1. Study Management
   1. Study name: Spring Kodiak Trawl (SKT)
   2. Agency: California Department of Fish and Wildlife (CDFW)
   3. Principal Investigator: Lauren Damon, Lauren.Damon@wildlife.ca.gov
   4. Project Lead: Vanessa Mora, Vanessa.Mora@Wildlife.ca.gov
2. Project description
   1. Purpose:
      1. The SKT conducts fish surveys to monitor and provide information on pre-spawning and spawning Delta Smelt (*Hypomesus transpacificus*) in the upper San Francisco Estuary (SFE). The objectives of this project are to: 1) improve the ability to detect Delta Smelt, 2) obtain maturity status for adult Delta Smelt, and 3) provide results to scientists and managers on a near real-time basis to aid in resource management decisions.
   2. Data collected:
      1. Surface water temperature (°C), surface water electro-conductivity (EC, µS/cm), Secchi depth (cm), water turbidity (NTU), water volume sampled (m3), tidal stage, water depth (feet), and the identification, counts, and lengths (mm, fork lengths or total length for species without a forked tail) of fishes to the lowest possible taxon. Gonadal maturity data is also collected for Delta Smelt.
   3. History
      1. The Spring Midwater Trawl (SMWT) was an extension of the Fall Midwater Trawl (FMWT) survey, surveying the months of January, February, and March from 1991-2001. Data collected by the SMWT provided information on the distribution of pre-spawning Delta Smelt (*Hypomesus transpacificus*) to assist in real-time management of water export operations within the Delta. However, net evaluation studies conducted in 1995 by the Interagency Ecological Program (IEP) compared the relative efficiency of three types of nets (Chipps Island Trawl, Midwater trawl, and Kodiak trawl) and determined that the most effective net for sampling adult Delta Smelt was the Kodiak Trawl. Therefore, in 2002, the SMWT was changed from an obliquely towed Midwater trawl to a surface towed Kodiak trawl.
3. Study design
   1. Effort:
      1. Period of record: 2002-01-07 to 2022-05-12 (automate on markdown)
      2. Sampling frequency: surveys are conducted monthly, beginning in early January and continues until late spring (month) or when spawning Delta Smelt can no longer be detected.
      3. 39 fixed stations from 2002 to 2004, 40 fixed stations from 2005 to present
         1. MAP, see table X for coordinates, sampling start and sampling end
   2. Fishing gear descriptions:
      1. The survey employs a standard Kodiak trawl. A weighted foot-rope and head-rope with floats allows the trawl to fish the top 1.8 m of the water column.
      2. Net length: 19.8 m (65 ft)
      3. Mouth opening (fully opened): 7.62 m by 1.83 m (25 ft by 6 ft)
      4. Mesh size: variable mesh size, from 2” knotted stretched mesh at the mouth, decreasing by ½” through a series of 5 panels to ¼” knotless stretched mesh at the cod-end.
      5. All fish are processed, counted, and measured immediately after each tow. Unidentifiable fish are returned to the Stockton laboratory for positive identification.
      6. Fish identified over time: see table X
   3. Environmental data:
      1. Secchi depth is taken prior to each tow at each station. Immediately after the tow begins, a flow meter is tossed into the water to begin measuring water volume sampled and a water sample is taken via a bucket from the surface of the water. Water temperature (°C), water turbidity, and water EC are recorded from the water sample.
      2. Flow meter readings are recorded at the start and end of each tow

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| --- | --- | --- | --- | --- |
| Variable | Equipment | Unit | Date Start | Date End |
| Water temperature (surface) | YSI 30 | C | XXX | XXX |
| Water turbidity (surface) | Hach Model #2100P | NTU | 2010 | Present |
| Water EC (surface) | YSI 30 | µS/cm |  |  |
| Secchi depth | Meter sticks | m |  |  |
| Flow meter |  |  |  |  |

* 1. Field protocols:
     1. Vessels:
        1. Two boats are required to execute a Kodiak trawl: a net boat and a chase boat. Generally, a 31’ Munson, the R/V Scrutiny, is preferred as the net boat, however, this vessel is shared among different fish surveys and may not always be available.
     2. Gear deployment
        1. The boat should be positioned so that the designated station coordinate is halfway through the tow.
        2. To execute the tow, the tied-off cod-end of the net is thrown overboard and the bridles are guided by two deckhands over the stern to prevent snags. The net is allowed to free-spool until the warp line is out 110 feet. Once the winches have stopped, the chase boat will come alongside with its port side paralleled to attach one side of the net. Once both sides are attached, both boats are put into forward gear, the net is opened, and the tow begins. Both boats are to remain parallel throughout the tow.
        3. Duration: 9.5 minutes (9 minutes and 30 seconds)
        4. Tows per station: 1
     3. Re-tows:
        1. Re-tows may be required if a tow is invalid for any reason, including any deviations from protocols. Examples include: the flowmeter reading is too low or high (normal range of 10000-30000), the cod-end has become untied, the net gets snagged, the net did not open correctly, or the net has filled with a large amount of mud or peat.
     4. Habitat type biases
     5. Content processing
        1. All fish are measured up to 50 individuals to the nearest mm fork length or total length (non-forked caudal tail). If there are more than 50 individuals, 50 individuals are randomly selected to be measured and the rest are enumerated as plus-counts or sub-sample.
           1. Plus-counts: defined as counting all remaining individuals without measurements
           2. Subsampling: can occur for extremely large catches, such as of Threadfin shad, Northern anchovy, or Siberian prawns

Defined as counting individuals into a sub-sample container (usually 1 liter) and multiplying by the total number of sub-sample containers it takes to hold all remaining individuals. For example, 50 individuals counted and measured + 100 individuals to fill a 1-liter container \* 5 1-liter containers to hold remaining fish = 550 fish caught.

* + - 1. Unidentifiable fish are placed into 10% formalin and returned to the Stockton lab for identification.
      2. Certain species are retained for further studies. Specifically, Longfin Smelt and Wakasagi are retained in ethanol, Delta Smelt in liquid nitrogen, and clipped salmonids in ice. All other species are released after being counted and measured.
    1. Delta Smelt processing
       1. 2002: during the first year of SKT, all Delta Smelt were returned to the laboratory to determine maturity stage. Therefore, all Delta Smelt lengths recorded for this year are affected by the effects of formalin preservation, i.e., shrinkage.
       2. 2003: all Delta Smelt were measured on board. Therefore, all Delta Smelt lengths are fresh lengths and not formalin fixed (like 2002). During surveys 11 (December) and 1 (January), Delta Smelt were returned to the CDFW lab in Stockton to determine maturity; after that, maturity stages were determined on the boat for the rest of the season.
       3. 2004: Due to limited funding, only egg samples from stage 4 females were retained, with a limit of no more than 30 stage 4 individuals per station.
       4. 2005: Egg samples were taken from only stage 3 and 4 females, with a limit of 20 fish per tow during Delta-wide surveys and 30 fish per tow during the supplemental surveys.
       5. 2006-present: All individuals are measured, and sex and maturity stages are determined on the boat.
    2. Delta Smelt Subsampling
       1. Beginning in 2009, a subsampling protocol was enacted to limit the number of Delta Smelt catch. Using historical SKT data, areas of high Delta Smelt catches are identified each year. In these areas, a 5-minute tow is conducted and up to 50 individuals are randomly selected to be measured while the remaining are counted and released back into the wild; if there are less than 50 individuals caught, a second 5-minute tow is conducted, and individual are counted and measured but only up to 50 total individuals for the entire station. These subsampling events can be identified by their 5-minute tows, as compared to the normal 10-minute tows.
  1. Calculations
     1. Relative density analysis: catch per unit effort (CPUE) is provided as standardized to 10000 m3 using the following equations:
        1. V = A\*K\*D, where:
           1. V = volume of water (m3) filtered through the net per tow
           2. A = mouth opening of the net (m2)
           3. K = calibration factor for the flow meter
           4. D = difference in flow meter counts during the tow
        2. N = F/V\*10000, where:
           1. N = number of fish per 10000 m3
           2. F = fish catch
           3. V = volume of water (m3) filtered through the net per station
     2. Delta Smelt Index of Relative Abundance:
        1. I = , where:
           1. I = Index
           2. s = survey, only for surveys 1 – 4 per season
           3. r = region, the 39 stations are defined across three regions (Table X)

Table

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* + - * 1. N = mean CPUE (as calculated above) of Delta Smelt per region (3 total)
  1. Data management
     1. Application: Microsoft Access database. All hard copies of the data sheets are retained.
     2. Locations of data: The database is copied across three different servers: 1) a back-end is hosted on the CDFW U: network drive; 2) a copy is hosted on the CDFW FTP website; and 3) a copy is hosted on a Tier 3 (defined as a data center that can be updated without being taken offline, with an expected downtime of 1.6 hours annually). The back-end contains the most recent data, the Tier 3 version is updated weekly during the sampling season, and the FTP version is updated at the end of the sampling season. Finalized data is also published to the Environmental Data Initiative (EDI) repository at the end of each season.
     3. Data entry protocols: Field data as soon as possible through a front-end application of the Access database, followed by two line-by-line manual QAQC of the entered data. The front-end allows for an orderly entry of the data into the back-end database.
     4. Data backup: There are three sources of data back-ups: 1) a weekly back-up to the Tier 3 server; 2) an archive of the database on the FTP website at the end of each season to the CDFW U: network drive; and 3) a back-up to the FTP website at the end of the season (after the previous year has been archived per step 2).
     5. QAQC protocols: After data is initially entered, two line-by-lines are immediately done. At the end of the field season, two additional line-by-lines of all entered data occurs. Following this, a survey lead will run a series of coded queries to analyze the underlying data distribution to detect potential outliers in the environmental data (generally calculated as beyond 2 standard deviations of the mean). Not all flagged data needs to be changed; these queries simply serve to alert the project lead of potentially erroneous data and care is taken to edit only data that truly needs to be edited, e.g., data entered incorrectly or caused by equipment failures. Queries are coded in Access and R, with the R script published on the EDI webpage of this project.
  2. Updates and publication
     1. Location(s): CDFW Tier 3 survey (weekly); CDFW FTP website (per season); and EDI repository (per season)
     2. Frequency: Data is uploaded to the Tier 3 on a weekly basis to be reported to various monitoring team. Finalized data is uploaded to the CDFW FTP website and the EDI repository at the end of each season.

1. Appendix
   1. Delta Smelt Gonadal Staging
      1. Table

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      2. Table

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   2. Historical changes over time:

|  |  |
| --- | --- |
| Year | Description |
| 2002 | Survey’s inception. Delta Smelt are returned to the lab for sampling. Delta Smelt lengths are formalin preserved for this year. |
| 2003 | Delta Smelt are sampled in the field and measured lengths are not formalin preserved. Sampling only takes place February to May; a January survey is not conducted. |
| 2004 | Egg samples are only retained for stage 4 females, collecting no more than 30 stage 4 females per station. Halfway through survey 3, the cod-end was caught in the propeller; the replacement cod-end had a 1/8” mesh (instead of ¼”) for the rest of the year. |
| 2005 | Station 719 (Sacramento Deep Water Channel) added. Only egg samples from stage 3 and 4 females are retained. 1/8” cod end mesh still used. |
| 2006 | No egg or caudal fin samples are collected or retained. |
| 2007 | Cod end mesh changed from 1/8” back to ¼” mesh. |
| 2008 | Elimination of Supplemental Surveys to reduce Delta Smelt take. |
| 2009 | Implementation of two 5-minute tows to reduce Delta Smelt take. Detailed here. |
| 2010 | Begin recording turbidity in NTU’s using a Hach Model #2100P turbidity meter. Survey 11 is a Smelt Turbidity Study. |
| 2011 |  |
| 2012 | Delta Smelt are field staged and preserved whole in liquid nitrogen |
| 2013 |  |
| 2014 | New nets purchased (made to standard specifications) on 03/25/2014 and used for the remaining of the season. Implementation of a new data management system. Data is now hosted in a back-end and uploaded to a Tier 3 server for display on the webpage. |
| 2015 | A new net was purchased from Research Nets (matching existing specifications) and used for the season. Delta Smelt Abundance Index was reviewed and changes were made. |
| 2016 |  |
| 2017 |  |
| 2018 |  |
| 2019 |  |
| 2020 |  |
| 2021 |  |
| 2022 |  |
| 2023 |  |

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