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

2010 Fish Community, Entrainment and Water Quality Monitoring Report - Revised

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Acronyms and 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
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 revised results of the 2010 fish community and fish entrainment monitoring for maintenance dredging in the Stockton Deepwater Ship Channel (SDWSC) and the Sacramento River Deepwater Ship Channel (SRDWSC). Monitoring was instituted in 2005, and has been conducted annually since then, 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. The 2010 report was revised due to data acquired about misidentification of delta smelt as wakasagi in several instances during 2010 monitoring. The error came to light after the initial 2010 report was provided. The corrected data is provided in this revised report.

Fish entrainment monitoring during the 2010 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 September 20, 2010, and ended on December 6, 2010. 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. Dredging operations in the SRDWSC concluded prior to December 1. Consequently, 24 hours a day fish monitoring aboard the dredge was not required in 2010 as in 2006 and 2007. Dredging in the SDWSC did extend beyond the USFWS work-window for delta smelt (November 30). However, based on an extension request from USACE, dredging was permitted. This was due to the ability of the monitoring methods to determine impacts to delta smelt, and the likelihood that there would be no impacts to delta smelt based on knowledge of timing and presence in the SDWSC.

The key findings of 2010 entrainment monitoring at dredged material placement (DMP) sites were:

- The prototype mobile entrainment screen was used at all DMP sites during the 2010 dredging season. This was the second dredging season that the sampling cell method was not used. The goal was to sample 6% or more of the dredge output and 7.23% of output was sampled. This represents a significant increase over previous years (compared to 5.64% of overall dredged material sampled in 2009, 4.4% in 2008, 0.35% in 2007, and 0.37% in 2006).
- There were 532 individual fish from 15 different taxa encountered during 31 entrainment surveys conducted.
- Six 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 the most common fish species found in entrainment samples and comprised 46.43% of the entrained individuals.
- Lamprey (*Lampetra* spp.) comprised 29.32% of the entrained individuals as the most common native species encountered in entrainment monitoring. There were 86 river lamprey collected and positively identified through morphologic analyses as well as 70 lamprey that escaped through the screen and so could not be positively identified. Based on lamprey encounters in

2010 and previous years, most of these fish are assumed to have been river lamprey. Lamprey, Sacramento splittail (*Pogonicthys macrolepidotus),* and delta smelt (*Hypomesus transpacificus*) were the only native fish encountered during entrainment monitoring. River lamprey is a California Department of Fish and Game species of special concern. Lamprey were not observed or encountered in the fish community monitoring within navigation channels.

- Similar to previous years, the majority of fish entrained were demersal species also encountered during fish community monitoring. Entrainment monitoring was not conducted at Antioch Bridge West and Spud Island reaches due to short duration dredge operations. However, attendant trawl sampling was conducted at these reaches.
- The volume of slurry (dredged water and sediment) sampled during 2010 monitoring varied from 5.59% of total deposited slurry at the S-31 B and C DMP / Man-made Channel 2 dredge reach, to 22.31% at the Roberts 1 DMP / Upper Roberts dredge reach. A total of 40,470,472 gallons of slurry was sampled during 2010 entrainment monitoring.
- Approximately 559,805,950 gallons of total slurry volume was placed at DMP sites during the 2010 maintenance dredging season. Of this volume, approximately 327,167,626 gallons of slurry were dredged from the SRDWSC and 232,638,324 gallons were from the SDWSC.

The key findings from the 2010 fish community (trawl) monitoring were:

- There were 4,328 individual fish encountered during 2010 trawl surveys. These fish represent 26 of approximately 55 species (Moyle, 2002) presently known to occur in the Sacramento and San Joaquin River Delta (the Delta).
- Thirty-three trawl surveys were performed in 2010. A total of 152 successful trawl tow replicates were conducted. No entrainment sampling was conducted at the Lower Bradford DMP site because the dredge was working in this reach for less than 24 hours. However, fish community monitoring was conducted. The total distance trawled was 63,409 meters.
- Eight of the fish species encountered are native to the Delta and 17 are introduced.
- Threadfin shad, an introduced species typically described as pelagic, was the most commonly encountered species during 2010 fish community monitoring and accounted for 57.07% of the individual fish encountered. In all previous years, white catfish, an introduced demersal (bottom-oriented) species, was the most commonly encountered species but white catfish accounted for only 14% of the individual fish encountered in 2010.
- Seven delta smelt were encountered while conducting fish community monitoring at S-31 in the man-made portion of the SRDWSC.
- Two green sturgeon were encountered in 2010 in the Upper Bradford Dredge reach.
- Fourteen of the twenty-six species encountered during 2010 fish community monitoring also occurred in the entrainment samples. The only native species encountered by both monitoring methods were Sacramento splittail and delta smelt. More splittail were encountered in 2010 trawl sampling than in previous years.
- Non-native species accounted for 98.37% of the individual fish encountered in both channels. Native fishes comprised 5.13% of total fish encountered from the SRDWSC and 0.83% of fish from the SDWSC.

All data collected in 2010 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 collection, 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 also enables 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 2010. 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 is currently conducting a 12-month status review of all west coast longfin smelt populations. The results of this review are due September 30, 2011. 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 2010.

Notable amongst the non-listed native fish species encountered by this monitoring program are Sacramento splittail (*Pogonicthys macrolepidotus)* and river lamprey. Sacramento splittail, a native minnow, have been encountered every year that this monitoring has been conducted, including 2010. 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, these species are recognized by USFWS and others (Moyle 2002, Goodman et al. 2009) as species that require greater conservation efforts. River lamprey have been encountered during each year of the study in the entrainment samples, and occasionally in the fish community samples. Particularly high abundances of river lamprey were entrained in 2010, relative to previous years.

All plans and reports stemming from this monitoring program since its inception are now available through a link from the following web address: http://www.mari-gold.biz.

2 Introduction

This document provides a description of the fifth year of fish community monitoring and the sixth 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. SWCA Environmental Consultants, Inc. (SWCA) designed and conducted this monitoring from 2006 through 2008. In 2009, a new contractor, Mari-gold Environmental Consulting Inc. (MEC), was selected by RISG to conduct this work. J. Gold, who provided the research vessel and much of the scientific expertise utilized by this monitoring program since its inception, founded MEC. 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 sampling methods since 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.

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 2081(a) Permit has several additional provisions including notification to CDFG if 50% of the allowable take is reached, and retention of osmerids and wakasagi for examination by CDFG.

To convert the NMFS mandated monitoring requirements into testable assumptions. The following hypotheses (H^1 and H^2) were developed prior to the initiation of the 2006 fish 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 September 20, 2010 through December 6, 2010. These monitoring activities consisted of sampling the fish community in the channel and sampling the dredged material for entrained fish. The fish entrainment sampling 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 the assessed potential impacts from annual maintenance dredging actions. Protections afforded these species can affect management and operations of SDWSC and SRDWSC dredging. 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

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 also maintains a list of fish Species of Special Concern. This list contains species that have experienced declines in population levels, have limited ranges, and/or are vulnerable to continuing threats of extinction. Some of these species have not yet been awarded any other state or federal status, and so have not yet impacted this monitoring program. However, the authors feel that it is prudent to list them here due to the likelihood of these fish species having an impact on monitoring and/ or dredging during the lifetime of this monitoring study. These species include:

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

River lamprey have been encountered in both shipping channels during each year that monitoring has been conducted. 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 likely, with attendant implications for dredging and monitoring, should listing occur. This monitoring program has encountered lamprey during both fish community and entrainment sampling. The lamprey encountered in the fish community and fish entrainment samples from all years of this study (identified in the field and laboratory utilizing morphological and genetic analysis) have all been river lamprey except for the single Pacific lamprey identified in 2009. 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 2010 again show a substantial number of "unidentified" lamprey due to these occurrences. However, all vouchered lamprey from 2010 were identified as river lamprey (except for a few poorly fixed individuals). Thus, although described in the data as "unidentified lamprey," these specimens are assumed to be river lamprey.

It is possible however, that Pacific lamprey, western brook lamprey and Kern brook lamprey have been among the lamprey previously encountered, and 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, though species determination within *Lampetra* ammocoetes encountered in the future may still require additional 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. CDFG also produces a frequently updated list of state and federally listed endangered and threatened animals of California. The July 2009 CNDDB and January 2010 CDFG lists were the latest available lists at the time of this writing. Both lists are 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). Though unable to receive special status (listing) due to the fact that they are not native fishes, their recent major population declines are of significant concern. Though encountering these species will not alter dredging or monitoring operations in the foreseeable future, the data from this annual monitoring program includes information about relative population levels of fish species in multiple Delta (channel) locations. This information is delivered to Interagency Ecological Program (IEP), CDFG, and other parties in order to satisfy permit requirements and for research interests. Use of this information on these and other species is an indirect benefit of this monitoring program. These species are:

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

Dredging and monitoring activities are affected by proposed listings, new listings, and indications of likely future listings of special-status species. 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 modification of dredging operations or monitoring due to status change during 2009 and 2010.

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 sampling, 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 entraining.

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 has initiated a 12-month status review for the entire longfin smelt population from Alaska to California. The finding of this review is due on September 30, 2011. No longfin smelt were encountered during 2009 or 2010 fish community trawl surveys or entrainment monitoring.

This annual monitoring report is submitted to USACE and CDFG as a reporting requirement for the fish monitoring of federal ship channel maintenance dredging activities. The collection details of any 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 sampling activities and ESA fish collections 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). 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) held by the investigative biologists conducting the fish monitoring. The SCP collections summaries are submitted to Paul Roberts or Russ Bellmer at CDFG (Sacramento) and now require a review period of 28 weeks 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 law are outside the monitoring requirements for dredging in the SRDWSC and SDWSC, the sampling methods used for monitoring yielded information on these species. 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 sufficient data are available. This report also discusses the efficacy of the monitoring methods, efforts to minimize sampling mortality, and adaptive management measures with suggestions for future monitoring.

3 Methods

3.1 Sampling Methods Overview

The sampling methods followed for fish community and entrainment monitoring during the 2010 SRDWSC and SDWSC maintenance dredging are described in the Fish Monitoring and water quality plan (FMP) (MEC and NAS, 2011). The methods were based on their appropriateness for sampling 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 2010 dredging operations did not extend beyond the 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 in the bottom trawl or entrainment screen samples, with some exceptions, were counted and identified to the species level. Fish were identified, counted, and classified by life history stage. Some, and in most cases all, of each fish species was measured for length. As many individual fish as possible were released back to the water with minimal harm. Stressed fish, or fish species easily injured by 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 or due to permit requirements, as was the case for osmerids and 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 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 sampling. 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 activity is often indicative of the presence of adult salmon or other large fish such as carp or catfish that are common sea lion prey in the Delta.

3.2 Sampling Effort, Timing, and Sampling Locations

An overview map of the project area including the sampling locations associated with each dredge reach is provided in Figure 1. Location data and activity periods are also summarized in Table 1. Prior to the 2010 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. Sampling was conducted during every day of active dredging. In general, fish community and entrainment sampling were conducted on alternating days. Due to inherent uncertainty regarding the exact timing of active dredging, fish community sampling was initiated within 24-hours of when active dredging actually commenced. Entrainment sampling was usually conducted on the second day of dredging at each dredge reach. Both types of sampling continued at each dredge reach until dredging at that reach was completed.

Antioch Bridge West (Scour Pond DMP) and Spud Island (Roberts 2 DMP) were short duration dredge reaches (10 and 7.5 hr operations, respectively) where only trawl monitoring occurred due to lack of ability to conduct both sampling types in the time available. At Lower Bradford Island, a short duration dredge reach, only entrainment monitoring was conducted due to time constraints.

The methods defined in the FMP were designed to sample as many diel/tidal regimes as possible. Consequently, sampling times were varied so that diurnal fish movements, as well as tidal elevation and river flow changes, would be reflected in the sampling results. Given the relatively few sampling events at each reach during each dredging season, however, it is not possible to capture a great deal of the possible variation that may occur. A random sample design was not employed since it was necessary for entrainment monitoring to coincide with active dredging. Sampling was performed under a variety of light conditions, though most occurred during daylight hours due to logistical, operational, and safety issues. Eight of 32 total entrainment events were conducted in low light/night conditions (five dusk, three night); two were in Man-made Channel 2 of the SRDWSC (1 dusk and 1 night event); the remaining 6 were conducted in the SDWSC (one night event at Turning Basin, one dusk and one night event at Scour Pond, and one dusk event each at Antioch Bridge East, Light 19, and Upper Roberts). Four of 33 total trawl surveys were conducted in low light/night conditions (all during dusk); one was in the SRDWSC at Man-made Channel 2; and three were in the SDWSC (one each at Scour Pond, Turning Basin, and Spud Island).

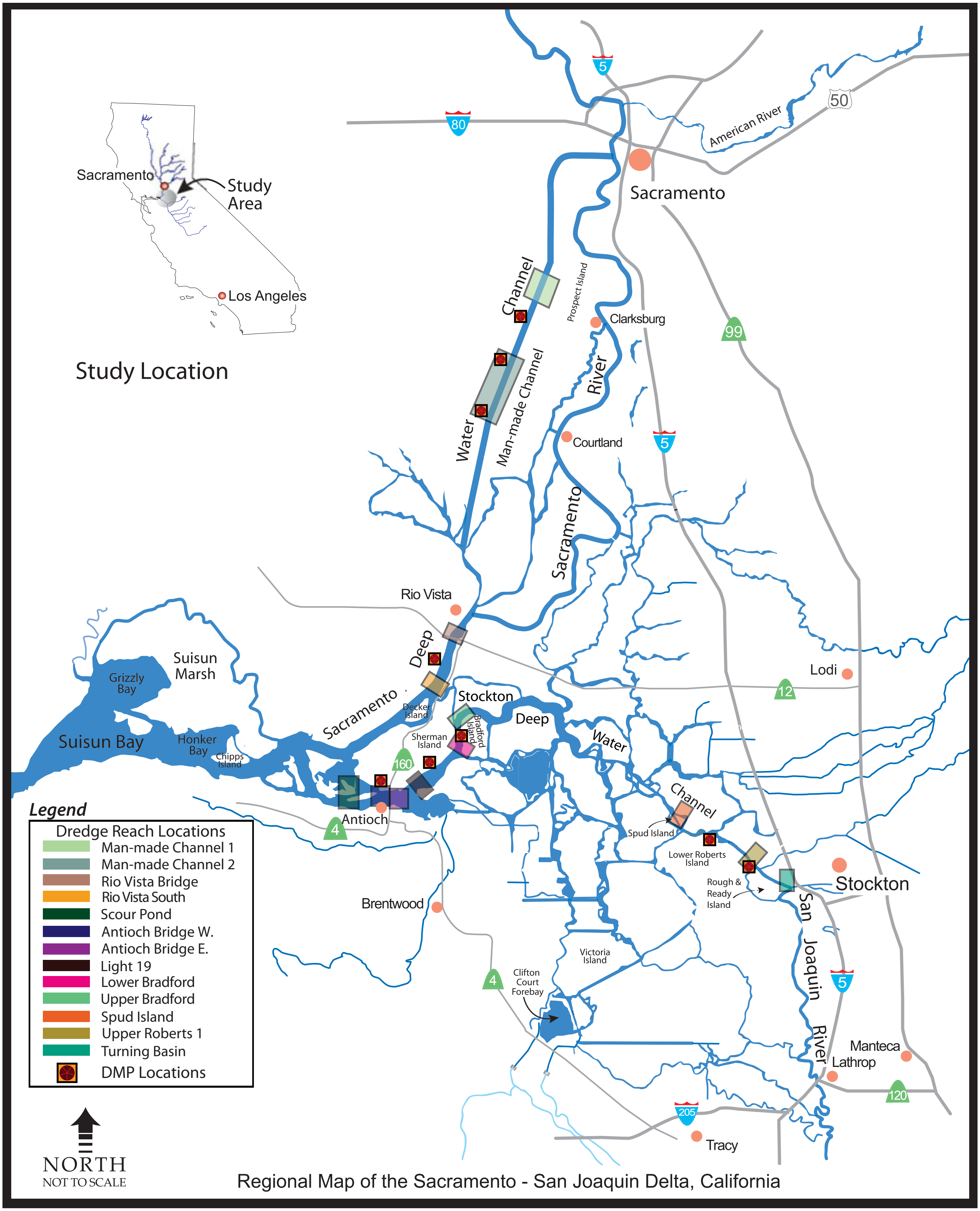


Figure 1. Project Area Map, Dredge Reaches, and DMP Sites

Adapted from USACE - SF District, LTMS Program Map

Table 1. SRDWSC and SDWSC 2010 Maintenance Dredging Locations

River Channel	Dredge Reach	Dredge Area (RM) From	To	Excavated Dry Material (cy)	Estimated Material Percent of Slurry	Estimated Total Slurry Volume (gal)	DMP Site	Time Frame Start	End
SRDWSC	Man-made Channel 1	33.71	34.85	18,153	6%	61,107,242	S-31 A	Sep 21	Sep 28
SRDWSC	Man-made Channel 2	27.95	30.87	92,852	8%	234,421,153	S-31 B and C	Sep 29	Oct 16
SRDWSC	Rio Vista Bridge	12.52	12.78	3,421	10%	6,909,531	Sandy Beach	Oct 19	Oct 20
SRDWSC	Rio Vista South	9.81	10.04	12,244	10%	24,729,700	Sandy Beach	Oct 21	Oct 23
SDWSC	Scour Pond	5.42	6.17	20,555	7%	59,308,230	Scour Pond	Oct 26	Nov 2
SDWSC	Antioch Bridge, West	8.33	8.45	10,313	30%	6,943,194	Scour Pond	Nov 3	Nov 3
SDWSC	Antioch Bridge, East	8.90	9.24	17,970	18%	20,163,740	Scour Pond	Nov 4	Nov 5
SDWSC	Light 19 Reach	11.17	11.33	13,092	8%	33,053,049	McCormack Pit	Nov 8	Nov 11
SDWSC	Lower Bradford	13.83	14.02	3,881	8%	9,798,265	Bradford Island	Nov 12	Nov 13
SDWSC	Upper Bradford	15.06	15.44	16,637	8%	42,003,023	Bradford Island	Nov 14	Nov 17
SDWSC	Upper Roberts	37.08	37.88	14,642	35%	8,449,439	Roberts 1	Nov 19	Nov 20
SDWSC	Turning Basin	39.77	39.96	23,711	8%	59,862,577	Roberts 1	Nov 21	Dec 2
SDWSC	Spud Island	31.50	31.65	1,278	8%	3,226,535	Roberts 2	Dec 6	Dec 6
TOTAL				248,749		569,975,679			

As listed in Table 1, a total of approximately 248,749 cubic yards of dredged material was placed at DMP sites during 2010. Approximately 122,079 cubic yards were dredged in the SDWSC and 126,670 cubic yards in the SRDWSC. 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 569,975,679 gallons. The approximate average pumping rate varied by location from 6,889 gallons per minute at the Turning Basin to 15,647 gpm for the Upper Roberts reach, both depositing material at the Roberts 1 DMP site.

This was the second consecutive year that the mobile screen device was used for entrainment monitoring at all DMP sites. Effort levels for 2010 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 sampling. Entrainment sampling was disrupted on several occasions in 2010, usually the result of unexpected dredge shutdowns or mechanical problems unrelated to fish monitoring activities. The goal for entrainment sampling was to sample at least 6% of the overall dredge output based on an expected average dredge run time of 20 hours per day. An overall total of 7.23% of the dredge output was sampled in 2010, representing a significant increase over previous years; 5.64% of overall dredged material was sampled in 2009, compared to 4.4% in 2008, 0.35% in 2007 and 0.37% in 2006. This increase is largely due to initiation of the entrainment screen method in 2008 as well as complete abandonment of the sampling cell method in 2009, due to its inability to assess significant portions of the dredge output.

Fish community sampling (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 fish encountered. Unsuccessful trawl tows, experienced during seven tows in five different reaches, were usually the result of large wood or other debris hung up in the net.

Table 2. 2010 Entrainment Monitoring Effort at DMP Sites

DMP Site	Dredge Reach	Date Start	Date End	Sampling Days	Sampling Attempts	Material Type	Sampled Vol. (gal)	Dredged Slurry Vol. (gal)	Sampled Percent
S-31 A	MM Channel 1	Sep 21	Sep 27	5	5	B	3,826,650	61,107,242	6.26
S-31 B and C	MM Channel 2	Sep 29	Oct 15	9	9	B and D	13,102,096	234,421,153	5.59
Sandy Beach	Rio Vista Bridge	Oct 20	Oct 20	1	1	A	748,566	6,909,531	10.83
Sandy Beach	Rio Vista S	Oct 22	Oct 22	1	1	A	1,844,416	24,729,700	7.46
Scour Pond	Scour Pond	Oct 16	Nov 2	4	4	A	6,425,055	59,308,230	10.83
Scour Pond	Antioch Bridge E	Nov 4	Nov 4	1	1	A	1,692,792	20,163,740	8.40
McCormack	Light 19	Nov 9	Nov 10	2	2	A	3,225,672	33,053,049	9.76
Bradford	Lower Bradford	Nov 13	Nov13	1	1	A	858,348	9,798,265	8.76
Bradford	Upper Bradford	Nov 15	Nov 17	2	2	B	3,400,340	42,003,023	8.10
Roberts 1	Upper Roberts	Nov 21	Nov 22	2	2	C	1,885,394	8,449,439	22.31
Roberts 1	Turning Basin	Nov 24	Dec 2	3	4	C and D	3,461,143	59,862,577	5.78
TOTAL				31	32		40,470,472	559,805,950	7.23

MATERIAL TYPE LEGEND: A = sandy, B = silty sand, C = mud, D = gravel and mud

NOTE: Antioch Bridge West DR (Scour Pond DMP) and Spud Island DR (Roberts 2 DMP) were short duration dredge reaches (10 and 7.5 hr operations, respectively) where only trawl monitoring occurred. Data on dredge slurry volumes for these 2 dredge reaches are not included here.

Table 3. 2010 Fish Community Monitoring Effort by Dredge Reach Locations

Dredge Reach	River Channel	DMP Site	Time Start	Time End	Sample Days	Trawls Attempted	Trawls Succeeded	Distance (m)
MM Channel 1	SRDWSC	S-31 A	Sep 20	Sep 28	5	21	21	7,640
MM Channel 2	SRDWSC	S-31 B and C	Sep 30	Oct 16	9	43	41	14,910
Rio Vista Bridge	SRDWSC	Sandy Beach	Oct 19	Oct 19	1	5	5	1,720
Rio Vista S	SRDWSC	Sandy Beach	Oct 21	Oct 23	2	10	10	3,019
Scour Pond	SDWSC	Scour	Oct 25	Oct 31	4	20	19	9,710
Antioch Bridge W	SDWSC	Scour	Nov 3	Nov 3	1	5	5	2,240
Antioch Bridge E	SDWSC	Scour	Nov 5	Nov 5	1	5	5	2,120
Light 19	SDWSC	McCormack Pit	Nov 9	Nov 11	2	10	10	5,100
Upper Bradford	SDWSC	Bradford Island	Nov 14	Nov 16	2	10	9	4,530
Upper Roberts	SDWSC	Roberts 1	Nov 20	Nov 20	1	5	4	1,490
Turning Basin	SDWSC	Roberts 1	Nov 23	Dec 3	4	20	18	8,110
Spud Island	SDWSC	Roberts 2	Dec 6	Dec 6	1	5	5	2,820
TOTAL:					33	159	152	63,409

NOTE: Fish community monitoring did not occur in the Lower Bradford dredge reach due to short duration of operation; entrainment monitoring was conducted at this site.

3.3 Fish Community Monitoring

Fish community sampling followed all relevant regulations and protocols to: ensure ESA and CESA compliance, prevent accidents, avoid in-channel obstructions, minimize sampling 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 2010 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. Communication with the dredge was maintained on fish community sampling days 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 sampling effort. 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 sampling areas (areas devoid of hazards such as utility crossings).

Fish community sampling 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 2). 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.

The 27-foot-long RV *Karen M.*, a custom aluminum jet boat, was used to conduct the trawling operations (Figure 3). 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 to 3 knots over water. 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 started as close as safely possible to the dredge location. The net was towed along the channel bottom for approximately 500 meters from the starting point 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 permanently 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.

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 sampling. 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.

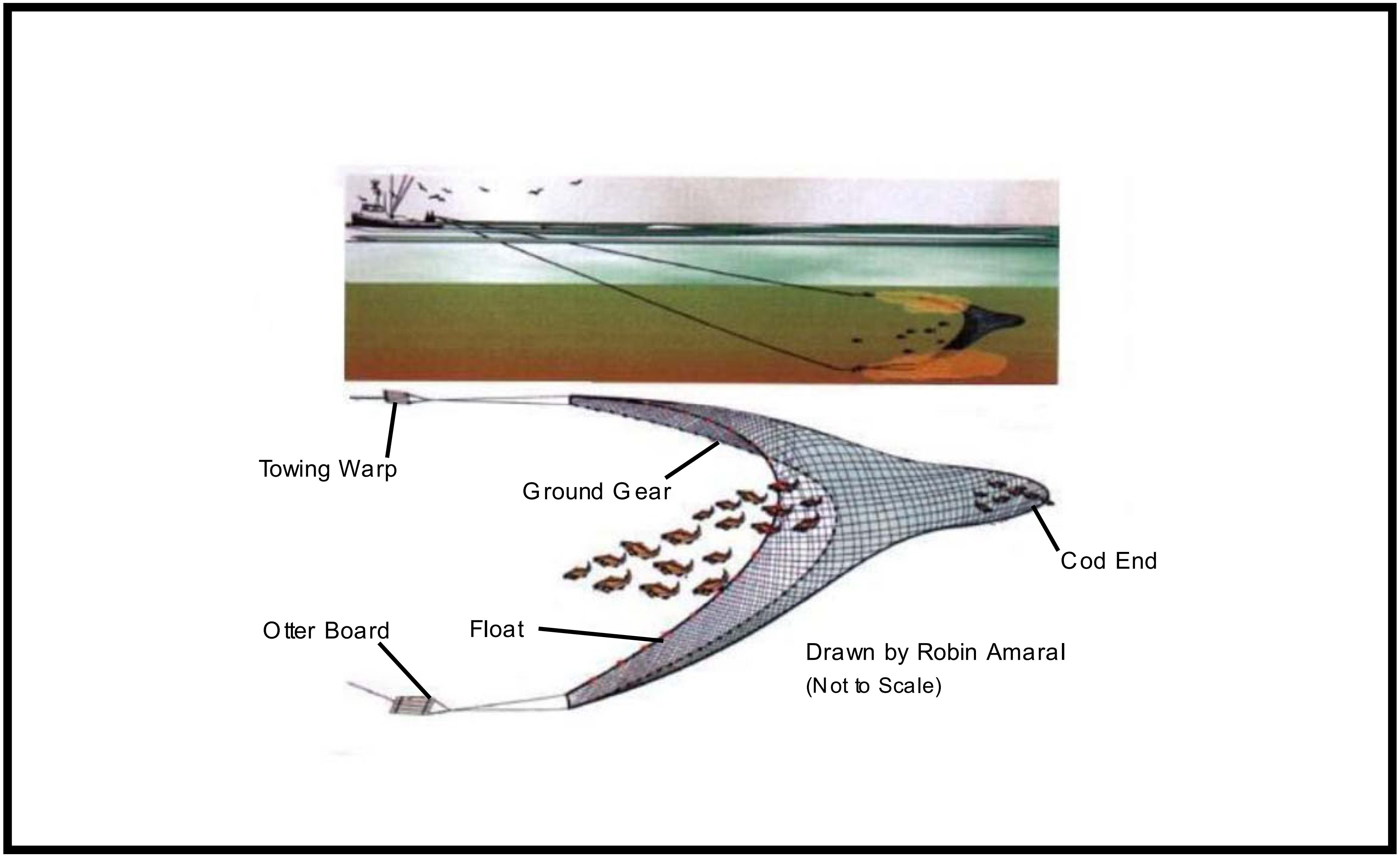


Figure 2. Otter Trawl Net Diagram

Source: Coonamessett Farm, 2001

Figure 3. *Karen M* Research Vessel

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 4). 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 little or no 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 full-length tows with no hang-ups or other gear related problems, or other problems that would diminish the usefulness of the data from an individual trawl.

In previous years, some special-status species (green sturgeon, longfin and delta smelt) were quickly documented and, if alive, were released prior to documenting the remaining catch. During 2010 sampling, two green sturgeon were encountered. They were measured, photographed, and quickly released. Wakasagi and delta smelt were encountered in the man-made portion of the SRDWSC. All osmerids are vouchered for research purpose under the requirements of the CDFG 2081(a) sampling permit.

Additionally collected trawl data included: tow duration; date and time; sampling depth; tidal phase; current speed and direction; boat speed and engine rpm; bird/sea lion presence; direction of water flow (upstream or downstream); 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 sampling. 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 activity could indicate of the presence of adult salmon or other large fish such as catfish and carp that are likely sea-lion prey.

Trawl survey and water quality data was entered into the customized MS Access database running on a portable computer as the information was acquired. Large catches of fish during individual trawls required the use of paper specimen forms (Appendix C) to document the catch as the need to minimize fish mortality outweighed the need to document the data electronically. Catch data was then entered into the database at a later date.

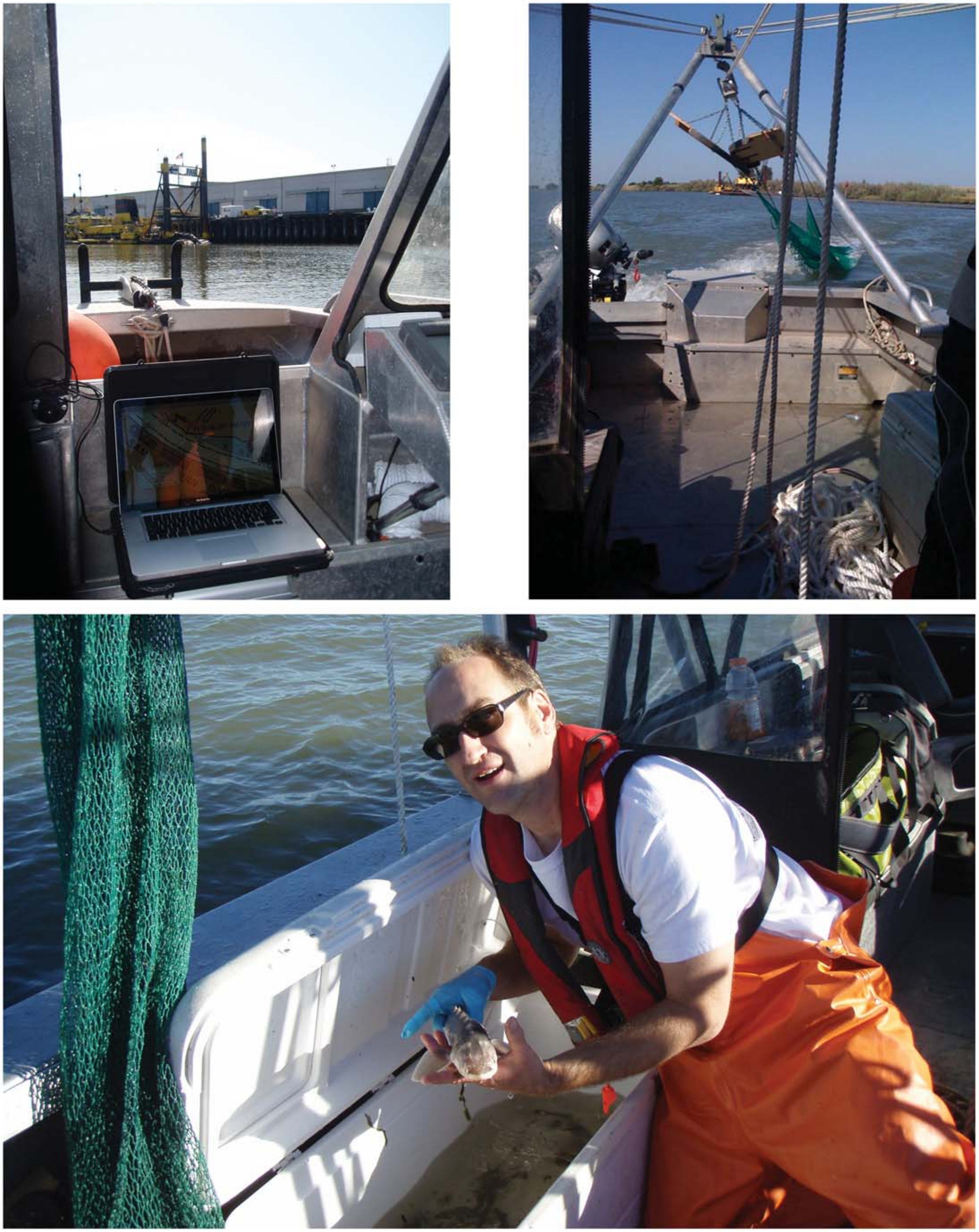


Figure 4. Examples of Fish Community Survey Tools and Methods

3.4 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 sample the dredge disposal stream, which is not uniform throughout the discharge pipe cross-section and thus requires sampling of the entire dredge output during discreet sampling periods.
- Avoid or minimize dredge shutdowns or head loss resulting from sampling.

Two entrainment monitoring alternatives were presented in the 2007-2008 FMP (SWCA, 2007). Both alternatives were modifications of methods that have been used to successfully monitor fish entrainment in Pacific Northwest dredging projects. The two alternatives were the sampling cell method and the collection basket (screen) method (Buell, 1992). The sampling cell method was used in 2006 and 2007. In 2008, the prototype mobile entrainment screen was completed and used at all DMP sites, except the Bradford and Decker Island sites. In 2009 and 2010, all of the entrainment sampling 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 three sampling 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 sampling cell method will again be utilized at these sites. Not used during 2009 or 2010, the method for sampling cell entrainment monitoring is no longer presented in the annual reports. Interested parties can read the 2006-2008 annual monitoring reports or FMPs for more information on this method (available: http://www.mari-gold.biz/).

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 sampling 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 sampling.

3.4.1 Mobile Entrainment Screen

The prototype mobile entrainment screen system was used at most of the DMP sites during the 2008 monitoring season. This system met the project goals of retaining all life stages of entrained organisms, except larval fishes, while also allowing large volumes of sediment to pass through the mesh. It achieved these goals since its use began, and so the screen was used at all sites in 2009 and 2010.

The 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 5). The dredge output pipe was connected to the top of the screen with a Y-valve (Figure 6) operated by the on-shore (fill) crew of the dredge, or the project biologists when fill crew were not available.

Figure 5. Entrainment Screen in Position and in Use at DMP Sites

Figure 6. 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 or 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 sampled 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 sampling 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 3/8-inch diameter 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 2010 is provided in Table 2. For the most part, the dredged sediments consist of sand and silt sized particles. However, a high degree of overall variation in grain size, organic debris, and trash exists among dredge reaches as well as within each dredge reach. The commonly found “U” shape of the typical channel cross-section explains the 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 (example shown in Figure 7), the flow was diverted until the screen was cleared.

High dredge pumping rates also overwhelmed the screen on occasion during 2010 as in 2009, generally when dredge activity was very close to the DMP site and using 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 not counted as sampling time, as any entrained organisms could have been carried off the end of the screen by the high flows and not be documented.

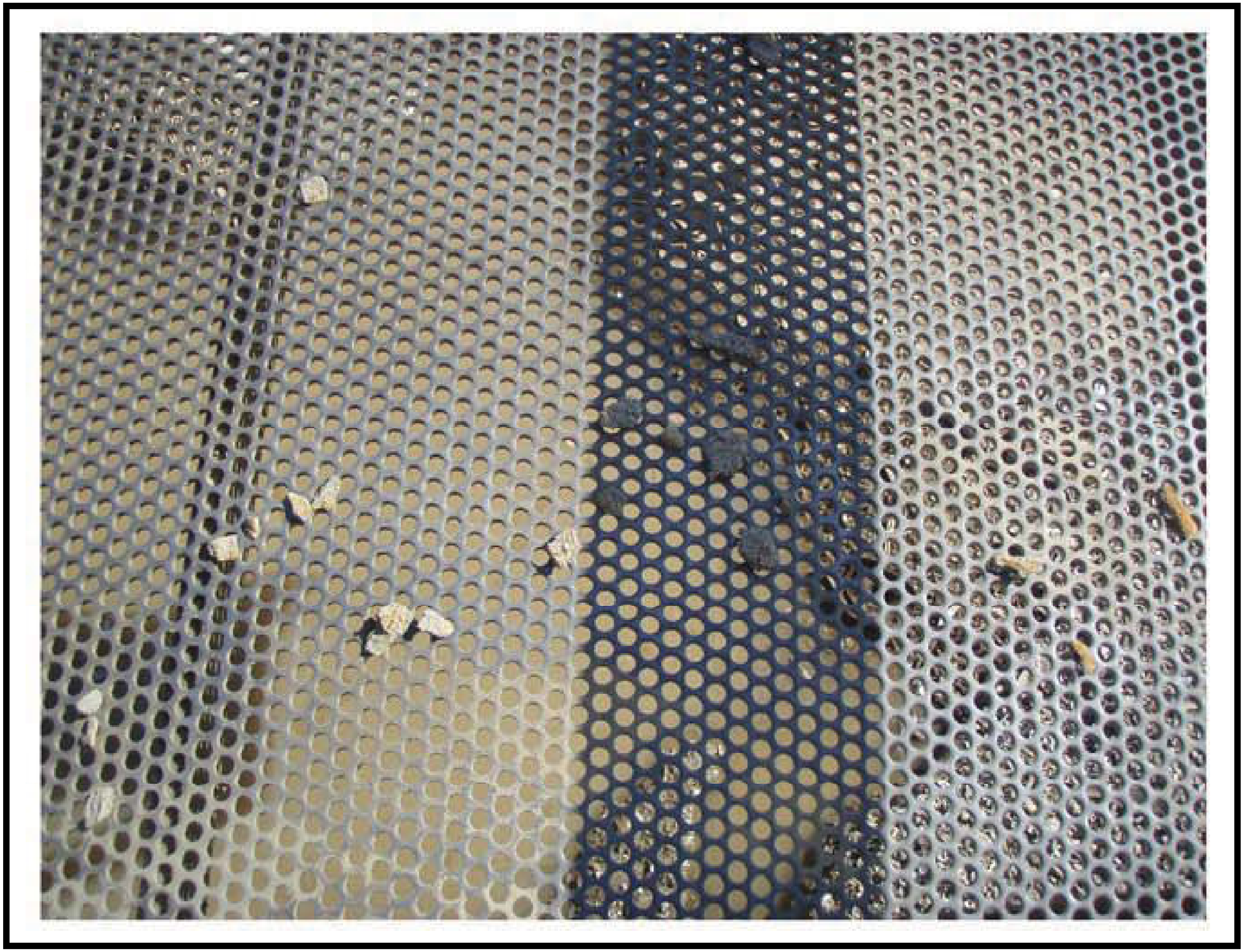
Figure 7. Example of Substrate Debris Collected during Entrainment Screen Collection

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. All but the smallest of the shells are retained by the screen. Many locations also have a percentage of 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.

The screen surface is 24 feet long by 6 feet wide. Modifications to the prototype screen were made prior to the 2010 season based on suggestions in the 2009 annual report (MEC and NAS, 2010) to:

- Maximize the length of time the screen could be operated without powering down the dredge (and thus affecting dredge production) by providing a commercial duty compressor to more reliably open and close the Y-valve.
- Prevent erosion under the axles by adding panels to the underbody of the screen to more effectively shield the axles from dredge slurry passing through the screen.
- Prevent splashing over the sides of the screen box by adding hinged removable lids to the first three sections of the screen.
- Add screening capacity by replacing the first solid panel with punch-hole steel plate to increase the screened area of the device. This solid panel had been placed where screen was intended to be to help shield the axels from splashing. However, it decreased the screens capacity significantly.
- Improve the function of the drop gate at the end of the screen by adding a worm-drive cable drum. The drop gate provides additional screening capacity when lifted, and is dropped out of the way when not needed, allowing debris to be more easily swept from the screen.
- Provide a more useful pressure water system by adding adjustable spray nozzles as well as hose bibs, and utilizing two pumps and a water tank to more consistently provide higher pressure and volume than had been available previously.

The 3/8-inch woven wire mesh screen that was initially used during 2008 monitoring was replaced prior to 2009 sampling with 3/8-inch punch-hole steel plate, with an effective open area of 51% (Figure 8). The punch-hole plate did not clog as quickly as the woven wire mesh and remained in use throughout 2009 and 2010. In addition to clogging less quickly, the punch-hole plate is smoother and easier to clear. It appears to be more fish friendly as well, as the entrained fish slide easily along the smooth steel plate, rather than bumping over wire-mesh. Additional improvements to the prototype screen are discussed in the revised sampling plan (MEC and NAS, 2011) and in the recommendations section of this report.



3/8 in Diameter Punch-Holed Steel Plate

Figure 8. Type of Screen Used for Entrainment Screen Sampling in 2010

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. Parameters were measured using a Horiba U-52 portable water quality meter (Figure 9). Parameters measured included water temperature, dissolved oxygen, pH, conductivity, turbidity, and salinity. For water quality collected prior to November 11, a nomogram was used to calculate DO percentage from the direct DO (ppm) and temperature measures (Hutchinson *in* Bell 1991). Secchi depth was also measured at the surface. Water quality readings were made within the same channel area as the trawl surveys.

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/.

Figure 9. Horiba U-52 Multi-parameter Portable Water Quality Meter

(Manufacurer's Image)

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 sampled, to the total number of gallons of slurry deposited at each DMP site. 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 1and 2).

Entrainment rates for specific species were extrapolated for each location where entrainment occurred during 2010 monitoring. This data should be assessed cautiously considering the small percentage of the dredge output used to calculate the overall entrainment rates. The overall percentage of dredged sediment from both shipping that was sampled in 2010 was 7.23 versus 5.64 in 2009, 4.4 in 2008, 0.35 in 2007 and 0.37 in 2006. Entrainment monitoring in 2009 and 2010 was completed using the entrainment screen at all DMP 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 sampled location, each channel, and both channels combined. The CPUE was determined by comparing numbers of individual fish caught to distance trawled. Mean CPUE for a survey was derived from the mean average of all successful trawl replicates during trawl survey sampling for that day.

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 sampling. 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. This mortality estimation may prove useful for development of best management practices for hydraulic cutter-head dredging.

Many types of fisheries monitoring methods result in mortality to some or all of the sampled fish. Sampling 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 sampling 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.

Percent mortality among fish encountered during community and entrainment sampling was calculated for community sampling 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 sampling, 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 sampling period 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 field laptop computers. 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 on the data collection forms before monitoring or sampling 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 2010, approximately 10% of the physical and water quality survey information was collected on paper forms providing a means to directly cross check duplicate data inputs. One data transcription error was identified and corrected through this data verification process. 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 sampling 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 sampling 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 printed report KML-formatted files from Google Earth are available at http://www.mari-gold.biz/ and provide an interactive display of the 2010 trawl survey locations and DMP sites using satellite imagery.