Interagency Ecological Program San Francisco Estuary Smelt Larval Survey (SLS) Metadata

Contents

Study Management

IEP Study Name: Smelt Larval Survey (SLS)

Program element: 096

Agency: Department of Fish and Wildlife, Bay Delta Region (R3)

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Study Overview

Purpose/Objective: Monitor and provide information on larval Longfin Smelt abundance and distribution in the upper San Francisco Estuary. Conduct larval fish surveys to determine the timing, distribution, and abundance of Longfin Smelt larvae. Help estimate larval Longfin Smelt fish losses and determine the magnitude of entrainment of larval Longfin Smelt at the CVP (Central Valley Project) and SWP (State Water Project) intakes.

Data collected: Surface water temperature (°C), surface and bottom electro-conductivity (EC, μS/cm, normalized at 25 °C), Secchi depth (cm), surface water turbidity (NTU), water volume (m^3), tidal stage,

and identification, counts, and lengths (mm, fork lengths or total length for species without a forked tail) of fishes to the lowest possible taxon.

Geographic range of work: Lower Napa River to the city of Napa, eastern Carquinez Strait upstream throughout Suisun Bay; San Joaquin River to Stockton, Old and Middle Rivers in the south Delta to West Canal; Sacramento River to Rio Vista; Cache Slough from Rio Vista to Shag Slough; 1 station at the mouth of the Sacramento Deep-water Ship Channel.

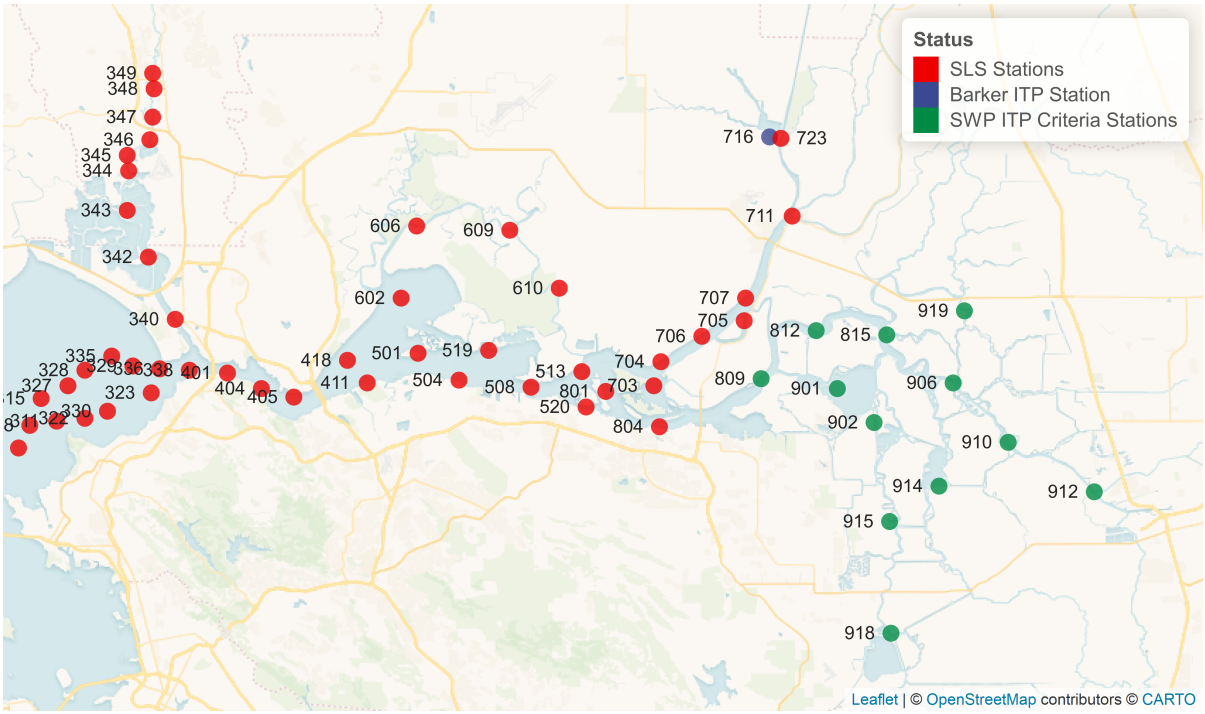

Figure 1: Map displaying the geographic range of work. Each point represents the location of a sampling station. Stations in the southern and central Delta (809-919) and at Barker Slough (716) have monitoring requirements tied to the 2020 SWP Incidental Take Permit (ITP) and are uniquely colored.

Number of sites: 59 stations. See the metadata section for additional details of each station.

Data range: 2009-01-05 to 2023-03-17 (YYYY-mm-dd)

Sampling frequency: Sampling begins in December and is conducted *every other week*. Sampling ends:

1. in March,
2. or when catch efficiency decreases,
3. or when high densities of Longfin Smelt are no longer found in the southern and central Delta and in danger of being entrained at the CVP and SWP intakes.

Field Sampling Methods

Net: The SLS samples using a cone shaped net with a length of 3.35 meters (m), a mouth area of 0.37 m^2, and a 505 μm NitexR mesh. The mesh size was altered prior to the 2014 season to 500 μm NitexR, when the original mesh size was no longer available and new nets were purchased (see 2014 changes below). These new nets were incorporated as old nets became unusable. The net is mounted on a fixed metal tube frame with skis and is connected to the frame by a canvas mouth. At the end of each tow, net contents are washed into a cod-end jar attached to the end of the net. A General Oceanics flowmeter is mounted across the net's

mouth to estimate the water volume filtered during each tow. Prior to 2015, all flowmeters were calibrated at UC Davis before the start of the season to determine its calibration factor required for water volume calculations. After 2015, the calibration flume at UC Davis became inoperable, and the meters were sent to General Oceanics for refurbishing before each field season and the factory calibration factor used. Since 2019, meters are inspected at the end of every field season and are replaced with new units if refurbishing is required to support the continued use of the factory calibration factor.

Tow: A single 10 minute stepped oblique tow with the boat moving at 1 m/s is conducted at each of the 44 sampling stations. The amount of cable released is dependent on the water depth at the station. A gradual oblique tow is achieved following the tow schedule specific to the amount of cable released and the duration of the tow. Although most tows are 10 minutes in length, tow time can be reduced during periods of heavy samples. If the net is clogged during algal blooms, jellyfish blooms, or heavy debris events the tow time can be reduced to 5 or 2.5 minutes, an alternate tow schedule is followed, and the duration is recorded. If material is still overflowing from the cod-end jar in a 2.5 minute tow, the entire station is dropped. Re-tows can occur if a sample is compromised or the flowmeter reading is less than 10000 or greater than 30000 m in a 10 minute tow. All abnormal events are to be recorded in the "comments" section of the datasheet.

Environmental and water quality data: Immediately prior to each tow, bottom and surface water samples are independently collected. From these water samples: 1) surface water temperature (°C) and surface and bottom EC (μS/cm, normalized at 25 °C) are recorded using a calibrated (before each season) and rinsed YSI Model 30; and 2) surface turbidity (NTU) is recorded using a calibrated (before each season) HACH 2100p turbidity meter (sample vials are cleaned before each sample). Secchi depth (m) is measured using Secchi discs mounted to rigid meter sticks to a maximum depth of two meters; values are measured in the shade without sunglasses on, off the side of the boat by the same person for the day for consistency. Water bottom depth (ft) is recorded using a depth finder on the boat. Tide data is recorded as the visually observed tidal stage by the crew during the tow as high slack, ebb, low slack, or flood.

Table 1: The SLS collects various environmental data per station.

Variable	Equipment	Unit
Water temperature (surface)	YSI ProDSS	°C
Water EC (surface)	YSI ProDSS	µm/cm
Water EC (bottom)	YSI ProDSS	µm/cm
Water turbidity (surface)	YSI ProDSS	FNU
Water turbidity (surface)	HACH 2100p	NTU
Secchi depth	Two meter sticks	m
Flow meter	General Oceanics 2030R	
Depth	Onboard meter	Feet
Tide	Visual	

Catch data: At the end of every tow, the net is washed down so that all visible vegetation, fish, sand, and debris are washed into the cod-end jar. Large debris and adult fish ($\geq$ 50 mm) can be removed if positively identified. If salmonids were caught, fork lengths are measured, presence of the adipose fin noted, and the fish are immediately released gently and alive. All other larval and juvenile fish are kept in distinctively labeled sampling jars and preserved in 10% buffered and dyed formalin for later processing in the laboratory.

Lab analysis, fish ID and QC

In the lab, before the next survey if possible, fish are identified from each sample under a microscope. First, fish are separated from debris and other organisms during a process referred to as "sorting". Then, the entire sample undergo a quality control (QC) check to ensure that fish were not missed during sorting. Finally, fish undergo a first ID and count by an identifier, followed by a QC from a larval fish ID specialist to confirm all species identifications and counts. This QC process is dependent on the experience of the identifier doing

the first ID. Fish identifiers will begin with all their identifications QC'ed and transition to having fewer and fewer samples QC'ed with experience, until the identifier is considered a larval fish ID specialist. Samples are randomly selected to undergo this QC process. Across all samples (QC required or not), all CESA and ESA fishes and any questionable fish IDs must undergo a second ID. All fish are identified to species or the lowest possible taxon. Since the inception of the survey, there have not been instances when of a species has been identified to a lower taxon or identified under a different name. Only the first 50 randomly selected individuals of each species from each tow are measured for lengths to the nearest millimeter, and the rest of the sample is simply enumerated. However, all Longfin Smelt and Delta Smelt are measured for lengths regardless of catch size.

Relative density analysis

The total number of fish per volume water sampled (standardized to 1000 m^3) is calculated using the following two equations:

$V_t = A * K * D_t$

Where:

V_t = volume of water (m^3) filtered through the net per tow t

A = mouth opening of the net (0.37 m^2)

K = calibration factor of the flow meter, 0.026873027 since 2015

D_t = difference in flow meter counts from start to finish of tow t

$n_t = F_t/V_t * 1000m^3$

Where:

n_t = number of fish per 1000 m^3 per tow t

F_t = fish caught per tow t

V_t = volume of water filtered through the net m^3 per tow t

Data management

All field data is entered into a digital Access database using forms between survey events during the season. Immediately after entry, data undergoes two rounds of 'line-by-line' checks, wherein all data fields are checked against the original datasheets for fidelity. At the end of the survey field season once all the fish samples have been processed in the laboratory and data entry is complete, all data is 'finalized' to be as accurate as possible for public use. The first step in this process is to conduct two additional line-by-lines. Next, a project lead will run a series of coded queries to analyze the underlying data distributions to detect potential outliers in the environmental data. Not all data is changed if it is flagged as an outlier (generally beyond 2 standard deviations of the mean). In most cases, outliers are real data. These queries simply alert the project lead of potential erroneous data, and care is taken to edit only data that truly needs to be edited, e.g., data that was entered incorrectly or caused by equipment failures. All resulting data edits are documented in a separate log file.

The provided data tables

The "Catch.csv", "FishCodes.csv", "Length.csv", "MeterCorrections.csv", "Station_Lookup.csv", "TowInfo.csv", and "WaterInfo.csv" are available "relational tables" from the SLS Access database. These tables are exported directly from Access in R and the only manipulations were to include relevant columns, fix Unicode encoding errors, and fix float formatting errors; all underlying data collected in the field and entered

into the database remained unmanipulated. The "SLS.csv" file is the integrated dataset that combines 6 relational tables (the "FishCodes.csv" table" is not included) together. Users should be aware of the units of the recorded values between the relational and integrated tables, as they may differ (documented in the metadata section of the EDI publication page). All steps are coded in R and the relevant codes are provided with the EDI publication and/or housed on trinhxuann/CDFW-IEP-Surveys GitHub page.

Zero filling

Zero filling is the process of assigning a count value of 0 for instances of no fish catch during a tow. No fish catch can be defined as two levels: 1) across all fish species (a tow that catches no fishes at all), or 2) specific to a singular species (a tow that catches no individuals of a particular species but does for other species). Instances of no fish catch of *any* fish species in a tow (level 1) *are not* recorded in the relational "Catch.csv" table, but the environmental data associated with that tow *is* recorded in the relational "TowInfo.csv" table. The joined "SLS.csv" table flagged these instances in the `Length_NA_flag` column and filled in the corresponding catch count value (`Count`) as 0. This zero-filling was not implemented for instances of no fish catch of a particular species in a tow (level 2) in the integrated "SLS.csv" file; however, code for this step is provided in the "SLSIntegrateEDI.R" script for users who are interested.

Count data

The `Count` data provided is the adjusted length frequency of each recorded length per species per tow:

$F_{a,l} = T_c\left(\frac{F_{m,l}}{T_m}\right)$

Where:

$F_{a,l}$ = adjusted frequency of each recorded length l

T_c = total catch

$F_{m,l}$ = measured frequency of each recorded length l

T_m = total number of fish measured

Project history

The table below is a timeline of critical changes to the survey methods since its inception. The years listed below are water years, which begins three months before the new calendar year on October 1.

Table 2: History of substantial changes to the SLS Survey since its inception. Rows are highlighted per unique water year.

Water Year	Note
2009	Project start. Five biweekly Delta-wide (35 stations) surveys conducted from early January to early March
2010	Temporal extension of sampling temporarily for this season; six biweekly (35 stations) surveys conducted from early January to late March (this addition lasted only this season)
2010	Implementation of using a Hach Model 2100P Turbidimeter as Standard Operating Procedure to record turbidity in NTU's
2010	Recorded sampling latitude and longitude on datasheets, but this data was not entered into the database.
2011	Latitude and longitude of tows recorded into database
2011	Yolk sac and oil globule presence noted in the data
2012	Sixth survey permanently added
2013	
2014	Spatial extension of sampling into the Napa River as part of an agreement with the State Water Contractors (stations 340, 342, 343, 344, 345, 346, 347, 348, and 349)
2014	Database was revised by Tuongvan Nguyen at ITB as part of the Bay Delta Application Hosting to move public facing data onto a secured Tier 3 server. Data is now entered into 'SLS_Local.mdb' (local server), and appended to the Tier 3 server before uploading to the public webpage
2014	New nets were incorporated (manufactured on 5/10/2013 by Lodi Tent and Awning) with a different Nitex Mesh purchased from Sefar (500 micron, 47% open space, part #06-500/47)
2015	Factory k value (0.026873027) used in the 'MeterCorrections' table. Flowmeters were not calibrated at UC Davis due to machinery malfunction. The facility is awaiting repairs.
2016	Continued using factory k value for 'MeterCorrections.' Flowmeters were sent to General Oceanics for refurbishing prior to field season.
2017	Continued using factory k value for 'MeterCorrections.' Flowmeters were sent to General Oceanics for refurbishing prior to field season.
2018	Continued using factory k value for 'MeterCorrections.' Flowmeters were sent to General Oceanics for reburbishing prior to field season
2019	Continued using factory k value for 'MeterCorrections.' Flowmeters were sent to General Oceanics for refurbishing prior to field season or replaced with new meters if readings are inaccurate (assessed at the end of a season)
2019	Spatial reduction of sampling. Ceased sampling stations within the Napa River (stations 340, 342, 343, 344, 345, 346, 347, 348, and 349)
2019	On 2019-09-10, two tables were removed from the local copy of the database: 'Zooplankton' and 'Zoo Catch'. These tables were appended to the database from the 20–mm database back in 2013. The SLS survey does not survey for zooplankton. More information and a copy of the tables can be found on the local server: U:/NativeFish/SmeltData/Zooplankton/SLS_Erroneous_ZooTables.xlsx
2020	Surveys 2 and 3 only sampled the high priority stations in the south and central Delta due to concerns related to the COVID-19 pandemic.
2021	Spatially constrained, temporal extension of sampling: two additional surveys were added in December and were limited in geographic range to the south/central Delta to inform risk of entrainment for larval Longfin Smelt.

2022	The two additional surveys in December are expanded to encompass all stations. Napa River stations (340, 342, 343, 344, 345, 346, 347, 348, and 349) have been added back to the surveys, including the supplemental December surveys.
2023	YSI change; add any other changes

Station metadata

Station theoretical latitudes and longitudes and start and end dates are provided in Table 2. A visualization of the number of surveys per water year (which encapsulates a field season) is also provided in Figure 2.

Table 3: List of stations sampled by SLS since its inception. "StartDate" indicates the date when sampling first began for a station; "EndDate" indicates the date when sampling last ended at a station, and "Ongoing" represents stations that are still actively sampled by the survey.

Station	Latitude	Longitude	StartDate	EndDate
306	38.00042	-122.4149	2022-12-06	Ongoing
308	38.01744	-122.4044	2022-12-06	Ongoing
311	38.02086	-122.3774	2022-12-06	Ongoing
315	38.03814	-122.3936	2022-12-06	Ongoing
322	38.02364	-122.3508	2022-12-06	Ongoing
323	38.04289	-122.2863	2022-12-06	Ongoing
327	38.04772	-122.3667	2022-12-06	Ongoing
328	38.06028	-122.3500	2022-12-06	Ongoing
329	38.06361	-122.3040	2022-12-06	Ongoing
330	38.02853	-122.3282	2022-12-06	Ongoing
335	38.07111	-122.3240	2022-12-06	Ongoing
336	38.06111	-122.2780	2022-12-06	Ongoing
338	38.06003	-122.2489	2022-12-05	Ongoing
340	38.09922	-122.2633	2014-01-07	Ongoing
342	38.14625	-122.2887	2014-01-07	Ongoing
343	38.18236	-122.3093	2014-01-07	Ongoing
344	38.21269	-122.3087	2014-01-07	Ongoing
345	38.22383	-122.3090	2014-01-07	Ongoing
346	38.23639	-122.2872	2014-01-07	Ongoing
347	38.25361	-122.2847	2014-01-07	Ongoing
348	38.27436	-122.2835	2014-01-07	Ongoing
349	38.28633	-122.2844	2014-01-07	Ongoing
401	38.05758	-122.2124	2022-12-07	Ongoing
404	38.04644	-122.1789	2022-12-07	Ongoing
405	38.03992	-122.1467	2009-01-08	Ongoing
411	38.05022	-122.0765	2009-01-08	Ongoing
418	38.06750	-122.0956	2009-01-08	Ongoing
501	38.07333	-122.0263	2009-01-07	Ongoing
504	38.05194	-121.9861	2009-01-08	Ongoing
508	38.04717	-121.9172	2009-01-07	Ongoing
513	38.05886	-121.8678	2009-01-07	Ongoing
519	38.07475	-121.9581	2009-01-07	Ongoing
520	38.03217	-121.8631	2009-01-08	Ongoing
602	38.11556	-122.0424	2009-01-08	Ongoing
606	38.17058	-122.0279	2009-01-08	Ongoing
609	38.16708	-121.9378	2009-01-08	Ongoing
610	38.12219	-121.8891	2009-01-08	Ongoing
703	38.04861	-121.7974	2009-01-06	Ongoing

704	38.06658	-121.7903	2009-01-06	Ongoing
705	38.09761	-121.7087	2009-01-06	Ongoing
706	38.08608	-121.7504	2009-01-06	Ongoing
707	38.11469	-121.7079	2009-01-06	Ongoing
711	38.17742	-121.6623	2009-01-06	Ongoing
716	38.23856	-121.6839	2009-01-06	Ongoing
723	38.23725	-121.6731	2009-01-06	Ongoing
801	38.04369	-121.8440	2009-01-07	Ongoing
804	38.01644	-121.7913	2009-01-07	Ongoing
809	38.05378	-121.6930	2009-01-20	Ongoing
812	38.08992	-121.6399	2009-01-06	Ongoing
815	38.08714	-121.5711	2009-01-06	Ongoing
901	38.04625	-121.6185	2009-01-20	Ongoing
902	38.02039	-121.5827	2009-01-05	Ongoing
906	38.05003	-121.5065	2009-01-05	Ongoing
910	38.00500	-121.4530	2009-01-05	Ongoing
912	37.96642	-121.3686	2009-01-05	Ongoing
914	37.97150	-121.5200	2009-01-05	Ongoing
915	37.94428	-121.5679	2009-01-05	Ongoing
918	37.85900	-121.5671	2009-01-05	Ongoing
919	38.10519	-121.4946	2009-01-05	Ongoing

Appendix

Species Sampled:

Table 4: The SLS Survey identifies all captured fish, jellyfish, and shrimp species. The date associated with the first identification of each species is provided. There is not been a taxa that is not identified by the survey if captured, although not all taxa are identified to the species level.

CommonName	Taxa	DateFirstID
American Shad	Alosa sapidissima	2021-01-13
Arrow Goby	Clevelandia ios	2009-01-08
Bay Goby	Lepidogobius lepidus	2009-01-07
Bay Pipefish	Syngnathus leptorhynchus	2021-01-13
Bigscale Logperch	Percina macrolepida	2009-03-03
Black Bullhead	Ameiurus melas	2020-03-16
Bluegill Sunfish	Lepomis macrochirus	2012-01-09
California Halibut	Paralichthys californicus	2023-03-16
California Tonguefish	Symphurus atricauda	2015-02-02
Carp	Cyprinus carpio	2017-02-27
Channel Catfish	Ictalurus punctatus	2012-01-23
Cheekspot Goby	Ilypnus gilberti	2012-02-22
Chinook Salmon	Oncorhynchus tshawytscha	2010-02-01
Delta Smelt	Hypomesus transpacificus	2009-01-23
English Sole	Pleuronectes vetulus	2018-02-28
Inland Silverside	Menidia beryllina	2009-01-08
Jacksmelt	Atherinopsis californiensis	2010-03-23
Longfin Smelt	Spirinchus thaleichthys	2009-01-05
Longjaw Mudsucker	Gillichthys mirabilis	2009-01-07
Mosquitofish	Gambusia affinis	2013-01-03
Northern Anchovy	Engraulis mordax	2010-01-04
Pacific Herring	Clupea pallasi	2009-01-06
Pacific Lamprey	Lampetra tridentata	2021-12-29
Pacific Staghorn Sculpin	Leptocottus armatus	2009-01-07
Plainfin Midshipman	Porichthys notatus	2012-01-10
Prickly Sculpin	Cottus asper	2009-01-05
Rainwater Killifish	Lucania parva	2012-01-09
Redear Sunfish	Lepomis microlophus	2018-01-29
River Lamprey	Lampetra ayresi	2021-12-16
Sacramento Sucker	Catostomus occidentalis	2011-03-22
Shimofuri Goby	Tridentiger bifasciatus	2010-03-24
Shokihaze Goby	Tridentiger barbatus	2010-03-24
Speckled Sanddab	Citharichthys stigmaeus	2016-01-21
Splittail	Pogonichthys macrolepidotus	2011-03-22
Spotted Bass	Micropterus punctulatus	2016-01-19
Starry Flounder	Platichthys stellatus	2023-03-15
Striped Bass	Morone saxatilis	2009-01-08
Threadfin Shad	Dorosoma petenense	2011-02-28
Threespine Stickleback	Gasterosteus aculeatus	2009-02-05

Topsmelt	Atherinops affinis	2015-03-26
Tridentiger spp.	Tridentiger NA	2014-01-07
Wakasagi	Hypomesus nipponensis	2011-03-02
Warmouth	Lepomis gulosus	2023-01-06
White Catfish	Ameiurus catus	2010-02-01
White Croaker	Genyonemus lineatus	2009-02-05
White Sturgeon	Acipenser transmontanus	2017-02-28
Yellowfin Goby	Acanthogobius flavimanus	2009-01-06