Stockton and Sacramento Deepwater Ship Channel Maintenance Dredging Project 2007 Fish Community and Entrainment Monitoring Report

Prepared for

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Abbreviations

Abbreviation	Full Term or Name
BO	biological opinion
CDFG	California Department of Fish and Game
CESA	California Endangered Species Act
Cond. (uS)	conductivity (in microsiemens)
Corps	U.S. Army Corps of Engineers
CPUE	catch per unit effort
CV	Central Valley
Delta	Sacramento and San Joaquin River Delta
DMP	dredged material placement
DO	dissolved oxygen
DPS	distinct population segment
DWSC	deepwater ship channel
EFH	essential fish habitat
ESA	Endangered Species Act
ESU	evolutionarily significant unit
FMP	fish entrainment and fish community monitoring plan
GPS	Global Positioning System
IEP	Interagency Ecological Program
IUNC	World Conservation Union
MSA	Magnuson-Stevens Fishery Conservation and Management Act
NMFS	National Marine Fisheries Service
NOAA	National Oceanographic and Atmospheric Administration
ORP	oxidation reduction potential
ppm	parts per million
ppt	parts per thousand
PODS	Pelagic Organism Decline Study
psu	practical salinity units
QA/QC	quality assurance/quality control
RISG	Ross Island Sand and Gravel
RM	river mile
sal	salinity
SD	standard deviation
SR	Sacramento River
SRSC	Sacramento River Deep Water Ship Channel
SSC	Stockton Deep Water Ship Channel
SWCA	SWCA Environmental Consultants, Inc.
turb	turbidity
USCG	U.S. Coast Guard
USFWS	U.S. Fish and Wildlife Service

1 Executive Summary

This document presents the results of the 2007 fish community and fish entrainment monitoring for maintenance dredging in two deepwater ship channels (DWSCs): the Stockton Deepwater Ship Channel (SSC) and the Sacramento River Deepwater Ship Channel (SRSC). Monitoring was instituted to ensure compliance with applicable environmental laws and regulations including Section 7 of the Endangered Species Act (ESA), to quantify the level of incidental take of special status fish species, and to provide feedback to the U.S. Army Corps of Engineers (Corps) regarding long-term dredging and dredged material placement activities. The Corps will use the feedback to assess and implement adaptive strategies that may decrease potential environmental impacts of the activities.

Bottom trawling was used to monitor the fish community in the active dredge area of the shipping channels. The entrainment sampling cell method was used to monitor fish entrained by the dredging operation. Observational monitoring, conducted aboard the dredge, occurred during dredge operations in the SRSC from December 1 through December 11, 2007.

The field season commenced on November 2, 2007, and ended on December 11, 2007. In general, each type of sampling (entrainment and fish community) was conducted on alternating days while the dredge was operating. Sampling did not occur on days when the dredge was being moved to a new location or was not in operation. Water quality sampling was conducted in conjunction with the fish community sampling efforts.

The key findings from the 2007 fish community (trawl) sampling include:

- 10,833 individual fish, representing 17 fish species among the 40 or so species presently known to occur in the Sacramento and San Joaquin River Delta (Delta) were collected during 2007 fish community monitoring.
- Six of the collected fish species are native to the Delta, 11 are introduced.
- White catfish, *Ameiurus catus,* an introduced demersal species, was the most commonly encountered species in the fish community monitoring trawl catch.
- Eleven delta smelt, *Hypomesus transpacificus,* listed as threatened under the ESA, were collected from 3 of 4 project dredge reaches during fish community monitoring.
- Non-native species accounted for 96.66 percent of the total catch. Delta smelt were the most commonly encountered native fish during 2007 fish community monitoring.
- Three fish taxa, *Ictalurus punctatus* (channel catfish) *Ameiurus catus* (white catfish), and *Acanthogobius flavimanus* (yellowfin goby), occurred in both fish community and entrainment samples.
- Two longfin smelt, *Spirinchus thaleichthys*, were collected during fish community sampling in 2007, one from the Decker Island area on the Sacramento River and one from the Antioch dredge reach in the lower San Joaquin River. Longfin smelt was the most common native species encountered in the 2006 trawl catch (most common overall at Decker Island, with smaller numbers collected from the Sandy Beach, Rio Vista, and Bradford Island locations).
- Native fishes comprised 6.05 percent of total fishes collected from Sacramento River locations and 0.13 percent at all San Joaquin River locations.

The key findings of the 2007 entrainment monitoring at the dredged material placement (DMP) sites include:

- A total of 12 individual fish (9 channel catfish, 2 yellowfin goby, and 1 white catfish) were collected during entrainment monitoring.
- No federal or state special status species were collected during entrainment in 2007.

- As was found during 2006 entrainment monitoring, in 2007, all entrained fish were demersal species that were also encountered during fish community monitoring.
- As in 2005 and 2006, the sampling cell entrainment monitoring method was effective at collecting entrained organisms, but did not provide a large sample volume in comparison with the total daily output of the dredge due to the time required to drain and fill the sampling cells, and due to site constraints on sampling cell creation and maintenance.
- Slurry volume sampled varied from 0.23 percent of total deposited slurry volume at the Scour Pond DMP site to 0.39 percent at the Bradford Island DMP site. Average dredge volume sampled was 0.35 percent for all sampled DMP sites.
- A total of approximately 214,127 cubic yards of dredged material was placed at the DMP sites during the 2007 maintenance dredging season. Approximately 175,257 cubic yards were dredged in the SSC and 38,870 cubic yards in the SRSC.
- Total sampled volume of dredged material was insufficient to accurately assess overall entrainment rates (extrapolated entrainment rates for individual species may not reflect actual rates of entrainment).

Collected data was incorporated into the Microsoft Access database constructed for this monitoring project in 2006. The database is a powerful tool that provides data integrity, streamlines in-field electronic data entry, and will enable examination of the complex relationships between fish presence and other environmental factors such as seasonality, water quality, tidal phase, presence/absence of other species and other variables. It may also enable assessment of changes to the fish community resulting from management actions, anthropogenic influences, and/or environmental fluctuations/perturbations.

Some special status species designations and take allotments changed during the 2007 monitoring period. Longfin smelt were petitioned for California and federal ESA listing on August 8, 2007. The petition was accepted by the California Fish and Game Commission on February 7, 2008 and special protections have been enacted for the species until final listing determination occurs, possibly in 2008. Take restrictions may affect monitoring and dredging for this project during 2008. Delta smelt take allotments were significantly reduced for all sampling programs under permitting by the Interagency Ecological Program (IEP) in the Bay-Delta region prior to commencement of monitoring in 2007.

2 Introduction

This document provides a description of the second year of fish community monitoring and the third year of dredge entrainment monitoring conducted by SWCA Environmental Consultants (SWCA) for the Sacramento District of the U.S. Army Corps of Engineers (Corps) through their contract with Ross Island Sand & Gravel Company (RISG). The Corps has an ongoing need to maintain channel depth and levee integrity along the Sacramento River Deepwater Ship Channel (SRSC) and the Stockton Deepwater Ship Channel (SSC). This monitoring program was mandated by the National Marine Fisheries Service (NMFS) through formal consultation with the Corps to:

- Ensure compliance with applicable environmental laws and regulations including Section 7 of the Endangered Species Act (ESA) and the Clean Water Act
- Quantify the level of incidental take of special status fish species
- Assess linkages between the fish community around the dredge and numbers and types of fish species entrained by the dredge
- Provide feedback to the Corps and other agencies to assess and implement adaptive strategies designed to diminish negative environmental effects of the long-term dredging and dredged material management activities that are required to maintain the appropriate (authorized) channel depths in the Corps-maintained federal shipping channels

The Corps and NMFS have developed a 10-year programmatic approach to maintain the SRSC and SSC to their authorized depths via maintenance dredging and levee stabilization, as described in the biological opinions (BOs) and supplemental documents for the shipping channels (NMFS 2006a,b). Although the timing of Delta dredging projects is regulated through area specific dredging windows, NMFS recognized in these BOs that additional protections for ESA-listed fish (salmon, steelhead and sturgeon) were needed. To that end, NMFS set annual monitoring requirements, which SWCA designed and conducted, beginning in 2006. As in 2006, SWCA's design for the monitoring activities conducted in 2007 was reviewed by the Corps and NMFS. These agencies determined that the design was consistent and appropriate with the requirements of the BOs for monitoring the effects of maintenance dredging and bank protection on fish in the SSC and SRSC.

To convert the monitoring requirements into testable assumptions, the following hypotheses were developed prior to the initiation of the 2006 sampling:

- H1: Maintenance dredging of the SSC and SRSC will result in take of listed and other fishes through direct dredge entrainment.
- H2: There is a correlation between presence of fish in the dredging areas and entrainment by the dredge.
- H2a: Differential use of the water column will result in different entrainment levels among fishes present in the project areas; that is, fish that are associated with the channel bottom (benthic and epibenthic species) will be entrained at higher levels than water column (pelagic) associated fish.

This report presents the results of sampling activities conducted from November 2, 2007 through December 11, 2007. These activities included fish entrainment and fish community sampling. The entrainment monitoring was designed to quantify the level of incidental take of special-status and other species by the dredging operation. The fish community monitoring was designed to assess which species are present in dredge areas and are potentially vulnerable to entrainment by the dredging operation.

The monitoring requirements are focused on species that are listed as threatened or endangered under the ESA. This report therefore includes information on the following federal special-status species that occur in the SSC and SRSC:

- Sacramento River winter-run Chinook salmon (*Oncorhynchus tshawytscha*) – endangered
- Central Valley spring-run Chinook salmon (*O. tshawytscha*) – threatened
- Central Valley steelhead (*O. mykiss*) – threatened
- delta smelt (*Hypomesus transpacificus*) – threatened
- green sturgeon (*Acipenser medirostris*) – threatened

It is important to note that special-status species designations are not limited to the federal ESA nor are they fixed. The monitoring activities were also accountable to provisions of the California Endangered Species Act (CESA), which affords special status to some species that do not have federal status. The CESA-listed species relevant to monitoring activities include:

- Sacramento splittail (*Pogonichthys macrolepidotus*) – threatened status under CESA
- longfin smelt (*Spirinchus thaleichthys*) – candidate for protected status under CESA

The project has also encountered other, non-native species that are currently a major focus of the Pelagic Organism Decline Study, due to their rapidly declining populations and their importance to the Delta ecosystem. These species are:

- American shad (*Alosa sapidissima*)
- threadfin shad (*Dorosoma petenense*)
- striped bass (*Morone saxatilis*)

As assessments of species status under the ESA and CESA are ongoing, dredging and monitoring activities are also affected by proposed listings, new listings, and indications of likely listings in the future. The dynamic nature of listing status had a direct effect on dredging and associated monitoring activities in 2007, as presented in the discussion section. Species in the project area with recent or pending changes to listing status include:

- longfin smelt, whose petition for candidacy under CESA was accepted for review by the California Fish and Game Commission in February 2008, with a final listing decision estimated for August 2008
- delta smelt, for which recent state and federal petitions have requested a status change from federally threatened to endangered

Species likely to occur in the project area that do not currently have any special state or federal status or conservation requirements, but that are considered to be in need of greater conservation efforts and/or are likely to be awarded special status during the lifetime of this project include:

- Pacific and river lamprey (*Lampetra tridentata* and *L. ayresii*)
- white sturgeon (*Acipenser transmontanus*)
- Central Valley fall/late fall-run Chinook salmon (*Oncorhynchus tshawytscha*)
- hardhead (*Mylopharodon conocephalus*)
- Sacramento-San Joaquin tule perch (*Hysterocarpus traski traski*)

Although species that do not have special status under federal law are outside the monitoring requirements for dredging in SRSC and SSC, the sampling methods used for monitoring yielded information on these species. Given that species-status determinations are ongoing and that any changes in status could affect dredging and monitoring activities, this report includes data on all species encountered.

In-season reporting for the 2007 monitoring effort involved reporting to both the Corps and the IEP. Several midseason catch summaries were provided to the Corps, Sacramento District at their request. Weekly reporting of ESA catch (including those weeks when no sampling occurred) was made to IEP via the ESA reporting website for research projects in the Bay-Delta region (CDFG 2008a). Regulatory agencies including NMFS, U.S. Fish and Wildlife Service (USFWS), and California Department of Fish and Game (CDFG) have access to the IEP database for the weekly updated ESA catch reports. Annual reports are provided to the Corps. Additionally, CDFG requires that annual reports be sent to Environmental Scientist K. Sousa (CDFG 4001 N. Wilson Way, Stockton, CA 95205) within one month of the completion and approval of this document by the Corps. The license and revenue branch of CDFG requires a collection summary in order to renew the state scientific collecting permits every two years.

Since this is only the second year of fish community sampling, this report describes the fish species collected at each site and compared sites based on simple assessments of catch per unit effort (CPUE), species composition, and overall numbers of fish collected. In addition, the report discusses the efficacy of the monitoring methods, efforts to minimize sampling mortality, and adaptive management with suggestions for future monitoring.

3 Materials and Methods

3.1 Sampling Methods Overview

Sampling methods for the 2007 SRSC and SSC maintenance dredging monitoring program followed those presented in the fish entrainment and fish community monitoring plan (FMP) for 2007–2008 (SWCA 2007a). The following methods were used because of their appropriateness to the activities in the area (i.e., dredging in deep water midchannel locations, with water column depths greater than 20 feet). The three methods used were:

- Bottom trawling, to monitor the fish community in the active dredge area of the shipping channels. Water quality parameters were measured in conjunction with the bottom trawling.
- Entrainment sampling cell method, to monitor fish entrained by the dredging operation.
- Observational monitoring, conducted aboard the dredge as required by the SRSC BO (NMFS 2006b) for dredging outside of the approved work window. Observational monitoring occurred during dredge operations in the SRSC from December 1 through December 11, 2007.

Beach seining, round haul purse seining, and electrofishing methods were not employed because these methods are suited to shallow water fish assessments or levee repair, neither of which occurred during the deepwater activities of the 2007 maintenance dredging and levee repair project.

All fish collected in the trawl or entrainment nets were counted and identified to the species level, with the exception of a single macrophthalmic lamprey, which was identified to genus. This preserved specimen was examined by USFWS experts and identified in February 2008. Invertebrates were identified to the highest taxonomic resolution feasible in the field, usually genus. Fish were identified, counted, and classified by life history stage. A subset of each fish species was measured for length. As many individual fish as possible were released back to the water with minimal harm. Stressed fish, or fish species easily injured by trawling activities, were quickly counted and released without further processing. Gross body abnormalities, injuries, fin clips, or other markings were noted. Bird and sea lion activity was closely observed during daylight sampling for two reasons. First, bird congregations over open water often indicate fish presence. Second, feeding activity by birds and sea lions in DMP sites is often an indicator of presence of entrained fish or other prey organisms.

3.2 Sampling Effort, Timing, and Sampling Locations

An overview of the 2007 fish community and entrainment sampling locations is provided in Figure 1 and corresponds to the dredging locations. Location data and activity periods are summarized in Table 1. The sampling schedule was based on communication with RISG, which is representative of the annual pattern for this project. At the onset of the project for 2007, RISG provided SWCA with a tentative schedule that included the approximate timing and location of each channel location to be dredged, also known as the dredge reach. Due to the inherent uncertainty regarding exact timing of initiation of dredging, fish community sampling was initiated within 24 hours of when dredging actually commenced. Entrainment sampling was usually conducted on the second day of dredging at each dredge reach. As such, fish community and entrainment sampling occurred on alternate days.

Table 1. Stockton and Sacramento Deepwater Ship Channel 2007 Maintenance Dredging Locations

Dredge Reach, River Channel	Dredge Area (RM)		Excavated Dry Material (cy)	Material % of Slurry	Equivalent Total Slurry Volume (gal)	DMP Site	Time Frame	
	From	To					Start	End
Port of Stockton – Rough & Ready Island, SSC	39.32	39.73	145,897	12	245,561,700	Roberts I	Nov 2	Nov 13
Antioch – West Island, SSC	5.49	5.66	29,360	10	59,299,570	Scour Pond	Nov 24	Nov 29
Natural Channel, SRSC	5.68	5.7	500	10	1,009,870	Decker Island	Dec 2	Dec 2
Man-made Channel – Port of Sacramento, SRSC	33.86	34.81	38,370	12	64,581,192	S-31	Dec 8	Dec 11

Entrainment sampling ponds were constructed at each of the individual DMP sites to sample the discharge slurry of the dredging operation. Figures 2 through 5 show recent aerial overviews of the individual DMP sites used in 2007. Effort levels for 2007 are summarized by monitoring method in Tables 2 and 3. These tables describe the level of effort attempted versus achieved during both entrainment and community sampling in 2007. Attempts to conduct entrainment sampling were hampered several times during the 2007 sampling efforts. One of the six attempts at Roberts I was unsuccessful due to an unexpected dredge shutdown. Two of the three attempts at Scour Pond were unsuccessful due initially to a breach of the sampling cell wall, and then due to uplift of the floor of the cell.

Table 2. 2007 Entrainment Monitoring Effort at DMP Sites

DMP Site Name, River	Date Start	Date End	Sampling Days/Attempts	Successful Events	Material Type	Sampled Vol. (gal)	Dredge Slurry Vol. (gal)	Sample %
Roberts I, SSC	Nov 2	Nov 13	6 / 6	5	Mud	960,000	245,561,700	0.39
Scour Pond, SSC	Nov 20	Nov 27	3 / 3	1	Sand	200,000	59,299,570	0.34
Decker Island, SRSC*	Dec 2	Dec 2	0 / 0	0	Sand	0	1,009,870	0*
S-31, SRSC	Dec 8	Dec 11	2 / 2	2	Mud	150,000	64,581,192	0.23
					Total	1,310,000	370,452,332	0.35

* did not conduct entrainment monitoring prior to dredge area shut down

Table 3. 2007 Fish Community Monitoring Effort by Dredging Reach

Dredge Reach, River Channel	DMP Site	Monitoring Time Frame		Sampling Days	Attempted Trawl Tows	Successful Trawl Tows	Distance Towed (m)
		Start	End				
Port of Stockton – Rough & Ready Island, SSC	Roberts I	Nov. 2	Nov. 13	6	30	28	12,499
Antioch – West Island, SSC	Scour Pond	Nov. 20	Nov. 29	5	25	24	12,626
Natural Channel, SRSC	Decker Island	Dec. 2	Dec. 2	1	2	2	1,051
Man-made Channel – Port of Sacramento, SRSC	S-31	Dec. 8	Dec. 11	1	4	4	2,043

Trawling locations were either directly upriver or directly downriver from the dredge's daily location within each dredging reach. Figures 6 through 9 display the 2007 trawling locations and the corresponding individual dredging reaches.

3.3 Fish Community Sampling

Fish community sampling followed all relevant regulations and protocols to ensure compliance with the ESA, prevent accidents, and avoid in-channel obstructions. These practices are summarized below. Required federal and state scientific research permits were obtained from CDFG and the Interagency Ecological Program (IEP) through IEP Program Element Number 2007-113. Prior to the onset of the 2007 dredge season, CDFG wardens were notified of the intended collection schedule and planned collection locations. ESA species contact notification requirements followed those in Appendix F of the FMP (SWCA 2007a) and included weekly reporting through the IEP website. Prior to each trawling effort for fish community sampling, the U.S. Coast Guard (USCG) and San Francisco Bay Vessel Traffic Information were made aware of our activities to help ensure the safety of the sampling vessel and other vessels in the area. Communication with the dredge was maintained through use of VHF (marine band) radio to ensure that the timing, methods, and location of trawling efforts did not hinder or compromise the dredge's operations or endanger personnel. The USCG required one VHF radio dedicated to the Vessel Traffic Information Channel; thus, two VHF radios were operated during all trawl sampling events, one to monitor vessel traffic and one to remain in constant communication with the dredge. The channel bottom in each dredge location was briefly surveyed using sonar and National Oceanographic and Atmospheric Administration (NOAA) charts to attempt to identify and avoid potential obstructions that might foul the net.

Fish community sampling was conducted up current of the dredge excavation point in the vicinity of the dredge, primarily in the main channel areas. An otter trawl, which is a semi-balloon type shrimp and fish trawl, was fished on the riverbed to target fish species assumed to be most susceptible to entrainment by the dredge. The otter trawl is a funnel-shaped net constructed with a floating headrope, a weighted footrope and doors attached just ahead of the net mouth to spread the net (Figure 10). The mouth of each trawl net used in 2007 measured approximately 1.25 x 7.9 meters with body stretched mesh of 3.8 cm and a cod end inner liner mesh size of 0.64 mm weave. The inner liner was composed of a soft nylon weave designed to be protective of fish scales and slime.

The 27-foot long *RV Karen M.*, a custom aluminum jet boat, was used to conduct the trawling operations. This vessel was modified in 2007 to include an A-frame and electronic windlass to aid in net deployment and retrieval (Figure 11). The A-frame allowed the crew to deploy the net from the stern without the need to haul the otter doors in and out on each trawl replicate. In 2006, the trawl net was deployed from the midship port side davit. Fewer net twists and unsuccessful tows resulted from use of the A-frame in 2007. The A-frame system provided the crew increased observation and control of the net as it was deployed, and increased the speed at which the net and bridle material could be managed.

A 275-foot long bridle between the net and the vessel exceeded a five-to-one scope (bridle length versus water depth) to ensure that the otter trawl would stay on the channel bottom while moving at efficient trawling speeds (2–3 knots) over water (SOW). Typically, five replicate trawl tows were conducted for each fish community sampling event. The direction of each individual tow was determined by current direction (always towing up current) and was initiated or ended as close as safely possible to the dredge's location. The net was towed along the river bed at least 500 meters (except for some tows at Roberts I which were reduced in length due to very high fish densities in this region) from the starting point as determined by a Lowrance Global Positioning System (GPS) chart plotter that logged vessel position, distance, bearing, and other information. GPS information was uploaded in real time to a portable computer running NobleTec navigation software to create vessel tracks of the trawl locations.

The length (in meters) of each tow was the distance that the net was fished along the river bottom as measured using the vessel track information collected from the GPS. GPS tracking began when the otter

trawl encountered the bottom and ended when the trawl tow was stopped prior to the vessel retrieving the net, providing an accurate measure of the real time and distance that the net was fished on the channel bottom. The vessel speed during net deployment was adjusted so that the vessel did not move forward over the bottom until the net was on the bottom, and, on retrieval, the vessel maneuvered directly over the net's position on the bottom and then brought the net directly upward through the water column. These methods were employed to concentrate on demersal species and minimize collection of water column and surface-associated fish.

To assess trawl catch, the cod end of the trawl net was placed in a cooler filled with river water and the trapped fish, invertebrates, and debris were released into it. Large debris was removed and the catch was then quickly assessed. Assessment involved a quick inspection and then rapid removal of the most fragile species to minimize mortality. Data were collected on individual fish specimens, which were then released back to the river outside the assessed channel area.

Trawl catch was sorted and counted as described above. Special status species were quickly documented and released (if alive) prior to documenting the remaining catch. Additional data recorded for each trawl included: GPS waypoints for beginning and end of tow; tow duration; date and time; sampling depth; tidal phase; current speed and direction; boat speed and engine rpm; bird activity; direction of water flow (upstream or downstream); and channel location. Water quality data were collected before the first and last tows of each fish community sampling event (Figure 12). Water quality monitoring and methods are described further in subsection 3.6 of this report.

3.4 Entrainment Sampling

Entrainment monitoring methods were selected based on the likelihood of their success to:

- Avoid and minimize damage or mortality ("take") to entrained fish, particularly ESA-listed species;
- Quantitatively sample the dredge disposal stream, which is not uniform throughout the discharge pipe cross-section; and
- Avoid or minimize dredge shut-downs or head loss resulting from sampling.

SWCA presented two entrainment monitoring alternatives in the 2007–2008 FMP (SWCA 2007a). Both alternatives were modifications of methods that have been used to successfully monitor fish entrainment in Pacific Northwest dredging projects. The two alternatives were the sampling cell method and the collection basket (screen) method. The sampling cell method was used for the limited 2005 SSC entrainment monitoring and the entire 2006 and 2007 entrainment monitoring for the SSC and SRSC. Though intended to be used in 2007, the entrainment screen device was unavailable during the 2007 monitoring season due to sourcing issues for several key components. Therefore, as in 2005 and 2006, the sampling cell approach was used exclusively. A sampling cell was constructed at each DMP site. The cells varied in size mostly due to DMP site constraints, but were 0.17 to 0.28 acres in surface area. One or two weirs were used to drain the cells. The number of weirs also varied based on DMP site constraints. Use of two weirs was desirable but not always possible. Use of a single weir resulted in longer cell draining and sample processing time, limiting the amount of the dredge's output that could be assessed for entrained organisms. The cells were filled with dredged material and then the material was filtered by attaching a sock- shaped net to the back of the weir(s) and allowing the material in the cell to slowly drain through the weir. The material retained in the net was then investigated and any organisms removed, identified, and enumerated.

Sampling Cells

The sampling cell method used for fish entrainment monitoring is based on a method employed by Buell (1992). Entrainment monitoring with the sampling cell method involves discharging all water and dredged material flowing from the dredge pipeline into a relatively small sampling cell. The cell was isolated from the overall DMP site pond by a temporary berm (Figure 13). Sampling cells varied in size from 0.17 acres at S-31 to 0.28 acres at Roberts I and Scour Pond. Overall sampling cell geometry, size, and placement were determined by the geography of the DMP site, its storage capacity, and the logistics of material placement.

In order to transfer the entire volume of the dredge's discharge to the sampling cell, a splitter valve was employed at the Roberts I and Scour Pond DMP sites (Figure 14). The entrainment sampling process was initiated by briefly idling the dredge pump motor long enough to switch the Y-valve lever. When switched, the pump was immediately brought back up to full speed. When the sampling cell approached full capacity the dredge pump motor was again idled and the valve switched back to direct flow to the main DMP site pond. At all other sites, the end of the discharge pipe was moved to and from the sampling cell by bulldozer, because this method is easier than using the splitter valve. The duration of discharge into a sampling cell was timed in order to calculate the volume of material sampled based on the dredge pumping rate.

Two weir box structures with 30-inch culverts were installed at the downstream end of the sampling cells at the Roberts I and Scour Pond DMP sites. At the S-31 site, a single weir box was used. Stop boards were placed in each weir structure to control volume and velocity of the slurry leaving the sampling cell. The outlet of each culvert/weir structure was at the level of the bottom of the sampling cell, allowing the pond to drain completely to the main DMP site when the stop boards were removed.

A specially designed net (Figure 15) was attached to the terminus of each culvert discharge pipe to capture any entrained fish moving over the weir structure and through the culvert with the slurry material. This net ensured that any dredge-entrained fish or invertebrates were collected in the nets before entering the main DMP site. The entrainment sampling nets were cylindrical in shape, 15 feet in length and 3 feet in diameter at the mouth tapering to 1.5 feet in diameter at the cod end. The nets were constructed of soft, knotless mesh to minimize damage to fish. Mesh size of the nets ranged from 0.5 inch at the mouth to 0.25 inch at the cod end. A zipper through the 0.25-inch portion of the net was installed to allow removal of debris, sediment, and entrained organisms. A canvas collar was sewn onto the opening of the net to allow the net to be secured to the culvert outlet. Nets were secured to the culvert with a stout rope or a ratcheting strap. A portable, high-pressure water pump fitted with a screened inlet and 0.75-inch outlet hose delivered fresh river water to the sampling cell site for use in sample washing and processing.

Any fish remaining in the sampling cell or passing through the weir and culvert into the net at the outlet were collected and identified as the sampling pond was emptied. Live fish were placed in plastic totes filled with river water and returned to the river after processing the catch. It is possible that some fish or invertebrates were killed during entrainment and deposited in the sampling cells without ending up in the net. It is also possible that some live organisms were mired in the bottom of the cell and not enumerated. The bottom of the cell was observed after each filling and emptying cycle to attempt to account for these organisms. Few entrained organisms were collected from the sampling cell bottom over the course of the 2007 entrainment sampling, and it is unlikely that a substantial number of entrained organisms were retained in the cells.

The length of time required to process each entrainment sample varied according to the capacity of the sampling cell and the length of time needed to drain the cell dredge slurry material after filling. Deposition

of sediments occurred with each cell filling cycle thus decreasing the capacity of the sampling cell during subsequent fill cycles. Stop boards were removed one by one to allow the slurry to pass over the weir at a rate slow enough to prevent clogging of the small mesh in the nets. In areas where substrates were dominated by sand, the steps of draining the cell, sorting through the material, and processing the samples required approximately 2 hours. When high volumes of organic material were encountered, sample processing times were generally 3 to 5 hours.

3.5 Dredge Observer Monitoring

The SRSC and SSC BOs (NMFS 2006a,b) state that for dredge work in the SRSC and SSC that occurs outside of the approved work window (June 1 to December 1) "the waterway adjacent to the dredge area (i.e., within 300 feet) is to be visually monitored for affected fish." Affected fish were defined in the BO as: 1) "dead or moribund fish at the water surface; 2) fish showing signs of erratic swimming behavior or other obvious signs of distress; 3) fish gasping at the surface; or 4) fish showing signs of other unusual behavior." Target fish species included, but were not limited to, Sacramento River (SR) winter-run Chinook salmon, Central Valley (CV) spring-run Chinook salmon, CV steelhead, and North American green sturgeon. To comply with the visual monitoring requirements, an observer was present 24 hours a day (three observers each working one 8-hour shift per day) onboard the RISG Dredge No. 7 for all dredging occurring after December 1 to visually monitor the waterway during dredge operation. For each affected fish, the following information was recorded: location of the fish, operational status of the dredge, environmental conditions at the time of the observation, and when possible, identification of the fish to species level. For safety and effectiveness, observers were equipped with VHF radios, spotlights, personal flotation devices, foul weather gear, nets and fish identification guides.

3.6 Water Quality Monitoring

In-situ water quality data were collected twice from the surface and near bottom during each trawl survey event; generally prior to the first and final trawl replicates of the day. Measurements were made and collected using a YSI MP-556 portable water quality meter (Figure 12). Parameters assessed included water temperature, dissolved oxygen, pH, ORP (oxidation-reduction potential), conductivity, and salinity. Turbidity data was collected via grab sample from the surface at all locations, and after November 19, near bottom turbidity samples were also collected. Turbidity was analyzed using a calibrated Hanna Model HI93703 turbidity meter. Water clarity was also measured at the surface with a Secchi disk during daytime sampling events.

3.7 Data Analysis/Reporting and QA/QC

Fish Entrainment

Overall entrainment rates were estimated for each species by extrapolating the numbers of entrained fish in the sampling cells to the overall volume of pumped material. Comparing the number of entrained fish in the sampling cells and the volume of the cells to the overall volume of pumped material allows a rough estimate of the overall species entrainment rates. However, this data should be assessed cautiously due to the small percentage of the dredge's output from which the overall entrainment rates were calculated.

Fish Community Sampling

Relative population abundance for each sampled location, each channel, and both channels combined was determined by ranking each species based on total numbers of individuals collected in all trawls. By comparing numbers of individual fish collected to distance trawled, CPUE was determined. Some of the

data from the Roberts I location represents estimated rather than calculated CPUE due to a few very large trawl catches that were subsampled.

Reporting

Field data from 2007 was entered into the project database, allowing rapid querying of data for desired outputs. Original field data sheets are archived at SWCA's office in Portland, Oregon. Copies of the original data sheets are available upon request. Information from all individual daily sampling efforts is available in a copy of the database included with this report. The present quantity of data available from this study and the rapidly changing fish populations of the Delta do not yet allow extensive statistical modeling that might help predict future entrainment rates.

Data Management

Data were documented in the field on paper data sheets and in the customized SWCA Dredge Monitoring Database created with Microsoft Access 2003 The database was created in 2006 to provide a streamlined data entry and management system for this study. This relational database allows sizeable amounts of information to be entered, stored, managed, verified, analyzed, and retrieved. It also provides common framework for both managing and analyzing the information from this multi-year project. The database stores information on aquatic organisms potentially vulnerable to impacts of dredge operations and provides the analytical tools to assess the data based on CPUE, species composition, and the overall number of fish collected.

Quality Assurance and Quality Control

In addition to saving time in the field, the project database is also a key step in quality assurance and quality control. To ensure consistency in data collection, data entry forms were created. These entry forms restrict the type of information being entered into the database, through focused user inputs and menus. In 2007, hardcopy data forms were used in conjunction with electronic entry forms created in the database.

In addition to focused inputs and menus to control data entry, Microsoft Access has user restrictions that provide a safeguard against multiple editors manipulating and changing the same tables and fields. These safeguards provide checks to ensure database tables and relationships are not compromised. The database was also backed up nightly on an external USB drive and copied to an office computer to further ensure integrity of collected data. Field crews were trained on the data collection forms before monitoring or sampling was carried out. Paper data collection forms may always be required for the collected specimen portion of the trawl survey and will continue to be used for data verification when time is an issue or another form of documentation is needed.

For this study, data entered into the database was cross-checked against paper forms collected in the field (SWCA 2007a). Data collection in 2007 relied more heavily on direct electronic entry into the database than in 2006. In the 2006 monitoring all field data was collected on paper and, at a later date, entered into the database. At the start of the 2007 monitoring season (the entire first trawl survey), all collected data was recorded on paper forms, as well as directly into the database while in the field. As samplers became more confident with the electronic entry forms, all data (except specimen data for each trawl replicate) were recorded directly in the database while in the field. Duplicate paper and electronic data entry were performed for all collected trawl data for four of the first five trawl surveys (30% of total trawl surveys). Field crews also made daily checks to ensure that the data were entered directly and accurately into the database without redundant paper copies.

Data verification was performed for specimen, trawl mortality, and water quality information. Over 90% of the specimen data entered electronically into the database was cross-checked with the specimen data collected on paper data sheets in the field. Through this data verification process, some errors were found. One omission error for length was identified and corrected and one incomplete record was identified as an undeleted redundant electronic entry. Trawl mortality results from the database queries were checked for errors against the paper release disposition entries of collected specimen data. No errors were found.

Water quality database results were checked against the paper copies collected for the first two water quality data collection events. The final summary reports for water quality data were scanned by the biologists who collected the data. One data entry error for pH measurement was identified and removed from the data set. Two data entry errors for date of collection were identified. Dates were corrected and confirmed with the associated trawl data entries, as water quality data was only collected on days when trawl surveys were conducted.

Specimen data (species of organism, enumeration, length, anomalies, life history stage, and disposition) were collected on paper field forms due to the speed required for data collection while rapidly processing fish and invertebrates to release them with minimal harm. Specimen data were then entered into the database at a later time. Individual trawl replicates that had very few specimens to document were entered directly into the database through the Replicate Specimen Form and checked for accuracy prior to leaving the survey location. Sample paper data entry forms are presented in Appendix (C), as are forms from the database. Original (paper) field data sheets are archived at SWCA's office in Portland, Oregon.

4 Results

4.1 Fish

A total of 10,845 individual fish representing 17 species were collected and identified during the fish community and entrainment sampling events in 2007. Table 4 lists all fish species collected in 2007 by total number, percent of total, and rank based on percent of total. It also describes origin (native or introduced) and ESA and CESA status. Of the 17 species encountered, 11 are introduced and 6 are native. Native fishes made up only 0.27% of the total number of fish collected. The three most abundant species, white catfish, threadfin shad and channel catfish, are all nonnative and accounted for 96.66% of the catch. The top 10 most abundant species accounted for 99.92% of the total number of fish collected.

Delta smelt was the most abundant native species encountered in 2007 and was represented by 11 individual fish, followed by white sturgeon and starry flounder (8 and 6 individuals, respectively). Two individual longfin smelt were encountered, as were single individuals for river lamprey and splittail. The juvenile lamprey collected in 2007, and those collected in 2006, were positively identified as *Lampetra ayresii*, the river lamprey.

Table 4. Ranked List of All Fish Collected from All Locations during 2007 Fish Community and Entrainment Monitoring of Stockton and Sacramento DWSC Maintenance Dredging

Rank	Percent	Number	Common Name	Genus	Species	Origin	Rule: Status *
1	87.39	9,477*	white catfish	*Ameiurus*	*catus*	Introduced	
2	5.80	629	threadfin shad	*Dorosoma*	*petenense*	Introduced	
3	3.47	376*	channel catfish	*Ictalurus*	*punctatus*	Introduced	
4	2.12	230	striped bass	*Morone*	*saxatilis*	Introduced	
5	0.79	86	American shad	*Alosa*	*sapidissima*	Introduced	
6	0.10	11	delta smelt	*Hypomesus*	*transpacificus*	Native	ESA: FT; CESA: ST, IUCN: EN
7	0.10	11	yellowfin goby	*Acanthogobius*	*flavimanus*	Introduced	
8	0.07	8	white sturgeon	*Acipenser*	*transmontanus*	Native	IUCN: LC
9	0.06	6	starry flounder	*Platichthys*	*stellatus*	Native	MSA: MEC -EFH
10	0.03	3	Shimofuri goby	*Tridentiger*	*bifasciatus*	Introduced	
11	0.02	2	longfin smelt	*Spirinchus*	*thaleichthys*	Native	ESA: FPT, DFG: SSC
12	0.01	1	black crappie	*Pomoxis*	*nigromaculatus*	Introduced	
12	0.01	1	blue catfish	*Ictalurus*	*furcatus*	Introduced	
12	0.01	1	brown bullhead	*Ameiurus*	*nebulosus*	Introduced	
12	0.01	1	common carp	*Cyprinus*	*carpio*	Introduced	
12	0.01	1	river lamprey	*Lampetra*	*ayresii*	Native	DFG: SSC
12	0.01	1	splittail	*Pogonichthys*	*macrolepidotus*	Native	DFG: SSC, IUCN: EN

Total Fish: 10,845

* Total catch includes estimated numbers from subsamples of very large catches of these fishes.

* Table 4 Status Key

ESA: federal Endangered Species Act	FPT Federally proposed for listing as Threatened FT Federally listed as Threatened
CESA: California Endangered Species Act	ST State-listed as Threatened
DFG: California Dept of Fish and Wildlife	SSC Species of Special Concern
MSA: Magnuson-Stevens Sustainable Fisheries Act	MEC-EFH Marine Estuarine Composite – designated Essential Fish Habitat
IUCN – The World Conservation Union	EN Endangered LC Least Concern

Introduced species of fishes dominated the catch from all locations in 2007. Very few native fish were collected in the Port of Stockton reach, as was the case in 2006. Figure 16 provides a graphical description of the percent native versus nonnative fish collected during fish community sampling at each dredging reach in 2007.

Special Status Species

Among the 6 species of native fishes encountered in 2007, only the delta smelt is presently accorded CESA or ESA status (CDFG 2008c,d). However, all other native species encountered are afforded special status by other entities or are presently petitioned for special status under ESA, CESA or both, as indicated in Table 4. Additional status and life history information for these species and all other special status species that use the DWSCs during some or all of their life cycle is provided in Appendix A.

Other than the 11 delta smelt, no federally listed fish species were captured during 2007 fish community monitoring of the DWSC areas. Federally listed fish species were not encountered during 2007 entrainment monitoring of the dredge slurry stream at the DMP sites. Delta smelt and longfin smelt were the most commonly collected special status species under California's species status classification. Starry flounder (*Platichthys stellatus)* were the ninth most commonly encountered fish species in 2007 and were the third most common native fish, behind delta smelt and white sturgeon. They are included here due to their Magnuson-Stevens Fishery Conservation and Management Act (MSA) status, in which they are an Estuarine Composite Species with Essential Fish Habitat (EFH) within the project area.

Fish Length

Table 5 provides summary length data for fish collected during 2007 fish community sampling. For 9 out of 17 species, at least 75% of those fish collected were measured. Protocols for determining which fish were measured are discussed in the materials and methods section. Overall, 401 fish out of 10,845 (3.7%) were measured for length (total length, standard length, or fork length, depending on species). Excluding white catfish, of which only 0.34% were measured, 27% of the rest of the fish were measured. The longest fish measured in 2007 was a white sturgeon (770 mm total length) and the shortest fish was a Shimofuri goby (42 mm total length).

Table 5. Summary Size Statistics for Fish Collected during 2007 Fish Community (Otter Trawl) Surveys.

Common Name	Minimum Length (mm)	Maximum Length (mm)	SD of Mean	Mean Total Length (mm)	n Measured	n Collected	% Measured
American shad	87	295	74.1	202	38	86	44.19
black crappie	315	315		315	1	1	100
blue catfish	268	268		268	1	1	100
brown bullhead	100	100		100	1	1	100
channel catfish	71	380	73.8	219	65	367	17.71
common carp	620	620		620	1	1	100
delta smelt	67	84	5.9	75	9	11	81.82
river lamprey	167	167		167	1	1	100
longfin smelt	61	113	36.8	87	2	2	100
Shimofuri goby	42	69	19.1	56	2	3	66.67
splittail	269	269		269	1	1	100
starry flounder	99	283	84.1	171	6	6	100
striped bass	79	350	44.7	144	92	230	40
threadfin shad	64	199	34.2	126	81	629	12.88
white catfish	61	270	47.3	170	32	9476	0.34
white sturgeon	416	770	122.6	535	6	8	75
yellowfin goby	121	206	31.5	163	8	9	88.89

Species with grey background are introduced.

4.2 Invertebrates

Several taxa of invertebrates were collected in both fish community and entrainment sampling during 2007 sampling events. The monitoring requirements that necessitate this sampling program do not require an assessment of impacts on invertebrates. However, invertebrates are commonly collected in the fish community and entrainment samples, and so they are briefly discussed in this section.

Freshwater shrimp, including the introduced *Palaemon macrodactylus* and *Exopalaemon modestus,* and at least one other unidentified species, were collected from the Port of Stockton and Antioch reaches of the SSC and only the Natural Channel reach of the SRSC. No shrimp were collected in either trawl or entrainment sampling from the Man-made Channel reach of the SRSC. The Asian green clam (*Corbicula fluminea*), was infrequently collected from all 2007 dredge locations. An unidentified and likely introduced species of jellyfish was collected only in the fish community samples at the Scour Pond site. Table 6 lists all invertebrates collected by community and entrainment sampling in 2007. Table 7 lists both fish and invertebrates collected during entrainment sampling at each site in 2007. The counts for shrimp were based on estimates and for all other invertebrate species on actual counts of each individual organism. Table 7 also provides an overall summary of the entrainment sampling conducted in 2007.

Table 6. Ranked List of All Invertebrates Collected from All Locations during 2007 Monitoring

Rank	Percent	Number	Common Name	Genus	Species	Origin
1	96.15	11,995	shrimp, freshwater	*Palaemon, Exopalaemon*	*spp.*	Introduced
2	2.36	295	clam, Asian	*Corbicula*	*fluminea*	Introduced
3	1.28	160	Siberian prawn	*Exopalaemon*	*modestus*	Introduced
4	0.15	19	jellyfish	*Palaemon, Exopalaemon*	*spp.*	Undetermined
5	0.02	3	clam, unidentified species	*Palaemon, Exopalaemon*	*spp.*	Undetermined
5	0.02	3	mussel, unidentified species	*unknown*		Undetermined
Total Invertebrates:		*12,475*				

Table 7. Entrainment Monitoring Results, 2007

DMP Site Name	ID	Date	Fill Start Time	Fill End Time	Cell Empty Time	Fill Duration (min)	Time to Empty (hr:min)	Cell Volume (gal)	Material Type	Total Sampled Vol. (gal)	Total Slurry Vol. (gal)	% sampled	Fish and Other Organisms Entrained
Roberts I	1	11/2	13:22	13:47	15:42	25	1:55	250,000	Muddy	960,000	245,561,700	0.39	0 fish 5 freshwater (FW) shrimp 2 Asian clam
	2	11/4	12:23	12:43	14:30	20	1:47	200,000	Muddy				1 yellowfin goby 4 FW shrimp 3 mussel (unidentified) 2 clam (unidentified)
	3	11/7	16:44	17:03	18:05	19	1:02	190,000	Muddy				0 fish 3 FW shrimp 1 clam (unidentified species)
	5	11/10	12:11	12:27	14:40	16	2:13	160,000	Muddy				2 channel catfish 1 white catfish 10 FW shrimp,
	6	11/12	15:01	15:17	17:45	16	2:28	160,000	Muddy				6 channel catfish 0 invertebrates
Scour Pond	7	11/24	13:16	13:36	23:59	20	10:23	200,000	Sandy	200,000	59,299,570	0.34	1 channel catfish 0 invertebrates
Decker Island	--	Did not conduct entrainment monitoring prior to dredge area shut down											
S-31	10	12/9	17:55	18:03	19:30	8	1:27	80,000	Muddy	150,000	64,581,192	0.23	0 fish 150 Asian clam
S-31	12	12/10	16:27	16:34	17:30	7	0:56	70,000	Muddy				1 yellowfin goby 75 Asian clam

Table 8. Summary Data of Catch and Effort for Fish Collected in 2007 Fish Community Trawl Surveys

River	Location	Trawl Tows	Distance Towed (m)	Percent of Total Trawl Effort	Number of Fish	Percent of Total Catch	CPUE (fish/m)
San Joaquin	Roberts I	28	12,499	44.29	10,537	97.27	0.84
San Joaquin	Scour Pond	24	12,626	44.74	48	0.44	0.004
Sacramento	Decker Island	2	1,051	3.72	187	1.73	0.18
Sacramento	S-31	4	2,043	7.24	61	0.56	0.03

Dredge reach locations, periods of operation, and quantities of dredge materials placed at each DMP site used in 2007 are listed in Table 1. A total of approximately 214,127 cubic yards of dredged material was placed at the DMP sites during the 2007 maintenance dredging season. Approximately 175,257 cubic yards were dredged in the SSC and 38,870 cubic yards in the SRSC. All material was dredged using RISG Dredge No. 7, a hydraulic cutterhead suction dredge with an 18-inch (inside diameter) discharge pipe. The dredged material was pumped to the DMP sites as discussed in the methods section.

Sample cell fill times and volumes are summarized in Table 7. Entrainment rates were calculated based on pumping rate and volume information provided by RISG. Conversion from dry dredged material amount to end of pipe slurry volume was made using the RISG provided estimates that final deposited material comprised 12% of total slurry volume at Roberts I and S-31 DMP sites, while a 10% conversion factor was applied to the Scour Pond DMP site. Entrainment assessments for individual species were based on extrapolation from the number of individuals entrained and the volume of dredged material sampled to the total amount of material dredged. Species specific entrainment rates were extrapolated for each location where entrainment occurred during 2007 monitoring. It must be stressed that these are approximate rates based on sampling a small amount of the total dredge volume. Future entrainment rates will likely be based on sampling a much higher percentage of the dredge's daily output (see SWCA 2007a) and should yield more accurate extrapolations of entrainment rates.

Roberts I (SSC): Approximately 960,000 gallons, or 0.39% of the total slurry volume, was sampled. Substrates were light sand to silty mud. Ten fish (8 channel catfish, 1 white catfish, and 1 yellowfin goby) were entrained during the monitoring at this site. Extrapolating from this entrainment rate, an estimated 2,046 channel catfish, 256 white catfish, and 256 yellowfin goby may have been entrained during the 2007 maintenance dredging operations at this site.

Scour Pond (SSC): Approximately 200,000 gallons, or 0.34% of the total slurry volume, was sampled. Substrates were predominantly sand. One channel catfish was entrained during the monitoring at this site. Extrapolating from this entrainment rate, an estimated 294 channel catfish may have been entrained during the 2007 maintenance dredging operations at this site. Site characteristics limited the opportunities to conduct successful entrainment sampling at the Scour Pond site during 2007. Hence, efforts for monitoring at this site shifted to in-channel trawl monitoring during the limited period of operations at the Scour Pond DMP site.

Decker Island (SRSC): The discharge stream at Decker Island was not monitored during maintenance dredging operations at this site. Delta smelt were collected during in-channel trawl monitoring on the evening of December 2, at the beginning of operations at this site. Dredge operations at Decker Island were postponed while pump repairs were undertaken shortly after dredge operations began at this site. The Corps then instructed RISG to cease dredging operations within the Sacramento River Natural Channel reach for the remainder of 2007 prior to the initiation of entrainment monitoring at the Decker Island DMP site.

S-31 (SRSC): Substrates in the Man-made reach of the SRSC were primarily light mud. Approximately 150,000 gallons, or 0.23% of the total slurry volume, was sampled. A single yellowfin goby was found during the two entrainment events conducted at this site. Based on this rate, an estimated 434 yellowfin gobies may have been entrained by dredge operations in this area.

Overall, a total of 12 nonnative fish were entrained during the course of eight individual, successful entrainment assessments conducted in 2007 (Table 7). These included 9 juvenile channel catfish, 2 yellowfin goby, and 1 juvenile white catfish.

4.3 Fish Community Sampling

The overall fish catch data for entrainment and community sampling in 2007 is documented in Table 3. All but 12 of the fish were collected during community sampling. Figure 16 depicts the percentage of native versus nonnative fish collected during fish community sampling in each dredging reach. The following sections further describe the fish community sampling results based on the individual shipping channels and individual dredge locations. Tables 2 and 3 in the materials and methods section describe the level of entrainment and fish community sampling effort during 2007. Table 8 summarizes the catch and effort data for fish collected by trawling in 2007 and provides a description of fish density at the trawl locations through the CPUE metric of number of fish collected per linear meter towed along the bottom.

Stockton Shipping Channel

White catfish was the most abundant fish species of the 15 fish species collected at San Joaquin River sites within the SSC and accounted for over 89% of the total catch at these sites. The five most common species (white catfish, threadfin shad, channel catfish, striped bass and American shad) are introduced and together represented 99.76% of the catch. Of the 15 species collected, only five are natives (represented by 14 individual fish), and together represented only 0.14% of the total number of individual fish collected at these sites. Table 9 provides a summary of all fish collected during fish community sampling of SSC sites in 2007. One individual ESA-listed fish, a delta smelt, was encountered in the SSC during 2007 fish community monitoring.

Table 9. Ranked Catch of Fish from 2007 Trawl Monitoring for All San Joaquin River Sites

River	Rank	Percent	Number	Common Name	Origin
San Joaquin	1	89.25	9,447	white catfish	Introduced
	2	4.38	464	threadfin shad	Introduced
	3	3.33	353	channel catfish	Introduced
	4	1.99	211	striped bass	Introduced
	5	0.81	86	American shad	Introduced
	6	0.06	6	starry flounder	Native
	6	0.06	6	yellowfin goby	Introduced
	7	0.05	5	white sturgeon	Native
	8	0.01	1	black crappie	Introduced
	8	0.01	1	blue catfish	Introduced
	8	0.01	1	brown bullhead	Introduced
	8	0.01	1	common carp	Introduced
	8	0.01	1	delta smelt	Native
	8	0.01	1	longfin smelt	Native
	8	0.01	1	splittail	Native
Total Fish:			*10,585*		

Roberts I / Port of Stockton (SSC): Maintenance dredging and concomitant monitoring occurred within the deep water navigation channel between river mile (RM) 39.32–39.73 near Rough and Ready Island and

the Port of Stockton. Table 10 provides a summary of the fish collected during community sampling within this dredging reach. White catfish was the most abundant fish species collected in trawl sampling from this reach, representing 89.66% of the catch. Two native fish species (Sacramento splittail and white sturgeon), represented by three individual fish, were collected, together representing 0.03 % of the total number of fish from this location.

Table 10. Summary of Fish Collected in 2007 Trawl Monitoring near Roberts I

Location	Rank	Percent	Number	Common Name	Origin
Roberts I	1	89.66	9,447	white catfish	Introduced
	2	4.35	458	threadfin shad	Introduced
	3	3.27	345	channel catfish	Introduced
	4	1.88	198	striped bass	Introduced
	5	0.75	79	American shad	Introduced
	6	0.03	3	yellowfin goby	Introduced
	7	0.02	2	white sturgeon	Native
	8	0.01	1	black crappie	Introduced
	8	0.01	1	blue catfish	Introduced
	8	0.01	1	brown bullhead	Introduced
	8	0.01	1	common carp	Introduced
	8	0.01	1	splittail	Native
		Total Fish:	*10,537*		

Scour Pond / Antioch (SSC): Fish community monitoring occurred in the main navigation channel from RM 5.49–5.66 on the lower SSC reach between Sherman and West Islands. Table 11 provides a summary of the fish collected during community sampling. Striped bass was the most abundant fish species collected in trawl sampling from this reach, representing 27% of the catch. Overall, introduced species represented 77.8% of the total catch. The single ESA-listed fish (a delta smelt) encountered from SSC dredge locations in 2007 came from this site.

Table 11. Summary of Fish Collected in 2007 Trawl Monitoring near Scour Pond

Location	Rank	Percent	Number	Common Name	Origin
Scour Pond	1	27.08	13	striped bass	Introduced
	2	16.67	8	channel catfish	Introduced
	3	14.58	7	American shad	Introduced
	4	12.50	6	starry flounder	Native
	4	12.50	6	threadfin shad	Introduced
	5	6.25	3	white sturgeon	Native
	5	6.25	3	yellowfin goby	Introduced
	6	2.08	1	delta smelt	Native
	6	2.08	1	longfin smelt	Native
		Total Fish:	*48*		

Sacramento River Shipping Channel

The SRSC locations sampled in 2007 presented a markedly different species composition than the SSC. The overall catch at all SRSC locations is shown in Table 12. The SRSC sites were dominated by threadfin shad. The four most abundant species were introduced, and together represented 91.53% of the catch.

Overall, native fish represented 6.04% of the catch. Of the 10 species collected, four were natives. This contrasts with the SSC, where 14 species were collected, five of them natives. Of the 11 delta smelt encountered during fish community monitoring in 2007, 10 came from SRSC sites.

Table 12. Ranked Catch of Fish from 2007 Trawl Monitoring for all Sacramento River Sites

River	Rank	Percent	Number	Common Name	Origin
Sacramento	1	66.53	165	threadfin shad	Introduced
	2	11.69	29	white catfish	Introduced
	3	7.66	19	striped bass	Introduced
	4	5.65	14	channel catfish	Introduced
	5	4.03	10	delta smelt	Native
	6	1.21	3	Shimofuri goby	Introduced
	6	1.21	3	white sturgeon	Native
	6	1.21	3	yellowfin goby	Introduced
	7	0.40	1	river lamprey	Native
	7	0.40	1	longfin smelt	Native
Total Fish:			*248*		

Decker Island / Natural Channel (SRSC): Fish community monitoring occurred in the Natural Channel reach from RM 5.68– 5.70 offshore of Sherman Island and downstream of the Decker Island DMP site. Table 13 provides the 2007 catch summary from this location. Delta smelt was the most abundant native fish at this site, representing 4.28% of the overall catch. Threadfin shad and striped bass represented over 93% of the individual fish collected from the limited trawl tows (two) conducted at this site in 2007. Native species (delta smelt, white sturgeon, river lamprey, and longfin smelt) represented 6.41% of the overall catch.

Table 13. Summary of Fish Collected in 2007 Trawl Monitoring near Decker Island

Location	Rank	Percent	Number	Common Name	Origin
Decker Island	1	83.96	157	threadfin shad	Introduced
	2	9.09	17	striped bass	Introduced
	3	4.28	8	delta smelt	Native
	4	1.07	2	white sturgeon	Native
	5	0.53	1	river lamprey	Native
	5	0.53	1	longfin smelt	Native
	5	0.53	1	white catfish	Introduced
Total Fish:			*187*		

S-31 / Man-made Channel (SRSC): Fish community monitoring took place between Sacramento River Man-made Channel RM 33.86 and 34.81, near the bend in the channel, downstream from the Port of Sacramento. Table 14 provides the 2007 catch summary for this site. Of the eight species encountered at this site, two were natives. White catfish were the most abundant fish representing 45.90% of the catch. Native species were represented by two individual delta smelt and one white sturgeon. These data come from a single community monitoring event, during which only four trawls were conducted due to the presence of delta smelt.

Table 14. Summary of Fish Collected in 2007 Trawl Monitoring near S-31

Location	Rank	Percent	Number	Common Name	Origin
S-31	1	45.90	28	white catfish	Introduced
	2	22.95	14	channel catfish	Introduced
	3	13.11	8	threadfin shad	Introduced
	4	4.92	3	Shimofuri goby	Introduced
	4	4.92	3	yellowfin goby	Introduced
	5	3.28	2	delta smelt	Native
	5	3.28	2	striped bass	Introduced
	6	1.64	1	white sturgeon	Native
		Total Fish:	*61*		

4.4 Water Quality Monitoring

Water quality monitoring data are reported in Appendix B. Surface and bottom measurements were acquired for all parameters except Secchi depth and were taken twice during each fish community sampling event. Water quality data were not collected during entrainment monitoring. Dissolved oxygen measurements ranged between 80 and 95% with one early morning reading dropping just below 80% (both surface and bottom) in the Port of Stockton reach on November 13, 2007. The maximum water temperature recorded for 2007 was 18.04°C for surface water near Roberts I on November 5, and minimum temperature was 10.19°C for surface and bottom near S-31 on December 11. Salinity levels varied from just over 0.2 ppt at the furthest upstream locations on both channels to just under 6.0 ppt at the Scour Pond location near Antioch.

4.5 Dredge Observer Monitoring

Dredge observers were onboard the dredge for all dredging that occurred between December 1 through December 11, 2007. This monitoring is required by NMFS (NMFS 2006a,b) for dredging occurring outside the approved work window in all locations where maintenance dredging occurs. No distressed fish were observed during 2007 monitoring.

4.6 Level of Take

One of the objectives of the monitoring program is to improve take estimates for maintenance dredging operations in the Delta. Original take estimates for the 2006 FMP (Table 15) were based on the estimates developed for the Stockton DWSC and the Sacramento DWSC BOs (NMFS 2006a,b). Take estimates have not been revised since the original 2006 estimates. The estimated mortality was based on NMFS estimates for dredging activities in the Stockton and Sacramento DWSCs. It is assumed that exposure of listed fish to sampling gear would be less than 25% of the potential exposure to dredging equipment, a very conservative estimate. Incidental and lethal take were authorized under Program Element Number 2007-113 for inclusion in the amended IEP Scientific Collecting Permit 1440. Estimates of take of delta smelt are not included, as NMFS does not provide take estimates for this species, nor were they established during previous informal consultations with the USFWS for this project.

Table 15. Estimated Incidental Take for 2006

Potential incidental take for fish community sampling in the Stockton DWSC 2007				
	Juveniles		Adults	
Species	No.	% of Total ESU/DPS*	No.	% of Total ESU/DPS*
Sacramento River winter-run Chinook salmon	650	0.85	1	<1
Central Valley spring-run Chinook salmon	1,250	0.32	1	<1
Central Valley steelhead	70	0.15	2	<1
North American green sturgeon	25 juveniles and adults combined (2% = 1 mortality)			
Potential take for fish community sampling in the Sacramento River DWSC 2007				
	Juveniles		Adults	
Species	No.	% of Total ESU/DPS*	No.	% of Total ESU/DPS*
Sacramento River winter-run Chinook salmon	650	0.85	1	<1
Central Valley spring-run Chinook salmon	1,250	0.32	1	<1
Central Valley steelhead	70	0.15	2	<1
North American green sturgeon	25 juveniles and adults combined (2% = 1 mortality)			

* ESU = evolutionarily significant unit DPS = distinct population segment

Eleven delta smelt were collected during fish community monitoring events in late November and early December 2007. In addition to the data included in Table 16 on these fish, a complete description of each delta smelt encounter is provided in Appendix D. Four of the eleven delta smelt were vouchered as they did not appear likely to survive. The seven remaining delta smelt appeared healthy after removal from the trawl and were released back to river at the collection locations. Other than the eleven delta smelt, no ESA-listed fish were encountered in 2007.

Table 16. Delta Smelt Encounters in 2007

Date, Trawl ID	Trawl Time	n Indiv.	DWSC	Location	Secchi Depth (cm)	Salinity (ppt)	Impact on Dredging
11/21, 8-3	14:13–14:20	1	SSC	West Island dredge reach. Navigation light 7 off NW end of West Island in navigation channel	78	3.88	None
12/02, 12-1	19:27–19:35	2	SRSC	Natural Channel, Decker Island dredge reach. Navigation light 13 downstream of Decker Island in the navigation channel	NA (dark)	0.22	Moved dredge
12/02, 12-2	19:57–20:05	6	SRSC	Natural Channel, Decker Island dredge reach. Navigation light 14 downstream of Decker Island in the navigation channel	NA (dark)	0.22	
12/11, 13-3	16:21–16:29	1	SRSC	Man-made Channel, Port of Sacramento. Navigation light 67 downstream of "the bend" in the navigation channel	27	0.39	Stopped dredging
12/11, 13-4	16:48–16:56	1	SRSC	Man-made Channel, Port of Sacramento. Navigation light 67 downstream of "the bend" in the navigation channel	27	0.39	

4.7 Mortality

Substantial mortality of certain species was an unavoidable result of the 2007 fish community and entrainment sampling regime. Table 17 provides information on the species sampling mortality. Mortality occurred in 7 of the 17 species collected in 2007. Delta smelt was the only native fish species that incurred sampling mortality during community sampling. No native fish were encountered in the 2007 entrainment monitoring efforts. Entrainment mortalities were limited to nonnative white and channel catfishes and yellowfin goby. Highest mortality rates were observed among threadfin shad, striped bass, delta smelt, and American shad. Several adjustments to the collection and data acquisition methods designed to reduce mortality in future collections are discussed in the adaptive management section and the suggestions for future monitoring section.

Percent mortality was calculated by comparing the observed mortality to the total number of individuals collected. Mortality numbers were estimated in large trawl catches. It is possible that some fish initially counted as mortalities actually recovered after release. It is also likely that an unknown number of fish that appeared healthy at release subsequently died due to unobserved injury or stress. A small number of fish were vouchered for further examination, resulting in immediate mortality of these individuals.

Table 17. Mortality of Collected Fish

Common Name	Total Mortalities	Percent Mortality
threadfin shad	211	33.65
striped bass	70	30.43
delta smelt	4	27.27 *
American shad	17	20.73
yellowfin goby	1	11.11
river lamprey	1	100 *
channel catfish	11	3.18
white catfish	53	0.57

Species with grey background are introduced. *= vouchered specimens accounted for most mortality

5 Discussion

5.1 Hypotheses

This monitoring program was developed to meet the requirements as stated in Conservation Measure 12 of the NMFS BOs (2006a,b). The conservation measures developed through these ESA consultations were created in addition to the established in-water work windows that regulate the timing of Delta dredging projects. The established annual work windows for maintenance dredging are from June 1 through December 31 for the SSC, and between June 1 and February 27 for the SRSC (restricted to upstream areas in the Man-made Channel beginning December 1). The additional conservation measures were based on recognition by NMFS that additional protections and measures to monitor project impacts were needed to help ensure that project actions would not jeopardize the viability and existence of protected species.

The following hypotheses were developed prior to the initiation of the 2006 sampling as the means to convert the monitoring requirements into heuristically testable assumptions and questions:

- H1: Maintenance dredging of the SSC and SRSC will result in take of listed and other fishes through direct dredge entrainment.

- H2: There is a relationship between presence of fish in the dredging areas and entrainment by the dredge.

- H2a: Differential use of the water column will result in different entrainment levels among fishes present in the project areas; that is, fish that are associated with the channel bottom (benthic and epibenthic species) will be entrained at higher levels than water column (pelagic) associated fish.

H1: This hypothesis was tested during 2006 and 2007 monitoring and proved to be partially correct. Fish species were entrained, though none were listed species. This may change in the future as the number and composition of listed species changes; as a result of future unforeseeable environmental perturbations/changes; and as a result of (planned) changes to the monitoring methods, effort, and locations.

H2 and H2a: The data set is not robust enough at this time to effectively answer these questions with a significant level of confidence. At least one and possibly more years will be needed before this question may be answered in a statistically valid and scientifically defensible manner. It can be stated now, however, that no fish species were entrained that were not also collected in the fish community samples, and that all entrained fish species (channel catfish, white catfish, and yellowfin goby in 2007, and Shokihaze goby, river lamprey, and white catfish in 2006) are demersal (bottom-oriented) fishes.

In order to fully test H2a, more knowledge of the fishes inhabiting the dredging sites is needed. This knowledge will be provided by future sampling efforts from this monitoring program and by other studies of Delta fish. IEP sponsors several long-term status and trends studies such as the Estuarine and Marine Fish Abundance and Distribution Survey and the Fall Midwater Trawl Survey, and recent studies initiated by IEP's Pelagic Organism Decline work team (POD). These and other studies will be used to assess the vulnerability of Delta fishes to dredge entrainment. Comparing data across studies will always be problematic since there are substantial differences in sampling timing, methods, and locations, as well as

substantial data gaps in many critical areas of the life history and population biology of listed and other Delta fish species. The lack of basic biological information for some Delta species is also compounded by the rapid changes (declines) that some populations are currently experiencing (Bennett 2005; IEP 2008).

Several other factors add additional complications to the hypothesis testing and analysis of vulnerability to entrainment. Among the 17 fish species collected in 2007 and the 26 species in 2006, approximately half can be readily defined as demersal rather than pelagic. These species include sculpin, goby, catfish, sturgeon, flounder and lamprey. The nondemersal species tend to use most or all of the water column, and some engage in diurnal migrations to the surface or bottom. Within species, behavior differences based on life stage also hamper a generalized discussion of water column usage. Additionally, the described behaviors for individual species are often based on observations from (all of) the inland California water bodies in which they occur rather than at specific Delta locations (Moyle 2002). There is some knowledge of specific use of areas of the Delta by individual species and of seasonal fluctuations of species presence in the shipping channel. However, many gaps exist for specific Delta locations and groups of fishes (Moyle 2002; Feyrer and Healey 2002, 2003; Bennett 2005; Nobriga et al. 2005; Brown and May 2006). Finally, although the sampled slurry volume was low, the very low fish entrainment rates observed in 2006 and 2007 are indicative of overall dredging impacts to Delta fish. Changes to the entrainment sampling methodology in 2008 and beyond should improve the predictive ability of the sampling. More robust entrainment estimates will help identify trends and further test the study's hypotheses. Changes to the entrainment sampling methodology are discussed in the adaptive management and recommendations sections.

5.2 Overview

The fish species encountered during 2007 and earlier fish community and entrainment monitoring are a subset of those described by Moyle (2002) for the Central Valley subprovince. The majority of the species described by Moyle as being present in the Delta that were not encountered during 2007 and earlier monitoring for this project, are species whose populations are known to be very low, such as Sacramento perch; species that are not known to inhabit the channel bottoms, such as largemouth bass; or species that are not known to occur in the areas being dredged, such as Sacramento sucker.

Recent precipitous declines in populations of several species of Delta fish such as delta smelt, longfin smelt, threadfin shad, striped bass and green sturgeon amply document the need for ongoing assessments of Delta fish populations. Since the inception of this study's fish community monitoring in 2006, several findings came to light that either contrast those described by others or corroborate similar observations. These trends, observations, and monitoring outcomes are listed below:

- The introduced Shokihaze goby was not previously described as inhabiting the upper Delta in 2002 (Moyle), but ranked twelfth in overall abundance of fish collected during 2006 monitoring.
- The white sturgeon to green sturgeon ratio was approximately 40:1 in 2006, much higher than the 5:1 ratio described by Moyle (2002), due to much lower numbers of green sturgeon. In 2007, eight white sturgeon were collected, but no green sturgeon were.
- The ranking of longfin smelt from lower Sacramento River locations was still very high in 2006 (895 were collected, ranked first among native species and fourth among all species), as opposed to other locations in the Delta and San Francisco Bay estuary where steep declines had recently been observed (Thomas Greiner, CDFG, personal communication). In 2007, only two longfin smelt were collected, mirroring the low catch of the Fall Midwater Trawl Survey

(CDFG 2008b). The 2006 sampling appears to have coincided with the reported center of abundance of spawning adults near Rio Vista (Moyle 2002).

- The most recent POD progress report (IEP 2008) reported the highest (worst) bloom on record of the algae *Microcystis aeruginosa* for 2007, centered near Antioch. Significant monitoring efforts from this study took place in this region during fall 2007 and the CPUEs were at least an order of magnitude lower than previously measured by this study at any other location.
- Delta smelt were not encountered by this study during 2006; however, in 2007, 11 delta smelt were collected during fish community monitoring in November and December. Of these 11 individuals, nine were from San Joaquin and Sacramento River locations near the confluence, and two were from the Sacramento River Man-made channel near the Port of Sacramento. In contrast, the 2007 Fall Midwater Trawl Survey team collected five delta smelt in November and 10 in December (CDFG 2008b).
- The salinity of the water in which this study encountered delta smelt in 2007 was lower than that observed for delta smelt collected by the Fall Midwater Trawl Survey.

Project Impacts related to Changes in Species Status

The NMFS monitoring requirements that have necessitated this study are focused on salmon, steelhead, and sturgeon populations that were listed as threatened or endangered under the ESA in 2006. It is important to note that special-status species designations are not limited to the species that are the responsibility of NMFS under the federal ESA, nor are they fixed in time. The monitoring activities conducted were also accountable to provisions of the California Endangered Species Act (CESA), which affords special status to some species that do not have federal status, and to species that may be listed under ESA but are the responsibility of USFWS rather than NMFS. As assessments of species status under the ESA and CESA are ongoing, dredging and monitoring activities are also affected by proposed listings, new listings, and indications of likely listings in the future. The dynamic nature of listing status had a direct effect on dredging and associated monitoring activities in 2007, due to changes in the CESA status of delta smelt.

While already listed as threatened under ESA and CESA, delta smelt were petitioned for a change in status under CESA from threatened to endangered in April 2007, and new interim protections were provided to delta smelt on December 14, 2007, through the Delta Smelt/OCAP decision in *NRDC v. Kempthorne*. Delta smelt were encountered during 2007 monitoring activities on November 21, December 2, and December 11. In light of the new protections and the collection of delta smelt in the fish community dredging and monitoring were suspended on December 12 for the remainder of 2007.

Changes in the status of additional species could present similar issues for dredging and associated monitoring activities, through new conservation requirements and new permit restrictions. To cite an ongoing example, longfin smelt were petitioned for federal ESA listing by the Bay Institute, the Center for Biological Diversity, and the Natural Resources Defense Council on August 8, 2007 and were previously listed as endangered by California. On February 7, 2008, the California Fish and Game Commission decided to accept the longfin smelt as a candidate species and enacted protections reflecting the change in status. This decision will result in take restrictions for this species that are anticipated to be in effect during monitoring activities in 2008.

Similarly, there is a potential for future listing of other species occurring in the project area, such as Pacific and river lamprey. These lamprey are known to occur in the Delta. The species identification of the little known and rare river lamprey was confirmed as the lamprey collected in both the fish community and fish

entrainment samples in 2006 and 2007. Although not currently protected under ESA or CESA, lamprey are recognized by USFWS and others as species that require greater conservation efforts. Both species were petitioned for listing under ESA in 2004, but were denied (USFWS 2004). Future petitions for CESA and/or ESA listing of these species are likely, with attendant implications for dredging and monitoring, should listing occur.

5.3 Discussion of Entrainment Monitoring

Entrainment monitoring was constrained by availability and reliability of equipment, sampling cell instability, delays in sampling cell construction, and new restrictions related to the presence of delta smelt. The specific constraints by DMP site are as follows.

As described in the 2007–2008 fish monitoring plan (SWCA 2007a), it was intended that a new screen device designed to assess entrainment rates would be used at some or all of the DMP sites in 2007; the purpose of this device is to allow sampling of a greater percentage of dredge output. However, this device was not available as planned, and all 2007 entrainment assessments were conducted as in 2006 and 2005, using the sampling cell approach. Also as before, the sampling cell approach to entrainment monitoring resulted in assessment of less than 1% of the total dredge output. The extrapolated entrainment rates are therefore less accurate than they could have been, had they been based on assessments of a higher percentage of the dredged material. The screen device is now complete (Figure 17) and will be available for testing and use during the 2008 dredging season

The sampling cell at the Scour Pond DMP site at the west end of Sherman Island, a peat-dominated area, experienced site constraint difficulties. As a result, only one successful entrainment monitoring event was completed at this DMP site. Breaching of the sampling cell by the nearby primary discharge outfall occurred on November 26. This breach flooded the sampling cell and made it unusable. At this time, the monitoring effort shifted to solely fish community monitoring, while waiting for the sampling cell to be rebuilt. Unfortunately, continued difficulties with soil movement in the sampling cell area caused the floor of the sampling pond to uplift which prevented rebuilding of the cell prior to moving from this dredging reach and DMP site (Figure 18). The constraints at the DMP site heavily weighted the fish monitoring effort at this location to fish community monitoring.

The sampling cell at the Decker Island DMP site had not yet been completed at the initiation of dredging in this reach. This resulted in conducting community sampling rather than entrainment sampling at the onset of monitoring this site. Monitoring was further limited by the presence of delta smelt, which were encountered during the initial community sampling. RISG was asked to move the dredge to the S-31 site, both due to the presence of delta smelt at Decker Island and due to the need to complete dredging at the S-31 site prior to Dec. 15. The combined effect of these constraints was that no entrainment monitoring was conducted at the Decker Island DMP site during 2007.

Entrainment sampling was conducted twice at the S-31 site prior to initiation of the first fish community sampling event in this dredging reach, due to mechanical problems with the community sampling vessel. The first community sampling event at this site was conducted on December 12 and revealed that delta smelt were present in the dredging reach. All remaining dredging was then suspended for the remainder of the 2007 dredging season at the request of the USFWS.

5.4 Discussion of Fish Community Monitoring

Fish community composition was effectively monitored in 2006 and 2007 by otter trawling in the vicinity of the dredging operations. Data acquired by the fish community monitoring portion of this study, along with data from other Delta fish studies will help clarify trends and changes to the fish community of the Delta; determine what linkages, if any, may be created between community sampling and entrainment rates; provide the regulatory agencies with the information and feedback needed to evaluate the efficacy of the monitoring requirements; and help determine if the dredging work windows continue to effectively protect ESA listed and other sensitive species.

Delta smelt were encountered during bottom trawl surveys in three of the four dredge locations during 2007 maintenance dredging operations. The first encounter occurred during the third of five afternoon trawl replicates on November 21. The dredge was operating in the Navigation Channel near the northwest end of West Island, across the river from Antioch. One delta smelt was captured and vouchered for positive identification. Upon analysis and confirmation of species identification on November 23, phone and email notifications were sent to the Corps-Sacramento District and IEP. (Dredging did not occur on November 22 and 23 in observance of Thanksgiving.) Dredge operations and monitoring continued at the Antioch-Scour Pond dredge area from November 23 to November 29 at the tail end of the normal in-water work period (NMFS 2006a,b). Dredge operations ceased at the Scour Pond site in order to move to the Decker Island dredge area prior to the December 10 in-water work extension deadline set for the Sacramento River Natural Channel reach at Decker Island. No additional delta smelt were encountered in the subsequent bottom trawl monitoring at the Antioch-Scour Pond reach. One of the two longfin smelt collected in the 2007 monitoring was from this location as well. At the Antioch-West Island reach, CPUE was much lower than at any other location (Table 8). This reach also contained the highest salinities and current strengths of the four dredge areas.

Dredge operations at the Decker Island reach began on December 2 and were ordered to cease by the Corps after consultation with USFWS on December 3 due to collection of delta smelt. Fish community monitoring on the evening of December 2 collected eight delta smelt during the first two trawl replicates at this location. The take allowance of three delta smelt per survey under the IEP permit (Program Element 2007-113) for the fish community monitoring was exceeded. The sampling was then discontinued and the monitoring team notified the Corps and IEP via cell phone from the vessel. The pertinent catch and water quality data was provided via email on December 3. This take of delta smelt occurred during the in-water work extension granted for this area of the Sacramento River. The USFWS conveyed to the Corps that the dredge operation did not have authorization for take of delta smelt and the dredge operations were ceased at Decker Island for the remainder of the dredge season. Salinity levels were low in this freshwater area during the sampling period. The only lamprey and second of only two longfin smelt collected during 2007 fish community monitoring came from this Sacramento Natural Channel dredge reach.

Fish community monitoring in the Man-made Channel of the Sacramento River near the Port of Sacramento was attempted on December 8; however, mechanical difficulties with the vessel required a return to the dock prior to initiation of trawling. Monitoring efforts shifted to entrainment monitoring using the sample pond at S-31 while the vessel was being diagnosed and a backup vessel made available. Trawl monitoring resumed on the afternoon and evening of December 11. Two delta smelt adults were collected in the last two of four replicate trawls. Water quality parameters at the dredge reach near the S-31 DMP site showed this freshwater area had low salinity and high turbidity levels. The monitoring team notified the Corps and IEP via cell phone from the vessel and provided the pertinent catch and water quality data via email on December 12. That night, after a conversation via phone between USFWS and the

Corps, dredge operations for the entire Sacramento River were ordered to cease, which was conveyed to the fish monitoring team by the RISG project manager. A subsequent teleconference on the morning of December 13 resulted in the Corps deciding to end both the Sacramento and Stockton ship channel maintenance dredging operations for the remainder of the 2007 dredge season for the Delta.

Trawl sampling in the Port of Stockton's Rough and Ready Island reach documented much higher density of fishes than any other location, as was also the case in 2006. Nearly all of the catch at the Port of Stockton was again introduced species, with white and channel catfish being the dominant species. After some very large catches of catfish occurred during the third trawl survey at this location, the target distance trawled was lowered to approximately 350 meters to avoid the need to subsample and reduce processing time for the collected specimens.

6 Adaptive Management

Adaptation of monitoring methods is likely to continue based on improvements to the methods and based on changes to the sampling needs, fish community, and sampling and dredging permits. In 2007 delta smelt were encountered in the fish community sampling for the first time and resulted in dredging and sampling management actions by the USFWS, the federal agency responsible for this species. Monitoring methods promulgated under the BOs issued by NMFS for the SSC and SRSC maintenance dredging operations were intended to monitor and provide measures of protection for fish species under their jurisdiction (salmon, steelhead, and sturgeon). Delta smelt are regulated by the USFWS, which informally consulted on the SSC and SRSC maintenance dredging operations in 2004 and concurred that delta smelt were not likely to be adversely affected by the project operations during normal in-water work windows. However, take of delta smelt during 2007 fish community monitoring resulted in USFWS requesting the Corps to first move the dredge to another location and then to cease dredging entirely. In light of these events, the Corps and USFWS will likely enter into formal consultation on the effects of maintenance dredging of the Delta's federal shipping channels and its attendant monitoring on delta smelt. This could result in additional protective measures and/or monitoring requirements. The effect of these actions on this monitoring project are yet to be determined.

6.1 Entrainment Monitoring

The high fine and organic content of the slurry, particularly near the bottom of the sampling cell, presented sampling challenges. Alternative methods of draining the sampling the cell were explored to reduce the amount of time necessary to sort through a sample. The sampling cells at Roberts and Scour Pond DMP sites in 2007 had larger capacity and were generally deeper than those used in 2006. To efficiently process the slurry using the entrainment nets for these larger capacity cells, a minimum of two weir boxes was needed to handle the increased discharge pressure. Infrequently, during the draining of Roberts I and Scour Pond sampling ponds, the monitoring team needed to stop flow through one culvert while either emptying or processing a full net, removing blockages, or re-adjusting a net that was at risk of slipping off. An on-site water pump provided ambient river water to aid in inspection of the material and organisms entrained in the net and holding water for any live organisms collected.

As in 2006, following the complete drainage of each sampling cell, the cell bottom was closely observed for organisms that may have been deposited in the remaining sediments. The dense consistency of the slurry material prevented dragging a beach seine through the sampling cell and often did not allow one to walk across most of the interior of the drained cell.

Other improvements made to entrainment monitoring from 2006 to 2007 included

- A greater proportion of sampling events were conducted during dusk or dark periods than in 2006 entrainment sampling events.
- A plywood pad was used at the culvert discharge point to prevent erosion around the sampling nets and provided a more stable work area, which increased sample processing efficiency.
- In locations where the splitter valve was not used, the sampling pond was located closer to the discharge location at the DMP site to ease logistics of moving the pipe via bulldozer between sample and disposal areas.
- The bulldozer operations provided a back-up mechanism for the splitter valve used at the Roberts I DMP site.
- Volume capacity of sample cells increased overall from those used in 2006 monitoring.

6.2 Fish Community Monitoring

All individual fish specimens were enumerated by their species, life stage, and disposition. However, individual fish length data was not always collected. The presence of easily stressed or sensitive fish species prompted the monitoring team to assess and collect data from such species first. Several fragile species were collected in 2007 trawl surveys, including delta smelt, longfin smelt, splittail, American shad, threadfin shad, and, to a lesser extent, striped bass. Large catches of white and/or channel catfish also resulted in the need to subsample and release some individuals without documenting their individual lengths. Length data was not assessed for individual invertebrates collected. Subsampling was also used to estimate the larger catches of freshwater shrimp.

The target trawl sample distance for fish community monitoring was a minimum of 500 meters per trawl tow at all sampling areas. One exception was made within the Port of Stockton reach where a successful trawl tow was ended at a sampling distance of less than 200 meters in order to avoid up-current ship traffic. The Port of Stockton reach also had very high densities of white and channel catfish, resulting in larger catches of fish per tow were than were previously encountered or anticipated at this location. This large catch required subsampling in an effort to reduce injury and mortality. After the initial large catch at this location, the targeted trawl distance was lowered to 350 meters. This reduction in trawl sample distance was limited to the Port of Stockton reach only for trawl surveys 4 to 6, which occurred between November 9 and November 13. All other trawl survey locations and replicates met the target distance of 500 meters. As in 2006, trawl distance data was acquired using GPS-based tracking software (Nobletec Navigation Software).

Modifications to monitoring methods for the 2007 monitoring incorporated the following recommendations from the 2006 monitoring report (SWCA 20007b). Water clarity was quantitatively measured using a Secchi disk. It was also visually estimated at the surface, as in 2006, to provide a back-calculation surrogate for Secchi depth measures of the 2006 visual estimates, if needed at a later time. Water samples were collected by grab sampling at the surface and at depth with a Van Dorn bottle at the beginning and end of each sampling event to provide samples for on-board turbidity monitoring. The proportion of 2007 fish community monitoring conducted during dusk or dark conditions also increased from 2006 levels.

7 Recommendations

7.1 Entrainment Monitoring

The sampling cell method for entrainment monitoring was used exclusively during the 2007 dredging season. It was anticipated that a prototype entrainment screen device being developed for the project (SWCA 2007a, Appendix C) would provide an additional sampling method to be used during the 2007 maintenance dredge operations in the Delta (Figure 17). Key components of the entrainment screen device requiring customized design and manufacture were not available in time to use of this method during the 2007 dredge operations.

The sampling cell approach continued to be problematic in 2007 as it was in 2006, mainly due to sample cell construction and maintenance issues that can reasonably be expected to continue to confound this approach to entrainment monitoring. We recommend that the entrainment screen device (Figure 17) be used at all DMP sites in 2008 and beyond. The screen device is likely to work well in areas with sandy material but may be more difficult to use at sites with very high organics loads and or very fine sediments that are bound to easily clog the screen. It is also likely that constraints at individual DMP sites such as access, geomorphology, and dredged material characteristics will not enable use of the screen device at all DMP sites. As a result, the sampling cell methodology will be retained during future monitoring events even if the screen is successful at most locations.

If the entrainment screen device does not prove efficient in some conditions present at a particular DMP site then the following points are recommended to improve the efficiency of the sample cell methodology:

- Enlarge the size of the sampling cell as much as possible to accommodate a greater volume of dredge slurry.
- Increase sample frequency to increase overall sampled volume of the dredges output. Greater effort will require increased labor efforts for monitoring.
- Ensure that the elevation of the sampling cell and work area at the sampling cell discharge location are sufficiently high to prevent backwatering of the DMP site pool into the entrainment work area.
- Flush the sampling cell (remove all stop boards and direct flow through the sampling cell) occasionally to remove buildup of fine sediments and organic material on the bottom of the cell to maintain its capacity.
- When using the sampling cell, use a splitter valve to direct flow into or around the cell.
- Use a Y-valve splitter or locate the sample cell a sufficient distance from the DMP site to reduce breach risks. As occurred in 2007 at the Scour Pond DMP site, location of the sample cell too close to the primary discharge location at the DMP site is likely to increase the risk of breaching into the sample cell.

7.2 Fish Community Monitoring

The following recommendations are made in order to maximize sampling efficiency, gather better information about the sampling target area, and increase the potential for future statistically valid comparisons of fish community monitoring data:

- During periods of high flow velocities or high debris content the monitoring team may reduce the length of the fine mesh, cod-end inner liner of the otter trawl to maintain the ability of the

net to reach the target sampling depth (bottom). The long segment of fine mesh tends to catch debris and create additional drag in such conditions. If this is done, testing should also be done to assess changes in fish retention based on the reduced length of the cod-end inner liner.

- If difficult-to-identify species (particularly juvenile lamprey) are collected, additional specimens will be preserved and vouchered for further laboratory identification and confirmation.
- In future collections of lamprey, particularly the rare river lamprey, specimens will be carefully preserved for morphological examination, with a portion of body tissue collected for submittal to USFWS for mitochondrial DNA analysis to improve taxonomy and field identification characteristics.

8 Conclusions

Dredge monitoring requirements promulgated in the BOs (NMFS 2006a, b) were successfully met during the third year of entrainment and second year of fish community sampling for maintenance dredging operations of the SSC and SRSC. Collection and take of listed delta smelt occurred in the fish community monitoring at the Antioch reach in the SSC, and the Natural Channel and Man-made Channel reaches of the SRSC. Take of listed fish species did not occur during the entrainment monitoring events at any of the DMP sites in 2007. Issues arose during the 2007 maintenance dredging regarding permitted incidental take of delta smelt by dredge operations. Take of this species during fish community monitoring in 2007 resulted in conservative management actions designed to prevent additional take (such as cessation of dredge operations at a site) despite the fact that delta smelt were not encountered in the entrainment samples. A possible result of the delta smelt encounters during 2007 monitoring will be re-initiation of consultation on the effects of maintenance dredging and NMFS-required monitoring between the Corps and USFWS.

Results of the 2007 monitoring studies indicate the utility of the fish community sampling to provide information on presence and potential vulnerability of particular species during the time, and in the location, of active dredge operations. Assessing the predictability of entrainment of sensitive species will require continued annual sampling to provide a scientifically defensible response regarding the assessment of the environmental effects of maintenance dredging in the SSC and SRSC. Introduction and use of the entrainment screen device for monitoring the dredge disposal stream in 2008 should improve the estimation of entrainment rates. This sampling program is likely to benefit the Corps and other agencies by providing important information about dredging impacts to listed and other fishes and changes to Delta fish populations, and by improving entrainment sampling methods for use in other dredging locations.

9 References

Bay Institute. 2003. The Bay Institute ecological scorecard: San Francisco Bay index 2003, fish index, draft technical appendix. Available: http://www.bay.org/Scorecard/Fish.pdf. (February 2008).

Bennett, B. 2005. Critical assessment of the delta smelt population. San Francisco Estuary and Watershed Science. 3(2):article 1 (September 2005).

Brown, L. R., and J. T. May. 2006. Variation in spring nearshore resident fish species composition and life histories in the lower Sacramento-San Joaquin watershed and delta (California). San Francisco Estuary and Watershed Science. 4(2):article 1 (September 2006). Available: http://repositories.cdlib.org/jmie/sfews/vol4/iss2/art1. (2007).

Buell, J. W. 1992. Fish entrainment monitoring of the Western-Pacific Dredge *R W Lofgren* during operations outside the preferred work period. Report of Buell & Associates to Western-Pacific Dredging Company.

California Department of Fish and Game (CDFG). 2008a. IEP endangered species take reporting. Resources Agency, Department of Fish and Game. Available: http://www.delta.dfg.ca.gov./data/esa/. (March 2008).

———. 2008b. Bay-Delta region fall midwater trawl indices. Resources Agency, Department of Fish and Game. Available: http://www.delta.dfg.ca.gov/data/mwt/charts.asp. (January 29, 2008).

———. 2008c. California natural diversity database, special animals (865 taxa), February 2008. Resources Agency, Department of Fish and Game. Available: http://www.dfg.ca.gov/biogeodata/cnddb/pdfs/SPAnimals.pdf. (February 2008)

———. 2008d. CDFG Biogeographic Data Branch and Habitat Conservation Branch webpages. Resources Agency, Department of Fish and Game. Available: http://www.dfg.ca.gov/bdb/pdfs/TEAnimals.pdf and http://www.dfg.ca.gov/hcpb/species/ssc/sscfish/sscfish.shtml. (February 2008).

Feyrer, F., and M. P. Healey. 2002. Structure, sampling gear and environmental associations, and historical changes in the fish assemblage of the southern Sacramento-San Joaquin delta. California Fish and Game 88(3):126–138.

———. 2003. Fish community structure and environmental correlates in the highly altered southern Sacramento-San Joaquin delta. Environmental Biology of Fishes 66:123–132.

Interagency Ecological Program (IEP). 2008. Pelagic organism decline progress report: 2007 synthesis of results. California Environmental Protection Agency, State Water Resources Control Board. Available: http://www.waterrights.ca.gov/baydelta/pelagicorganism.html. (January 15, 2008).

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

Moyle, P. B., R. M. Yoshiyama, J. E. Williams, and E. D. Wikramanayake. 1995. Fish species of special concern in California. Final Report for Contract No. 2128IF, June 1995. Report to the State of

California Resources Agency, Department of Fish and Game, Inland Fisheries Division, Rancho Cordova.

Nobriga, M. L., F. Feyrer, R. D. Baxter, and M. Chotkowski. 2005. Fish community ecology in an altered river delta: spatial patterns in species composition, life history strategies, and biomass. Estuaries 28(5):776–785.

NMFS (National Marine Fisheries Service). 2006a. Biological and conference opinion for the Stockton deep water ship channel maintenance dredging and levee stabilization project. SWR-2004-SA-9121:JSS, April 4, 2006. Prepared for the U.S. Army Corps of Engineers, Sacramento District.

———. 2006b. Biological opinion for the Sacramento deep water ship channel (SDWSC) maintenance dredging and bank protection project. SWR-2006/00041, August 29, 2006. Prepared for the U.S. Army Corps of Engineers, Sacramento District.

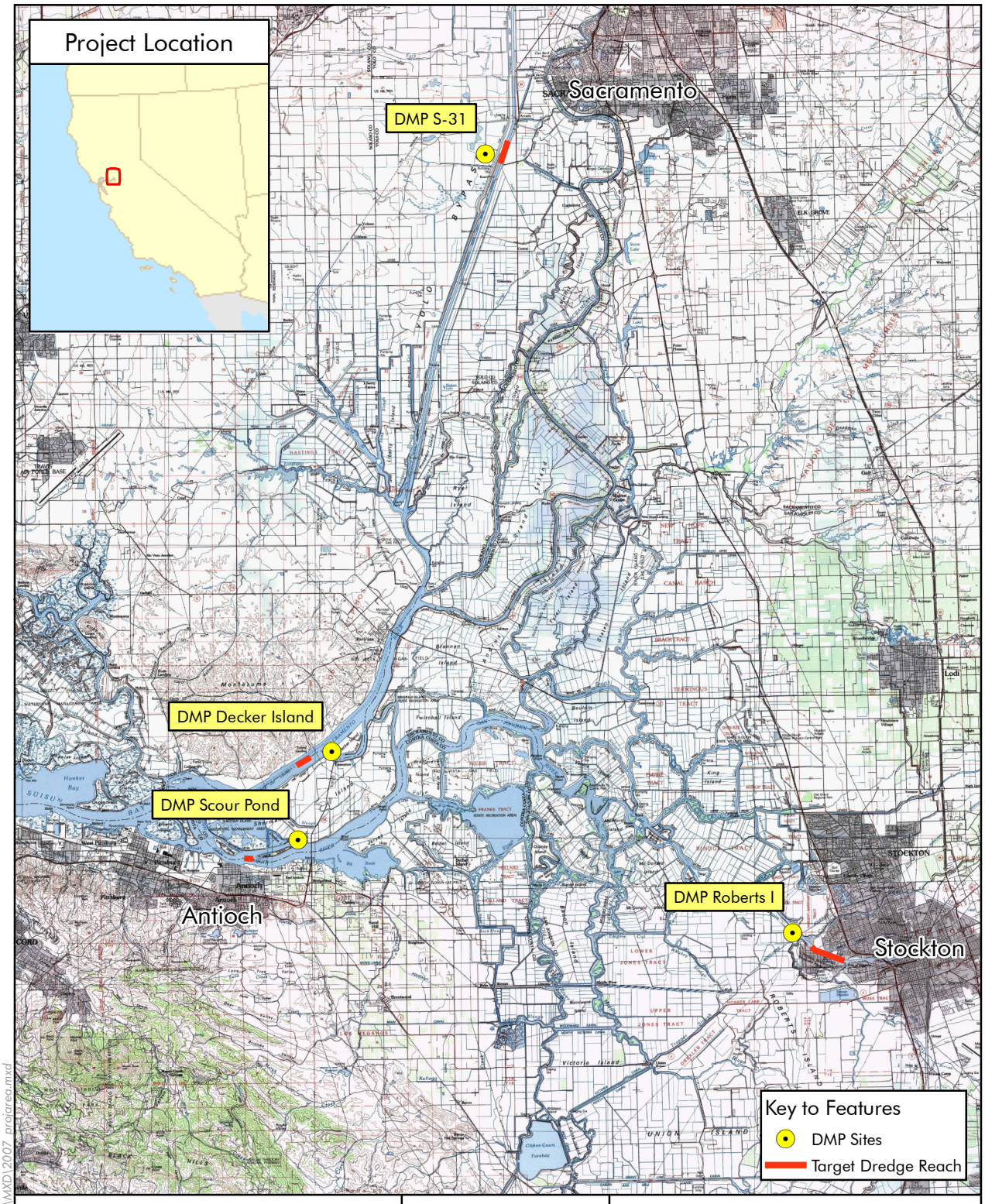
SWCA Environmental Consultants (SWCA). 2006. Fish entrainment and fish community monitoring plan for the 2006 Stockton and Sacramento deepwater ship channel maintenance dredging project. Report to U.S. Army Corps of Engineers, Sacramento District. September 2006. SWCA, Portland.

———. 2007a. 2007–2008 fisheries monitoring plan for the Stockton and Sacramento deepwater ship channel ID/IQ maintenance dredging operations and IEP program element 2007-113. Report to U.S. Army Corps of Engineers, Sacramento District. Submitted to IEP/CDFG and USACE July 31, 2007. SWCA, Portland.

———. 2007b. Stockton and Sacramento deepwater ship channel maintenance dredging project 2006 fish community and entrainment monitoring report. Report to U.S. Army Corps of Engineers, Sacramento District. August 2007. SWCA, Portland.

U.S. Fish and Wildlife Service (USFWS). 2004. 90-day finding on a petition to list three species of lampreys as threatened or endangered, Notice of Petition Finding. Federal Register 69:270(December 27, 2004):77158-77167.

Figures



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Source:
Map created with Topo! National Geographic.

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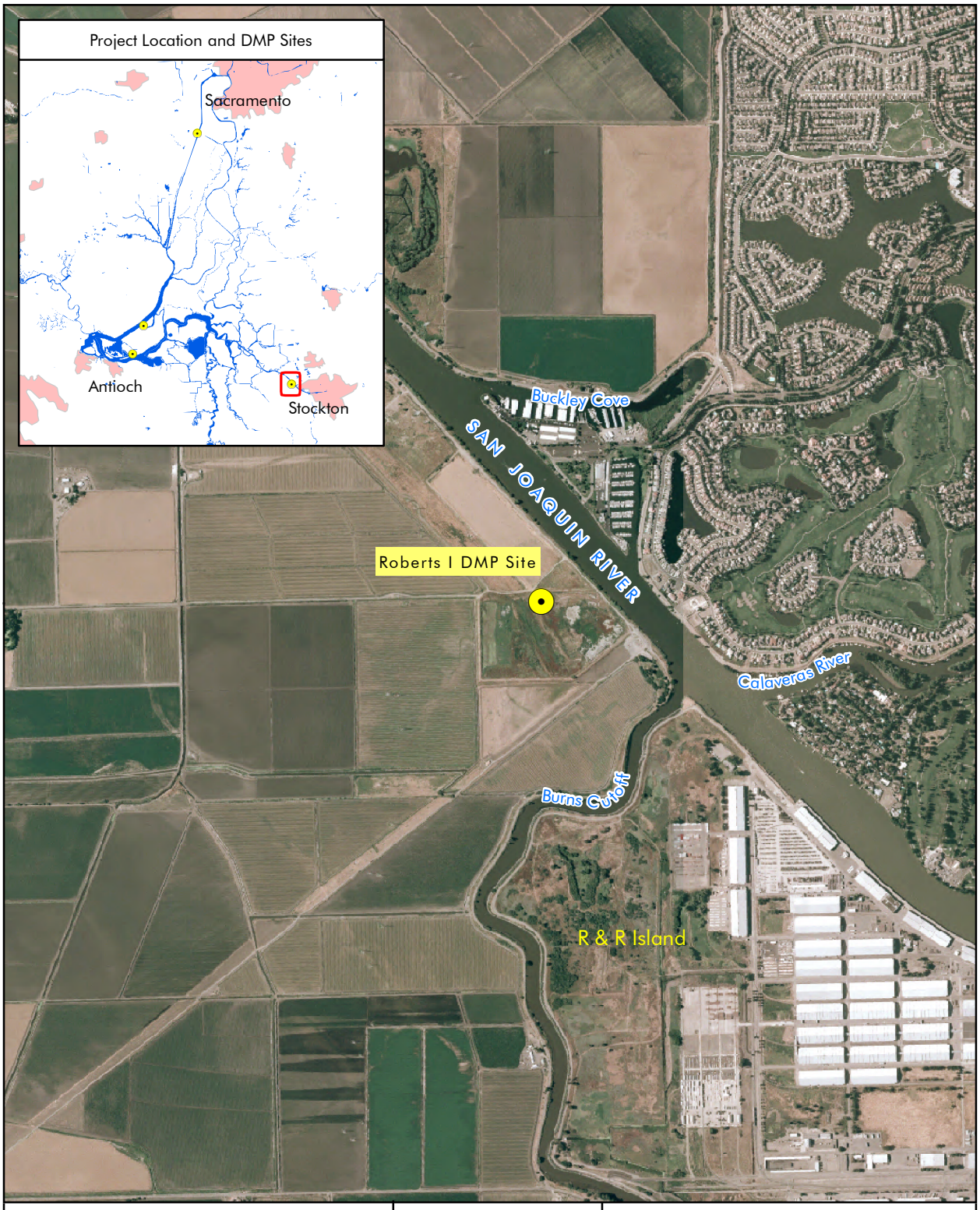
Figure 1. Project Area Map, Dredge Reaches, and DMP Sites



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NORTH

Source:
Aerial imagery available online [http://gdw.apfo.usda.gov].
Accessed January 2008.

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Figure 2. Dredged Material Placement Site Roberts I
RM (39.32 - 39.73)

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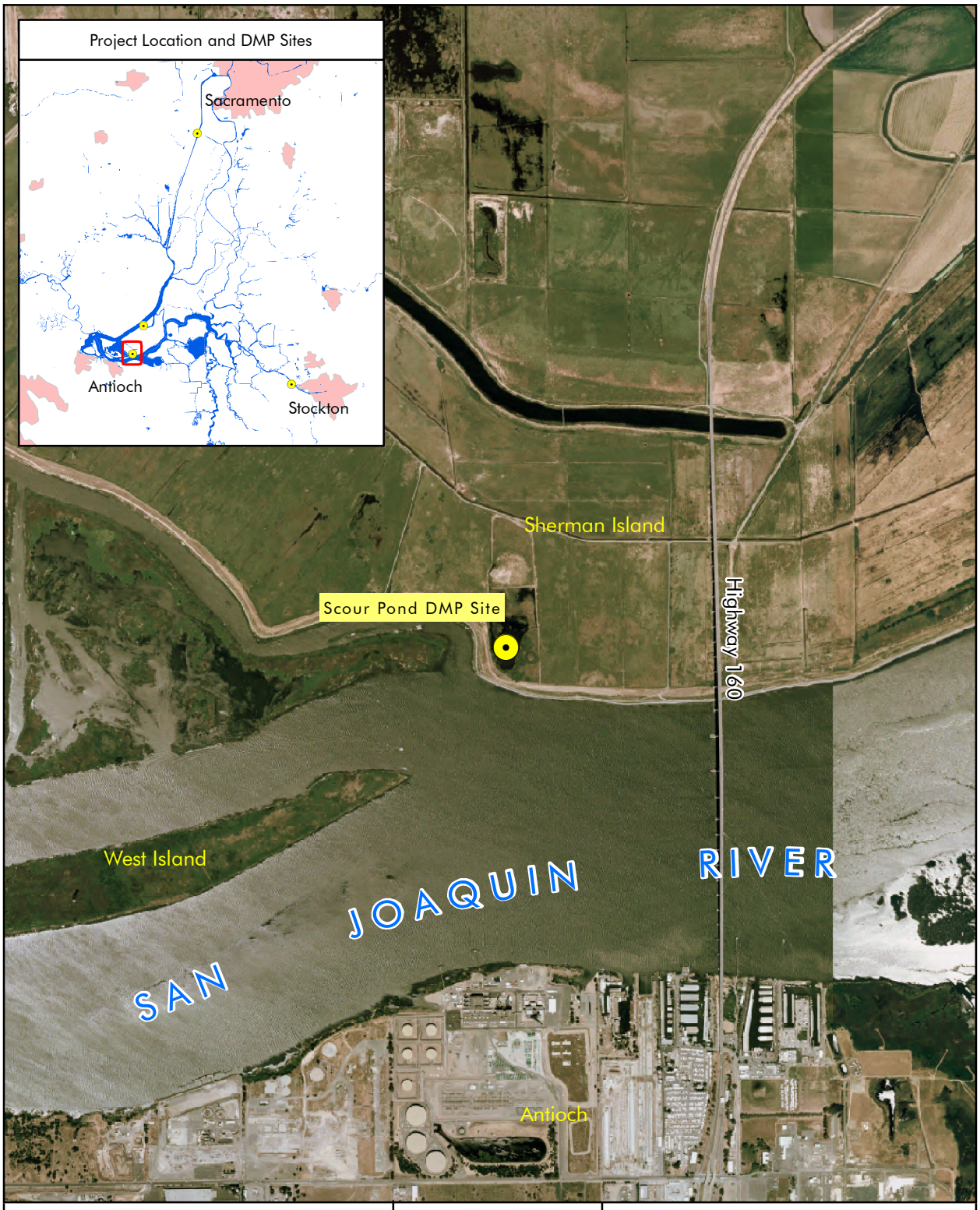

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Source:
Aerial imagery available online [http://gdw.apfo.usda.gov].
Accessed January 2008.

SWCA ENVIRONMENTAL CONSULTANTS

Stockton-Sacramento Deepwater Shipping Channel Maintenance Dredging Program
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Figure 3. Dredged Material Placement Site
Scour Pond
RM (5.49 - 5.66)

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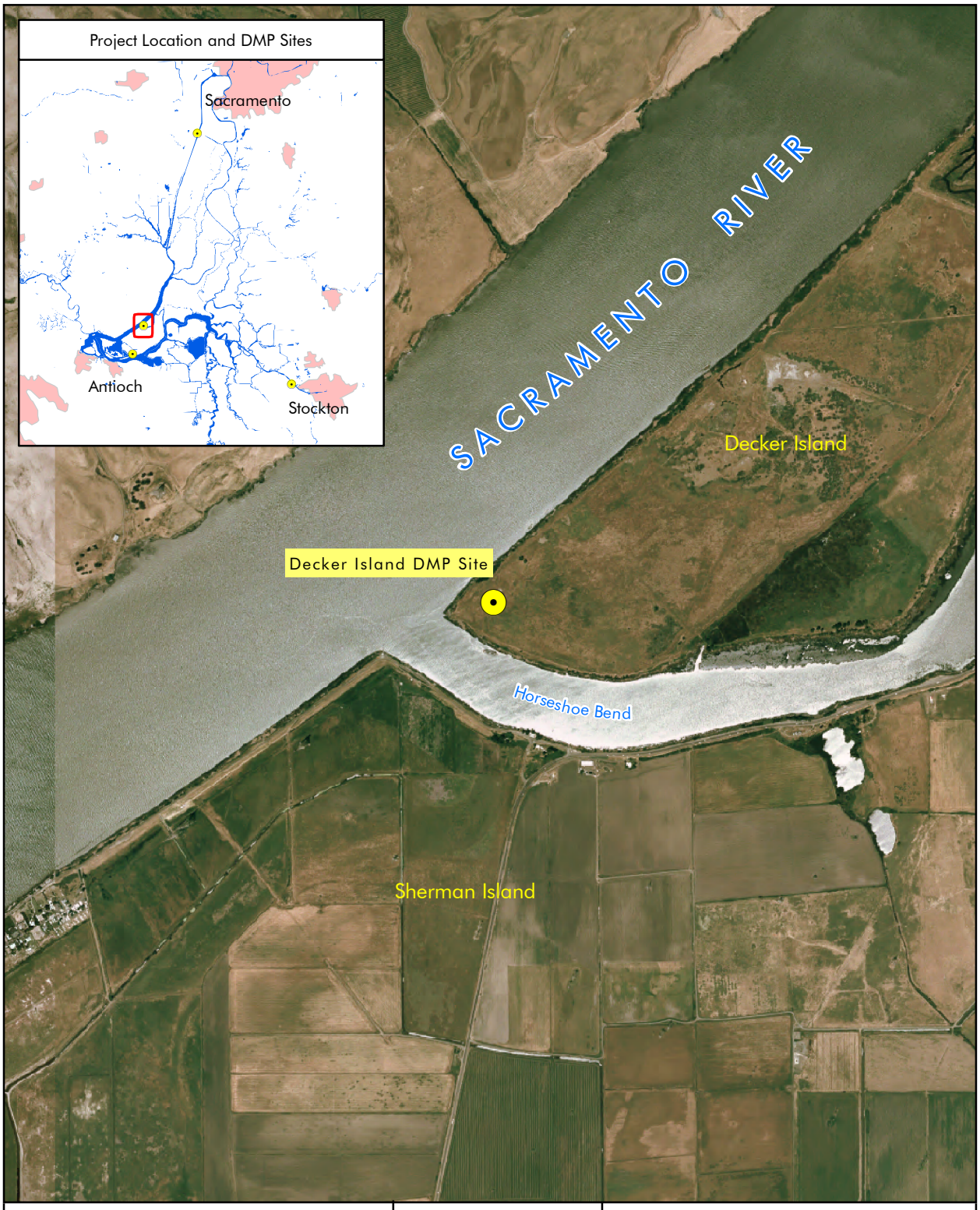

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Source:
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Accessed January 2008.

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2007 Fish Monitoring Report

Figure 4. Dredged Material Placement Site
Decker Island
RM (5.68 - 5.70)

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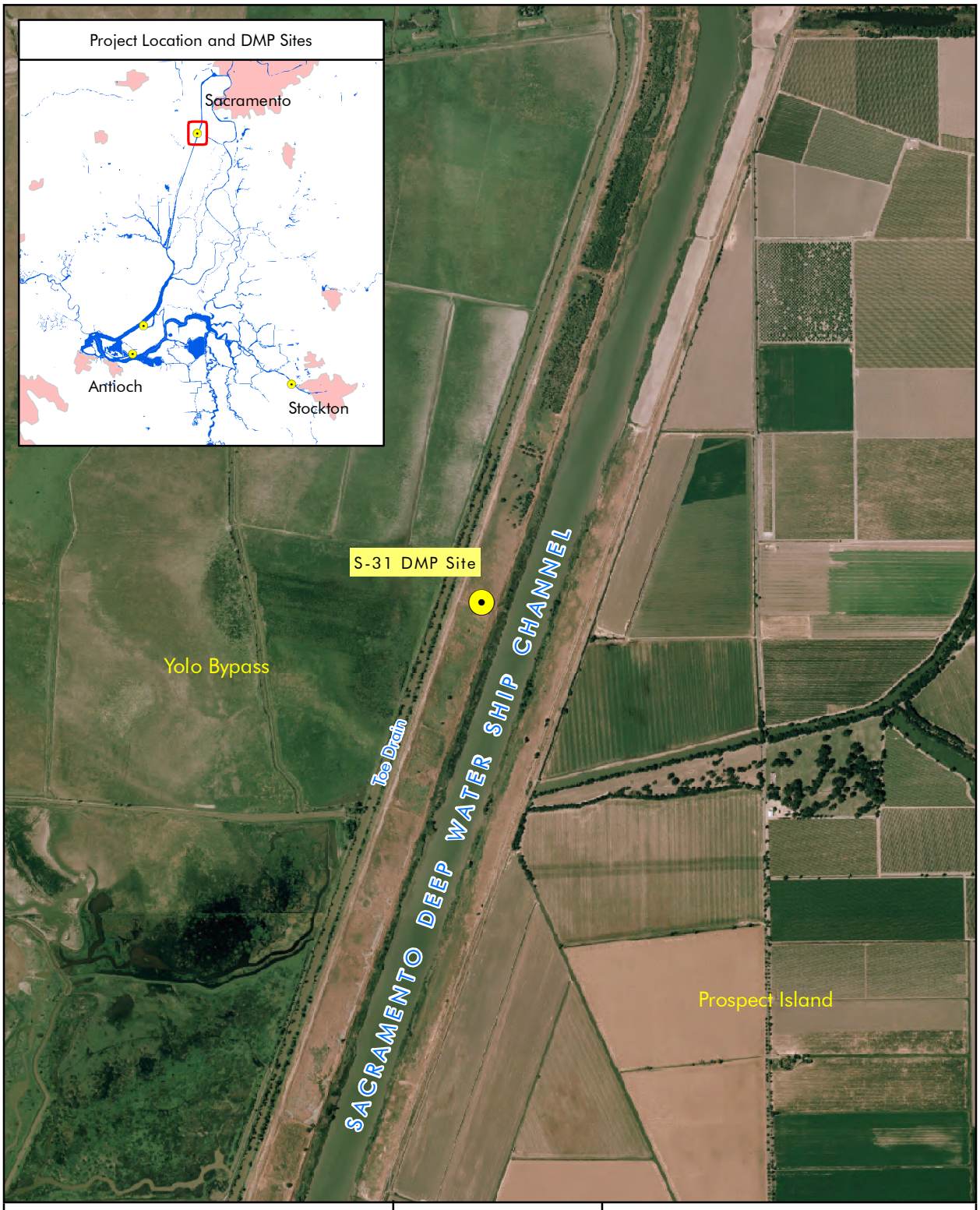

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Source:
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Accessed January 2008.

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Figure 5. Dredged Material Placement Site
S-31
RM (33.86 - 34.81)

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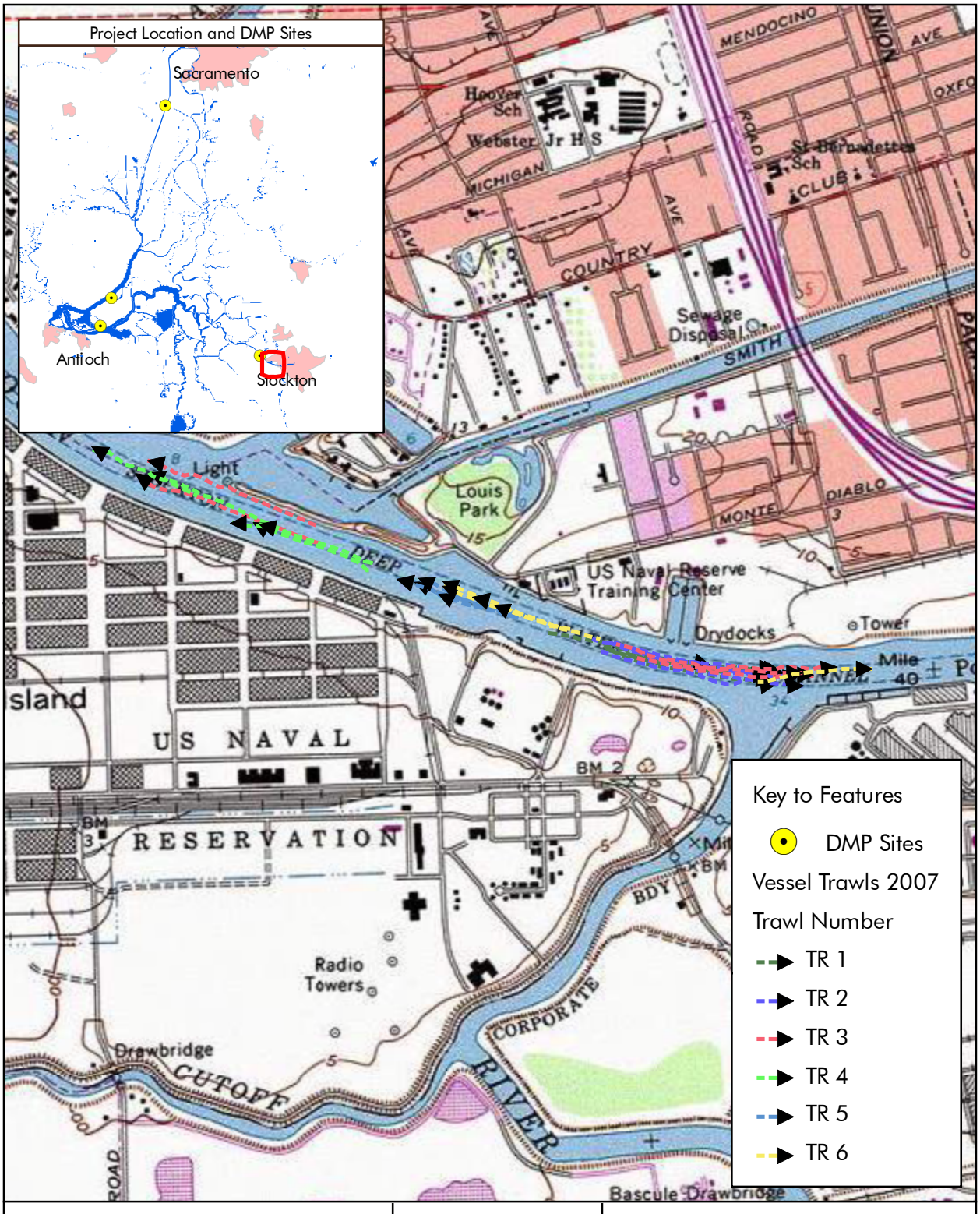
Project Location and DMP Sites
Sacramento
Antioch
Stockton
Key to Features
DMP Sites
Vessel Trawls 2007
Trawl Number
TR 1
TR 2
TR 3
TR 4
TR 5
TR 6
0 250 500 1000 1500 Feet
NORTH
Source:
Map created with Topo!© National Geographic.
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Stockton-Sacramento Deep Water Ship Channel Maintenance Dredging Program
2007 Fish Monitoring Report
Figure 6. Trawl Survey Locations in Port of Stockton - Rough & Ready Island Reach SCC (RM 39 - 40)
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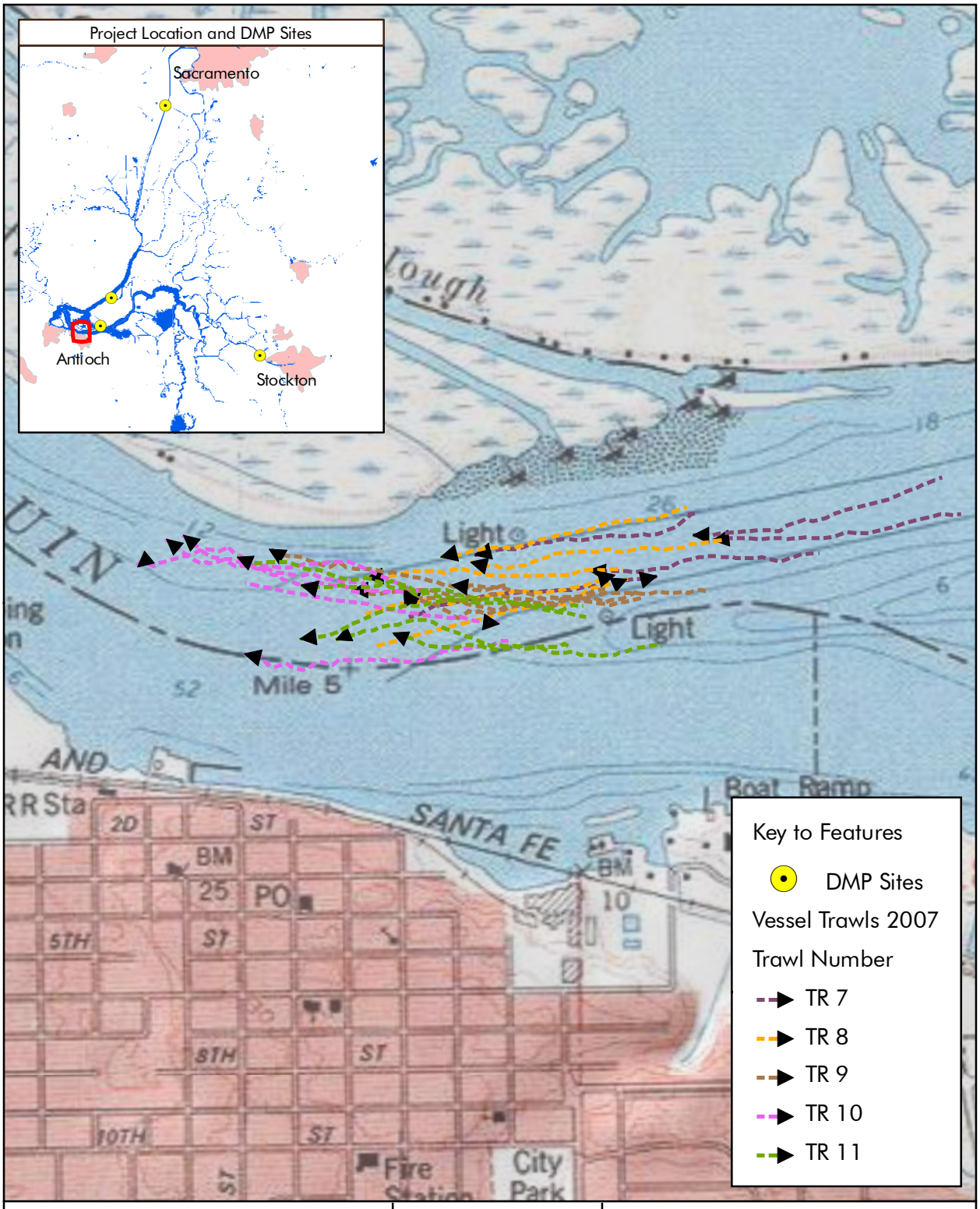

Source:
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Figure 7. Trawl Survey Locations in Antioch - West Island Reach SCC (RM 5 - 6)

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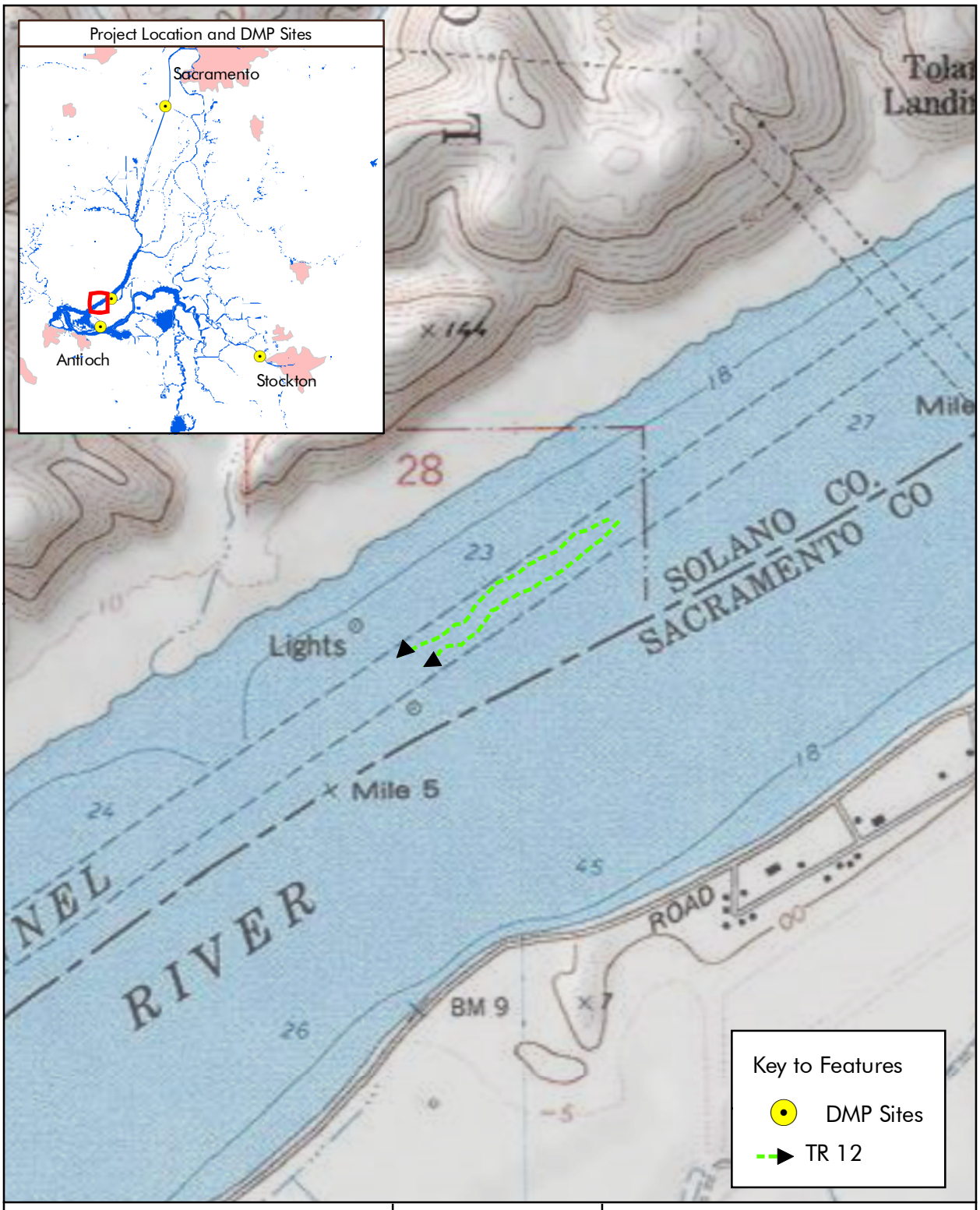

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Source:
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Figure 8. Trawl Survey Locations in Natural Channel - Sacramento River Reach SRCS (RM 5.5 - 6)

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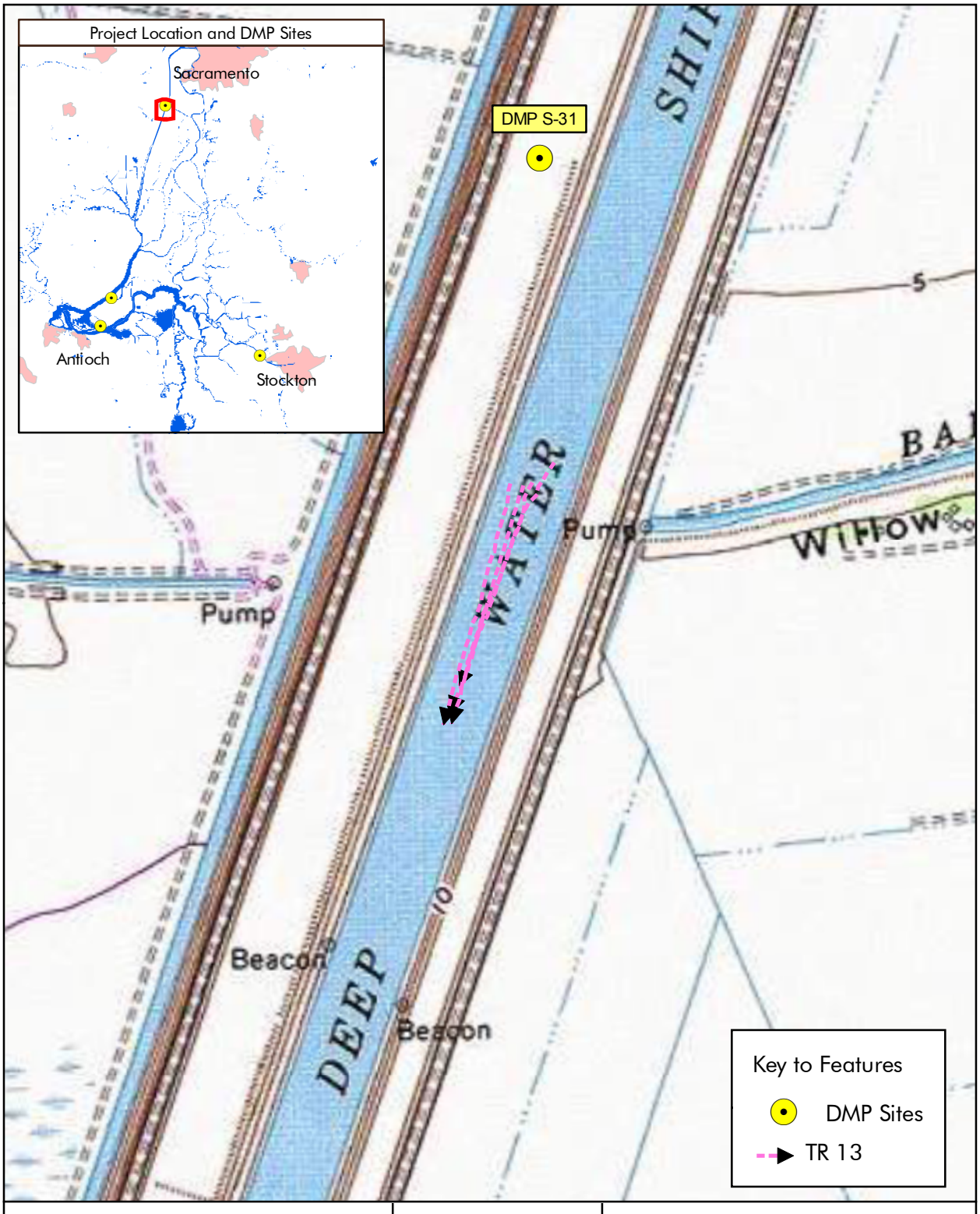

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Source:
Map created with Topo!© National Geographic.

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Figure 9. Trawl Survey Locations in the Man-made Channel, Port of Sacramento Reach SRCS (RM 33.5 - 40)

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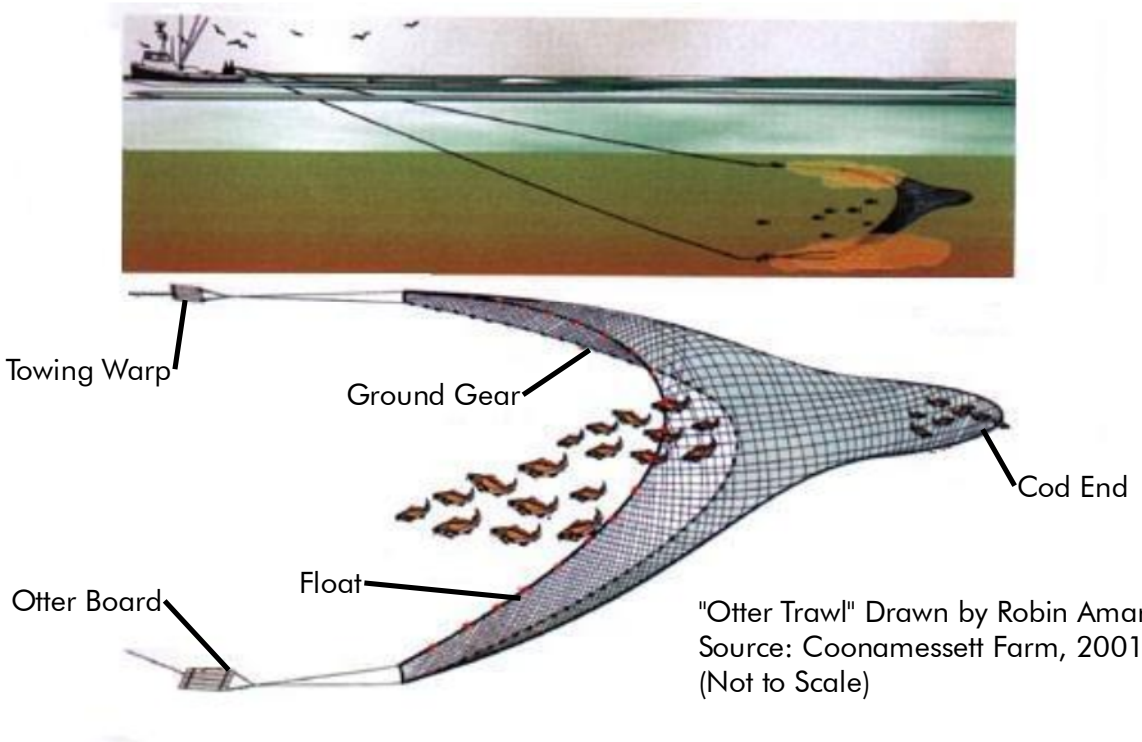

"Otter Trawl" Drawn by Robin Amaral
Source: Coonamessett Farm, 2001.
(Not to Scale)

Stockton-Sacramento Deep Water Ship Channel Maintenance Dredging Program 2007 Fish Monitoring Report	SWCA ENVIRONMENTAL CONSULTANTS	Figure 10. Otter Trawl Diagram

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Stockton-Sacramento Deep Water Ship Channel Maintenance Dredging Program 2007 Fish Monitoring Report	SWCA ENVIRONMENTAL CONSULTANTS	Figure 11. Trawl Vessel RV Karen M

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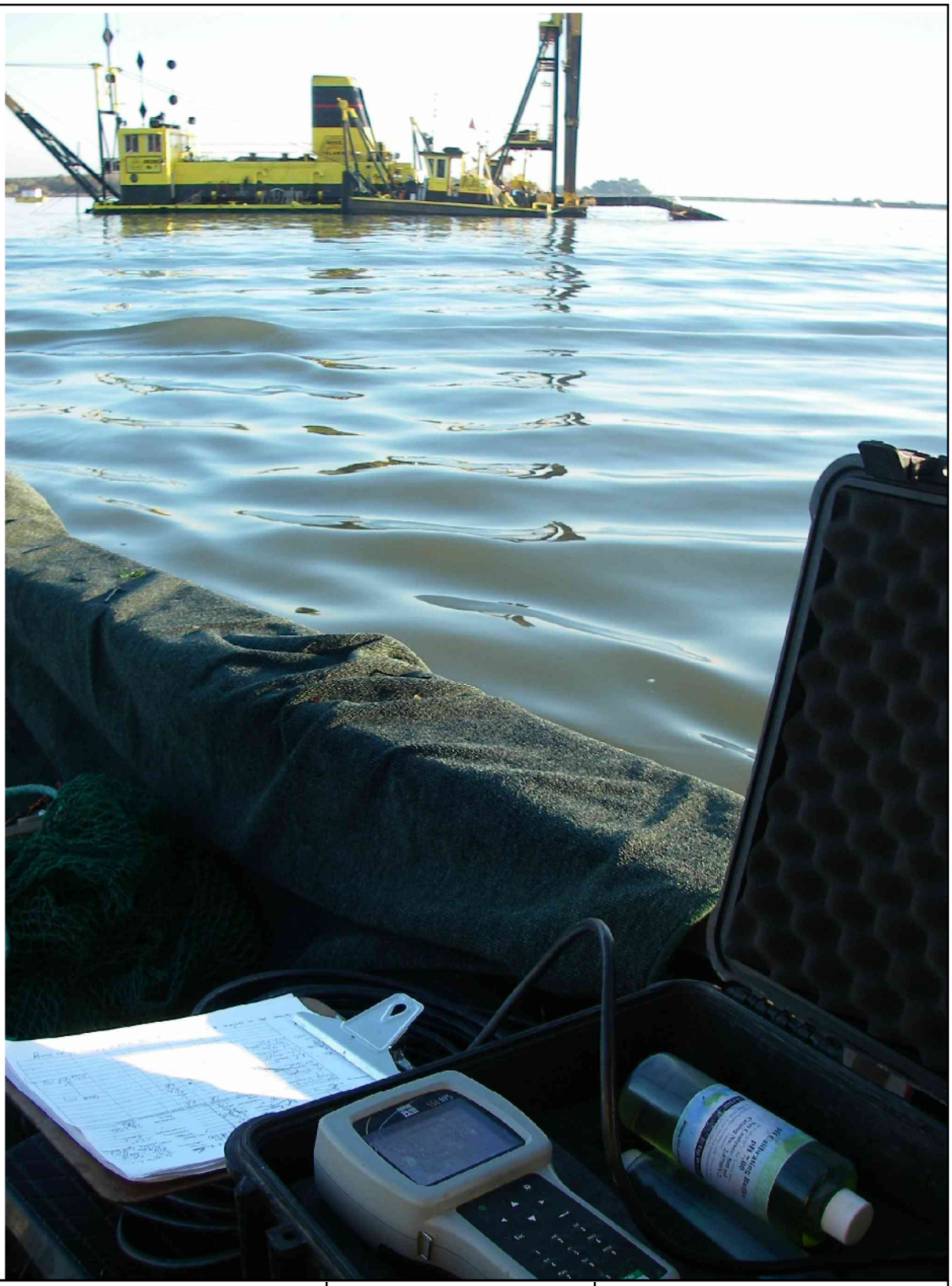

Stockton-Sacramento Deep Water Ship Channel Maintenance Dredging Program 2007 Fish Monitoring Report

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Figure 12. Water Quality Monitoring (YSI-556/MPS) During Fish Community Sampling RISG Dredge No. 7 in the Background

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Figure 13. Entrainment Sampling Cell
Roberts I DMP Site

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Stockton-Sacramento Deep Water Ship Channel Maintenance Dredging Program 2007 Fish Monitoring Report	SWCA ENVIRONMENTAL CONSULTANTS	Figure 14. Discharge Pipeline Splitter Valve at Roberts I DMP Site

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Figure 15. Entrainment Net at Roberts I DMP Stie

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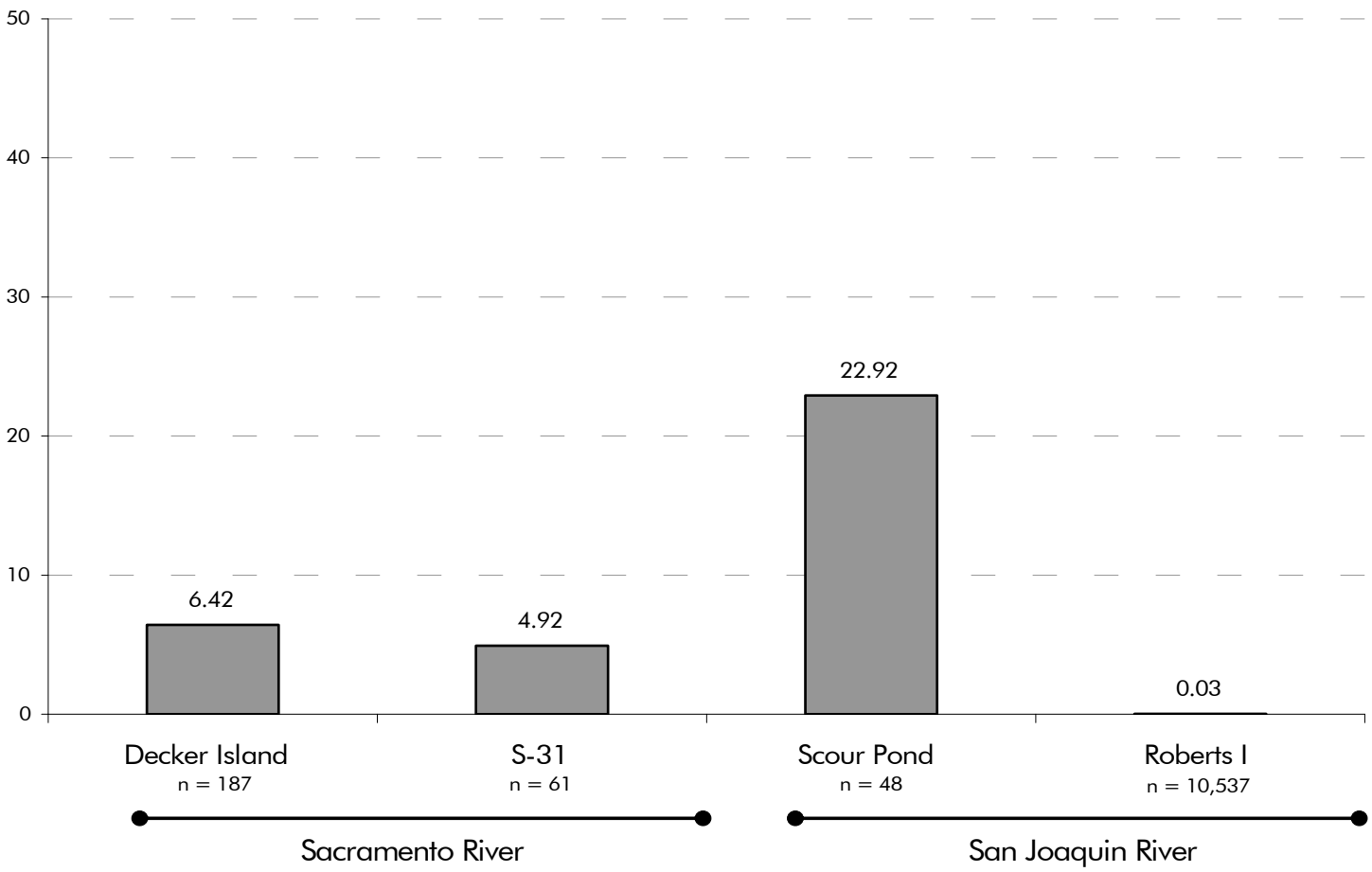

Stockton-Sacramento Deep Water Ship Channel Maintenance Dredging Program
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Figure 16. Percent Native Fish Collected at Each Fish Community Monitoring Location

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Figure 17. Entrainment Collection Screen System

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2007 Fish Monitoring Report

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Figure 18. Uplifted Floor of Sampling Cell at Scour Pond DMP Site, November 27, 2007

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Appendices

A Special Status Species Life History Information

B Water Quality Data

C Data Collection Forms

D Delta Smelt Catch Data

Appendix A Special Status Species Life History Information

Appendix A. Special Status Species Life History Information

Designated Critical Habitat

The designated critical habitat of Sacramento River winter-run Chinook salmon occurs at the origin of the SRSC adjacent to Kimball, Browns, and Winter Islands near RM 4 of the San Joaquin River and is inclusive of the aquatic habitat below the ordinary high water mark surrounding these islands. The winter-run Chinook ESU has designated critical habitat in the SRSC beginning at the Chipps Island, the western margin of the Sacramento-San Joaquin Delta. Designated critical habitat for Central Valley spring-run Chinook salmon borders the northern edge of the San Joaquin River from the confluence of the Mokelumne River west to the boundaries of Suisun Bay and the Delta hydrologic sub units at approximately RM 4 of the San Joaquin River. This includes the waters of Three Mile Slough and New York Slough. Critical habitat for CV Chinook salmon includes the Sacramento River from Keswick Dam in Shasta County through the San Francisco Bay. Individuals of both Chinook salmon Evolutionarily Significant Units (ESUs) can occupy waters within the SSC and SRSC action area. Designated critical habitat for the Central Valley steelhead ESU occurs along the entire length of the SSC and SRSC below the ordinary high water mark. The delta smelt has designated critical habitat that includes the action area of the project. The recently listed Southern Distinct Population Segment (DPS) of green sturgeon's critical habitat designation is not yet proposed. The longfin smelt was petitioned for listing under the ESA and CESA early in 2008. Other key species of interest that are at least seasonally present in the action area include: delta smelt, Sacramento splittail, Pacific and river lamprey.

Sacramento River winter-run Chinook salmon (*Oncorhynchus tshawytscha*)

ESA status: Endangered, critical habitat designated
California status: Endangered
Sources: CalFed 2005; Fry 1961, 1973; Hallock and Fry 1967; Hallock et al. 1970; Miller and Lea 1972; Moyle 1976; Sasaki 1966; Wang 1986

Use of project area waters by this ESU of Chinook salmon is primarily for adult spawning migrations, and juvenile rearing and outmigrations. Winter-run Chinook adults migrate upstream from December to July with spawning in accessible upper reaches of the Sacramento River basin occurring from April through July.

Chinook alevins have been collected from Suisun Bay in January and February. Larger parr-juveniles have been found from April to June. Juvenile life stages are commonly found inshore, in shallow water and throughout estuarine habitat. Some Chinook salmon delay their downstream migration until the early smolt stage. Juvenile outmigration peaks from May to June. Juvenile Chinook salmon feed primarily on various aquatic and terrestrial insects, crustaceans, chironomid larvae and pupae, and caddisflies when they are in fresh water. When found in saline waters, the Chinook smolt diet changes to mainly *Neomysis spp*., *Gammarus spp*., and *Crangon spp*. Juvenile salmon are prey for many animals, including birds and other fishes.

Central Valley spring-run Chinook salmon (*O. tshawytscha*)
ESA status: Threatened, critical habitat designated
California status: Threatened
Sources: CalFed 2005; Fry 1961, 1973; Hallock and Fry 1967; Hallock et al. 1970; Miller and Lea 1972; Moyle 1976; Sasaki 1966; Skinner 1972; Wang 1986

Uses of the project areas by spring-run Chinook salmon are of the same types as described for the winter-run ESU. Spawning migration timing differs with spring-run Chinook moving upstream from April to October, and spawning from August through October. Juvenile usage in the areas of concern is similar to that described for winter-run Chinook.

Central Valley steelhead (*O. mykiss*)
ESA Status: Threatened, critical habitat designated.
Sources: CalFed 2005; Hallock et al. 1970; Hallock and Fry 1967; Moyle 1976; Wang 1986

After an ocean residence of 2–3 years, anadromous adults of the Central Valley steelhead ESU make their upstream migrations beginning in July (peaking in September and October), and spawn from December through April. Steelhead primarily use the project areas as a migration corridor, with some juvenile rearing overlapping with their smoltification and outmigrations. Spawning and incubation, along with the majority of rearing, occurs farther upstream than for Chinook salmon. Juveniles feed on diverse aquatic and terrestrial insects and other small invertebrates, primarily occupying the water column and near surface when over deeper waters. Though juvenile Central Valley steelhead outmigrate to the ocean from December through August, most are found migrating through the project areas in spring.

Delta smelt (*Hypomesus transpacificus*)
ESA status: Threatened, critical habitat designated
California status: Threatened
Sources: Bennett 2005; CalFed 2005; Ganssle 1966; Herald 1961; McAllister 1963; Messersmith 1966; Moyle 1976, 2002; Moyle et al.1995; Radtke 1966; Wang 1986

The endemic delta smelt is a euryhaline fish that ranges from the lower reaches of the Sacramento and San Joaquin Rivers, through the Delta, and into Suisun Bay. They have been found in the SRSC and SSC in low abundance. The abundance of this fish is closely associated with salinities between 0 and 7 practical salinity units (psu), with an upper tolerance of 19 psu and a significant preference centered near or upstream of the 2 psu zone. The delta smelt is not present in waters over 25˚C, and is rarely found in water temperatures above 22˚C.

Delta smelt spawn in deadened sloughs, near-inshore areas of the Delta, and shallow fresh water channels of the Delta and Suisun Bay. In the fall, prior to spawning, delta smelt congregate in upper Suisun Bay and the lower reaches of the Delta. The spawning period is estimated to be from February to June. Eggs are demersal and adhesive. The delta smelt may prefer spawning over vegetation, if present, but often deposit their eggs over submerged tree branches and stems, or in open water over sandy and rocky substrate, and may even use the shallower areas of Delta levees. Newly hatched larvae float near the surface of the water column in both inshore and channel areas. Larval movements are variable and follow tides and discharge. Data from trawl and trap net catches show that larger juveniles and adults are abundant during spring and summer

in Suisun Bay and the Delta. The smelt swim in large schools. Seasonal migrations occur within a short section of the upper estuary. Juvenile smelt move downstream to San Pablo Bay and Carquinez Strait before turning back to Suisun Bay or upstream sloughs for spawning. During average and high outflow years, delta smelt congregate from upper Suisun Bay to the Sacramento River near Decker Island. During low outflow and drought years their pre-spawning congregations are centered in the channel of the Sacramento River and are rarely further downstream in Suisun Bay. Juvenile delta smelt primarily eat planktonic crustaceans, small insect larvae, and mysid shrimp. Delta smelt mature quickly, with most adults dying after spawning their first year. The few adults that survive to their second year have vastly higher fecundity.

Green sturgeon (*Acipenser medirostrus*)

ESA status: Threatened (June 6, 2006), Southern DPS
California Status: Threatened
Sources: Adams et al. 2002; CalFed 2005; Fry 1973; Radtke 1966; Wang 1986

The little-studied green sturgeon occurs in the Sacramento and San Joaquin Rivers and the Delta. The Southern DPS consists of fish in the San Francisco Bay and Delta that spawn in the Sacramento River basin. A number of presumed spawning populations of green sturgeon have been lost since the 1960s and 1970s — from the Eel River, South Fork Trinity River, and San Joaquin River.

Green sturgeon inhabit near shore oceanic waters, bays, and estuaries. Early life-history stages (<4 years old) reside in fresh water, with adults returning to freshwater to spawn when they are more than 15 years of age and more than 130 cm in size. Spawning occurs in spring and summer in reported locations of the upper Sacramento River and tributaries to the Sacramento River such as the Feather, Yuba, and American Rivers. Developmental biology of this species is essentially unstudied. Little is known about the age and growth of the green sturgeon but juveniles of two apparent size groups (fork length range of 20–58 cm) have been collected in the Sacramento and San Joaquin Rivers and Suisun Bay. The diet of juvenile sturgeon consists mostly of amphipods and mysid shrimps in the Delta.

Estuarine Composite Species with Essential Fish Habitat

The following fishes, though not listed under ESA, are included here as they are part of the estuarine composite species with essential fish habitat (EFH) protections under the Magnuson-Stevens Fishery Conservation and Management Act (MSA); and are the most likely of their composite to utilize the upper portions of the Delta affected by the project. These species have also been included in the EFH assessment for the Stockton SSC Maintenance Dredging and Levee Stabilization Project (NMFS 2006a).

Starry flounder (*Platyichthys stellatus*)

ESA status: None,
MSA species, estuarine composite EFH
Sources: CalFed 2005; Fry 1973; PFMC 1998; McCain et al. 2005; NMFS 2006; Radtke 1966; Wang 1986; Wydoski and Whitney 2005

The starry flounder is a marine flatfish with both eyes on the same side of its head. Starry flounder are white on the ventral side and have conspicuous ventral black bands on their dorsal and anal fins. They have a tolerance for a variety of salinities and are found along the coast and in estuaries and lower rivers. Juveniles and adults are demersal and prefer sandy to muddy substrates. Starry flounder have been recorded at a depth of 900 feet. Studies have shown starry flounder can move a considerable distance between estuarine and ocean habitats (440 nautical miles). Juveniles and sub-adult life stages extend the upstream freshwater use to the Bay and lower reaches of the Delta. Adults may reach a length of 3 feet and a weight of 20 pounds. Females grow faster than males and are heavier at a given length. Males mature at 2 years and females at 3 years. They spawn in winter with water temperatures averaging 11°C (51.8°F). Eggs and larvae are epipelagic and occur near the surface over water that ranges from 20 to 70 m (65 to 30 feet) deep. They feed on copepods, amphipods and annelid worms and, as adults, include crabs, mollusks, and echinoderms. Feeding slows in winter as temperatures drop. Starry flounder provide both recreational and commercial fisheries. Juveniles may occur on the bottom in the lower portion of the SSC and SRSC.

English Sole (*Pleuronectes vetulus*)
ESA status: None
MSA species, estuarine composite EFH
Sources: McCain et al. 2005; NMFS 2006; PFMC 1998; Wang 1986; Wydoski and Whitney 2005

English sole are an inner shelf-mesobenthal flatfish species that ranges from Mexico to Alaska and is abundant in the San Francisco Bay estuary system. Adults generally spawn during late fall to early spring in inshore waters over soft mud bottoms to 70 m (230 feet). Epipelagic larvae are carried by wind and near-surface tidal currents into bays and estuaries where they metamorphose to demersal juveniles. Juveniles rear in the inshore areas and in the bays and estuaries moving offshore as they age. Juvenile English sole seek food and shelter in shallow near-shore, inter-tidal, and estuarine waters. Prey items include small crustaceans (e.g., copepods and amphipods) and polychaete worms. English sole provide commercial and recreational fisheries. Bottom-oriented juveniles may occur in the lower portion of the SSC and SRSC.

Species of Special Concern

The following fishes, though not listed under ESA, nor protected under the MSA, have been listed or petitioned for listing in the recent past, and are presently considered species of special concern by the State of California . Information on these species is being sought by NMFS and USFWS. This background information is provided since these fish were encountered by the fish community and or entrainment monitoring conducted in 2007.

Lamprey, Pacific and river (*Lampetra tridentata* and *L. ayresii*, respectively)
ESA status: Not warranted (decision 2005)
California Status: Watch list – river lamprey
Sources: Kostow 2002; Moyle 2002; Wydoski and Whitney 2005

Anadromous Pacific and river lamprey co-occur in SSC and SRSC. Little is known about population trends for the river lamprey at the southern end of its distribution. Most records of this

species in California are from the Feather River and the lower Sacramento-San Joaquin River system. Both species are lumped together here due to the difficulty in discriminating between the two species at the life stage encountered during the 2006 monitoring effort. Adult lamprey of both species migrate upstream in early spring and spawn during late spring and early summer in gravel substrates upstream of the Delta and lower Sacramento-San Joaquin river system. Adult Pacific lamprey generally hibernate for a year in freshwater after their initial spawning migration. During this time they hide in substrates near their spawning area and do not feed prior to spawning the following year. The filter-feeding ammocoetes develop for years burrowed into soft substrates in freshwater. Lamprey encountered during the 2006 and 2007 sampling were at lengths and displayed characteristics of the macropthalmic life-history stage. Macropthalmia are transforming or newly transformed adults that undergo physiological and morphological changes that allow them to shift from a freshwater to saltwater environment. River lamprey begin their transformation from ammocoete to adult form at about 120 mm total length, Pacific lamprey at approximately 140 to 160 mm. Metamorphosis lasts from 9 to 10 months in river lamprey, the longest known in this family of fishes. During this time, both lamprey species congregate close to the saltwater-freshwater interface in estuaries.

Macropthalmia have large, well-developed eyes, and their body coloration is silvery on the lateral and ventral aspects with blue to dark gray coloration along the dorsal aspect. During this stage, mouth dentition forms adult teeth used to prey or parasitize other fishes. It is noted in Pacific lamprey that full development of the middle tooth of the supraoral lamina develops during the transforming adult stage, complicating field identification at the macropthalmic stage. Following complete transformation, macropthalmia migrate downstream to the ocean, likely in the winter and spring, when outflow is high. River lamprey may spend their entire life history in freshwater and are more parasitic in freshwater than Pacific lamprey. Adult river lamprey spend less time in the ocean, migrating back to freshwater in the fall and winter. Adult Pacific lamprey generally migrate from stream to spawning areas in winter and spring.

The vouchered and preserved lamprey specimens from 2006 and 2007 were macropthalmia. Identification for these specimens was confirmed by USFWS and Western Fishes taxonomic experts as *Lampertra ayresii*(river lamprey). Newly developed field identification techniques based on mitochondrial DNA analysis will aid in positive field identification of macropthalmia and ammocoetes collected in future monitoring.

Sacramento splittail (*Pogonichthys macrolepidotus*)

ESA status: species of concern (2003), formerly listed as threatened (1999)
Sources: Moyle 2002; USFWS 2003; Wang 1986

The Sacramento splittail is found only in California's Sacramento-San Joaquin Delta, streams of the Central Valley, and the Napa and Petaluma rivers. This native minnow (family Cyprinidae) received protection as a threatened species in February 1999 (64 FR 5963). The USFWS delisted the splittail on September 22, 2003 (68 FR 55140). The relatively long-lived splittail (up to 9 years) can grow up to 400 mm long. The upper part of the tail is enlarged and appears to be split, hence its common name. Historically, the splittail occurred in the Sacramento River as far north as Redding, as far south in the San Joaquin River as Friant Dam near Fresno, and as far west as the Petaluma River. They are adapted to living in estuarine systems and are tolerant of salinities from

10 to 18 ppt. Young-of-year and yearling splittail are most abundant in shallow water and are able to swim in strong current. Adults exhibit slow upstream movement during winter and spring to forage and spawn in flooded areas. Their small, subterminal mouth with barbels and pharyngeal teeth, along with the large upper tail lobe, reflect their preference for feeding on bottom invertebrates in low to moderate current strength. Splittail reach adulthood at approximately 170 mm in their second year. Splittail populations have declined as dams and diversions have prevented fish from access to upstream areas of large rivers. Reclamation and modification of flood basins also have reduced the species' spawning grounds.

Longfin smelt *(Spirinchus thaleichthys)*

ESA status: none, petitioned for listing
California status: petitioned for listing, State Candidate
Sources: CDFG 2000, 2007; Moyle 2002; Moyle et al. 1995

Longfin smelt are a euryhaline and anadromous fish that was historically one of the most abundant fish in the San Francisco estuary and the Delta, but have since declined precipitously there and elsewhere in its range. Longfin smelt can be distinguished from other California smelts by their long pectoral fins, which reach or nearly reach the base of their pelvic fins. These fish reach a maximum size of about 150 mm (total length) and mature near the end of their second year. As they mature in the fall, adults found throughout San Francisco Bay migrate to brackish or freshwater in Suisun Bay, Montezuma Slough, and the lower reaches of the Sacramento and San Joaquin Rivers. They congregate for spawning at the upper end of Suisun Bay and in the lower and middle Delta, especially in the Sacramento River channel and adjacent sloughs. In April and May, juveniles are believed to migrate downstream to San Pablo Bay; juvenile longfin smelt are collected throughout the Bay during the late spring, summer, and fall and occasionally venture into the Gulf of the Farallones. Juveniles tend to inhabit the middle and lower portions of the water column. Their decline is likely due to multiple factors including: reduction in outflows, entrainment losses to water diversions, climactic variation, toxic substances, predation and introduced species. The USFWS was petitioned to list longfin smelt as endangered in 1992. The petition was denied in 1993. Longfin smelt were again petitioned for federal listing on August 8, 2007, and outcome of the current listing process is in process.

References

Adams, P. B., C. B. Grimes, J. E. Hightower, S. T. Lindley, and M. L. Moser. 2002. Status review for North American green sturgeon, *Acipenser medirostris*. National Marine Fisheries Service, Southwest Fisheries Science Center, Santa Cruz, California.

Bennett, W. A. 2002. Critical assessment of the delta smelt population in the San Francisco estuary, California. California Bay Delta Authority and John Muir Institute for the Environment, University of California, Davis.

CalFed (US Bureau of Reclamation and California Department of Water Resources). 2005. South delta improvements program draft environmental impact statement/environmental impact report. October 2005.

California Department of Fish and Game (CDFG). 2000. Fish species of special concern in California, Bay-Delta monitoring, San Francisco Bay monitoring, fish, longfin smelt. California Department of Fish and Game, Central Valley Bay-Delta Branch, 2000.

———. 2007. Longfin smelt in San Francisco Bay. California Department of Fish and Game, Bay Delta Region. Available: http://www.delta.dfg.ca.gov/baydelta/monitoring/lf.asp. (August 10, 2007).

Fry, D. H., Jr. 1961. King salmon spawning stocks of the California Central Valley, 1940-1959. California Fish and Game 47(1):55–71.

———. 1973. Anadromous fishes of California. California Department of Fish and Game, Sacramento.

Ganssle, D. 1966. Fishes and decapods of San Pablo and Suisun bays. Pages 64–94 *in D.* W. Kelley, compiler. Ecological studies of the Sacramento-San Joaquin estuary, part 1. California Department of Fish and Game, Fish Bulletin 133, Sacramento.

Hallock, R. J. and D. H. Fry, Jr. 1967. Five species of salmon Oncorphynchus, in the Sacramento River, California California Fish and Game 53(1): 5–22.

Hallock, R. J., R. F. Elwell, and D. H. Fry, Jr. 1970. Migrations of adult king salmon *Oncorhynchus tshawytscha* in the San Joaquin Delta. California Department of Fish and Game, Fish Bulletin 151, Sacramento.

Herald, E. S. 1961. Living fishes of the world. Doubleday, New York.

Kostow, K. 2002. Oregon lampreys: natural history status and problem analysis. Oregon Department of Fish and Wildlife, Portland.

McCain, B. B., Miller, S .D., and W. W. Wakefield II. 2005 life history, geographical distribution, and habitat associations of 82 West Coast groundfish species: a literature review, draft January 2005 *in* Appendix H of Essential Fish Habitat Designation and Minimization of Adverse Impacts Draft Environmental Impact Statement, Vol. 4, February 2005. National Marine Fisheries Service, Northwest Fisheries Science Center, Seattle.

McAllister, D. E. 1963. A revision of the smelt family, Osmeridae. National Museum of Canada, Bulletin 191, Ottawa.

Messersmith, J. D. 1966. Fishes collected in Carquinez Strait in 1961–1962. Pages 57–63 *in* D. W. Kelley, compiler. Ecological studies of the Sacramento-San Joaquin estuary, part I. California Department of Fish and Game, Fish Bulletin 133, Sacramento.

Miller, D. J., and R. N. Lea. 1972 (1976). Guide to the coastal marine fishes of California. California Department of Fish and Game, Fish Bulletin 157, Sacramento.

Moyle, P. B. 1976. Inland fishes of California. University of California Press, Berkeley.

———. Inland fishes of California (revised and expanded). University of California Press, Berkeley.

Moyle, P.B., R. M. Yoshiyama, J. E. Williams, and E. D. Wikramanayake. 1995. Fish species of special concern in California. Final Report for Contract No. 21281F to State of California, Resources Agency, Department of Fish and Game, Inland Fisheries Division, Rancho Cordova, June 1995.

National Marine Fisheries Service (NMFS). 2006. Biological and conference opinion for the Stockton deep water ship channel maintenance dredging and levee stabilization project. SWR-2004-SA-9121:JSS, April 4, 2006. Prepared for the U.S. Army Corps of Engineers, Sacramento District.

Pacific Fisheries Management Council (PFMC). 1998. Essential fish habitat – West Coast groundfish. Modified from: Final Environmental Assessment/Regulatory Impact Review for Amendment 11 to the Pacific Coast Groundfish Fishery Management Plan, October 1998. Portland, Oregon. Available: http:/www.pcouncil.org.

Radtke, L. D. 1966. Distribution of smelt, juvenile sturgeon, and starry flounder in the Sacramento-San Joaquin Delta with observations on food of sturgeon. Pages 115–129 *in* J. L. Turner and D. W. Kelley, compilers. Ecological studies of the Sacramento-San Joaquin delta, part II. California Department of Fish and Game, Fish Bulletin 136, Sacramento.

Sasaki, S. 1966. Distribution and food habits of king salmon, *Oncorhynchus tshawytscha*, and steelhead rainbow trout, *Salmo gairdnerii*, in the Sacramento-San Joaquin Delta. Pages 108–114 *in* J. L. Turner and D. W. Kelley, compilers. Ecological studies of the Sacramento-San Joaquin delta, part II. California Department of Fish and Game, Fish Bulletin 136, Sacramento.

Skinner, J. E. 1972. Ecological studies of the Sacramento-San Joaquin Estuary. California Department of Fish and Game, Delta Fish Wildlife Protection Study Report 8, Sacramento.

United States Fish and Wildlife Service (USFWS). 2001. Annual progress report: abundance and survival of juvenile Chinook salmon in the Sacramento-San Joaquin estuary. Stockton, California.

Wang, J. C. S. 1986. Fishes of the Sacramento-San Joaquin estuary and adjacent waters, California: a guide to the early life histories. Interagency Ecological Study Program for the Sacramento-San Joaquin Estuary, Technical Report 9 (FS/B10-4ATR 86-9), Sacramento.

Wydoski R., and R. Whitney. 2003. Inland fishes of Washington. University of Washington Press, Seattle.

Appendix B Water Quality Data

Appendix B. Water Quality Data

2007 Water Quality Monitoring

				Surface Measurements										Near Bottom Measurements										
Survey ID	WQ Location	WQ Date	Secchi Depth (cm)	Time	Depth [m]	Temp [C]	DO [ppm]	DO %	pH	ORP	Cond [µS]	Sal [ppt]	Turb [ntu]	Time	Depth [m]	Temp [C]	DO [ppm]	DO %	pH	ORP	Cond [µS]	Sal [ppt]	Turb [ntu]	Comments
TR1	Roberts I	2-Nov	92	14:37	0.3	17.26	9.39	97.7	7.55	-45.4	435	0.25	8.66	14:41	11	16.46	8.52	87.3	7.44	-38.4	471	0.27		Water quality meter was fully calibrated today. Bottom turbidity sampler not yet available.
TR1	Roberts I	2-Nov		18:07	0.3	16.74	9.06	93.4	7.46	-39.7	451	0.26		18:11	10	16.51	8.54	87.5	7.35	-33.6	446	0.26		Dark; thus no Secchi depth. Bottom turbidity sampler NA.
TR2	Roberts I	5-Nov	88	15:40	0.5	16.83	8.75	90.4	7.61	-51.2	502	0.29	13.08	15:42	11	16.15	8.20	83.5	7.46	-42.3	483	0.28		WQ meter fully calibrated today. Bottom turbidity sampler NA.
TR2	Roberts I	5-Nov		18:04	0.3	18.04	8.59	88.0	7.54	-47.1	479	0.29	10.62	18:08	7	16.38	8.54	87.3	7.51	-45.3	478	0.28		Dark; thus no Secchi depth. Ship "Great Immensity" just passed upstream to turning basin; thus likely a well mixed water column. Bottom turbidity sampler NA.
TR3	Roberts I	7-Nov	77	8:52	0.3	15.6	8.46	85.1	error	-45.9	445	0.26	12.01	8:56	10	15.59	8.21	82.6	7.53	-46.7	443	0.26		Bottom turbidity sampler NA.
TR3	Roberts I	7-Nov	77	12:17	0.3	16.12	8.44	85.7	7.71	-56.8	444	0.26	14.37	12:19	10	15.6	8.06	80.9	7.52	-45.8	440	0.26		Bottom turbidity sampler NA.
TR4	Roberts I	9-Nov	82	13:19	0.3	16.32	9.00	92.4	7.71	-57.2	501	0.29	7.52	13:23	12	15.38	8.51	85.2	7.61	-51.1	493	0.3		Bottom turbidity sampler NA.
TR4	Roberts I	9-Nov	82	16:04	0.3	1607	9.03	91.8	7.46	-42.7	476	0.28	10.50	16:11	12	15.54	8.72	87.6	7.38	-38.1	472	0.28		Bottom turbidity sampler NA.
TR5	Roberts I	11-Nov	62	14:08	0.3	15.78	8.65	87.5	7.5	-45.0	502	0.30	21.46	14:13	12	15.56	8.33	83.8	7.47	-43.1	492	0.29		Bottom turbidity sampler NA.
TR5	Roberts I	11-Nov	42	16:45	0.3	15.75	8.52	85.6	7.45	-42.3	498	0.30	18.06	16:48	7	15.76	8.41	84.9	7.46	-42.5	498	0.3		Bottom turbidity sampler NA. Ship "Moonstar" passed between top and bottom readings.
TR6	Roberts I	13-Nov	63	8:28	0.3	15.32	7.82	78.7	7.5	-44.1	455	0.27	20.33	8:32	12	15.31	7.68	76.8	7.46	-43.2	457	0.27		Near bottom turbidity NA - sampling bottle shipped.
TR6	Roberts I	13-Nov	66	10:52	0.3	15.33	7.98	79.8	7.44	-41.4	447	0.27	17.11	10:57	12	15.2	8.08	80.6	7.43	-41.1	436	0.26		Near bottom turbidity NA - sampling bottle shipped.
TR7	Scour Pond	20-Nov	68	11:58	0.3	15.2	9.50	96.1	7.64	-52.8	3771	2.50	13.10	12:13	10	15.19	9.39	95.5	7.68	-54.8	5323	3.6	24.40	Dredge reach in Nav Chan on NW end of West Island - San Joaquin Light 7.
TR7	Scour Pond	20-Nov	83	14:00	0.3	15.34	9.68	98.4	7.68	-55.7	4415	2.93	13.40	14:04	9	15.2	9.44	96.1	7.67	-54.6	5234	3.55	14.72	Dredge reach in Nav Chan on NW end of West Island - San Joaquin Light 7.
TR8	Scour Pond	21-Nov	78	12:58	0.3	15.09	9.53	96.8	7.71	-56.1	5391	3.67	18.01	13:09	8	15.02	9.47	96.2	7.71	-57.4	5709	3.88	24.96	Dredge reach NNW end of West Island - Lights 7 to 9 San Joaquin River.
TR8	Scour Pond	21-Nov	84	15:06	0.3	15.06	9.69	98.3	7.69	-55.5	5064	3.43	14.95	15:10	9	15	9.62	97.5	7.69	-55.7	5315	3.62	46.93	Dredge reach NNW end of West Island - Lights 7 to 9 San Joaquin River.
TR9	Scour Pond	25-Nov	60	12:29	0.3	13.63	9.49	93.2	7.63	-53.3	4717	3.28	17.57	12:31	11	13.62	9.31	91.9	7.7	-56.1	5881	4.16	38.17	
TR9	Scour Pond	25-Nov	68	14:28	0.3	13.72	9.39	93.6	7.68	-54.9	7463	5.36	23.40	14:31	11	13.71	9.27	92.7	7.66	-54.8	8120	5.89	33.90	
TR10	Scour Pond	27-Nov	92	13:18	0.3	13.31	9.37	90.8	7.62	-50.7	3404	2.35	12.16	13:26	9	13.17	9.24	89.8	7.64	-52.0	4503	3.16	16.16	
TR10	Scour Pond	27-Nov		15:30	0.3	13.4	9.35	92.0	7.63	-52.2	6271	4.49	19.33	15:35	3	13.37	9.21	90.9	7.64	-52.9	6673	4.83	25.11	Secchi depth NA (current too strong) see earlier reading for today. Location near Light 8.
TR11	Scour Pond	28-Nov	78	15:36	0.3	13.04	9.16	88.9	7.64	-52.8	4711	3.27	12.18	15:43	26	13.04	8.98	87.4	7.63	-51.9	5489	3.94	19.98	
TR11	Scour Pond	28-Nov		17:36	0.3	13.09	9.04	88.4	7.67	-53.9	6174	4.86	12.69	17:42	8	13.15	8.95	88.0	7.64	-53.7	7149	5.21	21.24	Dark; thus no Secchi depth.
TR12	Decker Island	2-Dec		18:13	0.3	10.71	9.67	86.7	7.57	-48.0	319	0.21	15.25	18:18	9	10.74	9.57	86.4	7.55	-47.7	326	0.22	21.97	Dark, slack tide, at night; thus, no Secchi depth.
TR13	S-31	11-Dec	27	15:14	0.3	10.19	10.52	93.8	8.05	-76.1	567	0.39	64.00	15:17	2	10.19	10.39	92.8	8	-73.1	571	0.39	66.00	Very shallow location off to East side of Nav Chan.

Appendix C Data Collection Forms


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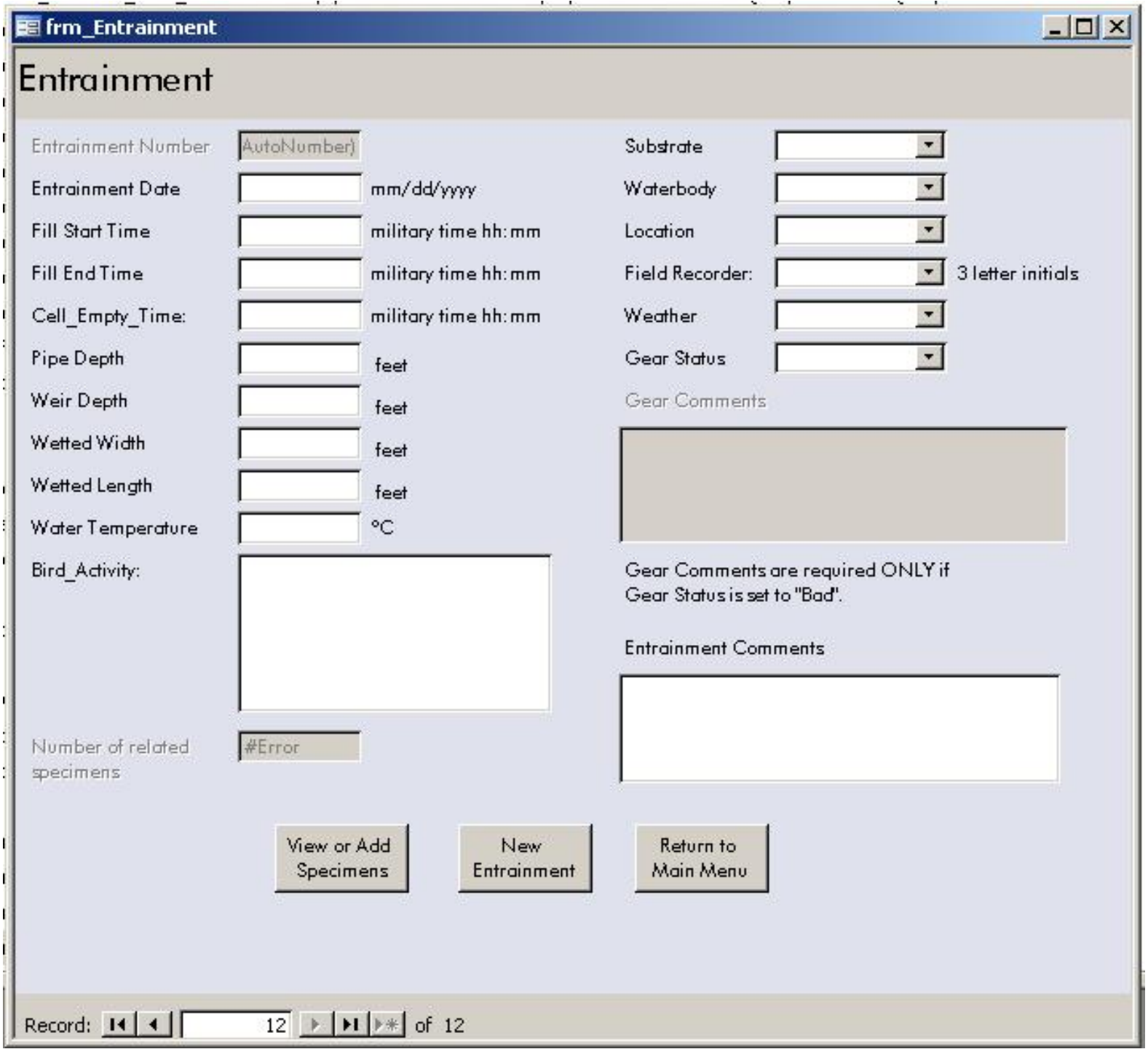
2007 Monitoring Data
Stockton, California
Choose a Survey Type below:
Trawl
Beach Seine
Purse Seine
Entrainment
Water Quality
Quit Application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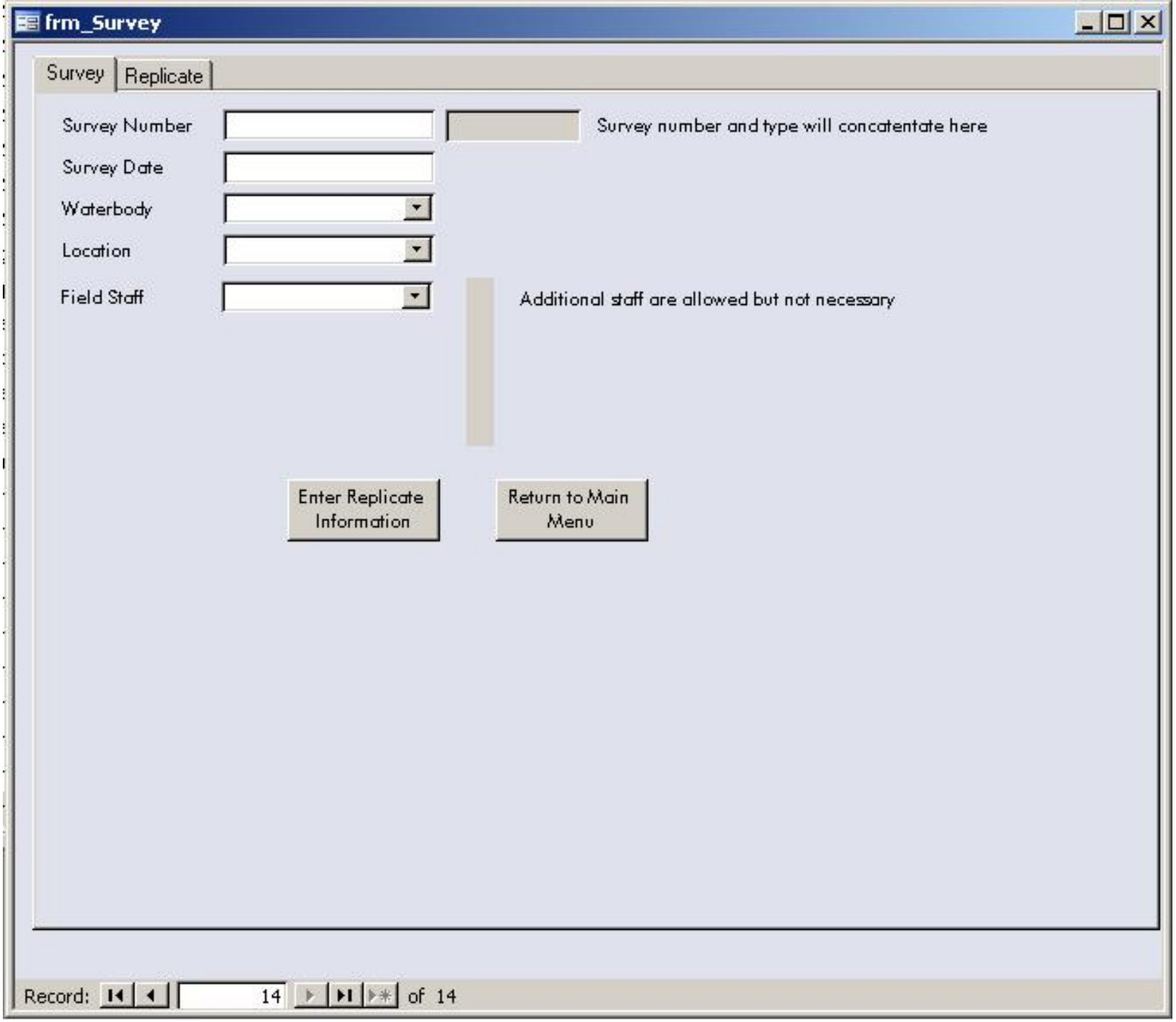
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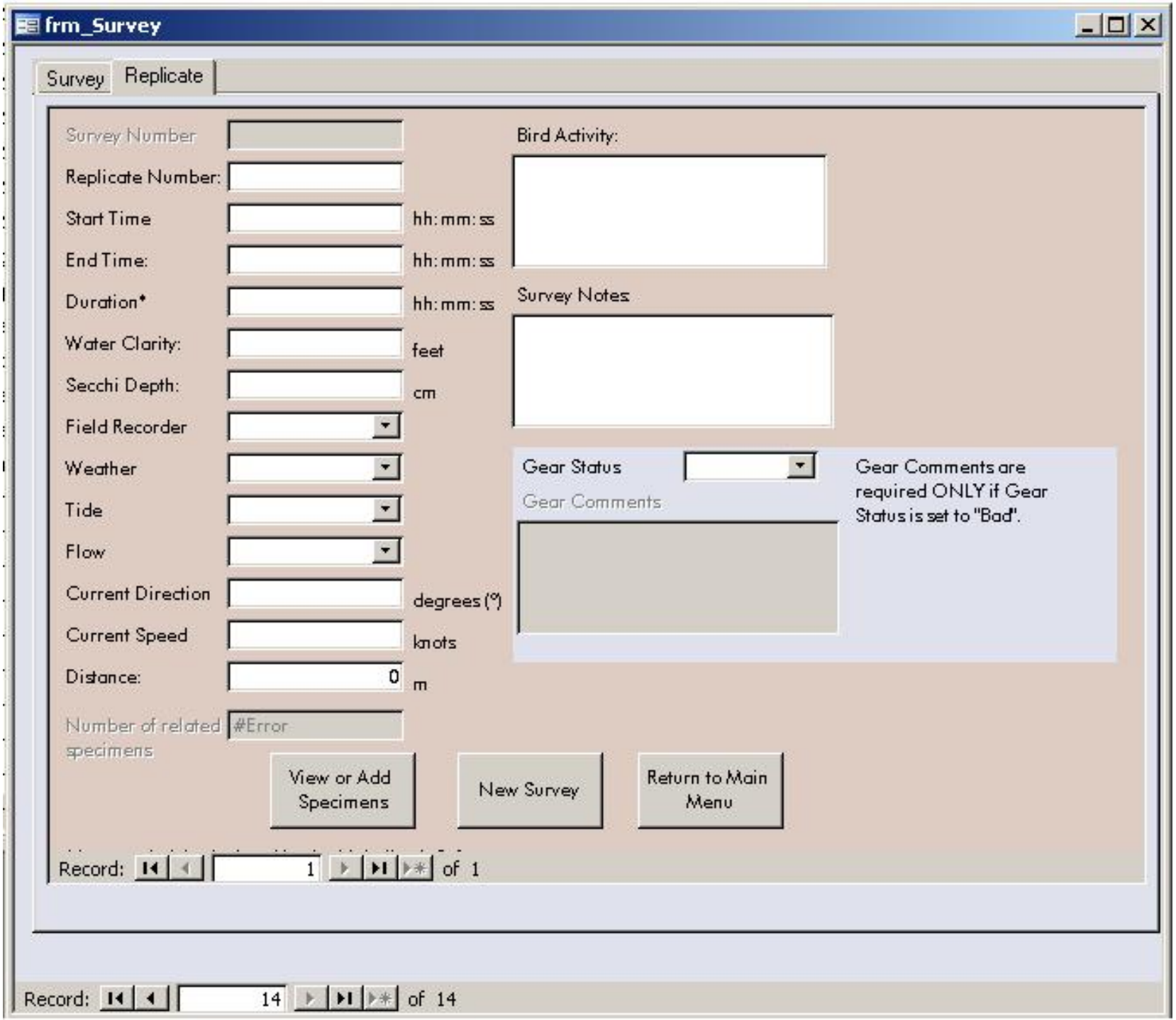
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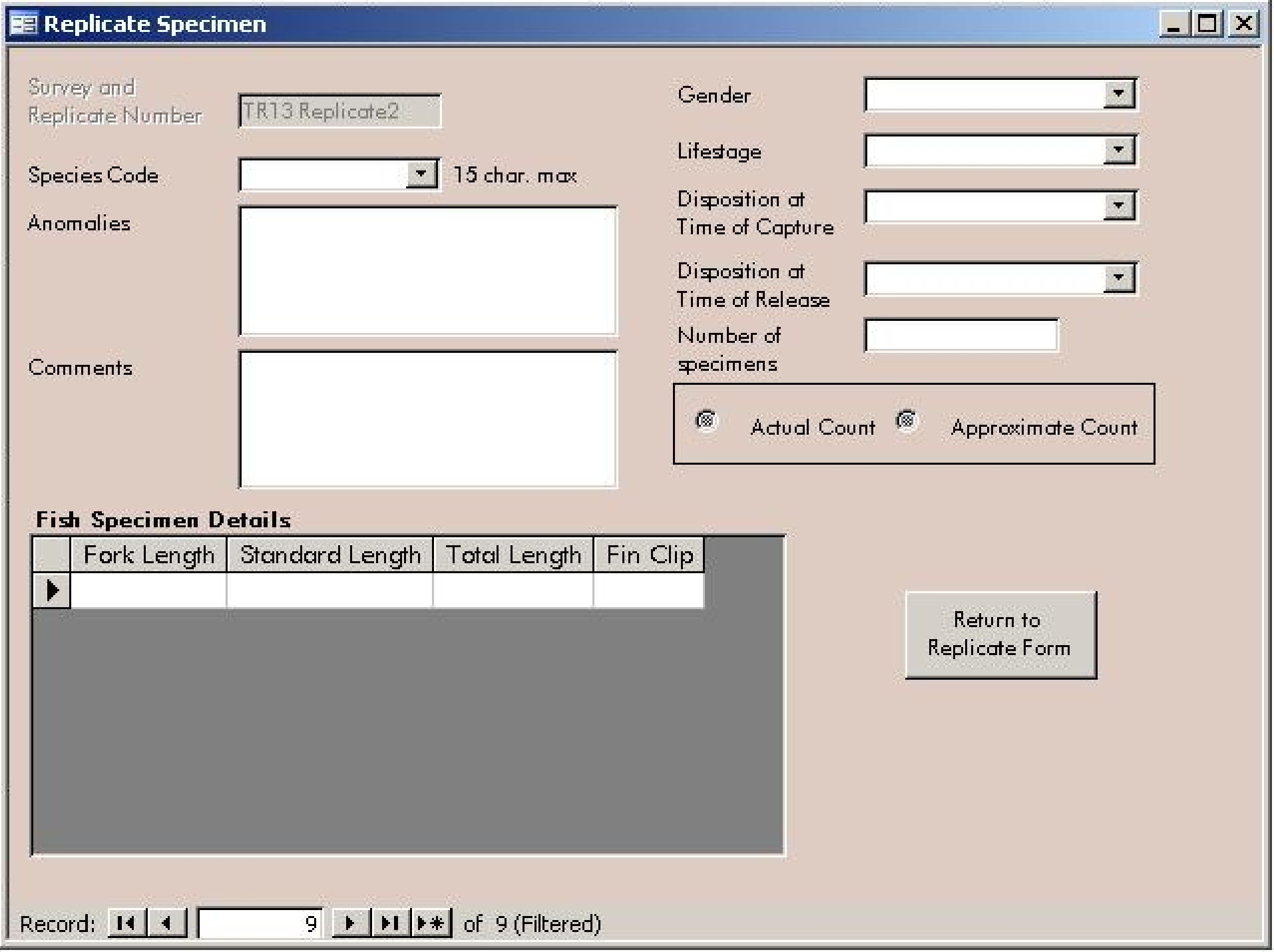
of 14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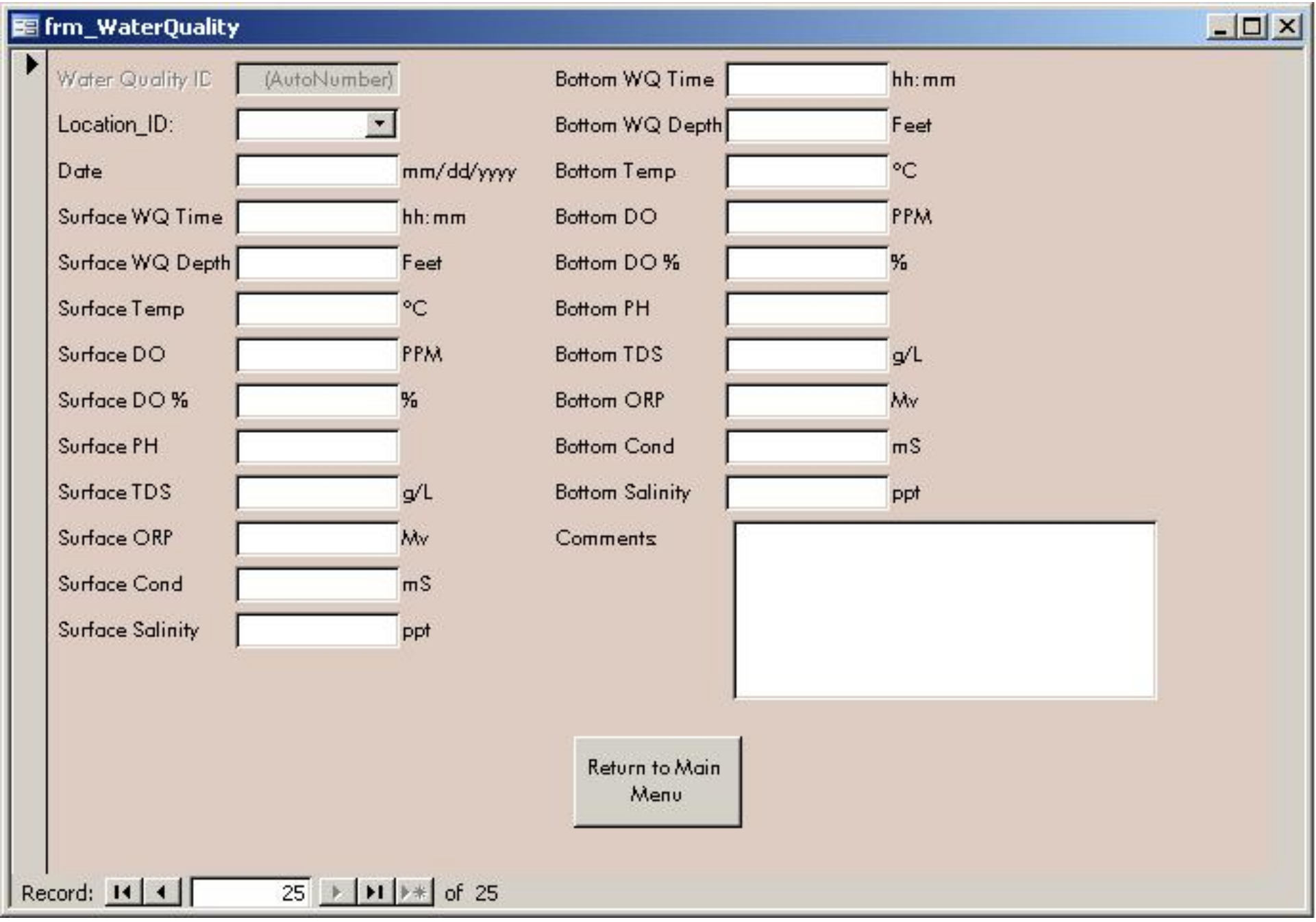
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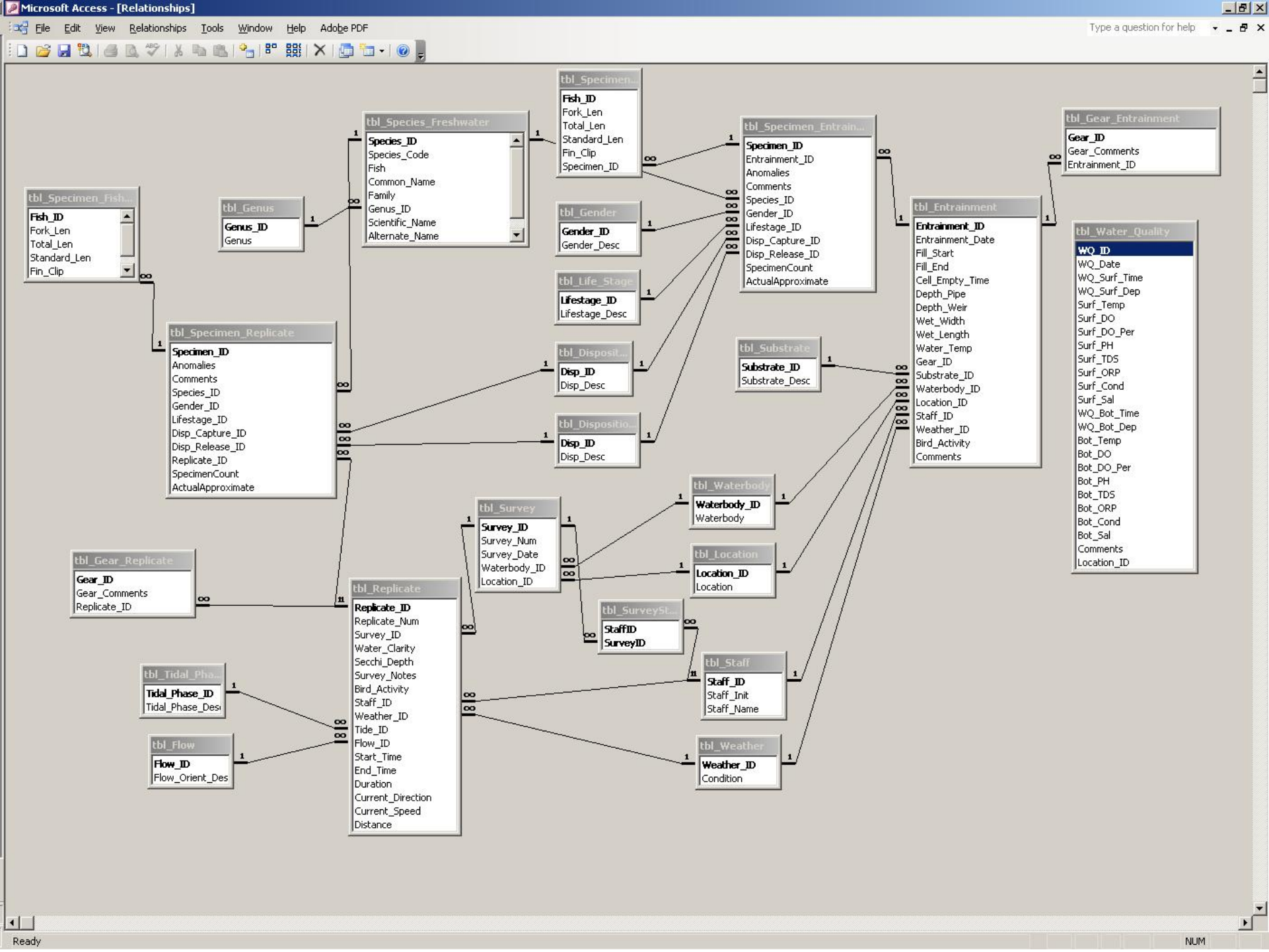
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tbl_Flow
Flow_ID
Flow_Orient_Des
tbl_Weather
Weather_ID
Condition
Ready
NUM

Appendix C. Database and Paper Data Entry Forms

Paper Data Entry Forms

Fish Sampling Data Sheet 2007

Sampling Method (survey type):		Dredge Reach:	
Sample ID:		Location Markers/Aids:	
Tow Replicate:		Tidal Phase:	ebb / flood / slack
Date:		Flow Direction:	upstream / downstream
Start Time:		Current Direction [° True North]:	
End Time:		Current Speed [kts]:	
GPS:	yes / no	Boat Speed [kts]:	
Survey Depth_Lower [ft]:		Speed over ground [kts]:	
Survey Depth_Upper [ft]:		Boat Power [rpms]:	
Tow distance [m]:		Weather:	
Subsample?	yes / no	Bird Activity:	
* Subsample percent (estimate):		River bed description:	
Gear Status:	good / bad	Sampling Staff / Recorder (circle):	
Gear Comments			

Entrainment Sampling Data Sheet (Sample Cell)

Date:		Sample Cell Fill Start Time:	
Sample ID:		Sample Cell Full Time:	
DMP Location:		Sample Cell Empty End Time:	
GPS		Dredge Pumping Rate [gpm]:	
GPS location at DMP:		Sampled Volume [gal]:	
Weather:		Approx. Avg. Wetted Width [ft]:	
Water Temperature:		Approx. Avg. Wetted Length [ft]:	
Substrate Description:		Approx. Avg. Area of Cell [ft]:	
Sampling Staff:		Sample Cell Description:	
Recorder:		Bird Activity:	

Gear Status / Notes: _____

Entrainment Sampling Data Sheet (Screen)

Page ____of_____

Date:		Sample Area Description:	
DMP Location:		Survey Start Time:	
GPS		Survey End Time:	
GPS location at DMP:		Total Elapsed Survey Time [hh:mm:ss]:	
Weather:		Dredge Pumping Rate [gpm]:	
Water Temperature:		Sampled Volume [gallons]:	
Substrate Description:			
Sampling Staff / Recorder:		Bird Activity at DMP Site:	
Gear Status / Notes:			

Specimen Collection Datasheet (2007)

Date ______________ Page ______ of ______

Survey ID ______________

Survey Replicate

[talley_count]

SPECIES_ SPECIMEN_CODE	LIFE HX STAGE	CAPTURE DISPOSITION	RELEASE DISPOSITION	FL (mm)	TL (mm)	SL (mm)	SEX	FIN CLIP	EXTERNAL ANOMALIES	COMMENTS

Notes:

Water Quality Monitoring Datasheet (2007)

Location:
Sampling Crew:
Recorder:
Associated Survey ID:
Date:

	Near Surface	Near Bottom
WQ Time:		
WQ Depth:		
Temp [°C]:		
DO [ppm]:		
DO [% saturation]:		
pH:		
Conductivity [µm]:		
Salinity:		
ORP [mV]:		
TDS [g/L]:		
Turbidity [ntu]:		

Gear Status / Notes:

Location:
Sampling Crew:
Recorder:
Associated Survey ID:
Date:

	Near Surface	Near Bottom
WQ Time:		
WQ Depth:		
Temp [°C]:		
DO [ppm]:		
DO [% saturation]:		
pH:		
Conductivity [µm]:		
Salinity:		
ORP [mV]:		
TDS [g/L]:		
Turbidity [ntu]:		

Gear Status / Notes:

Appendix D Delta Smelt Catch Data

Appendix D. Delta Smelt Catch Data

The following data on catch of delta smelt (the only ESA-listed fish encountered) were reported to the IEP Management Team in accordance with IEP 2007 Sampling Reinstatement Criteria for delta smelt, Version 2, August 1, 2007. During five trawls on three dates, 11 delta smelt were encountered.

Latitude and longitude information for each trawl reflects the approximate midpoint of the trawl tow. Current directions are given relative to true north.

1) ID TR 8-3: West Island Dredge Reach, SSC, Nov. 21, 2007

Catch data for: 1 delta smelt, adult, male

Fork length / total length: 60 mm / 67 mm

Disposition (capture / release): alive / killed (vouchered)

Comments: appeared in spawning/pre-spawn condition
photos, vouchered for positive ID

Other catch:
1 channel catfish, juvenile
1 starry flounder, juvenile
1 yellowfin goby, juvenile
4 Asian clams
20 mixed shrimp (including Siberian prawn).

Of interest:
No other delta smelt encountered in other trawl tows for this date/location.
Low numbers in catch throughout all tows at this location.
1 longfin smelt captured and released alive in 4th tow (TR 8-4) on 11/21/07

Date, time: 11/21/2007, 14:13–14:20

Latitude, longitude: 38°1.343′ N, 121°48.349′ W

Location: San Joaquin River, Navigation Light 7 off NW end of West Island in navigation channel

Conditions: sunny

Secchi depth: 78 cm

Tide: rising, nearing high slack

Current direction: 128 degrees

current speed: 0.1 knots to 0.0 at slack tide

Trawl Distance: 514 m

Depths: 33–40 feet

Boat speed over ground: 2.4 kts

Water quality: near bottom depth of 27 feet at 13:09

Temp: 15.02°C

DO: 9.47 ppm or 96.2%

pH: 7.71

Conductivity: 5709 µS

Salinity: 3.88 ppt

Turbidity: 24.96 NTU

2) ID TR 12-1: Natural Channel, Decker Island Dredge Reach, SRSC, Dec. 2, 2007

Catch data for: 2 delta smelt, adult, undetermined sex

Fork length / total length:	Disposition (capture / release):
72 mm / 79 mm	alive / alive
70 mm / 78 mm	alive / alive

Other catch:
40 threadfin shad, juvenile
7 striped bass juvenile
6 threadfin shad, adult
1 white sturgeon juvenile
20 mixed shrimp (including Siberian prawn)

Date, time: 12/02/2007, 19:27–19:35

Latitude, Longitude: 38°4.678′ N, 121°45.892′ W

Location: Sacramento River, Navigation Light 13 downstream of Decker Island in the navigation channel

Conditions: Dark, windy, cloudy

Secchi depth: NA (dark)

Tide: rising

Current direction: 94 degrees

Current speed: 0.4 knots

Trawl distance: 537 m

Depths: 32–34 feet

Boat speed over ground: 2.2 kts

Water quality: near bottom at depth of 30 feet at 18:18

Temp: 10.74°C

DO: 9.57 ppm or 86.4%

pH: 7.55

Conductivity: 326 µS

Salinity: 0.22 ppt

Turbidity: 21.97 NTU

3) ID TR 12-2: Natural Channel, Decker Island Dredge Reach, SRSC, Dec. 2, 2007

Catch data for: 6 delta smelt, adult, undetermined sex

Fork length / total length:	Disposition (capture / release):
77 mm / 84 mm	alive / alive
67 mm / 73 mm	alive / alive
66 mm / 73 mm	alive / alive
76 mm / 83 mm	alive / dead (vouchered)
66 mm / 72 mm	alive / dead (vouchered)
65 mm / 70 mm	alive / dead (vouchered)

Comments: Photos for all 6; vouchered the 3 dead delta smelt (whole) in 10% Formalin

Other catch:
93 threadfin shad, juvenile
9 striped bass, juvenile
8 threadfin shad, adult
1 longfin smelt, adult (released alive)
1 macrophthalmic lamprey (vouchered)
1 white catfish
1 white sturgeon, juvenile
25 mixed shrimp (including Siberian prawn).

Date, time: 12/02/2007, 19:57–20:05

Latitude, longitude: 38°4.711′ N, 121°45.807′ W

Location: Sacramento River, Navigation Light 14 downstream of Decker Island in the navigation channel

Conditions: Dark, windy, cloudy

Secchi depth: NA (dark)

Tide: rising

Current direction: 94 degrees

Current speed: 0.5 knots

Trawl distance: 514 m

Depths: 31–35 feet

Boat speed over ground: 2.1 kts

Water quality: near bottom at depth of 30 feet at 18:18

Temp: 10.74°C

DO: 9.57 ppm or 86.4%

pH: 7.55

Conductivity: 326 µS

Salinity: 0.22 ppt

Turbidity: 21.97 NTU

4) ID TR 13-3: Man-made Channel, West Sacramento, SRSC, Dec. 11, 2007

Catch data for: 1 delta smelt, adult, undetermined sex

Fork length / total length:	length not measured to release alive	**Disposition (capture / release):** alive / alive	
Comments:	appeared healthy		
Other catch:	Included with data on following trawl (ID TR 13-4)		
Date, time: 12/11/2007, 16:21–16:29	**Latitude, longitude:** 38°26.605′ N,121°35.863′ W	**Location:** Sacramento River, Man-made Channel, Navigation Light 67 downstream of "the bend" in the navigation channel	
Conditions: Dusk, partly cloudy, windy	**Secchi depth:** 27cm	**Tide:** rising	**Current direction:** NA at this location
Current speed: NA at this location	**Trawl distance:** 518 m	**Depths:** 33–44 feet	**Boat speed over ground:** 2.0 kts
Water quality: surface at 15:14		**Temp:** 10.19°C	**DO:** 10.52 ppm or 93.8 %
pH: 8.05	**Conductivity:** 567 µS	**Salinity:** 0.39 ppt	**Turbidity:** 64 NTU

5) ID TR 13-4: Man-made Channel, West Sacramento, SRSC, Dec. 11, 2007

Catch data for: 1 delta smelt, adult, undetermined sex

Fork length / total length: not taken

Disposition (capture / release): alive / alive

Comments: photo (blurry)
fish released and observed swimming away

Other catch from all 4 tows completed on 12/11/2007:

18 white catfish juveniles
14 channel catfish, juvenile
7 white catfish, adult
6 threadfin shad, juvenile
5 threadfin shad, adult
3 Shimofuri goby, adult
3 yellowfin goby, juvenile
2 striped bass, juvenile
1 white sturgeon, juvenile
95 Siberian prawns

Date, time: 12/11/2007, 16:48–16:56

Latitude, longitude: 38°26.589′ N, 121°35.858′ W

Location: Sacramento River - Man-made Channel
Navigation Light 67 - downstream of "the bend" in the navigation channel

Conditions: Dusk, partly cloudy, windy

Secchi depth: 27cm

Tide: rising

Current direction: NA at this location

Current speed: NA at this location

Trawl distance: 506 m

Depths: 37–42 feet

Boat speed over ground: 2.2 kts

Water quality: surface at 15:14

Temp: 10.19°C

DO: 10.52 ppm or 93.8 %

pH: 8.05

Conductivity: 567 µS

Salinity: 0.39 ppt

Turbidity: 64 NTU