Quality Assurance
and
Quality Control Protocol
for the
Bay-Delta and Special Water Project's
Young Striped Bass Studies

Fall Midwater Trawl Survey Protocol

Prepared by Project Staff
California Department of Fish and Game
Central Valley and Bay-Delta Branch
2109 Arch Airport Rd.
Stockton, CA 95206

November 20, 1991
Revised December, 1995
Revised November 1997
Revised 1999 (R.G. Gartz)
Revised August 2004 (K. Souza)
Revised October 2020 (J. White)
Revised August 2021 (J. White)

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Revision Note, 2013
This update reflects an extension to the 2m secchi disk. At locations where the visibility of the secchi pole was greater than two meters, a weighted secchi mounted to transect tape was used to take this measurement.

Revision Note, 2010
This update reflects our official addition of five stations in the Sacramento Deep Water Shipping Channel and one station in Cache Slough to aide delta smelt distribution. In addition, Meso-/Macro-zooplankton sled procedures are also included in the "Towing Procedures" section.

Revision Note, 2009
This is the sixth revision of Midwater Trawl Protocol and reflects additions to our sampling and protocol. A Hach 2100P turbidity meter has been added to our sampling and preservation methods for fish have been changed.

Revision Note, 2007
This is the fifth revision of the Midwater Trawl Protocol and reflects changes in regards to QA/QC procedures. In addition, the YSI 30 field EC meter was replaced with a 6600 sonde (due to malfunctions) and the collection of striped bass stomachs was discontinued in 2004. A change in the protocol itself was made to make it a coherent read. Procedures no longer occurring were removed and placed into appendix 10.

Revision Note, 1999
This is the third revision of the Midwater Trawl Protocol since its first writing in 1991. This revision reflects changes that occurred in the 1998 sampling season, most notably, the provision for the Midwater Trawl to take stomachs from age 1 and 2 striped bass. I have left the 1997 revision intact to provide an ad hoc history of the Midwater Trawl and indicated my changes where they are applicable. Also, the Midwater Trawl Survey is thirty years old and knowing how things were done in the past can be useful in answering future questions. The reader should read through the entire protocol and note where the latest changes are.

Revision Note, 2020
Minor updates include: 1) Updated list of station location descriptions. Appendix 1. 2) Corrected a typo throughout document that listed area weights (used for index calculations) in units of a thousand acre-feet ($x10^{-3}$) instead of the correct units of ten-thousand acre-feet ($x10^{-4}$). 3) Updated data base parameter additions since 2007 in section titled "Data Adjustments". 4) Updated currently used datasheet (Appendix 4).

Revision Note, 2021
1) Updated list of station location descriptions. Appendix 1. Station 721 has been difficult to sample in the past few years due to aquatic vegetation loads fouling gear. It has been

replaced with station 722 which is further south and deeper, with less vegetation. This is the same station as SKT 716. 2) Updated Station checklist to reflect current sampling effort. Appendix 5. 3) Updated *Microcystis* qualitative scale to reflect updated field reference images used by DWR and other agencies. Rankings past and present are still valid, this just uses higher quality reference images. Appendix 12.

Project Description and Study Objectives

The fall midwater trawl survey (FMWT) produces an index of the relative abundance of young striped bass (*Morone saxatilis*) as well as other fish to evaluate potential water project effects on their survival. The sum of the monthly indices are compared to the Summer Townet abundance index to evaluate survival over the summer.

The FMWT survey has been conducted every year since 1967 except for 1974 and 1979. From 1967 to 1977, the survey length was variable, sometimes starting in July or August, but most commonly in September. Until the 2002 sampling season, the Spring Midwater Trawl Survey (SMWT) was conducted from January through March, to detect delta smelt distribution. In 2002, the SMWT was discontinued and replaced with the Spring Kodiak Survey. In January 1970, sampling in San Pablo Bay was increased to 40 stations with every other station being dropped in upstream areas. In 1973, a data analysis indicated most of the time striped bass were upstream of San Pablo Bay therefore 20 stations were eliminated from San Pablo Bay and sampling was resumed at nearly all sites upstream (except 801, 803, 805). In 1980, the survey period was shortened from September to December due to variability in abundance indices associated with winter storm events. We also sampled stations 101-113 and 201-211 in San Francisco Bay until 1978 prior to the San Francisco Bay Study which began in 1980. The FMWT stations used in calculating the indices have been generally constant since 1980. In a few years during the 1980's, Delta sampling (stations 812-815 and 900's) was curtailed after the September or October surveys.

Delta smelt sampling

Additional stations and months were added to more adequately sample the distribution

and abundance of delta smelt. In 1990, four stations were added in the delta to increase sampling for delta smelt (712, 713, 715, and 717). In 1991, six stations (341, 919, 920, 921, 922, and 923) were added as well as resuming sampling in the spring. Stations 925 and 926 were added to the survey but dropped soon afterwards because snags in Hog and Sycamore Sloughs prevented towing. In the fall of 1992, six stations (70, 72, 725, 73, 735, and 74) were added to the survey. In 1992, a spring survey was added to include January through April for delta smelt excluding most San Pablo Bay stations (stations 305 - 337, 339). The Napa River stations 338, 340, and 341 are still sampled during this time. The month of August was added to the survey in 1992 for delta smelt however delta smelt were not large enough to be sampled in August of 1995. In 2004, two new station numbers were created to replace existing stations that were being sampled downstream of their intended locations. Station 724 replaced station 725 and station 736 replaced station 74. In 2009, six stations (723, 719, 797, 796, 795, and 794) were added as an extra sampling effort for delta smelt in the Sacramento Deep Water Channel. In 2010, six stations were officially added to FMWT, five stations in the Sacramento Deep Water Channel (723, 719, 797, 796, and 795) and one station in Cache Slough (721).

To evaluate net escapement by delta smelt, an outside smaller mesh was added to the regular FMWT net during Spring 1992 to Fall 1993 for sampling delta smelt stations from September through December and continuously for all other months.

Description of Study Activities

Planning and Scheduling

Generally, the survey starts at the beginning of the month and runs for eight days each

month. The survey starts on the first Monday of the month avoiding holidays and weekends and is finished the following Thursday. Scheduling of the boat and the boat operator is done during the month prior to the beginning of survey. Schedules are sent to all parties involved with the program, i.e., boat operators, seasonal aids and supervisors.

Supplies

Very little planning is required. We need to inventory data forms, sampling nets, buckets, thermometers, secchi discs, electrical conductivity (EC) bottles or meter and measuring boards. Beginning in spring 1994, a YSI 30 EC meter was purchased to use on the survey. In 2005, the YSI 30 EC meter was replaced with the YSI 650 MDS display/logger equipped with a 6600 sonde.

Additional supplies, 2004 to present

The lead biologist maintains the majority of the equipment in the supply cage at CVBDB, Stockton and collects necessary items prior to survey. The nets, bridles, spectra-line, and feed buckets are housed at Delta base in Antioch. The lead boat operator is responsible for gearing up the boat prior to the first survey.

Crew

The crew usually consists of a scientific aide, biologist, and boat operator. Depending on the boat or if high catch is expected, a deckhand may be added to the crew.

Boat Preparation

Nets are rigged, spare nets and equipment are put on board. The winch is mounted and tested. The LORAN and fathometer are checked to ensure proper function.

Midwater Trawl Field Activities

Sampling Schedule - The daily order of station sampling is as follows:

1 327, 315, 314, 307, 306, 305, 308, 309, 311, 310, 321, 322, 323, 326

2 328, 334, 335, 329, 325, 336, 337, 339, 338, 340, 341, 401, 404, 403

3 406, 405*, 407, 408, 409, 410, 411*, 412, 413, 501*, 502, 503, 504*, 505

4 414, 415, 416, 417, 418*, 603, 602*, 604, 605, 606*, 601, 802*, 804*

5 515, 516, 517, 518, 519*, 507, 508*, 510, 511, 512, 513*, 608*

6 701, 703, 704*, 705, 706*, 707*, 708, 709, 710, 711*, 713, 715, 716*, 721*

7 806, 807, 808, 809*, 902, 915, 914, 913, 910*, 911, 912*, 909, 906*, 908

8 919*, 920, 921, 922, 923, 903, 815*, 904, 905, 814, 813, 812*, 811, 810

9 723*, 719*, 797*, 796*, 795*

10 717, 72, 724, 73, 735, 736, 712

11 Spare Day

* meso/macro-zooplankton tow conducted before or after tow

Personnel and Duties

Three persons are required to do the survey.

Boat operator - usually a person with Mate-Fisheries Vessel classification, who operates the boat, finds the stations, determines current direction and directs fishing operations.

Deckhand No. 1 operates one winch and aids in net retrieval and deployment (typically a scientific aide).

Deckhand No. 2 operates the winch and helps deploy and retrieve the net. This person should be either a biologist by training or someone with sufficient skills to correctly identify fish.

This person records all measurements and observations.

Station Locations

The station descriptions from STORET are listed in Appendix 1. The locations of stations currently sampled are indicated in Figure 1.

Boat Description, 2000 to the present

Since 2000, a number of boats have been used to conduct FMWT. These include the Little Munson (CF), the Scrutiny (CF), and the New Alosa (CF). Since 1978, we have also used a General Oceanics flowmeter to measure the velocity of water moving past the boat during a tow.

Equipment

Net Description

The midwater trawl net has been described by Von Geldern (1972). It has a mouth opening of 12 foot by 12 foot (3.7 m^2). The mouth area is 13.4 $m^{2.}$ The mesh size decreases from eight inch stretch mesh in the forward panel to one half inch mesh at the cod end.

Volume Sampled by the Net

The San Francisco Bay Study assumes that 0.80 percent of the mouth area is fishing. They assume that the net volume is about 7000 m^3 per tow. We made similar assumptions and calculated a value of 6351 m^3 but have made no published account of the data using these assumptions. We generally have reported data in terms of catch per tow.

Check list of equipment

Equipment used for the survey is listed in Appendix 2.

Towing Procedures

Setting the Net

The net cod end is tied off using a double loop around the net and a slip knot. The net is thrown overboard and trails behind boat.

Procedures, 1995 - Present

With the new winches, some procedures changed in 1995. Each deckhand now operates one winch and the depressors and hydrofoils are no longer thrown. The depressors and hydrofoils are brought up to the blocks hanging from the davits and released when the cable is let out. The mate stops and starts the hydraulics when needed.

The length of cable released is based on a table of depth-cable length values (Appendix 3). If the cable warp to be released is 200 ft, the 200 ft marker bead is stopped at the main block at the stern. The boat speed is adjusted so that the net is set near or at the bottom and fishing properly.

Procedure Notes, 1998 to the Present

According to Appendix 3 the net should actively fish for 12 minutes; 8 minutes at depth and 4 minutes to retrieve the 100' long bridles. However, Appendix 3 is based on the *Alosa*'*s* winch configuration (winch retrieval speed 25 ft/min). Since the *Alosa* has been surveyed retrieve the net with a retrieval speed as close to 25ft/min and fish net as close to the provisions of Appendix 3.

Since the time the net is fishing maybe in doubt flowmeter readings are essential. Flowmeter data can calculate the volume of water, and the density of fish that has been strained by the net can be determined. The flowmeter is deployed when the net has been fully

deployed and when trawling has begun (the net starts fishing) and is retrieved when the net is roughly 25 feet from stern of the boat (the net stops fishing).

Retows, 1998 to the Present

If for some reason the net's mouth is not fully open (ie, the doors become twisted) sample or "retow" that station again. If more than 20 minutes have elapsed between the beginning of the first tow and the retow, a new set of environmental data is needed. Do not discard the catch from the first tow. Although it will not be recorded in the FMWT database, catch of any species of concern must be reported to the Interagency Ecological Program (IEP). Record all delta smelt (*Hypomesus transpacificus*), longfin smelt (*Spirinchus thaleichthys*), splittail (*Pogonichthys macrolepidotus*), chinook salmon (*Oncorhynchus tshawytscha*), steelhead (*O. mykiss*), and striped bass from the first tow. Make sure to record whether or not salmonids had an adipose fin or not and whether or not they are dead. On the first tow's data sheet write "retow" and the reason for the retow and turn the data sheet in with the other data sheets. The other reason for a retow is if the cod end cannot be opened. This includes snagging the net on large objects (logs, chairs, etc) or if the net is filled to the point with mud/peat that the net has to be cut open to examine it. In these cases, examine catch if possible, retow and send the original data sheet back to Stockton, as above.

Net Retrieval and Physical Measurements

The deckhand engages the hydraulic system. While retrieving the net the winch operator adjusts the cables if necessary so that the two sides are retrieved at the same speed. With the old winches, this was done by disengaging the clutch and applying the brakes as needed but with the new winches, the winches are put in neutral. After retrieval of 25 ft of cable, the

hydraulic system is disengaged until it is time to pull in the next 25 ft. The retrieval time intervals are listed in Appendix 3.

The cable angle while fishing is to be maintained as best as possible to assure equal sampling of each stratum of the water column. We know from extensive bathykymograph sampling that there is a lot of inconsistency in achieving the ideal tow. Some of the tows in deep water do not sample close to the bottom.

The boat operator checks the angle of declination and if it is incorrect at any time during the tow and the boat speed is adjusted. For the *Alosa* when one marker is at the block and a marker that is two markers further along the cable is at the water surface, the angle is correct. The boat operator speeds up the engine to raise the net above the surface to help wash down the net. The net is rapidly brought on board by the boat operator and one deckhand while the other deckhand operates the winch. With the new winches, the net is brought on board by the two deckhands.

Secchi readings, 2013 to present

A secchi reading is made, on the shaded side of the boat if possible. When the white segments on the disk just disappear, the depth from the disk to water surface in cm is noted. Data for the date, time, survey, station, depth, speed, temperature, secchi depth, cable length, flow meter readings and tide code are recorded on the Field form (Appendix 4). In 2013 where the secchi measurement exceeds 2 meters, a weighted secchi mounted to transect tape was used to get the true secchi reading measurement.

Procedure Changes, 1998 to the Present

The meter is thrown overboard when the net begins fishing and the start time is recorded

on the datasheet. When the flowmeter is pulled back on board the tow has officially ended; record the end time on the data sheet (see Appendix 4).

The cod end is untied and the catch is dumped into an aluminum tub containing a small amount of water. The net is examined for any fish stuck to it and the fish removed. The cod end is tied off and the net, hydrofoils and depressors are laid out for the next tow at the next station. The boat operator checks off the station just completed on the station checklist to ensure all stations are sampled (Appendix 5).

Electrical Conductivity (EC) Readings, 2005 to 2006

Starting in 2005, the YSI 30 field EC meter was replaced with an YSI 650 MDS Display/Logger equipped with a 6600 sonde. In the morning of each survey day, the biologist will need to calibrate the sonde. First vent the sonde by unscrewing the canister so that only 3 to 4 threads hang on. Turn on the sonde and allow it to warm-up for approximately five minutes. First calibrate the atmospheric pressure and then the DO. Before the tow has begun, a crew member will use the YSI 650 MDS to select the correct file to store the EC information. The sonde will be deployed over the vessel and a surface EC reading and temperature will be taken when the sensor is within the first foot of water when it has stabilized (~ 1 min.). The sonde will be let down until it touches the bottom, where the crew member will lift it approximately a foot off the bottom until readings have stabilized and record the bottom EC reading. The sonde is then retrieved and wrapped in a wet cloth.

Microcystis 2007 to present

Microcystis was discovered in the early 2000's in the San Joaquin River. Beginning in 2007, microcystis density was recorded based on visual observations (Appendix 12) taken on

the sunny side of the boat at each station. To ensure that there is no microcystis in the water, the bucket of water obtained for the surface EC is inspected for the presence of microcystis. In addition, a wave code, weather code, and starting and ending latitude/longitude (recorded with a GPS 76) were also added and recorded.

Turbidity Meter 2009 to present

Both the surface and bottom water that are collected for the EC readings are used to record turbidity for the surface and bottom water. A 20 ml plastic syringe (without the needle is used to collect the water and feed it into the vial. The surface water is sucked into the syringe and is used to rinse the inside of the vial. The contents within the vial are then poured out and refilled with the remaining water within the bucket. The outside of the vial is wiped with a chemwipe so no fingerprints or outside precipitation occur. Additionally, there should be no air bubbles within the vial. The same procedures are conducted for the bottom water sample collected with the Van Dorn. If the sample is muddy and the turbidity meter blinks 1000, note "Muddy Sample >1000" as the reading.

Meso-/Macro-zooplantkon Tow Protocol 2009

In conjunction with delta smelt catch, a Meso-/Macro-zooplantkon tow was conducted at that same station. The Meso-/Macro-zooplantkon sled was connected to the port side warp and the Meso-/Macro-zooplantkon flowmeter were recorded before the start of the tow. The Meso-/Macro-zooplantkon sled was deployed to the proper depth, which was determined by the station depth. The 10 minute tow schedule (provided by the Zooplankton study) was followed to complete an oblique tow. Once the tow is completed, the sled is brought back onboard and the Meso-/Macro-zooplantkon flowmeter were recorded. Each net is washed

down from the outside of the net so no sample contamination occurs and the contents are collected into a jar. The jar is disconnected from the net and contents are poured into a quart jar containing 10% rose Bengal formalin solution. To ensure all content in the collecting jar has been transferred, the collecting jar is submerged in water half way, swirled around, and then the contents are poured into the quart jar. If any water enters the collecting jar through the mouth top, another sample must be collected.

Meso-/Macro-zooplantkon Protocol 2010

Beginning in 2010, Meso-/Macro-zooplantkon tows will be conducted at 31 stations. The Meso-/Macro-zooplantkon sled was connected to the port side warp and the Meso-/Macro-zooplantkon flowmeter were recorded before the start of the tow. The Meso-/Macro-zooplantkon sled was deployed to the proper depth, which was determined by the station depth. The 10 minute tow schedule (provided by the Zooplankton study) was followed to complete an oblique tow. Once the tow is completed, the sled is brought back onboard and the Meso-/Macro-zooplantkon flowmeter were recorded. Each net is washed down from the outside of the net so no sample contamination occurs and the contents are collected into a jar. The jar is disconnected from the net and contents are poured into a quart jar containing 10% rose Bengal formalin solution. To ensure all content in the collecting jar has been transferred, the collecting jar is submerged in water half way, swirled around, and then the contents are poured into the quart jar. If any water enters the collecting jar through the mouth top, another sample must be collected. (Please note that only 10 Meso-/Macro-zooplantkon tows were collected in 2010 because the sled was lost and there was no back up).

Meso-/Macro-zooplantkon Protocol 2011

The permanent number of Meso-/Macro-zooplankton tows increased to 32 stations.

Processing the Sample

Procedures, 1995-Present

The data form was modified to accommodate changes in the measuring procedures (Appendix 4). After the tow is completed, all striped bass are measured to the nearest mm fork length (FL) and lengths are tallied by the deckhand on the data form. The total catch of striped bass 0 is recorded in the appropriate column. Striped bass scales are taken for aging when the length indicates that the striped bass could be either a young-of-the-year or one year old, or one year old or two years old, or two years old or three years old (See Appendix 6 for length ranges). Scales are taken from the side of the fish between the lateral line and the first dorsal fin. The area is scraped or wiped to remove the fish slime then the scales are removed by scraping or plucking and placed in a coin envelope labeled with the date, station, and fish length. Only six to eight scales need to be taken since reading the age usually requires only three good scales.

As of 1991, all delta smelt and longfin smelt are measured and counts recorded. All delta smelt are preserved in whirl packs with tags noting the month, day, year, and station where they were collected. The fish are placed in jars according to the area (1-17) where they are collected. All other fish are identified to the lowest possible taxon and a random sample of up to 50 fish from each species is measured to the nearest mm F.L. If more than one liter of a single fish species is caught, the total volume is measured and 1/4 (for small fish) to one liter (for large fish) subsamples are taken depending on the size of the fish. From the

subsample, 50 fish are selected to be measured as described above and the remainder is counted to determine number per unit volume. Total catch is calculated as the product of the total volume and number per volume.

Any fish not identifiable in the field is brought back in 10% formalin. The fish will be identified in the lab and a second ID will be confirmed by another biologist. If a discrepancy on the fish ID arises between biologists, then a third biologist will be brought in to confirm the ID.

Changes in Sample Processing, 1998 to the Present

The minimum length requirement (above) is removed; identify/measure all fish that are clearly beyond the larval stage. Measure all of the following species: striped bass (regardless of age), delta smelt, chinook salmon, and steelhead. Measure up to 50 of all other fish species. If striped bass are keyed out (Appendix 7) as older than 2 years write in the margin "SBIII+" and the fork lengths. In the margin record the catch of jellyfish and mitten crabs. After handling mitten crabs it is recommended that personnel wash their hands as mitten crabs in China are a vector for lung flukes (no cases of lung fluke infections have been reported in California as of December, 1998).

Changes in Sample Processing, 2001 to the Present

Beginning in 2001, jellyfish are speciated and enumerated when possible. Depending on the amount of jellyfish present, it can be possible to count them all. However, if there is a large catch, "eyeballing" the number is more practical. It is important that the data recorded reflect the order of magnitude of the jellyfish catch, when an exact number can not be accurately obtained. As always, the catch should be thoroughly sorted first, separating

different species of jellyfish. Unidentifiable jellyfish can be brought back to the lab preserved in formalin.

If more fish are captured at a station than can be processed between stations then the contents of the second station are put into buckets containing water until the fish from the first station are completed. All fish are retained in a bucket of water until release when the net is not fishing (to avoid recapture).

Changes in Sample Processing, 2007 to the Present

All striped bass older than age-2 will be recorded as age-3+ fish.

Changes in Data Recording, 2010 to the Present

On the data sheet, if no fish are caught, but invertes (jellyfish or shrimp) are caught, "No Fish" is written on the datasheet. If no fish or invertes are caught, "No Catch" is written on the data sheet.

Laboratory Procedures

Laboratory Procedures for Delta Smelt

Jars containing smelt are brought into the laboratory and the whirl packs of smelt are rinsed under the hood. Laboratory personnel process all delta smelt according to diet analysis procedures from one station at the same time.

Laboratory Procedures for Scale Analysis

Scale samples are read by the laboratory assistants on the adult striped bass project using a dissecting microscope. The age is recorded on the scale envelope and returned to the biologist who notes the fish age on the field sheet.

Changes in Scale Reading, 1998 to the Present

Scale samples which came from striped bass that had their stomachs removed will initially be read by Young Fish Investigations personnel. This is done in order to expedite correction of the MWT data sheets.

Data Editing, Storage and Reporting

Editing field sheets prior to Key Entry

A biologist ascertains that all numbers are legible and no stray marks occur. All date, survey, station, time, speed, depth, cable length, meter readings and tide code fields must be filled. All temperature, secchi and EC fields should be filled unless data are missing. All editing is to be done with blue or red pencil to distinguish it from original data.
A biologist ascertains that all EC data have been transcribed correctly from the laboratory computational sheet if this was used.

A biologist ascertains that a catch is legible and the corresponding lengths are on one line. If more than one line has been used to record lengths then all lengths must be circled and it is made clear (e.g. by an arrow) that the lengths recorded are for one species only. If any fish not printed on the data sheet already are caught, the biologist must enter the species code from the list (Appendix 8).

A biologist ascertains that all tallies of bass by length are properly summed and the number recorded in the catch column opposite their age group.

In 2008, 32 age-2 striped bass were changed to age-3+ as the fork lengths fell out of the age-2 range. A new species code (109) was added for age-3+ striped bass. Prior to 2007 age-3+ striped bass were inconsistently measured and not entered into the database because they

were considered by catch.

Data Storage Requirements

Prior to 1994, data were key entered by the State Water Resources Control Board Data management section or by U.C. Davis, computer service. In 1994, a permanent half-time keypunch operator (Diana Jones) was hired by the Bay-Delta Division to key all data. Data files were typically ASCII and had to be imported into ACCESS.

Beginning in 2002, data was key-punched (offsite) directly in ACCESS on a monthly basis. These files are then electronically sent and uploaded into the MWT database. This process ended in 2013.

Beginning in 2013, a new database was developed within the DFG IT department by Tuongvan Nguyen. Four inter-twining databases were created each with one sole purpose. "MWT_Local.mdb" was created for data entry, editing, and transferring data onto the local database. "MWT_Query.mdb" was created to extract data out of the database. "MasterStandAloneMWT.mdb" was created so researchers could obtain a copy of the entire Fall Midwater Trawl database. "ManagedAccessLogin.mdb" was created to transfer data from the local database to the Tier 3 server in Sacramento. The database was written in Structured Query Language (SQL) with a MS Access frontend (similar to the one created in 2002) and allows for infinite record retention. The database application to enter the data resides on the LTM drive (U:\LTM\FMWT\Database Tier 3 Application), however data is now stored in Sacramento.

Current protocol calls for database "MWT_local.mdb" to be entered from U:\LTM\FMWT\Database (DO NOT COPY THIS FILE ONTO YOUR COMPUTER AND

ENTER DATA). The project lead(s) or scientific aide(s) enter data into database "MWT_local.mdb" from the datasheets. Once the data has been entered, a paper record is generated and another person (other than the people who entered that data) goes through each record to ensure all data matches the datasheets and that no data is missed or erroneous. Any erroneous or missed data is corrected in the database and transferred onto the local database. Once the data has been transferred, database "ManagedAccessLogin.mdb" (located at: D:\Data\FMWT\Database) is used to upload the data using the "Upload Data to Tier 3 Server" button and browsing to the "MWT_Query.mdb" database at U:\LTM\FMWT\Database. This data is transferred onto the main server in Sacramento by an Admin user (the project leads/supervisors).

Information Reported

Abundance Index

An abundance index for the population is calculated by the following procedures (see Appendix 7):

(a) Catches are summed by area (there are a total of 14 areas) and a mean catch per tow is calculated.

(b) The mean catch per tow is weighted by the water volume (acre ft. x 10^{-4}) for that area.

(c) The weighted catches are summed over all areas by survey. This sum is the survey index.

(d) These data are mostly hand calculated prior to key entry and the data reported as soon as possible to DFG management and staff for use in data analyses.

Length data collected on striped bass for all years and on other species beginning in 1969 (MWT6994L.ssd) are stored separate from the catch data (MWT6794C.ssd). Data from the

outside net special study are in a separate file. Length data were collected for striped bass 0 from 1967-1968 but the data are missing. **All monthly index values are rounded to the nearest whole number.**

Data Reporting, 1998 to the Present

The striped bass length data from 1967-68 have been recovered. The SAS data sets are periodically updated and now in ".sd2" format. The catch and length files indicate the beginning and ending years for that current data set. For example data set "MWT6798C.sd2" contains catch data from 1967-1998. The MWT data base is also provided in ACCESS and can be useful for finding quick answers.

The biologist in charge of the MWT shall write a memo to all interested parties on the distribution and indices of age-0 Striped Bass, Delta Smelt, Longfin Smelt, American Shad, and Threadfin Shad after obtaining **approval from the regional manger**.

All ESA take shall be reported within a month of the survey ending on the ESA website. See document "ESA Reporting Instructions.docx" for more information.

QA/QC Query Reports from 2006 to Present

1. At the end of the season, biologist will create queries from Access to create cross tabulations for water temperature, conductivity, sampling date, secchi, flowmeter, plus counts, and striped bass and delta smelt serial numbers to check for missing or inconsistent values both temporally and spatially. Refer to *FMWT 2006 QA_QC Query Report.doc* located at *H:\Database\QA_QC Documents* and Appendix 9 for information on how to perform these queries.

2. The biologist will perform an index check for all index species and threadfin shad to identify any miscalculation of the FMWT monthly indices. The index check will be done after each survey has completed and the monthly indices are being calculated. Refer to *Fall Midwater Trawl Index Check.doc* located at *H:\Database\QA_QC Documents* for information on how to perform the index check.

3. The biologist will keep a survey by survey back-up of any changes made to the FMWT database. Archived back-ups will be kept on C:/Data/IEPData and H or G:/FMWT/Database, where each back-up will be kept in a separate folder named *DatabaseBackup Date (MM-DD-YYYY)*. Please refer to *Fall Midwater Trawl File Storage and Transfer Protocol.doc* located at *H:\Database\QA_QC Documents* and Appendix 9 for more information.

Data Adjustments

Changes in Area Station Groupings

Stations 419, 712, 713, 714, 715, 918 and 919 were dropped from the calculations of the abundance indices in June, 1994 because they were inconsistently sampled throughout the survey.

Changes in Station Designation

In 1971, the station designation was changed to the current scheme while in previous years data were collected with a different station numbering scheme.

Changes in Station Location

During the 2003 season it was discovered that 2 stations were not being sampled at the

locations described in the protocol. Information was gathered from boat operators familiar with the survey in order to decide whether or not sampling would continue at the existing location, or be moved back to the originally intended locations farther upstream. Since more years of sampling had been conducted at the current location, it was decided to abandon the original stations, create new numerical designations (724 and 736), and continue sampling in the current locations. Catch and sample data tables in the Midwater Trawl database have been adjusted to document these changes. All records associated with station 725 have been changed to 724, and all records associated with station 74 have been changed to 736.

Changes in Data Recording

From 1967 to 1970, a Hach turbidometer was used to measure turbidity since then a Secchi disk has been used to measure water clarity. These measurements were converted to estimate Secchi values by a regression relationship of Secchi and turbidity. The original regression equation used is not available and data for turbidity and Secchi were confounded in the file. A new algorithm to convert turbidity to estimated Secchi by using records where the two measurements were made simultaneously in the early 1970's. The best empirical fit to the data was the following relationship: $1/\text{Secchi (m)} = 0.2802 + 0.084\,(\text{JTU}) - 0.000035(\text{JTU})^{2.}$ Secchi was estimated from turbidity values for surveys in the period 1967 to 1970. This revised estimated Secchi and turbidity records were put into the file in early November 1997.

Changes in Data Base Parameters - Variables which have been added or dropped are as follows:

Year	Variable	Added/Dropped
1971	Turbidity	Dropped
1971	Water clarity (Secchi)	Added
1978	Boat speed (Speed)	Added
1978	Time of sampling (Time)	Added
1978	Bottom depth (Depth)	Added

1985	Tidal stage (Tide)	Added
1985	Tow direction (Direction)	Added
1985	Flow meter measurement (Meter_in, Meter_out)	Added
1995	Bottom EC	Added
1997	Start Time (Beginning of Fishing)	Added
1997	End Time (End of Fishing)	Added
1997	Time of Sampling (Time)	Dropped
1997	Flowmeter serial number	Added
2005	Serial Numbers for STRBAS & DELSME	Added
2007	Start and end of tow GPS coordinates	Added
2007	Microcystis qualitative estimate	Added
2009	Turbidity	Added
2010	Wind Direction	Added
2011	Bottom water temperature	Added

Changes in FMWT Indices

Around April 2007, FMWT biologist Dave Contreras created queries within MS Access to calculate abundance indices. The new query calculations resulted in many of the older FMWT indices to be changed. The changes were recorded in excel spreadsheet "FMWT New Indices vs Old Indices.xls". These set of indices were independently checked and verified by Supervising Biologist Randy Baxter and USFWS statistician Ken Newman.

Additionally in 2007, age-0 and age-1+ indices were calculated in MS Access for longfin smelt, delta smelt, threadfin shad, American shad, and splittail from 1990-current. This may have shifted indices from 1990-2006 by one or two because of rounding issues of age-0 and age-1+ fish in each month.

In 2010, index changed by one or two for longfin smelt (2001), American shad in (2002), and threadfin shad (2003). The error occurs because the MS Access query only calculated indices on measured fish, however there were three stations after 1999 where 1 fish of each species was counted and not measured.

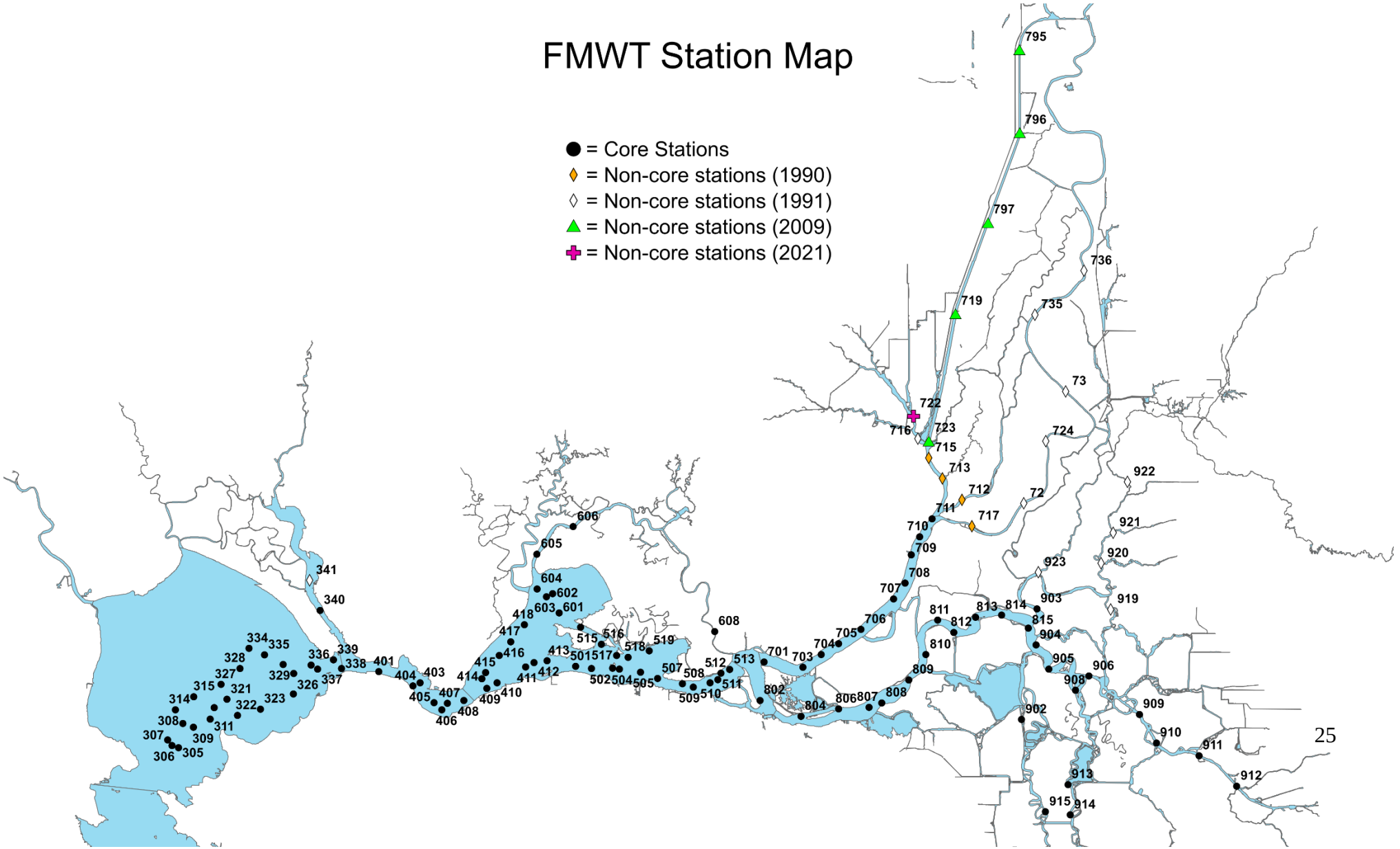
In 2010, indices changed for American shad in 1991, 1992, and 2004. It remains unclear as to what caused the changes in the indices, but the new indices appear to be correct.

References

Miller, D, J. and R. N. Lea. 1972. Guide to Coastal Marine Fishes of California. California Department of Fish and Game Bulletin 157:1-249.

Von Geldern Jr., C. E. 1972. A midwater trawl for threadfin shad, *Dorosoma pretense*. California Department of Fish and Game, 58(4):268-276.

Appendix 1 – Stations and Locations



FMWT survey station descriptions, location, and average depth

For open water locations, sampling may begin within a 0.25 nautical mile radius of the location as long as sampling remains in the designated channel or shoal depth range. Channel ≥7m (22 ft) and shoal < 7m (22 ft).

Station	Description	Lat(D)	Lat(M)	Lat(S)	Long(D)	Long(M)	Long(S)	Depth(ft)	RKI
72	SACRAMENTO RIVER 700 YDS S. OF LDG NO 40	38	11	15.9	121	34	50.1	13	RSAC113
73	SACRAMENTO RIVER 700 YDS S OF VORDEN	38	16	27.6	121	32	21.7	24	RSAC128
305	SP BAY - 2900 YDS NE OF LT 4 OPPOSITE THE SISTERS	37	59	55.3	122	24	31.0	35	RSAC027
306	SP BAY 1900 YDS SW OF BUOY BW "E" IN SHIP CHANNEL	38	0	1.5	122	24	53.6	52	RSAC028
307	SP BAY 3760 YDS NE OF SISTERS; 845 YDS NW OF STATION 306	38	0	17.0	122	25	9.1	35	LSPD02
308	SP BAY - 1200 YDS N OF BUOY BW "E" IN SHIP CHANNEL	38	1	2.8	122	24	15.8	40	RSAC029
309	SP BAY- 1500 YDS NE OF BUOY BW "E" IN SHIP CHANNEL	38	0	51.9	122	23	37.9	41	RSAC030
310	SAN PABLO BAY - BETWEEN CHANNEL LT 7 AND 8	38	1	46.9	122	22	24.8	39	RSAC032
311	SP BAY - 2000 YDS NW OF PT. PINOLE	38	1	15.1	122	22	38.7	30	RSAC031
314	SP BAY - 2500 YDS N OF MARKER 5	38	1	41.2	122	24	42.0	12	LSPD05
315	SP BAY - 2600 YDS WNW OF PINOLE SHOAL CHANNEL LT 7	38	2	17.3	122	23	37.0	12	LSPD07
321	SP BAY - IN CH HALFWAY BTWN MKRS 7 & 8 AND 9 & 10	38	2	10.0	122	21	39.7	35	RSAC033
322	SP BAY - 2400 YDS NE OF PT PINOLE	38	1	25.1	122	21	2.8	12	LSPE08
323	SP BAY - 3300 YDS SE OF SHIP CH LIGHT 10	38	1	42.7	122	19	41.4	11	LSPE11

325	SP BAY - 700 YDS SW OF CHANNEL LT 15	38	3	21.8	122	17	43.8	36	RSAC039
326	SP BAY - 2800 YDS W OF RODEO	38	2	25.4	122	17	45.3	11	LSPE13
327	SP BAY- 1900 YDS NW PINOLE SHOAL CHANNEL LIGHT 9	38	2	51.8	122	22	0.2	11	LSPD10
328	SP BAY - 2400 YDS NW OF SHIP CHANNEL LT 11	38	3	36.2	122	20	54.3	9	LSPD12
329	SP BAY - 1125 YDS NNE OF SHIP CHANNEL LIGHT 13	38	3	47.2	122	18	21.2	11	LSPD16
334	SP BAY - 3620 YDS NNW OF SHIP CHANNEL LIGHT 11	38	4	31.9	122	20	21.6	8	LSPC14
335	SP BAY - 2800 YDS NNW OF SHIP CHANNEL LIGHT 11	38	4	13.8	122	19	27.5	9	LSPC16
336	SP BAY - 1620 YDS E OF LIGHT 15	38	3	45.9	122	16	43.5	28	RSAC040
337	SP BAY - 2320 YDS E OF CHANNEL LT 15	38	3	34.2	122	16	20.4	54	RSAC041
338	CAR ST - MOUTH OF CARQUINEZ ST OPPOSITE NAPA RIVER; 1500 YDS S OF LT 2	38	3	36.1	122	14	56.1	49	RSAC043
339	SP BAY - ALONG ROCKWALL 600 YDS SW CHANNEL LT 17	38	4	0.1	122	15	24.5	32	RSAC042
340	NAPA RIVER - MARE ISLAND ST OPP S PART OF HARBOR	38	6	18.3	122	16	11.6	20	RNAP005
341	NAPA RIVER - MARE ISLAND 1100 YDS N OF HWY 37 BRIDGE	38	7	41.8	122	16	48.7	20	RNAP007
401	CARQ STRTS - ALONG CH SUGAR DOCK 1500 YDS E OF BRIDGE	38	3	27.3	122	12	44.8	60	RSAC047
403	CARQ STRTS - EDGE OF FLATS 1400 YDS E OF LT 22	38	2	55.8	122	10	18.9	14	RSAC051
404	CARQ STRTS - INSHORE 700 YDS SE OF LIGHT 22	38	2	47.2	122	10	43.9	55	RSAC050
405	CARQ STRTS - 450 YDS E OF LIGHT 25	38	2	0.7	122	9	29.3	30	RSAC052

406	CARQ STRTS - EAST OF OZOL DOCK; 1600 YDS SE LIGHT 25	38	1	40.8	122	9	2.1	45	RSAC053
407	CARQ STRTS - MIDCHANNEL 1100 YDS NW OF DOCKS	38	1	58.7	122	8	42.5	42	RSAC054
408	CARQ STRTS - CHANNEL 1100 YDS DOWNSTREAM BENICIA BRIDGE	38	2	6.5	122	7	44.3	56	RSAC055
409	SUISUN BAY - CHANNEL 1600 YDS UPSTREAM FROM SP RR BRIDGE	38	2	40.4	122	6	22.9	47	RSAC057
410	SUISUN BAY - CHANNEL 350 YDS E LIGHT 7	38	2	55.8	122	5	47.3	45	RSAC059
411	SUISUN BAY - CHANNEL 635 YDS NE FROM LT 10	38	3	40.2	122	4	5.8	40	RSAC061
412	SUISUN BAY - CHANNEL 280 YDS E OF LIGHT 11	38	3	52.6	122	3	36.3	40	RSAC062
413	SUISUN BAY - CHANNEL HALFWAY BTWN LTS 13 & 14 AND 15 & 16	38	3	57.4	122	2	50.3	35	RSAC063
414	SUISUN BAY - 620 YDS N OF LIGHT 2	38	3	7.7	122	6	40.6	35	LSBB01
415	SUISUN BAY - 1800 YDS SW OF LIGHT 4	38	3	24.4	122	6	27.8	32	LSBB02
416	SUISUN BAY - 880 YDS NNE OF LIGHT 4	38	4	12.7	122	5	38.9	31	LSBB04
417	SUISUN BAY - 150 YDS NW LIGHT 6 NEAR RESERVE FLEET	38	4	50.7	122	4	58.8	29	LSBB06
418	SUISUN BAY - 2600 YDS NE OF LIGHT 6	38	5	37.8	122	4	11.0	30	LSBB07
501	SUISUN BAY - CHANNEL 130 YDS S OF LIGHT 17	38	3	42.0	122	1	10.4	36	RSAC065
502	SUISUN BAY - CHANNEL 400 YDS SW LIGHT 19	38	3	35.9	122	0	14.3	36	RSAC067
503	SUISUN BAY - BETWEEN LIGHTS 21 & 22	38	3	36.8	121	58	59.5	35	RSAC069
504	SUISUN BAY - CHANNEL 740 YDS E OF LIGHT 22	38	3	34.0	121	58	36.1	35	RSAC070

505	SUISUN BAY - 800 YDS E OF LIGHT 24	38	3	25.7	121	57	21.5	35	RSAC071
507	SUISUN BAY - 630 YDS SW OF SIMMONS PT	38	3	8.2	121	56	20.4	36	RSAC073
508	SUISUN BAY - 970 YDS NNE OF LIGHT 28	38	2	53.3	121	54	53.7	41	RSAC075
509	SUISUN BAY - 1800 YDS ENE FROM LIGHT 28	38	2	43.7	121	54	14.8	45	RSAC076
510	SUISUN BAY - 85 YDS S OF LIGHT 31	38	2	56.0	121	53	16.2	39	RSAC077
511	SUISUN BAY - 970 YDS ENE OF LIGHT 31	38	3	4.7	121	52	48.0	39	RSAC078
512	SAC RIVER - 985 YDS SW OF LIGHT 33	38	3	23.0	121	52	38.0	30	RSAC079
513	SAC RIVER - 190 YDS NW OF LIGHT 34	38	3	33.1	121	52	6.3	55	RSAC080
515	SUISUN BAY - 1050 YDS SE OF PT BUCKLER	38	5	31.2	122	0	53.0	31	LSBB15
516	SUISUN BAY - 300 YDS SW OF WEST END OF FREEMAN IS.	38	4	43.2	121	59	38.7	18	LSBB17
517	SUISUN BAY - 1000 YDS SSE OF EAST END OF FREEMAN IS.	38	4	12.8	121	58	45.8	16	LSBB19
518	HONKER BAY - 1040 YDS S OF MOUTH OF CHAMPION SL.	38	4	7.5	121	58	4.9	11	LSBB21
519	HONKER BAY - 3200 YDS NW OF SIMMONS PT	38	4	25.6	121	56	50.1	7	LSBB23
601	GRIZZLY BAY - 1200 YDS NNE OF GARNET PT. OF RYER ISLAND	38	6	11.2	122	2	8.2	13	LSBB13
602	GRIZZLY BAY - 2500 YDS E OF LIGHT 10	38	7	4.2	122	2	30.6	7	LSBB12
603	GRIZZLY BAY - 1800 YDS ESE FROM LIGHT 10	38	6	55.9	122	2	53.0	10	LSBB11
604	GRIZZLY BAY - 715 YDS NE OF LIGHT 10	38	7	17.9	122	3	25.8	12	LSBB10
605	W END OF MONTEZUMA SL. 2700 YDS UPSTREAM OF	38	8	54.7	122	3	26.6	21	SLMZU02

	MOUTH								
606	W END OF MONTEZUMA SL. 300 YDS E OF CABLE AREA	38	10	11.3	122	1	18.4	26	SLMZU06
608	MONTEZUMA SL - 420 YDS S OF E END OF ROARING RVR SL.	38	5	19.3	121	52	60.0	22	SLMZU29
701	SAC RIVER - 80 YDS E OF BETWEEN LIGHTS 5 & 6	38	3	54.2	121	50	5.1	33	RSAC083
703	SAC RIVER - CHANNEL 330 YDS E OF LIGHT 9	38	3	39.1	121	47	48.9	34	RSAC086
704	SAC RIVER - CHANNEL 1800 YDS SW OF LTS 13 & 14	38	4	15.1	121	46	44.1	32	RSAC088
705	SAC RIVER - CHANNEL 660 YDS NE OF LIGHTS 13 & 14	38	4	45.3	121	45	42.5	31	RSAC090
706	SAC RIVER - CHANNEL 300 YDS NE OF LIGHTS 15 & 16	38	5	25.1	121	44	24.0	32	RSAC092
707	SAC RIVER - CHANNEL 300 YDS NE OF LIGHTS 19 & 20	38	6	50.3	121	42	28.7	32	RSAC096
708	SAC RIVER - 300 YDS N OF LIGHT 24	38	7	33.9	121	41	48.1	31	RSAC098
709	SAC RIVER - 225 YDS S OF LIGHT 27	38	8	52.3	121	41	25.7	33	RSAC100
710	SAC RIVER - 500 YDS UPSTREAM OF RIO VISTA BRIDGE	38	9	43.2	121	40	56.2	32	RSAC102
711	SAC RIVER - 600 YDS UPSTREAM OF LIGHT 36A	38	10	33.4	121	40	13.0	41	RSAC103
712	STEAMBOAT SLOUGH - N OF WINDMILL BTWN SIPHONS; 2700 YDS UPSTRM OF MOUTH	38	11	25.5	121	38	27.4	11	SLSBT03
713	CACHE SLOUGH - 350 YDS N OF LIGHT 43	38	12	25.6	121	39	36.3	36	SLCCH03
715	CACHE SLOUGH - 70 YDS S OF BETWEEN LIGHTS 47 & 48	38	13	22.6	121	40	25.0	40	SLCCH05
716	CACHE SL. - AT OLD CABLE FERRY 1 & 51; AT MOUTH PROPSECT SL.	38	14	16.3	121	41	3.8	30	SLCCH08

717	LOWER SAC RIVER - 517 YDS DNSTRM OVHD PWR CABLE	38	10	12.6	121	37	53.0	12	RSAC107
719	DWSC - 130 YDS N OF BETWEEN LIGHTS 59 & 60	38	20	3.4	121	38	50.4	35	SHSAC13
723	DWSC - 225 YDS S OF BETWEEN LIGHTS 51 & 52	38	14	10.1	121	40	24.5	37	SHSAC00
724	SAC RIVER - AT RYDE HOTEL; 200 YDS S OF WATER TANK	38	14	8.8	121	33	31.6	28	RSAC123
735	AT COURTLAND 1200 YDS ABOVE MOUTH SUTTER SL.	38	20	0.3	121	34	10.8	18	RSAC136
736	SAC RIVER - AT HOOD, 800 YDS N OF LIGHT 6	38	22	2.5	121	31	17.0	19	RSAC144
795	DWSC - BETWEEN LIGHTS 75 & 76	38	32	15.7	121	35	4.8	38	SHSAC36
796	DWSC - BETWEEN LIGHTS 71 & 72	38	28	25.9	121	35	3.8	35	SHSAC28
797	DWSC - BETWEEN LIGHTS 65 & 66	38	24	16.6	121	36	56.2	31	SHSAC22
722	CACHE SLOUGH - 540 YDS S OF FORK CACHE & SHAG SL. **(Same as SKT 716)**	38	15	18.1	121	41	18.9	25	SLCCH11
802	SAN JOAQUIN RIVER - 730 YDS N OF PT. BEENAR	38	2	7.0	121	50	19.5	30	RSAN003
804	SAN JOAQUIN RIVER - 1050 YDS UPSTRM LT 8; 1000 YDS DNSTRM LT 9	38	1	23.1	121	47	55.2	39	RSAN007
806	SAN JOAQUIN RIVER - 600 YDS E OF LIGHT 11	38	1	43.4	121	45	42.1	37	RSAN011
807	SAN JOAQUIN RIVER - 870 YDS E OF LIGHT 17	38	1	47.8	121	43	55.3	36	RSAN013
808	SAN JOAQUIN RIVER - 200 YDS N OF LIGHT 18A	38	2	0.1	121	43	9.9	41	RSAN015
809	SAN JOAQUIN RIVER - 525 YDS DNSTRM OF LT 24 AT JERSEY PT	38	3	4.3	121	41	35.0	39	RSAN018
810	SAN JOAQUIN RIVER - 750 YDS UPSTREAM FROM	38	4	15.0	121	40	34.4	37	RSAN021

LIGHT 26

811	SAN JOAQUIN RIVER - 530 YDS E FROM LT 33	38	5	50.7	121	39	53.5	44	RSAN024
812	SAN JOAQUIN RIVER - 275 YDS S OF LIGHT 35	38	5	16.5	121	38	55.8	41	RSAN026
813	SAN JOAQUIN RIVER - 350 YDS S OF LIGHT 39	38	5	59.2	121	37	39.6	45	RSAN028
814	SAN JOAQUIN RIVER - 100 YDS N OF LIGHT 42	38	6	4.6	121	36	7.9	39	RSAN031
815	SAN JOAQUIN RIVER - 280 YDS W OF LIGHT 49	38	5	28.7	121	34	33.1	38	RSAN033
902	HOLLAND CUT JUST S OF NORTH TIP OF HOLLAND TRACT	38	1	13.8	121	34	57.2	25	CFHLNO
903	MOKELUMNE RIVER - JUST OFF N TIP OF WILLOW BERM HBR	38	6	22.6	121	34	2.9	12	RMKL002
904	SAN JOAQUIN RIVER - 330 YDS N OF LIGHT 54	38	4	41.8	121	34	6.5	49	RSAN035
905	SAN JOAQUIN RIVER - 190 YDS S OF PRISONERS PT. LT 57	38	3	34.3	121	33	20.6	42	RSAN037
906	SAN JOAQUIN RIVER - 100 YDS W OF BETWEEN LIGHTS 5 & 6	38	3	14.8	121	30	59.5	40	RSAN041
908	MIDDLE RVR 300 YDS S OF JUNCTION W/ THREE RVR REACH	38	2	35.1	121	31	47.3	26	RMID00
909	SAN JOAQUIN RIVER - 400 YDS N OF LIGHT 18	38	1	27.9	121	28	1.4	38	RSAN046
910	SAN JOAQUIN RIVER - 100 YDS E OF LIGHT 21	38	0	8.2	121	27	1.3	35	RSAN050
911	SAN JOAQUIN RIVER - 612 YDS UPSTREAM OF LTS 33 & 34	37	59	32.9	121	24	31.5	35	RSAN053
912	SAN JOAQUIN RIVER - BETWEEN LIGHTS 41 & 42	37	58	7.8	121	22	18.2	35	RSAN058
913	MIDDLE RIVER OFF SW END OF MILDRED ISLAND	37	58	12.4	121	32	13.4	23	RMID11

914	MIDDLE RIVER - 645 YDS N OF OVHD PW CBL NEAR BASCULE BR	37	56	47.8	121	32	5.1	17	RMID15
915	OLD RIVER ALONG SE SIDE OF FAY ISLAND	37	56	56.4	121	33	32.7	18	ROLD26
919	LITTLE POTATO SL. 2500 YDS N OF JTN WITH WHITE SLOUGH	38	6	20.6	121	29	42.9	17	SLLPT4
920	SOUTH FORK MOKELUMNE RIVER AT SYCAMORE SL.	38	8	29.0	121	30	17.1	20	RSMKL12
921	S MOKELUMNE RIVER - AT MOUTH OF HOG SLOUGH	38	9	54.5	121	29	34.9	11	RSMKL15
922	S MOKELUMNE RIVER - 1800 YDS N OF MOUTH OF BEAVER SLOUGH	38	12	15.8	121	28	44.0	12	RSMKL19
923	MOKELUMNE RIVER - JUST N OF FORK BTN N & S MOKE. RVRS	38	8	4.0	121	33	58.5	15	RMKL007

updated Aug 2021 by James White

Appendix 2 – Equipment List

FMWT Equipment Checklist

- ☐ Spare Nets - MWT (x1), CB (x1), Mysid (x1)
- ☐ MWT Doors
- ☐ Door Shackles
- ☐ Amsteel spare bridles (x1)
- ☐ Mysid Towing Frame
- ☐ Fish Handling Tubs (x2)
- ☐ Measuring Boards (x2)
- ☐ Buckets (x3)
- ☐ Flowmeter (x2)
- ☐ Small Ice Chest
- ☐ YSI Pro30
- ☐ Turbidity Meter
- ☐ Secchi (x2)
- ☐ GPS Unit (x2)
- ☐ Timer
- ☐ C Batteries (x8)
- ☐ AA Batteries (x12)
- ☐ AAA Batteries (x1)
- ☐ Datasheets
- ☐ Protocol
- ☐ Fish ID Guide
- ☐ Station Maps/Charts
- ☐ Fish Tags (Unid, etc)
- ☐ CB/Mysid Tags
- ☐ Perforated Plastic Baggies
- ☐ Scale Envelopes
- ☐ Clipboard
- ☐ Pencils
- ☐ Net Repair Kit
- ☐ First Aid Kit
- ☐ Eye Wash
- ☐ Tools
- ☐ CWT Wand
- ☐ Datasheet Container
- ☐ Tag Container
- ☐ Gallon jugs with preservation material (x3-10% formalin, x1-95% Ethanol)

Appendix 3 – Towing Schedule

Tow Schedule based on *R/V Alosa*

TRAWL SCHEDULE OF STOPS

DEPTH	CABLE OUT (EXCEPT BRIDLES)	STOPS
0-10	BRIDLES ONLY	8 MIN @ 0‘
11-15	50	4 MIN @ 50' 2 MIN @ 0'
16-20	100	2 MIN @ 100' 1 MIN @ 75' 1 MIN @ 50'
21-25	125	2 MIN @ 125' 1 MIN @ 75'
26-30	150	45 SEC @ 150' 45 SEC @ 100' 45 SEC @ 50'
31-35	175	1 MIN @ 100'
36+	200	NONE

Appendix 4 - Datasheet

FALL MIDWATER TRAWL SURVEY DATASHEET

Operator: _____ Crew: _____ Boat: _____ FMWT Net #: ____

M M D D Y Y | Survey | Station | Flow meter # | Depth Logger #

Tide (1. High Slack 2. Ebb 3. Low Slack 4. Flood) | Depth | Cable Out | Tow (1. With 2.Against 3.Unknown) | Weather (1. Cloud (0-33%) 2. Cloud (33-66%) 3. Cloud (66-100%) 4. Rain) | Waves (1. Calm 2. Waves w/o whitecaps 3. Waves w/ whitecaps) | Wind Dir

Secchi | Microcystis (1. Absent 2. Low 3. Medium 4. High 5. Very High) | Bottom - Temp | Bottom - EC | Top - Temp | Top - EC | Top-Turb

Meter In | Start Time | 3 ° Start Lat (N) ' " | 1 2 ° Start Long (W) ' "

Meter Out | End Time | End Lat (N) 3 ° " | End Long (W) 1 2 ° "

Species	Code	Catch	Lengths	Plus Count

Errors:

- ☐ Net
- ☐ Flowmeter
- ☐ Tow
- ☐ Data
- ☐ Sample
- ☐ Other

Comments:

Marine Mammal Sightings: (if within 50 yds)	
# near net: Harbor Seals / Sea Lions	# Contacts with gear: Harbor Seals / Sea Lions
/	/

Updated August 2020 by J.White

Appendix 5 – Station List

FMWT Station Checklist									
Date Boat	Date Boat	Date Boat	Date Boat	Date Boat	Date Boat	Date Boat	Date Boat	Date Boat	Date Boat
Day 1	**Day 2**	**Day 3**	**Day 4**	**Day 5**	**Day 6**	**Day 7**	**Day 8**	**Day 9**	**Day 10**
	zoo.	zoo.	zoo.	zoo.	zoo.	zoo.	zoo.	zoo.	
327	328	406	414	515	701	806	919*	723*	717*
315	334	405	415	516	703	807	920*	719*	72*
314	335	407	416	517	704 p	808	921*	797*	724*
307	329	408	417	518	705	809	922*	796*	73*
306	325	409	418	519	706 p	902	923*	795*	735*
305	336	410	603	507	707	915	903		736*
308	337	411	604	508	708	914	904		712*
309	339	412	605 p	509	709	913	905		
311	338	413	606 p	510	710	910	815		
310	340	501	602 p	511	711	911	814		
321	341*	502	601	512	713*	912	813		
322	401	503	802 p	513	715*	909	812		
323	404	504	804	608	716*	906	811		
326	403	505			722*	908	810		

* = non-index station

p= phytoplankton sample = Meso/Macrozooplankton tow

Salinity Control Gate

Appendix 6 – Striped Bass Age-Length Key

Midwater Trawl Age-Length Key for Striped Bass
1998 Key, 1999 Revision
1964 Key, 1997 Revision
Memo, explaining analysis for the 1998 Key

1998 Age-Length Key, All ranges are in fork lengths (mm)

	STRIPED BASS AGE GROUP AND YEAR CLASS				
MONTH	SB 0 (1964)	SB 0 (1963)	SB I (1962)	SB II (1961)	SB III+ (1960)
JUNE		0-79	80-199	200-329	330 +
JULY		0-89	90-229	230-329	330 +
AUGUST		0-109	110-239	240-359	360 +
SEPTEMBER		0-129	130-259	260-379	380 +
OCTOBER		0-149	150-269	270-389	390 +
NOVEMBER		0-149	150-279	280-399	400 +
DECEMBER		0-149	150-289	290-409	410 +
JANUARY		0-149	150-289	290-409	410 +
FEBRUARY		0-149	150-289	290-409	410 +
MARCH		0-169	170-289	290-409	410 +
APRIL		0-169	170-309	310-439	440 +
MAY		60-179	180-319	320-439	440 +
JUNE	0-79	80-199	200-329	330-459	460 +
JULY	0-89	90-219	220-349	350-469	470 +
AUGUST	0-119	120-239	240-359	360-479	480 +

ADDENDUM NOTES FOR THE MIDWATER TRAWL PROTOCOL.

06/5/98

Revision of scale sampling for striped bass (*Morone saxatilis*) for the Fall Midwater Trawl Survey based on a new age-length key.

INTRODUCTION

The midwater trawl tracks the abundance of age 0+, 1+ and 2+ year old striped bass (*Morone saxatilis*). Differentiation of ages is made with an age-length key developed in 1964 (the 1964 key) using aging data from 1963 to 1964 (Table 1).

Table 1. Age-length key for 0+, 1+, and 2+ year old striped bass (*Morone saxatilis*) in the Sacramento-San Joaquin Estuary for 1963-1964. Length intervals are by month, starting in June, 1963 and continuing to April, 1964. (The original table went from June, 1963 to August, 1964.)

MONTH	FORK LENGTH RANGE (mm) 0+	1+	2+
JUNE	0-79	80-199	200-329
JULY	0-89	90-229	230-329
AUGUST	0-109	110-239	240-350
SEPTEMBER	0-129	130-259	260-370
OCTOBER	0-149	150-269	270-380
NOVEMBER	0-149	150-279	280-390
DECEMBER	0-149	150-289	290-400
JANUARY	0-149	150-289	290-400
FEBRUARY	0-149	150-289	290-400
MARCH	0-169	170-289	290-400
APRIL	0-169	170-309	310-430

In recent years samples are taken from juvenile striped bass according to a predetermined schedule (Table 2). This schedule has two range bands designed to "straddle" the boundary between ages 0+ and 1+ and the boundary between ages 1+ and 2+. The scales are read and the data sheets then corrected. It has been recognized that the 1964 key may be inadequate and the current sampling schedule needed review. Also it is desirable to take the minimum scale samples to saves time and effort.

I evaluated the 1964 key and determined a new sampling schedule for the midwater trawl survey.

METHODS

Scale samples were taken from ages 0+, 1+ and 2+ striped bass and aged from 1992 to 1998. Months were numbered with April starting at 1 to indicate the first month of a 1+ fish. Although samples were taken from August to March the majority of samples were taken from August to December during the years 1992, 1996, 1997 (note, no survey was conducted in August of 1992). I pooled these samples and calculated a linear regression with fork length as the dependent variable and month as the independent variable. From this regression (Figure 1) I determined a 95 percent prediction interval and predicted mean fork lengths for age 1+ striped bass and used this as a new age 1+ age length key. For age 0+ fish I set the range at 0 mm to the lower 95% prediction limit. For age 2+ fish range I used the upper limit of the 95% prediction interval to the upper limit of the 1964 key.

Table 2. Scale sampling schedule for the striped bass midwater trawl survey in the Sacramento-San Joaquin Estuary as of March, 1998.

MONTH	FORK LENGTH RANGE (mm) LOWER RANGE	UPPER RANGE
AUGUST	90-130	220-260
SEPTEMBER	110-150	240-280
OCTOBER	130-170	240-290
NOVEMBER	130-170	260-300
DECEMBER	130-170	270-310
JANUARY	130-170	270-310
FEBRUARY	130-170	270-310
MARCH	150-290	270-310
APRIL	150-290	280-320

The new scale sampling schedule was determined as follows. For each month I used two 40 mm length range bands. The range of the lower band was from 5 mm less than the lower 95% prediction interval limit to 35 mm greater than the lower 95% prediction interval limit. The range of the upper band was taken from 35 mm less than the upper 95% prediction interval limit to 5 mm greater than the upper 95% prediction interval limit. The premise for setting the bands is that it is more important to distinguish between age 0+ and 1+ fish as the midwater trawl net is not designed to catch 2+ fish and they are essentially by-catch that has historically been monitored. I then compared the new key and sampling schedule and the 1964 key and sampling schedule to data from August to December, 1992-1997 (n = 391). The number of fish that would have been incorrectly aged were identified. The criteria for correctly aging a fish were: (1) the key correctly aged the fish or (2) the sampling schedule would dictate a sample to be taken for aging. The numbers of fish that would not have been aged correctly ("misses") were compared between the two keys and sampling schedules and compared month by month. Misses are classified as: an age 0+ fish identified as an age 1+, an age 1+ fish identified as an age 0+ or age 2+, and an age 2+ identified as an age 1+ fish or an age 3+ or greater.

RESULTS

The resulting regression equation is:

Fork length, age 1+ fish (mm) = 153.37 mm + 8.85 (mm/month) *(month)
(Std. Err. = 12.14) (Std. Err. = 1.72)

with the following results: $F = 26.505$, $p = 0.0001$ (based on 1 and 292 degrees of freedom), and R^2 (adjusted) = 0.0803. Predicted values and upper and lower 95% prediction intervals are listed in Table 3. The new age-length key is presented in Table 4 and the following scale sampling schedule in Table 5. The results of the comparison of the data from the 1964 key and the new key are presented in Table 6.

Table 3. Predicted average fork lengths (mm) and upper and lower 95% prediction interval bounds (mm) for age 1+ striped bass in the Sacramento-San Joaquin Delta from August to December, 1992-1997.

MONTH	LOWER 95% BOUND	PREDICTED MEAN	UPPER 95% BOUND
AUG	126.1	197.6	269.1
SEP	135.2	206.5	277.7
OCT	144.1	215.3	286.5
NOV	152.9	224.2	295.4
DEC	161.5	233.0	304.5

Table 4. New age-length key (Fall, 1998 key) for ages 0+, 1+ and 2+ striped bass in the Sacramento-San Joaquin Delta, August through September. All length intervals are in millimeters.

MONTH	0+	1+	2+
AUGUST	0-125	126-269	270-350
SEPTEMBER	0-134	135-278	279-370
OCTOBER	0-143	144-287	288-380
NOVEMBER	0-152	153-296	297-390
DECEMBER	0-161	162-305	306-400

Table 5. Scale sampling schedule for age 1+ striped bass in the Sacramento-San Joaquin Estuary.

MONTH	LOWER BAND (mm)	UPPER BAND (mm)
AUGUST	120-160	234-274
SEPTEMBER	129-169	243-283
OCTOBER	138-178	252-292
NOVEMBER	147-187	261-301
DECEMBER	156-196	270-310

Table 6 reveals that the new key reduced miss-aged 0+ and 1+ fish but not age 2+ fish. Most age 2+ fish that were "missed" were longer than the upper end of the either key (Tables 1 and 4). Most missed age 1+ were missed because the sampling schedule band was not "wide" enough on the high end. However, the above numbers are small compared to the sample size (391).

Table 6. Numbers of fish incorrectly assigned ages based on the 1964 key and the new 1998 key for striped bass ages 0+, 1+, and 2+ in the Sacramento-San Joaquin Delta for August to December, 1992-1997.

MONTH	NEW, 0+	1964, 0+	NEW, 1+	1964, 1+	NEW, 2+	1964, 2+
AUGUST	0	0	3	3	2	2
SEPTEMBER	0	2	0	1	4	4
OCTOBER	0	0	2	2	0	0
NOVEMBER	1	2	0	0	3	3
DECEMBER	1	2	1	1	3	3

DISCUSSION

There are always a few fish that fall on the extremes of the growth distribution for a given age. However our resources would be better spent by studying the overall picture of striped bass and not individual extremes. The new key and sampling schedule will better reflect this overall picture while minimizing resources spent to age striped bass.

CHANGE TO THE MIDWATER TRAWL PROTOCOL

The new key (Table 4) designated the "Fall, 1998" key will be used to differentiate between ages 0+ and 1+ striped bass and ages 1+ and 2+ striped bass. Scale sampling will be done in accordance with Table 5 with the addition of scale samples taken from all age 2+ fish and above. A key for January through march will be written before December, 1998.

RUSSELL G. GARTZ
BIOLOGIST (MARINE/FISHERIES)
CALIFORNIA DEPARTMENT OF FISH AND GAME
BAY/DELTA AND SPECIAL WATER PROJECTS DIVISION

Appendix 7 – Organism Codes

Midwater Trawl Species Names and Codes

MIDWATER TRAWL SPECIES CODES AND STORET CODES

COMMON NAME	SCIENTIFIC NAME	CODE	SMK
BAT RAY	*Myliobatis californica*	1	590
BIG SKATE	*Raja binoculata*	2	304
CARP	*Cyprinus carpio*	3	012
CHANNEL CATFISH	*Ictalurus punctatus*	4	016
WHITE CATFISH	*Ameiurus catus*	5	058
BLACK CRAPPIE	*Pomoxis nigromaculatus*	6	005
WHITE CRAPPIE	*Pomoxis annularis*	7	059
JACKSMELT	*Atherinopsis californiensis*	8	613
CHINOOK SALMON	*Oncorhynchus tshawytscha*	9	083
PACIFIC LAMPREY	*Lampetra tridentata*	10	577
RIVER LAMPREY	*Lampetra ayersii*	11	584
MISSISSIPPI SILVERSIDE	*Menidia audens*	12	411
NORTHERN ANCHOVY	*Engraulas mordax*	13	596
PLAINFIN MIDSHIPMAN	*Porichthys notatus*	14	607
PACIFIC POMPANO	*Peprilus simillimus*	15	649
PACIFIC HERRING	*Clupea harengus*	16	595
PACIFIC SANDDAB	*Citharichthys sordidus*	17	664
PACIFIC TOMCOD	*Microgadus proximus*	18	567
AMERICAN SHAD	*Alosa sapidissima*	19	164
THREADFIN SHAD	*Dorosoma petenense*	20	333
SHINER PERCH	*Cymatogaster aggregata*	21	623
CRANGON SHRIMP	*Crangon* spp.	22	710
PALAEMON SHRIMP	*Palaemon macrodactylus*	23	765
DELTA SMELT	*Hypomesus transpacificus*	24	599
LONGFIN SMELT	*Spirinchus thaleichthys*	25	601
NIGHT SMELT	*Spirinchus starski*	26	600
SURF SMELT	*Hypomesus pretiosis*	27	598
WHITEBAIT SMELT	*Allosmerus elongatus*	28	597
SACRAMENTO SPLITTAIL	*Pogonichthys macrolepidotus*	29	605

COMMON NAME	SCIENTIFIC NAME	CODE	SMK
PACIFIC STAGHORN SCULPIN	l*eptocottus armatus*	30	569
STEELHEAD	*Oncorhynchus mykiss*	32	039
STRIPED BASS AGE0	*Morone saxatilis*	33	052
STRIPED BASS AGE1	*Morone saxatilis*	34	052
STRIPED BASS AGE2	*Morone saxatilis*	35	052
GREEN STURGEON	*Acipenser medirostris*	36	592
WHITE STURGEON	*Acipenser transmontanus*	37	593
THREESPINE STICKLEBACK	*Gasterosteus aculeatus*	38	614
TOPSMELT	*Atherinops affinis*	39	612
TULE PERCH	*Hysterocarpus traski*	40	628
WHITE CROAKER	*Genyonemus lineatus*	41	619
YELLOWFIN GOBY	*Acanthogobius flavimanus*	42	641
WALLEYE SURFPERCH	*Hyperprosopon ellipticum*	43	626
RUBBERLIP SEAPERCH	*Rhacochilus toxotes*	44	631
CALICO SURFPERCH	*Amphistichus koelzi*	45	621
REDTAIL SURFPERCH	*Amphistichus rhodoterus*	46	622
PILE PERCH	*Damalichthys vacca*	47	515
BARRED SURFPERCH	*Amphistichus argenteus*	48	620
BLACK PERCH	*Embiotoca jacksoni*	49	624
DWARF PERCH	*Micrometrus minimus*	50	629
SACRAMENTO PERCH	*Archoplites interruptus*	51	616
BLUEGILL	*Lepomis macrochirus*	52	008
GREEN SUNFISH	*Lepomis cyanellus*	53	025
WARMOUTH	*Lepomis gulosus*	54	056
LARGEMOUTH BASS	*Micropterus salmoides*	55	031
BROADNOSE SEVENGILL SHARK	*Notorynchus maculatus*	56	585
SPINY DOGFISH	*Squalus acanthias*	57	154
LEOPARD SHARK	*Triakis semifasciata*	58	587
BROWN SMOOTHHOUND	*Mustelus henlei*	59	586
CALIFORNIA SKATE	*Raja inorata*	60	589

COMMON NAME	SCIENTIFIC NAME	CODE	SMK
HITCH	*Lavinia exilicauda*	61	562
SACRAMENTO BLACKFISH	*Orthodon microlepidotus*	62	045
SACRAMENTO PIKEMINNOW	*Ptychocheilus grandis*	63	553
GOLDFISH	*Carassius auratus*	64	024
GOLDEN SHINER	*Notemigonus crysoleucas*	65	022
SACRAMENTO SUCKER	*Catostomus occidentalis*	66	554
GRAY SMOOTHHOUND	*Mustelus californica*	67	691
BLACK BULLHEAD	*Ameiurus melas*	68	004
BROWN BULLHEAD	*Ameiurus nebulosus*	69	010
WESTERN MOSQUITOFISH	*Gambusia affinis*	70	407
BAY PIPEFISH	*Syngnathus leptorhynchus*	71	579
BIGSCALE LOGPERCH	*Percina macrolepida*	72	580
PRICKLY SCULPIN	*Cottus asper*	73	555
BAY GOBY	*Lepidogobius lepidus*	74	647
CHEEKSPOT GOBY	*Ilypnus gilberti*	75	646
ARROW GOBY	*Clevelandia ios*	76	642
CALIFORNIA TONGUEFISH	*Symphurus atricauda*	77	671
CALIFORNIA HALIBUT	*Paralichthys californicus*	78	666
PACIFIC HALIBUT	*Hippoglossus stenolepis*	79	673
SPECKLED SANDDAB	*Citharichthys stigmaeus*	80	665
SAND SOLE	*Psettichthys melanostictus*	81	513
DIAMOND TURBOT	*Hypsopsetta guttulata*	82	668
ENGLISH SOLE	*Pleuronectes vetulus*	83	501
FLATFISH		84	
ROCK SOLE	*Lepidopsetta bilineata*	85	507
LINGCOD	*Ophiodon elongatus*	86	652
WOLF EEL	*Anarrhichthys ocellatus*	87	638
OSMERIDS		88	
SPOTFIN SURFPERCH	*Hyperprosopon anale*	89	625
WHITE SEAPERCH	*Phanerodon furcatus*	90	630
PACIFIC ELECTRIC RAY	*Torpedo californica*	91	588

COMMON NAME	SCIENTIFIC NAME	CODE	SMK
CHAMELEON GOBY	*Tridentiger trigonocephalus*	92	648
WAKASAGI	*Hypomesus nipponensis*	93	672
SMALLMOUTH BASS	*Micropterus dolomieu*	94	
SHIMOFURI GOBY	*Tridentiger bifasciatus*	95	
PACIFIC SARDINE	*Sardinops sagax*	96	
SHOKIHAZE GOBY	*Tridentiger barbatus*	97	
UNIDENTIFIED JELLYFISH	n/a	98	
WHITE SEA BASS	*Atractoscion nobilis*	99	
MOON JELLIES	*Aurelia spp.*	100	
MAEOTIAS	*Maeotias marginata*	101	
BLACKFORDIA	*Blackfordia virginica*	102	
SIBERIAN PRAWN	*Exopalaemon modestus*	103	
REDEAR SUNFISH	*Lepomis macrolophus*	104	
POLYORCHIS	*Polyorchis penicillatus*	105	
SCRIPPSIA PACIFICA	*Scrippsia pacifica*	106	
SEA GOOSEBERRY	*Pleurobrachia bachei*	107	
CALIFORNIA GRUNION	*Leuresthes tenuis*	108	
STRIPED BASS AGE3+	*Morone saxatilis*	109	
SILVER SURFPERCH	*Hyperprosopon ellipticum*	110	
AEQUOREA	*Aequorea spp.*	111	
RIFFLE SCULPIN	*Cottus gulosus*	112	
SPOTTED BASS	*Micropterus punctulatus*	113	
RAINWATER KILLIFISH	*Lucania parva*	114	
CHRYSAORA	*Chrysaora fuscensens*	115	
LIZARDFISH	*Synodus lucioceps*	116	
MISSISSIPPI GRASS SHRIMP	*Palaemontetes kadiakensis*	117	

Updated 01/06/2014

Appendix 8 – QC Procedures

QA/QC Queries for FMWT Implemented 11/28/06

Prepared By John Edward Budrick and Dave Contreras 12/27/2006

-Cross tabulation of water temperature, conductivity, sampling date and secchi across surveys and stations. Used to analyze whether trends in these variables respond in a reasonable pattern with regard to the proximity of sites and expected variation in results.
Required Tables: Sample
Selected Fields: SampleDate (ascending), SampleTimeStart (ascending), SurveyNumber - #, StationCode, and one of the following tables depending on query: WaterTemperature, Secchi, ConductivityTop , or ConductivityBottom.

_____ QC_Query_Water_Temp
_____ QC_Query_Secchi
_____ QC_Query_Top_EC
_____ QC_Query_Bottom_EC
_____ QC_Query_Sample_Date

After the query is developed, look at the variable in question to ensure there are no extreme value differences between stations.

-Query for low flow meter readings, flow meter readings that overlap between tows and inconsistent increases in flow meter reading with tow time. The column for Meter Difference is used to identify low flow meter readings that may be the result of either equipment malfunction or recording error in the field or key punch error in recoding the data in the database. Comparison of the Meter Out from one row to the Meter In from the row below allows a check on the consistency of increasing flow meter readings with progressive tows. If the Meter Out exceeds Meter In from the reading below by a great extent, this indicates that either there was an error in data recording or in key punch entry. If the flow meter readings increase suddenly between tows or are out of sequence, an inspection of the hard copy data is required.
Required Tables: Sample
Selected Fields: SampleDate (ascending), SampleTimeStart (ascending), SurveyNumber - #, StationCode, MeterStart, and MeterEnd
Calculated Field: FlowDiff: ([MeterEnd]-[MeterSTart]). This will calculate a flowmeter difference between the MeterStart and MeterEnd

_____ QC_Query_Flowmeter

-Query for plus count entries to ensure that plus counts have been entered. This query identifies the plus counts for a date, station and tow. By looking over the raw data sheets and comparing listed plus counts to from the query to the plus counts on the

datasheet, you can identify any plus counts that were not included in the MS Access database and enter them.
Required Tables: Sample, Catch, Length
Selected Fields: SampleDate (ascending), SampleTimeStart (ascending), SurveyNumber - #, StationCode, OrganismCode, Catch, Forklength – 0.

QC_Query_Plus_Count

After the query is developed, export the data into an excel spreadsheet for each survey. Check every written data sheet against the excel spreadsheet to ensure that all plus counts are represented and accurate.
-Query serial numbers for Striped Bass and Delta Smelt. This query identifies all serial numbers by date, station, and fork length. Comparison between the raw data sheets' serial number to the queried data sheet will identify any errors to the serial number itself or serial number's fish assignment. Errors will be identified and edited in the MS Access database.
Required Tables: Sample, Catch, Length, LengthSupplement
Selected Fields: SampleDate (ascending) > date, SampleTimeStart (ascending) – don't display, SurveyNumber - #, StationCode, OrganismCode - ##, SerialNo, ForkLength.

QA/QC Field Procedures for FMWT Implemented 2010

In 2010, a QC of field catch was implemented. Each survey day a random station was chosen to recount all fish, shrimp, and jellyfish. During the QC process, the deck, debris, and net is gone through from the cod end to the 1.5-in. mesh to check if any fish were missed. All fish caught are then recounted to see if any were missed. This data is recorded on a separate data sheet "Fall Midwater Trawl Survey QA/QC Data Sheet".

Fall Mid Water Trawl MS Access Database File Storage, Backup and Transfer Protocol

Introduction

The following are protocols for storage, backup and transfer of the Fall Mid Water Trawl Database from the FMWT biologist's C hard to backup on external hard drives and backup servers, and to make updated copies accessible on the ltm$ server. These protocols are to be followed in order to prevent inadvertent overwriting of up to date copies of the database with older versions that do not contain editorial changes or recent data.

Back Up of the FMWT database on the FMWT Biologists Personal Server

The working database is maintained on the U drive under the pathway of U:\LTM\FMWT\Database. After each survey the FMWT working database will be duplicated to the FMWT biologists personal computer, their I drive, and an external thumb drive.

Appendix 9 – Historical Survey Procedures

This appendix shows old protocol procedures that were removed or have been replaced. They are arranged under their retrospective subject heading.

Project Description and Study Objectives

Additional Sampling, 1998 to 2004

Age 1 and 2 striped bass stomach analysis

In order to satisfy the requirements of the Endangered Species Act (ESA) in regards to stocking yearling striped bass the FMWT was assigned the task of collecting stomachs from age 1 and 2 striped bass from all stations west of, and including, station 513 (Collinsville). This also requires taking a scale sample for age verification. Stomachs are returned to the DFG Adult Striped Bass Program for analysis. However, Young Fish Investigations is responsible for supplying tags and coin envelopes for this project. This program is expected to last until 2008.

Midwater Trawl Field Activities

Survey Day	Stations and Berthing
1	329, 335, 334, 328, 327, 315, 314, 308, 307, 306, 305, 309, 310, 311, 321, 322, 323, 326, 325, 336, 337, 339, 338 - Berth at Crockett
2	340, 401, 404, 403, 405, 406, 407, 408, 409 - Berth at Martinez
3	414, 415, 416, 417, 418, 603, 602, 604, 605, 606, 601, 515, 516, 517, 518, 519, 507, 505, 504, 503, 502, 501, 413, 412, 411, 410 - Berth at Martinez
4	508, 509, 510, 511, 512, 513, 608, 701, 802, 804, 806 - Berth at Antioch
5	703, 704, 705, 706, 707, 708, 709, 710, 711, 713, 715, 712, 717, 810, 809 - Berth at Antioch
6	811, 812, 813, 814, 815, 903, 904, 905, 908, 906, 909, 910, 911, 912, 902, 808, 807 - Berth at Antioch

New Schedule (1993)

1 305, 306, 307, 308, 309, 310, 311, 314, 315, 321, 322, 323, 325, 326, 327, 328, 329, 334, 335, 336, 337, 338, 339, 340, 341

2 401, 403, 404, 405, 406, 407, 408, 409, 410, 411, 412, 413, 504, 505, 507, 508

3 414, 415, 416, 417, 418, 601, 602, 603, 604, 605, 606, 501, 502, 503, 515, 516, 517, 518, 519

4 509, 510, 511, 512, 513, 608, 701, 802, 804, 806 807, 808, 809, 810, 811, 812, 813, 814

5 703, 704, 705, 706, 707, 708, 709, 710, 711

6 815, 902, 903, 904, 905, 906, 908, 909, 910, 911, 912, 913, 914, 915

7 712, 713, 715, 716, 717, 70, 72, 725, 73, 735, 74

8 919, 920, 921, 922, 923

Sampling Schedule, Fall, 1998 to 2004

1 329, 335, 334, 328, 327, 315, 314, 308, 307, 306, 305, 309, 311, 310, 321, 322, 323, 326, 325, 336, 337, 339, 341, 340, 338

2 401, 404, 403, 405, 406, 407, 408, 409, 410, 411, 412, 413, 501, 502, 503, 504, 505, 507, 508, 509, 510, 511, 512, 513

3 414, 415, 416, 417, 418, 603, 602, 604, 605, 606, 601, 515, 516, 517, 518, 519, 608, 701, 802, 804, 806

4 807, 808, 809, 810, 811, 812, 813, 814, 815, 904, 905, 906, 909, 910 911, 912

5 902, 915, 914, 913, 908, 919, 920, 921, 922, 923, 903

6 703, 704, 705, 706, 707, 708, 709, 710, 711, 713, 715, 716

7 717, 72, 725, 73, 735, 74, 712

8 SPARE DAY

Sampling Schedule, 2004 to the 2008

1 329, 335, 334, 328, 327, 315, 314, 308, 307, 306, 305, 309, 311, 310, 321, 322, 323, 326, 325, 336, 337, 339, 341, 340, 338

2 401, 404, 403, 405, 406, 407, 408, 409, 410, 411, 412, 413, 501, 502, 503, 504, 505, 507, 508, 509, 510, 511, 512, 513

3 414, 415, 416, 417, 418, 603, 602, 604, 605, 606, 601, 515, 516, 517, 518, 519, 608, 701, 802, 804, 806

4 807, 808, 809, 810, 811, 812, 813, 814, 815, 904, 905, 906, 909, 910 911, 912

5 902, 915, 914, 913, 908, 919, 920, 921, 922, 923, 903

6 703, 704, 705, 706, 707, 708, 709, 710, 711, 713, 715, 716

7 717, 72, 724, 73, 735, 736, 712

8 SPARE DAY

Description of Study Activities

Additional Supplies, 1998 to 2004

Tags (the tag for the stomach and the coin envelope for the scale sample) must be serialized before the survey begins. This is to ensure that each fish which had its stomach removed can uniquely be identified. Currently, tags are serialized at the beginning of the Fall Midwater Trawl Survey (August through December) and continued through the Spring Midwater Trawl Survey (January through March). Include size 6 whirl packs to contain the stomachs. An ice chest must also be included as the labs cannot process stomachs preserved in formalin. Keep the cooler at lest half full of ice (not liquid water) and replenish the ice as needed. After sampling west of, and including station 513 (Collinsville) and all 600 stations return the stomachs, scale samples, and stomach sampling equipment to Stockton.

Additional Crew Requirements, 1998 to the 2004

An additional technician/scientific aid may be required to remove stomachs from

age 1 and 2 year old striped bass.

In Situ Instrumentation

A LORAN is used to program station location. Electrical Conductivity (EC) samples were returned to the lab for processing until the Spring 1995 FMWT when a YSI 30 field EC meter was bought for the project. In 1995 the FMWT started to take EC readings from the bottom at selected stations. This required the use of a suitable sampling device. Currently a Van Dorn Bottle is used to retrieve the sample from the bottom.

Boat Description

The *Alosa*, a 32 foot shallow draft style gill netter, has been used for sampling since 1967. The boat is rigged with an A-Frame and a heavy duty winch for retrieving the 200 ft. of cable used. Prior to 1995, the winches used were Model m310CDEE winches made by Braden Winch Co. Broken Arrow, Oklahoma 74102. In August 1995, two anchor winches from Kinematics, Inc. Redmond, Washington were put on the *Alosa*, one on each gunwale near the boat house. The winch cables run through blocks mounted on aluminum davits over hanging the water. In September 1997, the *Alosa* was found unfit for duty and the *Scrutiny* was borrowed from DWR to run the survey.

A Kenyon boat speedometer was used in the 1970's to determine boat speed but became inoperable in 1983. It measured water going past the hull in feet/second. Since 1985, the LORAN on the *Alosa* is used to measure boat speed while fishing the net but unlike the Kenyon speedometer the LORAN measures speed relative to the ground covered. The units for this measure need to be ascertained. As of November 1997 this portion of the data base has not been rationalized and finalized. However, the LORAN

was broken from 1994 to 1995 and no boat speed could be recorded for those years.

Towing Procedures

Procedures, 1967-1994 - With the old winches, the two deckhands lifted the hydrofoils and depressors and when the net has cleared the deck the depressors are dropped straight down into the water and hydrofoils are thrown out to the side. The boat operator communicated the station depth to the winch operator either before the net is put overboard or as the winch operator began to release the cable to fish the net. Deckhand No. 1, operated the winch to let out sufficient cable length for the water depth at the station. Deckhand No. 2 detached the cables from the clips holding them to the A-frame. The winch operator controlled the amount and speed of the cable warp released by using the brake. Care was taken to keep the cable taut enough so that the gear did not dive and dig into the bottom but not so taut that it did not dive at all. After the correct warp was released, the clutch was engaged, brake released and the stop watch set operator started the stop watch which was set at eight minutes.

Net Retrieval and Physical Measurements

The deckhand now scoops a bucket of surface water, from which an EC sample is taken and temperature is measured. Care should be taken to get an unbiased temperature measurement. If there is a metal jacket surrounding the thermometer to hold a water sample and it is hot from exposure to the sun, it should be cooled before the water sample is taken and temperature read. If a pocket thermometer is used it must remain in the water until the temperature is read. In 1995, temperature and EC are measured with a YSI 30 hand held conductivity meter. Water collected from the surface is measured in a bucket by deckhand #2 while a bottom sample is collected by deckhand #1 using a Van

Dorn. Bottom EC will only be taken in 1995.

After 50 feet of cable are retrieved the deckhand attaches the cables to the clip on the A-frame.

Electrical Conductivity (EC) Readings, 1998 to 2004

Bottom EC readings are taken as part of the normal environmental data collected at certain stations. Take top (surface) and bottom EC readings up to and including station 705 on the Sacramento River and station 806 on the San Joaquin River. At these stations use the following formula:

$$\%\ \text{difference, EC} = \frac{(\text{bottom reading} - \text{top reading}) \times 100}{\text{top reading}}$$

If the %difference, EC is less than 10% of the top reading take only top EC readings as you proceed upriver. If the %difference, EC is greater than 10% of the top reading continue to take top and bottom EC readings until the %difference, EC is less than 10% of the top EC reading. Continue this process independently for each river i.e., up the Sacramento River (stations upstream of 705) and up the San Joaquin River (upstream and in Delta of station 806). Temperature readings are taken for only the top sample. Ensure that the YSI 30 is in specific conductance (conductivity corrected to 25 degrees Celsius) by have the degrees Celsius indicator flashing (YSI 30 Manual, pages 6-7).

Processing the Sample

Procedures, 1967-1994

Until the fall 1995, fish were processed as described. After the tow is completed, the winch operator sorts out all fish from water and debris and places them on the measuring board. All fish are identified to the lowest possible taxon, measured to the

nearest mm F.L. and the data recorded by the deckhand on the Striped Bass Trawl Survey field form (Appendix 4). All bass are measured and lengths are tallied on the form. Samples of striped bass scales are occasionally taken for aging when the length indicates that the striped bass could be either a young-of-the-year or one year old, or one year old or two years old, or two years old or three years old (See Appendix 6 for length ranges). Scales are taken from the side of the fish between the lateral line and the first dorsal fin. The area is scraped or wiped to remove the fish slime then the scales are removed by scraping or plucking. Only six to eight scales need to be taken since reading the age usually requires only three good scales.

Only 6 to 15 lengths for each of the other species can be recorded because of the limited space. However, the number of fish caught in excess of those measured is added to the number measured and that number is recorded as the catch. Beginning in 1991, all delta smelt and longfin smelt are measured.

Since 1976 other species have been measured whenever possible but the length data were not keypunched until the current data form, first used in 1986, provided a better format for key entry of the data. For the fall 1995 MWT, the data sheet was revised to leave space for recording additional fish lengths.

Identification materials are provided in the field notebook (Appendix 7) as well as in CDFG Bulletin No. 157.

Removing Striped Bass Stomachs - 1998 to 2004

Complete the processing of the catch and the bagging of delta smelt and other samples first and then start to remove stomachs from age 1 and 2 striped bass. If the catch is easily manageable remove stomachs concurrent with processing the catch;

otherwise wait until the catch is processed or have an extra crew member embarked to remove the stomachs.

Collect as many stomachs as possible. Get stomachs from all age 2 fish and randomly subsample age 1 fish if necessary. If stations are closely located together and several bass are caught at each station, take stomachs every other station.

Observe the following precautions when removing stomachs. Be careful not to cut or stab yourself with the scissors, and keep an eye out for swallowed hooks. Striped bass have sharp spines which can cause painful injuries. If the weather is too rough to safely cut with the scissors forego taking stomachs at that station.

The "cutting kit" should include the following: a tackle box to hold supplies, surgical scissors, tags, and non-perforated whirl packs. The tags are serially numbered and have two parts: a tag for the stomach (the stomach tag) and a coin envelope for the scale sample that will be used for age estimation. The stomach tag and the scale envelope should both have the following information recorded on them when the stomach is removed: date, station, and fork length. The stomach tag has a "1" and a "2" that is circled to indicate the fish's age as keyed out on the boat. Remember; one fish, one serial number.

Below is a recommended procedure for removing the stomach. Measure and age the fish according to Appendix 7. Kill the fish by striking it hard on the dorsal surface just posterior to the head. Insert one blade of the scissors into the body cavity through the vent. Begin cutting anteriorly keeping the scissors close to the ventral surface of the fish as to avoid cutting the viscera. Cut anteriorly to the ismuthus and through the pelvic girdle. Insert your thumbs into the incision just posterior to the gill covers and pull open

the body cavity. The stomach will appear as a whitish or cream colored muscular tube with the liver (tan to brown in color) and the gall bladder (a small light green grape-like organ) attached to it. Locate the esophagus and cut it just posterior to the gill arches. If you have difficulty locating this point, stick your finger down the fish's esophagus (striped bass have no cutting or chewing teeth). It is important to cut the esophagus and not the stomach; this will help food items from falling out or inadvertently cutting food items. Cut the membrane that holds the stomach and other organs to the dorsal wall of the body cavity and cradle the stomach and other organs out of the body cavity. Cut the intestine and separate the following organs from the stomach; the liver, the gall bladder, and the spleen. The liver and gall bladder can be removed by cutting or pinching them off. The spleen (bright to dark red in color) is easily removed when the intestine is cut away. Fat and pyloric caeca need not be removed. Place the stomach and its associated tag in a whirl pack and put it in the ice chest; do not use formalin! If some food items do fall out of the stomach place them in the whirl pack with the stomach/tag. Take a scale sample as described above and place the numbered scale envelope in a safe, dry place. Remember, scale envelopes are not water proof and are best handled with dry hands. Return the stomachs and scale samples as soon as possible to the Fish and Game office in Stockton. Return the scale samples to the biologist in charge of the Midwater Trawl Survey. Maintain the stomachs, with their associated tags, in their whirl packs and place the whirl packs into large plastic bags. Label each large plastic bag "MWT AGE 1 AND 2 SB STOMACHS" and record the following information on the outside of each large plastic bag: month, year, number of whirl packs in the large plastic bag. Number the large plastic bags as "1 of 3", etc and place them in a designated freezer.

Laboratory Procedures

Laboratory Processing of Electrical Conductance (EC) Samples

Prior to 1995, the same procedures are followed here as described on page 54 for the striped bass egg and larva survey (Part I). Following the processing of samples the corrected EC values are recorded on the field forms for each station. EC bottles are stored in the warehouse when not in use.

Before each survey, the YSI 30 field meter probe should be cleaned by dipping it in Dow Chemical Bathroom cleaner for two to three minutes. The probe should be scrubbed with a small test tube brush to dislodge any contaminants and thoroughly rinsed in distilled water. Calibration is rarely needed even after battery changes, but if it does become necessary details of calibration are described on pages 9-10 of the YSI 30 meter manual.

From Appendix 6

SCALE SAMPLING SCHEDULE, 1997 REVISION.

Scale samples for aging are taken from striped bass which meet the following size criteria based on the 1964 age-length key the actual 1964 key is presented else where in this protocol:

Month	**Size**	**Month**	**Size**
Aug	90-130 220-260	Jan	130-170 270-310
Sept	110-150 240-280	Feb	130-170 270-310
Oct	130-170 240-290	Mar	150-290 270-310
Nov	130-170 260-300	April	150-290 280-320
Dec	130-170 270-310		

Appendix 10 – 1976 Indices Memo

State of California
Department of Fish and Game

M e m o r a n d u m

Date: November 10, 2011

To: File
Fall Midwater Trawl Study
Department of Fish and Game

From: Dave Contreras, Randall Baxter, and Steven Slater
Fisheries Biologists
Department of Fish and Game

Subject: Fall Midwater Trawl 1976 Fish Abundance Indices Investigation

In 1976, the Fall Midwater Trawl (FMWT) September and December surveys were not conducted due to boat problems and prevented the traditional calculation of an annual index for six species: age-0 Striped Bass (*Morone saxatilis*), Delta Smelt (*Hypomesus transpacificus*), Longfin Smelt (*Spirinchus thaleichthys*), American Shad (*Alosa sapidissima*), Splittail (*Pogonichthys macrolepidotus*), and Threadfin Shad (*Dorosoma petenense*). The FMWT annual abundance indices are calculated as the sum of the September through December (Sep-Dec) monthly indices. In the absence of September and December sampling data, previous FMWT biologists derived monthly indices based on inter-month relationships and monthly indices available for October and November 1976, and January 1977. These derived monthly indices contributed to the 1976 annual indices reported in the IEP Newsletter Status and Trend's articles until 2006 as well as and other published works. In about 2006, biologists working in the Young Fish Investigations Unit, of which FMWT is part, became skeptical of the validity of the 1976 index calculation, and removed them. In retrospect, further investigation was warranted. The purpose of this document is to present the methods and rational used to derive the 1976 September and December monthly and annual indices for six FMWT fish species.

The 1976 September fish abundance indices were calculated for each species by getting a catch ratio for September and October indices (September / October) for pre-*Corbula amurensis* years 1967-1973, 1975, 1977-1978, 1980-1987. This catch ratio were averaged for the aforementioned years and multiplied by the 1976 October index to generate the 1976 September index (Table 1). The 1976 December index was calculated for each species by averaging the 1976 November and 1977 January

indices (Table 1).

To investigate the validity the annual index we calculated in part from derived monthly indices, least squares linear regressions were conducted for each species. The summed Oct-Nov indices were used as the independent variable and the annual indices were used as the dependent variable for pre-*C.amurensis* years (<1988; n=18). The derived 1976 annual index for each species was then plotted on its respective regression to see if it fell within the upper and lower 95% confidence intervals (Figures 1-6).

The relationship between the summed Oct-Nov indices and the annual indices was significant ($P<0.001$) for each of the six fish species, with 69 to 98% of the variance in the dependent variable explained by the independent variable, depending on the species (Figures 1-6).

The results support how the 1976 indices were derived and add confidence that they will not cause erroneous variation to other abundance relationships. We conclude that the 1976 annual index for each species should be included in the reporting of FMWT abundance indices. The 1976 annual index was reintroduced during the 2011 status and trends report and updated on the web.

References

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cc: DFG
Marty Gingras, Supervising Biologist

Table 1. Fall Midwater Trawl 1976 Sep:Oct index quotient, monthly, and annual indices. September and December indices (*) were calculated from other indices as described in text rather than from catch data; October, November and January indices were calculated from catch data.

		Monthly indices					Annual index
	Sep:Oct	Sep*	Oct	Nov	Dec*	Jan	Sep-Dec
Age-0 striped bass	2.044	239	117	243	821	1399	1420
Delta smelt	1.648	69	42	121	127	133	359
Longfin smelt	1.234	15	12	90	541	992	658
American shad	1.377	95	69	102	80	58	346
Splittail	1.920	0	0	1	1	0	2
Threadfin shad	3.765	1585	421	323	628	933	2957

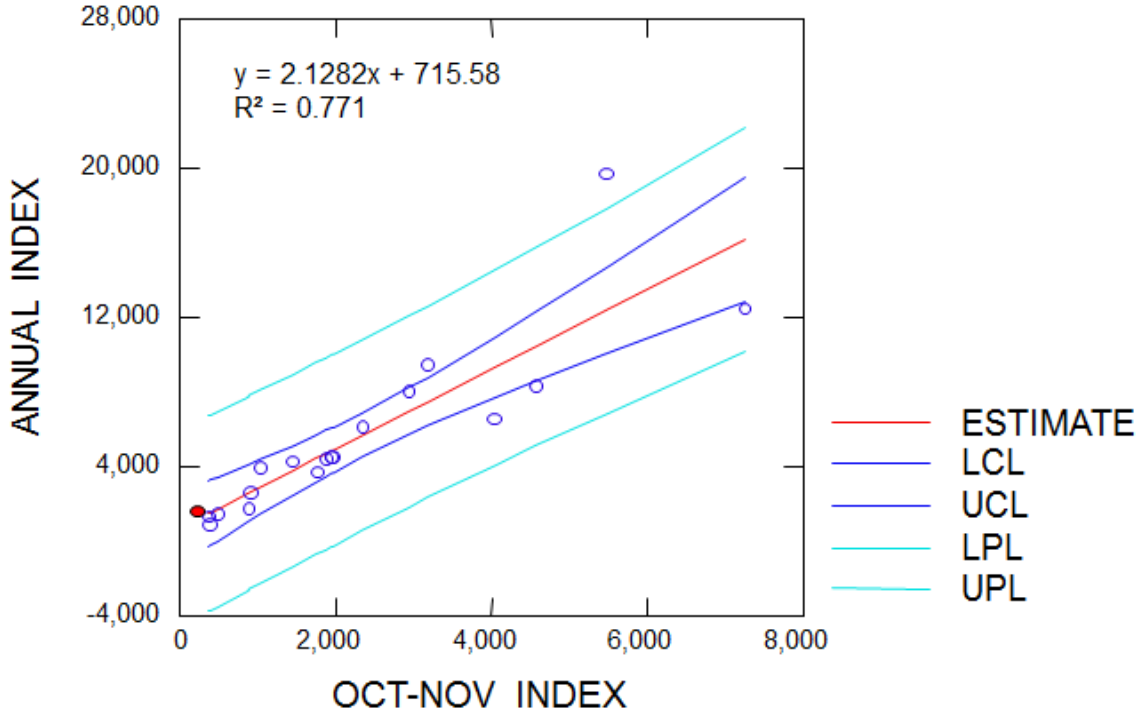


Figure 1. Fall Midwater Trawl age-0 Striped Bass summed October and November (Oct-Nov) and annual index relationship with upper and lower 95% confidence and prediction limits. Red dot represents the estimated 1976 annual index.

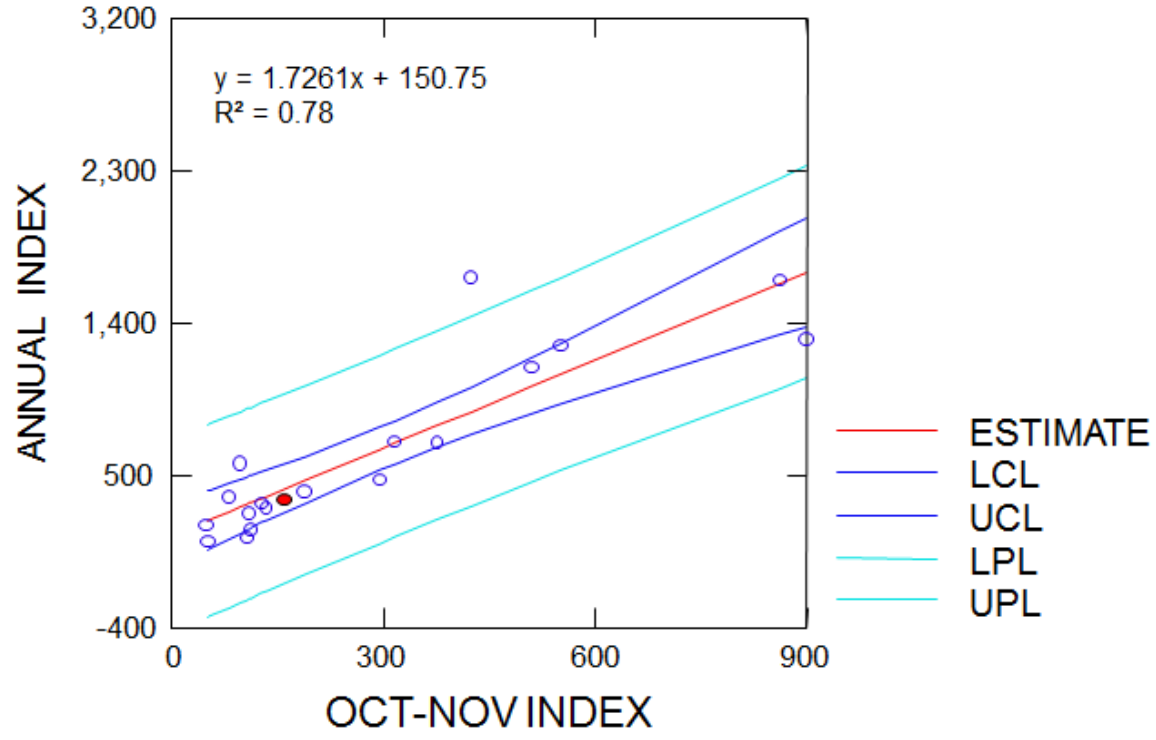


Figure 2. Fall Midwater Trawl Delta Smelt summed October and November (Oct-Nov) and annual index relationship with upper and lower 95% confidence and prediction limits. Red dot represents the estimated 1976 annual index.

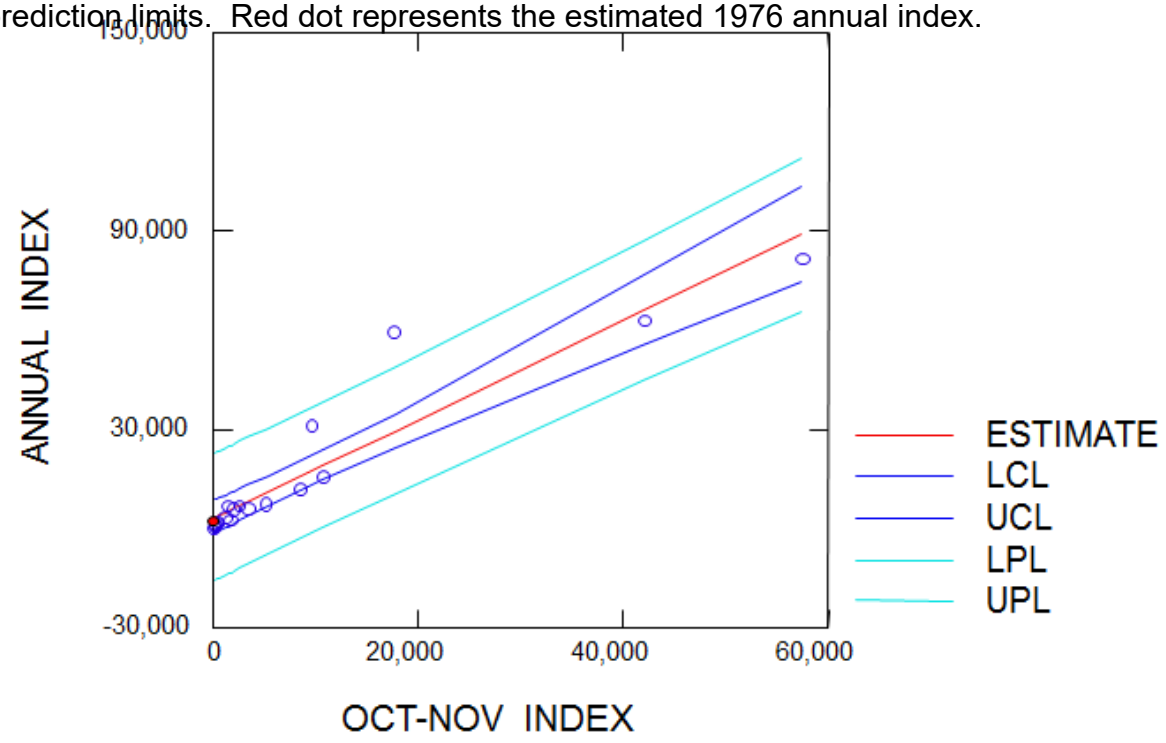
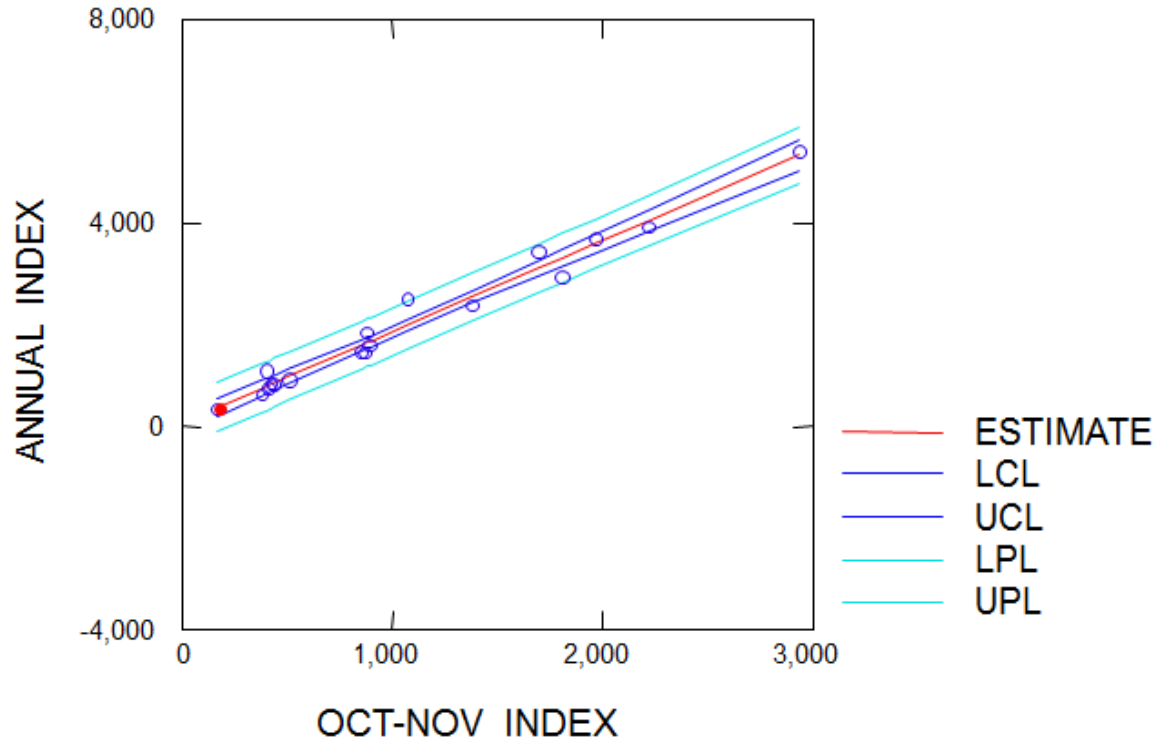


Figure 3. Fall Midwater Trawl Longfin Smelt summed October and November (Oct-Nov) and annual index relationship with upper and lower 95% confidence and prediction limits. Red dot represents the estimated 1976 annual index.



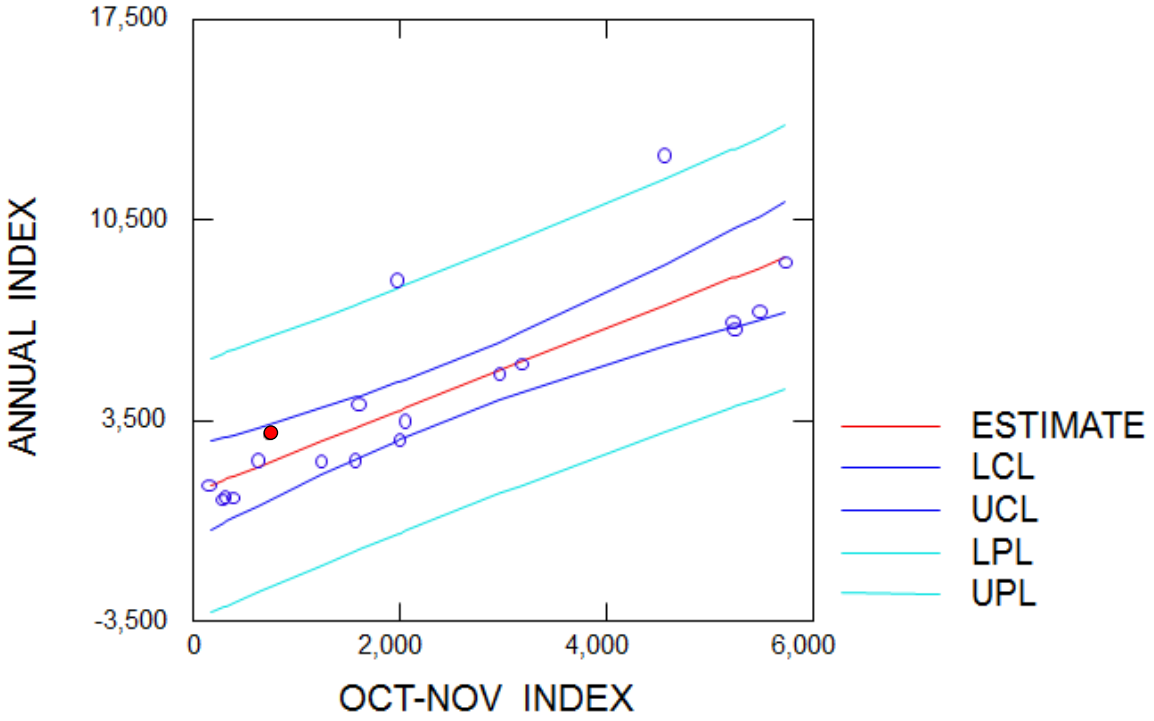


Figure 5. Fall Midwater Trawl Threadfin Shad summed October and November (Oct-Nov) and annual index relationship with upper and lower 95% confidence and prediction limits. Red dot represents the estimated 1976 annual index.

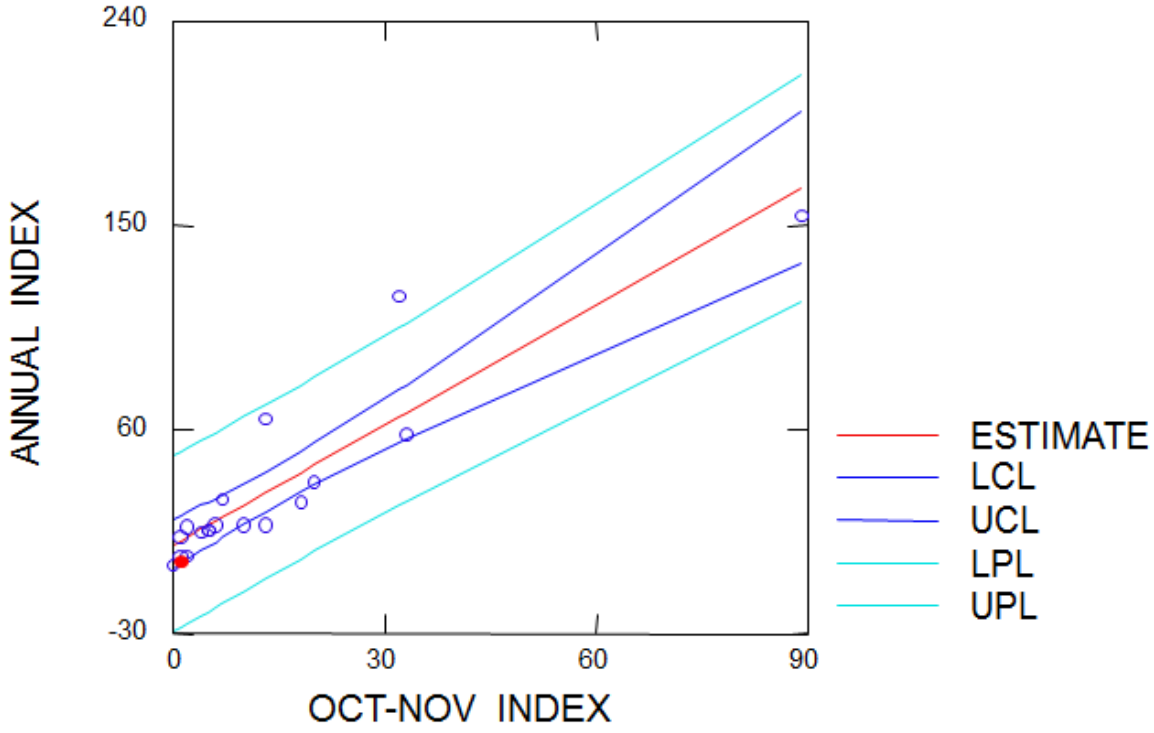


Figure 6. Fall Midwater Trawl Splittail summed October and November (Oct-Nov) and annual index relationship with upper and lower 95% confidence and prediction limits. Red dot represents the estimated 1976 annual index.

Appendix 11 – Area Volumes and Weight Factors

Area Volumes and Weight Factors, and Area and Station Lists Used for Fall Midwater Trawl Monthly and Annual Index Calculations

Created March 10, 2010

History

Biologist Jerry Turner established the Fall Midwater Trawl sampling stations in 1967, using area volumes from the Department of Water Resources (Table 1), elected for 1 station per 10,000 acre feet of water upstream of the Martinez Bridge (station ≥409) and 1 station per 100,000 acre feet of water downstream of the Martinez Bridge (station ≤408). Prior to beginning the 1970 survey, stations were added and a change was made so that roughly 1 station per 20,000 acre feet of water was sampled downstream of Martinez Bridge (station ≤408).

Table 1. Original Fall Midwater Trawl area list, station composition and weight factors.

Area	Historic stations (# of stations)	Area volume (acre feet)	Area weight factor (volume x 10^{-4})
1	336-339 (4)	81,000	8.1
2	320 (1)	28,000	2.8
3	321-326 (6)	113,000	11.3
4	327-329 (3)	65,000	6.5
5	330-335 (6)	122,000	12.2
6	317-319 (3)	59,000	5.9
7	312-316 (5)	102,000	10.2
8	303-311 (9)	185,000	18.5
9	301-302 (2)	30,000	30.0
10	340 (1)	48,000	4.8
11	401-408 (8)	160,000	16.0
12	409-419 (11)	140,000	14.0
13	501-520 (20)	180,000	18.0
14	601-608 (8)	50,000	5.0
15	701-711 (11)	120,000	12.0
16	801-815 (15)	140,000	14.0
17	901-919 (19)	200,000	20.0

The earliest literature mention of the FMWT abundance index calculation methods was Stevens (1977), but the first mention of the source of the area weight factors was reported in Stevens and Miller (1983; pg 428):

> "Monthly abundance indices were calculated for each species by: (1) dividing the survey area into 17 regions; (2) multiplying the mean catch of each species at the stations within each region by the water volume estimated by the California Department of Water Resources to be in each region; and (3) summing those products."

The Department of Water Resources (DWR) has provided area volume estimates to the Department of Fish and Game (DFG) for other sampling programs including the Summer Townet Survey (Chadwick 1964). Area volume estimates for the Summer Townet Survey remain in use.

From inception in 1967 through at least the mid-1970s changes in the FMWT areas and stations sampled were made based on evolving knowledge of the distribution of age-0 striped bass and the need to sample that distribution. The changes made were deemed appropriate for age-0 striped bass.

Sampling and Data Adjustments

Changes have occurred over time to the lists of areas and stations used to calculate the survey and annual indices (Table 2). The areas in current use have been used to calculate abundance indices since the survey began in 1967. The number of stations within each area has varied through time. The "index stations" listed in Table 2 are used to calculate monthly and annual abundance indices; those in parentheses are no longer sampled, but must be used to properly calculate historical indices.

Areas 2, 6, and 9, and the stations within each, are not used in index calculation. The stations in areas 2, 6, and 9 have not been routinely sampled since 1973 with the exception of a few high outflow years.

Table 2. Area and station lists for abundance index calculations, 1967-present. Areas 2, 6, and 9 are not used in index calculation. Stations no longer sampled, but are needed for index calculation, are listed in parentheses. Stations dropped from the sampling list are identified in text following this table.

Area 1 = 336, 337, 338, 339
Area 3 = 321, 322, 323, 325 326 (324 not currently sampled)
Area 4 = 327, 328, 329
Area 5 = 334, 335 (330, 331, 332, 333 not currently sampled)
Area 7 = 314, 315 (312, 313, 316 not sampled)
Area 8 = 305, 306, 307, 308, 309, 310, 311 (303 not currently sampled)
Area 10 = 340
Area 11 = 401, 403, 404, 405, 406, 407, 408 (402 not currently sampled)
Area 12 = 409, 410, 411, 412, 413, 414, 415, 416, 417, 418
Area 13 = 501, 502, 503, 504, 505, 507, 508, 509 510, 511, 512, 513, 515, 516 517, 518, 519 (506, 514 not currently sampled)
Area 14 = 601 , 602, 603, 604, 605, 606, 608 (607 not currently sampled)
Area 15 = 701, 703, 704, 705, 706, 707, 708, 709, 710, 711 (702 not currently sampled)
Area 16 = 802, 804, 806, 807, 808, 809, 810, 811, 812, 813, 814, 815
Area 17 = 902, 903, 904, 905, 906, 908, 909, 910, 911, 912, 913, 914, 915 (901, 907 not currently sampled)

The number of stations sampled increased sharply after 1969 for areas 1, 4, 5, 7, 10 and 11 (San Pablo Bay and Napa River) and decreased for areas 12 through 17 (Suisun Bay and Delta; Table 3 at end of this Appendix).

Stations 419, 712, 713, 714, 715, 918 and 919 were dropped from the calculations of the abundance indices in June, 1994 because they were infrequently sampled to that point in the survey.

Index Calculations

Caveats to index calculations

a) NOVEMBER 1969: Only 15 stations used in the index calculation were sampled during November 1969. Therefore, the November 1969 index is the average of the October and December 1969 index.
b) SEPTEMBER and DECEMBER 1976: No survey was conducted during the months of September and December in 1976, therefore no index was calculated for 1976.
c) Sampling was not conducted in 1974 and 1979.

Index calculation steps

During Fall Midwater Trawl survey sampling, a single oblique midwater tow is conducted at each station. The abundance index is calculated using the following procedures:

a) Catch per tow is averaged for stations within each area (currently there are 14 areas).

b) Each mean catch per tow is multiplied by a corresponding weight factor (a scalar developed from the water volume, see Table 1) for that area.

c) The products of mean catch per tow and the weight factor for each area are summed for each monthly survey to produce monthly indices (rounded to the nearest whole number).

d) The monthly indices (September - December) for each year are summed to generate the annual index.

The FMWT survey historically and currently uses catch per tow (syn. trawl) as its standard unit of effort for index calculation. The monthly and annual abundance indices are the sums of the products of fish counts (i.e., fish per tow) and water volumes (i.e., weight factors) with units of fish per tow * acre feet (10^{-4}), which are not reported because of their limited interpretive value (see critical review of index methods and calculation in Newman 2008).

Historically no measure was taken of the distance traveled by the trawl during each tow (see next paragraph). Without a measure of tow distance and an estimate of net-mouth area, no estimate of the water volume sampled or fish density can be calculated.

Estimates of fish density provide the basis for developing a measure of fish population size. Other information, such as size selectivity of the gear, is also needed (see Newman 2008).

Beginning in 1985 field crews consistently set and retrieved flowmeters coincident with the start and end of each tow to measure the approximate distance traveled through the water, which along with an estimate of the mouth area of the trawl, can be used to calculate volume filtered by the trawl. Volumes filtered can be used to generate a measure of density or catch-per-unit-effort (CPUE) for each trawl:

CPUE: (([Total species catch]/[Volume filtered])*10,000) or catch per cubic hectare

The FMWT sampling methodology employed from 1967 through 1984 allows for the determination of relative abundance and distribution of fish, but not density. Beginning in 1985 the use of flowmeters to measure trawl travel through the water and an estimate of net mouth area at 10.7 m^2 have been used to calculate fish densities. Although Herbold (1996) observed that FMWT data had not been used to generate a population estimate and argued that this was because several putative population model assumptions (random sampling, independent samples, equal distribution of organisms within strata) were violated, more recently FMWT data have been used to develop initial estimates of delta smelt population size with numerous caveats (Newman 2008).

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	Area 1				Area 3						Area 4			Area 5						Area 7					Area 8							
Year	336	337	338	339	321	322	323	324	325	326	327	328	329	330	331	332	333	334	335	312	313	314	315	316	303	305	306	307	308	309	310	311
1967			4		4		4	4				3														4						
1968			4		4		4	4				4										4				4						
1969			4		4		4	4	1			3	4			4		4			4	4		4		4						1
1970	2	4	4		4	4	4	4	2	3	3	4	4	4	4	4	4	4	3	2	2	4	4	1	2	4	2	2	3	3	2	2
1971	4	4	4	4	3	4	4	4	4	4	4	4	4	4	4	3	4	4	4		1	3	4	3	4	4	3	3	3	4	4	3
1972	4	2	4	1	4	4	4	4	4	4	2	2	4	3	3	1	4	2	3			3	2	3	3	3	2		3	2	4	
1973	4	3	4	3	4	4	4	4	4			4	4						4						2	3	3	3	3	3	3	3
1975	4	4	4	4	3	3	4	4	4			4	4						4						2	3	3	3	3	3	3	3
1976	2	2	2	2	2	2	2	2	2		2	1	2				1	2	2										1	1	2	2
1977	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	1		4	4	3	3	4	2	3	3	4	4	3
1978	3	4	4	2	4	4	3	4	4	4	3	3	4	3	3	2	4	2	4		2	4	3	3	4	4	3	4	3	4	3	4
1980	2	3	4		4	4	4		4	4	4	4	4						4			4	4			4	2	4	4	4	4	2
1981	3	4	4	2	4	4	4		4	4	3	3	4						3			4	3			3	3	4	2	3	3	2
1982	4	4	4	3	4	4	3		4	4	4	4	4						4			3	4			3	4	4	4	4	1	4
1983	4	4	4	4	4	4	4		4	4	4	4	4	1	1	1	1	4	4	1	1	4	4	1		4	4	4	4	4	4	3
1984	4	4	4	4	4	4	4		4	4	4	4	4	2	2	2	2	4	4	1	1	4	4	2		3	3	4	4	4	3	4
1985	4	4	4	4	4	4	4		4	4	4	4	4					4	4			4	4			4	4	4	4	4	4	4
1986	4	4	4	4	4	4	4		4	4	4	4	4					4	4			4	4			4	4	4	4	4	2	4
1987	4	4	4	4	4	4	4		4	4	4	4	4					4	4			4	4			4	4	4	4	4	4	4
1988	4	4	4	4	4	4	4		4	4	4	4	4					4	4			4	4			4	4	4	4	4	3	4
1989	4	4	4	4	3	4	4		4	4	3	4	4					4	4			3	3			4	4	4	4	4	4	4
1990	4	4	4	4	4	4	4		4	4	4	4	3					4	4			4	4			4	4	4	3	4	4	4
1991	4	4	4	4	4	4	4		4	4	4	4	4					4	4			4	4			4	4	4	4	4	4	4
1992	4	4	3	4	3	4	4		4	4	4	4	4					4	4			4	4			3	3	4	3	3	3	4
1993	4	4	4	4	4	4	4		4	4	4	4	4					4	4			4	4			4	4	4	4	4	4	4
1994	4	4	4	4	4	4	4		4	4	3	4	4					4	4			4	4			4	4	4	4	4	4	4
1995	4	4	4	4	4	4	4		4	4	4	4	4	4	4	4	4	4	4			4	4			4	4	4	4	4	4	4
1996	4	4	4	4	4	4	4		4	4	4	4	4	3	3	3	4	4	4	1		4	4			4	4	4	4	4	3	4
1997	4	4	4	4	4	4	4		4	4	4	4	4					4	4			4	4			4	4	4	4	4	4	4
1998	4	4	4	4	4	4	4		4	4	4	4	4					4	4			4	4			4	4	4	4	4	4	4
1999	4	4	4	4	4	4	4		4	4	4	4	4					4	4			4	4			4	4	4	4	4	4	4
2000	4	4	4	4	4	4	3		4	4	4	4	4					4	4			4	4			4	4	4	4	4	4	4
2001	4	4	4	4	4	4	4		4	4	4	4	4					4	4			4	4			4	4	4	4	4	4	4
2002	4	4	4	4	4	4	4		4	4	4	4	4					4	4			4	4			4	4	4	4	4	4	4
2003	4	4	4	4	4	4	4		4	4	4	4	4					4	4			4	4			4	4	4	4	4	4	4
2004	4	4	4	4	4	4	4		4	4	4	4	4					4	4			4	4			4	4	4	4	4	4	4
2005	4	4	4	4	4	4	4		4	4	4	4	4					4	4			4	4			4	4	4	4	4	4	4
2006	4	4	4	4	4	4	4		4	4	4	4	4					4	4			4	4			4	4	4	4	4	4	4
2007	4	4	4	4	4	4	4		4	4	4	4	4					4	4			4	4			4	4	4	4	4	4	4
2008	4	4	4	4	4	4	4		4	4	4	4	4					4	4			4	4			4	4	4	4	4	4	4
2009	4	4	4	4	4	4	4		4	4	4	4	4					4	4			4	4			4	4	4	4	4	4	4
2010	4	4	4	4	4	4	4		4	4	4	4	4					4	4			4	4			4	4	4	4	4	4	4
2011	4	4	4	4	4	4	4		4	4	4	4	4					4	4			4	4			4	4	4	4	4	4	4
2012	4	4	4	4	4	4	4		4	4	4	4	4					4	4			4	4			4	4	4	4	4	4	4
2013	4	4	4	4	4	4	4		4	4	4	4	4					4	4			4	4			4	4	4	4	4	4	4

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	Area 10	Area 11								Area 12										Area 13 (cont.)											
Year	340	401	402	403	404	405	406	407	408	409	410	411	412	413	414	415	416	417	418	501	502	503	504	505	506	507	508	509	510	511	512	513
1967	2					4				4	4	4	4	4	4	1	4	1	4	4	4	4	4	4	4	4	4	4	4	4	4	4
1968						4				4	4	4	4	4	4		4		4	4	4	4	4	4	4	4	4	4	4	4	4	4
1969	1					3				3	3	3	3	3	3		3		3	3	3	3	3	3	3	3	3	3	3	3	3	3
1970	4	4	4		4	4	4	4	2		4		4		4		4		4	4		4		4		4		4		4		4
1971	4	4	4		3	4	4	4	4		4		4		4		4		4	4		4		4		4		4		4		4
1972	4	4	4		4	4	4	4	2		4		4		4		4		4	4		3		4		4		4		4		4
1973	4	4	4		4	4	4	4		4	3	3	4	3	4	4	4	4	4	4	4	4	4	4	2	4	4	4	3	4	3	3
1975	4	4	3	1	4	4	4	4	2	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4		4	4	3	4	4	2	3
1976	2	2	2		2	2	2	2		2	2	2	2	2	2	2	2	2	2	2	2	2	2	2		2	2	2	2	1	2	1
1977	4	4	4		4	4	4	4		4	4	4	4	3	4	4	4	4	4	4	4	4	4	4		4	4	4	4	2	3	3
1978	4	4	3	1	4	3	4	4		4	4	4	4	3	4	3	4	3	4	4	4	4	4	4		4	3	4	2	4	2	3
1980	4	3		3	4	4	2	2	1	4	2	4	3	4	4	4	4	4	4	4	4	4	4	3		4	4	1	4	4	2	4
1981	4	4		4	4	4	3	4	3	4	4	4	4	4	4	4	4	4	4	4	4	4	3	4		4	4	3	4	4	2	4
1982	4	4		4	4	4	3	3	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4		4	4	4	4	4	4	4
1983	4	4		4	4	4	4	4	3	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4		4	3	4	4	4	2	3
1984	4	4		4	4	4	4	4		4	4	4	4	4	4	4	4	4	4	4	4	4	4	4		4	4	4	4	4	3	2
1985	4	4		4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4		4	4	4	4	3	3	4
1986	4	4		4	4	4	4	4	4	4	4	4	4	3	4	4	4	4	4	4	4	4	4	4		4	4	4	4	4	4	4
1987	4	4		4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	3	4		4	4	4	4	4	4	4
1988	4	4		4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	3		3	4	4	4	4	4	4
1989	4	4		4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4		4	4	4	4	4	4	4
1990	4	4		4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4		4	4	4	4	4	4	4
1991	4	4		4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4		4	4	4	4	4	4	4
1992	4	4		4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4		4	4	4	4	4	4	4
1993	4	4		4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4		4	4	4	4	4	4	4
1994	3	4		4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4		4	4	4	4	4	4	4
1995	4	4		4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4		4	4	4	4	4	4	4
1996	4	4		4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4		4	4	4	4	4	4	4
1997	4	4		4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4		4	4	4	4	4	4	4
1998	4	4		4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4		4	4	4	4	4	4	4
1999	4	4		4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4		4	4	4	4	4	4	4
2000	4	4		4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4		4	4	4	4	4	4	4
2001	4	4		4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4		4	4	4	4	4	4	4
2002	4	4		4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4		4	4	4	4	4	4	4
2003	4	4		4	4	4	4	4	4	4	4	4	3	4	4	4	4	4	4	4	4	4	4	4		4	4	4	4	4	4	4
2004	4	4		4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	3	4	4	4	4		4	4	4	4	4	4	4
2005	4	4		4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4		4	4	4	4	4	4	4
2006	4	4		4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4		4	4	4	4	4	4	4
2007	4	4		4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4		4	4	4	4	4	4	4
2008	4	4		4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4		4	4	4	4	4	4	4
2009	4	4		4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4		4	4	4	4	4	4	4
2010	4	4		4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4		4	4	4	4	4	4	4
2011	4	4		4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4		4	4	4	4	4	4	4
2012	4	4		4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4		4	4	4	4	4	4	4
2013	4	4		4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4		4	4	4	4	4	4	4

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	Area 13 (cont.)						Area 14								Area 15										
Year	514	515	516	517	518	519	601	602	603	604	605	606	607	608	701	702	703	704	705	706	707	708	709	710	711
1967	4	4	4	3	4	3	4	3	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	
1968	4	4	4	4	4	4	4	3	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	
1969	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	2	3	1	
1970		4	1	4		4		4		4		4		4	4		4		4		4		3		1
1971		4		4		4		4		4		4		4	4		4		4		4		4		1
1972		4		4		4		4		4		4		4	4		4		4		4		4		4
1973		4	3	3	4	4	3	4	4	4	4	4		4	4		4		4		4		3		3
1975		4	4	4	4	4	4	4	4	4	4	4		4	4		4		4		3		2		1
1976		2		2	2	2	2	2	2	2	2	2		2	2		2		2		2		2		2
1977		4	2	2	4	4	4	4	4	4	4	4		4	4	4	4	4	4	4	4	4	4	4	4
1978	1	4	4	3	4	4	4	4	4	4	4	4		4	3	4	4	4	4	4	4	4	4	4	4
1980		4	4	1	4	4	4	4	4	4	4	4		4	4		4	4	4	4	4	3	4	4	
1981		4	4	4	4	4	4		4	4	4	4		4	4		4	4	4	4	4	4	3	3	1
1982		4	4	4	4	4	4	3	4	4	4	4		4	4		4	4	4	4	4	4	4	4	2
1983		4	4	4	4	4	4	4	4	4	4	4		4	3		4	4	4	4	4	4	4	3	3
1984		4	4	4	4	4	4	4	4	4	4	4		4	4		4	4	4	4	4	4	4	4	1
1985		4	4	3	4	4	4	4	4	4	4	4		4	4		4	4	4	4	4	4	4	4	3
1986		4	4	4	4	4	4	4	4	4	4	4		4	4		4	4	4	4	4	4	4	4	3
1987		4	4	4	4	4	4	4	4	4	4	4		4	4		4	4	4	4	4	4	4	4	4
1988		4	4	4	4	4	4	4	4	4	4	4		4	3	1	4	4	4	4	4	4	4	4	3
1989		4	4	4	4	4	4	4	4	4	4	4		4	4		4	4	4	4	4	4	4	4	4
1990		4	4	4	4	4	4	4	4	4	4	4		4	4		4	4	4	4	4	4	4	4	4
1991		4	4	4	4	4	4	4	4	4	4	4		4	4		4	4	4	4	4	4	4	4	4
1992		4	4	4	4	4	4	4	4	4	4	4		4	4		4	4	4	4	4	4	4	4	4
1993		4	4	4	4	4	4	4	4	4	4	4		4	4		4	4	4	4	4	4	4	4	4
1994		4	4	4	4	4	3	3	4	4	4	4		4	4		4	4	4	4	4	4	4	4	4
1995		4	4	4	4	4	4	4	4	4	4	4		4	4		4	4	4	4	4	4	4	4	4
1996		4	4	4	4	4	4	4	4	4	4	4		4	4		4	4	4	4	4	4	4	4	4
1997		4	4	4	4	4	4	4	4	4	4	4		4	4		4	4	4	4	4	4	4	4	4
1998		4	4	4	4	4	4	4	4	4	4	4		4	4		4	4	4	4	4	4	4	4	4
1999		4	4	4	4	4	4	4	4	4	4	4		4	4		4	4	4	4	4	4	4	4	4
2000		4	4	4	4	4	4	4	4	4	4	4		4	4		4	4	4	4	4	4	4	4	4
2001		4	4	4	4	4	4	4	4	4	4	4		4	4		4	4	4	4	4	4	4	4	4
2002		4	4	4	4	4	4	4	4	4	4	4		4	4		4	4	4	4	4	4	4	4	4
2003		4	4	4	4	4	4	4	4	4	4	4		4	4		4	4	4	4	4	4	4	4	4
2004		4	4	4	4	4	4	4	4	4	4	4		4	4		4	4	4	4	4	4	4	4	4
2005		4	4	4	4	4	4	4	4	4	4	4		4	4		4	4	4	4	4	4	4	4	4
2006		4	4	4	4	4	4	4	4	4	4	4		4	4		4	4	4	4	4	4	4	4	4
2007		4	4	4	4	4	4	4	4	4	4	4		4	4		4	4	4	4	4	4	4	4	4
2008		4	4	4	4	4	4	4	4	4	4	4		4	4		4	4	4	4	4	4	4	4	4
2009		4	4	4	4	4	4	4	4	4	4	4		4	4		4	4	4	4	4	4	4	4	4
2010		4	4	4	4	4	4	4	4	4	4	4		4	4		4	4	4	4	4	4	4	4	4
2011		4	4	4	4	4	4	4	4	4	4	4		4	4		4	4	4	4	4	4	4	4	4
2012		4	4	4	4	4	4	4	4	4	4	4		4	4		4	4	4	4	4	4	4	4	4
2013		4	4	4	4	4	4	4	4	4	4	4		4	4		4	4	4	4	4	4	4	4	4

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	Area 16												Area 17													
Year	802	804	806	807	808	809	810	811	812	813	814	815	901	902	903	904	905	906	907	908	909	910	911	912	913	914	915
1967	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	
1968	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	3	3	3	1	3	3	3	3	3	3	3	1
1969	3	3	3	3	3	3	3	3	3	3	3	3	3	3	2	3	3	3	3	3	3	3	2	1	3	3	3
1970	4	4	4		4		4		4		4			4	4	4		4		4		4				4	4
1971	4	4	4		4		4		4		4			3	4	3		4		4		3		1		2	2
1972	4	4	4		4		4		4		4			4	4	4		4		4		3		2		3	1
1973	4	4	4		4		4	2	1		1			1	1	1		1		1		1		1		1	
1975	4	4	4	4	4	4	4	4	3	2	1			1	1	1		1		1		1		1		1	1
1976	2	2	2	2	2	2	2	2	2	2	2			1	1	2		2		1		2		1		1	1
1977	4	4	4	4	4	4	4	4	4	4	4			3	4	4		4		4	2	4	2	4			
1978	4	4	4	4	4	4	4	4	4	2	4				2	4		4		2	3	3	2	2			
1980	3	4	4	4	3	4	4		4		4				3	4	1	4		4	4	4	4	4			
1981	4	4	4	4	4	4	4		4		4			4	4	3	4	3		3	3	3	2	1			
1982	4	4	4	4	4	4	4	4	4	3	3			3	4	4	4	4		4	3	2	2	2			
1983	4	4	4	4	4	4	4	3	3	3	3	1	2	2	3	3	3	3		3	3	2	2	2			
1984	4	4	4	3	2	3	3	4	4	4	3		1	1	1	1	1	1		1	1	1	1	1			
1985	4	4	4	3	3	4	4	4	4	4	4			1	2	2	2	2		2	2	2	2	2			
1986	4	4	4	4	4	4	4	3	3	3	3			3	3	3	3	3		3	3	3	3	3			
1987	4	4	4	4	4	4	4	4	4	4	4	3		4	4	4	4	4		4	4	4	4	4			
1988	4	4	4	4	4	4	4	3	3	3	3	3		3	3	3	3	3		3	3	3	3	3			
1989	4	4	4	4	4	4	4	4	4	4	4	2		4	4	4	4	4		3	4	4	4	4			
1990	4	4	4	4	4	4	4	4	4	4	4	3		4	4	4	4	4		4	4	4	4	4			
1991	4	4	4	4	4	4	4	4	4	4	4	4		4	4	4	4	4		4	4	4	4	4	4	4	4
1992	4	4	4	4	4	4	4	4	4	4	4	4		4	3	4	4	4		4	4	4	4	4	4	4	4
1993	4	4	4	4	4	4	4	4	4	4	4	4		4	4	4	4	4		4	4	4	4	4	4	4	4
1994	4	4	4	4	4	4	4	4	4	4	4	4		4	4	4	4	4		4	4	4	4	4	4	4	4
1995	4	4	4	4	4	4	4	4	4	4	4	4		4	4	4	4	4		4	4	4	4	4	4	4	4
1996	4	4	3	4	4	4	4	4	4	4	4	4		4	4	4	4	4		4	4	4	4	4	4	4	4
1997	4	4	4	4	4	4	4	4	4	4	4	4		4	4	4	4	4		4	4	4	4	4	4	4	4
1998	3	3	3	3	3	3	3	4	4	4	4	4		3	4	4	4	4		4	4	4	4	4	3	3	3
1999	4	4	4	4	4	4	4	4	4	4	4	4		4	4	4	4	4		4	4	4	4	4	4	4	4
2000	4	4	4	4	4	4	4	4	4	4	4	4		4	4	4	4	4		4	4	4	4	4	4	4	4
2001	4	4	4	4	4	4	4	4	4	4	4	4		4	4	4	4	4		4	4	4	4	4	4	4	4
2002	4	4	4	4	4	4	4	4	4	4	4	4		4	4	4	4	4		4	4	4	4	4	4	4	4
2003	4	4	4	4	4	4	4	4	4	4	4	4		4	4	4	4	4		4	4	4	4	4	4	4	4
2004	4	4	4	4	4	4	4	4	4	4	4	4		4	4	4	4	4		4	4	4	4	4	4	4	4
2005	4	4	4	4	4	4	4	4	4	4	4	4		4	4	4	4	4		4	4	4	4	4	4	4	4
2006	4	4	4	4	4	4	4	4	4	4	4	4		4	4	4	4	4		4	4	4	4	4	4	4	4
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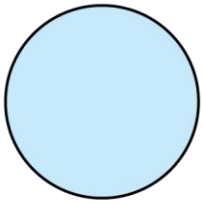
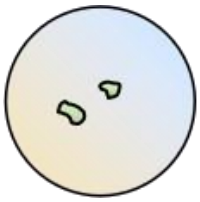
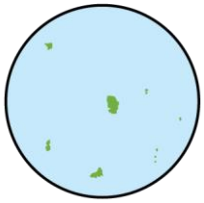
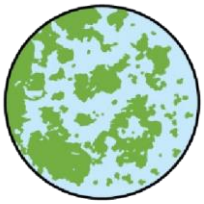
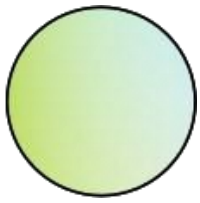
2008	4	4	4	4	4	4	4	4	4	4	4	4		4	4	4	4	4		4	4	4	4	4	4	4	4
2009	4	4	4	4	4	4	4	4	4	4	4	4		4	4	4	4	4		4	4	4	4	4	4	4	4
2010	4	4	4	4	4	4	4	4	4	4	4	4		4	4	4	4	4		4	4	4	4	4	4	4	4
2011	4	4	4	4	4	4	4	4	4	4	4	4		4	4	4	4	4		4	4	4	4	4	4	4	4
2012	4	4	4	4	4	4	4	4	4	4	4	4		4	4	4	4	4		4	4	4	4	4	4	4	4
2013	4	4	4	4	4	4	4	4	4	4	4	4		4	4	4	4	4		4	4	4	4	4	4	4	4

Appendix 12 – Microcystis Density Chart

Update to Microcystis Scale Graphics

Old Graphic	Updated Graphic	Score
		**1 – Absent** No visible *Microcystis* colonies
		**2 – Low** Visible but widely scattered *Microcystis* colonies.
		**3 - Medium** Adjacent colonies of *Microcystis*.
		**4 - High** Contiguous colonies of *Microcystis*.
		**5. Very High** Concentrated contiguous colonies of *Microcystis* forming mats or scum.

Graphics for the Microcystis Scale were updated using Adobe Illustrator based on photographs of *Microcystis* blooms found in peer-reviewed online publications.

References

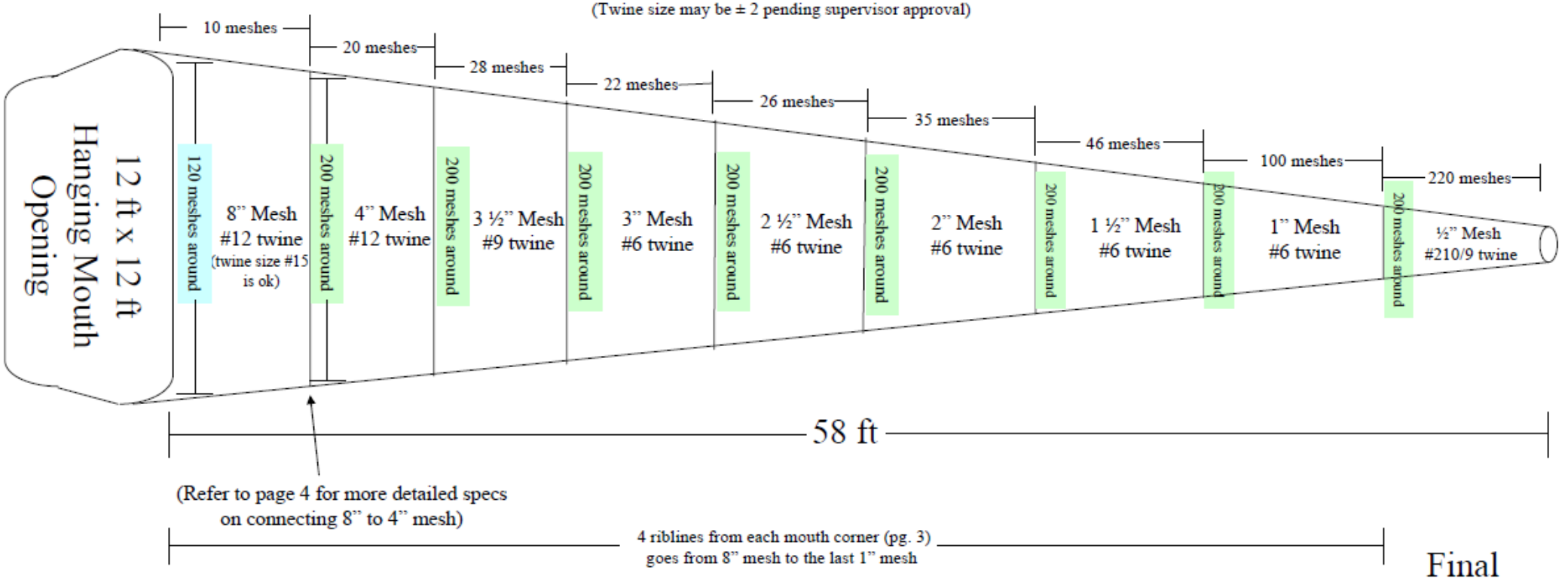
Berdalet E, Kudela R, Urban E, Enevoldsen H, Banas NS, Bresnan E, Burford M, Davidson K, Gobler CJ, Karlson B, Lim PT. GlobalHAB: a new program to promote international research, observations, and modeling of harmful algal blooms in aquatic systems. *Oceanography*. 2017 Mar 1;30(1):70-81.

USGS. Photograph taken by Jennifer L. Graham, June 29, 2006. Downloaded on 1/30/2020 from https://toxics.usgs.gov/highlights/algal_toxins/.

Appendix 13 – Net Specifications

FMWT Net Specifications

All mesh is nylon, bonded, single knot, dyed green.
All mesh measurements are stretched
(Twine size may be ± 2 pending supervisor approval)



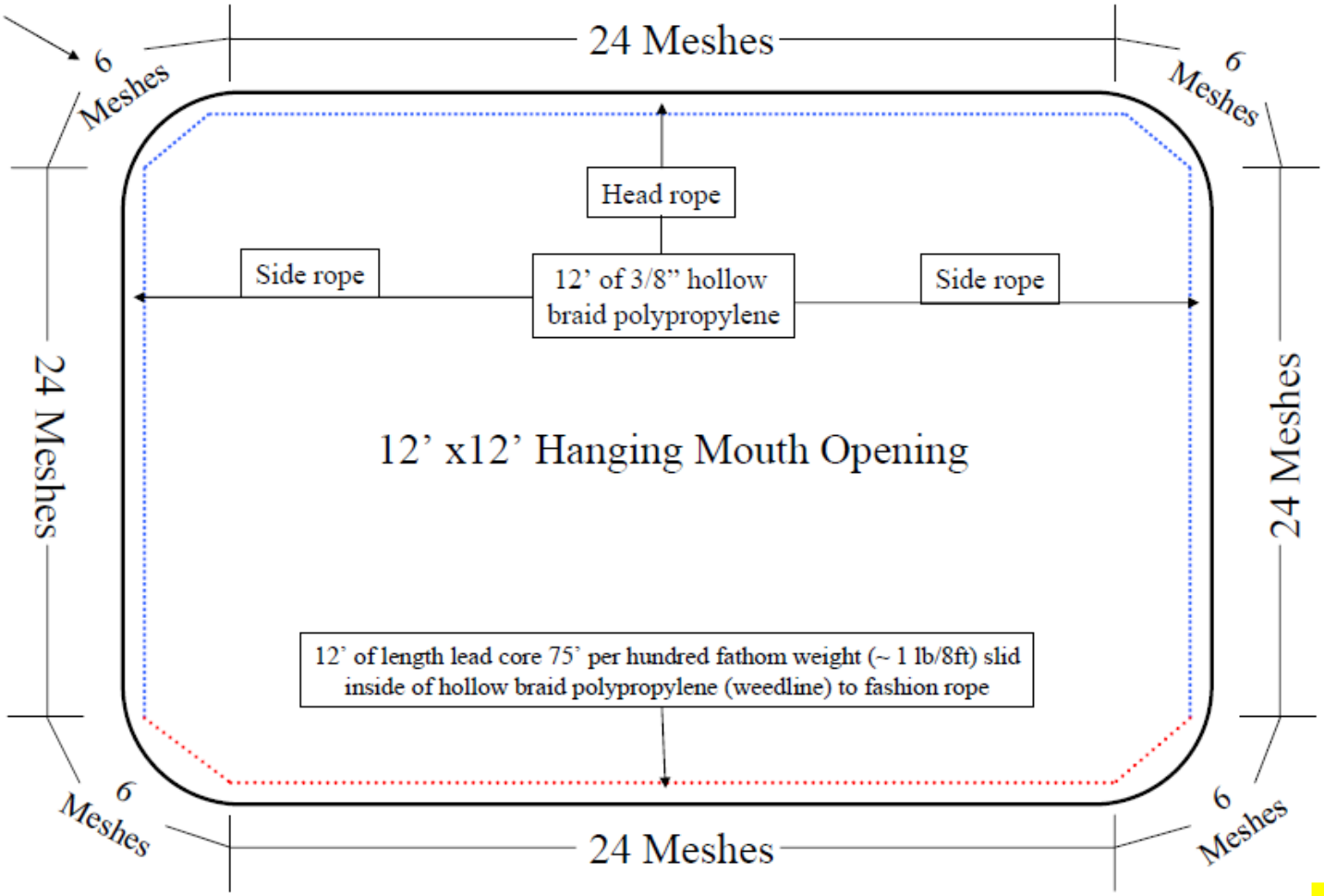
Final

Net NOT drawn to scale

Page 1

(Last Updated November 25, 2009 By D. Contreras)

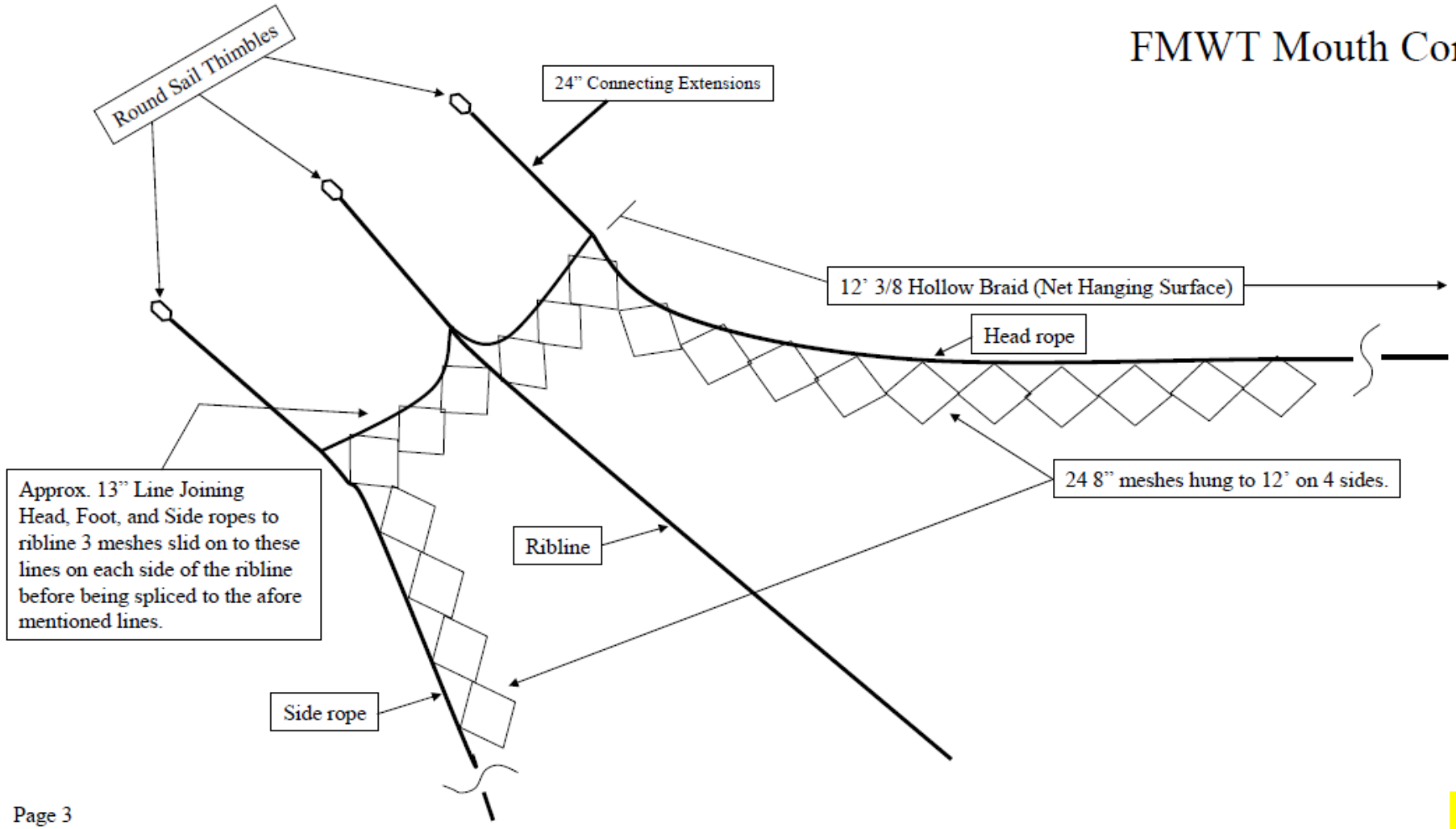
(Refer to page 3 for more detailed specs on each mouth corner)



Final

Net NOT drawn to scale

FMWT Mouth Corner Specs



Final

Net NOT drawn to scale

8” to 4” mesh sewn to seam