Napa River Fisheries Monitoring Program
Final Report
2003

Prepared for

U.S. Army Corps of Engineers

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EXECUTIVE SUMMARY

The Napa River/Napa Creek Flood Protection Project was designed by the Napa County Flood Control and Water Conservation District and the U.S. Army Corps of Engineers to provide flood protection and improve habitat in the vicinity of the City of Napa by reconnecting the Napa River to its floodplain, creating wetlands throughout the area, maintaining fish and wildlife habitats, and restoring the natural characteristics of the river. The Napa Project is being implemented along 6.9 miles of the Napa River in Napa County, California. The Project features include dike removal, channel modifications to create floodplain and marsh plain terraces, levees and floodwalls, bridge relocations, pump stations, and maintenance roads/recreation trails for the reach of the river from Highway 29 to Trancas Street. The Fisheries Monitoring Program involves sampling the enhanced areas and the surrounding habitats to evaluate the use of the areas by various fish species. The purpose of the Fisheries Monitoring Program is to determine fish use of the restored and created habitats (open water, marsh plain, and floodplain) created by the Napa Project, with special emphasis on threatened and endangered species.

Fish were captured using beach seines, otter trawls, purse seines, and fyke nets. The otter trawl and purse seine were fished actively in the open water, marsh plain, and floodplain terrace sites, during high tide slack water. The beach seine was fished in the marsh plain and floodplain terraces at varying high tidal heights. Fyke nets were used in small channels in the marsh plain terrace where fish were likely to be concentrated during a falling tide.

Sampling to date has documented that restoration of the area is already providing habitat for native and non-native species. In 2003, a total of 4,007 larval fish and 2,922 juvenile and adult fish were captured. The larval catch was dominated by longfin smelt, and the juvenile and adult species were dominated by Pacific herring and threadfin shad. The sampling program to date (March 2001 to July 2002 and January 2003 to July 2003) has documented use of the Napa Project area by 69,801 larval, juvenile, and adult fish of 34 species. The number of fish captured varied widely between sampling sites within the Napa Project area.

Final
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Annual Report
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1 INTRODUCTION

1.1 Background

The Napa River/Napa Creek Flood Protection Project ("Napa Project") was designed by the Napa County Flood Control and Water Conservation District and the U.S. Army Corps of Engineers (USACE) to provide flood protection for and improve habitat in the vicinity of the City of Napa by reconnecting the Napa River to its floodplain, creating wetlands throughout the area, maintaining fish and wildlife habitats, and restoring the natural characteristics of the river. The Project consists of five separate contracts developed as a cooperative effort between the City of Napa, Napa County, the USACE, Community Coalition, Federal and State resource agencies, and consultants. Construction of the Project is currently phased over seven years from 2000 through 2006.

The Napa River Fisheries Monitoring Program (FMP) was developed as a requirement of the 9 April 1999 U.S. Fish and Wildlife Service (USFWS) Biological Opinion for the Napa Project. The FMP is primarily designed to detect the presence of fish species in the program area before and after construction of the Napa Project. Fish habitat restoration features of the flood protection project are being evaluated to determine use of the area by various fish species. A work plan for the FMP was published in March 2003 (USACE 2003a). The FMP is coordinated with other government sponsored scientific studies in the Bay-Delta, and is Interagency Ecological Program Element 2002-105. Fish surveys began in July 2001 and have continued through July 2003.

1.2 Project Description

The Napa Project is being implemented along 6.9 miles of the Napa River in Napa County, California (Figure 1-1 and Figure 1-2). Project features include dike removal, channel modifications to create floodplain and marsh plain terraces, bridge relocations, and construction of levees and floodwalls, pump stations, maintenance roads, and recreation trails for the reach of the river from Highway 29 to Trancas Street.

The Napa Project also includes the Napa River Enhancement Plan for the South Wetlands Opportunity Area (SWOA). This enhancement plan calls for restoration of physical and biological processes in the Napa River estuary and the SWOA, extending along the west side of the river from Newport North Marina to the Highway 29 bridge. The enhancement plan also calls for creating 104 acres of emergent marsh, converting 262 acres of farmland to emergent marsh, and creating and enhancing 136 acres of seasonal wetlands (USACE 2001a). The enhancement plan includes lowering levees, breaching dikes, and constructing marsh plain and floodplain terraces.

The FMP involves sampling of the enhanced areas and surrounding habitats to evaluate the use of the areas by various fish species. Information gathered as part of the FMP will potentially influence future management decisions and restoration designs, and serve to validate environmentally fish-friendly designs in future flood control programs. Data collected as part of the FMP will also be used to guide the adaptive management decisions described in the Mitigation Monitoring Program for the Napa Project (Jones and Stokes 2001).

1.3 Construction Project Status

The construction contracts completed to date include:

Table 1-1. USACE Construction Project Status.[1]

Construction Project	Description	Status
Contract 1A	Terrace excavation and construction of vineyard dike	Completed fall 2000
Contract 1A	Revegetation Contract	Completed fall 2003
Contract 2	Napa Valley Wine Train Phase 1 Relocation	Completed January 2003
Petroleum Contaminated Soil Remediation	Creation of marsh plain terrace and floodplain terrace habitat	Completed December 2002
Sixth Street Remediation		Completed summer 2003
Contract 1B	Marsh plain and floodplain excavation	Scheduled to begin in summer 2004

[1] Mike Dietl, USACE, pers. comm., 2002 and Will Hall, USACE, pers. comm., 2003

1.4 Fisheries Monitoring Status

The purpose of the FMP is to determine fish use of the restored and created habitats (open water, marsh plain, and floodplain) created by the Napa Project, with special emphasis on threatened and endangered species. Sampling efforts in 2003 consisted of monthly sampling between January and July, plus semi-monthly sampling in March and April.

Site 3-1, January 2003.

Although this annual report is for 2003, parts of this report also include data from 2001 and 2002 (particularly Appendix A and B). Tables and figures are labeled according to the year data were collected.

The FMP has the following objectives:

1) Document presence and relative abundance of fish species (particularly delta smelt and Sacramento splittail) utilizing restored and created habitats.

2) Document life stages and seasonality of fish species (particularly delta smelt and Sacramento splittail) in restored and created habitats.

3) Determine if correlations exist between collected fish species and environmental conditions at each sampling site.

In order to meet these objectives, the following hypotheses were developed as part of the monitoring program:

Fish, in particular delta smelt and Sacramento splittail, will use habitat created or restored by the Napa Project.
Certain life stages of fish species, in particular delta smelt and Sacramento splittail, will use specific habitat types in the Napa Project area during specific seasons and environmental conditions.

Fish surveys have documented that the restoration of the SWOA is providing habitat for native and non-native species. In 2003, a total of 5,501 fish were sampled, including 1,494 juvenile and adult fish from 21 species, and incidental capture of 4,007 larval fish from 8 identified species. To date (July 2001-July 2002, and January 2003–July 2003), a total of 9,915 juvenile and adult fish have been captured, representing 31 species.

Sacramento sucker caught at Site 1B-1, March 2003.

Native species captured in 2003 included Sacramento splittail, Pacific herring, Chinook salmon, threespine stickleback, staghorn sculpin, prickly sculpin, Sacramento sucker, and tule perch. Introduced species captured included yellowfin goby, American shad, threadfin shad, shimofuri goby, black crappie, striped bass, inland silverside, mosquitofish, common carp, bluegill, largemouth bass, rainwater killifish, and white catfish.

Subsequent sections of this document present the methods and results of the FMP to date, and begin to address the objectives and hypotheses stated above. Background information, data, and reports associated with the FMP (including this report) are available online at http://www.napariverfishmonitoring.org.

Site 1A-10, May 2003.

2 METHODS

Sampling methods consisted of deploying various gear types (Table 2-1) at selected sites (USACE 2001b) on a monthly or semi-monthly schedule (Table 2-2), to capture various life stages of the fish species that occurred in the area.

Table 2-1. Napa River Fisheries Monitoring Program: Gear Specifications and Level of Effort in 2003.

Gear/ Sampling Technique	Dimensions	Mesh Size	Site Locations	Sampling Duration	Number of Samples per Sampling Event
Fyke Nets	Opening: 0.9-1.2 m Length: 6.1-9.2 m Leads: 3.1 m	0.64 cm	SWOA Slough (1A-6), SWOA Marsh (1A-7), SWOA-Horseshoe Bend Marsh (1A-10)	4-6 hours per set	1 set
Otter Trawl	Opening: 1 x 2.5 m Length: 5.3 m	Variable: 0.64 cm– 3.8 cm	Open Water-Horseshoe Bend (1A-2), Open Water (1A-1), Open Water (2-1), Open Water (1B-1)	10-15 minutes per tow, at 1-2 knots	2-3 tows
Purse Seine	Length: 30.5 m Depth: 1.8 m	0.64 cm	Open Water (3-1)	20-30 minutes per set	2-3 sets
Beach Seine	Length: 30.5 m and 15.2 m Depth: 1.2 m Plus bag	0.64 cm	Floodplain Terrace (1A-4), Marsh plain Terrace (1A-3), Marsh plain Terrace (2-2)	20 minutes per haul	2-3 hauls

Table 2-2. Napa River Fisheries Monitoring Program: Monthly Sampling Schedule in 2003.*

Site	Classification	Description	Jan	Feb	March		April		May	June	July
			29 & 31	26-27	13	27-28	10-11	24-25	13-14	7-8	23-24
1A-1	Open water	Open water (River)	OT	OT	OT	OT	OT	OT	OT	OT	OT
1A-2	SWOA	SWOA slough	OT	OT	OT	OT	OT	OT	OT	OT	OT
1A-3	Marsh plain	Marsh plain terrace	BS	BS	BS	BS	BS	BS	BS	BS	BS
1A-4	SWOA	Floodplain terrace	BS	BS	BS	BS	BS	BS	BS	BS	BS
1A-6	SWOA	SWOA marsh	-	-	FN	FN	FN	FN	FN	FN	FN
1A-7	SWOA	SWOA marsh	-	-	FN	FN	FN	FN	FN	FN	FN
1A-10	SWOA	SWOA HB marsh	-	-	FN	FN	FN	FN	FN	FN	FN
1B-1	Open water	Open water (River)	OT	OT	OT	OT	OT	OT	OT	OT	OT
2-1	Open water	Open water (River)	OT	OT	OT	OT	OT	OT	OT	OT	OT
2-2	Marsh plain	Marsh plain terrace	BS	BS	-	-	-	-	-	-	-
3-1	Open water	Open water (River)	PS	PS	PS	PS	PS	PS	PS	PS	PS

*FN = fyke net; PS = purse seine; OT= otter trawl; BS = beach seine.

2.1 Site Selection

On 8 June 2001, Stillwater staff and USACE personnel established 13 fish monitoring sample sites along 6.9 miles in the Napa Project area, including the SWOA (Figures 2-1 through 2-4). Individual sites were typically marked by 1.3-2.4 m (6-8 ft) metal posts driven into the substrate, spray-painted orange, and flagged with green tape. Chaudhary and Associates surveyed the selected sample sites (USACE 2001b) to a tolerance of 0.3 m for latitude and longitude, and 0.15 m for elevation. The 13 sites represent three habitat types that may attract breeding and rearing of delta smelt and Sacramento splittail: marsh plain terrace, floodplain terrace, and open water habitat. There are seven SWOA sites, including two sites in the Horseshoe Bend channel and five sites north of the levee breach. There is one marsh plain site, which is located east of the SWOA area. The four open water sites can be found throughout the main waterway of the Napa River. The open water sites begin just east of the SWOA in the main channel and continue throughout the 6.9 mile Project area. Table 3 summarizes locations of sampling sites for 2003. Three sites were subject to minor relocations from 2001 to 2002. One site was removed from the sampling list due to ineffectiveness and lack of fish caught (Site 1A-5). In 2003, two sites were not sampled due to lack of funding (Sites 1A-8 and 1A-9). One new site was discontinued to concentrate sampling effort to sites with historical data (Site 2-2). These changes are noted in Table 2-3 and are detailed in the site descriptions that follow.

2.2 Site Locations

Sampling locations are documented in Figures 2-1 through 2-4. Locations and elevations of the sites are shown in Table 2-3. Brief descriptions of each site are provided below.

Table 2-3. Location of Sampling Sites for the Napa River Monitoring Program.

Site No.	Latitude			Longitude			Elevation
	Degrees	Minutes	Seconds	Degrees	Minutes	Seconds	(feet)
1A-1	38	15	17.7	122	17	0.3	N/A
1A-2**	38	14	54.567	122	17	16.942	4.0
1A-3	38	16	2.0674	122	17	11.425	0.6
1A-4*	38	16	1.378	122	17	15.732	5.7
1A-6**	38	15	13.487	122	17	37.573	-3.2
1A-7	38	15	21.592	122	17	34.580	-0.5
1A-8***	38	15	21.339	122	17	38.150	-1.1
1A-9***	38	15	11.124	122	17	38.159	4.3
1A-10**	38	14	57.725	122	17	16.777	-3.3
1B-1	38	16	23.1	122	17	4.7	N/A
2-2***	38	17	24.7	122	16	53.9	N/A
2-1	38	17	10.1	122	17	0.2	N/A
3-1	38	18	8.708	122	16	43.884	26.5
Standpipe*	38	16	4.838	122	17	26.263	2.6

* Standpipe and a t-bar post at Site 1A-4 were used for obtaining position bearings during roving beach seines in the SWOA if a GPS signal could not be recorded.

** Positions approximate due to minor relocations in 2002

*** Positions not sampled in 2003.

Site 1A-1 is sampled with an otter trawl (Figure 2-1). The site position was previously established by CDFG for the 20 mm tow-net surveys in 2001. This site is located by the SWOA in the main Napa River channel, in close proximity to the peninsula formed by Horseshoe Bend.

Site 1A-2 is sampled with an otter trawl. It was originally located in the upper reaches of the main drainage channel in Horseshoe Bend (west of current Site 1A-10). However, due to excessive and repeated clogging of the otter trawl by debris (automobile tires), the site was relocated to the main channel that flows north-south through the SWOA (Figure 2-1).

Site 1A-3 is sampled with a beach seine and is located on the west bank of the main channel of the Napa River, just upstream of the JFK Park boat ramp (Figure 2-2). The site is located on bare earth or mud where a levee was removed by the USACE as part of the Napa Program. The site is inundated during high tides. Site 1A-3 was originally sampled with a fyke net, but it was found to be more effectively sampled with a beach seine.

Site 1A-4 is an area at the north end of the SWOA sampled by beach seine (Figure 2-2). The roving beach seine was used to sample various locations in the marsh during the flood, high, and ebb tides.

Beach seining at Site 1A-4, February 2003.

Site 1A-5 was sampled by a fyke net and was initially sampled through November 2001 (Figure 2-1). However, since the fyke net did not capture fish, sampling effort was discontinued to other sites.

Site 1A-6 was sampled with a fyke net (Figure 2-1). The location of this site was moved out of the main SWOA channel due to human safety and fish injury concerns: ie the placement and removal of the fyke net in high velocity water was dangerous, and the potential for injury and mortality to the fish captured was high. The site was first moved to the east side of the terrace where water velocities were lower. The site is currently located about 7 m west from its initial location, across the main channel, in a small channel that drains the southwest part of the SWOA. The substrate is mud. This site is currently positioned to sample fish that concentrated in the tidal channel during a receding tide.

Site 1A-7 is sampled with a fyke net (Figure 2-1). This site is located in a tidal channel that drains from the eastern side of the SWOA marsh into the main marsh channel, which drains into Horseshoe Bend. This site was established to sample fish that concentrate in the tidal channel during a receding tide.

Site 1A-8 is sampled with a fyke net similar to Site 1A-6 and 1A-7. It is located in a tidal channel that drains from the western side of the SWOA marsh (Figure 2-1). This site was located to sample fish that concentrate in the tidal channel during a receding tide. This site was not sampled in 2003 due to budget constraints.

Site 1A-9 is sampled with a purse seine and is located at the levee breach where the main SWOA marsh channel enters Horseshoe Bend (Figure 2-1). This site was established to sample fish distributed in mid-water depths at the levee breach. This site was not sampled in 2003 due to budget constraints.

Site 1A-10 is sampled with a fyke net and is located slightly upstream of the peninsula levee breach (Figure 2-1). The substrate is mud. This site was established to sample fish distributed in the channel during a receding tide. The location of this site was moved due to human safety and fish injury concerns: ie the placement and removal of the fyke net in high velocity water was dangerous, and potential injury and mortality to the fish captured was high. The site was moved about 9.5 m northwest from its initial location to an outflow channel that allows safer boat and wading access in 2002.

Site 1B-1 is in open water and is sampled by otter trawl. It is located in the main Napa River channel, 1 km upstream of the JFK Park boat ramp (Figure 2-2).

Site 1B-1, June 2003.

Site 2-1 is in open water and is sampled by otter trawl. It is located in the main Napa River channel, at Jacks Bend (Tulocay Creek confluence) (Figure 2-3).

Site 2-2 is sampled with a beach seine and is located on the east bank of the main channel of the Napa River, just upstream of New Tulocay Creek (Figure 2-3). The site is located on bare soil or mud where a levee was removed by the USACE as part of the Napa Project. The site is inundated during high tides. This site was discontinued in 2003 due to budget constraints.

Site 2-2 at low tide, January 2003.

Site 2-2 at high tide, January 2003.

Site 3-1 is in open water and is sampled by purse seine. This site is located in the main Napa River channel, just downstream of the First Street Bridge (Figure 2-4). This site was chosen to provide a more upstream mid-water habitat area.

2.3 Gear Types

Various gear types tested in 2001 and subsequent adjustments are presented in detail in the 2001 Napa River Fisheries Monitoring Program Annual Report (USACE 2002). Except where noted, sampling during the January 2003 through July 2003 period used these same gear types and methods.

2.4 Quality Control Procedures

The methodology and standard operating procedures implemented for quality control (Q/C) are described in the Final Workplan and QA/QC Plan for Implementation of the Year 2001 Napa River Fisheries Monitoring Program (USACE 2001a) and summarized below.

2.4.1 Preparation of equipment

All equipment was prepared and calibrated prior to use each month. The following list itemizes equipment preparation procedures:

- YSI 85 meter (DO, Salinity, Temperature, Conductivity): calibrate to manufacturer's specifications.
- General Oceanics flow meter: Initially calibrate the number of revolutions with the distance traveled through the water. Recheck calibration prior to use each month.
- The "calibration checklist" on the data sheets was used to verify completed calibration procedures for all equipment, and completion was noted on the data sheets for each field effort.

2.4.2 Sample replications

Replicate samples of two or three tows, or sets, were performed at sites where an otter trawl, purse seine, or beach seine was used.

There were no replicate samples taken at the fyke net sites. Individual fyke nets were set monthly or semi-monthly at each site, and generally "fished" from high slack until their retrieval near low tide.

2.4.3 Sample preservation, transportation, storage and disposal

Specimens used to confirm positive fish species identification in larval and adult samples collected by the FMP Implementation Team were preserved in 10 percent formalin and placed in glass or plastic specimen jars for storage. Jars were labeled with date, time, location, and the sample collector's name. Fish collected for fish identification are currently being stored at Stillwater Sciences in Arcata.

2.4.4 Sample and data collection

Field data were collected on standard forms to minimize the potential for missing values. The Field Leader, or other crew members that did not record the data, reviewed the datasheets on a daily basis for the following:

- Completion of all data fields
- Reasonableness of measurements
- Legibility of recorded data

The reviewer initialed each data sheet as having been reviewed for accuracy and completeness before leaving the site on each sampling date.

2.4.5 Data summary and processing

Following field data checking, additional Q/C measures were implemented during data entry and data summary. During data entry into the relational database, the database software was able to prevent or detect many types of errors with the following methods:

Mandatory Fields. Although not all fields must be entered for every record, there are many mandatory fields, such as sampling-site identification number and date.

Data Format Checks. The data entry form prevented the wrong type of data from being entered into a field. For example, text could not be entered into numeric fields, and numeric data must be entered with the correct decimal placement.

Lookup Tables. Many data elements had unique values that must be used; such as fish sample method and sampling plot identification number. Rather than enter values for these fields and risk making a typographical error, lookup tables were used with data entry drop-down menu lists, so that only a listed, valid value could be selected.

Numeric Range Tests. For numeric data elements, such as fish counts, the value entered was tested against preset minimum and maximum values, to ensure that the data entered was within the valid range.

Incomplete or Illegible Data. If the field data collection forms had illegible or missing mandatory data, the data was corrected and a member of the QA/QC team revised the database with the correct information.

Data Entry Report and Field Form Comparison. At the completion of each data entry session, the data entry technician printed out a report of the data entered. This printout was compared to the field data entry forms for accuracy.

2.5 Sampling Methods

Four gear types were used to sample fish in the Project area, using a 6.4 m (21 ft) aluminum workboat. Fyke nets were used in small channels in the marsh plain terrace where fish were likely to be concentrated during a falling tide. The purse seine was fished in the open water sites, during high tide slack water. The otter trawl was fished in the open water sites at varying tidal heights. The beach seine was fished in the marsh plain and floodplain terraces at varying high tidal heights and during flooding periods. Gear specifications and replicate numbers can be found in Table 2-1.

2.5.1 Fyke nets

Deploying fyke net at Site 1A-7, July 2003.

Fyke nets were deployed to capture fish in shallow marsh areas with moderate to swift current. The fyke nets were approximately 3.6 m (12 ft) long with 0.64 cm (¼ in) mesh. Each net consisted of seven 0.91 m (3 ft) diameter hoops with two 3 m (10 ft) leads. Fyke nets were secured in the current by t-posts that had been driven into the substrate. Four pieces of PVC pipe were attached to the entrance of the net and each wing, and slid over the t-posts. The pipe facilitated deployment and retrieval, and a secure fit of the nets to the t-posts. Fyke nets were deployed during daytime high tides and were fished for approximately four to six hours during the receding tide. During the receding tide, the fyke net wings diverted the fish into the traps. The field crew retrieved the nets during the ebbing tide, and collected all fish that were captured. All fyke nets were removed from the water after each sample was collected. Catch per unit effort (CPUE) was calculated by dividing the number of fish of each species by the time the fyke net was fished (beginning at the time of slack tide).

2.5.2 Otter trawls

Otter trawling at Site 1A-2, March 2003.

Otter trawls are funnel-shaped nets used to sample benthic and mid-water column fish. The tail, or "cod" end of the net is 0.64 cm (¼ in) mesh, and the mouth opening is 1 x 2.5 m (8.2 ft). The length is approximately 5.3 m (17.4 ft). The otter trawl was towed from the stern of the boat. The otter trawls were fished once or twice a month during daylight hours, around high tide slack water. The duration of each trawl was short (approximately 10-15 minutes), to minimize stress to captured fish. The water volume sampled by the trawl was calculated using a General Oceanics flow meter that was towed from the side of the boat. The flow meter was calibrated over a measured distance prior to sampling. Volume was calculated by multiplying the distance sampled (represented by flow meter readings that accounted for the horizontal distance traveled and the current) by the known area of the net opening. CPUE was calculated by dividing number of fish of each species by the volume of water sampled.

2.5.3 Purse seines

A purse seine was used to sample fish concentrated in the mid-water zone. The seine was a 30.4 m (100 ft) long by 2.5 m (8 ft) deep net with 0.64 cm (¼ in) mesh. The top of the net was connected to floats which supported the net in open water. The net was deployed off the boat in a circular pattern. Once the circle was completed, the purse line along the bottom of the net was pulled tight to seal the opening, trapping the fish. The volume of water was sampled by estimating the length and the width of the deployed seine once the enclosure was complete. CPUE was calculated by dividing the number of fish of each species by the water volume.

Purse seine deployment at Site 3-1, March 2003.

2.5.4 Beach seines

Two beach seines were used alternately to target fish in shallow water habitats with low to moderate current. The first beach seine measured 30.5 m (100 ft) long by 1.8 m (6 ft) high. The second seine measured or 15.3 m (50 ft) long, and was also 1.8 m (6 ft) high. Both seines had 0.64 cm (¼ in) mesh and a 1.8 m^2 (6 ft^2) bag. Once deployed, the seine created a net wall extending from the surface with a floated line, to the bottom of the water column with a lead line. The mesh panels hanging from the float line to the lead line prevented fish from escaping. One sampling method involved deploying the beach seine from the boat, which required one end of the seine to be secured onto the bank and one end secured to the boat. The boat was backed away from the shore, deploying the net, and then was driven back to the shore downstream or upstream of where the seine was secured on the bank. The seine was then pulled onto the shore by hand. Alternatively, in shallow water, the beach seine was stretched out between two people and dragged through the water toward shore or back to the boat where it was hauled out of the water. Beach seining was conducted during the day, near slack water at high tide each month. The volume of water sampled was estimated by multiplying the seine width by water depth and the distance covered. CPUE was calculated by dividing the number of fish of each species by the calculated volume of water sampled.

2.5.5 Fish processing

After the fish were retrieved from the sampling gear, they were placed into buckets with water. Fish were kept in water during processing, and gloves used where necessary and practical to minimize injury to fish. If necessary, an anesthetic such as MS222 or CO_2 was available for use. All fish specimens were collected, processed, and returned to the water as soon as possible.

Carp captured at Site 2-1, March 2003.

The following data were recorded for fish collected at each sampling site location:

- Identification of all fish captured to species level;
- Fork length (mm). If large numbers of a non-listed fish species were captured [e.g., inland silversides], then fish were counted and a representative sample of size ranges was measured. In July 2003 we began measuring standard length (mm) and total length (mm) of splittail to facilitate age/length correlations. For splittail data analysis, fork length was converted to standard length ($y = 0.8722x - 0.2657$) (Randy Baxter, California Department of Fish and Game, 2003);
- Weight (g) was measured for all listed species;
- Reproductive state or spawning stage was verified for specimens of listed species by applying mild pressure to belly to examine if milt or eggs were present;
- Noticeable lesions were recorded for listed species specimens;
- Photos were taken of representative fish species.

2.5.6 Larval fish processing 2003

The 2003 surveys incidentally captured larval fish in the adult and juvenile sampling gear (fyke nets, otter trawls, and beach seines). Larval fish captured in 2003 were processed using the larval fish processing protocol of 2001 (USACE 2002). Larval fish were identified to determine if any listed species were sampled. For samples containing more than one hundred fish of the same species, the first one hundred were measured and lengths were estimated on the additional fish. Quality Assurance and Quality Control (QA/QC) was performed by a larval fish specialist to insure correct identification of larval fish.

2.5.7 Environmental conditions

Environmental conditions were measured while sampling at each site on each sampling day. The Napa River discharge was determined upstream of the tidal influence, from the Napa River gaging station. The gaging station is located 9.6 km upstream of the Project area (38^{o} 36' 70"N, 122^{o}30'00"W) and did not include inflow from Napa Creek and Soda Creek, as their confluence with the Napa River is below the gaging station. Digital photographs were taken at each site to document vegetation conditions, site conditions, and examples of captured fishes. These digital photographs were catalogued along with the associated site identification. The following data were collected at each site and input into the FMP database:

Tule perch captured at Site 1B-1, July 2003.

- Dissolved oxygen (mg/l), water temperature (^{o}C), and salinity (ppt) were measured at the surface and bottom at each site with a YSI Model 85 meter.
- Turbidity (mm) was measured using a secchi disk. The disk was lowered into the water column on a cable, and the greatest depth at which the disk could be observed was recorded in cm.
- Tidal elevation (ft) was noted daily from a Napa River gage near the Horseshoe Bend confluence. The tide elevation during each sampling event was calculated with the use of a Nautical Software tidal chart for the Napa River.
- Water depth (ft) was measured via marks on a stadia rod or with a depth sounder.
- Photos were taken with a Cannon A40 digital camera (resolution 1024x768).

3 RESULTS

3.1 Fish Relative Abundance and Distribution

The results of the FMP 2003 field effort, including the number of each species captured during each sampling effort by site and gear type, are presented in Table B-1 (Appendix B). In 2003, a total of 1,494 juvenile and adult fish were sampled, representing 8 native and 13 non-native species (Table 3-1 and Table B-1), and a total of 4,007 larval fish were captured (Table 3-2), representing 4 native and 4 non-native species (Table 3-1).

All gear types captured fish in 2003 (Figure A-1 [Appendix A]): the beach seine captured the greatest percentage of fish (48 percent), followed by otter trawl (31 percent), fyke nets (19 percent), and purse seine (2 percent). The dominant species captured by each gear type were threadfin shad in the beach seine (42 percent), Pacific herring in the fyke net (79 percent), striped bass in the otter trawl (28 percent), and threadfin shad in the purse seine (67 percent) (Figure A-2).

The number of juvenile and adult fish captured varied widely between sampling sites within the Napa Project area (Figures A-3 through A-13). The most common non-larval species captured in 2003 was juvenile threadfin shad (n= 803), found mostly in July, followed by Pacific herring (n=648) found mostly in April (Table B-1). The next most numerous species was inland silverside (n=406), followed by shimofuri goby (n= 341).

Differences in fish species composition were also observed in different habitat types from January to July 2003 (Figures A-14 through A-16). Open water habitat catches were dominated by striped bass (31 percent), followed by threadfin shad (25 percent) and Pacific herring (19 percent). Marsh plain habitat catches were dominated by threadfin shad (54 percent) followed by inland silverside (21 percent), shimofuri goby (7 percent), and starry flounder (4 percent). SWOA habitat catches were dominated by Pacific herring (47 percent), followed by shimofuri goby (23 percent) and inland silverside (16 percent).

While sampling for juvenile and adult fish in the SWOA and open water habitat, larval fish were caught using beach seines, fyke nets, and otter trawls. Sampling efforts for juvenile and adult fish captured 4,007 larval fish, including eight identified species (Tables 3-1 and 3-2). The dominant larval species captured were longfin smelt (89 percent), followed by striped bass (6 percent), and unidentified damaged larvae (5 percent); Pacific herring, yellowfin goby, shimofuri goby, inland silverside, prickly sculpin, and starry flounder totaled less than 1 percent of the total catch (Figure A-17). All larval longfin smelt were captured in the months of February through April, where as all larval striped bass were captured during June and July. Larval longfin smelt were captured by otter trawls and fyke nets. Larval striped bass were captured by otter trawls, fyke nets, and beach seines (Table 3-2).

Table 3-1. Napa River Fisheries Monitoring Program: Fish Species Captured in July 2001-July 2002 and January 2003-July 2003.

Common Name	Scientific Name	Juvenile and Adult Fish	Larval Fish	Native or Introduced
American shad	*Alosa sapidissima*	• * ■		Introduced
Arrow goby	*Clevelandia ios*		•	Native
Bay goby	*Lepidogobius lepidus*		•	Native
Black crappie	*Pomoxis nigromaculatus*	* ■		Introduced
Bluegill	*Lepomis macrochirus*	■		Introduced
Channel catfish	*Ictalurus punctatus*	*		Introduced
Chinook salmon	*Oncorhynchus tshawytscha*	* ■		Native
Carp	*Cyprinus carpio*	• * ■		Introduced
Delta smelt [FT, CT]	*Hypomesus transpacificus*	*	•	Native
Golden shiner	*Notemigonus crysoleucas*	*		Introduced
Inland silverside	*Menidia beryllina*	• * ■	• ■	Introduced
Jack smelt	*Atherinopsis californiensis*		•	Native
Largemouth bass	*Micropterus salmoides*	■		Introduced
Longfin smelt [CSC]	*Spirinchus thaleichthys*	•	• * ■	Native
Long-jawed mudsucker	*Gillichthys mirabili*	• *	•	Native
Mosquitofish	*Gambusia affinis*	• * ■		Introduced
Northern anchovy	*Engraulis mordax*	•	• *	Native
Pacific herring	*Clupea pallasii*	* ■	• * ■	Native
Pacific sanddab	*Citharichthys sordidus*	*		Native
Prickly sculpin	*Cottus asper*	• * ■	• ■	Native
Rainwater killifish	*Lucania parva*	■		Introduced
Sacramento splittail [FT, CSC]	*Pogonichthys macrolepidotus*	• * ■	•	Native
Sacramento sucker	*Catostomus occidentalis*	■	•	Native
Shimofuri goby	*Tridentiger bifasciatus*	• * ■	• * ■	Introduced
Staghorn sculpin	*Leptocottus armatus*	• * ■		Native
Starry flounder	*Platichthys stellatus*	• ■	■	Native
Steelhead [FT]	*Oncorhynchus mykiss*	*		Native
Striped bass	*Morone saxatilis*	• * ■	• ■	Introduced
Threadfin shad	*Dorosoma petenense*	• * ■	•	Introduced
Threespine stickleback	*Gasterosteus aculeatus*	* ■	•	Native
Tule perch	*Hysterocarpus traski*	• * ■		Native
Wakasagi	*Hypomesus nipponensis*	• *		Introduced
White catfish	*Ameiurus catus*	■		Introduced
Yellowfin goby	*Perca flavescens*	• * ■	• * ■	Introduced

• July – December 2001

* February – July 2002

■ January – July 2003

FT = Listed as threatened under ESA

CT = Listed as California Threatened

CSC = Listed as California Species of Concern

In 2003, both native and non-native species were represented in the catch (Figure 3-1). Native fish dominated the catch in April of 2003, mostly represented by the high numbers of Pacific herring. Non-native species dominated the catch during January through March, and May through July 2003. When the most dominant native species (Pacific herring) and non-native species (threadfin shad) are excluded from the data, the April catch is dominated by non-native species (Figure 3-2).

A notable difference can be seen between the distribution of native and non-native species by the habitat types represented in the Napa River Project area in 2003. In the open water and marsh plain habitat, introduced species represented 74 and 88 percent of the catch respectively (Figure 3-3). In the SWOA, the fish composition dramatically changes, showing the native species dominating with 54 percent of the catch. In the SWOA and marsh plain the proportion of native and introduced species was similar, compared to the open water where a higher proportion of introduced species dominated the catch (Figure 3-4).

Table 3-2. Larval fish results for the Napa River Project Area in 2003.

Location Code / Gear Type / Replicate Number	Striped bass	Pacific herring	Longfin smelt	Yellowfin goby	Shimofuri goby	Inland silverside	Prickly sculpin	Starry flounder	Unidentified (damaged)	Total
Date: 2/26/03										
1A-1 Otter Trawl 1 of 2			4						2	6
1A-1 Otter Trawl 2 of 2			12						3	15
1A-2 Otter Trawl 1 of 2			41							41
February Subtotal	0	0	57	0	0	0	0	0	5	62
Date: 3/13/03										
1B-1 Otter Trawl 1 of 2			12						5	17
1B-1 Otter Trawl 2 of 2			74						9	83
2-1 Otter Trawl 1 of 2			152						38	190
2-1 Otter Trawl 2 of 2			1,262						47	1,309
1A-1 Otter Trawl 1 of 2			292						22	314
1A-1 Otter Trawl 2 of 2			586	2					45	633
1A-2 Otter Trawl 1 of 2			166	2					2	170
1A-2 Otter Trawl 2 of 2		1	155	1						157

Location Code / Gear Type / Replicate Number	Striped bass	Pacific herring	Longfin smelt	Yellowfin goby	Shimofuri goby	Inland silverside	Prickly sculpin	Starry flounder	Unidentified (damaged)	Total
Date: 3/27/03										
1A-6 Fyke		2				1				3
1A-7 Fyke		1	3							4
Date 3/28/03										
1A-1 Otter Trawl 1 of 2			147		1		1		6	155
1A-1 Otter Trawl 2 of 2			59				2		3	64
March Subtotal	0	4	2,908	5	1	1	3	0	177	3,099
Date: 4/10/03										
1A-1 Otter Trawl 1 of 2			2							2
1A-1 Otter Trawl 2 of 2			8							8
1B-1 Otter Trawl 1 of 2		1	53						1	55
1B-1 Otter Trawl 2 of 2			14						4	18
2-1 Otter Trawl 1 of 2			2							2
1A-2 Otter Trawl 1 of 2			246	5				1	3	255
1A-2 Otter Trawl 2 of 2			202				1	1		204
Date: 4/11/03										
1A-6 Fyke			21							21
Date: 4/24/03										
1A-1 Otter Trawl 1 of 2		1	2							3
1A-1 Otter Trawl 2 of 2			3							3
1A-2 Otter Trawl 1 of 2			11							11
1A-2 Otter Trawl 2 of 2			15		1					16
Date: 4/25/03										
1A-6 Fyke			1							1
1A-7 Fyke		5	2		1					8
April Subtotal	0	7	582	5	2	0	1	2	8	607

Location Code / Gear Type / Replicate Number	Striped bass	Pacific herring	Longfin smelt	Yellowfin goby	Shimofuri goby	Inland silverside	Prickly sculpin	Starry flounder	Unidentified (damaged)	Total
Date: 6/7/03										
1A-6 Fyke	4									4
1A-7 Fyke	1									1
2-1 Otter Trawl 1 of 2	73									73
2-1 Otter Trawl 2 of 2	21									21
1A-4 Beach Seine 1 of 4	11									11
Date 6/8/03										
1A-1 Otter Trawl 1 of 2	3									3
1A-1 Otter Trawl 2 of 2	9									9
2-1 Otter Trawl 1 of 2	27									27
1B-1 Otter Trawl 1 of 2	30									30
1B-1 Otter Trawl 2 of 2	33									33
1A-2 Otter Trawl 1 of 2	13									13
1A-2 Otter Trawl 2 of 2	5									5
1A-3 Beach Seine 1 of 2	2									2
1A-3 Beach Seine 2 of 2	5									5
June Subtotal	237	0	0	0	0	0	0	0	0	237
Date 7/24/03										
2-1 Otter Trawl 1 of 2	1									1
1B-1 Otter Trawl 1 of 2	1									1
July Subtotal	2	0	0	0	0	0	0	0	0	2
Total Larval Fish 2003	239	11	3,547	10	3	1	4	2	190	4,007

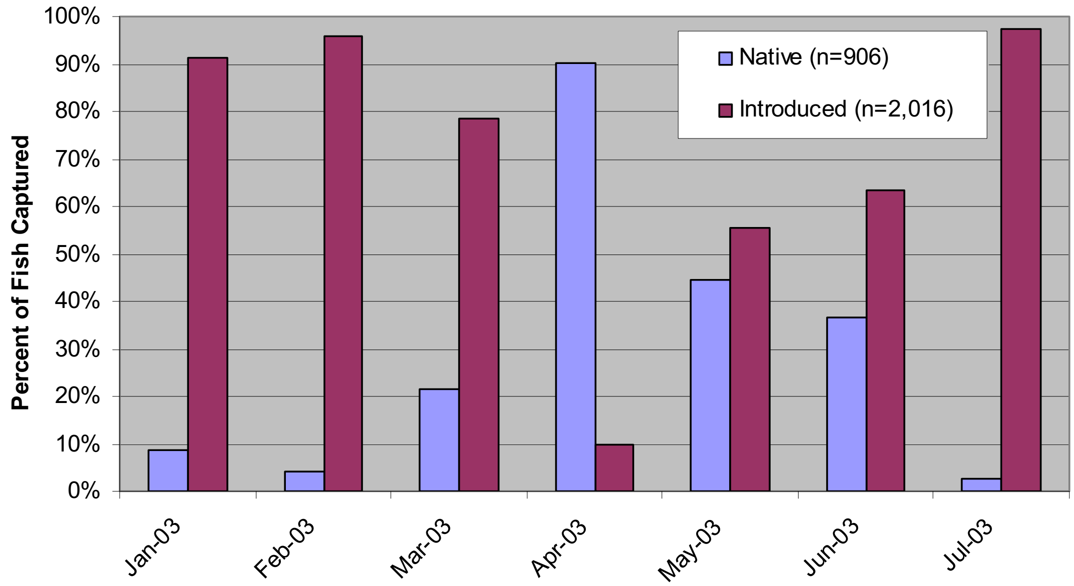

Figure 3-1. Percent of native and introduced fish captured in 2003 by month in the Napa River Project area.

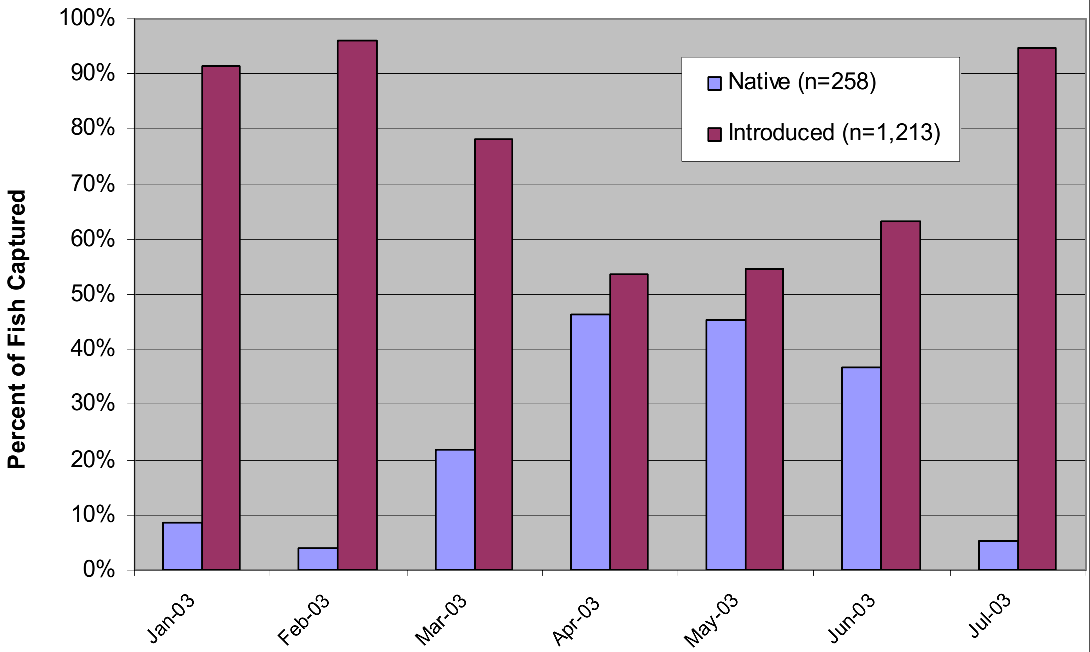

Figure 3-2. Percent of native and introduced fish, excluding the two most dominant species (threadfin shad -- introduced, and Pacific herring -- native), captured in 2003 by month in the Napa River Project area.

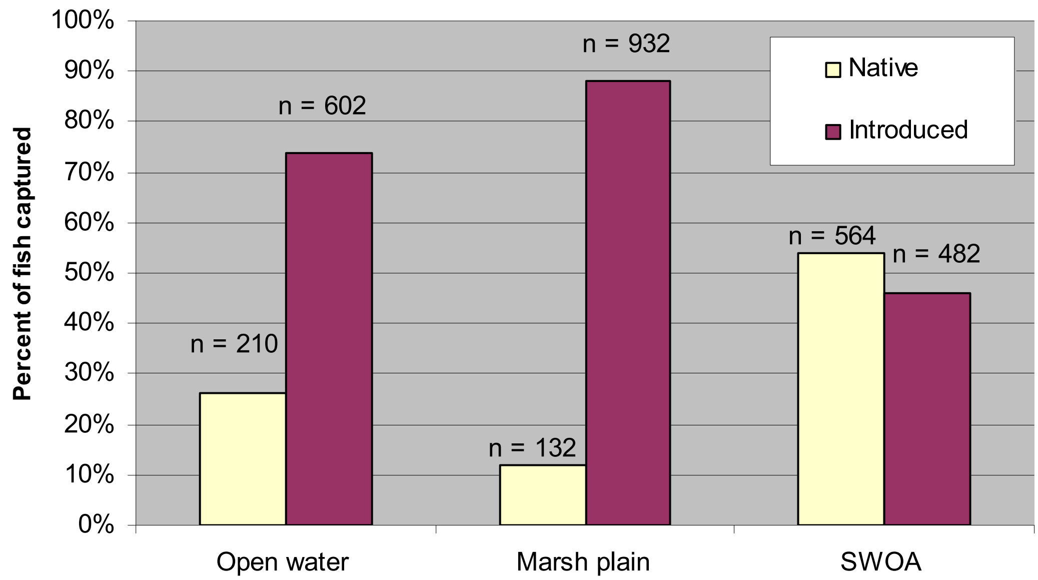

Figure 3-3. Percent of native and introduced juvenile and adult fish captured in all habitat types in the Napa River Project area in 2003.

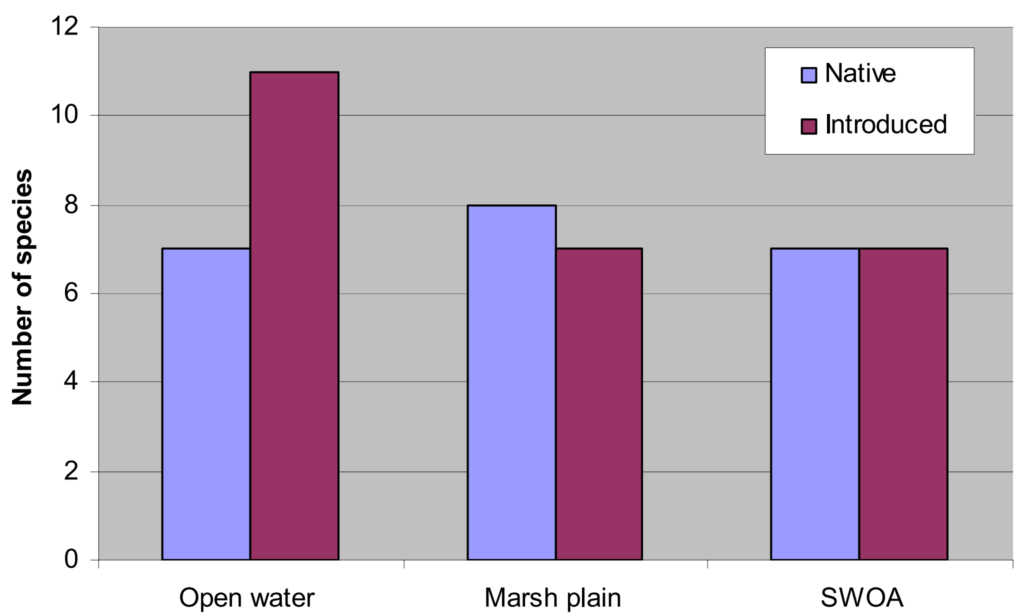

Figure 3-4. Number of species captured by habitat type in the Napa River Project area in 2003.

3.2 Environmental Conditions

During January through July 2003, physical parameters in the project area varied by season in a manner similar to surveys in prior years. The physical parameters during the winter months were characterized by low water temperatures, very low salinities, high dissolved oxygen, and high freshwater inflow (Figures A-18 through A-21). In the spring, salinity levels began to increase along with water temperatures, while dissolved oxygen decreased. Summer conditions exhibited moderately high temperatures, low dissolved oxygen, and higher salinity levels. This is presumably due to higher freshwater inflows beginning in December and tapering off in the spring. With decreased freshwater inflow in the summer and fall months, the salinities increased; temperatures increased and dissolved oxygen decreased during the summer months as the flow of fresh water through the system decreased. Detailed results of environmental conditions at each sample site to date are presented in Tables C-1 through C-3 (Appendix C).

The average environmental conditions for the 2003 juvenile and adult fish sampling period are summarized in Table 3-3. Water temperature during the 2003 sampling period ranged from a low of 12.7^{o}C in February 2003 and steadily increased throughout late winter, spring and early summer to a high of 26.1^{o}C in July 2003. Salinity ranged from a low of 0.0 ppt in February 2003 to a high of 10.8 ppt in July 2003, and dissolved oxygen decreased from a high of 14.0 mg/l in February 2003 to a low of 2.7 mg/l in July 2003 (Table 3-3).

Table 3-3. Napa River Fisheries Monitoring Program: Average Environmental Conditions During Juvenile and Adult Fish Sampling in 2003.

Sample Date	Location	Water Depth (m)	Water Temperature Surface (°C)	Water Temperature Bottom (°C)	Water Turbidity [Secchi Depth] (cm)	Dissolved Oxygen Surface (mg/l)	Dissolved Oxygen Bottom (mg/l)	Water Salinity Surface (ppt)	Water Salinity Bottom (ppt)	Daily Mean Flow (cfs)
Jan-03	Open Water	4.6	13.9	13.7	82.5	9.8	10.1	0.2	0.2	638.5
	SWOA	0.8	13.8	13.8	32.0	9.9	9.4	0.5	0.5	
	Marsh Plain	0.7	13.7	13.4	57.0	11.0	10.3	0.3	0.3	
Feb-03	Open Water	3.7	13.3	13.3	96.3	9.9	9.3	0.6	0.6	270.7
	SWOA	0.3	13.6	13.6	30.4	14.0	14.0	0.0	0.0	
	Marsh Plain	2.8	12.7	13.0	53.9	9.9	9.6	0.7	0.7	
Mar-03	Open Water	4.0	16.3	16.2	63.8	10.6	8.0	0.8	0.8	264.6
	SWOA	1.2	16.1	16.2	33.6	9.2	8.7	2.2	2.2	
	Marsh Plain	0.9	16.7	16.6	55.0	10.3	9.7	0.6	0.6	
Apr-03	Open Water	5.9	15.7	15.4	93.6	10.8	9.4	0.7	1.6	255.5
	SWOA	1.1	15.2	15.4	36.0	8.8	8.3	3.0	3.2	
	Marsh Plain	0.9	15.5	15.5	50.0	10.7	9.8	0.9	0.9	
May-03	Open Water	5.8	17.6	17.7	90.0	9.1	9.2	0.3	0.3	268.2
	SWOA	0.9	22.1	21.9	21.2	12.4	11.3	0.3	0.3	
	Marsh Plain	0.3	17.7	17.6	50.0	9.5	9.0	0.2	0.2	
Jun-03	Open Water	3.9	21.4	21.3	45.4	6.6	5.9	0.6	0.7	23.5
	SWOA	0.9	20.1	20.2	39.4	6.2	6.1	2.7	2.4	
	Marsh Plain	0.8	20.7	20.7	30.0	7.1	7.0	1.3	1.3	
Jul-03	Open Water	4.7	15.8	15.3	41.2	4.7	2.7	3.9	4.5	6.5
	SWOA	1.1	23.8	23.7	45.4	6.4	5.5	10.5	10.8	
	Marsh Plain	2.8	26.1	26.0	40.0	7.6	7.6	9.1	9.0	

3.3 State and Federally Listed Species

Chinook salmon captured at Site 1A-7, May 2003.

Reporting requirements were established as part of the take permit for listed species (steelhead, delta smelt, and Sacramento splittail). Special status species captured during the sampling are listed in Table 3-4. On 13 May 2003, NMFS was contacted regarding the mortality of one juvenile Chinook salmon captured at Site 1A-7 in the SWOA using a fyke net. At the time of capture, the water salinity was 0.3 ppt, temperature was 25.4 ^{o}C, and dissolved oxygen was 16.5mg/l. The Chinook was weighed, measured, and photographed. High water temperatures and suffocation due to algae clogging likely caused the Chinook mortality. Chinook salmon are not reported to occur or reproduce in the Napa River system (NMFS 1998). The specimen was frozen and retained at Stillwater Sciences' Davis office. The USFWS was notified regarding one Sacramento splittail mortality that occurred during the 2003 sampling. Sacramento splittail were removed from the list of threatened species by the USFWS on 22 September 2003 (USFWS 2003).

During the 2003 sampling efforts, the only listed species that was captured was Sacramento splittail (n=48) (Table B-1). Splittail were caught in February, and late April through July. Splittail were caught in all habitat types, including open water, marsh plain, and SWOA with the use of beach seines, purse seines, and otter trawls (Table 3-5; Figures A-22 through A-25).

Table 3-4. State and Federally Listed Species Captured in the Napa River Project area in 2003.

	Federal Listing	State Listing
Sacramento splittail	Threatened (USFWS delisted on 9/22/03)	Special concern
Longfin smelt		Special concern

Sacramento splittail captured at Site 1A-3, June 2003.

Splittail were examined for their reproductive state at the time of capture. Out of the 48 splittail captured in 2003, 21 adults showed no evidence of spawning, no adults showed milt (males), 2 adults had spawning colors, and 25 were determined to be juveniles. A total of 131 splittail have been captured between July 2001 and July 2002, and January to July 2003. In March and April, adults were seen with spawning colors, or with milt or eggs (Figure 3-6). Adults with no evidence of spawning were dominant in February and April. Juveniles were dominant in May through July.

Sacramento splittail numbers were highest from April through July in 2003 (Figure A-22). The CPUE of splittail captured by each gear type varies between habitat types (Figures A-23 through A-25). For 2003, the CPUE of splittail captured by otter trawl was higher in the SWOA than in the main channel; CPUE for the fyke net was not comparable to other gear types as it only fished the SWOA; the beach seine had a higher CPUE in the marsh plain than in the SWOA. In 2003, the fyke net had the highest CPUE (fish/minute) in May (Figure A-26). The beach seine had the highest CPUE (fish/m^3) in late April, May, and June (Figure A-27). In July 2003, the purse seine had the highest CPUE (fish/m^3). The most successful gear types for capturing splittail in 2001-2002 were the beach seine (63%), followed by the otter trawl (29%), and fyke net (5%) (Table 3-5 and Figure A-28).

In 2003, all but one splittail (mortality) was released. Four splittail had lesions or slight abnormalities.

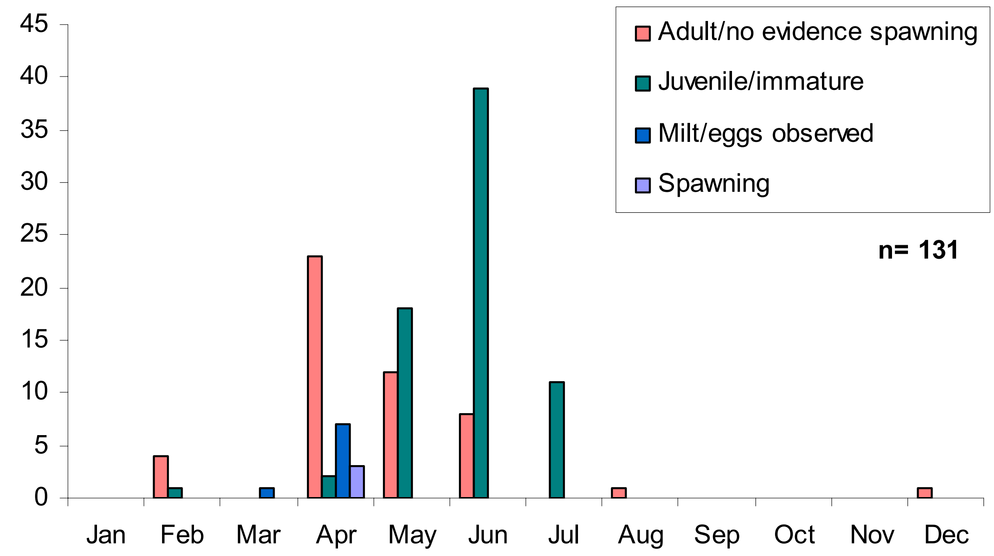

Figure 3-4. Spawning status of Sacramento splittail captured in the Napa River Project area between July 2001-July 2002 and January 2003-July 2003.

Table 3-5. Sacramento Splittail Caught in the Napa River Project Area in 2003.

	1A-1	1A-2	1A-3	1A-4	2-2	1A-6	1A-7	1A-10	1B-1	2-1	3-1	Total Per Month
	Otter Trawl	Otter Trawl	Beach Seine	Beach Seine	Beach Seine	Fyke Net	Fyke Net	Fyke Net	Otter Trawl	Otter Trawl	Purse Seine	
January												0
February			2									2
March												0
April-early												0
April-late	2		8	2								12
May		2	4	2			1					9
June		3	14									17
July	1		3						3		1	8
Total Per Site	3	5	31	4	0	0	1	0	3	0	1	48

Age/standard length correlations indicate that age 1+ splittail range from 111.4 mm-171.2 mm, age 2+ fish range from 171.2 mm-215 mm, and age 3+ fish range from 215 mm-250 mm (Daniels and Moyle 1983). The 2003 splittail captures indicate that the majority were YOY, followed by 1+, 2+, and 3+ aged splittail, as well as a few individuals that were potentially older than 3+ (Figure 3-7).

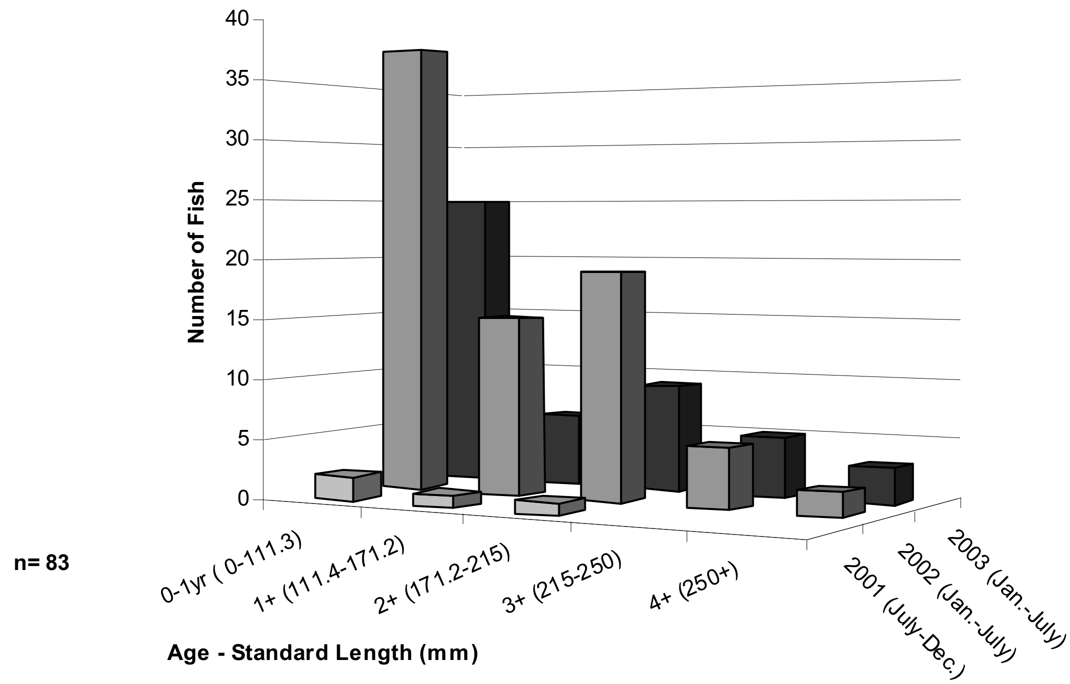

Figure 3-5. Age class distribution and lengths of captured Sacramento splittail in the Napa River Project area between July 2001-July 2002 and January 2003-July 2003.

3.4 Vegetation Types

Contract 1A has provided approximately 2,000 linear feet of emergent vegetation, seasonal wetland, and riverbank vegetation along the Napa River. Throughout four acres, a total of 130,000 plantings, not including grasses, were initiated including: rush spp., bulrush spp., common cattail, salt grass, jaumea, gum plant, pickleweed, fat hen, willow spp., oak spp., Fremont cottonwood, and California walnut.

In 2003, most of the SWOA is still in the early stages of transition from mud flats to estuarine aquatic vegetation, following the rapid conversion from meadow vegetation to mud flats once flooding began in June 2001. The substrate is currently mud with some vegetation, primarily consisting of previously established estuarine plants (such as tule reeds, pickle weed, and algae). Photos at sampling sites in the SWOA reflect the transformation from meadow to tide flats. It appears that the abrupt transition from meadow to tide flats will be followed by a very gradual colonization by various aquatic and emergent estuarine plants, which in turn will provide habitat for various species and food webs. Future observations in the area, and photos taken at each site, will continue to document plant colonization in the SWOA.

4 DISCUSSION OF 2003 RESULTS

4.1 Fish Abundance and Distribution

In this section fish species composition, abundance, and distribution between main channel sites were compared to the recently restored SWOA sites. In addition, the results of the 2003 monitoring efforts were compared with 21 years of data collected in Suisun Marsh and Bay, located approximately 20 km southeast of the Napa FMP study area, to better understand fish species relationships to environmental variables in the Napa River.

Relative abundance of fish species captured in 2003 was similar to that found in 2001 and 2002. The most abundant species captured during 2003, beginning with the most numerous, were threadfin shad, Pacific herring, and inland silverside. From 2001 to 2003, the most abundant species were Pacific herring, inland silverside, threadfin shad, and striped bass (Table 3-1) (USACE 2003b). These species were also collected in the Suisun Marsh studies; however, the order of relative abundance differed, with striped bass, inland silverside, yellowfin goby, and threespine stickleback being the most abundant (Matern et al. 2002).

Juvenile threadfin shad, a non-native species, was the most abundant species captured in 2003. In contrast, in 2001 and 2002, only 18 threadfin shad were captured. In 2003, most threadfin shad were captured in July in marsh plain habitat, but not in the SWOA. Surface water temperatures in the study area reached 26°C in July. The literature indicates that threadfin shad survival and growth rates are higher when water temperatures are greater than 22° to 24°C (Moyle 2002). Apparently, a successful spawning year combined with favorable rearing conditions in the marsh plain resulted in large numbers of rearing juvenile threadfin shad during July 2003. Almost all (98 percent) of the threadfin shad were caught in July. In contrast, threadfin shad in Suisun Marsh were associated with cooler winter temperatures, with numbers in the catch peaking from December through February (Matern et al. 2002). Average monthly summer temperatures in Suisun Marsh typically exceeded 20°C. The Napa River estuary is apparently a highly variable system. In 2002 pacific herring dominated the catch, while in 2003, threadfin shad dominated the catch. A variety of factors such as environmental conditions, numbers of spawning adults, spawning success and other variables may favor one species over another and influence yearly and seasonal abundance.

Pacific herring captured at Site 1B-1, July 2003.

Juvenile Pacific herring was the second most abundant species captured in 2003 and the most abundant in 2002. Pacific herring occurred primarily in the spring; 99 percent of the 2003 non-larval catch was captured in April. In April, juvenile Pacific herring was the most abundant species throughout the SWOA in both 2002 and 2003 (76 percent and 99 of the total catch, respectively). Unlike threadfin shad, Pacific herring appeared to use the SWOA as rearing habitat. In Suisun Marsh, Pacific herring made up less than one percent of total catch (Matern et al. 2002), likely due to the distribution of spawning. In San Francisco Bay, Pacific herring spawn adhesive eggs on seagrasses and other substrates along the shoreline in intertidal and shallow subtidal areas primarily from the Richmond-San Rafael Bridge in the north to Candlestick Point in the south (Watters et al. 2003); they do not spawn as far east as Suisun Marsh.

Inland silverside were consistently abundant in the catch throughout the January through July 2003 sampling period, with the largest numbers captured in February and March. Most inland silverside were caught in beach seines at Site 2-2, which is the most recently restored habitat. In fall 2001 and summer 2002, inland silverside were most abundant in the marsh plain and SWOA sites. Inland silverside were also found to be abundant in Suisun Marsh beach seine surveys, where they were the second-most abundant species captured (Matern et al. 2002).

In 2003, 94 percent of striped bass (mostly juveniles) were captured in July, with 85 percent captured in open water sites. Similarly, in Suisun Marsh striped bass were most abundant in the catch in June (Matern et al. 2002). Although striped bass was the most abundant species captured in Suisun Marsh, the number of juvenile striped bass appears to be declining significantly over the long term (Matern et al. 2002). Striped bass may spawn in the Napa River although it has not been documented. Their main spawning area is the nearby San Francisco estuary (Moyle 2002). Striped bass are known to rear in Suisun Bay (Stevens et al. 1985, as cited in Moyle 2002) and rearing appears to take place in the Napa River, although its importance as rearing habitat to the larger San Francisco Bay striped bass population is unknown.

Larval fish were not targeted by the methods used in the FMP, but they were incidentally captured by otter trawl, fyke net, and beach seine. All larval fish collected in the samples were identified and counted as part of this study.

Longfin smelt, a native species of special concern, was the most abundant larval species captured in the Napa River in 2002 and 2003. In 2003, all larval longfin smelt were captured in open water, compared to 2002, when the majority were captured in the SWOA. In 2001, longfin smelt were also the most abundant larval fish captured in CDFG's 20-mm tow-net trawls (over 30,000) (USACE 2002). Only one adult longfin smelt has been captured during the Napa River monitoring studies. Populations of longfin smelt in Suisun Marsh are believed to be undergoing severe long-term declines (Matern et al. 2002). It is known that longfin smelt spawn in the lower reaches of the San Joaquin and Sacramento rivers (Moyle 2002); the presence of larval longfin smelt in the Napa River may indicate that longfin smelt are using the Napa River for spawning.

Native and non-native fish displayed seasonal changes in distribution in the Napa River study area, with native fish captured primarily in the spring when temperatures were cooler and non-native fish dominating the catch in the warmer summer months. In 2003, numbers of fish captured (both native and non-native) were lowest in January, February, and March and highest in July. Matern et al. (2002) found similar trends in native and non-native fish distribution.

Beach seining at Site 1A-3, February 2003.

In 2003, only 26 percent of the catch in open water and marsh plain habitats was comprised of native fish (Figures 3-3 and 3-4). In contrast, 54 percent of the catch in the SWOA was comprised of native fish, predominantly juvenile Pacific herring captured in spring (Figure 3-5).

To date, the FMP project has documented the presence of 32 species (16 native) in the study area, as compared to the 53 species (28 native) found in Suisun Marsh by Matern et al. (2002). The percentage of native species found in the two studies is similar. The reason for the high abundance of non-native species in the San Francisco Bay area has been attributed to drastic changes that have occurred to the ecosystem, from introduced species to land reclamation to changes in freshwater inflow (Nichols et al. 1986). The San Francisco Bay estuary is considered one of the most disturbed aquatic ecosystems in North America (USFWS 1995). The Napa River feeds into San Pablo Bay, which is part of San Francisco Bay.

Populations of native fish species that are only seasonally present in Suisun Marsh (e.g., longfin smelt and delta smelt) appear to be experiencing long term declines in Suisun Marsh, whereas populations of native species that are present year-round in Suisun Marsh (e.g., Sacramento splittail and Sacramento sucker) appear to have declined and then stabilized at lower numbers. Non-native species that tend to be found in Suisun Marsh year-round (e.g., striped bass, yellowfin goby, shimofuri goby, carp, white catfish, inland silverside) have exhibited no clear trends in long-term abundance (Matern et al. 2002). Due to the short-term duration of the FMP, no conclusions regarding long-term trends in abundance of fishes in the Napa River estuary can be made at this time.

4.1.1 State and federal listed species

Sacramento Splittail

Although splittail was one of the most abundant species captured in Suisun Marsh (Matern et al. 2002), representing 8 percent of the otter trawl catch, it was not commonly captured during the Napa FMP. In 2002, 79 splittail were captured in the Napa River compared to 48 captured in 2003. In the Napa River study area, catch of Sacramento splittail in both 2002 and 2003 increased beginning in April, peaked in June, and then declined in July. In contrast, in Suisun Marsh the numbers of splittail captured remained consistent throughout the year (Matern et al. 2002). Splittail are considered to be a resident species in Suisun Marsh, but their use of the Napa River estuary appears to be more seasonal.

Adult and juvenile splittail appear to use different habitat types. Adult splittail were typically captured in deep, open water, whereas juveniles were typically captured in marsh plain habitats. Spawning adults were also captured in marsh plain habitats in April. Spawning of Sacramento splittail, which occurs primarily from March through May, is believed to be triggered by rising temperatures in the spring (Moyle 2002). Spawning habitat consists of slow-moving reaches in large rivers, flooded vegetation in tidal freshwater, and in estuarine marshes and sloughs (Moyle 2002).

Shallow water habitats, such as inundated floodplains, provide important spawning, rearing, and foraging habitat for recently delisted Sacramento splittail (Sommer et al. 1997, Sommer et al. 2002). During the course of the FMP, most juvenile splittail were captured in shallow water habitats (marsh plain and SWOA) in spring. Young-of-the-year splittail were caught in large numbers by beach seines in Suisun Marsh from June to September (Matern et al. 2002).

All life stages of splittail have been captured within the study area. This study, along with the 2001 CDFG 20-mm tow-net surveys, successfully captured splittail of various size and age classes, including larvae, and age 1+, 2+, and 3+ fish. Sexually mature adults (age 2+ and greater) were identified by their spawning coloration or the presence of milt and eggs, indicating that spawning occurs in the project area. Adults and juveniles appeared to be using the marsh plain habitat for spawning and early rearing in the spring. Juveniles were less abundant in marsh plain habitats in the summer, when temperatures were typically warmer.

Chinook Salmon
One juvenile Chinook salmon was captured in the study area in 2003; a total of three Chinook salmon has been captured to date. Whether these fish occurred from fish that spawned naturally in the Napa River or in the Sacramento/San Joaquin rivers, or were the result of hatchery releases from the Sacramento/San Joaquin rivers remains uncertain. One of the Chinook salmon had a clipped adipose fin, which indicated that it came from a hatchery release. The NOAA Fisheries did not include the Napa River within any of its central valley or coastal Chinook salmon evolutionarily significant unit (ESU) designations (Myers et al. 1998). Chinook salmon ESUs in the region include Sacramento River Winter-Run, California Coast, and the Central Valley Spring, Fall and Late-fall runs. Further investigations, such as conducting spawning surveys on the Napa River and genetic testing of juvenile fish collected in the Napa River could be conducted to determine whether the juvenile Chinook salmon captured in the Napa River originate from any of these ESUs.

Delta Smelt
Delta smelt prefer euryhaline habitats, but spawn in fresh water. Shortly before spawning, adult delta smelt disperse widely into river channels and tidally influenced backwater sloughs (Moyle 2002, Radtke 1966, Wang 1991). Spawning takes place in shallow, fresh, or slightly brackish water (Wang 1991), primarily in sloughs and along the shorelines of large rivers (Moyle 2002; USFWS 1995). The spawning season varies from year to year and may occur from early winter (December) to mid-summer (July). Eggs are adhesive and demersal, and are usually attached to substrate (Moyle 2002; Wang 1991). Capture of larval delta smelt in the main stem of the Napa River in 2001 documented that spawning occurred in this area. After the June 2001 levee breach, the Napa River floodplain was expected to begin providing suitable larval rearing habitat for delta smelt throughout the restored marsh area.

CDFG captured numerous delta smelt larvae in their 20-mm tow-net surveys in the main channel (USACE 2002b). Only one adult delta smelt was captured by fyke net in 2002 in the SWOA (1A-7), but none were captured in 2003. Considering that thousands of larvae were captured in the 20-mm tow-net surveys in 2001, it would be expected that juveniles and/or adults would be collected during the 2002 and 2003 sampling efforts. The capture of only a single adult delta smelt may be due to several factors, including gear selectivity, daily movements of delta smelt, interannual variability in the use of habitats sampled, or low survival of that year-class. Adult and juvenile delta smelt may not be as vulnerable to capture by fyke nets, otter trawls, beach seines, or purse seines as other species. In addition, the mesh size used in these studies is not designed to capture larval delta smelt, although delta smelt were captured in otter trawls with similar mesh sizes in Suisun Marsh (Matern et al. 2002). In addition, the daily or monthly timing of sampling may not have been conducive for sampling delta smelt. All sampling was conducted consistently during the daylight hours and at a similar phase of the tidal cycle, which may have limited the opportunity for delta smelt capture. Alternatively, delta smelt may not have used these habitats in 2002 and 2003. Assessment of delta smelt abundance and distribution in the project area will likely require an increased effort to better sample both larval and adult stages. Conducting surveys at different times of the tidal cycle or during the night, perhaps using light traps, may be necessary to increase the probability of capturing delta smelt.

Steelhead
Winter-run steelhead generally enter spawning streams from fall through spring as sexually mature adults and spawn a few months later in late winter or spring (Roelofs 1985, Meehan and Bjornn 1991, Behnke 1992). Juvenile steelhead in California typically rear in freshwater for one to two years before migrating downstream to the ocean as smolts, typically at a length of 150 to 200 mm (Meehan and Bjornn 1991). Steelhead have been observed spawning in Dry Creek, a tributary of the Napa River near the study area (J. Cook, tenant, pers. comm., 2003). The NOAA Fisheries included the Napa River within its Central California Coast steelhead ESU (Busby et al. 1996).

A single juvenile steelhead was captured by purse seine in the deep main channel (Site 3-1) in 2002, but none were captured in 2003. The capture of a single specimen may have been a result of gear selectivity, poor gear efficiency, or low abundance in the project area. Salmonids may be better able to avoid gear that is fished in the day rather than the night, compared to other less mobile and visually oriented species. Continued sampling may result in additional captures of juvenile anadromous salmonids, which may give further insights as to the effectiveness of the sampling gear and the distribution and abundance of salmonids and their use of habitats in the project area.

4.2 Vegetation Types

Vegetation that has been re-established in the Napa River project area and SWOA is providing habitat for non-aquatic species. The area is already attracting large numbers of a variety of shorebirds, waterfowl, and their predators, including peregrine falcons. The SWOA tidal flat has been exposed to daily flooding for approximately one-and-a-half years, and is still in the very early stages of restoration. The number and diversity of bird species using the SWOA, however, suggests that salt marsh restoration efforts are succeeding in achieving their goals. Continued monitoring will document changes occurring in the restored salt marsh.

4.3 Black Sea Jellyfish

Tens of thousands of Black Sea jellyfish (*Maeotias marginata*) were captured for the first time in the Napa River in July 2003, primarily in open water habitats. This non-native species of jellyfish was first discovered in San Francisco Bay in the 1990s (Mills 2001). These small jellyfish (< 3-cm bell diameter) have also been found in Suisun Bay and in the Napa and Petaluma rivers (Rees and Kitting 2002).

4.4 Environmental Conditions and Habitat Use

4.4.1 Environmental conditions

Environmental conditions in the Napa River varied by season and habitat type. Temperatures and salinities increased from January to late summer. In both 2002 and 2003, salinity and temperature were typically higher in the SWOA than in open water or marsh habitats. In 2003, average bottom water temperatures in the SWOA were 1.7°C warmer than the deeper open water sites, and 0.3°C warmer than the shallow marsh plain sites. Additionally, average bottom salinities in the SWOA were 1.6 ppt higher than deep open water sites, and 1.0 ppt higher than marsh plain sites. Dissolved oxygen (DO) concentrations were lowest in the SWOA and averaged 8.8 mg/l, whereas DO averaged 9.5 mg/l in open water sites and 9.4 mg/l in marsh plain sites.

Salinity in 2003 did not increase between March and June, as was found in 2002, but remained fairly constant (less than 5.0 ppt), probably due to higher discharge from the Napa River in 2003. The daily average flow for the entire March-June period in 2002 was 84 cfs, whereas in 2003 it was 203 cfs. In July 2003, freshwater flow decreased and salinities increased to values similar to those recorded in 2002. The highest average monthly flow to date for the FMP (1,524 cfs) was observed in December 2002.

Matern et al. (2002) noted that environmental variables such as temperature, salinity, and freshwater flow were correlated with catch, but they did not believe this correlation implied cause. In general, they noted that fish species response to environmental variables appeared weak and hypothesized that younger life stages were affected by environmental variables more than juvenile or adult life stages. The relationship between relative abundance and environmental variables for the Napa FMP is evaluated further in Chapter 5.

Relative abundance of native and non-native fish species may shift on the basis of environmental conditions such as water temperature and salinity. Non-native species such as striped bass are associated with warmer temperatures and more saline conditions in nearby Suisun Marsh (Matern et al. 2002). The Napa FMP analysis (Chapter 5) found a significant relationship between the relative abundance of non-native inland silverside and the salinity/temperature group of variables, based on beach seine data. These associations suggest that the higher salinity and temperatures of the SWOA areas may be favorable for some non-native species.

4.4.2 Habitat use

Restored Habitat
Restored areas consist of all sites located in the SWOA, which is isolated from the main channel, and a marsh plain site located along the main channel. Throughout the project area, temperature, salinity, and dissolved oxygen were higher in both the SWOA and the restored marsh plain compared to open water habitat. This is largely due to shallower water in restored areas resulting in higher residence time for water, and consequently, heating and higher temperatures. In the Sacramento-San Joaquin Bay Delta, Brown (2003) concluded, based on Simenstad et al. (2000), that intertidal areas favored native fishes, as compared to the deeper subtidal areas, which favored non-native fishes. The restored areas of the Napa River FMP project, however, appear to be functioning as habitat primarily for threadfin shad, Pacific herring, inland silverside, and shimofuri goby, mostly non-native species.

Temperatures and salinities in the SWOA are probably not favorable for most native fish species in the summer. In the spring, the SWOA appears to provide habitat for native juvenile Sacramento splittail and Pacific herring. During the summer, water temperatures and salinities increase, and the SWOA becomes more suitable for non-native species, such as inland silverside and striped bass. In the summer, temperatures in the SWOA may be too warm for Sacramento splittail; temperatures in June and July often exceed 20ºC, which has been noted as the temperature at which juvenile Sacramento splittail appear to leave the floodplain (P. Moyle, pers. comm., 2002). Interestingly, in Suisun Marsh, peak beach seine catches of splittail young of the year were recorded from June through September, when average monthly temperatures (based on data from 1979-1999) exceeded 20ºC.

Native juvenile Pacific herring and splittail appear to use the SWOA habitats seasonally. The vast majority of juvenile Pacific herring were captured in the SWOA in March and April. Although juvenile splittail were captured in the SWOA, more juvenile splittail utilized the cooler shallow marsh plain water habitats compared to the warmer shallow water habitats of the SWOA (p=0.0140) (Table 5-4). More juvenile splittail were captured in spring compared to summer (although not statistically significant), suggesting that they may be leaving the shallow water habitats of the SWOA for other areas during the warmer summer months.

It does not appear that adult Sacramento splittail are using the SWOA extensively. Few adults were captured in the SWOA, and only two were in spawning condition. Temperatures in the SWOA appear to be favorable during the spawning season; however, continually inundated vegetation is required as fertilized eggs must be submerged until they hatch (Moyle 2002). The vast majority of the SWOA does not provide consistently submerged vegetation—at low tide the vegetation becomes exposed; therefore, the SWOA appears to provide little habitat for successful splittail spawning.

Adult and juvenile splittail utilized the restored marsh plain more than any other habitat type in the study area; most splittail (53 percent) were captured from this one site (Site 1A-3). The marsh plain habitat type is typified by shallow water depth along with temperatures, salinities, and dissolved oxygen levels that were intermediate between open water and SWOA habitats. Splittail may be favoring these more intermediate conditions. Although spawning adults and juveniles were captured at this site, the majority of the catch was represented by juveniles.

Primarily non-native species appear to be utilizing the SWOA. Inland silverside utilized the SWOA during all seasons. In 2001 and 2003, recently restored wetlands were initially dominated by inland silversides, similar to the pattern found during other evaluations of restoration projects in the Sacramento-San Joaquin Delta (Lindberg and Marzuola 1993, and England et. al 1990 as cited in Brown 2003). Inland silversides prefer shallow water habitat with aquatic vegetation (Moyle 2002), and spawning is known to occur between April and September (Wang 1986, as cited in Moyle 2002). Inland silversides are hypothesized to be a potential predator on larval delta smelt (Bennett and Moyle 1996).

During the FMP, the most abundant non-native species captured in the restored marsh plain were threadfin shad and inland silverside. The vast majority of threadfin shad were captured during July of 2003, when temperatures and salinities were the highest of the 2003 sampling period. Juvenile threadfin shad appeared to be primarily utilizing the restored marsh plain, whereas juvenile and adult life stages of inland silverside appeared to be utilizing the restored marsh plain as well as the SWOA.

Non-restored Habitat

Historic land management practices have resulted in channelization and elimination of shallow water habitats in the study area. Sampled non-restored areas consisted of all sites located in deep, open water in the main channel. No shallow water habitats were sampled, since the vast majority of the non-restored study area is deeper water habitat. In general, water temperature and salinity were lower in the non-restored sites compared to in the SWOA or the restored marsh plain. The deeper non-restored areas appear to be providing habitat primarily for striped bass, threadfin shad, and Pacific herring, consistent with Brown's (2003) conclusion, based on Simenstad et al. (2000), that subtidal areas favor non-native species.

The catch in deeper non-restored areas was dominated by juvenile non-native species, particularly striped bass and threadfin shad. These species were mostly captured in July, when temperature and salinity increased. Threadfin shad and striped bass appear to be using the shallower restored areas as well.

Native splittail and Pacific herring were captured in deep open water habitat of the non-restored areas. Both adult and juvenile splittail were captured, however the majority were adults and none were in spawning condition. Juvenile Pacific herring were captured primarily in early April, preceding the timing of peak catch in the restored areas by two weeks. Juvenile Pacific herring may be utilizing the non-restored areas during the early stages of rearing.

5 CUMULATIVE PROGRAM TO DATE ANALYSIS

5.1 Methods

Cumulative data were analyzed for Sacramento splittail, Pacific herring, inland silverside, and striped bass, using basic multivariate linear modeling and ANOVA techniques per the "Final Work Plan and QA/QC Plan for Implementation for the Year 2002 Napa River Fisheries Monitoring Program" (USACE 2001a). Sacramento splittail was chosen as a cumulative analysis species since it was a listed species at the time of field sampling. Pacific herring and inland silverside were selected because they were the two species that dominated the overall catch. Striped bass was selected because it was an abundant species hypothesized to have potential impacts on other species. Delta smelt were omitted from the analysis due to the extremely low number of fish captured (one fish from 2002-2003). Data from 2001 were also omitted from the analysis because sampling was conducted during a different season (July to December in 2001, versus January to July in both 2002 and 2003). Data from Site 2-2 was omitted, due to low sampling effort relative to other sites. For analysis purposes, habitats were classified into the following area types: open water, SWOA (channel or floodplain), and marsh plain (restored) (Table 5-1).

Table 5-1. Classification of area types for sites sampled (in 2002 and 2003), and used for the cumulative program to date analysis, Napa River Monitoring Program.

Site	Classification	Gear Type
1A-1	Open water	Otter trawl
1A-2	SWOA (channel)	Otter trawl
1A-3	Marsh plain (restored)	Beach seine
1A-4	SWOA (floodplain)	Beach seine
1A-6	SWOA (floodplain)	Fyke net
1A-7	SWOA (floodplain)	Fyke net
1A-8*	SWOA (floodplain)	Fyke net
1A-9*	SWOA (floodplain)	Purse seine
1A-10	SWOA (floodplain)	Fyke net
1B-1	Open water	Otter trawl
2-1	Open water	Otter trawl
3-1	Open water	Purse seine

*Sampled in 2002 only.

The main purpose of this analysis was to identify possible relationships between CPUE (the response variable) and environmental parameters. Potential explanatory variables included: a) categorical variables – gear type, year, season, habitat area type, and b) numerical variables – temperature, salinity, and turbidity. Water depth and tidal variables were not included, due to the fact that individual gear types were not deployed over the full range of depths, tidal stages, and tidal cycles. Flow was not included, due to the difficulty in separating its effect from those of other environmental variables. Dissolved oxygen was not included in the linear model analysis, because the measurements were relatively imprecise. However, water depth, tidal stage, tidal cycle, and dissolved oxygen were all included in an exploratory graphical assessment of possibly significant statistical relationships. Average values of surface and bottom measurements of temperature and salinity were used for the analysis. For the restored marsh plain and SWOA habitats, the bottom and surface measurements differed only slightly. In deep open water habitats, there were greater differences between surface and bottom measurements (Table 3-3). However, species included in our analysis were not necessarily associated with bottom or surface conditions, and therefore an average was used for temperature and salinity. All analyses were performed using the S-Plus 6 statistical package (Version 6.0.2, Insightful Corp., Seattle, WA, USA).

Catch-per-unit-effort was calculated as: $CPUE_i = C_i/E_i$, where C_i is the total catch and E_i is the total expended capture effort for a single given location and set of environmental parameters *i*. Site-specific capture effort was uniquely characterized for each gear type as:

$$E(F)_{ij} = m_{ij}$$

for fyke (*F*) net sampling, where m_{ij} is the number of minutes that the fyke net was fished during sampling event *j* for a given set of environmental parameters *i* (beginning with slack tide);

$$E(O)_{ij} = \frac{r_{ij}}{c} \cdot 2.5 \cdot 1$$

for otter (*O*) trawl sampling, where r_{ij} is the total number of rotations recorded on a General Oceanics flow meter per trawl *j*, *c* is a constant representing the calibrated number of rotations per meter, and 2.5 m and 1 m are the trawl opening length and width respectively;

$$E(B)_{ij} = s_{ij} \cdot a_{ij} \cdot d_{ij}$$

for beach (*B*) seining during set *j*, where s_{ij} is the visually estimated linear distance (in meters) from the physical start of the seining event to the bank, a_{ij} is the visually estimated width (in meters) of the seining area, and d_{ij} is the visually estimated average water depth (in meters);

$$E(P)_{ij} = l_{ij} \cdot w_{ij} \cdot d_{ij}$$

for purse (*P*) seining during set *j*, where l_{ij} (in meters) and w_{ij} (in meters) are the visually estimated length and width of an approximately rectangular seining area, and d_{ij} (in meters) is the depth of the purse seine.

Total daily capture effort for a single location and set of environmental parameters was then calculated as:

$$E(gear)_i = \sum_{j=1}^{T} E(gear)_{ij} \ ,$$

where *gear* is gear type *B*, *F*, *O*, or *P*, and *T* is the total number of sampling events.

Water depth at the time of sampling was typically less than 1 m for habitat sampled by beach seine or fyke net, whereas water depth was greater than 1 m for habitat sampled by purse seine or otter trawl. Therefore, data from beach seine or fyke net sampling were considered to be representative of shallow water habitat, whereas data from purse seining or otter trawling were considered to be representative of deep water habitat.

Exploratory graphics were employed, using the S-Plus function `splom( )` to visually observe potential relationships between all possible pairs of variables. Linear models were then fitted for each species, regressing CPUE on gear, area type, temperature, salinity, season, and turbidity.

Separate analyses were conducted for each gear type to examine the relationship between CPUE and the environmental variables among area types. Where possible, data were compared from main river and SWOA habitats sampled by the same gear type.

For interpretation of our results, the variables temperature and salinity were clustered into one group; season and turbidity were not grouped. Significant relationships of CPUE with either temperature or salinity were considered to be evidence of a relationship with both variables, since these variables are typically interrelated.

Sizes of Sacramento splittail and striped bass (fork length in mm) were compared in different habitat area types using a standard two-sample *t*-test. The habitats compared were shallow water habitats sampled by beach seine (SWOA floodplain and the restored marsh plain on the main channel) and deeper water habitats sampled by otter trawl (open water and the SWOA channel).

5.2 Results and Discussion

Exploratory graphs confirmed the likelihood of strong relationships between Julian date and salinity, Julian date and temperature, Julian date and dissolved oxygen, flow and temperature, flow and salinity, and flow and dissolved oxygen (Figures D-1 through D-4, Appendix D). We therefore determined that it was reasonable to drop flow and Julian date as explanatory variables since they were clearly associated with the other explanatory variables, and would have confused interpretation of the regression statistics for individual variables.

Sacramento splittail and Pacific herring appear to utilize different habitats and have differing susceptibility to capture by a particular gear type, based on a significant relationship between CPUE and the two variables consisting of gear and area type (p=0.0008 and p=0.0240, respectively) (Table 5-2). It was assumed that a significant relationship between relative abundance and one of these two variables indicates a significant relationship between relative abundance and both variables, since gear types were specific to certain habitat types.

Table 5-2. Results of the complete linear model (response = CPUE) fitted for Sacramento splittail, Pacific herring, inland silverside, and striped bass, Napa River Fisheries Monitoring Program, 2002-2003

	***p*-values for**			
Explanatory Variables	**Sacramento splittail**	**Inland silverside**	**Pacific herring**	**Striped bass**
Gear	0.3222	0.0912	**0.0240**	0.1876
Year	0.9944	0.8858	0.0521	0.4529
Season	0.0655	0.5802	0.4415	**0.0020**
Area type	**0.0008**	0.6443	0.6141	0.5307
Salinity	0.1345	0.1042	0.2788	0.2395
Temperature	0.2058	0.7237	0.6768	**0.0453**
Turbidity	0.4731	0.4005	0.5001	0.5071

*Significant *p*-values bolded; *p*-values were based on *t*-tests for the coefficients.

Striped bass and splittail appeared to have a seasonal distribution, based on the complete linear model regression analysis. The complete linear model included gear type as an explanatory variable, whereas subsequent analyses did not. The relationship between CPUE and season was only significant for striped bass (p=0.0020), although it was nearly significant for splittail (p=0.0655) (Table 5-2).

Turbidity did not appear to influence the relative abundance of any species analyzed, based on the complete linear model regression analysis. No species exhibited a significant relationship between CPUE and turbidity (Table 5-2).

Only striped bass CPUE appears to be affected by temperature/salinity, based on the complete linear model regression analysis. Striped bass exhibited a significant relationship with the variable of temperature (p=0.0453) (Table 5-2).

The complete linear model that was chosen, appeared to be appropriate, based on results of the linear regression analyses. For all species, except Pacific herring, the complete model was significant (α=0.05) (Table 5-3), signifying that CPUE was affected by the chosen explanatory variables.

Table 5-3. Regression statistics for the completed linear model fitted, catch-per-unit effort regressed on year, season, area, salinity, temperature, and temperature, Napa River Fisheries Monitoring Program, 2002-2003.

Species	**Regression Statistics**			
	Residual S.E.	**Multiple R^2**	**F**	***p***
Sacramento splittail	0.0031	0.2317	4.140	<0.0001
Inland silverside	0.0200	0.1355	2.152	0.0199
Pacific herring	0.8186	0.0896	1.351	0.2023
Striped bass	0.0033	0.1909	3.238	0.0005

Separate analyses were conducted by gear type if 30 or more fish of a particular species were captured by a particular gear type. Using data from less than 30 fish captured would lead to an invalid statistical analysis due to inadequate sample size. For splittail and striped bass, only data from beach seine and otter trawl sampling were used. Pacific herring data were analyzed for all gear types, and inland silverside data were analyzed for all gear types except the otter trawl (Table 5-4). Results for each species are described below.

Table 5-4. Values of coefficients and *p*-values for linear models fitted by gear type to Sacramento splittail, inland silverside, Pacific herring, and striped bass, Napa River Fisheries Monitoring Program, 2002-2003.

Gear	Coefficients	*p* values for:							
		Sacramento splittail		Inland silverside		Pacific herring		Striped bass	
		Value	*p*	Value	*p*	Value	*p*	Value	*p*
Beach seine	Intercept	0.0042	0.6293	-0.0066	0.7550	0.0519	0.4820	-0.0103	0.0207
	Year2003	0.0008	0.7674	-0.0109	0.1229	-0.0269	0.2684	-0.0007	0.6199
	Seasonsummer	-0.0072	0.1178	-0.0048	0.6680	0.0131	0.7349	0.0096	0.0001
	Seasonwinter	-0.0012	0.6388	0.0032	0.6215	-0.0252	0.2577	0.0009	0.4795
	AreaS	-0.0062	0.0140	0.0023	0.6913	0.0167	0.4140	0.0003	0.8028
	Salinity	0.0005	0.3536	-0.0012	0.3662	-0.0028	0.5271	-0.0009	0.0015
	Temperature	0.0002	0.7238	0.0011	0.3508	-0.0013	0.7377	0.0008	0.0011
	Turbidity	-0.0001	0.4707	0.0002	0.3237	0.0001	0.9124	0.0000	0.4825
	Overall model		0.1436		0.7138		0.6715		0.0008
Fyke net	Intercept			0.0139	0.7541	1.9655	0.3676		
	Year2003			0.0077	0.6454	-1.5934	0.0582		
	Seasonsummer			0.0244	0.3817	1.1994	0.3771		
	Seasonwinter			-0.0067	0.7666	-0.0131	0.9905		
	Salinity			0.0055	0.0410	-0.1566	0.2217		
	Temperature			-0.0006	0.7683	-0.0498	0.5994		
	Turbidity			-0.0007	0.4499	0.0308	0.4767		
	Overall model				0.0486		0.5346		
Otter trawl	Intercept	-0.0007	0.3550			0.0023	0.6322	-0.0081	0.1794
	year2003	-0.0004	0.0232			0.0013	0.2968	-0.0018	0.2587
	Seasonsummer	-0.0008	0.0443			-0.0017	0.5322	0.0016	0.6416
	Seasonwinter	0.0000	0.9255			-0.0024	0.0807	0.0007	0.6531
	AreaS	0.0001	0.7289			-0.0002	0.8537	-0.0009	0.5936
	Salinity	0.0000	0.6296			0.0004	0.2526	-0.0001	0.7754
	Temperature	0.0001	0.1286			-0.0003	0.3091	0.0005	0.1022
	Turbidity	0.0000	0.6135			0.0000	0.0983	0.0000	0.3761

Table 5-4 (continued). Values of coefficients and *p*-values for linear models fitted by gear type to Sacramento splittail, inland silverside, Pacific herring, and striped bass, Napa River Fisheries Monitoring Program, 2002-2003.

		***p* values for:**							
		Sacramento splittail		**Inland silverside**		**Pacific herring**		**Striped bass**	
Gear	**Coefficients**	**Value**	***p***	**Value**	***p***	**Value**	***p***	**Value**	***p***
	Overall model		0.0309				0.3033		0.1357
Purse seine	Intercept			-0.0158	0.4561	0.0254	0.6413		
	Year2003			-0.0072	0.4851	0.0020	0.9393		
	Seasonsummer			0.0026	0.9188	0.0243	0.7160		
	Seasonwinter			-0.0074	0.4572	-0.0039	0.8805		
	AreaS			0.0015	0.9381	0.0522	0.3223		
	Salinity			-0.0013	0.7509	-0.0050	0.6431		
	Temperature			0.0011	0.3625	-0.0012	0.6942		
	Turbidity			0.0001	0.1685	0.0000	0.8458		
	Overall model				0.7830		0.8062		

[a] *p*-values are based on t-tests for the coefficients and F-statistic computed for the overall model.

[b] Reference categories were: year2002; seasonspring; areaR (restored marsh plain) for beach seine data, or areaO (open water) for otter trawl and purse seine data.

5.2.1 Sacramento splittail

Juvenile splittail appear to prefer restored marsh plain to the SWOA floodplain sites. CPUE was significantly higher within the restored marsh plain (p=0.0140), based on beach seine data (Table 5-4). Juveniles represented 70% of the splittail catch by beach seine. Unfortunately, CPUE could not be compared across restored (SWOA floodplain and restored marsh plain) and non-restored areas, since beach seines only sampled restored areas. CPUE could not be compared among shallow water habitats based on fyke net data, since fyke nets only sampled SWOA floodplain areas. However, fyke nets captured four splittail within the SWOA floodplain, three of which were juveniles. Either use of the sampled SWOA floodplain was limited (which is supported by the beach seine data), and/or fyke nets were not an effective gear type for capturing splittail.

Adult splittail did not appear to have a preference for habitat area type within deep water habitats (i.e., SWOA channel or open water), based on otter trawl data (p=0.7289) (Table 5-4). The otter trawl catch was dominated by adults (83% of the total splittail catch) (Table 5-5).

Table 5-5. Numbers of adult and juvenile splittail by gear type and year, Napa River Fisheries Monitoring Program, 2002-2003.

Gear Type	Year	Number of Adults			Number of Juveniles
		Spawning	Not Spawning	Total	
Beach	2002	2	6	8	40
	2003	2	15	17	18
	Total	4	21	25	58
Fyke	2002	0	1	1	2
	2003	0	0	0	1
	Total	0	1	1	3
Otter	2002	6	18	24	1
	2003	0	5	5	6
	Total	6	23	29	7
Purse	2002	1	2	3	0
	2003	0	0	0	1
	Total	1	2	3	1

The relative abundance of adult and juvenile splittail was higher in the spring than the summer, as indicated by the analysis of otter trawl data (p=0.0443) for adults, and to some extent the beach seine data for juveniles (although not formally significant; p=0.1178) (Table 5-4). Adults may be more abundant in spring than summer, because of spawning movements in the spring. Juveniles may also be more abundant in shallow water habitats during spring, because they were spawned during this time, and temperatures in the spring appear to be more favorable for juveniles than in the summer. Juvenile (and adult) splittail appear to prefer temperatures less than 20ºC on floodplains (Moyle, pers. comm., 2002). Temperatures typically exceeded 20ºC by June and July, and sometimes as early as May in shallow water habitats. These results were somewhat different from those found in Suisun Bay (Matern et al. 2002), where catches of splittail were typically consistent throughout the year.

It appears that more adult splittail utilized the study area in 2002 than in 2003, whereas a similar number of juveniles utilized the study area in 2002 and 2003. There was a significantly greater abundance of adult splittail in 2002 than in 2003 based on otter trawl data (p=0.0232) (Table 5-4).

In contrast, beach seine data did not indicate a significant difference in relative abundance of juvenile splittail between years (Table 5-4). Nine of 36 adult splittail showed evidence of spawning (i.e., spawning colors or milt/eggs) in 2002, as compared to only 2 of 22 adults captured in 2003. Splittail exhibited a decline in Suisun Marsh not exhibited elsewhere in the estuary; it was hypothesized that this was due to localized spawning outside of the marsh in some years and more widespread spawning in others (Matern et al. 2002). A more intensive sampling effort would be needed to evaluate distribution of splittail spawning in the Napa River.

There was evidence that the relative abundance of adult splittail increased with increasing temperature and salinity. Adult splittail exhibited a positive relationship (although not formally significant; p=0.1286) between relative abundance and the group of variables consisting of salinity and temperature within deep open water habitat (Table 5-4). When the model without the year variable was fitted to the otter trawl data, the coefficient for salinity became significant (p=0.0491) (Table 5-6). However the relationship between relative abundance and salinity, although significant, was weak (coefficient value = 0.0001) (Table 5-6). There may be a relationship between the relative abundance of adult splittail and temperature and salinity specific to the Napa River estuary. However, it seems likely that the significance of the relationship is a statistical artifact, due to the short duration of our project (based on analysis of 2 years of data). Matern et al. (2002) found no significant relationships between relative abundance of splittail and any environmental variables, based on 21 years of data.

Table 5-6. Regression statistics for model fitted to Sacramento splittail otter trawl data, regressing catch-per-unit effort on season, area, salinity, temperature, and turbidity, Napa River Fisheries Monitoring Program, 2002-2003.

Coefficient	Value	S.E.	t value	P
Intercept	-0.0003	0.0007	-0.3990	0.6915
Seasonsummer	-0.0010	0.0004	-2.4640	0.0170
Seasonwinter	-0.0001	0.0002	-0.5233	0.6029
AreaS	-0.0001	0.0002	-0.6763	0.5017
Salinity	0.0001	0.0000	2.0132	0.0491
Temperature	0.0000	0.0000	0.7618	0.4495
Turbidity	0.0000	0.0000	-0.4218	0.6749
Overall model				0.1212

[a] Overall model p is based on F-statistic on 6, 54 degrees of freedom.

[b] Reference categories were: seasonspring and areaR (restored marsh plain).

5.2.2 Inland silverside

Inland silversides did not show a preference for a habitat area type. No statistical difference in relative abundance was detected between the SWOA floodplain and restored marsh plain habitat, based on the analysis of beach seine data (p=0.6913), or between SWOA channel and open water based on analysis of purse seine data (p=0.9381) (Table 5-4). No statistical analysis could be conducted regarding habitat area type based on fyke net data. Fyke nets only sampled SWOA floodplain habitat. However, fyke nets captured 127 inland silversides, the second highest total of any species captured by fyke net. Either the fyke net capture probability of inland silverside was much higher than for most other species, and/or inland silverside were more abundant than most other species within the SWOA floodplain.

There appeared to be no seasonal or annual differences in relative abundance of inland silversides. No significant differences in relative abundance of inland silversides between seasons or years were detected in any of the analyses. However, in Suisun Bay catches of silverside peaked in July with no long-term pattern in relative abundance (Matern et al. 2002).

Inland silversides were associated with higher salinities. Relative abundance of silversides was significantly related to the variable of salinity within the SWOA floodplain, based on fyke net captures (p=0.0410) (Table 5-4).

5.2.3 Pacific herring

Pacific herring were more dominant in 2002 than in 2003. CPUE was significantly greater in 2002 than 2003, based on the analysis of fyke net data (although not formally significant; p=0.0582) (Table 5-4). Adult splittail were also more dominant in 2002 than in 2003. This apparent concordance in abundance between Pacific herring and adult splittail was consistent with the finding of concordance in abundance for native species identified in Suisun Bay (Matern et al. 2002).

Pacific herring did not exhibit any clear relationship between abundance and environmental parameters. There was a nearly significant relationship (p=0.0983) between relative abundance and turbidity detected in deep open water habitat, based on analysis of data from otter trawl sampling (Table 5-4), possibly due to a behavioral response indicative of habitat preference (foraging or refuge), a change in the relationship between catch and effort during more turbid conditions, or a simple statistical artifact. A change in the relationship between catch and effort complicates any kind of interpretation of the analysis with regard to the relationship between CPUE and environmental parameters, since the statistical model assumes catch varies with effort due to changes in habitat conditions and associated preferences, and not due to changes in probability of capture.

5.2.4 Striped bass

More juvenile striped bass were captured in shallow water habitats during summer, compared to spring, as indicated by the analysis of beach seine data (p=0.0001). Nearly all striped bass captured by beach seine (97%) were juveniles less than 80 mm in fork length. Similarly, in Suisun Bay the peak beach seine catch of juvenile striped bass was recorded in June (Matern et al. 2002).

Striped bass relative abundance did not appear to differ between years. There was no statistical difference in relative abundance between the two years detected for striped bass in any of the sampled habitats, as was true for the non-native inland silverside.

Juvenile striped bass were associated with warmer temperatures. Juvenile striped bass exhibited a significant relationship between CPUE and temperature within shallow water habitats, based on analysis of beach seine data (p=0.0011) (Table 5-4). In their 21-year study of Suisan Marsh, Matern et al. (2002) found that juvenile striped bass exhibited a strong association with warmer temperatures.

Striped bass did not appear to be associated with any of the environmental parameters within open water habitat. Significant relationships between relative abundance and environmental variables were not found in open water habitat, where the most striped bass were captured. This could be due to multicollinearity, or correlations between the explanatory variables. The *p*-value for the overall fitted model was not particularly high compared to other models at 0.1357 (Table 5-4). Within the deep open water habitat, there was a much greater size range and mixture of age classes of striped bass, possibly confusing the detection of any relationships.

The potential exists for striped bass to prey upon other smaller fishes. Striped bass are highly piscivorous, including splittail among their prey. However native species have historically been found in great abundance along with large striped bass populations (Moyle 2002). Predation by striped bass on juvenile splittail in shallow water habitats is unlikely in the Napa River.Nearly all (97%) of the striped bass captured in shallow water habitats were juveniles of similar size to juvenile splittail.

5.2.5 Size distribution of Sacramento splittail and striped bass

Striped bass were larger in the SWOA channel than in open water, based on analysis of the striped bass data (from 2002-2003) using a standard two-sample *t*-test ($p<0.0001$) (Table 5-7). Striped bass were also larger within the SWOA floodplain than the restored marsh plain ($p=0.0053$).

Splittail did not appear to differ in size between deep water habitats (i.e. SWOA channel or open water), based upon no significant difference in size of splittail between the two areas ($p=0.8100$) (Table 5-7). However, splittail were larger within the shallow SWOA floodplain than the restored marsh plain ($p=0.0160$).

Table 5-7. Mean fork length (mm) and *t*-test results for Sacramento splittail and striped bass, comparing the SWOA floodplain to restored marsh plain habitat based on beach seine data, and open water to SWOA channel based on otter trawl data.

Species	Gear Type	SWOA			Restored marsh plain			Open water			*t*-test results	
		n	Mean FL	SD	n	Mean FL	SD	n	Mean FL	SD	*t*	*p*
Sacramento splittail	Beach seine	14	159.4	90.42	69	108.9	65.49	-	-	-	2.4615	0.0160
	Otter trawl	9	191.7	83.51	-	-	-	27	197.9	60.04	0.2423	0.8100
Striped bass	Beach seine	7	128.7	138.18	34	56.9	24.26	-	-	-	2.9514	0.0053
	Otter trawl	13	250.4	85.21	-	-	-	283	115.2	57.59	8.0803	<0.0001

*Results of t-tests are based on the alternative hypothesis that the true difference in means is not equal to 0.

*Comparison for beach seine was based on SWOA floodplain v. restored marsh plain; for otter trawl, based on SWOA channel v. open water.

5.2.6 Use of restored areas

Inland silversides were found in the recently restored areas. The creation of shallow water habitat areas appears to favor conditions for inland silversides (Moyle 2002). Delta smelt, one of the two listed species in the area, are known to spawn in shallow water areas where silversides are typically abundant, particularly during dry years, so there is potential for decreased survival of delta smelt where these two species overlap (Moyle 2002). Silversides are known to prey upon fish larvae and may prey on larval delta smelt (Moyle 2002). Indirect effects are also possible, as silversides may deplete the inshore plankton and insect prey base, reducing the growth and survival rates for juvenile fishes of other species that feed upon the same prey (Moyle 2002). Delta smelt and inland silverside are both cool water plankton-feeding fish that co-occur in Suisun Bay (Matern et al. 2002).

There appears to be little use of the SWOA floodplain by splittail, and moderate use by inland silverside. Only 21 of the total 127 splittail were captured within the SWOA floodplain in 2002-2003. Juvenile splittail preferred restored marsh plain to the SWOA floodplain (Table 5-4). No difference in silverside preference was found between the restored marsh plain and the SWOA floodplain, based on beach seine data (Table 5-4). Fyke nets captured 127 silversides and only 4 splittail within the SWOA floodplain. Conditions within the SWOA floodplain appear to be more favorable for inland silversides than for splittail, due to the strong positive relationship between relative abundance and salinity for inland silverside when compared to splittail, and the higher salinity of the SWOA floodplain compared to the other habitat area types.

There is substantial use of the SWOA floodplain by juvenile Pacific herring for rearing. The majority (90%) were captured within SWOA floodplain fyke net sites, and the largest measured fish was 60 mm in fork length. Statistical analyses failed to reveal any potential reason for juvenile Pacific herring to prefer the SWOA floodplain. Although the greatest relative abundance of Pacific herring occurred in April, the analyses did not detect any significant difference in relative abundance between seasons. A statistical difference may not have been detected, since the majority of fyke net sampling effort occurred in spring. Pacific herring did not appear to have any associations with temperature or salinity. There were no significant relationships detected between CPUE and any of the environmental variables (Tables 5-2 and 5-4).

Smaller striped bass and splittail are using the main channel habitats (i.e., open water, restored marsh plain) more than the shallow floodplain terrace or the deep channel in the SWOA, based on measured sizes of fish captured by otter trawl and beach seine (Figures 5-1 and 5-2). Smaller striped bass appear to prefer the deeper open water to the SWOA channel, based on otter trawl sampling (Figure 5-1). Smaller splittail appear to prefer restored marsh plain over deeper waters and shallow SWOA areas, based on beach seine sampling (Figure 5-2). The absence of smaller fish from SWOA habitats suggests that the SWOA channel and floodplain are not being used as rearing habitat for young splittail and striped bass. Strong currents, a lack of vegetative cover, and a brief period of de-watering during low tide may discourage smaller splittail and striped bass from using this area.

Larger splittail appear to be using all habitats sampled by beach seine and otter trawl (Figure 5-2), whereas larger striped bass appear to be using primarily SWOA habitats and the deeper open water habitat (Figure 5-1). Larger splittail and striped bass may be using the SWOA areas for foraging during high tides. However larger splittail appear to be utilizing the restored marsh plain, whereas larger striped bass do not appear to be using this habitat to any great extent.

Otter trawl capture probabilities for larger fish may be higher in the SWOA channel than in open water habitat. The SWOA channel (Site 1A-2) can be more thoroughly sampled than the open water habitat, because it is a relatively confined channel (approximately 30 ft wide) with a smaller volume of water than in the main channel. Capture probabilities for smaller fish may be similar between the SWOA channel and open water, since they may not be able to physically take full advantage of the increased space for avoidance of capture. However, few smaller fish were captured in the SWOA, either in shallow or deeper water habitats. This indicates larger individuals are using the SWOA and that it is unlikely that the SWOA is being used for rearing by either striped bass or splittail at this time.

Although very few listed species (i.e., delta smelt, steelhead, and Chinook salmon) were captured, the majority of them were captured within the SWOA floodplain. The listed species were captured in only 3 of the 13 sites sampled; Sites 1A-4 (SWOA floodplain), 1A-7 (SWOA floodplain), and 3-1 (open water). The only delta smelt captured, an adult, was at Site 1A-7, within the SWOA floodplain (26 March 2002). The importance of freshwater tidal wetlands for native delta smelt is mostly speculative, and any benefits may be indirect (Brown 2003). Two of the three Chinook salmon captured were also from the SWOA floodplain, one of which was an AD-CWT fish. Shallow water areas are known to provide rearing habitats for juvenile salmon and splittail (Moyle 2002). Increasing freshwater tidal wetlands may provide improved conditions for rearing and refuge of anadromous salmonid fry, but freshwater tidal wetlands also tend to be dominated by non-native species, including species that may be active predators on larvae and juveniles of native species (Brown 2003).

Site 1A-4 appears to be a successful SWOA restoration area, based on the presence of splittail and listed species. Recently de-listed splittail were also captured at each of the sites where the other listed species were captured. Adult splittail in spawning condition were only captured at Site 1A-4, a SWOA floodplain site. However, the majority of splittail were captured from Site 1A-3, a restored marsh plain site that is adjacent to Site 1A-4. It is possible that Site 1A-4 and 1A-3 were used by both adult and juvenile splittail, because of the similarity of the habitats.

Currently, the SWOA does not appear to be benefiting native species more than non-native species. Non-native species (e.g. inland silverside), as well as native species, appear to be benefiting from the SWOA and restored marsh plain. In the Sacramento-San Joaquin Bay Delta, most resident fishes utilizing freshwater tidal wetlands are non-native (Brown 2003). However, it should be noted that the restored habitats of the Napa River FMP project area are in the early stages of regeneration and have not progressed very far towards becoming a fully restored marshland. At this time, it may be premature to draw conclusions about the effectiveness of the restoration efforts for native species.

6 RECOMMENDATIONS FOR 2004 PROGRAM

6.1 Sampling Schedule and Methodology

Deploying fyke net at Site 1A-6, May 2003.

Comprehensive fisheries monitoring of the restored areas should include year-round sampling on at least a monthly basis, and larval sampling to help document spawning in the SWOA and restored marshes. In addition, semi-monthly sampling in March and April is recommended to document seasonal spawning use. The proposed 2004 sampling schedule, from the original Request for Proposals, is shown in Table 6-1. The final sampling schedule will depend on availability of funding. If sufficient funding can be secured, larval light trapping and CDFG 20-mm otter trawls are recommended to better document delta smelt and splittail use of the SWOA and marsh plain terraces.

In order to make best use of available resources in 2003, sampling efforts were concentrated during the critical March through April period when delta smelt and Sacramento splittail were most likely to be found in the project area. Semi-monthly sampling between March and April was successful in documenting the presence of delta smelt, Sacramento splittail, and Chinook salmon. Sacramento splittail and Pacific herring were captured in greatest numbers between March and April. Increasing the number of fish that are captured will improve the ability to make more conclusive statements regarding seasonal distribution and abundance in the project area, in relation to environmental variables. Therefore, semi-monthly sampling in March-April is also recommended for 2004.

Delta smelt are the only listed species found in the project area; therefore, documenting their presence in the study area is of primary importance in this monitoring effort. The CDFG captured over 3,800 delta smelt larvae in 20-mm tow-net surveys in the Napa River/project area in 2001 (USACE 2002). In contrast, only one adult delta smelt was captured by fyke net in the SWOA in 2002 [under the current monitoring program]. Sampling of larval stages may help to identify important spawning and early rearing areas, and to elucidate factors affecting survival of larval and juvenile fish in the project area, and to understand the effects of environmental conditions/variables on their abundance and distribution. This type of approach is also suggested by Matern et al. (2002). Sampling between November and February with an otter trawl and purse seine may also increase catch of juvenile delta smelt (Matern et al. 2002).

In 2004, three new sites will be added (Sites 1B-2, 1B-3, and 2-3). Site 1B-2 and Site 2-3 will be sampled with a fyke net and Site 1B-3 will be sampled with a beach seine. The addition of sampling with a fyke net in the marsh/flood plain terraces will greatly increase the value of the SWOA fyke net data by enabling comparisons between different habitat types.

Table 6-1. Proposed Monthly Sampling Schedule and Gear Type for 2004.*

		Sampling Dates (Alternate Dates)								
		Jan	Feb	March		April		May	Jun	Jul
Site	Location	5-7 (21-23)	3-4 (18-20)	3-4	17-19	13-15	27-29	13-15 (27-29)	14-16 (26-28)	12-14 (26-28)
1A-1	Open Water (River)	O	O	O	O	O/LT	O/LT	O/LT	O	O
1A-2	SWOA Slough	O	O	O	O	O/LT	O/LT	O/LT	O	O
1A-3	Marsh Plain Terrace	BS	BS	BS	BS	BS/LT	BS/LT	BS/LT	BS	BS
1A-4	Floodplain Terrace	BS	BS	BS	BS	BS/LT	BS/LT	BS/LT	BS	BS
1A-5	Emergent Marsh	--	--	--	--	--	--	--	--	--
1A-6	SWOA Marsh	--	--	F	F	F/LT	F/LT	F/LT	F	--
1A-7	SWOA Marsh	--	--	F	F	F/LT	F/LT	F/LT	F	--
1A-8	SWOA Marsh	--	--	--	--	--	--	--	--	--
1A-9	SWOA Levee Breach	--	--	--	--	--	--	--	--	--
1A-10	SWOA HB Marsh	--	--	F	F	F/LT	F/LT	F/LT	F	F
1B-1	Open Water (River)	O	O	O	O	O/LT	O/LT	O/LT	O	O
1B-2	Marsh Plain Terrace	--	--	F	F	F/LT	F/LT	F/LT	F	F
1B-3	Floodplain Terrace	BS	BS	BS	BS	BS/LT	BS/LT	BS/LT	BS	BS
2-1	Open Water (River)	O	O	O	O	O/LT	O/LT	O/LT	O	O
2-2	Marsh Plain Terrace	BS	BS	BS	BS	BS/LT	BS/LT	BS/LT	BS	BS
2-3	Floodplain Terrace	F	F	F	F	F/LT	F/LT	F/LT	F	--
3-1	Open Water (River)	P	P	P	P	P/LT	P/LT	P/LT	P	P

*FN = fyke net; PS = purse seine; OT = otter trawl; BS = beach seine, 20mm = CDFG 20mm otter trawl, LT = light trap

Note: This table is subject to change.

6.2 Statistical Analysis

Application of the multivariate linear modeling and ANOVA techniques for statistical analysis of the Napa Program data was sufficient to establish the significance of trends in the relationships between various environmental parameters and fish use of the area. Strengths of this approach to the analysis included the ability to detect significant relationships between relative abundance and environmental variables, to include an unlimited number of explanatory variables that could influence relative abundance, and to assess how well the linear model fits the data.

Limitations of the statistical analysis may include use of CPUE as an index of abundance. Due to the relatively low numbers of the primary target fish species (i.e., delta smelt and splittail), inherent imprecision in characterizing some of the capture efforts (e.g., approximations of beach seine haul length and average sampling depths, estimated size of purse seine enclosure, etc.), and some uncertainty in the relationship between effort and capture numbers (e.g., changes in the nature of the relationship due to varying environmental conditions), CPUE may be limited as an index of abundance.

As more data are collected, alternate approaches to the sampling and statistical analysis should be considered. These alternatives include the following.

- A generalized linear model (GLM) could be developed. Although the results of this type of approach may be quite similar to the results generated to date, the GLM could directly utilize the numbers of fish and the capture effort as data to drive the model, rather than relying on CPUE. In addition, a more precise fit of the model to the data may be possible by specifying a non-normal error distribution such as a Poisson distribution.

- For species with low capture numbers, analyses could focus more specifically on presence/absence rather than numbers captured. This type of analysis could be incorporated into a GLM with presence/absence as a binary response variable.

- Larval life stages could be targeted in future field sampling. Matern et al. (2002) found that the strongest correlations between abundance and environmental variables were detected for larval fish. Thus, this type of field sampling may strengthen the power of the statistical analyses in uncovering significant relationships between variables.

Bluegill captured at Site 1A-1, March 2003.

7 PROGRAM TEAM MEMBERS

The Napa River Fisheries Monitoring Program team members for 2003 are listed in Table 7-1.

Table 7-1. Napa River Fisheries Monitoring Program Team.

Name	Affiliation	Experience	Program Responsibility
Mike Dietl	Army Corps of Engineers	B.S. Fisheries Seven years experience in environmental management and fishery biology.	USACE Program Manager, Contracting Officer's Representative
Sharon Kramer	Stillwater Sciences	Ph.D. Marine Biology M.S. Zoology B.S. Aquatic Biology 27 years experience in marine, estuarine, and stream ecology in California and elsewhere.	Principal Investigator
Scott Wilcox	Stillwater Sciences	M.Ed. Natural Resources Management; B.S. Wildlife and Fisheries Biology. 24 years experience in fisheries and aquatic resource studies in California.	Project Manager
Steven Kramer	Stillwater Sciences	M.S. Natural Resources/Fisheries B.S. Fisheries Biology 22 years experience in marine, estuarine, and stream ecology.	Field Leader
Stephanie Theis	Jones and Stokes	M.S. Applied Ecology and Conservation Biology B.S. Fisheries Biology 14 years of fisheries experience.	Field Leader
Lauren Dusek	Stillwater Sciences	B.S. Wildlife, Fish, and Conservation Biology. Three years of experience conducting fisheries studies in the Delta and tributary streams.	Field Biologist
Peter Baker	Stillwater Sciences	Ph.D. Mathematics B.A. Mathematics. 15 years of experience analyzing fisheries data.	Statistical Analysis
David Zajanc	Stillwater Sciences	B.S. Resource Management. M.S. Fisheries Biology Five years of statistical analysis experience.	Statistical Analysis
Donna Maniscalco	Jones and Stokes	B.S. Wildlife, Fish, and Conservation Biology Five years conducting fisheries surveys of anadromous salmonids.	Field Biologist
Susan Davis	Jones and Stokes	M.A. English Literature B.A. English Literature Six years of technical computer experience.	Web Developer
Micah Rousey	Jones and Stokes	Certified in Microsoft Access, Excel, and Relational Database Management Systems. 6 years experience developing custom databases and business applications.	Database Administrator
Johnson Wang	Consultant	Ph.D. Fisheries Over 30 years experience in larval fish studies.	Larval Fish Expert

8 MATERIALS PURCHASE REPORT

No durable, capital expense items were purchased for the Napa River Fisheries Monitoring Program in 2003.

9 LITERATURE CITED

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