Metadata Report

2008-2010 Nearshore Survey Database Metadata Report for Sacramento-San Joaquin Electrofishing and Submerged Aquatic Vegetation Surveys conducted by UC Davis Departments of Environmental Science & Policy (Sih Laboratory) and Wildlife, Fish, and Conservation Biology (Moyle Laboratory)

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Introduction

This report provides metadata for the electrofishing surveys and submerged aquatic vegetation (SAV) sampling efforts that were conducted for research funded by the Interagency Ecological Program (IEP) in 2008 ("Impacts of largemouth bass on the Delta ecosystem," IEP Project Number 2010-176) and in 2010 ("Influences of water quality and submerged aquatic vegetation on largemouth bass distribution, abundance, diet composition and predation on Delta smelt in the Sacramento-San Joaquin Delta", IEP Project Number 2011-176). The purpose of the report is to detail the sampling methods for both fish and SAV survey efforts, and to describe the design and use of the accompanying MS Access database, "NearshoreSurveyUC200810."

The primary purpose of this research project was to document abundance and habitat associations of largemouth bass (LMB) in the Sacramento-San Joaquin Delta (Delta) because relatively recent trends demonstrate an increasing LMB population in the Delta nearshore environment while many native pelagic species have shown a decline. In particular, a major goal was to quantify the association between LMB and SAV, particularly the highly invasive ecosystem engineer Brazilian waterweed *Egeria densa*, which proliferated throughout Delta waterways during the same time period that LMB populations flourished (Brown and Michniuk, 2007). To determine the level of direct impact via predation that LMB have on native fishes, a second goal was to describe the LMB diet as a function of LMB size along a gradient of SAV biomass density. In order to get a higher resolution picture of the LMB interactions with pelagic habitats, the work funded by IEP in 2008 also included work tracking LMB using acoustic telemetry and a lab-based mesocosm experiment examining effects of SAV density and turbidity on LMB prey choice. In 2010, IEP funded a continuation of the electrofishing and SAV surveys that began in 2008, as well as two additional field efforts to determine SAV-invertebrate interactions and targeted surveys for abundance and diet of LMB and other putative predators in areas with known presence of Delta smelt. However, only the electrofishing and SAV field sampling efforts that took place between October 2008 – October 2010 and collection and

analysis of LMB diet samples during the same time period are summarized in this report. The telemetry work, mesocosm experiments, and targeted predator surveys are summarized in other reports.

Description of Sampling Methods

A. Determination of Sampling Locations

Thirty-three sites were sampled for fishes via electrofishing and for SAV on a bimonthly basis. These sites were chosen from a random sample of 50 locations generated by the Center for Spatial Technology and Remote Sensing (CSTARS) at UC Davis. Criteria for location selection included the following: (1) SAV detected within the site at least once since 2004 during CSTARS' annual fly-overs to collect aerial hyperspectral imagery of the Delta and subsequent classification of SAV presence within images (Hestir et al., 2008), and (2) water depth no greater than 3 meters, as this is considered a limit for effective electrofishing as well as the depth at which light levels may limit SAV establishment and growth. Hyperspectral imagery results from 2004-2008 were merged to create a unique layer designated as SAV presence. Water depth was derived from the Department of Water Resources (DWR) bathymetry layer. Fifty random points within the SAV layer and 50 within the water depth layer were generated, and then screened to eliminate adjacent locations, such that the minimum distance between locations was 100 meters. A final set of 50 points were then visited in the field. SAV community composition, logistics and boat travel distance were the criteria used for the final selection of 33 sites (map, Fig. 1). Originally, 30 sites were selected, but in February 2009 sites in Big Break (BIG_2), Miner Slough (MIN_2), and Sherman Lake (SHE_1) were added to the site list due to an interest in including another shallow, open water site (BIG_2), and expanding the site distribution in the northern (MIN_2) and western (SHE_1) regions of the Delta. Latitude and longitude for each site location are provided in TblSiteInfo in the database; these coordinates are based on data collected during the February and April 2009 sampling sessions.

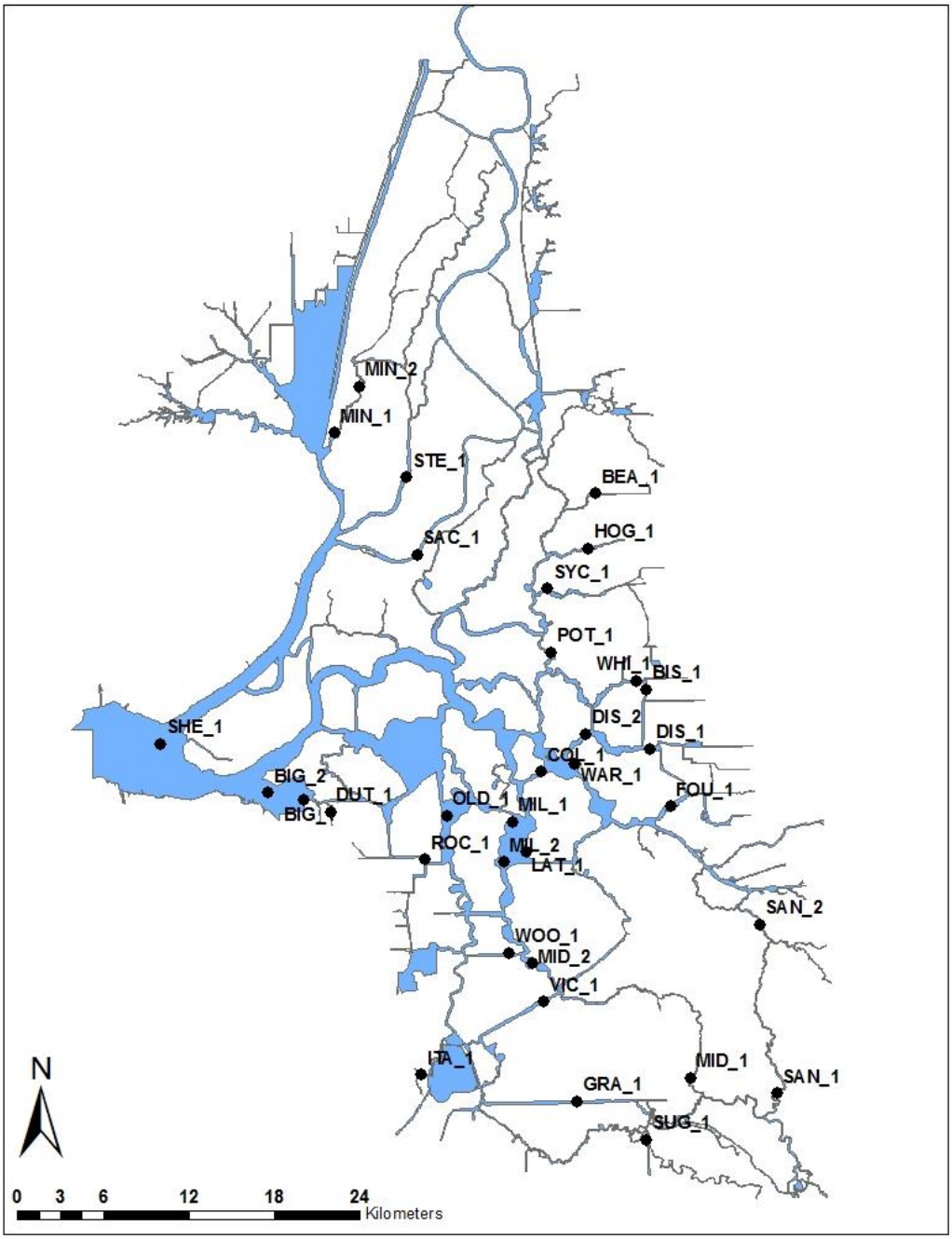


Figure 1. Map of 33 electrofishing and SAV survey sites, revisited on a bimonthly basis from October 2008 – October 2010.

B. Electrofishing Methods

The Secchi depth was recorded to the nearest 1/10 meter upon arrival to the sampling site unless the substrate was clearly visible. The location at which the Secchi depth was taken was recorded in a handheld GPS data logger (Trimble Geo Series, accuracy of 1-3 meters), and the same point was revisited when recording Secchi depth in subsequent site visits.

Electrofishing was carried out in a Smith-Root 18' vessel specialized for electrofishing with a 5.0 GPP marine generator. This vessel (CF 9146 XS) was loaned to UC Davis for this project at no cost from the California Department of Fish & Game Stockton office (Marty Gingras: mgingras@dfg.ca.gov). A single pass on a transect of approximately 300 meters was conducted at each site visit. The transect line was recorded in the GPS data logger such that the same line could be seen in the GPS unit and revisited at each sampling event. Occasionally it was necessary to deviate from the transect line to avoid other boats or objects in the way and these cases were noted. The line fished was recorded for each site visit. Since it was often necessary to stop electrofishing over the course of the transect to retrieve shocked fish behind the boat, the recorded line was cleaned of these non-fishing loops in ArcGIS after sampling in order to accurately estimate the effort (meters fished) for each site.

Electrofishing was generally conducted at 6 -10 Amps (50-500 volts, 50-80% of range). Two people netted the fish from the bow of the boat while a third person operated the boat. Occasionally, when conductivity was high, the percent of range level had to be adjusted in order to achieve adequate amperage for shocking the fish. Surveys were conducted in all weather conditions except during wind and rain events that significantly limited visibility of stunned fish in the water or the ability of the boat operator to control the boat and keep it on transect at acceptable speeds. An array of cables hanging vertically from the bow was used as the cathode rather than the boat hull. Anodes were deployed with Wisconsin rings attached to booms on either side of the bow. The netters controlled electrical output with a foot pedal at the bow, and the automatic timer on the boat counted the number of seconds the voltage was on. Thus, fishing effort was recorded in both shocking seconds and the number of meters fished.

Every effort was made to capture every fish that was visibly shocked by netting them with a heavy duty electrofishing nets (8-foot handles and ½ inch mesh net bags), and placing them in an on-board livewell. In August 2010, the net mesh size was reduced to ¼ inch mesh for the purpose of a separate project that required capture of even smaller juvenile LMB. For data analysis purposes for the survey data, we excluded any fish measuring less than 20mm throughout the project, as this was considered a minimum size for effective catch with the 1/2" inch mesh nets. The only species routinely not brought on board were large common carp, because their large serrated spine damaged the nets, and once on board their thrashing about in the livewell would injure or kill other captured fish. Instead, stunned carp were tallied during electrofishing in order to obtain an abundance estimate. All captured fish were identified to species, counted, and up to 50 individuals per species were measured to fork length (FL), or total

length (TL) for any species lacking a forked tail (e.g., yellowfin goby). For LMB, all captured individuals were measured, except in a few cases when large a number were caught:

Site	Date	#Captured	#Measured	#Unmeasured
ITA_1	12/9/2008	108	48	60
ITA_1	6/16/2009	278	64	214
WOO_1	8/20/2009	272	125	147
MIL_2	8/12/2009	201	98	103
ROC_1	8/12/2009	127	102	25
POT_1	8/14/2009	187	108	79
VIC_1	8/18/2009	151	106	45

Table 1. Site visits where >50 individual LMB were captured and only a portion were measured.

Our analyses quantify the proportion of individuals classified as juveniles (FL≤125mm) and non-juveniles (FL>125mm) captured during each site visit, and in order to deal with the aforementioned instances where some LMB were not measured, we calculated the proportion of juvenile versus non-juveniles for measured LMB and adjusted it for all individuals captured.

In addition, the weight was measured for all largemouth bass measuring >175mm FL by placing the fish into a tared plastic bucket placed on a hanging scale with a digital display. All largemouth bass that were released were also tagged with a yellow Floy Tag (Floy Tag, Inc.) with an individual ID number on it. For a majority of the study, this tag also contained a contact phone number of the Sih lab at UC Davis so that the fish's tag number could be reported if caught by an angler. The tag was inserted alongside the dorsal fin.

All fish were processed at the transect itself, or nearby (within ~60m) in a sheltered location, and all fish were promptly released in the same location, except for a maximum of 10 LMB measuring <175mm that were sacrificed and preserved for diet analyses in the laboratory.

C. LMB Diet Collection and Sample Analysis

All LMB measuring ≥ 175mm FL were subjected to gastric lavage in order to collect a diet sample. This procedure was carried out without anesthesia as the bass were generally still somewhat stunned after electroshocking. A pressurized garden sprayer filled with water was used for lavage, with the application tip modified with a copper tube that was long enough to insert well into a large LMB stomach. The fish was placed in a V-shaped wooden holder and tipped slightly so that the mouth was pointed downward into a clean, empty aquarium net to capture the diet sample. At least two spray sessions were applied to each fish. Before the fish was released, the inside of the mouth was always checked for contents that had not completely exited the esophagus or were loose inside the mouth, and if contents were visibly still exiting the esophagus or were loose inside the mouth, they were removed with forceps and preserved. If no stomach contents resulted from the first two sprayings, a third spraying was sometimes applied if

stomach contents were felt through the abdominal wall or if contents could be seen partially emerged from the esophagus. After the lavage procedure was complete, the tagged fish was released.

In order to characterize diet contents of the smaller LMB, up to 10 LMB measuring <175mm FL per site were sacrificed and preserved as whole fish in 10% buffered formalin for later stomach content analysis in the laboratory. For every LMB captured, whether or not a diet sample was attempted was recorded (Field "StomachSampled" in TblLMB), as well as the method of diet sample collection (Lavage, Preserved, or N/A for fish that were released without sampling; Field "StomachMethod" in TblLMB) was recorded. For lavaged fish, the presence or absence of a diet sample was recorded immediately after lavage (0=absent; 1=present), and for preserved fish, it was recorded after laboratory dissections. Once stored at the laboratory for at least one week, all diet samples (lavaged and whole preserved fish) were transferred to a 70% ethanol solution. Upon dissecting preserved fish, relative stomach fullness was assigned a visual rating (0=empty, no sample, 1= 1-25% full, 2 = 26-50% full, 3 = 51-75% full, and 4 = 76-100% full). In addition, notes were made regarding the level of *Contracaecum* sp. parasite infestation within the fish including number of individual parasites and location found within the body, and any other observed abnormalities regarding organ condition.

To characterize LMB diet, stomach contents were placed into taxonomic groupings as follows. Fish prey items were classified to the lowest feasible level of classification. For fish identification, cleithrum morphology was used to achieve a lower level of identification (to genus or species rather than "unidentified fish") whenever the fish was too degraded to be identified easily, and when the cleithrum could be found. The guide used for cleithrum identification was prepared by Denise de Carion (denise.decarion@gmail.com), based on dissection of cleithra from 1-2 specimens collected from the Delta of common LMB fish prey species. Crustaceans were grouped into decapods into crayfish (of which most specimens were observed to be redswamp) and shrimp categories, cladocerans, copepods, and amphipods, with the latter identified to the family level. Insects were classified to the order or suborder level. After categorizing stomach contents, the number of individuals in each group was counted, and all individuals in the group were weighed together. This protocol yielded not only the frequency of occurrence of each prey group, but also the proportion by number and weight of each prey type.

To ensure proper identification of diet contents a spot-checking protocol was implemented. For every bimonthly sampling visit, approximately twenty percent of the samples collected by lavage and approximately twenty percent of the stomach contents collected from preserved fish were selected randomly for spot-checking. The identity of all species found in the sample was again determined. We did not recount or reweigh any prey items, unless the amount in the taxonomic group in question clearly differed from what was previously recorded amount. Any differences found between original and spot-checked samples were noted (categorized as having "no changes" or "changed"), and adjustments to the diet database were made. In addition,

any samples collected during the months October 2008 to July 2009 whose gut contents contained fish were re-analyzed (n=176) using cleithrum identification, which had previously not been employed.

Tables 2a & 2b display the number of samples re-checked, both for re-analyzing gut contents containing fish from October 2008- July 2009 and for the spot-checking effort. This led to the high percentage of samples being checked, which in the tables displayed below are greater than 20%, as required of the spot checking protocol. For the actual spot checking procedure, 679 samples were re-checked. Of those 679 samples, 265 required a change in the diet data, which is roughly a 40% error rate. However, of the 265 changes we made, 64 were merely additions of invertebrates for which were previously unaccounted, changing the error rate to 30%. 52 of the 265 samples were accidentally not analyzed in the first installment of diet analysis. Combining the numbers for additions and unanalyzed samples, our overall error rate for diet analysis is only ~22%.

Table 2a. Accuracy level of diet identification for preserved LMB gut contents:

Sample Month	Total Preserved Samples	Total Preserved Checked	% Preserved Checked	# Preserved w/ Errors	% Preserved Errors
Oct-08	175	42	24	20	48
Dec-08	104	26	25	6	23
Feb-09	56	15	27	8	53
April-09	118	38	32	14	37
June-09	138	74	54	33	45
Aug-09	199	40	20	19	48
Oct-09	189	37	20	14	38
Dec-09	84	18	21	6	33
Feb-10	113	28	25	5	18
April-10	124	28	23	11	39
June-10	159	26	16	8	31
Aug-10	233	75	32	47	36
Oct-10	247	43	17	10	23

Table 2b. Accuracy level of diet identification for lavaged LMB gut contents:

Sample Month	Total Lavage Samples	Total Lavage Checked	% Lavage Checked	# Lavage w/ Errors	% Lavage Errors
Oct-08	73	29	40	19	66
Dec-08	88	56	64	30	54
Feb-09	68	35	51	19	54
April-09	125	54	43	30	56
June-09	124	84	68	37	44

Aug-09	105	22	21	13	59
Oct-09	74	18	24	5	28
Dec-09	51	10	20	2	20
Feb-10	101	20	20	5	25
April-10	68	14	21	1	7
June-10	91	17	19	5	29
Aug-10	61	12	20	0	0
Oct-10	60	11	18	6	55

Table 3. List of 52 LMBRecIDs corresponding to samples that were overlooked during the first installment of diet analysis, and were analyzed concurrent with the spot-checking effort.

LMBRecID	LMBRecID	LMBRecID	LMBRecID	LMBRecID
COL_1_080210_1	DIS_2_020209_11	FOU_1_101410_4	SUG_1_081810_3	SYC_1_080410_15
COL_1_080210_10	FOU_1_081610_1	HOG_1_100810_7	SUG_1_081810_4	SYC_1_080410_6
COL_1_080210_2	FOU_1_081610_10	MIL_1_101609_1	SUG_1_081810_5	SYC_1_080410_7
COL_1_080210_3	FOU_1_081610_2	MIL_2_101310_7	SUG_1_081810_6	SYC_1_080410_8
COL_1_080210_4	FOU_1_081610_3	MIL_2_101310_8	SUG_1_081810_7	SYC_1_080410_9
COL_1_080210_5	FOU_1_081610_4	MIL_2_101310_9	SUG_1_081810_8	SYC_1_101909_13
COL_1_080210_6	FOU_1_081610_5	MIN_1_101510_1	SUG_1_081810_9	SYC_1_101909_2
COL_1_080210_7	FOU_1_081610_6	STE_1_081710_2	SYC_1_080410_11	WAR_1_020209_8
COL_1_080210_8	FOU_1_081610_7	STE_1_081710_4	SYC_1_080410_12	
COL_1_080210_9	FOU_1_081610_8	STE_1_081710_5	SYC_1_080410_13	
DIS_1_100708_5	FOU_1_081610_9	SUG_1_081810_10	SYC_1_080410_14	

D. Water Quality and SAV Collection and Analysis

After electrofishing, SAV was sampled and water quality profiles were recorded every 60m at six points along the fishing transect, and each sampling location was recorded in the Trimble GPS data logger. The water quality profile was recorded with an YSI 6920 multiparameter sonde equipped with temperature, conductivity, dissolved oxygen, pH, and turbidity sensors. All data was logged to the sonde and downloaded at the end of the day with EcoWinn software. The SAV sample was collected with a collapsible 16-foot double-headed metal garden rake. The rake was lowered straight down the water column, rotated 360° while in contact with the bottom, and continually rotated while raising it straight up the water column. This protocol provided a sampling method standardized for surface area, allowing an estimation of the SAV biomass density (Kenow *et al.*, 2007). As the fish community and CPUE is likely influenced by the environment surrounding the fishing transects, the SAV/water quality sampling procedure was repeated at a series of four parallel points up to 60m away from the transect in either direction. In sloughs that are less than 60m in width, off-transect points were taken a

minimum of 40m away from the transect, or not collected at all. This protocol yielded up to 14 SAV/water quality points for each transect (Fig. 2); however, as most transects are located directly adjacent to the shoreline, only one set of off-transect points were acquired for the majority of sites, for a total of 10 points.

Figure 2. Sample electrofishing transect lines with SAV and water quality sampling points indicated. Left: OLD_1 mid-channel transect with rake-off points on both sides. Right: MIN_2 shoreline transect with rake-off points on only one side.

In the laboratory, SAV from each rake sample was separated by species and rinsed prior to recording wet weights for each species. Results from previous work in the CSTARS group (Drs. Erin Hestir and Maria Santos at UC Davis) quantified the relationship between wet and dry weights for each SAV species.

Table 4. Regression equation for SAV species to derive dry weight from fresh weight data. All equations have an R2 value >0.97.

Code	SppName	Formula
EGDE	*Egeria densa*	DW=0.0579FW+0.1819
MYSP	*Myriophyllum spicatum*	DW=0.0508FW+1.6131
CEDE	*Ceratophyllum demersum*	DW=0.0503FW-0.0642
CACA	*Cabomba caroliniana*	DW=0.0624FW-0.613
ELCA	*Elodea canadensis*	DW=0.0568FW+0.0093
STPE	*Stuckenia pectinata*	DW=0.0789FW-0.3408
STFI	*Stuckenia filiformis*	DW=0.0237FW+1.1305
POCR	*Potamogeton crispus*	DW=0.0666FW+0.0119
PONO	*Potamogeton nodosus*	DW=0.0801FW+0.0003

Water quality profiles were screened and averaged to get a single value for each of the following parameters at each site: dissolved oxygen (mg/L), pH, specific conductance (µS), temperature (°C), and turbidity (NTU). The screening process consisted of three steps. The first step was a manual screen that eliminated all nonsensical values associated with the sonde

collecting data while out of the water (e.g., negative turbidity values). Any points removed from this manual screen were removed for all parameters. After the initial manual screen, a quantile screen was performed for each parameter individually. We determined the 2.5 and 97.5 quantiles and eliminated all values that did not fall within those quantiles. After the quantile screen there was a final manual screen of the turbidity data. This final screen was used to eliminate values recorded after the sonde hit the substrate. This was accomplished by plotting turbidity values against time, and removing data with values that clearly denoted substrate disturbance. These data were removed from all parameters. After all of the screening was complete, the means of all remaining data in the profile were taken for each parameter for each sampling point. The average values for all profiles at each site were then averaged, resulting in single average values for each water quality parameter at each site.

In October, 2008, the YSI multi-parameter sonde was not yet available for use and no water quality profiles were taken. During this month, temperature and conductivity were recorded at the water surface, but turbidity (NTU) was not measured. In February, 2010, the turbidity sensor on the multiparameter sonde malfunctioned for the entire month- such that it was not possible to collect NTU data. Occasionally, water quality data was also not available due to technical issues with the sonde or data transfer from the sonde unit. For site visits with missing water quality data, surrogate data was acquired whenever possible from the nearest gauge with continuous data collection supplied to the California Data Exchange Center (CDEC, http://cdec4gov.water.ca.gov/). To determine whether the CDEC data was appropriate as a surrogate for water quality data measured at the site, the CDEC data and on-site measured data were compared for all dates and times when both were available. If the average of the CDEC data fell within the value of two standard deviations of the data measured on site for every date compared, then the gauge data was deemed appropriate for filling in missing data. Exceptions to this rule were only made when the standard deviation of the data measured on site was extremely small (e.g., <5 NTUs). Site visits where CDEC data was used instead of measured data at the site are indicated in "TblWaterQuality" of the database, with the CDEC Station name abbreviation also noted.

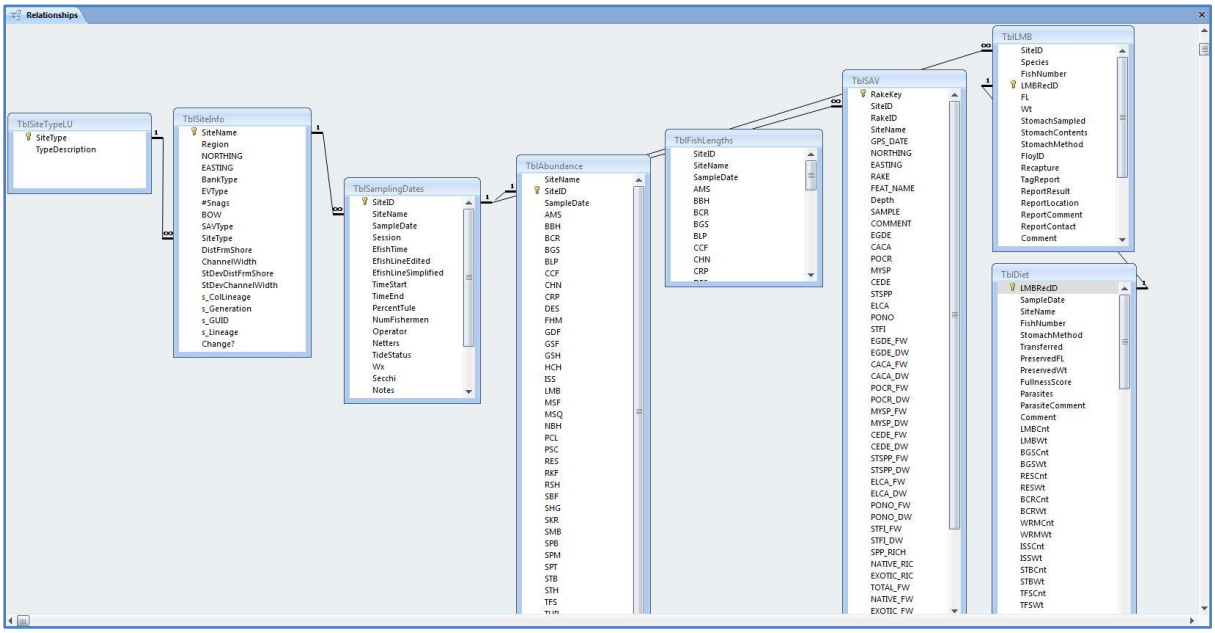
Database Structure

All data were organized in an MS Access database, using the table structure depicted in Figure 2. The SiteID field in "TblSiteInfo", "TblSamplingDates", "TblSAVType" and "TblAbundance" and "TblFishLengths" is a unique identifier for each site visit. It is composed the first three letters of the body of water and one following digit (e.g. Beaver Slough is BEA_1) and a six digit date (e.g. 10/16/2010 for 101610). For "TblLMB" the primary key is "LMBRecID", which is a unique code assigned to each individual largemouth bass captured at each time point throughout the survey. It is comprised of "SiteName", "SampleDate", and "FishNumber", of which "FishNumber" is a randomly assigned number based on when the largemouth bass was processed sequentially on the boat. Similarly, "TblSAV" has a primary key field labeled "RakeKey", which is an automatically generated unique number assigned by MS

Access to each vegetation sample corresponding to its own GPS point along each transect for each site visit.

Figure 3. Relationships among tables in MS Access database.

Each relationship between tables is established through either "SiteID" or "LMBRecID", and each relationship is designed to enforce referential integrity. Note: TblFishLengths does not have a defined relationship because there are multiple unique values for each SiteID, which we found to create querying difficulties if related by SiteID to other tables.



MS Access Database Table Descriptions

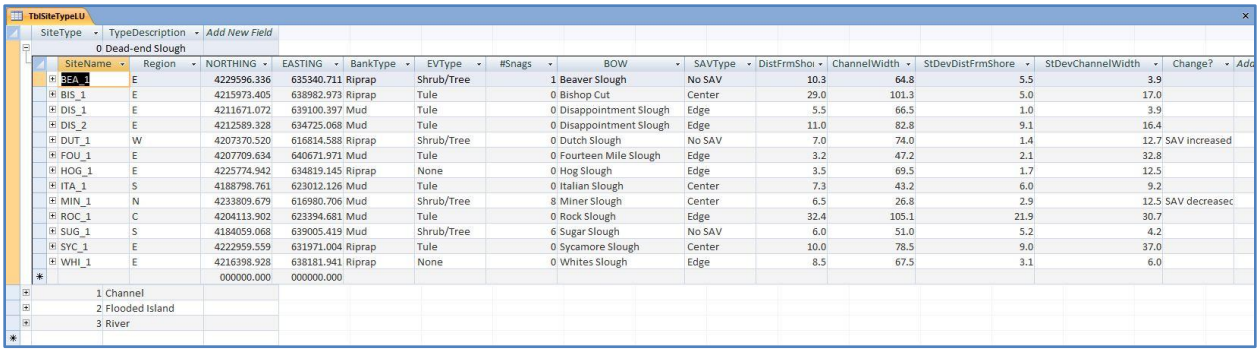
The following tables include information describing the data found in each respective MS Access table, as copied from the "DesignView" into MS Excel spreadsheets.

Metadata tables

MS Access Table 1. Description and functionality of TblSiteTypeLU.

TblSiteTypeLU is a look up table that assigns each survey location a habitat category: 0= dead-end slough (n=13); 1= channel (n=8); 2= flooded island (n=7); and 3=river (n=5). The basis on which the locations were rated is the California Department of Water Resource's Delta Simulation Model II version 8.0.6, which is a one-dimensional mathematical model for dynamic simulation of one-dimensional hydrodynamics, water quality and particle tracking in a network of riverine or estuarine channels (and can be accessed with the following URL: http://baydeltaoffice.water.ca.gov/modeling/deltamodeling/models/dsm2/dsm2.cfm).

The screenshot depicted below demonstrates the look-up function for survey locations that are classified as dead-end sloughs:



TblSiteTypeLU

SiteType	TypeDescription	Add New Field
0	Dead-end Slough	
1	Channel	
2	Flooded Island	
3	River	

SiteName	Region	NORTHING	EASTING	BankType	EVType	#Snags	BOW	SAVType	DistFrmShor	ChannelWidth	StDevDistFrmShore	StDevChannelWidth	Change?	Add
BEA_1	E	4229596.336	635340.711	Riprap	Shrub/Tree	1	Beaver Slough	No SAV	10.3	64.8	5.5	3.9		
BIS_1	E	4215973.405	638982.973	Riprap	Tule	0	Bishop Cut	Center	29.0	101.3	5.0	17.0		
DIS_1	E	4211671.072	639100.397	Mud	Tule	0	Disappointment Slough	Edge	5.5	66.5	1.0	3.9		
DIS_2	E	4212589.328	634725.068	Mud	Tule	0	Disappointment Slough	Edge	11.0	82.8	9.1	16.4		
DUT_1	W	4207370.520	616814.588	Riprap	Shrub/Tree	0	Dutch Slough	No SAV	7.0	74.0	1.4	12.7	SAV increased	
FOU_1	E	4207709.634	640671.971	Mud	Tule	0	Fourteen Mile Slough	Edge	3.2	47.2	2.1	32.8		
HOG_1	E	4225774.942	634819.145	Riprap	None	0	Hog Slough	Edge	3.5	69.5	1.7	12.5		
ITA_1	S	4188798.761	623012.126	Mud	Tule	0	Italian Slough	Center	7.3	43.2	6.0	9.2		
MIN_1	N	4233809.679	616980.706	Mud	Shrub/Tree	8	Miner Slough	Center	6.5	26.8	2.9	12.5	SAV decreasec	
ROC_1	C	4204113.902	623394.681	Mud	Tule	0	Rock Slough	Edge	32.4	105.1	21.9	30.7		
SUG_1	S	4184059.068	639005.419	Mud	Shrub/Tree	6	Sugar Slough	No SAV	6.0	51.0	5.2	4.2		
SYC_1	E	4222959.559	631971.004	Riprap	Tule	0	Sycamore Slough	Center	10.0	78.5	9.0	37.0		
WHI_1	E	4216398.928	638181.941	Riprap	None	0	Whites Slough	Edge	8.5	67.5	3.1	6.0		
		000000.000	000000.000											

MS Access Table 2. Name, data type, and descriptions in TblSiteInfo.

Information for each site that did not vary between bimonthly site visits is provided with a single row for each of the 33 sites. These data include: the Delta region (assigned using the region delineations given in Brown and Michniuk, 2007), bank type, emergent vegetation type (EVType) number of large woody debris snags, body of water (BOW), distance of the transect from shore, channel width at the location of the transect, the standard deviation of distance from shore, the standard deviation for channel width, and if/how the SAV landscape was observed to change drastically over the duration of the two year study. In order to ground-truth channel width for each site, we used rangefinder readings, ArcGIS, and GoogleEarthPro technologies. Each method had its own shortfall: rangefinders are limited in their ability to determine distances under 40 meters; and the GIS Delta shapefile was suspected to be inaccurate due to the nature of changing shoreline morphology as a result of floating and emergent vegetation. First we obtained rangefinder readings from "Rake on" and "Rake off" points to the farthest shore. Next, we plotted these distances onto GoogleEarthPro to estimate the distance closest to shore from each point. Then we added these two distances to obtain a total channel width estimate from each point, and then we averaged of all of the estimates for one single channel width value. GoogleEarthPro was used for sites where rangefinders were ineffective such as flooded islands and narrow sloughs.

MS Access Table 3. Fish species code, common name, family, classification, and native versus introduced status of Delta fishes surveyed in TblSpeciesInfo.

Code	CommonName	Family	Classification	Native/Introduced
BGS	bluegill sunfish	Centrarchidae	*Lepomis macrochirus*	I
MSQ	mosquitofish	Poecilidae	*Gambusia affinis*	I
SKR	Sacramento sucker	Catostomidae	*Catostomus occidentalus*	N
TFS	threadfin shad	Clupeidae	*Dorosoma petenense*	I
CRP	common carp	Cyprinidae	*Cyprinis carpio*	I
RKF	rainwater killifish	Fundilidae	*Luciana parva*	I
SPT	Sacramento splittail	Cyprinidae	*Pogonichthys macrolepidotus*	N
WRM	warmouth sunfish	Centrarchidae	*Lepomis gulosus*	I
SKB	threespine stickleback	Gasterosteidae	*Gasterosteus aculeatus*	N
BLP	bigscale logperch	Percidae	*Percina macrolepida*	I
FHM	fathead minnow	Cyprinidae	*Pimephales promelas*	N
RBT	steelhead/rainbow trout	Salmonidae	*Oncorhynchus mykiss*	N
ISS	inland silverside	Atherinopsidae	*Menidia beryllina*	I

TUP	tule perch	Embiotocidae	*Hysterocarpus traski*	N
HCH	hitch	Cyprinidae	*Lavinia exilicauda*	N
GSF	green sunfish	Centrarchidae	*Lepomis cyanellus*	I
SHG	shimofuri goby	Gobiidae	*Tridentiger bifasciatus*	I
PCL	pacific lamprey	Petromyzontidae	*Lampetra tridentata*	N
DES	delta smelt	Osmeridae	*Hypomesus transpacificus*	N
BCR	black crappie	Centrarchidae	*Pomoxis nigromaculatus*	I
NBH	brown bullhead	Ictaluridae	*Ameiurus nebulosus*	I
BBH	black bullhead	Ictaluridae	*Ameiurus melas*	I
LFS	longfin smelt	Osmeridae	*Spirinchus thaleichthys*	N
MSF	miscellaneous sunfish	Centrarchidae	Lepomis <40mm in length, or Lepomis hybrid	I
CHN	chinook salmon	Salmonidae	*Oncorhynchus tshawytscha*	N
AMS	American shad	Clupeidae	*Alosa sapidissima*	I
WCR	white crappie	Centrarchidae	*Pomoxis annularis*	I
SBF	Sacramento blackfish	Cyprinidae	*Orthodon microlepidotus*	N
SPM	Sacramento pikeminnow	Cyprinidae	*Ptychocheilus grandis*	N
PSC	prickly sculpin	Cottidae	*Cottus asper*	N
GSH	golden shiner	Cyprinidae	*Notemigonus crysoleucas*	I
STB	striped bass	Moronidae	*Morone saxitalis*	I
SMB	smallmouth bass	Centrarchidae	*Micropterus dolomieu*	I
WCF	white catfish	Ictaluridae	*Ameiurus catus*	I
REB	redeye bass	Centrarchidae	*Micropterus coosae*	I
GDF	common goldfish	Cyprinidae	*Carrasius auratus*	N
RES	redear sunfish	Centrarchidae	*Lepomis microlophus*	I
LMB	largemouth bass	Centrarchidae	*Micropterus salmoides*	I
SPB	spotted bass	Centrarchidae	*Micropterus punctulatus*	I
CCF	channel catfish	Ictaluridae	*Ictalurus punctatus*	I
YFG	yellowfin goby	Gobiidae	*Acanthogobius flavimanus*	I

Data tables

MS Access Table 4. Name, data type, and descriptions in TblSamplingDates.

TblSamplingDates provides electrofishing survey information collected during each site visit. The "TimeStart" field reflects the beginning of the overall survey while the "TimeEnd" is the time that the entire survey (fish and SAV sampling) were completed. The duration and GPS locations of the transect line were recorded in the Trimble GPS logger and can be found in the associated ESRI shapefiles (not the Access database). The field "TideStatus" (low, high, receding, or rising) was recorded based on tidal predictions from the gauge closest to each transect. Comments about the site condition or anything relevant to the survey were often recorded in the "Notes" field or if more extensive, in field notebooks (e.g. "See LC notebook" translates into "See Louise Conrad's field notebook", and "See MY notebook" refers to Matthew

Young's notebook). An electronic copy of these hand-written field notes will append this document.

Field Name	Data Type	Description
SiteID	Text	Unique site visit identifier: SiteName & 6-digit sample date (Primary Key)
SiteName	Text	Unique site name identifier, composed of first 3 letters of the body of water & 1 unique digit
SampleDate	Date/Time	Date survey was conducted
EfishTime	Number	Seconds spent electrofishing the transect
EfishLineEdited	Number	GIS-edited measurement of the electrofishing transect in meters
EfishLineSimplified	Number	GIS-simplified measurement of the electrofishing transect in meters
TimeStart	Date/Time	Start time of electrofishing transect
TimeEnd	Date/Time	End time of electrofishing transect
PercentTule	Number	Percent of shoreline populated by tule reeds along electrofishing transect
NumFishermen	Number	Number of fishermen present along electrofishing transect
Operator	Text	Boat operator initials
Netters	Text	Names or initials of people netting fish during electrofishing survey
TideStatus	Text	Tidal stage: low, high, receding, or rising
Wx	Text	Weather
Secchi	Number	Water clarity measurement (m)
Notes	Memo	Miscellaneous notes

MS Access Table 5. Name, data type, and descriptions in TblAbundance.

This table provides the number of individuals of each species captured for each site visit. Tallies of the number of individual fish that accidentally went overboard before being measured were recorded and included in the total.

MS Access Table 6. Name, data type, and descriptions in TblFishLengths.

For each electrofishing transect, we measured the FL (mm) of up to 50 captured individuals of each non-LMB species according to the methods described previously in this document.

MS Access Table 7. Name, data type, and descriptions in TblLMB.

This table provides somatic measurements, presence/absence of stomach contents, and tag information for each individual LMB captured during each site visit. Individual fish are given a unique identifier, "LMBRecID", based on the site, sample month, and the fish number assigned to them during the collection process. In addition, any recapture information reported by anglers is included in this table.

Field Name	Data Type	Description
SiteID	Text	Unique site visit identifier: SiteName & SampleDate
Species	Text	LMB = largemouth bass
FishNumber	Number	Number assigned to each LMB caught on electrofishing boat
LMBRecID	Text	Unique fish identifier: SiteID and FishNumber (Primary Key)
FL	Number	Measured fork length (mm)
Wt	Number	Measured weight (g)
StomachSampled	Text	Yes/No
StomachContents	Text	0= Contents absent, 1=Contents present
StomachMethod	Text	Method for gut content extraction, N/A indicates the fish was not sampled for stomach contents
FloyID	Text	Floy tag code
Recapture	Text	Yes, No, or Not Available (N/A); only refers to recaptures occurring on the electrofishing boat, not angler reports
TagReport	Yes/No	Yes/No. Indicates that an angler report was received for this Floy Tag
ReportResult	Text	Angler either released fish with tag intact or removed it; or angler harvested fish
ReportLocation	Text	Location that angler captured fish
ReportComment	Memo	Report information: date of capture, weight or length of fish, other angler comments
ReportContact	Text	Name/phone number of angler
Comment	Memo	Comment regarding fish captured on electrofishing boat
Wt Comment	Text	Comment regarding fish weight source

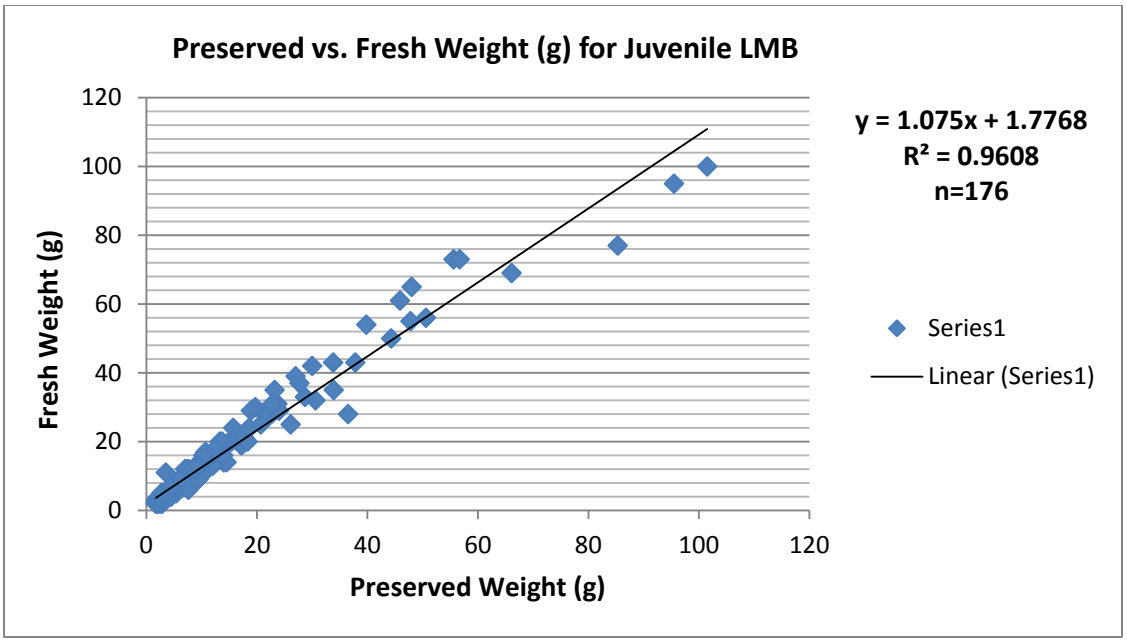


Figure 4. Linear regression for estimating fresh weight of juvenile LMB using preserved weight data.

MS Access Table 8. Name, data type, and descriptions in TblDiet.

The purpose of TblDiet is to describe the composition of diet contents found in each LMB stomach analyzed in the laboratory. Dissection data precludes the ingested prey item columns because the preserved fish had to be dissected before having their stomachs analyzed. To quantify gut content analysis findings, there are generally two columns for each possible diet item, including a count and a weight, with the exception of the categories "Copepod/CladoceranWt" and "DetritusWt", which were reserved for more ambiguous specimens. The columns "TotalItem" and "TotalWt" were calculated in MS Access at the conclusion of our spot-checking efforts. There are instances where primary analyzers did not record their initials; however, during the spot-checking process, secondary analyzers were religious about recording their initials in "CheckInitials" and noting if they changed the identifications, counts or weights in the rows "Checked?", "Changed?", and "CheckComment".

MS Access Table 9. Name, data type, and descriptions in TblSAV.

TblSAV consists of field and laboratory vegetation data. The field data includes the "Rake" number assigned to each vegetation sample by the boat operator, which corresponds to the latitude and longitude recorded for each point in the Trimble GPS logger (with the exception of October 2010 when our new Trimble unit was not compatible with our old software and for some reason Lat/Long did not record as an attribute). Recording depth at individual rake points was not a routine part of the field protocol until the October 2009 sampling session, but for each session thereafter a depth measurement was taken from the 0.1m measurements demarcated on

the rake itself. When the depth was greater than the length of the rake, the depth field was blank and "no-no rake" was recorded in the "Sample" category field to indicate that it was impossible to collect either an SAV sample or record depth. Once each individual rake sample was sorted into individual SAV species in the laboratory, the presence/absence and wet weight (g) of each species was recorded. As stated previously, wet weights were measured in the laboratory, but dry weights in this table were derived from a known linear regression.

Field Data	Data Type	Description
RakeKey	AutoNumber	AutoID number, cannot be edited (Primary Key)
SiteID	Text	Unique site visit identifier: SiteName & SampleDate
RakeID	Text	Unique rake sample identifier: SiteID & Rake
SiteName	Text	Unique site name identifier, composed of first 3 letters of the body of water & 1 unique digit
GPS_DATE	Date/Time	Date survey was conducted
NORTHING	Number	Geographic Positioning System northing
EASTING	Number	Geographic Positioning System easting
RAKE	Text	Number indicating vegetation point sampled by rake
ID_LINK	Text	Combination of 'Site' and 'Rake'
FEAT_NAME	Text	Vegetation sample collected along electrofishing transect or off-transect at predetermined point
Depth	Number	Depth at time of vegetation sample (m)
SAMPLE	Text	SAV collected by rake: 'Yes', 'No-no sav'; or didn't reach bottom: 'No-no rake'
COMMENT	Text	Miscellaneous comments
EGDE	Number	Brazilian waterweed (Egeria densa) in sample? (0=absent; 1=present)
CACA	Number	Fanwort (Cabomba caroliniana) in sample? (0=absent; 1=present)
POCR	Number	Curly-leaved pondweed (Potamogeton crispus) in sample? (0=absent; 1=present)
MYSP	Number	Eurasian milfoil (Myriophyllum spicatum) in sample? (0=absent; 1=present)
CEDE	Number	Coontail (Ceratophyllum demersum) in sample? (0=absent; 1=present)
STSPP	Number	Stuckenia in sample? (0=absent; 1=present)
ELCA	Number	Elodea (Elodea canadensis) in sample? (0=absent; 1=present)
PONO	Number	American pondweed (Potamogeton nodosus) in sample? (0=absent; 1=present)
STFI	Number	Fineleaf pondweed (Stuckenia filiformis) in sample?(0=absent; 1=present)
EGDE_FW	Number	Wet weight of EGDE in sample (g)
EGDE_DW	Number	Dry weight of EGDE in sample (g)
CACA_FW	Number	Wet weight of CACA in sample (g)
CACA_DW	Number	Dry weight of CACA in sample (g)

POCR_FW	Number	Wet weight of POCR in sample (g)
POCR_DW	Number	Dry weight of POCR in sample (g)
MYSP_FW	Number	Wet weight of MYSP in sample (g)
MYSP_DW	Number	Dry weight of MYSP in sample (g)
CEDE_FW	Number	Wet weight of CEDE in sample (g)
CEDE_DW	Number	Dry weight of CEDE in sample (g)
STSPP_FW	Number	Wet weight of STSPP in sample (g)
STSPP_DW	Number	Dry weight of STSPP in sample (g)
ELCA_FW	Number	Wet weight of ELCA in sample (g)
ELCA_DW	Number	Dry weight of ELCA in sample (g)
PONO_FW	Number	Wet weight of PONO in sample (g)
PONO_DW	Number	Dry weight of PONO in sample (g)
STFI_FW	Number	Wet weight of STFI in sample (g)
STFI_DW	Number	Dry weight of STFI in sample (g)
SPP_RICH	Number	Species richness
NATIVE_RIC	Number	Native species richness
EXOTIC_RIC	Number	Exotic species richness
TOTAL_FW	Number	Sum of wet weight for all species in sample (g)
NATIVE_FW	Number	Sum of wet weight for native species in sample (g)
EXOTIC_FW	Number	Sum of wet weight for exotic species in sample (g)
TOTAL_DW	Number	Sum of dry weight for all species in sample (g)
NATIVE_DW	Number	Sum of dry weight for native species in sample (g)
EXOTIC_DW	Number	Sum of dry weight for exotic species in sample (g)
DENSITY_DW	Number	Density of dry weight

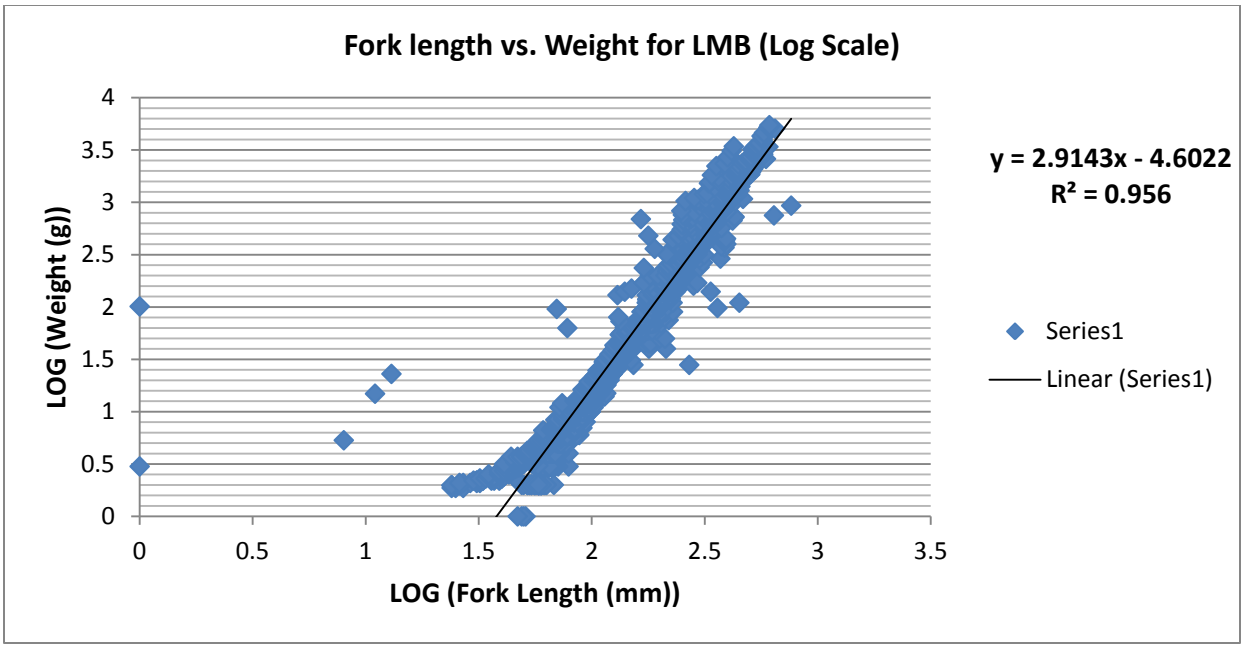


Figure 5. Linear regression used to estimate weight using known fork length and weight relationships.

MS Access Query Descriptions

A. "Abundance_Summary_Session" summarizes the sum of each species captured and the total meters fished (as a measure of effort) during each bimonthly electrofishing survey.
B. "Abundance_Summary_Site" summarizes the sum of individuals as they fall into categorical groups of fishes captured at each of the 33 electrofishing sites.
C. "CPUE_Summary_Session" summarizes the catch per unit effort of each species (CPUE= fish per meter) during each bimonthly electrofishing survey.
D. "Diet_Summary_FishCnt_Site" summarizes the number of ingested prey fish identified in LMB gut contents at each of the 33 electrofishing sites.
E. "Diet_Summary_FishWt_Site" summarizes the total weight of ingested prey fish identified in LMB gut contents at each of the 33 electrofishing sites.
F. "Diet_Summary_NonFishCnt_Site" summarizes the number of ingested non-fish prey items identified in LMB gut contents at each of the 33 electrofishing sites.
G. "Diet_Summary_NonFishWt_Site" summarizes the total weight of ingested non-fish prey items identified in LMB gut contents at each of the 33 electrofishing sites.
H. "MeasuredFL_VS_Abundance_Site" summarizes the number of measured individuals and the number of captured individuals for each site visit.
I. "Qry_TblLMB_FL>50" summarizes the number of measured LMB individuals and the number of captured LMB individuals for each site visit.

J. "Qry_TblLMB_Otoliths" summarizes which individual LMB, as represented by their uniquely assigned LMBRecID, were used in the age and growth study via otolith microstructural analyses.
K. "SAV_Summary_Biomass_Site&Session" summarizes total biomass of each SAV species for each site visit.
L. "SAV_Summary_VarianceOfRichness_Site&Session" summarizes the variance of richness of categorical groups of SAV species for each site visit.
M. "SiteSpecific_Summary" summarizes the physical characteristics of the habitat and the amount of effort spent in meters fished and in seconds fished for each of the 33 electrofishing sites.

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