Stockton and Sacramento Deep Water Ship Channel Maintenance Dredging and Dredge Material Placement Projects

2012 Fish Community, Entrainment and Water Quality Monitoring Report

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Abbreviations

Abbreviation	Full Term or Name
BO	biological opinion
CDFG	California Dept. of Fish and Game (changed to CDFW effective January 1, 2013)
CDFW	California Dept. of Fish and Wildlife
CESA	California Endangered Species Act
CNDDB	California Natural Diversity Database
Corps or USACE	U.S. Army Corps of Engineers
CPUE	catch per unit effort
Delta	Sacramento River and San Joaquin River Delta
DMP	dredged material placement (site)
DPS	distinct population segment
DR	dredging reach
DWSC	deepwater ship channel
EFH	essential fish habitat
ESA	Endangered Species Act
ESU	evolutionarily significant unit
FMP	fish entrainment and fish community monitoring plan
FMWT	Fall Midwater Trawl [survey]
GPS	global positioning system
Hx	hypothesis
IEP	Interagency Ecological Program
IUCN	The World Conservation Union
MEC	Mari-Gold Environmental Consulting, Inc.
MSA	Magnuson-Stevens Fishery Conservation and Management Act
NAS	Novo Aquatic Sciences, Inc.
NMFS	National Marine Fisheries Service
NOAA	National Oceanographic and Atmospheric Administration
ntu	nepholometric turbidity unit
ppm	parts per million
ppt	parts per thousand
POD	Pelagic Organism Decline (study)
RM	river mile
SCP	scientific collecting permit
SD	standard deviation
SE	standard error
SF	San Francisco
SRDWSC	Sacramento River Deep Water Ship Channel
SDWSC	Stockton Deep Water Ship Channel
SWCA	SWCA Environmental Consultants, Inc.
USCG	U.S. Coast Guard
USFS	U.S. Forest Service
USFWS	U.S. Fish and Wildlife Service
Vortex	Vortex Marine Construction, Inc.

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1 Executive Summary

This document presents the results of the 2012 fish community and fish entrainment monitoring for maintenance dredging in the Stockton Deepwater Ship Channel (SDWSC) and the Sacramento River Deepwater Ship Channel (SRDWSC). Although no monitoring was conducted in the SRDWSC during 2012, data from previous years monitoring in the SRDWSC is presented in this report for comparison purposes.Monitoring began in 2005, though only three entrainment monitoring events were conducted that year. In 2006, both entrainment and fish community monitoring was conducted throughout the entire dredging season, and has been conducted annually since then. The monitoring methods were developed 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 (USACE) regarding long-term dredging and dredged material placement activities. Monitoring results are used by USACE to assess and implement adaptive strategies that may decrease potential environmental impacts of the activities.

Monitoring was conducted as described in the Fish Entrainment and Fish Community Monitoring Plan (FMP), (MEC and NAS, 2011). Fish entrainment monitoring during the 2012 dredging season was performed exclusively with the mobile entrainment screen prototype constructed in early 2008. Bottom trawling was used to monitor the fish community in active dredging areas of the shipping channels. Water quality monitoring was also conducted during each fish community monitoring effort.

Dredging commenced on November 3, 2012, and ended on December 10, 2012. In general, each type of monitoring (entrainment and fish community) was conducted on alternating days while the dredge was operating. Occasional night monitoring was conducted for comparative purposes. Monitoring did not occur on dates when the dredge was being moved to a new location or was otherwise not in operation. Water quality monitoring was conducted in conjunction with the fish community monitoring efforts. In 2012, all of the dredging was conducted in the SDWSC, and none was conducted in the SRDWSC. During all previous years, dredging occurred in both ship channels. The other significant change that occurred in 2012 was that Vortex Marine Construction was the prime contractor (dredger), replacing Ross Island Sand and Gravel, the dredger during all previous years during which monitoring was conducted. The dredge and dredging equipment were different, but the monitoring personnel, equipment, and techniques were the same as those used in previous years; with the exception of the use of a new valve to shunt dredged material to the entrainment monitoring screen.

The key findings of 2012 entrainment monitoring at dredged material placement (DMP) sites were:

- 2012 was the fourth year in which the mobile entrainment screen was used at all DMP sites. Overall, 8.18% of the dredged material was monitored, similar to previous years.
- 24 individual fish of seven different species were encountered during 16 entrainment monitoring events conducted in 2012.
- No special status species were encountered while entrainment monitoring in 2012.
- The introduced shimofuri goby *(Tridentiger bifasciatus)* was again the most common fish species encountered during entrainment monitoring, comprising 50% of the individual fish encountered.
- 2012 was the first year during which river lamprey *(Lampetra ayresii)* were not encountered during entrainment monitoring.

The key findings from the 2012 fish community (trawl) monitoring were:

- Fish community monitoring was conducted at all dredging reaches in 2012.
- There were 2,629 individual fish encountered during 2012 trawl surveys. There were 15 species represented, from among the 55 species (Moyle, 2002) presently known to occur in the Sacramento and San Joaquin River Delta (Delta).
- There were 16 days during which fish community monitoring fish trawls were conducted. 65 individual trawls were attempted, of which 57 met the quality assurance criteria for success. Total distance trawled was 27,700 meters.
- Of the 15 species encountered, only two were natives, Sacramento splittail and prickly sculpin, together representing only 1.5% of the individual fish encountered.
- Striped bass were the most frequently encountered fish while community monitoring in 2012, comprising 35.1% of the individuals encountered. Previously, white catfish had been the species most frequently encountered in all years except 2010, when threadfin shad were the most common species.
- No special status species were encountered while fish community monitoring in 2012.
- Fall-run Chinook salmon were observed being preyed on by California sea lions on a very frequent basis during 2012 monitoring.

All data collected in 2012 were incorporated into the modified Microsoft (MS) Access database originally constructed for this project in 2006. The database provides data integrity for this large and growing data set, streamlines electronic field data entry, and can 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 additional variables. It may also aid in the assessment of changes to the fish community resulting from management actions, anthropogenic influences, and/or environmental fluctuations/ perturbations. Additionally, it allows cost effective revisions of previous year's data when necessary, such as when a name change to a fish or invertebrate species occurs. The database is used during the production of the annual report, to provide data from previous years monitoring for analysis.

There was only one significant change to special status species designations in 2012 that may ultimately effect dredging, the advancement of longfin smelt to candidacy for protection under the Federal Endangered Species Act (ESA) by the United States Fish and Wildlife Service (USFWS). Longfin smelt were listed as threatened under the California Endangered Species Act (CESA) on June 25, 2009. The USFWS recently conducted a 12-month status review of all west coast longfin smelt populations. The results of this review were published on April 3 2012 (http://www.fws.gov/cno/es/speciesinformation/longfin.html), finding that the San Francisco Bay population of longfin smelt warranted protection under ESA and should be advanced to candidacy. No new protections are enacted when a species is advanced to candidacy, in the case of the San Francisco Bay (and Delta) population of longfin smelt, significant protections are already in place due to their listing under CESA.

Notable amongst the non-listed native fish species encountered by this monitoring program are Sacramento splittail *(Pogonichthys macrolepidotus)* and river lamprey. Sacramento splittail, a native minnow, have been encountered every year that this monitoring has been conducted, including 2012. On January 22, 2010, the Center for Biological Diversity won a lawsuit requiring the USFWS to make a new finding by September 30, 2010 on whether listing splittail as threatened or endangered is warranted. The listing was denied. Sacramento splittail have been encountered during all years of monitoring, in most dredge reaches, though never in large numbers relative to other species.

River lamprey have been encountered in many dredge reaches during all previous years of this monitoring program, including reaches dredged in 2012, though none were encountered in 2012. All four species of lamprey endemic to the Sacramento and San Joaquin River watersheds were denied ESA listing in 2004, largely due to lack of basic knowledge.

Two species of lamprey are known to occur in the project area: Pacific lamprey *(Entosphenus tridentata)* and river lamprey *(Lampetra ayresii)*. Though Western brook lamprey *(Lampetra richardsoni)* and Kern brook lamprey *(Lampetra hubbsi)* may be present in the Delta, though Brown and Moyle (1993) described both species as utilizing higher elevation portions of the San Joaquin River. If either species is present in the project area, it is more likely the western brook lamprey, as this species is known to inhabit larger river systems than the Kern brook lamprey. Although not currently protected under ESA or CESA, the USFWS and others recognize these species as fish that require greater conservation efforts (Moyle 2002, Goodman et al. 2009).

2 Introduction

This document provides a description of the seventh year of fish community monitoring and the eighth year of dredge entrainment monitoring conducted for the U.S. Army Corps of Engineers - Sacramento District (USACE) through its contract with Ross Island Sand and Gravel Company (RISG) from 2005 through 2011, and its contract with Vortex Marine Construction Inc., (Vortex) beginning in 2012. Fish monitoring was conducted by SWCA Environmental Consulting from 2005 through 2008, and has been conducted by Mari-Gold Environmental Consulting, Inc. (MEC) and Novo Aquatic Sciences, Inc. from 2009 through 2012, though the principal scientists have remained the same since the inception of the monitoring program. USACE is authorized and required to maintain channel depth and levee integrity along the SRDWSC and the SDWSC. This monitoring program was mandated by the National Marine Fisheries Service (NMFS) through formal consultation with USACE to:

- Ensure compliance with applicable environmental laws and regulations including Section 7 of the 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 reach and the numbers and types of fish species entrained by the dredge.
- Provide feedback to USACE, NMFS and other agencies to assess and implement adaptive strategies designed to diminish negative environmental effects of the long-term dredging and dredged material management.

The U.S. Army Corps of Engineers Sacramento District and NMFS developed a ten-year programmatic approach to maintain the SRDWSC and SDWSC to their authorized depths via maintenance dredging and levee stabilization, as described in the biological opinions (BO) and supplemental documents for the shipping channels (NMFS 2006a,b). Although the annual timing of dredging projects in the Delta is regulated through area-specific dredging windows, NMFS has recognized that additional protections for ESA-listed fish (salmon, steelhead, and sturgeon) were needed. To that end, NMFS tasked USACE with developing and conducting fisheries monitoring associated with Delta ship channel maintenance dredging. USACE and NMFS annually review the plans and reports for this project to determine that they are consistent with and appropriate for the BO(s) requirements (i.e., monitoring effects of maintenance dredging and bank protection on fish in the SDWSC and SRDWSC). An updated monitoring plan was produced in 2011 (MEC and NAS, 2011). The updated plan describes regulatory and permitting changes as well as changes to monitoring methods since the last plan revision (SWCA, 2008).

This monitoring program was developed to meet the NMFS requirements of BO Conservation Measures 12 (2006a), and 16 (2006b) – Note: Conservation Measures 1 through 11, and 1 through 15 address dredging operations rather than fisheries monitoring). NMFS is required to ensure that project actions do not jeopardize the viability and existence of protected species (steelhead, salmon and green sturgeon) under their jurisdiction. The conservation measures developed through ESA consultations augment established in-water work windows to regulate the timing of Delta dredging projects. The established annual dredging work windows are June 1 through December 31 in the SDWSC, and June 1 through February 27 in the SRDWSC (restricted to upstream area of Man-made Channel from December 1).

Following the collection of delta smelt during fish community monitoring of this study in November and December 2007, USACE - Sacramento District requested clarification and guidance from the USFWS regarding incidental take of delta smelt during future maintenance dredging and monitoring activities. In August 2008, in order to minimize potential effects to delta smelt, the USFWS appended the deepwater ship channel maintenance dredging projects to their programmatic consultation on the issuance for Section 10 and 404 permits (Service File Number 1-1-04-F-0345). Under the appended consultation, the normal in-water work window for protection of delta smelt was then further restricted from August 1 through November 30. Additionally, during each week of the permitted dredging season a maximum of ten delta smelt may be collected during monitoring. Take of delta smelt is reported to FWS on a weekly basis when encountered. Dredging may occur before or after the delta smelt work window based on permit amendments requested by USACE. Justification for such requests has been based on lack of likelihood of encountering delta smelt due to the location of the dredging. This occurred again in 2012 when dredging was allowed in the upper reaches of the SDWSC until December 10.

Collection of longfin smelt during fish community monitoring in 2006 and 2007 prompted inclusion of the monitoring under the Interagency Ecological Program (IEP) as program element 113 and required issuance of a CDFW Section 2081(a) Permit to the fish biologists who conduct the monitoring. This permit allows an annual take of no larvae (< 20 mm FL), 150 juveniles (20-84 mm FL), and 150 adults (> 84 mm FL). Permitted fish community monitoring activities under this 2081(a) are restricted to bottom trawling (with a small, 25-foot head-rope otter trawl) within portions of Yolo, Sacramento, Solano, Contra Costa and San Joaquin counties; specifically, a) the Sacramento River DWSC upstream to the Port of Sacramento, b) the Sacramento River in the vicinity between Sherman Island and Rio Vista, c) the San Joaquin River in the vicinity of the Antioch Bridge upstream to Spud Island and in the vicinity of Rough and Ready Island and d) the San Joaquin River DWSC to the Port of Stockton. The 2081(a) permit issued for 2012 included several additional provisions, including notifying CDFW if 50 percent of the allowable take was reached. No longfin smelt were encountered in 2012, a not unsurprising result considering the location of the dredging reaches in the upper portions of the SDWSC.

To convert the NMFS mandated monitoring requirements into testable assumptions. The following hypotheses (H1 and H2) were developed prior to the initiation of the 2006 monitoring:

H^1: Maintenance dredging of the SDWSC and SRDWSC will result in take of listed and other fishes through direct dredge entrainment.

H^2: There is a correlation between presence of fish in the dredging areas and entrainment of fish by the dredge.

H^2a: Differential use of the water column will result in different entrainment levels among fishes present in the project areas; that is, demersal fish that are associated with the channel bottom (benthic and epibenthic species) will be entrained in higher numbers than water column (pelagic) fish.

This report presents the results of monitoring activities conducted from November 3 through December 10, 2012. These monitoring activities consisted of monitoring the fish community in the shipping channels around the dredge when dredging was underway, and monitoring the dredged material for entrained fish. The fish entrainment monitoring was designed to quantify the level of incidental take of special status and other (fish) species by the dredging operation. The fish community monitoring was designed to assess which species are present in dredge areas during active dredging and are therefore potentially vulnerable to entrainment by the dredging operation. This report also compares results of 2012 monitoring with previous years, where cogent.

The monitoring requirements are focused on species that are listed as threatened or endangered under the ESA, due to the assessed potential impacts from annual maintenance dredging actions. Therefore, this report includes information on the following federal special-status species that occur in the project area:

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
longfin smelt *(Spirinchus thaleichthys)* – candidate

It is important to note that special-status species designations are not limited to the federal ESA nor are they fixed. These monitoring activities are also accountable to provisions of CESA. The CESA-listed species relevant to these monitoring activities consist of:

longfin smelt *(Spirinchus thaleichthys)* – threatened
delta smelt *(Hypomesus transpacificus)* – endangered
winter-run Chinook salmon *(Oncorhynchus tshawytscha)* – endangered
Central Valley spring-run Chinook salmon *(O. tshawytscha)* – threatened

CDFW also maintains a list of fish Species of Special Concern. These species include:

Chinook salmon – Central Valley fall / late fall-run *(Oncorhynchus tshawytscha)* ESU
river lamprey *(Lampetra ayresii)*
Pacific lamprey *(Entosphenus tridentatus)*
hardhead *(Mylopharodon conocephalus)*
Sacramento splittail *(Pogonicthys macrolepidotus)*

River lamprey have been encountered in both shipping channels during each year that monitoring has been conducted except 2012. A single Pacific lamprey (an ammocoete) was encountered for the first time in 2009. These species, along with two other lamprey species endemic to California, were petitioned for listing under the ESA in 2003 but all were denied (USFWS 2004). Future petitions for CESA and/or ESA listing of these species are possible, with attendant implications for dredging and monitoring, should listing occur. This monitoring program has encountered lamprey during both fish community and entrainment monitoring. With the exception of the single Pacific lamprey, all of the other lamprey encountered during all years of this study (identified in the field and laboratory utilizing morphological and genetic analysis) have been river lamprey. In 2010, many observed individuals were able to escape through the mesh of the entrainment screen and so were counted, but not further examined. The results from 2011 again describe a small number of "unidentified" lamprey due to these occurrences, though fewer as less lamprey were encountered in 2011 than in 2010. However, all vouchered lamprey from 2010 and 2011 were identified as river lamprey. Thus, although described in the data as "unidentified lamprey," these specimens are assumed to be river lamprey.

In early years of this monitoring program a possibility existed that lamprey encountered were incorrectly identified (as river lamprey) due to the difficulty in resolving these fish to species level, especially when in the ammocoete stage. Goodman et al. (2009) described morphological characters that allowed the authors confidence in the use of morphologic characteristics to differentiate between *Entosphenus* and *Lampetra* during field identification. Species determination within *Lampetra* ammocoetes encountered in the future may yet require further laboratory analysis. If necessary, species confirmation will be made by USFWS (Goodman) on preserved specimens.

There are several other native fishes that utilize the Delta channels and have been, or could be, encountered while conducting this monitoring program. These fish species or evolutionarily significant units (ESU) are all considered to be imperiled to one degree or another. These species have been awarded special status by several entities not yet mentioned, such as the American Fisheries Society (AFS), the USFWS, and The World Conservation Union (IUCN). This information is continually refined and updated by CDFW and is reported in The California Natural Diversity Database (CNDDB) special animals list. The January 2013 CNDDB list was the latest available at the time of this writing the list is available at: http://www.dfg.ca.gov/biogeodata/cnddb/pdfs/TEAnimals.pdf. Further details on special status fish species pertinent to this monitoring are provided in Appendix A.

This project has also encountered and documented non-native fish species that are currently a major focus of the Pelagic Organism Decline Study (PODS) due to their rapidly declining populations and their importance to the Delta ecosystem (IEP 2008) (the POD also includes the native species delta and longfin smelt). These species are:

threadfin shad *(Dorosoma petenense)*
striped bass *(Morone saxatilis)*

Dredging and monitoring activities are affected by proposed and new listings. The dynamic nature of listing status had a direct effect on dredging and associated monitoring activities in 2007 and 2008, due to changes in the CESA status of delta smelt and longfin smelt that resulted in shortening of the dredging windows and added conservation measures and take restrictions to the monitoring. There were no further modifications of dredging operations or monitoring due to status change from 2009 through 2012, though USFWS did request weekly updates of encounters with delta smelt beginning in 2011.

Recent state and federal petitions have requested that delta smelt be up-listed from threatened to endangered under CESA and ESA. California up-listed delta smelt to endangered status on March 4, 2009 (Final Statement issued on November 10, 2009). USFWS completed a five-year status review of delta smelt on September 13, 2010, (http://ecos.fws.gov/docs/five_year_review/doc3570.pdf), and did not change their protective status.

During 2007 fish community monitoring, one delta smelt was encountered on November 21 in the SDWSC, and ten delta smelt were encountered between December 2 and December 12 in the SRDWSC. This led to a mandatory shift in dredging locations and then the suspension of remaining 2007 dredge operations in the SRDWSC. In 2008, dredging was started in the SRDWSC in August and finished in the SDWSC in November. Twenty-two delta smelt were encountered from August 6 to September 6 in the SRDWSC, and three were encountered on September 21 near the upstream end of West Island in the SDWSC. No delta smelt were found upstream of Antioch Bridge in the SDWSC from late September to late November during the end of 2008 dredging season. Delta smelt were not encountered during 2009. In 2010, dredging at S- 31 in the man-made portion of the SRDWSC started on September 20 and ended on October 16. Seven delta smelt were encountered while community monitoring and six while entrainment monitoring. In 2011, three delta smelt were encountered while entrainment monitoring and six while community monitoring; all were encountered at the S-31 location in the SRDWSC between August 19 - 24. Delta smelt were not encountered in 2012 monitoring, an unsurprising result given the dredging locations in the upper reaches of the SDWSC.

The California Fish and Game Commission enacted protections for longfin smelt in 2008, which was a CESA candidate species at that time. Incidental take of longfin smelt while conducting fish community monitoring was restricted to 150 juveniles and 150 adults for the entire year. Longfin smelt were accepted as threatened under CESA by the Commission on March 4, 2009. Federal protection of the longfin smelt was recently denied by the USFWS following review of the petition to list the longfin smelt under the ESA (April 9, 2009). The USFWS found that the San Francisco Bay - Delta longfin smelt did not qualify as a distinct population segment (DPS). The USFWS initiated another 12-month status review and published its finding on April 3, 2012. This latest review found that the San Francisco Bay population merited protection and advanced it to candidacy. Final listing is not likely to occur for several or more years. New federal dredging regulations (resulting from USFWS consultation with USACE) will not be forthcoming until listing occurs, though new regulations under CESA are a possibility. No longfin smelt have been encountered during fish community or entrainment monitoring since 2008.

The annual monitoring report is submitted to USACE and CDFW as required. The details of any encounters with ESA-listed fish are reported within 24-hours to the Environmental Scientist of the Sacramento District of USACE and the Project Manager at RISG; subsequent notifications are then made by USACE to the regulatory agencies of NMFS, USFWS, and/or CDFW. Additional requirements include reporting of monitoring activities and ESA fish encountered on a weekly basis to the ESA Reporting Website of IEP, a requirement for research projects conducted in the SF Bay - Delta region (CDFG 2008a), and weekly reporting of delta smelt encounters to USFWS. Resource agencies (including NMFS, USFWS and CDFW) may access the IEP database for updated ESA catch reports. The license and revenue branch of CDFW requires an annual collection summary for review and renewal of state scientific collecting permits (SCP) and 2081(a) MOU's held by the investigative biologists conducting the fish monitoring. The SCP collections summaries are submitted to CDFW prior to the renewal of permits. CDFW also requires reporting of all state Endangered, Threatened and Special Concern species to the California Natural Diversity Database (CNDDB). All longfin smelt (California Code of Regulations - Longfin Smelt 2084 Regulation) and sturgeon encounter data are sent to biologists at the Bay - Delta Branch of CDFW as detailed in specific measures of SCP.

This report describes fish species encountered at each dredging location and compares sites based on simple assessments of catch per unit effort (CPUE), species composition, and overall numbers of fish. Although species that do not have special status under federal and state law (ESA and CESA) are outside the monitoring requirements for dredging in the SRDWSC and SDWSC, the monitoring methods yield information on these species as well. Since species status determinations are ongoing and any changes in status could affect dredging and monitoring activities, this report includes data on all species encountered. Comparisons with data from previous years are made when cogent and when sufficient data are available. This report also discusses the efficacy of the monitoring methods, efforts to minimize mortality during fish community monitoring, adaptive management measures employed and suggestions for future monitoring.

3 Methods

3.1 Monitoring Methods Overview

The monitoring methods followed for entrainment and fish community monitoring during the 2012 SRDWSC and SDWSC maintenance dredging season are described in the Fish Monitoring and Water Quality Plan (FMP), (MEC and NAS, 2011). The methods were developed based on their appropriateness for monitoring the maintenance dredging locations (i.e., dredging in deepwater mid-channel locations with water column depths greater than 20 feet), the ability to avoid dredge shutdowns, and the ability to monitor the entirety of the dredge's output during entrainment monitoring.

The methods were:

- Bottom trawling against the current, to monitor the fish community in the active dredge area of the shipping channels (the channel bottom), with water quality parameters measured in conjunction with bottom trawling.
- Entrainment monitoring (end of pipe) using the mobile entrainment monitoring screen (screen).

Timing of 2012 dredging operations did not extend beyond the originally approved work window (December 1 in the SRDWSC and December 31 in the SDWSC). As a result, observational monitoring 24 hours a day aboard the dredge was not required as it was in 2006 and 2007.

All fish encountered while conducting fish community or entrainment monitoring, with some exceptions, were counted and identified to the species level. Fish were identified, counted, and classified by life history stage. Fish length measurements were made for all species, though, among the more abundant species, only of subset of the individuals were measured for length. As many individual fish as possible were released back to the water to minimize harm. Stressed fish, or fish species easily injured by handling, were quickly counted and released without further processing. Gross body abnormalities, injuries, fin clips, or other markings were noted. Fish are sometimes required to be vouchered for further analysis. Osmerids and lampreys have been vouchered in previous years, though no fish were vouchered in 2012. These and other species may be required to be kept for further analysis in the future.

Invertebrates were, in most cases, identified to species level. Abundance of each species was determined by directly counting individuals or was estimated in the case of clams and shrimp. Estimation of abundance for clams and shrimp, rather than direct counts, is necessary due to high abundance and lack of need for greater accuracy.

Fish-eating bird and sea lion activity was closely observed while monitoring during daylight hours. Bird congregations over open water often indicate fish presence, and feeding activity by birds at DMP sites is often an indicator of the presence of entrained fish or other prey organisms. Sea lion presence indicates that large fish such as adult salmon, carp or catfish are present. The prey of the sea lions can sometimes be determined through visual observation and or by finding halves of fish while fish community monitoring, an infrequent but not uncommon occurrence near the Port of Stockton.

3.2 Monitoring Effort, Timing, and Locations

An overview map of the project area including the monitoring locations associated with each dredge reach is provided in Figure 1. Prior to the 2012 dredge season, Vortex provided MEC with a tentative dredging schedule. The schedule included the approximate timing and location of each channel location (dredge reach) to be dredged. Monitoring was conducted during every day of active dredging. In general, fish community and entrainment monitoring were conducted on alternating days. Due to inherent uncertainty regarding the exact timing of active dredging, fish community monitoring was initiated within 24-hours of when active dredging actually commenced. Entrainment monitoring was usually conducted on the second day of dredging at each dredge reach. Both types of monitoring were conducted at all dredge reaches in 2012. Location and timing of dredging and dredged volumes are summarized in Table 1.

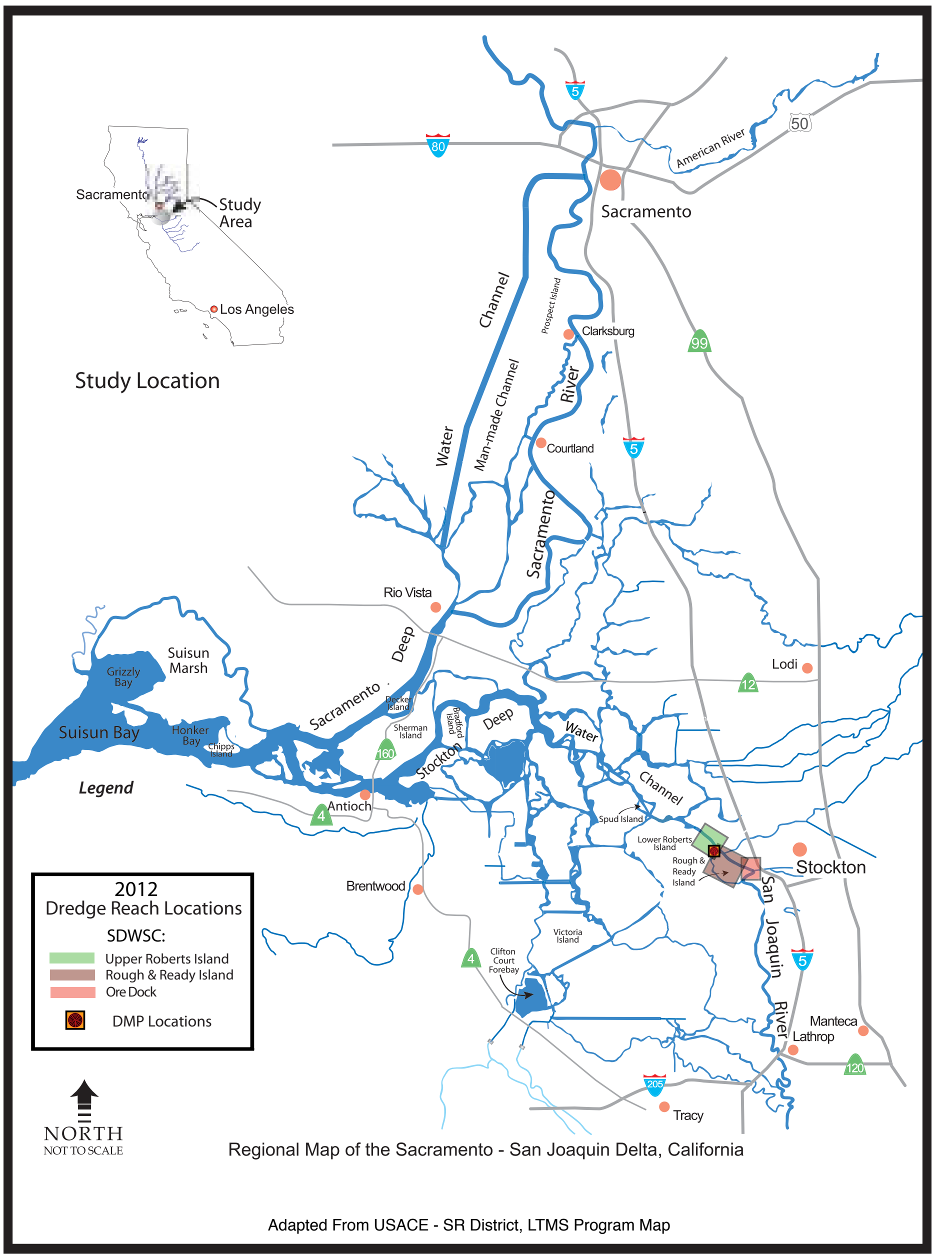

Figure 1. Project area map depicting DR locations and DMP site

Table 1. 2012 maintenance dredge reaches — Roberts 1 DMP

Dredge Reach	From (RM)	To (RM)	Excavated Dry Material (cy)	Est. % Material in Slurry	Est. Total Slurry Vol. (gal)	Start	End
Rough and Ready	38.64	39.20	21,979	10	44,391,871	3 Nov	12 Nov
Ore Dock *	39.68	40.06	82,340	10	166,305,413	13 Nov 26 Nov	19 Nov 8 Dec
Upper Roberts	36.84	37.78	7,600	10	15,350,026	9 Dec	10 Dec
TOTAL			**111,919**		**226,047,310**		

* Time break in Ore Dock operations due to dredging work for Port of Stockton.
NOTE: Rough and Ready amount included 16,879 cy plus Port of Stockton's 2 foot over-dredge for a total of 21,979 cy of excavated dry material.

As listed in Table 1, a total of approximately 111,919 cubic yards (dry) of dredged material was placed at DMP sites in 2012. All material was dredged using Vortex's dredge *Veracious*, a hydraulic cutter-head suction dredge with an 16-inch (inside diameter) discharge pipe. The total estimated overall slurry output from the dredge was 226,047,310 gallons. The approximate average pumping rate varied by reach location from 9,275 gallons per minute (gpm) at the Rough and Ready Island dredge reach to 12,350 gpm for both Ore Dock and Upper Roberts reaches.

The methods defined in the FMP were designed to monitor during as many diel/tidal regimes as possible. Consequently, monitoring times varied so that diurnal fish movements, as well as tidal elevation and river flow changes, would be reflected in the monitoring results. Given the relatively few monitoring events at each reach during each dredging season, it is not possible to capture a great deal of the possible variation that may occur. A randomized monitoring design was not employed since it was necessary for entrainment monitoring to coincide with active dredging. During 2012, more entrainment monitoring was conducted during low light conditions (nighttime) than has been done in previous years, due to a dramatic increase in ship traffic to and from the Port of Stockton (POS). Exact figures for numbers of ships were not obtained from POS, but shipping traffic appeared to increase from approximately one ship every other day during previous year's monitoring efforts, to approximately two ships per day during 2012 monitoring. Much of this traffic occurred during daylight hours. The dredge ceased operations and moved to the side of the channel when a ship was transiting the area. Typically, dredge shutdowns for ships last several hours, as the dredge tends to get out of the ship's way significantly before the ship transits by the dredge's location. This is done so that there is no chance that the dredge, pipe, or the dredge's tugs, cranes, and tenders are in the way of the ship as it goes by. After a ship passes, it usually takes 15 to 30 minutes before the dredge moves back into position and resumes digging. Of course, no entrainment monitoring may occur unless the dredge is working, so the timing of the individual monitoring events was constrained by the ship traffic in 2012 to a much greater degree than it has been in previous years. Timing of the fish community monitoring is also constrained by ship traffic, though to a much lesser extent than entrainment monitoring. The research vessel is highly maneuverable, and typically only needs a few minutes to get out of the way of a transiting ship. So as usual, timing of the 2012 fish community monitoring efforts was not largely affected by ship traffic.

All of the entrainment monitoring efforts at the Rough and Ready dredge reach were conducted during dusk or night. Forty percent of the entrainment monitoring at the Ore Dock reach was conducted during dusk or night, and the single event at Upper Roberts was at dusk. Forty-five percent of the fish community monitoring was conducted during dusk, and the other 55% was conducted during daylight.

Effort levels for 2012 are summarized by monitoring method and presented in Tables 2 and 3. These tables present the level of effort attempted, versus results achieved, during both entrainment and trawl monitoring. Entrainment monitoring was disrupted on several occasions in 2012, usually the result of unexpected dredge shutdowns or mechanical problems unrelated to monitoring activities. The monitoring goal described in the FMP is the assessment of 5-10% of the annual dredge output of slurry.

Table 2. 2012 entrainment monitoring effort by dredge reach — Roberts 1 DMP

Dredge Reach	Start	End	Monitoring Events	Monitoring Attempts	Material Type	Monitored Vol. (gal)	Dredged Slurry Vol. (gal)	Monitoring %
Rough and Ready	3 Nov	12 Nov	5	5	C	5,424,116	44,391,871	12.2
Ore Dock	15 Nov 27 Nov	19 Nov 8 Dec	10	10	B & C	11,344,915	166,305,413	6.8
Upper Roberts	9 Dec	9 Dec	1	1	C	1,720,972	15,350,026	11.2
TOTAL			**16**	**16**		**18,490,003**	**226,047,310**	**8.2**

* Time break in Ore Dock operations due to dredging work for Port of Stockton.
LEGEND: A = sandy; B = silty sand; C = mud.

Table 3. 2012 fish community monitoring effort by dredge reach — Roberts 1 DMP

Dredge Reach	Start	End	Monitoring Events	Trawls Attempted	Trawls Succeeded	Distance (m)
Rough and Ready	7 Nov	11 Nov	5	20	19	9,330
Ore Dock	13 Nov 26 Nov	18 Nov 8 Dec	10	40	33	16,010
Upper Roberts	10 Dec	10 Dec	1	5	5	2,360
TOTAL			**16**	**65**	**57**	**27,700**

* Time break in Ore Dock operations due to dredging work for Port of Stockton.

Fish community monitoring (trawl) locations within each dredge reach were either directly upriver of the dredge during an outgoing (ebb) tide or directly downriver during an incoming (flood) tide. Trawl surveys, DMP sites, and corresponding reaches are displayed in Sections 4.3.1 and 4.3.2 along with tabular descriptions of the fish encountered. Unsuccessful trawl tows, experienced during eight individual tows in two different reaches, were usually the result of large wood or other debris hung up in the net.

3.3 Entrainment Monitoring

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

- Avoid and minimize take (damage or mortality) to entrained fish, particularly special status species protected by ESA or CESA.
- Quantitatively monitor the dredge disposal stream, which is not uniform throughout the discharge pipe cross-section and thus requires monitoring of the entire dredge output during discrete monitoring periods.
- Avoid or minimize dredge shutdowns or head loss resulting from monitoring.

In 2008, the prototype mobile entrainment screen was completed and used at all DMP sites, except the Bradford and Decker Island (SRDWSC) sites where the entrainment cell method was used. Since 2009, all of the entrainment monitoring was conducted using the mobile entrainment screen. It is the intention of this program to use this device at all sites during future monitoring efforts, as this prototype has proven its efficacy during the past five monitoring seasons. However, there are DMP sites with access issues that may make it difficult to transport the screen to the site. If there are active sites in future years where the mobile entrainment screen cannot be used, then the entrainment cell method will again be utilized at these sites. Not utilized since 2008, the methods for entrainment cell monitoring are no longer presented in the annual reports. Interested parties can read the 2006-2008 annual fish monitoring reports (or earlier FMPs) for more information on this method (available by request of USACE - Sacramento District).

The mobile entrainment screen system addresses the goals stated above in the following ways:

- The grain size of the majority of the dredged material found in all Delta dredge reaches is small enough to pass through the screen while fish and invertebrates are retained.
- Organisms not apparently damaged by their passage through the dredge are easily collected and returned alive to the shipping channel.
- The entire output of the dredge is passed over the screen, effectively monitoring all cross-sections of the discharge pipe.
- Operating the valve that switches the dredge discharge from the main DMP pond to the screen does not normally require any action by the dredge, thus minimizing dredge shutdowns or dredge pump head loss resulting from monitoring.

3.3.1 Mobile Entrainment Screen

This was the fourth consecutive year that the mobile entrainment monitoring screen (screen) was used for entrainment monitoring at all DMP sites. The screen was built on trailer axles, enabling transport to the DMPs. Once on site, the screen was positioned in a stable location appropriate for discharge of the dredged material (Figure 2). The dredge output pipe was connected to the top of the screen with a Y-valve (Figure 3) operated by the on-shore (fill) crew of the dredge, or the project biologists when fill crew were not available. A new, pneumatically controlled y-valve was used for the first time in 2012. The new valve simplified switching the flow of material from the DMP to the screen, and back again. The screen is 24 feet long and six feet wide. The last four feet of the screen is a tailgate that is raised and lowered with a worm-drive winch operated by hand. The tailgate is lowered when the additional screen surface is not needed, and is raised when required. The metal mesh that makes up the filtering portion of the screen is made of 1/8th inch thick steel plate with 3/8th inch punched holes. The effective open area is approximately 51% of the overall surface area of the screen.

Figure 2. Mobile entrainment monitoring screen

Figure 3. Photograph of discharge pipeline y-valve

When the dredge output was not directed to the screen, it flowed directly to the DMP site pond. When in use, the slurry passed over the screen to allow sorting and observation of all entrained materials and organisms that did not pass through the screen. Trackhoes and bulldozers were used to clear material below the screen at DMP sites where necessary due to large grain size of material, lack of sufficient elevation for material flow, or other logistical considerations.

Each entrainment survey began by switching the Y-valve to direct the entire dredge discharge onto the screen. The length of time that the valve directed flow to the screen was used to calculate the monitored percentage of the dredge output. Two biologists trained in handling ESA-listed fish were stationed on either side of the screen to observe and collect entrained organisms as the slurry stream filtered through the screen mesh. Dredged material was allowed to flow over the screen until the screen clogged with material, the monitoring period expired, or the dredge itself shut down. Small pumps, with intakes in the river, supplied the screen with pressure water to wash the accumulated material and organisms that did not pass through the 3/8th inch diameter holes in the screen. Large rubber squeegees, small nets, and various rakes and shovels were also employed to sort the material and keep the screen clear, thereby allowing longer periods of continuous monitoring of the discharge stream without directing the flow back to the main DMP site. After the accumulated material was sorted, it was swept off the end of the screen. All fish retained by the screen were documented. Fish were collected, examined, measured, and then released back into the river.

The ability of the screen to pass dredged material through the mesh was dependent on the grain size of the dredged material. A general description of the dredged material found at each dredge location in 2012 is provided in Table 2. For the most part, the dredged sediments consisted of sand and silt sized particles. However, a high degree of overall variation in grain size, organic debris, and trash existed among dredge reaches as well as within each dredge reach. The commonly found “U” shape of the typical channel cross- section explains some of the sediment load variation experienced on the entrainment screen. To achieve target channel depth and width, the dredge may not have varied the height of the cutter-head as it swept across the bottom, effectively dredging deeper into material from each side of the channel than toward the center. This resulted in occasional pulses of heavier sediment loads on the screen corresponding to the dredge being near the side of the channel, interspersed with lighter sediment loads with more shells and debris from the surface of the channel-bed corresponding to the dredge having been in the center of the channel.

All of the material retained by the screen was sorted to find and document the entrained organisms. This process could be completed without diverting the material flow back to the main DMP area as long as the grain size was appropriate and the percentage of retained material to organisms was low. When this process could not be completed because the grain size was inappropriate or the percentage of retained organisms was high, as depicted in Figure 4, the valve was switched and flow was diverted back to the DMP site until the screen was cleared. Monitoring in low light conditions was accomplished by placing a large diesel powered light plant on top of the front section of the screen.

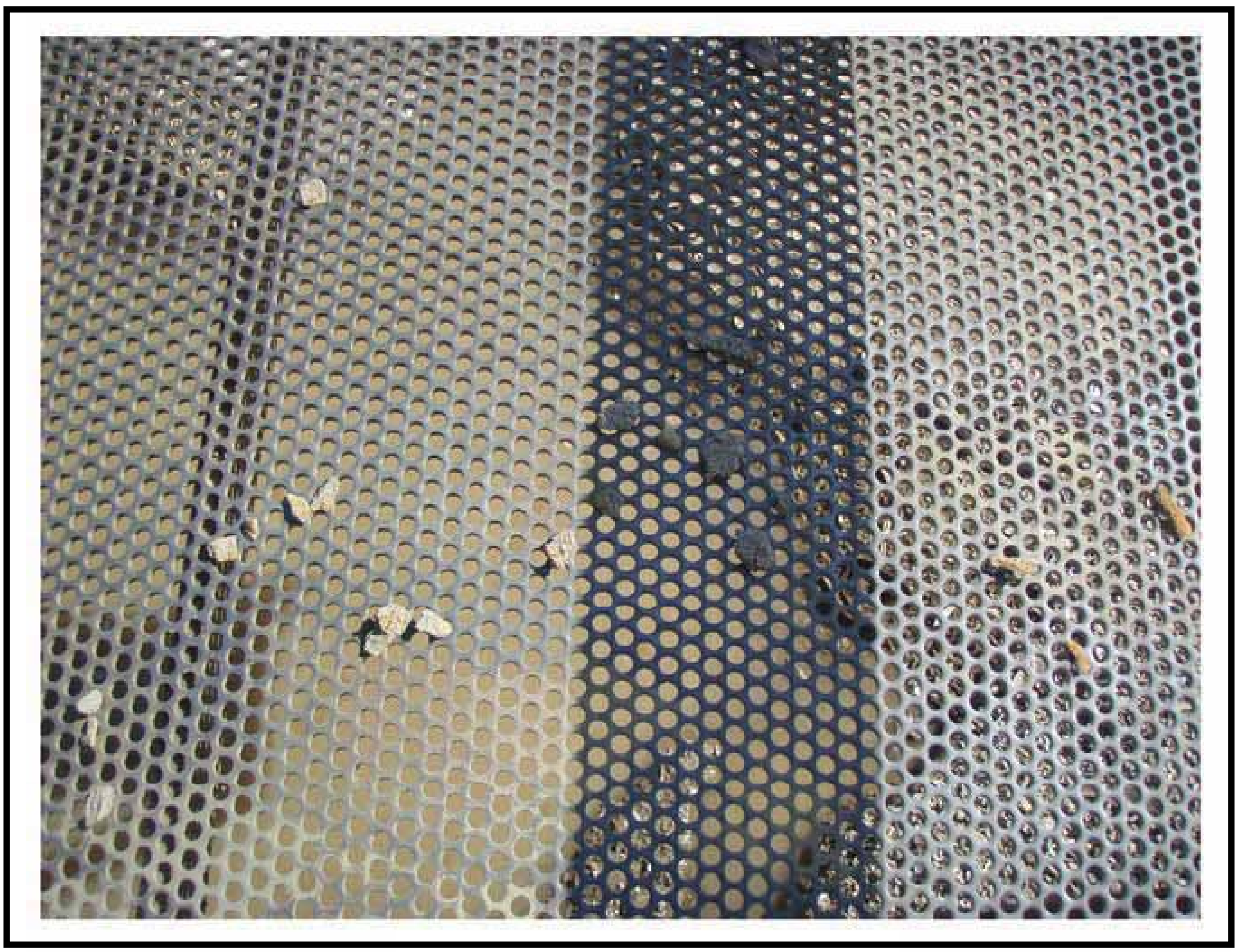

Figure 4. Metal mesh used for entrainment monitoring screen

There are vast shoals of Asian clams *(Corbicula fluminea)* in many locations in the SDWSC and SRDWSC, with wide variation in shell size and live to dead (empty shell) clam ratio. The screen retains all but the smallest of the shells. Many locations also have some larger grain size sediments in addition to the predominant sand or silt, ranging from pea gravel to large rock. Trash, bones, clay balls, golf balls, fishing gear and other items are among the things that do not pass through the screen. In 2009 and 2010, more so than in previous years, introduced Brazilian water weed *(Egeria densa)* was common among the material retained by the screen at some dredge reaches, though in 2011 and 2012, less *Egeria densa* was entrained, likely due to location differences. Figure 5 displays an image of shells and sediment retained by the screen.

Figure 5. Example of substrate debris

High dredge pumping rates occasionally overwhelmed the screen. This occurred more frequently when dredging was conducted very close to the DMP site, resulting in a short discharge pipe. When this occurred, it was usually only for a small but significant portion of time, during the dredge swing across the channel bottom. These overwhelmed periods were timed, and discounted from monitoring time, as any entrained organisms could have been carried off the end of the screen by the high flows and not be documented. Improvements suggested for the screen are provided in the recommendations section of this report.

3.4 Fish Community Monitoring

Fish community monitoring followed all relevant regulations and protocols to: ensure ESA and CESA compliance, prevent accidents, avoid in-channel obstructions, minimize mortality, and acquire high quality data. These practices are summarized below. In general, the trawling methods employed follow those described by O'Rear and Moyle (2009), utilized in the ongoing UC Davis Suisun Marsh fish monitoring program.

Required federal and state scientific research permits were obtained from CDFW and the IEP through IEP Program Element Number 2010-113. Prior to the onset of the 2012 dredge season, CDFW wardens were notified of the intended collection schedule and locations. Notification requirements for ESA-listed species contact followed those described in the FMP (MEC and NAS, 2011). These included weekly reporting through the IEP website, and would have included weekly reporting to USFWS and USACE to describe delta smelt encounters, had any occurred. Communication with the dredge was maintained during fish community monitoring events through use of VHF marine band radio or cell phone to ensure that the timing, methods, and location of trawling efforts did not hinder or compromise the dredge operations or endanger personnel. Other information exchanged included vessel traffic, tidal phase, and any other important details concerning the monitoring efforts. An additional VHF radio was used to monitor USCG and Vessel Traffic Information. The channel bottom in each dredge location was surveyed using sophisticated side and bottom scan sonar, and National Oceanographic and Atmospheric Administration (NOAA) based digital charts to attempt to identify and avoid potential obstructions that might foul the net, and to determine the best channel monitoring areas (areas devoid of hazards such as utility crossings).

Fish community monitoring was conducted up-current of the working dredge, in the main navigation channel. 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 7 meter long floating head-rope, a weighted foot-rope, and otter doors attached just ahead of the net mouth to spread the net (Figure 6). The mouth of the trawl net measured approximately 1.25 by 7.9 m with the body stretched; the body mesh of the net was 3.4 centimeters stretched, and the bag end was 3.1 cm stretched. The net had a 2 m long cod-end inner liner of 1 cm (stretched) mesh. The inner liner was composed of a soft nylon delta-style weave designed to be protective of fish scales and slime.

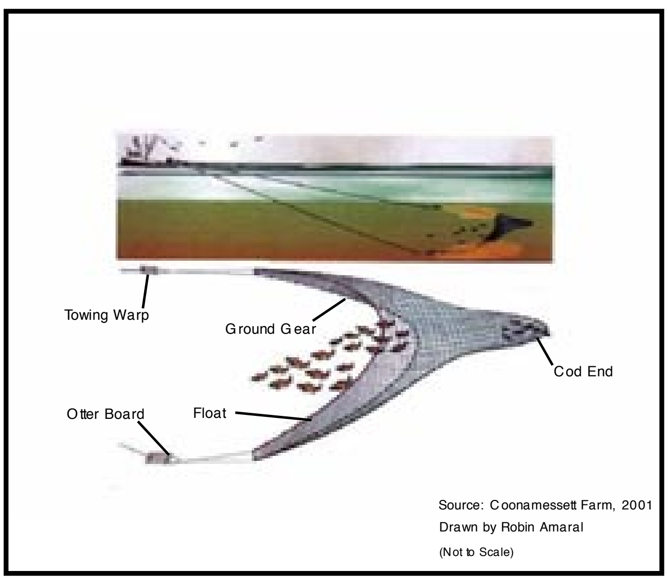

Figure 6. Otter trawl net diagram

The 27-foot-long RV *Karen M.*, a custom aluminum jet boat, was used to conduct the trawling operations (Figure 7). The *Karen M.* utilized an A-frame and davit equipped with electronic windlasses for net deployment and retrieval. The A-frame allowed the crew to deploy the net from the stern without the need to haul the otter doors in and out of the boat after each trawl replicate. Use of the A-frame resulted in fewer net twists, and increased control and speed of net deployment. A 275- foot-long bridle was used between the net and the vessel in order to achieve a minimum five-to-one scope (bridle length versus water depth) and help ensure that the otter trawl lead line stayed on the channel bottom while moving at efficient trawling speeds of 2.5 to 3 knots over ground. Typically, five replicate trawl tows (trawls) were conducted during each day of fish community monitoring. The direction (up- or down-river) of each individual trawl was determined by river direction (the flow was often upstream during incoming tides). Trawls were always conducted by towing into the direction of the current unless conducted at slack tide when no currents were perceptible. Trawls were started as close as safely possible to the dredge location, often within 50 meters or less of the working dredge. The net was towed along the channel bottom for approximately 500 meters from the starting point, as determined by a MacBook Pro portable computer running the latest version of MacENC software with a USB 20 channel SiRF III global positioning system (GPS) receiver that logged vessel position, track, bearing, speed over ground and speed over water, and other information. Vessel tracks and vessel location were displayed in real-time with a nautical chart (NOAA) overlay, aiding the operator in keeping the vessel in the desired position in the channel and continuously documenting the location, depth and timing of each trawl. GPS vessel tracking information provided accurate measurements of the length (meters) and time (minutes and seconds) of each trawl that the net was fished along the channel bottom; tracking from when the net encountered the bottom to when the tow stopped, prior to retrieval.

Figure 7. *Karen M.* research vessel

When beginning a trawl, the net was let out as rapidly as possible, only slowing it down enough to keep the doors from fouling on their way to the bottom. Vessel speeds when trawling were typically 2.5 to 3 knots speed over ground. The speed was frequently adjusted to trawl as fast as possible while maintaining contact with the bottom. The operator could feel the net drag on the bottom and adjusted the vessel speed accordingly. During retrieval, the vessel stopped and then backed up to the position of the net on the bottom while the bridle was hauled at first by hand, and then directly upward through the water column using the windlass. Hauling the net straight up through the water column at relatively slow speed compared to towing speed allowed the doors to come together, thus pinching the mouth of the net shut so that the net did not tend to collect fish on the way to the surface. These methods were employed to ensure collection of demersal species and minimize collection of pelagic fish (fish associated with the water column and the surface, rather than the bottom) to the maximum extent feasible when using a surface deployed otter trawl for benthic surveys. It typically took about 30 seconds to deploy the net and the individual trawls were from 5 to 10 minutes in duration depending on fish density and current velocity. Individual tows were shortened in areas of high fish density due to the desire to avoid large catches. Large catches can result in greater fish mortalities due to handling stress and increased retention times due to the need to document the catch. High current velocities typically resulted in longer duration tows as the tows were always up current and it took longer to tow the desired distance along the bottom than when currents were of lower velocity.

Following retrieval, the cod end of the net (the back of the net, where the fish collected) was brought to the side of the vessel by hauling on the cod end brailing line with the davit-mounted windlass. The brailing line extends from the port side otter door to a series of rings sewn into the front of the cod end. Hauling on the brailing line closes the cod end off from the rest of the net, trapping the fish. The cod end was then placed in a cooler filled with river water and the fish, invertebrates, and debris released into it (Figure 8). Large debris was removed and the catch was then quickly assessed. Assessment involved quick inspection and then rapid removal of the most fragile species to minimize mortality (e.g. special status fishes, shads, and striped bass). Data were then collected on all individual specimens of fish and macroinvertebrates, or on a subset of the catch, based on the number of individuals of each species encountered, their condition, and the desire to minimize mortality to the maximum extent possible. Collected data included: species, length, and any abnormal characteristics such as scars, tumors or parasites. Fish and invertebrates were then released back to the river a short distance away from the channel area where the trawls are conducted, to minimize re-sampling the same individual fish during consecutive tows. Bird and marine mammal presence was documented as well as ship activity. Analyses were made from "successful" trawls and only "successful" trawls were included in CPUE determinations. "Success" was defined as bottom tows with no net hang-ups, other gear related problems, or other problems that would diminish the usefulness of the data from an individual trawl.

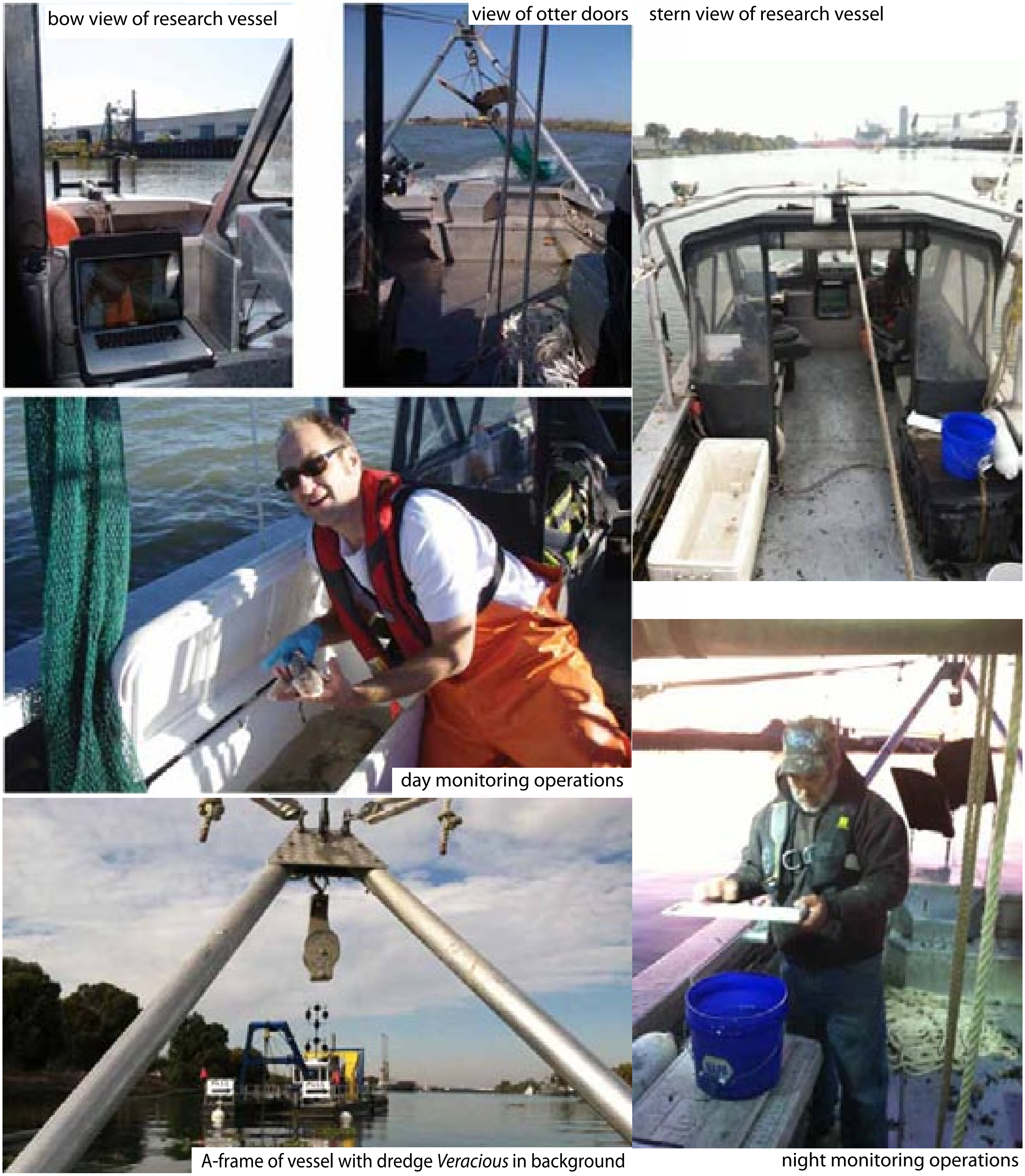

Figure 8. Examples of fish community monitoring tools and methods

In previous years, some ESA or CESA listed species (green sturgeon, longfin and delta smelt) were encountered. All green sturgeon were measured and then released alive. CDFG required vouchering of all osmerids through 2010, but dropped this requirement during 2011 operations. However, delta smelt typically die during processing and identification, resulting in vouchering of the dead listed fishes. During 2012, no protected species were encountered.

Additionally collected trawl data included: tow duration; date and time; monitoring depth; tidal phase; current speed and direction (upstream or downstream); boat speed and engine rpm; bird/sea lion presence; ship activity; and channel location. Water quality data were generally collected (upstream from the dredge) before the first and last replicate tow of each fish community survey. Water quality monitoring and methods are provided in Section 3.5.

Fish-eating bird and sea lion activity was observed and documented while monitoring during daylight events. Bird congregations over open water often indicated fish presence, and feeding activity by birds in DMP sites was often an indicator of the presence of entrained fish or other prey organisms. Sea lion presence can indicate the presence of adult salmon or other large fish such as catfish and carp that comprise sea lion's freshwater prey.

Trawl survey data was entered into the customized MS Access database running on a portable computer as the information was acquired. Large numbers of fish encountered during individual trawl tows required the use of paper specimen forms to document the catch (Appendix C), as the need to minimize fish mortality outweighed the need to document the data electronically. The specimen data was then entered into the database at a later date.

3.5 Water Quality Monitoring

In situ water quality data were collected from the surface and near bottom twice during each trawl survey event, generally prior to the first and after the final trawl replicates of the day. Water Quality parameters were obtained using a Horiba U-52 portable water quality meter (Figure 9). Parameters measured included water temperature, dissolved oxygen, pH, conductivity, turbidity, and salinity. Secchi depth was also measured at the surface. Water quality parameters were obtained within the same channel area as the trawl surveys.

Figure 9. Horiba U-52 multi-parameter portable water quality meter

Additional water quality data can be downloaded at the California Data Exchange Center (CDWR 2009) for Antioch, Rough and Ready Island and other areas in the Delta. Data on the website include river stage, pH, temperature, dissolved oxygen, conductivity, turbidity and other parameters taken on an hourly basis. Daily Delta outflow data is available from the U.S. Bureau of Reclamation: http://www.usbr.gov/mp/cvo/.

3.6 Reporting, Data Management, Quality Assurance and Quality Control

3.6.1 Entrainment Monitoring

Overall entrainment rates were estimated for each species by extrapolating from the numbers of entrained fish per gallon of dredge slurry monitored, to the total number of gallons of slurry deposited at each DMP site {(number of fish/gallon monitored) x (total number of gallons deposited) = total fish entrained}. Pumping rate and volume information were provided by Vortex. Conversion from dry dredged material amount to end of pipe slurry volume was made using the Vortex provided estimates. Deposited material comprised 10% of total slurry volume per reach (Tables 1 and 2).

Entrainment rates for individual species were extrapolated for each location where entrainment of that species occurred during 2012 monitoring. This data should be assessed cautiously considering the small percentage (8.18% in 2012) of the dredge output used to calculate the overall estimated entrainment rates. Confidence in estimated overall entrainment of fishes is higher at those DMP sites where more of the dredge's output was monitored relative to other sites.

3.6.2 Fish Community Monitoring

Relative population abundance by species was assessed by simply ranking each species based on numbers of individuals encountered for: each monitored location, each channel, and both channels combined. The CPUE was determined by comparing numbers of individual fish encountered to the distance trawled (number of fish of each species/meter). Mean CPUE was derived from the mean of all successful trawls conducted during each day of fish community monitoring. Table 3 provides the dates, locations, number of trawl reps. and distance trawled (total meters successfully trawled/dredge reach).

3.6.3 Mortality Estimation

Estimation of mortality during fish community monitoring is conducted and the results presented due to interest in documenting the "costs" of monitoring, and because the mortality estimation may prove useful for development of best management practices for hydraulic cutter-head dredging.

All entrained fish are "assumed mortalities" due to entrapment in the DMP sites. Fish observed during entrainment monitoring are released in the channel at the entrainment location after enumeration and observation. Their release disposition is noted and mortality is estimated for these fish as well.

Many types of fisheries monitoring methods result in mortality to some or all of the fish encountered. Monitoring mortality is weighed and justified from the standpoint of research need, government mandate, ability to obtain permits, and species conservation measures, as well as cultural and ethical considerations. The investigators that conduct this monitoring program seek to minimize mortality wherever and whenever possible, and have in some cases decided to reduce the amount of data gathered based on the desire to minimize mortality to non-target species. Data gathered by this monitoring study on non-special status species may prove useful to this and other studies. However, in large part, this data is not central to the requirement to conduct the monitoring. The monitoring mandate is related to a very small subset of the species encountered, due to (and required by) their current rarity in the project area.

This monitoring program continually requires a compromise between gathering more data and increasing the mortality of encountered fish by delaying their release. The investigators addressed this during community monitoring by sorting the catch based on data needs, data availability from this and other studies, and interspecies variability in survival rate. The result was that the field biologists immediately removed and returned to the river (without measuring) most striped bass, American shad, threadfin shad, and channel and white catfish. In the case of the catfish, the field biologists continued to gather ample data on a subset of these abundant introduced fishes. In the case of the other fishes that exhibited high handling stress, only a quick return to the river helped minimize mortality. During 2012 and previous years, no rare and or special status species (if not vouchered) was ever returned to the river without acquiring length measurements and making other observations. Mortality was estimated by directly counting dead fish prior to and after release.

Mortality among fish encountered during community and entrainment monitoring was calculated by comparing the observed or estimated mortality for each species to the total number of individuals of that species that were encountered. 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, predation or stress. In past years, a small number of fish were vouchered for further examination, resulting in immediate mortality of these individuals, though no fish were vouchered in 2012. During entrainment monitoring, all fish that were collected were placed in water filled buckets so that they could be held for later measurement. Mortality was assessed at the end of the end of each monitoring event after the fish were measured.

3.6.4 Data Management

Data were documented in the field directly into the Dredge Monitoring Database created with MS Access 2003 (upgraded in 2009 to MS Access 2007) using portable computers. Paper data sheets were used when time was of the essence, such as in collection of specimen data during trawls. Data from paper date sheets was then later entered into the database. This 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 a common framework for 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 analytical tools to assess the data based on CPUE, species composition, and overall number of fish.

3.6.5 Quality Assurance and Quality Control

The MS Access database designed for this project provides structured data entry forms for consistent data collection on laptop computers used in the field. These entry forms restrict the type of information being entered into the database through focused user inputs and menus. In addition to focused inputs and menus to control data entry, MS 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. Regular database backups were made to an external computer storage drive and copied to an additional project computer to further ensure integrity of collected data. Field crews were trained in the use of data collection forms before monitoring was carried out. Waterproof paper data collection forms continued in use for data verification purposes, foul weather/rough conditions, and for efficiency reasons in the case of specimen data collection. During 2012, approximately 6% of the physical and water quality survey information was collected on paper forms providing a means to directly cross check duplicate data inputs. No data transcription errors were identified. Field crews made daily checks of the database to ensure accurate collection when redundant paper copies were not collected. Project biologists responsible for collecting the data re-checked and verified the database outputs.

As in past years, specimen data from each monitoring event (species, length, anomalies, developmental stage, and disposition) were collected on waterproof paper field forms, because rapid data collection was often required when large numbers of fish and invertebrates were encountered in wet/dusty conditions. These data were later entered into the MS Access database.

Individual trawl replicates that had few specimens were entered directly into the database and checked for accuracy prior to leaving the survey location. Sample paper data entry and database forms are presented in Appendix C. Original field data sheets are archived at the MEC office in Canby, Oregon.

Vessel location of each trawl tow was logged at 15-second intervals using GPS and a portable Macintosh computer running MacENC navigation software (V 7.4). The start and stop times and distance of individual vessel tracks were directly recorded into the MS Access database to document trawl distance and duration. The vessel tracks were checked to ensure accuracy and identify anomalies that could skew the data. Vessel tracks are documented in this report using MacENC GPX-NavX software to display the tracks overlaid on NOAA navigation charts. In conjunction with this report, KML-formatted files from Google Earth are available from the Sacramento District of USACE that provide an interactive display of the 2012 trawl survey locations and DMP sites using satellite imagery.

4 Results

4.1 Fish

A total of 2,653 individual fish of 15 different species were encountered and identified during the fish community and entrainment monitoring events conducted during 2012 maintenance dredging (Table 4). Seven fish species were encountered during entrainment monitoring (Table 5) and all of these species were also encountered during fish community monitoring. Entrained fish accounted for only 0.9% (n = 24) of the fish encountered during 2012 monitoring, down from 6.8% in 2011. The entrained fish were encountered while monitoring 8.18% of the slurry in 2012, down slightly from the 8.34% monitored in 2011.

Table 4. Ranked list of fish encountered at all 2012 sites during fish community and entrainment monitoring

Rank	Percent	No.	Common Name	Genus	Species Name	Origin	Demersal or Pelagic	Rule: Status
1	34.8	924	striped bass	*Morone*	*saxatilis*	Introduced	Pelagic	
2	27.7	735	threadfin shad	*Dorosoma*	*petenense*	Introduced	Pelagic	
3	21.9	582	white catfish	*Ameiurus*	*catus*	Introduced	Demersal	
4	8.4	222	American shad	*Alosa*	*sapidissima*	Introduced	Pelagic	
5	3.4	90	channel catfish	*Ictalurus*	*punctatus*	Introduced	Demersal	
6	1.2	33	Sacramento splittail	*Pogonichthys*	*macrolepidotus*	Native	Pelagic	AFS: VU, CDFW: SSC, IUCN: EN
7	0.6	15	bluegill	*Lepomis*	*macrochirus*	Introduced	Pelagic	
8	0.8	20	shimofuri goby	*Tridentiger*	*bifasciatus*	Introduced	Demersal	
9	0.3	9	prickly sculpin	*Cottus*	*asper*	Native	Demersal	
10	0.3	8	redear sunfish	*Lepomis*	*microlophus*	Introduced	Pelagic	
11	0.2	4	warmouth	*Lepomis*	*gulosus*	Introduced	Pelagic	
11	0.2	4	brown bullhead	*Ameiurus*	*nebulosus*	Introduced	Demersal	
12	0.1	3	yellowfin goby	*Acanthogobius*	*flavimanus*	Introduced	Demersal	
13	0.1	2	blue catfish	*Ictalurus*	*furcatus*	Introduced	Demersal	
13	0.1	2	bigscale logperch	*Percina*	*macrolepida*	Introduced	Demersal	
TOTAL		**2,653**						

Percent Native = 1.5   Number Native Species = 2   Introduced Species = 13

NOTE: Total numbers include 1 striped bass, 1 shimofuri goby and 1 American shad dead prior to encountering gear, while 2 threadfin, 1 white catfish and 1 shimofuri goby were injured prior to encounter and capture disposition for 1 threadfin shad could not be determined.

Status Key (IUCN 2011. IUCN Red List of Threatened Species. Version 2011.2. <www.iucnredlist.org>. Downloaded 8 March 2012.)

AFS: American Fisheries Society	TH Threatened; VU vulnerable, EN endangered
CDFW: California Dept. of Fish and Wildlife	SSC Species of Special Concern
IUCN: International Union for Conservation of Nature	EN Endangered; NT Near Threatened; LC Least Concern

Among the 15 fish species encountered, the only native fishes were Sacramento splittail (n = 33), and prickly sculpin (n = 9). Prickly sculpin were encountered during both fish community and entrainment monitoring in 2012. Sacramento splittail were only encountered during fish community monitoring in 2012, though they have been encountered during entrainment monitoring in previous years. Sacramento splittail were also the most commonly encountered native species in 2010.

Introduced species have been encountered far more frequently than native species during fish community and entrainment monitoring at almost all locations during all years of this study (2006-2012). The top five species encountered in 2012 were all introduced, and together comprised 96.2 % of the individual fish.

Comparisons between the fish encountered in the SDWSC and SRDWSC cannot be made for 2012, due to lack of dredging in SRDWSC locations. In previous years, SRDWSC and lower SDWSC reaches had higher percentages of native species than upper SDWSC reaches, while upper SDWSC reaches had the highest diversity of species overall. For 2012, comparisons are presented among SDWSC reaches monitored in 2012 and previous years.

No fish species were encountered in 2012 that have not been encountered during previous annual monitoring efforts. In 2011, an individual (half) of a Chinook salmon was encountered during fish community monitoring. This was the first encounter with Chinook, though not the first time that halves of large fish such as carp and catfish were encountered during fish community monitoring. In 2012, the front and rear half of a large hatchery fall-run Chinook was seen floating on the surface by the scientists while they were preparing to conduct a trawl, and the pieces were netted for closer examination (Figure 10). This fish, the Chinook encountered in 2011, and the halves of large fish previously encountered, showed evidence of having been preyed on by sea lions, who tear their prey in half in order to eat the internal organs when the fish are too large to swallow whole. Sea lions were frequently observed eating salmon and other species while monitoring in 2012.

Figure 10. Example of sea lion predation on Chinook salmon (lack of adipose fin indicates hatchery origin)

4.1.1 Special-status Species

Unlike previous years, no special status species were encountered in 2012. In previous years, delta smelt and green sturgeon have been encountered while monitoring in the SDWSC. River lamprey are not protected, but are considered to be imperiled. 2012 is the first year since monitoring commenced, during which no lamprey were encountered. Sacramento splittail are also not protected, though have twice been petitioned for listing under ESA. 2012 was the second consecutive year during which they were the most commonly encountered native species. The Chinook salmon encountered in 2012 was not counted as a monitoring or dredging take, as it was dead prior to being encountered and its carcass looked precisely like a salmon that had been torn in half by a sea lion. 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. Location and additional encounter information for listed species from all other years is provided in Table 23.

Starry flounder were not encountered during 2012, but were encountered in the SDWSC, as far upstream as the Port of Stockton during previous years. They have been commonly encountered in a variety of reaches in the SRDWSC as well. Starry flounder was the 17th most commonly encountered fish species in 2011. Starry flounder is a special-status species under the Magnuson-Stevens Fishery Conservation and Management Act, as an estuarine composite species with essential fish habitat within the project area as described in Amendment 11 of the Pacific Coast Groundfish Fisheries Management Plan (PFMC 1998).

4.2 Entrainment Monitoring

Entrainment monitoring in 2012 was again conducted solely with the mobile entrainment screen, the fourth year in which the screen was used at all locations. A total of 24 individual fish were encountered while monitoring. The monitored portion of the total dredge output was 6.8% at the Ore Dock reach, 12.2% at the Rough and Ready Island reach and 11.2 % and the Upper Roberts Island reach. The monitored portion averaged 8.18% among all reaches combined. Table 5 presents a ranked list of all fish encountered during 2012 entrainment monitoring, while Tables 6a-c present the ranked list of entrained fish segregated by individual dredge reach.

Table 5. Ranked list of fish encountered from all sites during 2012 entrainment monitoring

Rank	Percent	Number	Common Name	Genus	Species Name	Origin	Demersal or Pelagic
1	50.0	12	shimofuri goby	*Tridentiger*	*bifasciatus*	Introduced	Demersal
2	12.5	3	threadfin shad	*Dorosoma*	*petenense*	Introduced	Pelagic
2	12.5	3	prickly sculpin	*Cottus*	*asper*	Native	Demersal
3	8.3	2	striped bass	*Morone*	*saxatilis*	Introduced	Pelagic
3	8.3	2	channel catfish	*Ictalurus*	*punctatus*	Introduced	Demersal
4	4.2	1	brown bullhead	*Ameiurus*	*nebulosus*	Introduced	Demersal
4	4.2	1	American shad	*Alosa*	*sapidissima*	Introduced	Pelagic
TOTAL		**24**					
	Percent Native = 12.5			Number Native Species = 1		Introduced Species = 6	

NOTE: Total numbers include 1 striped bass dead prior to encounter and 1 threadfin shad whose capture disposition could not be determined.

Shimofuri goby were the most commonly encountered species in 2012, comprising 50% of the entrained individuals observed while monitoring. The other six species that were encountered in 2012 all occurred in low numbers, from one to three individuals. Shimofuri goby were also the most commonly entrained fish during the three prior years. In 2008, channel catfish and white catfish were first and second, while shimofuri goby were a distant seventh, comprising only 2.16% of all fish encountered. River lamprey have been among the top five species entrained in the SRDWSC and SDWSC since 2008. River lamprey comprised 5.40% of entrained individuals in 2008, 4.71% in 2009, 29.32% in 2010, and 9.33% in 2011, though none were encountered in 2012. Native species, such as river lamprey, delta smelt, white sturgeon, prickly sculpin and Pacific staghorn have been encountered while entrainment monitoring in the SDWSC in previous years. Delta smelt have been entrained in lower reaches of the SDWSC in previous years, though never in the upper reaches of the SDWSC where dredging occurred in 2012. A white sturgeon entrained in the SDWSC in 2011 was the first sturgeon observed since inception of entrainment monitoring.

4.2.1 Stockton Deep Water Shipping Channel Locations

Rough and Ready Dredge Reach and Roberts 1 Dredge Material Placement Site:

Since monitoring began in 2006, this section of the SDWSC (river mile 38.64-39.20) was dredged for the first time in 2009 and for the second time in 2012. Substrates from this dredge reach were primarily mud. Approximately 5,424,116 gallons or 12.2% of the total slurry volume dredged from this reach was monitored during the five entrainment monitoring events conducted between November 3, and November 12. Only two species of fish, white catfish and shimofuri goby were encountered during 2009 monitoring, while five species were encountered in 2012. All of the species encountered at this reach in 2012 have been previously encountered in nearby locations during previous monitoring efforts. Table 6a presents the numbers and species of fish encountered during 2012 entrainment monitoring at the Rough and Ready dredge reach.

Table 6a. Summary data for fish encountered during entrainment monitoring at Rough and Ready Island DR – Roberts 1 DMP

Rank	Percent	Number	Common Name	Origin
1	50.0	6	shimofuri goby	Introduced
2	16.7	2	threadfin shad	Introduced
2	16.7	2	channel catfish	Introduced
3	8.3	1	prickly sculpin	Native
3	8.3	1	American shad	Introduced
TOTAL		**12**		

Percent Native = 8.3 Number Native Species = 1 Introduced Species = 4

NOTE: Total numbers include 1 threadfin shad whose capture disposition could not be determined.

Ore Dock Dredge Reach and Roberts 1 Dredge Material Placement Site:

Dredging and monitoring has occurred in all or portions of this section of the SDWSC (RM 39.68 – 40.06) during all years since 2006, except 2009. Substrates from this dredge reach were primarily silty sand and mud. Approximately 11,344,915 gallons, or 6.8% of the total slurry volume dredged from this reach, was monitored during the ten entrainment monitoring events that were conducted between November 11-19, and November 26 through December 8. The fish encountered at this location in 2012 were among the more common of the species encountered there previously. Table 6b presents the numbers and species of fish encountered during 2012 entrainment monitoring at the Ore dock dredge reach.

Table 6b. Summary data for fish encountered during entrainment monitoring at Ore Dock DR – Roberts 1 DMP

Rank	Percent	Number	Common Name	Origin
1	42.9	3	shimofuri goby	Introduced
2	14.3	1	threadfin shad	Introduced
2	14.3	1	striped bass	Introduced
2	14.3	1	prickly sculpin	Native
2	14.3	1	brown bullhead	Introduced
TOTAL		**7**		

Percent Native = 14.3 Number Native Species = 1 Introduced Species = 4

NOTE: Total numbers include 1 striped bass dead prior to encountering gear.

Upper Roberts Dredge Reach and Roberts 1 Dredge Material Placement Site:

Dredging with required fish monitoring has occurred in portions of this section of the SDWSC (RM 36.84 - 37.78) during 2006, 2008, 2010, and 2012. Substrates from this dredge reach were primarily mud. Approximately 1,720,972 gallons or 11.2% of the total slurry volume dredged from this reach was monitored during the single entrainment monitoring event that was conducted on December 9. The fish encountered at this location in 2012 were among the more common of the previously encountered species. Table 6c presents the number and species of fish encountered during 2012 monitoring at the Upper Roberts dredge reach.

Table 6c. Summary data for fish encountered during entrainment monitoring at Upper Roberts DR – Roberts 1 DMP

Rank	Percent	Number	Common Name	Origin
1	60.0	3	shimofuri goby	Introduced
2	20.0	1	striped bass	Introduced
2	20.0	1	prickly sculpin	Native
TOTAL		**5**		

Percent Native = 20.0 Number Native Species = 1 Introduced Species = 2

Extrapolated entrainment totals for each species encountered in all 2012 dredge reaches are provided in Table 7. These extrapolations simply multiply the number of individuals of each species encountered in each dredge reach by the monitored proportion of material dredged in that reach. The totals were estimated without regard to the high likelihood of fish density patchiness throughout the length of each dredge reach; this method simply assumes that the fish density (or entrainment likelihood) for each species for the entire reach was the same as that in the sub-set of material monitored from that reach. Based on these extrapolations, an overall total of approximately 246 fish may have been entrained by dredging operations in 2012.

Table 7. Extrapolated results from all 2012 fish entrainment monitoring

DR:	**Rough and Ready**	**Ore Dock**	**Upper Roberts**	**Extrapolated**
Monitored %:	*12.2*	*6.8*	*11.2*	**Total Fish**
American shad	8	0	0	**8**
channel catfish	16	0	0	**16**
prickly sculpin	8	15	9	**32**
shimofuri goby	49	44	27	**120**
threadfin shad	16	15	0	**31**
brown bullhead	0	15	0	**15**
striped bass	0	15	9	**24**
TOTAL	**98**	**103**	**45**	**246**

NOTE: Shaded rows indicate introduced fish species; fish that were dead prior to encounter with dredge were not included as entrained fish.

4.3 Fish Community Monitoring

The following sub-sections describe the 2012 fish community monitoring results for the SDWSC overall, and by individual dredge reach. Table 8 presents the numbers and species of fish encountered during all 2012 fish community monitoring efforts.

Table 8. Ranked list of fish encountered at all sites during 2012 fish community monitoring

Rank	Percent	Number	Common Name	Genus	Species Name	Origin	Demersal or Pelagic
1	35.1	922	striped bass	*Morone*	*saxatilis*	Introduced	Pelagic
2	27.8	732	threadfin shad	*Dorosoma*	*petenense*	Introduced	Pelagic
3	22.1	582	white catfish	*Ameiurus*	*catus*	Introduced	Demersal
4	8.4	221	American shad	*Alosa*	*sapidissima*	Introduced	Pelagic
5	3.3	88	channel catfish	*Ictalurus*	*punctatus*	Introduced	Demersal
6	1.3	33	Sacramento splittail	*Pogonichthys*	*macrolepidotus*	Native	Pelagic
7	0.6	15	bluegill	*Lepomis*	*macrochirus*	Introduced	Pelagic
8	0.3	8	shimofuri goby	*Tridentiger*	*bifasciatus*	Introduced	Demersal
8	0.3	8	redear sunfish	*Lepomis*	*microlophus*	Introduced	Pelagic
9	0.2	6	prickly sculpin	*Cottus*	*asper*	Native	Demersal
10	0.2	4	warmouth	*Lepomis*	*gulosus*	Introduced	Pelagic
11	0.1	3	yellowfin goby	*Acanthogobius*	*flavimanus*	Introduced	Demersal
11	0.1	3	brown bullhead	*Ameiurus*	*nebulosus*	Introduced	Demersal
12	0.1	2	blue catfish	*Ictalurus*	*furcatus*	Introduced	Demersal
12	0.1	2	bigscale logperch	*Percina*	*macrolepida*	Introduced	Demersal
TOTAL		**2,629**					

Percent Native = 1.5 Number Native Species = 2 Introduced Species = 13

NOTE: Total numbers of specimens include 1 American shad and 1 shimofuri goby dead prior to encounter as well as 1 threadfin shad, 1 shimofuri goby and 1 white catfish injured prior to encounter with gear.

The fish species encountered during 2012 fish community monitoring of the three upper SDWSC dredge reaches were similar to those encountered in upper SDWSC reaches during previous years, though the relative abundance of the common species has changed among the years. The five most common species of fish encountered during fish community monitoring in the upper SDWSC since 2009 have been striped bass, white and channel catfish, and threadfin and American shad. Among the native species, Sacramento splittail, prickly sculpin, starry flounder and white sturgeon have been the most frequently encountered in previous years, though no sturgeon or starry flounder were encountered in 2012. The other commonly encountered species in the upper SDWSC include bluegill, warmouth and redear sunfish, yellowfin goby and brown bullhead. The only species rarely seen in the upper SDWSC that was encountered in 2012 was the blue catfish. Bigscale log perch, though not common, have been encountered nearly every year. They may in fact be more common than the data suggests, as they may be slipping through the meshes of the net, given their small size. Figure 11 provides images of some of the more commonly encountered species during 2012 and previous years fish community monitoring.

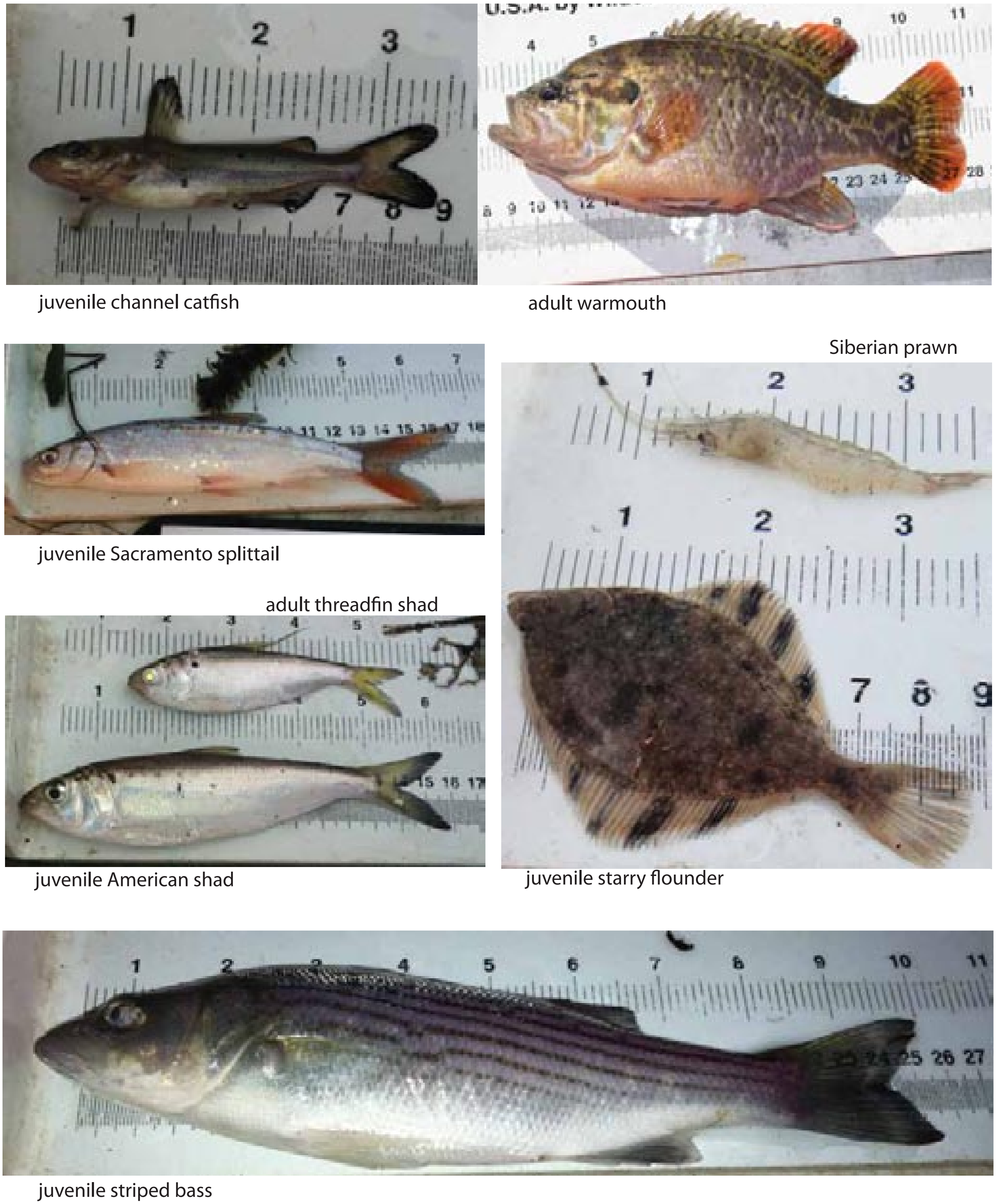

Figure 11. Examples of fish encountered during fish community monitoring in 2012 and previous years

Catch per unit effort (CPUE) for the fish community monitoring has been determined during all previous years of this monitoring effort as a means to compare the abundance of fish among reaches both within and between years. All species are lumped in this comparison, though the contribution of common species to the overall CPUE comparison among reaches is described in general terms and could be easily computed if interest warranted. Table 9 provides the 2012 summary of the catch and effort data, and Figure 12 provides a simple graphic depiction of the differences among CPUE for the 2012 reaches. Upper SDWSC reaches have always had the highest CPUE's among all of the reaches monitored each year. Though, as previously discussed, 2012 was the first year during which there was no dredging in the SRDWSC. This leaves little in the way of comparison for 2012 data, except for previous years. In that regard, 2012 CPUE's were similar to that of previous years from the same reaches. Upper SDWSC reaches are often dominated by large numbers of threadfin shad and white catfish. Very occasionally, the net has run into large, dense balls of white and channel catfish. This unpredictable occurrence of large numbers of catfish and threadfin shad has resulted in large increases in CPUE in upper SDWSC reaches relative to other locations.

Table 9. Summary catch and effort data for all fish encountered during 2012 fish community monitoring

Dredge Reach	CPUE Trawl Tows	CPUE Trawl Distance (m)	% Total Effort	No. of Fish	% Total Catch	CPUE (fish/m)
Rough and Ready	20	9,000	34.6	729	27.7	0.08
Ore Dock	40	14,650	56.3	1,412	53.7	0.10
Upper Roberts	5	2,360	9.1	488	18.6	0.21
TOTAL:	**65**	**26,010**	**100**	**2,629**	**100.0**	**0.10**

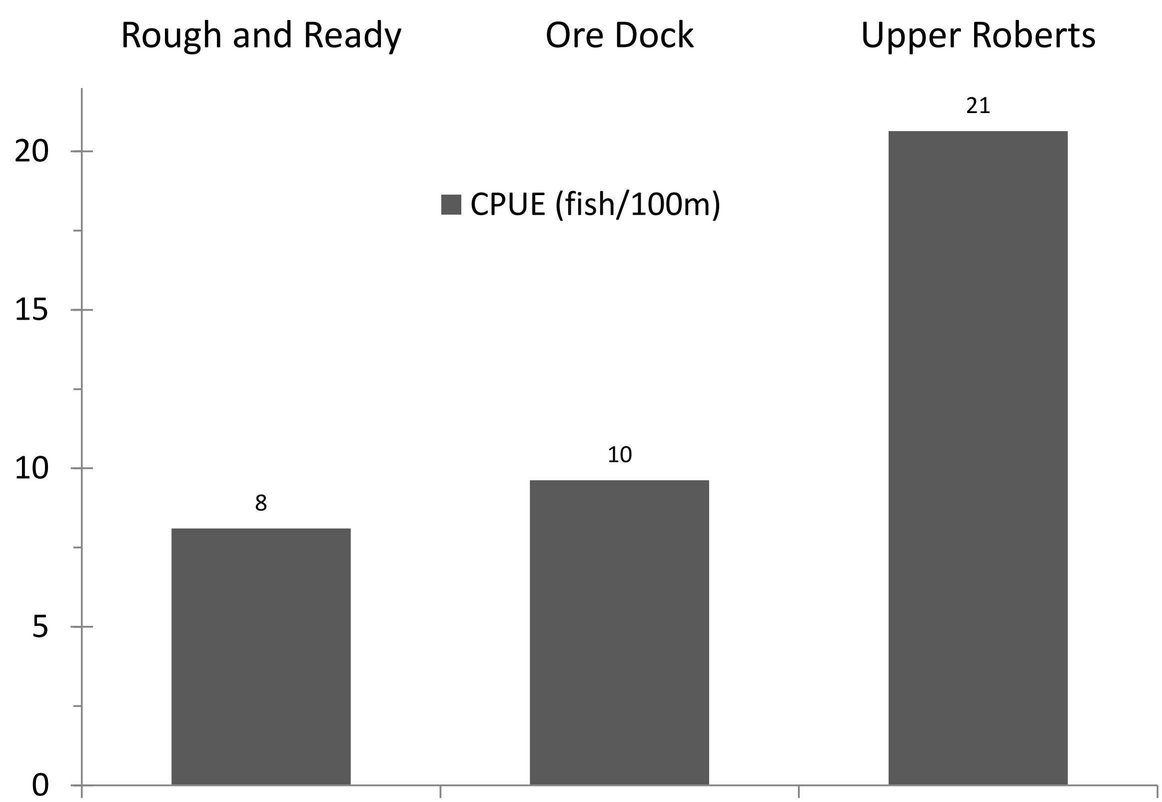

Figure 12. Mean CPUE for fish community monitoring at each 2012 dredge reach

4.3.1 Stockton Deep Water Shipping Channel Locations

Details of the species and individual fish encountered during 2012 fish community monitoring are described individually for each dredge reach. This data is presented in Table(s) 10a-c. The individual trawl tracks are presented in Figures 13-15 as dashed lines overlaid on an image of the NOAA nautical chart of the region.

Rough and Ready Dredge Reach and Roberts 1 Dredge Material Placement Site:

The Rough and Ready dredge reach had the lowest CPUE among the three reaches and was in the middle in terms of species diversity (n = 10). 34.6% of the total annual monitoring effort was expended at this reach. The was the only reach where Sacramento splittail comprised a significant portion of the fish encountered, though they have been encountered in locations throughout the SDWSC and SRSWSC in previous years. The blue catfish encountered at this reach in 2012 were unusual because they have only rarely been encountered during previous monitoring, and because they were much larger than those previously encountered.

Table 10a. Summary data for fish encountered during fish community monitoring at Rough and Ready Island DR – Roberts 1 DMP

Rank	Percent	Number	Common Name	Origin
1	43.5	317	striped bass	Introduced
2	32.6	238	threadfin shad	Introduced
3	8.8	64	channel catfish	Introduced
4	7.8	57	white catfish	Introduced
5	4.4	32	Sacramento splittail	Native
6	1.8	13	American shad	Introduced
7	0.4	3	warmouth	Introduced
8	0.3	2	redear sunfish	Introduced
8	0.3	2	blue catfish	Introduced
9	0.1	1	bluegill	Introduced
TOTAL		**729**		
	Percent Native = 4.4		Number Native Species = 1	Introduced Species = 9

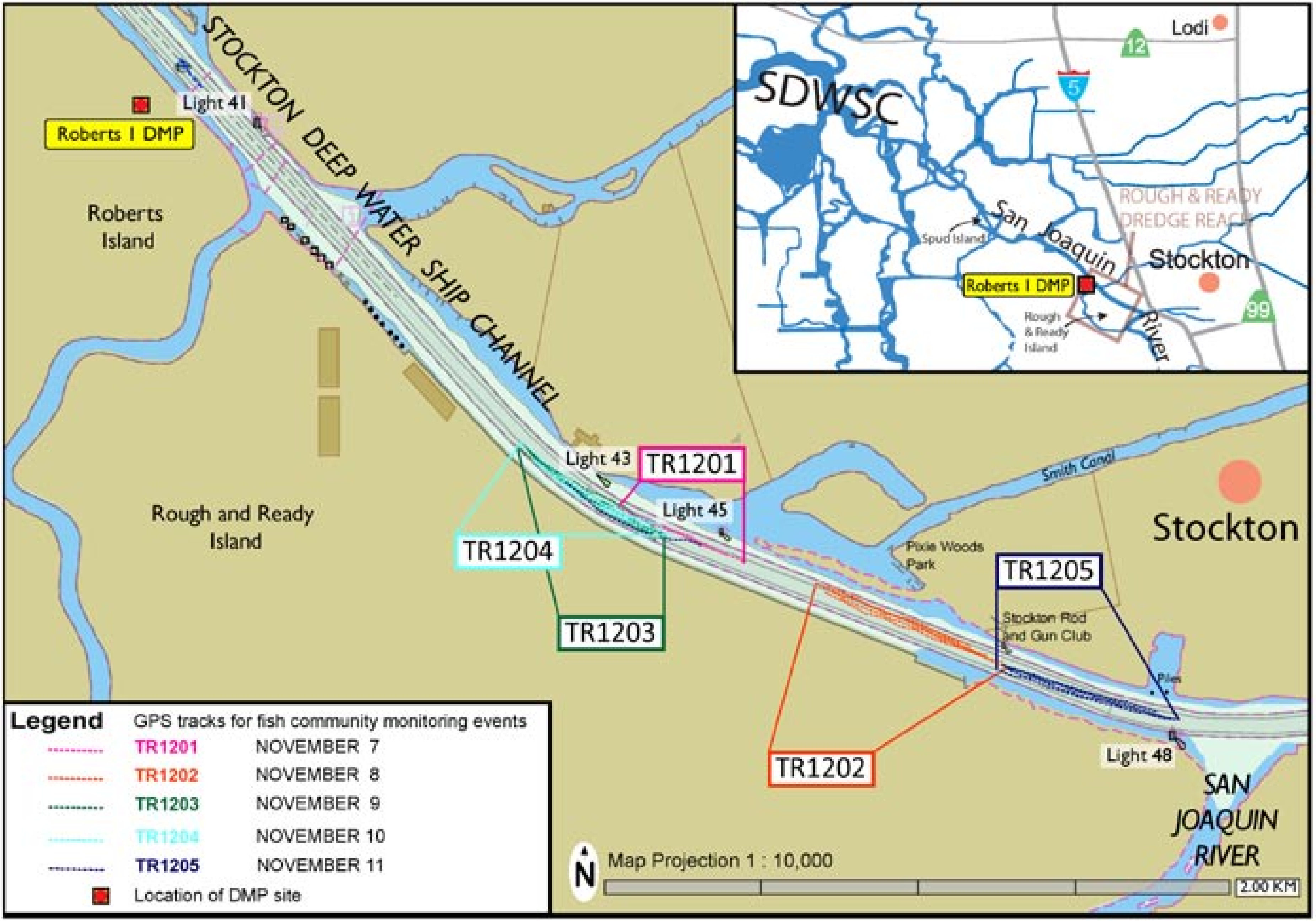

Figure 13. Fish community surveys at the Rough and Ready DR and Roberts 1 DMP

Ore Dock Dredge Reach and Roberts 1 Dredge Material Placement Site:

The Ore Dock dredge reach had a slightly greater CPUE than the Rough and Ready dredge reach. It also had the highest diversity of species among all three reaches (n = 13), and the greatest number of native species (n = 2). 56.3% of the annual monitoring effort was expended at this reach.

Table 10b. Summary data for fish encountered during fish community monitoring at Ore Dock DR – Roberts 1 DMP

Rank	Percent	Number	Common Name	Origin
1	41.6	587	striped bass	Introduced
2	35.0	494	threadfin shad	Introduced
3	14.7	208	American shad	Introduced
4	4.5	64	white catfish	Introduced
5	1.5	21	channel catfish	Introduced
6	1.0	14	bluegill	Introduced
7	0.5	7	shimofuri goby	Introduced
8	0.4	6	redear sunfish	Introduced
9	0.3	4	prickly sculpin	Native
10	0.2	3	brown bullhead	Introduced
11	0.1	2	yellowfin goby	Introduced
12	0.1	1	Sacramento splittail	Native
12	0.1	1	bigscale logperch	Introduced
TOTAL		**1412**		
	Percent Native = 0.4		Number Native Species = 2	Introduced Species = 11

NOTE: Total numbers of specimens include 1 American shad dead prior to encounter as well as 1 threadfin shad and 1 shimofuri goby injured prior to encounter.

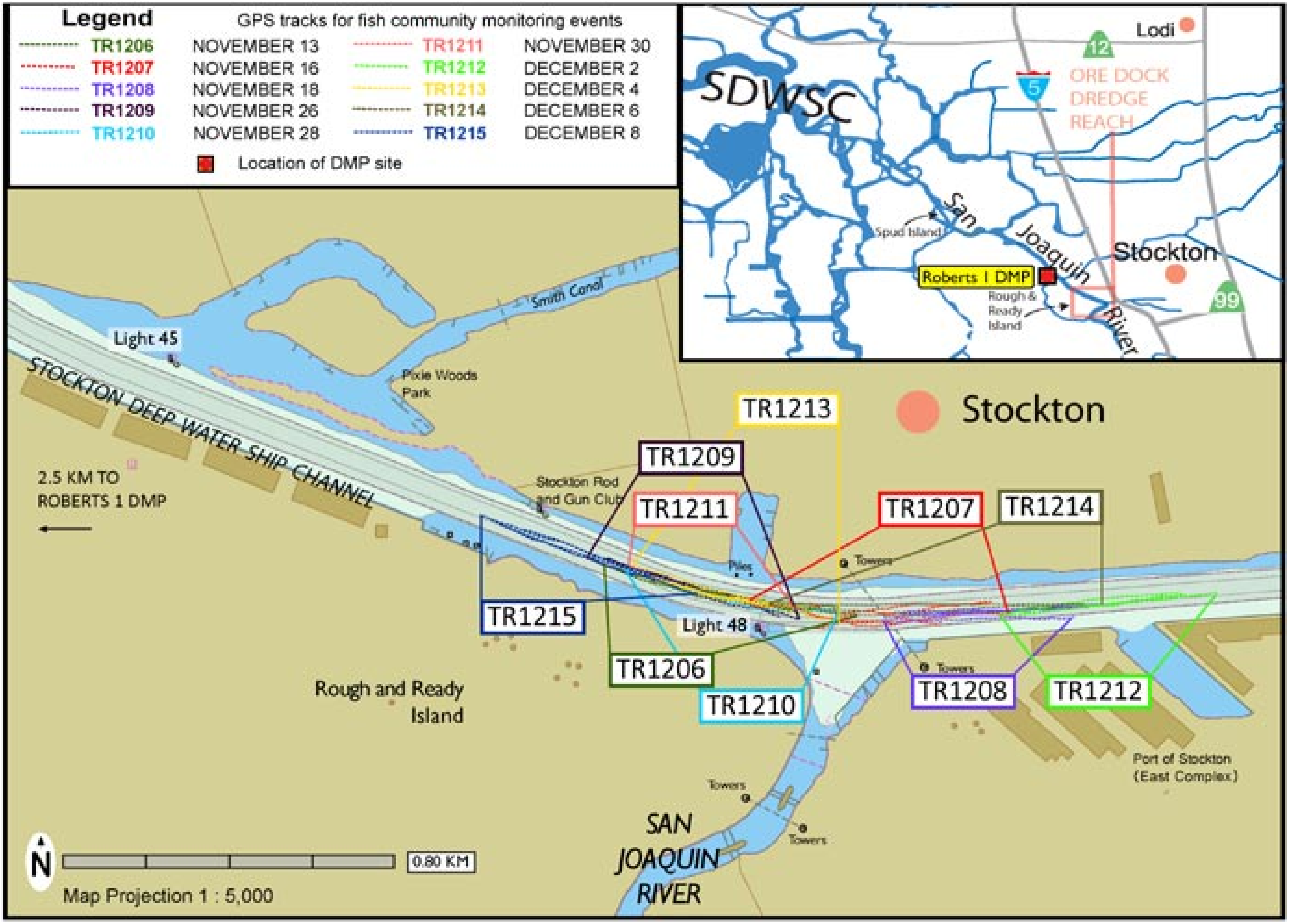

Figure 14. Fish community surveys at the Ore Dock DR and Roberts 1 DMP

Upper Roberts Dredge Reach and Roberts 1 Dredge Material Placement Site:

The Upper Roberts dredge reach had the highest CPUE of all 2012 reaches, though it also had the lowest species diversity, and was only represented by one day's monitoring effort due to the brevity of the dredging at this reach. Only 9.1% of the total annual monitoring effort was expended at this reach. This monitoring effort is also an example of the net running into a large dense group of white catfish, which comprised 94.5% of the individual fish encountered during the five individual trawls that were conducted. This density is far greater than that of any other single species at all 2012 reaches monitored.

Table 10c. Summary data for fish encountered during fish community monitoring at Upper Roberts DR – Roberts 1 DMP

Rank	Percent	Number	Common Name	Origin
1	94.5	461	white catfish	Introduced
2	3.7	18	striped bass	Introduced
3	0.6	3	channel catfish	Introduced
4	0.4	2	prickly sculpin	Native
5	0.2	1	yellowfin goby	Introduced
5	0.2	1	warmouth	Introduced
5	0.2	1	shimofuri goby	Introduced
5	0.2	1	bigscale logperch	Introduced
TOTAL		**488**		
	Percent Native = 0.4		Number Native Species = 1	Introduced Species = 7

NOTE: Total numbers of specimens include 1 shimofuri goby dead prior to encounter and 1 white catfish injured prior to encounter.

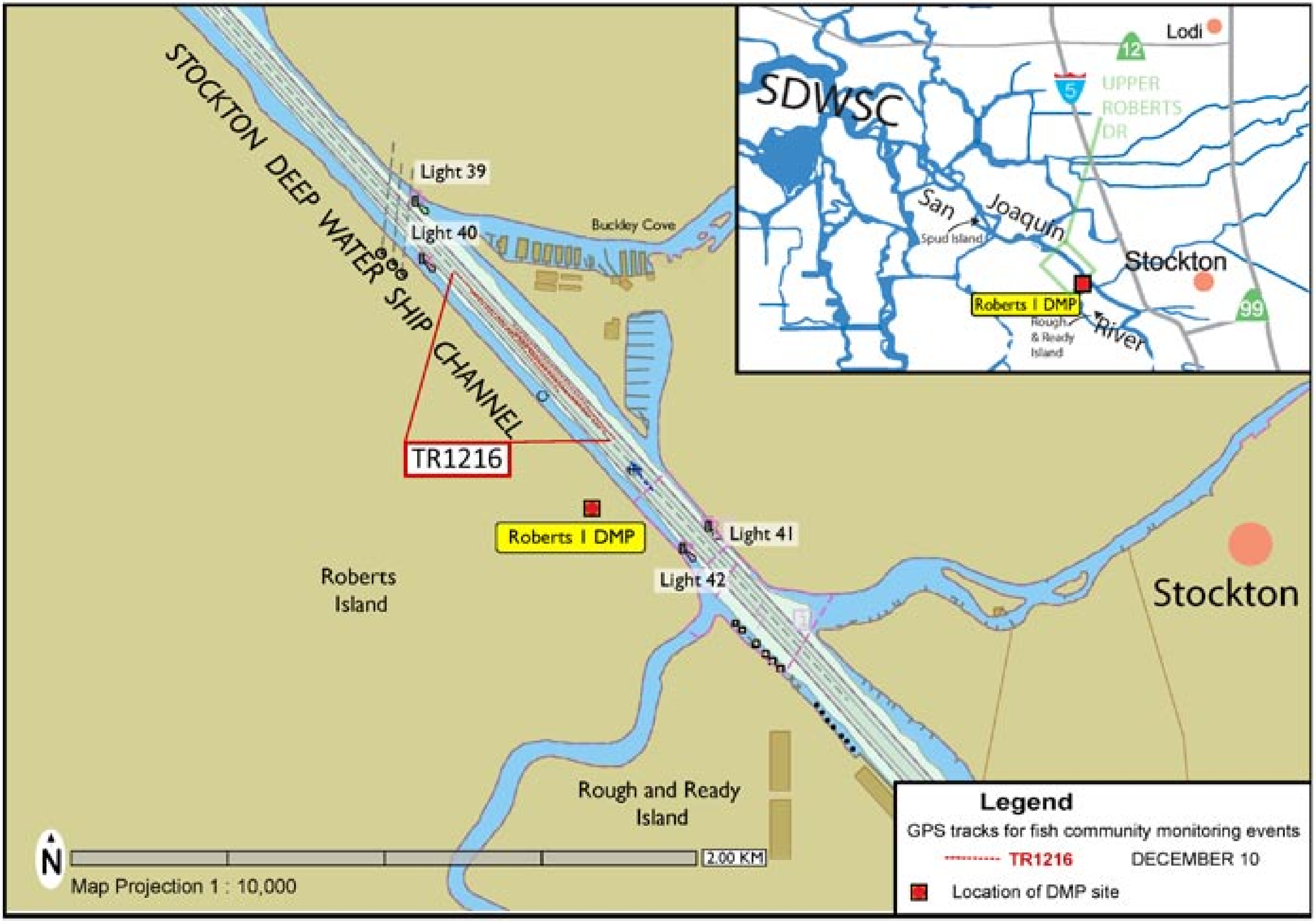

Figure 15. Fish community surveys at the Upper Roberts DR and Roberts 1 DMP

4.4 Fish Length

4.4.1 Entrainment Monitoring

Of the 24 individual fish that were observed in 2012 while entrainment monitoring, 22 were retained, examined, measured, and returned to the river. There were 2 fish that were visually identified to species but escaped collection over the end of the entrainment screen or through the screen mesh. These unmeasured fish were documented in the entrainment results. Figure 16 provides some images of fish encountered during 2012 and previous years monitoring. The summary length statistics for all entrained fish that were measured in 2012 is provided in Table 11. Overall, 91.7% of fish encountered during 2012 entrainment monitoring were measured prior to release.

Table 11. Summary length data for fish encountered during all 2012 entrainment monitoring

Common Name	Lifestage	Total Length Min (mm)	Total Length Max (mm)	SD of Mean	Mean Length (mm)	No. Measured	No. Captured	% Measured
Native								
prickly sculpin	Juvenile	51	72	11	63	3	3	100
Introduced								
American shad	Juvenile	76	76	--	76	1	1	100
brown bullhead	Juvenile	135	135	--	135	1	1	100
channel catfish	Juvenile	86	101	11	94	2	2	100
shimofuri goby	Adult	53	96	15	69	9	9	100
shimofuri goby	Juvenile	42	48	4	45	2	2	100
striped bass	Juvenile	102	102	--	102	1	1	100
threadfin shad	Juvenile	75	88	7	83	3	3	100

Figure 16. Examples of fish encountered during entrainment monitoring in 2012 and previous years

Table 12 provides the summary length statistics for all measured fish from 2012 trawl surveys. Overall, 1,882 fish out of 4,657 encountered (40.41%) were measured for total, standard, or fork length. Only five of the species encountered (American and threadfin shad, channel and white catfish and striped bass) were so abundant that not all individuals were measured. These species were sub-sampled to determine fish sizes while minimizing mortality by returning fish to the river as quickly as possible. Overall, 36.4% of the individual fish that were encountered while monitoring were measured.

Table 12. Summary length data for fish encountered during all 2012 fish community monitoring

Common Name	Lifestage	Total Length Min (mm)	Total Length Max (mm)	SD of Mean	Mean Length (mm)	No. Measured	No. Captured	% Measured
Native								
prickly sculpin	Adult	80	116	16	101	4	4	100
prickly sculpin	Juvenile	65	71	4	68	2	2	100
Sacramento splittail	Adult	225	275	13	251	26	26	100
Sacramento splittail	Juvenile	206	235	11	219	7	7	100
Introduced								
American shad	Juvenile	97	221	26	139	103	198	52.0
American shad	Smolt	230	340	29	266	23	23	100
bigscale logperch	Adult	109	110	1	110	2	2	100
blue catfish	Juvenile	216	240	17	228	2	2	100
bluegill	Adult	152	225	23	172	10	10	100
bluegill	Juvenile	46	62	7	58	5	5	100
brown bullhead	Adult	175	220	33	198	2	2	100
brown bullhead	Juvenile	120	120	--	120	1	1	100
channel catfish	Juvenile	79	298	63	172	76	88	86.4
redear sunfish	Adult	182	212	13	197	4	4	100
redear sunfish	Juvenile	141	166	11	152	4	4	100
shimofuri goby	Adult	54	103	16	76	8	8	100
striped bass	Adult	365	505	61	429	5	5	100
striped bass	Juvenile	13	348	50	148	290	917	31.6
threadfin shad	Adult	110	286	23	141	132	345	38.3
threadfin shad	Juvenile	77	117	9	104	132	387	34.1
warmouth	Adult	164	203	20	187	3	3	100
warmouth	Juvenile	151	151	--	151	1	1	100
white catfish	Adult	235	283	13	246	11	17	64.7
white catfish	Juvenile	53	230	48	157	101	565	17.9
yellowfin goby	Adult	135	183	25	156	3	3	100

NOTE: Percent measured results use lumped data from all lifestages in total number captured.

Figure 17 presents a comparison between the mean length of the entrained fish versus the fish encountered during fish community monitoring. This comparison has been presented in all of the recent annual reports, though, the dearth of data for entrained fish makes the comparison tenuous in 2012. The 2012 data is consistent with previous years, however. That is, for most species, the mean length of the fish encountered during fish community monitoring is longer than that of the same species of fish observed during entrainment monitoring, though the differences have been insignificant for most species during most years.

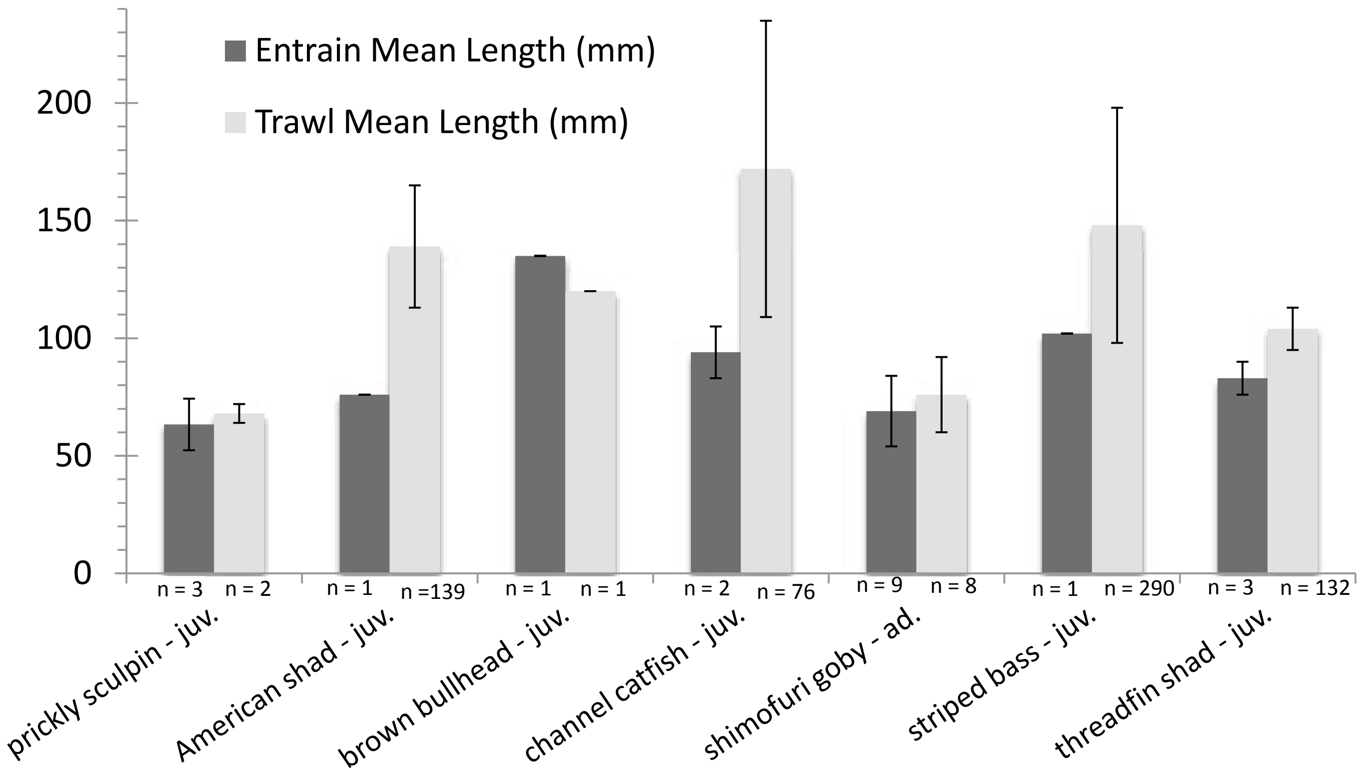

Figure 17. Mean size of fish species encountered by monitoring method

4.5 Invertebrates

Invertebrates have been encountered during both fish community and entrainment monitoring since project inception, though the monitoring methods employed were designed specifically for collection of fish. Information on the numbers and species of invertebrates encountered continues to be collected due to its potential utility in assessments of the indirect impacts of maintenance dredging in the shipping channels. A total of approximately 628,156 invertebrates were encountered during entrainment monitoring in 2012 and 5,619 were encountered during fish community monitoring. The numbers for most invertebrate species are estimates (as described in methods). These estimates are necessary due to the large numbers encountered and the practical need to focus on the primary project objective of monitoring fish.

As in previous years, the most commonly encountered species during both types of monitoring were Asian clams and Siberian prawns *(Exopalaeomon modestus)*, both introduced species. Leeches were encountered quite frequently during entrainment monitoring, but never during fish community monitoring, though this is not surprising given the methods. Large populations of clams and shrimp exist in many of the monitored locations. Thus, clams and shrimp are commonly retained by the entrainment screen and in the cod-end of the trawl net. In addition, clam shells persist in the channel sediments for many years after the clam dies, and frequently comprise a large percentage of the detritus left on the entrainment screen or mixed with the fish in the cod-end of the net.

Two species of crayfish, Signal crayfish, *Pacifasticus leniusculus* (native) and red swamp crayfish *Procambarus clarkii* (introduced) were again encountered, as they were each year since 2009.

The California floater *(Anodonta californiensis)*, a native freshwater mussel, was again encountered during the entrainment monitoring. This mussel species is a federal species of concern. The occurrence of the native mussels during the monitoring appears to coincide with fine, organic and detritus rich sediments.

One introduced mud snail *(Cipangopaludina japonica)* was entrained in 2012. This species has been encountered during previous years as well, though always in small numbers. Shells of native (but displaced) bivalves such as the bay mussel *(Mytilus edulus)* and the native oyster *(Ostreola conchaphila)* were occasionally found during the entrainment monitoring as well but are not enumerated. The probable source of these shells is transfer via ship bottom. Invertebrates encountered in 2012 are listed in Table 13 and Table 14 by respective monitoring type.

Table 13. Summary data for invertebrates encountered during all 2012 entrainment monitoring

Rank	Percent	Number	Common Name	Genus	Species	Origin
1	97.75	614,000	asian green clam	*Corbicula*	*fluminea*	Introduced
2	1.47	9,240	leech	Unknown	spp.	Unknown
3	0.45	2,805	siberian prawn	*Exopalaemon*	*modestus*	Introduced
4	0.17	1,058	California floater	*Anondonta*	*californiensis*	Native
5	0.17	1,050	dragonfly	Unknown	spp.	Native *
6	0.00	2	oligochaete worm	Unknown	spp.	Native *
7	0.00	1	mud snail	*Cipangopaludina*	*japonica*	Introduced
TOTAL		**628,156**				

Percent Native = 0.34 Number Native Species = 3 Introduced Species = 3

* Organisms not differentiated to determine origin; dragonfly larvae and oligochaete worms assumed native.

Table 14. Summary data for invertebrates encountered in all 2012 fish community monitoring

Rank	Percent	Number	Common Name	Genus	Species	Origin
1	66.88	3,758	asian green clam	*Corbicula*	*fluminea*	Introduced
2	32.78	1,842	siberian prawn	*Exopalaemon*	*modestus*	Introduced
3	0.23	13	California floater	*Anondonta*	*californiensis*	Native
4	0.09	5	red swamp crayfish	*Procambarus*	*clarkii*	Introduced
5	0.02	1	signal crayfish	*Pacifastacus*	*leniusculus*	Introduced
TOTAL		**5,619**				

Percent Native = 0.23 | Number Native Species = 1 | Introduced Species = 4

Far fewer invertebrates have been encountered while fish community monitoring than have been encountered during entrainment monitoring during 2012 and previous years, as might be expected. The ratio of clams to shrimp varies dramatically between monitoring methods. This makes sense given the inability of the clams to avoid the dredge, and the likelihood that the trawl under-samples clams relative to shrimp. Shrimp may be able to avoid the dredge, but also may be able to swim under the net or through the meshes. Clams are routinely caught by the trawl net, as they are just below the surface of the sediment, and the bottom of the net has a chain sewn into it that digs into the bottom a bit during portions of every trawling effort.

Total numbers of entrained invertebrates were extrapolated based on the number of organisms documented and the amount (gallons) of the total dredged material that was monitored. These numbers have not been converted into organisms per square meter (or other density measurement). The extrapolated numbers are in some cases very large. However, they describe the estimated number of entrained invertebrate organisms across the entire dredge reach. The extrapolated totals are provided in Table 15. This information is presented because indirect impacts of dredging are in part based on impacts to benthic ecology such as community disturbance and prey removal. These types of impacts could harm listed and other species. Though not directly addressed by this monitoring program, entrainment rates of invertebrates by dredge may be useful to assess indirect impacts. The introduced Asian green clam was the dominant taxon at all DMP sites. Asian clams accounted for 97.75% of the predicted total of entrained invertebrates, similar to 2011, though in 2011 and 2012, clams were more abundant relative to shrimp than they had been in previous years, possibly due to changes in abundance of Siberian prawns in 2011 and 2012.

Table 15. Extrapolated total of invertebrates entrained during 2012 by dredge reach — Roberts 1 DMP

DR:	Rough and Ready	Ore Dock	Upper Roberts	Overall Total
Monitored %:	*12.2*	*6.8*	*11.2*	**Invertebrates**
asian green clam	2,054,010	4,161,765	714,286	6,930,060
leech	46,236	48,382	2,679	97,297
Siberian prawn	21,686	1,176	670	23,532
dragonfly	8,224	294	223	8,742
California floater	4,755	4,971	1,241	10,966
oligochaete worm	0	29	0	29
mud snail	0	15	0	15
TOTAL	**2,134,910**	**4,216,632**	**719,098**	**7,070,641**

NOTE: Unshaded rows indicate native species

4.6 Bird and Marine Mammal Activity Observations

Observations of piscivorous birds were made at all DMP's during entrainment monitoring, and of marine mammals and piscivorous birds during fish community monitoring. Observations of bird activity at Roberts 1 DMP were limited to one or two wading white egrets. There were many entrainment events where no birds were observed.

During fish community monitoring events, gulls, cormorants, and terns were frequently observed at all three reaches of the upper SDWSC. These birds were seen flying and diving in the case of the terns, and sitting on the water and overhead wires as well as feeding in the case of the cormorants and gulls. Herons and egrets were commonly observed in low numbers along the channel banks.

California sea lions were observed on most days during fish community monitoring. Dredge operations staff also reported observations of sea lion activity near the dredge on most days. On approximately half of the fish community monitoring events, sea lions were observed actively feeding on larger fish including salmon (Figure 10), and other species.

4.7 Comparison of Monitoring Method Results

Assessments of relationships between the species, habits, and relative abundance of the fish encountered during fish community and entrainment monitoring are made where enough data exists to reasonably make such assessments. These comparisons help answer questions about the suitability of the fish community monitoring methodology for testing the hypotheses about the subset of fish species likely to be most susceptible to entrainment by the hydraulic cutter-head dredges used to conduct the maintenance dredging. Comparisons of fish encountered during both monitoring methods are of course less tenuous and therefore more useful when significant numbers of fish are entrained. Previous years comparisons are more useful than 2012, due to the significantly larger sample size from those years (more fish were entrained).

Fish were categorized into demersal (benthic and epi-benthic) and non-demersal (pelagic) fish types based descriptions in Moyle (2002), Wydoski and Whitney (2003), Nobriga et al. (2005), and Brown and May (2006). During 2012, demersal species encountered during fish community monitoring were encountered in lower percentages (among all species combined), than they were during entrainment monitoring, except at the Upper Roberts reach where abundant white catfish were encountered during fish community monitoring. This trend in higher abundance of demersal fish encountered during entrainment monitoring than fish community monitoring is clear when looking at previous years data. The only exceptions have been at lower SDWSC reaches where very few fish are encountered, thus obscuring trends, and at upper SDWSC reaches where there have been occasional encounters with large numbers of (demersal) catfish during fish community monitoring. Table 16 provides abundance data for demersal fish encountered during 2012 entrainment and fish community monitoring. Figure 18 presents the 2012 comparison in a bar graph format.

Table 16. Demersal fish encountered during fish community and entrainment monitoring at each 2012 dredge reach

Dredge Reach	% Demersal Fish in Entrainment	Extrapolated Entrained Total Fish	% Demersal Fish in Trawl	Mean Trawl CPUE (fish/100m)
Rough and Ready	75.0	98	16.9	8
Ore Dock	71.4	103	7.2	10
Upper Roberts	80.0	45	96.1	21

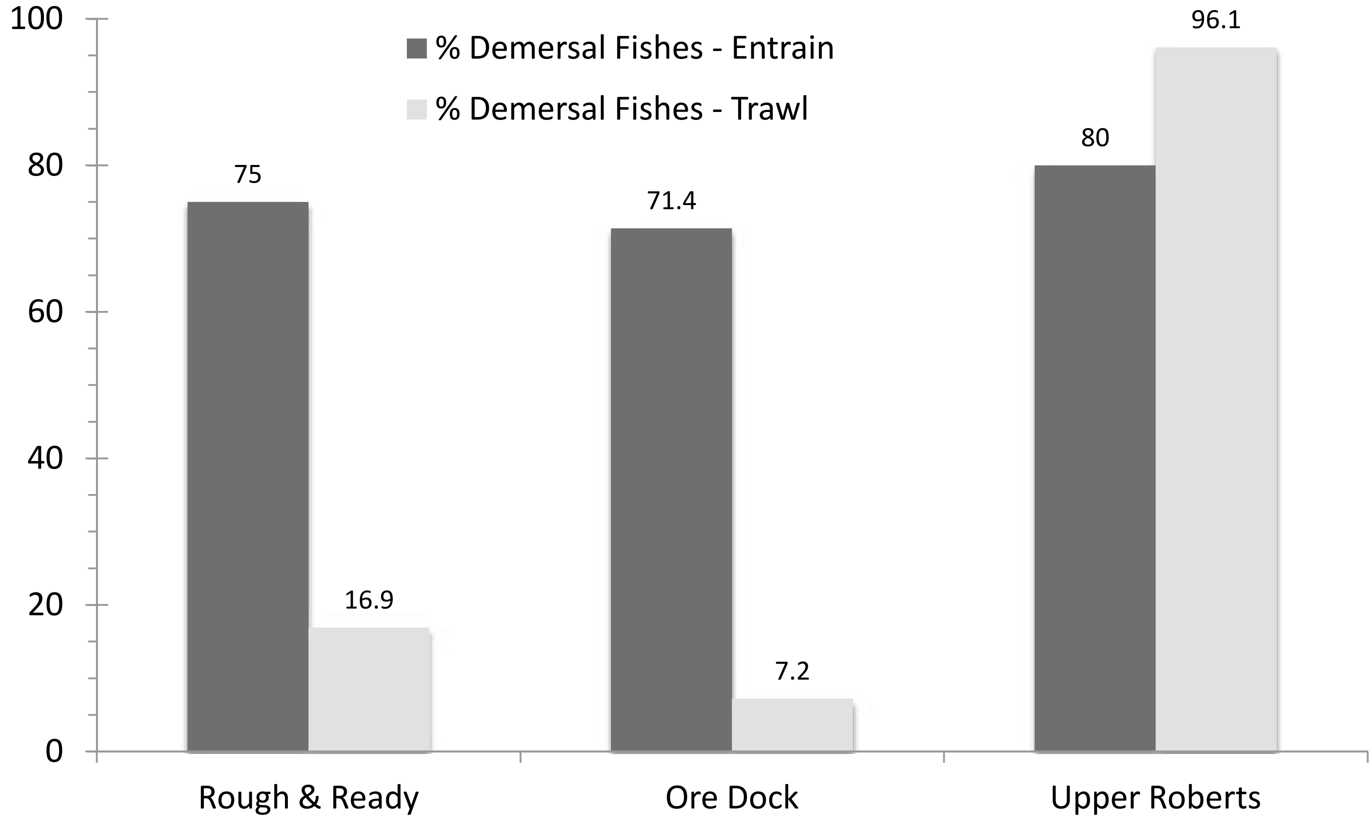

Figure 18. Percent demersal fishes encountered by monitoring method

Presence during fish community monitoring has predicated presence during entrainment monitoring with few exceptions during all years of monitoring, as might be expected. However, relative abundance of species during fish community monitoring has not directly correlated with relative abundance observed during entrainment monitoring. Since 2008, the only fish species encountered during entrainment monitoring but not during fish community monitoring has been the river lamprey. They have been part of the fish community catch in the past, though never in high numbers (one in 2007 and 13 in 2006). Given their presence during entrainment monitoring in all years except 2012, this is most likely due to gear efficiency rather than absence in the fish community, though lack of their presence during 2012 may indicate their recent extirpation from the upper SDWSC. However, only future years monitoring will confirm or deny this. The very few fish that were entrained overall in 2012 suggest that additional data is needed in order to make this determination.

Shimofuri goby was the most commonly entrained fish species from 2009 through 2012, though it was not abundant during fish community monitoring. This may be due to gear efficiency also, similar to river lamprey. Table 17 provides additional details about species encountered during both types of monitoring. Among the "pelagic" species encountered during all years of entrainment monitoring, only wakasagi and delta smelt encountered in the SRDWSC have been proportionally more abundant than they were among the species encountered during fish community monitoring.

Table 17. Comparison of relative abundance of encountered fish species by monitoring method

% Catch of Trawl	Trawl Count	% Catch of Entrainment	Entrainment Count	Common Name	Origin	Demersal or Pelagic
35.1	922	8.3	2	striped bass	Introduced	Pelagic
27.8	732	12.5	3	threadfin shad	Introduced	Pelagic
22.1	582	0.0	0	white catfish	Introduced	Demersal
8.4	221	4.2	1	American shad	Introduced	Pelagic
3.3	88	8.3	2	channel catfish	Introduced	Demersal
1.3	33	0.0	0	Sacramento splittail	Native	Pelagic
0.6	15	0.0	0	bluegill	Introduced	Pelagic
0.3	8	50.0	12	shimofuri goby	Introduced	Demersal
0.3	8	0.0	0	redear sunfish	Introduced	Pelagic
0.2	6	12.5	3	prickly sculpin	Native	Demersal
0.2	4	0.0	0	warmouth	Introduced	Pelagic
0.1	3	0.0	0	yellowfin goby	Introduced	Demersal
0.1	3	4.2	1	brown bullhead	Introduced	Demersal
0.1	2	0.0	0	blue catfish	Introduced	Demersal
0.1	2	0.0	0	bigscale logperch	Introduced	Demersal
TOTAL	**2,629**		**24**			
		Percent Native = 1.5		Number Native Species = 2	Introduced Species = 13	

NOTE: Shaded rows indicate observation of this species in one type of monitoring only. Entrainment totals include encounters with 1 striped bass that was dead and 1 threadfin shad of undetermined disposition prior to encounter with dredge. Fish community monitoring totals include 1 American shad and 1 shimofuri goby dead prior to encounter as well as 1 threadfin shad, 1 shimofuri goby and 1 white catfish injured prior to encounter.

4.8 Water Quality Monitoring

Surface and bottom measurements were acquired during all fish community monitoring events, and Secchi depth was measured during all daylight fish community monitoring. Water quality parameters were typically acquired at the beginning and end of each set of five trawls for each fish community monitoring event. The complete multi-parameter results from surface and bottom are presented in Appendix B. The water quality data discussed below are near bottom measurements.

Readings of bottom water temperature were 17.4°C on November 7, and fell steadily to 13.5°C on December 10. Salinity was low, varying from 0.20 to 0.40 ppt. Turbidity was generally low, between 8.60 and 44.40 ntu, except when measured immediately after a ship’s passage, when a high of 192.0 ntu was measured. Dissolved oxygen varied between 86.0% and 62.7%.

4.9 Level of Take

An important objective of this monitoring program is to improve take estimates of special status fish species during ship channel maintenance dredging operations in the Delta. Original take estimates in the 2006 FMP (Table 18) were based on the estimates developed for SDWSC and SRDWSC maintenance dredging through consultation between USACE and NMFS (NMFS 2006a, b). These original estimates assumed exposure of listed fish to monitoring gear would be less than 25% of the potential exposure of these species to dredging activities and associated shipping. This was likely an overestimate. No salmon or steelhead (alive), and only four green sturgeon, have been encountered since monitoring began in 2006.

Table 18. ESA and CESA incidental take allotments for ship channel fish monitoring

Potential Annual Incidental Take of NMFS Listed Fish for the SDWSC Fish Monitoring Program (original estimate 2006)				
Species	**Juveniles**		**Adults**	
	No.	**Percent of Total ESU/DPS**	**No.**	**Percent 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, Southern DPS	25 juveniles and adults combined (2% = 1 mortality)			
Potential Annual Incidental Take of NMFS Listed Fish for the SRDWSC Fish Monitoring Program (original estimate 2006)				
Species	**Juveniles**		**Adults**	
	No.	**Percent of Total ESU/DPS**	**No.**	**Percent 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, Southern DPS	25 juveniles and adults combined (2% = 1 mortality)			
Incidental Take of USFWS Listed Fish for the SRDWSC and SDWSC Fish Monitoring Program (established 2008)				
Species	**Juveniles**		**Adults**	
	non-lethal	**lethal**	**non-lethal**	**lethal**
delta smelt	10 per week, lethal and non-lethal, no life history differentiation			
IEP-CESA Annual Incidental Take Allotments for the SRDWSC and SDWSC Fish Monitoring Program (updated annually)				
Species	**Juveniles**		**Adults**	
	non-lethal	**lethal**	**non-lethal**	**lethal**
longfin smelt	150		150	

Estimates for take of delta smelt were not included originally, as NMFS does not provide take estimates for these fish species, and this monitoring program is a result of consultation between USACE and NMFS (NMFS 2006a, b). Nor were they established during previous informal consultations with the USFWS, the federal consulting agency for delta smelt. Encounters with delta smelt during previous fish community monitoring required re-initiation of consultation with USFWS which resulted in an amendment (file number 81420-2008-F-1775-1) to the prior USFWS Informal Consultation decision for maintenance dredging (Service File Number 1-1-04-F-0345). A monitoring take of up to ten delta smelt per week was allowed during normal dredging operational windows. No delta smelt were encountered during 2012 monitoring.

Incidental and lethal take for longfin smelt during fish community monitoring was authorized under IEP Program Element Number 2010-113 for inclusion in the amended IEP Scientific Collecting Permit 1440. The IEP permit allowed 150 adults and 150 juvenile longfin smelt in the take allotment for 2012 monitoring of this study, as described in the 2081a permit issued to J. Gold and S. Novotny. No longfin smelt were encountered or observed during fish community or entrainment monitoring in 2012.

4.10 Monitoring Mortality

Some mortality among encountered fish is an unavoidable result of fish community and entrainment monitoring, although in the case of the entrainment monitoring, all entrained fish are assumed to die as a result of being entrained to a DMP site. De-watering of DMP sites is not conducted in an effort to save entrained fish that may still be alive when de-watering occurs. Rather, it is conducted out of necessity to remove the water from the sites. Entrainment monitoring probably reduces overall dredge entrainment mortality as live fish collected during monitoring are returned to the river. In this sense, documentation of entrainment mortality serves a separate purpose than that of community monitoring mortality. This data may prove useful for development of best management practices for dredging, as the entrainment screen methodology could be used to collect entrained fish and other organisms such as native mussels, and return them to the water.

Table 19 provides mortality data for fish encountered during entrainment monitoring. The mortality data is "estimated" as it cannot be determined what happens to the fish after they are released back into the water.

Table 19. Total estimated fish mortality among fish observed during 2012 entrainment monitoring

Common Name	Total Mortalities	Total Encountered	% Entrainment Mortality	% Mortality for Species	Origin
American shad	1	1	11.1	100	Introduced
brown bullhead	1	1	11.1	100	Introduced
shimofuri goby	5	12	55.6	41.7	Introduced
threadfin shad	3	3	22.2	66.7	Introduced
TOTAL	**10**	**17**			

NOTE: Total numbers include 1 threadfin shad whose capture disposition could not be determined - thus, assumed alive; and exclude1 striped bass dead prior to encounter.
Zero mortality for all other species encountered (channel catfish, prickly sculpin, striped bass, and brown bullhead).

Table 20 provides mortality data from 2012 fish community monitoring. A total of 362 individuals, or 19.29% of the individual fish encountered, were recorded as mortalities during fish community monitoring, very similar to 2011 (19.82%). Threadfin shad comprised 66.3% of these mortalities, also very similar to the 2011 estimate (70.81%). American shad and striped bass also had relatively high mortality rates during 2012 and previous years.

Table 20. Total estimated fish mortality among fish encountered during 2012 fish community monitoring

Common Name	Total Mortalities	Total Encountered	% Fish Community Mortality	% Mortality for Species	Origin
American shad	59	220	16.3	26.8	Introduced
bigscale logperch	1	2	0.3	50.0	Introduced
striped bass	62	922	17.1	6.7	Introduced
threadfin shad	240	732	66.3	32.8	Introduced
TOTAL	**362**	**1,876**			

NOTE: Total numbers include 1 threadfin shad whose capture disposition could not be determined - thus, assumed alive; and exclude 1 shimofuri goby and 1 American shad that were dead prior to encounter. Zero mortality for all other fish species encountered (refer to Table 8).

4.11 Vouchered Specimens

No specimens were vouchered during 2012. Lamprey, longfin and delta smelt may be vouchered during future years. Entrained green sturgeon, steelhead and salmon may be released if alive after photographs are taken, though so far, none of these species have been encountered during entrainment monitoring. Green sturgeon have been encountered during fish community monitoring, and have been released (apparently) unharmed after measurements and photographs were taken.

4.12 Combined Data for All Years

Tables 21 and 22 present combined fish entrainment and community monitoring data for all years (2006-2012) without regard to inter-annual differences in effort, location, methods or timing. The information presented in this manner provides an overall description of the fish species that have been present, and the subset of those species most susceptible to entrainment, in the portions of the shipping channels where and when maintenance dredging was occurring. Introduced species greatly outnumbered natives both by number of species and by number of individuals.

Table 21. Combined total of all fish encountered during entrainment monitoring 2006-2012

Rank	Percent	Number	Common Name	Origin	Demersal/Pelagic
1	50.57	892	shimofuri goby	Introduced	Demersal
2	15.36	271	channel catfish	Introduced	Demersal
3	13.44	237	lamprey, species undet. *	Native	Demersal
4	3.80	67	striped bass	Introduced	Pelagic
5	2.95	52	yellowfin goby	Introduced	Demersal
6	2.38	42	Shokihaze goby	Introduced	Demersal
7	2.32	41	river lamprey	Native	Demersal
8	1.87	33	white catfish	Introduced	Demersal
8	1.87	33	prickly sculpin	Native	Demersal
9	1.53	27	wakasagi	Introduced	Pelagic
10	0.91	16	brown bullhead	Introduced	Demersal
11	0.96	17	threadfin shad	Introduced	Pelagic
12	0.79	14	American shad	Introduced	Pelagic
13	0.34	6	delta smelt	Native	Pelagic
14	0.23	4	Pacific staghorn sculpin	Native	Demersal
15	0.17	3	bluegill	Introduced	Pelagic
16	0.11	2	warmouth	Introduced	Pelagic
16	0.11	2	bigscale logperch	Introduced	Demersal
16	0.11	2	common carp	Introduced	Demersal
16	0.11	2	white sturgeon	Native	Demersal
17	0.06	1	Sacramento splittail	Native	Pelagic
	Total	**1,764**			

Percent Demersal = 92.23 Native Species = 7 Introduced Species = 14

* This number includes river lamprey, Pacific lamprey, and observed but undetermined lamprey specimens; lamprey specimens from 2006 & 2007 not identified to species and treated as one species.

Table 22. Combined total of all fish encountered during fish community monitoring 2006-2012

Rank	Percent	Number	Common Name	Origin	Demersal/Pelagic
1	48.00	20,953	white catfish	Introduced	Demersal
2	21.21	9,259	threadfin shad	Introduced	Pelagic
3	12.10	5,283	striped bass	Introduced	Pelagic
4	7.41	3,234	American shad	Introduced	Pelagic
5	5.23	2,281	channel catfish	Introduced	Demersal
6	2.10	918	longfin smelt	Native	Pelagic
7	0.69	300	wakasagi	Introduced	Pelagic
8	0.47	203	yellowfin goby	Introduced	Demersal
10	0.40	176	shimofuri goby	Introduced	Demersal
9	0.37	162	splittail	Native	Pelagic
11	0.29	127	white sturgeon	Native	Demersal
12	0.27	118	redear sunfish	Introduced	Pelagic
13	0.25	107	starry flounder	Native	Demersal
14	0.23	99	Shokihaze goby	Introduced	Demersal
15	0.18	79	tule perch	Native	Pelagic
16	0.16	71	bluegill	Introduced	Pelagic
17	0.11	46	brown bullhead	Introduced	Demersal
18	0.10	43	common carp	Introduced	Demersal
19	0.10	42	delta smelt	Native	Pelagic
20	0.09	40	prickly sculpin	Native	Demersal
21	0.06	28	warmouth	Introduced	Pelagic
22	0.04	17	blue catfish	Introduced	Demersal
23	0.03	13	lamprey species *	Native	Demersal
24	0.02	10	Sacramento blackfish	Native	Pelagic
25	0.02	9	black crappie	Introduced	Pelagic
26	0.02	7	bigscale logperch	Introduced	Demersal
26	0.02	7	Pacific staghorn sculpin	Native	Demersal
27	0.01	5	unidentified goby **	Introduced	Demersal
28	0.01	4	green sturgeon	Native	Demersal
29	0.01	3	Sacramento pikeminnow	Native	Pelagic
29	0.01	3	white crappie	Introduced	Pelagic
30	0.00	1	golden shiner	Introduced	Pelagic
30	0.00	1	Chinook salmon ***	Native	Pelagic
30	0.00	1	largemouth bass	Introduced	Pelagic
30	0.00	1	Mississippi silverside	Introduced	Pelagic
	TOTAL	**43,651**			

Percent Demersal = 55.25 Native Species = 13 Introduced Species = 21

* This number includes river lamprey and Pacific lamprey, and observed but undetermined lamprey specimens assumed to be one of these two species; lamprey specimens from 2006 & 2007 were not identified to species and at the time, treated as one species.

** Unidentified goby not treated as separate species, but origin as one of the newly introduced gobies.

*** Chinook salmon was the only additional fish species not encountered in prior years and was dead prior to encounter with sampling gear.

The proportion of demersal to pelagic species was higher both in species and in numbers of individuals encountered during entrainment monitoring than it was among fish encountered during fish community monitoring at most reaches, during all years of monitoring. The instances where this has not been the case, have been dredge reaches with very low abundance and diversity of fish, and upper SDWSC reaches where occasionally, large numbers of catfish have been encountered.

Largely due to the presence of lamprey, individuals of native species have been more commonly encountered during entrainment monitoring than they have been during fish community monitoring (expressed as a percentage of the total number of individuals encountered). Except for delta smelt, all native species observed during entrainment monitoring have been demersal, while seven of the thirteen native species encountered during fish community monitoring have been pelagic.

Green sturgeon, longfin smelt and delta smelt are the only special status (listed) species that have been encountered over all years of this monitoring program, though Pacific lamprey, river lamprey and Sacramento splittail are CDFW Species of Special Concern. White sturgeon encounter data are included in this section as surrogate data due to lack of green sturgeon data. NMFS has also routinely used white sturgeon data as surrogate data for green sturgeon, when no green sturgeon data is available. The white sturgeon data produced by this monitoring program was used to help establish the critical habitat for green sturgeon in the Delta.

Encounters with special status species are further described in Table 23, though only threatened and endangered species are included. Most lamprey were encountered during entrainment monitoring, although a few have been encountered during fish community monitoring. For the second time, in 2011, a listed species was encountered during entrainment monitoring: three delta smelt were encountered in the SRDWSC. This occurred first in 2010 when six delta smelt were entrained. No Green sturgeon or other special status species have been encountered during entrainment monitoring since 2008 when the screen was used at most of the DMP sites. However, the single white sturgeon entrained in 2011 is significant, it is the first documented occurrence of sturgeon entrainment while monitoring hydraulic cutter-head dredging in the Delta. Green sturgeon, longfin smelt and delta smelt have all been encountered during fish community monitoring. However, very few longfin smelt have been encountered during fish community monitoring since the screen has been in use.

Table 23. Special status fish species encountered by DMP and DR during all years of monitoring

Year	DR Location	DMP Site	Rank	No	Proportion	Common Name
2006	Decker Island	Decker Island	17	2	0.03	green sturgeon
2006	Sherman-Bradford	Bradford Island	5	2	1.60	longfin smelt
2006	Decker Island	Decker Island	1	881	47.72	longfin smelt
2006	Sandy Beach	Sandy Beach	5	8	4.12	longfin smelt
2006	Rio Vista	Rio Vista	7	4	2.52	longfin smelt
2006	Decker Island	Decker Island	5	75	4.06	white sturgeon
2006	Sandy Beach	Sandy Beach	9	3	1.55	white sturgeon
2006	Rough & Ready Island	Roberts I	8	1	0.02	white sturgeon
2006	Sherman-Bradford	Bradford Island	5	2	0.16	white sturgeon
2006	Rio Vista	Rio Vista	8	3	1.89	white sturgeon
2007	Antioch Br - West Island	Scour Pond	6	1	2.08	longfin smelt
2007	Decker Island	Decker Island	5	1	0.53	longfin smelt
2007	Antioch Br - West Island	Scour Pond	6	1	2.08	delta smelt
2007	Decker Island	Decker Island	3	8	4.28	delta smelt
2007	Man-made Channel	S-31	5	2	3.28	delta smelt
2007	Antioch Br - West Island	Scour Pond,	5	3	6.25	white sturgeon
2007	Rough & Ready Island	Roberts I	7	2	0.20	white sturgeon
2007	Decker Island	Decker Island	4	2	1.07	white sturgeon
2007	Man-made Channel	S-31	6	1	1.64	white sturgeon
2008	Antioch Br - West Island	Scour Pond	8	25	0.33	delta smelt
2008	Decker Island	Decker Island	9	21	0.27	longfin smelt
2008	Decker Island	Decker Island	16	7	0.09	white sturgeon
2009	Man-made Channel	S-31	7	5	1.11	white sturgeon
2009	Light 21	McCormack Pit	5	2	0.74	white sturgeon
2010	Upper Bradford	Bradford Island	6	2	4.10	green sturgeon
2010	Man-made Channel 1	S-31	7	2	0.55	delta smelt
2010	Man-made Channel 2	S-31	8	4	1.09	delta smelt
2010	Man-made Channel 2	S-31	5	6	2.64	delta smelt *
2010	Man-made Channel 2	S-31	11	1	0.12	white sturgeon
2010	Turning Basin	Roberts I	11	1	0.03	white sturgeon
2011	Man-made Channel 1	S-31A	6	2	1.30	delta smelt
2011	Man-made Channel 1	S-31A	4	2	1.23	delta smelt *
2011	Man-made Channel 2	S-31C	3	4	8.16	delta smelt
2011	Man-made Channel 2	S-31C	4	1	2.63	delta smelt *
2011	Man-made Channel 1	S-31A	3	3	1.95	white sturgeon
2011	Sandy Beach	Sandy Beach	4	5	17.86	white sturgeon
2011	West Island	Scour Pond	5	7	3.85	white sturgeon
2011	West Island	Scour Pond	5	1	2.38	white sturgeon *
2011	Light 19	Roberts 2	8	1	0.20	white sturgeon
2011	Light 21	Roberts 2	3	1	3.57	white sturgeon
2011	Turning Basin	Roberts 1	12	2	0.08	white sturgeon

NOTE: Unshaded cells = Sacramento River Ship Channel (SRDWSC); Shaded cells = Stockton Ship Channel (SDWSC).
Species are listed by year and location of occurrence. Rank & proportion of species is calculated by location. No special status species encountered in 2012.
* Encountered during entrainment monitoring; prior to 2010, only encountered during trawl monitoring.

California Delta fish species are well documented by Turner and Kelly (1966), McGinnis (1984), Moyle (2002) and others. However, surprisingly, some information gaps exist in details of life history and present range. For the majority of the approximately 55 species of fish that now occur in the Delta, though, presence or absence in the channel bottom habitat is fairly well understood. One of the central themes encountered when considering the utility of monitoring programs is the assessment of efficacy of methods in answering the monitoring mandates. To that end, the authors have spent considerable effort describing the fish species encountered during community and entrainment monitoring. An alternative approach is to examine those species not encountered and then, for each species, to describe its rarity and the likelihood of its utilization of the channel bottom.

Table 24 provides a list of Delta fish species that have not been encountered since monitoring began. Five species (steelhead, Chinook salmon, hitch, hardhead and black bullhead) are discussed below. The other fifteen species are either rare or do not utilize the channel bottom habitats where dredging occurs, or both, and so for these species, lack of encounters are not surprising.

Table 24. Delta fish species not encountered during all years of monitoring

Species	Origin	Utilizes Channel Bottom Habitat	Rare in the Delta
Sacramento sucker *Catostomus occidentalis*	Native	No	No
steelhead *Oncorhynchus mykiss*	Native	No	Yes
hitch *Lavinia exilicauda*	Native	No	Yes
riffle sculpin *Cottus gulosus*	Native	No	No
hardhead *Mylopharodon conocephalus*	Native	No	Yes
threespine stickleback *Gasterosteus aculeatus*	Native	No	No
topsmelt *Atherinops affinis*	Native	No	No
California roach *Hesperoleucus symmetricus*	Native	No	No
speckled dace *Rhinichthys osculus*	Native	No	No
American eel *Anguila rostrata*	Introduced	Questionable	Yes
black bullhead *Ameiurus melas*	Introduced	Questionable	No
pumpkinseed *Lepomis gibbosus*	Introduced	No	No
green sunfish *Lepomis cyanellus*	Introduced	No	No
smallmouth bass *Micropterus dolemieu*	Introduced	No	No
spotted bass *Micropterus punctulatus*	Introduced	No	No
goldfish *Carrasius auratus*	Introduced	No	No
western mosquitofish *Gambusia affinis*	Introduced	No	No
rainwater killifish *Lucania parva*	Introduced	No	No
fathead minnow *Pimephales promelas*	Introduced	No	No
red shiner *Cyprinella lutrensis*	Introduced	No	No

Until 2011, steelhead and Chinook salmon had not yet been encountered by this study. Although they are not extirpated from the monitoring locations, winter-run fish are very rare and Chinook salmon are not often observed using channel bottom habitat (NMFS 2006a, b). The single half of the dead Chinook salmon encountered while fish community monitoring in 2011 and the hatchery fall-run fish encountered in 2012 informs us more about the continued presence of fall-run Chinook salmon when and where dredging occurs, and the feeding habits of sea lions, then it does about dredging impacts to winter-run Chinook adults or smolts.

Hitch and hardhead have also not been encountered. Although known to occur in the Delta, no specific information has been found that documents their presence in the channel bottom habitat that is being assessed. Black bullhead have not been encountered either, though they are present in the Delta. Specific documentation of their occurrence in the channel bottom habitat is lacking. However, it would not be surprising if they did utilize this habitat. It is also possible that investigators have encountered black bullhead but misidentified them as brown bullhead due to their possible co-occurrence and similar appearance.

5 Discussion

5.1 Hypotheses

The methods utilized by this monitoring program were developed to assess NMFS questions and assumptions about levels of incidental take of listed salmonids and green sturgeon during SRDWSC and SDWSC maintenance dredging. NMFS assumed an unknown level of take of these species, though likely low. The current NMFS BO required that a monitoring program be developed and conducted to determine level of take, and also required the continued development of measures to avoid, minimize, and monitor the impacts of maintenance dredging on listed salmonids, green sturgeon and their habitat.

The hypotheses were developed prior to the initiation of 2006 monitoring as the means to convert the monitoring requirements into heuristically testable assumptions and questions. They are repeated here again for clarity:

H^1: Maintenance dredging of the SDWSC and SRDWSC will result in take of listed and other fishes through direct dredge entrainment.

H^2: There is a correlation between presence of fish in the dredging areas and entrainment by the dredge.

H^2a: Differential use of the water column will result in different entrainment levels among fishes present in the project areas; that is, demersal fish that are associated with the channel bottom (benthic and epibenthic species) will be entrained in higher numbers than water column (pelagic) fish.

H^1: This hypothesis has been tested during all years of this monitoring program. In 2012, H1 again proved to be partially correct. Fish species were entrained, though they were few in number and none were listed.

When the 2012 entrainment data is extrapolated, based on the percentage of total dredge output monitored, the total number of fish entrained from this project at all sites was approximately 246, far fewer than during previous years. In 2011, the estimation was 3,950 fish. In 2010, the estimation was 7,828 fish, and in 2009, estimated take was 7,500 fish. Prior years estimated annual totals are not included due to much lower entrainment monitoring effort during those years that resulted from using a less effective monitoring method. Inter-annual variation in the take estimates is due to changes in dredging effort and timing from year to year, as well as, changes in the number and composition of the species of fish in the dredged areas. This was true moreover in 2012, the shortest dredging season since the inception of monitoring. Another possible explanation for inter-annual variation in entrainment emerged in 2012 for the first time. The horsepower and pumping specifications of Vortex's dredge are different from Ross Island Sand and Gravel's dredges used in prior years. It is possible that dredge design differences could affect entrainment rates. Monitoring during future years while Vortex's dredge is used should provide answers to the questions about variation in entrainment rates based on dredge differences.

One pattern that is beginning to emerge is that a large number of the entrained species have been native fish. This is largely due to the presence of river lamprey, but also due to entrainment of Sacramento splittail, prickly sculpin, Pacific staghorn sculpin, delta smelt and white sturgeon. To date, the only listed species observed to have been entrained is delta smelt. This does not ensure that other listed species have not been entrained over this time period, nor does it guarantee that listed species have not been subjected to take from dredging impacts other than direct entrainment. Fish community monitoring in previous years has demonstrated that listed fish species do occur within the dredging reaches, although in relatively low numbers.

H^2 and H^2a: These hypotheses are important because a goal of this monitoring program is to provide information to Federal and state resource management agencies about both susceptibility to entrainment (from hydraulic cutter-head dredging) and presence of listed and other species utilizing the dredged areas. The data set has gained strength through the development and use of the mobile entrainment screen by allowing assessment of an order of magnitude more of the dredge output than was previously possible with the entrainment cell method. Increasing the monitored amount of dredge material increased the accuracy and utility of the comparison between the species utilizing the channel bottom and those that are entrained. Fish community assessments conducted in conjunction with entrainment monitoring provides information useful for determining the likelihood of entrainment. Simply stated, rarity in the environment decreases entrainment rates. However, rarity in the environment also confounds our ability to assess likelihood of entrainment based on described or un-described behavioral differences among species of interest. With the exception of delta smelt, the investigators conducting this monitoring program have so far been faced with interpreting potential for incidental take based on data from non-special status species. NMFS predicted that take of green sturgeon would be higher than listed salmonids based partly on the differential habits of these fish (demersal vs. non-demersal or pelagic). Thus, H^2 and H^2a provide the framework to assess whether demersal fish actually are entrained at higher rates than pelagic fish.

Classification of fish species as demersal or pelagic was based on general feeding habit and habitat preferences, following Moyle (2002), Wydoski and Whitney (2003), Nobriga et al. (2005), and Brown and May (2006). Other environmental factors that may affect whether a species occupies demersal habitats, such as altered habitat and altered predator-prey relationships, were not considered due to lack of site- specific information. These altered environmental and ecological factors may affect migratory, diel, and feeding behavior of Delta fishes with potential for greater overlap of pelagic and demersal behaviors (Feyrer and Healey 2002, 2003; Norbriga et al. 2005), further confounding the ability to describe some species as “demersal” or “pelagic”. A recent study conducted in January and December 2011 (Bennett and Burau, submitted), indicated that delta smelt presence in the navigation channel varied substantially with the tide. Delta smelt appeared to migrate into the shallow areas that occur near the shoreline during ebb tides, and then move back into the channel during flood tides. This behavior allows delta smelt to exploit flood tidal currents and move upriver, while utilizing shallow areas during ebb tides to avoid transport downriver. According to Bennett, this behavior is likely to have evolved to reduce the energetic costs associated with migrating against extremely strong tidal and river currents in the Sacramento River during winter.

While entrained fish represent a subset of the fish encountered during fish community monitoring, relative abundance of species varies dramatically between entrained species and species utilizing the channel around the dredge. Pelagic fish have been comparatively rare during entrainment monitoring relative to fish community monitoring. Among the species of fish that have been encountered during both entrainment and community monitoring, several species appear to be more vulnerable to entrainment when their relative proportions among each monitoring method are compared. In other words, these species seem to be more vulnerable to entrainment than their relative abundance in the fish community would suggest. The top ten, in order of the strength of the relationship, are: Lamprey spp. shimofuri goby, prickly sculpin, pacific staghorn sculpin, Shokihaze goby, brown bullhead, bigscale logperch, yellowfin goby, delta smelt, and channel catfish. The lamprey, gobies and bigscale logperch may be under-represented by the fish community method as their small size may allow them to swim through the trawl net meshes. Also, bigscale logperch, pacific staghorn sculpin, delta smelt and brown bullhead were encountered in low numbers compared to the other species, confounding this analysis. Additionally, differential annual efforts must be considered when comparing susceptibility to entrainment among species. For example, no delta smelt should have been entrained during 2012 due to the dredging locations. For delta smelt in particular, this assessment is tenuous due to permit restrictions. When delta smelt have been present in the fish community around the dredge, the fish community monitoring effort has been reduced in order to avoid exceeding the take limit. However, when this has occurred, entrainment monitoring effort has not also been reduced as the entrainment monitoring observations of take by the dredge are not limited by number of individuals. Therefore, the strength of the relationship between relative abundance in the fish community versus entrained individuals is likely to be overestimated for delta smelt and the other species that would have co-occurred with them should the monitoring effort not have been curtailed. Extrapolated data comparisons help ameliorate this issue, however the low level of monitoring effort introduces considerable uncertainty into the extrapolated data.

Longfin smelt were frequently encountered during 2006 fish community monitoring in the lower Delta. However, since very little entrainment monitoring was conducted in 2006, a similar assessment of vulnerability to entrainment cannot be utilized for this species. Because very few longfin smelt have occurred in the fish community since that time (since the screen has been in use).

Lamprey were not encountered while monitoring during 2012. This is the first time that this has occurred since monitoring began. Most of the river lampreys previously encountered have exhibited characteristics of the free-swimming, juvenile phase of development. Though smaller than adults, these fish (termed macropthalmia) share some adult characteristics: large, well-developed eyes, developing teeth, white/silver side and ventral coloration and bluish to black dorsal coloration. Though capable of migration, the larger numbers of lamprey entrained in 2010 and 2011 at the Sandy Beach DMP suggest they either dwell in the sediment or sediment/water interface, or potentially burrow into the sediment to escape the disturbance of the dredge cutter-head. Most importantly, macropthalmia are strong swimmers with an ideal size and shape to escape through the trawl mesh, although 13 have been encountered during fish community monitoring since monitoring began. The size of the trawl net mesh is larger than the size of the entrainment screen holes. Furthermore, their potential behavioral response to disturbance may allow them to effectively dive under the net and more effectively avoid encounters with the otter trawl (Hayes et al. 1996). These factors likely increase the chances that small lamprey are retained by the entrainment screen but more able to escape the trawl net. Thus, for lamprey it can be assumed that fish community monitoring, as currently conducted, may not be capable of establishing a relationship between abundance in the channel and entrainment rates. However, absence of any lamprey during 2012 is a more important issue to consider than whether their relative abundance to other species is accurately represented by the fish community methodology.

To date, only four species of demersal fish that have been encountered during fish community monitoring have not also been encountered during entrainment monitoring. These species are: green sturgeon, unidentified goby, blue catfish, and starry flounder. Together, these demersal fish only made up 0.31% of the total fish encountered during community monitoring; 133 individuals, 107 of which were starry flounder. Lack of documented entrainment of green sturgeon is fairly simply explained due to their rarity. The unidentified goby were an artifact of 2006 monitoring before the program resolved all individuals to species. They were very likely shimofuri or Shokihaze goby, both of which have been entrained. All the blue catfish that have been encountered have been very small except for the two fish encountered during 2012. This makes them difficult to differentiate from similar sized channel catfish. This leaves starry flounder: Many species of flounder are vulnerable to bottom trawling as the net disturbance tends to herd demersal fishes up off the bottom into the net mouth

(Hayes et al. 1996). Starry flounder are capable of short and swift bursts of swimming (Orcutt, 1950). This burst speed may allow them to easily avoid the disturbance of the cutter-head dredge, possibly explaining why they have not been encountered during entrainment monitoring.

A higher percent of encountered fish were measured in 2010, 2011 and 2012 relative to previous years. The robust fish length data from the last three years has allowed comparison between more fish species, and within species, between adult and juvenile life stages. Differences in the overall mean total length of fishes generally does not demonstrate a significant difference in the sizes of fish that are encountered during entrainment and fish community monitoring, though there has been a non-significant trend towards encountering slightly smaller fish during entrainment monitoring. Data from 2010 showed that smaller sized juveniles were entrained among white and channel catfish, striped bass, and American shad than those encountered during fish community monitoring. However, in that same year, length differences are not apparent for seven of 11 comparable fish and life stages. Among the commonly encountered entrained fish species in 2009, mean total length was smaller than that of those same species encountered in fish community monitoring. In 2008, an unequal variance t-test of significance was performed for channel catfish and white catfish that indicated a significant difference showing smaller channel catfish and white catfish were more susceptible to entrainment than larger fish of the same two species. This relationship was also likely to be stronger than could be demonstrated, as the larger catfish are more able to avoid the trawl net and thus are not represented in the fish community data. Observations of fish subject to sea lion predation demonstrate that larger catfish are present in the monitored reaches than are encountered during fish community or entrainment monitoring. The 2010 length data demonstrated that smaller catfish (white and channel) continue to be more commonly entrained than those that are encountered fish community monitoring. However, the expanded comparison across the greater numbers of fish species garnered in 2011 demonstrated no apparent size difference for the majority of the fish species encountered while conducting both monitoring methods. Future monitoring should bolster data strength and provide more detailed information about which species and sizes of fish are most vulnerable to entrainment.

In order to fully test H^2a, more knowledge of the fish inhabiting the dredging reaches is needed. This knowledge will be provided by future monitoring efforts from this monitoring program and by other studies of Delta fish. The IEP sponsors several long-term status and trends studies, such as the Estuarine and Marine Fish Abundance and Distribution Survey (Bay Study) and the Fall Midwater Trawl Survey. There are also other recent studies such as those initiated by the Pelagic Organism Decline (POD) work team. These and other studies will continue to be used to assess the vulnerability of Delta fishes to dredge entrainment. However, comparing data across studies will always be problematic since there are substantial differences in timing, methods, and locations. Substantial data gaps still exist 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 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 35 fish species encountered during fish community monitoring in all years, 16 can be readily defined as demersal rather than pelagic. These species include: sculpin, goby, catfish, sturgeon, flounder, lamprey, and carp. The trawl net samples from the channel bottom up into the water column while it is open during the tow. The exact height of the cork-line above the bottom has not been determined, but may approach one-third of the total water column height at times and so reach into the zone that pelagic fish may be utilizing. In comparison, the dredge cutter-head stays buried in, or very close to, the channel bottom while entrainment monitoring is conducted. The pelagic species may utilize the entire water column in some cases and others may engage in diurnal migrations to the surface or the bottom. Within species, behavioral differences based on life stage may also limit 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 (Moyle 2002), rather than at specific navigation channel locations. There is some knowledge of which specific areas of the Delta are used by individual species and of how seasonal fluctuations impact species presence in the shipping channel. Yet, many gaps remain 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).

5.2 Monitoring Design Efficiency

The magnitude of percentage increase in the total volume of dredged material monitored during recent years may be attributed to continued refinement of the screen and its methodology of use. With continued use of the pneumatic-assisted Y-valve (installed in 2008) and refinement of its operation during initial uses in 2009, and every year until 2011, the dredge pumping rate remained unaltered while the output was diverted from the DMP site to the monitoring screen. The efficiency of entrainment monitoring has thus improved over prior years; when there was more need to idle the dredge to divert material for entrainment monitoring. This was further improved in 2012 when an improved pneumatic valve was implemented for the first time. This valve still needs some improvement. However, it will continue to simplify and speed up the process of switching material flow from the screen to the main DMP, and back again.

Dredge slurry with abundant organic debris created, at times, a short-term build-up of mixed sediment and debris on the screen surface. Occasionally, the flow of organic material caused the discharge to over-top the sides and/or run off the dump-end of the screen. Also in 2012, as in previous years, there were several occurrences of rapid overwhelming of the screen due to excessive volume of clams and clam shells, clay balls, and at times gravel and rock. These incidences of over-topping or overwhelming were infrequent and short-lived, usually lasting between 15 to 60 seconds in the case of the over-topping. Because the discharge stream could not be adequately screened or observed for potential organisms during these occurrences, screen operators noted the duration of such events and reduced the total time for that entrainment monitoring event accordingly. During incidences of overwhelming, the dredge material was diverted and monitoring discontinued until the screen could be cleared and monitoring resumed.

Improvements to the entrainment screen requested for 2012 are discussed in the adaptive management portion (Section 5.5). If implemented, these improvements should increase the predictive ability of the monitoring. More robust entrainment estimates will help identify trends and further test the established hypotheses. Improvements requested for the entrainment screen and changes related to these improvements are discussed in the adaptive management and recommendations sections.

A maximum of five daily trawls were performed during each day that fish community monitoring was conducted. No additional trawls were conducted at any sites in 2012. Based on the assessment of the species that have not been encountered during fish community monitoring, we believe that five trawls per day accurately describe the demersal fish community in the shipping channel with few exceptions.

The authors recognize the possibility that increased monitoring effort would increase our understanding of the presence of the rare species, as well as refine our understanding of relative abundance and other population parameters of fishes that utilize the shipping channels such as tidal or diel fluctuations. However, any increase in fish community monitoring effort would increase costs as well as mortality among fish encountered.

5.3 Overview

The fish species encountered during all years of fish community and entrainment monitoring are a subset of those described by Moyle (2002) for the Central Valley sub-province. The majority of the species described by Moyle as being present in the Delta that have not been encountered while monitoring are species with the following traits: rare species; species not known to inhabit the channel bottoms, such as red shiner, and western mosquitofish; or species not known to occur in the areas being dredged, such as Sacramento sucker or topsmelt. Pelagic fish species with relatively high abundances in the Delta (i.e., striped bass and threadfin shad) have been commonly encountered during fish community monitoring but have rarely been encountered while entrainment monitoring. Although 15 different native species (including river lamprey and other possible but unconfirmed *Lampetra* spp.) have been encountered during fish community monitoring, only six native species have so far been observed over all years of entrainment monitoring: river lamprey, Pacific lamprey, delta smelt, Sacramento splittail, Pacific staghorn sculpin, prickly sculpin, and white sturgeon. All of these species have been entrained in small numbers relative to the other entrained species, with the exception of river lamprey, which has been entrained in relatively large numbers.

Recent precipitous population declines in several species of Delta fish such as delta smelt, longfin smelt, threadfin shad, striped bass (CDFG 2009a,b,c), listed salmonids, and green sturgeon (NMFS 2006a,b) suggest the ongoing need for assessments of Delta fish populations. Since the inception of fish community monitoring in 2006, several findings have become known that either corroborate similar observations or, instead, contrast with those of others in the area. These trends, observations, and monitoring outcomes are listed below.

- The introduced Shokihaze goby was not previously described as inhabiting the upper Delta by Moyle (2002), however it is the sixth most common entrained fish encountered during all years of entrainment monitoring, and the 14th most common fish encountered during all years of community 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). The two green sturgeon encountered in 2010 were the first since 2006 and white sturgeon less common during recent years than they were during the early years of this monitoring program. Encounters with white sturgeon have occurred in both channels near the confluence of the two river systems, at Roberts 1 in the SDWSC and at S-31 in the SRDWSC. In 2010, the largest white sturgeon to date was encountered during fish community monitoring near the ore dock in the SDWSC Turning Basin at the Port of Stockton. In 2011, the first documented entrainment of white sturgeon occurred while monitoring. The white sturgeon data generated by this program may provide useful surrogate data for the presence of green sturgeon in these locations. No white or green sturgeon were encountered in 2012.
- There were 895 longfin smelt encountered during fish community monitoring at lower SRDWSC locations in 2006, ranking first among native species and fourth among all species encountered. This occurred while steep declines in relative abundance of longfin smelt were being documented in other locations in the Delta and SF Bay estuary. The 2006 monitoring appears to have coincided with the reported annual center of abundance of spawning adults near Rio Vista (Moyle 2002). In 2007, only two longfin smelt were encountered near Decker Island in December, while in 2008, 21 longfin smelt were encountered, all from Decker Island in the SRDWSC in late August and early September. No longfin smelt have been encountered while monitoring since 2008. The Bay Study (http://www.dfg.ca.gov/delta/projects.asp?ProjectID=BAYSTUDY) conducts both

mid-water and otter trawl surveys throughout the SF Bay and in limited Delta locations over each month of the year. The overlap timing of dredge monitoring varies from year to year, as the timing and duration of dredging varies every year. This data set does not appear to be able to predict entrainment of longfin smelt by the dredge except in a very general way. One reason is that the data is not available coincident with the occurrence of dredging. In terms of its ability to hind-cast, it is clear that dredge locations around the confluence of the SDWSC and SRDWSC are most likely to produce encounters with longfin smelt while conducting maintenance dredging in the Delta. These are locations where longfin smelt have been recently most infrequently encountered by the Bay study and other CDFW and IEP monitoring and other studies, though these locations have been utilized by longfin smelt historically. Given the 2006 co-occurrence of dredging when longfin smelt were present near Rio Vista, it is possible that this will occur again in this region. If so, the screen should be able to determine whether longfin smelt are susceptible to entrainment by the hydraulic cutter-head dredge in use. The monitoring ponds used to document entrainment in 2006 could not achieve this capability.

- No delta smelt were encountered in 2006, 2009 or 2012. In 2007, 11 delta smelt were encountered during November and December trawls. Of these 11 individuals, nine were from locations near the confluence of the San Joaquin and Sacramento rivers, and two were from the SRDWSC Man-made Channel near the Port of Sacramento. In 2008, 25 delta smelt were encountered during community monitoring; 22 of the specimens were encountered in the SRDWSC between August and early September. Of these 25 specimens, 21 were in the vicinity of Decker Island, one was from the Man-made Channel early in August. The remaining three individuals were encountered in the SDWSC near Antioch during a single night tow on September 21. In 2010, seven delta smelt were encountered during fish community monitoring and 6 while entrainment monitoring, all in the SRDWSC between September 20th and October 16th. In 2011, six delta smelt were encountered during fish community monitoring and three were encountered during entrainment monitoring. All were encountered at S-31 in the man-made portion of the SRDWSC in mid to late August. It is unsurprising that no delta smelt were encountered in 2012; since all dredging occurred in the upper SDWSC, upstream of recent observations of delta smelt.
- The CDFG Fall Mid-water Trawl Study has documented very low abundance of delta smelt since 2006. This data set is available at: http://www.dfg.ca.gov/delta/projects.asp?ProjectID=FMWT.
- Entrainment monitoring conducted aboard the federal hopper dredge Essayons during July and August 2011 documented entrainment of 20 species of fish in San Francisco, San Pablo and Suisun Bay, including longfin and delta smelt, further improving the knowledge of dredging impacts to listed and other species. This monitoring was conducted for the San Francisco District of the USACE and may be available by request.
- Studies referenced above indicate that delta and longfin smelt populations remain very depressed and are typically found further downstream in the SF Bay - Delta system than locations where most SRDWSC and SDWSC maintenance dredging occurs. However, documented presence in the lower river miles of both channels and areas of the Man-made Channel indicates potential for the continued presence of both species during maintenance dredging operations. Occurrence of delta smelt and wakasagi during fish community and entrainment monitoring in 2010 and 2011 reinforces the view that monitoring methods are appropriate for detecting longfin and delta smelt, even though they were not specifically designed for them, and that should future presence of smelt species occur during maintenance dredging, entrainment is likely to result.

- The encounter with adult Chinook salmon during 2011 and 2012 around the dredge documents that maintenance dredging in the upper SDWSC co-occurs with migrating fall-run Chinook salmon during some years. No salmonids of any life-stage have been encountered while conducting entrainment monitoring.
- Lampreys are among the least studied group of fishes in California. At least seven species occur in freshwater habitats within the state, and all are species of special concern in need of greater conservation efforts (Moyle et al., 2009). Four species may occur in the project area, Kern brook, western brook, river, and Pacific (Moyle, 2002). All four of these species were petitioned for listing under ESA in 2003. The USFWS denied the listing in 2004 largely due to lack of information (http://www.fws.gov/pacific/news/2004/lampreyNR.pdf). The USFWS has an ongoing West Coast lamprey conservation initiative in which they describe dredging as one of the significant impacts to west coast lampreys (http://www.fws.gov/pacific/fisheries/sp_habcon/lamprey/index.htm). Both Pacific and river lamprey have been observed during entrainment monitoring, though only a single Pacific lamprey has been identified to date; the remainder have been river lamprey. The Pacific lamprey was identified without the benefit of USFWS genetic analyses and was possibly a misidentified river lamprey. Though Kern brook and western brook lamprey may occur in the project area, none have been encountered.
- High numbers of river lamprey (relative to previous monitoring) were entrained during 2010 and 2011 dredge entrainment monitoring near Rio Vista, possibly indicating an area of abundance not previously indentified. Lack of information on these endemic species is partially due to their being underrepresented by the monitoring gear currently employed in the ongoing status and trends studies (Bay Study, Fall Mid-Water Trawl, Suisun Marsh Study, etc). The fish community monitoring conducted for this program reflects similar results. Very few lampreys have been encountered in trawl surveys. However, the screen may be the most effective lamprey monitoring study currently underway in the California Delta, even though the methods were not specifically developed to target lamprey.
- Due to the need for greater conservation measures for lamprey, and the possibility of future listings, USWFS requested that any lamprey encountered in 2012 be retained and provided to them to further the knowledge of this poorly understood group of fishes (Damon Goodman USFWS, personal communication). The current monitoring provides opportunity to better ascertain survival rates through the development of an entrained lamprey mortality study. Should survival rates be high, then it is likely that entrained lamprey salvage and release could be considered a viable best management practice for ongoing maintenance dredging and proposed channel deepening.
- The fact that 2012 is the first year in which no lamprey were encountered during entrainment monitoring indicates their possible extirpation from the upper SDWSC, and should be a cause of concern.

5.4 Bird Activity Monitoring

Presence of piscivorous birds near dredge operations often indicates an abundance of fish in the area. Fish or invertebrates entrained by the dredge may also attract birds to the DMP sites. However, in past years we've also observed birds hunting newly displaced terrestrial prey. Sea lion presence is also noted since their presence in large freshwater rivers can indicate presence of large fish not effectively monitored by the trawl, such as adult salmonids. This is particularly true when feeding behavior can be observed, as was the case in 2012 within the three upper reaches of the SDWSC.

Sea lion observations and active piscivory by birds have predominantly occurred in the upper reaches of the SDWSC during previous years. Most of these past observations occurred during October through December concurrent with lower water temperatures and increased seasonal movements of fishes. This period is during the latter portion of the currently permitted Ship Channel dredging window, the period monitored in 2012. Bird activity in 2012 while dredging all upper SDWSC reaches was rarely observed at the Roberts 1 DMP site during entrainment monitoring, but consistently observed in the channel reaches, along with sea lions, during trawl monitoring. Larger fish were observed being eaten by sea lions, with documentation of adult salmon taken by these marine mammals. The low level of bird activity at the 2012 DMP site may indicate fewer organisms entrained by the dredge or better forage opportunities from the channel habitats. These upper SDWSC reaches have relatively high fish CPUE indices for all years of monitoring.

5.5 Adaptive Management Strategies and Recommendations for Future Monitoring Efforts

NMFS requires that adaptive management strategies be employed and discussed in the annual report of this monitoring program. Since its inception, the focus has been on testing and improving the project methodology through constant evaluation while monitoring is underway; followed by careful analysis of the annual monitoring results that includes comparisons with other available data. Adaptive management, in past years specifically, focused on improvements to entrainment monitoring methods and responding to the presence of delta and longfin smelt in the fish community. Pertinent and previous adaptive management actions with recommendations for future actions are presented in the following sections.

5.5.1 Entrainment Monitoring

Modifications to monitoring methods for the 2009 and 2010 monitoring incorporated the following changes

The mobile entrainment screen was used successfully at all DMP sites in 2009 and 2010, dispensing completely with the entrainment cell methodology and allowing a significant increase in monitored dredge output with no increase in monitoring effort. Two of the cross bars on the screen were removed based on analysis of structural integrity impacts of removal deemed minimal versus vastly improved ease in material clearance off the screen.

The dump gate at the end of the screen was re-worked prior to the start of the 2010 monitoring. The gate is now much easier to use. The first section of screen was removed and replaced with steel plate early during 2008 monitoring due to washout of the axles under the screen by slurry erosion underneath this forward section of the device. This plate replacement of screen decreased the effective area of the screen by approximately 20 percent. Frequent entrainment screen over-loading in some locations during 2009 monitoring demonstrated the need to return to the originally engineered screen capacity. This section of plate was removed and replaced with the 3/8-inch punch-hole steel plate used in the rest of the device. Additional modifications to direct the draining dredge slurry away from the trailer axels were also incorporated. Hinged aluminum plates were installed on the first 3 sections of screen to eliminate slurry splashing over the sides of the screen during periods of high slurry discharge. Hinges allow opening of these lids for cleaning the debris that accumulates on the screen during use - a daily maintenance chore.

Recommendations for 2011

The Y-valve currently in use to direct slurry to the entrainment screen or main DMP was scheduled for replacement prior to commencement of dredging in 2011. However, the replacement valve did not arrive until after the 2011 season began. It required extensive modifications to be placed in service and so, not made available in 2011. This valve replacement was intended for the start of the 2010 dredging, but was on backorder. While the original valve did work, a biologist had to get off of the screen and walk over to switch the valve to direct slurry away from the screen and back to the DMP when the screen clogged with debris. This became a serious problem in 2009 and limited monitoring effort at times during 2009, 2010 and 2011, due to frequent screen inundation at some locations.

The new Y-valve will be operable without the need to get off the screen or ask for help from the dredge crew. The new valve should result in the ability to monitor more of the dredge output without a further increase in the level of effort or cost, as the biologists should be able to spend more time monitoring and less time clearing debris. The Y-valve modifications have been completed and the new valve is expected to be used starting in 2012.

A new water pump and spray system was installed to increase the amount and pressure of water available to sort and clean entrained materials. This system still needs improvement in both areas. One possibility is use of a powered pressure washer mounted on the screen.

The screen was tilted at several locations to allow gravity to help move material off the screen. The screen should be modified to allow easier tilting once in use. Tilting allows the screen to be adjusted to the variety of slurry volume and pressure that occur due to changing discharge pipe lengths. A system of pneumatic or hydraulic jacks should be utilized to allow rapid adjustment of the screen tilt so that it may be readily adjusted to changing volume and composition of the dredge slurry.

Lighting system improvements for the screen remain a high priority. The light plant provided by RISG is not able to position the light directly over the screen. Partial shadowing of the screen surface results, decreasing visibility for any entrained organisms on the shadowed portion of the screen. The screen should have additional lights mounted in such a way that none of the surface of the screen is shadowed. The lights should be very bright and should be as close to full spectrum as possible. Lack of useful lighting hinders the ability to conduct nighttime and early morning monitoring. This issue was partially ameliorated in 2011 by placing the light plant directly on top of the screen. This is not an ideal solution for the following reasons: it was difficult to position the light plant on top of the screen in some locations; the light plant is loud and hindered communication; at times, the exhaust blew into the work area of the screen; and finally, the location of the light plant on the screen was sometimes problematic for other nighttime dredging operations that needed light elsewhere.

The section above was left in present tense as it appeared in the 2011 report to indicate the author's expectations for 2012 operations. The following section describes additional recommendations from 2012 monitoring.

Recommendations for 2013

- Improvements to the controls and operation of the new Y-valve should be completed so that its original design function may be attained. The ability to shift material flow from the screen to the DMP and back while operating simple controls from the screen needs to be finalized before 2013 operations commence.
- Move the tailgate winch to allow removal of the cross bar on which it is mounted. The winch should be mounted on either side of the screen at the aft end.
- Add a jack system or hinge the screen to allow changing the angle of the screen once placed at the fill site.
- Improve the water system to provide more volume and pressure.
- Add a dedicated generator to the device to power a compressor for the valve, and to power an improved lighting system to facilitate nighttime monitoring. Nighttime monitoring needs to be daylight bright to be effective. Mounting a light plant to the top of the screen (as has been done in 2011 and 2012) is effective, but prevents opening of the clean-out lids on the screen, which is a significant problem.

5.5.2 Fish Community Monitoring

The following modifications to the fish community monitoring methods were incorporated in 2009

Upgrades were made to the computers and software of the monitoring vessel, allowing improvements in navigation in the shipping channels as well as improvements in data acquisition and manipulation.

The following modifications to the fish community monitoring methods were incorporated in 2010

A dissecting microscope and magnifying lenses were used on board the vessel to effectively differentiate wakasagi from delta smelt.

Improvements to the database and electronic forms allowed more data to be directly entered while conducting the fish community monitoring.

The following modifications to the fish community monitoring methods were incorporated in 2011

This monitoring program was requested to participate in sturgeon tracking studies being conducted by the Biotelemetry Laboratory at UC Davis. The goals of the studies are to provide increased knowledge of habitat use and migration patterns of green and white sturgeon. The studies are funded in part by US Bureau of Reclamation and USACE - San Francisco district. The intended participation of this dredge monitoring program was to tag green sturgeon encountered during fish community monitoring. This would increase the number of tagged fish in the study and provide valuable information that would otherwise not be generated. The project biologists were trained to tag green sturgeon, but none were encountered in 2011.

The following modifications to the fish community monitoring methods were incorporated in 2012

A side and forward scanning sonar unit and a 4G high speed/high resolution radar were added to the monitoring vessel. This improved the ability to avoid submerged objects that might snag the net, and improved knowledge of the bottom topography in the dredge reaches. The new radar increased vessel safety and navigation abilities.

New LED lights were added to the vessel to improve safety and navigational abilities during nighttime monitoring.

The following modifications to the fish community monitoring methods will be incorporated in 2013:

- New computers with increased processing speed and longer battery life will be used, allowing faster and more seamless data acquisition.
- The database will be updated and improved, increasing its utility and ease of use for both onboard and land based data entry, processing and output.
- New nets will be used that may allow faster trawling before lifting off bottom.

5.6 Conclusions

Key Conclusions:

- Fisheries monitoring requirements stipulated by the NMFS BOs (NMFS 2006a,b) for the SDWSC and SRDWSC were successfully met during the 2011 dredge season.
- The fish community in the SDWSC continues to be dominated by non-native fish; fish community and entrainment monitoring data continues to exhibit significant inter-annual variation.
- Entrainment monitoring efficiency was increased substantially by improvements to the mobile entrainment screen. Continued improvements will yield additional gains.
- Take of listed and other species during future dredging events may be predicted by presence of these species in the fish community.
- Delta smelt and wakasagi encountered during entrainment and fish community monitoring during previous years indicates that longfin and delta smelt will be entrained if dredging coincides with presence of these listed species.
- Entrainment of a white sturgeon in 2011 provides evidence that both white and green sturgeon may be entrained when present in the dredge reaches.
- Lack of occurrence of lamprey during 2012 monitoring is surprising given their previous presence in the upper SDWSC and should be a cause of concern, even though endemic lamprey are not currently afforded any legal protection.

6 References

Bell, M.C. 1991. Fisheries handbook of engineering requirements and biological criteria. U. S. Army Corps of Engineers, North Pacific Division. Fish Passage Development and Evaluation Program. Portland, OR.

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

Bennett, W. and J. Burau (submitted manuscript, *How did I get here? Tinkering with turbidity, tides, and twilight for migrating delta smelt.* 2012).

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 and 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. California natural diversity database, special animals (865 taxa), February 2008. Available: http://www.dfg.ca.gov/biogeodata/cnddb/pdfs/SPAnimals.pdf. (February 2008).

_____. 2008c. CDFG Biogeographic Data Branch and Habitat Conservation Branch webpages. Available: http://www.dfg.ca.gov/bdb/pdfs/TEAnimals.pdf and http://www.dfg.ca.gov/hcpb/species/SDWSC/SDWSCfish/SDWSCfish.shtml. (February 2008).

_____. 2008d. Bay-Delta region fall midwater trawl indices. Available: http://www.delta.dfg.ca.gov/data/mwt/charts.asp. (January 29, 2008).

_____. 2009a. Bay-Delta region fall midwater trawl indices. Available: http://www.delta.dfg.ca.gov/data/projects/?ProjectID=FMWT. (January 12, 2009).

_____. 2009b. Bay-Delta region summer townet survey - delta smelt indices and fish distribution maps. Available: http://www.delta.dfg.ca.gov/data/projects/?ProjectID=TOWNET. (January 12 and February 9, 2009).

_____. 2009c. Bay-Delta region San Francisco Bay study - Otter trawl survey and mid-water trawl survey delta smelt and longfin smelt indices and fish distribution maps. Available: http://www.delta.dfg.ca.gov/data/projects/?ProjectID=BAYSTUDY. (January 12 and February 12, 2009).

California Department of Water Resources (CDWR). 2009. California data exchange center. Available: http://cdec.water.ca.gov/. (April 23, 2009).

Clemens, W. A. and G. V. Wilby. 1961. Fishes of the Pacific Coast of Canada. Bulletin No. 68. (Sec. Ed.) Fisheries Research Board of Canada. Ottawa. 443 pp.

Dean, S., and B. Illowsky. Hypothesis testing of single mean and single proportion: assumptions. Available at: http://cnx.org/content/m17002/1.7/. (February 7, 2009).

Federal Register. 2012. Vol. 77. FR 19756. 12-Month Finding on a Petition to List the San Francisco Bay-Delta Population of the Longfin Smelt as Endangered or Threatened; Proposed Rule. USFWS. April 2. Available: http://www.fws.gov/policy/library/2012/2012-7198.html

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.

Goodman, D. H., Kinziger, A. P., Reid, S. B., and Docker, M. F. 2009. Morphological diagnosis of *Entosphenus* and *Lampetra* ammocoetes (Petromyzontidae) in Washington, Oregon, and California. American Fisheries Society Symposium. 72: 223-232, 2009.

Goodman, D. H. USFWS. Personal communication regarding retention of lamprey for USFWS. June 21, 2012. Pacific Lamprey Summit III, Portland, Oregon.

Hayes, D. B., C. P. Ferreri, and W. W. Taylor. Active fish capture methods. pp 193-220 in B. R. Murphy and D. W. Willis, eds. Fisheries Techniques, 2nd edition. American Fisheries Society. Bethesda, Maryland.

Howard, J. 2010. The other Freshwater Mussels: Native Freshwater Species in California. Delta Science Program Brown Bag series. 2010.

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).

Mari-Gold Environmental Consulting and Novo Aquatic Sciences (MEC and NAS). 2010. Stockton and Sacramento Deepwater Ship Channel Maintenance Dredging 2009 fish community, entrainment and water quality monitoring report. Submitted April 2010.

_____. 2011. Fish Monitoring and Water Quality Plan: Stockton Deep Water Ship Channel and Sacramento Deep Water Ship Channel Maintenance Dredging and Dredged Material Placement Projects. Prepared for U.S. Army Corps of Engineers, Sacramento District. Submitted April 2011.

_____. 2012a. Stockton and Sacramento Deepwater Ship Channel Maintenance Dredging 2010 fish community, entrainment and water quality monitoring report. Prepared for U.S. Army Corps of Engineers, Sacramento District. Submitted March 2012 (originally submitted May 2011).

_____. 2012b. Stockton and Sacramento Deepwater Ship Channel Maintenance Dredging 2011 fish community, entrainment and water quality monitoring report. Prepared for U.S. Army Corps of Engineers, Sacramento District. Submitted August 2012.

McGinnis, S. M. 1984. Freshwater fishes of California. University of California Press, Berkeley. Moore, D. S. 1995. The basic practice of statistics. W.H. Freeman. New York. Moore, D. S. and G. P. McCabe. 1993. Introduction to the practice of statistics. W.H. Freeman. New York.

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

Moyle, P. B., Brown, L. R., Chase, S. D., and Quinones, R. M. 2009. Status and conservation of lampreys in California. American Fisheries Society Symposium 72:279 -292, 2009.

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.

Orcutt, H. G. 1950. The life History of the Starry Flounder, *Platichthys stellatus (Pallas)*1. State of California Department of Natural Resources Division of Fish and Game Bureau of Marine Fisheries Fish Bulletin NO. 78.

O'Rear, T.J. and P. B. Moyle. 2010. Long Term and Recent Trends in Fishes and Invertebrates in Suisun Marsh. Interagency Ecological Program. 232, Spring 2010.

Pacific Fishery Management Council (PFMC). 1998. Final environmental assessment/regulatory impact review for Amendment 11 to the Pacific Coast Groundfish Fishery Management Plan. October 1998.

SWCA Environmental Consultants (SWCA). 2007. 2007-2008 fisheries monitoring plan for the Stockton and Sacramento Deep Water 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.

_____. 2008. Stockton and Sacramento Deep Water Ship Channel Maintenance Dredging Project 2007 fish community and entrainment monitoring report. Report to U.S. Army Corps of Engineers, Sacramento District. Submitted March 2008. SWCA, Portland.

_____. 2009. Stockton and Sacramento Deep Water Ship Channel Maintenance Dredging Project 2008 fish community and entrainment monitoring report. Report to U.S. Army Corps of Engineers, Sacramento District. Submitted March 2008. SWCA, Portland.

Turner, J. L., and D. W. Kelly. 1966. Ecological studies of the Sacramento-San Joaquin Delta - Part 2, Fishes of the Delta. California Department of Fish and Game.

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.

Wang, J.C.S. 2007. Spawning, early lifestages, and early life histories of the Osmerids found in the Sacramento-San Joaquin Delta of California. Tracy Fish Collection Facility Studies. Volume 38. U.S. Bureau of Reclamation, Mid-Pacific Region and Denver Technical Service.

Wydoski, R. S., and R. R. Whitney. 2003. Inland fishes of Washington, 2nd edition. American Fisheries Society. Bethesda, Maryland.

Appendix A. Special Status Species Life History Information

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Special Status Fish Species

The mandated fish monitoring is required as one of the permit conditions for maintenance dredging specifically because of the special status of certain fish species, primarily driven by Section 7 of the federal Endangered Species Act (ESA) and the Magnuson-Stevens Fishery Conservation and Management Act (MSA), and also involving the California Endangered Species Act (CESA). The status of a particular species may change with the latest assessments of what are known under the ESA as an evolutionarily significant units (ESU) or distinct population segment (DPS). Due to the number of listed species that use the monitoring program's action area (at least for a portion of the year), and petitions for new listings or status changes, permit conditions change frequently. These changes have effects on monitoring, maintenance dredging, and other area projects including port and marina dredging, and such changes can be expected to continue.

The recent changes that affected the 2012 Ship Channel Fish Monitoring Program are highlighted here. Details are provided in following subsections for ESA critical habitat designations, status, and pertinent biology for each fish species - grouped by jurisdictional agency.

The California Fish and Game Commission (CDFG) enacted protections for longfin smelt in 2008, a CESA candidate species at that time. Currently longfin smelt are listed as threatened under CESA (March 4, 2009) and the fish community monitoring is restricted under a IEP-2081 permit allowing annual incidental take of 150 juvenile and 150 adult longfin smelt for the entire year. Federal protection of the longfin smelt was recently denied by the USFWS (April 9, 2009) finding that the San Francisco Bay-Delta longfin smelt did not qualify as a distinct population segment (DPS). The results of the recently concluded 12-month status review of all west coast longfin smelt populations found that the SF Bay – Delta longfin smelt population warranted ESA protection and should be advanced to candidacy (Fed. Reg., April 3, 2012, http://www.fws.gov/cno/es/speciesinformation/longfin.html). However, formal listing is currently precluded by other higher priority species and Candidate species do not receive statutory protection under the ESA. Other key species of interest that are not currently listed under the federal ESA but are present in the action area include: Sacramento splittail, and Pacific lamprey and river lamprey.

Recent state and federal ESA petitions have resulted in decisions to change listing of delta smelt from threatened to endangered. California up-listed delta smelt to endangered status on March 4, 2009 (Final Statement issued on November 10, 2009). The USFWS' five-year status review of delta smelt began March 24, 2009. Most recent is the USFWS 12-month finding reclassifying delta smelt status from threatened to endangered is warranted but precluded by other higher priority listing actions (75 FR 17667, April 7, 2010).

The southern DPS of North American green sturgeon was listed as threatened in 2006 (71 FR 17757), with designated critical habitat and final ESA protective regulations established (75 FR 30714). On October 24, 2012, NMFS initiated a 5-year review of the southern population green sturgeon to collect the best available science and most recent information to ensure the accuracy of the listing classification (77 FR 64959).

The September 29, 2010 status review listing decision was found as not warranted for the Sacramento splittail due to new information showing recent abundance increases (Vol. 75 FR 62070). Other decisive factors noted were: habitat improvements targeted for this species, improved flow conditions, and diminishing threats in the recent past.

Designated Critical Habitat

Critical habitat is established for fish species listed under the federal ESA and habitat areas designated by either the NMFS of USFWS using the latest information and best available science. The delta smelt is the endangered fish species under USFWS jurisdiction that has designated critical habitat (1994, 59 FR 65256) throughout the project areas waters.

For species under NMFS jurisdiction critical habitat consists of the aquatic habitat below ordinary high water, including navigation channels, for all designated areas. Critical habitat for Sacramento River winter-run Chinook salmon was designated on June 16, 1993 (50 FR 33212) and includes the main Sacramento River channel from Keswick Dam (RM 302) downstream to Chipps Island (RM 0) at the westward margin of the Delta; then most all connected waters from Chipps Island westward through the San Francisco Bay. Rivers and sloughs of the Sacramento above Chipps Island (including the entire San Joaquin River Basin and central Delta) are excluded from critical habitat in the 1993 designation. 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 spring-run Chinook salmon includes the Sacramento River from Keswick Dam in Shasta County through the San Francisco Bay including Yolo Bypass and associated sloughs; however, the man-made portion of the SRDWSC is excluded from designation (70 FR 52488). Individuals of both Chinook salmon Evolutionarily Significant Units (ESUs) can occupy waters within the SDWSC and SRDWSC action area. Designated critical habitat for the Central Valley steelhead ESU occurs along the entire length of the SDWSC and SRDWSC below the ordinary high water mark. The recently listed Southern Distinct Population Segment (DPS) of green sturgeon's critical habitat Final Rule was published in the Federal Register (74 FR 52300) on October 9, 009 and includes the entire Sacramento and San Joaquin Delta.

Listed Fish Species Under the Jurisdiction of NMFS

Sacramento River winter-run Chinook salmon *(Oncorhynchus tshawytscha)*
ESA status: Endangered, critical habitat designated
California status: Endangered
Sources: CDFG 2009, 2010 2012, 2013; CalFed 2005; Fry 1961, 1973; Hallock and Fry 1967; Hallock et al. 1970; Miller and Lea 1972; Moyle 1976; Sasaki 1966; Wang 1986

This Chinook salmon ESU listing as endangered was re-affirmed in 1994 (59 FR 440). The winter-run Chinook may use the project area waters primarily for adult spawning migrations and juvenile outmigrations, with some usage overlap for juvenile rearing. Winter-run Chinook adults migrate upstream from December to July and spawn in accessible upper reaches of the Sacramento River basin 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 *Gammarids*, *Neomysids*, and *Crangon* shrimp species. 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: CDFG 2009, 2010, 2012, 2013; CalFed 2005; Federal Register 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.
California Status: none
Sources: CDFG 2010, 2013; CalFed 2005; Hallock et al. 1970; Hallock and Fry 1967; Moyle 1976; Wang 1986

Residing in the ocean for 2–3 years, anadromous adults of the Central Valley steelhead ESU make their upstream spawning migrations beginning in July (peaking in September and October). Spawning occurs from December through April. Central Valley steelhead primarily use the project areas as a migration corridor, with some juvenile rearing overlapping with their smoltification and outmigration processes. Spawning and incubation, along with the majority of rearing, occurs farther upstream than for Chinook salmon and that of the project area. Freshwater residence of juveniles may be from 1-3 years where they feed on diverse aquatic and terrestrial insects and other small invertebrates. Juveniles primarily occur near the surface and in the water column when over deeper waters. Though juvenile Central Valley steelhead do outmigrate to the ocean from December through August, most are found migrating through the project areas in spring.

Green sturgeon *(Acipenser medirostrus)*
ESA status: Threatened (July 6, 2006), Southern DPS, critical habitat designated.
California Status: none
Sources: Adams et al. 2002; CDFG 2009, 2010, 2013; CalFed 2005; FR 2009. Fry 1973; Gisbert (2006); Klimley 2007; NOAA 2009; Radtke 1966; Van Eenenaam (2005); Wang 1986.

The rare and little studied green sturgeon occurs within the project area 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 sub-adults and adults inhabit near shore oceanic waters, bays, and estuaries but also migrate to and from freshwater habitats. Early life-history stages (<4 years old) reside in fresh water, with adults returning to freshwater to spawn (first spawn age range of 10-15 years and > 130 cm in size). Recorded spawning locations are known from the upper Sacramento River and tributaries such as the Feather, Yuba, and American Rivers, with spawning in spring and summer. Recent studies have improved the knowledge of the biology and ecology of this fish, though substantial gaps still exist regarding its habits in the project area and elsewhere in its range. 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. Green sturgeon can be distributed throughout the freshwater portions of their habitat the entire year (at least the juvenile life stage). The diet of juvenile sturgeon consists mostly of amphipods and mysid shrimps in the Delta. Additional information on green sturgeon is available at NMFS web site (http://www.nmfs.noaa.gov/pr/species/fish/greensturgeon.htm).

Listed Fish Species Under the Jurisdiction of USFWS

Delta smelt *(Hypomesus transpacificus)*
ESA status: Endangered (reclassified from threatened but precluded), critical habitat designated
California status: Endangered
Sources: Bennett 2005; CDFG 2010, 2012, 2013; CalFed 2005; Federal Register 2010; 2008, 1994; Ganssle 1966; Herald 1961; McAllister 1963; Messersmith 1966; Moyle 1976, 2002; Moyle et al.1995; Radtke 1966; Swanson et al. 2000; Wang 1986

The 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. It is endemic to the Delta and have been found in the SRDWSC and SDWSC in low abundance. Delta smelt was listed as threatened under the ESA on March 5, 1993 (FR 58, 12854). Final critical habitat designation for delta smelt (Federal Register 59, 65256; December 19, 1994) includes the Stockton and Sacramento DWSCs. On March 24, 2009, the USFWS initiated a five-year status review of delta smelt. As of April 7, 2010, reclassification status of delta smelt to endangered is warranted but precluded (75 FR 17667; for additional information on why). The state status of delta smelt under CESA was recently elevated from threatened to endangered (March 4, 2009).

The abundance of this fish is closely associated with salinities between 0 and 7 practical salinity units (psu). Delta smelt have an upper salinity tolerance of 19 psu and a significant habitat preference near or upstream of the 2 psu zone. They are not present in waters over 25°C, and are rarely found in water temperatures above 22°C. A similar and introduced smelt the wakasagi *(H. nipponensis)* has a larger temperature and salinity tolerance, as well as stronger swimming ability. Delta smelt spawn in dead-end 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. 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. 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. Recent spring Kodiak trawl surveys and summer tow-net surveys by the IEP in the DWSC have shown delta smelt to use the Man-made Channel portion up to the Port of Sacramento, are present in the DWSC year-round, and that these smelt may be genetically distinct from delta smelt occurring in other portions of the Delta.

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.

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). They are administered by the NMFS and are the most likely of their composite to utilize the portions of the Delta within the project area. These species were included in the EFH assessments for the Sacramento River and Stockton Ship Channel Maintenance Dredging and Levee Stabilization Projects (NMFS 2006a, 2006b).

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 and orange 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 the lower portions of 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. One juvenile flounder was collected near the Port of Stockton in 2009 and this may represent an extension of its known range in the Delta.

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 SDWSC and SRDWSC. However, none have been encountered during monitoring of dredge operations.

Fish Species Listed under CESA

Longfin smelt *(Spirinchus thaleichthys)*
ESA status: candidate, SF Bay – Delta DPS
California status: State Threatened
Sources: CDFG 2000, 2007, 2009, 2010, 2012, 2013; Love 2011; Moyle 2002; Moyle et al. 1995

Longfin smelt are a small-sized euryhaline and anadromous fish that was historically one of the most abundant fish in the San Francisco estuary and the Delta. Their abundance has declined precipitously throughout its range during the past quarter century. Longfin smelt are 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. Adults 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. Juveniles tend to inhabit the middle and lower portions of the water column. 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 offshore as far as the Gulf of the Farallones. In coastal waters they are found in surface waters and deeper waters, to depths of 450 feet. They feed in the water column and at, or near, the bottom. Their continuing decline in abundance is likely due to multiple factors including: reduction in outflows, entrainment losses to water diversions, shifts in hydrologic regime and climactic variation, toxic substances, predation and introduced species.

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 here because these species were encountered during fish community and or entrainment monitoring.

Lamprey, Pacific *(Entosphenus tridentate)*
Lamprey, river *(Lampetra ayresii)*
ESA status: Not warranted (decision 2005)
California Status: Watch list – river lamprey
Sources: Goodman et al. 2009, Kostow 2002; Moyle 2002; Wydoski and Whitney 2005

Anadromous Pacific and river lamprey co-occur in SDWSC and SRDWSC. Little is known about population trends for the river lamprey at the southern end of its distribution. Recorded occurrences of river lamprey in California are primarily from the Feather River and the lower Sacramento-San Joaquin River system, including the area of Ship Channel maintenance dredging. 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 in freshwater for up to a year during their upstream 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 (up to six) burrowed into soft substrates in freshwater. 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 is the term applied to the lampreys' transformational stage between filter-feeding ammocoete and parasitic adult. During this period they 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. Adult teeth used to prey on or parasitize other fishes develop and grow in macropthalmia. Full development of the third, or middle, tooth of the supraoral lamina in Pacific lamprey develops during this stage, previously complicating field identification of the early macropthalmic stage with that of the two-toothed river lamprey. However, new studies combining DNA analysis with certain morphological characteristics (Goodman et al. 2009) now allow for greater confidence in field differentiation of these two genera.

Fully developed macropthalmia migrate downstream to the ocean, likely between late fall and spring, when outflows are high. Some river lamprey may spend their entire life history in freshwater. River lamprey appear to be more parasitic in freshwater than Pacific lamprey. Adult river lamprey spend less time in the ocean or estuary migrating back to freshwater in the fall and winter. In general, adult Pacific lamprey migrate from stream to spawning areas in winter and spring.

Sacramento splittail *(Pogonichthys macrolepidotus)*
ESA status: species of concern (2003), formerly listed as threatened (1999)
CESA status: none
Sources: Federal Register 2010. CDFG 2010, 2013; 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). This decision was prompted by a court case challenging the Service on the merits of the prior 2003 ESA not warranted listing determination and alleging improper political influence of the former Deputy Assistant Secretary for Fish Wildlife and Parks, J. MacDonald (Case4:09-cv-03711-PJH). On September 29, 2010 a new status review was published with and the 21-month finding listing decision as not warranted for the Sacramento splittail due to new information showing population increases over the most recent years of study.

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. With the exception of an index of 15 for splittail in 2011, the IEP's Fall Mid-water Trawl Survey has had very low, single-digit, indices since 2001. Reclamation and modification of flood basins also have reduced the species' spawning grounds.

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).

———. 2009. State and Federally Listed Endangered and Threatened Animals of California. Department of Fish and Game. Available: http://www.dfg.ca.gov/biogeodata/cnddb/pdfs/TEAnimals.pdf. (January 2010).

———. 2010. State and Federally Listed Endangered and Threatened Animals of California. Department of Fish and Game. July 2010. Available: http://www.dfg.ca.gov/biogeodata/cnddb/pdfs/TEAnimals.pdf. (July 2010).

———. 2012. State and Federally Listed Endangered and Threatened Animals of California. Department of Fish and Game. January 2011. Available: http://www.dfg.ca.gov/biogeodata/cnddb/pdfs/TEAnimals.pdf. (December 2012).

———. 2013. State and Federally Listed Endangered and Threatened Animals of California. Department of Fish and Wildlife. January 2013. Available: http://www.dfg.ca.gov/biogeodata/cnddb/pdfs/TEAnimals.pdf. (March 2013).

Federal Register. 1994. Vol. 59 FR 65256. Critical habitat determination for the delta smelt. Final Rule. Final designated. USFWS. December 19. http://ecos.fws.gov/docs/federal_register/fr2751.pdf

———. 2005. Vol. 70. FR 52488. Designation of Critical Habitat for seven Evolutionarily Significant Units of Pacific salmon and steelhead in California. Final Rule. NMFS. September 2. http://www.gpo.gov:80/fdsys/pkg/FR-2005-09-02/pdf/05-16389.pdf

———. 2008. Vol. 73 FR 39639. 90-Day Finding on a Petition to reclassify the delta smelt *(Hypomesus transpacificus)* from threatened to endangered. Notice 90-day Petition Finding of Substantial. USFWS. July 10. http://www.gpo.gov:80/fdsys/pkg/FR-2008-07-10/pdf/E8-15747.pdf#page=1

———. 2008. Vol. 73 FR 52084. Proposed Rulemaking to Designate Critical Habitat for the threatened Southern distinct population segment of North American green sturgeon. Proposed Rule. NMFS. September 8. http://www.gpo.gov:80/fdsys/pkg/FR-2008-09-08/pdf/E8-20632.pdf

———. 2009. Vol. 74 FR 52300. Final Rulemaking to Designate Critical Habitat for the threatened Southern distinct population segment of North American green sturgeon. Final Rule. NMFS. October 9. http://www.gpo.gov:80/fdsys/pkg/FR-2009-10-09/pdf/E9-24067.pdf#page=1

———. 2010. Vol. 75 FR 17667. 12-Month Finding on a Petition to reclassify the delta smelt from threatened to endangered throughout its range. Notice 12 month petition finding of warranted but precluded. USFWS. April 7. http://www.gpo.gov:80/fdsys/pkg/FR-2010-04-07/pdf/2010-7904.pdf#page=1

———. 2010. Vol. 75 FR 62070. 12–month Finding on a Petition to list the Sacramento splittail as endangered or threatened [Docket No. FWS-R8-ES-2010-0013]. Notice of 12–month petition finding of not warranted. USFWS. October 7. http://www.gpo.gov:80/fdsys/pkg/FR-2010-10-07/pdf/2010-24871.pdf#page=1

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.

Goodman, D. H., Kinziger, A. P., Reid, S. B., and Docker, M. F. 2009. Morphological diagnosis of *Entosphenus* and *Lampetra* ammocoetes *(Petromyzontidae)* in Washington, Oregon, and California. American Fisheries Society Symposium. 72: 223-232, 2009.

Gisbert, E. and S. Doroshov. 2006. Allometric Growth in Green Sturgeon larvae. Journal of Applied Ichthology. 22 (Suppl.1) (2006), 202-207.

Hallock, R. J. and D. H. Fry, Jr. 1967. Five species of salmon *Oncorhynchus*, 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.

Klimley. A. P., P. J. Allen, J. A. Israel, and J. T. Kelly. 2007. The green sturgeon and its environment: past, present, and future. Environmental Biology of Fishes (2007) Volume 79, Numbers 3-4 / August, 2007.

Love, M. S. 2011. Certainly more than you want to know about the fishes of the Pacific Coast – A postmodern experience. 649pp. Really Big Press, Santa Barbara.

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.

———. 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. 21281F to State of California, Resources Agency, Department of Fish and Game, Inland Fisheries Division, Rancho Cordova, June 1995.

National Marine Fisheries Service (NMFS). 2002. Biological Opinion for the Decker Island Fish Monitoring Program. SWR-00-SA-5820: MEA.

———. 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 and conference opinion for the Sacramento River deep water ship channel maintenance dredging and levee stabilization project. ARN 15 1422SWR200600041:JB, August 29, 2006. Prepared for the U.S. Army Corps of Engineers, Sacramento District. http://swr.nmfs.noaa.gov/sac/myweb8/BiOpFiles/2006/SRDWSC_BO.pdf

NOAA 2009. 50 CFR Part 226. [Docket No. 080730953–91263–02] RIN 0648–AX04. Endangered and Threatened Wildlife and Plants: Final Rulemaking To Designate Critical Habitat for the Threatened Southern Distinct Population Segment of North American Green Sturgeon. Federal Register / Vol. 74, No. 195 / Friday, October 9, 2009.

Pacific Fishery 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. 46 pp. 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.

Swanson, C., T. Reid, P. S. Young and J.J. Cech Jr. 2000. Comparative environmental tolerances of threatened delta smelt *(Hypomesus transpacificus)* and introduced wakasagi *(H. nipponensis)* in an altered California estuary. Oecologia Vol. 123, Number 3, 384-390.

U.S. Fish and Wildlife Service (USFWS). 2009. Delta smelt spotlight species action plan 2010-2014. Aug. 27. http://ecos.fws.gov/docs/action_plans/doc3168.pdf

Van Eenenaam, J. P., J. Linares-Casenave, X. Deng, and SI. Doroshov. 2005. Effect of incubation temperature on green sturgeon embryos, Acipenser medirostris. Environmental Biology of Fishes. Volume 72, Number 2 / February, 2005

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

Surface Water Quality Readings

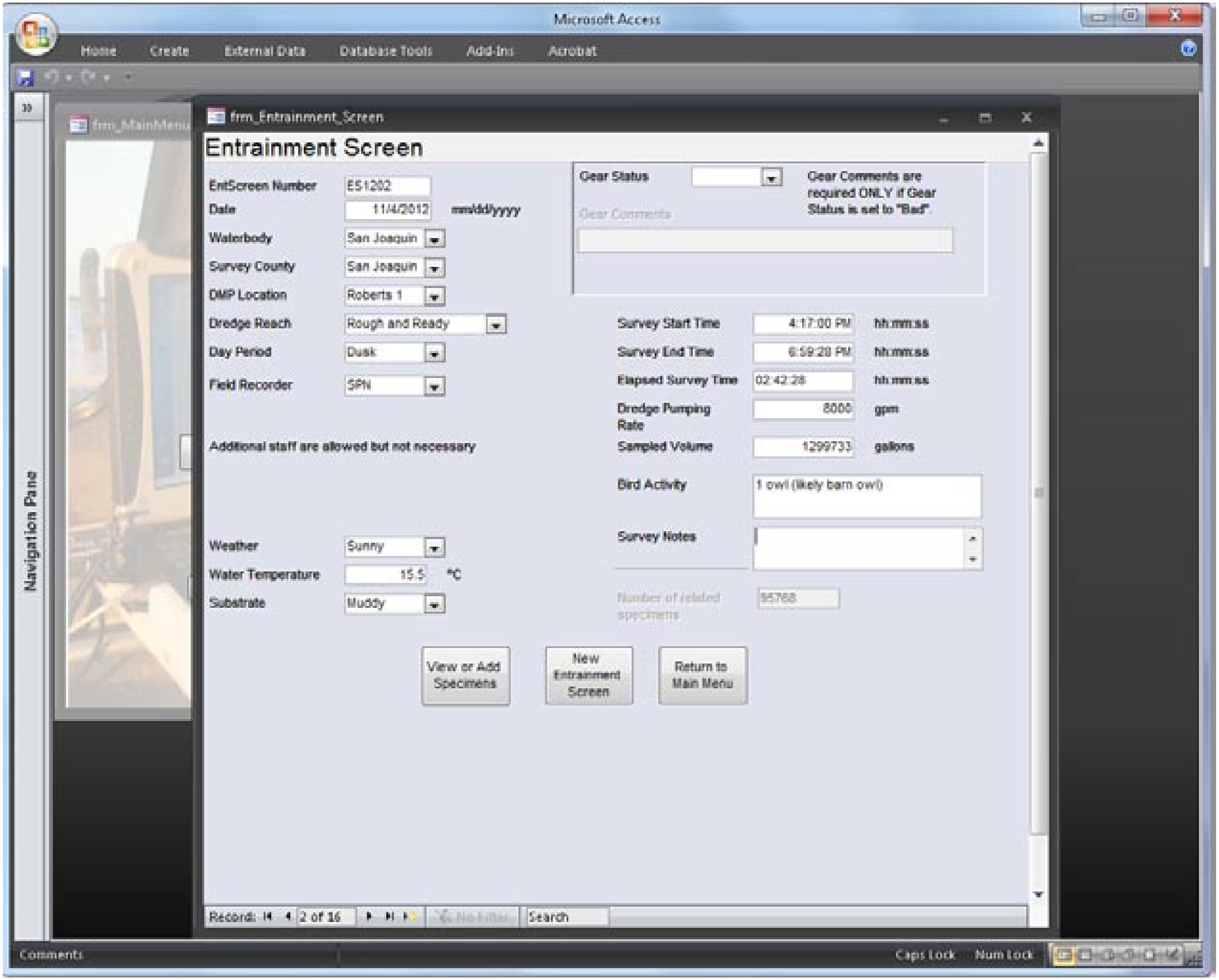
WQ Survey Number	Trawl Survey Number	DR	Date (m/d/y)	Time (hh:mm)	Depth (ft)	Temp. (°C)	DO (ppm)	DO (%)	pH	Secchi Depth	Conductivity (µS)	Salinity (ppt)	Turbidity (ntu)
WQ1201	TR1201	Rough and Ready	7 Nov	16:20		17.40	7.55	81.50	7.04	146			0.00
WQ1202	TR1202	Rough and Ready	8 Nov	14:34	2	17.32	7.24	77.90	7.50		510	0.2	17.60
WQ1203	TR1202	Rough and Ready	8 Nov	17:12	2	17.12	6.74	72.20	7.15	104	554	0.3	17.50
WQ1204	TR1203	Rough and Ready	9 Nov	11:11	2	17.11	6.95	74.40	7.42		548	0.3	27.00
WQ1205	TR1203	Rough and Ready	9 Nov	14:12	2	16.53	6.84	72.40	7.24	124	501	0.2	11.30
WQ1206	TR1204	Rough and Ready	10 Nov	9:42	2	16.77	7.02	74.70	7.25	114	570	0.3	17.80
WQ1207	TR1204	Rough and Ready	10 Nov	12:45	2	16.74	6.59	70.10	7.20	123	529	0.3	13.00
WQ1208	TR1205	Rough and Ready	11 Nov	14:04	3	16.55	6.57	69.60	7.38	130	535	0.3	15.00
WQ1209	TR1205	Rough and Ready	11 Nov	16:01	3	15.63	7.09	73.70	7.31	104	556	0.3	20.30
WQ1210	TR1206	Ore Dock	13 Nov	11:01	2	15.88	6.85	71.60	7.43	194	609	0.3	7.40
WQ1211	TR1206	Ore Dock	13 Nov	12:55	2	15.15	6.78	69.70	7.34	189	647	0.3	9.00
WQ1212	TR1207	Ore Dock	16 Nov	10:47	2	15.27	6.88	71.00	7.44		689	0.3	9.90
WQ1213	TR1207	Ore Dock	16 Nov	13:51	2	15.14	6.79	69.80	7.37	206	688	0.3	7.50
WQ1214	TR1208	Ore Dock	18 Nov	10:41	2	15.52	6.80	70.50	7.32	149	696	0.3	10.80
WQ1215	TR1208	Ore Dock	18 Nov	13:11	2	15.14	7.75	79.70	7.13	198	682	0.3	5.70
WQ1216	TR1209	Ore Dock	26 Nov	15:48	2	14.48	7.52	76.30	7.04	168	625	0.3	8.70
WQ1217	TR1210	Ore Dock	28 Nov	14:12	2	14.33	7.84	79.30	7.23	132	696	0.3	17.70
WQ1218	TR1211	Ore Dock	30 Nov	14:15	2	14.64	7.55	76.90	7.27	132	676	0.3	14.50
WQ1219	TR1212	Ore Dock	2 Dec	14:25	2	14.48	7.57	76.80	7.23	106	639	0.3	30.30
WQ1220	TR1212	Ore Dock	2 Dec	16:56	2	14.09	7.03	70.60	6.94	126	656	0.3	18.50
WQ1221	TR1213	Ore Dock	4 Dec	12:06	3	14.11	6.98	70.20	6.80	28	488	0.2	106.00
WQ1222	TR1213	Ore Dock	4 Dec	14:44	3	14.06	6.77	68.00	6.93	36	490	0.2	114.00
WQ1223	TR1214	Ore Dock	6 Dec	13:17	2	13.93	6.20	62.20	6.75	46	445	0.2	46.70
WQ1224	TR1215	Ore Dock	8 Dec	14:13	2	13.76	6.37	63.60	6.82	62	463	0.2	17.90
WQ1225	TR1215	Ore Dock	8 Dec	16:51	2	13.83	6.49	64.90	6.99	56	467	0.2	19.60
WQ1226	TR1216	Upper Roberts	10 Dec	12:22	2	13.64	6.56	65.40	7.06	94	510	0.2	8.30
WQ1227	TR1216	Upper Roberts	10 Dec	14:56	3	17.40	7.55	81.50	7.04	76	514	0.2	20.60

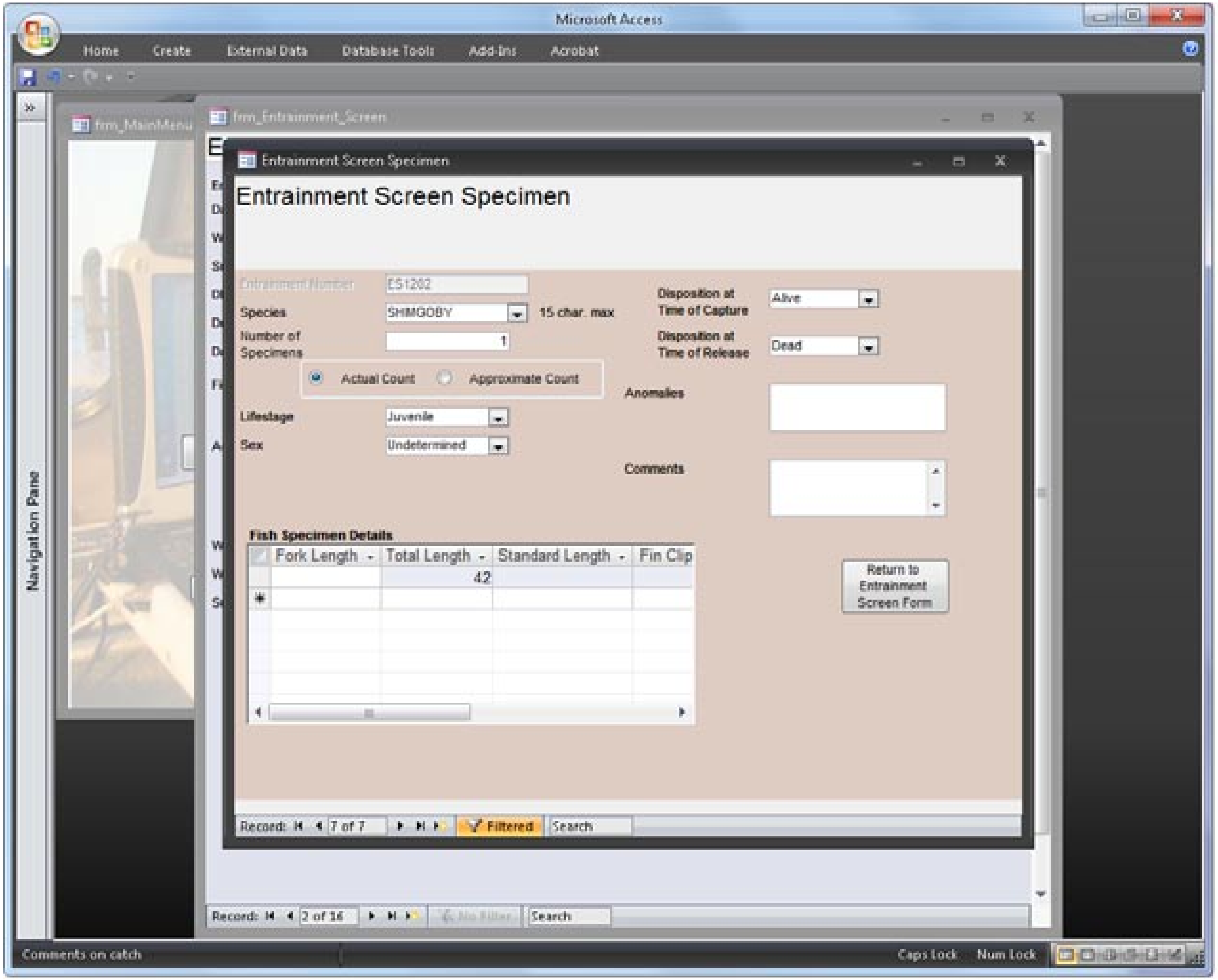
Bottom Water Quality Readings

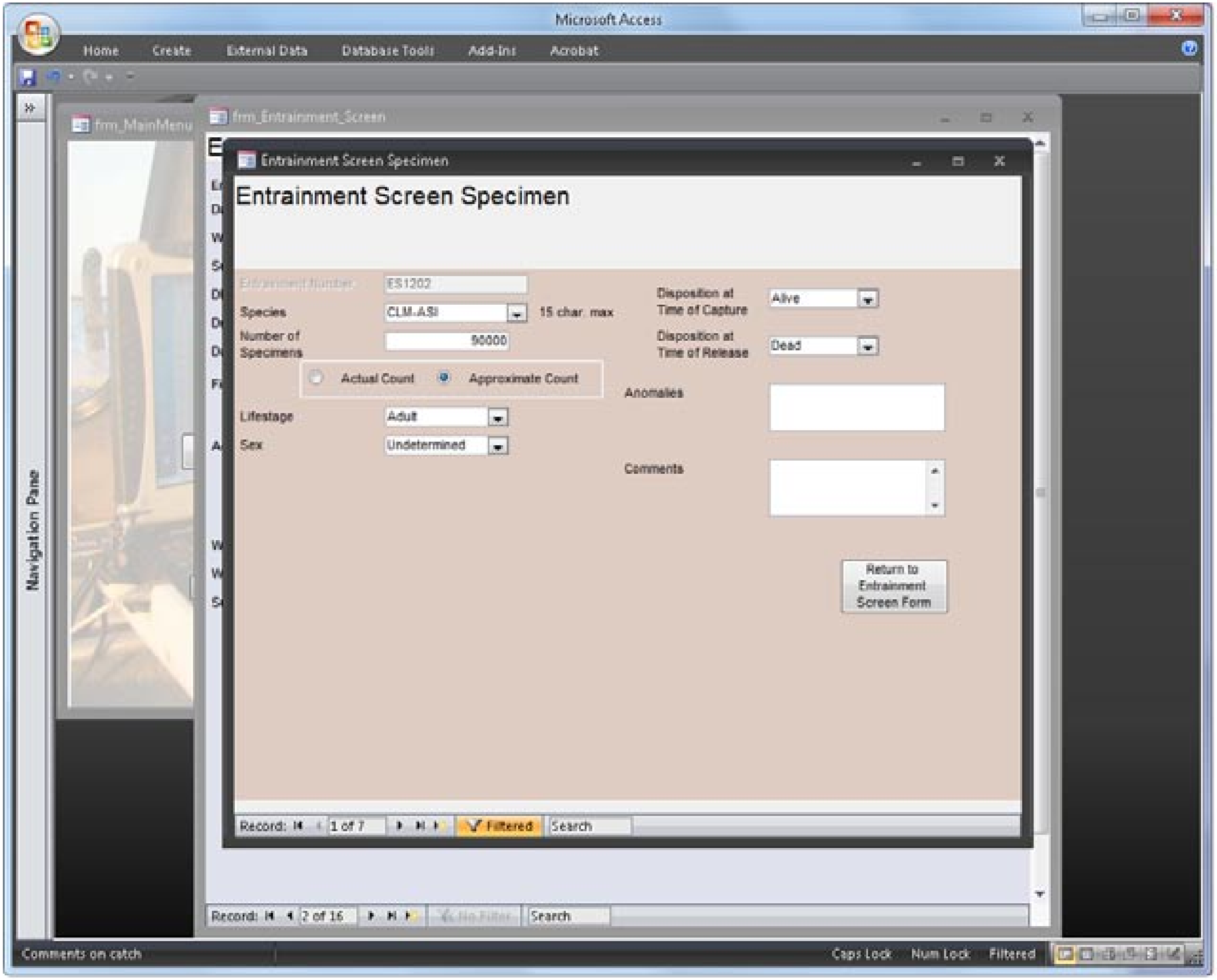
WQ Survey Number	Trawl Survey Number	DR	Date (m/d/y)	Time (hh:mm)	Depth (ft)	Temp. (°C)	DO (ppm)	DO (%)	pH	Conductivity (µS)	Salinity (ppt)	Turbidity (ntu)
WQ1201	TR1201	Rough and Ready	7 Nov									0.00
WQ1202	TR1202	Rough and Ready	8 Nov	14:40	32	17.41	7.53	81.20	7.49	517	0.20	18.00
WQ1203	TR1202	Rough and Ready	8 Nov	17:15	35	17.34	7.11	76.60	7.62	555	0.30	20.90
WQ1204	TR1203	Rough and Ready	9 Nov	11:25	35	16.98	7.02	75.00	7.45	554	0.30	26.60
WQ1205	TR1203	Rough and Ready	9 Nov	14:14	36	16.86	7.27	77.50	7.50	507	0.20	16.20
WQ1206	TR1204	Rough and Ready	10 Nov	9:44	34	16.25	6.99	73.60	7.37	567	0.30	19.60
WQ1207	TR1204	Rough and Ready	10 Nov	12:47	36	16.65	7.19	76.30	7.27	539	0.30	28.80
WQ1208	TR1205	Rough and Ready	11 Nov	14:06	35	16.38	6.64	70.20	7.29	550	0.30	20.20
WQ1209	TR1205	Rough and Ready	11 Nov	16:03	37	16.27	6.70	70.60	7.43	564	0.30	36.90
WQ1210	TR1206	Ore Dock	13 Nov	10:57	37	15.28	7.15	73.90	7.43	783	0.40	8.60
WQ1211	TR1206	Ore Dock	13 Nov	12:58	36	15.60	6.81	70.70	7.44	655	0.30	8.20
WQ1212	TR1207	Ore Dock	16 Nov	10:52	36	15.06	7.01	72.00	7.45	710	0.30	16.30
WQ1213	TR1207	Ore Dock	16 Nov	13:54	35	14.15	7.41	76.30	7.48	699	0.30	13.90
WQ1214	TR1208	Ore Dock	18 Nov	10:45	39	14.92	7.60	77.80	7.53	702	0.30	10.60
WQ1215	TR1208	Ore Dock	18 Nov	13:14	36	14.92	7.47	76.50	7.46	699	0.30	27.40
WQ1216	TR1209	Ore Dock	26 Nov	15:52	38	14.69	7.92	80.70	7.32	690	0.30	12.10
WQ1217	TR1210	Ore Dock	28 Nov	14:19	36	14.44	8.28	84.00	7.20	693	0.30	18.80
WQ1218	TR1211	Ore Dock	30 Nov	14:19	36	14.31	8.39	84.80	7.35	683	0.30	20.10
WQ1219	TR1212	Ore Dock	2 Dec	14:28	34	14.47	8.47	86.00	7.29	683	0.30	14.60
WQ1220	TR1212	Ore Dock	2 Dec	16:59	34	14.46	7.48	75.90	7.32	687	0.30	13.20
WQ1221	TR1213	Ore Dock	4 Dec	12:16	39	14.06	7.10	71.40	6.91	486	0.20	192.00
WQ1222	TR1213	Ore Dock	4 Dec	14:47	37	14.06	7.02	70.50	6.94	478	0.20	153.00
WQ1223	TR1214	Ore Dock	6 Dec	13:21	39	14.19	6.79	68.50	6.94	512	0.20	44.40
WQ1224	TR1215	Ore Dock	8 Dec	14:03	38	13.86	6.68	66.90	7.03	463	0.20	18.70
WQ1225	TR1215	Ore Dock	8 Dec	16:54	37	13.73	6.28	62.70	6.96	472	0.20	40.50
WQ1226	TR1216	Upper Roberts	10 Dec	12:26	38	13.53	6.71	66.70	7.08	508	0.20	41.90
WQ1227	TR1216	Upper Roberts	10 Dec	15:01	36	13.50	6.96	69.10	7.03	514	0.20	29.70

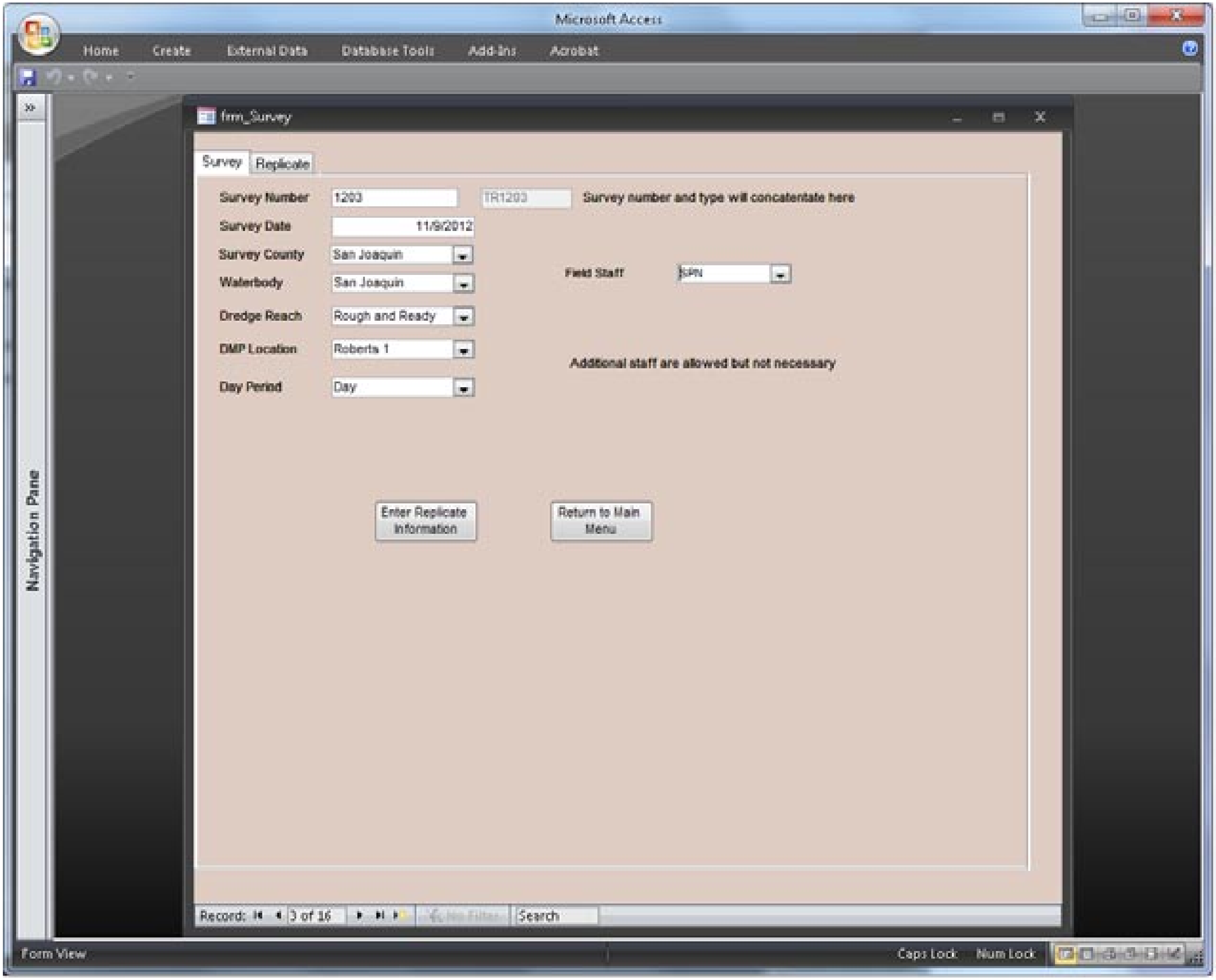
Appendix C. Field Data Collection Forms and Database

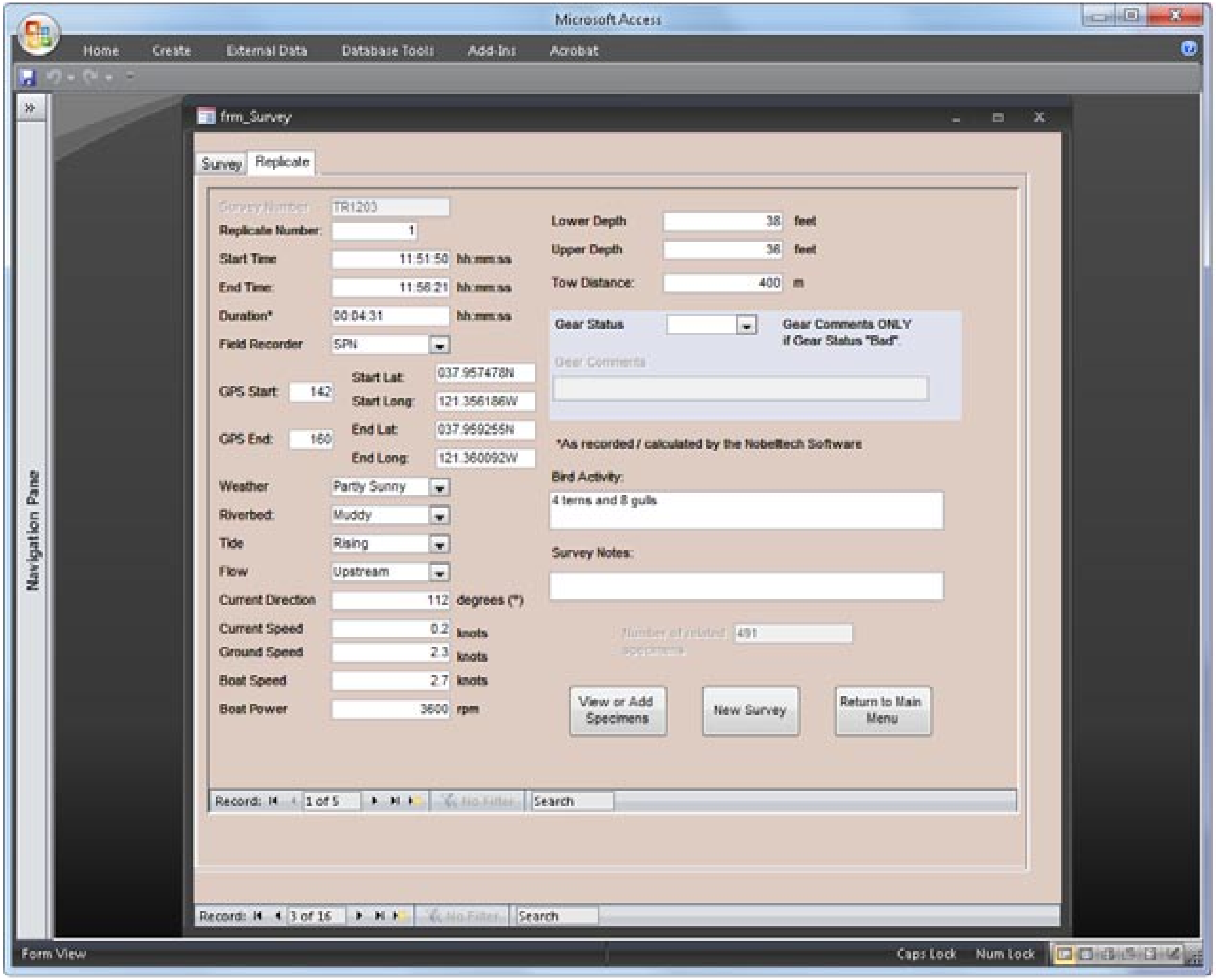

Microsoft Access
Home
Create
External Data
Database Tools
Add-Ins
Acrobat
frm_MainMenu
2012 Fish Monitoring Data
California DWSC
Dredging Operation
Choose a Survey Type below:
Trawl
Water Quality
Entrainment Screen
Purse Seine
Beach Seine
Entrainment Cell
Quit Application
Navigation Pane
Form View
Caps Lock
Num Lock

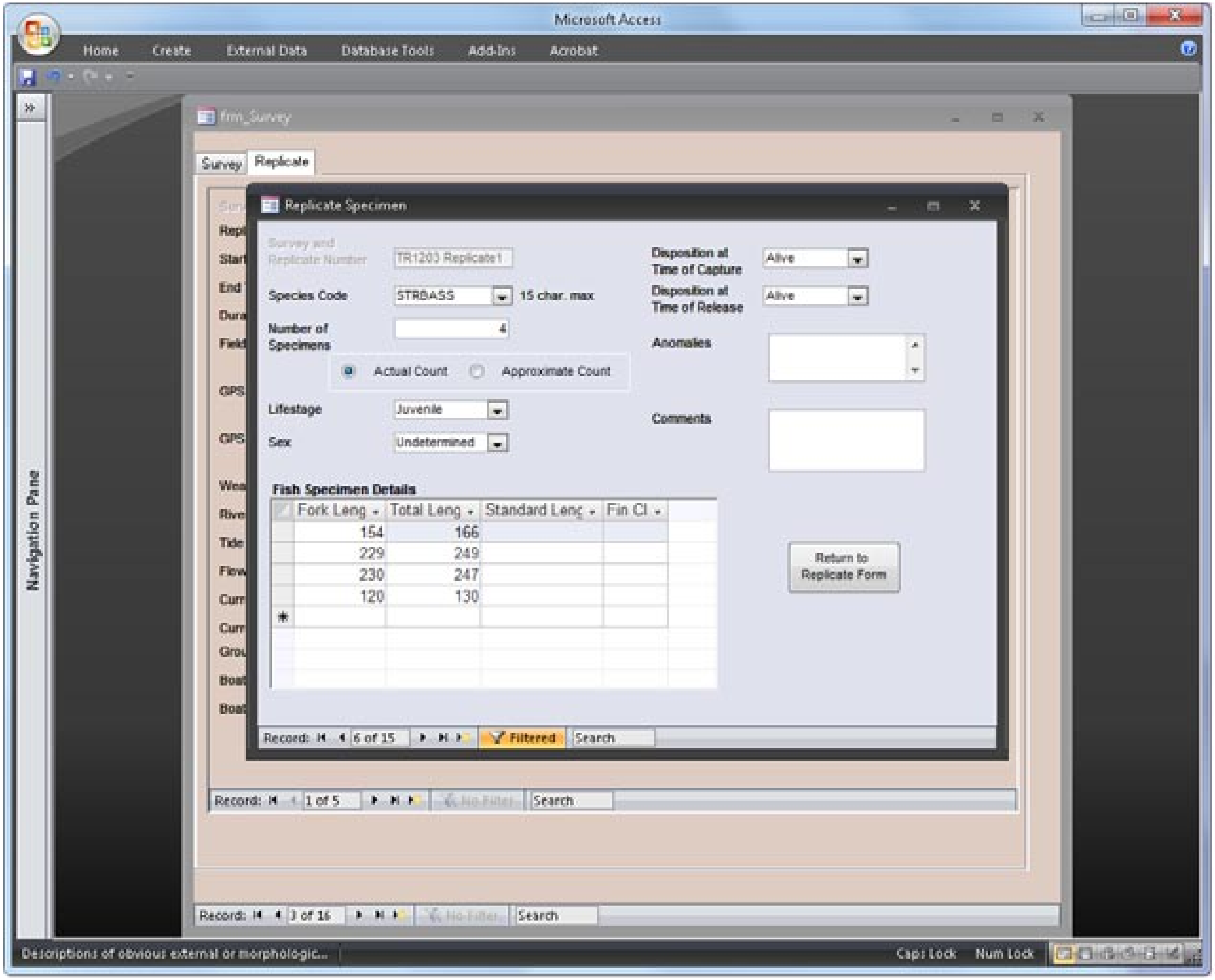

Microsoft Access
Home
Create
External Data
Database Tools
Add-Ins
Acrobat
frm_MainMenu
frm_Entrainment_Screen
Entrainment Screen
EntScreen Number
ES1202
Date
11/4/2012
mm/dd/yyyy
Waterbody
San Joaquin
Survey County
San Joaquin
DMP Location
Roberts 1
Dredge Reach
Rough and Ready
Day Period
Dusk
Field Recorder
SPN
Additional staff are allowed but not necessary
Weather
Sunny
Water Temperature
15.5
°C
Substrate
Muddy
Gear Status
Gear Comments are required ONLY if Gear Status is set to "Bad".
Gear Comments
Survey Start Time
4:17:00 PM
hh:mm:ss
Survey End Time
6:59:28 PM
hh:mm:ss
Elapsed Survey Time
02:42:28
hh:mm:ss
Dredge Pumping Rate
8000
gpm
Sampled Volume
1299733
gallons
Bird Activity
1 owl (likely barn owl)
Survey Notes
Number of related specimens
95768
View or Add Specimens
New Entrainment Screen
Return to Main Menu
Record: 2 of 16
No Filter
Search
Navigation Pane
Comments
Caps Lock
Num Lock

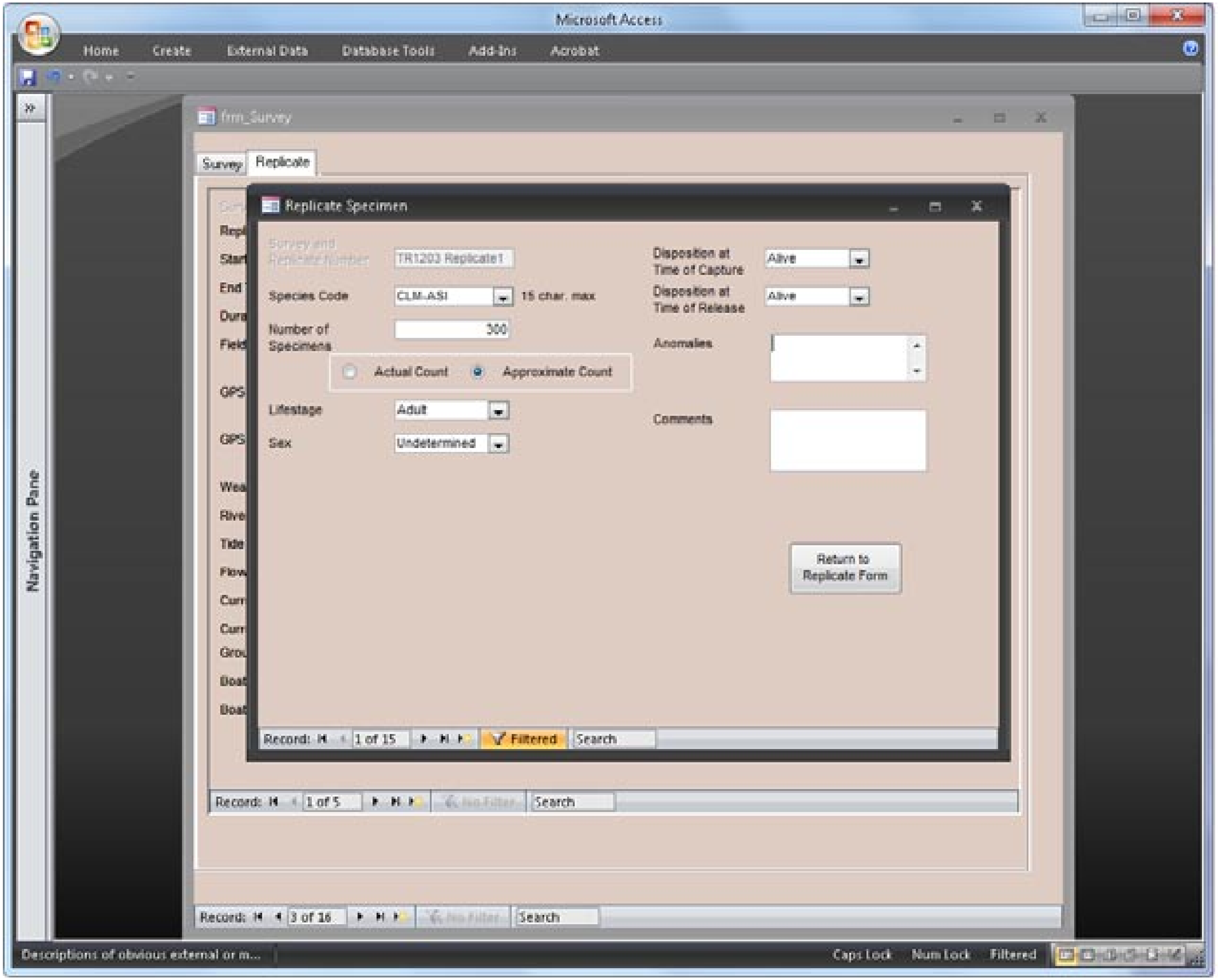

Microsoft Access
Home
Create
External Data
Database Tools
Add-Ins
Acrobat
Navigation Pane
frm_MainMenu
frm_Entrainment_Screen
Entrainment Screen Specimen
Entrainment Screen Specimen
Entrainment Number
ES1202
Species
SHMGOBY
15 char. max
Number of Specimens
1
Actual Count
Approximate Count
Lifestage
Juvenile
Sex
Undetermined
Disposition at Time of Capture
Alive
Disposition at Time of Release
Dead
Anomalies
Comments
Fish Specimen Details
Fork Length
Total Length
Standard Length
Fin Clip
42
Return to Entrainment Screen Form
Record: 7 of 7
Filtered
Search
Record: 2 of 16
No Filter
Search
Comments on catch
Caps Lock
Num Lock

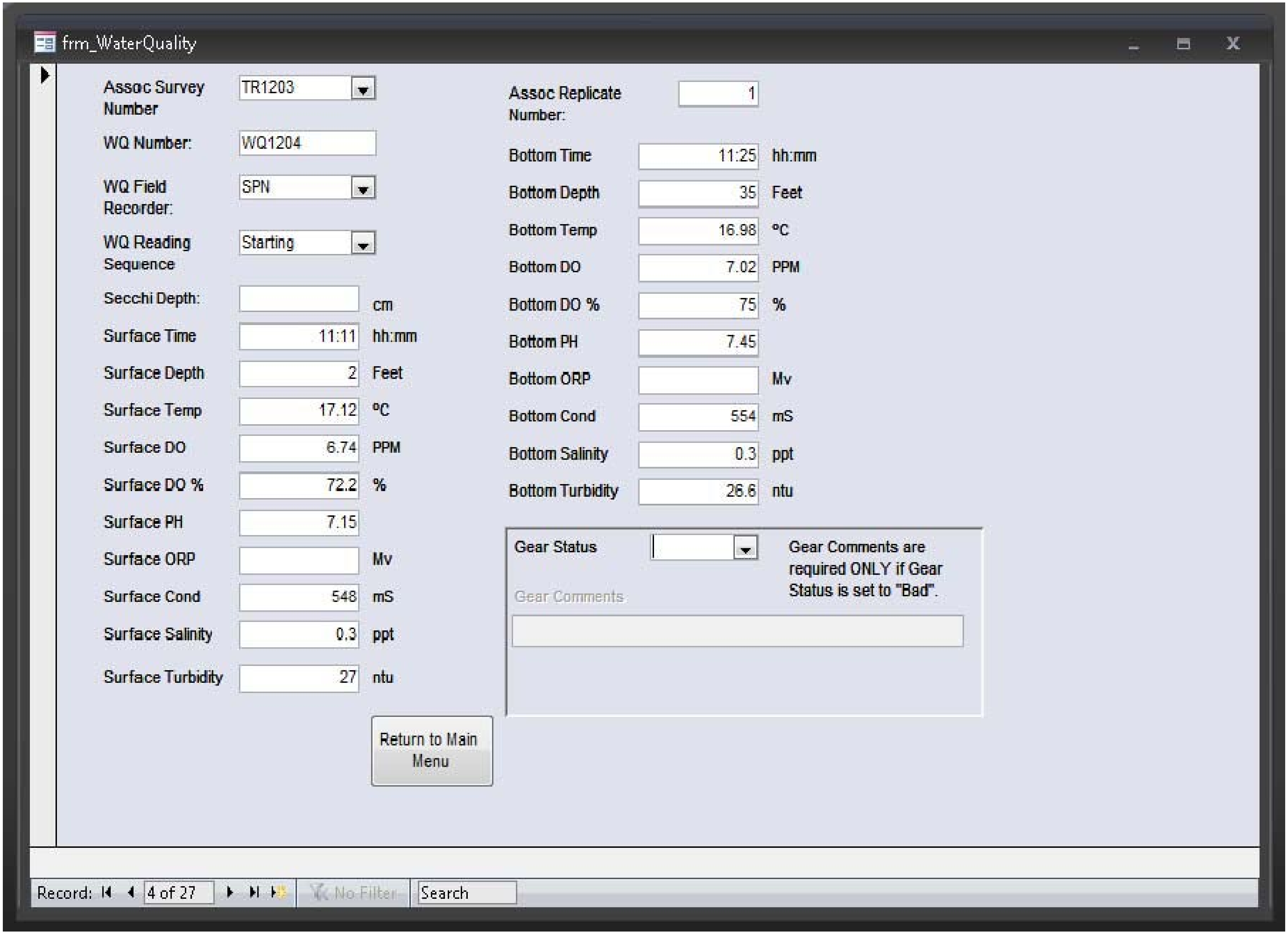

Microsoft Access
Home
Create
External Data
Database Tools
Add-Ins
Acrobat
Navigation Pane
frm_MainMenu
frm_Entrainment_Screen
Entrainment Screen Specimen
Entrainment Screen Specimen
Entrainment Number
ES1202
Species
CLM-ASI
15 char. max
Number of Specimens
90000
Actual Count
Approximate Count
Lifestage
Adult
Sex
Undetermined
Disposition at Time of Capture
Alive
Disposition at Time of Release
Dead
Anomalies
Comments
Return to Entrainment Screen Form
Record: 1 of 7
Filtered
Search
Record: 2 of 16
No Filter
Search
Comments on catch
Caps Lock
Num Lock
Filtered


Microsoft Access
Home
Create
External Data
Database Tools
Add-Ins
Acrobat
frm_Survey
Survey
Replicate
Survey Number
1203
TR1203
Survey number and type will concatentate here
Survey Date
11/9/2012
Survey County
San Joaquin
Waterbody
San Joaquin
Field Staff
SPN
Dredge Reach
Rough and Ready
DMP Location
Roberts 1
Additional staff are allowed but not necessary
Day Period
Day
Enter Replicate Information
Return to Main Menu
Record: 3 of 16
Search
Navigation Pane
Form View
Caps Lock
Num Lock


Microsoft Access
Home
Create
External Data
Database Tools
Add-Ins
Acrobat
frm_Survey
Survey
Replicate
Survey Number
TR1203
Replicate Number:
1
Start Time
11:51:50
hh:mm:ss
End Time:
11:56:21
hh:mm:ss
Duration*
00:04:31
hh:mm:ss
Field Recorder
SPN
GPS Start:
142
Start Lat:
037.957478N
Start Long:
121.356186W
GPS End:
160
End Lat:
037.959255N
End Long:
121.360092W
Weather
Partly Sunny
Riverbed:
Muddy
Tide
Rising
Flow
Upstream
Current Direction
112
degrees (°)
Current Speed
0.2
knots
Ground Speed
2.3
knots
Boat Speed
2.7
knots
Boat Power
3600
rpm
Lower Depth
38
feet
Upper Depth
36
feet
Tow Distance:
400
m
Gear Status
Gear Comments ONLY if Gear Status "Bad"
Gear Comments
*As recorded / calculated by the Nobeltech Software
Bird Activity:
4 terns and 8 gulls
Survey Notes:
491
View or Add Specimens
New Survey
Return to Main Menu
Record: 1 of 5
No Filter
Search
Record: 3 of 16
No Filter
Search
Navigation Pane
Form View
Caps Lock
Num Lock


Microsoft Access
Home
Create
External Data
Database Tools
Add-Ins
Acrobat
Navigation Pane
frm_Survey
Survey
Replicate
Replicate Specimen
Survey and Replicate Number
TR1203 Replicate1
Species Code
STRBASS
15 char. max
Number of Specimens
4
Actual Count
Approximate Count
Lifestage
Juvenile
Sex
Undetermined
Disposition at Time of Capture
Alive
Disposition at Time of Release
Alive
Anomalies
Comments
Fish Specimen Details
Fork Leng
Total Leng
Standard Lenç
Fin Cl
154
166
229
249
230
247
120
130
Return to Replicate Form
Record: 6 of 15
Filtered
Search
Record: 1 of 5
No Filter
Search
Record: 3 of 16
No Filter
Search
Descriptions of obvious external or morphologic...
Caps Lock
Num Lock


Microsoft Access
Home
Create
External Data
Database Tools
Add-Ins
Acrobat
Navigation Pane
frm_Survey
Survey
Replicate
Replicate Specimen
Survey and Replicate Number
TR1203 Replicate1
Species Code
CLM-ASI
15 char. max
Number of Specimens
300
Actual Count
Approximate Count
Lifestage
Adult
Sex
Undetermined
Disposition at Time of Capture
Alive
Disposition at Time of Release
Alive
Anomalies
Comments
Return to Replicate Form
Record: 1 of 15
Filtered
Search
Record: 1 of 5
No Filter
Search
Record: 3 of 16
No Filter
Search
Descriptions of obvious external or m...
Caps Lock
Num Lock
Filtered


frm_WaterQuality
Assoc Survey Number: TR1203
WQ Number: WQ1204
WQ Field Recorder: SPN
WQ Reading Sequence: Starting
Secchi Depth: cm
Surface Time 11:11 hh:mm
Surface Depth 2 Feet
Surface Temp 17.12 °C
Surface DO 6.74 PPM
Surface DO % 72.2 %
Surface PH 7.15
Surface ORP Mv
Surface Cond 548 mS
Surface Salinity 0.3 ppt
Surface Turbidity 27 ntu
Assoc Replicate Number: 1
Bottom Time 11:25 hh:mm
Bottom Depth 35 Feet
Bottom Temp 16.98 °C
Bottom DO 7.02 PPM
Bottom DO % 75 %
Bottom PH 7.45
Bottom ORP Mv
Bottom Cond 554 mS
Bottom Salinity 0.3 ppt
Bottom Turbidity 26.6 ntu
Gear Status
Gear Comments are required ONLY if Gear Status is set to "Bad".
Gear Comments
Return to Main Menu
Record: 4 of 27
No Filter
Search

Water Quality Monitoring Datasheet (2012)

Associated Survey Number: ____________________

WQ Sample Number: ____________________

WQ Field Recorder: ____________________

Starting WQ Reading:

Associated Replicate Number: ____________________

Measurements Taken	**Near Surface**	**Near Bottom**
Secchi Depth [cm]:		
WQ Time:		
WQ Depth:		
Temp [°C]:		
DO [ppm]:		
DO [% saturation]:		
pH:		
Conductivity (μm):		
Salinity:		
ORP [Mv]:		
TDS [g/L]:		
Turbidity [ntu]:		
Gear Status:	Good/Bad	Good/Bad
Gear Comments*:		

Ending WQ Reading:

Associated Replicate Number: ____________________

Measurements Taken	**Near Surface**	**Near Bottom**
Secchi Depth [cm]:		
WQ Time:		
WQ Depth:		
Temp [°C]:		
DO [ppm]:		
DO [% saturation]:		
pH:		
Conductivity (μm):		
Salinity:		
ORP [Mv]:		
TDS [g/L]:		
Turbidity [ntu]:		
Gear Status:	Good/Bad	Good/Bad
Gear Comments*:		

*Gear Comments ONLY if Gear Status is Bad

Tow Replicate Sampling Data Sheet

– Trawl Survey Method (2012)

Survey Replicate Number:		Subsample?	yes / no
Start Time:		(IF SUBSAMPLE,	
End Time:		then percentage estimate)	
Total Survey Time (calculated)		Gear Status:	Good / Bad
[hh:mm:ss]		Gear Comments*:	
Starting GPS Track ID Num:			
Ending GPS Track ID Num:			
Field Recorder:		* Gear Comments ONLY if Gear Status is Bad	
Weather:		Piscivorous Bird Activity:	
Substrate Desc:			
Tidal Phase:	ebb / flood / slack:		
Flow Direction:	upstream / downstream		
Current Direction [° True North]:			
Current Speed [kts]:			
Ground Speed [kts]:		Other Survey Notes:	
Boat Speed [kts]:			
Boat Power [rpms]:			
Survey Depth_Lower [ft]:			
Survey Depth_Upper [ft]:			
Tow distance [m]:			

Entrainment Sampling Data Sheet – Screen Method (2012)

EntScreen Number:		EntScreen Start Time:	
EntScreen Date:		EntScreen End Time:	
Survey Waterbody:		Total Survey Time [hh:mm:ss]	
Survey County:			
DMP Site:		Dredge Pumping Rate [gpm]	
Dredge Reach:			
Daylight Conditions:		Sampled Volume [gallons]	
Field Recorder:			
Weather:		Bird Activity:	
Water Temp:			
Substrate Desc:			
GPS Track ID Number (for ref in case of malfunction):		Other Survey Notes:	
Gear Status:			
Gear Comments*:			

*Gear Comments ONLY if Gear Status is Bad

Specimen Collection Datasheet (2012)

Associated Sample Type
& Sample Number: ______________ Page ______ of ______

SPECIMEN TALLY		SPECIES	LIFE STAGE	SEX	FL (mm)	TL (mm)	SL (mm)	FIN CLIP	CAPTURE DISP	RELEASE DISP	EXTERNAL ANOMALIES	OTHER COMMENTS
Actual / Approximate												
Actual / Approximate												
Actual / Approximate												
Actual / Approximate												
Actual / Approximate												
Actual / Approximate												
Actual / Approximate												
Actual / Approximate												
Actual / Approximate												
Actual / Approximate												
Actual / Approximate												
Actual / Approximate												
Actual / Approximate												
Actual / Approximate												
Actual / Approximate												
Actual / Approximate												
Actual / Approximate												
Actual / Approximate												

ID: DATE: LOC: USACE SACRAMENTO/STOCKTON SHIP CHANNEL FISH MON S.NOVOTNY 8979 & J. GOLD 0993 FL: mm TL: mm	ID: DATE: LOC: USACE SACRAMENTO/STOCKTON SHIP CHANNEL FISH MON S.NOVOTNY 8979 & J. GOLD 0993 FL: mm TL: mm	ID: DATE: LOC: USACE SACRAMENTO/STOCKTON SHIP CHANNEL FISH MON S.NOVOTNY 8979 & J. GOLD 0993 FL: mm TL: mm
ID: DATE: LOC: USACE SACRAMENTO/STOCKTON SHIP CHANNEL FISH MON S.NOVOTNY 8979 & J. GOLD 0993 FL: mm TL: mm	ID: DATE: LOC: USACE SACRAMENTO/STOCKTON SHIP CHANNEL FISH MON S.NOVOTNY 8979 & J. GOLD 0993 FL: mm TL: mm	ID: DATE: LOC: USACE SACRAMENTO/STOCKTON SHIP CHANNEL FISH MON S.NOVOTNY 8979 & J. GOLD 0993 FL: mm TL: mm
ID: DATE: LOC: USACE SACRAMENTO/STOCKTON SHIP CHANNEL FISH MON S.NOVOTNY 8979 & J. GOLD 0993 FL: mm TL: mm	ID: DATE: LOC: USACE SACRAMENTO/STOCKTON SHIP CHANNEL FISH MON S.NOVOTNY 8979 & J. GOLD 0993 FL: mm TL: mm	ID: DATE: LOC: USACE SACRAMENTO/STOCKTON SHIP CHANNEL FISH MON S.NOVOTNY 8979 & J. GOLD 0993 FL: mm TL: mm
ID: DATE: LOC: USACE SACRAMENTO/STOCKTON SHIP CHANNEL FISH MON S.NOVOTNY 8979 & J. GOLD 0993 FL: mm TL: mm	ID: DATE: LOC: USACE SACRAMENTO/STOCKTON SHIP CHANNEL FISH MON S.NOVOTNY 8979 & J. GOLD 0993 FL: mm TL: mm	ID: DATE: LOC: USACE SACRAMENTO/STOCKTON SHIP CHANNEL FISH MON S.NOVOTNY 8979 & J. GOLD 0993 FL: mm TL: mm
ID: DATE: LOC: USACE SACRAMENTO/STOCKTON SHIP CHANNEL FISH MON S.NOVOTNY 8979 & J. GOLD 0993 FL: mm TL: mm	ID: DATE: LOC: USACE SACRAMENTO/STOCKTON SHIP CHANNEL FISH MON S.NOVOTNY 8979 & J. GOLD 0993 FL: mm TL: mm	ID: DATE: LOC: USACE SACRAMENTO/STOCKTON SHIP CHANNEL FISH MON S.NOVOTNY 8979 & J. GOLD 0993 FL: mm TL: mm
ID: DATE: LOC: USACE SACRAMENTO/STOCKTON SHIP CHANNEL FISH MON S.NOVOTNY 8979 & J. GOLD 0993 FL: mm TL: mm	ID: DATE: LOC: USACE SACRAMENTO/STOCKTON SHIP CHANNEL FISH MON S.NOVOTNY 8979 & J. GOLD 0993 FL: mm TL: mm	ID: DATE: LOC: USACE SACRAMENTO/STOCKTON SHIP CHANNEL FISH MON S.NOVOTNY 8979 & J. GOLD 0993 FL: mm TL: mm
ID: DATE: LOC: USACE SACRAMENTO/STOCKTON SHIP CHANNEL FISH MON S.NOVOTNY 8979 & J. GOLD 0993 FL: mm TL: mm	ID: DATE: LOC: USACE SACRAMENTO/STOCKTON SHIP CHANNEL FISH MON S.NOVOTNY 8979 & J. GOLD 0993 FL: mm TL: mm	ID: DATE: LOC: USACE SACRAMENTO/STOCKTON SHIP CHANNEL FISH MON S.NOVOTNY 8979 & J. GOLD 0993 FL: mm TL: mm
ID: DATE: LOC: USACE SACRAMENTO/STOCKTON SHIP CHANNEL FISH MON S.NOVOTNY 8979 & J. GOLD 0993 FL: mm TL: mm	ID: DATE: LOC: USACE SACRAMENTO/STOCKTON SHIP CHANNEL FISH MON S.NOVOTNY 8979 & J. GOLD 0993 FL: mm TL: mm	ID: DATE: LOC: USACE SACRAMENTO/STOCKTON SHIP CHANNEL FISH MON S.NOVOTNY 8979 & J. GOLD 0993 FL: mm TL: mm
ID: DATE: LOC: USACE SACRAMENTO/STOCKTON SHIP CHANNEL FISH MON S.NOVOTNY 8979 & J. GOLD 0993 FL: mm TL: mm	ID: DATE: LOC: USACE SACRAMENTO/STOCKTON SHIP CHANNEL FISH MON S.NOVOTNY 8979 & J. GOLD 0993 FL: mm TL: mm	ID: DATE: LOC: USACE SACRAMENTO/STOCKTON SHIP CHANNEL FISH MON S.NOVOTNY 8979 & J. GOLD 0993 FL: mm TL: mm