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

2011 Fish Community, Entrainment and Water Quality Monitoring Report

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Abbreviations

Abbreviation	Full Term or Name
BO	biological opinion
CDFG	California Department of Fish and Game
CESA	California Endangered Species Act
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 (location)
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
H^x	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)
RISG	Ross Island Sand and Gravel
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

1 Executive Summary

This document presents the results of the 2011 fish community and fish entrainment monitoring of the annual maintenance dredging in the Stockton Deepwater Ship Channel (SDWSC) and the Sacramento River Deepwater Ship Channel (SRDWSC). Monitoring began in 2005, though only three entrainment monitoring events were conducted. 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 feedback is 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 2011 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 fish community monitoring.

Dredging commenced on August 19, 2011, and ended on November 30, 2011. 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.

The key findings of 2011 entrainment monitoring at dredged material placement (DMP) sites were:

2011 was the third year in which the mobile entrainment screen was used at all DMP sites. Overall, 8.34% of the dredged material was monitored, an increase over previous years.

There were 343 fish from 17 individual taxa encountered during 38 entrainment monitoring surveys conducted.

Three delta smelt were encountered during entrainment monitoring at S-31 in the man-made portion of the SRDWSC.

The introduced shimofuri goby *(Tridentiger bifasciatus)* was again the most common fish species encountered during entrainment monitoring and comprised 53.35% of the entrained individuals.

River lamprey comprised 9.33% of the individuals encountered while entrainment monitoring and was second most frequently encountered overall (tied with white catfish). There were thirty-two individual lamprey observed, though seven could not be captured for further identification. All of the lamprey that were examined were river lamprey *Lampetra ayresii*, so it is assumed that the unexamined individuals were as well.

An individual white sturgeon *(Acipenser transmontanus)* was entrained while monitoring at the Scour Hole DMP of the SDWSC. This is the first sturgeon (white or green) entrained while dredge monitoring in the Delta.

The key findings from the 2011 fish community (trawl) monitoring were:

Fish community monitoring (bottom trawling) was conducted at all dredging locations in 2011.

There were 4,644 individual fish encountered during 2011 trawl surveys. These fish represent 24 of approximately 55 species (Moyle, 2002) presently known to occur in the Sacramento and San Joaquin River Delta (the Delta).

Thirty-eight trawl surveys were performed in 2011. A total of 163 successful individual trawl tows were conducted during 168 attempts. Total distance trawled was 70,190 meters.

Eight of the species encountered were native and sixteen were introduced.

White catfish, *Ameiurus catus* was the most common species encountered in 2011, comprising 29.76% of the individuals. White catfish have been the most commonly encountered species in all years but 2010, when threadfin shad were the most common species.

Six delta smelt were encountered, all in the man-made portion of the SRDWSC.

Nineteen white sturgeon were encountered, but green sturgeon were not. Small numbers of green sturgeon were encountered in previous years.

The first Chinook salmon encounter since the inception of fish community monitoring; however, it was only half a fish with the appearance of being preyed on by a sea lion, present in the area (Port of Stockton). This finding confirms that Chinook salmon were present in the area in which dredging and monitoring were being conducted.

All of the fish species encountered during entrainment monitoring with the exception of river lamprey were also encountered during fish community monitoring. River lamprey have very rarely been encountered when trawling, but have been common during entrainment monitoring.

All data collected in 2011 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.

There were no changes to special-status species designations in 2011. Longfin smelt was petitioned for California and federal ESA listing on August 8, 2007. The California Fish and Game Commission accepted the petition on February 7, 2008, and longfin smelt were listed as threatened under California Endangered Species Act (CESA) on June 25, 2009. On April 8, 2009, the US Fish and Wildlife Service (USFWS) concluded that the San Francisco (SF) Bay - Delta population of longfin smelt did not meet the legal criteria for protection as a species subpopulation or distinct population segment (DPS). The USFWS conducted a 12-month status review of all west coast longfin smelt populations. The results of this review were published (http://www.fws.gov/cno/es/speciesinformation/longfin.html) on April 3 2012, and found that longfin smelt warranted protection under ESA and should be advanced to candidacy. Delta smelt were accepted as state candidates for up-listing from threatened to endangered status under CESA on January 16, 2009. Take allotments for delta and longfin smelt encountered by this monitoring program remained unchanged during 2011.

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 2011. 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. 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, 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). River lamprey have been encountered during each year of the study during entrainment monitoring, and occasionally during fish community monitoring.

2 Introduction

This document provides a description of the sixth year of fish community monitoring and the seventh 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). 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 and other agencies to assess and implement adaptive strategies designed to diminish negative environmental effects of the long-term dredging and dredged material management.

USACE and NMFS developed a ten-year programmatic approach to maintain the Sacramento River Deep Water Ship Channel (SRDWSC) and Stockton Deep Water Ship Channel (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 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 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), which 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 Measure 12 (2006a, b – Note: Conservation Measures 1 through 11 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

to November 30. Additionally, each week of the permitted dredging season a maximum of ten delta smelt may be collected during monitoring. 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.

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 CDFG 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 2010-2011 2081(a) permit included several additional provisions, including notifying CDFG if 50 percent of the allowable take was reached (this threshold was not reached).

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 August 19, 2011, through November 30, 2011. This report also compares results of 2011 monitoring with previous years, where cogent. 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.

The monitoring requirements are focused on species that are listed as threatened or endangered under the ESA, due to 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

CDFG and USFWS also maintain lists 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 *(Pogonichthys macrolepidotus)*

River lamprey have been encountered in both shipping channels during each year that monitoring has been conducted. 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. The lamprey encountered during all years of this study (identified in the field and laboratory utilizing morphological and genetic analysis) have all 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 confidence in the use of morphologic characteristics to differentiate between *Entosphenus* and *Lampetra* during field identification since that time. Species determination within *Lampetra* ammocoetes encountered in the future may yet require further laboratory analysis.

There are several other native fishes that utilize the Delta channels and have been, or could be, encountered while conducting this monitoring program – some 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 CDFG and is reported in The California Natural Diversity Database (CNDDB) special animals list. The January 2011 CNDDB list was the latest available at the time of this writing the list is available at: www.dfg.ca.gov/biogeodata/cnddb/. 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). 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 monitoring measures. There were no further modifications of dredging operations or monitoring due to status change from 2009 through 2011, 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 had not yet commented on the petition to up-list delta smelt from threatened to endangered status at the time of this writing, though they did announce the initiation of a five-year status review on March 24, 2009.

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 delta smelt were encountered at the S-31 location in the SRDWSC from August 19 through August 24.

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 dredging regulations (resulting from USFWS consultation with USACE) will not be forthcoming until listing occurs. No longfin smelt have been encountered during fish community or entrainment monitoring since 2008.

The annual monitoring report is submitted to USACE and CDFG 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 CDFG. 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 CDFG) may access the IEP database for updated ESA catch reports. The license and revenue branch of CDFG 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 CDFG prior to the renewal of permits. CDFG also requires reporting of all state Endangered, Threatened and Special Concern species to the California Natural Diversity Database (CNDD). 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 CDFG 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 (FESA 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 2011 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 dredging locations (i.e., dredging in deepwater mid-channel locations with water column depths greater than 20 feet).

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 portable entrainment monitoring screen.

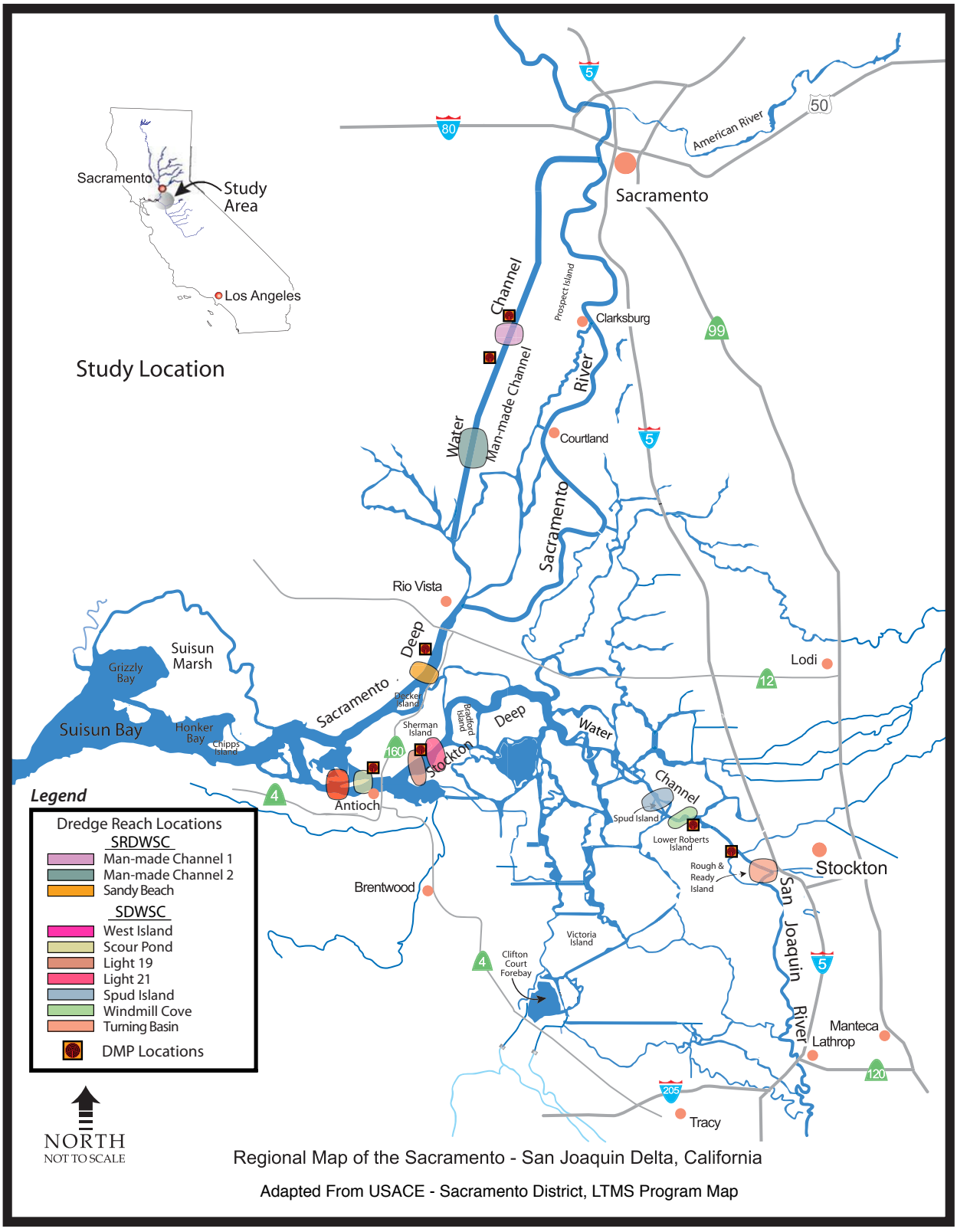
Timing of 2011 dredging operations did not extend beyond the originally approved work window (December 1 in the SRDWSC and December 31 in the SDWSC). As a result, observational monitoring 24 hours a day aboard the dredge was not necessary as in 2006 and 2007.

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 proportionally for abundant species. 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 were sometimes vouchered for further assessments, as was the case for osmerids and some lampreys.

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 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 in 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.

Figure 1. 2011 Project Area Map, Dredge Reaches, and DMP Sites



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 2011 dredge season, RISG 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 2011. Location and timing of dredging and dredged volumes are summarized in Table 1.

As listed in Table 1, a total of approximately 331,405 cubic yards (dry) of dredged material was placed at DMP sites during 2011. Approximately 289,018 cubic yards were dredged in the SDWSC and 42,387 cubic yards in the SRDWSC. The majority of the dredging in the SDWSC in 2011 took place at the Port of Stockton turning basin, which utilized the Roberts 1 DMP. All material was dredged using RISG Dredge No. 8, a hydraulic cutter-head suction dredge with an 18-inch (inside diameter) discharge pipe. The total estimated overall slurry output from the dredge was 597,234,571 gallons. The approximate average pumping rate varied by reach location from 6,986 gallons per minute (gpm) at the Turning Basin reach (Roberts 1 DMP site), to 10,783 gpm for the Light 19 reach (McCormack Pit DMP site).

Table 1. 2011 SRDWSC and SDWSC Maintenance Dredging Locations

River	Dredge Reach	From (RM)	To (RM)	Excavated Dry Material (cy)	Est. % Material in Slurry	Est. Total Slurry Vol. (gal)	DMP Site	Start	End
SRDWSC	MM Channel 1	33.30	32.50	23,680	8	59,784,312	S-31A	19 Aug	24 Aug
SRDWSC	MM Channel 2	27.80	27.20	11,404	5	46,066,236	S-31C	25 Aug	29 Aug
SRDWSC	Sandy Beach	9.46	9.09	7,303	6	24,583,605	Sandy Beach	1 Sep	3 Sep
SDWSC	West Island	5.53	6.12	40,421	15	54,426,749	Scour Hole	10 Sep	15 Sep
SDWSC	Scour Pond	7.52	8.05	7,529	5	30,412,683	Scour Hole	16 Sep	18 Sep
SDWSC	Light 19 Reach	10.85	11.23	23,975	7	69,177,128	McCormack Pit	20 Sep	2 Oct
SDWSC	Light 21 Reach	11.55	11.74	15,556	8	39,274,354	McCormack Pit	3 Oct	6 Oct
SDWSC	Spud Island	31.44	31.63	1,576	5	6,366,221	Roberts 2	16 Oct	16 Oct
SDWSC	Windmill Cove	34.22	34.56	9,073	7	26,178,171	Roberts 2	18 Oct	20 Oct
SDWSC	Turning Basin	39.20	40.00	190,888	16	240,965,112	Roberts 1	24 Oct	30 Nov
TOTAL				**331,405**		**597,234,571**			

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.

Monitoring was performed under a variety of light conditions, though most occurred during daylight hours due to logistical, operational, and safety issues. Sixteen of 38 total entrainment events were conducted

in low light/night conditions (eight during dusk, eight at night). This number represents a nearly two-fold increase in low light entrainment monitoring from the prior year (from 25 to 42 percent). In the SRDWSC one dusk monitoring event occurred at the Man-made Channel 2 reach. The remaining 15 low light monitoring events were conducted in the SDWSC as follows: one dusk and one night event at West Island reach, the single event at Scour Pond reach was during dusk, a dusk and night event at Light 19, one dusk event at Light 21, the only Spud Island event was at night, one night event at Windmill Cove, with four night and three dusk events conducted within the Turning Basin reach. Of the 37 total trawl survey days, 14 were conducted in low light/night conditions; one dusk trawl survey in the SRDWSC at Man-made Channel 2; the remaining 13 were in the SDWSC (two dusk trawls at West Island, one dusk and one night trawl at Light 19, one night at Spud Island, with seven dusk and one night surveys in the Turning Basin reach). Overall, fish community monitoring during low light conditions increased from 12 to 38 percent between 2010 and 2011.

Effort levels for 2011 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 2011, usually the result of unexpected dredge shutdowns or mechanical problems unrelated to monitoring activities. The goal for entrainment monitoring was to monitor at least as much of the overall dredge output as was monitored in 2010 (7.23%). In 2011, 8.34% was monitored, significantly more than our goal. During each year of monitoring since 2006, an increased percentage of dredged material has been monitored. Monitoring of overall dredged material was 5.64% in 2009, compared to 4.4% in 2008, 0.35% in 2007 and 0.37% in 2006. The large increase in 2008 over previous years was due to initiation of the entrainment screen method in 2008 as well as complete abandonment of the entrainment cell method in 2009, due to its inability to assess significant portions of the dredge output. Subsequent smaller increases in more recent years are due to the improvements made to the screen allowing more efficient monitoring.

Table 2. 2011 Entrainment Monitoring Effort at Dredge Material Placement Sites

DMP Site	Dredge Reach	Start	End	Monitoring Events	Monitoring Attempts	Material Type	Monitored Vol. (gal)	Dredged Slurry Vol. (gal)	Monitoring %
S-31A	MM Channel 1	20 Aug	24 Aug	3	3	C	4,796,454	59,784,312	8.02
S-31B	MM Channel 2	26 Aug	28 Aug	2	2	C	2,993,032	46,066,236	6.50
Sandy Beach	Sandy Beach	1 Sep	3 Sep	2	2	A	3,093,040	24,583,605	12.58
Scour Hole	West Island	10 Sep	14 Sep	3	3	A	5,002,480	54,426,749	9.19
Scour Hole	Scour Pond	18 Sep	18 Sep	1	1	A	1,927,676	30,412,683	6.34
McCormack Pit	Light 19	20 Sep	1 Oct	4	4	A	5,730,985	69,177,128	8.28
McCormack Pit	Light 21	3 Oct	5 Oct	2	2	A	3,378,980	39,274,354	8.60
Roberts 2	Spud Island *	18 Oct	18 Oct	1	1	C	1,226,366	6,366,221	19.26
Roberts 2	Windmill Cove	19 Oct	20 Oct	2	2	B	3,126,560	26,178,171	11.94
Roberts 1	Turning Basin	24 Oct	30 Nov	16	18	B & C	18,561,103	240,965,112	7.70
TOTAL				**36**	**38**		**49,836,676**	**597,234,571**	***8.34**

MATERIAL TYPE LEGEND: A = sandy, B = silty sand, C = mud.

* Short duration of dredging operations (11 hours) at Spud Island DR (Roberts 2 DMP).

Table 3. 2011 Fish Community Monitoring Effort by Dredge Reach Locations

Dredge Reach	DMP Site	Start	End	Monitoring Events	Trawls Attempted	Trawls Succeeded	Distance (m)
MM Channel 1	S-31A	19 Aug	23 Aug	3	9	9	4,230
MM Channel 2	S-31B	25 Aug	29 Aug	3	7	6	2,170
Sandy Beach	Sandy Beach	2 Sep	2 Sep	1	5	5	2,330
West Island	Scour Hole	11 Sep	15 Sep	3	15	15	7,520
Scour Pond	Scour Hole	17 Sep	17 Sep	1	5	5	1,840
Light 19 Reach	McCormack Pit	21 Sep	2 Oct	6	29	29	9,690
Light 21 Reach	McCormack Pit	4 Oct	6 Oct	2	7	6	2,870
Spud Island *	Roberts 2	16 Oct	16 Oct	1	5	5	2,070
Windmill Cove	Roberts 2	19 Oct	21 Oct	2	9	9	3,400
Turning Basin	Roberts 1	25 Oct	29 Nov	16	77	74	34,070
TOTAL				**38**	**168**	**163**	**70,190**

***** Short duration of dredging operations (11 hours) at Spud Island DR (Roberts 2 DMP).

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 two 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 those of ESA-listed species.
- 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 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 four monitoring seasons. However, there are DMP sites with access issues that may make it difficult to utilize the screen. 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 used since 2008, the method for entrainment cell entrainment monitoring is no longer presented in the annual reports. Interested parties can read the 2006-2008 annual fish monitoring reports (or 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 dredged material 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 head loss resulting from monitoring.

3.3.1 Mobile Entrainment Screen

This was the third consecutive year that the mobile screen device was used for entrainment monitoring at all DMP sites. The entrainment monitoring screen (screen) was built on trailer axles, enabling transport by road from site to site. 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. 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 screen itself 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 Screen Collection System

Figure 3. Photographs of Discharge Pipeline Y-valve

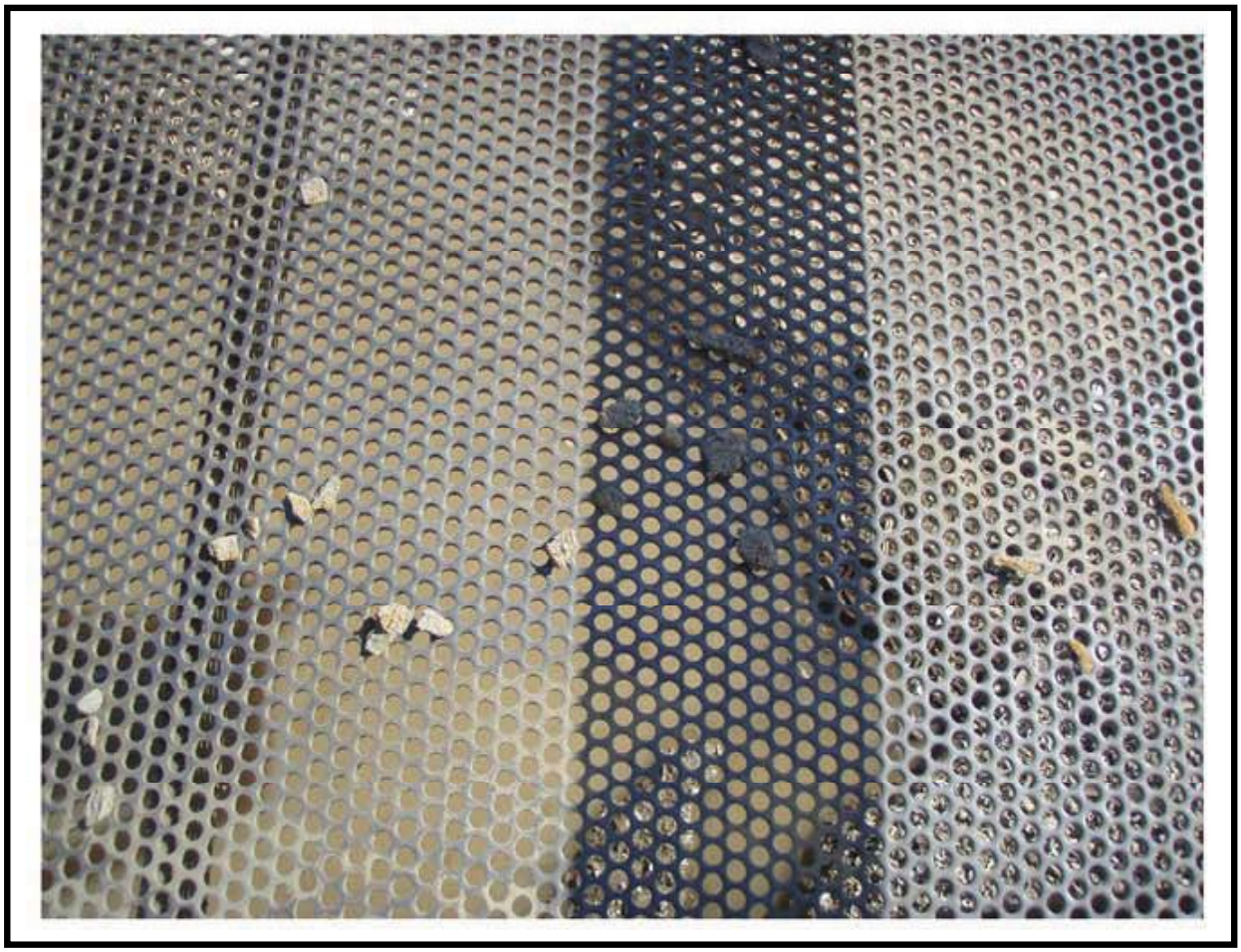
When the dredge output was not directed to the screen, it flowed directly to the DMP site pond. When in use, the slurry passed over the screen to allow sorting and observation of all entrained materials and organisms that did not pass through the screen. Track hoes and bulldozers were used to clear material 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 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. After the accumulated material was sorted, it was swept off the end of the screen. All fish either retained by the screen or observed passing through it were documented (some lamprey and gobies were observed but not netted before escaping). Both live and dead retained fish were collected, examined, measured, and then released back into the river or vouchered for further examination.

The ability of the screen to pass dredged material through the mesh is dependent on the grain size of the dredged material. A general description of the dredged material found at each dredge location in 2011 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 vary the height of the cutter head as it sweeps across the bottom, effectively dredging deeper into material from each side of the channel than toward the center. This appears to result in pulses of heavier sediment loads on the screen corresponding to the dredge being near the side of the channel that are interspersed with lighter sediment loads with more shells and debris from the surface of the riverbed corresponding to the dredge being in the center of the channel.

All of the material retained by the screen was sorted to determine and document what organisms were present. This process could be completed without diverting the material flow back to the main DMP pond 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 flow was diverted until the screen was cleared.

Figure 4. Screen Used for Entrainment Monitoring in 2011



3/8 in Diameter Punch-Holed Steel Plate

There are vast shoals of Asian clams *(Corbicula fluminea)* in many locations in both channels, 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, less Egeria densa was entrained. Figure 5 is an image of shells and sediment retained by the screen.

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.

No improvements were made to the screen during the 2011 monitoring season, though several are discussed in the revised monitoring plan (MEC and NAS, 2011) and in the recommendations section of this report.

Figure 5. Example of Substrate Debris Collected during Entrainment Screen Monitoring

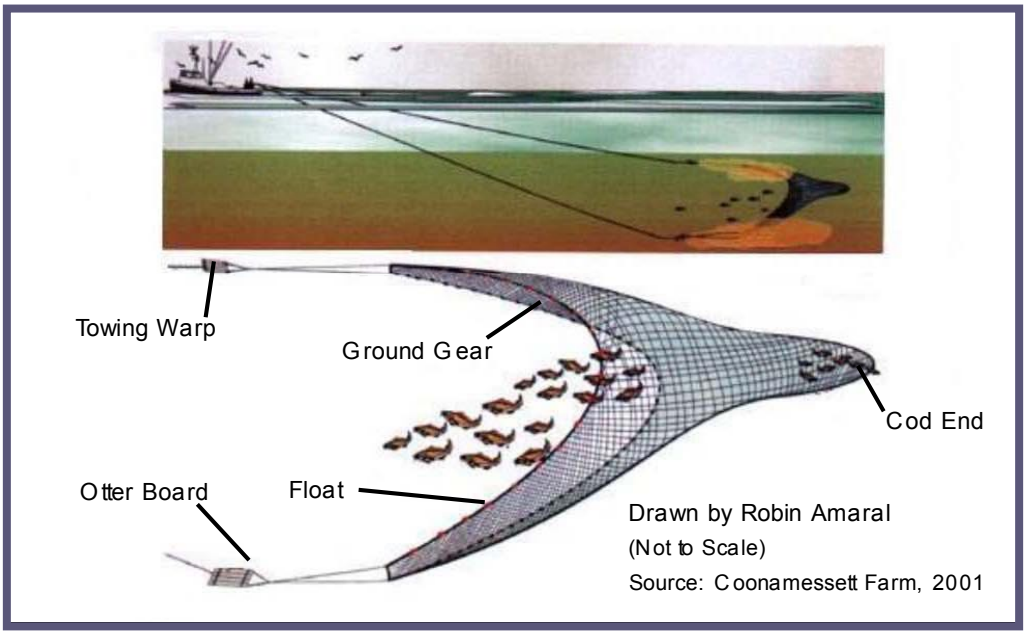
3.4 Fish Community Monitoring

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 CDFG and the IEP through IEP Program Element Number 2010-113. Prior to the onset of the 2011 dredge season, CDFG 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), and included weekly reporting through the IEP website and weekly reporting to USFWS and USACE to describe delta smelt encounters. Communication with the dredge was maintained on 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 briefly surveyed using 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).

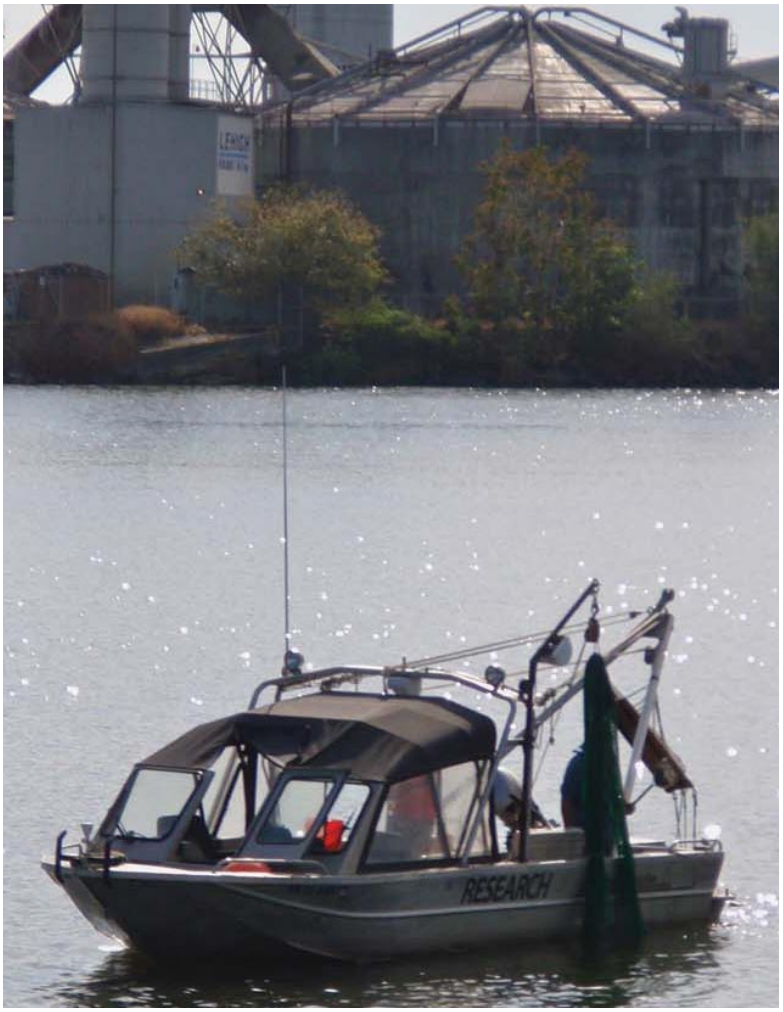
Fish community monitoring was conducted up current of the working dredge, in the main navigation channel. An otter trawl, which is a semi-balloon type shrimp and fish trawl, was fished on the riverbed to target fish species assumed to be most susceptible to entrainment by the dredge. The otter trawl 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 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 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 was maneuvered over the position of the net on the bottom, and then hauled directly upward through the water column. 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 were) was brought to the side of the vessel by hauling on the cod end brailing line with the davit. The brailing line is a line that 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. listed fishes, shads, and striped bass). Listed fish were released quickly with minimal handling. Data were then collected on all individual specimens of fish and macro-invertebrates, 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. Data collected 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 will be 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.

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 all die during processing and identification, resulting in vouchering of the dead listed fishes. During 2011, the only protected species encountered were delta smelt.

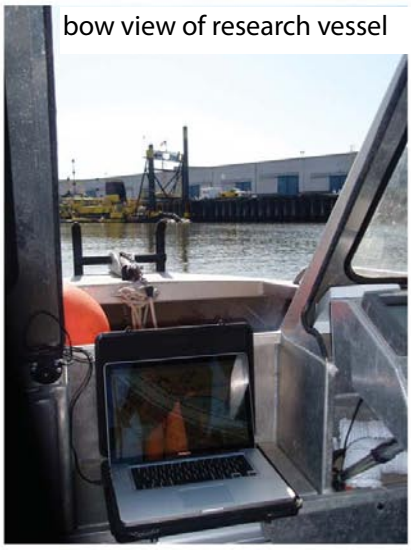
Additionally collected trawl data included: tow duration; date and time; monitoring depth; tidal phase; current speed and direction (upstream or downstream); boat speed and engine rpm; bird/sea lion presence; ship activity; and channel location. Water quality data were generally collected (upstream from 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 prey when in fresh water.

Trawl survey data was entered into the customized MS Access database running on a portable computer as the information was acquired. Large catches of fish encountered during individual trawls 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.

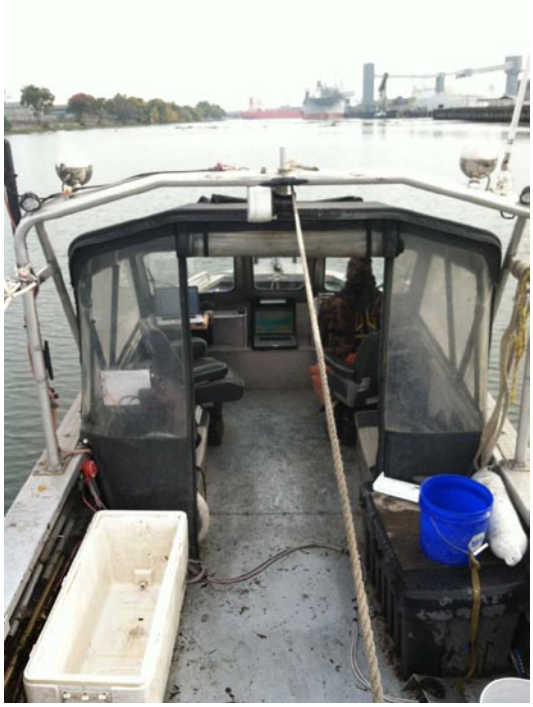
Figure 8. Examples of Fish Community Survey Tools and Methods

bow view of research vessel



view of otter doors

stern view of research vessel



day monitoring operations

otter doors with dredge shown
(in background of photograph)

night monitoring operations

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.

(Manufacturer's Image)

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 (# of fish/gallon X total # of gallons = total # of fish entrained). Pumping rate and volume information were provided by RISG. Conversion from dry dredged material amount to end of pipe slurry volume was made using the RISG provided estimates. Deposited material comprised 6% to 30% of total slurry volume per DMP site (Tables 1 and 2).

Entrainment rates for individual species were extrapolated for each location where entrainment of that species occurred during 2011 monitoring. This data should be assessed cautiously considering the small percentage (8.34% in 2011) 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 (# 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, # 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 "mortalities" due to entrapment in the DMPs. Fish observed during entrainment monitoring are released in the channel at the entrainment location after enumeration and observation. 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, 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.

The monitoring program consistently requires compromise between gathering more data and increasing the mortality of encountered fish by delaying their release. The investigators address 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 is that the field biologists immediately remove and return 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 continue to gather ample data on a subset of these

abundant introduced fishes. In the case of the other fishes that exhibit high handling stress, only a quick return to the river can help minimize mortality. No rare and or special status species (if not vouchered) is ever returned to the river without acquiring length measurements and making other observations. Mortality is estimated by directly counting dead fish prior to and after release.

Mortality among fish encountered during community and entrainment monitoring was calculated for community monitoring 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. A small number of fish were vouchered for further examination, resulting in immediate mortality of these individuals. 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 event when the fish were measured.

3.6.4 Data Management

Data were documented in the field on portable computers directly into the Dredge Monitoring Database created with MS Access 2003 (upgraded in 2009 to MS Access 2007), and on paper data sheets. 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 2011, approximately 8% 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 checked 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 while trawling 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 raster scanned versions of 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 2011 trawl survey locations and DMP sites using satellite imagery.

4 Results

4.1 Fish

A total of 4,987 individual fish of 27 species were encountered and identified during the fish community and entrainment monitoring events in 2011 (Table 4). Entrained fish comprised 16 of the species and accounted for 6.8% (n = 343) of the total number of fish encountered during 2011 monitoring. Fish community monitoring accounted for the rest of the fish. The entrained fish were encountered while monitoring 8.34% of the overall slurry output of the dredge. Extrapolated totals for each entrained species observed are presented in section 4.2.3.

Of the 27 species encountered, 17 were introduced and 10 were native. The three most abundant species in order of abundance were white catfish, threadfin shad and striped bass. These three species have been the three most abundant during all years of monitoring since 2006, though in 2010 threadfin shad were more abundant than white catfish for the first time. The most commonly encountered fish during fish community monitoring was the white catfish (28.35%). However, the most common fish encountered during entrainment monitoring was the shimofuri goby (53.35%). Shimofuri goby comprised 3.89% of the fish encountered during fish community monitoring.

Introduced fish species have been encountered far more frequently than natives during fish community and entrainment monitoring at almost all locations during all years of this study (2006-2011). The top six species encountered in 2011 are all introduced and together comprise 91.36% of the individual fish encountered. SRDWSC and lower SDWSC reaches continue to have higher percentages of native fish than upper SDWSC reaches, while upper SDWSC reaches have the highest diversity of species.

Table 4. 2011 Ranked List of Fish Encountered from All Sites for All Monitoring Combined

Rank	Percent	No.	Common Name	Genus	Species	Origin	Demersal or Pelagic	Rule: Status *
1	28.35	1,414	white catfish	*Ameiurus*	*catus*	Introduced	Demersal	
2	20.81	1,038	threadfin shad	*Dorosoma*	*petenense*	Introduced	Pelagic	
3	17.83	889	striped bass	*Morone*	*saxatilis*	Introduced	Pelagic	
4	10.75	536	channel catfish	*Ictalurus*	*punctatus*	Introduced	Demersal	
5	9.73	485	American shad	*Alosa*	*sapidissima*	Introduced	Pelagic	
6	3.89	194	shimofuri goby	*Tridentiger*	*bifasciatus*	Introduced	Demersal	
7	2.03	101	Sacramento splittail	*Pogonichthys*	*macrolepidotus*	Native	Pelagic	AFS: VU, DFG: SSC, IUCN: EN
8	1.30	65	redear sunfish	*Lepomis*	*microlophus*	Introduced	Pelagic	
9	0.78	39	yellowfin goby	*Acanthogobius*	*flavimanus*	Introduced	Demersal	
10	0.70	35	wakasagi	*Hypomesus*	*nipponensis*	Introduced	Pelagic	
11	0.64	32	brown bullhead	*Ameiurus*	*nebulosus*	Introduced	Demersal	
11	0.64	32	river lamprey **	*Lampetra*	*ayresii*	Native	Demersal	DFG: SSC, AFS VU
12	0.58	29	common carp	*Cyprinus*	*carpio*	Introduced	Demersal	
13	0.40	20	white sturgeon	*Acipenser*	*transmontanus*	Native	Demersal	AFS: EN, IUCN: LC
14	0.36	18	prickly sculpin	*Cottus*	*asper*	Native	Demersal	
15	0.32	16	bluegill	*Lepomis*	*macrochirus*	Introduced	Pelagic	
16	0.18	9	delta smelt	*Hypomesus*	*transpacificus*	Native	Pelagic	ESA: FE, DFG: SE, AFS: TH, IUCN: EN
17	0.16	8	starry flounder	*Platichthys*	*stellatus*	Native	Demersal	MSA: MEC with EFH
17	0.16	8	tule perch	*Hysterocarpus*	*traskii*	Native	Pelagic	
18	0.14	7	Shokihaze goby	*Tridentiger*	*barbatus*	Introduced	Pelagic	
19	0.10	5	warmouth	*Lepomis*	*gulosus*	Introduced	Pelagic	
20	0.06	3	Pacific staghorn sculpin	*Leptocottus*	*ayresii*	Native	Demersal	
21	0.04	2	bigscale logperch	*Percina*	*macrolepida*	Introduced	Demersal	
22	0.02	1	Chinook salmon	*Oncorhynchus*	*tshawytscha*	Native	Pelagic	undetermined
22	0.02	1	Sacramento pikeminnow	*Ptychocheilus*	*grandis*	Native	Pelagic	

TOTAL **4,987**

Percent Native = 4.03 Number Native Species = 10 Introduced Species = 15

NOTE: Specimens dead prior to encounter included 1 Chinook salmon, 1 white catfish, 1 channel catfish, 1 common carp, and 1 threadfin shad; capture dispositions of 1 brown bullhead and 1 threadfin shad were undetermined.

** All lamprey are assumed to be river lamprey for data analysis purposes.

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

ESA: federal Endangered Species Act	F\E Federally listed as Endangered; FT Federally listed as Threatened
CESA: California Endangered Species Act	ST State-listed as Threatened; SE State-listed as Endangered
CDFG: California Dept of Fish and Game	SSC Species of Special Concern
MSA: Magnuson-Stevens Sustainable Fisheries Act	MEC-EFH Marine Estuarine Composite – designated Essential Fish Habitat
IUCN: International Union for Conservation of Nature	EN Endangered; NT Near Threatened; LC Least Concern
AFS: American Fisheries Society	TH Threatened; VU vulnerable, EN endangered

The only new species encountered in 2011 that had not been encountered during prior years monitoring was an individual Chinook salmon. The monitoring only encountered the front half of the dead adult, which had the appearance of being halved by a sea lion (Figure 10). Sea lions sometimes eat only the internal organs of the large fish they catch, and commonly tear them in half in the process. Halves of carp and catfish have also been encountered while monitoring, sometimes so fresh that catfish were observed at the surface still trying to swim. The salmon was found while conducting fish community monitoring just downstream of the Turning Basin at the Port of Stockton, an area frequented by sea lions.

Figure 10. Example of Possible Sea Lion Predation

4.1.1 Special-status Species

Unlike previous years, delta smelt were the only special status species encountered during 2011 monitoring. Like 2010, the 2011 delta smelt were encountered at S-31 in the SRWDSC. Fewer lamprey were encountered than in 2010, and Sacramento splittail was the most common native fish for the first time. The Chinook salmon encountered was not counted as a monitoring or dredging take, as it was dead prior to being encountered. 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 is listed later in Table 30. Green sturgeon were not encountered in 2011. As in the past, white sturgeon data is provided as a surrogate for green sturgeon due to the dearth of green sturgeon encounters.

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 was conducted with the mobile entrainment screen at all sites in 2011, making this the third year in which the screen was used all DMPs. A total of 343 individual fish were encountered while monitoring. The monitored portion of the total dredge output varied from 6.34% to 19.26% among the 10 dredge reaches monitored, and averaged 8.34% overall. Table 5 presents a ranked list of all fish encountered during 2011 entrainment monitoring, while Tables 6 through 9e present the ranked list of entrained fish segregated by river channel and dredge reach. Shimofuri goby were the most commonly entrained species in 2011, comprising 53.35% of the entrained individuals. River lamprey and white catfish were second and third most common respectively. Other than river lamprey, delta smelt, white sturgeon, prickly sculpin and Pacific staghorn sculpin were the other native species encountered while entrainment monitoring in 2011. Delta smelt were also entrained in 2010, in similar numbers. The white sturgeon was the first sturgeon observed while entrainment monitoring. Shimofuri goby were also the most commonly entrained fish in 2009 and 2010. 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 since 2008, comprising 5.40% of entrained individuals in 2008, 4.71% in 2009, 29.32% in 2010, and 9.33% in 2011.

Table 5. 2011 Ranked List of Fish Encountered in All Sites During Entrainment Monitoring

Rank	Percent	Number	Common Name	Genus	Species	Origin
1	53.35	183	shimofuri goby	*Tridentiger*	*bifasciatus*	Introduced
2	9.33	32	river lamprey	*Lampetra*	*ayresii*	Native
2	9.33	32	white catfish	*Ameiurus*	*catus*	Introduced
3	8.16	28	striped bass	*Morone*	*saxatilis*	Introduced
4	4.08	14	prickly sculpin	*Cottus*	*asper*	Native
5	3.50	12	channel catfish	*Ictalurus*	*punctatus*	Introduced
6	2.62	9	yellowfin goby	*Acanthogobius*	*flavimanus*	Introduced
7	1.75	6	threadfin shad	*Dorosoma*	*petenense*	Introduced
7	1.75	6	Shokihaze goby	*Tridentiger*	*barbatus*	Introduced
8	1.46	5	wakasagi	*Hypomesus*	*nipponensis*	Introduced
8	1.46	5	American shad	*Alosa*	*sapidissima*	Introduced
9	1.17	4	brown bullhead	*Ameiurus*	*nebulosus*	Introduced
10	0.87	3	delta smelt	*Hypomesus*	*transpacificus*	Native
11	0.29	1	white sturgeon	*Acipenser*	*transmontanus*	Native
11	0.29	1	common carp	*Cyprinus*	*carpio*	Introduced
11	0.29	1	bigscale logperch	*Percina*	*macrolepida*	Introduced
11	0.29	1	Pacific staghorn sculpin	*Leptocottus*	*ayresii*	Native
TOTAL		**343**				
	Percent Native = 14.87			Number Native Species = 5		Introduced Species = 12

NOTE: Specimens dead prior to encounter included 1 white catfish, 1 channel catfish, 1 threadfin shad, and the common carp; capture dispositions of 1 brown bullhead and 1 threadfin shad were undetermined.

4.2.1 Sacramento River Deep Water Ship Channel

Three different dredge reaches in the SRDWSC were dredged and monitored in 2011, two in the man-made portion of the channel utilizing the S-31 DMP, and one using the Sandy Beach DMP, in the natural portion of the channel downstream of Rio Vista. Table 6 provides the details of the fish entrained at all three sites combined, and Tables 7a-c provides details of the entrained fish at each dredge reach. The top three species entrained in the SRDWSC were shimofuri goby, river lamprey and prickly sculpin, in order of abundance. Shimofuri goby were also present in the SDWSC, but were far more abundant among entrained fish in the SRDWSC in 2011, and were the most abundant entrained fish among all reaches combined. The three delta smelt and five wakasagi entrained in the SRDWSC in 2011 are similar to the numbers entrained in 2010, the first time entrainment of delta smelt was observed since the inception of monitoring in 2005.

Table 6. 2011 Summary Results of Entrainment Monitoring Events for All SRDWSC Locations

Rank	Percent	Number	Common Name	Origin
1	74.37	177	shimofuri goby	Introduced
2	13.02	31	river lamprey	Native
3	5.04	12	prickly sculpin	Native
4	2.10	5	white catfish	Introduced
4	2.10	5	wakasagi	Introduced
5	1.26	3	delta smelt	Native
6	0.84	2	yellowfin goby	Introduced
6	0.84	2	American shad	Introduced
7	0.42	1	Shokihaze goby	Introduced
TOTAL		**238**		
	Percent Native = 19.33		Number Native Species = 3	Introduced Species = 6

Man-made Channel 1 Dredge Reach and S-31A DMP Site:

This dredge reach vicinity was monitored in 2007 and 2008 as well as 2011. Substrates in this portion of the SRDWSC were primarily mud. Approximately 4,796,454 gallons, or 8.02%, of the total slurry volume dredged at this reach was monitored during the three entrainment events conducted. A total of 163 fish were observed during entrainment monitoring at this dredge reach (Table 7a). Wakasagi were entrained at this DMP in 2009 and 2010, as well as 2011. Shimofuri goby were very common here relative to the other fish entrained. Delta smelt were entrained at this reach in 2011, and a few river miles downstream of this reach in 2010; the first occasions that this monitoring has observed delta smelt entrainment.

Table 7a. 2011 Summary Results of Entrainment Events for Man-made Channel 1 DR — S-31A DMP

Rank	Percent	Number	Common Name	Origin
1	88.96	145	shimofuri goby	Introduced
2	4.29	7	prickly sculpin	Native
3	2.45	4	white catfish	Introduced
3	2.45	4	wakasagi	Introduced
4	1.23	2	delta smelt	Native
5	0.61	1	yellowfin goby	Introduced
TOTAL		**163**		
	Percent Native = 5.52		Number Native Species = 2	Introduced Species = 4

Man-made Channel 2 Dredge Reach and S-31C DMP Site:

The reach dredged in 2011 was the furthest downstream reach to use the S-31 DMP since fish monitoring began in 2006. The 2010 reach section of the same name was further upstream of the 2011 dredge location. Substrates in this portion of the SRDWSC were primarily mud. Approximately 2,993,032 gallons, or 6.50%, of the total slurry volume dredged at this reach was monitored during the two entrainment events conducted. A total of 38 fish were observed during entrainment monitoring at this dredge reach (Table 7b). Shimofuri goby were very common here relative to the other fish entrained. Wakasagi were also entrained at this DMP in 2009 and 2010. Delta smelt were entrained at this reach in 2011, as were prickly sculpin, the only other native species observed.

Table7b. 2011 Summary Results of Entrainment Events for Man-made Channel 2 DR — S-31B DMP

Rank	Percent	Number	Common Name	Origin
1	73.68	28	shimofuri goby	Introduced
2	10.53	4	prickly sculpin	Native
3	5.26	2	American shad	Introduced
4	2.63	1	yellowfin goby	Introduced
4	2.63	1	white catfish	Introduced
4	2.63	1	wakasagi	Introduced
4	2.63	1	delta smelt	Native
TOTAL		**38**		
	Percent Native = 13.16		Number Native Species = 2	Introduced Species = 5

Sandy Beach Dredge Reach and Sandy Beach DMP Site:

The reach dredged in 2011 was the furthest downstream reach to use the Sandy Beach DMP since the inception of monitoring in 2005. Substrates in this portion of the SRDWSC were primarily sand Approximately 3,093,040 gallons, or 12.58% of the total slurry volume dredged at this reach was monitored during the two entrainment events conducted. A total of 37 fish were observed during entrainment monitoring at this dredge reach (Table 7c). The majority of the entrained fish were river lamprey, similar to previous years monitoring conducted at this DMP. Prickly sculpin was the only other native species observed while monitoring this reach.

Table 7c. 2011 Summary Results of Entrainment Events for Sandy Beach DR — Sandy Beach DMP

Rank	Percent	Number	Common Name	Origin
1	64.86	24	river lamprey	Native
2	18.92	7	lamprey, species undet. *	Native
3	10.81	4	shimofuri goby	Introduced
4	2.70	1	Shokihaze goby	Introduced
4	2.70	1	prickly sculpin	Native
TOTAL		**37**		
	Percent Native = 86.49		Native Species = 2	Introduced Species = 2

* These 7 lamprey were likely river lamprey but had slipped through entrainment screen mesh prior to further examination.

4.2.2 Stockton Deep Water Ship Channel Locations

Seven different dredge reaches in the SDWSC were monitored for entrainment of fish in 2011. Table 8 provides the details of the fish entrained at all SDWSC reaches combined. Tables 9a through 9e provide details of the fish entrained at each monitored reach where more than a single fish was entrained. Fish were not encountered during entrainment events at the Light 21 dredge reach, so a table is not provided for monitoring at Light 21. Only a single fish was entrained while monitoring at the Scour Pond reach (a yellowfin goby), so a table is not provided for this reach either. The top three species entrained from the SDWSC, in order of abundance, were striped bass, white catfish, and channel catfish. 2011 was the first year in which striped bass were the most common entrained fish. Prickly sculpin, white sturgeon, river lamprey, and Pacific staghorn sculpin were the native fish encountered during entrainment monitoring at all SDWSC reaches in 2011. Overall, fifteen species of fish were observed while entrainment monitoring in the SDWSC, many more than the nine species observed in the SRDWSC. Two species not observed in the SDWSC but observed in the SRDWSC were delta smelt and wakasagi. Descriptions of previous dredging at the dredge reaches only refers back to 2006, when the monitoring program began to monitor at all reaches throughout the entire annual dredging season.

Table 8. 2011 Summary Results of Entrainment Monitoring Events for All SDWSC Locations

Rank	Percent	Number	Common Name	Origin
1	26.67	28	striped bass	Introduced
2	25.71	27	white catfish	Introduced
3	11.43	12	channel catfish	Introduced
4	6.67	7	yellowfin goby	Introduced
5	5.71	6	threadfin shad	Introduced
5	5.71	6	shimofuri goby	Introduced
6	4.76	5	Shokihaze goby	Introduced
7	3.81	4	brown bullhead	Introduced
8	2.86	3	American shad	Introduced
9	1.90	2	prickly sculpin	Native
10	0.95	1	white sturgeon	Native
10	0.95	1	river lamprey	Native
10	0.95	1	Pacific staghorn sculpin	Native
10	0.95	1	common carp	Introduced
10	0.95	1	bigscale logperch	Introduced
TOTAL		**105**		
	Percent Native = 4.76		Number Native Species = 4	Introduced Species = 11

NOTE: Of these numbers, 1 white catfish, 1 channel catfish, 1 threadfin shad, and 1 common carp were dead prior to encounter; prior disposition could not be determined for 1 brown bullhead and 1 threadfin shad specimen.

West Island Dredge Reach and Scour Hole DMP Site:

All of this reach was also monitored while maintenance dredging in 2010, 2008 and 2007. Substrates in this reach were primarily sand. Approximately 5,002,480 gallons, or 9.19% of the total slurry volume dredged at this reach was monitored during the three entrainment events conducted. A total of 42 fish were observed while entrainment monitoring (Table 9a). Striped bass the most commonly entrained fish species at this reach. A single white sturgeon was observed, the first sturgeon to have been observed during entrainment monitoring since the inception of this monitoring program. A pacific staghorn sculpin was the only other native species observed.

Table 9a. 2011 Summary Results of Entrainment Events for West Island DR — Scour Hole DMP

Rank	Percent	Number	Common Name	Origin
1	61.90	26	striped bass	Introduced
2	9.52	4	white catfish	Introduced
3	7.14	3	Shokihaze goby	Introduced
3	7.14	3	American shad	Introduced
4	4.76	2	channel catfish	Introduced
5	2.38	1	white sturgeon	Native
5	2.38	1	Pacific staghorn sculpin	Native
5	2.38	1	threadfin shad	Introduced
5	2.38	1	shimofuri goby	Introduced
TOTAL		**42**		
	Percent Native = 4.76		Number Native Species = 2	Introduced Species = 7

Scour Pond Dredge Reach and Scour Hole DMP Site:

Portions of this reach were dredged in 2009, and all of it was dredged in 2008. Substrates in this portion of the SDWSC were primarily sand. Approximately 1,927,676 gallons, or 6.34% of the total slurry volume dredged at this reach was monitored during the single entrainment monitoring event conducted. A total of 1 fish was encountered while entrainment monitoring at this dredge reach - a single, non-native, yellowfin goby.

Light 19 Dredge Reach and McCormack Pit DMP Site:

Portions of this reach were also dredged in 2010 and 2008, Substrates in this portion of the SDWSC were primarily sand. Approximately 5,730,985 gallons, or 8.28% of the total slurry volume dredged at this reach was monitored during the four entrainment events conducted. A total of 9 fish were encountered while entrainment monitoring at this dredge reach (Table 9b). Shokihaze goby, shimofuri goby, and channel catfish were the most abundant. River lamprey and prickly sculpin were the only native species observed.

Table 9b. 2011 Summary Results of Entrainment Events for Light 19 DR — McCormack Pit DMP

Rank	Percent	Number	Common Name	Origin
1	22.22	2	Shokihaze goby	Introduced
1	22.22	2	shimofuri goby	Introduced
1	22.22	2	channel catfish	Introduced
2	11.11	1	yellowfin goby	Introduced
2	11.11	1	river lamprey	Native
2	11.11	1	prickly sculpin	Native
TOTAL		**9**		
	Percent Native = 22.22		Number Native Species = 2	Introduced Species = 4

Light 21 Dredge Reach and McCormack Pit DMP Site:

This reach was the furthest upstream reach to use the McCormack Pit DMP since monitoring began. Substrates in the Light 21 portion of the SDWSC were primarily sand. Approximately 3,378,980 gallons, or 8.60% of the total slurry volume dredged at this reach was monitored during the two entrainment events conducted. No fish were observed while entrainment monitoring at this dredge reach.

Spud Island Dredge Reach and Roberts 2 DMP Site:

Most of this reach was also dredged in 2010. Substrates in this portion of the SDWSC were primarily mud. Approximately 1,226,366 gallons, or 19.26% of the total slurry volume dredged at this reach was monitored during the single entrainment monitoring event conducted. A total of 9 fish were encountered while entrainment monitoring at this dredge reach (Table 9c). White catfish and threadfin shad were the most abundant fish. Prickly sculpin was the only native species observed.

Table 9c. 2011 Summary Results of Entrainment Events for Spud Island DR — Roberts 2 DMP

Rank	Percent	Number	Common Name	Origin
1	33.33	3	white catfish	Introduced
1	33.33	3	threadfin shad	Introduced
2	11.11	1	yellowfin goby	Introduced
2	11.11	1	prickly sculpin	Native
2	11.11	1	channel catfish	Introduced
TOTAL		**9**		
	Percent Native = 11.11		Number Native Species = 1	Introduced Species = 4

NOTE: Short duration of dredging operations (11 hours) at Spud Island DR (Roberts 2 DMP).

Windmill Cove Dredge Reach and Roberts 2 DMP Site:

This portion of the Windmill Cove dredge reach was dredged for the first time in 2010. Substrates in this portion of the SDWSC were primarily mud. Approximately 3,126,560 gallons, or 11.94% of the total slurry volume dredged at this reach was monitored during the two entrainment events. A total of 26 fish were observed while entrainment monitoring at this dredge reach (Table 9d). White catfish was the most abundant fish. No native species were observed while monitoring.

Table 9d. 2011 Summary Results of Entrainment Events for Windmill Cove DR — Roberts 2 DMP

Rank	Percent	Number	Common Name	Origin
1	73.08	19	white catfish	Introduced
2	11.54	3	shimofuri goby	Introduced
3	7.69	2	yellowfin goby	Introduced
4	3.85	1	striped bass	Introduced
4	3.85	1	channel catfish	Introduced
TOTAL		**26**		
	Percent Native = 0		Number Native Species = 0	Introduced Species = 5

Turning Basin Dredge Reach and Roberts 1 DMP Site:

Portions of this reach in the Port of Stockton area have been dredged every year since 2006 monitoring began. Substrates in this portion of the SDWSC were primarily mud and silty sand. Approximately 18,561,103 gallons, or 7.70% of the total slurry volume dredged at this reach was monitored during the 16 entrainment events conducted. A total of 18 fish were encountered while entrainment monitoring at this dredge reach (Table 9e). Channel catfish and brown bullhead were the most abundant fish. No native species were observed while entrainment monitoring.

Table 9e. 2011 Summary Results of Entrainment Events for Turning Basin DR — Roberts 1 DMP

Rank	Percent	Number	Common Name	Origin
1	33.33	6	channel catfish	Introduced
2	22.22	4	brown bullhead	Introduced
3	11.11	2	yellowfin goby	Introduced
3	11.11	2	threadfin shad	Introduced
4	5.56	1	white catfish	Introduced
4	5.56	1	striped bass	Introduced
4	5.56	1	common carp	Introduced
4	5.56	1	bigscale logperch	Introduced
TOTAL		**18**		

Percent Native = 0 Number Native Species = 0 Introduced Species = 8

NOTE: Of these numbers, 1 channel catfish, 1 threadfin shad, the white catfish and the common carp were dead prior to encounter; prior disposition could not be determined for 1 brown bullhead and 1 threadfin shad.

Extrapolated entrainment totals for each species encountered in each 2011 dredge reach are provided in Table 10. These extrapolations simply multiply the number of individuals by 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; simply assuming 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 3,950 fish may have been entrained by dredging operations in 2011.

Table 10. 2011 Extrapolated Results of Fish Entrainment Events for All Dredge Reach Locations

DR	*MMC 1*	*MMC 2*	*Sandy Beach*	*West Island*	*Scour Pond*	*Light 19*	*Light 21*	*Spud Island **	*Windmill Cove*	*Turning Basin*	
DMP	S-31A	S-31B	Sandy Beach	Scour Hole	Scour Hole	McCormack Pit	McCormack Pit	Roberts 2	Roberts 2	Roberts 1	**Extrapolated**
Monitored %	**8.02**	**6.5**	**12.58**	**9.19**	**6.34**	**8.28**	**8.6**	**19.26**	**11.94**	**7.7**	**Total Fish**
shimofuri goby	1,808	431	32	11		24			25		**2,331**
striped bass				283					8	13	**304**
white catfish	50	15		44				16	159		**283**
river lamprey			246			12					**259**
prickly sculpin	87	62	8			12		5			**174**
channel catfish				22		24		5	8	65	**124**
yellowfin goby	12	15		11	16	12		5	17	26	**115**
Shokihaze goby			8	33		24					**65**
wakasagi	50	15									**65**
American shad		31		33							**63**
brown bullhead										52	**52**
threadfin shad				11				16		13	**40**
delta smelt	25	15									**40**
bigscale logperch										13	**13**
white sturgeon				11							**11**
staghorn sculpin				11							**11**
TOTAL	2,032	585	294	468	16	109	0	47	218	182	**3,950**

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

* Short duration of dredging operations (11 hours) at Spud Island DR (Roberts 2 DMP)

4.3 Fish Community Monitoring

The following sub-sections describe the 2011 fish community monitoring results by shipping channel and individual dredge reach. Table 11 provides the numbers of fish encountered from all locations.

Table 11. 2011 Ranked Catch of Fish From All Sites During Trawl Monitoring Surveys

Rank	Percent	Number	Common Name	Genus	Species	Origin
1	29.76	**1,382**	white catfish	*Ameiurus*	*catus*	Introduced
2	22.22	**1,032**	threadfin shad	*Dorosoma*	*petenense*	Introduced
3	18.54	**861**	striped bass	*Morone*	*saxatilis*	Introduced
4	11.28	**524**	channel catfish	*Ictalurus*	*punctatus*	Introduced
5	10.34	**480**	American shad	*Alosa*	*sapidissima*	Introduced
6	2.17	**101**	Sacramento splittail	*Pogonichthys*	*macrolepidotus*	Native
7	1.40	**65**	redear sunfish	*Lepomis*	*microlophus*	Introduced
8	0.65	**30**	wakasagi	*Hypomesus*	*nipponensis*	Introduced
8	0.65	**30**	yellowfin goby	*Acanthogobius*	*flavimanus*	Introduced
9	0.60	**28**	brown bullhead	*Ameiurus*	*nebulosus*	Introduced
9	0.60	**28**	common carp	*Cyprinus*	*carpio*	Introduced
10	0.41	**19**	white sturgeon	*Acipenser*	*transmontanus*	Native
11	0.34	**16**	bluegill	*Lepomis*	*macrochirus*	Introduced
12	0.24	**11**	shimofuri goby	*Tridentiger*	*bifasciatus*	Introduced
13	0.17	**8**	starry flounder	*Platichthys*	*stellatus*	Native
13	0.17	**8**	tule perch	*Hysterocarpus*	*traskii*	Native
14	0.13	**6**	delta smelt	*Hypomesus*	*transpacificus*	Native
15	0.11	**5**	warmouth	*Lepomis*	*gulosus*	Introduced
16	0.09	**4**	prickly sculpin	*Cottus*	*asper*	Native
17	0.04	**2**	Pacific staghorn sculpin	*Leptocottus*	*ayresii*	Native
18	0.02	**1**	Shokihaze goby	*Tridentiger*	*barbatus*	Introduced
18	0.02	**1**	Chinook salmon	*Oncorhynchus*	*tshawytscha*	Native
18	0.02	**1**	bigscale logperch	*Percina*	*macrolepida*	Introduced
18	0.02	**1**	Sacramento pikeminnow	*Ptychocheilus*	*grandis*	Native
TOTAL		**4,644**				

Percent Native = 3.23 Number Native Species = 9 Introduced Species = 15

NOTE: Of the species totals, 4 threadfin shad, 1 striped bass, 1 redear sunfish, 1 common carp, and this program's first documented Chinook salmon were dead prior to encountering gear; 5 white catfish, 3 channel catfish, 1 striped bass, and 1 brown bullhead were injured prior to encounter.

The 2011 data are compared with previous years when relevant. Comparison of data across years is approached with caution. Readers should carefully consider that when comparing the data across years, the timing, exact locations (dredge reaches), effort, and environmental factors (such as rainfall and delta outflow) have all varied significantly during each year since 2006. In 2009, only 10.7% of the locations (river miles) had been previously dredged since monitoring began in 2005. In 2010, none of the reaches were the same as those dredged in 2009. In 2011, many but not all of the reaches had previously be dredged. Nonetheless, although the exact dredging reaches and trawl locations have changed from year to year, DMP sites have been fairly consistent. Due to this consistency, general comparisons within DMP sites are provided.

In 2011, non-native species accounted for 96.77% of the individual fish encountered during community monitoring, similar to previous years. Notably, white catfish were again more abundant than threadfin shad among the fish encountered. In 2010, threadfin shad were encountered more frequently than white catfish for the first time since monitoring began. No green sturgeon were encountered as they were in 2010 and 2006. Threatened or endangered fish encountered during 2011 trawling included six delta smelt. Sacramento splittail were encountered in the highest numbers since monitoring began. This also occurred in 2010, suggesting two consecutive years of high abundance. Species encountered previously in low numbers, but absent in 2011 were: green sturgeon, Sacramento blackfish, white crappie, black crappie, longfin smelt, largemouth bass, blue catfish, golden shiner, and Mississippi silverside. Chinook salmon is the only new species of fish encountered while fish community monitoring in 2011, and inclusion of this species is debatable, as the single fish encountered was dead when it ended up in the trawl. Redear sunfish were more abundant than during previous years and shimofuri and Shokihaze goby were both less abundant. Striped bass was the only species present at all dredge reaches. White catfish were ubiquitous as well, absent only from the Light 21 reach, an area of very low fish abundance in comparison with the other reaches monitored since 2006.

The CPUE in 2011 was higher at the Windmill Cove dredge reach than at all other fish community monitoring locations, due to the high abundance of white catfish there. The Stockton Turning Basin had the highest CPUE in 2010. The upper reaches of the SDWSC have yielded the highest CPUE metrics during all years since 2006. These high CPUEs reflect the relatively large numbers of introduced white and channel catfish, threadfin shad, striped bass, American shad, and sunfish species compared with other locations where fish community monitoring has occurred. A relatively high diversity of species has been encountered in these locations as well. Fish CPUE in 2010 and 2011 was also relatively higher in the upper reaches of the SDWSC than at other locations during previous years due to high numbers of threadfin shad. Figure 11 and Table 12 provide the 2011 CPUE information in graphic and tabular format.

Table 12 summarizes the effort data for 2011 fish community monitoring and provides a description of relative fish density and comparative abundance of demersal species at the trawl locations through the CPUE metric. The CPUE is expressed as the number of fish encountered per linear meter that the net is towed along the bottom.

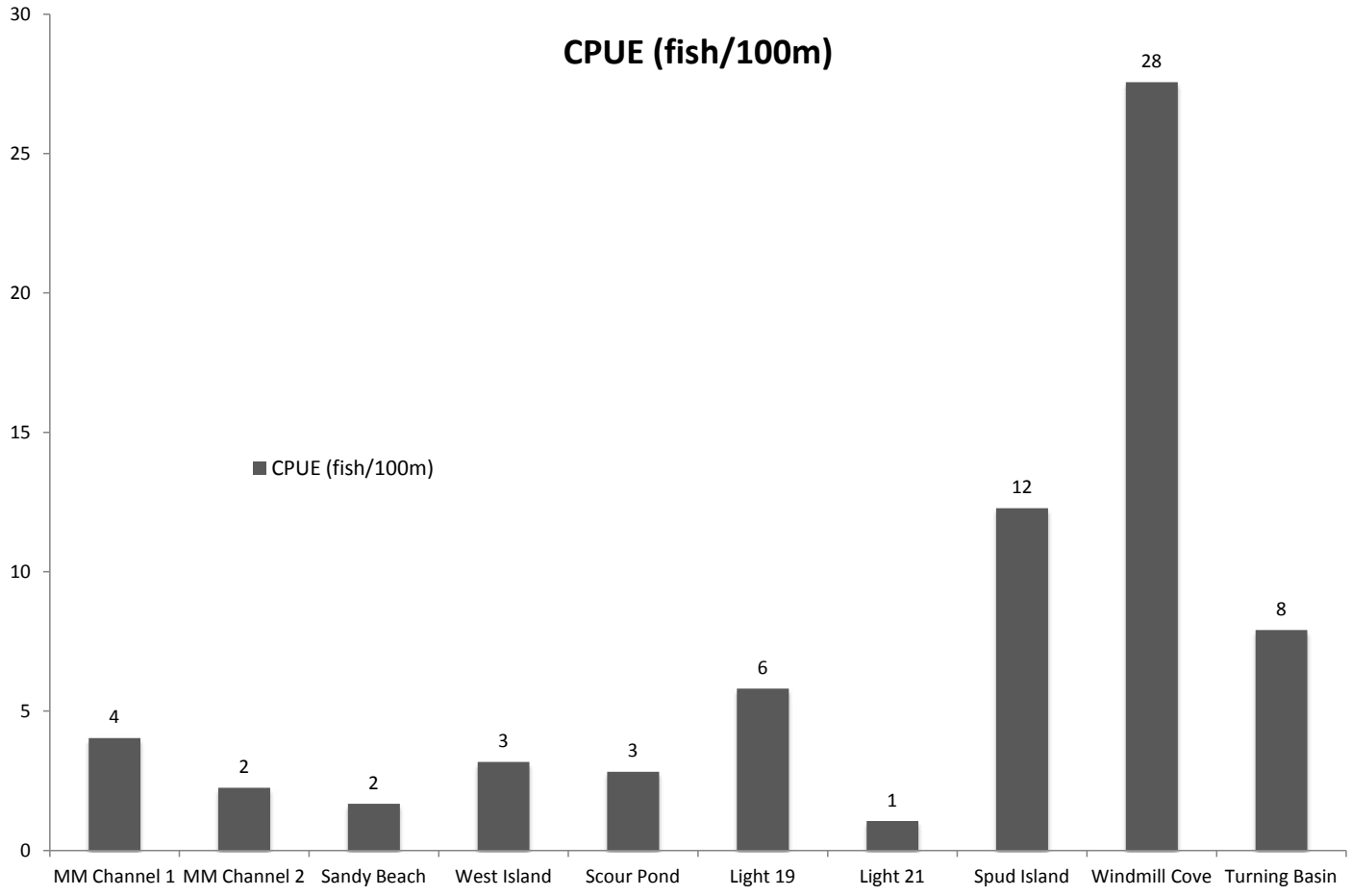


Figure 11. Mean CPUE for Each Fish Community Survey

Table 12. 2011 Summary Catch and Effort Data for Fish Encountered in Trawl Surveys

River	Dredge Reach	CPUE Trawl Tows	CPUE Trawl Distance (m)	Vol. Monitored (m^3)	% Total Effort	No. of Fish	% Total Catch	CPUE (fish/m)
SRDWSC	MM Channel 1	9	3,820	30,178	6.04	154	3.31	0.04
SRDWSC	MM Channel 2	6	2,180	17,222	3.45	49	1.05	0.02
SRDWSC	Sandy Beach	5	1,670	13,193	2.64	28	0.60	0.02
SDWSC	West Island	15	5,740	45,346	9.08	182	3.91	0.03
SDWSC	Scour Pond	5	1,310	10,349	2.07	37	0.79	0.03
SDWSC	Light 19	29	8,560	67,624	13.54	497	10.67	0.06
SDWSC	Light 21	6	2,650	20,935	4.19	28	0.60	0.01
SDWSC	Spud Island	5	2,060	16,274	3.26	253	5.43	0.12
SDWSC	Windmill Cove	9	3,280	25,912	5.19	904	19.41	0.28
SDWSC	Turning Basin	74	31,940	252,326	50.53	2,525	54.22	0.08
TOTAL		**163**	**63,210**	**499,359**		**4,657**	**163**	

4.3.1 Sacramento River Shipping Channel Locations

Table 13 provides the combined data for all fish encountered during fish community monitoring at all SRDWSC locations during 2011. Three different dredge reaches were monitored, two in the man-made portion of the shipping channel and one in the natural channel near Rio Vista. Eleven species were encountered, five native and six introduced. As in previous years, introduced species dominated in terms of individual fish encountered. White catfish was the most common fish, comprising 61.04% of the total individuals encountered; followed by wakasagi and striped bass, comprising 12.99% and 4.76% respectively. Introduced species made up the top four species in terms of relative abundance, together comprising 83.12% of the individual fish encountered. Native fish comprised 11.25% of the individuals encountered. Sacramento splittail were abundant in 2010 and 2011 relative to previous years, though they have always been present in low numbers. In 2011, starry flounder were not encountered, unlike prior years. Delta smelt, prickly sculpin, tule perch and white sturgeon were the other native species encountered. Delta smelt and wakasagi were the fish species encountered in the SRDWSC that were not also encountered in the SDWSC. Tables 14a-c provide details of the fish encountered while fish community monitoring at each SRDWSC dredge reach.

Table 13. 2011 Summary Results of Fish Encountered during All SRDWSC Trawl Surveys

Rank	Percent	Number	Common Name	Origin
1	61.04	141	white catfish	Introduced
2	12.99	30	wakasagi	Introduced
3	4.76	11	shimofuri goby	Introduced
4	4.33	10	striped bass	Introduced
4	4.33	10	Sacramento splittail	Native
5	3.90	9	channel catfish	Introduced
6	3.46	8	white sturgeon	Native
7	2.60	6	delta smelt	Native
8	1.73	4	American shad	Introduced
9	0.43	1	tule perch	Native
9	0.43	1	prickly sculpin	Native
TOTAL		**231**		
Percent Native = 11.26			Number Native Species = 5	Number Introduced Species = 6

Man-made Channel 1 Dredge Reach and S-31A DMP Site:

Nine successful trawl tows were conducted at this reach located between river mile 33.30 and 32.50 during three days of monitoring between August 19 and 24, 2011. Monitoring efforts were curtailed due to presence of delta smelt. Figure 12 displays the trawl survey locations and DMP site for this dredge reach. Table 14a provides abundance data for the fish encountered during fish community monitoring at this reach. In 2011, nine species of fish represented by 154 individuals were encountered. White catfish were the most abundant fish, as they were at S-31 reaches in all previous years. In 2011, white catfish comprised 78.57% of the individual fish. Shimofuri goby and wakasagi were second and third most abundant respectively, though in previous years their abundance was reversed. Two of the six delta smelt encountered in 2011 were from this reach. Sacramento splittail and white sturgeon were the other native species encountered. Native fish comprised 5.84% of the total number encountered, fifth among the ten reaches monitored. The CPUE (described as total number of fish per meter trawled) was 0.04. This reach had the fifth highest CPUE among all ten reaches in 2011. It ranked first in CPUE amongst SRDWSC reaches, as it was in 2010.

Table 14a. 2011 Summary Results of Trawl Surveys in the Man-made Channel 1 Reach

Rank	Percent	Number	Common Name	Origin
1	78.57	121	white catfish	Introduced
2	6.49	10	shimofuri goby	Introduced
3	5.84	9	wakasagi	Introduced
4	2.60	4	Sacramento splittail	Native
5	1.95	3	white sturgeon	Native
5	1.95	3	American shad	Introduced
6	1.30	2	delta smelt	Native
7	0.65	1	striped bass	Introduced
7	0.65	1	channel catfish	Introduced
TOTAL		**154**		
	Percent Native = 5.84		Number Native Species = 3	Introduced Species = 6

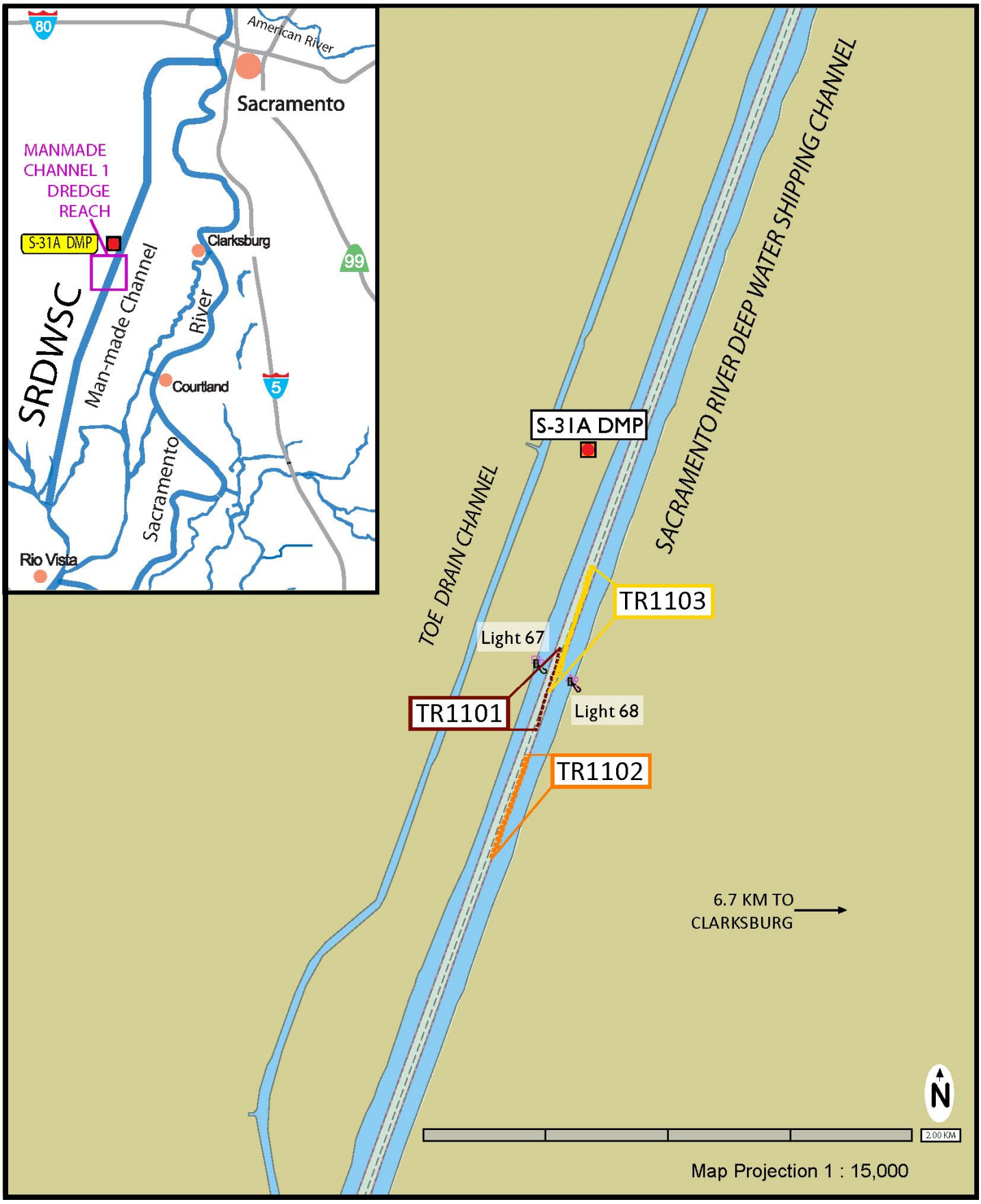


Figure 12. 2011 Fish Community Surveys at the Man-made Channel 1 DR and S-31A DMP

Man-made Channel 2 Dredge Reach and S-31B DMP Site:

Six successful trawl tows were conducted at this reach located between river mile 27.80 and 27.20 during three days of monitoring between August 26 and 28, 2011. Monitoring efforts were curtailed due to presence of delta smelt. The trawl survey locations and DMP site for this dredge reach are displayed in Figure 13. Abundance data for the fish encountered during fish community monitoring events at this reach are provided in Table 14b. In 2011, seven species of fish represented by 49 individuals were encountered. Wakasagi were the most abundant fish, only slightly more abundant than white catfish, comprising 42.86% and 40.82% of the fish encountered respectively. Delta smelt were the third most abundant species. Four of the six delta smelt encountered in 2011 were from this reach. Prickly sculpin was the only other native species encountered. Native fish comprised 10.2% of the total number of fish encountered, second among the ten reaches monitored. The CPUE was 0.02 fish per meter, tied for seventh among the ten reaches monitored in 2011.

Table 14b. 2011 Summary Results of Trawl Surveys in the Man-made Channel 2 Reach

Rank	Percent	Number	Common Name	Origin
1	42.86	21	wakasagi	Introduced
2	40.82	20	white catfish	Introduced
3	8.16	4	delta smelt	Native
4	2.04	1	striped bass	Introduced
4	2.04	1	shimofuri goby	Introduced
4	2.04	1	prickly sculpin	Native
4	2.04	1	channel catfish	Introduced
TOTAL		**49**		
	Percent Native = 10.20		Number Native Species = 2	Introduced Species = 5

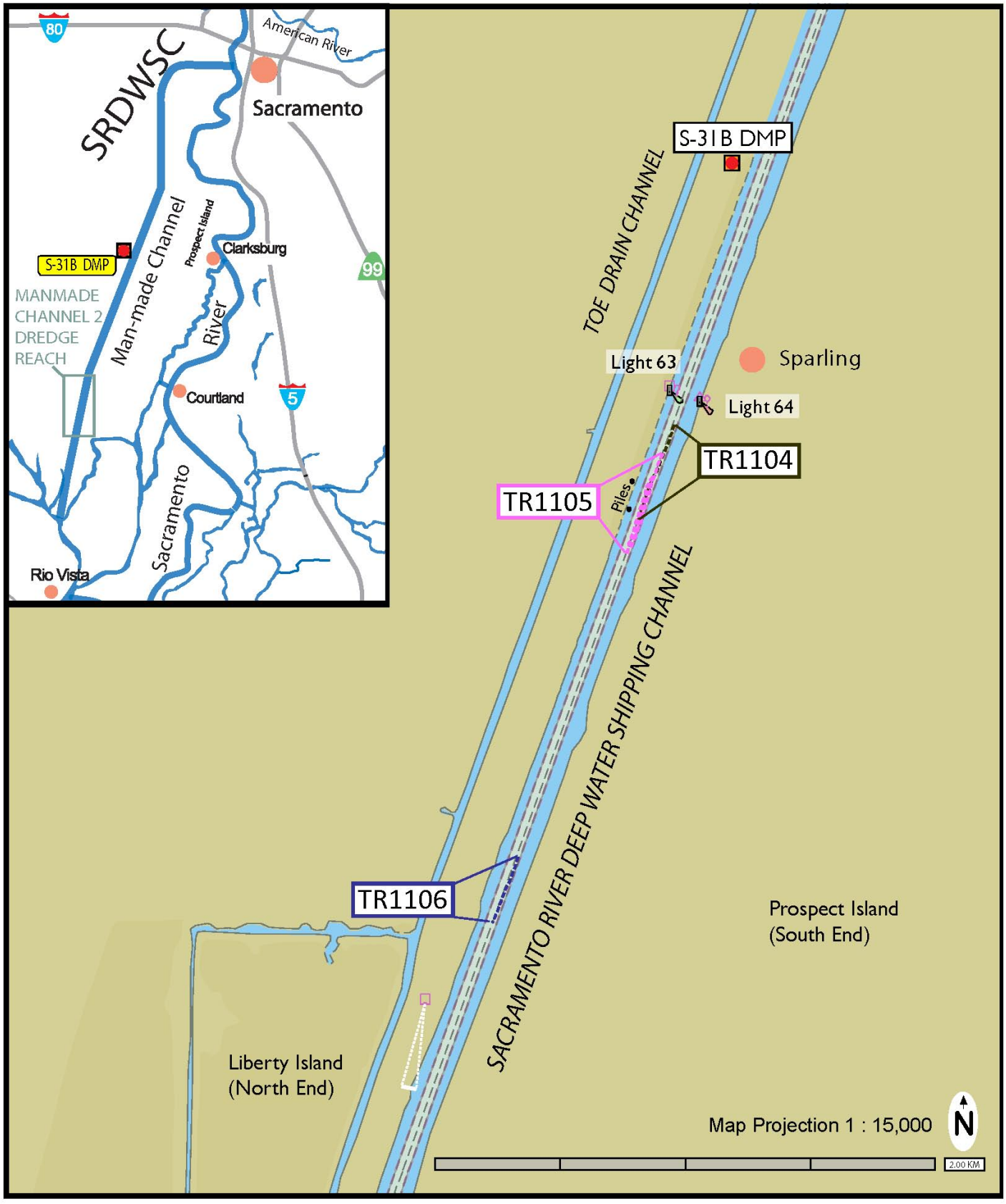


Figure 13. 2011 Fish Community Surveys at the Man-made Channel 2 DR and S-31B DMP

Sandy Beach Dredge Reach and Sandy Beach DMP Site:

Five successful trawl tows were conducted at this reach located between river mile 9.46 and 9.09 during one day of monitoring on September 2, 2011. Figure 14 displays the trawl survey locations and DMP site for this dredge reach. Data for fish encountered during fish community monitoring at this reach are listed in Table 14c. In 2011, six species of fish represented by 28 individuals were encountered. Striped bass were the most abundant fish, but channel catfish, Sacramento splittail, and white sturgeon were also abundant, respectively comprising 28.57%, 25%, 21.43%, and 17.86% of the fish encountered. Sacramento splittail, white sturgeon and tule perch were the native species encountered, together comprising 42.86% of the fish encountered. This reach had the highest percentage of native individuals among all reaches monitored in 2011 by a wide margin. This has been true of other monitored reaches in this area in previous years, as well. White sturgeon, longfin smelt, starry flounder, Sacramento splittail and river lamprey have all been abundant in this region. The CPUE was 0.02, tied for seventh among the ten reaches monitored in 2011.

Table 14c. 2011 Summary Results of Trawl Surveys in the Sandy Beach Reach

Rank	Percent	Number	Common Name	Origin
1	28.57	8	striped bass	Introduced
2	25.00	7	channel catfish	Introduced
3	21.43	6	Sacramento splittail	Native
4	17.86	5	white sturgeon	Native
5	3.57	1	tule perch	Native
5	3.57	1	American shad	Introduced
TOTAL		**28**		
	Percent Native = 42.86		Number Native Species = 3	Introduced Species = 3

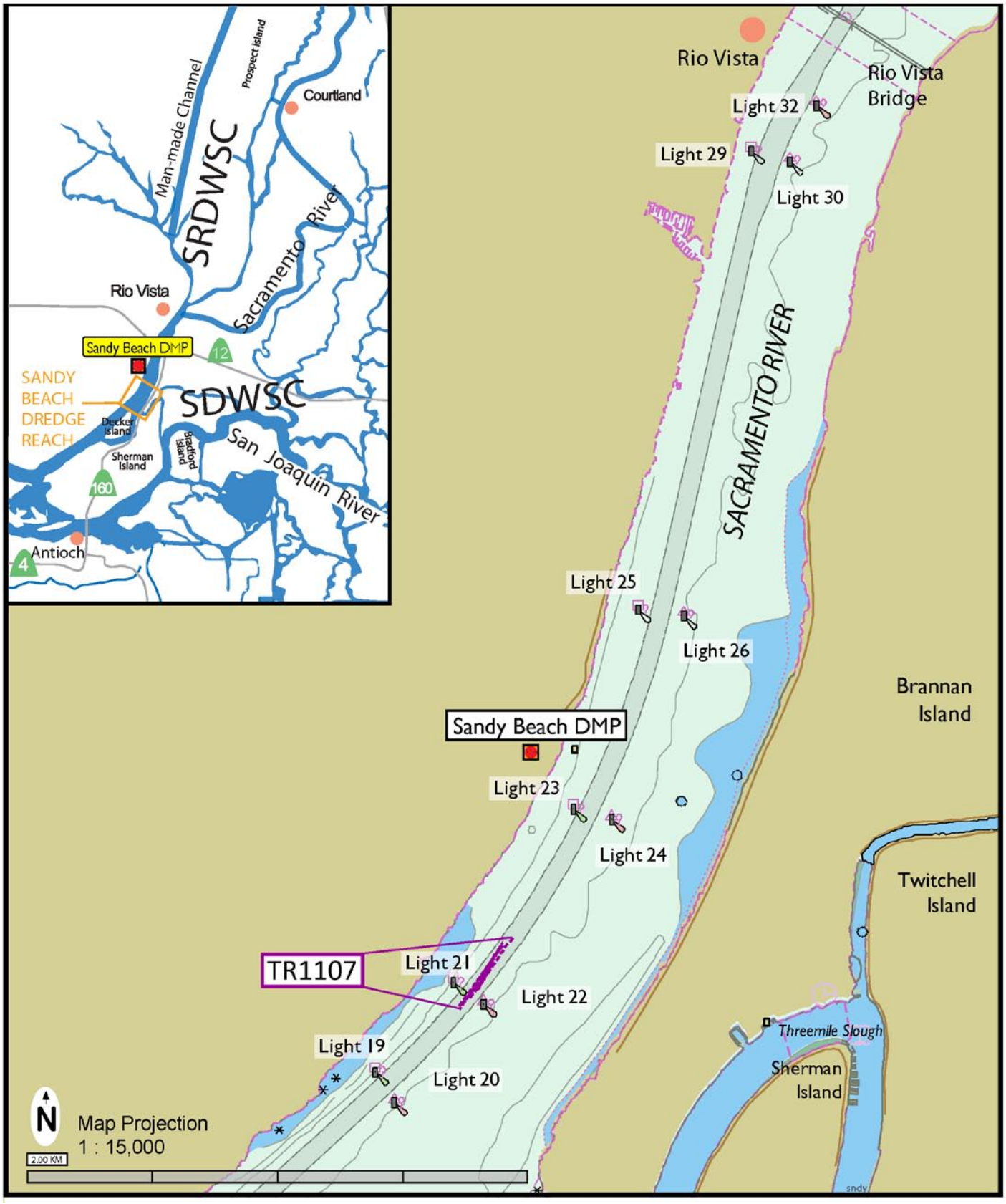


Figure 14. 2011 Fish Community Survey at the Sandy Beach DR and Sandy Beach DMP

4.3.2 Stockton Shipping Channel Locations

The combined data for all fish encountered during fish community monitoring at all SDWSC locations during 2011 is provided in Table 15. Seven different dredge reaches were monitored. Twenty-one species were encountered, compared with 11 in the SRDWSC. Eight of the species were native and 13 were introduced. As in previous years, introduced species also dominated in terms of individual fish encountered. White catfish was the most common, comprising 28.12% of the individual fish encountered, followed by threadfin shad and striped bass, comprising 23.39% and 19.28% respectively. Introduced species made up the top five species in terms of relative abundance, together comprising 93.25% of the individual fish encountered. Native fish comprised 2.81% of the individual fish encountered. Sacramento splittail were abundant in 2010 and 2011 relative to previous years, though they have always been present in low numbers. Delta smelt and wakasagi were two species encountered in the SRDWSC that were not also encountered in the SDWSC. Wakasagi have not been encountered in the SDWSC since the inception of monitoring, and delta smelt have only been encountered in small numbers at the lower-most SDWSC dredge reaches. Tables 16a-g provide details of the fish encountered while fish community monitoring at each SDWSC dredge reach.

Table 15. 2011 Summary Results of Fish Encountered in All SDWSC Trawl Surveys

Rank	Percent	Number	Common Name	Origin
1	28.12	1,241	white catfish	Introduced
2	23.39	1,032	threadfin shad	Introduced
3	19.28	851	striped bass	Introduced
4	11.67	515	channel catfish	Introduced
5	10.79	476	American shad	Introduced
6	2.06	91	Sacramento splittail	Native
7	1.47	65	redear sunfish	Introduced
8	0.68	30	yellowfin goby	Introduced
9	0.63	28	brown bullhead	Introduced
9	0.63	28	common carp	Introduced
10	0.36	16	bluegill	Introduced
11	0.25	11	white sturgeon	Native
12	0.18	8	starry flounder	Native
13	0.16	7	tule perch	Native
14	0.11	5	warmouth	Introduced
15	0.07	3	prickly sculpin	Native
16	0.05	2	Pacific staghorn sculpin	Native
17	0.02	1	Chinook salmon	Native
17	0.02	1	Shokihaze goby	Introduced
17	0.02	1	bigscale logperch	Introduced
17	0.02	1	Sacramento pikeminnow	Native
TOTAL		**4,413**		

Percent Native = 2.81 | Number Native Species = 8 | Introduced Species = 13

NOTE: Of the species totals, 4 threadfin shad, 1 striped bass, 1 redear sunfish, 1 common carp, and this program's first documented Chinook salmon were dead prior to encounter.

West Island Dredge Reach and Scour Hole DMP Site:

Fifteen successful trawl tows were conducted at this reach located between river mile 5.53 and 6.12 during three days of monitoring from September 11 to September 15, 2011. Trawl survey locations and the DMP site for this dredge reach are displayed in Figure 15. Abundance data for the fish encountered during fish community monitoring at this reach is listed in Table 16a. In 2011, nine species of fish represented by 182 individuals were encountered. Striped bass were the most abundant fish, comprising 41.21% of the individuals. Channel catfish and white catfish were second and third most abundant, respectively comprising 32.42% and 14.84% of the total. White sturgeon, starry flounder, prickly sculpin and Sacramento splittail were the native species encountered. Native fish comprised 6.59% of the total fish encountered, fourth among the ten reaches monitored. The CPUE was 0.03 (the same as Scour Pond DR), fourth lowest among all ten reaches in 2011.

Table 16a. 2011 Summary Results of Trawl Surveys in the West Island Reach

Rank	Percent	Number	Common Name	Origin
1	41.21	75	striped bass	Introduced
2	32.42	59	channel catfish	Introduced
3	14.84	27	white catfish	Introduced
4	4.40	8	American shad	Introduced
5	3.85	7	white sturgeon	Native
6	1.10	2	starry flounder	Native
6	1.10	2	prickly sculpin	Native
7	0.55	1	threadfin shad	Introduced
7	0.55	1	Sacramento splittail	Native
TOTAL		**182**		
	Percent Native = 6.59		Number Native Species = 4	Introduced Species = 5

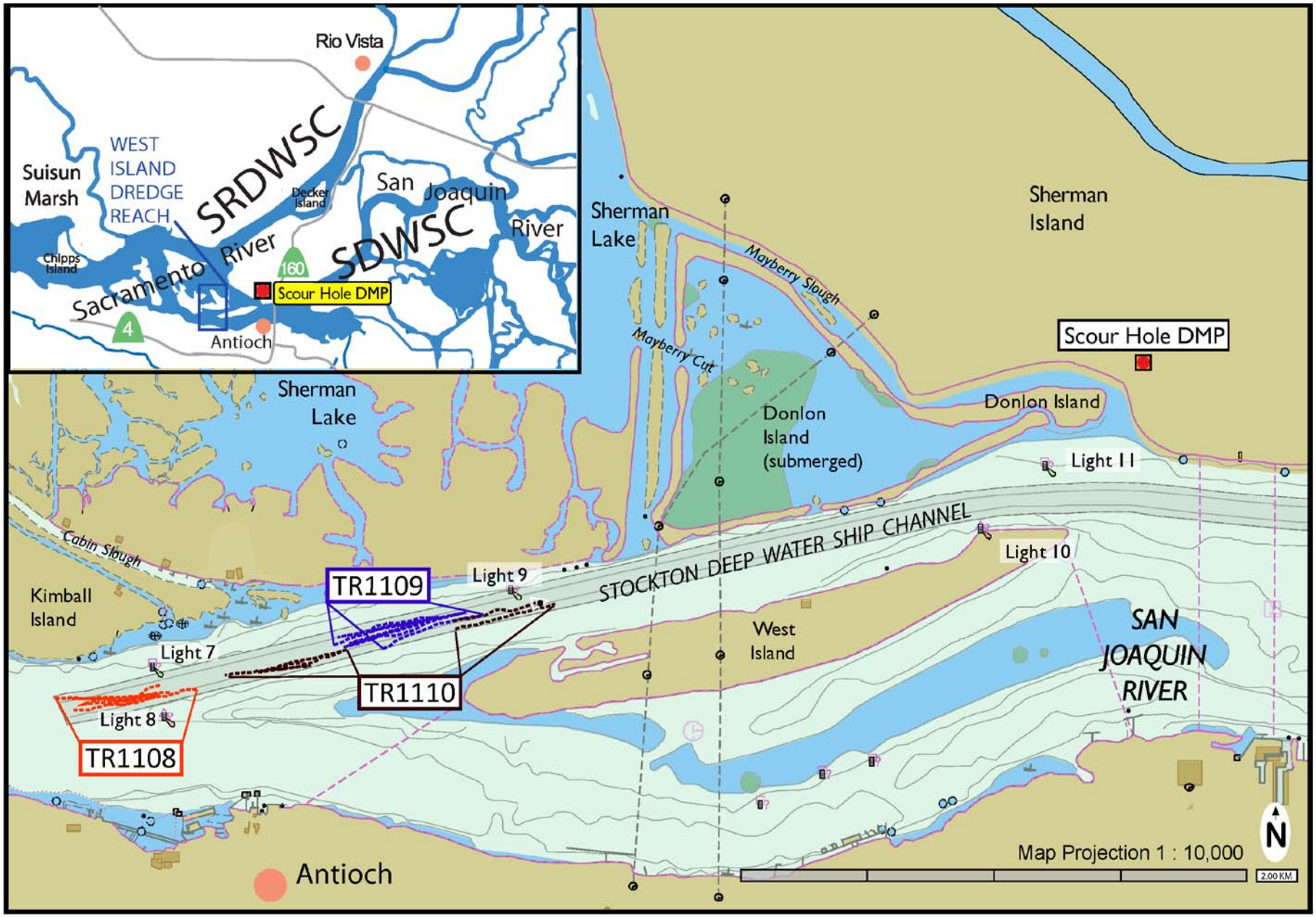


Figure 15. 2011 Fish Community Surveys at the West Island DR and Scour Hole DMP

Scour Pond Dredge Reach and Scour Hole DMP Site:

Five successful trawl tows were conducted at this reach located between river mile 7.52 and 8.05 during one day of monitoring between on September 17, 2011. Figure 16 displays the trawl survey locations and DMP site for this dredge reach. Fish encounter data for community monitoring at this reach are provided in Table 16b. In 2011, four species of fish represented by 37 individuals were encountered. White catfish were the most abundant fish. In 2011, white catfish comprised 67.57% of the individual fish. Channel catfish, striped bass, and were second and third most abundant, respectively comprising 21.62%, 8.11% and of the fish encountered. No native fish were encountered at this reach; the least of all 2011 reaches. The CPUE was 0.03, as with West Island reach, the fourth lowest in 2011.

Table 16b. 2011 Summary Results of Trawl Surveys in the Scour Pond Reach

Rank	Percent	Number	Common Name	Origin
1	67.57	25	white catfish	Introduced
2	21.62	8	channel catfish	Introduced
3	8.11	3	striped bass	Introduced
4	2.70	1	American shad	Introduced
TOTAL		**37**		
	Percent Native = 0		Number Native Species = 0	Introduced Species = 4

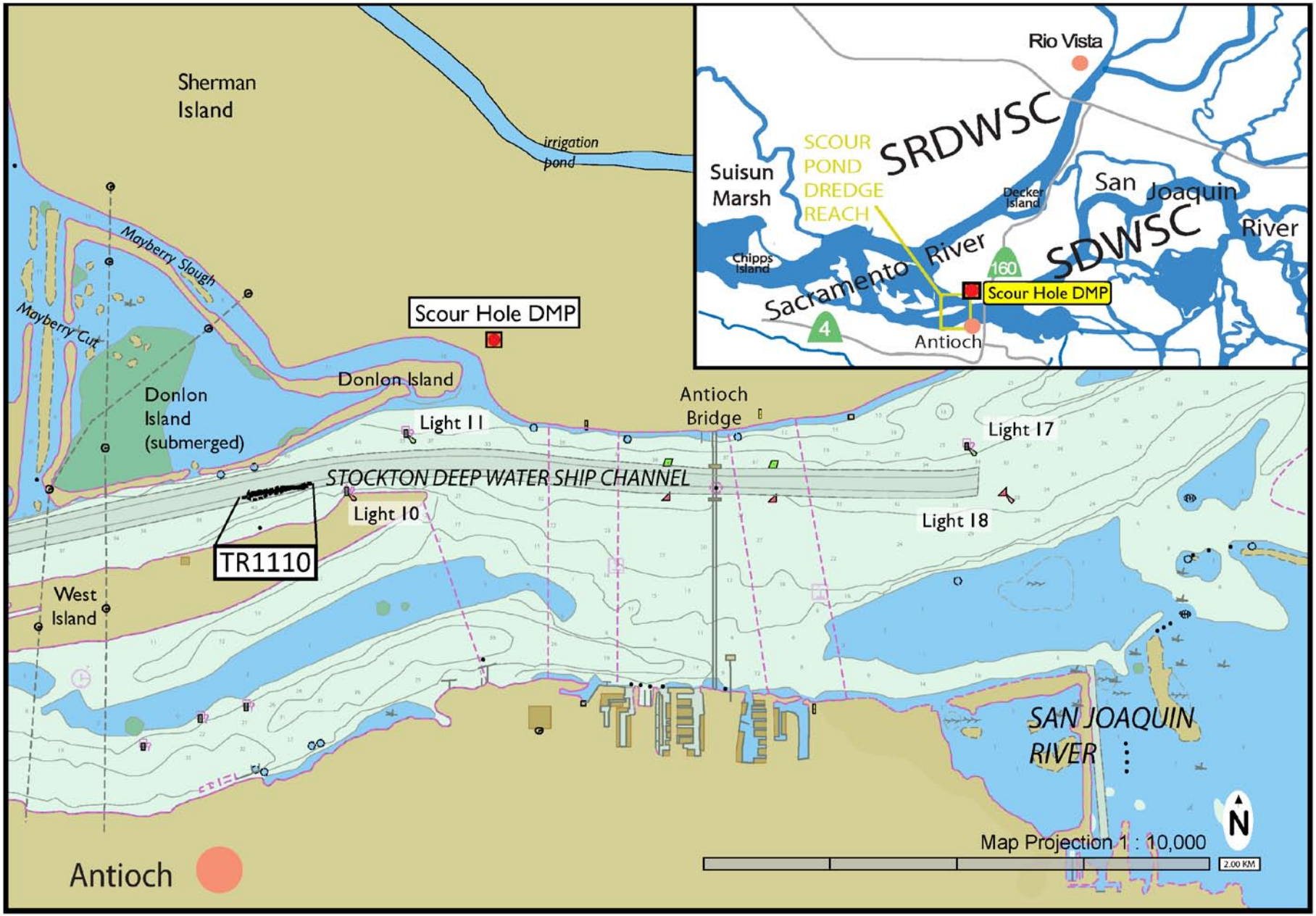


Figure 16. 2011 Fish Community Survey at the Scour Pond DR and Scour Hole DMP

Light 19 Dredge Reach and McCormack Pit DMP Site:

Twenty-nine successful trawl tows were conducted at this reach located between river mile 10.85 and 11.23 during six days of monitoring between September 21 and October 2, 2011. Figure 17 displays the trawl survey locations and DMP site for this dredge reach. Table 16c lists abundance data for the fish encountered during fish community monitoring at this reach. In 2011, nine species of fish represented by 497 individuals were encountered. Striped bass were the most abundant fish, comprising 53.52% of the individuals encountered. American shad and channel catfish were second and third most abundant, respectively comprising 28.17% and 8.65% of the fish. Tule perch, Sacramento splittail, starry flounder, and white sturgeon were the native species encountered. Native fish comprised 4.29% of the total number encountered, sixth among the ten reaches monitored. Overall CPUE was 0.06, fourth highest among all 2011 reaches.

Table 16c. 2011 Summary Results of Trawl Surveys in the Light 19 Reach

Rank	Percent	Number	Common Name	Origin
1	53.52	266	striped bass	Introduced
2	28.17	140	American shad	Introduced
3	8.65	43	channel catfish	Introduced
4	3.82	19	white catfish	Introduced
5	1.61	8	threadfin shad	Introduced
6	1.41	7	tule perch	Native
6	1.41	7	Sacramento splittail	Native
7	1.21	6	starry flounder	Native
8	0.20	1	white sturgeon	Native
TOTAL		**497**		
	Percent Native = 4.29		Number Native Species = 4	Introduced Species = 5

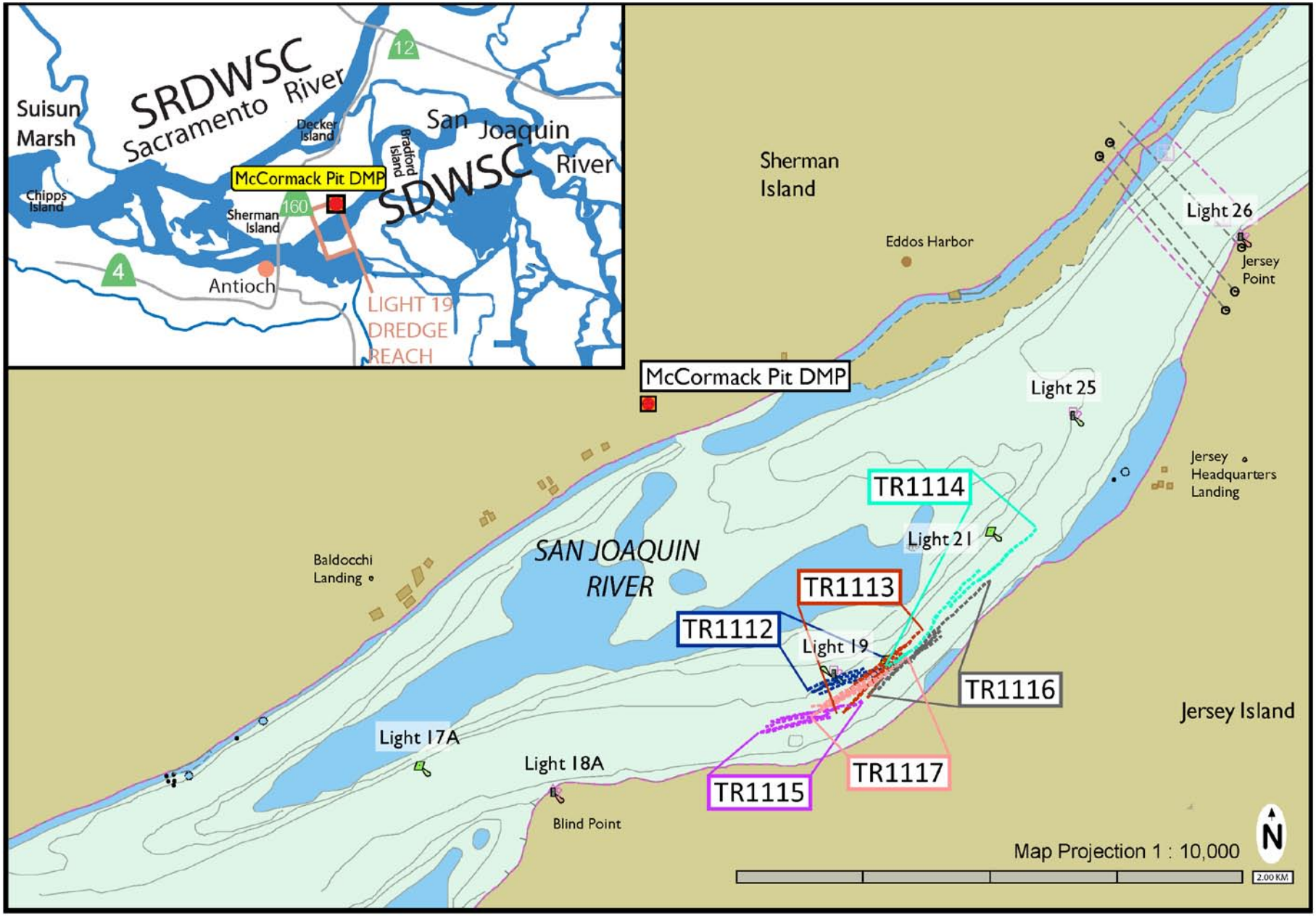


Figure 17. 2011 Fish Community Surveys at the Light 19 DR and McCormack Pit DMP

Light 21 Dredge Reach and McCormack Pit DMP Site:

Six successful trawl tows were conducted at this reach located between river mile 11.55 and 11.74 during two days of monitoring between October and October 6, 2011. Figure 18 displays the trawl survey locations and DMP site for this dredge reach. Table 16d provides the abundance data for the fish encountered during fish community monitoring at this reach. In 2011, six species of fish represented by 28 individuals were encountered. Striped bass were the most abundant fish, comprising 50% of the individuals encountered. American shad was the second most abundant species; comprising 35.71% and the rest were tied at third. White sturgeon and Sacramento splittail were the two native species encountered. Native fish comprised 7.14% of the total number of fish encountered, third highest among reaches monitored. The CPUE was 0.01, eighth among the ten reaches in 2011.

Table 16d. 2011 Summary Results of Trawl Surveys in the Light 21 Reach

Rank	Percent	Number	Common Name	Origin
1	50.00	14	striped bass	Introduced
2	35.71	10	American shad	Introduced
3	3.57	1	yellowfin goby	Introduced
3	3.57	1	white sturgeon	Native
3	3.57	1	Sacramento splittail	Native
3	3.57	1	channel catfish	Introduced
TOTAL		**28**		

Percent Native = 7.14 | Number Native Species = 2 | Introduced Species = 4

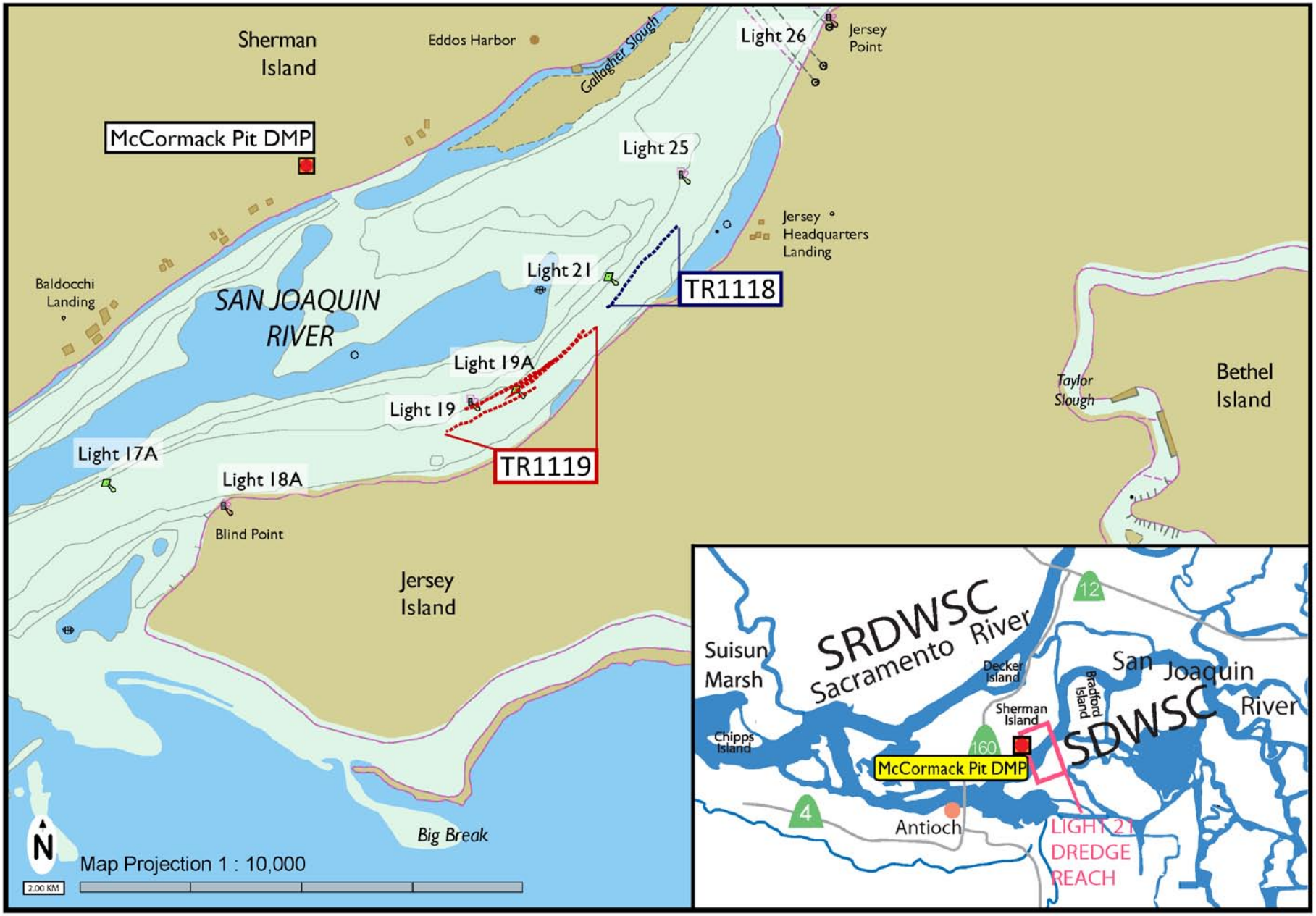


Figure 18. 2011 Fish Community Surveys at the Light 21 DR and McCormack Pit DMP

Spud Island Dredge Reach and Roberts 2 DMP Site:

Five successful trawl tows were conducted at this reach located between river mile 31.44 and 31.63 during one day of monitoring on October 16, 2011. Figure 19 displays the trawl survey locations and DMP site for this dredge reach. Table 16e lists abundance data for the fish encountered during fish community monitoring at this reach. In 2011, three species of fish represented by 253 individuals were encountered. White catfish were the most abundant fish, comprising 96.05% of the individuals encountered. Striped bass and prickly sculpin were second and third most abundant, respectively comprising 3.56% and 0.40% of the fish. Prickly sculpin was the only native species encountered. It comprised 0.40% of the total number, the second lowest native percentage among the ten reaches monitored. The CPUE was 0.12 at Spud Island, second highest among all ten reaches in 2011.

Table 16e. 2011 Summary Results of Trawl Surveys in the Spud Island Reach

Rank	Percent	Number	Common Name	Origin
1	96.05	243	white catfish	Introduced
2	3.56	9	striped bass	Introduced
3	0.40	1	prickly sculpin	Native
TOTAL		**253**		

Percent Native = 0.40 Number Native Species = 1 Introduced Species = 2

NOTE: Short duration of dredging operations (11 hours) at Spud Island DR (Roberts 2 DMP).

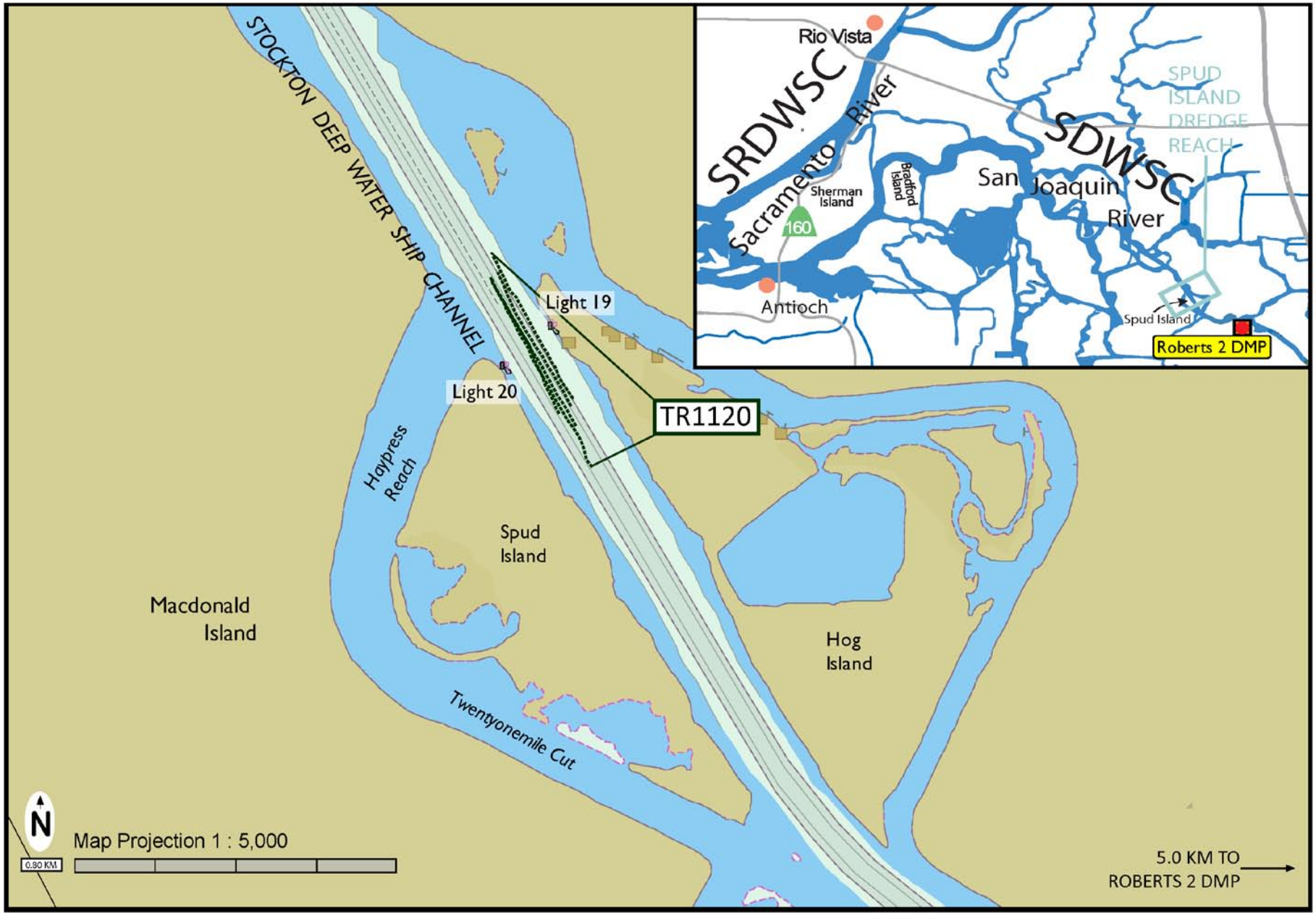


Figure 19. 2011 Fish Community Survey at the Spud Island DR and Roberts 2 DMP

Windmill Cove Dredge Reach and Roberts 2 DMP Site:

Nine successful trawl tows were conducted at this reach located between river mile 34.22 and 34.56 during two days of monitoring between October 19 and 21, 2011. Figure 20 displays the trawl survey locations and DMP site for this dredge reach. Table 16f provides the abundance data for the fish encountered at this reach. In 2011, seven species of fish represented by 904 individuals were encountered. White catfish were the most abundant fish, comprising 94.58% of the individuals encountered. Sacramento splittail and striped bass were second and third most abundant, respectively comprising only 1.77% and 1.33% of the fish. Sacramento splittail represented the only native species encountered. Native fish comprised 1.77% of the total number of fish encountered, eighth among the ten reaches monitored. The CPUE was 0.28, highest of all reaches in 2011.

Table 16f. 2011 Summary Results of Trawl Surveys in the Windmill Cove Reach

Rank	Percent	Number	Common Name	Origin
1	94.58	855	white catfish	Introduced
2	1.77	16	Sacramento splittail	Native
3	1.33	12	striped bass	Introduced
4	1.22	11	threadfin shad	Introduced
5	0.88	8	channel catfish	Introduced
6	0.11	1	Shokihaze goby	Introduced
6	0.11	1	American shad	Introduced
TOTAL		**904**		

Percent Native = 1.77 | Number Native Species = 1 | Introduced Species = 6

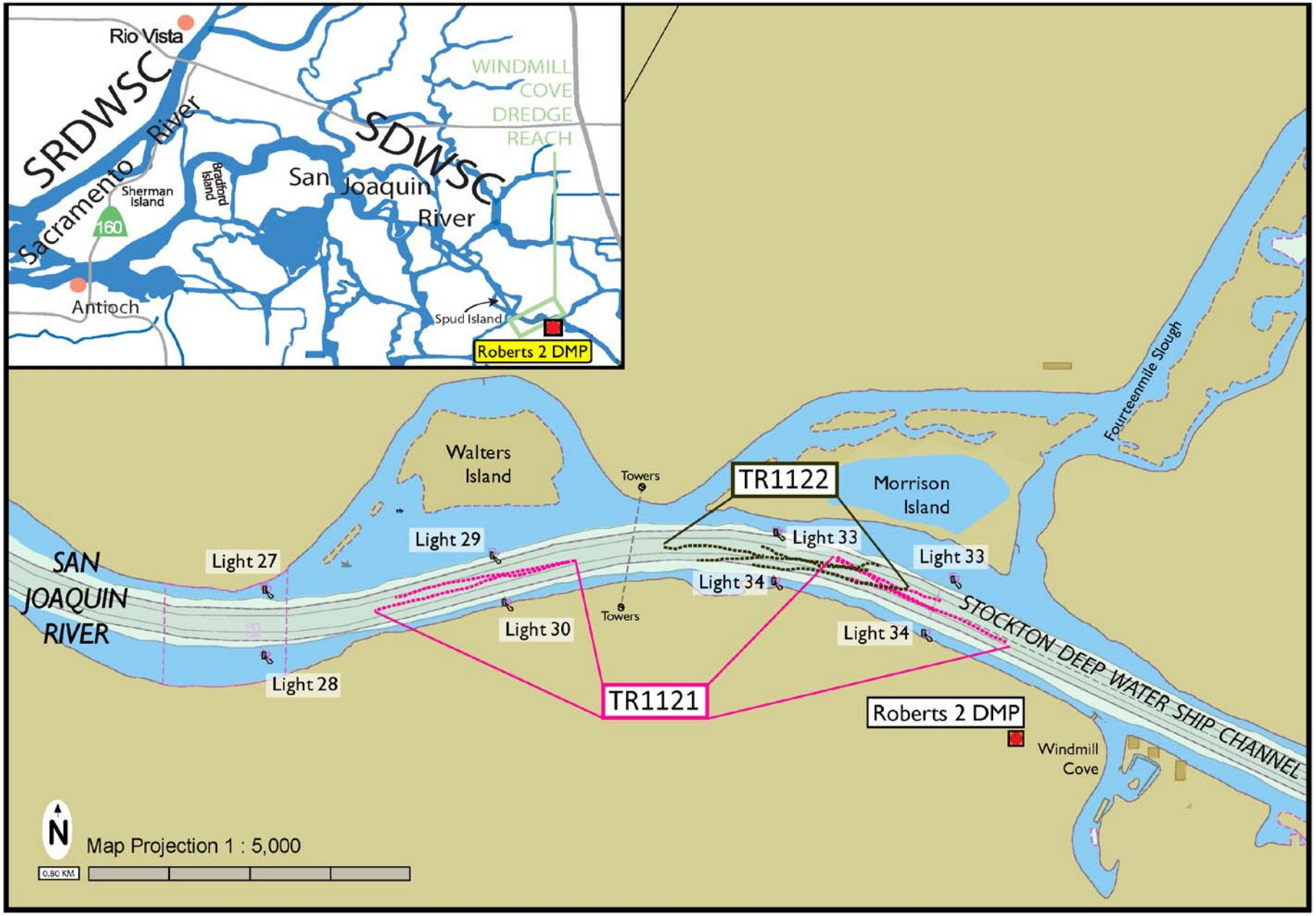


Figure 20. 2011 Fish Community Surveys at the Windmill Cove DR and Roberts 2 DMP

Turning Basin Dredge Reach and Roberts 1 DMP Site:

A total of 77 successful trawl tows were conducted at this reach (RM 39.20 – 40) during 16 days of monitoring between October 25 and November 29, 2011. Figure 21 displays the trawl survey locations and DMP site for this dredge reach. Table 16g lists abundance data for the fish encountered during fish community monitoring at this reach. In 2011, eighteen species of fish represented by 2,512 individuals were encountered. Threadfin shad were the most abundant fish, comprising 40.29% of the individuals encountered. Striped bass, channel catfish American shad and white catfish were second, third and fourth most abundant, respectively comprising 18.79%, 15.76%, 12.58% and 2.87% of the fish. Sacramento splittail, Pacific staghorn sculpin, white sturgeon, Chinook salmon, and Sacramento pikeminnow were the native species encountered. Native fish comprised 2.87% of the total number of fish encountered, seventh among the ten reaches monitored. The CPUE was 0.08, third highest among all ten reaches in 2011.

Table 16g. 2011 Summary Results of Trawl Surveys in the Turning Basin Reach

Rank	Percent	Number	Common Name	Origin
1	40.29	1,012	threadfin shad	Introduced
2	18.79	472	striped bass	Introduced
3	15.76	396	channel catfish	Introduced
4	12.58	316	American shad	Introduced
5	2.87	72	white catfish	Introduced
6	2.55	64	redear sunfish	Introduced
7	2.63	66	Sacramento splittail	Native
8	1.15	29	yellowfin goby	Introduced
9	1.11	28	brown bullhead	Introduced
9	1.11	28	common carp	Introduced
10	0.64	16	bluegill	Introduced
11	0.20	5	warmouth	Introduced
12	0.08	2	Pacific staghorn sculpin	Native
12	0.08	2	white sturgeon	Native
13	0.04	1	bigscale logperch	Introduced
13	0.04	1	Chinook salmon	Native
13	0.04	1	redear sunfish	Introduced
13	0.04	1	Sacramento pikeminnow	Native
TOTAL		**2,512**		

Percent Native = 2.87 Number Native Species = 5 Introduced Species = 13

NOTE: Of these numbers, 4 threadfin shad, 1 striped bass, 1 redear sunfish, 1 common carp, and this program's first documented Chinook salmon were dead prior to encounter.

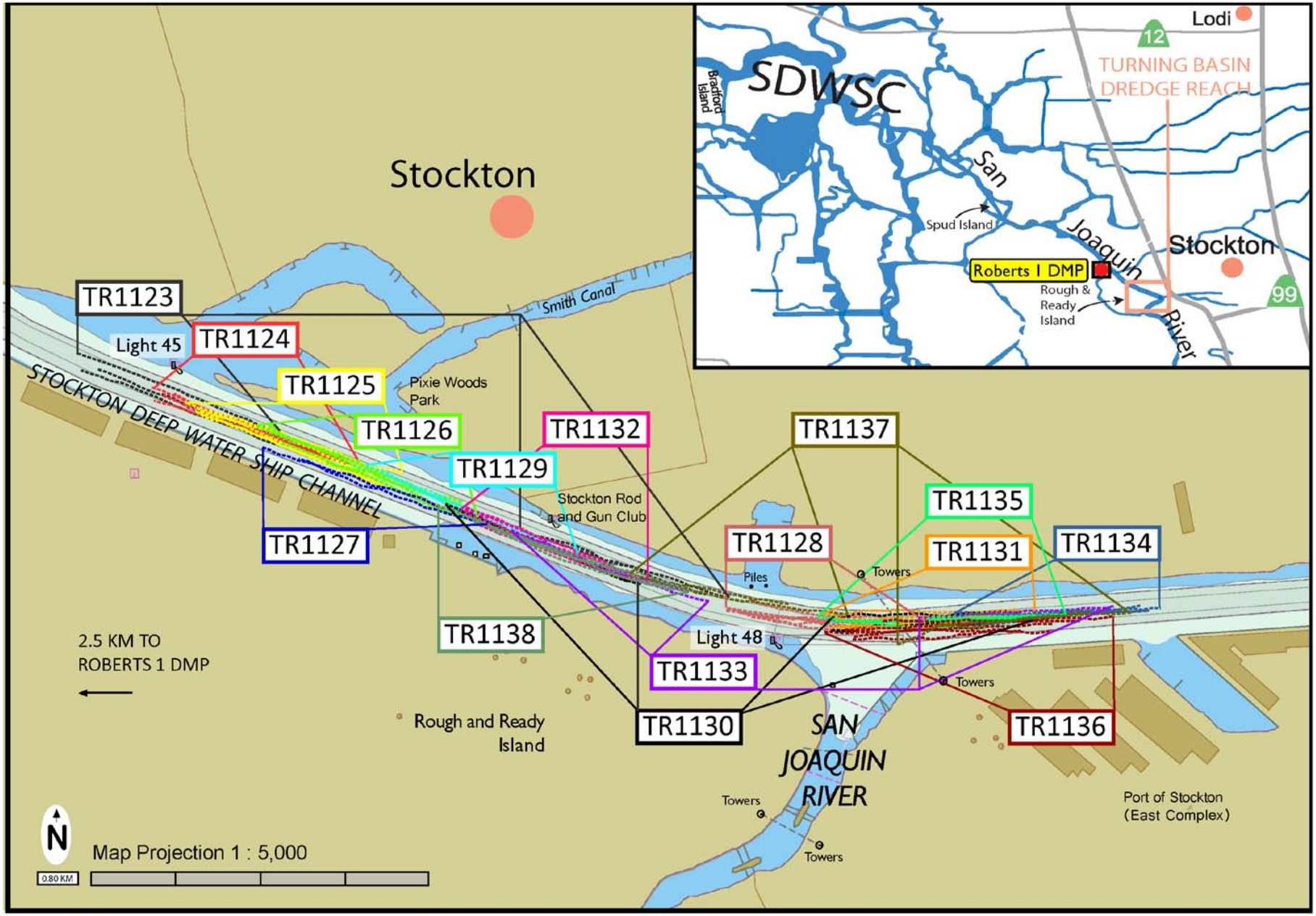


Figure 21. 2011 Fish Community Surveys at the Turning Basin DR and Roberts 1 DMP

4.4 Fish Length

4.4.1 Entrainment Monitoring

The majority of entrained fish were retained, examined, measured and returned to the river. Occasionally, fish were observed but not measured. There were a few reasons why individual entrained fish went unmeasured. There were fish that were visually identified to species but escaped collection over the end of the entrainment screen or through the screen mesh. These fish were documented in the entrainment results. Typically, they were individuals of the most common species (lamprey, gobies, and catfish), for which an abundance of length data has been collected. A few fish escaped on their way to the collection bucket and there were also a few partial (unmeasurable) fish showing signs of damage from the dredge. Figure 22 provides some images of fish encountered during 2010 and 2011 entrainment monitoring. The summary length statistics for all entrained fish that were measured is provided in Table 17. Overall, 58.89% of fish encountered during 2011 entrainment monitoring were measured prior to release or vouchering.

images of single adult Sacramento splittail possibly injured by dredge activity (2010)

juvenile white sturgeon (2011)

adult bigscale logperch (2011)

Figure 22. Examples of Fish Encountered During Entrainment Monitoring

Table 17. Summary Size Data for Fish Encountered in All 2011 Entrainment Monitoring

Common Name	Lifestage	Total Length Min (mm)	Total Length Max (mm)	SD of Mean	Mean Lgth (mm)	Total No. Measured	Total No. Fish	% Measured
Native								
delta smelt	Adult	84	84		84	1	1	100
delta smelt	Juvenile	53	57		55	2	2	100
lamprey, species undet.	Juvenile					0	7	0
Pacific staghorn sculpin	Adult	135	135		135	1	1	100
prickly sculpin	Adult	68	110	15.2	81	6	6	100
prickly sculpin	Juvenile	44	68	7.4	58	8	8	100
river lamprey	Juvenile	110	180	14.2	136	22	25	88.00
white sturgeon	Juvenile	270	270		270	1	1	100
Introduced								
American shad	Juvenile	34	80	22.5	59	5	5	100
bigscale logperch	Adult	93	93		93	1	1	100
brown bullhead	Adult	238	238		238	1	1	100
brown bullhead	Juvenile	85	187		136	2	3	66.67
channel catfish	Juvenile	57	330	81.9	125	10	12	83.33
common carp	Adult					0	1	0
shimofuri goby	Adult	47	85	11.0	61	27	56	48.21
shimofuri goby	Juvenile	20	46	13.4	33	37	127	29.13
Shokihaze goby	Juvenile	35	55	7.2	43	6	6	100
striped bass	Juvenile	57	96	11.0	75	27	28	96.43
threadfin shad	Juvenile	66	96	12.6	79	4	6	66.67
wakasagi	Adult	91	102	6.6	116	4	4	100
wakasagi	Juvenile	84	84			1	1	100
white catfish	Juvenile	35	191	45.6	107	31	32	96.88
yellowfin goby	Adult	137	173	15.0	131	6	7	85.71
yellowfin goby	Juvenile	36	44	5.7	40	2	2	100

4.4.2 Fish Community Monitoring

Table 18 lists the summary length statistics for all measured fish from 2011 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. Figure 23 provides some examples of fish encountered during 2011 fish community monitoring.

Table 18. Summary Size Data for Fish Encountered in All 2011 Fish Community Monitoring

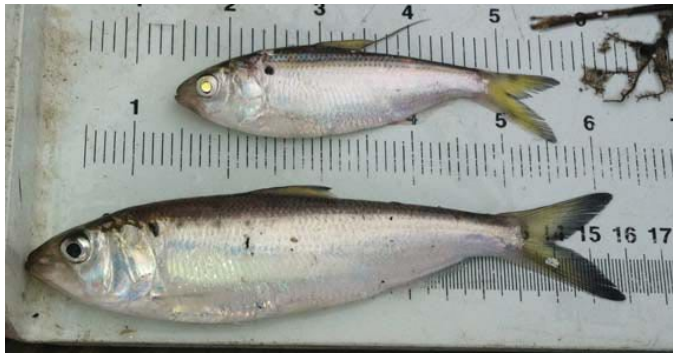
Common Name	Lifestage	Total Length Min (mm)	Total Length Max (mm)	SD of Mean	Mean Lgth (mm)	Total No. Measured	Total No. Fish	% Measured
Native								
Chinook salmon	Adult					0	1	0
delta smelt	Adult	83	94	4.8	90	5	5	100
delta smelt	Juvenile	54	54		54	1	1	100
Pacific staghorn sculpin	Adult	155	175		165	2	2	100
prickly sculpin	Adult	63	150		107	2	2	100
prickly sculpin	Juvenile	57	68		63	2	2	100
Sacramento pikeminnow	Adult	329	329		329	1	1	100
Sacramento splittail	Adult	252	276	10.7	267	5	5	100
Sacramento splittail	Juvenile	99	267	37.6	152	95	96	98.96
starry flounder	Juvenile	79	260	61.1	115	8	8	100
tule perch	Adult	166	174		170	2	2	100
tule perch	Juvenile	100	126	9.9	118	6	6	100
white sturgeon	Juvenile	182	360	46.2	282	19	19	100
Introduced								
American shad	Smolt	207	370	49.6	275	21	21	100
American shad	Juvenile	57	215	32.2	114	172	453	37.97
American shad	Adult	308	450	56.2	378	6	6	100
bigscale logperch	Adult	89	89		89	1	1	100
bluegill	Juvenile	41	117		79	2	2	100
bluegill	Adult	153	233	21.2	184	14	14	100
brown bullhead	Juvenile	169	169		169	1	1	100
brown bullhead	Adult	175	352	50.3	263	27	27	100
channel catfish	Juvenile	37	303	53.0	122	304	514	59.14
channel catfish	Adult	285	472	54.1	363	10	10	100
common carp	Juvenile	163	259	27.5	219	26	28	92.86
redear sunfish	Juvenile	130	208	5.1	136	4	4	100
redear sunfish	Adult	160	242	16.7	199	56	61	91.80
shimofuri goby	Juvenile	21	39	6.7	28	7	7	100
shimofuri goby	Adult	60	85	11.1	69	4	4	100
Shokihaze goby	Adult	92	92		92	1	1	100
striped bass	Juvenile	58	319	61.2	131	475	814	58.35
striped bass	Adult	323	520	49.7	389	47	47	100
threadfin shad	Juvenile	54	111	14.8	87	178	836	21.29
threadfin shad	Adult	111	189	24.5	135	71	195	36.41
wakasagi	Juvenile	67	84	6.6	78	9	9	100
wakasagi	Adult	85	102	5.7	93	21	21	100
warmouth	Adult	171	189	7.9	178	5	5	100
white catfish	Juvenile	33	235	59.0	129	192	1,328	14.46
white catfish	Adult	230	350	21.7	263	50	54	92.59
yellowfin goby	Adult	136	188	12.9	168	30	30	100

juvenile channel catfish

adult warmouth

juvenile Sacramento splittail

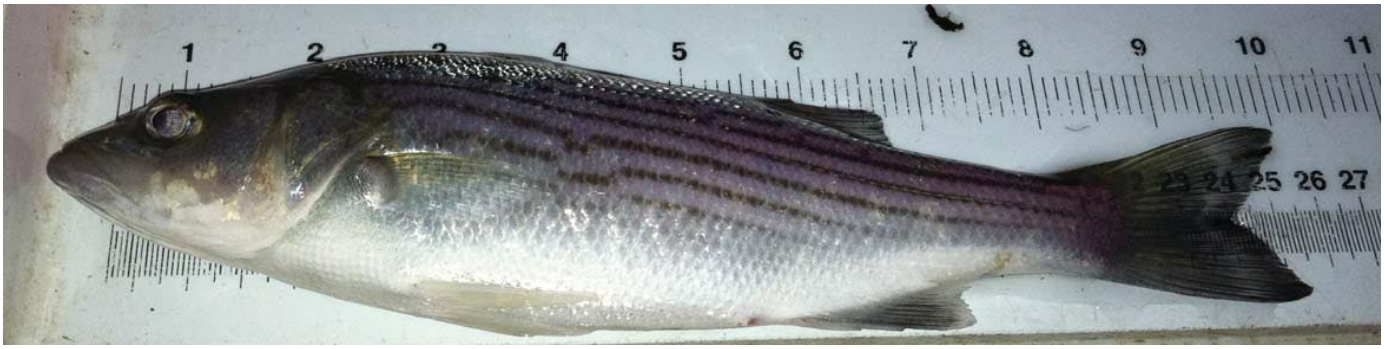
adult threadfin shad



juvenile American shad

Siberian prawn

juvenile starry flounder



juvenile striped bass

Figure 23. Examples of Fish Encountered During Fish Community Monitoring

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 308,172 invertebrates were encountered during entrainment monitoring in 2011 and 7,512 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 in both types of monitoring were Asian clams and Siberian prawns *(Exopalaeomon modestus)*, both introduced species. Large populations of these 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. Siberian prawns were less abundant than in previous years,

Two species of crayfish, Signal crayfish, *Pacifasticus leniusculus* and red swamp crayfish *Procambarus clarkii* (both introduced) were again encountered as they were in 2010 and 2009. All were located in the upper portion of the SDWSC at Spud Island and Windmill Cove dredge reaches.

The California floater *(Anodonta californiensis)*, a native freshwater mussel, was again encountered in the entrainment monitoring from Man-made Channel reaches in the SRDWSC, but more often from the upper reaches of the SDWSC. This mussel species is a federal species of concern. The presence of the native mussels in our monitoring appears to coincide with large numbers of leeches (in the SDWSC), lamprey ammocoetes, and fine, organic and detritus rich sediments.

In 2011, the introduced Asian overbite clam *(Corbula amurensis)* was found in the lowest SRDWSC reach, Rio Vista South, and the three most downstream dredge reaches in the SDWSC. These clams were previously encountered in the lower reaches of both shipping channels. The overbite clam comprised a far greater proportion of clams entrained in the Scour Pond reach than at other monitored dredge reaches where present. The lower ends of the Ship Channels are at the freshest limit of their salinity tolerance. Black Sea jellyfish *(Maeotias marginata)* were encountered only from fish community surveys in the Scour Pond dredge reach, the most saline location monitored to date by this program.

Other species of invertebrates such as mud crabs *(Rhithropanopeus harrisii)* and the Chinese mitten crab *(Eriocheir sinensis)* have been encountered in previous years, but were not encountered in 2010. Two introduced mud snails *(Cipangopaludina japonica)* were entrained in 2011 and three were encountered during fish community monitoring. These snails were observed in 2008 and 2009 as well in very low numbers. Shells of native but displaced bivalves such as the bay mussel *(Mytilus edulus)* and the native oyster *(Ostreola conchaphila)* are 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 2011 are listed in Table 19 and Table 20 by respective monitoring type.

Table 19. 2011 Ranked List of Invertebrates Encountered during Entrainment Monitoring

Rank	Percent	Number	Common Name	Genus	Species	Origin
1	96.49	297,350	clam, Asian green	*Corbicula*	*fluminea*	Introduced
2	1.94	5,972	Siberian prawn	*Exopalaemon*	*modestus*	Introduced
3	0.74	2,278	clam, overbite	*Corbula*	*amurensis*	Introduced
4	0.62	1,912	leech	Unknown	spp.	Introduced
5	0.18	564	California floater	*Anondonta*	*californiensis*	Native
6	0.03	92	dragonfly	Unknown	spp.	Native
7	0.00	2	signal crayfish	*Pacifasticus*	*leniusculus*	Introduced
8	0.00	2	mud snail	*Cipangopaludina*	*japonica*	Native
TOTAL		**308,172**				

Percent Native = 0.21 | Number Native Species = 3 | Introduced Species = 6

Table 20. 2011 Ranked List of Invertebrates Encountered during Fish Community Monitoring

Rank	Percent	Number	Common Name	Genus	Species	Origin
1	49.79	3,740	Siberian prawn	*Exopalaemon*	*modestus*	Introduced
2	49.63	3,728	clam, Asian green	*Corbicula*	*fluminea*	Introduced
3	0.25	19	signal crayfish	*Pacifasticus*	*leniusculus*	Introduced
4	0.19	14	California floater	*Anondonta*	*californiensis*	Native
5	0.09	7	red swamp crayfish	*Procambarus*	*clarkii*	Introduced
6	0.04	3	mud snail	*Cipangopaludina*	*japonica*	Native
7	0.01	1	jellyfish	all	spp.	Introduced
TOTAL		**7,512**				

Percent Native = 0.23 | Number Native Species = 2 | Introduced Species = 5

Total numbers of entrained invertebrates are 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 21. 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 clam was the dominant taxon at all DMP sites. Asian clams accounted for 96% of the predicted total of entrained invertebrates, higher than in previous years, apparently due to less abundant Siberian prawns.

Table 21. 2011 Extrapolated Invertebrate Entrainment Data for Location and Species

DR	*MMC 1*	*MMC 2*	*Sandy Beach*	*West Island*	*Scour Pond*	*Light 19*	*Light 21*	*Spud Island **	*Windmill Cove*	*Turning Basin*	
DMP	S-31A	S-31B	Sandy Beach	Scour Hole	Scour Hole	McCormack Pit	McCormack Pit	Roberts 2	Roberts 2	Roberts 1	**Extrapolated**
Monitored %	**8.02**	**6.5**	**12.58**	**9.19**	**6.34**	**8.28**	**8.6**	**19.26**	**11.94**	**7.7**	**Total of Inverts.**
clam, Asian	209,476	88,462	31,797	108,814	141,956	118,357	63,953	93,458	259,631	2,435,065	**3,550,969**
Siberian prawn	44,888	27,692	8	1,469	32	48	12	260	838	3,623	**78,869**
clam, overbite	0	0	0	24,483	237	36	116	0	0	0	**24,872**
leech	0	0	0	0	0	0	0	0	17	24,805	**24,822**
California floater	50	0	0	0	0	0	0	78	260	6,675	**7,063**
dragonfly	100	262	40	0	0	0	0	52	377	91	**921**
mud snail	0	0	0	0	0	24	0	0	0	0	**24**
signal crayfish	0	0	8	0	0	0	0	0	8	0	**16**
TOTAL	2,032	585	294	468	16	109	0	47	218	182	**3,950**

Note: Shaded rows indicate introduced species.

* Short duration of dredging operations (11 hours) at Spud Island DR (Roberts 2 DMP)

4.6 Bird and Marine Mammal Activity Observations

Observations of piscivorous birds were made at all 2011 trawl and DMP site locations during active monitoring periods. Piscivorous bird activity was not observed during entrainment and trawl surveys throughout the SRDWSC. It was also not observed in the SDWSC until reaching Light 21 reach in mid October with cooling water temperatures and co-occurring weather changes.

Piscivorous bird activity during fish monitoring, and the few sea lion observations, occurred only late in the season at the Turning Basin reach in the upper SDWSC at the Port of Stockton reach. Cormorants were again observed in the Stockton Turning Basin reach in November, primarily perched, with occasional observations of active feeding in the channel.

4.7 Comparison of Monitoring Method Results

Assessments of relationships between the species, habits, and relative abundance of the fish encountered in the community and entrainment monitoring are made where enough data exists to reasonably make such assessments. Making these comparisons helps answer questions about the suitability of the fish community monitoring methodology for testing the hypotheses about the subset of species most susceptible to entrainment.

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 2011, demersal species encountered during fish community monitoring varied by dredge location; from lows of 10.7% at the Light 21 reach and 13.9% at the Light 19 reach due to high numbers of (pelagic) striped bass, and 22.2% at the Turning Basin reach due to abundant threadfin shad; and up to 96.4% and 95.6% at Windmill Cove and Spud Island due to abundant white catfish. Table 22 provides abundance data for demersal fish encountered during 2011 entrainment and fish community monitoring.

Table 22. 2011 Percent Demersal Fishes by Location for Trawl and Entrainment Monitoring

Dredge Reach	DMP Location	% Demersal Fish in Entrainment	Extrapolated Entrained Total Fish	% Demersal Fish in Trawl	Mean Trawl CPUE (fish/100m)
MM Channel 1	S-31A	96.3	2,032	87.7	4
MM Channel 2	S-31B	89.5	585	46.9	2
Sandy Beach	Sandy Beach	100	294	42.9	2
West Island	Scour Hole	27.9	468	53.3	3
Scour Pond	Scour Hole	100	16	89.2	3
Light 19	McCormack Pit	100	109	13.9	6
Light 21	McCormack Pit	--	0	10.7	1
Spud Island *	Roberts 2	96.2	218	95.6	28
Windmill Cove	Roberts 2	66.7	47	96.4	12
Turning Basin	Roberts 1	83.3	182	22.2	8

* Short duration of dredging operations (11 hours) at Spud Island DR (Roberts 2 DMP)

The percentage of demersal fish at each location during entrainment and fish community monitoring is charted in Figure 24. In most instances the percentage of demersal fish encountered is higher during entrainment monitoring than it is during fish community monitoring. The abundance of demersal fishes encountered during entrainment monitoring was higher than during fish community monitoring at all locations in 2011 except for Spud Island (Figure 23). The high numbers of striped bass entrained there in 2011 make this the only location where this has occurred since 2008. During 2011 entrainment monitoring, there were 47 individual pelagic fish (13.7%) out of 343 total fish observed. Encountered fishes included as pelagic are: wakasagi, delta smelt, striped bass, Sacramento splittail, threadfin shad, American shad, and bluegill. All of these pelagic species utilize the channel bottom at times, as all have been encountered during fish community and entrainment monitoring.

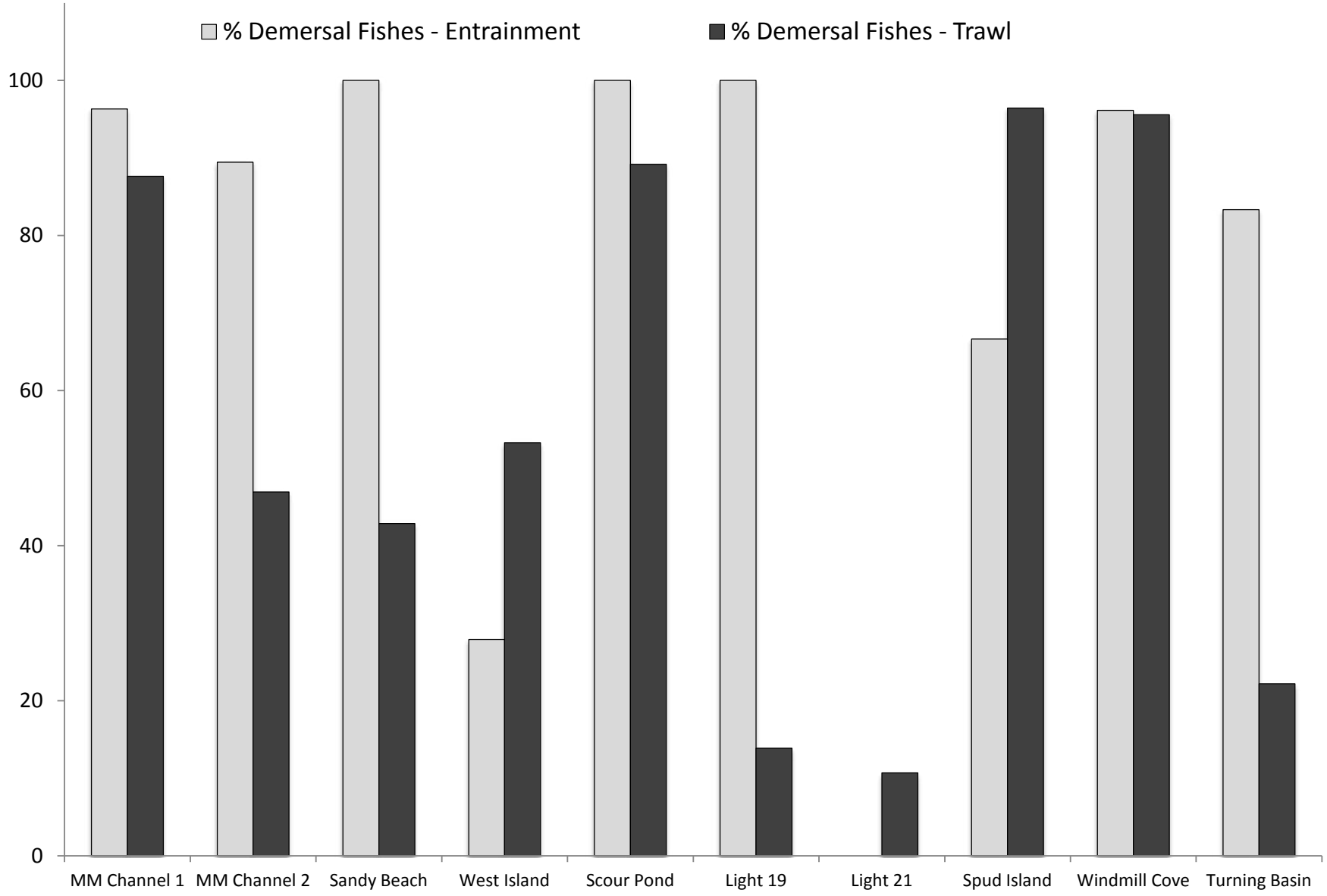


Figure 24. Percent Demersal Fishes in Catch by Survey Type

Presence during fish community monitoring predicates presence during entrainment monitoring with few exceptions, as might be expected. However, relative abundance of species during fish community monitoring does not directly correlate with relative abundance observed during entrainment monitoring. Since 2008, the only fish species encountered during entrainment monitoring but not while fish community monitoring is 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 this is most likely due to gear efficiency rather than absence in the fish community. Eight additional fish species were encountered during fish community monitoring but not during entrainment monitoring in 2011: Sacramento splittail, starry flounder, redear sunfish, warmouth, tule perch, bluegill, Chinook salmon and prickly sculpin. None of these fishes were commonly encountered. The combined total of these species comprised 4.4% of all fish encountered during fish community monitoring.

Shimofuri goby was the most commonly entrained fish species from 2009 through 2011, though it was not abundant during fish community monitoring. This may be a due to gear efficiency also, similar to river lamprey. Table 23 provides additional details about species encountered during both types of monitoring. Among the "pelagic" species encountered during entrainment monitoring, only wakasagi and delta smelt were proportionally more abundant than they were among the species encountered during fish community monitoring.

Table 23. 2011 Trawl and Entrainment Percentage for Fish Species Observed in Both Methods

Entrainment to Trawl Ratio	% Catch of Trawl	Trawl Count	% Catch of Entrainment	Entrainment Count	Common Name	Origin	Demersal or Pelagic
237.46	0.25	11	58.84	183	shimofuri goby	Introduced	Demersal
85.64	0.02	1	1.93	6	Shokihaze goby	Introduced	Demersal
49.96	0.09	4	4.50	14	prickly sculpin	Native	Demersal
14.27	0.02	1	0.32	1	bigscale logperch	Introduced	Demersal
7.14	0.05	2	0.32	1	Pacific staghorn sculpin	Native	Demersal
6.12	0.16	7	0.96	3	delta smelt	Native	Pelagic
4.28	0.68	30	2.89	9	yellowfin goby	Introduced	Demersal
2.38	0.68	30	1.61	5	wakasagi	Introduced	Pelagic
2.04	0.63	28	1.29	4	brown bullhead	Introduced	Demersal
0.75	0.43	19	0.32	1	white sturgeon	Native	Demersal
0.51	0.63	28	0.32	1	common carp *	Introduced	Demersal
0.46	19.40	861	9.00	28	striped bass	Introduced	Pelagic
0.33	31.13	1,382	10.29	32	white catfish *	Introduced	Demersal
0.33	11.80	524	3.86	12	channel catfish *	Introduced	Demersal
0.15	10.81	480	1.61	5	American shad	Introduced	Pelagic
0.08	23.25	1,032	1.93	6	threadfin shad *	Introduced	Pelagic

* One specimen from each of these total counts for entrainment was dead prior to encounter with dredge equipment.

Total length was measured for individual fish encountered during both entrainment and fish community monitoring. Figure 25 displays a bar chart comparison of the mean size of fishes encountered during both monitoring methods. The difference in mean size among species encountered by both monitoring allows assessment of correlations between the size of fish present around the dredge and the likelihood of entrainment. Length data for 2011 was partitioned by species and life stage, and then compared between methods only where two or more fish of each species were measured. This year, fourteen fish species were comparable between monitoring methods, with juveniles and adult length comparisons available for four of these. For the majority of the species and life stages, it appears that the dredge entrains slightly smaller individuals than does the trawl used to monitor the fish community.

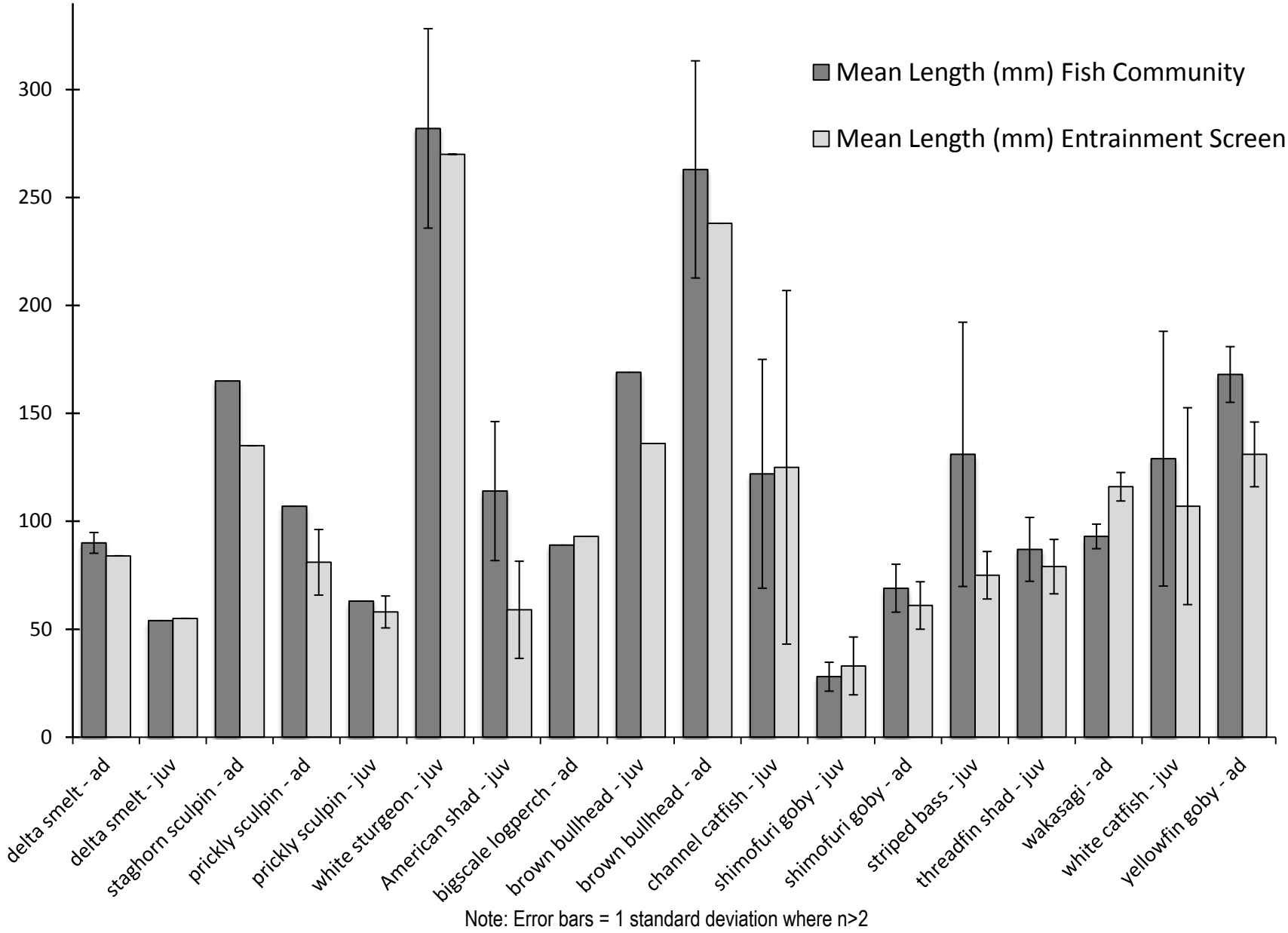


Figure 25. Mean Size of Fish Species Encountered by Survey Type

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 was 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 are presented in Appendix B. The water quality data discussed below are near bottom measurements.

Readings of bottom water temperature exceeded 20°C in all SRDWSC and lower SDWSC monitoring locations until reaching the Light 21 reach October 3. The maximum water temperature recorded for 2011 was 23.9°C in the Man-made Channel 1 reach of the SRDWSC on August 23 and the minimum temperature was 11.6°C in the Upper Turning Basin of the SDWSC, November 29. Salinity was predominantly low, not exceeding 0.4 psu throughout all locations. The highest turbidity readings (generally above 100 ntu) were recorded in the Man-made Channel reaches (range 86-155), similar to previous years. Turbidity readings below 50 ntu predominated all other reaches, though a few cases of elevated bottom turbidity readings were recorded in the SDWSC Turning Basin reach in early November.

4.9 Level of Take

An objective of this monitoring program is to improve take estimates for ship channel maintenance dredging operations in the Delta. Original take estimates found in the 2006 FMP (Table 24) were based on the estimates developed for SDWSC and SRDWSC maintenance dredging through consultation between USACE and NMFS (NMFS 2006a, b). The original estimates assumed exposure of listed fish to monitoring gear would be less than 25% of potential exposure to dredging activities and associated shipping. This was likely an overestimate. No salmon or steelhead (alive), and only 4 green sturgeon, have been encountered since monitoring began in 2006.

Estimates for take of delta smelt were not included in the original take estimates, 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), the federal consulting agency for delta smelt. Nor were they established during previous informal consultations with the USFWS. 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), allowing monitoring take of up to ten delta smelt per week during normal dredging operational windows. Six delta smelt were encountered while fish community monitoring in 2011.

Incidental and lethal take for longfin smelt during fish community monitoring was authorized under 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 2011 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 2011.

Table 24. ESA and CESA Incidental Take Allotments for Ship Channel Fish Monitoring

Potential Annual Incidental Take of NMFS Listed Fish for the SSC 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 SRSC 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 SRSC and SSC 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 SRSC and SSC Fish Monitoring Program (updated annually)				
Species	**Juveniles**		**Adults**	
	non-lethal	**lethal**	**non-lethal**	**lethal**
longfin smelt	150		150	

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 also 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 river channel.

Table 25 provides mortality data for fish encountered during entrainment monitoring. Lampreys experienced some mortality during entrainment monitoring. Seven lamprey escaped through the entrainment screen mesh and were counted as mortalities as were all entrained fish not released alive. These fish and the vouchered fish were used to estimate total entrainment. However, the vouchered specimens were excluded from the mortality assessment.

Table 25. 2011 Total Fish Mortality for Entrainment Monitoring

Common Name	Total Mortalities	Total Encountered *	% of Entrainment Mortality	% Mortality for Species	Origin
American shad	5	5	4.72	100	Introduced
bigscale logperch	1	1	0.94	100	Introduced
brown bullhead	1	4	0.94	25.00	Introduced
channel catfish	3	12	2.83	25.00	Introduced
lamprey, species undet.	7	7	6.60	100	Native
river lamprey	1	25	0.94	4.00	Native
shimofuri goby	63	183	59.43	34.43	Introduced
Shokihaze goby	1	6	0.94	16.67	Introduced
striped bass	10	28	9.43	35.71	Introduced
threadfin shad	4	6	3.77	66.67	Introduced
wakasagi	5	5	1.89	100	Introduced
white catfish	2	32	1.89	6.25	Introduced
yellowfin goby	6	9	5.66	66.67	Introduced
TOTAL	**106**	**323**			

* Total numbers include 1 brown bullhead and 1 threadfin shad whose capture disposition could not be determined - thus, assumed alive; and exclude 1 white catfish, 1 channel catfish, 1 threadfin shad, and 1 common carp that were dead prior to encounter.

Table 26 provides mortality data from the fish community monitoring. A total of 884 individuals, or 19.82% of the individual fish encountered, were recorded as mortalities during fish community monitoring. Threadfin shad comprised 70.81% of these mortalities. American shad and striped bass also had relatively high mortality rates. All wakasagi and delta smelt were collected as required by CDFG, and thus not included in the mortality estimations. Wakasagi and delta smelt are relatively fragile fish, as are all smelts, and the mortality rate might reach at least 50% if it were to be determined.

Table 26. 2011 Total Fish Mortality for Fish Community Monitoring

Common Name	Total Mortalities	Total Encountered *	% of Trawl Mortality	% Mortality for Species	Origin
American shad	121	480	13.69	25.21	Introduced
bluegill	1	16	0.11	6.25	Introduced
channel catfish	22	524	2.49	4.20	Introduced
delta smelt **	6	6	0.68	100	Native
Sacramento splittail	5	101	0.57	4.95	Native
striped bass	64	861	7.24	7.43	Introduced
threadfin shad	626	1,032	70.81	60.66	Introduced
wakasagi **	30	30	3.39	100	Introduced
white catfish	8	138	0.90	0.58	Introduced
yellowfin goby	1	30	0.11	3.33	Introduced
TOTAL	**884**	**4,462**			

* Total excludes those fish that were dead prior to encounter with trawl monitoring gear.

** Mortality 100% for all native delta smelt (n = 6) and introduced wakasagi (n = 30) as handling and process of proper identification to species typically results in death of the individual.

4.11 Vouchered Specimens

Overall, only nine fish were vouchered in 2011: all delta smelt that were encountered. The details are provided in Table 27. Delta smelt are fragile fish and cannot be distinguished from wakasagi or hybrids without the fish expiring in the process. Once a fish has been examined and determined to be a delta smelt, it is preserved. However, vouchered delta smelt are no longer provided to CDFG as the permit requirement to do so was rescinded in 2011.

Table 27. 2011 Vouchered Specimens Collected during Fish Monitoring

Species	Number Vouchered	River	Method of Collection	Reason	Repository Location	Origin
delta smelt	6	SRSC	Trawl	further studies; ref. collection	DFG - Stockton	Native
delta smelt	3	SRSC	Entrainment	further studies; ref. collection	DFG - Stockton	Native
TOTAL	**9**					

4.12 Combined Data for All Years

Tables 28 and 29 present combined fish entrainment and community monitoring data for all years (2006-2011) 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 species and by number of individuals.

Table 28. Combined Total Fish Encountered for All Entrainment Events 2006-2011

Rank	Percent	Number	Common Name	Origin	Demersal or Pelagic
1	50.60	880	shimofuri goby	Introduced	Demersal
2	15.47	269	channel catfish	Introduced	Demersal
3	13.63	237	lamprey species *	Native	Demersal
4	3.74	65	striped bass	Introduced	Pelagic
5	2.99	52	yellowfin goby	Introduced	Demersal
6	2.42	42	Shokihaze goby	Introduced	Demersal
7	2.36	41	river lamprey	Native	Demersal
8	1.90	33	white catfish	Introduced	Demersal
9	1.73	30	prickly sculpin	Native	Demersal
10	1.55	27	wakasagi	Introduced	Pelagic
11	0.86	15	brown bullhead	Introduced	Demersal
12	0.81	14	threadfin shad	Introduced	Pelagic
13	0.75	13	American shad	Introduced	Pelagic
14	0.35	6	delta smelt	Native	Pelagic
15	0.23	4	Pacific staghorn sculpin	Native	Demersal
16	0.17	3	bluegill	Introduced	Pelagic
17	0.12	2	warmouth	Introduced	Pelagic
17	0.12	2	bigscale logperch	Introduced	Demersal
17	0.12	2	common carp	Introduced	Demersal
17	0.12	2	white sturgeon	Native	Demersal
18	0.06	1	Sacramento splittail	Native	Pelagic
TOTAL		**1,740**			

Percent Demersal = 91.96 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.

The proportion of demersal to pelagic species was higher both in species and in numbers of individuals in the entrainment monitoring than it was in the fish community monitoring. Largely due to the presence of lamprey, individuals of native species are more commonly entrained than they are encountered in the fish community around the dredge. Except for delta smelt, all native species observed during entrainment monitoring were demersal, while 54% of the native species encountered during fish community monitoring were pelagic.

Table 29. Combined Total Fish Encountered for All Trawl Events 2006-2011

Rank	Percent	Number	Common Name	Origin	Demersal or Pelagic
1	49.66	20,371	white catfish	Introduced	Demersal
2	20.79	8,527	threadfin shad	Introduced	Pelagic
3	10.63	4,361	striped bass	Introduced	Pelagic
4	7.34	3,013	American shad	Introduced	Pelagic
5	5.35	2,193	channel catfish	Introduced	Demersal
6	2.24	918	longfin smelt	Native	Pelagic
7	0.73	300	wakasagi	Introduced	Pelagic
8	0.49	200	yellowfin goby	Introduced	Demersal
9	0.38	154	shimofuri goby	Introduced	Demersal
10	0.35	143	Sacramento splittail	Native	Pelagic
11	0.31	127	white sturgeon	Native	Demersal
12	0.27	110	redear sunfish	Introduced	Pelagic
13	0.26	107	starry flounder	Native	Demersal
14	0.24	99	Shokihaze goby	Introduced	Demersal
15	0.19	79	tule perch	Native	Pelagic
16	0.14	56	bluegill	Introduced	Pelagic
17	0.10	43	brown bullhead	Introduced	Demersal
17	0.10	43	common carp	Introduced	Demersal
17	0.10	42	delta smelt	Native	Pelagic
18	0.08	34	prickly sculpin	Native	Demersal
19	0.06	24	warmouth	Introduced	Pelagic
20	0.04	15	blue catfish	Introduced	Demersal
21	0.03	13	lamprey species *	Native	Demersal
22	0.02	10	Sacramento blackfish	Native	Pelagic
23	0.02	7	black crappie	Introduced	Pelagic
23	0.02	7	bigscale logperch	Introduced	Demersal
23	0.02	7	Pacific staghorn sculpin	Native	Demersal
24	0.01	5	unidentified goby **	Introduced	Demersal
25	0.01	4	green sturgeon	Native	Demersal
26	0.01	3	Sacramento pikeminnow	Native	Pelagic
26	0.01	3	white crappie	Introduced	Pelagic
27	0.00	1	golden shiner	Introduced	Pelagic
27	0.00	1	Chinook salmon ***	Native	Pelagic
27	0.00	1	largemouth bass	Introduced	Pelagic
27	0.00	1	Mississippi silverside	Introduced	Pelagic
Total		**41,022**			
	Percent Demersal = 58.57		Native Species = 13		Introduced Species = 21

* 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.

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

*** Chinook salmon was the only fish species not encountered before 2011; fish was dead prior to encounter with sampling gear.

Table 30. Special Status Fish Species Encountered by Location Through All Years of Study

Year	DR Location	DMP Site	Rank	No.	Percent	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	6	1	2.08	longfin smelt
2007	Decker Island	Decker Island	5	1	0.53	longfin smelt
2007	Antioch Br - West Island	Scour	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	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	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	MM Channel 1	S-31	7	2	0.55	delta smelt
2010	MM Channel 2	S-31	8	4	1.09	delta smelt
2010	MM Channel 2	S-31	5	6	2.64	delta smelt *
2010	MM Channel 2	S-31	11	1	0.12	white sturgeon
2010	Turning Basin	Roberts I	11	1	0.03	white sturgeon
2011	MM Channel 1	S-31A	6	2	1.30	delta smelt
2011	MM Channel 1	S-31A	4	2	1.23	delta smelt *
2011	MM Channel 2	S-31C	3	4	8.16	delta smelt
2011	MM Channel 2	S-31C	4	1	2.63	delta smelt *
2011	MM 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	5	7	3.85	white sturgeon
2011	West Island	Scour	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.
* Encountered during entrainment monitoring; prior to 2010, only encountered during trawl monitoring.

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 CDFG Species of Special Concern. White sturgeon encounter data are included here as surrogate data due to lack of green sturgeon data.

Encounters with special status species are further described in Table 30, 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 in the SRDWSC. This occurred first in 2010 when six delta smelt were entrained. The single white sturgeon entrained in 2011 is significant, as it was the first documented occurrence of sturgeon entrainment while monitoring in the Delta. Additionally, NMFS has routinely used white sturgeon data as surrogate data for green sturgeon, when no green sturgeon data is available.

California Delta fish species are well documented by Turner and Kelly (1966), McGinnis (1984), Moyle (2002) and others. 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 continuing to impact monitoring programs is the assessment of efficacy of methods in answering the research questions for the monitoring mandates. To that end, the authors have spent considerable effort describing here the fish species encountered in community and entrainment monitoring. An alternate 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 31 provides these details for all species not encountered during the lifetime of this project. Five species emerge from this assessment:

- Until 2011, steelhead and Chinook salmon had not yet been encountered by this study. Although they are not extirpated from the monitoring locations, these fish are very rare and 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 informs us more about the continued presence of this species when and where dredging occurs, and the feeding habits of sea lions, then it does about dredging impacts.
- 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 these fish and misidentified them as brown bullhead.

Table 31. Delta Fishes Not Encountered in Trawl or Entrainment Surveys During Study Lifetime

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 *Carassius 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

All other species known to occur in the Delta are rare and/or unlikely to utilize the channel bottom habitat, thus decreasing the likelihood of encountering them during fish community or entrainment monitoring. The only additional species encountered during 2011 was the dead Chinook observed during fish community monitoring.

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 2011, H^1 again proved to be partially correct. Fish species were entrained, including ESA listed delta smelt. A white sturgeon was also encountered for the first time while entrainment monitoring.

When the 2011 entrainment data is extrapolated, based on the percentage of total dredge output monitored, the total number of fish entrained from this project across all sites was approximately 3,950. In 2010, the estimation was 7,828 fish, and in 2009, estimated take was 7,500 fish. Priors years estimated annual take are not included due to the lower entrainment monitoring effort from those years 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.

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 has demonstrated that listed fish species 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 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 amount of dredge material monitored increases the accuracy 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 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 of non-special status species. NMFS predicted that take of green sturgeon would be higher than listed salmonids based partly on the differential (demersal vs. non-demersal or pelagic) habits of these fish. 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 2011 and December 2011 (Bennett and Burau, submitted), indicated that delta smelt presence in the navigation channel varies substantially with the tide. Delta smelt appear to migrate into the shallow areas to 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.

With the exception of lampreys, which are underrepresented by the fish community monitoring, entrained fish continue to represent a subset of the fish encountered during fish community monitoring, though 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 sixteen species of fish that were encountered during both entrainment and community monitoring in 2011, 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. They are, listed in order of the strength of the correlation, Shimofuri goby, shokihaze goby, prickly sculpin, delta smelt, big scale log perch and pacific staghorn sculpin. The gobies may be underrepresented by the fish community method as their small size may allow them to swim through the trawl net meshes. Big scale log perch and pacific staghorn sculpin were encountered in very low numbers, confounding this analysis. However, for prickly sculpin and delta smelt, this relationship is more robust, indicating that these species may be more susceptible to entrainment than the other species that utilize the channel bottom.

Longfin smelt were frequently encountered during 2006 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.

River lamprey and unidentified lamprey assumed to be river lamprey were again observed during entrainment monitoring but not during fish community monitoring. Most of the lampreys 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 one specimen was encountered in 2007 using the same-sized trawl net. 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.

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 0.32% of the total fish encountered during community monitoring; 131 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. This makes them difficult to differentiate from similar sized channel catfish. Their identification may therefore be erroneous in some or all cases when they have been documented during community monitoring. Regardless of this, only 15 blue catfish individuals have been documented during 2006-2011 fish community monitoring, meaning that their extreme rarity may explain why they have not been encountered during entrainment monitoring. 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, explaining why they have not been encountered during entrainment monitoring.

A higher percent of encountered fish were measured in 2010 and 2011 relative to previous years. The robust fish length data from 2011 has allowed comparison between more fish species, and within species, between adult and juvenile life stages. Differences in the 2011 overall mean total length of fishes (Figure 24) 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 this year demonstrates 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. 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 also hamper 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 Efficiency of Monitoring Design

The magnitude of percentage increase in the total volume of dredged material monitored in 2011 relative to prior years may be attributed to continued refinement of the device and 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 since, the dredge pumping rate remains unaltered while the output is 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.

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 2011, 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 event accordingly. During incidences of overwhelming, the dredge material was diverted and monitoring discontinued until the screen could be cleared and sampling 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 2011. 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 sampled fish.

5.3 Overview

The fish species encountered during all project 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 are rarely 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 native species have so far observed during 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 come to light 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 has been the sixth most common entrained fish encountered during entrainment monitoring, and the 9th most common fish encountered during 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 were also less common in 2010. 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.
- 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 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, while in 2008, 21 longfin smelt were encountered, all from the SRDWSC in late August and early September. The 2009 (CDFG) Summer Tow Net Survey (CDFG 2009b) documented presence of longfin smelt primarily from lower SF Bay sites between June and mid-August, and up to the lower end of Sherman Island during the last week in July. The Bay Study (CDFG 2009c) 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. The mid-water trawl survey of the 2008 Bay Study found areas of higher longfin smelt abundance occurred at, or downstream of, Chipps Island in October and November, with presence at Decker Island in October. Fish community monitoring during 2008 found longfin smelt distributed downstream of Sherman Lake until November with presence near Decker Island in December.

- No longfin smelt were encountered in 2009, 2010 or 2011. The Bay Study data showed that longfin smelt were present downstream of dredging locations during the 2009 season. Some longfin smelt did move into the western Delta area that corresponds with some dredging locations in both channels in January of 2010, but had moved downstream again in February. No longfin smelt were found in the delta during the 2011dredging season. The IEP 20mm Survey designed to document distribution and relative abundance of delta smelt added four new monitoring stations in the SRDWSC in 2011. Longfin smelt were found at these new stations, including near the Port of West Sacramento. This recent data indicates that presence of longfin smelt in the SRDWSC is a distinct possibility during future maintenance dredging operations. This data set is available at: http://www.dfg.ca.gov/delta/projects.asp?ProjectID=BAYSTUDY.
- High abundance of longfin smelt in 2006 did not coincide with documented entrainment. However, less than 1% of the dredge output was monitored in 2006. Since increasing the amount of the dredge output monitored in 2008, High abundance of longfin smelt has not co-occurred with the timing and locations of Delta maintenance dredging, based both on lack of their presence in the fish community, and on results of IEP status and trends surveys.
- In 2007 the PODS progress report (IEP 2008) described the highest (worst) bloom on record of the algae *(Microcystis aeruginosa)* centered near Antioch. Significant efforts from the fish monitoring for maintenance dredging also took place in this region during fall 2007, and the CPUE numbers were at least an order of magnitude lower than previously measured by this study at any other location. The 2008 CPUE number at the Antioch dredge reach was higher than that of 2007 and similar to other lower river sites monitored this year. In 2009, very little monitoring was conducted in these locations. However, CPUE numbers here were again lowest among all sites. In 2010, CPUE numbers were again low in these locations as they were in 2011.
- No delta smelt were encountered in 2006, or 2009. In 2010, 7 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 3 were encountered during entrainment monitoring. All were encountered at S-31 in the man-made portion of the SRDWSC in mid to late August. 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 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. 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. However, documented presence in the lower river miles of both channels and areas of the Man-made Channel indicates potential for their continued presence 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 not specifically designed for them, and that future presence of smelt species during maintenance dredging, should it occur, is likely to result in entrainment.
- The single encounter with a Chinook salmon during 2011 fish community monitoring is not surprising given their very low populations, and the timing and location of 2006-2011maintenance dredging apparently avoiding that of migrating salmon.

5.4 Bird and Marine Mammal Activity Monitoring

Piscivorous bird presence around the dredge area is indicative of an abundance of fish in the area. Fish or invertebrates entrained by the dredge may also attract birds to the DMP sites. Sea lion presence has also been documented, 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 if feeding behavior can be observed.

Piscivorous bird activity was not observed during entrainment and trawl surveys throughout the SRDWSC. The few sea lion observations, and active piscivory by birds were only observed in the Turning Basin reach in the upper SDWSC navigation channel. Bird activity at a DMP site can be an indicator of organisms entrained by the dredge. However, it can be an attraction response to sources of flowing water, or, as was occasionally observed (2008, 2009, and 2011) predation of birds on newly displaced terrestrial prey. Bird activity in 2011 appeared to coincide with the change toward cooling weather and water in mid October. Cormorant observations were again concentrated in the Stockton Turning Basin reach in November. The Turning Basin reach has had consistently high fish CPUE over all years of monitoring, and migrating fishes following seasonal cues may draw sea lions upriver for forage as winter and cooler temperatures approach.

5.5 Adaptive Management Strategies and Recommendations for Future Monitoring Efforts

NMFS requires that adaptive management strategies be employed and discussed as part 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 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 that were deemed minimal versus vastly improved ease in material clearance off the screen.

Additional modifications utilized in 2010

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 and 2012

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 apparently 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 valve currently in use does work, a biologist must 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 clogs 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.

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 rest 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 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 dredge entrainment screen device 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 may request that all lamprey 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 amount of assessed dredge slurry has increased yearly since the inception of monitoring. Increase in assessed volume has been accomplished without an increase in the level of effort or cost. Use of the entrainment screen at all sites starting in 2009 provided an order of magnitude increase over previous years. These incremental yearly increases are due to relatively small changes in the operation of the screen. It is anticipated that use of a new Y-valve in 2012 will result in further increased assessment. This and other future improvements will continue to provide important gains in the power of the entrainment monitoring to predict the total number and species of entrained organisms, while maintaining the currently funded level of effort.

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 will be 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 will improve the ability to avoid submerged objects that might snag the net, improve knowledge fish in the dredge reaches, and the new radar will improve vessel safety and navigation abilities.

5.6 Conclusions

Key conclusions of the 2011 monitoring program are:

- 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 Delta continues to be dominated by non-native fish; fish community and entrainment monitoring data continues to exhibit significant inter-annual variation.
- Entrainment monitoring efficiency and quantitative capability were 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.
- Lamprey species are particularly susceptible to dredge entrainment and should be a focus of management agency attention due to their sensitive status. Though not currently listed, likelihood of future listing is high.
- Delta smelt and wakasagi encountered during entrainment and fish community monitoring indicates that longfin and delta smelt would 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.

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Appendix A. Special Status Species Life History Information

Appendix A. Special Status Species Life History Information

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). Given the number of listed and other species that utilize the project area, listing status changes could affect future maintenance dredging and monitoring.

The recent changes that affected the 2011 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 in 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, 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 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 SRSC 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, 2009 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; 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; 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; 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; 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; 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 they 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 2010, 2009, 2007, 2000; 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. 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; 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. The Fall Mid-water Trawl Survey (IEP) caught zero splittail in 2010 and only two individuals in the prior four years. Reclamation and modification of flood basins also have reduced the species' spawning grounds.

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Appendix B. Water Quality Data

Bottom Water Quality Readings

Survey ID	Dredge Reach	Date (m/d/year)	Time (hh:mm)	Depth (ft)	Temp (°C)	DO (ppm)	DO (%)	pH	Bot_Cond	Cond (uS)	Turb (ntu)
WQ0001	Man-made Channel 1	8/19/2011	16:27	30	22.91	7.62	90.9	8.29	861	0.4	124
WQ0002	Man-made Channel 1	8/21/2011	11:11	-30	21.86	7.81	91.5	8.18	787	0.4	136
WQ0003	Man-made Channel 1	8/23/2011	15:11	-28	22.33	6.81	80.5	8.02	798	0.4	122
WQ0004	Man-made Channel 1	8/23/2011	17:43	-31	22.24	7.86	92.7	8.21	819	0.4	120
WQ0005	Man-made Channel 3	8/25/2011	17:09	-30	22.42	8.04	95.1	7.88	530	0.3	107
WQ0006	Man-made Channel 3	8/27/2011	17:20	-32	22.64	7.48	88.8	7.83	481	0.2	155
WQ1107	Man-made Channel 3	8/29/2011	17:12	-30	22.8	8.21	97.7	7.77	401	0.2	137
WQ1108	Sandy Beach	9/2/2011	10:56	26	21.7	8.2	95.6	7.02	149	0.1	24.8
WQ1109	Sandy Beach	9/2/2011	13:05	-30	21.72	8.22	95.9	7.33	149	0.1	30.9
WQ1110	West Island	9/11/2011	16:32	-30	20.92	8.87	102.1	7.63	676	0.3	46.9
WQ1111	West Island	9/11/2011	18:34	-30	20.91	8.83	101.7	7.53	599	0.3	49.6
WQ1112	West Island	9/13/2011	15:17	-30	21.06	8.81	101.6	7.48	505	0.2	51.4
WQ1113	West Island	9/13/2011	19:14	-35	21.07	8.43	97.3	7.68	521	0.3	36.1
WQ1114	West Island	9/15/2011	17:37	-28	21.06	9.08	104.7	7.72	448	0.2	33.8
WQ1115	West Island	9/15/2011	20:17	-28	20.91	9.11	104.9	7.42	377	0.2	32.2
WQ1116	Scour Pond	9/17/2011	16:52	-32	21.39	8.68	100.8	7.54	297	0.1	19.3
WQ1117	Scour Pond	9/17/2011	19:39	-30	21.02	8.42	97	7.57	384	0.2	22.5
WQ1118	Light 19	9/21/2011	20:02	-30	22.53			7.64	222	0.1	12.2
WQ1119	Light 19	9/23/2011	16:59	-30	22.53	8.67	102.6	7.42	248	0.1	9.3
WQ1120	Light 19	9/23/2011	18:49	-35	22.44	9.03	106.7	7.37	206	0.1	10.9
WQ1121	Light 19	9/28/2011	13:28	-34	21.39	8.49	98.5	7.14	178	0.1	5.8
WQ1122	Light 19	9/28/2011	15:59	-30	21.69			7.32	237	0.1	12.9
WQ1123	Light 19	9/29/2011	14:37	-30	21.69	8.84	103.1	7.25	197	0.1	7.4
WQ1124	Light 19	9/29/2011	16:38	-30	22	8.95	105	7.61	266	0.1	11.4
WQ1125	Light 19	9/30/2011	11:58	-30	21.27	8.14	94.2	7.47	213	0.1	13.1
WQ1126	Light 19	10/2/2011	10:47	-30	20.64	7.93	90.8	7.51	249	0.1	9.5
WQ1127	Light 19	10/2/2011	13:04	-32	20.68	8.11	92.9	7.2	240	0.1	11.1
WQ1128	Light 21	10/4/2011	12:39	-33	19.98	8.08	91.3	7.37	233	0.1	14
WQ1129	Light 21	10/4/2011	14:31	-33	20.06	7.66	86.7	7.53	245	0.1	8.8
WQ1130	Light 21	10/6/2011	15:45	-33	18.88	7.23	84.6	7.23	240	0.1	8.8
WQ1131	Spud Island	10/16/2011	16:30	-30	18.08	7.46	81.4	6.7	235	0.1	26.4
WQ1132	Windmill Cove	10/19/2011	12:59	-29	18.21	8.34	91.2	6.51	229	0.1	18.3
WQ1133	Windmill Cove	10/19/2011	15:58	-33	18.04	8.83	96.2	6.63	229	0.1	12.3

Bottom Water Quality Readings

Survey ID	Dredge Reach	Date (m/d/year)	Time (hh:mm)	Depth (ft)	Temp (°C)	DO (ppm)	DO (%)	pH	Bot_Cond	Cond (uS)	Turb (ntu)
WQ1134	Windmill Cove	10/21/2011	14:53	-30	18.2	8	87.5	6.74	229	0.1	12.7
WQ1135	Windmill Cove	10/21/2011	16:57	-30	18.09	7.84	85	6.74	285	0.1	12.7
WQ1136	Sediment Trap	10/25/2011	17:22	-30	17.33	7.81	84	6.96	308	0.1	35
WQ1137	Sediment Trap	10/25/2011	19:53	-30	16.96	8.33	88.9	6.98	294	0.1	26.2
WQ1138	Sediment Trap	10/27/2011	15:37	-32	15.89	8.83	92.2	7.03	290	0.1	39.6
WQ1139	Sediment Trap	10/27/2011	18:05	-32	16.06	8.57	89.8	6.83	281	0.1	69.2
WQ1140	Sediment Trap	10/29/2011	15:22	-32	15.3	8.87	91.5	7.21	634	0.3	40.6
WQ1141	Sediment Trap	10/29/2011	17:49	-35	15.1	9.61	98.8	6.99	484	0.2	47.9
WQ1142	Sediment Trap	10/31/2011	10:05	-35	15.06	8.6	88.3	7.09	300	0.1	133
WQ1143	Sediment Trap	10/31/2011	12:10	-36	15.09	8.73	89.7	7.02	300	0.1	155
WQ1144	Sediment Trap	11/1/2011	10:53	-32	15.03	9.18	94.1	7.01	283	0.1	56.9
WQ1145	Sediment Trap	11/3/2011	15:29	-32	14.18	9.1	91.6	7.17	292	0.1	93.9
WQ1146	Sediment Trap	11/3/2011	17:52	-35	14.21	9.14	92.2	7.07	294	0.1	31.3
WQ1147	Sediment Trap	11/5/2011	10:00	-30	13.1	9.37	92.2	7.22	323	0.2	38.8
WQ1148	Sediment Trap	11/5/2011	12:45	-35	13.29	9.32	92	7.08	317	0.2	50.1
WQ1149	Sediment Trap	11/11/2011	10:20	30	12.75	9.48	92.6	7.61	548	0.3	92.6
WQ1150	Sediment Trap	11/11/2011	12:47	-36	12.79	9.69	94.8	7.24	546	0.3	76
WQ1151	Sediment Trap	11/13/2011	18:29	-36	12.85	9.37	91.8	7.41	627	0.3	9.2
WQ1152	Sediment Trap	11/13/2011	20:40	-34	12.8	9.77	95.5	7.24	634	0.3	25.4
WQ1153	Sediment Trap	11/15/2011		-35	12.98	9.22	90.6	7.47	671	0.3	9.9
WQ1154	Sediment Trap	11/15/2011	17:40	-38	12.86	8.69	85.1	7.43	689	0.3	85.3
WQ1157	Sediment Trap	11/17/2011	14:55	-33	13.33	9.47	93.7	7.57	605	0.3	5.1
WQ1158	Sediment Trap	11/17/2011	18:21	-35	13.29	10.09	99.8	7.51	607	0.3	26
WQ1159	Sediment Trap	11/19/2011	15:20	-36	13.25	9.46	93.4	7.59	613	0.3	79.6
WQ1160	Sediment Trap	11/21/2011	15:59	-37	12.67	9.57	9.57	7.77	610	0.3	23.7
WQ1161	Sediment Trap	11/21/2011	17:04	-37	12.93	9.3	91.2	7.57	612	0.3	53.6
WQ1162	Ore Dock	11/23/2011	9:06	-34	12.36	9.04	87.5	7.52	614	0.3	11.1
WQ1163	Ore Dock	11/23/2011	11:21	-35	12.44	9.44	91.6	7.57	608	0.3	89.2
WQ1164	Sediment Trap	11/27/2011	11:34	-30	11.87	9.73	93.2	7.48	667	0.3	9.2
WQ1165	Sediment Trap	11/27/2011	14:05	-35	11.79	9.09	86.9	7.68	887	0.4	42.5
WQ1166	Sediment Trap	11/29/2011	12:31	-36	11.57	8.97	85.3	7.64	677	0.3	45.7
WQ1167	Sediment Trap	11/29/2011	14:55	-36	11.58	9.79	93.2	7.7	669	0.3	16

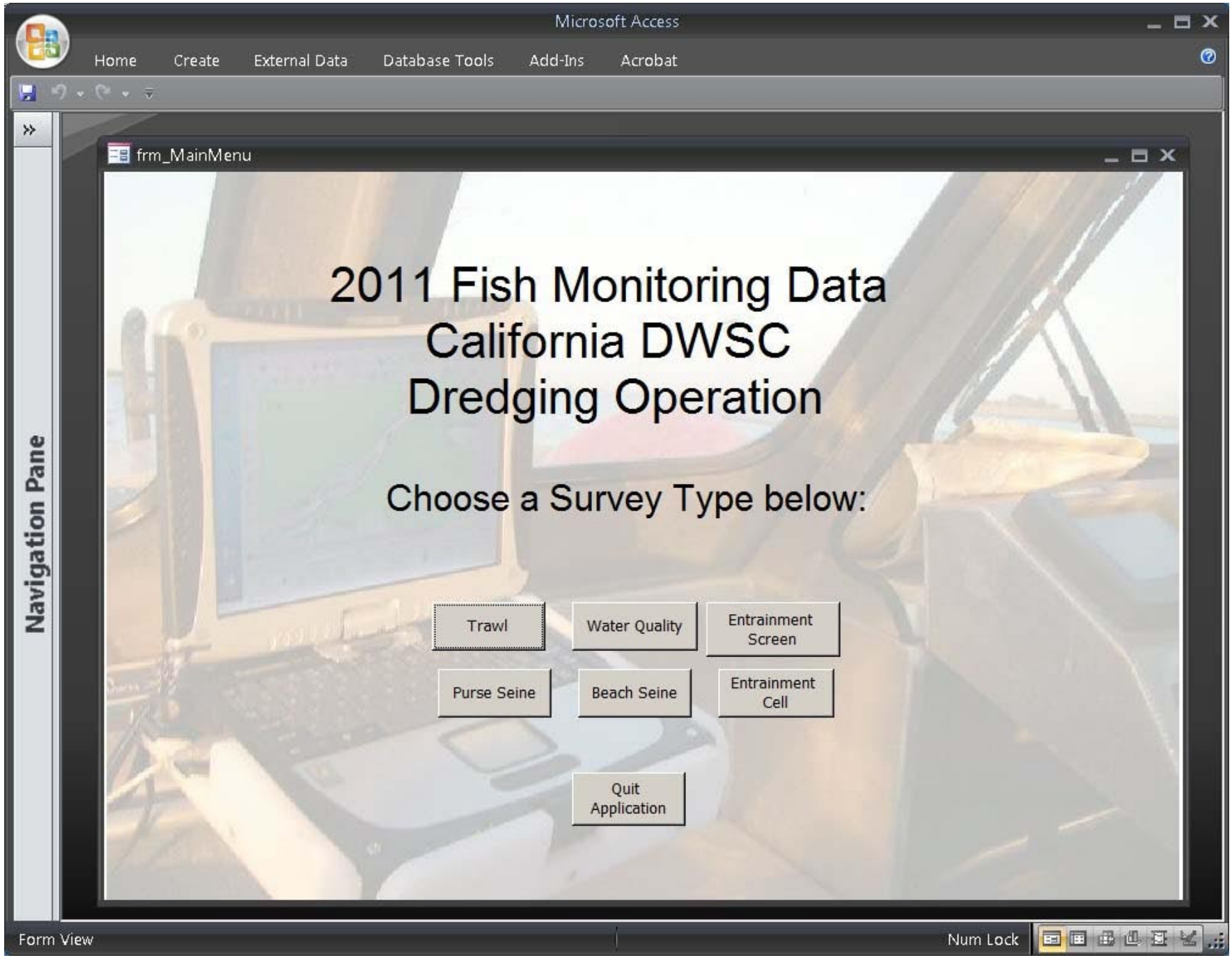
Surface Water Quality Readings

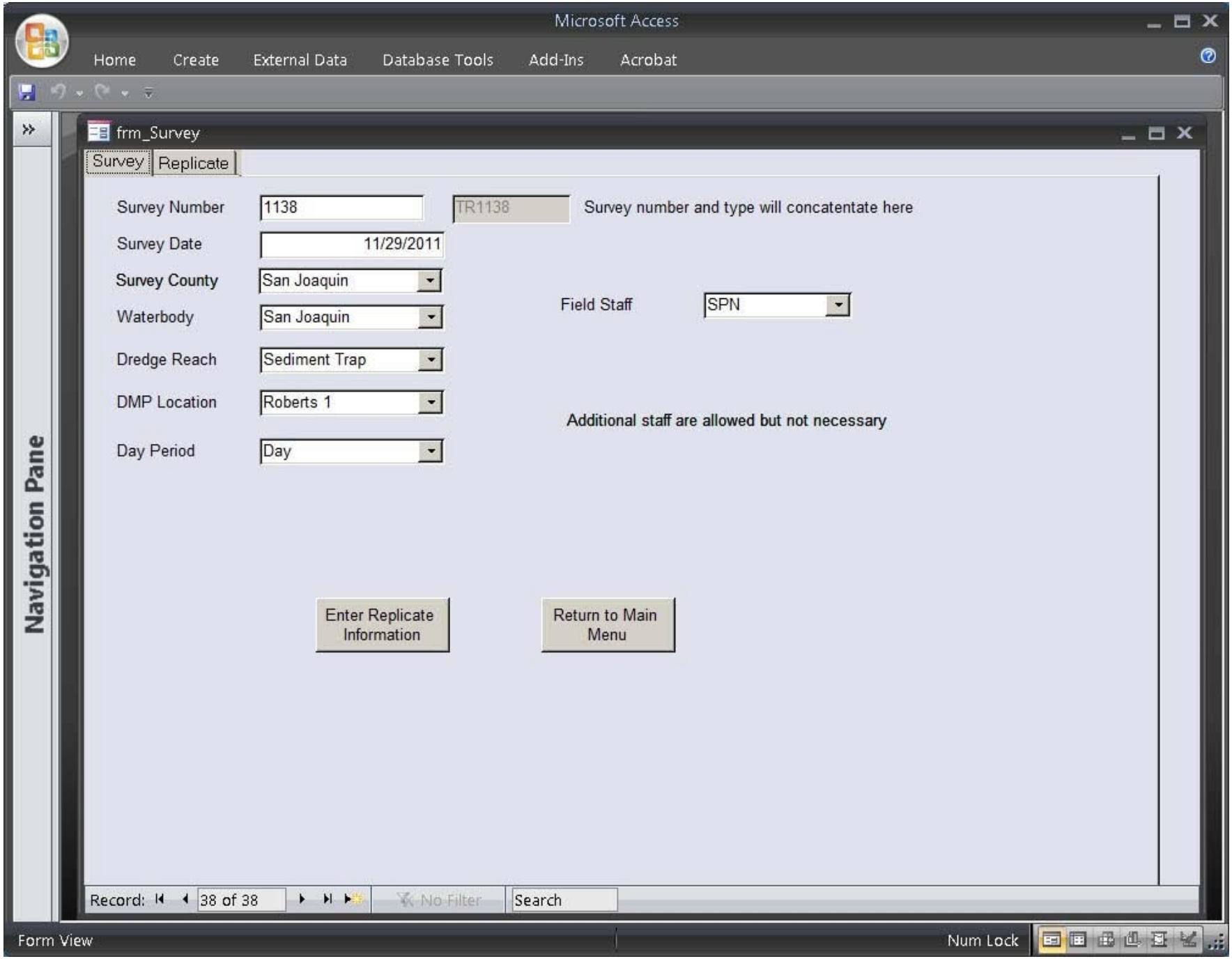
Survey ID	Dredge Reach	Date (m/d/year)	Time (hh:mm)	Depth (ft)	Temp (°C)	DO (ppm)	DO (%)	pH	Bot_Cond	Cond (uS)	Turb (ntu)
WQ0001	Man-made Channel 1	8/19/2011	16:23	2	23.55	8.23	99.2	8.13	846	0.4	91.4
WQ0002	Man-made Channel 1	8/21/2011	11:07	-1	22.06	8.11	95.4	7.9	785	0.4	128
WQ0003	Man-made Channel 1	8/23/2011	15:16	-2	23.34	7.27	87.3	8.36	813	0.4	102
WQ0004	Man-made Channel 1	8/23/2011	17:39	-2	23.87	8.27	100.3	8.43	847	0.4	86.1
WQ0005	Man-made Channel 3	8/25/2011	17:05	-2	23.62	8.31	100.2	7.95	526	0.3	95.1
WQ0006	Man-made Channel 3	8/27/2011	17:15	-1	23.02	7.6	90.8	7.69	485	0.2	135
WQ1107	Man-made Channel 3	8/29/2011	17:09	-2	22.89	9.31	110.9	7.55	408	0.2	124
WQ1108	Sandy Beach	9/2/2011	10:49	-2	21.69	8.38	97.8	7.01	149	0.1	26.4
WQ1109	Sandy Beach	9/2/2011	13:02	-2	21.79	8.03	93.8	7.06	148	0.1	24.4
WQ1110	West Island	9/11/2011	16:28	-2	20.87	8.91	102.5	7.48	678	0.3	46.9
WQ1111	West Island	9/11/2011	18:31	-2	20.95	8.96	103.2	7.89	571	0.3	43.6
WQ1112	West Island	9/13/2011	17:11	-2	21.64	8.62	99.5	7.63	558	0.4	44.8
WQ1113	West Island	9/13/2011	19:11	-2	21.15	8.66	100.1	7.83	468	0.2	32.5
WQ1114	West Island	9/15/2011	17:32	-2	21.07	8.65	99.9	7.81	455	0.2	36.2
WQ1115	West Island	9/15/2011	20:13	-2	20.89	9.18	105.6	7.79	364	0.2	46.1
WQ1116	Scour Pond	9/17/2011	16:45	-1	21.36	8.9	103.2	7.63	296	0.1	16.1
WQ1117	Scour Pond	9/17/2011	19:35	-2	20.99	8.43	97.2	7.7	390	0.2	23.9
WQ1118	Light 19	9/21/2011	15:52	-2	22.47	9.47	111.9	7.64	225	0.1	9
WQ1119	Light 19	9/23/2011	16:55	-2	22.9			7.45	243	0.1	8.1
WQ1120	Light 19	9/23/2011	18:45	-2	22.51	8.58	101.5	7.46	208	0.1	7.9
WQ1121	Light 19	9/28/2011	13:26	-2	21.61			78.17	180	0.1	6.2
WQ1122	Light 19	9/28/2011	15:56	-2	21.7			7.54	237	0.1	10.6
WQ1123	Light 19	9/29/2011	14:32	-2	21.75	8.52	99.5	7.4	203	0.1	9.1
WQ1124	Light 19	9/29/2011	16:36	-2	22.02	8.45	99.1	7.71	313	0.1	13.9
WQ1125	Light 19	9/30/2011	11:54	-2	21.29	8.5	98.4	7.33	214	0.1	12
WQ1126	Light 19	10/2/2011	10:54	-2	20.69	8.94	102.5	7.61	263	0.1	8.8
WQ1127	Light 19	10/2/2011	12:59	-2	20.79	8.04	92.3	7.6	237	0.1	9.5
WQ1128	Light 21	10/4/2011	13:35	-1	19.99	8.17	92.4	7.37	228	0.1	14.6
WQ1129	Light 21	10/4/2011	14:27	-2	20.15	8.46	96	7.57	251	0.1	10.6
WQ1130	Light 21	10/6/2011	15:41	-2	18.9	7.77	86.1	7.43	234	0.1	8.8
WQ1131	Spud Island	10/16/2011	16:26	-2	18.51	7.89	86.8	6.49	241	0.1	14.9
WQ1132	Windmill Cove	10/19/2011	12:50	-2	18.76	8.34	92.2	7.02	228	0.1	13.1
WQ1133	Windmill Cove	10/19/2011	15:54	-2	18.64	6.76	100.8	6.76	230	0.1	18.1

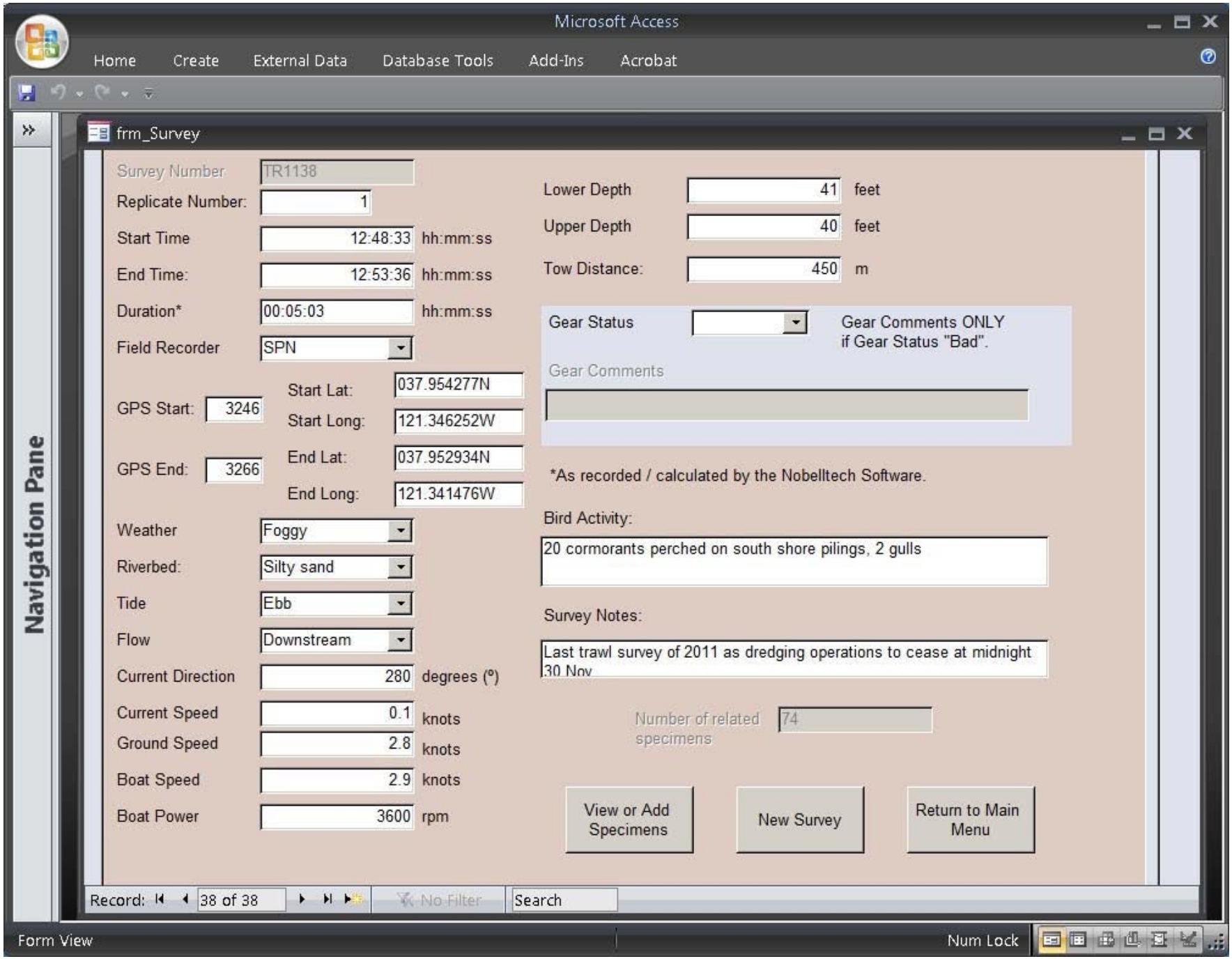
Surface Water Quality Readings

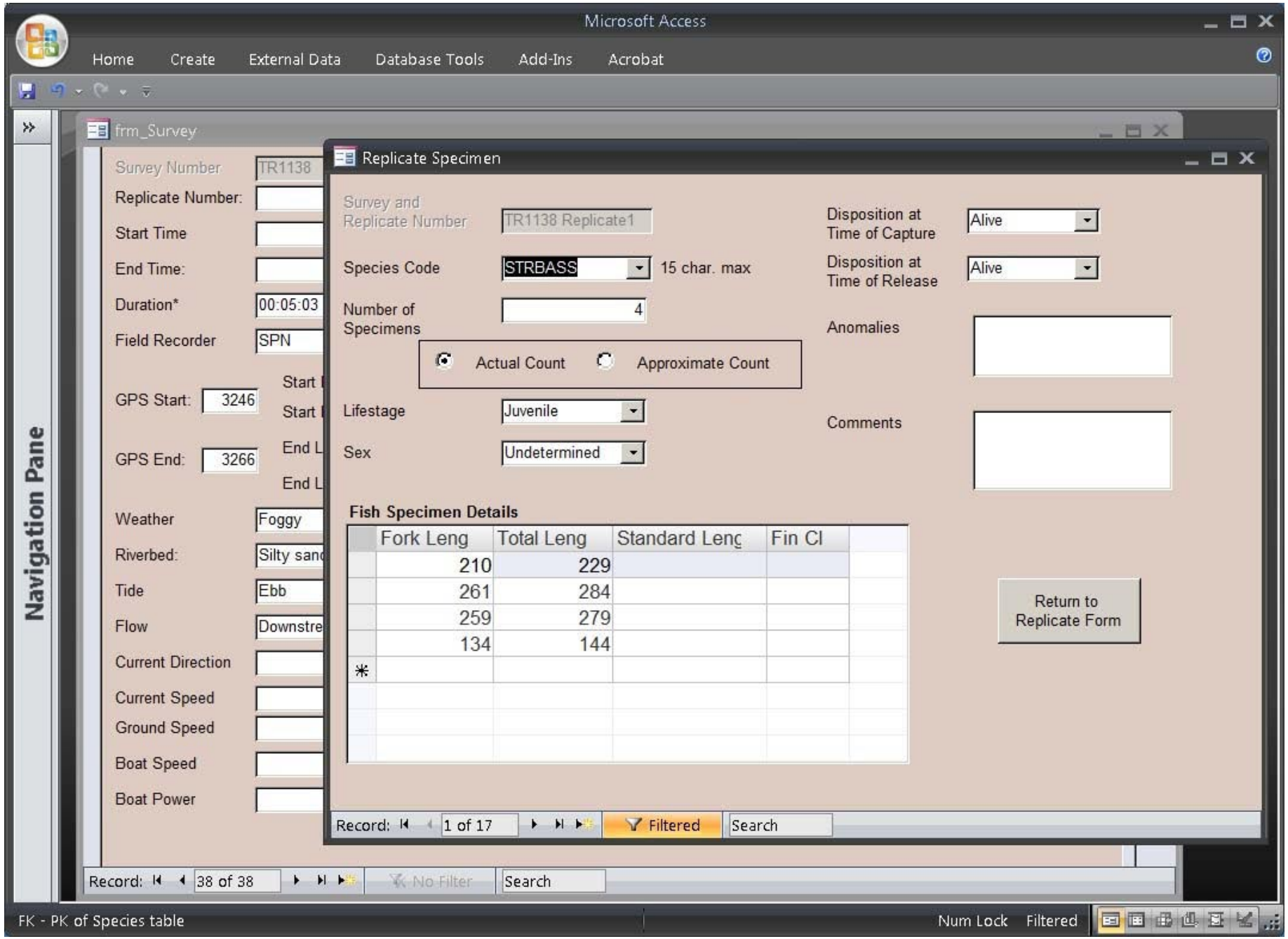
Survey ID	Dredge Reach	Date (m/d/year)	Time (hh:mm)	Depth (ft)	Temp (°C)	DO (ppm)	DO (%)	pH	Bot_Cond	Cond (uS)	Turb (ntu)
WQ1134	Windmill Cove	10/21/2011	14:48	-2	18.92	8.56	95	6.62	297	0.1	10.9
WQ1135	Windmill Cove	10/21/2011	16:53	-2	18.67	8.53	94.1	6.86	302	0.1	8.53
WQ1136	Sediment Trap	10/25/2011	17:18	-2	17.89	8.59	93.4	7.12	319	0.2	32.8
WQ1137	Sediment Trap	10/25/2011	19:50	-2	17.44	8.42	90.7	7.09	304	0.1	25.9
WQ1138	Sediment Trap	10/27/2011	15:43	-2	17.06	8.54	91.3	7.2	294	0.1	20.8
WQ1139	Sediment Trap	10/27/2011	18:02	-2	16.97	8.45	90.2	7.12	292	0.1	26.5
WQ1140	Sediment Trap	10/29/2011	15:20	-2	16.13	9.07	95.2	6.92	305	0.1	6.5
WQ1141	Sediment Trap	10/29/2011	17:35	-2	16.32	8.52	89.7	7.03	278	0.1	29.5
WQ1142	Sediment Trap	10/31/2011	10:01	-2	15.22	8.89	91.5	6.97	305	0.1	25.6
WQ1143	Sediment Trap	10/31/2011	12:06	-2	15.33	9.26	95.6	7.26	311	0.1	26.2
WQ1144	Sediment Trap	11/1/2011	10:49	-2	15.06	9.28	95.2	7.05	284	0.1	47.7
WQ1145	Sediment Trap	11/3/2011	15:37	-2	14.38	9.51	96.2	7.5	297	0.1	40.2
WQ1146	Sediment Trap	11/3/2011	17:49	-2	1419	9.29	93.5	7.41	293	0.1	30.3
WQ1147	Sediment Trap	11/5/2011	9:57	-2	13.09	9	88.6	7.22	323	0.2	31.5
WQ1148	Sediment Trap	11/5/2011	12:40	-2	13.39	9.49	93.9	7.47	311	0.1	26.4
WQ1149	Sediment Trap	11/11/2011	10:16	-2	12.72	9.45	92.2	7.33	546	0.3	31.4
WQ1150	Sediment Trap	11/11/2011	12:44	-2	12.8	9.03	88.3	7.45	542	0.3	23.3
WQ1151	Sediment Trap	11/13/2011	18:24	-2	13.11	9.49	93.4	7.32	553	0.3	10.7
WQ1152	Sediment Trap	11/13/2011	20:36	-2	13.04	9.63	94.7	7.45	557	0.3	10.1
WQ1153	Sediment Trap	11/15/2011	15:48	-1	13.51	9.92	98.5	7.48	606	0.3	0.3
WQ1154	Sediment Trap	11/15/2011	15:37	-2	13.14	8.52	83.9	7.62	617	0.3	3.4
WQ1157	Sediment Trap	11/17/2011	15:01	-2	13.42	9.28	92	7.84	586	0.3	3.3
WQ1158	Sediment Trap	11/17/2011	18:14	-2	13.4	9.56	94.7	7.55	608	0.3	9.5
WQ1159	Sediment Trap	11/19/2011	15:14	-2	13.38	9.52	94.3	7.82	613	0.3	22.6
WQ1160	Sediment Trap	11/21/2011	14:57	-2	13.25	9.58	94.6	7.77	610	0.3	25.7
WQ1161	Sediment Trap	11/21/2011	17:01	-2	13.38	9.34	92.5	7.77	602	0.3	11.3
WQ1162	Ore Dock	11/23/2011	9:01	-2	12.41	7.66	8.94	86.6	612	0.3	18.5
WQ1163	Ore Dock	11/23/2011	11:25	-2	12.63	9.19	89.5	7.73	604	0.3	9.9
WQ1164	Sediment Trap	11/27/2011	11:30	-2	12.07	9.53	91.7	7.66	616	0.3	2.6
WQ1165	Sediment Trap	11/27/2011	13:59	-2	11.81	9.38	89.7	7.84	636	0.3	14.9
WQ1166	Sediment Trap	11/29/2011	12:25	-2	11.57	9.06	86.2	7.82	675	0.3	10
WQ1167	Sediment Trap	11/29/2011	14:52	-2	11.57	9.5	90.4	7.88	669	0.3	10.3

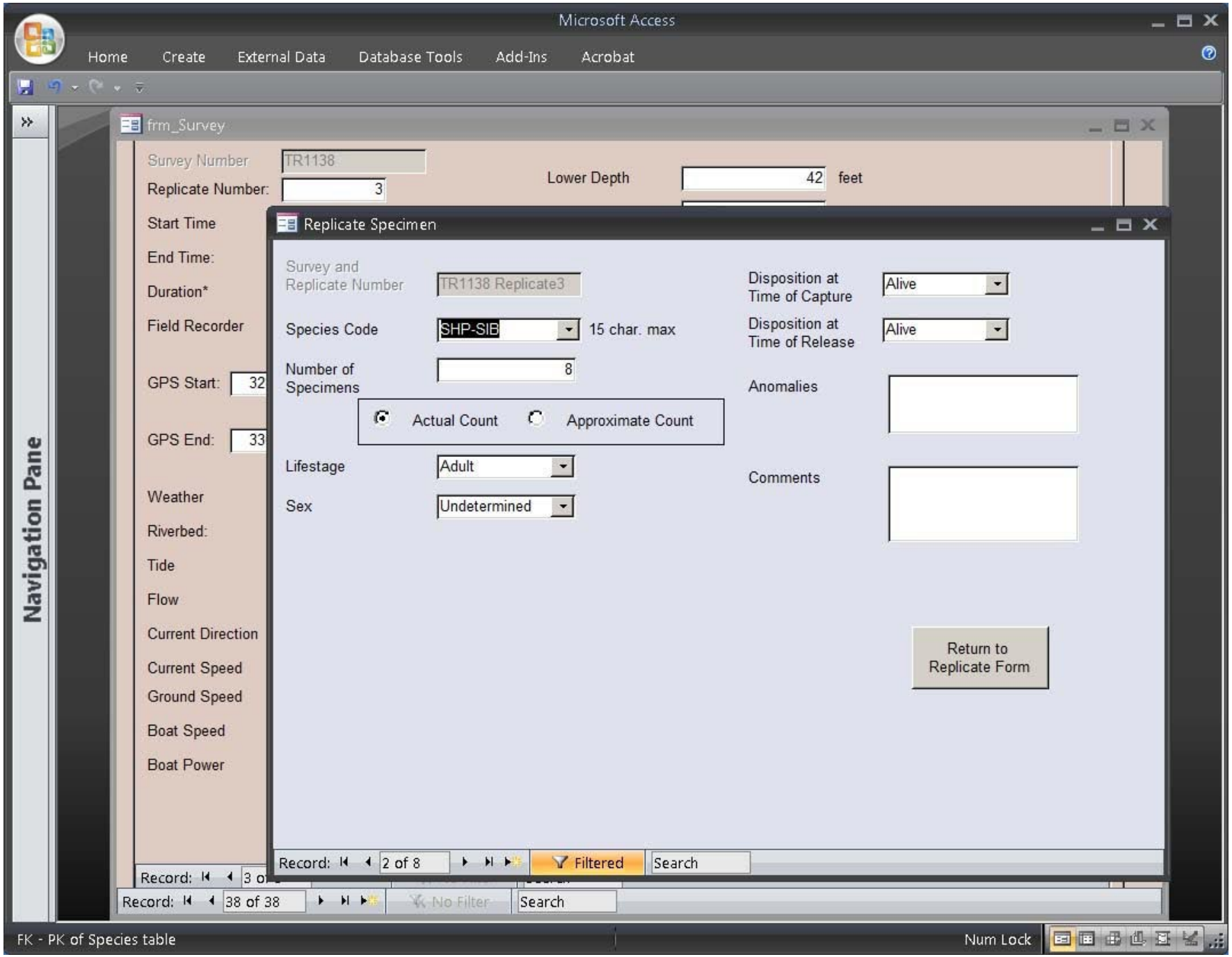
Appendix C. Field Data Collection Forms and Database

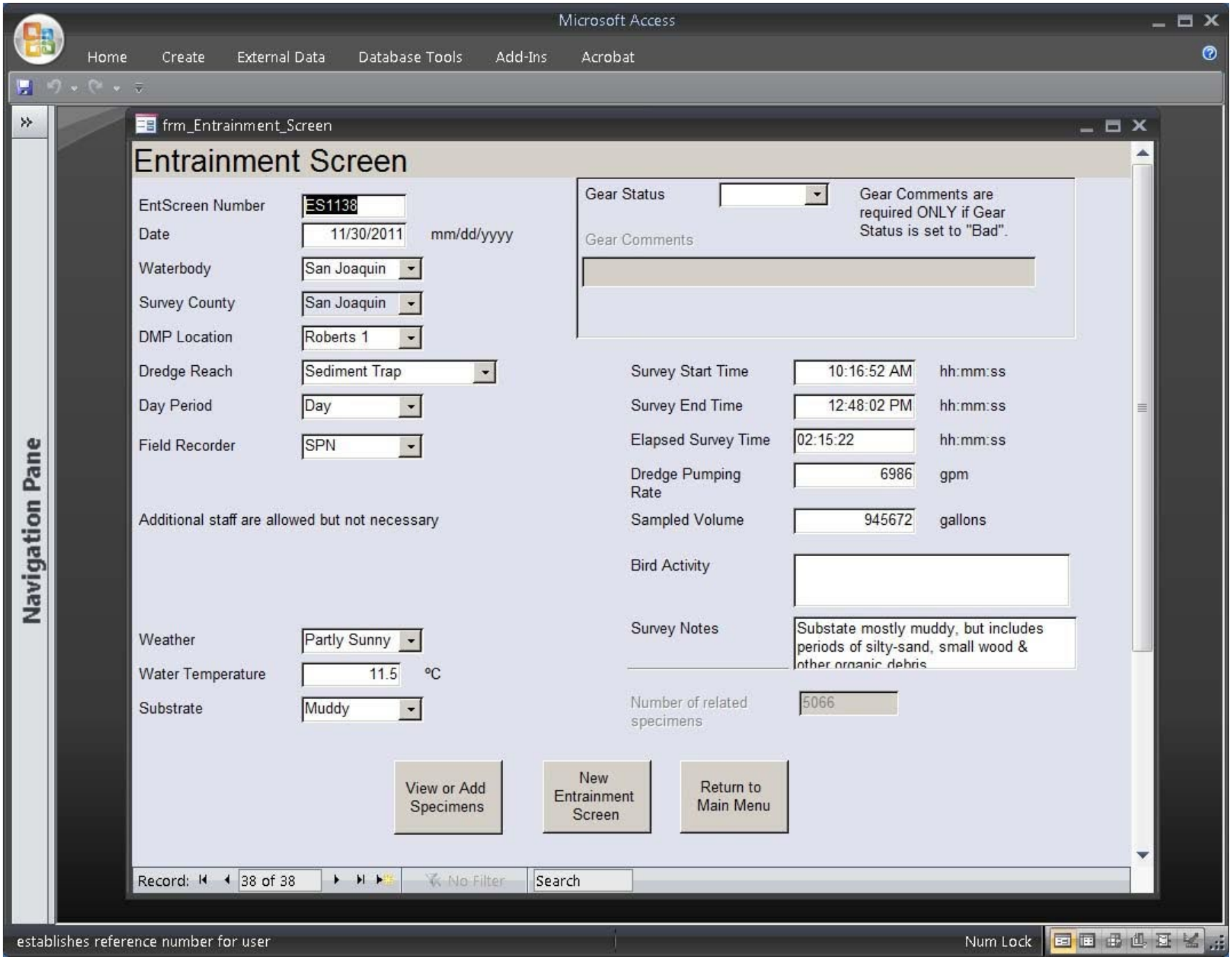

Microsoft Access
Home
Create
External Data
Database Tools
Add-Ins
Acrobat
frm_MainMenu
2011 Fish Monitoring Data
California DWSC
Dredging Operation
Choose a Survey Type below:
Trawl
Water Quality
Entrainment Screen
Purse Seine
Beach Seine
Entrainment Cell
Quit Application
Navigation Pane
Form View
Num Lock

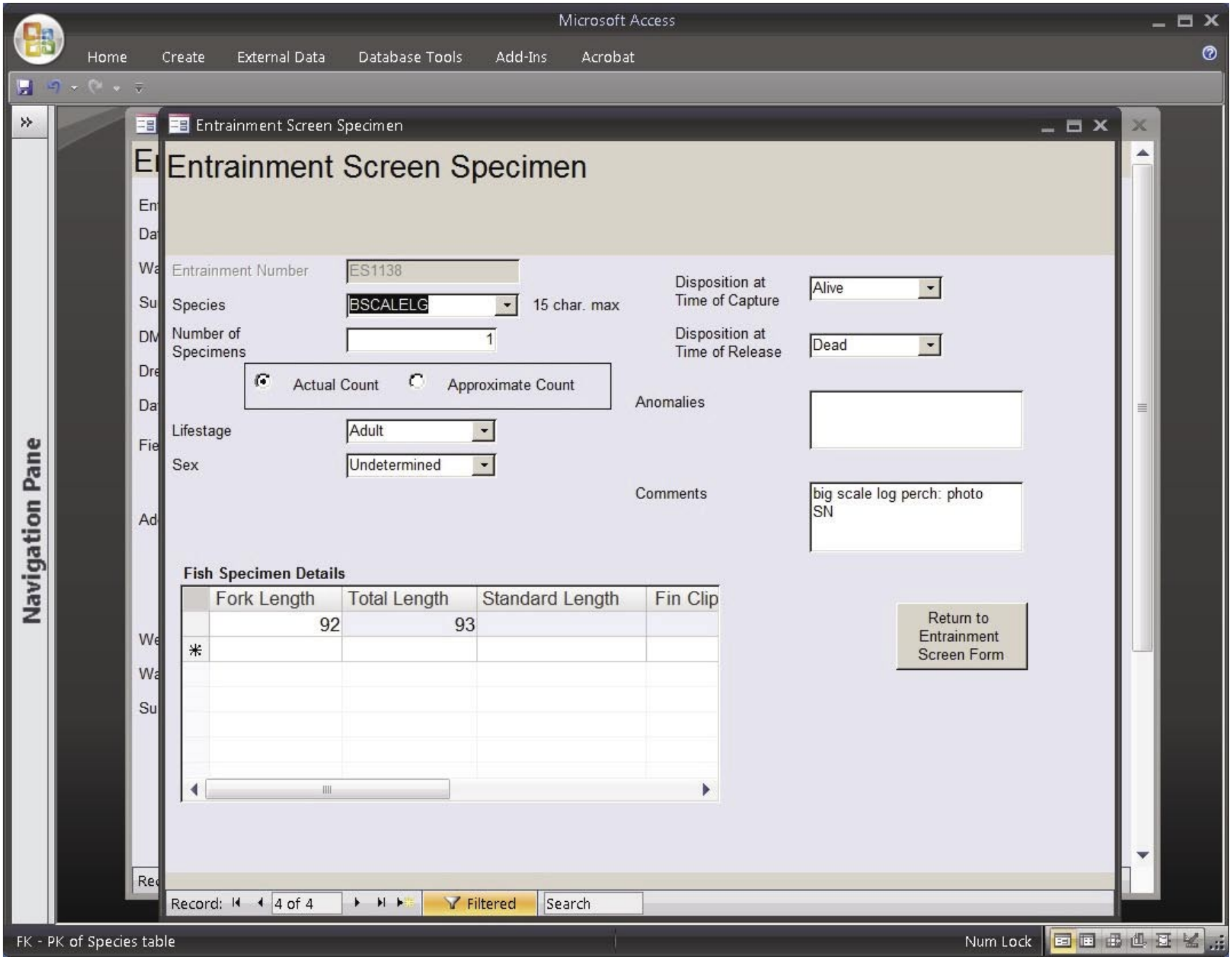

Microsoft Access
Home
Create
External Data
Database Tools
Add-Ins
Acrobat
frm_Survey
Survey
Replicate
Survey Number
1138
TR1138
Survey number and type will concatentate here
Survey Date
11/29/2011
Survey County
San Joaquin
Waterbody
San Joaquin
Field Staff
SPN
Dredge Reach
Sediment Trap
DMP Location
Roberts 1
Additional staff are allowed but not necessary
Day Period
Day
Enter Replicate Information
Return to Main Menu
Navigation Pane
Record:
38 of 38
No Filter
Search
Form View
Num Lock

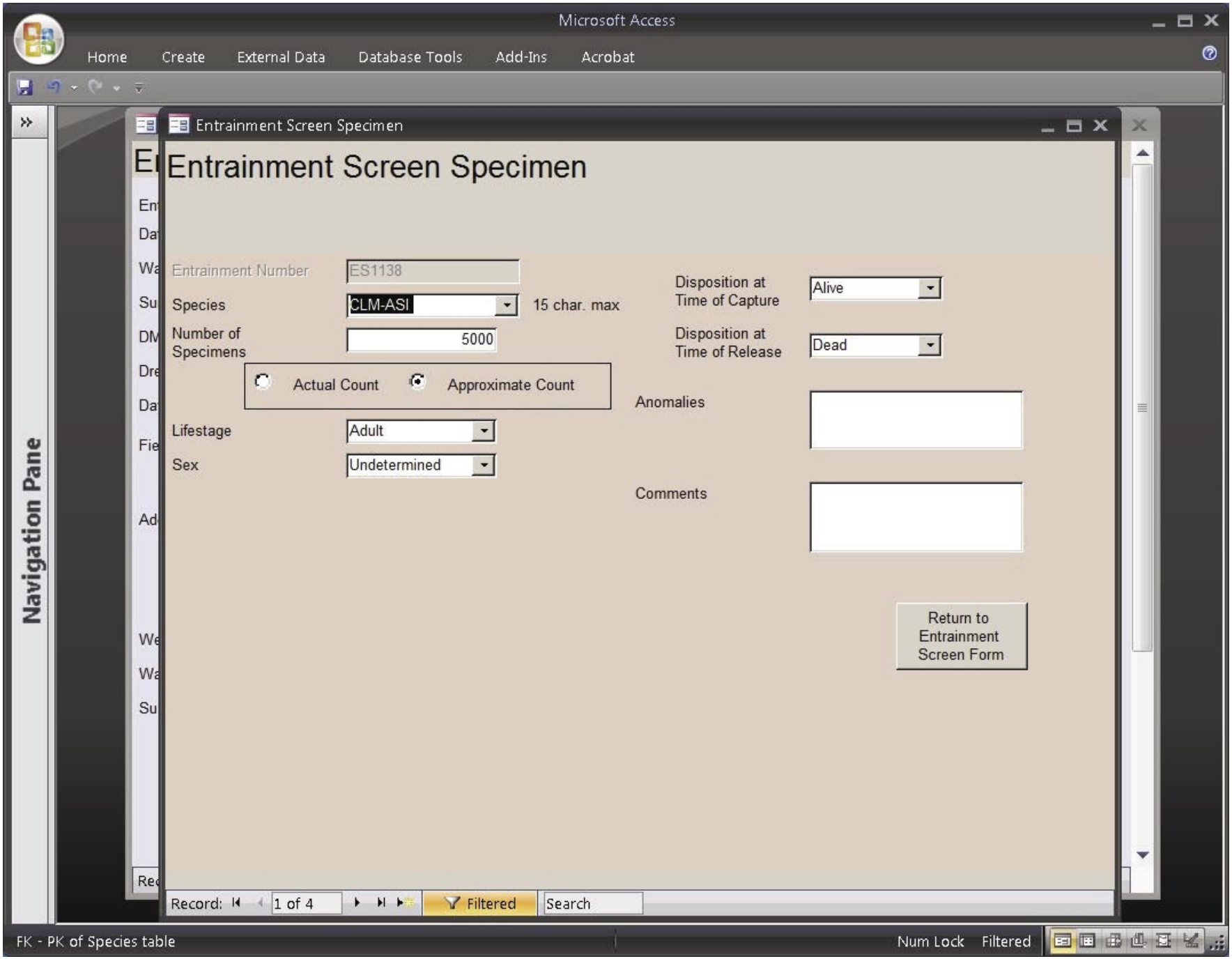

Microsoft Access
Home
Create
External Data
Database Tools
Add-Ins
Acrobat
frm_Survey
Navigation Pane
Survey Number
TR1138
Replicate Number:
1
Start Time
12:48:33
hh:mm:ss
End Time:
12:53:36
hh:mm:ss
Duration*
00:05:03
hh:mm:ss
Field Recorder
SPN
GPS Start:
3246
Start Lat:
037.954277N
Start Long:
121.346252W
GPS End:
3266
End Lat:
037.952934N
End Long:
121.341476W
Weather
Foggy
Riverbed:
Silty sand
Tide
Ebb
Flow
Downstream
Current Direction
280
degrees (°)
Current Speed
0.1
knots
Ground Speed
2.8
knots
Boat Speed
2.9
knots
Boat Power
3600
rpm
Lower Depth
41
feet
Upper Depth
40
feet
Tow Distance:
450
m
Gear Status
Gear Comments ONLY if Gear Status "Bad".
Gear Comments
*As recorded / calculated by the Nobelltech Software.
Bird Activity:
20 cormorants perched on south shore pilings, 2 gulls
Survey Notes:
Last trawl survey of 2011 as dredging operations to cease at midnight 30 Nov
Number of related specimens
74
View or Add Specimens
New Survey
Return to Main Menu
Record:
38 of 38
No Filter
Search
Form View
Num Lock

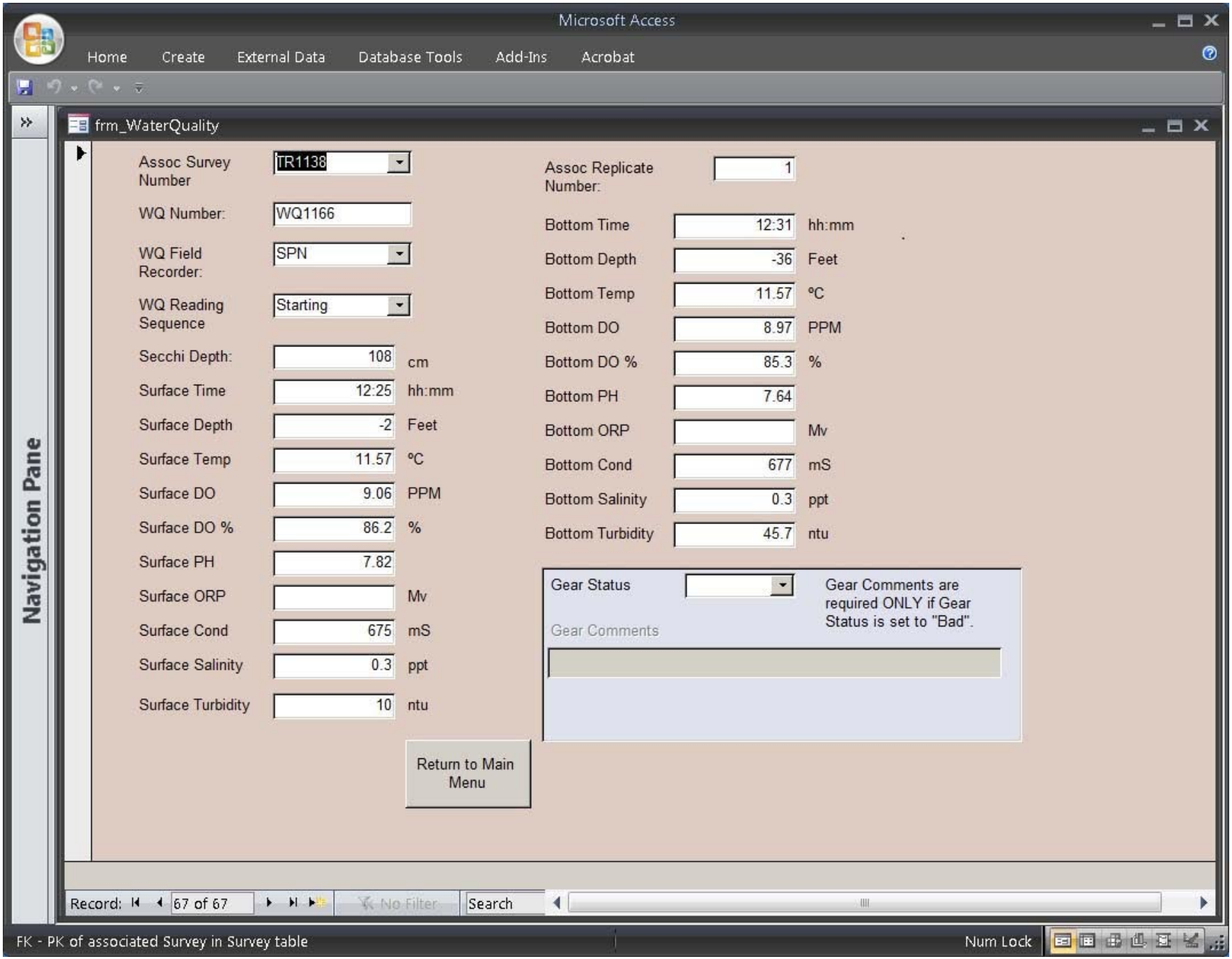

Microsoft Access
Home
Create
External Data
Database Tools
Add-Ins
Acrobat
Navigation Pane
frm_Survey
Survey Number
TR1138
Replicate Number:
Start Time
End Time:
Duration*
00:05:03
Field Recorder
SPN
GPS Start:
3246
GPS End:
3266
Weather
Foggy
Riverbed:
Tide
Ebb
Flow
Current Direction
Current Speed
Ground Speed
Boat Speed
Boat Power
Record:
38 of 38
No Filter
Search
Replicate Specimen
Survey and Replicate Number
TR1138 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 Leng
Fin Cl
210
229
261
284
259
279
134
144
Return to Replicate Form
Record:
1 of 17
Filtered
Search
FK - PK of Species table
Num Lock
Filtered


Microsoft Access
Home
Create
External Data
Database Tools
Add-Ins
Acrobat
frm_Survey
Survey Number
TR1138
Replicate Number:
3
Lower Depth
42
feet
Start Time
End Time:
Duration*
Field Recorder
GPS Start:
32
GPS End:
33
Weather
Riverbed:
Tide
Flow
Current Direction
Current Speed
Ground Speed
Boat Speed
Boat Power
Navigation Pane
Replicate Specimen
Survey and Replicate Number
TR1138 Replicate3
Species Code
SHP-SIB
15 char. max
Number of Specimens
8
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: 2 of 8
Filtered
Search
Record: 38 of 38
No Filter
Search
FK - PK of Species table
Num Lock


Microsoft Access
Home
Create
External Data
Database Tools
Add-Ins
Acrobat
frm_Entrainment_Screen
Entrainment Screen
EntScreen Number
ES1138
Date
11/30/2011
mm/dd/yyyy
Waterbody
San Joaquin
Survey County
San Joaquin
DMP Location
Roberts 1
Dredge Reach
Sediment Trap
Day Period
Day
Field Recorder
SPN
Additional staff are allowed but not necessary
Weather
Partly Sunny
Water Temperature
11.5
°C
Substrate
Muddy
Gear Status
Gear Comments are required ONLY if Gear Status is set to "Bad".
Gear Comments
Survey Start Time
10:16:52 AM
hh:mm:ss
Survey End Time
12:48:02 PM
hh:mm:ss
Elapsed Survey Time
02:15:22
hh:mm:ss
Dredge Pumping Rate
6986
gpm
Sampled Volume
945672
gallons
Bird Activity
Survey Notes
Substate mostly muddy, but includes periods of silty-sand, small wood & other organic debris
Number of related specimens
5066
View or Add Specimens
New Entrainment Screen
Return to Main Menu
Record:
38 of 38
No Filter
Search
Navigation Pane
establishes reference number for user
Num Lock


Microsoft Access
Home
Create
External Data
Database Tools
Add-Ins
Acrobat
Entrainment Screen Specimen
Entrainment Screen Specimen
Entrainment Number
ES1138
Species
BSCALELG
15 char. max
Number of Specimens
1
Actual Count
Approximate Count
Lifestage
Adult
Sex
Undetermined
Disposition at Time of Capture
Alive
Disposition at Time of Release
Dead
Anomalies
Comments
big scale log perch: photo SN
Fish Specimen Details
Fork Length
Total Length
Standard Length
Fin Clip
92
93
Return to Entrainment Screen Form
Record:
4 of 4
Filtered
Search
Navigation Pane
FK - PK of Species table
Num Lock


Microsoft Access
Home
Create
External Data
Database Tools
Add-Ins
Acrobat
Entrainment Screen Specimen
Entrainment Screen Specimen
Entrainment Number
ES1138
Species
CLM-ASI
15 char. max
Number of Specimens
5000
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
Navigation Pane
Record:
1 of 4
Filtered
Search
FK - PK of Species table
Num Lock
Filtered


Microsoft Access
Home
Create
External Data
Database Tools
Add-Ins
Acrobat
frm_WaterQuality
Navigation Pane
Assoc Survey Number
TR1138
WQ Number:
WQ1166
WQ Field Recorder:
SPN
WQ Reading Sequence
Starting
Secchi Depth:
108
cm
Surface Time
12:25
hh:mm
Surface Depth
-2
Feet
Surface Temp
11.57
°C
Surface DO
9.06
PPM
Surface DO %
86.2
%
Surface PH
7.82
Surface ORP
Mv
Surface Cond
675
mS
Surface Salinity
0.3
ppt
Surface Turbidity
10
ntu
Assoc Replicate Number:
1
Bottom Time
12:31
hh:mm
Bottom Depth
-36
Feet
Bottom Temp
11.57
°C
Bottom DO
8.97
PPM
Bottom DO %
85.3
%
Bottom PH
7.64
Bottom ORP
Mv
Bottom Cond
677
mS
Bottom Salinity
0.3
ppt
Bottom Turbidity
45.7
ntu
Gear Status
Gear Comments are required ONLY if Gear Status is set to "Bad".
Gear Comments
Return to Main Menu
Record:
67 of 67
No Filter
Search
FK - PK of associated Survey in Survey table
Num Lock

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

Water Quality Monitoring Datasheet (2011)

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 (2011)

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 (2011)

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

2011 Sacramento and Stockton Deepwater Ship Channel Fish Monitoring Program

Specimen Collection Datasheet (2011)

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												

General Notes: