0	0	0	3	0	0
Channel Catfish *Ictalurus punctatus*	10	265	0	1	1	0	0	3	0
Wakasagi *Hypomesus nipponensis*	20	1	2	271	728	9	0	0	0
Surf Smelt *Hypomesus pretiosus*	0	0	0	0	0	0	0	0	44
Delta Smelt *Hypomesus transpacificus*	29	0	1,160	0	63	5	0	0	0
Longfin Smelt *Spirinchus thaleichthys*	1	2	90	0	0	0	0	0	2
Steelhead *Oncorhynchus mykiss*	132	10	37	2	5	6	0	0	0
Unmarked Steelhead	8	10	6	0	5	0	0	0	0
Marked Steelhead	124	0	31	2	0	6	0	0	0
Juvenile Chinook Salmon *Oncorhynchus tshawytscha*	2,799	4,438	2,554	2,193	3,288	448	19	8	3
Unmarked winter-run	29	70	45	11	11	0	1	0	0
Unmarked fall-run	2,086	2,003	1,215	2,082	3,135	405	10	6	2
Unmarked spring-run	258	1,149	761	76	114	41	7	1	0
Unmarked late fall-run	1	0	0	11	12	0	0	0	0
Unmarked not raced	0	19	0	0	0	0	0	0	0
Marked w/ CWT	425	1,197	533	13	16	2	1	1	1
Topsmelt *Atherinops affinis*	0	0	8	0	0	0	0	0	5,567
Jacksmelt *Atherinopsis californiensis*	0	0	0	0	0	0	0	0	14
Inland Silverside *Menidia beryllina*	164	5,398	1	4,739	14,229	7,208	2,759	5,516	12
Rainwater Killifish *Lucania parva*	0	0	0	1	9	114	264	0	5
Western Mosquitofish *Gambusia affinis*	1	0	0	453	132	501	138	187	0
Threespine Stickleback *Gasterosteus aculeatus*	0	0	11	0	97	13	0	0	98
Bay Pipefish *Syngnathus leptorhynchus*	0	0	0	0	0	0	0	0	176
Prickly Sculpin *Cottus asper*	0	7	0	6	49	27	24	80	0

Table A.3. Continued.

Fish species	Trawl site: Sacramento	Trawl site: Mossdale	Trawl site: Chipps Island	Beach seine region: 1	2	3	4	5	6
Pacific Staghorn Sculpin *Leptocottus armatus*	0	0	1	0	22	73	2	4	147
Tidepool Sculpin *Oligocottus maculosus*	0	0	0	0	0	0	0	0	2
Cabezon *Scorpaenichthys marmoratus*	0	0	0	0	0	0	0	0	6
Striped Bass *Morone saxatilis*	1	878	1,185	5	143	33	27	23	33
Green Sunfish *Lepomis cyanellus*	0	1	0	2	4	4	26	0	0
Pumpkinseed *Lepomis gibbosus*	0	1	0	0	0	0	0	0	0
Warmouth *Lepomis gulosus*	1	0	0	0	1	4	2	0	0
Bluegill *Lepomis macrochirus*	5	55	3	78	100	165	440	77	0
Redear Sunfish *Lepomis microlophus*	1	30	1	36	151	460	1237	33	0
Smallmouth Bass *Micropterus dolomieu*	0	3	0	0	15	0	0	0	0
Spotted Bass *Micropterus punctulatus*	0	17	0	33	68	12	3	18	0
Largemouth Bass *Micropterus salmoides*	3	15	9	341	270	470	320	119	0
White Crappie *Pomoxis annularis*	0	5	0	57	2	0	0	0	0
Black Crappie *Pomoxis nigromaculatus*	1	9	0	214	8	3	1	65	0
Bass unknown *Micropterus* spp.	0	2	0	0	0	0	0	1	0
Bigscale Logperch *Percina macrolepida*	0	3	0	567	112	10	74	153	0
Barred Surfperch *Amphistichus argenteus*	0	0	0	0	0	0	0	0	37
Shiner Perch *Cymatogaster aggregata*	0	0	0	0	0	0	0	0	55
Black Perch *Embiotoca jacksoni*	0	0	0	0	0	0	0	0	4
Walleye Surfperch *Hyperprosopon argenteum*	0	0	0	0	0	0	0	0	21
Tule Perch *Hysterocarpus traskii*	0	25	14	20	445	454	19	5	0
Dwarf Surfperch *Micrometrus minimus*	0	0	0	0	0	0	0	0	186
White Seaperch *Phanerodon furcatus*	0	0	0	0	0	0	0	0	1
Pile Perch *Rhacochilus vacca*	0	0	0	0	0	0	0	0	2
Penpoint Gunnel *Apodichthys flavidus*	0	0	0	0	0	0	0	0	2

Table A.3. Continued.

Fish species	Trawl site			Beach seine region					
	Sacramento	Mossdale	Chipps Island	1	2	3	4	5	6
Saddleback Gunnel *Pholis ornata*	0	0	0	0	0	0	0	0	1
Crevice Kelpfish *Gibbonsia montereyensis*	0	0	0	0	0	0	0	0	6
Yellowfin Goby *Acanthogobius flavimanus*	0	0	3	1	111	163	6	0	33
Arrow Goby *Clevelandia ios*	0	0	0	0	0	0	0	0	133
Longjaw Mudsucker *Gillichthys mirabilis*	0	0	0	0	0	0	0	0	1
Bay Goby *Lepidogobius lepidus*	0	0	0	0	0	0	0	0	21
Shokihaze Goby *Tridentiger barbatus*	0	0	3	0	0	0	0	0	0
Shimofuri Goby *Tridentiger bifasciatus*	0	0	6	0	460	31	1	0	5
Chameleon Goby *Tridentiger trigonocephalus*	0	0	0	0	0	0	0	0	2
Speckled Sanddab *Citharichthys stigmaeus*	0	0	0	0	0	0	0	0	2
California Halibut *Paralichthys californicus*	0	0	0	0	0	0	0	0	7
English Sole *Parophrys vetulus*	0	0	0	0	0	0	0	0	58
Starry Flounder *Platichthys stellatus*	0	0	8	0	1	2	0	0	8
Diamond Turbot *Pleuronichthys guttulatus*	0	0	0	0	0	0	0	0	3
Sand Sole *Psettichthys melanostictus*	0	0	0	0	0	0	0	0	2
Unidentified fish	0	0	0	0	0	0	0	0	1

Table A.4. Total of individuals observed in samples used to assess the fish assemblage structure during the 2013 field season. Counts are grouped by species and trawl site or seine region. Fish species are listed in phylogenetic order. Beach seine regions represent sites as assigned in Table A.1.

Fish species	Trawl site			Beach seine region					
	Sacramento	Mossdale	Chipps Island	1	2	3	4	5	6
River Lamprey *Lampetra ayresii*	0	4	1	0	0	0	0	0	0
Pacific Lamprey *Lampetra tridentatus*	39	727	0	0	0	0	0	0	0
Lamprey unknown *Lampetra* spp.	18	5	0	0	16	0	0	0	0
White Sturgeon *Acipenser transmontanus*	0	0	2	0	0	0	0	0	0
Northern Anchovy *Engraulis mordax*	0	0	85	0	0	0	0	0	405
American Shad *Alosa sapidissima*	133	41	9,866	17	55	49	2	0	6
Pacific Herring *Clupea pallasii*	0	0	335	0	0	0	0	0	307
Threadfin Shad *Dorosoma petenense*	106	13,910	359	2,451	824	2,227	909	154	0
Goldfish *Carassius auratus*	0	0	0	0	3	0	0	0	0
Red Shiner *Cyprinella lutrensis*	0	89	0	685	20	1	174	13,134	0
Common Carp *Cyprinus carpio*	16	11	0	60	4	0	0	1	0
Hitch *Lavinia exilicauda*	0	1	0	23	4	0	0	1	0
Hardhead *Mylopharodon conocephalus*	0	1	0	64	0	0	0	1	0
Golden Shiner *Notemigonus crysoleucas*	5	53	1	493	36	148	93	55	0
Sacramento Blackfish *Orthodon microlepidotus*	0	1	0	1	0	0	0	1	0
Fathead Minnow *Pimephales promelas*	1	1	0	1,308	49	3	0	21	0
Sacramento Splittail *Pogonichthys macrolepidotus*	2	239	234	227	547	78	12	47	0
Sacramento Pikeminnow *Ptychocheilus grandis*	10	1	0	1,076	320	79	11	23	0
Sacramento Sucker *Catostomus occidentalis*	4	8	0	7,089	6,228	627	34	145	0
White Catfish *Ameiurus catus*	4	229	1	2	2	0	0	0	0
Black Bullhead *Ameiurus melus*	0	2	0	0	0	0	0	0	0
Brown Bullhead *Ameiurus nebulosus*	0	2	0	0	0	0	3	0	0
Channel Catfish *Ictalurus punctatus*	2	1,362	0	16	0	0	0	2	0

Table A.4. Continued.

Fish species	Trawl site			Beach seine region					
	Sacramento	Mossdale	Chipps Island	1	2	3	4	5	6
Wakasagi *Hypomesus nipponensis*	11	6	4	12	19	2	0	0	1
Surf Smelt *Hypomesus pretiosus*	0	0	0	0	0	0	0	0	32
Delta Smelt *Hypomesus transpacificus*	0	0	369	0	37	89	1	0	0
Night Smelt *Spirinchus starksi*	0	0	1	0	0	0	0	0	0
Longfin Smelt *Spirinchus thaleichthys*	0	15	1,046	0	0	0	0	0	0
Steelhead *Oncorhynchus mykiss*	11	11	56	7	2	5	0	0	0
Unmarked Steelhead	3	10	7	2	1	1	0	0	0
Marked Steelhead	8	1	49	5	1	4	0	0	0
Juvenile Chinook Salmon *Oncorhynchus tshawytscha*	2,982	5,331	3,014	4,023	2,730	202	12	45	2
Unmarked winter-run	74	2	65	180	98	13	0	0	0
Unmarked fall-run	1,937	4,657	1,635	3,612	2,322	148	12	43	1
Unmarked spring-run	392	627	600	195	278	39	0	2	1
Unmarked late fall-run	11	0	14	5	5	0	0	0	0
Unmarked not raced	0	0	0	0	0	0	0	0	0
Marked w/ CWT	568	45	700	31	27	2	0	0	0
Striped Mullet *Mugil cephalus*	0	0	0	0	0	0	0	0	1
Topsmelt *Atherinops affinis*	0	0	1	0	0	0	0	0	3,693
Jacksmelt *Atherinopsis californiensis*	0	0	1	0	0	0	0	0	11
Inland Silverside *Menidia beryllina*	116	45,999	0	8,935	25,006	13,721	14,825	14,207	96
Rainwater Killifish *Lucania parva*	0	0	0	1	12	28	145	0	10
Western Mosquitofish *Gambusia affinis*	2	0	0	902	226	367	150	99	0
Threespine Stickleback *Gasterosteus aculeatus*	3	0	3	9	25	4	0	0	121
Bay Pipefish *Syngnathus leptorhynchus*	0	0	0	0	0	0	0	0	287
Brown Rockfish *Sebastes auriculatus*	0	0	0	0	0	0	0	0	4
Lingcod *Ophiodon elongatus*	0	0	0	0	0	0	0	0	3

Table A.4. Continued.

Fish species	Trawl site			Beach seine region					
	Sacramento	Mossdale	Chipps Island	1	2	3	4	5	6
Prickly Sculpin *Cottus asper*	0	4	0	9	33	34	17	5	1
Pacific Staghorn Sculpin *Leptocottus armatus*	0	0	7	0	2	17	0	0	335
Tidepool Sculpin *Oligocottus maculosus*	0	0	0	0	0	0	0	0	22
Cabezon *Scorpaenichthys marmoratus*	0	0	0	0	0	0	0	0	11
Striped Bass *Morone saxatilis*	3	1,594	1,061	6	126	65	61	46	26
Green Sunfish *Lepomis cyanellus*	4	2	0	5	2	0	0	0	0
Warmouth *Lepomis gulosus*	4	0	2	0	0	2	0	0	0
Bluegill *Lepomis macrochirus*	11	595	9	101	67	296	253	357	0
Redear Sunfish *Lepomis microlophus*	1	42	0	31	164	1,604	584	51	0
Smallmouth Bass *Micropterus dolomieu*	0	3	0	0	28	2	0	1	0
Spotted Bass *Micropterus punctulatus*	1	9	0	40	146	9	7	19	0
Largemouth Bass *Micropterus salmoides*	7	14	3	359	107	535	272	80	0
White Crappie *Pomoxis annularis*	0	4	1	7	3	10	0	0	0
Black Crappie *Pomoxis nigromaculatus*	2	13	0	81	2	8	3	17	0
Bigscale Logperch *Percina macrolepida*	0	8	0	497	110	104	27	18	0
White Croaker *Genyonemus lineatus*	0	0	0	0	0	0	0	0	1
Barred Surfperch *Amphistichus argenteus*	0	0	0	0	0	0	0	0	74
Shiner Perch *Cymatogaster aggregata*	0	0	0	0	0	0	0	0	246
Black Perch *Embiotoca jacksoni*	0	0	0	0	0	0	0	0	9
Walleye Surfperch *Hyperprosopon argenteum*	0	0	0	0	0	0	0	0	10
Tule Perch *Hysterocarpus traskii*	2	16	10	37	455	372	28	6	0
Dwarf Surfperch *Micrometrus minimus*	0	0	0	0	0	0	0	0	669
White Seaperch *Phanerodon furcatus*	0	0	0	0	0	0	0	0	18
Penpoint Gunnel *Apodichthys flavidus*	0	0	0	0	0	0	0	0	12
Saddleback Gunnel *Pholis ornata*	0	0	0	0	0	0	0	0	14

Table A.4. Continued.

Fish species	Trawl site			Beach seine region					
	Sacramento	Mossdale	Chipps Island	1	2	3	4	5	6
Crevice Kelpfish *Gibbonsia montereyensis*	0	0	0	0	0	0	0	0	9
Yellowfin Goby *Acanthogobius flavimanus*	0	1	9	0	238	243	11	0	53
Arrow Goby *Clevelandia ios*	0	0	0	0	0	0	0	0	72
Bay Goby *Lepidogobius lepidus*	0	0	0	0	0	0	0	0	2
Shokihaze Goby *Tridentiger barbatus*	0	0	7	0	0	0	0	0	0
Shimofuri Goby *Tridentiger bifasciatus*	0	2	20	0	199	18	9	0	2
Chameleon Goby *Tridentiger trigonocephalus*	0	0	0	0	0	0	0	0	1
Rock Sole *Lepidopsetta bilineata*	0	0	0	0	0	0	0	0	1
California Halibut *Paralichthys californicus*	0	0	0	0	0	0	0	0	3
English Sole *Parophrys vetulus*	0	0	0	0	0	0	0	0	99
Starry Flounder *Platichthys stellatus*	0	0	20	0	0	0	0	0	7
Diamond Turbot *Pleuronichthys guttulatus*	0	0	0	0	0	0	0	0	9
Sand Sole *Psettichthys melanostictus*	0	0	0	0	0	0	0	0	7
Unidentified fish	0	1	0	0	0	0	0	0	0

Table A.5. Number of sample days and average number, standard deviation, and range of trawls per sample day for trawl sites within sample weeks during the 2012 field season.

	Chipps Island (SB018M, N, S)			Mossdale (SJ054M)			Sacramento (SR055M)		
Sample week	Sample days	Average trawls per sample day (SD)	Range	Sample days	Average trawls per sample day (SD)	Range	Sample days	Average trawls per sample day (SD)	Range
8/1/2011	3	9 (1.73)	7–10	3	10 (0)	10	3	10 (0)	10
8/7/2011	3	10 (0)	10	3	10 (0)	10	3	10 (0)	10
8/14/2011	3	10 (0)	10	3	10 (0)	10	3	10 (0)	10
8/21/2011	3	10 (0)	10	3	10 (0)	10	3	10 (0)	10
8/28/2011	3	8.7 (2.31)	6–10	3	9.3 (1.15)	8–10	3	8.7 (2.31)	6–10
9/4/2011	3	9.3 (1.15)	8–10	3	10 (0)	10	3	10 (0)	10
9/11/2011	3	10 (0)	10	3	10 (0)	10	3	10 (0)	10
9/18/2011	3	10 (0)	10	3	10 (0)	10	3	10 (0)	10
9/25/2011	3	10 (0)	10	3	10 (0)	10	3	10 (0)	10
10/2/2011	2	9.5 (0.71)	9–10	3	10 (0)	10	3	9.7 (0.58)	9–10
10/9/2011	3	10 (0)	10	3	10 (0)	10	3	10 (0)	10
10/16/2011	2	10 (0)	10	3	10 (0)	10	2	10 (0)	10
10/23/2011	1	10 (0)	10	3	10 (0)	10	3	10 (0)	10
10/30/2011	1	5 (0)	5	3	10 (0)	10	3	10 (0)	10
11/6/2011	1	1 (0)	1	3	10 (0)	10	3	10 (0)	10
11/13/2011	1	10 (0)	10	3	10 (0)	10	3	10 (0)	10
11/20/2011	1	6 (0)	6	3	9.3 (1.15)	8–10	3	8 (2.65)	5–10
11/27/2011	1	8 (0)	8	3	10 (0)	10	3	9.3 (1.15)	8–10
12/4/2011	3	9.7 (0.58)	9–10	3	10 (0)	10	3	10 (0)	10
12/11/2011	3	6 (4.58)	1–10	3	10 (0)	10	3	10 (0)	10
12/18/2011	2	5.5 (0.71)	5–6	3	8.7 (2.31)	6–10	3	7 (3.00)	4–10
12/25/2011	3	4 (1.00)	3– 5	3	9.3 (1.15)	8–10	3	9 (1.73)	7–10
1/1/2012	3	10 (0)	10	3	10 (0)	10	3	10 (0)	10
1/8/2012	2	8 (2.83)	6–10	3	10 (0)	10	3	10 (0)	10
1/15/2012	2	2.5 (0.71)	2–3	3	10 (0)	10	3	10 (0)	10
1/22/2012	2	6.5 (4.95)	3–10	3	10 (0)	10	3	10 (0)	10
1/29/2012	2	5 (2.83)	3–7	3	10 (0)	10	3	10 (0)	10
2/5/2012	2	9.5 (0.71)	9–10	3	9 (1.73)	7–10	3	10 (0)	10
2/12/2012	2	4 (1.41)	3–5	3	9.3 (1.15)	8–10	3	9 (1.73)	7–10
2/19/2012	2	9.5 (0.71)	9–10	3	10 (0)	10	3	10.3 (0.58)	10–11
2/26/2012	2	4 (0)	4	3	10 (0)	10	3	10 (0)	10
3/4/2012	2	9 (1.41)	8–10	3	10 (0)	10	3	10 (0)	10
3/11/2012	2	6.5 (4.95)	3–10	3	10 (0)	10	3	8.3 (2.89)	5–10
3/18/2012	2	10 (0)	10	3	10 (0)	10	3	10 (0)	10
3/25/2012	2	10 (0)	10	3	10 (0)	10	3	10 (0)	10

Table A.5. Continued.

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
4/1/2012	2	7.5 (3.54)	5–10	5	10 (0)	10	3	10 (0)	10
4/8/2012	2	10 (0)	10	5	10 (0)	10	3	10 (0)	10
4/15/2012	2	10 (0)	10	5	10 (0)	10	3	10 (0)	10
4/22/2012	2	9.5 (0.71)	9–10	5	11 (2.24)	10–15	3	10 (0)	10
4/29/2012	2	8 (2.83)	6–10	5	10 (0)	10	2	10 (0)	10
5/6/2012	2	10 (0)	10	5	10.4 (0.89)	10–12	2	10 (0)	10
5/13/2012	2	10 (0)	10	5	10 (0)	10	2	10 (0)	10
5/20/2012	2	10 (0)	10	5	10 (0)	10	2	10 (0)	10
5/27/2012	2	10 (0)	10	5	10 (0)	10	2	10 (0)	10
6/3/2012	2	10 (0)	10	5	10 (0)	10	2	10 (0)	10
6/10/2012	2	7.5 (3.54)	5–10	4	10 (0)	10	2	10 (0)	10
6/17/2012	2	8.5 (0.71)	8–9	3	10 (0)	10	2	10 (0)	10
6/24/2012	2	7.5 (3.54)	5–10	3	10 (0)	10	2	10 (0)	10
7/1/2012	2	7.5 (0.71)	7–8	3	10 (0)	10	3	10 (0)	10
7/8/2012	2	7.5 (3.54)	5–10	3	10 (0)	10	3	10 (0)	10
7/15/2012	2	7.5 (3.54)	5–10	3	10 (0)	10	3	10 (0)	10
7/22/2012	2	9 (1.41)	8–10	3	10 (0)	10	3	10 (0)	10
7/29/2012	1	6 (0)	6	1	6 (0)	6	1	10 (0)	10

Table A.6. Number of sample days and average number, standard deviation, and range of trawls per sample day for trawl sites within sample weeks during the 2013 field season.

	Chipps Island (SB018M ,N, S)			Mossdale (SJ054M)			Sacramento (SR055M)		
Sample week	Sample days	Average trawls per sample day (SD)	Range	Sample days	Average trawls per sample day (SD)	Range	Sample days	Average trawls per sample day (SD)	Range
8/1/2012	1	10 (0)	10	2	10 (0)	10	2	10 (0)	10
8/5/2012	2	10 (0)	10	3	10 (0)	10	3	10 (0)	10
8/12/2012	2	7 (4.24)	4–10	3	10 (0)	10	3	10 (0)	10
8/19/2012	2	10 (0)	10	3	10 (0)	10	3	10 (0)	10
8/26/2012	2	7.5 (3.54)	5–10	3	10 (0)	10	3	10 (0)	10
9/2/2012	2	10 (0)	10	3	10 (0)	10	3	10 (0)	10
9/9/2012	2	10 (0)	10	3	10 (0)	10	3	10 (0)	10
9/16/2012	2	10 (0)	10	3	10 (0)	10	3	10 (0)	10
9/23/2012	2	9 (1.41)	8–10	3	10 (0)	10	3	10 (0)	10
9/30/2012	2	10 (0)	10	3	10 (0)	10	3	10 (0)	10
10/7/2012	2	6.5 (0.71)	6–7	3	10 (0)	10	3	10 (0)	10
10/14/2012	2	10 (0)	10	3	10 (0)	10	3	10 (0)	10
10/21/2012	3	8 (2.00)	6–10	3	8.3 (2.89)	5–10	3	10 (0)	10
10/28/2012	3	10 (0)	10	3	10 (0)	10	3	10 (0)	10
11/4/2012	3	10 (0)	10	3	10 (0)	10	3	10 (0)	10
11/11/2012	3	10 (0)	10	3	10 (0)	10	3	10 (0)	10
11/18/2012	3	10 (0)	10	3	9.7 (0.58)	9–10	3	10 (0)	10
11/25/2012	3	10 (0)	10	2	10 (0)	10	1	10 (0)	10
12/2/2012	3	2.7 (1.15)	2–4	3	9.3 (1.15)	8–10	3	7 (3.61)	3–10
12/9/2012	2	7 (2.83)	5–9	3	10 (0)	10	3	10 (0)	10
12/16/2012	3	10 (0)	10	3	10 (0)	10	3	10 (0)	10
12/23/2012	2	10 (0)	10	2	10 (0)	10	3	10.3 (8.08)	3–19
12/30/2012	3	10 (0)	10	3	10 (0)	10	3	10.3 (0.58)	10–11
1/6/2013	3	10 (0)	10	3	10 (0)	10	3	10 (0)	10
1/13/2013	3	10 (0)	10	3	10 (0)	10	3	10 (0)	10
1/20/2013	3	10 (0)	10	3	10 (0)	10	3	10 (0)	10
1/27/2013	3	10 (0)	10	3	10 (0)	10	3	10 (0)	10
2/3/2013	3	10 (0)	10	3	10 (0)	10	3	10 (0)	10
2/10/2013	3	9.3 (1.15)	8–10	3	10 (0)	10	3	10 (0)	10
2/17/2013	3	10 (0)	10	3	10 (0)	10	3	10 (0)	10
2/24/2013	3	10 (0)	10	3	10 (0)	10	3	10 (0)	10
3/3/2013	3	10 (0)	10	3	10 (0)	10	3	10 (0)	10
3/10/2013	3	10 (0)	10	3	10 (0)	10	3	10 (0)	10
3/17/2013	3	10 (0)	10	3	10 (0)	10	3	10 (0)	10
3/24/2013	3	10 (0)	10	3	10 (0)	10	3	10 (0)	10
3/31/2013	3	10 (0)	10	4	10 (0)	10	3	10 (0)	10
4/7/2013	3	10 (0)	10	5	10 (0)	10	3	10 (0)	10

Table A.6. Continued.

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
4/14/2013	3	10 (0)	10	4	12.25 (4.50)	10–19	3	10 (0)	10
4/21/2013	3	10 (0)	10	5	11 (2.24)	10–15	3	10 (0)	10
4/28/2013	3	10 (0)	10	5	10.4 (0.89)	10–12	2	10 (0)	10
5/5/2013	3	10 (0)	10	5	10.2 (0.45)	10–11	2	10 (0)	10
5/12/2013	3	10 (0)	10	5	11 (2.24)	10–15	2	10 (0)	10
5/19/2013	3	10 (0)	10	5	10 (0)	10	2	10 (0)	10
5/26/2013	3	10 (0)	10	4	10 (0)	10	2	10 (0)	10
6/2/2013	3	10 (0)	10	5	10 (0)	10	2	10 (0)	10
6/9/2013	3	10 (0)	10	3	10 (0)	10	2	10 (0)	10
6/16/2013	3	10 (0)	10	3	10 (0)	10	2	10 (0)	10
6/23/2013	3	10 (0)	10	3	10 (0)	10	2	10 (0)	10
6/30/2013	3	9.3 (1.15)	8–10	3	10 (0)	10	3	10 (0)	10
7/7/2013	3	10 (0)	10	3	10 (0)	10	3	10 (0)	10
7/14/2013	3	10 (0)	10	3	10 (0)	10	3	10 (0)	10
7/21/2013	3	10 (0)	10	3	10 (0)	10	3	10 (0)	10
7/28/2013	2	10 (0)	10	2	10 (0)	10	2	10 (0)	10

Table A.7. Beach seine sites that fish samples were collected at least once within a sample week in the Lower Sacramento River Seine Region during the 2012 field season.

Sample	Station code							
week	SR144W	SR138E	SR130E	SR094E	SR119E	SR090W	SR080E	SR071E
8/1//2011	X	X	X	X		X	X	X
8/7/2011	X	X	X	X		X	X	X
8/14/2011	X	X	X			X	X	X
8/21/2011	X	X				X	X	X
8/28/2011	X	X	X	X		X	X	X
9/4/2011	X	X	X	X		X	X	X
9/11/2011	X	X	X	X		X	X	X
9/18/2011	X	X		X		X	X	X
9/25/2011	X	X				X		X
10/2/2011	X	X	X			X	X	X
10/9/2011	X	X	X	X		X	X	X
10/16/2011	X	X	X	X		X	X	X
10/23/2011	X	X	X			X	X	X
10/30/2011	X	X	X	X		X	X	X
11/6/2011	X	X	X			X	X	X
11/13/2011	X	X	X			X	X	X
11/20/2011	X	X	X	X		X	X	X
11/27/2011	X	X	X	X		X	X	X
12/4/2011	X	X	X			X	X	X
12/11/2011	X		X			X	X	X
12/18/2011	X		X	X		X	X	X
12/25/2011	X	X		X		X	X	X
1/1/2012	X					X	X	X
1/8/2012			X		X	X	X	X
1/15/2012			X		X	X	X	X
1/22/2012	X				X	X	X	X
1/29/2012		X	X	X	X	X	X	X
2/5/2012					X	X	X	X
2/12/2012		X	X	X	X	X	X	X
2/19/2012		X	X		X	X	X	X
2/26/2012		X		X	X	X	X	X
3/4/2012		X	X		X	X	X	X
3/11/2012		X		X	X	X	X	X
3/18/2012		X	X	X	X	X	X	X
3/25/2012	X	X				X	X	X
4/1/2012	X	X			X	X	X	X
4/8/2012	X	X	X	X	X	X	X	X
4/15/2012	X	X			X	X		
4/22/2012	X	X	X	X	X	X	X	X

Table A.7. Continued.

Sample week	Station code							
	SR144W	SR138E	SR130E	SR094E	SR119E	SR090W	SR080E	SR071E
4/29/2012	X	X			X	X		X
5/6/2012		X	X			X		X
5/13/2012		X		X	X	X	X	X
5/20/2012	X	X	X		X	X	X	X
5/27/2012		X			X	X	X	X
6/3/2012		X			X	X	X	X
6/10/2012		X	X		X	X	X	X
6/17/2012		X	X		X	X	X	X
6/24/2012	X	X			X	X	X	X
7/1/2012	X	X			X	X	X	X
7/8/2012	X	X				X	X	X
7/15/2012	X	X			X	X	X	X
7/22/2012	X	X	X		X	X	X	X
7/29/2012	X	X			X	X	X	X

Table A.8. Beach seine sites that fish samples were collected at least once within a sample week in the Lower Sacramento River Seine Region during the 2013 field season.

Sample	Station code							
week	SR144W	SR138E	SR130E	SR119E	SR094E	SR090W	SR080E	SR071E
8/1/2012								
8/5/2012	X	X		X		X	X	X
8/12/2012		X		X	X	X	X	X
8/19/2012	X	X		X		X	X	X
8/26/2012	X	X		X		X	X	X
9/2/2012	X	X		X		X		X
9/9/2012		X		X		X		X
9/16/2012		X	X	X	X	X	X	X
9/23/2012		X	X	X	X	X		X
9/30/2012		X		X		X	X	X
10/7/2012		X	X		X	X	X	X
10/14/2012		X		X	X	X	X	X
10/21/2012		X	X	X	X	X	X	X
10/28/2012		X	X	X	X	X	X	X
11/4/2012		X		X	X	X	X	X
11/11/2012				X	X	X	X	X
11/18/2012	X	X		X	X	X	X	X
11/25/2012			X	X	X	X	X	X
12/2/2012	X	X				X	X	X
12/9/2012	X	X		X		X	X	X
12/16/2012	X			X	X	X	X	X
12/23/2012	X	X	X			X	X	X
12/30/2012	X	X		X	X	X	X	X
1/6/2013		X		X		X	X	X
1/13/2013	X	X		X		X	X	X
1/20/2013	X	X		X		X	X	X
1/27/2013	X	X	X	X		X	X	X
2/3/2013	X	X		X	X	X	X	X
2/10/2013		X	X	X	X	X	X	X
2/17/2013		X	X	X	X	X	X	X
2/24/2013		X			X	X	X	X
3/3/2013		X	X	X		X	X	X
3/10/2013		X	X			X	X	X
3/17/2013		X	X	X		X	X	X
3/24/2013		X	X	X		X	X	X
3/31/2013		X	X	X	X	X	X	X
4/7/2013		X	X	X	X	X	X	X
4/14/2013		X	X	X	X	X	X	X
4/21/2013		X	X	X		X		X

Table A.8. Continued.

Sample week	Station code							
	SR144W	SR138E	SR130E	SR119E	SR094E	SR090W	SR080E	SR071E
4/28/2013		X	X	X		X	X	X
5/5/2013		X	X	X		X	X	X
5/12/2013	X	X		X	X	X	X	X
5/19/2013	X	X	X	X		X	X	X
5/26/2013	X	X	X	X	X	X	X	X
6/2/2013	X	X		X	X	X	X	X
6/9/2013	X	X		X		X	X	X
6/16/2013		X		X	X	X	X	X
6/23/2013	X	X		X	X	X	X	X
6/30/2013	X	X		X		X	X	X
7/7/2013	X	X		X	X	X	X	X
7/14/2013	X	X		X		X	X	X
7/21/2013	X	X		X	X	X	X	X
7/28/2013								

Table A.9. Beach seine sites that fish samples were collected at least once within a sample week in the North Delta Seine Region during the 2012 field season.

Sample week	Station code SR060E	AM001S	SR049E	SR043W	SS011N	XC001N	SF014E	GS010E	SR024E	SR017E
8/1/2011	X	X	X	X			X	X	X	X
8/7/2011	X	X	X	X	X		X	X	X	X
8/14/2011	X	X	X	X	X		X	X	X	X
8/21/2011	X	X	X	X	X		X		X	X
8/28/2011	X	X	X	X			X	X	X	X
9/4/2011	X	X	X	X	X		X	X	X	X
9/11/2011		X	X				X	X	X	X
9/18/2011	X	X	X	X	X		X	X	X	X
9/25/2011	X	X	X	X	X		X	X	X	X
10/2/2011	X	X	X	X	X		X	X	X	X
10/9/2011	X	X	X	X			X	X	X	X
10/16/2011	X	X	X	X			X	X	X	X
10/23/2011	X	X	X	X	X		X			X
10/30/2011	X	X	X	X			X	X	X	X
11/6/2011	X	X	X				X	X	X	X
11/13/2011	X	X	X	X	X		X	X	X	X
11/20/2011	X	X	X	X		X	X	X	X	X
11/27/2011	X	X	X	X	X	X	X	X	X	X
12/4/2011	X	X	X	X	X		X	X	X	X
12/11/2011	X	X	X	X	X		X	X	X	X
12/18/2011	X	X	X	X			X	X	X	X
12/25/2011	X	X	X	X	X	X	X	X	X	X
1/1/2012	X	X	X	X	X	X	X	X	X	X
1/8/2012	X	X	X	X	X		X	X	X	X
1/15/2012	X	X	X	X		X	X	X	X	X
1/22/2012	X		X	X	X		X	X	X	X
1/29/2012	X	X	X		X		X	X	X	X
2/5/2012	X	X	X	X	X	X	X	X	X	X
2/12/2012	X	X	X	X	X		X	X	X	X
2/19/2012	X	X	X	X	X	X	X		X	X
2/26/2012	X	X	X	X	X		X	X	X	
3/4/2012	X	X	X	X	X		X	X	X	
3/11/2012	X	X	X	X	X		X	X	X	
3/18/2012	X	X	X	X		X	X	X	X	X
3/25/2012	X	X	X	X	X		X	X	X	X
4/1/2012	X	X	X	X						
4/8/2012	X	X	X	X	X		X	X	X	X
4/15/2012	X	X	X		X	X	X	X	X	X
4/22/2012	X	X	X	X	X		X	X	X	X

Table A.9. Continued.

Sample week	Station code									
	SR060E	AM001S	SR049E	SR043W	SS011N	XC001N	SF014E	GS010E	SR024E	SR017E
4/29/2012	X	X	X	X		X	X	X	X	X
5/6/2012	X	X	X	X		X	X	X	X	X
5/13/2012	X	X	X	X		X	X	X	X	X
5/20/2012	X	X	X	X	X		X	X	X	X
5/27/2012	X	X	X	X		X	X		X	X
6/3/2012	X	X	X	X	X		X	X	X	X
6/10/2012	X	X	X	X	X	X	X	X	X	X
6/17/2012	X	X	X				X	X	X	X
6/24/2012	X	X	X	X	X		X	X		X
7/1/2012	X		X	X	X		X	X	X	X
7/8/2012	X	X	X	X	X	X	X	X	X	X
7/15/2012	X	X	X	X			X	X	X	X
7/22/2012	X	X	X	X			X	X	X	X
7/29/2012	X	X	X	X			X	X	X	X

Table A.10. Beach seine sites that fish samples were collected at least once within a sample week in the North Delta Seine Region during the 2013 field season.

Sample week	Station code SR060E	AM001S	SR049E	SR043W	SS011N	XC001N	SF014E	GS010E	SR024E	SR017E	SR015E
8/1/2012											
8/5/2012											
8/12/2012	X	X		X	X		X	X	X	X	
8/19/2012	X		X	X	X		X		X	X	
8/26/2012		X	X	X	X		X	X	X	X	
9/2/2012	X	X	X	X	X		X	X	X	X	
9/9/2012	X	X	X	X		X	X	X	X	X	
9/16/2012	X	X		X	X		X	X	X	X	
9/23/2012	X	X	X	X	X	X	X	X	X	X	
9/30/2012	X	X	X				X	X	X	X	
10/7/2012	X	X	X		X		X	X	X	X	
10/14/2012	X	X	X	X	X		X	X	X	X	
10/21/2012	X	X	X	X	X	X	X	X	X		X
10/28/2012	X	X	X	X	X		X	X	X	X	X
11/4/2012	X	X	X	X	X	X	X	X	X	X	X
11/11/2012	X	X	X	X	X	X	X	X	X	X	
11/18/2012	X	X	X	X	X	X	X	X	X	X	
11/25/2012	X	X	X	X	X		X	X	X	X	
12/2/2012	X	X	X	X			X		X	X	
12/9/2012	X	X	X	X			X		X	X	
12/16/2012	X	X	X	X			X	X	X	X	
12/23/2012	X		X	X			X		X	X	
12/30/2012	X	X	X	X			X		X	X	
1/6/2013	X	X	X	X	X	X	X	X	X	X	
1/13/2013	X	X	X	X	X		X	X	X	X	
1/20/2013	X	X	X	X		X	X	X	X	X	
1/27/2013	X	X	X	X		X	X	X	X		
2/3/2013	X	X	X	X			X	X	X	X	
2/10/2013			X			X	X	X	X	X	
2/17/2013	X	X	X	X			X		X	X	
2/24/2013	X	X	X			X	X			X	
3/3/2013	X	X	X	X		X	X	X	X	X	
3/10/2013	X	X	X	X		X	X	X	X	X	
3/17/2013	X	X	X	X		X	X	X	X	X	
3/24/2013	X	X	X	X		X	X	X	X	X	
3/31/2013	X	X	X	X			X	X	X	X	
4/7/2013	X	X	X	X		X	X	X		X	
4/14/2013	X	X	X	X	X	X	X	X	X	X	
4/21/2013	X	X	X	X	X		X	X	X	X	

Table A.10. Continued.

Sample week	Station code										
	SR060E	AM001S	SR049E	SR043W	SS011N	XC001N	SF014E	GS010E	SR024E	SR017E	SR015E
4/28/2013	X	X	X	X	X		X	X	X		
5/5/2013	X	X	X	X		X	X		X		
5/12/2013	X	X	X	X			X	X	X		
5/19/2013	X	X	X	X		X	X	X	X	X	
5/26/2013	X	X	X	X	X		X	X	X	X	
6/2/2013	X	X	X				X			X	
6/9/2013	X	X	X	X				X	X	X	
6/16/2013	X	X	X	X	X	X	X	X			
6/23/2013	X	X		X			X	X		X	
6/30/2013	X	X	X			X	X			X	
7/7/2013	X	X	X	X	X		X	X	X	X	
7/14/2013	X	X	X	X	X		X	X	X	X	
7/21/2013	X		X		X		X	X	X	X	
7/28/2013	X	X	X	X	X	X	X	X	X	X	

Table A.11. Beach seine sites that fish samples were collected at least once within a sample week in the Central Delta Seine Region during the 2012 field season.

Sample	Station code								
week	DS002S	LP003E	MK004W	SR014W	SR012W	TM001N	MS001N	SJ005N	SJ001S
8/1/2011	X	X		X	X	X	X	X	X
8/7/2011	X	X	X	X	X	X	X	X	X
8/14/2011	X	X	X	X	X	X	X	X	X
8/21/2011	X		X	X			X	X	X
8/28/2011	X	X	X	X	X	X	X	X	X
9/4/2011	X	X	X	X	X	X	X	X	X
9/11/2011	X	X	X	X	X	X		X	X
9/18/2011	X	X	X	X	X		X	X	X
9/25/2011	X	X	X	X	X			X	X
10/2/2011	X	X	X	X	X	X	X	X	X
10/9/2011		X	X	X	X	X	X	X	X
10/16/2011	X	X	X	X	X		X	X	
10/23/2011	X	X	X	X	X	X	X	X	X
10/30/2011	X	X	X	X	X		X	X	X
11/6/2011	X	X	X	X	X	X	X	X	
11/13/2011	X	X	X	X	X	X	X	X	X
11/20/2011		X			X			X	
11/27/2011	X		X				X		X
12/4/2011	X	X	X	X	X		X	X	
12/11/2011		X	X	X	X	X	X	X	
12/18/2011	X		X	X				X	
12/25/2011	X		X	X		X	X	X	X
1/1/2012	X	X	X	X	X			X	
1/8/2012	X	X	X	X	X		X	X	X
1/15/2012	X	X	X	X	X	X	X	X	X
1/22/2012	X		X	X	X	X	X	X	X
1/29/2012	X	X	X	X	X	X	X	X	
2/5/2012	X	X	X	X	X	X	X	X	X
2/12/2012	X	X	X	X	X		X	X	
2/19/2012	X	X	X	X		X	X	X	X
2/26/2012	X	X	X	X	X		X	X	X
3/4/2012	X	X	X	X		X		X	X
3/11/2012	X	X	X	X	X			X	
3/18/2012	X	X	X	X	X			X	
3/25/2012	X	X	X	X	X	X	X	X	X
4/1/2012	X	X	X	X	X	X	X	X	X
4/8/2012	X		X	X			X	X	X
4/15/2012	X	X	X	X	X	X	X	X	X
4/22/2012	X	X	X	X	X	X	X	X	X

Table A.11. Continued.

Sample week	Station code								
	DS002S	LP003E	MK004W	SR014W	SR012W	TM001N	MS001N	SJ005N	SJ001S
4/29/2012	X	X	X	X	X	X	X	X	X
5/6/2012	X	X	X	X	X		X	X	X
5/13/2012	X	X	X	X	X	X	X	X	X
5/20/2012	X	X	X	X	X	X	X	X	X
5/27/2012	X	X	X	X	X	X	X	X	X
6/3/2012	X			X		X		X	X
6/10/2012	X	X	X	X			X	X	X
6/17/2012	X	X	X	X	X	X	X	X	X
6/24/2012	X	X	X	X	X		X	X	
7/1/2012	X	X	X	X		X	X	X	X
7/8/2012	X	X	X	X	X	X	X	X	X
7/15/2012	X		X	X	X	X		X	X
7/22/2012	X	X	X	X	X	X	X	X	X
7/29/2012									

Table A.12. Beach seine sites that fish samples were collected at least once within a sample week in the Central Delta Seine Region during the 2013 field season.

Sample week	Station code DS002S	LP003E	MK004W	SR014W	SR012W	TM001N	MS001N	SJ005N	SJ001S
8/1/2012	X		X	X	X	X		X	X
8/5/2012	X	X	X	X	X	X	X	X	X
8/12/2012	X	X	X	X	X			X	X
8/19/2012	X	X	X	X	X	X	X	X	X
8/26/2012	X	X	X	X	X	X	X	X	X
9/2/2012	X	X		X	X		X	X	X
9/9/2012	X			X	X	X	X	X	X
9/16/2012		X	X	X	X	X	X		X
9/23/2012	X	X	X	X	X	X	X	X	X
9/30/2012			X	X	X		X	X	X
10/7/2012	X		X	X			X	X	X
10/14/2012			X	X	X		X	X	X
10/21/2012	X	X	X	X	X		X	X	X
10/28/2012	X	X	X	X	X	X	X	X	X
11/4/2012		X		X	X	X		X	
11/11/2012	X	X	X	X	X	X	X		X
11/18/2012	X	X					X		X
11/25/2012	X	X	X	X	X	X	X	X	
12/2/2012		X	X		X		X	X	X
12/9/2012	X	X	X	X				X	
12/16/2012	X	X	X	X	X		X	X	X
12/23/2012	X	X	X		X		X	X	
12/30/2012	X	X	X	X	X		X	X	
1/6/2013		X	X	X	X		X	X	
1/13/2013	X	X	X	X	X	X	X	X	X
1/20/2013	X	X	X	X			X	X	X
1/27/2013		X	X	X	X	X		X	X
2/3/2013	X	X	X	X	X		X	X	
2/10/2013	X	X	X	X	X	X	X	X	X
2/17/2013	X	X	X	X	X	X	X	X	
2/24/2013	X	X	X	X	X	X		X	X
3/3/2013	X	X	X	X	X		X	X	
3/10/2013	X	X	X	X	X	X		X	X
3/17/2013		X	X	X	X		X	X	
3/24/2013	X		X	X	X	X	X	X	X
3/31/2013	X	X	X	X	X	X	X	X	
4/7/2013	X	X	X	X	X	X	X	X	X
4/14/2013	X		X	X	X		X	X	X
4/21/2013	X	X	X	X	X	X		X	X

Table A.12. Continued.

Sample	Station code								
week	DS002S	LP003E	MK004W	SR014W	SR012W	TM001N	MS001N	SJ005N	SJ001S
4/28/2013	X	X	X	X	X	X	X	X	
5/5/2013	X	X	X	X	X	X		X	X
5/12/2013	X	X	X	X	X	X	X	X	X
5/19/2013	X	X	X	X	X	X		X	X
5/26/2013	X	X	X		X	X	X	X	X
6/2/2013	X	X	X	X	X	X	X	X	X
6/9/2013	X	X	X	X	X	X	X	X	X
6/16/2013	X	X	X	X	X		X		X
6/23/2013	X	X	X	X	X	X		X	X
6/30/2013	X	X	X	X	X		X	X	X
7/7/2013	X	X	X	X	X			X	X
7/14/2013	X	X	X	X	X			X	X
7/21/2013	X	X	X	X			X	X	X
7/28/2013	X	X	X	X			X	X	X

Table A.13. Beach seine sites that fish samples were collected at least once within a sample week in the South Delta Seine Region during the 2012 field season.

Sample	Station code									
week	SJ041N	SJ032S	SJ026S	OR003W	WD002W	OR014W	OR019E	OR023E	MR010W	SJ051E
8/1/2011										X
8/7/2011	X	X	X	X	X	X				X
8/14/2011										
8/21/2011	X	X	X	X	X					
8/28/2011		X	X	X		X	X		X	X
9/4/2011	X	X	X	X		X			X	
9/11/2011		X		X		X			X	X
9/18/2011	X	X	X	X						
9/25/2011	X	X		X		X			X	X
10/2/2011	X	X	X							
10/9/2011	X	X		X		X			X	X
10/16/2011	X	X		X					X	
10/23/2011	X	X		X	X	X			X	X
10/30/2011		X				X				
11/6/2011	X	X	X	X	X					X
11/13/2011	X	X							X	
11/20/2011		X	X							X
11/27/2011	X	X							X	
12/4/2011		X								X
12/11/2011	X								X	
12/18/2011		X								X
12/25/2011	X	X	X		X	X			X	
1/1/2012	X	X			X				X	
1/8/2012	X	X		X	X	X			X	X
1/15/2012	X	X								
1/22/2012		X	X	X	X	X			X	X
1/29/2012	X	X								
2/5/2012	X	X				X			X	X
2/12/2012	X	X				X				X
2/19/2012	X	X	X	X	X		X		X	X
2/26/2012	X									X
3/4/2012	X	X	X	X	X	X	X	X	X	X
3/11/2012	X	X								X
3/18/2012	X	X	X	X	X	X			X	X
3/25/2012	X	X								X
4/1/2012	X	X	X	X	X	X			X	X
4/8/2012	X									X
4/15/2012	X	X	X	X	X	X			X	
4/22/2012										X

Table A.13. Continued.

Sample	Station code									
week	SJ041N	SJ032S	SJ026S	OR003W	WD002W	OR014W	OR019E	OR023E	MR010W	SJ051E
4/29/2012	X	X	X		X	X			X	X
5/6/2012										X
5/13/2012	X	X	X	X	X	X			X	X
5/20/2012										X
5/27/2012	X	X	X	X	X	X	X	X	X	X
6/3/2012									X	X
6/10/2012	X	X	X	X	X	X			X	X
6/17/2012		X	X							X
6/24/2012	X	X	X		X	X		X	X	X
7/1/2012		X			X	X			X	
7/8/2012	X	X	X							
7/15/2012	X	X	X			X			X	
7/22/2012	X	X	X		X				X	
7/29/2012	X	X	X	X	X	X			X	X

Table A.14. Beach seine sites that fish samples were collected at least once within a sample week in the South Delta Seine Region during the 2013 field season.

Sample	Station code									
week	SJ041N	SJ032S	SJ026S	OR003W	WD002W	OR014W	OR019E	OR023E	MR010W	SJ051E
8/1/2012										
8/5/2012	X	X	X							
8/12/2012	X	X	X	X	X					X
8/19/2012										
8/26/2012	X	X	X	X	X				X	X
9/2/2012	X		X						X	
9/9/2012	X		X	X	X				X	X
9/16/2012						X			X	
9/23/2012		X			X	X			X	X
9/30/2012										X
10/7/2012	X	X	X							
10/14/2012		X				X				X
10/21/2012	X	X	X	X	X	X			X	
10/28/2012	X	X	X		X	X			X	X
11/4/2012										
11/11/2012		X			X				X	X
11/18/2012	X	X	X		X			X	X	
11/25/2012	X	X							X	X
12/2/2012		X								
12/9/2012	X	X	X		X				X	X
12/16/2012		X								
12/23/2012										X
12/30/2012	X								X	X
1/6/2013	X	X	X	X	X	X			X	X
1/13/2013		X							X	X
1/20/2013	X	X	X	X	X	X			X	X
1/27/2013	X	X	X	X	X	X			X	X
2/3/2013	X	X								X
2/10/2013	X	X			X	X			X	X
2/17/2013	X	X	X		X				X	X
2/24/2013	X	X	X	X	X		X	X	X	X
3/3/2013	X	X	X		X					X
3/10/2013	X	X	X	X	X	X	X	X	X	X
3/17/2013	X	X	X	X	X		X		X	X
3/24/2013	X	X	X	X	X	X	X		X	X
3/31/2013	X	X								X
4/7/2013	X	X	X	X		X	X	X	X	X
4/14/2013	X									X
4/21/2013	X	X	X	X	X		X		X	X

Table A.14. Continued.

Sample	Station code									
week	SJ041N	SJ032S	SJ026S	OR003W	WD002W	OR014W	OR019E	OR023E	MR010W	SJ051E
4/28/2013	X	X	X							X
5/5/2013	X	X	X	X	X	X	X	X	X	X
5/12/2013		X	X			X			X	X
5/19/2013	X	X	X	X	X	X	X		X	X
5/26/2013	X									X
6/2/2013	X	X	X	X	X	X	X	X		
6/9/2013			X							X
6/16/2013	X	X	X	X	X	X	X		X	X
6/23/2013		X								X
6/30/2013	X	X	X	X	X	X	X	X		
7/7/2013		X	X		X	X	X			X
7/14/2013	X	X	X	X	X	X	X		X	
7/21/2013	X	X	X						X	
7/28/2013										

Table A.15. Beach seine sites that fish samples were collected at least once within a sample week in the Lower San Joaquin River Seine Region during the 2012 field season.

Sample	Station code											
week	SJ083W	SJ079E	SJ077E	SJ076W	SJ074W	SJ074A	SJ070N	SJ068W	SJ065W	SJ063W	SJ058W	SJ056E
8/1/2011	X		X		X					X	X	X
8/7/2011	X		X		X						X	X
8/14/2011												
8/21/2011												
8/28/2011	X		X		X					X	X	X
9/4/2011												
9/11/2011	X		X		X					X	X	X
9/18/2011												
9/25/2011	X		X		X					X	X	X
10/2/2011												
10/9/2011	X		X		X					X	X	X
10/16/2011												
10/23/2011	X		X		X					X	X	X
10/30/2011												
11/6/2011	X		X		X						X	X
11/13/2011												
11/20/2011	X		X		X						X	X
11/27/2011												
12/4/2011										X	X	X
12/11/2011												
12/18/2011				X							X	X
12/25/2011												
1/1/2012		X		X		X					X	X
1/8/2012		X		X		X					X	X
1/15/2012		X		X		X						
1/22/2012											X	X
1/29/2012					X						X	X
2/5/2012		X		X		X	X		X		X	X
2/12/2012	X		X		X			X			X	X
2/19/2012			X		X			X		X	X	X
2/26/2012	X		X		X					X	X	X
3/4/2012	X		X		X			X		X	X	X
3/11/2012	X		X		X			X		X	X	X
3/18/2012	X		X		X					X	X	X
3/25/2012	X		X		X					X	X	X
4/1/2012	X		X		X						X	X
4/8/2012	X		X		X						X	X
4/15/2012												
4/22/2012	X		X		X					X	X	X

Table A.15. Continued.

Sample week	Station code											
	SJ083W	SJ079E	SJ077E	SJ076W	SJ074W	SJ074A	SJ070N	SJ068W	SJ065W	SJ063W	SJ058W	SJ056E
4/29/2012	X		X		X						X	X
5/6/2012	X										X	X
5/13/2012	X				X						X	X
5/20/2012	X		X		X						X	X
5/27/2012	X		X		X						X	X
6/3/2012	X		X		X					X	X	X
6/10/2012	X		X		X			X		X	X	X
6/17/2012	X		X		X			X		X	X	X
6/24/2012	X		X		X			X		X	X	X
7/1/2012			X		X			X		X	X	X
7/8/2012												
7/15/2012			X		X			X			X	X
7/22/2012												
7/29/2012			X					X			X	X

Table A.16. Beach seine sites that fish samples were collected at least once within a sample week in the Lower San Joaquin River Region during the 2013 field season.

Sample	Station code						
week	SJ083W	SJ077E	SJ074W	SJ068W	SJ063W	SJ058W	SJ056E
8/1/2012							
8/5/2012							
8/12/2012		X	X	X		X	X
8/19/2012							
8/26/2012		X	X	X	X	X	X
9/2/2012							
9/9/2012		X	X		X	X	X
9/16/2012							
9/23/2012	X	X	X	X	X	X	X
9/30/2012	X	X	X	X	X	X	X
10/7/2012							
10/14/2012	X		X		X	X	X
10/21/2012							
10/28/2012	X	X	X	X	X	X	X
11/4/2012							
11/11/2012	X	X	X	X	X	X	X
11/18/2012							
11/25/2012			X	X	X	X	X
12/2/2012							
12/9/2012							X
12/16/2012							
12/23/2012	X					X	X
12/30/2012	X		X	X	X	X	
1/6/2013	X	X	X	X	X	X	X
1/13/2013	X	X	X	X	X	X	X
1/20/2013	X	X	X	X	X	X	X
1/27/2013	X	X	X	X	X	X	X
2/3/2013	X	X		X	X	X	X
2/10/2013	X	X			X	X	X
2/17/2013	X	X	X	X	X	X	X
2/24/2013	X	X		X	X	X	X
3/3/2013	X	X		X	X	X	X
3/10/2013	X	X	X	X	X	X	X
3/17/2013	X	X	X	X	X	X	X
3/24/2013	X	X	X		X	X	X
3/31/2013	X	X	X		X	X	X
4/7/2013	X	X	X		X	X	X
4/14/2013	X	X	X	X	X	X	X
4/21/2013	X	X			X	X	X

Table A.16. Continued.

Sample week	Station Code SJ083W	SJ077E	SJ074W	SJ068W	SJ063W	SJ058W	SJ056E
4/28/2013	X	X	X	X		X	X
5/5/2013	X	X		X	X	X	X
5/12/2013	X	X	X	X	X	X	X
5/19/2013	X	X	X	X	X	X	X
5/26/2013	X	X	X	X	X	X	X
6/2/2013	X	X	X	X	X	X	X
6/9/2013	X	X	X	X	X	X	X
6/16/2013	X	X	X		X	X	X
6/23/2013			X	X	X	X	X
6/30/2013							
7/7/2013		X	X	X	X	X	X
7/14/2013							
7/21/2013							
7/28/2013							

Table A.17. Beach seine sites that fish samples were collected at least once within a sample week in the San Francisco and San Pablo Bays Region during the 2012 field season.

Sample	Station code								
week	SA010W	SA004W	SA008W	SP000W	SP001W	SP003E	SA009E	SA007E	SA001M
8/1/2011	X		X						
8/7/2011						X	X	X	X
8/14/2011	X		X	X	X				
8/21/2011						X	X	X	X
8/28/2011	X		X	X	X				
9/4/2011						X	X	X	X
9/11/2011	X	X	X	X	X				
9/18/2011						X	X	X	X
9/25/2011	X	X	X	X	X				
10/2/2011						X	X	X	X
10/9/2011	X	X	X	X	X				
10/16/2011						X	X	X	X
10/23/2011	X	X	X	X	X				
10/30/2011						X	X	X	X
11/6/2011	X	X	X	X	X				
11/13/2011						X	X	X	X
11/20/2011	X	X	X	X	X				
11/27/2011						X	X	X	X
12/4/2011	X	X	X	X	X				
12/11/2011						X	X	X	X
12/18/2011	X	X	X	X					
12/25/2011						X	X	X	X
1/1/2012	X		X	X	X				
1/8/2012						X	X	X	X
1/15/2012	X	X	X	X	X				
1/22/2012						X	X	X	X
1/29/2012	X		X	X	X				
2/5/2012						X	X	X	X
2/12/2012	X		X	X	X				
2/19/2012						X	X	X	X
2/26/2012	X		X	X	X				
3/4/2012						X	X	X	X
3/11/2012	X		X	X	X				
3/18/2012						X		X	X
3/25/2012			X	X	X				
4/1/2012						X	X	X	
4/8/2012	X		X						
4/15/2012							X	X	X
4/22/2012	X		X		X				

Table A.17. Continued.

Sample week	Station code								
	SA010W	SA004W	SA008W	SP000W	SP001W	SP003E	SA009E	SA007E	SA001M
4/29/2012						X	X	X	X
5/6/2012	X		X						
5/13/2012						X	X	X	X
5/20/2012	X		X						
5/27/2012						X	X	X	X
6/3/2012	X		X						
6/10/2012						X	X	X	X
6/17/2012	X		X						
6/24/2012						X	X	X	X
7/1/2012	X		X						
7/8/2012						X	X	X	X
7/15/2012	X		X						
7/22/2012						X	X	X	X
7/29/2012									

Table A.18. Beach seine sites that fish samples were collected at least once within a sample week in the San Francisco and San Pablo Bays Region during the 2013 field season.

Sample	Station code								
week	SA010W	SA004W	SA008W	SP000W	SP001W	SP003E	SA009E	SA007E	SA001M
8/1/2012	X		X						
8/5/2012						X	X	X	X
8/12/2012	X	X	X	X	X				
8/19/2012							X	X	X
8/26/2012		X	X	X	X				
9/2/2012						X	X	X	X
9/9/2012		X	X	X	X				
9/16/2012							X	X	X
9/23/2012	X	X	X	X	X				
9/30/2012						X	X	X	X
10/7/2012	X	X	X	X	X				
10/14/2012						X	X	X	X
10/21/2012	X	X	X	X	X				
10/28/2012						X	X	X	
11/4/2012	X	X		X	X				
11/11/2012						X	X	X	X
11/18/2012	X		X	X	X				
11/25/2012						X	X	X	X
12/2/2012	X	X		X	X				
12/9/2012							X	X	
12/16/2012	X		X	X	X				
12/23/2012						X	X	X	X
12/30/2012	X		X	X	X				
1/6/2013						X	X	X	X
1/13/2013	X		X	X	X				
1/20/2013						X	X	X	X
1/27/2013	X	X	X	X	X				
2/3/2013						X	X	X	X
2/10/2013	X		X						
2/17/2013						X	X	X	X
2/24/2013	X	X	X	X	X				
3/3/2013						X	X	X	X
3/10/2013	X	X	X	X	X				
3/17/2013									
3/24/2013	X	X	X	X	X	X	X	X	X
3/31/2013						X	X	X	X
4/7/2013	X		X						
4/14/2013						X	X	X	X
4/21/2013	X	X	X	X	X				

Table A.18. Continued.

Sample				Station code					
week	SA010W	SA004W	SA008W	SP000W	SP001W	SP003E	SA009E	SA007E	SA001M
4/28/2013	X	X	X	X	X				
5/5/2013						X	X	X	X
5/12/2013	X		X	X	X				
5/19/2013						X	X	X	X
5/26/2013	X		X						
6/2/2013						X	X	X	X
6/9/2013	X	X							
6/16/2013	X	X	X	X	X				
6/23/2013							X	X	X
6/30/2013	X		X	X	X				
7/7/2013							X	X	
7/14/2013		X	X	X	X				
7/21/2013							X	X	X
7/28/2013									

Table A.19. Water year types for the Sacramento and San Joaquin River basins from 1978 to 2013 (CDWR 2014b). 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
2012	BN	D
2013	D	C

Table A.20. Recoveries of all coded wire tagged juvenile winter-, fall-, late fall-, and spring-run Chinook Salmon by the DJFMP and fish facilities during the 2012 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 (MokeFH), Nimbus Fish Hatchery (NimbFH), and Merced River Fish Facility (MercFF; PSMFC 2014).

Release location (hatchery of origin)	Recovery location									
	Region 1	Region 2	Region 3	Region 4	Region 5	Region 6	Sacramento Trawl Site	Mossdale Trawl Site	Chipps Island Trawl Site	**DJFMP total**
Winter-run										
Caldwell Park (LivinNFH)	0	0	0	0	0	0	13	0	8	**21**
Fall-run										
American River (NimbFH)	0	1	0	0	0	0	57	0	60	**118**
Battle Creek (ColemNFH)	0	1	0	0	0	0	211	0	112	**324**
Elkhorn (FeathFH)	10	0	0	0	0	0	15	0	14	**40**
Hatfield SP (MercFF)	0	0	0	0	1	0	0	121	0	**122**
Mare Is. (NimbFH)	0	0	0	0	0	0	0	0	2	**2**
Merced River (MercFH)	0	0	0	1	0	0	0	1027	2	**1028**
Mokelumne River (MokeFH)	0	0	0	0	0	0	0	0	1	**1**
San Pablo Bay (FeathFH)	0	0	0	0	0	1	0	0	4	**5**
Sherman Island (MokeFH)	0	0	0	0	0	0	0	0	175	**175**
Yolo Bypass (FeathFH)	0	0	0	0	0	0	0	0	0	**1**
Late fall-run										
Battle Creek (ColemNFH)	1	2	0	0	0	0	27	0	22	**52**
Spring-run										
Boyd's Ramp (FeathFH)	2	12	2	0	0	0	90	0	112	**218**
Thermalito BP (FeathFH)	0	0	0	0	0	0	1	0	5	**6**
San Pablo Bay (FeathFH)	0	0	0	0	0	0	0	0	1	**1**
Unknown	0	0	0	0	0	0	11	49	15	**75**

Table A.21. Recoveries of all coded wire tagged juvenile winter-, fall-, late fall-, and spring-run Chinook Salmon by the DJFMP during the 2013 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 (MokeFH), Nimbus Fish Hatchery (NimbFH), and Merced River Fish Facility (MercFF; PSMFC 2014).

Release location (hatchery of origin)	Recovery location									
	Region 1	Region 2	Region 3	Region 4	Region 5	Region 6	Sacramento Trawl Site	Mossdale Trawl Site	Chipps Island Trawl Site	**DJFMP total**
Winter-run										
Caldwell Park (LivinNFH)	7	0	0	0	0	0	1	0	1	**9**
Fall-run										
American River (NimbFH)	0	0	0	0	0	0	99	0	74	**173**
Battle Creek (ColemNFH)	4	0	1	0	0	0	204	0	134	**343**
Elkhorn (FeathFH)	2	0	0	0	0	0	4	0	1	**7**
Jersey Point (MercFF)	0	0	0	0	0	0	0	0	33	**72**
Mokelumne River (MokeFH)	0	0	0	0	0	0	0	0	1	**1**
Mossdale (MercFF)	0	0	0	0	0	0	0	39[a]	0	**39[a]**
Sherman Is. (MokeFH)	0	0	0	0	0	0	0	0	270	**270**
San Pablo Bay (FeathFH)	0	0	0	0	0	0	0	0	4	**4**
Yolo Bypass (FeathFH)	2	0	0	0	0	0	0	0	0	**2**
Late fall-run										
Battle Creek (ColemNFH)	12	26	0	0	0	0	34	0	68	**140**
Spring-run										
Boyd's Ramp (FeathFH)	1	0	1	0	0	0	215	0	80	**297**
Crockett (FeathFH)	0	0	0	0	0	0	0	0	18	**18**
Gridley (FeathFH)	0	0	0	0	0	0	1	0	2	**3**
Unknown	3	1	0	0	0	0	10	6	14	**34**

[a] RMIS lists release location as Jersey Point, however notes that a proportion of fish were released at Mossdale due to truck malfunction (PSMFC 2014). These fish were assumed to have been released at Mossdale.

Table A.22. Total adult Chinook Salmon escapement estimates by race for the Sacramento and San Joaquin River basins from 1978 to 2013 (CDFW 2014).

Year	Winter-run	Fall-run	Late fall-run	Spring-run
1978	25,012	156,962	12,479	8,126
1979	2,364	227,646	10,284	3,116
1980	1,156	172,137	9,093	12,464
1981	22,797	260,259	6,718	22,105
1982	1,281	230,706	6,899	27,890
1983	1,831	205,290	15,089	7,958
1984	2,763	262,907	10,388	9,599
1985	5,407	356,304	10,180	15,221
1986	2,596	297,820	8,301	25,696
1987	2,185	301,583	16,571	13,888
1988	2,878	268,436	13,218	18,933
1989	696	182,350	12,872	12,163
1990	430	87,853	8,078	7,683
1991	211	132,455	8,263	5,926
1992	1,240	110,413	10,131	3,044
1993	387	165,423	1,267	6,076
1994	186	220,667	889	6,187
1995	1,297	330,168	489	15,238
1996	1,337	351,551	1,385	9,083
1997	880	402,797	4,578	5,193
1998	2,992	246,026	42,419	31,649
1999	3,288	414,259	15,758	10,100
2000	1,352	485,681	12,883	9,244
2001	8,224	624,631	21,813	26,663
2002	7,441	872,669	40,406	25,043
2003	8,218	590,992	8,882	30,697
2004	7,869	386,848	14,150	17,150
2005	15,839	437,693	16,282	23,093
2006	17,296	292,954	15,089	12,906
2007	2,541	97,168	18,843	11,144
2008	2,830	71,291	10,372	13,387
2009[a]	4,537	53,129	10,318	4,505
2010[a]	1,596	163,190	9,986	4,623
2011[a]	827	227,889	8,446	7,408
2012[a]	2,674	341,823	5,969	22,249
2013[a]	6,123	453,650	8,953	23,697

[a] indicates years containing preliminary data

Table A.23. 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 2012 field season.

Sample	Station codes							
week	SR080E	SR071E	SR062E	SR060E	AM001S	SR057E	SR055E	SR049E
10/2/2011	3	3	3	3	1	3	3	3
10/9/2011	3	3	3	3	1	3	3	2
10/16/2011	3	3	3	3	1	3	3	2
10/23/2011	3	3	2	3	1	2	3	2
10/30/2011	3	3	2	3	1	3	3	3
11/6/2011	3	3	3	3	1	3	3	3
11/13/2011	3	3	2	3	1	3	2	2
11/20/2011	3	3	3	3	1	3	3	3
11/27/2011	3	3	2	3	1	3	3	3
12/4/2011	3	3	3	3	1	3	3	3
12/11/2011	3	3	3	3	1	3	3	3
12/18/2011	3	3	3	3	1	3	3	2
12/25/2011	3	3	2	3	1	3	3	3
1/1/2012	1	1	1	1	1	1	1	1
1/8/2012	1	1	0	1	1	1	1	1
1/15/2012	1	1	1	1	1	1	1	1
1/22/2012	1	1	1	1	0	1	1	1
1/29/2012	2	2	0	2	1	1	1	2

Table A.24. 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 2013 field season.

Sample	Station code							
week	SR080E	SR071E	SR062E	SR060E	AM001S	SR057E	SR055E	SR049E
9/30/2012	3	3	3	3	1	3	3	1
10/7/2012	3	3	3	3	1	2	3	3
10/14/2012	3	3	2	3	1	3	3	3
10/21/2012	3	3	3	3	1	3	3	3
10/28/2012	3	3	3	3	1	3	3	3
11/4/2012	3	3	3	3	1	3	3	3
11/11/2012	3	3	3	3	1	3	3	3
11/18/2012	3	3	3	3	1	3	3	3
11/25/2012	3	3	2	3	1	3	2	2
12/2/2012	3	3	2	3	1	1	0	4
12/9/2012	3	3	3	3	1	2	3	3
12/16/2012	3	3	2	3	1	2	3	3
12/23/2012	2	2	1	1	0	2	1	2
12/30/2012	3	3	2	3	1	2	2	4
1/6/2013	3	3	3	3	1	3	3	3
1/13/2013	3	3	3	3	1	3	3	2
1/20/2013	3	3	3	3	1	3	3	2
1/27/2013	3	3	2	2	1	2	2	3